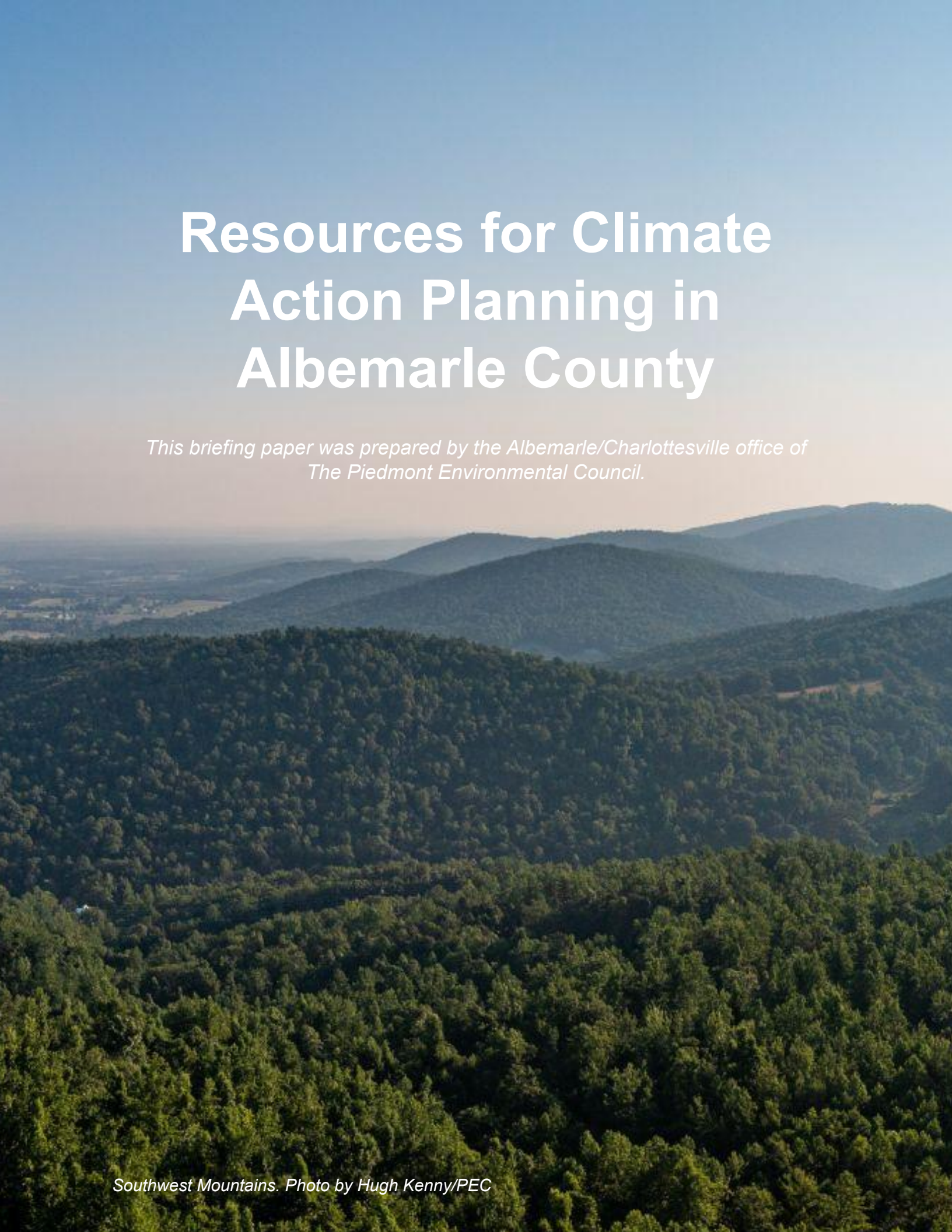
Resources for Climate Action Planning in Albemarle County

This briefing paper was prepared by the Albemarle/Charlottesville office of The Piedmont Environmental Council.



Southwest Mountains. Photo by Hugh Kenny/PEC

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Acknowledgements

This climate action planning brief was prepared for The Piedmont Environmental Council Albemarle County board and represents insights provided by a variety of resource specialists. PEC would like to thank the following individuals and organizations for their contributions: Rod Walker and Jim Hurley, Blue Ridge PRISM; Brian Morse, McChesney Goodall and Leif Riddervold, Virginia Wildlife and Forestry Group; David Powell, Karl Didier and Amanda Scheps, Virginia Department of Forestry; Bill Kittrell, Nature Conservancy; and Marcia Geyer, co-chair of the climate advocacy group CVille 100.

Additionally, many Piedmont Environmental Council staff were instrumental in the research, preparation, writing and editing of this document: Senior Conservation Fellow Kat Imhoff, Field Representatives Rex Linville, Peter Krebs, Christopher Hawk, Peter Hujik, and Adam Gillenwater, Senior Advisor and Director of Strategic Partnerships John McCarthy, Communications Advisor Cindy Sabato, and climate interns Henry Cohen and Joshua Press-Williams.

We acknowledge that the various contributors to this paper are not climate scientists, but a collection of land use planners and natural systems specialists who seek to build a shared understanding of climate change and its impact at the local level. With that understanding, we hope to provide a springboard for conversations about positive local action.

Introduction

The Piedmont Environmental Council was formed in 1972 with a mission to promote and protect the natural resources, rural economy, history and beauty of the Virginia Piedmont. In the simplest of terms, we accomplish that mission, in collaboration with landowners, residents, and local leaders of our nine-county region, through conservation of land, restoration of wildlife habitat, and advocacy for best land management practices and smart land use and land planning decisions. By its very nature, our work has increased resilience to environmental change and has yielded important climate mitigation and adaptation strategies and outcomes since our founding a half century ago. As we look back and celebrate our achievements to date, we must also look forward at the next 50 years and rise to the challenge ahead.

Climate mitigation—efforts to reduce the impacts and emissions of greenhouse gases responsible for changing climate conditions—is important and morally imperative work. PEC's promotion of multi-modal transportation, walkable towns, distributed renewable energy production, and carbon sequestration through conservation open spaces, are just a few mitigation strategies that support a global effort to reduce greenhouse gas emissions. However, because the effects of climate mitigation are felt on a local level, the focus of this paper is climate *adaptation.*

Climate adaptation is the making of local-level adjustments to reduce the negative effects of changing climate conditions on our way of life, regardless of their causes. Climate adaptation is critically important to preserving public health and safety, ensuring the security of a clean and abundant water supply, and protecting the built environment, food supply, and environmental benefits of forested lands and open spaces. Adaptation strategies include increasing green infrastructure to help insulate residents from heat, planning for a higher frequency of more severe storms in disaster response plans or increasing the robustness of natural ecosystems.

Though the effects of greenhouse gas emissions and the resultant warming temperatures are often framed at a global level, we are beginning to see a startling picture of our future at the local level. For example, Albemarle County is already seeing more days above 95°F and more severe storms.

Average warming within this century is now expected to be between 4.7°F and 7.4°F, with a less than 5% chance that temperature rise will remain under 3.6°F and an almost 20% chance that temperatures will rise more than 8.1°F.[1] Even the global 2.7°F (1.5°C) warming mark that climate scientists hoped temperatures would level at by 2050 could now be realized within the next five years, according to a recent report by the World Meteorological Organization.[2] If these predictions prove true, Virginia's climate would resemble that of north Florida by the end of the

[1] Sherwood et al., "An Assessment of Earth's Climate Sensitivity Using Multiple Lines of Evidence."
[2] WMO, "WMO Global Annual to Decadal Climate Update for 2020–2024 - World."

century; a “business as usual track” could even complete that process in half the time.[3] These effects will cause significant disruption to the natural ecosystems in Virginia and will likely change more quickly than our natural forests and ecosystems are able to keep up with. Effects of this nature would be disastrous for Virginia, but the effects of a changing climate are not distributed evenly. The effects of climate disasters like hurricanes, flooding and health issues are disproportionately felt by our most vulnerable—often non-white or low-income—communities due to systemic neglect and environmental inequity. With this knowledge, climate adaptation efforts must include a focus on increasing equity and ensuring that historically excluded members of the community are fairly included in decision-making processes and planning.

As climate conditions continue to rapidly change, the people of Albemarle County and the entire Virginia Piedmont are at a crucial moment to respond and adapt in ways that will continue to protect the history and beauty, as well as the people, of this region. The destructive effects of changing climate conditions, such as flooding, drought, and invasive species, are not bound by jurisdictions; uncoordinated efforts at adaptation will leave our ecosystems and communities at risk. The Piedmont needs a combined and unified program of climate action. The goal of this climate action planning paper is to provide context for climate change in Albemarle County, as well as to establish a common vocabulary and highlight specific strategic areas, such as forest and farms, with potential to inspire successful adaptation strategies.

> ***“Climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes.”***
>
> ***-IPCC Sixth Assessment Report, 2021[4]***

[3] Nash, *Virginia Climate Fever: How Global Warming Will Transform Our Cities, Shorelines, and Forests*.
[4] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis.

Why Climate Change Matters Here

Climate action planning at any level must start with *community will* and individuals and leaders who understand the gravity of our current situation. In the past, PEC has successfully built grassroots support for land conservation and smart land use planning. Now, we have an urgent and growing need, as well as opportunity, to build community-level understanding about how climate change will directly affect the farms, forests, water bodies and everyday lives of people in the Piedmont. Albemarle County, the City of Charlottesville and the University of Virginia each have a unique opportunity to rise to the challenge.

Recognizing the need for collaboration, the two localities and the university joined together in 2009 to develop strategies to reduce their emissions through the Local Climate Action Planning Process (LCAPP). Built with community input and staff recommendations, these strategies were intended to guide the Charlottesville City Council, Albemarle County Board of Supervisors, and UVA's Corporate Board.[5] Building on this earlier sustainability effort, all three organizations made a new commitment to climate action in 2019 by setting emissions reduction goals and beginning to develop separate climate action plans. Albemarle County published its Climate Action Plan - Phase 1[6] in winter 2020; its stated goal is to "reduce the community's contributions to global climate change while advancing the [c]ounty's vision of a thriving, vibrant community for every resident."[7] Albemarle County will begin its comprehensive plan update in late 2021, and climate mitigation and adaptation will be addressed in the document. Charlottesville is developing a climate action plan which is planned to be completed in late 2021. Charlottesville's comprehensive plan update will conclude in mid or late 2021 and has included a commitment to environmental and climate leadership. UVA committed to becoming carbon neutral by 2030 and fossil fuel free by 2050. In October 2020, UVA was able to launch a sustainability plan for 2020-2030 that would help it achieve these goals.

Current Planning Status	**Timetable**
Albemarle County	2020: Adopted a climate action plan. 2021: Working to create a climate vulnerability and risk assessment.
City of Charlottesville	2021: Working to create a climate action plan.
University of Virginia	2020: Completed a sustainability plan.

[5] "Climate Action Planning Info."
[6] Albemarle County Climate Action Plan
[7] "Climate Action Plan Draft."

Albemarle County: Demographic Overview[8]

All statistics are from the 2019 census.

Category	Albemarle County	City of Charlottesville
Population	• 109,330; • 10.4% growth since 2010 • Avg. growth: 1% per year	• 47,266 • 8.8% growth since 2010 • Avg. 0.9% per year
Demographic	• 81% White • 9% Black or African American • 5% Asian • 5% Hispanic	• 71% White • 18% Black or African American • 7% Asian • 6% Hispanic
Education Level	• 91% high school diploma or higher • 53% bachelor's degree or higher	• 91% high school diploma or higher • 55% bachelor's degree or higher
Average Commute Time	• 22 minutes	• 17 minutes
Median Household Income	• $75,394 • 9% below the federal poverty line	• $59,471 • 22.1% below the federal poverty line
Size	• 720 square miles	• 10 square miles
Population Density	• 137 people per square mile	• 4,426 people per square mile

[8] "U.S. Census Bureau QuickFacts."

Albemarle County: Climate Overview

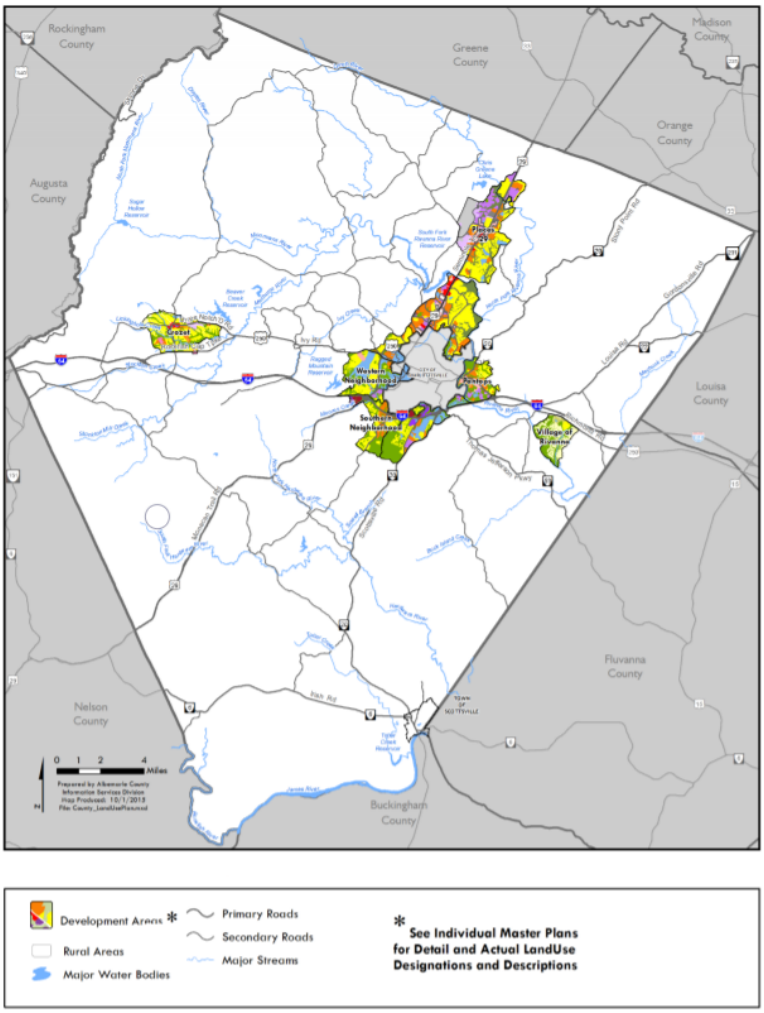

Figure 1: Albemarle County Development Areas (2015 Comprehensive Plan)

While national and global models are fundamental to climate research, they can leave a typical resident of the Piedmont unaware of what a disrupted climate looks like in their own community. To combat the tendency for climate change to appear both temporally and geographically distant, this section provides a brief list of statistics, models, and recent events specific to Albemarle County and Virginia.

PAST

The National Oceanic and Atmospheric Administration (NOAA) has collected county-level precipitation (Figure 2) and temperature (Figures 3 and 4) data dating back to 1895. The graphs and information below summarize the changes from 1920 to 2020 to encapsulate the last century of temperature and precipitation. While the local trendline is less dramatic than national

or international averages, it illustrates that Albemarle County is not immune to changing climate conditions.

Key Climate Data Points:

- In Albemarle County, the average annual temperature has increased an average of 0.2°F per decade from 1920 to 2020. Importantly though, this rate of advance has sped up drastically. From 1980 to 2020, the average annual temperature has increased by 0.6°F per decade in Albemarle County. Each year from 2014 to 2020, the average yearly temperature has stayed well above the mean of average yearly temperatures from 1980 to 2020. These findings show the rapid warming that has occurred at the end of the 20th century and beginning of the 21st century.[9] While temperatures all over Virginia are increasing, the steepest warming trend during this period has occurred in the Southern Piedmont climate zone where Albemarle County sits.

- Precipitation in Albemarle County has increased by an average of 0.54 inches per decade from 1920 to 2020. Analyzing the recent period of 1980 to 2020 shows similar trends to temperature, with rapidly increasing changes in precipitation at an average of 1.42 inches per decade.

- The numbers can be abstract, but these changes impact everyday life in tangible ways. For example, the mosquito season in central Virginia is increasing in length due to the changes in temperature. Since 2006, mosquito season in central Virginia has lasted an annual average of 131 days, compared to an average of 109 days between 1980 and 1989.[10] Mosquitos are a public health issue because of the diseases they spread and are an annoyance for those who work or recreate outside. Changes in precipitation have similar everyday effects. In the last 60 years, Virginia has seen a 33% increase in heavy snowstorms and rainstorms, and the largest storms have brought 11% more precipitation.[11] An increase in storms and precipitation can cause flooding and overwhelm stormwater infrastructure creating problems for Albemarle County residents.

[9] Nash, *Virginia Climate Fever: How Global Warming Will Transform Our Cities, Shorelines, and Forests*.
[10] "This News Bites."
[11] Madsen and Willcox, "When It Rains, It Pours."

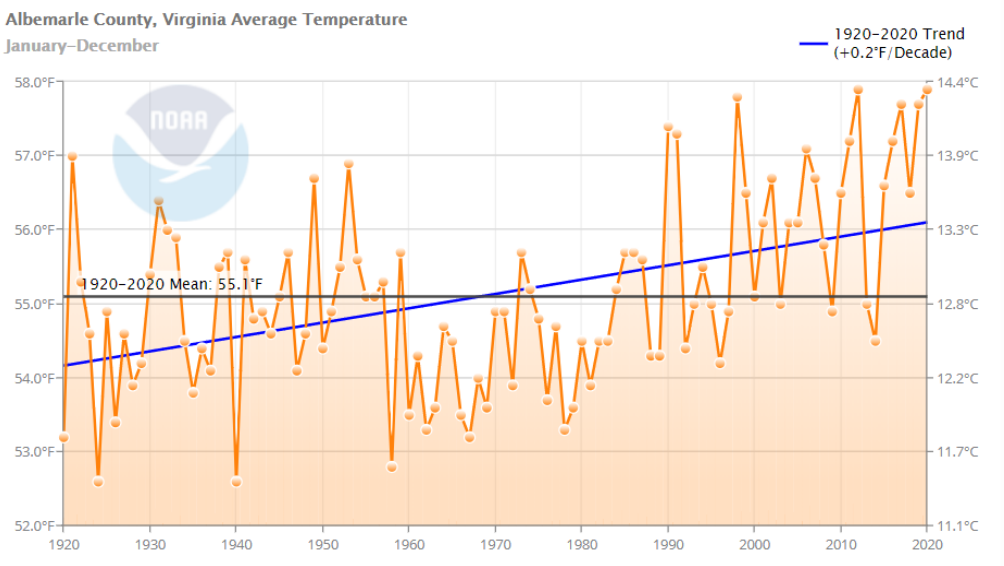

Figure 2: Albemarle County Average Annual Temperature 1920 – 2020[12]

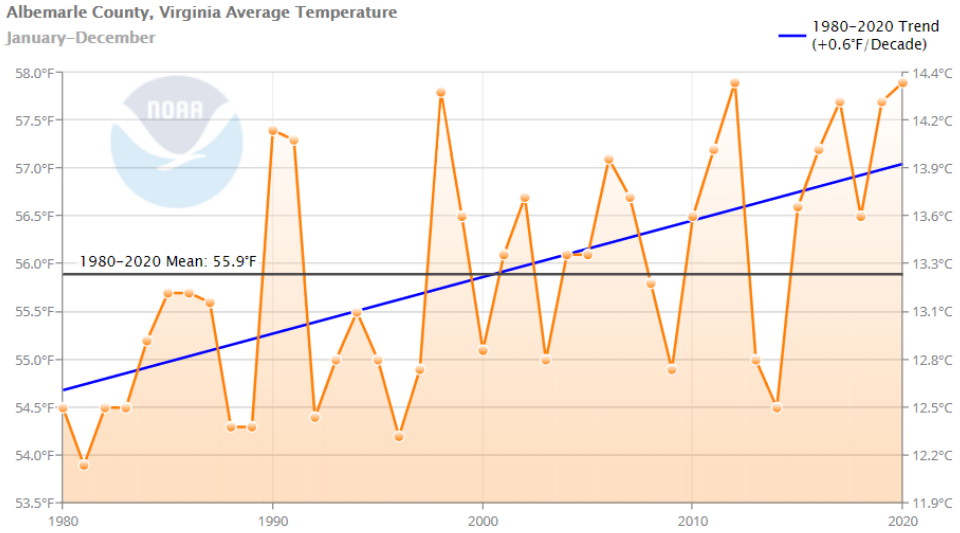

Figure 3: Albemarle County Average Annual Temperature 1980 – 2020[13]

[12] "Climate at a Glance | National Centers for Environmental Information (NCEI)."
[13] "Climate at a Glance | National Centers for Environmental Information (NCEI)."

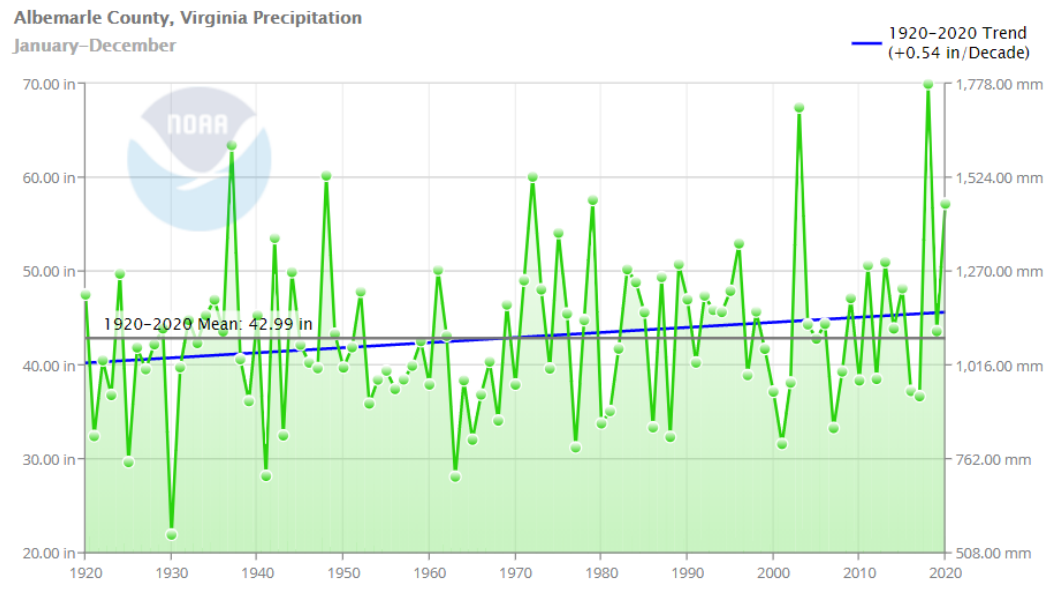

Figure 4: Albemarle County Average Annual Precipitation 1920 – 2020[14]

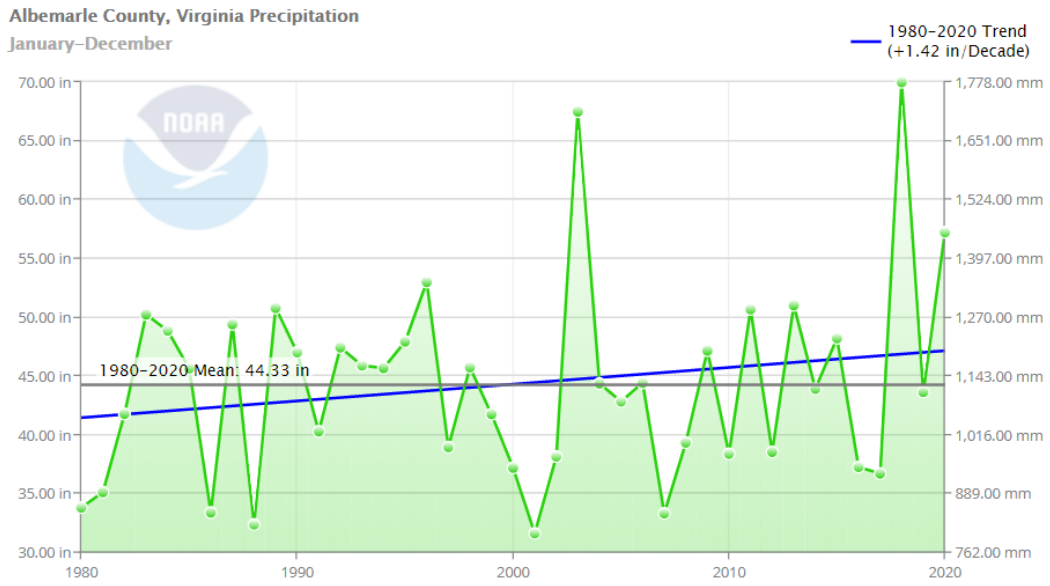

Figure 5: Albemarle County Average Annual Precipitation 1980 – 2020[15]

[14] "Climate at a Glance | National Centers for Environmental Information (NCEI)."
[15] "Climate at a Glance | National Centers for Environmental Information (NCEI)."

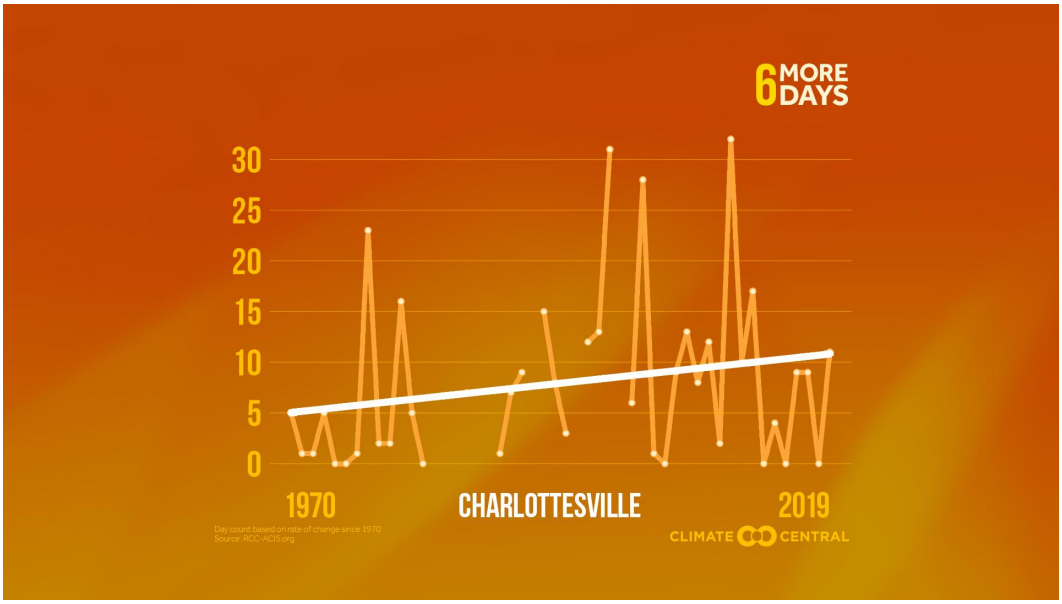

Figure 6: Days Above 95º in Charlottesville[16]

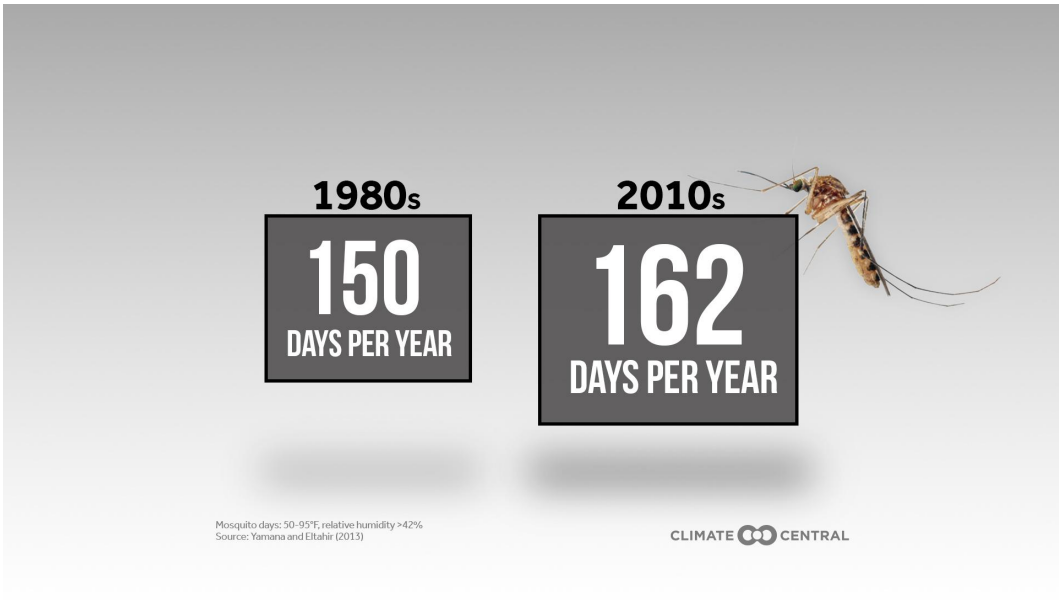

Figure 7: Change in mosquito season for Charlottesville[17]

PRESENT

Recent droughts, floods and extreme weather events cannot stand alone as evidence of a

[16] "2020 More Extreme Heat."
[17] "This News Bites."

changing climate, but they are important reminders that Albemarle County is already experiencing the effects of a drastically disrupted climate over time.

Climate Data Points:

- Charlottesville experienced an average of six (6) more days of temperatures above 95ºF in 2019 than in 1970.[18]

- Most of Virginia has warmed 1ºF in the last century[19]

- The amount of precipitation during heavy storms has increased 27% between 1958 and 2012 in Virginia.[20]

FUTURE
Local-level climate modeling is by nature more variable and circumstantial than at a global scale. It is not an *exact* prediction of what our environment will be like when stepping out of our homes 50 years from now. However, these models do provide a reasonable picture of the disruption we can expect, and they yield useful information when viewed in conjunction with national and international trends.

Climate Data Points:

- By 2085, temperatures are estimated to rise above 95°F for approximately 20 to 40 days per year in Virginia, compared with an average of 10 days per year in 2016.[21]

- Central Virginia could see a 10-15% decrease in annual rainfall by 2080. While other models also often show a potential *increase* in rainfall as a result of climate change, this increase in precipitation will likely come in shorter, more intense bursts that evaporate at a faster rate once the rain reaches the ground.[22] These changes in precipitation could affect the groundwater supply in Albemarle County. Changes to the groundwater supply are extremely important to consider as 44% of county homes rely on well water or springs.[23]

- Changes in precipitation and air temperatures are likely to result in changes to groundwater recharge rates. These changes are difficult to measure for specific regions, but climate change is generally expected to reduce renewable surface water;

[18] "2020 More Extreme Heat."
[19] EPA, "What Climate Change Means for Virginia."
[20] EPA, "What Climate Change Means for Virginia."
[21] EPA, "What Climate Change Means for Virginia."
[22] Nash, *Virginia Climate Fever: How Global Warming Will Transform Our Cities, Shorelines, and Forests*.
[23] "Albemarle County Comprehensive Plan"

changes to groundwater recharge rates would increase significantly with more greenhouse gases in the atmosphere.[24] At the same time, changes to precipitation and temperature are also expected to increase groundwater recharge in certain regions such as those at high latitudes or those with above average precipitation. It is clear that there is some uncertainty as to how and to what magnitude that climate change will affect groundwater. This uncertainty underlines the need to act now to increase water security in Albemarle County.

- Based on a "business as usual" emissions scenario, the average daily winter temperature in Albemarle County could rise from the 2020 average of 37°F to 42-43°F by the end of the century. In the same time period, summer heat in Albemarle County could rise drastically, from an average daily temperature of 74°F to 83-84°F.[25]

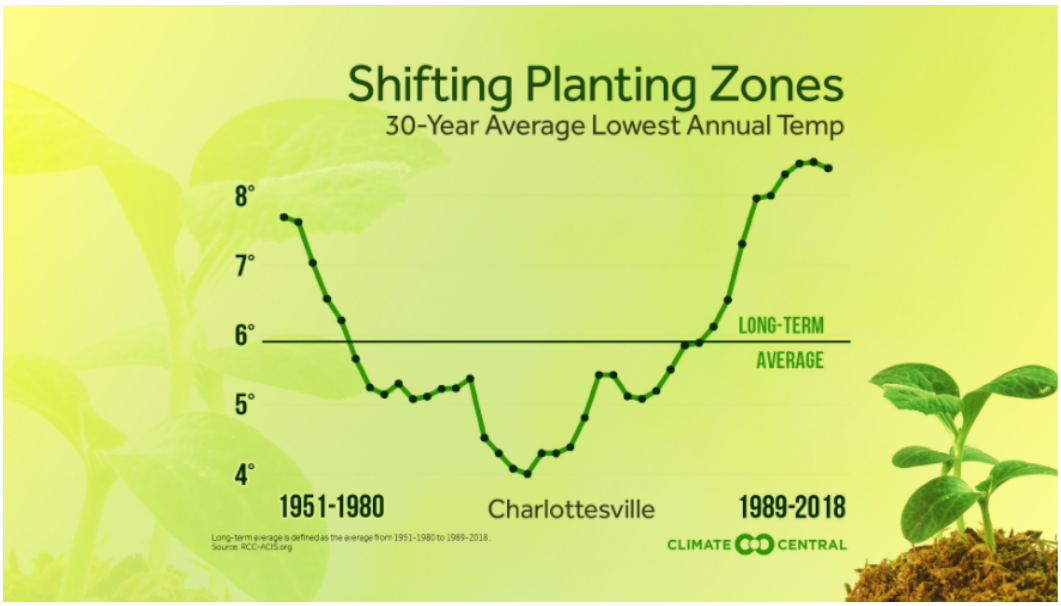

Figure 5: Shifting Planting Zones for Charlottesville[26]

- A warming climate will lead to dramatic shifts for species habitat in Virginia and Albemarle County. Our current plant hardiness zone is likely to continue moving north, leading to changes in the flora grown in the Piedmont.[27] The National Wildlife Federation Climate Vulnerability Assessment shows multiple Virginia species experiencing severe decreases under both high and low emissions scenarios. Red spruce, yellow birch, northern red oak, eastern hemlock, and white pine could disappear from Virginia within the next century, as well as cold-water fish such as

[24] Jiménez Cisneros et al., "2014: Freshwater Resources"; Green, "Linking Climate Change and Groundwater."
[25] Nash, *Virginia Climate Fever: How Global Warming Will Transform Our Cities, Shorelines, and Forests*.
[26] "Planting Zones Moving North."
[27] "Planting Zones Moving North."

Virginia's State fish, the brook trout.[28]

- Species in Virginia at the northern limits of their range could conversely become increasingly common in this area, including bald cypress and multiple new species of frogs and toads.[29]

- The Audubon Society has listed 36 Virginia bird species whose habitat will be moderately or highly vulnerable in a 2.7°F warming scenario and 51 bird species who will be vulnerable in a 3.6°F warming scenario.[30] If these bird species disappear, the Virginia landscape will dramatically change.

Model Climate Action Plans

As a predominantly rural county with a dense urban area, Albemarle County has the opportunity to be a leader in climate action work that has historically been spearheaded by larger, denser cities. Albemarle County has already done commendable work in water supply planning and growth management, which can be found in its Comprehensive Plan[31], and could serve as a model for other rural and "small-city" communities in regards to climate action planning.

Climate action planning is well underway in Albemarle County. The county approved greenhouse gas emission reduction targets of 45% by 2030 and zero net emissions by 2050.[32] Its Climate Action Plan with strategies to reach these targets was adopted October 7, 2020. The county is currently in its next phase of climate action planning, which includes the implementation of the developed Climate Action Plan. This phase of planning also includes the development of a climate resiliency plan which will focus on risk management and adaptation strategies.

To help guide Albemarle County through its climate action journey, this brief compiles six planning strategies championed by other localities across the United States. All six offer important lessons in the areas of rural planning, racial equity, and implementation and evaluation. It is important to note that many of these communities decided to proactively address climate change to reduce financial cost while still maximizing impact.

All city statistics are taken from the 2019 census.[33]

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[28] Kane et al., "Virginia's Climate Modeling and Species Vulnerability Assessment."
[29] Kane et al.
[30] "How Climate Change Will Affect Virginia's Birds."
[31] Albemarle County Comprehensive Plan
[32] "Climate Protection | Albemarle County, VA."
[33] "U.S. Census Bureau QuickFacts."

Sample Approach	Location	Population	Land Area (sq. mi)	Population Density (avg. people / sq. mi)
Reference	Albemarle County, VA	109,330	720	137
1. Focus on Local Voices	Blacksburg, VA	44,233	20	2,143
2. Take a Community Approach	Missoula, MT	75,516	28	2,697
3. Prioritize Scoring	Everett, WA	111,475	33	3,378
4. Seize Local Opportunities	Summit County, CO	31,011	608	51
5. Let New Voices Lead	Dane County, WI	546,695	1,197	456
6. Describe why it Matters Here	Fort Collins, CO	170,243	54	3,136
7. Follow Through	Montgomery County, MD	1,056,668	491	2,138

Example 1. - Focus on Local Voices – Blacksburg, VA

Figure 6: Geographic Location of Blacksburg, Virginia

Population = 44,233
Land area = 20 square miles
Population Density = 2,143 people / square mile (average)

Blacksburg and Albemarle County are both in Virginia and located relatively close together. Blacksburg is the site of Virginia Tech and Albemarle County surrounds Charlottesville which is the site of the University of Virginia. The similarities in climate and demographics mean that Blacksburg's climate action plan is very relevant to Albemarle County, and therefore useful to consider.

First, the plan has a clear focus on public involvement, with a strong presentation of individual actions in each section of the plan's several focus areas. These actions include those more immediate and easily fulfilled, such as using the cold-water wash setting on a washing machine, and longer-term actions that are larger in scale, such as home energy efficiency. Each section highlights a local individual or business that is "leading by example" with individual climate actions that may serve as inspiration for more individual actions that, taken together, will help the broader community reach its emissions reduction targets.

Another element of Blacksburg's climate action plan that is particularly relevant for Albemarle County and Charlottesville is its acknowledgement of the importance of housing policy in transportation emissions reduction. Because transportation in American cities is one of the biggest contributors to overall emissions, strategies for reducing transportation emissions are necessary to meet emission reduction goals. In Blacksburg, transportation emissions account for 19% of total emissions, and in Albemarle County, transportation accounts for 48% of total emissions.[34] Blacksburg's climate action plan makes an important acknowledgement that the high number of community members that must commute to work is an indication of an imbalance in the city's housing affordability. This imbalance is attributed to the high number of Virginia Tech student renters in the area. The climate action plan concludes that meeting transportation emission reduction goals will require improving housing affordability in Blacksburg.

Many people who work at Virginia Tech commute into Blacksburg while living in the surrounding communities. Many people who live in Albemarle County commute into Charlottesville to work at UVA. Housing-workplace imbalance like this will raise transportation emissions in both communities. Albemarle County acknowledges this importance by combining its transportation and land use categories. To further reduce emissions, Albemarle County should focus on policies that reduce reliance on automobiles such as locating housing near transit, creating walkable mixed use development and providing more connectivity for non-automobile transportation like biking or walking.

Key Takeaway: Albemarle County can draw many lessons from Blacksburg's climate action plan. The first is Blacksburg's focus on individual action during their climate action plan and the second is Blackburg's focus on reducing housing inequality to reduce transportation emissions.

[34] "Town of Blacksburg Climate Action Plan.""Albemarle County Climate Action Plan."

Example 2. Take a Community Approach – Missoula, MT

Figure 7: Geographic Location of Missoula, Montana

Population = 75,516
Land area = 28 square miles
Population Density = 2,697 people / square mile (average)

Missoula, Montana (Figure 5) is nearing a decade of dedicated climate action planning that began in 2012 with its *City Conservation and Climate Action Plan*. The plan focused on a goal for city government operations to be carbon neutral by 2025. Building upon this foundation document, Missoula was able to work toward the completion of its *Community Climate Smart Action Plan,* which included goals and strategies for the whole community well beyond the municipal boundaries.

Much like the major sectors outlined in Albemarle County's Draft C*limate Action Plan*, Missoula identified areas of community focus, called "climate buckets," that were used to categorize its climate strategies. The 12 "climate buckets" were developed with input from community members collected during two community *Climate Summit* meetings, multiple workshops, events, and extensive individual conversations with community leaders. The result was a comprehensive, uniquely *Missoulian* framework for Missoula's Climate Action Plan, which encompassed far more than the generalized topics typically presented in climate plans. These 12 "climate buckets" were:

- *Education & Outreach*
- *Green Building, Energy Efficiency and Conservation*
- *Healthy, Thriving Community*
- *Inventory and Metrics*
- *Local Food and Agriculture*
- *Renewable Energy*
- *Smart Growth*
- *Sustainable Economic Development*
- *Transportation*
- *Urban and Wildland Forest and Open Lands*
- *Water Conservation and Protection*
- *Zero Waste*

Key Takeaway: For Albemarle County, Missoula offers successful strategies that began with municipal operations and could be naturally scaled up in impact and ambition. While Albemarle County may not need to expand to 12 sectors, Missoula's bucket framework does pave the way for more community-specific categories that may incorporate more strategies down the road.

Example 3. Prioritize Scoring – Everett, WA

Figure 8: Geographic Location of the City of Everett, Washington

Population = 111,475
Land area = 33 square miles
Population Density = 3,378 people / square mile (average)

Despite the city's location on the opposite side of the country, Everett, Washington's (Figure 6) *Climate Action Plan* provides a unique set of strategies worth considering through the lens of Albemarle County. One of the plan's strongest elements emphasizes compact, multi-modal land use and transportation. Everett recognizes that conservation and protection of its rural natural assets depends on the creation of centralized activity centers with a dense and diverse mix of services well-served by public transit. This led the city to boldly adopt a *Transit Communities Policy* and create a Transit Communities Development Authority to expedite development in urban areas and prioritize capital improvements along transit corridors.

Everett also dedicates a significant portion of its Climate Action Plan to ensuring that it actually results in *climate action* as opposed to stagnating. After outlining the climate strategies, the plan concludes with a multi-criteria analysis assessing the potential benefits associated with each action (Figure 7). They are all scored within the categories of *Impact, Equity, Cost/Affordability, Feasibility, and Co-Benefits*. This relatively simple process converts what may seem like a daunting list of dozens of strategies into a prioritized list of actions, weighted to reflect the values of the community. Finally, each action is mapped on an implementation

matrix with an associated timeframe, lead entity, potential partners, cost, potential funding strategies, metrics, unintended consequences, and key next steps.

Overall Scores: A score of 5 is the highest possible score, indicating very high alignment with the criterion. A score of 1 is the lowest possible score, indicating very low alignment with the criterion.		Score Out of 5	Impact	Equity	Cost/ Affordability	Feasibility	Co-Benefits
			30%	20%	17%	17%	17%
ID	**Action**						
T-1.1.1	Incentivize transit use by promoting benefits such as pre-tax transit passes and rebates to employees who give up use of employer parking facilities.	**2.6**	3.8	1.0	3.0	3.0	1.4
T-1.1.2	Advocate for regional congestion pricing authority, with flexibility to dedicate revenues to projects and services that would serve a variety of different transportation modes and options.	**2.6**	3.8	1.0	3.5	1.6	2.6

Figure 9: Everett scoring matrix screen shot

Key Takeaway: Everett understands the importance of land use for climate action planning. Its outline for *Transit Communities* gives the Climate Action Plan real teeth when it comes to development in the urban area. The city's emphasis on implementation and evaluation keeps the document from being merely an aspirational list, and instead leaves the community with a prioritized plan of attack.

Example 4. Seize Local Opportunities – Summit County, CO

Figure 10: Geographic Location of Summit County, Colorado

Population = 31,011
Land Area = 608 square miles
Population Density = 51 people / square mile (average)

The Summit County, Colorado *Community Climate Action Plan* presents one of the best examples of rural, county-level climate planning and could set a positive model for Piedmont counties to take an active role in regional climate efforts.

Located 50 miles west of Denver, Summit County, Colorado (Figure 10) is best known for its ski resorts and stunning mountain views. Set against this landscape, Summit County produced a distinctly rural C*limate Action Plan* that places tourism, agriculture, recreation, and quality of life at the heart of each of its strategies. By assessing these qualities for every climate action strategy they suggest, Summit County positions their plan as more than just a means to address climate change.

One of the most applicable aspects of the Summit County *Climate Action Plan* is its emphasis on forests. In addition to the more typical "climate buckets" (e.g., renewable energy and transportation), Summit County's plan recognizes the immense value of its forests, positioning them as a key component of their overall climate strategy. The *Forests Sector* section outlines the serious threats facing the county's forests as temperatures rise (e.g., increased fires, insect invasions) and concludes with a call to develop and implement a community-wide Forest Management Plan.

Key Takeaway: Summit County understands that its residents' way of life is directly tied to the health of their environment and it takes a leadership role in the fight to reduce emissions. Summit County's Climate Action Plan is also one of the first in the United States that includes forests in a greenhouse gas inventory, recognizing the important role forests play in sequestering carbon and regulating the climate.

Example 5. Let New Voices Lead – Dane County, WI

Figure 11: Geographic Location of Dane County, Wisconsin

Population = 546,695
Land area = 1,197 square miles
Population Density = 456 people / square mile (average)

Dane County, Wisconsin (Figure 11) shares many similarities to Albemarle County as a suburban county surrounding a university (University of Wisconsin - Madison) metropolitan area. The Dane County Office of Energy & Climate Change has been working on climate action since 2017 and released a Comprehensive Plan with goals for "deep decarbonization" in April 2020.[35]

As Albemarle County strives to develop a climate action plan that recognizes and reconciles historical inequities, the Dane County plan offers a strong model for placing equity and justice at the center of climate action. Paragraphs on equity and climate justice are common in climate action documents; however, they often result in token apologies and vague language about "doing better" without concrete actions. Contrary to this norm, Dane County uses its *Climate Action Plan* to welcome previously excluded groups into the planning process, actively seeking new voices to lead the charge for a sustainable future.

The Ho-Chunk Nation of Wisconsin wrote its own introduction to Dane County's *Climate Action Plan,* sharing the history of its territory, removals under colonization, and recent revival. The write-up included ways the Ho-Chunk continue to use sustainable and energy-efficient business practices and concludes by stating, "We look forward to sharing the knowledge passed down and the role of stewardship with those who wholeheartedly take on the responsibility alongside us."[36]

Before Dane County's *Climate Action Plan* begins listing goals and objectives, it outlines six (6) guiding principles for the plan: (1) *Equity and Justice; (2) Economic Benefits; (3) Health Benefits; (4) Resilience/Security; (5) Ecosystem Services;* and *(6) Bridging the Urban and Rural Divide*. The plan is one of few county-level plans to mention the need for both urban and rural solutions, stating "The CAP will recognize the critical role that the rural areas play in Dane County's economy and quality of life and the enormous role rural areas can play in climate solutions."[37]

Key Takeaway: In emphasizing equity and inclusion throughout its planning process, the Dane County *Climate Action Plan* moves beyond platitudes and lets the voices of those historically excluded speak in calling for a brighter and more sustainable future. The guiding principles, expressed in the introduction, lay the foundation for the nuts and bolts of the plan and establish climate action as a holistic community effort.

[35] "Climate Action Plan | Office of Energy and Climate Change."
[36] "2020 Dane County Climate Action Plan."
[37] "2020 Dane County Climate Action Plan."

Example 6. Describe Why it Matters Here – Fort Collins, CO

Figure 12: Geographic Location of Fort Collins, Colorado

Population = 170,243
Land area = 54 square miles
Population Density = 3,136 people / square mile (average)

Fort Collins, Colorado (Figure 12) first calculated and reported its community greenhouse gas emissions in 1999, leading to nearly two (2) decades of deliberate climate action planning. As Albemarle County is only beginning to enact its climate action plan, enacted in late 2020, Fort Collins is a model for consistent, long-term evaluation and re-defining of goals and expectations based on each round of new data. For example, Fort Collins' City Council originally targeted greenhouse gas emission reductions of 20% below 2005 levels by 2020. When its most recent C*limate Action Plan* was released in 2015, it revealed there had only been a 5% reduction of emissions. While it was clear Fort Collins was lagging behind its original emissions reduction target, the area was experiencing sizable growth in population (16%) and economic prosperity (22% measured by sales and use tax) during the same time period. Fort Collins set new, larger goals in the 2020 *Climate Action Plan* that kept the original 20% reduction by 2020, but included a larger reduction of 80% by 2030. These goals are aspirational but are premised on the fact that much of the area's growth came from people *choosing* Fort Collins because of its natural beauty, active outdoor lifestyle and focus on climate change. People who choose Fort Collins for these attributes will welcome the positive changes, like more bike routes or new technologies for emissions reductions, that come with continuing climate action.

The Fort Collins *Climate Action Plan* has been successful in bringing the threat of future climate impacts close to home. Moving beyond global models and predictions, its "Why climate change matters in Fort Collins" section lists what could be expected from climate change in Fort Collins if greenhouse gas emissions were not dramatically reduced. The descriptions of soaring summer temperatures, longer and more intense droughts, and increased threats of fires, insects, and disease in the area's forests paint an alarming yet localized picture of the future.

The city has experienced 20+ years of successful climate action work because the community was able to understand the risks of inaction.

Key Takeaways: Fort Collins realized that to continue positive growth, it needed to focus on the elements of Fort Collins that make it an attractive place to live - natural beauty and an active outdoor lifestyle. Fort Collins saw that to maintain these qualities, they needed to focus on climate action. Albemarle County should come to a similar conclusion and focus on climate action to maintain the qualities that make Albemarle County a desirable and special place to live.

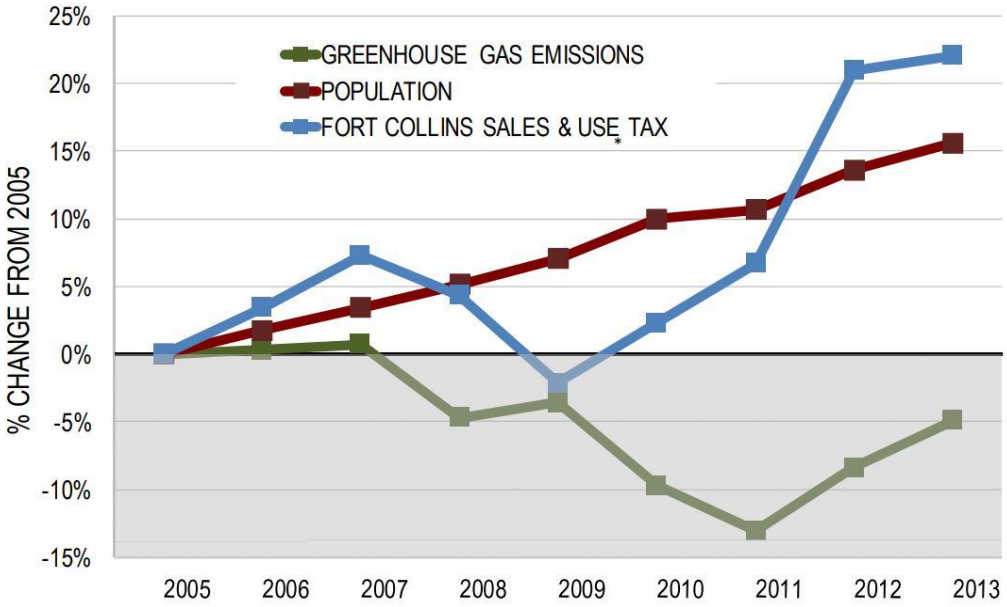

Figure 13: Fort Collins Percent change in GHG emissions, population and sales tax revenue over time.[38]

Example 7. Follow Through – Montgomery County, MD

[38] "Fort Collins 2015 Climate Action Plan Framework."

Figure 14: Geographic Location of Montgomery County, Maryland

Population = 1,050,668
Land Area = 491 square miles
Population Density = 2,138 people / square mile (average)

Montgomery County has been a long-standing national leader in addressing climate change, dating back to 2008 when the county established a Sustainability Working Group and began developing an initial *Climate Protection Plan*. The plan contained 58 specific recommendations across a broad spectrum of activities with the overall goal to halt county-wide greenhouse gas emissions increases by 2010 and to reduce emissions by 10% every five years through 2050.[39]

Now, more than a decade later, Montgomery County is building upon its previous work by launching a planning process to develop a *Climate Action and Resilience Plan* to be completed by early 2021. The new *Climate Action and Resilience Plan* hopes to be more ambitious than previous climate action undertaken by Montgomery County. Work groups have already developed more than 800 recommendations that will provide a roadmap to achieve zero emissions, as well as recommendations for adapting to a changing climate.[40] The strength of Montgomery County's climate planning work lies in its committed and sustained prioritization of climate change as an issue that deserves both attention and funding. Even though the 2009 *Climate Protection Plan* took a considerable capital and time investment, the county understood that it was only the beginning. Since then, it has leveraged its momentum and kept climate action a driving factor in planning and county operations.

Over the years, Montgomery County has fought to keep its climate work fresh, and the recent emphasis on resilience in its current planning efforts shows its ability to adapt as times change and grow more urgent. The county has also steadily moved toward physical implementation of its new climate strategies and kept the public updated on its progress. Each month, a *Climate News* newsletter highlights emissions data updates, green job postings, and at-home DIY projects, such as growing native plants.[41] Together, these efforts serve as a steady reminder to the Montgomery County community that climate change is a constant priority and builds a foundation for community support for larger in-scope projects in the future. Montgomery County's Solar Study is a good example.[42] The study analyzed the amount of land where solar panels could theoretically be placed throughout the county. It then compared this area to the estimated amount of land necessary to house enough solar panels to power the entire county exclusively. Based on rough estimations for how much solar would be needed, they found that they had enough open land, rooftops, parking lots, and under transmission lands to power all of the county's electricity needs through solar power.

[39] "Montgomery County, Maryland Climate Protection Plan."
[40] "Climate Action Plan - Department of Environmental Protection, Montgomery County, MD."
[41] "New Data Shows That Greenhouse Gas Emissions Are Falling in the County."
[42] "Solar Energy in Montgomery County."

Key Takeaway: Montgomery County's continued communication with the public, along with specific climate action strategies, offers accountability from residents to the county for continued action. Continuous progress in any climate action plan requires the persistence demonstrated by Montgomery County. Albemarle could draw from its public releases, ambitious goals, and specific actions to ensure sustained success.

Strategic Opportunities

Although much can be learned from other localities' successful approaches to climate action, Albemarle County must also focus on strategies that are best suited to its specific geography and demographics. Examples that work elsewhere might reasonably be tailored to the unique attributes of Albemarle. The following section outlines some of these promising strategies and provides important focus areas for a potential climate action blueprint in Albemarle County.

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1. Carbon Credits

Carbon credits are an emerging opportunity to work on both climate change mitigation and adaptation. Carbon credits work in many different ways; the most relevant to Albemarle County is a "forest carbon credit market," in which an organization with the capacity for forest management takes on active management of a forest intending to maximize carbon capture potential.Land commonly used for this purpose are forested lands that landowners lack the capacity to manageor old farmland that is no long productive for agricultural purposes. Under active management, these lands will ideally capture and store more carbon from the air over time. The forest manager can then measure the difference between the forests' carbon captures

under active management versus before active management and "sell" that difference in the form of a carbon offset.

Companies can buy these carbon credits either because they are required to by state laws, such as Virginia's Regional Greenhouse Gas Initiative (RGGI), or because they voluntarily want to offset their carbon emissions to please stakeholders or generate positive publicity. The funds generated by the sale of carbon credits can potentially be reinvested into ongoing management of the forest or be paid to participating landowners. This can offer landowners a good way to earn passive income from their land.

The challenge of such programs lies in their significant upfront resource requirements, including accurate forest inventories, complex statistical analyses used to measure the carbon produced by the forest, active ongoing assessment of forest condition, and then the actual timbering and management of the forest. However, where they've been successfully implemented, these programs have been shown to drastically increase carbon intake, produce meaningful financial benefits to landowners and significantly improve forest health.

One prime example is the Clinch Valley carbon credit program managed by The Nature Conservancy (TNC). TNC acquired timber and ecosystem services rights for 22,052 forested acres of privately-owned land in Southwestern Virginia for management and partnered with the Walt Disney Company to sell the carbon credits produced by the forest. TNC manages the forest, the private landowners retain ownership of the land and receive an annual paycheck for the value of the timber in the forest, and Disney is able to offset the carbon they emit. The private landowners don't have any headache from managing their forest themselves, Disney has a reliable source of carbon credits to offset emissions, and the arrangement benefits the forest and community as well. Clear-cut timbering and built development on the land is restricted in perpetuity. Water quality and habitat are improved for wildlife supported by the forest. Forest management provides long-term jobs occupied by surrounding community members. While this program worked largely because TNC was able to pay the large up-front costs, it offers one of the first models of a successful carbon credit program. The question that must be answered, for applicability in Albemarle County, is how this model can be scaled down to work with more landowners and smaller parcels of land.

The answer may lie in an example from Vermont, where the organization *Cold Hollow to Canada* has helped landowners use 7,500 acres of forestland in the Green Mountains in the first-ever forest carbon cooperative in the U.S.[43] The program allows landowners to pool their land together so that they can split the up front costs of participating in the program and then receive a payout for the carbon credits they produce together. If these program strategies can be applied within Albemarle County, it could mark the beginning of successful carbon credit programs in the Piedmont.

[43] "Forest Carbon Cooperative - Vermont Forests Reduce Carbon Pollution."

Carbon credit programs also, perhaps rightly, receive criticism. One is the reliability of the carbon storage obtained through a forest management program. Mismanagement of the forest can lead to an increase in carbon emissions and a failure to generate either the financial incentive for the managing organization or the promised carbon credits for the purchasing corporation. Forest management is also not the best way to solely store carbon; if the forest is cut down in the future, some of the stored carbon will be released into the atmosphere. Significant start-up costs make these programs a challenge at smaller scales, as previously mentioned. Active forest management for the purposes of carbon generation makes carbon generation the primary goal and sidelines goals of biodiversity and creating a healthy ecosystem. These management techniques therefore could have long term consequences on biodiversity and create forests that are less resilient to climate change impacts like invasive species or temperature change.

Carbon credit programs are also shrouded in ethical concerns. Companies can take advantage of these programs to justify their claims of being carbon neutral or to appear in compliance with state laws without reducing their carbon emissions at all. Some early programs have proven to be simply profit-driven exercises, such as the Green Trees programs, in which pre-established forests were enrolled in carbon credit programs.[44] When enrolling these forests, Green Trees falsely reported that there had been no forest on the land before and claimed that the forest had been planted through their program. This meant that Green Trees was able to collect and sell many more carbon credits than they were actually generating. Carbon credits can also be artificially inflated through a creative measurement of the current carbon captured versus carbon captured if the forest had been almost entirely clear cut.[45] Oftentimes, the forests had already been protected and were in no real danger of intense logging. Critics of carbon credit programs also argue the ethics of a company like Royal Dutch Shell profiting off of oil while offsetting its carbon emissions with carbon credits from forest projects that had been in progress for decades and would have continued without carbon credit funding, all the while claiming to be carbon neutral.[46]

While it is true that carbon credit programs have potential to be abused by unscrupulous corporations, they can emerge as an innovative way to fund much-needed forest management and to strengthen forest preservation. When the major issue facing Piedmont's forests is a lack of funding for conservation, strong forest management by way of carbon credit programs could provide help toward protecting these areas from development threats, increasing temperatures, and acute threats, such as of invasive species.

Strengths and criticism of carbon credit programs aside, it is clear they will increase in number. The Biden Administration has promised to include carbon banks and carbon credits as a central part of his environmental policy.[47] Additionally, in July 2020, Virginia became a member of the

[44] Elgin and Mider, "The Real Trees Delivering Fake Corporate Climate Progress."
[45] Elgin, "Nature Conservancy Hooked Corporate America on an Empty Climate Solution."
[46] Pearce, "Is the 'Legacy' Carbon Credit Market a Climate Plus or Just Hype?"
[47] Manning, "Biden's Climate Plan Features 'carbon Bank' Aimed at Farmers."

Regional Greenhouse Gas Initiative (RGGI), the first mandatory market-based, greenhouse gas emission reduction program in the United States.[48] RGGI will require power companies to purchase carbon offsets at auction to offset the carbon they produce. RGGI adds to a growing market of carbon credits primarily led by California's Global Warming Solutions Act, which requires California companies to purchase credits for the carbon they produce. Legislation around these programs is changing, and Virginia recently funded a task force to analyze the potential of these programs in the commonwealth.[49] Carbon credits are a double-edged sword; they can offer landowners funds for much needed forest preservation and management while helping mitigation efforts, or offer companies another avenue to skirt environmental regulation and continue polluting the environment.

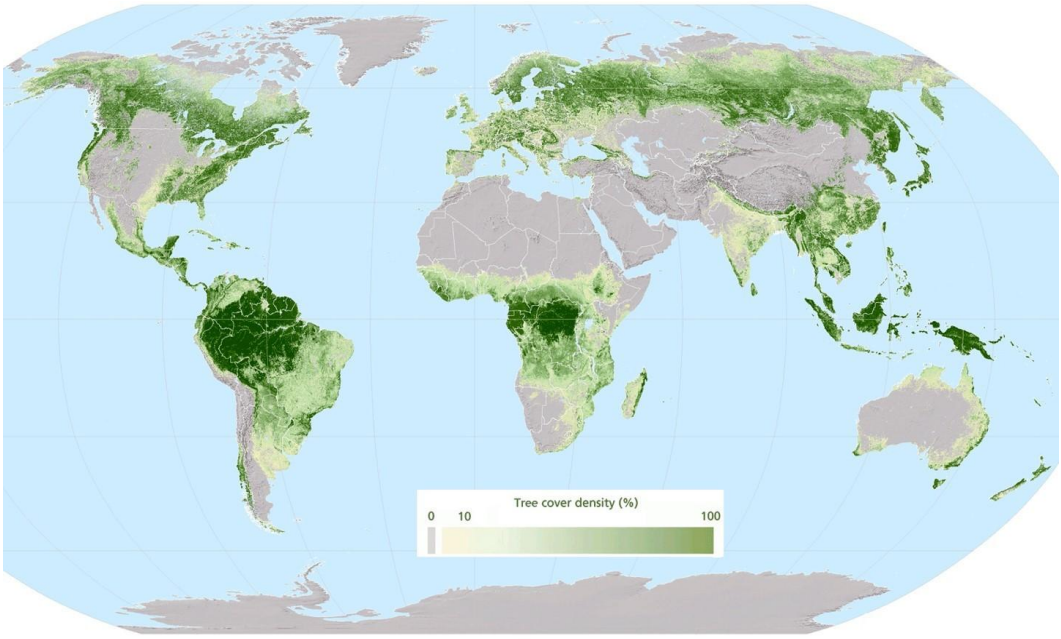


Figure 15: Global Forests[50]

2. Utility-scale and Distributed Solar

The Piedmont Environmental Council supports solar energy, especially small rooftop and ground mount systems designed to meet local demand. This distributed form of generation is a cost-effective way to increase energy security, address environmental challenges and provide power at peak times while reducing the need for larger centralized power facilities and associated infrastructure. By comparison, the size and nature of utility-scale solar creates challenges to the protection of important resources and public health, safety, and community

[48] "RGGI States Welcome Virginia as Its CO2 Regulation Is Finalized."
[49] Vogelsong, "In 'sleeper' Environmental Bill, Virginia Lawmakers Eye Carbon Sequestration Possibilities."
[50] "Global Forest Resources Assessment."

welfare. Utility-scale solar facilities also create new transmission challenges that must be considered.

In Virginia, thousands of acres of rooftops, parking lots, landfills, and contaminated and/or underutilized industrial sites are devoid of solar panels in areas of moderate to high energy demand. Charlottesville's distributed solar potential has been quantified and is publicly available on the city's website; no such analysis has been conducted for Albemarle County.[51] PEC holds the position that these areas should be developed into future solar sites first because of their high energy potential andow risk of environmental damage.

The evolution of state and federal policies, steadily declining cost of solar panels and rising demand for green energy have spurred interest in the development of utility-scale solar throughout Virginia. These facilities are often sited in rural areas and incorrectly promoted as *solar farms*. They have many of the same environmental benefits as rooftop solar, including zero emissions and the ability to provide power at times of peak-demand, but they are not agriculture, and it is proving difficult to protect our natural, cultural, and historic resources from poorly-sited facilities—even "small" ones—on agricultural lands and other forested or open spaces.

Utility-scale solar requires a vast amount of acreage for energy production—as much as seven to 10 acres per megawatt (MW) of rated capacity. A solar farm with a 1 MW capacity is capable of powering 200 households.[52] Solar projects can have detrimental impacts on the surrounding area, causing significant habitat loss or fragmentation, degrading scenic landscapes and viewsheds, removal and/or compaction of agricultural-quality topsoils, and utilization of hazardous materials with potential to harm employees, land and wildlife. Localities must have criteria and means to accurately assess and evaluate a solar project's effects on its proposed location.

Utility-scale solar will play a role in the commonwealth's energy mix, but it should not come at the cost of our most productive agricultural and forested areas. Nor should it be allowed to harm important scenic and historic resources upon which we rely for tourism and recreation.[53]

A growing number of successful projects in small, rural communities have maintained and *deepened* their connection to the landscape through solar power.

Plains, Georgia

[51] "Renewable Energy: Solar."
[52] Solar Farm Land Requirements: How Much Land Do You Need? (greencoast.org)
[53] "Utility-Scale Solar Policy Document."

Figure 16: Geographic Location of Plains, Georgia

Population = 640
Land area = 0.8 square miles
Population Density = 786 people / square mile (average)

Plains, Georgia receives nearly half of its power from solar panels built on a nearby, historic property—President Jimmy Carter's farm. A farming community of less than 700 residents, the Town of Plains disproved the misconception that renewable energy is only politically viable near a major city.[54] Using only 10 acres of land, the solar panels are able to power 50% of the town's electricity. The project demonstrates the potential for success of small-scale solar to power rural communities.

Fayetteville, North Carolina

Figure 17: Geographic Location of Fayetteville, North Carolina

Population = 211,657
Land area = 146 square miles
Population Density = 1,375 people / square mile (average)

The Public Works Commission (PWC) in Fayetteville, North Carolina introduced a community solar program in 2019, coined *PWC Community Solar,* that is available for consumption to all of its metered retail electric customers via monthly subscriptions.[55] The 1-MW facility, located on the grounds of the city's energy generation plant, houses approximately 3,384 solar panels.[56] According to PWC, a customer who subscribes to the maximum allowable five (5) solar panels

[54] Crider, "A Georgia Town Gets Half Of Its Electricity From President Jimmy Carter's Solar Farm."
[55] "PWC Community Solar Program Frequently Asked Questions."
[56] "PWC Community Solar Program Frequently Asked Questions."

per household could reduce their monthly energy bill by nearly 20 percent.[57] Subscriptions cost $1.53/panel/month and require a one-time activation fee.[58]

PEC has identified the potential for the Rivanna Solid Waste Authority solar project to act as a catalyst for future brownfield solar development in Albemarle. The RSWA solar project is a plan in progress to convert part of the former Ivy landfill to a solar plant.[59] The proposed plant would generate two megawatts of power annually without disturbing the landfill cap. The project is still in planning but RSWA hopes to begin construction in spring 2022 with the cooperation of Dominion Power. [60] The county should explore additional locations to replicate this type of community-based solar while examining urban sites such as the expansive parking lots of Albemarle Square and Fashion Square malls. Reducing emissions in the county by meaningful measures will require outside-the-box energy solutions and prudence to ensure that any future energy decisions align with the values of people living in both urban and rural areas.

3. Water Resource Planning

Albemarle has, thus far, chosen to supply its water needs from sources within its own watershed where it can be controlled by local officials.[61] Planning for a long-term sustainable water supply is imperative for the future growth of Albemarle County, especially under the continued impacts of climate change. Globally, 90 percent of all disasters are water-related, and Albemarle's water supply must be able to withstand disasters such as floods, hurricanes and drought.

[57] "PWC Community Solar Program Frequently Asked Questions."
[58] "Community Solar | FAYPWC.COM."
[59] "RSWA Goes Solar!"
[60] "Board of Directors Meeting."
[61] "Community Water Supply Plan - Cvillepedia."

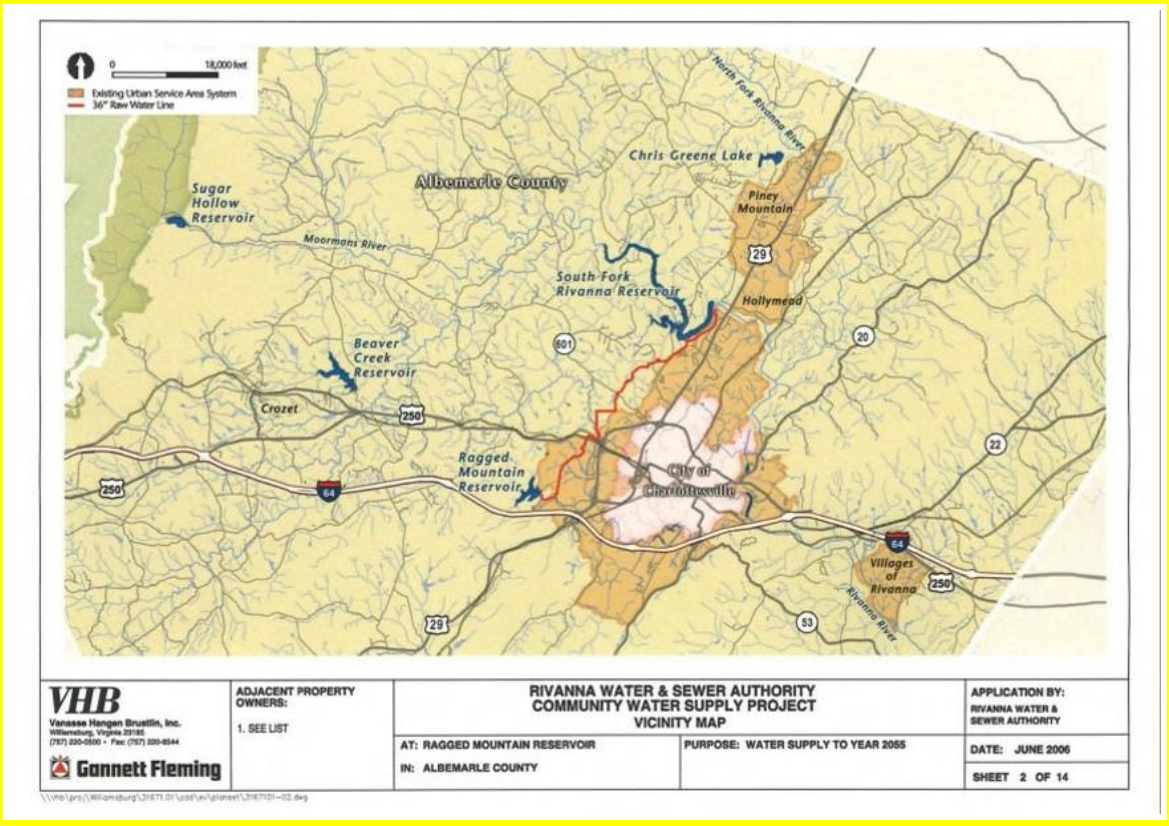


Figure 18: Water Supply Map (VHB)

Charlottesville and Albemarle County's water supply is undergoing much discussion and change. The water supply is managed by Rivanna Water and Sewer Authority (RWSA), [62] a taxpayer-funded, wholesale agency that works to provide water to Albemarle and Charlottesville. The water supply comes from Sugar Hollow Reservoir, Ragged Mountain Reservoir, South Fork Rivanna Reservoir and Beaver Creek Reservoir. The Sugar Hollow Reservoir is dammed by Sugar Hollow Dam on the Moormans River. The Ragged Mountain Reservoir currently receives water through the Sugar Hollow Pipeline and the dam height and storage capacity were increased in 2014.[63] The South Fork Rivanna Reservoir is on the South Fork Rivanna River and has a hydroelectric plant on the dam which has been decommissioned. [64] Finally, the Beaver Creek Reservoir supplies water mostly for the Crozet area.

[62] "Water Supply - Cvillepedia."
[63] "Ragged Mountain Dam - Cvillepedia."
[64] "Drinking Water Reservoirs"; "South Fork Rivanna Reservoir - Cvillepedia."

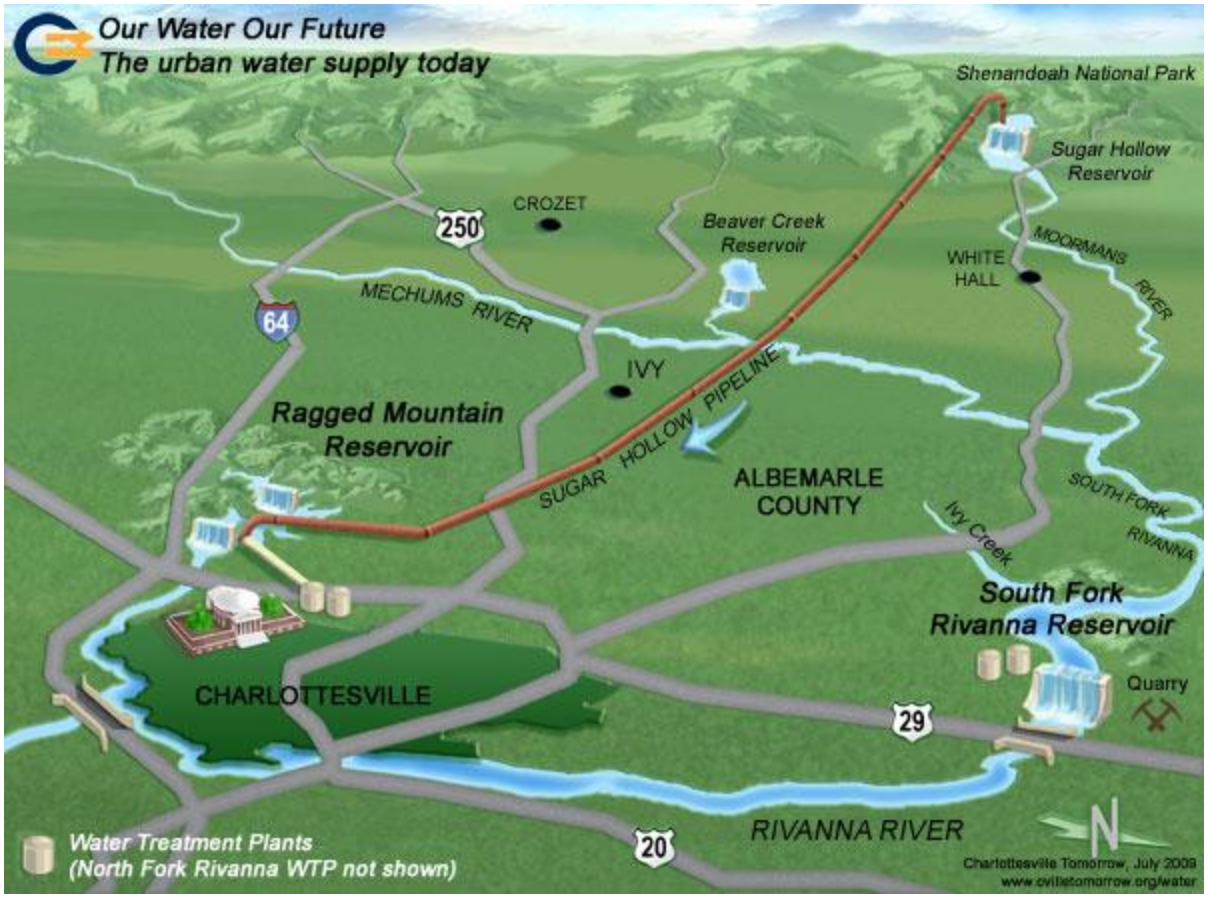


Figure 19: Charlottesville Water Supply[65]

The Central Virginia area suffered a major drought in 2001-2002.[66] The drought lasted 18 months and proved that neither the county nor the city had an adequate supply of water.[67] This sparked a major planning process, with multiple competing viewpoints and much contention, to develop a new community water supply plan.

In 2012, after a decade of discussions, the RWSA created a Community Water Supply Plan document that proposed an expansion of the community water supply. The plan called for a new earthen dam at the Ragged Mountain Reservoir, a water line from the South Rivanna Reservoir to the Ragged Mountain Reservoir, and finally, the raising of the Ragged Mountain Reservoir's water level by an additional 12 feet once water demand reached 85 percent of available capacity. The RWSA completed the Ragged Mountain Dam in 2014, and this new dam added a billion gallons of water to the Ragged Mountain Reservoir.[68] RWSA is still working on the new pipeline connecting the South Rivanna Reservoir to the Ragged Mountain Reservoir and waiting

[65] "Water Supply - Cvillepedia."
[66] "South Rivanna Reservoir to Ragged Mountain Reservoir Water Line Project | Rivanna Authorities."
[67] "South Rivanna Reservoir to Ragged Mountain Reservoir Water Line Project."
[68] "South Rivanna Reservoir to Ragged Mountain Reservoir Water Line Project."

for demand to reach 85% of available capacity to raise the water level in the Ragged Mountain Reservoir.

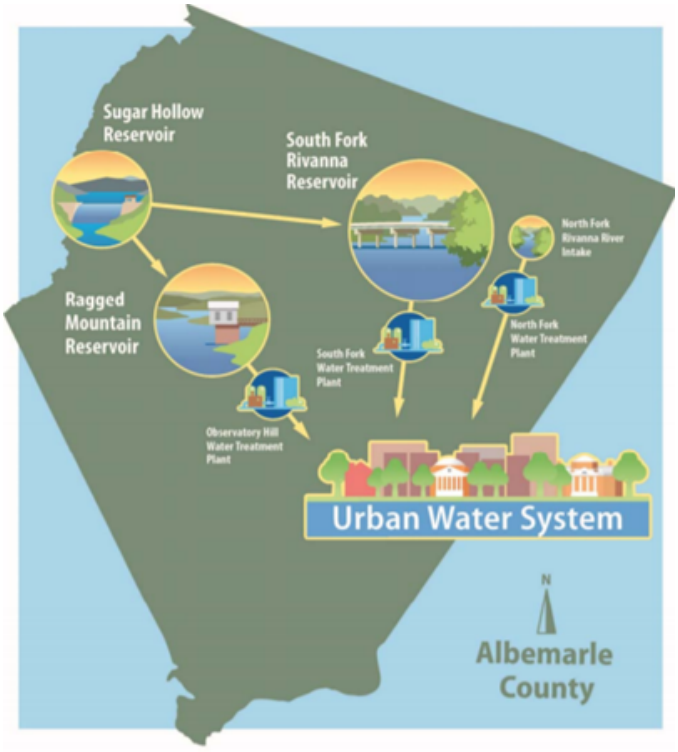


Figure 20: RWSA Urban Water System Schematic[69]

Currently, the Ragged Mountain Reservoir is filled by a pipeline that connects to it from the Sugar Hollow Reservoir.[70] The pipeline was constructed in 1925 and has recently experienced difficulty. It has broken 17 times in a five-year period from 2002 to 2007. One break cost nearly $200,000 to repair. In order to increase water security for the future, this pipeline will be retired and replaced with a new pipeline from the South Fork Rivanna Reservoir to Ragged Mountain Reservoir. Importantly, the new pipeline will allow drinking water to be provided to Charlottesville and Albemarle from multiple different facilities, leading to more dependability during drought or incident.[71] It will also increase the water supply in the Ragged Mountain Reservoir and allow for restoration of the natural instream flowing into the Moorman's River. As of summer 2021, the new pipeline is still in planning phases. RWSA is working to acquire permanent easements to construct the pipeline and avoid conflicts with property owners, and plans to complete the pipeline sometime between 2027 and 2040. This schedule was endorsed by the Charlottesville City Council and the ACSA Board of Directors.

[69] "RWSA Safe Yield and Reliability Analysis Update Report."
[70] "Sugar Hollow Pipeline - Cvillepedia."
[71] "South Rivanna Reservoir to Ragged Mountain Reservoir Water Line Project."

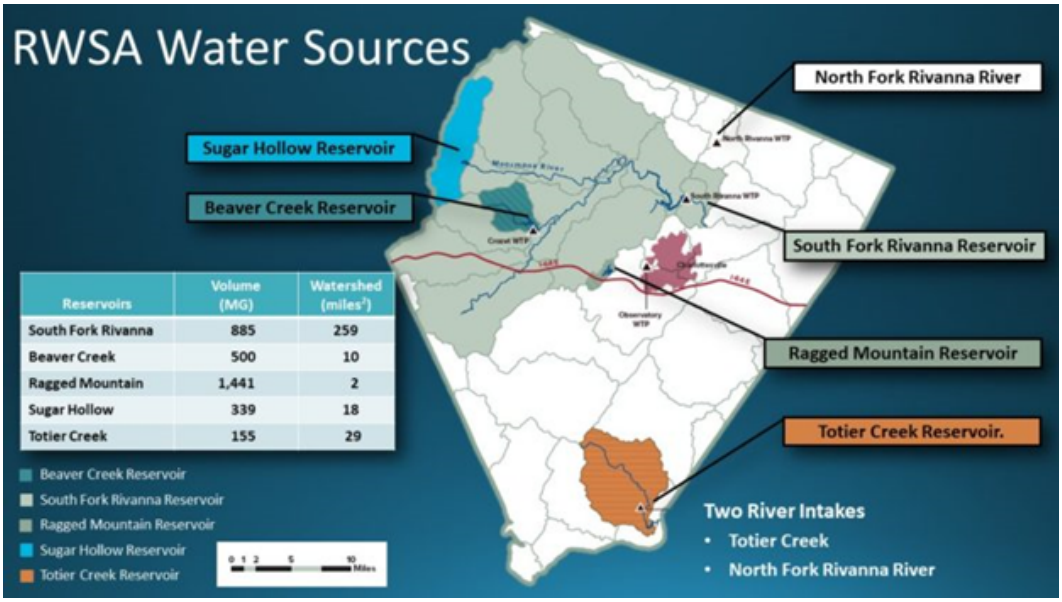


Figure 21: RWSA Water Sources[72]

Following the severe effects of the drought of 2002, drought planning is ongoing in the region. Charlottesville and Albemarle have access to several emergency water sources: RWSA has emergency plans to draw water from Beaver Creek Reservoir, Chris Greene Lake and Lake Albemarle.[73] Multiple reports concluded in 2020 about future water supply demands and supply extending to 2070, and these reports found that Charlottesville and Albemarle should have an adequate supply for this time frame if the new pipeline is completed.[74]

However, it is important to note that these reports, as required by law, calculate the safe yield. The safe yield they calculate is defined as the minimum withdrawal rate available to withstand the worst drought on record in Virginia since 1930. In other words, RWSA has planned for emergency water supply needs based on the historic 1930 and 2002 droughts; they do not take into consideration future drought predictions resulting from accelerated climate change. In an attempt to plan for climate change, and at the behest of citizens and advocacy groups, RWSA reviewed several climate change studies to guide its plans.[75] These studies simply conclude that more research is needed to determine the specific effects of climate change. Current models seem unable to predict changes to Virginia's precipitation. One such study concludes that "the lack of specific information on the impacts hinders Virginia's ability to adapt and prepare for these changes."[76] The safe yield reports are reviewed and updated every 10 years, so RWSA will continue to assess the ongoing and predicted impacts of climate change as time goes on. There is a possibility that the impacts of climate change will drastically change the water

[72] Woods, "Rivanna Water Quality Has Impact Downstream."
[73] "Drought Response and Contingency Plan."
[74] "RWSA Safe Yield and Reliability Analysis Update Report."
[75] "RWSA Urban System Water Demand Forecast Report."
[76] Bryant, "Governor's Commission on Climate Change."

demand and supply in our region, and it is crucial that these impacts be understood and factored into water supply planning.

Finally, there are existing environmental impacts to local streams and rivers.[77] Stormwater runoff from our region flows downstream into the James River, carrying with it a significant risk of devastating algal blooms resulting from excess nitrogen and phosphorus. RWSA works with the Rivanna Conservation Alliance to monitor local streams and rivers for harmful algal blooms.

The Virginia Department of Environmental Quality conducts testing on waterways in Virginia. Its 2020 integrated report found 73% of Virginia rivers, 87% of estuaries and 83% of lakes analyzed to be impaired or not suitable for drinking, swimming and fishing.[78]

Locally, the DEQ reports that 56% of Albemarle County's river and stream miles are impaired. In response, Albemarle County in 2017 launched Stream Health Initiative—a four-phase effort to 'develop strategies for improving stream health in Albemarle County using a collaborative and inclusive process.'[79] The initiative is currently still in phase 1, which is focused on 'building a shared understanding of the current conditions of our waters'. The next phase will focus on identifying the challenges that streams face. Phase 3 will focus on developing proposals for improving stream health, followed by phase 4, during which strategies for improving stream health will be decided on by county staff and stakeholders and begun. The county hopes to move rapidly through each subsequent phase of the program after phase 1. Phases 2 and 3 will include community engagement meetings to develop a plan of action for addressing stream health. Phase 4 will focus on putting strategies into action and is scheduled for the end of 2021.

4. Green Infrastructure

As climate change models predict more precipitation in intense bursts, Albemarle County needs to plan for ways to endure the impacts of these storms. As storms drop water on urban areas, runoff flows from impervious surfaces such as parking lots and rooftops through sewers and gutters, then into nearby bodies of water, picking up and carrying with it a tremendous amount of pollution.[80]

[77] Woods, "Rivanna Water Quality Has Impact Downstream."
[78] "Executive Summary: 2020 Integrated Report."
[79] "Stream Health Initiative - Rural Area Focus - PublicInput.Com."
[80] US EPA, "What Is Green Infrastructure?"

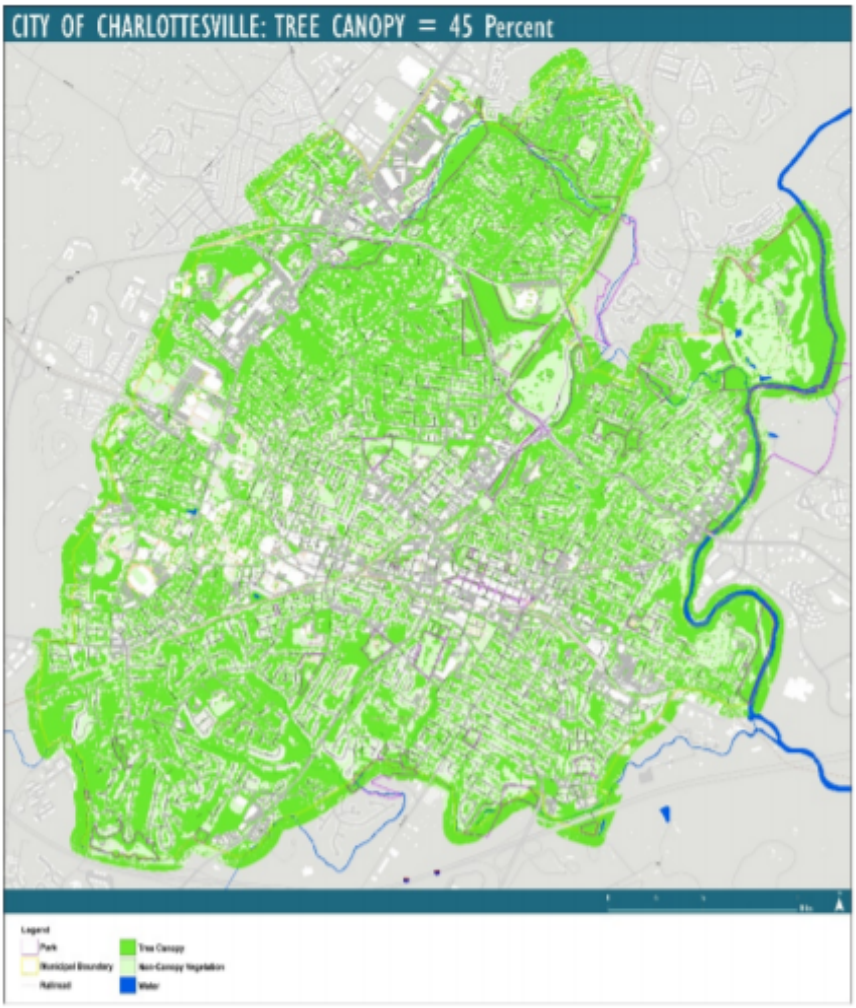


Figure 22: Charlottesville Tree Canopy[81]

Flowing untreated in streams and other waterways, stormwater runoff is a major cause of pollution in downstream and nearby natural areas; with increased storm intensity, it also causes erosion, flooding and damage to people or property.

A cost-effective method of "treating" this water is through the creation of green infrastructure, defined as soils and plants or other permeable surfaces that allow stormwater to be absorbed and reduce stormwater flow through normal runoff systems.[82] Green infrastructure can include the planting of trees to increase an urban canopy that protects residents from summer heat, planting rain gardens that use plants, grass or pebbles to filter rainwater, planting vegetation on rooftops to manage stormwater and decrease heat, and many other strategies. Green infrastructure has many environmental, social and economic co-benefits.

[81] "City Greenprint 1.0: Charlottesville's Green Infrastructure Guide."
[82] US EPA; Denchak, "Green Infrastructure."

Building and maintaining robust green infrastructure will be an important strategy for adapting to climate change, specifically in the county's more urban areas. In July 2018, the City of Charlottesville released its City Green Print 1.0, setting a vision for Charlottesville to be "clean, green, connected and beautiful," and presenting an inventory of what green infrastructure has already been created and what data exists within the city. This inventory has led to the development of the city's online City Green Map, a "virtual library of green infrastructure projects in both the public and private sectors."[83] This type of inventory could also be extended to the county and beyond.

At its best, green infrastructure combines urban and 'natural' areas to create a wealth of benefits for natural systems and residents. While the city's plan recognizes this, and lists further collaboration with UVA and Albemarle County as potential next steps, tremendous opportunity exists for strategic efforts at a *regional* level. As temperatures rise and severe storms increase in frequency, shade and stormwater retention from trees will be paramount for communities in the Piedmont to survive.

5. Forest Management

Forests in Albemarle County provide a wide array of benefits, from the wildlife habitat and nutrition to unique and recognizable scenery. They also help combat the threat of climate change in myriad ways. On the adaptation side, forests shade our soils and our streams. As temperatures rise, this will become an ever more urgent requirement to prevent rapid change in the composition of streams and soils. Forests moderate against many types of disasters, slow down flood runoffs—which allows for water to be absorbed into the soil—and decreases erosion. On the mitigation side, forests are natural carbon sequesters. A single mature tree can absorb 48 pounds of CO2 every year.[84] Importantly, mature forests with older and larger trees can sequester double the carbon that younger forests can. Mature forests are also more resilient to climate impacts of wildfires and drought. Forest carbon sequestration is an inexpensive and simple method of mitigation that will be necessary to meet climate goals.[85] Forest protection is imperative under climate change.

Another reason to protect our forests is the many economic benefits they provide to our region. All of the forests in the county have been timbered at some point in time, and in 2015, timbering of [86] Albemarle County and Charlottesville forests provided an economic impact of $102.2 million. [87] More than their economic value, they help give the land its characteristic scenery, contributing immensely to Albemarle County's appeal to residents and tourists.

[83] "Charlottesville City Green Resource Map."
[84] "Tree Facts."
[85] Law and Moomaw, "Curb Climate Change the Easy Way."
[86] "Albemarle County Biodiversity Action Plan."
[87] Rephann, "The Economic Impact of Virginia's Agriculture and Forest Industries."

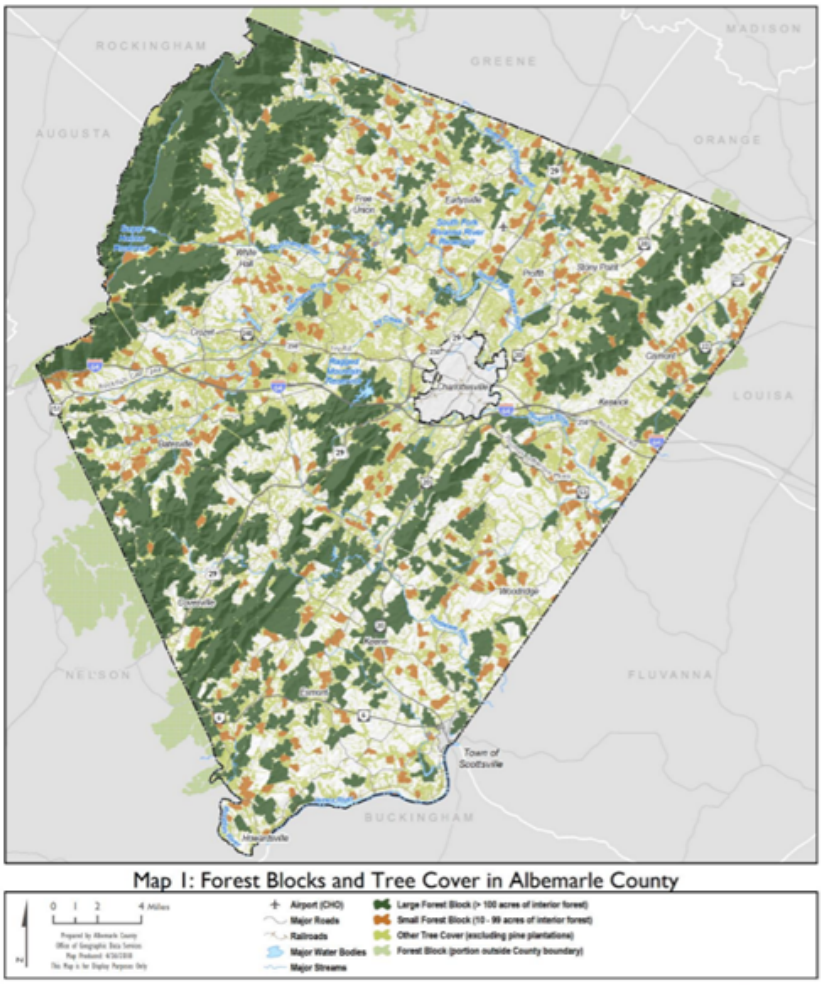


Figure 23: Forest Blocks and Tree Cover in Albemarle County[88]

The forests in Albemarle County are faltering under threats that promise only to get worse as climate change becomes more extreme. These include high temperatures and drought, and invasive species. These issues are compounded by development—which is the most prominent threat to Albemarle County forests. Development causes the fragmentation of forests, habitat destruction, the break up of wildlife corridors, pollution due to fertilizer runoff from lawns, and increased human activity in natural areas, among other issues. These pressures have contributed to the destabilization of much of the county's forests.

Improper forest management across the U.S. has contributed to the risk of forest fire under climate change scenarios. Forest suppression regimes—popularized despite historical use of fire in ecosystems by Indigenous peoples—have significantly changed the species composition

[88] "Albemarle County Biodiversity Action Plan."

and physical characteristics of forests, such as the proportion of dead vegetation.[89] In the case of forest fires, dead vegetation equals fuel. Forest suppression could lead to larger, more uncontrolled fires under climate change. Over 84 percent of forest fires are caused by human ignition, but climate change provides a catastrophic catalyst.[90]

Another large threat to Albemarle County's forests is invasive species. Invasive species are broadly defined as non-native species that cause harm to native species or humans.[91] Typically, invasive species can tolerate a broader range of climates and conditions than native species. This means as climate change worsens, invasive species will continue to outcompete native species.[92] There is evidence that in the next century, invasive species will completely outcompete native species in many areas and fundamentally change our landscapes[93] In 2005, the estimated losses due to invasive species in Virginia were as high as $1 billion annually.[94] Specifically, the impact of invasive plant species could fundamentally change the composition of wildlife in Albemarle County. These invasive plants often have no natural predators. Because of this, the impact of invasive plants spreads rapidly up the food chain and affects our entire ecosystem. Invasive species can also significantly affect the forest canopy. In Albemarle County, there are many invasive vine species such as kudzu or oriental bittersweet that strangle and destroy large native trees and cause gaps in the forest canopy.[95] These gaps result in soil and streams to heat up at a faster rate. As our climate warms, we can therefore expect a significant change in the composition of our forests ecosystems.

[89] "Albemarle County Biodiversity Action Plan."
[90] Short, Karen C. 2017. Spatial wildfire occurrence data for the United States, 1992-2015 [FPA_FOD_20170508]. 4th Edition. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2013-0009.4
[91] Virginia Invasive Species Council, "Virginia Invasive Species Management Plan."
[92] Nash, *Virginia Climate Fever: How Global Warming Will Transform Our Cities, Shorelines, and Forests*.
[93] Thomas, "Translocation of Species, Climate Change, and the End of Trying to Recreate Past Ecological Communities."
[94] Pimentel, Zuniga, and Morrison, "Update on the Environmental and Economic Costs Associated with Alien-Invasive Species in the United States."
[95] Rod & Jim conversation

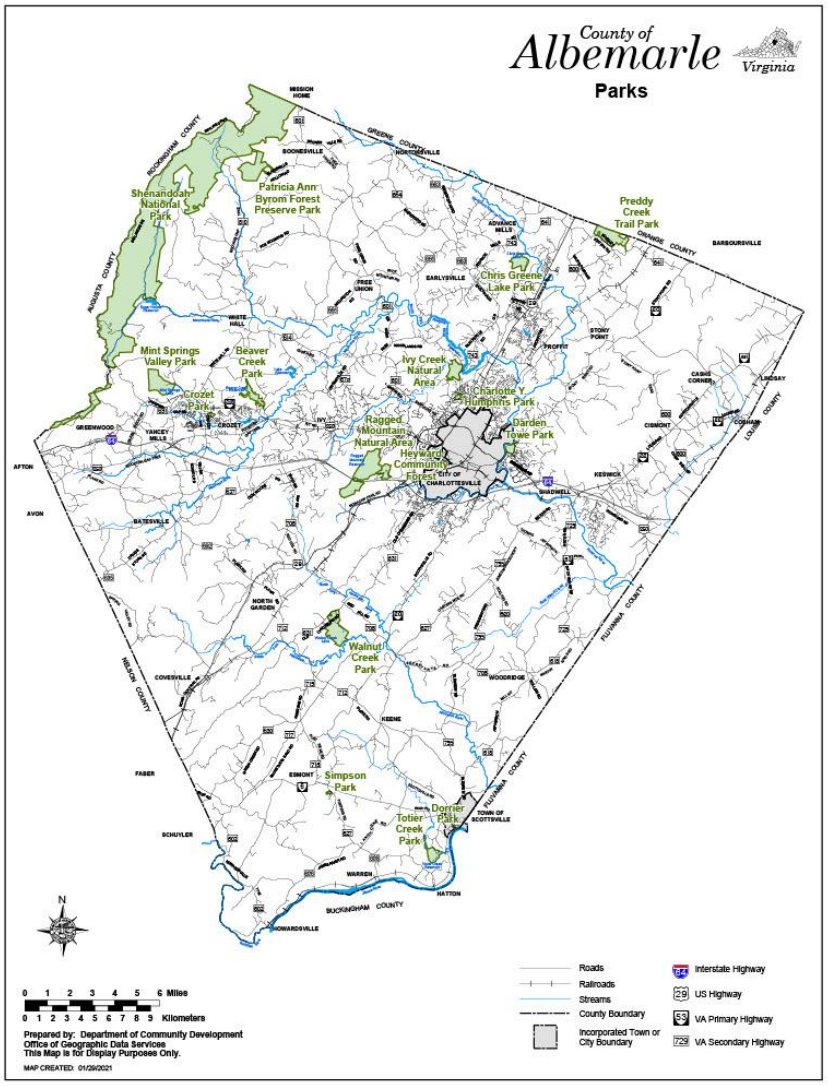


Figure 34: County Owned Parks[96]

It is important to realize how integral private landowners will have to be to protect our forests and control invasive species throughout the Piedmont. The above map shows just how small a proportion of the land in Albemarle is managed by county agencies. Because climate threats don't recognize the boundaries of ownership for land, it is imperative that any forest management program works to provide resources to private landowners for managing their own land. Only when private landowners are sufficiently engaged can forests be effectively managed in Albemarle County.

[96] "County Maps | Albemarle County, VA."

6. Agricultural Land Management

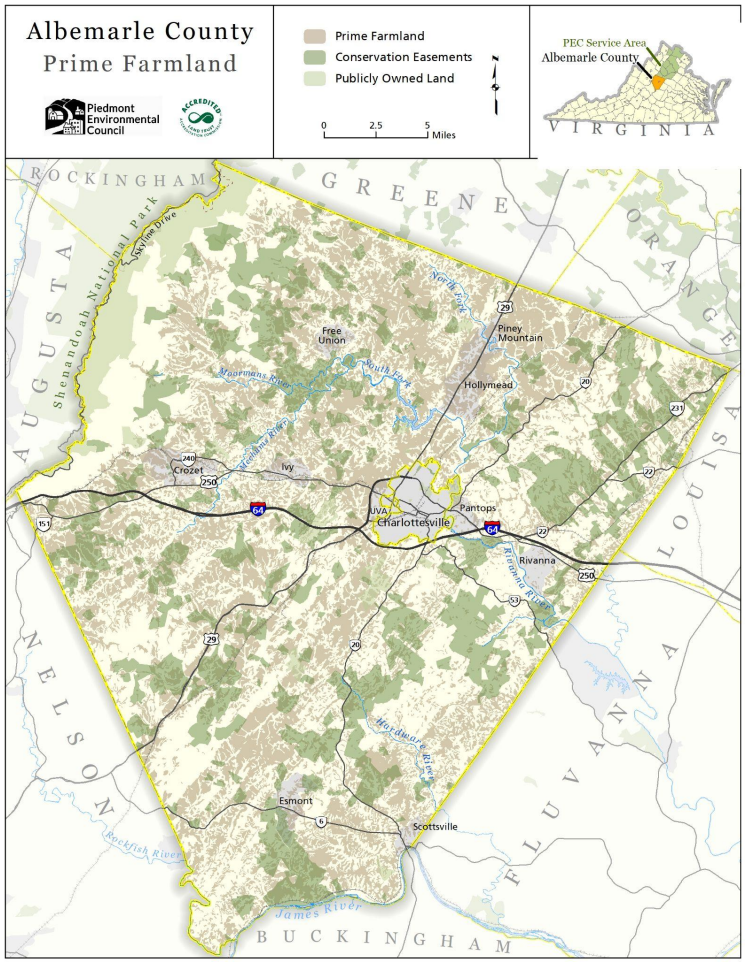


Figure 35: Albemarle County Prime Farmland

Farming is a central resource for Albemarle County. In 2015 alone, agriculture accounted for $546 million of total economic impact in Charlottesville and Albemarle.[97] Yet, farmland in Albemarle County and Virginia as a whole is facing a number of threats. Perhaps the number one threat for Albemarle County farms is development. Nationwide, 11 million acres of farmland were converted into residential or urban land use between 2001 and 2016.[98] A compounding threat of development for farmland is "parcelization," as land is subdivided into smaller parcels.[99] When this happens, quality and ecological value of properties are lost, and the small new sizes of the parcels affect their viability and profitability for farming and forestry. One of the goals of

[97] Rephann, "The Economic Impact of Virginia's Agriculture and Forest Industries."
[98] Freedgood et al., "Farms Under Threat: The State of the States."
[99] "Albemarle County Biodiversity Action Plan."

the 2018 Biodiversity Action Plan is to improve the policies for subdivision in order to maintain sufficient property sizes for rural industry and to prevent habitat fragmentation.

Climate change also poses numerous threats to farming. [100] Weather-related disasters in 2012 caused $15.7 billion in damage to crops nationwide; 2011 saw 12 climate-related disasters that exceeded $1 billion dollars in crop damage each. These large disruptions in crops caused by floods, storms and droughts are projected to increase as a result of changing climate conditions.

In Virginia, expected increases in precipitation could cause flooding, loss of topsoil and crop damage, all of which are likely to decrease crop production. Anticipated rising temperatures may lead to drier soils, reduced organic carbon levels in soils, and displacement of crops northward, forcing farmers around Albemarle County to change their crops to adapt. Hotter summers and warmer winters could also allow pests and diseases a larger window of opportunity to impact crop yields.

7. Regional Coordination

Even the best intentioned climate goals and strategies are not sufficient without buy-in from a regional community. Much like issues of housing and transportation, climate action planning in Albemarle County is plagued by complex and often rigid jurisdictional boundaries between the County, UVA and the City of Charlottesville. The devastating consequences of a warming climate in Virginia though, present challenges that can no longer be tackled from isolated municipal silos.

Much of this important work can begin through partnerships with organizations that are already spearheading climate agendas across jurisdictional boundaries. Albemarle County recently rejoined the international non-governmental organization ICLEI, which is currently hosting a six-month emissions monitoring training for climate leaders from the county, city and UVA. [101] ICLEI works with local governments to establish emissions reduction targets and strategies for achieving their targets.[102] Albemarle County's membership in programs like ICLEI is part of a much larger Livable Communities Planning Project through the Thomas Jefferson Planning District Commission. It also builds upon the region's 1998 Sustainability Accords, which laid the groundwork of planning a sustainable future for the entire region and has been included as part of the comprehensive plans for both Albemarle and Charlottesville.[103][104] However, despite the decades of cooperative planning efforts, climate and sustainability initiatives have remained predominantly independent. Even the *Climate Action Together* website, which was designed to be a central repository for community engagement and public input for the city, county and

[100] Easton and Faulkner, "Climate Change Adaptation for Agriculture: Mitigating Short- and Long-Term Impacts of Climate on Crop Production."
[101] Woods, "Charlottesville to Participate in Carbon Capture Training Cohort."
[102] "ICLEI - Local Governments for Sustainability - Cvillepedia."
[103] "Livable Communities Planning Project."
[104] "1998 Sustainability Accords."

UVA, generally only lists what each community is doing on tracks that are parallel but not united.

Thankfully, where the challenge is great, so is the opportunity. The beautiful landscapes, rich history, and high quality of life abound in the Piedmont transcend the jurisdictional boundaries of city, county and university. The magnitude and complexity of the climate crisis also pushes communities to look for new and holistic solutions that—like Dane County has—can "bridge the urban and rural divide." The region's ability to bridge this divide will be a crucial factor in the success of local climate action planning and the region's ability to weather an uncertain future.

PEC has a unique opportunity to act as a connector between Charlottesville, Albemarle County and UVA. Many proposed climate change solutions require these three groups to share common goals. PEC should work to encourage centralized climate planning and ensure a united front.

The Way Forward

Climate change is real and human-caused. This report captures, for a brief moment in time, the challenges of anthropogenic climate change faced by Albemarle County. These challenges will continue to evolve into new, unforeseen impacts over the next century. The ramifications of climate change and our fight against it should not be siloed. It is imperative for local and regional action to be taken now.

The commendable work that Albemarle County has achieved toward sustainable climate action through the production of climate planning and the upcoming vulnerability reports should be expanded. Albemarle County must continue to hold a focus on environmental justice and protect the historically marginalized members of the community who are most vulnerable to climate impacts. Climate change is an opportunity to place equity in the forefront of our consciousness.

As Albemarle County looks toward the upcoming comprehensive plan review process and the years ahead, climate change must be one of a select few lenses through which all decisions are viewed. The residents of Albemarle County, PEC and our local government must consider the impacts of climate change when planning infrastructure upgrades, business permits, land development and all of the other decisions that comprise county operations. If we do not plan for the future of Albemarle County with a mind towards our changing climate, we will lose the qualities that make the county such a desirable and promising place to live.

VI. Additional Resources

1. NASA Climate Time Machine
Interactive timeline maps for sea ice, sea level rise, carbon dioxide, and global temperature over the past century.

2. 2019 Yale Climate Opinion Maps
Maps showing how Americans' climate change beliefs, risk perceptions and policy support vary by county. For example, they estimate close to 85% of adults in Albemarle County support tax rebates for people who purchase energy-efficient vehicles or solar panels.

3. Virginia Climate Modeling and Species Vulnerability Assessment
A comprehensive report from the National Wildlife Federation and VDGIF on how climate data can inform management and conservation. The report's models on species' shifts across the state are referenced above and include multiple sets of maps though not at the county level.

4. *Virginia Climate Fever* by Stephen Nash
Built on extensive research, interviews and travel across the state, Nash provides a "practical approach to and urgent warning about the impending impact of climate change in Virginia."

5. Google Climate Engine
County level data sets on temperature, precipitation and drought dating back to the 1980s. This interface also has an easy option for producing maps and graphs for any of the given datasets in a region or at a Lat/Long point.

6. Climate Ready Communities
Practical, step by step guide to creating a community Climate Resilience Plan. This guide focuses on "whole community resilience" defined as the ability to "predict, prepare and respond to change in a positive manner"

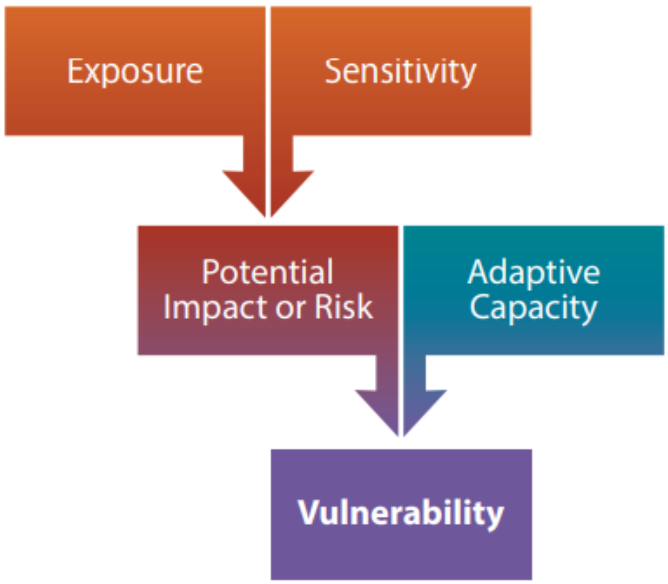
7. UMD Global Forest Change Maps
Worldwide Landsat maps showing forest extent and change between 2000 and 2019.

8. *Radically Rural: Rural voices vital part of solving climate crisis*
This article has good information on ag-exemptions to non-renewable taxes/fees. "We can help farmers feed us," Richter says, noting that agriculture only amounts to approximately 0.06% of overall emissions.

VII. Appendices

A. Overview of Vulnerability Assessments[105]

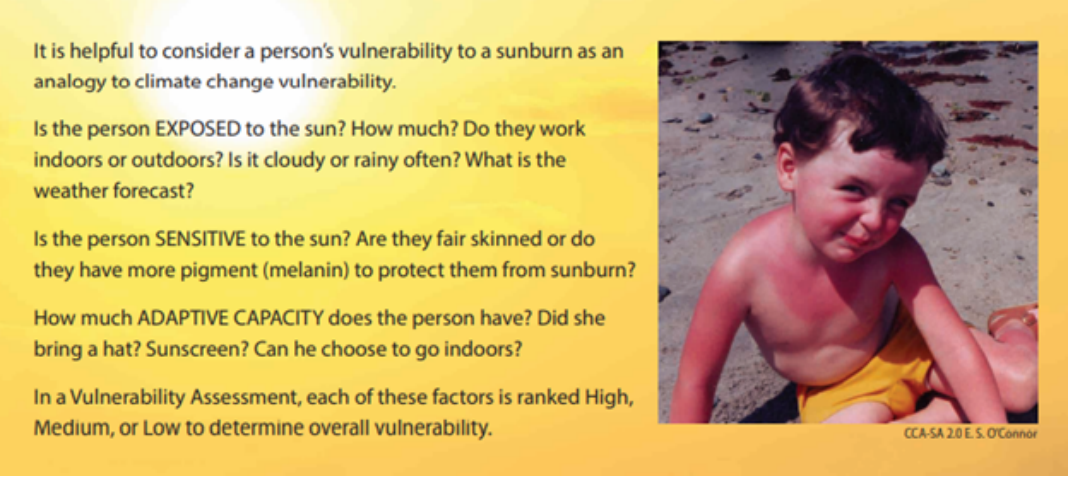
The following is an overview of potential vulnerability assessments. It is important to define several terms that a vulnerability assessment addresses. **Vulnerabilities** are locally specific because they depend on geographic location, size of the community, economic drivers, historic patterns of development, social equity, condition of natural resources, and other important factors. A vulnerability assessment focuses on how specific and local resources and populations are expected to be impacted by climate change. **Climate Change Vulnerability** is a function of three variables: **Exposure, Sensitivity** and **Adaptive Capacity**. The formula for Climate Change Vulnerability governs what is included in a vulnerability assessment as this assessment analyzes climate change vulnerabilities for a variety of impacts.



Exposure and **Sensitivity** together define the impact or risk. **Adaptive capacity** can act to lessen the impact or risk. **Exposure** is a measure of the character, magnitude, and rate of climatic changes a resource or population is exposed to. The assessment of exposure includes the certainty of different model data. **Sensitivity** is the extent to which specific resources or populations are expected to be impacted by the projected changes. Some resources or populations are more sensitive to changes than others. Finally, **Adaptive Capacity** includes existing behaviors or resources that can help reduce or avoid negative impacts. There are often many things people can do to respond to climate change impacts and reduce their vulnerability. Changing behavior, technology, or distribution of resources can reduce vulnerability to certain impacts. It is important to note that adaptive capacity (existing options) is different from

[105] "Climate Ready Communities: A Practical Guide to Building Climate Resilience."

resilience strategies (new options). In general, adaptive capacity is expected to occur without additional outside encouragement or incentives. Following, is an example of all the factors that make up a climate change vulnerability.



In addition to assessing exposure, sensitivity and adaptive capacity, a vulnerability assessment will also consider secondary impacts. People are expected to respond to climate change in a variety of ways. In many cases, their responses can also have negative impacts, potentially even worse than the initial climate impact.

Each individual impact requires the assessment of many different items. For each of these individual impacts related to climate change variables, there are specific factors that will be addressed in a vulnerability assessment which are listed here.

· **Risk** – The specific impact or effect you are concerned about. An example is
  - o Increase in asthma from ground level ozone related to heat.

· **Exposure** – The climate change related projection or trends leading to this risk. These are the projections
  - o Broadly
    - § Changes in temperature
    - § Changes in precipitation
    - § Sea level rise
    - § Increased storm intensity or frequency
    - § Shifts in dominant vegetation
    - § Increase in wildfire frequency and severity
  - o Specific examples
    - § Examples include: · 80% decline in snowpack ·
    - § Doubling of the number of days above 100°F ·
    - § Shift from coniferous forest to deciduous woodlands

- **Time Frame** – Specific dates associated with a projected trend, or general time frames for each impact. Some examples are
    - Short-term (within 15 years or already occurring)
    - Mid-term (occurring by 2050)
    - Long-term (occurring between 2050-2100)

- **Certainty** – Ranked as Low, Medium, or High. Certainty is based on the level of agreement among the models as well as the time frame. Short-term projections have higher certainty than long-term projections, for example.
    - Both temperature increase and loss of snowpack are considered High Certainty climate projections (or trends) because the climate models largely agree on their trajectory and they are already occurring in most areas.
    - Loss of coniferous forest, however, may have lower certainty because the models do not accurately project when or how forests will experience landscape-level change.

- **Sensitivity** – How much the focal population or resources will be affected by the risk, and/or the severity of the effect. These are ranked as Low, Medium, or High.

- **Adaptive Capacity** – Ranked as Low, Medium, or High based on whether behaviors or resources are already in place to protect the focal resources or populations from the risk.

- **Other Stressors** – Past and ongoing stressors that exacerbate this risk. Some examples may include
    - Air pollution from vehicles (exacerbates asthma or other respiratory disease)
    - Development in the Wildland Urban Interface (exacerbates increase risk of wildfire to homes and other development)
    - Fish passage barriers such as dams, levees, or other structures (exacerbates low flow and warm water impacts to fish and to Native Americans who rely on subsistence fisheries)

- **Secondary Vulnerabilities** – Likely responses to climate change that could exacerbate the risk. Some examples include:
    - Increased demand for water for agriculture leading to pressure to build new dams and water storage, which affect fish and fisheries
    - Loss of important wildlife habitat due to the development of renewable energy
    - Increased pesticides and herbicides applied to control pests, disease, and invasive species

- **Focal Populations** – The populations or resources at risk.

- **Solutions** – Ideas for solutions may come up, but this is not the focus of the vulnerability assessment.

To illustrate, the following is an example of completed charts identifying all these factors for various impacts.

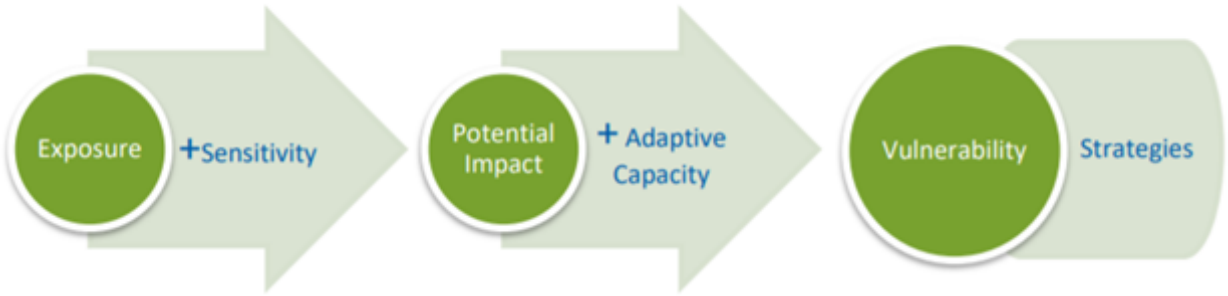
Risk	Exposure	Time Frame	Certainty	Sensitivity	Adaptive Capacity	Focal Populations	Other Stressors	Secondary Vulnerabilities	Solutions
Increased rates of asthma and allergies	More severe heat; doubling of # days above 100° F	Near-term	High (models agree on warming)	High	Low	Children most at risk; people with respiratory illnesses	Poor air quality	None noted	
Higher demand and lower availability for water for agriculture	Higher temperatures cause more evaporation and evapotranspiration	Mid-term	High	High	Medium (different crops can be planted)	Farmers (specific crops, like rice, that need a lot of water	Competing water demands and declining ground water stores	None noted	Research new crops that use less water; upgrade water infrastructure
Loss of tourist revenue due to smoke and heat waves	More severe heat and more frequent heat waves	Near-term (already happening)	High	Medium	High (activities can shift from summer to shoulder seasons)	Local businesses, especially rafting outfitters	Low flows due to overdraft of the river already limiting rafting and fishing	Proposals for new water storage infrastructure and water diversions for agriculture	

Here are two examples of real-world climate vulnerability assessments that can be examined to learn more about what real world impacts could be included in a vulnerability assessment.

Examples – Metropolitan Council Climate Vulnerability Assessment Introduction[106]

This assessment includes the definitions of climate impacts that can be analyzed to see how these definitions could be changed to refer more effectively to climate impacts faced by a specific community.

Figure 5. Generalized CVA Process



Climate vulnerability assessments analyze climatic impacts on a series of chosen indicators or assets. Each asset has an adaptive capacity to a potential impact. This adaptive capacity is a product of the exposure to the impact and the sensitivity of the asset to the impact. The product of the exposure/sensitivity and potential impact/adaptive capacity is a measure of the indicator's

[106] "Regional Climate Vulnerability Assessment."

vulnerability. This measure of vulnerability can be used to create a targeted menu of adaptation strategies to better maintain, plan for, and manage Council assets.

For this reason, the Metropolitan Council's Climate Vulnerability Assessment (CVA) focuses on regional climate hazards related to localized flooding and extreme heat.

· **Exposure** – Exposure is a degree of climate stress upon a particular asset or indicator; it may be represented as either long-term change in climate conditions, or by a change in climate variability, including the magnitude and frequency of extreme events. Unless otherwise indicated in this assessment, sensitivity of a given asset is combined with exposure to produce a relative metric for asset risk.

· **Potential Impact** – The potential impact is a combination of exposure and sensitivity in light of a climate hazard. The potential impact can be offset by adaptive capacity, or its ability to bounce back.

· **Adaptive Capacity** – Adaptive Capacity is the ability of a system to adjust to changes, manage damages, take advantage of opportunities, or cope with consequences. This assessment does not consider adaptive capacity of assets, though this would provide a better estimate of specific vulnerability.

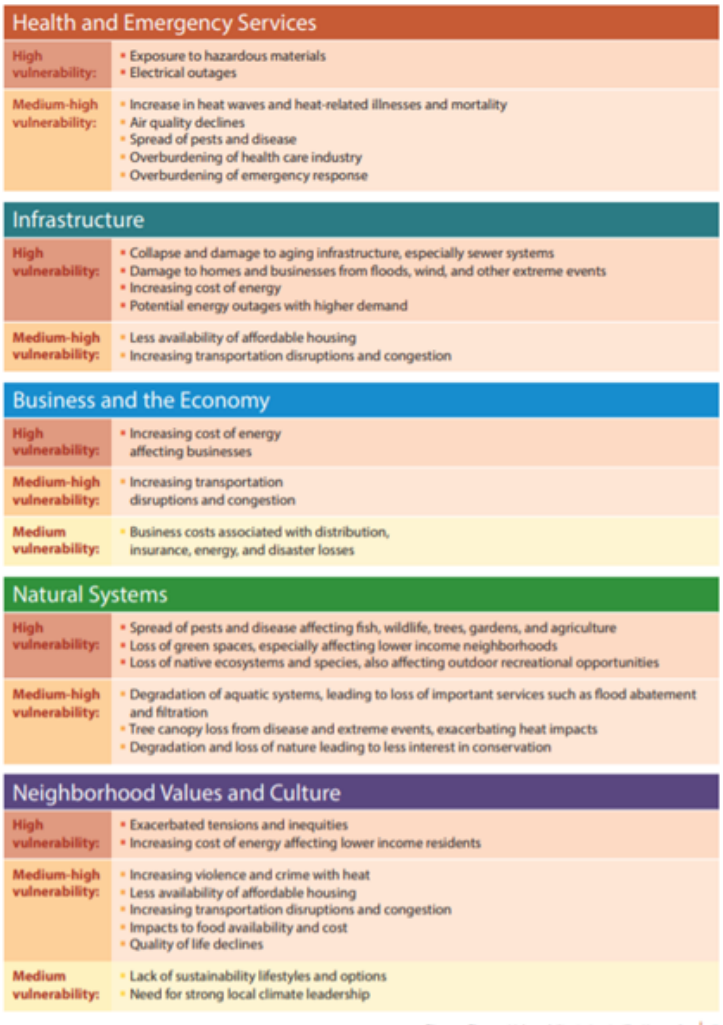
· **Vulnerability** – The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

· **Strategies** – Strategies are recommended actions that consist of best practices to preserve or enhance system assets. These strategies will most often encompass adaptation to climate change impacts, but some may include mitigation measures, like tree planting to offset GHG emissions

Examples – Louisville Climate Vulnerability Assessment[107]

Here are some examples of the climate impacts that Louisville found and how they relate to the specific locational and demographic make up of the city:

[107] "Climate Change Vulnerability in Louisville, Kentucky."



Health and Emergency Services	
High vulnerability:	• Exposure to hazardous materials • Electrical outages
Medium-high vulnerability:	• Increase in heat waves and heat-related illnesses and mortality • Air quality declines • Spread of pests and disease • Overburdening of health care industry • Overburdening of emergency response

Infrastructure	
High vulnerability:	• Collapse and damage to aging infrastructure, especially sewer systems • Damage to homes and businesses from floods, wind, and other extreme events • Increasing cost of energy • Potential energy outages with higher demand
Medium-high vulnerability:	• Less availability of affordable housing • Increasing transportation disruptions and congestion

Business and the Economy	
High vulnerability:	• Increasing cost of energy affecting businesses
Medium-high vulnerability:	• Increasing transportation disruptions and congestion
Medium vulnerability:	• Business costs associated with distribution, insurance, energy, and disaster losses

Natural Systems	
High vulnerability:	• Spread of pests and disease affecting fish, wildlife, trees, gardens, and agriculture • Loss of green spaces, especially affecting lower income neighborhoods • Loss of native ecosystems and species, also affecting outdoor recreational opportunities
Medium-high vulnerability:	• Degradation of aquatic systems, leading to loss of important services such as flood abatement and filtration • Tree canopy loss from disease and extreme events, exacerbating heat impacts • Degradation and loss of nature leading to less interest in conservation

Neighborhood Values and Culture	
High vulnerability:	• Exacerbated tensions and inequities • Increasing cost of energy affecting lower income residents
Medium-high vulnerability:	• Increasing violence and crime with heat • Less availability of affordable housing • Increasing transportation disruptions and congestion • Impacts to food availability and cost • Quality of life declines
Medium vulnerability:	• Lack of sustainability lifestyles and options • Need for strong local climate leadership

Some of the most important impacts to Louisville include disruptions to major transportation hubs, failure of aging infrastructure, health impacts associated with heat and air quality, exacerbated impacts to populations and resources already under stress, and degradation of natural systems that are vital to the health and well-being of local residents.

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