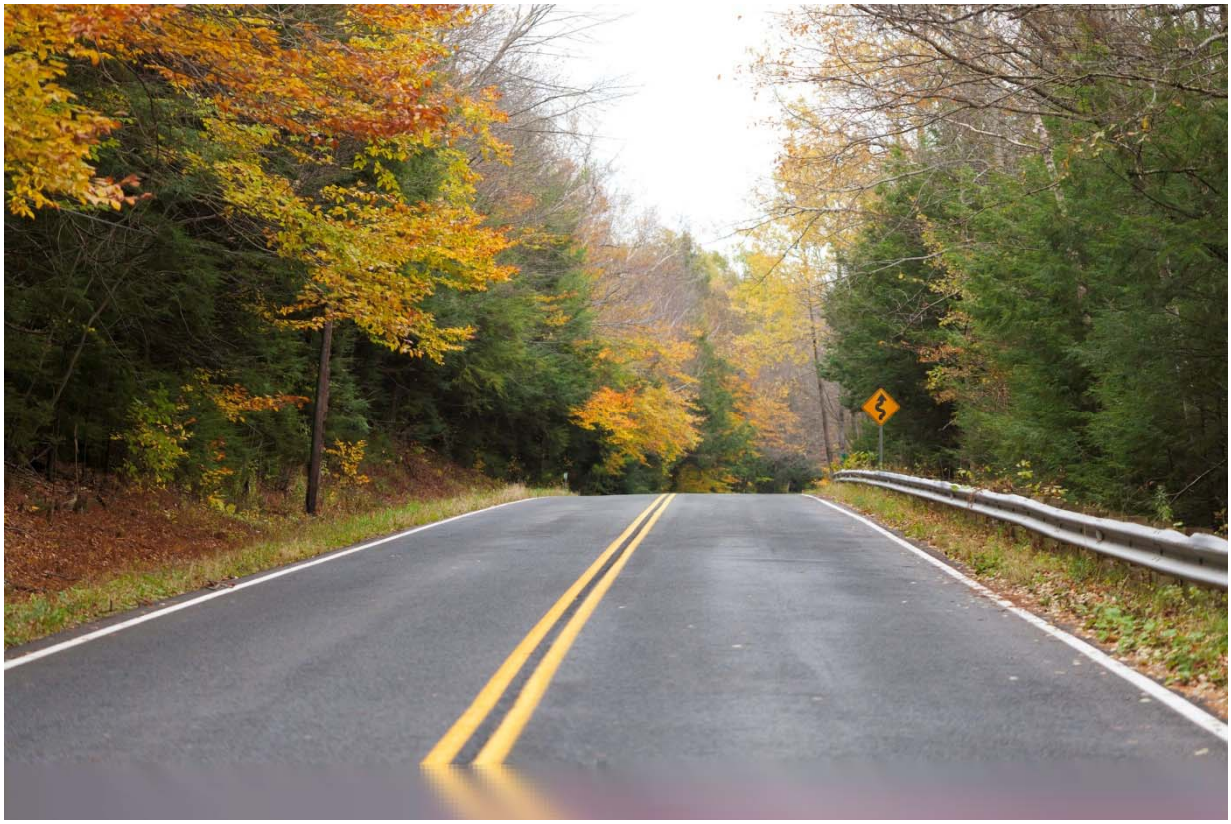
Municipal Vulnerability Preparedness
Community Resilience Building Workshop



Northern Hilltowns Collaborative

SUMMARY OF FINDINGS

For the Towns of Chesterfield, Cummington, Goshen, and Worthington, MA
February 18, 2020

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All four of the northern hilltowns are in the Westfield River watershed, portions of which have been federally designated as part of the Wild and Scenic Rivers program. To qualify, a river must have at least one outstanding natural, cultural, historical, or recreational feature. Photo credit: Wikimedia Commons user John Phelan.

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Overview

Over recent years, communities across the Pioneer Valley have realized the need to increase planning for extreme weather events and escalate adaptation efforts for climate resilience. For the communities nestled amongst the foothills of the Berkshire Range (known locally as the "hilltowns"), the climate change related shift in weather patterns is disrupting routine seasonal activity and strains municipal budgets as highway staff and emergency responders react to the increased frequency of events such as downed trees and limbs, ice events and snap freezes, and power outages. Examples of recent events that have disrupted normal operations within the hilltowns of the Pioneer Valley include:

- The December 2008 ice storm, which caused widespread damage to electrical infrastructure, buildings, and other personal property due to falling trees and tree limbs. Many parts of the hilltown area were out of power for a week, and some locals were out for up to 10 days.
- Hurricane Irene (2011) caused many local roads to wash out or flood, leaving some residents stranded for a day or more while emergency repairs took place.
- The February 2017 tornado, which touched down in the Town of Goshen before moving to the Town of Conway. The tornado caused significant tree damage on Pine Road in Goshen, leaving two homes damaged and roadways littered with woody debris. Local emergency and highway crews cleared municipal roadways and worked with MassDOT to clear MA Route 9. The detouring of traffic off of Route 9 caused damage to local gravel roads, which were in a state of thaw due to unseasonably warm weather.

These and other recent events in nearby communities have reinforced the need for urgent climate adaptation, and compelled the four neighboring communities of Chesterfield, Cummington, Goshen, and Worthington to come together to proactively plan for and mitigate potential risks through a community-driven process. Ultimately, the commendable leadership demonstrated by these four "northern hilltowns" will reduce the exposure and vulnerability of their citizens, infrastructure, and ecosystems. This work also contributes to the greater climate resilience of the entire Pioneer Valley region.

Recognizing the importance of both mitigation and adaptation strategies to deal with the challenges of climate change, the northern hilltowns used the Municipal Vulnerability Preparedness (MVP) Planning Grant as an opportunity to integrate these objectives into existing programs and collaborative partnerships. In 2019, the northern hilltowns successfully pursued and received funding from the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) to advance a series of Community Resilience Building workshops within the four towns under the MVP program.

The core directive of the MVP program is to engage community stakeholders to facilitate the education, planning, and ultimate implementation of priority climate change

adaptation actions. Completion of the MVP process will enable this inter-municipal partnership to achieve MVP certified community status for each of the four individual towns by June of 2020 and receive preference for future state grants.

This report provides an overview of the top hazards, current concerns and challenges, strengths, and proposed actions to improve the northern hilltowns resilience to natural and climate-related hazards today and in the future.

Community Resilience Building Workshop

The Towns of Chesterfield, Cummington, Goshen, and Worthington came together in the winter of 2020 as the "northern hilltowns" to employ a unique "anywhere at any scale" community-driven process known as the Community Resilience Building (CRB) framework to host three five-and-a-half hour workshops: a shared CRB workshop between Cummington and Worthington on February 1**;** Chesterfield and Goshen on February 5; and a regional four-town workshop on February 13. The list of workshop invitees and workshop content were guided by input from the core MVP team (made of elected officials from each of the four communities). The range of stakeholders invited comprised Town elected officials, community members, local business owners, staff from regional organizations and land-holding agencies, and consultants from the Pioneer Valley Planning Commission.

The workshops' central objectives were to:

- Affirm community consensus of the local meaning of extreme weather and local natural climate-related hazards;
- Identify existing and future vulnerabilities and strengths in each community specifically and across all four communities;
- Develop and prioritize actions for each Town and a broad stakeholder network;
- Identify opportunities for the four communities to advance actions to reduce risk and increase resilience, regionally and locally.

Approximately 14 participants from Worthington and 7 from Cummington participated in the February 1 workshop; 21 from Goshen and 9 from Chesterfield participated in the February 5 workshop; and 15 participants representing the four communities and other regional stakeholders participated in the workshop on February 13. Each workshop included a combination of large group presentations and small group activities. Pioneer Valley Planning Commission (PVPC) began the workshop with a presentation outlining the CRB process and goals, updating participants on past and ongoing local planning efforts, and presenting new state-provided climate projection data to enable both decision-support and risk visualization. Participants then broke out into small groups and assumed different participatory roles and responsibilities to engage in a rich dialogue and share ideas and experiences.

Clockwise from top left: Small groups identify features and strategies for Worthington, Cummington, Goshen, and Chesterfield.

While PVPC kept the format of all three workshops nearly identical, the two workshops dedicated to a local CRB process for Cummington/Worthington and Chesterfield/Goshen featured slightly different content than the regional four-town workshop. While each of the two local workshops allowed cross-dialogue between the communities involved, each town was designated to work within their own small groups to populate municipally-specific features and actions within the CRB matrix framework. Thus, at each local workshop the two participating communities had the benefit of learning from their neighboring community while developing their own strategies to address climate vulnerabilities. At the regional workshop, representatives from all four communities and regional stakeholders were intentionally spread throughout three small groups in order to facilitate the identification of regional features and actions to benefit the northern hilltowns as a group.

Top Hazards & Vulnerable Areas

Leading up to the workshops, the core MVP team worked with input from Town officials to identify some of the top ongoing concerns and challenges for each of the northern hilltowns. PVPC compiled this information and conducted research into past planning efforts (such as each community's Hazard Mitigation Plans, Open Space and Recreation Plans, and any local site plans and master plans) conducted by each community to understand the area's infrastructural, societal, and environmental trends. A large component of the pre-workshop research was conducted by students in a Smith College Environmental Science and Policy class (ENV312). Instructed by professors Camille Washington-Ottombre and Patricia H. Mangan, these 18 undergraduates engaged town staff, volunteers, and community members to document existing and potential future conditions of five key areas relative to climate change in the hilltowns: drinking water vulnerability; climate migration and its potential regional impacts to land use and social structure/public health; culverts; winter weather emergency preparedness; and forest health.

At the workshops, PVPC presented participants with a summary of this research in addition to new UMass climate change projections down-scaled to the Westfield River watershed. Participants at each workshop used this information to talk through the suite of priority weather hazards and negotiate common agreement on the top four climate drivers to be used in the CRB process. For all three workshops, participants agreed on four drivers as being the most pressing for the region.

The core MVP team met with Smith College students to discuss local and regional points of concern.

Top Climate Drivers

The top four climate drivers for the workshop as identified by the CRB participants were (in no particular order):

1. Rising average & extreme temperatures
2. Increase in high intensity, short duration precipitation
3. Increase in frequency of extreme weather events
4. Increase in consecutive dry days

Areas of Concern

Transportation Infrastructure: the age and condition of culverts; the state of repair of vehicular bridges over waterways; the early arrival of "mud season" due to warming average temperatures and the effect this has on the condition and passability of dirt and gravel roads; the general passability of roads in time of emergency; and the lack of public transit

Power Grid/Utility Infrastructure: vulnerability of powerlines to weakened trees and tree limbs; the northern hilltowns' location at the end of their service providers' lines

Vulnerable Populations: the aging population; the lack of air conditioning (AC) in most hilltown homes; the general lack of medical offices and grocery stores in the area; spotty cell phone service and lack of high speed internet; and new-comers or seasonal residents may be less experienced with and more vulnerable to extreme weather events

Drinking and Wastewater Infrastructure: drinking water wells' vulnerability to drought and contamination (particularly to roadway salting); reliance on power grid for continued well operation; aging pipes serving the limited public water systems that do exist; the age and condition of private septic systems

Communication Challenges: many residents don't seek, or may refuse, help during extreme weather events; spotty cell phone service and the transition from landlines; emergency radio dead spots; lack of high speed internet

Municipal Capacity: reliance on volunteerism to fulfill town's basic functions and emergency response; very limited tax base from which to finance municipal services

Natural Resources: health and condition of trees and forested areas; invasive vegetation and insects; vector-borne diseases and habitat shift of pest species; road salt contamination of groundwater

Zoning and Future Development Patterns: restrictive zoning; climate migration; municipal code that is in great need of updates

Current Concerns & Challenges by Hazard

The northern hilltowns face multiple challenges related to the impacts of climate change and natural hazard-related weather events. In particular, workshop participants expressed concern over the effect of extreme weather on aging infrastructure; the financial and staffing capacity of the communities to meet unprecedented impacts of climate change, and the effects of an aging and generally declining population.

Participants of the Northern Hilltowns Collaborative MVP workshops were generally in agreement that the towns and region are experiencing more intense and frequent storm events, the impacts of which affect the daily activities of all residents. There was also common concern about the challenges of being prepared for future severe weather events, including the ability to fund and administer adaptation projects in communities with limited tax bases and that run on volunteerism; the resilience of the transportation network to changing weather and temperature fluctuations and the need for the system to remain operational for emergency travel, at a minimum; and the desire to ensure aging residents are able to access the resources they need in the face of extreme weather. Furthermore, participants established a common directive to address the uncertainty of what would occur if the groundwater, which supplies their drinking water wells, were to be compromised.

A 36-hour ice storm culminating on December 30, 2019 resulted in many power outages and left roads impassable across the hilltown region. Photo source: Chesterfield Police Department.

Specific Categories of Concerns & Challenges

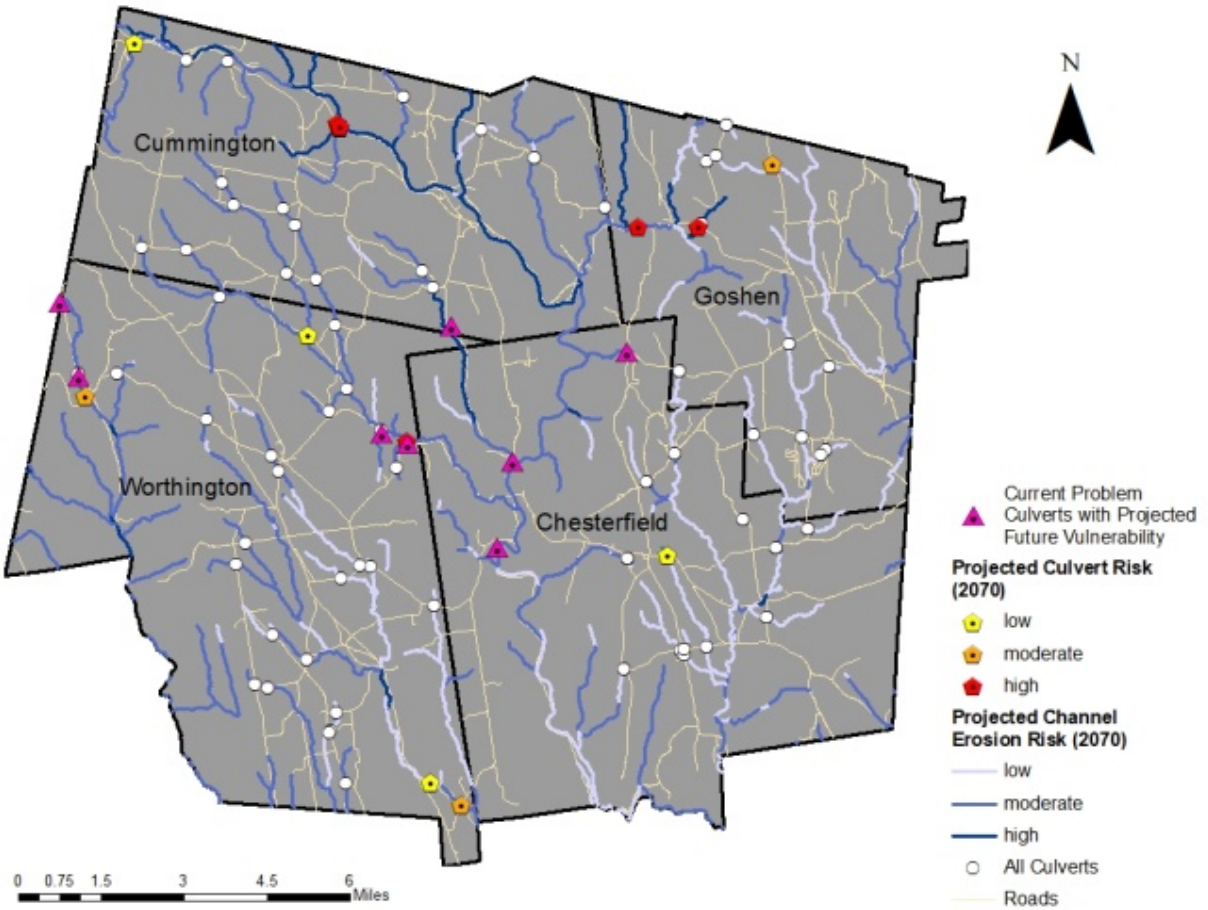
Transportation Infrastructure:

Participants at each of the three workshops expressed great concern over the condition of roadways, especially dirt and gravel roads. Rising average temperatures are destroying road surfaces, and “mud season”, which occurred only seasonally in spring, is now occurring multiple times throughout winter and spring. Dirt and gravel roads need to be regraded more frequently throughout the winter after rutting from rapid ice melt and extreme precipitation events, and paved roads are developing more frequent and larger

potholes, all of which strains municipal highway budgets.

Flash run-off conditions in the spring, coupled with heavy precipitation in the summer months, have created serious flooding and erosion problems in recent years, especially on the many sloped dirt roads throughout the region. These types of flash warming events are likely to become more frequent with the changing weather patterns brought on by climate change. Furthermore, an increase in ice events is creating an unwelcome burden on local

MA Route 9, the major east-west route in the area, is a hilly and winding road which can be vulnerable to winter hazards and downed tree limbs. Credit: Wikimedia Commons users John Phelan (top) and JJBer (bottom).



Smith College students generated this map, which overlays data about existing problem culverts with those projected to fail as precipitation increases. Source: Smith College.

highway department, when roads still require treatments to reduce hazards even without visible snowfall. As the rain and cold increases, so has the stress on the roads and crews who keep them safe.

Limited road passability also affects residents' ability to conduct routine activity (such as getting to work or going to the grocery store) and emergency travel (such as getting to a medical office or evacuating). Roadway maintenance and condition across town boundaries was cited as another concern, where a road may be well-treated for a winter storm in one community while conditions on the same road across town lines might be unsafe.

Culverts were also identified as a specific concern, as those that are undersized and/or in poor repair can lead to road washouts, erosion of embankments, and localized roadway flooding. Culverts are also of extreme importance to the region's many streams. Participants also noted the importance of wildlife passage, which may not be possible through these aged structures.

Smith College students identified a total of 113 total culverts in the hilltowns using the UMass Stream Continuity Project data (2017). Working with local staff, the students classified approximately one in five as a problem culvert—a total of 22 problem

culverts across the region. Eleven of these problem culverts (50%) were reported to experience flooding due to beaver activity. Eight, or 36% of problem culverts, were reported to flood in heavy rain events of one to two inches in a 24-hour period. An additional two (about 9%) are vulnerable to flooding only in extreme weather events or major storms such as Hurricane Irene. Finally, one culvert is constantly underwater. For more information, see their reports attached to this Summary of Findings.

Finally, participants at all three workshops identified the lack of public transportation as a major problem, particularly for residents with limited access to a personal vehicle. Participants noted that the lack of transit also cements their reliance on personal vehicles, which implies continued emissions of greenhouse gases.

Local Concerns

Worthington - River Road Bridge was identified at the workshop as a critical element of the Town's transportation network and future priority for repair. Smith College students identified five problem culverts in town, two along Pierce Road, two on Williamsburg Road, and another on Indian Oven Road.

Cummington - A large culvert on Stage Road contributed to localized flooding and impairs road passability. Smith students identified a culvert on Fairgrounds Road on the Worthington border as "constantly underwater."

Goshen - Goshen has already identified its top four priority culverts as located on Sears Road and Fuller Road, though another on Hyde Hill Road reportedly floods in heavy rains.

Chesterfield - At least nine culverts in Chesterfield were identified by the Smith College research team as problematic due to beaver activity. These are located on Willcutt Road, Main Road, South Street, Bryant Street, and Ireland Street Another four culverts were identified as undersized and causing flooding during heavy rains (on Ireland Street and Bissell Road) or extreme events (on Cummington Road).

Power Grid/Utility Infrastructure: Each community noted the vulnerability of powerlines to trees within the region's rights-of-way. Eversource Energy (serving the Towns of Chesterfield, Cummington, and Worthington) and National Grid (serving Goshen) all proactively trim tree limbs and remove hazard trees from utility lines; however, strong wind and heavy ice and snow still leave residents at risk of power outages due to weakened trees. Additionally, the hilltown region is at the end of each of these service provider's lines, meaning that when power goes out regionally, these communities are among the last to recover power after maintenance.

In 2008, a major ice storm left most of the area without electricity and roads blocked with downed trees and debris for days. Local and regional emergency responders, residents, and volunteers rallied together to clear debris and open roadway access for emergency vehicles and repair crews to access powerlines. In Goshen, this "ad hoc" response was repeated after the 2017 tornado littered local roads and MA Route 9 with woody debris. Despite the tenacity exhibited by hilltown residents to work together to respond to these challenges, workshop participants explained how such events demonstrate a need for a more organized and pre-planned approach for

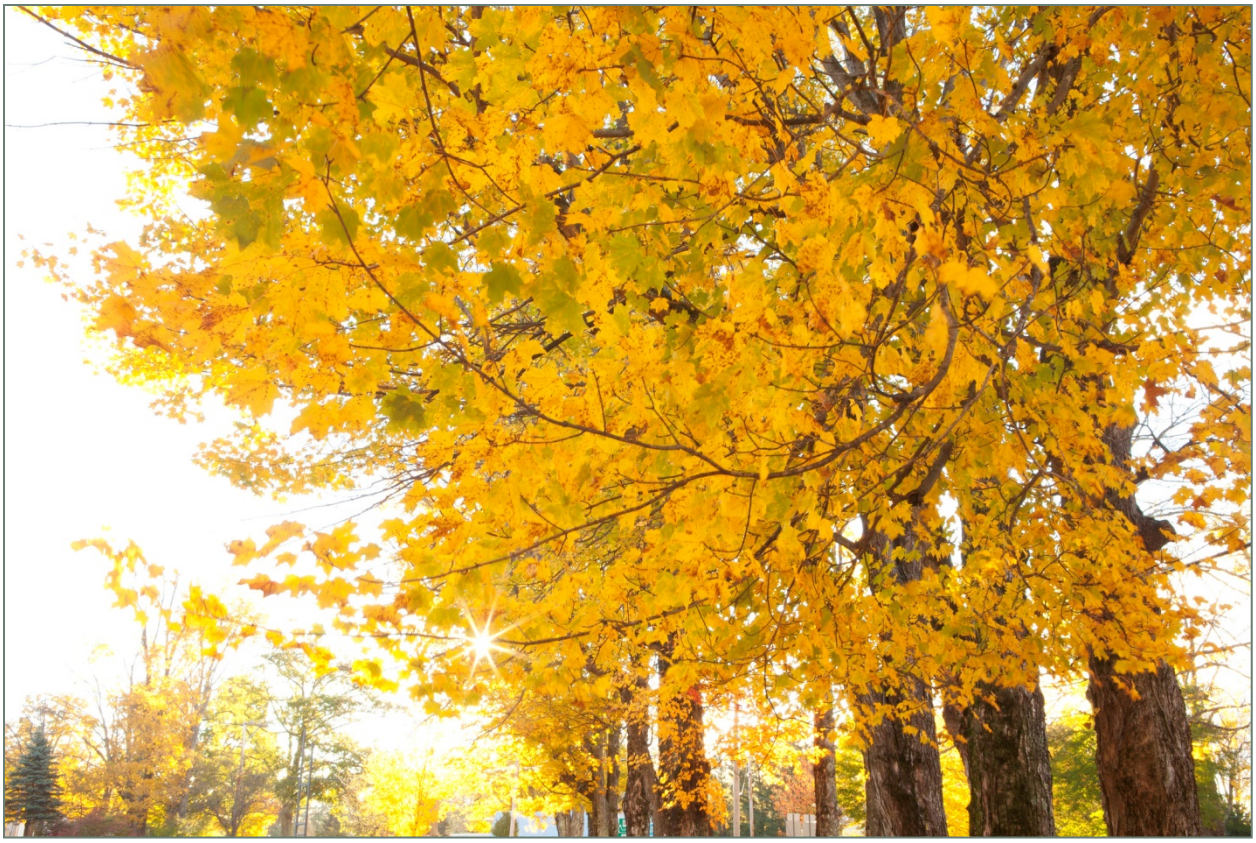
after-event debris management on a regional scale.

The electrical distribution systems in all four communities are highly vulnerable to prolonged interruptions from storm events. The many residents that are elderly, mobility limited, less technologically advanced, or health impaired in any way are particularly vulnerable to the secondary impacts of a power outage, including prolonged exposure to extreme cold or heat.

Spotty cellphone service, radio dead spots, and lack of high speed internet infrastructure were also identified as top concerns. These are explored more fully under “Communication Challenges” below.

Vulnerable Populations: Each of the four communities has an aging population, and, with the exception of Goshen, each community’s population is expected to decline by 2035 as well (UMass Donahue Institute). Some participants noted, however, that population could increase due to broad band installation, lower property costs, and cooler summer temperatures overall in the hilltowns.

The greatest concerns with the senior population are isolation, power outages, and prolonged exposure to extreme cold or heat. Power outages, especially when concurrent with extreme temperatures, leave the elderly and medically vulnerable populations at extremely high risk.



With a long legacy of maple sugaring, the northern hilltowns have many streets lined with grand maple allées such has this one in neighboring Williamsburg. Important symbols of town character, they are also a risk to the street side electric wires. Source: Flickr user Massachusetts Office of Travel & Tourism.

For seniors that live alone, workshop attendees wanted to ensure that emergency response teams would know who these seniors are and where they are located for emergency check-ins.

Because these communities are small, census data regarding the number of other potentially vulnerable populations within this region has a high margin of error and is unreliable. However, participants of all three workshops discussed the potential challenges that residents of color, who speak languages other than English, and/or who might have a cognitive, seeing, hearing, mobility, or self-care impairment might face in staying resilient during extreme weather events.

Time and again, participants referred to the fact that long-time residents of the hilltowns are likely to own generators and have experience hunkering down during extreme events, especially winter weather events. Those who are likely to be caught off-guard during emergencies are recent residents of the hilltowns—those that are accustomed to the services offered in urban or suburban areas, and who don't know to expect relatively frequent power outages. Across all three workshops, there was one impact of climate change for which even old-time hilltowners seem to be unprepared: extreme heat. Residents of the hilltowns are unlikely to own air conditioners because they have never needed them before. However, many workshop participants noted that they had either recently installed or are considering installing, for the first time, AC units in their own homes and ensuring cooling shelters exist within their communities.

Drinking and Wastewater Infrastructure: As all residents of the northern hilltowns rely on groundwater for their drinking water, quality and quantity of groundwater is of prominent interest to workshop participants. Of particular concern is Department of Transportation (MassDOT)'s practice of over-salting the state roadways that run though the four communities. Highway Department staff noted that while MassDOT strongly encourages local road managers to attend workshops around best practices on winter road preparation and reducing salt loads, MassDOT operators routinely over-salt routes under its jurisdiction in advance of winter storms.

Road salt poses a particular threat to drinking water quality due to its high permeability through soil and bedrock, and its corrosive nature. Drinking water wells located close to roads are at elevated risk for road salt contamination, and wells near roads operated by the Massachusetts MassDOT are at a heightened risk due to the department's practice of over-salting roads. Several noted that MassDOT's practices have been an ongoing issue and even referenced in reports dating back to the 1980s. As winter precipitation increases with climate change, especially in the form of rain, it is reasonable to anticipate that local highway staff and MassDOT will only increase the number of times per year that they salt the roads.

Road salt poses a particular threat to drinking water quality due to its high permeability through soil and bedrock, and its corrosive nature. Source: "White out" by Flickr user Kate Ter Haar.

Smith College students conducted a geographic information system (GIS) analysis of water quality vulnerability through a map detailing vulnerability to road salt. Students gauged vulnerability, using several considerations: geologic condition, proximity to major roads, and number of people served by a given well. The students ranked wells in terms of their vulnerability and priority for enhanced protection, with consideration to the type of well (public or private), the size of the Interim Wellhead Protection Area (IWPA), and the surficial geology of the area. Through the ranking and mapping processes, the students identified specific geographic areas of intense vulnerability to contamination, and their report designated five public wells as high-priority for protection: one in Worthington, three in Chesterfield, and one in Goshen. These wells are all proximate to MassDOT routes: MA 143 in Chesterfield, MA 9 and in Goshen, and MA 112 in Worthington. For more information, see the Appendix for their full report.

Communication Challenges: Like many rural towns in the region, the hilltowns are beset by spotty cell service and limited internet access. Poor cell coverage is a real challenge for residents, businesses, and first responders. Participants are hopeful that internet service will be drastically improved within the coming years when new

broadband networks come online – all four towns are slated to be complete in 2020.

First responders report that there are many dead spots for emergency radio-to-radio connections as well, potentially delaying or limiting their capacity to respond quickly.

In addition to equipment and infrastructure challenges, workshop participants noted a need to increase education about and uptake of existing communication channels that could serve residents during an emergency and for day-to-day announcements. All four towns subscribe to some sort of emergency communications or reverse 911 system that can distribute information to any residents who sign up for alerts. Cummington uses Blackboard Connect, Chesterfield and Goshen use CodeRed, and Worthington uses CivicReady. While these systems are useful tools for emergency preparedness and response, they can only help those residents who know about the tools and elect to sign up to use them. Residents who haven't opted in, along with non-residents visiting or travelling through the town, would not be notified of a local emergency.

Workshop participants also expressed concern over the social isolation that ensues from residents aging in place without close neighbors, and needing to institutionalize a system of checking in on one another when preparing for a winter storm or during power outages. Informal lists of residents requiring extra support or services currently exist with the Councils on Aging in Chesterfield and Goshen and Fire Department in Cummington, but it is unclear how these lists are maintained and who can access them. The needs for improved community gathering spaces, such as senior centers, and increased diversity of communication methods were highlighted.

Over the course of the two local workshops and the regional workshop, it also became clear that there was a lack of awareness about a number of resources that already exist. For example, many local participants highlighted a need for a regional pet shelter or a plan for sheltering pets in event of emergency. However, Chesterfield and Goshen's regional EMD noted at the regional meeting that this plan and system already exists. Therefore, increased communication around and dissemination of existing systems and resources became the ultimate strategy. In studying local emergency response plans and the needs of local residents, Smith College students developed a strategy for disseminating more of this information with a series of workshop topics.

The four communities also noted that as population in most of the towns has declined in past years, they have turned to regionalization of services (schools, emergency management, etc.). While regionalization is often an efficient and cost-effective way of continuing levels of service that might otherwise be impossible in these small towns, participants indicate it has contributed to a loss of community identity and shared culture. In particular, Cummington participants noted that with the closing of their local Berkshire Trail Elementary School in 2017 there have been ramifications for dissemination of communications throughout the town. The school had been a focal point for many in the community, and was therefore an easy way to send news to local households. As Cummington is sending students to the Central Berkshire Regional School District, there is no longer an easy way to get a

large population of the town together regularly.

Municipal Capacity: Many of the climate impacts the northern hilltowns are facing are universal across the Pioneer Valley. Though the details may be different town by town, nearly all MVP certified communities in western Massachusetts have identified more frequent power outages, an increasing and more frequent need for road maintenance and repair, and concern about drinking water quantity and quality as top concerns. One aspect unique to small, rural communities such as those in hilltowns, however, is the greatly limited capacity of local elected officials and local budgets. The four communities of the northern hilltowns run largely on volunteer labor, and key positions—ranging from Town Administrator to firefighter—are filled by local residents who often have fulltime jobs out of the region. While these volunteers are devoted to their communities and perform exemplary work, they may be unable to react as quickly to new state programming or grant opportunities as those communities that have professional staff.

The reliance on volunteerism also means that some positions may go unfilled for long periods of time if no one is able to step in. With many residents working full time, facing long commutes to work and sometimes additional drive time to drop off and pick up children from school in a different town, available time for high-impact volunteer work is extremely limited. Worthington noted that the town has had a dearth of volunteer firefighters, leaving the community vulnerable without full capacity response.

The aging and generally declining population of the four communities also

Residents and visitors to the hilltowns alike enjoy the area for the variety of outdoor activities available, such as cross-country skiing, but which are under increasing threat from climate change. Source: Flickr user Massachusetts Office of Travel & Tourism.

threatens a system of government reliant on volunteers. As the residential population either becomes too old or too few to meet the rigorous demands of running a municipality, these positions become less and less likely to be filled.

The municipal capacity of the four communities is also undercut by their small budgets. Small towns with between 400-600 households each, the tax base is limited in all four towns. A recent study in Chesterfield showed that over the past 30 years, the combination of a 10% reduction of the state share in the municipal budget and the removal of nearly 3,000 acres of land from

the tax rolls, due to permanent conservation, has contributed to the great challenge in meeting municipal costs. While the state does provide Payment in Lieu of Taxes for conserved lands that it owns, these payments are not in keeping with local needs. The Town of Chesterfield, in turn, has leaned heavily on increasing the local tax rate for remaining taxable properties to try to make up differences. They have also deferred maintenance on many infrastructure assets, including the fire station, which dates to the 1950s, and Town Offices, which dates to the 1940s.

The hilltown region also struggles to support many commercial operations or small businesses, limiting tax revenue from this sector, and those businesses, for which the area is known, rely on seasonal weather and temperature patterns that are already shifting with climate change. Historically, maple sugaring, gift shops and food operations catering to "leaf peepers," and outdoor tourism has driven much of the local economy, suggesting a real prospect of declining local revenue in the future.

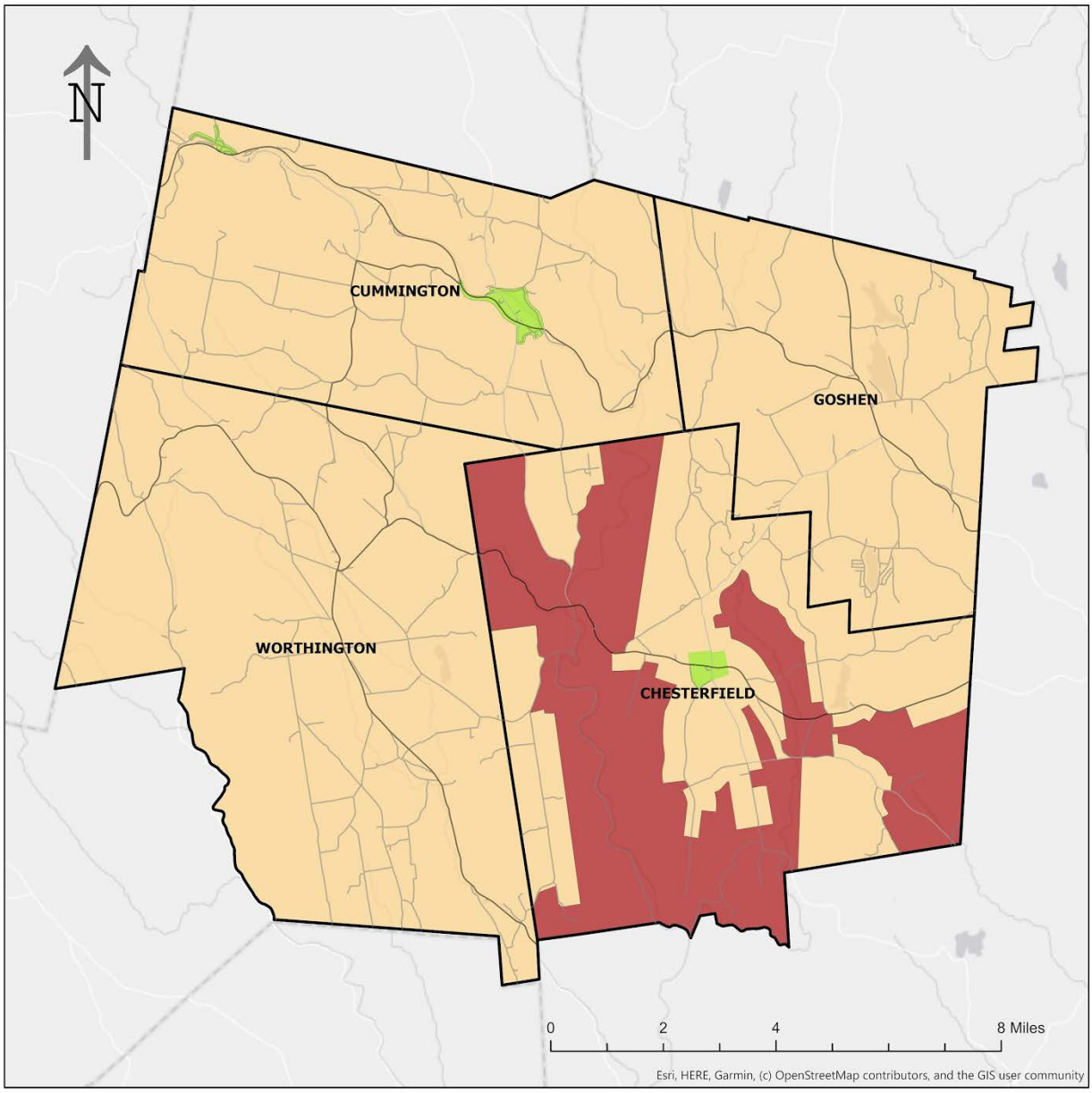
Natural Resources: Invasive species and habitat shifts were another topic of conversation, especially as they relate to tree mortality, riparian erosion, and vector-borne diseases. Participants noted that vegetative invasives were encroaching on conservation land and riparian areas, and that Japanese knotweed in particular was crowding out native habitat and destabilizing soils along stream and riverbeds. Also of concern were the north-shifting habitats of mosquitoes and ticks, and the introduction of new insects into the landscape.

Participants discussed the destruction or weakening of trees in the right-of-way, near homes and buildings, and on forested land by invasive insects such as the emerald ash borer and the hemlock woolly adelgid. Participants also noted the cultural effect that new or more prevalent occurrences of vector-borne diseases, such as eastern equine encephalitis (EEE) and Lyme disease, were having on their communities and recreational activities. Hilltown residents are considering hiking less and spending less time outdoors.

Zoning & Future Development: The majority of development within the northern hilltowns is large lot, single-family residential, and the need to reconsider existing zoning code in all four towns was highlighted in each workshop. As the population ages, seniors living in larger homes don't have an easy way of downsizing to smaller, less expensive homes as zoning codes in each community promote low-density residential development and have stringent restrictions on two-family homes and apartment dwellings.

Interviews by Smith College students with elected officials revealed that the bylaws are no longer desirable for many residents, with one respondent dubbing them "snob zoning." Currently, neither Worthington nor Goshen has a downtown zoning district that facilitates denser development than other "rural" residential zones, and Worthington does not allow for multi-family homes at all.

Maple sugaring is a large component of the local hilltown economy. Top right: Windy Hill Farm in Worthington sells products on site; Bottom right: Justamere Tree Farm in Worthington is a staple at farmers markets in larger towns, such as this one in Northampton; and Left Bottom to Top: Red Bucket Sugar Shack in Worthington welcomes visitors to its restaurant during the late winter to watch sugaring in action, sample the syrup on homemade pancakes, and purchase products on-site. All images source: Flickr user Massachusetts Office of Travel & Tourism.



Smith College students mapped the zoning code in each community by least restrictive (green) to most restrictive (red). Source: Smith College.

Goshen requires a special permit for building two-family dwellings—generally, the extra administrative onus of applying for a special permit and uncertainty of acquiring one is considered to be a deterrent for many developers. Large lot, single family homes may be unaffordable to young families or undesirable for aging or small households, and restrictive zoning could contribute to the population decline of the area as young adults, new families, and aging or smaller households move elsewhere to find housing stock that suits their needs. See the Smith College report titled “Climate Migration: A Changing Landscape in the Northern Hilltowns?” in Appendix D for more information on zoning in specific communities.

Participants also explored the possibility of future climate migration to their area. Already a popular destination for summertime vacationers and second homes, the northern hilltowns offer an abundance of water, relatively cool summer temperatures, and clean air. The prospect that these assets could attract new residents from the greater region, or eventually even from all over the east coast, was not lost on workshop participants. While the populations may be currently declining, workshop attendees discussed possible scenarios about future build-outs of their communities, and population growth resulting from the rollout of broadband, and what strengths and vulnerabilities the arrival of new residents may bring. Specifically, existing roadway infrastructure and the local, small or regional school systems may be burdened; however, new residents could fill empty volunteer positions in the towns and boost the tax base.[1]

Either way, participants were generally in agreement that zoning overhauls are needed—both to meet the needs of existing residents and to preserve the small town character of their communities while providing more housing options for the future. The new zoning code in each community should provide laxer restrictions on the type and size of housing built and encourage density in town centers, while also preserving natural resources and protecting the small town aesthetic.

Master Plans and Other Guiding Documents: A Master Plan guides the orderly development of cities, towns, or regions by identifying shared community goals and influencing legal documents such as zoning code. Master Plans should generally be updated every ten years, and be consistent with regional plans or guidelines from the state. In the early 2000s, Massachusetts Executive Order 418 provided resources for municipalities to develop comprehensive, strategic plans for future development under the "Community Development Program." Since that time, none of the communities in the Northern Hilltowns Collaborative MVP have undertaken town-wide master planning processes. Open Space planning is one important element of master planning, especially with regards to community-level adaptation to climate change, and can help ensure that investments in land protection and the management of protected areas stay relevant as the climate changes. In

Open Space and Recreation Plans identify habitats of threatened, rare, and endangered species such as this Cardamin diphylla *in Cummington. Photo credit: Flickr user Doug McGrady.*

[1] It is important to note that the idea of residential uses "boosting the tax base" runs somewhat counter to analysis by both American Farmland Trust and UMass Amherst, which have done cost of services analysis showing that residential land uses typically have higher expense to revenue ratios than other land uses. For example, a 2017 analysis done by UMass shows that for every $1 of revenue brought in from residential land in Whately, $1.13 is spent by the Town in providing services for that land. In contrast, for every $1 of revenue brought in from commercial/industrial land or open space land, only $0.56 and $0.46 respectively is spent providing services for those lands.

Massachusetts, communities are required to update their Open Space and Recreation Plans (OSRP) every seven years in order to remain eligible for a number of state grants that assist in land protection. The participating hilltowns' OSRPs were last updated in 2003 (Chesterfield), 2011 (Cummington), 2012 (Goshen, with an update now underway), and 2006 (Worthington).

Current Strengths & Assets

As a result of the hilltown's broad experience with extreme weather, in addition to residents' pride of place, workshop participants were quick to point out their communities' strengths in responding to the challenges identified above, summarized here:

- Transportation Infrastructure
- Power Grid/Utility Infrastructure
- Vulnerable Populations
- Drinking and Wastewater Infrastructure
- Communication Challenges
- Municipal Capacity
- Natural Resources
- Zoning & Future Development

Reinforcing and expanding upon these strengths and community assets to increase resiliency against the impacts of climate change is a common theme to the proposed actions within this report.

Some of the key strengths discussed included:

Chesterfield

- The regional shelter is located at New Hingham Elementary School in town
- The abundance of permanently protected lands, including agricultural land
- The extent of canopy cover
- The Chesterfield General Store

Cummington

- Municipal, gravity-fed water in town center
- Quality of groundwater
- Rural character of the community, and the ability to choose to live on private roads with low traffic
- Historic housing stock
- Existing partnerships between neighboring communities to assist in

Cummington identified The Old Creamery, a local grocery cooperative (right), and historic buildings, such as the William Cullen Bryant House (left), as assets. Source: Flickr user Massachusetts Office of Travel & Tourism.

times of need
- A self-sufficient community which is generally able to shelter-in-place
- Proximity to the Westfield River
- Extensive canopy cover
- Large lots and existing agriculture indicates ability to grow our own food
- The Cummington Creamery

Goshen

MA Route 9 brings visitors through town and allows convenient access to the region

- Council on Aging and existing level of services for seniors
- The volunteers that run the town and its departments are highly committed
- Extensive tree canopy
- Quality of ground and surface water is generally very high
- Large amounts of conserved land

Worthington

- The Community Health Center in town center
- Volunteerism exhibited by residents
- General preparedness amongst residents, including widespread ownership of personal generators
- Maples, the affordable housing development in the center of town
- The proactive trimming of limbs within the rights-of-way by Eversource
- Clean groundwater, and the general abundance of natural resources such as tree canopy and surface water

Regional

- Existing agreements of mutual aid and regional services
- Land-based occupations and eco-tourism provide for local economy
- The Westfield River, and other streams and surface waters are abundant
- Extensive tree canopy
- Extensive amount of conserved land
- Rural aesthetic
- Self-sufficient “Yankee” attitude of locals

- Attractiveness of area to potential climate migrants

Top Recommendations to Improve Resilience

In each local workshop, small groups from each community identified strategies that the towns, in collaboration with neighboring municipalities, regional partners, and state agencies, should take to improve resilience to climate change impacts. Toward the end of the workshop, each of the small groups presented two or three local and one regional top priority actions to the large group, and these actions were assembled with any other like actions from the same community, resulting in the priority actions listed below. Participants from each community had the opportunity to vote on the most pressing strategies for their communities to undertake. Participants were only allowed to vote on their own community’s strategies. The highest priority actions are shown in green.

The regional workshop followed the same format, with strategies developed for

regional actors, and with all participants allowed to vote for any strategy.

Chesterfield

Chesterfield was represented by one small group. Workshop participants identified three local and one regional priority actions listed below (in no specific order).

- Conduct an analysis and assessment of culverts and bridges and seek funding for improvements
- Research best practices on planting new tree species for climate resilience and implement (Regional)
- Update planning documents, particularly the Open Space and Recreation Plan
- Conduct a public education campaign on preparedness and improve general communications

Strategies from a separate recently completed study in Chesterfield speak to the importance of related economic elements that greatly contribute to the Town's overall resiliency. These include: improving state PILOT payments to ensure the Town can better provide needed services; working with land conservation organizations to integrate considerations of rural economy and affordable housing in local planning and acquisition activities; bolstering the recreational economy with solutions that are scaled to what the Town envisions; and coordinating with neighboring towns to hire a joint economic development director.

Cummington

Cummington was represented by one small group. Workshop participants identified three local and one regional priority actions listed below (in no specific order).

- Continue efforts to evaluate, assess, and design new replacement culvert/bridge for Stage Road
- Improve community outreach and enhance communication to improve community cohesion and preparedness
- Conduct a study of nature-based solutions and invasive removal for floodplain control along the Westfield River corridor
- Conduct a regional road evaluation to plan for existing and future use. Current roads were designed and laid out in the early 1700s (Regional)
- Undertake a cultural and ecological revitalization program centered on Cummington's former Berkshire Trail Elementary school. The project would include restoration of the East Branch Westfield River floodplain at this location, and a building retrofit to serve as a tourist hostel and regional emergency operations center

Goshen

Goshen was represented by three small groups. Workshop participants identified 16 priority actions, which were assembled with like actions from the other small group, resulting in the nine local priority actions and three regional priority actions listed below (in no specific order).

- Improve watershed quality by collaborating with Westfield Wild and Scenic Committee and neighboring

towns (Regional)

- Develop a Hilltown Regional Debris Management Plan and implement with MoUs to accept and process debris (Regional)

- Assess and enhance communication capabilities to and with residents to ensure all are resilient (Code Red, Town website, etc.)

- Conduct a town visioning process followed by regulatory changes as needed to ensure a climate resilient town—including formalizing General Bylaws

- Map municipal wells and investigate the quality and quantity of water supply therein

- Conduct a viability study and design for the new Highway Department facility

- Replace/re-size the top four problem culverts after conducting an inventory and assessment of all culverts and incorporating nature-based solutions as practicable

- Identify and remove hazard trees and investigate potential funding to do so

- Develop a road maintenance prioritization plan

- Ensure the regional shelter provides services for children, the elderly, and special needs residents (Regional)

Worthington

Worthington was represented by two small groups. Workshop participants identified seven priority actions, which were assembled with like actions from the other small group, resulting in the five local priority actions and two regional priority action listed below (in no specific order).

- Research/address drinking water sources/supplies, including a hydrology study of aquifers, to ensure resilient water supply

- Conduct a study to determine strategies for improving drainage to prevent mud, wash out, and improve passability of dirt and gravel roads (Regional)

- Set up / opt in to Wireless Emergency Alerts (WEA) through MEMA. WEA is an area-wide notification system to ping all cell phones in a specified area, not just those that have signed up for reverse-911 systems, during an emergency.[2] (also a regional action)

- Conduct a feasibility study to develop a shared, paid staff position for fire and emergency services; develop a fire volunteer recruitment plan; and hold CPR and emergency response classes for schools, residents, and employers

[2] According to the Cummington Emergency Manager, Massachusetts towns can sign up for WEA through the Massachusetts Emergency Management Agency (MEMA) if the town meets certain standards. WEA messages may be geographically limited, such that any WEA-enabled cell phone within the specified notification area would receive a message.

- Care for economically, socially, and otherwise vulnerable residents by starting/reinvigorating the process to address affordable housing issues, including: reconsidering the CPA; revising local zoning to make more housing options available (such as accessory dwelling units and/or tiny homes); conducting an inventory of vulnerable residents and developing a check-on list during and after emergency events; and assisting residents in signing up for reverse 911 system

- Conduct a feasibility study to determine the ability to establish a Red Cross certified shelter in town, with a pet plan, and conduct outreach to residents to ensure they know about the sheltering services currently provided at the school and fire station

Regional

Representatives from all four towns split into three small groups, along with participating stakeholders from Wild and Scenic Westfield River Committee, the Hilltown Community Health Center, Pioneer Valley Planning Commission, Hilltown Land Trust, Hillltown Community Development Corporation, Smith College, and Westfield River Watershed Association. Each of the three groups identified nine priority actions, which were assembled with like actions, resulting in the eight priority regional actions listed below (in no specific order).

- Conduct a wildfire area assessment and emergency plan.

- Conduct a regional culvert inventory, assessment, and management plan considering future needs based on climate change projections. Survey all culverts in the four towns and identify the most ecologically crossings; coordinate with highway departments to identify the culverts and bridges currently most vulnerable to changing conditions and at risk of failure; identify culverts that impact critical evacuation routes; and use all of the information to develop a regional culvert repair and replacement plan.

- Implement recommendations from the 2019 *Rural Policy Plan for the Commonwealth of Massachusetts* that call for creating micro-transit and other alternative transit options.
- Conduct a study of inter-municipal roadways, especially dirt and gravel roads, and develop a prioritization plan for improvement.

- Obtain state funding to subsidize water quality testing of private wells. Analyze collected data collected to identify trends in the watershed and determine best practices for groundwater protection.

- Protect groundwater quality by:
  1. Requiring local highway departments and MassDOT to employ alternative ice management strategies to reduce heavy salting,

  2. Conduct a regional study of groundwater and aquifer recharge dynamics to identify vulnerabilities and best practices going forward,

3. Secure support from MassDOT to remediate wells contaminated from historically heavy road salt applications, and

4. Install a municipal car wash to protect municipal vehicles from salt degradation, to prevent polluted car wash runoff to nearby streams, and to reduce the spread of invasive species.

All actions recommended during the CRB workshop were shared with the public in the Summary of Findings document, posted to each town's website for public review and comments. Additional public engagement surrounding the MVP planning process is described in the "Public Engagement" section, later in this report.

A full list of the final recommendations from the CRB Workshops, organized by high, medium, and low priority, follows on the next few pages.

Please note that within each category, the actions are not listed in any specific order. All resiliency recommendations received outside of the CRB Workshop are assigned a priority level of "Not Specified."

Regional Actions

No.	Sector	Feature	Action	Priority
1	ENV	Westfield River; rivers & streams generally abundant	Implement recommendations from upcoming Westfield River Watershed Action Plan (WWAAP)	H
2	ENV		Make sure all towns are aware of their role and responsibilities in maintaining a healthy Westfield River.	H
3	ENV	Invasive Species (Vegetative)	Conduct a study to determine which species are posing the biggest threats throughout the region and what locations are most under threat, how best to address, what resources are available, and what are best practices for disposal	H
4	ENV		Implement recommendations from The Nature Conservancy and WWAAP on invasives management (using the Early Detection Rapid Response Map)	H
5	ENV	Tree Canopy	Review resources and adopt tree planting guidelines that address appropriate species to plant near ROWs and power lines (size, branching, root depth, etc.) and distribute to residents	H
6	ENV		Review resources and adopt regionally-relevant list of climate-resilient species that landowners can use to repopulate their forest stands and/or use in the landscape	H
7	ENV		Lobby state for more money to support forest maintenance best practices	H
8	ENV		Secure grant funding to conduct a regional urban heat island/hot spots analysis and plant trees accordingly	H
9	ENV	Drinking Water Wells / Groundwater quality & quantity	Develop a regulatory prohibition on water-mining in Town, and consider doing the same across the region in order to protect the health of our rivers and streams and provide long-term protection of drinking water resources	H
10	ENV		Develop alternatives to heavy salting on roadways for environmental protection and lobby for the same for MassDOT	H
11	ENV		Conduct an assessment of groundwater recharge in region & a hydrology study of aquifers to ensure protection	H
12	ENV		Get commitment from MassDOT to remediate wells with existing contamination linked to historical road salting practices	H
13	ENV		Obtain funding to subsidize testing of private wells, the results of which could help to understand water quality trends throughout the region	H
14	ENV		Develop hilltown-specific material for outreach to residents, businesses, etc. on best practices for groundwater supply protection, including education on maintaining septic systems	H
15	ENV	Invasive Species (Insect) - shifts in range	Share educational campaign for residents around firewood transportation between community boundaries to reduce spread of invasive species	H
16	ENV		Conduct public health outreach campaign around vector-borne diseases, including identification of symptoms, methods of prevention, and environmentally-friendly/drinking-water friendly ways of discouraging large populations of mosquitos/ticks, such as encouraging natural predation by native species (bats, dragonflies, possums, etc.)	H
17	ENV	Pollinator Decline	Disseminate information around causes of pollinator decline and address regionally (incl. installing bee friendly habitat, protecting native plant communities)	H
18	ENV		Get buy-in from neighboring towns to become a pollinator-friendly region, including adopting policies for organic property maintenance on municipal parcels and educating residents around same	H
19	ENV	Conserved Land / Low Tax Base	Lobby state for increased compensation/increased of Payment In Lieu of Taxes (PILOT) payments in order to promote land conservation in the context of a limited tax base	H
20	ENV	Wildfire Risk	Conduct a wildfire risk assessment and create an emergency plan of action for wildfire	H
21	ENV		Promote long-term strategies to promote healthy and diverse forests to reduce wildfire risk	H

No.	Sector	Feature	Action	Priority
22	INF	Dirt / Gravel Roads; Road Passability Generally	Conduct study of existing conditions of inter-municipal roadways, esp. dirt and gravel roadways, & develop and implement a prioritization plan for maintenance/repair of critical/evacuation routes, including considering paving options	H
23	INF		Conduct a study to determine strategies for improving drainage on gravel and dirt roads to prevent mud ruts, washouts, and to improve passability while keeping dirt roads unpaved	H
24	INF		Conduct study to determine best strategies to avoid snow drifts onto roads (snow fences, hedgerows) and distribute regionally	H
25	INF		Evaluate regional road network to plan for existing and future use, as current roads were laid out and designed in early 1700s	H
26	INF		Collaborate across towns on roadside plantings with templates for planting designs and plants to use	H
27	INF	Post-disaster debris management (ad hoc)	Develop a Hilltown Regional Debris Management Plan and system for implementation with Memorandums of Understanding to accept and process debris	H
28	INF	Culverts, bridges (and drainage infrastructure)	At a regional scale, identify ecologically and infrastructurally significant culverts and priority roads, and overlay this data to develop a regional prioritization and implementation plan	H
29	INF		Conduct a regional culvert and drainage system inventory using modern technology to detect unknown infrastructure locations and conditions. Use previously conducted studies and inventories as a starting point. Implement a maintenance and management plan.	H
30	INF		Explore alternative design and construction methods for culverts and drainage infrastructure.	H
31	INF		All above to include bridges as well.	H
32	SOC	Towns run on volunteerism	Work with Western MA delegation to research, identify and implement innovative funding ideas, such as a state fund to reimburse municipal volunteers with tax breaks	H
33	SOC	Mutual Aid AND Regional Services	Work with Western MA delegation to see if it is possible to get the State to honor the original commitment to fund 100% of school transportation costs if the municipalities regionalized, and advocate for electric buses	H
34	SOC		Encourage at least 1 pre-winter regional coordination meeting of highway department staff from local communities to plan for road maintenance continuation across borders	H
35	SOC	Public Health / Communications	Develop a regional strategic plan to ensure health care services are available and can run uninterrupted despite severe climate and weather events	H
36	SOC		Develop a welcome packet for new residents including information about winter road maintenance, locations of comfort stations (heating shelters), regional shelters & services, Points of Distribution (POD), and emergency contacts	H
37	SOC		Educate residents on the services currently offered by the regional shelters and ensure the regional shelters provide for the needs of all residents (accessibility, children, seniors, special needs, etc.)	H
38	SOC		Educate residents about the existing sheltering plan for both domestic pets, farm animals, and livestock	H
39	SOC		Work with MEMA to opt in to Wireless Emergency Alerts (WEA). This would set up a non-voluntary area-wide notification system to ping any cell phone in the area, not just individual Town residents' numbers or those that have signed up for reverse-911 systems, during an emergency .	H
40	SOC		Conduct outreach and training to potential volunteers for emergency shelter teams	H
41	SOC	Lack of public transportation	Implement Rural Policy Plan recommendations for micro-transit and other alternative public transit ideas in rural towns	H
42	SOC		Advocate to Capitol Hill for increased funding to regional transit authorities	H
43	SOC		Seek opportunities for dedicated multi-modal routes throughout the hilltown region	H
44	SOC	Aging Population	Support COAs and Hilltown CDC in services to seniors.	H

No.	Sector	Feature	Action	Priority
45	SOC		Create new or expand upon existing voluntary inventory of vulnerable populations, using a localized, neighbor to neighbor approach (formalize informal support services that currently exist with the Councils on Aging or Fire Department)	H
46	SOC	Lack of economic base	Advocate for funding from state to establish a shared economic development director for the hilltowns	H
47	SOC	Regional School	In Cummington: Retrofit local school building as emergency shelter and office space, allowing Community House to return to community and socially oriented programming. Incorporate nature based flood protection and stormwater management at neighboring town park.[3]	H
48	SOC	Community Identity	Provide better outreach and visual materials to residents on town services and successes.	H
49	ENV	Invasive Species (Vegetative)	Focus on working along waterways to eradicate invasive species, moving from upstream to downstream.	M
50	ENV	Drinking Water Wells / Groundwater quality & quantity	Install a regional carwash to wash salt from municipal vehicles and stop spread of invasive vegetation	M
51	ENV	Solar/Wind/Land Use	Form regional working group for wind energy (like existing group for solar)	M
52	ENV		Conduct a regional feasibility study and implementation plan for renewable energy in the region.	M
53	INF	Dirt / Gravel Roads; Road Passability Generally	Explore options for pervious road surfaces and alternative road construction methods (for example using a Scandinavian model and BMPs).	M
54	INF	Lack of cell service / radio dead spots	Secure grants to build towers and install repeaters as needed to improve radio communications	M
55	INF		Work with radio stations to ensure radio DJs distribute appropriate information regarding emergency news & resources for those without power who are tuned in to a battery-powered radio (as opposed to directing them to online resources, etc.). Also consider designating a single Public Information Officer or emergency point of contact for each town, who may come together during a regional emergency to form a Joint Information Center.	M
56	INF		Develop a regional station to distribute locally relevant information, both during times of emergency and potentially during business-as-usual	M
57	INF	Funding Uncertainty/Lack of Capacity to Chase & Secure Grants	Develop a regional position for grant making, grant writing, and project management for resilience and nature-based projects	M
58	INF	Power Grid	Explore options for microgrid development to build a more climate-resilient power grid	M
59	INF		Redesign existing power grid to be a smart grid - build in redundancy	M
60	SOC	Towns run on volunteerism	Develop and implement student volunteer civics program with schools	M
61	SOC	Limited Access to Food Retail	Develop a regional strategic plan to ensure food supplies are available locally and can be accessed uninterrupted in event of limited transportation mobility or other emergency event	M

[3] Note: upon review of the workshop findings, this action was deemed to be a municipally-specific action for Cummington, rather than a regional action.

No.	Sector	Feature	Action	Priority
62	SOC		Ensure residents know about emergency Point of Distribution (P.O.D.)	M
63	SOC	Regional Communication	Increase person to person conversations between town officials of municipalities within the region.	M
64	SOC	Regional School	Protect local schools in the region as community sites.	M
65	ENV	Westfield River; rivers & streams generally abundant	Improve watershed quality: collaborate with neighboring towns to study water quality and develop a plan for the river	L
66	ENV	Wastewater-Septic	Work for state-level policy to allow for composting toilets, reducing the risk of septic systems contaminating groundwater	L
67	INF	Power Grid	Conduct a feasibility study to determine the cost and barriers of burying powerlines most at risk by tree limbs, ice, etc.	L
68	INF	Paved Roads	Improve communication with state on road salt usage in the region	L
69	INF		Track road salt usage at the regional level	L
70	INF		Explore alternative road de-icing treatments to move away from road salt	L
71	SOC	Land-based occupations (agriculture, forestry, tourism, etc.)	Conduct outreach to those in land-based occupations (agriculture, forestry, tourism, etc.) to connect them with best practices for climate adaptation and research coming from institutes like UMass.	L
72	SOC	Lack of economic base	Create new Regional Community/Economic Development Plan to help develop and increase the tax base in the hilltowns. This plan should identify groups, individuals, and funding to implement identified actions and should begin with a conversation about regional identity.	L
73	SOC		Create a regional hostel at the former elementary school in Cummington to attract visitors.	L
74	SOC		Create a grant program to support awareness of local arts scene (such as paying for one free art class with a local artist)	L
75	SOC	Towns run on volunteerism	Tie into succession planning for Town boards to help ensure sufficient knowledge transfer and provision of services despite the towns' reliance on volunteerism	NS
76	SOC	Vulnerable deaf, blind, physically challenged populations	Identify specific needs of vulnerable deaf, blind, physically challenged populations and work with Stavros or other such agency to understand available services	NS

Acronyms and Abbreviations:

ENV Environmental
INF Infrastructure
SOC Societal
NS Not specified (regarding prioritization)

Note: In most cases, actions are presented in the table above as written by CRB Workshop participants. Where proposed actions in their original form lacked clarity or detail, the project team expanded upon the action in order to promote project-readiness.

Chesterfield Actions

No.	Sector	Feature	Action	Priority
1	SOC	Access to fuel, both gas and propane	Develop regional strategic plan to address issues including access to fuel, food, and health care	H
2	SOC	Water supply, and specifically need for electricity to power pumps	Conduct outreach and education to generate more awareness so people not caught off guard when they lose access to drinking water in the event of a power outage; also share information on how to prepare for such an event, and where other sources of drinking water are available	H
3	SOC	Access to food	Develop regional strategic plan to address issues including access to fuel, food, and health care	H
4	SOC	Access to health care	Develop regional strategic plan to address issues including access to fuel, food, and health care	H
5	SOC	Communications network / "Reverse 911"	Expand and increase education and outreach on emergency communications tools and resources, preparedness, and who to contact; distribute "Go Kits" to all residents. Target outreach to aging population, among others.	H
6	INF	Power grid (Eversource)	Continue to work on clearing hazard trees that not in Eversource's domain (other side of street from power lines) to reduce debris blocking roadways and/or impacting power infrastructure	H
7	INF	Road surfaces	Analyze and prioritize dirt roads for paving	H
8	INF	Bridges and culverts	Analyze bridges and culverts and prioritize for fixes	H
9	ENV	Lack of plan that identifies priority areas for protection / priority areas for development	Establish open space and recreation committee to develop or update a plan that identifies priority areas for protection / priority areas for development	H
10	ENV	Lack of plan that identifies priority areas for protection / priority areas for development	Update open space and recreation plan	H
11	ENV	Lack of plan that identifies priority areas for protection / priority areas for development	Update Community Development Plan/Master Plan	H
12	ENV	Trees and forest health	Assess condition of trees, develop a management plan for climate resilience with special attention to vulnerable vs. resilient species and existing problems, and implement plan	H
13	ENV	Existing protected lands, including agricultural land	Support land conservation	H
14	ENV	Existing protected lands, including agricultural land	Conduct additional public education about incentives for protecting lands, including agricultural land	H
15	ENV	Invasive species	Determine how best to address invasive species, what resources are available, and what are the best practices for disposal	M

No.	Sector	Feature	Action	Priority
16	ENV	Existing protected lands, including agricultural land	Examine what resources available to demonstrate values of ecosystem services	M
17	ENV	Debris	Identify local woody debris disposal location	M

Acronyms and Abbreviations:

ENV Environmental
INF Infrastructure
SOC Societal
NS Not specified (regarding prioritization)

Note: In most cases, actions are presented in the table above as written by CRB Workshop participants. Where proposed actions in their original form lacked clarity or detail, the project team expanded upon the action in order to promote project-readiness.

Cummington Actions

No.	Sector	Feature	Action	Priority
1	INF	Dirt Roads	Continue ongoing maintenance and independent existing road improvement plans for dirt roads	H
2	SOC	Regional Network/Resources	Maintain / increase community cohesion despite regionalization of services, such as the school	H
3	SOC	Reverse 911 / Emergency Communication	Continue to improve town emergency communications, including utilizing reverse 911 system as a resource	H
4	ENV	Ability to grow food	More education on alternative approaches to growing local food (science-based, more hands-on growing, more people)	NS
5	ENV	Ability to grow food	Rethink what we foods are growing and eating	NS
6	ENV	Forest cover	Implement forest management plans to ensure forest cover adapts to climate change	NS
7	ENV	Forest cover	Conduct studies to develop forest and tree planting recommendations for climate resilience	NS
8	ENV	Forest cover	Lobby state for more money to support forest maintenance best practices	NS
9	ENV	Forest cover	Support forestry plans for small properties that are currently not eligible for state support	NS
10	ENV	Forest cover	Establish programs for bulk purchasing of trees to ensure resilient forest cover	NS
11	ENV	Westfield River and invasive vegetation	Create a riverwalk along the Westfield River to improve access/education/and public health	NS
12	ENV	Westfield River and invasive vegetation	Foster a stronger relationship with Westfield Wild & Scenic to develop better stewardship opportunities (water temp, invasive species removal, etc.)	NS
13	ENV	Westfield River and invasive vegetation	Support efforts to safely control invasive vegetation along the Westfield River, including non-chemical/toxic options	NS
14	ENV	Westfield River and invasive vegetation	Explore funding sources for studies to understand increased potential for flooding along the Westfield River due to climate change	NS
15	INF	Culverts (Stage Rd)	Continue to utilize grant funding to improve culverts to accommodate for increased precipitation	NS
16	INF	Culverts (Stage Rd)	Implement new culvert designs to accommodate for increased precipitation and habitat connectivity	NS
17	INF	Culverts (Stage Rd)	Explore need for a bridge at Stage Rd culvert	NS
18	INF	Electric Grid	Establish hardwired back-up power to critical facilities	NS
19	INF	Electric Grid	Establish a micro-grid that can be islanded	NS
20	INF	Internet/Cell Service	Continue to implement improvements to local internet and cell service	NS
21	INF	Municipal Water	Provide permanent back-up power for municipal water pumping stations	NS
22	INF	Municipal Water	Increase existing fuel supply and storage capacity at municipal water facilities to ensure adequate power to keep system running	NS
23	INF	Older building stock	Provide back-up power for the Community House (shelter) in the village center	NS
24	INF	Older building stock	Explore potential for solar and battery storage or other non-fossil fuel storage and back-up for municipal buildings	NS

No.	Sector	Feature	Action	Priority
			in the village center	
25	INF	Older building stock	Continue to explore options for reuse of school building	NS
26	INF	Older building stock	Implement energy retrofits for municipal buildings via Green Community funding	NS
27	INF	Private and Public Roads	Study current road designs and specifications to ensure designs are resilient to changing climactic conditions	NS
28	INF	Resource delivery disruption	Encourage appropriate stockpiling of resources via a public outreach campaign to reduce future instances of resource delivery disruption	NS
29	INF	Resource delivery disruption	Study municipal stockpiling needs and work with Community Emergency Response Team (CERT) team to implement to reduce future instances of resource delivery disruption	NS
30	INF	Resource delivery disruption	Study/Map community resources in case of emergency	NS
31	INF	Wells and Septic Systems	Increase public awareness of resources available for residents on private wells and septic systems	NS
32	INF	Wells and Septic Systems	Promote and purchase hand-pumps for drinking water resilience on properties reliant on private wells	NS
33	SOC	Climate Refugees	Implement zoning changes to plan for/accommodate future climate migrants and refugees while protecting natural resources	NS
34	SOC	Existing Hazard Mitigation Plan & others	Actively implement existing plans, including the Hazard Mitigation Plan and others	NS
35	SOC	Regional Network/Resources	Continue to support regional programs, such as the Disaster Assistance Response Team (DART), Highland Ambulance, Mobile Market	NS
36	SOC	Regional Network/Resources	Explore opportunities for public transit that connects to a regional network	NS
37	SOC	Self-sufficient community	Create an opt-in email list to ensure greater outreach and communication	NS
38	SOC	Vulnerable population	Implement improvements in municipal buildings to better serve vulnerable populations	NS
39	SOC	Vulnerable population	Continue to encourage tracking/voluntary list of vulnerable populations for wellness check & emergency planning	NS

Acronyms and Abbreviations:

ENV Environmental
INF Infrastructure
SOC Societal
NS Not specified (regarding prioritization)

Note: In most cases, actions are presented in the table above as written by CRB Workshop participants. Where proposed actions in their original form lacked clarity or detail, the project team expanded upon the action in order to promote project-readiness.

Goshen Actions

No.	Sector	Feature	Action	Priority
1	ENV	Open space vulnerable to development	When updating Open Space and Recreation Plan (OSRP), identify priority parcels for protection using climate resilient tools in order to reduce vulnerability of open space to development	H
2	INF	Aging built infrastructure	Implement Rural Policy Plan (RPP) recommendations related to aging built infrastructure including septic tanks and leach fields. Recommendations include developing a rural fund for septic.	H
3	INF	Culverts (East St especially)	Lobby MassDOT on culvert / road improvements	H
4	INF		Secure funding to fix the already identified top 4 problem culverts including Fuller RD, Sears Rd, and East St., and consider nature based solutions as part of the solution to assure maximum climate resilience	H
5	INF		Complete and maintain a culvert conditions assessment and prioritization plan to use to secure funding for culvert redesign and replacement	H
6	INF	Dirt Roads	Explore options for dirt road maintenance (paving? Alternative solutions)	H
7	INF		Study of existing conditions on all dirt roads, and prioritization of critical roads (evacuation routes, etc.) for improvement	H
8	INF	Flooding of roadways/snow piling	Route 9 improvement to reduce flooding and snow piling. Include roadway widening, sidewalks, bike lanes, and green stormwater management	H
9	INF	Police station, critical facilities	Conduct a feasibility study for where and how to build a new public safety complex to co-locate fire, police, and highway garage.	H
10	INF	Utility lines	Seek additional funds and equipment for ongoing tree maintenance for municipal trees to reduce power line vulnerability	H
11	INF		Continue working with National Grid on preemptive tree maintenance to reduce power line vulnerability	H
12	INF	Vulnerable electric utilities and limited broadband and cell	Complete broadband process and implement RPP recommendations related to broadband, cell access etc., in order to reduce vulnerability of electric utilities and communications	H
13	INF	Wells and small public water supply	Secure state or other research and funding assistance to understand how to de-contaminate public drinking water supplies, including the well at Town Hall and others contaminated by road salt	H
14	SOC	CoA/Senior Services	Harness relationships within the Council on Aging (COA), Elder Services, and others to work to assure all seniors sign up for code red emergency alert systems	H
15	SOC	Interdepartmental coordination for emergency services	Improve TV/Antenna service for improved communication (need a free way to communicate with all residents) and better interdepartmental coordination for emergency services	H
16	ENV	Declining bee populations	Understand causes of declining bee population and address (incl. installing bee friendly habitat)	M
17	ENV	Flood plains	Integrate a floodplain district into zoning as called for in Hazard Mitigation plan	M
18	ENV	Lack of forest management and debris in woods	Create a regional debris management plan (for roadway debris and debris in the woods) with MOUs for implementation & enforcement	M
19	ENV	Land Conservation/Low Tax Base	Lobby state for increased compensation for land conservation	M
20	ENV	Ticks and invasive insects	Explore options for population control of ticks and invasive insects	M
21	ENV	Trees!	Prioritize roadside trees for maintenance	M

No.	Sector	Feature	Action	Priority
22	ENV		Encourage robust, environmentally friendly forest management amongst stand owners	M
23	ENV	Water Quality	Secure funding possibly from state to conduct a representative sampling of ~500? wells to assess possible contamination and water quality	M
24	ENV		Continue to advocate for reduced road salt use by MassDOT to safeguard drinking water quality and protect aquatic ecosystems	M
25	INF	Dams	Continue monitoring and maintenance of dams	M
26	INF		Seek funding for needed dam repairs	M
27	INF	Inaccessibility to Boston	Implement the proposed East-West rail to improve accessibility to Boston and other population centers	M
28	INF	Lack of public transportation	Implement RPP recommendations for micro-transit and other alternative public transit ideas in rural towns to address the lack of public transportation	M
29	INF	Police station, critical facilities	Explore options/conduct studies on water quality at police station and other public facilities	M
30	INF	Route 9	Work with state to assure rural character can be integrated into Rt. 9 road design, maintenance and safety	M
31	SOC	Business community	Encourage more business development in Goshen, starting with seasonal options	M
32	SOC		Implement Conway School's 2019 Town Center Plan with pop-up, small-scale businesses and improvement of pedestrian connections	M
33	SOC	Mutual Aid/Regional Services	Explore options for improved regional shelters (better communication on services available; make shelters more comfortable/accessible/offer more services) via mutual aid or regional services agreements	M
34	SOC	Population growth/decline	Update zoning to plan for future populations/development and natural resource protection	M
35	SOC	Restriction on dev in local zoning	Conduct a Town visioning process with related General Bylaw and Land Use Regulatory Bylaw changes to assure climate resilience	M
36	SOC		Modify local zoning for conversion of seasonal to year-round with climate resilience in mind	M
37	SOC	Tax Base: lack of bus +limited State res = Muni Fin trouble	Work with Western MA delegation to see if it is possible to get the State to honor the original commitment to fund 100% of school transportation costs if the municipalities regionalized	M
38	SOC	Council on Aging/ Senior Services	Explore permanent location for senior center in Goshen	L/M
39	SOC	Volunteers including Firefighters and Town government	Work with Western MA delegation to research, identify and implement innovative funding ideas, such as a state fund to reimburse municipal volunteers with tax breaks	L/M

Acronyms and Abbreviations:

ENV Environmental
INF Infrastructure
SOC Societal
NS Not specified (regarding prioritization)

Note: In most cases, actions are presented in the table above as written by CRB Workshop participants. Where proposed actions in their original form lacked clarity or detail, the project team expanded upon the action in order to promote project-readiness.

Worthington Actions

No.	Sector	Feature	Action	Priority
1	SOC	Community Health Center	Establish an agreement to have the Community Health Center (CHC) in Worthington serve as a secondary Emergency Operations Center for the town.	NS
2	SOC	Maturing Populations	Encourage use of existing services for maturing populations and conduct outreach to de-stigmatize participation in and with these services	NS
3	SOC		Follow through with Senior Center design and construction in Worthington	NS
4	SOC		Develop an opt-in list for seniors and disabled populations for emergency response staff to check-up on during and after an emergency	NS
5	SOC	Volunteerism	Conduct a feasibility study to hire paid staff for fire services and emergency response to take place of or supplement current reliance on volunteers, possibly as a shared position between multiple towns	NS
6	SOC		Hold CPR and emergency response classes for schoolchildren, residents, and Town employees	NS
7	SOC		Develop a fire station volunteer recruitment plan to address and reverse declining rates of new volunteers	NS
8	SOC	Radio dead spots & lack of high-speed internet	Secure grants to build towers and install repeaters as need to improve radio communications and reduce radio dead spots	NS
9	SOC		Secure grants to acquire higher frequency radios to reduce the incidence of radio dead spots	NS
10	SOC		Complete broadband buildout to ensure all hilltown residents and businesses have access to reliable high speed internet	NS
11	SOC	Limited access roads (winter maintenance, etc.)	Develop a welcome packet for new residents including info about winter road maintenance (especially on limited access roads), locations of heating shelters, and emergency contacts	NS
12	SOC	Warming/Cooling Shelters	Conduct outreach to ensure residents know the Worthington Fire House offers heating shelter services	NS
13	SOC		Conduct a study to determine the feasibility of the Worthington Fire House and (Conwell Elementary??) school becoming Red Cross certified emergency shelters	NS
14	SOC		Develop a plan for how to house animals if owners are sheltering (or see existing plan??)	NS
15	SOC	Mobility Concerns	Work with MassDOT to ensure multi-modal design is considered in the upcoming Rt. 143 roundabout project	NS
16	SOC	Town voted down Community Preservation Act (CPA)	Re-consider adopting the Community Preservation Act (CPA) to fund a Housing Production Plan (HPP), accessory dwelling unit (ADU) work, etc.	NS
17	SOC	Very limited housing options	Re-consider CPA as a way to fund housing planning for the Town, including creating a fund to off-set the cost of creating ADUs for home-owners.	NS
18	INF	Worthington Fire District Town Water Supply	Conduct a conditions assessment on the Worthington Fire District Town Water Supply to determine any vulnerabilities in the face of climate change	NS
19	INF	Coordination between towns re: emergency and muni. Services	Continue and upkeep existing emergency response mutual aid agreements between neighboring towns	NS
20	INF		Encourage at least 1 pre-winter regional coordination meeting of highway department staff from local communities to plan for road maintenance continuation across borders	NS
21	INF	River Road Bridge	Apply for MassDOT Small Bridge grant for a total rebuild of the River Road Bridge.	NS

No.	Sector	Feature	Action	Priority
22	INF	Culverts	Ensure all culvert upgrades are designed to consider NAACC standards.	NS
23	INF	Dirt & Gravel Roads	Conduct a study to determine strategies for improving drainage on gravel and dirt roads to prevent mud ruts, washouts, and to improve passability	NS
24	INF		Research and learn from other countries/localities that have climate resilient pavement and secure funding to test it out as an alternative to dirt and gravel roads	NS
25	INF	Back-up generators in public and private buildings	Secure funding to acquire a back-up generator for Town Hall	NS
26	INF		Conduct feasibility study to determine if solar-to-battery generator would work for Town Hall, as opposed to gas-powered	NS
27	INF		Research viability of micro-grid for Town center as a means to increase resilience to power outages	NS
28	INF	Communications & Reverse 911	Customize Reverse 911 settings so that residents can opt-in to receive the types of notifications they find relevant and train departmental/emergency response staff on how to send notifications	NS
29	INF		Set up / opt in to Wireless Emergency Alerts (WEA) through MEMA. WEA is an area-wide notification system to ping all cell phones in a specified area, not just those that have signed up for reverse-911 systems, during an emergency.	NS
30	INF	"Too strong" land use regulations limit development	Integrate flexible climate resilient land use regulations into the Town's bylaws to encourage appropriate development	NS
31	INF	No reliable comprehensive list of vulnerable populations	Research best practices for developing and maintaining reliable lists of vulnerable populations, especially examples from similar rural MVP towns in MA who have increased enrollment in reverse 911 and created an ongoing outreach/engagement plan for improved relationships with vulnerable populations	NS
32	INF	Affordable Housing	Expand housing options (beyond the 22 HUD-funded affordable housing units currently available for elderly and disabled residents, but open to all eligible in USA & 2-3 year wait list) by integrating an accessory dwelling unit (ADU) bylaw and possibly developing a Housing Production Plan or other community process to identify the kinds of housing people want and develop a plan to build it	NS
33	INF	No public transportation	Implement the mobility and alternative transit recommendations included in the Rural Policy Plan (RPP)	NS
34	INF	Reliance on Electric Grid	Research viability of a solar powered micro-grid with battery storage for the Maples residential facility and Community Health Center to reduce reliance on the existing electric grid, and reduce the town's vulnerability to outages that results from its location at the "end of the line" for service and repairs	NS
35	ENV	Tree maintenance and debris removal	Develop tree planting guidelines that address appropriate species to plant near rights of way and power lines (size, branching, etc.) and distribute to residents. This would reduce maintenance needs and decrease weather-generated debris.	NS
36	ENV		Educate residents on how to navigate around downed wires and hazard trees	NS
37	ENV		Participate in a regional Tree Management plan and inventory with guidance for replacing dead or currently hazardous trees with newer, climate resilient species	NS
38	ENV		Conduct a study to determine best strategies to avoid snow drifts onto roads (snow fences, hedgerows) and distribute to residents and town officials	NS
39	ENV	Rivers & Streams	Develop a regulatory prohibition on water-mining in Town, and consider doing the same across the region in order to protect the health of our rivers and streams and provide long-term protection of drinking water resources	NS
40	ENV		Develop alternatives to heavy salting on roadways for environmental protection and lobby for the same for MassDOT	NS

No.	Sector	Feature	Action	Priority
41	ENV	Invasive insects	Educate residents around firewood transportation between community boundaries to avoid the spread of invasive species	NS
42	ENV		Conduct public health outreach campaign around vector-borne diseases	NS
43	ENV	Clean Aquifer / Ground water	Conduct a drinking water resource needs assessment and hydrology study of local aquifers to plan for future drinking water quality and supply	NS

Acronyms and Abbreviations:

ENV Environmental
INF Infrastructure
SOC Societal
NS Not specified (regarding prioritization)

Note: In most cases, actions are presented in the table above as written by CRB Workshop participants. Where proposed actions in their original form lacked clarity or detail, the project team expanded upon the action in order to promote project-readiness.

Public Engagement

A Creative Approach for Small Communities

As previously described, many of Western Massachusetts' small, rural municipalities are limited in the capacity of their local elected officials and local budgets. As the northern hilltowns are largely run by volunteers who hold other paid and volunteer positions in and out of the region, the core municipal MVP team felt that it would be too arduous and impractical to ask these volunteers to plan and attend a traditional MVP Public Listening Session (PLS) in addition to the three CRB workshops they had already completed.

In order to alleviate this burden and to reach a broader segment of each community's residents, the core municipal MVP team worked with EEA to design an approach that would satisfy the PLS requirements while also meeting the needs of the Northern Hilltowns Collaborative. Ultimately, the team designed an appropriate way to solicit feedback on the top five regional actions identified during the three CRB workshops. The MVP team decided to highlight regional actions both because they understand that hilltown residents use resources and infrastructure on a regional scale, and because they believe that a collaborative approach, drawing on the resources of all four communities, would have the most momentum and be most likely to succeed as a future MVP Action Grant.

The regional action options are as follows:

- Wildfire Resilience Plan: Study How Climate Change Affects Wildfire Risk in the Hilltowns
- Conduct a Regional Culvert Inventory

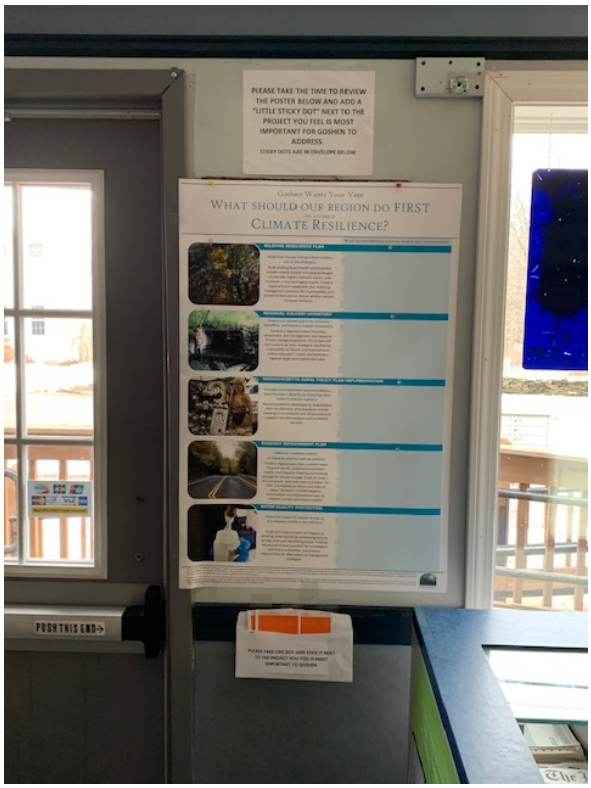
- Prioritize and Implement the Massachusetts Rural Policy Plan's Recommendations as they Relate to Climate Change
- Roadway Improvement Plan: Adapt Our Roadway Network to Changing Weather and Use Patterns
- Water Quality Protection: Assess the Impact of Climate Change on Groundwater Quality in the Hilltowns

The solution the core team developed was to create an online survey to be hosted on each town's website and to develop posters explaining the MVP process and describing the top five regional actions. These posters were to be displayed in two or three public and well-trafficked locations in each town for two weeks, along with a package of sticky dots for residents to vote on their top priority action.

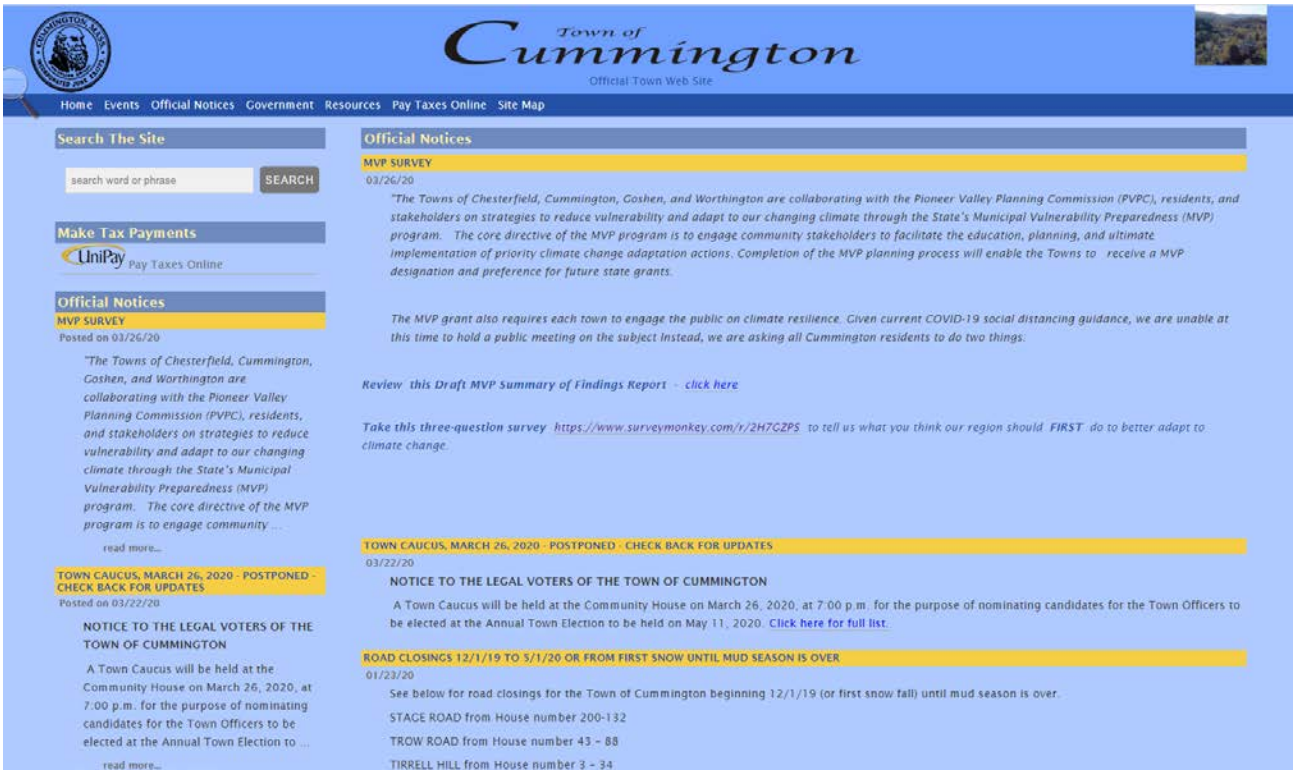
Originally, the towns had plans to display posters in locations selected for visibility and level of exposure to wide cross-section of residents. However, with the closure of non-essential businesses and the stay at home advisory issued by the Baker Administration during the onset of the novel coronavirus (COVID-19) pandemic in March, the Northern Hilltowns Collaborative amended their strategy.

Adapting the PLS to the Stay at Home Advisory for COVID-19

On March 23, 2020, Governor Charlie Baker directed the Department of Public Health to issue a stay at home advisory to all Massachusetts residents, encouraging self-isolation and social distancing protocols. Residents were advised to stay home and avoid unnecessary travel and other



The Towns hung their public engagement posters in highly trafficked areas, such as in the post office (Goshen, top) and the town hall (Chesterfield, bottom).



The Town of Cummington, like the other communities, announced the draft Summary of Findings for review and provided a link to the survey on the front page of their town website.

unnecessary activities during this time period, which at the time of this report extends from March 24 through an anticipated end date of May 4, 2020.

This order came just several days after the posters had been printed and before the communities had hung them in their public locations. In response, the northern hilltown MVP team was concerned about their residents' ability to safely vote via sticky dot on the communal posters while maintaining social distancing protocol. Therefore, the team decided to display the posters in post offices, which remained open during this period, with a note attached to direct respondents to the survey link on the towns' websites instead of voting on the posters directly. The Town of Cummington further publicized the survey by implementing automated calls to local residents.

Results of PLS Survey

As of April 16, 2020, there were 58 total responses to the engagement survey. The online survey asked respondents to identify their town of residence, their age group, and to rank the five projects in order of preference for soonest implementation.

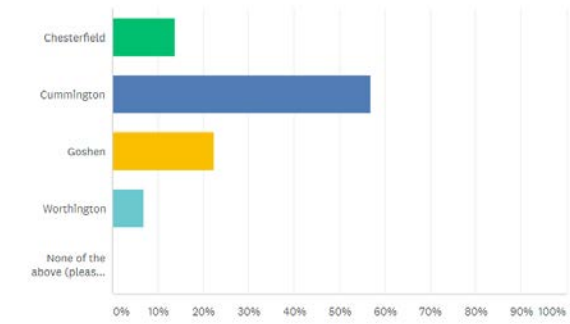
Of the responses, 57% were Cummington residents, 22% were Goshen residents, 14% were Chesterfield residents, and 7% were from Worthington. Just over 60% of the respondents identified themselves as 60 years old or older.

"Water Quality Protection" was the most popular first choice for soonest implementation, with over 40% of the first choice votes. This was followed by the Roadway Improvement Plan with over 25%

Q1

Which town do you live in?

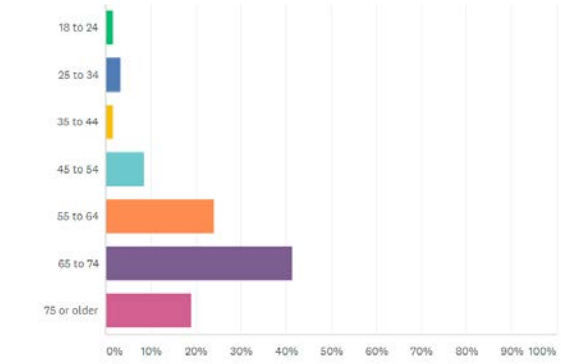
Answered: 58 Skipped: 0



Q2

What is your age?

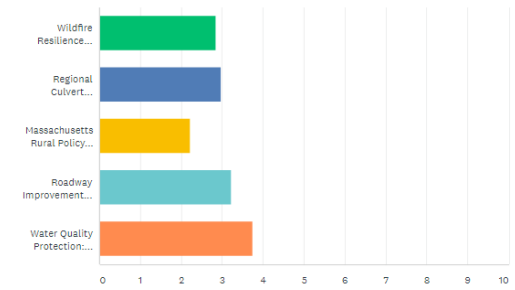
Answered: 58 Skipped: 0



Q3

In February, 2020, the towns and PVPC held a series of Community Resilience Building workshops where key stakeholders from the four towns and broader region discussed climate vulnerabilities and identified approximately 75 actions that the towns, in collaboration with neighboring municipalities, local and regional partners and state agencies, should take to improve resilience to climate change impacts. At the end of the workshops, participants selected their highest priority regional actions from the suite of actions developed during the workshop. These regional actions are presented here in no specific order. Rank the following priority projects to indicate what our region should do FIRST to address climate resilience?

Answered: 58 Skipped: 0



The results of the public engagement survey, pulled from Survey Monkey.

of the vote, the Rural Policy Plan implementation and Regional Culvert Inventory tied at about 12% each, and finally the Wildfire Resilience Plan received slightly more than 9% of the votes.

Additional Comments from the Public Engagement Period

During the public engagement period, residents were also encouraged to contact their town's representative on the core MVP team with any comments they might have. One resident of Chesterfield commented that they believed the Chesterfield Gorge, a Trustees property, should be identified as a town asset. There were no other additional comments.

Workshop Participants

Approximately 14 participants from Worthington and 7 from Cummington participated in the February 1 workshop; 21 from Goshen and 9 from Chesterfield participated in the February 5 workshop; and 15 participants representing the four communities and other regional stakeholders participated in the workshop on February 13. The participant check-in list is provided in Appendix C.

Citation

Northern Hilltowns (Chesterfield, Cummington, Goshen, and Worthington) Community Resilience Building Workshop Summary of Findings (2020). Pioneer Valley Planning Commission. Massachusetts.

MVP Core Team/ Working Group

Bill Adams, Cummington Select Board Chair
Dave Christopolis, Hilltown CDC Executive Director
Susan Labrie, Chesterfield Town Administrator
Peg O'Neal, Worthington Select Board Executive Assistant
Angela Otis, Goshen Select Board Chair
Charley Rose, Worthington Select Board Chair
James Wettereau, Cummington Board of Health

Workshop Facilitators

(All of the Pioneer Valley Planning Commission)

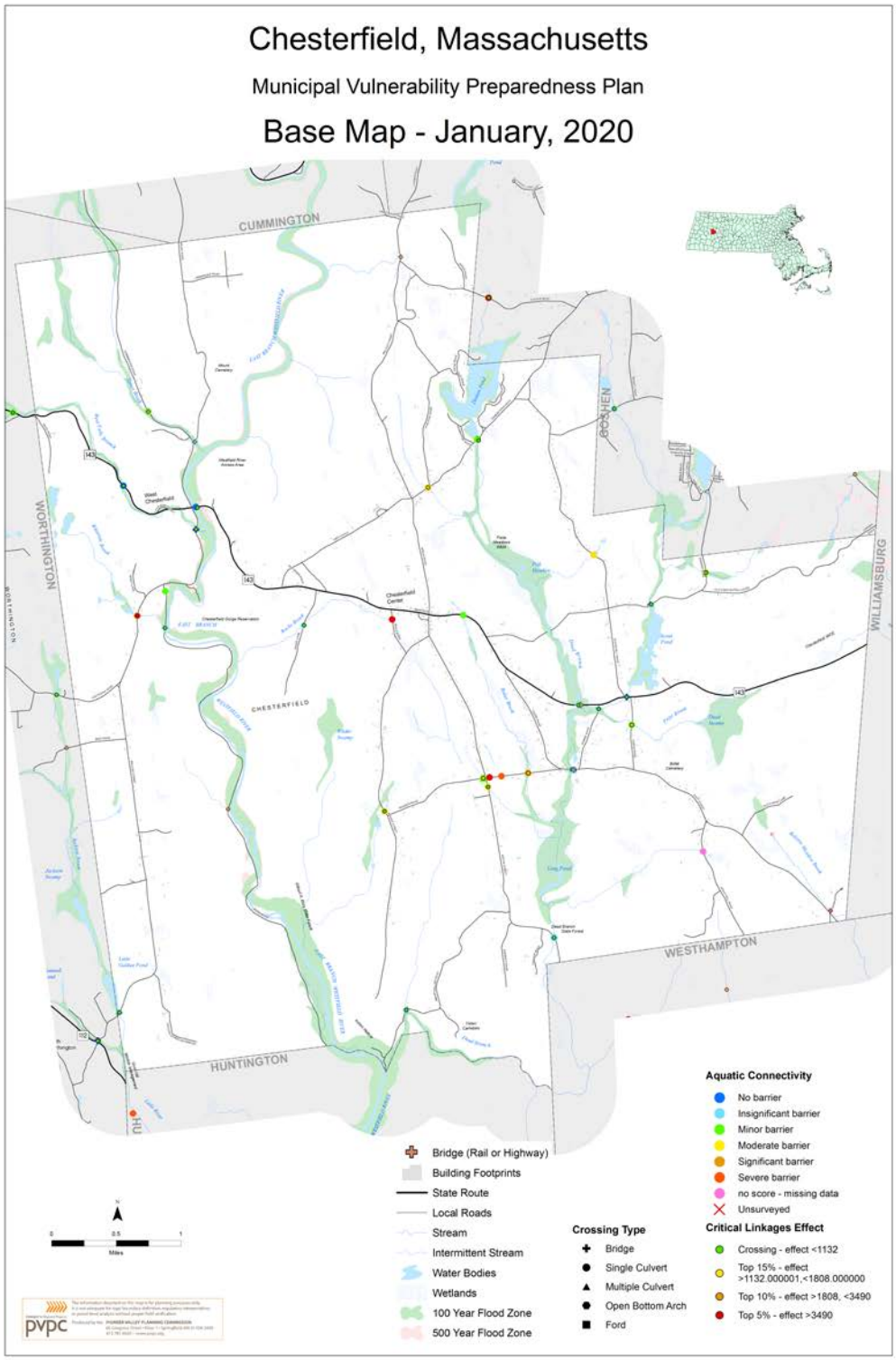
Ken Comia, Senior Planner, Land Use and Environment
Patty Gambarini, Land Use and Environment Section Manager
Corrin Meise-Munns, Senior Planner, Land Use and Environment
Catherine Ratte, Land Use and Environment Section Manager
Emily Slotnick, Senior Planner, Land Use and Environment

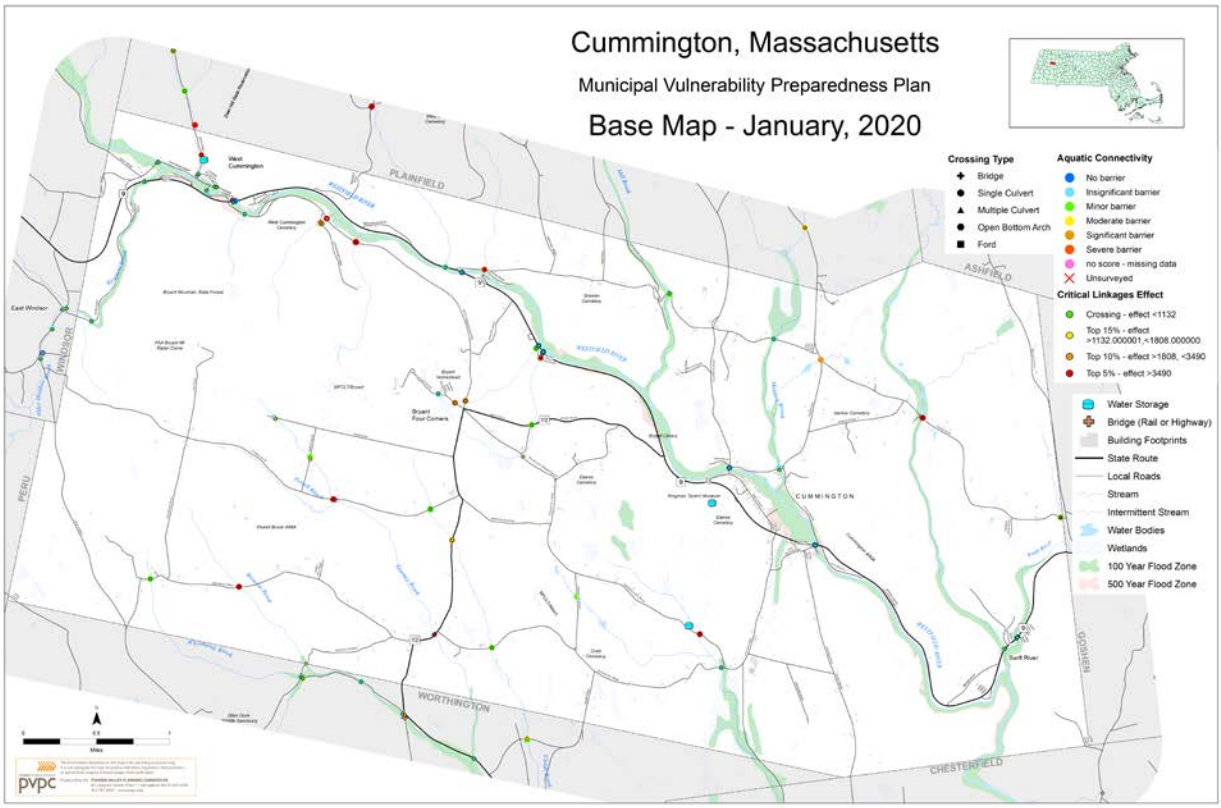
Acknowledgements

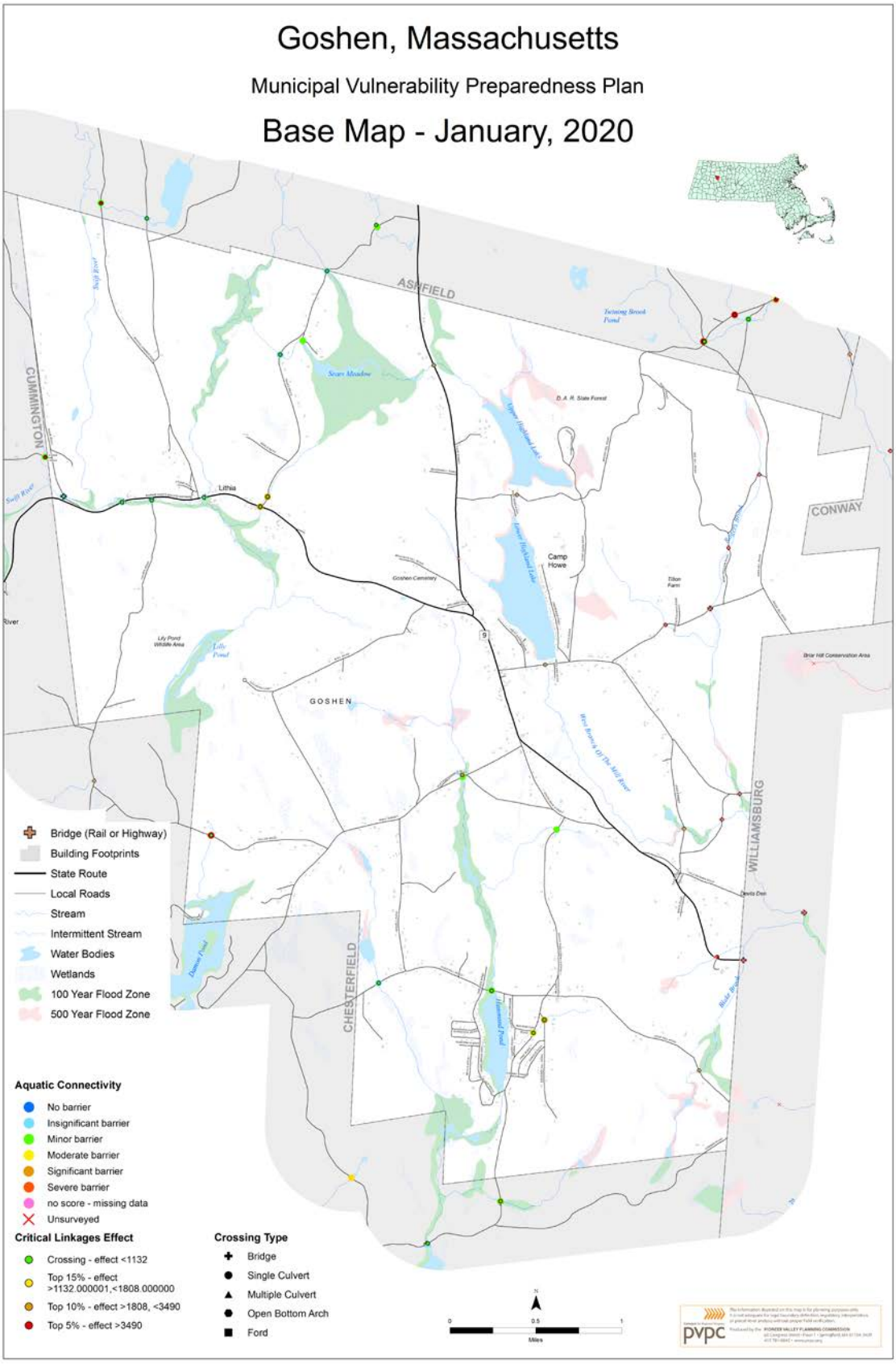
Special thanks to all Northern Hilltowns Collaborative MVP core team members who have contributed countless hours to this process. Also thanks to the Town of Goshen and the Town of Worthington for providing meeting spaces in their Town buildings for MVP workshops. The project team was grateful for the work of Smith College students from the ENV 312 class, and for the strong leadership and thoughtful guidance provided by their professors Camille Washington-Ottombre and Patricia H. Mangan. Finally, thank you to all town staff who supported this project through in-person and phone interviews and email exchanges for their willingness to enhance this process.

This project was made possible through funding from the Massachusetts Executive Office of Energy and Environmental Affairs.

Appendix A: Workshop Basemaps




Cummington, Massachusetts
Municipal Vulnerability Preparedness Plan
Base Map - January, 2020
Crossing Type
Bridge
Single Culvert
Multiple Culvert
Open Bottom Arch
Ford
Aquatic Connectivity
No barrier
Insignificant barrier
Minor barrier
Moderate barrier
Significant barrier
Severe barrier
no score - missing data
Unsurveyed
Critical Linkages Effect
Crossing - effect <1132
Top 15% - effect >1132.000001,<1808.000000
Top 10% - effect >1808, <3490
Top 5% - effect >3490
Water Storage
Bridge (Rail or Highway)
Building Footprints
State Route
Local Roads
Stream
Intermittent Stream
Water Bodies
Wetlands
100 Year Flood Zone
500 Year Flood Zone
PLAINFIELD
ASHFIELD
WINDSOR
PERU
CUMMINGTON
WORTHINGTON
CHESTERFIELD
GOSHEN
pvpc


Goshen, Massachusetts
Municipal Vulnerability Preparedness Plan
Base Map - January, 2020
ASHFIELD
CUMMINGTON
CONWAY
GOSHEN
CHESTERFIELD
WILLIAMSBURG
Lithia
Camp Howe
Bridge (Rail or Highway)
Building Footprints
State Route
Local Roads
Stream
Intermittent Stream
Water Bodies
Wetlands
100 Year Flood Zone
500 Year Flood Zone
Aquatic Connectivity
No barrier
Insignificant barrier
Minor barrier
Moderate barrier
Significant barrier
Severe barrier
no score - missing data
Unsurveyed
Critical Linkages Effect
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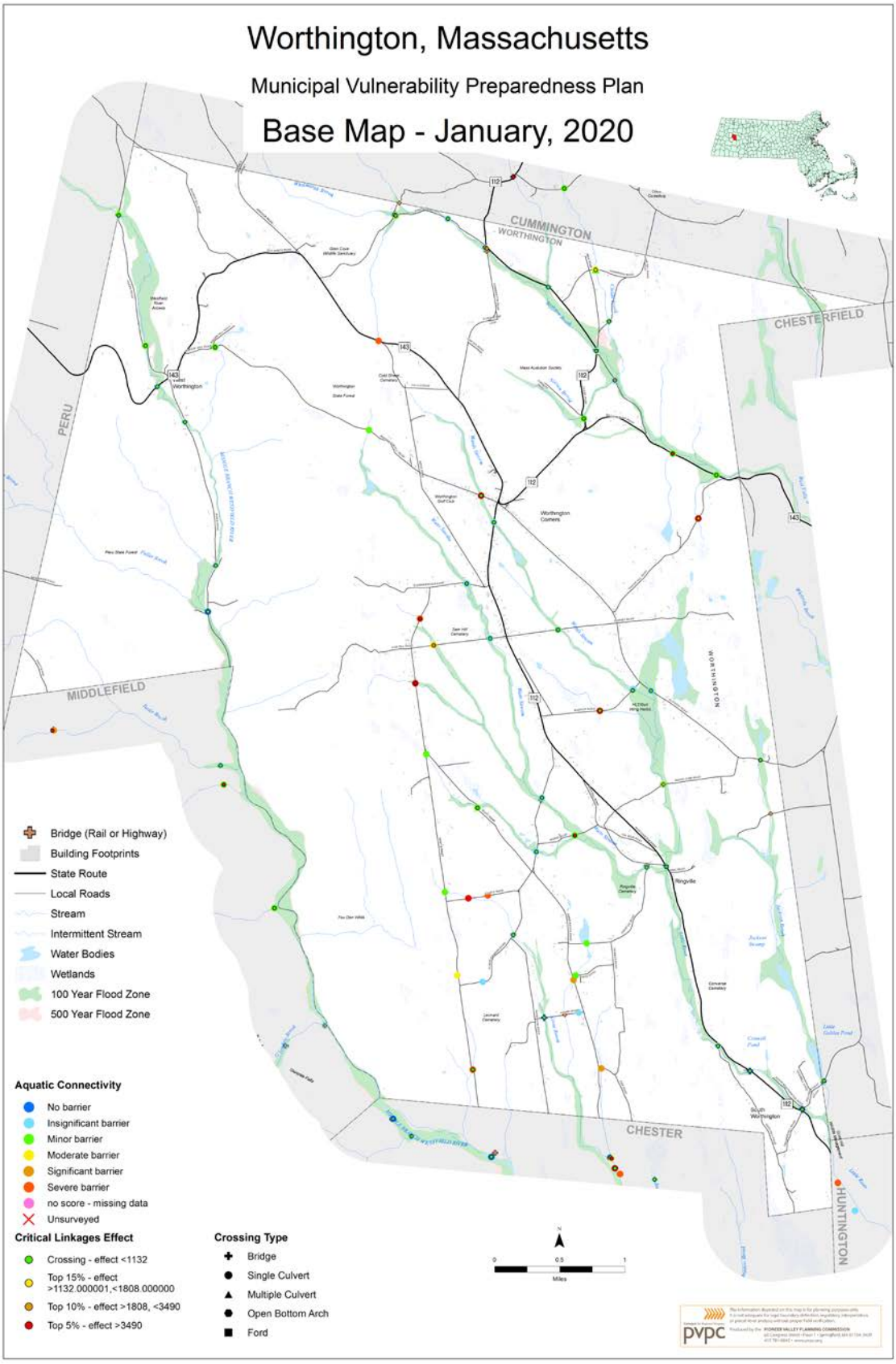
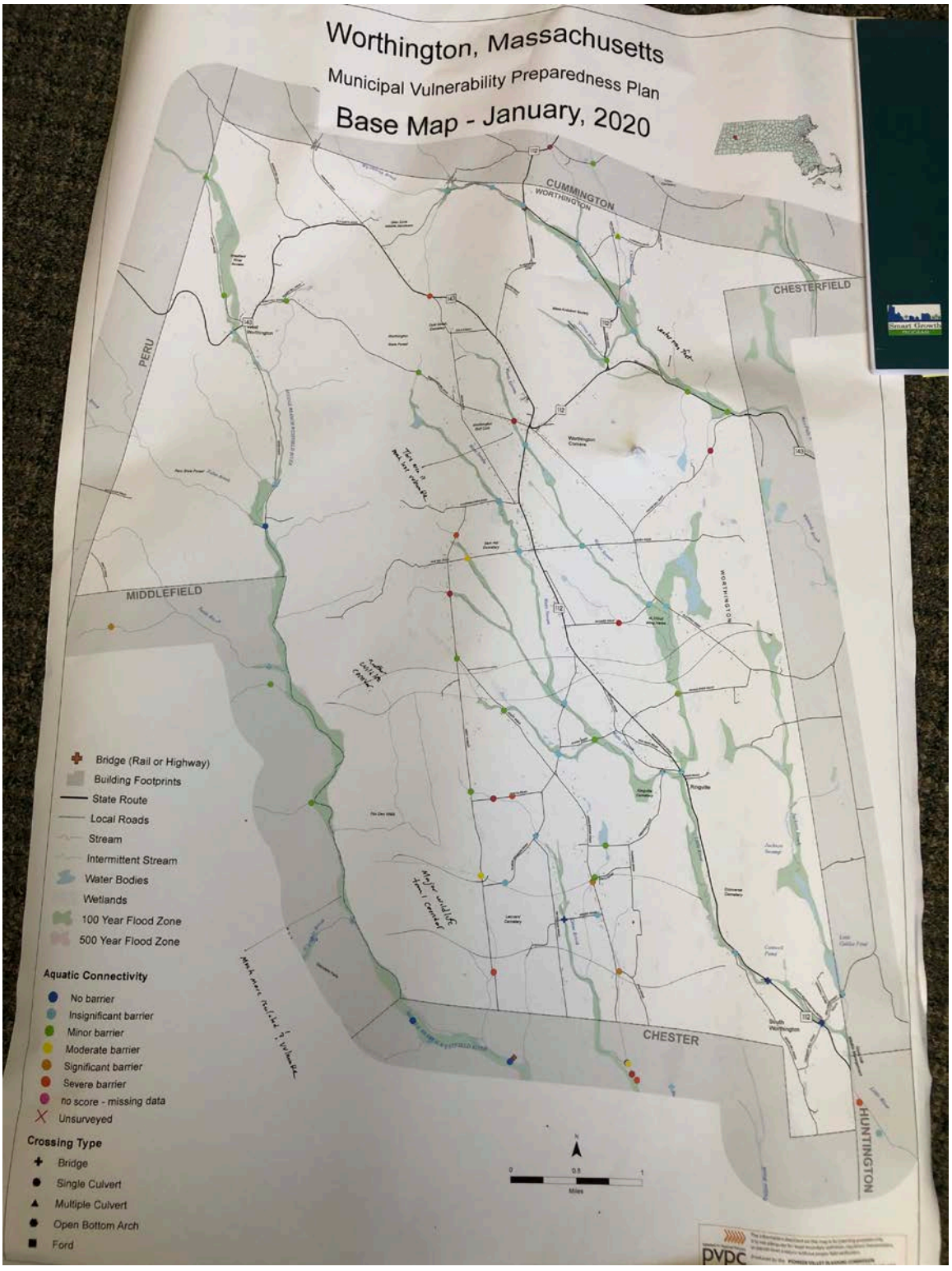
Top 10% - effect >1808, <3490
Top 5% - effect >3490
Crossing Type
Bridge
Single Culvert
Multiple Culvert
Open Bottom Arch
Ford
Miles
pvpc


Worthington, Massachusetts
Municipal Vulnerability Preparedness Plan
Base Map - January, 2020
CUMMINGTON
WORTHINGTON
CHESTERFIELD
PERU
MIDDLEFIELD
CHESTER
HUNTINGTON
Bridge (Rail or Highway)
Building Footprints
State Route
Local Roads
Stream
Intermittent Stream
Water Bodies
Wetlands
100 Year Flood Zone
500 Year Flood Zone
Aquatic Connectivity
No barrier
Insignificant barrier
Minor barrier
Moderate barrier
Significant barrier
Severe barrier
no score - missing data
Unsurveyed
Critical Linkages Effect
Crossing - effect <1132
Top 15% - effect >1132.000001,<1808.000000
Top 10% - effect >1808, <3490
Top 5% - effect >3490
Crossing Type
Bridge
Single Culvert
Multiple Culvert
Open Bottom Arch
Ford
Miles
pvpc

Appendix B: Participatory Mapping Results

Cummington/Worthington Workshop (February 1, 2020)

Worthington Table 1



Worthington Table 2

As the results of this small group's mapping exercise were negligible, the map is not included.

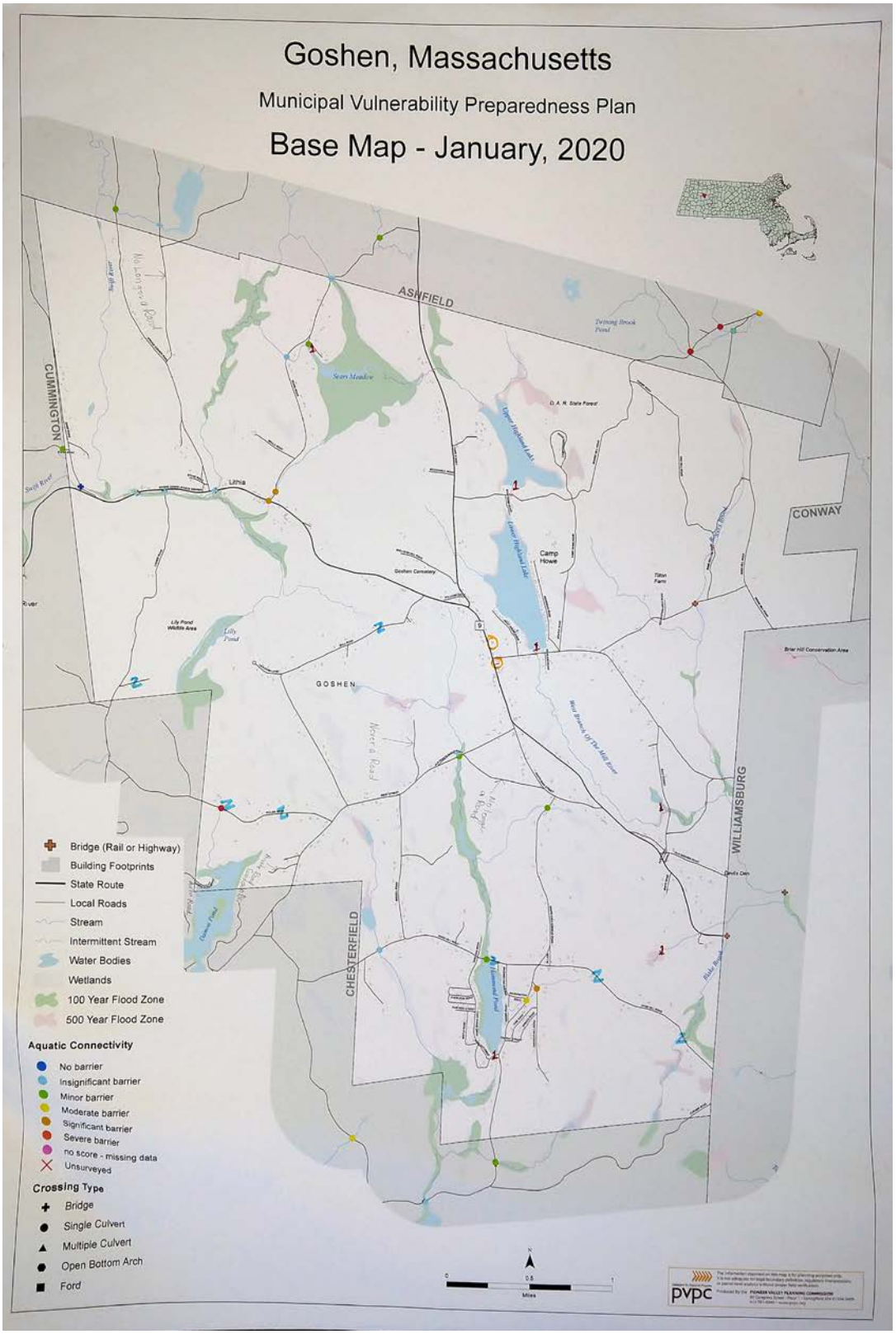
Cummington Table 1

Chesterfield/Goshen Workshop (February 5, 2020)

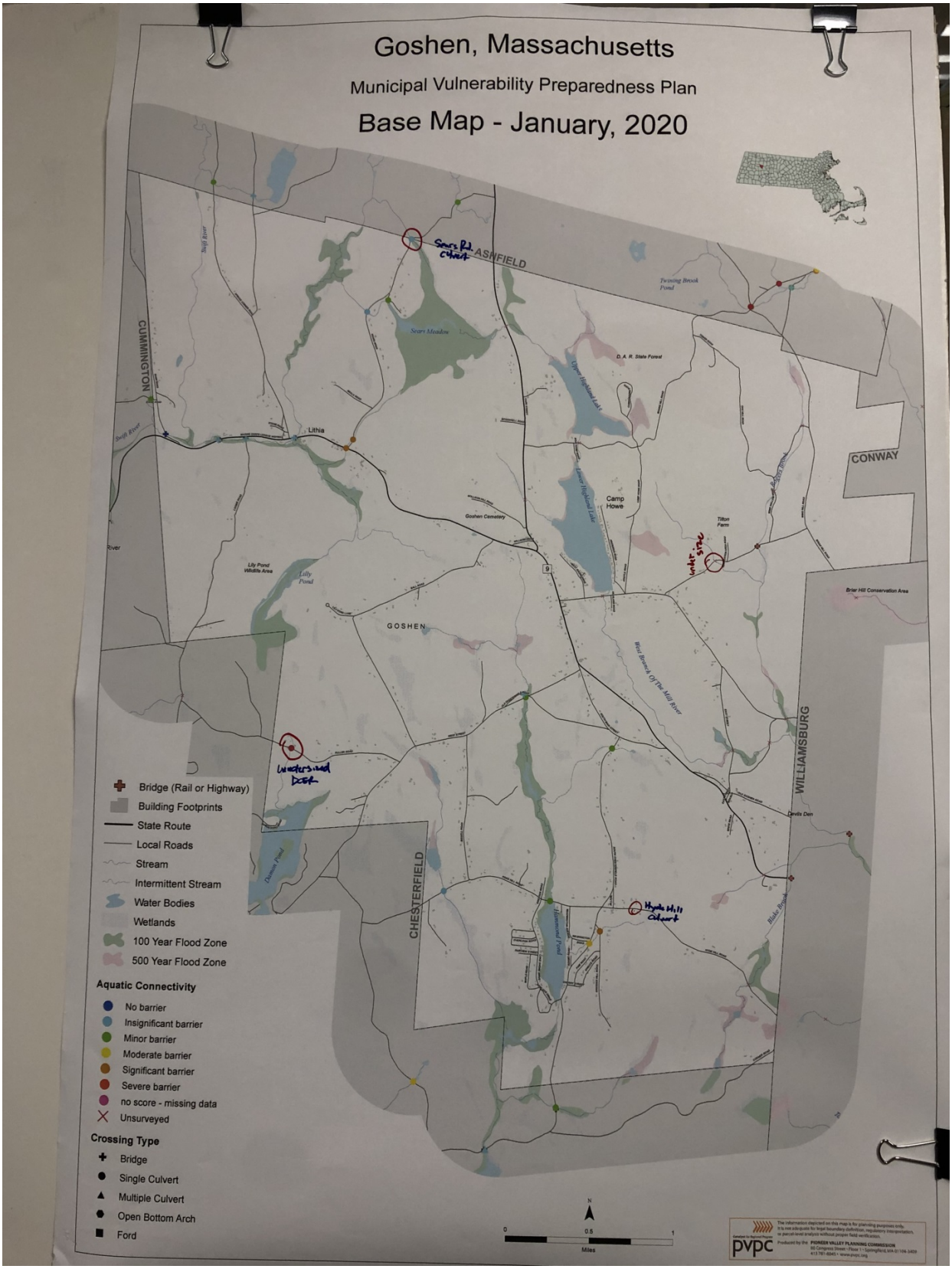
Chesterfield Table 1

As the results of this small group's mapping exercise were negligible, the map is not included.

Goshen Table 1



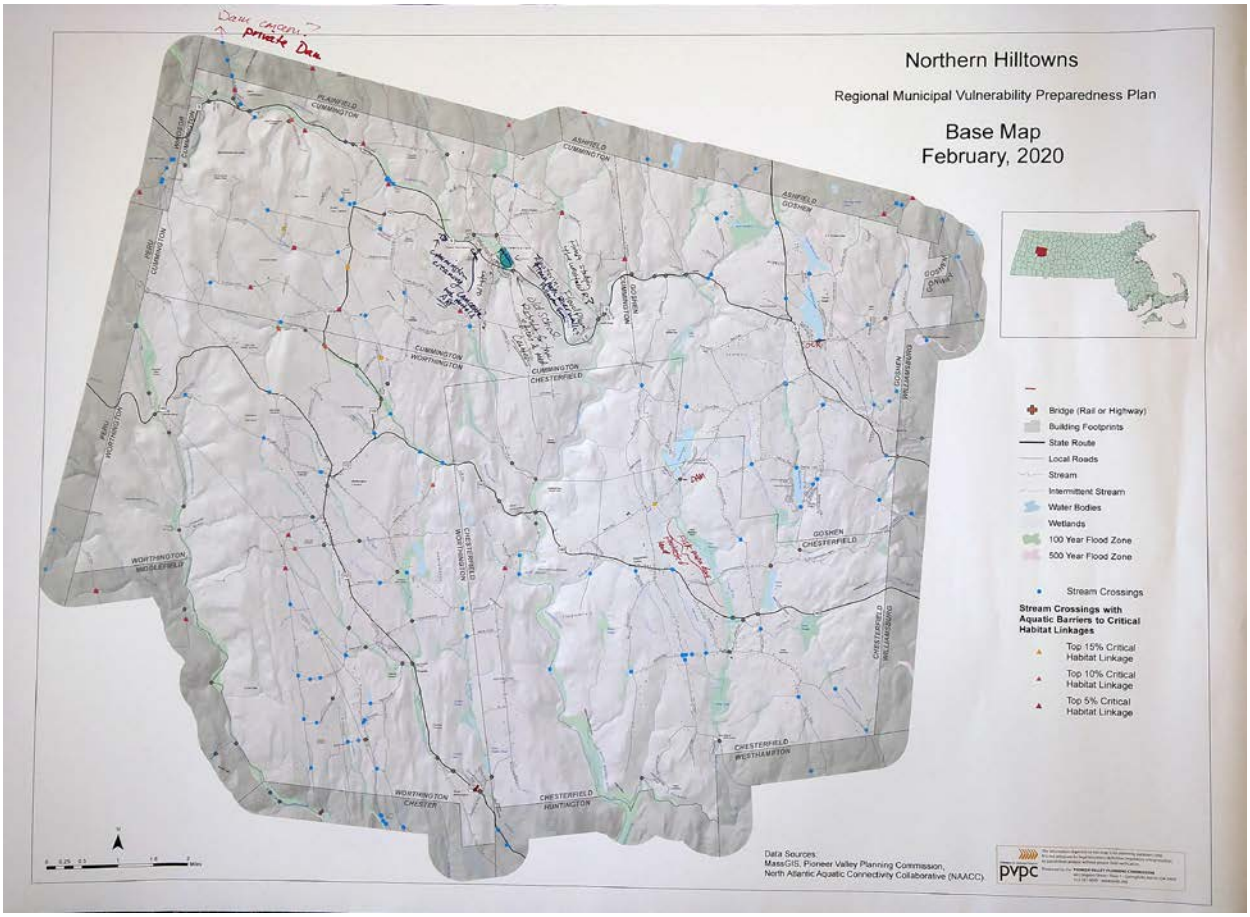
Goshen Table 2



Goshen Table 3

As the results of this small group's mapping exercise were negligible, the map is not included.

Regional Workshop (February 13, 2020)



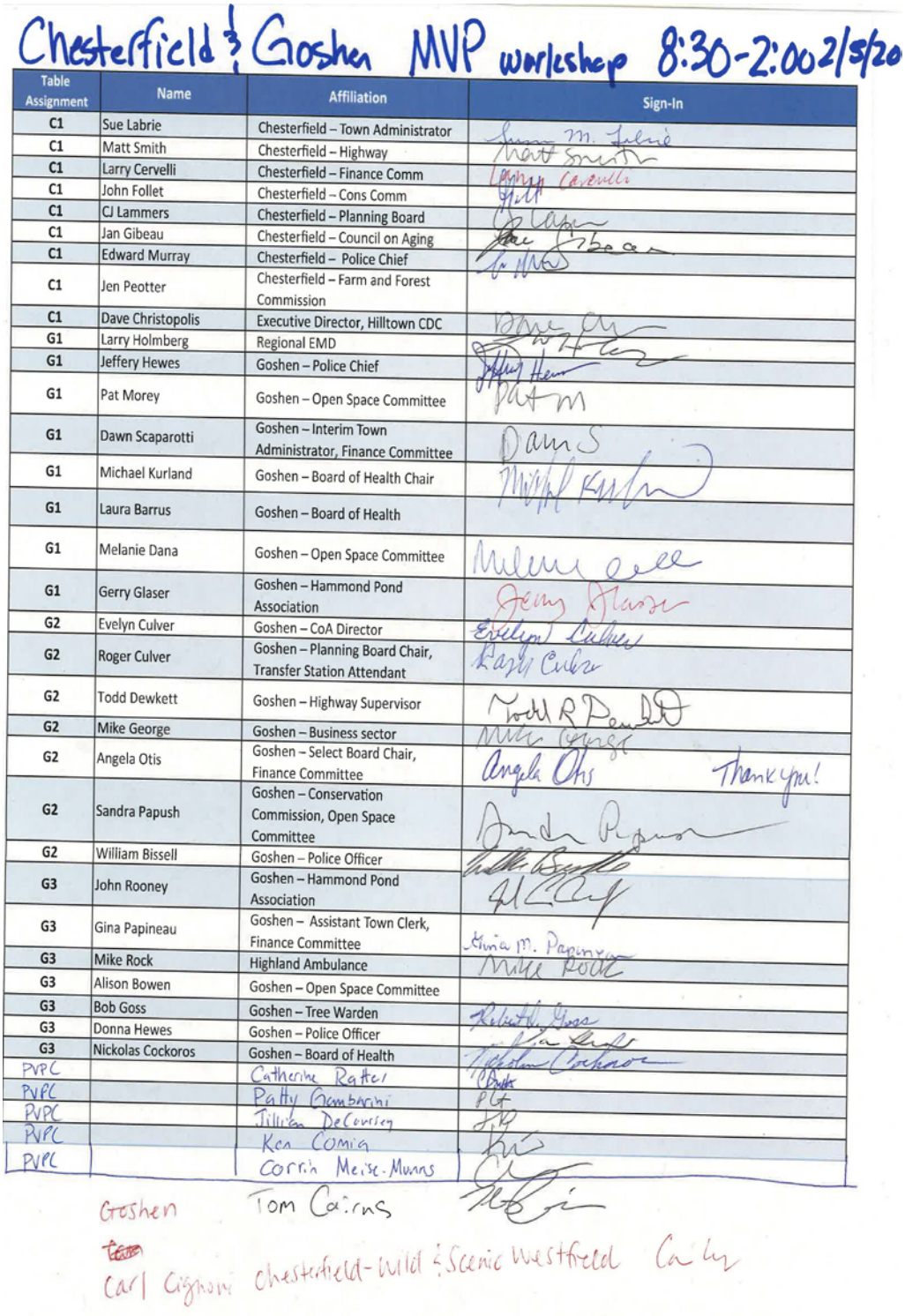
Appendix C: Workshop Materials

Sign-in Sheets

Cummington and Worthington Workshop, February 1, 2020

Name	Affiliation
Mike Perkins	Cummington - Police Chief
Adam Dragon	Cummington – Fire Chief, EM Director
Jim Wettereau	Cummington – Chairman, Board of Health
Sarah Fournier	Cummington – Member, Conservation Commission
Alan Taylor	Cummington – Highway Superintendent
Bernie Forgea	Cummington – At Large
Dan Emerson	Cummington – Member, Water Board
Bill Adams	Cummington – Chairman, Selectboard
Margaret O'Neal	Worthington – Executive Assistant, Cons Comm
Liese Schaff	Worthington – Trails Committee
Kyle Challet	Worthington – Fire Department
Kevin Porter	Worthington – Fire Department
David Mendehlson	Worthington – EMD
Cork Nugent	Worthington – Highway Superintendent
Fran Ryan	Worthington – Gazette Reporter
Jay Dwight	Worthington – Planning Board
Diane Brenner	Worthington – Board of Health
Katrin Kaminsky	Worthington – Board f Health and Town Clerk
Ben Brown	Worthington – Tree Warden
Charley Rose	Worthington – Selectboard Chair
Patty Kimura	Worthington – Manager of the Maples
Ed Lewis	Worthington – Conservation Commission
Bob Reinke	Worthington – Police Chief
Shelley Rice	Worthington – Council on Aging Director
Larry Holmberg	Regional EMD
Dave Christopolis	Hilltown CDC

Chesterfield & Goshen Workshop, February 5, 2020



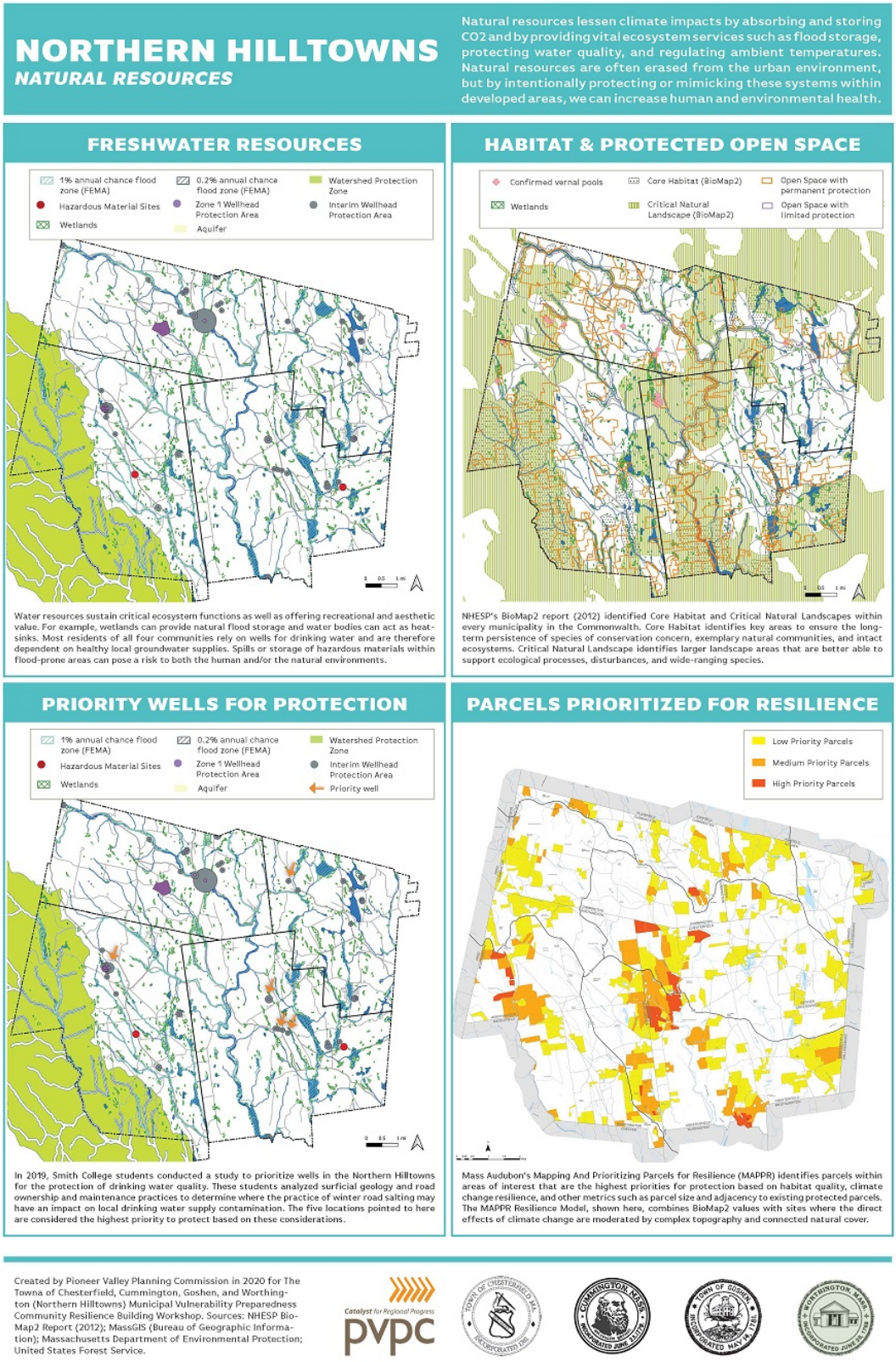
Chesterfield & Goshen MVP workshop 8:30-2:00 2/5/20

Table Assignment	Name	Affiliation	Sign-In
C1	Sue Labrie	Chesterfield – Town Administrator	
C1	Matt Smith	Chesterfield – Highway	
C1	Larry Cervelli	Chesterfield – Finance Comm	
C1	John Follet	Chesterfield – Cons Comm	
C1	CJ Lammers	Chesterfield – Planning Board	
C1	Jan Gibeau	Chesterfield – Council on Aging	
C1	Edward Murray	Chesterfield – Police Chief	
C1	Jen Peotter	Chesterfield – Farm and Forest Commission	
C1	Dave Christopolis	Executive Director, Hilltown CDC	
G1	Larry Holmberg	Regional EMD	
G1	Jeffery Hewes	Goshen – Police Chief	
G1	Pat Morey	Goshen – Open Space Committee	
G1	Dawn Scaparotti	Goshen – Interim Town Administrator, Finance Committee	
G1	Michael Kurland	Goshen – Board of Health Chair	
G1	Laura Barrus	Goshen – Board of Health	
G1	Melanie Dana	Goshen – Open Space Committee	
G1	Gerry Glaser	Goshen – Hammond Pond Association	
G2	Evelyn Culver	Goshen – CoA Director	
G2	Roger Culver	Goshen – Planning Board Chair, Transfer Station Attendant	
G2	Todd Dewkett	Goshen – Highway Supervisor	
G2	Mike George	Goshen – Business sector	
G2	Angela Otis	Goshen – Select Board Chair, Finance Committee	Thank you!
G2	Sandra Papush	Goshen – Conservation Commission, Open Space Committee	
G2	William Bissell	Goshen – Police Officer	
G3	John Rooney	Goshen – Hammond Pond Association	
G3	Gina Papineau	Goshen – Assistant Town Clerk, Finance Committee	
G3	Mike Rock	Highland Ambulance	
G3	Alison Bowen	Goshen – Open Space Committee	
G3	Bob Goss	Goshen – Tree Warden	
G3	Donna Hewes	Goshen – Police Officer	
G3	Nickolas Cockoros	Goshen – Board of Health	
PVPC		Catherine Ratter	
PVPC		Patty Gambarini	
PVPC		Jillian DeCourcey	
PVPC		Ken Comia	
PVPC		Corrin Meise-Munns	
Goshen		Tom Cairns	
~~Town~~			
Carl Cignoni		Chesterfield-Wild & Scenic Westfield	

Regional Workshop, February 13, 2020

Table Assignment	Name	Affiliation	Sign-In
1	Bernie Forgea	Cummington – Former EMD	
2	Bill Adams	Cummington – Select Board Chair	Bill Adams
3	Caitlin Marquis	Collaborative for Educational Services – Healthy Hampshire	
2	Camille Washinton-Ottombre	Smith College – Associate Professor	
2	Charley Rose	Worthington – Select Board Chair	
1	Dave Christopolis	Executive Director, Hilltown CDC	
2	Dawn Scaparotti	Goshen – Interim Town Administrator, Finance Committee Chair	
1	Eliza Lake	Regional Health Center – Executive Director	
2	Eric Weiss	PVPC – Regional and Municipal Services Manager	
3	Jake Lehan	DER; WRWA Exec.Board; WWaS Board/State Rep (WRWA) (WWaS)	
1	Katy Eiseman	Cummington – Cummington Creamery, WWaS, Planning Board	
3	Kaylan Water	Cummington – Planning Board	Kaylan Water
3	Larry Holmberg	Regional EMD	
2	Meredyth Babcock	WWaS – Outreach Coordinator	
1	Peggy O'Neal	Worthington – Executive Assistant to the Select Board	Peg O'Neal
~~1~~	~~Sally Loomis~~	Hilltown Land Trust – Executive Director	
3	Sue Labrie	Chesterfield – Town Administrator	
3	Tessa Dowling	Hilltown Land Trust – Land Stewardship Coordinator	Tessa Dowling
	Emily Slotnick	PVPC – Senior Land Use / Environment Planner	EJ
3	Corrin Meise-Munns	PVPC – Senior Land Use / Environment Planner	
2	Jill DeCoursey	PVPC – Senior Land Use Planner	JD
1	Patty Gambarini	PVPC – Principal Planner, Environment Lead	PG
1	AMY WANG	SELECT BOARD MEM- WORTHINGTON	AMY WANG
2	David Mendlisch	Worthington Sup	
3	ANGELA OTIS	Goshen Select Board Chair	
1			
2			
3			
	Peter Spotts	Country Journal	
3	JAMES WETTERLAU	Cummington BOH	

Natural Resources Mapping



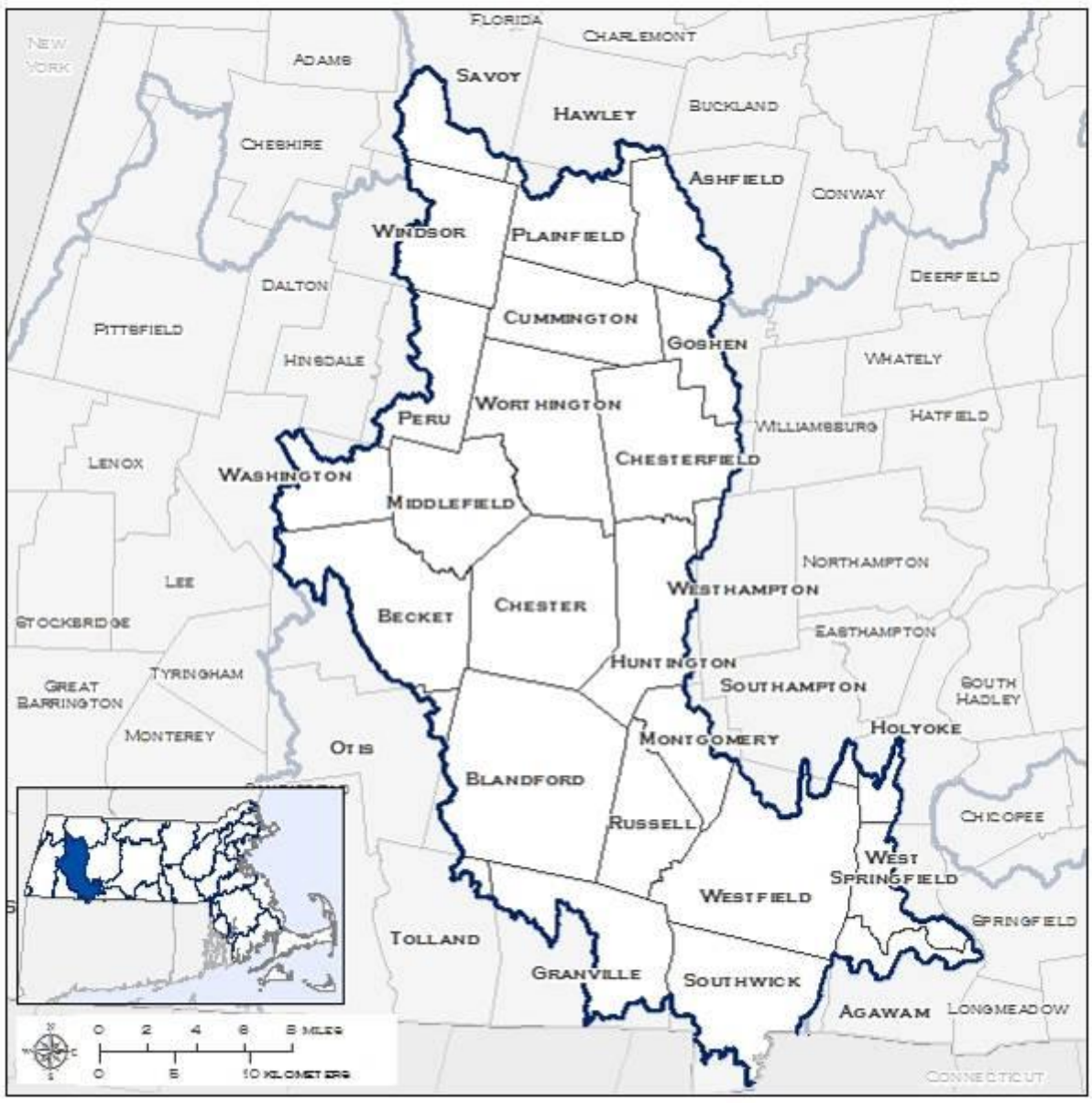
Appendix D: Participant Handouts

NECSC Climate Projections – Westfield Basin Excerpt

WESTFIELD BASIN

MUNICIPALITIES WITHIN WESTFIELD BASIN:

Agawam, Ashfield, Becket, Blandford, Chester, Chesterfield, Cummington, Goshen, Granville, Hawley, Holyoke, Huntington, Middlefield, Montgomery, Otis, Peru, Planfield, Russell, Savoy, Southampton, Southwick, Tolland, Washington, West Springfield, Westfield, Westhampton, Windsor, and Worthington



Many municipalities fall within more than one basin, so it is advised to use the climate projections for the basin that contains the majority of the land area of the municipality.

WESTFIELD BASIN

Westfield Basin		Observed Baseline 1971-2000 (°F)	Projected Change in 2030s (°F)	Mid-Century Projected Change in 2050s (°F)	Projected Change in 2070s (°F)	End of Century Projected Change in 2090s (°F)
Average Temperature	Annual	45.0	+2.3 to +4.6	+3.1 to +6.6	+3.6 to +9.2	+4.2 to +11.2
	Winter	23.3	+2.5 to +5.5	+3.2 to +8.3	+4.1 to +9.9	+4.5 to +11.2
	Spring	43.2	+1.8 to +3.6	+2.5 to +5.7	+3.1 to +7.7	+3.6 to +9.4
	Summer	65.7	+2.3 to +4.5	+3.0 to +7.1	+3.5 to +10.2	+4.0 to +12.5
	Fall	47.4	+2.3 to +5.3	+3.8 to +6.9	+3.8 to +9.9	+4.2 to +12.1
Maximum Temperature	Annual	55.8	+2.1 to +4.4	+2.8 to +6.7	+3.3 to +9.3	+3.8 to +11.3
	Winter	32.9	+2.0 to +4.9	+2.8 to +7.4	+3.4 to +8.9	+3.8 to +10.0
	Spring	54.4	+1.7 to +3.5	+2.4 to +5.6	+3.0 to +8.0	+3.6 to +9.7
	Summer	77.3	+2.1 to +4.7	+2.8 to +7.3	+3.3 to +10.6	+3.9 to +13.0
	Fall	58.3	+2.5 to +5.2	+3.6 to +7.3	+3.6 to +10.2	+4.2 to +12.5
Minimum Temperature	Annual	34.2	+2.4 to +4.8	+3.4 to +6.8	+4.1 to +9.0	+4.5 to +11.1
	Winter	13.6	+2.7 to +6.2	+3.7 to +8.9	+4.8 to +10.8	+5.2 to +12.0
	Spring	32.1	+1.9 to +3.8	+2.6 to +6.0	+3.3 to +7.6	+3.7 to +9.2
	Summer	54.2	+2.5 to +4.6	+3.3 to +7.1	+3.6 to +9.8	+4.1 to +12.0
	Fall	36.6	+2.0 to +5.3	+3.7 to +6.8	+3.9 to +9.5	+4.2 to +11.8

- The Westfield basin is expected to experience increased average temperatures throughout the 21st century. Maximum and minimum temperatures are also expected to increase throughout the end of the century. These increased temperature trends are expected for annual and seasonal projections.
- Seasonally, maximum summer and fall temperatures are expected to see the highest projected increase throughout the 21st century.
    - Summer mid-century increase of 2.8 °F to 7.3 °F (4-9% increase); end of century increase of 3.9 °F to 13.0 °F (5-17% increase).
    - Fall mid-century increase of 3.6 °F to 7.3 °F (6-13% increase); end of century increase by and 4.2 °F to 12.5 °F (7-21% increase).
- Seasonally, minimum winter and fall temperature projections are expected to see increases throughout the 21st century.
    - Winter mid-century increase of 3.7 °F to 8.9 °F (27-65% increase); end of century increase by 5.2 °F to 12.0 °F (38-88% increase).
    - Fall mid-century of 3.7 °F to 6.8 °F (10-19% increase); end of century increase of 4.2°F to 11.8 °F (11-32% increase).

WESTFIELD BASIN

Westfield Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Maximum Temperature Over 90°F	Annual	3	+4 to +13	+6 to +24	+7 to +42	+9 to +60
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	<1[99]	+<1[99] to +<1[99]	+<1[99] to +1	+<1[99] to +2	+<1[99] to +3
	Summer	3	+4 to +11	+5 to +21	+6 to +36	+8 to +49
	Fall	<1[99]	+<1[99] to +1	+<1[99] to +2	+<1[99] to +6	+1 to +8
Days with Maximum Temperature Over 95°F	Annual	<1[99]	+1 to +4	+1 to +9	+2 to +20	+2 to +33
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	0	+0 to +<1[99]	+0 to +<1[99]	+<1[99] to +<1[99]	+0 to +1
	Summer	<1[99]	+1 to +4	+1 to +9	+1 to +18	+2 to +30
	Fall	<1[99]	+<1[99] to +<1[99]	+<1[99] to +1	+<1[99] to +1	+<1[99] to +2
Days with Maximum Temperature Over 100°F	Annual	0	+<1[99] to +1	+<1[99] to +2	+<1[99] to +5	+<1[99] to +11
	Winter	0	+0 to +0	+0 to +0	+0 to +0	+0 to +0
	Spring	0	+0 to +<1[99]	+0 to +<1[99]	+0 to +<1[99]	+0 to +<1[99]
	Summer	0	+<1[99] to +1	+<1[99] to +2	+<1[99] to +5	+<1[99] to +11
	Fall	0	+0 to +<1[99]	+0 to +<1[99]	+0 to +<1[99]	+0 to +1

- Due to projected increases in average and maximum temperatures throughout the end of the century, the Westfield basin is also expected to experience an increase in days with daily maximum temperatures over 90 °F, 95 °F, and 100 °F.
    - Annually, the Westfield basin is expected to see days with daily maximum temperatures over 90 °F increase by 6 to 24 more days by mid-century, and 9 to 60 more days by the end of the century.
    - Seasonally, summer is expected to see an increase of 5 to 21 more days with daily maximums over 90 °F by mid-century.
    - By end of century, the Westfield basin is expected to have 8 to 49 more days.

[99] Over the observed period, there were some years with at least 1 day with seasonal Tmax over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

WESTFIELD BASIN

Westfield Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Minimum Temperature Below 0°F	Annual	13	-5 to -9	-7 to -10	-7 to -11	-8 to -12
	Winter	12	-5 to -8	-6 to -10	-7 to -11	-7 to -11
	Spring	1	-0 to -1	-0 to -1	-0 to -1	-0 to -1
	Summer	0	-0 to -0	-0 to -0	-0 to -0	-0 to -0
	Fall	<1[100]	-0 to -0	-0 to -0	-0 to -0	-0 to -0
Days with Minimum Temperature Below 32°F	Annual	167	-11 to -28	-20 to -38	-22 to -53	-24 to -62
	Winter	86	-1 to -5	-2 to -8	-3 to -14	-3 to -17
	Spring	46	-5 to -10	-6 to -15	-8 to -20	-9 to -22
	Summer	<1[100]	-0 to -0	-0 to -0	-0 to -0	-0 to -0
	Fall	34	-5 to -13	-10 to -16	-10 to -22	-10 to -24

- Due to projected increases in average and minimum temperatures throughout the end of the century, the Westfield basin is expected to experience a decrease in days with daily minimum temperatures below 32 °F and 0 °F.
- Seasonally, winter, spring and fall are expected to see the largest decreases in days with daily minimum temperatures below 32 °F.
    - Winter is expected to have 2 to 8 fewer days by mid-century, and 3 to 17 fewer days by end of century.
    - Spring is expected to have 6 to 15 fewer days by mid-century, and 9 to 22 fewer days by end of century.
    - Fall is expected to have 10 to 16 fewer days by mid-century, and 10 to 24 fewer days by end of century.

[100] Over the observed period, there were some years with at least 1 day with seasonal Tmin under a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

WESTFIELD BASIN

Westfield Basin		Observed Baseline 1971-2000 (Degree-Days)	Projected Change in 2030s (Degree-Days)	Mid-Century Projected Change in 2050s (Degree-Days)	Projected Change in 2070s (Degree-Days)	End of Century Projected Change in 2090s (Degree-Days)
Heating Degree-Days (Base 65°F)	Annual	7620	-658 to -1335	-901 to -1866	-1031 to -2442	-1186 to -2821
	Winter	3775	-207 to -512	-279 to -758	-366 to -897	-417 to -1027
	Spring	2017	-151 to -313	-217 to -491	-269 to -636	-317 to -753
	Summer	206	-69 to -120	-93 to -154	-109 to -178	-120 to -189
	Fall	1621	-187 to -431	-313 to -535	-305 to -743	-328 to -853
Cooling Degree-Days (Base 65°F)	Annual	317	+176 to +362	+231 to +631	+271 to +978	+314 to +1311
	Winter	0	-1 to +3	+1 to +7	-0 to +4	+0 to +11
	Spring	15	+6 to +20	+12 to +39	+15 to +68	+15 to +99
	Summer	275	+139 to +299	+176 to +493	+204 to +755	+241 to +961
	Fall	25	+19 to +63	+28 to +104	+35 to +184	+45 to +251
Growing Degree-Days (Base 50°F)	Annual	2013	+382 to +764	+517 to +1204	+620 to +1807	+702 to +2283
	Winter	3	-1 to +7	+1 to +8	+0 to +12	+2 to +18
	Spring	223	+54 to +118	+80 to +207	+102 to +307	+102 to +409
	Summer	1451	+209 to +410	+276 to +647	+316 to +931	+364 to +1144
	Fall	326	+102 to +261	+155 to +374	+158 to +570	+204 to +710

- Due to projected increases in average, maximum, and minimum temperatures throughout the end of the century, the Westfield basin is expected to experience a decrease in heating degree-days, and increases in both cooling degree-days and growing degree-days.
- Seasonally, winter historically exhibits the highest number of heating degree-days and is expected to see the largest decrease of any season, but spring and fall are also expected to see significant change.
    - The winter season is expected to see a decrease of 7-20% (279 -758 degree-days) by mid-century, and a decrease of 11-27% (417 -1027 degree-days) by the end of century.
    - The spring season is expected to decrease in heating degree-days by 11-24% (217-491 degree-days) by mid-century, and by 16-37% (317-753 degree-days) by the end of century.
    - The fall season is expected to decreases in heating degree-days by 19-33% (313-535 degree-days) by mid-century, and by 20-53% (328 -853 degree-days) by the end of century.
- Conversely, due to projected increasing temperatures, summer cooling degree-days are expected to increase by 64-180% (176 -493 degree-days) by mid-century, and by 88-350% (241-961 degree-days) by end of century.

- Seasonally, summer historically exhibits the highest number of growing degree-days and is expected to see the largest decrease of any season, but the shoulder seasons of spring and fall are also expected to see an increase in growing degree-days.
    - The summer season is projected to increase by 19-45% (276-647 degree-days) by mid-century, and by 25-79% (363-1144 degree-days) by end of century.
    - Spring is expected to see an increase by 36-93% (78-207 degree-days) by mid-century and 46-184% (102-409 degree-days) by end of century.
    - Fall is expected to see an increase by 47-115% (155-374 degree-days) by mid-century and 62-218% (204-710 degree-days) by end of century.

WESTFIELD BASIN

Westfield Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Days with Precipitation Over 1"	Annual	8	+<1[101] to +2	+1 to +4	+1 to +3	+1 to +5
	Winter	1	-0 to +1	+<1[101] to +1	+<1[101] to +1	+<1[101] to +2
	Spring	2	-0 to +1	+<1[101] to +1	+<1[101] to +1	+<1[101] to +2
	Summer	2	-0 to +1	-0 to +1	-0 to +1	-0 to +1
	Fall	2	-0 to +1	-0 to +1	-0 to +1	-0 to +1
Days with Precipitation Over 2"	Annual	1	-0 to +1	-0 to +1	+<1[101] to +1	+<1[101] to +1
	Winter	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]
	Spring	<1[101]	-0 to +<1[101]	-0 to +<1[101]	+<1[101] to +<1[101]	+<1[101] to +<1[101]
	Summer	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]
	Fall	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]
Days with Precipitation Over 4"	Annual	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]
	Winter	0	-0 to +0	-0 to +0	-0 to +0	-0 to +0
	Spring	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]
	Summer	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]
	Fall	<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]	-0 to +<1[101]

- The projections for expected number of days receiving precipitation over one inch are variable for the Westfield basin, fluctuating between loss and gain of days.
    - Seasonally, the winter season is generally expected to see the highest projected increase.
    - The winter season is expected to see an increase in days with precipitation over one inch of 0-1 days by mid-century, and an increase of 0-2 days by the end of century.
    - The spring season is expected to see an increase in days with precipitation over one inch 0-1 days by mid-century, and of an increase of 0-2 days by the end of century.

[101] Over the observed period, there were some years with at least 1 day with seasonal precipitation over a certain threshold while in all the other years that threshold wasn't crossed seasonally at all.

WESTFIELD BASIN

Westfield Basin		Observed Baseline 1971-2000 (Inches)	Projected Change in 2030s (Inches)	Mid-Century Projected Change in 2050s (Inches)	Projected Change in 2070s (Inches)	End of Century Projected Change in 2090s (Inches)
Total Precipitation	Annual	50.7	-0.2 to +5.1	+1.2 to +6.9	+2.0 to +8.1	+2.1 to +9.1
	Winter	11.2	-0.4 to +2.3	+0.2 to +2.8	+0.3 to +3.2	+0.8 to +4.1
	Spring	13.4	+0.0 to +2.2	+0.3 to +2.2	+0.7 to +3.0	+0.7 to +3.1
	Summer	13.2	-0.1 to +2.0	-0.1 to +2.1	-0.1 to +2.1	-0.6 to +2.0
	Fall	12.9	-1.4 to +1.7	-1.4 to +2.0	-1.7 to +2.0	-2.1 to +1.7

- Similar to projections for number of days receiving precipitation over a specified threshold, seasonal projections for total precipitation are also variable for the Westfield basin.
    - The winter season is expected to experience the greatest change with an increase of 2-25% by mid-century, and of 7-36% by end of century.
    - Projections for the summer and fall seasons are more variable, and could see either a drop or increase in total precipitation throughout the 21st century.
        - The summer season projections for the Westfield or basin could see a decrease of 0.1 to an increase of 2.1 inches by mid-century (decrease of 1% to increase of 16%) and a decrease of 0.6 to an increase of 2.0 inches by the end of the century (decrease of 5% to increase of 15%).
        - The fall season projections for the Westfield basin could see a decrease of 1.4 to an increase of 2 inches by mid-century (decrease of 10% to increase of 15%) and a decrease of 2.1 to an increase of 1.7 inches by the end of the century (decrease of 16% to increase of 13%).

Westfield Basin		Observed Baseline 1971-2000 (Days)	Projected Change in 2030s (Days)	Mid-Century Projected Change in 2050s (Days)	Projected Change in 2070s (Days)	End of Century Projected Change in 2090s (Days)
Consecutive Dry Days	Annual	17	-0 to +1	-0 to +2	-1 to +2	-0 to +3
	Winter	12	-1 to +1	-1 to +1	-1 to +1	-1 to +1
	Spring	12	-1 to +1	-1 to +1	-1 to +1	-1 to +1
	Summer	11	-1 to +1	-0 to +1	-1 to +2	-2 to +2
	Fall	12	-0 to +2	-0 to +2	-0 to +3	-0 to +3

- Annual and seasonal projections for consecutive dry days, or for a given period, the largest number of consecutive days with precipitation less than 1 mm (~0.04 inches), are variable throughout the 21st century.
    - For all the temporal parameters, the Westfield basin is expected to see a slight decrease to an increase in consecutive dry days throughout this century.
    - Seasonally, the fall and summer seasons are expected to continue to experience the highest number of consecutive dry days.
        - The fall season is expected to experience an increase of 0-3 days in consecutive dry days by the end of the century.

Smith College Reports

Assessing Drinking Water Vulnerability in the Hilltowns

A Report Prepared by Nicole Ferreira, Shea Leibow, Amaya Ramsay-Malone, and Natalie Schad
ENV 312, Smith College
Advisors: Camille Washington-Ottombre and Patricia H. Mangan

Executive Summary

The focus of this report is on four Massachusetts Hilltowns - Chesterfield, Cummington, Worthington, and Goshen. As climate change impacts worsen, extreme weather events and precipitation in the Northeast are projected to increase. This poses a particular concern to the Hilltowns, where a majority of household water is sourced from private wells - increased precipitation poses the risk of increased pollutant transmission into groundwater sources, accompanied with potential rising groundwater levels. Road salt poses a particular threat to drinking water quality due to its high permeability through soil and bedrock, and its corrosive nature. Drinking water wells located close to roads are at elevated risk for road salt contamination, and wells near roads operated by the Massachusetts Department of Transportation (MassDOT) are at a heightened risk due to the department's practice of oversalting roads.

A series of meetings and interviews indicated that drinking water quality was an issue of concern for many Hilltown residents. The lack of available data on contamination in private wells, as well as a general lack of understanding surrounding why public wells contained specific contaminants, prompted us to direct our project towards comprehensively presenting and mapping data surrounding current and projected risks to drinking water quality in the Hilltowns.

We mapped water quality vulnerability through a map detailing vulnerability to road salt in reference to areas of geologic vulnerability and proximity to major roads. Additionally, we evaluated public wells' vulnerability and ranked them in terms of their priority to protection. Through our ranking and mapping processes, we identified specific geographic areas of intense vulnerability to contamination, and five public wells we designated as high-priority for protection.

Applying this information, we drafted road salt recommendations aimed towards protecting high-vulnerability zones, suggesting “reduced salt areas”, road salt alternatives, and collaborative Hilltown/MassDOT workshops. Moreover, we drafted bylaw recommendations aimed towards protecting prioritized public wells with the aim of guiding efforts to prevent future contamination.

Introduction

The regionally specific effects of climate change in the Hilltowns are expected to have a diverse range of consequences directly linked to the ecosystem services currently being provided to the towns, including local groundwater resources. One observed trend that will have an effect on water quality and availability in the Hilltowns is the increase in rainfall intensity, which was predicted to increase further in the winter and spring in NOAA’s Fourth National Climate Assessment. In a high warming scenario, monthly precipitation in the Northeast is predicted to be about 1 inch greater from the months of December through April by the end of the century (NOAA, 2018). In the Hilltowns, the majority of household water comes from private wells, aside from two municipally-controlled community wells, which are the Cummington water system and the West Cummington water system.

A trend of increased annual rainfall could have adverse effects on groundwater resources, resulting in an increase in pollutants such as pesticides and herbicides, metalloids and trace metals, nutrients, endocrine disrupting chemicals (EDCs) and pharmaceuticals, and dioxins in water bodies (Kibria, 2014). Increased periods of alternate floods and droughts have also been found to be associated with groundwater contamination in Bangladesh (Kibria, 2014).

Groundwater contamination and other threats to water quality and availability are not addressed as potential hazards in any of the four towns’ Hazard Mitigation plans. Currently, two

of the towns - Worthington and Cummington - have Water Protection Districts in their zoning bylaws that regulate development on aquifer recharge zones. One study on the connection between climate change and groundwater points out that the most common governmental approach to groundwater management is “to neglect the data collection and analysis needed to support informed groundwater management until problems materialize”, which is a flawed approach because many groundwater resources are nonrenewable on human time scales (Green, 2016). We aim to develop proactive approaches to addressing low-probability, high-magnitude hydroclimatological events, and is recommended as an essential component of an integrated approach to groundwater resource management.

One additional issue that climate change is beginning to affect is groundwater storage levels. Groundwater is the primary source of drinking water for wells and although more research needs to be done, current research seems to indicate that fluctuating water tables have a negative effect on drinking water quality and accessibility. A 2016 study by David Boutt of the University of Massachusetts-Amherst states that “Groundwater and streamflow anomalies are strongly influenced by variations in climatic conditions, and both have their own degree of sensitivity attributed to watershed and hydrogeologic properties” (Boutt, 2016).

In the case of lowering water tables, such as in the case of a drought, well-owners face the possibility of their wells running dry, and a lack of water accessibility. Since 2000, the longest duration of drought (D1-D4) in Massachusetts lasted 48 weeks beginning on June 07, 2016 and ending on May 2, 2017 (National Integrated Drought Information System). When the water table runs low, shallow wells are at risk of their pump not reaching the water table and therefore not able to supply water to the homeowner. In this case, digging deeper wells can mitigate these problems, but can be an expensive endeavor. In the case of higher water tables,

such as in the case of extreme precipitation events and earlier snowmelt, well owners face the risk of contamination, and poor well quality. In this case, the water is more easily exposed to bacteria and can become contaminated when they come in contact with open environments such as in the case of flooding basements (Waller, 2016). This will increasingly become a problem in the wake of climate change. “Trends in aquifer storage when averaged over the 124 wells in the study region show an upward positive trend indicating that the water table has risen over the last 40 years” (Boutt, 2016). Overall, we are more likely to see a higher water table over the coming years but we must be prepared for any climatic disturbances that may occur.

Additionally, when wells are dug during periods of drought or flood, the well depth can be over or under-estimated and experience problems when the water table returns to normal levels. The instability of the climate that we are facing and is only getting worse will cause many problems with wells and decrease drinking water accessibility and quality.

One of the main contaminants in drinking water comes from road salts. This contaminant is unique because it is directly from human intervention whereas other contaminants can be naturally occurring. Road salts have high permeability in soil and are generally very corrosive (Holbrook, 2017). Road salts found in domestic wells can cause high sodium concentrations and/or high chloride concentrations. A study by Bob Newton of Smith College showed that bedrock, which is the main type of surficial geology in the Hilltowns, has a much higher vulnerability for road salt contamination (Newton, 2008). High sodium content is often found in wells near major roads or highways. This is because these roadways are more widely used, and therefore need more road salt to be safe to drive on.

Health Canada, the department responsible for public health in Canada, conducted a study assessing the effects of road salts on the area around the roads they’re used on. Within this

study, they constructed a numerical solute transport model to analyze the way that road salt travels through the ground around roads. The environment was modeled after an unconfined sand aquifer, and they found that after 100 days, a road salt solution of 10mg/L traveled about 40 meters. Although it is difficult to standardize a universal distance from the road due to aquifer properties, the gradient of the slope, and the groundwater flow, they concluded based on their model that wells, and especially shallow wells, within 20 meters of salted roads are at the greatest risk of contamination (Health Canada, 2001). In another study at the University of New Hampshire, road salts were detected up to 350 meters away from the roads in the snowpack, which suggests that the contaminant can travel farther above ground, with implications for both surface water and the potential for the contaminant to travel to areas where the surficial geology makes the groundwater below more vulnerable, even if the surficial geology at the site of deposition is less vulnerable (Lazarcik et al., 2017).

One way to decrease sodium contamination from road salts is to use road salt alternatives when looking to combat storms. One pioneer for snow and ice management we can look to learn from is the state of Colorado. They use alternatives such as salt brine before storms, and after storms they use Chloride when above 16 degrees Fahrenheit, Cold Temperature Magnesium Chloride mixed with corn by-product when below 16 degrees, and another type of magnesium chloride blend called Apex when above -4 degrees Fahrenheit (Colorado Department of Transportation). As new technologies emerge, we can only look forward to more environmentally friendly alternatives for road salt management practices. There are many variables that go into switching road snow and ice management practices including economic and environmental factors. Although the Hilltowns face some economic disadvantages being mostly upheld by tax revenues of a small population, we still believe it is important to start

looking into and implementing these alternatives in order to better protect our drinking water resources.

Methodology

Interviews

At the Municipal Vulnerability Preparedness kick off meeting in September, drinking water quality issues were mentioned. The meeting took place at the Goshen Town Hall where a sign was posted that people should not drink the water. This spurred our interest in researching drinking water quality and protections to contribute to the MVP workshops.

For the first step in our process, we wanted to know what Hilltown residents knew about their water quality and what contaminants they faced. We went about this by conducting interviews with various people who had experience with well contamination, town administration, planning, and government regulations. We prepared for these semi-structured interviews by compiling open ended questions tailored to each interviewee's knowledge base, experiences, or expertise. We took notes from our interviews by having one person type while the other group members asked the questions. We followed up via email if we had further clarifying questions that weren't asked in the original interview.

Our first interview was with Dave Christopolis of Hilltown CDC. Hilltown CDC is a non-profit that is based in Chesterfield. Dave had spoken to our class previously about his highly contaminated well - in our meeting, he detailed the contamination he had discovered in the CDC well, and told us that although he tried drilling a new well it was more contaminated than the first. From this interview we learned about water infrastructure, public water systems, septic,

zoning in the Hilltowns, and he gave us contacts of people that could potentially help us with our project.

Our next interview was with Susan Labrie, the town of administrator of Chesterfield. She was present at the kickoff meeting, and so she acted as a helpful resource for our questions surrounding the MVP program. Susan reiterated that most Hilltown residents own private wells, and because most individuals do not test their wells general contamination levels remain unknown. Susan showed us zoning maps of Chesterfield that they had in the town hall - these maps were from the early 2000s and showed a small water supply protection district which was for Northampton's water supply. We also learned from Susan that road salt was a major contaminant. It was briefly mentioned that MassDOT was notorious for oversalting the roads at the kick off meeting and ignoring "reduced salt area" signs.

Patty Gambarini of the Pioneer Valley Planning Commission was our next interview. She provided extensive expertise surrounding water planning to our project that we were lacking at that stage. In our meeting, she told us about groundwater wells, different research studies on the water table, Title 5 and septic systems, Mass GIS and Mass Oliver, snow and ice management on roads, and warned us about pointing to specific properties in our analysis. She provided us with a study on the Barnes aquifer and their road salt contamination. We discussed at length how road salt could contaminate wells through the bedrock geology and she recommended we reach out to Bob Newton, a Smith College Geology Professors, who had done research on geology and drinking water in southern New Hampshire.

Before our scheduled interview with Bob we had a phone call with Catherine Skiba from Massachusetts Department of Environmental Protection (MassDEP). Catherine was able to inform us about the regulations of public wells and the different types of public wells. She

explained that Zone Ones, the immediate area around a wellhead, are regulated by MassDEP, but the owner has to protect the area to the best of their ability. She also explained that the Interim Wellhead Protection Area (IWPA) did not take into account the surficial geology, only the number of gallons that are pumped out of the well.

Bob Newton was instrumental in helping us direct our project toward LIDAR mapping, a way to measure the thickness of glacial till. He outlined many big contaminants that could be affecting the Hilltowns. The main contaminant was road salt, which he referred to as a public safety issue. He mentioned that Westfield had used a road salt alternative after finding high sodium contamination levels - the town has used MgCl for three to five years, but had recently stopped. Although we had been steered towards looking at septic contamination in our previous meetings, Bob did not see this as a pressing issue. Instead, he recommended that we look into the surficial geology of the Hilltown area as a tactic to understand and predict road salt contamination.

Catherine Skiba put us in contact with Catherine Sarafinas, another MassDEP employee who specializes in drinking water supply planning. Catherine Sarafinas directed us toward the idea of recommending townwide general bylaws, telling us that “in communities with private wells the best approach to groundwater project is a combination of Board of Health regulations and general bylaws that limit hazardous waste generation, impervious surface runoff and require best management practices to prevent the accidental release of contaminants”. This suggestion moved us away from zoning, and towards centering bylaw recommendations in our final project.

From all of these interviews we gathered anecdotal information, previous research, government reports and regulations, and general guidance that charted the course of our research. Our project took many paths as we learned more about various contaminants. After our original

focus on septic was deemed to be “not the biggest issue”, we dove into road salt application as it is a contaminant that humans distribute, and therefore control.

Vulnerability Map

LIDAR

In order to assess the geologic vulnerability of specific sites to groundwater contamination, we constructed a map of the geologic composition of the Hilltowns. To create this map, we used the National Ocean Service’s LIDAR (Light Detection and Ranging) data. LIDAR is a “remote sensing method” using “light in the form of a pulsed laser to measure ranges to the Earth” - this data is useful because it demonstrates, among other things, the thickness of bedrock and till in any given landscape (US Department of Commerce, n.d.). Using ArcMAP, a desktop version of ESRI’s ArcGIS program, we overlaid the relevant LIDAR data onto an outline map of the four Hilltowns.

After we had this basic map demonstrating geologic composition of the Hilltowns, we wanted to specifically highlight the areas with exposed bedrock as areas of high geologic vulnerability. On this map, “rougher” textures - I.E., areas where lines from the LIDAR program were closer together - represented areas with more exposed bedrock, and thus a minimal if existent layer of glacial till. This absence of glacial till indicates increased groundwater vulnerability to contaminants: glacial till acts to “control in varying degree the availability of groundwater” through slowing “the infiltration of precipitation to underlying aquifers” (Norris, n.d.). The reduced permeability of glacial till acts to limit the entrance of contaminants into groundwater sources - thus, the presence of exposed bedrock acts to indicate increased vulnerability to contamination.

Once we had our basic LIDAR map overlaid onto the Hilltown outline, we added a layer showing public wells in the area. This map is Figure 1. After this, we wanted to create a map specifically quantifying areas of high geologic vulnerability due to exposed bedrock. To identify these vulnerable areas, we began by creating polygons encompassing areas that we identified as "rough" based on a shared visual rubric. Once we created these polygons, we rasterized the layer and coded it for vulnerability, with "1" indicating the vulnerable bedrock polygons. This map is Figure 2.2.

Roads

The second part of the vulnerability ranking process entailed modelling the impact of the different wells' proximity to roads, and how heavily salted those roads are. To accomplish this, we reviewed existing literature to find an indicator of the average distance from a salted road that the contaminant will travel, and found the Canada Health study mentioned in the introduction, in which a model was created to estimate this distance. The model found that the area within 20 meters of roads presents the most risk of contamination to groundwater wells, but also found that contaminants could travel up to 40 meters from the original point of salting over the course of 100 days.

From our interviews with community members and town officials, and from reviewing the Massachusetts Department of Transportation (MassDOT) salting procedures, we gathered that roads under the jurisdiction of the state agency are the most heavily salted in the region. Because of this, we attributed the larger value of 40 meters to these roads, and the more conservative estimate of 20 meters to the roads under the jurisdiction of the towns or the State/Federal forest service departments.

Next, we attained the publicly available Massachusetts roads jurisdiction ArcGIS layer. We constructed buffers around MassDOT roads of 40 meters on each side, and around the towns' roads of 20 meters on each side. We coded the area within the buffer of the town roads with the value of "1", representing medium levels of vulnerability, and the area within the buffer of MassDOT roads with the value of "2", representing high levels of vulnerability. The rest of the area, along with any roads not recognized by the towns, were coded with the value of "0". This proximity to roads map is Figure 2.2.

Combining the maps

Finally, we combined the LIDAR map indicating geologic vulnerability and the road map indicating proximity to road salt by importing the rasterized road map onto the existing LIDAR layer. Our end product was our Water Quality Vulnerability Map, which is figure 2.3. This map highlights areas of low (green), moderate low (yellow), moderate high (orange), and high (red) vulnerability to road salt contamination based on the location's proximity to roads, road jurisdiction, and the surrounding geologic landscape. Areas within a road buffer and on top of exposed bedrock are highlighted in red, demonstrating the highest-vulnerability area.

Well Priority Rankings

The data that was available to us in terms of water quality was data pertaining to public wells, which MassDEP requires regular testing of.

In order to model the effects of the potential for future contamination of wells due to climate change, we wanted to create a framework to identify wells that should preemptively be prioritized and protected. To accomplish this, we created a ranking system for each of the public wells based on 4 criteria, outlined in figure 4.1.

The first criterion is the type of well, as categorized by the MassDEP. Every public well is categorized by MassDEP as either a transient, non-community well, a Municipal Water System, a non-transient, non-community well, or a Groundwater well.

A transient, non-community well is a well that does not serve the same group of people every day, and that is not a shared (community) well; this category pertains to wells in places like restaurants and campgrounds that serve different people and have less than 15 service connections. We gave these wells a priority ranking of "0" because they do not serve fixed populations and are not serving multiple connections, making the potential impact of contamination smaller than for other wells.

The second type of well is a municipal water system, which is a public, municipally owned water system that is regulated by MassDEP, with a pre-established "Zone II" protection area that restricts activity in the area according to "the most severe pumping and recharge conditions that can be realistically anticipated" (Massachusetts Department of Environmental Protection, 310 CMR 22). We ranked these wells with the value of "1" because there are already detailed restrictions on what activities can be done near them, so they are not a priority in the same way that other public wells are, but they are still important wells that provide water to various, often fixed, populations.

The last two categories of wells, the non-transient, community wells and groundwater wells, were given the highest priority ranking of "2". Non-transient, non-community wells are wells that serve the same population consistently, and that have less than 15 service connections, while Groundwater wells (which are essentially non-transient, community wells) serve the same population consistently and have 15 or more service connections. We ranked these as the highest

priority because they serve fixed populations, so the potential impact of contamination is higher than other wells, as the same people are consistently drinking the water from these wells.

The second criterion we developed was a binary “0” or “1” ranking in which wells in towns with municipal water systems were given the value of “0” and those in towns without municipal water systems were given the value of “1”. The logic behind this criteria is that municipally controlled water systems give local governments control over the well and could serve as a potential source of water in the case of an emergency in which a private well is contaminated. In towns without a municipally controlled water system, this potential is not present, which means that other public wells should be prioritized more as potential sources of water in an emergency.

The third criterion relates to the size of the Interim Wellhead Protection Area (IWPA) around the well. IWPAs are designated areas around public wells which are identified as the most important to protect to prevent well contamination; MassDEP creates these based on a calculation of the amount of water being pumped out of the well. These IWPAs have no legal implications, as MassDEP cannot control land use within the towns, and serve as references only for well owners and municipalities. We included IWPA size as a criterion because it represents the amount of water being pumped out of a well, which is indicative of the amount of people using the water, and created an equation to calculate the rank of each well based on the area of the IWPA, with x=the size of the IWPA in square feet:

$$[?][?](x) = x0.001$$

Lastly, we ranked each well according to the local surficial geology using the Lidar map we generated, which is indicative of the amount of glacial till present (Figure 1). The smoother the area, the more till is present, and the rougher the area, the more exposed bedrock is present.

Contaminants can seep through bedrock and into groundwater much faster than through till, so the wells in rougher areas of the map, where there is less till, are more at risk to contamination. We ranked each well as smooth, medium smooth, medium rough, or rough, giving each the respective values of 0, 0.5, 1, and 1.5.

After ranking each public well according to these criteria and adding up each value to calculate the final, overall ranking, we generated a map showing these rankings (Figure 4.2). This map shows the higher ranked wells in a deeper red, and the lower ranked wells in lighter red or white, and allowed us to identify the wells that should be prioritized to protect in the context of climate change.

Results

Vulnerable Areas

Figure 1 shows the base LIDAR map with public wells overlayed. The color of the map relates to elevation of the area. The “rough” areas are where there is exposed bedrock and the “smooth” areas are where there is more glacial till.

Figure 2.1 maps the roads in the Hilltowns with added 40 meter buffers, highlighted in red, along MassDot roads and 20 meter buffers, highlighted in orange, along roads with town jurisdiction. Chesterfield is largely comprised of roads that are owned by the town. Whereas Goshen and Cummington have Route 9 and 112 running through it, a major MassDOT road.

Using the LIDAR map in Figure 1, we created Figure 2.2, which is a polygon layer that represents the areas of exposed bedrock, “rough”, as red and areas of glacial till, “smooth”, as white. We combined Figure 2.2 and Figure 2.1 to created Figure 2.3, the final vulnerability map.

From the final combined vulnerability map we identified multiple high vulnerability areas. In Figure 2.3 the red areas are the high vulnerability areas. These are along Route 9 and 112 in Goshen and Cummington and the southern part of Route 112 in Worthington. These areas are highly vulnerable because they are situated on exposed bedrock with little to no glacial till and they are within 40 meters of a road with state jurisdiction, meaning they are vulnerable to road salt contamination.

Moderately high vulnerable areas are located along the major state roads, Route 9, 112, and 143 as well as some roads with town jurisdiction. These are areas near the roads but not on exposed bedrock.

Moderate low vulnerability areas are those that are primarily exposed bedrock without a major road running near it. Low vulnerability areas are characterized by thicker glacial till and no exposed bedrock.

Figure 3 maps the public wells in the Hilltowns along with wells that have been contaminated by Iron and Sodium within the past five years. Iron is a naturally occurring contaminant but sodium is not.

Figure 4 combines the Figure 3 and Figure 2.3 to create a map that showcases vulnerable areas and current contamination. Two contaminated wells are situated on areas that we designated as high vulnerability.

Rankings

Through our ranking system identified in the methodology section, we discovered five public wells to prioritize. The New Hingham Elementary School, Hilltown CDC, Davenport building, Wildwood condominiums, and the Worthington Fire District are the five wells with the

highest ranking based on the gallons of water pumped, if there is a municipally controlled system in the town, who they serve and for how many days, and surficial geology. Figure 5.1 outlines the ranking criteria. Figure 5.2 visualizes the ranking system developed in Figure 5.1. The gradient of light to dark red displays the priority of the well with the darker red being the highest priority.

Table and figures

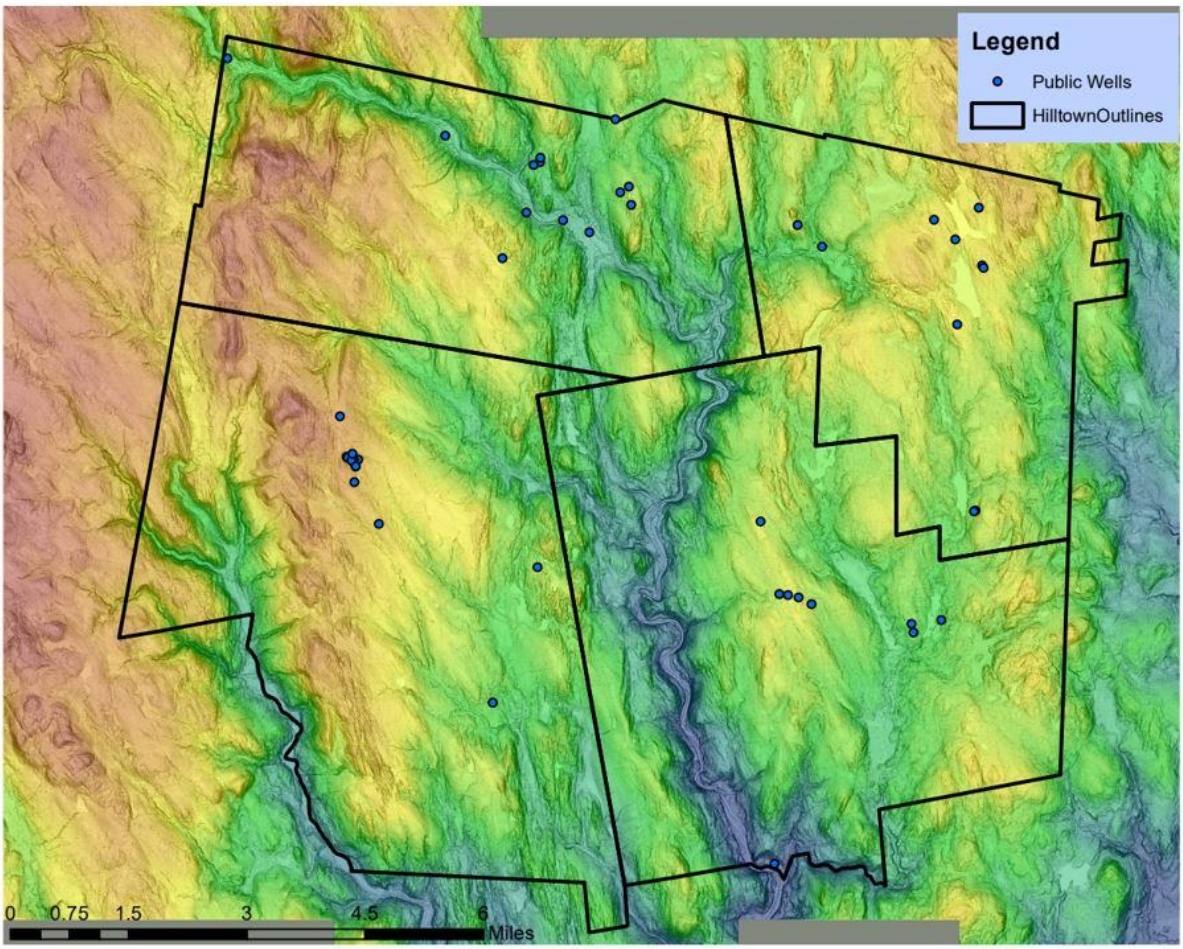


Figure 1: Lidar map of surficial geology. Colors represent elevation. High frequency, i.e. "roughness" of lines represents exposed bedrock, low frequency of lines, i.e. "smoothness" represents thicker till.

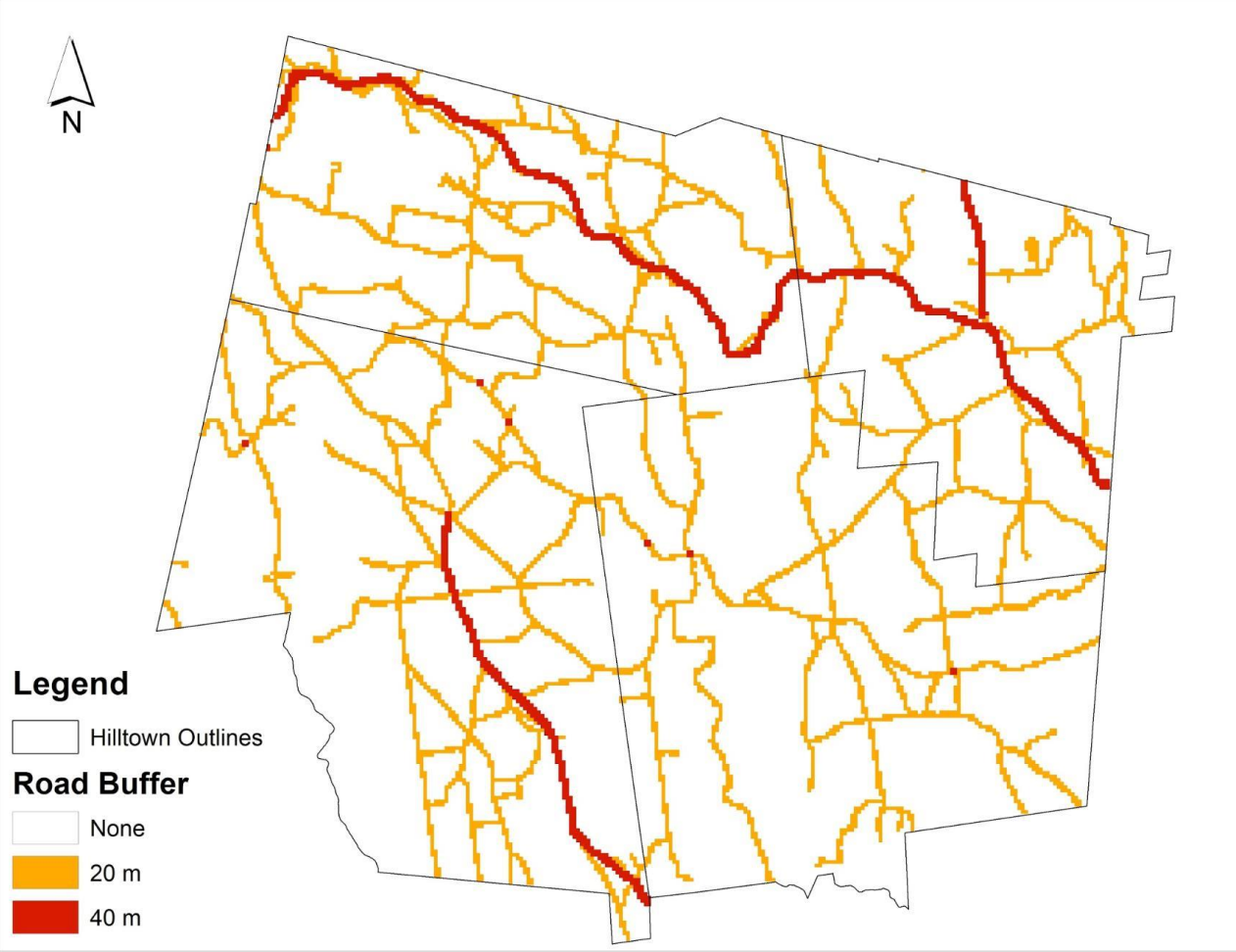


Figure 2.1: Road Buffer map. Red represents MassDOT roads, with a buffer of 40m. Orange represents all other officially recognized roads, with a buffer of 20m.

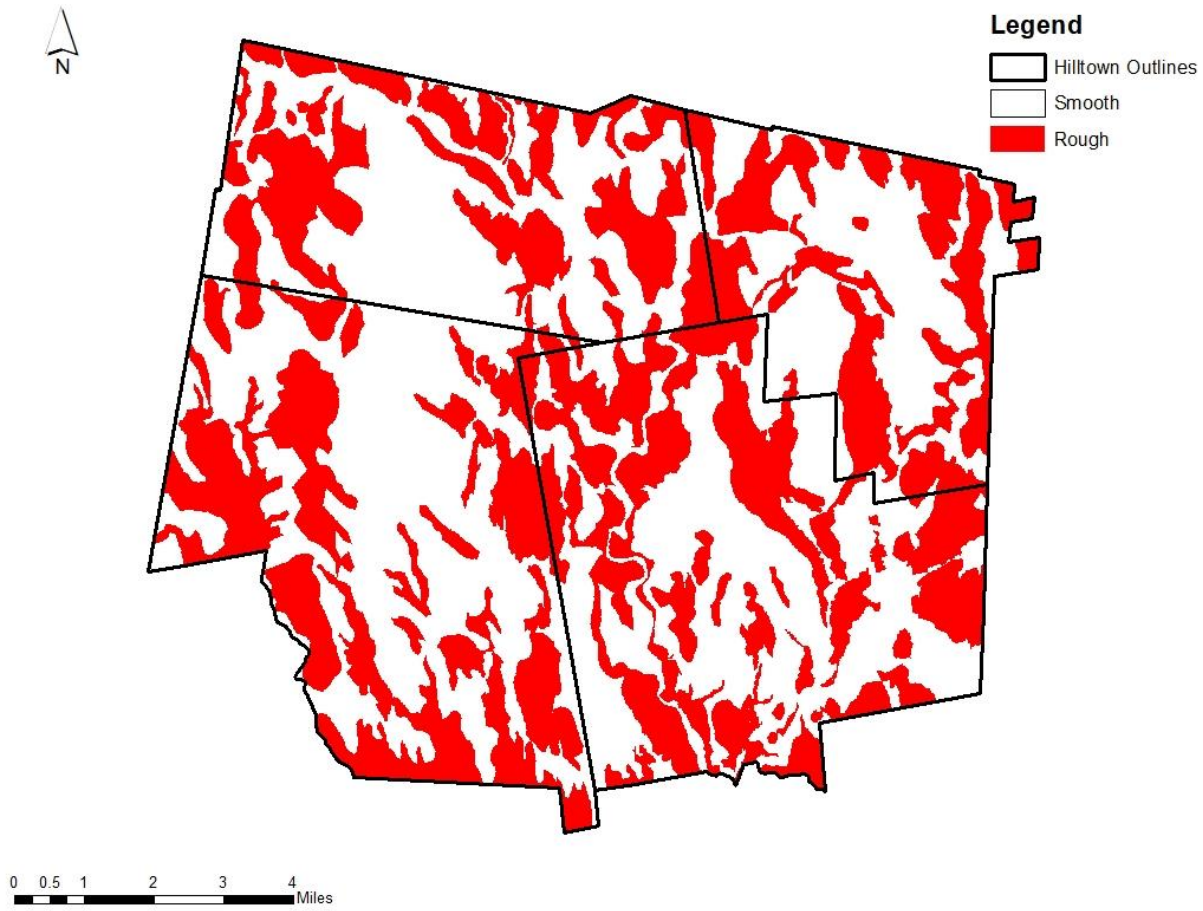


Figure 2.2: Surficial Geology map. Red represents areas of more exposed bedrock, white represents areas of less exposed bedrock.

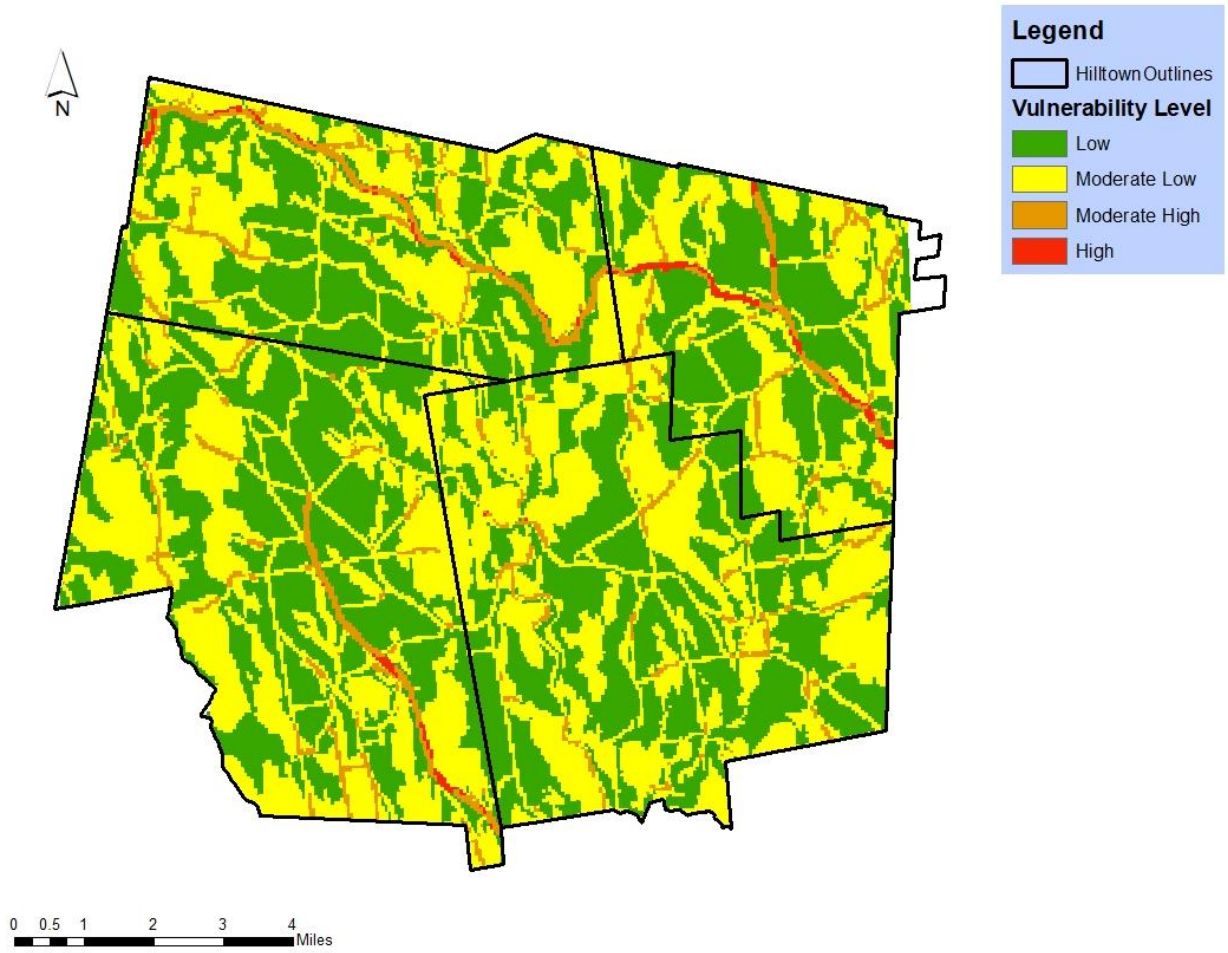


Figure 2.3: Vulnerability map. Combination of Figures 2.1 and 2.2, green represents least vulnerable areas to groundwater contamination, yellow is moderate-low vulnerability, orange is moderate-high vulnerability, red is high vulnerability.

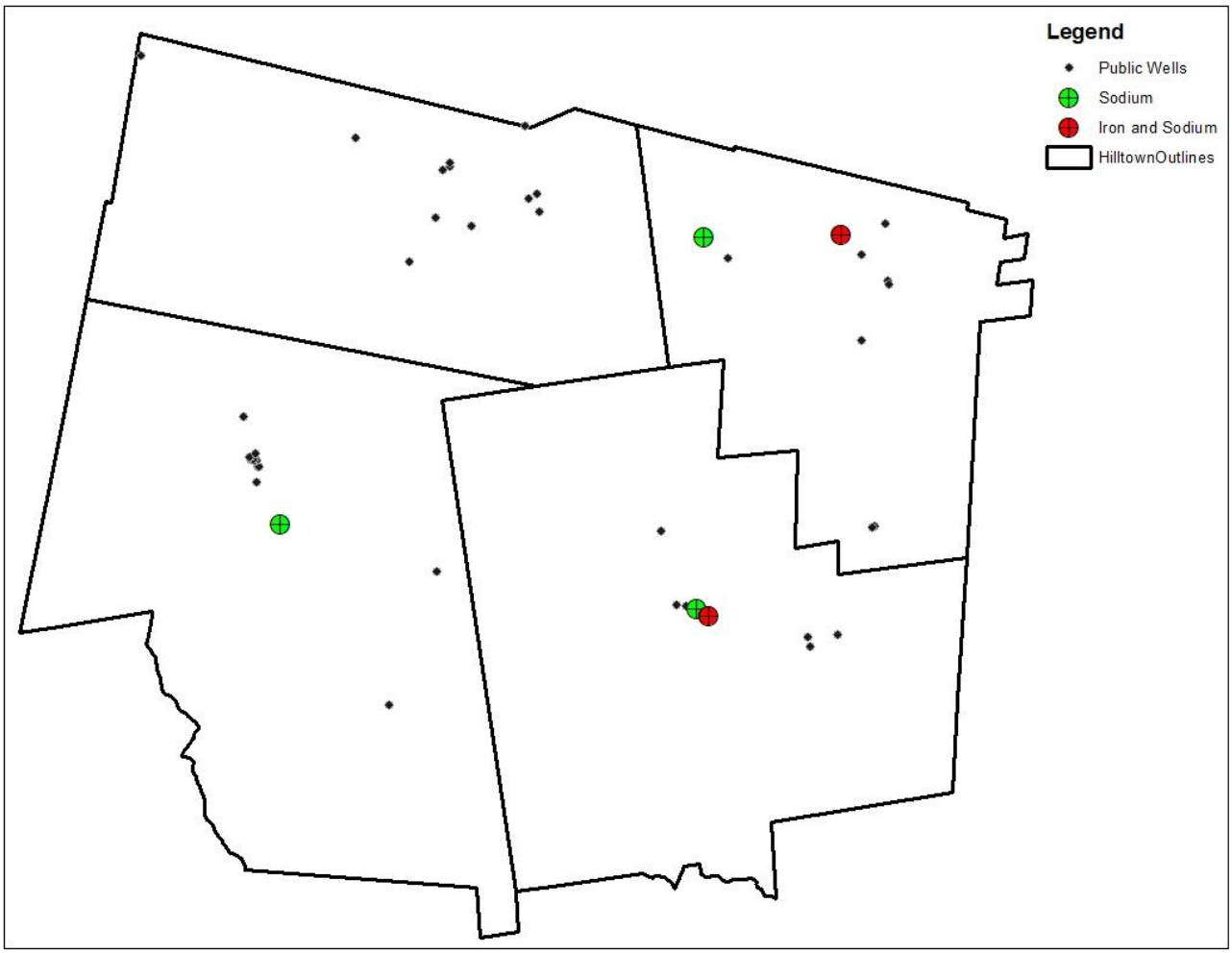


Figure 3: Public Well Contamination map. Public wells that have been contaminated at least once by iron or sodium in the past five years.

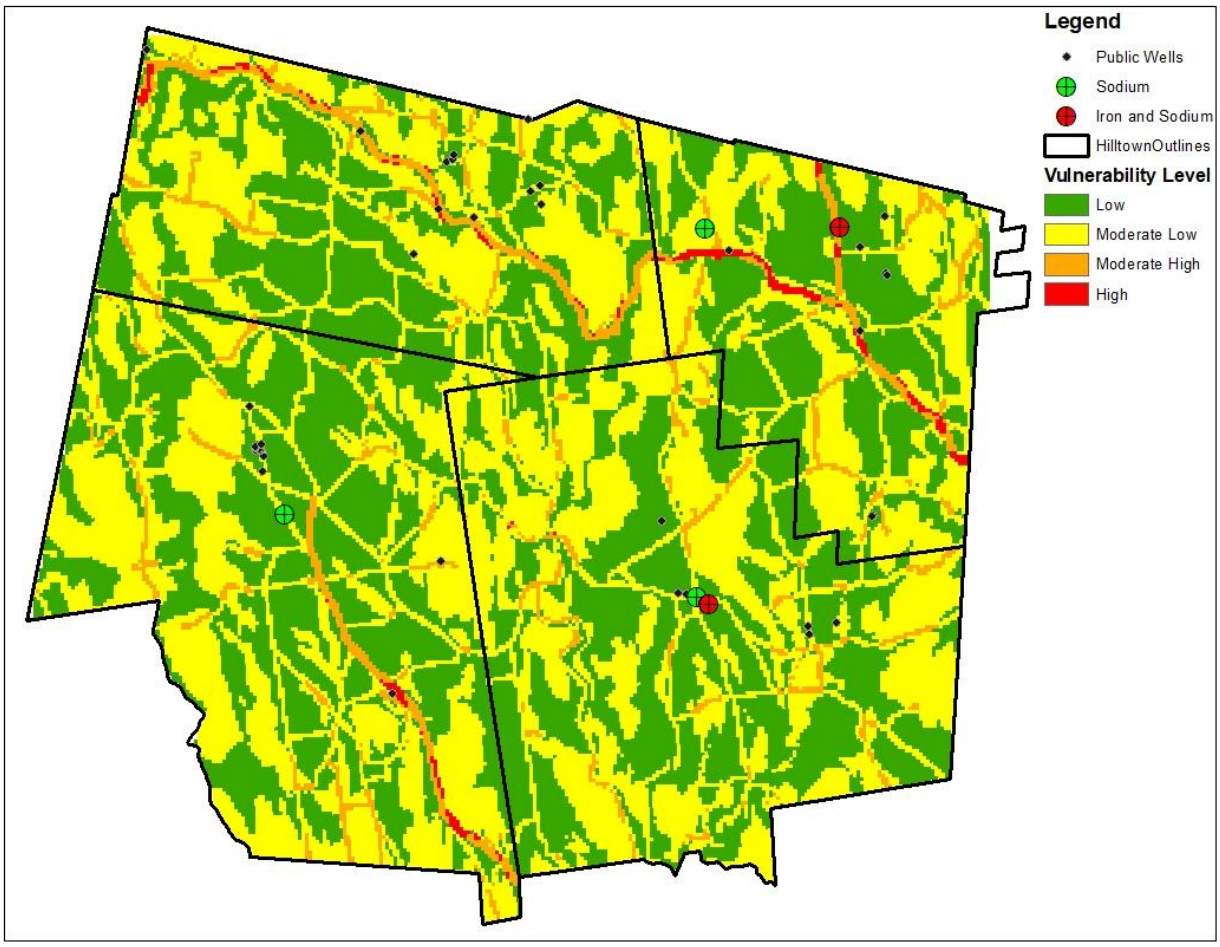


Figure 4: Public Well and Vulnerability Map. Combination of Figures 2.3 and 3, shows public wells that have been contaminated and their relationship with our vulnerability model.

Figure 5.1: Ranking Criteria table. Each public well was ranked according to these criteria to create priority rankings.

Criteria	Types	Ranking
Type of well	1. Transient, non community (Restaurants/campgrounds)	0
	2. Municipal Water Systems	1
	3. Non-transient, non-community (schools), Non-transient, community (GW)	2
Is there a municipal water system?	Yes	0
	No	1
IWPA size	Size of IWPA	$f(x)$= x0.001 x=size of IWPA in ft
Surficial geology	1. Smooth	0
	2. Medium smooth	0.5
	3. Medium rough	1
	4. Rough	1.5

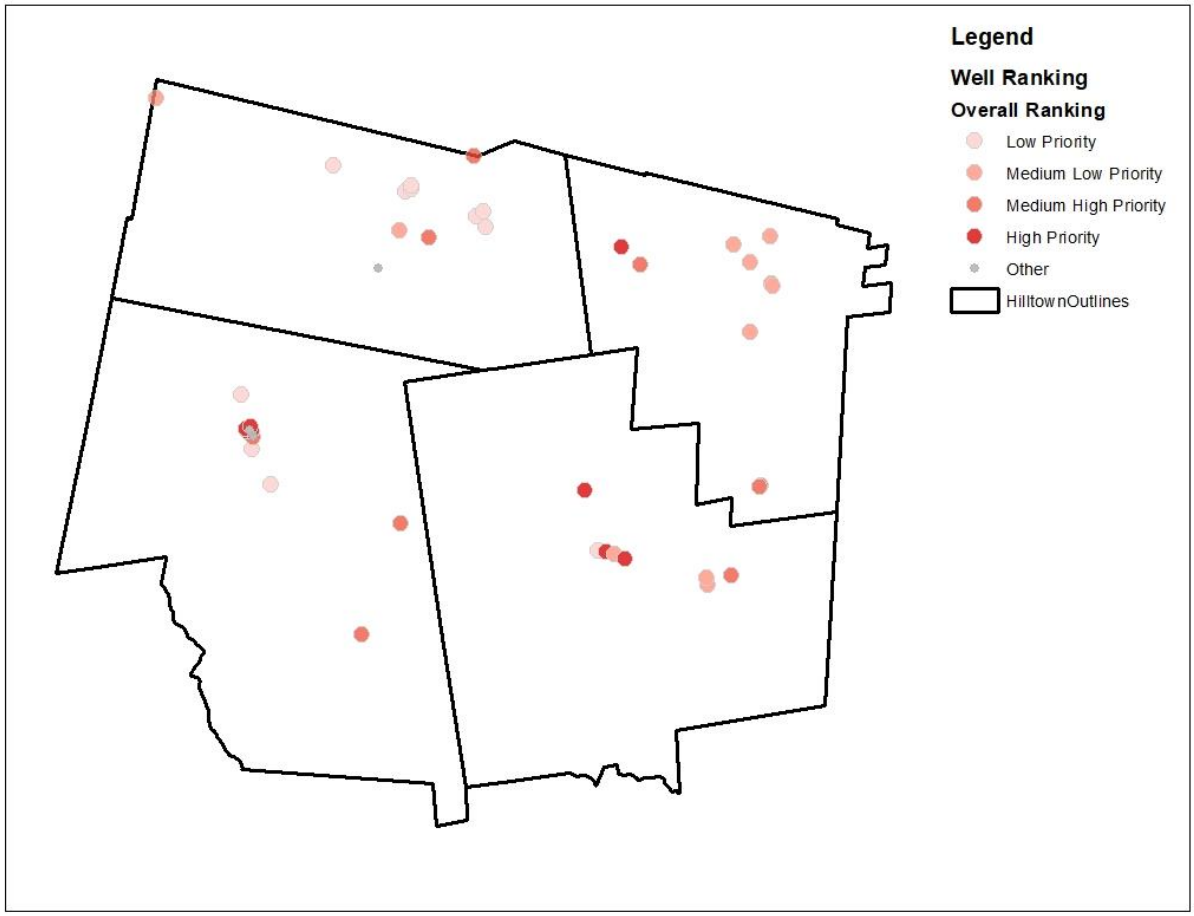


Figure 5.2: Well Priority Ranking Map. The result of the ranking process in Figure 5.1; the darker red color represents wells of higher priority, and lighter red represents lower priority.

Discussion

Road Salt Recommendations

After doing some research and talking to Hilltown community members, we generated recommendations for possible actions to take against road salt contamination. These actions include creating “reduced salt areas”, the towns taking over jurisdiction of the roads in vulnerable areas, and workshopping with MassDOT, as well as looking into road salt alternatives. There are advantages and disadvantages within all of these possible actions. The advantages of creating reduced salt areas would be having signs to warn the public and plows to use less salt in these areas. The disadvantages to this is that often these signs go unfollowed by MassDOT and over-salting still occurs even with these precautions. The advantages of the towns taking over jurisdiction of the roads is that they can control exactly how much salt is used on their roads, and subsequent road salt contamination in those areas. The disadvantages of the towns taking jurisdiction is that it would be very costly to increase their supply of salt and plows. Advantages of workshopping with MassDOT would be to provide open communication between them and the towns so they can convey the importance of using less salt and the impacts on their drinking water and environment.

Some road salt alternatives we looked into include Magic-0 and Salt Brine. These were discussed in a study by Westfield State University, and Magic-0 has been effective in other states such as Colorado. Magic-0 is a magnesium chloride blend that is a byproduct of the distilling process. It is non-toxic and biodegradable. It is to be applied to roads before storms or onto rock salt and continues to melt ice below -35 degrees F. The only disadvantage to this new option is that computer controlled liquid spreaders will have to be installed in trucks in order to get an

even coat of the liquid, which may be an expensive upgrade, but will be worth it to better protect against sodium contamination in drinking water from road salt.

The second more environmentally friendly de-icer we looked into was salt brine. This mixture is half salt and half water and is applied before storms. Salt brine also works at lower temperatures than rock salt alone. It is less likely to pollute local water resources because it stays on the ground where it is applied, whereas rock salt is prone to bouncing off the road and into water resources. When these road salt alternatives are used as a pre-application to rock salt, less overall salt is applied and it is more effective at lower temperatures than salt alone. The result is road salting practices that are better for the environment, work at lower temperatures, and are less harmful to drinking water.

Bylaw Recommendations

To protect the five prioritized public wells we recommend institution Drinking Water Protection Bylaws as town wide general bylaws (MassDEP, 2011). Drinking Water Protection bylaws would impose similar limitations to Water Supply Protection Districts but they would be specific to the vulnerable wells and the areas surrounding them. The purpose of these bylaws is to promote the health, safety, and welfare of the community by ensuring access to safe, clean drinking water. It is important to protect drinking water at these locations, especially New Hingham Elementary School which serves a vulnerable population, children, and acts as an emergency shelter in extreme weather events.

In these bylaws we recommend that the following activities be restricted or limited:

- landfills and open dumps
- automobile graveyards and juknyards

- disposal or stockpiling of de-icers, chemically treated snow and ice
- storage of petroleum, fuel, oil, and heating oil stations
- storage of non-sanitary wastewater
- facilities that relate to hazardous waste
- removal of soil, loam, sand, gravel, or other mineral substances
- storage of sludge and septic waste
- storage of animal manure
- storage of commercial fertilizers.

These activities are potential contaminants to groundwater drinking supplies and should be limited to avoid polluting the groundwater aquifer. The operator of the wellhead should also procure the land in the zone I of the wellhead in order to better limit the dangerous activities. Implementing these bylaws would be instrumental in improving the Hilltown's drinking water supply to climate change and the rising water table.

Conclusion

We identified three main roadways along which we identified a higher risk of road salt contamination by modelling based on two factors: surficial geology and road jurisdiction. These roads are Route 143 in Chesterfield, Route 9/112 in Goshen, and Route 112 in Worthington, and are represented in red in our vulnerability map (Figure 2.3). These roads are under the jurisdiction of MassDOT. We learned from our interviews with community members of the Hilltowns that MassDOT often oversalts roads, even when proper signage for low salt areas are in place. Current MassDOT ice and snow management practices recommend an application of rock salt at 240 lb/Ln/mile, and we found up to 86.4 mg/L of sodium within wells in the

Hilltowns - more than 4 times the EPA's contamination limit guideline of 20 mg/L. Road salt contamination is important because of the various health effects of ingesting too much sodium, ranging from high blood pressure to an increased risk of heart disease, stroke, and congestive heart failure.

We also recommend implementing Drinking Water Protection Bylaws that would limit hazardous activities in areas that are potentially susceptible to contamination and around wells that are important to protect. Towns could adopt these bylaws as townwide general bylaws that would be site specific to the prioritized and vulnerable wells at New Hingham Elementary School, Hilltown CDC, Davenport building, Wildwood Condominiums, and the Worthington Fire District.

Important research to be conducted in the future would relate to the water table in the Hilltowns: currently there is a lack of data on the water table in the area; a rising water table could pose serious risks to drinking water quality, and it is essential to preemptively identify this hazard. There is available data on well depth to bedrock provided by the MassDEP, but centralized data collection and presentation regarding the state of the water table in various areas and how deep the wells are would support towns like the Hilltowns looking to draft more informed bylaws and road salt suggestions. Future projects could also look at how other factors besides climate change will impact water quality. We received feedback from our interviews that septic contamination could be common. In an ideal situation, all well owners would be able to test their wells regularly and there would be publicly accessible data available to determine the exact threats the Hilltowns will face.

Our final deliverables for this project to use for reference in the MVP planning process are our vulnerability map, well rankings map, suggestions relating to road salt, and town wide

general bylaw recommendations. We hope that these would support community members and town officials in the planning stages of the MVP process to decide how to develop an integrated regional drinking water plan, which could be funded by an MVP action grant. Safe and clean drinking water is a fundamental component of a healthy community, and we hope that this report will contribute to the Hilltowns' ongoing effort to protect resident health, safety and wellness.

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Climate Migration: A Changing Landscape in the Northern Hilltowns?

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Executive Summary

Climate change has already impacted patterns of human migration globally, as people are pushed out of their homes due to natural disasters, extreme weather, and other climate change related stressors. This climate migration is also happening in the U.S., and may affect the Northern Hilltowns in Massachusetts, which includes the towns of Worthington, Cummington, Chesterfield, and Goshen. In order to best prepare these municipalities in the event of population change, we aim to explore the question of how climate migration will affect the towns. To examine this question, rather than attempting to predict complex patterns of human migration, we considered two scenarios: population increase and population decrease. For each scenario, we gathered evidence supporting each case, as well as the opportunities, constraints, and vulnerabilities of each.

The Northern Hilltowns have an aging population and often experience out-migration of their younger population, supporting the scenario of population decline. This sentiment was reflected in interviews we conducted with Northern Hilltown residents. Population decrease would burden the volunteer-based social services, strain the majority tax-based town revenues, and impact the sustainability of businesses and schools in the towns. However, the combination of flooding and extreme weather patterns in low-lying areas of western Massachusetts with sea-level rise, flooding, and the urban heat island effect in urban areas of eastern Massachusetts may stimulate migration to less climate change impacted areas like the Northern Hilltowns, causing population growth. Population increase would burden volunteer-based social services, strain the few remaining schools which are at capacity, and increase traffic and required maintenance of dirt roads. Population growth is currently constrained by restrictive zoning bylaws in the towns,

but also is an opportunity for economic development and sustainability in maintaining town infrastructure.

As we found evidence for both scenarios -- population growth and population decline -- our objective was to compile a set of recommendations that are applicable to both population change scenarios. We recommend increased community outreach and discussion concerning the schools in the region, regional strategic planning and regionalization of volunteer based services like storm management, as well as the consideration of relaxing zoning bylaws to allow for more affordable housing and development. Additionally, we have supplied a list of grant opportunities relevant for both individuals and businesses in the towns. By preparing for climate migration now, the Northern Hilltowns can put themselves in a more informed position to promote sustainable development, infrastructural soundness, and climate resilience in the event of population change.

Introduction

In the coming years, climate change will render some currently populous areas uninhabitable, thus affecting human migration patterns; climate migration will be necessary for many peoples' survival (DePaul, 2012). Climate migration refers to the movement or migration of people from their homes due to climate change-related pressures (Rigaud et al, 2018). These pressures include more immediate dangers, such as hurricanes and other natural disasters, or extreme weather such as flooding and drought. Other pressures to consider are more gradual, such as decreased land fertility and crop productivity, loss of property due to sea-level rise, or increased urban heat island effect due to rising temperatures. Climate migration has been noted to be one of the greatest impacts of climate change. Recent estimates put the number of climate

migrants at 200 million by 2050, but these estimates are admittedly uncertain as future migration patterns are highly unpredictable and complex (Brown, 2008).

Climate refugees and migrants may come from other countries and regions where climate change has created nearly unlivable conditions, but may also come from within the US where climate change is either catastrophic or simply a nuisance (Milman, 2018). Cities including Buffalo, New York, Duluth, Minnesota, and Cincinnati, Ohio are currently preparing for climate migration and setting themselves up to be havens for these migrants (Malo, 2019). These cities are in some ways less vulnerable to climate change as they are cooler and away from coastlines. Furthermore, urban centers tend to be more established in terms of social services and infrastructure, and generally have more willingness to grow and develop. Still, as the flow of human migration pushes more and more people into urban areas, cities struggle with the pressure of increased population, stressed infrastructure, outdated policy, and other effects such as exacerbated urban heat island effect (Murrell & Sasko, 2019).

New England's rural communities are not exempt from the effects of climate change and climate migration. Climate scientists predict that New England will experience more extreme weather patterns including more frequent and heavier rainstorms, more droughts, sea-level rise on the coastlines, et cetera (Dupigny-Giroux, 2018). All four seasons will be exaggerated, causing extreme snow, drought, and rain, as well as increased flooding events and heat waves. Sugar maples, a main economy and cultural touchstone in the Northern Hilltowns, will also experience decreased productivity due to these climate-induced seasonal changes. These impacts may also trigger communities in coastal and lower elevation regions to migrate inland or to higher elevation areas, either permanently or seasonally (Dupigny-Giroux, 2018). While climate migration may have negative impacts on communities such as conflict, gentrification, and

cultural tension, there may also be opportunities if migration is properly prepared for (Black, 2011).

The Fourth Assessment for the Northeast Region predicts flows in and out of urban regions like Boston, especially as it is vulnerable to sea-level rise, and highlights the necessity for planning for inland climate migration in New England (Dupigny-Giroux, 2018). Additionally, valleys in the Northeast, including the Pioneer Valley, are often populous hubs of agriculture. Climate variability will increase extreme precipitation patterns in these areas, making valleys at risk for flooding (Dupigny-Giroux, 2018). In the Pioneer Valley where agriculture is ubiquitous, extreme flooding would pose a risk to this staple of the economy. Current infrastructure, especially in rural areas like Western Massachusetts, may not be prepared to adapt and respond to these hazards. With the complex patterns of population flow both in and out of cities, there is an increased need to boost resilience, establish emergency preparedness, and organize sustainable urban planning and development (Black, 2011).

The Northern Hilltowns, all sitting at above 1,000 feet elevation, could potentially experience an influx of these climate migrants, which will change the physical and socioeconomic landscape of the towns. However, these towns are sparsely populated and may not be willing or prepared to grow, socially and/or economically. Furthermore, in the case of population increase, it is useful to assess where this development might happen as well as pinpoint infrastructural vulnerabilities in each municipality that could be stressed due to climate migration.

As the Northern Hilltowns collaborate on the Municipality Vulnerability Program (MVP) workshop and action grant process with the support of the Pioneer Valley Planning Committee (PVPC), it is time to think about both more immediate climate change impacts (such as storm

management, emergency preparedness, et cetera) and future, more long-term impacts like climate migration.

In our project, we collect, compile, and visualize data to inform adaptation strategies for potential climate migration into the Northern Hilltowns. Climate migration is the subject of cutting edge planning research and discourse (Milman, 2018) and is vital to consider, especially when preparing a grant proposal like the MVP program. We analyze various impacts of climate migration on the towns to help inform future action plans for conscientious and sustainable development, infrastructural soundness, and climate resilience in the event of climate migration.

Methodology

The issue of climate migration is complex, abstract, and will mostly materialize in the upcoming decades. With this in mind, our challenge was to approach the issue of climate migration from a practical lens, with the goal of providing concrete recommendations and next steps for the stakeholders of the Northern Hilltowns participating in the MVP program. While research is being conducted to predict human migration patterns related to climate change over the next 50-100 years, this research is often global or national, and is in its early stages of development. Therefore, to approach the issue, we decided rather than attempt to predict what climate migration will occur locally, instead to explore each possible scenario: the scenario where climate migration causes an increase in population, and where climate migration causes a decrease in population of the Northern Hilltowns.

To delve into each of these scenarios, we gathered evidence in support of either occurring, as well as the potential impacts, constraints, and opportunities of both. From there, we considered next steps which would be applicable in the case of *either* scenario, to best prepare

the Northern Hilltowns for both population growth and decline. The assemblage of information and maps that we created will aid in ameliorating the potentially dramatic impact of climate in-migration in the Northern Hilltowns and prepare residents with the information they need to plan a sustainable community in the context of growing populations and changing climates. Planning ahead for this introduction of new residents will give the Northern Hilltowns the opportunity to avoid excess strain on the social services and infrastructure of the community. This study may also serve as a model for other rural New England communities preparing for potential climate migration in the coming decades.

In order to understand the current state of the towns, we collected data about them. This includes census and age data, town revenue sources, and median home value. We also mapped food retailers, public schools, and zoning regions in the towns. Additionally, we analyzed the zoning bylaws to better understand the potential for growth and development in the Northern Hilltowns, with respect to both businesses and commerce as well as residential areas. This data gave us a sense of the current strains and potential vulnerabilities in the towns given a population growth or a population decline.

Of course, the best source to assess current sentiments on population change and willingness to grow in the towns is the community. After identifying and reaching out to key stakeholders in the MVP process, we interviewed nine residents and government officials of the towns. In these interviews, we discussed current sentiments on climate change, concerns and hopes for future population change and development in the towns, and concerns regarding infrastructure and services in these municipalities. Our interview template is attached in the appendix (see page 32).

We compiled these data and used them to develop a two-pronged scenario approach in order to explore potential population change in the Northern Hilltowns, which we describe in further detail in the following section. From these two different scenarios, we developed a set of recommendations that are applicable in both cases to help prepare the Northern Hilltowns for the future in the context of climate change and climate migration.

Results

Population Decrease Scenario

The evidence that the population of the Northern Hilltowns is decreasing stems from the status quo of its population demographics. Currently, the populations of these towns are aging, as is displayed in the population pyramids on pages 23-24. The bulk of the population is above forty-five years old, which translates to fewer people who are able to contribute to the volunteer services and town government that these municipalities rely on. Additionally, an aging populace translates to a decrease in the amount of townspeople, which could place stress on local businesses as they struggle with lack of a customer base.

As is demonstrated in the pie charts located on pages 25-26, most of the towns' income comes directly from taxes. This highlights the town's dependence on the tax base; in the event of a population decrease where the tax revenue falls, the town becomes vulnerable to losing most of its income.

The map on page 27 displays the two schools that are in these four towns: New Hingham Regional Elementary and RH Cromwell Elementary. A decrease in the population and tax base would strain the schools, as they consume most of the towns' budgets for both Chesterfield and Worthington. Since the towns have so few children, many students come from other districts to

fill seats in the classroom and help fund these expensive schools. In Cummington, Berkshire Trail Elementary School was closed after the 2014-2015 academic year due to insufficient funds. (Demers, 2014) Both Chesterfield and Worthington's schools could potentially face similar challenges in the event of a significant population decrease.

The aforementioned map on page 27 also highlights that these four towns are food deserts. There are few options to procure food in any of these municipalities; note that even the towns that have the most options, Worthington and Chesterfield, still only have four each. Interview respondents noted that it's already difficult for businesses to stay open due to the sparsely populated nature of these towns. In the event of a population decline, there would be an even smaller patronage to support these businesses.

These four towns pride themselves on their rural character. They acknowledge — and even take pride in — the fact that these towns are not always the most convenient places to inhabit. There is currently a project underway to install broadband in these four municipalities, although interview respondents bemoaned how long this process has taken and how distant they are from attaining broadband. The inconvenience of living in a rural rather than metropolitan area could discourage future settlement, but as will be explored in the next section, this dissuasion probably wouldn't be sufficient to overcome the more attractive features of the hilltowns.

Population Increase Scenario

Climate-related pressures to relocate are affecting residents of Massachusetts both to the east and west of the Northern Hilltowns. The probability of climate-induced urban flooding in Massachusetts is likely to increase in the coming years; sea levels are currently rising by approximately one inch every eight years (Massachusetts' Sea Level Has Risen 8" Since 1950).

The FEMA flood maps on pages 29 show that Boston and its surrounding suburbs are a high risk coastal area for flooding. Closer to the Northern Hilltowns, the FEMA flood map on page 28 shows that there are populous areas in the Pioneer Valley that are vulnerable to flooding. As floods and sea levels encroach on both of these high population areas, residents will be forced to relocate.

Pressure to relocate will only be exacerbated by the urban heat island effect, wherein reduced vegetation, large amounts of heat-retaining urban materials, urban geometry, and anthropogenic heat contribute to significantly higher temperatures within city centers (U.S. EPA, 2008). As can be seen on the map on page 31, FEMA buyouts due to flooding have occurred on both sides of the state of Massachusetts. The Northern Hilltowns are situated in an area that could be attractive to climate migrants from both the Berkshire mountains, Pioneer Valley, and Boston.

These four municipalities all rely on volunteers to maintain their town governments. Crucial municipal institutions such as the fire departments and police stations both depend on volunteers. In the event of a population increase, there would be more people to occupy these positions, but there would also be a strain on these services due to an increased need for them.

As is shown on page 27, these hilltowns are food deserts. If there is an uptick in population, this situation will be exacerbated due to the lack of food availability. While there would be an opportunity for increased town commerce, the businesses would have to rise to this occasion, which might place undue strain on them.

The two schools in these towns, located in Worthington and Chesterfield, both have limited capacity, which would be problematic in the event of a population increase. If these schools were to reach capacity, it would be necessary to reject students from outside districts that

currently attend these schools. In the event that they reach capacity, it is possible that children from within these districts would not be able to attend the schools that their parents pay taxes for. If this were to happen, these students would have to be sent to a school outside of their district, which the town would then be responsible to pay for.

The main infrastructural concern in this scenario is the stress that increased traffic would pose on dirt roads. Interview respondents mentioned that dirt roads are prevalent throughout their towns and are already under stress due to the increased frequency and intensity of storms (a direct result of climate change). If more people arrive in the hilltowns, this increased traffic would strain the dirt roads, thus burdening local highway departments.

All of these towns have inexpensive housing as compared to the state median; Chesterfield's median home value is 33% lower than the state median at $237,500, and Goshen's median at $276,600 is 22% lower than the state median. (Town of Chesterfield, Town of Goshen) Worthington and Cummington both fall within this range, demonstrating that all four towns are relatively inexpensive in terms of home value. This is a huge incentive to move to the hilltowns; if not for a primary residence, then for a summer home. Not only are the hilltowns scenic, replete in natural resources, and charming — they also boast relatively cheap housing, allowing for them to be accessible to a wide range of potential climate migrants.

As was mentioned in the previous section, there is an ongoing effort to bring broadband to all four of the Northern Hilltowns. Some interview respondents expressed hope that this could attract people who work from home and thus open the hilltowns to a younger population that wouldn't need to commute elsewhere. In any case, the concern that many hilltown residents have expressed due to their lack of internet will be soon be allayed, and this exciting new development has the potential to attract a variety of newcomers to the area.

Examining the zoning bylaws informed this project about how prepared these municipalities are to grow. In all four towns, zoning discourages growth through low-density residential development and stringent restrictions on two-family homes and apartment dwellings. Interviews with elected officials revealed that the bylaws are no longer desirable for many residents, with one respondent dubbing them "snob zoning."

The rural character of these towns has a cultural relevance that is revealed in the bylaws. For example, Cummington explicitly mentions that "[t]he purpose of these regulations...is to preserve the rural character of the Town of Cummington and to protect the town's natural resources, especially the prime water supplies." (Town of Cummington Bylaws) The presence or absence of a district zoned for the town center is also indicative of the town's attitude towards businesses. Towns with a district allotted for the town center demonstrate the importance of a commercial district that is not centered around agriculture.

There are constraints in the status quo that result from the zoning bylaws, both for housing and commerce. The ban on multi-family homes and apartments in Worthington would prove problematic in the event of a population increase, and would be a barrier for low-income climate migrants. At present, Cummington is the only town of these four that allows for two-family dwellings without a special permit. Two-family homes encourage denser development than single family units and oftentimes are the more inexpensive option. The discouragement of their establishment in the current bylaws has the potential to dissuade some climate migrants from settling in the Northern Hilltowns, but would not halt this influx altogether.

The bylaws' stringence towards businesses might also need revision in the event of an uptick in population, so as to have sufficient commerce to accommodate a larger population. Goshen, for example, requires a special permit in order to run a business from home, with the

exception of agriculture, horticulture, floriculture, or viticulture. Other concerns include the lack of a downtown district that facilitates dense development in both Worthington and Goshen. Such a district would also allow for a greater diversity of businesses than is currently permitted, thus stimulating the local economy and bolstering the town budget via tax revenue. Additionally, these towns are generally zoned at a two-acre density, which does not accommodate for dense development. In the event of a population increase, this could lead to inefficient sprawl in the towns if the bylaws remain unrevised.

Discussion

Evidence shows the potential for climate migration to have a profound impact on the Northern Hilltowns within the coming years. Current trends in economic and census data indicate the possibility for a population decrease in the Northern Hilltowns, while climate pressures from high population metropolitan areas and the unique attractive qualities of the Northern Hilltowns could encourage and facilitate population increase. In either case, we recommend preparation for a significant change in population in the coming years.

Climate change and resultant migration patterns will have a significant effect on the Northern Hilltown communities, as is corroborated by a substantial and growing body of research. The Fourth Assessment for the Northeast region is a relatively representative example of the causes for climate migration and the impacts that it might have on the Northern Hilltowns. Our area of study will not be immune to climate pressures such as flooding and increasingly extreme weather events, which could increase the possibility of seasonal and permanent migration to the area. Additionally, one study lists the potential for community disruption, such as conflict, gentrification, and cultural tension, with population change (Black, 2011). Evidence

of this as it applies to the Northern Hilltowns is unmistakable; some interviewees expressed a strong desire to grow while others expressed distinct disinterest.

The study of climate migration is a relatively new field. As such, when we entered the project we were largely responsible for creating our own parameters for study. Much of the literature is not based in the US, much less in New England or rural Massachusetts. In recognizing the uniqueness and singularity of the Northern Hilltowns, we aimed to make this project as specific to them as possible to facilitate an easier application to the MVP grant. While the conceptual notions and research of the literature informed our framework, the iterative process was what created our methodology. To this end, it is difficult to identify any results that were unexpected. However, some of the most surprising findings from our study were the wide range of opinions recorded amongst Northern Hilltown residents regarding population increase.

Due to time and resources being finite, this study has some limitations. A great deal of our conclusions and research were dependent on interviews with Hilltown residents; unfortunately, time constraints limited us to contacting only a few residents from each municipality (in total, we conducted interviews with nine people). Further interviews with a broader cross section of each Northern Hilltown community would have given us a more complete view of population change sentiments in the area. Additionally, each Northern Hilltown community is its own separate entity. While our recommendations address the possibility of population increase or decrease, they are meant to span all four towns. Perhaps given more research, further recommendations could be developed that are tailored specifically to each community.

As climate migration spans decades, further research is necessary to explore this issue. Rural western Massachusetts is situated near two large coastal metropolitan areas (Boston and

New York); further research could easily be conducted to study the implications of climate migration from each of these two areas into western Massachusetts.

The implications of this study are far reaching, as the community structures of the Northern Hilltowns are likely to be impacted by population change in the coming years. With deliberate planning, the Northern Hilltowns have the opportunity to directly confront climate migration and population change, while maintaining the well-loved aspects of their communities.

Recommendations

In order to preventatively address the impacts of climate migration on the Northern Hilltowns, we have prepared a set of recommendations that apply in either population change scenario. The following items are the most salient concerns for addressing this flux, although future research could prove this list inexhaustive.

Schools

In the event of population increase *or* decrease, there will be inevitable pressure on school systems in the Northern Hilltowns. Diminishing populations would require bussing in and funding children from other districts to stay afloat, while increasing populations would stress facilities that are already almost at capacity. To that end, we encourage an ongoing regional discussion regarding the local schools. Community dialogue and outreach across communities are vital to ensure the continued success of these schools.

Regional Cooperation

In a broader context beyond schools, regional cooperation between the Northern Hilltowns will allow for more resilient communities in the face of climate migration. These

communities have already begun the process by collaborating together on the Municipal Vulnerability Preparedness program. We recommend continuing this process in the years to come. Additionally, establishing a regional strategic plan and bilateral town infrastructure will aid in preparing for future population change. Regional storm management, road maintenance, infrastructural services, and volunteer services and expertise can be regionalized in order to create a more efficient system. Cummington has already begun this process in their strategic plan; this would serve as a useful template for future collaboration.

Zoning Bylaws

The current zoning bylaws discourage dense settlement, which would be problematic in the likely event of a population increase. In lieu of specific recommendations for zoning (we do not inhabit these towns and thus cannot learn all of its intricacies in the space of a semester), our suggestions are as follows:

1. **Critically examine current zoning bylaws and ensure they align with each town's willingness to grow and develop.** Interview respondents expressed dissatisfaction with the current bylaws, which might be a widespread sentiment. If so, we recommend that zoning is revised to accommodate for future population growth. Some concrete ways of achieving this include allowing for two-family homes and apartments in all four towns without special permitting, and allowing for a wider variety of businesses in town centers.
2. **Ensure that all four towns have easily accessible zoning maps.** Our group was unable to locate a zoning map for Goshen, despite the bylaws being available online. This made mapping more difficult and also left us with unanswered

questions, such as if there are any overlay districts in the town (i.e. watersheds, wetlands, etcetera).

3. **Consider allowing for more affordable housing.** The town of Worthington, for example, does not allow for apartments. Interview respondents informed us that there are still apartments being built in Worthington as illegal dwellings, which has been the source of some tension and even lawsuits. Special permits are required for two-family dwellings in every town except for Cummington, discouraging dense settlement. In the event of a population increase, there could be a housing shortage for low-income residents if the bylaws remain unrevised.

Grants

One interview respondent requested that we compile grants that might be useful for the hilltowns' economies. To this aim, we have synthesized in the appendix grants and microloans that could stimulate business. These grants would encourage economic growth and development as well as ensuring the towns remain sustainable and liveable in the face of an aging population. Conversely, these grants would also help burgeoning businesses establish themselves in the hilltowns, aiding a larger economy in the event of a population increase. The list of grants can be found on page 33 of the appendix.

Conclusion

Climate migration is a global, national, and local problem, and is the current topic of rigorous study within the climate science realm. In the Northern Hilltowns, while there is evidence for both population decline and population growth, climate migration will most likely spur an increase in population. Nonetheless, in either scenario, the towns are currently vulnerable

to population flux. By discussing and preparing for population change and climate migration now, the Northern Hilltowns can prepare for sustainability and growth moving forward. Strengthening dialogue about schools, grants, regional strategy, and zoning bylaws as delineated in our recommendations will prepare the towns for the future and maintain a sustainable and cohesive community.

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Figures

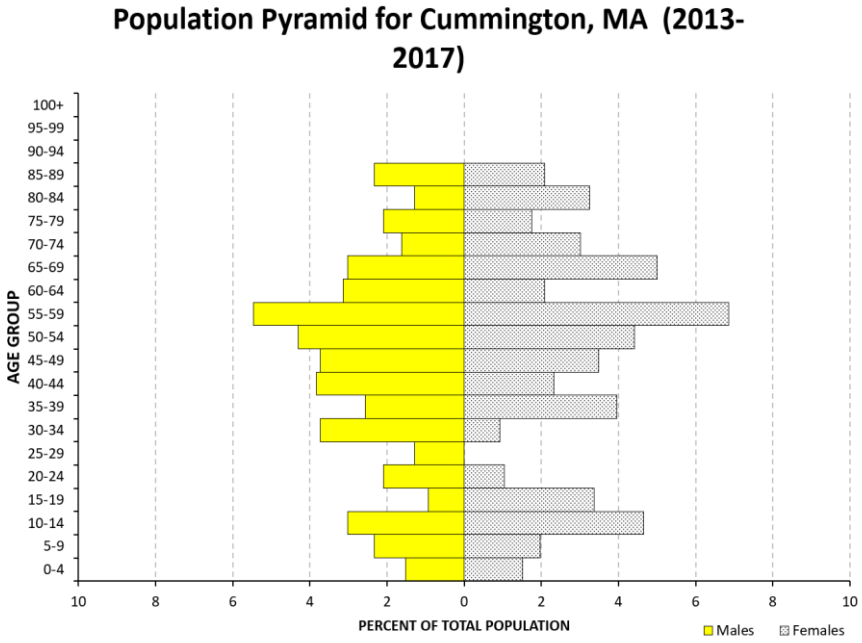
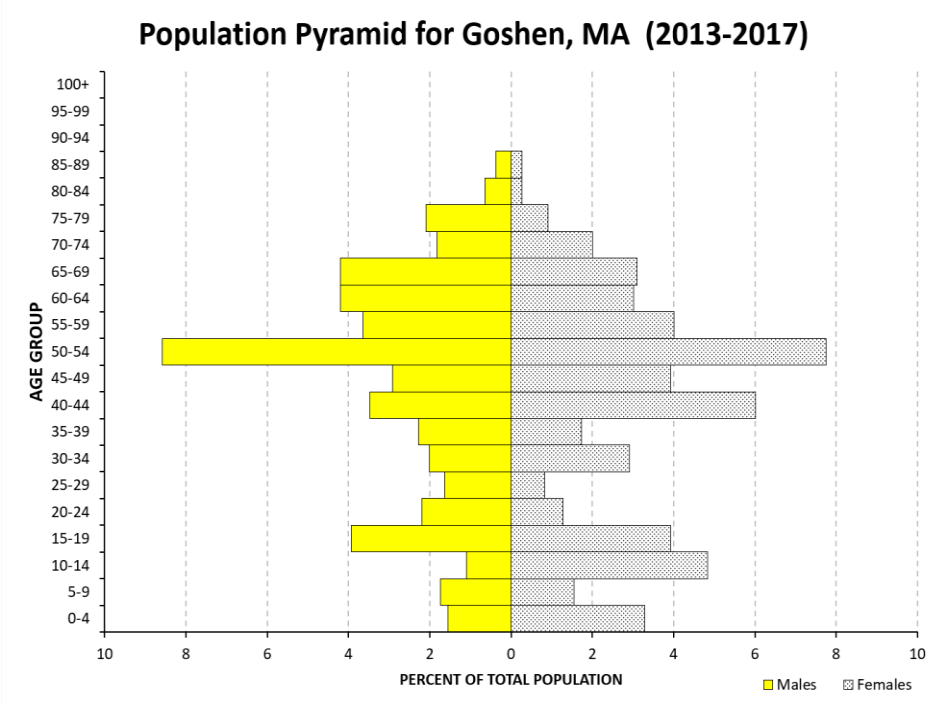


Figure 1 This figure illustrates the 2013-2017 population distribution by sex



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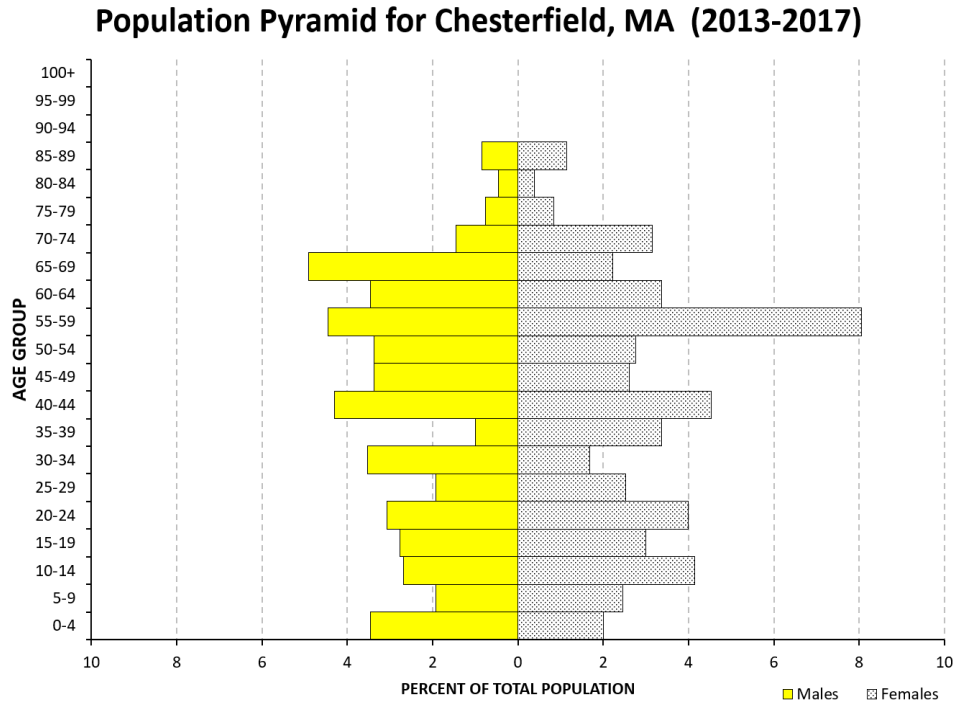


Figure 3 This figure illustrates the 2013-2017 population distribution by sex within age

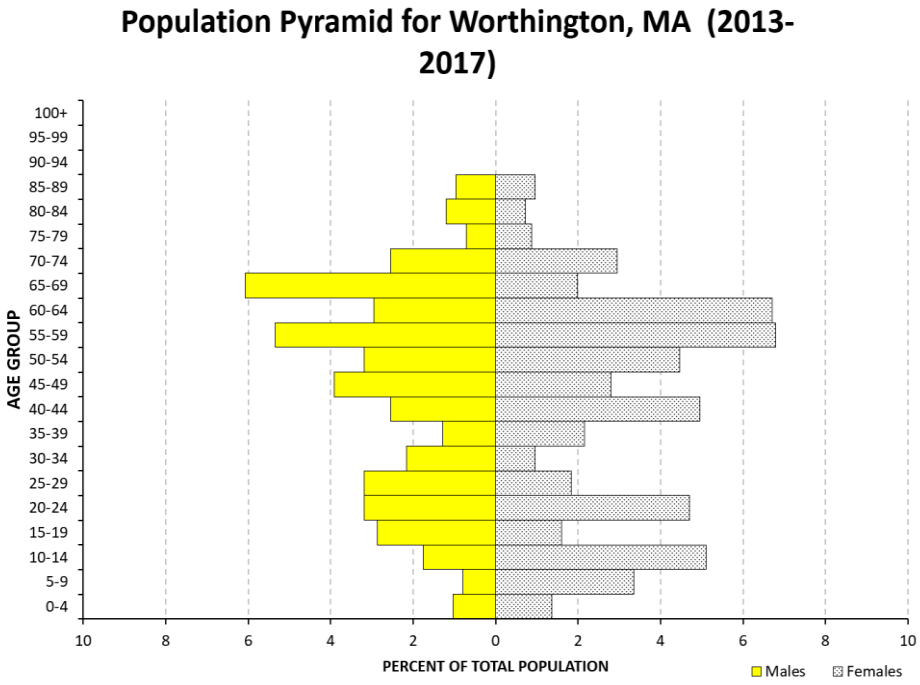


Figure 4 This figure illustrates the 2013-2017 population distribution by sex within

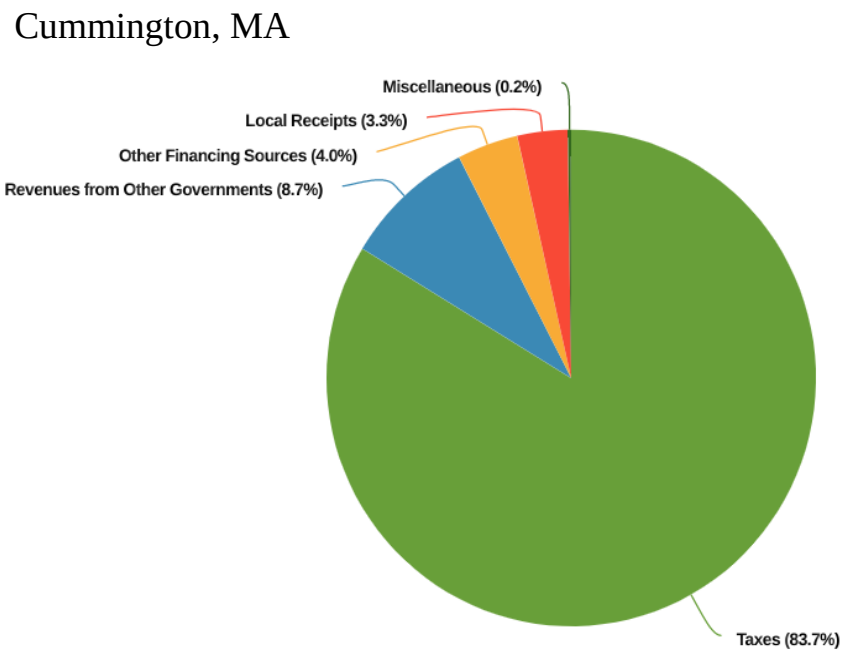


Figure 5 Total revenue for the town of Cummington, MA in 2018. Image from

Goshen, MA

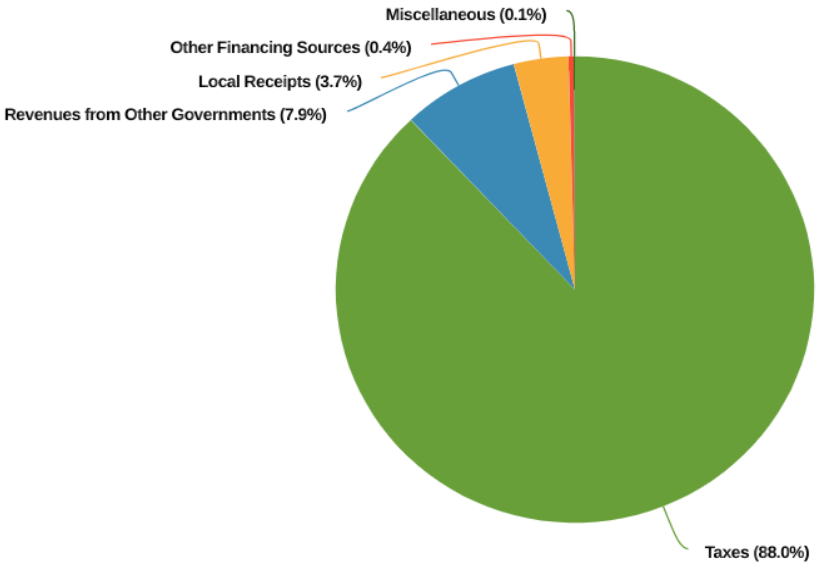


Figure 6 Total revenue for the town of Goshen, MA in 2018. Image from

Chesterfield, MA

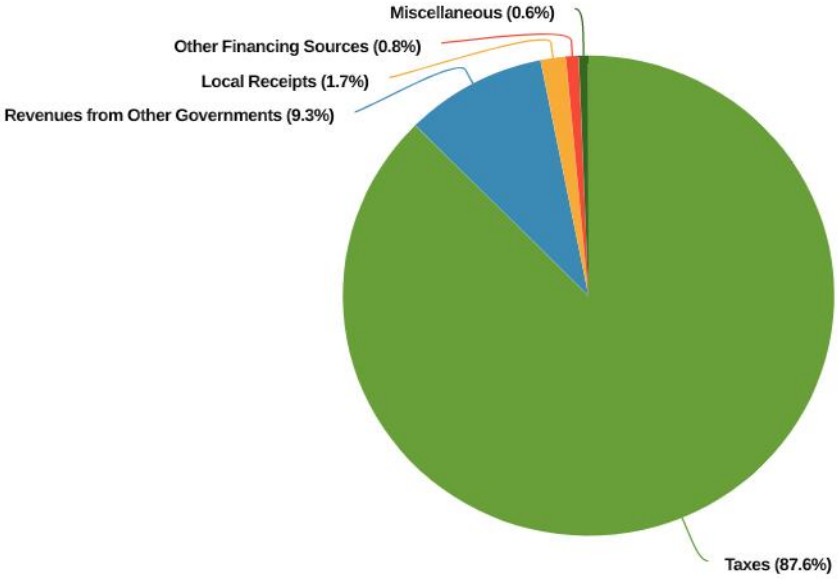


Figure 7 Total revenue for the town of Chesterfield, MA in 2018. Image

Worthington, MA

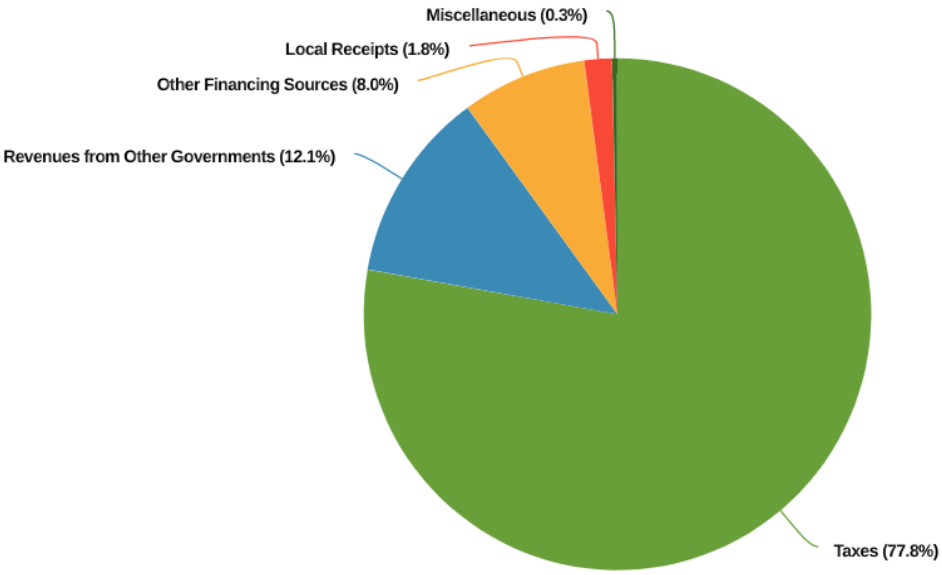


Figure 8 Total revenue for the town of Worthington, MA in 2018. Image from

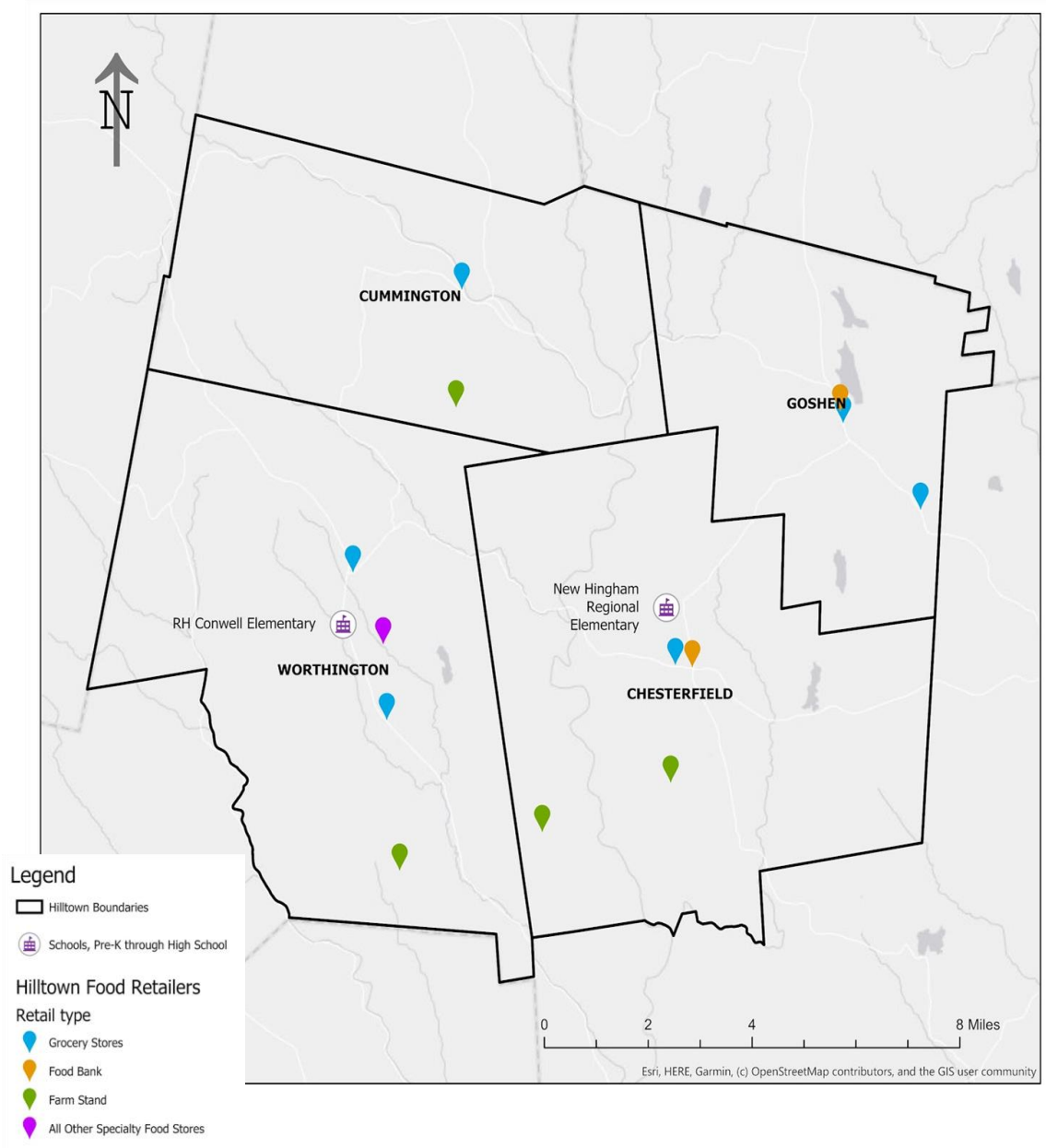
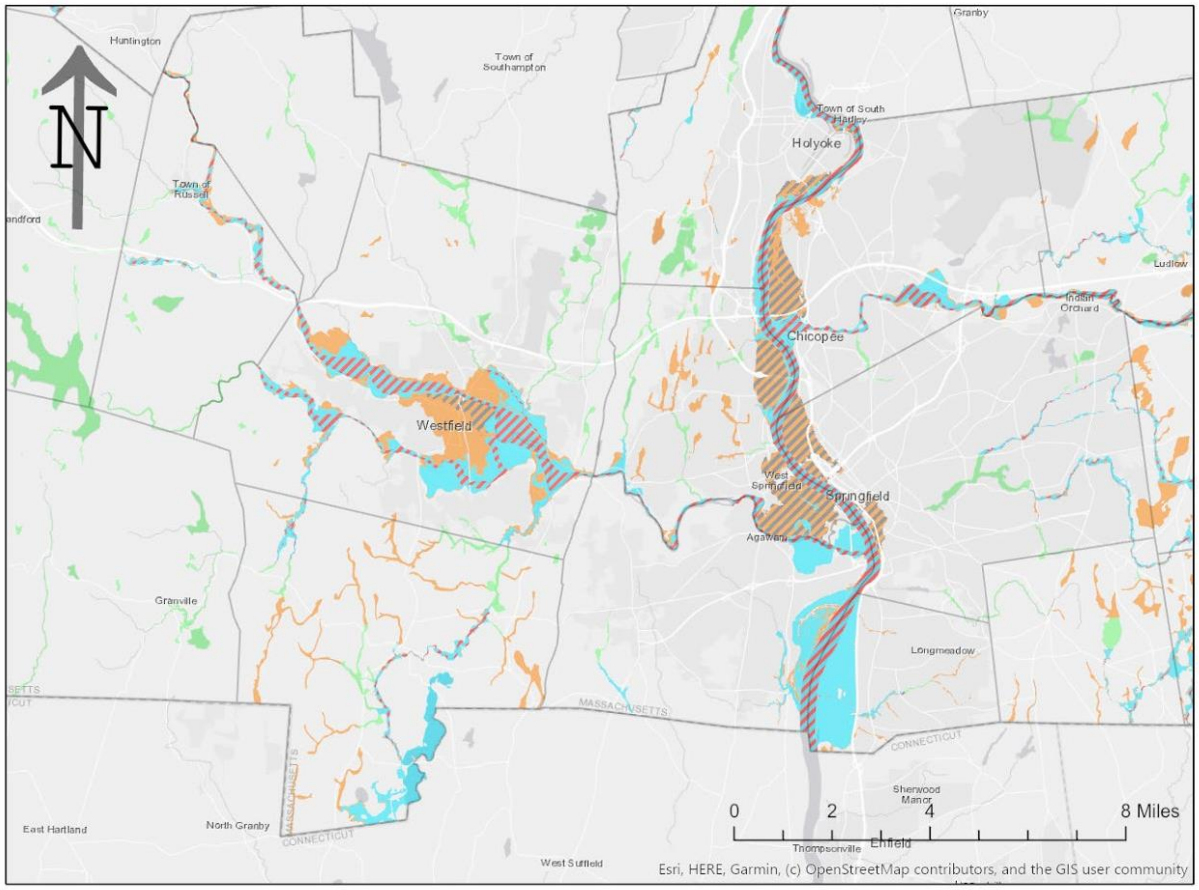


Figure 9 A map depicting grade schools and food retailers within the boundaries of Cummington, Goshen, Worthington, and Chesterfield, MA. Data for hilltown boundaries and schools from MassGIS. Data for hilltown



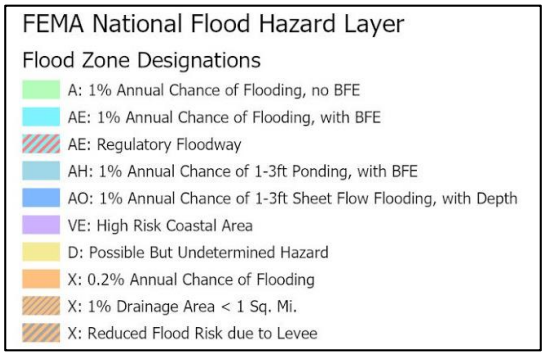


Figure 10 FEMA flood map depicting the Pioneer Valley and Westfield in Massachusetts. Data from FEMA.gov.

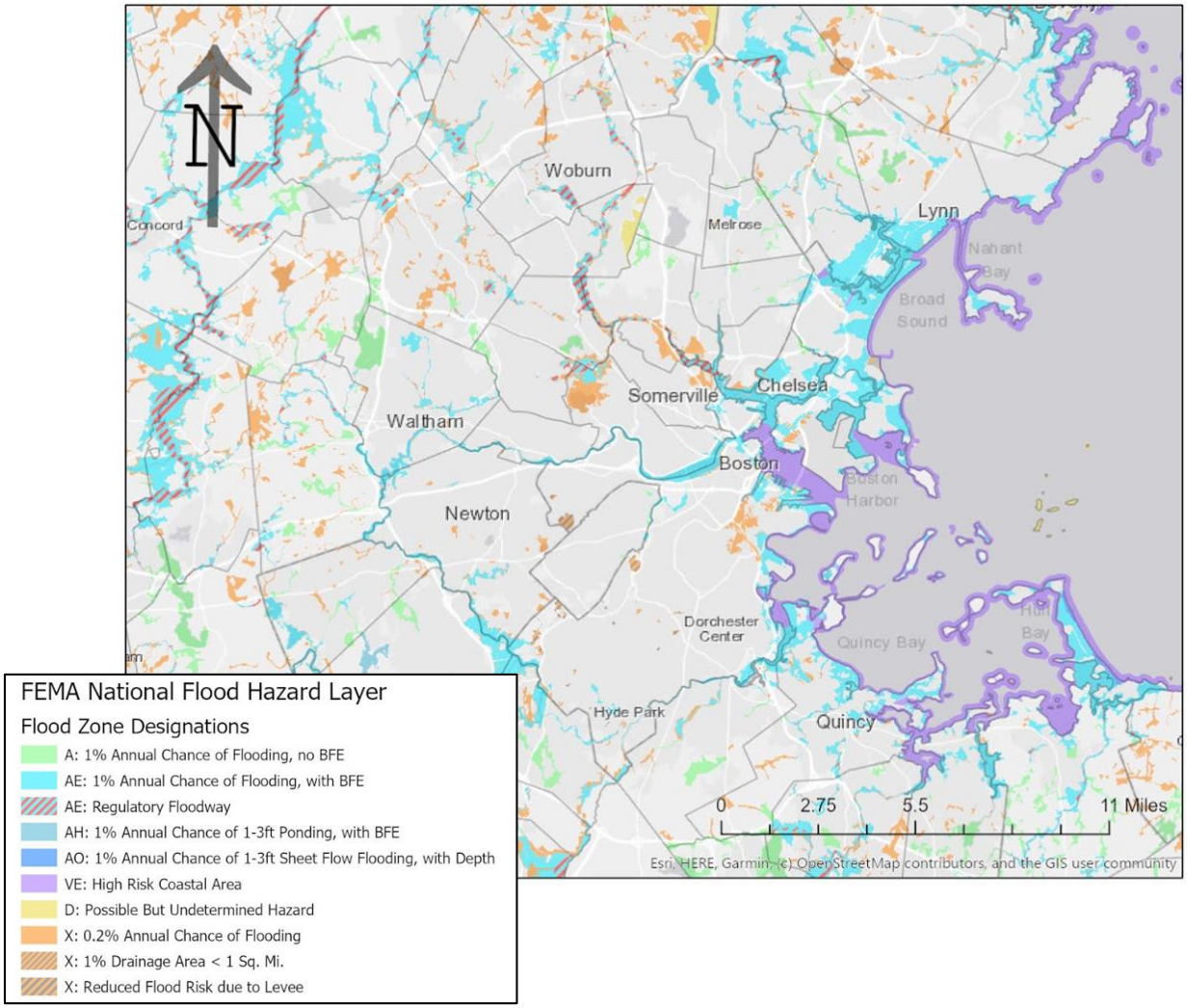


Figure 11 FEMA flood map depicting the Boston metropolitan area flood zones. Data from

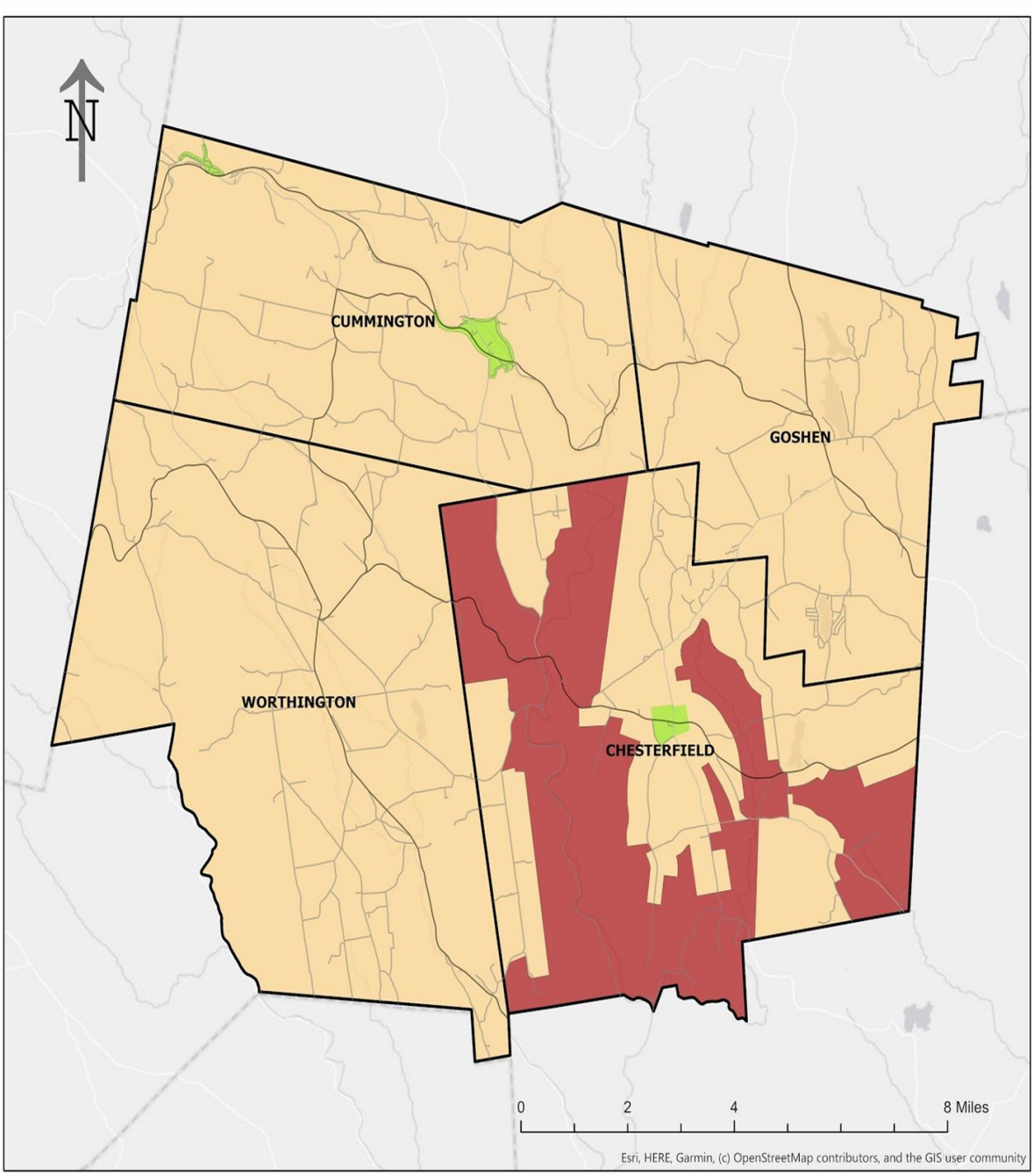


Figure 12 Map depicting relative zoning restriction of the four Northern Hilltowns. Data for hilltown outlines from MassGIS.com. Zoning data for Cummington, MA from http://www.cummington-ma.gov/; zoning data for Goshen, MA from goshen-ma.us; zoning data for Chesterfield, MA from

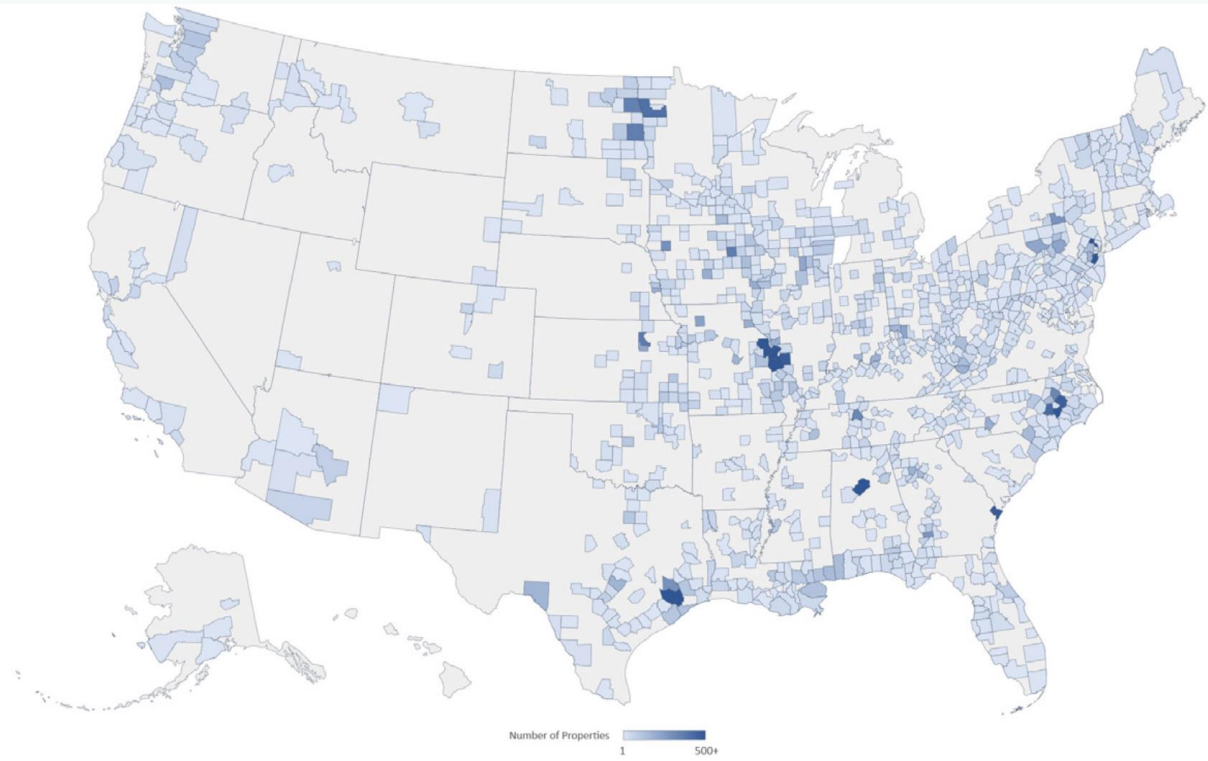


Figure 13 FEMA-funded buyouts from 1989-2018 colored by county, with darker blues indicating more buyouts. The Northern Hilltowns sit squarely between FEMA buyout zones in Western and Eastern Massachusetts.

Appendix

Interview Template

- How long have you lived in __?

- How long have you been in this position? Do you hold any other positions in the town?'
- Is there a prevailing sentiment about climate change in the Hilltowns? If so, would you describe it?
- Scenario questions:
    - How do you feel about population increase? In the case of population increase, how do you perceive town sentiments (willingness to change), and how would this help/stress your town?
    - How do you feel about population decrease? In the case of population decrease, how do you perceive town sentiments (willingness to change), and how would this help/stress your town?
    - How do you feel about population stability? In the case of population stability, how do you perceive town sentiments (willingness to change), and how would this help/stress your town?
- Concerns about climate migration:
    - What kinds of infrastructure are most vulnerable in your town?
    - What kinds of infrastructure in the town are most likely to be affected by changing population?
    - What kinds of social services will be affected by population change? How do you think they will be affected?
    - Can you think of any particularly vulnerable populations in your town?
- Zoning:
    - How are you involved in your town's zoning bylaws?
    - A lot of the zoning code emphasizes maintaining the rural character of the town; how do you think climate migration will affect this?
    - In your personal experience, has development been limited in your town?
    - Do you think zoning should accommodate for more or less development? Where would you like to see that development the most?

Grants

1. **Organization:** USDA Rural Development

   Program: Business and Industry Guaranteed Loan

Description: This program improves the economic health of rural communities by increasing access to business capital through loan guarantees that enable commercial lenders to provide affordable financing for businesses in eligible rural areas. Lenders such as federal or state-chartered banks, savings and loans, farm credit banks, and credit unions can apply for the program. Businesses can qualify for loan guarantees.

How to apply: Applications are accepted on a rolling basis and can be sent via mail. More information can be found on the website.

Website: http://www.rd.usda.gov/programs-services/rd-apply

Contact: Jennifer Lerch

jennifer.lerch@ma.usda.gov

413-253-4316

451 West Street, Suite 2

Amherst, Massachusetts 01002

2. **Organization**: Economic Development Administration, Department of Commerce

   Program: Public Works Program

   Description: This program empowers distressed communities to revitalize, expand, and upgrade their physical infrastructure, and generate or retain long-term, private sector jobs and investment.

   How to apply: Application packages are available at www.grants.gov. Applications will be accepted on an ongoing basis until the publication of a new EDA Programs Federal Funding Opportunity.

   Website: https://www.eda.gov/funding-opportunities/

   Contact: Debra Beavin

dbeavin@eda.gov

215-597-8719

900 Market Street, Room 602

Philadelphia, Pennsylvania 19107

3. **Organization**: Economic Development Administration, Department of Commerce

   Program: Economic Adjustment Assistance Program

   Description: This program assists state and local interests in designing and implementing strategies to adjust or bring about change to an economy. The program focuses on areas that have experienced or are under threat of serious structural damage to the underlying economic base.

   How to apply: Application packages are available at www.grants.gov. Applications will be accepted on an ongoing basis until the publication of a new EDA Programs Federal Funding Opportunity.

   Website: https://www.eda.gov/funding-opportunities/

   Contact: Debra Beavin

   dbeavin@eda.gov

   215-597-8719

   900 Market Street, Room 602

   Philadelphia, Pennsylvania 19107

4. **Organization**: Small Business Administration (SBA)

   Program: 504 Fixed Asset Program (Certified Development Company)

Description: The 504 Loan Program provides approved small businesses with long-term, fixed-rate financing used to acquire fixed assets for expansion or modernization. 504 loans are made available through Certified Development Companies (CDCs), SBA's community based partners for providing 504 Loans.

How to apply: Visit website

Website: https://www.sba.gov/offices/headq

uarters/ofa/resources/4049

Contact: Robert Nelson

rhnelson@sba.gov

617-565-5561

10 Causeway Street Room 265

Boston, Massachusetts 02222

5. **Organization**: Small Business Administration (SBA)

   Program: 7(a) Loan Guarantee

   Description: The 7(a) program is a flexible tool that can be used to finance a variety of business purposes. The proceeds of a 7(a) guaranteed loan may be used to purchase machinery, fixtures, and supplies; make improvements to land and buildings; finance receivables and augment working capital; acquire and start businesses; and refinance existing debt under certain conditions. The regular 7(a) program’s maximum loan amount is $5 million. There is no minimum amount. Other, more specialized 7(a) programs have different terms and guaranty amounts.

   How to apply: Borrowers must submit SBA From 1919 for a 7(a) business loan to private lenders. The lender will review the application, complete SBA Form 1920, and

then submit it to the SBA's Loan Guaranty Processing Center through SBA's E-Tran website.

Website: https://www.sba.gov/document/?program=7(a)

6. **Organization**: Small Business Administration (SBA)

   Program: Community Advantage Pilot

   Description: Community Advantage is a pilot initiative aimed at increasing the number of SBA 7(a) lenders who reach underserved communities, targeting mission-focused financial institutions which were previously not able to offer SBA loans. The maximum loan size is $250,000. Guarantee can be up to 85 percent for loans up to $150,000 and 75 percent for those greater than $150,000.

   How to apply: All small business applicants must complete SBA Form 1919, Borrower Information Form, and 2449, Community Advantage Addendum. Lenders must complete SBA Form 1920.

   Website: https://www.sba.gov/document/?program=7(a)

7. **Organization**: Small Business Administration (SBA)

   Program: Microloan Program

   Description: The purpose of the Microloan Program is to assist women, low income, veteran, and minority entrepreneurs, and other small businesses in need of small amounts of financial assistance. Under the Microloan Program, SBA makes direct loans to Intermediaries that, in turn, use the proceeds to make small loans to eligible micro borrowers. Up to $50,000 is available.

   How to apply: Visit the website

   Website: https://www.sba.gov/partners/lenders/microloan-program/list-lenders

8. **Organization**: United States Department of Agriculture

   Program: Rural Business Development Grants (RBDG)

   Description: "RBDG is a competitive grant designed to support targeted technical assistance, training and other activities leading to the development or expansion of small and emerging private businesses in rural areas that have fewer than 50 employees and less than $1 million in gross revenues. Programmatic activities are separated into enterprise or opportunity type grant activities...There is no maximum grant amount for enterprise or opportunity type grants; however, smaller requests are given higher priority. Generally, grants range from $10,000 up to $500,000. There is no cost sharing requirement. Total opportunity type grant funding is limited statutorily to up to 10% of the total RBDG annual funding."

   How to apply: "Applications are accepted through USDA Rural Development's local or State offices once per year. Applicants are advised to view program information specific to your local or State office to learn about local application timelines, concept paper requirements, etc. Grant awardees will need to complete required paperwork and comply with the terms and conditions of the award. Contact your local or State office for details."

   Website: https://www.rd.usda.gov/programs-services/rural-business-development-grants/ma

9. **Organization**: USDA

   Program: Rural Microentrepreneur Assistance Program

   Description: "Provides loans and grants to Microenterprise Development Organizations (MDOs) to:

• Provide microloans to help microenterprises startup and grow through a Rural Microloan Revolving Fund

• Provide training and technical assistance to microloan borrowers and micro entrepreneurs.”

Eligible for businesses with ten or fewer full-time employees

How to apply: Applications are accepted on an ongoing basis. Please reach out to your local state office for additional information and to apply.

Website: https://www.rd.usda.gov/programs-services/rural-microentrepreneur-assistance-program

Culverts in a Changing Climate: Stormwater Management in the Hilltowns

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18 December 2019

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Executive Summary

This project conducted an integrative analysis of culverts and stormwater management in the Northern Hilltowns of Massachusetts which include Goshen, Worthington, Chesterfield, and Cummington. Specifically, our research brought current data on flood-prone culverts into conversation with projections of future culvert and streambed vulnerability. First, we gathered data on existing problem culverts through interviews with the towns' highway departments and from current reports on area culvert management. We then compared that data to projections of future flooding vulnerability based on streamflow velocity and stream erosion vulnerability. From the results of the compared data, we developed recommendations for the Hilltowns' culvert management prioritization methodology. By directing resources toward current problem culverts, which are also projected to have elevated risk in the future, the Hilltowns can address today's stormwater management concerns, while also enhancing their resilience to climate change.

The effects of climate change are manifesting in the Hilltowns in the form of increased overall precipitation and more frequent extreme weather events. Culverts are at the forefront of mitigating stormwater-related damage. Our literature review found implementing green infrastructure, in addition to the upkeep of gray infrastructure, to be an effective mode of reducing overall stormwater volume. Our research suggests that, because of their aptitude for dealing with heavy rainfall, snow, and ice, bioswales are the most appropriate option for implementation in the Hilltowns. A further incentive for implementing green infrastructure is that it would make municipalities eligible for grants from the Department of Urban Development, Department of Transportation, and Environmental Protection Agency to implement more green infrastructure.

Introduction

The Northern Hilltowns

The Western Massachusetts Hilltowns are a collection of rural municipalities in the Northwestern Pioneer Valley. Among these, Cummington, Worthington, Goshen, and Chesterfield comprise the Northern Hilltowns. The towns all have relatively large landmass, but sparse population, making the character of the area very rural. The four towns' combined population is approximately 4,313 (United States Census Bureau, 2019). Because of their small populations, the towns share numerous combinations of resources including regional schools, grocery stores, and emergency shelters. Much of their land is forested, and a network of streams and rivers run throughout the Hilltowns. Many of the roads throughout the Hilltowns are dirt or gravel, in addition to some asphalt roads and highways.

In places where roads intersect streams, culverts are necessary to allow the road to pass over water without disrupting the stream's flow. Culverts usually take the form of open cylindrical channels laid under the road and surrounded by the packed soil. According to the Nature Conservancy, an ideal culvert lets "a stream be a stream. It is big enough and wide enough. It will let a fish move upstream. And it lets the stream flow past material and prevents clogging. Anything a natural stream will do, a good culvert will let that stream do" (The Nature Conservancy, 2016). While many culverts in the Hilltowns achieve this, some are prone to flooding and require additional maintenance to function optimally.

Aging Culverts/ Types of problem culverts

A problematic culvert is a piece of infrastructure that, due to age, wear, or unforeseen conditions fails to let a stream act as it naturally would without the barrier of a road. Some common culvert issues include channels that are undersized to deal with the volume of water that

regularly flows through them. This causes a buildup of water behind the culvert creating an unnatural pond and flooding the surrounding area. The flooding will erode the sediment bank around the culvert.

Although erosion is a common geologic occurrence, when water velocity increases, erosion will also increase. This is seen in streams with undersized culverts. When streamflow surpasses the culvert's maximum capacity, the increased water's velocity will erode the sediment bank and the surrounding area. Undersized culverts can also compound blockage and clogging problems. When culverts are too small they are unable to pass leaf and stick debris that streams regularly carry. The most extreme example of an undersized culvert affecting the Hilltowns is a problem culvert in Cummington near the border of Worthington that is "constantly underwater" due to its inadequate size (Adams, 2019).

Conversely, oversized culverts can also cause issues for stream flow. These are culvert channels that are too wide to appropriately deal with the small volume of water that flows through them. Here, the water will not have the correct velocity to travel since the culvert is too wide, leading the water to fill the channel, but the water will either not move or it will move at a slower pace. In addition, the shallow depth of water moving through the infrastructure creates challenges for fish and other aquatic wildlife using the culvert for migration (Bates, 2003).

Another common issue with culverts is perching, which is where a culvert sits above the regular water level of the stream it serves. When this occurs, streamflow is halted as it cannot reach the opening of the culvert, which then causes the stream to form a pond at the base of the culvert. This is also harmful to migrating fish and aquatic organisms which become unable to utilize culverts as byways for movement and migration (Bates, 2000).

Exposed unnatural bedding such as metal or concrete, as opposed to sediment, can interrupt wildlife migration, and decrease the friction between the water and the sediment channel. Since metal has a smoother surface than sediment, the friction between the water and the culvert would be less, causing the water to flow too quickly (Bates, 2003). In addition, the concrete, too, would increase velocity. Although these seem like exceptional ideas to avoid ponding, the metal bedding would oxidize, leading to breakage from rusting, while the concrete would undergo cracking from too much stress. Therefore, due to regular wear and tear on culverts that are installed with a layer of natural sediment bedding, the sediment would be able to act as a natural sediment bed, but the weight of the soil in metal or concrete culvert might lead to damage as well.

All culverts have the potential to become problematic due to beaver activity. Beavers sense water moving through infrastructure and often identify the culvert as a suitable location for a dam to be built. The result is a clogged culvert that floods the surrounding area. Even if the dams are removed and the beavers relocated they are likely to return to the site of the original dam, creating a long-term issue (The Beaver Institute, 2017).

Culverts that are inefficient for one or more of the reasons outlined above have the potential to disrupt non-aquatic wildlife movement. When culverts are too small or regularly flooded, they prevent wildlife from accessing the infrastructure as a byway through the road without interacting with traffic on the physical street. Studies have shown that areas with efficient and condition-appropriate culverts can reduce the number of roadkill deaths in the surrounding area (Gaskill, 2013; Clevenger, 1999).

Culverts in a Changing Climate

Climate change is expected to manifest in various ways, all of which will cause increased stress on existing infrastructure and may present volumes of water beyond current capacity. As Chesterfield's 2016 Hazard Mitigation Plan explains, Western Massachusetts is expected to experience increased extreme weather, including sustained extreme hot and cold spells. Such substantial heating and cooling can challenge the structural integrity of gray infrastructure, especially concrete. Precipitation will increase by 14% by the end of the century, mostly in the form of rain as opposed to snow. This precipitation is expected to be concentrated in the winter months, meaning more frequent extreme weather events, such as hurricanes, tornadoes, and general flooding (Town of Chesterfield; PVPC, 2016).

Our research finds that currently approximately one in five culverts in the Hilltowns is problematic and prone to flooding. The Hilltown Highway Departments are in large part already working at their full capacity with the resources and staff currently accessible to them. The impacts of climate change are already beginning to affect Western Massachusetts, as has been noted by Chesterfield's Highway Superintendent, in the form of changing precipitation and seasonal patterns (Smith, 2019). Climate change will also bring more major storms such as 2011's Hurricane Irene. Such storms generate elevated levels of debris that clog culverts and damage infrastructure, and it can take days or even weeks for the highway departments to set all the issues right. Some culverts and infrastructure may even need to be replaced after major storms (Somerville, 2019). With the current number of employees and resources, the highway departments may not have the capacity to keep up with repairs needed to maintain working culverts and clear roads in the face of climate change, were infrastructure not to be updated to consider climate change.

Methods

Our research used two primary methods to gather information: a literature review and interviews. We analyzed and presented the data we gathered in two forms: by mapping our data using ArcMap Geographic Information System (GIS) software and creating a green infrastructure information grid. The grid is organized to show descriptions of various options of green infrastructure that could potentially be implemented in the Hilltowns, and their pros and cons. From these products, we deduced our final recommendations.

Literature Review

We began by looking at existing literature on the Hilltowns concerning stormwater management, mainly the towns' Hazard Mitigation Plans (HMPs), all of which were published the year 2016 except that of Worthington, published in 2010. In all of the HMPs, culvert management and repair is a top priority (Town of Chesterfield; PVPC, 2016; Town of Worthington; PVPC, 2010; Town of Cummington; PVPC, 2016; Town of Goshen; PVPC, 2016). This led us to concentrate on culverts more than other forms of stormwater-related infrastructure such as bridges and dams. Additionally, culverts have shorter lifespans than dams or bridges, and we found that our research could be most helpful if it could effectively inform a process with a much higher turn-over rate (being the upkeep of culverts). Finally, culverts are municipally owned in the Hilltowns while other types of infrastructure such as dams are often owned privately. Recommendations for culvert management will thus be feasible for municipalities to implement.

Part of our literature review dealt with examining the existing Massachusetts Municipal Vulnerability Preparedness Program Action Grant Projects. Through these, we gathered information on what types of projects the Hilltowns could receive funding for when they apply

for their own Action Grants. One key resource in our literature review was a study by the City of Somerville on the feasibility of implementing green stormwater infrastructure, in addition to their already existing culvert and sewer systems. Somerville installed stormwater management systems of bumpouts, rainwater planter boxes, subsurface trenches, rain gardens, green roofs, and permeable pavements at various locations throughout their community and tested the stormwater flood volume reduction results in varying conditions based on projected rain conditions associated with the area's changing climate. All of the areas within the City of Somerville that installed green stormwater infrastructure saw reductions of stormwater flood volume between 12.5 and 21.7% (Somerville, 2019). This suggests that, while on its own, green stormwater infrastructure is not an appropriate solution for dealing with flooding due to rainfall, green infrastructure in combination with existing gray infrastructure can reduce the load on culverts and therefore lengthen the life of gray infrastructure. Based on these findings, we began to investigate the pros and cons of individual green infrastructure types to best form recommendations for the Hilltowns.

Types of green stormwater infrastructure we investigated included bioswales, permeable pavement, and bumpout boxes. The characteristics of these measures were cataloged in an expansive document, which recorded a general description, benefits and drawbacks, possible locations within the Hilltowns, and cost considerations for each.

Interviews

As we gathered information from published reports, we also conducted interviews to gain a comprehensive understanding of the current stormwater management situation in the Hilltowns. Much had changed since the time the towns researched and published their most recent HMPs. Many of the most problematic culverts had been repaired, while other culverts that had been

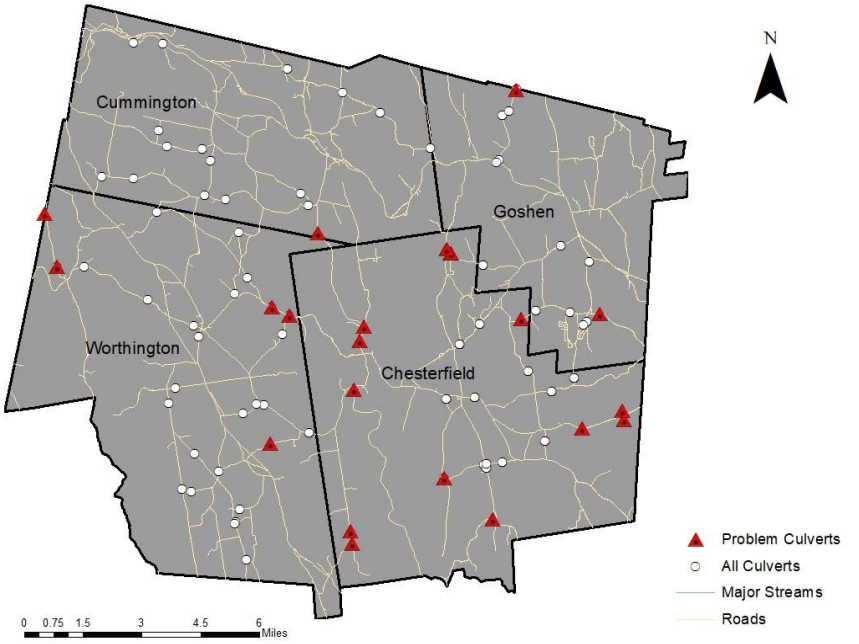
functional in 2010 or 2016 had become problematic. Stormwater management, because it relates to roadways, falls under the jurisdiction of the Highway Departments. We began by reaching out to the Highway Superintendents of each of the four towns.

Through phone conversations, emails and in-person meetings with the Highway Department Superintendents, we gathered information regarding the current state of roadway flooding in all four towns. We began by asking the superintendents about the state of culverts that were mentioned as being problematic in existing reports. From this, we learned which culverts were still problematic, and which ones had changed since the HMPs had been published. The superintendents' responses identified the causes of the problem culverts (e.g., beaver activity, culvert being disproportionate to the volume of water passing through it, debris causing clogging, etc.). For some of these culvert locations, we were able to obtain exact GPS coordinates to be entered into our map, but some were more difficult to find.

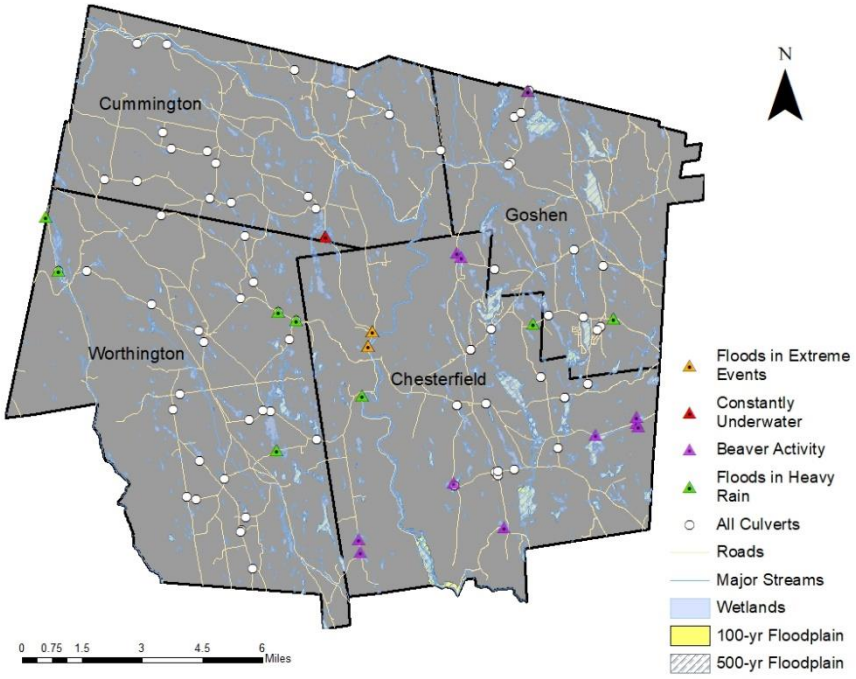
To pinpoint the exact locations of these more obscure culverts, we contacted the Highway Department employees from each town for their perspective. We met with Matt Smith, the highway superintendent from the town of Chesterfield, who drove us to the precise location of each problem culvert. When in person meetings were not possible, we asked highway departments to circle locations of problem culverts on maps. From this, we were able to compile and map our GIS dataset regarding culvert locations. Apart from the Highway Departments, we were in contact with Select Board members and assistants to the select board, who provided us with existing literature and helped to connect us with Highway Department Employees.

Mapping

We used the data we collected through correspondence and interviews with our Highway Department contacts to generate a variety of maps. Using ArcMap GIS software, we first created a map of all of the current problem culverts which our contacts identified. We created new spatial data as a shapefile based on locations our contacts provided. For Chesterfield, this data was based on a map on which Matt Smith had circled the locations of problem culverts. For Goshen and Worthington, our contacts provided problem culvert locations in list form, often naming a road and citing a feature such as a stream or town boundary where the culvert was situated along the road. We then cross-referenced these with culverts shown on the Past and Present Hazards with Critical Facilities maps in the towns' HMPs to determine their exact location. For Cummington, town assessor Joy Johns provided instructions over the phone to locate the town's single problem culvert using satellite imagery on the town's internal map system. We compiled these data points to create a shapefile layer illustrating all of the current problem culverts (Map 1). We also created a shapefile of all culverts in the Hilltowns based on a 2015 UMass Amherst study (North Atlantic Aquatic Connectivity Collaborative, 2019). This study includes data on all crossings of roads over streams; we selected only culverts and imported that data from an Excel file into ArcMap. Map 1 shows the current problem culverts (red) overlaid with all culverts in the Hilltowns (white).



Map 1. All culverts including current problem culverts.



Map 2. All culverts categorized by problem type.

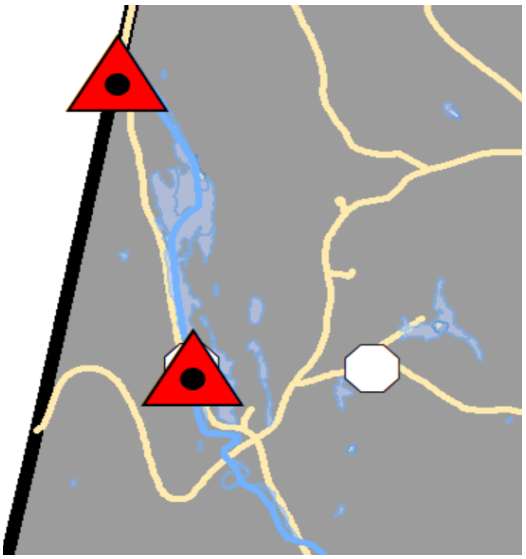


Figure 1. Zoomed-in portion of Map 1. This illustrates the confluence of roads, streams, wetlands and problem culverts.

After generating a map of all flooding-prone culverts, we classified the culverts by the nature of their problems. To do so we created a new shapefile for each category of problem, using data from Map 1. Map 2 shows the problem culverts differentiated by whether they tend to flood due to beaver activity, heavy rain events, extreme weather events, or are constantly submerged.

This typology is based on a definition of heavy rain as one to two inches of rainfall in a 24 hour period. Extreme weather events are defined as major storms such as 2011's Hurricane Irene. Map 2 also delineates the locations of wetlands in the four towns. We chose to visualize wetlands along with our problem culvert typology as a foundation for analysis of how a culvert's location relates to the type of problem it is prone to.

In addition to mapping and classifying current problem culverts, we decided to bring that data into conversation with future projections of culvert risk as climate change continues to take effect. To do this, we downloaded spatial data published in a 2015 study by the MassDOT Highway Division. The study presented how the culverts and sediment erosion, if unchanged, would respond to the predicted increase of heavy precipitation in 2070.

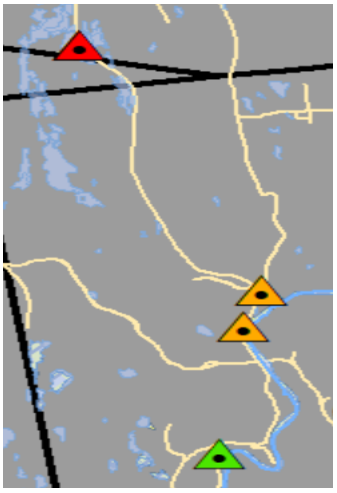


Figure 2. This is a Zoomed-in portion of Map 2, showing different types of problem culverts and their location along roads, streams and wetlands.

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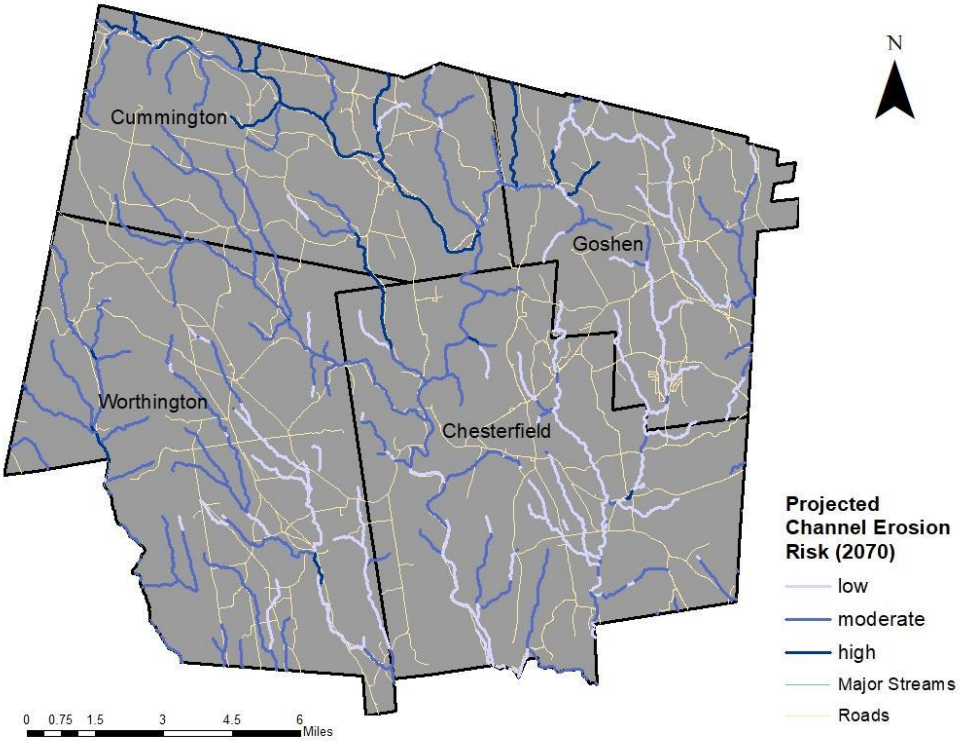
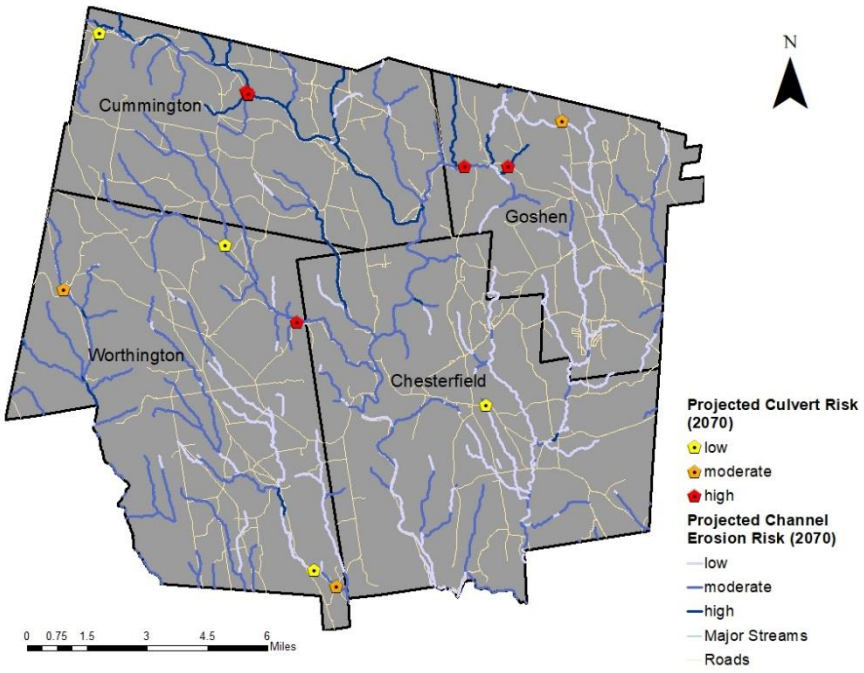
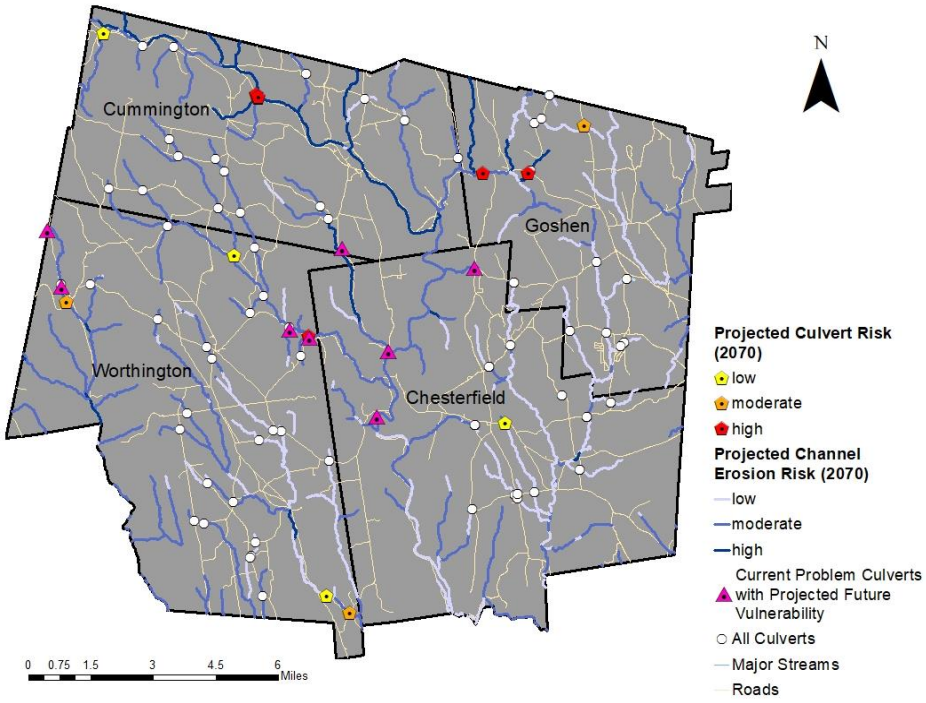
(Below) **Map 3a.** Shows the study's projections of streambed erosion vulnerability in 2070. These projections were calculated based on streamed geology and streamflow velocity (MassDOT, 2018).





Map 3b. This map shows which culverts are projected to have low, moderate, or high vulnerability to failure and flooding.

Finally, we chose to visualize the future projections shown above together with our map of current problem culverts. To do so, we activated map layers of projected streambed erosion and culvert risk at the same time as the layer of current problem culverts. We then created a new layer by selecting the current problem culverts which were either projected to be high-risk in 2070 or which were situated in streams with moderate or high erosion potential. This new layer of current problem culverts with considerable projected future vulnerability is shown in magenta on Map 4.



Map 4. Current problem culverts and projected future vulnerability.

Results

Of the 22 problem culverts we identified, 11 or 50% were reported to experience flooding due to beaver activity. Eight, or 36% of problem culverts, were reported to flood in heavy rain events of one to two inches in a 24-hour period. An additional two, or about nine percent are vulnerable to flooding only in extreme weather events or major storms such as Hurricane Irene. Finally, one culvert is constantly underwater. This breakdown is visualized on Map 2.

There are a total of 113 total culverts in the Hilltowns (shown in white on Maps 1 and 2) (UMass Stream Continuity Project, 2017). Of these, approximately one in five -- 19.5% -- is classified as a problem culvert in our data. Just under 10% of all culverts experience flooding due to beaver activity; seven percent flood in heavy rain; about two percent flood in major

storms and .008% are constantly submerged. The comparison of problem culvert types with all culverts can also be seen on Map 2.

Discussion

In the early stages of our research, we narrowed our focus to culverts because they seemed to be the aspect of stormwater infrastructure with simultaneously the most impact and the greatest potential for upgrades at the municipal level. Similar logic underlies our suggestion to install bioswales: it is the most effective option for the effort and cost it would require to implement. That said, we would like to acknowledge other methods with which stormwater management issues in the Hilltowns could be tackled, as well as the possible ways our research could be continued in the future.

Dams and Bridges

In addition to culverts, dams and bridges are very important infrastructure in stormwater management. Dams have the potential to cause the most damage if they fail, but their failure is highly unlikely as publicly owned dams are highly regulated. Still, measures can be taken to prepare for dam failure, such as reinforcing stormwater infrastructure below dams (using the methods recommended by this report, including simply enlarging culverts) as well as fortifying or raising the structures in the potential flood path (e.g., homes, businesses, roadways, etc.). Smaller, privately owned dams, especially older ones that are latent and go unmaintained, would best be removed because they could break, releasing the water built up behind them downstream into culverts too small for the load and causing flooding. Some culverts that flood frequently, or that are at risk due to upstream dams and/or floodbank erosion vulnerability, might be best replaced altogether with a bridge, allowing water to pass freely, and largely removing the road from the risk of flooding.

Green Infrastructure

Green infrastructure has an important role to play in stormwater management, though it is not a silver bullet. Continued gray infrastructure maintenance and updates are still necessary on top of which green infrastructure, and specifically bioswales, can work to lessen the total volume of stormwater flowing through culverts and onto roads. We considered several options when compiling a grid of pros and cons of different types of green infrastructure (Appendix A). While these other green infrastructure types such as permeable pavement would help, they would be difficult to implement in the Hilltowns. We ultimately selected bioswales as the most practical option for the area because of the relatively low cost of installation in comparison to other measures. While bumpout boxes and permeable pavement require the destruction and editing of roads and paved lots, bioswales can be installed next to and improve pre-existing roads.

Bioswales have also proven effective in freezing winter conditions which, due to the Hilltowns' cold climate, was deemed a priority. A study of bioretention infrastructure, such as bioswales, in Minnesota over the course of three winters found that "three of the four studied bioretention cells remained hydrologically active during cold climate conditions most of the time. The fourth cell, although infiltrating some water, appeared limited in both warm and cold weather due to its poorly draining soils" (Davidson et al 2008, LeFevre et al 2009). The ice and freezing temperatures that occur during cold months do not negatively affect bioswales' performance (Roseen et al, 2009). Meaning that bioswales that work well in warm conditions should also perform well in the Winter.

Prioritization Methodology

Taking into consideration the multiplicity of variables that determine risk and vulnerability related to stormwater, we believe it would be useful for future research to complete a deep analysis of all factors to determine a prioritization methodology that is comprehensive and minimizes unforeseen risks. Such a prioritization methodology would take into consideration, in addition to streamflow velocity/stream erosion vulnerability and general culvert updates, latent dams, potential benefits of new green infrastructure, the implementation of bridges instead of culverts, as well as other factors which would surely surface upon deeper research.

Keeping Updated Data

As further research is carried out, we suggest the new data be added to our current map, and that the map be updated as changes to culverts are implemented. Having an updated map that features the full scope of variables affecting stormwater management can inform prioritization methodology, and maximize the effectiveness of work that is done and money that is spent. Water systems are dynamic, especially in this age of climate change, meaning that approaches to stormwater mitigation must be equally as dynamic to be effective.

One aspect of maintaining current mitigation methodologies is the sharing of data, allowing municipalities to learn from one another. As this report has benefitted from looking at the work and outcomes of various towns with similar situations, other towns could benefit from this report. Such sharing of findings is the best way to learn about new technologies and methods that could improve results overall by replicating methods that were found successful, which could potentially be done by other rural municipalities using this report as a model. As we recommend the continued utilization of reports published by other municipalities to inform management decisions, we recommend the sharing of the Hilltowns' own findings.

This report could reach its full potential by being published online, in a journal or otherwise, and by the maps we have created being uploaded onto the ArcGIS website. ArcGIS Online hosts an archive of maps and spatial data from around the world, providing a wealth of geospatial information for consultants and researchers. Uploading the GIS data we have collected would literally put the Hilltowns on the map, making them a reference for other municipalities with similar stormwater situations and perhaps even opening up new dialogues. If the maps from our research were to be published and maintained, it would be important to designate people either within the Hilltowns or on a future research team who could take responsibility for updating the maps with new data as new research and changes to infrastructure took place. Regardless of whether or not our data is published, we recommend keeping consistent records in an easily accessible format that can be shared for the benefit of the Hilltowns. Such records can reveal patterns that will be increasingly useful in making informed decisions to mitigate damages related to climate change.

Further research might also probe the relationship between municipal and state-level culvert management. Researchers could look into areas in which communication, record-keeping and other management areas with both state and municipal stakeholders could be improved. In a future of increasingly unpredictable weather, collaboration across local and state levels of government will be essential to resilience. Water does not know municipal boundaries, and nor should the infrastructure in place to manage it.

Conclusion

It became apparent from our research that existing problematic infrastructure in the Hilltowns will only become exacerbated as climate change increases the quantity and frequency of rainfall. However, there are ways to simultaneously improve the current problem

infrastructure and plan for a resilient future. Through our research, a flooding-erosion feedback (FE) loop relationship between climate change-induced rainfall, problematic culverts, and erosion became apparent (Appendix B). With increasing rainfall, more water will put additional strain on already-problematic culverts. These culverts will then cause the water to flood and back up, eroding stream banks. As stream banks erode and widen, higher volumes of water will flood the culvert and erode more sediment. This cycle is present today in the problematic culverts in the Hilltowns and will likely be exacerbated by climate change.

In addition to the flooding and erosion loop, Map 4 shows the overlap between the current problematic culverts, problematic culverts vulnerability in the future, and the risk of erosion in the future. The problematic culverts predicted to have a high vulnerability to failure in the future tend to occur on streams that are projected to have a moderate or high erosion risk. The processes underlying this can be understood through the FE loop (Appendix B). Streambeds with higher vulnerability to erosion are likely to become more eroded during flooding and therefore more prone to additional flooding, overburdening the culvert in a self-perpetuating cycle.

From these observations, we propose two recommendations concerning green infrastructure. The first is the dual implementation of green and grey infrastructure. Together, both of these infrastructure types will decrease stormwater runoff and flooding. Bioswales implemented adjacent to roads would be able to filter stormwater back into the water table, which in turn, eases the stress on culverts and reduces flooding. In addition to installing bioswales, we recommend application to additional grants which fund green infrastructure projects. Two grants that are specifically awarded for bioswale installation are from the Environmental Protection Agency (EPA) called “Greening America’s Communities” and from

the “Federal Highway Administration Surface Transportation” (Environmental Protection Agency, 2017). In addition to these grants, green infrastructure projects can strengthen communities’ applications for Community Development Block Grant funding from the U.S. Department of Housing and Urban Development (Environmental Protection Agency, 2018)

Coupled with our recommendations, the Hilltowns will receive three deliverables. The first being the maps that indicate which current culverts will later become the most vulnerable, and cause high risk erosion. Additionally, the town will receive a grid with in depth cost benefit analysis of various types of green infrastructure that could be implemented in the Hilltowns. This would allow the Hilltowns to review other means of green infrastructure. Lastly, the Hilltowns will be given infographics that illustrate different types of stormwater management solutions (Appendix B).

We hope that our research and recommendations provide useful information to the Hilltowns in making culvert and stormwater management prioritization decisions. From upgrading current and projected future problem culverts to implementing bioswales and applying for other green infrastructure grants, our recommendations chart a path for the Hilltowns to enhance their stormwater resiliency for today and tomorrow.

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Appendix A

Graph 1. This is the grid which contains the cost-benefit analysis of different applicable green infrastructures.

Infrastructure Type	Description	types of location suitable for implementation	feasible locations within the Hilltowns	Benefits	Drawbacks	Cost Considerations
Bioswale	A bioswale is a long, channeled depression or trench that recieves runoff and has vegitation to slow runoff and filter poiltants. They serve as an alternative to concrete gutters.	currently underutilized space,	Along sidewalks in downtown centers, alongside roads	Bioswales can absorb runoff from small rain events, and purify water through filtration through natural sediment and plants. The addition of permeable materials such as gravel beds beneath the sediment for the plant's roots, can add to the bioswale's water storage capacity. Because of the natural bass present in bioswales as opposed to unnatural materials like metal and concrete, they can help mainatin natural water flowrates and reduce water runoff overall. They are relatively inexpensive to maintain because of their utilization of native perennial plants. They require infrequent mowing.	Bioswales require a high initial investment in material and installation labor costs. They are unable to completely deal with major flooding events. The presence of long native grass can make them hotbeds for ticks that may carry disease.	Cost of materials and installation labor. Cost of labor to monitor and maintain the bioswale (not constant but regular). Cost of replacing the bioswale's plants and sediment every few years or so.
Permeable Pavement	Unlike traditional asphalt, concrete, or compressed dirt paving, permeable pavement allows water to soak through the surface back into the groudwater supply. This strategy is bet implemented over large expanses of pavement such as parking lots.	sidewalk, currently underutilized space,	Parking lots within the downtown centers of the Hilltowns.	Permeable pavement manages stormwater by allowing infiltration of water back into the ground therefore preventing runoff, flooding, and erosion. Permeable pavement is effective in both small and large scale storm conditions by completely eliminating runoff in smaller storms and reducing water runoff volume, velocity, and flooding, in large events. Permeable pavement is durable and thus appropriate in low, medium, and high traffic conditions. Because it doesn't allow water to pool, permeable pavement is effective in reducing ice conditions and therefore increases driver safety and reduces the need for heavy duty road salt use. These pavements have similar lifespans to traditional asphalt paving materials.	Permeable pavements is expensive to initially install. Continued effectiveness of these pavement structures requires regular maintenance and semi regular replacement of materials to prevent clogging. If permeable pavement is installed in an area with high rates of pollution such as a gas station, car repair shop, or facility that processes chemicals there is potential for groundwater supply contamination.	Cost of installation labor and materials. Because of the high amout of materials required for the project, there is a high initial cost. Because of its runoff reducing properties, permeable pavement has the potential to reduce wear and tear on traditional stormwater management systems thus indirectly reducing sewer maintenance costs.
Bumpout	Bumpouts are self contained landscape features are typically placed in a wide street that collect, treat, and temporarily hold stormwater before filtering into an already existing catch basin. Infiltrates through permeable sediment and vegetation and is stored in underlying sediment then slowly releases into through a drain or sewer into an existing downstream basin.	roadway, roadway, parking stalls, driving aisle, Must be in a roadway shoulder or parking lane. Must be on the right sie of the road (to allow for vehicles to exucute turning maneuvers). Must be upstrem of existing catch basin.	Downtown centers near the individual town halls in each of the Hilltowns	Bumpouts filter stormwater runoff through vegetation and soil, which improves water quality. They narrows streets which improves pedestrian crossing and reduces vehicle speed (which was cited as an issue in some of the Hilltown's downtown centers). bumpouts provide habitat for wildlife. With the reduction of permeable pavement and increase in plant material, bumpouts have the effect of sequestering carbon and slightly reducing the effect of carbon emissions. If perrenial plants are chosen to populate the structure, bumpouts have the benefit of requiring little maintenance past installation.	Bumpouts require wide streets which limits possible implementation within the Hilltowns. There is a high initial cost associated with construction and installation. While green stormwater infrastructure reduces flooding overall, their impact is more subtle than other measures like culvert improvement and they are ill equipped to deal with crisis extreme flooding.	Cost of installation labor and materials. Because of the high amout of materials (vegetation, soil, piping, curbing, overflow structure, etc...) required for the project, there is a high initial cost. There are also hidden underlying costs such as need for updated catchment basins, piping systems, etc. Because of their runoff reducing properties, bioswales have the potential to reduce wear and tear on traditional stormwater management systems thus indirectly reducing sewer maintenance costs.
Wetland restoration	Many natural wetlands are drained. These areas are prone to flooding, or cause adjacent lands to flood. Restoring historic wetlands can reduce flood risk and improve ecological health. This can be iplemented in multiple ways, sometimes by inviting back beavers.		Historic flood plane land			
Flow Devices	For areas where there is unwanted beaver activity: Flow devices can be installed to silence the sound of running water, which is what attracts beavers to damn an area.		Matt mentioned beavers?			
Replacing Culverts with bridges and sustainable culverts	A culvert is a tunnel that allows a road to cross over a stream or waterway. Currently, an issue facing the Hilltowns is the presence of many undersized, too shallow, and perched culverts that disrupt stream flow, prevent wildlife crossing, cause flooding and erosion, and require near constant maintenance. Replacing these problem culverts with bridges or large scale culvert improvement projects could solve these issues.	roads that cross streams and waterways	existing culvert locations within the Hilltowns	"a good culvert lets a stream be a stream. It is big enough and wide enough. It will let a fish move upstream. And it lets the stream flow past material. Anything a natural stream will do a good culvert will let that stream do." "With climate change, we have seen an increase in extreme storm events so that means we need to make our culverts bigger." "Culverts play a major part of protecting bridges and neighborhoods and homes."	high initial installation expense "I think the biggest barrier that municipalities see when they start thinking about improving culverts is the cost. When a culvert fails, a structure is usually damaged beyond repair. The road is destroyed. The extent of the damage can be astrobnomical. When you start tallying up those costs it's really a no brainer to put in the right sized structure from the beginning." "You really need to be thinking outside of those traditional boxes in order to implement projects like these going forward. We need to be thinking about climate change and climate adaptation, transportation, and resiliency. We need to really explore all angles and think about all the different benefits that projects like this achieve." "We've seen evidence that these improved culverts really save money in the long run. So we've put in a structure and it will last 100 years. That's a pretty good investment." "What's going to happen is that, this road crew is never going to have to come in and maintain this"	cost of materials, cost of labor for installation, cost of environmental consulting impact report,
Current system: Culvert matinence	Because many of the Hilltown's existing culverts are undersized, too shallow, or perched many culverts require extensive regular declogging and maintenance by town highway workers.	roads that cross streams and waterways	existing culvert locations within the Hilltowns	little to no material cost	This system requires constant labor by highway workers presenting a large labor cost overtime. The need for regular culvert maintenance prevents highway workers from working on other road issues. Not replacing culverts with undersizement, perching, and shallowness issues harms ecosystems by preventing wilderness crossing and causing habitat fragmentation.	cost of labor for maintenance workers, cost of environental degradation and damage to surrounding natural resources caused by the symptoms of problem culverts

Appendix B

Figure 3. This infographic not only shows the different types of solutions, but also describes the effectiveness and applicability.

Figure 4. This illustrates the definitions of problem culverts.

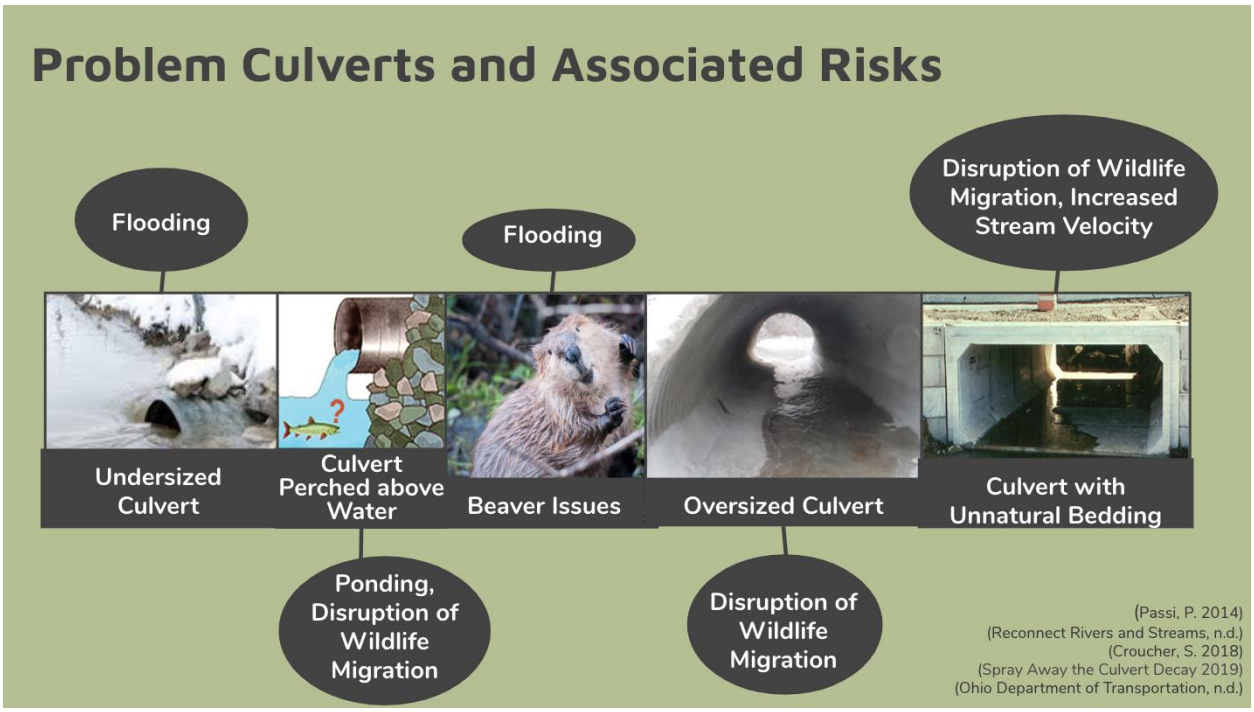
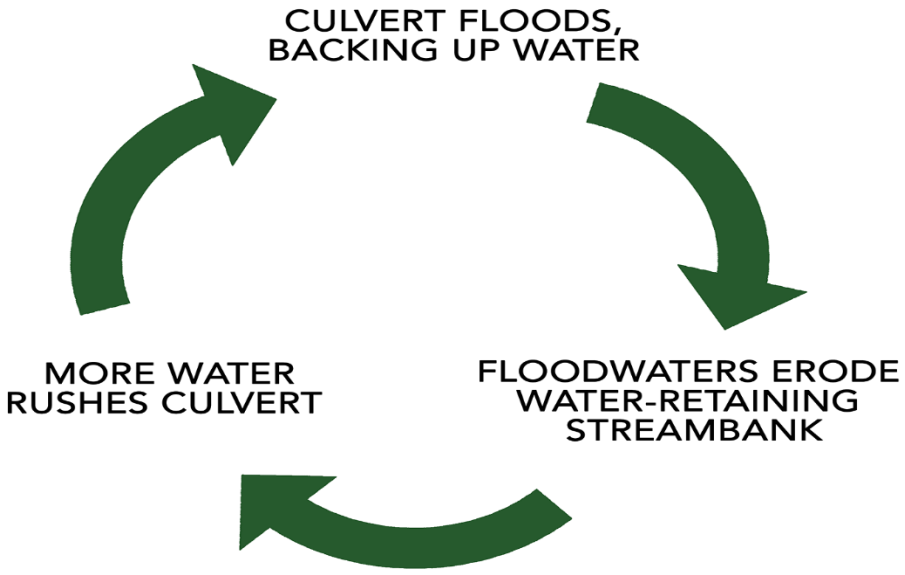


Figure 5. The figure below shows the flooding and erosion loop



Northern Hilltowns Winter Emergency Preparedness

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Advisors: P.H. Mangan and C. Washington-Ottombre

December 18, 2019

I. Executive Summary

Climate change is producing weather conditions that have begun to damage communities in ways that are becoming more difficult to mitigate. While much national attention is given to sea-level locations in the scope of climate change research, little attention is given to places that one may not think of immediately when picturing climate change (William & Jeffrey, 2016). Our project chose to focus on the Northern Hilltowns of Goshen, Chesterfield, Cummington and Worthington in western Massachusetts, and the issues faced in all four towns regarding winter storm emergency preparedness and response. Our research culminated in a proposal of a workshop series on emergency preparation, held in the Hilltown communities.

The most prominent results we found were the four shared needs discovered between the towns: Power outages, lack of reliable cell and Internet service, lack of community and lack of emergency preparedness education. Based on these and other needs, we developed a workshop series with three goals in mind: community-building, education and awareness, and resource and skill-sharing related to winter storm emergency preparation.

We propose this workshop series have four topics. The first is general preparedness, an overview of the resources and skills residents can develop in their own houses during a winter storm. The second workshop is about sheltering and serves as a way for residents to become more familiar with the local sheltering services. Residents will have a better idea of the resources available to them within the Hilltowns in case they are required to evacuate their homes. The third workshop is ons family preparedness, which will be open to both parents and children. The parents would learn practical skills, while the children would receive educational childcare related to emergency preparedness. Everyone would reconvene to participate in a group activity

as a family at the end. The fourth workshop is on volunteering, for those who would like to be more involved in the volunteer network (such as the fire department, sheltering managerial positions, town office positions, etc) in the Hilltowns. Each workshop would also have a related take-home gift for participants.

We believe that our proposal addresses many of the needs the Hilltowns face, though it is not a perfect solution to all issues. Our group worked to identify these needs, however, none of us are experts in emergency management. By outlining the workshop series, we give residents more flexibility in executing their responses to the most prominent needs in each of their respective towns. We believe the workshop series will increase the Hilltown community's resilience to climate change through community engagement and education between the Hilltowns.

II. Introduction

This project was inspired by the threats that climate change poses to vulnerable populations in Western Massachusetts and the clear need to increase resilience in the face of those threats. The Northern Hilltowns are an example of a community that will see increasing dangers due to more extreme and more frequent weather events in their area. Meanwhile, at the Municipal Vulnerability Preparedness (MVP) kickoff meeting in September, attendees expressed that the Northern Hilltowns, as well as much of rural Western Massachusetts, often appear to be neglected by the state and federal government in terms of aid and funding. Therefore, we feel it is important that the Hilltowns develop a strategy to tackle the issues that climate change presents to them and build their climate resilience. Through our research, we learned that snow and ice storms have historically been the most devastating for the Hilltowns, and are expected to

become more dangerous and more frequent with time. We therefore decided to focus our proposal on mitigating the impacts of these snow and ice storms.

Over the course of our research, we analyzed a plethora of issues that have arisen from snow and ice storms in the Hilltowns and envisioned multiple solutions to these problems before landing on our final deliverable. In the end, we chose to propose a workshop series on winter emergency preparedness. We think that this approach will help to raise awareness and increase public education about emergency preparedness while serving as an important source of community building, a vital part of climate resilience.

III. Methodology

At the beginning of the project, we knew the focus we wanted to hone in on was emergency management and preparedness within the Northern Hilltowns. During the first few weeks of the semester, our group performed research on changing weather conditions in Western Massachusetts, narrowing our sources down to the most relevant information, which included after-action reports we were able to obtain for past weather emergencies in the Hilltowns, as well as case studies that we identified of weather emergencies in other locations comparable to the Northern Hilltowns (L. Holmberg, personal communication, Oct. 23, 2019). Emergency preparedness improvements have become a higher priority in the Hilltowns since the 2008 ice storm (L. Holmberg, personal communication, Oct. 23, 2019; S. Fornier-Scanlon, personal communication, Nov. 12, 2019), which left many of the towns vulnerable and necessitated the renovation of the New Hingham Elementary School in Goshen so it could subsequently be used as an emergency shelter. The Community Emergency Response Team (CERT) program, a

federal program under the Federal Emergency Management Agency (FEMA) for dealing with community response after a disaster, was also established in response to the 2008 storm.

At the beginning of November, we decided to narrow our focus to emergency preparedness and response during winter snow and ice storms. During the following weeks, our group attended several town meetings, including multiple Emergency Management Committee (EMC) meetings in Chesterfield. At these meetings, we learned more about the existing methods of preparedness in the Hilltowns, and expanded our network of experts by contacting several town officials, volunteer organization staff, and members of the community. We also learned that the Hilltowns receive both state and regional aid during natural disasters, such as the establishment of CERT in Cummington and other towns in western Massachusetts (Lindahl, 2016).

We decided that, to get the best data for our project, we would need firsthand accounts from both town officials who had worked during snow and ice emergencies, as well as accounts from citizens of the towns who had experienced them. We were able to interview several residents (S. Labrie, personal communication, Nov 13, 2019; K. Savery, personal communication, Nov. 12, 2019; C. Hayes, personal communication, Nov. 6, 2019; S. Wildfield, personal communication, Nov. 9, 2019) and town officials such as Emergency Management Directors (EMDs), CERT managers, select board members, as well as the Fire Department and members from the regional Red Cross. We wanted unique perspectives from both the population who worked directly with the formal emergency management plans drawn up by each town, and those whom these plans serve.

By establishing contact with experts through town meetings and information available online, we were able to meet with both officials from different organizations and residents from all four towns. Common issues such as power outages and road debris blockage were prevalent in both testimonies from officials and residents, and other similar perspectives were found; however, we also discovered some gaps between the knowledge of both groups of people.

A) Pet Shelter

Based on the information from the initial interviews and meetings, our project began with the idea of a pet shelter. While not many of the residents we spoke with had much use for an emergency shelter and most people preferred to stay in their homes during an emergency, we found that many people do not want to leave their pets behind even if it is dangerous for them to stay in their homes (Neiberger Miller et. al., 2008; L. Holmberg, personal communication, Oct. 23, 2019; S. Fornier-Scanlon, personal communication, Nov. 12, 2019; B Forgea, personal communication, Oct. 30, 2019).

After speaking with Susan Labrie, the Chesterfield Fire Chief (S. Labrie, personal communication, Nov 13, 2019), at another EMC meeting on October 28th, we learned that the New Hingham Elementary School is used as a shelter for Goshen and Chesterfield, as the regional shelter previously used in Williamsburg was shut down after 2008, and requires separate care for pets, as is the law in Massachusetts. Smith Vocational School, the regional shelter in Northampton for all of Hampshire County, also has accomodations for pets. We wanted to improve upon the current pet sheltering operations and spread more awareness about them in advance of an emergency.

B) Pamphlet

We later moved towards the idea of a pamphlet that would provide important emergency preparedness education to residents that could be distributed at town meetings or sent out with a town newsletter. However, through additional research, we realized that there were already similar materials in existence and of course, an abundance of general preparedness information available online, rendering a pamphlet redundant. We also realized that there would be little incentive for people to read this information if they didn't already have an awareness of the importance of emergency preparedness.

C) Video Series

We expanded into more interviews with more organizations involved in emergency preparedness in the Hilltowns including the regional Red Cross, MEMA, and Hilltown Fire Chiefs. For three of the hilltowns,we were able to speak with at least the Fire Chief and Emergency Management Director, who often hold more than one position in the Hilltown community. The CERT coordinator in Cummington, Sarah Fornier-Scanlon, informed us about some of the existing emergency response tactics such as the reverse 911 system and door-to-door wellness checks performed by volunteer firefighters in the Hilltowns. She mentioned that more care for young children and the elderly (those with special needs during emergencies) was sorely needed in the sheltering system (S. Fornier-Scanlon, personal communication, Nov. 12, 2019).

After our conversation with Fournier-Scanlon, we also interviewed Susan Labrie, Goshen Fire Chief and Town Administrator. She told us that while the wellness checks were beneficial, especially for an older generation of people, the people who did them had to quit their day jobs in order to participate. So, she would like to see more volunteers in the position (personal

communication, Nov 13, 2019). MEMA and FEMA already have several brochures about preparedness for a winter storm, but she mentioned training classes as a better method to engage the community.

D) Workshop Series

Sienna Wildfield is the founder of the Hilltown Families blog, an online community platform where Hilltown residents can get news about town events and activities, as well as receive updates about weather conditions and subscribe to a weekly newsletter. The website has over two million total visitors, with 14,000 receiving daily news. We learned that a regional broadband project would bring high-speed internet to Chesterfield and Goshen as well as several other Hilltowns in Massachusetts in the coming years.

With information gathered from interviews, we decided that our project would focus on outlining a series of +/- 5 minute-videos to be posted on this platform. However, since not everybody has access to high-speed internet in the Hilltowns yet, we geared the video series to our final project idea of a four-part workshop series held in the Hilltowns, focusing on *General Preparation, Sheltering, Family Preparation, and Volunteering*. Taking into account the interviews we had with Hilltown residents and town officials, who both emphasized a need for more community and coordination during emergencies (especially for populations who need more help like children and the elderly), we developed an idea for workshops that are run by EMDS as well as other town officials in the Northern Hilltowns.

Our goals with the workshops are three-fold: community building, education and awareness, and resource and skill-sharing. We noticed there were a few gaps between the EMDs, who were more familiar with the instructions on official town documents for dealing with

emergency preparation, and residents who were subjected to these instructions without fully trusting the town system. The Hilltown families blog, as well as the Hilltown fire chiefs, informed us that there is a prominent informal system in many of the towns during emergencies: Neighbors will often check on each other to see if they are okay, or offer accommodation for the night if somebody's power goes out. Not only would the residents get to know and trust their EMDs and other emergency response officials better, residents and officials would both be able to share their skills or resources with the community more easily, whether that be operating a chainsaw or the best way to help a baby fall asleep during a thunderstorm. This informal system of skill-sharing and community engagement could complement the more formal reverse 911 system, wellness checks, and other emergency preparedness methods to improve the emergency system in the Northern Hilltowns.

This project is designed to be salient and flexible for implementation in each of the Hilltowns, and aims to strengthen community bonds between residents, as well as awareness of the impending changes climate change will bring about to rural places such as the Northern Hilltowns.

IV. Results

For this report, we have gathered an extensive amount of information from Hilltown residents and several organizations that serve the Northern Massachusetts area. The Hilltown residents have provided insights into the issues their communities face due to snow and ice storms. Each of the four Hilltowns have their own needs that are specific to their towns. However, there are several concerns that are shared among all four Hilltowns. Figure one in the

Tables and Figures Section organizes these concerns based on the town-specific needs and shared needs.

Our proposal of a workshop series aims to address the shared needs among the Hilltowns. The four overlapping needs we found include power outages, lack of reliable cell and internet service, lack of community emergency preparedness education, and the need for more community building. Based on this data, our recommendation is to establish a workshop series in the Hilltowns that focuses on various topics in emergency preparedness.

A) General Preparedness

The following topics should be considered for the workshop series: General Preparedness, Sheltering, Family Preparedness and Volunteering. The General Preparedness workshop would begin the series. The goal of this workshop would be to provide an introduction to the overall workshop series. There would also be an opportunity for Hilltown residents to meet their town's Emergency Management Director and Municipal Vulnerability Preparedness (MVP) representatives, and perhaps other town officials as well. Emergency preparedness information that would apply to the general population of the Hilltowns would be provided at this workshop. For example, there would be information about first aid and what types of supplies should be included in emergency kits. There would also be additional information specific to elderly community members and to pet owners in emergencies.

B) Sheltering

We propose the Sheltering workshop as the second workshop in the series. The purpose of this workshop would be to introduce and familiarize the Hilltown residents with their local evacuation centers. It would also provide information about pet shelters. Thus, residents would

have an opportunity to learn more about the services that are available for pets and the locations and procedures of nearby pet shelters.

We recognize that a majority of the population will stay in their homes during an emergency if they are not required to evacuate. The Sheltering workshop would exist primarily for those who are interested in learning more about the resources found within the emergency shelters within the Hilltowns.

C) Family Preparedness

The Family Preparedness workshop is the third workshop in our proposed series. The goal of this workshop would be twofold: to allow parents to share skills and resources among one another, and to teach young children the importance of emergency preparedness in a fun and engaging way. Parents would be encouraged to attend this workshop with their children. Upon arrival, they would be separated into two groups in two seperate areas. In the parents' group, adults would be able to participate in a practical skill-sharing activity related to emergency preparedness. For example, they may learn how to safely operate a chainsaw or how to safely store fuel at home. Residents could sign up in advance to share their own unique skills that could be applied during a snow or ice storm. While the parents are doing their own activity, educational childcare would be provided for the children. We think it would be most practical to gear the curriculum towards grades 1-5, which are the ages most in childcare that the topic of emergency preparedness is appropriate for, and the ages generally most receptive to educational games. The children would participate in their own activities playing emergency preparedness games such as the Emergency Clue Game (FEMA) or the Natural Disaster Contrast Game

(FEMA). Towards the end of this workshop, the parents' and children's groups would come together for a practical, fun, all-ages activity such as vegetable fermentation.

D) Volunteering

We propose the Volunteering workshop be the final workshop in the series. This workshop would provide an opportunity for Hilltown residents to network with representatives from local volunteer organizations. Representatives from organizations such as the Red Cross, the Hampshire Regional Medical Reserve Corps, the Salvation Army, local Fire Departments and CERT would be invited to lead a skill-sharing activity related to their organization. From this workshop, Hilltown residents would become more familiar with the resources these organizations provide. This workshop could also be used as a recruitment opportunity for the volunteer organizations. After having the opportunity to network with the representatives, the Hilltown residents may decide to get involved by becoming a volunteer if they are interested.

E) Take-Home Gifts

In addition to the workshops, we also hope to provide gifts related to emergency preparedness for the workshop participants to take home. The take-home gift ideas we have imagined include a portable emergency weather radio, a portable thermal emergency blanket paired with a MEMA pamphlet (see Appendix B), fermented vegetables from the family activity along with recipes for how to ferment vegetables at home, and finally an electric lighter.

V. Tables and Figures.

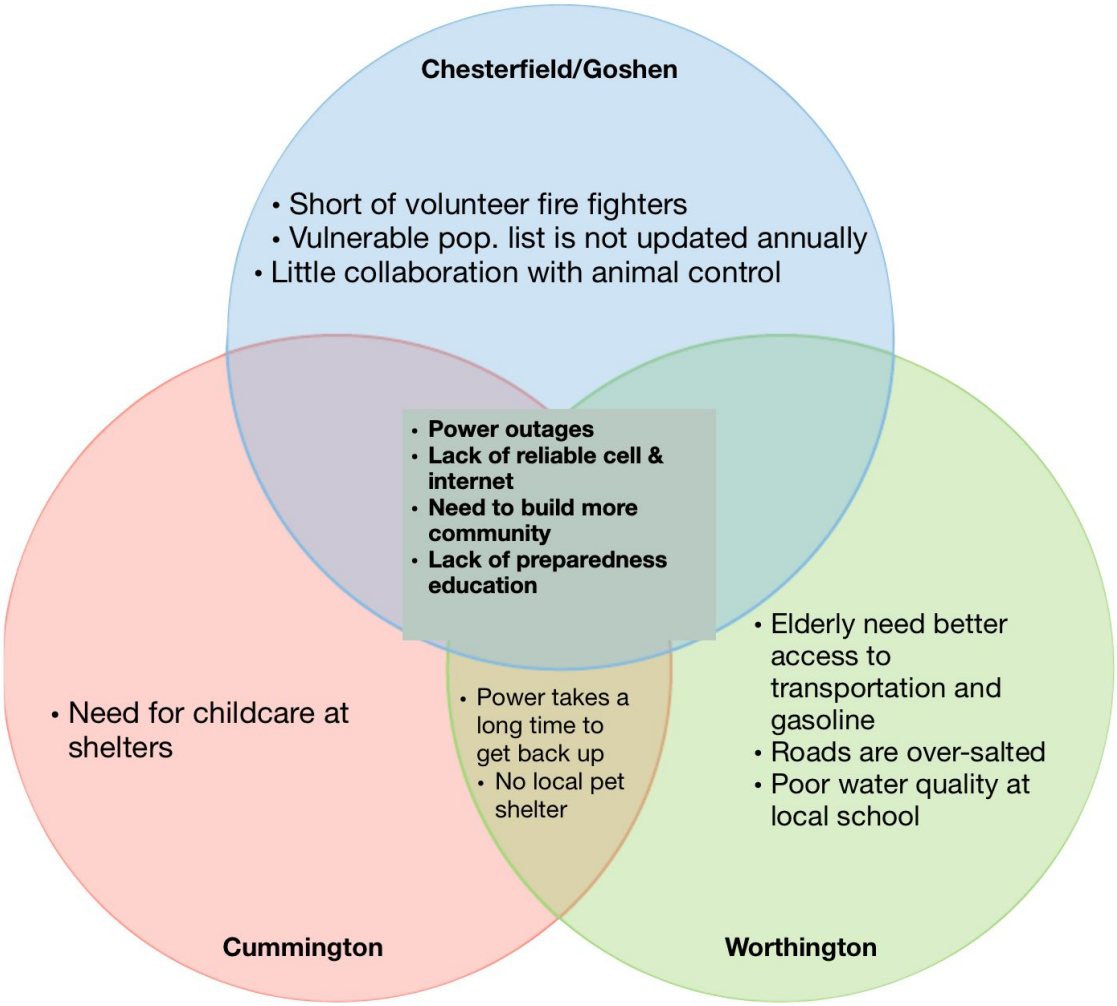

Figure 1: Hilltown issues during snow and ice storms

VI. Discussion

Through in-depth interviews with Hilltown residents, officials, and emergency response experts, we identified emergency response issues that impact the communities. Our proposal for

a localized workshop series cannot directly address most of the issues we found. Considering the scope and goal of the MVP Program, our proposal decided to address not one specific concern, but proposing a time and space where the communities could find ways to raise and solve various concerns through networking, trust-building, and education. First, this section will discuss how our workshop series proposal aligns with the goals of the MVP and the goals of our project. Secondly, we will describe the strengths and limitations of our proposal.

A) Alignment with MVP Goals

To start with, our proposal for a workshop series matches Municipal Vulnerability Preparedness Action Grant's initiative. The goal of the MVP program is to provide support for towns to begin the process of planning for climate change resiliency and implementing priority projects. The towns that finish an MVP grant would be eligible for an Action Grant that can potentially fund projects that improve community resilience (Mass.gov, 2019). Our project aims to match a Public Education and Communication project, a project that increases public understanding of climate change preparedness within and beyond the scope of community, foster partnership among Hilltowns, and develop residents' trust and support to the public emergency facilities.

A similar program within the same category, Pelham MA created an intergenerational story sharing initiative between Pelham's elders and the Pelham Elementary 6th grade class (Youtube, 2019). The program produced a video that features children interviewing elders in the community about their observation of climate change (Mass.gov, 2019). The Pelham video program, in this case, is a public education initiative that uses the MVP Action Grant to foster intergenerational communication and climate change education in the community. Our team

developed our project based on similar methods used in the program. The project not only teaches residents knowledge, resources and skills, but provides them a chance to communicate and learn from the community.

B) Alignment with Project Goals

The workshop proposal has four sections: general preparedness, sheltering, family preparedness, and volunteering. Our team proposed these four topics in response to the current issues surrounding emergency preparedness that we identified through our research.

i) General Preparedness

The first topic we propose is General Preparedness. All Hilltowns are required to have an Emergency Management Director, who prepares plans and procedures for responding to natural disasters and other emergencies. The EMDs also coordinate response teams during and after emergencies. Based on our research, the vast majority of Hilltown residents have never stayed in an evacuation shelter during an emergency. After working with Larry Holmberg (the EMD for Goshen and Chesterfield), Adam Dragon (the EMD of Cummington), and Charley Rose (Select Board Member of Worthington), we identify the need for the community to engage the EMDs with the community more often. Thus, in our proposal, we suggest that the EMDs and other town leadership should take a lead in workshop organization and implementation, particularly in the first workshop in the series, General Preparedness.

ii) Sheltering

Through our research, we came to recognize the importance of residents' trust and comfort level with their local emergency shelters. We set out to increase those levels of trust and comfort through a Sheltering workshop. According to many interviewees, Hilltown residents

have a strong tendency to stay independent, self-sustained, and private. Many of the residents would not leave their homes for several reasons. For example, their house might be their only property, they want to stay at home to take care of their pets, or they wish to maintain their privacy or comfort.

According to George Heake, the Director of Mass Voluntary Organization Active in Disaster, one way to address residents' hesitance to use public emergency facilities is to host an open house at the local shelter (G Heake, personal communication, Nov. 13, 2019) . At the open house, residents would be invited to visit the facilities, connect with the local emergency response teams, and ask questions about the shelter. Both local shelters, the New Hingham Regional Elementary School and the Cummington Town Hall, are important community centers, but residents lack a solid understanding of how they operate as emergency shelters. The Sheltering workshop addresses this problem. If residents are exposed to the functions of local shelters and bring their concerns to the officials and volunteer groups at the workshop, they have the potential to grow a collective trust in the public emergency facilities and officials.

iii) Family Preparedness

The Family Preparedness workshop is intended as an opportunity for residents to connect and learn from one another, and to prepare for winter emergencies as families. Compared to single households, young families need additional family preparedness education including how to contact each family member, additional food preparation, and specialized preparedness education for children. According to Sienna Wildfield, founder of Hilltown Families, young parents are usually less experienced in skills and winter preparation than the elderly residents (S. Wildfield, personal communication, Nov. 13, 2019). Building a platform where people could

introduce themselves to the community and ask for help becomes significant in rural areas where people may not know their neighbors. The Family Preparedness Workshop takes a dual approach to help these young families.

The skill-sharing activity allows for residents to get acquainted and connected with others, whether they live in one house or one town over. As kids may not be able to operate chainsaws or cleanup fallen debris, we chose to include a fun, educational curriculum for children as a way to introduce the concept of climate change and how it can affect our own communities early on in their lives. Children can learn faster than adults, and they tend to be more creative. By establishing climate change as less of an abstract concept and more of a consequential reality, we can help the younger generations in the Hilltowns facilitate a better understanding of the climate.

Towards the end of this workshop, we propose that the parents' and children's groups come together for another practical, fun, skills activities for all ages such as vegetable fermentation. We chose the example of vegetable fermentation because it is a low cost method of long term food storage, and fermented vegetables can be kept in an unheated space such as a garage over winter, so if the power goes out in a storm and you can't cook and food in your refrigerator spoils, you still have a healthy, easy food source. By engaging together at the workshop, everyone could learn a new skill and have a useful take home gift they made themselves as a family that can even be a part of their emergency kit. Moreover, this activity can serve as a bonding activity within and across hilltown families.

In the future, workshop planners could partner with local elementary schools, learning from the Town of Pelham's experience, create a community event would facilitate

intergenerational connections. Overall, this workshop would encourage Hilltown families to approach emergencies together.

iv) Volunteering

We propose to dedicate the final workshop topic to volunteering in the hope to increase community involvement in and awareness of highlight through the workshops consists of local volunteer organizations, including the local Fire Departments, CERT, and local chapters of major independent organizations like Red Cross and the Salvation Army, all of which contribute to emergency response efforts. The local Fire Departments and CERT in particular conduct wellness checks for families with children, elderly households, and residents on medical equipment (S. Labrie, personal communication, Nov. 13, 2019; S. Fornier-Scanlon, personal communication, Nov. 12, 2019). After in-depth interviews with experts from these two local organizations, we found that there is a serious need for additional volunteers to maintain the services these organizations offer. We propose a Volunteering workshop to simultaneously address these organizations' needs for both publicity and recruitment of volunteers.

v) Incentives

In addition to the workshops, we also propose ideas for take-home gifts that are related to emergency preparedness for the workshop participants. These would serve as an incentive to attend, a reminder of the event, and an important supply in an emergency kit that many people may be missing or even unaware of. We selected four gifts, one for each workshop, based on this criteria.

We chose the Esky portable emergency weather radio (eskynow.com) since it has a powerful flashlight, a USB port that can charge a small device such as a smartphone, and is

rechargeable by crank or solar power as well as electricity, which would make it functional even in a blackout. We believe a radio is incredibly valuable because of the ability to convey important information about weather conditions and emergency services via local radio stations.

We chose a portable thermal emergency blanket (redcross.org) since it could be useful at home in the case of a power outage or in an evacuation situation, and is extremely packable so as to easily fit in an emergency kit. We chose fermented vegetables because it relates to the group activity and is a low cost, low effort, and healthy alternative to commercial canned food, which is essential in any emergency that is accompanied by a long term blackout. Finally, we chose a Tesla electric lighter (FoxandGrapes.com)because it is rechargeable via a USB port (could be used with the radio) and could be used to start fires for warmth or cooking in the case of a power outage. Since it has no lighter fluid, it never runs out and it is more environmentally friendly. Additionally, because it is lit by pressing a button, it is much easier and safer than conventional lighters or matches for people who have hand conditions such as arthritis.

All of the above mentioned gift items are simply ideas, and could easily be swapped out for any other gift idea that fits the criteria of being an incentive as well as a practical addition to an emergency kit.

C) Strengths and Limitations

Our proposal for a workshop series does not aim to solve every concern the residents have. Improving the emergency response system in Hilltowns requires infrastructural change, collaboration among communities and long-term community engagement. The workshop series aims to be a starting point, where as many residents as possible could be familiar with the general idea of climate change and emergency preparedness, practice useful skills, develop

necessary connections within the community, and bring their perspectives and concerns to the officials. These workshops lay the foundation for future improvements.

Our team also acknowledges that this proposal is far from perfect. Due to time constriction, we did not have a chance to separate "opinions" from "truths" in the interview scripts. For example, Jan Gibeau, the Director of Northern Hilltowns Consortium on Aging, mentioned that there is no kitchen in one of the local shelters (J. Gibeau, personal communication, Nov. 22, 2019). After our presentation, Larry Holmberg pointed out that there is a kitchen in the New Hingham Elementary School (L. Holmberg, personal communication, Dec. 16, 2019). If we had more time to compare and summarize the interview scripts, we might be able to figure out why there is an informational gap between different town officials.

Another weakness of our proposal is that we didn't reference similar workshops that happened before in the region. During the presentation, a community member from Plainfield mentioned that there was a Sustainability Conference in the region seven years ago. This is new information to us. If we knew the existence of this conference, we would ask more specific questions to those who organized it and seek opportunities to improve what they had done.

A final limitation we acknowledge is the current rate of turnover of hilltown EMDs, which limited our access to key information about two of the towns. While Goshen and Chesterfield share one EMD, Worthington does not have an active EMD, Cummington's EMD is new to the position. Considering two out of three EMDs are new to the communities, one element we highlight in the workshop is to introduce the EMDs and their duties to the communities.

VII. Conclusion

Our research was able to narrow down a few main issues brought on by snow and ice storms that were common to all four towns. These included power outages, lack of communication infrastructure, lack of emergency preparedness resources, and a desire for community building within and across the towns. Although we briefly toyed with solutions to the former two, we ultimately found that they were not viable and decided that the MVP Action Grant would be better equipped to deal with the latter two. Our workshop series deliverable was therefore developed with a focus on education and community building, with recommended topics including general preparedness, sheltering, family preparedness, and volunteering.

Ideally, this series would be expanded to other Hilltowns and would lead to the creation of additional offshoot community building and educational events. We would love to see this series result in more collaboration between the four towns on various plans and events, even more than just emergency planning. We hope that the Volunteering workshop, specifically, will lead to greater long term community involvement and strengthen ties between existing local organizations. We believe that this will build a stronger bond between the towns and demonstrate that they can make greater progress on a variety of common goals when they work together and pool their resources.

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IX. Appendix

A) We would like to thank those involved in this project:

- **Goshen/Chesterfield:**
  - Larry Holmberg, Emergency Management Director, interviewed October 23, 2019
  - Diane Mukuchi, resident, interviewed on November 11, 2019
  - Jan Gibeau, Emergency Management Committee and Council on Aging, interviewed on November 22, 2019
  - Michael Sarrafin, west Chesterfield cell tower land owner, interviewed on November 16, 2019
  - Susan Labrie, fire chief and town administrator, interviewed on November 13, 2019
  - Sienna Wildfield, founder of Hilltown Families blog, interviewed on November 9, 2019

- Dave Christopolis, executive director of Hilltown Community Development

➔ **Cummington**:

- Adam Dragon, Emergency Management Director and fire chief, interviewed on October 17, 2019
- Bernard Forgea, former fire chief, interviewed on November 13, 2019
- Sarah Fournier-Scanlon, CERT coordinator and EMD assistant, interviewed on November 12, 2019

➔ **Worthington**:

- The Maples Residents:
  - Carol
  - Peggy
  - Theresa
  - Georgianna, interviewed on November 15, 2019
- Eliza Lake, Chief Executive Officer at Hilltown Community Health Centers, interviewed on November 30, 2019
- Patty Kimura, Director of Maples Senior Housing Community, interviewed on November 1, 2019
- Charley Rose, Select Board Chair, interviewed on November 6, 2019

➔ **Other organizations:**

- Hilltown Elderly Network:
  - Charlie Hayes, Social Services program manager, interviewed on November 6, 2019

- Mass VOAD:
    - George Heake, Coordinator for Team Rubicon and Chair for Mass National Voluntary Organization Active in Disaster, interviewed on November 13, 2019
- Salvation Army:
    - Emily Mew, director of the state Salvation Army Emergency Disaster Service, interviewed on November 5, 2019
- Hilltown Health Center:
    - Kim Savery, Director of Community Programs and Family Support, interviewed on November 12, 2019
- Hampshire County Medical Reserve Corp:
    - Loren Davine, interviewed on November 15, 2019
- Red Cross:
    - Mary Nathan, Coordinator, interviewed on November 13, 2019
- Smith College:
    - Dano Weisbord, Administrative director of CEEDS
- Northern Hilltown MVP:
    - Emily Slotnick, Senior Environmental Planner for PVCP

B) Brochure

EMERGENCY TRAINING IN THE HILLTOWNS

Online Resources

FEMA

HILLTOWN EMERGENCY PREPAREDNESS TRAINING

Online MEMA Training System:

- Free online training courses with limited class size
- Familiarize yourself with the Incident Command System (ICS) used in emergencies
- Learn the basics of being an Emergency Management Director or CERT Team Manager

Navigate here to register:
https://mematraining.chs.state.ma.us/TRS/home.do

3 Primary Federal Emergency Management Agency (FEMA) training divisions:

1. Center for Domestic Preparedness (CDP)
2. Emergency Management Institute (EMI)
3. National Training and Education Division (NTED)

Search through national preparedness courses here!
https://www.firstrespondertraining.gov/frts/npccatalog

Youth Emergency Prep and Online Games for Kids:
https://www.fema.gov/media-library/assets/documents/34411

FUTURE FOREST RISK IN THE NORTHERN HILLTOWNS

Report prepared by Kay Colletti, Frances Kretschmer, and Eve Zikmund-Fisher

ENV 312/ENX 301: Sustainable Solutions

Smith College

Advisors: P.H.Mangan and C. Washington-Ottombre

December 18, 2019

Acknowledgements

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Executive Summary

This 2019 Report details the current and coming concerns for trees in the face of a changing climate. The goal of this report is to detail the issues facing the forests and individual trees in the Northern Hilltowns and to outline potential routes for risk mitigation, community resilience building, and further collaboration opportunities between the Northern Hilltowns, the Five Colleges, and beyond.

Key Concerns

Trees We identified three major concerns for Hilltown Trees that will be exacerbated by climate change. The first is weather. Increased frequency of extreme temperature fluctuations and the rapid cycling of freeze-thaw, increased strength and frequency of hurricanes, and increased periods of intense precipitation are all projected to occur and will have an impact on the health of all forests in New England. The second concern is disease. Stress due to unpredictable weather will leave trees more vulnerable to disease. Finally, insect pests are a growing concern in the Northern Hilltowns. Besides compromising the structural integrity of woody plants, these invasives carry new diseases that trees in the area have little resistance to. Invasives such as the emerald ash borer or spotted lantern fly will be moving in.

Towns For the towns, the key concerns were the result of the unique nature of small town Massachusetts. Without a county government and limited tax revenue, towns depend on volunteers to run town operational services. The tree warden role is required by state law for all towns in Massachusetts, but this is an unfunded mandate. This limits the ability of tree wardens to perform the full duties outlined by law. Without essential documents such as a town tree

inventory, a Disaster Debris Management Plan, or a Tree Management Plan, the Northern Hilltowns are liable for damages incurred as a result of falling trees and may even miss out on crucial disaster relief aid.

Going Forward

We recommend three strategies to dealing with the concerns identified.

1. #### Ongoing Cooperation and Collaboration

   Continued collaboration between the power companies and municipalities regarding ROW maintenance. Further cooperation between Northern Hilltowns beyond the MVP grant writing process. Future Five College collaboration with the Northern Hilltowns could be a way to circumvent funding problems.

2. #### Grant Writing

   There are numerous, forestry specific grant opportunities available if the towns were interested in funding future projects. More information regarding the grant details can be found in our Discussion and Recommendations section.

3. #### Official Documentation

   We strongly recommend that the Northern Hilltowns create an official town tree inventory, a Disaster Debris Management Plan, and a Tree Management Plan. Thanks to climate change, in the coming years these plans will become more essential for swiftly handling forestry related issues.

Introduction

Project Origins

Our project began at the MVP Kickoff Meeting in Goshen on September 30. At that meeting, representatives from Chesterfield, Goshen, and Worthington all mentioned issues with

trees as part of local climate change impacts. In multiple towns, there were trees needing to be removed from power lines and away from utility boxes that were not being dealt with. Changes in season timing was hitting trees hard, particularly the sugar maples. Because of a recent pattern of droughts and floods, many trees were looking stressed. Susan Labrie from Chesterfield mentioned that the town had its first tree cap forest fire in 2016 because the trees were so dry. There were also concerns of invasive species entering the four towns. Specific tree species that were mentioned as dying or being stressed due to some factor included white pine, hemlock, ash, and sugar maple.[1]

At first, we were particularly interested in the issues surrounding sugar maple trees. New England as a region gets a not insignificant stream of revenue from fall tourism to see its trees (Dupigny-Giroux et al., 2018), and the sale of maple sugar products (National Agricultural Statistics Service, 2017) paired with increased traffic to sugar shacks in the spring.[2] If sugar maples were dying or not producing as much sap, this could have a real impact on the industry and the people who rely on it. We originally proposed to examine the damage done to sugar maples within the four Northern Hilltowns, and how that would impact the sugar shacks in the area monetarily as damage from climate change worsens over time.

After making our initial proposal to the class, as well as to Dano Weisbord from Smith and Corrin Meise-Munns from the Pioneer Valley Planning Commission, the feedback we received indicated that focusing on maple sugar was too narrow of an approach for this project. We realized that we needed to have a much wider angle in order to effectively help the Northern Hilltowns. As a result, we elected instead to explore issues of general tree health in the area. We

[1] See Kickoff Meeting notes in appendix
[2] See Jerry Mollison interview transcript in appendix

initially avoided a narrower focus within that, as we did not have enough of an understanding of the problem to make that sort of judgement. After interviews with multiple people, we decided to focus on trees within the public right of way, with an emphasis on maintenance and safety.

Current Climate Concerns

There is already a large body of research relating to forests and forest management in New England, from the whole landscape down to individual trees. Researchers have used a variety of methods to gain insight into the future of forests of New England. For example, one study used computer models informed by historical patterns to simulate different scenarios of land use change and to quantify their effect on the forests. The models generated detailed predictions of land-use change throughout New England. Relevant findings include a predicted 38% increase in low-density development in 50 years, as well as an expansion of protected land from 26% in 2010 to 59% in 2060. Carbon storage, an important ecosystem service, could actually increase in the long term, as climate change will lengthen the tree growing season (Duveneck and Thompson, 2019).

Other researchers have made predictions about the future by conducting interviews with people professionally involved with forest management in the public and private sectors. Some common themes relevant to the Hilltowns found in one study include an accelerating rate of land ownership transfer resulting from an aging population, the economic viability of maintaining private forest land, and a lack of political and social support for environmental management. Participants in the study also identified opportunities for achieving sustainable land use, which include proactive town planning, landowner incentives, and valuing ecosystem services (McBride et al., 2019). Although some of the trends and predictions in these studies may not

apply to the Hilltowns, changes in forest management across the region will still affect them. It is useful to take them into account when creating a climate adaptation plan.

There is extensive research on the effects of different forest management approaches. One article investigates the impact of salvage harvesting on ecosystems by analyzing multiple studies. Researchers simulated a large hurricane by pulling down trees, then harvested them in some areas and left them in others (Cooper-Ellis et al. 1999, cited by Foster and Orwig, 2006). They found that when downed trees were left where they had fallen, the disturbance to the ecosystem was reduced and the forest had a more diverse age composition (Foster and Orwig, 2006). Another study on the effects of the hemlock woolly adelgid found that when dead hemlocks were left in the forest, fewer invasive species were present years later. There were also lower rates of nitrate leaching in the soil, which can be harmful to water quality (Kizlinski et al. 2002, cited by Foster and Orwig, 2006). Of course, salvaging is necessary when fallen trees interfere with human infrastructure. However, this approach might be useful to municipalities when they are making decisions about fallen trees that don't directly impact people, or when they are approving logging permits.

Another study analyzed the effects of climate-suitable planting in forests. Climate-suitable planting is a way for foresters to introduce tree species that are adapted to warmer climates in order to prepare for climate change. This can be done through a "seedlot selection tool", which would allow foresters to find seedlots in climate zones that are similar to the projected future climate of their region. Computer models found that this would lead to increased species diversity and biomass in forests as climate changed. However, there is a risk that these introduced trees could damage native species (Duveneck and Scheller, 2015).

These studies are just examples of the work that is being done in the field of forest management. Our project seeks to identify strengths and areas of need in the management of local trees in the Hilltowns, while keeping these larger trends in mind.

Methods

Literature review

When selecting articles for our literature review, we looked for studies that were specific to New England, and that had a forest management perspective in some way. We chose studies that analyzed larger time and spatial scales to complement the information we gathered from experts that was specific to the Northern Hilltowns. We felt that this would help us place what we learned in a broader context. Finally, we tried to find a variety of research methods, including computer models, stakeholder interviews, and biological studies.

Tree Warden interviews

Massachusetts General Law mandates that all towns and cities in Massachusetts must have a tree warden. Whoever holds this position oversees maintaining, monitoring, and removal of any tree located on public lands. In the best cases, the tree warden is full time, expert arborist. Unfortunately for the tree wardens in small towns, the job is unpaid and often held by people uninterested in the position. In 1996, an amendment made to the original 1899 law required that all appointed tree wardens meet certain qualification standards. A 1999 recommendation, which outlined the qualification requirements for tree wardens, does not apply to towns with a population of fewer than 10,000. Therefore, in the Northern Hilltowns, a tree warden does not need to have any relevant qualifications to hold the position. Despite these circumstances, many

small towns do have dedicated tree wardens. We felt it was crucial to meet with the tree wardens of the Northern Hilltowns to better understand what risks were already identified.

As of December 2019, the current tree wardens are:

Chesterfield	Cummington	Goshen	Worthington
JB Lynch	Alan Taylor	Bob Goss	Ben Brown
treemanjb@yahoo.com	413-634-8818	hillwoodfarm@yahoo.com	benbrownwindsors@gmail.com

When speaking with the tree wardens, we used these questions to guide our interview:

1. How did you become the tree warden and how long have you had this position?
2. What does your formal arborist training experience look like, if any?
3. What are your day to day duties?
4. What is your annual budget?
5. Do you frequently hire contractors to do tree management work? If so, who do you primarily work with?
6. What do you consider the primary threat in the area? Some examples of threats include:
    a. Diseases
    b. Pests
    c. Weather
7. Tree database access? How many trees are you responsible for? Where are these trees located?
8. How often do you have to deal with regular maintenance versus emergency tree removal?
9. How often does the public contact you about problems?[3]

Expert Interviews

In addition to the tree wardens, we spoke to multiple experts in the Western Massachusetts region. These individuals ranged from state government employees to academics

[3] See Bob Goss Interview notes, J.B. Lynch interview notes, and Ben Brown interview transcript in appendix

within the Five Colleges. Initially, we conducted our search for experts in a purposefully loose, unstructured manner. To begin, we spoke to Larry Holmberg, the Emergency Management Director of Goshen and Chesterfield, and Benjamin Green, the Chief Arborist at the Smith College Botanic Garden. Rather than following a strict interview question format, we mostly introduced our research project and asked them for any information they felt would be pertinent. We then asked them who else they felt we should be talking to and contacted those people to repeat the process. Over the course of the semester, we spoke to the following people:

- Mollie Freilicher, Community Action Forester at the Massachusetts Department of Conservation and Recreation (MA DCR)
- Nicole Keleher, Forest Health Program Director at the MA DCR's Bureau of Forest Fire Control and Forestry
- Brian Kane, Professor of Commercial Arboriculture at the UMass Amherst Department of Environmental Conservation
- Alan Snow, the Tree Warden for the Town of Amherst
- Rob Dextraze, Assistant Tree Warden for the Town of Cummington
- The Cummington Conservation Commission

In most interviews, we elected to maintain a conversational tone with experts. We wanted to encourage them to share information that we had not necessarily thought to ask about. The typical interview began with a question about their title, expertise, and duties in their job, and an explanation of our project and the MVP process. From there we probed further into subjects that came up organically, asking the expert to expand on specific points that we found particularly relevant.

In keeping with the spirit of our original proposed project, we also wanted to talk to sugar shack owners within the four Northern Hilltowns to discern if they had noticed changes in their sugar maples and if it had affected their businesses at all. Unfortunately, due to our inquiries being in the off-season for maple sugar we were only able to interview one sugar shack owner,

Jerry Mollison from Windy Hill Farm in Worthington. We used the following questions to guide our interview:

1. How long have you been running the business and how did you get into it?
2. Approximately how many trees do you have on your property?
3. Are there any diseases or problems with your trees that you have seen in the past?
4. Have you noticed any changes in weather affecting your tapping season or anything else?

Because we were only able to interview Mr. Mollison, we believe it is critical to get in contact with other sugar shack owners to see their perspective on this issue.[4]

Resident Interviews

Interviews with Northern Hilltowns residents were conducted to get information about what, regarding the forests, has caught the untrained eye. Residents of the Hilltowns live there for its rural character and that includes the vast forests that the town was built within. We visited The Old Creamery Co-op in Cummington on a Saturday afternoon to get resident's perspective. While there, we spoke to five residents.

The questions we used during our interviews were written following our interviews with experts and the local tree wardens. Using the information gained from those interviews, we wrote these questions to guide our resident interviews.[5]

1. Where do you live? (which town)
2. Do you own property with forest?
3. Have you noticed trees falling on roads, buildings, etc.?
    a. How long did it take to get removed?
    b. How did it affect you?

[4] See Jerry Mollison interview transcript in appendix
[5] See Old Creamery Coop Interviews in appendix

4. Is there anything related to forests you would want your town to be doing if money wasn't an issue?
5. Do you, or your friends or neighbors work in a tree-related industry? E.g. logging, sugaring
6. Have you noticed any obvious sick or damaged trees?
7. Have you noticed any changes in weather or seasons, and how does this affect you if at all?
8. When there is a storm do you usually lose power?
    a. When was the last time you remember losing power? How long did it take for the power to come back on? How does this affect you?

Our Findings

Tree Wardens

Common themes in all of the tree warden interviews included the impact of road salt on sugar maples and the limited budget and resources available for tree removals. With the exception of Goshen, none of the towns have a tree inventory. We also found that the tree wardens are limited by money, with yearly budgets ranging from $5000 to $10,000. According to Bob Goss, the tree warden of Goshen, his yearly budget can pay for two men, a truck, and a wood chipper for 4 days.[6] Clearly this makes doing maintenance difficult and planting new trees almost impossible. Because tree warden is a volunteer position, they are also limited by time. All of the tree wardens work full time jobs with the exception of Bob Goss who is retired. Because of these limitations, the tree wardens all rely on the power companies to perform maintenance and to remove dead trees.[7]

We also found that there is no official tree inventory for any of the Hilltowns. A tree inventory is an assessment of the trees on public lands. There are two basic approaches: top

[6] See Bob Goss interview notes in appendix
[7] See Bob Goss Interview notes, J.B. Lynch interview notes, and Ben Brown interview transcript in appendix

down, using satellite imagery, or bottom-up, using data collected by people on the ground. See Figures 1 and 2 for an example of this from the town of Amherst. Out of the four towns, Goshen is the only one that has a tree inventory. Bob Goss, the tree warden, keeps a notebook where he records information about all of the trees (see Figure 3). He regularly drives around town and updates it with their condition.[8]

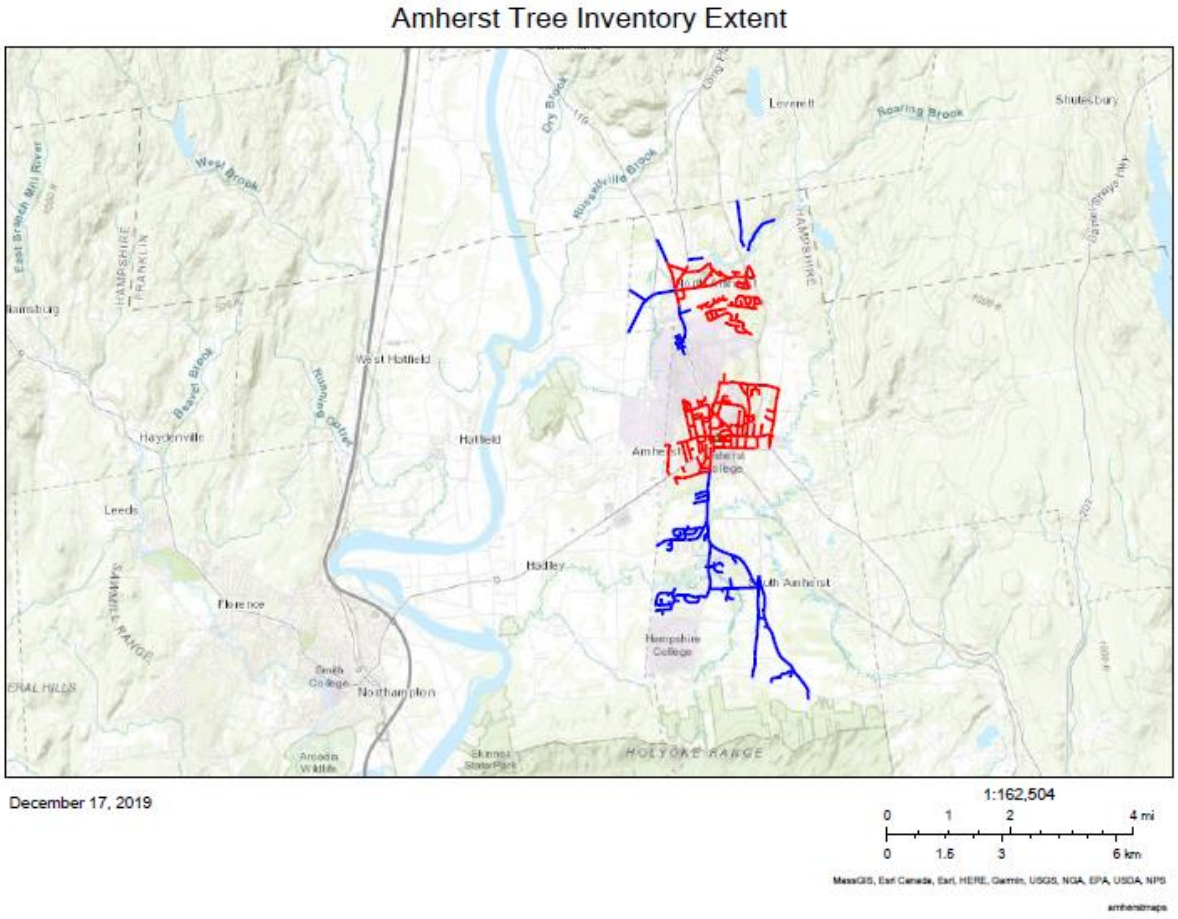


Figure 1. Tree inventory map for the town of Amherst, MA, available on the municipal website. Red lines indicate streets where the trees were inventoried in 2010, and blue lines indicate streets that were surveyed in 2012.

[8] See Bob Goss interview notes in appendix

DAVEY

Amherst, MA

Quantity Report: Botanical

Botanical	*Total*	*Percentage of Entire Population*
Acer saccharum (maple, sugar)	486	17.45%
Acer platanoides (maple, Norway)	319	11.45%
Acer rubrum (maple, red)	275	9.87%
Picea abies (spruce, Norway)	162	5.82%
Ulmus americana (elm, American)	132	4.74%
Quercus rubra (oak, northern red)	128	4.60%
Pinus strobus (pine, eastern white)	128	4.60%
Prunus serotina (cherry, black)	109	3.91%
Picea pungens (spruce, Colorado)	100	3.59%
Fraxinus pennsylvanica (ash, green)	90	3.23%
Quercus palustris (oak, pin)	89	3.20%
Tsuga candensis (hemlock, eastern)	88	3.16%
Malus spp. (crabapple, flowering)	87	3.12%
Tilia cordata (linden, littleleaf)	53	1.90%

Figure 2. Excerpt from the tree inventory report for the town of Amherst, MA, found on the city website.

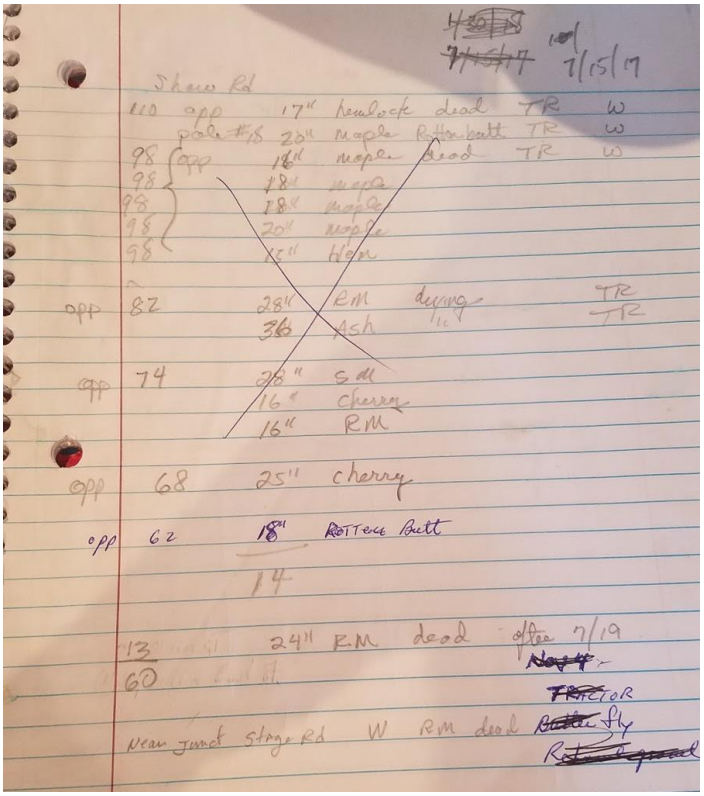


Figure 3. Excerpt from the notebook of Bob Goss, the tree warden of Goshen, MA, showing data he collects on municipal trees.

Power Outages

National Grid and Eversource provide some support for maintaining the right of way (ROW). Figures 3 and 4 demonstrate the area of Chesterfield and Cummington that Eversource have included in their 2018-2019 operational plan.

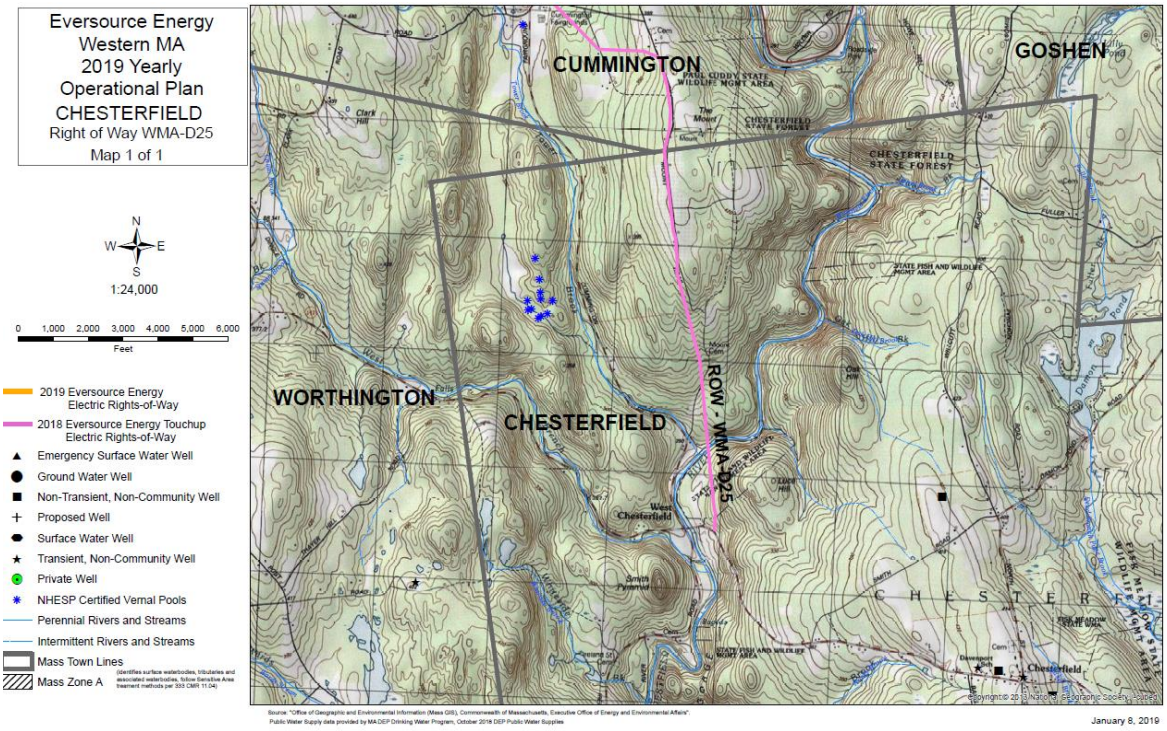


Figure 4. *Eversource Energy Operational Plan for Chesterfield, MA from 2019. Blue dots indicate areas where right of way herbicide spraying was planned.*

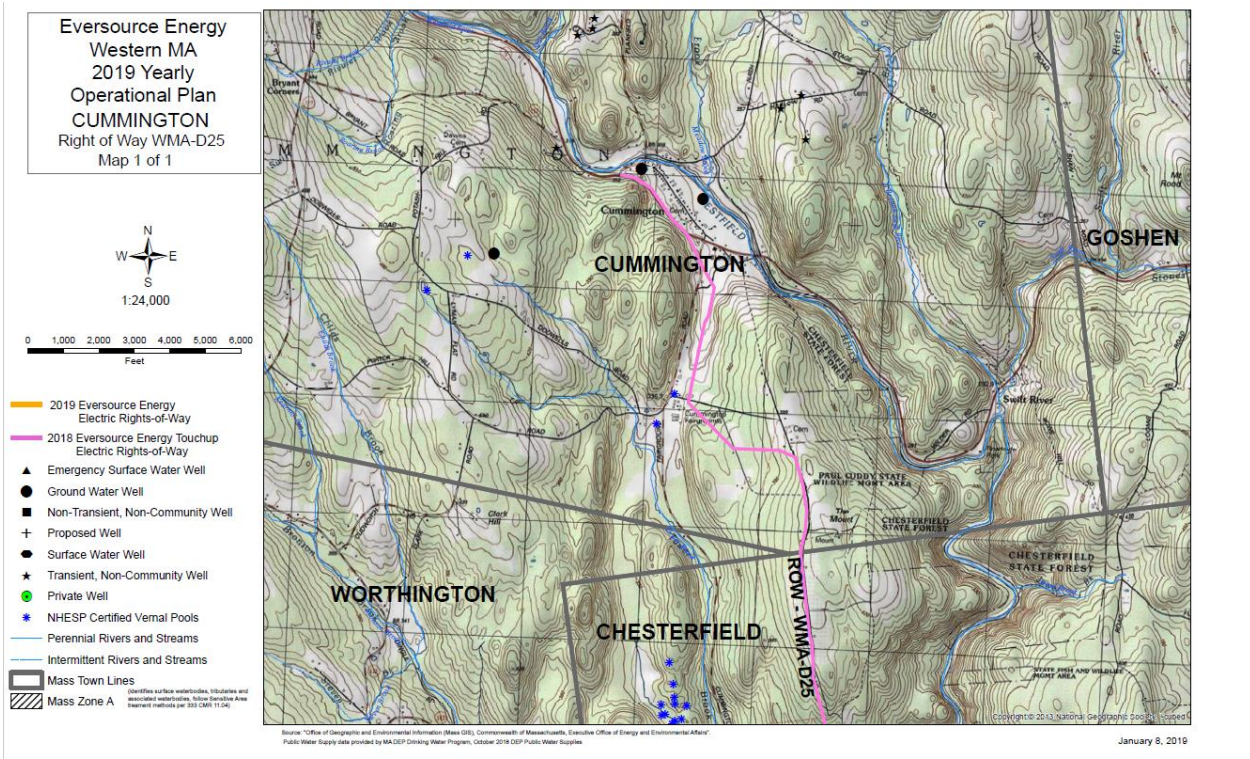


Figure 5. *Eversource Energy Operational Plan for Cummington, MA from 2019. Blue dots indicate areas where right of way herbicide spraying was planned.*

These locations have been targeted for herbicide treatment as part of a larger vegetation management plan (Eversource, 2019). A map for Worthington is not available. National Grid does not provide town specific operational plans, so it is unclear if they are planning to treat any portion of Goshen's ROW (National Grid, 2019). Generally, residents are pleased by the work that Eversource and National Grid perform, but all five residents we spoke to at the Old Creamery Co-op in Cummington said that they had experienced at least one power outage in the last month.[9] Severe weather events and tree debris are major contributors to power outages. Improperly maintained ROWs increase the incidence of tree caused power outages. As mentioned in the above section, due to limited time on the part of the Hilltown tree wardens,

[9] See Old Creamery Coop Interviews in appendix

their ROW maintenance is limited to triage and they are highly dependent on the electricity companies for tree removal support.

Debris Management Plan

Within the Hilltowns, most woody debris are collected by residents for firewood. In cases of extreme weather events such as ice storms or hurricanes, more debris than can be collected by the town is produced. The Federal Emergency Management Agency (FEMA), MassDEP and MEMA all recommend that towns have an official Debris Management Plan (DMP) (FEMA P604, 2009; Mass DEP, 2014; FEMA-325, 2019). A DMP should be "a comprehensive [document that] incorporate[s] best practices in debris removal, reflect[s] FEMA eligibility criteria, and tailored to the specific needs and unique circumstances of each applicant" (FEMA P604, 2009; FEMA-325, 2019). For towns to receive the maximum amount of FEMA assistance, they must have a DMP that meets FEMA guidelines.

Liability

In all the Northern Hilltowns, we were unable to find an official Tree Management Plan. Such a plan is based off an inventory of the trees in the public right of way and is critical to protect the towns from potential liability in case of damage from tree failure. This document usually outlines which areas of the town are a priority for maintenance, how often specific roads will be checked for tree health status and details a systematic plan for dealing with diseased or otherwise failing trees. Without such a document, the town cannot prove that they are reasonably taking care of tree maintenance in the right of way and are liable for damages if a tree falls on a person, cars, or other property.[10]

[10] See Larry Holmberg interview notes in appendix

Road Salt and Maple Sugar

Sugar maple trees are particularly sensitive to salinity in the soil. This makes them vulnerable near roads where salt is used during the winter. Because of increased precipitation with the onset of climate change, more salt from the road is leaching into the ground than before. As a result, sugar maples near roadways are dying.[11]

Discussion and Recommendations

Goals

We identified three principles that informed the recommendations we are suggesting. Each recommendation combines aspects of two or more principles to create meaningful deliverables which can be used regardless of MVP status.

Public Safety & Risk Mitigation

A priority for all municipalities. Any recommendations offered should improve overall public safety and wellbeing.

Informed & Active Citizens

Citizens that are well educated on an issue are in the best position to make decisions regarding that issue. Climate change (specifically the future of tree health) is complicated, so any recommendation should serve to educate residents.

Community Resilience Building

Increasing the ability of a town to bounce back from climate change caused disruptions. The Northern Hilltowns have a unique opportunity to work together to strengthen their ability to adapt to new and old challenges.

Tree inventory

As previously stated, none of the Northern Hilltowns have a publicly available tree inventory. One of our top recommendations is that the governments of the Hilltowns organize a

[11] See Bob Goss interview notes, Brian Kane interview transcript, and JB Lynch interview notes in appendix

tree inventory, either individually or as a group. We believe that this is an attainable goal that could be accomplished with the help of volunteers. It could also be another opportunity for the Hilltowns to collaborate with the Five Colleges, as they could be a source of expertise and volunteers.

The project could start with the identification of high priority areas, such as the town centers, which would then be inventoried first. There are also ways to randomly sample parts of the towns and then generalize the results. By using one of these methods, the Hilltowns would get the information they need most in the least amount of time. We recommend conducting a bottom-up tree inventory using iTree Eco. This free program only requires the collection of a few simple data points, such as diameter at breast height (DBH), and species. The inventory can also be expanded to record land use, tree condition, and other variables. Volunteers could work with arborists or other community members with tree expertise to collect data on the trees in a selected area. The information can be recorded on a smartphone or a paper form. In the case of Goshen, much of this data has already been collected. The data would then need to be entered in iTree, another task that could be accomplished by volunteers. The program generates a summary report. A more detailed description of the iTree software can be found in the Resources section of this report.

There are numerous benefits to having an updated tree inventory for each town. The first is that it allows tree wardens and other officials to create a management plan for public trees. Using the report generated by a tree inventory, which gives information on tree size, species, and condition, officials can determine areas of their towns that need more monitoring and maintenance. Although many of the tree wardens probably have a good sense of this already, it is important for it to be in the form of an official document. One reason is that it protects the town

from liability if a tree or branch falls and causes damage or injury.[12] Furthermore, it would make the transition between tree wardens smoother if there was an easily accessible management plan in place.

Another benefit to having a tree inventory is that it informs future decision-making. By knowing which trees are growing where, officials can more easily identify areas of need and opportunities for planting (Department of Public Works, n.d.). They will also have a concrete sense of the benefits of local trees, as iTree Eco reports detail ecosystem services down to their dollar value in some cases. This will help officials to weigh the benefits of preserving or adding to the urban forest versus developing land for other uses. In the longer term, a tree inventory will help with climate change adaptation and mitigation. It is already known that certain species of trees are more vulnerable to the effects of climate change, so a report that maps out where different species of trees are in a town is hugely beneficial. For example, sugar maples have been found to be particularly vulnerable to road salt, and more road salt will need to be used as weather patterns change.[13] With a tree inventory, officials would know where there are sugar maples growing near the road, and therefore would be able to focus their maintenance in those areas. Another important aspect of climate change adaptation is resilient tree planting. A tree inventory would allow tree wardens and others to vary the tree species and genera they planted in the same area, making the landscape more resilient to pests and diseases.[14]

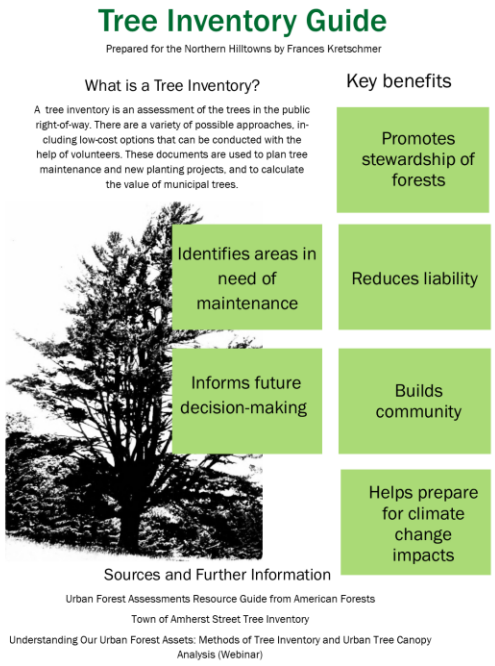
Finally, the tree inventory process has the potential to promote community engagement and stewardship of forests. When we interviewed residents of the Hilltowns, many of them

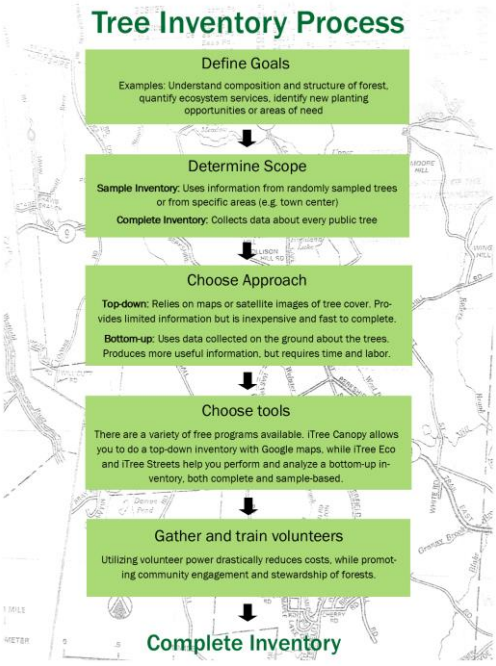
[12] See Mollie Freilicher interview transcript in appendix
[13] See Bob Goss interview notes, Brian Kane interview transcript, and JB Lynch interview notes in appendix
[14] See Brian Kane interview transcript in appendix

expressed their interest in and appreciation for the local forests. For some of the people we talked to, this was part of why they had moved to the area.[15] We believe that people would be interested in learning how to identify trees and help with the tree inventory. Aside from making the town's tree inventory easier, involving volunteers could improve tree management overall. Most of the forested land is privately owned, so it is critically important that residents are informed on this topic. Volunteers who help with the tree inventory process would then have the knowledge to conduct an inventory of the trees on their own land. In general, community engagement and participation is necessary for any climate adaptation plan to succeed.

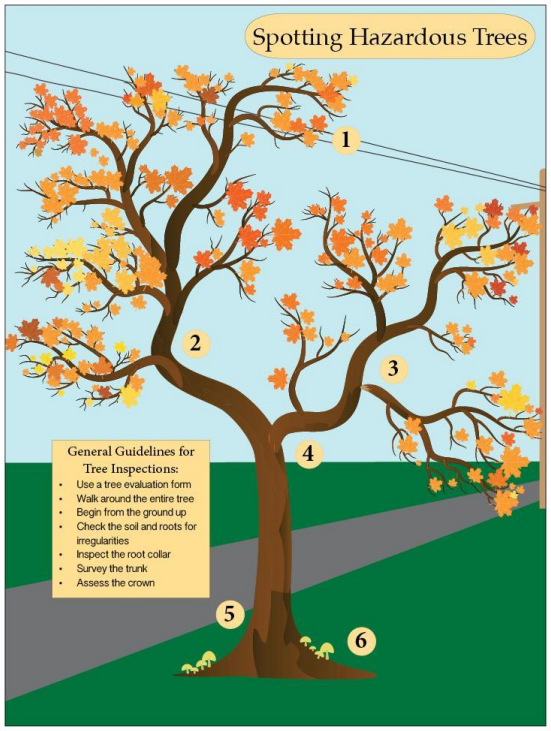
We designed a flier aimed at Hilltown officials that summarizes this information and details how to conduct a tree inventory. The front page explains what a tree inventory is, summarizes the benefits, and provides sources where they can learn more. The back side is a flow chart that explains the process, as well as some of the different approaches and options. We hope that this will be useful if the towns decide to go forward with a tree inventory, whether it is part of the MVP process or not.

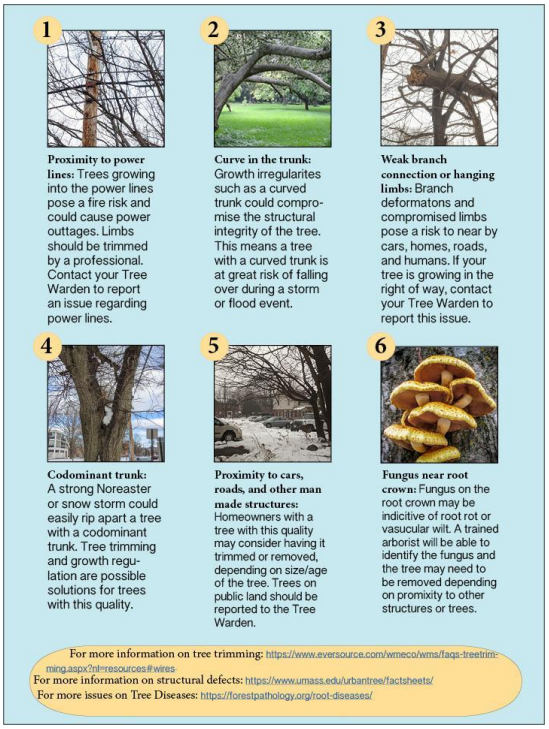
[15] See Old Creamery Coop Interviews in appendix





Hazard Identification





All trees pose a certain amount of risk but not all trees are hazards. This means that there is the possibility of an undesired outcome (such as limb failure), but that outcome is not inevitable. Tree hazards refer to any potential failure caused by a structural defect in the tree which may result in injury to humans or property damage (Indiana Forestry, n.d.). As a by-product of our first and second recommendation principles, we felt it was important to create a resource for private landowners to educate themselves on common tree hazards. This guide can be used to spot hazardous trees on their own land. In all four Northern Hilltowns, 80% or more of the town is forested (Goshen Hazard Mitigation Committee, 2016; The Chesterfield Hazard Mitigation Planning Committee, 2017; The Cummington Natural Hazards Mitigation Planning Committee, 2017; The Worthington Natural Hazards Mitigation Planning Committee, 2010). A majority of this land is privately owned which means the tree warden is not responsible for damaged, fallen, or diseased trees on this land. Homeowners must take responsibility for risk mitigation. Therefore, it is crucial that all landowners are educated on what the most common tree hazards are, and what to do about managing them.

The front page depicts a maple tree with various structural defects marked by numbers. Each number corresponds to a visual on the back page. These common tree defects are explained with more detail and there are guides on what to do and who to contact depending on the location of the tree. Any tree within the public right of way with a hazard should be reported to the tree warden and to the power company if it poses a risk to electrical lines. For more detailed information about these hazards, there are external links included at the bottom of the back page. Downloadable PDF copies of this infographic should be available in the appendix and on your town website.

Community Collaboration

As part of our recommendations, we want to stress both a need and an opportunity to increase collaboration in the Northern Hilltowns, both between the towns themselves and with outside resources. With that in mind, we have come up with multiple opportunities for collaboration to potentially occur in the future. We wanted to briefly mention that, in addition to these opportunities, our interview with Jerry Mollison from Windy Hill Farm indicated a potential opportunity for students interested in staying in the region and becoming involved with maple sugar, arboriculture, or agriculture. Students that fit this profile could possibly train with or apprentice under older farmers or sugar shack owners, with the idea being that they could take over the business when the original proprietor retires.[16]

The tree inventory, rather than being another task handed over to just the tree wardens, can be accomplished with volunteer power both from the towns and from outside locations like UMass or other of the Five Colleges. Such a setup is completely feasible in this context. Our interviews with residents indicate that many people are interested in learning more about trees in their area and helping to protect them.[17] Tapping into that enthusiasm can make the work of creating a tree inventory much easier and bring residents from several of the towns together.

A debris management plan is a clear opportunity to really promote cooperation between the governments of the four Northern Hilltowns. Such a plan is too resource heavy to expect each Northern Hilltown to create one on their own, so a joint plan is critical. Franklin County has approved a plan to set up a county-wide debris management operation, and that document can serve as a template for the Northern Hilltowns moving forward. It is important to note, however, that Franklin County's plan has still not been implemented, as the individual towns have not

[16]See Jerry Mollison interview transcript in appendix
[17] See Old Creamery Coop Interviews in appendix

signed off on their roles such as housing all the debris from the other towns.[18] With the Northern Hilltowns, there is an opportunity to avoid a similar pitfall by having all the town governments explicitly collaborate from the outset. This would allow a plan to be implemented instead of just staying on paper.

We also think that a joint debris management plan might be a good project for a future ENV 312/ENX 301 collaboration, if the two classes were to end up combining again. Students could do research on previous municipal debris management plans, emphasizing ones where multiple municipalities worked together. They could work with the four towns to understand their individual needs and constraints and assist in getting the town governments to really work together on a joint plan. If an ENV 312/ENX 301 partnership does not occur, this could also be an opportunity for an interesting Special Studies.

In addition to the grant money potentially available through the MVP process, we have compiled a list of grants tailored specifically to forestry and forest projects. Receiving these grants will take time and effort to fill out the applications and file paperwork. This too could be an opportunity for a Special Studies, if a student was interested in learning more about the grant proposal process. Having the work be through an academic project would also relieve stress from the towns and the tree wardens, who are already stretched for time as it is.

Grants

The following grants were compiled as potential alternative resources for tree wardens and other town officials to consider in the long run. The grant information includes links to find

[18] See Larry Holmberg interview notes in appendix

out more about each grant. Each heading contains an embedded link to the grant program website. Follow the links for more information about qualifications, deadlines, and how to apply.

NGO Grants

Cedar Tree Foundation:
Provides grants to municipalities and organizations for forest conservation projects and sustainable agriculture programs.

Federal Grants

Forest Legacy Program: This is a grant for private landowners to either sell their land or to enter a conservation easement, in which they retain ownership over the property but give up development rights. The program targets "environmentally important forest areas that are threatened by conversion to non-forest uses (Forest Service website)." Applications are managed through the state, which has instructions for how to apply on their website.

Conservation Innovation Grants: Both public and private entities can apply for this grant and it funds projects that are up to three years long. The natural resource concerns that are prioritized change over the years, but tend to be agriculture-focused.

Acer Access and Development Program: Grant aimed at research institutions. This grant funds the promotion of sugaring activities. This grant could be awarded to one of the Five Colleges as a larger project aimed at supporting the maple sugar industry in the pioneer valley and the Hilltowns.

State Grants

Urban and Community Forestry Challenge Grants:
These are 50/50 matching grants for creating and/or sustaining programs that, "plant, protect and maintain a community's public tree resources and develop partnerships with residents and community institutions." Developing and implementing a Tree Management Plan through conducting a Tree Inventory is one of the example projects. Local tree departments are explicitly encouraged to apply for this grant.

Community Forest Grant Program: This program awards grant funding to establish Community Forests through purchase of private forest land

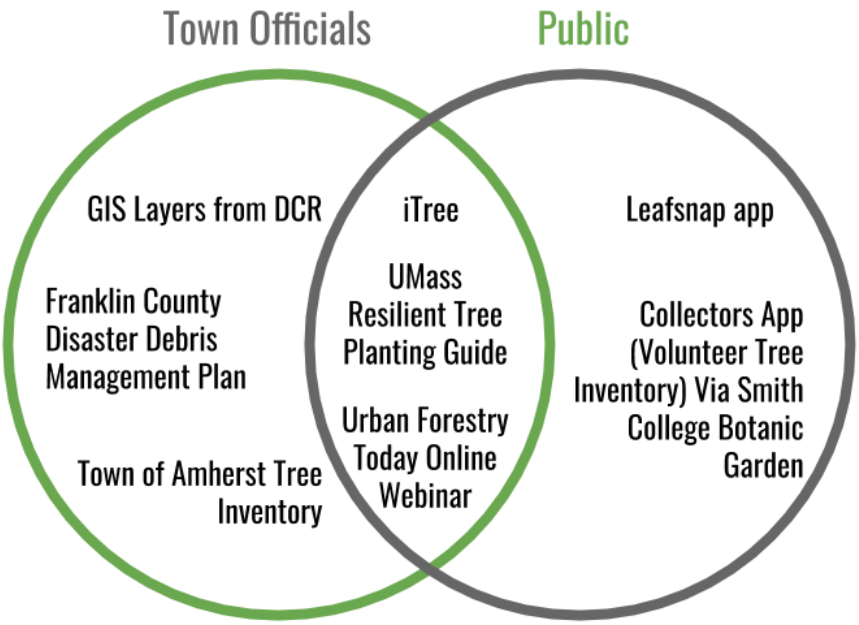
Urban and Community Forestry National Grid Partnership Challenge Grants: Municipalities in which National Grid has completed their ACT Reliability Improvement Program are eligible for matching grants to promote "community tree replacement planting and building local capacity for excellent urban and community forestry." Forestry Management Plans are specifically cited as an example of uses for this grant.

Urban and Community Forestry Eversource Go Green Grants: Municipalities within Eversource's service territory are also eligible for matching grants to promote "community tree planting and building local capacity for excellent urban and community forestry." Tree Management Plans are a listed example of an appropriate project

Reference Resources

Throughout the research process, we identified a number of websites, applications, reports, and webinars which contain valuable information for those interested in learning more

about the topic of urban forestry and land stewardship. Many of the residents we spoke to were interested in getting involved and felt passionately about trees, but were unsure how to approach the issue. The general agreement among residents interviewed was that they loved the forest, but did not feel informed enough to speak to the issue. We believe that one solution was to provide a collated list of relevant reference resources that both town officials and residents could use to better approach the issue. As mentioned in our goals, the success of any municipal project depends on having informed and active citizens.



UMass Resilient Tree Planting Guide: "Planting for Resilience: Selecting Urban Trees in Massachusetts" is a guide released by UMass Amherst written by graduate researcher Ashley McElhinney. It is intended to help tree wardens, urban foresters, professional arborists, nonprofit volunteers, and private residents choose and plant appropriate trees within Massachusetts. The guide contains characteristics of trees such as height, pest vulnerability, and other factors. It also contains a list of trees to be excluded due to either their invasive or potentially invasive nature within the region. The overall goal of the document is to provide localized, updated information on tree planting and forestry in the face of climate change in the state.

Franklin County Disaster Debris Management Plan:
We recommend establishing a Disaster Debris Management Plan (DDMP) between the four Northern Hilltowns as a way of reducing the financial burden of writing and executing such a plan. Another regional DDMP has been accepted in Franklin County. Using their DDMP as a guide may make the process of writing and executing a DDMP simpler.

iTree: iTree is a set of free software programs developed by the USDA Forest Service and several collaborators for forestry analysis. The two tools most potentially useful to the Hilltowns are iTree Eco and iTree Canopy. iTree Eco analyzes data from a bottom-up inventory, where people on the ground collect information about trees. The minimum data needed is DBH (diameter at breast height) and species for a complete inventory, plus percent measured and percent tree cover for a sample inventory. However, there are also options to collect
more information such as tree height, land use, and GPS coordinates. It comes with paper forms and a mobile website for data collection. The program then generates a tree inventory report, which details forest composition and structure, as well as benefits such as carbon storage, pollution removal, and structural value. There is also the option to run models that predict things like tree die-off. iTree Canopy lets you conduct a top-down tree inventory using Google Maps satellite imagery. It works by selecting random locations, then prompting the user to categorize them by land cover. The program generates a report estimating urban forest benefits, however it is less detailed and accurate than the information that iTree Eco generates.Finally, MyTree works on a smaller scale to assess the benefits of individual trees using similar data as iTree Eco. This resource could be used by residents to assess trees on their property.

Urban Forestry Today Online Lectures and Video Archives:
The Urban Forestry Today Webcast Series is sponsored by the University of Massachusetts Department of Environmental Conservation, in cooperation with the USDA Forest Service, Massachusetts Department of Conservation and Recreation, University of Massachusetts Extension, and Massachusetts Tree Wardens' & Foresters' Association. Lectures are taught by various experts are also available on the website. They cover a wide array of subjects including debris, pest control, GIS tutorials, climate change, pruning, and more. These lectures are curated by UMass Amherst Extension Associate Professor Rick Harper, who is a specialist in Community Forestry and Urban Landscaping.

Town of Amherst Tree Inventory: The town of Amherst has already inventoried a large portion of their public trees, and their reports are a useful reference for the Hilltowns. There are interactive maps available online in addition to a Partial Urban Forest Status Report published in 2011. This is an example of a tree inventory that did not analyze every tree in the town, but instead focused on high priority areas such as the town center.

GIS Layers from DCR: These GIS layers include information about forest health, and are used to determine areas that should be prioritized for community forestry grants. This could be an opportunity to collaborate with someone from Smith or one of the other Five Colleges, which all have subscriptions to ArcGIS. Many students are looking to gain experience using this software. Someone could potentially take on the project of creating maps to help the Hilltowns analyze their surrounding forests and to strengthen their grant applications. Layer Download Link.

Leafsnap app: "Leafsnap: An Electronic Field Guide" is a series of free mobile apps being developed by researchers at Columbia University, the University of Maryland, and the Smithsonian Institution. It uses visual recognition software to determine a tree species from a photo of a leaf and provide information about the species to interested members of the public. Currently, the apps cover trees in the Northeastern United States and Canada with a separate app for the United Kingdom.

Collectors App (Volunteer Tree Inventory):
Polly Ryan is the Manager of Special Projects at The Botanic Garden of Smith College. She is also a member of the Plainfield Tree Alliance. Ryan has created an app which allows for mobile tree data collection. The Collectors App could be used during a tree inventory and would expedite the digitization process. Currently this app is not publically available, but the Plainfield Tree Alliance is interested in sharing their resources with other Hilltowns.

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