High Performance Urban Ecosystems

In a world where six million people are being added each month, every site matters
Over 50% of the global population – 80% in the U.S. and Europe – now live in urban areas
Census: Austin fastest-growing metro in Texas, third-fastest in nation

Mar 26, 2015, 8:00am CDT    Updated Mar 26, 2015, 12:47pm CDT

INDUSTRIES & TAGS  Commercial Real Estate, Residential Real Estate, Demographics, Jobs
Our interactions with nature and the benefits it provides most often occur in developed landscapes.
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In our quest for sustainability, we habitually neglect the potential of urban landscapes
Why not demand more?
Lawn irrigation consumes 30% of municipal freshwater in the eastern United States and up to 60% in the west.

US EPA
85% of the invasive woody plant species in the U.S. were introduced for landscape or ornamental use, and approximately 5,000 species have escaped into natural systems.

Stormwater runoff from developed land is the leading cause of water pollution in urban areas

Loizeaux-Bennet 1999
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Think broadly about our developed landscapes and recognize their untapped potential.
Ecosystem services *n.* - goods and services provided by ecosystems that *sustain and fulfill human life.*

The provision of ecosystem services is a **key attribute** of **sustainable design.**

$16 - $54 trillion per year. **Twice the global GNP**
Global and local climate regulation
Micro-climate: Urban heat island - A single tree: 9ºF reduction in surface air temp. Green façade: up to 30ºF reduction in building wall temp during summer months. 50% tree canopy over roads: reduce road surface temps by 28ºF
Cleanse and store water
Capture sediment & other suspended particles transported by stormwater

Capture airborne pollutants on leaves, stems, & bark

Roots uptake harmful substances along with water & nutrients

Roots excrete compounds that are a food source for microorganisms, which break down & immobilize pollutants

Roots bind contaminated soils in place
healthy soil has amazing water-retention capacity. Every 1% increase in organic matter results in as much as 25,000 gal of available soil water per acre.

Source: Kansas State Extension Agronomy e-Updates, Number 357, July 6, 2012

Want more soil secrets? Check out www.nrcs.usda.gov

USDA is an equal opportunity provider and employer.
Water quality and quantity – Green infrastructure neighborhoods can decrease storm flow by 42%.
2000 sq. ft. bioretention garden and outdoor classroom at Mt. Tabor Middle School in Portland manages runoff from 30,000 sq. ft. of impervious surface. Saved the City over $100,000 in upgraded infrastructure costs.
Figure 5.23: Kresge Foundation headquarters stormwater management diagram.
Pollination and habitat
Diverse habitats - Wildlife refugia - ‘Stepping stones’ for habitat connectivity. Lincoln Park – 20 million human visitors and 158 bird species reported by citizen scientists.
‘Bottom-up’ influences on biodiversity – Groups of yards working together can potentially double native bird species richness.
Physical and mental health
Physical activity – ‘Green exercise’ – Food gardens – Neighborhoods with more vegetation near homes are more likely to engage in frequent physical activity. 40% less likely to be obese
Mental health and well-being – visual and physical access to nature has been linked to restored concentration, positive attitudes and improved productivity.
Design Solutions

How do we design spaces that improve ecosystem function and build natural capital?
Plants are **essential** to the provision of ecosystem services
Potential Annual Benefits of a Tree

Absorb 48 lbs of air pollutants

Produce 260 lbs of oxygen

Reduce cooling costs by up to 13%

Increase property value by 15%

Habitat for over 500 insect species

Intercept 4000 gallons of stormwater
A site’s vegetative biomass can indicate its productivity, with more plant layers typically providing greater benefits.
Ecosystem Service Benefits

- Supporting Services
- Provisioning Services
- Regulating Services

Triple bottom line costs

- Site Clearing
- Plant production/transportation
- Establishment
- On-going maintenance

On-going maintenance

Establishment

Plant production/transportation

Site Clearing

Regulating Services

Provisioning Services

Supporting Services

Ecosystem Service Benefits
increases environmental and economic costs
Incorporate existing appropriate vegetation into the design.
<table>
<thead>
<tr>
<th>Bur Oak 5” dbh</th>
<th>Bur Oak 25” dbh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercepts 331 gallons of stormwater</td>
<td>Intercepts 7,996 gallons of stormwater</td>
</tr>
<tr>
<td>Annually sequesters 86 lbs CO₂</td>
<td>Annually sequesters 877 lbs of CO₂</td>
</tr>
</tbody>
</table>
Eliminate potable water use after plant establishment
In the US, 52,620,000 metric tons of CO₂ – the equivalent to the amount generated by 10 million cars – is released each year by water treatment facilities (US EPA 2010).
Water Balance

Water needs of the landscape = Precipitation and on-site alternative water resources
Active Rainwater Harvesting

catchment area (ft$^2$) x rainfall (ft) x 7.48 gal/ft x runoff coefficient = net runoff (gal)
Passive Rainwater Harvesting

catchment area (ft²) x rainfall (ft) x 7.48 gal/ft x runoff coefficient = net runoff (gal)
Air Conditioner Condensate

• The average single-family home produces 5 to 10 gallons/per day

• Connect to rainwater system or store separately
Greywater

- Wastewater from the shower, sink and washing machine
- Approximately 50% to 80% of residential wastewater
- Average U.S. household generates 35 gallons per person/day
Mineral fraction – sand, silt, and clay

Organic matter – all C-containing substances both living and non-living

Gases – O₂, CO₂, N₂

Water – necessary for chemical reactions that release or tie up nutrients and many soil organisms

Protect and restore ecosystem services provided by soils.
Ecosystem services provided by soils

• Absorbs rainfall and mitigates flooding

• Removes pollutants and cleanses water

• Stores water for plants, wildlife and people

• Provides nutrients

• Stores atmospheric carbon

• Provides habitat for millions of microbes, insects, plants and animals
Co$_2$ Pools

- Oceans: 36,000 Pg
- Soil: 1,500 Pg
- Fossil Fuel: 5,000 Pg
- Plants: 550 Pg
- Atmosphere: 750 Pg

Pg = petagrams = $10^{15}$ grams = 1 billion tonnes
Once lost, soil carbon pools can take decades or centuries to rebuild. Plants can slowly restore carbon pools but thoughtful plant selection and maintenance is required to ensure the site remains a net carbon sink.
Root Systems of Prairie Plants

The fundamental basis for encouraging use of native plant species for improved soil erosion control in streams and stormwater management lies in the fact that native plants have extensive root systems which improve the ability of the soil to infiltrate water and withstand wet or erodible conditions. Native plant species, like those listed in this guide, often have greater biomass below the surface. In this illustration, note the Kentucky Bluegrass shown on the far left, which, when compared to native grass and forb species, exhibits a shallow root system. Illustration provided by Heidi Natale of the Conservation Research Institute.
What is the most common constraint with urban soils in regards to ecosystem function?

1. Compaction
2. pH
3. Soil microbes
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A:

1. Compaction
2. pH
3. Soil microbes
Soil Compaction
Weight from a single intense force or small repeated forces pushes soil particles together causing them to compact.

Compacted soils:
- Contribute to erosion
- Restrict plant growth
- Limit the soil’s ability to absorb water
- Decrease the soil’s biological activity
Common Causes of Soil Compaction

- Construction and maintenance equipment
- Repeated pedestrian and animal traffic
- Rainfall on bare soils
- Continually removing organic matter such as leaves or lawn clippings from the landscape
- Working wet soils
- Repeated tillage
Design Strategies for Landscapes Under Construction

• Conduct a site analysis before design starts

• Develop a soil preservation plan

• Enforce tight limits of disturbance

• Designate areas for parking and storage
Design Strategies for Landscapes Under Construction

- Harvest and store topsoil for reuse
- Protect soils with mulch
- Use the lightest equipment possible
- Avoid working soils when wet
Soil volume impacts plant size, life span, health and resiliency and irrigation and nutrient requirements. A minimum of 2 cubic feet of soil per 1 square foot of mature tree canopy.
Move from schedule maintenance to **adaptive maintenance** based on monitoring that guides the landscape towards **increased performance**
Continued learning and information feedback loops to improve future work and the industry.
Evaporate, Infiltrate or Reuse stormwater on-site (80th percentile)
Improve function of Waller Creek
Restore damaged soils - Increase planting soil volume
Increase biodiversity – Reduce maintenance
Provide access to nature to a much larger segment of the population
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