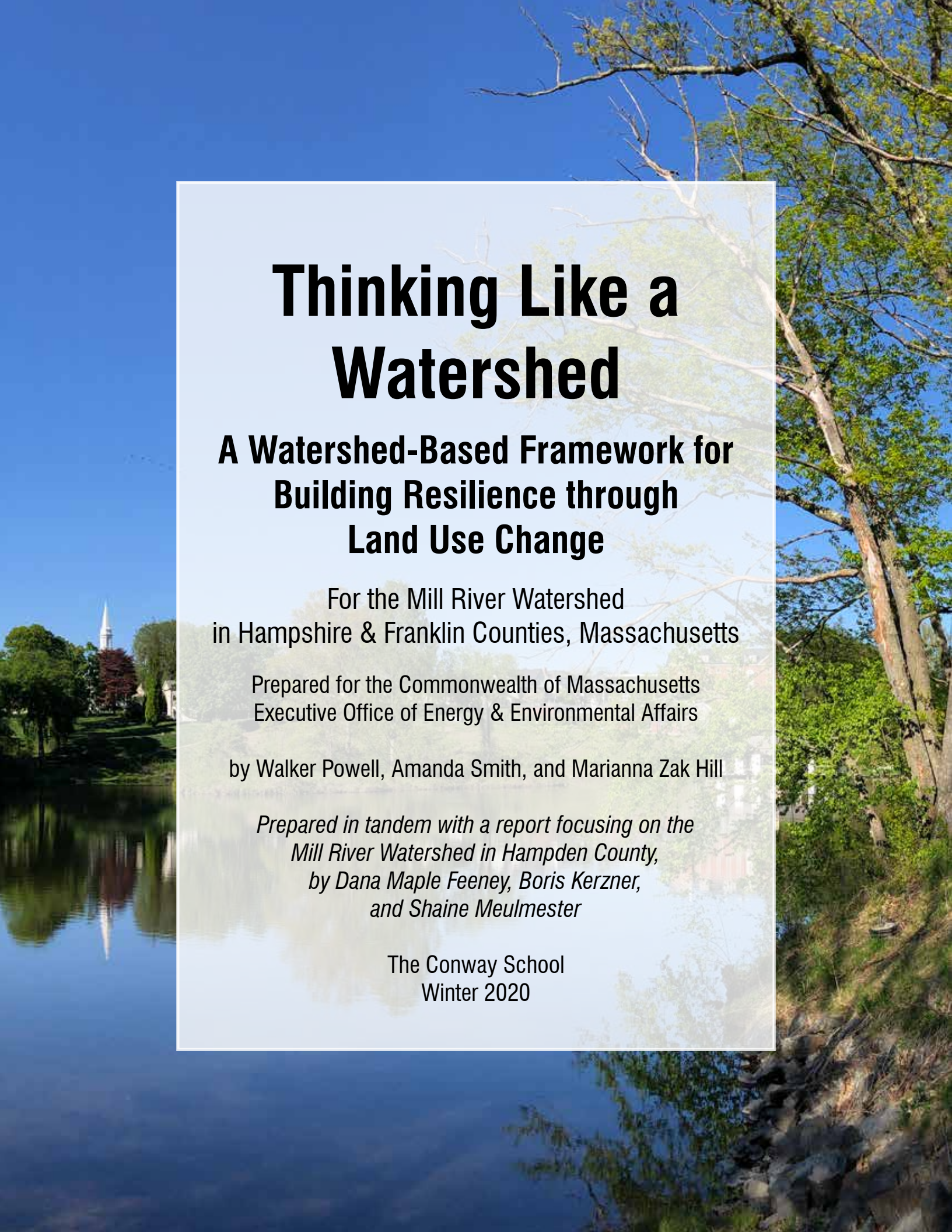


Thinking Like a Watershed

A Watershed-Based Framework for Building Resilience through Land Use Change

For the Mill River Watershed
in Hampshire & Franklin Counties, Massachusetts

Prepared for the Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

by Walker Powell, Amanda Smith, and Marianna Zak Hill

Prepared in tandem with a report focusing on the Mill River Watershed in Hampden County, by Dana Maple Feeney, Boris Kerzner, and Shaine Meulmester

The Conway School
Winter 2020

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This report was prepared by a team of graduate students from the Conway School, Northampton, Massachusetts, January through March 2020, for the Resilient Lands Initiative, a working group of the Massachusetts Executive Office of Energy and Environmental Affairs, under the direction of Robert O'Connor, Director of Conservation Services.

This report is one of two produced by Conway teams during the same time period. Walker Powell, Amanda Smith, and Marianna Zak Hill produced this report, focusing on the mostly rural watershed of the Mill River that drains to the Connecticut River in Northampton, Massachusetts. This team worked in conjunction with their counterpart team (Dana Maple Feeney, Boris Kerzner, and Shaine Meulmester) whose work focuses on the mostly urban watershed of the Mill River that enters the Connecticut River in Springfield, Massachusetts. The two teams collaborated to prepare the framework and analysis processes found in each report.

This work would not be possible without the support and input of numerous stakeholder groups in the area, including the Williamsburg MVP, Greenway, and Open Space Committees, Northampton Planning & Sustainability Department and Public Works Department, the Hilltown Land Trust, and others.

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Cover photo: Paradise Pond, Northampton
Photos by Marianna Zak Hill

CONTENTS

INTRODUCTION 1

What is the Resilient Lands Initiative?
Climate Change: How Will it Affect the Northeast?
What is the Resilient Lands Initiative?
Why Plan at the Watershed Scale?
What is Resilience?
What is Sustainable Land Use?
Why These Watersheds?
Comparing Watersheds Across the State
Summary of the Process

PART ONE Assessment Framework Summary 10

PART TWO Mill River Watershed Assessment 16

STEP ONE Forming a Watershed Working Group 18

STEP TWO Identifying Risks and Community Priorities 20

What is the History of the Mill River Watershed?
How is the Climate Likely to Change in this Region?
What Do the Communities Perceive to be the Biggest Risks?

STEP THREE Analyzing Assets and Vulnerabilities 26

Impervious Surfaces
Tree Cover
Ground-truth Analyses

STEP FOUR 46

Identifying Sites
Mill River Watershed Recommendations
- Conservation
- Restoration
- Stewardship
- Policy and Regulations

CONCLUSION 64

APPENDIX A: TERMS AND DEFINITIONS 70

APPENDIX B: REFERENCES 75

Acronyms & Key Terms

APR	Agricultural Preservation Restriction
BMP	Best management practice
CPA	Community Preservation Act
CR	Conservation Restriction
EEA	Executive Office of Energy and Environmental Affairs
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GWSA	Global Warming Solutions Act
HMP	Hazard Mitigation Plan
HUC	Hydrologic Unit Code
IPCC	Intergovernmental Panel on Climate Change
MVP	Municipality Vulnerability Preparedness
NACRP	National Association of Climate Resilience Planners
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
OSRP	Open Space and Recreation Plan
PVPC	Pioneer Valley Planning Commission
RLI	Resilient Lands Initiative
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
WPA	Wetland Protection Act

Executive Summary

How can human resilience in the face of climate change be measured and improved in each one of Massachusetts' watersheds?

This report presents a framework for developing resilience planning initiatives that address regional and local vulnerabilities to climate change impacts using a watershed approach. Like ecological systems, climate-related threats function at regional scales, beyond the scope of singular political authorities. Therefore, a systemic and cooperative approach is necessary to support both ecological and social wellbeing. This report uses the watershed scale as the base unit for resilience planning because it is defined hydrologically, rather than politically, and it is a standardized unit for measuring ground and surface water resources.

There are many definitions of resilience, and this report uses the definition: "the capacity of social, economic, and environmental systems to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation" (IPCC 5). This document is specifically focused on developing a framework to identify priorities areas for land-based interventions that could increase resilience of human communities to the effects of climate change. Using a watershed in western Massachusetts as a case study, this report presents a process that communities can use to develop coordinated planning initiatives that will provide benefits to the resilience of human communities within the watershed. The goal for this framework is that it will be replicable for any watershed throughout the state.

Many state programs are already available to support and encourage municipal-led resilience planning, including the Municipality Vulnerability Preparedness (MVP) program. The framework represented in this report is looking beyond individual towns to identify shared resources and threats, and to facilitate concerted efforts that will benefit all municipalities involved. Many municipalities have already acknowledged in their MVP documents that some threats to their communities are regional and beyond their ability to address.

This report presents a series of steps designed to give municipalities a way to work together to implement land-use interventions that may reach across political boundaries and that could have impacts beyond a single municipality. These steps begin with a thorough analysis of research and work already done to identify threats and potential interventions, both by looking at municipal visioning documents and watershed-scale GIS analysis. In the Mill River watershed, many of the towns have already accomplished a great deal on their own, and are already beginning to think of ways to work together to combat climate change.

Once the information is gathered and assessed, the next step is to identify locations in the watershed where land-use change could provide the greatest boost to human resilience. Interventions were divided into four broad categories: restoration of human-disturbed ecosystems and installation of nature-based solutions to increase ecological functioning of more urban areas; conservation of areas that possess healthy ecosystems; stewardship of conserved or managed land in order to increase the resilience and ecological functioning in areas such as farmland, woodlots, and managed green spaces; and policy or regulatory changes that can create more sustainable land use in the long term. To truly capitalize on the benefits of watershed-scale planning, these interventions should be implemented across political boundaries, with the goal of increasing resilience of all human communities within the watershed.





Introduction

Climate Change: How Will it Affect the Northeast?

In the Fourth National Climate Assessment, published in 2018, the chapter on the Northeast outlines the climate change threats that are most likely to impact this region (Dupigny-Giroux, L.A., et al., 2018). These include rising temperatures, ocean changes, and increased extreme precipitation events. The Northeast is predicted to see a faster and higher rise in average temperatures than any other area of the contiguous United States. This will impact seasonal patterns and is already causing shifts in spring warming trends and milder winters. Although the growing season is getting longer, the risk of late spring frost harming crops is increasing, due to the variability in frost dates and warming trends. On the coasts, rates of sea level rise and warming are predicted to be higher in the Northeast compared to other regions. This is likely due to the fact that in addition to polar ice melt, the ground itself is slowly sinking, due to the lingering effects of the glaciar withdrawal 10,000 years ago, as well as a weakening of the Gulf Stream, which is related to climate change. Another ocean-related issue is ocean acidification, which has increased rapidly in the last 200 years, and has wide-ranging impacts on ocean biodiversity and the health of ocean ecosystems. This acidification is likely to particularly impact economically valuable seafood such as oysters and other shellfish. The third primary threat in the Northeast is increased extreme precipitation events, which includes events such as rainstorms, hurricanes, ice storms, and blizzards. Since 1958, the Northeast has already seen a 70% increase in the volume of precipitation falling during extreme events, which are defined as the heaviest 1% of all rain events, and this is projected to continue, although annual precipitation may not increase significantly. Periods of drought are also likely to increase.

Human communities will feel the impact of these threats in all aspects of their lives. Key areas where climate change is predicted to have the greatest impact are human health, human safety, economic stability, and human migration patterns (Dupigny-Giroux, L.A., et al., 2018). Human health impacts in the Northeast include issues related to increased temperatures, pollution, flooding, and more frequent droughts. The decrease in air quality and increased temperatures will contribute to rising rates of asthma, heart disease, and heat-related illness and deaths. Degradation of water quality may also pose risks to human health if warmer waters lead to bacterial growth, and drought may affect drinking water supplies and water quality. Human safety will be impacted due to more extreme storms and altered patterns of snowmelt in the spring, which will lead to more flooding. Many Massachusetts communities are built in floodplains or near rivers, and are often vulnerable to floods already. Sea level rise also significantly impacts human safety as coastal towns suffer more frequent inundations due to regular and very high tides. The storm surge inundation caused by more intense storm events, also an effect of climate change, is exacerbated by sea level rise. The climate

Smith College, Northampton

effects on economic stability will be felt by all communities as changing weather patterns and extreme storms impact rural, urban, and coastal economies. Changing spring weather patterns have already caused hardship for farmers and maple syrup producers, which are key elements of the rural Massachusetts economy, as well as timber harvests, which require frozen ground to prevent soil degradation and erosion. Massachusetts tourism, ski, and outdoor recreation industries will also feel the impacts of warmer temperatures, less regular seasons, and less snow. Ocean warming and acidification will only exacerbate the issues already faced by fisheries and aquaculture farms, such as declining fish populations due to overfishing. Another concern particularly in Western Massachusetts is the potential shift in human migration patterns; although the research remains unclear, it is possible that sea level rise and changing temperatures will result in migration of people from coastal to inland areas, and from urban areas in floodplains or along coasts to rural, upland areas. This shift could lead to increased development pressure on areas that may not be currently protected from development.

In the face of these threats, Massachusetts is addressing climate change at a state-wide level. The state has a variety of policies and programs to reduce greenhouse gas emissions and improve resilience and adaptability to climate impacts at both the statewide and community levels.

In addition, the Baker-Polito Administration announced in January 2020 a resolution to reach net carbon neutrality by 2050 and has included $298 million in the 2021 budget to help support resiliency, preparedness, and data collection efforts to combat climate change. The Executive Office of Energy and Environmental Affairs (EEA) is taking a leading role in the state's efforts to combat climate change and improve energy efficiency.

What is The Resilient Lands Initiative?

The Resilient Lands Initiative is guided by a steering committee of over fifty environmental stakeholders convened by the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) to inform an updated statewide conservation plan. The previous plan was created in 2001 and adopted in 2003. The Resilient Lands Initiative steering committee explores how conservation and other nature-based solutions can mitigate and help communities adapt to climate change. The RLI helps identify opportunities to build more resilient communities and shift development towards more sustainable land use strategies, with a focus on municipal, regional, and statewide actions. Increasing the sustainability of land use has benefits beyond increasing community resilience to climate change because these changes can also help mitigate other issues, such as land degradation. Nature-based solutions can also increase opportunities for human connections with nature, outdoor recreation, pedestrian connectivity, and environmental education, and support biological communities.

The Resilient Lands Initiative uses eight themes to guide its work: farms, forests, wildlife habitat, parks and public health, outdoor recreation, water supply protection, protection from climate impacts, and economic stability. By illuminating common goals across these eight themes, the RLI can identify and promote the policies, land uses, and education necessary to shape more resilient communities across the state.

Successful applications of innovative land management strategies in Massachusetts, such as the creation of parks and the conservation of land, engender sustainable forestry practices and have economic benefits (RLI, November 2019).

The **Global Warming Solutions Act (GWSA)** of 2008, which "requires a 25% reduction in greenhouse gas (GHG) emissions from all sectors of the economy below the 1990 baseline emission level in 2020 and at least an 80% reduction in 2050."

The 2018 **Environmental Bond Bill**, which provides grants and loans to aid businesses and communities to achieve greater resilience and adapt to climate impacts.

The **Municipal Vulnerability Preparedness (MVP)** program, which "provides support for cities and towns in Massachusetts to begin the process of planning for climate change resiliency and implementing priority projects," by providing funding for the process of completing vulnerability assessments. Municipalities that complete the program qualify for MVP Action Grants to enact recommendations from their report.

The **Green Communities Grants** program, "provides funding opportunities to reduce municipal energy use and costs by way of clean energy projects in municipal buildings, facilities, and schools; guidance, technical assistance, and local support from Regional Coordinators."

Community Preservation Act (CPA), helps communities fund historic and open space conservation, expand outdoor recreation opportunities, and build affordable housing. The CPA is funded through a local surcharge on property taxes and these funds are matched by the state.

Having a framework or process for decision-making that acknowledges the importance of natural systems may help decision-makers see those systems and justify their protection in land use decisions. As discussed further below, planning explicitly at the watershed scale allows (and requires) communities to think about ecological processes; planning informed by such ecological processes is more likely to lead to sustainable land uses (RLI, November 2019). This report, commissioned by Robert O'Connor, Director of Conservation Services at the Massachusetts Executive Office of Energy and Environmental Affairs, supports the Resilient Lands Initiative's work by using watershed planning to enhance climate change resilience, presenting a framework for communities to identify climate change risks and priorities, analyze vulnerabilities, and develop land use interventions at the watershed scale.

Why Plan at the Watershed Scale?

Watershed planning is emerging as a model to protect and improve water quality. Watershed management typically focuses on improving socio-economic stability and human health through improved water quality. For example, decreasing pollutants in a stream can increase outdoor recreation opportunities and reduce human exposure to health hazards.

While it is slightly unconventional to use the watershed as a framework for assessing climate change resilience, many of the risks that watershed plans consider, such as flooding, are exacerbated by climate change. Confronting these unprecedented challenges within communities will require new partnerships among stakeholders, such as the ones the RLI steering committee seeks to promote through its work. Understanding how climate change will affect watershed communities, such as increased flooding, runoff into streams, and channelization upstream impacting communities downstream, could highlight areas where communities may benefit from working together.

This document asks: How can watershed planning be applied as a framework for assessing human resilience to climate change, and improving resilience through land use changes? How can using the watershed as a unit of planning engender new forms of cooperation and support to communities as they take steps towards climate change preparedness?

The challenge at hand, to protect humans through land use changes, requires paradigm shifts. The management of watersheds, as with all environmental management, requires a shift in social attitudes away from granting primacy to short-term economic need towards a more ecologically-minded, resilient vision (Beheim et al 2010. vi). One such shift is that the "highest and best use" for land may not always be development, such as commercial and residential construction, or the paving over of open space.



The Connecticut River Watershed includes parts of Connecticut, Massachusetts, Vermont, New Hampshire, and Quebec. Source: ctriver.org

Conservation, natural open space, regenerative agriculture, and other sustainable uses may have equal or greater benefits.

Massachusetts currently has watershed-based plans to protect and restore water quality in all twenty-seven basins, based on EPA guidelines (mass.gov, 2020). This report differs from these other watershed plans in that it focuses on a watershed which is a sub-basin of one of the larger twenty-seven watersheds, and it explores issues posed by climate change that are not solely related to water quality.

Watershed-based plans represent a multidisciplinary approach to community-based resource management (Shriyana et al. 2020). At the watershed scale, it becomes apparent that resources such as forested land and wetlands and challenges such as flooding are shared among municipalities and require a cross-municipality approach.

Understanding climate risks at the watershed scale can also enable resource sharing and partnerships. In its guidelines for watershed planning the EPA writes, "[b]ringing together people, policies, priorities, and resources through a watershed approach blends science and regulatory responsibilities with social and economic considerations"

What is Resilience?

Resilience is a word with several distinct definitions. What is meant by "resilience" in this context?

Crawford Stanley Holling's seminal paper "Resilience and Stability," from 1973, makes the distinction between two different definitions of resilience: engineering and ecological. He describes engineering resilience as the ability of a system to return to a state of equilibrium after a disturbance (1). In this definition, the more quickly a system returns to its pre-disturbance state, the more resilient it is. Holling describes ecological resilience, on the other hand, as "the magnitude of the disturbance that can be absorbed before the system changes its structure" ("Engineering Resilience versus Ecological Resilience" 33). While this view similarly sees systems as inevitably returning to a point of equilibrium, it allows for many states of equilibria. In this view, a system may, as the result of a disturbance, flip between these alternate equilibria.

More recently, a third concept, socio-ecological resilience, has emerged (Folke et al.). This perspective challenges the notion of equilibrium altogether and acknowledges the "complex, non-linear, and self-organising" nature of ecological systems (Berkes and Folke 12), and sees those systems that possess "the ability to persist and[...]adapt" as the most resilient (Adger 1). The Intergovernmental Panel on Climate Change's definition of resilience echoes this; it defines resilience as "the capacity of social, economic, and environmental systems to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning, and transformation" (IPCC 5).

Many disciplines apply the engineering definition, and in doing so interpret resilience as the ability to bounce back to the previous state (the "normal" state) after an impact, without considering whether normal is desirable (Pendall 3). For example, when the National Flood Insurance Program repeatedly subsidizes the rebuilding of homes in a flood zone, the homes are still subject to the same flood risk as before—an undesirable "normal" (Moore). In planning projects where the focus is on long-term adaptive capacity building, however, socio-ecological resilience is a more appropriate goal. This theoretical framework has implications for the practice of planning itself (Sellberg et al. 1). Planning for socio-ecological resilience favors those interventions which work with—rather than attempt to control—the complex, self-organizing, and adaptive nature of systems (Davoudi 304).

In applying the socio-ecological definition, this document sees interventions that allow the basic structure and critical functions of communities to persist after a disturbance, while also allowing for temporary or long-term shifts in function and structure, as increasing the resilience of these communities. Disturbances can take multiple forms. Chronic stressors weaken the strength of a community gradually. Examples of chronic stressors include economic inequality, segregation, chronic health conditions, racism, unemployment, hotter temperatures and sea level rise. Acute shocks, on the other hand, are sudden events like natural disasters (tornado, hurricane, etc.) or terrorism that create critical conditions in a brief period of time. Both chronic stressors and acute shocks wear down the resilience of a community, but the impact of acute shocks is often more severe when people and communities are experiencing chronic stressors as well.

The focus of this project is increasing resilience of human communities to the effects of climate change by using land use interventions to buffer both chronic stressors and acute shocks—in other words, helping communities adapt. For example, a park that floods during large storm events and is closed for a duration afterwards buffers the acute risk of flooding for local homes without compromising the park's essential function for the neighborhood. Adding trees to a largely paved neighborhood reduces the chronic stress of urban heat island effect (high temperatures in urban areas). Land use interventions can include policies, physical changes to the landscape, and practices.



(EPA, 2008). Although watershed planning may initially require additional efforts to create new frameworks for intra-municipality organization, eventually it could lead to towns being able to efficiently share resources, like planning efforts and financial resources, protect forested land, and create connected conservation areas and wildlife corridors. To this effect, Massachusetts is developing legislation called the GreenWorks bill, which among other things, enables groups of municipalities to apply for funding for resilience improvements and investments together (Golden, 2019).

In the face of climate change, it is ever more important to plan regionally. While it may seem that regional planning in Massachusettscould be conducted on the county scale, the state does not currently have strong county-based planning (O'Connor 2020). Watershed planning provides not only a framework from which to begin that regional planning, but could make planning more responsive to ecological functions than political boundaries.

This report is one of two watershed-based community resilience plans produced by the Conway School for the Massachusetts Executive Office of Energy and Environmental Affairs. The following pages describe a framework devised to identify key risks and vulnerable areas within a watershed, and recommend land use changes that would augment human resilience in the face of climate change. This framework was developed based on two study areas, the Mill River watershed of Hampden County and the Mill River watershed of Hampshire and Franklin Counties.

What is Sustainable Land Use?

Sustainable land uses support resilience within socio-economic and ecological systems. Whereas resilience is defined here as the ability to cope, respond, and adapt to natural disturbances, sustainability is the practice of minimizing human impact on the natural functions which enable resilience.

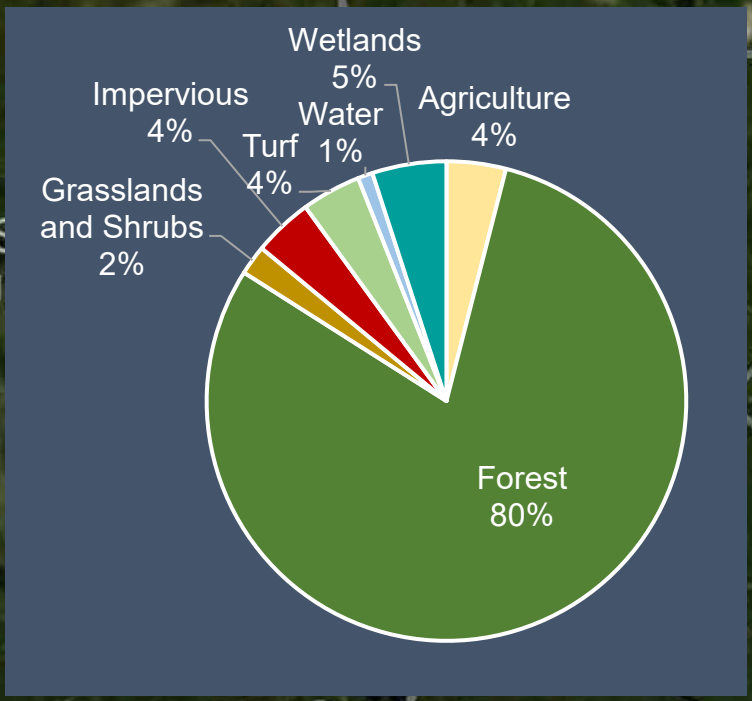
In 1987, the Brundtland Report defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs, and it acknowledged that "many of us live beyond the world's ecological means, for instance in our patterns of energy use" (The World Commision on Environment and Development 41, 42). The challenge is thus to understand how our actions impact future generations in light of climate change.

Why these Watersheds?

The RLI chose two watersheds in Western Massachusetts for teams from the Conway School to analyze to create a watershed resilience framework. This report focuses on the watershed of one of the many Mill Rivers in Massachusetts, which begins in the hilltowns of Conway and Goshen and flows for twenty miles down through Williamsburg and Northampton before joining the Connecticut River near the Northampton/Easthampton town line. The watershed covers about 57 square miles and is notable for its steep topography and heavily forested land cover. The densest areas of development are clustered at the base of the

Existing Land Cover:

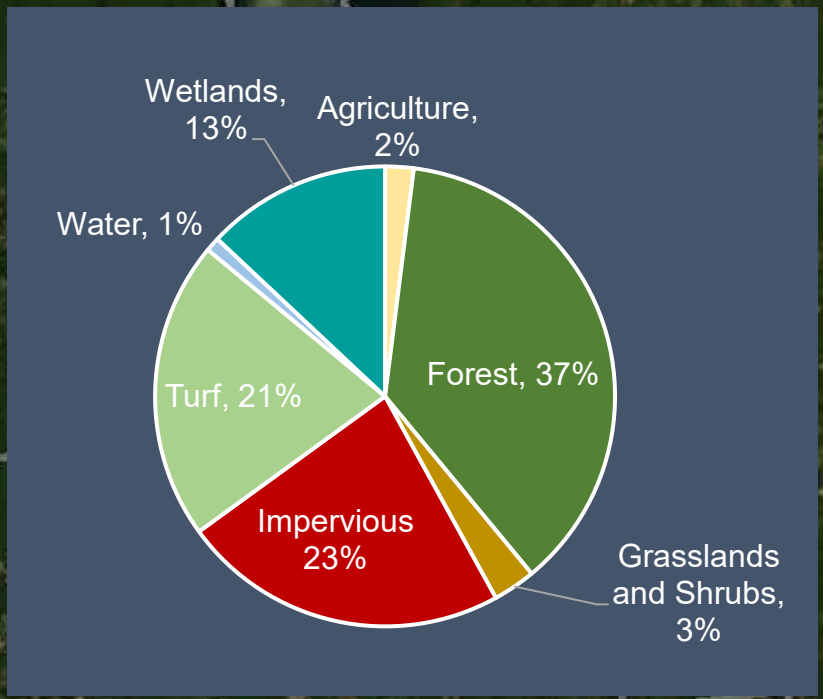
Hampshire/Franklin Counties Watershed





watershed in Northampton and spread up along the river into Williamsburg center. Compared to other watersheds in the state, this watershed has higher than average forest cover and slightly lower than average impervious surface cover, by percent total cover. The second Mill River watershed focused on by the other Conway Team, located in Hampden County, has much higher than average impervious cover and lower than average forest cover. The watersheds also differ in topography, with the northern watershed being far steeper, with an elevation drop of over 1,000 feet greater than the southern watershed. These watersheds are different, physically and socially: a rural forested area, less densely populated, with small towns, and an urban/suburban developed area with a denser population and more impervious surfaces. The watersheds both drain into the Connecticut River and both are located in the Pioneer Valley, an area with a distinct cultural and geographic character. The similarities and differences between these two watersheds provide an opportunity to explore different qualities and to develop a framework widely applicable to a range of watersheds in Massachusetts.

Hampden County Mill River Watershed



WORCESTER COUNTY

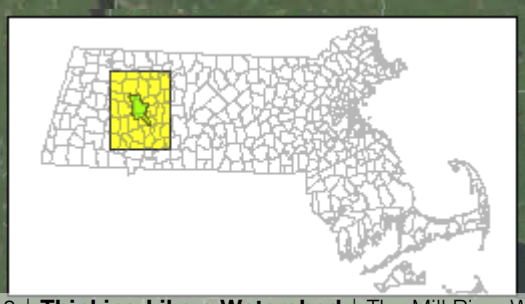
MILL RIVER WATERSHED
34 square miles

0 25 50 75 100 Miles

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

*The **Mill River Watershed**, Hampshire & Franklin Counties*

In the Mill River watershed that is the focus of this report, the river remains a vital center for culture and recreation. The story of the river and the potential impacts the river will have on the resilience of the communities in the watershed are explored in more detail below.



Summary of the Process

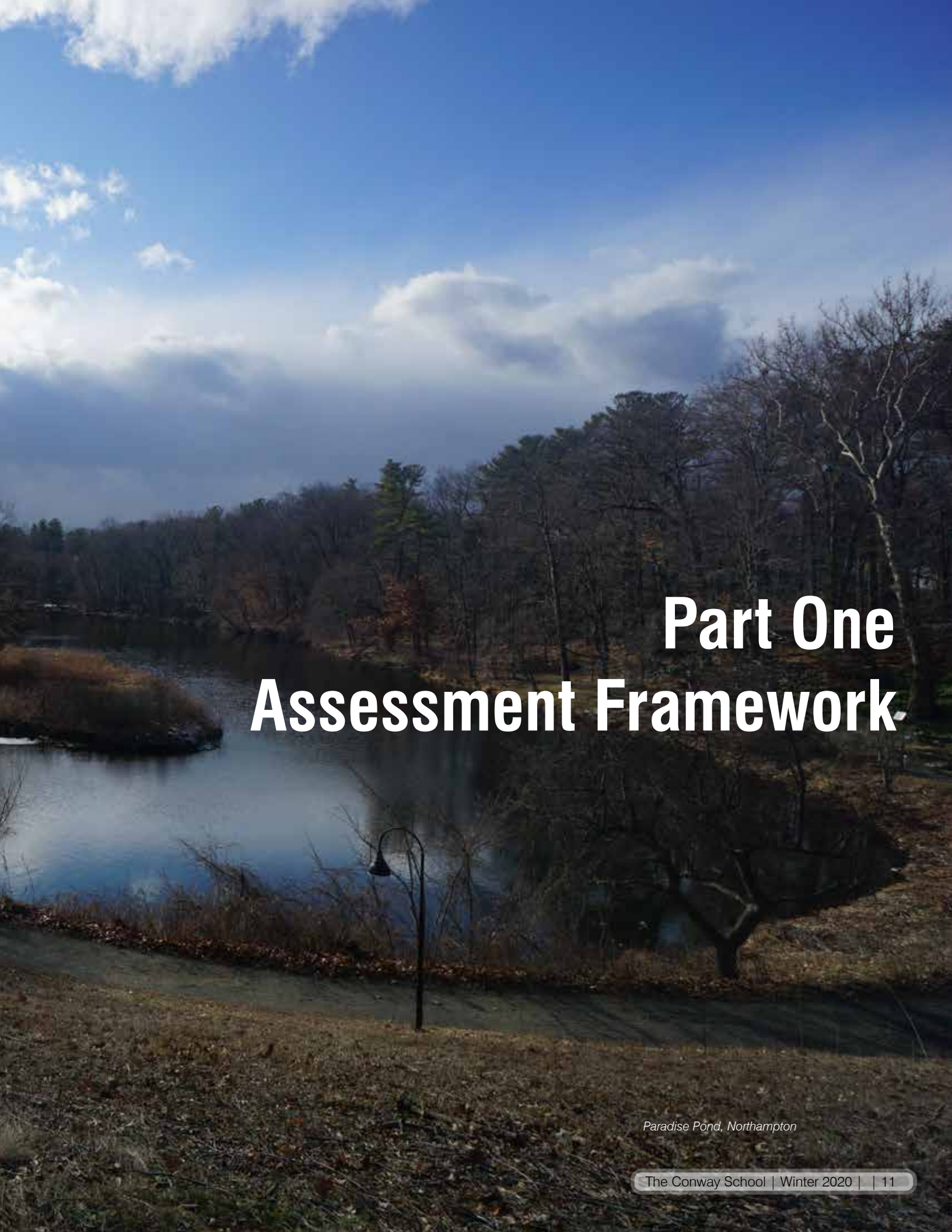
The primary purpose of this document is to explore the potential benefits of resilience planning at the watershed scale; the potential interventions in land use planning explored in the latter section of this document are secondary, and no actions should be undertaken without further study, as outlined in Step 3 and Step 4 of the framework.

Developed within two watersheds in western Massachusetts (this document within the Mill River watershed Hampshire and Franklin Counties and the other within Hampden County), this framework is designed to be applicable to watersheds throughout the state. The work was informed by and hopefully complementary to ongoing efforts within the watersheds. Each municipality's Hazard Mitigation Plan and other planning documents, to the extent possible, informed which hazards were studied within each area; however, the Conway teams, due to time constraints and the nature of the scope of this project, were not able to conduct a thorough review of existing documents and plans, or a robust public participation process.

Any process for assessing resilience at the watershed scale must acknowledge that climate change effects are not limited to watershed boundaries. The framework makes room for individual watershed planning groups to determine what is most relevant to their community.

The following pages present the framework in the context of the Mill River watershed of Hampshire and Franklin Counties. They also include recommendations for future assessments. Following this, a short outline summarizes the assessment framework. Preliminary recommendations for interventions are then offered for the Mill River watershed, as well as a discussion of the process as a whole. A critical step of the analysis, which this report identified but which was outside of the project's scope, was to ground-truth findings with input from community members to ensure that land use interventions were appropriate based on the values of the community.





Part One
Assessment Framework

Paradise Pond, Northampton



Mill River West Branch, Williamsburg

Part One: Assessment Framework

Building on analyses, existing frameworks by other authors, and groundwork done by agencies within the Mill River watersheds, the Conway teams developed a framework for assessing resilience at the watershed scale. This framework was designed to be applied to other watersheds in Massachusetts to help identify regional risks and priorities, analyze human vulnerability to local climate impacts using GIS modeling, and explore intervention opportunities that are most appropriate and will have the greatest positive impact on the health, safety, and resilience of human communities within the watershed. Much of the information that will be reviewed through this process may be familiar to some communities, such as risks and vulnerabilities that have already been evaluated during previous municipal or regional planning efforts, such as the MVP program or Hazard Mitigation Plans (HMPs), but there is value to considering this information more broadly using a watershed-based scale. Planning at the broader scale may reveal opportunities for municipalities to come together to compare priorities and values, achieve goals, and broaden their impact. Within the framework, all values, criteria, and assessments were informed by the RLI's motivation to ensure human health and safety in the face of climate change, and the initiative's goal to use land protection, planning, and management to mitigate and buffer climate threats. Applying the framework with other values in mind, such as protecting the resilience of wildlife and natural communities to climate change, could lead to different priorities and intervention recommendations, and is not the focus of this study.

Overview

The steps of the framework are laid out below in brief. The first step involves forming a committee of regional stakeholders to oversee the process and concurrently work to ensure that the public participation and feedback process remains robust and pertinent.

Once the committee is formed, the next step is to identify risks, vulnerabilities, and community priorities by taking a look at regional climate change projections and individual municipal planning documents, and collecting local feedback through public meetings, surveys, interviews, and other appropriate measures. Once the information is gathered, overlaps and gaps between plans can be identified and evaluated. This step precedes conducting GIS analysis to help ensure that the process is adapted to the community's culture, history, and values, and to avoid repeating analysis that has already been done at the municipal scale.

The third step attempts to supplement work that has been done thus far in communities by conducting analysis at the watershed scale, beginning with an examination of historical patterns and how they impact current levels of resilience of human communities in the watershed. Following this, the current conditions in the watershed are mapped and the implications of these conditions on resilience, given threats posed by climate change, are considered. GIS models are used to evaluate areas of human vulnerability to climate change threats. The Conway teams developed models that assess the areas of highest human vulnerability to the most significant threats within the watersheds; the teams identified the heat island effect and flooding as the most significant threats posed by climate change to human communities in the watersheds that they examined. These threats were also identified as priorities in municipal planning documents and conversations with community members. Similar assessments could be done for other threats, and in different watersheds. The scope for this project did not include thorough assessment of every possible climate threat, and it should be noted that future research and more robust models and analyses should be developed to improve upon this preliminary framework.

Opportunities for further research are noted throughout the report.

The final step takes the analyses of existing conditions and vulnerabilities and begins to consider potential interventions that could be pursued. The interventions are divided into four categories that reflect the focus of the RLI on land use change. These categories are broad enough to be applied to other watersheds. As interventions are considered, they will need to be cross-referenced back to municipal documents and ongoing or forthcoming plans to ensure efforts are not duplicated.

Following the outline of the framework laid out below, this report applies the steps of the framework to the Mill River watershed to the degree possible during the time frame of this project.



Mill River & Paradise Pond, Northampton

Framework Outline

Step 1: Form a Watershed Working Group

1. Assemble a working group to oversee the watershed assessment process. Consider including municipal, county and/or state government officials; environmental, community health, affordable housing non-profits; local business leaders; community members; academics; municipal and/or regional planners; natural resource managers; conservation organizations; recreation groups; and others.*

Step 2: Identify Risks and Community Priorities

1. How and why has the landscape changed over time? Research geological, ecological, and cultural history of the watershed, especially in how it impacts present conditions.
2. What are the climate change projections for the area? Assess climate change predictions and latest data for target watershed.
3. What do the communities perceive to be the greatest risks to human health and safety? Review municipal documents prepared for or by municipalities within the watershed. Note the risks covered by each plan. Where are the plans in agreement? Where do the plans conflict? Are there climate change projections that are not addressed in the plans? If planned projects have not been implemented, why not? Where possible, map identified threats and resources.* Examples of these documents include:

- Hazard Mitigation Plans (HMP)
- Open Space & Recreation Plans (OSRP)
- Municipal Vulnerability Plans (MVP)
- Master Plans and Comprehensive Plans
- Water Quality Reports
- Watershed Studies (some communities have already conducted assessments at the watershed scale)

Step 3: Analyze Vulnerability

What are the conditions of the watershed now? Generate maps of current conditions, including:

1. Infrastructure and the built environment.
    - Impervious surfaces
    - Road network
    - Zoning and current land use
2. Social factors:
    - Demographics and Environmental Justice populations
    - Population density by block
3. Ecological factors:
    - Land cover
    - Soils and bedrock geology*
    - Hydrology: rivers, wetlands, reservoirs, aquifers
    - Water quality
        - Stormwater infrastructure
        - MA Integrated List of Waters
        - MS4 Regulations
        - Stormwater bylaws*
        - Stormwater utility fees*
4. Farmland (location, type, APR or not)*
5. Already conserved land by type (also percent of total area)
6. Where are human communities most vulnerable to climate change impacts? Which impacts pose the most severe threats?**
    - Watershed issues
        - Flooding
        - Water pollution
    - Non-watershed issues
        - Heat
        - Air pollution
        - Drought
        - Pests
        - Coastal storm surges
        - Fire
        - Changes to soil chemistry
        - Erosion
        - Climate migration
    - How do these vulnerabilities interact?
        - Are there areas of overlap? Are areas located in neighborhoods with high population density? Environmental justice blocks?
7. Ground-truth.* Verify assessments are correct through in-person analysis and consultation with local stakeholders and a public participation process.

Step 4: Find Opportunities for Land Use Interventions

1. Reference "Menu of Interventions," or consider building one.
2. To identify land for conservation: map parcels with high conservation value based on community priorities.
3. To identify where developed land which could be remediated/restored/greened:
    - Map vacant parcels
    - Map tax delinquent parcels
    - Map parcels owned by city or state
    - Map brownfields
    - Analyze specific sites mentioned by local stakeholders
4. To identify open space which could be better stewarded:*
    - Identify conserved areas that are at high risk for degradation due to pests, pathogens, or invasive species.
    - Identify conserved forests near water supply areas.
    - Identify developed open space parcels where management practices could be improved.
5. Ground-truth intervention targets. Verify target sites are viable through in-person analysis and consultation with local stakeholders and a public participation process.*
6. Cross-check with municipal plans*
    - Revisit plans. Are there interventions which would mitigate climate risks for more than one municipality? If so, could the municipalities apply for funding together? What conflicts could be addressed?
7. Prioritize recommendations*
8. Consider creating a prioritization framework based on vulnerability assessment (Step 3), factoring in the goals and values of the municipalities within watershed.
9. Use models to predict the potential impact of interventions.

**Steps that were not feasible to pursue due to time constraints, but are considered integral and would recommend in future assessments.*

***Given the priorities of the RLI steering committee, the analysis was constructed to identify the key risks climate change poses to human communities. A watershed assessment done with different goals (for example, wildlife habitat, or critical infrastructure) could perform a similar analysis with different variables in Step 4.*





Part Two
Mill River Watershed Assessment





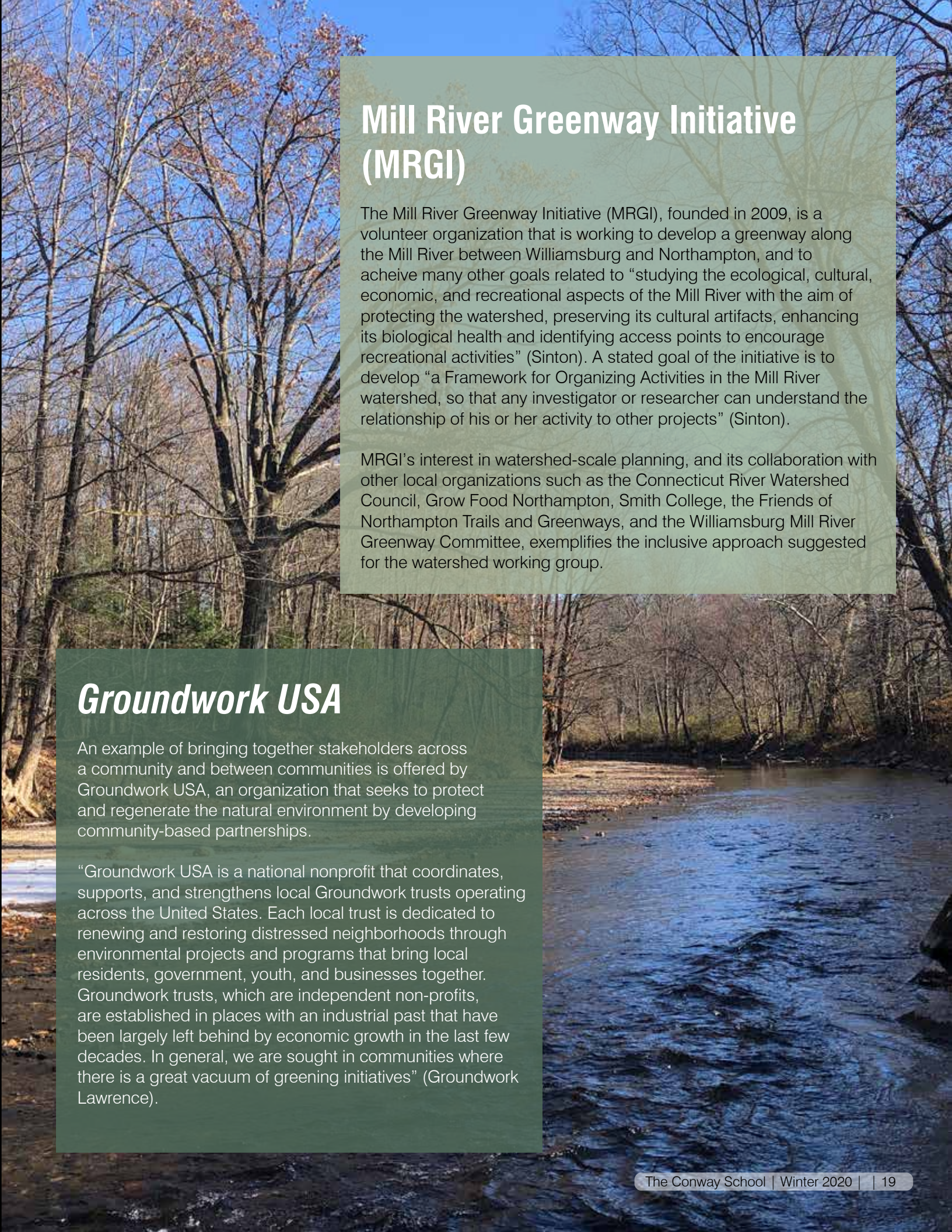
Step One: Form a Watershed Working Group

Communities within different watersheds may choose alternate methods of guiding and completing the resilience assessment process. If consultants are hired to carry out the process, it will be important for their work to be guided by a working group of stakeholders that represents a cross-section of interests and viewpoints across the region. This working group will guide the work of the consultants (or carry out the process itself).

The RLI itself offers a valuable precedent in its inclusion of land-related stakeholders from local and state governments and a wide range of non-profit organizations. A similar group could be formed within each watershed, emphasizing local governments rather than state officials, as well as non-profit organizations (such as land trusts), farmers and agricultural groups, foresters, hunters, tribal and indigenous people, and other important stakeholders in the region. The group itself cannot include all stakeholders, but should represent them, their interests, and their values as comprehensively as possible through a robust public participation process. As stated in a framework for community-driven resilience planning drafted by the National Association of Climate Resilience Planners, in support of forming regional resilience teams, "There are few, if any, single organizations with the capacity to carry out all the components of the planning process and yet they are all essential to climate resilience outcomes. Forming regional teams of actors who can play discreet, yet synergistic roles helps to ensure communities have the capacity to develop, advance, and manage long term climate resilience solutions" (NACRP, 2018). Using communication and decision-making techniques that emphasize collaboration and consensus, this group would seek to transcend political boundaries and limits.

Ensuring Robust Community Participation

Throughout the process the working group will need to repeatedly engage the community in a variety of ways, taking steps to seek feedback from all groups, especially those that are traditionally underrepresented at community meetings, such as minority and lower-income populations.



Mill River Greenway Initiative (MRGI)

The Mill River Greenway Initiative (MRGI), founded in 2009, is a volunteer organization that is working to develop a greenway along the Mill River between Williamsburg and Northampton, and to acheive many other goals related to "studying the ecological, cultural, economic, and recreational aspects of the Mill River with the aim of protecting the watershed, preserving its cultural artifacts, enhancing its biological health and identifying access points to encourage recreational activities" (Sinton). A stated goal of the initiative is to develop "a Framework for Organizing Activities in the Mill River watershed, so that any investigator or researcher can understand the relationship of his or her activity to other projects" (Sinton).

MRGI's interest in watershed-scale planning, and its collaboration with other local organizations such as the Connecticut River Watershed Council, Grow Food Northampton, Smith College, the Friends of Northampton Trails and Greenways, and the Williamsburg Mill River Greenway Committee, exemplifies the inclusive approach suggested for the watershed working group.

Groundwork USA

An example of bringing together stakeholders across a community and between communities is offered by Groundwork USA, an organization that seeks to protect and regenerate the natural environment by developing community-based partnerships.

"Groundwork USA is a national nonprofit that coordinates, supports, and strengthens local Groundwork trusts operating across the United States. Each local trust is dedicated to renewing and restoring distressed neighborhoods through environmental projects and programs that bring local residents, government, youth, and businesses together. Groundwork trusts, which are independent non-profits, are established in places with an industrial past that have been largely left behind by economic growth in the last few decades. In general, we are sought in communities where there is a great vacuum of greening initiatives" (Groundwork Lawrence).



Mill River East Branch, Williamsburg

Step Two: Identify Risks and Community Priorities

History Impacts Present Conditions

The resilience of the people living in the Mill River watershed today is inextricably connected to the human and ecological histories of the watershed. The historical patterns of land use and human interaction with the land informs how the communities in the watershed will be affected by climate change. Historical processes that helped shape the contemporary landscape of human settlement also helped shape cultural values of the communities in the watershed, which in turn influence how residents perceive climate-related threats. Taking these local values into account is recognized as a vital piece of creating a resilience plan that will have lasting success. As stated by the NARCP: "effective climate resilience plans are those that are rooted in the cultural and ecological assets of a given region, address the unique challenges of that region, and facilitate meaningful participation among its residents, thus contributing to an increased sense of 'place'" (Gonzalez, 2017).

The history of the Mill River reflects the changing ways in which humans have interacted with water throughout the history of human settlement in the Connecticut River Valley. Water has played a central role in human society here since the first people arrived. Beginning around 12,000 years ago, as forests began to return to the areas of Massachusetts from which the glaciers had recently retreated, nomadic humans began to hunt and gather food in the Pioneer Valley. Their temporary settlements and pathways tended to follow the rivers and streams, as did the animals they hunted. About 3,000 years ago, indigenous tribes began building permanent settlements near floodplains, where the repeatedly flooded soil provided a wealth of edible wild plants and animals as well as a fertile basis for early agriculture. Although they altered the ecological processes significantly through practices such as burning, management of game animals, and caring for or planting edible crops, people lived with the flow of the river, accepting that the seasonal flooding would inundate fields and low settlements, and moved out of the way as needed (Sinton, 2019).

The entrance of European settlers into this environment in the early 1600s began a process that ultimately altered almost every natural process of the Mill River

and the surrounding forests. Along with the removal of the indigenous people through the introduction of disease, war, and forced resettlement, the settlers also pushed their own traditional theories of agriculture onto the land, bringing cows, sheep, and pigs into the floodplain meadows; cutting down forests to heat their homes and provide income in the form of potash; and—perhaps most damagingly given the already flood-prone nature of this watershed—altering the natural flow of the river. Mills became essential to the function of the colonists' settlements and economy. Every settlement needed a sawmill for wood and a grist mill for grain, and later the settlers also built mills to produce products for sale, such as silk, buttons, cutlery, or other specialty goods. They had built 70 dams in the Mill River and its tributaries by the peak of production in the late nineteenth century. Each mill needed its own pond and controlled flow of water to ensure that the mill could run steadily both in the high water seasons and drier summers. Permanent settlements were built near the river, allowing people to work the mills and use the fertile soil. With the creation of dams, hardened riverbanks, bridges, and canals, segments of the river were pushed and shoved, narrowed and channelized, and forced to go where humans wanted. Despite frequent losses of infrastructure, agriculture, and human life to floods, the general pattern of developing near the river continued. In 1874, a dam on the east branch of the Mill River in Williamsburg broke unexpectedly, killing 139 people and wiping out dams, bridges, and buildings in four villages downstream; in1936 a disastrous flood covered much of downtown Northampton in several feet of water; this flood was followed rapidly by the historic hurricane of 1938. Afterwards, instead of advising that people move out of the floodplain or give up their way of life, Northampton engineers proposed an alternative: move the river instead. In 1939, the Army Corps of Engineers (ACE) rerouted the Mill River's path and built a massive system (approximately 4,800 feet) of levees to keep the floodwaters out of Northampton (Sinton, 2019). This flood infrastructure protects historic buildings, tightly knit neighborhoods, and vibrant downtowns and community destinations that have survived major flooding events over the centuries. Communities take pride in these features, and aspects of the local economy depend upon these elements of the built environment. Yet they are vulnerable to the impacts of climate change.

The landscape has always shown ecological resilience, in which the plants and animals regrow and change as the conditions demand. Despite the near-total clearcut of the watershed in the late nineteenth century and the decrease in water quality and biodiversity in the watershed due to factory and sewage runoff during the twentieth century, the watershed today is a lushly forested, diverse, ecosystem of young trees and wildlife, with above-average water quality. This ecosystem looks vastly different from the lightly managed old-growth forests and wet meadows of the pre-European era, and the introduction of invasive plants, which began with the arrival of the European settlers and has continued since, has altered it further. Recent trends of increased development across the state may threaten the forests in the watershed.

The physical patterns of living close to the river and using floodplains for development and agriculture and the deep-rooted cultural values are vital parts of the human communities in the watershed that cannot be ignored or easily changed. However, the demonstrated ecological and human resilience of these communities can play an important role in planning for the future.



Mill River at the Brassworks Dam, Haydenville, Williamsburg

The NACRP recommends "draw[ing] upon rooted and historical wisdom of place and the adaptive capacity that communities have built over generations of hardship and crises," as part of a holistic planning process (Gonzalez, 2017). However, vulnerabilities inherent in these historical patterns must also be recognized, and these are likely to be exacerbated by climate change. These impacts have already begun to stress the ecological and human systems in the watershed and in many cases are threats for which the communities in the watershed may not be fully prepared.

Present and Future Development Patterns

Development pressure is currently fairly low in the Mill River watershed. Based on information from Mass Audubon's *Losing Ground* report, released in 2020, the Connecticut River watershed, of which the Mill River watershed is a portion, added 1,597 acres (2.4 acres per square mile) of new development land between 2012 and 2017. Out of the 27 major watersheds in Massachusetts, this rate of development places the Connecticut River at the rank of 19. This rate of development represents a significant decline from the 2,735 acres (4.1 per square mile) developed between 1999 and 2005, and a slight decline from the 1,721 acres (2.6 per square mile) developed between 2005 to 2013. In comparison, a total of 20,852 acres were conserved in the region between 2012 and 2017, the highest amount of any watershed in the state and an increase in land conserved each year compared to the previous reports. This increased the percentage of permanently protected land within the Connecticut River watershed to 24% of total land area; GIS analysis conducted for this report suggests that the Mill River watershed contains a higher percentage, with a total of 34% of the land permanently protected (see Figure 12).

Although the Mass Audubon data does not present an exact projection of the specific rates of development within the Mill River watershed, the increase in land conservation as shown by GIS mapping and data from individual towns, suggests that the rate of conservation is significantly higher than that of development within the Mill River watershed. For example, permanently protected land in Chesterfield more than doubled between 1990 and 2019, while development—measured by the number of new homes built—only grew by 17% in the same timeframe (Chesterfield Financial Report, 2020). Williamsburg showed a similar development rate: between 2000 and 2009, the number of residential parcels increased by about 7% and the number of commercial parcels increased by about 5%. Development can increase vulnerability of communities to climate change by putting people in areas subject to risks such as flooding, or by increasing vulnerability of people downstream (by increasing runoff). However, municipalities do have the ability to influence where and how development happens. For example, in Northampton, the most densely populated municipality in the watershed, development is primarily occurring outside of the floodplain, and the City encourages Smart Growth, which prioritizes denser growth in already developed areas (Northampton Sustainability Plan, 2015).

These patterns of high rates of conservation and relatively slow rates of development indicate that while development pressure may be a concern in this area, it is not the primary threat to the resilience of these communities.

How Will Climate Change Impact this Region?

Looking beyond the general overview of climate change threats in the Northeast presented in the introduction, the wide physical variability of regions within Massachusetts means that climate impacts could vary widely across the state.

One resource for information about these varied impacts is the Climate Change Clearinghouse for the Commonwealth (resilientma.org), which has interactive data available at a watershed scale.The clearinghouse allows for the calculation of predicted precipitation increases and temperature increases for 2030 and 2090 and for high and medium emissions scenarios (resilientma.org/map).

The Connecticut River Valley is likely to see precipitation increases of 3.88 to 6.01 inches per year by 2090, and 1.63 to 2.44 more days per year with precipitation over 1 inch by 2090 (Resilient MA). Temperatures are projected to rise by an average of 5.09 to 9.48 °F by 2090, with 1.08 to 14.39 more days per year over 100 °F (Resilient MA).

Data for other climate risks, such as flooding impacts given climate change projections, are not always as easily available. However, given the existing flooding issues in the watershed, increased precipitation is likely

to cause more frequent and severe flooding. While heat is not currently as important an issue, the temperature increases predicted could cause significant heat-related impacts in the coming years.

What Do the Communities Perceive as the Greatest Risks?

Many Massachusetts communities have already conducted planning work to identify climate-related risks and vulnerabilities. For instance, every town and city in Massachusetts has a Hazard Mitigation Plan (HMP) in process or completed, and as of March 2020, 82% of municipalities are enrolled in the Municipal Vulnerability Preparedness program (Mass.gov). In addition, projects are ongoing throughout the state to increase resilience or energy efficiency, reduce pollution or emissions, or otherwise mitigate and adapt to climate change. Many towns also have an Open Space and Recreation Plan (OSRP) that catalogs a municipality's growth and development patterns, environmental and open space inventories, and goals for future land use changes.

Instead of repeating this effort, a helpful early step in the resilience assessment process is to gather information from municipalities about which risks they have already identified. In most cases this will begin with information from any MVPs, HMPs, OSRPs, and Master Plans the municipality has begun or completed, as well as any additional plans or steps the community has taken toward resilience or climate preparedness.

In addition, projects and conservation or restoration goals that have been put into place by communities should be identified. Some watersheds also have watershed organizations or regional planning agencies that are already doing work at this scale.

In the Mill River watershed, two of the ten municipalities have a master plan or comprehensive plan, an MVP, and an OSRP, five have an MVP and an OSRP, and there is one each that has just an OSRP or an MVP. In some cases, these plans are in development or are outdated (see figure 1 below). (Note that the Conway team did not review each document in depth for the Mill River watershed; in addition, several plans were still in process and were not available for review and incorporation into this report.)

Community Priorities and Values

In addition to self-identified risks, the values and priorities of the communities will also play an important role in any actions taken. Some information on this can be acquired from the municipal and regional documents described in the previous section, and a community participation process will reveal additional information. Also, bringing together people from different towns within the watershed for discussion may help them to see where their concerns align and do not align. Ideas for how to acquire this information from community members in an equitable and effective way are listed in the NACRP report, including:



Paradise Pond, Norhtampton

- "Host resident conversations at community-based institutions, such as schools, faith-based spaces, service organizations, and base-building organizations to ground development of planning model[s] in strategic conversations and to engage a wide range of stakeholders, experiences and perspectives."
- "Identify barriers to participation among residents of vulnerable communities."
- "Hold creative town hall meetings using arts, culture & critical dialogue to articulate a place-based definition of resilience."
- "At least one community-based organization in the coalition develops a youth-led process for defining resilience and researching/developing solutions. Include key moments for youth leaders to design and facilitate intergenerational engagement activities."(Gonzalez, 2017)

Figure 2. Vulnerability map (right) based on MVP data, and stakeholder interviews.

MVP documents (from Northampton, Williamsburg, Westhampton, and Goshen) were used to create this preliminary vulnerability map, which shows approximate locations of each threat or vulnerability mentioned in the documents relating to climate change threats and land use. Most of the items marked are roads, culverts, or bridges that are known to experience flooding issues. Also shown are some beaver ponds that present potential threats to roads or human habitations, some human dams that may be high hazard or in poor condition, and two proposed solar fields that could impact runoff rates into the river.

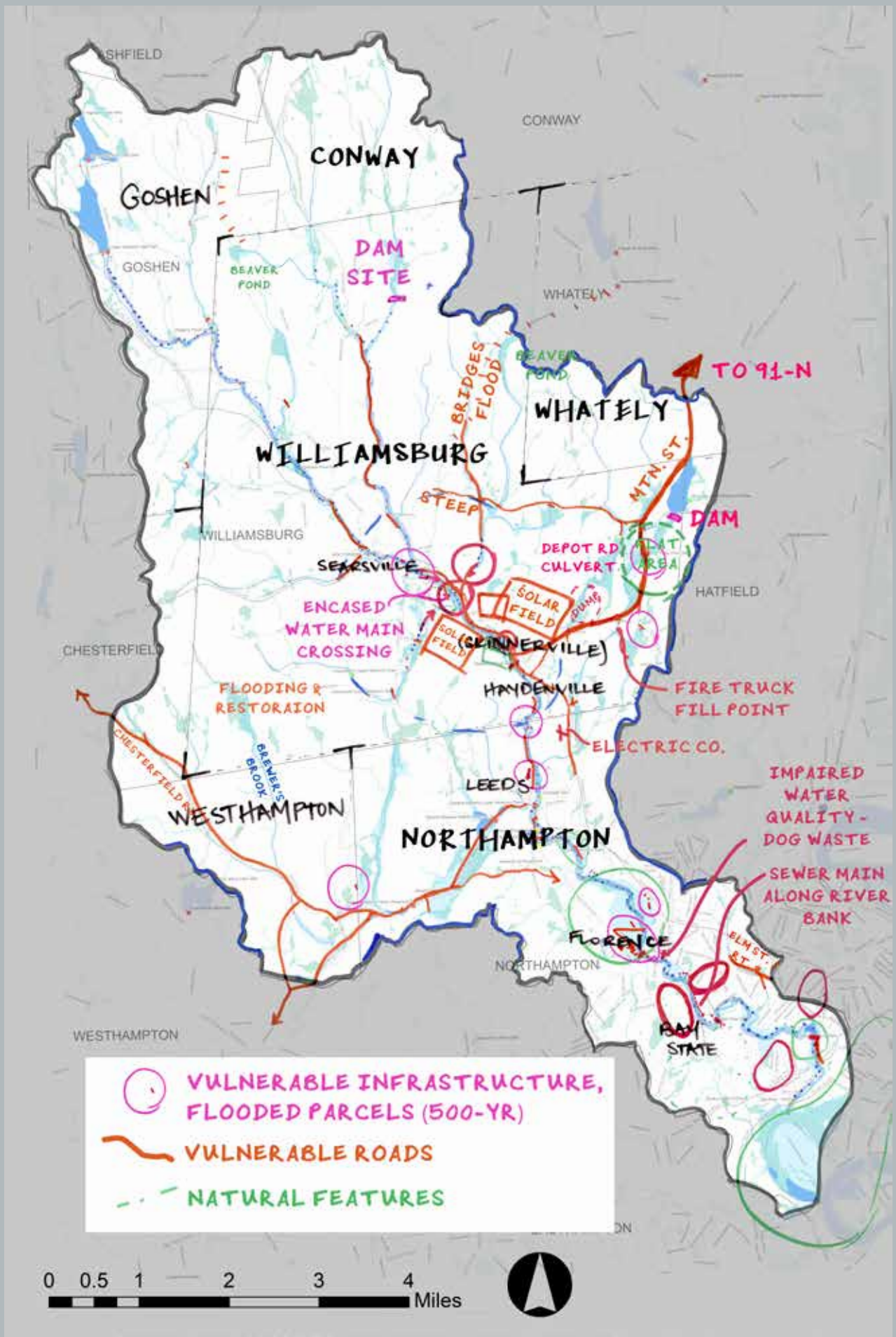
The patterns seen in the map highlights the location of Williamsburg in the middle of the watershed, with flooding impacts from upriver and the potential to reduce flooding and runoff issues downriver.



Figure 1. Town planning documents related to land use and climate change (as of March 2020)
Purple: a master plan, an MVP, and an OSRP
Blue: an MVP and an OSRP
Green: MVP only
Brown: OSRP only

Some documents are in development or outdated.

Darker area indicates watershed boundary


CONWAY
GOSHEN
DAM SITE
BEAVER POND
WHATELY
BRIDGES FLOOD
TO 91-N
WILLIAMSBURG
STEEP
MTN. ST.
DAM
DEPOT RD CULVERT
SEARSVILLE
SOLAR FIELD
ENCASED WATER MAIN CROSSING
(SKINNERVILLE)
HATFIELD
CHESTERFIELD
FLOODING & RESTORAION
HAYDENVILLE
FIRE TRUCK FILL POINT
ELECTRIC CO.
LEEDS
BREWER'S BROOK
WESTHAMPTON
NORTHAMPTON
IMPAIRED WATER QUALITY - DOG WASTE
SEWER MAIN ALONG RIVER BANK
FLORENCE
ELM ST.
BAY STATE
VULNERABLE INFRASTRUCTURE, FLOODED PARCELS (500-YR)
VULNERABLE ROADS
NATURAL FEATURES
0 0.5 1 2 3 4
Miles



West Branch of the Mill River in Williamsburg

Step Three: Analyze Vulnerability

Why Multiple Approaches to Analysis?

Using information gained from reviewing municipal documents and conducting a participatory process with residents of the watershed, planners can draw valuable insights into how communities perceive their resilience and vulnerability to climate change impacts, both individually and collectively. Watershed-scale analysis that incorporates wider-reaching GIS data may reveal regional patterns that are not visible or significant on the municipal scale but will still have impacts on overall resilience. Regional-scale GIS analyses can also show relationships between different areas of the watershed that may be obscured when focused in on individual municipalities.

Analysis Components

This section contains two parts. The first is an assessment of existing conditions within the Mill River watershed and how these conditions might be affected by climate change. The second part is a vulnerability analysis that uses GIS mapping software to model the impacts of heat and flooding on the human communities of the watershed. This analysis is based on the projected temperature and precipitation increases for the Connecticut River watershed (see page 21), risks identified by reviewing existing planning documents and communicating with community members, and existing conditions analysis at the watershed scale.

Current Conditions

Infrastructure and the Built Environment

Impervious Surfaces

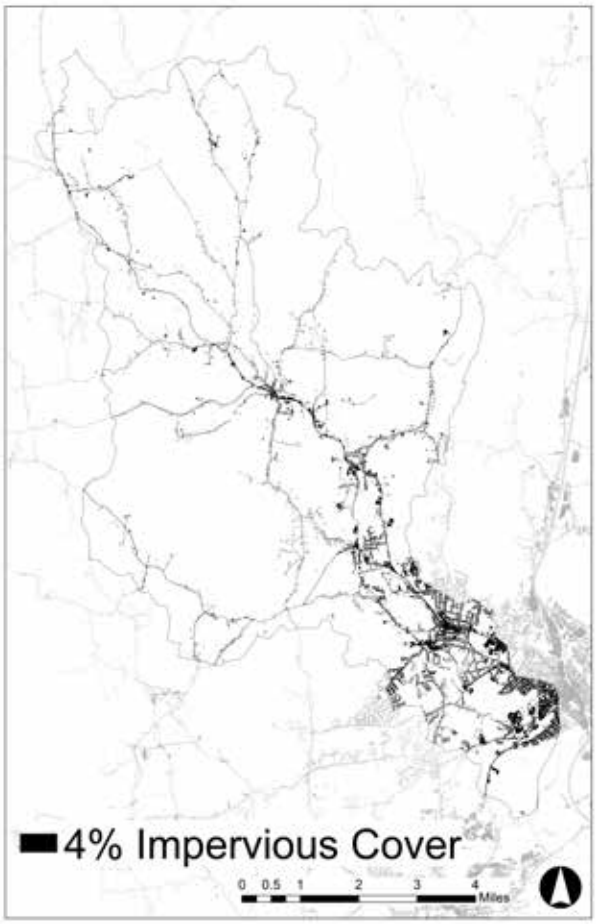


Figure 3. Most of the watershed is undeveloped. The impervious cover is clustered along the river and at the southeast section of the watershed. This reflects the historic and present day patterns of development, and exacerbates runoff, erosion, flooding, and water quality problems due to the loss of flood storage area when the floodplain was developed and the direct discharge of runoff from impervious areas into the river and other waterbodies.

Road Networks

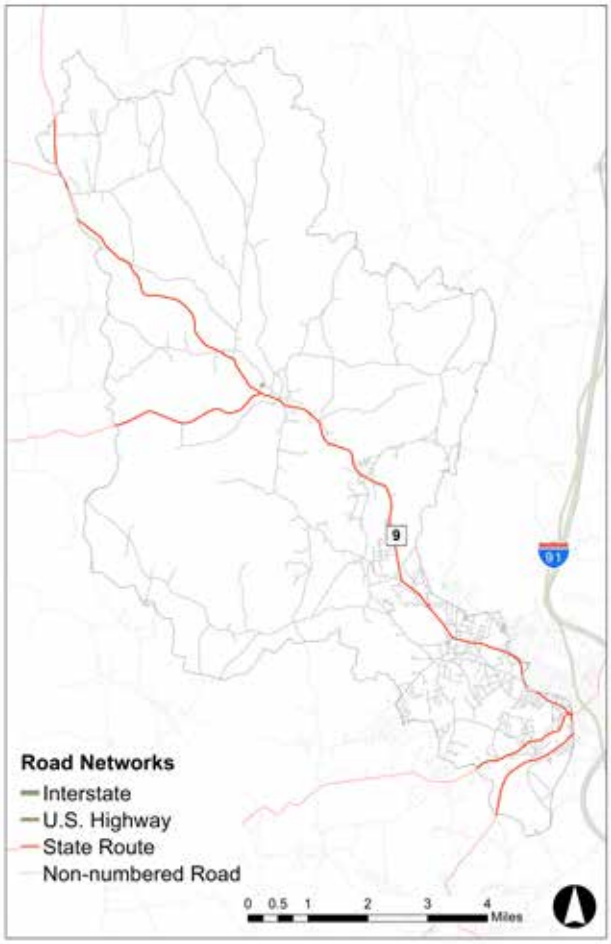


Figure 4. The main road networks in the watershed follow the river, often closely. Proximity to the river can put roads at risk of flooding and erosion, which can prevent passage intermittently and damage roadway infrastructure. Further, these vulnerabilities pose the risk of cutting off access to or from emergency services and other resources, especially when alternate routes are much longer or do not exist. Additionally, as noted in Town MVP documents, there are numerous road crossing with outdated and undersized bridges and culverts, making them a significant risk to flood damage.

Current Conditions

Infrastructure and the Built Environment

Water Quality (MA Integrated List of Waters)

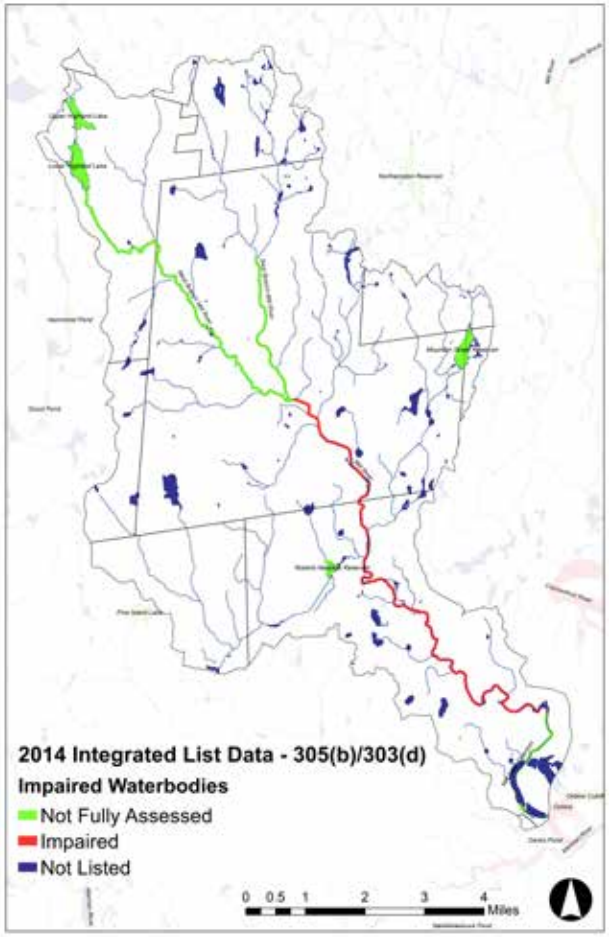


Figure 5. Most of the waterways within the watershed have not been evaluated for water quality issues, or have only been partially evaluated with no issues found. However, the main stem of the Mill River, spanning ten miles between Williamsburg and Northampton, is listed as impaired by MassDEP. Impairment is due to an excess of pollutant(s) such as nutrients, metals, pesticides, solids, and pathogens, and required the development of a total maximum daily load (TMDL) to reduce the pollutants to acceptable water quality standards. Water impairment is addressed in more detail on page 43.

Farmland

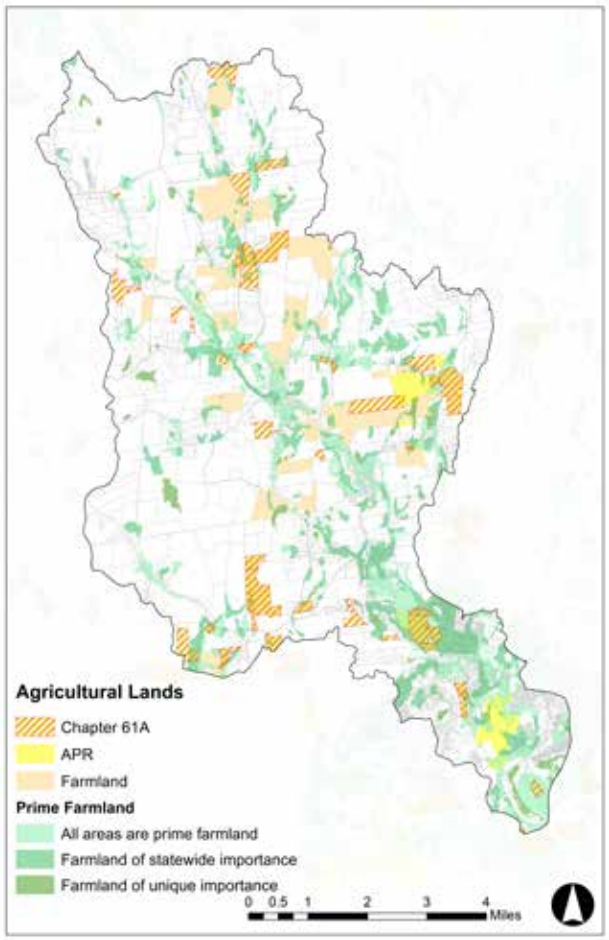


Figure 6. The watershed does not contain a high percentage of farmland. Most of its farmland is hay fields or pasture, especially in the higher elevations, also known as the headwaters. More croplands are found in the floodplains near the mouth of the river. While farmland is important for food production and pastures can serve as habitat for rare bird species, farmland can also present issues such as increased runoff, water quality impairments, and soil loss due to erosion.

Current Conditions

Social Factors

Population Density
*Demographics**

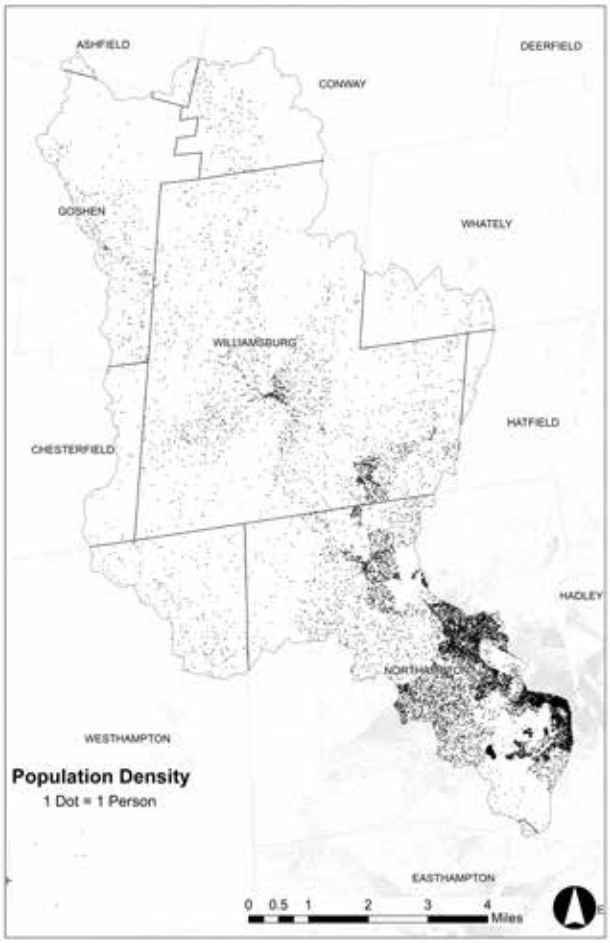


Figure 7. Population density within the watershed follows the same patterns as impervious surfaces, as would be expected. Although overall the watershed is sparsely populated, the lower elevations, often near floodplains where the topography is flatter, contain denser settlement, particularly in Northampton and Williamsburg. These areas are at a higher risk for flooding.

Environmental Justice Populations

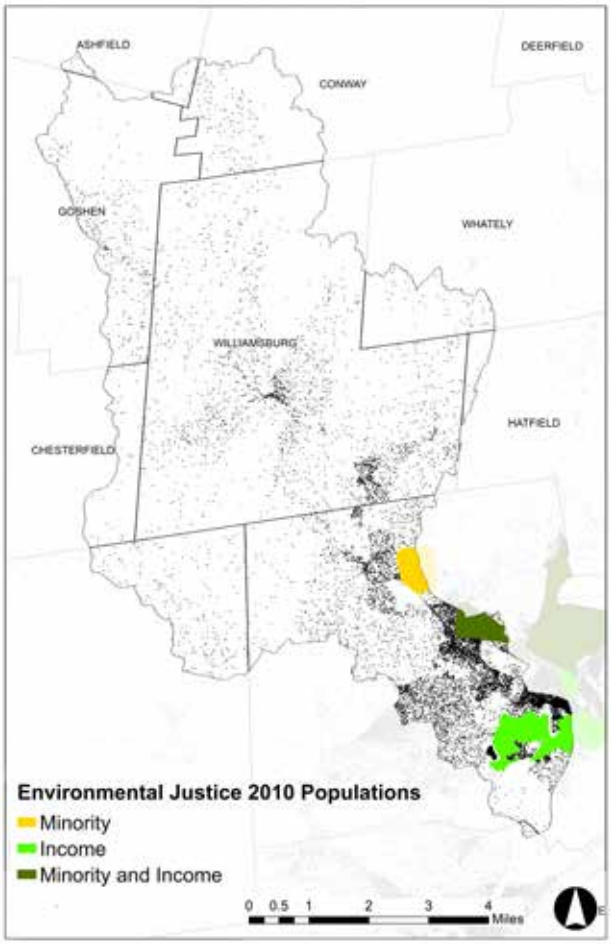


Figure 8. Three types of Environmental Justice (EJ) populations are found within the watershed: minority groups, low-income groups, and groups that fall into both categories. These neighborhoods extend across the watershed boundary in Northampton, highlighting the importance of spatial relationships and the limitations that result from restricting analysis to any specified boundary. Human and terrestrial wildlife are not bound by hydrologic units and therefore travel and access to resources outside the watershed are also important.

Current Conditions

Ecological Factors

Land Cover

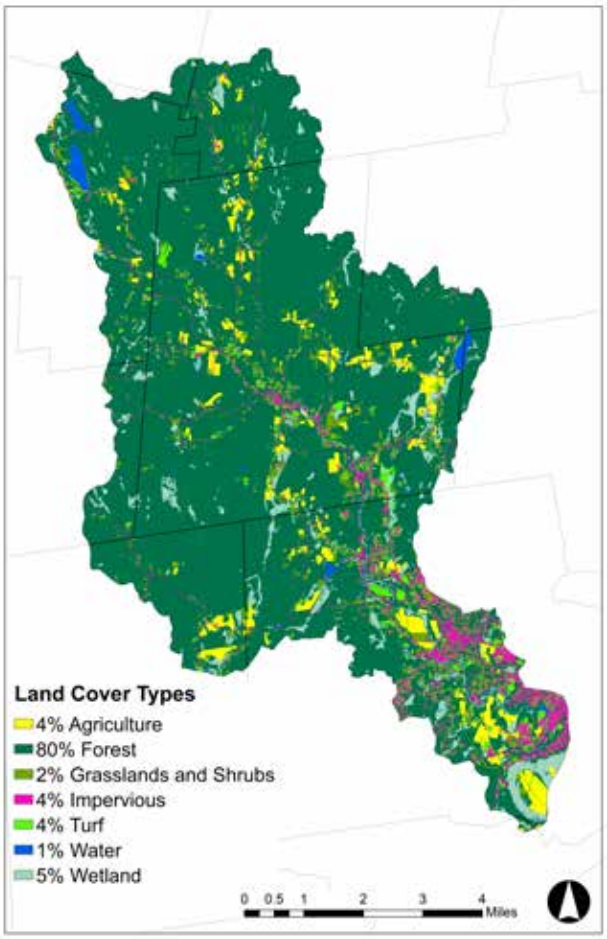


Figure 9. The watershed is primarily forested, with 80% of the land covered with trees, both evergreen and deciduous. In addition, wetlands are common and found throughout the watershed, often in forests. Forests and forested wetlands in particular are two of the most valuable land cover types for increasing resilience. Forested areas reduce flood risk, regulate temperature, clean water and air, and provide human access to green spaces.

Geology

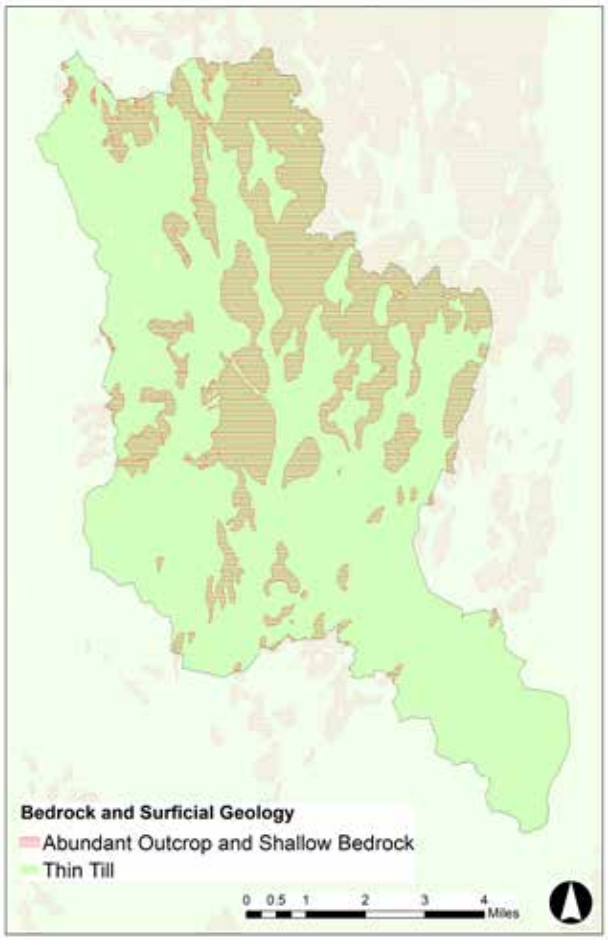


Figure 10. Two types of surficial geology occur in the watershed, thin till and shallow bedrock with abundant outcrops. Bedrock near the surface, which is concentrated in the central and northeastern sections of the watershed, increases runoff rates and speeds up the flow of water. This characteristic, paired with the steep slopes in this area, can lead to frequent and abrupt floods as rain washes rapidly into the river during heavy storms. This rapid rise in water level is known as flashiness.

Current Conditions

Ecological Factors

Hydrology:
Rivers, Wetlands, Reservoirs, Aquifers, Dams

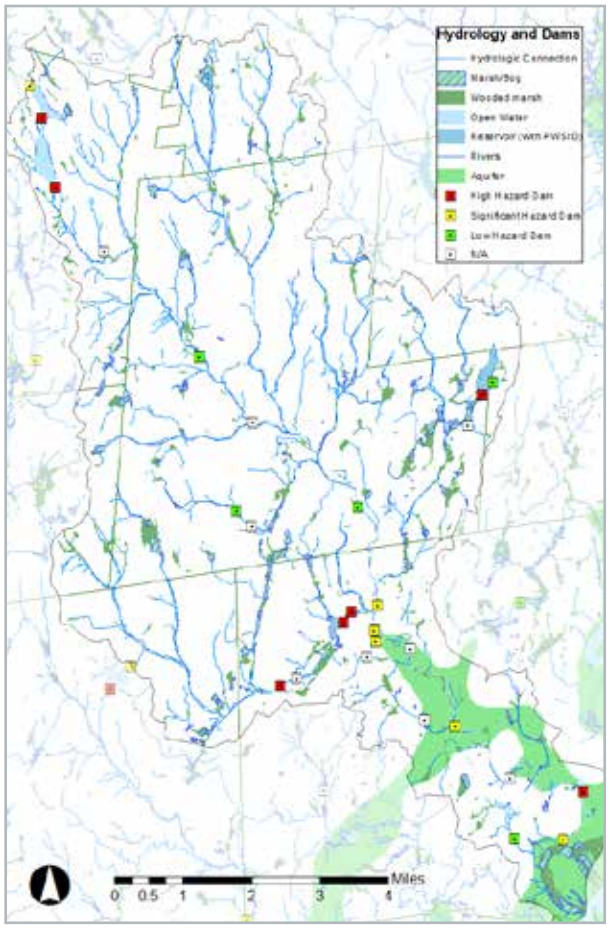


Figure 11. The watershed is evenly covered with a network of wetlands, streams, rivers, and larger waterbodies. An aquifer underlays the southeastern part of the watershed. There are many dams in the watershed, including seven that are designated as "high hazard" by the Office of Dam Safety, which means that failure would likely cause loss of life and serious damage to property, utilities, and roads. Available data regarding dams and hazard status is from 2012 and may not be accurate. This hazard rating refers to the predicted consequences if the dam were to fail, not its structural condition or likelihood of failure.

Protected Land

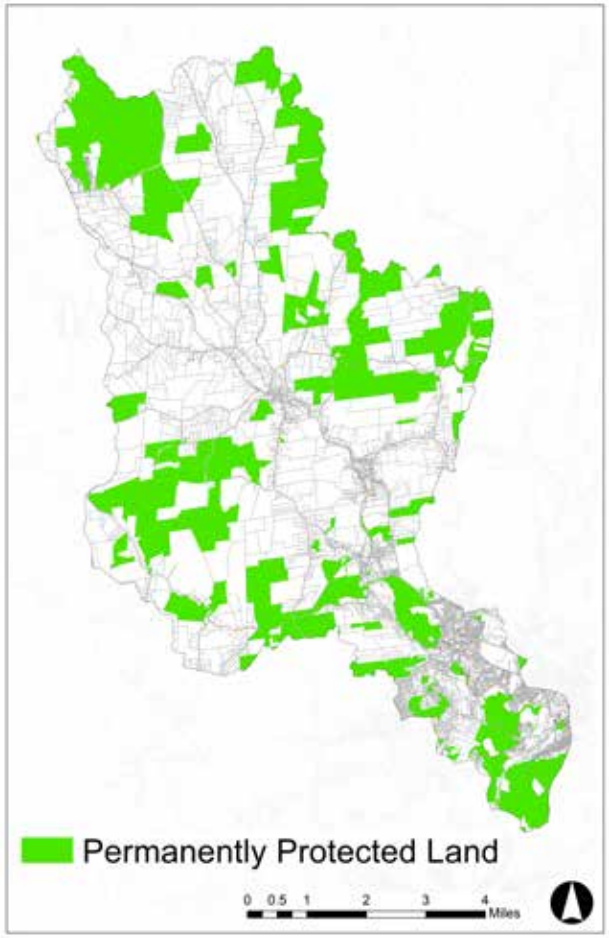


Figure 12. 34% of the watershed is currently permanently protected, with fairly even distribution across the watershed. In general, these parcels represent areas of high ecological or human value. Some significant gaps in protection still exist and could be addressed.

Using GIS Mapping to Assess Human Vulnerability to Climate Change Impacts

Climate change threatens humans in many ways. The Northeast Region section of the Fourth National Climate Assessment describes those impacts that are most likely to affect Massachusetts. Of those impacts, this Mill River watershed assessment focuses on flooding, the heat island effect, and water quality issues. These were the impacts that initial analysis and community input identified as already occurring in the watershed.

Climate Change Threats

Threats in bold are modeled for the Mill River watershed on the following pages.

- **Flooding**
- **Heat**
- **Water pollution**
- *Air pollution*
- *Drought*
- *Pests*
- *Coastal storm surges*
- *Fire*
- *Changes to soil chemistry*
- *Erosion*
- *Climate migration*

The Mill River in Florence, Mass.



Temperature and the Heat Island Effect

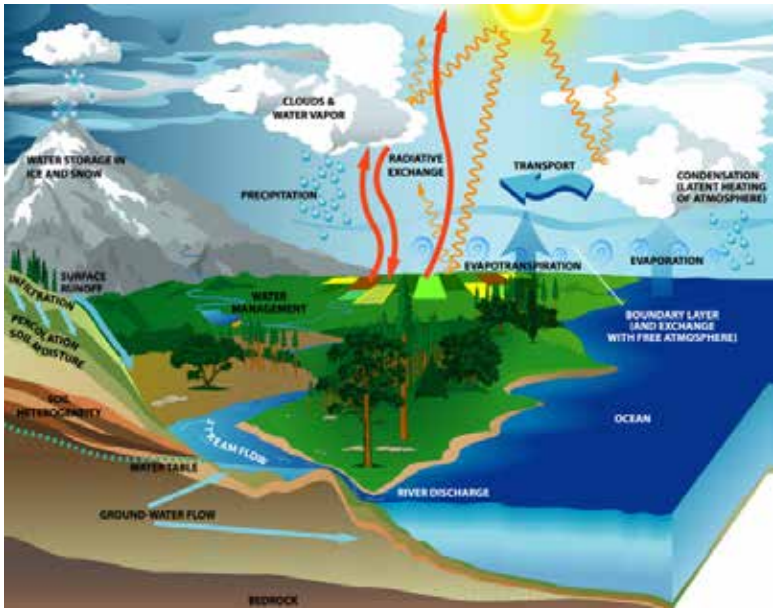
Climate projections warn of increasing temperatures in the northeast region of the United States. To understand how and where these changes will impact communities, a simple GIS model was developed to provide a very general analysis of heat island trends within the Mill River watershed. The model uses land use and land cover types as a proxy for the potential to hold heat and the potential to provide cooling through evapotranspiration (see "Water Cycle & Evapotranspiration"). Using information from a 2015 study by Ellen Gray, NASA's Earth Science News Team, the Conway teams developed a system for reclassifying land cover types based on their potential to reflect, absorb, or mitigate the heating effects of the sun. (For example, developed land cover types are given values between 2 and 4, because they represent areas of impervious cover and impervious cover absorbs heat; for comparison, forest is given a value of 0 because forests reduce heat effects.) High-density development tends to have a higher percentage of impervious cover compared to low-density development, and therefore is assigned a higher heat factor. The NASA study explores the complex relationship between solar radiation, impervious surfaces, and various types of vegetative cover to measure the influence they have on amplifying or mitigating heat island effects. Impervious surfaces, especially dark colored asphalt, generally absorb and hold solar radiation, whereas vegetative land cover cools the air through the process of transpiration, which releases moisture into the air. The results of the study were that densely developed urban areas were at a much higher risk of heat island effect than their rural neighbors, and that land types with tree canopy cover provided greater mitigation than areas with just lawn. The term "heat island effect" is used to describe urban areas that are significantly warmer than surrounding rural areas (US EPA). After assigning each land cover type a temperature-based classification code, the model developed a temperature gradient by weighting the temperature of each area based on the temperature of adjacent areas. This weighting process illustrates the way that high temperature is made more or less intense based on land cover types and density of development.

This model can be used to identify overarching patterns and relative degrees of vulnerability to the heat island effect within any watershed, but it has some limitations and further research is needed to improve its accuracy. For example, large tracts of dense impervious cover will be significantly warmer than small clusters of impervious cover surrounded by vegetation. However, the model does account for the variability of cooling effects from different vegetation types, for example, forested areas provide more cooling than agricultural land uses, as the NASA study demonstrated.



Splash pad in Quincy, Mass.

Water Cycle & Evapotranspiration



Source: NASA

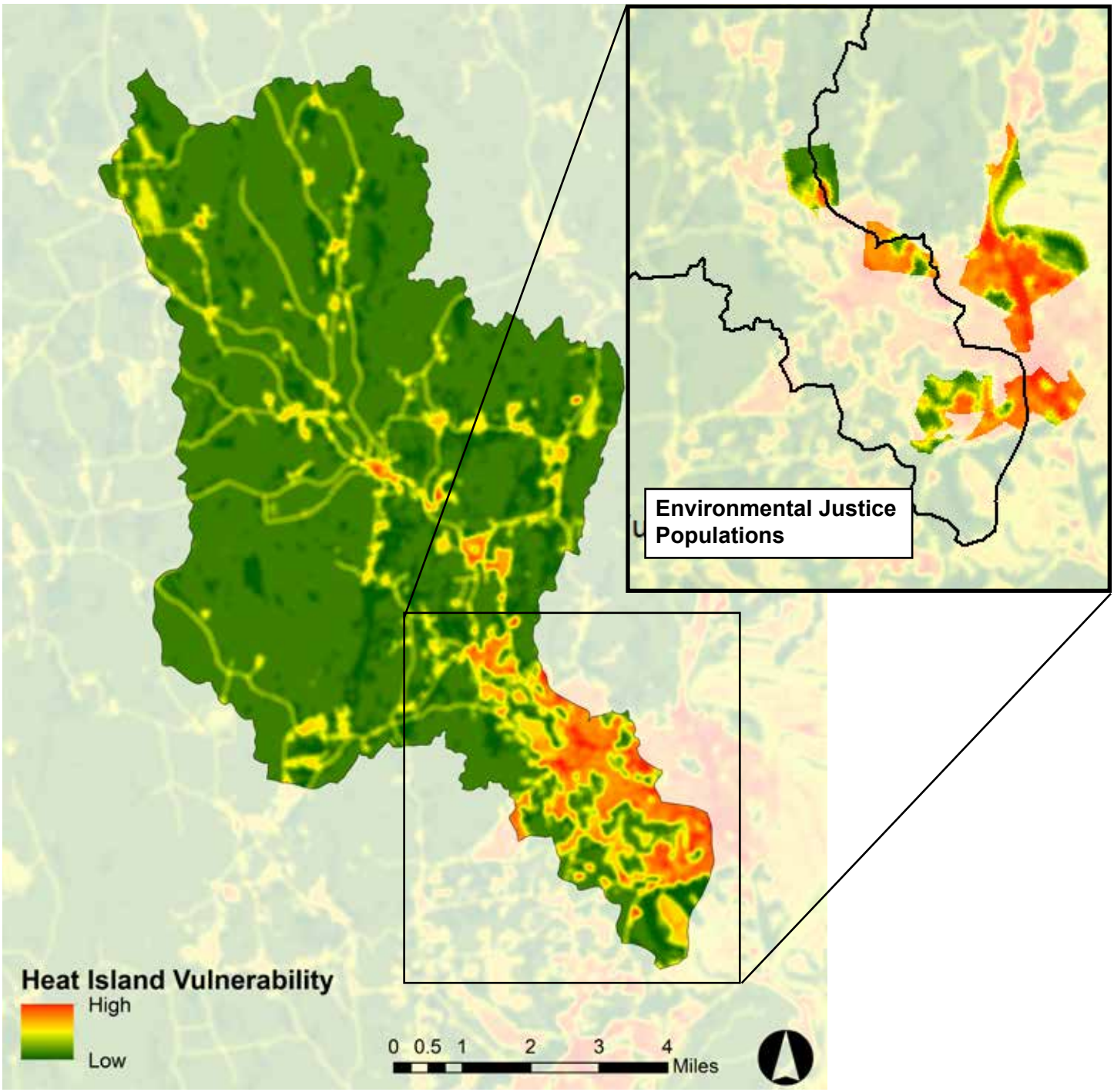
The *water cycle* is the flow of moisture in different forms through the atmosphere. Moisture in the atmosphere falls as rain and snow. This water on the ground flows into the soil, runs into rivers and streams, gets sucked up by plants (*water uptake*), and some evaporates back into the air. Plants also breathe water back into the air as water vapor in a process called *transpiration*. Surface water that flows into a greater water body such as a lake or ocean also eventually evaporates back into the system.

Ecosystem services are the services performed by plants, soil, water, and the atmosphere that are critical to human health. Though invaluable, these services are sometimes quantified with a dollar value that approximates the equivalent cost of replicating these services artificially. Some ecosystem services are those provided by trees, such as water uptake, cooling, and carbon sequestration, and by soil, such as reducing flooding by absorbing moisture.

Trees provide a valuable ecosystem service by transpiring moisture back into the air, which also has a cooling effect. Trees also draw up water from the ground when it isn't raining, helping to dry out wet areas and reduce flooding, and cooling the air even in dry weather. Trees also capture carbon dioxide from the atmosphere in a process called respiration, turning it into biomass (wood and leaves) and breathing clean oxygen back into the air. The process of converting gaseous CO2 from the atmosphere and converting and storing it as biomass is called carbon sequestration.

Heat Island Vulnerability

Figure 13. More developed areas of the watershed are likely to experience more extreme heat island effects during hot weather. The severity of the heat island effect is determined by the density of paved areas and vegetation. The darkest red areas on the map below correlates with the denser areas of Northampton and Williamsburg. Environmental Justice (EJ) populations are often located in areas with high heat vulnerability (inset).



Heat Island Vulnerability Implications

High temperatures have a significant impact on human health, particularly for vulnerable populations, such as the elderly, children, and pregnant women. This effect is not evenly distributed; urban areas have much higher temperatures than rural areas, and also experience higher levels of heat-related risks such as air pollutants like ground-level ozone (Dupigny-Giroux, et al. 694). The combination of higher heat and worse air quality leads to higher rates of illness, especially respiratory illness and death. Along with the vulnerable populations listed above, other groups are also disproportionately affected by heat. These include persons who live in older homes, who are isolated, or who do not have air conditioning; and people who qualify as lower income, minority groups, or other traditionally disadvantaged groups (697).

Some of these traditionally disadvantaged groups are classified as Environmental Justice (EJ) communities, as previously mentioned in the Existing Conditions. In Massachusetts, EJ communities are defined by three criteria: income, which is equal to or less than 65% of the statewide median, race (25% or more of the residents identify as non-white), or English isolation, when 25% or more families contain no adults who speak English, or a combination of these factors (Mass.gov, par. 1). EJ communities experience increased health and environmental impacts from climate change. They are also more likely to be living in urban areas with less access to green-space.

The impacts of rising temperatures and the heat island effect are predicted to become more serious with climate change. For example, deaths from ozone pollution in the Northeast are predicted to increase by 200 to 300 by 2050, and other air pollution related health risks are likely to show similar increases (Dupigny-Giroux, et al. 700). Wildfires are also projected to increase in frequency and severity, which will lead to lower air quality due to smoke; even though wildfires are not a common problem in the Northeast, smoke can travel for hundreds of miles. Other health risks that are linked to rising temperatures are allergies, from higher levels of pollen, and reductions in indoor air quality due to increased mold growth (700).

In the Mill River watershed, heat vulnerability is an important issue. Both Northampton and Williamsburg mention in their MVP's a lack of air conditioning in most schools. Williamsburg also mentioned a lack of air conditioning in most buildings in town. In the rural areas, most houses are older and many people live in isolated areas (Northampton and Williamsburg MVPs). Unlike flooding, heat is not an historical issue in this area, so communities may be less prepared to deal with extreme temperatures.

The inset of Figure 13 shows the distribution of EJ communities in the watershed and their proximity to areas predicted to experience heat island effects. Beyond these communities, even fairly small areas of development, such as Haydenville and Williamsburg centers, are likely to experience heat island effects as well.

Large areas of impervious surface in Florence (left) and Williamsburg (right) could heighten the effects of rising temperature and lead to heat island effects.





Flood Risk

Along with rising temperatures, climate change projections warn of increased intensity of precipitation events and higher risk of flooding. While flooding is a natural process in riverine systems, development in the floodplain can pose a serious threat to human health, safety, and property. A variety of factors influence where and when flooding will occur, many of which are outside of human control. Physical characteristics of a watershed, such as topography, can greatly influence the speed, volume, and direction that water moves across the landscape. These dominant factors are beyond human control, but land use and land cover are two factors that humans have significant influence over. This includes the placement of development, infrastructure, and other human resources in the flood zone. FEMA, the Federal Emergency Management Association, compiles flood maps, which delineate two regions—the 100-year and 500-year floodplain areas, or the areas with a 1 in 100 and 1 in 500 chance, respectively, of flooding in any given year. The 100-year floodplain is also referred to as "high-hazard" and development in that area is regulated.

As extreme weather events and natural disasters continue to devastate communities across the country and the world, the 100-year flood zone has become more of a baseline flood level, and the 500-year flood zone is no longer seen as a minor threat, but rather as a significant one. Many flood maps are also outdated. The Northampton FEMA flood map was created in 1978. Flood maps that do not incorporate recent data or the best available predictions for climate change impacts may underplay the risk faced by communities. However, they do provide a baseline understanding of vulnerable areas that can be cross-checked with data from local stakeholders.

Within the Mill River watershed, significant correlation between existing flooding issues, as described in MVP and HMP documents, and FEMA maps indicates that the maps are relatively accurate. This comparison also supports the assumption that land in the mapped flood zones is at risk of flooding now or in the future, and buildings and infrastructure within these areas could be damaged.

For this report, maps were created that show the location of both 100-year and 500-year flood zones in the Mill River watershed. Over 7% of the watershed is located in the flood zones, with over 5% within the 100-year flood zone and the remaining 2% in predominately undeveloped areas. Additional maps analyzing the potential impacts on human resources were generated using a standardized flood zone that combines both the 100- and 500-year flood zones. These additional analyses map parcels that overlap the flood zone, parcels with buildings located in the flood zone, roads within the flood zones, and the location of emergency services relative to the flood zone. Emergency services includes hospitals, fire stations, and police stations, as well as community health centers, and long-term care facilities such as nursing homes where there are vulnerable populations.

These maps offer a preliminary analysis of vulnerable buildings and populations within the flood zones. Many of these locations are highlighted in community MVP and HMP documents, but these maps can help communities better conceptualize how the impacts of flooding can have a cascade effect into adjacent towns. Additionally, developing a comprehensive inventory of parcels located within the flood zones could inform future planning decisions, including priority areas for restoration, conservation, or stewardship efforts to reduce downstream flooding and protect water quality.



Flooding in the Oxbow, the pond into which the Mill River flows before it connects to the Connecticut River. The presence of the Oxbow and the floodplains and wetlands around it offer invaluable flood protection to the city of Northampton.

Flood Vulnerability: FEMA Flood Zones

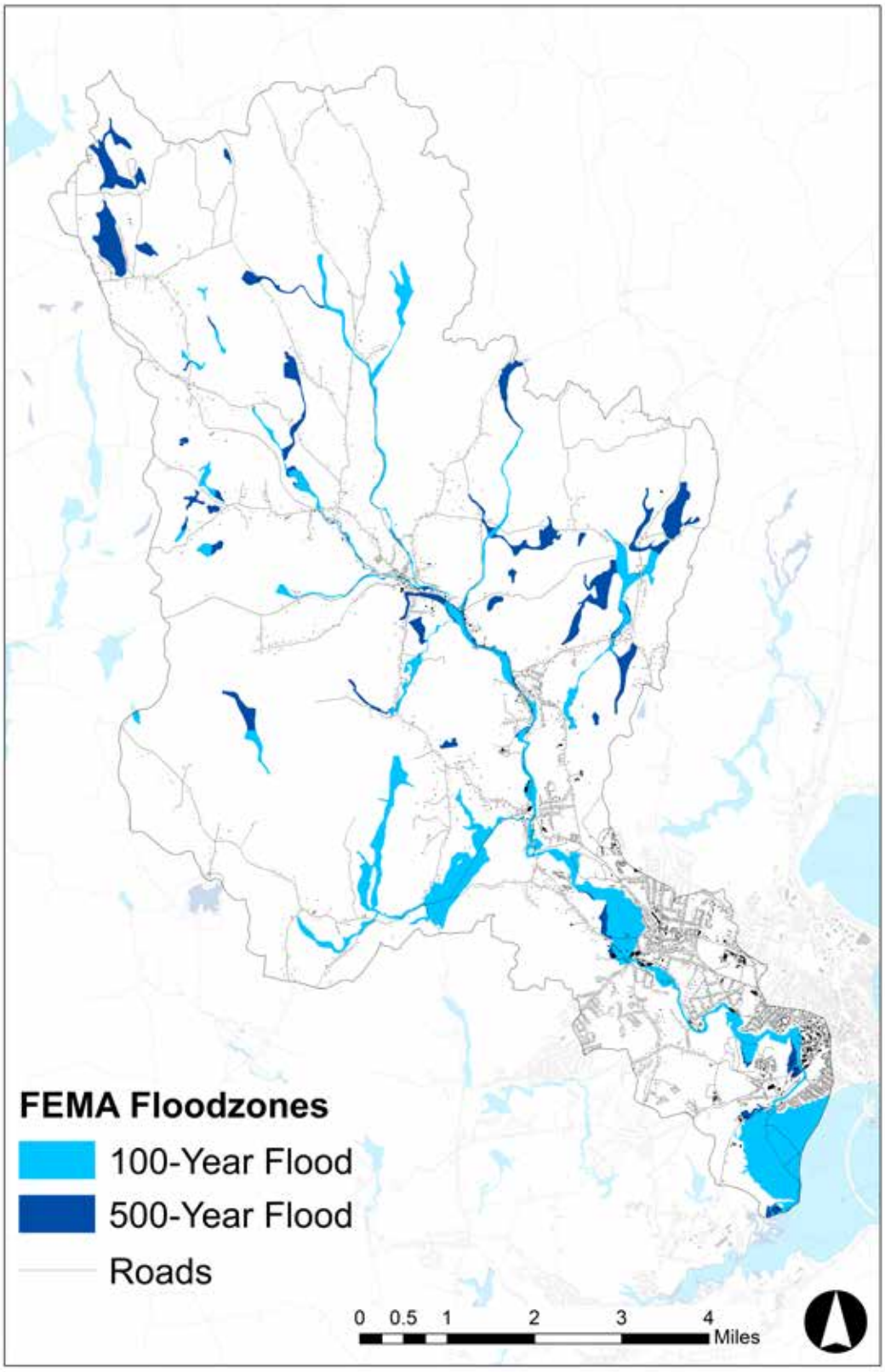


Figure 14. 100-year and 500-year flood zones. The headwaters of the watershed, which are steeper and have narrower riverbeds, have a higher percentage of 500-year flood zones, while the lower, less steep portions of the watershed, where the river channel is wider, contains more 100-year flood zones.

Flood Vulnerability: Parcels and Buildings in Flood Zones

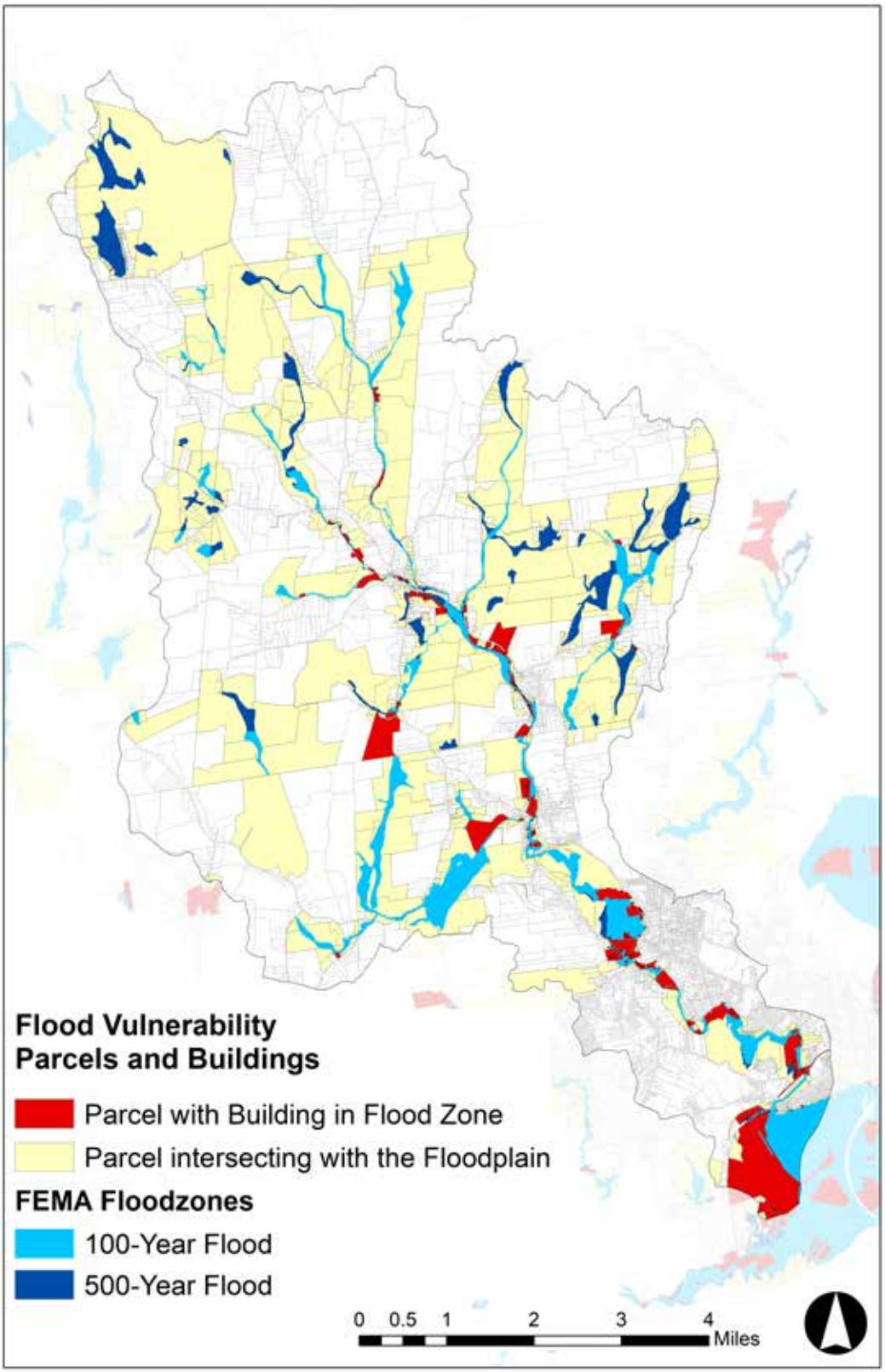


Figure 15. Parcels and buildings in flood zones. Parcels that are completely or partially located within a flood zone are highlighted yellow. Parcels with a building that is located within a flood zone are shown in red. Parcels within the flood zones are distributed evenly across the watershed but the type and severity of flood risk that could impact each parcel could vary depending on factors such as topography, land cover, and location of other features such as dams or culverts.

Flood Vulnerability: Emergency Services and Roads in Flood Zones

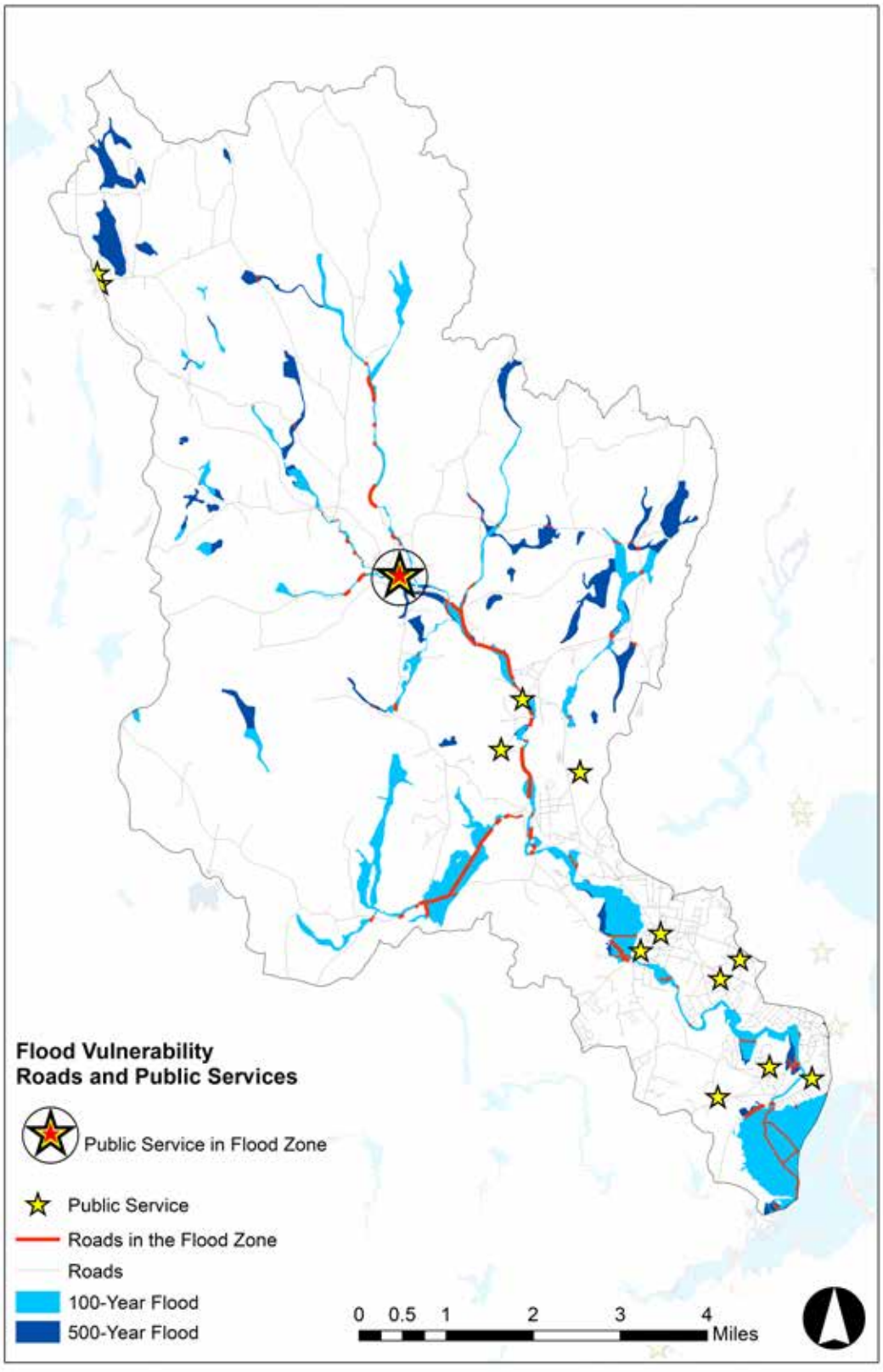


Figure 16. Only one emergency service center is located within a flood zone. This is Williamsburg's emergency service complex, which is currently slated for relocation in conjunction with the town's MVP plan. In addition, the primary stretch of vulnerable road, Route 9 south of Williamsburg toward Northampton, is undergoing a complete renovation to reduce flood and erosion hazards. (Williamsburg MVP).

Water Quality

As mentioned previously on page 30 and shown in figure 5, a portion of the Mill River has been listed as impaired by the EPA due to high levels of E. coli (*Escherischia coli),* a type of potentially harmful bacteria (EPA Water Quality Report, 2010). The source for this bacteria has not been determined, although in one area near Smith College in Northampton, excessive dog feces is a suspected contributer (LaValley, pers. comm). Under the Clean Water Act, all states, territories, and tribes are required to develop a comprehensive program for monitoring and assessing the health of waters within their jurisdiction and submit a biannual report. Waterbodies that do not meet water quality standards are designated as impaired and the state is required to develop a total daily load limit (TMDL). A TMDL specifies the quantity of an identified pollutant that the waterbody can receive while still meeting water quality standards. A TMDL has not been developed for this waterbody at this time.

In addition to this formal categorization of water quality impairment, more densely paved areas of the watershed may also be at risk for lower water quality. In rural parts of Massachusetts, it is common to see general patterns of development and impervious cover following river corridors, where roads and railroads are also often located. While it is unrealistic to move all impervious cover and development out of the river corridor, there are other opportunities to address the overall density of impervious cover.

Watersheds are composed of various catchment areas or subbasins, which are smaller drainage areas such as the land surrounding a tributary or small branch of the main river. By delineating subbasins within the larger Mill River watershed, it is possible to look at the percentage of impervious land cover in a more detailed way. Studies indicate that streams within watersheds with greater than 5 to 10% impervious cover tend to have degraded water quality and this has the potential to impact public water supplies (NOAA). Identifying which subbasins have greater than 10% impervious surface could give communities the opportunity to identify areas where water management interventions could have the greatest impact. Larger municipalities may already be planning with these considerations in mind thanks to the National Pollutant Discharge Elimination System (NPDES), a federal permit program that addresses water pollution by regulating point source pollutant discharges. There are many ways to address pollution and runoff, but using nature-based solutions and green infrastructure can also provide ecological benefits. These techniques are described in more detail later in this report.

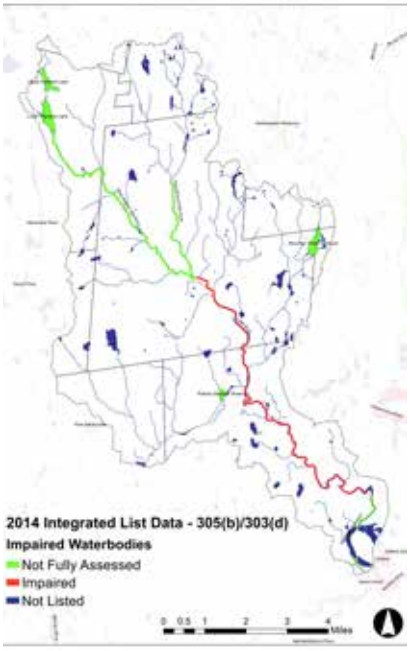


Figure 17. Known water quality issues in the Mill River Watershed

NPDES and MS4

In 2003, the NPDES program expanded to include a Small Municipal Separate Storm Sewer System (MS4) permit to address municipal stormwater systems, prioritizing combined sewer systems. Combined sewer systems are sewers that collect rainwater runoff and sewage in the same pipe and transport it to water treatment facilities. During extreme precipitation events these systems are overloaded, and the overflow is discharged directly into surface water bodies; this event is called a combined sewer overflow (CSO). While the Mill River watershed does not have any Combined Sewer, CSOs are not the only concern.

Stormwater & Pollutants

Stormwater runoff carries pollutants, including bacteria, chemicals, nutrients, and sediment, directly into waterbodies and is the leading cause of water quality problems in the country (EPA). And while many of these pollutants are naturally occurring, they can have serious impacts when in excess. For example, nutrients, such as phosphorus and nitrogen, cause algal blooms and eutrophication, a process where oxygen is depleted from water bodies, resulting in mass fish kills. And sediment fills in streams and ponds, and can clog culverts and storm drains, resulting in flooding and increasing the risk of road washouts.

Percentage of Impervious Land Cover by Subbasin

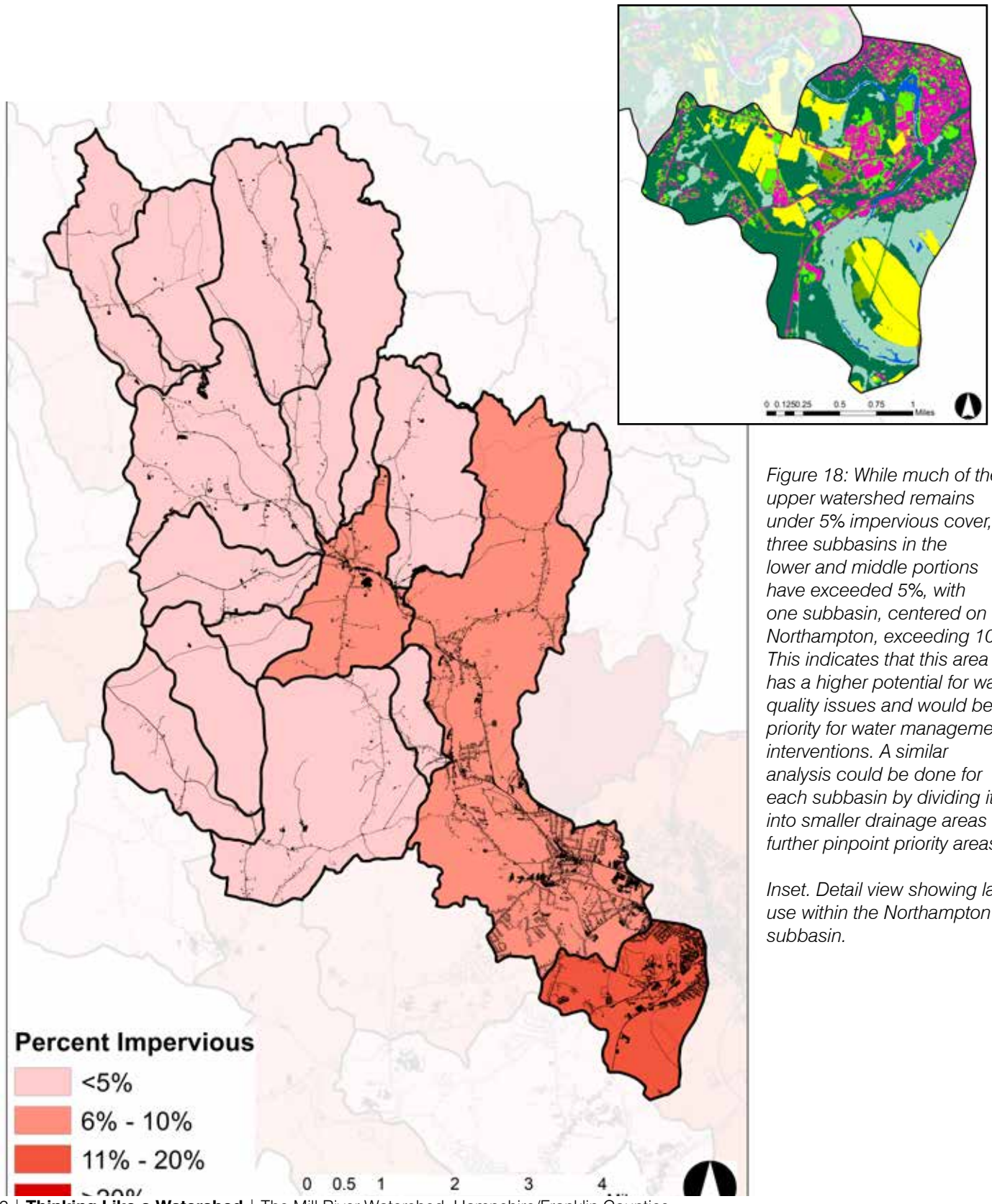


Figure 18: While much of the upper watershed remains under 5% impervious cover, three subbasins in the lower and middle portions have exceeded 5%, with one subbasin, centered on Northampton, exceeding 10%. This indicates that this area has a higher potential for water quality issues and would be a priority for water management interventions. A similar analysis could be done for each subbasin by dividing it into smaller drainage areas to further pinpoint priority areas.

Inset. Detail view showing land use within the Northampton subbasin.

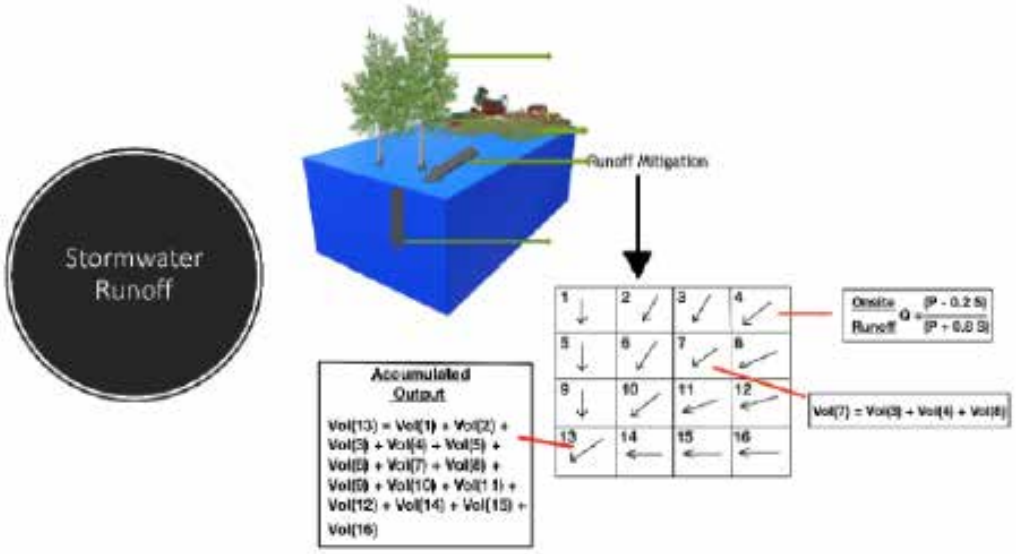
I-CARES Model

Climate change projections stress that there will be changes in hydrologic regimes, This includes changes in rainfall patterns that could result in extended periods of drought and brief periods of heavy precipitation. The quality and quantity of water available throughout the year fluctuates as it flows through the hydrologic cycle. The previous section looked at the percent of impervious cover as a marker for water quality issues. Dr. Timothy Randhir at UMASS Amherst has developed a more detailed and nuanced method of modeling the impact of land cover on water runoff rates. Although the model does not directly show water quality, rates of runoff and types of land cover can be used to predict areas where water quality could become an issue.

Climatic Adaptation and Restoration of Ecosystem Services for Urban and Agricultural Landscapes (I-CARES)

A project led by Dr. Timothy Randhir of the University of Massachusetts Department of Environmental Conservation

Based on recent watershed, natural resources, land use and climate change research, this model will help local communities set priorities for conservation and restoration projects to reduce climate impacts like flooding, drought and extreme heat. The model includes 30 years of recent precipitation and temperature data, new land use data accurate to one meter, soils data, topography and future climate change scenarios. The model will show the importance of communities planning conservation and restoration projects on a watershed basis because it will show the benefits of projects like tree planting, conversion of unused, developed sites to parks and forests, implementing cover crops on farms, and conserving forested sites instead of developing them. By showing how downstream flooding changes with green infrastructure projects, communities can forge new partnerships to implement projects. The below graphic shows how the model predicts water storage and flow across developed and natural landscapes. Within the model, communities will be able to change existing land uses (like planting trees in urban neighborhoods, changes parking lots to urban forests or parks, or developing hillside forests with development that has recently occurred nearby) to show downstream flooding and stormwater impacts. The UMass team will add an urban heat island model that will show the impacts of conservation or restoration project on neighborhood extreme heat events, which will become more prevalent later in this century. The model will also show the runoff and flooding benefits of planting cover crops on farm fields and help farmers to decide when to plant these crops. The model will be tested by communities and released for general use. The Conway team applied the model to their watershed as described on the following pages. Dr. Randhir's project is funded by grants from MA EEA and NIFA McIntire-Stennis Project (MAS00036) - Spatial and Temporal Management of Forest Cover and Urban Impacts for Water Resources Sustainability.



Runoff Values

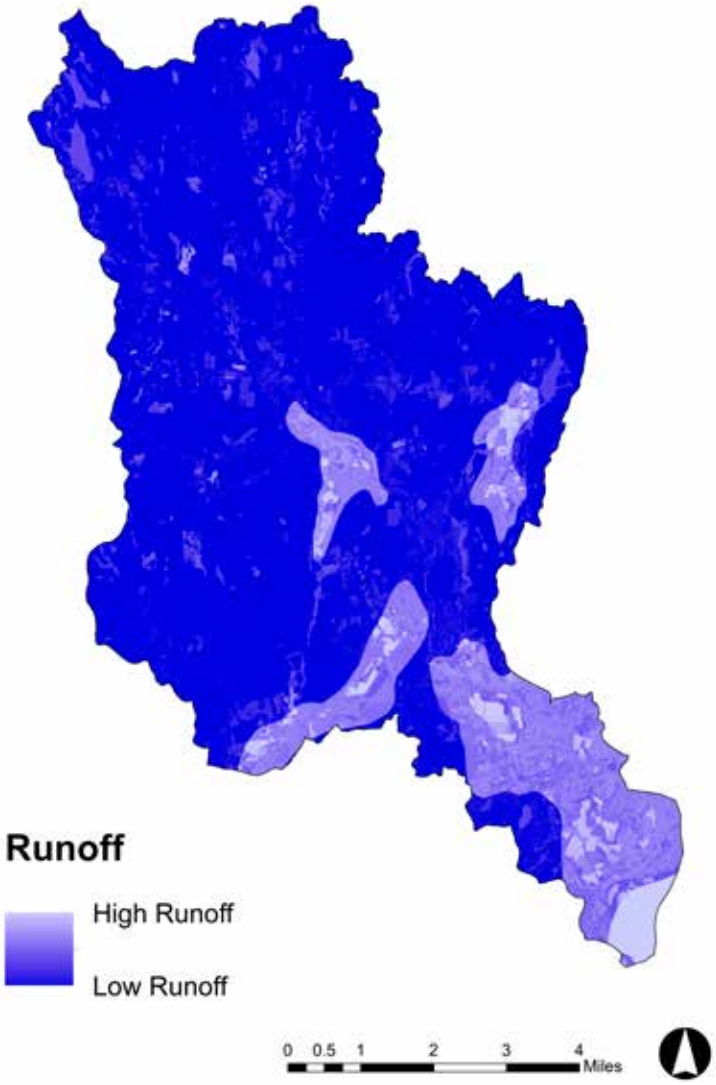


Figure 19

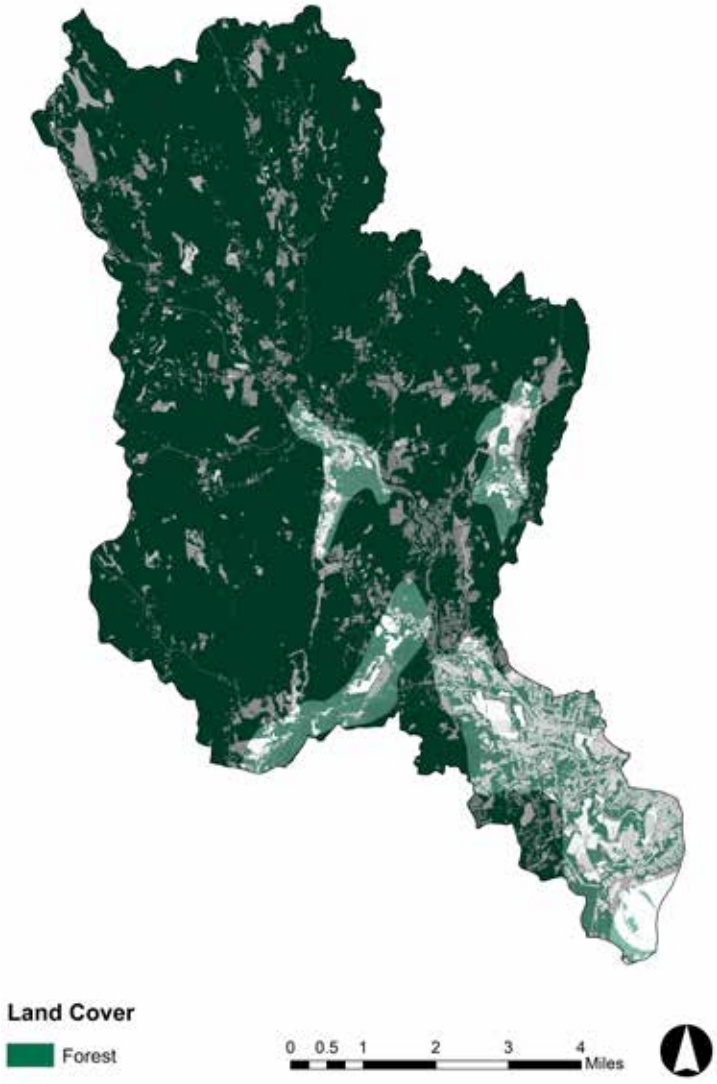


Figure 20

As part of the preliminary analysis for this watershed, the Conway team looked at the patterns of high and low runoff areas in the watershed, using data from Dr. Randhir's runoff model. Most of the headwaters were classified as having low runoff values, and there was a strong correlation with forested lands. If the current land management practices or land cover type is changed from forest to impervious cover, it would significantly alter runoff and the potential impact of flooding downstream. This tool provides a method of testing and measuring the resulting severity and locations of impacts throughout the watershed with different land-use change scenarios. The following page shows runoff values imposed over all land use types, revealing that impervious areas have higher runoff values, as expected. Agricultural land use also has higher runoff values, as does developed open space. This data is not surprising but does offer an additional way to identify areas for land use change interventions.

When Dr. Randhir's model is finalized, communities could use it to further demonstrate the impact downstream of conserving or developing unprotected parcels. This could help communities determine priority areas for conservation as well as parcels that could be developed with minimal impact downstream.

Runoff Values with Land Cover Type

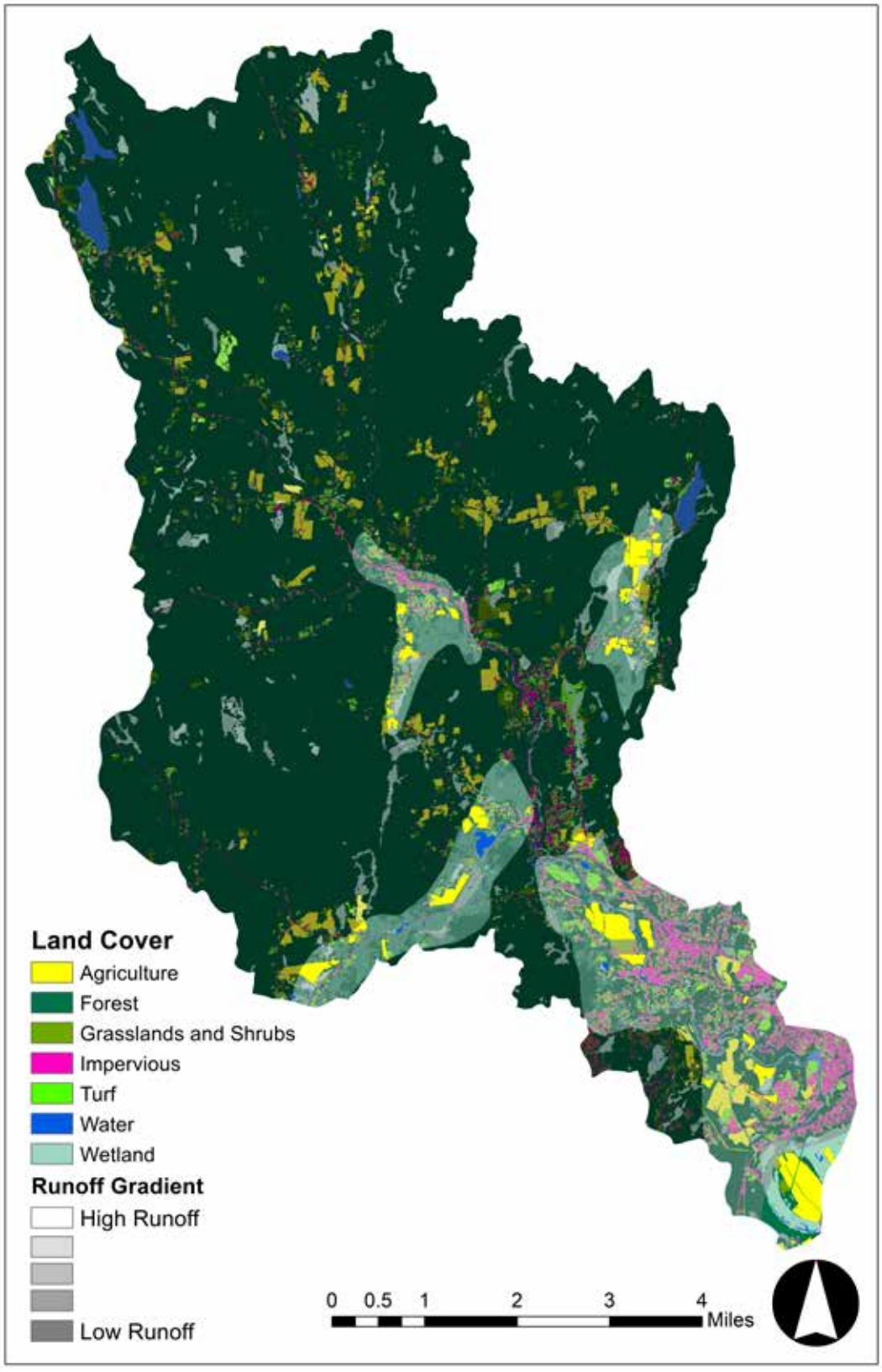


Figure 21. Runoff values compared to land cover types. Highest runoff values are seen in areas with impervious, agricultural, and developed open space (turf) land covers.



Step Four: Pursue Interventions

Spatial analysis (using GIS) of the watershed, review of existing planning documents, and input from community members will guide interventions that are most appropriate for this watershed and community. RLI focuses on land use conversion and land management; therefore, the recommendations that emerge from this framework are geared towards management practices, restoration activities, protection of essential resources, and the institutionalizing of natural infrastructure. All recommended interventions were selected because they incorporate nature- and land-based strategies that improve watershed health, community resilience, and quality of life.

Due to the timeframe and objectives guiding this report, as well as the rapidly evolving fields of study surrounding climate change and resilience planning, the feasibility of the interventions outlined below will require further assessment. Additionally, some of the interventions may currently be under consideration, or may have been found to be unfeasible. The results of this report are not intended to provide the answer to the problems, but rather the methods, tools and processes to get communities started. Therefore, conducting a comprehensive analysis of existing conditions and implementing a robust community participation process was beyond the scope of the project.

The interventions have been loosely grouped into four categories: conservation; restoration; stewardship; and policy and regulation. These interventions are integrated and complementary by design.

Each category also includes some key challenges that have been identified in case studies, municipal documents and conversations with community members. In each section, case studies are provided, usually from within or near the watershed, that are linked back to different recommendations and challenges.

Conservation

Conservation is a land protection strategy that is most important for areas of high ecological value and areas with high development pressure. Forested land, in particular, provides numerous services to humans in the watershed, such as regulating the flow of water in rivers and streams, filtering surface water that drains to public drinking water supplies, and sequestering carbon from the atmosphere (lessening global warming). There are various ways to protect land from development, including deed restrictions which can be placed on all or part of a parcel, as well as enrollment in tax incentive programs such as Chapter 61 and the Agricultural Preservation Restriction Program (APR). Some conservation restrictions can be temporary, such as enrollment in Chapter 61, while others are permanent, such as APR and Deed Restrictions. The one commonality across these programs is the restriction of development. Preventing development in these areas helps to preserve the ecological services and benefits provided to the public. Additionally, preserving lands that connect wildlife habitats increases resilience of natural communities by facilitating dynamic populations and genetic diversity, as well as allowing plant



Paradise Pond, Northampton

and animal species opportunities to migrate as the climate changes.

Conservation strategies generally focus on unfragmented areas with high levels of biodiversity and connectivity, as well as lands of historical or agricultural value. This has also been the strategy in the Mill River watershed, resulting in a large percentage of the watershed's ecologically valuable areas already being permanently protected. But even though the large tracts of priority land are protected, that does not mean there are not other critical areas in need of protection. This could include placing conservation restrictions around wetland resources on developed parcels, as well as conserving small parcels or public green spaces that can benefit humans and provide wildlife corridors between large tracts of protected land.

One strategy is to develop an ecological asset management program, similar to infrastructure asset management systems, that maps and inventories all ecological resources in the watershed. This comprehensive dataset could then be used to model the dynamics, functions and interactions of the watershed system and could be used to inform management and planning decisions. While applying this type of model may be unfeasible at this time due to the cost and technical complexity, it is a developing technology that could become more accessible in the future. Furthermore, the International Union for Conservation of Nature funded a comprehensive review of existing tools of this nature in 2018. The in-depth report compares multiple aspects of each tool including practical considerations such as finance, time and expertise. A potential example of a similar strategy was discussed on page 43, in the form of Dr. Randhir's runoff model, which allows communities to assess the impact of land-use conversions on the runoff values on a given parcel.

There are various challenges to conserving large areas in perpetuity, including the financial implications which will be discussed in the Policy section, and concerns about giving up future development options. Conservation is important, but development may be inevitable and necessary as human populations continue to grow. If all developable land were permanently protected, the only place left for development would be in already developed areas and regulated areas such as wetland buffers and riverfront. In this watershed, however, most of the existing development is already within or adjacent to critical resource areas, and restricting all development to these areas may be ill advised. Therefore, identifying and reserving development rights in appropriate areas is important in this watershed.

Another conservation strategy is to identify areas of importance to human health and safety. This includes forested lands around reservoirs, land in the active riverfront area, and areas that are suitable for or currently used for agriculture.

In more developed areas of the watershed, spaces are conserved for a broader variety of reasons. In Northampton, conserved open spaces include public parks, agricultural land, high priority habitats such as wetlands and riverbanks, and greenways and trails, in addition to forested or undisturbed lands. Most of these parcels allow and encourage public use and in the cases of parks in particular, they can be intensively managed. Open space in urban areas is limited and there is less opportunity to protect new parcels or increase the size of existing conserved parcels.



Williamsburg

However, innovative models such as urban land trusts can be utilized to take advantage of unused spaces such as vacant lots. Urban land can be conserved in a way that limits its use to community garden space or other forms of urban agriculture.

Taking small unused spaces and creating pocket parks or other green spaces can have positive impacts on surrounding neighborhoods in terms of cooling, air filtration, and stormwater retention and filtration, as well as giving residents a place to go to spend time outside. Areas that are undeveloped that would be candidates for conservation due to proximity to already conserved parcels, ecological value, or agricultural use may be harder to find, and the focus for conservation might be placed on parcels such as golf courses and parks that are not currently permanently protected from development. In addition, landowners of larger parcels, such as farmers, could be approached about protecting their land from development. A more innovative option may be to require conservation with new developments; an example of this is natural resource protection zoning (NRPZ), already in use in some Massachusetts municipalities, which requires that a minimum of 65% of a site be left as open space and relaxes frontage, setback, and minimum lot size regulations to encourage denser development. This and other methods are discussed in more detail later in this section.

Winslow Peace Park in Worcester was a Conway School project in 2006. Proposed by Women Together, a non-profit that aimed to end violence in its neighborhood, this park is permanently conserved with a Conservation Restriction held by the Greater Worcester Land Trust. Built in 2008, the park is located on a previously vacant half-acre lot, and includes gathering spaces, a play area, and a community garden and adds tree cover and greenspace to a neighborhood that previously had little access to these resources. The park was built using funds acquired from an Urban Self-Help Grant, and has remained a well-loved heart of the community. Permanently conserving vacant lots as parks and community gardens is a strategy that could benefit any city or town.

Conservation is a valuable tool to combat the threats of climate change, especially in urban areas. Protecting land from development is the best way to ensure open natural spaces persist with growing populations, especially given the potential for climate migration from the coastal areas into Western Massachusetts. Protecting farmland is also vital, as food security and access is an important part of ensuring that communities and regions are resilient. The value of conserving forested and farmable land in the Mill River watershed is likely to have positive impacts far beyond the watershed boundary, given the carbon sequestration ability of forests.

Examples of funding and incentives for encouraging conservation (from the Resilient Lands Initiative draft list of recommendations, March 2020):

- Federal tax incentives for conservation – include fee interest and climate change response qualification.

Case Study

Chesterfield Financial Report 2020

PVPC and Chesterfield committee

This report addresses concerns by town officials that the large percentage of permanently protected land in Chesterfield, coupled with the federal government's interest in protecting an additional 3,724 acres as part of the Silvio O. Conte Wildlife Refuge, will place an undue financial burden on the town, which is heavily reliant on a residential tax base to support its economy. If the additional land was conserved, the town would have 57% of its total acreage in permanent protection (compared to 38% currently).

Since 1990, the town has seen a significant loss in available funds, due to property tax revenue loss as land is conserved or placed in the Chapter 61 program, and a decrease in state funding for the town. The town has compensated for this decrease by raising property tax rates, from $14.97 per acre in 1990 to $19.99 per acre in 2019, and by deferring repairs and maintenance costs on municipal buildings.

Although the town receives payments from the state and federal government for land that is conserved by state and federal agencies, through payment in lieu of taxes (PILOT) programs, these payments are lower than residential tax rates ($10.84 per acre for the state-owned lands and around $8.90 per acre for federal lands).

Despite the concerns, the report states that "there are few hard conclusions that can be drawn to connect economic trends since 1990 directly to the doubling of permanently protected land acreage in Chesterfield during this same period. Too many variables are at play to be able to point to direct cause and effect. Rather, the story is more about the convergence of multiple factors that left the Town of Chesterfield with few options but to lean more heavily on property tax increases to continue to be able to provide local services in this period" (Chesterfield Report 22). However it does seem probable that conserving more land will only increase the financial burden on the town, especially if the land is to be owned by the federal government.

The report proposed three alternative scenarios, of which the third, "an active program that promotes balance," provides for a future that offers both environmental and economic stability. This scenario proposes protecting land through Conservation Restrictions that offer higher tax rates than federal conservation rates, seeking ways to increase state PILOT payments, and concentrating development close to the village center to preserve open space and encourage a vibrant cultural center.

The report also suggests the possibility of forming a collaborative with other rural towns nearby to encourage sharing resources, integrating schools, marketing and promotion for the region, and supporting local businesses. This has been done successfully in six nearby hilltowns (Blandford, Chester, Huntington, Middlefield, Montgomery, and Russell), who formed the Hilltown Collaborative in 2017.



Chesterfield Gorge

- Expand riparian forest conservation and restoration and tree planting projects upstream of cities, towns and water supplies and as parks along urban and suburban rivers – "make room for the river" (conduct statewide analysis of high priority riparian areas to conserve and restore and set a statewide goal to conserve and restore these areas).
- Increase Payment in Lieu of Taxes for rural communities that adopt NRPZ or exceed a forest conservation goal for their town.
- Expand landscape-scale forest and farm conservation projects in public drinking water supply watersheds that also focus on premier unfragmented ecosystems and cold-water habitats with EEA agencies and regional and statewide land trusts and watershed organizations – drinking water protection is a "lens for conservation."

Challenges to conservation efforts, identified by town documents and conversations with community members, include:

- Rural towns often have tight budgets and small tax bases. Each parcel of land placed into conservation reduces or even removes revenue from the town's coffers, and towns can reach a point of being unable to cover the costs of critical town functions, operations, and services, let alone pursue the acquisition of land for conservation and/or management of that land.
- Most of the forestland in Massachusetts is privately owned and not all landowners are willing to consider selling their land or placing it in permanent conservation out of a fear of losing out on the value of their land.
- Many towns also face development pressure for the conversion of forest to solar fields, and do not have the language in their zoning bylaws to regulate this.
- Farmland faces the highest development pressure because soils are typically well-suited to septic system development for homes.
- Higher land values and more intense development pressure can make conserving parcels in suburban and urban areas more difficult.
- Higher population density can lead to more intensive human use of conserved lands and cause issues such as erosion, pollution, and the introduction of invasive species.
- Conserving land next to residential areas may raise concerns among residents about the presence of ticks, mosquitos, increased fire hazard, and other perceived human health risks.
- Converting vacant lots to open spaces may be difficult due to financial pressure from developers.
- Neighborhoods that would most benefit from urban green spaces typically comprise low income and minority groups, which may not have the funds to acquire or manage open space.
- Parks and other public open spaces may not be permanently protected from development.

The Hilltown Land Trust (HLT) spans thirteen towns within and adjacent to the upper portions of the Mill River watershed. Founded in 1986, HLT "protects land and promotes ecological diversity and health, respectful land stewardship, historic character, and natural beauty in [the] hilltowns." HLT has protected over 2,500 acres of land and currently owns and manages nine properties. HLT has the potential to become a valuable partner in any watershed working group that formed.

Restoration

Restoration is the process of improving a disturbed or developed area to a state of improved ecological function, sometimes but not necessarily to approximate its pre-disturbance state. The two variations of restoration explored below include traditional ecological restoration and ecological enhancement. Both variations yield benefits for plants, animals, and people.

Traditional ecological restoration seeks to restore disturbed or degraded open spaces by removing invasive species, planting native species, and increasing the diversity of plant species and ages, to maximize the ecological function and reduce vulnerability to current and future disturbances. These projects may include the restoration of forests, wetlands, floodplains, or other kinds of ecosystems. Frequent human use of these areas is limited in order to maximize the landscape's ecological functioning. However, a degree of programming for outdoor recreation may be suitable; an example of this is a floodplain park that temporarily stores floodwaters, includes plant communities typical of floodplains, and contains trails or boardwalks. This form of restoration could also include increasing the plant diversity of solar fields, lawns, or fallow farm fields.

Ecological enhancement modifies developed spaces to increase ecological functioning and improve human health. Examples of this may include replacing impervious pavement with pervious pavement, increasing the use of nature-based stormwater capture (e.g., bioswales) which mimic natural systems, increasing diverse, native vegetation and canopy cover, and allowing for innovative Smart Growth designs when redevelopment occurs in or near sensitive resource areas. This may also include encouraging property owners to voluntarily move existing uses or activities out of floodplains, or restore areas of their property that are within the 500-year floodplain. These restoration projects could be implemented collaboratively between property owners and the watershed associations to install and maintain interventions. These projects could also be used to address common conditions and uses of resource areas and buffers that reduce function and resilience, such as frequently

mown turf lawn, armored riverbanks, riprap slopes, or compacted soils.

Flooding was identified as a primary risk for the Mill River watershed, especially in areas where development is located in a floodplain or near a river. Restoration projects that address stormwater runoff and localized flooding in developed areas or increase floodplain area and widen river banks to slow the flow of the river can help soften the impact of extreme precipitation events and seasonal flooding. These interventions would have the additional benefits of cleaning water and if trees and green spaces were added, would also cool and clean the air. The benefits of access to green spaces on human physical and mental health are well documented.

Green Infrastructure / Bioretention / Urban Green Space

On many developed sites, more area is paved than is necessary, since paving is more cost-effective and low maintenance than many landscaped alternatives. Often, a project owner opts to maximize parking or driving lanes, or zoning codes require them to do so. Stormwater flows across paved surfaces quickly, often picking up pollutants and heating up on the hot surface. In developed parts of the Mill River watershed, when runoff drains from paved surfaces, it is often piped directly to an outfall to the river. The high speed of runoff drainage and conveyance to the river contributes to its "flashiness," or how quickly the water level rises.

In some areas, paved area could be reduced significantly and replaced with softscape or green space. If stormwater can be captured and held on site and released slowly and/or infiltrate into the ground, the volume of polluted runoff could decrease. Increasing green space in paved areas has numerous co-benefits, including a cooling effect, pollinator habitat, and aesthetic and restorative benefits for humans. At Pulaski Park in Northampton, park renovations included a bioswale that treats and infiltrates water draining to a catch basin on Main Street, and educational signage about green stormwater systems.

Challenges to restoration, identified by town documents and conversations with community members, include:

- Funding for restoration projects could be hard to come by.
- Experts who are qualified to assess and install restoration projects may be hard to find.
- Parcels that are suited for restoration may be privately owned and owners may not want to participate.
- Reducing paved area can be unpopular and hard to push through.

Case Study

City Park Golf Course in Denver, Colorado

A public golf course in the heart of Denver is currently undergoing renovations to integrate stormwater management into the course.

During major storms, the redesigned City Park Golf Course will temporarily hold and slow floodwaters while protecting the course from damage. The detention area is an essential part of a larger stormwater system design within the city. It will reduce runoff from the golf course, helping protect some of the city's most at-risk neighborhoods from flooding. Outside of major storms, the area will remain a dry, fully functioning golf course.

Based on technical assessments and community input, City Park Golf Course was selected for a stormwater management installation because it will protect a large number of homes and businesses; enhance an existing city asset; reduce the need for private property acquisition; and provide for future irrigation needs. (www.cityofdenvergolf.com)

Stewardship

Stewardship is the management of land, which could potentially cover any management practice on any type of land, ranging from leaving conservation land as wilderness to the intensive management of a golf course or public park, but the interventions below focus on a narrower definition of conscious, deliberate management of land for the purpose of long-lasting health and benefit both to the land and the humans who live on or near it. For example, different logging and management practices may result in different levels of runoff retention/infiltration, soil health, and biodiversity levels. Most private landowners want to manage their land responsibly, but many lack the comprehensive guidance or resources to do so. Forest cutting plans filed for properties that are not enrolled in Chapter 61 may be implemented without using best management practices.

Massachusetts Department of Conservation and Recreation (DCR) foresters provide regulatory oversight, reviewing, and signing off on all forest cutting plans, but they can not force property owners to implement long term management plans designed to support ecological sustainability as well economic gain. Land that is not filed under Chapter 61 can

implement short-term cutting plans which allow for the land to be stripped of all marketable material without regard for the ecological condition after. Furthermore, limited resource availability and lack of communication between property owners and service foresters can lead to oversights, misunderstanding and negligence, whether intentional or unintentional.

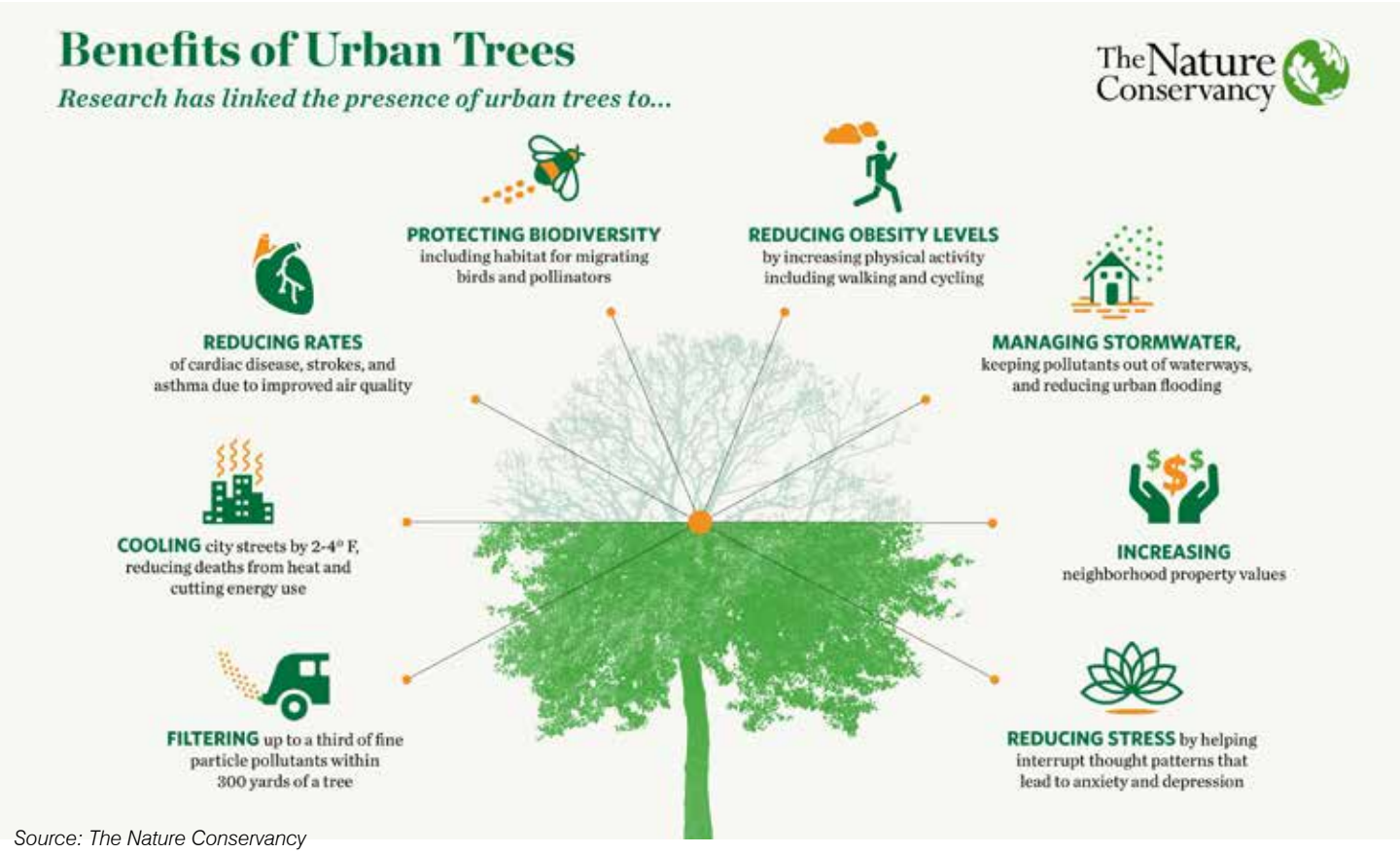
Opportunities to focus on stewardship in order to increase resilience to climate change should include lands that are already permanently protected but are at risk from other pressures, such as invasive species, pests and pathogens, or climate-related pressure; privately owned woodlots; agricultural lands, whether protected or not; suburban yards; and publicly owned open spaces. In all of these cases, outreach and education will be critical for success, and effort should be made to prioritize lands that can increase the resilience of vulnerable human communities or supply vital resources such as drinking water.

Forests

Forest management practices are undergoing extensive research to determine which techniques are best to meet a variety of goals, including carbon sequestration, maintaining public water supplies and facilitating the development of resilient forest communities that will continue to thrive as the climate changes. While simply allowing large areas of woodland to grow, change, and regenerate without human interference is generally accepted to be the best management option, the current state of New England's forests and the changing climate may negate this idea. The New England landscape has been historically clear-cut, and continues to be significantly altered and fragmented, and because of this, the forest system has not had time to self correct and fully recover. Because of this, most of our forested lands could greatly benefit from some level of intervention to facilitate their recovery to more dynamic, diverse and resilient forests.

There is often a stigma associated with cutting and harvesting as a result of poor practices and misconceptions; but thoughtful and ecologically guided cutting could greatly improve the health and resilience of our forestlands. This is not to say that old growth forests need to be managed, or that all woodlands need to be regularly logged in order for them to be healthy. Management can mean a variety of different things, and it is the role of the forester to assess the current conditions and provide recommendations to help landowners better steward their forests.

As the climate continues to change, many of the forests in Massachusetts will become increasingly vulnerable to extreme storms, droughts, invasive pests, and other threats that are becoming more common. An example of our forests' current vulnerability is when the hurricane of 1938 leveled entire forests. The history of clear cut logging resulted in even aged stands of trees which were knocked down in large numbers by a single storm. Forests of diverse age have a multi-story structure that is stronger against extreme winds compared to a stand of trees of similar



Source: The Nature Conservancy

height and width. For this reason, careful management techniques can be used to increase species and age class diversity and support rapid and healthy regeneration of native species. Ensuring that our forests continue to thrive under future climate conditions is essential to the well-being of human communities nearby.

The state offers a variety of programs to encourage forest stewardship, resources for which are listed in detail in Appendix B and further discussed in the Policy section of the recommendations.

Examples of techniques for managing forests to improve health and resilience include (Catanzaro et al.):

- Professional, site-specific forest management planning.
- Planting native trees that are likely to do well with changing climate conditions.
- Planting trees native to a bordering, warmer USDA zone.
- Managing deer populations to encourage more regeneration of trees and understory plants.
- Removing or managing invasive species.
- Selectively cutting trees rather than clearcutting stands in order to minimize impact of runoff on water supply near reservoirs.
- Using fire to support fire-adapted ecosystems where appropriate.
- Revegetating disturbed sites with species that are adapted to future conditions.
- Preserving soil health through careful timing of harvest, leaving woody debris on soil, and replanting groundcover plants after harvest.
- Retaining older trees and thinning to select for a wider range of age-classes.

Challenges to sustainable forest management practices in the Mill River watershed, identified by town documents and conversations with community members, include:

Precedent:

Increasing Forest Resiliency for an Uncertain Future

co-created by Paul Catanzaro (UMASS Amherst), Anthony D'Amato (University of Vermont), and Emily S. Huff (Michigan State) and Funded by USDA and MA DCR

This 25-page booklet was funded by the USDA to "provide landowners, foresters, conservation organizations, and municipal officials a framework for addressing [climate-related] challenges in an integrated way that is specific to your forest and takes into consideration your individual goals, available time, and resources."

This user-friendly guide includes a checklist that allows anyone to assess, increase and monitor the resilience of their forest.

- Lack of understanding about management options
- Overwhelming numbers of resources, programs, and options can lead to confusion, frustration, and misinformation.
- Failure to notify foresters prior to the start of harvest. This can result in poor practices and negative impacts that could have been prevented.
- Ensuring landowners and conservation groups are aware of management techniques and have access to foresters and loggers who understand how to apply these techniques.
- There is a gap between a landowner's goal and the on-the-ground process of logging and even well-written harvesting plans can have significant negative impacts if best management practices are not followed during the harvest.
- In some areas, invasive plants and pests may be impossible to fully control.
- The increasing frequency of pest and pathogen pressure can make retaining a healthy forest more challenging.



Smith College, Northamtpon



Pasture in Williamsburg

Farmland

Protecting farmland is a strategy that can increase access to local food, which increases the resilience of nearby communities. Existing farmland can also be managed to ensure that soil health does not degrade and that the farm is improving the health of nearby ecosystems, and adding farmland, especially in urban areas, also increases availability of local food. Farmland can aid in climate change mitigation; as the American Farmland Trust points out, "when properly managed, farmland and ranchland support wildlife and biodiversity, recharge aquifers, clean water, and . . . . sequester carbon" (farmland.org, par. 1). In particular, farming in floodplains, a practice that occurs throughout Massachusetts, requires thoughtful care so that farmers are using management practices that support water health and do not increase flood risk downstream.

Techniques for dealing with climate-related impacts such as flooding, erosion, or soil degradation on farmland range from simply installing berms to prevent fields from flooding, to changing the crop the farm produces to decrease tilling and increase floodwater detention potential, to managing the soil. However, only some of these techniques also serve to decrease pollution or runoff from the farm and actively improve soil and ecosystem health on and near the farm (Warner, et al., 7-8). The field of regenerative agriculture is actively exploring strategies to make farms more resilient to future climate impacts and help farms actively contribute to climate mitigation and adaptation.

Expanding vegetated buffers between farmland and water resources protects the water quality of those resources, prevents erosion, and slows floodwaters (3). Foresting these buffers yields many advantages: trees uptake the greatest amounts of water and provide shade to waterways. There may be ways to productively incorporate these buffers into the farm, such as planting saleable crops like elderberries or working to create a market for other floodplain species (e.g., basket willow for basket-making). Rotationally grazed livestock may be appropriate in areas where runoff of manure would not be an issue. Research at the Center for Environmental Farming Systems has shown that silvopasture can be a productive and sustainable use for farmlands in floodplains (Franzluebbers).

Adding additional sources of locally grown food and incentivizing the sale and purchasing of local food are also methods that can increase resilience. Here the priorities should be targeting food deserts, making it easier and more profitable to farm in urban areas, and supporting links between farmers and institutions such as schools and hospitals.

Examples of techniques that improve farm resilience and reduce emissions or sequester carbon, include:

- Switch to no-till or low-till methods to increase soil health and carbon sequestration.
- Plant cover crops to maintain soil health on fields that are not actively farmed.
- Add trees to livestock pastures and between crop rows to increase shade and moisture retention.
- Switch to agroforestry and silvopasture methods to improve carbon sequestration rates.
- Plant crops suited to local climate conditions and resistant to local pests.
- Plant a diversity of crops and use rotation, companion planting, and IPM (integrated pest management) to reduce the need for pesticides.
- Plant crops that can be sold locally to boost local food security and economy.
- Transition to organic practices to improve health and

resilience of plants.
- Rotate livestock on pasture and manage manure runoff to keep water healthy.
- Expand and protect river and wetland buffers to protect these resources.
- Work to permanently protect existing farmland and expand protections to include high-quality farmland that is not currently being actively used .

Examples of potential funding strategies that improve farm financial and ecological resilience and increase access to local food (from the Resilient Lands Initiative draft list of recommendations, March 2020) include:

- Develop flexible programs that help farmers diversify their activities so they can make a living in challenging times.
- Use MVP grants to help deal with food security and to promote regenerative farming practices.
- Offer refundable tax credits for the restoration of fallow agricultural land including in cities.
- Develop incentives and program changes to help expand local farming by helping farmers with the high cost of MA regulations, the high cost of housing, and the high cost of employees.
- Encourage links between urban farmers and large institutions (hospitals, schools).
- Develop farmer estate planning/succession programs to ensure farmland stays in farm use.
- Support incubator programs when new/beginning farmers can "test" their venture without a huge initial investment.
- Establish incentives for "carbon farming" – building up organic matter in poor pasture soils to utilize manure, store carbon and enhance pasture productivity and manage pastures to accommodate rare and declining species.
- Create simple carbon/ecosystem services payments/ incentives for farmers.

The Natural Resources Conservation Service (NRCS) offers a variety of financial programs that aid farmers in conserving or managing their land to improve its resilience, increase ecological health, and decrease harmful impacts on surrounding wildlife habitat, water quality, and other environmental resources. In particular, these programs help soften the financial impact and risk of switching to a new farming practice or transitioning to organic certification; encourage diversification in order to minimize financial risk; aid in increasing or better managing conserved land; build soil health and reduce erosion by switching to no or low-till practices and adding cover crops; and much more. The NRCS can also provide equipment to farms that lack the financial resources to buy it themselves. This program is nationwide and similar assistance could be given at the state level to farms that are seeking to improve their environmental impact.

Grow Food Northampton's mission is to promote food security by advancing sustainable agriculture. Located in Northampton, MA, this organization is an example of the ways in which a single organization can have far-reaching impacts on a broad range of food-related issues. Sited on 120 acres, the organization's farm serves as a community garden, provides access to land and markets to beginning farmers, offers a variety of programs to provide fresh local food to low-income residents and food pantries, and runs educational programs for school children in Northampton and surrounding towns. The farms and gardens that collaborate on the land use organic regenerative practices and offer a place for community members to learn more about these methods of farming. This farm is located within a floodplain of the Mill River and the entire area is protected under an APR, making the farm also an example of how to protect floodplain areas while keeping them productive. Other farms that follow similar models could form a network to supply food across the watershed, aid beginning farmers, and educate children, while sharing resources, knowledge, and learning about regenerative farming techniques. (growfoodnorthampton.com)

Challenges to sustainable agriculture practices, identified by town documents and conversations with community members, include:



Williamsburg

CASE STUDY

Forest Management for Water Supply Protection in the Quabbin Reservoir

In 1996, the Quabbin Science and Technical Advisory Committee (QSTAC) was convened to reassess forest management techniques in the area around the Quabbin Reservoir in central Massachusetts. They were tasked to deal with the public controversy surrounding timber harvest in a beautiful natural forested area, and assess silviculture methods to determine the best practices for ensuring a continuous supply of clean drinking water to Boston.

To this end, the committee modeled the effects of a prolonged drought followed by a hurricane that blows down the majority of the mature trees on the water supply and quality. This was seen as a sort of "maximum load" type of scenario, similar to those used by engineers when designing key structures, such as bridges.

Onto this scenario were imposed a variety of silvilculture techniques, beginning with no harvest in any part of the forest. The basic assumption was that even-aged forests, when hit by a hurricane, will experience far greater blowdown and tree loss than stands with two or more age classes. The majority of forests in Massachusetts are even-aged, due to past harvests, and this pattern is true for the Quabbin watershed area as well.

Based on this assumption, forest management techniques that encourage regeneration of younger trees leads to a forest that is more resilient to storms and will recover more quickly, leading to a lower impact on water supply and quality in the event of a massive storm.

"Since these watersheds must be protected and managed in perpetuity, patience, not efficiency, is the key measure of forest stewardship." (Barten et al)

The QSTAC report highlights the benefit of thoughtful management to improve forest health, when the primary goal is to ensure human health or safety. While active management is not the ideal practice for all forests, the intensive history of disturbance and resulting current even-aged stands that dominate the forests in Massachusetts may require some management to acheive the desired diversity and resilience to storms that help ensure the forest is able to supply the ecosystem services that humans rely on.

In particular, management practices that prioritize goals other than timber values, such as wildlife habitat or water quality, can aid in improving the resilience of the forest (Barten et al.).



Big River Chestnuts in Sunderland is "a chestnut agroforestry project for food, soil health, demonstration, and regional resilience." Located on seven acres of permanently protected fertile floodplain adjacent to the Connecticut River, this farm serves as a demonstration site for agroforestry with the goals of providing food while protecting the riparian buffer, developing a chestnut industry in Massachusetts, and studying the soil carbon sequestration benefits of agroforestry and silvopasture. Planned as a research site and educational opportunity for other farmers, the farm also recently began incorporating small-crop fruits such as berries and collaborated with another farmer to bring livestock, in the form of pastured chicken, into the system. Again, a system like this has multiple benefits that could be recreated throughout the watershed in different forms, using tree and shrub crops and livestock species appropriate for specific conditions in each area, and is an example of farming with carbon sequestration as an explicit goal. (regenerativedesigngroup.com)

- Transitioning to a new farming technique can be too expensive and risky for many farmers to consider.
- Soils in many areas may already be degraded and rebuilding health and topsoil depth will take time.
- Expanding riverfront and wetland vegetated buffers may reduce usable farmland.
- Regenerative agriculture can be more labor-intensive.
- Farmers in Massachusetts are aging and transitioning to new ownership of farmland can be a challenge.
- Farmland prices are prohibitively high for young and beginning farmers.
- Farmland is facing very high development pressure in many areas.

Lawns

Lawns cover 400,000 acres in Massachusetts, roughly 8% of the state (Healthy Soils Action Plan draft). Lawn care also contributes tons of CO2 to the atmosphere every year, and fertilizer and pesticide use can cause degradation of soil health and water quality, especially when lawns are located in or near water resource buffers. There are simple and accessible ways to reduce these harmful effects, ranging from simply changing management practices to entirely replacing a lawn with less energy-intensive or more productive plants. These changes also serve to mitigate the effects of heat island and air pollution, as less frequent mowing leads to fewer emissions and in some cases lawns can become carbon sinks through appropriate management techniques.

Landowners who live in or near wetland buffers, riverfront and floodplains could be encouraged to manage their land in a way that retains the function of vegetation and soils to absorb, slow and store flood waters as needed.

Examples of techniques to improve the health of lawns while reducing emissions, increasing carbon sequestration rates, and reducing runoff, include:

- Limit lawn area to the minimum space required for desired uses.
- Treat soil with amendments as needed to increase soil and lawn health.
- Use natural fertilizers and treatments only when necessary.
- Raise the height of mower blades to three inches and leave clippings on the lawn, which allows lawns to sequester carbon.
- Use electric mowers and trimmers when practical, or mow less often to reduce fuel consumption.
- Use grass species that are adapted to local and future conditions to reduce water and fertilizer inputs once established.
- Allow some weeds in order to reduce herbicide use.
- Replace some or all of the lawn with native groundcovers, which will not require water or fertilizer.
- Replace some of the lawn with edible crops.
- Special consideration should be taken in areas near rivers, streams, and wetlands. Adding native shrubs or trees is the most beneficial option in these areas to ensure these water resources remain healthy.

An initiative to increase the combined impact of small farms is currently in the works in Greenfield, MA. This vision, a **Network for Carbon Farmers**, aims to connect farmers, gardeners, and homesteaders across the region to share resources, knowledge, and labor while working toward a common goal of sequestering carbon and building soil health. Using techniques such as silvopasture, agroforestry, perennial crops, and other regenerative practices that can be applied on large-scale farms or in small backyards, the Network would seek to magnify the impact possible by any one farm and create a concerted and directed movement toward meaningful change on a regional scale. In addition to the goals of soil health and carbon sequestration, regional goals could be implemented that aim to specifically address local issues, such as erosion or sediment runoff, water quality issues, or lack of food access to low-income families. This model could also be adapted in urban areas to encourage productive use of vacant lots, backyards, and other open spaces. Longer term goals would be to gain funding to allow the Network to conserve land being farmed and provide land and education to beginning farmers, either by purchasing land in danger of being developed, or working with retiring farmers to take over existing farm operations. The Network would use a single resource, such as the Healthy Soils Action Plan, to come up with guidelines for all members to follow and methods for evaluating progress.



Pioneer Valley Planning Commission (PVPC)

Valley Vision 4: The Regional Land Use Plan for the Pioneer Valley

The goals of PVPC's Valley Vision regional planning document include:

- Manage growth and development, include innovations such as transit-orientedness.
- Integrate and coordinate between the region's land use and transportation plans.
- Advance equity and address environmental justice.
- Compare with strategies of neighboring regions.

(Valley Vision 4)

The report investigates where current policies are working well or need revision, how the region is growing and changing currently and into the future, and what specific zoning codes can be drastically improved. While the Plan outlines many criteria for better development practices, the following specifically address stormwater and flooding:

- **Smart Growth Zoning Districts** (Chapter 40R) – zone for higher density residential use with design standards to preserve existing character in the district.
- **Farmlands with Transfer of Development Rights Zoning** – allow development rights to be purchased in a Sending Area and transferred to a Receiving Area.
- **Incentives for Cluster Development** – replicate traditional New England land use pattern and limit impervious area by clustering homes on smaller lots surrounded by protected open space.
- **River Protection Overlay Districts** – to restrict inappropriate uses along river corridors.
- **Scenic Upland Protection Zoning** – regulate alterations to ridgeline and hillside land which may have significant effects on these natural resources.
- **Critical Lands Acquisition Programs & Funds** – community-established land preservation funds to help protect critical lands such as water supply areas, farmlands, and recreation areas.
- **Low Impact Development (LID) Standards** – bylaws establish standards for shared driveways, permeable pavers, and bioretention to reduce impervious cover and improve water quality.
- **Stormwater and Erosion Control Standards** – bylaws to require all new development retain as much stormwater on-site as possible.
- **Green Infrastructure Zoning Incentives** – for green roofs, permeable parking lots, on-site stormwater recharge, and other green infrastructure.
- **Urban Growth Boundaries** – zoning incentives to promote compactness of development in designated areas with disincentives for development outside.
- **Stormwater Utilities** – fees assessed based on amount of impervious surfaces, revenue used to fund stormwater improvement projects.

Village Hill Smart Growth District, Northampton



Challenges to sustainable lawn care practices, identified by town documents and conversations with community members in the Mill River watershed, include:

- Many people have a strong attachment to tidy, manicured lawns.
- Homeowners Associations often dictate or manage landscaping practices.
- Education on lawn management and lawn alternatives can be difficult due to lack of understanding and exposure to lawn alternatives.
- Many lawn vegetation alternatives are not as tolerant of foot traffic and heavy use as non-native grass.
- Access to waterfront areas is considered an amenity and it can be a challenge to convince landowners to replant buffers because it will obstruct their view or access.
- Fear of insects and vector-borne diseases, such as ticks which may carry Lyme-disease, discourage people from letting grass grow taller.

Public Open Space

Public and government-owned open space could have a huge impact on sustainability. Changing management practices for parks, government-owned areas, parking lots, and schools in ways that retain more water, use less energy, and promote native plants and pollinators would provide both environmental and educational benefits. This could range from technical infrastructural interventions such as the addition of green infrastructure (described in more depth in the Restoration section) to changing the management practices of these lawn areas in similar ways as described above in the lawn section. The techniques below seek to remove or mitigate features that increase the vulnerability of surrounding communities, stack functions to maximize the benefit of these urban green spaces, and provide educational information and interactive opportunities so community members understand why changes are being made.

Examples of techniques to reduce emissions and increase cooling, food production, and resilience of public open spaces, include:

- Encourage more community gardens, backyard gardens, and other urban agriculture techniques in order to increase availability of local food.
- Install community gardens or pollinator meadows in parks and schools.
- Plant native and edible trees in parks to provide shade and food.
- Alter mowing practices to reduce water and energy use.
- Reduce lawn area where practical by replacing with native groundcovers or shrubs/trees.
- Target higher density impervious surface areas (heat islands) when planning where to install street trees and pocket parks.
- Use rain gardens and bioswales to demonstrate ways to slow stormwater runoff.
- Decrease area of underused parking lots by planting strips of trees or native plants, or by replacing parking lots entirely with green space.

Concord, Massachusetts, has several initiative to educate and engage the community to improve the city's resilience to climate impacts. This includes reducing water use, capturing stormwater and improving soil health through sustainable landscaping practices. In partnership with MAPC and the Barr Foundation, Concord installed three demonstration gardens across the town where residents can see, touch, smell, and experience alternative lawn covers. The goal is to educate and encourage residents to implement lawn alternatives at home to reduce greenhouse gas emissions and water consumption rates that are typical of traditional landscaping practices.

Challenges to sustainable care of public spaces, identified by town documents and conversations with community members in the watershed, include:

- Public perception often associates areas of native plants or tall grass with a lack of care and a higher risk of ticks and other unwanted insects.
- Local DPW and park management crews face barriers to changing management practices that may be more time-consuming or unfamiliar.
- School gardens in particular face a lack of care as overburdened school staff lack resources to maintain them, especially in the summer.
- Zoning regulations can limit changes in use, particularly when agricultural uses are suggested.
- Pollution from roads and industrial uses could make urban soils unsuited for edible plants.
- Many cities already face a high demand for parking, and community support for decreasing parking may be difficult to obtain.
- Densely developed areas do not always have the space for strategies such as green infrastructure, or even street trees.

Policy/Regulations

Policy and regulation interventions involve reconsidering suggestions and/or requirements put in place by municipal, regional, state, and federal agencies. Policies are rules put in place by organizations in order to help them reach a defined set of goals, whereas regulations are directives with specific criteria and requirements. Generally, policies and regulations are relatively slow to change and require cooperation of many individuals. However, in the face of a changing climate and in many quickly developing areas, it is critical that lawmakers and constituents work together to

Northampton, Massachusetts

Smart Growth Overlay District (SGOD)

Located just south of the Mill River in Northampton, the Village Hill neighborhood on the grounds of the former state psychiatric hospital, is a mostly completed Smart Growth neighborhood and the product of successful zoning overlay district innovation.

In 2001, the City designated the area as a Planned Village District, waiving minimum lot sizes and requiring at least 40% open space. In 2007, the City of Northampton amended its zoning regulations to add a new Smart Growth Overlay District consistent with State code MGL 40R.

State code MGL 40R, or Chapter 40R, "seeks to substantially increase the supply of housing and decrease its cost, by increasing the amount of land zoned for dense housing" (MGL 40R). This act "encourages communities to create dense residential or mixed-use smart growth zoning districts, including a high percentage of affordable housing units, to be located near transit stations, in areas of concentrated development such as existing city and town centers, and in other highly suitable locations" (mass.gov). The State gives incentives for Smart Growth development by streamlining the development process and providing funding incentives.

The 16-acre site in Northampton is elevated above the Mill River and its 500-year floodplain. It includes numerous Smart Growth and low-impact development elements, including green stormwater infrastructure, shared driveways, residential solar conversion, cluster development, high density residential, and small lot sizes. The site is adjacent to public access APR land and trails along the Mill River, and neighbors the Northampton community gardens.

The Village Hill Smart Growth neighborhood is also home to the Conway School, within easy biking and walking distance from other parts of Northampton and neighboring towns.
(mass.gov, mapc.org)

help communities adapt. In many areas, including parts of the Mill River watershed, these changes are already taking place and communities are starting to see successful outcomes.

Interventions related to policy and regulation may include:

- Establishing a Watershed Council
- Forming zoning overlay districts for smart growth development
- Developing tax incentive programs
- Adopting regional bylaws & ordinances

Establish a Watershed Council

Establishing a Watershed Council or Watershed Planning Authority would help communities in the watershed achieve watershed-scale goals. A dedicated watershed staff person could facilitate collaboration between municipalities as a neutral third-party. This council could provide technical assistance to smaller communities such as updating zoning bylaws and implementing the strategies outlined above. A watershed planning agency could better coordinate efforts throughout the watershed, and with regional and statewide efforts. Large-scale coordination would facilitate concentrated efforts and resources throughout the watershed. A Watershed Planning Agency could also coordinate, apply for, and administer grants to create a more efficient and concerted implementation effort.

Planning at a watershed scale is needed to protect the function of ecological systems which extend beyond administrative boundaries, particularly water. A watershed connects numerous communities through both surface water flows and groundwater supplies.

The **Connecticut River Conservancy** (originally called the Connecticut River Watershed Council) is a non-profit organization that works across both municipal and state lines to unite people and efforts to improve the health of the Connecticut River. Established in 1952, the organization continues to engage communities spanning four states to protect and restore the river and its tributaries. Most notable of the Conservancy's efforts is the annual Source to Sea Cleanup which unites thousands of people to remove trash from the river and its banks.



Village Hill Smart Growth District, Northampton

Watershed-scale planning may not be appropriate for addressing all climate-related threats, for example, heat-island and air-quality risks, but it would help to facilitate integrated planning and collaboration between municipalities. As these collaborative efforts continue, the watershed boundary may no longer serve as the defining factor driving cooperation across municipal lines.

The Watershed Planning Agency could provide resources to advise, implement, and oversee management practices on public land, as well as engaging private stakeholders and overseeing compliance with management practices regulated under incentive programs.

State Programs and Tax Incentives

Innovative policies and regulations could be used to give incentives for restoration activities in areas of high human risk and high ecological value. These might include tax incentive programs to support property owners who restore, conserve, or implement specified best management practices on their property, with an emphasis on areas of regionally significant ecological function. They might also include reviews and expansions of existing forestry regulations and programs, such as the Forest Cutting Practices Act and Chapter 61. Currently, there are three chapter programs that provide tax incentives. Chapter 61 covers forested land, Chapter 61A covers agricultural land, and Chapter 61B covers recreational land.

Parcels under Chapter 61 that have a forest cutting plan receive greater tax incentives compared to those without forest cutting plans. While management activities have the potential to introduce invasive species and poor harvesting practices by loggers can significantly degrade these areas, thoughtful planning and analysis and professional oversight and management could be a benefit to many of our forests. Professional management will benefit a forest more quickly than waiting for natural disturbances to reset the diversity and dynamics of our historically altered woodlands. Unmanaged forests are generally more resilient because they are less likely to be exposed to invasive species, accumulated organic material covering the forest floor creates a healthy soil community, and there is minimal compaction or impairment to hydrologic processes. An exception to this may be forests that have already experienced intense disturbance or heavy invasive pressure.

Family Forest Carbon Program

The Family Forest Carbon Program, co-created by the American Forest Foundation & the Nature Conservancy aims to address climate change through family-owned forest lands in the US, and to provide companies the opportunity to buy carbon offsets to reduce their carbon footprint.

Families and individuals own 38% of forests in the US, or 290 million acres. In Massachusetts, two-thirds of our forests are privately owned. This program addresses the costs and complexity of selling carbon offsets, making the option more accessible to these private landowners.

Landowners can participate in two practices based on the existing condition of their lands:

- **Growing mature forests – this practice promotes growth of larger, higher quality trees by limiting harvest over a 20-year period.**

- **Enhancing future forests – this practice promotes regeneration by having the landowner manage competing vegetation before or after a regeneration harvest, to allow quality trees to have the resources to thrive.**

Carbon growth is monitored and measured in an efficient way to reduce the cost to landowners by 75% from traditional markets. (forestfoundation.org)

Challenges to implementing tax incentive programs include:

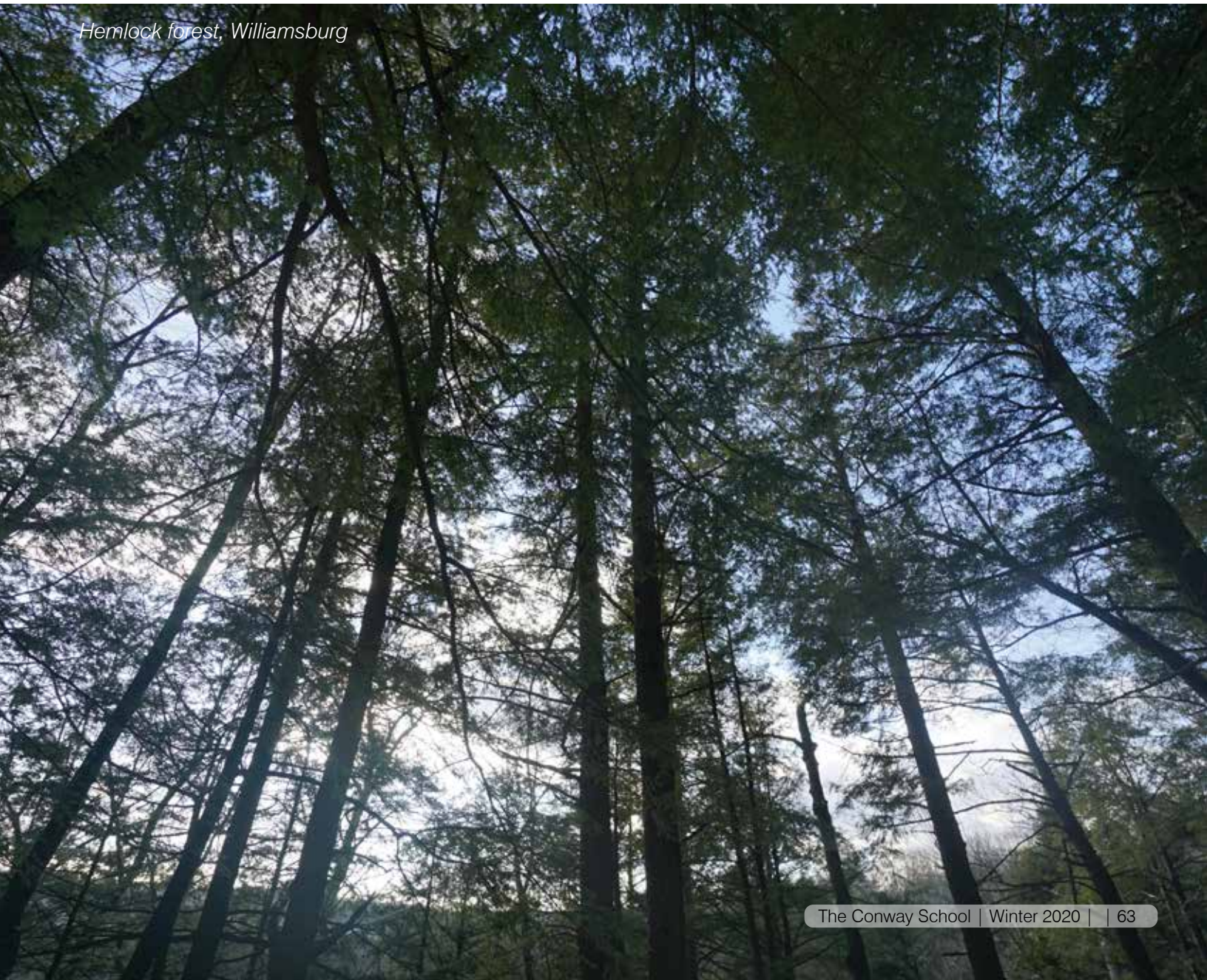
- Overwhelming numbers of resources, programs, and options leads to confusion, frustration, and misinformation.
- Inconsistencies in the tax incentive rates which are based on physical location in the state rather than the value of benefits provided by the land.
- Measurement and valuation of ecological systems is very complicated and most attempts to create a monetary value of these benefits are inaccurate.

Bylaws and Ordinances

Municipalities are already developing new bylaws and ordinances that regulate new development and redevelopment in the face of current and projected climate conditions. For example, Smart Growth policies and overlay districts encourage increased density in already-developed areas while directing new development to areas with the least negative impact on ecological resources. Another example is updating stormwater bylaws and regulations that require all new impervious areas to retain and infiltrate the maximum possible runoff onsite based on the most current rainfall projections, as well as incorporate shade trees, other vegetation, limited impervious footprint, renewable energy sources, and other ecological building practices. Some communities in the watershed have been working with PVPC to implement Smart Growth planning.

Challenges:

- Regulatory review and oversight is inconsistent across municipalities.
- Administrative bodies within municipal governments are often compartmentalized which can result in a lack of collaboration and coordinated efforts.
- Not all municipalities are subject to the same regulations; for example, the NPDES MS4 permit is only required in designated “urban areas” and generally not in rural municipalities.



Hemlock forest, Williamsburg





Conclusion



Conclusion

Above: Williamsburg,
Right: Paradise Pond, Northampton

This report has sought to present a preliminary framework for assessing the vulnerability of humans within watersheds throughout Massachusetts. Using land use change, such as conservation or restoration of high-value areas, and adding green infrastructure to urban areas has the potential to soften the impact of climate change on human well-being and increase the resilience of human communities. The framework presented in this report aims to consider the steps necessary to reach a deeper understanding of how past land use patterns and present-day human and ecological conditions within a watershed may affect resilience to climate change. The goal is to ensure equal and active participation of communities throughout the watershed and to capitalize on the benefits of planning at a watershed scale, rather than community-by-community.

Benefits of Working at a Watershed Scale

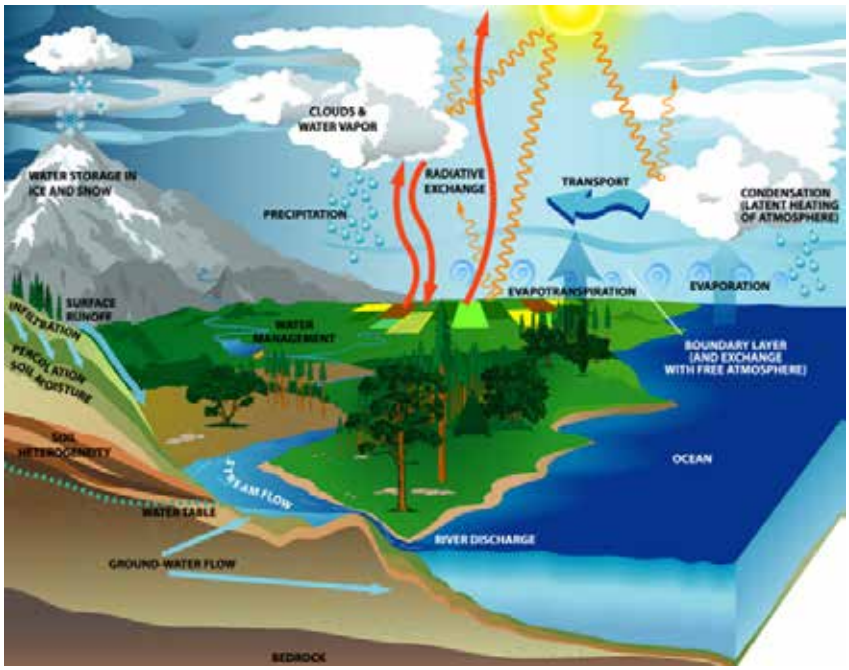
Many of the risks that are projected to worsen with climate change, such as flooding, occur in broader regions than a single community. In addition, actions taken by one community within a watershed has the potential to impact communities up- or downstream, often in unintentional and even possibly harmful ways.

At the watershed scale, it becomes apparent that resources such as forested land and wetlands, as well as challenges such as flooding, are shared amongst municipalities and require a cross-municipality approach. Understanding how climate threatens these resources can lead to partnerships to conserve and share resources.

Watershed planning enables communities to identify where their interests intersect, and develop effective ways to work together, collaborate on planning efforts, share financial resources, protect forested land, and create connected conservation areas and wildlife corridors. Collaboration across disciplines can support the shift towards planning based on ecological functions in addition to political boundaries.

Projects that will have a significant impact on improving resilience in human communities could be too large or expensive for a single community, especially a small rural community, to achieve on its own. A watershed scale plan would allow groups of municipalities to apply for funding for resilience improvements and investments together and therefore magnify the impact of their actions as well as increasing the resilience of a much broader region.





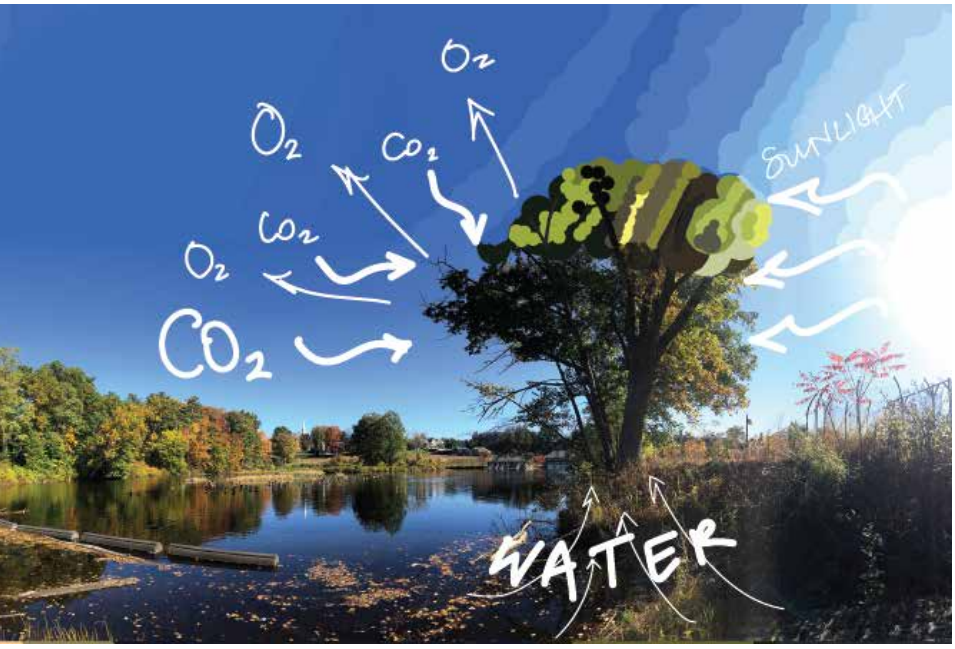
Source: NASA

Summary of Terms

A **watershed**, or **basin**, is the area of land that drains to a single **outlet** or body of water. Watershed boundaries are formed by connecting high points and ridges that divide **runoff** into separate basins. Watersheds can be evaluated at many different scales. The watershed of a single storm drain, also referred to as its **catchment area**, is the area that drains to that one point. Since water always drains downslope, watershed areas are determined by topography and do not change without intervention (human or geological/hydrological). In North America, the Continental Divide is the ridgeline along the Rocky Mountains that divides flow to the Pacific and Atlantic Oceans. In Massachusetts, the Connecticut River basin is one of 20 watersheds at that scale, as defined by USGS and coded as **hydrologic unit code (or HUC)** 8. The Mill River watershed is one of 251 basins at its scale, HUC 12, in Massachusetts.

A watershed often drains to a river. Tributaries are smaller streams that feed into the river. Headwaters are the smallest tributaries at the higher elevations, or uplands, in the watershed. Streams are evaluated by their order in the watershed, with headwaters forming the highest-order tributaries (check). Rivers and streams flow from upstream (higher) to downstream (lower). The **downstream** areas of a watershed, or lowlands, tend to experience more flooding where the topography flattens out. River systems and watersheds can be described by their flashiness, which refers to how quickly a river rises during and after a storm event. Steeper and more paved or impervious areas tend to discharge runoff more quickly, contributing to high flashiness and flash flooding. Slowing down runoff discharge into a river can decrease its flashiness. The word fluvial is used to describe something pertaining to a river or stream system, and alluvial describes sediment deposited by a river system.

Storm events include rain and snow storms that drop a measurable amount of precipitation on an area in a defined window of time. Snowmelt also discharges runoff and causes flooding. Designers use rainfall data to define typical storms for a geographical area based on a statistical **return interval**. Stormwater management regulations are based on this data, or **design storms**, and new development may be



required to retain certain amounts of rainfall onsite rather than piping runoff directly to a **discharge point**, or outfall. Due to climate change, storm intensity has increased significantly and continues to do so, but many regulations still reference outdated design storm data.

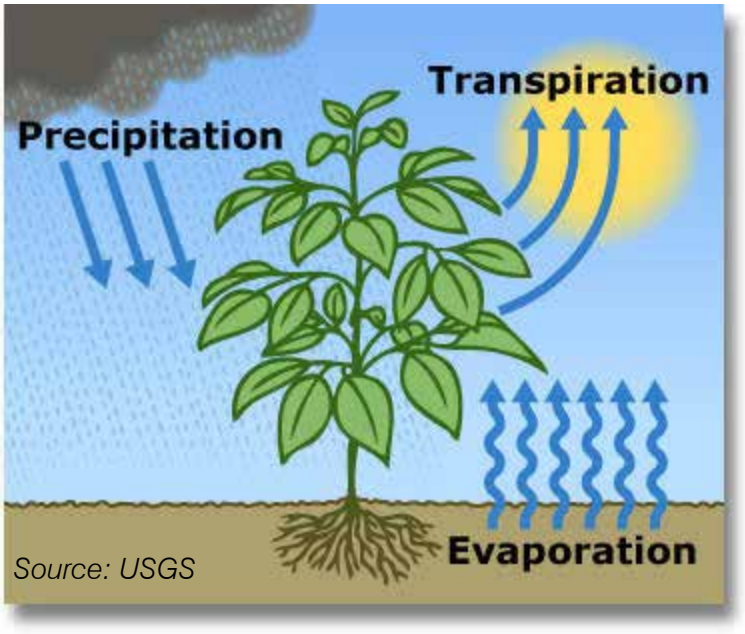
The **water cycle** is the flow of moisture in different forms through the atmosphere. Moisture in the atmosphere falls as rain and snow. This water on the ground flows into the soil, runs into rivers and streams, gets taken up by plants (**water uptake**), and some evaporates back into the air. Plants also breathe water back into the air as water vapor in a process called **transpiration**. Surface water that flows into a greater water body such as a lake or ocean also eventually evaporates back into the system.

Ecosystem services are the services performed by plants, soil, water, and the atmosphere, that are necessary to humans. Though invaluable, these services are sometimes quantified with a dollar value that approximates the equivalent cost of replicating these services artificially. Some ecosystem services are those provided by trees, such as water uptake, cooling, and carbon sequestration, and by soil, such as reducing flooding by absorbing moisture.

Trees provide a valuable ecosystem service by transpiring moisture back into the air, which also has a **cooling effect**. Trees also draw up water from the ground when it isn't raining, helping to dry out wet areas and reduce flooding, and cooling the air even in dry weather. Trees also capture carbon dioxide from the atmosphere through photosynthesis, turning it into biomass (wood and leaves) and breathing clean oxygen back into the air. The process of converting gaseous CO2 from the atmosphere and converting and storing it as biomass is called carbon sequestration.

In the Mill River watershed, as an example, flooding is a primary concern in Northampton, at the lowest elevations of the watershed. Most of the watershed's population lives in Northampton and in the developed corridor along the Mill River and Route 9. The upland communities of the watershed, known locally as the "hill towns," are rural, forested, and sparsely populated. Without much tax revenue from businesses, these communities depend on property tax for their municipal operating budgets. When land is put into conservation, the towns lose tax revenue. However, conserving forested land prevents conversion to a land use that may increase the vulnerability of downstream communities to the effects of climate change. Thus, conservation of forested land is a top priority for mitigating climate change and protecting human and natural communities from the effects of the changing climate, especially flooding downstream.

The flow of water in a river naturally fluctuates throughout the year, and the course of a river also



Source: USGS

shifts over time where not constrained by human development. In general, in the Northeast, river levels rise in the spring, drop or dry up in the summer and rise again in the fall. Storm events and snowmelt cause river levels to rise. A river's banks are formed by the flow of water and forces of gravity and erosion. Softer/looser soils erode more easily than harder stone or human-placed riprap (large stones placed to prevent scour and erosion) and retaining walls. Generally, during and following spring snowmelt and rains, rivers flood their usual banks in flatter areas where they are able to do so. In steep parts of a watershed where rising waters don't have room to spread out, flow becomes faster and more turbulent, eroding river banks and endangering people, creatures, and infrastructure. Flow is measured by two properties, multiplied together: velocity and cross-sectional area. When more water enters into a system, it will either spread out, speed up, or both. Where the flow area is allowed to expand, the speed of the water slows down. Where the flow area is held constant or limited, the speed increases in order to pass the increased volume of water through the same area. (Imagine covering part of a hose nozzle with your thumb.)

The areas where the river is able to flood its banks are called **floodplain**, and they're mapped based on the annual probability of being flooded. Technically, an area that can be expected to flood every year would be considered the one-year floodplain, or an area with a 100% of flooding in a given year. The 100-year floodplain is the area that has a 1%, or 1-in-100, chance of flooding in a given year. In our changing climate, however, these numbers are not accurate in describing the likelihood of a flood in a given year, and many communities have experienced several 100-year floods in the past decades. For reference, the flooding experienced in western New England during Hurricane Irene in 2011 was considered a x00-year storm by today's standards. River/Flood elevation graphics/ sections

While the "100-year" (1% annual return interval) floodplain is regulated, the "500-year" (0.2% annual return interval) is often not regulated. As storms and precipitation become more intense, these areas are both flooded more often, and the return interval for which they were delineated no longer accurately reflects the probability of flooding in those areas. Increasing floodplain area, or low-lying, flat areas that are able to flood regularly, and allowing rivers to flood, protects downstream communities by dissipating flow energy and storing water volume before it reaches them.

Without human intervention, woody plant material that falls in and across a river becomes part of the riverbed and system, slowing flow of water, providing habitat for organisms and wildlife, and protecting the streambed from being eroded, or incised, by fast-flowing floodwaters. In developed areas and on navigable rivers, deadfall is often removed, causing river channels to cut deeper than they naturally would or historically did, dropping the flow of water lower and farther from its floodable banks.

Restoration is the process of restoring a disturbed or developed area to a state of improved ecological function, sometimes but not necessarily to approximate its pre-disturbance state. Restoration projects can include revegetating riverbank and stream buffers to manage invasive species, provide native habitat, prevent erosion, and shade a stream, as well as reducing pavement cover and increasing stormwater storage on a developed site.

Conservation is a term used broadly to refer to a range of designations that protect land from development, either temporarily or in perpetuity. Land with conservation status is referred to in many ways, such as: conserved or conservation land, open space, CR (conservation restriction), Chapter 61 lands, APR (agricultural preservation restriction), and water supply lands. Often, conservation lands are owned by the state, municipality (a town or city), a land trust or other nonprofit, or the federal government, in the form many people are most familiar with, as fields and forests with public recreation access. A conservation restriction is a designation used on property, where the owner can place a deed restriction preventing future development of the site or a portion of it, while continuing to live there. Chapter 61 lands have a temporary restriction on development, where the owner must renew on a regular basis to receive a tax break for farming or forest management. Water supply lands are owned by a state or municipal water commission and managed to protect the drinking water supply for that region. These lands are usually not open for recreation. APR lands are farm and forest land with a permanent conservation restriction.

Forest management is a term used broadly to describe practices used to maintain forest land, often with respect to timber harvest. Different forest

management strategies are used to optimize a forest's performance for specific goals or ecosystem services – timber production, wildlife habitat, carbon sequestration, and slowing stormwater runoff are some of the common forest management goals in this watershed. Forest management tactics include harvest of timber trees, thinning of smaller trees, removal of harmful invasive species, burning, removal of deadfall, propagation of trees to improve age or species biodiversity, and others. According to some stakeholders, there is a lack of consistent information and procedures for property owners on how to manage forest land.

Biodiversity is a measure of how many species of plants and animals are present in an area. Higher biodiversity is often correlated with higher resilience of an area, as disturbances are less likely to cascade through the food web. Invasive species are often considered harmful as they tend to spread quickly and choke out native species, making an area less biodiverse. Additionally, as invasive species are often not recognized as a food source for other species, this loss of biodiversity is often amplified beyond the initial effects. Pests and pathogens are also harmful to forest species, most notably to certain species of trees, and contribute to forest loss. Greater diversity of tree species in an area decreases the likelihood of the forest being wiped out by a single vector. Forest loss is also exacerbated by increasing temperatures, which are changing faster than tree species can evolve or migrate. Forest restoration projects can seek to stay ahead of forest loss by planting more resistant or resilient species or those adapted to a warmer climate.

Connectivity is a measure of how easily wildlife can pass from one area to another, considering that fragmented protected wildlife areas are of lower habitat value than larger areas, or corridors connecting areas.

The State **Executive Office of Energy and Environmental Affairs (EEA)** is an office of the Massachusetts government that focuses on legislation to mitigate and adapt to climate change. The EEA commissioned this report.

The **Resilient Lands Initiative (RLI)** is a subset of the EEA. This group focuses on actionable climate change efforts on the ground, coordinating with stakeholders across sectors to identify priorities and solutions. The eight lenses of the RLI's approach are: farms, forests, water supply, parks & public health, recreation, economic stability, and climate change.

The State's **Municipality Vulnerability Preparedness program (MVP)** helps provide municipalities with the resources to address weakness locally. Communities outline hazards and vulnerabilities in an report and are then eligible to apply for grants to fund improvement projects. Municipalities can also compile an Open Space and Recreation Plan (OSRP), cataloging lands, development patterns, and conservation/recreation goals, which makes them eligible for other state grants to conserve more lands. The Community Preservation Act (CPA) is a state law adopted by municipalities allowing them to tax property owners to fund historic preservation, recreation, and open space projects. The state matches the funds derived from the tax.

The **Pioneer Valley Planning Commission (PVPC)** is the regional planning agency that serves Hampden and Hampshire counties in the Pioneer Valley of Western Massachusetts. The PVPC supports planning efforts in its communities, such as MVP and OSRP production, and provides planning, development, and building standards and ratings. The PVPC published a document called *Valley Vision 4*, which outlines some of the smart growth and green infrastructure policies we refer to in this report.

Green (stormwater) infrastructure, sometimes called **nature-based (stormwater) solutions** is the practice of capturing stormwater as close as possible to where it falls, and infiltrating as much as possible into the ground. Infiltrating stormwater into the ground recharges groundwater aquifers, where much of our drinking water is stored, and prevents concentrated volumes of surface water from flowing directly into streams and rivers, worsening flooding. When stormwater flows across the ground surface without infiltrating, it's called runoff. Different types of surfaces, soils, and slopes have different infiltration capacities, ranging from paved/impervious surfaces (high runoff / no infiltration) to undisturbed forest land with sandy soils (high infiltration / low runoff). When soils are already saturated, however, they cannot infiltrate more water, and additional stormwater will run off – this is often a cause of flooding during sudden, intense rainstorms that dump water faster than soils can absorb it, as opposed to more frequent, lower volume storm events, which can be better absorbed by soils.

A component of a stormwater management system that captures, treats, stores, conveys, or discharges water

is called a **BMP**, or **best management practice**. Traditional, or "grey" infrastructure, used in developed areas generally consists of catch basins (or storm drains) that connect to pipes, that discharge water to an outfall at a point lower than the drained surfaces, in a place that will keep the development from flooding. Often, these systems discharge directly to rivers or wetlands, although modern design standards no longer allow this practice. Country drainage is the practice of draining a surface without using drains or pipes, such as pitching a roadway to drain into an adjacent ditch or swale, or to run off untreated. The use of gray infrastructure, or piping runoff directly into a river system, increases the **flashiness** (quickness to flood) of the river, endangering people, property, infrastructure, and ecology/wildlife. One benefit of replacing grey infrastructure with green infrastructure is that by slowing or removing discharge of water to the river system, the river may become slower to flood and less of a threat to surrounding communities and downstream water bodies. Additionally, green infrastructure can include more vegetation in paved areas, providing cooling, improving air quality, taking up excess water, creating habitat for wildlife, and providing a public health and aesthetic amenity. Green infrastructure BMPs include any practices that slow, treat, infiltrate and detain stormwater and often include vegetation. Green infrastructure BMPs include rain gardens or bioretention basins, vegetated swales, tree filters, permeable pavement, and engineered treatment, filtration, and storage systems.

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