Introducing Green Infrastructure for Coastal Resilience

National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management
John Rozum

Lighthouse Point, New Haven, CT
Wikimedia Commons
What Is “Resilience”? 

Introducing Green Infrastructure for Coastal Resilience

Lyme, CT
Beth Lawrence, UConn
Course Objectives

Participants:

- Recognize green infrastructure terms and concepts that contribute to community resilience
- Understand ecological, economic, and societal benefits of green infrastructure
- Understand the wide variety of contexts and scales of approaches
- Understanding of how green infrastructure fits into existing planning processes, tips on engaging stakeholders, and potential funding opportunities
- Identify local green infrastructure activities and experts with additional information and resources
Course Outline

Introducing Green Infrastructure for Coastal Resilience

1. Green Infrastructure Concepts and Principles
2. The Practice of Green Infrastructure
3. Implementing Green Infrastructure
Who’s in the Room?

• One Word you think of when you hear the term “Green Infrastructure”
Section 1
Green Infrastructure Concepts and Principles

Courtesy National Resource Conservation Service
The Terminology Thicket
Foundations of Green Infrastructure

Green Infrastructure Concepts and Principles

- Landscape Architecture (1860s)
- Landscape Ecology (1930s)
- Design with Nature (1960s)
- Conservation Biology (1970s)
- Clean Water Act (1970s)
Foundations of Green Infrastructure

Green Infrastructure Concepts and Principles

Landscape approach?

Site-level approach?
Applicability across Scales

Green Infrastructure Concepts and Principles

Landscape and watershed

Community and site

Shore and coastal zone
Importance of Context

Green Infrastructure Concepts and Principles

Green infrastructure practices are context sensitive.

- Rural
- Coastal
- Urban
- Upland
Why Green Infrastructure?

Green Infrastructure Concepts and Principles

Coastal Shoreline Counties

123.3 million
Coastal Shoreline County population in 2010.

39%
Percent of the U.S. population that resides in Coastal Shoreline Counties in 2010.

34.8 million
Coastal shoreline county population change from 1970 to 2010, a 39% increase.
(U.S. average 9%)

10 million
Projected population change in Coastal Shoreline Counties from 2010 to 2020, an 8% increase.
(U.S. average 10%)

The Bottom Line

In 2010, 123.3 million people, or 39 percent of the nation’s population lived in Coastal Shoreline Counties. Population growth in these counties occurred at a lower rate than the nation as a whole from 1970 to 2010. The population in Coastal Shoreline Counties increased by 34.8 million people, a 39 percent increase, while the nation’s entire population increased by 52 percent over the same time period.
Why Green Infrastructure?

Green Infrastructure Concepts and Principles
Why Green Infrastructure?

Green Infrastructure Concepts and Principles

Courtesy, Adam Whelchel, TNC
Exposure to Coastal Hazards

Green Infrastructure Concepts and Principles

- Shallow Coastal Flooding
- FEMA Flood Zones
- Storm Surge
- Sea Level Rise

coast.noaa.gov/digitalcoast/tools/flood-exposure
Ecosystem Services

Green Infrastructure Concepts and Principles

Natural ecosystems provide multiple benefits to people, including food and water production, improved air and water quality, and recreation and spiritual inspiration.
Multiple Benefits

• Environmental

• Societal

• Economic

nca2014.globalchange.gov/report/regions/coasts
A wide variety of stakeholders stand to benefit. Engaging stakeholders is an essential part of understanding the benefits and how they are valued by people.
What coastal hazard issues is your community experiencing? (e.g., flooding, stormwater runoff)
Section 2
The Practice of Green Infrastructure
Planning Concepts

- Approach will depend on the *scale* you are addressing
- All practices, regardless of scale, use *ecosystem services* to acquire maximum benefits
- Design methods are repeatable and grounded in *science*
- *Context* is important
Successful green infrastructure practices incorporate:

- Multi-functionality
- Resilience
- Sense of place
- Return on investment
Green Infrastructure in Practice

The Practice of Green Infrastructure

Landscape and watershed

Community and site

Shore and coastal zone
# Landscape Design Concepts

*The Practice of Green Infrastructure*

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Watershed Design Concepts

The Practice of Green Infrastructure

- Preserve native vegetation
- Protect steep slopes
- Buffer stream channels
- Reduce connected impervious cover
- Seek multiple benefits

Source: Horsley Witten Group; Center for Watershed Protection
Landscape and Watershed Approaches and Resilience

• Recent study* on flood reduction during Hurricane Sandy showed:
  – Coastal wetlands saved more than $625 million in flood damages
  – Where they exist, coastal wetlands reduced damages by more the 10% on average
  – In Ocean County, NJ wetland conservation can reduce average annual losses by more than 20%

*Coastal Wetlands and Flood Damage Reduction: Using Risk Industry-Based Models to Assess Natural Defenses in the NE USA, 2016.
Community and Site Design Concepts
The Practice of Green Infrastructure

- Natural areas and open spaces should serve multiple functions (e.g., recreation, stormwater storage, filtration)
- Connect people to open areas through greenways and trails
- Preserve or mimic the natural hydrological functions of a site or drainage area
- Use urban streetscapes to provide ecosystem benefits in urban areas
Community and Site Approaches

The Practice of Green Infrastructure

Urban Forestry

• Trees provide enormous environmental, economic, and societal benefits

• Develop a tree planting program designed to maximize benefits

• To the extent possible, protect existing forested areas, particularly large specimen trees
Community and Site Approaches

The Practice of Green Infrastructure

Green Streets

- Key linking component in green infrastructure network
- Design dependent on local conditions but generally include
  - Alternative street widths
  - Swales
  - Bioretention
  - Permeable pavements
- Provides multiple benefits

Philadelphia Water Department

Coos Bay, Oregon
Community and Site Approaches

The Practice of Green Infrastructure

Environmental Site Design

- Place the site in context to greater community
- Preserve and enhance natural features
- Mimic or enhance existing hydrology
- Minimize impervious cover
- Key component of low impact development (LID)

TrockWorks Architectural Services
Community and Site Approaches

The Practice of Green Infrastructure

Low Impact Development Practices

- Bioretention (Infiltration and Filtering)
  - Rain gardens
  - Bioswales
  - Stormwater planters

- Green Roofs (Storage and Evapotranspiration)
  - Blue roofs
  - Cisterns

- Permeable Pavements (Infiltration)
  - Porous asphalt/concrete
  - Grass or gravel pavers
  - Pavers
Community and Site Approaches and Resilience

• Many studies on the effectiveness of these practices for
  – Reducing the heat island effect
  – Improving water quality
  – Recharging groundwater
  – Providing societal benefits

• For LID, flood reduction is a ‘co-benefit’
  – City of Portland, OR reduced peak flow of stormwater runoff by 93%, cooling costs by 27%, and heating costs by 15%.
Shoreline Design Concepts

The Practice of Green Infrastructure

• Natural or Nature-Based
  – Dunes and beaches
  – Vegetated features (salt marsh, wetlands, submerged aquatic vegetation)
  – Oyster and coral reefs
  – Barrier islands
  – Maritime forest/shrub communities

• Hybrid
  – Natural and structural features

• Nonstructural
  – Floodplain policy and management
Shoreline Approaches

The Practice of Green Infrastructure

Natural or Nature-based

Dune and Beach Creation
- Break offshore waves
- Attenuate wave energy
- Slow inland water transfer

Salt Marshes, Wetlands, Vegetation, SAV
- Break offshore waves
- Attenuate wave energy
- Slow inland water transfer
- Increase infiltration

Oyster and Coral Reefs
- Break offshore waves
- Attenuate wave energy
- Slow inland water transfer

Salisbury Beach
Courtesy, MA Office of Travel

Courtesy, Waquoit Bay NERR

OFFICE FOR COASTAL MANAGEMENT
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Shoreline Approaches

Hybrid

- Blends both nature-based and structural approaches
- Derives benefit of wave energy dissipation from structural practices
- Derives ecosystem service benefits from nature-based practices

http://sagecoast.org/info/information.html

 Courtesy, Tracy Skrabal, NC Coastal Federation
Shoreline Approaches and Resilience

*Study* conducted in North Carolina before and after Hurricane Irene showed:

- Marshes with and without sills are more durable and protected shorelines from erosion better than the bulkheads during the Category 1 storm.
- 76% of bulkheads were damaged in the storm.
- No damage occurred to shorelines with or without sills.

*Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane, 2014*
What green infrastructure-related projects are you working on now, or hope to, that contribute to preserving resilience-enhancing ecosystem services in your community?

Record one sentence project description, location, your contact information

Put a “P” if it is an existing or planned project
Put an “I” if it is an idea.
Section 3
Implementing Green Infrastructure
# Barriers to Green Infrastructure

## Implementing Green Infrastructure

### Technical and Physical
- Lack of understanding
- Lack of data showing benefits, costs, and so on
- Insufficient technical knowledge or experience
- Lack of design standards, codes, and ordinances

### Financial
- Not enough data about costs and economic benefits
- Perceived high costs over short and long terms
- Lack of funding for implementation
- Too much risk – not enough incentives

### Legal and Regulatory
- Local rules lacking, conflicting, or restrictive
- State policies
- Property rights issues
- Federal rules can be conflicting

### Community and Institutional
- Insufficient information and green infrastructure benefits for political leaders, administrators, staff, developers, builders, and landscapers
- Community and institutional values that underappreciate green infrastructure aesthetics and characteristics
- Lack of interagency and community cooperation
Incorporate green infrastructure into planning efforts:

- Comprehensive
- Transportation
- Smart growth
- Watershed
- Conservation
- Hazard mitigation

- Stormwater
- Climate change adaptation
- Resilience
- Land use
Green Infrastructure Can Inform Planning

Implementing Green Infrastructure

Maryland State Plan

Prince George’s County

Bowie Planning Area
Comprehensive, Hazard Mitigation, and Climate Adaptation Planning

Implementing Green Infrastructure
Multiple Benefits

Implementing Green Infrastructure
Engaging Stakeholders

- Have a plan
- Speak to their interests, not yours
- Explain the hazard risk and offer solutions
- Use multiple ways to communicate

Implementing Green Infrastructure

cost.noaa.gov/digitalcoast/tools/canvis
Engaging Stakeholders

Implementing Green Infrastructure

Get nature’s benefits between you and the next coastal storm

coast.noaa.gov/digitalcoast/training/gi-animation
Engaging Stakeholders

Implementing Green Infrastructure

Put Green Infrastructure between Your Community and the Next Coastal Storm.
There are many benefits.

- **Tidal and Forested Wetlands**
  - Slow waves
  - Filter and clean floodwaters
  - Provide food and jobs

- **Green Streets**
  - Capture and clean stormwater
  - Beautify streets and encourage economic development
  - Provide pedestrian-friendly walkways

- **Oyster and Coral Reefs**
  - Slow storm surge
  - Provide food
  - Clean water

- **Sand Dunes**
  - Buffer waves as a first line of defense
  - Build economy through tourism

- **Open Space and Parks**
  - Store floodwaters and recharge aquifers
  - Increase property values

- **Urban Trees**
  - Reduce runoff and absorb Roadwaters
  - Shade and cool homes and businesses
  - Provide clean air and water

- **Living Shorelines**
  - Slow waves and reduce erosion
  - Protect property

Here’s What You Can Do to Protect Your Community.
Green infrastructure can have multiple functions and cost less than using only gray infrastructure.

### Conserve Existing Natural Areas
- Natural areas such as wetlands, dunes, and vegetated shorelines absorb storm surge waves, reducing damage to nearby homes and roads.

**How do we know it works?** A study after Hurricane Sandy showed that areas containing wetlands had less damage than those without. Wetlands prevented an estimated $660 million in property losses.

### Increase Your Community’s Ability to Absorb Stormwater
- Protect and plant trees
- Implement other practices such as green streets to keep stormwater from running into sewers, lessening the strain on existing systems.
- Use capital improvement projects as an opportunity to fund stormwater projects.

**How do we know it works?** The City of Portland, Oregon, used a combination of green roofs, green streets, trees, and rain gardens to reduce the peak flow of stormwater runoff by 99 percent, cooling costs by 27 percent, and heating costs by 15 percent.

### Create Natural Shorelines
Create living shorelines using seagrass, marsh grass, and other natural materials to absorb wave energy and reduce erosion.

**How do we know it works?** North Carolina properties that used natural shoreline protection measures withstand wind and storm surge during Hurricane Irene better than properties using seawalls or bulkheads.

To learn more, visit coast.noaa.gov/digitalcoast/topics/green-infrastructure.

Office for Coastal Management
Digital Coast

See the reverse of this page to learn more.
Engaging Stakeholders

Implementing Green Infrastructure

**Costs of Low Impact Development**

LID Saves Money and Protects Your Community's Resources

Are Low Impact Development (LID) Practices More Economical Than Conventional Practices?

In many cases, the answer is yes. LID typically involves a variety of low-cost elements such as bioretention gardens that use rain water and encourage it to soak into the ground rather than allow it to run off into storm drains where it would otherwise contribute to flooding and pollution problems. LID projects typically include smaller overall development footprint, reduce the amount of runoff generated, and increase the amount of natural areas on a site, thereby reducing costs when compared to traditional stormwater management and flood control.

**Example Economic Benefits of LID Elements**

- Adding rainwater harvesting, making pools easier and less subject to ponding water, can reduce the cost of maintaining and maintaining runoff systems.
- Installing green roofs, using rooftop surfaces that absorb solar energy and store water, can reduce energy costs by eliminating the need for costly rainfall water management systems.
- Developing new commercial residential areas saves money by eliminating the need for costly rainfall water management systems.
- Using existing trees and vegetation saves money by reducing the need for stormwater management systems.

**Case Studies for Low Impact Development**

- **Seattle, Washington**: Seattle’s 21st Avenue Street Edge Alternative project repurposed an existing street with LID technologies to address stormwater issues in the city. The project saved $60,000 in avoided maintenance costs compared to a conventional solution, which would have cost an estimated $450,000.
- **Rensselaer, New York**: The city of Rensselaer, New York, installed a low-cost, low-maintenance stormwater management system at its downtown bus terminal, saving an estimated $140,000 in avoided maintenance costs compared to a conventional solution.

**Maintenance of Low Impact Development**

Communities are easily managing LID practices

- **Implementation of Green Infrastructure**
- **What is LID?**
- **What can you do?**
- **Green Financing**
- **Best Management Practices**

**FAQ**

- Why should I use LID practices?
- How do LID practices work?
- What are the benefits of LID practices?
- How can I get started with LID practices?

**Implementing Green Infrastructure**

**National Oceanic and Atmospheric Administration**

**www.epa.gov/green-infrastructure/overcoming-barriers-green-infrastructure**
Funding for Green Infrastructure

Implementing Green Infrastructure

- US Environmental Protection Agency
- NOAA
- Federal Emergency Management Agency
- National Park Service
- National Endowment for the Arts
- US Department of Transportation
- Economic Development Administration
- National Recreation and Parks Association
- Funders Network for Smart Growth and Livable Communities
- Qualified Energy Conservation Bonds
Group Discussion 3

Implementing Green Infrastructure

• **Part 1**: What barriers have you run into around implementing green infrastructure?

• **Part 2**: How can you overcome these barriers?
One Last Thing . . .

Please fill out the Evaluation!

Thank You!

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