Source: Grand Canyon Trust

Advancing Flagstaff Resilience
A Resource Document

A collaboration by Northern Arizona University's Climate Science and Solutions Master of Science students

November 2021

Table of Contents

Introduction

Background

Flagstaff is a unique southwestern community surrounded by mountains and forests whose true wealth resides in its abundance of cultural and natural resources. Flagstaff has generous access to many beautiful desert and forest landscapes, outdoor recreational opportunities, and hosts a blended community rich with history, ceremony, and wisdom. Flagstaff is situated just below the San Francisco Peaks, revered by 13 different tribes including the Hopi, Navajo, and Havasupai Nations, and is in close proximity to the neighboring Hopi and Navajo Reservations. The authors and contributors to this document honor the legacies, traditions, and continued contributions of the Indigenous peoples residing in and around Flagstaff and acknowledge the significance of the surrounding mountains to them. Over 10 percent of Flagstaff residents are Indigenous, an additional 20 percent of the local population is Latinx, and about 60 percent have Caucasian/European ancestry; the remaining 10 percent of residents are of African American, Indian, Asian, or Pacific Island ancestry[27]. Around 76,000 people reside in Flagstaff, including 21,000 students at Northern Arizona University (NAU) contributing to the Flagstaff community as temporary residents.

The city is surrounded by over 1.8 million acres of mixed conifer forests including pinyon, juniper, and the largest contiguous ponderosa pine forest in the U.S. These alpine forests are bordered by hundreds of miles of red rocks, canyons, high-desert shrubs, and grasslands. Flagstaff is considered one of the snowiest citiesin the U.S. as it sits at 7,000 feet in elevation and averages 101.7 inches of snow per year, according to National Weather Service statistics [28,29].

Flagstaff's abundant snowpack provides a portion of the freshwater that supplies the local ecosystem and water reserves. However, the dry, arid climate claims a fair amount of fallen snow through evaporation before it melts and moves down into the local freshwater system. Flagstaff also receives regular precipitation through seasonal late summer monsoons. Climate change has shown that varying patterns of precipitation increase the risk of less precipitation overall, despite the increase in storm and flooding intensity. Flagstaff consistently records its highest temperatures and driest days during June, even if the rains come in the late summer. These days often dry out the local forests and increase the risks of wildfire.

Flagstaff is already feeling the effects of climate change. In the summer of 2021, thousands of community members were on evacuation standby due to the Rafael Fire. Just one month later, thousands of residents faced shelter in place orders due to extreme flood events. The increase in wildfire severity and flood events already has had a direct impact on community health and will continue to be a threat to vulnerable neighborhoods. These events threaten safety, reduce air quality, and damage personal property and infrastructure. Flagstaff residents are also at risk for other climate change-induced impacts such as reduced snowfall, drought, warmer temperatures, and increased intensity of precipitation and storm events. For these reasons, it is important that the City of Flagstaff and the community are prepared to adapt to current and future climate change impacts. In recognition of these goals, the City of Flagstaff declared a Climate Emergency in June of 2020 to respond to the community's concern for the growing intensity of climate change impacts. Additionally, the City of Flagstaff passed the Carbon Neutrality Plan (CNP) in 2021, which sets the goal to achieve carbon neutrality, or net-zero emissions, by 2030.

In partnership with the City of Flagstaff, this document aims to be a resource for adaptation and resilience strategies. It integrates information from the following documents published by the City of Flagstaff: The Climate Profile for the City of Flagstaff, the Flagstaff Vulnerability Assessment, the City of Flagstaff Resiliency and Preparedness Study, the 2018 Flagstaff Climate Action and Adaptation Plan (CAAP), and the 2021 CNP. This document also presents research provided by students in the Climate Science and

Solutions (CSS) Masters program at NAU. This project's goal is to create a working resilience resource document that includes:

- Resources and information for current climate conditions.
- Community and local government engagement to generate a dialog on climate matters.
- Strategic tools that local residents can actively utilize to build individual and neighborhood resiliency and climate adaptation skills.
- Solutions and discussions that prioritize marginalized groups that are most vulnerable to climate change impacts.

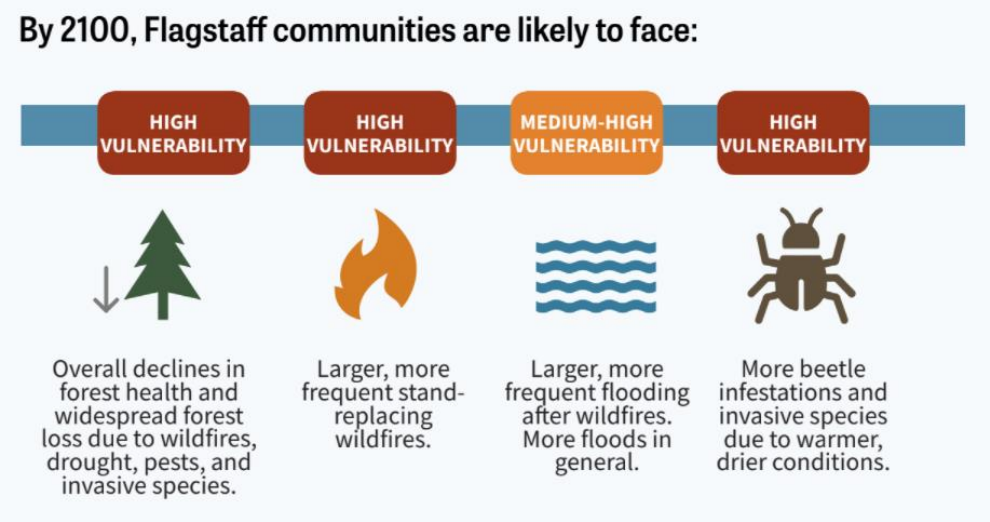

Figure 1: Depicts impacts Flagstaff is particularly vulnerable to due to climate change.
Source: City of Flagstaff 2018 CAAP

Justice and Equity

Climate justice and equity are often forgotten, but they are crucial discussion points in the climate change conversation. Climate change is a crisis that is already having adverse impacts on society, and climate justice reminds us that those adverse impacts are not felt equitably by everyone. In Flagstaff, a disproportionate amount of communities of color, low-income individuals, disabled individuals, youth, the elderly, and other marginalized groups are on the front lines of climate change impacts and could likely see the worst consequences it will bring. A truly resilient community is diverse, inclusive to all, and free of injustices.

In each content chapter of this document, vulnerable groups are placed at the forefront of community resilience discussions and the development of climate change adaptation strategies. The history of Flagstaff's marginalized groups must also be considered. Identifying why a group is vulnerable is the first step to properly reducing their vulnerability and improving their strength and resilience; see Flagstaff's Vulnerability Assessment to learn more.[1] It is recommended that the City of Flagstaff hold these principles of equity at the forefront of their decision-making processes and prioritize adaptation efforts within marginalized and vulnerable communities.

Climate Science Background

When discussing climate science, it is important to clarify the differences between the following scientific concepts:

The field of climate science is highly sophisticated and demonstrates an enormous amount of collaborative research and modeling. The Intergovernmental Panel on Climate Change (IPCC) is an integrative council of top scientists around the world and is a credible source of climate science information. Each edition of the IPCC report takes years of collaboration and research to determine confidence levels on future predictions. The most recent publication distributed from the IPCC is their 6th Assessment Report (AR6), which includes a physical science-based "Summary for Policymakers" (SPM). This publication provides an integrative scientific summary of the current state of the climate, including how it is changing, the role of human influence, and possible climate futures.

Our local Flagstaff community should take specific notice to the following conclusions from the SPM that will determine our future climate including: heavy precipitation and flood events (See Figure 2), heatwaves, droughts, reduced snow cover, and increased wildfire intensity[34]. These scientific projections illustrate why developing climate adaptation skills and resources is so important right now for our communities and their most vulnerable residents and resources.

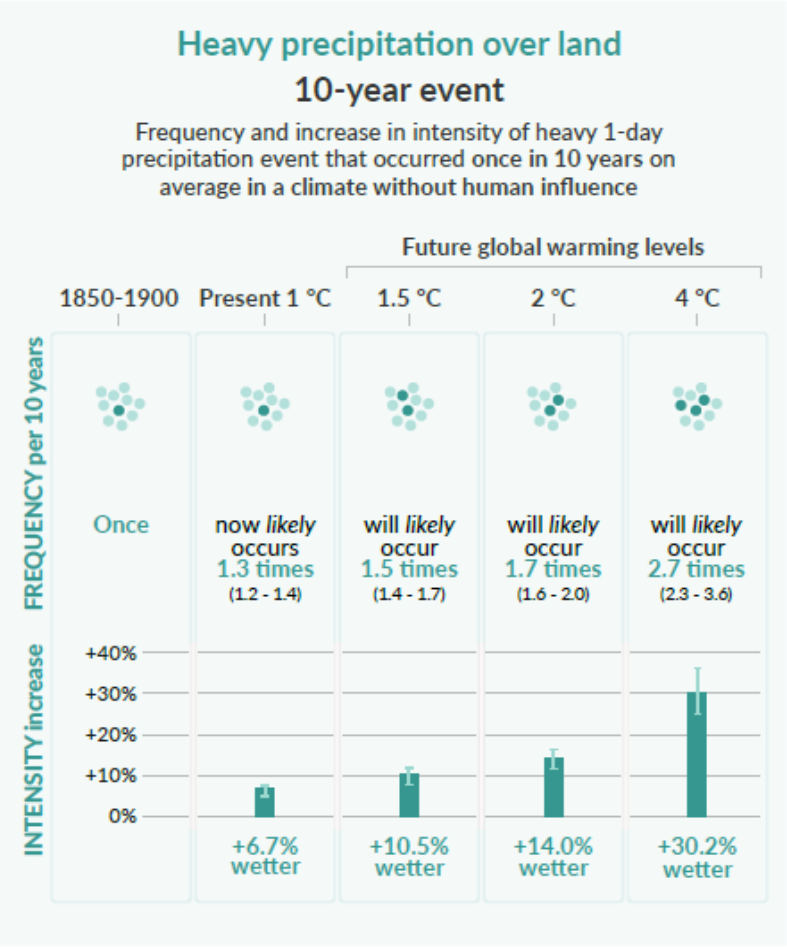

Figure 2: Illustrates the projected increases in frequency and intensity of precipitation events over land. Source: IPCC AR6 SPM

Review of Relevant Documents

The City of Flagstaff has published several documents related to climate change and how it will impact our city and community. These documents are available for reference online and are briefly reviewed below.

The 2018 Climate Profile for the City of Flagstaff was created to project future climate conditions, also referred to as "climate projections." These projections are developed using computer-based climate models based on historical and projected data that provide scenarios of possible future climate conditions. The goal of this climate profile for the City of Flagstaff is to reveal trends that can help the City of Flagstaff plan for its future.

The 2018 Flagstaff Vulnerability Assessment builds upon the projected temperature and precipitation changes in the Climate Profile, and identifies key climate-related risks to Flagstaff's communities, resources, and systems.[1] By using this information, the city will be able to decide which adaptation strategies to pursue when building Flagstaff's resilience. This document focuses on the climate impacts projected for:

- Public health and safety
- Emergency response
- Land use
- Infrastructure
- Cost of living
- Forest health
- Water supply and quality
- Tourism and recreation

The 2012 City of Flagstaff Resiliency and Preparedness Study helps to address the question: How can we reduce our vulnerability to the effects of climate change and build local resilience against risk from climate variability and weather-related impacts?[4] The purpose of the vulnerability and risk assessment is to help the city build a substantial foundation for addressing this challenge. This study was conducted to improve understanding of how the impacts of local climate changes will directly affect city operations like emergency services, energy, forest health, public health, stormwater, transportation, and water distribution. Recently, Flagstaff has experienced record warming, persistent drought-like conditions, and severe precipitation events. Building local resilience within the municipal organization to these changes helps to ensure continued prosperity. This study assessed the level of vulnerability, the degree of risk, and the potential impacts of 115 areas of the city's operations that are exposed to local climate variability.

The 2018 Climate Action and Adaptation Plan (CAAP) examines how climate change will affect the community and describes anticipated future impacts including: wildfires, longer and hotter summers, less snowpack, more severe drought conditions, and increased risk of heat-related and mosquito-borne illnesses.[2] The CAAP's goal is to guide the community in preparing for these climate risks and reducing greenhouse gas (GHG) emissions to protect the well-being of current and future residents for years to come.

Methodology

To generate a dialog about climate change impacts and request feedback on the project's goals, CSS students presented the framework for this project to the Sustainability Commission, Flagstaff City Council, the Diversity Awareness Commission, and the Commission on Inclusion and Adaptive Living. CSS students also organized a public survey and hosted a public forum to obtain feedback from the Flagstaff community.

Sustainability Commissioners encouraged engaging with students to evaluate the basis for knowledge and cooperation towards climate adaptation. They specifically expressed concern over vehicles and reducing GHG emissions. Reducing GHG emissions is a means to mitigation (reducing the causes of climate change), so this strategy is not specifically represented in this project as the focus is on adaptation strategies (reducing the effects of climate change impacts). Another important idea the commissioners expressed was to engage local business owners regarding the economy and to request feedback on measures toward economic adaptation in Flagstaff. The commissioners also recommended conducting a public survey to generate a collection of diverse responses and feedback. Feedback from the Sustainability Commission was presented to Flagstaff City Council. Council members recognized the value of the project's goals, noted the disconnect from the NAU student population, and recommended more engagement and outreach on campus.

Students also presented to the Commission on Diversity Awareness. Commissioners referenced the delicate cultural issue of using reclaimed water for snow production at Snowbowl, the housing shortage crisis, and the increasing cost of living; all of which have the potential to harm diverse populations in Flagstaff.

Additionally, a Climate Resilience Public Forum was held to invite public engagement. The goal of this forum was to generate a dialog with diverse members of the community to understand their climate concerns and determine what actions they felt would be valuable to implement when protecting local communities from future climate change impacts. Forum participants were also invited to complete a set of survey questions to assess their concern for local climate change impacts. Local residents were invited to participate in the survey, which was open from October 18, 2021 to November 1, 2021.

Members of the community that attended the forum expressed concerns about wildfires, water scarcity, and flooding, all of which have already impacted and will continue to impact Flagstaff. Survey participants indicated that their largest concerns for climate change impacts (in order of greatest concern) were wildfire, flood, drought, and reduced snowpack, followed by increased temperatures, decreased air quality, and longer allergy seasons. In addition to physical systems, survey respondents expressed high levels of concern for how climate change impacts would further increase the cost of living, increase water scarcity, and decrease access to affordable foods. These concerns were followed by concerns about negative impacts to housing costs, the job market, and medical expenses.

Summary

This project's goal is to create a working resilience resource document that includes:

- Resources and information for current climate conditions.
- Community and local government engagement to generate a dialog on climate matters.
- Strategic tools that local residents can actively utilize to build individual and neighborhood resiliency and climate adaptation skills.
- Solutions and discussions that prioritize marginalized groups that are most vulnerable to climate change impacts.

The Flagstaff Resilience Resource Document is organized according to the major areas of vulnerability as identified by the Flagstaff Vulnerability Assessment: public health, infrastructure and housing, the natural environment, water supply and resources, and tourism and recreation. Each section will provide a brief summary of current climate impacts, the nature of the problem, the associated social impacts, and potential adaptation solutions and strategies to build community resilience and climate adaptation skills. These resources can increase our community's success in adapting to current and future climate change impacts in Flagstaff.

To promote the dissemination of these resources, each vulnerability focus area will also be presented in a short video. Each of these videos will be a chapter in a short series of Climate Adaptation Videos hosted by the NAU CSS Masters Program Students and can be directly accessed, downloaded, and shared through the CSS webpage. Please enjoy sharing these videos with your colleagues, neighbors, friends, and family to promote and prepare for climate change adaptation in Flagstaff. Thank You!

Public Health

Introduction

As climate change affects the environmental, social, and economic determinants of Flagstaff's overall wellbeing, the City's strategies for public health will need to adapt. Surrounded by beautiful natural resources and countless opportunities for recreational activities, Flagstaff prides itself on being an active and health-focused community with growing potential for diverse populations to build a connection with the outdoors. To protect this unique lifestyle and ensure a high quality of life for all Flagstaff residents, public health adaptations will need to range from extreme event response systems and emergency resource plans to long-term reinforcement of the healthcare system overall. Perhaps most importantly, support for the most vulnerable groups (including those who are low-income, elderly, disabled, racial groups who have been historically underrepresented, or those experiencing homelessness) will need to be prioritized, as these community members are at the highest risk for exposure to public health hazards, while they also are the least capable of developing resiliency without direct and strategic adaptations.

Flagstaff residents evacuating their homes due to the impending Museum Fire in 2019. Image credit: National Weather Service

Environmental Impacts

Climate changes are already taking place throughout Northern Arizona and will continue to progress through time. Changes such as increased drought and higher temperatures have direct impacts on environmental processes. Drier and hotter forests experience an increased risk of severe wildfire and disease. Higher air temperatures and longer warm seasons can increase environmental allergens, reduce snowpack, increase the presence of vector-carrying insects, and decrease air quality[3]. More extreme precipitation patterns in conjunction with burn scars can lead to increased flooding and sedimentation of waterways[4]. Sedimentation occurs when ground material such as mud and soil settle into a body of water. Risks of sedimentation include decreased water quality and increased aerosolization, in which particles become airborne. These ecological impacts directly affect human health and wellbeing, as described below.

Social Impacts

The second goal of Flagstaff's CNP is to "prepare Flagstaff's communities, systems, and resources to be more resilient to climate change impacts." Implementing this goal involves increasing both the awareness of climate impacts and resilience actions.

From 1950 through 2017, Flagstaff saw an average of two days above 90°F each year. Projections indicate that over 80 days per year may be recorded above this benchmark by the end of the century[2]. Although year-to-year changes in temperature are natural and expected within the region, there has been a fairly consistent increasing trend in annual temperatures since the 1980s[2]. Almost every year since 1985 has seen annual temperatures above the long-term average. Coconino County's annual average temperature is projected to be 4-5°F higher than the current average[2] (see Figure 3). This has significant impacts on public health, including an increase in heat-stress related illnesses, such as respiratory illness and dehydration, particularly for community members that do not have reliable access to air conditioning, work outdoors, or are experiencing homelessness. From 2005-2015, there were 18 deaths in Coconino County from exposure to excessive natural heat, and approximately 20 emergency department visits and hospital inpatient stays[1]. For those who do have access to air conditioning, increased costs of cooling homes can become a financial burden.

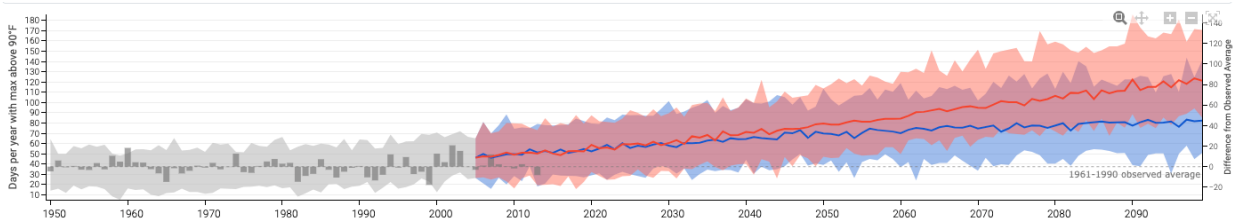

Figure 3: By the end of the century, Flagstaff is projected to experience temperatures of 90 degrees or higher for 80 or more days a year.
Source: NEMAC Climate Explorer.

Increased heat, longer warm seasons, and increased flooding also lead to an increase in vector-borne and infectious disease, as favorable conditions for disease-carrying species expand[4]. This may include Valley fever, West Nile virus, hantavirus, and Rocky Mountain spotted fever. Those older than 65 are particularly susceptible to both Valley fever and West Nile virus. As Flagstaff's retirement-age population is expected to grow significantly in the coming decades, additional resources may be needed to protect vulnerable residents and to prevent and treat these diseases[1].

On average, Flagstaff has experienced 197 days per year in which minimum temperatures drop below freezing (32° F). By the year 2100, Flagstaff could experience as few as 100 days that reach freezing temperatures[2]. This impacts snowpack and subsequent water availability as Flagstaff is partially reliant on snowmelt as a water resource, threatening access to potable water. Although Flagstaff is committed to providing its citizens with access to potable water for a variety of uses, if today's agreements and infrastructure projects do not account for future snowpack changes or threats to watersheds, Flagstaff may not be able to achieve this established goal[4]. For those experiencing homelessness, rising temperatures may actually be a benefit, because fewer consecutive cold days may reduce the risk of cold-related injuries and death[1]. However, those experiencing homelessness (including forest dwellers) remain among the most vulnerable to health risks from "very hot" days (above 90°F) and "very cold" days (below 32°F) that are projected for up to half of the year (130 to 180 days) by 2100.

Flagstaff's unhoused and transient population are also at particular risk during dry, wildfire-prone summers. These populations commonly live in and around the forest in the summer months. When the Forest Service closes Coconino National Forest, as happens in extremely dry and fire-prone years, these populations may be forced out of the places they live for the summer, losing access to resources they may need to survive. This, combined with the City of Flagstaff's anti-camping ordinance, means that transient and unhoused populations who are forced to come into the city due to these closures may not have anywhere to go, sleep, or cook food. The fire restrictions are necessary because increasingly dry and warm weather caused by climate change puts these vulnerable populations at higher risk.
Flooding and heavy precipitation events are a threat to public safety through an increased risk in storm- and flood-related injuries. The flood events that occurred in 2021 not only impacted residents as floodwaters entered their neighborhoods, damaging their streets, yards, and homes, but weather-related transportation injuries were exacerbated throughout the region[4]. Additionally, increased flooding and drought threaten water security. Flooding and subsequent erosion lead to sedimentation of water sources, particularly Lake Mary. Both drought and heavy precipitation events impact the occurrence of algae, erosion, and siltation. Siltation refers to the buildup of sediment such as in a water reservoir. Drought impacts the availability of water. Combined, these threats limit access to potable and quality of water sources[4].

Increased forest fires and higher temperatures lead to higher levels of air pollutants, which decrease air quality. Loss of vegetation from more frequent, large, stand-replacing wildfires and more frequent, longer-lasting drought can also lead to more dust[1]. Stand-replacing wildfires occur when a wildfire burns intensely to the point an entire group of trees is killed and will need to be replaced. Airborne particulates and pollutants cause respiratory illnesses and allergies, and aggravate existing health conditions.

In addition, extreme weather threatens public safety through infrastructure damages. Weather-related power outages can negatively impact critical emergency operations and create obstacles for residents receiving public notifications. Heavy precipitation impacts the safety of roads and bridges and can cause landslides and road hazards for drivers[4].

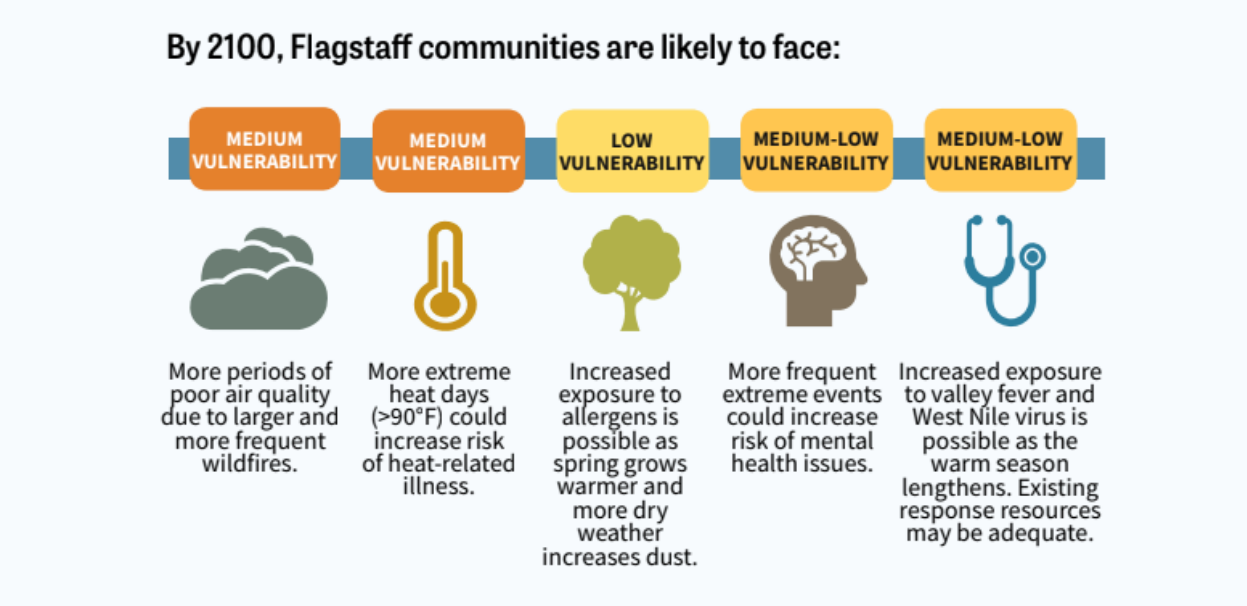

Figure 4: By 2100, Flagstaff residents and communities are likely to face vulnerabilities related to poor air quality, extreme weather, disease, and mental health issues, among others.
Source: City of Flagstaff's 2018 CAAP

Climate change additionally impacts local and regional agriculture. Drought and heavy precipitation events can impact food production, which threatens Flagstaff's access to quality food[4]. Similarly, increased pressures on livestock, including exposure to heatwaves, drought, and ecological changes may result in less nutritious or abundant grazing areas, causing negative effects on ranchers[4].

Climate impacts also cause individual and community migration. In Flagstaff, this includes the movement of those experiencing homelessness to forest areas, where there is heightened protection from the elements. In general, current and predicted climate migrations into Flagstaff can strain public resources, such as healthcare services. Increased migration from low-lying regions may result in higher rates of elevation sickness, dehydration, and respiratory illnesses associated with changes in elevation.

In addition to physical health, climate change significantly impacts mental health. Increases in extreme weather events and associated crises, as well as concern over current and predicted changes, can create or exacerbate anxiety, acute stress, and post-traumatic stress disorder (PTSD). Loss of life, resources, property, or social support, forced relocation, or other extensive changes to daily routines increases the risk of mental health challenges[1]. Impacts to mental health are associated with other public health concerns, such as increased substance use[1]. Additionally, decreased access to forests and other natural spaces due to wildfire and flooding have significant impacts on mental health for forest users and those who culturally and spiritually value healthy ecosystems[4].

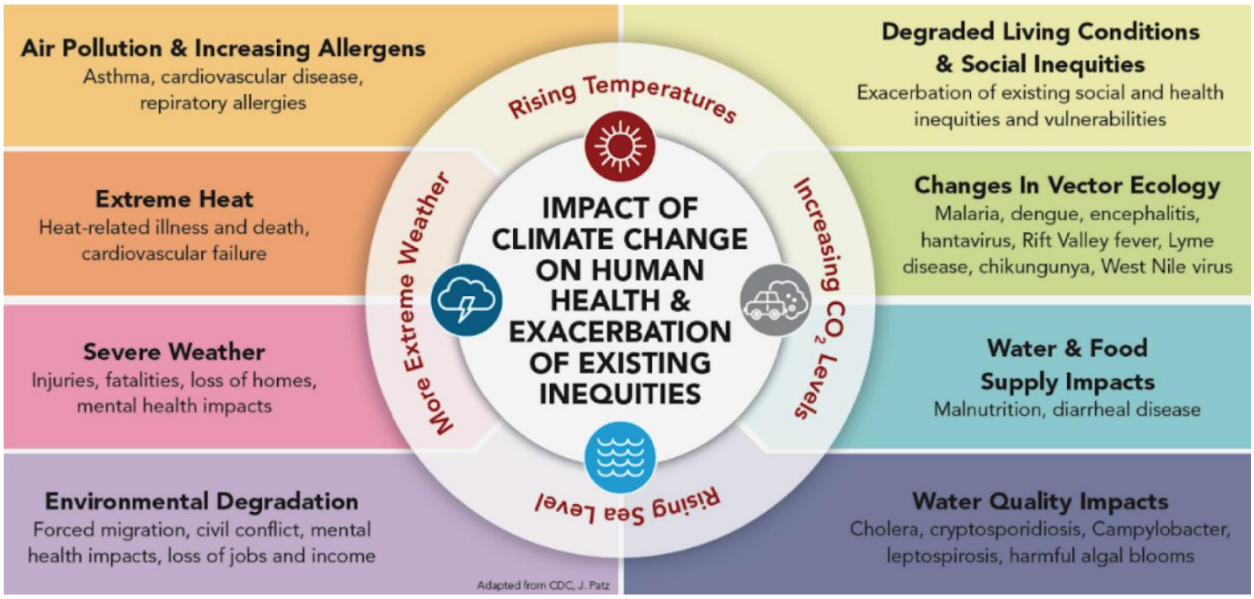

Figure 5: Overview of potential climate change impacts on human health.
Figure adapted from the California Climate Change and Health Equity Plan.

Equity Considerations

It is important to note that climate change disproportionately impacts vulnerable communities. Specific factors that influence climate vulnerability include:

- age
- education level
- gender and sexual orientation
- health, ability, and disability
- immigration status; language abilities
- level of housing security
- neighborhood and physical location
- race and ethnicity
- social ties
- socioeconomic status and income
- technology and internet access
- working conditions, including exposure to the elements[3]

Although vulnerable demographics often contribute least to GHG emissions, they typically suffer the greatest impacts of climate change. Different groups in Flagstaff have different levels of resilience to withstand challenges such as power outages, school closures, or medical emergencies caused by climate change. In Flagstaff, low-income communities are disproportionately communities of color, specifically Hispanic (33 percent) and Indigenous (29 percent) households[1]. Those with lower incomes face several barriers, such as limited access to quality healthcare and the challenge of making difficult decisions, such as paying for cooling and heating versus meeting other basic needs. The elderly, undocumented migrants, or people from families with mixed immigrant status are less likely to leave their homes to seek aid[1].

According to the EPA, there is growing evidence of "intra-urban" heat islands, or areas within a city that are hotter than others due to the uneven distribution of heat-absorbing buildings and pavements and cooler areas with trees and greenery. This leads to disproportionate impacts on those who live in high-density, commercial, and industrial areas in comparison to those who live in suburban areas. This often correlates

with the demographics of residents, with factors such as race and income influencing who bears the brunt of extreme heat[3].

In order to address these issues, it is advised the City of Flagstaff undertake the following actions to achieve equitable systems:

- Target policies and programs that serve disadvantaged communities first, such as communities experiencing high pollution burdens, low-incomes, poverty, health issues, and exposure to climate hazards. Identify areas where vulnerable groups have already been affected by climate change and where gaps in trust might exacerbate existing disparities in the community[3].
- Engage with the community and community leaders on an ongoing basis.
- Use the "operationalizing equity checklist" from the 2018 Flagstaff CAAP when implementing actions.

Social Solutions

Prioritizing Vulnerable Communities: Consider the increase of impacts when the climate is combined with pollution, poverty, and scarcity of resources; target city employees that may be adversely impacted (outdoor workers, emergency responders, etc); continue to coordinate with social service and public health agencies that assist with vulnerable residents including transient populations; identify resources necessary to support Woods Watch programming that meets community needs; integrate cooling and warming centers into planning efforts for emergency shelters and aid stations; support FireWise programming in all neighborhoods[4].

Clean electricity*:* In addition to reducing GHG emissions, clean electricity improves air quality and can reduce energy bills. Burning gas within homes releases nitrogen oxides and particulates, which can have serious health consequences that can be avoided by clean energy. Black, Indigenous, and Hispanic communities have been particularly harmed by the extraction and combustion of fossil fuels. Lower bills can increase safety and comfort during particularly hot and cold periods by financially decreasing the cost of heat and cooling. Notably, renters often have minimal input on the source of their home's electricity, and homeowners have little incentive to invest in clean energy when renters pay the utility bill[3].

Reduced building energy use: More efficient buildings lead to lower heating and cooling energy usage and reduced bills, which can help Flagstaff residents to better cope with extreme weather such as extreme heat, large winter storms, or extreme cold. Heat pumps allow for the use of electricity instead of fossil fuels, and can also be used as air conditioners, which can help communities cope with increased heat[3].

Tree Planting & Protection: The planting of trees can provide shade, decreasing heat impacts. The protection of healthy forests provides ecosystem services, such as the protection of water resources and the decrease of wildfire. Decreased wildfires improve air quality and decrease flooding risks[3].

Expansion of Flagstaff HEPA Purifier Program: Expanding the Flagstaff HEPA Purifier program can increase community resilience to smoke and low air quality, especially for the most vulnerable[3].

Community Gardening: A community garden allows access to healthy and delicious foods as well as mental, social, and physical health opportunities for neighborhood residents[3] (See Figure 6).

Figure 6: Colton Community Garden in Flagstaff. Wheelchair-accessible paths and garden beds make the garden accessible to everyone.
Source: Museum of Northern Arizona

Economic Impacts

As a result of climate change impacts on livelihoods and infrastructure, Flagstaff's economy may experience increased stress from a number of aspects related to public health. As discussed in the sections above, health impacts associated with climate change range from respiratory distress and heat-related illnesses to pressure on livestock and access to nutritious foods. Diverse sectors of the city's economy will need to adapt and prepare for the public health repercussions of a changing climate. Flagstaff's CNP introduces the costs and benefits of investing in mitigation efforts, emphasizing that emissions reductions are not only about avoiding costs but also improving life for residents. Adaptation costs are an important consideration to ensure that Flagstaff is prepared for the public health impacts of climate change that cannot be avoided[3].

The primary economic concern Flagstaff will need to address when preparing for increased public health stress is the reinforcement and expansion of emergency services and healthcare systems[4]. As public health declines due to climate change, the cost and effort required to meet the needs of the Flagstaff community will continue to climb. Increased frequency of extreme events such as storms, flooding, intense wildfires, and heat waves can lead to increased numbers of severe accidents and injuries, unsafe working conditions for emergency responders, and outages of critical resources like electricity, natural gas, and water[4] (See

Figure 7). As a result of this increased stress, Flagstaff emergency services will likely see increased demand for:

- Specialized equipment and training for search and rescue.
- Public health services in outlying communities, such as Kachina Village.
- Treatment of respiratory and heat-induced illnesses and infectious diseases.
- Treatment of storm and flood-related injuries.
- Frequent and extended hospitalizations.
- Back-up generators for emergency and critical operations.
- Crisis counselors and mental health providers.
- Emergency food, water, and shelter.
- Animal management agencies as residents may abandon pets and livestock to seek shelter from disaster.

Figure 7: Emergency crews clean up debris from flash flooding in east Flagstaff on July 14th, 2021. Source: Flagstaff City Government.

In addition to emergency and rapid response systems in the context of extreme events, the overall conditions created by a changing climate will call for reinforcement and expansion of the entire healthcare system. While increased demand for healthcare has been identified as a low level of vulnerability considering there is an existing capacity to treat more patients than is currently needed[1], the increased frequency and intensity of health issues, as well as an increased population due to climate migration, may require expansion of

capacity in the form of personnel, equipment, and facility space[4]. The Flagstaff healthcare system may see increased demand for:

- Specialty providers and healthcare staff.
- Affordable and accessible mental health resources and providers.
- Hospital space and specialized unit beds.
- Public transportation services to and from healthcare facilities.
- Outreach programs to educate community members about preventative measures and resources available.

The specific economic impact in terms of dollars associated with this need for investment in Flagstaff's emergency and healthcare systems is unknown and should be investigated by the city to ensure capacity exists to meet the needs of the community as they evolve over time. Community members are less able to thrive and participate in the city economy when experiencing health issues, making the investment in expansion and reinforcement of the healthcare system an important driver for economic resiliency as well. This expansion can create many robust employment opportunities in Flagstaff and is a necessary step for the city to prepare for increased demand as climate change progresses.

Public health issues associated with climate change can also create financial strain for individuals and families. Increased frequency and intensity of common chronic health issues, such as worsened asthma and allergy conditions, may leave community members with the need to pay for potentially expensive and/or frequent treatments and healthcare provider visits. This issue also disproportionately affects vulnerable groups, who may not have health insurance or reliable access to healthcare facilities. Similarly, in order to avoid health consequences, groups with particularly high risk for heat-related illnesses (such as the elderly and disabled) may be required to spend money running air conditioning units and other cooling devices that were previously not needed. In general, degradation of the natural environment (including lower air quality, higher temperatures, and reduced access to safe open spaces) may lead community members to spend more time indoors - in turn reducing levels of exercise, vitamin D exposure, and other factors which can result in long-term physical and mental health consequences. Economic adaptation for public health should include targeted support for community members experiencing health-related financial strain; this could include providing frequent and accessible community health clinics, encouraging and incentivizing Flagstaff businesses to provide employees with robust health benefits, and outreach programs focused on relevant prevention and financial planning resources.

Toolkit

Neighborhood Help Map

There are several ways to offer help to neighbors in times of need. The creation of a "help map" or "help guide," in which neighborhood resources and services are cataloged and offered freely, is gaining popularity as a climate resilience method. Help maps can be both digital or physical, and provide contact information for neighbors that are willing to offer resources to one another. For example, neighbors with air conditioning may offer their home as a place of temporary refuge to vulnerable neighbors during a particularly dangerous heatwave. During wildfire season, when air quality is low, neighbors with air purifiers may offer their space or lend their purifier to those with respiratory conditions or risks. Able-bodied neighbors may offer to place sandbags (which help prevent flood water from entering property and homes) for those who are unable or who need extra hands. The resources and services that can be offered can be just as creative and diverse as those offering them.

Below are a few suggestions for setting up a help map.

NextDoor App: NextDoor, a free, popular app that allows community members to communicate with one another virtually, has a user-friendly help map feature in which community members can simply list services and resources that they are willing to share.

- Instructions for installing NextDoor can be found here.
- Instructions for using NextDoor's Help Map can be found here.
- *Note: It would be helpful to have a volunteer community member that can serve as a liaison for those who are unable to use smartphone applications.*

Physical Map/Guide: To accommodate neighbors who may not use technology, or to provide a non-technological source of information in the case of grid failure, physical maps or lists can be printed and distributed. This takes more coordination, as resource information and contact information would need to be collected directly from neighbors.

- *Note: it would be helpful to have a volunteer to keep this information relevant and ensure it is distributed.*

Note: NextDoor has verification options to ensure that only those within your neighborhood are allowed to access the community forum. There are also additional security measures. For example, the address for those offering help is not displayed, but members can provide their contact information voluntarily or use the messaging feature within the app to contact one another.

Planting Trees to Reduce Heat-Related Illness

Community members can take strategic action to prepare homes and businesses for increased temperatures and weather extremes in order to reduce public health hazards. One strategy for reducing exposure to heat-related illnesses and general discomfort is planting trees and vegetation to reduce the impact of the urban heat island effect (See Figure 8). EPA guidelines recommend planting deciduous trees or vines to the west of any building for the most effective cooling factor. Partial shading of the building's windows and roof also boost the efficiency of the cooling effect. This approach may be particularly beneficial for low-income community members that may not have the ability to install air conditioning units in their homes (or those who do not have the desire to), as well as for buildings that are not equipped for AC installation.

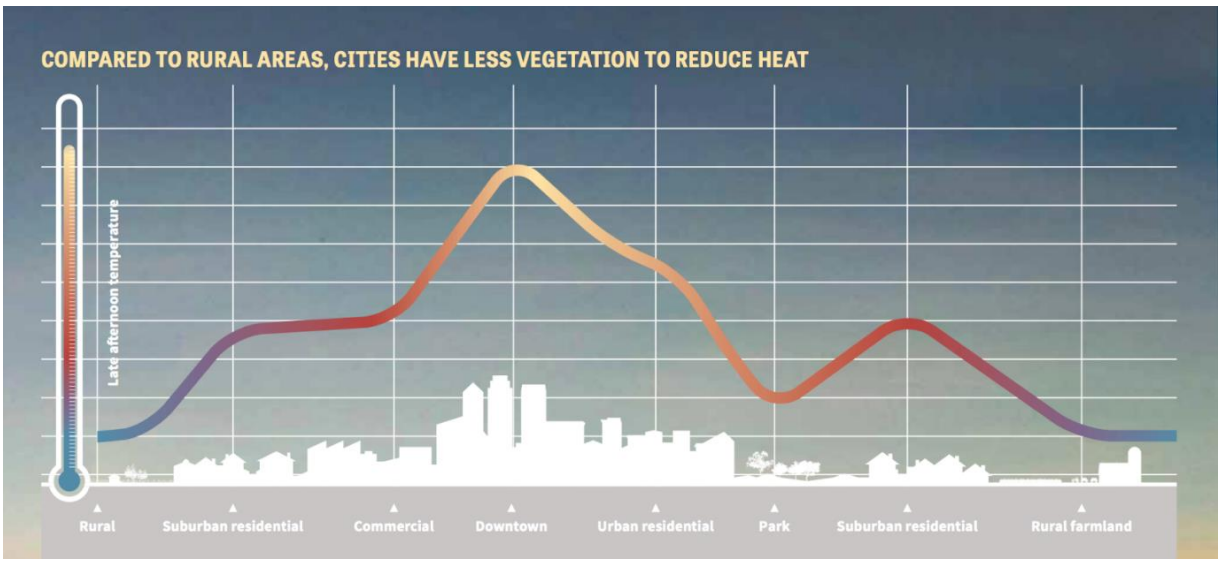

Figure 8: Increased temperatures in the summer will be magnified by the urban heat island effect, which results from higher concentrations of heat-retaining materials in urban environments. Figure from the City of Portland Climate Action Plan, source: Portland Bureau of Planning and Sustainability.

Emergency Plans and Preparedness Kits

The frequency and severity of extreme weather events and natural disasters is predicted to increase under climate change. It is important that Flagstaff residents and their families be prepared for wildfires, flash floods, extreme heat, and other potentially harmful events. One simple and easy way to prepare for these events is to create an emergency plan and emergency preparedness kit. Having these resources on hand can help you and your loved ones stay safe during an emergency. The federal government has a website dedicated to helping citizens create emergency plans and kits along with a multitude of other resources. The City of Flagstaff also has a website dedicated to emergency preparation. An Emergency Preparedness Guide specific to Coconino County was recently published in 2020 and contains helpful information and resources.

Tips on creating an emergency plan:

- Know your city and county emergency response organizations and understand how they can help you during an emergency.
- Get to know your neighbors and make sure you have their contact information.
- Have your emergency plan and kit easily accessible and update them regularly.

Tips on creating a low-cost emergency supply kit:

- Host a supply swap with neighbors/family/friends.
- Find supplies at thrift stores and second-hand stores.
- Find free supplies on Craigslist or Freecycle.
- Keep an eye out for sales and discounts.
- Get broken emergency kit items fixed for free at the City of Flagstaff's Fix-it Clinic.

Summary

Climate change poses significant threats to public health. Poor air quality, heat-related illness, mental health challenges, respiratory illness, and exposure to pathogens are a few of many public health concerns expected to increase in coming years. Certain community members, such as the elderly, communities of color, and those experiencing homelessness are especially vulnerable. These impacts are expected to strain the local economy through an increased need for healthcare and other public services.

To address these current and projected vulnerabilities, the City of Flagstaff, as well as community members, can take action. The City can increase funding for emergency medical services, mental health services, and crisis materials to ensure preparedness. Communities can set up neighborhood help maps, create emergency plans and preparedness kits, and increase (or advocate for) tree coverage and green spaces.

Negative physical events are certain as climate change continues to intensify. However, negative impacts can be decreased or avoided through proper planning, preparedness, and resilience efforts.

Infrastructure and Housing

Introduction

Flagstaff is a destination for many families and visitors who want to experience the beautiful scenery, as well as for those seeking to start a family. The serene nature of this city continues to attract people here, and this contributes to the growing population of Flagstaff.

Flagstaff's GHG emissions sources include the consumption of electricity and the burning of natural gas by residential, commercial, and industrial buildings. Emissions are predicted to grow 35 percent by 2030. By 2050, Flagstaff will experience hotter temperatures and longer summers, which is likely to increase energy consumption due to the increased use of air conditioning. The increased demand may strain energy systems, creating shortages, outages, and increased prices. An increase in the demand for energy may cause the cost of energy to rise, which will in turn put a stress on low-income families. This compounds Flagstaff's need to adapt to the increased energy demand and the need for the addition of renewable, local energy sources[36].

Currently, emissions from the transportation sector are estimated at approximately 40 percent of the city's overall GHG emissions, with the majority of emissions resulting from residentially owned vehicles[2]. As the population continues to increase, and as the city simultaneously aims to reduce GHG emissions, Flagstaff's transportation infrastructure needs are complex. While Flagstaff does have policies in place to advocate for the use of bicycles, walking, and other forms of micro-mobility there needs to be an increase of safe pedestrian infrastructure to meet policy goals. Currently, traveling by single-passenger vehicle remains the preferred choice of residents; this is potentially due in part to safety concerns. With an increase of safe pedestrian infrastructure, the city could see a decrease of personal-vehicle ownership and use.

This chapter aims to explore ways in which the city can increase the resiliency of its infrastructure to climate change. The impacts of climate change on physical infrastructure, as well as on social systems that rely on infrastructure, are explored. In response to these risks, recommendations are provided for the City of Flagstaff as well as individuals and communities.

Physical infrastructure

Transportation Infrastructure

Flagstaff is home to an extensive network of transportation infrastructure that includes, but is not limited to, the Flagstaff Pulliam Airport, public transportation via Mountain Line and Greyhound buses, the Amtrak station, roads and highways, and a small, but growing, network of bike and pedestrian pathways. Flagstaff's transportation infrastructure is already stressed by non-climatic factors such as aging infrastructure, traffic congestion and increased population[4], which exacerbates vulnerabilities to climate change impacts.

Roads and Bridges: Flagstaff is largely a car-dependent city, consisting of both local trips and visitor traffic. A majority of Flagstaff's transportation-related GHG emissions come from resident-owned vehicles, about 98 percent[2]. This high rate of car use leads to heavy dependence on roads, bridges, parking lots, and other car-centered infrastructure. Emergency services also depend on this transportation infrastructure to quickly respond to emergency situations. As Flagstaff is expected to experience more days above 90ºF in the coming decades, the higher temperatures will likely damage pavement and asphalt on roads, leading to increased maintenance costs[4] (See Figure 9). This may be countered somewhat by fewer freeze-thaw cycles that may reduce some pavement maintenance needs[3]. In addition, the increased likelihood of wildfires and 100-500 year flood events increases the potential for bridges to collapse[4]. This can lead to reduced access for emergency services, food supply deliveries, evacuation routes, and other critical city functions[4].

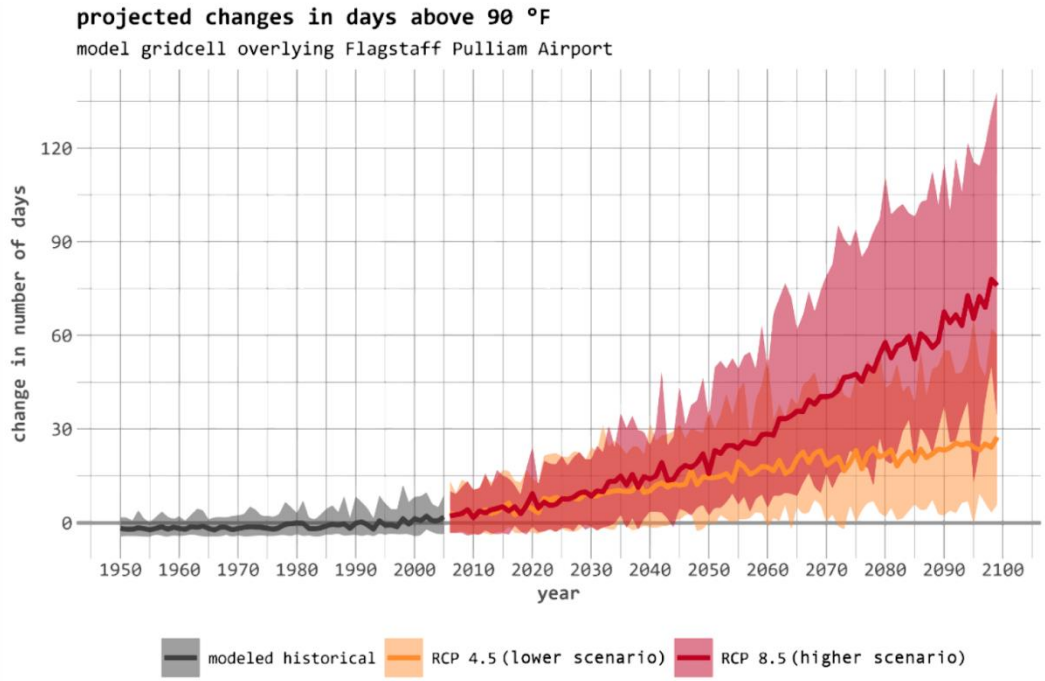

Figure 9: Graph visualization of expected number of days that reach temperatures above 90ºF across the different IPCC climate scenarios.
Source: City of Flagstaff's 2018 Climate Profile

Airport and Rail: Increases in extreme weather and hotter temperatures increase the potential for flight cancellations and delays[4], as well as damage to runways and aircraft. In addition, extreme weather events may affect railroad tracks and disrupt rail traffic, which increases the chance for hazardous events along the tracks and increases the time needed to transport goods via rail[4].

Public Transportation: Despite Flagstaff's high reliance on cars for transportation, many residents rely on the public transportation system. Hotter temperatures, decreased air quality from wildfire smoke, and flood-impacted infrastructure may increase public transit ridership, as well as demand for Paratransit services for people with disabilities who cannot ride fixed-route transit options. Vulnerable residents without cars may be forced to forego walking and biking and turn to public transit to escape these impacts[24]. At the same time, extreme weather events such as wildfire and flooding threaten the reliability of public transportation services, which may lead more residents with access to private vehicle transportation to use that option[4].

Active Transportation: Flagstaff's walking and biking infrastructure may be both positively and negatively affected by climate change impacts. For example, decreased rates of precipitation and warmer temperatures may induce more people to opt for biking and walking, which would lead to increased demand for pedestrian-friendly infrastructure and expansion of the urban trail system[4]. However, during extreme weather events walking and biking become riskier due to health risks and increased potential for weather-related transportation injuries[4], as well as damage to trails and loss of access to bike lanes. Additionally, citizens who choose to walk and bike will be more vulnerable to the decreased air quality from increased wildfire frequency.

Water Infrastructure

Flagstaff's water system includes two water reclamation facilities, two water treatment facilities, twenty-four active wells, five main pressure zones, three concrete storage reservoirs, six steel water storage tanks, and seven pump stations[1]. Many of these utilities are over 50 years old and need to be refurbished. The biggest areas of concern for Flagstaff's water infrastructure are disruption of water distribution and reduced stormwater operations. For more information about threats to Flagstaff's water supply and resources, please visit the water chapter of this document.

Disruption of Distribution: Both dry and wet conditions can affect pipes, and with the increased risk of drought and flooding events, water distribution pipes are at risk of damage[4]. In the event of a wildfire in the basin above Lake Mary, water treatment facilities will need to be expanded, new wells will need to be drilled, and Lake Mary will need to be dredged to remove sediment from post-fire erosion[26]. Additional water supplies may need to be secured to provide drinking water to residents, which will increase the demand and delivery distance of water resources[24]. In April of 2021, Flagstaff drilled its first new water well in twelve years in preparation for a growing population[23], demonstrating the anticipated stress on water infrastructure. The water wells and pump stations in the forested watershed of Flagstaff, as well as the pipes that connect those stations to homes, are also at risk from wildfires[1], threatening the distribution of water from those areas. In addition, power outages caused by wildfires may affect the city's ability to distribute and treat water[1].

Reduced Stormwater Operations: Growth in Flagstaff's population has led to increased development, which removes beneficial native vegetation and natural surface depressions that store water runoff from storms[25]. Without these natural storage systems, more severe storms will overwhelm Flagstaff's built stormwater infrastructure and will increase the severity of peak flooding events.

Energy Infrastructure

Climate change impacts will affect Flagstaff's residential, commercial, and supplier energy infrastructure. Hotter temperatures and increased demand for water can reduce the efficiency of thermal power plants[4], resulting in more fuel being needed to produce sufficient energy. Utility lines that transport energy to homes and businesses may be damaged by high winds, fallen trees, and other conditions, leading to longer power

outages[4]. This can also cause a disruption in communication services, such as cellular service towers, which will leave people unable to reach help during an emergency. This may lead to a higher need for backup generators to fill the gaps during blackouts. Hotter temperatures will also increase demand for air conditioning in homes and businesses, which will result in increased energy demand and costs[24].

Housing Infrastructure and Cost of Living

With Flagstaff's population projected to increase to 82,000 by 2030 and 93,000 by 2050[3], the housing market is already facing stress, resulting in increased housing costs and associated gentrification. This increase is exacerbated by a lack of affordable housing and an increase in purchases of second homes and vacation rental homes. Climate change impacts, increased energy costs, and wildfire/flood events are expected to further increase the cost of living.

Energy costs are expected to increase for residents as homes and buildings require more energy to cool during hotter temperatures[1]. In addition, homes located in wildfire and flood-prone areas are especially at risk from these climate impacts which also exacerbate lack of access to necessary emergency services. Several low and moderate-income neighborhoods in Flagstaff are located in these types of high-risk areas including: Sunnyside, Southside, Plaza Vieja, Pine Knoll, Mobile Haven, Woodland Hills, and Kit Carson[1].

Societal Impacts of Infrastructure

Climate change will have impacts on Flagstaff's infrastructure and therefore its residents and visitors. Flagstaff is expected to see an increase in frequency of wildfire and flood events[2]. Extreme flooding events that were normally only seen on a 100-year and 500-year basis are expected to become more frequent[1]. This will affect all of Flagstaff. However, many low- to moderate-income neighborhoods, including Kit Carson, Mobile Haven, Pine Knoll, Plaza Vieja, Southside, and Woodland Hill, are disproportionately affected due to their location in wildfire and flood prone areas[4].

Public Transportation

Due to increases in heat and wildfire smoke, more people will choose to drive or use public transportation instead of biking or walking. The increase in commuters will increase traffic congestion. In 2001, public transportation rides totaled 200,000. By 2016 this number had risen to 1.96 million[4]. Without proper preparation for an increase in rides due to climate change, stress will be put on these facilities. Notably, only 59 percent of Flagstaff's population lives within a walkable distance to a public transportation stop[4]. This puts public transport out of the reach for many, forcing them to be exposed to the elements and climate hazards.

Source: Flagstaff Carbon Action & Adaptation Plan

Emergency Services

Increased wildfire and flood events decrease the accessibility of roads, highways and emergency evacuation routes[4]. This puts all of Flagstaff's residents at risk during events that require evacuation. These road closures will also affect the response time of emergency vehicles[4]. Delays of emergency services will have increased effects in rural areas, which already face higher emergency response times. Due to the limited number of roads accessing many rural areas, climate change effects can severely limit the ability of emergency vehicles to respond, especially in times of wildfire or flooding. Additionally, it may also take longer for utilities, communications, and power to be restored after a disaster[4].

Housing

Flagstaff's housing costs are 37 percent higher than the national average[4]. This puts financial stress on many and housing is completely out of reach for many others. In general, affordable housing is generated very slowly due to issues such as securing funding[10]. Housing costs are already expected to rise due to increases in population size and the Baby Boomer population beginning to retire and purchase second homes in Flagstaff[1]. Climate refugees fleeing areas such as Phoenix in order to escape extreme temperatures may place further stress on Flagstaff's housing market.

Energy

As temperatures rise in Flagstaff, buildings will require more energy to cool, resulting in potential increases in electricity prices and bills. This will also increase the city's energy demand and the cost to produce water[4]. Additionally, an increase in temperatures will likely result in an increase in air conditioner installation and utilization. Air conditioning units require significant amounts of energy and are expensive to run. This makes summer cooling out of reach for many households[2]. In addition to the increase in energy costs, wildfire frequency is also expected to increase in Flagstaff. This means many residents will be forced to choose between opening their windows for some relief from the heat or keeping their windows closed to protect themselves and their homes from hazardous wildfire smoke.

The increased likelihood of wildfire and flood events also means a potential increase in the frequency and duration of power outages throughout the city. This will increase the need for backup generators[4]. Generators, however, are expensive and may be out of reach for many households and small businesses. Additionally, most generators at this scale are gasoline powered, meaning they will emit GHG emissions and further contribute to these issues.

Water

Much of Flagstaff's critical water infrastructure is at risk to wildfires, especially infrastructure elements near Lake Mary. Wildfires can affect the pipes connecting watersheds to homes, disrupting water supplies. Much of this current infrastructure is at least 50 years old, increasing the likelihood and severity of damage[1]. This can ultimately have implications such as decreased access to water and increased distance traveled to obtain water[4]. Those located in wildfire-prone neighborhoods are the most at risk. For more information about threats to Flagstaff's water supply and resources, please visit the water chapter of this document.

Economic Impacts of Infrastructure

Flagstaff residents, businesses, and City of Flagstaff public works rely heavily on well-maintained infrastructure to function. Climate change impacts will have significant economic costs to infrastructure in Flagstaff.

Transportation Infrastructure

The largest economic impact for transportation infrastructure stems from maintenance costs to repair damaged roads and bridges. Hotter temperatures may lead to a reduction in pavement integrity, resulting in increased maintenance costs for asphalt and pavement, and damage to vehicles[4]. Increases in traffic-related congestion as the population in Flagstaff grows may lead to more crashes and injuries[4], increasing health-related costs for individuals and demand for emergency services. Road closures due to heat damage or disaster events may also prevent people from visiting Flagstaff, leading to a loss in revenue from tourism activities.

Water Infrastructure

The economic costs of addressing damage to water infrastructure could be significant. Based on a cost avoidance study, it would cost between $17 million and $37 million to drill new wells, dredge Lake Mary, and expand treatment facility capacity in the event of a wildfire in the basin above Lake Mary[1]. In addition, the City of Flagstaff could lose $48,000 per day in revenue if a power outage affected water distribution and treatment, with additional costs added to provide drinking water to residents from alternative sources[1].

Energy Infrastructure

Climate change has economic impacts on energy infrastructure on many fronts. Energy costs are expected to increase for residents as homes require more energy to cool during hotter temperatures[1]. Businesses may also experience higher operating costs due to increased energy demand. Decreased efficiency of thermal power plants results in more fuel use, increasing operating costs. Damage to utility lines will require higher maintenance costs, and an increase in power outages would result in the loss of economic productivity as businesses lose power and are unable to operate.

Housing Infrastructure and Cost of Living

Damages to homes due to wildfire and flooding may carry significant costs for Flagstaff's residents, particularly to low and middle-income residents whose homes are located in wildfire and flood-prone areas. Homeowners may also see their insurance rates go up due to the higher risk of disasters[24]. In addition, increased energy costs would take up a larger portion of resident and business budgets, further increasing the cost of living.

Toolkit

Actions at different levels within the City of Flagstaff can help residents, businesses, communities, and the city as a whole prepare for these climate change impacts to infrastructure. Below is a collection of possible actions that individuals, communities, and the City of Flagstaff can take to enable adaptation to infrastructure hazards.

Individual actions

- Participate in one of the free Home Energy Efficiency 101 Workshops through the City of Flagstaff: Energy Efficiency at Home. Residents receive free kits including a low-flow showerhead and an LED light bulb as well as installation demonstrations. Residents can also install solar films on their windows to regulate indoor temperature and keep the room cool in the summer and warm in the winter. This will save money in the long run, as it will reduce water and energy usage, therefore reducing bills.
- Utilize the Flagstaff Bikding Organization's resources to learn about cycling advocacy. Road Bike Advocacy Archives • Flagstaff Biking Organization contains valuable resources for attending city council meetings, filling out petitions and more ways to engage with city council on improving cycling infrastructure throughout Flagstaff.

Community actions

- Advocate and promote the Flagstaff Biking Organization, make community members aware of their presence and activities. Events Archives • Flagstaff Biking Organization contains community events that promote safe bicycling, constructing mountain biking trails, cycling to work to raise awareness, and more events to elevate bike culture in Flagstaff.
- Organize a walking school bus: Walking School Bus. A walking school bus is a group of children walking to school together, along with one or more adults. Coordinate with the parents in the neighborhood to create a route and a schedule.

City actions

- Expand Flagstaff's public transportation system to support the growing population and increased transportation use due to climate change impacts. This includes Paratransit, transportation services for those with disabilities who are unable to use public transportation.
- Increase funding to extend available Mountain Line routes and increase bus operating times to make public transportation a more accessible and convenient option.
- Improve existing roads using materials that better withstand high temperatures; using a permeable material would have the added effect of reducing run-off during periods of intense rain, which are projected to become more frequent[21,22].
- Maintain bike lanes and pedestrian pathways by sweeping and plowing to ensure safety, especially during poor weather conditions. Safe, clean active transportation infrastructure will encourage more residents to walk or bike, reducing the burden on the bus system.

- Require the building of energy efficient, affordable housing that is not in wildfire or flood prone areas. Flagstaff needs more affordable housing, especially as the population grows; however, the city should only approve housing projects in areas that will be less impacted by climate change so that low income residents do not have to live in vulnerable areas.

Summary

We find that the need for infrastructure adaptation overhaul to be simultaneously obvious, and existing on a rapidly shrinking timescale. Flagstaff exists in a state of both advantageous and disadvantageous climate factors. While we may be better positioned than some places such as Phoenix, when it comes to temperature rise and water resources, we also find ourselves extremely exposed to wildfire dangers, uneven community growth coupled with housing deficits, and a transportation system that is not currently prepared to handle oncoming climate impacts. Adaptation on all fronts must be enacted quickly; regardless of our own rate of implementation, Flagstaff's infrastructure stands to be heavily impacted by climate change. The city and community must work together in adapting to climate threats.

Natural Environment

Introduction

Arizona has a unique climate and natural landscape ranging from vast deserts to towering mountains. Of these Arizona landscapes, a place that stands out is Flagstaff. The natural beauty surrounding this city provides visitors and residents with clean air and places to explore. In addition, it is a hub for cultural heritage dating back hundreds of years. Some structures still stand and are protected to preserve the stories of how people survived in this area. Traditions from that time are still being passed down, such as the Kachina doll for the Hopi tribes. These dolls are carved from cottonwood roots and would represent a higher entity that would protect the tribes[41]. The hope of protecting these areas is that these stories and traditions will continue to be passed down for generations to come. Flagstaff is also home to the Coconino National forest, the largest ponderosa pine forest in the world. Protection of this forest is important in order to protect biodiversity and natural resources. Over the years, the area has come to be more susceptible to more frequent and intense wildfires. As the fires increase in intensity it makes it harder for plants and animals to survive and leaves a path open for unwanted insects and disease to take over. Areas damaged in fire events become susceptible to flooding and erosion, as the root structure is no longer there. Without proper care and protection, Flagstaff's forest will remain vulnerable to the effects of Climate Change.

Fire

- Increased chance of severe wildfires due to climate change induced drought and low-moisture vegetation, with warmer temperatures through the summer months, (May-August) is expected[33].
- More drought impacted trees may lead to higher Western/Mountain Pine Beetle infestations and more fire-prone trees[32].
- Populated Flagstaff areas are at a 90 percent greater wildfire risk compared to the rest of the country.

Wildfires have always been part of Flagstaff's forest health and naturally occur every 5 to 25 years. These fires reduce ground litter build-up, help fire dependent ponderosa pines reproduce, and maintain open forest sections of trees. The main difference between stand-replacing and healthy wildfires is the intensity at which they burn. High-intensity wildfires are driven by climate change, creating an increase in drought-stressed trees in close proximity. These trees are more susceptible to wildfires that burn at extreme heights and easily spread in the tree canopy, burning down entire tree stands in the process.

On average, 9 out of 10 wildfires are started by humans. As communities move deeper into natural spaces this trend will likely continue. As Flagstaff's population grows nearly 30 percent by 2050, there could be more incidents of human-caused fires[1]. Climate change is causing an increase in extreme summer heat, droughts, and decreased winter snowpacks. This leads to lower fuel-moisture levels and forests that are more susceptible to intense fires. Additionally, drought stricken trees cannot fend off forest pests like the pine beetle as effectively, leading to more infected trees. In these ways climate change does not directly increase wildfires, but instead increases the chance of severe wildfires.

Wildfires in Flagstaff can cost millions of dollars and take away funding from forest climate adaptation projects. As stated in the Flagstaff Vulnerability Assessment, "In 2010, the Schultz Fire burned over 15,000 acres northeast of Flagstaff and cost an estimated $193 to $207 million to respond, mitigate, and recover from the fire[1]."

Aside from forest health and economic losses to land and property, wildfires are also commonly coupled with flooding when extreme precipitation occurs following a fire. When wildfires burn they damage the soil, foliage, and roots. This creates conditions in which soils are unable to absorb large volumes of rain water, potentially leading to mud/landslides and flooding. It takes years for fire scarred areas to recover to a healthy state. Communities located near the forest edge will be most vulnerable to fire related flooding.

Figure 10: Visualization of the Museum Fire scar and the flood zone associated with it.

Source: National Weather Service

With increasing risk of high-intensity wildfire and post-fire flooding, it will be important to ensure that both our forest and community are prepared (See Figure 11). There are many steps we can take to reduce the risk of high-severity wildfires in our forest, all beginning with proper forest management. This includes ensuring proper density of trees and not allowing for large builds up of plant debris. Activities like forest thinning and prescribed burns can help with these goals. In the event that fire does occur, it is important that the community is prepared for and adapted to fire. This includes ensuring defensible space is maintained around homes and promoting firewise building practices. These practices can be promoted through city policy or educational campaigns. Finally, simple activities such as raking leaves, cleaning gutters, or planting more fire-resistant species of trees around homes can make all the difference if a fire reaches a community.

Tool kit ideas:

- Complete an ember-aware checklist for all homes and ensure defensible space is created and maintained
- Create a neighborhood communication thread and evacuation plan

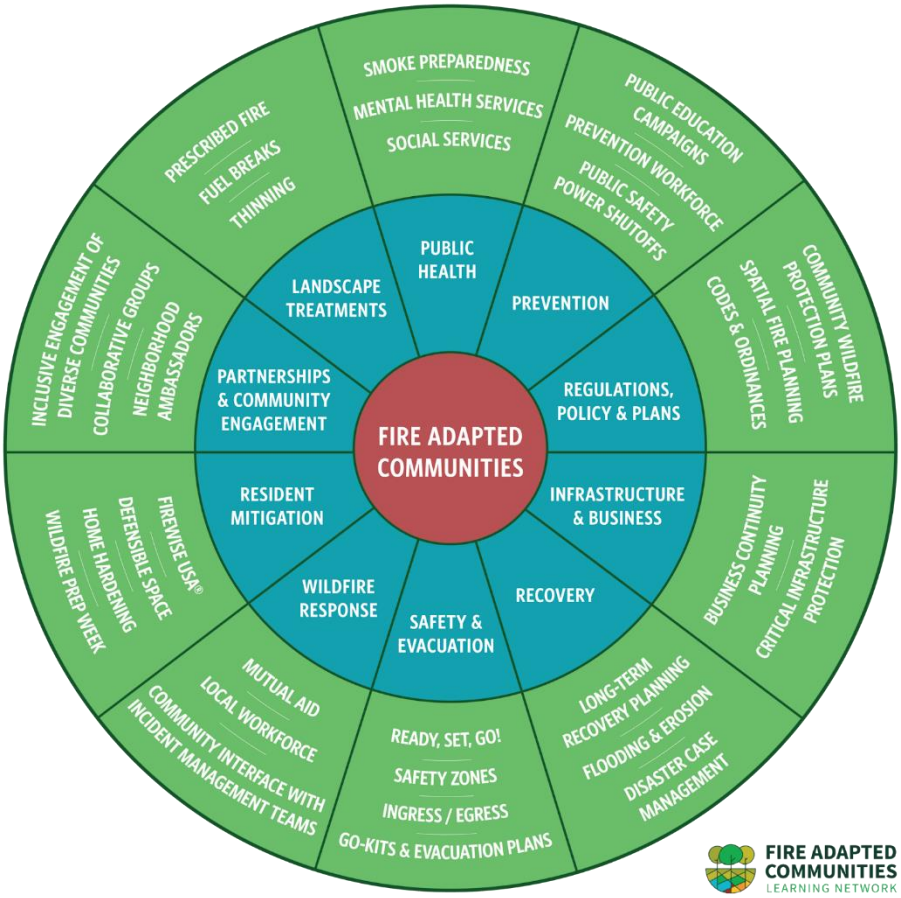

Figure 11: Fire Adapted Communities Connection Web.
Source: Fire Adapted Communities Learning Network

Plants and Animals

- Plants and animals that are geographically isolated on the San Francisco Peaks may become trapped on the summit as they try to escape increasingly warmer temperatures by migrating higher in elevation.
- More severe and longer lasting droughts will stress wildlife and cause organisms to perish or migrate to more suitable environments.
- Climate change intensified wildfires will open up areas to invasive species that may displace native plant species, changing forest composition.
- Ponderosa pine forests may give way to shrub or grasslands in response to changing environmental conditions, resulting in the decline of native organisms that can not adapt to new conditions.

Flagstaff's natural environment is unique not only because of the large expanse of ponderosa pine forest but also because of the small alpine ecosystem on the San Francisco Peaks. Characterized by cooler temperatures, these ecosystems are specially adapted to historic environmental conditions that are now undergoing drastic changes. The climate related impacts we see on Flagstaff's plants and animals are mainly due to increasing temperatures, prolonged droughts, and increasingly intense wildfires.[1,2]

While some of the species in the area are capable of adapting to these swiftly changing conditions, others are more specialized and restricted in what conditions they can persist in. Globally, we are seeing organisms respond to increasing temperatures by migrating higher in latitude and elevation, where temperatures are cooler and more tolerable. One of the problems with this strategy for Flagstaff's organisms is that they are relatively isolated geographically, meaning there is no clear migratory path for organisms that does not involve crossing distances through warmer environments they cannot tolerate. The problem becomes even more dire for the organisms on the peaks, as they can only migrate upward so far before they are trapped at the summit unable to escape ascending warmer temperatures (See Figure 12). At this point, species will often perish if steps towards assisted migration are not taken. One organism currently at risk due to these circumstances is the San Francisco Peaks ragwort *(Packera franciscana)*, an endemic plant species found only on the San Francisco Peaks that is currently listed as threatened on the federal endangered species list[11,12].

San FranciscoPeaks Ragwort. Source: fs.usda.gov

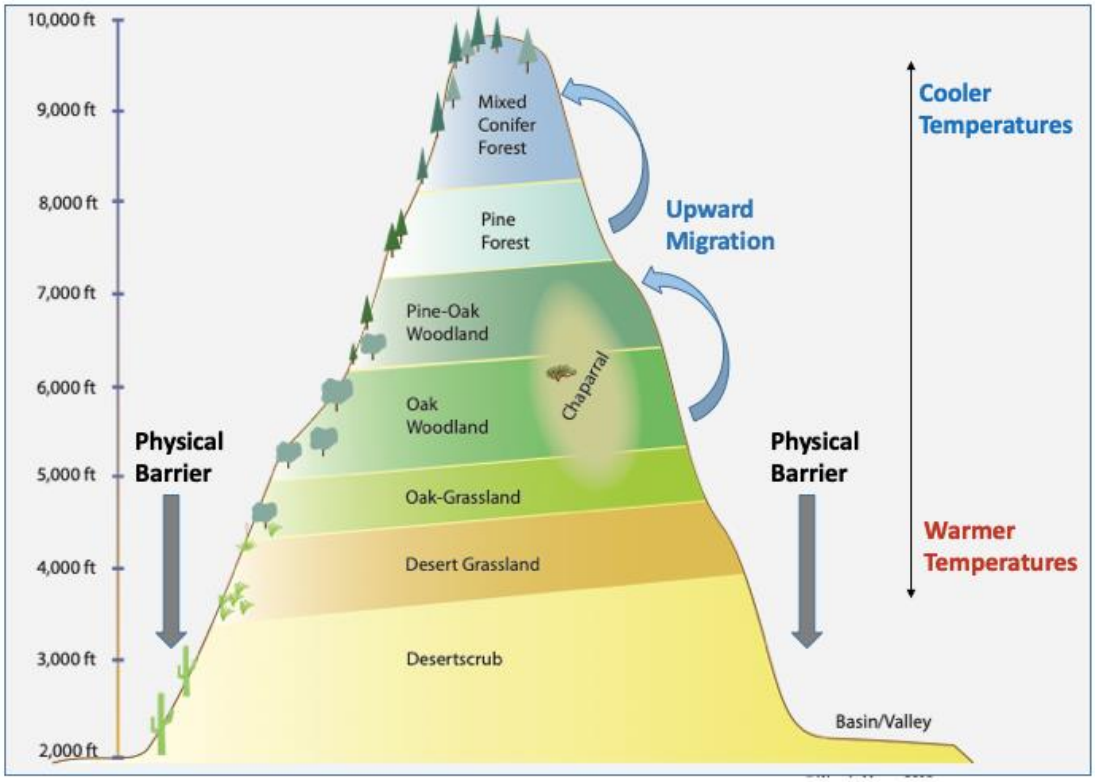

Figure 12: Geographic Isolation On San Francisco Peaks.
Source: Modified from Wendy Moore 2013.

As the climate continues to warm, Flagstaff's natural environment will also have to contend with an increase in drought length and severity. Drought can result in the death of organisms that cannot survive extended dry periods, or cause migration in search of more favorable and wetter conditions. Organisms that rely on perennial (year round) and ephemeral (seasonal) aquatic ecosystems may also be threatened as these ecosystems dry up and reduce in size due to drought. Even if organisms do not die from drought directly, the lack of moisture can severely stress wildlife and increase the probability of insect infestations and disease outbreaks[1].

Climate change intensified wildfires pose a unique threat to Flagstaff's plants and animals. The stand-replacing wildfires we are currently experiencing are more likely to have large impacts on forest health because they burn and kill trees that under normal wildfire conditions would survive and thrive in the aftermath.[1] When old, established patches of forest are wiped out by intense fire, the land they once occupied becomes open to fast growing, invasive species. These invasive species then occupy the space and prevent new ponderosa pines and other native plants from regrowing within the burned area[14].

The combined effects of these vulnerabilities in the Flagstaff natural environment may lead to a change in the composition of the ecosystem. As conditions continue to get drier and warmer, ponderosa forests may shift to the east where conditions may be more tolerable and be replaced by grass and shrublands. In response to this, the plant and animal populations currently found in these forests may decline if they are unable to adapt to these changes or migrate to more suitable environments. Elk and deer for example may decline if new grasslands cannot support their populations, which in turn would impact the many Native American tribes that rely on them for food and cultural uses[1].

While the ponderosa pine forests are a massive and complex ecosystem, there are steps that can be taken to help them adapt to the changes occurring due to climate change. Organisms that face challenges migrating to more suitable areas due to factors like habitat fragmentation and geological isolation may benefit from assisted migration. This would involve the removal and transplant of organisms through human efforts to regions where they may be better suited and would otherwise migrate to if not for physical barriers preventing it[13]. It is recommended that the City of Flagstaff collaborate with land managers and the research community to establish potential assisted migration projects, and identify possible plant varieties that are more tolerant to drought and warmer temperatures. Land managers involved in future restoration projects should also make an effort to increase the number of climate-adapted native plants that will be able to tolerate warmer and drier conditions. There is also potential in expanding current programs that promote the growth of climate-adapted, low water requiring varieties of native plants within the City of Flagstaff. Increasing community engagement, educational programs, and campaigns would be beneficial to raise awareness of the benefits and techniques involved with building native, climate adapted gardens and landscapes[2].

There are also steps that can be taken to protect and restore the ecosystems that have been impacted by climate change related hazards. Flagstaff managers should aim to reduce urban encroachment into forested areas, and support planning and zoning efforts directed at protecting natural resources. These efforts may be more successful with increased funding and management of designated open spaces. Programs like Leave No Trace would also benefit the environment if implemented into city programs, allowing the community to get actively involved in forest protection. Invasive plants can be addressed by working with partners like the San Francisco Peaks Weed Management Area, who aid in mapping areas with high abundance of invasive species and develop management plans for their removal[2].

Insects and Disease

- Flagstaff's ponderosa and limber pine forests are most susceptible to dwarf mistletoe, western pine beetle, and mountain pine beetle.
- Warming winter temperatures will lead to stronger beetle populations.

Increasing temperature and drought conditions will leave Flagstaff's forest ecosystems susceptible to insect and disease outbreaks. Ponderosa and limber pine forests are most susceptible to dwarf mistletoe, western pine beetle, and mountain pine beetle[1].

Dwarf Mistletoe. Source: csuhort.blogspot.com

Dwarf mistletoe is the most common pathogen across the Southwest and currently affects more than one-third of ponderosa pine forests in the region[15]. Dwarf mistletoe reduces growth, wood quality, seed production ability, and the lifespan of infected host trees. It also predisposes trees to drought, which in some cases makes trees more susceptible to beetle attack[17]. Dwarf mistletoe may grow less vigorously in a drier future, but infected trees, especially those in dense stands, are expected to be at increased risk of drought, insect infestation, and mortality[16,17].

The greatest opportunity to control dwarf mistletoe is by the removal of infested stands and replacement with mistletoe-free seedlings[19]. Dwarf mistletoe has been reduced somewhat in ponderosa pine stands using prescribed underburning, with heavily infested trees less than half as likely to survive underburning than their healthy counterparts. Additionally, the chemical Florel is registered for dwarf mistletoe control.

Bark beetle infestations are expected to increase with a warming climate. While there is significant variability year to year, both western pine beetle and mountain pine beetle pose threats to Flagstaff's forest health. Forest ecosystems rely on intense winter periods (-20F and lower for a few days) to cause heavy mortality to overwintering broods[18]. Continued global warming will result in fewer periods of extreme cold, therefore strengthening beetles' populations.

There are a number of proposed solutions for pine beetle management. While woodpeckers and insect enemies of the western pine beetle do exert pressure on western pine beetle populations, these natural enemies have not been enough to effectively collapse beetle outbreaks[18]. A necessary first step in the prevention of beetle attacks is the identification of trees and stands most likely to support heavy beetle populations. The U.S. Forest Service has a comprehensive Hazard Rating System for identifying susceptible trees and stands involving tree age, crown size, and dominance[18]. Older trees with poor thin crowns and slow growth rates are considered most likely to be attacked and killed by the beetle.

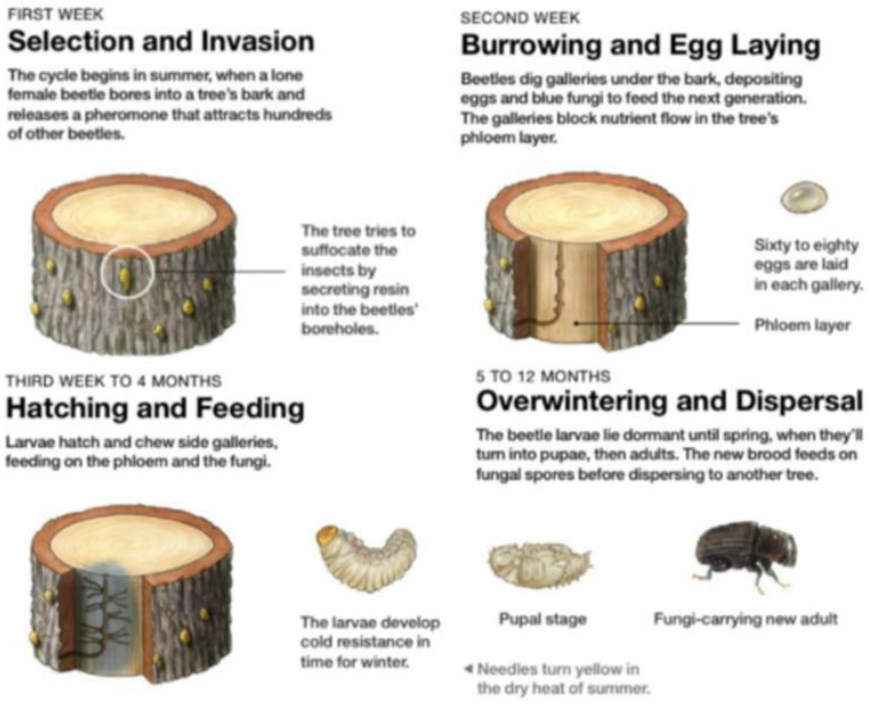

Figure 13: Bark Beetle life cycle
Source: National Geographic

Foresters recommend pest management via forest thinning. In stands where high-risk tree removal strategies have been implemented, beetle-caused mortality has been reduced by as much as 70 percent[18]. Thinning the trees will increase tree vigor, and reduce the risk of beetle attack in the remaining trees. Research scientists at the US Forest Service also propose pheromone strategies and preventative sprays to manage beetle outbreaks[18]. Certain insecticides may be applied to susceptible trees prior to beetle flight to protect trees from attack.

Toolkit

Within the city's Resilient Neighborhood Network framework, choose an activity that your neighborhood network would like to focus on. A list of activities that you or your neighborhood can engage in to create a more resilient community and natural environment can be found below.

Help increase local plant and animal biodiversity

Plant a neighborhood biodiversity garden
Identify an open space where you can plant native plants in your community. This could be a space in someone's yard, a right-of-way area, or even a vegetated median. Next, determine the amount of sunlight the space receives - this will help in determining which type of plants are best suited for the space. Use the resources below or work with a local business or organization specializing in native plants to determine a planting strategy for what and when to plant.

- Northern Arizona Native Plants - Flagstaff Landscaping
- Flagstaff Arboretum Native Plants
- Northern Arizona Native Plants
- Flagstaff Plant Lists by Neighborhood
- Arizona Native Plant Society - Flagstaff
- Arizona Native Plant Society - Northern Arizona
- Consider planting a low-water use garden to qualify for City of Flagstaff's Low Water Landscape Rebate Program.

Coordinate with a local agency or organization to organize a volunteer day with neighbors to help restore endangered species habitat.

- Agencies to contact to organize a volunteer work day:
    - Greater Flagstaff Forests Partnership
    - Arizona Department of Forestry and Fire Management
    - Flagstaff Watershed Protection Project
    - Four Forests Restoration Initiative
    - NAU's Ecological Restoration Institute
    - The Nature Conservancy - Arizona
    - USDA Forest Service - Coconino National Forest
    - Coconino Natural Resource Conservation District
- Organize a community-wide fundraising campaign to restore endangered species habitat or donate to a local forest agency for work on our surrounding forests.

Organize a community campaign to make your neighborhood more resilient to wildfire

Assess your neighborhood or community's wildfire risk

- Fire Adapted Communities Learning Network Self-Assessment Tool.

Create a community campaign or work day prior to the onset of fire season

Your neighborhood can create defensible space surrounding homes and other neighborhood structures to keep wildfire from getting too close. Work through the International Association of Fire Chief's Wildfire Checklist located on pages 8-11 to ensure that all zones of your home and property are prepared for fire. You can also compost debris collected from these activities in your existing compost or start a new compost at your home using this composting guide.

Plant fire-resistant native plants

Check out this list of native tree species above 6,000 feet in Arizona to determine good native options to plant. In neighborhoods with greater fire threat, it may be prudent to create an active fire break between the surrounding forest and houses within the neighborhood. Consult with local regulatory authorities before undertaking projects on public lands

- USDA Forest Service - Coconino National Forest
- Coconino Natural Resource Conservation District
- Coconino County
- City of Flagstaff

Organize a semi-annual gutter-cleaning week within your neighborhood

Twice a year (following the fall of fall foliage, and in the spring prior to the onset of wildfire season), organize a neighborhood-wide campaign to clean out leafy and other dry debris from gutters.

Organize an educational campaign within your community on fire-safe and ember-aware housing practices

Some general information and a comprehensive guide to addressing ember-vulnerable components of homes can be found here:

- Wildfire Home Retrofit Guide
- Ember Awareness Checklist
- Wildfire Home Assessment and Checklist
- More specifics on fire-safe roofing can be found here
- More specifics on fire-safe decking can be found here
- More specifics on fire-safe fencing can be found here

Create a neighborhood communication thread, group, or forum, like those on NextDoor or Facebook, focused on wildfire preparedness

- Invite your neighbors and share helpful information and updates there to establish the space as a valuable source of information and connection, find more information here: Make Preparedness a Priority: Project Ideas for Wildfire Prep Day 2021
- Choose a project from Fire Adapted Communities' list of Wildfire Prep Day activities that you or your neighborhood can complete on National Wildfire Community Preparedness Day (May 1st).
- Create and share a community evacuation plan.
    - In the event that wildfire is imminent, be prepared with a community evacuation plan. Some resources on evacuation planning can be found here: Evacuation Planning.
    - This plan should include evacuation routes, residents' contact information, and a list of residents who are less mobile and will likely need help with transportation out of the at-risk area.
    - Ensure that every resident in the community has their own evacuation details in order. This includes a list of any necessary medications, water, food, and a strategy to remove pets or animals in the event of an evacuation. Follow these guidelines for creating a go-bag for your family as well as a family emergency plan.
- Identify key community members (elderly, disabled, etc.) who may need help cleaning gutters, creating defensible space, completing the ember aware checklist, or evacuating in the event of an emergency, and put in a plan to assist them with these tasks.

Minimize the risk of flash flooding in your neighborhood

Create rain gardens

Rain gardening within your neighborhood will increase soil infiltration during heavy rain events. Resources for creating rain gardens can be found here.

Install rain barrels to capture rainwater runoff from roofs

The rain collected in these barrels can then be used for gardening, landscaping, or even deployed as a protection tool in the event of nearby wildfire.

- Check out the City of Flagstaff's Rainwater Harvesting Rebate Program to see if your rainwater harvesting tank qualifies for a rebate.
- Check out this video to learn how to install your own rain barrel. For larger systems. check out one of these Flagstaff area contractors: Polaris Roofing, Sky Water Rain Water Harvesting, Spot on Services, All Seasons Inc.

Minimize impervious surfaces in your neighborhood

- Use permeable pavement when installing new driveways or sidewalks.
- Advocate for permeable pavement in roadways or medians.
- Advocate for vegetated medians planted with xeriscaping.

Host a neighborhood sandbag event

In the event that flash flooding does occur, ensure your community is prepared by hosting a sandbag fill day. Then, distribute filled sandbags to neighbors individually within your community or decide on a designated community storage space. Work with your neighborhood to create a neighborhood-wide sandbag deployment plan in the event of potential flash flooding and mudslides. This plan should account for people who are unable to move/place sandbags themselves, and also include plans for people who are not at home in the case of an emergency flood warning.

Create and share a community evacuation plan

In the event that severe flooding/mudslides are imminent, be prepared with a community evacuation plan. See the resources listed under creating a fire resilient community above for creating an evacuation plan, including a go-bag and family emergency plan.

Help to improve the resilience and health of our forests

Coordinate with a forest agency for:

- An invasive species removal work day with a group of volunteers from your neighborhood.
- A re-planting work day in a recently burned area with a group of volunteers from your neighborhood.
- A forest restoration/tree thinning work day with a group of volunteers from your neighborhood.
- A tree pest management work day with a group of volunteers from your neighborhood.
    - This could look like thinning of tree stands to prevent canopies from touching to limit beetle movement, or could be a coordinated campaign where your neighborhood checks and empties a certain number of pheromone traps on a regular basis.
- Agencies to coordinate these volunteer activities with:

- Greater Flagstaff Forests Partnership
- Arizona Department of Forestry and Fire Management
- Flagstaff Watershed Protection Project
- Four Forests Restoration Initiative
- NAU's Ecological Restoration Institute
- The Nature Conservancy - Arizona
- USDA Forest Service - Coconino National Forest
- Coconino Natural Resource Conservation District

Summary

Due to the changing conditions of our climate, Flagstaff's natural environment is being faced with more challenges. Climate change-induced drought and low-moisture vegetation will be more likely in the future, leaving Flagstaff vulnerable to increased intensity wildfires and post-fire flooding. Wildfires also have the potential to open up previously forested areas to invasive species that may displace native plant species. Plants and animals that are geographically isolated on the San Francisco Peaks may become extinct from the summit as they try to escape increasingly warmer temperatures by migrating higher in elevation. Additionally, ponderosa pine forests may give way to shrubs or grasslands in response to changing environmental conditions, resulting in a decline of native organisms. Warming winter temperatures will likely lead to stronger bark beetle populations, further stressing the Flagstaff forest ecosystems. Without proper action, the forest that Flagstaff knows today will be forever changed and with that will come a decrease in biodiversity and an increase in vulnerability. Solutions do exist as outlined in the previous sections and toolkit, but early action and planning are essential to increase forest resiliency.

Water Supply and Resources

Introduction

Water is a crucial resource for the City of Flagstaff. Flagstaff depends on water for both human and natural uses. The natural environment, infrastructure, societal function, and economy all stand to be dramatically impacted by threats to water resources. Flagstaff residents have witnessed droughts, forest fires, and flash floods in recent years, and these extreme events are only predicted to increase in frequency as a result of climate change. Water is pivotal to everyday life in Flagstaff, and no discussion of resilience would be complete without addressing how to adapt to an increasingly limited supply as well as a continued increase in intensity of precipitation events.

It is well known that climate change has had and will continue to have severe consequences on water resources. Arizona is no stranger to water stress and scarcity: throughout the 2000's Coconino County has experienced drought levels ranging from moderately dry to severe drought[38]. The extent of drought severity can be seen in Figure 14. This trend is likely to continue and become even more severe as climate change impacts continue to increase. Northern Arizona precipitation typically follows a bi-seasonal pattern; in the winter months, pacific frontal storms typically contribute to significant snowpack accumulation, while summer precipitation frequently comes in the form of monsoons and can result in intense flash floods[38].

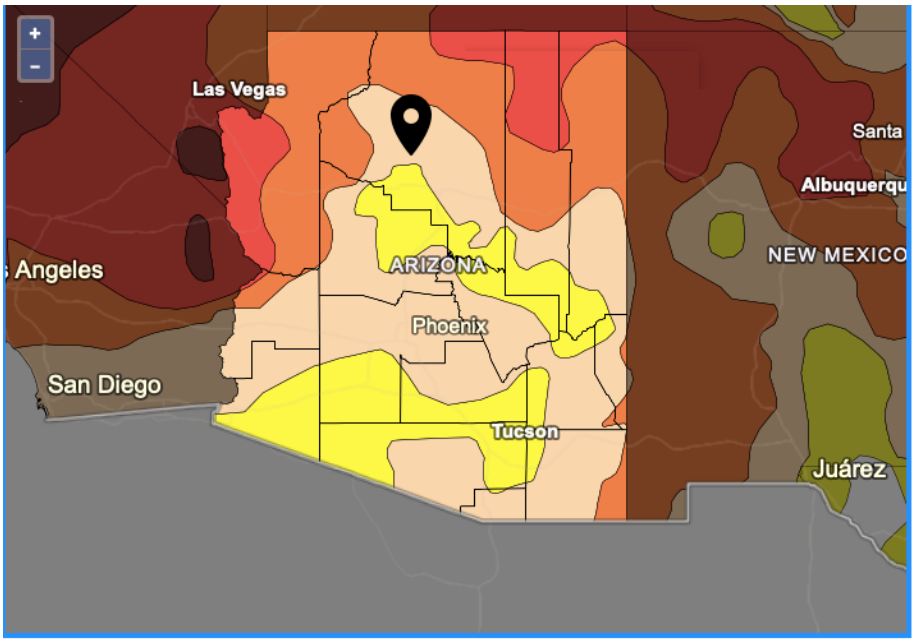

Figure 14: Illustrates drought severity across the region, Flagstaff is shown to be impacted by moderate drought.
Source: NDMC, NOAA, USDA

According to the Environmental Protection Agency (EPA), in the past century average temperatures in Arizona have risen by 2 degrees Fahrenheit. This increase in temperatures will result in warmer winters and a shift in precipitation from snow to rain[39]. These changes will lead to less snowpack accumulation which is critically important for the groundwater recharge that Flagstaff depends on. A study conducted by NASA and the University of California - Irvine, emphasizes the gravity of this decrease in groundwater and found that much of this area is already experiencing large amounts of groundwater pumping. These scientists estimate that the Colorado River Basin has already lost 41 million acre feet of groundwater due to over pumping,[39] depicting the gravity of the water crisis occurring in the Southwest. Since 2019, Flagstaff residents have consumed an average of 59 million gallons of water per week. With 65 percent of the city's potable water collected from the ground, groundwater loss is very concerning and should further inspire residents to advocate for more sustainable methods of water practices. Additionally, it should be noted that sufficient aquifer or groundwater recharge will be even more unlikely during La Niña conditions settling in the Pacific Ocean. La Niña is associated with drier winter conditions in the United States Southwest region which implies that there will be less snowfall to seep into the ground.

Flagstaff's other major source of water is Lake Mary, which makes up 30 percent of the city's potable water use. The projected impacts of climate change and their adverse effects on Arizona groundwater may create a situation in which Flagstaff must rely more heavily on Lake Mary as a water source. Similar to groundwater recharge, snowmelt is the most important driver in replenishing water levels in Lake Mary. Thus a decreased snowpack will have grave implications for both of the city's main water supplies[40]. The combined effects of decreased snowmelt, hotter temperatures, and increasing water demands, due to a growing population, create a significant vulnerability that the city will need to consider and address in order to create a more resilient community.

Source: Lake Mary, Flickr

In addition to the impacts listed above, climate change may also bring a decrease in water quality within Flagstaff. Drought can cause persistent low flow water levels, which, when combined with an increased rate of wildfires and intense flash flooding, can lead to higher sediment levels in rivers, creeks and lakes, lowering the quality of water in these sources[41].

Infrastructure

The city's 2018 Vulnerability Assessment underscores that water infrastructure is highly vulnerable due to anticipated increased flooding from precipitation[1]. Additionally, critical infrastructure is at risk from increased wildfire, especially near Lake Mary. As mentioned above, many elements of the city's water system needs to be refurbished and or replaced as most of the utilities are over 50 years old. Replacing aging infrastructure helps reduce the city's vulnerability and capitalizes on incorporating more resilient designs. New facilities are more likely to handle the pressure on water demand from increased population, and withstand critical damage from major flooding or storm events. The investments made to protect and modernize this infrastructure would help limit the costs of adaptation for Flagstaff[1]. The water system would be able to recover more quickly or avoid distribution issues all together. Furthermore, it establishes a proactive approach to adaptation rather than adopting a nature of simply reacting to costly repairs.

Similarly, expanding the water capacity of Flagstaff would help limit interruptions during major storm or emergency events. To achieve this goal, the city needs to increase the effort placed on identifying more feasible options for potable reuse, water importation, and groundwater mining. The City's recent investments in backup generators for the water and wastewater infrastructure will help sustain water services in the event of severe power loss[1]. The city could explore new water conservation requirements for construction, such as rainwater harvesting for irrigated spaces. By incorporating adaptation into new construction there is a potential for increased savings. These savings could be realized by retrofitting existing buildings with infrastructure that embodies adaptation and resilience[2]. For instance, Low Impact Development (LID)--design practices that emphasize natural infiltration and storage could be implemented to protect water resources and infrastructure.

On another note, education within the community will be critical to adopting adaptation measures. As people become more sensitized about the impacts of climate change on Flagstaff and the threat to water resources, they may be more willing to adopt the "one water" concept proposed by the city. This notion considers all urban sources of water (surface water, groundwater, stormwater, and wastewater) as resources and encourages the management of these resources for long-term resilience and reliability[42]. It is possible that water infrastructure improvements could gain more support as residents realize the significance of protecting these resources. Hence, officials may begin to prioritize water infrastructure projects (less likely to go unfunded) as the community pushes for it.

The ongoing efforts by the city to maintain the rural floodplain ordinance (areas of the delineated 100-year floodplain that cannot be disturbed or developed except for roadway and utility crossings) could be bolstered by maximizing passive and active community rainwater infiltration[2]. The city avoids the related adaptation costs of lifting houses, or otherwise protecting buildings in these areas if they remain undeveloped. Furthermore, the city could increase resilience by prioritizing the use of reclaimed water. This approach would help alleviate the use of groundwater resources thereby allowing aquifers enough time to recharge naturally as water filters through recharge zones. Ultimately, for Flagstaff to meet its water infrastructure needs, the city must incorporate more LID and water programs (reclaimed, recycling, treatment and harvesting) while enforcing development ordinances and effective stormwater management[2].

Societal Impacts and Equity

Water supply has a social aspect with deep roots in water equity. Water equity includes the ability of all residents to have equitable access to high quality water, to be resilient to flooding and drought, and the equitable distribution of stormwater infrastructure systems. Potential impacts to water systems due to climate change include increased demand for water resources from a growing population, a decrease in groundwater and surface sources, and a potential decrease in accessibility of water due to damages to infrastructure from climate hazards.

Access to water is becoming increasingly inequitable - in the past decade, the price of water has risen over 30 percent, rising 3.6 percent in 2019 alone, with the average US household paying $104/month for water and wastewater services[35]. In Flagstaff, prices are rising, but not quite that rapidly. According to the City of Flagstaff, after conducting a cost analysis of water rates for customers, it was determined that there was a need to increase annual prices by 4.4 percent for water, 7 percent for sewer, and 6 percent for stormwater, as a result of inflation. As Arizona's water resources are being depleted, alternative resources are being sought out, which often require transportation to Arizona, rather than coming from a local source, increasing the overall price with the additional miles traveled.

As the average cost of water rises, low income families may lose access to this precious resource and have to go without water in their homes. Others may resort to accessing water through alternative means, both legal and non-legal, which may result in health impacts from improperly treated water[4]. Not only are drier conditions increasing current demands to our water system, but more severe versions of these conditions in neighboring areas have already, and will continue to, result in an increase in migration to Flagstaff from drier areas, further increasing the demand on our water systems. This increased stress will affect Flagstaff's most vulnerable populations first, such as low-income residents or the immunocompromised, who may be more susceptible to disease from poor water quality.

In addition to lack of access to clean drinking water, hazards such as flash flooding have large social and equity impacts on Flagstaff's community. The combination of a recent wildfire just north of the city and higher than average intensity of precipitation events during the 2021 monsoon season led to intense flash flooding in Flagstaff neighborhoods. The flooding made national news with videos of a Toyota Prius being swept down the street in multiple feet of water. This flooding severely affects residents' quality of life and personal health - especially in areas of Flagstaff that continually prove to be flood-prone, such as the

Museum Fire Burn Scar flood zone - contributing to stress, anxiety, and even loss of housing security. These floods also present a safety issue: with changes to seasonal precipitation patterns, stormwater infrastructure may be overwhelmed, causing roads to flood. This flooding can result in closures, presenting challenges for emergency services which are especially needed during extreme weather events. Additionally, these flooded roads can cause harm to the community and their vehicles when drivers may become trapped in the deep water or hydroplane, resulting in accidents and damages to health and property.

Source: 2018 Flooding, AZ Daily Sun

Economics

Arizona's rivers, lakes, and streams are not only intrinsically valuable but they also provide economic boosts that benefit much of the state. These bodies of water support over 100,000 jobs and contribute $13.5 billion a year to our economy from recreation alone (Audubon, 2019). The growing demands for water will undoubtedly impact the economy - and with a decrease in the supply of water due to climate change, demand-based solutions need to be taken into account. Fortunately, researchers have found that water demand could be lessened by adopting more productive water practices. For example, findings show that increasing water efficiency could lead to an 8.3 percent increase in water flow in the Colorado River basin (Martson, 2021). This implies that limiting demand for water will not necessarily be an economic drain on the City of Flagstaff and these types of measures should be adopted by the city.

The City of Flagstaff lists 53 new businesses as being granted operational licensing status during the month of September 2021. These include restaurants, bars, retail stores, personal transportation and both residential and automotive purchases and servicing. An "Open for Business" application/app will be accessible in the future for up-to-date consumer guidance as to information pertaining to specifics of each business operating in, or within close proximity, of the city.

Post-pandemic economic recovery is under the supervision of the City of Flagstaff Re-Entry Plan. The Protocol chart has outlined four "phases" or steps that provide regulations as to the safety requirements for the reopening of public areas and governmental operations. Following the listed guidelines indicates that announced directives will be forthcoming as to a return to "pre-pandemic" status.

The city also has an “Economic Development Team” that works with the Downtown Business Alliance to organize data on local businesses and post-pandemic assistance. In addition, projects include relief funding incentives for entrepreneurship relocation, plastic recycling, and building code compliance.

Toolkit

Energy Efficiency Home Workshops

Receive a free home energy efficiency kit to kick-start energy upgrades when you attend Energy Efficiency Home Workshops. The kit includes weather-stripping, caulking, a low-flow showerhead, a faucet aerator, an LED light bulb, and much more. By installing the low-flow showerhead and faucet aerator, residents can feel confident that they are conserving water by using these tools, even without making any lifestyle changes. In addition to installing tools to conserve water, residents can do it themselves by practicing mindful consumption. By paying attention to their water usage and making small changes such as turning off the sink while brushing their teeth, or taking slightly shorter showers, Flagstaff residents can continue to conserve past what can be achieved by installing efficiency tools to their water appliances.

Rain Barrels

Flagstaff residents can use this water conservation methods at home to reduce their purchased water consumption. By collecting rainwater in rain barrels, residents can use this for car washing, watering plants, etc, rather than using filtered, purchased water when it’s not necessary.

Business Water Conservation

The “Water Wise Business Certification Program" enables local entrepreneurs the opportunity to ensure sustainable water use practices. Commercial buildings can be given information and professional assistance with plumbing equipment. Successful participants have been awarded certification that displays exactly how many gallons of water a business saved using sustainable practices. Some specific measures include:

- Bathroom sink flow = maximum 0.5 gallons.
- Showerhead flow = maximum 2.5 gallons.
- Linens and towel program usage for hotels.
- Fixing leaks.

The “We Mean Business” Coalition is a national group of non-profits and businesses advocating for climate action, and includes some of Flagstaff’s larger companies such as Walmart and Purina. . Many commercial buildings will need new fittings in order for sustainable compliance policy objectives to be met. By joining the We Mean Business Coalition, large business owners can collaborate on meeting carbon neutrality policies and encourage others to do the same.

Summary

Flagstaff and its residents face many water-related challenges in the face of climate change. The best strategies to tackle these challenges is to first understand what is at high risk and then furthering education on how severe these impacts will be on the various topics discussed here. With temperatures continuing to rise, the likelihood of snowfall in colder months diminishes, leading to decreases in Flagstaff’s reserves of groundwater. Less annual snowpack will also lead to decreased water levels in Lake Mary, another source of water for the surrounding areas. This stress on water availability could lead to higher prices on residents’ water bills and would disproportionately affect low-income households. Water availability is not the only anxiety that residents can expect to face. Damage to road infrastructure and a strained sense of home security due to excessive flooding during monsoon season can add to this building mental distress. Damages

not only threaten roads and homes, but businesses as well. Flagstaff's economy is likely to be impacted as billions of dollars are tied to water statewide, whether it be for consumption or recreation, and Flagstaff will not be an exception if water sources continue to be threatened by climate change. Water is crucial to all life and at the same time can cause harm to it. Sustainable practices, adaptation plans, and education regarding climate impacts on water need to be implemented so that the City of Flagstaff can continue to grow and thrive.

Tourism and Recreation

Introduction

With its proximity to the Grand Canyon, the red rocks of Sedona, Lowell Observatory, Route 66 nostalgia, the nation's largest contiguous ponderosa pine forest, and a booming local craft beer scene, Flagstaff draws tourists in from near and far. In 2017, Flagstaff was the 14th most-visited city in the United States, and in 2019 Flagstaff welcomed more than 5 million annual visitors. These visitors contributed $500 million to the local economy and supported an estimated 8,000 jobs[5]. By 2050, visitation to Flagstaff and Northern Arizona is projected to reach 9.5 million people annually[6]. Nearby outdoor recreation facilities such as national monuments, forests, parks, Arizona Snowbowl, and Lowell Observatory drive Flagstaff's tourism-centric economy.

The impacts of climate change threaten the Flagstaff area natural resources. Projections of decreased snowpack will impact winter recreation and tourism, while increases in summer temperatures, drier conditions, and wildfire risk to ponderosa pine forests could alter visitation during spring, summer, and fall. As cities in central Arizona experience increasingly extreme summer temperatures, more individuals may visit Flagstaff to seek refuge from the summer heat. Flagstaff's economic dependency on at-risk natural resources and tourism creates a possible point of contention as our community seeks to become more sustainable. As visitation increases, so will the need to maintain and enhance infrastructure. For example, higher visitor demand and vehicle travel in national forests may require more frequent road maintenance and increase stress on water resources[7]. Additionally, invaluable cultural resources are at risk of vandalism as visitation surges[8]. Finally, with more individuals visiting Flagstaff and purchasing seasonal homes, housing demand will increase pressure on low-income communities. Despite these vulnerabilities, visitation is an important driver of the Flagstaff economy and contributes significantly to the quality of life in Flagstaff. It is important to take into account addressing the goals of decreasing GHG emissions,

maintaining a rich economy, balancing visitation with natural resource conservation, and taking equitable climate action.

Physical Sciences

Winter

Currently, Flagstaff's average winter temperature is 34.5°F and is expected to increase approximately 4°F by 2050. Some winters, the average temperature may exceed 41°F. As a result, more precipitation is expected to fall as rain rather than snow, driving an estimated 40 percent decline in snowpack by the 2041-2070 period compared to the 1971-2000 period. The Southwest's ski areas are projected to lose comparatively more snowpack than U.S. ski resorts with colder climates.

Excerpt from Flagstaff Climate Profile:

Given the importance of Flagstaff's winter tourism, we also examined the minimum temperature threshold of 32°F (the temperature at which snow begins to melt). Since 1950, Flagstaff has averaged 197 days per year with minimum temperatures below 32°F (See Figure 15). In Figure 15 the straight horizontal line represents the average number of days with temperatures below 32°F, blue bars represent years in which days below 32°F have been higher than the long-term average, and orange bars represent years in which those days have been below the long-term average. The number of days has ranged from a maximum of 230 in 1971 to a minimum of 170 days in 1992. Consistent with the data showing that temperature trends are being driven by increasing low temperatures, we note that in the 31 years since 1985, Flagstaff has experienced fewer cold days (below 32°F) than in the period from 1950–1985. As is expected with natural temperature variability, there have still been some years above the long-term average during this more recent period[8].

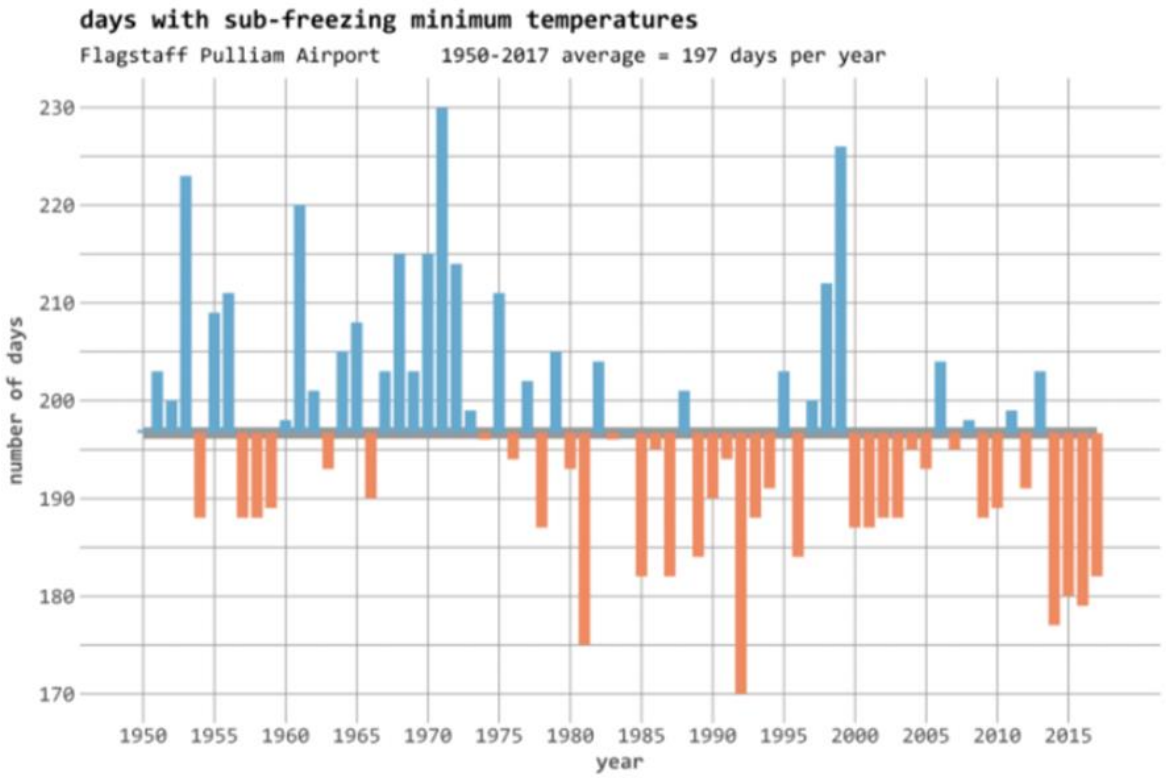

Figure 15: Number of days in which the minimum temperature fell below 32°F at the Flagstaff airport from 1950-2017.
Source: Flagstaff Climate Profile

Summer

Warming temperatures could have devastating effects on Flagstaff. Higher probabilities of wildfire and drought could lead to damaged forests, poor air quality, and reduced water supply. Increased fire risk may often also result in forest closures. In addition, higher temperatures can contribute to an increase in the mosquito population, a longer pollen season, and other heat-related complications that can compromise the livability of Flagstaff.

Societal Impacts of Vulnerabilities:

Winter

As snowpack declines, losses in snow-based tourism and recreation are expected. Our businesses and services will need to be ready to continue to diversify tourism and recreation activities and prepare for low-snow years. Flagstaff's winter recreation and tourism depend on a robust snowpack that is already declining as winter temperatures warm. On average, 104,900 people visit Snowbowl each year[5]. Already, low-snow years generate fewer visits from skiers, fewer jobs, less labor income, and less value added to the economy than high-snow years. From November 1999 to April 2010, there were 29 percent fewer skiers visiting resorts across Arizona in low-snowfall years than in high-snowfall years, resulting in a $18.6 million loss to the economy and 226 fewer jobs on average in those low-snowfall years. From 2001 to 2016, similar impacts from low snowfall were reported in Arizona. Regions—and ski resorts—with average winter

temperatures between 23°F and 41°F are most vulnerable to snow loss in the future because they tend to receive less snow than their high-elevation, high-latitude counterparts.

One estimate suggests potential daily revenue losses at the Southwest's warmer ski areas ranging from 7 percent with major adaptation efforts to 100 percent with no adaptation efforts[7]. Snowmaking will likely remain viable all season at Snowbowl until 2030 and only viable in the coldest months by 2050[4]. By 2080, without snowmaking efficiency improvements, snowmaking will be increasingly expensive and likely no longer viable[7]. Snowbowl may need to redirect resources to recreation in other seasons.

Snow play is another large draw for Flagstaff's winter tourism. With many areas south of Flagstaff being too warm for snow during most of the winter, families commonly come to Flagstaff for sledding, snowshoeing, and cross country skiing. Places like Fort Tuthill County Park and Arizona Nordic Village draw people from Southern Arizona, California, and even Mexico to experience snow play opportunities that are not available in their regions.

With less natural snowpack available for snow play, businesses like the Nordic Village that do not make their own snow are likely to struggle economically in the winter months. In addition to the businesses that are reliant on the snow, many restaurants and businesses throughout Flagstaff make a significant portion of their profits from visitors who travel to Flagstaff for snow play. With fewer snow days and warmer low temperatures, these businesses are likely to suffer from lower profit margins in the winter months, thus negatively impacting employees who are reliant on income and tips from winter visitors. For example, a waiter at a restaurant who is reliant on tips may struggle with less visitation because fewer people are eating at the restaurant. With fewer people and tips, this person may not be able to pay their rent or other monthly payments. This example demonstrates the negative and inequitable impacts of less snowpack on the Flagstaff community.

Source: Discover Flagstaff

Summer

Hotter summers in southern Arizona and fewer snow-based recreation opportunities locally may shift some of Flagstaff's recreation and tourism to the summer months and shoulder seasons (spring and fall). National economic studies suggest gains in warm-season tourism may compensate for losses in cold-season tourism. However, Flagstaff's already-robust tourism infrastructure may need additional capacity to meet higher demand. With visitors concentrated in the warm season, unintended environmental stresses such as greater water demand or increased trampling of natural areas may also occur. Microbiotic crust—a fragile, nutrient-rich microscopic layer covering many Colorado Plateau landscapes—is more sensitive to trampling during dry conditions[9]. Additionally, the potential for more visitors in summer, spring, and fall due to rising temperatures elsewhere may be constrained by other climate change impacts that reduce access, increase safety risks, or impair scenery:

Wildfire: Sunset Crater National Monument is estimated to have lost 12,000 visitors and $225,000 in local economic spending due to the 2002 wildfire season, the most recent data available[5]. However, this kind of impact is not typically long-lasting; studies show that at popular destinations in other parts of the country, tourism has returned to pre-fire levels within one year. Hikers in particular may return to recently burned areas to view wildflowers.

Drought: Visits to Lake Powell and Glen Canyon National Recreation Areas have declined in response to a drop in reservoir levels: 500,000 fewer visitors and a loss of $32.1 million in visitor spending and 758 jobs were reported during the extreme drought in 2003[5]. Compared to other water recreation, boating is especially sensitive to water levels.

The close proximity of these areas not only have a direct impact on Flagstaff due to the effects of decreased recreation in Page, AZ or Las Vegas, NV on the local tourism industry, but they also show how drought can impact recreation in the future. Average temperatures of Lake Powell and Glen Canyon are currently higher than the average temperature of Flagstaff, but as climate change causes warmer conditions, water recreation in Lake Mary could be significantly reduced.

Extreme heat: The risk of heat-related illness and death may increase in desert destinations such as Grand Canyon National Park, resulting in fewer visitors or an increased need for emergency services. Winter tourism in desert areas, however, may increase as temperatures warm.

Reduced water supply and quality: River-based tourism such as rafting and fishing may decline as streamflow declines, warmer water stresses fish, and more sediment enters waterways after wildfires. Given the popularity of the Colorado River, reduced flows there could be especially detrimental to regional river-based tourism. Hikers, mountain bikers, and backpackers may also choose other destinations if water sources near paths dwindle or disappear.

Toolkit

Diversify Recreation Activities

Despite having few substitutes for snow-based recreation and tourism, Flagstaff's efforts to diversify tourism opportunities year-round will help reduce economic impacts in low-snowfall years. For example, despite a dry year in 2017, 2018 winter visitation and visitor spending did not plummet. Diverse marketing messages may have played a role: they were focused on Flagstaff's craft beer and food culture, the Museum of Northern Arizona, dark skies, Lowell Observatory, and surrounding monuments. To continue this trend

of recreational diversification, Flagstaff can look to cities and states with economies that have similar levels of reliance on winter tourism. As noted by the 2019 Colorado Rural Adaptation Report, it is important for staple businesses - such as Snowbowl - to diversify the types of services they offer, as well as the locations in which they are offered. In doing so, services not reliant on snowfall (ex: guided educational experiences, seasonally-themed events, etc.) can provide revenue when core services aren't available and the chances of all revenue-generating activities being interrupted by localized shocks like wildfires and flooding are limited[9]. In addition to diversifying the recreational services offered, the 2019 Colorado Rural Adaptation Report also stresses the significance of collaboration between stakeholders at multiple levels - city representatives, outdoor industry advocacy groups, community groups, non-profits, and others. This collaboration can lead to collective problem-solving and mutually beneficial partnerships, specifically between the city, the Flagstaff Chamber of Commerce, the Downtown Business Alliance, and any outdoor recreation advocacy groups. Increased collaboration and partnership within the local business community, especially, can aid in the success of newly-introduced attractions aimed at improving the diversification of tourism in Flagstaff.

Diversify Job Market and Industry

In addition to diversifying tourism opportunities, diversifying Flagstaff's job market and economy as a whole will help protect against potential revenue losses as a result of decreases in tourism. The City of Flagstaff's business attraction programs help address this need by bringing new businesses to the city that are less reliant on tourism to turn a profit. Incentives for already-established businesses include financial reimbursement for business retention and expansion, construction or renovations, and job creation. Moonshot, a business incubator and education non-profit, operates out of the Northern Arizona Center for Entrepreneurship and Technology (NACET) campus in Flagstaff. This space is used to incubate startups and foster business ideas by offering educational training and mentorship. The organization does not offer financial capital, but they do work with startups to find investors, industry mentors, and future customers. By continuing to offer and support these incentive programs and business incubation efforts, Flagstaff's job market and the overall economy will become better prepared and more resilient in low-snowfall years, as well as years with forest closures that decrease tourism.

Summary

The tourism and recreation industry, which contributes significantly - both directly and indirectly - to Flagstaff's local economy, is growing increasingly vulnerable to the effects of climate change. Winter recreation, a substantial draw for Flagstaff, will be hindered by the projected decrease in snowpack as a result of rising annual temperatures. Summer recreation will also face challenges as wildfires, drought conditions, and extreme heat limit access to forest recreation, put strains on our water resources and lead to comparatively less desirable weather conditions. These economic vulnerabilities pose a significant risk to seasonally-employed people, as well as our vulnerable unhoused population. As a consequence of the decreasing viability of winter recreation, the number of service industry jobs throughout Flagstaff may similarly decrease. Due to the increased frequency and intensity of wildfire events, forest access and camping could be restricted, which will displace those in the unhoused population that traditionally rely on these areas for shelter. Despite Flagstaff's vulnerability to the effects of climate change, there are future actions that can be taken - and current efforts that can be expanded - in order to increase our economic resiliency. The primary route for increased economic resiliency is to diversify the recreation and tourism activities offered, as well as the areas in which they are offered. With increased diversification in this industry, heightened collaboration and partnerships between businesses are necessary to ensure new activities are successful. The second solution for increased economic resiliency is to continue support the expansion of the city's Business Attraction and Retention incentive programs, as well as of local business incubation non-profits, like Moonshot. General economic and industry diversification will allow for a more

comprehensive economy, which will increase Flagstaff's resiliency - and decrease our vulnerability - to the effects of climate change in the coming decades.

References

1	City of Flagstaff, “Flagstaff’s Vulnerability to Climate Change”, Flagstaff, AZ, 2018.
2	City of Flagstaff, “Climate Action and Adaptation Plan”, Flagstaff, AZ, 2018.
3	City of Flagstaff, “The Flagstaff Carbon Neutrality Plan: An Evolving Framework for Action”, Flagstaff, AZ, 2021.
4	City of Flagstaff, “City of Flagstaff Resiliency and Preparedness Study, Flagstaff, AZ, 2012.
5	“Fiscal Year 2017 Annual Report and Fiscal Year 2018 Marketing Plan” Flagstaff Convention & Victorious Bureau, 2018. https://en.calameo.com/discoverflagstaff/read/0050207466245301304ce
6	“Flagstaff Regional Plan 2030; 2016 annual report” City of Flagstaff, 2017. https://www.flagstaff.az.gov/DocumentCenter/View/49295/0-FullPlan_webreduced?bidId=
7	R.H. Bark, “Assessment of climate change on local economies.” Sonoran Institute and Lincoln Institute of Land Policy. 2009. https://www.lincolninst.edu/es/publications/working-papers/assessment-climate-change-impacts-local-economies
8	“Flagstaff Open Space 2018 Annual Year in Review” City of Flagstaff Sustainability Program. 2018.
9	Even, T. & Ojima, D. "Changing Weather and Livelihoods in Rural Colorado: A report on 21st century impacts and adaptation in the farming, ranching, and outdoor recreation sectors." Colorado State University. 2019. https://www.nrel.colostate.edu/wp-content/uploads/2019/04/Colorado_Rural_Adaptation_Report_FinalwPhotos2019.pdf
10	Meadow, A.M., LeRoy, L., Weiss, J., Keith, L., “Climate Profile for the City of Flagstaff”, University of Arizona, 2018.
11	U.S. Forest Service, "Ecology of a threatened, single mountain endemic plant species, Packera franciscana (San Francisco Peaks ragwort)," Rocky Mountain Research Station, 2009.
12	U.S. Fish and Wildlife Service, "San Francisco Peaks ragwort (Packera franciscana)," Environmental Conservation Online System, 2021.
13	U.S. Forest Service, "Assisted Migration," Climate Change Resource Center, 2018.
14	Northern Arizona Invasive Plants, "Why should we care about invasive plants?" The University of Arizona Cooperative Extension, Coconino County, 2021
15	U.S. Forest Service, "Forest insect and disease conditions in the Southwestern region, 2015," U.S. Forest Service Southwest Region, 2016.
16	C. P. Bickford, T. E. Kolb and B. W. Geils, "Host physiological condition regulates parasitic plan performance: Arceuthobium vaginatum subsp. cryptopodum on Pinus ponderosa," Oecologia, vol. 146, pp. 179-189, 2005.

17	T. E. Kolb, C. J. Fettig, M. P. Ayres, B. J. Bentz, J. A. Hicke, R. Mathiasen, J. E. Stewart and A. S. Weed, "Observed and anticipated impacts of drought on forest insects and diseases in the United States," Forest Ecology and Management, vol. 380, pp. 321-334, 2016.
18	Carol Bell Randal, "Management Guide for Western Pine Beetle," U.S. Forest Service Forest Health Protection, 2004.
19	James T. Hoffman, "Management Guide for Dwarf Mistletoe," U.S. Forest Service Forest Health Protection, 2004.
20	City of Flagstaff, "Flagstaff Climate Action and Adaptation Plan: Strategies and Actions", Flagstaff 2018
21	Mullan, M., "Climate-resilient Infrastructure," OECD, December 2018. https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf
22	Jiang, W., Huang, Y., Sha, A., "A review of eco-friendly functional road materials, Construction and Building Materials, Volume 191, 2018, Pages 1082-1092, https://www.sciencedirect.com/science/article/pii/S0950061818324887.
23	Heinsius, R., "Flagstaff Drills First Well in 12 Years to Shore Up Water Supplies", April 2021. https://www.knau.org/knau-and-arizona-news/2021-04-28/flagstaff-drills-first-well-in-12-years-to-shore-up-city-water-supplies
24	Frazee, G., "How climate change is changing your insurance", Nov 2018. https://www.pbs.org/newshour/economy/making-sense/how-climate-change-is-changing-your-insurance
25	New Jersey Stormwater Best Practices Manual, "Chapter 1: Impacts of Development on Runoff", Feb 2004. https://www.njstormwater.org/bmp_manual/NJ_SWBMP_1%20print.pdf
26	Ryan, S.E., Dwire, K.A., Dixon, M.K., "Impacts of wildfire on runoff and sediment loads at Little Granite Creek, western Wyoming." Feb 2011. https://www.fs.fed.us/rm/pubs_other/rmrs_2011_ryan_s001.pdf
27	Arizona Demographics, "Is Flagstaff the best Arizona city for your business?" https://www.arizona-demographics.com/flagstaff-demographics
28	Johnson B. Weldon, "Where does it snow in Arizona? And what's the snowiest place?" Feb. 2018 https://www.azcentral.com/story/travel/arizona/road-trips/2018/02/15/where-does-snow-arizona-and-whats-snowiest-place/339057002/
29	World Population Review, "Snowiest Cities in the US 2021" https://worldpopulationreview.com/us-city-rankings/snowiest-cities-in-the-us
30	USGS, "Sublimation and the Water Cycle," https://www.usgs.gov/special-topic/water-science-school/science/sublimation-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects
31	USDA, "Wildfire Risk to Communities," https://www.fs.usda.gov/managing-land/fire/wildfirerisk
32	*Negron, Jose. Forest Ecology and Management - Fs.fed.us. https://www.fs.fed.us/rm/pubs_other/rmrs_2009_negron_j001.pdf.*

33	University of California - Los Angeles. "Increasingly frequent wildfires linked to human-caused climate change." ScienceDaily. ScienceDaily, 5 November 2021. <www.sciencedaily.com/releases/2021/11/211105114305.htm>.
34	IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change
35	Bluefield Research. (2019). U.S. water & wastewater bills climb, exposing questions of affordability. Boston.
36	Gaille Louise, "21 Big Pros and Cons of Living in Flagstaff, Arizona," Nov. 2019, https://vittana.org/21-big-pros-and-cons-of-living-in-flagstaff-arizona
37	Vila, B., Reddigari, M. "7 Things to Know Before Tinting Home Windows," https://www.bobvila.com/articles/tinted-home-windows/.
38	EPA, "What Climate Change Means for Arizona," Aug. 2016, https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?West
39	Arizona Department of Water Resources, "Drought Status," Oct. 2021, https://new.azwater.gov/drought/drought-status
40	National Climate Assesment, "Water Supply," 2014, https://nca2014.globalchange.gov/highlights/report-findings/water-supply#statement-16587
41	Miller-Wilson, Kate, "Kachina Dolls: Values and Meanings of Hopi Collectibles," https://antiques.lovetoknow.com/Collectible_Kachina_Doll
42	City of Flagstaff, "Water Supply Options," https://www.flagstaff.az.gov/3845/Future-Water-Supply-Options