Southern Appalachian Highlands Conservancy

Climate Change Action Plan

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SAHC Climate Change Action Plan Organization and Purpose

The Southern Appalachian Highlands Conservancy (SAHC) Climate Change Action Plan is intended to serve as an internal resource for employees, interns, and AmeriCorps participants to communicate the following:

- What are the regional impacts of climate change on the Southern Appalachians?
- How has SAHC’s previous work contributed to climate change adaptation, mitigation, and resilience?
- What steps is SAHC currently taking to intentionally address climate change?
- What future actions can SAHC reasonably take to build upon these steps?

This Action Plan outlines the basic science of climate change, and delves into the regionally-specific climate impacts that we can expect to see (and in some instances, are already seeing) throughout Southern Appalachian ecosystems. Our understanding of these impacts shape the guiding principles of climate-responsive actions SAHC can take going forward. Following a brief explanation of specific climate mitigation and adaptation strategies, the Action Plan then outlines the ways in which SAHC’s work has already contributed to climate change action, and makes recommendations as to how the organization can more actively incorporate these strategies into our work.

The Climate Change Action Plan is a living document that should be regularly revisited and updated. Advances or changes in climate research, policy, planning strategies, and other pertinent topics should be reflected in this Action Plan. In the future, SAHC may also incorporate into the Action Plan a brief list of its climate-responsive projects, to serve as a convenient reference for related communications.

Introduction

Since 1974, SAHC has permanently protected over 80,000 acres of unique plant and animal habitat, clean water, farmland, scenic beauty, and places for all people to enjoy throughout the mountains of North Carolina and Tennessee. Anthropogenic climate change is affecting ecosystems and communities across the Southern Appalachians, while the region experiences dramatic population growth. Our cities and towns are growing, with people moving here from all over the country for our temperate climate and high quality of life. Places that formerly felt remote are facing the threat of development and land use change to meet the needs of our growing communities. People need places to live, but unfettered or poorly planned development can hinder the health and functionality of landscapes. In turn, this compromises landscapes’ capacity to deflect the impacts of climate change, as well as their ability to provide humans with ecosystem services and native species with habitat.

We’re thus faced with the dual threat of development pressure and climate change. As a regional land trust, SAHC is uniquely positioned to identify and respond to unique climate threats in the Southern Appalachians. Climate-conscious land conservation, protection, and stewardship not only safeguards ecosystems and communities from climate change threats, but it also strengthens the landscape’s ability to mitigate and adapt to these threats in the long run. Being a community-based organization, it is also imperative that we engage stakeholders, landowners, and community members in contributing to and catalyzing climate action.

Addressing climate change is fundamental to perpetuating our mission of conserving the wildlife, natural resources, and scenery of the Southern Appalachians. This Climate Change Action Plan aims to provide SAHC with a consolidated resource to help the land trust communicate how its work fits into climate change action at a regional scale. It also intends to guide SAHC’s future efforts to more explicitly incorporate climate responsiveness into its conservation work.
Background: Climate Processes, Impacts, and Benefits of Action

Climate Processes and Impacts
Climate change is defined as long-term changes in regional or global climate patterns, including cooling, warming, and other atmospheric conditions. The climate has been changing for millions of years, with changes resulting from natural geological and solar cycles. Recent overall warming trends, however, show that global temperatures are rising at an unprecedented pace. This pattern is attributed to human activities since the industrial revolution (primarily the burning of fossil fuels) that have increased atmospheric greenhouse gas (GHG) concentrations, speeding up the greenhouse effect and warming the atmosphere (NASA).

GHGs — carbon dioxide, methane, nitrous oxide, water vapor, chlorofluorocarbons, and hydrofluorocarbons — retain and re-radiate heat in Earth’s atmosphere. GHGs are generally long-lived in the atmosphere, meaning that they build up over time. This trapping of heat in the atmosphere and subsequent atmospheric warming is referred to as the greenhouse effect. GHGs are released naturally, but anthropogenic emission of GHGs is occurring at a much more rapid rate that is reflected in increases in atmospheric temperatures. The rapid and large-scale burning of fossil fuels to power industries represents the largest source of anthropogenic GHG emissions. Land conversion is another major source of GHGs, but to a lesser extent. An increase in GHG emissions has intensified the greenhouse effect, speeding up the rate of atmospheric warming. GHGs are described as a climate change “forcing” because they are an initial driver of warming (other drivers include solar irradiance and aerosols, i.e., dust/smoke/soot). The anthropogenic intensification of the greenhouse effect is termed “anthropogenic forcing,” and it is this process that encapsulates the “climate change” discussed by scientists, politicians, and practitioners.

Warming caused by an intensified greenhouse effect triggers cascades of climate feedbacks that may contribute to further warming and stretch far beyond changes in temperature. Climate feedbacks cause shifts in atmospheric, hydrological, geological, and ecological processes, fundamentally changing natural systems. Interactions between climate forcings and feedbacks are extremely complex and vary across scales and ecosystems, lending a degree of uncertainty to climate projections.

Climate change interacts with stressors, meaning that its impacts interact with or exacerbate existing environmental and social challenges; conversely, stressors can also make social and natural systems more vulnerable to climate change impacts. Unsustainable development and urbanization, natural disasters, social inequality, biodiversity loss, land and water degradation, and food insecurity are just some examples of stressors whose threats magnify or are magnified by climate change. Many of these issues are inextricable, which underscores the interconnectedness of social and natural systems—particularly amid climate change (Intergovernmental Panel on Climate Change, 2022).

Climate Change and Ecosystem Services
Ecosystem services are the multitude of benefits that nature provides to humans, and they fundamentally represent the dependence of societies on natural resources. Healthy, functioning, and biodiverse ecosystems are the foundation of all ecosystem services. Therefore, climate change impacts to species, populations, and ecosystems affect the delivery and availability of ecosystem services. Weiskopf, et al.’s summary (2020) of the 4th National Climate Assessment (2018) states that as communities face losses in ecosystem services due to climate change impacts, they will likely experience declines in physical health, mental health, and economic livelihoods. Southern Appalachian communities will likely experience changes in ecosystem services, affecting the way people farm, fish, hunt, work, and recreate. As delineated in Climate Change Impacts and Feedbacks in the Southern Appalachians, these changes will manifest differently across SAHC’s conservation focus areas.
Taking Action
International collaborative efforts on climate science and policy have stressed the importance of collective action to mitigating climate change. In 2022, the United Nations’ Intergovernmental Panel on Climate Change (IPCC) stated that global warming, reaching 1.5°C in the coming decades, “would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans.” IPCC also states that near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages compared to higher warming levels, but cannot eliminate them all (2022). More broadly, IPCC recognizes that since 2014, climate change has grown in salience worldwide across all levels of government, NGO, businesses, and citizens.

Climate change is often discussed at the global scale, but local knowledge is essential to helping decision-makers plan for climate change effects faced by communities and surrounding ecosystems (Howarth & Painter, 2016). Land management organizations and agencies play a key role in implementing climate change solutions that are sensitive to the needs of local ecosystems and communities. As a regional land trust with nearly fifty years of conservation work, SAHC can contribute to nature-based climate change solutions that are founded on local ecological knowledge and social contexts. As of 2016, over 80% of Southern Appalachian land is privately owned, with approximately 75% of Western North Carolina forests under private ownership (Southern Appalachian Vitality Index). This means that private landowners have considerable control over the health and future of Southern Appalachian forests. In combination with the trust SAHC has built with Southern Appalachian landowners, this high degree of private ownership presents us with opportunities to work with landowners to implement climate mitigation and adaptation measures.

As a land protection organization that has been conserving natural heritage and building community trust for nearly fifty years, SAHC is well-positioned to help forge a climate-resilient Southern Appalachian landscape. In doing so, SAHC ensures the viability of its mission amid a rapidly changing climate, and joins the global effort to mitigate and adapt to the effects of climate change.

Climate Change Impacts and Feedbacks in the Southern Appalachians

The Southern Appalachians are home to some of the world’s most biodiverse temperate ecosystems. This is a result of the region’s age, geologic and ecological history, and variation in topography and environmental conditions. This diversity is reflected throughout SAHC’s six conservation focus areas. From the French Broad River Valley’s cove forests to the high elevation spruce-fir forests of the Highlands of Roan, climate change is expected – and is already impacting – our conservation focus areas in myriad ways.

Climate predictions for the Southern Appalachians are not easily simplified, but it’s agreed that warming is intensifying the severity of the region’s weather cycles. Wet seasons are becoming wetter; hot and dry seasons are becoming hotter and drier. In typically wet seasons, heavy rainfall is becoming more extreme and frequent, as warm air holds more water vapor. Hot and dry months are accompanied by more common and severe drought and more high-temperature days. Winter temperatures are consistently rising, decreasing snowpack and allowing pests to subsist for longer. Along with the unique challenges imparted by changing seasonality, an increasingly severe “pendulum effect” characterized by a regimen of climate extremes represents a pressure in itself.

Rainfall, Rivers, Riparian Areas, & Watersheds

Changes in Precipitation
Precipitation and flooding models performed in the 2020 North Carolina Climate Science Report (Kunkel et al.,
2020) predict a “very likely” increase in extreme precipitation events (defined as yielding ≥3 inches per hour) for a significant portion of the Southern Appalachian region during wet seasons.¹ Heavy precipitation events are associated with severe inland flooding, and in mountainous areas, landslides caused by destabilized ground. Although heavy precipitation events are expected to increase in frequency, this frequency will be seasonally concentrated; essentially, wet months will become wetter, and dry months drier. Appalachian State University researchers estimate that May and October will see increases in monthly precipitation upwards of 30%, and similar increases during June (22%) and July (26%). Monthly precipitation in August and September is projected to decrease by 9% and 12% (Kowalczyk et al., 2020).

Changes in hurricane and storm regimes are expected to contribute to increases in precipitation as well. Although the exact future of hurricane patterns in the Southeast is unpredictable, there is consensus that hurricanes will generally become more frequent (Kunkel et al., 2020). Hurricanes may not pose a direct threat to the Southern Appalachians, but recent extreme precipitation events and resultant hazards (e.g., inland flooding, infrastructure damage, geologic hazards) in this region have been associated with large hurricanes such as Fred (2021), Florence (2018), Frances, and Ivan (2004) (Stewart & Berg, 2018; Covell and Yuh-Lang, 2008; Collins, 2014; Vaillancourt, 2021). The effects of changing hurricane patterns on the Southern Appalachians are further discussed in Wildfire and Severe Weather Risks.

Precipitation models predict a very likely decrease in total snowfall, and fewer heavy snowstorms, with more winter precipitation occurring as rainfall. Conditions favorable for snow formation and sustained snowcover have varied greatly since the 1980s, but recent years have seen below average periods of time offering favorable conditions, as well as an overall reversal of the cooling patterns and anomalously high snowfall that occurred in the mid-late 20th century (Kunkel, 2020; Eck, 2017).

In periods of drought, ridgetop forests are expected to increase their water consumption, reducing overland streamflow. This is partially due to changes in forest composition further contributing to a lack of water availability (see Forests).

**Rivers & Riparian Areas**
A warming climate is reflected in mountain streams and rivers, threatening aquatic habitats for thermally sensitive native species like the Appalachian brook trout. Coldwater species are expected to shift their habitats towards headwater streams, with some coldwater species possibly facing future extirpation. Many coldwater aquatic species are already making this shift, and this trend is projected to continue (e.g. Hickling et al, 2006; Comte et al, 2013). An analysis by Comte and Grenouillet (2013) suggests that although species ranges are shifting in response to climatic changes, ranges of some stream fish may not be changing quickly enough to cope with future climate modifications.

As the highest elevation streams in the Southern Appalachians, headwater streams are aquatic climate refugia, but their habitability amid climate change remains uncertain. Stream habitat modeling performed by E&S Environmental Chemistry, USDA Forest Service (USFS), and Oregon State University found that a significant number of Southern Appalachian headwater streams have experienced some degree of acidification and may not be hospitable for acid-sensitive coldwater species. These species would therefore be constrained to mid-elevation streams where temperature remains a stressor. The model findings translate to average losses of around 10% of stream habitat for coldwater aquatic species for seven national forests in the Southern Appalachians, and up to a 20% loss of stream habitat in the Pisgah and Nantahala National Forests (McDonnell et al., 2015).

¹ These models are in reference to the Western Mountains Region of North Carolina, a 25-county region in which the majority of SAHC’s conservation focus areas are situated.
Forests

Forests in the Southern Appalachians range widely in composition and structure, fostering incredible biodiversity and important ecosystem services like carbon storage, clean water provision, flooding control, and timber products. The U.S. Forest Service recognizes eleven Southern Appalachian forest types, each distinguished by unique vegetation, environmental factors, and ranges (USDA Forest Service, 2022). Climate change is projected to shift forest ranges and harm the health of forests, hindering their productivity and ability to provide ecosystem services to regional communities.

The many variations in environmental factors and topography in the Southern Appalachians – including variations across SAHC’s conservation focus areas – make it difficult to predict small-scale changes in forest types in response to climate change. However, the effects of climate change on high elevation spruce-fir forests are particularly tangible. Climate modeling predicts that future warming will shrink the ranges of spruce-fir forests, replacing cold-loving red spruce and Fraser fir with hardwood trees that can thrive in warmer temperatures. Spruce-fir forests are made even more vulnerable to climate change by their limited range, which is constrained to the highest summits of the Southern Appalachians; as well as a history of intensive logging and the threat of the balsam wooly adelgid. The future of spruce-fir forests is discussed in more detail in High Elevation Mountains.

The interaction between warming temperatures and pests is not limited to spruce-fir forests. In general, warmer winter temperatures will enable pests to survive through normally too-frigid conditions, giving them more time to move and reproduce. The hemlock wooly adelgid and the emerald ash borer are examples of invasive pests that are harming Southern Appalachian forests en masse (DeSantis, et al., 2013).

Warming temperatures will increase rates of evapotranspiration, subjecting forests to more severe and frequent droughts. Drought is a natural component of Southern Appalachian climate patterns, but increasingly severe and frequent droughts place trees under heightened stress, eventually causing mortality or making them more susceptible to other, potentially fatal stressors like pests and disease. We can expect to see a shift in habitat ranges for different forest types based on different species’ varying tolerance for drought (McNulty, et al., 2013).

Increased evapotranspiration also leads to higher fuel aridity, putting forests at greater risk of wildfires. Fire is a natural disturbance regime in the Southern Appalachians, but an intensifying fire regime may be to the detriment of forest health. An increase in dry, dead vegetation and plant litter will fuel wildfires that are more harmful to forest health and regeneration (Kunkel et al., 2020; Carter et al., 2018). Decades of fire suppression policies and improper logging practices have transformed natural fire regimes and created forests vulnerable to fire. This further contributes to heightened wildfire risk in the Southern Appalachians (Nowacki & Abrams, 2008). Research suggests that in the long term, increased drought and drought-induced fires will potentially shift the landscape away from this “mesophied” state, away from highly biodiverse but fire-intolerant mesic species (e.g. tulip poplar, maple) to more fire-tolerant species (e.g. oak, hickory) (Fesenmyer and Christiansen, 2010). These changes in disturbance regime affect their suitability as habitat for a plethora of native species such as elk and the Carolina northern flying squirrel (North Carolina Wildlife Resources Commission, n.d.).

The forested watersheds of the Southern Appalachians provide and purify water for regional communities.
and aquatic ecosystems. Forest streams yield water supplies to over ten million people in the Southeastern USA, with many residing in major cities (Caldwell et al., 2016). These ecosystem services are contingent on forest health. Recognizing this, SAHC has protected several forested municipal watersheds, including the Marshall, Woodfin, Weaverville, Canton/Waynesville, and Rough Creek watersheds. Recent studies have found forest health in decline due to emerging patterns of extremes, which comprise alternating periods of severe drought and heavy precipitation (Kunkel et al., 2020). A projected increase in precipitation during wet periods does not necessarily alleviate drought stress; rather, research has shown that drought stress drives trees to consume more water when it’s available. The result is a reduction in streamflow and groundwater availability that in turn deprives downslope environments of water (McQuillan et al, 2022).

These changes in water uptake have manifested over longer time periods and larger scales. In a 2016 study, researchers found that water yields from unmanaged forested Southern Appalachian watersheds declined from the 1970s through 2013, by as much as 22% in a given year. This decline was linked primarily to changes in both climate and forest composition, as oak-hickory forests were replaced by maple-poplar forests that consume up to four times more water (Caldwell et al., 2016).

High Elevation Mountains

Notable high elevation ecosystems in the Southern Appalachians comprise spruce-fir forests, grassy and health balds, and rock outcrops. Distinguished by their unique environmental conditions, these ecosystems are home to a breadth of endemic and rare species that thrive in cooler temperatures and cloud-immersed landscapes. The cooler temperatures of high elevation mountains create climate refugia that are buffered from the macroscopic effects of climate change. Scientists agree that rising temperatures are causing species to migrate to higher elevations and latitudes in search of more hospitable and moderate temperatures, with many species already making these shifts. Preserving high elevation habitats is integral to creating wildlife corridors for migrating high-elevation flora and fauna.

Spruce-Fir Forests

Because of their isolation among the highest elevation summits in the Southern Appalachians, high elevation spruce-fir forests are particularly vulnerable to climate change. As temperatures increase, fast-growing hardwood tree species become more competitive against red spruce and Fraser fir, which are adapted to cooler temperatures. A 1998 study (Delcourt & Delcourt) predicted that a 3°C increase in July temperature would raise climate elevation bands by 480 meters; with spruce-fir species already occupying the highest mountain summits, these alpine forests will be unable to migrate to higher elevations (McNulty et al, 2013). Moreover, numerous studies (e.g., Ulrey et al., 2016; Berry & Smith, 2013) suggest that climate warming will decrease the frequency of cloud immersion, an important source of water for spruce-fir populations.

Rising temperatures compound pressure from species competition by fostering more favorable environments for pests, which can kill trees outright or weaken them to other stressors. The balsam wooly adelgid has historically decimated spruce-fir forests and remains a threat. Warmer winters and high elevation temperatures will enable the balsam wooly adelgid to expand its range and seasonality, increasing the damage done to spruce-fir forests (Hrinkevitch et al., 2016; Paradis et al., 2008). Without conscientious stewardship efforts such as restoration and invasive pest removal (which SAHC currently conducts), spruce-fir habitats can be expected to shrink and be replaced by more competitive hardwood species. The loss of spruce-fir forests presents endangered endemic species, such as the spruce-fir moss spider, with considerable habitat loss.

Grassy and Heath Balds & Rock Outcrops

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3 For further reading on forests as a water source, see this publication by the North Carolina Forest Service and the USFS Forests to Faucets Story Map.
The United States Geological Survey (USGS) classifies Southern Appalachian balds and rock outcrops as “insular ecosystems” which occupy small, isolated areas of land but constitute significant biodiversity. They are generally characterized by little variation in temperature and relative humidity. Although these microclimates serve as a buffer from the macroscopic effects of climate change, it is unknown whether they can withstand rapidly shifting weather patterns and temperature increases in the long term. It is possible that species specializing in these sites may be particularly sensitive to climate change, because their highly specific adaptations may hinder them from adapting to the more forceful “pendulum swings” of changes in weather patterns (Berry and Smith 2013; Culatta and Horton, 2014). Warmer and drier summers, disturbances like more frequent freeze-thaw cycles during warmer winters, and less frequent cloud cover events (resulting in moisture regime changes) may increase mortality of endemic bald and rock outcrop species (Ulrey et al., 2016).

Grassy and heath balds are immediately threatened by competitive species for which rising temperatures are more amenable. This includes woody encroachment from hardwood trees and shrubs, in addition to invasive species, including a large number of non-native grasses, thistles, garlic mustard, and knapweed. Health balds are less prone to woody encroachment because they are typically characterized by acidic, poor-quality soil that inhibits the growth of nonnative species (Cartwright & Wolfe, 2016).

**Wildfire and Severe Weather Risks**

Across virtually all Southern Appalachian ecosystems, climate change, in tandem with increased development, is expected to increase the frequency and severity of severe weather risks that pose a threat to ecosystems, natural resources, and communities. Broadly, these risks comprise wildfires, drought, floods, landslides, and extreme precipitation events (Kowalczyk et al., 2020).

**Wildfires**

Wildfires are a natural disturbance regime in the Southern Appalachians, helping to maintain stable forest conditions and biodiversity. However, decades of misguided forest management strategies, unsustainable logging, and unmanaged development are coupling with an intensifying drought season to produce wildfires that are increasingly destructive and difficult to control. Moreover, researchers predict that climate-altered fire regimes will impart long-term shifts in forest composition that could reduce water quality and quantity (Mitchell et al., 2014).

The expansion of the wildland-urban interface (WUI) plays a prominent role in exacerbating exposure to (and sometimes severity of) severe weather risks, especially wildfires. As cities and towns continue to grow, development expands into forests and other natural, undeveloped landscapes that serve as buffers from natural disasters – buffers that shrink as more people move into them. With an ever-expanding WUI follows heightened exposure to natural disasters, and in turn, heightened risk. This issue builds upon itself with time: communities living in the WUI complicates prescribed burn efforts⁴ and may encourage fire suppression that, over time, makes future wildfires more difficult to contain. An expected increase in wildfires due to climate change will make living in the WUI even more dangerous, affecting the social and economic landscapes of communities.

Worsening wildfire seasons mean that SAHC will likely need to remain cognizant of how its protected forest ecosystems respond to changing fire regimes, as well as emerging challenges and hazards faced by landowners and other stakeholders.

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⁴ Like natural fires, prescribed burns can degrade air quality and harm human health, posing a challenge to conducting safe prescribed burns.
**Drought**

Increasing temperatures are projected to intensify dry seasons and drought in the Southern Appalachians. Drought in this region is expected to increase with respect to magnitude, frequency, and length (Voss et al., 2016). Intensifying drought will impose a multitude of challenges for the Southern Appalachian region’s natural and social landscapes. As discussed in *Forests*, exceedingly dry conditions induce drought stress in trees, harming forest health and hindering forest water provision. Drought also creates ideal conditions for wildfires, and models suggest that drought and wildfires are becoming increasingly correlated (Kunkel et al., 2020).

**Heavy Precipitation, Landslides, & Floods**

A changing precipitation regime, in which heavy precipitation events become more frequent, may cause more landslides and inland flooding in the Southern Appalachian region. The Southern Appalachians are a “hotspot” for landslides because of their steep topography. Landslides impart significant economic and physical damage to communities, and some rural communities are especially vulnerable to these impacts. More frequent extreme precipitation events may more intensely destabilize landscapes over time, causing a subsequent rise in the number of landslide events. Heavy precipitation events have also been correlated with inland flooding, as well as areas with relatively large areas of impervious surfaces (Kowalczyk, 2020).

**Farms and Local Food Security**

Southern Appalachian small farms are a fundamental part of the region's natural and cultural heritage. They also constitute an important source of food security and livelihood for many communities. Climate change is already impacting small-scale agriculture in this region.

It is difficult to pinpoint the exact effects of a changing climate on Southern Appalachian agriculture, due to the uncertainties of climate change and variations in ideal growing conditions for different crops. However, the increased frequency of climate-induced hazards such as flooding, landslides, wildfires, and drought will negatively impact farm stability and local food security. Shifting weather patterns, including late spring freezes, severe summer droughts, and extreme precipitation that washes away crops and soils, also threaten the viability of crops.

The small family-owned farms with which SAHC typically works are especially vulnerable to climate risks, in addition to the population growth driven by climate risks in other parts of the U.S. As farmers age and pass their properties to younger generations, and as shifting weather patterns obfuscate the economic viability of small-scale farming, landowners may choose to sell their properties for development instead of continuing farming traditions. Even the loss of inactive farms is significant, because the unique topography and agriculturally valuable soils that distinguish these farms can potentially serve future small-scale farmers. These important land features are lost forever if farmland is converted for real estate development.

The dual threat of extreme weather and development pressure is expected to continue as climate change progresses. Farmers may face increasing risks to their livelihoods as the climate changes. Shifting climate patterns and risks will translate to changes in best management practices for Southern Appalachian farmers. These new practices, intended to increase climate mitigation and resilience of farms, aim to enable farmers to grow their crops more efficiently while yielding better economic returns (Environmental Defense Fund, 2022).
Cities and Towns

From rural to urban, communities across the Southern Appalachian region will feel the effects of climate change in myriad ways. Isolated from the sea level rise, hurricane damage, heat waves, and severe droughts impacting other areas of the United States, the Southern Appalachians are currently considered a climate refuge compared to other parts of the United States. Social scientists note, for example, that the threat of sea level rise and worsening hurricanes are prompting residents from the coastal United States to relocate to inland areas of the Southeast, including the Southern Appalachian region (Hauer, 2017).

Climate change is still expected to affect – and is currently affecting – the Southern Appalachians, albeit at a pace slower than other regions of the country, as projected by Rhodium Group’s Climate Impact Lab (2020). The natural resource and development pressure caused by a drastic influx of people will have wide-ranging effects on Southern Appalachian ecosystems affected by climate change, as well as the health, safety, and economies of its existing communities.

The Appalachian Regional Commission reports that between 2010 and 2019, the population of Southern Appalachia increased by 7.6 percent, surpassing the national average growth rate of 6.1 percent and the Appalachian average of 1.8 percent (Pollard & Jacobsen, 2021). With increasing population densities follow development pressure and changes in land use, including the expansion of developed areas and impervious surfaces at the expense of natural landscapes and family farms.

Without the proper implementation of land protection and planning, land use change will harm ecosystems and wildlife directly, hindering their ecological resilience to climate change and the stressors it magnifies. This has a dual deleterious effect: without this resiliency, ecosystems and wildlife will be more vulnerable to climate change, which in turn threatens the provision of certain ecosystem services such as clean water supply, carbon storage, flood control, and more – ecosystem services that integral to sustaining Southern Appalachian communities and future growth.

Development in ecologically sensitive areas expands the WUI, leading to increased exposure to life-threatening environmental risks, including landslides, flash flooding, and wildfires. The Western Mountain region of North Carolina, which encompasses a considerable proportion of SAHC’s conservation focus areas, experiences the most landslides in the state. More extreme precipitation events are expected to correspond to a rise in landslide frequency, and expansion into previously undeveloped areas may heighten the threat of exposure (Kowalczyk, 2020).

Urban areas will experience climate change uniquely from rural and agricultural communities. Replacing vegetated areas with paved surfaces and infrastructure removes vital ecosystem services provided by vegetation, including flooding, surface runoff control, temperature regulation, air and water purification, and groundwater recharge (de la Barrera et al, 2016). More impervious surfaces and increased energy use from development lead models to predict a worsening heat island effect, which encompasses more aggressive heat waves and elevated emissions of air pollutants (EPA, n.d.(a)). Within urban areas, historically marginalized urban populations, including minority and low-income communities, have particularly high exposure to the risks of urban climate change, deepening social inequity (EPA, n.d.(b)). Nature-based solutions such as green spaces and smart growth are essential to protecting the health and safety of Southern Appalachia’s urban populations, while providing opportunities for carbon sequestration.  

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5 ARC also states that the Southern Appalachian region was the only Appalachian subregion where population growth rate exceeded the national average. The report also states that Tennessee and North Carolina saw especially rapid population growth since 2010, with increases exceeding 11%.

6 More information on mitigating the effects of urban climate change can be found on the EPA Website.
As discussed in *Farms and Local Food Security*, all of these environmental hazards pose a risk to agricultural productivity in the Southern Appalachians, which has implications for an economy that relies greatly on agriculture. Worsening climate change induced hazards also have direct effects on other economically significant sectors, including commercial forestry, aquaculture, transportation, water infrastructure, and recreation/tourism (Van Houtven et al, 2020). This also encompasses the financial strain that will come with recovering from climate change induced hazards. Rural communities are especially vulnerable to these hazards, as they often lack the financial resources to recover from disasters and implement resiliency measures to adapt to changing environmental patterns (Kowalczyk et al., 2020).

**SAHC Preserves and Easements (and other protected land)**

SAHC’s protected areas, which total over 80,000 acres, will inevitably experience the effects of climate change. The ecological and environmental diversity of these protected areas means all of the above climate change impacts will be felt across SAHC’s protected properties and adjacent lands.

The best management practices currently established for SAHC’s protected mountain and agricultural preserves may not apply in a future climate. It’s likely that SAHC will need to consider adaptive management strategies for its farmland, mountain, and forested properties, and in the future, draft easements that account for the unpredictability of climate change.

**Guiding Principles for Climate-Responsive Land Trust Actions**

The following guiding principles embody our understanding that climate change is a global issue that must be studied and addressed in a local context – both ecologically and socially.

- Incorporate adaptive management principles into strategies for land protection, stewardship, and community engagement; adaptive management reflects the dynamicity and variability of climate change impacts. Monitoring and evaluation can help guide adaptive management.
- Inform land protection efforts with up-to-date, preferably high-resolution scientific information, including maps and datasets.
- Design land management strategies that prioritize ecological functions, processes, and systems with an overarching goal of protecting terrestrial diversity. In this way, we recognize the inextricable relationship between abiotic and biotic diversity in the Southern Appalachians.
- Engage with stakeholders and landowners to continually address their needs and concerns.
- Recognize the interconnectedness of (and within) ecological and social systems throughout the Southern Appalachians.
- Use appropriate climate communication strategies to connect with a multitude of audiences, continuing to build trust with current and potential landowners.

**Climate Mitigation and Adaptation Potential**

Mitigation and adaptation represent two distinct yet equally important pathways of climate change action. Whereas mitigation aims to reduce anthropogenic impacts to climate systems (including controlling the emission of greenhouse gasses), adaptation focuses on adjusting or preparing natural and human systems for the effects of climate change (EPA, 2013). In the United States, federal, state, and local entities recognize mitigation and adaptation as distinct and vital climate change ways to address climate change. Notably, in 2018, Governor Roy Cooper issued Executive Order No. 80, titled “North Carolina’s Commitment to Address Climate Change and Transition to a Clean Energy Economy,” which aims to reduce North Carolina’s greenhouse gas emissions to pre-2005 levels through adaptation and mitigation (Exec. Order No. 80, 2018).
SAHC’s conservation and stewardship work inherently carries out mitigation and adaptation measures, but the degree to which our work explicitly addresses climate change in these ways can be enhanced in the coming years.

Given the mitigation and adaptation potential of Southern Appalachian forests and farms, SAHC is met with an opportunity to bolster this potential by taking advantage of scientifically-informed carbon storage and climate adaptation strategies. There are growing efforts by scientists, policymakers, and stakeholders to recognize the mitigating and adaptive capacities of the region’s natural and working lands (North Carolina Dept. of Environmental Quality & North Carolina Dept. of Natural and Cultural Resources, 2020; Nicholas Institute, 2021).^7

**Climate Mitigation With Natural Climate Solutions**

Climate change mitigation refers to actions that reduce or prevent the emission of greenhouse gasses. Broadly, this translates to reducing greenhouse gas emissions in the first place, or removing carbon from the atmosphere through technological or natural means. Carbon can be naturally removed from the atmosphere with natural climate solutions – conservation, restoration, and stewardship actions that better enable landscapes to accumulate and store carbon as natural carbon sinks. Landmark research led by The Nature Conservancy (TNC) suggests that natural climate solutions could mitigate over one-third of carbon emissions needed by 2030 to avoid an increase of 2°C (Griscom et al., 2017). Moreover, in the United States, natural climate solutions could potentially provide mitigation equivalent to 21% of the nation’s net annual emissions in 2025 (Fargione et al., 2018).

When disruptive land use change or disturbances destroy vegetation, terrestrial carbon sinks are upended, and they become sources that release stored carbon back into the atmosphere. To effectively store carbon, it is therefore vital to maintain sinks with land management best practices, and demonstrate their additionality for mitigation. Protecting land through fee-simple transactions and easements conserves them as carbon sinks by preventing development; active land management strategies such as stewardship and restoration help maintain the health and productivity of these sinks. Much of SAHC’s historical and current work therefore inherently contributes to mitigation. However, there are growing efforts by organizations and governments (e.g. State of California) to foster best management practices that enhance carbon storage capacity for parcels while working with landowners to ensure their economic and cultural needs are met.

Out of TNC’s 21 tangible natural climate solutions, forest and agricultural land management actions represent the highest proportion of mitigation potential (Fargione et al., 2018). Given the ubiquity of forests in the Southern Appalachians and our involvement with farmland preservation, there are significant opportunities for SAHC to contribute to natural climate solutions.

Preventing land use and land cover conversion of vegetated areas is one of the most effective ways to mitigate climate change, as doing so prevents carbon sinks from being destroyed in the first place. Preventing land use change also buffers protected areas: land use change around conservation easements can reduce their effective size and limit their ability to conserve biodiversity, as it interrupts ecological processes and connectivity (Hamilton et al., 2013). Considering the cost-intensive process of stewardship for carbon sequestration, simple prevention of land conversion is perhaps the most efficient way for SAHC to contribute to climate change mitigation.

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^7 For an interactive exploration of how natural and working lands facilitate ecosystem services and carbon storage, see the Nicholas Institute’s [Natural and Working Lands Project](https://www.nicholas.duke.edu/natural-and-working-lands-project). Although this project is focused on North Carolina, many other governments and coalitions have been working to quantify ecosystem services on their own natural and working lands across the United States.
Conservation easements are an invaluable means of mitigation because they can restrict inappropriate development and land use change throughout ownership transfers and increasing development pressure. At the same time, easements that incorporate climate mitigation should still enable farmers to keep their land economically viable. Land conversion may be necessary when population increases require development in an area, but when possible, development should be carried out in a manner that integrates natural climate solutions.

**Carbon Storage in Forests & Forest Soils**

Forests and their soils are a globally significant carbon sink. The world’s forest ecosystems store more than 80% of terrestrial carbon and over 70% of soil organic carbon. In the United States, forests and forest products capture and store approximately 15% of fossil fuel-emitted carbon emissions. Maintaining forests and ensuring their ability to sequester carbon is therefore a cornerstone of climate change mitigation. International institutions (e.g. Kyoto Protocol) and environmental organizations (e.g. TNC), and individual nations including the United States recognize that managing land and forests for carbon sequestration is vital to reaching global climate change goals (Ameray et al., 2021).

When forests are degraded, removed, or destroyed, they become a carbon source, releasing large amounts of carbon dioxide back into the atmosphere and contributing to greenhouse gas emissions. Thus, protecting forests from land use change inherently preserves them as a carbon sink, but sustained protection through stewardship is essential to keeping carbon sequestered in biomass and soils (Marx et al., 2021; Ling et al., 2020).

A 2021 analysis by TNC found that forests across the continental United States could potentially remove up to 865 million metric tons of carbon dioxide from the atmosphere each year between now and 2050, if protected from major disturbances (The Nature Conservancy, 2021). Protecting undeveloped forests increases their carbon sequestration potential; research has shown that conserving mature forests results in greater soil carbon storage (Luysaert et al 2008). It has also been observed that under proper best management practices, commercial forests can mitigate emissions considerably (Forster et al., 2021). A significant portion of SAHC’s protected properties contain forested land that also exhibits considerable carbon sequestration potential (Figure 1). Thus, the land trust’s decades of protection efforts have contributed to mitigation through forest carbon sequestration. Through fee-simple transactions, conservation easements, and land transfers, continuing to protect forested properties throughout the our conservation focus areas undoubtedly builds upon this contribution.

Research shows that different forest and soil types vary in carbon sequestration potential, thereby requiring different management strategies (e.g., Nabuurs and Mohren 1995, Forster et al 2021). Building on current practices of maintaining general forest health and productivity, SAHC can potentially bolster its forest carbon sequestration efforts by implementing silvicultural, restoration, and stewardship practices that help promote carbon storage, depending on the type of forest that covers a property. Prescribed burns, for example, have been shown at times to aid in more sustainable soil carbon sequestration and prevent intense wildfires that destroy or severely damage forests (Pellegrini et al 2021; US Forest Service). For forests under conservation easements, SAHC should engage with landowners in conversations and resources on how to best manage their individual forested lands for carbon sequestration (e.g., Marx et al, 2021).

Intentionally managing forests for carbon sequestration is not without its challenges. According to Andy Tait, Co-Director of Forestry at EcoForesters, forest management solely for carbon sequestration presents trade-offs at the expense of other forest co-benefits. For example, forests that most successfully sequester carbon in the long run are typically mature and undisturbed; encouraging this kind of forest growth compromises opportunities for other important ecosystem services, such as habitat for endangered species.
(e.g., Golden-winged Warbler), climate resilience, and recreational opportunities (A. Tait, personal communication, July 7, 2022). “Think about the negative outcomes of our forests when we managed them for a single purpose – timber – for over a century,” says Tait. He stresses that at a time when forests need to withstand the impacts of climate change, managing a forest solely to maximize its carbon sequestration potential may present its own drawbacks.

**Farmland as a Carbon Sink & Climate Smart Farming**

Just as forests and their soils can aid in the storage of carbon, so too can soils and agricultural vegetation across Southern Appalachian farms. There is untapped potential in utilizing farmland as carbon sinks: with proper management, U.S. farms alone can mitigate approximately 315 megatons of carbon dioxide per year (Fargione et al, 2018).

Agriculture in the U.S. releases large amounts of greenhouse gasses; in fact, the EPA estimates that in 2020, agriculture accounted for 11.2 percent of the nation’s emissions. Conventional, often unsustainable farming practices are significant drivers of these emissions. Adopting climate-smart farming practices in place of these actions can help mitigate emissions and enhance the sustainability of the agricultural sector. Examples of these actions include crop rotation, higher-residue crops, reducing fallow croplands, conservation tillage, changes in grazing practices, and agroforestry (Mulligan et al., 2018). Implementing sustainable farming practices can aid the capacity of farmland soils and vegetation to act as carbon sinks, while improving the productivity of these farms. Managing working lands for carbon sequestration also yields co-benefits that can contribute to climate adaptation and resilience. Some of these include biodiversity, water supply and quality protection, pollinator habitat, flood attenuation, and recreational opportunities (Nicholas Institute, 2021).

Although climate-smart agricultural practices offer innumerable environmental and social benefits, there may be a degree of challenge in encouraging farmers to take on the responsibility of adopting new best management practices. The process of identifying and implementing appropriate sustainable farming approaches may burden farmers and commercial foresters with more immediate logistical challenges such as training, financial costs, and possible changes in crop yields. Therefore, these practices may not be immediately attractive to farmers and commercial foresters. There is potential for SAHC to leverage its Farmland Program, including connections with regional sustainable farmers and institutions like North Carolina State University, to help alleviate these issues. For more information about how SAHC practices sustainable agricultural practices on its Community Farm, see [Grow: Incorporating Sustainability Into Our Operations](#).

**Carbon Offsets & Markets**

Carbon offsets (aka carbon credits) offer economic incentives to individuals and businesses to mitigate their GHG emissions. Offsets are generated through either by reducing or ceasing emissions, or sequestering carbon, usually through the creation and maintenance of carbon sinks. Carbon markets present a potential financial opportunity for land trusts and landowners. They can act as a source of revenue for landowners implementing natural climate solutions on their lands. More significantly, carbon offsets can serve as a revenue stream that helps land trusts finance focal projects (Chiang et al., 2020(a)). In the future, there may be potential in encouraging small landowners to engage in carbon projects; more than one-third of U.S. forests are stewarded by individuals and families, and this number is much higher in the Southern Appalachians, at approximately 70 to 80% (Southern Appalachian Vitality Index).

Entering carbon markets can be costly, resource intensive, and complicated. Despite the challenges that carbon finance currently presents to SAHC, the carbon finance landscape is constantly changing. Small landowners have historically been excluded from carbon markets, but recent initiatives (e.g., [Family Forest](#)
Carbon Program; Forest Carbon Co-op) provide funding and expertise to small landowners who wish to enter carbon markets (Scarlett, 2020). There is also a growing pool of resources for land trusts seeking to set up carbon projects and engage in carbon finance. Among these resources are carbon market literature specific to land trusts; organizations offering decision-making and organizing guidance; and programs that offer land trusts the tools they need to execute their own carbon projects. In 2020, Land Trust Alliance partnered with Finite Carbon and The Climate Trust to launch a five-year carbon offset pilot program, which includes the Improved Forest Management Offset pilot program. Appalachian Carbon Exchange, an initiative of the Tennessee River Gorge Trust, poses another potentially valuable opportunity in which SAHC could participate. Case studies of land trusts that participate in carbon finance are also available for review.

For SAHC, parcel acreage represents an obstacle for engaging in carbon markets: current minimum acreage standards for cost effectiveness are beyond the land trust’s capacity (M. Pugliese, 2022, personal communication, July 7, 2022). Aggregation and co-operative approaches may help alleviate this problem with their focus on pooling acreages into individual carbon projects (Chiang et al., 2020(a)).

Carbon offsets are a valuable mitigation tool, but their effectiveness and conscientiousness requires careful implementation, especially as carbon markets continue to evolve. Furthermore, as a small land management organization, we will need to navigate unique challenges that require strategic long-term planning. Land Trust Alliance has published the following guidance intended specifically for land trusts seeking to engage in carbon markets:

- Carbon Markets: Are They Right for Your Land Trust? (Chiang et al., 2020(a))
- Carbon Offsets in Conservation Easements: The Essentials For Land Trusts (Chiang et al., 2020(b))

Carbon markets and mitigation policies are rapidly changing: policymakers and practitioners are increasingly recognizing the urgency of climate change mitigation, and working to make carbon offset trading more accessible to smaller organizations. While carbon markets currently pose numerous hurdles for SAHC and its landowners, it would be valuable to periodically revisit the idea of carbon finance as policies continue to change.

**Climate Adaptation**

Climate adaptation involves adjusting to changes in climate and weather regimes, with the overall goal of reducing the vulnerability of species, ecosystems, and communities to harmful climate change impacts. When faced with changing environmental conditions that push their limits, species can respond by adapting to their new environment (through behavioral changes and phenotypic plasticity), migrating to more favorable conditions that resemble their optimal habitat, or becoming extirpated (Davis et al., 2005). Research shows that the climate is changing faster than species can adapt and migrate, with anthropogenic barriers complicating these processes (Parks et al., 2020). Land managers are thus faced with the task of implementing adaptation strategies to help species either migrate to new environments (a form of assisted migration), or adapt in place.

Underlying a species’ capacity to migrate to more hospitable environments, is the amount of new habitat available to it. Equally important is the accessibility of this habitat, highlighting the need for habitat connectivity. Wildlife corridors will need to account for climate connectivity, which focuses on facilitating movement across a landscape in response to a changing climate. Climate connectivity differs from general habitat connectivity in that the former must anticipate climatic changes within a landscape over time. Wildlife corridors have long been a cornerstone of conservation, but future land protection efforts must look to climate corridors – wildlife corridors that correspond to projected shifts in habitat ranges and facilitate migration. Prioritizing certain landscape features and climate refugia will aid in these efforts – see “Building Climate Resilience” and “Conserving the Stage’ of the Southern Appalachians” for elaboration.
At the same time, factoring human land use into climate connectivity efforts is essential for ensuring that species can migrate effectively. According to the U.S. Forest Service, the majority of climate vulnerability assessments do not account for human impact, even though human land use substantially hinders climate connectivity (Parks et al., 2020). Given the growing development pressure in the Southern Appalachians, and the tendency for land to be subdivided as it is sold, accounting for anthropogenic influences is especially pertinent to our work. In cases where properties fall within or adjacent to climate corridors, SAHC can work with landowners to facilitate climate connectivity on their lands through easements and appropriate land management strategies.

Conscientious stewardship and restoration is essential to maintaining climate adaptation measures, and these practices also play into helping species adapt in place. Stewardship practices should be responsive to local and regional climate change impacts, with the goal of enhancing the general health of species and ecosystems. In-place climate adaptation may involve modifying a habitat to make it more amenable for a species – for example, increasing the amount of stream shading for native brook trout by planting streamside trees. Another form of in-place climate adaptation involves selectivity populating an ecosystem or landscape with species that can survive projected changes in climate. A more scientifically intensive version of this involves selectively breeding plants, trees, and (to a lesser extent) animals that have higher tolerance for disturbances. Depending on available resources, stewardship and restoration can incorporate species, or variants of species, that are more tolerant of extreme weather, pests, and disease.

Partnerships with organizations that have the resources to carry out long-term ecological studies can contribute to an understanding of climate change impacts on Southern Appalachian ecosystems. Through these partnerships, our properties can serve as a living laboratory for a science-based exploration of how human-led efforts can help sensitive species adapt to climate change impacts.

USFS provides additional resources for climate change adaptation through its Climate Change Resource Center.

Building Climate Resilience

As discussed in previous sections, climate change will have distinct and remarkable impacts on ecosystems throughout the Southern Appalachians, with impacts often taking the form of magnified stressors and severe, rapid changes in climate patterns that must be withstood by species and ecosystems. Adaptation is a pathway to climate resilience, which is the ability of ecosystems and communities to prepare for, recover from, and adapt to the impacts of climate change. Climate resilient ecosystems also protect communities from harm: ecosystems that can bounce back from major disturbances can more readily continue to provide essential services to the people who rely on them (Trust for Public Land; Center for Climate and Energy Solutions).

The Nature Conservancy has extensively quantified ecosystem resilience across the United States. Most notably, in 2016, TNC released its “Resilient and Connected Landscapes” project, the first study to comprehensively map resilient lands and significant climate corridors across Eastern North America. Climate resilient landscapes are characterized by high microclimatic diversity and low levels of human modification. These landscape characteristics allow species to migrate and find amenable microclimates in which they can thrive (TNC, 2016). TNC’s Resilient Landscapes research has been integral to informing our conservation priorities. Refer to Protect: Using Resilience to Guide Conservation Priorities for more information about the role of resilience data in our land protection efforts.

Identifying and protecting resilient landscapes is just one component of safeguarding overall resilience. Effective stewardship of these lands at the ecosystem and species level is essential to helping species adapt to
changing conditions and reach a state of resilience. With the threat of development pressure and natural resource strain projected to impact the Southern Appalachian region in tandem with climate change, enhancing ecosystems’ ability to “bounce back” from both natural and human disturbances is crucial. As outlined by the Northern Institute of Applied Climate Science, limiting land conversion, preserving ecosystem connectivity, reducing stressors, and addressing vulnerabilities are four broad strategies to achieve resilience goals (Ferrare et al., 2019). Learn more about how we carry out these strategies in Steward: Building Resilience Through Climate-Responsive Stewardship & Restoration.
“Conserving the Stage” of the Southern Appalachians

Conserving nature’s stage (or conserving the stage) actively incorporates the diversity of landforms, geology, soil, and topography (i.e., abiotic diversity, or geodiversity) into conservation planning. Research has demonstrated that abiotic diversity drives biological diversity through the creation of microclimates that house endemic or highly specialized species. Thus, by conserving abiotic diversity we can more effectively protect biodiversity (Anderson and Ferree, 2010).

In the context of climate change, conserving the stage is a particularly valuable approach to species conservation. This is because in addition to preserving the abiotic features that support biodiversity in the first place, conserving the stage also contributes to climate adaptation by anticipating shifts in species’ habitat ranges. Thus, conserving the stage plays into facilitating connectivity – enabling species to reposition themselves across landscapes as the climate changes. Microclimates can also serve as climate refugia, meaning they are relatively buffered from macroscopic climate change impacts. Analysis suggests that the relationship between geodiversity and biodiversity is strongest at the landscape and regional scale (Lawler et al., 2015), underscoring our role in conserving the stage by protecting tracts of land.

In combination with latitude, age, and geologic history, it is the abiotic and topoclimatic diversity of the Southern Appalachians that helps facilitate its biodiversity, including a high concentration of native and endemic species (Estill & Cruzan, 2001). This array of diversity manifests across SAHC’s six conservation focus areas. The Highlands of Roan represent a significant portion of this abiotic and biological diversity; these mountains host numerous federally-listed endangered species whose existence hinges on the protection of high-elevation habitats. Our flagship Highlands of Roan Conservation Program demonstrates a commitment to conserving valuable microclimates that also serve as climate refugia for species expected to migrate to higher elevations. The TNC Resilient Lands Mapper shows that the Highlands of Roan are generally characterized by slightly above average to above average landscape diversity. Moreover, we actively work to build upon the connectivity of the Roan’s high elevation landscapes, helping to increase their resilience and building their capacity as climate corridors.

At a continental scale, conserving the stage of the Southern Appalachians may help foster climate connectivity across the larger Appalachian Mountain Range. Species migration models for both animals and plants generally predict north-to-south and upslope movement patterns as temperatures warm and make lower-latitude and downslope habitats less hospitable. Creating wildlife corridors in accordance with these patterns, particularly those that align with the Eastern Wildway conceptualized by the Wildlands Network, contributes to climate adaptation and resilience, because doing so preserves the conditions to which different species can migrate.

It’s important to note that the effectiveness of conserving the stage may vary according to factors such as latitude, scale, and biotic drivers like human interference. Conserving the stage, therefore, shouldn’t be considered a panacea to conservation planning. Instead, it should be seen as a valuable framework that can be readily adapted and combined with other conservation approaches, for example enhancing ecological connectivity (Lawler et al., 2015). In the Southern Appalachians, this translates to prioritizing abiotically diverse properties from development, while also ensuring these landscapes’ connectivity.
Southern Appalachian Highlands Conservancy Actions

SAHC’s 2020 - 2025 strategic planning objectives comprise four overarching goals.

**Protect** priority lands that further our conservation mission.

**Steward** land and conservation easements that SAHC holds, and lead the way in landscape-scale stewardship of the globally significant fragile ecosystems of the Highlands of Roan.

**Connect** people with land for outdoor recreation, health, fitness, wellbeing, farming, livelihood and learning, striving to create equitable access to land for all people.

**Grow** our organizational and financial capacity while supporting an equitable and inclusive culture in order to achieve our ambitious program goals and assure SAHC’s future sustainability to meet long-term responsibilities.

By preventing land conversion, stewarding land with scientifically informed management strategies, encouraging and implementing sustainable farming practices, and engaging stakeholders and communities in dynamic outreach initiatives, SAHC’s work since 1974 has inherently buffered Southern Appalachian landscapes from the effects of climate change. We have recently taken steps to make this work explicitly climate-responsive, particularly with respect to resilient and sensitive ecosystems.

Given the rapid pace of climate change, we will continue to actively incorporate climate-responsive actions into every facet of our work, principally through its strategic planning goals.

**Protect: Using Climate Change to Guide Conservation Priorities**

Climate-responsive conservation is foundational to any effective climate change action plan and our goal of protecting priority lands. Recognizing the distinct impacts of climate change throughout our conservation focus areas enables us to define conservation priorities, identify lands that embody these priorities, and strategize for their effective conservation in an era of emerging climate threats. Conservation easements and scientifically-informed priority planning are two examples of tools SAHC uses to carry out our conservation work. Going forward, it’s important that these tools account for climate mitigation, adaptation, and resilience potential of Southern Appalachian landscapes.

**Climate-Responsive Conservation Easements**

Conservation easements are a powerful tool for avoiding unsustainable land use change and development that can exacerbate climate change impacts or decrease resilience. Since easements are designed to protect land in the long term, they should certainly account for climate change and be responsive to localized impacts. In designing easements, land trusts should also provide landowners with the decision-making tools and knowledge needed to manage resilient landscapes. Land Trust Alliance recommends that easements should be designed to encourage adaptive management, allowing managers to address changing conditions and conservation values. Specifically, Land Trust Alliance recommends the following (2015):

- Identify conservation values that will endure
  - Recognize that some may change over time with climate pressures. What will it take to conserve these values over time? How can the ties between easement restrictions and purposes be clearly communicated?
- Provide comprehensive and detailed, project-specific background information.
- Provide sufficient flexibility to account for changes in species composition and the uncertainty of the effects of climate change, while still protecting the identified conservation values.
- Predict and address possible points of friction, to avoid challenges from future owners that the
An easement is too restrictive or out-of-date under changed conditions.

- Strive for clarity in what an easement prohibits and what it permits.
- Define specific terms, including those that refer to climate change specific impacts and processes.
- Incorporate performance, prescriptive, or compliance standards so that easement goals can be more readily met as the climate changes.
  - Performance standards may offer more flexibility than rigid standards, while avoiding technical violations that may not actually adversely affect protected conservation values.
  - Consider if some reserved rights should be contingent based on changes in best practices in agriculture, forestry, or land management.
- As conditions change over time, consider including discretionary approval or consent provisions, to avoid obsolescence.
  - Doing so may help landowners and SAHC meet unforeseen circumstances, while adapting to changes in conservation practices, evolving science, and shifts in environmental and social circumstances.
- Determine whether easement requirements that look to the law should be fixed to current law, attaching a copy of the law as an exhibit if necessary.
- Avoid unnecessary restrictions, keeping in mind that easements are best used to prevent harmful activities rather than to prescribe affirmative land management activities.
  - Provide a strong rationale for restrictions that strip economic value from the land.
- Recognize that landscape features, as well as ecological conditions, may change over time with temperature, hydrology, and other processes. Flexible land management plans and zone boundaries may help.

These guidelines are further described in Land Trust Alliance’s “Practical Pointers” document Drafting Conservation Easements to Adapt to Climate Change.

**Climate Resilient Parcel Prioritization**

SAHC deliberately incorporates climate resilience data into its conservation planning strategies, and has long demonstrated its commitment to the protection of highly significant resilient land. Prior to updating its geospatial decision support tool with climate resilience data in 2018, SAHC’s work had already protected over 64,000 acres of TNC identified priority resilient land through permanent conservation measures including conservation easements, fee simple acquisitions, and transfers to the US Forest Service and the State of North Carolina. This protected land lies primarily within SAHC’s conservation focus areas, which include over 1.7 million acres of “Far above average”, “Above average”, or “Slightly above average” resilient land, as calculated using TNC resilience data. SAHC’s service area also covers over 580,000 acres (37%) of the Open Space Institute’s Southern Blue Ridge Resilient Focus Area.

Selecting parcels for conservation poses a challenge to small organizations with limited resources and an abundance of priorities. Prioritizing these parcels is further complicated by the myriad impacts and unpredictability of climate change, highlighting the importance of informing climate-responsive conservation decisions with science and quantifiable data. Since 2013, SAHC has used geospatial decision support tools and datasets to quantify the conservation values of parcels. These conservation values are not meant to strictly limit SAHC land protection efforts to a given set of parcels; rather, they act as a guide as part of a more holistic prioritization process.

In 2018, SAHC integrated climate resilience data into its geospatial decision support tools. These datasets include TNC Final Resilience Scores, Open Space Institute’s Climate Resilient Southern Blue Ridge Focus Area, and Wildlands Network Underrepresented Settings. Developing a prioritization model that incorporates numerous climate resilience datasets has allowed us to identify new priority parcels.
and priority zones that inform broader land protection goals amid a changing climate. In line with the concept of “conserving the stage,” these datasets incorporate abiotic diversity into their climate resilience calculations. Recognizing the diversity of land cover and land use throughout its service areas, like differences in conservation values, SAHC has developed distinct land protection strategies, including separate prioritization models for both agricultural and non-agricultural parcels.

Throughout its history, SAHC has focused largely on high elevation natural areas in the Highlands of Roan – and properties in this conservation focus area are some of the most resilient in the Southern Appalachians. “Previously, we’d always prioritized these lands for other conservation values, like scenic views,” says Michelle Pugliese, Director of Land Protection (July 7, 2022). “Now, with climate change so immediate, we’re appreciating these properties’ added benefits of climate resilience and protection of sensitive habitats.”

**Steward: Building Resilience Through Climate-Responsive Stewardship & Restoration**

Responsible stewardship of conserved lands is a primary obligation of SAHC. Similar to the natural relationship between conservation and climate change, stewardship and restoration projects also inherently contribute to climate change mitigation and adaptation. Afforestation and reforestation are among some of the most effective natural climate mitigation solutions in the United States (Fargione et al., 2018). With respect to adaptation, traditional stewardship tactics like removing stressors and addressing vulnerabilities are more important than ever, because healthy species are better equipped to withstand rapidly emerging threats and changes in disturbance regimes induced by climate change.

SAHC has demonstrated its capabilities for climate-responsive stewardship in numerous ways. Examples include:

- **Creating and managing a conifer corridor to reforest at-risk high elevation ecosystems:** Maintaining a network of high elevation spruce-fir forests in the Roan Highlands helps foster habitat connectivity for climate-sensitive species.
  - SAHC is an active member of the *Southern Appalachian Spruce Restoration Initiative (SASRI)*, and has been awarded grants to carry out scientifically-informed land management actions – for example, planting over 5,000 red spruce seedlings in the Haw Orchard Ridge and Peake preserves. These two restoration sites have been selectively chosen, with the aim of creating a large, connected red spruce habitat.
  - SAHC’s spruce-fir restoration project also contributes to stream shading the high elevation streams that serve as native brook trout habitat.

- **Maintaining species and ecosystem health**
  - Across its forested properties, SAHC regularly conducts invasive pest treatment programs to enhance forests’ ability to withstand more extreme weather patterns while continuing to serve as habitat for other species.
  - In the Roan Highlands, SAHC works in partnership with the USFS and Appalachian Trail Conservancy to improve the health of sensitive high elevation species like *Gray’s lily*, in an effort to bolster these plants’ climate resilience.

- **Stewardship of municipal watersheds across the Southern Appalachians**, including the Marshall, Woodfin, Weaverville, Canton/Waynesville, and Rough Creek Watersheds, in addition to lands adjacent to the Asheville Watershed.
  - The protection and stewardship of municipal watersheds protects conservation values that serve both people and species. Safeguarding clean water sources is of ever-growing importance as populations grow and drought becomes more frequent. At the same time,
maintaining these watersheds enhances habitat connectivity for species.

- Encouraging or requiring agricultural and forest best management practices
  - Farmland easements incorporate specific best management practices, including rotational grazing, low-cost riparian buffers to protect streams from cattle, and cover crops. Many SAHC easements are also easements under the North Carolina Department of Agriculture (NCDA) and the USDA Natural Resources Conservation Service.

Going forward, SAHC may design and implement land management projects that are deliberately built upon climate-responsive strategies and goals. Climate vulnerability assessments can help identify anticipated climate risks, serving as a foundation for active stewardship goals. For example, in the design of climate resilient restoration projects, Simonson, et al. (2021) recommend the following framework:

1. Consider climate change uncertainties when setting restoration objectives
2. Select sites based on an understanding of projected changes to climate and wildlife connectivity
3. Account for future distribution and fitness when choosing target species and ecosystems
4. (Re)establish or manipulate key ecosystem interactions and microclimatic niches
5. Identify and mitigate for site-level climate change risks
6. Align project with long-term policies, seeking synergies across multiple objectives
7. Design monitoring framework that enables adaptive management of the restoration trajectory

Climate-responsive stewardship and restoration are essential to maintaining landscapes’ capacity to endure and adapt to climate change while providing natural climate solutions. If SAHC chooses to incorporate carbon projects into its work, stewardship and restoration may also incorporate mitigation strategies such as carbon storage projects (see Mitigation).

**Connect: Climate Change & Place-Based Conservation**

Climate change has historically been a polarizing topic, complicating climate communication strategies for nonpartisan organizations. As stated by Land Trust Alliance, although climate change has recently become a mainstream issue, effectively communicating its importance and urgency remains difficult. Climate change is a global issue, but it manifests in localized ways and impacts everyone differently, enabling people to connect with the issue in highly personal ways.

A “sense of place” has always been an important component of conservation, as it ties social values and cultural meanings into people’s natural surroundings (Foote & Azaryahu, 2009). Climate change and sense of place are inextricably connected, as climate change threatens to transform or destroy the places with which people have connected throughout their lives. By extension, the recreational activities and natural resources that shape people’s lives are threatened. In the Southern Appalachians, this means drastic changes in the way people – including future generations – hunt, fish, bird, hike, garden, eat, and farm. As a regionally-focused and community-based organization, SAHC can foster personal connections between people and climate change through education and outreach strategies. Connecting people with the land is one of SAHC’s core goals, and it is by nurturing this connection that the land trust has successfully carried out its land management projects (e.g., through volunteer projects and landowner cooperation).

Climate change communication experts, including Dr. Katharine Hayhoe, stress that climate change should be communicated to individuals and communities in a relatable manner. Inundating people with facts about broad environmental processes is less effective – and often counterproductive – compared with storytelling and one-on-one conversations. SAHC should continue to focus on cultivating appropriate language for communicating climate change to broad audiences. The organization can also tie place-based conservation into its educational outreach, emphasizing the specific ways in which
climate change affects the Southern Appalachian region and its socio-cultural landscapes. Further, SAHC can incorporate the concept of ecosystem services into outreach. This will help underscore the role of healthy and resilient ecosystems in all aspects of people’s lives, and how climate-responsive land conservation and stewardship in the Southern Appalachian Mountains amid a changing climate helps safeguard the region’s recreational opportunities, scenic landscapes, and clean water.

Jay Leutze, SAHC Senior Advisor to the board, follows this approach in conversations with landowners, legislators, and local decision makers. “You can’t deny the shifts we’re seeing, whether it’s in habitat ranges, precipitation, temperature,” he says. “So the question really is: how do we communicate these shifts as climate change to communities of people who may be resistant to that term?” Essentially, “it’s important to make a human connection between the changes in people’s own lives, and what conservation needs to look like in the future.”

**Grow: Incorporating Sustainability Into Our Operations**

Besides including climate change in its overall organizational work, SAHC is also committed to decreasing its carbon footprint in its daily operations. The organization has taken initiative on reducing its reliance on fossil fuels, and should continue to build upon these efforts going forward.

**Remote monitoring**

Annual monitoring of SAHC’s parcels is an important part of the land trust’s stewardship work. It is also essential to maintaining its accreditation through the Land Trust Accreditation Commission (LTAC). However, given the sheer acreage under SAHC’s protection, travel for on-site evaluations can be fuel-intensive, translating to increases in carbon footprint, especially as the land trust acquires more parcels that require regular monitoring.

Like other land trusts, SAHC has incorporated aerial monitoring into its stewardship practices, and has developed its own aerial monitoring protocol. In 2020, SAHC developed a geospatial tool that prioritizes parcels for aerial monitoring, increasing the efficiency of this practice in its land protection work.

Given the knowledge gaps inherent in remote sensing data, occasional in-person visits are required for properties. LTAC currently requires land trusts that use aerial monitoring to conduct on-the-ground monitoring at least once every five years (LTAC, 2021).

Recognizing the increased use of remote monitoring by land trusts, organizations such as Land Trust Alliance have established [grant programs](#) and other funding sources to grant land trusts the resources they need to conduct remote monitoring that ensures successful land protection and decreases carbon emissions.

**Commute flexibility (work from home)**

The COVID-19 pandemic has normalized work-from-home policies across the world - including at SAHC. Allowing employees to work from home reduces fossil fuel emissions generated by daily commutes.

**Reducing paper use**

SAHC has also reduced its paper use, relying on digital files in its daily operations and communications. Staff now utilize digital maps and surveys during field visits and have the ability to utilize digital signatures on formal documents. Reducing paper use translates to fewer emissions generated in the paper manufacturing process, and contributes to preventing deforestation.

**Solar panels on office and farm venue**

In 2019, SAHC added solar panels to its office roof, enabling the building to run on renewable energy. Additionally, solar panels and a solar powered system were installed to the SAHC Community Farm education
center and kitchen. In its Community Farm tours, SAHC teaches visitors about how solar energy works.

The addition of this system was made possible by the Southwestern NC Resource Conservation & Development REAP grant. The REAP (Rural Energy for America Program) provides small businesses and farmers with financial resources to improve energy efficiency.

Following in the footsteps of its solar panel installation projects, SAHC can continue to seek out resources to subsidize renewable or sustainable energy use.

Farm Practices
Serving as an educational site and working farm, the SAHC Community Farm is integral to educating the public about sustainable farming practices and the importance of locally-sourced agriculture. Local agriculture mitigates GHG emissions by reducing the need for long-distance transportation of agricultural products. SAHC is committed to making the production and procurement of local agriculture more accessible through its Farmer Incubator Program.

The Farm itself is managed with a suite of environmentally-friendly best management practices that include the following:

- **Conservative Farming**, which focuses on conserving arable land by “promoting maintenance o a permanent soil cover, minimum soil disturbance, and diversification of plant species” (United Nations Food and Agriculture Administration, n.d.)
- SAHC’s use of **Perennial Crops** enriches and stabilizes soil, fosters strong pest control, and requires less fossil fuel use in comparison to traditional, annual crops.
- **Silvopasture**, including a shortleaf pine reforestation project, contributes to carbon sequestration and overall soil health, while providing habitat for wildlife.
- **Black Soldier Fly Composting**: Food that is thrown away and decomposes without oxygen creates methane, a process that occurs in many landfills. Composting converts food waste with the help of microbes (e.g., black soldier flies) to create fertilizer instead of methane.
Monitoring, Evaluation, and Adaptive Management

As SAHC moves to integrate climate action into all facets of its work, the organization commits to a continual evaluation of these efforts. Climate change is catalyzing shifts in conservation values, ecosystem processes, and habitat ranges that will require corresponding changes in land management plans and organizational strategies. A basic understanding of these shifts not only contributes to a greater understanding of regional climate change in the Southern Appalachians, but also allows SAHC to understand the effectiveness of its own work and its role in imparting climate change action.

Monitoring & Evaluation (M&E) encompasses a broad range of activities necessary for tracking mitigation and adaptation progress over time. Monitoring refers to the continuous gathering of qualitative and quantitative information throughout stewardship efforts. Evaluation denotes comprehensive assessments of stewardship effectiveness, serving as a valuable launching point for future recommendations. SAHC already incorporates qualitative, anecdotal monitoring into its stewardship protocols, primarily to track compliance/violations and assess major changes on its easements and properties. Ideally, monitoring for climate change impacts would build directly upon current M&E protocols.

Selection of monitoring parameters should be guided by individual project goals, as well as climate vulnerability assessments that target specific species, ecosystems, or habitats in the context of anticipated climate impacts. Examples of parameters include biological/ecological data (e.g., species abundance, composition; indicators of health) and data on physical processes (e.g. hydrology - streamflow, water temperatures; erosion). Because the area of land SAHC monitors is expansive, monitoring may be limited to properties with particularly sensitive ecosystems, or properties that are being actively stewarded. The USFS Climate Change Performance Scorecard serves as an example of a M&E framework that can be adapted to SAHC’s needs. For more information on climate vulnerability assessments, refer to the Massachusetts Wildlife Climate Action Tool.

Rigorous, quantitative monitoring can be resource intensive and costly. SAHC can partner with organizations, agencies, and outside consultants to leverage their scientific knowledge and resources in tracking the effects of climate change on SAHC properties and easements. Citizen science projects, such as bio-blitzes, may represent another means of gathering large amounts of data over time while educating communities on the impacts of climate change.

Adaptive management is a powerful tool for forging long-lasting climate solutions because its flexibility anticipates the unpredictability of climate change. Evaluation of monitoring data can guide adaptive management frameworks to iteratively evaluate and adjust climate-responsive land protection and stewardship efforts. Broadly, adaptive management involves implementing a management strategy, closely monitoring its effects, and then adapting future actions based on the observed results. SAHC can also apply M&E and adaptive management principles to its organizational approaches and community engagement strategies. Land Trust Alliance summarizes the six general steps of adaptive management:

1. Assess current conditions; identify any problems; determine goals.
2. Design a management plan that incorporates these goals.
3. Implement the management plan.
4. Monitor the impact(s) of the management plan.
5. Evaluate the results of the monitoring process.
6. Modify the plan as needed to respond to changing conditions, as identified through the monitoring and evaluation process.

Further resources on adaptive management include:

Moving Forward: Future Actions and Considerations

The following list provides general suggestions for improving SAHC’s approach to a climate-responsive organizational strategy:

1. This climate change action plan should be treated as a living document, undergoing revisions in response to the most current scientific literature, policies, and SAHC’s organizational goals and strategic planning.
2. Continue to refine GIS prioritization models with respect to climate resilience, possibly developing higher-resolution models and refining models as new climate data become available.
3. Maintain up-to-date information on ecological resilience of the Southern Appalachian region, including wildlife connectivity, productivity, and diversity.
4. Refer to Land Trust Alliance’s *Conservation in a Changing Climate* library to guide project frameworks and train land protection staff.
5. Connect with and consult a range of climate experts, especially those who have specialized knowledge of climate change effects in the Southeast.
6. Establish a plan to further incorporate climate-responsive agricultural practices into the Farmland Program; provide farmers with training and resources needed to implement these practices.
7. It may be helpful for SAHC to engage in training for communicating climate change to different audiences.
8. Participate in regional climate change conferences such as the Southeast Climate Adaptation Science Symposium, and engage with climate-related speakers, workshops, and other climate-conscious land trusts at Land Trust Alliance Rally.
9. Communicate with other land trusts that have established climate change strategies; look to successful case studies that have been carried out by land trusts and are explicitly focused on climate change mitigation, adaptation, and resilience.
10. Work as part of regional partnerships (e.g., Southern Appalachian Spruce Restoration Initiative (SASRI), Roan Stewardship Committee, Conservation Trust for North Carolina) to implement climate change action.
11. Partner with science-based organizations and agencies to guide climate actions with the best available science, using SAHC protected lands as a living laboratory for research.
12. Consider climate connectivity in the context of the greater Appalachian Range, and partner with organizations that focus on larger-scale climate connectivity issues, such as the Appalachian Landscape Conservation Cooperative.
13. Provide landowners with the resources they need to understand climate change science and its impact on the Southern Appalachian region. Also provide landowners with decision-making tools to help them play a role in climate change mitigation, adaptation, and building resilience.
14. Continue to seek out funding to plan and implement climate change mitigation and adaptation projects, for example through Open Space Institute and Land Trust Alliance.
Conclusion

SAHC has been protecting Southern Appalachian natural heritage and building public trust for nearly fifty years. With climate change threatening our ecosystems and communities, it is our responsibility to respond to regional climate change impacts. Stewardship Associate Chris Kaase states that, “our mission hasn’t changed, but the onus is on us to respond to climate change. So is knowing how to articulate it, and having a formulated idea of how our organization fits into the broader picture. What will we do moving forward? How should we think about it in the context of what we already know?” Acknowledging the difficulties of navigating conversations about climate change, he adds, “the danger of not formalizing or discussing these issues, or making them amenable to public input, is getting stuck in your own ideas and resisting necessary change. As a community-focused organization that relies on voluntary conservation, local knowledge and input are incredibly important.”

Climate change is a global issue that has already begun to affect Southern Appalachian ecosystems and communities in myriad ways. SAHC is committed to addressing these impacts through climate-responsive land protection and stewardship efforts. It is through these actions that we can contribute to global climate change action, while sustainably perpetuating our mission of preserving scenic landscapes, recreational opportunities, significant ecosystems, and ecosystem services in the coming decades.
Key Literature and Recommended Reading

This reading list is adapted from the Deschutes Land Trust’s 2017 Climate Change Strategy.

Academic Articles and Reviews


Agency & Organization Reports and Gray Literature

Assessing Climate Risk and Resiliency in Rural Appalachia - Appalachian State University, 2020
- This report assesses climate change risks to communities in rural Southern Appalachian communities.

“Fraught Forests” - Carolina Public Press, 2022
- A five-part series of articles on the effects of climate change on Western North Carolina’s forests.
- An accompanying panel (June 2022), featuring practitioners spanning the public and non-profit sectors (including SAHC), is available here.

Fourth National Climate Assessment - United States Global Change Research Program, 2018
- A comprehensive, government-published report on climate change and its impacts in the United States, with chapters devoted to specific ecosystem types, sectors, and regions. National Climate Assessments are periodically published by the U.S. Global Change Research Program.
- Chapters that may be especially relevant include: chapters 2-7, 10-11, 17 (National Topics), 19 (Southeast Region); 28-29 (Responses).

From the Ground Up: How Land Trusts and Conservancies Are Providing Solutions to Climate Change - Lincoln Institute of Land Policy, 2022
- A review of how land trusts, conservancies, non-profits, and NGOs are addressing climate change in their regions.

North Carolina Climate Science Report - North Carolina Institute for Climate Studies, 2020
- Sections of this report are devoted to the Western Mountains Region of North Carolina, which comprises a significant portion of SAHC’s conservation focus areas.

Sixth Assessment Report - United Nations Intergovernmental Panel on Climate Change, 2022
- The latest Assessment Report from the IPCC, delineating the latest findings on climate science, impacts, and recommended actions.
Websites

**Conservation in a Changing Climate** - Land Trust Alliance
- A continually updated library of intermediate-level guidance about climate change and conservation responses in the U.S. conservation community.

**Climate Change Response Framework** and **Adaptation Workbook** - Northern Institute of Applied Climate Science
- Offers land managers frameworks and decision-making tools to design climate change strategies for a variety of ecosystems and goals.

**Climate Change and Global Warming** - NASA
- This website provides general information on climate change science and solutions. It also includes a regularly updated “News and Features” section.

**Conservation Gateway: Climate Change** - The Nature Conservancy
- Includes information and further resources on climate adaptation, resilience, and connectivity.

**U.S. Climate Resilience Toolkit** - United States Global Change Research Program
- A comprehensive guide and resource center for climate adaptation and resilience.

**USFS Climate Change Atlas**
- Information on natural heritage in the context of climate change, including projected habitat models for tree and bird species.

Interactive Datasets & Maps

- A landmark analysis assessing the most resilient and connected landscapes throughout the U.S., based in part on connectivity and abiotic diversity.

**Migrations in Motion** - The Nature Conservancy
- Models the general trajectories of approximately 3,000 mammals, birds, and amphibians in response to climate change.

**What Will My City’s Climate Feel Like in 60 Years?** - University of Maryland, Center for Environmental Science
- A tool that approximates the future climate of a given city in the next 60 years.

**Forests to Faucets StoryMap & Data Explorer** - USDA Forest Service, 2022
- A web app that visualizes forests’ role in providing drinking water.

**Natural & Working Lands in North Carolina StoryMap & Dashboards** - Nicholas Institute for Environmental Policy Solutions, 2021
- A series of dashboards summarizing the ecosystem services provided by natural and working lands in North Carolina.

**Climate Change Pressures in the 21st Century** - USDA Office of Sustainability and Climate, 2022
- StoryMap offering an overview of temperature changes across the U.S.

**Conservation Carbon Mapper** - Trust for Public Land
• Provides forest carbon stock and yearly sequestration potential by state and county across the U.S. Also identifies threats and co-benefits (rare ecosystems, drinking water, and habitat cores), suggesting where conservation can have the greatest impacts.

**Southern Appalachian Vitality Index Mapper** - Southern Appalachian Man and the Biosphere Cooperative

• A multi-faceted mapper that provides data on the natural environment, demographics, built environment, and economic context of the Southern Appalachian region.

**Adaptation Workbook: Explore Climate Impacts by Region** - Northern Institute of Applied Climate Science

• An interactive map that highlights regional findings from the Fourth National Climate Assessment (2018).
**Books**

- An up-to-date primer on climate change.

- A series of comprehensive solutions in response to global climate change impacts.

- In the four years between *Drawdown* and *Regeneration*, the urgency of climate change underwent considerable metamorphosis. Building on *Drawdown*, Hawken approaches solutions to the climate crisis with a focus on solving existing and immediate problems.

- A climate scientist’s case for communicating climate change to individuals and communities through shared values and personal conversations.

- An anthology of essays and poems written by women involved in climate science, policy, and activism. Provides a holistic, interdisciplinary understanding of the climate crisis.

- A blistering case for the role of anthropogenic climate change in causing the Earth’s six mass extinction.

- An exploration of technology-based human interventions to climate change.

- Convincingly outlines the nexus of socioeconomic and political systems with environmental issues and climate change.

- A somewhat older but very comprehensive, science-based overview of the current and future consequences of climate change.
- An overview of basic climate science, impacts, politics, and actions.

- Outlines climate change’s impacts on natural systems, and consequent impacts on natural resources and societies.
References & Acknowledgements

This Action Plan was written with considerable reference to the structure, content, and language of the Deschutes Land Trust Climate Change Strategy, written by Fiona Noonan (2017). We thank them for granting permission for us to use their Strategy as a guide for this Action Plan.

We also acknowledge Land Trust Alliance and The Nature Conservancy for providing much of the guidance and research that informed this Action Plan.


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Appendix I: Glossary

This glossary has been adapted from the Deschutes Land Trust’s 2017 Climate Change Strategy.

**Adaptation:** Adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001).

**Additonality:** Additionality occurs when—holding all other factors constant—an emissions reduction would not have occurred without the introduction of a specific strategy or approach. If a project would have happened regardless of its emissions impacts, it cannot be called additional. Meaningfully curbing emissions requires projects to be additional.

**Afforestation:** Adding trees to an area that was not historically a forest, usually to enhance carbon storage.

**Agroforestry:** The integration of trees, shrubs, and other elements of forests into crop cultivation and management. Agroforestry practices can reduce runoff, mitigate climate change impacts, provide shade and forage, and create socioeconomic benefits.

**Business as Usual:** An emissions trajectory that follows historical trends. In other words, this is a scenario in which all current policies and practices remain in place, and little to no mitigation occurs. “Business as usual” is often considered a type of baseline scenario to which other, more proactive climate modeling outcomes can be compared.

**Carbon Offsets:** An arrangement in which one entity pays another to emit less in order to offset the offsets of the entity making the payment. This is a part of the broader scheme of carbon trading, and is generally considered an emissions reduction strategy.

**Carbon Sequestration:** Removal from the atmosphere and subsequent storage of carbon dioxide. Sequestration can occur both naturally and artificially; natural carbon sinks include forests, peat lands, oceans, and any photosynthesizing species. Also commonly referred to as carbon storage.

**Climate Change:** Long-term changes in regional or global climate patterns, including cooling, warming, and other atmospheric conditions.

**Climate Refugia:** “Areas relatively buffered from contemporary climate change over time that enable persistence of valued physical, ecological, and socio-cultural resources” (Morelli et al., 2016: 1).
**Climate-Responsive:** For the purposes of this Action Plan, any climate-responsive action—or climate-responsiveness—an action carried out in a manner consistent with climate change adaptation and/or mitigation.

**Climate Vulnerability Assessment:** Decision-making tool that focuses on species, ecosystems, habitats, or other systems of interest to assess exposure, sensitivity, and adaptive capacity to anticipated impacts of climate change.

**Co-benefits:** Broadly, co-benefits are the positive benefits that accompany climate mitigation. Examples include habitat creation, biodiversity, clean air and water provision, shade, and recreational opportunities.

**Connectivity:** The degree to which a landscape facilitates ecological flow. Connectivity is a key aspect of terrestrial resilience.

**Conserving Nature’s Stage:** Focusing on protecting abiotic landscapes since they are more climate-resilient than their biotic inhabitants. In theory, conserving the stage in a way that preserves diverse terrestrial features will provide more habitats and will protect biodiversity into the future, even if the species composition in a conserved area ultimately changes.

**Conversion:** Taking lands and resources out of their natural state to use for farmland, ranchland, developments, or any other kind of anthropogenic land use.

**Ecoregions:** Areas smaller than bioregions with similar ecosystems and biotic and geographical characteristics.

**Ecosystem Services:** According to the USDA Forest Service, ecosystem services are the benefits people derive from ecosystems, including:

- Provisioning services: providing people with food, clean water, fuel, fiber, and other material goods.
- Regulating services: ecological processes that provide a habitable environment, such as climate, hydrological cycles, disease regulation, and pollination.
- Supporting services: necessary for the production of all other ecosystem services, for example, biomass production, soil formation, nutrient cycling, and oxygen production.
- Cultural services: educational, aesthetic, cultural, heritage values; as well as recreation and tourism.

**Evapotranspiration:** The combined sum of water that is evaporated from land surfaces, and water that is transpired by plants. Evapotranspiration is determined by temperature, relative humidity, wind and air movement, soil-moisture availability, and vegetation type (USGS). In the Southern Appalachians, warmer temperatures drive up evapotranspiration and dry out vegetation more quickly.

**Feedback Loop:** Any process that amplifies or de-intensifies an existing climate forcing (warming). Negative feedback loops reduce an initial forcing, while positive feedback loops add to an existing forcing. These feedbacks often reinforce cyclical processes, such as the carbon cycle.
**Fossil Fuels:** Any combustible fuel derived from the organic materials of long-decomposed plants and animals. These fuels include petroleum, natural gas, and coal, and their combustion is the number one source of GHGs on Earth.

**Fuel Aridity:** The dryness of vegetation that may serve as fuel in the event of a fire. In general, greater fuel aridity leads to larger and more intense fires.

**Greenhouse Gasses:** Gasses that absorb energy and radiation, which leads to the warming of the atmosphere. The “greenhouse effect” keeps the planet inhabitable, but unprecedented greenhouse gas emissions and concentrations are the leading cause of anthropogenic climate change. The most abundant greenhouse gasses—GHGs—are water vapor, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, and hydrofluorocarbons. Each GHG stays in the atmosphere for a different amount of time and has a different Global Warming Potential, which is a measurement of a gas’s ability to warm the atmosphere.

**Land Cover Change:** Changes in the physical characteristics of the land’s surface; often refers to changes in vegetation cover during land use change.

**Land Facets:** According to Beier and Brost (2012), land facets are “recurring landscape units of relatively uniform topography and soils.” Defining and conserving land facets is a key element of conserving nature’s stage and of approximating terrestrial resilience to climate change. Conserving a diversity of land facets should also facilitate habitat connectivity.

**Land Use Change:** Any change in the way land is used or the activities taking place on land. Oftentimes this refers to the conversion of land away from its natural state.

**Mainstreaming:** An approach to accomplishing climate change action, solutions, and policy by integrating it into all facets of, in this case, conservation and stewardship, rather than creating separate initiatives to achieve discrete goals.

**Microclimate:** A climate restricted to a small area that can differ from the climate of a broader surrounding region. Urban heat islands are one example of a microclimate. Other microclimates could exist near water or in an area of high topographic diversity, such as a canyon.

**Mitigation:** Any action that reduces anthropogenic contributions to greenhouse gas concentrations.

**Near-Surface Temperature:** The air temperature close to Earth’s surface. This is correlated with changes in atmospheric CO₂ concentrations. This is one component of topoclimate diversity.

**Phenotypic Plasticity:** The ability for an organism to change in response to its environment. Phenotypic plasticity “can be a major mechanism of response to environmental variability, which may allow organisms to cope with rapid environmental changes, including global change” (Bonamour et al., 2019).
Reforestation: Replacing trees in areas that have been deforested or otherwise degraded.

Representative Concentration Pathways: Representative Concentration Pathways, or RCPs, are four distinct greenhouse gas concentration trajectories that the IPCC used to model climate change scenarios in its 2014 Fifth Assessment Report. These pathways represent various climate futures based on different amounts of greenhouse gas emissions. The RCPs are RCP2.6, RCP4.5, RCP6, and RCP8.5; these numbers refer to possible radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m², respectively). RCP8.5 is usually considered a worst-case scenario, in which emissions continue to increase throughout the 21st century. This is also called a “business-as-usual” scenario because of the inaction it assumes.

Resilience: Also called terrestrial resilience. Resilient lands are places where complex topography and high quality connectivity/connected land cover make conservation more likely to succeed in the future, even in the face of climate change or other environmental changes.

Sense of Place: the emotions someone attaches to an area based on their experiences.

Soil Moisture: Soil moisture helps to control heat and energy exchange between the land and atmosphere, and plays an important role in creating weather and climate patterns. Soil moisture is one component of topoclimate diversity.

Topoclimate Diversity: Buttrick et al. (2015) define topoclimate diversity as “the range of temperature and moisture regimes available to species as local habitat refugia under climate change scenarios.” Topoclimate diversity is one component of terrestrial resilience, and more topographically diverse areas may increase species diversity and likelihood of survival across spatial and temporal scales.

Urban Heat Island: An urban area that is significantly warmer than the surrounding rural or natural lands, mostly due to land use, land cover change, and other human activities.

Vulnerability: The degree to which a region, ecosystem, or species is susceptible to the impacts of climate change. Vulnerability is a function of sensitivity, rate of change, magnitude, and ability to adapt.

Wildland Urban Interface (WUI): The zone of transition between unoccupied land and human development. WUI represents the area where human development meets or intermingles with undeveloped wildland or vegetative fuels.

Working Lands Conservation Easements: Conservation easements in which the owner is allowed to continue ranching, farming, foresting, or making some other use of the property’s natural resources.
Appendix II: Abbreviations

GHGs: Greenhouse gases
IPCC: Intergovernmental Panel on Climate Change
M&E: Monitoring & Evaluation
NCDA: North Carolina Department of Agriculture
NASA: National Aeronautics & Space Administration
SAHC: Southern Appalachian Highlands Conservancy
SASRI: Southern Appalachian Spruce Restoration Initiative
TNC: The Nature Conservancy
USDA: United States Department of Agriculture
USFS: United States Forest Service
USGS: United States Geological Survey
WUI: Wildland Urban Interface
Appendix III: Maps

Across all maps, “SAHC Protected Lands” includes conservation easements, fee-simple properties, transfers to public lands, assists, and life estates.
Total Forest Carbon Sequestration on SAHC Protected Lands

Estimated Total Forest Carbon Storage, relative to Southeastern regional average

- SAHC Protected Properties
- SAHC Focus Areas

Below Average
- Average
- Slightly Below Average
- Slightly Above Average
- Above Average

Total carbon storage includes aboveground biomass, debris, and soil carbon. Estimates are from 2010.

Total forest carbon storage includes aboveground biomass, debris, and soil carbon. Estimates are from 2010. The average total carbon storage across SAHC’s Focus Areas exceeds the regional average by approximately 33%.
TNC-Scored Climate Resilience of SAHC Protected Lands

Legend:
- SAHC Protected Properties
- SAHC Focus Areas
- Most resilient
- More resilient
- Slightly more resilient
- Average/median resilience
- Slightly less resilient
- Less resilient
- Least resilient
- Developed
- Indigenous Lands

The Southern Appalachians - and SAHC's Conservation Focus Areas - are characterized by remarkably high climate resilience scores relative to much of the Southeast. This resilience extends northwards across the greater Appalachian Mountain Chain, highlighting the role of the Southern Appalachians in facilitating trans-regional habitat connectivity.
This dataset comes from TNC’s Resilient Land Mapping Tool. As stated by TNC:

“Resilience scores estimate site capacity to maintain species diversity and ecological function as the climate changes. The score is calculated within ecoregions based on all cells of the same geophysical setting and is described on a relative basis as above or below the average.”

Climate resilience is calculated using the following components:

- **Landscape Diversity:** microhabitats and climatic gradients immediately adjacent to any 30-meter cell of land.
- **Local Connectedness & Fragmenting Features:** the degree of fragmentation and strength of barriers that create resistance to movement within a landscape. Barriers in this study are anthropogenic - major roads, development, energy infrastructure, and industrial farming and forestry land.
- **Geology and Soils:** the variety of soils and bedrock geology that explain basic biodiversity patterns.
- **Elevation:** elevation and life zones are strong drivers of biodiversity patterns, particularly in mountainous regions where lowland habitats differ dramatically in composition and structure from high elevation habitats.
- **Landforms:** used as the base for estimating microclimate diversity (i.e. topoclimate diversity). Individual landform units reflect local variations in land position, slope, solar radiation, moisture availability, and susceptibility to wind and other disturbances. High microclimate variation allows species to persist at sites even when the regional climate appears unsuitable.”

(TNC, 2016).
TNC Climate Resilience & Connectivity of SAHC Protected Lands
The climate resilience and biodiversity of the Southern Appalachians - and SAHC’s Conservation Focus Areas - stand out from much of the Eastern U.S. This connectivity extends northward along the greater Appalachian Mountain Chain.
This dataset comes from TNC’s Resilient and Connected Landscapes analysis. Definitions of legend terms are as follows (TNC Eastern Division, 2016):

“Resilient Area: places buffered from climate change because they contain many connected micro-climates that create climate options for species.

“Flow: the movement of species populations over time in response to climate. Flow tends to concentrate in the zones and corridors described below.

- **Climate Corridor**: narrow zone of highly concentrated flow, often riparian corridors or ridgelines.
- **Climate Flow Zone**: broad areas of high flow that is less concentrated than in the corridors. Typically intact forested regions.

“Confirmed Diversity: known locations of rare species or unique communities based on ground inventory. Unconfirmed areas may contain the same species.”

An interactive version of this dataset, in addition to the methods for determining climate resilience and connectivity, is available under “Interactive Datasets and Maps.”
SAHC Protected Lands & Significant Watersheds for Surface Drinking Water

“Significance” denotes forests’ ability to provide clean surface drinking water.

Index of Importance to Surface Drinking Water
- 57 - 60
- 61 - 70
- 71 - 80
- 81 - 90
- 91 - 99

Index is calculated on a scale of 0 - 100, with a score of 100 representing watersheds most important to providing surface drinking water. The national average is 43.3, and the national median is 40.
Significant Watersheds for Surface Drinking Water in the Southern U.S.

"Significance" denotes forests' ability to provide clean surface drinking water. Index is calculated on a scale of 0 - 100, with a score of 100 representing watershed forests most important to providing surface drinking water.

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Southern U.S.  50  56
SAHC Focus Areas  87  87