Green Infrastructure and the Urban Forest: Thinking Outside the Planter Box

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Watershed Management Group
Let’s put a tree there!
What is Green Infrastructure?

• WMG: “constructed features that use living, natural systems to provide environmental services, such as capturing, cleaning and infiltrating stormwater; shading and cooling streets and buildings; and calming traffic.”

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What is Green Infrastructure?

- Low Impact Development (LID)
- Integrated Water Management
- Water Sensitive Urban Design
- Best Management Practices for Stormwater Quality (BMP’s)

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What is Green Infrastructure?

- Bioretention
- Traffic Chicanes
- Green Roofs
- Stormwater BMPs
- Permeable Paving
- Preservation of Natural Systems

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Why Green Infrastructure?

- **Environmental Benefits**
  - Flood Control
  - Reduce Urban Heat Island
  - Carbon Sequestration
  - Water Quality
  - Remove Pollutants
Increased Runoff and Flooding
Increased Runoff and Flooding
Decreased groundwater recharge

Approximate decline in groundwater levels, 1940-1995

Decreased groundwater recharge

Santa Cruz River @ Tucson, 1904
Decreased groundwater recharge

Santa Cruz River @ Tucson, 1981
Decreased groundwater recharge
Urban Heat Island
Urban Heat Island
Urban Heat Island

Weather Research Forecasting Model
2 m air temperature simulations
1700 LST 14 July 2003
spatial resolution = 1 km

Source: Susanne Grossman-Clarke
## Urban Heat Island

<table>
<thead>
<tr>
<th>In Sun:</th>
<th>In Shade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass: 91.0° F</td>
<td>Grass: 64.1° F</td>
</tr>
<tr>
<td>Soil: 91.0° F</td>
<td>Soil: 56.2° F</td>
</tr>
<tr>
<td>Litter: 101.1° F</td>
<td>Litter: 60.6° F</td>
</tr>
<tr>
<td>Rock: 131.8° F</td>
<td>Rock: Unmeasured; nearby Cement 76.9° F</td>
</tr>
</tbody>
</table>

3:50 p.m. on May 19, 2010
Park and University
Non-Point Source Pollution
Non-Point Source Pollution
Non-Point Source Pollution
Soils and Bioretention

Source: Scheyer, 2005
Soils and Bioretention

Source: Scheyer, 2005
Soils and Bioretention

The Soil Food Web

First trophic level: Photosynthesizers
- Plants: Shoots and roots
- Organic Matter: Waste, residue and metabolites from plants, animals, and microbes

Second trophic level: Decomposing Mutualists
- Nematodes: Root-feeders
- Fungi: Mycorrhizal fungi, Saprophytic fungi

Third trophic level: Shredders, Predators
- Arthropods: Shredders, Predators
- Nematodes: Predators
- Protozoa: Amoebae, flagellates, and ciliates

Fourth trophic level: Higher level predators
- Bacteria: 
- Birds: 
- Animals: 

Fifth & higher trophic level: Higher level predators

Source: Scheyer, 2005
Soils and Bioretention
Soils and Bioretention

Labile Carbon

<table>
<thead>
<tr>
<th></th>
<th>Native</th>
<th>Urban</th>
<th>Rain garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg C/g soil</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Organic Matter

<table>
<thead>
<tr>
<th></th>
<th>Native</th>
<th>Urban</th>
<th>Rain garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

Microbe Population

<table>
<thead>
<tr>
<th></th>
<th>Native</th>
<th>Urban</th>
<th>Rain garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>ug C/g soil</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: Pavao-Zuckerman, 2013
Soils and Bioretention

Activity in Response to Metals Addition

Source: EPA

Source: Pavao-Zuckerman, 2013
# Soils and Bioretention

**TABLE 1 LABORATORY AND ESTIMATED BIORETENTION**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Removal Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Phosphorus</td>
<td>70%-83%</td>
</tr>
<tr>
<td>Metals (Cu, Zn, Pb)</td>
<td>93%-98%</td>
</tr>
<tr>
<td>TKN</td>
<td>68%-80%</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>90%</td>
</tr>
<tr>
<td>Organics</td>
<td>90%</td>
</tr>
<tr>
<td>Bacteria</td>
<td>90%</td>
</tr>
</tbody>
</table>

Source: ¹Davis et al. (1998)  
²PGDER (1993)
Why Green Infrastructure?

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  • Remove Pollutants

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Gray Infrastructure vs. Green Infrastructure

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Gray Infrastructure

Alters pre-development hydrology:

• Increased runoff

• Remote, large scale retention/detention results in high maintenance and wasted space

• Decreased infiltration

• Downstream flooding

• Erosion/Sedimentation

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Green Infrastructure

Mimics pre-development hydrology:

• Local micro-retention
• Decreases runoff
• Increased infiltration and local soil moisture
• Reduced downstream flooding and erosion
• Reduced burden on public storm water systems

Photo Credit: Rainwater Harvesting for Drylands and Beyond, Lancaster

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- **Livability / Quality of Life**
  - Shade
  - Traffic Calming
  - Increased Property Values
  - Crime Reduction
  - Community Building

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Functional Goals of Green Infrastructure

- Mimic Pre-Development Hydrology → Reduce Flooding
- → Reduce Flooding and Harvest Storm →
- → Increase Infiltration and Local Soil Moisture
- → Support Urban Forest and Reduce Urban Heat Island →
- → Increase Livability of Cities!
- Decrease up-front and lifetime project costs
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- **Economic Benefits**
  - Reduce energy consumption
  - Extend life of infrastructure
  - Reduce cost of new construction
Costs of Green Infrastructure

Retrofitting:
• G.I. retrofitting slightly more costly than rehabilitating of conventional infrastructure
• G.I. retrofitted incrementally can spread cost over long period of time
• Savings realized in long term operation and maintenance

New Construction:
• G.I. often 10-20% less costly than conventional infrastructure
• G.I. less costly in lifetime operation and maintenance
• Secondary and ‘trickle up’ economic benefits

Redevelopment = Opportunity

Source: Natural Resources Defense Council
Costs of Green Infrastructure

Why GI/LID makes $ sense:

- Reduced street widths = less pavement, curb and gutter
- Bioretention = fewer costly detention basins = less piped conveyance = reduced burden on public stormwater system
- Reduced lot sizes = reduced grading and building prep = more lots available for sale
- Preserving natural systems = reduced landscape costs = increase property values
- Harvested Storm water = Reduced Irrigation Demand = Sustainable Urban Forest

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Tools for Green Infrastructure

Curb Cuts

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Tools for Green Infrastructure

Curb Cores

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Tools for Green Infrastructure

Street-side Basins

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Tools for Green Infrastructure

Street-side Basins

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Street-side Basins

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Chicanes

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Street-width reduction

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Street-width reduction

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Traffic Circles

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Pocket Parks

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Parking Lot Retrofits

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Bioretention

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## Tools for Green Infrastructure

### Bioretention & Urban Forests

![Image of urban forest](image)

<table>
<thead>
<tr>
<th></th>
<th>CO$_2$ Sequestered (kg/tree)</th>
<th>Aboveground Biomass (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basin tree</td>
<td>1754.2</td>
<td>745.7</td>
</tr>
<tr>
<td>Non-basin tree</td>
<td>678.0</td>
<td>288.2</td>
</tr>
</tbody>
</table>

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Best Practices

- Utility placement and setbacks
- Runoff Management
- Planting – Right Plant, Right Place
- Overflow
- Sediment Management
- Maintenance, Maintenance, Maintenance!!!
Best Practices

- Maintenance, Maintenance, Maintenance!!!
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Best Practices

- Maintenance, Maintenance, Maintenance!!!
Upcoming Retrofits

Green Infrastructure Retrofits

Tucson:
Ward 1 Council Office
April 24, 2013
Upcoming Retrofits

Green Infrastructure Retrofits

Phoenix:
Sky Harbor Neighborhood
April 21, 2013

Roosevelt Row Neighborhood
April 27, 2013
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