Creating Flood-Resilient Landscapes

A Primer for New Jersey Communities

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INTRODUCTION

Floods pose significant risk to human health and infrastructure in the landscapes where people live. In the United States, more property is lost, and more people die from flood events than from tornados, earthquakes, and wildfires combined. In communities near the ocean, flooding and flood risk are often associated with catastrophic coastal storms, such as hurricanes and nor'easters. In New Jersey, we often think about Hurricane Sandy and the damage to life and property it caused. However, flooding is not just a coastal problem, nor does it occur only as a result of severe storms. On the contrary, flooding has impacted nearly all of New Jersey's 564 municipalities. With more than 1,800 miles of coastline and 6,450 miles of rivers, over 629,250 properties in New Jersey have greater than a 26% chance of being severely affected by flooding over the next 30 years. Making matters worse, New Jersey is the most densely populated state in the nation, resulting in much of the landscape be used for development and infrastructure. Without ample natural ecosystems to absorb rainfall and runoff, even just a few inches of rain can cause flooding in many New Jersey communities. Further, future rain events and coastal storms are predicted to increase in frequency and severity, leading to the potential for lasting, reverberating impacts on entire neighborhoods, landscapes, and natural resources.

To combat these challenges, New Jersey has become a leader in efforts to increase flood resilience. One successful effort is the acquisition of flood-prone properties across the state through buyout programs, in which willing residents sell their properties at fair-market value to the state or local government and relocate to areas outside of designated flood zones. The acquired properties become permanently protected open space. Existing structures are removed, and the parcels are either aggregated into nearby state parks or managed by local government entities.

Removal of structures from within flood zones immediately promotes flood resilience by protecting human health and safety and reducing the risk of damage to personal property and infrastructure resulting from flood events. However, at least three new challenges emerge from buyout initiatives. Properties purchased with federal or state dollars now need to be managed as public open space, and they are deed restricted to protect against alterations that would reduce the landscape's capacity to absorb flood waters. Maintaining newly acquired areas using conventional techniques that are appropriate for park-like settings (i.e. mowing) adds an unsustainable burden on public staff and financial resources and is not a feasible long-term management approach for many communities. Similarly, leaving the properties alone and allowing 'nature to take its course' also is not a viable option. Buyout areas often suffer from reduced ecological function (including lowered infiltration rates and flood storage capacity) due to the legacy effects of previous development. Soils may be compacted, contaminated, or in otherwise poor health. Historic hydrologic patterns may have been altered and flood areas filled to accommodate development, resulting in poor drainage. In addition, areas may be perpetually threatened by environmental stressors from the surrounding landscape (e.g., pollution, invasive species, temperature extremes). A 'no-management' option in many cases will provide little to no improvement in flood mitigation and can also contribute to negative perceptions about flood resilience initiatives. Finally, vacated parcels can serve as a constant reminder of previous flood disasters and the loss they created.

These challenges can be overcome through an ecologically centered landscape resilience approach that combines principles of engineering, ecology, and landscape architecture with social science to transform acquired properties into public assets. However, existing guidelines or best practices do not currently exist. We present here a primer that will serve as a guide for creating flood-resilient landscapes across the communities of New Jersey. Although much of this work focuses on landscape transformation of buyout areas, the information contained here applies to any landscape resilience project regardless of size or jurisdiction.

In Section I, we provide an overview of flooding and its impact in New Jersey. We outline a framework for developing a landscape resilience strategy, and we highlight some of the many important challenges that must be addressed to achieve success. In Section II, we describe the natural function of flood-prone landscapes and illustrate how development impacts flood vulnerability. We also explain the importance of biodiversity in driving ecological function, and we illustrate important concepts pertaining to the maintenance of biodiversity. Finally, in Section III, we outline specific methods and techniques for designing, implementing, and maintaining a sustainable, ecologically based landscape resilience initiative. The information presented has been generated by an interdisciplinary team of ecologists, landscape architects, engineers, and land managers. It has been reviewed by a technical panel with expertise in ecological restoration, social science, floodplain management, and municipal governance. We hope that this guidance document will assist municipal leaders, technical professionals, and other stakeholders in restoring ecological function to flood prone landscapes as they work to make their communities more resilient.

Photo Credit: Jeremiah Bergstrom

SECTION I: FRAMING THE PROBLEM FACING NEW JERSEY COMMUNITIES

The Borough of Sea Bright is a thin strip of land sitting between the Atlantic Ocean and the Navesink and Shrewsbury Rivers. (Photo Credit: Pia Tolentino)

01

Key Topics

WHAT IS FLOODING?

CONSEQUENCES OF FLOODING

NEW JERSEY'S FLOOD VULNERABILITY

WHY IS NEW JERSEY ESPECIALLY AT RISK FOR FLOODING?

NEW JERSEY'S VULNERABILITY TO FLOODING

Osborne Street, Keyport (Photo Credit: Michael Lane, Keyport resident)

WHAT IS FLOODING?

Flooding is the inundation of typically dry land, and it occurs when the amount of water exceeds the ability of the land to absorb it. Floods are most often associated with the overflow of inland or tidal waters into surrounding areas, or from an excessive accumulation of water due to heavy rains or catastrophic infrastructure failures (such as dam or levee breaks).

The National Weather Service characterizes flood severity into 3 categories. **Minor flooding** is associated with little to no property damage but may introduce some threats to public safety. Minor flooding is most typically considered an inconvenience. **Moderate flooding** produces some inundation of structures and roads near surface water bodies. Evacuations of low-lying areas may be needed. **Major flooding** results in significant inundation of structures and roads and requires large-scale evacuations of people and property.

Depending on the source and environmental conditions, floods can be classified in one or more of the following groups:

Collapsed Mantaloking Bridge after Hurricane Sandy
(Photo Credit: USGS)

River Road, Hillsborough after Hurricane Ida
(Photo Credit: Pete Coady, Hillsborough resident)

Coastal Flooding

Coastal floods occur when low-lying land is inundated with seawater. These floods are primarily caused by coastal processes, such as storm surge, wind-driven waves, and high or 'king' tides. However, heavy rainfall and/or increased river flows can combine with seawater to flood coastal areas.

River Flooding

A river (or fluvial) flood occurs when the river overtops its banks and flows into the surrounding floodplain. River floods are typically caused by heavy rains, melting snow, or in some cases, high tides. They are a natural phenomenon and are important for maintaining fertile and nutrient-rich soils for agriculture and other ecosystems.

Flash Flooding

A flash flood occurs when runoff from excessive rainfall over a short period of time (typically <6 hours) causes a rapid rise in water level. Flash floods are often associated with low-lying areas with poor drainage, but they can happen anywhere. Flash floods are the most dangerous form of flooding because they peak rapidly (sometimes within minutes) and come with little to no warning.

Urban Flooding

Pluvial flooding is a unique category of flooding. It is not typically associated with an overflowing body of surface water. Rather, pluvial (sometimes referred to as *urban)* flooding occurs when rainwater overwhelms the stormwater drainage capacity of a densely populated area. This occurs predominantly in areas with high coverage of impervious surfaces (roads, buildings, parking lots, etc.). Pluvial flooding can be linked to extreme weather events and is more pronounced in low-lying developed areas close to rivers and large surface waters.

It is important to note that while these flood types have distinct definitions, they are not mutually exclusive. In addition, coastal, fluvial, and flash flooding are natural processes that are important for maintaining ecosystem integrity. Flooding becomes a problem primarily when it damages built landscapes and interrupts the flow of our daily lives.

Flooding along Long Beach Boulevard, Long Beach Township, during a summer thunderstorm (Photo credit: Deb Berk)

Flooded residential area after a rainstorm (Photo Credit: Aly Noonan, Keyport resident)

Nuisance Flooding

Minor flooding in developed areas is also referred to as *nuisance* flooding, which is defined as low levels of inundation that do not pose significant threats to public safety or cause major property damage, but that can disrupt daily routine activities, put added strain on infrastructure, and cause minor property damage. Nuisance flooding occurs when water overtops existing barriers (natural or engineered) and spills over into the built environment, or when precipitation rates exceed the infiltration capacity of existing drainage infrastructure, resulting in ponding or overland flow.

Compared to extreme events, the impacts of nuisance flooding are not well understood and have been largely overlooked. They have often been assumed to have minimal impacts. However, nuisance flooding recently has been shown to contribute to reductions in property values, loss of income, and increased public health risks. Furthermore, these chronic events likely have considerable cumulative impacts, particularly on local communities. In some cases, the summative costs of long-term nuisance flooding can far outweigh the costs of severe, but less frequent, storm events. Importantly, financial assistance is not typically available for events not declared federal or state disasters.

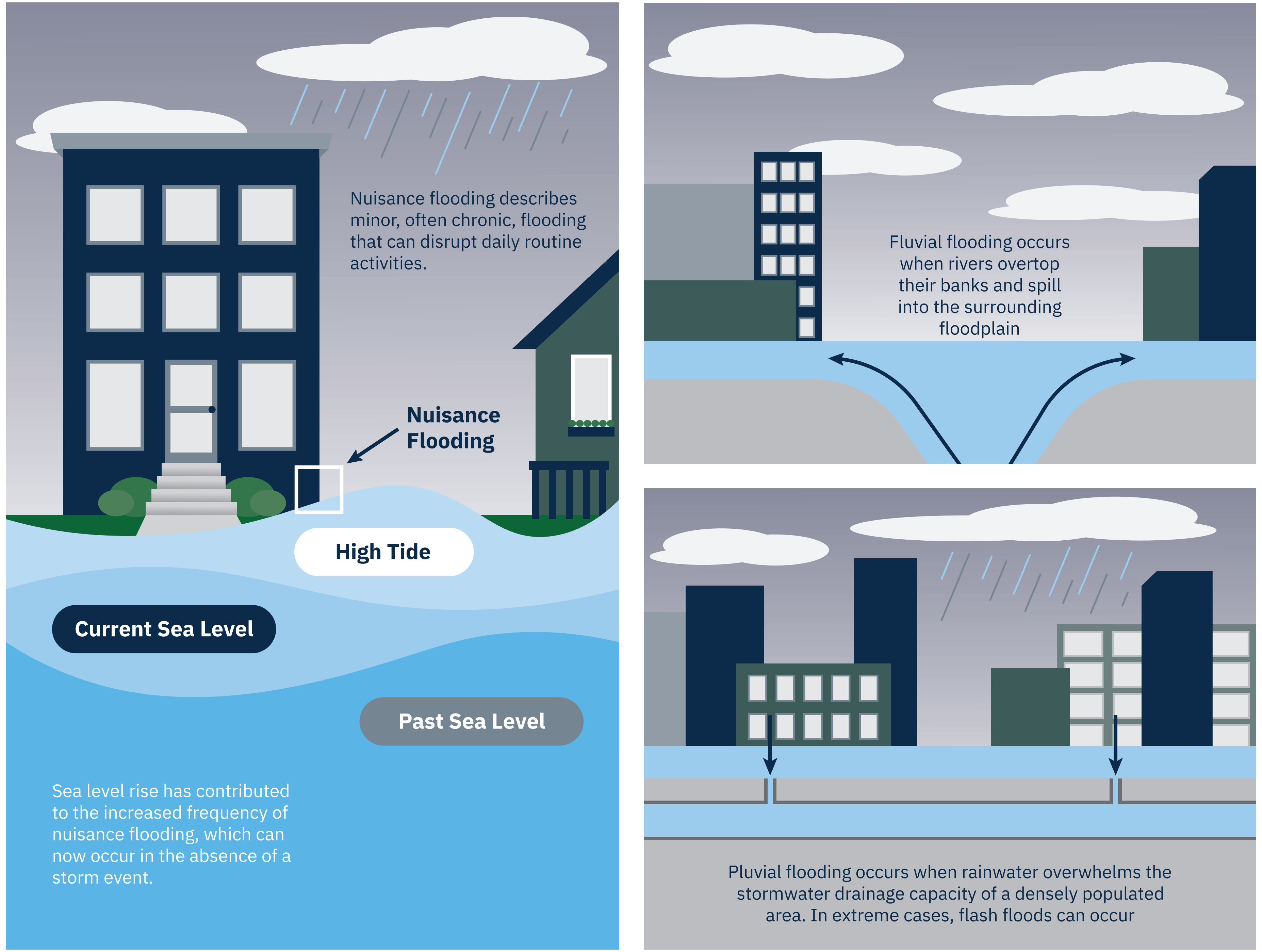


Figure 1.1 Flooding in Developed Areas Due to the decreased infiltration capacity of paved roads and other impervious surfaces, risk of pluvial, fluvial, coastal, and nuisance flooding is heightened.

Aftermath of a flash flood event during Hurricane Ida
(Photo Credit: Michael Kerwin, Somerville resident)

CONSEQUENCES OF FLOODING

Floods impact both individuals and communities, and they have social, economic, and environmental implications. In natural ecosystems, floods play an important role in maintaining ecosystem function and biodiversity. Floods recharge groundwater repositories, fill wetlands, transfer nutrients to the soil, and connect aquatic and terrestrial habitats. Seasonal floods also trigger breeding, migration, and dispersal of many species. Therefore, aside from the more extreme events, flooding can have positive environmental impacts that support ecosystems, agriculture, and fisheries production.

However, floods pose significant risk to human health and infrastructure in human-modified landscapes. In the United States, more property is lost, and more people die from flood events than from tornados, earthquakes, and wildfires combined. Direct costs of flooding include loss of life, physical injury, property damage and repair expenditures, and crop losses. Such costs can be calculated from multiple national datasets, including the National Weather Service, National Flood Insurance Program, and the Spatial Hazard Events and Losses Database for the United States, also known as SHELDUS. However, there are several indirect impacts of flood events that are difficult to quantify, yet still important. These include loss of business and personal income, reduction in property value, reduction in tax revenue, psychological impacts, and depletion of ecosystem services.

NEW JERSEY'S FLOOD VULNERABILITY

Economic Impacts of Flooding

New Jersey ranks in the upper half of the United States in the amount of casualties (fatalities and injuries) and property damage resulting from flood events. As of August 2019, National Flood Insurance Program (NFIP) policyholders in New Jersey received ~$5.27 billion (2018 USD) in total payments on 160,169 claims made from >97% of the municipalities in the state. Three quarters of the payouts were made in response to damages caused by Hurricane Sandy. However, a sizeable amount of money was allocated in support of claims not associated with a major storm event. With flooding frequency expected to increase, impacts will likely rise in all categories. For example, 25,000 to 100,000 residential properties in New Jersey will be at risk by 2045. By the end of the century, that number will increase to 250,000. Similarly, 2,600 commercial properties will be at risk by 2045 and 11,000 properties by 2100).

Table 1.1 Direct losses due to flood events in New Jersey, 1960-2020 (Data source: SHELDUS, www.sheldus.org, accessed January 17, 2022)

Impact	Amount
Fatalities	58
Injuries	260
Property Damage	$23,484,474,504
Crop Damage	$1,101,465

Environmental Impacts of Flooding

Extreme or large-scale flooding can result in significant negative impacts both to natural ecosystems and developed landscapes.

Water Quality

In New Jersey, surface water withdrawals represent 75% of the state's total water use. With more intense rain events, surface and groundwater quality can become impaired as runoff washes excess nutrients and contaminants into surface waters. Coastal areas also face saltwater intrusion in groundwater aquifers and freshwater bodies. In addition, harmful algal blooms, caused in part by excess nutrient loadings and water flow alterations, are likely to become more frequent due to the increases in temperature and precipitation caused by climate change.

Erosion

Erosion and sedimentation are natural processes and occur as water runs over land, breaks the surface down, and carries sediment to a new location. Gradual erosion occurs naturally as water levels and rainfall fluctuate. However, human presence and activities increase rates of erosion. Human activities that interfere with waterways and increase erosion include infrastructure development, farming, and livestock cultivation. Soil erosion can lead to a reduced ability of the soil to store water and nutrients, higher rates of runoff, and loss of newly planted crops. Increased water flows in rivers and streams erode banks and degrade natural habitats. Excess erosion impacts ecosystem function and water quality as runoff enters streams, rivers, lakes, and coastal areas, creating sediment traps, overly vegetated waterways, and dams.

Water-borne Diseases

Flooding and flood events have the potential to increase the transmission of communicable diseases. While global-scale communicable diseases, such as typhoid fever, cholera, malaria, and yellow fever are not risks in New Jersey, residents in the state are still at risk from such pathogens as *Escherichia coli* (*E. coli*) and norovirus. Ponded areas also promote mosquito breeding, which potentially increases the threat of vector-borne diseases such as West Nile virus.

Flooding & Wildlife

Flooding has a significant impact on local wildlife populations. Rising water levels can benefit fish, but too much water can destroy fish nests or strand fish when water levels recede. Ground- or shrub-nesting birds lose habitats, nests, and/or young birds. Most significantly, large-scale flooding destroys habitat. Repetitive flooding damages wetland habitats, destroying vegetation and food webs. Flooded rivers, filled with fast-moving water, lose macroinvertebrates, the base of many food chains, and sediment loads reduce oxygen levels, potentially killing river- and stream-dwellers across the food web.

WHY IS NEW JERSEY ESPECIALLY AT RISK FOR FLOODING?

New Jersey contains 1,792 miles of coastline and 6,450 miles of rivers, which are distributed throughout all 21 counties. Flood risk in New Jersey is driven by 4 primary and interconnected factors: sea level rise; land subsidence; increased frequency and severity of storms; and human activities. Over the past century, the Earth has experienced a global average temperature increase of ~2°F due to production of greenhouse gases. These rising temperatures melt glaciers and ice sheets, causing sea levels to rise. Warmer water also takes up more space (called thermal expansion), which contributes to sea level rise.

Along the Northeast Atlantic coastline, water temperatures have risen faster than the global ocean average over the past decade, which is currently the largest contributor to sea level rise. This phenomenon is largely due to the transporting of warm, salty water from the tropics to northern Europe and returning colder water south along the ocean floor. This system, known as the Atlantic Meridional Overturning Circulation (AMOC), distributes heat and energy throughout the Earth and helps maintain the global climate. Fresh water from melting glaciers and ice sheets enters the ocean, reducing salinity and making it lighter. That lighter water can't sink to the ocean floor and ultimately retains more heat.

"New Jersey has significant, serious, chronic flooding problems...Everyone understands that New Jersey is at risk. At least 15% of the state lies within a flood plain." *(NJDEP Assistant Commisioner Vincent Mazzei)*

Warmer oceans also contribute to the intensity of major storms (e.g. hurricanes, nor'easters). As a weather disturbance moves across the ocean, it draws in heat and water vapor. Warmer sea surface temperatures allow storms to acquire more energy and moisture, leading to stronger wind speeds and heavier rainfall. Combined with already elevated water levels, the risk of flooding from rainfall and storm surge magnifies. In New Jersey, over 33% of the total land area is developed (with potential to rise to 47%), further reducing the state's capacity for infiltration and drainage. In addition to the named storms, total annual precipitation in New Jersey is expected to increase by 4% to 11% over the next three decades. Additionally, it is highly likely that the intensity of precipitation events will increase across the state by mid-century. Under a moderate emissions scenario, by mid-century there is a 17% chance that rainfall during a 100-year storm event will increase by as much as 45-50% in some parts of the state.

New Jersey is also sinking – a process called subsidence – due to natural causes and the withdrawal of groundwater from aquifers. Lowered ground elevations exacerbate the effects of rising seas, resulting in New Jersey experiencing a 1.5-foot rise in sea level over the past century (compared to 0.6 feet globally).

These factors combine to result in more frequent and intense major and minor flood events that impact the daily lives of residents in the State and strain the resources of local governments and emergency responders. For example, the average number of flood days in Atlantic City between 1990-2009 was ~5; between 2010-2019 that number rose to 10. Without mitigation measures, the National Oceanic and Atmospheric Administration (NOAA) predicts that by 2030 there will be at least 25 flood days a year in Sandy Hook and 20 in Atlantic City.

"One of DEP's most important jobs is protecting people and property from flood hazards, which have worsened significantly over the last 20 years, and we must help communities get ahead of the next storm."

(Commissioner of Environmental Protection, Shawn M. LaTourette)

South Branch of the Raritan River after Hurricane Ida (Photo Credit: Pete Coady, Hillsborough resident)

Backyard flooding, Hurricane Ida (Photo Credit: Anne Ippolito, Hillsborough resident)

Exchange Field Park off of Peter's Brook (Photo Credit: Michael Kerwin, Somerville resident)

02

Key Topics

WHAT IS RESILIENCE?

RESILIENCE VS. DISASTER AVOIDANCE

LANDSCAPE RESILIENCE GOALS

A COLLABORATIVE APPROACH FOR CREATING RESILIENT LANDSCAPES

LANDSCAPE RESILIENCE IN A CHANGING CLIMATE

Delaware Avenue in Camden, NJ after a significant rain event (Photo Credit: Cooper's Ferry Partnership)

WHAT IS RESILIENCE?

The word resilience is a very popular term that is used in several disciplines. In ecology and natural resource management, resilience describes an ecosystem's capacity to persist after a natural disturbance (e.g. fire, flood, etc.). Similarly, economic resilience is seen as the ability to foresee, adapt to, withstand and recover from a market shock. Within a social or psychological context, resilience is defined as the capacity to recover quickly from difficulties; a measure of toughness.

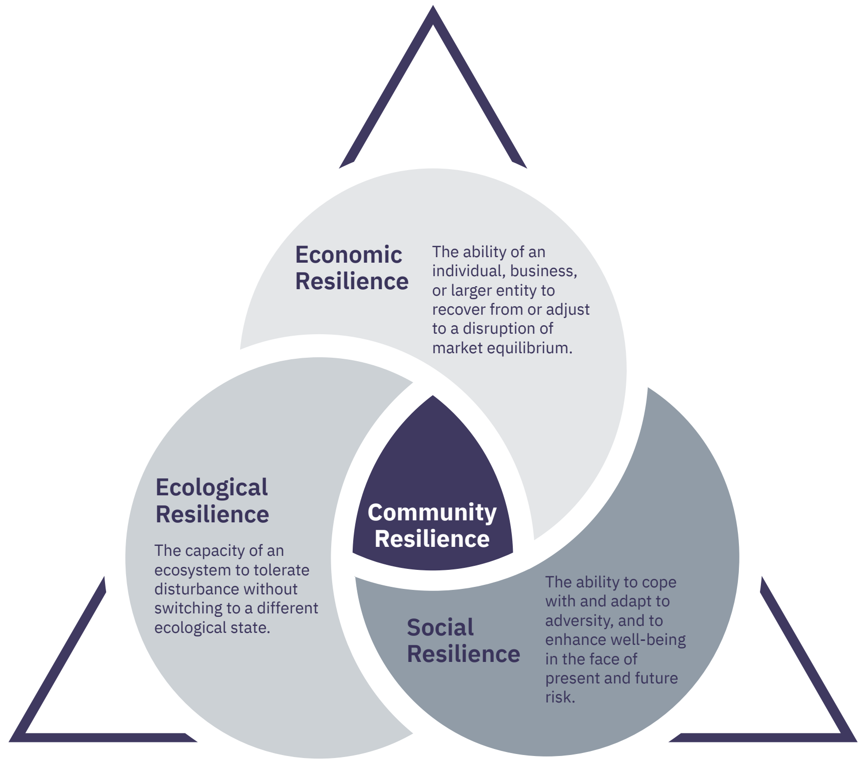
The State of New Jersey defines resilience as the ability of social and ecological systems to absorb shocks and stresses resulting from a changing climate, while becoming better positioned to respond in the future.

By their very nature, ecosystems are inherently resilient. In fact, ecosystems rely upon natural disturbances to maintain their physical structure and ecological function. In contrast, the built environment is not resilient. On the contrary, it is designed to remain static and unchanged in order to meet social and economic objectives. While engineered and designed landscapes are adequate for maintaining conditions falling within the design specifications, they do not adapt to the accelerated environmental change we are experiencing. Further, the built environment constrains the natural landscape's ability to adapt and recover, limiting its capacity to withstand external stressors.

Where ecological resilience is low, economic resilience falters. As an example, many small businesses in coastal areas primarily rely upon the income generated between Memorial Day and Labor Day. Nuisance flooding occurring in shore towns over the summer season may inhibit access to local stores, restaurants and amusements, reducing the number of patrons visiting these establishments. Summed over the season, lost revenue may be substantial. Local enterprises unable to cope with the loss may close down, leading to personal as well as community-level economic losses. Repeated infrastructure damage and economic losses, in turn, negatively affect social resilience at both the individual and community scale. Socially resilient communities have strong networks of organizations that support a broad range of resident and institutional needs. This framework for open communication and support raises confidence in proactive actions to improve resilience, increases competence in responding to and mitigating disasters, and garners support from multiple social groups and economic levels throughout the community.

These three pillars provide the foundation for community resilience to climate change. Ecological resilience will support healthy economic and social instituions while strengthening a community's ability to recover from climate-induced stressors and adapt to changing climate conditions.

Figure 2.1 Relationship Between Ecology, Economics, and Society in Creating Community Resilience Community resilience to climate change impacts depends upon the interactive effects of initiatives aimed at supporting the resilience of ecosystems, the economy, and society.



What is Landscape Resilience?

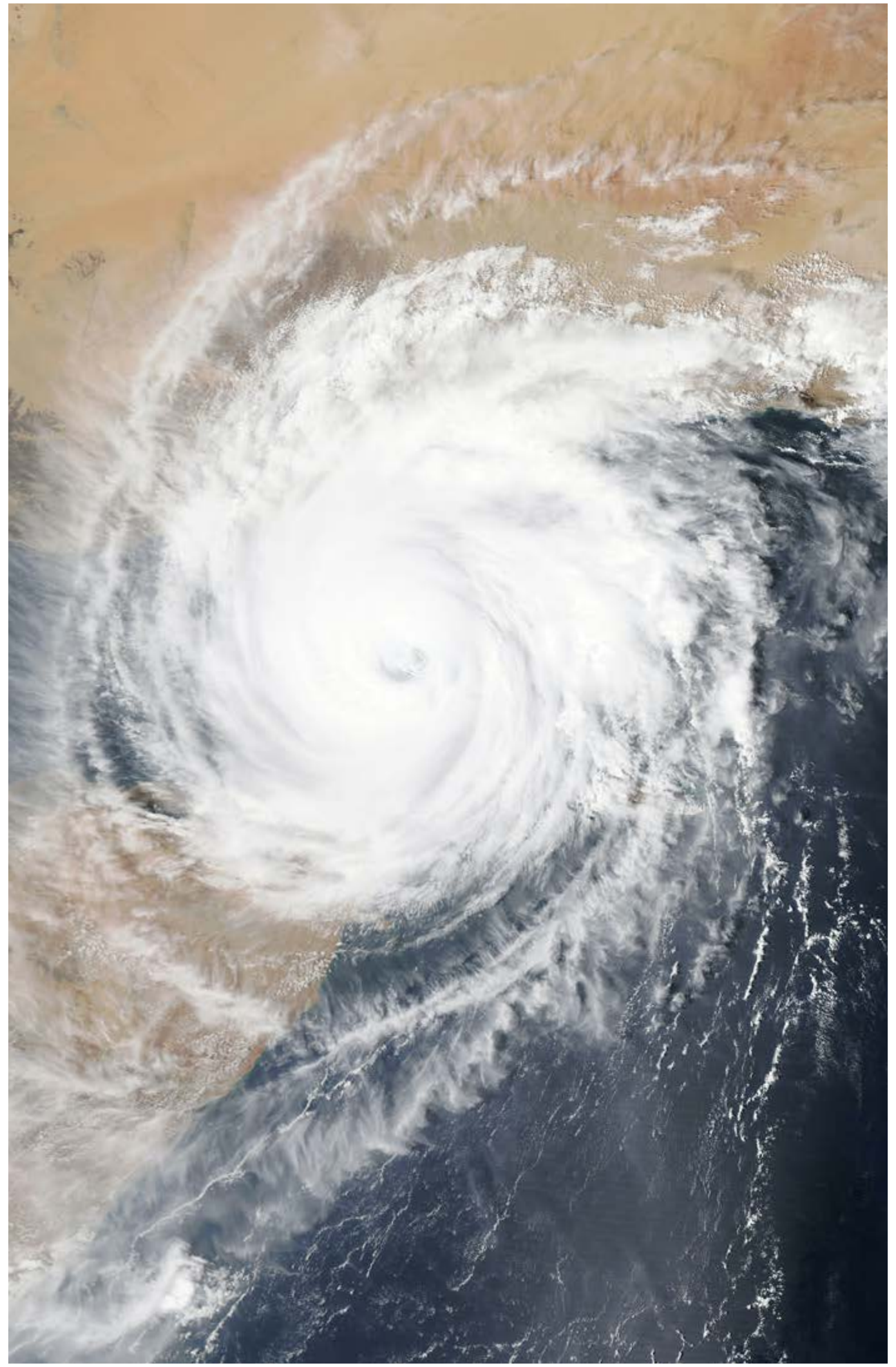
Resilient landscapes contribute to overall climate resilience by supporting ecological functions that promote and support populations of plants and animals. This, in turn, produces many co-benefits for people in the form of ecosystem services. Resilient landscapes mitigate flooding, retain soils, regulate the local climate, protect critical infrastructure (i.e. hospitals, power stations), and regulate the local climate. They provide opportunities for recreation, aesthetic enjoyment, and spiritual connections with the natural world. Communities often place multiple requirements on the landscape that can compromise its ability to recover from disturbance. The resilient landscape has the capacity to adapt to a changing environment while maintaining its core function. Resilient landscapes in our communities need to be flexible and free to adapt to change while also incorporating redundancy to be able to recover should one component be lost or damaged.

RESILIENCE VS. DISASTER AVOIDANCE

The issues of resilience and disaster avoidance are closely related, and often disaster avoidance is mistakenly referred to as resilience. Disaster avoidance (or hazard mitigation) is a type of planning employed to reduce the loss of life and property damage by avoiding disaster situations altogether. Its primary goal is to prevent the disaster. Tide gates, sea walls, and levees can be considered examples of disaster avoidance strategies because they create a physical barrier between the water and the landscape they are protecting. Other measures, such as concrete channels, piping, and pump stations, reduce flooding by redirecting water away from protected areas. While armoring and engineering solutions can be effective, they will fail when environmental conditions exceed their design specifications. Therefore, disaster avoidance measures are a component of a landscape resilience strategy, but they are ineffective as a standalone approach.

The seawall protecting the Borough of Sea Bright and Monmouth Beach, New Jersey is designed to prevent storm surge from reaching the built landscape (Photo Credit: Pia Tolentino)

The living shoreline along the edge of Wreck Pond that borders Shore Road, Spring Lake is designed to allow flood water to expand across the land and infiltrate the ground (Photo Credit: Arden Maslo)



LANDSCAPE RESILIENCE GOALS

This document has been prepared to guide communities working to restore or rehabilitate flood-prone landscapes to increase community and ecological resilience. In the past decade financial resources have been provided from Federal and State governments for the acquisition of flood-prone properties, and many communities now have vacant areas that they are responsible for maintaining. Little to no guidance has been made available to these communities outlining what to do with the landscapes once they have been purchased and transferred to the local governing body. What most people understand is that "you cannot build on these lots." This is true. We want to remove residents and properties from dangerous areas through property acquisition. However, these 'buyouts' are also opportunities to create landscapes that better serve and support our community.

To do that, an integrated approach of managed retreat, ecological restoration, and green infrastructure is required. The physical interventions must be coupled with community education and outreach to empower communities to adopt proactive resilience strategies and generate tangible socioeconomic benefits. Successful resilience frameworks strive to balance four overarching goals designed to ensure appropriate, ecologically based landscape stewardship while also meeting individual and community needs.

Aftermath of Hurricane Ida in Manville, NJ
(Photo Credit: Haley Hostos, Manville resident)

Beach Haven West, Stafford, New Jersey
(Photo Credit: Meghan Kolk)

Resilience Goal 1: Protect Human Health and Safety

Improving human health and safety is a major component of increasing community resilience to storms and flood events. The primary resilience goal for improving human health and safety is to reduce the number of people at risk from storm or flood events. This can be achieved by directly removing structures from a flood zone, as well as by implementing resilience projects involving green infrastructure and ecological restoration. These projects directly improve human health and safety by increasing flood storage capacity and reducing water and soil contamination.

Resilience Goal 2: Protect Infrastructure and Property

Physical infrastructure includes residential and commercial buildings, roads, bridges, and essential systems such as water and power supply, health care, food supply, and communications. This infrastructure allows for the delivery of critical services within a community. Increasing resilience of physical infrastructure to flooding and storm events helps decrease interruptions in transportation, emergency services, business operations and economic activities, making it easier for communities to rebound following significant storm events. There are two primary objectives for this resilience category: 1) reduce the number of residential, commercial, cultural and heritage properties, as well as critical facilities at risk to potentially damaging inundation; and 2) reduce total miles of roads, highways, and rail lines at risk to potentially damaging inundation. Removing or relocating infrastructure built in flood-prone areas, coupled with ecological restoration interventions aimed at mitigating flood risk, reduces flood risk to adjacent parcels.

Resilience Goal 3: Enhance Integrity and Function of Natural Areas

Natural areas enhancement improves community resilience in two major ways: by allowing community members to enjoy open space and amenities near their homes, and by increasing biodiversity-based ecosystem services. Improving amenities includes increasing the number of recreational sites to residents in a community, diversifying the type of recreational activities available, and increasing public access. Biodiversity refers to the variety of plant and animal life on Earth, and ecosystem services refers to the positive benefits provided by nature to people at no cost, such as pollination, seed dispersal, and flood storage. Improving biodiversity through habitat restoration strengthens the resilience capabilities of ecosystem services.

Resilience Goal 4: Empower Communities

Empowering a community begins by establishing a vision for a resilient future and then securing the political interest and support as well as the organizational and technical resources needed to move forward. Communities must plan for, withstand, and recover from a disaster. Through maintaining up-to-date data about on-the-ground conditions, effective emergency plans, and community preparedness, a community can weather the storm and recover after it. Developing collaborative relationships and engaging with community members empowers communities to take proactive steps in promoting resilience. An empowered community will:

- Communicate well with institutional partners
- Involve residents and stakeholders
- Build and maintain political support for action
- Collect and disseminate information and data
- Acknowledge institutional partners responsibilities and competencies
- Set goals, objectives, and targets

A COLLABORATIVE APPROACH FOR CREATING RESILIENT LANDSCAPES

Moving forward on a landscape resilience project requires a collaborative approach. Building and maintaining support for a complex and often lengthy project is critical for the success of resilient landscape planning and implementation. The following steps are part of a structured approach that can serve as a guide for stakeholders planning a resilient landscape project.

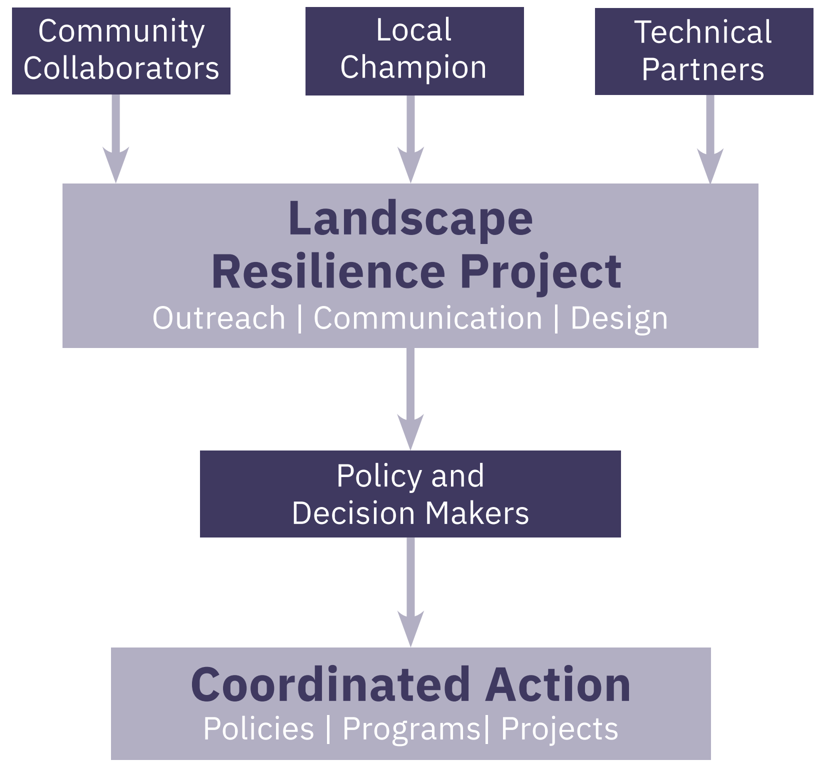
Engagement

Successful projects benefit from a local champion along with a team of experts and local representatives to support the effort. Most projects require a multi-year commitment. The establishment of a clear set of expectations among the project participants will set a project on a positive trajectory. Identifying key participants in the early stages of a project will help to propel it forward. However, it is also important that the structure and participation of project teams remain open and flexible to allow for new ideas, energy and resources.

- **Local Champion:** This is a partner or stakeholder consortium that is willing to support and advocate for the resilience initative. This entity is passionate about solving the landscape resilience challenge and is willing to collaborate to achieve project goals. The local champion has the political capital to bring organizations to the table during the formative period.
- **Technical Partners:** Landscape adaptation projects require a multi-disciplinary team and a variety of skills, areas of expertise, and views to be successful. Scientists, landscape architects, planners, and engineers are critical in developing and guiding the organization, planning, research, and implementation of projects. These partners can be individuals or organizations.
- **Community Collaborators:** Local residents, businesses, and organizations provide unique, relevant perspectives and critical support in early phases of goal setting and conceptual planning. The input of community collaborators is essential in developing local ownership as well as long-term stewardship for projects. These participants are also important in establishing the multi-year monitoring and maintenance programs that are needed once a project has been constructed.

Leadership, commitment, and investment are key in the engagement process. Resilience projects take time. The long-term efforts to participate and contribute throughout the entirety of a landscape resilience initative should be understood by all constituents. Investments will be needed from the community, its technical partners, and outside entities. These investments of time and resources will provide the foundation for moving the project forward from an idea to reality.

Figure 2.2 Key Players on a Landscape Resilience Project Assembling individuals to perform key roles from the inception of a landscape resilience project through its completion will facilitate the implementation of meaningful and sustainable landscape interventions that can also satisfy the social aspects of community resilience.



Organization

Each community is unique in its leadership, and the experiences, as well as the structure of its neighborhoods and local organizations. These differences require that project leaders be flexible and willing to adapt to meet the specific needs and expectations of each community. Establishing strong partnerships and open, clear lines of communication will build capacity for long-term resilience. Regular meetings and communication throughout the project will create and support effective collaboration and decision-making.

Communication is the foundation for an effective landscape resilience plan. Regular and reliable dialogue is necessary to keep multiple partners informed of activities and maintain trust. Early in the process, partners need to identify and agree on communication strategies and procedures. In addition to communication between active partners, continuous engagement and feedback with community members is needed. Direct communication with residents, organizations, and other community stakeholders builds capacity for influencing local leaders and policy makers.

Discussion of stormwater management options with residents of an active adult community (Photo Credit: Rutgers Cooperative Extension)

Collaboration

With the successful establishment of an engaged project team, project partners can collaborate on the development of a set of shared goals and objectives (i.e., flood mitigation, public access, recreational opportunities) for the resilient landscape. Once these goals are defined, project partners can work together on proposing landscape interventions that will address all needs while balancing tradeoffs.

As a project develops, project partners should engage local elected officials and other members of government to generate support and endorsement for actions that support the project. Such endorsement of landscape resilience projects can increase the likelihood of securing external funding or technical assistance.

Sustaining Impact

With established relationships between organizations, joint action to secure funding and technical assistance can elevate the relevance and significance of the landscape resilience project. Once established, project partners must be willing to jointly evaluate the effectiveness of projects, programs, and strategies. A continued re-evaluation of current conditions, coupled with adaptive modifications to the original project plan, will allow for continued project sustainability as both environmental and social conditions change.

Woodbridge Township and its technical partners received a 2017 Outstanding Floodplain Management Award from the New Jersey Association for Floodplain Management for their landscape resilience plan for the Woodbridge River floodplain. (Photo Credit: Woodbridge Township)

03

OVERCOMING CHALLENGES OF CREATING RESILIENT LANDSCAPES

Key Topics

FEASIBILITY CHALLENGES

ECOLOGICAL CHALLENGES

SOCIAL CHALLENGES

A restoration initiative at the north end of Barnegat Light in 2020 aimed to maintain early successional habitat to support breeding shorebirds of conservation concern while promoting storm protection through the creation of primary dunes. (Photo Credit: Conserve Wildlife Foundation of New Jersey)

The design and implementation of landscape resilience projects present unique challenges for communities. Obstacles may come in the form of feasibility (such as deed restrictions, land use regulations, and financial requirements), ecological (such as site and environmental conditions), and social challenges (public misperceptions about how natural ecosystems function and use of the project site). Each of these challenges can slow momentum and must be overcome to not threaten the progress that has been made and maintain the patience, effort, and vigilance needed to be successful. In this section, we highlight some of the common challenges associated with creating resilient landscapes and suggest ways to overcome them. It is important to remember that unforeseen challenges may also occur, which will require creativity, collaboration, and communication to develop innovative solutions.

FEASIBILITY CHALLENGES

Establishing the Footprint for a Large-Scale Landscape Intervention

Existing open space provides opportunities to implement landscape interventions that can increase flood resilience. Where open space parcels are limited in size or surrounded by development, only small-scale resilience projects may be possible. However, even modest landscape alterations can be beneficial. For example, converting turf areas to wildflower meadows or woodlands is a relatively simple way to increase the landscape's capacity to collect and filter stormwater while also promoting biodiversity conservation. Designed green stormwater infrastructure (GSI), such as rain gardens or bioswales, provide additional flood management benefits. However, flood resilience is maximized when flood water has ample room to spread over the landscape and slowly infiltrate into the ground. In addition, large-scale landscape resilience projects have the potential to also conserve biodiversity and provide public passive recreation opportunities and access to nature (see Chapter 5). Therefore, exploring ways to expand the footprint of landscape resilience initiatives is important.

Increasing the potential footprint for a large-scale landscape intervention, particularly in developed areas, can be achieved by connecting existing open space where landscape alterations are allowable. Such parcels may include township or county-owned lands, rights-of-way, and properties with conservation or access easements. Once the backbone of clustered open space parcels is identified, strategic acquisition of privately owned properties can connect and augment project areas. Identifying these high priority parcels before a major flood event provides an opportunity to coordinate with property owners so that acquisitions can be secured quickly once disaster funding is made available.

A 179-acre landscape resilience project within the area of MacArthur Avenue in Sayreville will connect an existing sports facility with a proposed natural area along the South River and Washington Canal. Parcels within the project footprint include Borough-owned green space (green), land owned by the Sayreville Economic Redevelopment Authority (SERA; yellow), NJDEP Blue Acres properties (blue), and a Middlesex County Utility Authority (MCUA) right-of-way.

Deed Restrictions and Other Land Use Considerations

Open space, conservation easements, and properties acquired through disaster relief programs may be deed restricted to limit future development. Such restrictions typically require that land is dedicated in perpetuity for public open space, recreation, or flood management. Deed restrictions are beneficial because they protect against landscape alterations that would restrict the ability of the site to convey flood flows, reduce the area's capacity to store floodwaters, increase downstream velocities, and/or restrict access into and out of the area. However, deed restrictions may also limit the installation of flood mitigation structures, which are part of an integrated stormwater management approach. Additionally, municipal, county, or state regulations are a factor that must be considered when determining what is permitted on any property. Prior to design work, a thorough investigation of the allowable structures on each parcel is needed, as well as what permits may be required for implementation. Work proposed in special flood hazard areas, wetlands, and shorelines will likely require both state and federal permits. In addition, the existence of cultural heritage areas or threatened and endangered species will affect what is allowable at the project site. Knowledge of these land use factors early on will facilitate the efficient and successful design of resilient landscapes that integrate both hard structures, as well as nature-based solutions.

Publicly owned parcels often carry several deed or land use restrictions on allowable uses. (Photo Credit: Brooke Maslo)

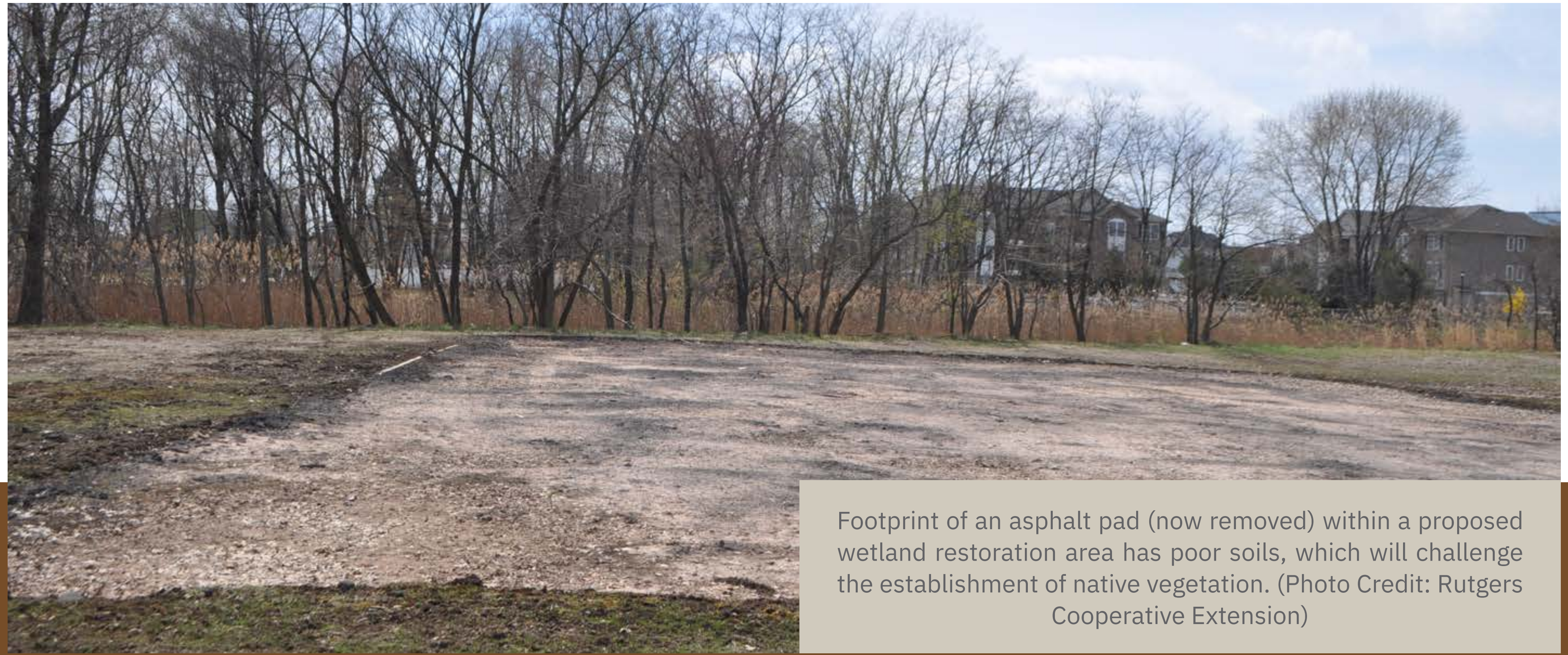
Funding Landscape Restoration and Long-term Maintenance

Landscape resilience projects occur in four distinct phases: 1) planning; 2) preliminary assessment and design; 3) final design and permitting; and 4) implementation and monitoring. **All phases require funding.** While funding assistance to support transitions to resilient landscapes is becoming increasingly available through Federal and State programs, as well as nonprofit organizations (see Chapter 9), local investment will also be critical for maintaining restored landscapes in perpetuity to ensure they continue to deliver flood resilience services over the long term. Resilient landscape project teams must consider the costs of acquiring critical parcels and permits, as well as the cost of the ecological restoration and engineering interventions needed to reduce flood risk. Those entities cultivating an integrated planning approach for implementing a holistic landscape resilience project will be in a strong position to leverage local financial streams with external funding opportunities. Additionally, projects demonstrating multi-agency partnerships that consist of local, state, and federal organizations are considered highly likely to succeed from the viewpoint of financial sponsors.

ECOLOGICAL CHALLENGES

Reversing Legacy Effects of Developed Landscapes

Restoring ecological function to previously developed landscapes is a challenge that can be hampered further by the legacy effects of former land uses. Soils may be contaminated, or they may have little organic matter, nutrients, or microbes needed for plants to grow. The natural hydrologic patterns of the site may have been altered in the past to accommodate the built environment. Sites may be overrun with non-native or invasive vegetation as well. Reversing these conditions will be required for successful landscape transformation. Landscape resilience teams must consider tradeoffs in time and money when determining how to overcome legacy effects of previous development and disturbance activities. A thorough investigation of the project area (see Chapter 6), as well as proper site preparation, monitoring, and maintenance (see Chapter 8), are important components of a successful, long-term resilience project.



Footprint of an asphalt pad (now removed) within a proposed wetland restoration area has poor soils, which will challenge the establishment of native vegetation. (Photo Credit: Rutgers Cooperative Extension)

Buffering External Environmental Stressors

In New Jersey, most resilient landscape projects will occur within or adjacent to developed landscapes. Because project sites and their surrounding locations are not pristine ecosystems, external environmental stressors will be a challenge resilience landscape teams will need to address so the integrity of the resilient landscape is not threatened. Nonpoint source pollution, invasive plant and animal species, and the increased temperatures that are associated with urban heat islands are examples of external stressors that can affect project areas and need to be considered in planning and designs. Establishing solid foundations for ecological restoration, as well as implementing a routine monitoring and maintenance plan, are all steps to take that can help to mitigate the effects of these challenges (see Chapter 8).

Floodplain forests and other natural habitats can be overtaken quickly by invasive plant species, such as mile-a-minute *(Persicaria perfoliata).* If such plants are not managed, they can smother restoration plantings and alter the trajectory of a resilience project. (Photo Credit: Rutgers Cooperative Extension)

SOCIAL CHALLENGES

Rebranding Landscape Transitions as New Opportunities

Landscape transition initiatives in flood-prone areas of New Jersey often occur as a response to major storms or other large-scale flood events, where the damage caused to human safety and property crystallizes the need for increased resilience. The removal of human structures within a community, which can precede a resilient landscape project, can trigger feelings of loss or abandonment and threaten community support for the project. To address these sentiments, community members should be included in the decision-making process for the resilient landscape project. In addition, the transformation of the properties should be framed both as an opportunity for meeting the challenges of climate change, as well as a way to increase the availability of public amenities. Careful landscape planning and ecological restoration can beautify areas and provide newfound public access to nature while also reducing flood vulnerability. Creating new destinations (i.e. public parks, recreational trails, community gardens, etc.) can also potentially boost local economies and provide other social benefits. These anticipated results should be communicated directly with communities adjacent to the project and with the larger community by heavily publicizing the benefits in local papers, news stations, and social media. Sharing detailed drawings and renderings of proposed landscape transformations can help stakeholders envision what is possible.

Removal of flooded, damaged, or abandoned homes can instill a feeling of abandonment in residents that remain in or adjacent to flood-prone neighborhoods. Outreach and educational information directed toward the public can help to mitigate the sense of loss and generate excitement about new landscape opportunities. (Photo Credit: Brooke Maslo)

Discouraging Inappropriate Human Uses

Management of landscapes undergoing ecological restoration or other public amenity improvements is needed to ensure conditions uphold public safety and environmental conditions. These project sites may appear deserted or forgotten and can become appealing locations for inappropriate human activities. Some activities may pose a risk to human health and safety (i.e. public consumption of alcohol or drugs), while others can cause negative impacts to the environment (i.e. illegal dumping, off-road vehicle use). This challenge can be addressed in some locations using signage, cameras, or physical barriers to protect landscapes under transformation. More persistent problems may need local community support through reporting from concerned citizens or neighborhood watch programs. In these cases, law enforcement may be required to ensure that the problem is addressed.

Signage indicating 24-hour surveillance of New Jersey Blue Acres properties in the Borough of Sayreville attempts to discourage trespassing or unlawful activities prior to ecological restoration. (Photo Credit: Rutgers Cooperative Extension)

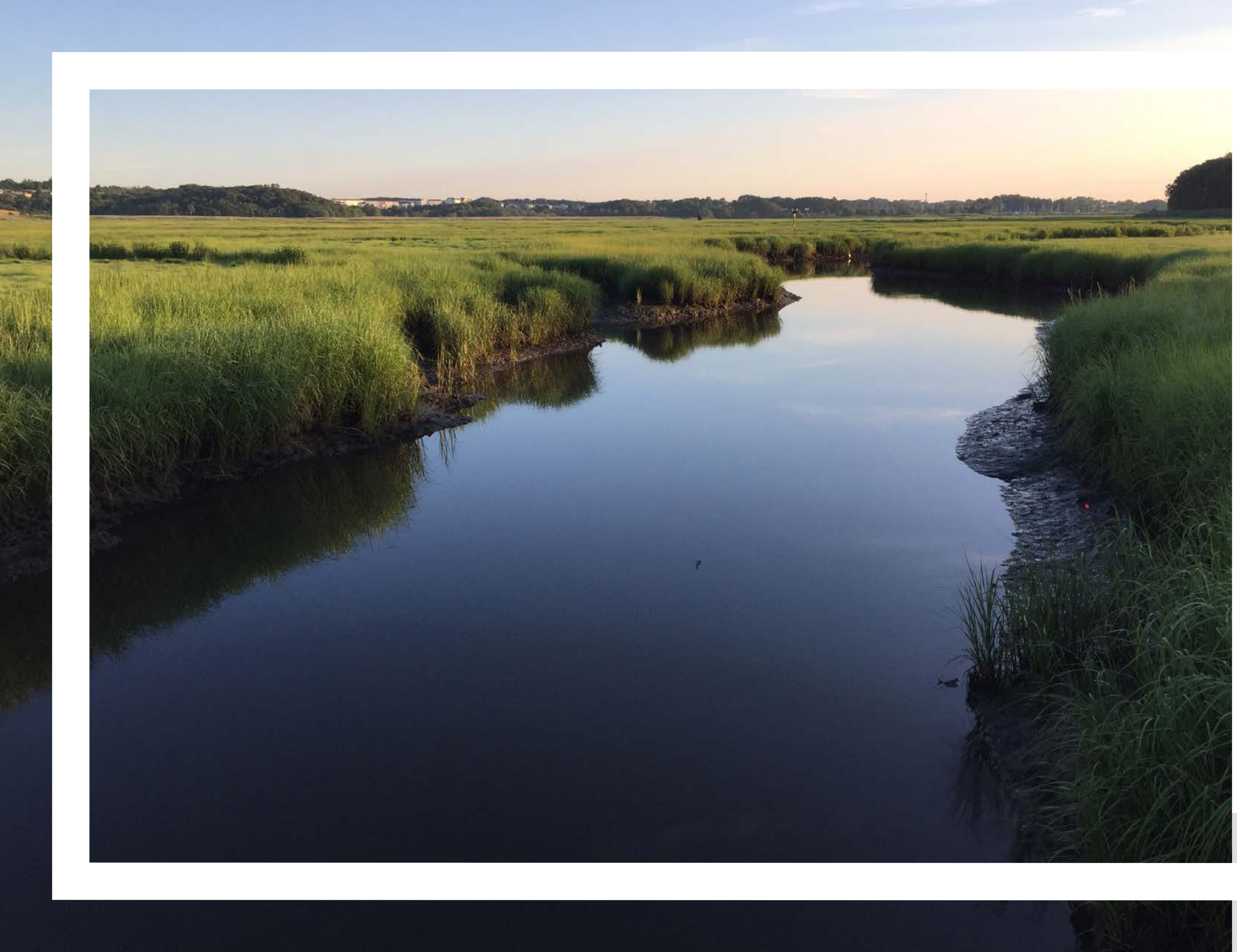
Managing Expectations of Outcomes

Resilient landscapes are cultivated and managed to thrive in a natural state, which may be perceived as ugly or overgrown to a public who is accustomed to mowed and trimmed landscapes. One of the most effective ways to manage this expectation is through consistent sharing of clear information. From start to finish, project leaders should lay out the goals and intended outcomes of the landscape resilience project. Importantly, changes may occur through the design and implementation of the project as site conditions are better understood or challenges emerge. Therefore, consistently updating stakeholders of modifications to the design or final project plan will help to keep expectations realistic and promote support for the result. It is also an obligation of the project leaders to prepare communities and stakeholders for possible future challenges of the completed project, whether they are structural (i.e. maintenance needs) or environmental (i.e. invasive species management), and propose potential solutions and contingency plans to address them.

Misperceptions of the Timeframe for Landscape Resilience Projects

At the completion of conventional landscape construction projects, the site conditions often look finished, with large trees in place and manicured turfgrass established. In contrast, nature-based projects, particularly those implemented with smaller-sized plants, will take years to reach maturity. With appropriate monitoring and maintenance plants will grow each year, and the landscape will continue to change over time (see Chapter 5). Such visible changes should be communicated to community members to promote understanding and support of these natural landscapes. Restored habitats will need initial monitoring and maintenance (see Chapter 8), as well as protection from herbivory and other environmental stressors. It is important that the landscape resilience team understands and exercises patience while allowing landscape transformations to occur and that a realistic timeframe be communicated to the community and stakeholders.

(Photo Credit: Brooke Maslo)



SECTION II: UNDERSTANDING HOW ECOSYSTEMS FUNCTION

Saline and marsh and tidal creek at Cheesequake State Park, Matawan, NJ. (Photo Credit: Brooke Maslo)

CHAPTERS

4

5

04

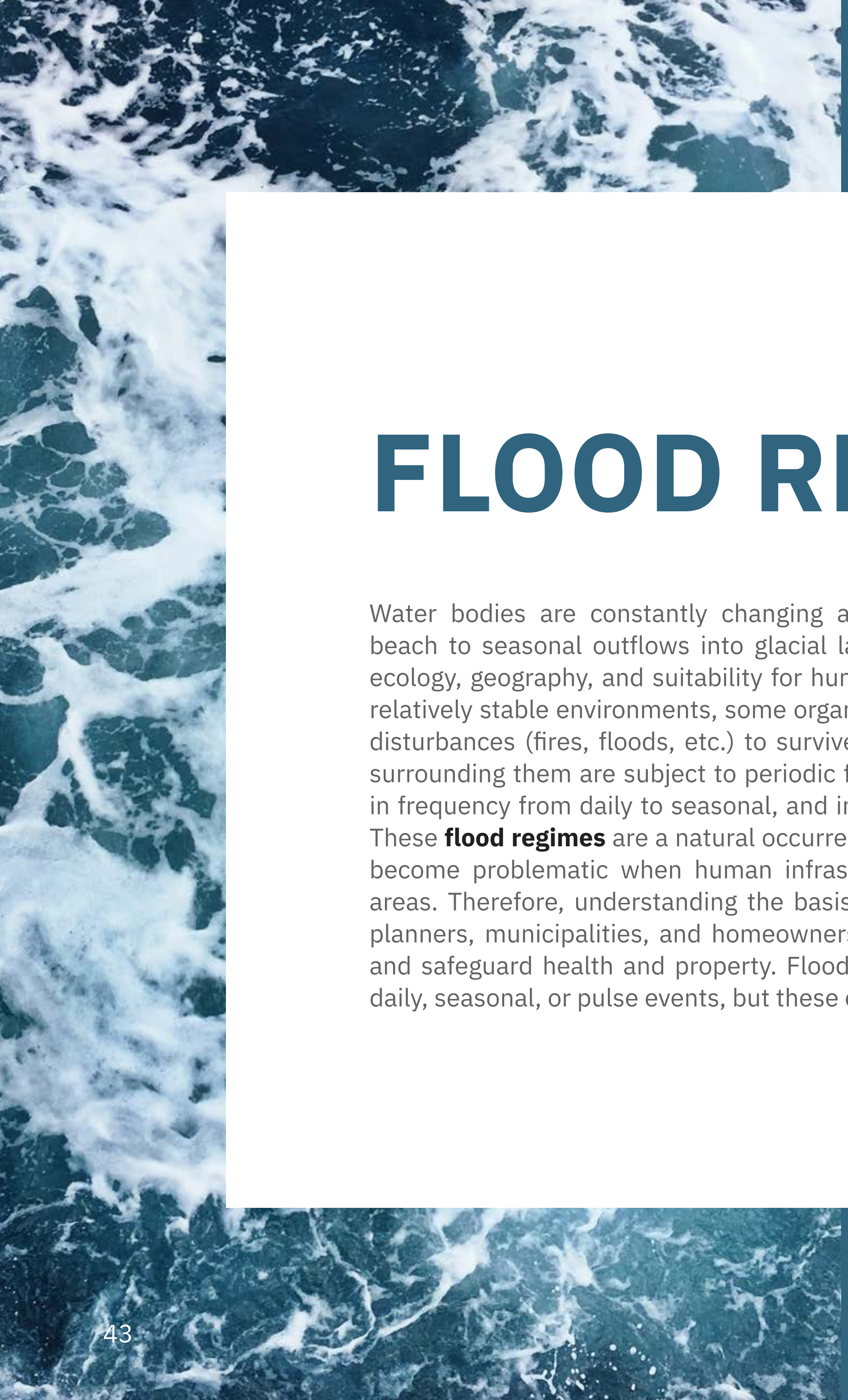
Key Topics

FLOOD REGIMES

FLOOD DEPENDENT ECOSYSTEMS

CHARACTERIZATION OF FLOOD-PRONE LANDSCAPES

Flooded coastal property after Hurricane Sandy. (Photo Credit: Jessica Bergman, Long Branch resident)



FLOOD REGIMES

Water bodies are constantly changing across time and space, from daily tides at the beach to seasonal outflows into glacial lakes. How frequently an area floods dictates its ecology, geography, and suitability for human populations. While people prefer to reside in relatively stable environments, some organisms require the seasonal or daily environmental disturbances (fires, floods, etc.) to survive. Water bodies and the landscapes immediately surrounding them are subject to periodic fluctuations in water levels. Fluctuations can vary in frequency from daily to seasonal, and in magnitude from less than a foot to several feet. These **flood regimes** are a natural occurrence in coastal and wetland communities, but they become problematic when human infrastructure and activities occur within flood-prone areas. Therefore, understanding the basis for when and why floods occur can help urban planners, municipalities, and homeowners develop sustainably, make informed decisions, and safeguard health and property. Flood regimes in New Jersey can be characterized as daily, seasonal, or pulse events, but these categories are not mutually exclusive.

Daily Flooding

Areas with a **daily flood regime** are inundated at least once, but more commonly twice, a day. The moon's gravitational pull on the earth drives the constant ebb and flow of oceans and other large water bodies, resulting in two high tides and two low tides every day. The daily changes in water level are most apparent along the coast where sections of the shore are exposed at low tide but are underwater at high tide. However, even freshwater systems (rivers, freshwater wetlands) can be tidally influenced. Daily flooding is critical for several ecosystems, including beaches, tidal pools, and salt marshes, where many plants and animals are adapted to both life on land and in the water.

Because it takes approximately 12 hours to complete a high and low tide cycle, areas affected by daily tides can experience drastic changes in water level over a relatively short period of time. Therefore, landscapes with daily flood regimes (e.g., coastal areas and marine wetlands) are extremely unstable and might not be suitable for permanent development.

Seasonal Flooding

Areas with a **seasonal flood regime** experience long-term inundation over the course of a few weeks to months. This flood regime is most apparent in areas with dramatic precipitation changes, often referred to as prolonged wet and dry seasons. Seasonal flood regimes are critically important in floodplains and deltas, and many resident organisms reproduce via mechanisms stimulated by inundation. Seasonally flooded areas are also agriculturally important. Although New Jersey does not have pronounced wet and dry seasons, rain events in late winter or early spring (in some cases, coupled with melting snow) can increase the likelihood of flooding.

Pulse Inundation

Pulse inundation flood regimes typically affect floodplains, or areas adjacent to rivers and other water bodies. Resulting flash floods typically follow a heavy rain event (the single pulse) that drastically increases the volume of water in a waterbody over an extremely short period of time. In many cases, the waterway is overwhelmed by such heavy volumes of water, which then spill over into the surrounding landscape. In developed areas, flash floods present an enormous risk to human health and safety as water passes through an area at high velocity and often carrying dangerous debris. The pulse inundation flood regime is the most difficult to predict because it is not periodic like daily or seasonal flood regimes.

Regulatory Terms Relevant to Flooding

There are many terms regularly used to describe areas that routinely flood or are at risk of flooding. These terms are used by regulatory programs as well as designers, planners, and engineers as they work to understand the impacts of flooding in the community.

Base Flood Elevation

The base flood elevation delineates the expected height in feet of flood waters that are expected to occur in a given location during a 100-year storm. It is calculated from historical weather data, topography, and the best available science, and it is used primarily to determine flood insurance premiums.

100-year Flood Zone

A 100-year flood zone is one that has a 1% chance of equaling or exceeding a location's base flood elevation each year. This term does not mean an area will flood only once in a 100-year period. Areas within the 100-year flood zone can be subject to regular flooding. As an example, a property constructed within a 100-year flood zone has a 26% chance of flooding over the life of a 30-year mortgage. If such properties are structures that are supported by a federally backed mortgage, they must carry flood insurance. Properties within a 100-year flood zone should be elevated above the base flood elevation to reduce risk of flood damage.

500-year Flood Zone

A 500-year flood zone is one that has a 0.2% chance of equaling or exceeding a location's base flood elevation each year. This term does not mean an area will flood only once in a 500-year period. Areas in this zone are considered at lower risk of flooding. However, due to their proximity to more flood-prone areas, properties within a 500-year flood zone can experience drainage issues, nuisance flood damage, or disruptions, such as flooded intersections, sewer backups, and minor property damage.

Special Flood Hazard Area (SFHA)

Special flood hazard areas are those indicated to have special flood or flood-related erosion hazards shown on Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps. In these areas the National Flood Insurance Program (NFIP) regulations must be enforced, and it is mandatory that flood insurance be purchased.

Regulatory Terms Associated with Freshwater and Riparian Areas

Floodway

The floodway includes the main river channel and areas immediately adjacent to the river. Its primary function is to move water from upstream to downstream. During flood events, water moves very quickly within the floodway and potentially causes damage to anything in its path. Obstructions in the floodway (i.e. fill, debris, structures) slow the flow of water, which leads to flooding in upstream areas. Therefore, the floodway should always remain clear of obstruction and debris. The New Jersey Department of Environmental Protection (NJDEP) and FEMA regulate any changes proposed in the floodway to preserve flood flows and protect upstream areas from increased flood risk.

Flood Fringe

The flood fringe is the area on either side of the floodway, located between the floodway and the edge of the floodplain. In contrast to the floodway, obstructions to water flow are permitted in this area. The flood fringe can be developed conditional upon meeting elevation and floodproofing requirements.

Riparian Zone

Riparian zones are the land areas immediately adjacent to waterways that support a variety of ecological functions and help to protect rivers, lakes, and streams from nearby disturbance. Healthy riparian zones moderate water temperatures, filter stormwater runoff, and provide habitat to many plants and animals. In New Jersey, regulations identify riparian zones to be protected ranging from 50-300 feet in width along naturally occurring rivers, lakes, and streams. These regulations help to ensure that natural areas along waterways remain to protect natural resources and water supply.

Freshwater Wetland

Freshwater wetlands can have permanent standing water for most of the year or be temporarily inundated with water for a significant part of the year. Wetland soils, hydrology, and vegetation must all be present for a wetland to exist. Freshwater wetlands are often adjacent to rivers, lakes, and ponds, and are most heavily influenced by precipitation and the evaporation of water from plants.

Wetland Transition Area

The wetland transition area is the immediate upland area surrounding the wetland. It provides an ecological buffer around a wetland to accommodate seasonal flooding, and it filters runoff from upland sources. In New Jersey, the width of regulated wetland transition areas is 50 feet for intermediate value wetlands and 150 feet for exceptional value wetlands. The wetland transition area can extend into properties without wetlands, requiring permitting even though wetlands may not be present on that property.

Regulatory Terms Associated with Coastal Areas

Flood maps in coastal areas delineate areas at high risk of flooding within the coastal Special Flood Hazard Area (SFHA). The coastal SFHA has three flood hazard zones: Zones VE (which are unique to coastal areas), AE and AO.

Coastal Wetland

Coastal wetlands are areas that experience permanent or seasonal inundation with fresh, brackish, or salt water. They are located within coastal watersheds that drain into the ocean. Typical examples of coastal wetlands include saline marshes, tidally influenced freshwater marshes, and forested swamps. Water levels in coastal wetlands are primarily influenced by tidal cycles, and the influx of nutrients and organic matter make them highly valuable habitats for wildlife.

Zone VE

Zone VE, also known as a *Coastal High Hazard Area,* is where wave action and fast-moving water can cause extensive damage during a base flood (1%-annual-chance).

Zone AO

Zone AO is used to map areas at risk of shallow flooding during a base flood, where water with average depths of 1 to 3 feet flows over sloping ground. On flood maps in coastal communities, Zone AO usually marks areas at risk of flooding from wave overtopping, where waves are expected to wash over the crest of a dune or bluff and flow down into the area beyond.

Zone AE

Zone AE indicates areas that have at least a 1%-annual-chance of being flooded, but where wave heights are less than 3 feet.

Limit of Moderate Water Action (LiMWA)

Flood maps in coastal areas may include a line called the Limit of Moderate Wave Action (LiMWA). The LiMWA marks the inland limit of the Coastal A Zone— the part of the coastal SFHA referenced by building codes and standards where wave heights can be between 1.5 and 3 feet during a base flood event. Past events have shown that waves as small as 1.5 feet can cause foundation failure and structural damage to buildings.

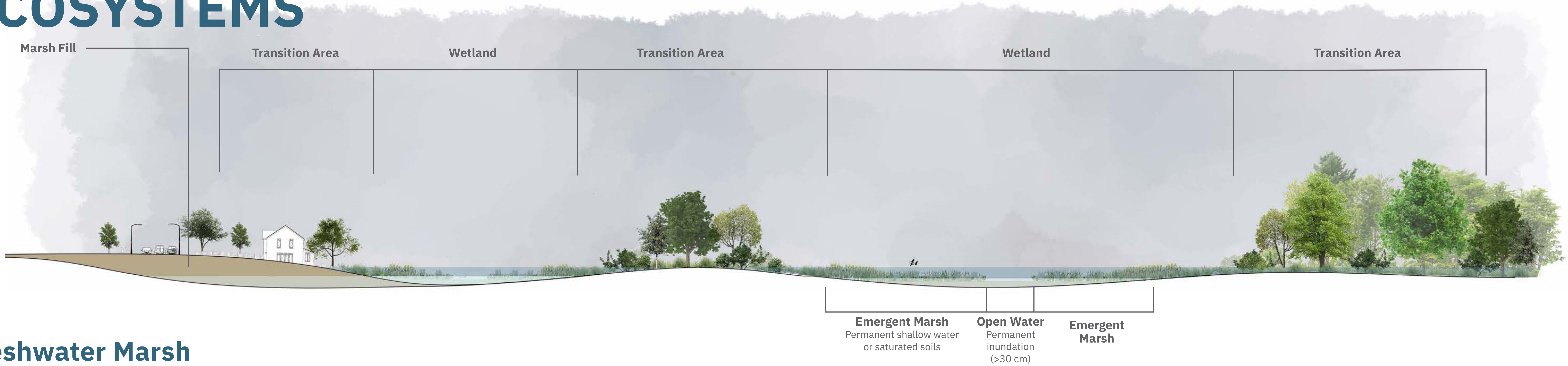
Overlap of the Built and Natural Landscape in Flood-prone Ecosystems

In the remainder of this chapter, we present a series of graphical representations of common flood-dependent ecosystems. We delineate the various habitat zones within each and provide details on the typical flood regime within each area. The cross ecosystem sections are overlaid with the regulatory zones described previously to illustrate how frequently flooding is expected to impact the infrastructure built within them.

(Photo Credit: Jon Sullivan)

Flooded neighborhood in Ship Bottom, Long Beach Island (Photo Credit: Matt Drews)

FLOOD DEPENDENT ECOSYSTEMS



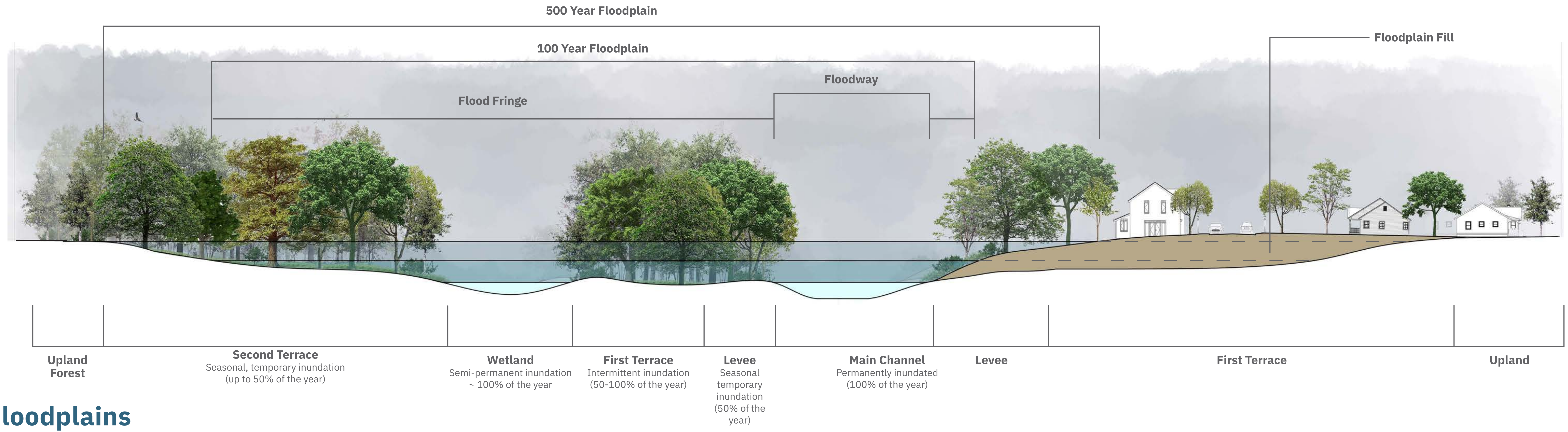
Freshwater Marsh

What is a Freshwater Marsh?

Freshwater marsh systems are typically dominated by grasses, sedges, and other freshwater emergent plants. Their other features are primarily determined by hydrology. Water levels in inland marshes are generally stable because their hydrology is primarily controlled by precipitation, evaporation, and transpiration. However, freshwater marshes near the coast may be tidally influenced, with water levels changing twice daily. Some marshes (i.e. vernal pools, wet meadows) may even dry down completely during the summer months. Freshwater wetlands reduce flooding by capturing stormwater and snowmelt. They protect against erosion by slowing down flood waters, and they filter the water before slowly releasing it. Because freshwater wetlands trap and metabolize nutrients, they are critical habitats for a multitude of organisms at all trophic levels.

Building in Freshwater Marshes

In the past, marshes and other freshwater wetlands were filled to allow for the construction of homes and infrastructure. Although the natural hydrology of the area is altered after a wetland is filled, flood risk is not eliminated. Wetland soils and high groundwater tables remain, often resulting in wet or waterlogged basements, foundations that settle, soggy yards and landscapes, and freeze/thaw heaving of paved areas. Wetland filling also increases the risk of flooding in surrounding areas because the flood storage capacity of the previously existing wetland is lost. Wetlands and the areas immediately surrounding them, the wetland transition area, are now legally protected. Activities that would drain, remove vegetation from, fill, or otherwise disturb them are regulated. Permits, and in some cases, mitigation, are required for most activities that disturb wetlands in New Jersey.



Floodplains

What is a Floodplain?

A floodplain is an area of low-lying, usually flat ground located adjacent to rivers. Natural floodplains are formed and maintained by periodic flooding after storms or snowmelts, during which nutrient-rich sediments are deposited over the land. Their overall shape can change over time as the main river channel migrates through erosional and accretional processes. Floodplains can support multiple habitat types depending on the surrounding environmental conditions, including forests, freshwater wetlands, and shrublands. They function in flood mitigation by temporarily storing floodwaters during storm events until there is capacity within the floodway to convey that water downstream. Stored water allows sediments and nutrients to filter out prior to conveyance. These processes reduce flooding impacts to downstream communities.

Building in the Floodplain

The primary function of the floodplain is to store and convey water during storm events. Filling and building on floodplains alters natural drainage patterns and reduces the flood storage capacity of the ecosystem, resulting in amplified flood levels within the built landscape and its surrounding area. The floodplain consists of the floodway, which includes the main river channel and the areas immediately adjacent to the river, which serve to move water from upstream to downstream. Filling and building in the floodplain reduces the amount of available flood storage, which forces flood waters to continue downstream and create health and safety concerns for the communities located there.

Ocean Beaches

What are Ocean Beaches?

Ocean beaches are relatively narrow strips of sand parallel to the main coastline. They consist of sand, shells, and pebbles and are characterized by sparse vegetation that is tolerant of sea spray. Tides and waves inundate the intertidal zone twice daily, with higher tides sometimes flooding the seaward portion of the berm. Spring high tides happen seasonally and can flood the entire beach berm. During storms, primary dunes protect the coastline by blocking waves and surge. In many cases, the seaward faces of foredunes are washed away but are later restored through natural coastal processes. Because they receive nutrient inputs from both the land and the sea, ocean beaches can be considered areas of high biodiversity and ecological function.

Building at the Ocean

Communities near the beach are some of the most desirable, yet most at-risk areas in New Jersey. Rising sea levels and intense storms resulting in coastal flooding threaten the integrity of many structures in these areas. Building on oceanfront coastlines requires special construction methods to secure structures, and the surrounding beach landscape can be quickly compromised by human activities. The beach, dunes and accompanying vegetation provide important protection against storms and wave action for coastal communities. Ensuring that these landforms remain is an important long-term resilience strategy. In New Jersey, tidal waterways and lands below the mean high water line are protected along with upland land areas within 100 to 500 feet of the mean high water line. Construction activities in these areas require regulatory review and approval.

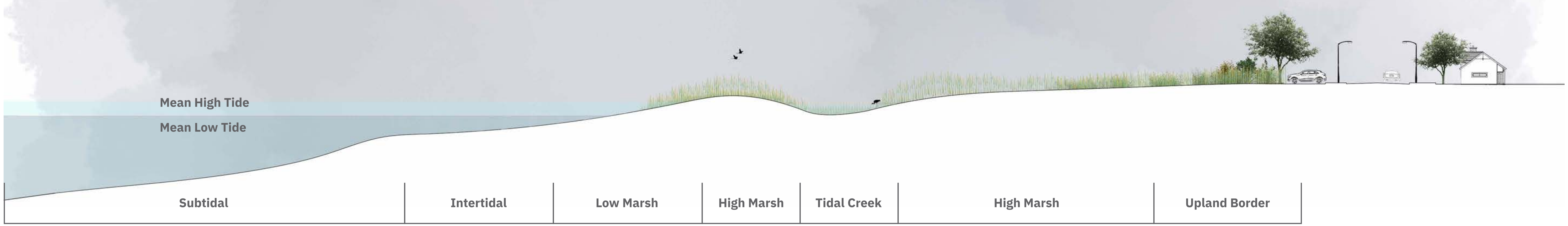
Saline Marsh

What is a Saline Marsh?

Saline marshes are intertidal wetlands that occur along coastlines wherever the rate of sedimentation is greater than the rate of subsidence and where there is protection from waves and storms. They are characterized by salt-tolerant vegetation surrounding sinuous tidal creeks. The vegetation in saline marshes occurs in distinct zones, which are delineated by tidal elevations, soil salinity, and other environmental factors. Saline marshes buffer coastlines against erosion by slowing down water and waves and trapping sediments. They increase water quality by absorbing excess nutrients from runoff, and they provide nursery habitat for many commercially and culturally important fisheries.

Building in Saline Marshes

Building has occurred in saline and coastal marsh areas to provide properties with scenic views and access to nearby waterways. The saline marshes that had previously trapped and filtered sediment and stormwater and buffered the coastline from wave energy are now absent having been replaced by bulkheads. Homes and businesses built on former saline marsh are at risk for significant damage due to wave action, tidal surge, and coastal flooding. Nearby waterways also are subject to increased erosion and sedimentation, as well as water quality issues. In New Jersey, coastal wetlands are protected. Activities aimed at filling, dredging, or altering existing coastal wetlands require regulatory review and approval.



05

Key Topics

WHAT IS BIODIVERSITY?

WHAT ARE ECOSYSTEM FUNCTIONS?

ECOLOGICAL PRINCIPLES UNDERPINNING RESILIENT LANDSCAPES

ECOLOGICAL UNDERPINNINGS OF RESILIENT LANDSCAPES

Resilient landscapes are those that can withstand moderate environmental disturbances and recover from severe ones. Their ability to do so is a function of environmental characteristics, habitat structure, and ecological processes. Environmental characteristics include such factors as temperature, precipitation, soils, and hydrology, and they dictate the types of species and habitats that can occur in a location. Habitat structure refers to such characteristics as species composition and interactions, configuration and redundancy of habitat patches, as well as the functions of particular ecotypes (i.e. flood storage of wetlands). Ecologically intact landscapes, those with high biodiversity and ecosystem function, are more robust to environmental disturbances because they buffer the effects of environmental stressors (i.e. wind, waves); they allow for species to seek refuge from impacted areas and then return once the disturbance is over; and they maintain themselves over the long term through the provisioning of resources important for species survival and reproduction. When designing for resilience, practitioners must have a solid understanding of the ecological principles underpinning resilient landscapes. In this chapter, we explain the link between biodiversity and ecosystem function, as well as the ecological theory behind it. We also link these principles to landscape design goals and provide a framework for deciding what habitat types to restore and where to restore them.

WHAT IS BIODIVERSITY?

The term *biodiversity* can be heard everywhere – in the news, popular media, as well as the scientific literature. This term can be defined in different ways. The most official definition of biodiversity stems from the 1992 United Nations Convention of Biological Diversity, which states that:

"Biodiversity is the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems."

Biodiversity can be broken down into three components: species diversity, genetic diversity, and community diversity.

Species Diversity

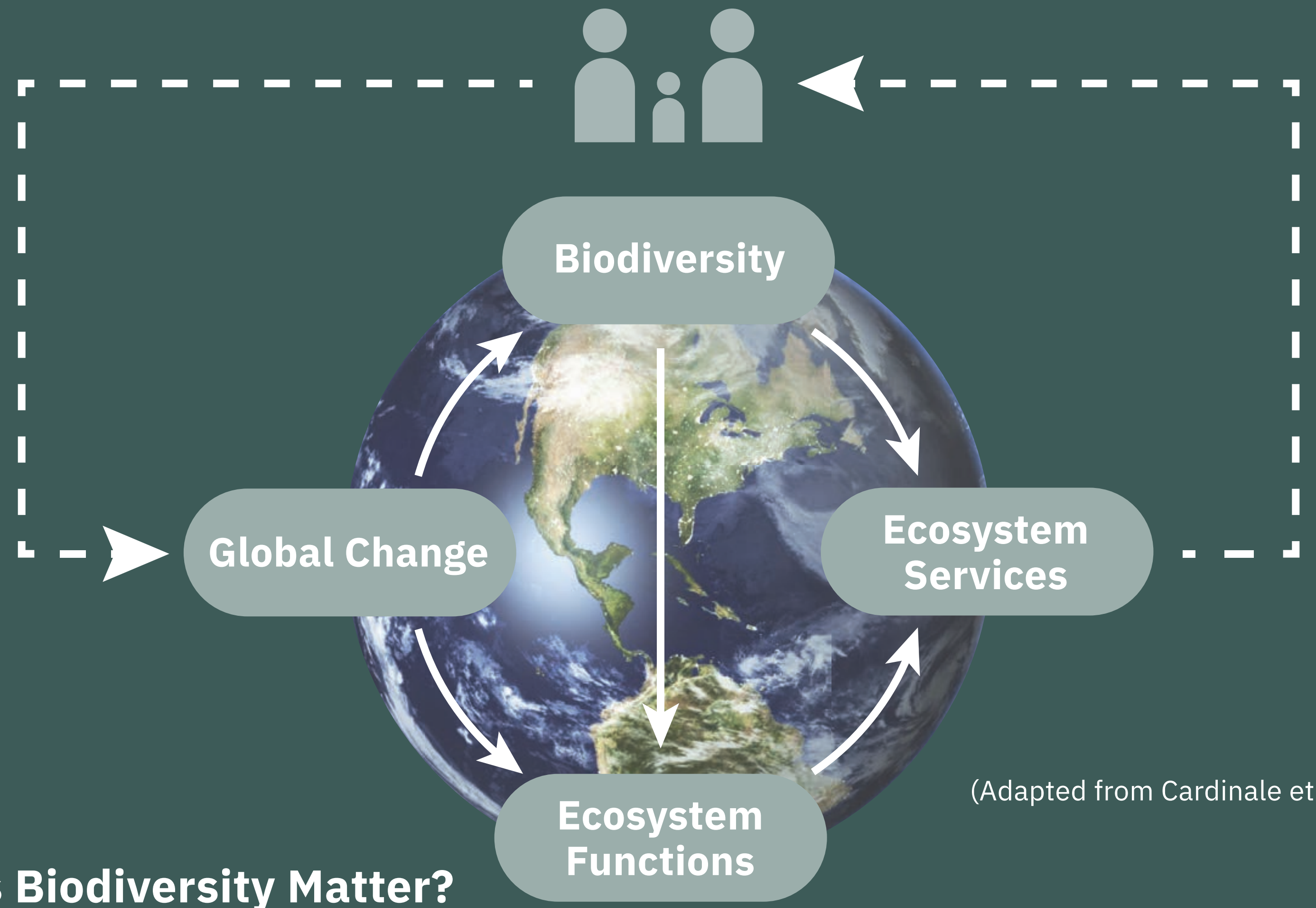
Species diversity describes how many species are present within an ecosystem (*species richness*), how many total individuals are in an ecosystem, regardless of what species they are (*abundance*), and how evenly distributed the individuals of each species are (*evenness*). For example, are most trees in a forest green ash? Or is the forest comprised of an even distribution of green ash, red maples, black gum, and swamp white oak? A green ash dominated forest would be under considerable threat due to the expansion of the invasive emerald ash borer into New Jersey, but a mixed forest community would be far less impacted.

Genetic Diversity

Genetic diversity is the genetic variation that exists both within and among species. Genetic variation is the basis for evolutionary change. Ecosystems where species exhibit high genetic diversity are more robust to environmental change. Sudden shifts in climate or hydrology, or the emergence of an invasive species or disease, can wipe out entire populations of plants and animals. However, where genetic diversity is high, there may be some individuals within the population that can withstand the new environmental conditions and provide a source of ecosystem recovery.

Community Diversity

Community diversity is the assemblage of plant or animal communities within a habitat. At a larger scale, it can also describe the assemblage of habitat types within an ecosystem. Community diversity is important because different ecological communities perform different ecosystem functions. Biological invasions or human-caused modifications of particular habitats will affect the species that make up certain ecological communities and change (usually reduce) how those communities function. Having diversity at the level of habitats helps to ensure that net ecological functions remain steady in the face of environmental change.



(Adapted from Cardinale et al. 2012)

Why Does Biodiversity Matter?

Biodiversity performs several *ecosystem functions*, which are the ecological processes that control the fluxes of energy, nutrients and organic matter through the environment. Examples of ecosystem functions include decomposition, carbon sequestration, pollination, and pest control. These ecosystem functions contribute to the provisioning of *ecosystem services*, the goods and services that Nature provides us for free, which directly maintain human health and quality of life. Some examples of ecosystem services include air and water filtration, food production, climate regulation, and flood mitigation. Biodiversity, or Nature itself, also gives us pleasure and improves mental health. We enjoy outdoor recreational activities, like going to the beach or taking a hike in the woods. (Note: There are also several ethical arguments for why biodiversity should be conserved, but these are not relevant in a sustainability or landscape resilience context and are omitted here). It is important to note that humans have the potential to greatly impact how ecosystems function through their contributions to global change. Where landscapes are urbanized or otherwise developed, human activities reduce ecosystem function, ecosystem services, and ultimately human quality of life. When ecosystems are restored, humans can improve ecosystem function and increase the provisioning of ecosystem services.

WHAT ARE ECOSYSTEM FUNCTIONS?

Ecosystem functions can be categorized into 4 primary groups: production functions; regulation functions; habitat functions; and information functions. Production functions describe the creation of ecosystem goods (timber, food, etc.) through such ecological processes as photosynthesis and nutrient uptake. Regulation functions refer to the ability of natural ecosystems to maintain, moderate and recover from ecological processes. Climate regulation, water filtration, and soil retention are examples of regulation functions. Habitat functions indicate how ecosystems conserve biological and genetic diversity by facilitating survival and reproduction of plants and animals. Finally, information functions allow for the maintenance of mental health by allowing opportunities for spiritual reflection. Although difficult to quantify, information functions as justification for restoring natural landscapes can resonate with the public and are important points to make.

ECOLOGICAL PRINCIPLES UNDERPINNING RESILIENT LANDSCAPES

Successfully designing and managing landscapes to promote biodiversity (and therefore, biodiversity-based ecosystem services) requires an understanding of some core ecological principles. These concepts pertain to the spatial relationships among habitat patches, corridors, and the landscape matrix, and how those relationships affect the ability of plants and animals to successfully move through the landscape and find the resources they need to survive and reproduce. They also are affected by time, whereby the local conditions within any habitat patch will change according to a generally predictable trajectory. Incorporating these core ecological principles into landscape resilience projects can help designers and landscape managers make informed decisions about how to foster biodiversity within specific sites, and how to configure landscape mosaics that will promote sustainability in natural populations of plants and animals over the long term.

Figure 5.1. The Relationship Between Biodiversity and Ecosystem Functioning As biological diversity increases within an ecosystem, the degree to which that ecosystem captures resources, cycles nutrients, filters water, etc. increases before reaching a maximum.

The Link Between Biodiversity and Ecosystem Function

Several decades of theoretical development and empirical research have converged on the relationship between biodiversity and ecosystem function as indicated in Figure 5.1. As biological diversity increases, ecosystem function increases and eventually reaches a saturation point. There are also at least 6 consensus statements regarding this relationship that form the foundation for increasing biodiversity as a means of promoting landscape resilience. Those consensus statements are:

1. There is unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients.
2. There is mounting evidence that biodiversity increases the stability of ecosystem functions through time.
3. The impact of biodiversity on any single ecosystem process is nonlinear and saturating, such that change accelerates as biodiversity loss increases (Figure 5.1).
4. Diverse communities are more productive because they contain key species that have a large influence on productivity, and differences in traits among organisms increase total resource capture.
5. Loss of diversity across levels of the food chain has the potential to influence ecosystem functions even more strongly than diversity loss within a single level.
6. Traits of organisms have large impacts on the magnitude of ecosystem functions, which give rise to a wide range of plausible consequences of species extinction on ecosystem function.

Habitat Heterogeneity

Biodiversity is maximized when there exist patches of different habitat types that stretch across a connected landscape. This is because all species have a unique *niche*, a range of environmental conditions in which it can live. Although niches can be similar between species, no two species can occupy the exact same niche. Competitive interactions between those species would result in the decline of the subordinate species. When habitats are heterogeneous, species can exploit slightly different microhabitats, which reduces competition among them and allows for more species to occupy the same area.

Dynamics

Ecological Succession

Ecological succession is the observed process of change in the species composition and structure of an ecological community over time. As conditions change, some species become less abundant (or entirely absent altogether), having been outcompeted by other colonizing species. Ecological succession occurs because established species have physical effects on their own environment. Every species has an optimal set of environmental conditions in which it can exist. Outside that niche, the environmental conditions are no longer hospitable, and that species cannot thrive.

As a species exists within an environment, it also causes subtle changes to the local environmental conditions. What was once optimal for that species has been altered and is now optimal for other species. Under the new conditions, the previously dominant vegetation will decrease in abundance as other species become ascendant. For example, as a meadow habitat transitions through multiple growing seasons, organic matter collects on the ground and alters the nutrient composition of the soil. Seeds deposited into the meadow by wind now have the appropriate soil conditions in which to germinate. As the trees and shrubs grow, they create shade and additional organic matter deposits, further improving soil conditions for woody species to grow and establish. As the woody vegetation grows larger, it provides an attractive perching spot for frugivorous (fruit-eating) birds that deposit seeds of flowering trees in their feces. Over time, the sun-loving meadow grasses and wildflowers are shaded out by taller vegetation. As the structure and composition of the habitat change, so does the wildlife community it supports.

(Photo Credit: Lizz Dinnigan, Keyport resident)

Figure 5.2 Phases of Ecological Succession As habitats change in vegetative species composition and structure over time, the wildlife communities they support also change.

Disturbance

Unless a disturbance event occurs, an ecosystem will continue to progress along its successional trajectory until it reaches its climax community. While a climax community may be indicative of a healthy and functioning ecosystem, biodiversity within the ecosystem is not typically at its highest level. In fact, biodiversity is maximized when there are moderate levels of disturbance. This phenomenon is known as the *intermediate disturbance hypothesis*. Managing landscapes for biodiversity within developed areas will likely require artificially creating disturbance events through prescribed fires, mowing, selective cutting, etc.

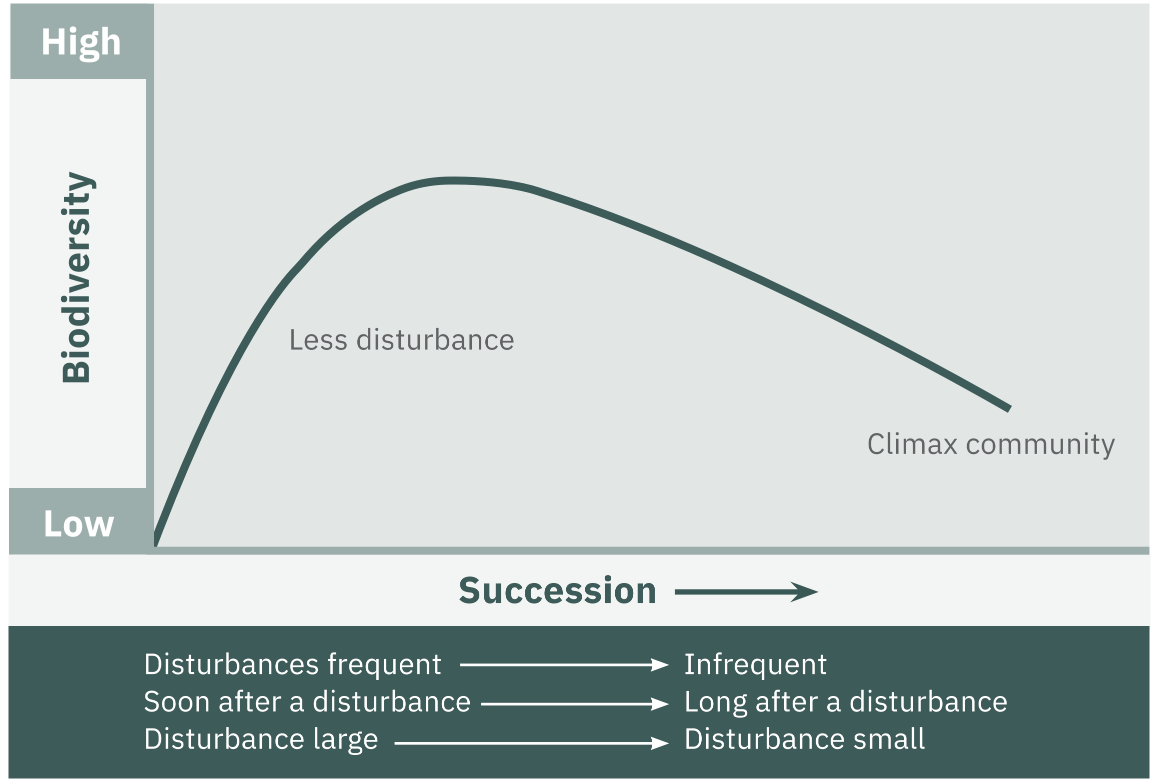


Figure 5.3 Maintenance of Biodiversity through Disturbance The intermediate disturbance hypothesis suggests that biodiversity is greatest at the midpoint of a successional trajectory, and that this biodiversity is maintained through moderate levels of environmental disturbance.

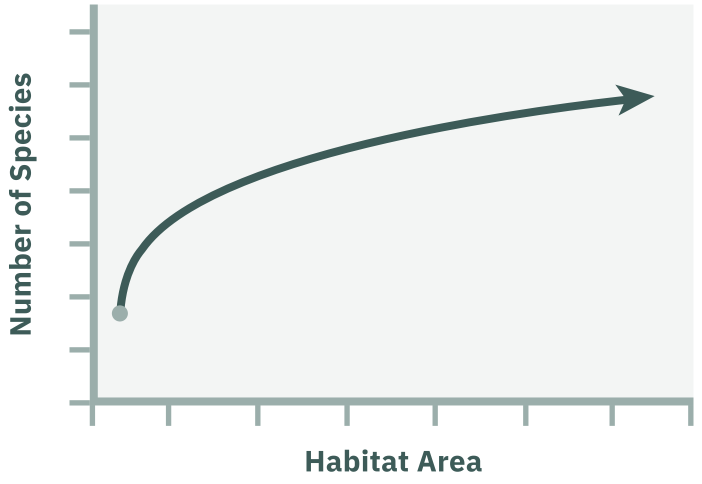
At low levels of disturbance, more competitive species will prevent weaker species from establishing. At high levels of disturbance, all species are at risk of local extinction. Moderate levels of disturbance even the playing field for all competitors, allowing them to establish within the ecosystem.

Prescribed fires are used to restore habitats by removing above ground biomass to allow tree seedlings to emerge. (Photo Credit: Bruce Dupree)

Patch Size

The patch size of any given habitat type should be maximized. This principle is rooted in what is known as the *species-area relationship*, which states that larger, contiguous land areas will contain relatively more species of plants and animals than smaller ones. One factor driving this relationship is simply that more habitat area provides additional space to support more species. However, large contiguous patches also serve to preserve communities of interdependent species (i.e. wildflowers and insect pollinators). Large habitat patches also can provide adequate resources for wildlife species with large home ranges.

Figure 5.4 Species-Area Relationship for Biodiversity Conservation



Patch Shape

To the extent possible, habitat patches should reduce the ratio of perimeter length to area. In more compact patches, the amount of core habitat is maximized, and the amount of habitat edge is reduced. In contrast, long and linear habitat patches have very little core habitat and are predominantly *edge habitats*. While softer habitat edges, termed *ecotones* (i.e. riparian edges, beach/dune interfaces), can increase biodiversity by drawing in species from multiple habitat types, hard edges associated with fragmentation (i.e. roads, forest clearcuts) create stressful conditions for plants and animals and ultimately lower their survival and reproductive capabilities. Hard habitat edges are often hotter and drier than interior habitats. They are prime locations for the establishment of invasive plant species, and they make it easier for predators to locate prey. Over the long term, desirable species will be eradicated by edge habitats.

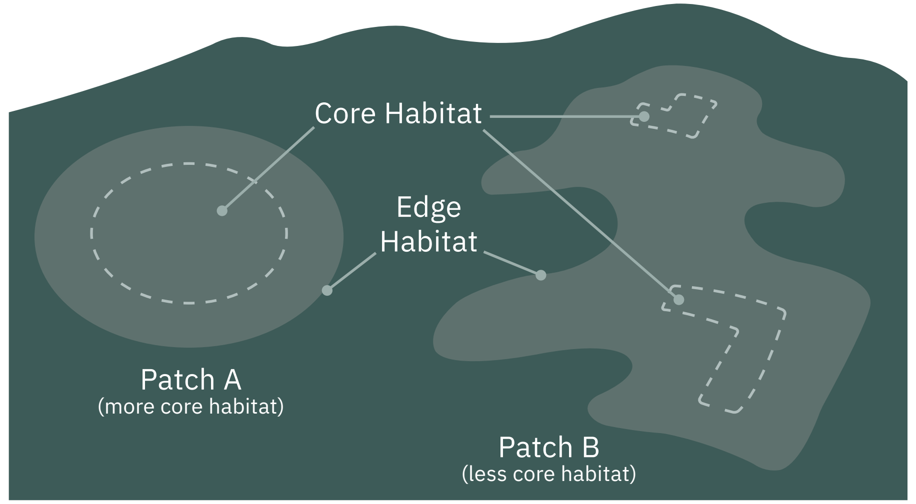


Figure 5.5 Importance of Core Habitat Areas Reducing the ratio of perimeter length to area of patches will result in the maintenance of more core habitat (Patch A) than patches with long and sinuous edges (Patch B).

The narrow strips between natural habitats and roadways represent hard ecological edges. These edges disrupt landscape connectivity and create harsh conditions for native plants and animals

(Photo Credit: Morgan Mark)

Landscape Linkages

Creating soft edges between adjoining habitat patches is an ideal way to reduce edge effects. In such landscape mosaics, there is no obvious distinction between suitable and unsuitable habitat, and mobile wildlife can move unrestricted throughout the landscape. Landscape mosaic creation is practical in projects where a significant portion of the landscape will remain in a natural (i.e. woodland, meadow) or semi-natural (i.e. cemetery, golf course) state. This approach will particularly benefit species with a high tolerance to existing land uses, as well as wide-ranging species that require large amounts of habitat.

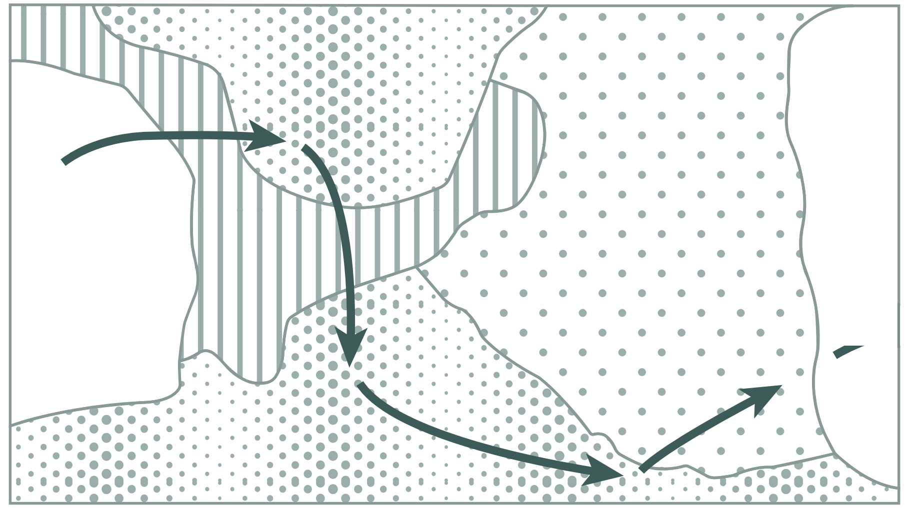
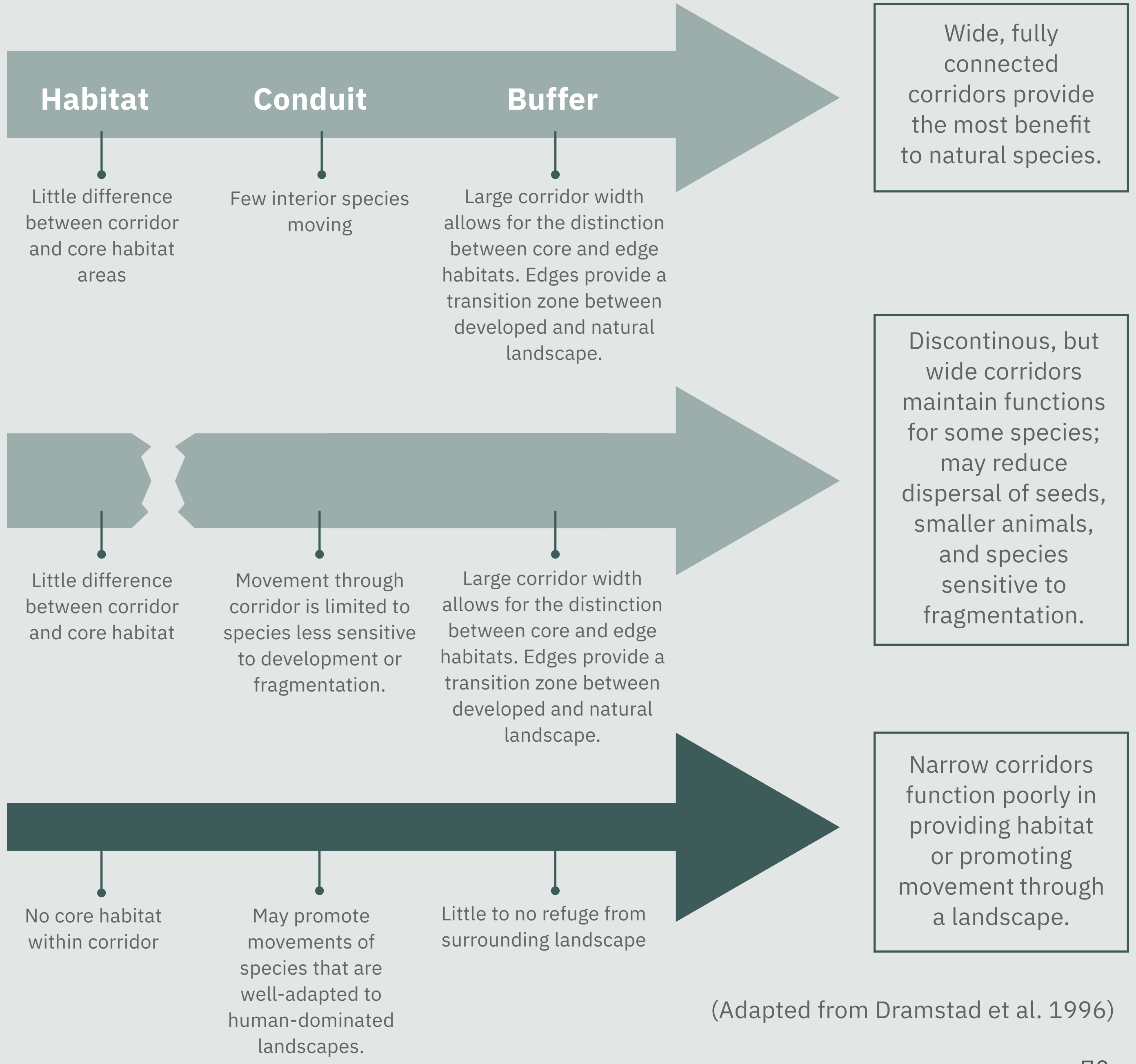


Figure 5.6 Connected Landscapes Landscapes in which there are no obvious distinctions between suitable and unsuitable habitat provide adequate mobility for plants and animals.

In developed landscapes, it is impossible to eliminate all hard edges. Built structures and supporting infrastructure are a necessary component of the social fabric of the landscape. Maximizing connectivity among habitat patches throughout the built landscape becomes an important goal for sustaining resilience. In these cases, habitat corridors may be a viable option. Habitat corridors can be defined as a continuous link of suitable habitat through an otherwise inhospitable landscape. They are most practical when resident wildlife are habitat specialists, have limited mobility, and are highly sensitive to human disturbance. Habitat corridors can also help to maintain ecosystem processes that require continuous undeveloped land (i.e. flood conveyance). The primary functions of a habitat corridor are to create habitat; facilitate animal and plant movement; and filter excess nutrients and water. When designing a habitat corridor, maximizing its width and reducing the curviness of its edges will allow it to maintain these functions at high levels.

Wildlife crossings provide safe corridors for animals to cross human-created barriers, such as highways.

Figure 5.7 Effectiveness of Habitat Corridors



(Adapted from Dramstad et al. 1996)

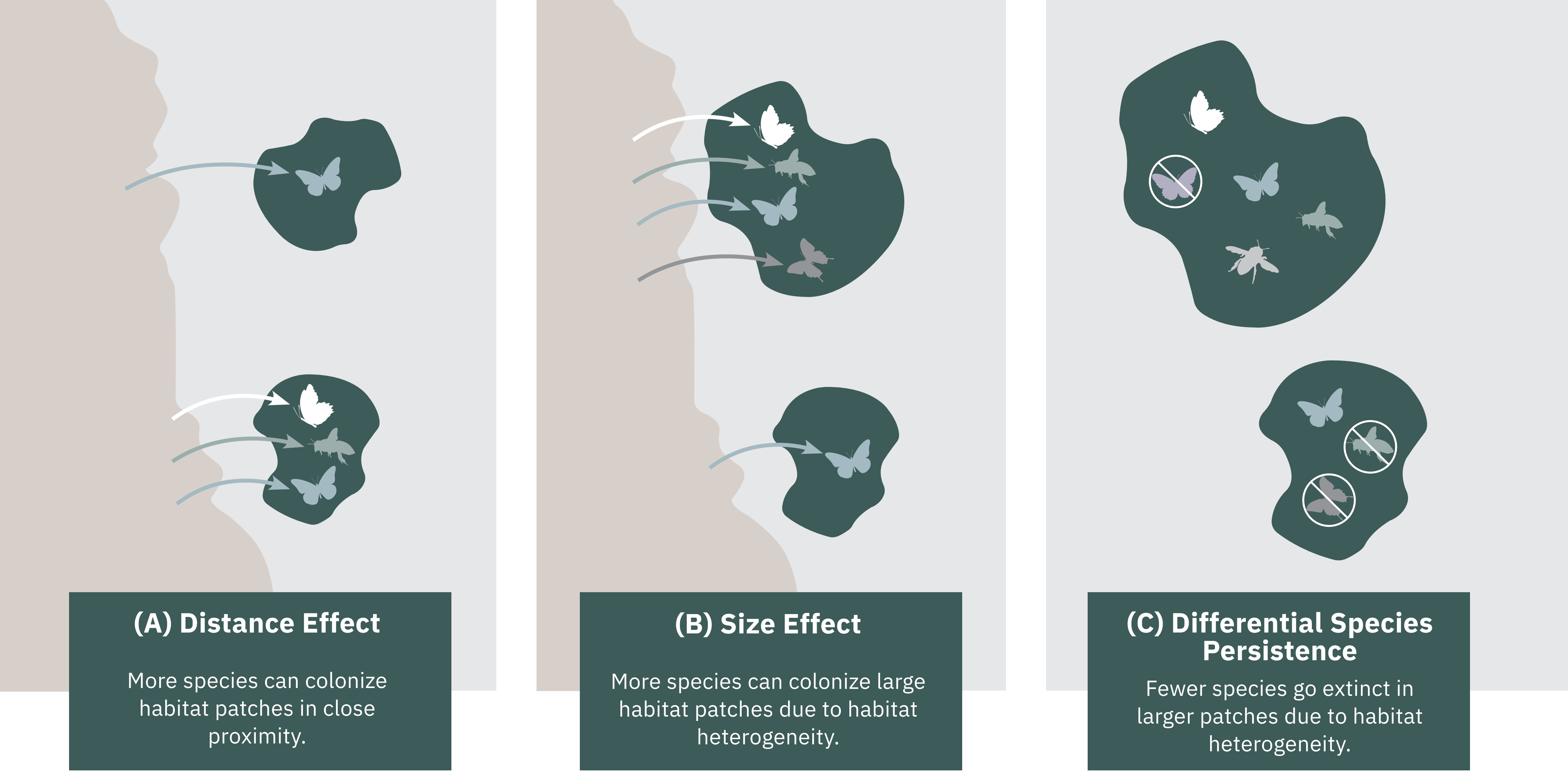


Figure 5.8 Effect of Patch Size and Distance on Biodiversity Fragmented patches of natural habitat can be considered as islands. The number of species a habitat island can support depends on its size and distance from other similar patches.

Where continuous landscape linkages are unattainable, “stepping stones” can still serve to maintain ecosystem processes and facilitate plant and animal movements. Stepping stones are patches of habitat that are arranged in relatively close proximity to one another but are not physically connected. They can be beneficial for highly mobile species (i.e. birds) that regularly move between different patches in a landscape and can tolerate moderate levels of human disturbance. When designing stepping stones, it is important to consider both the species-area relationship (Figure 5.4), as well as the *theory of island biogeography*. This concept describes how the number of species within a habitat patch results from species immigration (colonizing the habitat) and extirpation (dying out). It predicts that the degree of isolation (how separated from other similar habitats a patch is) will lower the number of species present in a habitat patch due to a reduction of species immigration into it (Figure 5.8). Using this principle, stepping stones in close proximity to each other can be smaller in size than spatially distant stepping stones.

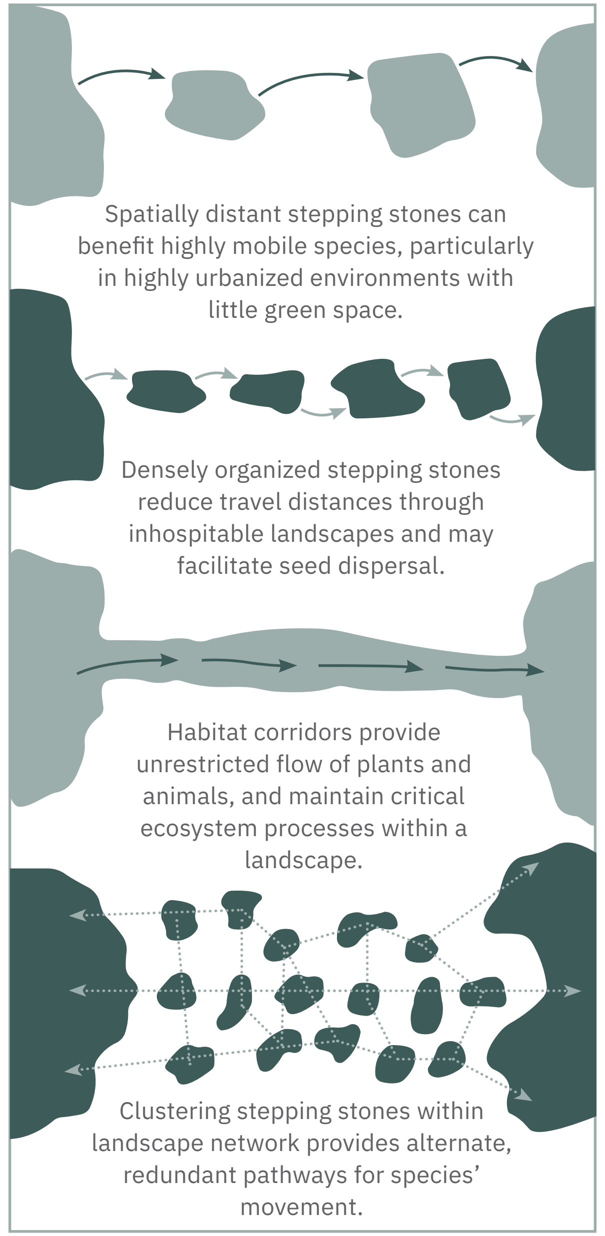


Figure 5.9 Options for Connecting Core Habitat Areas The level of mobility desired can dictate the size, distance, and configuration of corridors or stepping stones.

A Note About Scale...

When deciding upon the appropriate design approach for maintaining landscape linkages, it is important to consider that connectivity can occur at multiple spatial scales. Landscape mosaics may be possible at small scales, such as floral patches within an urban park. However, connecting the park to another urban green space may only be possible using a stepping stone approach. Table 5.1 provides examples of appropriate landscape linkages across a range of spatial scales. The temporal scale is equally as important. Food resources for wildlife are often patchy and ephemeral; therefore, providing access to multiple resource options is critical for supporting biodiversity.

Table 5.1 Example habitat features that can maintain landscape connectivity using multiple approaches across a range of spatial scales

Landscape Configuration	Local Scale *~ 0.5 mile*	Landscape Scale *0.5 - 10s of miles*	Regional Scale *100s of miles*
Habitat Corridor	Hedgerows; fencerows; streams; roadsides; forest corridors; underpasses	Rivers and associated riparian vegetation; broad links between reserves	Major river systems; mountain ranges; isthmus between land masses
Stepping Stones	Patches of plants; small woods; plantations; chains of small wetlands	Series of small reserves; woodland patches in farmland; urban parks	Chains of islands in an archipelago; wetlands along waterfowl flight paths; alpine habitats along a mountain chain
Habitat Mosaics	Patchily cleared vegetation in farmland; mosaic of gardens and parks in cities	Mosaics of regenerating and old-growth forest in forest blocks	Regional soil mosaics and geological supporting different vegetation communities

SECTION III: CREATING AND SUSTAINING FLOOD-RESILIENT LANDSCAPES

Oyster castle living shoreline restoration project at the Rutgers University Aquaculture Innovation Center, Cape May, New Jersey. (Photo Credit: Mark Baranoski)

CHAPTERS

6 7 8 9

06

Key Topics

LANDSCAPE TRANSFORMATION

DESIGN GOALS FOR RESILIENT LANDSCAPES

ESTABLISHING AN ECOLOGICAL PLANNING AND DESIGN PROGRAM

DESIGN STRATEGIES AND TECHNIQUES

PUBLIC ACCESS: TRAILS AND SIGNAGE

DESIGNING RESILIENT LANDSCAPES

Floodplain habitat and trails (Photo Credit: Jeremiah Bergstrom)

LANDSCAPE TRANSFORMATION

Resilient and ecologically functioning designs focus on creating landscapes that can handle new climate trends, help mitigate further climate damage, and work to preserve and generate resources for human use. An ecological design approach integrates both human and non-human communities and systems into landscapes. By considering humans and other organisms collectively and treating both groups as important contributors to the health and resilience of each other, we can steward landscapes with the ability to adapt and recover from large-scale flood events while also reducing the frequency and negative impacts of small-scale flooding. There are six key factors to consider in the design and management of resilient landscapes: **context; ecosystem drivers; connections; biodiversity; redundancy;** and **scale.** These factors contain both ecological and social dimensions, which must be addressed synergistically to identify the opportunities and constraints for transforming flood-prone areas into resilient landscapes that adapt to changing conditions and provide public amenities for communities.

Figure 6.1 Key Factors in Resilient Landscape Design

Context

The design process begins with a clear understanding of the physical landscape, its land use history, and the current community culture. The physical properties of a site, including soils, geology, hydrology, and landscape position provide the foundation for realizing the ecological potential of a project. Past land uses provide important information regarding potential contamination or subsurface structures, as well as underlying causes for current ecological stressors. Built infrastructure, land use, and human activity provide a framework for embedding a design into the social fabric of the community. An ecological design project strives to minimize negative impacts on the environment by building on the living processes of a site to support both human and non-human biological communities.

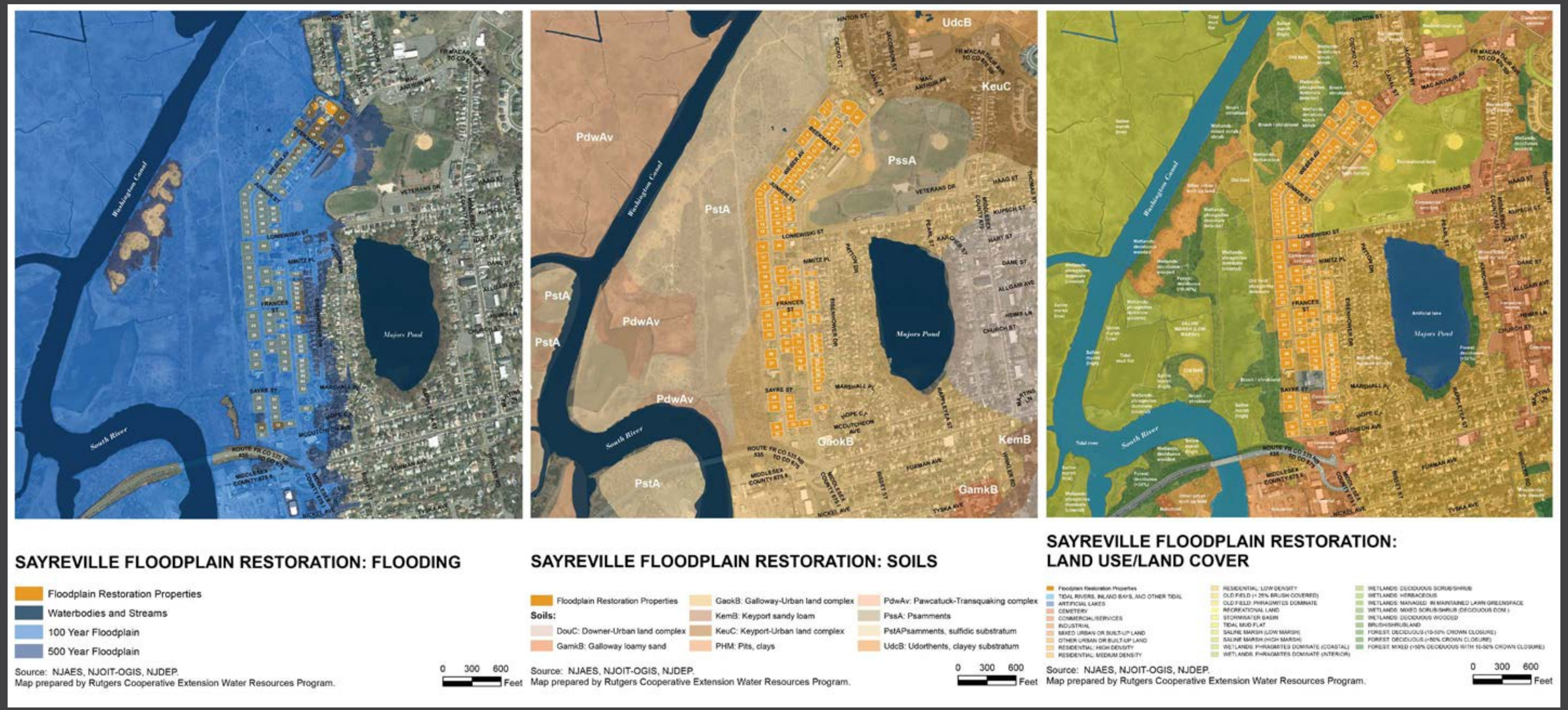


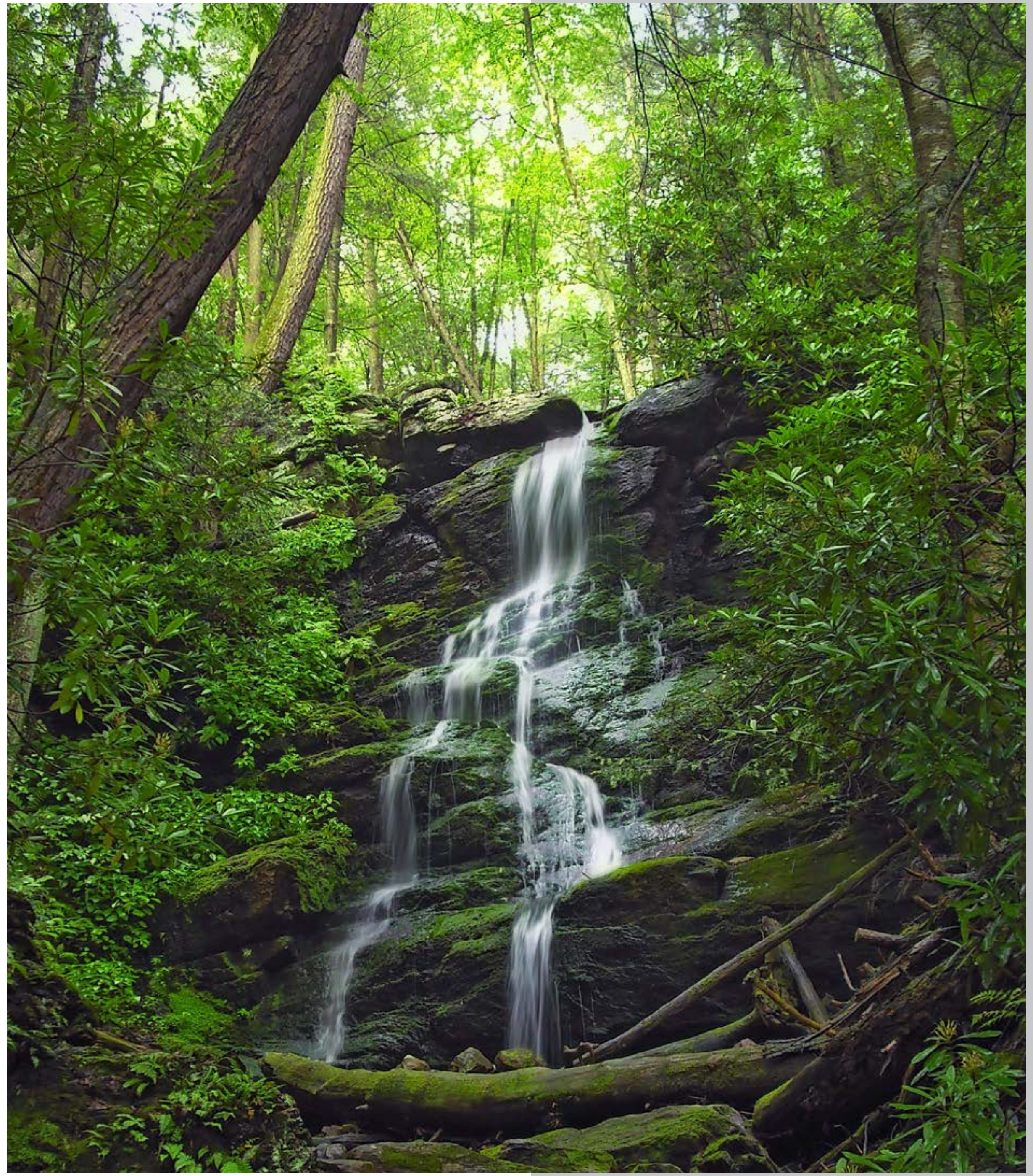
Figure 6.2 Understanding the Context of a Resilient Landscape Project (a) The 100-yr and 500-yr floodplains of the Washington Canal and South River affecting the MacArthur Avenue neighborhood in Sayreville are mapped along with existing soils (b) and land cover (c) to better understand the potential for future flooding and the types of habitats that can be enhanced and restored. (Credit: Rutgers Cooperative Extension)

Ecosystem Drivers

Natural and human-derived disturbances have both direct and indirect impacts on ecosystems. Resilient ecological designs work to mitigate the impacts of negative drivers where possible while also creating sustainable landscapes that can absorb periodic natural disturbances. Significant drivers impacting flood prone landscapes and ecosystems include land cover transitions, changes in hydrologic regimes, climate change, invasive species (both plants and animals), and pollution.

Land cover change in New Jersey is exemplified by the historic conversion of forest to agricultural land, and more recently urbanization. The trajectory and long-term sustainability of restored ecosystems will be influenced by historic changes in soil conditions, as well as inputs and stressors from surrounding urbanized landscapes.

Aerial imagery of Cream Ridge, NJ, where large tracts of forest were converted into agricultural and residential areas (Photo Credit: Steve Stanger)



Hydrology refers to the type of water that flows into and out of an ecosystem, as well as the ways in which water flows. Hydrologic factors include tidal regime, salinity, precipitation, runoff, and groundwater levels, which are influenced at both the scale of the restoration site as well as by the larger geographic area. Site hydrology can also change due to interactions with other factors (i.e. climate change, land cover change).

The Silver Spray Falls in Layton, NJ is an important means of water transport in the Delaware Water Gap (Photo Credit: Ron B. Ami)

Climate change triggers multiple phenomena that can lead to changes in ecosystem health and function. Warmer temperatures contribute to species' range shifts, alter the timing of seasonal events and wildlife behaviors (flowering times, migrations, etc.), and exacerbate the periodic emergence of pests and diseases. The shifting climate also leads to changes in the frequency and severity of extreme weather events (i.e. droughts, storms), increasing vulnerability of natural and built infrastructure.

Climate change can lead to environmental asynchronies, such as flowers blooming when there is still the possibility of frost (Photo Credit: Niel Bornstein)

Biological invasions are defined as the accidental or deliberate movement of organisms into new areas. These introduced plants and animals have caused severe declines in populations of native wildlife, contributed to agricultural crop losses, and degraded natural habitats. These losses, in-turn, reduce ecosystem-level processes and the services they provide. Established populations of invasive species also thwart ecological restoration efforts of native populations and habitats through competition, predation, or herbivory.

The spotted lanternfly *(Lycorma delicatula)* is a recent invader from China that is threatening forests throughout a significant part of the eastern and midwestern United States (Photo Credit: Morgan Mark)

Pollution encompasses a broad category of environmental issues; however, the most critical form of pollution in the context of landscape transformation is excessive nitrogen and phosphorus loading, particularly in aquatic habitats. High concentrations of these nutrients cause low oxygen levels and algal blooms in aquatic environments, leading to die-offs of aquatic organisms, contamination of drinking water, and air pollution from nitrogen oxides in urban areas. Designing landscapes that can filter runoff and establish in nutrient-rich soil (or can be improved through soil quality amendments) will help maintain the stability of restored ecosystems.

Stormwater discharge to the Pascack Brook in Hillsdale, NJ (Photo Credit: Rutgers Cooperative Extension)

Human communities can positively or negatively affect the integrity of ecosystems through social interactions and governance. How humans use the landscape can be influenced by religious values, cultural beliefs, and social norms. Population size places pressure on natural systems through per capita resource consumption rates (i.e. energy use, waste generation). In addition, the configuration of infrastructure largely determines the amount of external stressors that will influence adjacent natural areas.

The New Jersey Folk Festival, held annually on Rutgers' Cook Campus, highlights human-human and human-ecosystem interactions (Photo Credit: Richard Arthur Norton)

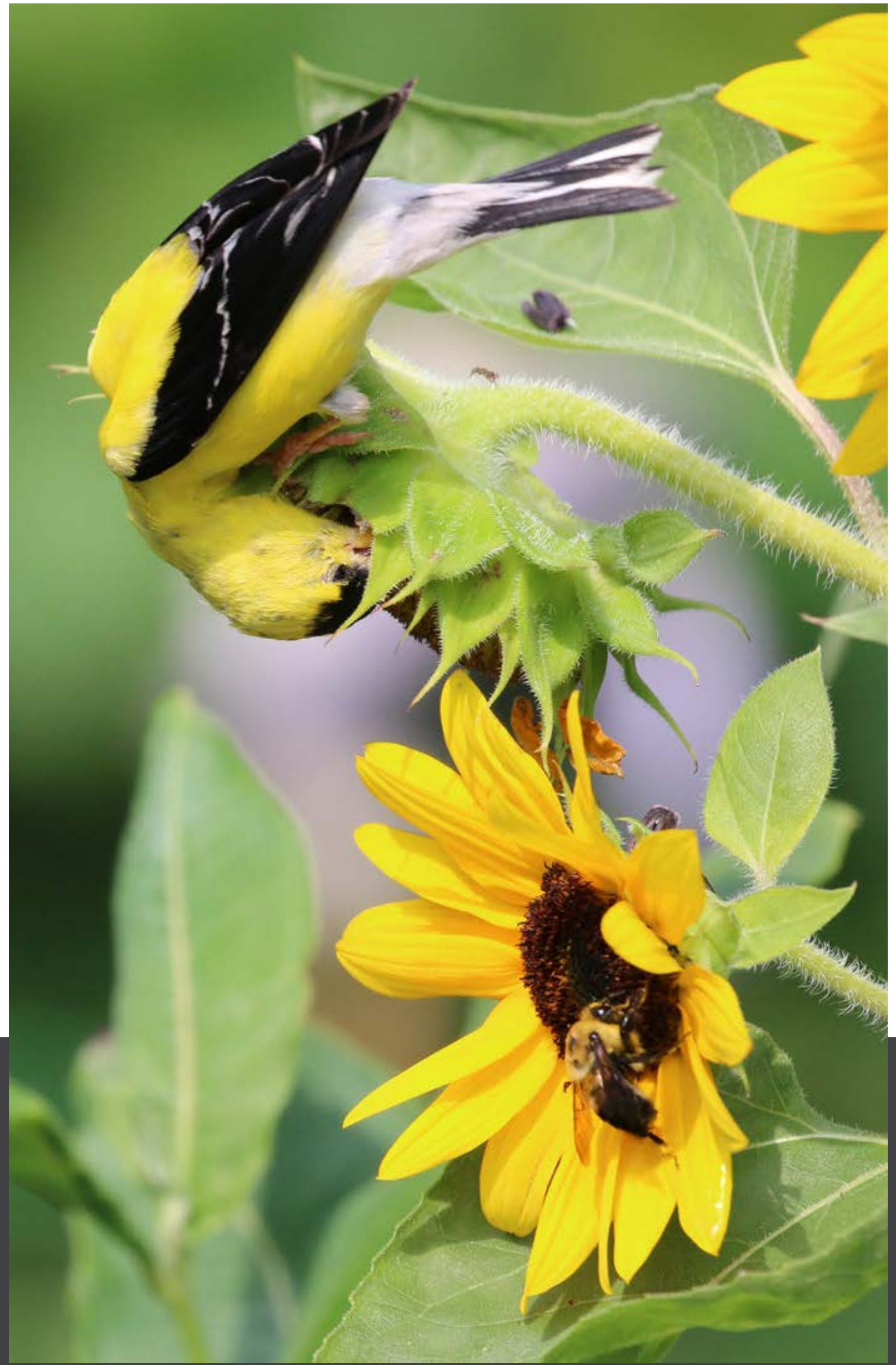
Connections

From an ecological perspective, connected habitats provide dispersal and migration corridors for plants and animals, which reduce mortality risk and maintain gene flow in natural populations. They also protect the health and integrity of adjoining habitats by buffering them against external forces (i.e. saline marsh buffers maritime forest against storm surge). Landscape connections for humans, including access to nature, trail systems, urban parks, passive recreation areas, and green spaces promote:

- Active and healthy lifestyles that can reduce healthcare costs
- Increased community engagement that can discourage crime
- Cleaner air for improved public health
- Cooler air for reducing the heat-island effect
- Equitable access to open spaces for all residents

An ecological design plan that evaluates and integrates connections between not only the biological systems underpinning the ecology of the landscape, but also the social systems that support the human community, can greatly increase the long-term viability of a landscape transformation project. This synergy promotes positive human interactions with (and ultimately stewardship of) the natural world. Smaller project sites are a component of a larger landscape and can be connected to such social networks as community or county parks, roadway corridors, or utility rights-of-way. Floodplains, marshes, and other conservation areas can also be incorporated into the larger scale design.

Wildlife crossings provide habitat connectivity and a safe way to traverse heavily trafficked roads (Photo Credit: Jeffrey Beall)



Biodiversity

The ability of a landscape to adapt and respond to change while maintaining ecosystem function is a core component of a resilience project's viability. Biodiverse ecosystems are more resilient to ever changing and evolving conditions, and they provide many ecosystem services that benefit human quality of life (see Chapter 5). Designing landscapes that promote variety, richness, and variability of habitats, species, and individuals will have beneficial downstream impacts on community resilience. Because ecological principles underpin all sustainable human systems, increasing biodiversity also provides people with the opportunity to rediscover and celebrate the significance of the natural world.

Biodiverse landscapes are resilient and can support a wide variety of organisms, from bees to birds. These organisms provide important services, such as pest control and pollination respectively (Photo Credit: Glen Miner)

Redundancy

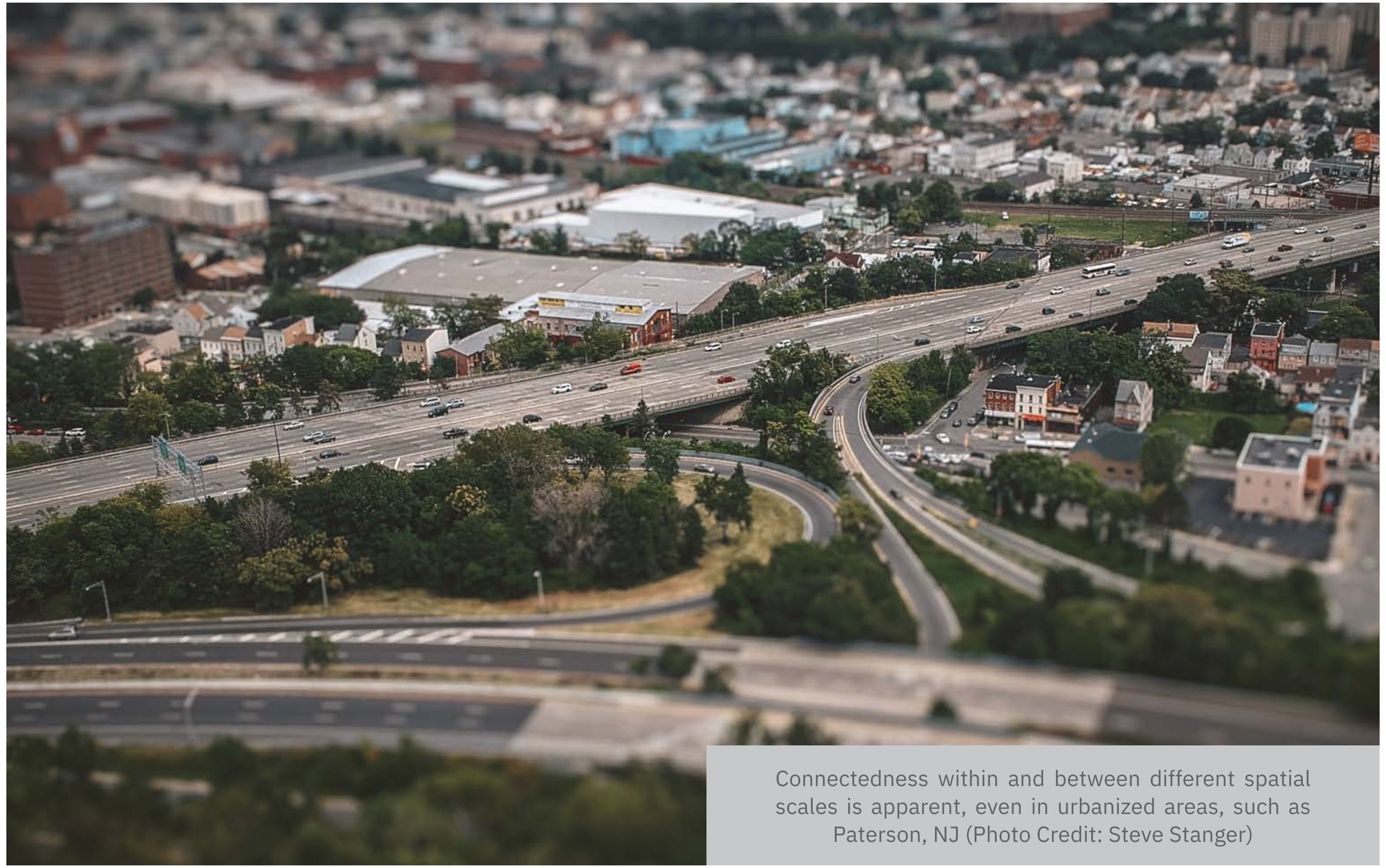
Redundancy in ecological design strengthens the likelihood that the landscape will survive a severe disturbance. Damage caused by extreme weather events can be patchy, with specific areas of damage largely influenced by storm track, wind direction, tide level, or other external factors. Such unpredictability makes it challenging to ensure long-term project success unless redundancy is added to the landscape. Purposefully integrating multiple patches of specific habitat types, as well as individuals of the same species, increases the likelihood of natural revegetation through local dispersal. Because multiple species can perform the same function (e.g., nitrogen fixation, carbon sequestration, infiltration), promoting redundancy means that whole ecosystems can maintain important functions even as parts of them recover from disturbance. Landscapes are always in transition, and stresses from human activity as well as unpredictable natural phenomena erode ecosystem stability. Through redundancy, designers can help to ensure that landscapes recover, adapt and continue to provide significant ecological services in support of people.

Bees and butterflies both pollinate native plants, like this swamp milkweed (Photo Credit: Jim Hudgins/USFWS)

Scale

The factors described here should be considered at all scales. For example, connected patches of similar vegetation at one site can support smaller, less mobile wildlife (pollinators, small mammals) locally. Connecting one natural area with another across an urbanized landscape supports movement by animals with larger home ranges (see Chapter 5), and it provides avenues of dispersal for vegetation. Communities can use a similar, scale-appropriate approach whether they are designing and constructing rain gardens at a resident's home, a community park, or a wetland habitat restoration project. The temporal scale of a resilience strategy must also be considered. Natural and assisted revegetation takes time (see Chapter 7). Having realistic expectations for a resilience project and an understanding of the ways in which natural systems change over time can help designers to phase projects. Flood impacts on a project area are driven by activities and phenomena beyond its boundaries. Individual community projects need to be considered within a larger watershed context. Flood resilient landscape projects often start with small and/or scattered acquisitions and interventions that take time

to come together into a cohesive unit. Connecting these efforts to develop and support a network of greenway trails, shoreline habitats, and recreational open spaces that bridge multiple communities can engage the larger community to ensure long term acceptance and viability of resilience planning and implementation initiatives.



Connectedness within and between different spatial scales is apparent, even in urbanized areas, such as Paterson, NJ (Photo Credit: Steve Stanger)

Table 6.1 Key Factors to Consider When Designing Resilient Landscapes

Consideration	Ecological Dimensions	Social Dimensions	Contribution to Resilience
Context	Geology, hydrology, soils, vegetative communities, landscape position	Demographics, land use, infrastructure, neighborhood 'personality'	Provides framework for decision making that supports long-term project success
Ecosystem Drivers	Disturbance regimes (i.e. flooding frequency), temperature range, nutrient inputs	Demographics, economics, technology, human use patterns (pedestrian, dog-walking, ATV/motorized vehicle use)	Indicates habitat types and vegetative communities likely to persist
Connections	Landscape linkages for movement of plants and animals (dispersal, migration, climate change refugia, etc.), edge effects; health of adjoining habitats	Greenways for pedestrian and passive recreation accessibility, park systems	Allows habitats and the plants and animals within them to shift as conditions change; provides public amenities and a 'destination' for people
Biodiversity	Diversity of habitats (vegetation type and structure); genetic variation; species' abundance and richness	Human interaction with the natural world promotes physical and mental health, education, and inspires	Buffers negative effects of environmental change on natural populations; reduces extinction probability of species and habitats; promotes long-term stewardship by the community
Redundancy	Multiple habitat patches and multiple individuals of desirable keystone species across a project site	Landscape services continually support human systems	Loss of a habitat patch does not result in total loss of that habitat type or species
Scale	***Spatial:*** habitat patches are sufficient in size and number to support viable populations of plants and animals ***Temporal:*** project planning allows sufficient time for ecological processes to occur (plant establishment, succession, etc.)	***Individual:*** property owners and residents can take action at their home ***Community:*** local groups can initiate community-wide landscape resilience actions	All members of the community are engaged and actively promoting resilience

DESIGN GOALS FOR RESILIENT LANDSCAPES

Resilient designs not only focus on the ability of a landscape to survive in the current conditions, but also to adapt to new ones as well. Resilient landscapes must have multiple levels of resilience and should strive to reduce risk, be scalable and diverse, have multiple co-benefits, and be able to recover with limited intervention. Design of resilient landscapes strives to achieve the following:

Landscape Restoration

Flood-prone landscapes in the built environment have been altered and disturbed for decades through development and construction of infrastructure and housing. With these changes the primary functions of the landscape have been lost or greatly diminished. Healthy soils and plants no longer exist to filter and absorb flood waters. Built structures increase stormwater runoff and impede flood flows, and backfilling or raising areas in flood zones reduces the capacity of these landscapes to store flood waters. Designers can recognize that landscapes have been altered to such a degree and are subject to external stressors that prevent the landscape from returning to its original condition. An ecological design approach restores functionality to the landscape, building on sound principles of science to set in motion the processes needed for that landscape to adapt and evolve. Restoration of ecological function and in particular, primary flood control function, is an important starting point for an ecological design approach for flood-prone landscapes. See Chapter 7 for in-depth guidance on successful ecological restoration initiatives.

Restoration of a forested wetland in place of a degraded marsh within a heavily developed floodplain (Photo Credit: Rutgers Cooperative Extension)

Community Engagement

Integrating appropriate levels of human engagement in the landscape builds the social capital needed to sustain a project. Through education, outreach, and physical engagement in the landscape, communities can garner the support needed to acquire, design, implement and maintain resilient landscapes in flood-prone areas. Resilient design provides an opportunity to improve and expand the community's network of publicly accessible recreation spaces, supporting active and healthier lifestyles and promoting community wellness.

Large contiguous open space areas can support a range of recreational activities. Trails support jogging, walking, and biking. In addition, wildlife observation areas are cost-effective improvements that can be integrated easily into floodplain open spaces. Mown paths and walking trails provide minimal burden on local resources and infrastructure while providing additional interest for visitors. Stormwater wetlands provide interesting views and experiences while also educating the public on best management practices for storing flood water and treating runoff. These improvements can take place within a larger interconnected system of recreational infrastructure within the community. More opportunities for walking, biking, play, and other outdoor activities supports both physical and mental well-being for residents. These landscapes can support a variety of interactions to strengthen community bonds, create safe neighborhoods, and encourage adults and youth to spend time outdoors. Increased outdoor physical and social activity improve cognitive function in children while minimizing behavioral problems.

Finally, open spaces and recreation areas become safe and inclusive places for residents. Highly used, functioning landscapes that encourage and support outdoor use become safe places where community members can gather and play. In addition, outdoor recreation is a free activity, and when designed to support a broad segment of the community, will provide opportunities for residents from all walks of life to interact with one another and support the resilient landscape effort.

Outreach and educational programs centered on natural flood-prone ecosystems increase awareness and stewardship (Photo Credit: Rutgers Cooperative Extension)

Economic Enhancement

Both social and economic resilience are necessary to support a resilient landscape project; a healthy landscape will support a strong economy. Monetizing economic benefits of an ecologically functional environment can be difficult and hard to comprehend; however, the environment provides us with clean air and water, and supports the pollinators of the food systems on which we rely, among other things (see Chapter 5). Direct economic impacts in our community resulting from resilient landscapes will include:

Increased Property Values

Fewer structures in flood-prone areas reduces the risk of future property damage. At the same time, green spaces and recreational networks are viewed as desirable amenities by residents and local governments. Nearby access to natural areas and parks will increase property values within the community.

Green spaces, such as parks, provide social, ecological, and economical benefits for residents (Photo Credit: fotogake)

Summer tourism fuels many shore towns in NJ, such as Asbury Park, which may be negatively impacted by severe weather events and flooding (Photo Credit: Jazz Guy)

Boosts to the Local Economy

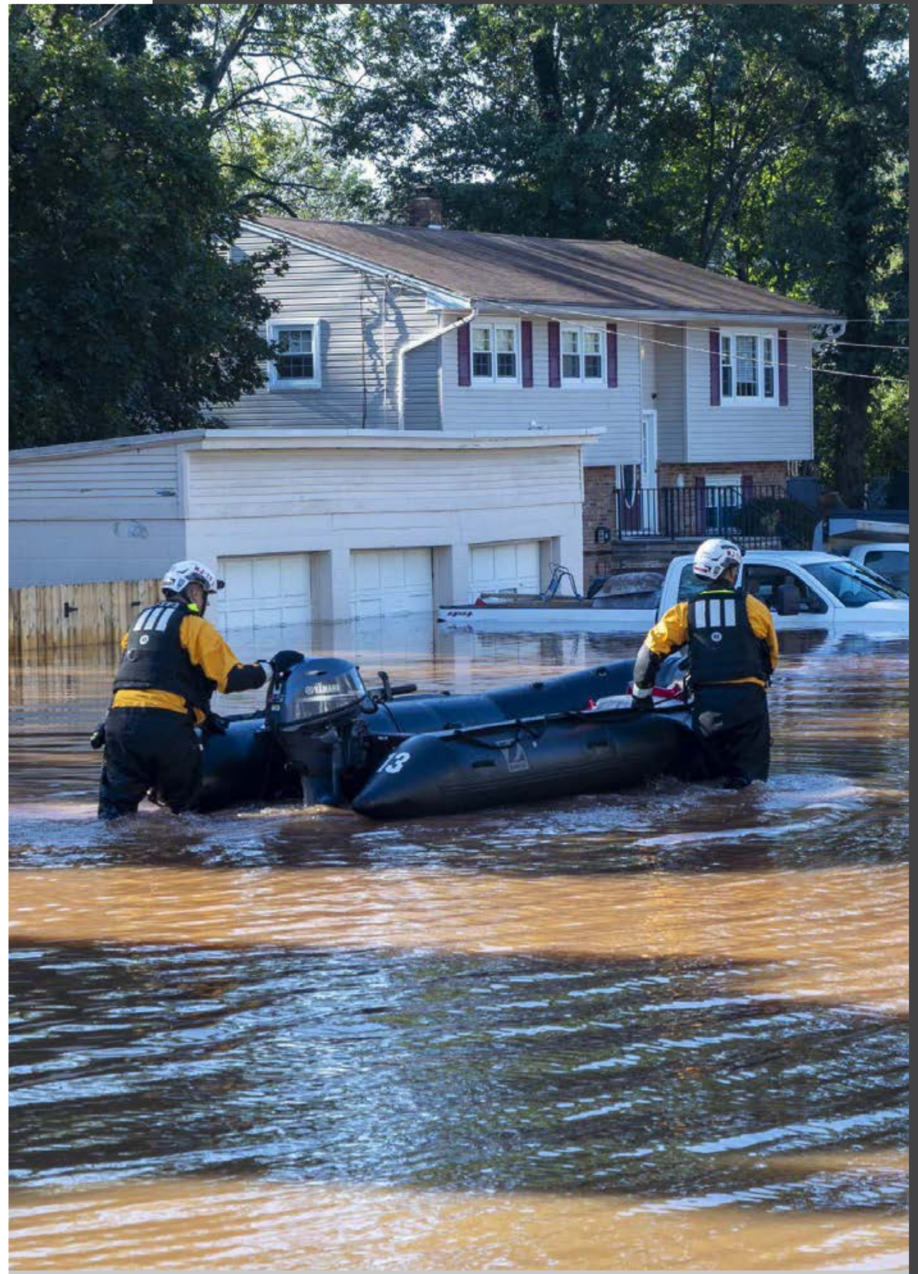
Communities that depend on recreational visitors and spending to support the economy (i.e. beachfront towns) can anticipate fewer shutdowns and be able to recover more quickly from storms when protected with healthy and ecologically functioning landscapes. Restored flood prone landscapes are important buffers that can protect property and critical infrastructure during extreme weather events minimizing damage and recovery effort. When connected with larger networks of open spaces, these landscapes also can become recreational destinations that attract new visitors to the community and support new economic growth.

Reduced Maintenance and Emergency Management Costs

Investment in ecological restoration not only benefits the private sector but also local government. With fewer people and properties and less critical infrastructure in harm's way, the effort and costs incurred by local governments to recover from storms and natural disasters lessens. While emergency management services will always be needed, the buffering landscape reduces risks to emergency responders having to protect and safeguard residents during flood events.

Risk Reduction

Risk reduction is particularly important as landscapes and the people they support become increasingly vulnerable to climate-related events. A key characteristic of a resilient landscape is that built structures are designated in appropriate locations. For example, critical infrastructure should not be constructed in high-risk areas; instead, communities can create natural buffers in areas at risk of severe and frequent flooding. In addition, resilient landscape designs include multiple and diverse modes of protection so that if one element fails during a significant disturbance, others can provide the support a community needs to protect itself and recover. For example, vegetated areas provide wildlife habitat and recreational opportunities, while green stormwater infrastructure creates flood control and enhances community open space. Resilient ecological design is meant to offer a variety of benefits so that a community can take up less space while gaining more than they had before.

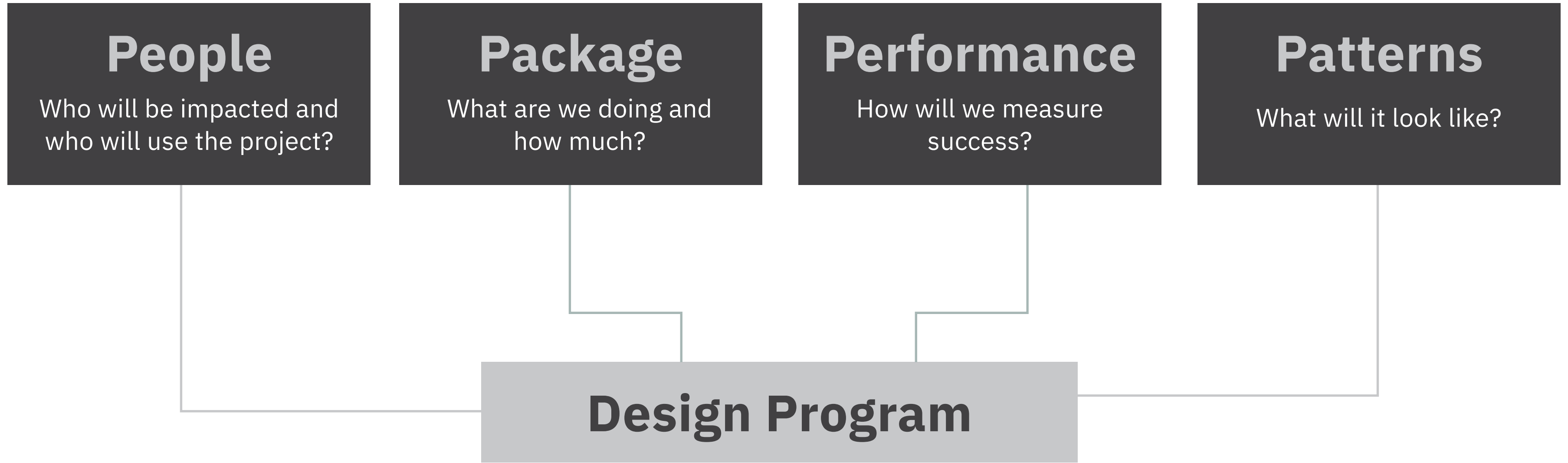


Emergency personnel conducting boat rescues after Hurricane Ida (Photo Credit: Matt Drews, Somerville resident)

ESTABLISHING AN ECOLOGICAL PLANNING & DESIGN PROGRAM

Ecological design involves expertise and knowledge from multiple professionals. An effective design effort includes a team of experts working with community leaders and may include ecologists and scientists, landscape architects, planners, as well as engineers. The design team and community leaders work together to develop the scope, purpose and level of achievement for a proposed ecological design effort, as well as provide a framework for action and decision-making. The design program serves as an overall guide and must remain flexible and able to respond to unforeseen obstacles or new opportunities. A design program defines the people, package, performance requirements, and pattern.

Figure 6.3 Development of an Ecological Design Program



People

Projects impact people. The first step to establishing a design program is to determine the people who will be part of the project and the community's particular needs. Project stakeholders are people or organizations that have a direct or tangible interest in the project. Users are those who will use the project but do not necessarily have ownership of it. Stakeholders can be users, but not all users are stakeholders.

Users have a direct interest in the planning and design of a site, but stakeholders will also have a say. Stakeholders include public bodies that provide approval for the project, elected officials, and agencies at higher levels of government. Other stakeholders may include environmental groups and neighbors who do not have a direct role in the decision process but may object to a project and even stall a project by appealing decisions or filing suits to block it.

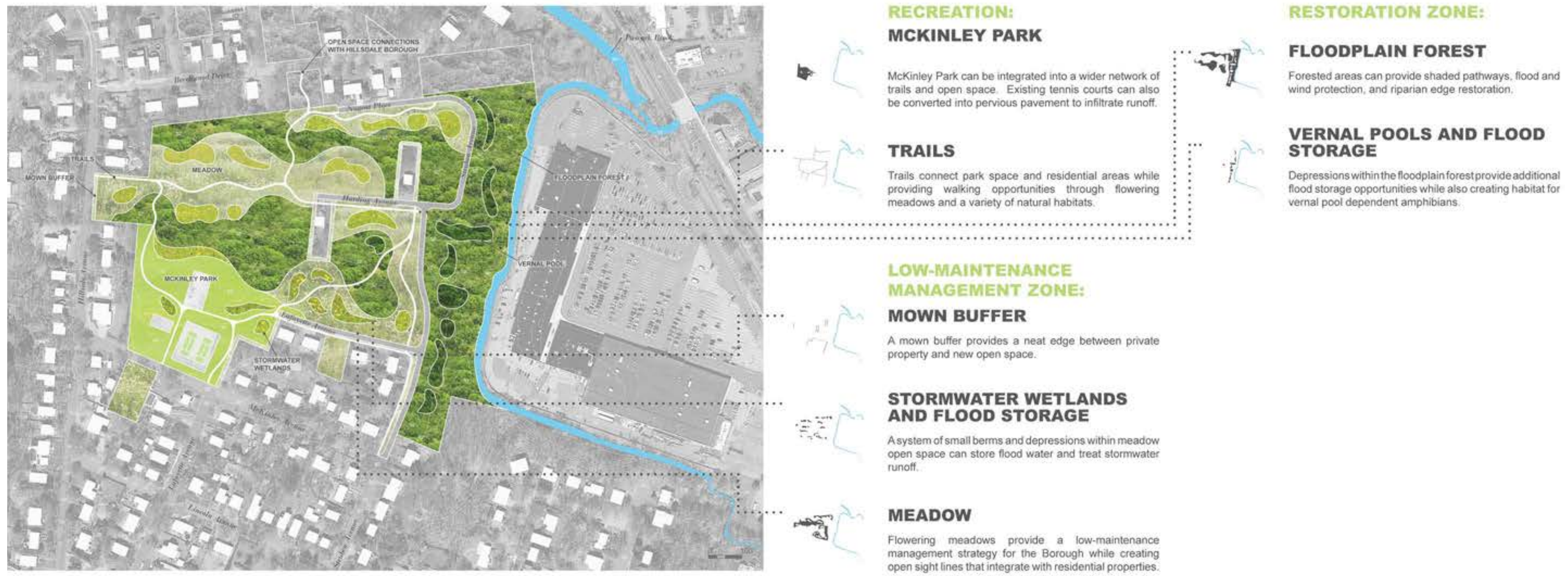
Identifying the users of the project is not always a simple process. Users would include people visiting and using any recreational features. Users may also include neighbors who live near or adjacent to the project. In the end, a user is someone who uses the space. The design team needs to work to ensure that the project attracts specific users, and they must understand how the site is to be used. With this knowledge a thorough evaluation of project needs can be established.

It is good practice to include the community in the design process of a public project and maintain consistent and open communication throughout a project. Developing an organized public engagement process will build a good rapport between users, stakeholders and the design team to create a positive feeling in the community towards the project. Public engagement is a way to identify user groups, learn the interests of these groups so that their opinions, wants, and needs can be incorporated into a project where appropriate, identify conflicting objectives, share conceptual site plans and receive feedback, and seek a balanced solution.

Package

With an understanding of community needs, it is time for the design team to determine what will be done. The program package will include maps, drawings, renderings, charts, and tables of the specific landscape interventions needed to achieve the goals of the project and meet the needs of the community. The program package provides for where things should happen and how much work is needed. Some projects may need minimal intervention while others require extensive site grading, invasive species control, and replanting. The extent of intervention is often limited by available resources and political capital; however, long-term vision, phasing of larger projects, and willingness of partners to commit to a multi-year effort can result in significant accomplishments.

Figure 6.4 Westwood Floodplain Restoration Conceptual Design The design features restoration zones for flood management, low-management areas in close proximity to remaining development, and a proposed trail system connecting the redesigned landscape with existing parkland. (Credit: Rutgers Cooperative Extension)



Performance Requirements

Performance requirements answer the questions, **How will we build the project?** and **How will we measure success?** This guidance begins to look beyond the project as well, addressing deeper questions, such as **How will the community manage and maintain the landscape?** and **What are the roles and responsibilities of project stakeholders and partners?** Performance requirements should allow for quantitative measurement but also be open ended and flexible enough to allow for innovative design approaches, adaptive management of unique characteristics of the project site, and integration of important community values.

Patterns

Finally, the design team needs to ask the questions **What will the end product look like?** and **How will it be perceived by the community?** Transforming landscapes from developed or highly maintained conditions to ecologically functioning habitat and flood control areas results in a dramatic visual and aesthetic change. These changes often are misunderstood, and nearby stakeholders and users may be unsettled with the transition and change. Designing buffer zones between residential areas and aggregating open space can maximize aesthetic value while decreasing maintenance requirements. Proposed public access can highlight scenic vistas and habitat features while working to define the neighborhood edge and provide visual and structural transitions to surrounding open space areas.

Figure 6.5 Urban to Natural Transition Zones This cross setion illustrates how a restored landscape will transition from the remaining residential area to natural habitat along the river. A mowed strip directly behind the house serves as a symbolic edge between the natural and built landscape. A swath of meadow habitat initiates the structural gradient of vegetation from low height to canopy-level vegetation. A trail through the meadow invites pedestrians to enjoy the natural beauty of the landscape. (Credit: Rutgers Cooperative Extension)

DESIGN STRATEGIES AND TECHNIQUES

Flood-prone lands purchased through New Jersey Blue Acres, Federal Emergency Management Agency (FEMA), and other disaster relief programs are deed restricted to limit future development. Such regulations are essential for maximizing the benefit of the public investment, while ensuring flood protection and minimizing future flood damage in the local community. These development limitations protect against implementation of commercial uses and other alterations to the landscape that would restrict the ability of the site to convey flood flows, reduce the area's capacity to store floodwaters, increase downstream velocities, and/or restrict access into and out of the area. Restrictions include built structures and paved surfaces (roads and parking). But, given these restrictions, multiple "compatible uses" are allowable on buyout areas that support resilience and ecological function.

Flood damaged house acquired by NJ Blue Acres, Woodbridge, NJ (Photo Credit: Brooke Maslo)

Examples of how communities have leveraged the resilient and ecological function potential of deed restricted flood-prone buyout properties include, but have not been limited to:

- Wetland management
- Nature reserves
- Managed habitat
- Parks
- Community gardens (or residential gardens)
- Buffers
- Greenway/urban trails
- Outdoor recreation
- Camping
- Wildlife habitat
- Pollinator habitat
- Educational centers or outdoor classrooms

Not all flood-prone landscapes are deed restricted with significant limitations on what can and cannot be built. In areas without deed restrictions, a more robust program can be proposed but should carefully consider site limitations and the potential for flooding.

Defining Open Space Typologies

Within developed flood-prone areas, land managers may be in a position to implement larger-scale restoration actions. In these cases, the principles highlighted in Chapters 5 and 6 should be followed. Often, however, properties acquired through buyout programs are scattered throughout a neighborhood. Due to the voluntary nature of buyout programs, it often takes years for a community to acquire and aggregate properties into a large contiguous area. When properties are scattered throughout an area, the potential for large scale habitat restoration or flood function is limited. But, these individual or smaller areas can still be improved, and steps should be taken to actively manage them. To begin planning for smaller landscape interventions, a community can establish a series of typologies or appropriate desired uses for these landscapes. Once established the design team in collaboration with nearby residents can select from the typologies to begin enhancing and pursuing a long-term intervention and management strategy. Typologies for flood-prone landscapes may include:

- **Community Gardens:** Community gardens can act as a athering place as well as space to cultivate fruit, vegetable, flowers and herbs. Urban and dense suburban landowners often lack the space required to successfully cultivate fresh fruits and vegetables. Community gardens also facilitate partnerships as residents engage in jointly determining whether a garden is communal or has individual plots, appropriately design the garden to meet the community needs, work together to apply an integrated pest management strategy, and prepare guidelines for safe and effective fertilization.
- **Neighborhood or Pocket Parks:** Smaller vacant parcels disconnected from larger restoration and resilience projects can provide an opportunity for local neighborhood recreation and outdoor activity. Playgrounds, picnic areas, canopy shelters that do not obstruct flooding, and fire pits can enhance neighborhood living and strengthen community engagement.
- **Pollinator Gardens:** A pollinator garden provides an attractive amenity to a neighborhood while also offering additional habitat area for birds, pollinators, and butterflies. Many perennial plants provide habitat and seasonal interest through the year to important insects and birds.
- **Tree Plantings:** Many of our communities lack a healthy tree canopy. Planting trees in open flood-prone landscapes provides shade, a windbreak, clean air, and habitat.
- **Green Stormwater Infrastructure:** Keeping stormwater runoff from rushing into the sewer and nearby streams helps reduce flooding. These practices are not only functional but also attractive amenities that contribute to both the ecological and social health of the community.
- **Backyards:** If community use and long-term maintenance is not desired and viable, an adjacent property owner may be willing to enter into a long-term agreement to maintain a vacant open space area. Again, limitations on use need to be clearly articulated between the community and the user so that new risks are not created.

Figure 6.6 Open Space Typology Interventions for Flood-Prone Parcels
(Credit: Rutgers Cooperative Extension)

Some isolated parcels can be converted into community gardens to cultivate fruit, vegetables, flowers and herbs. Such gardens can act as gathering places for community members to trade gardening techniques while cultivating communal or individual garden plots.

Pocket parks can be geared towards active recreation and exercise, especially in locations where the nearest playground is several blocks away. Play structures and a soft substrate provide children an opportunity to play while close to home. Benches and flower beds also provide a sitting area.

Figure 6.6 (Continued) Open Space Typology Interventions for Flood-Prone Parcels
(Credit: Rutgers Cooperative Extension)

Small lots can create new connections. In this example, a walking path lined with bright flowers leads pedestrians from the neighborhood to adjacent parkland.

A municipality may choose to enter into a long-term agreement with homeowners adjacent to an acquired parcel to use the space as an extended backyard. In such cases, homeowners would maintain the space as a manicured lawn or garden and erect no permanent structures. The extended backyard can be enjoyed with a variety of activities.

Green Stormwater Infrastructure

Green stormwater infrastructure (GSI) practices, such as rain gardens and bioretention systems, bioswales, permeable pavements, and green streets are distributed landscape practices that capture, filter, and infiltrate stormwater runoff near its source. By managing even small amounts of stormwater on individual sites, communities are able to reduce pressure on aging stormwater infrastructure and protect flood-prone landscapes. In addition, these small-scale cost-effective practices provide for a variety of environmental, social, and economic benefits. Green stormwater infrastructure practices use vegetation, soils, and other materials to mimic the water cycle and restore natural processes required to manage water in the landscape. At the neighborhood or site scale, these practices will soak up, filter, and store water to minimize nuisance flooding and reduce flows in nearby stormwater infrastructure networks.

Integrating GSI into a restoration project enhances the landscape's ability to absorb flood waters and keep pollutants out of sensitive habitats and nearby waterways. These landscape systems provide a wide range of benefits while helping to protect neighborhoods near flood prone areas from nuisance flooding. GSI benefits include:

- Flood storage
- Infiltration
- Wildlife habitat
- Biodiversity
- Filtering of pollutants

Rain Gardens and Bioretention Areas

These shallow landscaped depressions can capture, filter, and infiltrate stormwater runoff from a home, parking lot, driveway or street. Locating these systems in areas upstream of where water collects or frequently floods helps to slow down and reduce incidents of nuisance flooding in the community. Larger bioretention systems up to 1,000 square feet are appropriate for commercial

Rain gardens offer smaller-scale stormwater management benefits, while providing pleasing aesthetics to built landscapes. (Photo Credit: Rutgers Cooperative Extension)

and institutional properties, and smaller rain gardens fit perfectly into residential landscapes. These systems are designed to have no more than 6-12 inches of water in them following a rainstorm and then to slowly infiltrate that water over 24-48 hours. After one or two days all the ponded water should be trapped in the soil or mulch or slowly released to downstream areas. A wide variety of native plants can be used in rain gardens, but the selected plants need to be able to withstand not only periodic flooding but also extended dry periods. These systems are best located along the perimeter of restoration projects to filter stormwater runoff from adjacent urban or built areas. These practices can slow down runoff from streets and paved areas to provide a line of defense against nonpoint source pollution damaging sensitive plantings or waterways. When planning or proposing rain gardens or bioretention areas, the following need to be taken into consideration:

- **Drainage area size:** The size of a rain garden or bioretention area is dependent on the area draining to it. The area needs to be accurately measured so that the volume of water flowing into the GSI practice can be determined.
- **Location:** These systems need to be located in relatively flat areas. Steep slopes move water too quickly and will damage the landscape plantings. Additionally, these practices should not be planned in areas that are regularly wet or saturated. Bioretention systems rely on the soil to infiltrate stormwater. Standing water for periods longer than 48 hours will damage plants and promote mosquito breeding.
- **Soils:** Healthy soils that allow water to infiltrate are key to a successful rain garden or bioretention system. Ensuring that soils in a rain garden adequately allow for water infiltration while also supporting healthy plant growth is an important first step in evaluating a site.

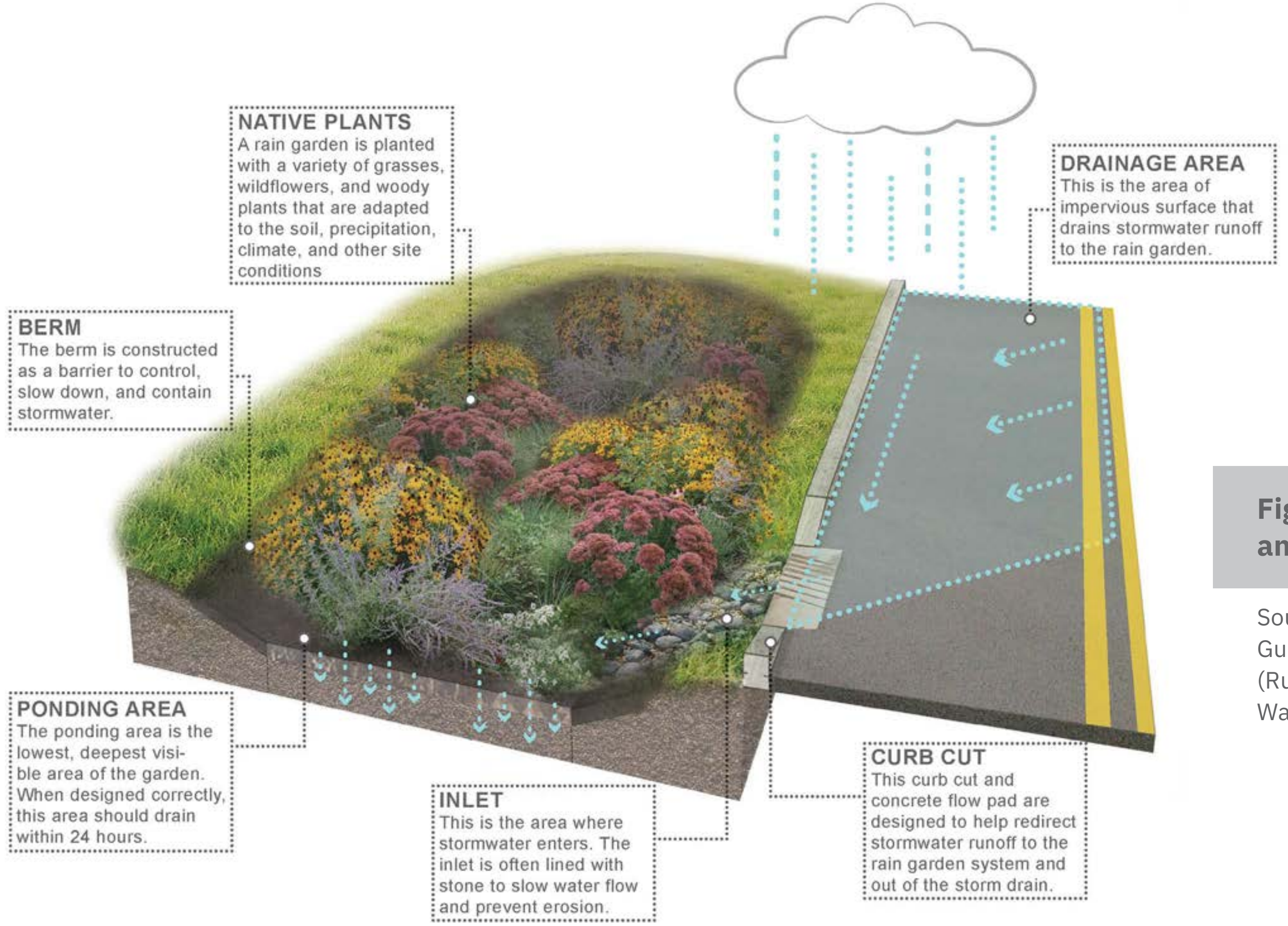


Figure 6.7 Rain Garden and Bioretention Diagram

Source: Green Infrastructure Guidance Manual for New Jersey (Rutgers Cooperative Extension Water Resources Program)

Bioswales

Bioswales are open vegetated channels that move water from one point to another. Because water is moving in them, they can be susceptible to erosion. The plantings in bioswales help to slow the water down and trap sediment. Keeping water out of pipes and in open channels helps to reduce the overall volume of runoff leaving a site. Bioswales should be used instead of pipes to distribute runoff through the landscape, slowing it down, and allowing the natural processes of infiltration, plant uptake, and filtering to occur. Using bioswales through a landscape can also support variations in habitats with wetland and wetter loving plants in and along the drainage way.

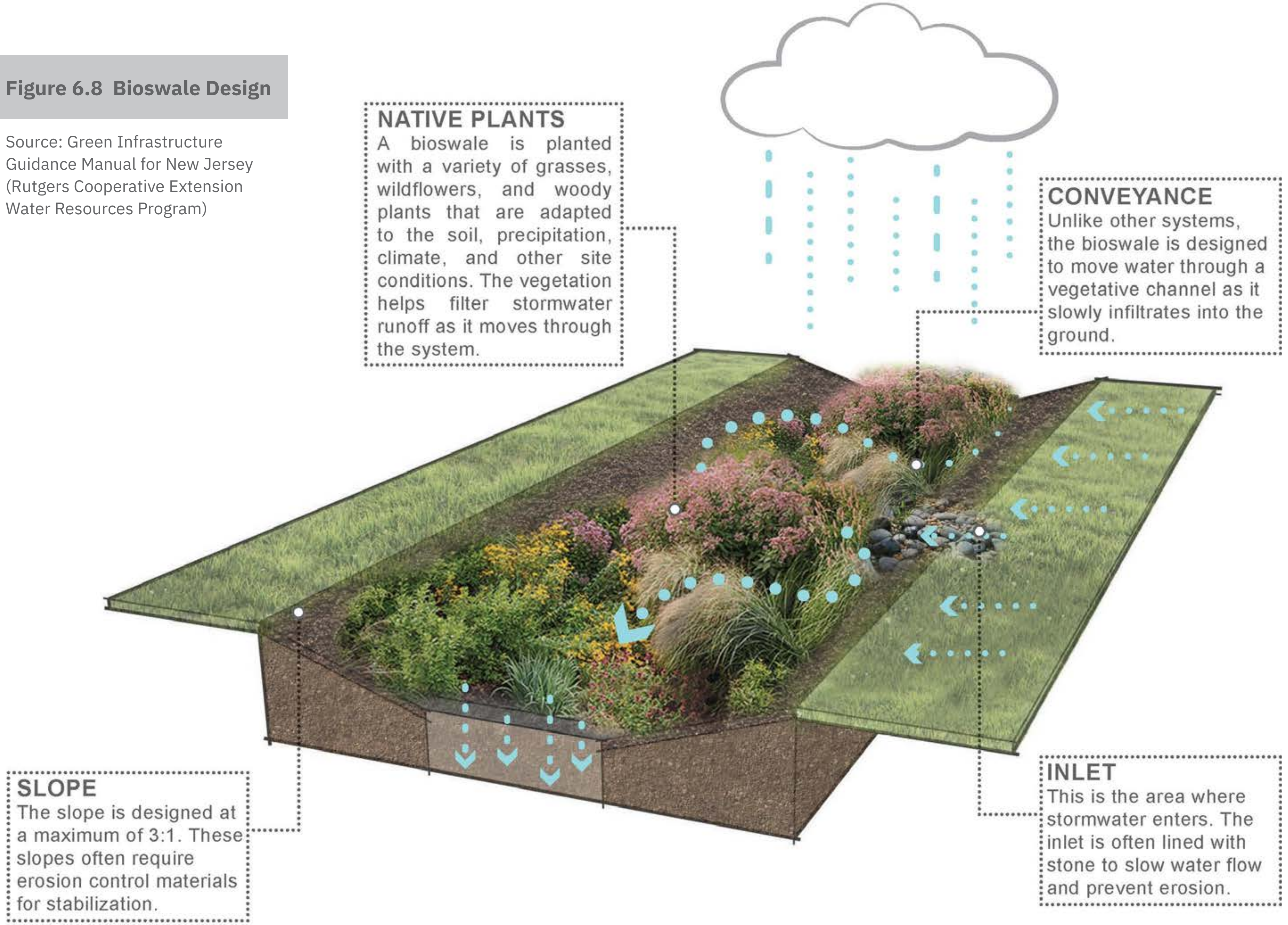
These systems are ideal where old stormwater pipe infrastructure is being disconnected. Bioswales can be used to move water from surrounding landscapes into and through the restoration where appropriate. Ideally, the swales will discharge at an existing location where no new disturbance will occur to the plantings or waterway. Monitoring these systems for erosion and making sure that plantings are healthy is important. Understanding the slope of the swale and the velocity of water moving through it will be necessary to ensure that appropriate materials are used to slow water down and protect again soil erosion. Disturbance in bioswales can lead to invasive species and downstream deposits of soil and sediment. Designing these systems so that sediment and debris are captured at an easily accessible forebay that can be cleaned out regularly is important. Moving water will always contain materials that need to settle out, and routine cleaning and maintenance is required.

Keeping stormwater runoff on the ground surface allows plants and soils to provide the benefits and functions that are intended. Bioswales can be designed to follow former streets and roads that have been removed. Also, enhancing existing drainageways carrying stormwater runoff with plants can improve the quality of water prior to it discharging to nearby waterways and wetlands.

Bioswales allow water to move away from infrastructure or other sensitive areas, while also providing infiltration and pleasing aesthetics. (Photo Credit: Rutgers Cooperative Extension)

Figure 6.8 Bioswale Design

Source: Green Infrastructure Guidance Manual for New Jersey (Rutgers Cooperative Extension Water Resources Program)



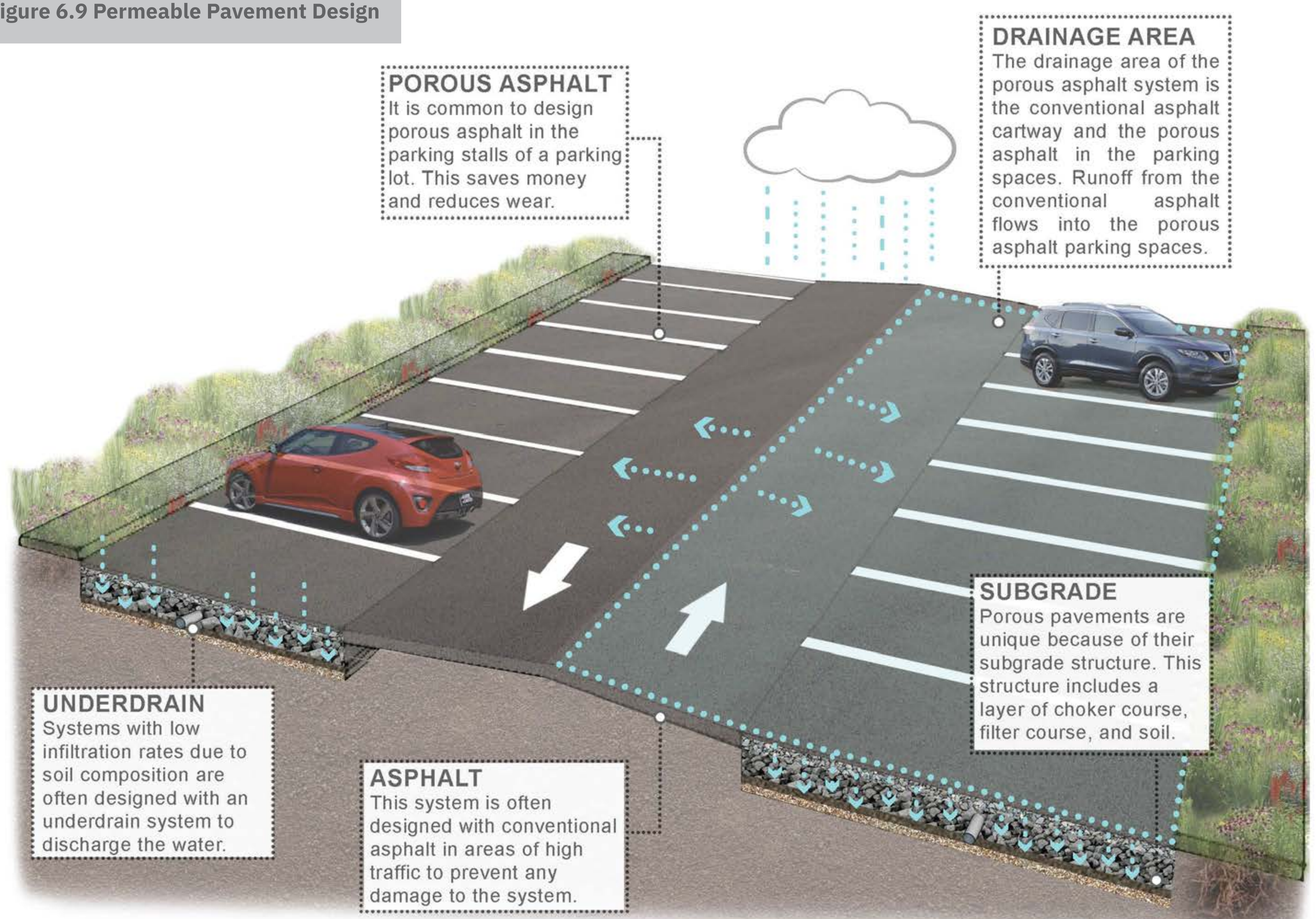
Permeable Pavements

Pavements do not always have to be sealed to prevent water from flowing through them. In appropriate locations, paved parking areas and drives can allow water to pass through the surface to be stored and infiltrated below. Permeable pavements provide an opportunity to capture and store significant volumes of stormwater runoff. Using special blends of asphalt, concrete, or pavers, these systems allow water to pass through the surface to an underground stone storage layer and slowly infiltrate into the soil or be released after the storm into the storm sewer system. Permeable pavement systems can significantly reduce the amount of stormwater runoff that flows off a paved area. Not all paved areas need be permeable. Often only portions of a parking lot or drive need to be permeable to capture all of the stormwater runoff from the paved area.

Permeable pavements are a great way to manage stormwater runoff on small sites with limited open space. By placing the stormwater management system below the pavement, the built and disturbed area can support multiple functions. A number of products and materials are available for permeable pavement installations. Effort should be given to identifying the most appropriate design to meet the needs of the community for cost and maintenance. Infiltrating stormwater from industrial or potentially polluted sites should not be done near sensitive habitats or in areas where groundwater contamination could occur. Permeable pavements store water in 1-3 feet of stone and soil below the pavement. This practice is not suitable in areas with high groundwater, which could limit storage volume and also provide a potential pathway for stormwater pollutants to get into groundwater systems. Drainage areas flowing to permeable pavements need to be stabilized immediately to prevent sediments from clogging the system. If clogging does occur, the pavement needs to be cleaned using a power washer or specialized vacuum machine.

Porous asphalt parking spaces adjacent to conventional asphalt driving lane (Photo Credit: Rutgers Cooperative Extension)

Figure 6.9 Permeable Pavement Design



Source: Green Infrastructure Guidance Manual for New Jersey (Rutgers Cooperative Extension Water Resources Program)

Green Streets

Green streets are designed to keep stormwater out of buried storm sewer pipes and manage it on the ground surface using a variety of strategies. Using street trees, permeable pavements, vegetated planters, permeable pavement, and bioretention cells, a green street will provide a number of environmental and social benefits, including:

- Reduced peak flows and flooding
- Removal of stormwater pollutants
- Improved air quality
- Improved aesthetics
- Increased tree canopy cover
- Safer pedestrian areas

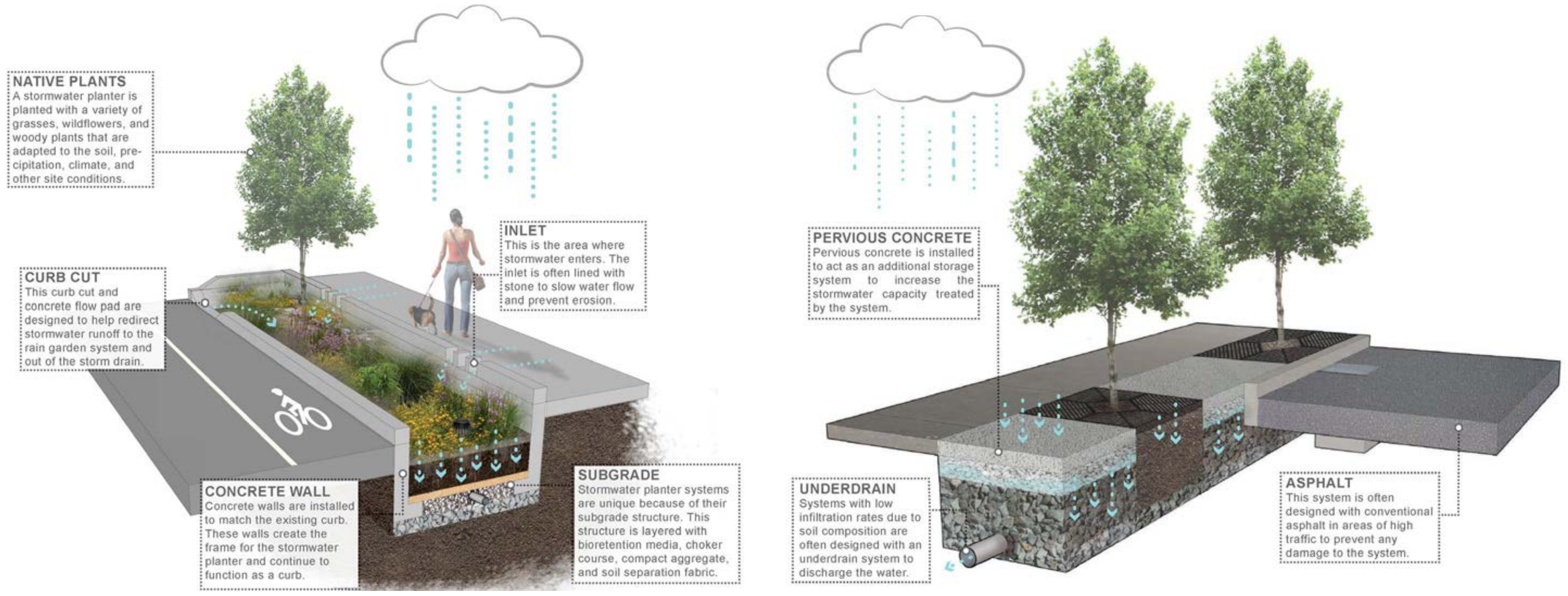
By thinking differently about what a street looks like and how it can manage stormwater, communities have the opportunity to create unique and highly functional ecological and social places that will improve quality of life for residents. Streets are not just for moving cars. They are an integral component of a healthy, vibrant community.

Stormwater planters located at intersections can shorten crosswalks making it safer for pedestrians. Planting trees intercepts and absorbs rainfall, separates pedestrians from motor vehicles, and provides shade for businesses and customers. Trees, planting, and green space create attractive neighborhoods and business districts supporting and enhancing economic activity and property values. Planning and implementing green streets is specific to the community and the neighborhood and should be done in open dialogue with residents, leaders, and designers. A wide variety of GSI practices can be integrated into green street designs, and programs and should be selected and designed to address constraints and limitations of the street function and character as well as ongoing maintenance.

Green street project (Photo Credit: flowstobay.org)

Figure 6.10 Green Street Design

Source: Green Infrastructure Guidance Manual for New Jersey (Rutgers Cooperative Extension Water Resources Program)



Communities can look to available design guidance to evaluate opportunities for integrating green stormwater infrastructure into an ecological design project. Available resources include:

Green Infrastructure Guidance Manual for New Jersey prepared by Rutgers Cooperative Extension Water Resources Program

Visit Source

U.S. Environmental Protection Agency (US EPA) Green Streets, Green Jobs, Green Towns (G3) Program

Visit Source

US EPA Green Streets Handbook

Visit Source

Natural System-based Solutions

Landscape interventions that maximize the use of plants, soils, and ecological services provide a foundation for resilient landscapes. Stabilizing disturbed and eroded flood prone areas using bioengineering techniques, creating living shorelines, and constructing wetlands buffer impacts of human and climate change on ecosystems and are strategies that can be successful in resilient landscape projects.

Urban rivers and floodplains suffer from a variety of impacts related to development and infrastructure. They are directly connected to the surrounding urban landscape and frequently discharge stormwater and pollutants that degrade water quality and destabilize the riparian zone. Excess runoff from impervious areas increases stream velocities and can incise stream beds to a degree that limits channel connection to adjacent floodplain areas. These impacts frequently result in severe erosion and deterioration. In addition, urban floodplains frequently are colonized by invasive plant species which provide less protection from erosion as well as offer limited wildlife habitat value. Soil bioengineering, living shorelines, and constructed wetlands help stabilize disturbed flood-prone landscapes and mitigate the impacts of urban conditions.

Soil Bioengineering

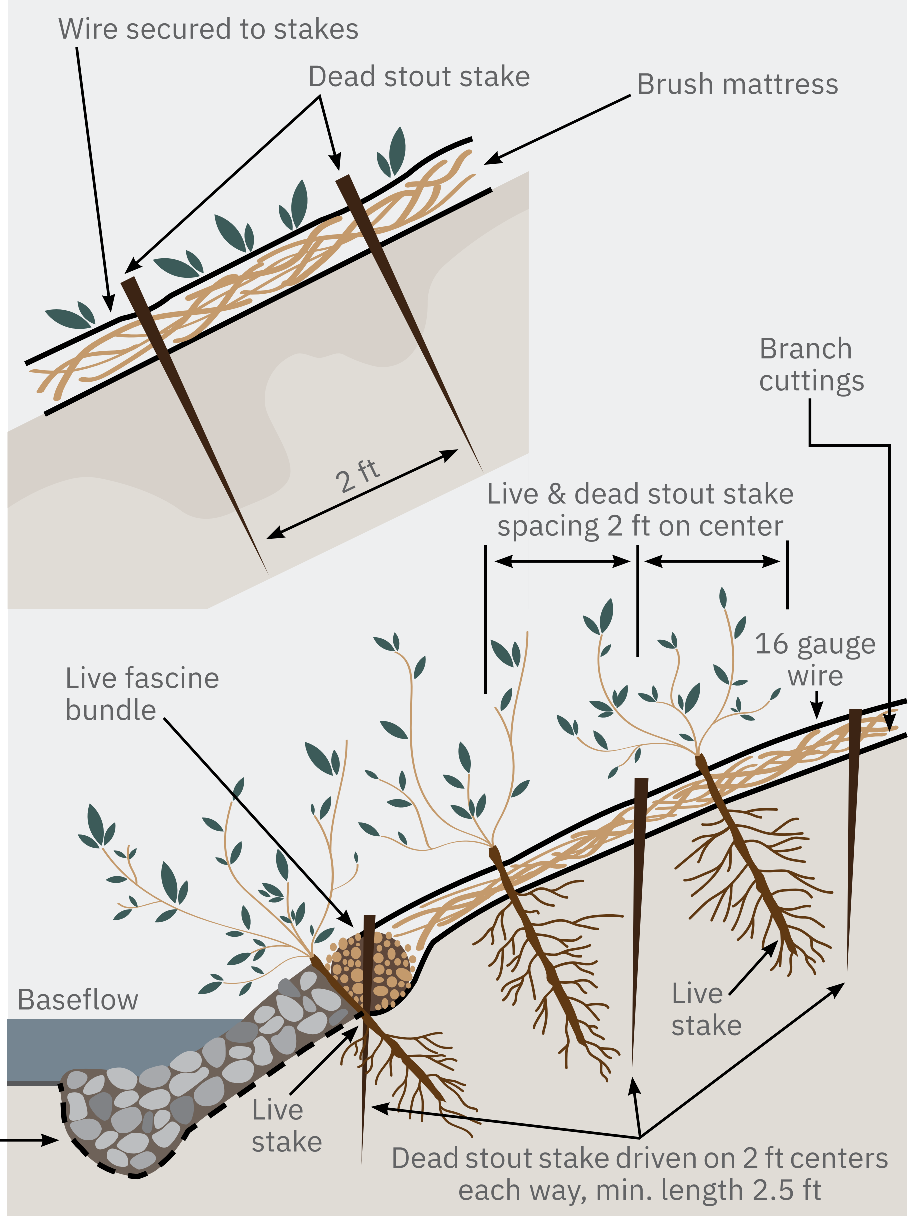
Soil bioengineering is defined as the use of living and nonliving plant materials in combination with natural and synthetic support materials for slope stabilization, erosion reduction, and vegetative establishment. Structural based bioengineering techniques include stone toes, vegetated gabions, and stone deflectors. These systems rely on a combination of inert materials, such as wood and stone, to provide strength while integrating native plant materials to provide habitat value and minimize surface soil erosion. Plant based techniques are characterized by reliance on live clumps, fascines, vertical bundles, brush mattresses, and brush revetments. These techniques fundamentally rely on riparian plants to provide long-term strength to the streambank. These systems can be cost-effective to install while providing both engineering and ecological benefits. Specifics on the application, design, and installation of soil bioengineering techniques have been developed by the U.S. Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS) and U.S. Forest Service *(https://www.fs.fed.us/t-d/pubs/pdf/fs683/cover.pdf).*

Plant-based materials like coconut fiber logs can be used effectively to stabilize habitat edges, trap sediment and provide suitable protected sites for establishing new restoration plantings (Photo Credit: Delaware River Shorelines Committee)

Methods for stabilizing disturbed streambanks using live cuttings, plantings, bioengineering systems, as well as stone armoring can be used to mitigate the impacts of urban stormwater runoff and begin repairing damage to improve the stability and health of an urban river and stream network.

Planting young trees or seedlings of woody plants, evenly distributed, along the sides of the stream and up to 30 feet away from the stream re-establishes root systems that reduce soil erosion and stabilize streambanks. These trees not only help hold soil in place but also soak up nutrients, absorb rainwater, and provide habitat for wildlife. Live staking is another practice, which can reintroduce native plant materials directly in the places that need it most, the stream banks. It has a low cost and is something that small groups of volunteers can easily accomplish with guidance. Stem cuttings taken from trees and shrubs during their dormant season (typically November to March before the buds break in the spring) are inserted directly into stream banks. These cuttings, referred to as "live stakes," will eventually grow into new trees and are an effective way to establish a root network in the stream banks and help prevent further soil loss. Native woody species that can effectively be used for live stakes include dogwood, willow, and viburnum.

Figure 6.11 Bioengineering Diagram of Brush Mattresses Used for Stabilization



Constructed Stormwater Wetlands

Constructed stormwater wetlands are specially designed to store and filter stormwater runoff from surrounding urban landscapes. Capturing stormwater in a wetland allows pollutant particles to settle out and nutrients to be taken up by vegetation. Microorganisms in the wetland system will break down many urban pollutants, including petroleum hydrocarbons carried in stormwater runoff from roads, driveways, and parking lots. Vegetation will take up metals that have settled out of stormwater and into the sediment. Stormwater wetlands are designed with multiple water depths to support a variety of aquatic habitats. During storm events, the system will discharge water that has been filtered by the wetland allowing for storage of new stormwater runoff. These systems increase the flood storage capacity of the floodplain and can add a unique and diverse habitat complex to the landscape. Stormwater wetlands can be located where existing storm sewers discharging directly to waterways can be diverted into adjacent flood-prone landscapes. By excavating and creating a wetland that first captures and filters the runoff, the adjacent waterway is protected.

Figure 6.12 Stormwater Wetland Zones
(Credit: Rutgers Cooperative Extension)

Stormwater wetlands support a variety of plants and aquatic life. The design of these systems needs provide a range of hydrologic zones that capture and filter stormwater runoff through settling, plant uptake, and other biological processes. Critical considerations when planning or proposing a stormwater include:

- Identifying a location where the soils and hydrology will support and sustain healthy wetland establishment. Other GSI practices need soils that will infiltrate stormwater, but wetlands require soils that hold and retain water.
- Ensuring that enough water will flow into the wetland. Typically, a stormwater wetland needs 10-25 acres of land draining to it to sustain an appropriate water balance.
- Designing for multiple wetland zones including open water pools, marsh areas, and semi-wet landscapes that will support a range of facultative and obligate plant species and a variety of aquatic organisms.

Stormwater wetland captures runoff from an adjacent developed area (Photo Credit: BlueCanoe)

Including GSI systems in a restoration project will require planning and site investigation. Additional guidance on the design of these practices can be found at:

Green Infrastructure Guidance Manual for New Jersey prepared by Rutgers Cooperative Extension Water Resources Program

Visit Source

Rain Garden Manual for New Jersey prepared by Rutgers Cooperative Extension Water Resources Program

Visit Source

New Jersey Stormwater Best Management Practices Manual prepared by NJDEP

Visit Source

Living Shorelines

Living shorelines protect and stabilize coastal zones and consist of natural materials including plants, stone, shell, wood, and coir fiber products. They also maintain connectivity among habitat components across the tidal spectrum. This approach can be used as an alternative to hard structures that limit and impede the development of healthy ecosystems. This restoration strategy costs less than hard structure alternatives and is practical and attractive. Living shorelines support a larger resilient landscape design, providing multiple ecological and social benefits. The vegetation enhances experiences for recreation while also providing habitat for wildlife, promoting biodiversity, and buffering against floods and storm surge. The approach includes a range of techniques that can be used in tributary streams, bays, estuaries and sheltered shorelines. Living shorelines protect sensitive habitats from erosion and degradation while providing valuable ecosystem services such as habitat, food production, nutrient and sediment removal and water quality improvement. Living shorelines:

- Involve the strategic placement of plants, stone, sand, and other materials to mimic natural conditions
- Can be installed in tidal and freshwater waterbodies
- Improve water quality
- Provide an attractive and dynamic shoreline edge that supports ecosystem function
- Protect against erosion caused by tidal surges, wave action, and boat wakes
- May not be suitable for some situations

Living shorelines are complex projects that require site and regionally specific design approaches and should be developed with support of experienced professionals and appropriate permitting agencies. Additional information on living shorelines is available from National Oceanic and Atmospheric Administration (NOAA) (https://www.habitatblueprint.noaa.gov/living-shorelines/).

Living Shoreline Installation Using Oyster Shells
(Source: Rutgers Cooperative Extension)

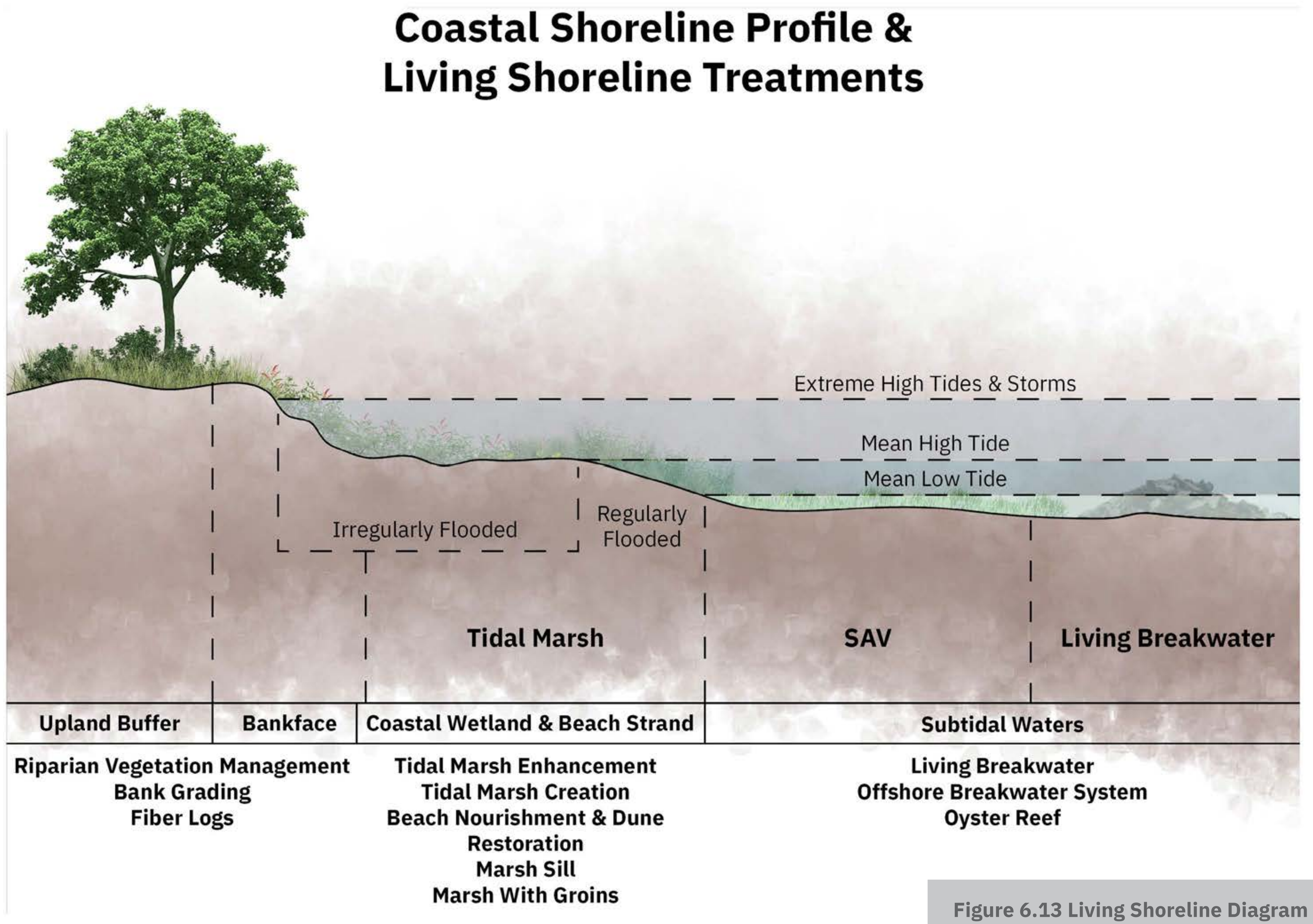


Figure 6.13 Living Shoreline Diagram

PUBLIC ACCESS: TRAILS AND SIGNAGE

Public access to the water fosters appreciation of a community's waterways and enhances stewardship of these important natural resources. Improving recreational opportunities, such as public access for water-oriented activities and trails along shorelines and the streambanks for pedestrian walking, hiking, and biking is a key component of a community's open space plan. Investments to connect to regional trail networks and recreation areas can increase the viability and use of these areas for residents and visitors alike. Enhancing the experience for visitors by creating safe and active points for accessing the water will continue to help build support for and stewardship of these important natural resources.

A robust trail and greenway network provides multiple benefits to communities, including public health, economic and transportation benefits, as well as instilling community pride and identity. Trails and greenways create healthy recreational and transportation opportunities by providing people of all ages with attractive, safe, accessible, and low- or no-cost places to cycle, walk, hike, jog, or skate. As tools for ecology and conservation, greenways and trails help preserve important natural landscapes, provide needed links between fragmented habitats, and offer tremendous opportunities for protecting plant and animal species. In addition, they can allow residents to experience nature with minimal environmental impact. To maximize public interest and natural benefits, trail networks through flood-prone areas should include a variety of experiences and build upon existing trails, where possible. As plans are developed and resources become available, a hierarchy of trails providing for both active transportation (i.e. biking and running) and nature viewing and appreciation experiences (i.e. hiking and bird watching) should be considered. Importantly, trail construction should minimize disturbance to sensitive habitats and not alter existing drainage patterns.

Different users desire different trail experiences. In addition, different landscapes support different trail construction. It requires conscious effort and discussion with community members to propose and design a trail network that can accommodate a variety of uses and experiences while not degrading the ecological integrity of the landscape. The following table provides an overview of different trail experiences and construction approaches.

Interpretive sign marking the entrance to a trail through a floodplain forest (Photo Credit: Rutgers Cooperative Extension)

Table 6.2 Guidelines for Selecting Trail Surfaces to Support Multiple Recreational Activities

Activity	Trail Type	Experience and Landscape
Nature Hiking and Birding	Unimproved trails/ mowed paths/ mulched surfaces	Appropriate in large wooded and meadow areas with minimal access for routine maintenance; trails should meander through the landscape avoiding major obstacles and highlighting desirable views and resources.
Dog Walking and Urban Hiking	Mulched surfaces/ gravel paths	Trails connect with nearby neighborhoods and attractions; they are carefully located near the perimeter of large habitats with opportunities for visitors to observe and learn about the surrounding landscape.
Jogging and Running	Gravel paths/paved trails	Trails often follow and connect with existing rights of way and deliberately direct users to multiple destinations; design should provide for circuits or loops as well as multiple access points.
Biking	Paved trails	Biking should be limited to hard-packed or paved surfaces to minimize damage to soils and sensitive habitats. If mountain biking or off-road biking is allowed, deliberate signage and plans for regular and routine maintenance and upkeep are needed.

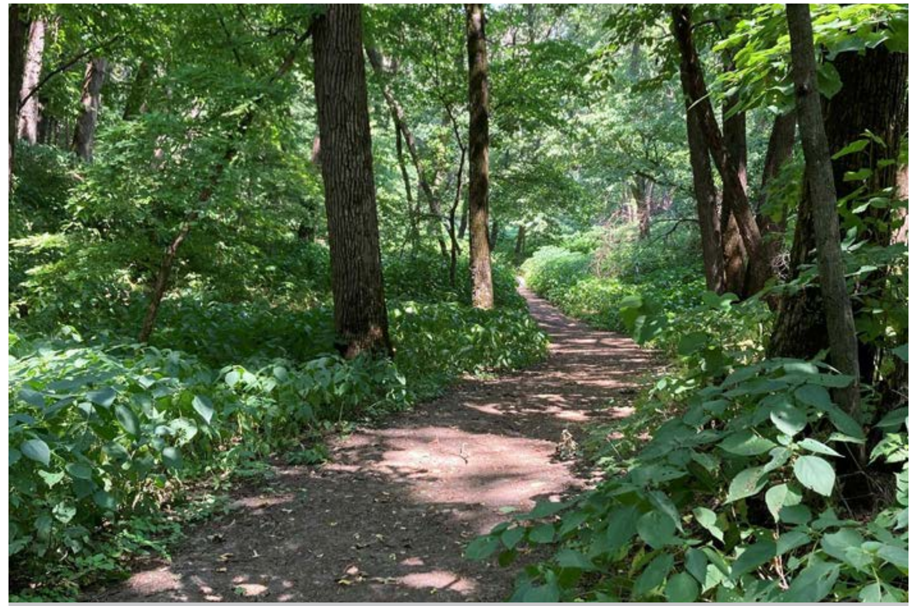
Trails provide the opportunity for physical activity as well as connections to the landscape. Selecting the appropriate trail experience based on environmental conditions and level of human activity then becomes the foundation for trails design and construction. An overview of trail design is provided, but more specific guidance on trail design and construction is available from several organizations including the Rails-to-Trails Conservancy, American Trails, and the National Park Service.

Unimproved Trails

Unimproved footpaths or hiking trails are designed to accommodate pedestrians and are not intended for cyclists or other wheeled users. These trails are most appropriate in large contiguous habitat area where access for maintenance is limited and use is geared toward more vigorous hiking. These natural surface trails typically make use of dirt, rock, soil, forest litter, pine mulch and other native materials for the trail surface. Preparation varies from machine-worked surfaces to those worn only by usage. This is the most appropriate surface for ecologically sensitive areas. These pathways, often very narrow, follow strenuous routes and may limit access to all but skilled users. Construction of these trails mainly consists of providing positive drainage for the trail tread and should not involve extensive removal of existing vegetation. Timbers may be used for steps along steep slopes. These trails vary in width from 3 feet to 6 feet, and vertical clearance should be maintained at 9 feet.

Improved Trails

Where regular, routine trail maintenance can be done, trails can be improved providing a more wearable surface. Often these trails are located near entry points and in areas with adequate accessibility for a variety of users. Providing compacted soils as well as surface materials of shredded hardwood mulch or gravel can support a wider variety of users and provide a park-like experience. These trails are generally wider with minimal cross slope and do not require users to navigate steep terrain. These trails provide a different level of service than unimproved trails and can support some limited wheel travel.



Unimproved trail (Photo Credit: Jeremiah Bergstrom)

Improved gravel trail (Photo Credit: Brooke Maslo)

Paved Trails

Typical pavement design for paved, off-road, multi-use trails should be based upon the specific loading and soil conditions for each project. These trails, typically composed of asphalt or concrete, should be designed to withstand the loading requirements of occasional maintenance and emergency vehicles. In areas prone to frequent flooding, it is recommended that concrete be used because of its excellent durability. One important concern for asphalt, multi-use trails is the deterioration of trail edges. Installation of a geotextile fabric beneath a layer of aggregate base course can help to maintain the edge of a trail. It is important to provide a 2'- wide graded shoulder to prevent trail edges from crumbling.

Paved concrete trail (Photo Credit: Jeremiah Bergstrom)

Boardwalks

Boardwalks, or wood surface trails, are typically required when crossing wetlands or poorly-drained areas. While boardwalks can be considered multi-use trails, the surface tends to be slippery when wet and not best suited for wheeled users. Pedestrian boardwalks in wetlands and riparian areas are required to be no more than 6 feet wide per NJDEP permit guidance. Wood surface trails are usually composed of sawn wooden planks or lumber that form the top layer of a bridge, boardwalk or deck. The most commonly used woods for trail surfacing are exposure- and decay- resistant species, such as pine, redwood, fir, larch, cedar, hemlock and spruce. Wood is a preferred surface type for special applications because of its strength and comparative weight, its aesthetic appeal and its versatility. Synthetic wood, manufactured from recycled plastics, is now available for use as a substitute in conventional outdoor wood construction. While these products are more expensive than wood lumber, recycled plastic lumber lasts much longer, does not splinter or warp and will not discolor.

Boardwalk at Teaneck Creek Conservancy (Photo Credit: Jon Lacy)

Boardwalk overlook in wetland habitat (Photo Credit: Jeremiah Bergstrom)

Boardwalk over a wetland area (Photo Credit: Jeremiah Bergstrom)

07

Key Topics

REGENERATION OR REVEGETATION?

SELECTING THE PLANT PALETTE

WHY NATIVE PLANTS?

ECOLOGICAL RESTORATION PLANNING

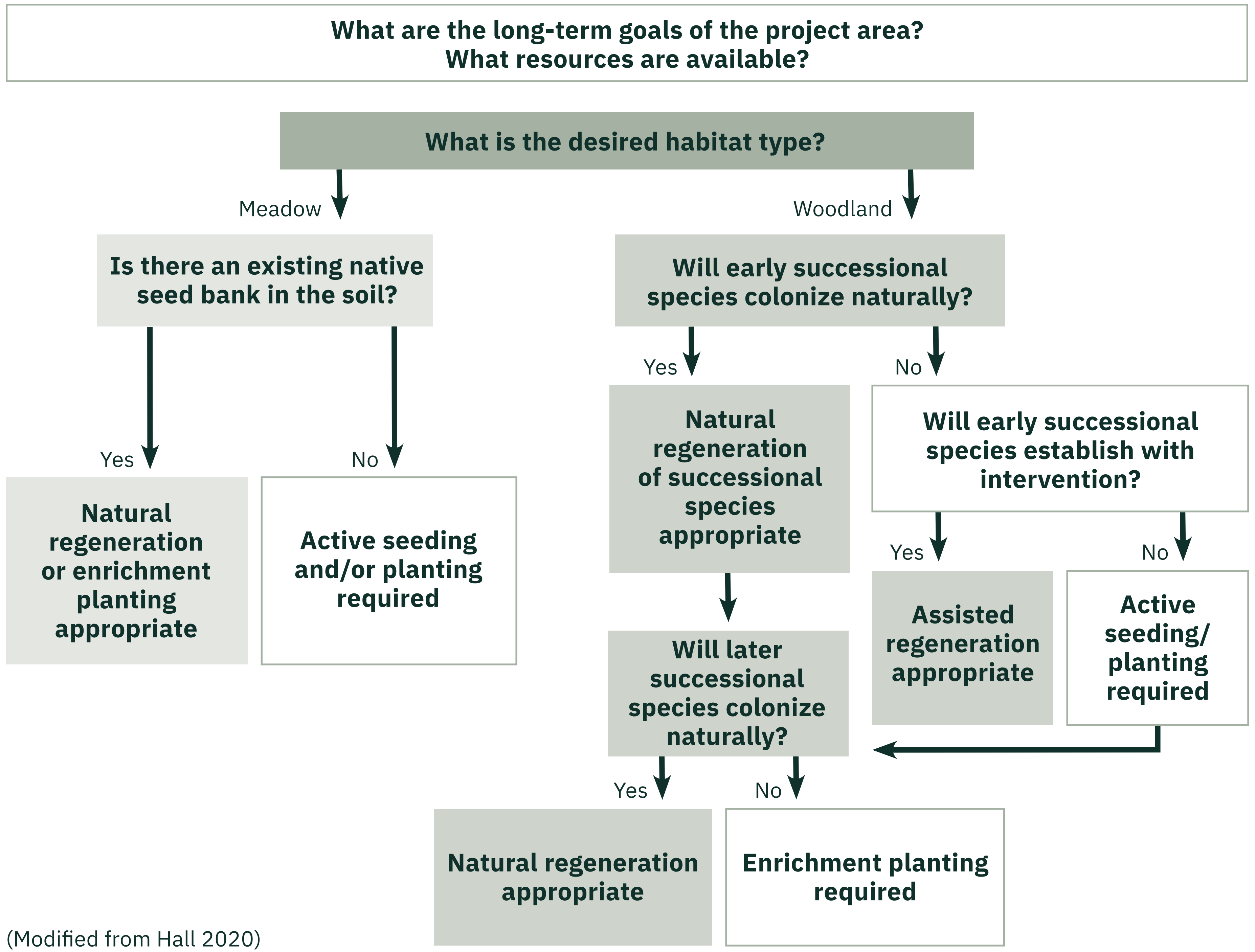
Restored tidal marsh (Photo Credit: Jeremiah Bergstrom)

REGENERATION OR REVEGETATION?

Determining the appropriate level of intervention needed to restore natural habitats can be challenging. In some cases, *natural revegetation* of the landscape can occur once the primary environmental stressor is removed. For example, management of invasive species in lightly degraded natural areas may promote germination of native plants from the underground seed bank. In some cases, restoring hydrology can allow wetland plants to regenerate, while also discouraging the growth of invasives. At the other extreme, however, the bare ground remaining after removal of human infrastructure (i.e. removal of homes and roads within flood zones) will require *active restoration* of vegetative communities. In addition, in highly disturbed natural areas, a 'hands-off' natural regeneration approach likely will not result in high quality, biodiverse and ecologically beneficial landscapes. Proactive establishment of desirable plant species is needed to create a landscape that can perform desired ecological functions and be resilient to surrounding threats and disturbance events.

Active restoration comes with increased costs for labor and materials; therefore, the intensity of active restoration needed to achieve the long-term project goal should be carefully considered. Where soils are barren and depleted of nutrients (i.e. where roadways or parking lots have been removed), complete revegetation may be the only successful strategy. However, complete revegetation of large areas may not be financially feasible without significant external funding. Practitioners can capitalize on several methods for jump-starting ecological processes to facilitate colonization of plants. This *assisted regeneration* includes such actions as planting small clusters of vegetation within a proposed forest area rather than evenly distributing plants throughout the entire site. These patches of vegetation attract seed-dispersing birds and small mammals, who use them as perching sites or predator refuges. Clusters of trees and shrubs also create shade, which chokes out sun-loving weeds and provides nursery sites for new tree seedlings. Another strategy is to allow areas to naturally colonize with early successional species (i.e. shrubs, wild cherry, eastern red cedars) that will replenish soil nutrients and create shade. After 3-10 years, later successional species that would not establish with active intervention can then be planted on the site (known as enrichment planting). Over time, these assisted regeneration processes create a diverse, spatially heterogeneous woodland that provides habitat for wildlife, as well as multiple ecosystem services such as carbon sequestration, stormwater infiltration, and improved air quality. Understanding the current environmental conditions of the project area, as well as establishing clear long-term goals, can help to develop a cost-effective and successful restoration strategy. The principles discussed here apply broadly to both upland and coastal habitats. In wetland areas, restoring the site's hydrology is a critical first step in the restoration process (see Chapter 6).

Figure 7.1 Decision Tree for Determining an Appropriate Revegetation Strategy The decision tree to the right provides guidance on how to design a restoration approach based upon the current site conditions and desired outcome, using terrestrial habitat as an example.



(Modified from Hall 2020)

SELECTING THE PLANT PALETTE

The primary focus of creating resilient landscapes in New Jersey communities is to restore ecosystem processes that can handle water inputs from terrestrial and aquatic sources. Open habitats in flood prone areas will be subjected to a wide range of environmental conditions and must be designed to withstand long periods of dry conditions as well as periodic inundation. Therefore, maximizing species diversity to the extent possible is highly recommended. There are several factors to consider when selecting a plant palette. To speed up ecological succession, reduce erosion, and keep invasive plant species at bay, a restoration plant list should include species with rapid growth rates and/or species that spread vegetatively via underground roots and rhizomes. Species that can tolerate variable hydrology (i.e. facultative wetland species), salinity, and low-nutrient soils (i.e. nitrogen-fixing species) are important. Fruit-bearing plant species should also be included to attract seed-dispersing animals.

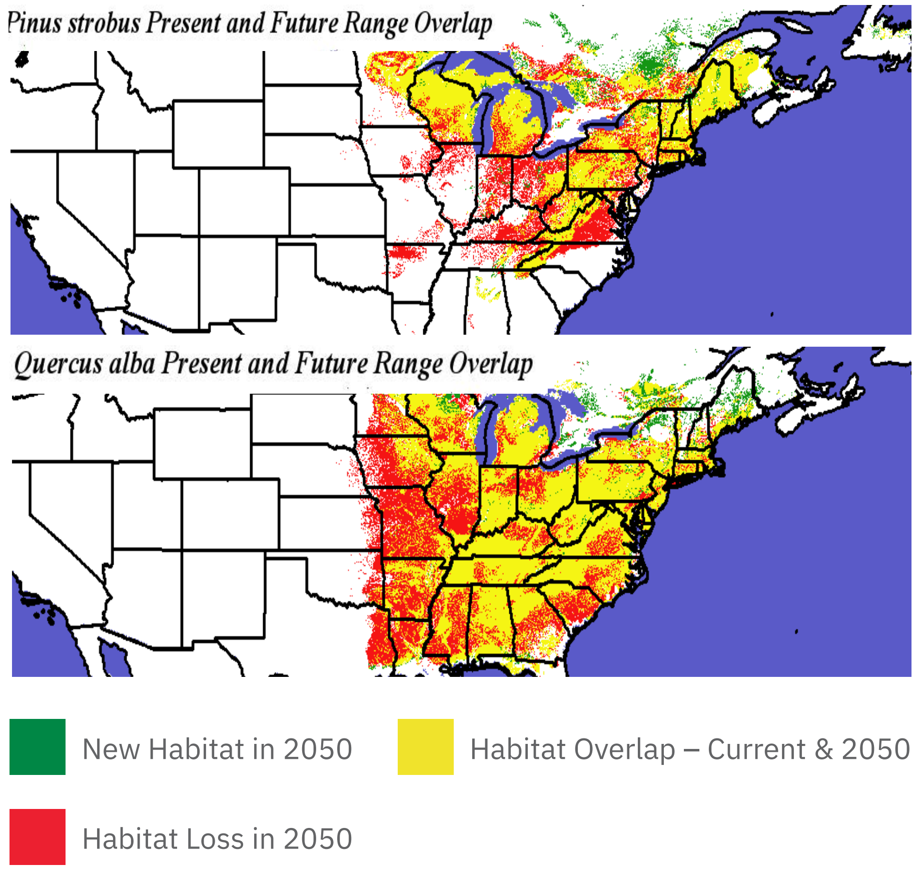


Figure 7.2 Impacts of Climate Change on the Geographic Distribution of Plants Predicted changes in the distribution of white pine (*Pinus strobus*, top) and white oak (*Quercus alba*, bottom) between now and 2100, based upon the Hadley Centre Coupled Model, Scenario A1F1 (data adapted from The ForeCASTS Project, USDA Forest Service Eastern Forest Environmental Threat Assessment Center). Maps indicate projected changes in climate conditions by 2050, where areas in red indicate lost habitat that would no longer support the species and areas in green indicate new habitats that would support the species. Yellow areas indicate no projected change over time.

Table 7.1 Plant Characteristics that Facilitate Restoration Success in Flood-Prone Areas

Characteristic	Explanation and Justification
Rapid Growth Rate	Fast-growing plants have a competitive edge against invasive species. They also create shade and improve soil quality, resulting in a nursery effect that promote seedling establishment.
Vegetation Growth	Plants that spread via underground roots and rhizomes can outcompete invasive plants. Their roots hold soil in place and prevent erosion, increasing soil quality.
Fruit or Nut-bearing	Large fruits and nuts attract wildlife species that can act as seed-dispersers and habitat engineers. Fecal deposits from wildlife add nutrients to the soil, further promoting plant production.
Tolerance of a Range of Hydrologic Conditions	Restored habitats in flood prone areas must contend with altered hydrology due to legacy changes in elevation and grading from previous development. Plants may be subject to extremely dry conditions, as well as periodic inundation, during the year.
Tolerance of Low-nutrient Soils	Previously developed landscapes typically have poor soils due to compaction and the introduction of fill. Plants that can fix nitrogen and can thrive in poor soils will improve soil quality to benefit other colonizing species.
Tolerant of Salinity or Acidity	Open areas adjacent to development often have elevated salinity or acidity due to runoff from yards or impervious cover. Freshwater, tidally influenced areas are subject to saltwater intrusion as sea levels rise.
Tolerant of Changing Climate	Climate change scenarios predict changes in temperature and moisture regimes, as well as a shift in suitable range for many plant species (see **Figure 7.2**).

WHY NATIVE PLANTS?

Native plants are species that occur within a specific geographic area and were not introduced to the current location by humans. Over the past several thousand years, native plant species have evolved complex and symbiotic relationships with the native wildlife that also occupy habitats in the region. These relationships form the foundation of nature's contributions to people by performing functions necessary (i.e. pollination, maintenance of food webs, nutrient cycling) to support ecosystems.

Classic suburban yards and other maintained open spaces consist of mowed lawns and, in most cases, non-native ornamental landscaping that do not support local biodiversity. In addition, these types of plantings require significant inputs of chemical fertilizers and pesticides, water, and manpower (i.e. lawn mowers, leaf blowers, weed whackers) to maintain them, contributing to noise and carbon pollution.

In contrast, when native species are planted within the appropriate soil, light, and water conditions (those in which the plant evolved), they require very little input from humans. Because they are already adapted to the local conditions, they do not require fertilizer or excessive watering to thrive, which creates healthier landscapes for people as well as reduced labor and supply costs.

Native perennials, such as boneset (*Eupatorium serotinum*), emerge from the existing seed bank after invasive species management on a NJ Blue Acres property. (Photo Credit: Kathleen Kerwin)

Recommended Native Plants for New Jersey

Several resources exist to provide technical guidance for selecting appropriate plant species palettes for habitats in New Jersey. Many websites, fact sheets, and other publications offer recommended plant lists for specific habitat types. When determining which species to include, consider the current and projected range of the species. Select plants that can adapt to climate shifts. In addition, confirm the wetland indicator status of the candidate species (i.e. upland, facultative, obligate wetland). Match the species with the soil and hydrologic conditions of the project area. Choosing a species palette that exhibits a range of bloom and fruit or seed set times ensures that habitats will provide resources for wildlife throughout the year, while also creating pleasing aesthetics for visitors across the seasons.

(Photo Credit: Daniel Fisher)

Selected resources for representative native plant palettes for New Jersey.

The Native Plant Society of New Jersey Plants Lists

Visit Source

Collins, B.R. 1994. Plant Communities of New Jersey: A Study in Landscape Diversity. Rutgers University Press, New Brunswick, NJ. 308pp.

Pinto, D. and M. Melendez. 2010. Incorporating native plants into your residential landscape. Rutgers Fact Sheet FS1140, Rutgers University, New Brunswick, NJ.

Visit Source

The National Wildlife Federation Garden for Wildlife.

Visit Source

Jersey-Friendly Yards

Visit Source

When are Non-native Species OK?

Horticultural and Landscape Plants Remaining in Buyout Areas

Some non-native plants do not readily spread and are considered non-invasive. In certain cases, it might be appropriate to leave the non-invasive species in place, especially if they serve an ecological benefit. For example, non-native trees and shrubs can help to shade out invasive plants like *Phragmites australis*. Non-native plants can also provide some benefits for wildlife (however, native plants will always provide more benefits). Woody vegetation in an otherwise barren landscape (i.e. areas where manmade structures have been removed) can also attract seed-dispersing birds and mammals, or they can act as nursery areas for natural revegetation processes. Some examples of ecologically benign non-native plants include evergreen shrubs, such as Japanese yew (*Taxus cuspidata*) and Arborvitae (*Thuja spp.*), or trees such as ginkgo (*Ginkgo biloba*). Prior to determining whether existing plants should remain within the project area, the species should be identified and cross-checked against the current list of invasive species in New Jersey. A list of the most common invasive plant species in New Jersey can be found later in this chapter, and the complete list of invasive species in New Jersey can be found here at NJ Invasive Species Strike Team: Invasive Species List.

Visit Source

Cover Crops

In some situations, actively planting non-native species can be an appropriate tool to use in the ecological restoration process. ‘Cover crops’ are fast growing plants that help restore a site prior to native planting by suppressing weeds and quickly stabilizing bare soil. Species classified as cover crops are annuals, meaning they only live for a single growing season They have not been shown to reduce early growth and establishment of native perennials, especially in restoration contexts. They are typically hardy and fast-growing, and they require little to no post-planting maintenance. Cover crops can be used to prepare a site for native planting that is scheduled for the following year, or it can be mixed in the with native seed mix. In either case, the cover crop grows quickly, shading out other annual fast-growing weeds that may live in the soil, while allowing slower-growing native perennial plants to survive. Good examples of appropriate cover crops include grain oats and grain rye, planted at 30 lbs/acre. Annual rye or brown top millet are also comparable considerations.

Limiting the Invasion

Some restoration sites are in close proximity to large source populations of invasive species, making it impossible to prevent future infestations. Common examples include sites adjacent to *Phragmites*-dominated marshland, highly invaded woodlots, or sites with invasive species seeds lying dormant in the soil (invasive seed bank). In these instances, permanent eradication of the invasive species is impractical. In such cases, the goal of the restoration should be to create an ecologically valuable plant community that can tolerate the presence of low levels of invasive species.

For example, the invasive vine mile-a-minute (*Persicaria perfoliata*) has long-lived seeds that reside in the soil for many years, making it highly unlikely to eradicate the plant even with chemical and mechanical management. Instead, the goal is to suppress the species for a few years until the restoration trees are large enough that they will not get smothered by mile-a-minute, and eventually they will be tall enough to help suppress mile-a-minute through shade.

In another example, *Phragmites australis* does not tolerate full shade. On sites adjacent to *Phragmites*-dominated marshland, larger fast-growing trees planted along the wetland perimeter can eventually create a dense canopy to help limit the spread of Phragmites to the forest edge.

In general, incorporating invasive species management strategies into planting designs will help keep them at tolerable levels of cover. Common strategies include planting fast-growing trees and increasing the density of native plantings to help reduce competition from invasive species.

Revegetation Methods

There are different methods available for revegetating a site with native plants. When installing a meadow or a ‘no-mow’ area, the two primary options include using seed mixes, or installing established plants that are typically available as 2” plugs or quart size containers from a nursery. Woody species are available in a variety of pot sizes, and trees can also be purchased as 1-2” caliper ball and burlapped individuals. Revegetation methods differ in costs, level of necessary post-planting management, and probability of establishment. Choosing the appropriate strategy for a given project will largely depend on available funding, project area size, and access to equipment and personpower.

Table 7.2 Tradeoffs in Costs, Labor Requirements, and Probability of Establishment for Revegetation Methods in Ecological Restoration

		Pros	Cons	Cost
Herbaceous Plants	Seeding	Less personpower to install	Random planting pattern; need special equipment (drill seeder) for large areas	$
	Plugs/Quarts	Establish faster than seed; you can create patterns/same-species clumps	More expensive; more labor intensive to plant	$$$
Woody Plants	Potted Plants	More resilient; more vigorous; easier to plant	Take longer to establish; need more protection and maintenance	$$
	Large trees, ball and burlap	Aesthetically pleasing; need less maintenance	Expensive; may experience 'transplant shock'; harder to plant	$$$$

Diversity is Key

When revegetating a site, planting a variety of different species is extremely important because it will help maximize biodiversity and ecosystem function. In undisturbed natural areas, there are different plant types of various ages, which creates vegetation structure. For example, mature forest habitats include layers: adult trees form a canopy, shrubs and young trees of various ages and heights form the understory, and herbaceous flowers and grasses grow on the forest floor or edge. This structure provides critical habitat for a variety of wildlife including insects, birds, pollinators, mammals, reptiles and amphibians. When designing a forest restoration, it is critical to pick a variety of tree and shrub species and cease mowing between the plantings to allow this structure to develop over time. Choosing woody species that produce fruits or nuts will increase value to wildlife.

In meadows, planting a variety of flowering species that bloom throughout the growing season will provide pollen and nectar for birds and pollinating insects. If planting plugs or quart size herbaceous plants, arranging them in groups will help birds and pollinators find these patches of vegetation.

When restoring any habitat type, remember to consider the conditions of the site, including hydrology, salt levels in adjacent waters, light conditions, and soil type. There are a variety of resources available online to help you determine which plant species will thrive in certain conditions.

Timing

To increase the likelihood of a successful revegetation initiative, implementation should be planned to coincide with the natural growth cycle of the species being planted. In general, planting should be restricted to mid to late spring (after the last frost date) and mid to late fall (before dormancy). Planting outside of these windows introduces stress on new plantings and jeopardizes their establishment. Timing can be extended on either side of these prime planting windows to accommodate scheduling and funding considerations; however, practitioners should anticipate additional monitoring and maintenance needs (watering, weeding, etc.) to avoid excessive plant mortality.

(Photo Credit: Brooke Maslo)

08

Key Topics

PRE-RESTORATION SITE PREPARATION

POST-RESTORATION MONITORING AND MANAGEMENT

GRAPHICAL TIMELINES FOR RESTORATION AND MANAGEMENT

MANAGING RESILIENT LANDSCAPES

Restoration planting (Photo Credit: Jeremiah Bergstrom)

PRE-RESTORATION SITE PREPARATION

Litter and Debris Removal

Natural lands and open space within or adjacent to developed areas can be prime locations for illegal dumping. Garbage and litter can also build up in unmanaged open areas, often collecting on the banks of rivers and streams or being caught up in existing vegetation. Prior to any site work, litter and debris should be removed from designated project areas. Large debris can impede access for heavy equipment or pose a hazard to equipment and personnel if partially buried or otherwise obstructed. Wildlife may accidentally ingest or become entangled in various types of litter. Removing litter and debris from the site will help build and maintain a desirable image of the project area for remaining residents and visitors. Litter and debris removal can be completed through a volunteer effort in coordination with the local governing body.

Removal of large debris from a restoration site (Photo Credit: Kathleen Kerwin)

Managing Invasive Species

What Are Invasive Species?

Non-native plants are species that do not naturally occur in a specific geographic area but were introduced by humans either deliberately or accidentally. *Invasive* plants are typically non-native species that have become major threats to native ecosystems because they typically lack any local predators, diseases, or competitors, making them very successful at establishing and spreading. Some native plants can also exhibit 'invasive' qualities, exerting significant negative impacts to biodiversity through competition, predation, or other ecological processes. Choosing whether or not to manage such native invaders should occur on a site-by-site basis.

Invasive plants in New Jersey cause serious ecological damage and cause millions of dollars in economic losses each year. Ecologically, invasive plants will crowd out native plants upon which wildlife rely. This results in localized species extinctions and a reduction in ecosystem function (and therefore, a loss of ecosystem services). For example, native songbirds rely on native plants for specific food resources, such as insects and fruit, that contain critical nutrient content. Without native plants, it becomes difficult for these birds to reproduce, migrate, or survive the winter. Fewer birds in an area lower rates of seed dispersal, reduce predation on insect pests, and disrupt the successional properties that maintain habitats. Economically, invasive plants negatively affect agricultural productivity, outdoor recreation, and even property values.

New Jersey is home to approximately 200 invasive plant species. Some of these plants such as Japanese barberry and butterfly bush are commonly used as landscaping plants and are often left behind after demolition on previously developed parcels. Other species such, as mugwort and Canada thistle, thrive on disturbed soils and will quickly invade a site post-demolition. See Table 8.1 for a list of 35 common invasive plants in New Jersey.

A forest floor dominated by the invasive vine mile-a-minute *(Persicaria perfoliata)* (Photo Credit: Kathleen Kerwin)

Table 8.1 Common Invasive Grass, Herbaceous, and Woody Plant Species in New Jersey

Plant Type: Grass

Scientific Name	Common Name
Eragrostis curvula	weeping lovegrass
Microstegium vimineum	Japanese stiltgrass
Phragmites australis	common reed

Plant Type: Herb

Scientific Name	Common Name
Alliaria petiolata	garlic mustard
Artemisia vulgaris	mugwort
Cirsium arvense	Canada thistle
Lespedeza cuneata	Chinese bushclover
Reynoutria japonica	Japanese knotweed

Plant Type: Shrub

Scientific Name	Common Name
Berberis thunbergii	Japanese barberry
Buddleja davidii	butterflybush
Cytisus scoparius	Scotch broom
Elaeagnus umbellata	autumn olive
Euonymus alatus	winged burning bush
Ligustrum obtusifolium	border privet
Ligustrum vulgare	European privet
Lonicera maackii	Amur honeysuckle
Rosa multiflora	multiflora rose

Plant Type: Tree

Scientific Name	Common Name
Acer palmatum	Japanese maple
Acer platanoides	Norway maple
Ailanthus altissima	tree-of-heaven
Albizia julibrissin	mimosa
Aralia elata	Japanese angelica tree
Paulownia tomentosa	princesstree
Prunus avium	sweet cherry
Pyrus calleryana	Callery (Bradford) pear
Robinia pseudoacacia	black locust

Plant Type: Vine

Scientific Name	Common Name
Ampelopsis brevipedunculata	porcelain-berry
Celastrus orbiculatus	Oriental bittersweet
Clematis terniflora	Japanese clematis
Hedera helix	English ivy
Humulus japonicus	Japanese hop
Lonicera japonica	Japanese honeysuckle
Persicaria perfoliata	mile-a-minute vine
Wisteria floribunda	Japanese wisteria
Wisteria sinensis	Chinese wisteria

Best Practices for Invasive Species Management

When preparing a site for ecological restoration, all invasive plants should be removed to prepare the site for native plantings. Although invasive plant management will need to occur at most sites on a long-term basis, managing invasive plants before the start of restoration efforts will significantly help the native plantings become established. If invasive plants are not managed appropriately in advance, they can quickly outcompete native plantings and jeopardize the entire restoration process.

Most invasive plant species require a combination of mechanical and chemical treatment (herbicides) to successfully manage them. In many cases, using mechanical treatment without herbicides will trigger the invasive plant to vigorously re-sprout and increase infestation. Broadleaf herbaceous and woody species respond well to targeted application of common herbicides, such as glyphosate.

- **Shrubs, woody vines, and small trees:** Seedlings of these plants can be removed manually or by applying herbicide, depending on the level of infestation. Larger plants should be controlled using the cut-stump method. First, use pruning sheers, hand saws, or similar tools to manually remove aboveground plant material. Immediately after cutting, apply a concentrated glyphosate solution to the stumps to prevent regrowth.

- **Larger trees (>6 inches DBH):** larger trees can be controlled using the frill girdle method, which consists of cutting a single line of overlapping downward axe cuts around the trunk and applying herbicide into the 'frills' using a squeeze bottle. The cuts should be deep enough to remove the vascular cambium (inner bark) of the tree. Over time, these resulting dead trees called 'snags' will become valuable wildlife habitat (foraging habitat, nesting sites, perching sites, etc.).

- **Herbaceous Plants:** Invasive herbaceous plants can be controlled by applying herbicide using backpack sprayers, which allows for targeted application and decreased risk of damaging non-target species. During late summer, perennial species are preparing for dormancy by sending sugars into their rhizomes for storage, which will help circulate the herbicide throughout the plant and increase effectiveness. Repeated spraying will be necessary to kill re-sprouting individuals.

Note: Herbicide treatments must be supervised by a New Jersey state licensed pesticide applicator to comply with state law.

Frill girdling a Chinese willow tree *(Salix babylonica)* (Photo Credit: Rutgers Cooperative Extension)

Backpack sprayers are utilized for targeted application of herbicide to herbaceous plants (Photo Credit: Rutgers Cooperative Extension)

Preparing the Soil

All soils are composed of minerals, organic matter, water, and air. Depending on the size of the soil particles, soil texture is classified as sand, silt, or clay. Intact and undisturbed soils will naturally form layers over time, with more fertile layers found in the upper regions where there is a higher ratio of organic matter. Soils are also home to a diverse variety of living organisms, ranging from earthworms and rodents, to fungi and bacteria. Both the organic matter and the living organisms in soil assist with nutrient cycling, water retention, soil aeration, and erosion resistance.

Soils left behind on buyout properties are heavily modified and disturbed, and often consist of offsite fill material. This results in a lack of natural soil layering (soils are homogenized) plus a decrease in organic matter and living organisms. It is impossible to restore soil layers once they have been mixed or removed. The first step in improving disturbed soil health is to have the soil tested to determine what soil-quality amendments should be added to help restore natural processes and to increase nutrient availability for native plants. Testing can be done through the Rutgers Cooperative Extension Soil Testing Laboratory.

The selected site's soil should be tested for pH and nutrient content. Soil pH can determine the nutrient availability in the soil and strongly influences what plants can thrive in a given site. Soils pH tends to range from 5.0 to 8.0. A pH level of 6.5 is generally considered to be optimal for garden soil, but what level of acidity or alkalinity is preferred depends on the specific needs of the native flora.

Most native plant species will colonize and establish in a nutrient poor soil. High nutrient soils or adding nutrients to soils can promote weed growth and provide a suitable site for invasive plant species. Maintaining a more nutrient deficient soil can help to minimize competition from undesirable plant species during the establishment period for native plantings. If needed, common soil quality amendments include: gypsum, lime, compost, and animal waste.

Many erosion control techniques can also help increase soil organic matter, such as laying down straw, hay, wood mulch. Erosion control cloths or other similar materials should be avoided where possible to minimize the risk of wildlife entanglement. Testing and amending soils prior to planting may significantly increase the success of your restoration efforts.

Turf Management

Turf management is required if you plan to install a meadow on the project site and can be achieved through two common methods:

Chemical Treatment

Three to four applications of a nonselective systemic herbicide such as glyphosate during the growing season is effective at killing turfgrasses and exhausting the weedy seed bank. The first application should occur in mid-May, with successive treatments occurring at 4 to 6-week intervals. If turfgrass or other nonnative species continue to re-grow, continue applications into early September. If you plan to install the meadow the following spring, the site may require a final herbicide treatment at least 1 week before seeding or planting.

Smothering

Cover the turf or soil surface for an entire growing season to kill any plant presently growing. Depending on the size of the site and budget, materials that can be used include black plastic, cardboard covered with leaves, plywood, or 6 inches of wood chips. Cover the area in late spring and keep it in place until the plants undernearth are dead and you are ready to install the meadow. Till the soil or rake away dead plant material before planting.

A turf area treated with herbicide prior to native planting
(Photo Credit: Kathleen Kerwin)

POST-RESTORATION MONITORING AND MANAGEMENT

Native plantings will require routine monitoring and maintenance to promote establishment. Relevant stressors on new plantings include herbivory, temperature and water stress, and competition from weeds and invasive species. These and other proactive strategies for proper maintenance will greatly increase survival of restored habitats and overall project success.

Watering

In the first growing season after planting (April - November), newly installed trees and shrubs should be watered weekly at a rate of 1-1.5 gallons per inch of stem caliper. Smaller trees and shrubs can be watered using a slow trickle from a hose; larger trees (>1" caliper) can be watered using tree bags (e.g., Treegator®) to provide a slow and consistent supply of water. Newly installed herbaceous plants in habitats other than upland meadows should be watered at a rate of ~1" per week. Upland meadows are typically comprised of warm-season grasses and wildflowers, and they would only require active watering during extremely dry spells. During the second and third growing seasons, plants should be watered as needed, particularly during hot and dry spells or when they are exhibiting signs of stress (e.g., wilting, browning of leaves).

Plantings must be watered during the first growing season (Photo Credit: Kathleen Kerwin)

Weeding

For a period of three years, a 3-ft radius around all new woody plantings should be kept clear of emerging seedlings (both native and invasive) to reduce competition for water and nutrients. This can be accomplished either through mechanical methods (i.e. weed trimmer) or careful herbicide application around each planting using backpack or hand-pump sprayers. Tree tubes usually lack ventilation holes on the first 12 inches closest to the ground to protect the plantings from herbicide drift.

Protecting Restored Areas from Herbivory

Woody Plants

All newly planted trees and shrubs should be protected with 3 to 5-ft tree shelters (i.e. Tubex®) to protect the plantings from herbivory. These hard-plastic cylindrical tubes force saplings to grow above the reach of deer browse, while also protecting them from ground-feeding mammals such as rabbits, mice, and voles. In addition to physical protection, the shelters are constructed of translucent, UV-stabilized plastic which creates a greenhouse microclimate of high humidity, reduced air movement, and lower light intensity inside the shelter, ultimately increasing sapling growth rate.

Tree shelters should be supported with a durable 1-inch square, wooden stake at least two thirds of the tube length and installed at least 12 inches below ground. Tree shelters should be secured to the stake by a minimum of 2 strong zip ties. While plant height is below the top of the tube, each shelter should be adorned with netting on the top to prevent songbirds from entering the tubes and getting trapped inside. The bird netting must be removed when the plant reaches the top of the tube to avoid terminal bud deformation, which can lead to decreased vertical growth and stem quality of the plant.

Installation of tree shelter over a native plant (Photo Credit: Kathleen Kerwin)

Tube shelters should be inspected at least twice per year (and preferably more) to fix any slanted or tipped over shelters, replace broken or rotten stakes, remove old leaves and debris from the bottom of the shelter, and remove any small mammal nests inside the shelter. Routine maintenance will help the trees stay free of disease and pests.

Tree shelters will accumulate dead leaves and debris which must be removed annually to help prevent disease and pests (Photo Credit: Rutgers Cooperative Extension)

Mice and other small mammals will build nests in tree tubes which should be removed in spring (Photo Credit: Rutgers Cooperative Extension)

Bird netting must be removed before trees reach the top of the tube to prevent irregular growth (Photo Credit: Rutgers Cooperative Extension)

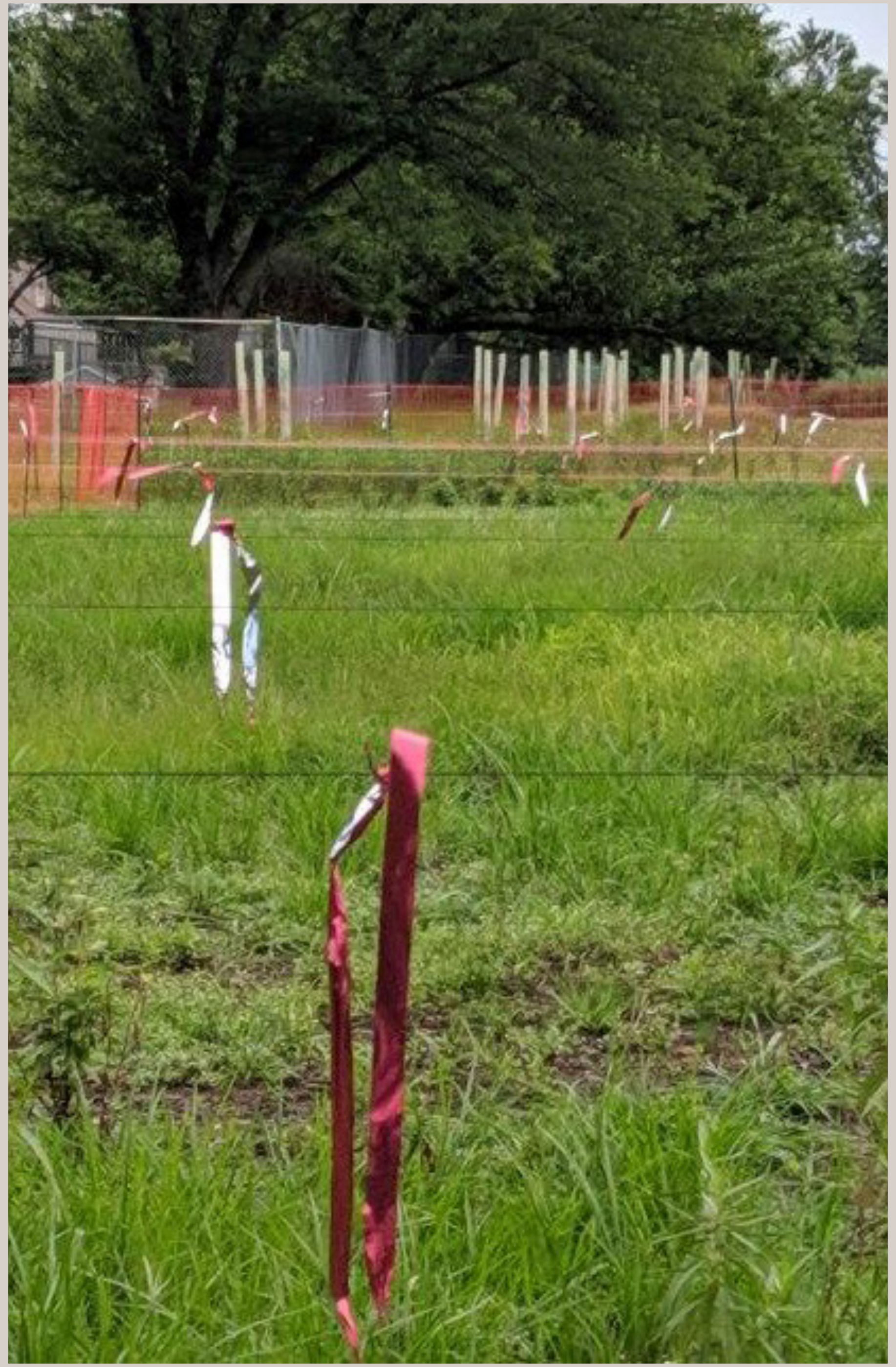
Herbaceous Plants

Upland meadow habitats should be initiated using native seed mixes that are comprised of predominantly 'deer-resistant' species (see recommendations for native seed mixes), reducing the need to protect large areas of plantings from herbivory. However, herbaceous wetland plants are particularly vulnerable to damage from Canada geese and must be protected until established. The standard practice for excluding geese from an area is to erect a grid-wire system.

Surround the perimeter of the planted area with heavy plastic snow fencing or chicken wire, supported by sturdy posts, such as metal T-posts, extending three to five feet above the ground. Hang grids of monofilament line or Kevlar wire above the plantings at a spacing of 2-6 feet. Overhead grids should be clearly visible and adorned with colored flagging or mylar tape to prevent injury to geese, people, and other animals.

Keeping Out Invasive Plant Species

Natural areas will always be at risk of biological invasions, but they are especially vulnerable early in the restoration process. Pre-restoration invasive species management will greatly increase the likelihood of project success but restored areas should be monitored throughout the growing season for the presence of invasive species for at least 5 years. After restoration implementation, any recurring invasive species vegetation should be managed as soon as possible to prevent re-establishment. Extreme care must be given to avoid herbicide contact of physical disturbance (i.e. trampling, cutting) with desirable plants.



Herbaceous plantings should be protected with snow fencing, grid wire, and mylar flagging to help deter Canada geese (Photo Credit: Kathleen Kerwin)

Monitoring and Maintenance of Green Stormwater Infrastructure

Green stormwater infrastructure (GSI) practices such as rain gardens, bioretention systems, bioswales and stormwater wetlands are an important component of restoration projects. These stormwater systems rely on healthy soils and plants to promote infiltration and uptake of stormwater runoff while filtering out pollutants. To ensure healthy and adequate function of this living infrastructure, regular and routine monitoring and maintenance is important. While not difficult, consistently addressing the following tasks will keep these systems functioning and attractive.

A newly planted rain garden to replace impervious pavement
(Photo Credit: Rutgers Cooperative Extention)

Volunteer efforts to remove debris from a bioswale
(Photo Credit: Rutgers Cooperative Extention)

Remove Litter and Debris, Clean Out Pipes and Outlet Structures
Flowing water will collect and deposit materials from the surrounding community in GSI systems. Maintaining plantings as well as an attractive landscape will require that any trash or debris left after storm events is removed and that none of the materials block or damage any physical structures. This is the simplest and should be the most frequently completed activity and ideally will be conducted every few months and after major storm events.

Removing Sediment Build Up and Monitoring for Erosion
GSI practices should be designed so that sediment is collected in a forebay or area near the inlet that can be easily accessed. Sediment is the number one pollutant in waterways across the United States and by using GSI, sediment loads can be significantly reduced. The buildup of sediment is typical, and removal of this material should be planned for twice each year. In addition, a heavy rain event may wash out plantings and mulch or begin to erode or wash away soils. It is important to monitor identify any erosion so that appropriate repairs can be made. Erosion will create conditions that could lead to failure of the GSI practice or increase the potential for invasive species to take over the landscape.

Weeding and Trimming
Maintaining plantings during the growing season is important to ensuring an attractive as well as a healthy landscape. Routine weeding as well as trimming of plantings should be done throughout the growing season to keep the GSI practice from becoming overgrown or overtaken by invasive plants. Pruning of shrubs and trees is necessary as they grow to maintain a desirable shape and configuration as well.

Repair and Replanting
If repairs are needed to keep the GSI practice functioning properly, they should be completed as soon as possible. Broken or damaged hardware, pipes, outlets, inlets, and overflows can be repaired whenever necessary. Mulching and planting should be done in early spring or late summer to minimize the need for supplemental watering.

Weeding out non-native species during the growing season helps the native plantings establish
(Photo Credit: Rutgers Cooperative Extention)

Annual Maintenance Planning	Clean-Up and Debris Removal	Sediment Removal	Weeding and Trimming	Repair and Replanting
January - March	X			
April - June	X	X	X	May
July - September	X		X	September
October - December	X	X		

Table 8.2 Recommended Maintenance Schedule for Green Stormwater Infrastructure provides a recommended schedule for planning GSI maintenance activities throughout the year. The frequency and attention given to these maintenance activities will determine the GSI system's overall attractiveness and function. This living infrastructure is very visible and often GSI practices are located at the edge of a floodplain restoration area to minimize the negative impacts of stormwater runoff on other restoration plantings and ecological communities. The GSI landscape will be seen by neighbors and community members. An investment in regular maintenance will help to ensure that the landscape appears attractive and cared for and continues to serve its important purpose as a component of the community ecological restoration project.

Who Should Do the Work?

Deciding who should do the work of landscape restoration and creation is an important part of the landscape transformation process. Several factors should be considered when choosing between volunteers and professional contractors, and there are trade-offs for each option. Volunteer workers are people who are not an employee, but instead they donate their work to an organization or project. Volunteers are not paid or given other compensation for their work.

Pros and Cons of Volunteer Workers

There are many good reasons to bring in volunteers to complete restoration and creation projects. Creating a volunteer work group engages a more diverse range of skills and informs the development and delivery of activities, projects, or services by bringing in new opinions and approaches. Volunteer work groups reach more users, raise awareness about relevant issues, build relationships within the community, and deliver services or projects in a more effective way that can save money and resources.

However, because they are not employees or under any formal contract, volunteers have no obligation to show up, and if a volunteer is no longer motivated or becomes busy, they may not return to the project. It also takes time to train volunteers, which takes up staff time. Managing volunteers is its own job. Activities such as recruiting volunteers, assigning tasks, and monitoring their work are very involved and take a lot of time and effort from staff.

Potential Community Groups to Involve to Restoration Activities:

- Master Gardeners
- Local environmental commission
- Girl Scouts and Boy Scouts
- Faith based organizations
- School groups

Volunteers help plant plugs in a wetland restoration (Photo Credit: Brooke Maslo)

Professional contractor grading the topography of a restored wetland (Photo Credit: Brooke Maslo)

Pros and Cons of Professional Contractors

The most obvious reason to hire professional contractors is their experience and certification. Before hiring a professional contractor, a client can review past projects and performances and "shop around" for the right company for the job. Professionals can also be held accountable and must complete their work.

Professional contractors can come with significant costs. When searching for a professional, project managers may find that local entities may not be sufficient, or do not have the expertise to complete the specific project. Contractors cannot be paid on salary either, which may lead to more expenses in the future. If a contractor does work that managers find unsatisfactory, they are stuck with the result and must either live with the end product or hire someone else to fix it.

An Integrated Approach

The best option for any given project depends upon the project. What resources does the project have? Who is paying for each part? What is needed in terms of local and community support? These factors are just a few that need to be considered. Often, budget is one of the biggest issues, so it is tempting to try to rely solely on volunteer work. In other cases, when there is enough funding for it, professional contractors seem to be the best option. Again, what is chosen is entirely dependent upon the individual project.

One solution may be to create a blend of professional contractors and volunteer workers. For example, a professional company can do the initial restoration work while volunteer groups maintain the landscape and help raise funds for the work. This way a project can include the community while ensuring that the project is completed professionally.

GRAPHICAL TIMELINES

Wetland Restoration and Management

1 Mow *Phragmites australis* the winter before restoration work (before March to prevent impacts on nesting birds). Mow the area a second time after July 15, and allow to regrow for at least 30 days.

2 In late August to mid-October, treat *Phragmites* regrowth with Rodeo ® or an equivalent version of glyphosate (safe for aquatic environments).

3 Regrade the wetland to meet the specifications laid out in the design, and add any required soil amendments.

Tip: Woody trees and shrubs should be protected from herbivory using tree shelters adorned with bird netting for two years. Herbaceous plantings should be protected wtih snow fencing, grid wire, and mylar flagging to deter Canada goose herbivory.

4 Plant native species based upon tolerance to inundation, sunlight, salinity (if necessary), and plant structure.

5 For a period of three years, water woody plantings at a rate of 1-1.5 gallons per inch of stem caliper. Water herbaceous wetland plants as needed.

Once stems emerge from the top of the tube, remove the bird netting and slice open the tube in a flower-like pattern to allow for branching to occur.

Maintain a 3’ weed-free buffer around woody plantings to reduce plant competition.

6 Spot treat *Phragmites* regrowth manually (i.e. brush cutting) or chemically (i.e. aquatic safe glyphosate).

Cut tree tube vertically along its entire length and loosely fasten to lower trunks to protect trees from buck rub.

The graphical timeline represents the general steps for restoring a wetland. Restoration of other wetland types, such as saline marshes or forested wetlands, are similar; however, restoration plans would be tailored to habitat-specific hydrology, vegetation structure, and invasive species. Wetland restoration plans must be prepared by a licensed engineer and implemented under the appropriate permits and approvals.

Meadow Restoration and Management

1

In May of the growing season prior to planting, apply a systemic herbicide (glyphosate) to the turf in the proposed meadow area. Repeat at 4-6 week intervals to stop regrowth and exhaust the seedbank within the existing soil.

2

In late fall, use a drill seeder to plant a native meadow seed mix. Seeds will lay dormant in the soil over the winter and will germinate the following spring.

Seeding rates are typically 5-10 pounds per acre. Areas with aggressive weed growth or extremely poor soils may benefit from increased rates.

Tip: Native grass and wildflower seeds are very small and light. Mixing 10 parts masonry sand with 1 part seed mix in the drill seeder will ensure even seed coverage across the planting area.

3

Most native wildflowers do not bloom in the first growing season, focusing instead on developing dense root systems. In contrast, weeds are annuals and will grow much taller than the natives. In the first growing season, mow the meadow monthly at a height of 12 inches to prevent annual weeds from shading out the natives and going to seed.

Tip: Newly planted meadows do not need to be watered except during extremely hot and dry spells.

Plant Selection: Choose species that are well adapted to the site conditions. Create a species mix to promote flowering across the growing season to support pollinators and promote visual aesthetics all season long.

Timing: Meadows can be planted in Spring as well. In such cases, more attention must be paid to watering emerging seedlings. In addition, roto-tilling may be a more appropriate method of soil preparation.

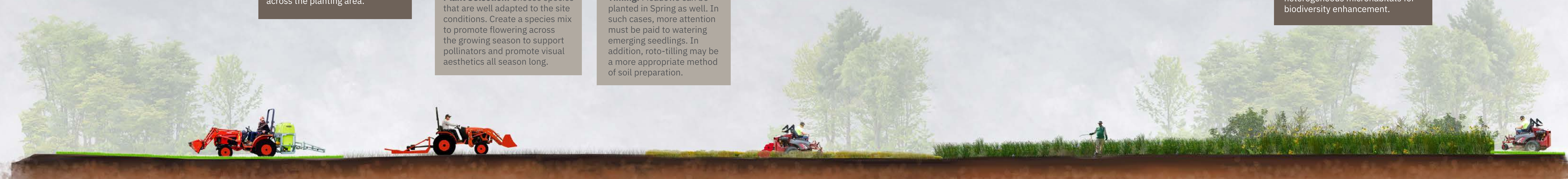
4

Monitor the meadow for colonization of invasive species. Spot treat or hand pull as needed being careful to preserve adjacent native plants.

5

Between 3 and 5 years after meadow installation, mow at a height of > 12 inches to eliminate woody vegetation. Mowing should be completed in late winter/early spring (no later than the first week of April). For long-term maintenance of meadow habitat, mow at 3-5 year intervals.

Tip: Mowing the entire meadow at one time is not necessary. Rotational mowing of meadow sections reduces work load, promotes survival of overwintering pollinating insects, and creates heterogeneous microhabitats for biodiversity enhancement.



Spring/Summer | Late Fall | Spring/Summer | Year 2-3 | Year 3+

Year 1

The graphical timeline represents the general steps for creating and sustaining meadow in an area currently maintained as turf grass.

Woodland Restoration and Management

1 On previously developed parcels, tilling or deep ripping the soil can reduce compaction prior to planting.

2 Plant Native trees and shrubs in a non-uniform pattern in canopy gaps or open understory areas.

Tree species and spacing will be determined during the design process.

Young trees should be adorned with tree shelters to enhance growing conditions and protect against herbivory.

3 Water plantings weekly at a rate of 1-1.5 gallons per inch of stem caliper.

Maintain a 3 ft. weed-free radius around plantings to reduce plant competition.

Tip: The tops of tree shelters should be covered with netting to prevent birds from becoming trapped inside. Mulch around new woody plantings to retain moisture and discourage weed growth.

4 Remove bird netting and slice open tree tubes once leaves and stems grow taller than the tube.

5 Manage invasive plants within the restoration area to reduce competition for resources.

The management method should be determined by what invasive species are present.

6 Cut tree tube in half vertically and loosely fasten to lower trunks to protect trees from buck rub.

7 Continuously monitor for encroachment by invasive plants and manage with appropriate methods.

The graphical timeline represents the general steps for restoring a woodland on newly acquired, open parcels.

09

INVESTING IN LANDSCAPE RESILIENCE: A PHASED APPROACH

In the previous chapters, we have provided a framework for transforming flood-prone landscapes into flood-resilient landscapes. In doing so, we hope to also have made a compelling argument for investing the appropriate financial resources required to successfully plan, design, implement, and maintain flood resilient landscapes. We do not deny that there are significant upfront costs associated with enacting a resilient landscape strategy. Similarly, we argue against restoring a landscape and walking away to let 'nature take its course.' In fact, we stress the need for continued monitoring and maintenance. Here we provide guidance on how to secure funding for landscape resilience projects and how such projects may be phased so that communities can steadily advance toward their resilience goals.

Pre-Disaster Planning

Pre-disaster planning provides a necessary foundation for increasing the scale, connectivity, and impact of resilient landscape interventions. Existing parks, greenways, and other open space within flood-prone areas can serve as the backbone of a landscape resilience project, which can then be augmented with additional property acquisitions. Buyout funding is often tied to declared state and federal disasters, and it becomes available to communities in the months following such events. At this same time, local officials and residents in heavily impacted areas are coping with the physical and emotional stress of the losses that they experienced. Knowing in advance where existing open space can be connected through buyouts puts communities in a position to capitalize on funding as it becomes available.

Pre-disaster planning begins by quantifying the magnitude of flood risk across the target area and determining the potential threats both to human health and safety, as well as critical infrastructure. By overlaying Federal Emergency Management Agency (FEMA) flood zones onto municipal tax maps, and in coastal areas New Jersey-specific information from *(https://www.njfloodmapper.org/)* communities can use GIS to estimate the total land area at risk of flooding now and into the future, as well as the number of residents at risk of personal safety or property damage. Such an analysis should also include a detailed evaluation of hydrology to understand how water moves across the landscape. Knowing where the water is coming from (e.g., upstream factors), as well as where it is going (e.g., discharge areas), is an important first step to determining the size and location of landscape features designed to manage flooding. Flood flows may also be impacted by tidal conditions, causing water to back up into stormwater systems or overtop physical barriers. Another important component of the landscape hydrology is stormwater runoff, which flows across the landscape and is also directed through belowground pipes to discharge areas. Landscape topography plays a key role as well, as water will collect at the lowest elevations. Finally, knowing the infiltration capacity of soils and the locations of wetlands will provide additional insight into the areas most likely to be affected by storm events.

Such mapping exercises and analyses can also quantify the amount of critical infrastructure (i.e. police stations, hospitals, utility services, gas stations, crucial community centers) at risk. This information can be supplemented with anecdotal accounts from both recent and historic flooding events to identify highly vulnerable areas that have been subject to repeated damage or flood management activities, including road closures, boat rescues, and structural repairs. It is important to note that some of the information suggested here may be considered confidential and will need to be handled appropriately by local officials. However, having an accurate representation of where floods have occurred gives a strong indication of where floods are likely to occur, and how severe those flood events may be, providing a strong justification for targeting the most at-risk properties and neighborhoods for a coordinated buyout strategy. Mapping of flood prone areas and at-risk properties can be combined with mapping of existing open space, parks, greenways, and trails. Using the landscape resilience planning process discussed in Chapter 2, a community can work with professionals and local stakeholders to develop conceptual plans and guidance to integrate recreation, open space, and ecological restoration enhancements into their resilience strategy.

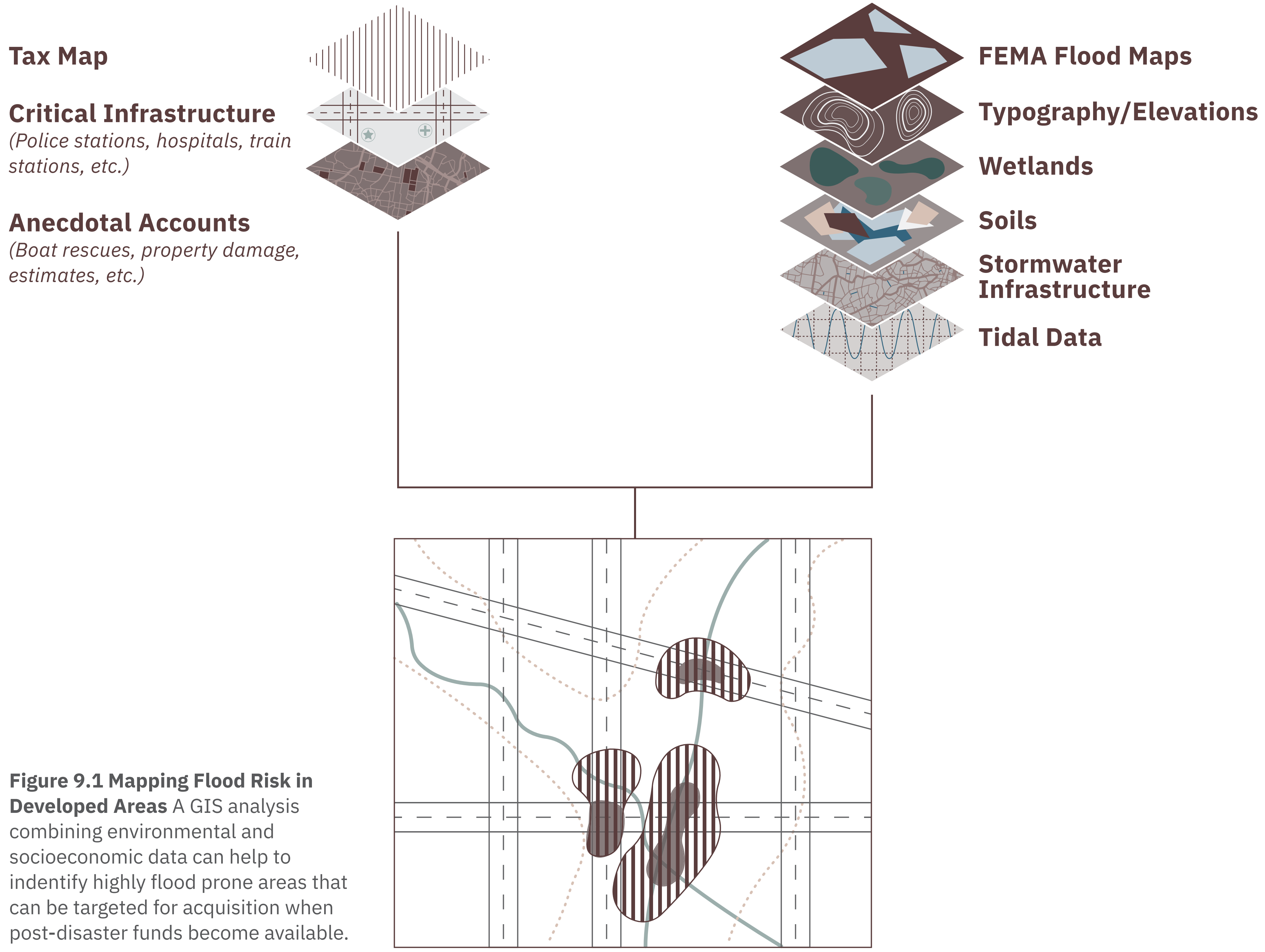


Figure 9.1 Mapping Flood Risk in Developed Areas A GIS analysis combining environmental and socioeconomic data can help to indentify highly flood prone areas that can be targeted for acquisition when post-disaster funds become available.

Planning requires an upfront commitment of time and resources from the community. Much of the work may need to be funded by the community itself. There are opportunities for planning initiatives to be integrated into existing community planning efforts, such as municipal master planning. Resources for pre-disaster planning can be found within New Jersey and through the federal government.

The Resilient NJ program, offered through the New Jersey Department of Environmental Protection (DEP), is an assistance program that provides planning support to municipalities, counties, and regions. This assistance occurs in several ways. DEP-approved consultant teams work directly with local governments, at no cost to the municipality or county, to conduct individualized planning activities, including outreach and engagement, vulnerability assessments, or development of resilience action plans. A community resilience action plan can accomplish the pre-disaster planning described in this document. Availability of assistance is announced on the program's website *(https://www.nj.gov/dep/bcrp/resilientnj/)* as funding becomes available. The Resilient NJ program also includes an online Local Planning for Climate Change Toolkit *(https://experience.arcgis.com/experience/9daab51c2f5542969d50437522e012c4)* that provides the necessary guidance and resources for municipalities interested in undertaking climate resilience planning activities on their own. Similarly, the New Jersey Department of Environmental Protection's Blue Acres Program plans for strategic, state led buyouts in flood prone and climate vulnerable areas. Utilizing a combination of federal grant funds and dedicated state monies Blue Acres works to buyout land that will allow for nature based solutions to reduce flooding and to mitigate the impacts of climate change.

FEMA provides guidance and limited funding to communities to develop hazard mitigation plans focused on rebuilding and recovery that reduces, or mitigates, future losses from natural disasters. FEMA has also issued a pre-disaster community planning guide designed to help local governments develop plans through a community engagement process. The FEMA pre-disaster planning guide is available at *https://www.fema.gov/sites/default/files/2020-07/pre-disaster-recovery-planning-guide-local-governments.pdf.* The federal government sponsors programs for communities looking to reduce risk from future disasters, such as the FEMA Hazard Mitigation Assistance Grants *(https://www.fema.gov/grants/mitigation).* However, municipalities investing internally in pre-disaster planning will be poised to capitalize on future federal allocations for flood resilience. They can also seek non-federal dollars to begin implementing resilience interventions on existing publicly owned lands within or adjacent to high-risk flood zones. A community with a plan that has been adopted and integrated into a master plan and vision for the future will be best prepared to take advantage of available funding to assist in recovery following a major flood event.

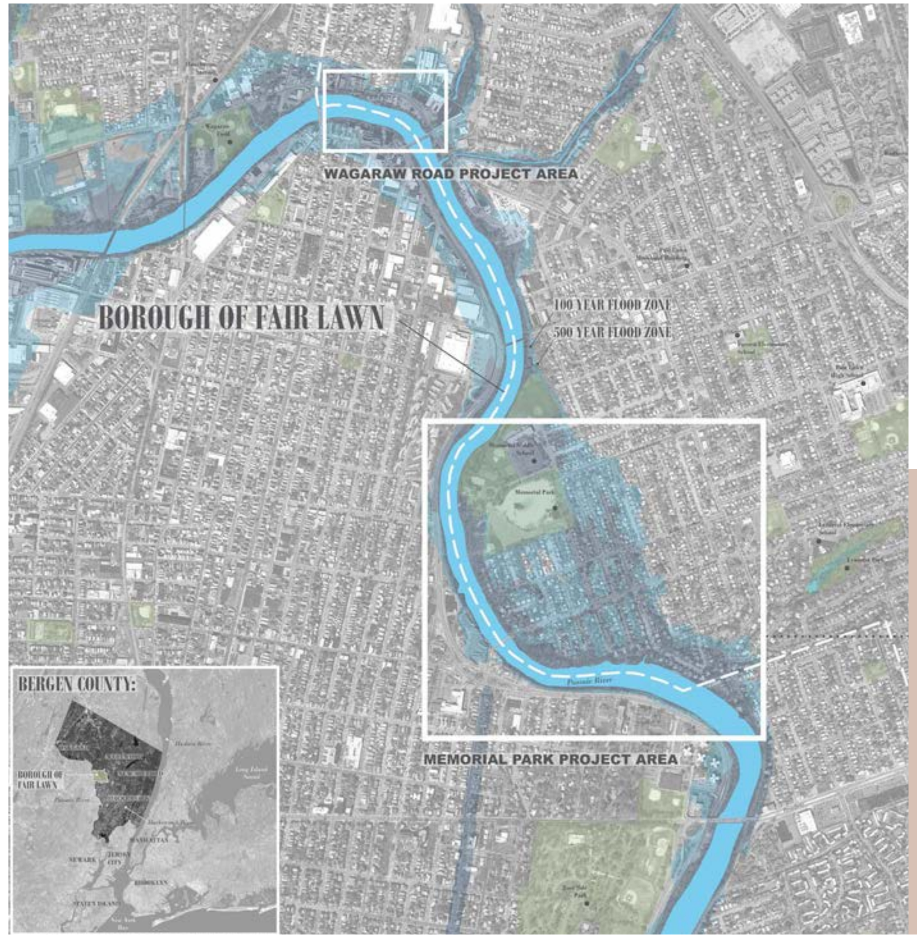


Figure 9.2 Preliminary Flood Risk Analysis for Fair Lawn, New Jersey Results of a preliminary flood risk analysis for the community of Fairlawn overlaying the FEMA 100-year and 500-year flood zones with an aerial photograph. This map identifies at-risk neighborhoods and specific tax parcels, and it highlights locations of existing open space within and in close proximity to the project area. Such maps provide the foundation for building community understanding of local flood risk and where existing open space can provide the foundation for larger interconnected ecological restoration projects. (Credit: Rutgers Cooperative Extension)

Figure 9.3 Fair Lawn Floodplain Conceptual Restoration Plan Conceptual plan for establishing a flood resilient landscape in a former residential section of Fairlawn. The preliminary design outlines areas for a variety of appropriate habitats as well as trails and open space amenities. Such conceptional plans provide a long-range vision of the landscape transition from inhabited neighborhoods to open space and identify areas where flood storage interventions are most feasible. (Credit: Rutgers Cooperative Extension)

PHASING IMPLEMENTATION OF RESILIENCE INTERVENTIONS

As discussed in Chapters 7 and 8, landscape resilience interventions require a long-term commitment to achieve success. The community will need to invest in not only the initial restoration and implementation, but also maintenance and management activities. Support from other sponsors and organizations can provide beneficial partnerships to leverage funding and person power to advance landscape resilience projects. Below are a range of activities and strategies that can begin to move a community forward. A community will need to work with a technical team and local leadership to evaluate their institutional capacity and determine levels of available resources and funding to plot a path forward (see Chapter 2).

Implementing Ecological Restoration

Implementation of ecological restoration efforts requires a long-term commitment and a willingness to work in phases. As discussed throughout this document, the landscape transformation process requires many partners and steps to realize success. While certain aspects of a project may need years of planning and preparation, such as creating a wetland or constructing a paved trail, there are other actions that community members and residents can immediately initiate to begin moving toward a more resilient landscape. A successful landscape resilience program will include a variety of phases and implementation efforts ranging from outreach and volunteer participation to detailed hydrologic design and habitat reconstruction. **Table 9.1** provides examples of the types of actions that are often part of a resilient landscape project. Potential actions are categorized by level of complexity and funding requirements, and guidance is provided regarding anticipated impacts, benefits, and approvals needed.

Community Engagement Actions

It is important to demonstrate to the community that open space is a valuable public asset. Establishing a program of river clean ups and volunteer plantings can give residents a sense of ownership and play an important role in building public support for larger and more intensive restoration efforts. Education programs as well as programs that support actions by homeowners that help to reduce runoff,

protect rivers and waterways, and promote biodiversity are effective ways to inform the community about plans for ecological restoration. Small scale, outreach initiatives include rain barrel installation programs, community planting days, etc. These types of activities can be implemented with limited resources and technical guidance and can continue throughout the life of a project. Local environmental nonprofit organizations, Rutgers Cooperative Extension, the Master Gardeners Program, and others can be effective community partners and may provide resources and guidance for this initial effort.

Feasible actions at the site scale must be determined on a case by case basis, depending on the individual project parameters and goals. Combining professional and volunteer support may offer a successful integrated approach. (Photo Credit: Rutgers Cooperative Extension)

Volunteers can be a valuable resource for installing large quantities of plant material within restoration sites. All volunteers should be properly trained and supervised to ensure that planting is completed in accordance with the restoration design and that the methods used promote establishment of vegetation. (Photo Credit: Rutgers Cooperative Extension)

Site Scale Actions

Many activities in ecological restoration projects require careful planning, design, and permitting. Larger scale plantings (>1 acre) will need funding and partnerships to implement. Areas infested with invasive plant species should be coordinated with deliberate efforts to replant and manage for persistence of native species. Recreational amenities, such as paved trails, boardwalks, and fishing piers require that engineering drawings be prepared and permits be secured. All projects should be identified and prioritized based upon a master plan.

Landscape Scale Actions

When considering ecological restoration that will involve extensive earth moving and disturbance in sensitive habitat areas, communities will need to look for long-term commitments and partnerships with dedicated professionals and funding organizations. Funding needs should be anticipated for the following four broad phases: 1) planning; 2) preliminary assessment and design; 3) final design and permitting; 4) implementation and monitoring. Additionally, in previously developed areas, decommissioning aging or obsolete infrastructure, such as roads, sewers, and electrical lines, as well as excavating and disposing of fill materials will require extensive design, planning, coordination, and permitting, which can come at increased costs.

Professional contractors are likely needed when conducting landscape-scale restoration activities, or those smaller scale activities that involve regrading landscape topography to manage flood water. (Photo Credit: Rutgers Cooperative Extension)

Table 9.1 Comparison of Flood Resilience Actions that can be Initiated by Communities

Actions are categorized by type, cost, impact, and regulatory requirements.

Action Type	Implementation Strategy	Project Type	Cost	Community Impacts	Flood Resilience Impact	Approvals Needed
Community Engagement	Green stormwater infrastructure	Downspout disconnection	$	Reduced stormwater runoff and improved water quality	Low	Resident
Community Engagement	Green stormwater infrastructure	Rain barrel	$	Reduced stormwater runoff and improved water quality	Low	Resident
Community Engagement	River clean up	Volunteers organized to remove debris	$	Community outreach and education/trash removal	Low	Community
Community Engagement	Pocket parks	Passive activities/pollinator plantings	$$	Increase in neighborhood recreation	Low	Municipal
Community Engagement	Pocket parks	Community garden	$$	Increase in neighborhood recreation	Low	Municipal
Community Engagement	Pocket parks	Active play	$$$	Increase in neighborhood recreation	Low	Municipal
Community Engagement	Streetscape	Street trees < 25	$$	Increase in canopy cover	Low	Municipal
Site Scale	River access	Scenic overlook	$$$	Increase in public relation	Low	NJDEP, County, and Municipal
Site Scale	Trails	Unpaved trails (per 100 linear feet)	$$	Increase in public relation	Low	NJDEP
Site Scale	Streambank stabilization	Streambank bioengineering plantings	$$	Reduced erosion, improved aquatic habitat	Medium	NJDEP
Site Scale	Green stormwater infrastructure	Residential rain garden	$$	Reduced stormwater runoff and improved water quality	Medium	Resident
Site Scale	Meadow establishment	Native meadow < 1 acre	$$	Increase in biodiversity, reduced mowing	Medium	Community
Site Scale	Invasive species management	Herbicide application < 1 acre	$	Increase in biodiversity and improved wildlife habitat	Low	Licensed applicator required
Site Scale	Forest establishment	Deer protection @ 1 acre	$$	Increase biodiversity and forest health	Low	Community
Site Scale	Invasive species management	Selective removal/girdling < 1 acre	$$	Increase in biodiversity and improved wildlife habitat	Low	Licensed applicator required
Site Scale	Forest establishment	Floodplain forest < 1 acre	$$	Increase in canopy cover	Medium	Community
Site Scale	Road removal	Road demolition < 10,000 sq ft	$$$	Less impervious cover, reduced maintenance	Medium	Municipal
Site Scale	River access	Fishing access	$$$	Increase in public recreation	Low	NJDEP, County, and Municipal
Site Scale	River access	Canoe/kayak launch	$$$	Increase in public recreation	Low	NJDEP, County, and Municipal
Site Scale	Streambank stabilization	Bioengineering up to 300 feet	$$	Reduced erosion, improved aquatic habitat	Medium	NJDEP
Site Scale	Parking	Install parking are for up to 12 vehicles	$$$$	Increase in public recreation	Low	NJDEP, County, and Municipal
Site Scale	Streambank stabilization	Rip rap stabilization up to 150 feet	$$$	Reduced erosion, improved aquatic habitat	Medium	NJDEP
Site Scale	Streetscape	Street trees > 25	$$$	Increase in canopy cover	Medium	Municipal
Site Scale	Stormwater wetlands	Constructed wetland < 1 acre	$$$	Flood protection and improved water quality	High	NJDEP
Landscape Scale	Trails	Boardwalk construction (per 10 linear feet)	$$$$	Increase in public recreation	Low	NJDEP
Landscape Scale	Trails	Paved walkways (per 100 linear feet)	$$$$	Increase in public recreation	Low	NJDEP
Landscape Scale	Invasive species management	Herbicide application > 1 acre	$$$	Increase in biodiversity and improved wildlife habitat	Medium	Licensed applicator required
Landscape Scale	Meadow establishment	Native meadow > 1 acre	$$$	Increase in biodiversity, reduced mowing	High	Community
Landscape Scale	Invasive species management	Selective removal/girdling > 1 acre	$$	Increase in biodiversity and improved wildlife habitat	Low	Licensed applicator required
Landscape Scale	Forest establishment	Floodplain forest > 1 acre	$$$$	Increase in canopy cover	High	Community
Landscape Scale	Green stormwater infrastructure	Right-of-way bioretention	$$$$	Reduced stormwater runoff and improved water quality	High	Municipal
Landscape Scale	Road removal	Road demolition > 10,000 sq ft	$$$$	Less impervious cover, reduced maintenance	High	Municipal
Landscape Scale	Stormwater wetlands	Constructed wetland > 1 acre	$$$$	Flood protection and improved water quality	High	NJDEP

FUNDING RESILIENCE PROJECTS

Sources of external funding are always shifting. Communities who have been proactively preparing to restore flood prone areas are in the best position to receive funds. Those communities with shovel-ready plans that demonstrate initial internal investment in sound science, preparedness, and an understanding of nature-based solutions for restoring ecological function and flood resilience are often the first to be recognized and receive funding. Communities also need to realize that rarely will one single funding source provide the entire sum of financial resources required to complete a project. Multiple funding mechanisms secured over several years are typically needed to move a project to completion. Additionally, a long-term commitment to manage and maintain the project is essential to ensuring success.

A variety of funding can be used to support ecological resilience projects. The following discussion outlines several funding sources and partnerships that the authors and communities have used. We do not aim for this to be a comprehensive list, as the funding landscape is continually in flux. Rather, we hope the information provided demonstrates the variety of potential funding sources available.

American Flood Coalition
Flood Funding Finder (floodcoalition.org)

The coalition consists of a consortium of elected officials, military leaders, businesses, and civic groups focused on finding solutions for flooding and sea level rise. They maintain a database of federal funding opportunities focused on addressing flooding in small communities.

Tidal marsh (Photo Credit: Rutgers Cooperative Extension)

Funding Level $-$$

Association of New Jersey
Environmental Commissions (ANJEC) *(anjec.org)*

This organization supports municipal environmental commissions and other similar groups to protect New Jersey's natural resources. Their grant program provides funds up to $1500 for open space stewardship projects.

New Jersey Urban and Community Forestry Program
(www.nj.gov/dep/parksandforests/forest/urbanandcommunity/index.html)
The Urban and Community Forestry program and NJDEP supports the stewardship and management of healthy trees and forests. Through technical assistance and funding the program provides opportunities to support efforts aligned with ecological restoration. Communities can become accredited after adopting and implementing an approved management plan for trees and forests, training and education, and annual reporting. Accredited communities are then eligible to apply for funding to conduct community tree and forest inventories, risk tree assessments, tree planting, and reforestation.

Sustainable Jersey
(www.sustainablejersey.com)
Sustainable Jersey is a network of communities, schools, and school districts working toward a sustainable future. Through partnerships with state agencies, nonprofit organizations, academia, and industry they provide technical assistance and funding to community collaborators. Certified communities can receive technical assistance and funding through Sustainable Jersey for environmentally focused projects and programs.

Funding Level $$-$$$

County Open Space Programs

County programs to support open space land acquisition and recreation development can provide opportunities for funding of ecological restoration projects that include floodplain protection and improved recreational access. Typically funding is dispensed through a grant application process.

New Jersey Corporate Wetlands Restoration Partnership

(www.njcwrp.org)

This public-private initiative focuses on preserving, enhancing and protecting aquatic habitats throughout New Jersey. The organization provides funding, technical design review, and in-kind services to projects on public and protected lands in New Jersey that improve the health of wetlands, coastlines, rivers and waterways.

USFWS Partners for Fish and Wildlife

(www.fws.gov/program/partners-fish-and-wildlife)

This program provides technical assistance to communities to improve wildlife habitat. By partnering with the USFWS communities can receive support for a variety of habitat enhancement activities including native plantings, meadow seeding, and invasive plant species control.

Funding Level $$$-$$$$

National Fish and Wildlife Foundation (NFWF)

(www.nfwf.org)

NFWF supports restoration and enhancement of habitats for fish, wildlife, and plants. The organization leverages funding from U.S. corporations and federal agencies in support of a wide variety of conservation and restoration activities. Through a competitive grant program, NFWF provides dollars to communities and nonprofit organizations to meet established conservation priorities.

New Jersey Green Acres

(www.nj.gov/dep/greenacres)

The Green Acres Program provides funding for acquisition and development of open space areas throughout New Jersey. The program is committed to preserving New Jersey's rich natural, historic, and cultural heritage. Through competitive grants and public and nonprofit partners, communities can secure funds to assist with open space projects.

New Jersey Blue Acres

(dep.nj.gov/blueacres)

The Blue Acres program in New Jersey works to protect public safety and the environment by relocating New Jersey families whose homes are subject to repeated flooding. Communities can work with Blue Acres to acquire properties that can then be used for natural flood storage, parks, and community open space.

FEMA

(www.fema.gov/grants)

The Federal Emergency Management Agency provides assistance to communities and people during and after natural disasters. The program provides funding for acquisition of flood prone properties as well as grants to communities for preparedness planning, resilience planning, and hazard mitigation.

U.S. Department of Housing and Urban Development

(https://www.hud.gov/program_offices/comm_planning/cdbg-dr)

HUD provides community development block grants to assist communities in recovering from disasters. These funds can provide seed money to cities and counties following presidentially declared disasters. The program is targeted for low-income neighborhoods and communities with limited resources to begin recovery activities.

Aquatic Ecosystem Restoration Program

(https://www.sas.usace.army.mil/Missions/CAP/Section-206-Aquatic-Ecosystem-Restoration/)

Under the authority provided by Section 206 of the Water Resources Development Act of 1996, The U.S. Army Corps of Engineers can implement projects to restore aquatic ecosystems for fish and wildlife. A non-federal partner must request assistance from the Army Corps, upon which a feasibility study of the project is initiated.

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