

"A GREEN OASIS"

A CLIMATE RESILIENT MASTER PLAN FOR THE ASHUELOT RIVER PARK ARBORETUM AND RACHEL MARSHALL OUTDOOR LEARNING LABORATORY



PREPARED FOR: THE CITY OF KEENE

Ashuelot River Park

312 Washington Street, Keene, NH 03431

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The Conway School
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the **Conway** School
Graduate Program in Sustainable
Landscape Planning + Design



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INTRODUCTION TO THE PROJECT

Located in the heart of downtown Keene, the Ashuelot River Park is beloved by many visitors. The park contains an arboretum, which consists of diverse garden beds and over 95 different species of trees, and an outdoor learning lab. As the impacts of climate change escalate the City of Keene asks, is the Ashuelot River Park thriving, is the park resilient, and how will features of the park change in the future?

Primary Goals

This master plan assesses the ecological resilience of the Ashuelot River Park Arboretum and Rachel Marshall Outdoor Learning Laboratory (referred to as RMOLL). This assessment involves examining the current ecosystem services that the park provides and identifies weaknesses in the landscape performance. This master plan:

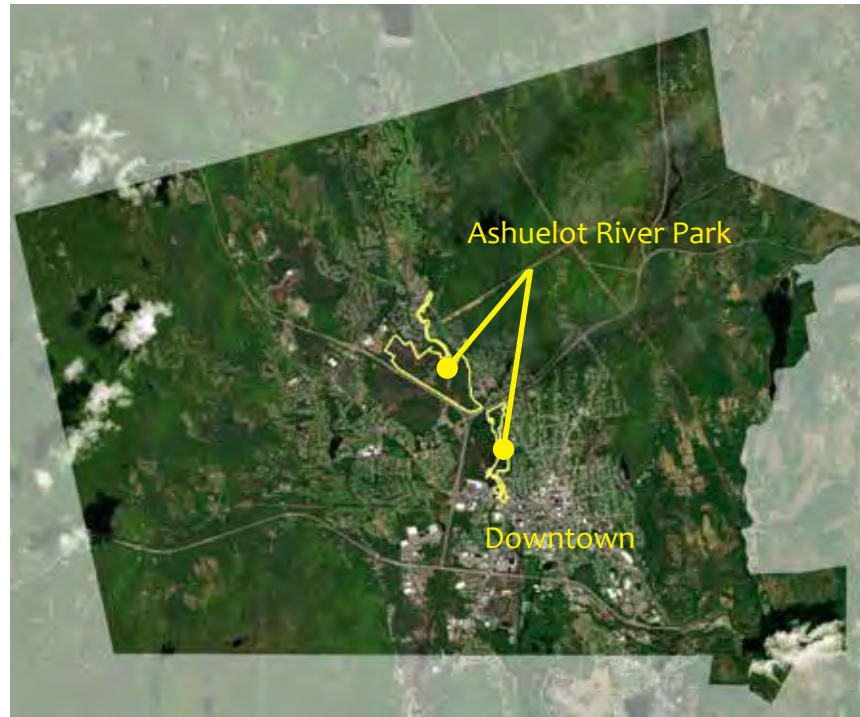
- Conducts an ecological analysis to identify ecosystem services provide by the park and the resilience of the park to the impacts of climate change.
- Identifies educational opportunities within the park.
- Assesses effectiveness of current park maintenance.
- Inventories plants and garden beds within the arboretum.
- Recommends plant palettes that increase native vegetation and biodiversity.

Secondary Goals

- Increases diversity of seating within the park.
- Proposes an invasive species management plan.
- Explores options for replacing the existing composting toilet.



The main pillars to achieve a resilient park include fostering community engagement and social equity, improving the ecological services already provided by the park, and planning for climate change.



The Ashuelot River Park is located in the center of Keene.



CLIENT

City of Keene
 Represented by: Andy Bohannon
 Parks, Recreation and Facilities Director

STAKEHOLDERS

Ashuelot River Park Advisory Board
 Friends of the Ashuelot River Park

While Ashuelot River Park is over 175 acres, this plan focuses on 5 acres closest to downtown. This area of focus includes an Arboretum east of the Ashuelot River and the RMOLL. A pedestrian bridge over the river connects these two spaces. The Arboretum also provides access to the Jonathan Myrick Daniels Trail extending to the north.

Both the Arboretum and the RMOLL were founded with a desire to create local access to both educational green spaces. The RMOLL in particular was intended to provide a place for the community to learn about its cultural and ecological heritage and to become caretakers of the land in the park, in Keene, and throughout the Monadnock Region. Over the years, active programming and volunteer involvement in both the arboretum and RMOLL have dwindled. There is a growing momentum to revitalize educational opportunities in the park, including the recent addition of bat houses and educational signs about them.



The 175 acre Ashuelot River Park encompasses multiple parcels. The area of focus for this master plan is located at the southern most portion of the park.



The area of focus for this master plan includes the arboretum and RMOLL.

PUBLIC OUTREACH

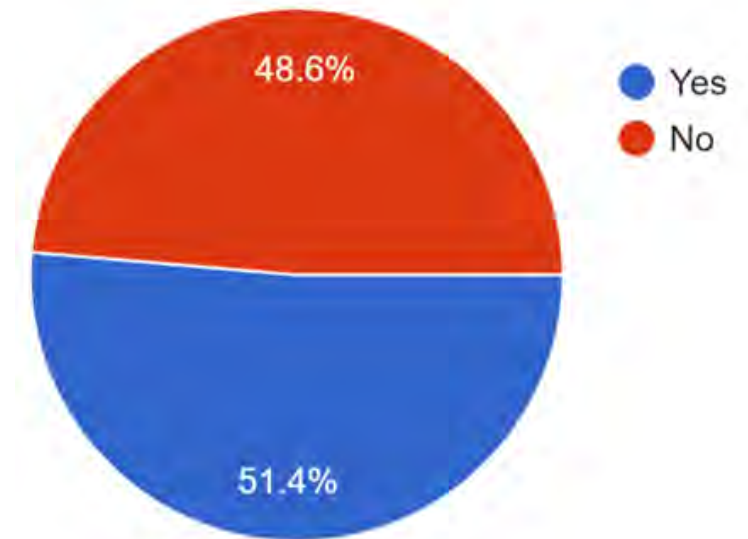
Two community meetings were held on May 5 and June 2, 2020 to gain input from stakeholders, organizations, and frequent park visitors to inform and guide the planning process.

The first community meeting, held May 5, 2020, via Zoom, had eleven attendees from the Ashuelot River Advisory Committee and Friends of Ashuelot River Park. This meeting was mainly used to collect information about features in the Arboretum and RMOLL that work well and those that do not work well, how attendees define resilience, and use of the Arboretum and RMOLL. Participants mentioned the need for refurbishing and new plantings in some of the garden beds, discouraging inappropriate activities by visitors such as smoking, and developing educational opportunities that are accessible and interactive. In discussing resilience, participants generally were concerned about the impacts of climate change on the park and expressed the need to increase community participation in the planning process, increase awareness of the Arboretum, and envision a future for the park.

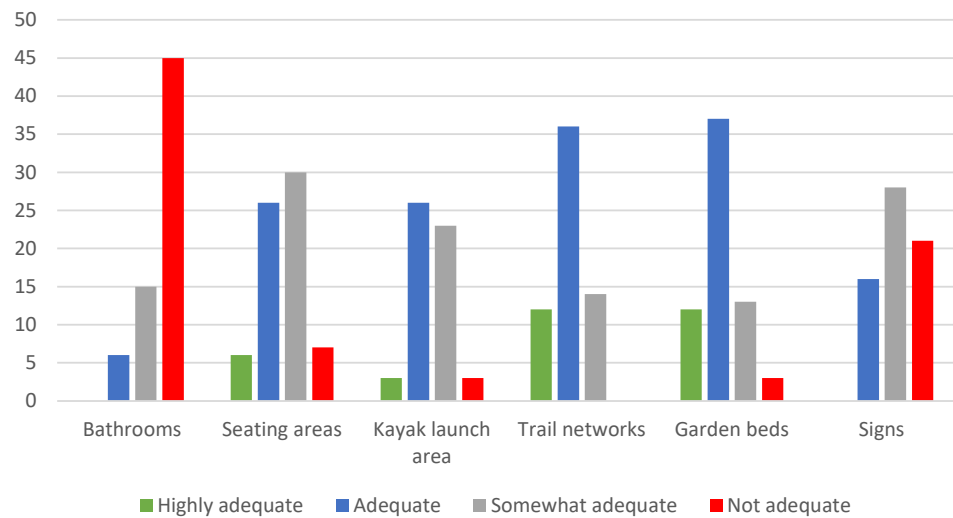
The second community meeting was held June 2, 2020, via Zoom with eight attendees, most of whom had attended the first meeting. Three different design alternatives were presented (see design alternatives on sheet 24) and participants shared feedback on what they liked, what they did not like, and how elements of each design could be refined and integrated into a final design.

The online survey was administered from May 29 to June 18, 2020 and received 75 responses. Questions pertained to the quality and accessibility of resources and facilities in the Arboretum and RMOLL, how the Arboretum and RMOLL are currently used, climate related concerns, social concerns including safety and unwanted behaviors, and overall participation and level of interest in certain park improvements or events. All graphs shown on this page reflect results from the online survey.

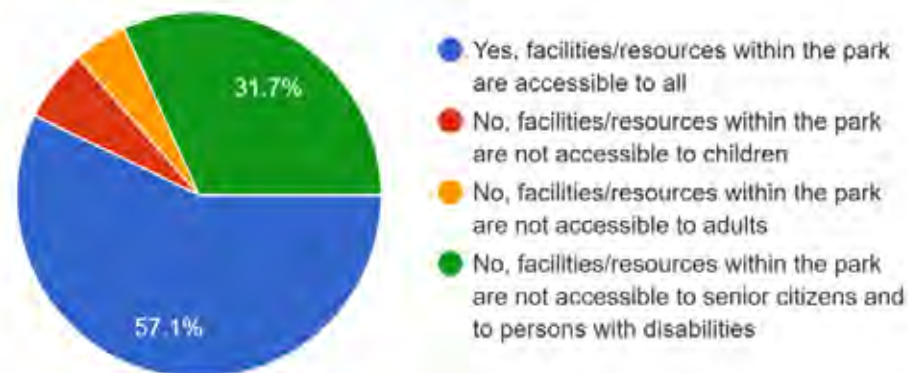
Did you know that the Ashuelot River Park features an Arboretum?



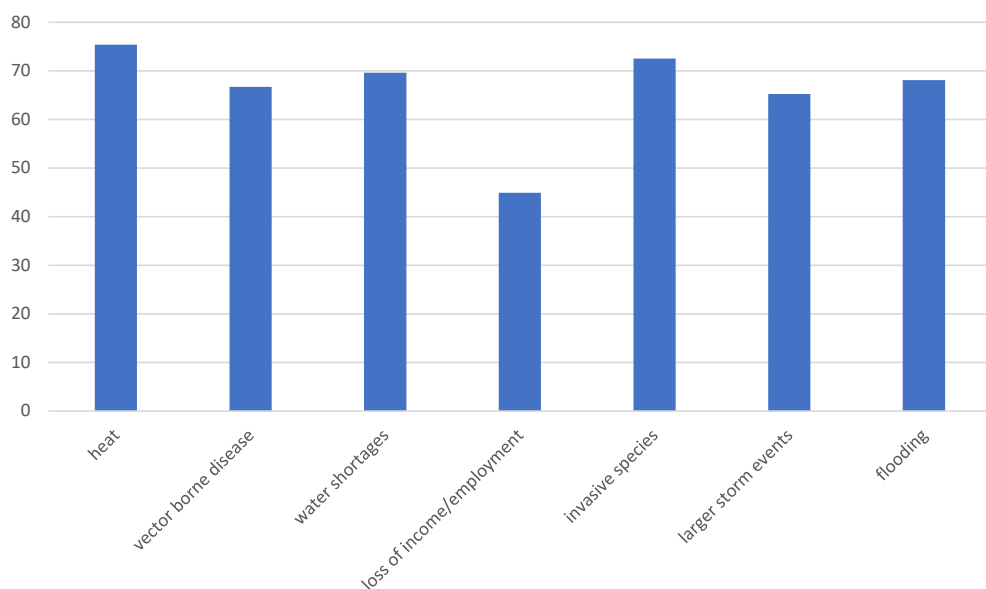
How adequate are current facilities/resources in the park?



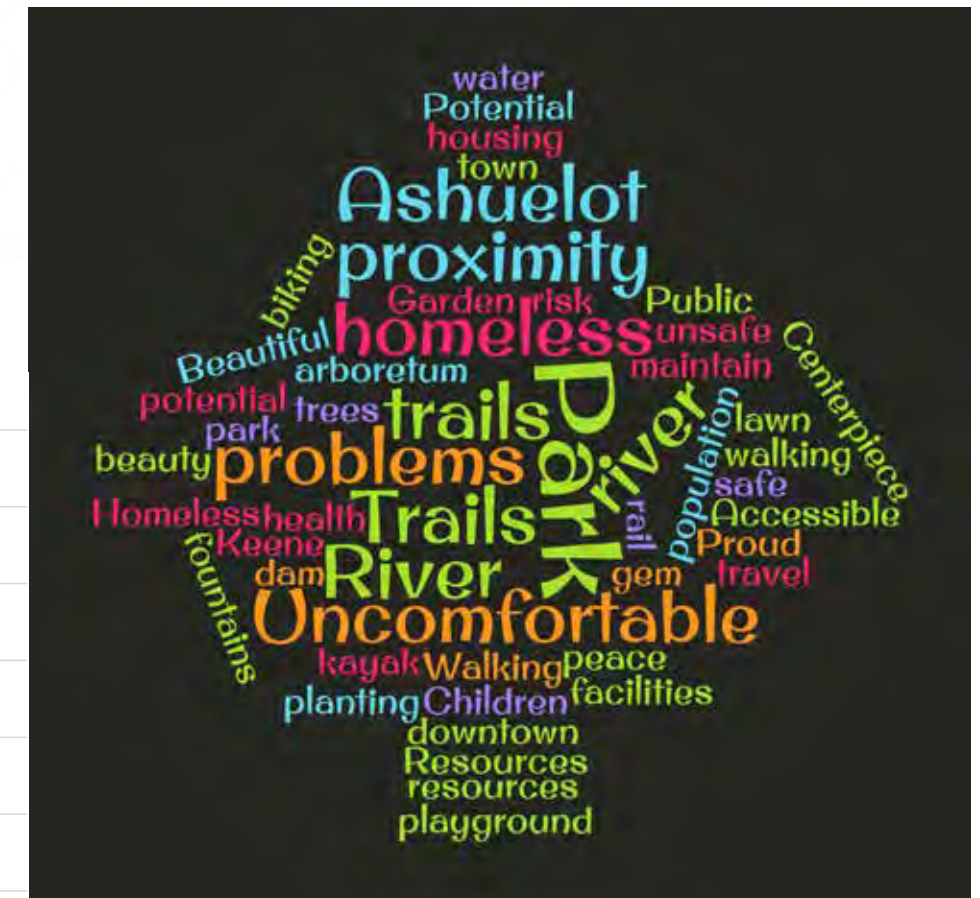
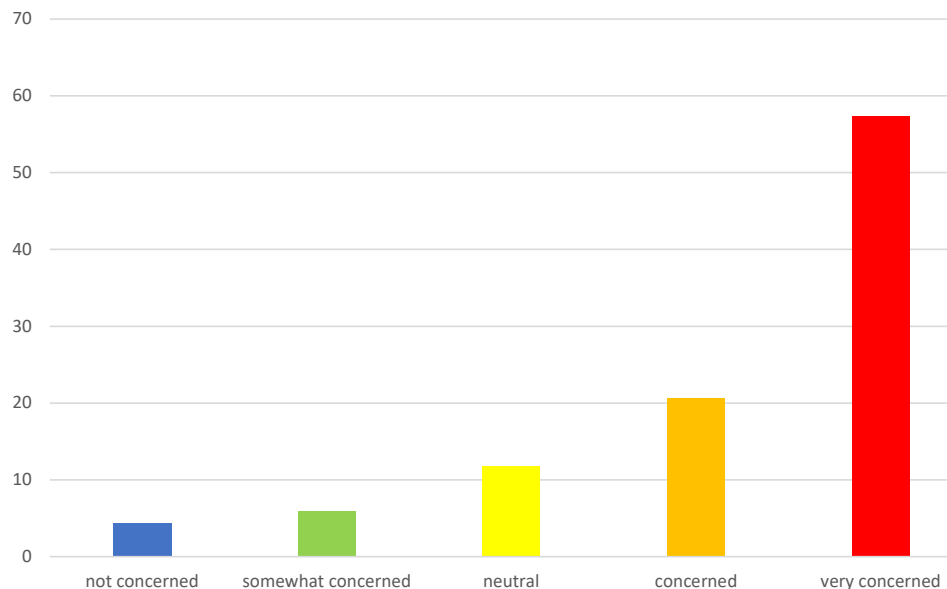
Are facilities/resources within the park accessible to all visitors?



Which issues concern you?



How concerned are you with climate change?



Final comments that online respondents left at the end of the survey were compiled into a word cloud. The largest words or phrases were those stated most.

Not for construction. Part of a student project and not based on a legal survey.

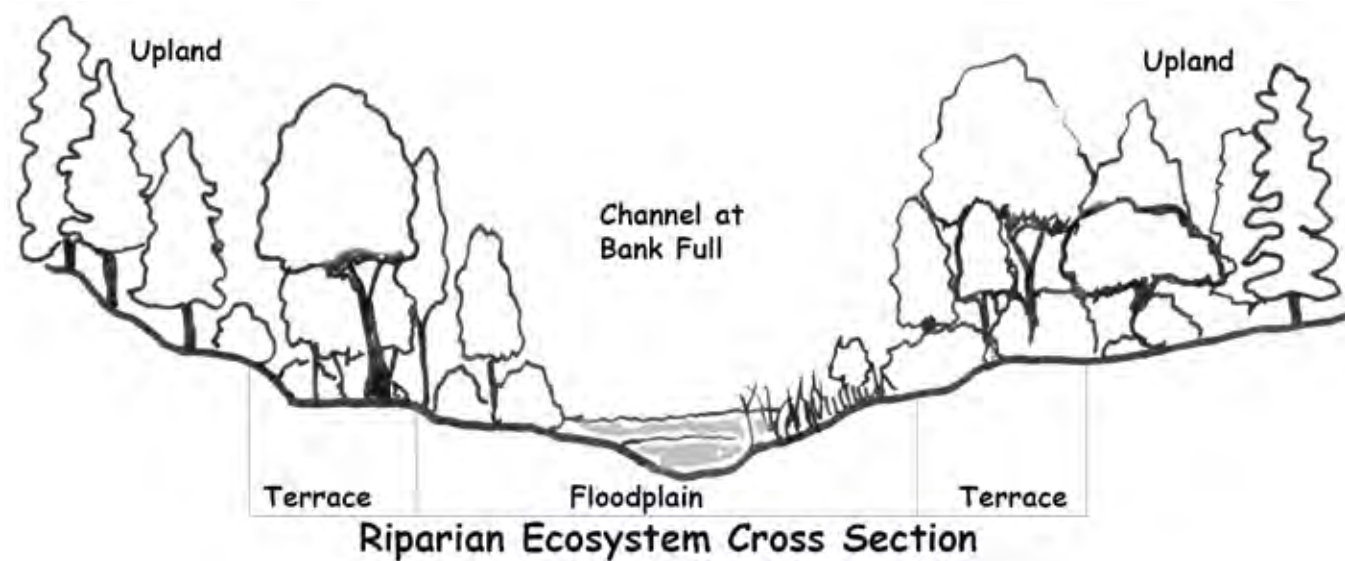
RESILIENCE

Resilience refers to the ability of a system to bounce back from or withstand disturbance, such as a natural disaster or development that interferes with wildlife habitat and natural processes.

The term resilience is used in many ways. This plan looks at resilience as a state in which human, animal, and plant communities do not necessarily return to their former state after a significant disturbance, but instead are able to change and evolve to persist and thrive into the future. As climate change perpetuates environmental shocks and disasters, it is important that the Ashuelot River Park can not only withstand disturbance, but has the ability to adapt and evolve over time.

In April 2000, the city of Keene signed on to the Cities for Climate Protection (CCP) Campaign administered by the ICLEI Local Governments for Sustainability. Since agreeing to participate in the CCP Campaign, Keene has developed a Climate Action Plan to lower its greenhouse gas emissions. Despite the city's commitments to climate mitigation, the impacts of climate change are already being felt. Increased and more severe storms and flooding, the spread of non-native plants and animals, and hotter temperatures have threatened ecosystem services as well as the city's resilience. Keene has committed to expanding climate adaptation programs that aim to address these impacts and help the city thrive well into the future.

ECOLOGICAL RESILIENCE

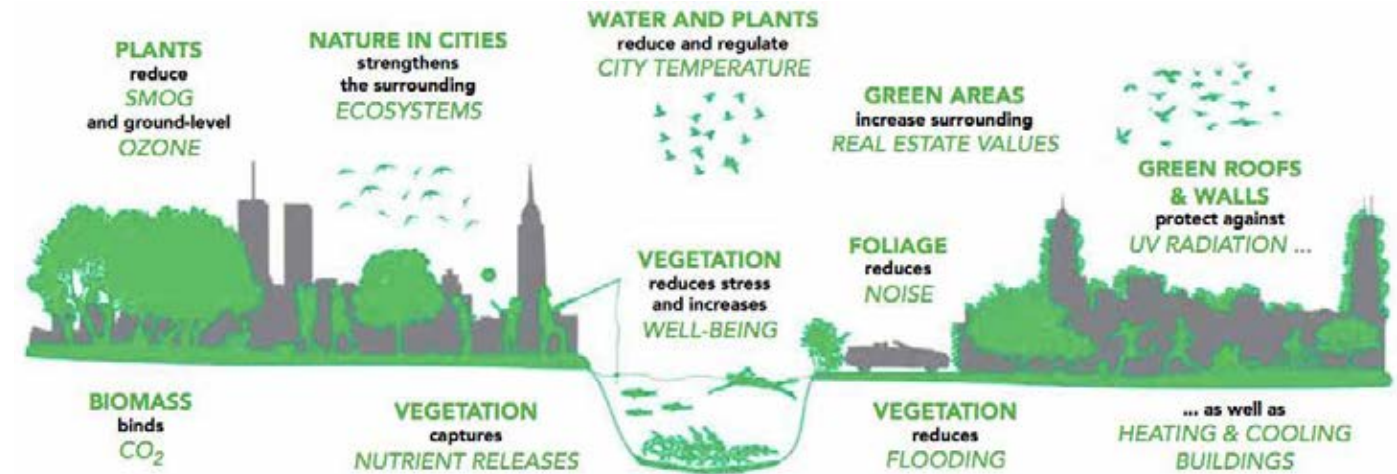


Riparian ecosystems provide a link between upland forests and aquatic habitats. Riparian ecosystems filter stormwater runoff pollutants, foster wildlife habitat, and support a variety of biodiverse vegetation and natural communities. The variety of functions that these ecosystems perform make them more resistant to disturbance and therefore more resilient.

From United States Forest Service "Riparian Restoration"

Ecological resilience is an aspect of overall resilience and refers to the adaptability of natural systems. In a town park, ecological resilience could be strengthened by having a diversity of plant species that serve similar functions so that those species more susceptible to certain conditions, such as extreme temperatures or pests, can be replaced by others. Additionally it is important that species and ecosystems in the park are multi-functional and biodiverse because that means they can withstand a variety of climatic and human induced conditions. The arboretum contains some trees that are in poor health and are vulnerable to the impacts of climate change, such as the ash and hemlock trees, which are vulnerable to the emerald ash borer and the woolly adelgid pest (see vegetation analysis on sheets 20-22).

SOCIAL ECOLOGICAL RESILIENCE



Humans not only rely on the ecosystem services provided by natural systems, humans are a part of the ecosystem. This graphic illustrates various ways that ecosystems function with the built environment.

From COCity.se

Social ecological resilience ensures that all people have access to necessary resources for survival without compromising the natural environment. Humans are part of the natural world, but also part of the built environment. Encouraging resilient communities means balancing interacting with the natural world and building where it makes sense so as to not disturb existing natural communities. Another component of social ecological resilience is social justice. Providing equitably distributed and accessible services in the park for all residents increases both mental and physical health and overall quality of life.

EXISTING CONDITIONS

The Arboretum and RMOLL, both founded in 1996, cover approximately 5 acres of the entire 175-acre Ashuelot River Park. Both the garden beds (shown in brown) and trees are primary components of the Arboretum. Visitors tend to enter through the front arch on West Street, which is surrounded on both sides by sugar maples. At the entrance, a gravel path leads visitors from the garden beds to the pedestrian bridge and north to the Jonathan Daniels Trail. The RMOLL contains a cobbled seating area where visitors can admire views of the Ashuelot river and West Street Dam. A narrow dirt path along the river meanders through the RMOLL north and ends northwest at the edge of the property boundary.



1

A formal archway frames the entrance from West Street.



2

Engraved cobbles line the paths and garden beds.



3

There are multiple entry points adjacent to the accessible parking area.



4

There are signs throughout the park to acknowledge and solicit volunteers.



5

Standing on the suspension bridge facing west toward the dam viewing area in the RMOLL.



6

Facing north, a footpath runs along the top of the levee in the outdoor learning laboratory.



7

Facing north, the entrance to the Jonathan Daniels Trail.

Not for construction. Part of a student project and not based on a legal survey.

HISTORY

"A GREEN OASIS"

The entire Ashuelot River Park abuts the Ashuelot River and acts as an isolated green oasis that is lined on two sides by roads, highways, and parking lots. The park offers an escape from the hustle and bustle of downtown Keene. As visitors sit beside the historic West Street Dam, listen to the sounds of running water and the birds chirping, and feel the refreshing mist from the Ashuelot River, they feel a sense of comfort and a sense of place. Community, education, and stewardship have been the foundation of this park since 1960 when the first 46 acres were offered to the city. These principles guided the park's development into a well-loved community resource that spans 175 acres of forested wetlands, trails, bike paths, an Arboretum, and the RMOLL, the latter of which are located in the heart of the city. This park has long been a part of Keene's identity and history, but in the face of climate change, both the community and the beloved Ashuelot River Park will need to be prepared to withstand changing conditions.

THE ASHUELOT RIVER

Referred to as "the place between" by the Pennacook people, the Ashuelot River flows fifty miles from Washington to its outflow into the Connecticut River and has helped shape the history of the Monadnock Region of New Hampshire. The southern portion of the Ashuelot River Valley was first inhabited by the Squakheag people. The lower river valley was later colonized by Europeans in the early 1700s, with settlement continuing to the upper valley by the late 1700s. In the nineteenth century, many industries were powered by the Ashuelot River, including the West Street Mill. While the West Street Dam no longer generates power, it remains a historic icon for many residents of Keene, as does the network of trails weaving through the floodplain. These trails are remnants of the paths created to provide mules with solid footing when dredging the river to keep it navigable by boats. As Keene continued to industrialize, the river began to be affected by residential and commercial activity. Industrial waste degraded water quality and harmed wildlife. By the start of the twentieth century, much of the land around the river had been cleared for fields and pastures. The former mill ponds were filled to make room for commercial developments along West Street. Some of this new land became incorporated into the Ashuelot River Park's West Street entrance area. Currently, the river runs through the Ashuelot River Park. Despite these changes, the river and land along the banks continue to be a place of beauty.

KEENE, NEW HAMPSHIRE

In 1733, two survey teams from the colony of Massachusetts were sent to lay out townships along the banks of the Ashuelot River. At this time, many of the eastern towns had become overpopulated and Governor Belcher of Massachusetts urged expansion to the north. He proposed creating seven new towns, including two on the Ashuelot River above Northfield. Keene, known then as "Upper Ashuelot," was created to the north of the river. Land was granted to anyone who was willing to settle in the town and make improvements. Development of the area began in 1736, with the construction of a sawmill on Beaver Brook and the widening of the central thoroughfare, giving Keene its distinct broad Main Street.



The vibrant and lively center of downtown Keene, NH.



Historic photo of West Street Mill in the early nineteenth century.



Photos showing garden and tree plantings in the newly established arboretum by the Friends of Ashuelot River Park and other volunteers as well as student research in the RMOLL. (From "The Land Between: A Celebration of the Ashuelot River and its Park" 1998)

Ashuelot is an Abenaki word meaning "place between waters" or "collection of many waters."

- Historical Society of Cheshire County



Ashuelot River from West Swanzey, NH, during the early 1900s.



Community involvement and stewardship played a prominent role in the park's establishment. Not for construction. Part of a student project and not based on a legal survey.

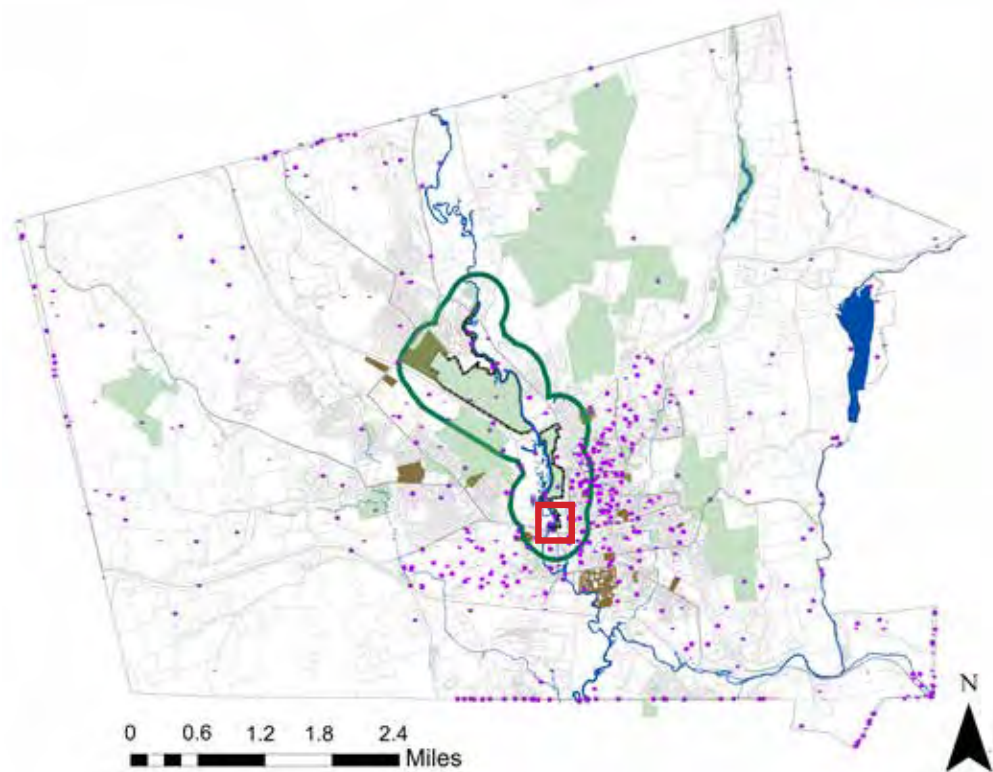
DEMOGRAPHICS

Keene has a population of approximately 23,146 people as of 2020 and it is the sixth largest city in New Hampshire. Spanning over 37 miles, Keene has a population density of roughly 624 people per square mile, with most living in the central and southern portions of the city.

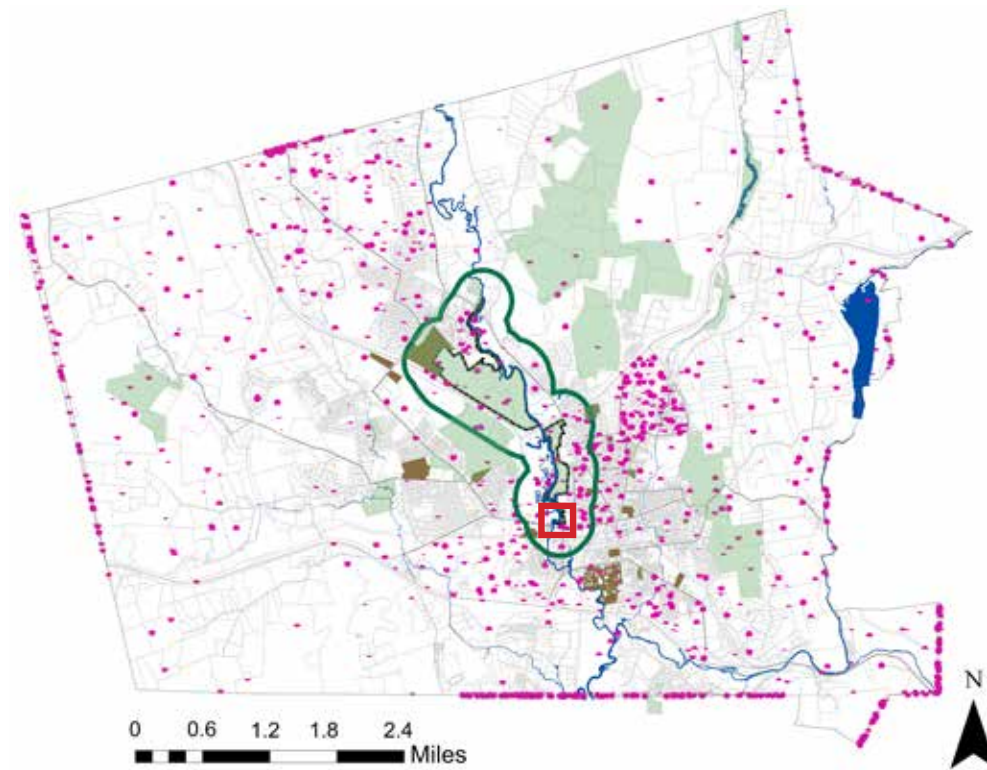
Based on the online survey results, over 74% of respondents said that they live within less than a mile to five miles of the park. However, over 50% of respondents said they drive to the park. Though there is a bike trail network, it does not connect to the schools south. Therefore, despite the park being centrally located there may be other factors, such as insufficient pedestrian or bicycle infrastructure. Most children in the City of Keene ages 17 and under live within a quarter mile to a half mile of the Ashuelot River Park. Most public K-12 schools are also within a quarter mile to a half mile of the park. Outdoor interactions are cultivated from a young age and these connections can improve both people's mental health and physical health and increase knowledge of the natural environment. When the park was first established

there was a prolific research component for high school students, particularly pertaining to the decline of the dwarf wedge mussel in the Ashuelot River. Currently, there is limited use of the RMOLL for educational purposes, such as student research.

Many people (earning \$30,000 per year or less) live within a mile of the park. Most of these areas line up where children 17 and under are living. Generally, there is a limited amount of publicly accessible green space in Keene, which places greater value on existing parks. In many urban areas, the distribution of green space is unequal. Many low income individuals in other cities live in areas most vulnerable to urban heat islands with limited access to green space (see heat island sheet 9). However, due to the park's central location in the city, many low income individuals do happen to live nearby. The park is therefore an important resource, offering a green refuge from the more densely developed downtown and residential areas.



Distance of low income people per census block from the park.



Distance of children under 17 per census block to the park and distance of schools to the park. Most children live within a quarter mile or less of the park. Area of focus for this master plan shown in red.

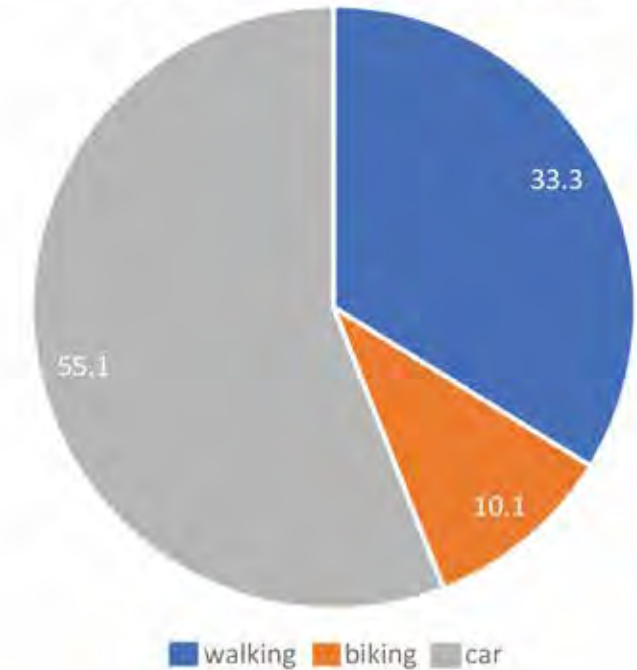
Demographics

- Parks
- Income >\$30,000/yr**
- 1 Dot = 10 People
- Income >\$30,000 per Census Block
- 1/4 Mile Buffer from ARP
- Ashuelot River
- Ashuelot River Park

Demographics

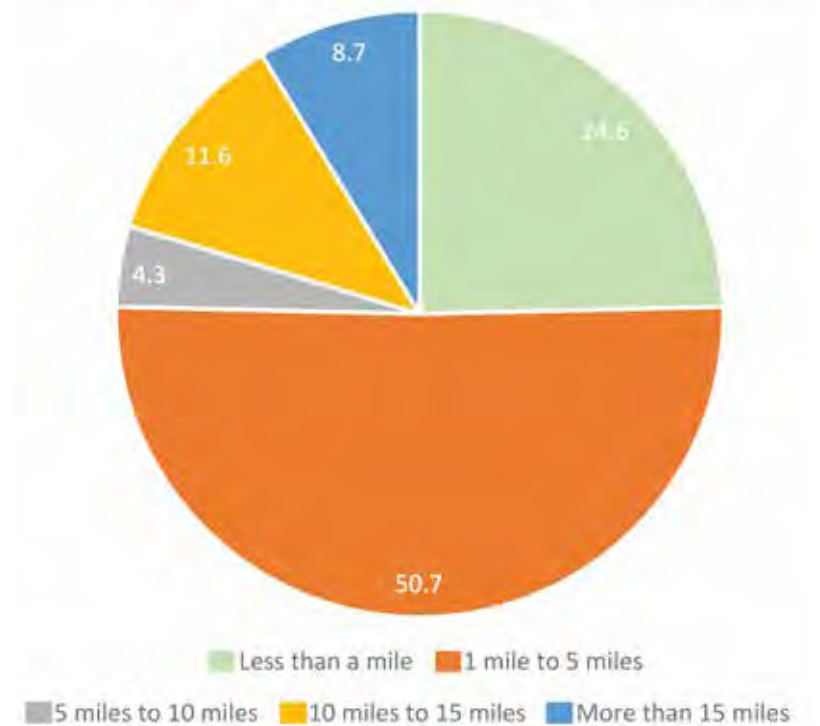
- Parks
- 1/4 Mile Buffer from ARP
- School Parcels
- Children 17 Under**
- 1 Dot = 10 Children
- Children Under 17 per Census Block
- Ashuelot River
- Ashuelot River Park

What method of transportation do you typically use to get to the park?



Most respondents to the online survey live close to the park.

How close do you live to Ashuelot River Park?



Most respondents to the online survey drive to the park, despite living nearby.

Not for construction. Part of a student project and not based on a legal survey.

SOCIAL CONTEXT

Of the total population in Keene, approximately 13.7% live below the poverty line and even more are considered low income (see income demographics map). Many housing-insecure individuals are frequent visitors to the Ashuelot River Park.

People who are housing-insecure are most often unable to acquire and maintain regular safe, secure, and adequate housing. Historically, addressing issues of homelessness in public parks has been controversial. On the one hand, public parks are resources for the entire community, providing valuable services to all. However, on the other hand, the prevalence of homeless individuals using park resources can put great pressure on the finite resources of parks and recreation agencies (NRPA, 2017 "Homelessness in Parks Survey").

The issue of homelessness in the Ashuelot River Park directly relates to resilience as it is a social justice issue. Social justice is the belief that every individual or group is entitled to fair and equal rights and participation in social, educational, and economic opportunities. Unfortunately, there is a stigma surrounding homelessness in Keene, and because of this many homeless individuals may also feel uncomfortable in certain spaces and may feel like they do not have a voice. The Ashuelot River Park acts as a comfortable and attractive green space that provides cooling relief from the sometimes stifling and hot conditions downtown, which is why it is used by so many housing-insecure individuals. With the notion of social resilience in mind, this park needs to be a place that is accessible and safe to all people.

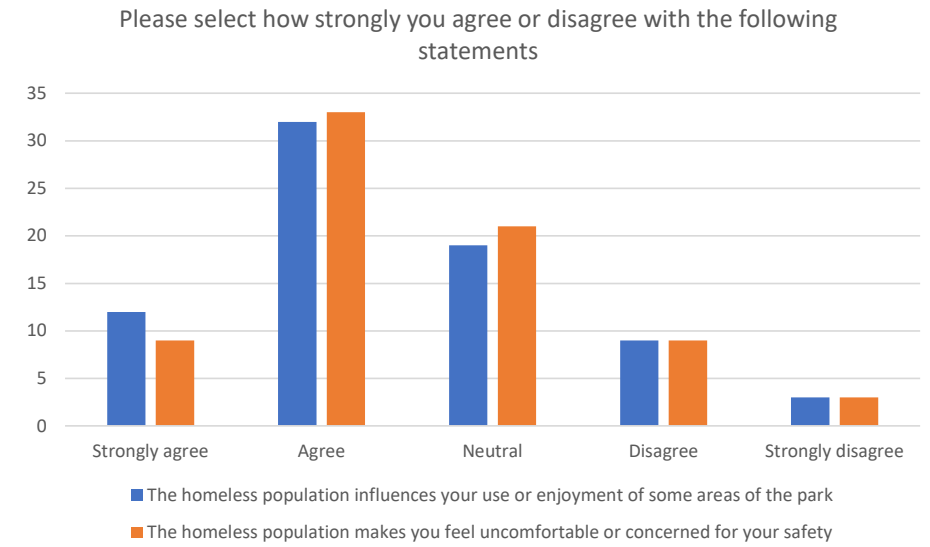
Public parks such as, Oppenheimer Park in Vancouver, British Columbia, and Eddie Maestas Park in Denver, Colorado, contain inclusive spaces and resources that make housing-insecure individuals and all people feel welcome. Oppenheimer Park is located within one of the

least affluent districts in the city of Vancouver. Major issues with the park, prior to the 2010 reconstruction, included drug use and safety. The new design for the park focuses on opening sight lines to increase safety. Eddie Maestas Park offers inclusion of homeless people by partnering with nearby soup kitchens and shelters to ensure these individuals are receiving the care and resources they need (Kingery-Page, 2019). Lines of sight into the arboretum and RMOLL can be improved, particularly in wooded areas near the conifer beds and gazebo and along the trails. Another way of accommodating housing-insecure people within the park could be to hire them as part-time volunteers to maintain garden beds and perhaps learn about resources in the park. Work opportunities may discourage inappropriate behavior and may also ensure greater inclusion.

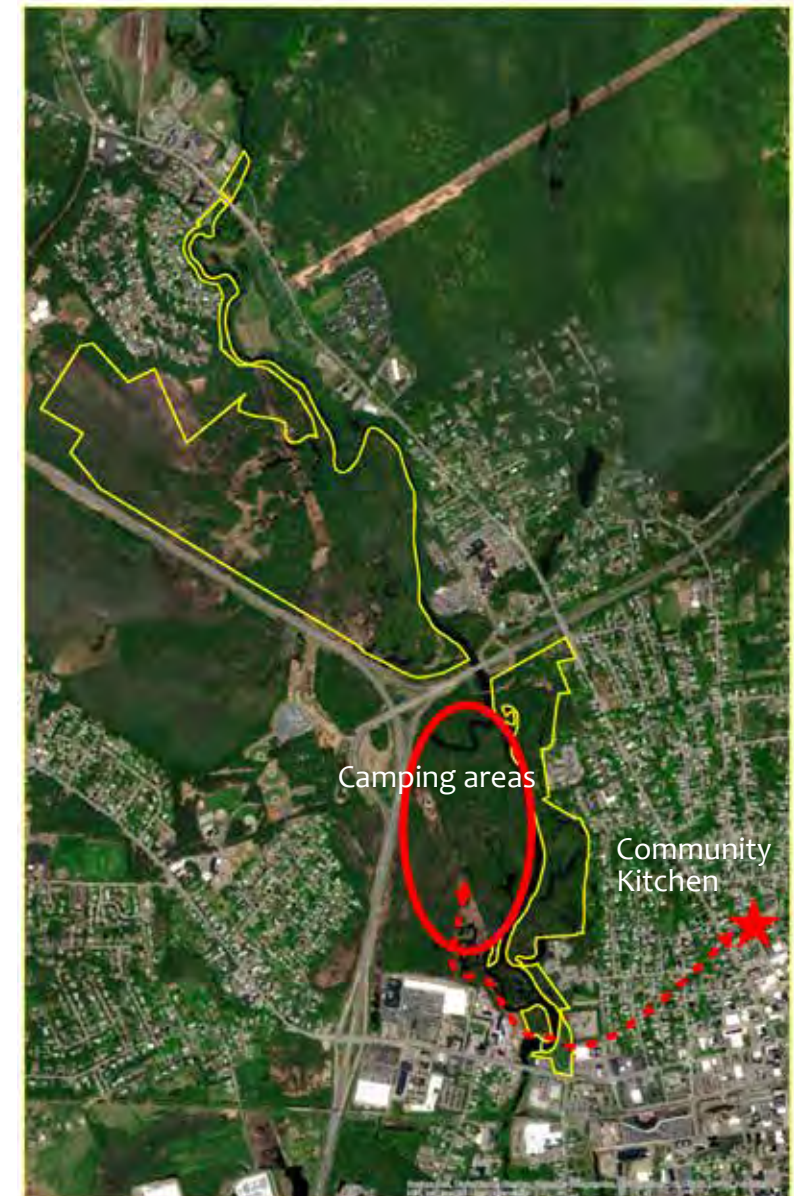
According to ASLA's "Designing with the Homeless" report, some actions and strategies for landscape designers and planners to destigmatize homelessness in public spaces include:

- Understanding conditions surrounding homelessness.
- Advocating for local municipalities and non-profits to help homeless individuals.
- Creating forums for homeless individuals to remind them of their worth and value.
- Working to dispel myths and fears about homelessness.
- Understanding the many points of views of homeless individuals.

The map on the right shows the main camp out areas of housing-insecure individuals within and near the Ashuelot River Park. These include near the trails in the RMOLL and outside the park along the Ashuelot River. Though the park is a refuge from downtown for many of these individuals, it also provides a convenient connection to the Community Kitchen, east of the park.



Many respondents to the online survey agree that the presence of homeless individuals impacts use or enjoyment of park resources.



Homeless camping areas in the park and location of the Community Kitchen. Many cross from the RMOLL trail to get to the Community Kitchen.

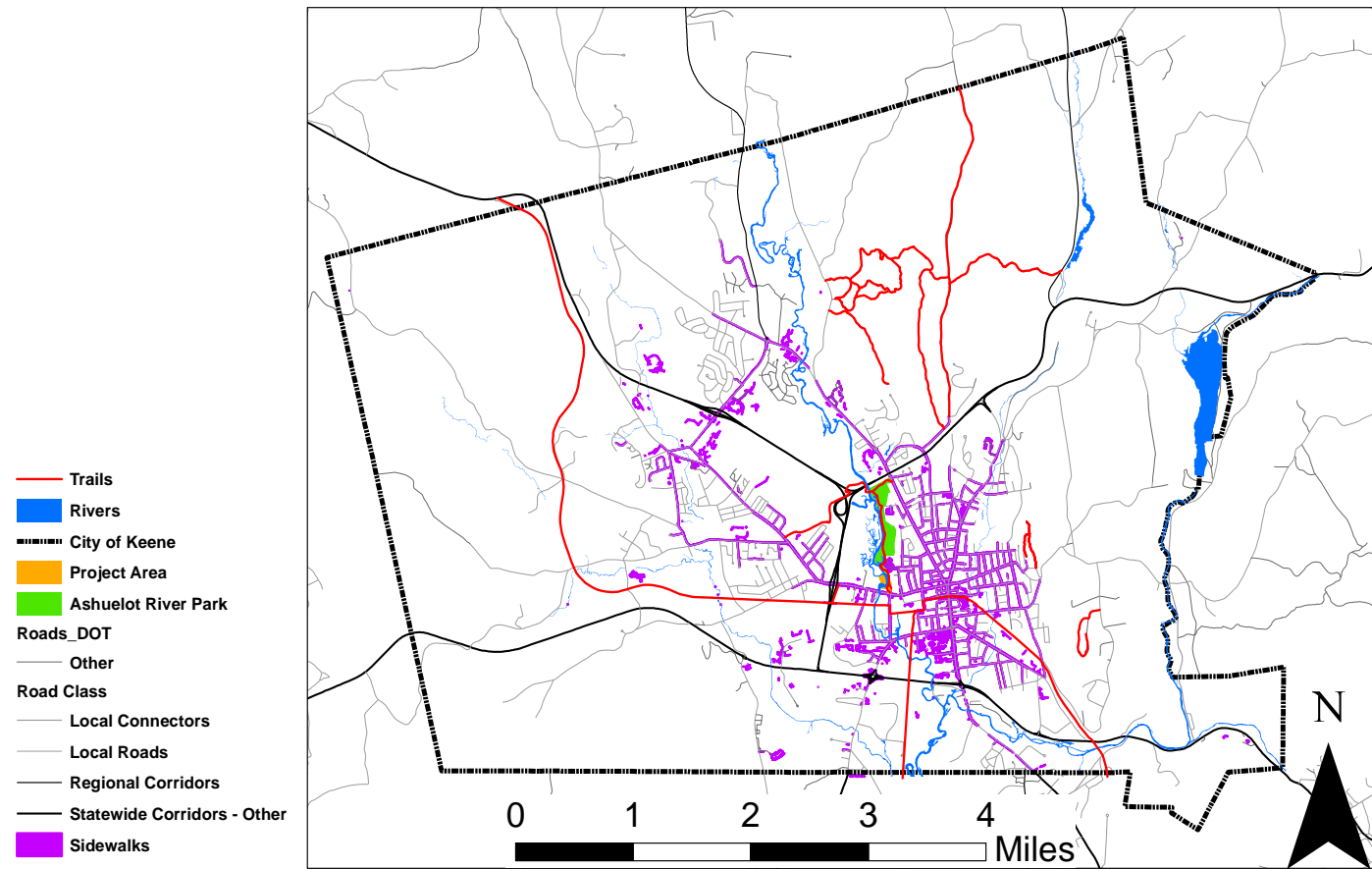


"One Hundred Nights" homeless shelter in Keene, NH open from mid- November to mid-April.

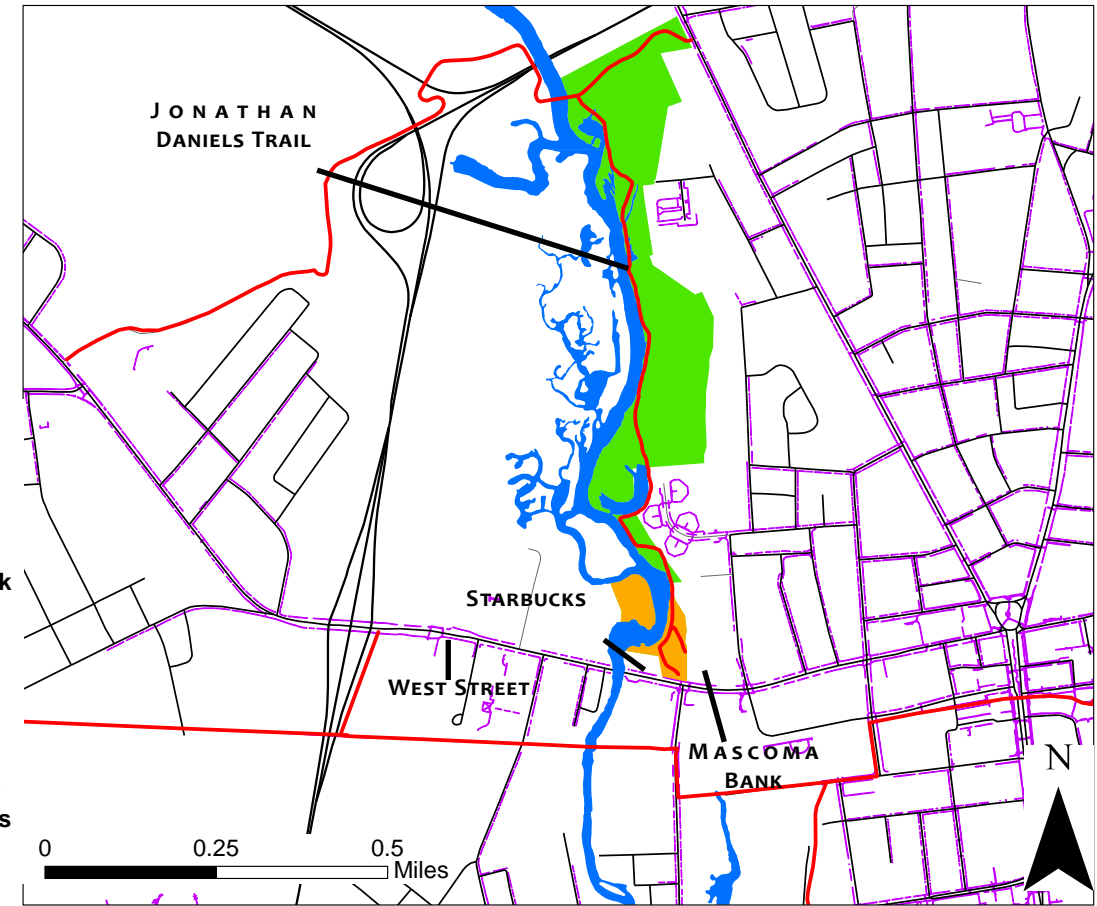


Homeless camp site in Keene, NH.

TRANSPORTATION ACCESS



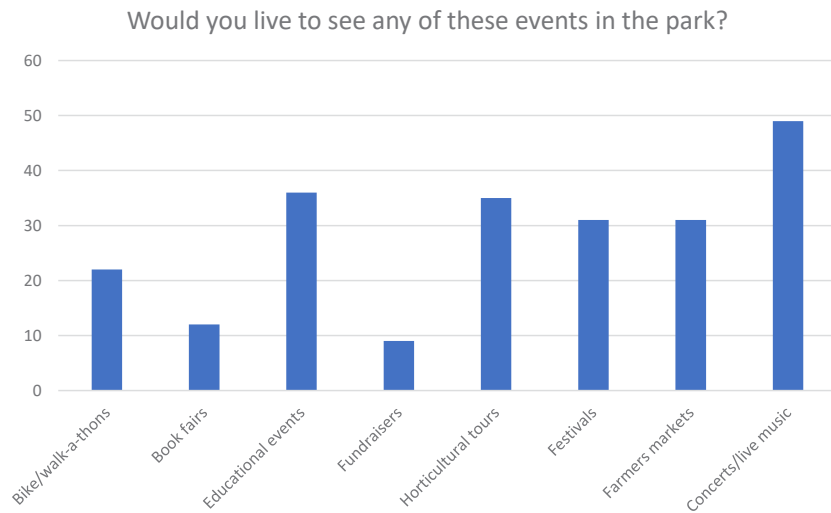
- Trails
- Rivers
- City of Keene
- Project Area
- Ashuelot River Park
- Roads_DOT
- Other
- Road Class
- Local Roads
- Regional Corridors
- Statewide Corridors
- Sidewalks



Roads

The Ashuelot River Park is centrally located for vehicle access. Located near the junctions of major state and local roads, NH Route 101 to the south and NH Routes 12 & 9 to the north provide easy access to the park for vehicles from outside of Keene. Vehicles primarily access Ashuelot River Park via West Street, which continues to the east about a half a mile into downtown Keene. There are accessible and non-accessible parking spaces designated for park visitors in the Mascoma Bank Parking lot along the Arboretum's east side. Visitors might also park in the Starbucks or Mascoma bank lots, although these lots are technically for customers.

According to the online survey, driving is the primary method visitors use for getting to the park even though some park users live nearby and the city bus does drive by the park entrance.

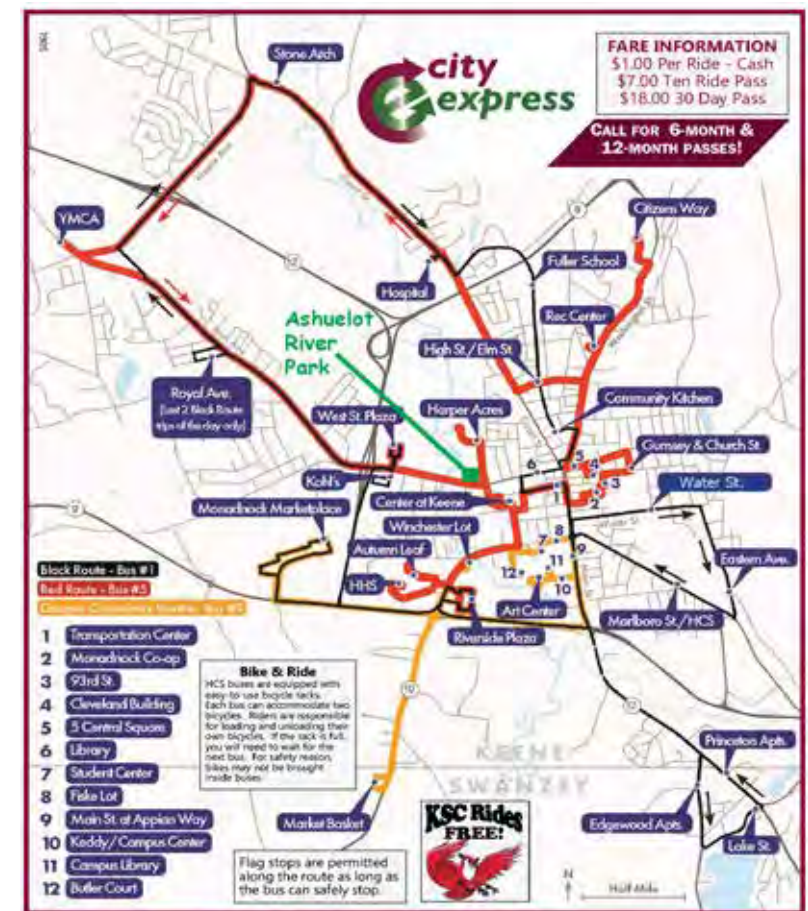


Sidewalks

The Ashuelot River park is connected by sidewalks to downtown Keene, which has the greatest concentration of sidewalks in the city and is less than a half mile away. Many residences and businesses are within a quarter mile or less of the park (see Demographics page 6). The main entrance to Ashuelot River Park is accessible from the west, south, and east by sidewalk, making it easy for pedestrians and non-auto users to enter the park.

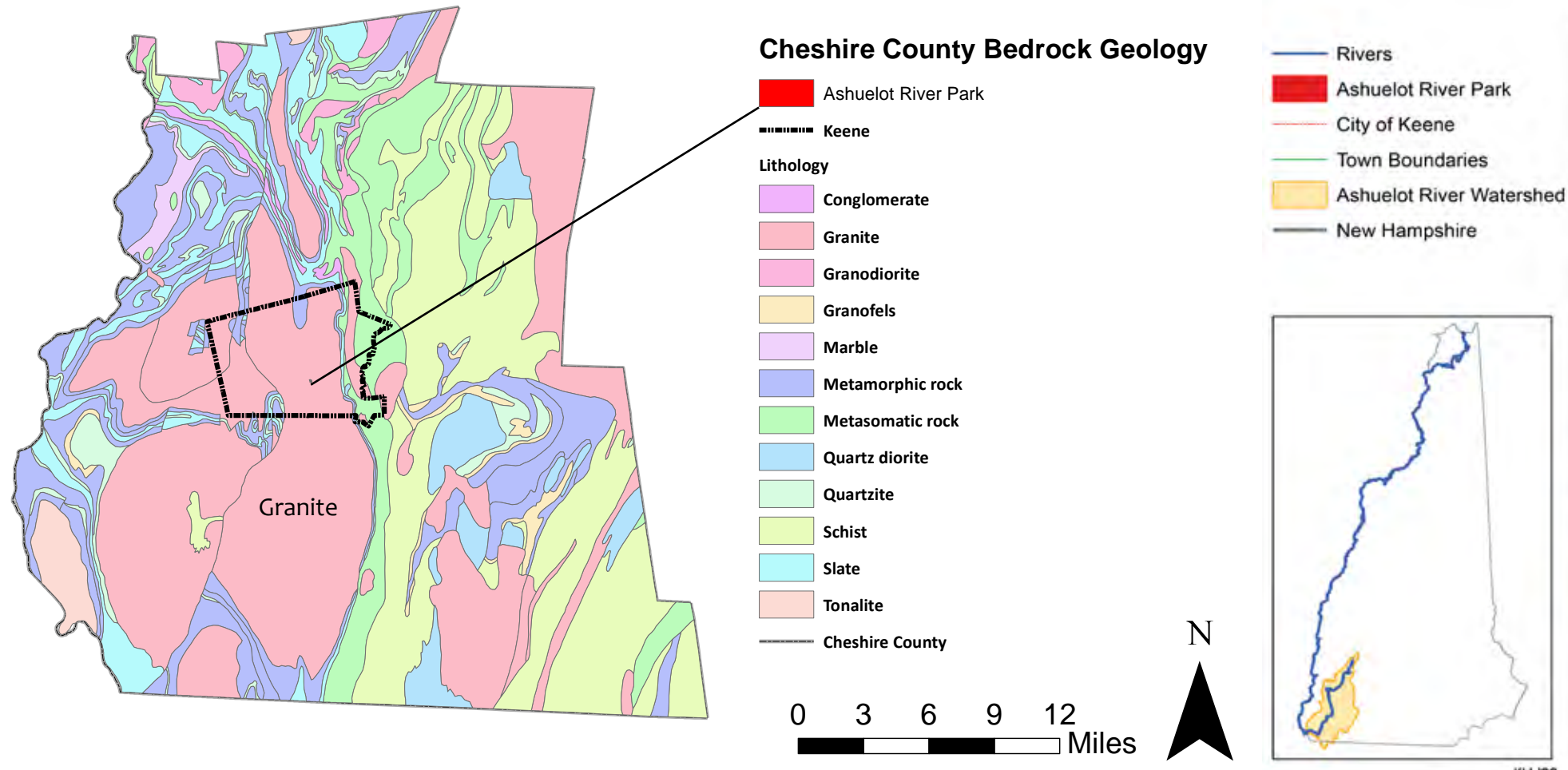
Trails

The Ashuelot River Park is centrally located between trail networks in Keene. The Jonathan Daniels trail, used by pedestrians and bicyclists, begins in the Arboretum and continues north to Apple Way. To the south, the Cheshire Recreation and Ashuelot Recreation Trails are less than a block away. The park is easily accessible for pedestrians and bicycles. Results from the survey showed that 22% of people are interested in a bike-a-thon event to be based in Ashuelot River Park. Encouraging alternate forms of transportation like city buses, biking, and walking, and adding bike racks, and a bus stop could reduce greenhouse gas emissions from cars, particularly those traveling short distances. However, further research should be conducted to examine what is preventing visitors from using these alternate modes of transportation. To further reduce the emissions from cars used to access Ashuelot River Park, no idling signs could be installed in the Mascoma Bank parking spaces on West Street reserved for park users.



Not for construction. Part of a student project and not based on a legal survey.

GEOLOGIC AND WATERSHED CONTEXT



Geologic Context

The Ashuelot River Park is located above plutonic granite bedrock that formed during the late Ordovician period. The region was covered with ice during the most recent glaciation at the end of the Pleistocene epoch about 12,000 years ago. As the ice sheet retreated, glacial Lake Ashuelot formed over the region where the city of Keene is located today. Fluvial erosion and deposition shaped the landforms seen in the region today. What remains is the Ashuelot River, which drains into the Connecticut River southwest of Keene at Hinsdale. Evidence of glacial activity is demonstrated along the river in the form of delta deposits, drumlins, potholes, and varved clay deposits.

Above the granite bedrock, unstratified glacial till can vary in size from boulders to clay particles and can reach depths of up to 125 feet below Keene. Layers of sedimentation above these glacial deposits indicate the formation of glacial Lake Ashuelot and its presence for thousands of years. When the Ashuelot River began to flow into the Connecticut River, organic matter and topsoil began to form over alluvial deposits (Natural Resource Inventory 2010).

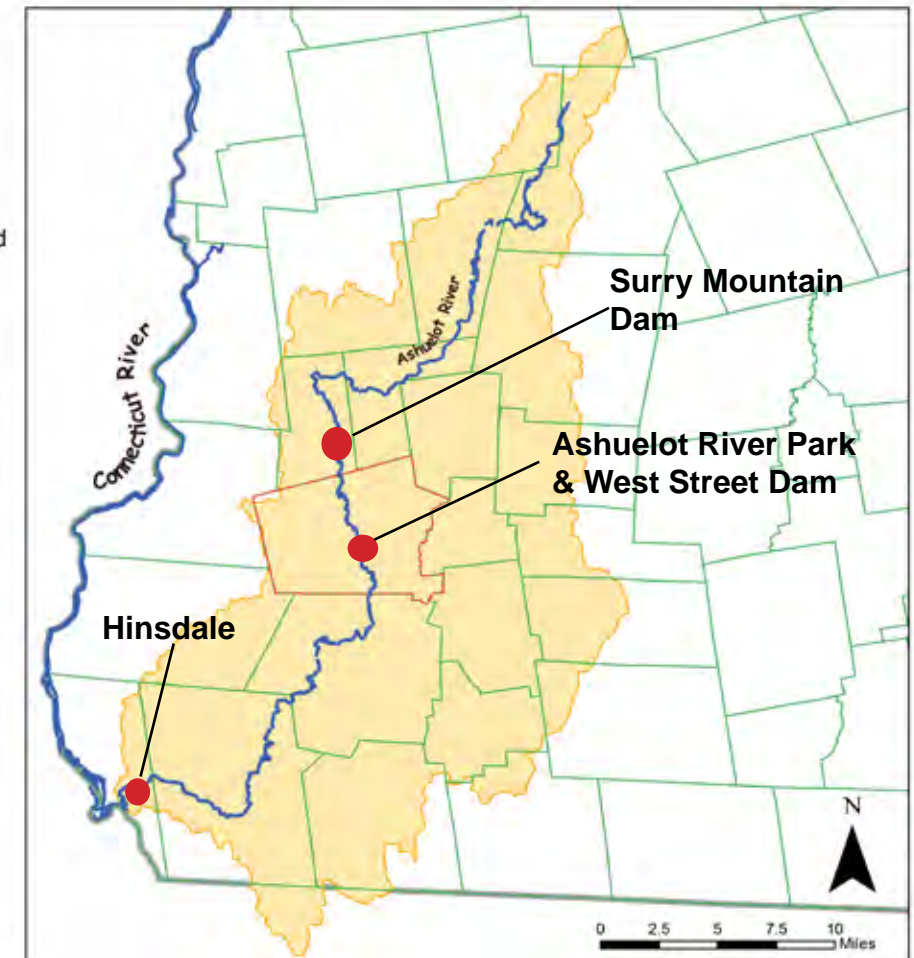
The Ashuelot River today meanders through these deposits upstream of the West Street dam unrestrained by bedrock or other geologic impediments. Multiple channels of the Ashuelot River and the established floodplain forest upstream of the dam are evidence of fluvial dynamics influenced by channel materials. Erosion and deposition of sediment will continue as the magnitude and duration of flows flux over time, potentially altering the current river channel.

Watershed Context

The Ashuelot River, a tributary of the Connecticut River, has a drainage basin of about 415 square miles and is 64 miles long. The Ashuelot River was included in the Silvio O. Conte National Fish and Wildlife Refuge Act, which was passed in 1991 to conserve, protect, and enhance the diversity of species that exist within the entire Connecticut River watershed (New Hampshire Department of Environmental Services, 2019).

The Ashuelot River Park is adjacent to the West Street Dam and the Surry Mountain Dam is located north of the park. The latter was built in 1941 after substantial flooding occurred in downtown Keene. This dam greatly regulates the flow of the downstream section of the Ashuelot River that flows through Ashuelot River Park and there has not been major flooding reported since it was built.

Currently, the southern stretch of the Ashuelot River that flows through Hinsdale, New Hampshire, is listed by the state of New Hampshire as an impaired river. In 2019, the Ashuelot River was given an impaired status due to elevated pH for aquatic life integrity. An elevated pH could result from increased water temperatures and/or pollutants that change the chemical composition of the water. Upstream communities like Keene could help to remediate this condition of the Ashuelot River by treating runoff from hot impervious surfaces and establishing riparian buffers to capture pollutants before runoff enters the river.



The southern portion of the Ashuelot River that flows through Hinsdale was reclassified in January 2020 as 3-ND, which means no data, for various chemicals including Acenaphthene, DDD, 2-Methylnaphthalene, DDE, and Dieldrin. Initial testing in 2006 showed elevated levels of these chemicals and, as a result, the Ashuelot River was listed as a 5-M impaired stream in poor condition that needed a total maximum daily load (TMDL), which is a legal limit of a nutrient or pollutant allowed in a water body. There is no data available for these chemicals mentioned above since the 2006 test results.

Designs for Ashuelot River Park should minimize downstream impacts by treating runoff, ensuring bank stabilization, and establishing riparian buffers.

SOILS

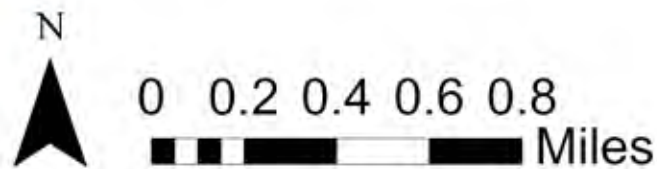
The northern half of the Ashuelot River Park, not included in this master plan's area of focus, is predominantly Ossipee Mucky Peat (shown in gray). This soil is poorly drained with frequent ponding and supports wetland and floodplain forest communities. The northern half of the Arboretum contains predominantly Rippowam Saco Complex (shown in dark green). This soil is also poorly drained. The southern half of the Arboretum is the site of a former mill pond that was gradually filled in when the West Street Mill closed in 1954; it was likely filled with displaced soils and debris from nearby commercial development. The soils in the RMOLL are Suncook Loamy Sand, which are excessively drained. The soils in the northern portion of the park,

between the Arboretum and northern half are Rippowam Saco Complex and Fine Sandy Loam, which are poorly drained. Caesar Loamy Sand, located outside the area of focus, is also excessively drained.

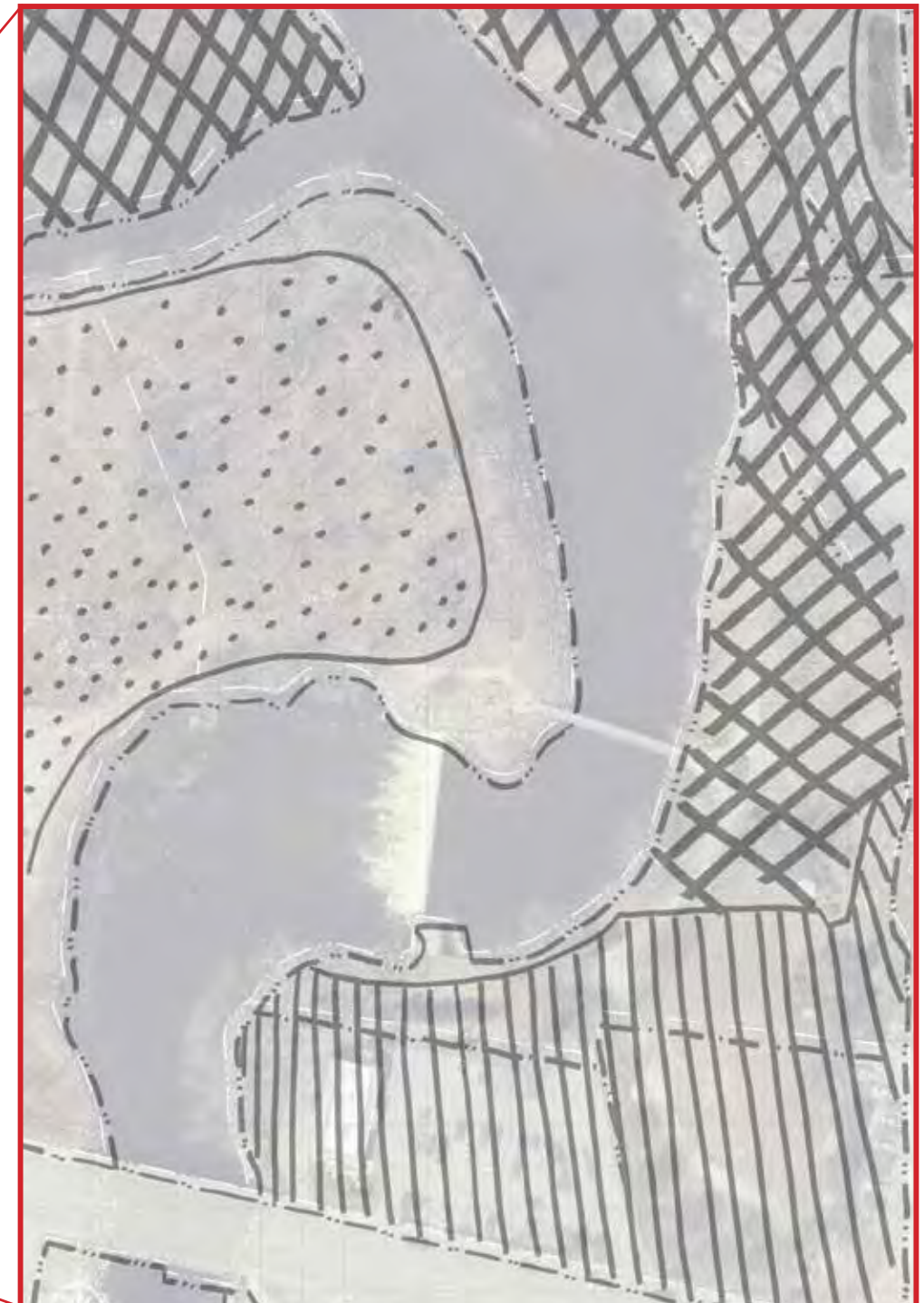
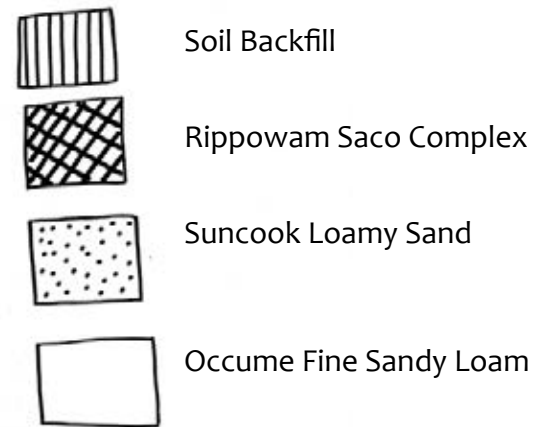
The glacial meltwater in Keene contributed predominantly to poorly drained floodplain clay-like soils. These soil qualities are evident in Rippowam Saco Complex found in the northern half of the Arboretum.

Though the soils in the Arboretum and RMOLL have different drainage classes and characteristics, both support floodplain ecosystems, but do not have any overlapping species. Suncook Loamy Sand soils in

the RMOLL, found in wooded pastures, support trees like sycamore, cottonwood, aspen, and silver maple. Rippowam Saco Complex soils in the northern half of the Arboretum, which formed from granite and gneiss, support red maple, willow, and alder trees. Knowing the types of tree species that tolerate these soil conditions is critical when selecting new trees for planting, as this can help ensure that the trees thrive. It is also helpful to have backup trees in mind in the event that replacements are needed for trees in poor or fair condition



Legend



Soils of the entire Ashuelot River Park. Project focus area shown in red. The main soil types for the project focus area are outlined in black.

Soils of project focus area.

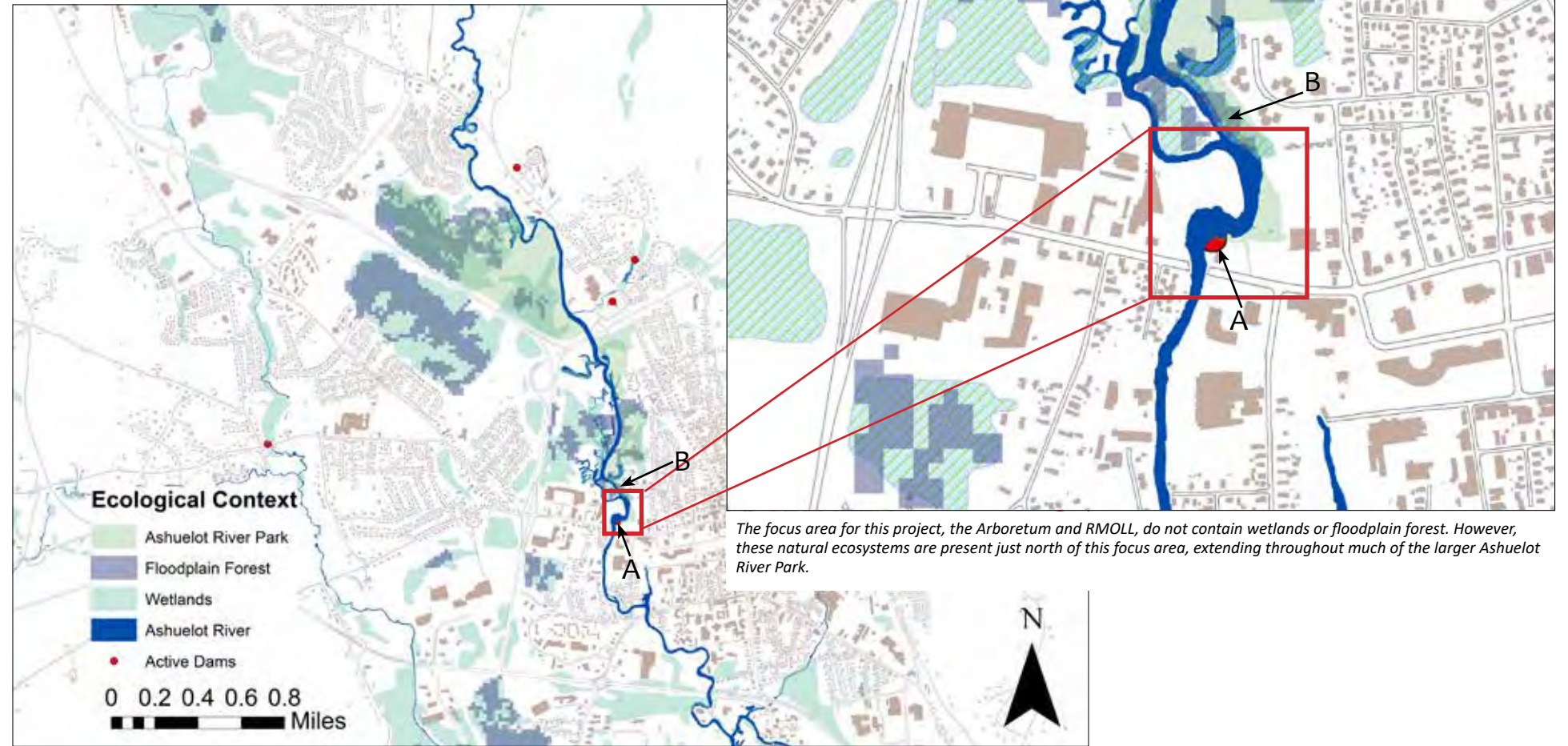
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PRIORITY ECOSYSTEMS

Floodplain forest and shrubby marsh wetlands covers the larger Ashuelot River Park. These ecosystems support diverse plant communities, filter stormwater runoff from adjacent developed areas, and mitigate excessive flooding. Wetlands and floodplain forests are found in areas with poorly draining hydric soils and offer flood storage which helps to protect the highly impervious downtown area from flooding. It is difficult to predict how increased frequency of storms and more severe precipitation events due to climate change will alter the hydrologic characteristics and functions of wetlands. Given the diversity of wetland types and their individual characteristics, the impacts resulting from climate change will be somewhat customized (Erwin). Nevertheless, the city needs to ensure that these valuable natural communities are preserved by preventing construction and regrading within these areas and protecting existing vegetation and wildlife.

The Ashuelot River has been dredged near the West Street Dam to prevent overtopping of banks, which minimizes flooding south of the park, but also eliminates flood storage due to riverbank channelization, forcing the water downstream to flow faster. The West Street Dam is a break in the river that divides upstream and downstream natural communities. Although for some aquatic species this is a barrier, the dam does preserve the important wetland communities upstream and removing the dam could result in loss of these wetland areas.

Keene is located at the bottom of what was formerly a glacial lake and the area held glacial meltwater, which contributed to the deposition of clay-like, poorly draining soils (see Soils Analysis, sheet 10). Keene was built on the Ashuelot River floodplain and regular flooding supported complex wetlands and thriving farming and fishing industries. After many floodplain forests and wetlands were drained and developed and infrastructure was built to control flooding, Keene lost a great deal of its natural resources and ecosystem services. The wetland and floodplain natural communities within the Ashuelot River Park are remnants of this larger, former wetland ecosystem.



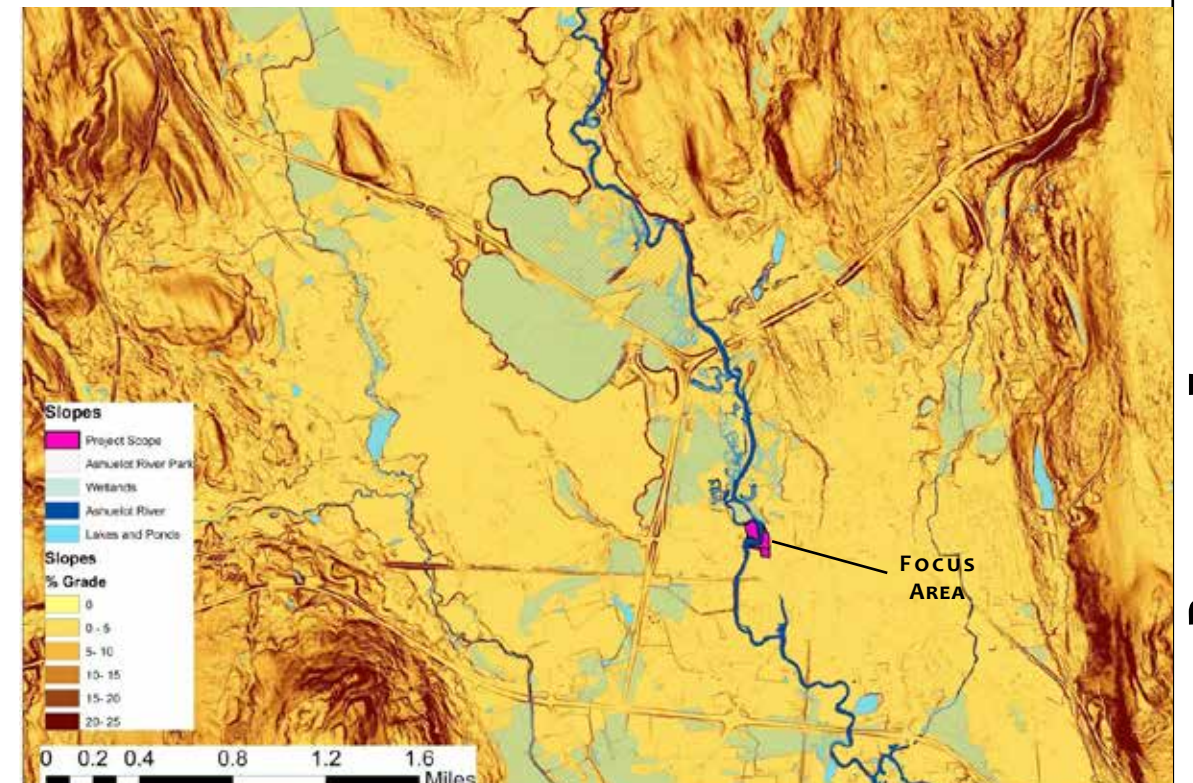
Most of the Ashuelot River Park is covered with shrubby marsh wetlands and floodplain forest. These priority ecosystems are a stark contrast to the highly impervious and urbanized downtown area.



A. West Street Dam



B. Floodplain Forest



The entire park is in the middle of a wide flat valley, where the wetlands are located, with steeply sloped north-south uplands to the east and west. The area of focus for this master plan is shown in pink.

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FLOOD ZONES

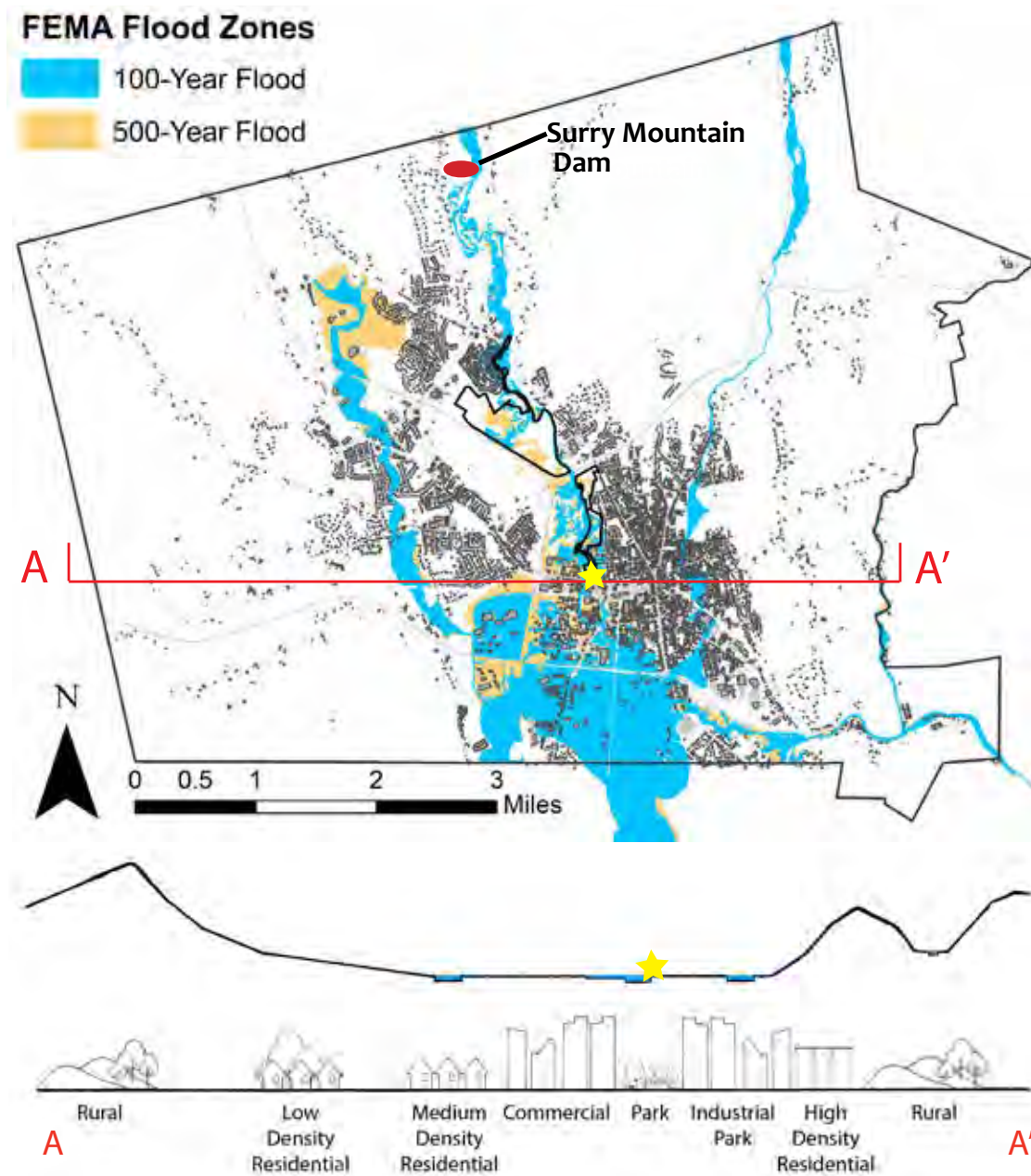
Based on the 2006 FEMA flood map, there are large areas of the Ashuelot River Park that fall within both 100- and 500-year floodplains. On the accompanying maps, the 100-year floodplain is indicated in blue and the 500-year floodplain in orange. The Arboretum is mostly elevated above both floodplains except for the northern portion by the kayak launch and the northeast area along the property boundary. The adjacent, rarely used parking lot to the northeast of the Arboretum does have a large area located in both the 100- and 500-year floodplain. When considering improvements to the northern section of the Arboretum, it is important to recognize that flooding in this area could occur. Structures and walkways should be designed to withstand flooding and vegetation could be added to areas currently

maintained as lawn to reduce the velocity of flood waters. Vegetation would also help to stabilize the soils and create habitat along the Ashuelot River.

The RMOLL is located in the 100- and 500-year floodplains. A levee runs 1,750 feet along the west side of the Ashuelot River north of the West Street Dam. This may reduce flood risks from 100-year flood events but does not protect the RMOLL from 500-year flood events. Maintaining the RMOLL in a natural state by preserving floodplain vegetation and minimizing man-made structures in this area will support the floodplain ecosystem response to a flood event and reduce hazards associated with flooding. Signs and educational tours in this

location could explain ecosystem functions of a floodplain forest.

It is important to note that upstream of the Ashuelot River Park is the Surry Mountain Dam, which was built in 1941 by the Army Corps of Engineers to control flooding downstream. The Surry Mountain Dam regulates the volume of water flowing downstream through Keene and the Ashuelot River Park. Given climate change and predicted increases in the frequency of 100- and 500-year storms, it is important to prepare for potential flooding in the Ashuelot River Park. Maintaining and enhancing riparian floodplain forests in the region increases the ability of the local ecosystem to respond to a flood disturbance.



Section A-A' across the City of Keene shows that the floodplain of the Ashuelot River is at the lowest elevation between dense urban developments.

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STORMWATER

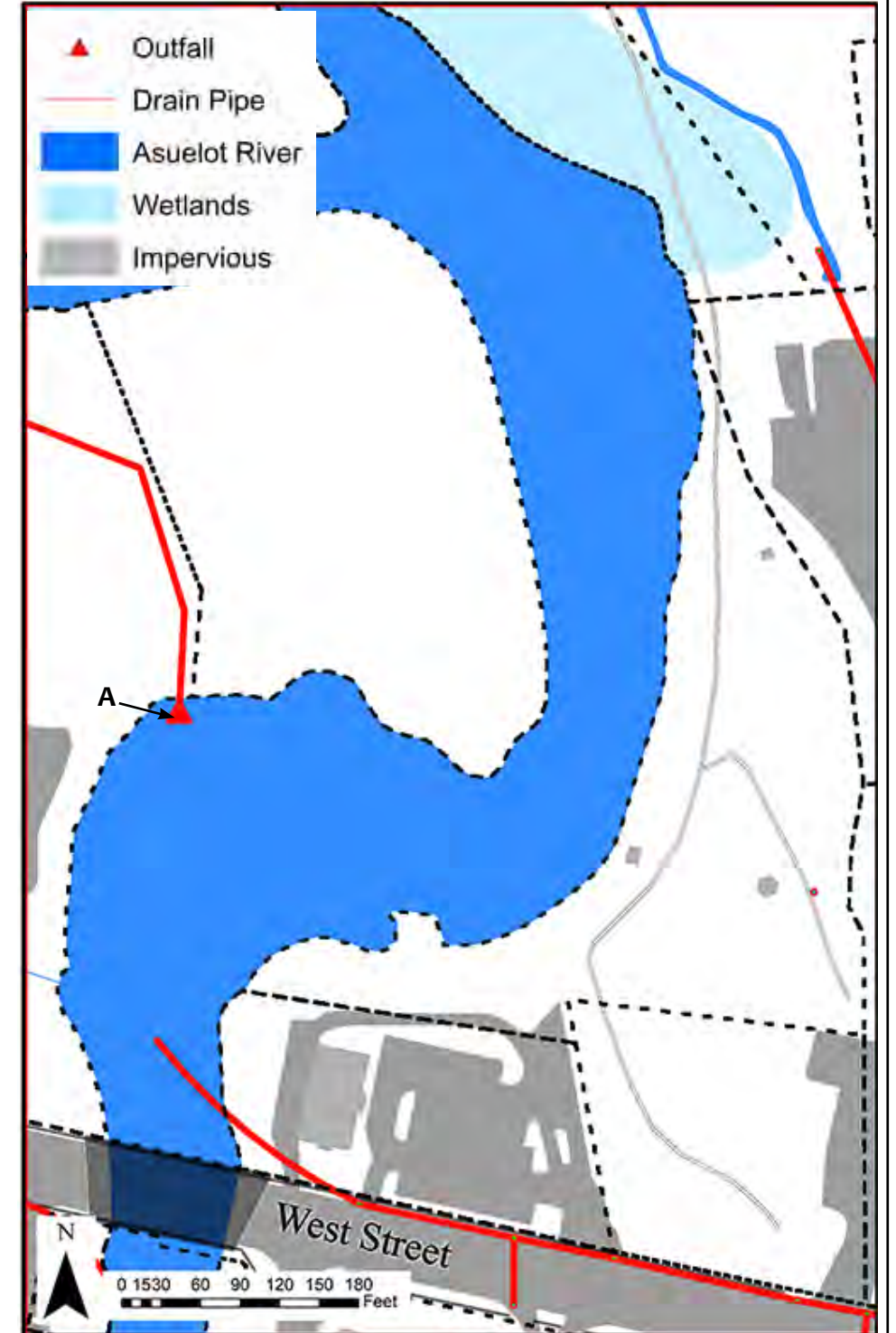
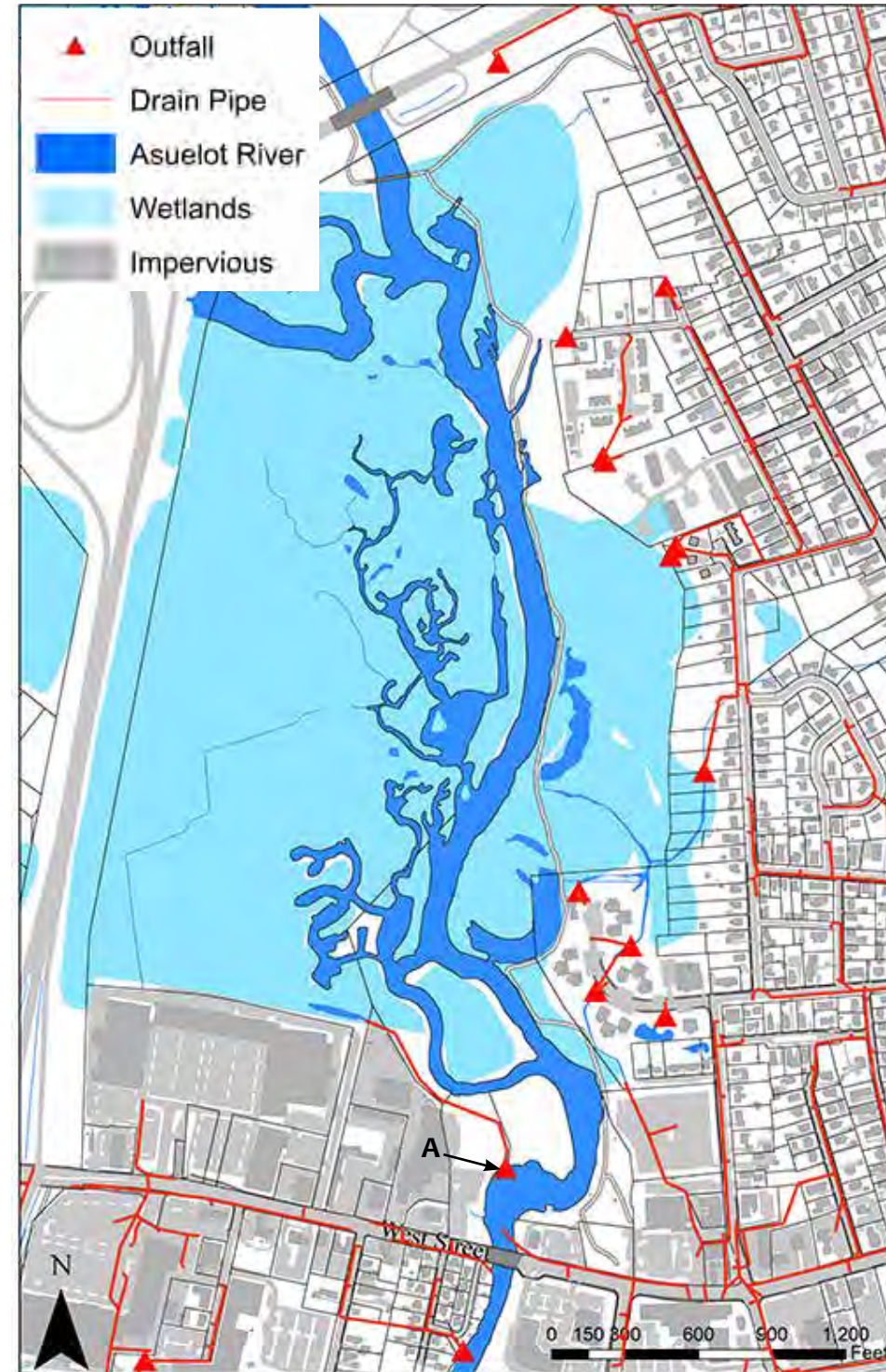
When stormwater resulting from a precipitation event hits a porous surface like vegetated ground, it is slowed down, cooled, and filtered prior to recharging groundwater or flowing into streams. When soils are saturated or the surface is impermeable, stormwater flows over the ground surface into stormwater pipes or directly into a waterbody. As it runs over these surfaces, stormwater can pick up pollutants, such as fertilizer from lawns or oil from roadways. Many pollutants enter water bodies directly through stormwater runoff and, therefore, managing stormwater can prevent water pollution. Pollution can be in the form of nutrients, sediment, temperature, bacteria, and chemicals.

The stormwater system for Keene does not have any outfalls that discharge into the Arboretum or the RMOLL. Farther north, however, there are two residential neighborhoods where outfalls discharge untreated stormwater into the eastern floodplain forest adjacent to the Ashuelot River Park. South of the RMOLL property boundary there is a direct discharge of stormwater into the Ashuelot River that originates from the commercial development to the west. These outfalls are sources of untreated stormwater from urban environments and potentially carry pollutants and heated water into Ashuelot River Park and the river itself. Additionally, during rain events large volumes of water are discharged into sensitive floodplain areas, potentially caus-

ing erosion and turbidity downstream. Stormwater from the Ashuelot Parking spaces enters a stormwater drain east of the park that discharges under the West Street Bridge into the Ashuelot River. In the northern portions of Ashuelot River Park, restoration of floodplain forests may be needed where the stormwater is discharged. Treating and reducing the volume of stormwater before it enters the Ashuelot River Park and the river will improve water quality for both human uses and river ecosystems. The addition of vegetation along the northern Arboretum riverbanks will also contribute to improving water quality by slowing down water, reducing erosion, catching sediment, and absorbing nutrients.



Photographs of the stormwater outfall downstream from West Street Dam, just south of the RMOLL western property line. The rust color is likely ironseep and it is evident at the discharge point into the Ashuelot River.



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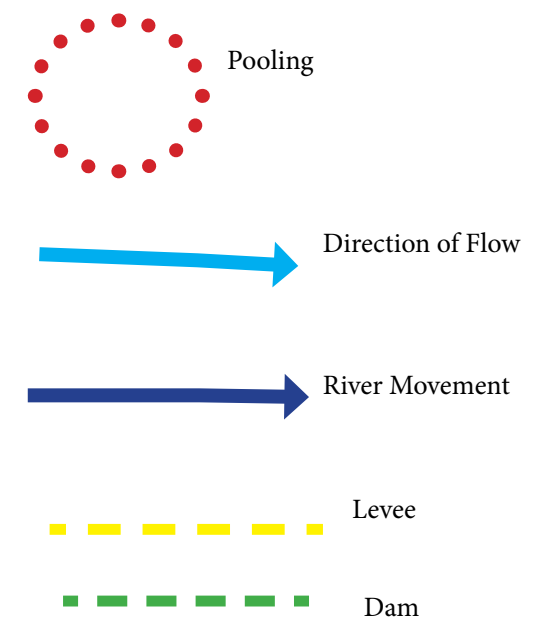
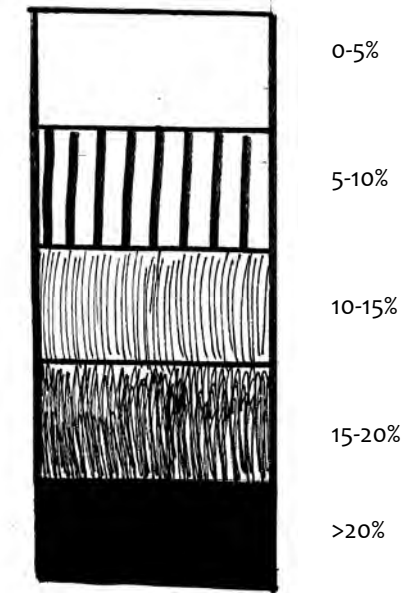
SLOPES AND DRAINAGE

Water moves down the steep banks of the RMOLL and northern Arboretum into the Ashuelot River. These banks are covered with predominantly invasive vegetation, like bittersweet, which helps to reduce erosion and offers some filtration. Expanding the width of these vegetated areas can increase filtration of runoff. The land cover within the flatter areas of the Arboretum, produces minimal runoff and does not appear to experience pooling. The trails in the northern part of the Arboretum abutting the abandoned parking lot are within the 100-year floodplain and subject to pooling. Water from the Starbucks parking lot moves south towards West Street where it enters the city storm drain system. Water moves west towards the Starbucks parking lot where it pools at the southwestern Arboretum boundary. The northern part of the Jonathan Daniels Trail (marked in red) is subject to soil compaction.

Increased precipitation events as a result of climate change will likely increase runoff into the Ashuelot River. The City of Keene should look to increase opportunities for green infrastructure, such as rain gardens and swales to effectively capture and store the excess rainwater that contributes to ponding (shown in red) in the park from runoff. The vegetated levee in the RMOLL shown in yellow helps mitigate some flooding into the city, but additional built structures in the RMOLL should be discouraged as further infrastructure disrupts natural ecosystem processes (see flooding analysis page 12).



Slopes % Grade



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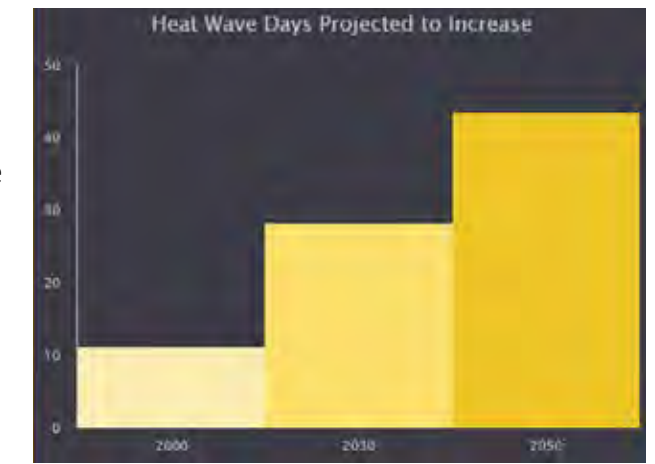
HEAT ISLAND EFFECT

Impervious cover, especially dense concentrations of impervious cover as found in urban areas, absorbs and radiates heat, raising the air temperatures. This is known as the heat island effect. Vegetation, especially large canopy trees, helps regulate air temperatures by capturing solar radiation, shading the ground below and re-releasing moisture into the air during transpiration. For this reason, green spaces are critical community resources that help to mitigate the impacts of the heat island effect, making the temperatures more bearable for both humans and wildlife.

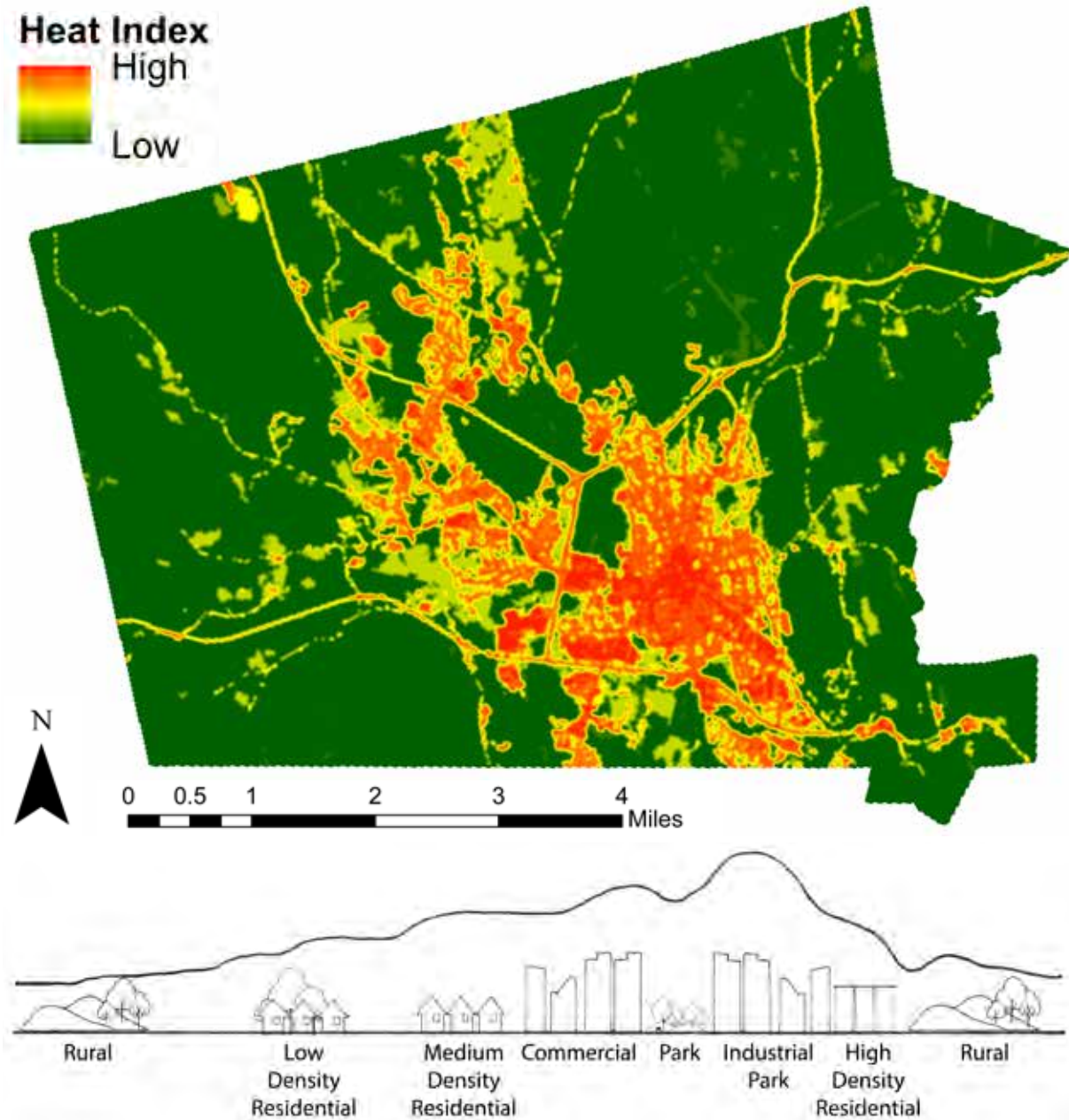
Numerous scientists, including the Union of Concerned Scientists, have been documenting temperature trends and calculating projections for the future. In the Northeast, it is projected that there will be a significant increase in heat waves, drought, and humidity. Additionally, extreme heat days are associated with increased levels of ozone pollution, which can cause asthma attacks, heat stroke, and other serious health afflictions (EPA.gov/heat-island).

Within Keene, the heat island effect is greatest around the downtown area. The Ashuelot River Park is shown on the map below as cooler than downtown areas, due to the density of tree cover; however, the southern Arboretum is very hot, due to the dense impervious cover of the road and adjacent parking areas radiating heat into the park. The RMOLL appears to be considerably cooler, likely due to its extensive canopy cover, its proximity to other forested spaces, and its distance from impervious areas.

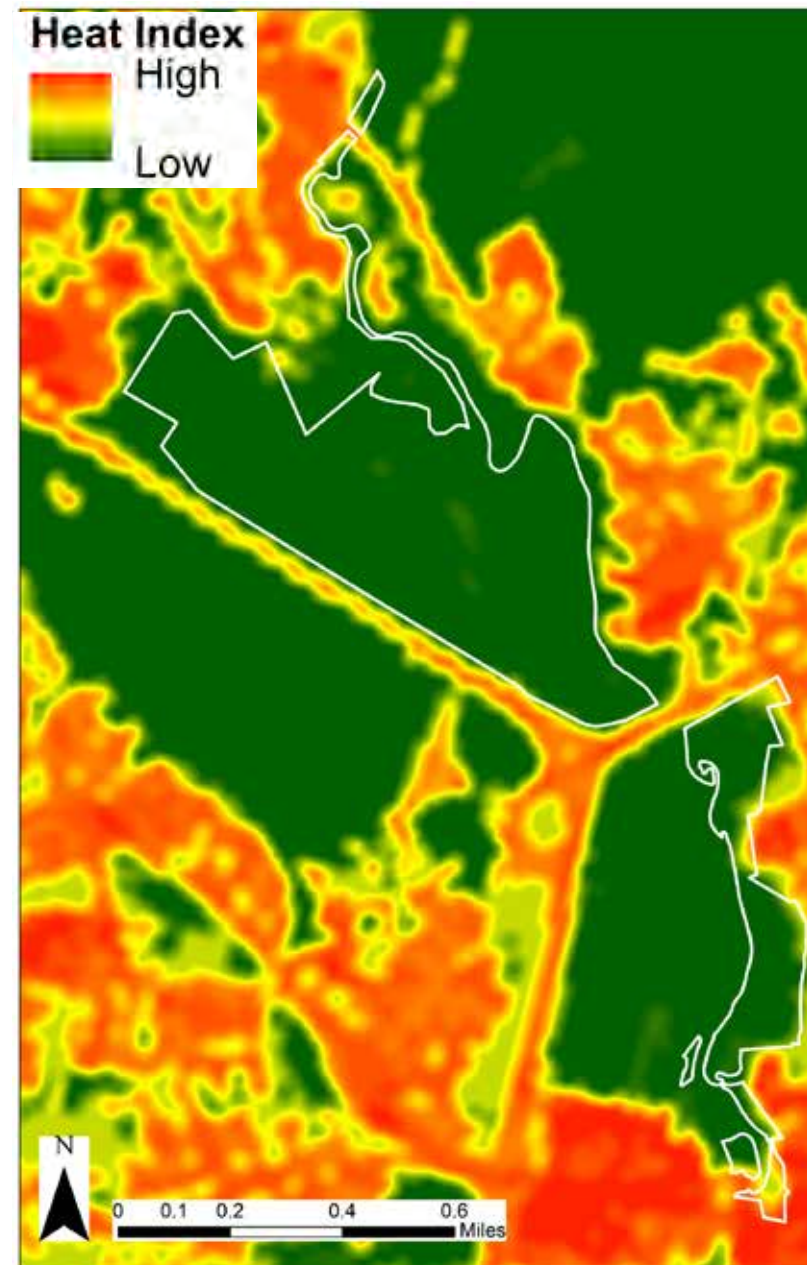
These maps are conceptual representations of heat island vulnerability. Using concentration and distribution of land cover types, these maps illustrate the areas most likely to experience heat during projected extreme heat days.



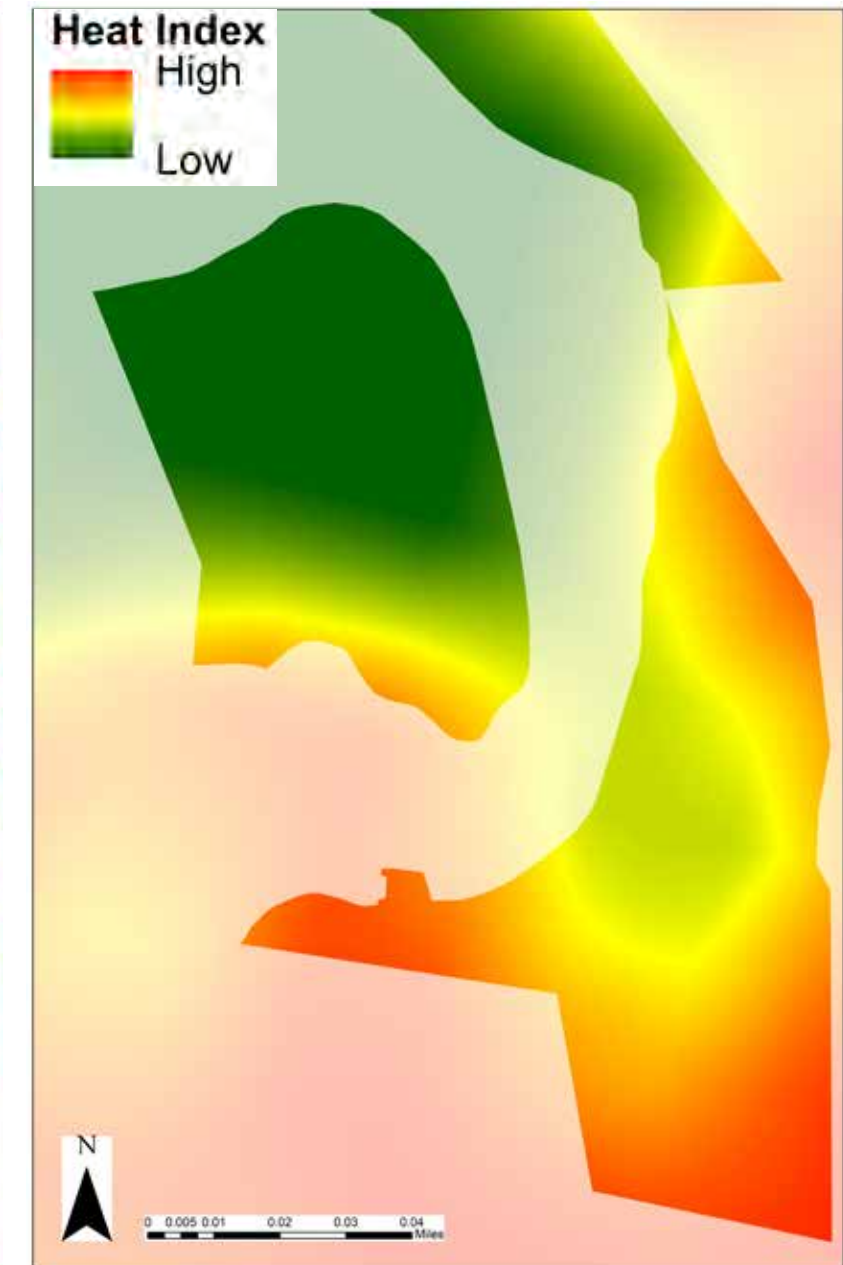
The Union of Concerned Scientists projects that extreme heat days (over 90° F) are expected to increase to over 40 days a year. Source: statesatrisk.org.



Adapted from *The Effect of Rapid Urbanization on the Physical Modification of Urban Areas*. The cross section illustrates how the heat island effect peaks in the commercial and industrial sections of the city, and gradually subsides in the rural parts of the city. The black line above the section reflects the temperature changes in different land use conditions.



The Ashuelot River Park appears significantly cooler than the surrounding area.



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REGULATIONS

KEENE ORDINANCES

Zoning

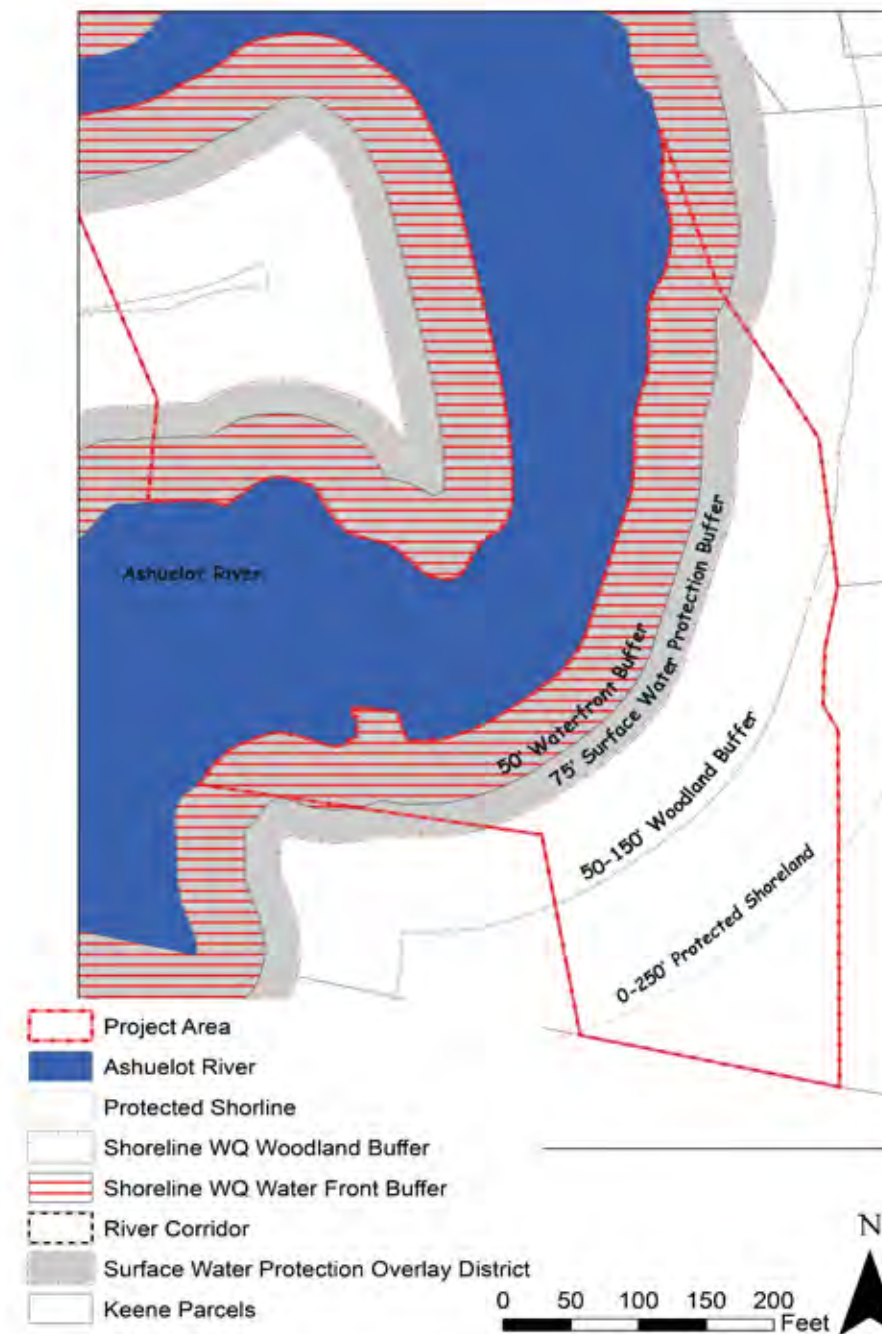
The Ashuelot River Park is zoned Conservation and has 50-foot property boundary setbacks for new structures. Any proposed activities are subject to the site plan review process and review by the Conservation Commission. The Conservation Commission retains the development rights to lands in the Conservation Zone or these lands are otherwise protected from development. Activities allowed in this zone include trails and educational activities, such as signs.

Surface Water Protection Overlay District

Article XVI of the Keene Zoning Ordinances establishes a surface water protection overlay district overlaying all other zoning districts. This district establishes a 75-foot buffer zone surrounding surface waters, which is to remain vegetated in an undisturbed and natural condition (pg. 224, 220). The current vegetation within the buffer consists of invasive species such as honeysuckle and bittersweet as well as native red twig dogwood, crabapple, and hawthorn. The purpose of this district is to protect the functions and values of surface waters and areas within the buffers associated with them and to prevent the deterioration of water quality associated with stormwater runoff, maintain the health and holding capacity of natural surface and ground waters, and protect the quality and connectivity of wildlife habitat and corridors (Sec. 102-1481).

Maintaining vegetative cover around surface waters and adjacent buffer areas is intended to slow stormwater flow, to facilitate infiltration, to moderate water temperature fluctuations of surface water bodies, and to allow bio-remediation of excess nutrients and introduced pollutants. It is also intended to preserve the ability of surface water and adjacent buffer areas to provide treatment of surface runoff for water quality improvement purposes (Sec.102-1481).

A conditional use permit is needed for new stormwater improvements within the 75-foot buffer of surface waters within the surface water overlay protection district. Restoration of the 75-foot buffer that stabilizes banks, captures surface runoff, and provides riparian habitat would improve current conditions in the Arboretum and RMOLL. Through design, paths and viewing areas can be added or changed to improve the ecological function of the riparian area defined by the 75-foot buffer zone while offering recreation and educational opportunities.



With local Keene ordinances and state regulations, permitting may be needed to undertake new projects in the Ashuelot River Park. Keene's Conservation Commission is a potential resource as the master planning process continues. Focused on protecting natural resources, the commission can provide insight and feedback on design plans and permitting needs.

NEW HAMPSHIRE REGULATIONS

Shoreland Water Quality Protection Act

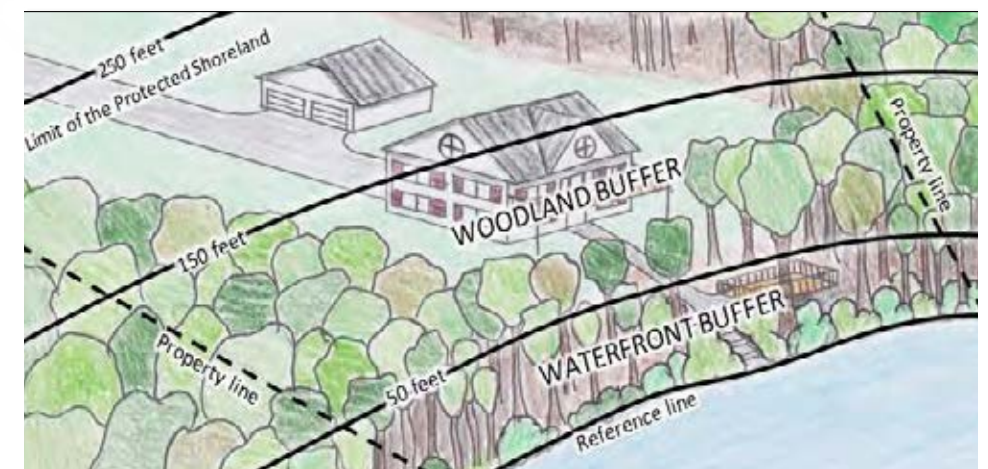
Land within 250 feet of the reference line of protected water bodies, including fourth order and greater streams and most designated rivers, is regulated under New Hampshire's Shoreland Water Quality Protection Act. The intent of this legislation is to protect the integrity of public waters. Impervious surfaces are limited to less than 20 percent of the parcel without requiring stormwater remediation systems. Vegetation is encouraged and not all new plantings require a permit. The Shoreland Water Quality Protection Act establishes waterfront and woodland buffer zones adjacent to the public water body with associated requirements.

Waterfront Buffer

From the reference line, or high-water elevation, extending back 50 feet is the waterfront buffer zone. Shrubs and groundcovers may not be removed in this zone. Trees and saplings should be managed to achieve 25 points per 25 by 50-foot grid section along the waterbody. Trees are awarded points based on their diameter at 4.5 feet above ground. Diameters are divided into four categories of points with a >12-inch diameter scoring 15 points, the greatest point category. Shrubs may not be trimmed to a height of less than 3 feet and pruning the bottom third of trees is permitted to achieve views.

Woodland Buffer zone

Between 50 and 150 feet from the reference line is the woodland buffer zone. 25 percent of this zone area must be managed as natural woodland. This area can be distributed across the woodland buffer zone, though vegetation including trees, shrubs and groundcovers must be allowed to grow in an unaltered state. Vegetation may be added to establish a natural woodland.



From New Hampshire Department of Environmental Services "Vegetation Management for Water Quality."

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UTILITIES

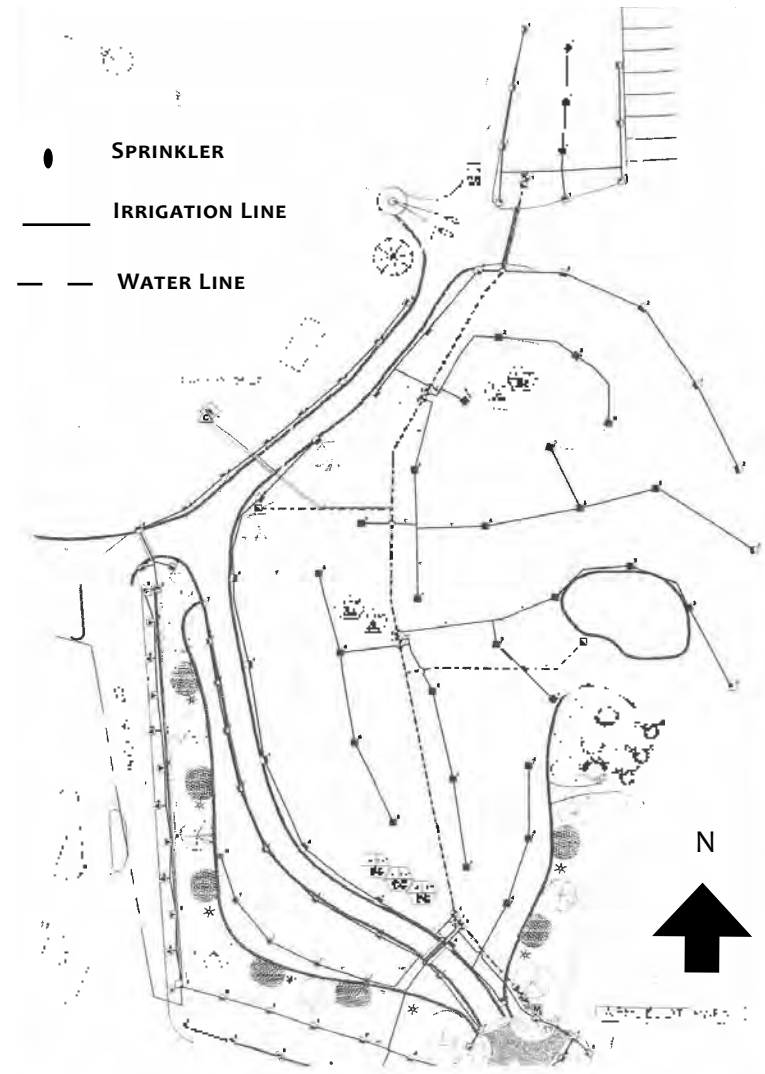


WATER AND SEWER

The water and sewer mains are along West Street, the southern border of the Arboretum. Currently, a water connection provides irrigation water, but there is not a sewer connection into the park. Composting toilets could provide an alternative to connecting to the sewer main. There is a closed composting toilet located in the northern portion of the Arboretum that needs repair and could potentially be relocated to a more visible location. A water line could be extended to provide drinking water in a central location.

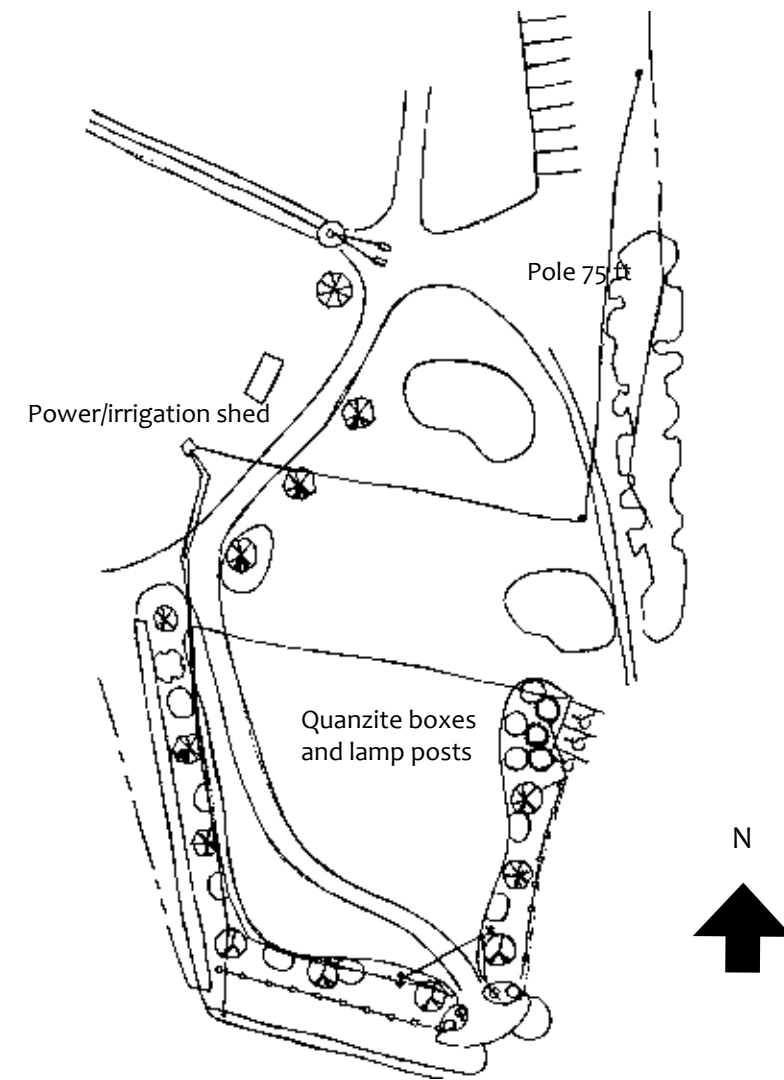


Closed composting toilet in northern Arboretum



IRRIGATION

The Arboretum has a sprinkler irrigation system, which is connected to city water in the southeast portion of the park. This relatively new system is dependable and irrigates both the lawn areas and the perennial beds. Irrigation does not extend to the RMOLL. Overhead sprinkler systems can be inefficient due to evaporation, water runoff, and overwatering. It is important to operate the system in the early mornings or evenings when there is less potential for evaporation. Alternatively, drip irrigation could be installed in garden beds allowing water drip into the root zones of plants, reducing water usage. Another strategy to reduce water use is to incorporate plants that can tolerate a wide range of moisture conditions. Drought-tolerant plants do not need as much water as those that are adapted to wet conditions. There are also species that can tolerate both wet and dry conditions. (See plant lists on pages 35-38.) Because the Arboretum irrigation system connects to the water supply main, there is potential to connect a separate line to supply potable water to a water bottle filling station or water fountain. If excavating for a new water line, protecting tree roots (which extend at least to the edge of the canopy of the tree) will help prevent crown dieback and protect the health of the tree.



ELECTRICITY

In the Arboretum, there are overhead lights and power to the maintenance shed, which has the irrigation controls and a power outlet. The lights increase visibility and safety in the park at night. Considering renewable energy options like solar to offset the electrical use of these safety lights could reduce dependency on fossil fuels and lower operating costs long term.



Typical light in main Arboretum.

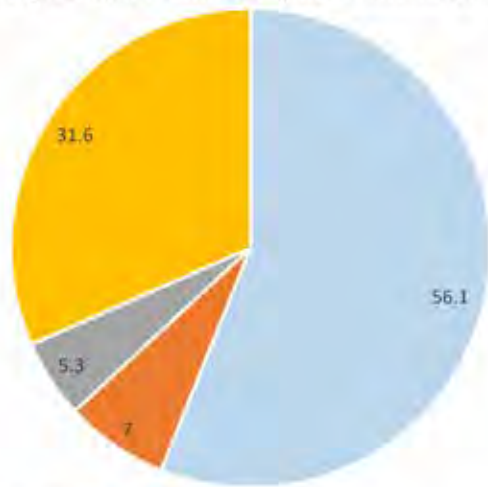
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ACCESS AND CIRCULATION

There are multiple ways to enter the park, some formal and some informal. Most people enter through the front entrance on West Street. Some other formal entrances include the Mascoma Bank parking lot (circled in blue) and the Starbucks parking lot (in pink). Some of the informal entrances include along the trail in the RMOLL and across the abandoned parking lot in the northern part of the Arboretum. People were observed walking, biking, and kayaking along the river. People were observed gathering in both sunny and shady areas, but primarily where there are benches. Most people park in the Mascoma Bank parking lot with some parking in the Starbucks lot.

Visitors to the park are deterred from using certain locations due to unwanted or inappropriate behavior by individuals within the wooded area near the RMOLL and in the gazebo. Very few people were observed admiring the garden beds and the trees, which are central features of the Arboretum and should be highlighted as they provide a valuable aesthetic and ecosystem services. Even though the accessible parking lot (in white) is quite close to the park, the garden bed west of the parking lot blocks universal access for people into the park. There are opportunities to further connect trail networks in general and create other formal entrances to the park.

Are facilities/resources within the park accessible to all visitors?



- Yes, facilities/resources within the park are accessible to all
- No, facilities/resources within the park are not accessible to children
- No, facilities/resources within the park are not accessible to adults
- No, facilities/resources within the park are not accessible to senior citizens and to persons with disabilities

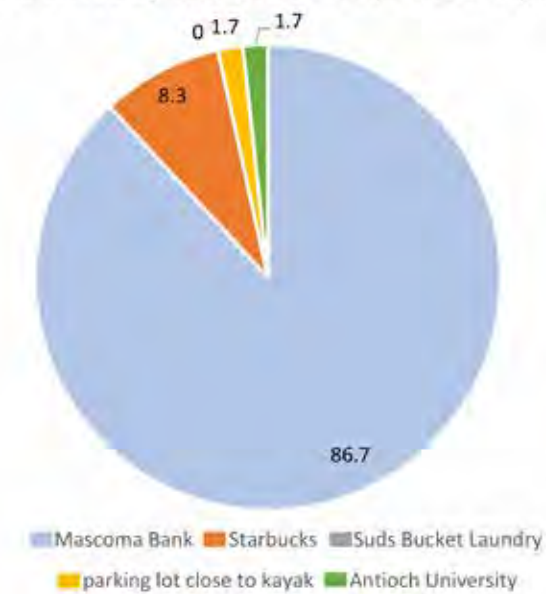
From online survey. Most respondents believe park resources are accessible, but some say not all resources are accessible to senior citizens and persons with disabilities.



A. West Street Parking Lot

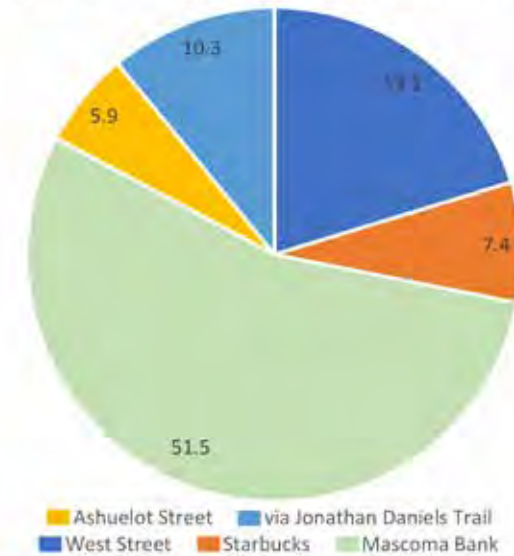


If you arrive by car, where do you usually park?



From online survey. Roughly 86% of respondents said they park in the Mascoma Bank lot when they drive to the Ashuelot River Park.

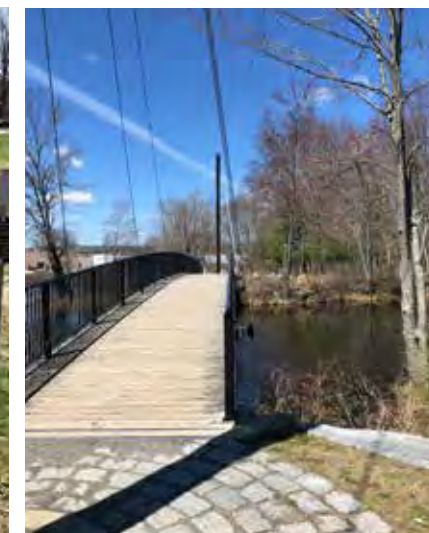
Which entrances do you typically use to access the park?



From online survey. Over 50% of respondents said they use the main entrance near Mascoma Bank to enter the Ashuelot River Park.



C. Trail



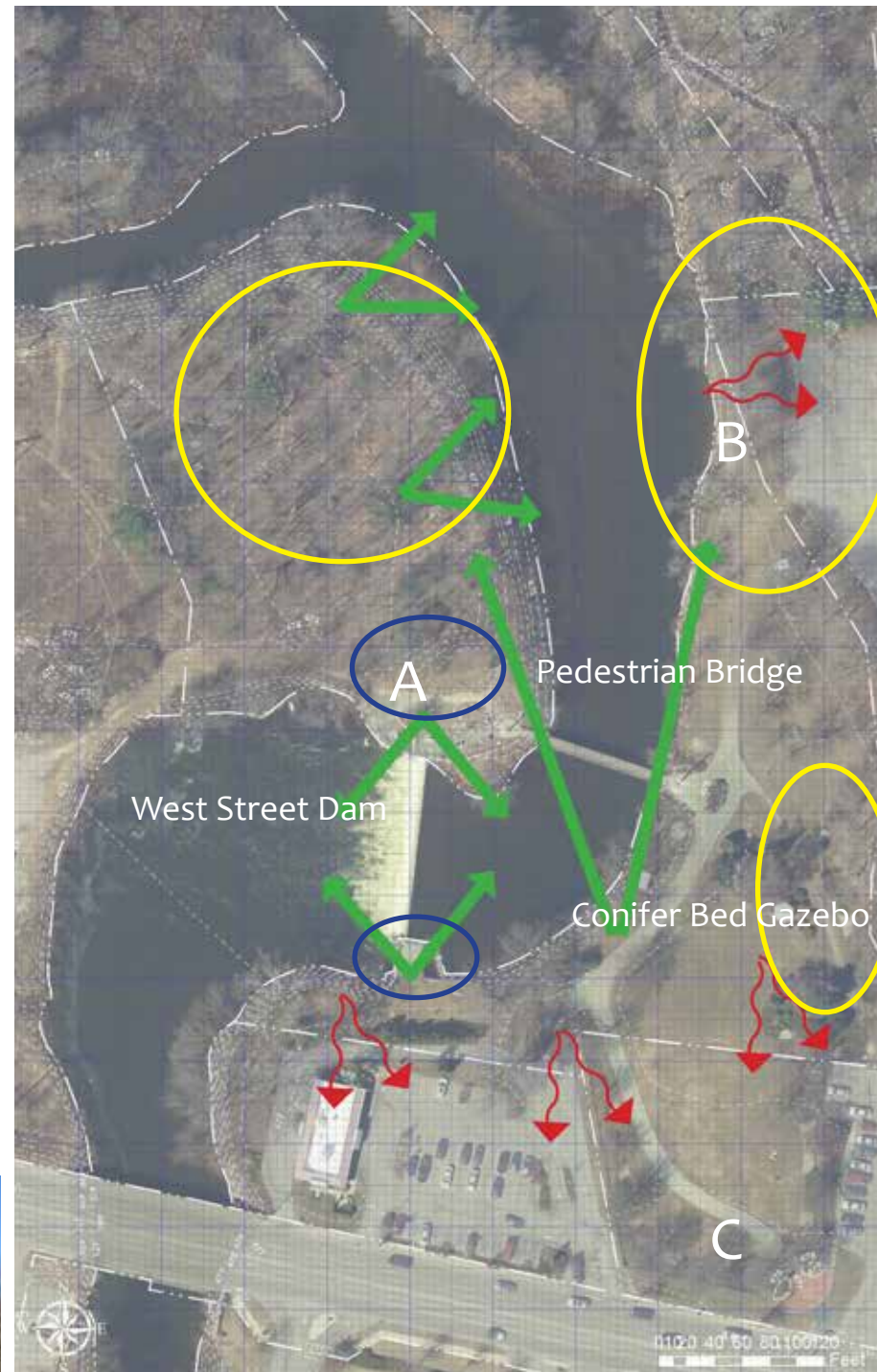
B. Pedestrian Bridge



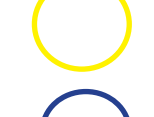

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VIEWS

Many people enter the park through the main entrance on West Street which is relatively noisy and highly trafficked. Trees along West Street and the western boundary of the park do not completely block views of parked cars and street traffic. There are not enough tall shade trees, particularly evergreen, to block views of parking lots and downtown traffic. Visitors admire views of the Ashuelot River from multiple places in the park, including from the pedestrian bridge and the benches in the RMOLL overlooking the dam. Though many areas are visible from the street and from pathways within the park, some areas are concealed by vegetation and structures. These low visibility areas are shown in yellow.

While trees along the edges of the Arboretum do not block views of parked cars and street traffic, they do allow views into the park, which can help to maintain a feeling of safety. Visitors are enamored with views of the river, yet these areas along the riverbank contain high amounts of invasive species and are prone to erosion. A balance between managing invasive species and providing access to views of the river could be achieved by adding native vegetation to stabilize the riverbanks and designated viewing areas. It is important to acknowledge low visibility areas as these places are often where inappropriate behavior occurs. These areas include in the back part of the RMOLL and near the gazebo and conifer bed.



-  Positive Views
-  Negative Views
-  Low Visibility Areas
-  Seating Areas to View Dam



A. View of the dam



B. View of the river at kayak launch






C. West Street

'Eyes on the Park'

Reducing isolated and hidden spaces by increasing views into and throughout the arboretum will contribute to the park being a place of safety and enjoyment. Visual barriers could be removed which would open views into the park from the public spaces along the periphery. Increasing lines of sight and opportunities for informal surveillance within the park could improve park safety and usage. Opening up views into the RMOLL would require pruning vegetation; this would impact the functioning and habitat value of this floodplain area.



-  Public Space - High Visibility from Street & Public Spaces
-  Dark Space - Low Visibility & Blocks Line of Sight into Park
-  Hidden Space - Not Visible from Public Spaces & the Street

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VIEWS

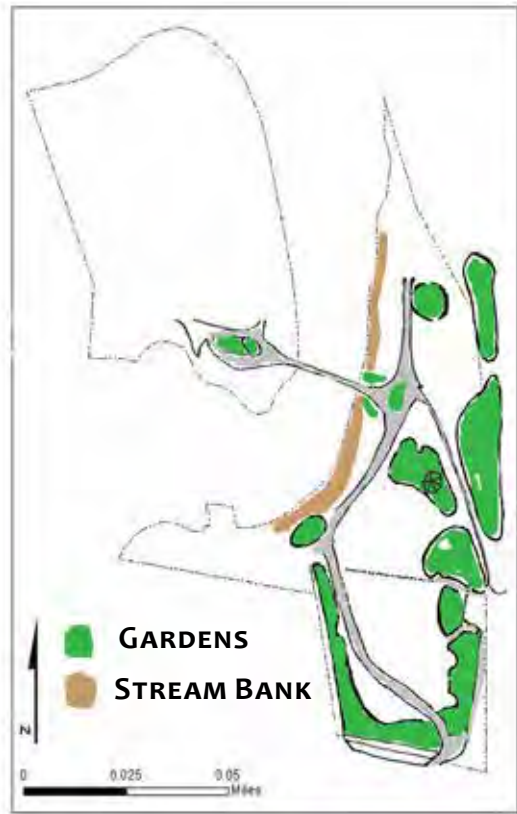
A MASTER PLAN FOR ASHUELOT RIVER PARK
FOR THE CITY OF KEENE, NEW HAMPSHIRE

DESIGNED BY: KATHERINE HOLDER, SAMANTHA PEIKES AND AMANDA SMITH

SPRING, 2020

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VEGETATION

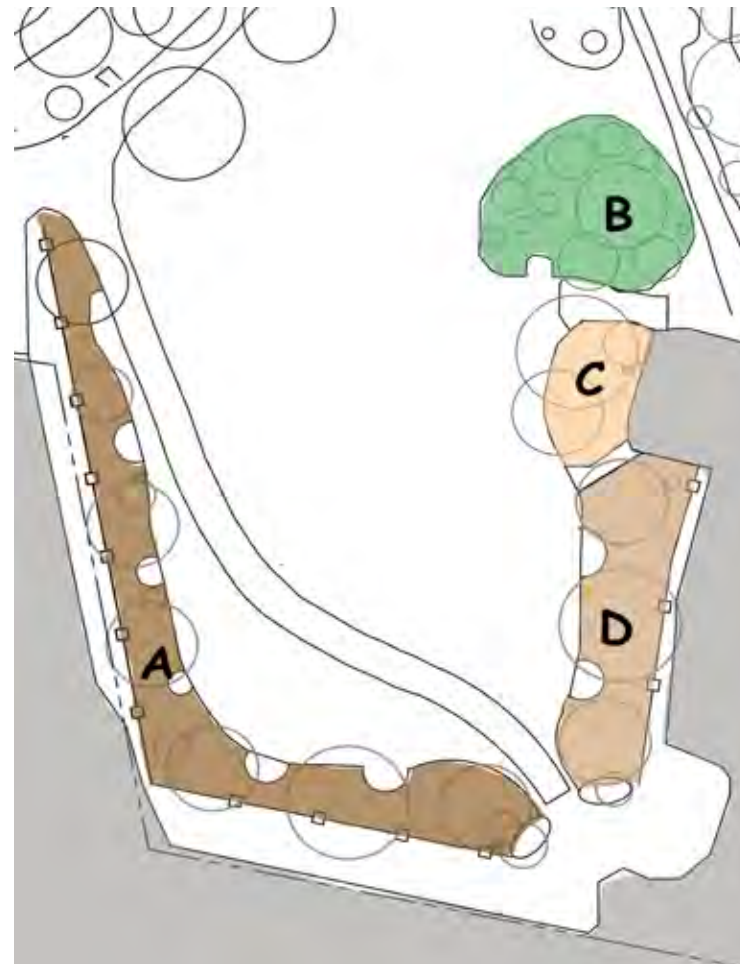


PERENNIAL GARDENS

Perennial gardens located along the edges and under canopy trees accent the arboretum specimens. Various perennials add character and interest to the large garden areas. Most perennial species are not native to the region, but contribute color, texture, and aesthetic value to the Arboretum.

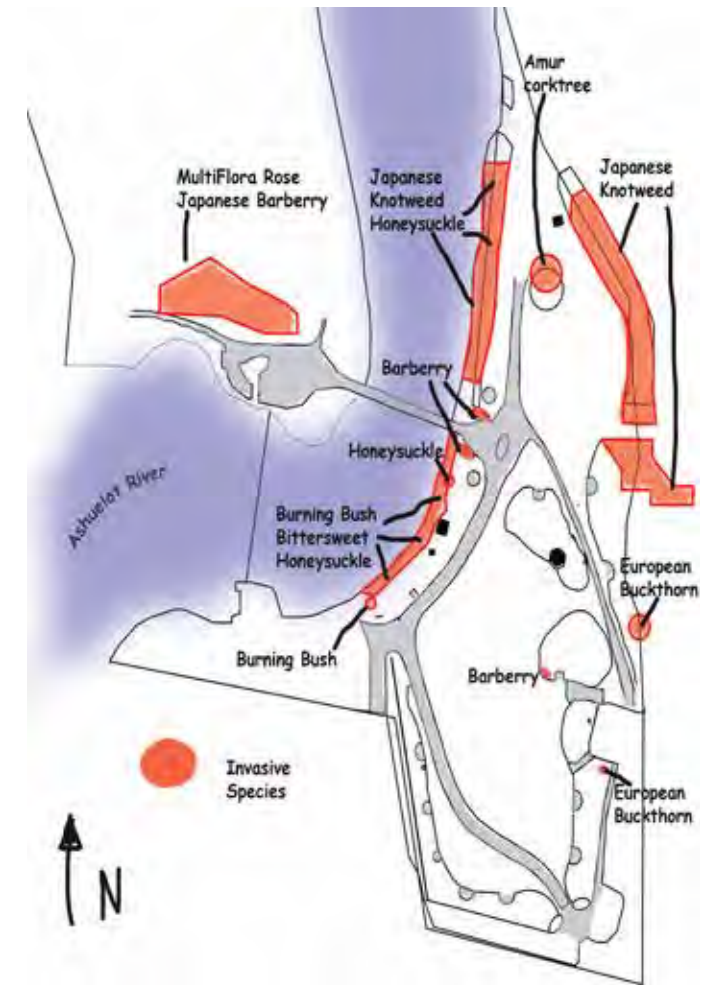
Currently, maintenance of the gardens is coordinated by Friends of Ashuelot River Park and volunteers from the community. Many hours are volunteered annually towards keeping the gardens looking good. Additional volunteers could help to share the burden of ongoing maintenance, but may be difficult to garner. A more successful approach might be to find opportunities to reduce maintenance. Weeding is an ongoing challenge despite mulching of the beds. The addition of more perennials could reduce open space and shade out weed seeds and prevent them from germinating. Groundcovers and colonizing plants could quickly cover open, mulched areas and add interest and texture to the gardens. Establishing more vegetation would also reduce evaporation and keep the soil from drying out.

When considering additions to perennial gardens, native species offer a diversity of choices that are tolerant of a range of conditions (See the plant lists on pages 35-38). Additionally, they have evolved with native pollinators and are adapted to regional environmental conditions. Locating native perennials in conditions where they are adapted to thrive would add seasonal color, reduce watering requirements, and provide habitat and forage for native pollinators and wildlife. It is also important to consider perennial additions that are adapted to future climate conditions. Many native species are tolerant of a range of temperature; however, as the climate warms, selecting species that tolerate the higher temperatures currently found in zones 6, 7, and 8 will increase the park's ability to adapt to climate change.



| Bed | Common Name | Botanical Name | Bed | Common Name | Botanical Name |
|---------------------|------------------------------|------------------------------|------------|-------------------|----------------------------|
| A | Daffodils | | B | Barberry | <i>Berberis thunbergii</i> |
| | Lilies | | | Day lily | |
| | Solomn's Seal | <i>Polygonatum</i> | | Daffodils | <i>Narcissus</i> |
| | Barrenwort | <i>Epimedium</i> | C | Plantain Lily | <i>Hosta</i> |
| | Easter Flower | <i>Hellebore</i> | | Day lily | |
| | Azalea | | Daffodils | <i>Narcissus</i> | |
| | Pulmonaria | <i>Pulmonaria</i> | D | Lilies | |
| | Colombine | <i>Aquilegia</i> | | Grasses | |
| | Peony | | | Iris | |
| | Rizomal Gernanium | <i>Geranium macrorrhizum</i> | | Cat Mint | <i>Nepita</i> |
| | Phlox | | | Coral Bells | <i>Heucura</i> |
| | Tickseed | <i>Coreopsis</i> | | Rizomal Gernanium | |
| | Siberian Iris | | | Daffodils | <i>Narcissus</i> |
| | Beach Rose | <i>Rosa Rugosa</i> | Rudebeckia | | |
| Annabelle Hydrangea | <i>Hydrangea arborescens</i> | | | | |
| May Apple | <i>Podophyllum peltatum</i> | | | | |
| Rose | | | | | |
| Varigated Dogwood | <i>Cornus Alba</i> | | | | |
| Cranesbill | <i>Geranium</i> | | | | |
| Rodgersia | <i>Saxifragaceae Sp</i> | | | | |

Testing soils in garden beds will help determine current soil conditions such as pH, organic matter, and nutrient levels. Soil test results will help indicate how to improve existing soils, for example through the use of compost or other amendments.



INVASIVE SPECIES

Invasive species are present in both the Arboretum and RMOLL. Management of these species will help native plants regenerate in the park and reduce the threat to surrounding ecosystems. Control of these species will likely be dependent on the species' life cycle. Mechanical removal of species will help reduce invasive populations, yet chemical treatments may be needed on more persistent species like Japanese knotweed. Chemical applications are known to have hazards to humans and the natural environment.



Invasive species along riverbank.

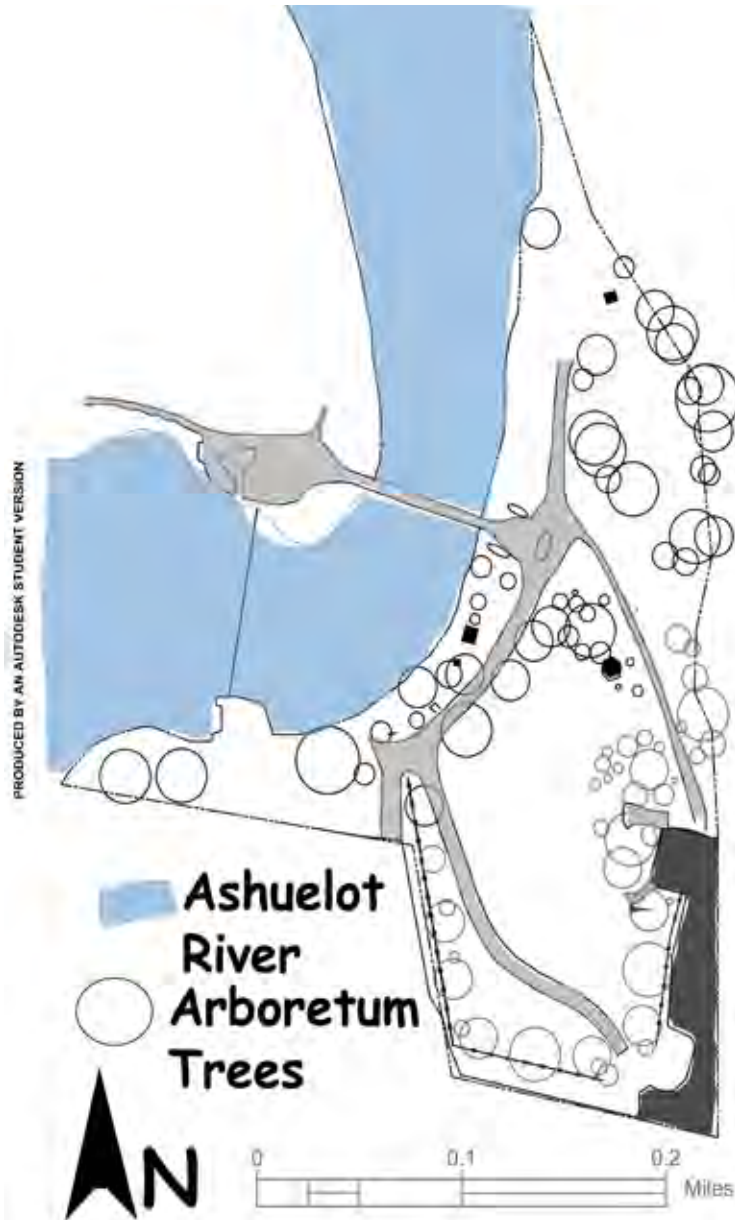


Common buckthorn hand drawing.

| Common Name | Botanical Name |
|----------------------|---------------------------------------|
| Japanese barberry | <i>Berberis thunbergii</i> |
| Bittersweet | <i>Celastrus orbiculatus Thunb</i> |
| Autumn olive | <i>Elaeagnus umbellata Thunb. var</i> |
| Burning bush | <i>Euonymus alatus (Thunb.) Sieb</i> |
| Japanese honeysuckle | <i>Lonicera japonica Thunb.</i> |
| Japanese knotweed | <i>Reynoutria japonica</i> |
| Common buckthorn | <i>Rhamnus cathartica L.</i> |
| Multiflora rose | <i>Rosa multiflora Thunb.</i> |
| Amur corktree | <i>Phellodendron amurense Rupr.</i> |

Not for construction. Part of a student project and not based on a legal survey.

ARBORETUM TREES



Weeping Hemlock



North Arboretum picnic rock

| Tree ID | Botanical Name | Common Name | Additional Information |
|---------|---------------------------------|-------------------------|-------------------------|
| 1 | <i>Rhamnus cathartica</i> | Buckthorn-European | frangula 'Asplenifolia' |
| 2 | <i>Acer rubrum</i> | Maple-Red | 'Red Sunset' |
| 3 | <i>Quercus palustris</i> | Oak-Pin | |
| 4 | <i>Acer saccharum</i> | Maple-Sugar | |
| 5 | <i>Magnolia sp</i> | Magnolia | lilliflora 'Ricky' |
| 6 | <i>Magnolia sp</i> | Magnolia | lilliflora 'Ricky' |
| 7 | <i>Picea pungens</i> | Spruce-Colorado Blue | 'Montgomery' |
| 8 | <i>Acer saccharum</i> | Maple-Sugar | |
| 9 | <i>Acer saccharum</i> | Maple-Sugar | |
| 10 | <i>Acer saccharum</i> | Maple-Sugar | |
| 11 | <i>Viburnum sp</i> | Viburnum | |
| 12 | <i>Quercus palustris</i> | Oak-Pin | |
| 13 | <i>Syringa vulgaris</i> | Lilac-Common | |
| 14 | <i>Acer rubrum</i> | Maple-Red | 'Red Sunset' |
| 15 | <i>Syringa meyeri</i> | Lilac-Meyer | |
| 16 | <i>Acer pseudoplatanus</i> | Maple-Sycamore | hybrid unknown |
| 17 | <i>Liriodendron tulipifera</i> | Tuliptree | |
| 18 | <i>Sophora japonica</i> | Pagoda Japanese | |
| 19 | <i>Acer saccharinum</i> | Maple Silver | |
| 20 | <i>Populus deltoides</i> | Poplar Eastern | |
| 21 | <i>Acer saccharinum</i> | Maple Silver | |
| 22 | <i>Cornus kousa</i> | Dogwood Kosa | |
| 24 | <i>Chamaecyparis pisifera</i> | Falsecypress-Sawara | |
| 25 | <i>Acer saccharinum</i> | Maple-Silver | |
| 26 | <i>Acer rubrum</i> | Maple-Red | |
| 27 | <i>Cladrastis kentukea</i> | Yellowwood | |
| 28 | <i>Quercus robur</i> | Oak-English | |
| 29 | <i>Gymnocladus dioica</i> | Coffeetree-Kentucky | |
| 30 | <i>Cercidiphyllum japonicum</i> | Katsuratree | |
| 31 | <i>Crataegus sp</i> | Hawthorn | |
| 32 | <i>Crataegus sp</i> | Hawthorn | |
| 33 | <i>Malus spp</i> | Crab Apple | |
| 35 | <i>Fraxinus pennsylvanica</i> | Ash Green | |
| 36 | <i>Populus tremuloides</i> | Aspen | |
| 37 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 39 | <i>Phellodendron amurense</i> | Corktree Amur | |
| 40 | <i>Carpinus carolinianan</i> | Hornbeam-American | |
| 41 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 42 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 43 | <i>Syringa reticulata</i> | Japanese Tree Lilac | |
| 44 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 45 | <i>Acer saccharinum</i> | Maple Silver | |
| 46 | <i>Ulmus americana</i> | Elm American | |
| 47 | <i>Acer rubrum</i> | Maple Red | |
| 48 | <i>Acer rubrum</i> | Maple Red | |
| 49 | <i>Acer saccharinum</i> | Maple Silver | |
| 50 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 51 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 52 | <i>Robinia pseudoacacia</i> | Locust Black | |
| 54 | <i>Acer rubrum</i> | Maple Red | |
| 55 | <i>Magnolia x soulangiana</i> | Magnolia-Saucer | |
| 56 | <i>Nyssa sylvatica</i> | Tupelo Black | |
| 63 | <i>Prunus serotina</i> | Cherry Black | |
| 64 | <i>Acer saccharinum</i> | Maple Silver | |
| 68 | <i>Betula nigra</i> | Birch-River | |
| 69 | <i>Betula nigra</i> | Birch-River | |
| 70 | <i>Cornus mas</i> | Dogwood-Corneliancherry | |
| 71 | <i>Aesculus hippocastanum</i> | Horsechestnut Common | |
| 72 | <i>Syringa reticulata</i> | Lilac-Japanese Tree | |
| 73 | <i>Picea pungens</i> | Spruce-Colorado Blue | 'Montgomery' |
| 74 | <i>Pinus flexilis</i> | Pine-Limber | |
| 75 | <i>Abies concolor</i> | Fir-White | 'Pendula' |
| 76 | <i>Tsuga canadensis</i> | Hemlock-Canadian | 'Sargentii' |
| 77 | <i>Cornus mas</i> | Dogwood-Corneliancherry | |
| 78 | <i>Magnolia x soulangiana</i> | Magnolia-Saucer | |
| 79 | <i>Picea pungens</i> | Spruce-Colorado Blue | 'Costers' |
| 80 | <i>Picea abies</i> | Spruce-Norway | 'Pendula' |
| 81 | <i>Chamaecyparis pisifera</i> | Falsecypress-Sawara | |
| 82 | <i>Pinus thunbergiana</i> | Pine-Japanese Black | |
| 83 | <i>Picea pungens</i> | Spruce-Colorado Blue | 'Pendula' |
| 84 | <i>Picea abies</i> | Spruce-Norway | 'Pendula' |

The Ashuelot River Park has 96 trees registered in the Arboretum. Native tree species include red maple, silver maple, sugar maple, hawthorn, black locust, yellow wood, elm, hemlock, hop hornbeam, green ash, and crabapple. Non-native species, plant species not endemic to the Northeast, include Japanese maple, Japanese tree lilac, sycamore maple, weeping Norway spruce, and Colorado blue spruce.

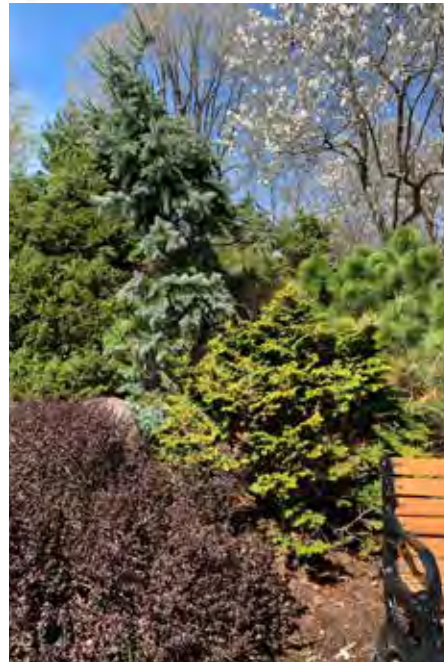
Trees offer many ecological benefits including bank stabilization, carbon sequestration, providing shade, habitat for wildlife, and absorbing stormwater.

Some trees will likely need to be replaced while others could be transplanted. For example, the young horse chestnut may need to be replaced because the large scar may limit its life expectancy, but the specimen conifers could be moved to a location with more sunlight.

Compaction of soils due to foot and maintenance vehicle traffic restricts root growth and infiltration of nutrients and water into soils, potentially impacting root development and tree growth. Establishing a root protection zones around trees will reduce soil compaction and increase infiltration of water and nutrients. A densely planted ground cover that tolerates shade could be used to deter foot traffic under the canopy of trees. Additionally, an educational sign could teach users about the presence of tree roots and how compaction of the soil can limit their growth.



Yellowwood



Conifer bed

Not for construction. Part of a student project and not based on a legal survey.

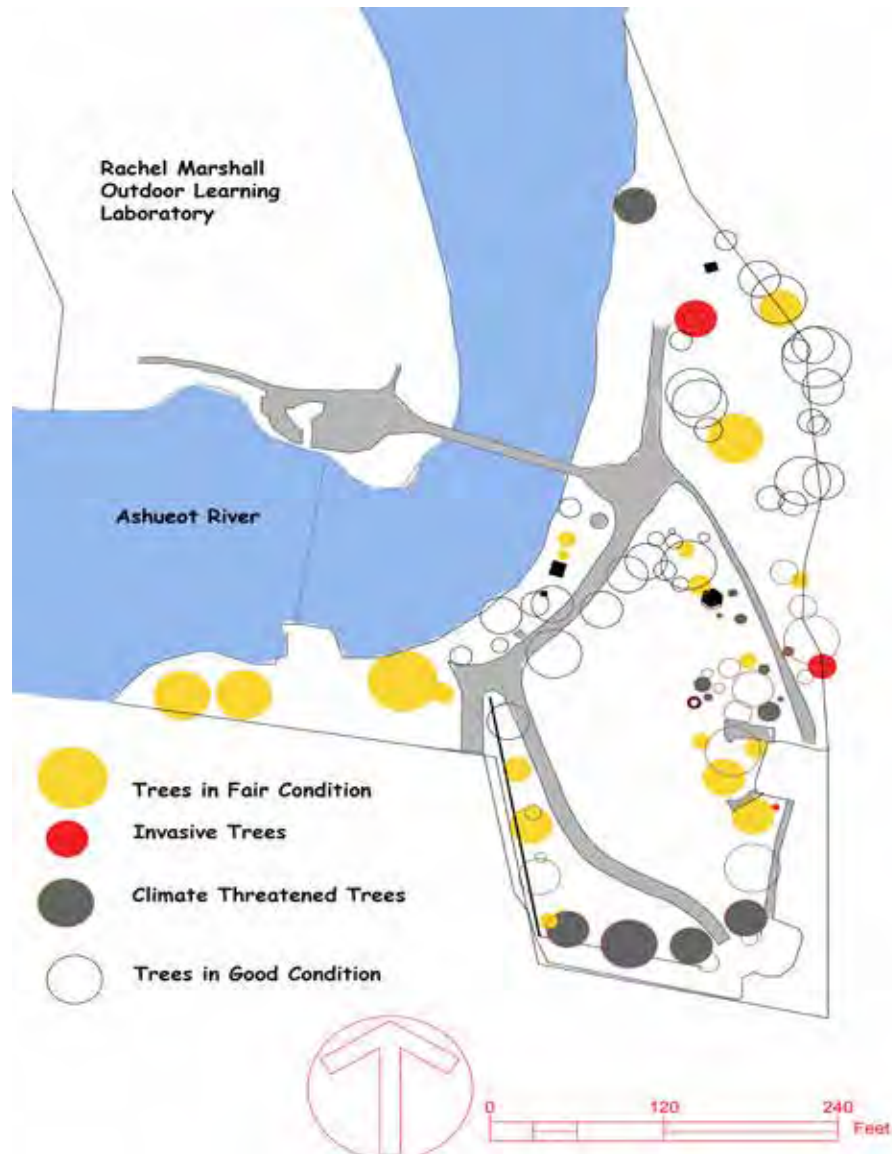
TREE HEALTH

Potential impacts to Arboretum trees from climate change include invasive pests, inability to respire in a carbon rich atmosphere, and changes to the precipitation patterns. Sugar maples that line the West Street portion of the park could potentially decline in health due to increases in carbon in the atmosphere (Oswald 2018). Pests populations like the emerald ash borer and the woolly adelgid will likely impact ash and hemlock tree species. These pests do not have a native predator and an increase in temperatures during the winter months will likely increase populations at a faster rate.

Selecting replacement tree species that would survive in projected climate conditions will increase the resiliency of the Ashuelot River Park. Looking to trees native to the east coast that are classified as zone 5, possibly even 7, will be more likely to tolerate warming trends predicted with climate change. Trees such as the sycamore and various oak species are tolerant of present and future condi-

tions in the Ashuelot River Park and could help transition the park into future climate conditions.

Most Arboretum trees are in good condition, yet some are in fair condition for various reasons due to damage, root girdling, and/or pests. For example, there are two large red maples with visible root girdling, which is when roots encircle the basal area of the tree and constrict the vascular system of the tree preventing water and nutrient movement. There is also a horse chestnut that has damage along its trunk, potentially exposing the tree to stress, pathogens, and a shorter life. According to Bartlett Tree experts, the large elm in the center of the Arboretum had Dutch elm disease, yet is still alive despite its condition (Bartlett 2014). Replacing these trees in the short term will ensure canopy cover and large Arboretum specimens in the future.



Root girdling of a red maple



Black locust basal scar



Sugar maples along West Street



Tree lilac

SUN & SHADE ANALYSIS



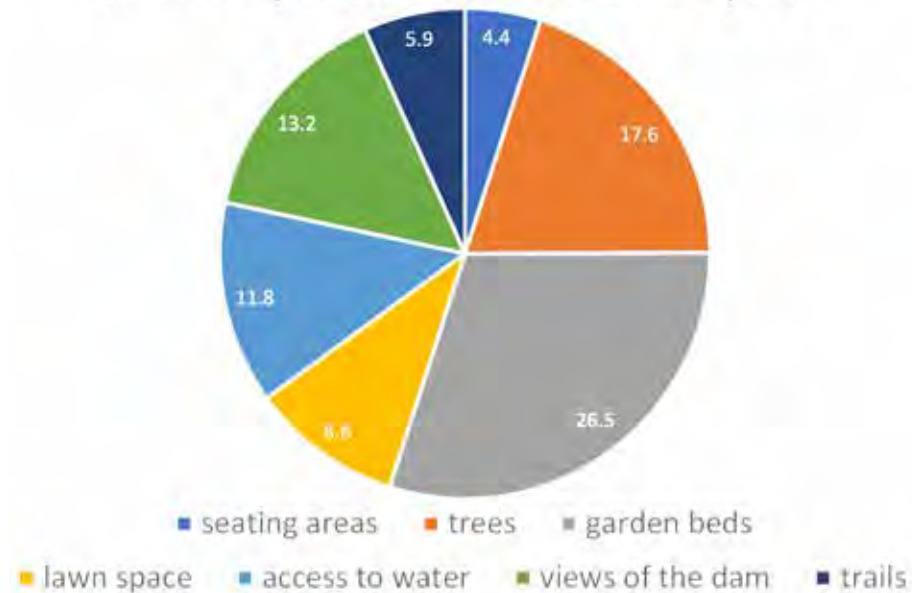
Dense deciduous canopies throughout the Arboretum cast localized shade throughout most of the growing season. The central lawn area in the Arboretum receives shadows in the morning and afternoon. The northern section along the river is in full sun most of the day. During the colder months, long shadows are cast in the Arboretum when the sun is low on the horizon.

Deciduous canopy trees offer relief from hot summer sun throughout the Arboretum. Successive tree plantings will succeed the mature trees once they reach their life expectancy, ensuring shade in the future. Due to the sunlight conditions around the perimeter of the park, perennials tolerant of sun and part sun are preferred with the exception of the western park entrance that is mostly shade.

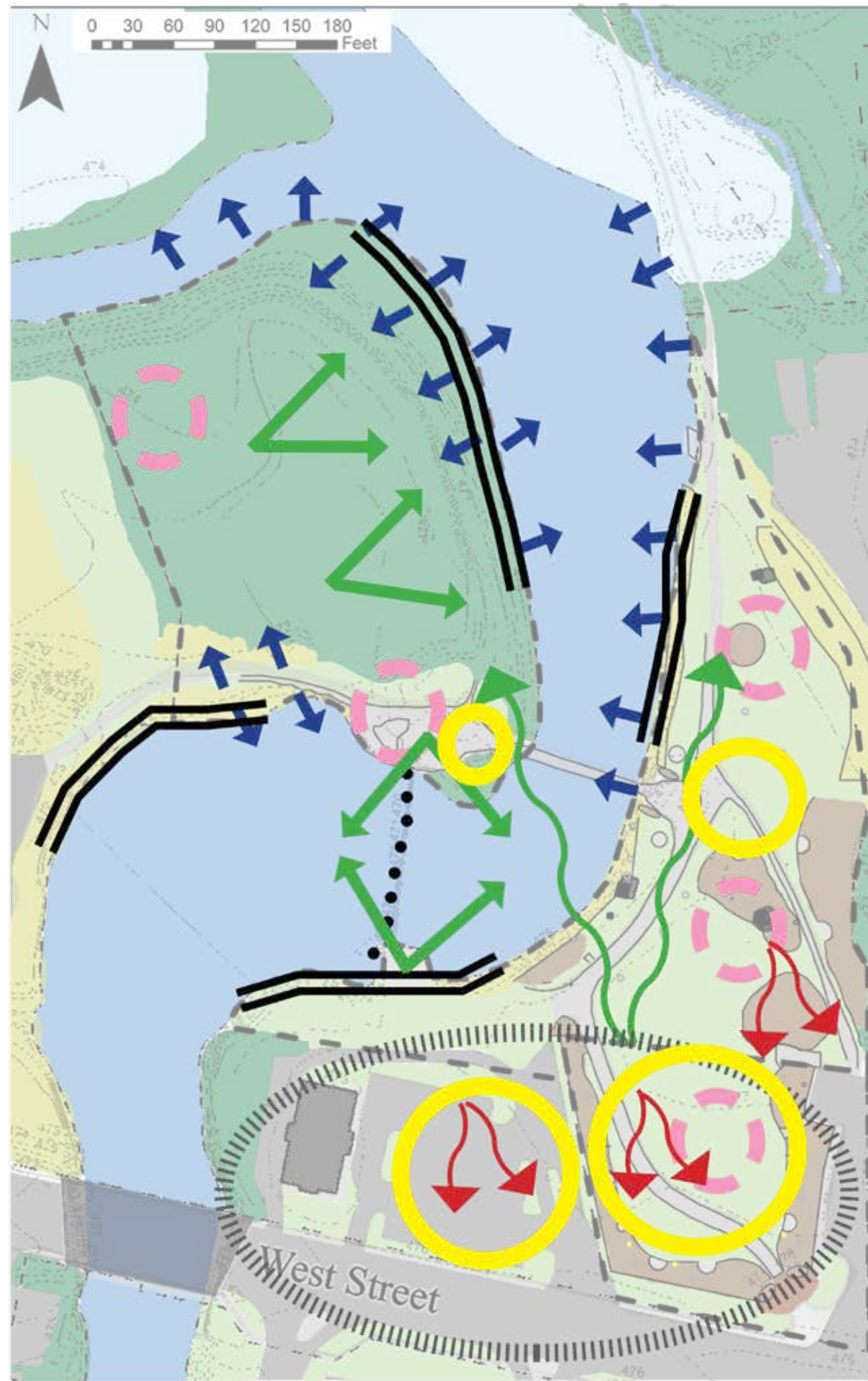
SUMMARY ANALYSIS

People who visit the Ashuelot River Park are drawn to views of the river and views of the West Street Dam. Unfortunately areas along the riverbank are overrun with invasive species and are prone to erosion. Though the invasive vegetation helps to stabilize some areas along the riverbanks, generally there needs to be an increase in native vegetation throughout the park to promote biodiversity and ecosystem services. The garden beds (in light brown) are a central component of the arboretum that attracts visitors (see survey graphs opposite). However, they are heavily mulched, plants are widely dispersed leading to weed invasions, and they lack diversity. Visitors to the park like to sit where there are benches and where there is open lawn space in the front part of Arboretum. These places though tend to be quite sunny and may become uncomfortable during warmer months, therefore it is advantageous to add more seating areas that are shaded from the sun. The gazebo is currently the only fully shaded seating area in the park, but visitors are often deterred from sitting there due to lack of visibility around the gazebo and long-term use of the gazebo by individuals. The RMOLL does not have a safe and accessible trail system and community members have noticed housing insecure individuals sleeping overnight in these areas. Disconnected and partially inaccessible trails and walking areas, lack of signage highlighting trees and formal garden beds, maintenance issues and lack of educational opportunities and signs in the RMOLL, have led the park to become used most often by visitors a pass-through instead of a place to stay and enjoy the planted areas.

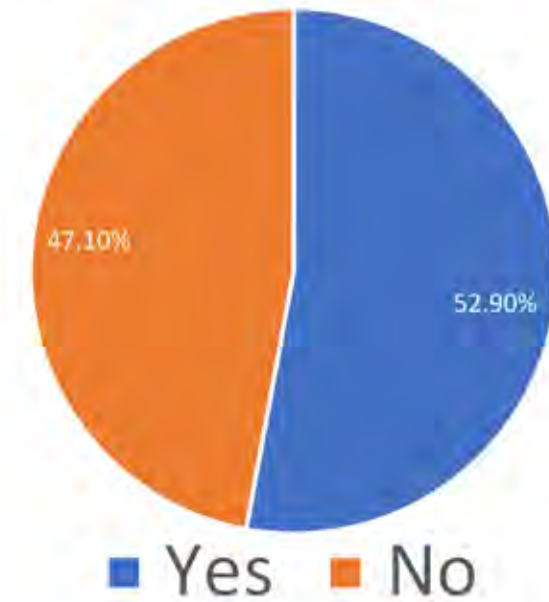
What do you like most about the park?



From online survey. Nearly half of respondents said that what they liked most about the Ashuelot River Park are the trees and garden beds. Still some left comments at the end denoting lack of visual appeal of the beds and decline of certain trees.



Did you know that the Ashuelot River Park features an Arboretum?



From online survey. Roughly half of respondents said they did not know the Ashuelot River Park features an Arboretum.

