



Pennsylvania
Emergency Management Agency



June 30, 2025

12:30PM-1:30PM ET

DBRC Enrichment Series –

Design for Flood Resilience

Part 2: Nature-based Solutions,
Green Infrastructure, and Low
Impact Development



Middle Delaware Enrichment Webinar #4

– Sponsored by Delaware River Basin

Commission & Presented by PEMA

WELCOME

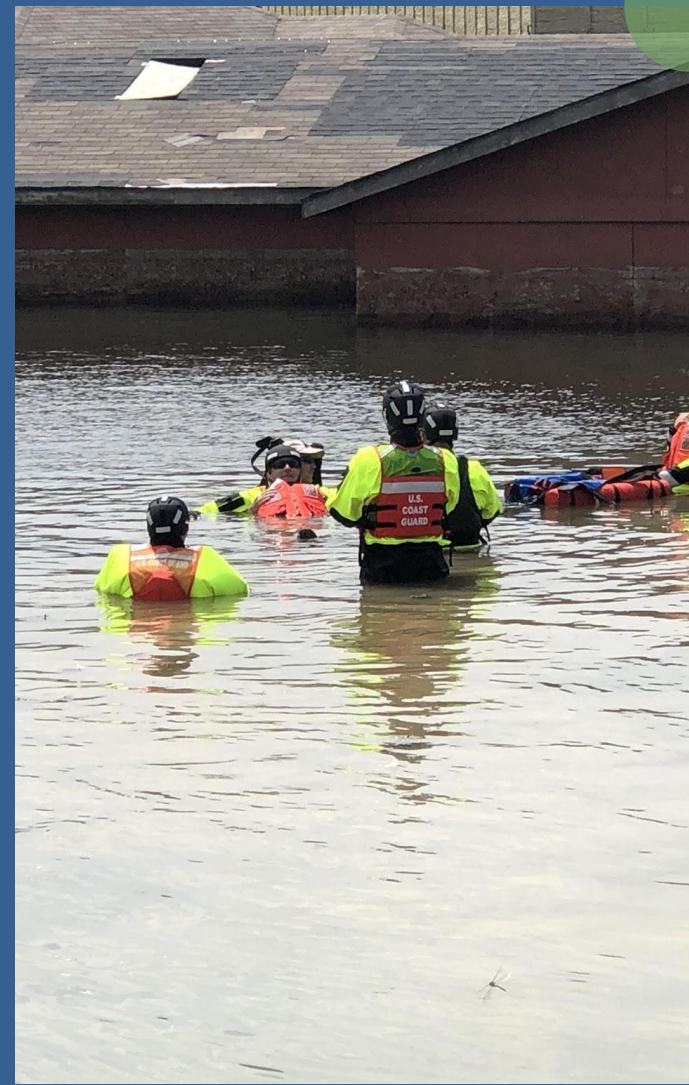
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Learning Objectives from Part 1 Discussion



- 1 Identify the **risks** associated with different types of flooding
- 2 Explain the advantages of **watershed management based on future conditions**
- 3 Describe **flood resistant design measures** for buildings and infrastructure

Today's Learning Objectives



- 1 Define **nature-based solutions** and identify key drivers of their **importance**
- 2 Understand the **benefits** of **nature-based solutions**
- 3 Identify **types of nature-based solutions** and **identify key elements** of green infrastructure
- 4 Understand **FEMA's role** in implementing nature-based solutions and **identify resources** for communities to fund and support nature-based solutions



Design for Flood Resilience

Learning Objective 1:

Define **nature-based solutions** and identify key drivers of their **importance**



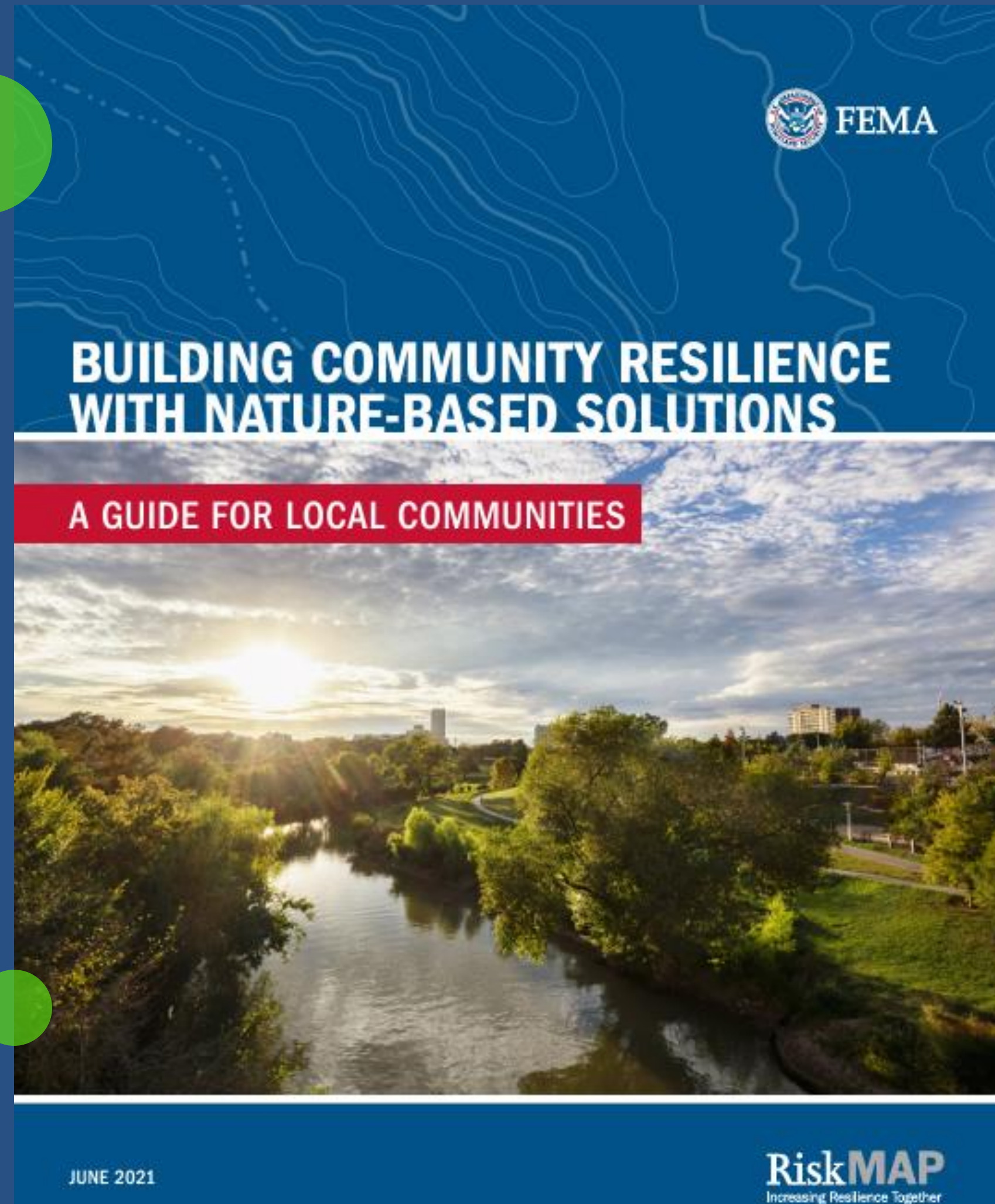
Nature-based Solutions

FEMA defines nature-based solutions as:

“Sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to build more resilient communities.”

Nature-based Solutions

- This decade FEMA has shifted to describe projects other institutions might refer to as “low impact development” or “green infrastructure” as “nature-based solutions”
- The common thread among these terms is that they all offer value beyond the mitigating effects provided by conventional, single-purpose infrastructure:
 - Environmental benefits
 - Social benefits
 - Economic benefits



What is Green Infrastructure/Low Impact Development?

- **Green Infrastructure:**

- No universal definition
- EPA uses term “Green Infrastructure”
- Broad concept - an umbrella term for concepts like low impact development, sustainable stormwater management, etc.

- **Low Impact Development**

- Site-specific approach to land development
- Focused on maintaining pre-development hydrology in an engineered environment
- Emphasizes preserving natural features like wetlands and floodplains

EPA Definition:

“Green infrastructure uses filtration, infiltration, and evapotranspiration to treat and soak up rainwater where it falls. It can deliver multiple environmental, social, and economic benefits beyond stormwater management alone.”

*Terms such as **nature-based solutions**, green stormwater infrastructure, and **low-impact development** are also used to describe green infrastructure installations, and there is overlap between these concepts.”*

Key Drivers of the Importance of Nature-based Solutions

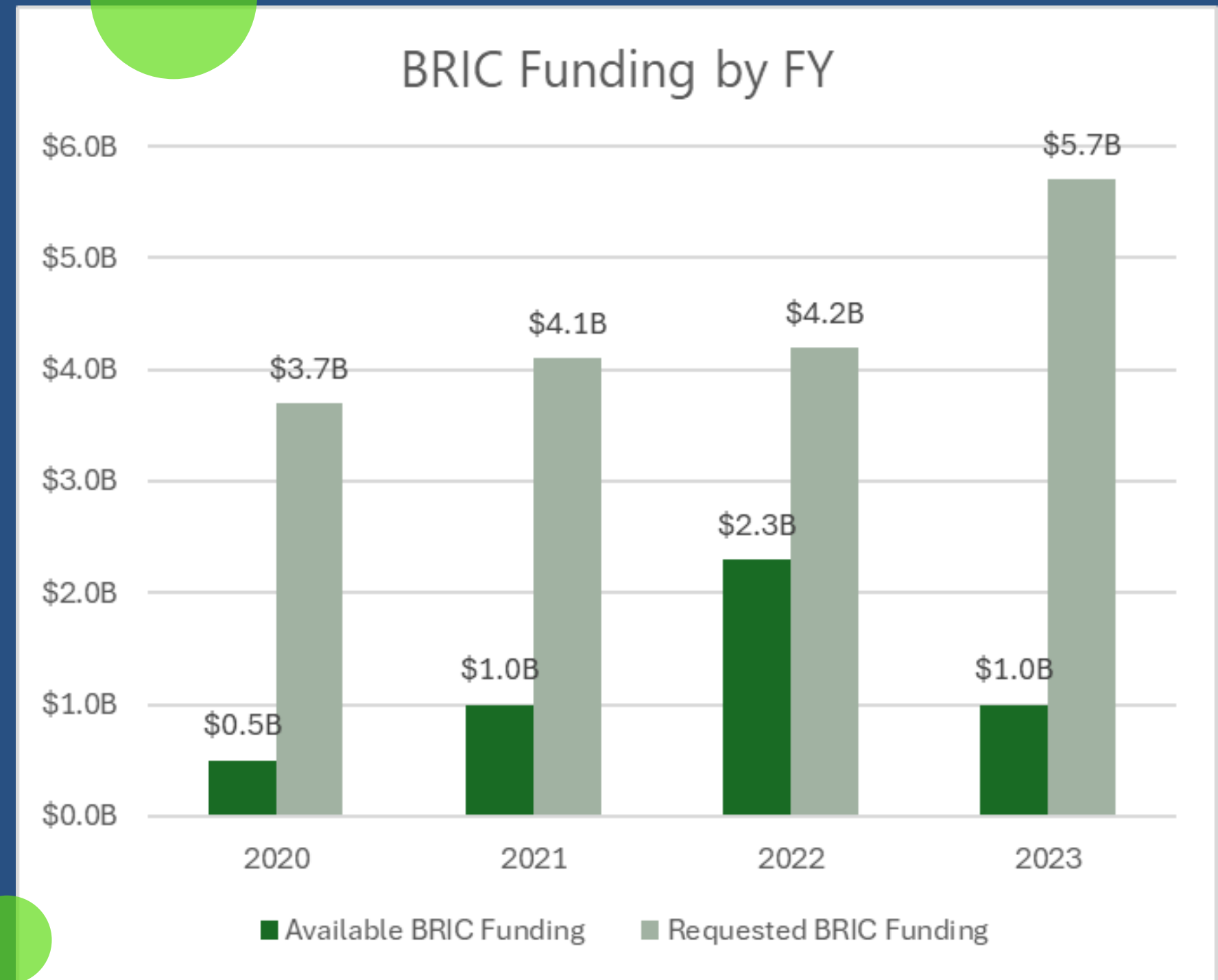
- Increasing frequency and severity of natural disasters
- Improved cost-effectiveness and resilience
- Benefits beyond mitigation of hazards
- Alignment with nation's previous climate and equity goals ([EO 14072](#))

<https://www.govinfo.gov/content/pkg/FR-2022-04-27/pdf/2022-09138.pdf>



The Expanding Role of NBS within FEMA HMA Programs

With the 2018 Disaster Recovery Reform Act, FEMA's HMA spending has significantly grown, particularly with the establishment of the BRIC program. With this, FEMA has increasingly recognized the importance of nature-based solutions in mitigating the impacts of flooding hazards. The use of nature-based solutions is cost-effective and provides benefits to the community beyond the hazard mitigation impacts.





Design for Flood Resilience

Learning Objective 2:

Understand the **benefits** of **nature-based solutions**

The Benefits of Nature-based Solutions

Hazard Mitigation Benefits:

- Mitigation benefits also offered by traditional engineering solutions
- Reduction in loss of life and property resulting from natural hazards

Community Co-Benefits:

- Benefits unique to natural-based solutions
- Contribute to a community's triple bottom line, adding social, environmental, and financial value

Hazard Mitigation Benefits:

Flood Risk Reduction



Riverine Flooding



Stormwater Drainage



Coastal Flooding

Hazard Mitigation Benefits:

Additional Risk Reduction



Drought



Landslide

Community Co-Benefits

“The biggest selling points for nature-based solutions are their many benefits beyond mitigating the effects of natural hazards.”

-FEMA Building Community Based Resilience With Nature-based Solutions Guide

The
Triple
Bottom
Line

Environmental



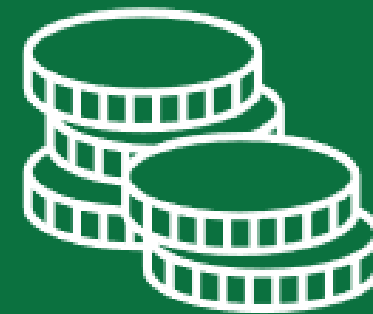
+

Social



+

Economic



Environmental Benefits



Social Benefits



Economic Benefits



Knowledge Check:

Learning Objective Two

1. What is the “triple bottom line”?
2. What is an example of an economic benefit provided by nature-based solutions?



Design for Flood Resilience

Learning Objective 3:

Identify **types of nature-based solutions** and **identify key elements** of green infrastructure

Scale of Nature-based Solutions



**Watershed or
Landscape Scale**



Neighborhood or Site Scale



Coastal Scale

Watershed/Landscape

Interconnected systems of natural areas and open space. These are large-scale practices that require long-term planning and coordination.

WATERSHED SCALE



LAND CONSERVATION

Land conservation is one way of preserving interconnected systems of open space that sustain healthy communities.

Land conservation projects begin by prioritizing areas of land for acquisition. Land or conservation easements can be bought or acquired through donation.



GREENWAYS

Greenways are corridors of protected open space managed for both conservation and recreation.

Greenways often follow rivers or other natural features. They link habitats and provide networks of open space for people to explore and enjoy.



WETLAND RESTORATION AND PROTECTION

Restoring and protecting wetlands can improve water quality and reduce flooding. Healthy wetlands filter, absorb, and slow runoff.

Wetlands also sustain healthy ecosystems by recharging groundwater and providing habitat for fish and wildlife.



STORMWATER PARKS

Stormwater parks are recreational spaces that are designed to flood during extreme events and to withstand flooding.

By storing and treating floodwaters, stormwater parks can reduce flooding elsewhere and improve water quality.



FLOODPLAIN RESTORATION

Undisturbed floodplains help keep waterways healthy by storing floodwaters, reducing erosion, filtering water pollution, and providing habitat.

Floodplain restoration rebuilds some of these natural functions by reconnecting the floodplain to its waterway.

Watershed Scale: Wetland Restoration

Wetland restoration is the manipulation of a former or degraded wetland's physical, chemical, or biological characteristics to return its natural functions. Restoration practices include:

- Re-establishment, the rebuilding a former wetland
- Rehabilitation, repairing the functions of a degraded wetland



Watershed Scale: Wetland Restoration

Practices to restore wetlands include:

- Restoring natural structure
- Restoring natural function
- Restoring native species of flora and fauna



Watershed Scale: Wetland Restoration

Wetlands are critical to supporting water resilience. Restoration of wetlands provides the following benefits:

- Water filtration
- Natural flood control and defense system
- Biological hotspots
- Carbon sinks
- Crucial to food security



Neighborhood or Site Scale

Distributed stormwater management practices that manage rainwater where it falls. These practices can often be built into a site, corridor, or neighborhood without requiring additional space.

NEIGHBORHOOD OR SITE SCALE



RAIN GARDENS

A rain garden is a shallow, vegetated basin that collects and absorbs runoff from rooftops, sidewalks, and streets.

Rain gardens can be added around homes and businesses to reduce and treat stormwater runoff.



VEGETATED SWALES

A vegetated swale is a channel holding plants or mulch that treats and absorbs stormwater as it flows down a slope.

Vegetated swales can be placed along streets and in parking lots to soak up and treat their runoff, improving water quality.



GREEN ROOFS

A green roof is fitted with a planting medium and vegetation. A green roof reduces runoff by soaking up rainfall. It can also reduce energy costs for cooling the building.

Extensive green roofs, which have deeper soil, are more common on commercial buildings. Intensive green roofs, which have shallower soil, are more common on residential buildings.



RAINWATER HARVESTING

Rainwater harvesting systems collect and store rainfall for later use. They slow runoff and can reduce the demand for potable water.

Rainwater systems include rain barrels that store tens of gallons and rainwater cisterns that store hundreds or thousands of gallons.



PERMEABLE PAVEMENT

Permeable pavements allow more rainfall to soak into the ground. Common types include pervious concrete, porous asphalt, and interlocking pavers.

Permeable pavements are most commonly used for parking lots and roadway shoulders.



TREE CANOPY

Tree canopy can reduce stormwater runoff by catching rainfall on branches and leaves and increasing evapotranspiration. By keeping neighborhoods cooler in the summer, tree canopy can also reduce the "urban heat island effect."

Because of trees' many benefits, many cities have set urban tree canopy goals.



TREE TRENCHES

A stormwater tree trench is a row of trees planted in an underground infiltration structure made to store and filter stormwater.

Tree trenches can be added to streets and parking lots with limited space to manage stormwater.



GREEN STREETS

Green streets use a suite of green infrastructure practices to manage stormwater runoff and improve water quality.

Adding green infrastructure features to a street corridor can also contribute to a safer and more attractive environment for walking and biking.

Neighborhood Scale: Biofiltration Swale

- Biofiltration swales are vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move stormwater
- Used in place of traditional curbs and gutters
- Vegetated swales slow, infiltrate, and filter stormwater flows.
- Suited for placement along streets and parking lots



Neighborhood Scale: Biofiltration Swale

- Biofiltration swales provide the following benefits:
 - Reducing downstream flooding
 - Improved water and air quality
 - Groundwater recharge
 - Aesthetic open space



Coastal Practices

Nature-based solutions that stabilize the shoreline, reducing erosion and buffering the coast from storm impacts. While many watershed and neighborhood-scale solutions work in coastal areas, these systems are designed to support coastal resilience.

COASTAL AREAS



COASTAL WETLANDS
Coastal wetlands are found along ocean, estuary, or freshwater coastlines. They are often referred to as "sponges" because of their ability to absorb wave energy during storms or normal tide cycles.



OYSTER REEFS
Oysters are often referred to as "ecosystem engineers" because of their tendency to attach to hard surfaces and create large reefs made of thousands of individuals. In addition to offering shelter and food to coastal species, oyster reefs buffer coasts from waves and filter surrounding waters.



DUNES
Dunes are coastal features made of blown sand. Healthy dunes often have dune grasses or other vegetation to keep their shape. Dunes can serve as a barrier between the water's edge and inland areas, buffering waves as a first line of defense.



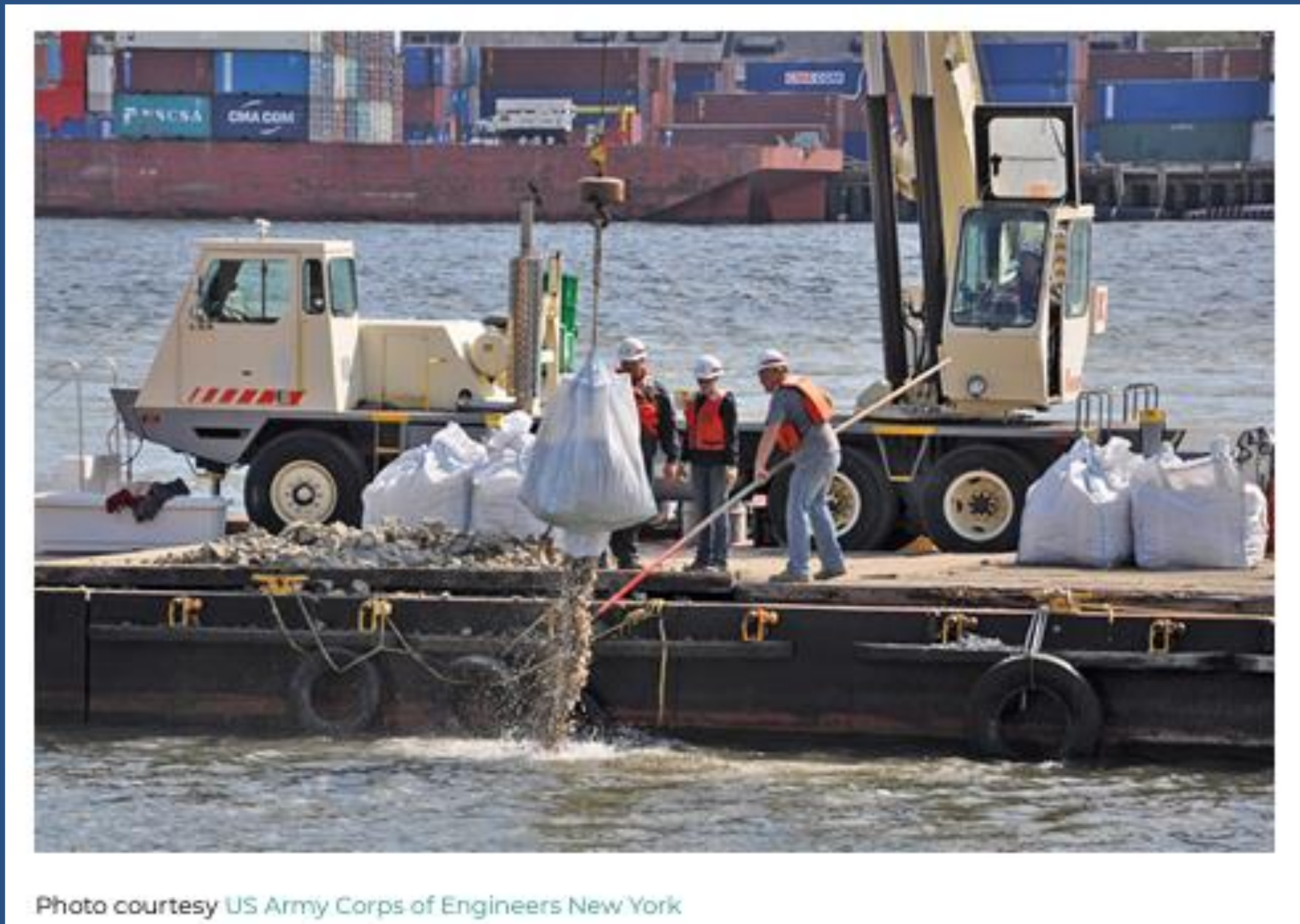
WATERFRONT PARKS
Waterfront parks in coastal areas can be intentionally designed to flood during extreme events, reducing flooding elsewhere. Waterfront parks can also absorb the impact from tidal or storm flooding and improve water quality.



LIVING SHORELINES
Living shorelines stabilize a shore by combining living components, such as plants, with structural elements, such as rock or sand. Living shorelines can slow waves, reduce erosion, and protect coastal property.

Coastal Scale: Oyster Reef Restoration

- Oysters are known as ecosystem engineers, forming large reefs that provide structural protection for coastal areas
- 85% of historic global oyster reefs have been lost
- Oyster reef restoration techniques include:
 - placing natural substrate material
 - installing artificial reef structures
 - oyster seeding



Coastal Scale: Oyster Reef Restoration

- **Benefits of oyster reef restoration include:**
 - **Reduced flooding**
 - natural breakwaters
 - can work in tandem with gray infrastructure like dikes, lowering wave height
 - **Storm protection**
 - mitigate land loss due to ability to hold sediment in place
 - **Improved water quality**
 - adult oysters filter up to 50 gallons of water a day, removing pollutants and sediments
 - **Resilient fisheries**
 - improved biodiversity and habitat for fish

Figure 8.2 Oyster castle artificial reef structure in the Delaware Bay

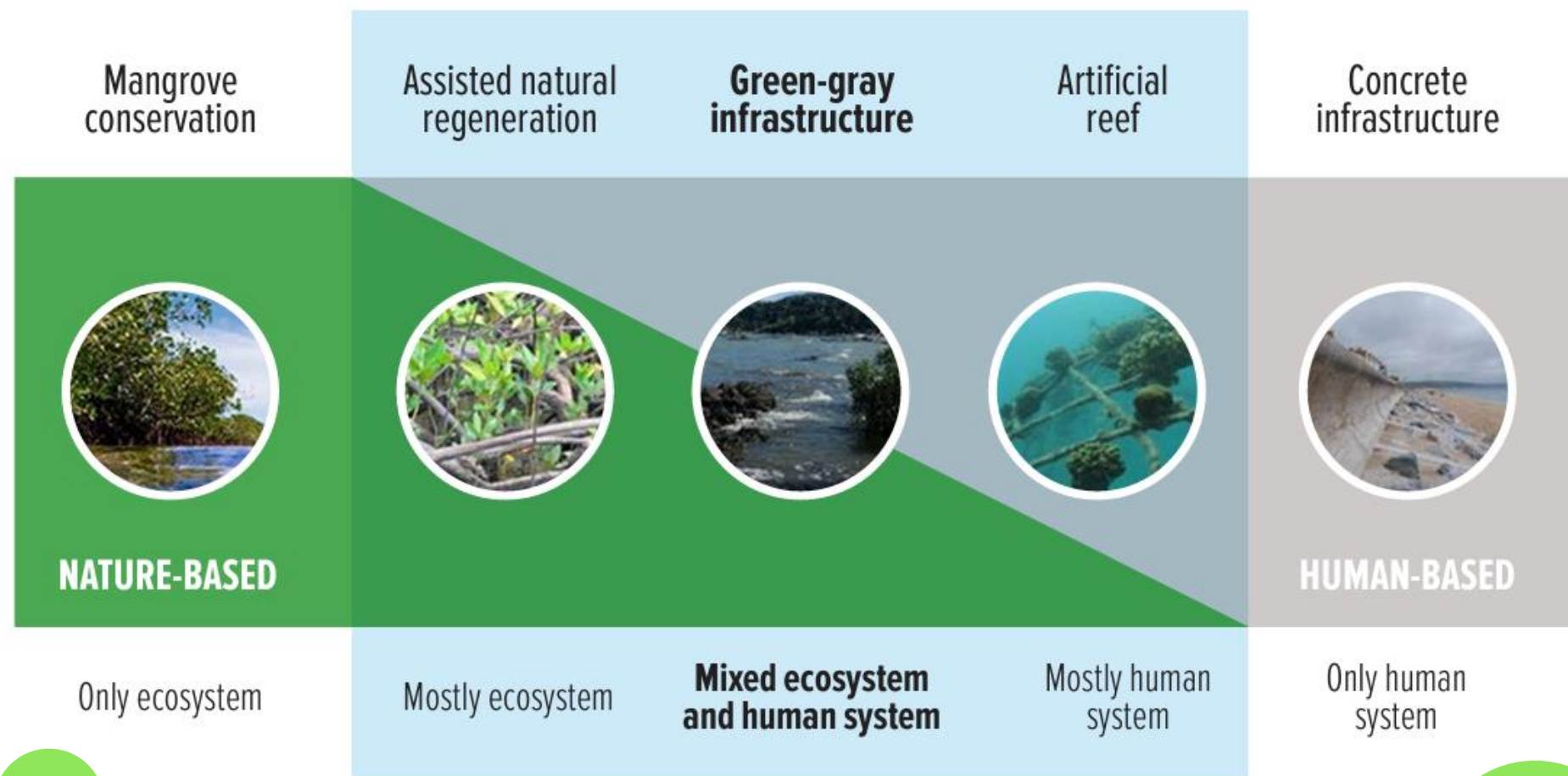


Photo courtesy US Fish and Wildlife Service

A Hybrid Approach: Green-Gray Infrastructure

SPECTRUM FROM GREEN TO GRAY

These solutions draw upon the best of our engineering achievements to create hybrid solutions along the green-to-gray spectrum



Green Infrastructure

Natural systems including forests, floodplains, wetlands and soils that provide additional benefits for human well-being, such as flood protection and climate regulation.

Gray Infrastructure

Conventional engineering solutions such as dams, seawalls, roads, pipes, and water treatment plants

Hybrid Approach: Green-Gray Infrastructure

Green-gray infrastructure combines conservation and/ or restoration of ecosystems with the selective use of conventional engineering approaches to provide people with solutions that deliver climate change resilience and adaptation benefits

A Hybrid Approach: Green-Gray Infrastructure

Examples of Green-Gray Infrastructure:

- Green rip-rap
- Artificial reefs
- Marsh-levee system
- Dune-dike system



Knowledge Check:

Learning Objective Three

1. Which of the following is **not** a benefit provided by wetland restoration?
2. Biofiltration swales are an example of what scale of nature-based solution?



Design for Flood Resilience

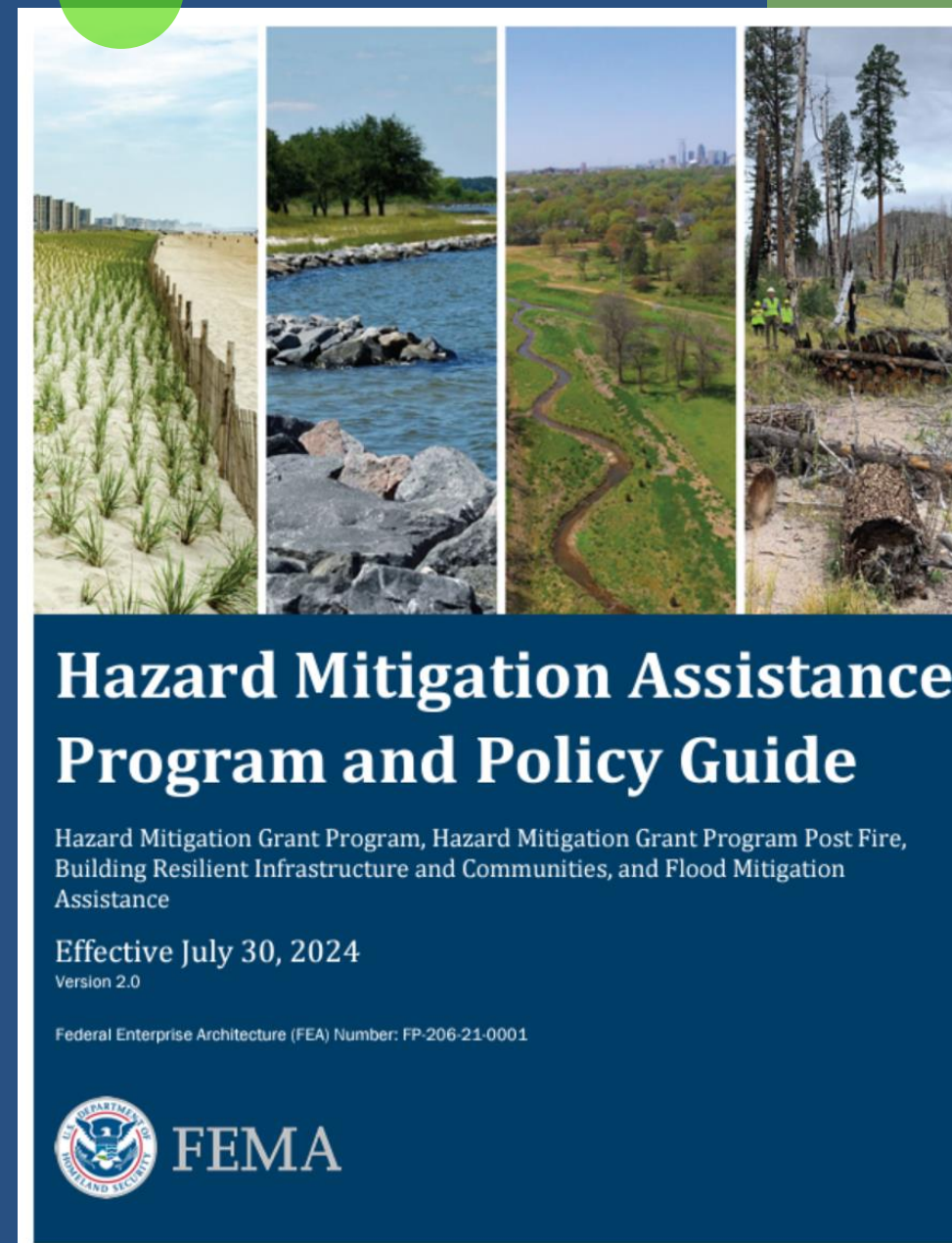
Learning Objective 4:

Understand **FEMA's role** in implementing nature-based solutions and **identify resources** for communities to fund and support nature-based solutions

Relevant Policy Guidance: HMA

Program and Policy Guide

- Refer to HMA Guidance **Part 12 Section A** for details on eligibility requirements for nature-based solutions
- Nature-based solutions still must meet all HMA eligibility criteria including **risk reduction benefits, cost effectiveness, & EHP/floodplain management requirements**



Part 12. Mitigation Projects

This section provides guidance on common project types that are generally eligible for Hazard Mitigation Assistance (HMA). Each project-specific section in this part generally follows the same outline by first providing an overview of the project type, followed by eligibility criteria and a description of eligible activities, application and submission information, subaward implementation, closeout and additional resources. To be eligible for HMA, all hazard mitigation projects must meet the general eligibility criteria and other requirements described in [Part 4](#).

Natural hazards such as flooding, high wind, extreme temperatures, drought, earthquakes, wildfires and landslides pose major threats to communities across the United States. Reducing these threats to lives, properties and the economy is a top priority for FEMA and many communities. Where appropriate, FEMA encourages evaluating nature-based solutions as a cost-effective and climate-resilient approach to keep natural hazards from becoming more costly disasters. For example, the [National Mitigation Investment Strategy](#) has recognized the many benefits nature-based solutions can offer and the diverse partners they can draw to the table. Therefore, as an overarching philosophy to hazard mitigation, this part's first section provides additional information on nature-based solutions.

A. Overarching Philosophy: Undertaking Hazard Mitigation with Nature-Based Solution Techniques

Nature-based solutions are sustainable planning, design, environmental management and engineering practices that simultaneously provide benefits for people and the environment to build resilient communities and mitigate the impact of climate change. FEMA uses the term "nature-based solutions" to refer to an umbrella of strategies, including green infrastructure, bioengineering, and/or natural infrastructure. Other agencies may also use the terms "natural or nature-based features" or "engineering with nature," which all fall under the term "nature-based solutions" in the HMA Guide.

Nature-based solutions can help reduce the loss of life and property, strengthening resilience against the nation's most common natural hazards.

These include, but are not limited to:

- Coastal flooding and storm surge
- Extreme temperatures
- Drought
- Landslides
- Riverine flooding

FEMA Funding Opportunities for Nature- based solutions

PRE-DISASTER	BUILDING RESILIENT INFRASTRUCTURE AND COMMUNITIES	The Building Resilient Infrastructure and Communities (BRIC) program is a pre-disaster grant providing funds for hazard mitigation projects and capability- and capacity-building activities that expand or improve the administration of mitigation assistance. Funding from this grant reduces reliance on reactive spending and increases proactive investments in science-based community resilience projects.
	FLOOD MITIGATION ASSISTANCE	The Flood Mitigation Assistance (FMA) program provides pre-disaster funds for the reduction or elimination of long-term flood risk to buildings, manufactured homes, and other structures insured by the National Flood Insurance Program (NFIP).
POST-DISASTER	HAZARD MITIGATION GRANT PROGRAM	The Hazard Mitigation Grant Program (HMGP) provides post-disaster recovery funds to rebuild in a way that reduces future disaster losses in the community. HMGP is often open state-wide, and it can be used to rebuild in damaged areas and to mitigate in non-damaged areas. This grant funding is available after a presidentially declared disaster.

BRIC: Notice of Funding Opportunity

- Nature-based solutions are listed as both a program **objective** and a program **priority** in the FY 2023 NOFO
- **Evaluation Criteria:**
 - **5 points** for neighborhood/site scale
 - **15 points** for watershed/landscape scale

- *Program Objectives:*

- Increase climate literacy among the emergency management community, including awareness of natural hazard risks and knowledge of best practices for mitigation (Strategic Objective 2.1)
- Increase awareness of stakeholders and partners with capabilities to support mitigation, preparedness, response, and recovery. (Strategic Objective 3.1)
- More innovative risk-informed mitigation projects are developed and completed, including multi-hazard resilience or nature-based solutions (Strategic Objective 2.3)
- Communities identify and mitigate the risks to natural hazards and their own threats from climate change. (Strategic Objective 2.2)
- FEMA directs increased resources to eliminate disparities in equitable outcomes across underserved communities (Strategic Objectives 1.2 & 1.3)

- c. **Priorities**

For FY 2023, the priorities for the program are to incentivize natural hazard risk reduction activities to include those that address multi-hazards that mitigate risk to public infrastructure and disadvantaged communities as referenced in EO 14008; incorporate nature-based solutions including those designed to reduce carbon emissions; enhance climate resilience and adaptation; and increase funding to applicants that facilitate the adoption and enforcement of the latest published editions of building codes.

FMA: Notice of Funding Opportunity

- Included in the **priority scoring criteria** for “Localized Flood Risk Reduction Projects”
- **Evaluation Criteria:**
 - **100 points** for the incorporation of nature-based solutions

Incorporation of Nature-Based Solutions ²³	Nature-based solutions are actions to protect, sustainably manage, or restore natural or modified ecosystems to address societal challenges, simultaneously providing benefits for people and the environment. Refer to https://www.whitehouse.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Roadmap.pdf FEMA recognizes that strategies for nature-based solutions are diverse; one size does not fit all. As such, examples of nature-based solutions may include wetland restoration and protection; greenways; stormwater parks; floodplain restoration; rain gardens; green roofs; permeable pavement; coastal wetlands; and living shorelines. Subapplications will receive 100 points if the project incorporates nature-based solutions. No partial points are assigned to this category.	100
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Key FEMA Resources: Building Community Resilience with Nature-based Solutions - A Guide for Local Communities

Tool for local practitioners to identify and engage necessary staff and resources for implementing nature-based solutions



STRUCTURE OF THE GUIDE

Some local communities may use this guide to learn about nature-based solutions and weigh their value for the community. Others may be ready to move from planning to action. The guide includes six sections, and users can jump in at any point, depending on their current knowledge base and interests. The six sections are described below.

WHAT ARE NATURE-BASED SOLUTIONS?

Describes three broad categories of nature-based solutions.
Identifies types of nature-based solutions in each category.

THE BUSINESS CASE

Outlines the many hazards that can be mitigated with nature-based solutions.
Discusses the multiple benefits of nature-based solutions, in addition to hazard mitigation.

PLANNING AND POLICY-MAKING PHASE

Identifies planning processes and programs that can help users invest in nature-based solutions.
Discusses how plans and policies can be updated to allow and encourage nature-based solutions.

IMPLEMENTATION PHASE

Reviews how local resources can be mobilized to preserve, restore, and build nature-based solutions.
Discusses innovative ways of promoting private investment.

FEDERAL FUNDING OPPORTUNITIES

Outlines federal funding sources for nature-based solutions.
Emphasizes FEMA's Hazard Mitigation Assistance (HMA) grant programs.

KEY TAKEAWAYS AND RESOURCES

Summarizes key points for communities.
Provides additional resources.



RiskMAP
Increasing Resilience Together

Key FEMA Resources: Building Community Resilience with Nature-based Solutions - Strategies for Success

Guide that provides community leaders with strategies to carry out successful implementation of nature-based solutions. Provides the value of each strategy, along with case studies and other helpful resources.

BUILDING COMMUNITY RESILIENCE WITH NATURE-BASED SOLUTIONS

ABOUT THIS GUIDE

Implementing NBS projects follows the same general process as traditional infrastructure projects. This guide covers five key strategies that work for every NBS project. These strategies can be applied across projects so they meet risk reduction, climate resilience and other community goals.

The Five Strategies



BUILDING STRONG PARTNERSHIPS.

NBS projects work best when different partners and organizations rally around common goals. Communities will benefit most by establishing partnerships early and fostering them through the life of a project.



ENGAGING THE WHOLE COMMUNITY.

Community engagement is key to carrying out NBS projects that work for the Whole Community. Community and project leaders will see better results by reaching out to all community members early and often.



MATCHING PROJECT SIZE WITH DESIRED GOALS AND BENEFITS.

The range of NBS and hybrid solutions provides many options to reduce risk. The size and reach of an NBS project, or group of projects, should match the level of benefits a community wants.



MAXIMIZING BENEFITS.

NBS offer many different benefits to communities. By making small additions to project designs or combining multiple solutions, communities can get more for their investment.



DESIGNING FOR THE FUTURE.

This means planning for a combination of changes in climate, population patterns and community development. Doing so helps communities implement solutions that can adapt to changing risks and reduce impacts of future events.

SUCCESS



The Community Rating System and Nature- based Solutions



OMB No. 1660-0022
Expires: March 31, 2020

National Flood Insurance Program
Community Rating System

Coordinator's Manual

FIA-15/2017



FEMA

The Community Rating System and Nature-based Solutions

- 2021 Addendum to the 2017 CRS Coordinator’s Manual includes updated credit opportunities for projects that “*preserve or restore the natural state of floodplains*”
- **Bonus Credit: Activity 420 (Open Space Preservation):**
“Extra credit is provided for open space areas that are preserved in their natural state; have been restored to a condition approximating their pre-development natural state; or have been designated as worthy of preservation for their natural benefits, such as being designated in a habitat conservation plan”

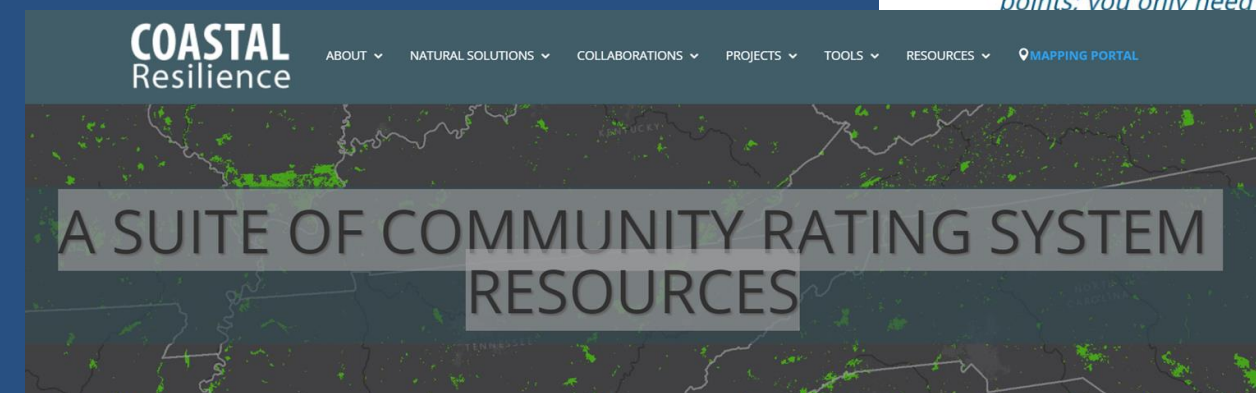
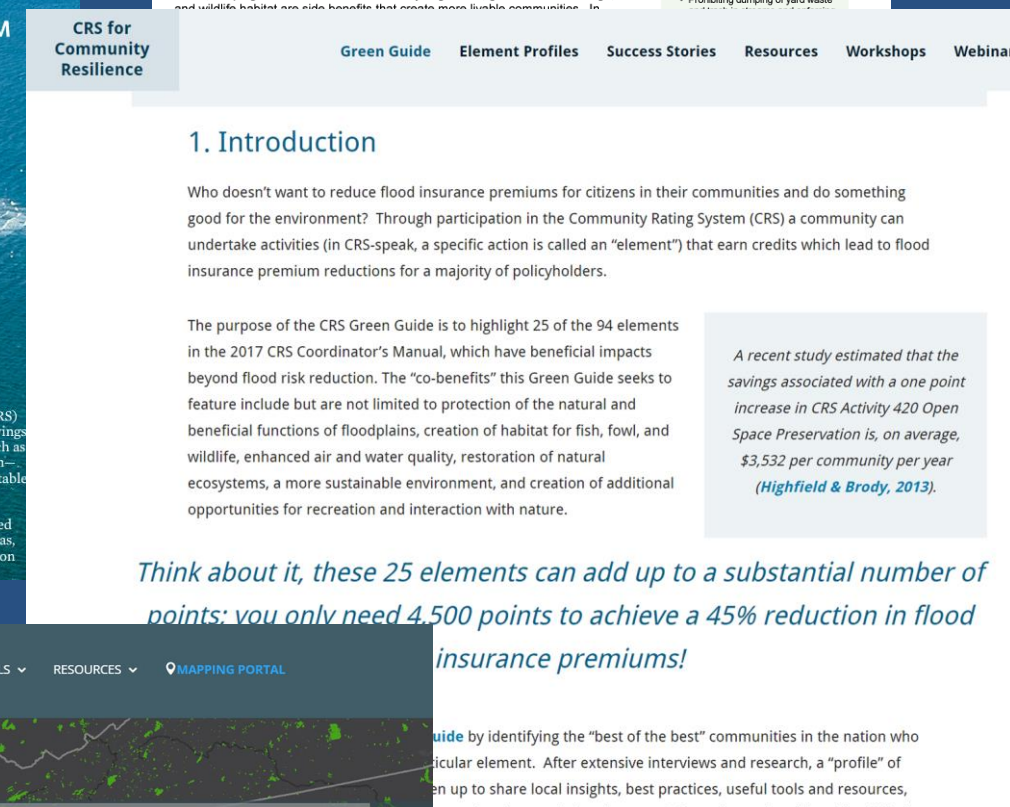
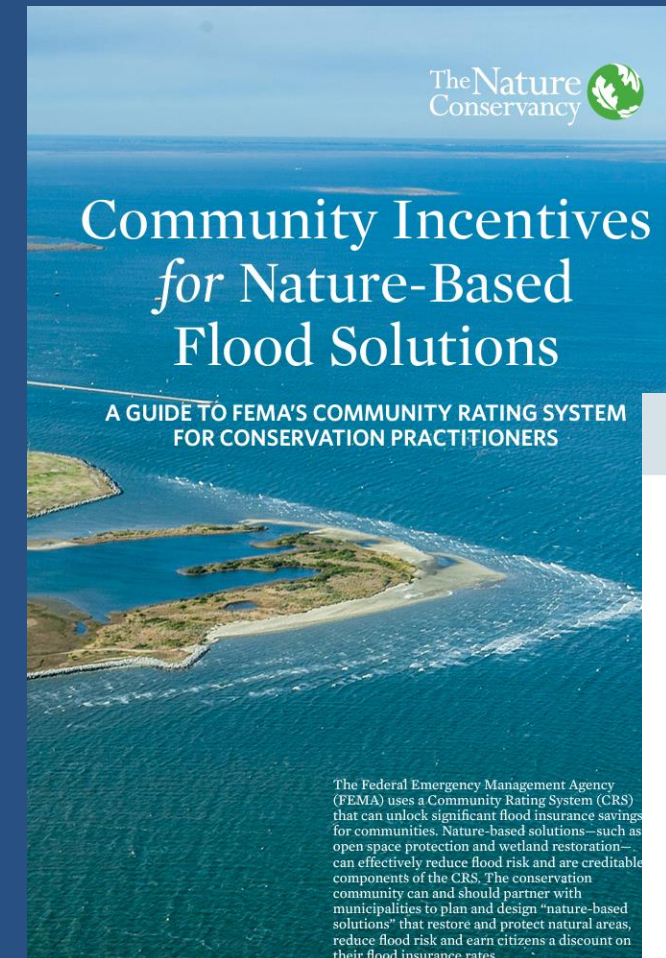
📌 The National Flood Insurance Program Community Rating System Coordinator’s Manual FIA-15/2017 and the 2021 Addendum to the Coordinator’s Manual, 2017 Edition, are undergoing limited revisions and are not available. The revised manual will be made available as soon as possible.

Table 110-2. Credit points awarded for CRS activities.*				
Activity	Maximum Possible Points	Maximum Points Earned	Average Points Earned	Percentage of Communities Credited
300 Public Information Activities				
310 Elevation Certificates	116	116	38	96%
320 Map Information Service	90	90	73	85%
330 Outreach Projects	350	350	87	93%
340 Hazard Disclosure	80	62	14	84%
350 Flood Protection Information	125	125	38	87%
360 Flood Protection Assistance	110	100	55	41%
370 Flood Insurance Promotion ⁵	110	110	39	4%
400 Mapping and Regulations				
410 Flood Hazard Mapping	802	576	60	55%
420 Open Space Preservation	2,020	1,603	509	89%
430 Higher Regulatory Standards	2,042	1,335	270	100%
440 Flood Data Maintenance	222	249	115	95%
450 Stormwater Management	755	605	132	87%
500 Flood Damage Reduction Activities				
510 Floodplain Mgmt. Planning	622	514	175	64%
520 Acquisition and Relocation	2,250	1,999	195	28%
530 Flood Protection	1,600	541	73	13%
540 Drainage System Maintenance	570	454	218	43%
600 Warning and Response				
610 Flood Warning and Response	395	365	254	20%
620 Levees	235	207	157	0.5%
630 Dams	160	99	35	35%
* Figures are based on communities that have received verified credit under the 2013 CRS Coordinator’s Manual (about 43% of CRS communities), as of October 2016. The maximum possible points are based on the 2013 Coordinator’s Manual. Growth adjustments are not included.				



The Community Rating System and Nature-based Solutions - *Additional Resources*

- **The Nature Conservancy:** Community Incentives for Nature-based Flood Solutions
- **The EPA:** Get Flood Insurance Discounts with Low Impact Development, Open Space Protection Plans, and Stormwater Management Regulations
- **The Flood Science Center:** CRS Green Guide
- **Coastal Resilience:** A Suite of Community Rating System Resources



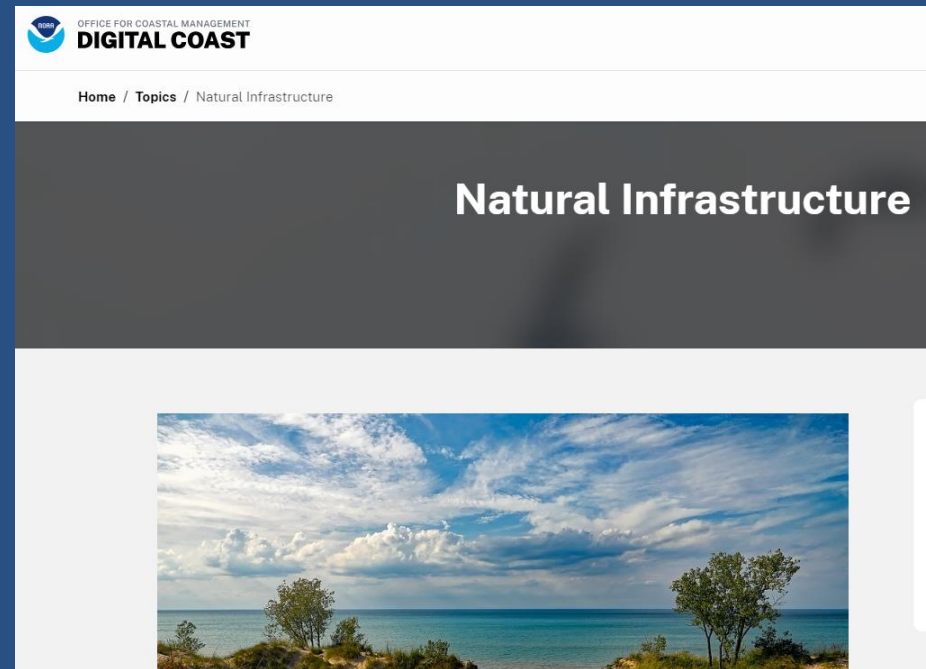
External Partners and Resources



The Nature
Conservancy



The
Environmental
Protection
Agency



The National
Ocean And
Atmospheric
Administration



The Army
Corps of
Engineers

External Partners and Resources:

The Nature Conservancy (TNC)

- Through the FEMA Cooperating technical Partners program, developed guide for stakeholders pursuing FEMA HMA grants for nature-based solutions
 - Grant opportunities
 - Most effective solutions by risk
 - Quantifying benefits of nature-based solutions
 - Tips for successful applications



External Partners and Resources:

The Environmental Protection Agency (EPA)

- **Green Infrastructure Webcast Series**
 - 2024 “Soak Up the Rain” webinar series showcases projects and practices at the intersection of equity and green infrastructure
 - All prior webcasts available on website
- **Bioretention Design Handbook**
- **Green Infrastructure Website**
 - Green infrastructure basics
 - Resources for planning, designing, and implementing
 - Permitting guidance

<https://www.epa.gov/green-infrastructure>





External Partners and Resources: The National Ocean and Atmospheric Administration (NOAA)

- Office for Coastal Management Digital Coast Program
- Series of Green Infrastructure-related trainings and tools
 - Live, quick reference, and self-paced trainings such as:
 - Nature-Based Solutions: Benefits, Costs, and Economic Assessments
 - Nature-Based Solutions for Coastal Hazards
 - Green Infrastructure Mapping Guide

Natural Infrastructure



Jump to Section

- Understand the Basics
- Communicate the Issue
- Analyze the Landscape
- Prioritize Options
- Explore Economic Approaches

Natural infrastructure, also referred to as green infrastructure, uses existing natural areas (and engineered solutions that mimic natural processes) to minimize flooding, erosion, and runoff. Additional benefits can include increased recreational opportunities and wildlife habitat, as well as cleaner water. Below are key Digital Coast resources useful for communities considering nature-based solutions to enhance their flooding resilience.

Understand the Basics

Training – Online Guide

[Nature-Based Solutions for Coastal Hazards: The Basics](#)

Learn an approach to identifying your community's coastal hazard issues, ecosystem services that can help reduce impacts, and green infrastructure practices that provide critical services.

<https://coast.noaa.gov/digitalcoast/>

External Partners and Resources:

US Army Corps of Engineers

- Engineering with Nature Program
- Developed guide for nature-based solutions specifically related to flood risk management
- EWN Atlas Series
 - highlight case studies of successful nature-based engineering solutions



Knowledge Check:

Learning Objective Four

1. How many points are available for in the prioritization evaluation criteria for “localized flood risk reduction projects” for nature-based solutions in the FMA program?
2. What external partner created the Bioretention Handbook?



Nature-based Solutions:

Case Studies

Coffee Island Oyster Reefs

Location: Portersville Bay, AL

Scale: Coastal site

Project: 1.02 miles of oyster reef

Results:

- Reduced coastal erosion rates
- Increased oysters settlement rates and juvenile fish populations
- Created 20 acres of seagrass and marsh habitat
- 33 full time jobs and 72,570 total implementation work hours



Sandpipers foraging
on reef balls

Oyster reef breakwater constructed from ReefBLK.
(Photo by Mary Kate Brown, The Nature Conservancy)

Exploration Green

Location: Clear Lake, TX

Scale: Landscape

Project: Converted 200-acre golf course to flood-water detention center with 39 acres of wetland

Results:

- 500 million gallons of flood water storage capacity
- Flood protection for 30,000 residents
- Water quality improvement
- 6 miles of hike and bike trails



New Haven Bioswale Success Story

Location: New Haven, CT

Scale: Neighborhood

Project: A public-private partnership in New Haven resulting in the installation of more than 250 bioswales in areas with localized flooding concerns

Results:

- Remove 70-75% of stormwater runoff
- Filter out metals from runoff
- Prevent up to 4 million gallons of runoff from

entering the Long Island Sound



1. **Each bioswale** is graded with a U-shape profile, where material in the center is lower than the soil at the edges. This helps water pool and properly drain.
2. **The inlet and raised bump** help channel water into the bioswale.
3. **Plants, shrubs, and perennials** are vegetation best suited to withstand flooding and drought. Peastone gravel helps aid in quick drainage, protect against erosion, and prevent weed growth.
4. **Edging installed along the sides** provides visual awareness and can help prevent the unintended growth of grass and weeds.
5. **The gabion** is a wire cage filled with larger aggregate stones compared to the rest of the bioswale, which has a top layer mix of sand and peastone above larger stones. This allows for more rapid drainage.

Implementing Green Infrastructure at Multiple Scales to Enhance Resilience

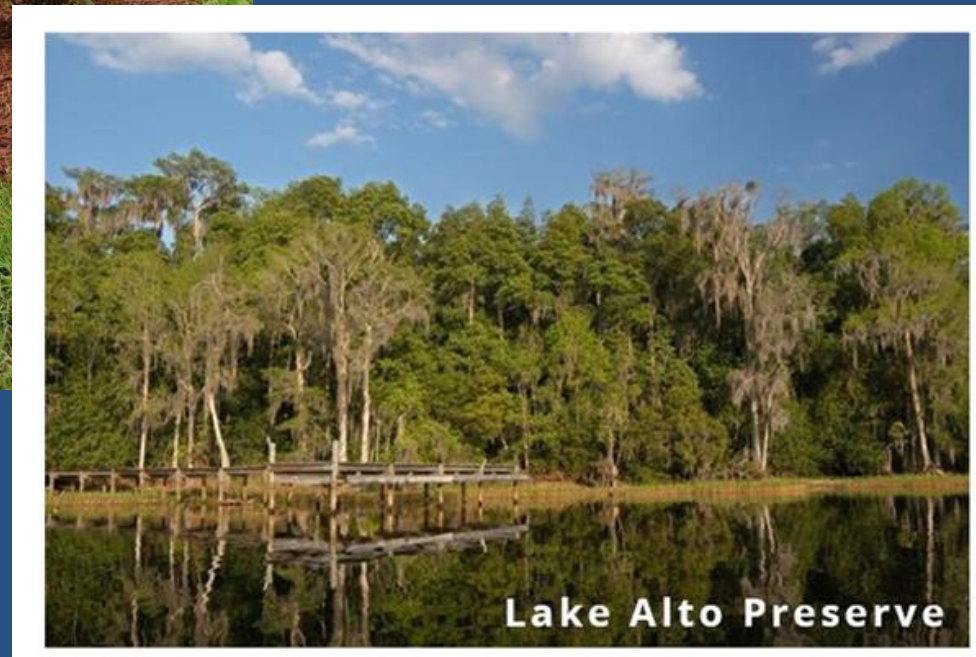
Location: Alachua County, FL

Scale: Landscape & Neighborhood/Site

Project: County-wide green infrastructure strategy involving improving land development codes, preserving open space, training for land developers on low-impact development practices

Read more about implementation here:

<https://coast.noaa.gov/digitalcoast/training/alachua-county.html>



Implementing Green Infrastructure at Multiple Scales to Enhance Resilience

*“Now, when a new development project comes in, code requires that **20 percent of the site be set aside as open space.***

*If this isn't viable for developers, they can **implement low impact development to get credit for the open space areas** they weren't able to conserve. Many developers are using these techniques, such as **bioretention and rain gardens**, to enhance the stormwater systems and increase their development potential.”*



Learning Objective Review



- 1 Define **nature-based solutions** and identify key drivers of their **importance**
- 2 Understand the **benefits** of **nature-based solutions**
- 3 Identify **types of nature-based solutions** and **identify key elements** of green infrastructure
- 4 Understand **FEMA's role** in implementing nature-based solutions and **identify resources** for communities to fund and support nature-based solutions



Q&A



Pennsylvania
Emergency Management Agency



THANK YOU !!