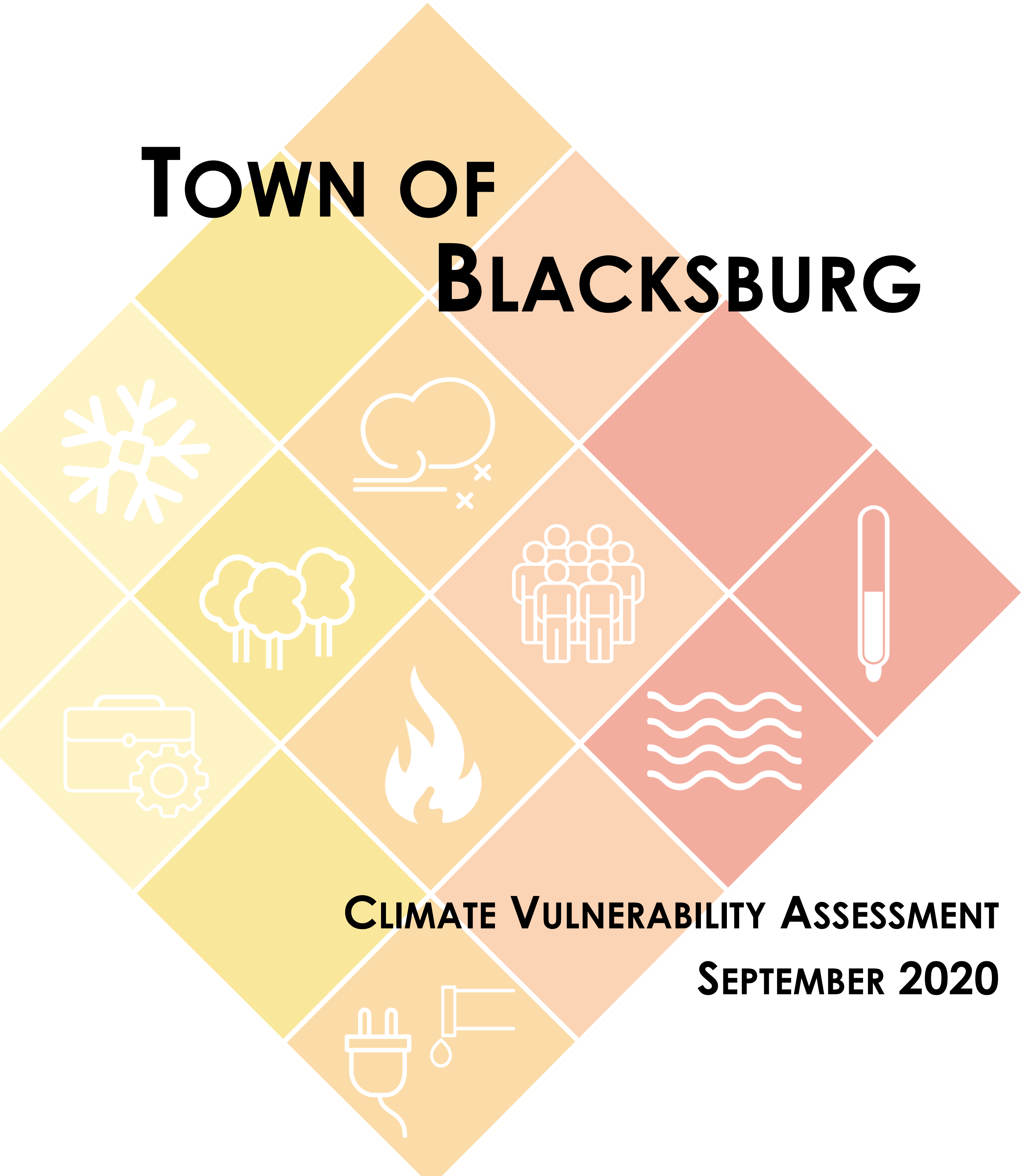
Town of Blacksburg



Climate Vulnerability Assessment

September 2020

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Message from Mayor Leslie Hager-Smith

Blacksburg is proud to be counted among the hundreds of local governments across America that are taking action to address climate change, while making their communities healthier and more resilient. We have long recognized our fundamental responsibility to take stock of our share of the planet's greenhouse gas emissions and hold up our end of the bargain to ensure a stable climate for future generations. One key way we are doing that is by integrating goals from Blacksburg's 2016 Climate Action Plan into its Comprehensive Plan, which will elevate climate priorities into future land-use, infrastructure, and transportation decision.

We also know that reducing emissions, while critically important, will not be enough. As a global community, we have been burning fossil fuels at an ever-accelerating pace since the advent of the industrial revolution. Those emissions are already in our atmosphere and we will have to contend with a certain amount of climate change that is already baked in.

Stressors like poverty, inequality, public health challenges, economic volatility, and environmental degradation will almost certainly be made worse by a changing climate. These changes have the potential to disrupt our lives and livelihoods in numerous ways, and we know we will need to adapt. For Blacksburg to do that, we need to first assess which community systems might be at risk. We also recognize that the needs of people who are likely to be hurt first and worst by climate change should be prioritized in our future plans for climate adaptation.

To become a truly climate-resilient community, Blacksburg has to do three things: continue to act boldly to reduce our greenhouse gas emissions; begin adapting to changes that cannot be avoided under a low-emissions scenario; and, pro-actively plan for how we might respond to the challenges of a high-emissions scenario. The good news is, climate mitigation and adaptation strategies can work in concert, providing benefits that align with community goals around affordable housing, resilient natural systems, expanded transportation options, and thriving civic spaces.

As I reflect on the ways in which Blacksburg has come together so many times in the past to overcome daunting challenges, I know we are equal to the task ahead of us.

Leslie Hager-Smith

Mayor of Blacksburg, VA

Centering Equity

Centering Equity in Climate Adaptation and Resiliency Planning & Implementation

Climate change does not affect everyone equally. In evaluating potential impacts a key consideration is to recognize that some people will be disproportionately worse off than others. These groups are commonly referred to as "vulnerable populations" or "marginalized groups." For the purposes of this report, they will be identified as **FRONTLINE COMMUNITIES**, because it is they who will be on the front lines of the unfolding climate emergency. Factors that increase the potential impact of climate hazards on individuals include:

- Age factors (very young and very old people are more vulnerable to heat stress)
- Complex health challenges -or- mobility, sensory or cognitive impairments
- Limited social connections or support networks
- Limited financial resources
- Working outdoors or in unconditioned spaces
- Inadequate, unstable or unaffordable housing options
- Insecure or unaffordable transportation options
- Language or cultural barriers

With the exception of age, the factors listed above are disproportionately found among people of color, indigenous peoples, immigrant communities, and in rural areas. The following excerpt from "Making Equity Real in Climate Adaptation and Community Resilience Guidebook", emphasizes the historical context and clear need to place equity at the center of climate adaptation work:

> *"Decades of underinvestment and unjust systems have left frontline communities with high levels of poverty and pollution, poorer health outcomes, a lack of quality jobs and education opportunities, outdated and weak critical infrastructure, disproportionately high costs for energy, transportation and basic necessities, and limited access to public services. Moreover, frontline communities have long been excluded from policy and funding decision-making processes that can be used to address the injustices they experience and support a transition to healthy communities. Exclusion from the decision-making table is one reason the needs of frontline communities have not been prioritized. As a result of these injustices, frontline communities have fewer resources to deal with the risks from climate change. These communities are often hit first and worst by climate impacts, which only exacerbate the environmental and socioeconomic inequities they already face."*

To make equity real in its climate adaptation and resilience work, the Town of Blacksburg commits to:

1. Embedding equity in the mission, vision and values for Blacksburg's adaptation and resilience plan.
2. Building equity and deep engagement into the planning and implementation process.
3. Ensuring equity outcomes by responding to community needs in policy-making and implementation.
4. Measuring and analyzing for equity outcomes over time with an eye toward continual improvement.

How hot is too hot and when does it become a problem?

How wet is too wet and when does it become a problem?

How do these and other changes to the climate intersect?

How should localities like Blacksburg plan and adapt?

The answers to these questions are challenging to navigate. We can explore the question through some comparative examples. Take for instance, a midsummer day in Anchorage, Alaska where a temperature above 80°F would be considered extremely hot, since the average daily highs in July are usually in the mid to high 60s. Yet this same temperature would be considered unseasonably cool for Phoenix, Arizona, where July average daily highs topping 105°F are the norm. In these two places, as in all places, both the natural systems and the built environment have emerged, were cultivated, or were constructed to accommodate a predictable range of climatic conditions.

Blacksburg falls between these two extremes, with an average high temperature in July in the low to mid 80s. Occasional hotter days are not unheard of in our region. The historic record shows that between 1950 and 2013, Blacksburg had around 4-5 days per year where the temperatures got above 90°F, with far fewer days that topped 95°F. (source: NOAA Climate Explorer, Blacksburg, VA in Montgomery County—Days with max >90°F, >95°F, Historical Observed).

Communities are built over a long time. Buildings and infrastructure are constructed to perform within a predictable range of conditions and are expected to be around for many decades, if not centuries. Similarly, natural systems, which contribute diverse and incalculable value to the surrounding community, are highly tied to a predictable set of climatic conditions for that region. Whole economies like agriculture and tourism revolve around predictability of the seasons. All of these systems become vulnerable and potentially unstable if climatic conditions change substantially.

Communities like Blacksburg will be well served by taking an honest look at the climate vulnerabilities they will be facing in the coming years and decades. Decisions we make now around infrastructure, land use, transportation investments, buildings, and public health can prepare us, not just to survive in a changing climate, but to thrive.

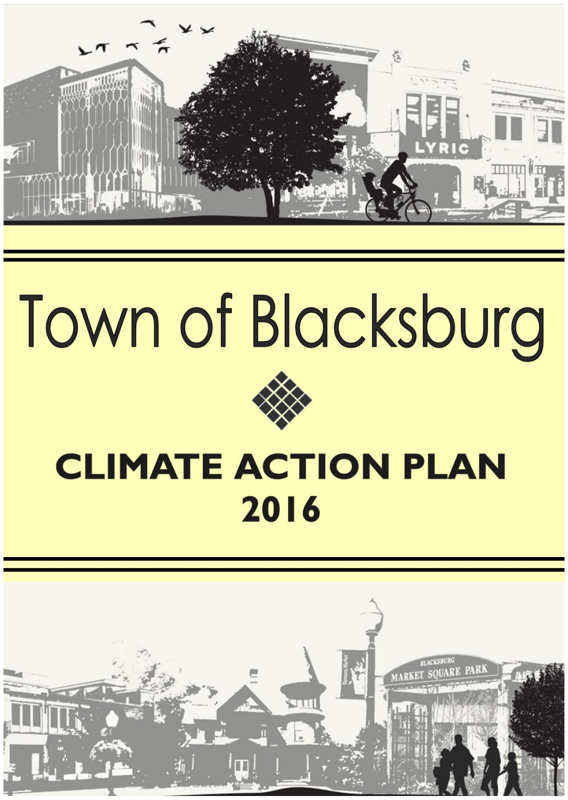
Introduction, Background & Process

Climate Action: Mitigation *and* Adaptation

Climate Change will be the defining challenge of the 21st century. Evidence continues to mount that continued inaction on greenhouse gas emissions could lead to catastrophic changes, destabilizing the very systems that support and sustain human civilizations. Billions of people will experience these changes through threats to public health, disruption of national and local economies, and food and water insecurity. Buildings and infrastructure will be increasingly impacted by the severity and frequency of weather events. For certain coastal communities, these threats will be amplified by rising sea levels.

A business-as-usual pattern of carbon emissions is likely to create 4°C of warming, and could lock in enough sea level rise to submerge land currently home to 470 to 760 million people, with unstoppable rise unfolding over centuries. By contrast, significant cuts to global carbon emissions limiting warming to 2°C could bring the number as low as 130 million people. Foreign policy experts increasingly warn that people internally displaced from sea level rise, droughts, wildfires, food insecurity, and super storms are considered a risk to domestic stability within their own countries and international security more broadly.

While a worldwide policy response to climate change is urgently required, a great deal of the action and implementation will have to take place at the local level. Back in 2007, Blacksburg was proud to join a growing list of U.S. cities that stepped forward to make a formal commitment to reduce their community's greenhouse gas emissions. In 2016, Blacksburg took a major step toward operationalizing that commitment by adopting a Climate Action Plan.



Blacksburg's Climate Action Plan (CAP) is solely focused on mitigation, and establishes a set of strategies that will enable Blacksburg to significantly reduce community-wide greenhouse gas emissions. While recognizing the seriousness of the climate crisis, the CAP does not attempt to evaluate ***how Blacksburg might be specifically vulnerable*** in a changing climate, or what we, as a community can do to prepare and adapt. Mitigation and adaptation measures are both clearly needed if we intend transition to a thriving, resilient future.

In the pages that follow, this Climate Vulnerability Assessment will demonstrate these area of heightened vulnerability for Blacksburg and will point toward a set of objectives for how Blacksburg can adapt.

Planning for the Unavoidable...and More

Climate change is already here. We can see the evidence in temperature records being broken year after year along with other accelerating indicators like sea level rise, melting glaciers, and more frequent and intense storms. Blacksburg has committed to doing its part to reduce its share of greenhouse gas emissions. At the same time, we also recognize that there is a certain amount of climate change that is unavoidable, even under a best-case scenario. Even if we are successful, not just locally, but as a global community in sharply reducing greenhouse gas emissions over the next decade, there is a certain amount of climate change that is simply "baked in" at this point. At a minimum, all communities should start planning now for how they will address the changes that are anticipated under this best case/low-emissions scenario. Despite near unanimity among climate scientists that this is a problem requiring urgent, bold, and coordinated action, it is increasingly unclear if the needed political leadership will emerge on the national and world stages to put us on a path to that lower-emission scenario. Therefore, common sense dictates that it would be wise to plan for higher-emissions scenarios as well.

Climate Metrics Considered

To evaluate the climate hazards Blacksburg may need to start planning for, thirteen key temperature and precipitation metrics were analyzed. Each of these metrics point to potential areas of vulnerability: to people, to natural systems, to the economy, and to infrastructure and basic services.

The climate metrics evaluated for this report include:

- **Cooling Degree Days** (indicator of energy required to cool buildings in warmer months)
- **Growing Degree Days** (indicator of agricultural production potential, as well as plant heat stress)
- **Modified Growing Degree Days** (indicator of heat-related plant stress for key agricultural staple crops)
- **Heating Degree Days** (indicator of energy required to heat buildings in cold months)
- **Days with Maximum Temperature > 90 degrees** (hot days—risk of heat stress)
- **Days with Maximum Temperature > 95 degrees** (very hot days—high risk of heat stress)
- **Days with Minimum Temperature < 32 degrees** (cold days)
- **Days with Maximum Temperature < 32 degrees** (very cold days)
- **Average Daily Minimum Temperature** (overnight temperatures)
- **Total Annual Precipitation** (indicator of changes to overall hydrological cycle)
- **Total Monthly Precipitation** (indicator of changes in seasonal precipitation)
- **Days with > 1" precipitation** (indicator of potential flooding events)
- **Dry Days, days with < .01" precipitation** (indicator of drought or change of precipitation frequency)

Temporal, Emissions, and Geographic Scopes Evaluated

While it might seem intuitive that only local changes to the climate would be relevant, changes at the national level may prove to be just as impactful. At the local level, we can anticipate vulnerabilities for individuals, private property, natural systems, and infrastructure. At the national level, we may see complex, interdependent systems like the electric grid or networks of food production stressed, possibly to the breaking point. Extreme changes to the climate may even make some parts of the country less livable to its residents prompting populations to voluntarily displace.

With an eye toward development of an adaptation and resiliency plan, it is also useful to explore different time scales. For some adaptation strategies, a shorter time horizon is most appropriate (e.g. a public engagement campaign on mitigating heat stress for outdoor workers). For others, particularly those that involve investments in infrastructure or buildings, a focus on climate realities nearer the end of this century are more salient.

For these reasons, mid-century and end-of-century time scales, low- and high- emissions scenarios, and local and national geographic scopes were evaluated for each of the thirteen climate metrics under consideration in order to identify and prioritize the top climate hazards of concern for Blacksburg.

Temporal Scopes & Emissions Scenarios

Historical Averages:

Local Observed Historical Average (1950-2013)

Local Modeled Historical Average (1950-2006)

National Observed Historical Average (1961-1990)

Mid-Century Projections/Modeling

Local Modeled Low-Emissions Scenario (avg. 2036-2065)

Local Modeled High-Emissions Scenario (avg. 2035-2065)

National Model Low-Emission Scenario (avg. 2050s)

National Modeled High-Emissions Scenario (avg. 2050s)

End-of-Century Projections/Modeling

Modeled Low-Emissions Scenario (avg. 2065-2095)

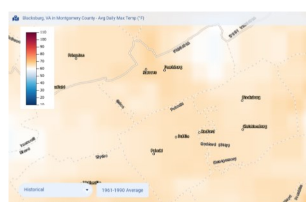
Modeled High-Emissions Scenario (avg. 2065-2095)

National Model Low-Emission Scenario (avg. 2090s)

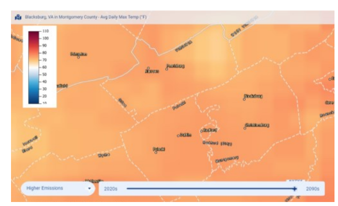
National Modeled High-Emissions Scenario (avg. 2090s)

Geographic Scopes

Local/Regional (Montgomery County, VA)

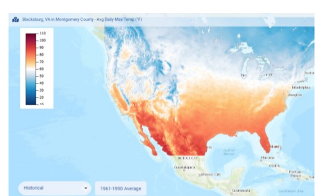


Low-Emissions Scenario

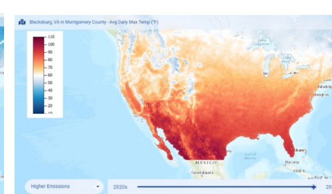


High-Emissions Scenario

Continental United States



Low-Emissions Scenario



High-Emissions Scenario

Identifying Top Climate Hazards

Evaluating each climate metric in this way indicates the primary climate hazards of concern for Blacksburg:

- **HOTTER SUMMERS** (Blacksburg and U.S.)
- **WARMER WINTERS** (Blacksburg and U.S.)
- **INCREASED PRECIPITATION** (Blacksburg) & **CHANGING PRECIPITATION PATTERNS** (U.S.)

Now that we have a sense of the degree of change (frequency, intensity) of each of the key climate metrics, we can turn our attention to what that might mean for Blacksburg. Specifically, what community systems might be most impacted?

Community Systems at Risk

Changes to the climate are expected to impact most aspects of our lives and livelihoods. Significant shifts in precipitation patterns and seasonal temperatures within and even beyond Blacksburg's borders have the potential to result in an array of local impacts that we can and should begin planning for today. However, in order to determine where the Town should focus its efforts, the critical community systems that may be at risk should first be identified. The table below organizes these community systems into four broad categories: people & community, natural systems, economy & employment, and infrastructure & basic services. Elements and systems that are critical to the functioning of our community and the well being of residents are listed below each heading.

Climate Hazards and Critical Community Systems: Potential Areas of Vulnerability

People & Community	Natural Systems	Economy & Employment	Infrastructure & Basic Services
A. Financial Wellbeing (HH)	G. Agriculture/Farming	L. Business Continuity	P. Emergency Services/Management
B. Food Security	H. Ecosystem Services	M. Employment Continuity	Q. Energy Access & Delivery
C. Homes & Buildings	I. Forests/Tree Cover	N. Industrial Operations	R. Internet & Communications
D. Human Health & Wellbeing	J. Hydrology/Watershed	O. Tourism	S. Law & Order
E. Population Displacement	K. Invasives/Species Shift		T. Stormwater Infrastructure
F. Public Safety			U. Transportation System
			V. Water Supply
			W. Water/Wastewater Infrastructure

Prioritizing Risks

To be sure, not all community systems are created equal, nor will they be equally impacted by hotter summers, warmer winters, and changing precipitation patterns. For each of the thirteen climate metrics the following questions were used to evaluate the relative vulnerability of each community system:

What is the **POTENTIAL IMPACT** of a given climate metric on this community system? (low to high)

- Probability, frequency, and intensity of change
- Community systems that could be adversely impacted
- Types and degree of anticipated impact on each community system
- Geographic scope of impact (narrow to broad)
- Demographic scope + equity lens: likelihood of disproportionate impacts on frontline communities

How much **ADAPTIVE CAPACITY** exists to mitigate these anticipated impacts? (high to low)

- Practical or technological feasibility of adaptation measures
- Degree of local control to enact adaptation measures
- Available resources to pursue adaptation measures

Within each chapter, a **CRITICAL COMMUNITY SYSTEMS TABLE** and **RISK PRIORITIZATION MATRIX** offer a snapshot of the community systems most at risk from each climate hazard. The Critical Community Systems Table is broken up into four groupings: People & Community, Natural Systems, Economy & Employment, and Infrastructure & Basic Services.

PEOPLE AND COMMUNITY

NATURAL SYSTEMS

ECONOMY AND EMPLOYMENT

INFRASTRUCTURE AND BASIC SERVICES

Note that the letters A-W in both the table and matrix correspond with one another. For both, the darker squares indicate the community systems that may be the most vulnerable in a changing climate. It is these areas of heightened potential vulnerability that will warrant special attention and focus for climate adaptation policy-making.

Critical Community Systems: Potential Areas of Vulnerability (Sample)			
People & Community	**Natural Systems**	**Economy & Employment**	**Infrastructure & Basic Services**
A. Financial Wellbeing (HH)	G. Agriculture/Farming	L. Business Continuity	P. Emergency Services/Management
B. Food Security	H. Ecosystem Services	M. Employment Continuity	Q. Energy Access & Delivery
C. Homes & Buildings	I. Forests/Tree Cover	N. Industrial Operations	R. Internet & Communications
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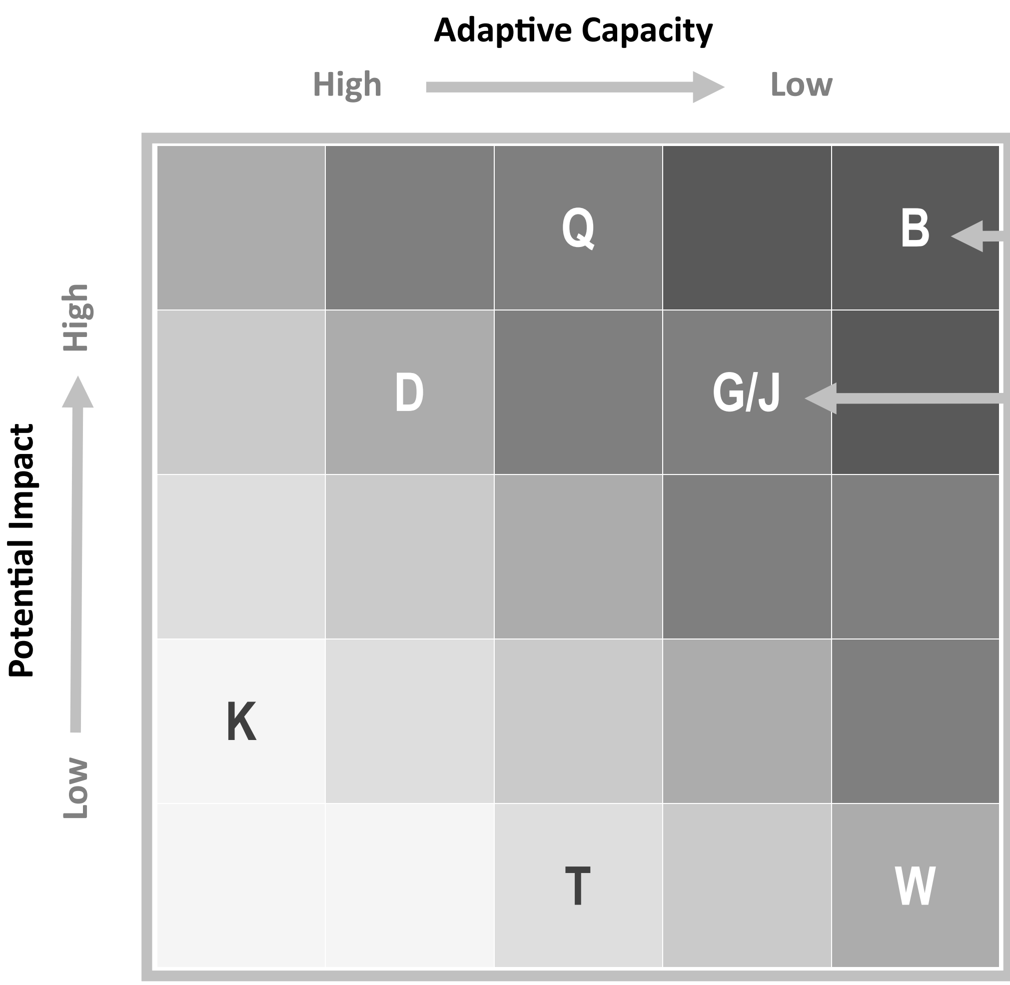
			W. Water/Wastewater Infrastructure



Risk Prioritization Matrix (Sample)

In the chapters that follow, you will find a paired community systems table (above) with a risk matrix (left) similar to the samples shown here.

These show the anticipated degree of risk for each community system relative to Blacksburg's primary climate hazards:

Hotter Summers
Warmer Winters
Changing Precipitation

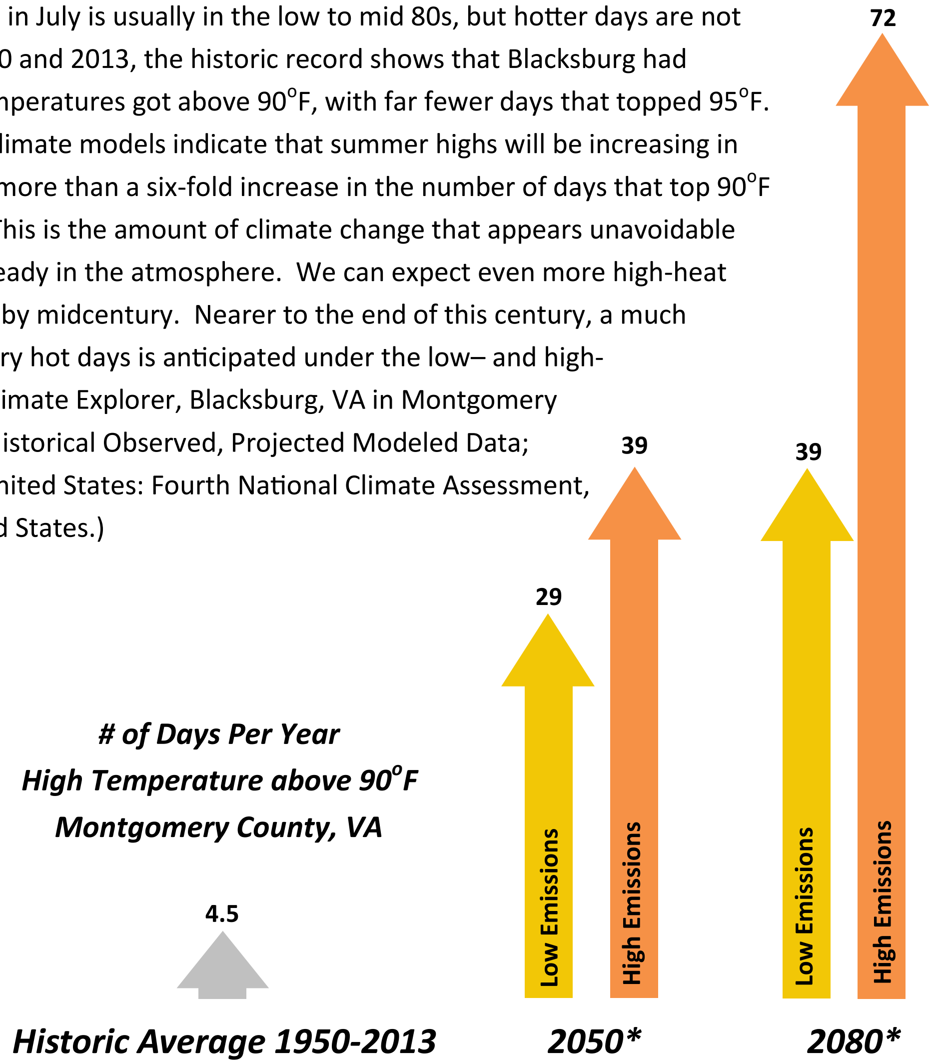
Proposed adaptation strategies will center around areas of highest anticipated risk (darker squares).

HOTTER SUMMERS

Hazard: Hotter Summers in Blacksburg

In Blacksburg, the average temperature in July is usually in the low to mid 80s, but hotter days are not unheard of in our region. Between 1950 and 2013, the historic record shows that Blacksburg had around 4-5 days per year where the temperatures got above 90°F, with far fewer days that topped 95°F. Looking ahead, the weighted mean of climate models indicate that summer highs will be increasing in our area. By 2050, we are likely to see more than a six-fold increase in the number of days that top 90°F even under a low-emissions scenario. This is the amount of climate change that appears unavoidable based on greenhouse gas emissions already in the atmosphere. We can expect even more high-heat days under a higher emissions scenario by midcentury. Nearer to the end of this century, a much sharper divergence in the number of very hot days is anticipated under the low– and high-emissions scenarios. (sources: NOAA Climate Explorer, Blacksburg, VA in Montgomery County—Days with max >90°F, >95°F, Historical Observed, Projected Modeled Data; Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II, Chapter 19, Southeast United States.)

Outdoor workers and people who lack air conditioning may experience extreme discomfort or heat illness on hot days, especially if humidity is high and wind is light. Hot days also stress plants, animals, and infrastructure such as electric lines, roads, and rails. Increased demand for electricity to cool homes and businesses also stresses energy infrastructure on hot days.



**30 year averages around each target year for low– and high-emissions scenarios; 2035-2065 and 2065-2095, respectively*

Climate modeling for our area also indicate other measures of heat increasing over the next century, with a range of potential impacts to people & community, natural systems, economy & employment, and infrastructure & basic services.

Frontline Communities & Hotter Summers

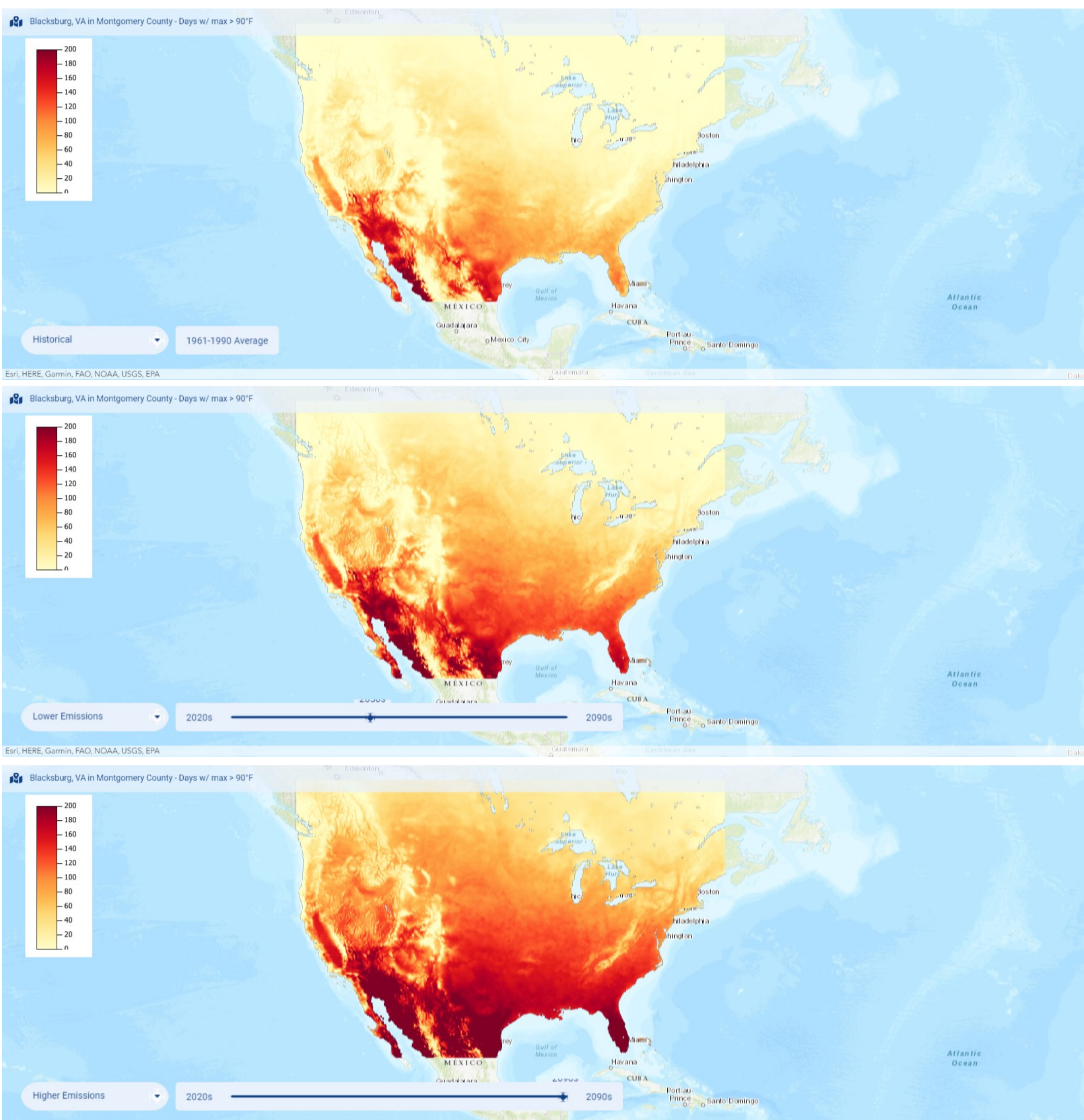
Frontline communities are likely to be disproportionately impacted by hotter summers. For instance, if someone is suffering from asthma that is exacerbated by an extended heat wave, and they don't have health insurance...how would they get the medical help they need? As we evaluate the range of possible adaptation strategies to hotter summers in Blacksburg, frontline communities should be at the decision-making table to guide the process of identifying and developing the policies and programs that will best align with their needs.

- Age factors (very young and very old)
- Complex health challenges
- Mobility, sensory or cognitive impairments
- Limited social connection or support networks
- Limited financial resources
- Working outdoors or in unconditioned spaces
- Inadequate, unstable or unaffordable housing
- Insecure or unaffordable transportation
- Language or cultural barriers

Hazard: Hotter Summers across the United States

Increasing heat beyond Blacksburg's borders also has the potential to create local impacts. The maps below compare different scenarios for # of days with a maximum temperature above 90°F. The top map shows the historical average, while the middle and bottom maps show the anticipated # of high-heat days across the continental United States by midcentury under low–emissions and end of century under a high-emissions scenarios, respectively. While an overall warming trend is indicated, note that greater relative warming that is expected for the South and Midwest. What might this mean for agricultural productivity and overall food security? Or for population migration due to water scarcity or wildfire risk? Or the range of certain disease-vector insects? In addition to the local heat-related hazards identified on the previous page, increasing summer heat at the national scale has the potential to create local impacts that should also be considered as we evaluate Blacksburg's vulnerabilities to climate change.

United States: # of Days Per Year with Maximum Temperature > 90°F



Historical Average 1961-1990

Low-Emissions Scenario 2050s

High-Emissions Scenario 2090s

Climate Metrics: Hotter Summers in Blacksburg & the U.S.

Hotter Summers: Key Climate Metrics & Findings

Of the thirteen climate metrics evaluated, these six point to an array of potential vulnerabilities for Blacksburg.

Cooling Degree Days (CDDs)

- The number of cooling degree days reflects the amount of energy typically used to cool a building when it is warm outside. At the household level, increasing cooling degree days will disproportionately impact low-income households, and people without air-conditioning or who live in older less energy-efficient homes. At the regional and national level, increasing cooling degree days points to the potential for energy infrastructure to become stressed beyond its capacity.

Modified Growing Degree Days

- Corn growers use the number of modified growing degree days to monitor the development of corn crops. As corn development occurs only when temperature is above 50°F but below 86°F, the standard calculation for growing-degree days is modified to omit conditions outside this range. In future decades, regions where temperatures regularly exceed 86°F may be less successful in growing corn and potentially other staple crops that form the backbone of our food system.

Days with Max Temp > 90 degrees and **Days w/Max Temp > 95 degrees** (hot and very hot days)

- Outdoor workers and people who lack air conditioning may experience extreme discomfort or heat illness on hot days, especially if humidity is high and wind is light. Hot days also stress plants, animals, and infrastructure such as electric lines, roads, and rails. A significant anticipated increase in hot and very hot days will lead to higher and more frequent peak demand for electric power, further stressing the electricity grid and increasing the risk of power interruptions.

Average Daily Minimum Temperature and **Days with Minimum Temperature > 80 degrees**

- A day's lowest (minimum) temperature usually occurs in the early morning, just before sunrise. Averaging the daily low temperatures for any period results in a mean minimum temperature for that period. These daily periods of low temperature give plants, animals, and people a chance to recover from daytime heat. When daily minimum temperatures aren't sufficiently cool, plant and animal responses can trigger ecosystem changes. The # of warm nights associated with rising average daily minimum temperatures, especially # of days with minimum temperature above 80 degrees can also increase the demand for energy in a 24-hour period and can stress energy infrastructure.

Prioritized Areas of Risk: Hotter Summers

Prioritized Areas of Risk

To identify areas of heightened potential vulnerability, climate metrics for hotter summers were evaluated relative to critical community systems for Blacksburg. In addition to evaluating the direction of anticipated change for these climate metrics, the following factors were explored to evaluate overall risk:

What is the **POTENTIAL IMPACT** of **HOTTER SUMMERS** on our critical community system? (low to high)

- Probability, frequency, and intensity of change
- Community systems that could be impacted
- Types and degree of anticipated impact on each community system
- Geographic scope of impact (narrow to broad)
- Demographic scope + equity lens: likelihood of disproportionate impacts on frontline communities

How much **ADAPTIVE CAPACITY** exists to mitigate these anticipated impacts? (high to low)

- Practical or technological feasibility of adaptation measures
- Degree of local control to enact adaptation measures
- Available resources to effectively pursue adaptation measures

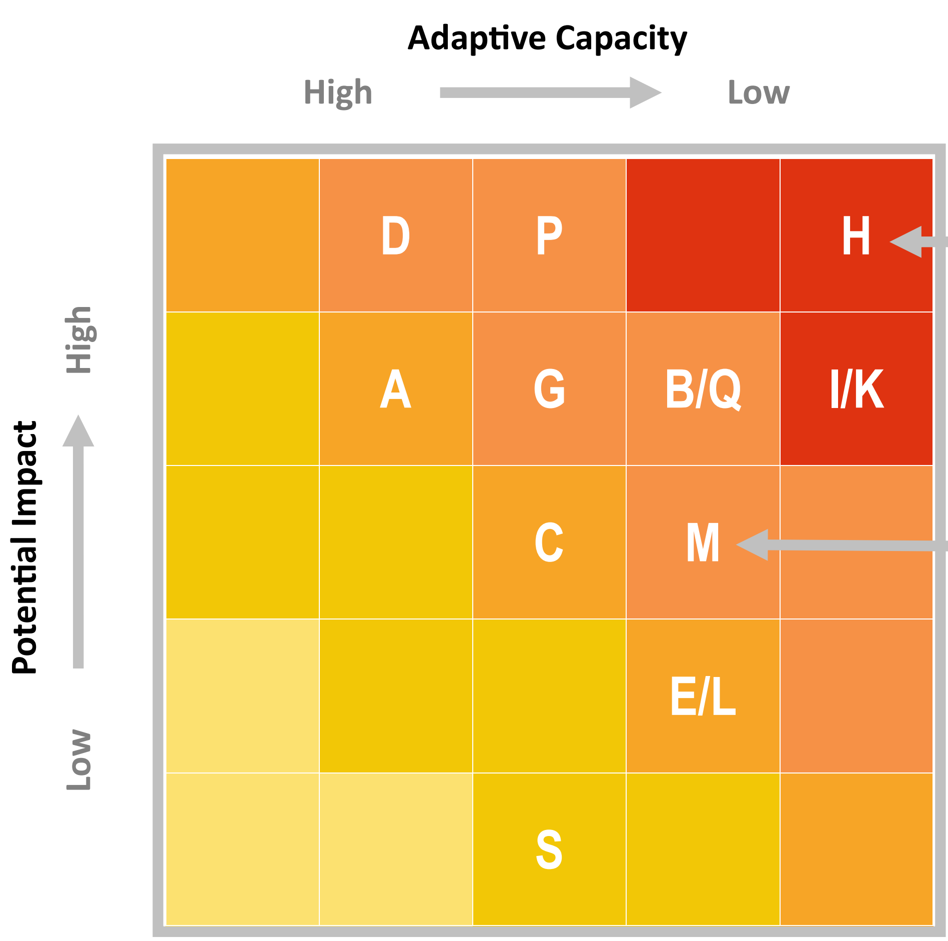
The **COMMUNITY SYSTEMS TABLE** and **RISK PRIORITIZATION MATRIX** on the following page offer a snapshot of the community systems most at risk from hotter summers. At a glance, it is apparent that hotter summers have the potential to disrupt most of our community's critical systems to some degree. Note that the letters A-W in the risk matrix correspond to the community systems listed in the community systems table above it. The darker squares indicate the systems that may be the most vulnerable to increasing heat in our community. It is these areas of heightened potential vulnerability that will warrant special attention and focus for climate adaptation policy-making.

To be sure, the task before us is daunting. For some of the community systems most at risk (ecosystem services), the scale of the challenge and our capacity to implement effective adaptation strategies seem quite limited. For others, (public health) a path forward to address heat stress and heat illness for vulnerable segments of the population may be more straightforward.

The following pages list out some recommended adaptation paths for community systems most at risk from hotter summers. Translating these recommendations into actionable policies and programs will require further collaboration with frontline communities, decision-makers and other stakeholders to ensure the resulting adaptation and resilience strategies are realistic, effective, and equitable.

Hotter Summers and Critical Community Systems: Potential Areas of Vulnerability

People & Community	Natural Systems	Economy & Employment	Infrastructure & Basic Services
A. Financial Wellbeing (HH)	G. Agriculture/Farming	L. Business Continuity	P. Emergency Services/Management
B. Food Security	H. Ecosystem Services	M. Employment Continuity	Q. Energy Access & Delivery
C. Homes & Buildings	I. Forests/Tree Cover	N. Industrial Operations	R. Internet & Communications
D. Human Health & Wellbeing	J. Hydrology/Watershed	O. Tourism	S. Law & Order
E. Population Displacement	K. Invasives/Species Shift		T. Stormwater Infrastructure
F. Public Safety			U. Transportation System
			V. Water Supply
			W. Water/Wastewater Infrastructure



Risk Prioritization Matrix

The climate hazard ***Hotter Summers*** has been evaluated for its potential to impact each of the critical community systems listed above.

The relative degree of risk for each community system is shown in the matrix at left with darker boxes indicating systems that may be the most vulnerable to increasing summer heat in our community.

Adaptation & Resilience Strategies: Hotter Summers

People and Community

Community System at Risk	Anticipated Impacts	Sources
Food Security	>> reduced ag output, rising food prices	21,22,23,25
Human Health & Wellbeing	>> heat related illness, quality of life	8,9,11,12

Natural Systems

Community System at Risk	Anticipated Impacts	Sources
Agriculture/Farming	>> reduced ag output and quality	18, 19, 20
Ecosystem Services	>> loss of biodiversity	6
Forests/Tree Cover	>> loss of heat intolerant tree species	6
Invasive Species	>> shift of invasive plants, insects	6

Economy and Employment

Community System at Risk	Anticipated Impacts	Sources
Employment Continuity	>> reduced productivity, outdoor workers	10, 13, 16

Infrastructure and Basic Services

Community System at Risk	Anticipated Impacts	Sources
Emergency Services/Mgmt	>> increase demand for EMS, urgent care	14
Energy Access & Delivery	>> critical stress on electrical grid	15

Recommendations: Hotter Summers + People and Community

- Convene a climate food resiliency and security stakeholder team for the region; develop a food resiliency plan.
- Develop a community heat action plan strategy >> advocate for adoption into regional heat action plan.

Recommendations: Hotter Summers + Natural Systems

- Identify and foster agricultural climate adaptation best practices (collaboration with ag extension).
- Protect open and natural spaces to serve a reservoir for biodiversity.
- Offer incentives/establish policies to plan tree species on private and public lands that are more heat tolerant.
- Develop invasive species management plans for public lands; encourage private landowners to adopt practices.

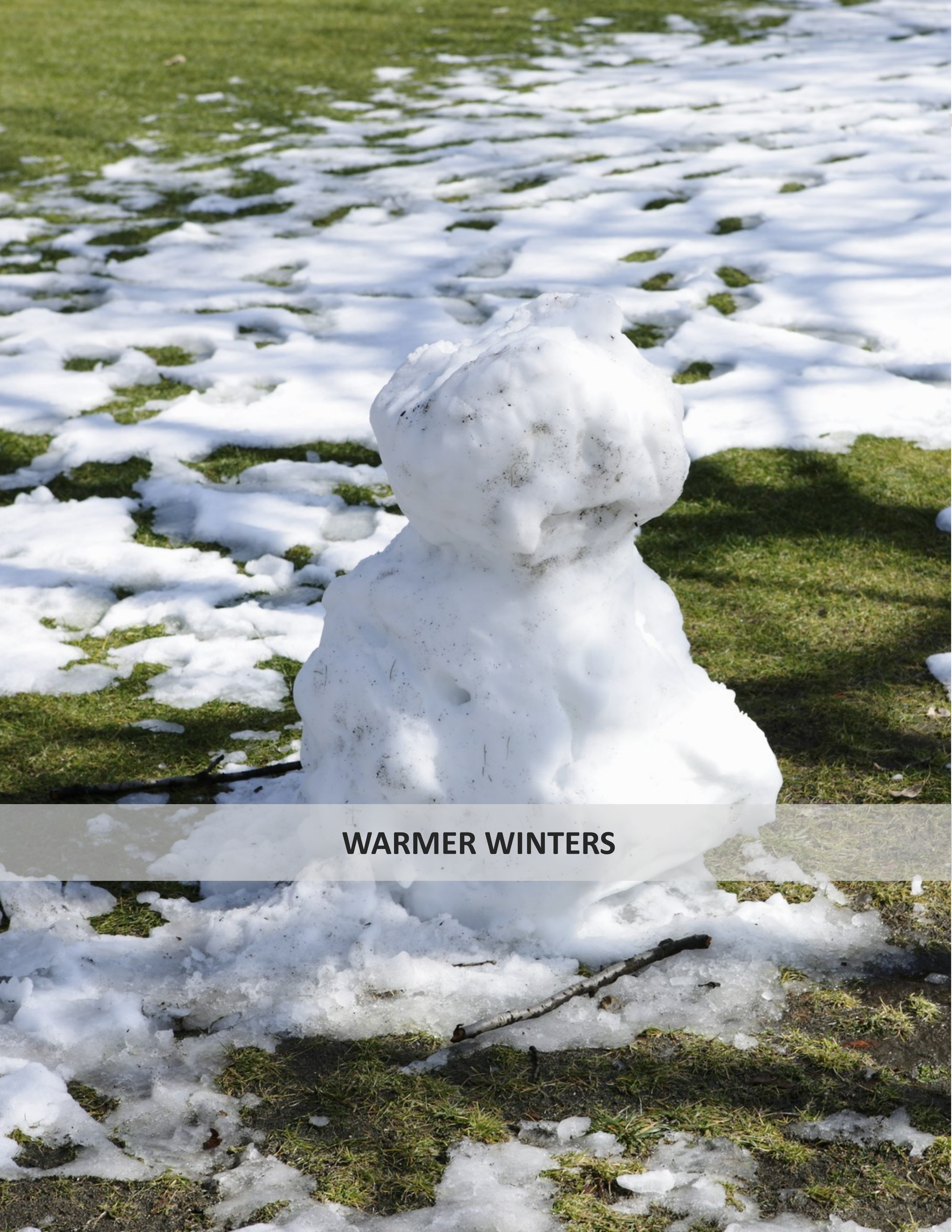
Recommendations: Hotter Summers + Economy & Employment

- Develop a hot weather employment safety and continuity plan (integrate into regional heat action plan)

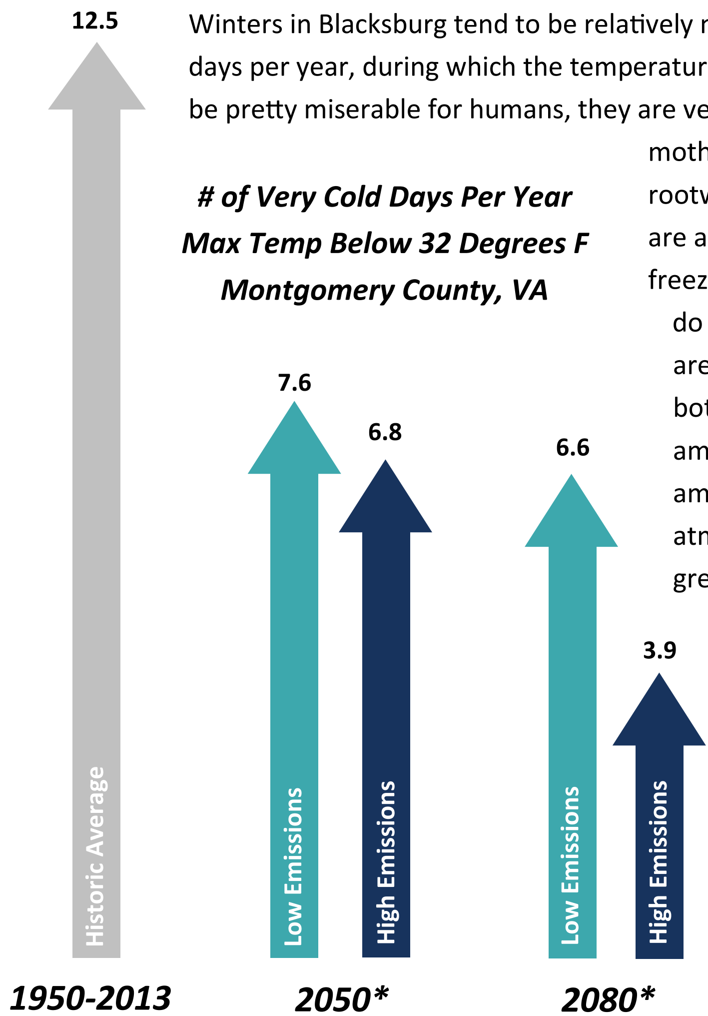
Recommendations: Infrastructure & Basic Services

- Develop a hot weather response plan for EMS and healthcare facilities (integrate into regional heat action plan)
- Provide accessible/cost-effective options for individuals to be safe in their homes and at work from heat illness

WARMER WINTERS



Hazard: Warmer Winters in Blacksburg



Winters in Blacksburg tend to be relatively mild. Traditionally, we have around a dozen deep freeze days per year, during which the temperature never gets above 32 degrees F. Although these days can be pretty miserable for humans, they are very important for the health of farms and forests. Gypsy moths, hemlock woolly adelgids, emerald ash borers, corn rootworm, southern pine beetles, and marmorated stink bugs are all susceptible to very cold temperatures. With fewer deep freeze events, populations of these pest insects may flourish and do major damage to our local forests and farms. By 2050, we are likely to see the number of very cold days cut in half under both the low-emissions and high-emissions scenarios. This amount of climate change appears unavoidable based on the amount of greenhouse gas emissions already in the atmosphere. Nearer to the end of this century, there is greater anticipated divergence between the low– and high-emissions scenarios, and the number of very cold days could fall to less than a third of the historic average. In addition to a reduction in the number of very cold days and deep freeze events, average daily temperatures in the winter months are expected to rise. This may bring about an additional agricultural challenge due to a reduction in "chill hours", periods when the temperature hovers just above freezing. Many fruit-bearing trees require a certain number of chill hours in order to produce fruit the following year.

**30 year averages around each target year for low– and high-emissions scenarios; 2035-2065 and 2065-2095, respectively*

Climate modeling for our area also indicate other measures of winter warming over the next century, with a range of potential impacts to people & community, natural systems, economy & employment, and infrastructure & basic services.

Frontline Communities & Warmer Winters

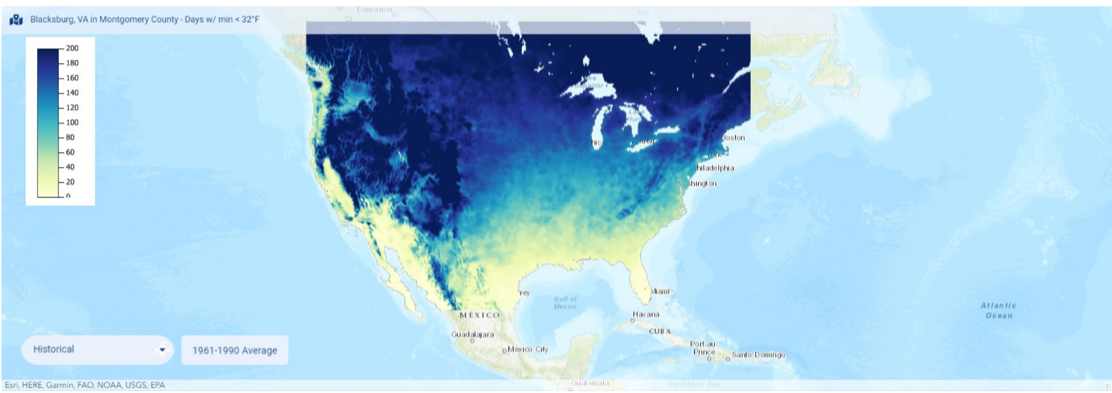
At the local geographic scale, warmer winters may not seem to pose much of a disproportionate risk to frontline communities, in fact, there is likely to be reduced energy cost burden in the winter months, a challenge for many low-income households. At a national geographic scale, however, warmer winters are anticipated to be very disruptive to ecological cycles and agricultural productivity. Warmer winters may also extend the range of disease-carrying insects farther north. As a result, vector-borne diseases and food insecurity may both rise.

- Age factors (very young and very old)
- Complex health challenges
- Mobility, sensory or cognitive impairments
- Limited social connection or support networks
- Limited financial resources
- Working outdoors or in unconditioned spaces
- Inadequate, unstable or unaffordable housing
- Insecure or unaffordable transportation
- Language or cultural barriers

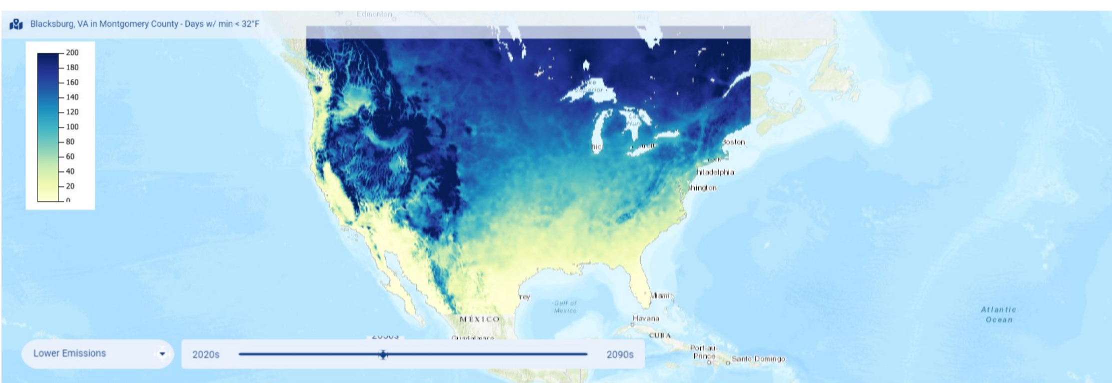
Hazard: Warmer Winters in the United States

In addition to concerns about the affect of warmer winters on farms and forests there are also public health implications to consider, namely that warmer winters across much of the U.S. are likely to expand the territory of human disease vector insects carrying tropical illnesses like malaria, yellow fever, Zika, dengue, and Chagas disease. Of these tropical diseases, dengue is probably the most concerning for Blacksburg and the surrounding region, as the northernmost bound of this virus is just to the south of us and may reach our area by 2085. For tick– and mosquito-borne diseases that are already here such as Lyme disease, Rocky Mountain Spotted Fever, and West Nile Virus, warmer winters will likely increase the number of ticks and mosquitoes that are able to survive the winter and expand the number of months per year when they are active.

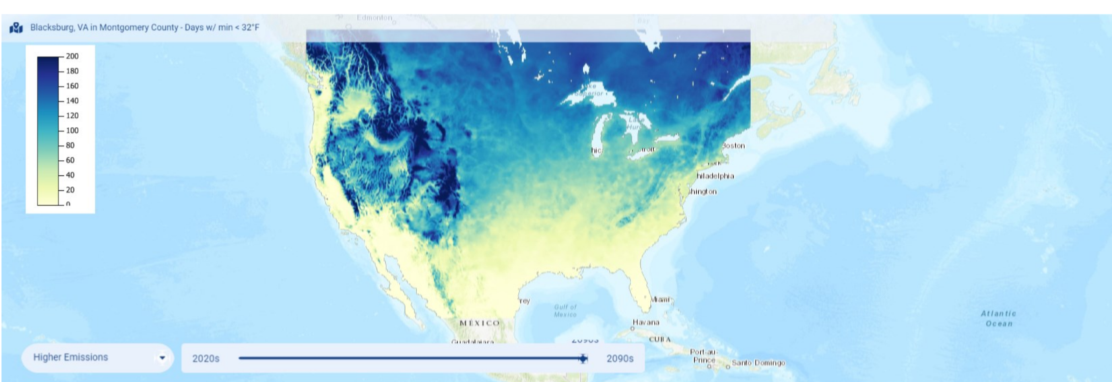
United States: # of Days Per Year with Minimum Temperature Below 32°F



Historical Average 1961-1990



Low-Emissions Scenario 2050s



High-Emissions Scenario 2090s

Climate Metrics: Warmer Winters in Blacksburg & the U.S.

Warmer Winters: Key Climate Metrics & Findings

Of the thirteen climate metrics evaluated, these three point to a mix of vulnerabilities and other outcomes for Blacksburg.

Heating Degree Days (HDDs)

- The number of heating degree days at any location reflects the amount of energy people use to heat a building when it is cool outside. Lower numbers of heating degree days indicate lower demand for energy. Heating degree days measure how much (in degrees), and for how long (in days), outside air temperature is below 65°F. Engineers and utility companies use a location's annual number of heating degree days as one input when estimating demand for energy in the cold season.

Days with Minimum Temperature < 32 degrees (cold days)

- The total number of days per year when the temperature dips below 32°F (0°C) is an indicator of how often cold days occur. A decrease in the number of days temperature drops below freezing promotes earlier spring snowmelt and runoff, with important consequences for managing water resources. Below-freezing temperatures can cause driving hazards, aircraft icing, and damage to infrastructure, yet ski resorts and other winter recreation businesses depend on sufficiently cold days to maintain snowpack. Some plants require a cumulative number of days below freezing before they can begin budding or blooming in the spring.

Days with Maximum Temperature < 32 degrees (very cold days)

- The total number of days per year when the highest temperature is less than 32°F (0°C) is an indicator of how often very cold days occur. Days when the highest temperature doesn't rise above the freezing point of water are called "icing days." The annual number of icing days tells us how much rest plants get from growing. With too few icing days, some plants do not perceive a "reset" signal to begin budding or blooming in the spring. The annual number of icing days can also help predict how populations of pest and disease-vector insects will grow or shrink in response to changing seasonal patterns.

Prioritized Areas of Risk: Warmer Winters

Prioritized Areas of Risk

To identify areas of heightened potential vulnerability, climate metrics for warmer winters were evaluated relative to critical community systems for Blacksburg. In addition to evaluating the direction of anticipated change for these climate metrics, the following factors were explored to evaluate overall risk:

What is the **POTENTIAL IMPACT** of **WARMER WINTERS** on our critical community systems? (low to high)

- Probability, frequency, and intensity of change
- Community systems that could be impacted
- Types and degree of anticipated impact on each community system
- Geographic scope of impact (narrow to broad)
- Demographic scope + equity lens: likelihood of disproportionate impacts on frontline communities

How much **ADAPTIVE CAPACITY** exists to mitigate these anticipated impacts? (high to low)

- Practical or technological feasibility of adaptation measures
- Degree of local control to enact adaptation measures
- Available resources to effectively pursue adaptation measures
- Available resources to effectively pursue adaptation measures

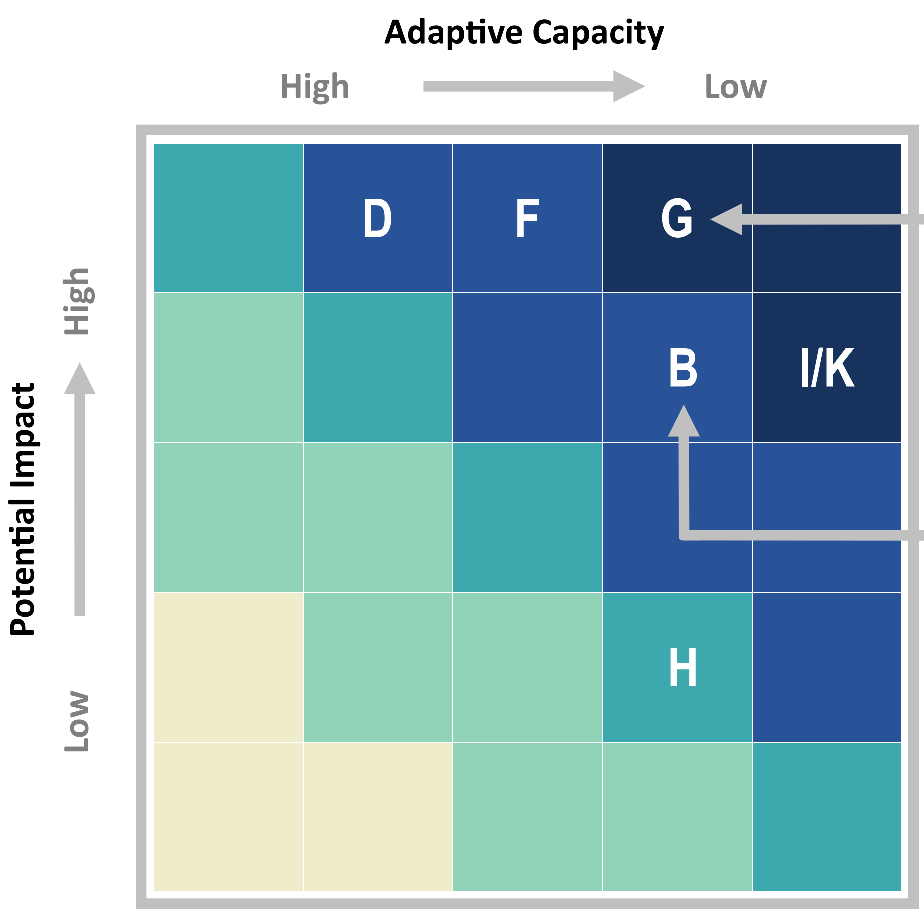
The **COMMUNITY SYSTEMS TABLE** and **RISK PRIORITIZATION MATRIX** on the following page offer a snapshot of the community systems most at risk from warmer winters. At a glance, it is apparent that warmer winters have the greatest potential to disrupt our natural systems with additional worrying impacts to food security and human health. Note that the letters A-W in the risk matrix correspond to the community systems listed in the community systems table above it. The darker squares indicate the systems that may be the most vulnerable to warmer winters in our community and beyond. It is these areas of heightened potential vulnerability that will warrant special attention and focus for climate adaptation policy-making.

As with hotter summers, warmer winters' potential to affect agricultural productivity at the national and international scale is worrying. Similarly, northward spread of disease vector insects, invasive species, and agricultural pests is likely. Local forestlands, with tree species that are accustomed to a certain climatic range may become stressed. All of these risks are very challenging to adapt to at the local level.

The following pages list out some recommended adaptation paths for community systems most at risk from warmer winters. Translating these recommendations into actionable policies and programs will require further collaboration with frontline communities, decision-makers, and other stakeholders to ensure the resulting adaptation and resilience strategies are realistic, effective, and equitable.

Prioritized Areas of Risk: Warmer Winters

Warmer Winters and Critical Community Systems: Potential Areas of Vulnerability			
People & Community	**Natural Systems**	**Economy & Employment**	**Infrastructure & Basic Services**
A. Financial Wellbeing (HH)	G. Agriculture/Farming	L. Business Continuity	P. Emergency Services/Management
B. Food Security	H. Ecosystem Services	M. Employment Continuity	Q. Energy Access & Delivery
C. Homes & Buildings	I. Forests/Tree Cover	N. Industrial Operations	R. Internet & Communications
D. Human Health & Wellbeing	J. Hydrology/Watershed	O. Tourism	S. Law & Order
E. Population Displacement	K. Invasives/Species Shift		T. Stormwater Infrastructure
F. Public Safety			U. Transportation System
			V. Water Supply
			W. Water/Wastewater Infrastructure



Risk Prioritization Matrix

The climate hazard
Warmer Winters
has been evaluated for its potential to impact each of the critical community systems listed above.

The relative degree of risk for each community system is shown in the matrix at left with darker boxes indicating systems that may be the most vulnerable to warming winters here in Blacksburg, but also at the national scale.

Anticipated Impacts: Warmer Winters in Blacksburg

People and Community

Community System at Risk	Anticipated Impacts	Sources
Food Security	>> reduced ag output, rising food prices	28, 29
Human Health & Wellbeing	>> increased risk of disease vector insects	27, 30-41
Public Health	>> introduction of novel diseases	35, 37

Natural Systems

Community System at Risk	Anticipated Impacts	Sources
Agriculture/Farming	>> reduced ag output and quality	29,30
Forests & Tree Cover	>> loss of trees intolerant to warmer winters	27
Invasives/Species Shift	>> geographic shift of invasive plants/insects	27

Economy and Employment

Limited Adverse Impact

Infrastructure and Basic Services

Limited Adverse Impact

Adaptation & Resilience Strategies: Warmer Winters in Blacksburg

Recommendations: Warmer Winters + People and Community
• Convene a climate food resiliency and security stakeholder team for the region; develop a food resiliency plan.
• Engage the public on behaviors and best practices to reduce residents' exposure to insect borne diseases.
• Develop an action plan to mitigate insect-borne disease; special focus on outdoor workers and vulnerable groups.

Recommendations: Warmer Winters + People and Community
• Identify and promote agricultural climate adaptation best practices
• Offer incentives/establish polices to plant tree species on private and public lands that are suited to warmer temps
• Develop invasive species management plans for public lands; encourage private landowners to adopt practices.

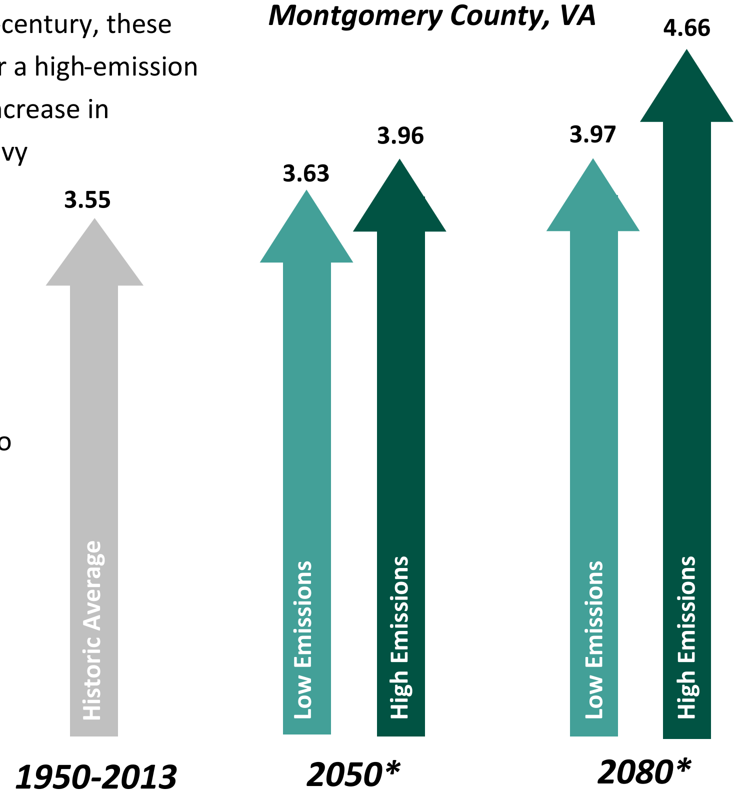
CHANGING PRECIPITATION PATTERNS

Hazard: Increased Precipitation in Blacksburg

Blacksburg typically gets between 38-39” of rain per year. While many parts of the country are anticipated to experience reduced precipitation and even severe drought conditions due to climate change, it appears that precipitation will be increasing in Blacksburg, particularly in the winter months. Climate modeling also indicates that we are likely to have a modest increase in the annual number of heavy rain events. Under both the low– and high-emissions scenarios by mid-century, these changes are likely to be nearly imperceptible. Under a high-emission scenario, however, we may see as much as a 31% increase in heavy rainfall events by the end of the century. Heavy rainfall events always have the potential to create flooding risks, putting people in harms way, and increasing the likelihood of costly damage to buildings and infrastructure.

While more overall precipitation is anticipated for the region, we are also (paradoxically) anticipated to have a slight increase in the number of dry days. Longer dry periods between rains, particularly heavier ones, can actually raise the risk of destructive flooding and even forest fires. Overall, there is a lot of uncertainty about how local ecosystems and the built environment could be impacted by changing precipitation patterns.

# of Days Per Year
Precipitation > 1 inch
Montgomery County, VA



**30 year averages around each target year for low– and high-emissions scenarios; 2035-2065 and 2065-2095, respectively*

Climate modeling for our area also indicate other measures of changing precipitation patterns over the next century, with a range of potential impacts to people & community, natural systems, economy & employment, and infrastructure & basic services.

Frontline Communities & Precipitation Patterns

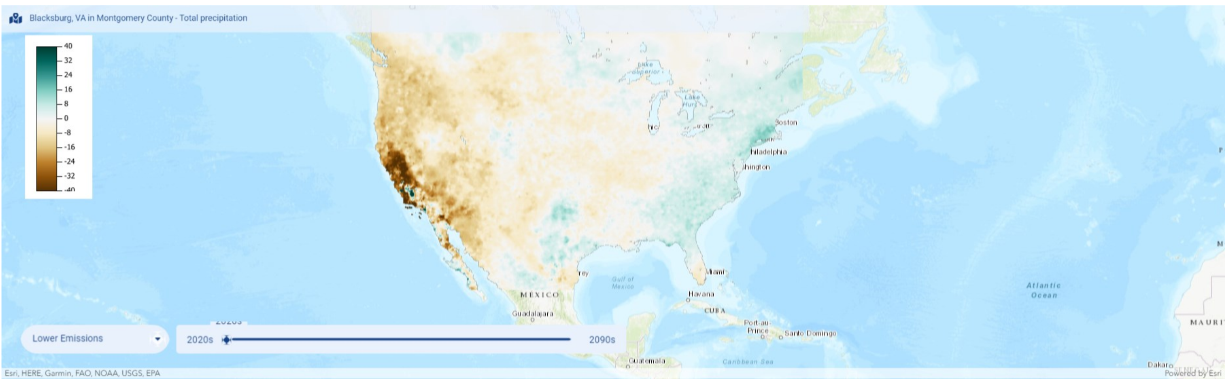
At the local geographic scale, total precipitation is anticipated to increase which may pose a disproportionate risk to frontline communities, who are statistically more likely to live in flood-prone areas. At a national geographic scale, widespread hydrological changes are anticipated. Some areas will see a substantial increase in annual precipitation while others will encounter drier conditions. Both are anticipated to be very disruptive to ecological cycles and agricultural productivity. As a result, vector-borne diseases and food insecurity may both rise.

- Age factors (very young and very old)
- Complex health challenges
- Mobility, sensory or cognitive impairments
- Limited social connection or support networks
- Limited financial resources
- Working outdoors or in unconditioned spaces
- Inadequate, unstable or unaffordable housing
- Insecure or unaffordable transportation
- Language or cultural barriers

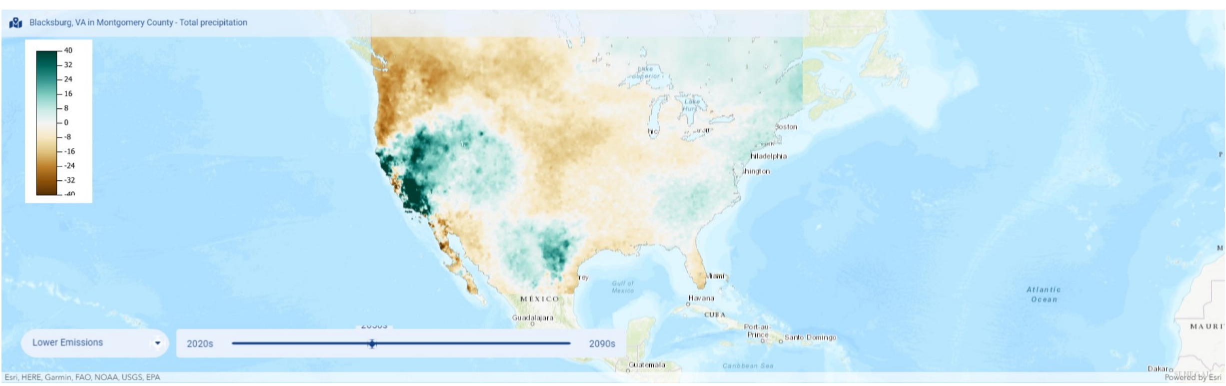
Areas of Vulnerability: Increased Precipitation in Blacksburg

At the national scale, there is great variability in what the climate models are telling us about precipitation patterns. Some areas may experience extended, severe drought while others will see a great deal more precipitation. These changes at the national scale have the potential to disrupt and destabilize food production, create widespread ecological disruption and loss of biodiversity, and could even contribute to population displacement due to repeated flooding, wildfires, and insufficient water supply.

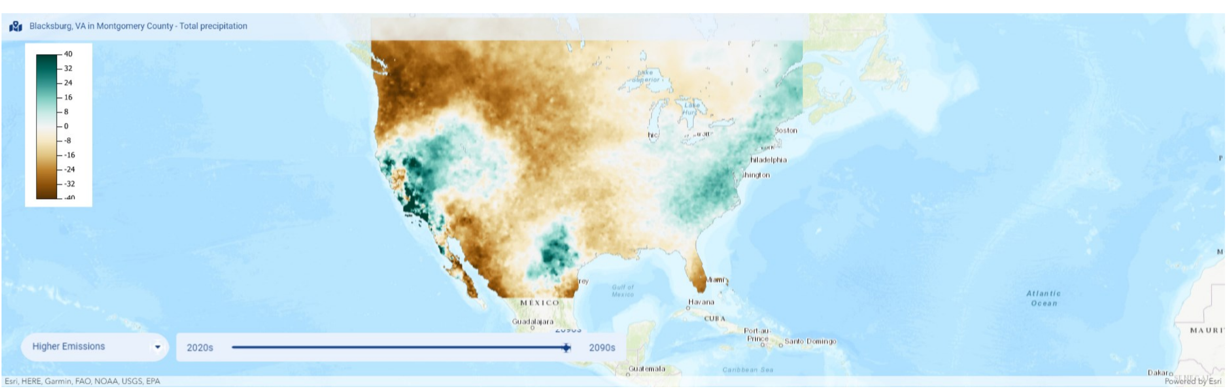
United States: Total Summer Precipitation



Low-Emissions Scenario 2020s



Low-Emissions Scenario 2050s



High-Emissions Scenario 2090s

Climate Metrics: Changing Precipitation Patterns in Blacksburg & the U.S.

Changing Precipitation Patterns Key Climate Metrics & Findings

Of the thirteen climate metrics evaluated, these three point to a mix of vulnerabilities and other outcomes for Blacksburg.

Total Annual Precipitation (indicator of changes to local and national hydrological cycle)

- At the local level, total annual precipitation is anticipated to increase around 5-6% by midcentury under both the low– and high-emission scenarios. Closer to the end of the century, there is more divergence between the low– and high-emissions scenarios, with an expected 7% and 10% average annual increase expected, respectively. At the national level, some areas are expected to receive more precipitation while others will be getting drier. All of these changes are anticipated to have wide ranging effects that could directly and indirectly impact Blacksburg.

Total Monthly Precipitation (indicator of changes in seasonal precipitation)

- In Blacksburg, the largest increase in precipitation relative to the historic average is expected for winter months by end of century under a high-emission scenario (15%), followed by spring (12%), summer (7%), and fall (3%). The unpredictability of the type of winter precipitation is a challenging factor to plan around. Snow and ice can increase road hazards and contribute to widespread disruption to the community. All types of increased precipitation have the potential to overwhelm stormwater infrastructure, particular in areas that are already at or near system capacity.

Days with > 1" precipitation (indicator of potential flooding events)

- The number of days per year when locations receive more than 1 inch of precipitation is an indicator of how often very heavy precipitation events occur. This measurement may also be used as an indicator of flood risk. Comparing the number of days with heavy precipitation at a single location over time can reveal a trend of increasing or decreasing flood risk.

Dry Days, days with <.01" precipitation

- The number of dry days per year—days when precipitation is less than 0.01 inches—gives a sense of the portion of the year when no moisture is being added to the environment. Changes in the number of dry days can indicate a tendency toward drier or wetter conditions. Paradoxically, while it appears that Blacksburg will see an increase in total precipitation, the # of dry days per year is also expected to increase slightly under a high emissions scenario, which may mean that we can expect precipitation events to become more intense. Additionally, when the ground is drier, these higher intensity precipitation events can be more damaging, with a higher risk of flash floods, erosion, mudslides, and sedimentation of local waterways.

Prioritized Areas of Risk: Changing Precipitation Patterns

Prioritized Areas of Risk

To identify areas of heightened potential vulnerability, climate metrics for warmer winters were evaluated relative to critical community systems for Blacksburg. In addition to evaluating the direction of anticipated change for these climate metrics, the following factors were explored to evaluate overall risk:

What is the **POTENTIAL IMPACT** of **CHANGING PRECIPITATION PATTERNS** on our critical community systems? (low to high)

- Probability, frequency, and intensity of change
- Community systems that could be impacted
- Types and degree of anticipated impact on each community system
- Geographic scope of impact (narrow to broad)
- Demographic scope + equity lens: likelihood of disproportionate impacts on frontline communities

How much **ADAPTIVE CAPACITY** exists to mitigate these anticipated impacts? (high to low)

- Practical or technological feasibility of adaptation measures
- Degree of local control to enact adaptation measures
- Available resources to effectively pursue adaptation measures
- Available resources to effectively pursue adaptation measures

The **COMMUNITY SYSTEMS TABLE** and **RISK PRIORITIZATION MATRIX** on the following page offer a snapshot of the community systems most at risk from changing precipitation patterns. At a glance, it is apparent that changing precipitation patterns have the greatest potential to disrupt our natural systems with additional worrying impacts to food security and an elevated risk to buildings, infrastructure, and public safety from flooding. Note that the letters A-W in the risk matrix correspond to the community systems listed in the community systems table above it. The darker squares indicate the systems that may be the most vulnerable to warmer winters in our community and beyond. It is these areas of heightened potential vulnerability that will warrant special attention and focus for climate adaptation policy-making.

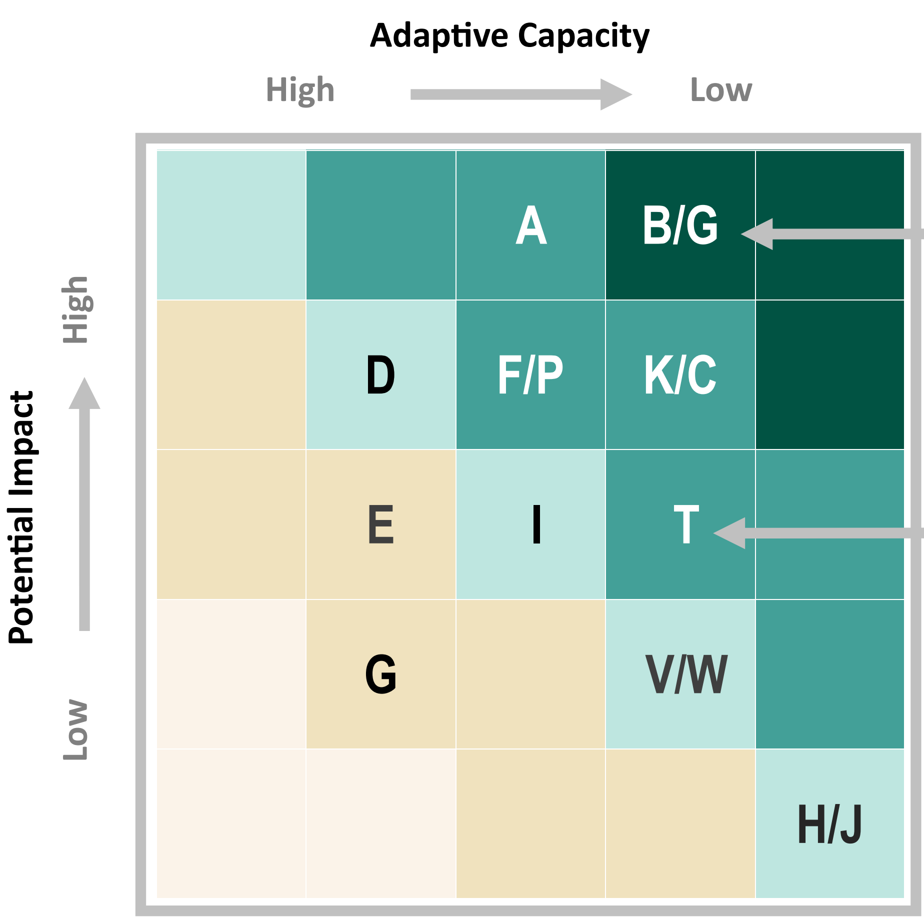
As with hotter summers and warmer winters, changing precipitation patterns have the potential to affect agricultural productivity at the national and international scale. Local biological communities and forestlands, with tree species that are accustomed to a certain range of hydrological conditions may become stressed. All of these risks are very challenging to adapt to at the local level.

The following pages list out some recommended adaptation paths for community systems most at risk from changing precipitation patterns. Translating these recommendations into actionable policies and programs will require further collaboration with frontline communities, decision-makers, and other stakeholders to ensure the resulting adaptation and resilience strategies are realistic, effective, and equitable.

Prioritized Areas of Risk: Changing Precipitation Patterns

Changing Precipitation and Critical Community Systems: Potential Areas of Vulnerability

People & Community	Natural Systems	Economy & Employment	Infrastructure & Basic Services
A. Financial Wellbeing (HH)	G. Agriculture/Farming	L. Business Continuity	P. Emergency Services/Management
B. Food Security	H. Ecosystem Services	M. Employment Continuity	Q. Energy Access & Delivery
C. Homes & Buildings	I. Forests/Tree Cover	N. Industrial Operations	R. Internet & Communications
D. Human Health & Wellbeing	J. Hydrology/Watershed	O. Tourism	S. Law & Order
E. Population Displacement	K. Invasives/Species Shift		T. Stormwater Infrastructure
F. Public Safety			U. Transportation System
			V. Water Supply
			W. Water/Wastewater Infrastructure



Risk Prioritization Matrix

The climate hazard ***Changing Precipitation*** has been evaluated for its potential to impact each of the critical community systems listed above.

The relative degree of risk for each community system is shown in the matrix at left with darker boxes indicating systems that may be the most vulnerable to changing precipitation patterns here in Blacksburg, but also at the national scale.

Anticipated Impacts: Changing Precipitation Patterns

People and Community

Community System at Risk	Anticipated Impacts	Sources
Financial Wellbeing (HH)	>> loss of property value, property damage	44, 51, 58
Food Security	>> reduced ag output, rising food prices	55, 57
Homes & Buildings	>> flood damage	43, 44
Public Safety	>> flash flooding	51

Natural Systems

Community System at Risk	Anticipated Impacts	Sources
Agriculture/Farming	>> reduced predictability of rainfall	54, 56
Invasive/Species Shift	>> geographic shift of invasive plants/insects	45, 46, 52

Economy and Employment

Limited Anticipated Impact

Infrastructure and Basic Services

Community System at Risk	Anticipated Impacts	Sources
Emergency Services/Mgmt	>> increased demand for EMS	51
Stormwater Infrastructure	>> stress on stormwater facilities	53

Adaptation & Resilience Strategies: Changing Precipitation Patterns

Recommendations: Changing Precipitation Patterns + People and Community
• Offer incentives for land and property owners to reduce flood risk for existing structures
• Convene a climate food resiliency and security stakeholder team for the region; develop a food resiliency plan.
• Expand land use policies and green/gray infrastructure to reduce flood risk for existing and future buildings
• Expand gray and green stormwater infrastructure in areas prone to flash flooding; public engagement on risk.

Recommendations: Changing Precipitation Patterns + People and Community
• Identify and promote agricultural climate adaptation best practices
• Develop invasive species management plans for public lands; encourage private landowners to adopt practices.

Recommendations: Changing Precipitation Patterns + People and Community
• Expand capacity of local EMS to respond to swift water and flash flood emergencies; public engagement on risk
• Expand gray and green stormwater infrastructure in areas prone to repeated or flash flooding

SOURCES, ACKNOWLEDGEMENTS, & NEXT STEPS

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Advisory Team Member	Area(s) of Expertise and Practice
Dr. Jacob Barney	***Invasive plants; habitat-level response to novel climate scenarios***
Dr. Jeb Barrett	***Climate trends and ecological processes: soils, hydrology, biodiversity***
Dr. Daniel Breslau	***Energy systems and society; energy transition***
Dr. Anamaria Bukvic	***Climate change adaptation, vulnerability and relocation***
Dr. Jonathan Czuba	***Surface water hydrology under extreme weather conditions***
Dr. Zachary Easton	***Land use and climate change impacts on water quality and quantity***
Dr. Andrew Ellis	***Climate modeling; hydroclimatic variability and change***
Christy Gabbard	***Food system resiliency***
Dr. Julia Gohlke	***Heat stress and public health, health outcomes and landscape change***
Maeve Gould	***Transportation & land use planning; comprehensive planning***
Kafi Howard	***Storm water engineering, water quality***
Dr. Vivica Kraak	***Food systems; nutrition and food policy***
Tianjun Lu	***Climate modeling and impacts for urbanized areas***
Dr. Todd Schenk	***Climate adaptation planning; infrastructure, community engagement***
Dr. Julie Shortridge	***Water systems and security in a changing climate***
Dr. Peter Sforza	***Mapping climate: heat stress, extreme temperatures, flooding***
Matt Stolte	***Civil engineering, infrastructure asset management***
Christy Straight	***Regional hazard mitigation planning***
Dr. Quinn Thomas	***Climate change and forest dynamics, ecosystem modeling***
Michael Walker	***Waste water infrastructure and operations***
Carol Davis	***Advisory group convener; Sustainability Manager, Town of Blacksburg***

Next Steps

Communities like Blacksburg will be well served by taking an honest look at the climate vulnerabilities they will be facing in the coming years and decades. Decisions we make now around infrastructure, land use, transportation investments, buildings, and public health can prepare us, not just to survive in a changing climate, but to thrive.

Blacksburg's Climate Vulnerability Assessment has revealed a handful of community systems that are most at risk in a changing climate, as highlighted in the chart below:

People and Community	Natural Systems	Economy and Employment	Infrastructure and Basic Services
Financial Wellbeing	Agriculture/Farming	Business Continuity	Emergency Services
Food Systems/Security	Ecosystem Services	Employment Continuity	Energy Access/Delivery
Homes & Buildings	Forests/Tree Cover	Industrial Operations	Internet/Communications
Human Health/Wellbeing	Hydrology/Watershed	Tourism	Law & Order
Population Displacement	Invasives/Species Shift		Stormwater Infrastructure
Public Safety			Transportation System
			Water Supply
			Water Infrastructure

Going forward, the Town intends to convene expert and equity-centered policy development teams to investigate our best strategy options for adaptation and future resilience. The four policy teams will focus on the following themes: **Food Resiliency & Security**, **Human Health & Wellbeing**, **Biodiversity & Ecosystems**, and **Infrastructure and Basic Services**.

The public is invited to share their ideas and priorities and submit questions as we investigate the range of potential adaptation strategies.

Next Steps

Feedback and Engagement Process

This report was developed to identify and prioritize the climate hazards that Blacksburg will be facing in the coming decades, the community systems that may be most at risk, and to put forth a set of broad policy recommendations to be considered. Translating those recommendations into actionable policies and programs will require collaborative and creative partnerships with the whole community.

If you have questions or feedback for the Climate Vulnerability Assessment Advisory Team or the Town, you can provide comments directly at **Let's Talk Blacksburg: Climate Vulnerability**. There you will find a separate tab for each of the four policy teams: Food Resiliency & Security, Human Health & Wellbeing, Biodiversity & Ecosystems, and Infrastructure & Basic Services.

You can also send questions or comments directly to the Sustainability Office: **sustainability@blacksburg.gov**