

Risk and Adaptation Advisory Report



Gold Hill, Colorado August 2019



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BACKGROUND INFORMATION

About ASG

Adaptation Services Group (ASG), is a Colorado company offering risk assessments, adaptation plans and programs, climate change planning and mitigation programs to state and local governments focused on helping their residents and businesses become more resilient in the face of climate change. ASG programs feature a customer-centric approach to implementation, putting the client at the center of the process. These programs help create more resilient communities that are adapting to the changing climate.

With our deep expertise in climate mitigation and adaptation strategies and analysis, the ASG team focuses exclusively on the challenges communities face due to the changing climate. ASG provides implementation of community based adaptation programs in the areas of wildfire, earthquakes, flooding, energy and drought.















ASG’s Risk and Adaptation Advisory Report

ASG’s Risk Adaptation and Advisory Report (RAAR) is a unique resource that connects the dots between academic research, climate modeling and community engagement. The RAAR is a community’s first step in overall adaptation planning. It provides a high-level view of the climate-related risks and hazards affecting community systems, as well as possible adaptation strategies and recommendations. The RAAR presents an introduction to planning for climate adaptation, which the community can then use as a foundation to build upon.



Seth Portner
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Key Terms

	Anthropogenic	Generated by human activity (specifically in reference to environmental change).
	Climate Change	Significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer.
	Climate Adaptation	Adjustments to natural or human systems in response to actual or expected climate change, including increases in the frequency or severity of weather-related disasters.
	Drought	Persistent lack of rainfall over one or more seasons leading to the depletion of surface and groundwater reservoirs.
	Forest Fire	Forest fire means a fire burning uncontrolled on lands covered wholly or in part by timber, brush, grass, grain, or other flammable vegetation. It is the most common hazard in forests.
	Greenhouse gases (GHGs)	Atmospheric gases that trap incoming solar radiation and contribute to the warming of the Earth's surface. The principle GHGs are carbon dioxide, methane, nitrous oxide and ozone.
	Hazard mitigation	Actions taken to reduce loss of life and property by lessening the impacts of adverse events.
	Heat waves	A period of at least 5 days where the temperature is at least 5 Celsius degrees above normal.
	IPCC	Intergovernmental Panel on Climate Change-- an intergovernmental body under the United Nations dedicated to providing objective and scientific information on climate change.
	Rainstorms	Extreme precipitation event without substantial wind.
	Resilience	The ability to prepare for, absorb, recover from and more successfully adapt to adverse events.
	Severe wind	Strong winds capable of property damage, dust storms and other hazards.

EXECUTIVE SUMMARY

While climate change is a widespread global occurrence that noticeably affects communities on a large scale, the effects can be felt down to the local level. Climate change influences all sectors including transportation, public health, tourism, water and waste management and overall quality of life. Local governments around the country are working with their community members to develop plans for addressing climate adaptation. ASG works in partnership with these communities to envision the first steps toward creating and reaching climate adaptation goals.

Through research and engagement with Gold Hill’s Sustainability Committee ASG identified the likely climate risks affecting Gold Hill. Using Temperate’s climate modeling aggregation and downscaling to project impacts from climate change, ASG worked with Gold Hill to “mine” local resources and knowledge. For Gold Hill, model results displayed primarily high heat threats as the most substantial manifesting as potential wildfire and other ecological impacts.

The effects of climate change vary based on a variety of meteorological and regional factors that can be difficult to model. Adding to the complexity of forecasting long term climatic changes are Gold Hill’s location in the mountains of Colorado spread across both elevation and rugged mountainous terrain. We found the modeling done locally for Gold Hill to align with the modeling that has been done for Boulder County more broadly, and consistent with other models that look generally at this area.

Adaptation recommendations were developed according to the identified risks. These recommendations provide the support for Gold Hill residents, particularly the Town Meeting and Sustainability Committee as they consider further action. The recommendations in this report are meant to inform Gold Hill about possible adaptation strategies for climate-related issues. The RAAR is a preliminary report to highlight the likely major risks threatening a community based on climate projection models. It is not meant to serve as a comprehensive climate adaptation plan, but instead be a starting point for future planning. It also does not provide a comprehensive outlook for all climate related risks and threats affecting an area. There may be climate related risks that are not realized at the time this report was written or cannot be captured accurately through climate modeling tools used in this report. Most importantly, this report is looking to the 2100 time horizon, some risks identified in this report have not yet been realized by Gold Hill.

Difference between adaptation and mitigation

Adaptation and mitigation both address climate issues, however they do so in slightly different ways. Mitigation addresses the causes of climate change, for instance decreasing the harmful amount of greenhouse gases in the atmosphere. Mitigation efforts for GHG reduction may include reforestation, which would increase the global carbon sink. Adaptation, on the other hand, addresses the present and future impacts of climate change (National Aeronautics and Space Administration, 2018). This involves adjusting our prevailing mindset, infrastructure and systems to prepare for future climate effects. The IPCC defines adaptation as the “adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2001). An example of adaptation is hardening structures against wildfire, as the risk of wildfire increases in a region. One approach is no more important than the other, rather they must be used in a simultaneous and synergistic manner.

ABOUT GOLD HILL

GOLD HILL FAST FACTS

Days with Good Air Quality: 296
Average High Temperature: 48-75 F
Population: 240 at 2010 Census



Gold Hill in January of 1859 was the first mining district created in the Nebraska Territory (Colorado attained statehood in 1876). Located 10 miles northwest of Boulder, Colorado at 8,300 feet, Gold Hill sits at the intersection of several mountain roads and above Fourmile and Lefthand Canyons. Gold Hill's location in a rugged and wooded mountain region makes it vulnerable to climate related impacts, and also challenging to enter and exit during extreme events (though it does have the benefit of being at the crossroads of several mountain roads). Featuring a mix of housing that is both historic, and more recently constructed, Gold Hill is an authentic community with mining roots that serves as a reminder of DNA that defined western Boulder County. Gold Hill is unincorporated and led by volunteer community members.

METHODOLOGY AND SURVEY

To assess the hazards affecting the town of Gold Hill, the ASG team met with the Gold Hill Sustainability Committee, as well as various members of the local leadership, over multiple meetings to discuss the community's current risk status and create this report. Local insights and expertise were heavily leveraged in the creation of this report given the high-level understanding of the issues contained therein by the Sustainability Committee. This report provides results for the adaptive need of each hazard.

PROCESS

Community Engagement
Gather stakeholders, engage the community, gather information

01

Assess Vulnerabilities
Identify and assess the vulnerabilities and risks that the community is facing.

02

Draft Goals
What are the community's objectives, intentions, and desired results?

03

Adaptation Plan
Develop adaptation plan for achieving goals.

04

Assess Progress
Create an iterative process to assess progress and make improvements. Reassess climate risks and develop new adaptation strategies, if necessary.

05

SURVEY RESULTS FOR GOLD HILL

In order to engage the community of Gold Hill and accurately capture the values of the community, ASG created and distributed a survey using the Climate Risk and Adaptation Framework and Taxonomy (CRAFT) to the Sustainability Committee. The purpose of the survey was to better understand the perceived climate-related risks affecting the community. Given the local and current knowledge of the climate, stakeholders completing the survey needed to consider the frequency and intensity over the next five years of specific hazards utilized by the CRAFT framework to assess risk. Stakeholders were then asked to consider the impact each hazard would have on every community system and estimate the capacity of Gold Hill to mitigate the effects of these hazards. The survey offers insight into the community's current assessment of how difficult will it be for Gold Hill to adapt to each hazard. Over time, this self-reported perceived risk may rise or fall as strategies are developed and implemented. The answers from the survey were used as data points for the CRAFT framework ASG uses to assess the self-reported perceived risk.

CLIMATE MODELING

Forecasting and modeling weather for the present is a challenging task due to the complexity of the ever-changing atmosphere. Predicting future climate conditions proves to be even more exacting. Creating a clear visual of the future environment involves input from a wide array of climate data and modeling tools to capture the range of variations and possibilities.

The data in this report's primary modeling tool (Temperate) is generated from 32 different Global Climate Models (GCMs). GCMs represent the interactions between different Earth systems, i.e. the atmosphere, oceans and vegetation. Combining the interactions for all these systems can provide a better picture of future climate conditions. Temperate can create a graphical aggregate output using all 32 models, a subset of models, or just a single model.

Because GCMs are complex and are created by different institutions, the models must be standardized in order to make them comparable. CMIP-5 is a framework that studies the outputs of different models and compares them based on a standard set of inputs. One of the most significant inputs is the amount of GHGs that will be present in the future atmosphere. CMIP-5 models two of the possible scenarios, known as Representative Concentration Pathways (RCPs). RCP 4.5 and RCP 8.5 are referred to, respectively as "low emissions" and "high emissions" scenarios in Temperate. This report is based on the high emissions scenario.

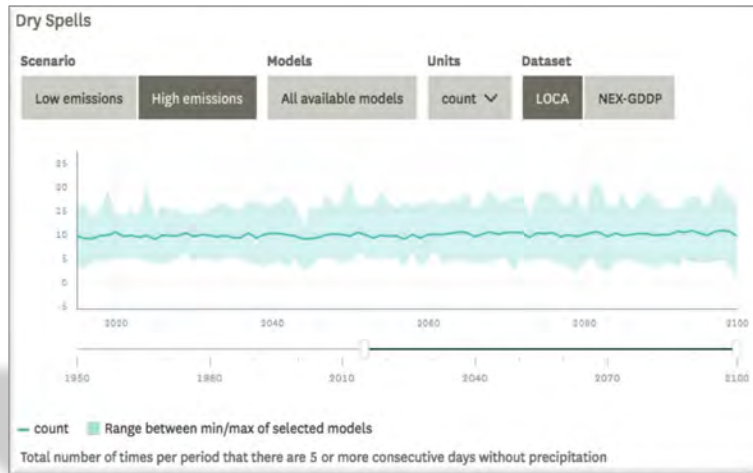
The results of the model runs can span hundreds of miles in scale and must be downscaled to gain a better understanding of localized impacts. Temperate uses two data sets for different downscaling approaches, LOCA (Locally Constructed Analogs) and NEX-GDDP (NASA Earth Exchange Global Daily Downscaled Projections). The results of this downscaling are the climate change data indicators, which are possible climate-related risks affecting a community.

Climate Change Impact

"Climate already affects a variety of resources managed by Boulder County, the City of Boulder, and other local municipalities. As an example, prolonged dry spells in the past decade have contributed to major wildfires on public lands that have threatened lives, impacted public health, damaged county and city property and infrastructure, and caused accelerated hill slope erosion that has polluted streams and water supplies. Resource managers working at county departments and throughout other jurisdictions already face challenges posed by the variability of climate across Boulder County". – **Boulder County Climate Change Preparedness Plan (2012)**

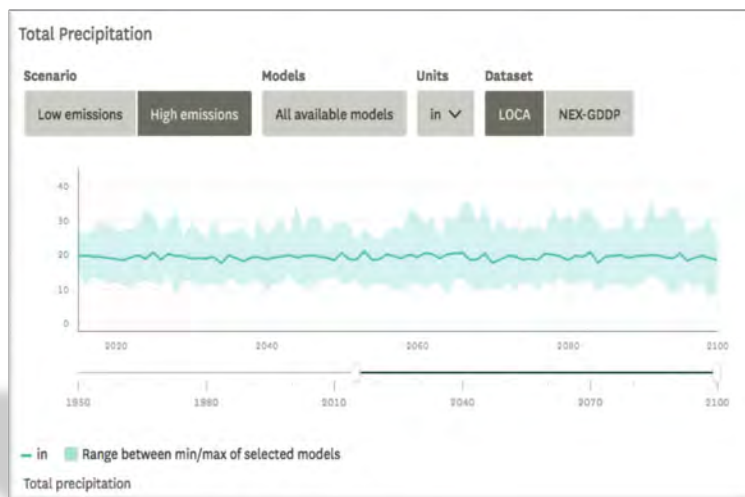
CLIMATE CHANGE INDICATORS

The following graphs display the climate change data indicators that will influence Gold Hill's risk in the coming years. A high emissions scenario, RCP 8.5, is used throughout to reflect high emissions conditions if there is little to no action to reduce and mitigate the emission of GHGs globally. The graphs below display the aggregate of the downscaled GCM outputs from the 32 models considered in Temperate. The climate change indicators described below are projected out to the year 2100.



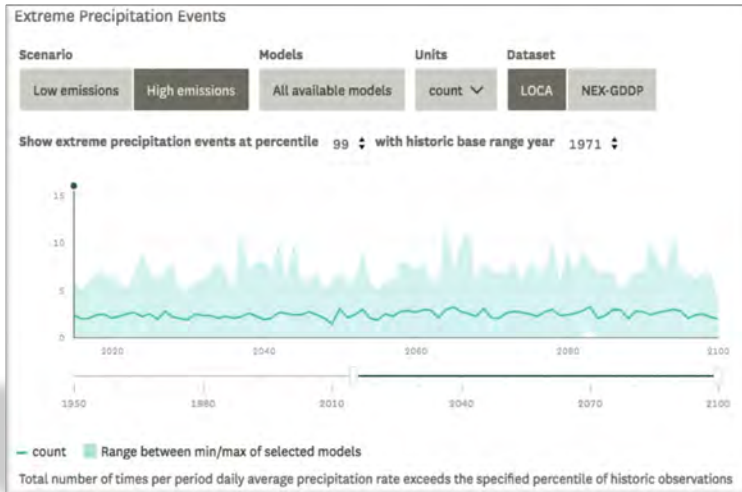
Dry Spells

Dry Spells are periods of 5 or more days without precipitation. The graph indicates that the number of dry spells will remain relatively constant-- in the range between 9 and 10 dry spells per year.



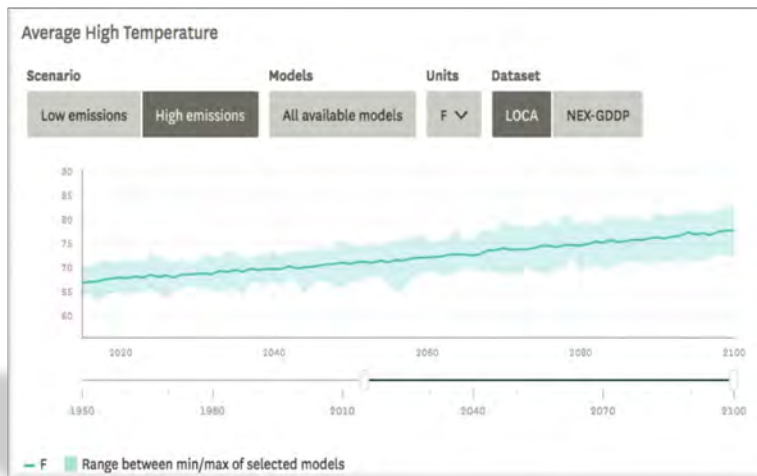
Total Precipitation

Total Precipitation is the summed precipitation volume in a given time period - in this case, 2000-2100. Total precipitation amounts will remain in the range between 19 inches and 18 inches per year.



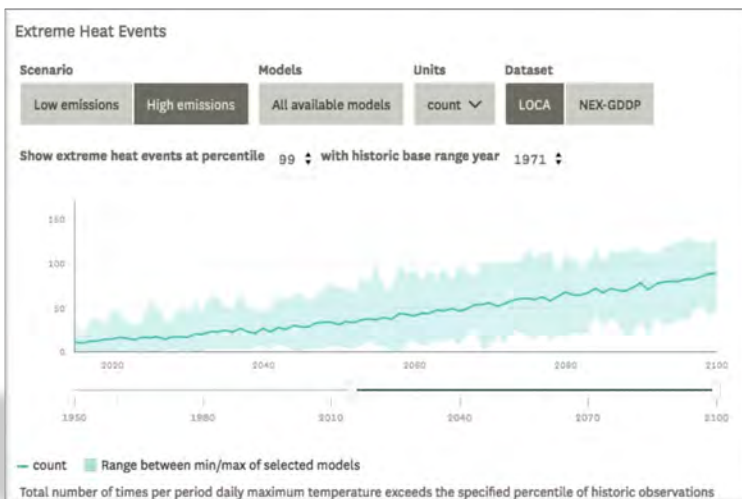
Extreme Precipitation Events

Extreme Precipitation Events counts the number of times total daily precipitation exceeds the specified percentile of total historical daily precipitation (Azavea, 2016-2017). The average number of extreme precipitation events will fluctuate between 2.37 in 2019 and 1.97 in 2100.



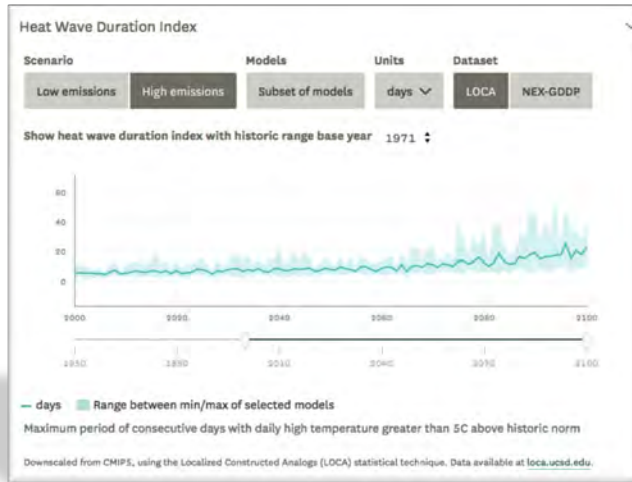
Average High Temperature

Average High Temperature is a calculation of composite daily high temperatures. They are expected to increase steadily from 66.71 degrees F to 77.61 degrees F by 2100.



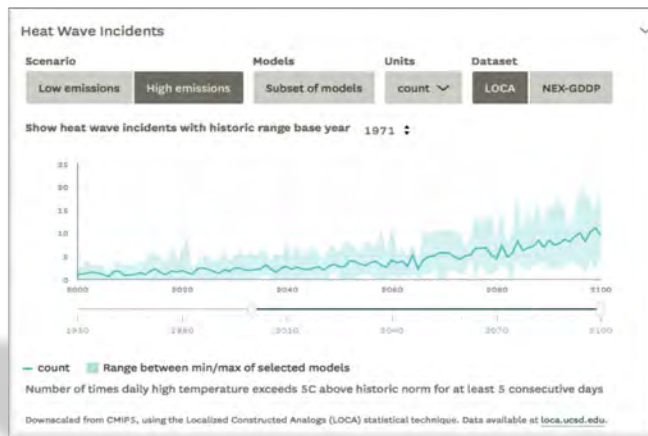
Extreme Heat Events

Extreme Heat Events counts the total times the daily average maximum temperature is above some percentile of historic observations (Azavea, 2016-2017). According to the graph the number of extreme heat events will increase rapidly between 2018 and 2100, rising from 11 extreme heat events per year to 88.83.



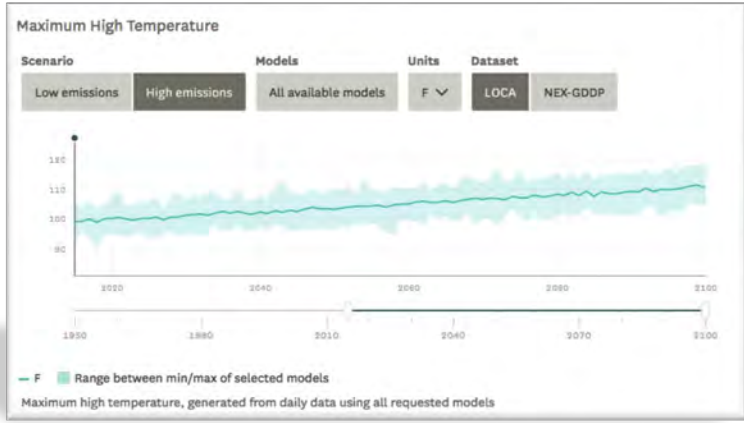
Heat Wave Duration Index

The Heat Wave Duration Index (HWDI) measures the the maximum period of at least 5 consecutive days with daily high temperatures greater than 5°C above historic average high temperature norms. Example: If the historic norm was 85°F, a period of 6 consecutive days with maximum daily temperatures above 94°F (5°C = 9°F) would register at 1 on the HWDI (Azavea, 2016-2017). The HWDI is expected to increase slowly through 2060, and more steadily 2060-2100 from 11-38 incidence.

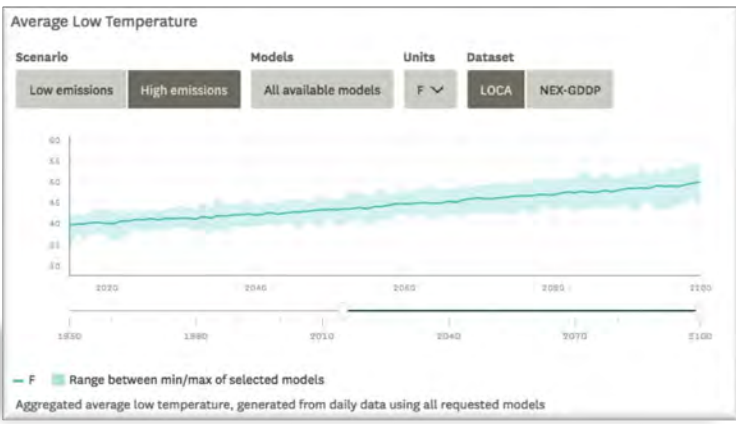


Heat Wave Incidents

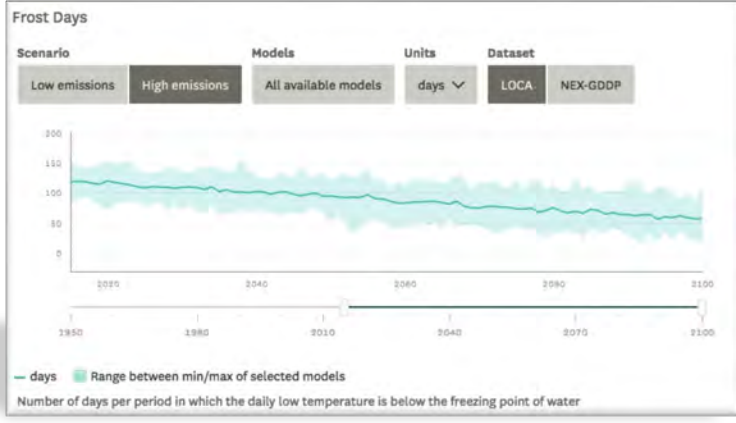
Heat Wave Incidents counts the days the daily high temperature exceeds 5°C above historic average high temperature norms for at least 5 consecutive days (Azavea, 2016-2017). Heat waves are expected to increase steadily from 5 to 16.



Maximum High Temperature
 Maximum High Temperature is currently around 99 degrees F. This number is expected to increase by 2100, reaching a maximum high temperature of 110 degrees F.



Average Low Temperature
 Average Low Temperature is currently around 39 degrees F. This number is expected to increase by 2100, reaching an average low temperature of 50 degrees F.

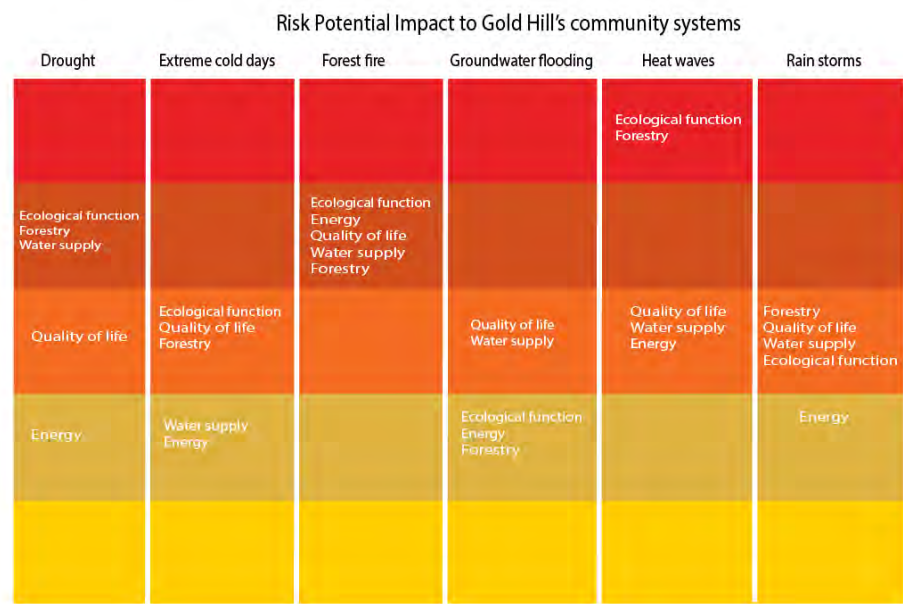


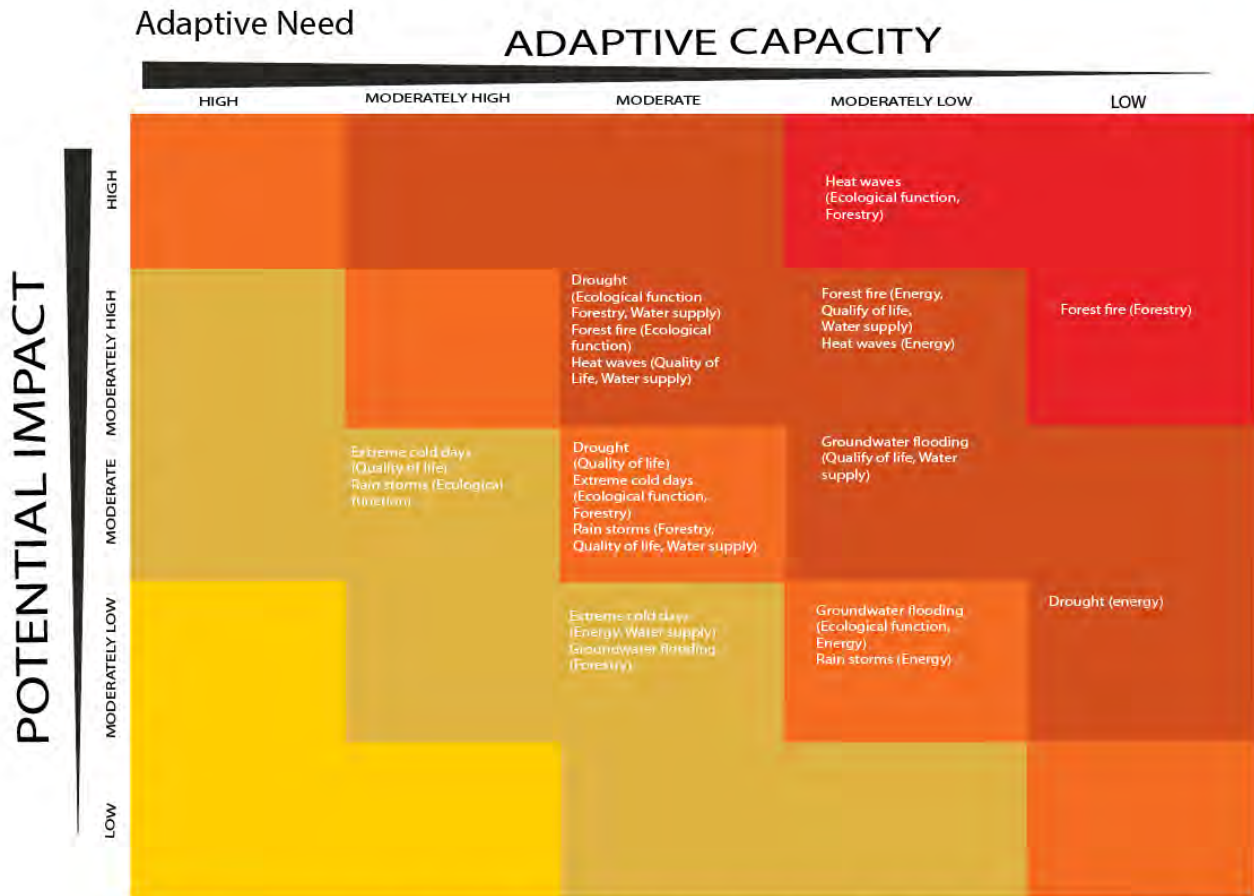
Frost Days
 Frost Days are the number of days the daily low temperature is below the freezing point of water. This is slated to change from 119 today to 56 days in 2100.

ADAPTIVE NEED OF GOLD HILL

Gold Hill is a small mountain town and its elevation provides some advantages in climate change adaptation. Soaring above the Front Range of Colorado, heat (which is already impacting the lower elevations) will take longer to substantially impact Gold Hill. The community sits above two canyons that have had severe flooding in the last decade.

The following graphics show Gold Hill's responses to the adaptive capacity and risk potential to their community systems in August 2019:

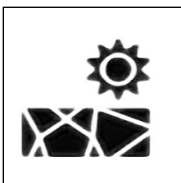




Adaptive need represents a risk's priority, from yellow (lowest) to deep red (highest). Its value depends on the risk's potential impact and Gold Hill's adaptive capacity to manage it.

CLIMATE CHANGE RISKS AND ADAPTATION RECOMMENDATIONS

Drought



A drought is defined as a shortage of water over an extended period of time (NOAA). This is caused by a less-than-average amount of precipitation falling for a particular region (US Geological Survey). The United States will see increasingly more instances of drought as a result of climate change, increasing the risk of wildfires and dependency on energy (Center for Climate and Energy Solutions, 2019). Drought can result from less annual snowfall or rainfall, or months long periods without precipitation, dependent on the season. Heat driven evaporation is also a significant driver in drought, important in light of forecasted temperature increases. Gold Hill found that the likelihood of drought, as well as the adaptive capacity were moderate. This aligns with the modeling that finds precipitation to be unlikely to be changed substantially however heat and changing weather patterns may impact how and when precipitation happens.

For the community of Gold Hill, instances of drought and the resulting water management challenges will be caused in part by a potential decrease in the annual snowpack, and/or the changing patterns of snowmelt as a result of increased heat. The Southwestern Rockies will see a 50% decrease in snowpack this century according to models, as up to 70% of the state's drinking water comes from snowpack (University of Colorado). Snowpack statewide has been below average since 2000, and will melt earlier each season as a result of climate change (Lukas, 2014). The Colorado Water Conservation Board finds that increased winter precipitation is likely, however, warmer temperatures are also predicted yielding changes in snowfall, and also earlier melt. (NOAA, 2019).

The risks of drought for Gold Hill are extensive. At a glance, drought affects forestry, vegetation, and the community's water supply. Drier forests substantially increase the risk of wildfire facing the community. There is also an increased risk of waterborne illness associated with a drought that may affect the community (Center for Disease Control, 2012).

Drought can also directly impact the community through increased strain on aquifer-fed wells, whose levels will be reduced by a decrease in the snowpack (US Geological Survey). Communities like Gold Hill that are already reliant on groundwater for consumption are particularly at risk, as their previous use of groundwater systems will reduce its ability to offset less available water from above-ground reservoirs and rivers (US Geological Survey). In instances of extreme drought, aquifers—and therefore wells—may run completely dry. NASA reports that 21 of the world's 37 largest aquifers are nearly devoid of water (Richey, 2015).

Vulnerable Communities

The history of North America has been shaped by drought from the ancient disintegration of the Pueblo societies of the Southwest to the 1930s Dustbowl. Drought impacts the most vulnerable first. The most likely impacts are financial should localized drought impact water availability and cost, food costs, and possibly energy needs. Mental health is another consideration. In a small connected community like Gold Hill the antidote is ensuring that vulnerable community members are being checked in with during times of stress.

Adaption Recommendations for Drought

Colorado is facing an average annual snowpack decrease and, partly as a result, an increase in drought. Gold Hill should consider the following adaption recommendations to help lessen the impacts from these droughts.

Restrictions on Water Use

In periods of drought, Gold Hill should implement a set a series of recommendations (dependent on the severity of drought) advising homeowners on water use and consumption. As groundwater wells are affected by reduced snowpack, homeowners should be cognizant of their water usage. In addition, wells tethered to the same aquifer or groundwater system will be equally affected, meaning the overuse of a well from an individual homeowner may have adverse effects on the water supply of others (US Geological Survey). Residents should be advised to be particularly light on water use during the months of September and October when groundwater has the least amount of opportunity to recharge their levels (Pennsylvania State University, 2016).

In addition, homeowners could be advised to purchase a meter for their on-site wells to monitor groundwater levels. These meters typically cost around \$300, and allow homeowners an at-a-glance reading of the water levels in their wells (Pennsylvania State University, 2016). The intensive fluctuation of the meter, particularly readings showing less-than-normal amounts of water remaining in the well, can result in more aggressive reduction in water use by homeowners.

Gold Hill should keep these sets of best practices available to offer residents during times of drought and also to be employed outside of periods of drought to encourage responsible water consumption. This may help reduce the impact on homeowners in periods of intense drought.

Reducing Overall Water Use

Citizens of Gold Hill should be encouraged to reduce their overall water consumption. This includes the use of educational programs on shorter showers and best practices around home utilities, like only using a washing machine and dishwashers with full loads.

Rainwater Harvesting

Gold Hill can encourage its residents to practice rainwater harvesting. Rainwater harvesting is the practice of collecting rainwater in bins or barrels and putting it to use. In Colorado, it is legal for an individual household to collect up to two barrels of rainwater at any one time on their property, with a maximum combined capacity of 110 gallons (Cabot, 2016).

Harvested rainwater can reduce the strain on community water resources, as the water harvested by a household can be put to use in both potable and non-potable ways. Unfiltered rainwater can be used in landscaping. Filtered, disinfected rainwater made to be potable can be run through a home's plumbing system and used in any number of traditional ways, such as dishwashing and showering (Innovative Water Solutions, 2018).

Xeriscaping

Xeriscaping is the practice of landscaping with plants and materials intentionally attempting to reduce water use. Considering that over 50% of water use in the west goes towards lawn care (Colorado Waterwise), xeriscaping can be an effective method of reducing Gold Hill's water consumption rate and minimizing the effects of drought on homeowners for those residents that use water in their landscapes. Understanding that Gold Hill's mountain terrain likely uses less water for landscapes, planting water-wise vegetation is best practice.

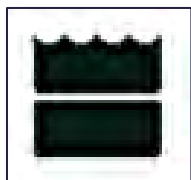
The use of wildflowers, flowering shrubs, and evergreen trees is common practice in xeriscaping. A combination of these plants, natural mulches and stone masonry can be used as replacements for traditional grass or sod lawns (Boulder Landscape and Design, 2019). These low-maintenance options, particularly when selected from plants native to the region, require significantly less water. Gold Hill could define a list of plants and trees to provide homeowners for suggested replacement when doing yard work that focuses on Gold Hill's priorities, such as low water use, support of pollinators, medical and food use. Colorado State University's Extension Office can help here: <https://extension.colostate.edu/topic-areas/yard-garden/>

Water Efficiency

New technologies in dishwashers, washing machines, toilets and sinks have yielded significantly more water-efficient machines. Gold Hill's residents could be encouraged to install these water-efficient pieces of equipment in their homes when replacement is an option.

Water efficiency supports Gold Hill's goals in several critical ways. It reduces the energy required for pumping well water out of the ground thereby reducing greenhouse gas emissions, it extends the life and health of the aquifer, thereby supporting the native infrastructure. Water conservation will also serve as best practice in a time of drought. Gold Hill also has some above groundwater resources that could be made available in times of emergency, for example, if well pumping is not available due to an extended power outage. Information on those resources can be included here.

Groundwater Flooding



Groundwater flooding is defined as a water table rising above ground due to the natural underground drainage systems' inability to drain rainwater quickly enough (Geological Survey Ireland, 2019). This is typically a result of intensive periods of heavy rain, overwhelming the capacity aquifers and bedrock drainage paths. Water from groundwater flooding can remain and continue to cause damage for longer periods than rainwater or river flooding (British Geological Survey, 2010). Because it originates from the water table, not above-ground waterways, floodwaters can emerge from unexpected locations such as hillsides (UK Environment Agency, 2011). Gold Hill found the adaptive capacity and likelihood of groundwater flooding were moderate to moderately low. The research agrees.

Although drought remains a concern for communities like Gold Hill, Gold Hill can anticipate an increase in extreme rainfall as a result of climate change (Great Lakes Integrated Sciences and Assessment). In addition, Gold Hill can anticipate more of its annual rainfall occurring in fewer days. (Pendergrass, 2018). These extreme rainfall events may lead to an increase in groundwater flooding events and have already yielded catastrophic floods, such as the 2013 flooding of Boulder County (NOAA, 2013).

Gold Hill is located at the top of watersheds flowing into portions of Fourmile and Lefthand Creeks. Considering the area's geography, underground drainage beneath the town may cause groundwater flooding to occur in the area if it becomes overwhelmed by extreme rainfall events. The attached map provided by Boulder County's Official Regulatory Floodplain tool demonstrates the at-risk waterways both to the north and south of the town; as these bodies become

Figure 1



inundated with water from heavy rains, the natural drainage systems feeding them may become overwhelmed, resulting in groundwater flooding (Boulder County, 2019).

As the water table rises above ground level, the resulting flooding can cause damage to buildings and infrastructure, particularly residential basements. In addition, the stagnant floodwater left behind poses a variety of health threats to a community, potentially harboring a range from infectious diseases to chemical hazards (Center for Disease Control and Prevention, 2017).

In addition, there are over 100 historic mine sites in the region (Colorado Geological Survey, 2012). These mines may potentially experience increases of acid mine drainage as a result of groundwater flooding, as more water leaches into old shafts. This heavy metal-laden runoff can have detrimental impacts on the surrounding, downstream watershed (US Geological Survey, 2000).

Adaption Recommendations for Groundwater Flooding

Groundwater flooding occurs when a water table rises as a result of heavy rainfall overwhelming natural drainage system capacity. With proper mitigation and adaption, the community of Gold Hill can help minimize structural damage and health risks from groundwater flooding.

Groundwater Mapping

Gold Hill could enlist the help of a groundwater surveying group to conduct a thorough groundwater mapping survey if not already done. This surveying will help to influence proactive flood management programs. Identifying the depth of an existing water table can be done through existing wells (US Geological Survey). However, if the location of the water table is unknown and no existing wells are available, a comprehensive survey to reveal the most at-risk areas in Gold Hill could be conducted.

Permeable Pavement

Gold Hill should consider using permeable pavement rather than traditional asphalt for any driveways, street paving or similar construction should that need arise over time. Permeable pavement is a surface that is intentionally made porous, allowing for water runoff to seep through (U.S. Geological Survey, 2018). The use of permeable pavement over traditional asphalt road and driveway surfaces can help combat groundwater flooding by easing the strain drainage systems may have in periods of heavy rain, as rainwater will have more natural methods of drainage. An additional benefit is a reduced need for the use of road salt during the winter, reducing environmental impact.

Planting Trees for Water Management

Planting trees in both areas most susceptible to groundwater flooding as well as along streets that serve as above-ground drainage can help mitigate floodwaters. Trees allow water to permeate into the soil almost three times faster than suburban turf (Penn State, 2015). This can help reduce the strain on natural drainage systems, as well as lessen the time floodwaters remain above ground.

Proactive Floodplain Management

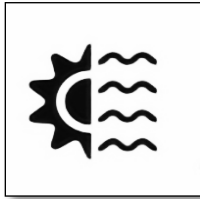
Floodplain management is a community plan to help reduce the impact of current flooding, as well as lessen the risk of future flooding (FEMA, 2018). Programs and policies may include restricting development in floodplains which should be prohibited by Boulder County regulations, setting a buffer zone for new construction and conducting a full watershed analysis to determine those areas within the community most prone to flooding and heavy rainfall.

Private Property Preparation

For homes in areas of Gold Hill deemed particularly at risk to groundwater flooding, homeowners should consider taking specific measures to prevent damage from groundwater flood events, such as sealing their basements should they exist (installing a waterproof membrane or sealant around a basement) and equipping their properties with sump pumps (UK Environment Agency, 2011) where applicable. These efforts can help protect existing properties at repeatable risk of groundwater flood events.

Any residences currently placed within a floodplain in Gold Hill could have their permits rescinded by the County Engineer as flood patterns and frequency change. Individual homes potentially affected should request a site visit from the County Engineer to ensure the continued safety and structural integrities of the home site (Boulder County Land Use, 2019). Flooding is defined as a water table rising above ground due to the natural underground drainage systems' inability to drain rainwater quickly enough (Geological Survey Ireland, 2019).

Heat Waves



Heat waves are defined as a period of at least two days of abnormal, higher-than-average warm temperatures (Climate Communication, 2019). Sometimes spanning weeks, heat waves, coupled with drought, cause the highest amount of fatalities of any natural disasters (Borden, 2008). Gold Hill believes that they are at moderate to high risk to heat waves, with moderate ability to adapt. The research concurs.

In the United States, there has been an upward trend in the number of heat waves experienced annually (Pryor, 2014). The map in Figure 2 (provided by NOAA) demonstrates the increased amount of heat waves regions will experience in the mid-21st century compared to the late 20th century. This is directly correlated to increased greenhouse gasses and is a result of climate change (Luber, 2008).

While the Southeast and Northeast regions of Colorado are the least prepared for dealing with extreme heat, the entire state will be affected by temperature changes, and has already seen a 2-degree average increase of temperature annually in

Figure 2

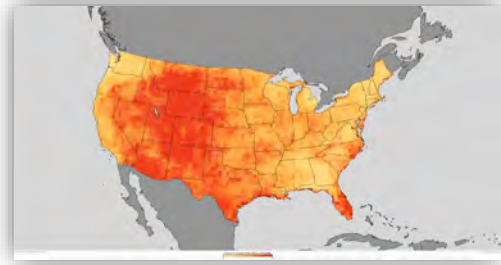
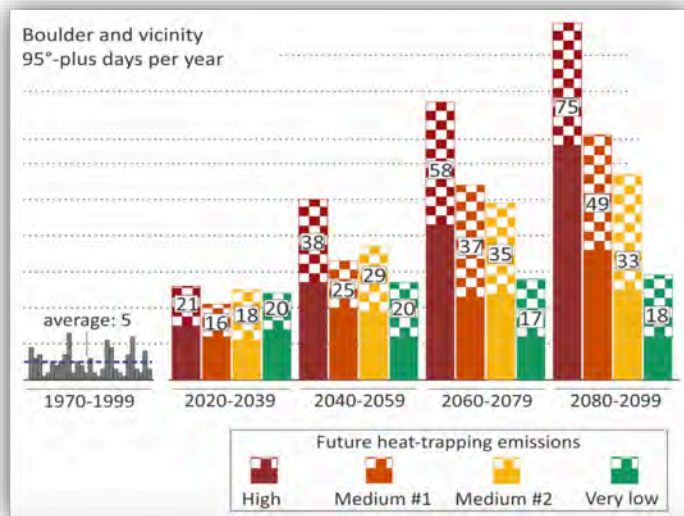


Figure 3



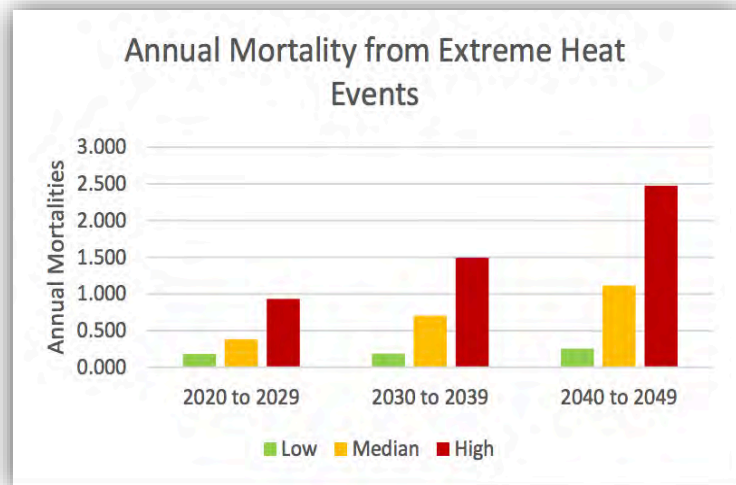
the past 30 years (Denver Post, 2019). Localized for Boulder County, the increase in heat waves and rising temperatures overall reflect the national trend. The Rocky Mountain Climate Organization (RMCO) reports that the county will see an average of 38 days of temperatures at or exceeding 95 degrees per year, a stark contrast to the average of 5 days of such weather experienced between 1970-1999.

The graph shown in Figure 3 (provided by RMCO) shows how this average of days at or over 95 degrees will continue to climb throughout the century in Boulder County. It also demonstrates how a decrease in heat-trapping emissions present in the atmosphere can significantly reduce the amount of days at or over 95 degrees annually (Saunders, 2016).

The Temperate model focused on Gold Hill area agrees, finding a steady increase in heatwaves through 2060, with acceleration in heat waves through the end of the century. The Colorado Health Institute found the Front Range communities of which Gold Hill is included to be “Vulnerable” to climate change-related risks, heat being among them (Colorado Health Institute, 2018).

The risks associated with an increase in heat waves are extensive for the community of Gold Hill, with threats ranging from health to environmental and social. A 2018 study conducted by Resilient Analytics highlights that the most at-risk populations in heat waves are the very old, very young, and individuals with preexisting conditions (Resilient Analytics, 2018). The report goes on to highlight the number of heat-related deaths predicted by the Colorado Department of Public Health, as demonstrated by the attached chart. The severe stress that heat has on the human body can cause a variety of conditions to worsen, as well as cause

Figure 4



heatstroke even in healthy individuals. As noted by Stratus Consulting, increasing nighttime temperatures (greater than 80 degrees) coupled with higher heat averages in Boulder County, will further exacerbate these risks to human health (Stratus Consulting, 2012). Though Gold Hill as a higher altitude community typically experiences evening dips in temperature, awareness about vulnerable populations that may lack cooling should be front of mind during heat

Vulnerable Communities

It is arguably the most vulnerable populations that are experiencing the heaviest burden in the face of the changing climate. Low-income populations, the homeless and the elderly are more susceptible to air pollution and heat-related risks. This is because they do not have access to adequate ventilation and air conditioning. Exposure and proximity to hazardous living situations is also more common for these populations.

events. As heatwaves become more common, dangers to public health are the most pressing concern for Gold Hill aside from fire.

Although today through-traffic is not a substantial issue for Gold Hill, rising car pollution from the Front Range may still have an adverse effect on air quality, particularly during heatwaves. Boulder County is already facing a growing concern of rising ozone levels as a result of increased traffic and oil and gas industry activity (Daily Camera, 2019). Air pollution is generated by the increase in ground-level ozone that is produced in the presence of more heat and the sun’s ultraviolet rays. The interaction between volatile organic compounds (for example, from car exhausts) and nitrous oxides (a product of burning fossil fuels) creates harmful ground-level ozone (United States Environmental Protection Agency, 2017).

Additional ramifications from high heat include societal ramifications. For a community like Gold Hill that has a large amount of outdoor opportunity, the time individuals can spend outside in the summers and healthily recreate will be severely diminished during heat waves, and even more so on the population centers below Gold Hill, driving outdoor higher into the mountains. In addition, laborers in construction or landscaping will have their working hours severely affected. Should a heatwave occur while school is in session, students in the Gold Hill schoolhouse will have an increasingly difficult time concentrating and may even face health risks should temperatures reach unsustainable levels, with studies showing a 1% decrease in content learned for every 1-degree increase above normal in classroom temperatures (Goodman, 2018).

Adaption Recommendations for Heat Waves

Heatwaves will become more common for Gold Hill. Coupled with average temperatures on the rise, heat will continue to be a growing threat to the community's well being in the coming decades. Gold Hill should consider the following adaption recommendations to offset the effects.

Cooling Centers

As many residential homes in Gold Hill may not yet be outfitted with air conditioning, community leadership could consider offering a cooling center where individuals can drop by during summer hours or during periods of intense heat. This is a relatively low-cost solution that allows residents to have a way to get out of the heat during daytime hours and also gives an opportunity to check in on at-risk populations who otherwise may not have ventured from their homes. As Gold Hill continues to evolve in thinking about a community center and/or fire station, considering the future needs for a cool space can be part of that planning. Gold Hill is researching how to fund these projects.



Green Roofs

Gold Hill can encourage residents who have the capability to create green roofs on their properties, particularly on free-standing garages or new construction. A green roof is essentially a vegetated and irrigated system on a building's roof. Some of the benefits of green roofs are highlighted below (Getter & Rowe, 2006), (Green Roofs for Healthy Cities, 2017):

- A green roof replaces the impervious surface of the original roof with plants, grasses and trees that can provide a natural green space in an otherwise built environment supporting many of Gold Hill's goals.
- Using natural elements on the roof can alleviate or slow storm water runoff providing many benefits outlined in this report.
- Green roofs provide a cooling effect for the building by increasing the albedo (or reflectivity) of the surface. Evapotranspiration from the plant surfaces also contributes to an overall cooling effect. Note that this may be a complement or even a solution for Gold Hill homes who do not have air conditioning units, or have units with a low capacity.
- This cooling effect is noticeable and cools the surrounding air temperature and the inside temperature as well. A building using a green roof uses less energy for air conditioning and other cooling mechanisms because it does not get as warm inside the building.



- Plants contribute to the reduction of CO₂ (through photosynthesis) and pollutants (through filtration) in the air, thus improving overall air quality.

There are also strategies involving making the roof of residential structures lighter in color to reduce daytime summer heating. Given Gold Hill’s dominant energy need is around winter heating; this strategy is not yet recommended.

Tree, Grass & Shrubbery Planting

Gold Hill can encourage the reforestation of native trees in areas where they have suffered badly from pine beetles, fire, and drought. Trees serve a dual purpose in reducing heat during a heatwave, first by removing carbon dioxide from the air, improving air quality, and second by providing shade. According to the EPA, shaded surfaces are typically 20–45°F cooler than the peak temperatures of unshaded materials (U.S. Environmental Protection Agency, 2016).

Gold Hill can complement these efforts with the planting of native shrubbery and grasses. The degradation of soil caused in part by higher temperature averages has negatively impacted the ability of some native tree species, such as the Douglas Fir and Ponderosa Pine, to regrow after a wildfire (Davis, 2018). For areas surrounding the Gold Hill that have been affected by fire, reestablishing forestry may be increasingly difficult without the addition of native shrubbery and grasses to help improve the quality of the soil. Native plants can help improve the ability of soil to take in water and withstand erosion (USDA, 2009).

This retention of groundwater may have the added effect of increased evapotranspiration (movement of water from land to air). Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9°F.



Energy Efficiency

As more residents of Gold Hill install air conditioning units and systems to their homes, energy efficiency and reducing overall demand for electricity are critical strategies to help support Gold Hill’s goals around sustainability and community resiliency. Boulder County and Xcel Energy will encourage residents to purchase energy-efficient cooling equipment to help curb energy use through their existing programs. Both organizations will encourage looking at the entire structure to help residents identify health and safety, comfort, energy-saving and load shedding opportunities. For example, LED lightbulbs use only 25% of the energy of traditional incandescent bulbs (US Department of Energy). As lighting typically accounts for up to 5% of a home’s energy consumption, these small changes in equipment can have a tangible reduction in overall energy use. In Gold Hill tightening the envelope of the building through insulation and air sealing are low-cost and high-payback strategies, especially when propane (high fuel cost) fuel is used for heating.

At the time of this report, Boulder County offers energy efficiency and renewable energy support through the EnergySmart program. Xcel Energy currently offers substantial incentives for residential energy audits through their Home Energy Squad program. The Home Energy Squad also provides “direct install” energy efficiency measures that include unlimited LED lights, weather-stripping, low-flow showerheads, and “smart” thermostats.

Law Enforcement

Even in small, tight-knit communities like Gold Hill, there is a direct correlation between increased heat and violence amongst residents in a given region (Anderson, 2001). Gold Hill can work with Boulder County Sheriffs during periods of extreme heat, ensuring that an officer is within a reasonable driving distance of the community particularly between the hours of 9AM and 3PM, when most heat-induced aggression is shown to occur. Boulder County's crime statistics (Boulder County) show few recorded events in the Gold Hill area, with home break-in being the most common, anecdotally domestic violence has also been discussed as a concern.

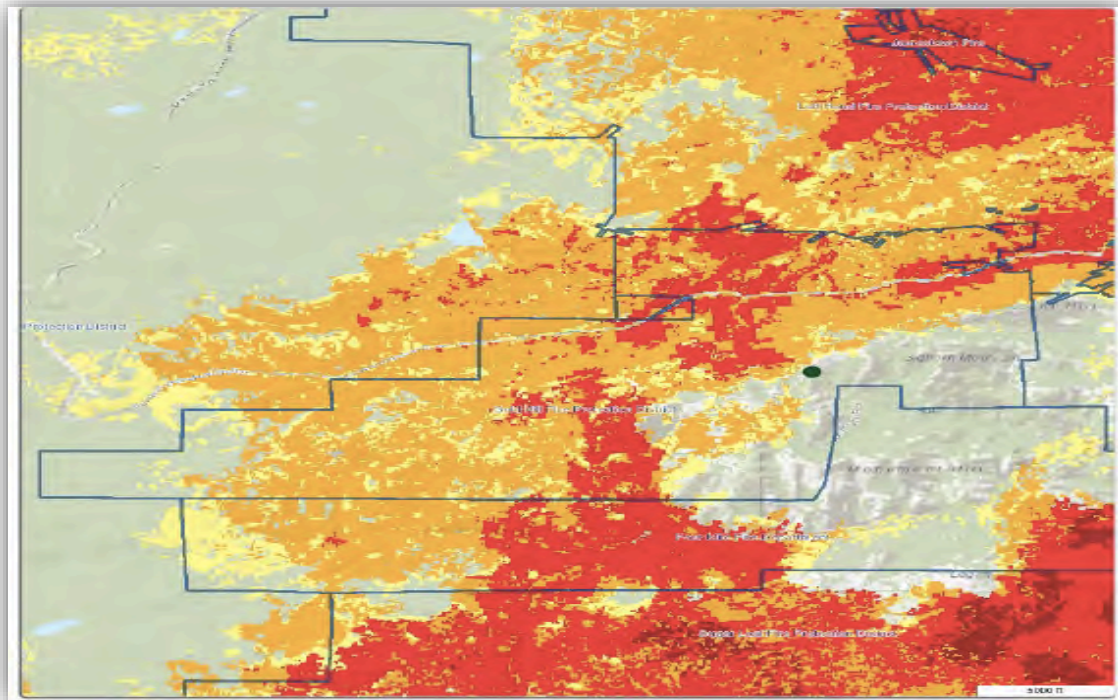
Forest Fires



A forest or wildfire is defined as an unplanned, unwanted fire burning in a natural area, such as a forest, grassland, or prairie (FEMA, 2014). Forest fires may occur naturally or as a result of man-made causes, such as dry vegetation making contact with utility equipment (National Park Service, 2018). Although forest fires are a natural part of a healthy forest's lifecycle, when they encroach on communities they can cause catastrophic damage. This can lead to intensive loss of personal and commercial property, leading to economic distress and displacement, as seen in the deadly impact California's 2018 Camp Fires had on the nearby town of Paradise (Cal Fire, 2019). In addition, fire can cause significant air pollution, lowering air quality in the surrounding regions and potentially posing a threat to human health (US Forest Service). Gold Hill finds their risk of wildfire to be moderately high, while the ability to adapt to be varied depending the community system.

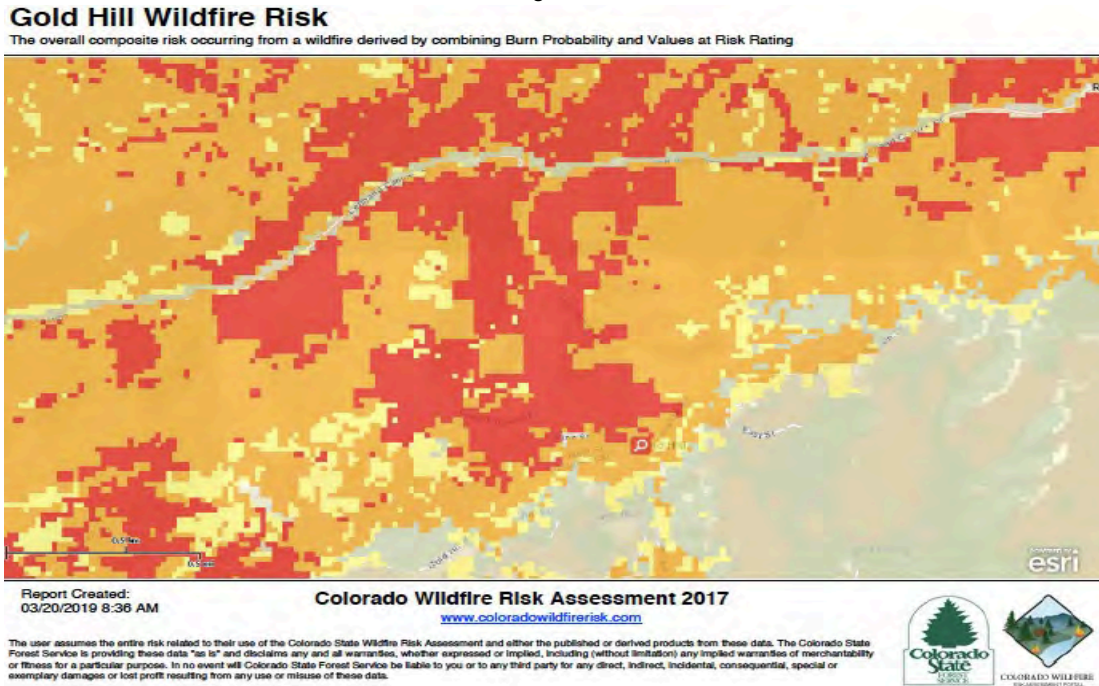
The map in Figure 5 (provided by the Colorado State Forest Service) shows that to date, the highest risk of forest fire lies in the Northwest area of Gold Hill's Fire Protection District (CSFS, 2018).

Figure 5



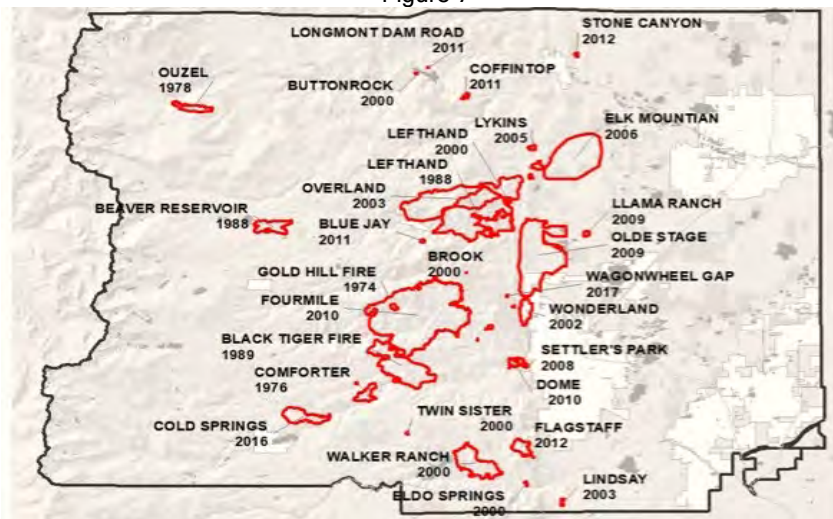
A risk assessment (shown in Figure 6), provided by Colorado State University in March of 2019, shows a close-up look at the Gold Hill community and the ranging risk of wildfire. The increasing presence of drought and extreme heat events, coupled with a reduction in annual snowpack, will yield an increase in frequency and intensity of forest fires in areas with an abundance of fuel (vegetation) (National Climate Assessment, 2017). Due to its heavily wooded surroundings, Gold Hill is subject to these increased risks, as exemplified by the Fourmile Canyon Fire which burned 5700 acres and 162 homes (Graham, 2012).

Figure 6



In addition, the following map provided by Boulder County outlines the history of wildfires in and near Gold Hill. This provides a sense of both the scale of historic wildfires, as well as demonstrates the uptick in number of wildfires experienced across the county in recent decades. A visual presentation on areas of Boulder County before and after being affected by wildfires is available in the appendix of this report.

Figure 7



Boulder County recognizes fuel as the only factor of forest fires that are under human control (Boulder County, 2019). As such, to adapt to the new conditions, residential mitigation of every home is recommended in the Wildland Urban Interface (WUI) (CFSS, 2018) as well as targeted mitigation projects of large stretches of federal and county land to stop or slow the spread of a forest fire before it reaches the town of Gold Hill. There are also additional programs aimed at the reduction of fuel sources to mitigate the spread of wildfire, such as community chipping events (turning waste wood into useful mulch/chip) that the town should adopt.



Gold Hill can apply for both Federal and State fuel mitigation grants to fund these programs, partnering with Boulder County where applicable. FEMA’s Hazard Mitigation Grant Program allows for a local government to apply for funding for a wildfire mitigation project (FEMA, 2018) which currently funds some Boulder County programs. Similarly, the Colorado State Forest Service has a series of assistance programs that provide grants for wildfire mitigation, both at the municipal and landowner level (CFCS, 2018).

Adaptation Recommendations for Forest Fires

The strong nexus between heat and an increase in forest fires will be a growing concern for Gold Hill. Forest fire adaption solutions help to reduce the ability of forest fire to start and spread through the community. Given the established increase in wildfire danger as indicated in the climate models and community shared experience, the following adaption programs are recommended.

Prescribed Burns

In order to both protect itself from wildfires in the future and to ensure the health of its wildlife and soil quality today, Gold Hill could work with public land stewards to plan a series of prescribed burns in the surrounding forest. A prescribed burn is a planned, sanctioned fire set to a predetermined area. It serves multiple purposes, but mainly to reduce fuel available to a wildfire, and to provide ecological benefits that are essential for a forest to thrive (National Park Service, 2017).



Forests nationwide have become overgrown and laden with fuel as a result of efforts to stop all wildfires, which are a necessary function of a healthy forest’s lifecycle. The Bureau of Indian Affairs (BIA), which is responsible for the management of wildlife on Native American lands nationwide, recognizes prescribed burns as the only effective method of restoring wilderness to a healthier state while maintaining the safety of surrounding communities (Bureau of Indian

Affairs). The BIA also recommends mitigation around important infrastructure, like municipal watersheds and vital roadways. Gold Hill's wildfire mitigation efforts could utilize the BIA's internal Fire Effects Guide, which will inform planners of the intensity and size an effective prescribed burn should be to maximize its utility on forestry (BIA, 2001). BIA's approach also encourages using prescribed fire to recognize cultural and other historic land uses.

Mitigation Programs

Mitigation of private properties is a frontline defense against the spread of forest fire. It requires the creation of a non-combustible barrier around all structures, as well as a series of other guidelines for restricting the access of fuel to an uncontained forest fire (CSFS, 2012). Gold Hill should ensure continued encouragement of mitigation of private property and provide the proper resources necessary to train homeowners. Gold Hill should specifically focus on creating mitigation programs for homeowners in the Northeast quadrant of the community, where risk of forest fire is substantially higher, including recommending Wildfire Partner home certification.

Vulnerable Communities

Gold Hill may have residents that are unable to properly mitigate their properties, or may be unequipped to respond in the event of an emergency. Having a plan in place to ensure the most vulnerable residents are assisted preemptively to avoid catastrophe, and also during an actual event are essential components of a community fire response plan.



The Wildfire Partners program provides support for homeowners to mitigate their properties. Boulder County offers individualized checklists and assessments of a home's preparedness and effectiveness at mitigating a threat from a forest fire. Upon enrolling in the program, a mitigation expert is sent to the property to assess

the grounds and provide a full list of recommended items to address. Once completed, the organization sends an expert back to ensure the items have been addressed and the home has been successfully mitigated, at which point a certification is issued for the property (Wildfire Partners, 2015). Gold Hill should also promote the recertification of homeowners already in the Wildfire Partners network to ensure the preparedness of their properties every 5 years.

In addition, Gold Hill should focus on fuel reduction efforts of National Forest Service (NFS) and Bureau of Land Management (BLM) land in the at-risk northeast quadrant of the community. The aforementioned federal and state grant programs may be considered as sources of funding for these targeted mitigation efforts once an assessment of the area is completed (USDA, 2019).

Community Chipping Program

A community chipping program is a group-based effort to clear both public and private land of sources of fuel for a forest fire. Typically, a community or neighborhood will organize a chipping event for their neighbors to incentivize mitigation programs or ease the strain on homeowners of disposing of waste from mitigation. Homeowners will trim branches, small trees, and other excess vegetation from their property and bring it to the curb. The community will then collect the waste and turn it into usable mulch/wood chips, typically at no cost to the homeowner.

The price of the wood chipping itself is offset by a Boulder County based program that grants up to \$4,000 to groups of 5 or more homeowners. Gold Hill may apply for multiple chipping events within their community, but only one will be funded (Boulder County, 2019).

Saws and Slaws

Gold Hill should consider exploring events with, or organizing events similar to, Saws and Slaws. This organization brings together community members to perform fire mitigation on both public and private land. Community members spend 4 hours performing brush and shrub removal before celebrating with a potluck, the goal being to increase the level of awareness and create comradery around forest fire mitigation (Saws & Slaws 2018).



Forest Service Fuel Break Program

A fuel break is “a strip of land in a strategic area...where fuel modification...can be accomplished” as an approach to fire mitigation (Green, 1977). By clearing most of the vegetation, a portion of land can be used as a buffer between an area a community seeks to protect and encroaching forest fires. Fuel breaks are often placed between dense areas of vegetation.

Gold Hill should consider creating fuel breaks in strategic locations that will allow for an opportunity to slow or halt a forest fire advancing toward the community. Natural breaks between areas of forest, such as ravines or ridges, should be utilized to maximize the effectiveness of the fuel break.

Evacuation Plans

Given the risk of forest fire in Gold Hill, emergency response professional evacuation will be utilized during an emergency to ensure the safety of residents. Individual resident and family plans are advised to be in place. Community plans can be developed in partnership with the local fire department. These plans should include the designation of authorities, a unified coordination process, traffic management processes, and a system for tracking evacuees (FEMA, 2018).



A program can also be put in place informing residents of the items they should bring in an evacuation, such as prescriptions and identification information. They should also be instructed on how to prepare their homes before exiting the property, like turning off propane to the home and placing a ladder against the front of the house (Rocky Mountain Insurance Information Association, 2015).

Because of the poor reception and difficulty of communication in the area surrounding Gold Hill, in the case of an emergency, the community should embrace grassroots efforts to disseminate information about wildfires, such as AirLink. AirLink is a community-run organization of volunteer HAM radio operators who maintain communication with the Boulder County Emergency Operations group in disaster scenarios, such as wildfires or severe floods. The operators can aid in vital communication, including evacuation notices, amongst neighbors and between towns (AirLink Amateur Radio Group, 2019).

Additional community-based programs such as NeighborLink should be utilized in evacuation planning—and in emergency response more broadly. NeighborLink, founded by Gold Hill community members in 2013, is a phone tree system designed to quickly communicate with the entire area of Gold Hill by connecting small groups of nearby neighbors which connect to larger neighborhood representatives, and finally connect to the four larger Gold Hill area leaders. This method of rapid communication between neighbors helps to ensure the safety of community members while simultaneously disseminating vital information and would be an effective tool during an emergency evacuation.

Fire Wise Community Program

Gold Hill can also consider becoming part of a formal community-based approach to wildfire mitigation and adaptation, such as a “Fire Wise” program. Run by the National Fire Protection Association (NFPA), a Fire Wise program brings together many of the above adaptation plans and corresponding stakeholders to create a community-wide effort to avoid sparking and stopping the spread of wildfires (NFPA, 2019).



FIREWISE USA®
RESIDENTS REDUCING WILDFIRE RISKS

In order to become a Fire Wise community, Gold Hill should first obtain a written wildfire risk assessment from the fire department, which should include plans for updating every five years. For reference, a Gold Hill risk assessment from 2006 is the last version and should be updated. In addition, community leadership should summarize the above programming and any additional forest fire mitigation and preparedness in an action plan, which should include plans for updating every three years. After such preparations have been made, Gold Hill can apply for certification as a Fire Wise community (NFPA, 2019).

Obtaining Additional Fire Department Resources

Gold Hill could benefit from an increase in resources for the local fire department. The vast majority of fire departments nationally are volunteer based, with 71% being fully volunteer and 16% being mostly volunteer (FEMA, 2019). If Gold Hill Fire Protection District is to remain a predominantly volunteer-based organization, they should consider joining the National Volunteer Fire Council (NVFC). The NVFC provides members with resources on education, training, and access to funding via federal grant programs (NVFC, 2019). There may be limitations for Gold Hill considering the size of their fire barn.

A Mill levy has been used by other rural communities in Colorado considering additional resources for their fire departments. A mill levy is an additional tax levied upon a homeowner based on property value, wherein one “mill” is one dollar per \$1,000 of assessed value. Boulder County has utilized mill levies for fire districts in the past, and Fourmile Fire District instituted a mill levy on residences (Daily Camera, 2017). Fourmile instituted a mill levy of 22.8 (current rate 2019) to bolster its fire district resources, meaning \$22.8 per \$1,000 of assessed value which is 7.15% of actual value as determined by Boulder County.

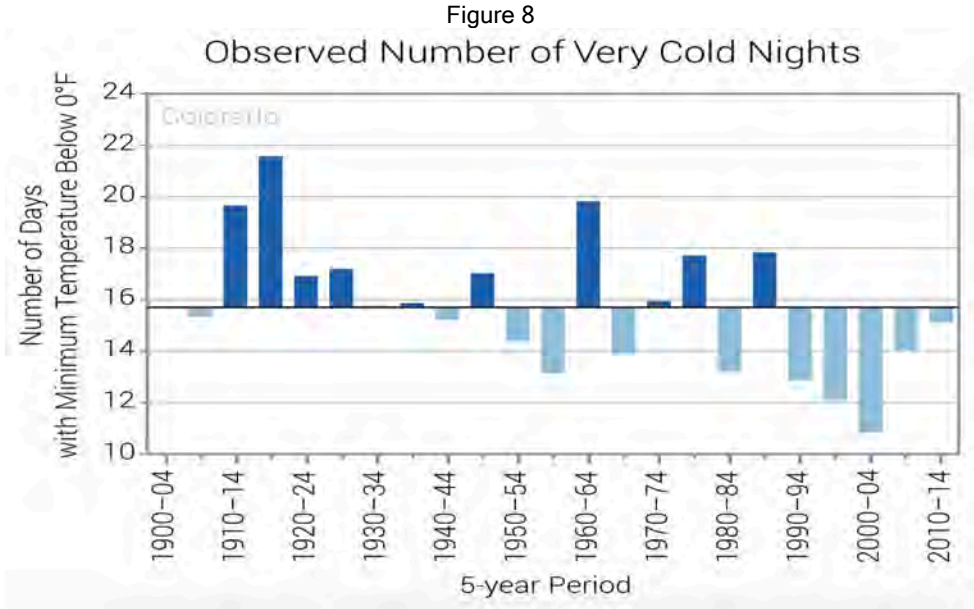


Extreme Cold Days



Characteristics of extreme cold days and cold events are defined as “temperatures at or below zero degrees for an extended period of time” (New York State, 2008). They are typically accompanied by winter weather. Communities like Gold Hill will experience fewer extreme cold days per winter as global temperatures continue to rise, a trend observable in Colorado since 1990 (Frankson & Kunkel, 2019). Gold Hill finds their ability to adapt to less cold winters to be moderately high, and their risks to be moderate to low.

The graph shown in Figure 8, provided by NOAA, demonstrates the number of very cold nights (days with an average temperature of less than 0 degrees F, similarly defined as extreme cold days) have been significantly reduced over the past three decades (NOAA). This reduction in extreme cold temperatures will yield higher average temperatures, which will result in a plethora of effects.



Warmer winters will have numerous effects on ecology, beginning with insect populations. Some pests, such as mosquitoes and ticks, will have longer seasons and thrive in larger numbers (Climate Central, 2015). Invasive species of insects that affect forestry, such as the Emerald Ash Borer, will survive winters that do not experience extreme cold conditions of less than -22 F, potentially leading to a rise of these populations (Christianson, 2018).

Although the Rocky Mountain Pine Bark Beetle epidemic peaked in 2008 (CSFS, 2018), they remain a threat to Colorado forests (CPR, 2019). This threat will grow stronger as warming winters will allow the bark beetles to survive the season in larger numbers (Los Alamos National Laboratory 2018). In addition, the State Forest Service has observed a growing number of Spruce Beetle infestations, populations of which will similarly be affected by warmer winters (CPR, 2019).

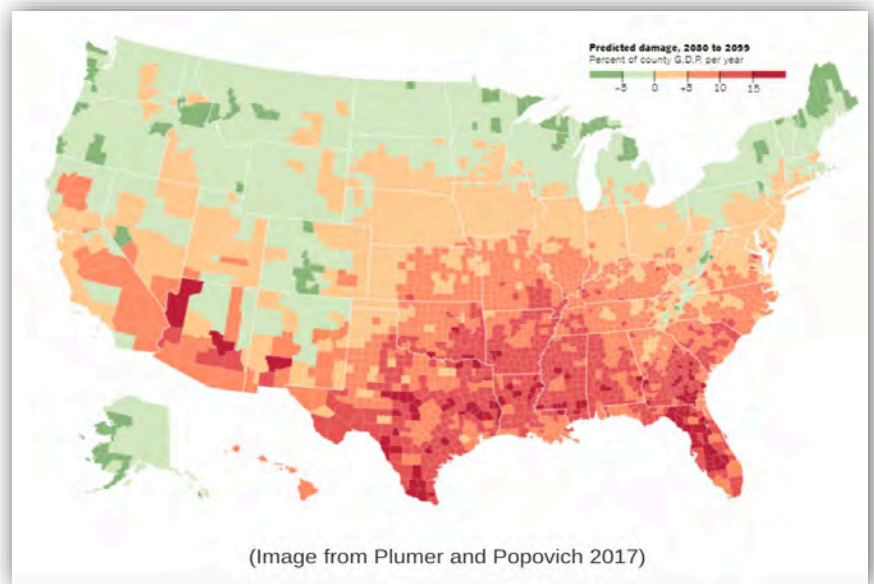
Additional ecological effects include longer allergy seasons and plant/pollinator mismatches. Plants like ragweed will have a longer season, affecting those with allergies in the population. Similarly, flowering plants blooming from climate signals before the natural active cycles of pollinating insects may lead to a reduction in pollination, reducing

the number of these plants (Irfan & Sukumar, 2019). Animal migration patterns may be affected by warming winters as well. As seen in Yellowstone National park, elk populations adapting to climate change may change their migratory patterns, potentially impacting the number of natural predators in the area (Rickbiel, 2019). The impacts of changing wildlife patterns are not necessarily negative and could create new wildlife-related opportunities.

Fewer extreme cold days will impact the area’s waterways as a result of lesser snowfall (Climate Signals, 2018). This lesser snowfall may also have an effect on the winter recreation & tourism in Gold Hill, such as backcountry skiers accessing terrain near the town. In addition, any privately owned snow removal operations in the town may be subject to an economic downturn.

The effects of fewer cold days may yield an influx of climate related migrants to Gold Hill, seeking moderate mountain temperatures while continuing to work on the Front Range. Colorado’s population is already experiencing and influx of residents from other states (Colorado Virtual Library, 2018). In greater numbers, individuals are moving to states with cooler temperatures and more moderate climates as a result of extreme heat or flooding in their former regions (Arcanjo, 2018). Colorado’s average cooler temperatures (shown as lack of GDP damage related to heat and other climate-related issues as demonstrated by the map in Figure 9) position Colorado to continue climate growth, in turn potentially increasing the awareness of Gold Hill.

Figure 9



Future state of climate and demographic changes in Colorado (Bell Policy Center, 2018) and other considerations may change housing needs and demands in Gold Hill. Limited opportunities to build as a result of available land, county regulations and other factors will limit growth. Other communities in Boulder County are facing similar challenges, and in some cases found innovative solutions. Lyons, CO created a pathway to a limited number of tiny homes (<400s.f.) through ORD 1047. Tiny homes can allow for additional residential occupancy in single-family zoned lots. Challenges include regulations, building codes and increased demands on wells and septic.

Adaptation Recommendations for Extreme Cold Days

Experiencing fewer extreme cold days and the corresponding warming winters will have a series of effects for Gold Hill. Adaption solutions, including effective pest control and planned water and utility usage for the community can help combat these effects. The following adaption programs are recommended for Gold Hill.

Water Use

One of the largest concerns for a community experiencing fewer extreme cold days, and as a result, less snowpack to fuel waterways, is a shortage of available water. The current water supply to Gold Hill relies heavily on precipitation and the aquifer both of which can be impacted from a reduction in annual snowpack (BASIN 2005).

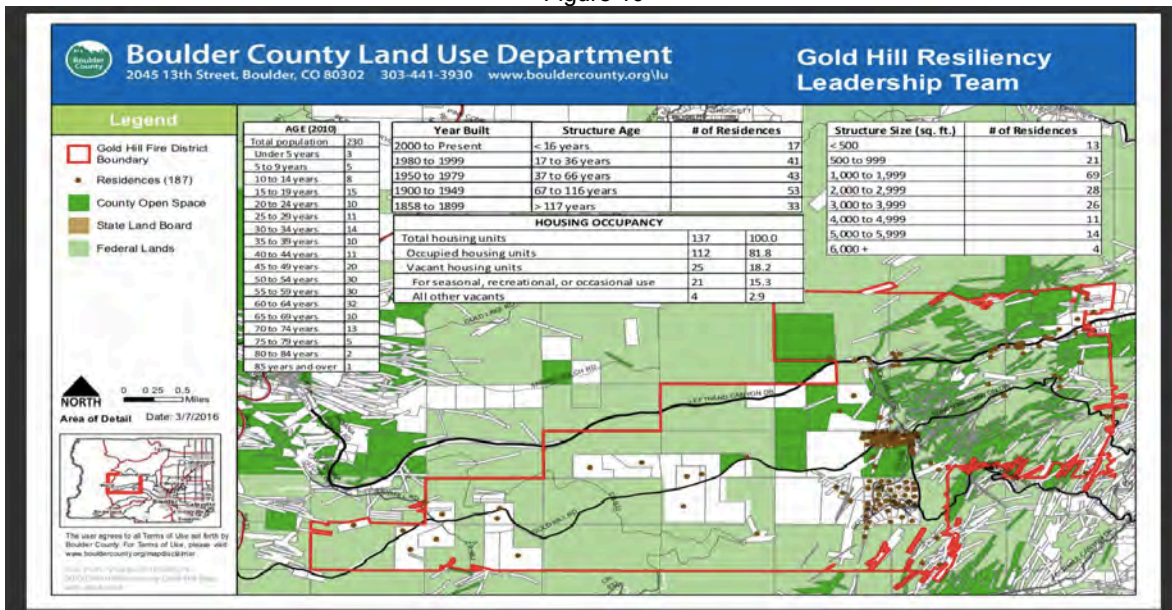
Similar to drought, the most effective strategies for adapting to lower snowpack conditions are to decrease community water usage. See section on Drought for more information on conserving community water and preserving water resources.

Planned Urban Growth & Infrastructure Improvements

As temperatures both within the state and around the nation increase, Gold Hill should anticipate a growing number of climate migrants noticing the community. Gold Hill can consider making a series of infrastructure improvements and adaptations to best equip the community for sustainable increases in human involvement. This includes any necessary preparations the town's roadways and traffic signage may require to accommodate increased daily traffic be it driven by residents or simply more people in the mountains, and putting a plan in place for expanding the capacity of the local school, community center, and fire department should less severe winters result in increased demand on community resources.

In addition, the community may anticipate needing additional power from Xcel Energy driven by an increased need for air conditioning units both in private and the few commercial properties as temperatures rise. Gold Hill can also consider creating a community solar project or smart grid project to incentivize homeowners to reduce their

Figure 10



dependence on the local power grid (US Department of Energy, 2010). Increased reliance on electricity should be anticipated regardless of an uptick in population growth because of the assumed heavier reliance on cooling. Building energy efficiency is addressed in Extreme Heat. Less severe winter weather will positively impact heating loads for buildings, saving residents money, and avoiding substantial greenhouse gas emissions. Given the fuel mix in Gold Hill for heating is primarily wood and propane, electricity savings are not likely to manifest.

With land availability and use being restricted in Gold Hill, the community will have challenges finding housing to meet the growing demand. Statutory communities such as Lyons, CO have allowed for the construction of ADU (Accessory Dwelling Units) such as “tiny homes” or mother-in-law suites on existing properties. Lyons worked with their municipal water and electric utilities to reduce or remove fees associated with ADUs and their connection to water, sewer and electricity. Allowing homeowners to construct ADU’s with minimal barriers provides an increase in housing stock, as well as supplemental potential income for property owners. Gold Hill may find barriers pertaining to septic, well water as well as allowable use of tiny homes (for example ensuring they are adding capacity for residents and not short-term rentals).

Infrastructure Development Grants

To improve the physical infrastructure of the community, Gold Hill can explore grant funding opportunities. An example of an infrastructure improvement grant comes from the Department of Transportation. The Infrastructure for Rebuilding America Grant has options specific to rural townships, and can be used for environmental mitigation and construction costs, ideal for a town revitalizing its utility network and mitigating the effects of climate change (US DOT, 2018) potentially relevant with respect to micro-grid or community solar projects.



Tree, Mosquito & Pest Treatment

To minimize the loss of forestation and risks associated with mosquitoes and ticks, proper preventative measures can be taken by Gold Hill.

There are a number of natural remedies to aid in mosquito and tick control. The community can recommend methods to homeowners of reducing mosquito populations, such as effective vegetation management and reducing standing water on their properties (American Mosquito Control Association, Date Unknown). These methods should also be effective in a community-wide approach. Similarly, effective landscape management, such as clearing low-lying tree branches to allow for more direct sunlight and xeriscaping, can reduce the presence of ticks if populations grow due to warming winter temperatures (Stafford, 2007). The community can also work with wildlife managers to examine the surrounding deer population to gauge a growing tick problem and effectively mitigate.

Colorado State Forest Service has a number of non-pesticide management options for bark beetles (CSFS, 2018). Gold Hill can prioritize the removal of trees infested by bark beetles to help mitigate the spread. The community can also create trap trees that are strategically placed to attract adult beetles, allowing the tree to become infested before burning or destroying it.

In addition, homeowners can be encouraged to spread suet near the base of trees, both on residential and state-managed forestry. This ecologically friendly solution to bark beetles attracts woodpeckers to trees, which are natural predators to the beetles (Mayntz, 2018). Additional methods of control include thinning of trees to promote healthier forests and pruning and properly disposing of branches that are affected by bark beetles, only between the months of November to January (University of California, 2008).

Community Pollination Efforts

Gold Hill can create community-based programs for improving conditions for pollinators. This includes encouraging homeowners to plant native, flowering plants in their yard over invasive species; and planting milkweed at elevations where it will survive as an annual or over-wintered indoors at higher altitudes, which specifically aids the health of Monarch Butterfly populations (National Geographic, 2015). In addition, Gold Hill should encourage the use of locally sourced mulches, which have the combined benefit of reducing weeds without the use of insecticides or pesticides and allow nesting for pollinators (Splawski, 2014). The same approaches should be applied to any gardens or landscaping managed by the community.

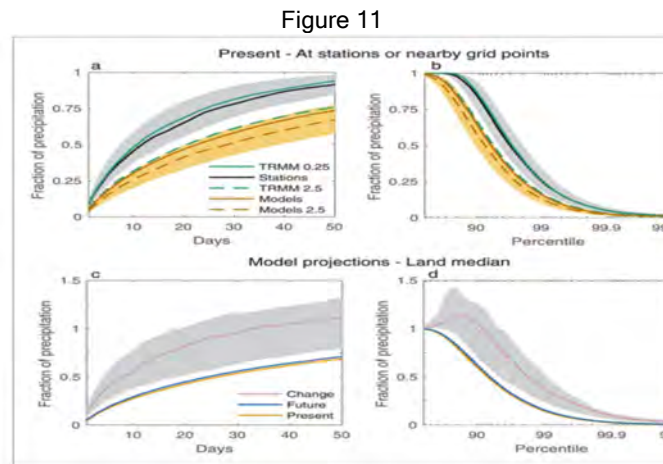


Rain Storms



While current climate models including Temperate don't predict an increase in rainstorm frequency, they do predict a

higher amount of annual precipitation occurring in individual storms, as demonstrated by Figure 11 showing present (A,B) and future (C,D) projections (Pendergrass, 2018). These instances of heavy rainfall present similar risks and challenges to Gold Hill as groundwater flooding, including flash flooding and water contamination. Gold Hill anticipates moderate risk pertaining rain storms, with a varied ability to adapt.



In heavy rain events, natural water drainage may become overwhelmed and lead to standing water and potential flooding. Standing water from heavy rains can carry health risks, including the potential to harbor E. Coli and other harmful pathogens (WHO).

Heavy rainstorms have the capability of cutting off transportation and potential evacuation routes for the community of Gold Hill. As demonstrated by the 2013 flooding of Boulder County, flooding from rainfall can potentially destroy the narrow canyon roads leading into town, creating a series of challenges for the community (Boulder County, 2019).

Adaptation Recommendations for Rain Storms

Storm Water Drainage Study

As recommended by FEMA, Gold Hill can have a storm water drainage study conducted for the community (FEMA, 2013). Conducted by an outside organization, this study will take a comprehensive look into existing and needed systems for storm water drainage. Gold Hill likely has historic knowledge of the pathways water take through town when rain is substantial. That local knowledge can also be harnessed to ensure that pathways remain clear of debris or unintentional/intentional blockage.

Rain Gardens & Bioswales

Rain gardens and bioswales are natural features that are created in the built environment to manage excess runoff and precipitation. In Gold Hill, they can be incorporated on both public and private lands. Similar to xeriscaping, when constructed partly from native plants, rain gardens and bioswales can help improve the ability of the ground to take in excess water, simultaneously replenishing the water table and reducing the chance of flooding aligning with the goals of the community to protect and recharge the natural environment.

Rain gardens are shallow basins that are filled with plants and other natural features and are generally used in mostly residential settings. Bioswales are similar to rain gardens in that they manage excess runoff with the use of vegetation or xeriscaping. However, they are linear in shape, allowing for placement alongside streets or driveways and therefore managing more water. In both instances, populating the features with appropriate and native vegetation can help restore the ecosystem and help the water system recharge.

Evacuation Routes

Similar to wildfires, Gold Hill should create evacuation plans in case of floods that cause Fourmile Canyon, Lickskillit, & Sunshine Canyon to be impassible. A plan should be put in place that includes the channels to be used for disseminating information, priority evacuees, and alternate routes for leaving the town. That plan can be attached here.

A WAY FORWARD

A Way Forward: Stewardship through action, culture and institutions

Communities throughout the mountain west, including Gold Hill and the wider Colorado Front Range, face intense pressure from climate change, rapidly growing recreational uses, and shifting economic and demographic structures. In combination these forces are undermining the intimate connection between mountain residents and the land and hollowing out historical communities while at the same time undermining regional ecological sustainability and increasing the frequency of extreme fire and other climate related events.

Effective responses to the evolving situation require stewardship of the mountain environment and the locally rooted communities that have a long history, familiarity and connection with the region. Vibrant communities with a strong stewardship ethic and practical resources are the front line for managing change and avoiding disaster.

Gold Hill proposes to establish itself as a model community of stewardship. Our stewardship efforts will focus on three areas:

1. The Community: its history, institutions, culture, economic foundations, historical structures, and people.

2. The Mountain Environment: the forests and biodiversity of the region, the hydrologic system, and the changing patterns of use.
3. Systems: Resilience of the critical systems on which communities depend and that shape the regional environment including energy, disaster response, transport, water, shelter, waste, etc.

Strategically, our approach to developing a model community of stewardship rests on four critical pillars:

1. Action: Rapid development of practical and very tangible activities to address critical vulnerabilities or take advantage of opportunities that have wide resonance in the community (e.g. wildfire mitigation, emergency preparedness, increasing solar generation, establishment of a community center, etc...);
2. Vision: Fleshing out a long-term stewardship vision and the practical avenues for putting that into action;
3. Engagement: Connecting broadly with spectrum of local residents and other actors (state, county, federal, non-profit) whose involvement and support are essential foundations for stewardship;
4. Institutions and resources: Exploring options for establishing a sustainable institutional foundation for regional stewardship that can attract and manage the resources necessary for sustained action.

OTHER ACTIONS

A conclusion reached through the Gold Hill RAAR project is that there is desire to create a space (literal or figurative) for resiliency. A physical “resiliency center” would serve several purposes, including as a hub for meeting in the event of an emergency or an extended power/other outage. The hub would ideally contain uninterruptable power, supplies, communication services, and also be a meeting place and could be co-located with a community center or new fire station.



In thinking about a future possible structure energy should be provided by solar that is feeding battery back-up, and possibly even a micro-grid serving the entire community or subsets of the community. This is allowable now via SB 9-2018 (<https://www.solarunitedneighbors.org/news/colorado-affirms-energy-customers-right-store-energy/>). By providing battery storage on site, availability of some power would be guaranteed to Gold Hill in the event of an interruption from Xcel’s power supply, and also lack of solar.

Colorado’s Department of Local Affairs (DOLA) has grant programs that help rural communities seeking to reach 100% renewable energy in planning and also in costs for infrastructure. The grant cycle is currently July-August and Gold Hill in partnership with Boulder County has submitted an application for renewable energy planning in August, 2019.

Also located on site could be a supply shed that contains some shared materials including manual well pumps enabling residents to access their water (if not available in a cistern) from a well.

Having a centralized resource for communications and meetings is also a valuable resource.

Gold Hill has questions about waste reduction. In speaking with Boulder County and Western Disposal, the poor economics of mountain recycling and compost were explained. Trucks running up hills to service low density communities are expensive. Western Disposal offers bags for recycling and picks them up when on-site getting the waste. Boulder County does provide recycling drop-off



facilities in Allens Park, Nederland, and Lyons. In 2018 Western Disposal hauled approximately 1,067 tons of recycling from these locations. Green Girl Recycling offers recycling services for Gold Hill. Costs are available on their website. Considering a centralized collection point for Gold Hill’s recycling would help keep costs down. Residential-scale composting is also an option for Gold Hill, though wildlife concerns will require modified approaches. Eco-cycle and Boulder County are both resources, with the County providing classes on composting.

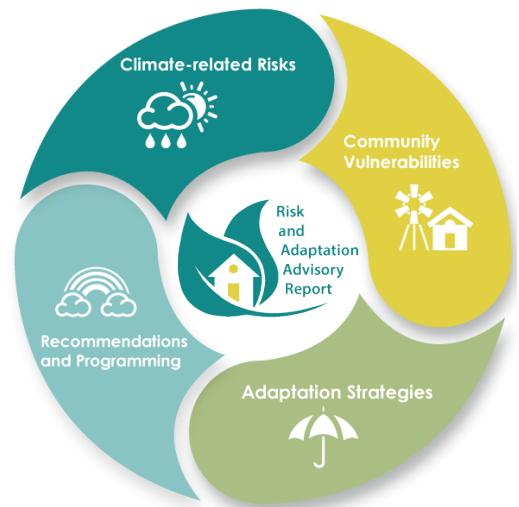
CONCLUSION

Gold Hill, a small mining community turned residential haven is a refuge for the residents and visitors. Gold Hill emphasizes quality of life, independence, sustainability and resiliency to be proper stewards of the mountains in which they reside. Because of this, planning for the future climate will be a necessity.

Boulder County has worked to create programs and policies that support clean energy, water conservation and emergency management. Utilizing these resources already in place, as well as the research done through this process will help Gold Hill adapt to the changing climate.

The Risk and Adaptation Advisory Report (RAAR) finds that higher heat will be the dominant change impacting Gold Hill. Utilizing the recommendations contained in this report to help mitigate against heat, changes in precipitation, and other changes will help Gold Hill adapt to future climate scenarios.

Gold Hill has a focused and committed population that care deeply about their environment, and that is by far their greatest resource.



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