Geography and Weather
Flagstaff's elevation of 7,000 feet ensures a variety of weather including cold winters and mild pleasant summers, moderate humidity, and considerable diurnal temperature changes. The average precipitation for Flagstaff is 21.77 inches. The average date of the last occurrence of 32°F in the spring is June 6 and that of the first 32°F temperature in the fall is September 23. However, the summers in Flagstaff are one of its best kept secrets with an average maximum temperature in July of 82.1°F, and an all-time record high of 97°F. On average, only three days in the summer have maximum temperatures of 90°F or higher. Summer minimum temperatures are cool with temperatures often dipping into the 40s with an occasional night in the 30s.

The moderate summer heat gives way to a cooler but nonetheless pleasant fall period with maximum temperatures generally in the 60s with minimum temperatures falling below freezing. Winter weather typically begins by November and becomes well entrenched by December, with frequent light to moderate snows and increasingly colder weather. By December, minimum temperatures are generally in the teens; however afternoon maximum temperatures still average in the 40s, due to the amount of sunshine Flagstaff receives. Because of its location with respect to the typical jet stream and its high altitude, Flagstaff is one of the ten sunniest locations of National Weather Service offices in the United States, averaging 78 percent of the possible sunshine throughout the year. Even with all of this winter sunshine, significant snowfall can be expected during the winter with an average snowfall of around 94 inches per year. Between storms, when dry high pressure builds in, winds become light, and fresh snow cover is on the ground, minimum temperatures can plummet. The all-time record low for Flagstaff is -30°F.

By mid-April, winter weather usually begins to break, and although snow is not uncommon in May, warm spells become more frequent. Spring in Flagstaff is typically breezy and dry with little precipitation occurring in May and early June. Due to the very dry airmass typical of the late spring months, late season frosts and freezes are still a possibility, with 32°F temperatures being recorded as late as June 29. Snowfall has been reported as late as the middle of June.

There are two distinct periods of precipitation in Flagstaff. The first occurs during the winter months from November through April when the jet stream can be located over the state allowing Pacific storm systems to move overhead. The other distinct period is classified as the summer rainy season, or 'summer monsoon.' The monsoon rainy period usually occurs during July and August when most of Arizona is subjected to widespread thunderstorm activity. These thunderstorms are extremely variable in intensity and location and occur mainly between the hours of 11 a.m. and 6 p.m. Some of these storms can reach severe levels, with large hail, damaging winds, and occasionally even a tornado. Prevailing winds at Flagstaff are southerly most of the year. This is due to terrain influences and short-wave weather disturbances moving across the Great Basin region of the West. Strong winds of 40 mph or greater are likely during the spring months, especially when low pressure moves into the Great Basin and eastward across southern Utah. Winds of damaging force (greater than 60 mph) are rare but may occur around some of the mountain locations during the winter and spring months. Additionally, some thunderstorms may produce local wind gusts over 60 mph for short durations.

Since there is no concentration of industry, pollution is not currently a significant public health challenge, and the air is remarkably free of contaminants of any kind, although smoke from residents' fireplaces can become a problem on some of the colder nights due to strong radiational inversions that develop. During the spring and fall months, prescribed burns take place in the region, contributing to occasional smoke and haze issues. During the winter and spring months, fog occasionally forms due to radiational cooling from snow cover on the ground. However, this fog usually breaks up quickly by morning. In spite of the elevation, periods of low ceilings and limited visibilities are usually of short duration.

Observed Climate Variations and Changes in Flagstaff and the Southwest

The term "climate," in contrast to "weather," describes the accumulated variations in measurements of atmospheric parameters, such as temperature, precipitation, snow, wind, or phenomena, such as hail, fog, lightning, over time periods longer than one week. A standard length of observed records for characterization of the climate of a city or region is 30 years. In the Southwest, there are superb proxy records of past climate, preserved in the multi-century variations of tree rings.

Key characteristics of the historic and pre-historic climate of Flagstaff and the southern Colorado Plateau include the following:

- High year-to-year variability in precipitation and temperature, due, in part to the famous El Niño (wet winter) and La Niña (dry winter) climate patterns (Hereford, Webb and Graham, 2002; Hereford, 2007).
- Multi-decade episodes of wet and dry conditions, due to long-term variations in the Pacific Ocean, and the interactions of wind and storm systems with persistent warm and cool bodies of water in the Pacific (Hereford, Webb and Graham, 2002; Sheppard et al., 2002; Hereford, 2007).
- There is no significant trend in precipitation during the last 50-to-100 years (Hereford, 2007; Cayan et al, 2012). There have been distinct drought episodes, including one beginning in the mid-1990s that has resulted in many years of below average Flagstaff winter and spring precipitation (Hereford, 2007). Recent drought has been severe, with impacts including reduced surface water supplies, extensive tree mortality, and large wildfires.

Projected Future Climatic Change in the Southwest and the Southern Colorado Plateau

Modeling future climate change does not produce predictions in the way that daily weather forecasts produce predictions. Rather, climate models produce projections of possible futures, that depend not only on the ability of the models to reproduce the dynamics of the global climate system, but also on factors that influence future emissions of greenhouse gases – such as, global population, economics, development and adoption of new technologies, laws and regulations, and the politics of global socio-economic relations.

Depending on the emissions scenario, climate models show average annual temperature increases of 1-4°F in the period 2021-2050, 1-6°F between 2041 and 2070, and 2-9°F between 2070 and 2099. The greatest projected temperature increases are in the summer and fall. Climate models project an increase in multi-day summer heat spell frequency and intensity. Cold spells are projected to not occur as often, but their intensity is not expected to diminish.

For all time periods and emissions scenarios, climate models project both increases and decreases in average annual precipitation in the Southwest (Cayan et al., 2012; Reclamation, 2011). Spring precipitation is projected to decrease on the southern Colorado Plateau (Garfin et al., 2010); ranging from 9% to 29%, during the period 2070-2099.

and Hydrology is ~~projected to be~~ is affected in various ways, including a reduction in late winter/early spring snowpack, mostly because of the effects of warmer temperatures (Cayan et al., 2012), and a decreased availability of snowmelt to sustain runoff from late spring through early autumn (Reclamation, 2011). Climate model projections show depleted June 1 soil moisture throughout much of Arizona, and lower April through July streamflow runoff in the region encompassing Flagstaff. Future droughts are projected to be hotter, which, given the effect of temperature on the recent observed tree mortality episode (Breshears et al., 2005; Adams et al., 2009), which has implications for impacts to ecosystems, such as tree species viability and mortality and the geographic distribution of wildlife habitat. and other species (Fleishman et al., 2012).

Building Regional Resiliency by Reducing Climate-related Risk and Vulnerability

Regional climate risks are well enough known to justify some actions now that can ensure a safer, more resilient, and prosperous future. This is particularly true in the case of investments in critical public infrastructure. As climate changes, responses and standards that public institutions have historically relied upon to inform their decisions may need to be adapted to address the potential impacts of future weather and climate.

A commitment to climate adaptation and resiliency will help the region better respond to the impacts of weather and climate by complementing response and relief efforts with preparedness and prevention measures. Infrastructure investments and development will affect the region in the long-term, and public resources will need to work to increase the resiliency of the region to the future effects of climate. The City of Flagstaff Resiliency and Preparedness Study (2012) introduces a vision and path to create resilient public resources and services. The Study assesses vulnerability and risk of local systems, such as water, public health and forest health that are affected by climate variability and extremes. Resiliency is built through awareness of how changes in climate conditions can impact the community's critical resources and in turn, the region's priorities. See The City of Flagstaff Resiliency and Preparedness Study (2012)

Reducing vulnerability to the changing climate requires identifying how vulnerable local government's operating efficiency, public health, infrastructure and economic competitiveness are to climate variability. This also requires local government to know where it lacks sufficient capacity to adapt, and what the risks are if it does not act. Preparing now to be more resilient to these changes is fiscally responsible, while inaction now can lead to higher costs in the future.

The Flagstaff region has a long history of weathering adversity and emerging as a stronger, more cohesive community. As climate and related extreme weather conditions change, the region is beginning to innovate in original ways to prepare. One of the biggest challenges in building resiliency is that segments within communities and organizations face varying risks given the differences in the degree to which they can be affected and their ability to cope with climate extremes. Climate related extreme events around the world have shown that when local governments and communities are prepared (i.e. residents are educated and aware, informed, prepared, have access to appropriate resources), then the impacts of adverse effects of extreme climate events can be less severe.

Local governments have the opportunity to bolster their community's preparedness and resilience to everything from extreme storm events to economic shocks. The tools for doing so range from land use planning to transportation and economic development policy to emergency and disaster preparedness initiatives. By building resiliency within a region's land use and transportation systems, the Flagstaff region can be a place where:

- A diverse and thriving economy can adapt to changing weather patterns.
- Natural resources are actively managed to continue to provide important services to users.
- Robust public health and emergency management infrastructure, social networks and other social systems enable the region to minimize the health impacts of climate change.
- Lives, homes and infrastructure are prepared for extreme weather events and related flooding, wildfires, landslide, and other hazards.
- Municipal operations incorporate resiliency and adaptability into existing and future plans, policies and procedures.

Goal E&C.1: Build, maintain and protect public resources, safety, and infrastructure by preparing for and effectively managing extreme weather events and related flooding, wildfires, and other natural and human caused hazards.

Policy E&C.1.1: Develop water use policies ~~which attempt to~~ that integrate current best projections of climate and its impacts on the Colorado Plateau's water resources, emphasize conservation and water harvesting, and minimize the energy-intensive transport and pumping of water.

Policy E&C.1.2: Encourage energy efficiency and conservation in the public, commercial, industrial and residential sectors through policies and regulations that promote more efficient lighting, better insulation, and increased use of alternative energy for generation of electricity. — these are strategies

Policy E&C.1.3: Promote active management strategies such as the Forest Health and Water Supply Protection Initiative to increase the resiliency of our watersheds and water supply to the effects of climate variability to reduce the region's vulnerability to catastrophic wildfire and insect pest outbreaks and threats to public infrastructure.

Policy E&C.1.4: Maintain and restore important wildlife corridors throughout the planning area to allow wildlife to find suitable habitat in the face of climate change by moving along vegetational and elevational gradients. this is in wildlife section

Goal E&C.2: Take into account design and economic elements along with weather extremes in City and County planning for new development and supporting existing development needs.
this is in public facilities - reworded to make sense.

Policy E&C.2.1: Consider the exacerbation of impacts to government operations when weather is combined with the circumstances of an aging and growing population as well as differential exposures to pollution, poverty and access to resources. in 2012 Resiliency Study

Policy E&C.2.2: Promote transportation options such as increased public transit and more bike lanes that will reduce congestion, fuel consumption, and overall carbon emissions and promote walkable community design.

Refer to inset.

3. Goals and Policies

a. Climate

As a result of its high elevation, geographic location, and low humidity, Flagstaff is characterized by a pleasant four-season climate with average winter highs of 45 degrees, average summer highs of around 80 degrees, and almost 300 days of sunshine a year (Hereford 2007). The greater Flagstaff area is a year-round recreational haven for residents and visitors alike. Climate also plays a pivotal role in shaping the abundance and quality of our region's natural resources, including our water supply, the composition of our ecosystems, and the availability of wildlife habitat.

True to the general pattern of precipitation across the southwest, on average almost two-thirds of Flagstaff's annual rain falls in distinct winter and summer peaks. Afternoon thunderstorms originating from the south typically develop during the July to September "monsoon" season. Summer rain is more abundant than winter, and less variable than rainfall in winter and spring. Long-term average annual precipitation in Flagstaff is 21.6 inches per year, and the amount can vary considerably from year to year (Hereford 2007). Winter and summer precipitation do not contribute equally to Flagstaff's water supply. Due to the greater amount of evaporation and surface runoff that occurs during monsoon season, summer precipitation does not appreciably increase available water supply, but can reduce peak water demand. Conversely, winter precipitation in the form of rainfall or snow increases the annual springtime surface water yield of bodies such as Lake Mary reservoir and the Inner Basin springs, despite its greater variability (Hereford 2007). Adequate snowfall plays a key role in providing the economic benefits that arise from Flagstaff's abundant winter recreational opportunities. Snow may fall in any season and averages, about 100 inches annually in the city. Extreme winter snowstorms may occur.

Local variations in climate play a major role in shaping the range of vegetation communities, ecosystems, and associated wildlife found in the region. While ponderosa pine forests predominate, elevation gradients of temperature and precipitation result in a diversity of plant communities ranging from arid grassland and pinyon-juniper shrubland at lower elevations of 4,000 feet [check facts] to mixed conifer and alpine tundra at the summits of the San Francisco Peaks at 12,800 feet [check facts].

Historic records from weather stations and prehistoric climatic indicators such as tree ring widths suggest that Flagstaff and the southwest in general have long been characterized by alternating dry and wet periods, and that these have sometimes lasted for many decades or even longer (Hereford et al. 2002, Hereford 2007). The past decade has seen a prolonged period of elevated temperatures and drought across the southwest and associated water level drops in many regional reservoirs (Univ. Colorado at Boulder 2009), and 1950-2007 records from the National Weather Service station at Pulliam Airport indicate the period since 1996 has been the driest during this interval in the Flagstaff area (Hereford 2007). Compared to other areas of the country, the increase in average temperatures in the southwest in recent years has been among the highest (U.S. Global Change Research Program 2009).

An unanswered question with large implications for future planning and conservation efforts in the Flagstaff area is the extent to which the recent trend toward a drier and hotter climate reflects a permanent shift associated with global climate change, and how this predicted warming will impact our