Site Design and Green Infrastructure for Changing Weather Patterns

Green Infrastructure Isn’t just for Stormwater Management

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World Population: Urban Share
1800 - 2050

Year 2025: 58% of world pop
Year 2050: 2/3 of world pop
GI is defined as...

- Cost-effective, resilient approach to managing wet weather impacts that provides many community benefits (U.S. EPA)

- An approach to water management that protects, restores, or mimics the natural water cycle

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**Traditional Solutions** (hard engineering)
- Building costly new water treatment plant
- Building a new water supply dam
- Building taller levees

**Natural Solutions** (soft engineering)
- Planting trees and restoring wetlands
- Choosing water efficiency
- Restoring floodplains

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**Clean water**
**Ecosystem Values & Functions**
**Benefits to People & Wildlife**
GI in U.S. Context

1972: Clean Air Act
- New provisions for management of diffuse pollutant sources from urban land uses; Regulatory need for practices that, unlike conventional drainage infrastructure, managed runoff at source.

1987: Amendments to the U.S. Clean Water Act
- Development of stormwater pollution prevention plans and the implementation of "source control practices"; EPA's 1993 handbook identified BMPs including vegetative controls, filtration practices and infiltration practices (trenches, porous pavement).

1990: EPA regulations for municipalities
- In a report to the governor on land conservation strategies, the term was intended to reflect the notion that natural systems are equally, if not more, important components of our "infrastructure."

1994 Term GI Coined in Florida
- GI as built structures for stormwater management; Low impact development (LID) as a design strategy for maintaining and replicating predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic site design.

2007 EPA use of the term GI as BMPs for LID
- GI as built structures for stormwater management; Low impact development (LID) as a design strategy for maintaining and replicating predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic site design.

GI in European Context

• A strategically planned *network of natural and semi-natural areas* with other environmental features designed and managed to deliver a wide range of *ecosystem services* in both *rural and urban* settings (European Commission, 2013)

• GI is based on the principle that ‘protecting and enhancing nature and natural processes that are consciously integrated into *spatial planning* and *territorial development*’ (European Commission, 2013)
Potential components of a Green Infrastructure:

- green wall
- green roof
- wildflower verge
- hedgerow
- biodiversity-rich business park
- beehives
- multifunctional farming
- wildlife overpass
- reedbed
- fish ladder
Ecosystem Services

“The benefits people obtain from ecosystems”
GI in Practice

Rain Garden
Bioretention
Detention pond
Bioswale
Dry swale
Filter strip
Vegetated roof
Vegetated wall
Pervious paving
Rainwater harvesting

Riparian buffer
Tree box filter
Surface sand filter
Underground sand filter
Infiltration trench
Infiltration basin
Constructed wetland
Swales vs Bioswales

SLOPE = RISE/RUN
BIOSWALE

Slope: 2%-10% for grassed swales
BIORETENTION

Process in which contaminants, sediments, and excessive flows from stormwater are collected

Through a process of infiltration water is cleaned and returned to the ground water or sent along in a stormwater mitigation chain.

Water can persist in a retention situation permanently; compared to detention, where the water should drain out within 24 to 48 hours.
Detention VS. Retention

DETENTION
Temporary = Dry Pond

RETENTION
More permanent = Wet Pond
Slope: 25% on grassed banks for detention basins
People Exposed At Risk of 100-yr Flood

Millions More Americans Face Flood Risks Than Previously Thought

This hurricane season, the United States saw widespread flooding as record-breaking storms, Hurricane Florence's flood in particular took a heavy toll on coastal areas. The storm's impacts were evident in North Carolina, with millions of people displaced and damage estimated in billions. With each flood season, the number of people exposed to flood risks continues to grow. 

The case in点 does not properly manage outflows from reservoirs to prevent flooding. Authorities suggest that a small reservoir could save billions. All flood control measures require significant investment and proper maintenance. Given these needs, increased resilience and the American public's understanding of flood risks are crucial.

Both large and small floods can cause significant damage. In the United States, this information is provided by the Federal Emergency Management Agency (FEMA), which produces maps of flood zones to help inform decisions under the National Flood Insurance Program.

The agency's FEMA flood maps, developing integrated flood models for small and large flood events, can help communities prepare and mitigate flood risks. In the short term, these maps are available online, and communities can use them to understand their flood risk and plan accordingly. For more information, the agency recommends visiting its website for comprehensive risk assessment.

41M

Wing et al.

FEMA

13M

Population exposed to 1 in 100-year flood per 100 km²
Green Infrastructure in Red Zones

How would communities be resilient?

Ecosystem resilience

Would the plants thrive?
Multifunctionality & GI Co-Benefits

**Environmental Benefit**
- Clean water
- Removal of air/water pollutants
- Pollination enhancement
- Protection against soil erosion
- Rainwater retention
- Increased pest control
- Improvement of land quality
- Mitigation of land take and soil sealing

**Climate Change Adaptation/Mitigation Benefits**
- Flood alleviation
- Strengthening ecosystem resilience
- Carbon storage and sequestration
- Migration of urban heat island effects
- Disaster prevention (storms, forest fires, landslides)

**Social Benefits**
- Human health and well-being
- Job creation
- Diversification of local economy
- Attractive, greener cities
- Higher property values
- Integrated transport/energy solutions
- Enhanced tourism/recreation opportunities

**Biodiversity Benefits**
- Improved habitats for wildlife
- Ecological corridors
- Landscape permeability
The Southwest

Arid environment
Sonoran Desert
Xeriscape
The Southwest

The University of Arizona Underwood Family Sonoran Laboratory

A model of water-conscious design

Image Credits: Ten Eyck Landscape Architects
Biodiversity
Permeability
Judicious use of hardscape
The South - NW Texas

Panhandle Plains
Dry Steppe
Flat
Playa system
Local flooding
Dust
Drought
How Do Playa Lakes Currently Function?

- Catch runoff that collects in low spots.
- Naturally restore capacity by evaporation or infiltration – slow process.
- Some overflow to the next downstream playa in larger rainfall events.
- Some lakes do not overflow even in a 0.2% chance annual rainfall event.
Forgotten Ecosystem Services

Altered Form

Urban Playas

Altered Function

Altered Context

Seasonal wet/dry cycles that encourage diversity of plants to support wildlife
- Filtration/Nutrient uptake/Phytoremediation
- Marginal habitat

Concentrated Pollution
- Increased Erosion
- Increased opportunity for longer-period wet cycles
May 2015 Storm Event

Severe storm, hail...

Add pics & videos

Look for statistics & graphics
We may have a torrential downpour, lighting and thunderstorm, but how much we should be patient with chronic flooding in this city? How long should we aquaplane, see stopped vehicles in the middle of a street, be surrounded by an incessant ambulance siren, and roll up trousers to walk on the campus? Total chaos!

City planners and engineers, can’t we really think of any alternatives other than the playa system?

https://www.facebook.com/hannah.mulloy1/videos/10206712380354465/
Lubbock Arboretum Clapp Playa Lake Park
111 acres of the entire project area: 93 acres of park and 18 acres of two playa lakes bisected by the walking path across it

RESTORATION PARTNERSHIP Proposal
- Removing litter
- Planting native seedlings
- Restoration planning and design
- Designing and implementing bioswales with vegetated buffers
- Sampling for water and sediment quality
- Assessing water and sediment quality using bioassays
- Macro-invertebrate sampling
Design Concept 1: Swale Removal & Revegetation
Design Concept 2: Ephemeral Wetland Habitat Learning Center
Challenges to Change
-or-
“Taxpayers paid for that concrete.”
GI Site Design Cases
The functional concept of the Llano Estacado, paired with the visual concept of a road trip on the Llano, provides a unique regional context to green infrastructure implementation while educating the public about the unique aspects of the region.
**Impermeability**

The campus is dominated by impervious surfaces. The flat 0.0% trend slope in the entire region means limited subsurface conveyance.

**Drainage Divides**

Campus-wide drainage boundaries with pour points are overlaid with 6-inch contours derived from a DEM (digital elevation model).

**Storm Water Flow**

Storm water runoff that exits the sub-basin is conveyed through sub-surface piping that transports runoff into 10th street.

**Site Inventory and Analysis**
Site Drainage
Elements that contributed to storm water runoff were analyzed, and a solution was derived by viewing the entire system as a whole.

The designed site captures storm water runoff, thus reducing the impact on the point of concentration in this subbasin.
City Park
Demonstration - Altered Playa Lake
Within the urban setting, playa lakes have been altered to retain stormwater.

Ogallala Aquifer Representation
The Ogallala is the main source of life-supporting water in the Texas Panhandle. It is also being depleted faster than it can be replenished.

Native Prairie - Mini-Playa Lakes
Playa lakes are only found in the northwest portion of the state of Texas and they generally come in two forms: altered and unaltered.

Agricultural Representation
Agriculture has been a driving economic and cultural force on the Llano Estacado for many years.

Residential Demonstration
The residential zone illustrates green infrastructure practices with pitched roofs connected to a downspout system that feeds into rain barrels.

Bioswale
Bioswales slow down the time of concentration of storm water and, with appropriate plant selection, increases storm water quality before it enters the municipal sewer system or local bodies of water.

Caprock Representation
The edge of the Llano Estacado is called the Caprock Escarpment. It is the geographic transition as the Llano descends into the surrounding landscape, and has a very distinct red sandstone laced with white gypsum.
**OASIS:**

**RETROFITTING UCONN'S ICONIC MIRROR LAKE**

**ROCK GARDEN VIEW**

**IMPLEMENTATIONS**

1. Eleven planted floating islands
2. Engaging Floating Island Educational Walkway
3. Tributary Rain Gardens
4. Restoration of 1.2 acres of native meadow
5. Enhancement of existing lake buffer

**PLAN**

**SITE ANALYSIS**

**PERGOLA VIEW**

**FLOATING ISLAND SECTION**

**PROJECT OUTCOMES**

1. Up to 50% more removal of nitrogen, phosphorus, and sediment due to floating islands alone
2. Decreased phosphorus, gasoline and chloride loading from the immediate watershed
3. Reduced Impairment of Roberts Brook downstream
4. Public engagement via the Floating Island Educational Walkway
5. Improved waterfront access around the perimeter of the lake
6. Increased biodiversity and ecosystem services
7. A celebration of Roberts Brook
Multi-Forces

Green Infrastructure (green space)

Blue Infrastructure (river, stream)

Grey Infrastructure (street)

Utility Infrastructure (power/sewer)

Gold Infrastructure (soil)

Integrative, Holistic Approach

Natural Climate/Landscape Solutions

Social Infrastructure

Public domain
- GI governance
- Culture/political will
- Land use policy/planning
- Civic engagement

Private domain
Sustainable SITES Initiative

- Sustainable Landscape Design and Development
- 5 SITES APs in Connecticut out of 240 in the U.S.

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<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<td>2016</td>
<td>The 1st SITES v2 Certified Project</td>
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| 2014 | SITES v2  
     | Rating System & Reference Guide  
     | GBCI |
| 2009 | SITES v1 (Pilot Version)  
     | Guidelines and Performance Benchmarks  
     | 46 certified projects in 20 states (1-4 stars) |
| 2000 | LEED Rating System |
| 1993 | USGBC established |
SITES Projects in U.S.

- 21 states
- 46 certified pilot projects (1-4 stars)
- 317 acres in total, 15 acres on average under SITES
- 80% redeveloped project (greyfield → open space)
- 3 rural, 16 suburban, 27 urban
- Total $99M, Ave. $10M
Take Home Message

Design Interventions that Care and Value

Ecosystem Services (Delivery)

Aesthetics

Process

Education

System Thinking

[Coupled Human-Ecological System]

Ecological Integrity
Urban ecology
Natural resources conservation

Ecological System

Human System

Safety
Wellness
Health
Quality of Life
Community Resiliency
Sustainability

Green infrastructure enhances ecosystem health and climate change resilience, and contributes to biodiversity, and benefits human populations.
Thank You!

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