CHARLOTTESVILLE
Acting on Climate Together

ICLEI
Local Governments for Sustainability

City of Charlottesville
Climate Risk & Vulnerability Assessment

EXECUTIVE SUMMARY

In response to the climate crisis and as part of the City's Global Covenant of Mayors for Climate and Energy (GCoM) commitment, the City of Charlottesville conducted a climate risk and vulnerability assessment (CRVA) to 1) better understand local climate risks and 2) lay a foundation for action to reduce those risks. This document shares the results from the completed assessment. Using climate data and community input as a foundation, this assessment identifies climate hazards of top concern for Charlottesville, the community systems (such as transportation, food, and public health systems) anticipated to be most impacted by those hazards, and identifies ways in which those community systems are susceptible to the impacts of climate hazards.

Looking at projected future climate conditions in Charlottesville at the middle and end of this century, hotter summers and extreme heat; increased intensity of precipitation and flooding, and changing seasonal patterns were identified as the climate hazards that pose the greatest risk. To understand how these hazards could impact community systems, the City led a stakeholder engagement process that brought together community members, City staff, local government representatives, and other stakeholders. In partnership with these stakeholders, the City identified Agriculture and Food Supply; Energy Supply, Delivery and Access; Forestry and Ecological Function; Public Health and Wellness; and Transportation as community systems that are highly susceptible to the impacts of the identified climate hazards. For each hazard, this assessment explores impacts on the three most-affected community systems as well as an initial assessment of each system's ability to adapt and respond to impacts.

This assessment will serve as the foundation for Charlottesville's climate change adaptation and resilience planning process.

PREFACE

This report provides background on the City's climate context, outlines the CRVA process, and describes results compiled through stakeholder engagement and research.

BACKGROUND

The first report section, Background, describes the context for a climate risk and vulnerability assessment, including the urgency of climate change, existing climate initiatives in Charlottesville, and the importance of climate adaptation.

ASSESSMENT PROCESS

The Assessment Process section describes the steps involved in the assessment, including data sources and stakeholder engagement.

ASSESSMENT PROCESS RESULTS

The Assessment Results section introduces local climate projections and presents information on Charlottesville's vulnerability through the lens of impacts and adaptive capacity. It includes inputs shared during the stakeholder engagement process.

NEXT STEPS

The Next Steps section outlines what comes next in Charlottesville's climate adaptation process and concludes the report.

TABLE OF CONTENTS

BACKGROUND

The science is clear: the climate emergency has reached a crucial moment, with its impacts already reaching communities across the region, including Charlottesville. A range of climate **hazards**—more frequent and longer-lasting extreme heat events, more intense precipitation and flooding events, and shifts in seasonal patterns among them—call for our community to urgently begin taking action to address our **climate vulnerabilities**. Adapting to **climate change** cannot be achieved by governments acting alone, but instead will require the support and partnership of the entire community. This process demands space be opened for all voices to be heard so that local climate vulnerabilities are understood, their degree of **impact** determined, and programs implemented to lessen Charlottesville's vulnerability to the changing climate. This climate risk and vulnerability assessment (CRVA) is the first step in this process.

The international community of climate scientists known as the Intergovernmental Panel on Climate Change (IPCC) confirmed in its 2022 Sixth Assessment Report that global warming is accelerating quickly and communities must turn their attention to adapting alongside their efforts to lower greenhouse gas (GHG) emissions.[1] Among its findings, the IPCC synthesis report suggests that Earth's biome is in big trouble: at 1.5 degrees Celsius of average global warming, scientists expect between 3 and 14% of the world's species on land to vanish. Human communities will suffer, too, if adaptation measures are not taken quickly. Community members who are already the most vulnerable, including those with lower incomes and communities of color, will bear the brunt of climate impacts. The report considers several projected scenarios for a warmer world—exploring futures where humans contribute very low GHG emissions over the coming decades to scenarios with very high emissions— and in all cases, the planet continues to warm.

1 IPCC, 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability (accessed 5.30.2023).

Climate Change/ Disruption	The long-term shift in global temperatures and weather patterns, presently due to human-caused greenhouse gas emissions. "Climate disruption" highlights the disruptive capacity of these changes.
Climate Hazards	Extreme weather events and other natural disasters exacerbated by climate change that adversely impact a community.
Exposure	The presence of people, places, and systems that could be adversely affected by hazards, specifically those exacerbated by climate change.
Vulnerability	Social, health, or economic factors that increase susceptibility to adverse impacts when exposed to a hazard.
Impacts	The effects on community systems by the interaction of climate hazards, exposure, and vulnerability.
Adaptation	Altering human systems and behaviors to better withstand the effects of the changing climate.
Resilience	The capacity of a system (can be social, economic, or natural) to cope with a hazardous event, trend, or disturbance.

REGIONAL IMPACTS: CLIMATE CHANGE IN THE SOUTHEAST

The United States' Fourth National Climate Assessment points to wide-ranging impacts in the Southeast of the United States.[2] The assessment's Southeast Chapter finds that many Southeastern cities, including Charlottesville, are particularly vulnerable to climate change compared to cities in other regions of the country. Impacts to infrastructure and human health are expected, with heat, flooding, and vector-borne disease among the top hazards. Some areas may experience more than 100 additional high-heat days (and nights) per year by the end of the century, which leads to impacts ranging from higher mosquito populations to strain on mental health. The combined effects of changing extreme rainfall events and sea level rise are already increasing flood frequencies both in coastal and inland communities, which affects property values and infrastructure viability. Furthermore, changing seasonal patterns will have impacts on agriculture, forestry, manufacturing and timber production—industries crucial not only to the region's economy but also to its cultural heritage.

High-heat days: when the maximum daily temperature is above 95°F.

High-heat nights: when the minimum overnight temperature is above 75°F.

2 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).

CLIMATE HAZARDS IN AND AROUND CHARLOTTESVILLE

The climate hazards projected for the Southeast region are, in some cases, playing out for Charlottesville not in the distant future, but as phenomena felt here and now. About half of the region's most damaging extreme weather events (events that caused more than $10,000 in damage) have occurred in only the last 10 years.[3] Intense thunderstorm events that produce high winds are the most damaging current hazards impacting Charlottesville and neighboring localities, followed by flash floods.

Downed trees, caused by heavy winds, are responsible for many high-damage instances, with several causing injuries. Of the 13 weather-induced injuries during the past 30 years, about half were related to high winds and half to lightning strikes. One example of an extreme event is the historic derecho (high wind event) that struck the Charlottesville area on June 29, 2012. The derecho caused severe damage across the mid-Atlantic states and 13 direct deaths, one of which was in Albemarle County.[4] In the Charlottesville area, the derecho caused significant tree damage, some structural damage (due to high winds), and power outages.

Severe heat impacts have also been reported in the area. Between 2011 and 2021, "heat" and "excessive heat" events were reported on 18 separate days in Albemarle County. Heat indices on these days exceeded 100°F. When high temperatures are coupled with high humidity, conditions are particularly dangerous for human health.

3 NCEI, n.d. Storm Events Database. The Storm Events Database, which is maintained by the National Oceanic and Atmospheric Administration (NOAA) tracks occurrences of weather phenomena that have caused loss of life or significant property damage. This information is tracked at the county level; therefore, a search of the database was conducted for Albemarle County for January, 2010 – March, 2022.

4 NOAA, 2013. The Historic Derecho of June 29, 2012 (accessed 5.30.2023).

CITIES LEADING THE WAY ON ADAPTATION

In the face of mounting climate challenges, cities are showing strong leadership. Over the past decade, more than 400 cities have determined their GHG emission baselines, set increasingly ambitious reduction targets, and published climate action plans. They have joined leadership campaigns including Global Covenant of Mayors for Climate and Energy (GCoM), networks such as ICLEI-Local Governments for Sustainability, and declared "We Are Still In" to uphold the US national contribution to the Paris Agreement. While much of this work has focused on climate mitigation—lowering GHG emissions—cities are now taking steps to include climate adaptation and equity as central pillars in local climate action. Charlottesville is among the cities taking this approach.

CHARLOTTESVILLE: A HISTORY OF CLIMATE ACTION

The City of Charlottesville has been pursuing climate action for more than 15 years, beginning with its joining of the US Mayors Climate Protection Agreement in 2006, followed by establishment of a funded and staffed Climate Protection Program in 2008. By 2017, the City had committed to developing a Climate Action Plan and a Climate Adaptation Plan as part of its GCoM commitment.

Charlottesville's Climate Action Plan for community-wide greenhouse gas emissions reductions was developed between 2020-2022, and officially adopted as an amendment to the City's Comprehensive Plan in January 2023.[1] Recognizing that climate impacts are being felt here and now, Charlottesville also participated in the 2021 NIHHIS-CAPA Heat Watch data mapping campaign, a nationwide citizen-science based effort to collect local data on temperatures and humidity levels across the city.[2] Shortly after, the City began working with ICLEI USA on the first phase of climate adaptation planning: completing this CRVA. This report brings heat into focus alongside precipitation changes, seasonal shifts, and other hazards impacting Charlottesville.

With climate change no longer a distant threat, it is critical that the City build on its history of climate successes. With this CRVA, the City is taking action to increase its resilience to climate change, in addition to its ongoing efforts to reduce GHG emissions.

1 City of Charlottesville, 2023. Climate Action Plan: A Plan for Reducing Greenhouse Gas Emissions (accessed 5.30.2023).
2 City of Charlottesville, n.d. Urban Heat Island Mapping Campaign (accessed 5.30.2023).

ASSESSMENT PROCESS

In general, CRVAs involve some combination of the following steps:

1. **Review of climate data to understand exposure to climate-related hazards**
2. **Identification of the specific community systems that are the most vulnerable to those hazards**
3. **Evaluation of these systems' capacity to adapt to change**

Several methodologies exist to complete each step. Some methodologies lean more heavily on technical resources and top-town data collection, while others rely more on qualitative input from community members. As there are benefits and drawbacks to every approach, many communities choose a combination of methods that suit their financial, administrative, and political limitations. In this CRVA, the City adopted such a blended methodology, which is described in more detail in the following report section.

ICLEI GREENCLIMATECITIES FRAMEWORK

For this CRVA, Charlottesville's process is informed by ICLEI's GreenClimateCities framework for integrated climate action. The City is following the stepwise approach shown in Figure 1, which involves collecting and analyzing climate data, action and implementation, as well as leadership and collaboration—always with an equity lens. Over 600 US communities have followed this basic framework, which was previously known as ICLEI's Five Milestones for Emissions Management, and today is represented through the streamlined Analyze-Act-Accelerate model shown to the right.[1]

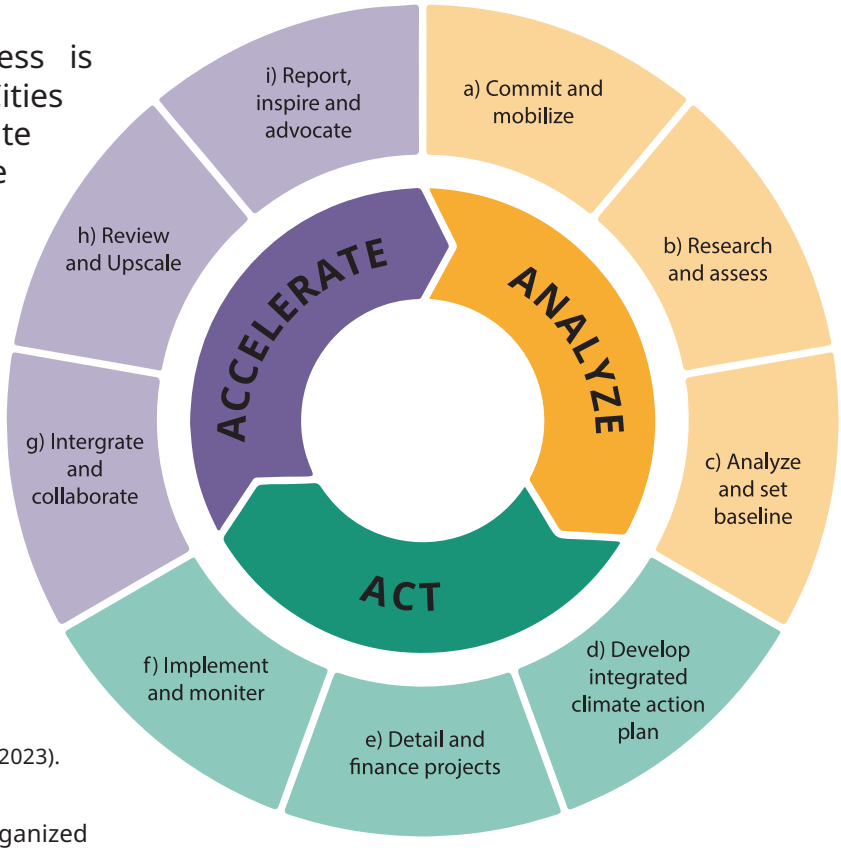


Figure 1: ICLEI's GreenClimateCities Framework is organized into Analyze, Act, and Accelerate phases for communities pursing integrated climate action.

1 ICLEI, n.d. GreenClimateCities Program (accessed 5.30.2023).

UNDERSTANDING OUR GCoM COMMITMENT

Charlottesville has already taken the important "Analyze" step to a) Commit and mobilize with its history of climate action and the City's more recent commitments as part of the Global Covenant of Mayors for Climate and Energy (GCoM).[2] This report moves the City into the b) Research and assess, and c) Analyze and set baseline steps. This report also meets the first two phases in the Adaptation track of the GCoM commitment (Figure 2).

2 City of Charlottesville, n.d. Global Covenant of Mayors Commitment (accessed 5.30.2023).

The City has achieved all three steps under climate mitigation and has completed the first two steps under adaptation. The third planning step is underway as of Fall 2023.

Figure 2

MITIGATION BADGE

Awarded as soon as one of the steps (i.e. Inventory, Target, or Plan) is accomplished

INVENTORY

GHG baseline emissions inventory submitted and validated (including all mandatory criteria)

TARGET

GHG emissions reduction/low emissions development target set and validated

PLAN

Separate or integrated climate action plan covering climate change mitigation submitted and validated

ADAPDATION BADGE

Awarded as soon as one of the Steps (i.e. Assessment, Goal, or Plan) is accomplished

ASSESSMENT

Climate risk and vulnerability assessment submitted and validated

GOAL

Climate change adaptation goal(s) set and validated

PLAN

Separate or integrated climate action plan covering climate change adaptation submitted and validated

CLIMATE RISK AND VULNERABILITY ASSESSMENT PROCESS STEPS

The following timeline outlines Charlottesville's steps for this CRVA. All activities were led by Climate Protection Program staff and a consultant (ICLEI USA). As is demonstrated below, the process relied heavily on the knowledge and experience of community members as well as City and other local government staff.

DATE	ACTIVITY
September 2021	Reviewed climate models and identified top climate hazards.
October 7, 2021	Published and advertised video overview of climate hazard data for future viewing and as necessary background for the workshops held later in the month.
October 15, 2021	Community session to present the upcoming assessment process and hear questions and recommendations from the community.
October 25, 2021	Workshops (one with City and regional government staff and one with community members) to discuss and rank the vulnerability of community systems for each of the top three climate hazards.
October 25, 2021 - November 29, 2021	Community workshop recording posted online and opened online input form for anyone unable to attend the workshops live.
December 2021 - March 2022	Analysis period for incorporating workshop input into the assessment.
January 20, 2022	Community Event - A Roundtable Discussion About Local Implications of Climate Change on Our Community's Health, Safety, and Ecology. Event was parallel to the assessment process and was organized in response to community feedback on October 7, 2021, that supplemental information sessions would provide useful context. Event was co-hosted with Albemarle County and the University of Virginia Office for Sustainability.
April 20 - May 20, 2022	Online survey to collect input on the magnitude of potential impact and preparedness of the community systems identified as most vulnerable during the first set of workshops. Multiple aspects for each community system were assessed.
June 8 - June 9, 2022	Facilitated workshops (one with City and regional government staff and one with community members) to discuss which aspects of the community systems are vulnerable to climate change.
June 13, 2022	Published Climate Vulnerability Assessment Survey Analysis memo for public comment.
July 2023	Finalized Charlottesville's CRVA report

IDENTIFYING CLIMATE HAZARDS

ICLEI USA reviewed the best available climate models, which indicate how the frequency, duration, and intensity of climate-related hazards are anticipated to change over time in Charlottesville. These climate projections and top climate hazards are described in a 30 minute video recording[1] that also introduces the climate risk and vulnerability assessment process and in a summary memo.[2]

1 ICLEI USA & City of Charlottesville, 2021. Charlottesville Vulnerability Assessment: Overview of Process and Climate Hazards video (accessed 5.30.2023).
2 ICLEI USA & City of Charlottesville, 2022. Climate Hazards - Summary of Projections for Charlottesville (accessed 5.30.2023).

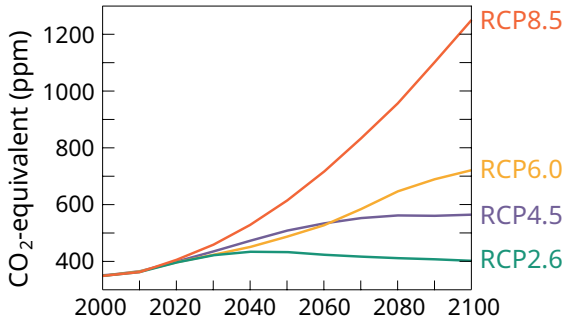
TEMPERATE

Temperate is an online tool that assists communities with conducting a CRVA and developing an adaptation strategy. The tool identified potential climate hazards in Charlottesville based on the geographic regions and findings of the 2014 National Climate Assessment. To understand how the magnitude and/or frequency of these hazards might change under different emissions scenarios, Temperate uses historical climate data from 1,000 US cities to make projections for two commonly used GHG emission scenarios through the end of the century.

To provide the most detail possible, Temperate averages more than 30 climate models created by a variety of research institutions around the globe. In addition to identifying hazards, Temperate displays which community systems are likely to be impacted by each hazard. The nexus between climate hazards and community systems is based on the Climate Risk and Adaptation Framework and Taxonomy (CRAFT) developed by GCoM, C40 Cities, and ARUP.[3]

Projections from Temperate used in this CRVA are based on RCP8.5, or the "business-as-usual" scenario. The City chose RCP8.5 in the interest of adopting a more conservative, risk-averse approach to climate adaptation. To learn more about climate projections for Charlottesville, see the City's memo on climate hazards.[4]

3 GCoM, 2022. Climate Risk and Adaptation Framework and Taxonomy (CRAFT) (accessed 9.2.2022).
4 ICLEI USA & City of Charlottesville, 2022. Climate Hazards - Summary of Projections for Charlottesville (accessed 5.30.2023).



PRIMER: GHG EMISSION SCENARIOS

The Representative Concentration Pathways (RCPs) are scenarios used in climate modeling that are based on a set of assumptions about GHG emissions and land use change. The RCPs are associated with different levels of warming by the end of the century.

The two most commonly used RCPs are RCP4.5 (sometimes called the "lower emissions scenario") and RCP8.5 (sometimes called the "higher emissions scenario"). RCP4.5 assumes that aggressive action is taken on a global scale to reduce emissions. RCP8.5 is the business-as-usual or no-action scenario under which GHG emissions continue to rise through the end of the century.

RISK FACTOR

As Temperate is limited to precipitation and temperature models, more data was needed to understand evolving flood risks in Charlottesville. Specifically, it was necessary to consider flood risk models that combine climate-informed precipitation models with on-the-ground conditions.

Using the First Street Foundation's probabilistic flood models, Risk Factor is a free tool that allows users to see current and projected flood risks in specific locations.[5] Risk Factor overlays flood models with national property data to determine the number of properties that are at risk of flooding now and projected to be at risk in the future, as well as the extent of that risk. Risk Factor models are based on the low emissions scenario, RCP4.5

Charlottesville's Water Resources Protection Program is currently developing a Community Flood Resilience Plan and developing local flood models as part of that effort. This work will be a part of Charlottesville's eventual Climate Adaptation Plan.

5 First Street Foundation, n.d. The Data Behind Flood Factor (accessed 9.2.2022).

IDENTIFYING VULNERABLE COMMUNITY SYSTEMS AND ASSETS

Assessing climate vulnerability is an exercise in looking at a range of community systems through the lens of top climate hazards. Stakeholders in Charlottesville considered many community systems in relation to its top three climate hazards and identified seven community systems as most likely to be impacted. These seven community systems were then further explored for specific anticipated impacts and adaptability.

COMMUNITY AND STAFF FORUMS

Assessing a community's vulnerability to climate change is not a desktop exercise. To maximize community voice and local knowledge in the process, Charlottesville and ICLEI USA hosted two online forums. One forum was for community members and organizations, the other was for City and other government staff. Prior to the forums, participants were asked to watch the climate hazards overview video and to review the climate hazards summary memo.

Each forum provided opportunities for City and community stakeholder input, revealing a number of insights detailed in the Results section of this report. During these forums, government staff and community members were asked to select 5 community systems they expect to be the most impacted by each of the three top climate hazards. An online form and a recording of the community forum were also posted online, to allow for additional input from participants and from anyone in the community who was not able to attend the forums. The selected systems formed the basis of the following Climate Vulnerability Assessment Survey.

WHAT ARE COMMUNITY SYSTEMS AND ASSETS?

Community systems are what keep our communities running and make them distinctive places to live and work. **Every community system is made up of many "community assets".**

Here, the phrase "community assets" refers to the tangible and intangible things that people and communities value. Community assets can be man-made or part of the natural world. Roads, bridges, wastewater treatment plants, schools, grocery stores, rivers, forests, and pollinators could all be considered community assets. Community assets may also be intangible, for example, public health, quality of life, and aesthetic value could all be considered community assets.

CLIMATE VULNERABILITY ASSESSMENT SURVEY

The City of Charlottesville's Climate Vulnerability Assessment Survey (open April 20 – May 20, 2022) asked respondents to evaluate risk levels for specific assets related to the identified community systems and three climate hazards. Between 5 and 8 assets were identified for each community system.

For each hazard-system pairing, respondents were asked to rank: 1) the impact of the hazard on each asset (using a 1-5 scale, with 5 being the greatest impact) and 2) the ability of the asset to adapt/respond (1-5 scale, with 5 being the greatest ability to adapt/respond). For the second part, respondents were encouraged to think about the ability to adapt/respond from the perspective of individual residents and Charlottesville as a community.

The survey also gave respondents the chance to write in "other aspects of this system not listed above that you are concerned about". These inputs are listed at the end of each hazard section and are labeled as "Additional Survey Input". In parallel with the survey, respondents were given access to an online GIS-based map and the opportunity to add points marking Locations of Climate Vulnerability Concern.

A more detailed breakdown analysis of the survey results can be found in the survey analysis memo.[1]

1 ICLEI USA & City of Charlottesville, 2022. City of Charlottesville Climate Change Vulnerability Assessment: Survey Analysis (accessed 5.30.2023).

COMMUNITY AND STAFF WORKSHOPS

A set of workshops were conducted with support and facilitation provided by Launch! Consulting in June of 2022. These workshops aimed to build upon, validate, confirm, and expand on information already collected during the assessment process.

The workshops had the following objectives:

- **Share and discuss the results of the City's Climate Vulnerability Assessment Survey with attendees**
- **Identify voices to include in the climate planning process in Charlottesville moving forward**
- **Collaboratively identify community assets that may be affected by climate hazards in Charlottesville**

After listening to an overview of the survey results, participants in the workshops went into breakout rooms for smaller discussions. Participants were randomly divided into three breakout rooms during round one, and another three breakout rooms during round two. In each breakout room, participants provided input on how the three top climate hazards affect the following seven community systems:

Round 1: Public Health and Wellness; Food and Agriculture; Energy Supply and Delivery

Round 2: Public Safety; Transportation and Housing (these two systems were combined in one breakout room discussion); Forestry and Ecological Function.

In the breakout rooms, participants were asked to describe specific community assets that need protection from climate change, which facilitators tracked on a shared "whiteboard" in each breakout room.

ANALYZING AND PRESENTING KEY RESULTS

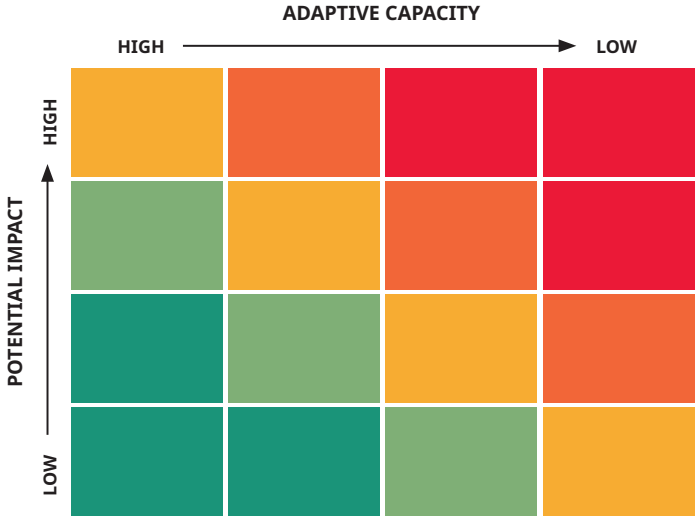
Multiple rounds of community and staff engagement provided a large volume of information on what Charlottesville's residents, local government staff, and partners see as the City's vulnerabilities. In order to present these inputs as a set of actionable findings, it was necessary to review, organize and consolidate them under a streamlined list of hazard-system pairings (Table 1). Each hazard is paired with three different community systems (making nine hazard-system pairings in total). Where appropriate, some topics were combined under existing systems for readability. These systems were compiled holistically based on survey responses and participant input shared during the workshops.

Table 1. Selected community systems and examples of community assets that fall under each system.

COMMUNITY SYSTEM	EXAMPLES OF COMMUNITY ASSETS
Agriculture and Food Supply	Local wineries and orchards, Community Supported Agriculture (CSAs)
Energy Supply, Delivery and Access	Electric grid reliability, medical equipment/services reliant on power
Forestry and Ecological Function	Trees, stream and river ecosystems
Public Health and Wellness	Outdoor work and workers, potable water supply
Transportation	Roadway safety, general connectivity

This report outlines risk by hazard-system pairing in the Assessment Results section. Risk is assessed through the lens of the potential impacts of the hazard on community systems and the ability of impacted community systems to adapt (in other words, their adaptive capacity).

Example of Assessment Results Chart



When determining the impacts of each hazard on the top community systems, we considered:

- **Potential probability, frequency, and intensity of change in the hazard**
- **Which community assets under each specific community system could be affected by potential changes**
- **The types and extent of potential impacts on the community system**
- **Geographic scale of impacts (narrow or broad)**
- **The equity lens and whether vulnerable communities would face disproportionate impacts**

To look at the potential of each top community system to adapt (adaptive capacity) to each hazard, we considered:

- **The extent to which adaptation measures are practically and technologically feasible**
- **Local ability and authority to enact adaptation measures**
- **Availability of resources to implement adaptation measures effectively and in a timely manner**

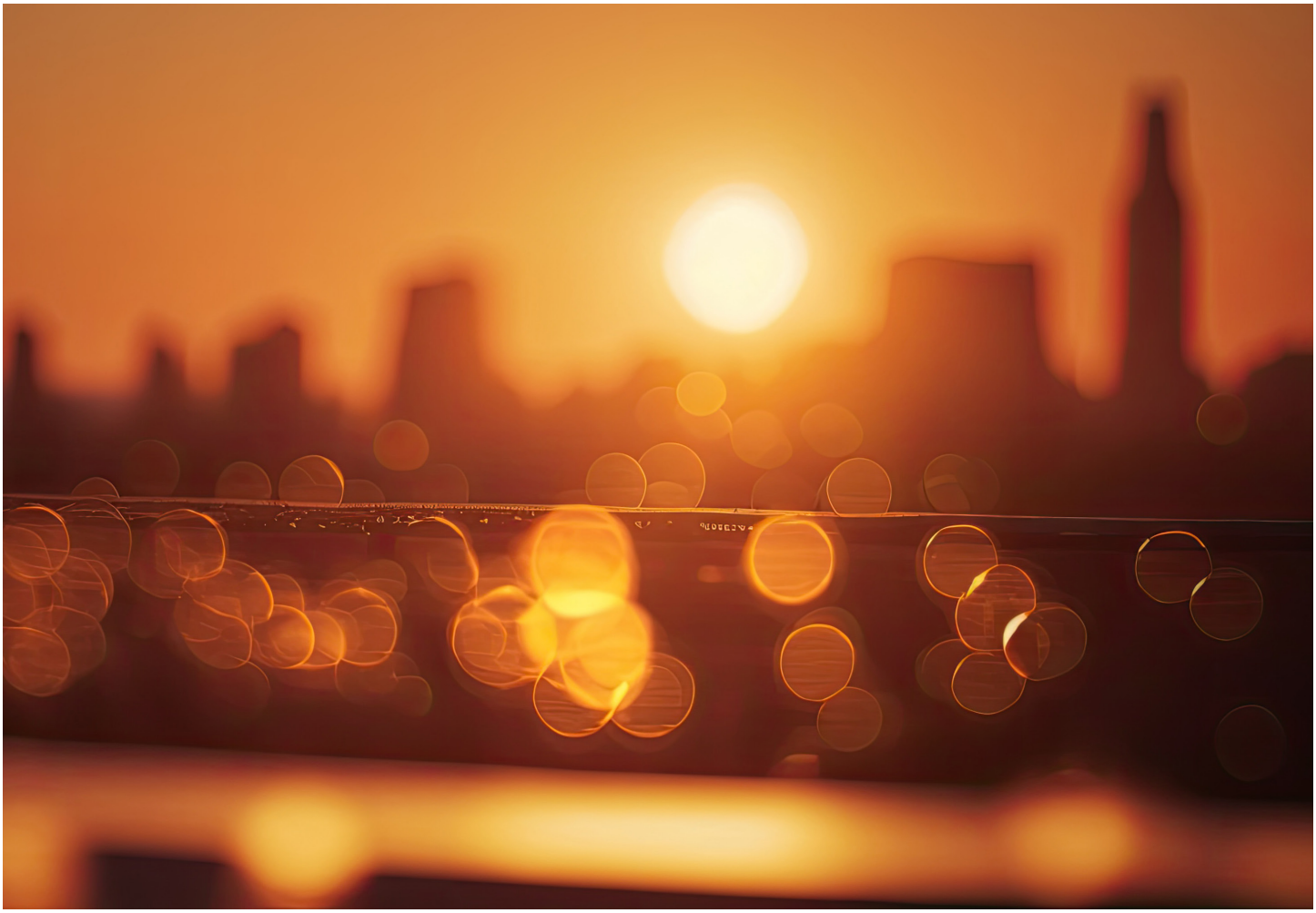
Sections on adaptive capacity and impacts include a mix of desk research and stakeholder feedback, which was reviewed and condensed. Research, local news, and City planning documents are also included to provide context.

ASSESMENT RESULTS

The following section presents the results of the assessment, organized by climate hazard with information about projected climatic changes (i.e., how that particular climate hazard could become more frequent or intense in the future) and vulnerable community systems. Each community system is mapped on a risk matrix based on the severity of impacts and adaptive capacity of that system.

HOTTER SUMMERS AND EXTREME HEAT

Charlottesville is projected to see a significant increase in the frequency, duration, and intensity of extreme heat. Climate models show that by 2050, Charlottesville may experience more than twice as many extreme heat events (when the daily maximum temperature is above 95°F) annually as there were in 2020 (Figure 3). By 2100, there may be more than seven times as many of these events.



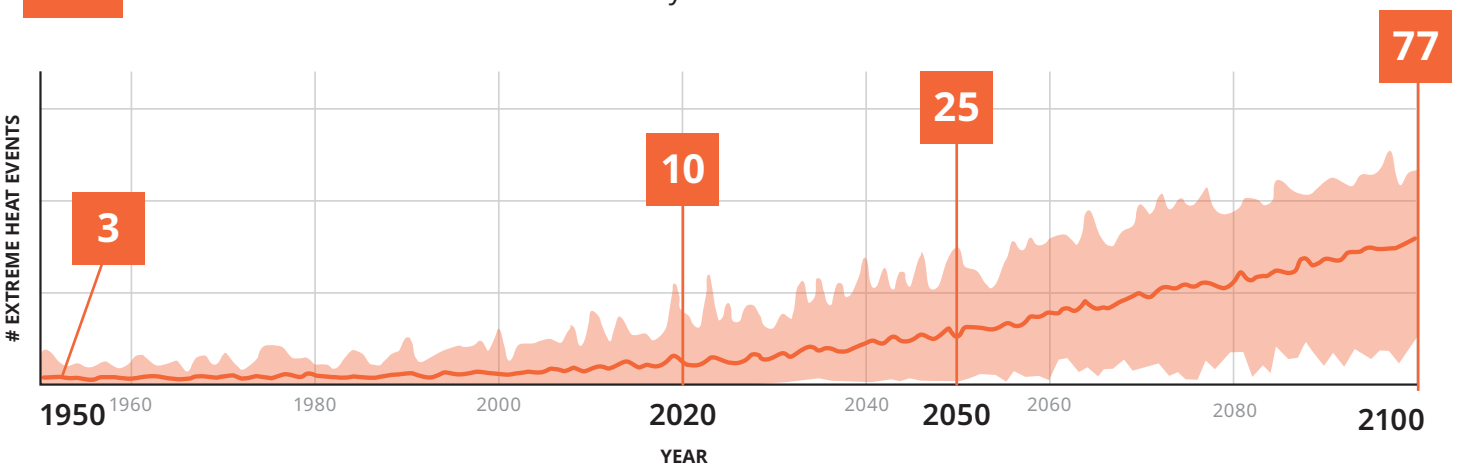


Figure 3. Projected number of extreme heat events, defined as the number of days per year temperatures exceed 95°F.[1]

Both the frequency and duration of heat waves (defined as five or more days of extreme heat) are projected to increase significantly over time (Figure 4). By 2050, Charlottesville may experience almost twice as many heat waves as there were in 2020 and they may be slightly longer. By 2100, there may be more than three times as many heat waves and they may also be three times as long.

1 Azavea, n.d. Temperate (accessed 5.30.2023).

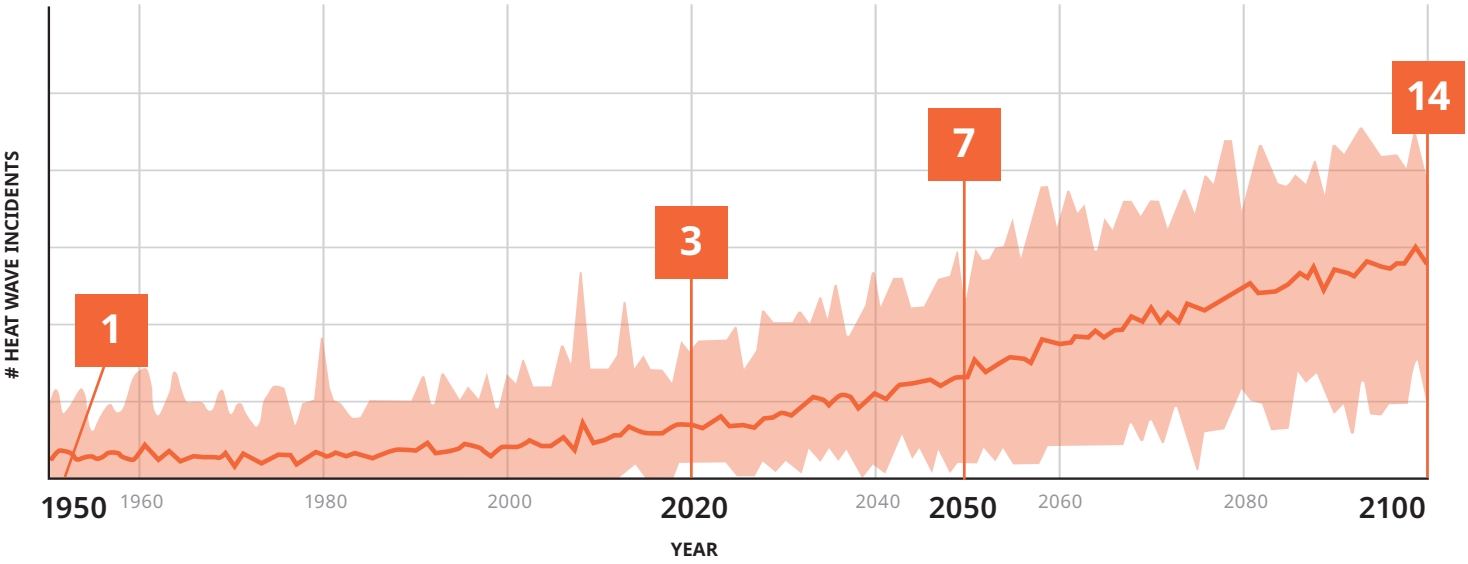


Figure 4. Projected number of heat wave incidents, defined as the number of times high temperatures exceed historical average for five or more more days.[2]

Working in partnership with the community and key stakeholders from across the local government, the City engaged with the issues of potential impacts and adaptive capacity across community systems. Review of the survey and workshop discussions around hotter summers and extreme heat pointed to three high-risk community systems: Public Health and Wellness; Forestry and Ecological Function; and Energy Supply, Delivery and Access.[3]

Potential impacts and adaptive capacity are explored in more depth below. Each system is also placed on a risk matrix. Each risk matrix indicates the level of "adaptive need" (or, in other words, the need for adaptation) for each hazard-system pairing. Survey data and workshop input was used to place systems on the risk matrices.

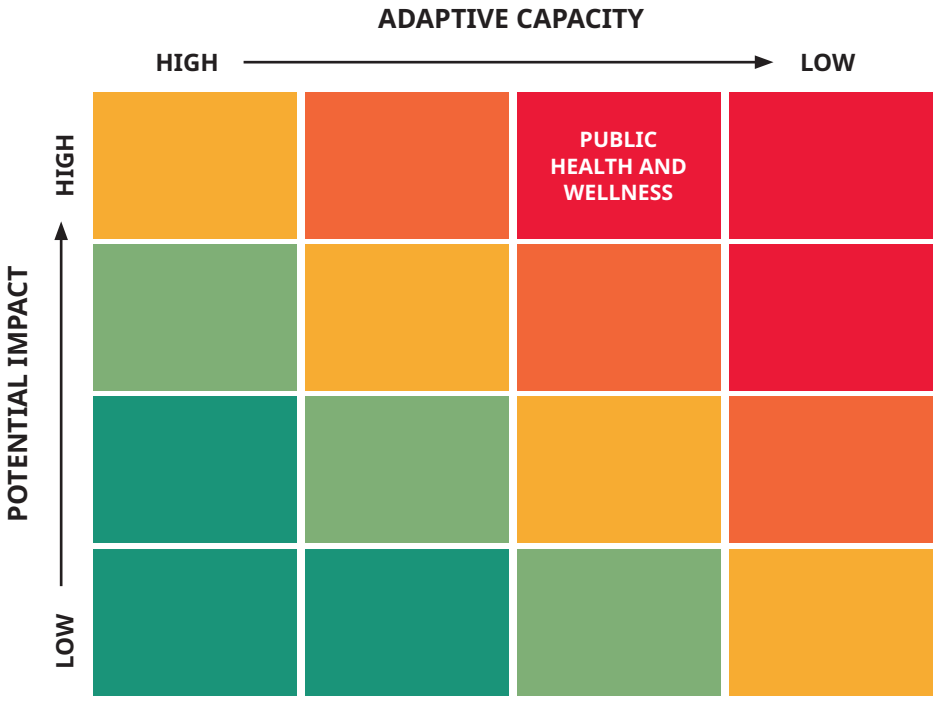
2 Azavea, n.d. Temperate (accessed 5.30.2023).

3 Agriculture and Food Supply was also considered for extreme heat. Findings on this community system are discussed in the section on Changing Seasonal Conditions.

PUBLIC HEALTH AND WELLNESS

POTENTIAL IMPACT: ***High***

ADAPTIVE CAPACITY: ***Moderately low***



Extreme heat will have a severe effect on the community, particularly populations who are more susceptible to heat-related illnesses and/or do not have access to air conditioning (A/C).[1] Workshop participants shared their concerns about those who would likely bear the greatest burdens: seniors, children, people with respiratory illnesses, outdoor workers, people who rely on public transit or walking (walking and waiting outdoors, sitting in poorly air conditioned buses, etc.), renters in properties with no A/C system, unhoused people, and households who have little to no financial capacity to afford to use or even install an A/C system. Power outages and rolling blackouts can expose people to dangerous heat conditions, regardless of access to A/C.

Workshop attendees noted that communities of color and low-income communities are often disproportionately impacted by the heat. The 2022 State of the Urban Forest report noted that low-income neighborhoods experienced the lowest area of tree canopy coverage.[2] The report identified Starr Hill and 10th and Page (both of which have below 20% canopy coverage) and Belmont, Rose Hill, and The Meadows (below 30% canopy coverage) as low-income areas with low canopy coverage. Workshop participants also identified these areas. A heat mapping analysis conducted by local volunteers and CAPA Strategies showed similar results: low canopy areas had higher temperatures.[3] Respondents to the City's Climate Vulnerability Assessment Survey identified several additional high-heat locations, including the city center, West Main, and other downtown areas.

Charlottesville has opened cooling centers on days with dangerous heat conditions, including three that were opened in July 2022 (Key Recreation Center, Tonsler Recreation Center, and JMRL Central Branch).[4] While this is definitely an adaptive factor, not everyone will be able to access these places if they do not have reliable transportation. Furthermore, these facilities can only hold so many people at once. More proactive solutions to mitigate indoor heat and the urban heat island are needed.

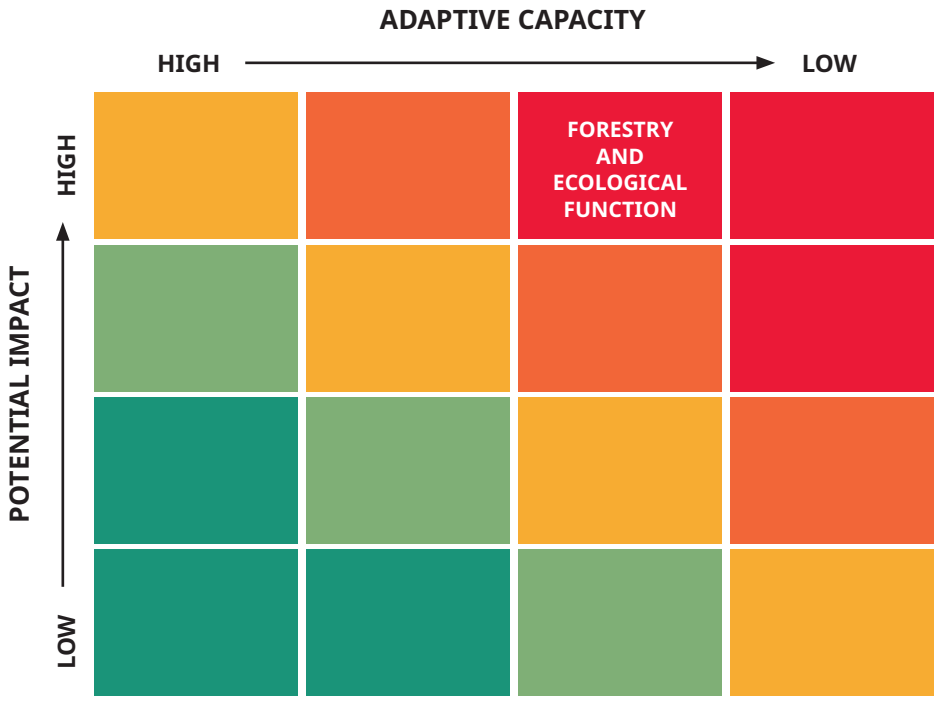
Increasing the extent of the tree canopy in Charlottesville has the potential to mitigate indoor and outdoor heat and reduce energy bills. With workshop participants indicating that trees are highly valued in the Charlottesville community, this could be a highly feasible solution.

1 USGCRP, 2016. "Chapter 2: Temperature-Related Death and Illness," in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (accessed 8.30.2022).
2 Charlottesville Tree Commission, 2022. State of the Urban Forest (accessed 5.21.2023).
3 City of Charlottesville, 2021. Urban Heat Island Mapping Campaign (accessed 5.21.2023).
4 Paschall, 2022. "Charlottesville Offering Cooling Centers," NBC 29 (accessed 9.2.2022).

FORESTRY AND ECOLOGICAL FUNCTION

POTENTIAL IMPACT: ***High***

ADAPTIVE CAPACITY: ***Moderately low***



Ecosystems and habitats in Charlottesville will change under exposure to extreme heat and warmer year-round conditions. The distribution of species will shift over time. Tree species that are present in Charlottesville today are shifting northward, with less cold-tolerant species from further south expanding their ranges into the area.[1] Pests and invasive species, which are often favored by warmer temperatures and changing conditions, will increasingly pose a threat to ecosystems in and around Charlottesville.[2]

Reports created by the City's Tree Commission have found that tree cover has been on the decline in Charlottesville.[3] Climatic changes and damage caused by invasive species are expected to exacerbate the downward trend. Trees that are stressed due to drought and changing conditions are more vulnerable to pests and invasive species such as the spotted lanternfly and emerald ash borer.[4] Invasive vines that have already been spreading in the region, including oriental bittersweet and kudzu, could pose an additional threat to Charlottesville's trees.[5]

Workshop participants expressed concerns about how hotter weather impacts river systems and aquatic ecosystems. Higher water temperatures, which are expected as temperatures rise, are known to be detrimental to species that are not adapted to warmer water.[6] Increased evaporation from water bodies lowers water levels, which can threaten wetland areas. Loss of riverine tree cover, often due to development, also has an impact on water temperature.

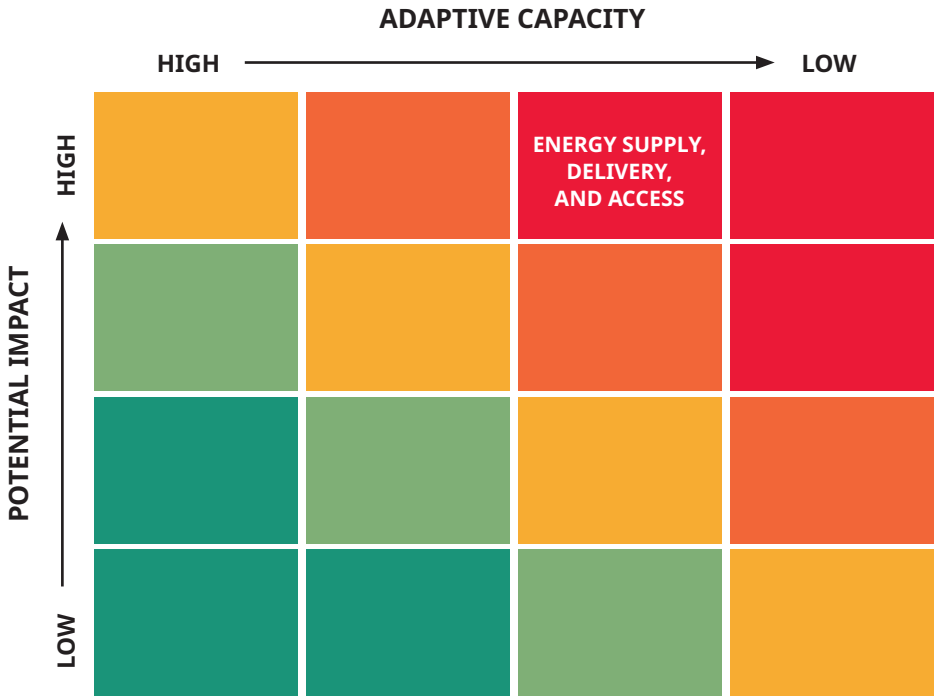
There are many unknowns involved when considering the potential for ecosystems to adapt to the heat. Where adaptation does occur, the ecosystems that remain will likely be significantly different compared to last century. Charlottesville has adopted some programs that attempt to protect ecosystems, including tree planting efforts and river ecosystem restoration. However, the efficacy of these programs (particularly when it comes to mitigating the impacts of heat on ecosystems) are not well understood.

1 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).
2 Ibid.
3 City of Charlottesville, n.d. Tree Canopy Reports (accessed 9.2.2022).
4 Ibid.
5 Virginia Department of Forestry, n.d. Invasive Plants in Virginia (accessed 9.2.2022).
6 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).

ENERGY SUPPLY, DELIVERY AND ACCESS

POTENTIAL IMPACT: ***High***

ADAPTIVE CAPACITY: ***Moderately low***



Extreme hot days and heat waves will increase the demand for energy for A/C, which could cause power outages and rolling blackouts. The cascading effect would be on public health, as A/C is a necessity for many people during extreme heat days. Meanwhile, increased temperatures reduce the capacity of power lines and transformers, meaning the grid will be straining to deliver at the same time demand is highest.[1] This combination is a recipe for blackouts, with higher rates of heat-related mortality and other health impacts.[2]

Higher demand leads to higher utility bills in connection to running A/C. Workshop participants expressed concern about how this will increase energy burden for people of low-income, those that live in older/less energy efficient housing stock, and renters. Continued cooling is critical for certain medications, oxygen generation, and other medical-related processes and can be threatened by power outages. It is also critical to make sure that food suppliers have adequate cooling to prevent food loss and waste.

Dominion Energy is the sole electricity provider to the City of Charlottesville. As an investor-owned utility regulated by the State Corporation Commission, Dominion has an obligation to provide adequate service to its territory, and the City has no control over grid capacity. Dominion offers a variety of programs aimed at energy efficiency and conservation, including home energy assessments, rebates for ENERGY STAR appliances and smart thermostats, and incentive programs for off-peak EV charging. Dominion also has a number of energy efficiency and solar programs that are age or income qualifying. Additionally, the City of Charlottesville works with local non-profit LEAP (Local Energy Alliance Program) to provide home energy assessments, weatherization services, and solar installations within the city.

1 US Department of Energy, 2013. U.S. Energy Sector Vulnerability to Climate Change and Extreme Weather (accessed 9.2.2022).
2 Casey et al., 2020. "Power Outages and Community Health: a Narrative Review," in Current Environmental Health Report (accessed 9.2.2022).

INCREASED INTENSITY OF PRECIPITATION AND FLOODING

Charlottesville is projected to experience increasingly intense precipitation and flooding. Precipitation amounts are not projected to change substantially, but there may be a moderate increase in occurrences of heavy (>2 inches) and extreme (>95th percentile compared to historical highs) precipitation. Heavy precipitation can include rain, snow, and hail. Over time, it is likely that Charlottesville will experience less precipitation in the form of snow due to rising winter temperatures and decreasing frost days. Figure 5 shows projected increases in the number of extreme precipitation events affecting Charlottesville.

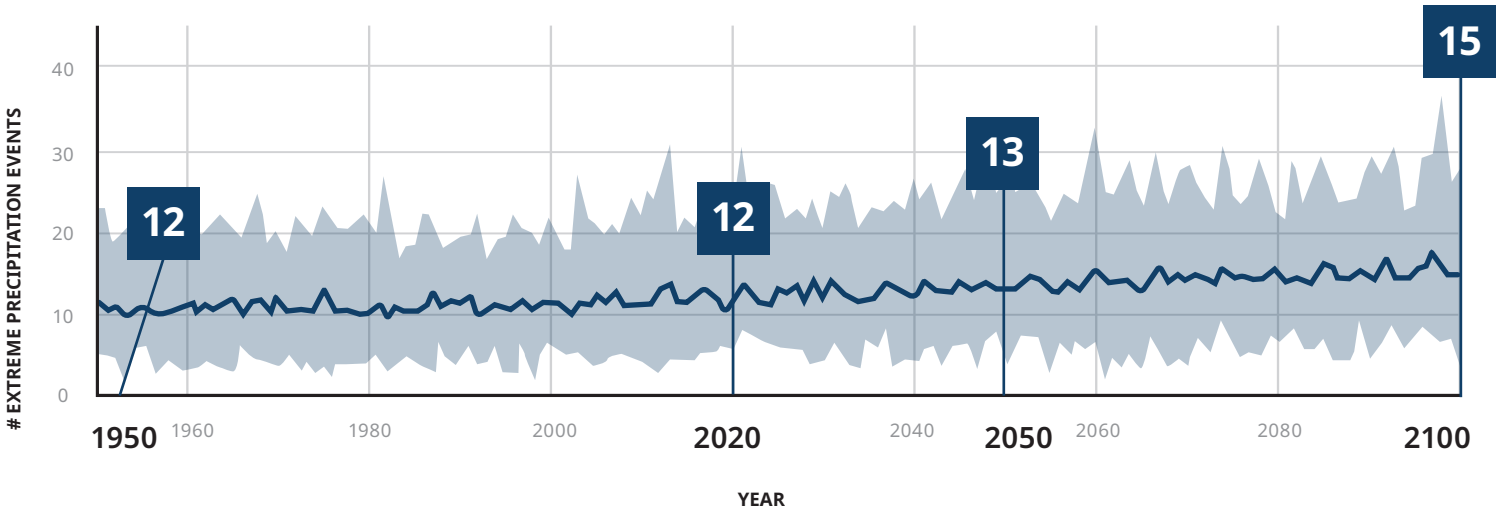


Figure 5. Projected number of extreme precipitation events, defined as precipitation events when the amount of precipitation exceeds 95th percentile historical highs.[1]

1 Azavea, n.d. Temperate (accessed 5.30.2023).

INCREASED INTENSITY OF PRECIPITATION AND FLOODING, CONTINUED

Flood events may not increase significantly in terms of frequency, but they may become more intense. A statistically significant flood event (<20% annual chance) will likely be of higher intensity in 2051 than an event with the same probability in 2021.

Table 2 breaks down the number of properties potentially affected at different flood probability levels in Charlottesville. The table indicates an upward trend in the potential impact of flood events at all probability levels. Most notably, a 5% annual chance flood event in 2051 may impact almost 12% more properties than that same event would have in 2021.

FLOOD LIKELIHOOD	NUMBER OF PROPERTIES POTENTIALLY IMPACTED			
	2021	IN 15 YEARS (2036)	IN 30 YEARS (2051)	% CHANGE BETWEEN 2021-2051
20%	332	339	345	3.92%
5%	587	621	655	11.58%
1%	1,180	1,202	1,224	3.73%
0.2%	1,495	1,530	1,565	4.68%

Table 2. Summary of Risk Factor data for Charlottesville.[1]
Note: these numbers do not reflect potential future development.

Working in partnership with the community and key stakeholders from across the local government, the City engaged with the issues of potential impacts and adaptive capacity across community systems. Review of the survey and workshop discussions around increased intensity of precipitation and flooding pointed to three high-risk community systems: Public Health and Wellness; Transportation; and Agriculture and Food Supply.[2]

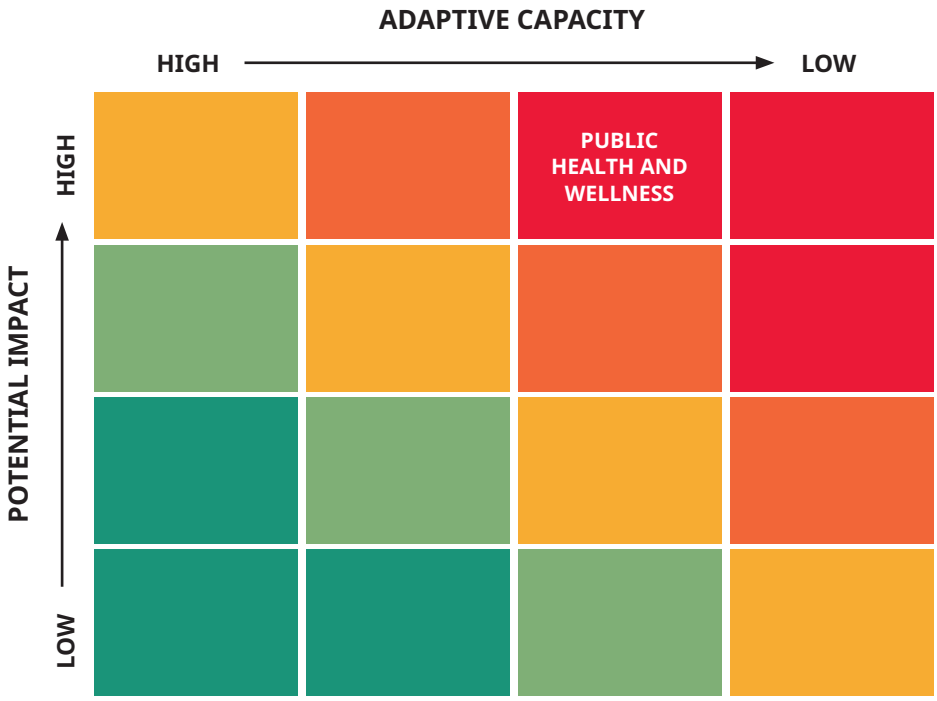
Potential impacts and adaptive capacity are explored in more depth below. Each system is also placed on a risk matrix. Each risk matrix indicates the level of "adaptive need" (or, in other words, the need for adaptation) for each community system-hazard combination. Both survey data and workshop input was used to place systems on the risk matrices.

1 First Street Foundation, n.d. Flood Factor: Charlottesville, VA (accessed 9.15.2021).
2 Energy Supply, Delivery and Access; Housing; and Public Safety were also considered for intense rainfall and flooding. Due to overlaps, these systems were folded into the three others covered in this section.

PUBLIC HEALTH AND WELLNESS

POTENTIAL IMPACT: ***High***

ADAPTIVE CAPACITY: ***Moderately low***



Storms and flooding have the potential to cause both immediate injury and death as well as delayed issues like mold growth in structures. Thus heavy precipitation and flooding should also be viewed through the interconnected lenses of public safety and housing quality issues.[1] Disruption and damage to critical infrastructure, including the electrical grid, transportation and communication systems, pose a threat to health care access and emergency response services.[2] Workshop participants expressed concerns about the risk flooding poses to popular recreation locations and remote areas.[3] Community members also shared concerns about how standing water after rainstorms and flood events supports mosquito breeding and spread of vector-borne disease. This concern echoes findings in the Fourth National Climate Assessment, which identified expanded range and longer warm seasons as a contributing factor to the spread of vector-borne disease in the Southeast region.[4]

Flood Factor modeling indicates that, were a 100-year storm event to occur in Charlottesville today, 1,209 properties could be affected.[5][6] This puts health and safety at risk. Workshop participants expressed concerns about how at-risk structures in Charlottesville, particularly housing for low-income residents and mobile homes (which are more vulnerable to flooding) may increasingly be in harm's way. Seniors, people with low income, and people with disabilities living in those areas due to their affordability could face outsize health risks. Stakeholders participating in the workshops also highlighted issues with early warning systems in Charlottesville, including inconsistencies in sending out alerts and lack of understanding among residents on how to respond.

Risk Factor analysis indicates that flood risk in Charlottesville will extend beyond areas currently identified by FEMA, which has not considered climate change in its flood maps. People in areas outside of the flood zones identified by FEMA may be unprepared for future flooding in Charlottesville.[7]

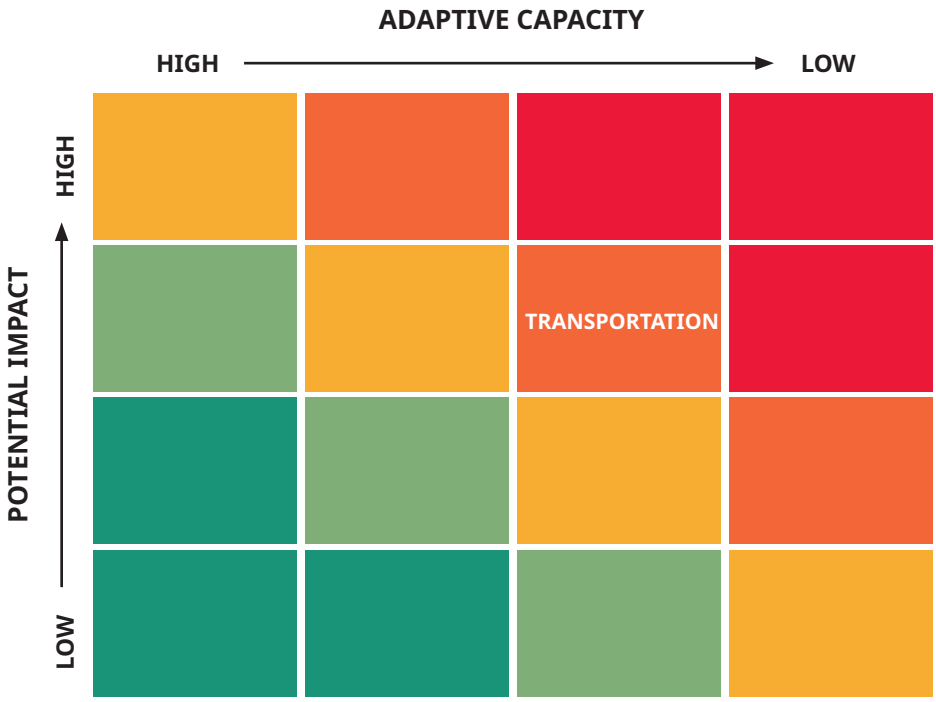
To address flood risk, the City of Charlottesville is currently undergoing a flood resilience mapping effort as part of the development of the Flood Resilience Plan.

1 USGCRP, 2016. "Chapter 6: Water-Related Illness," in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (accessed 8.30.2022).
2 USGCRP, 2016. "Chapter 4: Extreme Events," in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (accessed 8.30.2022).
3 Note that many such locations are under the jurisdiction of Albemarle County, not the City of Charlottesville.
4 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).
5 First Street Foundation, n.d. Flood Factor: Charlottesville, VA, (accessed 9.2.2022).
6 This number considers currently existing structures only and does not account for future development.
7 First Street Foundation, n.d. Flood Factor: Charlottesville, VA (accessed 9.2.2022).

TRANSPORTATION

POTENTIAL IMPACT:
Moderately high

ADAPTIVE CAPACITY:
Moderately low



Currently, few areas within the City have been subject to road flooding. However, that may change: over the next 30 years, 51 miles out of 242 miles of roads in the City face "major" flood risk, according to Risk Factor.[1] Flooded roads can prevent vehicles, including emergency response vehicles, from accessing certain areas. On the Climate Vulnerability Assessment Survey, respondents added multiple points to the map that they claim show areas where drainage infrastructure, such as some box culverts, has been overwhelmed.

Stakeholders in the workshops noted that traffic accidents are more common during and after extreme precipitation events, which can stretch emergency response services. Additionally, city stakeholders pointed out that flooding continues to negatively impact infrastructure in Charlottesville. Damage to transportation infrastructure from flooding, downed trees and utility lines, and erosion are delayed impacts that emerge with time in connection to prolonged/recurring heavy rainfall and flooding. Over time, they can lead to increased maintenance needs and repair costs.

Community stakeholders expressed concern over how public transportation, routes to work and school, and charging of electric vehicles are disrupted during storms and related power outages.

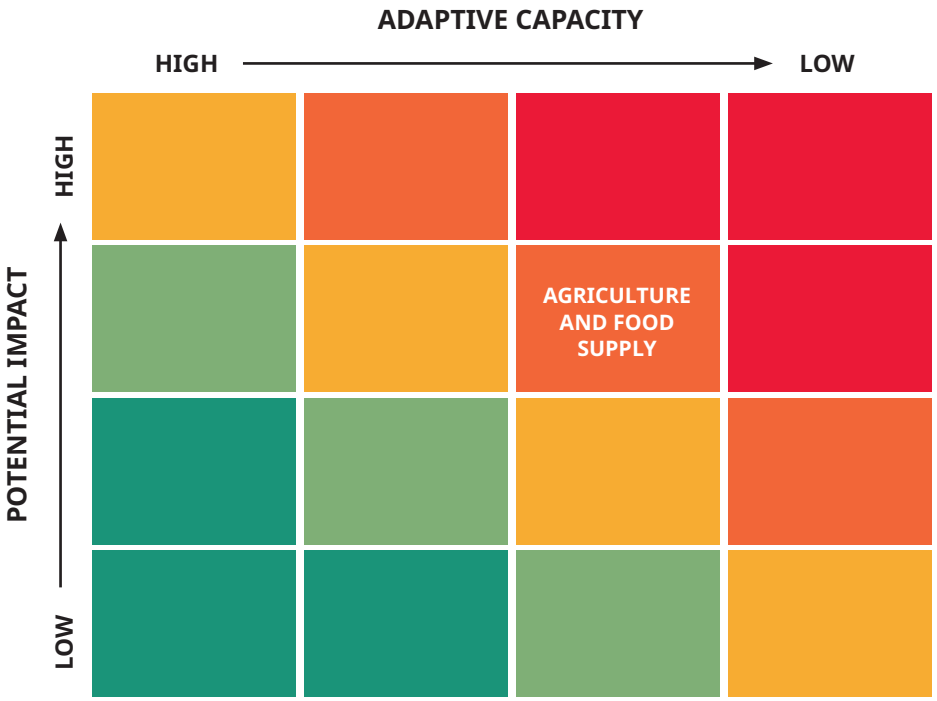
Road flooding and flood risk to other critical infrastructure is an area of ongoing work by the City as part of its 2023 flood resilience planning effort.

1 First Street Foundation, n.d. Flood Factor: Charlottesville, VA (accessed 9.2.2022).

AGRICULTURE AND FOOD SUPPLY

POTENTIAL IMPACT:
Moderately high

ADAPTIVE CAPACITY:
Moderately low



Impacts on agriculture are expected to be primarily regional in nature, though that does not mean that they will not affect Charlottesville. Workshop participants highlighted a number of concerns, including water-logged fields, flooded roads that prevent worker and delivery access to crops, and losses on regional orchards and vineyards that have the potential to negatively impact economic development and employment in the region. Flooding also has negative impacts on the health, safety, and wellbeing of agricultural workers, in addition to putting their livelihoods at risk.

Stakeholders participating in the workshops expressed concerns about how flooding is impacting urban agricultural sites in and around Charlottesville. According to participants, urban agriculture sites are often on marginal land (including on floodplains and vacant lots in densely developed areas) which experience high levels of surface runoff. Community garden users shared concerns about the flood and erosion susceptibility of these parcels. Besides causing damage, flood waters can carry pathogens and pollution, which pose a risk to food safety.[1]

Climate-smart agriculture refers to a set of practices that integrate climate change and sustainability.[2] For producers, implementing climate-smart agriculture means considering future climate conditions when deciding which crops to grow and which management practices to use.[3] Agricultural adaptation strategies, which can include, for example, purchasing insurance, changing crop mix/varieties, adopting soil conservation practices, and installation of water management systems, can have high knowledge and cost barriers.[4] Agricultural extensions and local farmer networks can provide critical opportunities for learning and technical support. Nonprofit organizations as well as agricultural and farming networks are active in the Charlottesville area (e.g., Piedmont Area Cooperative Extension, New Roots, and the Charlottesville Food Justice Network); these groups may be able to support this work.

1 USGCRP, 2016. "Chapter 7: Food Safety, Nutrition, and Distribution," in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment (accessed 8.30.2022).
2 Lipper et al., 2014. "Climate-Smart Agriculture for Food Security," in Nature Climate Change (accessed 9.5.2022).
3 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).
4 US Department of Agriculture, 2013. "Climate Change and Agriculture in the United States: Effects and Adaptation" (accessed 8.30.2022).

CHANGING SEASONAL PATTERNS

As the climate changes, Charlottesville is expected to experience changing seasonal patterns and drought. Increasing average low temperatures and cooling degree days, along with decreasing frost days, extreme cold days, and increasing heating degree days signify that weather is changing in Charlottesville. Winters may become milder overall, and the growing season may shift or become more unpredictable. Warmer overall temperatures may also intensify naturally occurring drought conditions through the evaporation of soil moisture. These changes are evident in Figures 6 and 7, which respectively show rising average low temperatures and a decreasing number of frost days.

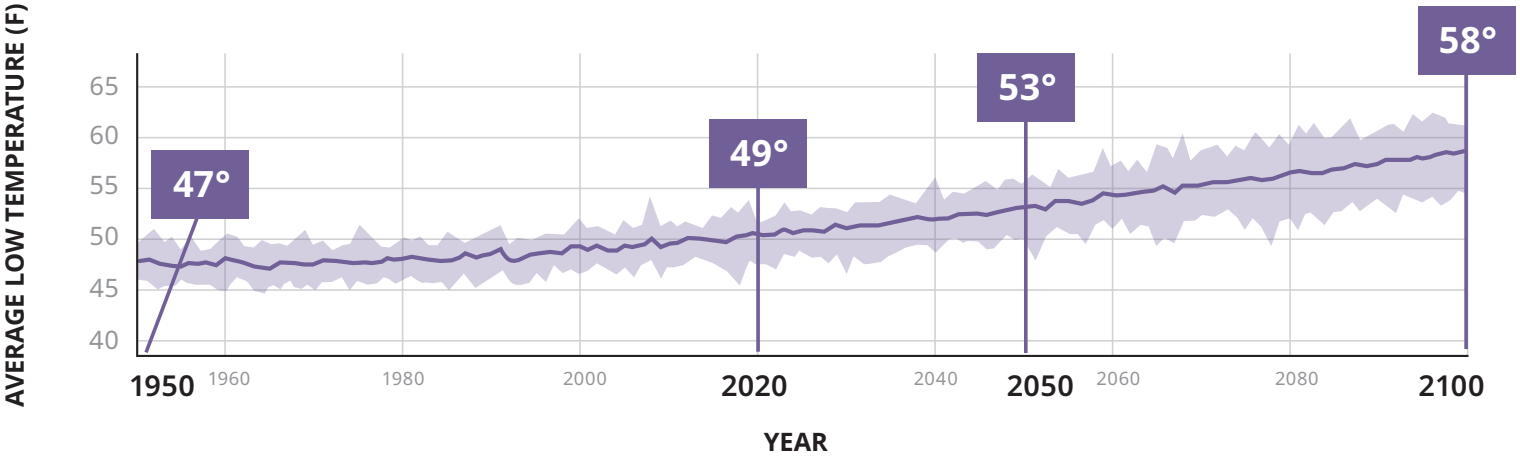


Figure 6. Projected average low temperature, defined as the average of lowest temperature each day over the course of the year.[1]

1 Azavea, n.d. Temperate (accessed 5.30.2023).

CHANGING SEASONAL PATTERNS

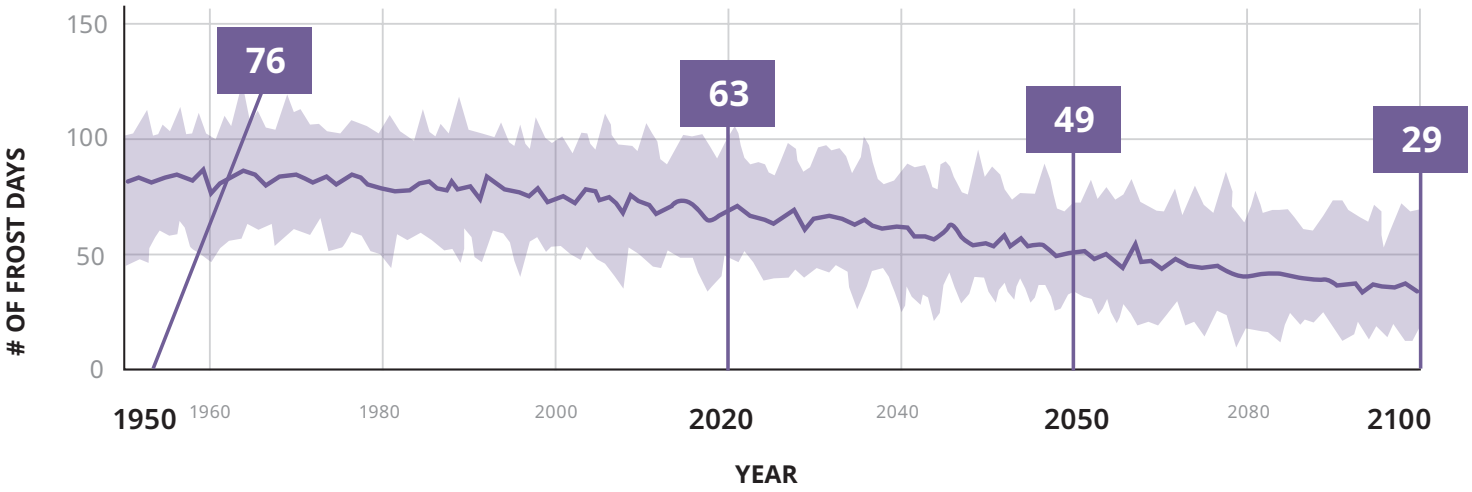


Figure 7. Projected number of frost days, defined as the number of days per year in which the daily low temperature is below the freezing point of water.[2]

2 Azavea, n.d. Temperate (accessed 5.30.2023).

Shifts in seasonality are projected to become more common in the Southeast in future years. These shifts can manifest in multiple ways, including earlier season onset of warm temperatures, which can leave crops vulnerable to late-season cold snaps, and delayed onset of cooler weather in fall.[3]

Working in partnership with the community and key stakeholders from across the local government, the City of Charlottesville engaged with the issues of potential impacts and adaptive capacity across community systems. Review of the survey and workshop discussions around changing seasonal patterns pointed to three high-risk community systems: Agriculture and Food Supply; Forestry and Ecological Function; and Public Health and Wellness.

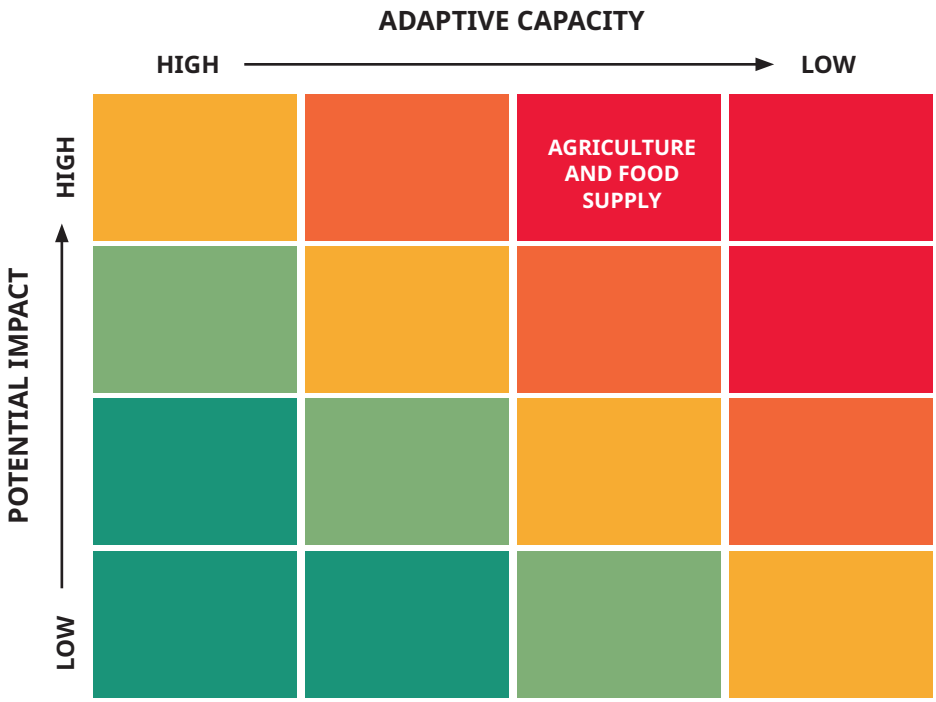
Potential impacts and adaptive capacity are explored in more depth below. Each system is also placed on a risk matrix. Each risk matrix indicates the level of "adaptive need" (or, in other words, the need for adaptation) for each community system-hazard combination. Both survey data and workshop input were used to place systems on the risk matrices.

3 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).

AGRICULTURE AND FOOD SUPPLY

POTENTIAL IMPACT: ***High***

ADAPTIVE CAPACITY: ***Moderately low***



Agriculture has been and will continue to be adversely affected by changed seasonal patterns in the wider region. As workshop participants pointed out, a healthy crop is highly dependent on precipitation and frost occurring at predictable times and levels each year; heavy precipitation and frost at the wrong time can devastate the harvest. Furthermore, changing seasonal conditions cause zonal shifts among species and support spread of pests and invasive species.[1]

In and around Charlottesville, warmer winter conditions and shifts in the timing of the first and last seasonal frosts can cause major disruptions to agriculture, promoting proliferation of weeds, insect pests, and damaging fruit production. Vineyards are already being impacted by changing seasonal conditions; for example, an unusually warm March followed by frost in 2016 negatively impacted vineyards in the region.[2]

The region's vineyards, breweries, and orchards are a draw for tourism. Participants in stakeholder workshops shared concerns over how jobs, revenue, and regional economic development could suffer if loss and damage to agricultural businesses is not avoided or mitigated.

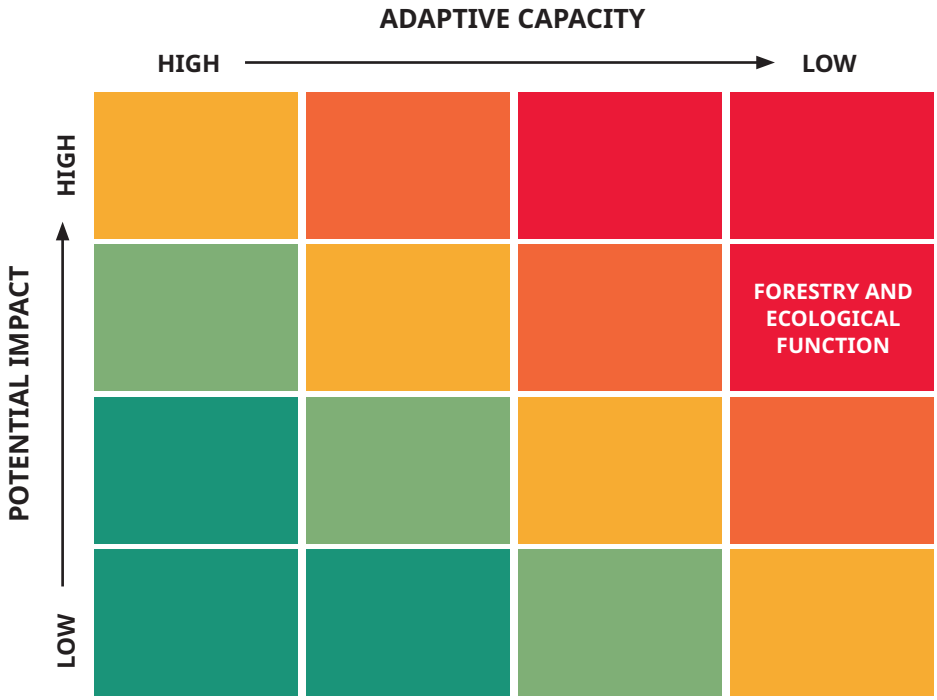
Drought and extreme heat also can be detrimental to crops. During the summer months, prolonged heat and drought conditions cause reductions in soil moisture that strain plants and, in some cases, can cause crop failure. Workshop participants also noted that urban agriculture may be challenged during drought conditions.

1 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).
2 For example, the effects of changing seasonal conditions on central Virginia wineries: Richardson, 2016. "Hard April frosts could spell trouble for Virginia wineries," Charlottesville Tomorrow (accessed 9.5.2022).

FORESTRY AND ECOLOGICAL FUNCTION

POTENTIAL IMPACT:
Moderately high

ADAPTIVE CAPACITY:
Low



The distribution of species is expected to shift over time in response to changing seasonal conditions. Tree species that are present in Charlottesville today are shifting northward, with less cold-tolerant species from further south expanding to take their place.[1] Prolonged dry periods can affect the health and thus the recreational and aesthetic value of Charlottesville's natural areas. Milder winter temperatures allow for spread of invasive species and pests, which threaten urban trees and green areas as well as aquatic ecosystems.[2]

Charlottesville's parks and rivers provide green space and recreational opportunities for residents and visitors. For instance, street and highway trees were frequently highlighted by workshop participants as important community assets. As the climate changes, species that do not do well under changing seasonal conditions are likely to decline, accelerating tree loss in Charlottesville.[3]

Workshop participants expressed concern about how changing seasonal patterns will affect local wildlife. For example, fish species rely on cooler temperatures for a certain span of time, as do other aquatic species of flora and fauna. Invertebrates also rely on certain seasonal cycles. Changing conditions threaten tree reproduction and conditions such as longer periods of drought and flooding weaken tree's defenses against pests and disease.[4]

Charlottesville has limited control over how changing seasonal conditions and drought impact ecosystems and native species in and around the city, though conservation efforts can help.

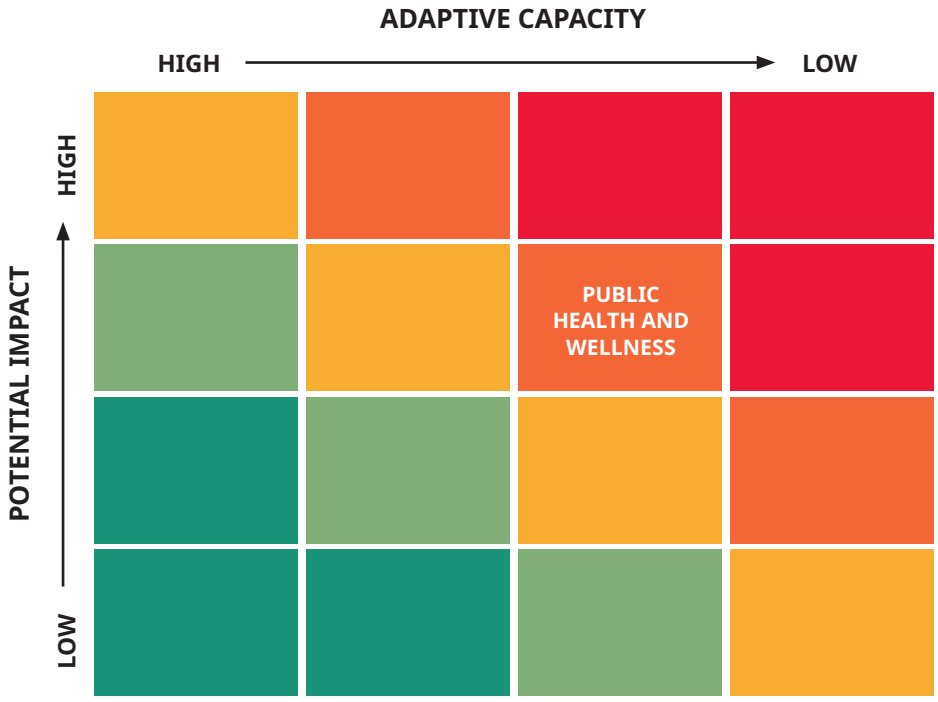
The City has some options for preventing loss of aesthetic and recreational value of natural areas. For example, it is possible to shift to more drought- and heat-tolerant tree species, though this will take time and does not protect existing tree stock in the city. Preservation of habitat can have a positive impact on ecosystem health (and therefore resilience) but does not address underlying climatological change.

1 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).
2 Ibid
3 The City has already experienced declines in the urban canopy: City of Charlottesville, n.d. Tree Canopy Reports (accessed 9.2.2022).
4 USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023).

PUBLIC HEALTH AND WELLNESS

POTENTIAL IMPACT:
Moderately high

ADAPTIVE CAPACITY:
Moderately low



Changing seasonal conditions will allow disease vectors, including ticks and mosquitoes, to spread widely in the Charlottesville region over longer periods in the coming years.[1] In the past, colder winter conditions limited the geographic and seasonal range of these pests; however, sharply declining frost periods in Charlottesville–frost days are expected to decline by approximately 50% by 2100–will mean increased opportunities for spread.

Longer and more severe allergy seasons linked to climate change may make outdoor recreation more difficult for people with allergies, which can reduce both physical and mental health and wellbeing.

The impacts of warmer temperatures and extreme heat on public health and wellness, particularly on Charlottesville's most vulnerable residents, are explored earlier in this chapter.

While the City's influence on allergy season is limited, mosquito eradication efforts may somewhat reduce population numbers and spread of disease. However, these efforts may have unintended deleterious impacts on ecosystems, including bird populations. Draining of wetland areas, another method of mosquito control, threatens nature-based flood control.

1 Ibid.

NEXT STEPS

Charlottesville's Climate Risk and Vulnerability Report underscores the urgent need for the City to adapt to the changing climate. Now is the time for the City–and the larger region–to work together to shore up the resilience of infrastructure, public services, and community systems to climate change. It is critical that future work be conducted with an equity lens, because the impacts of climate change will not be equitably distributed across the City. It is imperative that future efforts involve, collaborate with, and empower frontline communities to steer and shape their own adaptive futures.

The City of Charlottesville is embarking on a collaborative climate adaptation and resilience planning effort with surrounding Albemarle County and the University of Virginia. Emergency Preparedness professionals know that one of the most effective things that can be done to prepare for an emergency is to get to know your neighbors. In that spirit, sustainability staff from the City, County, and UVA are designing a collaborative framework for climate adaptation and resilience planning. The impacts of climate disruption in our region will not respect the jurisdictional boundaries between city and county. Based on initial community engagement, we know area residents think about the impacts of climate change regionally and there is interest in the local governments working together. Most community-based organizations already work regionally and across jurisdictional boundaries, which reflects the reality on the ground that social and environmental challenges crosscut our communities. Embarking on a regional resiliency planning effort will strengthen the relationships between each jurisdiction in ways that will result in being a more resilient community.

The Resilient Together project seeks to develop parallel, community-centered Climate Adaptation and Resilience Plans informed by stakeholders within and served by the City and County. Sustainability staff from the City and County will lead the development effort, with significant input from staff across our local governments and UVA, representatives from regional public institutions, members of local community-based organizations, and the public.

The final plans for each entity will be similarly organized around goals, strategies, and actions, including specific projects to implement, monitor, and evaluate. It will cover the following topics:

- **Importance of Adapting and Building Community Resilience to Climate Disruption**
- **Guiding Principles and Goals**
- **Summary of Local Climate Hazards and Vulnerabilities**
- **Summary of Local Strengths: Government and Community Assets**
- **Adaptation and Resilience Strategies**

DEFINITIONS

Adaptive Capacity	The ability of people, systems, or community assets to adjust to a hazard, take advantage of new opportunities, or cope with change.
Climate Change/ Disruption	The long-term shift in global temperatures and weather patterns, presently due to human-caused greenhouse gas emissions. "Climate disruption" highlights the disruptive capacity of these changes.
Climate Change Adaptation	Changing human systems and behaviors to better withstand the effects of the changing climate.
Climate Risk and Vulnerability Assessment (CRVA)	A qualitative and/or quantitative assessment of the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. CRVAs often evaluate exposure, sensitivity, and adaptive capacity, and provide rankings of the seriousness of various climate risks.[1]
Community Assets	The places, services, infrastructure, ecosystems, institutions, and other resources that a community believes it is important to protect. In other words, community assets are the tangible and intangible things that people and communities value.
Community Systems	Refer to the built, natural, and human networks that provide or support important services, activities, and sectors within a community or region.[2]
Cooling Degree Days	A unitless measure that approximates air conditioning use.[3]
Energy Burden	The percentage of household income spent on energy bills.[4]
Environmental justice	The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.[5]
Equity	Just and fair inclusion into a society in which all can participate, prosper, and reach their full potential.[6]
Exposure	The presence of people, places, and systems that could be adversely affected by hazards, specifically those exacerbated by climate change.

1 Adapted from: USGCRP, 2018. Fourth National Climate Assessment (accessed 5.30.2023); CDP, 2018. CDP 2018 Reporting Guidance (accessed 9.22.2022).
2 Adapted from: University of Washington Climate Impacts Group, 2007. Preparing for Climate Change: A Guidebook for Local and Regional Governments (accessed 5.30.2023).
3 Adapted from: Azavea, n.d. Indicator Dictionary (accessed 5.30.2023).
4 Adapted from: American Council for an Energy-Efficient Economy (ACEEE), n.d. Understanding Energy Affordability (accessed 5.30.2023).
5 Adapted from: EPA, n.d. Learn About Environmental Justice (accessed 5.30.2023).
6 Adapted from: Policy Link, n.d. The Equity Manifesto (accessed 5.30.2023).

DEFINITIONS

Extreme Cold Events	A count of the total times the daily average minimum temperature is below some percentile of historic observations. It is used to understand where projections deviate from historic extremes.[1]
Extreme Heat Events	A count of the total times the daily average maximum temperature is above some percentile of historic observations. It is used to understand where projections deviate from historic extremes.[2]
Frost Days	A county of the number of days where the daily low temperature drops below 32°F or 0°C.[3]
Hazard (also referred to as "climate hazard")	Extreme weather events and other natural disasters exacerbated by climate change that adversely impact a community. In this document, the term "hazard" primarily refers to climate-related physical events or trends.
Heating Degree Days	A unitless measure that approximates heating use.[4]
Impacts	Consequences or outcomes, which can be positive or negative. In this document, the term "impacts" primarily refers to the effects of climate disruption on natural and human systems. Potential impact is a function of sensitivity and exposure.
Mitigation	Processes that can reduce the amount and speed of future climate change by reducing emissions of heat-trapping gasses or removing them from the atmosphere.
Projections	Potential future climate conditions calculated by computer-based models of the Earth system. Projections are based on sets of assumptions about the future (scenarios) that may or may not be realized.
Resilience	The capacity of a system (can be social, economic, or natural) to cope with a hazardous event, trend, or disturbance.
Risk	The potential for negative consequences where something of value is at stake. In the context of the assessment of climate impacts, the term risk is often used to refer to the potential for adverse consequences of a climate-related hazard. Risk can be assessed by multiplying the probability of a hazard by the magnitude of the negative consequence or loss.
Sensitivity	The degree to which people, systems, or community assets are or might be affected by hazards.
Vulnerability	Social, health, economic, or environmental factors that reduce adaptive capacity or increase adverse impacts when exposed to a hazard.

1 Azavea, n.d. Indicator Dictionary (accessed 5.30.2023).
2 Ibid.
3 Ibid.
4 Ibid.

ABBREVIATIONS

CRAFT	**Climate Risk and Adaptation Framework and Taxonomy**
CRVA	**Climate risk and vulnerability assessment**
GCoM	**Global Covenant of Mayors for Climate and Energy**
GHG	**Greenhouse gas**
IPCC	**Intergovernmental Panel on Climate Change**
LEAP	**Local Energy Alliance Program**
NCEI	**National Centers for Environmental Information**
NOAA	**National Oceanic and Atmospheric Administration**
RCP	**Representative Concentration Pathway**
USGCRP	**US Global Change Research Program**