

2020

CLIMATE SMART
LARIMER COUNTY FRAMEWORK

RECOMMENDATIONS FOR A CHANGING CLIMATE
September 30, 2020



COMMISSIONER JOHN KEFALAS:

MY COMMITMENT TO ADDRESSING CLIMATE CHANGE

Larimer County is a beautiful and unique place to live, work and play. All of us who call this place home value our rich quality of life. Unfortunately, that quality of life is threatened by our changing climate. County elected officials and employees alike are organized to serve the public today and into the future. How we serve the public will need to change with our changing climate; how much our climate changes in turn partly depends on the actions we take today to reduce our impact on the environment.

The major aspirations that run through our organization's vision, mission and guiding principles include:

- Ensuring access to health, safety, well-being, and quality of life for everyone
- Adding value to the lives of our residents today and in the future
- Promoting innovation, collaboration, and continuous improvement
- Being good and accountable stewards of public resources
- Empowering people to take responsibility through civic engagement and community-building

Larimer County's Comprehensive Plan presents a 20-year framework for smart decision-making and planning with a focus on regional connectivity and careful consideration of the diverse interests of our rural and urban areas between the mountains and the Front Range. This plan aligns with our Community Resiliency Framework and recommends strategies and policies to address complex issues today and into the future. Our Strategic Plan further provides us with five-year goals regarding public infrastructure, economic opportunities and public services. Community members, stakeholders and experts recommended that we take on these intersecting and priority issues.

Our purpose with this initiative is to provide a framework for supplemental deliberation and action regarding climate change, its impacts on our residents and the county's identified priorities and aspirations. We call this initiative the Climate Smart Larimer County (CSLC) Framework. At my request, we formed a working group of county employees and agency partners who've dedicated their time and expertise to preparing this document, which contains baseline information about the county's current policies and practices related to environmental responsibility, sustainability and climate action – internally (organization) and externally (community). This document offers ideas and recommendations for future county actions in the areas of adaptation and mitigation.

Climate Change can be a polarizing issue but taking a deliberative and inclusive approach that involves all stakeholders benefits everyone involved. How we frame this topic and how we engage the community are critically important elements of this project. While climate change has profound global impacts, research shows that focusing on local impacts and people's connections to their communities can achieve more robust community engagement and produce common-ground solutions. It is a fair statement that we all value clean air, clean water and clean land, whether we work in a Fort Collins coffee shop or we work the land as a farmer or rancher in the Waverly-Buckeye area.

Thank you to our county employees and agency partners for your informed work on this project and thank you to my fellow Commissioners for engaging in this discussion.

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I. EXECUTIVE SUMMARY

The Climate Smart Larimer County (CSLC) Framework provides information about current observed impacts of climate change in Larimer County's, as well as recommendations for strategic action. This document is the result of a year-long analysis compiled by county staff and community partners that highlights climate change impacts in their areas of expertise and responsibility.

In our 2019 Strategic Plan, Larimer County describes itself as a “a great place to be; an innovative community to live, work, and play for everyone.” Our 2013 Vision and Goals framework outlines key strengths, priorities, and guiding principles that serve as touchstones for the Climate Smart Framework:

- Our strength lies in the diversity, talents, and character of our people
- We encourage and foster an environment of respect, supporting both physical and mental health
- Our county is beautiful and clean
- We protect our air and water, open spaces, and natural resources
- We are prepared for wildfires, floods, and water supply
- There are plenty of things to do both in nature and within our local communities
- We have safe and clean neighborhoods, schools, businesses, roads, structures, and parks throughout our county.
- Our prosperous economy is powered by innovation, education, a business-friendly atmosphere, well-paying jobs, affordable housing, and convenient transportation networks that keep pace with growth.
- We place a priority on our youth and their healthy development so that quality of life extends to future generations
- We “tell our story” so our residents understand, engage, and are fully vested in our shared community vision
- We promote collaboration with citizens, local governments, businesses, non-profits and community organizations by working together to create the County's future

These visions reflect our county's character and informed the Climate Smart Larimer County process. The goal of the Framework is to incorporate climate change research conducted in the County and State, and utilize technology, innovation, and community input to plan a path forward. The Framework provides recommended actions to better adapt to - and mitigate against - the social, economic, and environmental risks that the County faces from climate change. Following the recommendations, we present a strategy for community conversations to prioritize and develop action steps to secure a safe, sustainable and prosperous future for Larimer County's community, environment and economy.



II. LARIMER COUNTY COMMUNITY PROFILE

Larimer County is located at the northern end of the Front Range, where Colorado’s eastern plains roll up into the Rocky Mountains. The county contains 2,634 square miles, of which 2,596 square miles are land and 38 square miles are water. Larimer County has three major river systems running from west to east: the Big Thompson, the Little Thompson and the Cache la Poudre rivers. The Western part of Larimer County is mostly rural, except for the Town of Estes Park. While the foothills and mountain make up most of the county’s land area, they account for only 4% of the total population. The area is home to multiple state and national protected areas, including Rocky Mountain National Park. The eastern portion of the county is mostly urban, with multiple municipalities growing along the I-25 corridor between the plains and the foothills.



Rocky Mountain National Park
Photo Credit: Larimer County Natural Resources

Larimer County borders the counties of Jackson and Grand to the west, Boulder to the south, Weld to the east and the State of Wyoming to the north. Major transportation corridors cross the county from east to west (State Highway 34) and north to south (I-25 and US Route 287). Many Larimer

County residents commute out of the county for work, while thousands of residents of nearby counties commute to their jobs here. The top five commuting destinations for Larimer County residents are Weld, Boulder, Denver, Adams, and Arapahoe Counties¹. This level of commuting increases congestion on transportation corridors and deteriorates air quality and overall public health.

In 2018, the population of Larimer County was 350,518 according to estimates from the Colorado State Demography Office. The state demographers forecast the projected population of Colorado and Larimer County in coming years in the following chart, based on “plausible courses of future population change.”

Area	2000	2010	2020	2030	2040
Colorado	4,338,801	5,049,717	5,924,692	6,519,379	7,752,887
Larimer County	253,087	300,532	360,434	424,882	483,322

Source: State Demography Office, Colorado (2015)

Figure 1: Population Forecasts for Larimer County, 2000-2040.

Over the last twenty years, the County’s population has grown by over 33% population. In 2010, Larimer County became the sixth most populated county in Colorado. Demands of a predominantly rural and

¹ Larimer County, 2020. “Work Force Talent – Work Force Efficiency.” <https://www.larimer.org/ewd/data-dashboard/work-force-talent-work-force-efficiency>, based on US Census Bureau, LEHD (Longitudinal Employer-Household Dynamics) program data, <https://onthemap.ces.census.gov/>

agriculturally based population are transforming as development, tourism, technology businesses and new homes stretch the limits of once-rural towns now considered small cities.

Net migration (the difference between the number of residents moving into and out of the county) accounted for over two thirds of the county's population increase between 1980 and 2009. Net migration accounts for over 78 percent of projected population growth between 2010 and 2039.²

In 2018, the median age of all Larimer County residents was 36.4 years.³ Native-born citizens, with a median age of 36, were on average younger than foreign-born citizens, with a median age of 42. Larimer County's population is aging, with the overall median age rising from 36 in 2017, highlighting the need for new or expanded services. In 2018, there were almost 9 times as many White⁴ (non-Hispanic) residents (288,000 people) in Larimer County than any other race or ethnicity. There were 32,400 White (Hispanic) residents and 8,290 residents with two or more races (non-Hispanic).

Median Larimer County property values and household income are also rising. The median income of Larimer County's 139,000 households grew from \$69,102 in 2017 to \$71,091 in 2018. Median property values rose from \$359,800 in 2017 to \$398,300 in 2018. The percentage of owner-occupied housing units fell from 66.6 in 2017 to 63 in 2018 as the percentage of people renting homes grew. Increased housing costs and a rising cost of living can lead to negative effects such as gentrification of neighborhoods, emigration of marginalized community members and increased homelessness.

III. LARIMER COUNTY CLIMATE HAZARDS

"Most climate projections indicate that heat waves, droughts and wildfires will increase in frequency and severity in Colorado by the mid-21st century due to the projected warming... The frequency and magnitude of extreme precipitation events are generally projected to increase globally as a warmer atmosphere is able to hold more water vapor. For Colorado, studies suggest that winter extreme precipitation events will follow this global increasing trend, but not necessarily summer extreme precipitation events."⁵

The natural hazards that most commonly affect Larimer County are severe weather events including tornadoes, lightning, blizzards, thunderstorms, hail, spring and winter storms. The two most frequent highly destructive hazards in Larimer County are severe flooding and wildfires. These hazards can be caused by weather events, such as lightning, or intensified by changing weather patterns. Blizzards and storms result from local weather events, but as the atmosphere warms, extreme storms become more likely. Wildfires - a natural part of the western landscape - can be caused by a weather event such as lightning, but climate change makes wildfires more frequent and intense by raising temperatures and drying out forests. Weather and climate patterns are the most important predictors of our wildfire and flooding risk, which can be reduced through community preparedness and improved emergency services

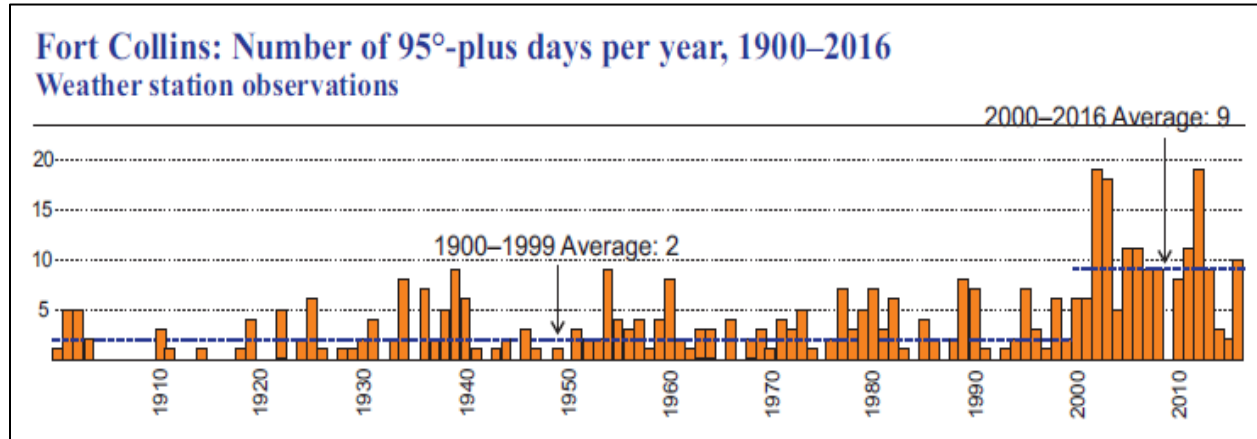
² Colorado Department of Local Affairs, 2020. "Demographic Profiles." <https://demography.dola.colorado.gov/population/data/profile-county/>

³ Larimer County Vital Statistics and Demographics, 2020. <https://www.larimer.org/about-larimer-county/vital-statistic-census-information/larimer-county-demographics>

⁴ United States Census Bureau, 2020. "White: a person having origins in any of the original peoples of Europe, the Middle East, or North Africa." <https://www.census.gov/topics/population/race/about.html>

⁵ Lukas, Jeffrey and Barsugli, Joseph, et al. 2014. "Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adaptation." *Colorado Water Conservation Board*, pg. 60.

response-times. One of the most visible consequences of climate change is the increased intensity and frequency of extreme weather events. In 2016, the Rocky Mountain Climate Organization (RMCO) released a study showing that both the frequency and extent of extremely hot days will increase in Larimer County “depending on whether global heat-trapping emissions continue on a high trajectory or



are reduced.”⁶

Figure 2: Days per year in Fort Collins with high temperatures of 95 degrees or higher at the city’s long-standing weather station. Days with highs of 95 degrees or more averaged two per year in previous century and 9 times a year in the first 17 years of this century.⁷

The RMCO projected that with continued increases in greenhouse gas emissions, the average number of days with temperatures of 95°F or more would increase from two per year (1970-1999), to 24 per year by mid-century (2040-2059) and 58 per year by late century (2080-2099). For the same time frames, the average number of days with temperatures of 100°F or more would rise from less than one per year to four by mid-century and 23 by late century. The average temperature of the 30 hottest days in a year is projected to rise from 91°F historically to 98°F by mid-century and 103°F by late century.⁷

Larimer County has witnessed an increase in the frequency of federally declared disasters since 1997, mostly due to wildfires in our wildland urban interface, flooding along our river systems, and the significant hail damage that occurs with some severe spring storms.

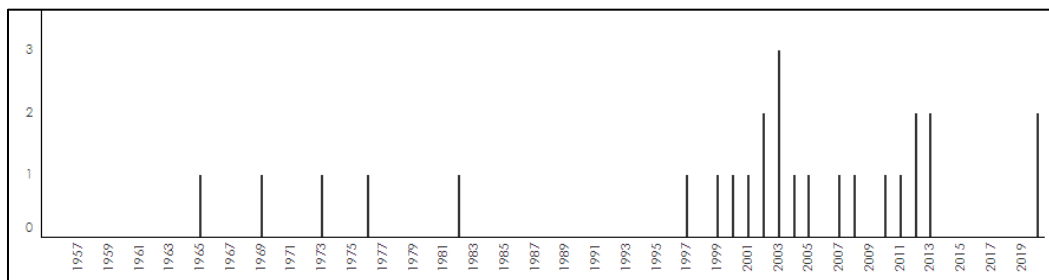


Figure 3: Natural disasters in Larimer County by year since 1957⁸

⁶ Rocky Mountain Climate Organization, 2016. “Future Climate Extremes in Larimer County.” http://rockymountainclimate.org/extremes/extremes_1.htm

⁷ *ibid*

⁸ Federal Emergency Management Agency, 2020. “Disaster Declarations for States and Counties.” <https://www.fema.gov/data-visualization-disaster-declarations-states-and-counties>

According to the Federal Emergency Management Agency (FEMA), Larimer County has experienced the most FEMA-declared disasters in the State of Colorado, with a total of 26 since 1953 (one every 3-4 years). These disasters cause great harm to private property, public lands and infrastructure.

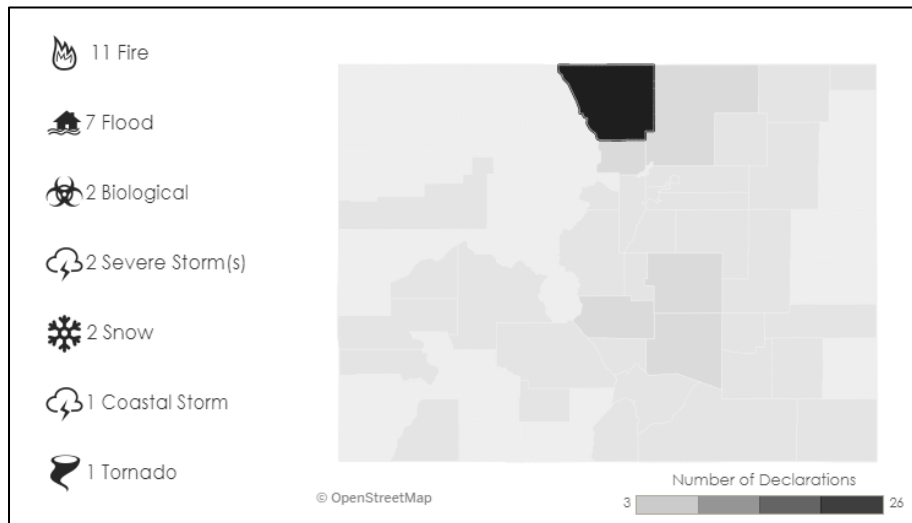


Figure 4 Federally declared disasters in Larimer County since 1953⁹

One measure of the economic impact of extreme weather is the increasing number of billion-dollar climate disasters. The following map provided by the Center for Climate and Energy Solutions¹⁰ shows all types of weather disasters, some of which are known to be influenced by climate change (such as floods) and some for which a climate influence is uncertain (tornadoes).

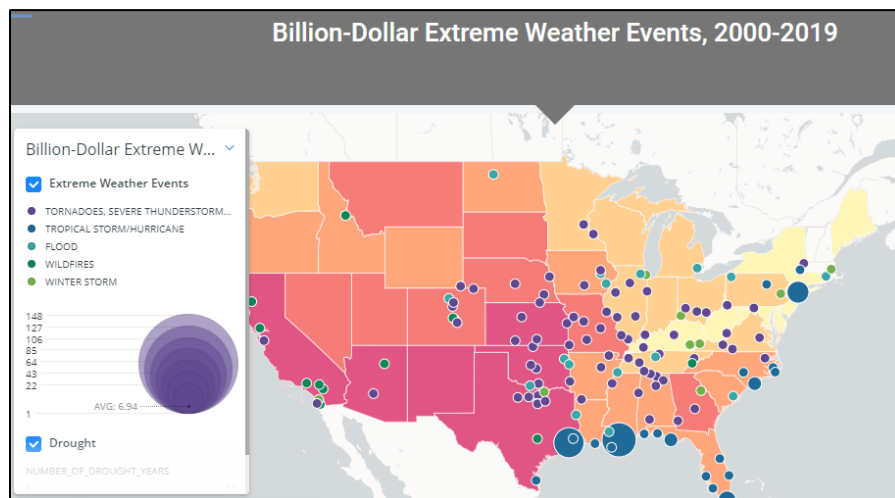


Figure 5 – Billion dollar extreme weather events in the US, 2000 – 2019

⁹ Federal Emergency Management Agency, 2020. “Disaster Declarations for States and Counties.” <https://www.fema.gov/data-visualization-disaster-declarations-states-and-counties>

¹⁰ Center for Climate and Energy Solutions, 2020. “Extreme Weather and Climate Change.” <https://www.c2es.org/content/extreme-weather-and-climate-change/>

¹¹ National Oceanographic and Atmospheric Administration, 2020. “Frequency of Billion-dollar disasters in the US double in recent decade.” <https://www.koaa.com/news/covering-colorado/frequency-of-billion-dollar-disasters-double-in-recent-decade>

Even after adjusting for inflation, the U.S. experienced more than twice as many billion-dollar weather and climate disasters during the 2010s compared with the 2000s, including a number of inland flooding events. From 2010 to 2019, the total cost for U.S. events exceeded \$800 billion from 119 separate billion-dollar events. Since 1980, the U.S. has sustained 258 billion-dollar disasters overall that have exceeded \$1.75 trillion in total damages.¹¹

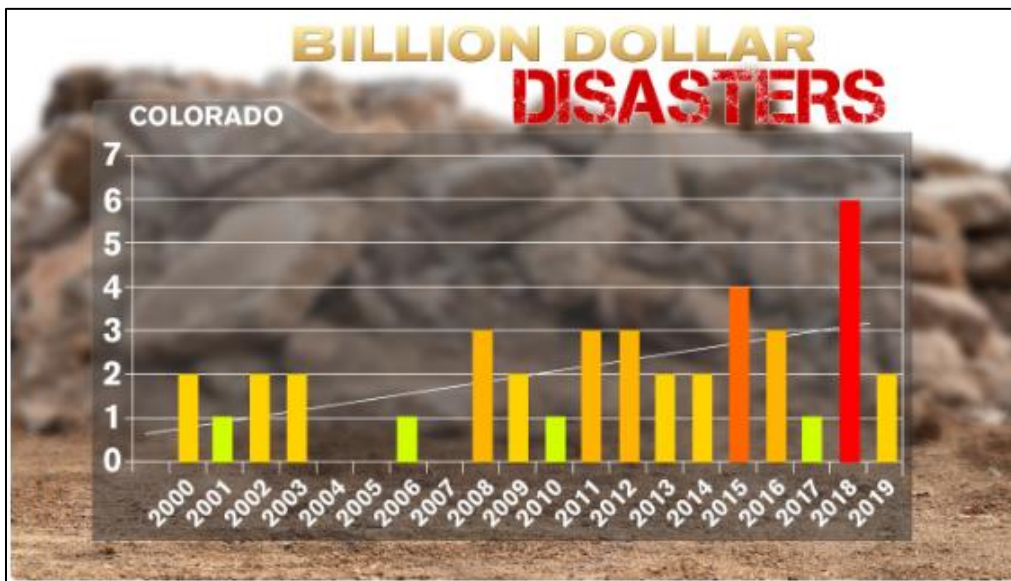


Figure 6: Billion Dollar Disasters in Colorado from 2000-2019¹²

In the 2000s, Colorado was affected by 13 disasters that each resulted in more than one billion dollars in damages. In the 2010s, Colorado was affected by 27 such events. According to the National Oceanic and Atmospheric Administration, “There were several notable events of high economic loss during the past decade in Colorado. The costliest wildfire in Colorado history, the Waldo Canyon Fire, occurred in 2012. In 2012, Larimer County suffered through its most destructive wildfire, the High Park Fire. In the summer of 2017, Denver saw the costliest hailstorm in state history, dealing \$2.3 billion in damage. Flooding in September 2013 in northern Colorado cost \$1.7 billion. Public infrastructure damages for the 2013 Flood totaled \$110 million in Larimer County alone, with an approximate cost to the county of \$25-30 million.

IV. WHY DEVELOP CLIMATE SMART ACTIONS FOR LARIMER COUNTY?

Across Colorado, rising temperatures will tend to reduce the amount of water in many of Colorado’s streams and rivers, melt mountain snowpack earlier in the spring, and increase the water needed by thirsty crops and cities¹³. To address the growing uncertainty of future water demand and availability, the Northern Integrated Supply Project plans to bring two new reservoirs to Northern Colorado, supplying 15 Northern Front Range water districts with 40,000 acre-feet of water. With rising

¹¹

¹² National Oceanic and Atmospheric Administration National Centers for Environmental Information, 2020. “Billion Dollar Weather and Climate Disasters: Events.” <https://www.ncdc.noaa.gov/billions/events>

¹³ Lukas, Jeffrey and Barsugli, Joseph, 2014. “Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adaptation.” *Colorado Conservation Board*, pg. 60.

temperatures and changing precipitation patterns, it is not clear if this supply project alone will provide a comprehensive solution to the County's growing population amidst a changing climate.

Beyond the threat from natural disasters to our environment and economy, the Colorado Health Institute research suggests that certain populations are more vulnerable to impacts from Colorado's changing climate, including children, people living in poverty, people with chronic diseases like asthma, and communities of color.¹⁴ Extreme heat affects cardiovascular, respiratory, and nervous systems. Heat contributes to the creation of ground-level ozone, pollutants, and dry conditions that lead to migrating smoke and wildfires.¹⁵

Population growth itself places an increased burden on our county's resources and services. Unless we as a County and community proactively and adaptively act, more extreme and more frequent climate-driven disasters will only exacerbate an already stressed system. Acting to both mitigate greenhouse gas emissions and adapt to the rapidly changing climate helps the County not only address health equity but also support the high quality of life that our residents have come to expect. Smart actions to curb the effects of climate change are essential for county residents and communities to continue to thrive.



Cameron Peak Wildfire 2020
Photo Credit: Justin Whitesell

The structure of state and county government in Colorado presents constraints and opportunities for county planning efforts to diminish the hazardous effects of climate change. Municipalities are often vertically integrated enterprises that provide most of the utilities and services to their residents. Larimer County, like other Colorado counties, does not own or manage utility infrastructure for county residents, and must collaborate with a variety of water, sewer, light and power districts, municipal governments, state and federal agencies and private sector organizations to achieve community-level goals.

Public opinion is changing as community members see first-hand the transformations associated with a changing climate. With each new disaster, from record-setting wildfires to massive hurricanes to unprecedented drought, more and more of the public comes to understand the links between human activity, our changing climate, and the social, economic, and environmental cost.

¹⁴ *Globalchange.gov*, 2018. "Fourth National Climate Assessment." Chapter 14: Human Health.
<https://www.globalchange.gov/nca4>

¹⁵ *United States Environmental Protection Agency*, 2016. "What Climate Change Means for Colorado."
<https://digital.library.unt.edu/ark:/67531/metadc949160/m1/1/>

V. CURRENT EFFORTS TO ADDRESS CLIMATE SMART ACTIONS

The CSLC Framework overlaps with and builds on other Larimer County planning efforts such as:

1. Larimer County's Guiding Principles

Throughout the planning process, the CSLC team ensured that the triple bottom line approach of social, economic and environmental equity guided our recommendations and aligned with Larimer County's guiding principles of *Being good stewards of public resources, Promoting innovation & continuous improvement, Providing quality customer service, Empowering people to take responsibility, Cultivating partnerships* and *Being a fulfilling and enjoyable place to work.*

LARIMER COUNTY GUIDING PRINCIPLES:



Larimer County 2019-2023 Strategic Plan

Developed by the Board of County Commissioners, this plan establishes priority management areas for the next five years. Larimer County gathered data (demographics, economic statistics and trends, community well-being measures, and broad infrastructure demand estimates) and qualitative input on the characteristics and needs of our community. These identified needs evolved into three strategic goals, defined by specific, measurable, feasible and time-stamped objectives to guide our community successfully into the future.

These three goals are listed below. The CSLC framework recommendations in areas like alternative transportation, more efficient water and waste reduction will assist in these efforts.

Goal 1 - The County works collaboratively to ensure adequate public infrastructure is available to support the needs of our growing community.

Within this goal are four objectives, which are supported by the CSLC framework.

- Support a county-led regional task force to prioritize regional transportation projects and evaluate funding options to pay for them.
- Begin to construct and operate core municipal solid waste disposal infrastructure improvements identified in the Solid Waste Infrastructure Master Plan (SWIMP) and divert at least 40% of the waste stream from the county landfill.
- Develop a rural infrastructure strategy to address growing demands for road improvements, broadband services, water supply and wastewater treatment in unincorporated areas.
- Complete a regional watershed management collaboration effort to 1) improve flood hazard mitigation efforts; 2) diversify water sharing strategies to preserve agriculture and

sustain water supplies; and 3) establish funding mechanisms to improve high hazard dams in the county.

Goal 2 - Everyone in Larimer County has access to economic opportunities and a vibrant quality of life. As a County, we work together to remove barriers. This goal also has four objectives.

- Measure and map community health, well-being and resilience, and implement long-term, sustainable strategies to improve community health by at least 2% annually.
- Increase quality childcare capacity by 50%, working with public and private partners.
- Reduce the overburdened housing ratio by at least 5%; increase access to affordable housing.

Goal 3 - Larimer County is ready to support the future service needs of our residents and visitors. Objectives 1-4 focus inwardly on subjects like reduced staff workspaces, employee skill identification and development, innovative service delivery methods and improved data utilization, while objective five, of this goal, aligns closely with the CSLC framework.

- Update the County’s environmental responsibility policy to ensure that it reflects current scientific findings and methods and balances the protection of natural resources with long-term economic considerations and community needs. Develop an implementation plan to raise staff awareness of the policy and assist departments with implementation.

In the past, the county briefly funded a Green Practices committee to study issues like recycling, energy, water and resource use, and employee transportation. The committee became inactive when the funding for a staff support position ended. Through the current 2019-2023 Larimer County Strategic Plan, a similar mission-driven committee, the Environmental Responsibility Team, has already updated the county’s Environmental Responsibility Policy, and is currently developing a sustainability plan for county operations.

<https://www.larimer.org/strategicplan>

2. Larimer County Comprehensive Plan

This two-phased policy document establishes an extensive blueprint for decision-making. Using inclusive outreach and building on existing plans highlighting goals, policies, and solutions unique to distinct planning areas, the Comprehensive Plan looked carefully at two distinct regions of the County: 1) Mountain Resilience Planning Area; and 2) Front Range Planning Area.

The CSLC framework highlights the different risks and opportunities that mountain and Front Range residents face, as well as other interwoven demographics. The framework’s public engagement section will improve county government’s knowledge on preparedness for future hazard events and accommodations to expected population growth, to better mitigate the increased social, economic, and environmental risks that the County faces as the climate warms.



https://www.larimer.org/sites/default/files/uploads/2019/larimercountycomprehensiveplan2019_vol1_0.pdf

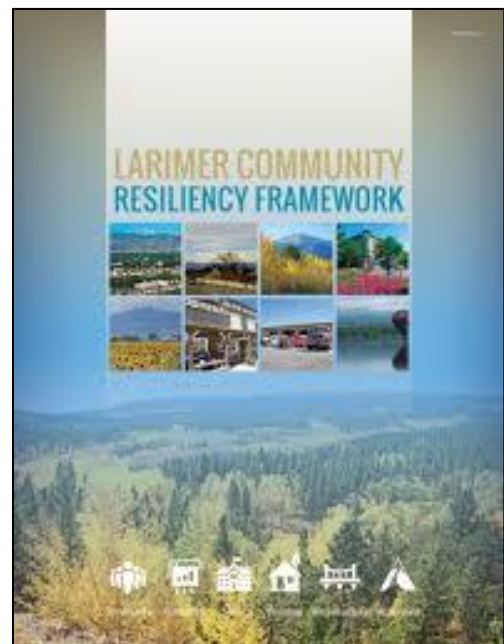
https://www.larimer.org/sites/default/files/uploads/2019/larimercountycomprehensiveplan2019_vol2_0.pdf

3. Larimer Resiliency Framework

In 2016, a collaborative group of governmental, non-governmental, volunteer, and private sector partners worked together for over six months to develop resiliency strategies for the future of Larimer County and its communities. The Larimer Community Resiliency Framework created a connected, collaborative, and cooperative region which proactively works together to strengthen social and physical systems and to resolve complex issues.

The CSLC framework supports the Larimer Community Resiliency Goals by promoting:

- Implementing regional, temporal, comprehensive planning.
- Promoting community behaviors that foster awareness, preparedness, self-sufficiency, and a greater sense of community.
- Developing and implementing construction standards that increase energy and resource efficiency and reduce risk.
- Diversifying housing options and increasing affordable housing stock through traditional means as well as creative land use, building codes, and measures for innovative housing.
- Developing and funding a regional, multi-modal transportation network.
- Managing natural resources through watershed restoration, floodplain and land use planning.
- Building public-private sector partnerships to achieve the community's vision and goals.



<https://www.larimer.org/emergency/recovery>

4. Larimer Multi-Jurisdictional Hazard Mitigation Plan

The Hazard Mitigation Plan (HMP) focuses on two main topics: what are the County's risks from hazards, and what projects can be implemented to reduce or eliminate those risks and vulnerabilities? As the County builds its Climate Smart recommendations, the HMP provides a foundation to ensure that future development, management, and growth is accomplished in a way that decreases the County's collective vulnerability to disasters.

<https://www.larimer.org/sites/default/files/larimer-hmp.pdf>

<https://www.larimer.org/emergency/hazard-mitigation-plan>

Other Larimer County Successes

- 2016 Economic and Tourism Asset assessment of our region's competitive standing
- Larimer Connects Program, implemented in 2018, increases community cohesion and education regarding mitigation and preparedness for risks and hazards.

<https://www.larimer.org/emergency/larimer-connects>

- Fort ZED partnership to establish net-zero energy, water, and waste neighborhoods and shelter-in-place locations. <https://www.fcgov.com/fortzed/>
- Rural Land Use Code adoption of incentive-based subdivision clustering standards creating approximately 80% open space, wildlife corridors and infrastructure efficiencies in rural areas. <https://www.larimer.org/planning/development/division>
- Collaboration with NOCO Housing Now group to address housing affordability
- The 2015 study “Needs and Opportunities in Housing and Care in Larimer County, Next 25 Years” helped community leaders prioritize housing challenges
- The Engineering Department identified all structurally deficient bridges in the County and plans to upgrade them all by the end of 2020
- Grant funding in 2016 enabled stream and rain gauge installations for advance flood risk warning along the Big Thompson River and the North Fork Big Thompson River
- Land Use Code Development Standards Section 8 (Article 4 in Land Use Code 2020 update) that ensures new development is more compatible with wetlands, wildlife habitat and natural systems than previous codes, were incorporated into the updated development review process. <https://www.larimer.org/planning/land-use-code>
- Partnership with four Watershed Coalitions¹⁶ actively working on watershed health and resilience through local ecosystem restoration projects
- Active participation in Climate Wise as a Platinum-level member¹⁷
- Solar panel installation on the roof of the Courthouse Office Building at 200 W. Oak
- Ground-mount solar array installation at the county’s Solid Waste Facility
- Installation of LED lighting, lighting occupant sensor controls and more efficient mechanical controls and rooftop HVAC units in many county buildings
- Updating the county’s stormwater quality program, which works to educate the community and construction sectors on ways to reduce pollutants in our waterways. <https://www.larimer.org/engineering/stormwater-quality>
- A new stormwater and land disturbance permit process is under development that will better safeguard water quality, erosion control and land management



¹⁶ Big Thompson Watershed Coalition, Little Thompson Watershed Coalition, Estes Valley Watershed Coalition and the Coalition for the Poudre River Watershed

¹⁷ Larimer County, 2018. “Larimer County awarded Platinum Level for participation in the Climate Wise Program.” <https://www.larimer.org/spotlights/2018/05/01/larimer-county-awarded-platinum-level-participation-climate-wise-program>

VI. LARIMER COUNTY GREENHOUSE GAS EMISSIONS PROFILE

The **greenhouse effect** is a natural process that traps heat in our atmosphere, warming our planet and making it habitable for all life. This warming is facilitated by a group of gases in our atmosphere referred to as **Greenhouse Gases (GHG)**. Greenhouse gases form through natural (**biogenic**) processes like volcanic activity, and more recently through human (**anthropogenic**) activities like gas heating, fossil fuel combustion associated with industry, transportation, and power generation. Greenhouses gases absorb infrared radiation (heat) that is reflected from the earth’s surface and prevent that heat from escaping into space. These gases comprise only a small amount of all the gases in the atmosphere, but together they have profound effects on the temperature of our planet and ultimately our global and local climate.

2017 Larimer County Community-Wide Emission Sources	MT CO ₂ e
Buildings	1,635,074
Vehicles	3,036,211
Landfill	162,453
Agriculture	0.19669
Total	4,833,738

The U. S. Environmental Protection Agency (EPA) recognizes the following greenhouse gases as most impactful: Carbon Dioxide (CO₂), Nitrous Oxide (N₂O), Methane (CH₄) and various fluorinated gases. The impact of each gas depends on its concentration in the atmosphere, the length of time it remains in the atmosphere, and its capacity to absorb energy, collectively known as its **global warming potential (GWP)**.¹⁸ To quantify and compare the effects of these GHGs, a standard measuring tool is used to determine the CO₂ equivalent in metric tons (MT CO₂e) of each greenhouse gas. By including a GHG inventory within the Climate Smart Larimer County framework, we can track emission trends and sources of CO₂e in our community.

To be consistent with other tracking tools used in our region, Larimer County’s GHG inventory¹⁹ follows the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (Community Protocol) designed by ICLEI – Local Governments for Sustainability. This protocol guides local governments through accounting and reporting on GHG emissions. To date, this report only includes a preliminary inventory for 2017; however, we also reviewed a prior inventory specific to the County’s operations completed in 2010 as a part of a US Dept. of Energy-funded *Energy Efficiency Block Grant*.

The total emissions identified in the 2011 Larimer County Operational Greenhouse Gas Inventory were estimated **at 92,315 MTCO₂e**. Nearly 73 percent of the total emissions were generated as part of Larimer County’s landfill operations. The next biggest source of emissions (about 16 percent) came from the use of electricity in County buildings. According to the EPA’s GHG Emissions Calculator, these emissions could have been avoided by running 19 wind turbines for one year or recycling an additional 31,400 tons of solid waste²⁰

¹⁸ Environmental Protection Agency, 2019. “Overview of Greenhouse Gases.”

<https://www.epa.gov/ghgemissions/overview-greenhouse-gases>

¹⁹ Longstein, Kirk, member, Larimer County Environmental and Science Advisory Board. For methodology and data sources, see

<https://drive.google.com/drive/folders/1nBUT25cpF0XxRbMOPWHy0mzSInKdSbFM?usp=sharing>

²⁰ United States Environmental Protection Agency, 2020. “Greenhouse Gas Equivalencies Calculator.”

<https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

For our 2017 GHG inventory, we only used emissions data from facilities and operations owned and sourced physically within Larimer County. For analysis, we followed the standards set by the EPA’s National Greenhouse Gas Inventory, as well as standards used for emissions inventories for other important air pollutants (e.g., air toxins) at the local scale. Community-wide, our 2017 inventory revealed the largest emission sources are vehicle use and the use of natural gas and electricity in buildings (Figure 7).

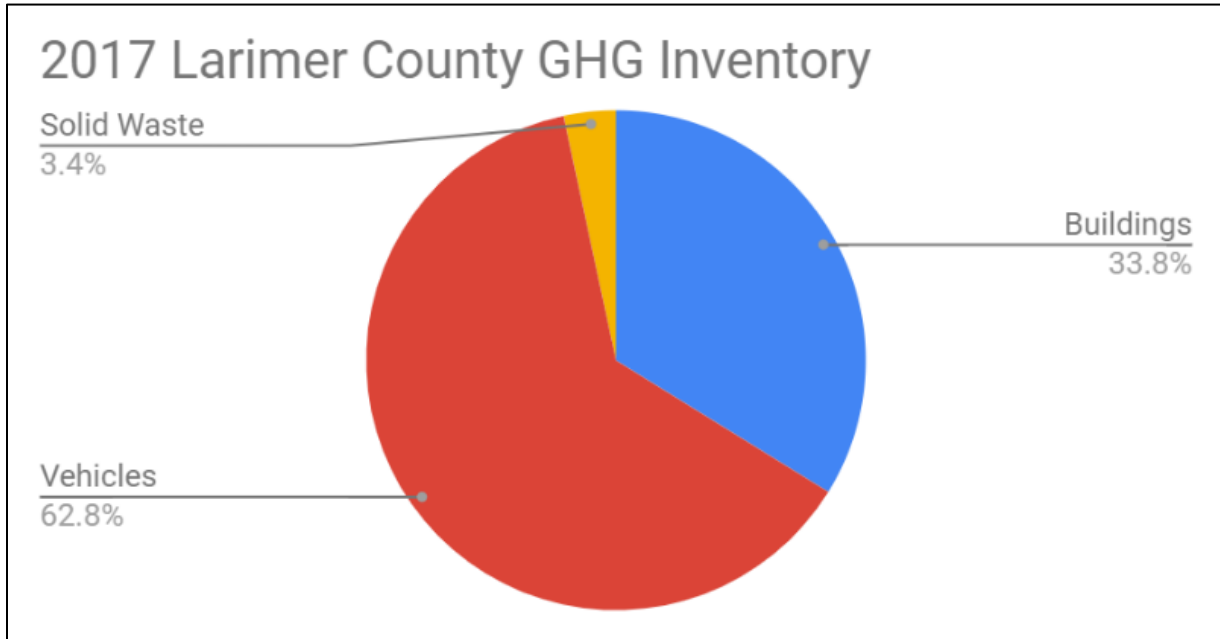


Figure 7: Larimer County Community-Wide Emissions from 2017

VII. CLIMATE SMART LARIMER COUNTY PLANNING AREAS

County staff divided research on climate change and its effects into the following planning areas:

- Building, Land Use and Energy
- Economic Health
- Emergency Management and Public Safety
- Natural Resource Management
- Public and Environmental Health
- Public Works and Engineering
- Greenhouse Gas Management

Climate change impacts all of us to some degree and will likely cause significant disruption to some of our lives; we cannot anticipate and prepare for all possible social, environmental, and economic impacts to our community. However, building community resilience is the best possible action to prepare for future changes and disruptions. The planning area service goals within this document are designed to help our communities become more resilient to such changes and disruptions. Each planning area includes a matrix describing the key areas of concern as they relate to the impacts of climate change. The goals within each planning area incorporated the philosophy of the **triple bottom line**, which considers impacts through the lens of society, the economy, and the environment

Additionally, each section provides information about existing county services that help provide opportunities to mitigate and/or adapt to local climate change impacts. By focusing on reducing our contribution to GHGs in the atmosphere (mitigation) and adapting to local environmental changes brought about by climate change (adaptation), Larimer County will be better prepared and more resilient to future challenges. Each section concludes with recommendations on how to take advantage of some of the opportunities. A full list of possible actions is presented in Appendix A.

Why is Larimer County creating recommendations for future climate action?

Recommendations for future action offer the following benefits:

- Preventing life and property losses
- Identifying economic opportunities in new markets
- Saving money, energy, water, and similar resources otherwise wasted
- Reducing vulnerability through revised development standards and land use codes
- Expanding and creating efficient inter-jurisdictional coordination, and
- Demonstrating a firm commitment to improving community health and safety
- Enhancing environmental stewardship and social equity

Once these recommendations are presented to the Board of Commissioners for their review and deliberation, a second phase of this planning effort will involve a community engagement process where recommendations will be tested and refined based on input from community members. Once input from the community is incorporated, the CSLC Framework will be revised, updated, and presented for approval to the Board of Commissioners.

A. Buildings, Land Use and Energy

Planning Area: Buildings, Land Use and Energy				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Flooding, seepages, foundation scour, ground erosion caused by more intense rain events, greater frequency of extreme flooding.	Injuries and deaths, displacement of residents, loss of lower-cost housing, likely increased social stratification.	Increased runoff and further erosion, dispersal of debris and pollutants, loss of natural features and wildlife habitat.	Damage to buildings, property losses, economic disruption, lost productivity.	Avoid construction and rebuilding in flood-prone areas, elevate higher above ground, move buildings out of flood plains, wet-floodproof existing buildings.
Increased risk of structure damage or collapse from more frequent intense snowstorms and high wind events.	Injuries and deaths, resident displacement, loss of lower-cost housing, likely increased social stratification, stress, anxiety.	Increased dust, debris, air and water pollution, increased load on landfills.	Damage to buildings, property losses, economic disruption, lost productivity.	Build and retrofit buildings to resist higher wind and snow loads.
Increased risk of destruction from wildfire caused by hotter, drier climate leading to increased fuel loading, spread of insects and damage to trees.	Injuries and deaths, displacement of residents, loss of lower-cost housing, likely increased social stratification, stress, anxiety	Increased ash, debris, air and water pollution, runoff and erosion in burned areas, increased load on landfills	Damage to buildings, property losses, economic disruption, lost productivity	Build new buildings and retrofit existing ones to minimize wildfire risk, create and maintain defensible space, reduce fuel loads.
Reduced building material durability, decreased building lifetime caused by increased UV radiation, rain events, and air pollutant effects at higher temperature.	Buildings wearing out sooner and needing more maintenance will place the greatest burden on low- and middle-income owners.	Greater material and energy use for increased maintenance and faster replacement will further increase GHG load and emissions.	Increased demand for materials will cause shortages, drive up costs.	Use more resilient and sustainable building materials.
Increased time and cost of construction caused by hotter summers that slow construction.	Increased cost of homes and buildings, wider gap between cost of housing and income, first-time buyers waiting longer to buy or not buy at all.	Increased negative effects of construction including waste, noise, dust, solid wastes, air and water pollution.	Higher costs, less disposable income for consumption and investment, economic slowdown, reduced productivity, inflation.	Shorten the construction process, do more work outside of peak summer season.

Planning Area: Buildings, Land Use and Energy				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Increased building energy costs, higher load on HVAC system, premature aging of heating and cooling appliances caused by increased cooling loads, new AC installations for occupant comfort.	More heat-related injuries and deaths, greater costs to run AC and replace equipment more frequently will hit low-income residents hardest.	More electricity use and GHG emissions, further raising temperatures. Faster equipment replacement will increase material/energy use.	Higher burden on property owners, increased demand and cost for equipment and electricity.	Better insulation and air sealing, proper solar orientation, strategic use of overhangs and tree shade, on-site energy production.

The building, land use and energy planning area comprises a broad swath of rules and procedures, both inward- and outward-facing, regulating how we construct and operate our homes, businesses, shops, agricultural, institutional, and other buildings. Buildings are one of the primary users of energy and one of the major sources of GHG emissions in Larimer County. **Land use** and **building codes** set rules for how people may develop land and construct buildings, while the county’s internal policies regulate how efficiently we operate our own buildings and manage our properties.

People in **buildings use energy** for cooling, heating, water heating, light, ventilation, refrigeration, cooking, appliances, computer and office equipment, and industrial processes. Fossil fuel combustion attributed to residential and commercial buildings, whether directly on site or off-site energy production and transmission, accounts for almost 30% of total US GHG emissions.²¹

Our **buildings are increasingly stressed by the increasing effects of climate change**. Buildings are typically designed for the local climate that exists when they are constructed. Homes in Colorado are designed differently from those in Seattle or Phoenix, depending on whether the main climate issue is snow, rain, or heat. However, the earth’s climate is changing faster than at any point in the last 65 million years.²² Since buildings may last 50 to 100 years or more, we should design our buildings for the climate of the next century, which will likely be very different from the one we now experience.

“Buildings will also be particularly affected by the effects of climate change: storms, flooding and seepages, reduced durability of some building materials and increased risk of structure damage or collapse (e.g. from severe storms) could all decrease building lifetime, while increasing health-related risks such as deteriorating indoor climate.”²³

²¹ Leung, Jessica. 2018. “Decarbonizing U.S. Buildings.” *Center for Climate and Energy Solutions*

²² *Scientific American*, 2013. “Today’s Climate Change Proves Much Faster Than Changes in Past 65 Million Years.” <https://www.scientificamerican.com/article/todays-climate-change-proves-much-faster-than-changes-in-past-65-million-years/>

²³ *Global Alliance for Buildings and Construction, United Nations Environment Program*, 2016. “Global Roadmap Towards Low-GHG and Resilient Buildings.”

Model building codes were originally created to address basic life safety issues and protection from hazards such as fire, structural collapse, poor indoor air quality, poor sanitation, lack of ventilation, overheating and freezing. These various hazards are commonly referred to by design and construction professionals under the umbrella term “health, safety, and welfare” (HSW), which forms a common foundation for modern building codes. The term “HSW” has evolved over time to incorporate changes driven by industrialization, naturally occurring and man-made disasters, and the demands of modern life.²⁴ The scope of building codes now includes energy efficiency, because a truly safe building requires a safe and stable climate.

When the three US national model building code organizations merged in the 1990s to form the International Code Council, they jointly produced the first truly national model energy code, the International Energy Conservation Code (IECC). The US Department of Energy (DOE) calculates the energy savings of buildings constructed under each new version of the IECC, which is published on a three-year cycle after an open public hearing process. From the 2006 to the 2012 IECC, energy efficiency increased by about 30% for residential buildings and about 25% for commercial buildings. Energy savings in the 2015 and 2018 code cycles are about 3% for residential and 15% for commercial buildings.²⁵ An energy savings of roughly 10% is expected when the 2021 IECC is widely adopted.²⁶

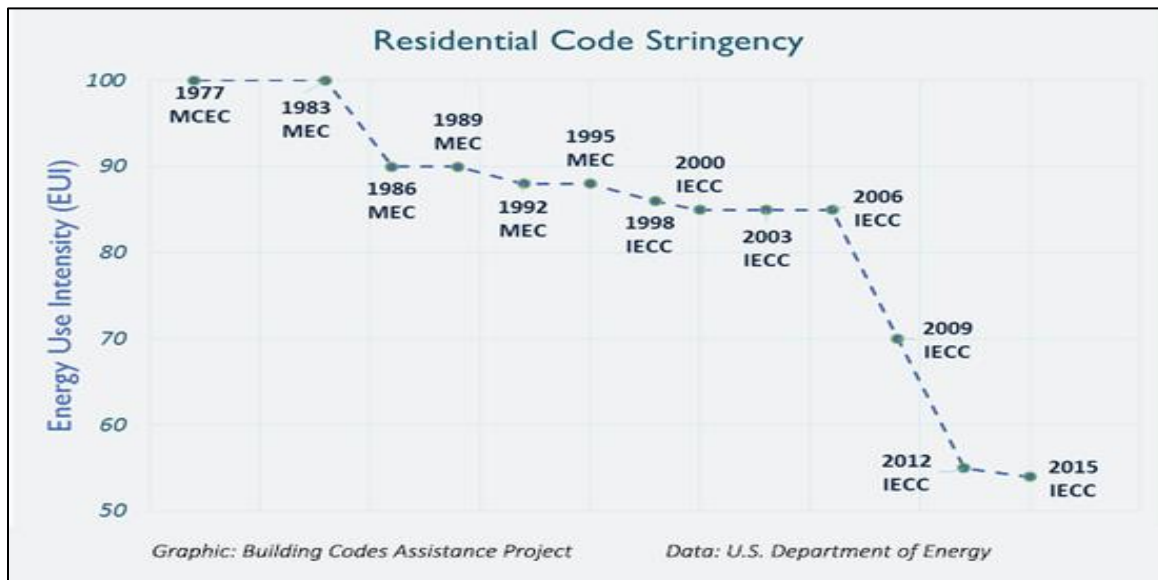


Figure 8: Building Codes versions efficacy in energy use intensity from 1977 baseline to 2015.

²⁴ American Institute of Architects, June 2018. “Disruption, Evolution and Change: AIA’s Vision for the Future of Design and Construction.”

²⁵ US Department of Energy, 2020. “Building Energy Codes Program.” <https://www.energycodes.gov>

²⁶ Southwest Energy Efficiency Project, 2019. “Energy Efficiency Wins Improvements to the Model Energy Code.” <https://swenergy.org/energy-efficiency-wins-improvements-to-the-model-energy-code>

As a home-rule state, Colorado does not adopt a statewide building or energy code nor require local jurisdictions to adopt one. In the 2019 session, the Colorado Legislature passed a bill (HB19-1260) requiring local jurisdictions that adopt building or energy codes to adopt one of the three most recent versions of the IECC, when updating their local codes. Since the biggest energy savings occurred by the 2012 IECC, this law will drive significant energy savings in areas that had been using older codes. Larimer County already adopted the 2018 IECC before passage of the new law, as did the City of Fort Collins. A survey of the eight incorporated cities and towns in Larimer County by the County Building Official shows that all eight have adopted at least the 2012 IECC as of February 2020.



Because buildings account for a large percentage of energy use and GHG emissions, updating energy codes saves a significant amount of energy. The DOE estimates that from 2010 to 2040, model energy code requirements for residential and commercial buildings are projected to cumulatively save \$126 billion in energy costs, 12.82 quads of primary energy (a quad is short for a quadrillion, or 10^{15} BTU) and avoid 841 million metric tons of carbon dioxide emissions nationally. These savings equate to the annual emissions of 177 million passenger vehicles, 245 coal-fired power plants or 89 million homes.²⁷ For

²⁷ Environmental Protection Agency, 2020. "Greenhouse Gas Equivalencies Calculator." <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

perspective, the primary energy consumption of the entire US commercial and residential building sectors in 2015 was estimated at 38 quads.²⁸

Extrapolating from the most recent US Census figures (2017), as well as Larimer County assessor data, there are about 150,000 housing units in Larimer County, including about 35,000 in the unincorporated area and 115,000 within the county portion of our eight incorporated municipalities (three towns span the Larimer/Weld County line). Of the current county population of about 350,000, roughly 75,000 people live in the unincorporated area, and 275,000 live inside municipal boundaries. County building codes therefore directly affects about 20% of the population and 25% of the homes. Fort Collins accounts for almost half the total county population, with Loveland accounting for another 22%. These two cities plus unincorporated Larimer County account for over 90% of the total county population.

The County Building Division issues about 150 permits a year for new dwelling units, which is less than half of one percent of existing housing stock. Although new codes will ensure buildings are constructed now to withstand future climate effects, programs to help property owners retrofit existing homes and businesses to be more efficient will have a much greater impact.

Larimer County directly influences development through land use regulation on about 30% of the total county land area. The remainder lies within city/town limits or is on federal or state land. Less than 5% of the population lives in the mountains and foothills, which account for 75% of the land mass.²⁹ Land use changes implemented along the Front Range, especially in collaboration with the cities of Fort Collins and Loveland, will affect over 95% of the county's population. The effect would be heightened further if Larimer County works with Weld and Boulder counties and their municipalities.



Larimer County has already taken a number of measures to lower the county's own carbon footprint and adopt energy-efficient building practices. While the county Facilities Department rarely goes through the Leadership in Energy and Environmental Design (LEED) certification process for new buildings and alterations, county building construction and facilities operations are generally highly energy efficient, which saves energy and taxpayer resources and increases occupant comfort. An internal Facilities Department study³⁰ shows that county facilities use on average 5.67 kilowatt hours (kWh) of electricity per

square foot, compared to a national average of 14 kWh/sf. Even the Courthouse Office Building at 200 West Oak St., Fort Collins, which houses most of the county's high-energy use computer servers, only uses about 10.4 kWh per square foot (see Attachments).

²⁸ Office of Energy Analysis, *US Energy Information Administration*, 2016. "Annual Energy Outlook 2016." Appendix A, Table A2. [https://www.eia.gov/outlooks/aeo/pdf/0383\(2016\).pdf](https://www.eia.gov/outlooks/aeo/pdf/0383(2016).pdf)

²⁹ Larimer County, 2019. "Larimer County Comprehensive Plan 2019." Appendix D.

³⁰ Larimer County, 2020. "Facility Energy Use Ranking Report." Appendix C.

In the wake of the 2008 recession and the passage of the American Recovery and Reinvestment Act of 2009, the county adopted a voluntary, above-code green building program. Certification as a green building, which was thought to offer a marketing advantage in a tough economy, was the primary advantage for participants. As it turned out, without greater incentives such as reduced fees, faster processing times, or code trade-offs for green buildings, customers were not enticed to participate.

As noted earlier, Larimer County has no utility department and does not provide electricity, gas, water, sewer, or other utility services to county residents. Property owners get their utilities from a myriad of providers, including Xcel, Poudre Valley REA, city and town utility departments, Platte River Power Authority, independent water and sewer districts, propane companies, on-site energy production, private septic systems, wells and cisterns. The County therefore lacks a built-in incentive to help customers save energy and in turn avoid utility capital investment and operating costs, as well as a direct mechanism to encourage efficient energy and water use through rebates and lower fees.

While energy efficient codes save homeowners energy and money over time, the up-front costs can be a significant hurdle. Even with energy-efficient mortgages, property-assessed clean energy programs and other tools, the increased cost can push buyers to purchase less expensive homes farther from their jobs and commute longer distances (“Drive until you qualify”). Energy savings from tighter building codes may inadvertently be offset through higher energy use and emissions from increased driving. Regional collaboration on land use and transportation planning, by determining appropriate locations for residential, commercial, and other developments and integrating transportation systems, will yield greater GHG savings and minimize climate change disruption more than tighter building codes.

Larimer County recently adopted a new Comprehensive Plan and is currently updating its Land Use Code, providing an opportune juncture to include considerations of climate change impacts and appropriate adaptation and mitigation measures in new county planning documents.

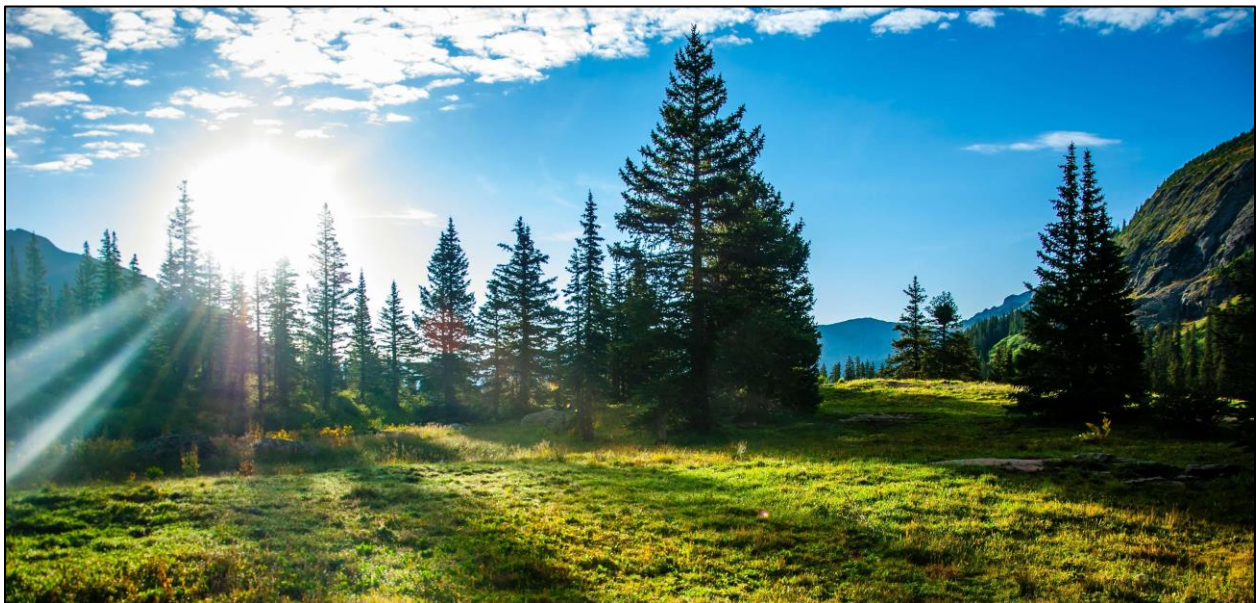


Photo Credit: Colorado Energy Office

Existing Adaptation and Mitigation Strategies

- 2018 International Building and Energy codes
- Larimer County Comprehensive Plan
- Larimer County Land Use Code
- Larimer County Open Lands Master Plan
- Larimer County Transportation Master Plan
- Cache La Poudre River - National Wild and Scenic River
- East Mulberry Corridor Plan
- Fossil Creek Reservoir Area Plan
- I-25 Corridor Plan
- LaPorte Area Plan
- Northwest Subarea Plan
- Plan for the Region between Fort Collins and Loveland
- Red Feather Lakes Area Plan
- Larimer County Facilities internal policies

Top Recommendations for Future Action (see Appendix A for full list of recommendations)

- Collaborating with the Efficiency Works program among local utility companies and increasing incentives for energy-efficiency equipment and appliances as well as retrofitting existing buildings, such as Larimer County Conservation Corps home efficiency assessments and Low-Income Energy Assistance programs.
- Adopt new Land Use Code rules to discourage sprawl by allowing more flexible use of Accessory Dwelling Units, Tiny Homes, smaller lot sizes (dependent on septic system solutions or sewer availability), multi-family, flexible occupant units, mixed use developments, transit-oriented development, planned "village" nodes, etc.
- Lead by example! Update internal county policies and the Facilities Master Plan to implement greater water and energy savings measures on county buildings and increase energy-efficient design standards.

Recommendations for Public Engagement

Engage our customers (developers, builders, contractors, DIY owners, architects, engineers) and ask:

1. Do you prefer mandatory code requirements or incentives for above-code programs?
2. Should the county focus on codes for new buildings or energy efficiency retrofits?
3. What energy efficiency improvements would you support?
4. What above-code existing or new programs do you favor?
5. How should the county land use code promote climate-smart policies?
6. How should Larimer County collaborate with other local governments, special districts, Colorado State University and non-governmental organizations?
7. What forms of renewable energy do you know about? What forms do you use? Why/why not?
8. What building operational changes to increase energy efficiency, do you now practice or can take on? For instance: air tightness, better windows, more insulation, switching to heat pumps, installing solar, tuning up mechanical equipment, updating lighting, etc.
9. How well do you understand the relationship between energy efficiency and indoor air quality?

"The best way to predict our future is to design it."

- Buckminster Fuller

B. Economic Health

Planning Area: Economic Health				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Job losses, especially in agriculture, tourism and natural resource-based occupations caused by climate uncertainty, decreased snowpack, water availability and cost, loss of crop yields, cascading effects of drought, heat waves, wildfire and drought.	Loss of economic opportunity and social mobility, particularly in areas that are tied to Colorado's identity, such as tourism, outdoor recreation, and agriculture.	People may commute farther for job opportunities if not available in Northern Colorado. Population loss.	Loss of wages, tax revenue. Reduced competitiveness as a region. Potential increase in demand for social services. Reduced	Focus economic development activities on sectors that can leverage existing skills in these areas and develop workforce programs that can re-skill people in promising "climate friendly" jobs. Create more climate awareness and resiliency training for people and firms in vulnerable positions.
Reduced private sector investment caused by climate uncertainty, vulnerability of Northern Colorado as a good place to do business, lowered perception of Northern Colorado as a good place to live, work and play.	Fewer job opportunities and less upward mobility.	There may be short term positive impacts to the environment by reduced or slowed building, development, consumption.	Reduced tax revenue, fewer job opportunities for residents, economic stagnation.	Create structure of incentives for investment that drives energy efficiency and productivity. Support incentives that push the private sector to help the region reach its climate goals.
Increased income inequality caused by changing cost structure due to climate change. Regulation that drives up costs makes parts of the region less economically viable for poorer families.	More of a wedge between the haves and have nots. Gentrification. Northern Colorado is less diverse and inclusive.	As costs rise in one area, people are forced to migrate to lower cost areas, which may increase development in other places and increase commuting and commute times.	Access to skilled labor is diminished. Increase in costs further exacerbating the problem.	Target economic resiliency strategies to individuals and families with fewer economic resources.

Planning Area: Economic Health				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Firm closures caused by a lack of economic opportunity in Northern Colorado. Greater certainty, economic returns or economic viability in other areas of the State/Country/World.	Loss of jobs (see cascading impacts).	Underutilized real estate assets. Unproductive power consumption for empty buildings.	Loss of jobs, wages, tax revenue. Underutilized real estate. Decrease in economic competitiveness. Increased reliance on public and non-profit services.	Build business awareness around climate change and its local and regional impacts. Connect businesses to resources, training, and programs to help them be more resilient in the face of changing climate.
Increased commute times caused by shifting job landscape due to climate change and or mitigation strategies.	Less time in community. Less time with family/friends. Increased stress of driving. Fragmented communities. Human safety on busy roads.	Increased GHG emissions by more vehicles driving more miles.	Access to skilled labor is diminished. Increase in personnel costs strain businesses.	Regional planning that takes into account where people can and will live and work, and how those dynamics can be impacted by a changing climate.
Degradation of public infrastructure, especially transportation infrastructure, caused by increased flood, fire, drought.	Decreased human safety. Increased time and cost to move goods, services and people throughout our region.	More construction. More resources requirements to keep up and maintain infrastructure.	Expensive to build and maintain infrastructure. Requires more tax dollars. Loss of productivity.	See other sections
Increased housing costs caused by changing climate (higher temperatures, erratic weather patterns, damaging storms). Increased regulation on energy efficiency.	Gentrification. Loss of diversity and decreased inclusiveness. People cannot afford to live and work in the same community.	Increased drive times and associated GHG emissions. More roads need to be constructed and maintained. loss of natural, open areas due to inefficient development patterns.	Hard to find labor for lower wage jobs. Loss of talent to lower cost areas.	Promote diversity of housing options and increased density in urban centers.

The Economic Health planning area focuses predominantly on climate change impacts affecting Northern Colorado’s ability to further build and maintain a robust, resilient, and inclusive economy. This area includes, but is not limited to, business retention and expansion, firm attraction, workforce development, addressing public funding allocations and investments and other economic conditions that impact the region’s competitiveness in the broader economy. Colorado benefits from a robust

economy, enjoying strong economic fundamentals based on natural resources. The State continues to out-perform the U.S. on many economic measures like higher education attainment and job creation.³¹

Many of the climate change questions around our economy relate to market risk and uncertainty. This uncertainty takes many forms, from trade policies to global disease pandemics to the financial implications of climate change. The following are some key economic issues relating to climate change.

Industries like outdoor recreation and tourism, agricultural production, and resource extraction (oil, gas, timber, and mining) are particularly vulnerable to climate change. Shifting and uncertain weather patterns create new hazards such as changing peak stream flows and fire behavior. Dangerous conditions can lead to human fatalities and natural resource degradation, where the environment recuperates more slowly, differently, or not at all. These changes can make visiting and recreating in our region less desirable, which can cause serious economic impacts.



“A tourism reduction of as little as 30 percent in Estes Park due to floods could amount to a decline in state economic activity of \$27.2 million, a loss of 335 jobs, and a \$13.9 million decrease in real household income. State tax revenue could fall by \$1.8 million and local tax revenue by \$1.3 million. If tourism activity in Estes Park were to decline 70 percent, it could translate into a loss

of 1,111 jobs, a \$90 million decrease in state economic activity, and a \$46.1 million drop in real household income. In addition, state tax revenue could dip by \$5.8 million and local tax revenue by \$4.4 million.”³²



Variation in snowpack and changing melting periods threatens more than tourism-based businesses. These changes also affect the livelihood of farmers, potentially raising their input costs such as water. Growing strife over increasingly expensive water rights highlights the colliding demands from not only the agricultural sector, but also from growing municipalities, industries, and the incorporation of natural stream-flow regimes. Water from the Colorado-Big Thompson Project sold for \$58,000 per acre-

foot in 2018, soaring from roughly \$15,000 in 2010.³³ The cascading effects of increased flooding, wildfires, drought, and similar catastrophes threaten profitable crop and livestock yields to our

³¹ Wobbekind, Rich, et. al. 2020 Business and Economic Outlook, Leeds School of Business, *University of Northern Colorado*, 2019.

³² Nelson, T., 2013. “Colorado’s economy impacted by damaging floods.” <https://economics.colostate.edu/news/colorados-economy-impacted-by-damaging-floods/>

³³ Smith, J., 2019. “Front Range housing boom sends water prices soaring.” <https://www.watereducationcolorado.org/fresh-water-news/front-range-housing-boom-sends-water-prices-soaring/>

community's agriculture-centric economy, combined with seasonal water shifts, growing pressure on water availability and poor ecological conditions.

Flood insurance is a proven approach to saving money on extreme flood events. The National Flood Insurance Program works to reduce the impact of flooding on private and public structures by providing affordable insurance to property owners, renters, and businesses, and by encouraging communities to adopt and enforce floodplain management regulations. According to FEMA, "These efforts help mitigate the effects of flooding on new and improved structures. Overall, the program reduces the socio-economic impact of disasters by promoting the purchase and retention of general risk insurance, but also of flood insurance, specifically."³⁴

Hotter temperatures lead to increased installation of air conditioning and cooling systems, greater use of existing equipment, higher air conditioning and cooling costs, and shortened equipment life, all of which place a disproportionate burden on lower-income households. People who cannot afford these costs face greater health risks from increasing temperatures. These costs are expected to rise significantly as Colorado reaches average annual temperatures currently found 500 miles south in Albuquerque, New Mexico by mid-century³⁵ without significant mitigation or adaptation actions.



As detailed earlier, warmer temperatures cause faster rates of evapotranspiration from vegetation and ground surfaces, providing more opportunity for fires. In Colorado, fire increasingly threatens suburban areas, rural homeowners, businesses, and our economy as a whole.

Extractive industries also face economic threats, as they are both influenced by and are an influencer of climate change. Climate impacts on natural-resource related industries cause spill-over effects to our broader economy. The three primary economic impairments are firm closures, job losses (especially in natural resources-based industries) and reduced private sector investment.

Indirect climate affects driving up the cost of living - particularly housing and utilities - might lead to an inequitable economy. Already an expensive market, Northern Colorado could become unaffordable for more people if the cost of building and maintaining a house keeps rising faster than wages. Decreasing home affordability could cause people to "drive until they qualify" for housing in their income range but further away from their job location, putting more cars on the road and resulting in more vehicle miles traveled (VMT). Moreover, gentrification in pockets of our region unfairly burdens our communities of color and those with fewer economic resources.

Colorado State University (CSU) is seeing more of their students commuting farther distances due to rising living costs in Fort Collins. A survey identifying transportation trends asked students for their zip

³⁴ *Federal Emergency Management Agency*, 2020. "National Flood Insurance Program." <https://www.fema.gov/national-flood-insurance-program>

³⁵ *Colorado Water Conservation Board, Western Water Assessment*, 2014. "Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adaptation." https://wwa.colorado.edu/climate/co2014report/Climate_Change_CO_Report_2014_FINAL.pdf

codes and found that more students live in Greeley and Windsor now than in previous years.³⁶ This study's findings led to a cooperative public transportation line between CSU, Transfort and GET (Greeley-Evans Transit) to provide the Poudre Express bus that started in 2020.



Although we mentioned monetary burdens from climate change, there are also economic gains as new markets emerge in renewable energy and other sustainable initiatives and investments. If we can capitalize on these upward trending markets, then the County can economically thrive through the unfamiliarity of climate change. Businesses in our jurisdiction are already changing their products and ethics due to consumer demands. The County's role in economic growth is to be one of the leaders in developing and implementing a vision of better environmental stewardship.

“Sustainability: It’s the right thing to do, it’s the smart thing to do, it’s the profitable thing to do.”
- Hunter Lovins, co-founder Rocky Mountain Institute, President of Natural Capital Solutions

Existing Adaptation and Mitigation Strategies

- Fort Collins Climate Wise participant
- C-PACE: Colorado Commercial Property Assessed Clean Energy
- CSU Extension
- Small Business Development Center and other business training programs
- Regional Business Retention and Expansion Program
- Economic Development Incentive Policy (Larimer County).
- Office of Economic Development and International Trade (OEDIT) incentive programs
- Local economic development programs (vary by municipality)
- Federal and State workforce development programs

Top Recommendations for Future Action (see Appendix A for full list of recommendations)

- Recruit firms with social and ecological corporate responsibility policies. Incentivize established firms to change behavior to address climate challenges. Build opportunity for renewable energy, clean tech, sustainable food and other industries. Attract businesses to come to Larimer County.
- Create workforce training programs that teach alternative skills in sustainable industries, especially for people impacted by employment loss due to climate change
- Serve as a test-bed of innovation for clean, renewable technology and economic investments, both internally and externally. Lead through innovation in internal operations. Be fiscally responsible in our approach.

Recommendations for Public Engagement

Reach out to business owners and ask:

- Does your business participate in any of the following programs (ex. C-PACE)?
- Does your business practice any sustainability initiatives? If so, which ones?
- Do you consider the lifecycle of your products?

³⁶ NEON Global Research, 2019. “CSU Transportation Annual Survey.”

- In what ways is your business impacted by the following climate change related topics: infrastructure vulnerability, changes in demand from customers, costs, etc.?
- Do you consider your employees in your decisions on sustainability (such as providing/incentivizing alternative forms of transportation)?
- Is your business covered by flood or fire insurance?
- Does investment in greenhouse gas mitigation improve or detract from your bottom line?
- What are the challenges you face with regard to sustainability efforts?
- What is the county's role in assisting the business community in addressing climate change?
- How do we engage your business in efforts to address climate change?
- How does your business fit into a Climate Smart Larimer County framework?

Reach out to community members and ask:

- Do you invest in anything you consider "sustainable" or "climate change" related?
- Is your property/home protected from flood by National Flood Insurance Program – NFIP?
- Have you spent money on the following: retrofitting homes, sustainable products, renewable energy, fire/flood damages, "green" infrastructure, third party certifications, etc.?
- Do you work in a job considered "climate-friendly," "sustainable," "renewable," or natural resource conservation based? Did you have a different job before?
- What percent of your income pays the expenses of your home (rent/mortgage and utilities)?

Inform/ask community members about their knowledge of cost associated with:

- Building in a floodplain zone
- Flood and fire insurance
- Water/energy waste from inefficiencies



C. Emergency Management and Public Safety

Planning Area: Emergency Management and Public Safety				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Increased drought potential caused by increasing temperatures pulling moisture from the land.	Impacts on agriculture could lead to economic strain and decreased well-being and migration of people to other areas, displacement.	Reduced drinking water availability, destruction of plant life and decrease of animal food supply, increased insect infestation and increase in wildfires, air quality concerns.	Crop loss due to drought, food costs spike and the threat of shortages begins to grow, decreases in dairy production increasing prices of goods.	Invest in new technologies for farming using less water, including drought-resistant crops. Consider additional reservoir capacity for water storage.
Increased flood potential caused by warmer temperatures in the winters and increased precipitation falling as rain instead of snow, leading to elevated stream flows and increased runoff.	Increased risk of exposure to food and waterborne illnesses, increase in injuries and drownings, infrastructure loss due to damages from storms, leading to egress issues and inability to reach essential services.	Environmental degradation, health and wellbeing of livestock and wildlife, riverbank erosion and sedimentation, dispersal of nutrients and pollutants, endangered surface and groundwater supplies, debris flows including hazardous materials and waste, and increase in waterborne outbreaks.	Damage to property, damage and destruction of livestock and wildlife, lack of supply of materials for repairs increasing the price. Increased risk of landslides, rockslides, erosion and deposition leading to closures, business delays, and supply chain disruption.	Reviewing and updating the Larimer County Transportation Master Plan to include building infrastructure resilient to climate impacts, including upgrading culverts and bridges for increased flows. Continue strict regulations on building in the floodway and floodplain to decrease loss of life.
Rising temperatures caused by increased frequency of extreme heat events, longer lasting events, and more severe events.	Increased discomfort and fatigue, heat cramps, increase in emergency room visits and hospitalizations, death, increased stress, syncope (fainting), and chronic diseases.	Harmful algal blooms thrive as surface water warms, demand for water increases, fire suppression difficulty due to lack of water and more fires leading to impacts such as air quality and land destruction.	Increased costs in transportation, agriculture, production, energy and infrastructure. Closure of airports, greater spoilage of refrigerated goods, decreased in poultry, cattle and milk production, inhibited crop yields and added demand for electricity for air conditioning.	Emergency Management planning efforts to establish warming centers for elderly, children and medically fragile persons. Same as Drought.

Planning Area: Emergency Management and Public Safety				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Extreme weather caused by larger amounts of snow and rain falling over shorter periods of time, leading to flooding, blizzards, and severe rain events.	Increased stress, increased health concerns due to lack of resources or access, increase in injuries, death, and infrastructure loss due to damages from storms.	Environmental degradation: erosion, groundwater supply, debris flows, livestock and wildlife wellbeing. Dispersal of nutrients, pollutants, hazardous waste. Increase in waterborne outbreaks in municipal drinking water systems and lakes/streams.	Damage to property, damage/destruction of livestock and wildlife, lack of supply of materials for repairs increasing the price, increased risk of landslides, rockslides, erosion and deposition leading to closures, business delays, and supply chain disruption.	Review Larimer Building Codes to ensure buildings can handle severe weather, greater snow loads, and hail. OEM and Engineering to work on erosion control efforts along major roadways and bridges.
Increased wildfire potential caused by dry spells, heat, low humidity, and wind increasing the susceptibility of vegetation to fire.	Increased risk due to development in hazard areas, air quality degradation affecting individuals, especially those with compromised respiratory systems. Evacuations causing a disruption in daily life, loss of homes and jobs due to fire damage and destruction.	Significant increase in stormwater runoff, loss of vegetation, debris transport, air quality degradation, physical, chemical, and biological deterioration of streams, rivers, lakes and reservoirs. Reduced seedling performance, ash and smoke contamination of drinking-water sources.	Agricultural, recreation and tourism industries, water resources, and critical facilities impacts. School and business closures, disrupted utility and transportation services, fires destroy crops, timber resources, recreation areas, and critical wildlife habitat, loss of structures and critical infrastructure.	Extending emergency management programs that increase social capital and community connections through preparedness efforts, network development, resource distribution, and the development of trust with informal and formal community leaders.
Electric utility disruption felt most significantly by the public during winter and summer due to heating and cooling demands.	Impacts to critical services such as hospitals, 911 dispatch centers, emergency services, food suppliers. Disruptions will affect the availability of fueling facilities.	Increased risk of fires, destruction from downed lines, arcing, heat.	Extended electric disruptions can lead to local economic losses when computers, lighting, refrigeration, gas pumps, and other equipment lose power during business hours.	Further programs to increase redundancy in critical systems, alternate generation, etc. Continue partnerships with private and non-govt partners in the utility sector.
Civil disturbance and crime caused by lack of climate action and climate effects. Higher temperatures lead to higher levels of criminal activity in short-term events.	Social unrest due to lack of action, displeasure. Blackouts from power surge leading to increase in fear and crime.	Fires, explosions, and contaminations have occurred as part of civil disturbance (Vail fires, water contamination, bombs, etc.)	Destruction of private, commercial, and public property. Costs from debris removal, maintenance, repair, and response. Loss of industrial/commercial productivity, service interruption.	Increase Neighborhood Watch Programs to build social capital and create sense of safety in populated areas. Expand Equity and Inclusion programs to build trust.

The Emergency Management and Public Safety planning area includes an analysis of the hazards that are most common within Larimer County, along with an explanation of how climate change affects those hazards. Additionally, this planning area includes human-caused risk, such as crime-related activities and other public safety threats from the impacts of climate change.

We live in a beautiful county, but the sources of that beauty also contain inherent dangers and the potential for disasters. Our natural waterways provide fishing, scenic and recreational opportunities, but when severe weather strikes, these waterways become paths of destruction. Our extensive trail systems, the National Forest, and Rocky Mountain National Park all provide the very best that nature has to offer, yet they also create a large amount of land with heavy fuel load for wildfires. These are only a couple of the tradeoffs associated with living in a place renowned for its quality of life.

The natural hazards that most affect Larimer County are severe Spring and Winter events including tornadoes, lightning, hail, thunderstorms, and winter storms or blizzards. The two most common and most destructive hazards in Larimer County are severe flooding and wildfires.³⁷ Both hazards are greatly affected by a changing climate. With an accelerated process of evapotranspiration, both drought and severe weather events become more likely; as more water is pulled from soil and vegetation into the atmosphere, the soil becomes drier, the water table drops, and the chance of drought increases.

“The Palmer Drought Severity Index (PDSI) shows a trend towards more severe soil-moisture drought conditions in Colorado over the past 30 years, reflecting the combination of the below-average precipitation since 2000 and the warming trend.” – Western Water Assessment 2014³⁸

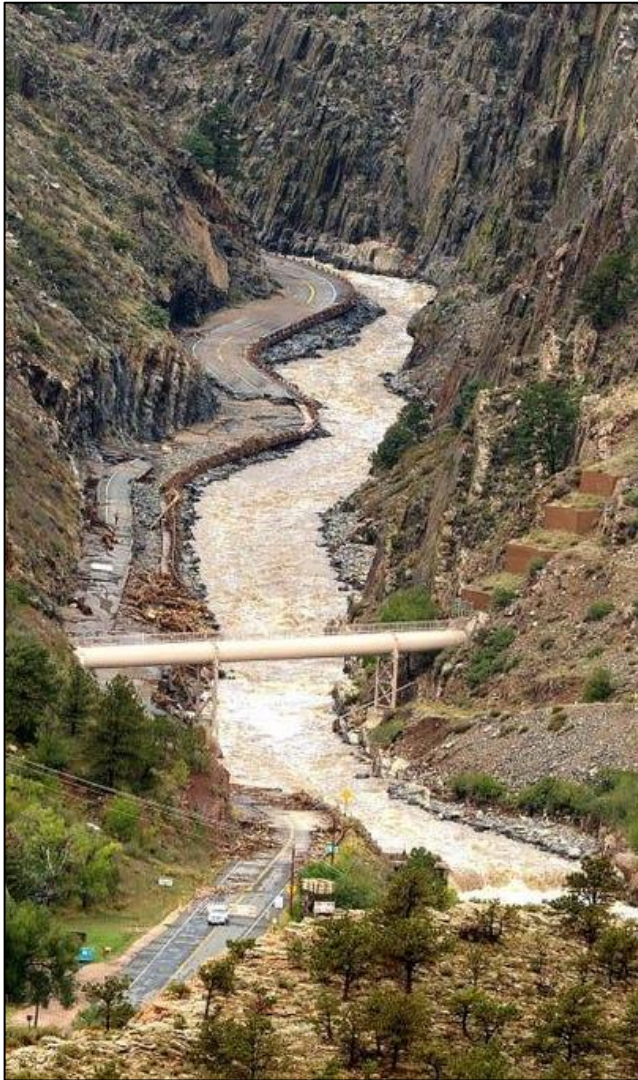
Climate is a major determinant of wildfire through its control of weather, as well as through its interaction with fuel availability, fuel distribution and flammability at the global, regional and local levels. With hotter temperatures, drier soil and worsening drought conditions in the county, our wildfires risk the potential to become more extreme. Currently, humans are the main cause of fire ignition globally, although lightning has been predominantly responsible for large fires in our county. Humans also actively deter fires by managing fuel loads to reduce its potential to spread. In recent years, we have seen significant increases in forest area burned in Colorado and the western U.S. The risk of wildfires in the future is expected to increase due to a lengthening fire season and drier conditions.

“Fire season has already lengthened by 18.7% globally between 1979 and 2013, with statistically significant increases across 25.3% but decreases only across 10.7% of Earth’s land surface covered with vegetation; with even sharper changes being observed during the second half of this period. Correspondingly, the global area experiencing long fire weather season has increased by 3.1% per annum or 108.1% during 1979–2013. Fire frequencies under 2050 conditions are projected to increase by approximately 27% globally, relative to the 2000 levels, with changes in future fire meteorology playing the most important role in enhancing global wildfires, followed by land cover changes, lightning activities and land use, while changes in population density exhibit the opposite effects.”³⁹
- International Panel on Climate Change (IPCC)

³⁷ Larimer County Office of Emergency Management, 2016. “Larimer County Multi-Jurisdictional Hazard Mitigation Plan.” <https://www.larimer.org/sites/default/files/larimer-hmp.pdf>

³⁸ Western Water Assessment, 2020. “Intermountain West Climate Dashboard.” <https://wwa.colorado.edu/climate/dashboard.html>

³⁹ Intergovernmental Panel on Climate Change, 2018. “Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.” <https://www.ipcc.ch/srccl/>



Big Thompson Canyon, 2013 Flood
Photo Credit: Larimer County

According to the National Oceanic and Atmospheric Administration, there is generally more rain and snow falling in the northern hemisphere as precipitation has increased by about 5% over the last century.⁴⁰ An increase in precipitation alone is not immediately alarming, but “factors such as precipitation intensity, soil moisture and snow conditions, and basin topography are also important in determining the occurrence and severity of flooding.”⁴¹ As with temperature, it is the extremes that matter most with regard to rainfall. According to Robert Hanson, author of *The Thinking Person’s Guide to Climate Change*, “Data shows a clear ramp up in precipitation intensity for the United States, Europe, and several other areas over the last century, especially since the 1970s. When it rains or snows in these places, it now tends to rain or snow harder, over periods ranging from a few hours to several days.”⁴² The 1997 and 2013 flood events caused widespread infrastructure damage, social instabilities, property damage, loss of life and changes along waterways throughout Larimer County and other areas of Colorado. Drought, precipitation intensity and changes in snowmelt patterns are overarching challenges we face in our county.

⁴⁰ Hanson, Robert, 2019. *The Thinking Person’s Guide to Climate Change*. American Meteorological Society, pg. 7.

⁴¹ Colorado Water Conservation Board, *Western Water Assessment*, 2014. “Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adaptation.” https://wwa.colorado.edu/climate/co2014report/Climate_Change_CO_Report_2014_FINAL.pdf

⁴² Hanson, Robert, 2019. *The Thinking Person’s Guide to Climate Change*. American Meteorological Society, pg. 80.

According to the IPCC Climate Change and Land Report (2018), there is high confidence in the scientific community that heat waves will increase in frequency, intensity and duration in most parts of the world, while drought frequency and intensity is projected to increase in already drought-prone regions.⁴³ Current research shows that the most recent heat waves throughout Colorado are within the range of historical variability.⁴⁴ However, heat waves and their associated health risks should not be discounted.



High Park Wildfire 2012
Photo Credit: U.S. Forest Service

Climate Change Impacts Each Phase of Emergency Management

Emergency Management integrates all phases of the disaster cycle, including Preparedness, Mitigation, Response, and Recovery. The impacts of climate change affect each of these four disaster management areas.

Preparedness: Climate change has been linked to causing natural hazards to be more frequent and intense. This means we might face hazards never experienced before, creating greater complexity and difficulty in planning efforts as the scope of impacts can be unknown.

Mitigation: Due to the increase in intensity and severity of climate-related hazards, mitigation efforts are equally complicated, as additional resources and funding are required to minimize potential impacts.



With an increase in catastrophic disasters nationwide in recent decades, funding for hazard mitigation efforts has decreased.

Response: Frequency or intensity of catastrophic events as a result of climate change alters the needs and opportunities for response. Future response and communication between our agency and the public will be more complicated and difficult to conduct due to the scope and unclear boundaries of

⁴³ *Intergovernmental Panel on Climate Change*, 2018. “Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems.” <https://www.ipcc.ch/srccl/>

⁴⁴ *Colorado Water Conservation Board, Western Water Assessment*, 2014. “Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adaptation.” https://wwa.colorado.edu/climate/co2014report/Climate_Change_CO_Report_2014_FINAL.pdf

these events. Also, displacement of residents as a result of catastrophic events (i.e. mass evacuations due to catastrophic wildfires) have a significant impact on the community economically and socially.

Recovery: There has been a 212% increase in disaster recovery costs nationwide in the past two decades. Many parts of the U.S. are experiencing multiple, repeated, and consecutive natural disasters, such as in the Gulf of Mexico and California. Larimer County is not immune to repeated natural disasters, as we experienced back-to-back federally declared disasters in 2012 (High Park Fire) and 2013 (Larimer County floods), subsequent smaller disasters in 2014-2015, and the county's largest wildfire (Cameron Peak) in 2020. Dealing with these events and preparing for possible future events results in increased taxpayer spending for recovery efforts and prolonged community recovery time. A lack of flood insurance creates an added economic strain and a more complex recovery for those most affected.

Additional Public Safety Concerns

Heat waves themselves don't cause power outages. Instead, the high temperatures cause people to increase the use of their air-conditioning, creating a strain on the transmission lines. In hot weather these transmission lines actually have a lower capacity and the increased demand of electricity can force the line to droop and potentially short-circuit. If this happens often enough, then a power outage will take place because there aren't enough transmission lines to carry the electricity needed.

Climate extremes that cause **disruptions to utility systems** will also increase the risk of crime-related events, such as burglary, looting, vandalism and arson. A research study by the University of Colorado at Boulder concludes that we could see tens of thousands of extra violent crimes every year in the United States due to climate change alone.⁴⁵

The researchers used data from an FBI crime database to understand the connections between global warming and crime rates, especially in winter. They found that warmer winters set the stage for more violent crime due to greater opportunity for interactions between people.

Increasing population plus climate change stressors lead to social vulnerability. Our county is experiencing population and density growth causing concern about crime, especially if exacerbated by climate change. Local vulnerability to disasters depends on more than the relationship between a place and its exposure to hazards. Social and economic factors – including race, age, income, renter status, or institutionalized living – directly affect a community's ability to prepare for and respond to change. The concept of social vulnerability helps explain why communities often experience a shock or stressor differently, even when they experience the same amount of physical impacts or property loss.

Very often, the impacts of hazards fall disproportionately on the most disadvantaged or marginalized people in a community – the poor, children, the elderly, the disabled, and minorities. During emergencies, for example, self-evacuation can be nearly impossible for disabled or institutionalized individuals. Additionally, the willingness of an individual/family to invest in long-term residential hazard reduction actions is often limited if their home is a rental. Factors like these not only limit the ability of some communities to get out of harm's way, they also decrease the ability of communities to recover from and thrive in the aftermath of a disaster event.

⁴⁵ Harp, Ryan and Karnauskas, 2020. "Global warming to increase violent crime in the United States." *Environmental Research Letters*.

Existing Adaptation and Mitigation Strategies

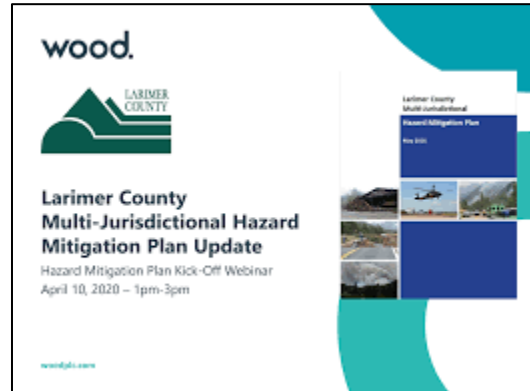
- The **2016 Larimer County Multi-Jurisdictional Hazard Mitigation Plan** outlines specific actions that can be taken to decrease risk from flooding, wildfires, spring storms, etc. (in this planning context, mitigation refers to the reduction or elimination of risk not specifically GHG emissions).
- The **Larimer Resiliency Framework** identifies risk throughout six core resilience areas: health and social, economy, housing, community, natural resources, infrastructure, and watersheds.
- The **Larimer Connects Program** was developed to build social capital and improve local community outcomes by providing a series of educational programs, workshops, and community engagement strategies.
- Larimer County **Micro-Grants Program** provides \$250-\$500 grants towards programs or events focused on community cohesion and resilience.
- Larimer County's **2020 Comprehensive Emergency Management Plan** outlines how the Office of Emergency Management will prepare for, respond to, mitigate against, and recover from emergencies and disasters.
- As part of the land use planning process in Larimer County, the Planning Division created the **Mountain Resilience Plan** to identify specific needs in our western rural areas, with recommendations for increased resilience. This was part one of the overall Comprehensive Plan.
- Larimer **Emergency Telephone Authority Emergency Notification System** provides text notifications to community members who opt in.



Top Recommendations for Future Action (see Appendix A for a full list of recommendations)

Climate change adaptation involves improving Larimer County's capacity to address existing vulnerabilities, building infrastructure that's resilient to newly identified perturbations, and engaging the public regarding risk and the actions required for subsequent public safety. The ways in which this can be done for the Emergency Management and Public Safety planning area include:

- Extend reach of current emergency management programs to incorporate equity and inclusion of formal and informal community leaders and members
- Deepen partnerships with private and non-governmental partners in the utility sector
- Update the Larimer County Multi-Jurisdictional Hazard Mitigation Plan with a climate adaptation lens to include these recommendations for 2021 (and continue this effort moving forward)



Recommendations for Public Engagement

The Office of Emergency Management regularly interacts with the public in a variety of ways, through emergency fairs and expos, preparedness classes, resiliency workshops, and response-related activities. In each instance there is an opportunity to engage with the public about how they wish to minimize risk in the community, decide what projects might be best suited for diverse areas, and learn about how communities are helping communities through local action.

Questions for consideration include:

- What actions do you take or can you take at your home to minimize the risks of climate change?
- How are farmers already utilizing best practices and innovative technologies to use less water or plant drought-resistant crops?
- How should the county address the possibility of diminishing water availability in a sustainable way?
- In what ways have you worked within your community to build relationships and networks?
- In what ways can community members help other community members during high heat events, air quality impacts, or power failure events?
- How can we strengthen county building codes in an equitable manner to decrease damage losses from wildfire and flood?
- What mitigation actions would be most appropriate to include in the new 2021 Hazard Mitigation Plan for Larimer County?
- In what ways should the county leverage technology to increase the resiliency of our critical lifelines (water, electricity, broadband, gas, etc.)?
- How can Larimer County and the community build programs that increase overall public safety and security?

D. Watershed, Agriculture, Open Spaces and Forestry

Planning Area: Watershed, Agriculture, Open Spaces and Forestry				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Increased frequency and intensity of natural disasters caused by climate change, poor land management practices and land use planning, incomplete recovery from previous disasters.	Displacement, anxiousness, loss of income and security.	Increased occurrence of invasive species, degradation of watersheds, loss of carbon sinks, reduced air quality.	Significant direct and indirect costs associated with rebuilding infrastructure and managing secondary impacts.	Limit development in forested areas or flood plains. Create buffers to protect resources. Conduct forest health projects. Restore wetlands and floodplains.
Poor air quality caused by climate change, aging transportation infrastructure, population growth, carbon emissions.	Detriment to human health, particularly to high-risk populations. Heightened risk of disease.	Reduced visibility, increased particulates, gases trap heat.	Increase in medical and transportation costs.	Invest in infrastructure and multi-modal transportation options. Incentivize emission reductions, restore marginal lands to native eco-systems that can act as CO ₂ sinks.
Increased occurrence of animal and plant pests caused by changing climate, population growth, ground disturbance, poor land management practices, unprotected vectors.	Property damage, heightened risk of disease, decreased water quality.	Leads to loss of biodiversity and eco-system processes. Alters community assemblages.	Increases costs to maintain infrastructure.	Better prevention, tracking and management of invasive species. Create more oversight and accountability when disturbance or unintended introductions occur.
Loss of biodiversity caused by warmer climate, population growth, ground disturbance, poor land management practices, habitat segmentation.	Reduction in wildlife and human resilience.	Reduces ability of species to adapt. Alters eco-systems and eco-system processes. Genetic bottlenecks can lead to extinction.	Increase in medical, food, wildlife and land management costs.	Conserve open space, restore native eco-systems to act as carbon sinks.

Planning Area: Watershed, Agriculture, Open Spaces and Forestry				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Loss of topsoil caused by higher winds, population growth, ground disturbance, poor land management practices.	Less food availability.	Loss of carbon sink, less area suitable for agriculture, increased use of fertilizers and pesticides, more erosion and flooding.	Higher costs of production and food.	Encourage, incentivize or mandate Best Management Practices, conserve undeveloped lands.
Reduction of water quality and quantity caused by increased drought, fewer glaciers, increased pollution runoff.	Economically vulnerable populations will be less water secure than affluent population.	Less water, increased flooding.	Higher water treatment costs due to higher pollution concentration.	Restore riparian corridors, wetlands and aquifers. Store municipal water underground. Establish agricultural buffer strips near waterways.

The Natural Resources planning area includes, but is not limited to, watersheds, soils, forests, agriculture, and plant and animal communities. The resiliency of these ecological features is dependent on our management and provides the high quality of life valued in Larimer County. Currently observed impacts of climate change on our natural resources include increased tree mortality⁴⁶ from diseases, fire, high temperatures and drought,⁴⁷ soil erosion, over-sedimentation in streams from scorched lands after fires,⁴⁸ and species relocating their habitats to higher elevations.⁴⁹

Forests and other vegetation store copious amounts of carbon and play a critical role in improving our air quality. Fire regimes that extend beyond their natural limits, typically due to active suppression, may cause unrecoverable damage to forest canopies and to homes bordering on or within natural areas.

Other deleterious effects of climate change on our natural areas include:

- Invasive species cause homogeneity and displace local species
- Algal blooms and hypoxic zones block photosynthesis in lower columns of stream channels and deplete oxygen necessary for fish and other aquatic life

⁴⁶ Law, Beverly E. et al. "Tree Mortality from Fires, Bark Beetles, and Timber Harvest During a Hot and Dry Decade in the Western United States (2003–2012)." *Environmental research letters: ERL*. 12.6 (2017): n. pag. Web. <https://iopscience.iop.org/article/10.1088/1748-9326/aa6f94/pdf>

⁴⁷ Singer, J., Turnbull, R., Foster, M., Bettigole, C., Frey, B., Downey, M., ... Ashton, M. (2019). Sudden Aspen Decline: A Review of Pattern and Process in a Changing Climate. *Forests*, 10(8), 671. doi: 10.3390/f10080671

⁴⁸ Law, Beverly E. et al. "Tree Mortality from Fires, Bark Beetles, and Timber Harvest During a Hot and Dry Decade in the Western United States (2003–2012)." *Environmental research letters: ERL*. 12.6 (2017): n. pag. Web. <https://iopscience.iop.org/article/10.1088/1748-9326/aa6f94/pdf>

⁴⁹ Sabuj Bhattacharyya & Chris Ray (2015) Of plants and pikas: evidence for a climate-mediated decline in forage and cache quality, *Plant Ecology & Diversity*, 8:5-6, 781-794, DOI: 10.1080/17550874.2015.1121520

- Human impacts on ecological functions of open spaces (e.g. social trails, trash and dog feces)
- Blocked wildlife corridors through and between cities stifling genetic diversity

Variations in stream flows, precipitation, development patterns and temperature impact floodplains when vegetation that typically protect stream embankments becomes stressed or dies as a result of these environmentally variable conditions.⁵⁰ Without a protective layer of vegetation, floodplain features like stream embankments become subject to the erosive forces of high river flows. Drought and flood effects on vegetation impact trail corridors, parks, wildlife habitat, flood storage and groundwater recharge, agricultural yields and potentially adjacent neighborhoods and communities.⁵¹ Projected water-related impacts from climate change, in Colorado, are shown in Table 1 below.

Sector	Projected changes & potential impacts to Colorado’s water resources
Overall surface water supply	Most projections of future hydrology for Colorado’s river basins show decreasing annual runoff and less overall water supply, but some projections show increasing runoff. Warming temperatures could continue the recent trend towards earlier peak runoff and lower late summer flows.
Water infrastructure operations	Changes in the snowpack and in streamflow timing could affect reservoir operations, including flood control and storage. Changes in the timing and magnitude of runoff could affect the functioning of diversion, storage, and conveyance structures.
Crop water demand, outdoor urban watering	Warming temperatures could increase the loss of water from plants and soil, lengthen growing seasons, and increase overall water demand.
Legal water systems	Earlier and/or lower runoff could complicate the administration of water rights and interstate water compacts and could affect which rights holders receive water.
Water quality	Warmer water temperatures could cause many indicators of water quality to decline. Lower stream flows could lead to increasing concentrations of pollutants.
Groundwater resources	Groundwater usage for agriculture could increase with warmer temperatures. Changes in precipitation could affect groundwater recharge rates.
Energy demand and operating costs	Warmer temperatures could place higher demands on hydropower facilities for peaking power in summer. Warmer lake and stream temperatures, and earlier runoff, could affect water use for cooling power plants and in other industries.
Forest disturbances in headwaters regions	Warmer temperatures could increase the frequency and severity of wildfire and make trees more vulnerable to insect infestation. Both have implications for water quality and watershed health.
Riparian habitats and fisheries	Warmer stream temperatures could have direct and indirect effects on aquatic ecosystems, including the spread of non-native species and diseases to higher elevations. Changes in streamflow timing can also affect riparian ecosystems.

⁵⁰ Earles, Andrew, Mackenzie, Ken, Bennetts, David and Traylor, Julia. 2015. [Planning for Variability & Uncertainty: Climate Change and the UDFCD Urban Drainage System](#). Wright Water Engineers, Inc. 141-102.000 1:26\

⁵¹ Earles, Andrew, Mackenzie, Ken, Bennetts, David and Traylor, Julia. 2015. [Planning for Variability & Uncertainty: Climate Change and the UDFCD Urban Drainage System](#). Wright Water Engineers, Inc. 141-102.000

Sector	Projected changes & potential impacts to Colorado’s water resources
Water- and snow-based recreation	Earlier streamflow timing could affect rafting and fishing. Changes in reservoir storage can affect recreation on-site and downstream. Declining snowpack can impact winter mountain recreation and tourism.

Table 1 Projected water related impacts on social, ecological and economical aspects.

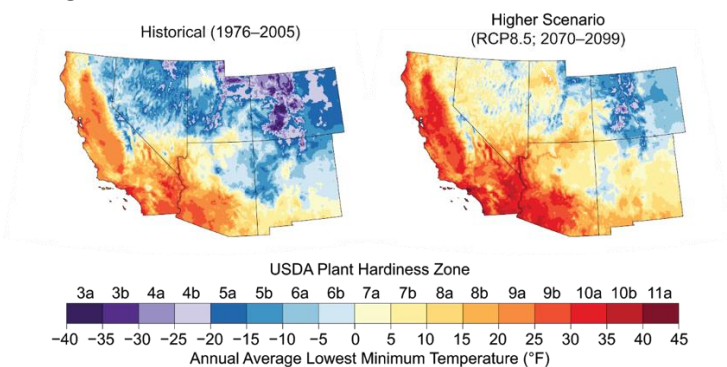
Source: Colorado State University Water Knowledge Extension

<https://waterknowledge.colostate.edu/climate/#tab-3-of-3-climate-change> Adapted from Lukas et al., 2014.

Larimer County has a long and rich agricultural history. We rank eleventh overall for total value of agricultural products sold in the State of Colorado, second for aquaculture and third for horses and dairy products. Due to development, the county’s agricultural lands have been steadily decreasing over the years. Over a 20-year period, Larimer County saw an overall drop of 16.1% in the total acreage in farmland. This trend is more pronounced in Larimer County than nationally or in the state of Colorado. Social and economic pressures on families and landowners make it harder to remain a profitable farmer or rancher when land is considered more valuable developed than in an agricultural or natural state. Larger farms going out of business and being resold as smaller 'ranchettes' is the main reason Larimer County has seen an increase in the number of farms along with a decrease in farm acreage.

Other “economic losses are incurred by the US livestock industries because farm animals are raised in locations and seasons where effective temperature conditions venture outside their zone of thermal comfort.”⁵² Projected shifts in agricultural zones due to temperature variations (shown in figure 6) predict that the number of crop and plant varieties will shrink, limiting what crops our farmers might successfully produce, as well as what feed might be available for livestock in our future.

Temperature changes affect crops and livestock through heat stress and heat exhaustion, leading to increased water consumption, reduced feed intake, reduced reproductive activity and reduced lactation yields, among other effects.⁵³ Due to pork and poultry production typically being housed in environmental-controlled facilities which shield animals from external pressures, cost of production might increase. Meanwhile, traditional



**Figure 9: Projected shift in Agricultural Zones:
Extreme heat map and crop temperature requirements**

outdoor production systems such as the beef and cattle industry will be effected by similar temperature-related issues.⁵⁴ Additionally, loss of seasonal synchrony between crops and pollinators due to climate change has been studied across U.S. agricultural lands, but has yet to be studied in Larimer County.

⁵² St-Pierre, N., Cobanov, B., & Schnitkey, G. (2003). Economic Losses from Heat Stress by US Livestock Industries. *Journal of Dairy Science*, 86. doi: 10.3168/jds.s0022-0302(03)74040-5

⁵³ M. Melissa Rojas-Downing, A. Pouyan Nejadhashemi, Timothy Harrigan, Sean A. Woznicki. 2017. Climate change and livestock: Impacts, adaptation, and mitigation, *Climate Risk Management*, Volume 16.

⁵⁴ *National Climate Assessment*, 2018. “Fourth National Climate Assessment.” Chapter10: Agriculture and Rural Communities. <https://nca2018.globalchange.gov/chapter/10/>

The following agricultural practices known to degrade ecosystems also indirectly affect climate change:

- Surface runoff of fertilizers and pesticides leads to nutrient loading in waterways and release of NO₂ (e.g. algae blooms and hypoxic zones)
- Fire suppression in grasslands, rangelands, and forest ecosystems causes larger fuel loads closer to buildings (e.g. barns and homes)
- Soil erosion from uncovered surfaces reduces soil quality, increases sedimentation in streams and raises downstream costs of water treatment
- Irrigation during warmest times of the day increases evaporation rather than transpiration

Agriculture plays a constant and significant role in the stability of society. With climate change affecting seasonal growth patterns and water availability, and increasing encroachment from urban sprawl and land uses, continued County support for agriculture is critical. Whether through policies, funding, community engagement or helping change consumer choices, county action is paramount to keeping Larimer County alive with healthy ranches, farms, and other vegetated areas. Sustainable agricultural practices can ameliorate the negative impacts of water and soil loss, monoculture crop failure, depleted nutrients and adverse health effects, as well as drive economic diversity and stability.

“Rural communities are the stewards of most national forests, watersheds, rangelands, agricultural lands and fisheries and much of the rural economy is closely tied to its natural environment.” - Fourth National Climate Assessment 2018

This framework outlines alternatives to ecologically damaging agricultural practices to mitigate GHG emissions, bolster the ecological capacity of the land, and strengthen our local economy. Climate change solutions for our agricultural community like Climate-Smart Agriculture (CSA), Regenerative Agriculture and an Agroecology ethic are discussed further in the recommendations section below.

“Do unto those downstream as you would have those upstream do unto you.”
— Wendell Berry

Existing Conservation, Adaptation and Mitigation Resources

- Help Preserve Open Space Sales Tax
- Natural Resources Conservation Services
- Colorado State University Extension services: Colorado Climate Center
- The Larimer County Open Lands Master Plan
- Larimer County Land Use Code
- Larimer County Noxious Weed Management Plan
- Larimer County Pest List
- Colorado Agricultural Workforce Development Program through the Colorado Department of Agriculture Conservation branch

Top Recommendations for Future Action (see Appendix A for a full list of recommendations)

- Encourage forest health projects such as prescribed fire and tree thinning on private and public lands throughout the county
- Inform the agricultural community on strategies to reduce heat stress impacts on livestock such as aligning feeding and management practices with cooler parts of the day and reducing the effort needed by an animal to obtain food and water

- Collaborate with CSU faculty and municipalities to implement urban ecology features within urban areas and Growth Management Areas, reducing urban heat island effects and building green patches for wildlife corridors

Recommendations for Public Engagement

The bottom line on mitigation and adaptation strategies for natural resources and agriculture is the cost or investment that citizens and landowners are willing to commit to strengthen the environment.

Aspects to consider or implement are:

- Identify and work with public engagement organizations such as the Headwater Institute (real-estate water conservation education), Northern Water, CSU Warner College of Natural Resources, etc.
- Public outreach to farmers and ranchers in frequently visited locations (e.g. JAX's farm and ranch store)
- Identify examples of sustainable practices on private ranches and farms; ask the ranchers and farmers if they are willing to provide tours to other community members
- Involve stakeholders like outdoor recreation companies and users, pet owners, natural area visitors, farmers, ranchers, water providers and the U.S. Forest Service

E. Public and Environmental Health

Planning Area: Public Health/Environmental Health				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Extreme temperature events caused by more frequent, drastic, and persistent high temperatures.	More frequent extreme temperatures will result in an increase in temperature related death and illness. Could disrupt schools without air-conditioned buildings.	More frequent extreme temperatures will result in an increase in temperature-related death and illness.	Inability for people who need work outside to actually work outside (farm workers, road workers, etc.).	Increase capacity to respond to extreme events via cooling shelters. Alter community design standards to reduce heat collection potential (asphalt) and increase green roofs and tree canopy.
Worsened and harmful air quality caused by ground level Ozone, particulate matter, and allergens	Increased ground level Ozone, particulate matter, and allergens will result in worsened air quality resulting in reduction of outdoor activity.	Increased ground level Ozone, particulate matter, and allergens will result in worsened air quality and lead to higher rates of cardiovascular, respiratory, and allergy-related illness and increased health care needs.	Increased hospitalization/health care costs - potential decrease of tourism.	Work to reduce ozone precursors in the community and to actively control particulates from activities in the community.
Water Quality caused by changes in seasonal weather patterns, increased extreme weather events, decreases in snowpack, leads to concentration of pollutants within water bodies.	While changes in seasonal weather patterns and decreased snowpack will result in less runoff, thus leading to clean water shortages, causing mental distress.	Increased temperatures impacting stream and lake water quality, extreme weather events, and pollution will result in worsened water quality, thus leading to a higher rate of water-borne disease and infection and harmful algae blooms.	Increased health care costs - potential decrease of tourism - disruption of businesses.	Work with recreational water bodies and water suppliers as appropriate to increase awareness and response capacity. Increase monitoring systems to track changes in water quality.

Planning Area: Public Health/Environmental Health				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Bad water quality caused by wildfire and flood events cause damage to or prevent effective operation of water and wastewater treatment systems.	Disruption of water or wastewater treatment may require temporary relocation or emergency service support.	Disruption of effective treatment systems would result in unsafe water supplies or untreated wastewater entering community waterways.	Increased hospitalization/health care costs, potential decrease of tourism, disruption of businesses, changes in development costs.	Evaluate changes to water and wastewater treatment systems to mitigate these risks.
Mental health deteriorates, caused by increasing concern about individual and community impacts of climate change and the scope of efforts to respond.	Natural disasters are associated with mental health problems. Wildfires, floods, and severe weather can cause extreme anxiety or long-term mental health problems such as depression, post-traumatic stress disorder, or suicide. Longer lasting events, such as droughts, may also have adverse mental health effects.	In addition, these events can impact physical health.	Reduction in worker productivity and school attendance	Work with providers to improve access to services and awareness of this contributing issue.
Vector-borne disease increases, caused by altered weather patterns and higher temperatures that change vector behavior and expand seasonal geographic range of vector mosquitoes.	Could result in changes to outdoor activities and events.	Increased geographical & seasonal range, change in vector behavior, expanded range of vector mosquitos.	Changes to seasonal outdoor activities and special events.	Revise community vector monitoring and control plans and activities regularly as information changes.
Food safety/ security decreases, caused by lower crop yields, increased growth of crop pathogens and pests.	Disruption in timing and supply of foods.	There is a small potential for change or increases in food-related infection (salmonella, Campylobacter, E. coli).	Changes to food supply sourcing, and increased food price.	Work closely with state food safety regulators, community food safety advocates, and the university system to identify specific risks and responses.

As with other county agencies, the Larimer County Department of Health and Environment (LCDHE) aims to prudently manage the effects of climatic changes. Unique among county agencies, LCDHE's primary goal is to protect the public's health. Climate change worsens a wide range of public health stressors across every demographic and throughout various terrains of the County. LCDHE's goal is to address these challenges even in a situation where significant operational constraints are largely beyond local control, such as state and federal legislative requirements, and available state and federal funding.

LCDHE has three service areas: Health Services offers vaccinations and community and family health services; Health Promotion supports maternal, child and family needs; and Environmental Health Services administers resource-oriented programs including air quality, water quality, food safety and vector control. LCDHE helps coordinate and manage responses to immediate public health threats from hazards such as floods and wildfires. As an example, LCDHE has an emergency mutual aid and assistance agreement with other Colorado public health agencies to cooperate in disaster prevention, preparedness, response, and recovery.



Climate change stresses human health and welfare. Our most basic needs for clean water, clean air, food, and shelter are affected by precipitation levels, impaired air quality, and warmer temperature ranges. Changing outdoor temperatures increase the cost of heating and cooling homes, schools, and office buildings. Extreme events like floods and wildfires cause death, injury, emotional trauma and long-term property impacts, while stifling accessibility to goods and services.

Modern commerce and communication interconnect our world, but they also bring the effects of climate change experienced by other states and countries to Coloradans, in addition to our own local climate effects. Large-scale crop failure from drought impacts the price and availability of nutritional food; floods and washed-out roads disable transportation corridors, isolating communities. We risk exposure to unprecedented infectious diseases as long-term weather patterns change the prevalence and range of many diseases, while global transportation of goods and people can amplify the spread.⁵⁵

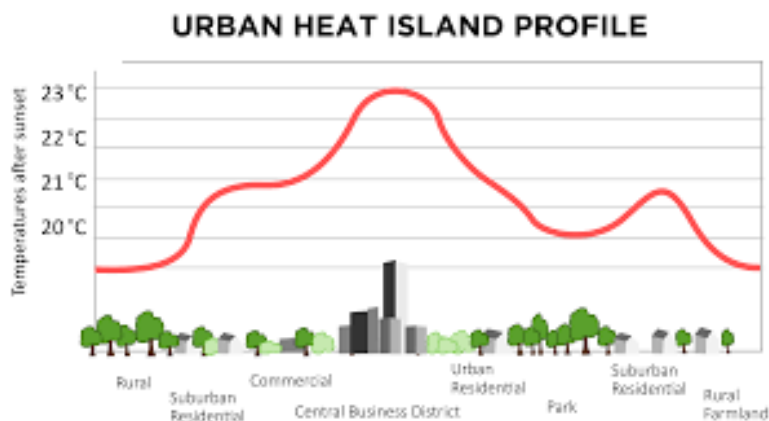
Climate change has serious and far-reaching health implications for present and future generations. Our observations show both direct and indirect impacts on human health in Larimer County.⁵⁶ Air pollution from power generation and transportation in the county and regional oil and gas development, plus reduced air quality from wildfire smoke, is worsening respiratory conditions and increasing allergies.

⁵⁵ Childress, Amber et al., 2015. "Colorado Climate Change Vulnerability Study."
http://www.colorado.edu/climate/co2015vulnerability/co_vulnerability_report_2015_final.pdf

⁵⁶ *The White House*, 2014. "The Health Impacts of Climate Change on Americans." Washington, DC: The White House.
https://obamawhitehouse.archives.gov/sites/default/files/docs/the_health_impacts_of_climate_change_on_americans_final.pdf

Poor air quality, including ground-level ozone and particulate emissions, exacerbate asthma, leading to increased incidences of “asthma-related hospital visits and premature deaths.”⁵⁷

To improve air quality, the State updated Regulation No. 3: Stationary Source Permitting and Air Pollutant Emission Notice Requirements, requiring “Prevention of Significant Deterioration” permits for GHG emission sources greater than 75,000 tons per year (tpy) CO₂e for a new major source, or an increase of 75,000 tpy CO₂e for an existing major source.⁵⁸ Additionally, the State recently adopted a Low-Emissions vehicle (LEV) and Zero Emission vehicle (ZEV) standard requiring manufacturers to provide a percentage of their fleet (Passenger Car and Pick-ups) as ZEVs manufactured for the year 2023 and after.⁵⁹ In addition, this regulation restricts the sale, rental, or registration of a model year new car^{60**} that does not meet California’s emission Code Title 13 after 2022.



Another public health concern for our growing community is a phenomenon known as the Urban Heat Island effect. Ambient temperatures are higher in developed areas than in their rural counterparts because of decreased surface albedo. Albedo is the Earth’s ability to reflect solar radiation (high albedo) or absorb it (low albedo), leading to temperature differences we feel on a warm or cold day, depending on what surface is below us and the local air circulation. Darker surfaces from building materials such as roofing, pavement, and asphalt, combined with reduced vegetation in urban zones, leads to a low albedo.⁶¹ On a hot, cloudless, summer day, low albedo surfaces exposed to the sun can reach 50 to 90°F

⁵⁷ Confalonieri, U., Menne, B., Akhtar, R., Ebi, K. L., Hauengue, M., Kovats, R. S. et al. (2007). Human health. In *Climate Change 2007: Impacts, Adaptation and Vulnerability* (pp. 391-431). Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (Eds.)]. Cambridge, UK, and New York: Cambridge University Press.

⁵⁸ Department of Public Health and Environment, Air Quality Control Commission, 2016. “Regulation No. 3 Stationary Source Permitting and Air Pollutant Emission Notice Requirements.”

https://drive.google.com/file/d/1_0oq-e_bYz_DT1y9h_rwn-O3gPQmQqa-/view?usp=sharing

⁵⁹ Department of Public Health and Environment, Air Quality and Control Commission, 2019. “Regulation No. 20 Colorado Low Emission Automobile Regulation.”

<https://drive.google.com/file/d/1JxotqZx6xBToVP7H5DUEbuTo5V5Zb83E/view?usp=sharing>

^{60**} “New cars” include new Passenger Car, Light-Duty Truck, Medium Duty Passenger Vehicles, and Motor-Vehicles. From: Department of Public Health and Environment. (2019). Regulation No. 20 Colorado Low Emission Automobile Regulation. Air Quality and Control Commission.

⁶¹ Frank Flocke, Gabriele Pfister, James H. Crawford, Kenneth E. Pickering, Gordon Pierce, Daniel Bon, and Patrick Reddy (2019). Air Quality in the Northern Colorado Front Range Metro Area: The Front Range Air

hotter than the air temperature, while vegetated, shaded or moist surfaces, often in more rural surroundings, remain close to air temperatures. On average, daytime surface temperature differences between developed and rural areas reach 18 to 27°F, with nighttime temperature differences of 9 to 18°F.⁶² Known impacts of the Urban Heat Island Effect reported in other communities include increases in energy consumption and costs, heat-induced strokes, other human health issues, and water quality degradation due to faster evaporation rates in urban waterways.

Ground-level ozone concentrations are shown to increase with heightened average temperatures along Colorado's Front Range. Ground-level ozone is a component of urban smog (smoke and fog) which has adverse health effects on the respiratory system, particularly those of children and the elderly,⁶³ pregnant women, outdoor workers, and individuals with cardiovascular disease. Ground-level ozone is created by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Major sources of NOx and VOCs are from industrial facilities and electric utilities, motor vehicle exhaust, fuel vapors, and oil and gas development activities.⁶⁴ When all other variables are equal, such as levels of NOx and VOC emissions, wind speed and direction, ground level ozone levels will be higher in hotter and sunnier weather. Therefore, elevated air temperatures due to our current ozone pollution levels, exacerbated by the Urban Heat Island effect, might increase the rate of ground level ozone formation as development expands into unincorporated areas of Larimer County.

Adverse respiratory health effects include:⁶⁵

- Aggravation of lung diseases such as asthma, emphysema, and chronic bronchitis
- Diminished lung function and higher susceptibility to infection
- Increases in premature deaths

Climate change increases stress on water quantity and quality. Larimer County will likely continue to see increases in precipitation associated with large-scale storm events, longer time between extreme events, and more precipitation falling as rain instead of snow. Together, these factors increase the probability of contaminant loading from septic or industrial sources in stormwater flows, and increase the potential for catastrophic flooding beyond floodplain boundaries (as we saw in both the 1997 and 2013 floods) as areas previously thought to be outside the flood zone are now vulnerable to inundation.

Water chemistry is sensitive to direct impacts of climate change such as temperature variations. Higher average ambient temperatures result in higher temperatures in streams and lakes. Algal blooms are exacerbated by high ambient and water temperatures, which lead to low oxygen concentration in water, which harm human consumptive and recreational uses, as well as wildlife. Algal blooms are exacerbated

Pollution and Photochemistry Experiment (FRAPPÉ). *Journal of Geophysical Research: Atmospheres*. 10.1029/2019JD031197

⁶²U.S. Environmental Protection Agency. 2008. Reducing urban heat islands: Compendium of strategies. Draft. <https://www.epa.gov/heat-islands/heat-island-compendium>.

⁶³ U.S. Environmental Protection Agency, 2008. "Reducing urban heat islands: Compendium of Strategies." <https://www.epa.gov/heat-islands/heat-island-compendium>.

⁶⁴ Flocke, Frank, et al., 2019. "Air Quality in the Northern Colorado Front Range Metro Area: The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ)." *Journal of Geophysical Research: Atmospheres*. 10.1029/2019JD031197

⁶⁵ American Public Health Association, 2020. "Climate Change Decreases the Quality of the Air We Breathe." U.S. Department of Human Health Services https://www.apha.org/media/files/pdf/factsheets/climate/air_quality.ashx?la=en&hash=2452C952E62C94E391543B4451627D732FEB8C48

by high ambient and water temperatures, low water levels (stagnation) and inputs of nitrogen and phosphorus.⁶⁶ Algal blooms are evident in various locations of our county’s watershed.

Climate changes increase potential vector-borne illness. Impacts to vegetation and average/extreme conditions expand host habitats for different disease vectors and reservoirs, such as mice, birds, mosquitos, deer, and bats.⁶⁷ Some possible changes include:

- Increased incidences of plague and tularemia if winters become warmer and rainier on average.
- Warmer weather might expand habitat ranges for some mosquito species;⁶⁸ increases in precipitation provide greater opportunities for disease carrying mosquito populations (e.g., *Aedes sp.*) whose lifecycles link to flooding.
- Expanding distribution of ticks, which can carry illnesses like Rocky Mountain Spotted Fever.⁶⁹
- More encounters with wildlife like raccoons, squirrels, deer, bears and coyotes in urban areas.



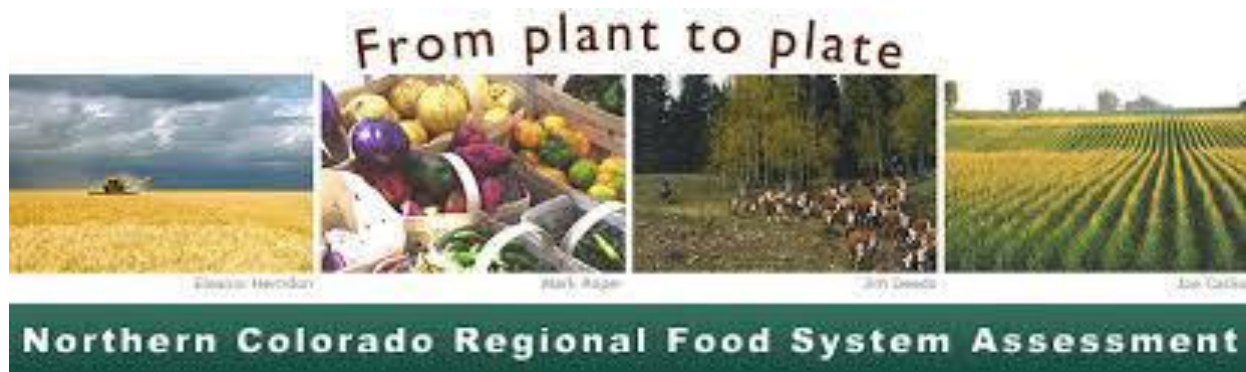
Climate change threatens food safety and security. Changes in seasonal weather, temperature and precipitation patterns may result in changes to crop pests, weeds, and yields, according to the Colorado State University Agriculture Department, which has extensively studied current and future agricultural impacts. Although local food production does not account for a large portion of the food consumed in Larimer County, negative impacts on local markets might arise, as well as road closures in the mountains and between floodplains destabilizing our transportation corridors and community’s typical food source.

⁶⁶ O’Neil, J.M., Davis, T.W., Burford, M.A., and Gobler, C.J., 2011. “The rise of harmful cyanobacteria blooms: The potential roles of eutrophication and climate change”. Elsevier. <https://doi.org/10.1016/j.hal.2011.10.027>

⁶⁷ Ebi, K.L., Balbus, J. Kinney, P. L., Lipp, E., Mills, D., O’Neill, M. S., et al. Effects of Global Change on Human Health. In J. L. Gamble (Ed.), *Synthesis and Assessment Product 4.6. Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems (2-22-2-26)*. Washington, D.C.: Environmental Protection Agency.

⁶⁸ Lars Eisen, Bethany G. Bolling, Caroll D. Blair, Barry J. Beaty, Chester G. Moore, Mosquito Species Richness, Composition, and Abundance along Habitat-Climate-Elevation Gradients in the Northern Colorado Front Range , *Journal of Medical Entomology*, Volume 45, Issue 4, 1 July 2008, Pages 800–811, <https://doi.org/10.1093/jmedent/45.4.800>

⁶⁹ Confalonieri, U., Menne, B., Akhtar, R., Ebi, K. L., Hauengue, M., Kovats, R. S. et al. (2007). Human health. In *Climate Change 2007: Impacts, Adaptation and Vulnerability* (pp. 391-431). Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (Eds.)]. Cambridge, UK, and New York: Cambridge University Press.



Climate change worsens mental health, in addition to effects on physical health, natural disasters are associated with mental health problems.⁷⁰ Wildfires, floods, and severe weather can cause extreme anxiety or long-term mental health problems such as depression, post-traumatic stress disorder, or suicide. Longer lasting events, such as droughts, may also have adverse mental health effects.⁷¹

Moreover, the health risks associated with climate change will not be shared equally among individual populations. These effects listed above will disproportionately burden the very young, senior adults, outdoor workers, people living with mental and physical disabilities, and low-income and marginalized communities, thereby exacerbating social and environmental injustices.^{72, 73} These disproportionate burdens are further discussed in the public engagement section.

Existing Adaptation and Mitigation Strategies

- LCDHE coordinates with the Office of Emergency Preparedness on all-hazard preparedness and response
- State and local water quality programs and associated regulations
- Regulation No. 3: Stationary Source Permitting and Air Pollutant Emission Notice Requirements
- Human Resources designed procedures to protect outside workers including Road and Bridge staff and all contractors exposed to extreme heat
- Vector and Animal Control
- LCDHE 2020 Strategic Plan priorities
- 2019-2023 LCDHE Community Health Improvement Plan:

⁷⁰ Hayes K, Blashki G, Wiseman J, Burke S, Reifels L. Climate change and mental health: risks, impacts and priority actions. *Int J Ment Health Syst.* 2018 Jun 1;12:28. doi: 10.1186/s13033-018-0210-6. PMID:29881451; PMCID: PMC5984805.

⁷¹ L.V. O'Brien, et al., "Drought as a Mental Health Exposure," *Environmental Research* 131 (2014): 181–87; Helen L. Berry, et al., "Climate Change and Mental Health: A Causal Pathways Framework," *Int. J. Public Health* 55 (2010): 123-132.

⁷² Flocke, F., Pfister, G., Crawford, J. H., Pickering, K. E., Pierce, G., Bon, D., & Reddy, P. (2020). Air quality in the Northern Colorado Front Range Metro Area: The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ). *Journal of Geophysical Research: Atmospheres*, 125, e2019JD031197. <https://doi.org/>

⁷³ The rise of harmful cyanobacteria blooms: The potential roles of eutrophication and climate change, J.M. O'Neil, T.W. Davis, M.A. Burford, C.J. Gobler University of Maryland, Center for Environmental Science, Horn Point Laboratory, Cambridge, Harmful Algae Volume 14, February 2012, Pages 313-334 <https://www.sciencedirect.com/journal/harmful-alg>

- 1) Promotes mental and emotional wellbeing across an individual's lifespan by addressing required continuum of care gaps, substance use treatment and primary prevention
- 2) Provides access to quality childcare by addressing affordability, recruitment and retention of the childcare workforce, as well as infant and toddler care

Top Recommendations for Future Action (see Appendix A for a full list of recommendations)

- Work with state and local partners to monitor health outcome data and community environmental data related to potential impacts such as air quality, water quality, temperature trends and behavioral health.
- Work with state and local partners to assure appropriate water-borne disease and harmful algal bloom tracking system is maintained or enhanced.
- Enhance community public health partnerships to address climate change in the areas of air quality, water quality and mental health.

Recommendations for Public Engagement

Use public forums and community events to engage the community about what services or programs are needed in Larimer County to enhance public and environmental health ability to respond to emerging risks, and provide incident-based services to adapt to our hazards (floods, fires, air quality, water quality, vector-borne disease and mental health).

Questions might include the following:

- What climate-related health impacts are most concerning to you and your family?
- How can the county make air quality and water quality data more accessible to community members and businesses?
- What changes to policies or regulations would you recommend for improving community health outcomes?
- Is there a local role in compliance assistance related to public and environmental health? If so, what services would be beneficial or a priority for the community?
- What are the behavioral changes you or your family would be willing to make to improve air or water quality? (Provide a list of options.)



Healthy Larimer

Following your lead to
a stronger community

F. Public Works and Engineering

Planning area: Public Works and Engineering				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Increased frequency and duration of extreme precipitation events/flooding caused by warmer air holding more moisture. More winter precipitation will fall as rain instead of snow, leading to seasonally early snowmelt. Higher temperature extremes in the summer lead to drying and drought conditions.	Isolation of small communities, water shortages, increased area floods may make it harder or more expensive for people to insure their homes/businesses/assets in risk-prone areas.	Intense erosion under or near vital infrastructure and extended periods of summer drought.	Potential for a major decline in tourism, crop profit loss, Interruption of water supply due to increased sediment loading (erosion) or pollution adding costs to municipal water suppliers.	Reestablishing and maintaining floodplain ecosystems in their natural state. Increasing the mosaic character of the floodplain by creating ecologically functioning buffer zones. Riparian, stream and wetland restoration. Placing a restrictive limit on development in and around floodplains.
Increased stormwater runoff caused by increased precipitation and increased frequency of flooding events.	Reduced water quality, water supply interruption, flooding of homes and trailers	High flows may disrupt the settling process and shorten the high rate of turnover of stormwater retention ponds during extreme conditions, which may lead to higher pollution concentrations and loads being emitted to the environment.	Increased damage to infrastructure.	Community outreach and education, Education and Outreach, pollution prevention, good housekeeping and reducing nutrients, green infrastructure such as permeable pavements, rain barrels, and "green" roofs, and the reduction of nutrient loads.

Planning area: Public Works and Engineering				
AREA OF CONCERN & DRIVERS (Something that influences the area of concern)	SOCIAL IMPACTS	ENVIRONMENTAL IMPACTS	ECONOMIC IMPACTS	ADAPTATION OPTIONS
Increased water pollution associated with stormwater, caused by discharges from septic systems and flooding carrying pollutants from surfaces such as pavement, grassy areas, and non-vegetated surfaces.	Health impacts for river recreators and pets, children sickened from toxic blue-green algae.	Higher pollution impacts wildlife and fisheries and algae blooms and toxic blue-green algae.	Increased regulatory obligation to the County to meet State regulations and mitigating toxic algae.	Community outreach and education, Education and Outreach, pollution prevention. Erosion control plan/stormwater management plan.
Increase in disruptions to transportation systems caused by more frequent flooding events.	Disruption of traffic, delay in construction activities, increased travel times and travel distances.	Changes in soil moisture, increased pollution associated with runoff, potential for landslides and washouts to occur more frequently.	Shortened life expectancy of roads, more construction, higher costs associated with managing road closures, higher costs associated in repairing roads.	Use USDOT Climate Change Guide, implement a traffic control plan, reinforce critical evacuation routes, update road drainage systems, increase culvert capacity, increase the standard for drainage capacity for new transportation infrastructure and major rehabilitation projects.
Increase in disruptions to transportation systems due to frequency and duration of extreme high temperatures caused by heat waves.	Disruption of traffic (increased construction, increased road deterioration), increased travel times, increase in frequency of vehicles overheating, increased road and lane closures, increased traffic congestion.	Increased pollution due to increased construction.	Shortened life expectancy of roads/more construction and labor losses.	Changes in cement mix.

Larimer County’s Public Works Department, through its several service areas including Engineering, Road and Bridge, and Solid Waste, provides safe, efficient, and adequately maintained transportation, infrastructure, water, and waste systems. Program areas including road improvements, road maintenance, public improvement districts, bridge and structure rehabilitation and replacement, traffic safety, stormwater, drainage, floodplain regulation and operation of the county landfill.

Since 2009, the County Landfill has reduced its GHG emissions by collecting and destroying about one-third of its produced methane. “Landfill gas is typically about 50 percent methane, which pound-for-pound is 21 times more potent than carbon dioxide as a global warming pollutant.”⁷⁴



Through a private/public partnership, Larimer County sold its rights to the landfill’s gas to Timberline Energy, LLC (now Larimer Energy LLC) in 2008. In 2009, Timberline Energy constructed a partial gas collection system, consisting of 41 vertical wells, collection piping, and a blower and utility flare. The system, which covers about one-third of the landfill, was started up in October 2009, and gas has been collected and combusted in the flare ever since. Our Solid Waste department tracks the annual volume of gas collected and

the metric tons of methane combusted at the flare. The goal has been for Larimer Energy to put the gas to a beneficial use; while over the last ten years they have investigated several different projects, to date nothing has been initiated.

By burning methane instead of releasing it into the atmosphere, the project takes the equivalent of about 7,500 cars off the road each year. These projects also can minimize other negative impacts to landfills, such as by preventing groundwater contamination.

As Larimer County anticipated reaching its landfill capacity by 2024, it convened the North Front Range Regional Watershed Coalition to develop the **2018 Solid Waste Infrastructure Master Plan**,⁷⁵ which guides the development of municipal solid waste disposal infrastructure over the next 30 years. By maximizing salvageable material recovery and minimizing materials going into a new landfill, the County expects to make significant greenhouse gas emissions savings. The Master Plan aims to:

- achieve a minimum landfill diversion rate of 40 percent by 2025
- divert from construction and demolition material waste through recycling or reuse
- divert organics or “green waste” such as yard and food waste through composting

When green waste (yard waste, grass clippings, organic food waste) is disposed of in the landfill, it generates avoidable GHG emissions (carbon dioxide and methane). As our 2011 GHG inventory

⁷⁴ *Colorado Carbon Fund*, 2020. “Larimer County Landfill Methane Capture.” <https://www.coloradocarbonfund.org/larimer-county-landfill#:~:text=Larimer%20County%20Landfill%20Methane%20Capture&text=Started%20just%20a%20year%20after.and%20the%20University%20of%20Utah>

⁷⁵ *Larimer County Engineering Department*, 2020. “Planning for the Future: North Front Range Regional Wasteshed (Solid Waste).” <https://www.larimer.org/solidwaste/wasteshed>

revealed, among all the County operations, our Landfill contributes the highest proportion (73%) of GHG emissions.⁷⁶ These emissions originate from decomposing green waste that could have been diverted from the landfill. Aside from GHG emissions, divertible wastes (green waste and recyclables) fill the limited space in the landfill, decreasing its longevity and capacity.

Diverting green waste (compostable items) and recyclables can also provide alternative economic opportunities. Large waste management companies such as Gallegos Sanitation in Fort Collins and smaller organizations now provide reliable services that range from collection to composting (turning green waste into mulch) and selling their product. This market has grown in part due to county and municipal support and directives. Composting provides valuable fertilizer and soil amendment products that can improve water quality. Compost contributes lower nutrient loads in stormwater runoff, as compared to commercially produced petroleum-based fertilizers.

Diverting composting green waste helps extend the life of the landfill (better land use outcomes), reduces leachate (protecting water quality) and lowers greenhouse gas emissions (climate mitigation).



Changing markets for recyclable materials present a challenge for waste diversion efforts. Much of the materials had historically been shipped to China. Due to heightened Chinese standards for acceptance of recyclables and the evolving US-China relationship, this market is shrinking. Not only here in Larimer County but across the US, the public and private sectors are seeking to develop new local markets and innovative ways to reuse and recycle these materials, rather than throw them out and make new ones.

The roads of today have been constructed with materials designed for the temperatures and rainfall patterns of today, not the temperature extremes and durations, and more frequent and intense flooding predicted with a hotter climate. Higher temperatures cause pavement to soften and expand, creating ruts and potholes in predominantly high-traffic areas. Higher temperatures also stress bridge joints.⁷⁷ Flood events result in debris and mudflows across roads, disrupting commutes and commerce when those roads are closed for repair.⁷⁸ Extreme flood events isolate cities and towns, as happened to Estes Park after the 2013 flood. Floods impact bridge integrity when backfill soils are washed out,

⁷⁶ Larimer County Greenhouse Gas Inventory, 2011.

https://drive.google.com/file/d/1BgiYB8Dqfg4ukflxOYi0YiXO_wK4FCwg/view?pli=1

⁷⁷ Environmental Protection Administration, 2016. "Climate Impacts on Transportation."

<https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-transportation.html#main-content>

⁷⁸ Kim, Yail & Marshall, Wesley & Pal, Indrani. (2014). Assessment of Infrastructure Devastated by Extreme Floods: A Case Study from Colorado, USA. Proceedings of the Institution of Civil Engineers. 167. 186-191. 10.1680/cien.14.00032.

leaving bridge abutments exposed.⁷⁹ Other damages include increased road scouring, road washout, and damages to railbed support structures.⁸⁰

Exposure to flooding shortens the life expectancy of highways and roads. Water stress may cause road damage, requiring more frequent maintenance, repairs, and road rebuilding.⁸¹ Floating debris can result in secondary impact damage to infrastructure.⁸² Flooding can also erode soil cover and cause sinking of the earth underneath pipelines.⁸³

Infrastructure stresses from flooding include:

- More damage to bridges, although the degree of damage depends on bridge location.⁸⁴
- Traffic disruption and delay in construction activities from heavy rains that result in flooding.⁸⁵
- Congestion due to traffic disruption causing increased travel times and pollution from idling cars.⁸⁶
- Potential for more frequent landslides and road washouts as saturated soils are exposed to more stormwater.⁸⁷
- Rail track expansion and buckling due to more frequent and severe heat waves, more frequent track repairs or speed restrictions to avoid heat-related derailments.⁸⁸
- Overloaded drainage systems from floods causing backups and further street flooding.
- Decreased structural integrity of roads, bridges, and tunnels due to flooding impacting soil moisture levels.⁸⁹

⁷⁹ Kim, Yail & Marshall, Wesley & Pal, Indrani. (2014). Assessment of Infrastructure Devastated by Extreme Floods: A Case Study from Colorado, USA. Proceedings of the Institution of Civil Engineers. 167. 186-191. 10.1680/cien.14.00032.

⁸⁰ National Research Council. (2008). The Potential Impacts of Climate Change on U.S. Transportation. Washington D.C. *(Mainly pages 175-189)

⁸¹ EPA. 2016, December 22. Climate Impacts on Transportation. Retrieved from https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-transportation_.html#main-content.

⁸² Kim, Yail & Marshall, Wesley & Pal, Indrani. (2014). Assessment of Infrastructure Devastated by Extreme Floods: A Case Study from Colorado, USA. Proceedings of the Institution of Civil Engineers. 167. 186-191. 10.1680/cien.14.00032.

⁸³ National Research Council. (2008). The Potential Impacts of Climate Change on U.S. Transportation. Washington D.C. *(Mainly pages 175-189)

⁸⁴ Kim, Yail & Marshall, Wesley & Pal, Indrani. (2014). Assessment of Infrastructure Devastated by Extreme Floods: A Case Study from Colorado, USA. Proceedings of the Institution of Civil Engineers. 167. 186-191. 10.1680/cien.14.00032.

⁸⁵ EPA. 2016, December 22. Climate Impacts on Transportation. Retrieved from https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-transportation_.html#main-content.

⁸⁶ Pregolato, M., Ford, A., Glenis, V., Wilkinson, S., & Dawson, R. (2017). Impact of Climate Change on Disruption to Urban Transport Networks from Pluvial Flooding. Journal of Infrastructure Systems, 23(4). doi: 10.1061/(asce)is.1943-555x.0000372

⁸⁷ EPA. 2016, December 22. Climate Impacts on Transportation. Retrieved from https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-transportation_.html#main-content.

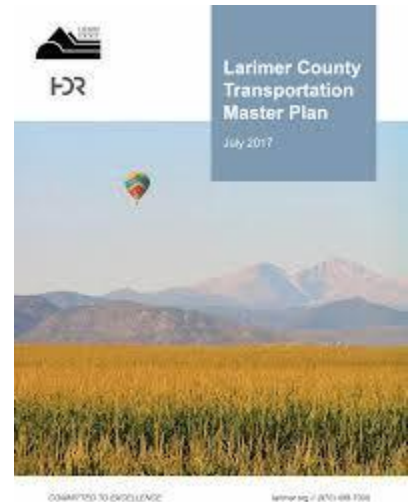
⁸⁸ EPA. 2016, December 22. Climate Impacts on Transportation. Retrieved from https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-transportation_.html#main-content.

⁸⁹ Kim, Yail & Marshall, Wesley & Pal, Indrani. (2014). Assessment of Infrastructure Devastated by Extreme Floods: A Case Study from Colorado, USA. Proceedings of the Institution of Civil Engineers. 167. 186-191. 10.1680/cien.14.00032.

The 2013-2018 Strategic Plan, Goal 4 (Transportation), committed Larimer County to ensure that 100% of publicly owned and maintained bridges on mainline collector or arterial roads in unincorporated Larimer County will be structurally sufficient by the end of 2020. According to Assistant County Engineer Rusty McDaniel, that milestone was reached by the summer of 2020.

In 2018 a task force was formed to explore funding to implement the **2017 Transportation Master Plan Update**,⁹⁰ including but not limited to these elements:

- Developing a multimodal transportation network including alternative to single occupancy vehicles like bicycling, walking, mass transit, and ride sharing.
- Designing county public roadways to widen road shoulders to accommodate bike lanes, especially on roadways that experience high bicycle demand.
- Evaluating pedestrian crossings to improve pedestrian safety, accessibility and enjoyability
- Coordinating with transit providers to increase transit access to unincorporated Larimer County



The County established a **coalition to promote the use of compressed natural gas (CNG)** through converting fleet vehicles to CNG and establishing convenient fueling sites. CNG results in lowered emissions compared to gas and diesel and higher fuel efficiencies.

Larimer County actively participates in **regional transportation planning**. The County is a member of the Planning Council for the North Front Range Metropolitan Planning Organization (NFRMPO) and the Upper Front Range Transportation Planning Region. In 2019, the NFRMPO Planning Council adopted the 2045 Regional Transportation Plan, which provides a vision for our regional transportation system and guides the implementation of multimodal transportation improvements, policies, and programs in the region. The Planning Council projects there will be significant regional population and density growth, with 88% more residents in 2045 than in 2015.⁹¹ The County is currently working on funding strategies to improve transit and road capacity to offset increased traffic congestion caused by population growth.

Changes in flooding frequency and intensity affect **stormwater runoff quantity and quality**. Increased stormwater runoff exacerbates existing pollution and capacity problems or introduces new ones. When contaminants such as trash, nutrients, sediment, or bacteria overwhelm the capacity of water-quality control infrastructure like infiltration ponds, these contaminants are discharged without treatment to our local waterways. Through participation with the Colorado Stormwater Council, Larimer County collaborates with other Front Range municipalities and local governments to improve stormwater water quality through pollution prevention programs and community outreach.

⁹⁰ Larimer County Engineering Department, 2020. “Transportation Planning.” <https://www.larimer.org/engineering/transportation/transportation-planning>

⁹¹ North Front Range Metropolitan Planning Organization, 2019. “2045 Regional Transportation Plan.” <https://nfrmpo.org/wp-content/uploads/2045-rtp-final.pdf>

Through **regional watershed management collaboration**, Larimer County is working to improve mitigation efforts for flood-related hazards, promote water sharing strategies to preserve agriculture and sustain water supplies, and improve several flood retention reservoirs. The County is collaborating with local entities to compile complete documentation of Stormwater Master Plans and develop a prioritized list of improvements for flood damage mitigation. We are also working with local ditch companies to preserve agriculture while providing municipalities with adequate water supplies, a model of alternative water transfers established by the Larimer County Natural Resources Department.

The County is working with other cities, towns, counties, and irrigation companies to **improve dam safety**. Five flood detention reservoirs constructed in the Boxelder Drainage Basin in the late 1970s and early 1980s by the NRCS (formerly the Soil Conservation Service) are now reclassified as High Hazard by the Colorado State Engineer's Office. Larimer County, the Town of Wellington, the Town of Timnath, the City of Fort Collins and Weld County, in collaboration with the North Poudre Irrigation Company, reached agreement to assign an internal consultant to review previous conclusions, and then provide the stakeholder group with a plan to come into compliance with this new standard.

Climate change also produces prolonged dry-weather periods. The lack of rain causes build-up of sediments, nutrients (nitrogen and phosphorus) and pollutants on catchment surfaces, which are then flushed at higher concentrations when storm events do occur. Hot and dry summers lower water levels in lakes, reservoirs, and rivers, which further concentrates pollutants and nutrients in water systems. Furthermore, drought conditions impact aquatic organisms when water temperatures exceed their livable threshold and oxygen levels are depleted. Under these conditions, high nutrient loads feed algal blooms, which can be toxic to people, pets and wildlife. Blue-green algae is a common and naturally occurring type of algae in Colorado that becomes toxic in high concentrations.⁹² Larimer County is already dealing with overgrowth of algae in its reservoirs and lakes as reports of the algae on public and private waterways are becoming more common. Lastly, increased stormwater can lead to flooding in

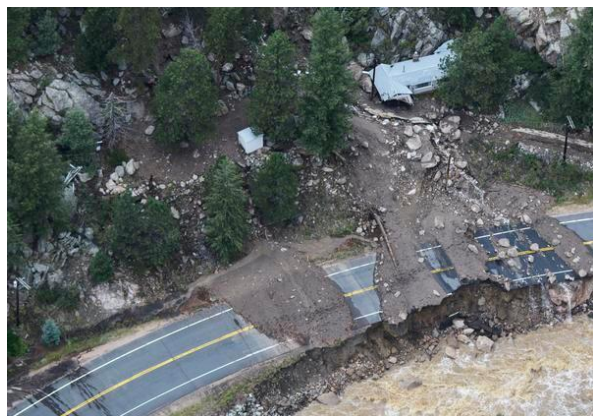


Photo Credit: Denver Post, September 12, 2013

residential and commercial areas when storm sewer systems become overwhelmed.

According to the Rocky Mountain Climate Organization, extreme precipitation events in Larimer County are expected to occur more often.⁹³ **Throughout the northern and central Rocky Mountains, the historic 100-year flood event may become two to five times more frequent by the end of the century.**⁹⁴ Warmer winter temperatures increase the likelihood that winter precipitation falls as rain instead of snow, which will reduce winter

⁹² Larimer County Public Health, 2019. "What is Blue-Green Algae?" <https://youtu.be/ktgSljqfp6l>

⁹³ Saunders, S., Easley, T., & Mezger, M. (2016). Future Climate Extremes in Larimer County. *Rocky Mountain Climate Organization*.

⁹⁴ Wobus, C., Gutmann, E., Jones, R., Rissing, M., Mizukami, N., Lorie, M., ... Martinich, J. (2017). Modeled changes in 100 year Flood Risk and Asset Damages within Mapped Floodplains of the Contiguous United States. *Natural Hazards and Earth System Sciences*, 1–13. doi: 10.5194/nhess-2017-152-ac1 <https://www.nat-hazards-earth-syst-sci.net/17/2199/2017/nhess-17-2199-2017.pdf>

snowpack and increase winter instream flows.⁹⁵ Warmer early spring temperatures will accelerate mountain snowmelt, increasing instream flows and the potential for spring flooding.⁹⁶ Earlier and faster snowmelt cause indirect repercussions such as shortened winter mountain sports seasons which brings significant revenue to Colorado's second largest industry.

"These impacts may be greatest during the mid to late summer demand season as stream flows recede sooner than in a typical year."

- National Resource Conservation Service Colorado

The 2019-2023 Strategic Plan Goal 3, Objective 5 commits **Larimer County to update its Environmental Responsibility policy**⁹⁷ by the end of 2020. The policy will guide County management practices to reflect current scientific findings and methods and balance the triple bottom line aspects of natural resources and ecology, economic longevity, and social justice (environment, economy, community). By the end of 2023, an implementation plan will guide the process of raising staff awareness of the new policy and ensure departments align their actions accordingly. Each department operates differently and will implement environmental responsibility in its own way.

Some obvious goals include reducing solid waste through greater recycling, reducing use of paper, and considering zero waste event planning. Other areas under consideration include using alternative transportation to get to work, adding electric vehicles to the County fleet, and education and outreach on good facility housekeeping practices. The County's commitment to environmental responsibility is further reflected through its conservation of open space, its water quality protection program, its floodplain regulatory program, its Facilities energy and water conservation program, and many other programs. Part of the implementation plan will be identifying measures that allow departments to track their successes in environmental responsibility, as well as note where improvement is needed.

Existing Adaptation and Mitigation Strategies

- Solid Waste Department's Landfill Methane Capture project
- 2018 Solid Waste Infrastructure Master Plan
- 2013-2018 Strategic Plan
- 2019-2023 Strategic Plan
- 2017 Transportation Master Plan Update
- Formed coalition to promote the use of compressed natural gas
- Member, Planning Council for the North Front Range Metropolitan Planning Organization and the Upper Front Range Transportation Planning Region
- 2045 Regional Transportation Plan
- Regional watershed management collaboration
- Updating Larimer County Environmental Responsibility Policy

⁹⁵ Colorado Conservation Board. (2014). Climate Change in Colorado: A Synthesis to Support Water Resource Management and Adaptation

https://wwa.colorado.edu/climate/co2014report/Climate_Change_CO_Report_2014_FINAL.pdf

⁹⁶ Saunders, S., Easley, T., & Mezger, M. (2016). Future Climate Extremes in Larimer County. *Rocky Mountain Climate Organization*.

⁹⁷ Larimer County. (2019). *Environmental Responsibility Policy*. Larimer County. Retrieved from: https://www.larimer.org/sites/default/files/environmental_responsibility_10292019.pdf

Top Recommendations for Future Action (see Appendix A for a full list of recommendations)

TRANSPORTATION

- Explore transportation alternatives, including passenger rail, interconnected bus systems, countywide carpooling application, county shuttle buses to open spaces and natural areas, enhanced bicycle lanes, electric vehicle infrastructure.
- Promote telework as an opportunity to reduce vehicle miles traveled and provide opportunities for flexible work schedules to avoid peak traffic.
- Support broadband infrastructure in rural areas to promote location-neutral jobs and reduce vehicle miles traveled.

FLOODPLAINS

- Restore and preserve the natural resources and functions of floodplains, through collaboration with Watershed Coalitions leading river restoration projects, and directly through projects on publicly owned Open Space properties such as River Bluffs and Lion's Park.
- Use flood prevention measures that increase the mosaic character of the floodplain, extend its ecosystem buffer zones, and restore riparian, stream, and wetland elements, and place a restrictive limit on development in and around floodplains.
- Encourage conservation of forested zones along low elevation and plains river and stream ecosystems to reduce erosion and improve water quality.

STORMWATER

- Educate the community through media outlets about the importance of stormwater quality and what they can do to reduce their contribution to water pollution.
- Use the Larimer County CSU extension office to increase educational opportunities for the agriculture and horticulture communities on the importance of best management practices for pollution prevention and water quality.
- Ensure that larger-scale green infrastructure management strategies for watershed health on County property, including preserving or restoring floodplains, open space, wetlands, and forests, are functioning optimally.

Recommendations for Public Engagement

Identified stakeholders include: Transfort, Poudre Express, FLEX, Bustang, bus riders, local floodplain restoration coalitions (Big Thompson Watershed Coalition, Coalition for the Poudre River Watershed, etc.), Colorado State University, municipalities.

Ask stakeholders and the public these questions in the following areas:

TRANSPORTATION

- How important to you is having access to multi-modal transportation options?
- Would you consider adjusting your driving habits to improve air quality?
- Would your employment/business options benefit from having broadband service?
- Is access to high speed rail along the Front Range a priority to you?
- Would you like to see the development of a network of electric vehicle charging stations?

FLOODPLAINS

- Are healthy, functioning watersheds important to you?
- Are you concerned that the risk of flooding where you live or work is increasing?

- Would you support incentives for floodplain restoration activities on private property?
- Would you consider developing a livestock management plan that includes limiting access to streams and rivers in order to conserve streamside vegetation and reduce erosion?
- Do you think floodplain restoration should be a priority for Larimer County owned properties?
- Do you support prohibiting development in the floodplain?
- Do you feel you are informed about the actions you can take to reduce your risk of flooding?

STORMWATER

- Are you concerned about water quality in the streams, rivers and lakes of Larimer County?
- Do you know where stormwater runoff goes after entering a curb inlet?
- Would you support incentives for low impact development and other green infrastructure techniques to manage pollutants associated with stormwater runoff?
- Are you aware of the impact that fertilizers have on water quality? Have you adjusted your lawn care practices to reduce the use of fertilizers?
- Would you support incentives for converting to xeriscaping?



G. GREENHOUSE GAS MANAGEMENT

Each of the Climate Smart Larimer County planning areas address recommendations for climate adaptation and mitigation strategies. Although program metrics have not been addressed relative to the County’s ability to respond to climate change, Greenhouse Gas inventory management plans are one example for tracking progress relative to a baseline. To understand how Larimer County is performing relative to other communities, the table below (figure 6) highlights per capita County GHG emissions (in metric tons of CO₂ equivalents) compared to other jurisdictions:

Jurisdiction	Per Capita Emissions (MT CO ₂ e)
Larimer County CO (2017)	14
Boulder, CO (2018)	14
Colorado (2018)	21
Denver, CO (2016)	15
Bloomington, IN (2016)	16
Fort Collins, CO (2017)	12

Figure 10: Per Capita Emissions by Jurisdiction

The metrics above come from the City of Boulder’s 2018 GHG Inventory. Since cities and counties with higher populations may have more emissions, considering emissions per resident (per capita) presents a more meaningful comparison.

Recommendations for Future Action:

Studies: This inventory does not currently account for emissions from trans-boundary sources, such as embodied carbon and materials waste. The report authors acknowledge that omitting these data sources creates a gap in the inventory of the community’s full GHG emissions. We recommend that Larimer County invest more in staff time and inter-department collaboration to review the activity data needed to compile a robust community-wide inventory. The County should also consider a consumption-based inventory, as that level of detail further identifies emission sources that will ultimately facilitate a more strategic course of action.

The following sources are known emission sources within the Larimer County and not included within the review as they were considered *de minimis* for inventory accounting purposes. County staff may consider including the following sources in the future:

- Stationary Sources:
 - Upstream emission sources; including oil and gas extraction (distribution, underground/surface mining, post-mining activities), stationary fuel combustion (biomass) and transmission lines.
- Mobile Combustion:
 - Airport travel and emission sources from terminal, ground support equipment, ground access vehicles, aircrafts, runway lighting, energy, etc.
- Wastewater Treatment
 - Upstream emissions associated with water supply, conveyance, treatment and delivery
- Carbon capture and sequestration potential (CCS) by locating carbon sinks; these are points where GHGs are captured and re-cycled through Earth’s natural processes (e.g., nitrogen fixation) to enhance soil formation). Although this report only looks at emission sources, identifying sinks and sequestration capabilities, to improve their conditions, should be pursued in the future, as more knowledge become available on the following:
 - Larimer County forested, vegetated and soil areas
 - Private agricultural land/practices
 - Land Uses (cropland maintained as cropland vs. impervious surfaces/ development)

Management: We cannot manage what we do not measure. A recurring GHG inventory would provide clear metrics for the Larimer County Board of Commissioners to inform governance decisions on our GHG emissions, which affect not only global temperatures but local climate and consequential public health outcomes. We recommend that the Board of County Commissioners direct the County Manager to allocate staff resources to generate a bi-annual GHG report, including measurable outcomes and progress towards any policy goals set by the board, similar to what Eagle and Summit Counties do.

We recommend that the Board of County Commissioners work with staff to set a GHG reduction goal and allocate funds to achieve the necessary strategies within a reasonable timeline. Appointing an employee dedicated to this work, who reports to the Public Health Director or the County Manager, would provide the staff time and accountability needed for a comprehensive GHG inventory.

Although there is not a *direct* correlation between GHG emissions and health effects, anthropogenic activities associated with GHG emissions release particulate matter (PM_{2.5}), sulfur dioxide (SO₂), nitrogen oxides (NO_x), ammonia (NH₃), and volatile organic compounds (VOCs) worsening health conditions of people with heart disease,⁹⁸ lung diseases (e.g., asthma, chronic bronchitis and emphysema), children whose lungs are developing, the elderly, and active people who exercise or work outdoors close to pollutant sources.⁹⁹ Beyond the physical health effects, pollution-related illnesses impose other ‘costs’ on people, such as lost wages or productivity when a person misses work or school and medical expenses and outdoor activity restrictions when air quality is poor. In addition, the secondary or indirect impacts of GHG emissions in Larimer County need to be addressed to understand the breadth of our emissions. This includes identifying scope 1, 2, and 3 emissions. Scope 1 emissions are direct emissions that an organization can control (e.g. fuel and industry combustion), scope 2 occur

⁹⁸ *Environmental Protection Agency*, 2018. “Health and Environmental Effects of Particulate Matter (PM).” <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>

⁹⁹ *National Park Service*, 2018. “Sulfur Dioxide Effects on Health.” <https://www.nps.gov/subjects/air/humanhealth-sulfur.htm>

from electricity purchased and used by the organization and scope 3 emissions are from activities of an organization from sources that they don't own or control (e.g. procurement, waste and water).¹⁰⁰

Recommendations for Public Engagement

Based on a public opinion study conducted by Yale's Climate Change Communication Program in 2019, 67% of Larimer County adults believe that global warming is mostly caused by human activities.¹⁰¹ We recommend that County staff include public engagement questions that seek to understand the services and incentives Larimer County community members need to reduce community GHG emissions and mitigate associated negative effects.

The following questions should be presented in an upcoming public involvement event:

- How do you think that GHG emissions affect you/your community?
- How do individuals emit GHG?
- Where do you rank climate change as a concern for you and your family?
- Should the County set carbon dioxide emission limits on known pollution sources like existing or proposed coal-fired power plants if it will reduce global warming and improve public health?
- Should the County impose taxes on GHG emitters, if the generated funds would be used on GHG sequestration strategies and related services to the community?
- Should the County provide sales tax rebates for people who purchase products within Larimer County that reduce their GHG emissions, such as energy-efficient vehicles or solar panels?
- What should be the first/next step for the County to reduce its GHG emissions? Change operations or provide services/programs for residents?



¹⁰⁰ *Green Element*, 2018. "What is the Difference Between Scope 1, 2 and 3 Emissions?"

<https://compareyourfootprint.com/difference-scope-1-2-3-emissions/>

¹⁰¹ Marlon, J., Mildemberger, P. H., Leiserowitz, M. H., Wang, A. H., & undefined, X. H. (2019, September 17). Yale Climate Opinion Maps 2019. Retrieved from <https://climatecommunication.yale.edu/visualizations-data/ycom-us/>

VIII. NEXT STEPS: PUBLIC ENGAGEMENT

Overview

The steps we take now to bring communities together to reduce greenhouse gas emissions will affect the magnitude of climate impacts and the extent to which our communities adapt, recover and thrive in the face of local climate-related disasters.

The purpose of community outreach is to actively involve and engage public and private sector stakeholders in further developing the Larimer County Climate Smart (CSLC) framework. Engaging the community through a deliberative process enables impactful and useful input that is essential to ensuring that the framework's intentions are feasible, equitable, and effectively implemented. The outreach plan consists of tools and strategies that embrace Larimer County's diverse values, needs and interests. Based on the social values of diversity, equity, inclusion and community-driven change, this framework will help identify and relay personal connections to the local impacts of climate change. Although the impacts of increased CO₂ emissions have global impacts, it is important to realize that marginalized communities are disproportionately impacted. For example, Latinx people who make up 11% of Larimer County's population suffer disproportionately from air pollution. "Nearly one in two Latinos live in counties with poor air quality, and Latino children are twice as likely to die from asthma than non-Latino whites."¹⁰²

Overview of the Deliberative Steps in our Community Outreach Plan

- Raise awareness within the community about the CSLC Framework.
- Take inventory of the County's community-wide knowledge of climate change impacts and adaptation/mitigation initiatives. (Recognizing that stakeholders will come to the table with various levels of knowledge regarding climate change, it is important to create a baseline of common understanding for participants about the purpose and recommendations of the CSLC Framework.)
- Inform the community on climate change issues that are impacting the County and individuals.
- Provide multiple opportunities for community input on the framework's recommendations.
- Involve community members who already show interest and recruit new participants throughout the assessment and implementation of the CSLC Framework recommendations to ensure diversity of opinions.
- Identify community ambassadors- leaders in various communities who will commit to serving as a conduit between their community and the CSLC Framework process.

Communication Strategies

Like other community outreach strategies the County leads, the topics presented should be targeted to the local community. Research shows that people are more apt to participate and engage in climate solutions when the issues and examples presented are relatable. A good example would be referencing the recent fires and floods experienced in Larimer County to promote the use of prescribed burns for

¹⁰² Rudolph, L., Harrison, C., Buckley, L., North, S., Kuiper, H., Baker, Z., ... Moore, E. (2018). *Climate Change, Health and Equity: A guide for Local Health Departments*. PDF. https://www.apha.org/-/media/files/pdf/topics/climate/climate_health_equity.ashx?la=en&hash=14D2F64530F1505EAE7AB16A9F9827250EAD6C79

fire risk mitigation, or the importance of relocating residential development out of floodplains. Setting up intermittent community workshops and deliberative forums are beneficial tools we know promote community engagement. Likewise, constructive feedback from residents can inform us about the community's perceptions of the county's role in mitigation and adaptation to climate change impacts.

We can use existing engagement tools for presenting dense or elusive topics like GHG emissions to audiences who may know little about those topics. A logic model, for example, helps communicate such topics to the community in a concise, effective, and easy to understand manner. Logic models are written as a series of if/then statements, so that the inputs and desired outcomes are clearly formatted step by step and show how the process gets from point A to point B. If community engagement involves deliberative forums, then individuals will become empowered because they are part of the process. Likewise, the County will gain a holistic understanding of community expectations, which will increase both public buy-in and sustained commitment. Explaining why public input is critical to developing the CSLC Framework will help establish buy-in and a sense of ownership by individuals and community sectors.

An example of a key message to present is:

Question: "Why should I participate in Larimer County's climate smart framework development process?"

Answer: "Various neighborhoods and groups in [Larimer] will be impacted differently by climate change.

By participating, you can voice specific concerns and priorities for your neighborhood or other communities you interact with."

One aim of extensive public engagement is to identify common themes in the community's concerns and suggestions so we can address them. Tactics can include breaking residents into small groups at town hall meetings and encouraging them to share their concerns/opinions about Larimer County climate mitigation/adaptation. The group facilitator should summarize those findings and provide responses either at that meeting or the next. Helping participants recognize common values will promote rational discussion. We should go beyond environmental reasoning when discussing why climate change affects communities, and present information in a way that affirms, rather than threatens, people's cultural identities. Access to these meetings should be as inclusive as possible, with meetings recorded and made available online. We can increase participation and reduce barriers by providing transportation and childcare options, alternative venues, and virtual platforms for discussion.

Before discussing the monetary costs associated with adaptation/mitigation strategies, engage in conversations that highlight why climate change mitigation/adaptation matters. Ask questions like *Have you been impacted by any natural disasters? Why does climate change matter to you? What are you most concerned about with climate change?* Informing local public and private sector opinion leaders about the CSLC Framework provides another important opportunity for buy-in when these leaders disseminate the information to their respective communities. For the success of this initiative, it is critical to reach out to rural and less populated Larimer County communities through community ambassadors and other best practices. Our goal is to generate participation from more of our diverse community, bring underrepresented voices to these discussions, and deepen the pool of opinions and expertise received.

These tools differ from traditional methods of waiting for community members to approach decision makers; they are designed to align with efforts from planning area members to engage their constituents with unique questions and seek feedback regarding the CSLC Framework.

Detailed Course of Action

1. Raise awareness within the community about the CSLC framework.

The public's introduction to the CSLC Framework will come through press releases to traditional media outlets and notifications to social media platforms in close coordination with the county public affairs director. Some ideas for spreading the information widely and managing the narrative include:

- Work with existing community-based organizations that provide community support services
- Disseminate information through social media, the Larimer County Connects Newsletter, commissioner communications and other county public information channels
- Host community events including community conversations, town halls, open houses and creative work sessions such as 'action and art' events
- Share the CSLC Framework with newly identified stakeholders
- Participate in various cross-sector community events including festivals, forums and neighborhood gatherings
- Create bi-lingual flyers, posters and pamphlets

2. Take inventory of community-wide knowledge of climate change impacts and adaptation/mitigation initiatives*.

The County will conduct a preliminary assessment of community knowledge of and interest in climate change-related topics through questions in the Board of County Commissioners' Larimer County Community Survey. Surveys create a baseline of community opinion and understanding. Because the County does not currently ask community members about climate change, this inventory is a critical first step for future climate smart, sustainable actions. Preliminary survey questions are in Appendix B.

3. Inform the community about climate change issues impacting the County and its residents.

More detailed education and outreach strategies will be developed based on the survey results. The county will launch a second wave of informational announcements, using additional marketing strategies, while still requesting public input on the recommendations.

4. Provide multiple opportunities for community input on the framework's recommendations.

Research shows that people are more likely to become engaged, and stay engaged, on sustainability issues when they feel like they have a choice to act with others in their community. Along with presenting information, we will solicit public input on the recommendations outlined in this CSLC Framework, taking into consideration psychological influences, physical and behavioral influences, cultural influences, and systems influences. Specifically, we will

- Work with existing organizations that provide services related to climate change, especially those that provide community support services to marginalized community members
- Use current public engagement strategies such as:
 - Workshops
 - Roundtable discussions
 - Webinars, podcasts, lectures, and social media
 - One-to-one outreach at public spaces

5. Continue involving stakeholders and community members who already show interest, and recruit and retain newly interested community members, throughout the assessment and implementation stages of the framework. Build a diverse stakeholder group.

This framework provides a foundation for future climate change-related policies, procedures, and programs. Therefore, decision makers will need to continuously engage with constituents to ensure that the County's actions meet public expectations. Currently, it is likely the County believes that community members know there are increasing risks from floods, heat waves, wildfires, and other hazards, and want to participate in reducing GHG emissions. Over time, the desires and needs of the community will evolve. It will be crucial to keep involving stakeholders in the decision-making process so we can develop workable, common-ground solutions together.

Assessment and Implementation

Ongoing assessment is essential to evaluate whether Larimer County staff and stakeholders are consistently following the framework's directives. Ongoing assessments from public input will be used to ensure that the programs and policies we enact work effectively once they are implemented.

Possible opportunities for assessment include:

- Distributing short written surveys at the end of community engagement activities to gauge the effectiveness of the activity and seek suggestions for improvement.
- Using a logic model to ensure that actions are broken down into specific deliberate steps. Intended outcomes are clearly stated for each step so that effectiveness, or lack thereof, can be determined and appropriate adjustments made.
- Communicating with stakeholders and county employees to maintain partnerships and gather information regarding their use of the framework.

Ongoing Engagement

Stakeholders include people, businesses, institutions and organizations impacted by climate change - the entire community, rural and urban, and those with an interest the successful implementation of the CSLC Framework . As people move into the county, they become potential new stakeholders and identifying new stakeholders should be an ongoing process. We can identify new stakeholders through networking with existing stakeholders and community members, and implementing continuous outreach and civic engagement efforts.

IX. GLOSSARY

Adaptation refers to adjustments that societies or ecosystems make in response to a pressure or force. Climate change adaptation can limit the negative effects or capitalize on the new conditions presented by a changing climate.

Albedo refers to the reflectivity of a surface. When sunlight hits a surface, solar radiation is absorbed or emitted back into the atmosphere to a varying degree depending on the type and color of the surface. Some surfaces are more reflective than others. For example, ice absorbs more solar radiation, while the dark ocean water it is replaced by when it melts reflects more of the radiation into the atmosphere.

Anthropogenic refers to something produced or being generated by human beings.

Biogenic refers to something produced or generated by living organisms or biological processes.

Carbon is an elemental molecule found in all living organisms. A primary constituent of fossil fuels, carbon combined with two oxygen molecules forms carbon dioxide (CO₂), a greenhouse gas.

Carbon cycle is process by which carbon is cycled through the atmosphere, sediments, soil, water and living organisms. To complete the cycle, carbon dioxide or methane is emitted from various sources on earth through respiration, combustion, or decay. Carbon returns to the atmosphere, where it is eventually cycled back to the earth through uptake by terrestrial plants, soils, and the ocean.

Carbon dioxide (CO₂) is a colorless gas comprised of one carbon atom bonded with two oxygen atoms. While its concentration in the earth's atmosphere is very small, that concentration has doubled since pre-industrial times. Produced from many sources, including respiration by living organisms, volcanoes, and the burning of fossil fuels, carbon dioxide is one of several greenhouse gases.

Carbon sequestration is the process of reabsorbing CO₂ from the atmosphere into a fixed molecule within living organisms, the soil, or the ocean. Carbon can be sequestered through preserving plants and soils in natural grasslands, agricultural lands, urban "green" areas, and forests. Areas where carbon sequestration occurs are commonly referred to as "carbon sinks."

Climate is a description of weather patterns typical for a place over a long period of time, such as 30-year periods. Climatic patterns are typically described using averages of precipitation, temperature, humidity, sunshine, wind, and other measures of weather. Climate is not synonymous with weather. If weather is your current mood, climate is your basic, long-term disposition.

Climate Change refers to the increasing changes in the measures of climate over long period of time. Those changes include high and low temperature extremes, high and low precipitation extremes, etc.

Global Warming refers to the rise in global temperatures as a result of increasing concentrations of greenhouse gases in the atmosphere. Global warming is one effect of climate change.

Embodied Carbon is the sum of all carbon dioxide emitted during the process of extracting, harvesting, processing, manufacturing, transporting, and installing a given material.

Emissions are substances released into the atmosphere. Emissions are measured as concentrations, typically as a percent of the atmosphere or a quantity like parts per million (PPM).

Global Warming Potential (GWP) is the ability of a greenhouse gas to absorb heat compared to carbon dioxide over a specified period of time, typically 100 years, but anywhere from 20 to 500 years.

Greenhouse Effect is the process of planetary warming as greenhouse gases absorb infrared radiation (heat) emitted from the earth's surface, and keep that heat trapped between the earth and the upper atmosphere instead of allowing it to escape. This process is natural and facilitates life on earth. As the concentration of greenhouse gases increase in the atmosphere, its capacity to hold heat increases.

Greenhouse Gases (GHG) are gases that trap heat in the atmosphere. Greenhouse gases include water vapor (H₂O), carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆).

Growth Management Areas (GMAs) are areas within the County that are planned to be annexed by a municipality that will provide urban-level services to the area within a 20-year time frame.

Hydrologic cycle is the process by which water cycles between the atmosphere and the earth's ecosystems. Water moves through this cycle by transforming from a liquid (water) to a gas (water vapor) to a solid (ice). Hydrologic cycle processes include evaporation, precipitation, runoff, condensation, transpiration, and infiltration.

ICLEI – Local Governments for Sustainability is a global network of more than 1,750 local and regional governments in over 100 countries committed to sustainable urban development. ICLEI aims to influence local policy and action for low-emission, nature-based, equitable, and resilient development.

LCDHE is the Larimer County Department of Health and Environment.

Mitigation refers to efforts that people, communities and governments take to reduce or prevent the emission of greenhouse gases. Examples of mitigation efforts include using new technologies and renewable energy sources, retrofitting older equipment for greater energy efficiency, and changing management practices or consumer behavior.

Photosynthesis is the process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct.

Non-renewable energy is energy from sources that once consumed are no longer available, such as fossil fuels. Fossil fuels derive from fossilized organic remains that over millions of years have been converted to oil, gas, and coal. Non-renewable energy sources are finite and cannot be replenished.

Renewable energy is energy from sources that are not exhausted by conversion to energy. Examples include wind, sun, water, biomass (vegetation) and geothermal heat. Renewable energy sources are not limited in quantity and continuously available.

Solar power refers to the production of energy from the sun as solar radiation is captured and then converted to thermal and/or electric power.

Social vulnerability to disasters refers to the characteristics and situation of a person or group that influence their capacity to anticipate, cope with, resist, or recover from the impact of a hazard. Social vulnerability is determined by a number of pre-existing social and economic characteristics.

Transpiration is the process by which plants take in water from the atmosphere, use it to produce energy, and then release it back to the atmosphere as water vapor through the process of evaporation.

Triple Bottom Line is the philosophy of considering the social, environmental, and economic impacts and benefits of a project or way of doing business. When all three aspects are equally considered in decision-making, the result is more likely to lead to a strong and successful strategy.

Weather refers to the short-term changes that take place in the lower parts of the atmosphere. Weather is the short-term temperature variations, rainstorms, snow, and wind events that can change rapidly and that differ from one place to the next. Weather is not synonymous with climate.

APPENDIX A: FULL LIST OF RECOMMENDATIONS FOR FUTURE ACTION

Building, Land Use and Energy Recommendations for Future Action

- Increase incentives for energy-efficiency retrofits on existing buildings, such as Larimer County Conservation Corps home efficiency assessments and Low-Income Energy Assistance programs.
- Adopt new Land Use Code rules to discourage sprawl by allowing more flexible use of Accessory Dwelling Units, Tiny Homes, smaller lot sizes (dependent on septic system solutions or sewer availability), multi-family, flexible occupant units, mixed use developments, transit-oriented development, planned "village" nodes, etc.
- Update internal county policies and the Facilities Master Plan to implement greater water and energy savings measures on county buildings and increase energy-efficient design standards.
- Develop on-site clean energy production on county lands and facilities.
- Establish climate-smart development guidelines and provide development incentives.
- Work with CSU's Institute for the Built Environment to look more deeply into current county policies and codes and develop recommendations for future action.
- Expand the availability of energy-efficiency information for consumers, property owners, and contractors in making better decisions on building construction, alteration, and operations. Include subjects such as air tightness, windows, insulation, heat pumps, solar, mechanical equipment tune-ups, updated lighting, etc.
- Expand training opportunities for staff on energy efficiency, green building, and climate adaptation and mitigation.
- Begin to move educational and code efforts towards all-electric buildings, moving from gas-fired furnaces and boilers to electric and geothermal heat pumps, as the electric grid decarbonizes.
- Develop voluntary, above-code incentives programs to increase energy efficiency of homes and commercial buildings, that may include fee reductions and/or fast track reviews.
- Expand involvement in programs such as Commercial Property-Assessed Clean Energy (C-PACE), Low-income Energy Assistance program (LEAP), and Fort Collins Utilities' Integrated Design Assistance Program. Increase community awareness of existing programs and their benefits.
- Require all new homes, or homes above a certain size, to install solar PV, be solar-ready and/or be oriented for maximum passive solar gain.
- Reduce barriers to solar PV installations, both on-site and utility scale, by becoming a SolSmart "solar-ready" community.
- Increase building/energy code mandatory requirements to get to a "Zero Energy Ready" level.
- Require third-party verification of insulation and air sealing for better installations.
- Require or encourage benchmarking of commercial building mechanical systems over a certain size, to uncover deficiencies and identify potential tune-ups to improve performance and reduce energy/emissions. Local rules could exceed state benchmarking rules.
- Collaborate with Front Range municipalities on a Transferable Development Units (TDU) bank to move development from foothills/mountains to urban corridor.

- Review landscaping requirements to encourage xeriscaping and reduce water use.
- Work with county and state Health Departments and the state Plumbing Board for greater flexibility for greywater systems to reduce water and energy requirements.
- Adopt WaterSense or other water efficiency requirements above current building code.

Economic Recommendations for Future Action

- Recruit firms with social and ecological corporate responsibility policies. Incentivize established firms to change behavior to address climate challenges. Build opportunity for renewable energy, clean tech, sustainable food and other industries. Attract businesses to come to Larimer County.
- Create workforce training programs that teach alternative skills in sustainable industries, especially for people impacted by employment loss due to climate change.
- Serve as a testbed of innovation for clean, renewable technology and economic investments, both internally and externally. Lead through innovation in internal operations. Be fiscally responsible in our approach.
- Implement economic development strategies that take into consideration short- and long-term costs of climate change related programs, studies and/or projects.
- Identify and connect municipality programs with sustainable or climate friendly missions in Larimer County to share resources and streamline efforts.
- Look at housing policies to make sure that the county provides affordable, equitable and sustainable options for current and future residents.
- Allocate funds for sustainable operational initiatives/pilot programs in County's budget.
- Identify which businesses are most at risk from climate change impacts, how they are adapting, if there are shifting job demands and if businesses are engaging in sustainable behavior (for example getting powered by renewable energy, investing in GHG offsets).
- Survey businesses engaging in sustainable behavior: does that make them more resilient to future climate impacts? Could they be held up as examples to other businesses?
- For internal operations: install more renewable energy, purchase renewable energy credits, purchase products through sustainable supply chains, incentivize/provide employees with alternative transportation options, continue retrofitting infrastructure to optimize resource efficiencies, pursue energy efficient options for fleet vehicles (electric, compressed natural gas), add good environmental record as a criterion for selecting contractors.
- Work with CSU's sustainable business programs to increase sustainable business models and policies.
- Reduce Vehicle Miles Traveled (VMT) by incentivizing creation, purchase and distribution of local goods and services, to decrease product transportation and associated miles traveled.
- Work with cities to upgrade their current housing stock to embody sustainable development and create incentives for homeowners and developers to do the same.
- Prevent "green gentrification" displacement and preserve low-income communities and small businesses while making infrastructure and social cohesion climate resilient.

- Hire residents from their own neighborhoods for county and city projects aimed at making their neighborhoods climate resilient.
- Identify the environmental values within the County’s Environmental Responsibility policy that the Economic Department reflects in practice.
- Educate community members on the National Flood Insurance Program and provide rebates for community members in floodplains who buy flood insurance.

Emergency Management and Public Safety Recommendations for Future Action

Climate change adaptation involves improving Larimer County’s capacity to address existing vulnerabilities, building infrastructure that’s resilient to newly identified perturbations, and engaging the public regarding risk and the actions required for subsequent public safety. The ways in which this can be done for the Emergency Management and Public Safety planning area include:

- Extend reach of current emergency management programs to incorporate equity and inclusion of formal and informal community leaders and members.
- Deepen partnerships with private and non-governmental partners in the utility sector.
- Update the Larimer County Multi-Jurisdictional Hazard Mitigation Plan with a climate adaptation lens to include these recommendations for 2021 (and continue this effort moving forward).
- Invest in new technologies for farming that use less water, including drought-resistant crops.
- Consider additional reservoir capacity for water storage and water conservation strategies.
- Update the Larimer County Transportation Master Plan to include building infrastructure resilient to climate impacts (e.g. upgrading culverts and bridges for increased flows).
- Increase regulations to discourage building in floodway and floodplains.
- Ensure that buildings and properties follow County codes and standards.
- Office of Emergency Management and Engineering work together on sustainable erosion control efforts along major roadways and bridges (i.e. ecological enhancements).
- Increase Neighborhood Watch Programs.
- Increase languages available for LETA alerts.

Watershed, Agriculture, Open Spaces and Forestry Recommendations for Future Action

- Encourage forest health projects such as prescribed fire and tree thinning on private and public lands throughout the county.
- Inform the agricultural community about strategies to reduce heat stress impacts on livestock such as aligning feeding and management practices with cooler parts of the day and reducing the effort needed by an animal to obtain food and water.
- Collaborate with CSU faculty and municipalities to implement urban ecology features within urban areas and Growth Management Areas, reducing urban heat island effects and building green patches for wildlife corridors.
- Restore ecosystem function and carbon sinks on marginal lands through collaboration.

- Consider alternatives for water storage.
- Identify human-wildlife conflicts (e.g. deer damage) and ameliorate.
- Prioritize drought-resistant and wildfire-resistant landscaping.
- Conserve native ecosystems that have not been severely degraded, or altered, and create conservation corridors.
- Establish regulations or best practices guidelines to plant buffer strips along wetlands and riparian corridors to filter pollutant.
- Establish development fees that offset forest health, wildfire mitigation and pest management costs.
- Coordinate tours at sustainable agriculture property to showcase profitable practices to other community members.
- Provide information to the agricultural community on Climate-smart agriculture (CSA) and Agroecology (AE) practices
- Promote Urban Agriculture by working with municipalities to plant vegetation that bears fruits/veggies/nuts in communities, especially low-income ones.
- Implement strategies on County lands to reduce soil erosion and water degradation.

Public and Environmental Health Recommendations for Future Action

- Work with state and local partners to monitor health outcome data and community environmental data related to potential impacts such as air quality, water quality, temperature trends and behavioral health.
- Work with state and local partners to assure appropriate water-borne disease and harmful algal bloom tracking system is maintained or enhanced.
- Enhance community public health partnerships to address climate change in the areas of air quality, water quality and mental health.
- Assure appropriate vector-borne disease tracking and response system is retained or enhanced.
- Identify LCDHE and county policies where climate change adaptations can be addressed.
- Conduct a regular greenhouse gas inventory and set targets for reductions. Include GHG inventory as part of county budget.
- Sponsor educational programs to inform the public about associated climate risks and protective measures. Target efforts to different communities to ensure equity in the messaging. Find community ambassadors to help incorporate and spread the message.

Public Works and Engineering Recommendations for Future Action

TRANSPORTATION

- Explore transportation alternatives, including passenger rail, interconnected bus systems, countywide carpooling application, county shuttle buses to open spaces and natural areas, enhanced bicycle lanes, electric vehicle infrastructure.

- Promote telework as an opportunity to reduce vehicle miles traveled and provide opportunities for flexible work schedules to avoid peak traffic.
- Support broadband infrastructure in rural areas to promote location-neutral jobs and reduce vehicle miles traveled.
- Implement and budget for transportation operation and maintenance activities that consider the costs associated with extreme snow events, increased flooding, increased duration of high heat periods, and other extreme climate conditions. Review and implement the Federal Highways Administration's guidance document "*Climate Change Adaptation Guide: For Transportation Systems Management, Operations, and Maintenance.*"
- Continue to be a leader in the North Front Range Metropolitan Planning Organization.
- Identify critical transportation networks and prioritize infrastructure improvements that ensure the infrastructure's resilience to flooding (i.e., increase capacity of crossing structures).
- Implement or prioritize the use of recycled materials in infrastructure improvements and design projects to avoid negative environmental impacts including impacts to wildlife, wetlands, and other critical habitats.
- Continue to prioritize the development of bike lanes along high-use road networks, add bike and pedestrian pathways.
- Continue to identify needs for transit into areas not currently served.
- Promote electric vehicle use in the county's fleet and promote or incentivize the establishment of electric charging stations.
- Determine feasibility in developing Electric Vehicle charging opportunities within our transportation systems, fleet management and at facilities such as The Ranch.
- Encourage use of alternative transportation for employees through the wellness program (Bike to Work Days, law enforcement on bicycles)

FLOODPLAINS

- Restore and preserve the natural resources and functions of floodplains, through collaboration with Watershed Coalitions leading river restoration projects, and directly through projects on publicly owned Open Space properties such as River Bluffs and Lion's Park.
- Use flood prevention measures that increase the mosaic character of the floodplain, extend its ecosystem buffer zones, and restore riparian, stream, and wetland elements, and place a restrictive limit on development in and around floodplains.
- Encourage conservation of forested zones along low elevation and plains river and stream ecosystems to reduce erosion and improve water quality.
- Incorporate floodplain restoration into capital improvement projects (transportation, parks, and open space) where possible, to reduce downstream impacts.
- Use engineering design elements that reduce erosion like terracing steep slopes, especially near waterways and other landscape architecture elements.

- Encourage riparian habitat restoration in floodplain areas through volunteer planting days and weed management efforts.
- Encourage leaving woody debris within high elevation streams.
- Have Larimer County join the Community Rating System (CRS) program for flood insurance.

STORMWATER

- Educate the community through media outlets about the importance of stormwater quality and what they can do to reduce their contribution to water pollution.
- Use the Larimer County CSU extension office to increase educational opportunities for the agriculture and horticulture communities on the importance of best management practices for pollution prevention and water quality.
- Ensure that larger-scale green infrastructure management strategies for watershed health on County property, including preserving or restoring floodplains, open space, wetlands, and forests, are functioning optimally.
- Through contracting requirements, ensure all contractors used by the County are trained in the use of best management practices for pollution prevention and good housekeeping.
- Participate with the local community, state and local governments, to monitor water quality within the stream and river reaches of urban Larimer County.
- Identify low impact development solutions and incentives to decrease stormwater impacts.
- Coordinate efforts on illicit discharge and pollution prevention between the Engineering and Environmental Health service groups.
- Implement site-scale green infrastructure techniques on County property that use the natural processes of soils and vegetation to capture, slow down, and filter runoff pollutants.

APPENDIX B:

COMMUNITY ENGAGEMENT SURVEY SAMPLE QUESTIONS AND IDENTIFICATION OF STAKEHOLDERS

Survey: We will include one or two questions in the next community survey to help gauge what the community wants and needs from County government. Potential survey questions include:

1. Do you feel that Larimer County is currently facing climate change issues?
2. We want to know your opinion on the County's proper role in climate change mitigation and adaptation. Please answer the following questions:
 - A. Do you know what Greenhouse Gas emissions are? Should the County reduce its operational greenhouse gas emissions?
 - B. Should the County provide the following services to the public: defensible space consultation, flood risk assessments, construction and green waste diversion from the landfill?
 - C. (Likert scale 1-5) Actions by residents in their homes can help make a difference in reducing GHG emissions and improving our local environment
 - D. (Likert scale 1-5) Larimer County government should take a strong leadership role to help inform and offer support for best practices in reducing climate change impacts

Identifying Stakeholders and Community Members: The County must continue recruiting diverse stakeholders (such as civic, environmental, faith-based, neighborhood) for community buy-in to this framework and to inform future decisions and services. Examples of key stakeholders include:

Health care providers (UC Health, Banner)
Breweries (Budweiser, micro-brews)
School districts
Homeowner Associations and apartment complexes

Mom and pop businesses
Local municipalities
Emergency Response
Religious Communities
Marginalized populations (see below)
Non-Profit Organizations (see below)

Marginalized populations: The county should recognize that marginalized community members exist, may have trouble engaging in public discourse and may be disposed to intersecting marginalized identities. For example, an older adult immigrant experiencing homelessness with multiple perspectives may be considered an intersecting marginalized identity. The following are identified marginalized community members with Larimer County as well as from across the U.S.:

- Aging residents
- Religious minorities (Interfaith Council, Korean church, Middle Eastern markets)
- Homeless (Outreach Fort Collins, Ft. Collins Rescue Mission, Salvation Army)
- Immigrants and people who speak English as a second language
- Latinx community (La Familia, Spanish-speaking churches, Mexican markets)
- LGBTQ+ communities
- People with disabilities
- Veterans

Non-profit organizations: These organizations typically provide social capital for natural resource projects and educational tools for public input. A few organizations to include for future stakeholder outreach include but are not limited to:

- Peaks to People Water Fund
- Colorado Water Trust
- Trees Water and People
- Coalition for the Poudre River Watershed
- Big Thompson Watershed Coalition
- Colorado State University's NGOs including The Water Center, Center for Protected Area Management, Center for the Built Institute, Center for Collaborative Conservation, and the Center for Public Deliberation

ATTACHMENTS

- Agricultural Best Management Practices
- Agricultural Organizations in Larimer County
- Environmental Responsibility Policy
- Stormwater Best Management Practices brochures for businesses and livestock small acreage
- Internal stormwater SOPs
- Department of Health and Environment pollution prevention brochures?
- Larimer County Extension Office fact sheets and brochures related to sustainability, Best Management Practices, and pollution prevention
- Larimer County Facility Energy Use Ranking Report, Facilities Department, 2/19/2020