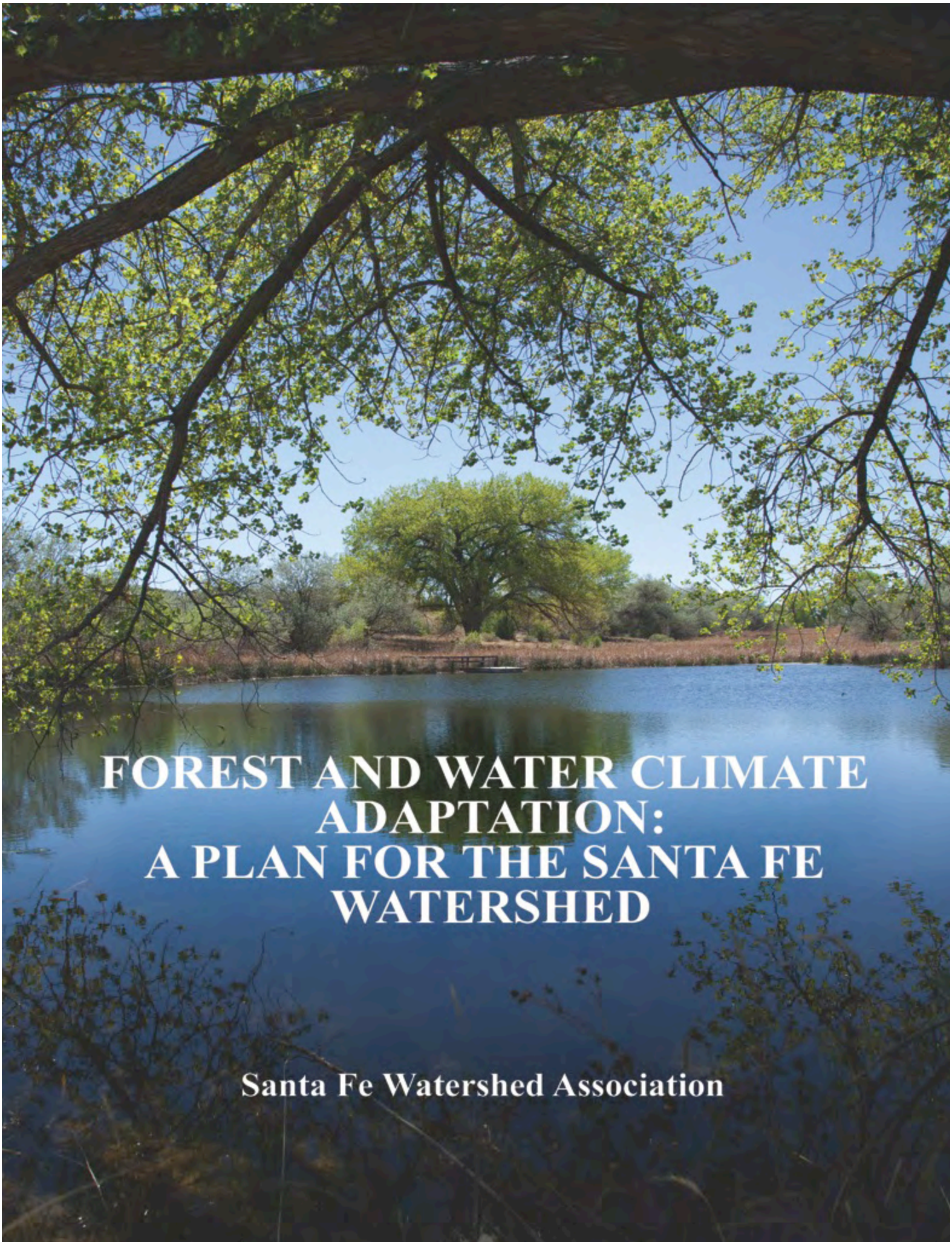


FOREST AND WATER CLIMATE ADAPTATION: A PLAN FOR THE SANTA FE WATERSHED

Santa Fe Watershed Association

FOREST AND WATER CLIMATE ADAPTATION: A PLAN FOR THE SANTA FE WATERSHED

Santa Fe Watershed Association

City of Santa Fe

Model Forest Policy Program

Cumberland River Compact

December 30, 2013
Revised, April 7, 2014

Author:

Esha Chiocchio

Editors:

Gwen Griffith, Toby Thaler, Todd Crossett, Alyx Perry, and Ray Rasker

Jemez y Sangre
Regional Water Planning Council

Model Forest Policy Program

Suggested citation: Chiocchio, E. & Thaler, T., Griffith, G., Perry, A., Crossett, T., Rasker, R. (Eds). 2013. *Forest and Water Climate Adaptation: A Plan for the Santa Fe Watershed.* Model Forest Policy Program in association with Santa Fe Watershed Association, the City of Santa Fe, Cumberland River Compact and Headwaters Economics; Sagle, ID.

Available for download from: www.mfpp.org
Date of publication: December, 2013
© 2013 Model Forest Policy Program

Copyright

It is the intent of the authors and copyright holder that this plan be implemented and used as a model for climate adaptation planning by other communities. Any part of this plan may be reproduced without permission for non-commercial purposes provided that it is reproduced accurately and not in a misleading context and the source of the material is clearly acknowledged by means of the above title, publisher, and date. The wide dissemination, reproduction, and use of the plan for non-commercial purposes are all encouraged. Users of the plan are requested to inform the Model Forest Policy Program at:

Model Forest Policy Program, P.O. Box 328, Sagle, Idaho 83860
ngilliam@mfpp.org, (509) 432-8679; www.mfpp.org

No use of this publication may be made for resale or any other commercial purpose whatsoever without prior permission in writing from the Model Forest Policy Program.

Cover photo © 2013 Esha Chiocchio

Disclaimer

The material in this publication does not imply the opinion, endorsement, views, or policies of the Model Forest Policy Program, the Cumberland River Compact or Headwaters Economics.

TABLE OF CONTENTS

GLOSSARY OF TERMS AND ABBREVIATIONS

Acequia:	A community operated watercourse used in Spain and former Spanish colonies in the Americas for irrigation. Also known as a ditch.
Acre feet (af):	The volume of water that is needed to cover an area of one acre to a depth of one foot. 43,560 cubic feet or 325,851.429 US gallons.
Arroyo:	A watercourse or gulch with a nearly flat floor that is usually dry, except after heavy rains.
Mayordomo:	An elected official responsible for the day-to-day management of an acequia.
Parciantes:	Members of an acequia who maintain and draw water from their affiliated acequia.

ASR:	Aquifer Storage and Recovery
BCC:	Board of County Commissioners
BDD:	Buckman Direct Diversion
BLM:	Bureau of Land Management
BOR:	Bureau of Reclamation
CIP:	Capital Improvement Plan
CNG:	Compressed Natural Gas
CWA:	Clean Water Act
CS:	Community Solar
CSU:	Climate Solutions University
DNR:	Department of Natural Resources
EERE:	Energy Efficiency and Renewable Energy
EPA:	Environmental Protection Agency
ESA:	Environmental Species Act
EUE:	Efficient Use of Energy Act
FDSI:	Forest Drought Stress Index
FEMA:	Federal Emergency Management Agency
GCC:	Green Chamber of Commerce
GCM:	General Circulation Models
GUEP:	Georgetown University Energy Prize
GPCD:	Gallons per Capita per Day
GPS:	Global Positioning System
LEED:	Leadership in Energy and Environmental Design
LLC:	Limited Liability Corporation
NDVI:	Vegetation Greenness Index
NEE:	New Energy Economy
NMED:	New Mexico Environment Department
NPDES:	National Pollutant Discharge Elimination System
PNM:	Public Utility of New Mexico
PPA:	Power Purchase Agreement
PRC:	Public Regulation Commission
PV:	Photovoltaic (solar panels)

QWEL:	Qualified Water Efficient Landscaper
REC:	Renewable Energy Credit
SC:	Sierra Club
SFAHAB:	Santa Fe Area Homebuilders Association
SFCC:	Santa Fe Community College
SFPP:	Santa Fe Public Power
SFWA:	Santa Fe Watershed Association
SSFC:	Sustainable Santa Fe Commission
SWQB:	Surface Water Quality Bureau
TMDL:	Total Maximum Daily Loads
TNC:	The Nature Conservancy
WQ:	Water Quality
WUI:	Wildland Urban Interface
UN:	United Nations
USDA:	United States Department of Agriculture
USFS:	United States Forest Service
USFWS:	United States Fish and Wildlife Service

FOREWORD

In 2013, the Model Forest Policy Program (MFPP), the Cumberland River Compact, and Headwaters Economics came together with the Santa Fe Watershed Association and the City of Santa Fe to create a climate adaptation plan for the Santa Fe watershed. Development of the plan came about because all parties, led by MFPP, recognized the critical need for local community resilience against the impacts of climate change by protecting forest and water resources. This climate adaptation plan for the Santa Fe watershed presents the results of a community team effort, deep and broad information gathering, critical analysis and thoughtful planning. The Santa Fe Watershed Association took the local leadership role to engage with the Climate Solutions University: Forest and Water Strategies program (CSU) and lead their community toward climate resilience with an adaptation plan that addresses their local climate risks and fits their local conditions and culture. This achievement was made possible by the guidance and coaching of the Climate Solutions University: Forest and Water Strategies program (CSU) created by the Model Forest Policy Program in partnership with the Cumberland River Compact and the assistance of Headwaters Economics. The goal of CSU is to empower communities to become leaders in climate resilience using a cost effective distance-learning program. The result of this collaborative effort is a powerful climate adaptation plan that the community can support and implement in coming years. The outcome will be a community that can better withstand impacts of climate upon their natural resources, economy and social structure in the decades to come.

ACKNOWLEDGEMENTS

A big thank you to those who contributed their time and expertise to the creation of this plan, specifically, the members of the planning team. Additional thanks to Jamey, Zubin and Ciela Stillings for their time and support.

Support from Climate Solutions University would not have been possible without the major funding of The Kresge Foundation and other funders, which allowed CSU to develop the in-depth curriculum and provide grants for local community participation.

The team that leads the CSU program includes: Nancy Gilliam, Gwen Griffith, Todd Crossett, Toby Thaler, Alyx Perry, Margaret Hall, Jeff Morris, Ray Rasker, Vanitha Sivarajan, Josh Dye, and Mike Johnson.

Thank you to the CSU community representatives in PA, OR, MI, and AK for their suggestions, inspiration and expertise.

EXECUTIVE SUMMARY

Long periods of drought, unprecedented storm events, warmer average temperatures, rising seas, unpredictable weather patterns - we are already seeing the impacts of a changing climate. Whether we like it or not, we are entering a period of warming on a global scale that is shifting weather patterns everywhere.

Here in the southwestern United States, these changes are being expressed through reduced snow pack, shifting precipitation patterns, decreased water supplies, and increased temperatures. As a result, we have already experienced catastrophic wildfires, flooding and reduced agricultural yields. Trends we expect to continue.

Fortunately, there is something we can do about it. Seeing these patterns taking hold, The Santa Fe Watershed Association (SFWA) contracted with the Model Forest Policy Program (MFPP) to develop a climate adaptation plan through their Climate Solutions University (CSU) planning process. A team of experts from the greater Santa Fe community worked with CSU to develop this plan from a holistic perspective to identify the most pressing vulnerabilities and create an action plan to add long-term resilience to the Watershed and Santa Fe community.

Over the course of several months, the planning team studied the predicted climate shifts as well as the forest, water and economic vulnerabilities of the area. From this information, they used a prioritization system to analyze the climate risks and determine the areas of highest priority. Perhaps not surprisingly, the resulting priorities include: reduced water supplies; increased risk of wildfire and forest degradation; flooding; and a dearth of job opportunities to retain and attract working families. Taking into consideration the pillars of sustainability, (environmental stewardship, economic health and social justice) the planning team developed five goals that

GOAL 1: Increase the water security and ecological integrity of the Santa Fe Watershed through conservation, infiltration, groundwater recharge, and reuse.

GOAL 2: Improve forest and ecosystem health for resilience in the face of climate change.

GOAL 3: Expand and develop the workforce-training programs needed to implement this plan.

GOAL 4: Increase energy efficiency and renewable energy (EERE) to reduce the use of fossil fuel-derived and water consumptive energy sources.

GOAL 5: Establish financing systems that facilitate investments, emergency funds, and cash flow availability to fund climate adaptation and innovation initiatives.

address these issues and have the greatest chance of long-term success.

The implementation of these goals will take time and resources. However, it is imperative that we continue to tackle the vulnerabilities we know exist on multiple levels. History tells us that when communities are faced with changes such as these, there are three potential strategies and outcomes: 1) they do nothing and are subject to the environmental impacts that ultimately destroy their cities, 2) they migrate from the area, or 3) they proactively work to adapt to the changes and ultimately thrive. What do we want for Santa Fe?

Through climate adaptation planning we can increase the resilience of our landscapes while improving our economy and creating new job opportunities. Specific strategies are available to safeguard water resources and reduce hazards from storms, fires and floods. These strategies include increasing rainwater infiltration, developing water reuse systems, expanding forest thinning treatments, improving the functionality of our rivers and arroyos and developing long-term financing structures that enable all of this work to be implemented.

As this plan is put into practice, its progress should be continually monitored and evaluated to determine if benchmarks are being met and changes should be made. This is a living document that provides suggestions to strengthen our resilience given the information that we have today. With time, conditions and resources may change, requiring a nimble approach to the implementation of the action steps.

Our overarching goal is to ensure that Santa Fe thrives for centuries to come. What will be your role in shaping Santa Fe's future?

INTRODUCTION

Photo 1: A patio at the Randal Davey Audubon Center exemplifies the adobe architecture of Santa Fe. *Source: Esha Chiocchio.*

Community Introduction

The Santa Fe River watershed is nestled at the southern tip of the Sangre de Cristo Mountains in the high desert region of north-central New Mexico. At an elevation of 7,000 feet, the city of Santa Fe enjoys four distinct seasons and the recreation activities that go with them: skiing, cycling, hiking, horseback riding, and more. Santa Fe has long been known for its artist community and boasts the third largest art market in the country (behind the much larger cities of New York and Los Angeles). It is also home to three annual events that bring thousands of visitors to our fine city: the Indian Market, the Spanish Market and the Folk Art Market. Hundreds more come to experience our world-renown *plein-aire* opera house, numerous concerts of all genres, and countless lectures by some of the world's most influential thinkers.

With so much emphasis on art and culture, much of Santa Fe's economy is dependent on tourism. People come to enjoy the charming adobe architecture, the winding streets, the galleries and museums and the mountains that provide such beauty and beckon us outdoors.

However, those mountains, and the forests that cover them, also represent a lynchpin for the community. When they are healthy and functioning optimally, they provide our drinking water, habitat for countless species, help stabilize soils, influence weather patterns, help cool the micro-climate and generally provide a certain degree of stability. Due to a convergence of factors, namely a century-long policy of fire suppression and an increase in temperatures due to climate change, these critical forests are at risk. Throughout the west, catastrophic forest fires and insect infestations have decimated huge swaths of forested lands, some frighteningly close to the Santa Fe watershed. With high tree densities due to fire-suppression, and increased temperatures due to climate change, these forests burn hotter than they would normally, leaving little life in their wake. In addition to the loss of forest cover and habitat, fires of this nature destroy the trees and vegetation that once stabilized the slopes, presenting significant flooding risks that can quickly fill reservoirs with sediment and debris, reducing the water storage capacity for the community.

As temperatures rise, another risk presents itself in the lower elevations of the watershed: desiccation. Similar to the situation in our forests, a convergence of century-long bioregionally inappropriate management practices and global climate shifts have slowly moved water out of the watershed, reducing groundwater supplies and soil moisture levels. In short, Santa Fe's infrastructure was designed to move water out of the streets and away from buildings as quickly as possible. However, in a city that only receives 12 inches of rain per year, the trees, plants and soil are in need of as much moisture as they can get.

Planning for a Changing Climate

In order to create a plan that increases the resiliency of the Santa Fe watershed in the face of a changing climate, the Santa Fe Watershed Association (SFWA) partnered with the Model Forest Policy Program (MFPP) to undergo a planning process through their Climate Solutions University (CSU) program.

The SFWA works to build vibrant, resilient ecosystems within the Santa Fe Watershed using a holistic approach of restoration, education, stewardship, and advocacy. SFWA staff builds alliances among decision makers, community members, business owners, and other organizations to promote smart resource planning and use, especially regarding water, within the watershed.

With this mission in mind, SFWA partnered with CSU to undergo a nine month planning process to develop a climate adaptation plan that would increase the resiliency of the Santa Fe watershed and reduce the risks and impacts of fire, flooding, drought and the economic hardships associated with the predicted impacts of climate change in the region.

The development of this climate adaptation plan was made possible through the guidance of the CSU staff and the Santa Fe watershed planning team, led by Esha Chiocchio. During the planning process, CSU presented bi-weekly webinars and engaged in coaching calls to help guide the team in gathering and synthesizing the necessary information. The Santa Fe team collaborated to produce this plan via bi-monthly meetings, email correspondence, webinars, and data exchange.

The local Santa Fe planning team consists of the following individuals:

Claudia Borchert, Water Resources Coordinator, City of Santa Fe Water Division
Felicity Broennan, Executive Director, Santa Fe Watershed Association
Esha Chiocchio, Climate Solutions Coordinator, Santa Fe Watershed Association; Vice-chair, Sustainable Santa Fe Commission (SSFC); and Chair, SSFC Energy Committee
Carl Dickens, President, La Cienega Valley Association
Brian Drypolcher, River and Watershed Coordinator, City of Santa Fe
Melissa Houser, Conservation and Stewardship Coordinator, Santa Fe Conservation Trust
Jan-Willem Jansens, Owner/Principle, Ecotone
Dale Lyons, Former Water Resources Coordinator, City of Santa Fe Water Division. Current Director of Fresh Water Programs, The Nature Conservancy
Katherine Mortimer, Sustainable Santa Fe Programs Manager, City of Santa Fe
Charlie Nylander, President, Water Matters, LLC.; Chair, Jemez y Sangre Regional Water Planning Council; Chair, Española Basin Technical Advisory Group; and Chair, Española Basin Regional Issues Forum
Mary Orr, Wildlife Biologist, U.S. Forest Service, Santa Fe National Forest
José Varela-Lopez President, Santa Fe-Pojaque Soil and Conservation District and member of the La Cienega Valley Association.

In addition to the core team, a group of advisors provided their expertise for specific portions of the plan. These include:

Bill Armstrong, United States Forest Service
Jon Boe, United States Forest Service
Ben Gurule, Santa Fe Parks Division Director
Katherine Harris Tijerina, Railyard Stewards Executive Director
Melissa McDonald, Santa Fe Water Conservation Committee
Mariel Nanasi, New Energy Economy Executive Director
Craig O'Hare, Santa Fe County Energy Programs Specialist
Grace Perez, Santa Fe Water Conservation Committee
Alex Puglisi, City of Santa Fe Water Division
Teresa Seamster, Sierra Club
Lara Wood Miller, The Nature Conservancy
Bob Wood, Urban Forest planner, City of Santa Fe

Photo 2: Children playing in the Santa Fe River during the spring flow of 2012.
Source: Esha Chiocchio.

CLIMATE PROJECTIONS FOR THE SANTA FE WATERSHED

The projected changes in climate conditions present an uncertain future for Santa Fe County. The high quality of life and picturesque landscapes that draw and keep people here could be in jeopardy due to changes in average temperature, stream flows, and precipitation.

Already, Santa Fe County is experiencing some unsettling signs of change. Over the past century, average temperatures in New Mexico have been increasing 50 percent faster than the global average at a rate of almost two degrees Fahrenheit since 1976. Annual precipitation patterns are also shifting. More precipitation is falling as rain, rather than snow, causing the spring thaw and peak runoff to come earlier, resulting in lower late summer flows. Projections in a study by the Bureau of Reclamation for the state of New Mexico forecast "a) declines in precipitation in the Rio Grande and Lower Colorado Basins of two percent or more by 2070, b) increases in temperatures of five degrees Fahrenheit, c) drastic declines of 70 to 100 percent in snowpack, and d) large declines of 20 percent or more in annual runoff" (Repetto 2012).

Photo 3: Newspaper vendor holding a newspaper with the headline "Unbelievable Rain" during the rainstorms that flooded Boulder, Colorado. *Source: Esha Chiocchio.*

Scientists anticipate that these trends will intensify. We can expect to see more frequent extreme droughts, larger wildfires, more insect infestations, greater stress on our wildlife and outbreaks of invasive species and disease due to the hotter and drier climate. It is anticipated that a growing percentage of precipitation will fall in heavy storms, leading to a higher frequency of spring floods (Repetto 2012). Recently, Boulder, Colorado received more rain in a short period of time

than they typically receive over an entire year, in what was labeled as a 1000-year flood (Yulsman 2013). Given the similarities in our climates, such extreme weather could just as easily happen in Santa Fe. Massive loss of life and property was the result, which will require years of recovery time. The effects of the intense rainfall was made worse by an upstream forest fire the year before, leaving bare hillsides unable to slow down and absorb the heavy rain. This scenario is what the climate models predict will occur more frequently in many parts of the country.

While we cannot predict the exact trajectory of change, we can prepare for the future based on a reasonable range of expected scenarios – and we should. By preparing now, we can limit the economic, environmental and social impacts of climate change while strengthening the resiliency of our fine city and surrounding watershed.

In order to better understand the climate projections for this area, the City of Santa Fe, Santa Fe County and the Bureau of Reclamation conducted a community climate change workshop in 2012 and produced *Climate Change in the Santa Fe Watershed: A Preliminary Assessment*. Below is an excerpt from the report that describes the climate predictions for the area.

Climate Change: What the Science Says
From "Climate Change in the Santa Fe Watershed: A Preliminary Assessment"

Human activities are increasing concentrations of greenhouse gasses such as carbon dioxide and methane in the atmosphere, and these gases trap heat near the Earth's surface. In response, global average air temperatures near the Earth's surface are rising; oceans are warming and expanding; land-based ice is melting; sea ice is thinning; permafrost is melting; precipitation patterns are shifting; and plants and animals are growing, migrating, and responding in different ways, places and times. Evidence for climate change documented throughout the world is concordant with the climate science and physics captured in global climate modeling; there is no longer any doubt that the earth's climate is changing (Gutzler 2012).

The lasting effects of the greenhouse gasses that have been released to date commit us to a certain degree of climate change, regardless of future emissions, and currently, global emissions are accelerating rather than decreasing. Therefore, human activities are committing the planet to increasing warming. This means that, in addition to working to limit future emissions and associated warming, the Santa Fe community needs to adapt to existing and at least near-future climate changes. This section discusses the general impacts climate change is likely to have on the Santa Fe Basin.

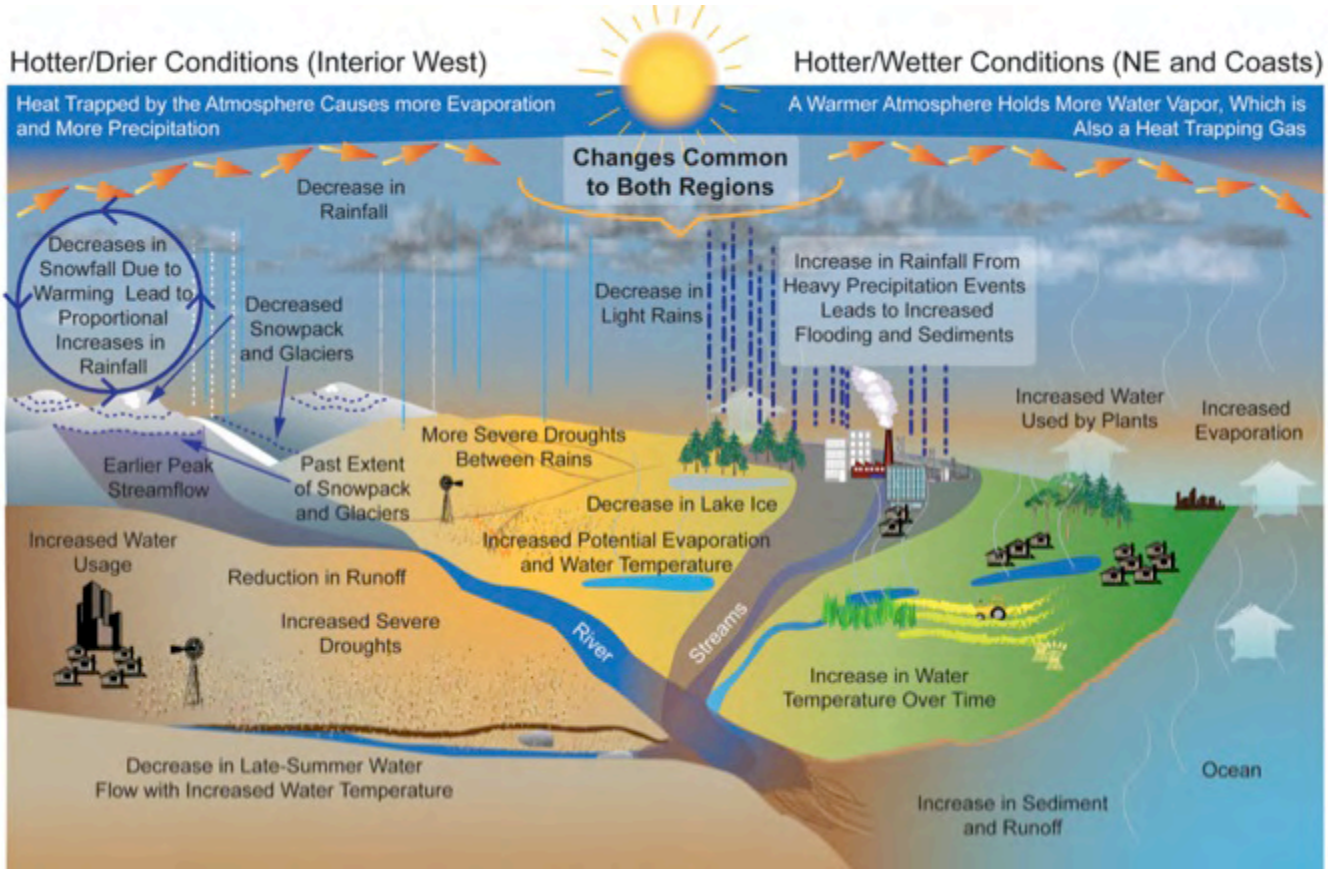


Figure 1: Projected changes in the water cycle. *Source: U.S. Global Change Research Program, 2009.*

Climate Change Projections for the Santa Fe Basin

Climate change is already occurring in the Santa Fe Basin, as evidenced by measured temperature increases. Average air temperatures in the watershed have risen about 2^{o} F since 1900 (Gutzler, 2012). Continuing CO_2 emissions around the world will trap additional heat near the Earth's surface, so that temperatures will continue to rise for the foreseeable future, in the Santa Fe watershed and elsewhere. Global climate models (called General Circulation Models, or GCMs) project that air temperatures in the Santa Fe Basin could increase an additional 5.5 to 6.5^{o} F by 2100 (Gutzler, 2012; Figure 2). Increasing temperatures impact the circulation of moisture in the atmosphere, which in turn impacts precipitation patterns. Simultaneously, warmer air holds more moisture and tends to dry out the soils more rapidly. Though models suggest that the amount of precipitation that falls in the Santa Fe watershed may remain relatively unchanged, when and how it falls is likely to shift. The combination of increasing temperatures and changes in precipitation patterns will significantly impact Santa Fe and surrounding communities, lands and ecosystems.

Future climate changes are not going to be smooth, steady changes over time. Instead, climate change is expected to increase the variability of the already extremely variable climate. Currently, record wet spells can be followed by record droughts; record-breaking, hot summers followed by record winter cold-spells. Climate change is likely to bring even more variability: higher high temperatures and higher low temperatures, plus more variability within and between seasons and from year to year. Spring and fall weather may become even more mercurial, with implications for plant survival and growth. Individual precipitation events may become more intense, while dry periods become longer and hotter. These impacts will exacerbate the already formidable water-management challenges in the Santa Fe basin, and may also create new water challenges.

Climate Change Impacts to Santa Fe Basin Hydrology

Projected changes in temperature and precipitation will have implications for summer aridity, for winter precipitation (increasingly falling as rain rather than snow), and for spring snowmelt runoff timing and volume.

Global climate models project a transition to a much more arid climate in the Southwest by the mid-21st Century, primarily due to increasing rates of evaporation and increasing water use by plants, which will result from the projected higher temperatures. Evaporation and plant water use are directly related to surface temperature; warmer air holds more moisture. If precipitation remains relatively constant and evaporation and plant water use increase, then surface runoff and groundwater recharge will decrease. Irrigation water demand and riparian water consumption will increase, and non-irrigated vegetation will likely become water stressed.

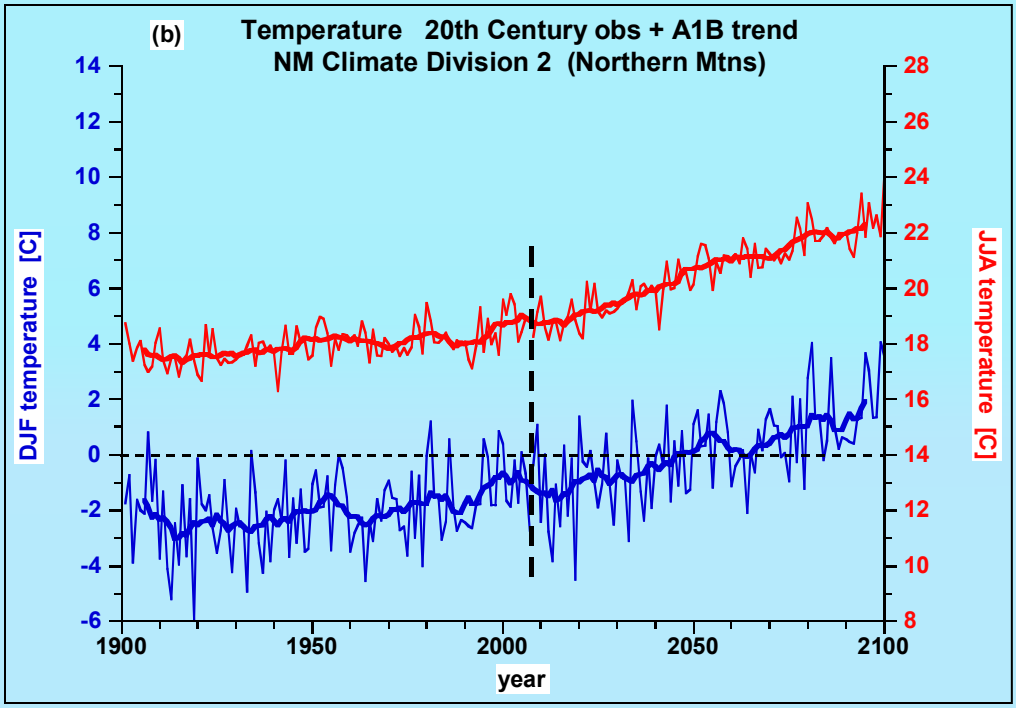


Figure 2: Measured and projected temperatures for winter (blue) and summer (red) seasons, 1900 to 2100, according to the IPCC A1B emission trends which assume a balanced portfolio of energy sources. *Source: Gutzler and Robbins 2010.*

Higher temperatures will also impact winter snowpack depth and spring snowmelt timing and volume. Climate models project decreases in snowpack throughout the western mountains because, as temperatures increase, more winter precipitation is expected to fall as rain rather than snow. By mid-century, the Southern Rocky Mountains are projected to experience a 20 to 70% reduction in March snowpack.

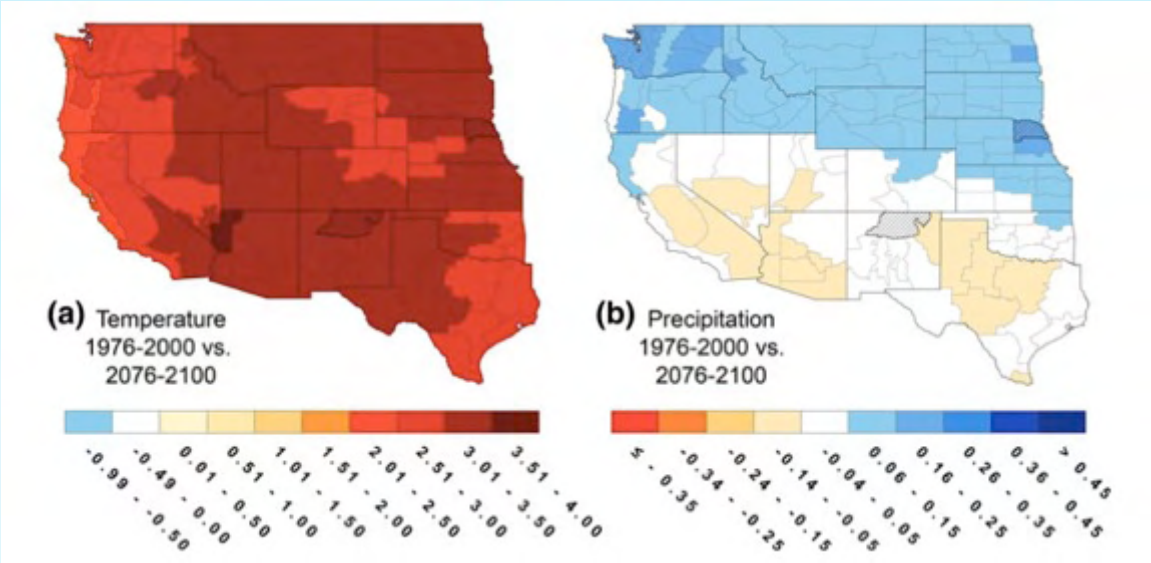


Figure 3: Temperature and precipitation predictions for the southwestern United States comparing 100-year differences between the last quarter-century of the twenty-first and twentieth centuries. *Source: Gutzler and Robbins 2010.*

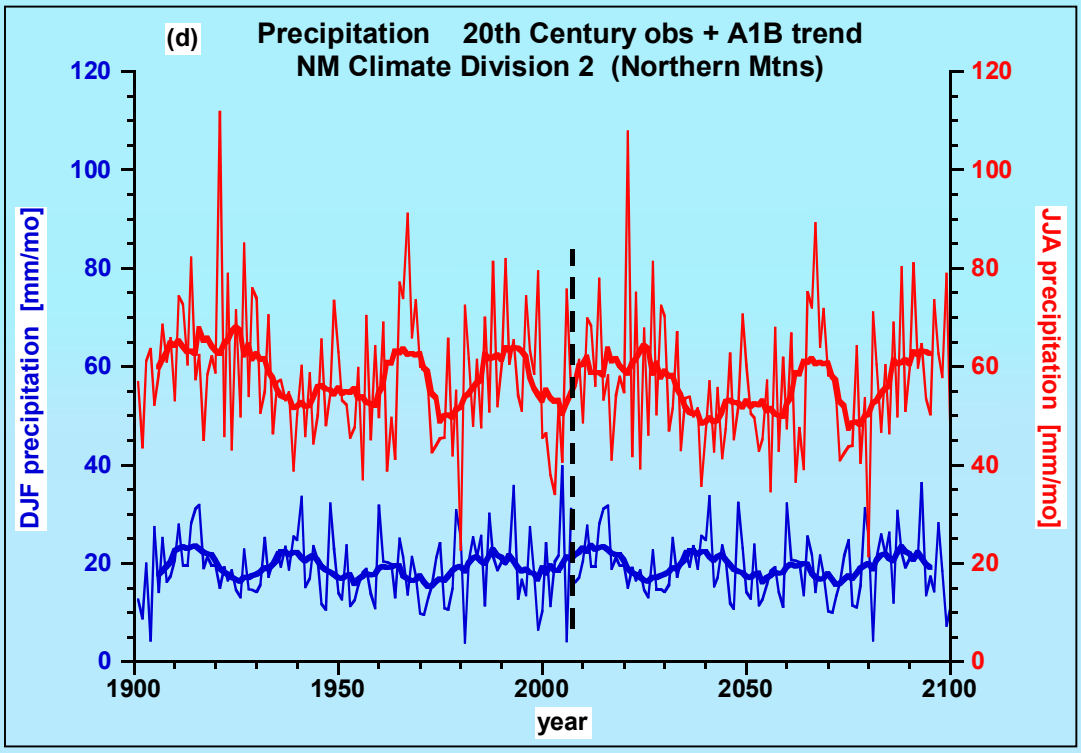


Figure 4: Measured and projected annual precipitation for winter (blue) and summer (red) seasons, 1900-2100, based on the ICPP's A1B greenhouse gas emission scenarios.
Source: Gutzler and Robbins 2010.

What snow does fall will melt earlier, due to higher spring temperatures, rain falling on snow, or intense spring windstorms blowing dust onto the snow, making it absorb more sunlight and melt faster. By 2050, spring runoff could be 15 to 35 days earlier than it was historically. This much-earlier peak runoff date, driven by warmer temperatures, may also have lower peak flows, due to less snow. Should snowmelt occur more suddenly, upper Santa Fe watershed reservoirs (McClure and Nichols) may fill in a relatively brief period and then overflow. Less snowmelt would result in reduced stored water. Overall, less water may be available in the future, and may result in reductions to the Santa Fe River water supply.

Snowpack currently feeds a late-spring flood pulse on the upper Rio Grande and its tributaries. In their 2008 paper, Hurd and Coonrod found that in the warmer climate projected for New Mexico; there would be an earlier and smaller snow-fed flood pulse, and a reduced total stream-flow volume, especially in the late spring to early summer. Their projected reductions in flow for the Middle Rio Grande are (Hurd and Coonrod, 2008):

2030: 4 - 14% reduction
2080: 8 - 29% reduction

Santa Fe River stream-flow projections are similar to those for the Middle Rio Grande. Cox et al., in their 2011 modeling analysis, project an annual decrease in stream flow above McClure Reservoir of 11-18% by 2060 compared to the historic record from 1950 to 1999. GCM

temperature and precipitation projections, and their associated impacts to snowpack, snowmelt, stream flow, evaporation and plant water use, have significant implications for virtually all water-related systems in New Mexico. Changes in volume and timing will impact reservoir storage and river operations; these in turn will affect water availability for urban, agricultural and ecosystem use. Changes in precipitation intensity and snowpack may impact groundwater recharge. All systems that depend on water need to be evaluated for their vulnerability to reduced water availability and changes in the timing of water availability, and for their sensitivity to high or highly variable temperatures, aridity, and drought.

Potential Effects of Climate Change on New Mexico

The projections of late 21st century New Mexico climate below are based on the assumption that global anthropogenic emissions of greenhouse gases continue to increase in a "business as usual" fashion, with no measures undertaken to reduce emissions globally:

Temperature

- *Average New Mexico air temperature substantially warmer*
- *Greater warming of winter temperatures, nighttime minimum temperatures, and higher-elevation temperatures*
- *More episodes of extreme heat*
- *Fewer episodes of extreme cold*
- *Longer annual frost-free periods*

Precipitation

- *A higher proportion of winter precipitation falling as rain; earlier snowmelt where snow still accumulates*
- *More extreme events (torrential rain, severe droughts)*
- *Potential exacerbation of historical patterns of wet and dry cycles, including likely recurrence of multiyear drought (like the 1950s)*

Source: Climate Change in the Santa Fe Watershed: A Preliminary Assessment, Technical State Agency Working Group, State of NM, 2005. This effort includes the evaluation of Southwest climate experts Dr. David Gutzler and Dr. Overpeck.

ECONOMICS AND THE ENVIRONMENT

Photo 4: Art is everywhere in downtown Santa Fe, as exemplified by this bronze stature near the plaza. *Source: Esha Chiocchio.*

Trends and Conditions

Santa Fe County has a rich history, enchanting landscapes and a vibrant art community. Boasting the third largest art market in the country, as well as many opportunities for recreation, including hiking and skiing, Santa Fe is an attractive tourist destination and locale for second homes. Over the past thirty years, the services sector, which includes the services related to tourism, has seen a growth rate of over 300% and currently employs 28,419 people in the County (U.S. DOC 2012a).

According to Robert Repetto's report, *New Mexico's Rising Economic Risks from Climate Change*, "In 2002, Santa Fe's arts and cultural industries and cultural tourism generated over $1 billion in receipts, employed 12,567 workers (17.5 percent of total employment in Santa Fe county), and paid $231.5 million in wages and salaries – numbers that have undoubtedly increased since then. Most of the spending is done by out-of-state visitors" (Repetto 2012).

With all of these tourists discovering the beauty of the area, the overall population of Santa Fe County has seen a significant increase in the past 40 years from 55,026 in 1970 to 145,648 in 2011. Between 2000 and 2011, Santa Fe County grew by 12% (15,808 people) with 65% of that

growth attributed to migration. By comparison, the City of Santa Fe has seen an increase of 9.2% with 62,203 people in 2000 and 67,909 people in 2011 (U.S. DOC 2012a, U.S. DOC 2000).

Many of those moving to Santa Fe County are retirees, as reflected in the shift in the median age from 37.9 in 2000 to 42.6 in 2011. With more people retiring in Santa Fe, the population has aged by 12.4% since 2000 (USDOC 2012b, U.S. DOC 2000).

In addition to an influx of retirees, the shift in the median age has been influenced by an exodus of 35 to 44 year olds, which saw a decrease of 3,014 individuals between 2000 and 2011 as shown in the graphs below (U.S. DOC 2012b, U.S. DOC 2000).

This shift in the median age of the population has led to an increase of 55.9% in the health care and social assistance service jobs between 2001 (6,638 jobs) and 2011 (10,350 jobs). As the baby boomer generation retires, the need for services will continue to increase and there may not be enough young people who are able to fill those positions.

The older generations are also more susceptible to the health impacts associated with climate change. As global warming raises the average temperature of our planet, heat waves are increasing in frequency, length and intensity. During an unprecedented heat wave in 2003, as many as 35,000 people died in Europe, sounding the alarm bell for the need for heat-related emergency preparedness (NRDC 2008). Many communities around the world are developing climate-health warning systems. Santa Fe recently began sending text messages to resident cell phones and airing public service warnings on radio stations to warn people of potential flash floods during storm events. Such warning mechanisms can be expanded to warn of extreme heat waves and other weather threats. In order to expand the reach of this program, a "buddy system" could be established so that individuals check in with vulnerable populations during climate disruptions.

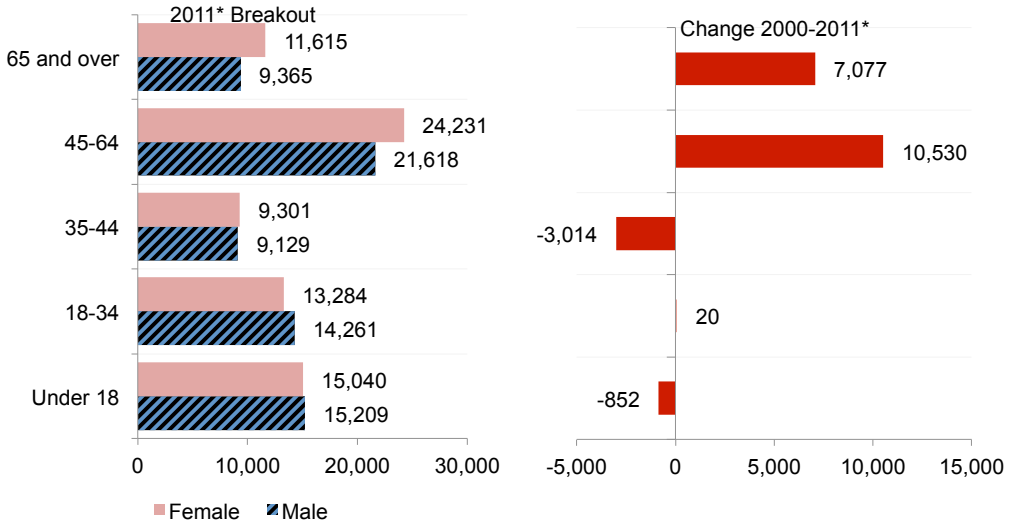


Figure 5: Santa Fe County 2011 population distribution and the change in population distribution between 2000 and 2011. *Source: U.S. DOC 2012b, U.S. DOC 2000.*

As health-care related jobs have increased, the manufacturing, construction and farm industries have seen decreases of 33.9%, 31.6 % and 23.8% respectively (U.S. DOC 2012a).

To revitalize the job market and attract younger employees and entrepreneurs to the area, climate adaptation projects can potentially attract those with expertise in water, forestry, storm water management and renewable energy.

Santa Fe County has an educated population, with 39.6% of the people over the age of 25 with a bachelor's degree or higher. As seen in the graph below, this is significantly higher than the state and national percentages and is a great asset to our community (U.S. DOC 2012b).

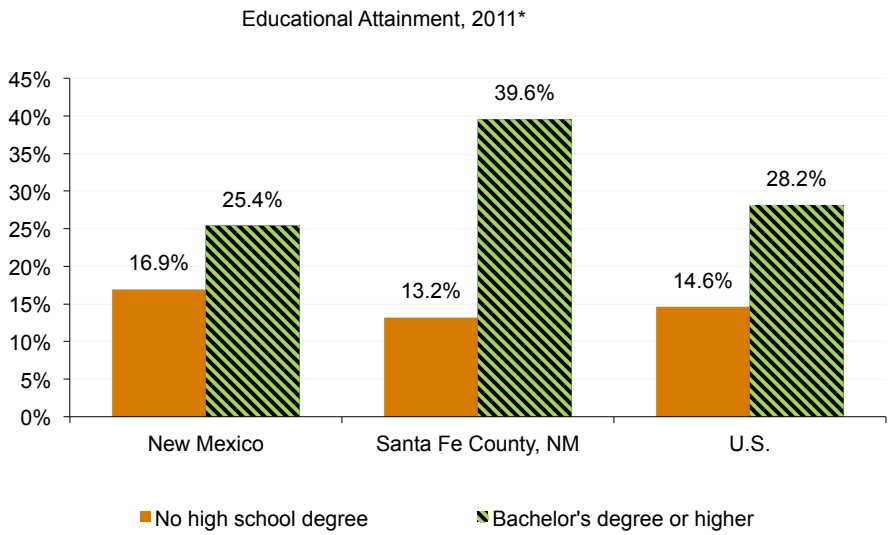


Figure 6: Educational attainment of residents of Santa Fe County in 2011.
Source: U.S. DOC 2012b.

Income within the County indicates there is a significant percentage of the population that is living below the poverty level. Between 2007 and 2011, the bottom 40% of households in Santa Fe County accumulated approximately 9.4% of total income, and the top 20% of households accumulated approximately 54.8% of total income. The graph below illustrates the income distribution for the County (U.S. DOC 2012b).

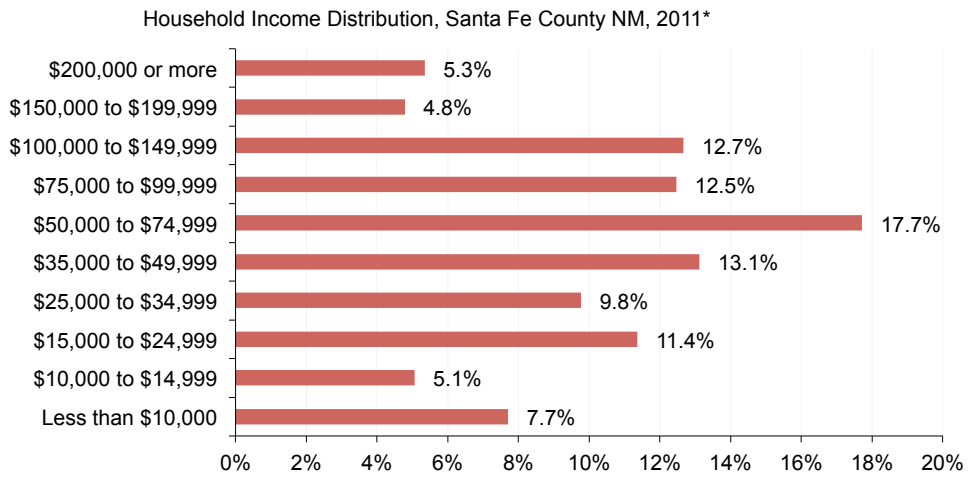


Figure 7: Santa Fe County household income distribution in 2011, based on annual surveys conducted during 2007-2011. *Source: U.S. DOC 2012b.*

By comparison, the per capita income and median household rate in Santa Fe County is slightly higher than that of the United States and significantly higher than that of New Mexico (U.S. DOC 2012b).

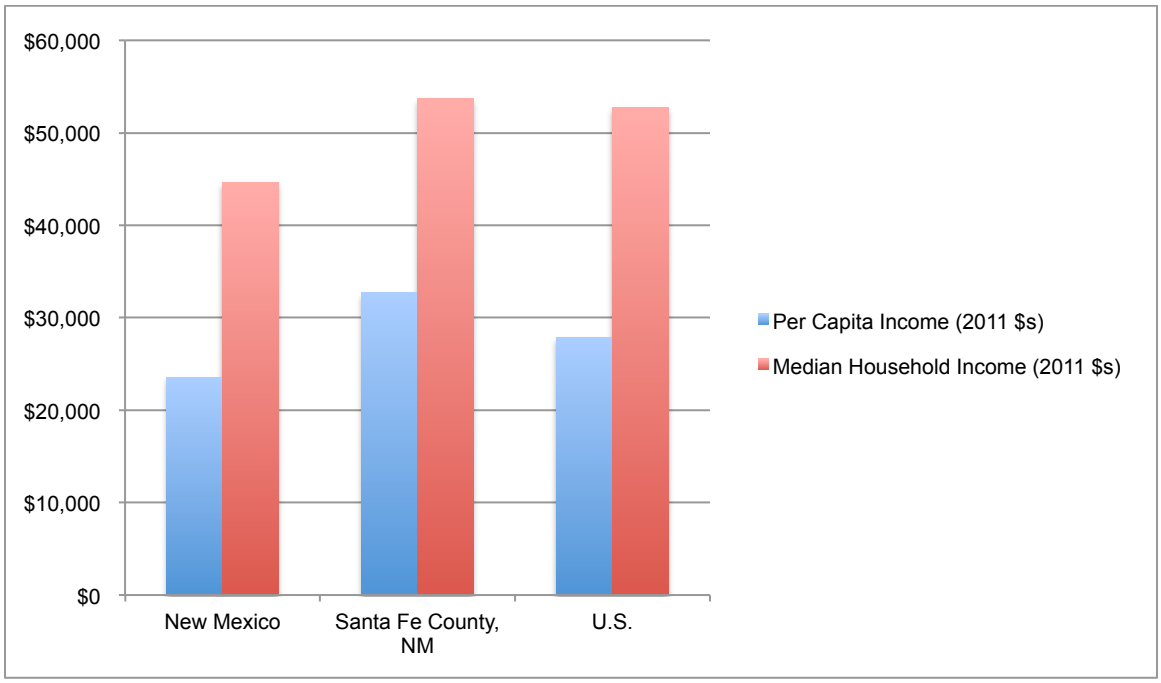


Figure 8: Comparison of income rates in New Mexico, Santa Fe County and the U.S. *Source: U.S. DOC 2012b.*

Despite these percentages that indicate a relatively high average per capita income, the Lorenz Curve, which shows a graphic representation of income distribution, paints a different picture. According to the graph below, over 40% of the population has less than 20% of the income.

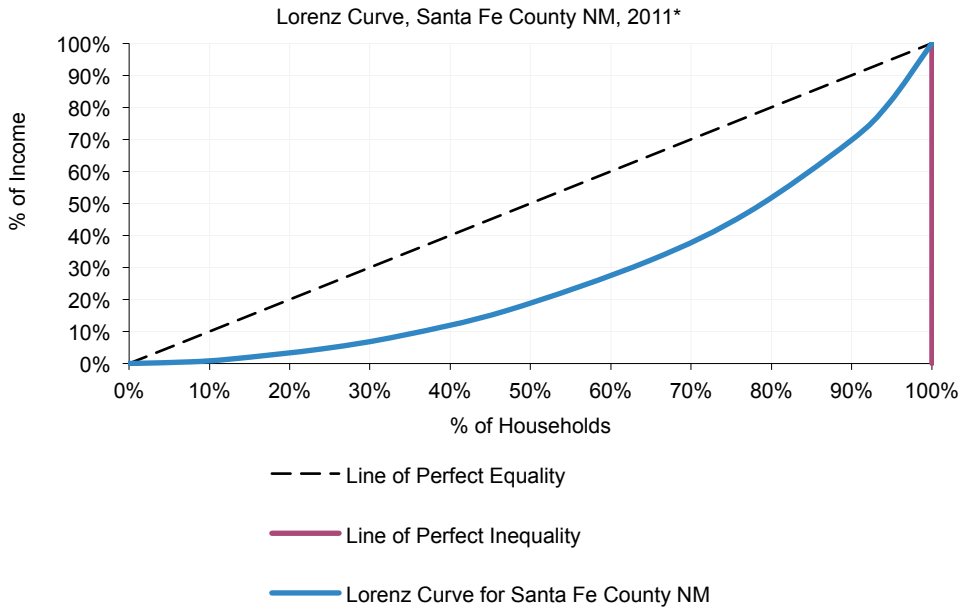


Figure 9: Lorenz Curve of income distribution for Santa Fe County in 2011. *Source: U.S. DOC 2012b.*

Meanwhile, housing costs in the County are relatively high and comprise a slightly higher percentage of household incomes than for the greater United States. The percentage of the population whose mortgages or rent make up over 30% of their income are estimated to be 43% and 48.6% respectively. The graph below illustrates how this compares with state and national percentages (U.S. DOC 2102b).

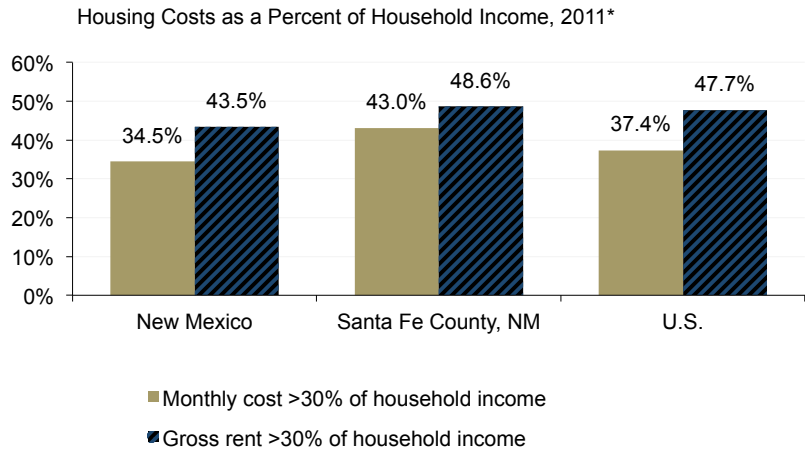


Figure 10: Housing costs as a percentage of household income for New Mexico, Santa Fe County and the U.S. in 2011. *Source: U.S. DOC 2012b.*

These economic markers indicate an area of concern when considering climate impacts in the County because those whose living expenses consume a high percentage of their earnings are less able to absorb the higher food, water and energy prices that could result from climate disruption. When considering strategies to strengthen our economy in the face of climate change, we must take into consideration the most vulnerable populations and design programs that add resilience to the environment and the economy.

Economic Vulnerabilities to Climate Change

Climate change will impact nearly every aspect of Santa Fe's economy. Climate predictions for the area include extended drought; less snowfall; more rain-on-snow events; a higher chance of severe weather events (such as extended drought and flooding); faster, earlier spring water runoff; drier, hotter summers; and increased forest fires and outbreaks of invasive species. This is already impacting the economy by affecting the snowpack and overall health of the environment, which is an essential component to the area's quality of life and a critical economic asset.

Photo 5: Holiday shoppers on the Santa Fe Plaza. *Source: Esha Chiocchio.*

As a result, Santa Fe businesses are feeling the economic impacts of the changing climate. Mary Wolf, the owner of Collected Works Bookstore, stated that her store's summer business dropped 13% after the Cerro Grande fire in 2000. "Persistent drought and record temperatures are a bigger threat now to my business than Amazon.com or e-readers," Wolf said (Hay 2013). Similarly, Dan McCarthy, owner of Santa Fe Mountain Sports said, "the negative economic impacts [of climate

change] on Santa Fe and the state of New Mexico are huge. Even if your thermostats aren't directly related to tourism, the health of our economy is and that hurts everyone." He went on to say, "we need to get the message across that climate change is real and you can do something about it. The repercussions of our inaction will cost us more in the long run and the legacy we leave our children will be irreversible. We must act now" (Hay 2013).

Stating the need for action, Santa Fe Mayor Coss said, "we have a moral obligation to the future to leave them a healthier planet. We need to be responsible stewards for where we live" (Hay 2013).

In addition to the effects of a reduction in tourism and the art market, wildfires and flooding events could significantly impact water supplies and infrastructure (water treatment facilities, reservoirs, roads, bridges, etc.) and have a substantial economic impact on the City and County. Repairing these systems after a catastrophic event could cost millions of dollars (if not more) while simultaneously reducing tax revenues through a decline in tourism and possible emigration from the area.

The insurance industry is also concerned with climate change, in particular the increased frequency of extreme events such as wildfire and floods. These concerns may be reflected in increased rates and regulations (for example, against building in the floodplain and wildland urban interface (WUI)).

Even if we do not incur a catastrophic event, the food and energy sectors will be impacted by the changing climate. According to a report from the Intergovernmental Panel on Climate Change (IPCC), global food production is predicted to decrease by two percent each decade for the rest of the century due to changes in the climate as a result of global warming. Meanwhile, demand is expected to rise as much as fourteen percent each decade. Global population is projected to reach 9.6 billion in 2050, from 7.2 billion today, with many of these people eating richer diets, as those in developing countries acquire the money to afford more expensive foods. Any shortfall would lead to rising food prices that would hit the world's poor hardest, as has already occurred from price increases in recent years (Gillis 2013).

Our local farmers have already seen reductions and inconsistencies in their water supplies, making it difficult to grow crops and raise animals. Ray Romero, the *mayordomo* of the La Cienega Acequia, which has 33 *parciantes* and is linked to 98.6 acres, says that the *Acequia* "is irrigating only 25% of the land that it used to." During a conversation in November 2013, he said:

> *When I started with the Acequia in 1958 the water flowed at 650 gallons per minute (gpm), now it flows at 180 gpm. We dug a well 8 years ago to supplement the surface water but the well only produces about 130 gpm and is expensive. Although some of this is due to the drought, the larger problem is the number of straws in the ground. I see three options for improving water supplies in the area: 1) we could drill another well and pump everyone dry (which we don't want to do), 2) we could file a priority call (which is expensive and takes a very*

long time), or 3) we can work with County to reduce the number of users on groundwater. The State Penitentiary was recently taken off of groundwater and moved to County supplies but we haven't seen a change yet. We are now working with the County to have the houses around the Racetrack area hooked up to County water. We have to act quickly before this area runs dry. If we are unsuccessful in our negotiations with the county, we will file our priority water rights.

Similarly, Charlie cde Baca, mayordomo of the Guicu Ditch (39.5 acres and 21 parciantes) says that their "water has been depleting for years and the last few years have been the worst. We are getting about 40% of what we used to get. Over the past five to ten years, my alfalfa harvests have gone from about 700 bales to only 200-250 bales per season."

Photo 6: A farmer directs water in a traditional acequia-irrigated field at Los Golondrinas in La Cienega. *Source: Esha Chiocchio.*

As climate trends intensify and global food prices rise, it will be increasingly important to grow food locally. With little to no water, however, this will become more difficult and cause food prices to rise further. Springs are drying due to population growth and reduced infiltration reduces the amount of water available, particularly in the agricultural areas of the Watershed.

Meanwhile, it is anticipated that the cost of electricity will be significantly influenced by climate change in New Mexico due, in part, to reductions in the Colorado River flows that provide cooling water for the coal-fired power plants in the Four Corners area (Repetto 2012). Currently, the San Juan Generating Station (a coal fired power plant that supplies the majority of Santa Fe's

power) uses an average of 22,000 acre feet of water per year – more than twice the annual water use for the entire City of Santa Fe (10,000 acre feet) (PNM website; Hook 2013). New Mexico has the country's second largest gas reserves and the fourth largest coal reserves, leading many industry representatives to believe that the state should oppose policies to reduce carbon dioxide emissions so they can reap the benefits of exploiting these resources. However, as Robert Repetto points out in his article *New Mexico's Rising Economic Risks from Climate Change*, "because hotter weather boosts the photochemical reactions that create atmospheric smog and national ozone standards are being tightened substantially, coal-fired power plants will have to install expensive controls on nitrogen oxide emissions, an ozone precursor, in order to keep operating" (Repetto 2012).

Perhaps more importantly, fossil fuels require massive amounts of water both during extraction and energy production. According to a recent report by the Earthworks Oil and Gas Accountability Project, natural gas exploration via hydraulic fracturing injects approximately five million gallons of fluid per well and 92 percent of that water never returns to the surface, meaning it is permanently removed from the water cycle (Hansen et al., 2013). Although both the San Juan Generating Station and the fracking wells are outside the boundaries of the Santa Fe Watershed, they are within the greater Rio Grande Watershed and are connected to the San Juan-Chama water supplies that feed the Buckman Direct Diversion (BDD) from which Santa Fe draws a significant percentage of its water supplies. As such, it is important for Santa Feans to consider their energy sources and the implications of the water-energy nexus in this region.

Photo 7: Solar panels on a roof in Santa Fe. *Source: Esha Chiocchio.*

Fortunately, New Mexico has significant wind resources (almost 50 gigawatts) and is situated in the sun-belt, making it a prime candidate for solar energy generation, both of which have seen significant growth in recent years (Repetto 2012). Worldwide, 2011 sales in wind and solar grew by 18 and 29 percent respectively (Business Green 2012). By investing in renewable energy, we can mitigate some of the anticipated climate impacts by reducing water use and greenhouse gas emissions, and simultaneously improve the local economy by creating installation jobs and locking in our energy rates for decades to come.

The Road Ahead…

It's clear we can strengthen our economy, increase and diversify job opportunities, and reduce the impacts of climate change on our environment and community. We can invest in climate adaptation strategies and shift policies that promote climate adaptation initiatives and renewable energy development. Investments in the following areas can directly mitigate the climate challenges we face while increasing the resilience of our environment, economy and society.

Climate Risk	Action/Job	Job Type
Forest Fire	Thinning/burning	Forestry
Flooding	Arroyo stabilization	Hydrologists, earth-movers, etc.
	Strengthen riparian corridors	Ecologists, foresters, etc.
Drought	Retrofit with efficient/smart plumbing and water catchment/reuse systems	Plumbers, construction workers
Increased Temperatures	Retrofit buildings for passive solar	Construction workers
	Tree planting to increase shade	Landscapers, arborists, parks dept.
GHG Concentrations	Install renewable energy systems	Electricians
	Energy audits and retrofits	Energy auditors, contractors
	Land Restoration	Ecologists, biologists, geologists
Community Destabilization	Neighborhood Association, business, non-profit and community coordination	Community organizing

Table 1: Job opportunities associated with climate change adaptation.

Currently, funding for climate adaptation projects generally comes from grants, bonds and other short-term investments. In order to ensure that long-term funding will be available in the decades to come, new financing structures should be researched and developed specifically for adaptation and community investment projects that have longer payback periods.

The goals identified in the subsequent chapters provide an opportunity to create jobs, strengthen the social and environmental fabric of our watershed, increase the resiliency of our landscape and infrastructure and ensure that Santa Fe thrives for at least another 400 years.

WATER RESOURCE ASSESSMENT FINDINGS

Wa•ter•shed \wo-ter-shed, wä-\
1. n. a) divide. b) a region or area bounded peripherally by a divide and draining ultimately to a particular watercourse or body of water.
2. adj. a crucial dividing point, line or factor: turning point.
Source: Merriam-Webster.com

The Contemporary Landscape

A watershed encompasses all of the land that drains to a particular stream, river, or bay. All land, from the limited access wilderness areas to the most densely developed urban neighborhood, is part of a watershed. When watersheds are healthy and functioning well, they provide food, clean water and habitat for plants and animals. Healthy watersheds work hard. They move sediment from the mountains to the rivers and on to the ocean, providing essential water and nutrients along the way to create diverse landscapes and habitats. They cycle nutrients and convert them into forms that living organisms can use. They purify and store water, and then slow its release into streams to reduce flooding and damaging erosion in the winter and to sustain flows and cool temperatures during the dry season. They even affect air quality by absorbing pollutants and greenhouse gasses. Well-functioning watersheds are more resilient to natural and human-induced disturbances than those that have been significantly altered from their natural form (Marin County Watershed Program).

Characteristics of a healthy watershed include:

- The streams and their floodplains are able to accommodate flood flows without regular destructive flooding and erosion.
- Streamflows are close to historic conditions with moderate peak flows after winter storms and stable summer baseflows. This is strongly correlated to the amount of hard, impervious surfaces such as roofs and pavements throughout the watershed, especially those that are directly connected to streams through ditches and storm drains.
- Native, keystone plant and animal species are able to sustain stable populations. Examples in the Santa Fe watershed include cottonwoods and willows.
- The riparian corridor has a dense, healthy native plant community that regenerates naturally.
- Upland forests are managed to promote rain infiltration, provide diverse habitat for

native wildlife, reduce soil erosion, reduce stand-replacement fires, and deliver clean water into streams.

Photo 8: The flowing Santa Fe River in June 2013. *Source: Esha Chiocchio.*

What can you do to help your watershed's future?

- → Learn more about your watershed and its specific issues and challenges. The Santa Fe Watershed Association leads hikes into the closed upper watershed where you can learn from foresters and water division staff about how your watershed works and what is being done to protect it.
- → Plant native plants that fit your specific location and conditions. When you can, plant a variety of native species and types of plants from grasses for erosion control and wildflowers for bees and butterflies, to shrubs and trees for birds.
- → Reduce impervious surfaces and disconnect them from arroyos and storm drains. Use porous alternatives such as gravel or pervious pavement for driveways and paths. Collect roof water and slow its release back into groundwater through ran barrels, rain gardens, and bioswales.
- → Keep water clean. Prevent soil erosion, use non-toxic household and garden products, and keep oil and animal waste out of streams and storm drains.

→ Repair erosion wherever possible with biotechnical and/or Permaculture techniques that incorporate native plants and land contouring. These methods allow for natural watershed functions to continue.

→ Protect and restore arroyos and riparian areas.

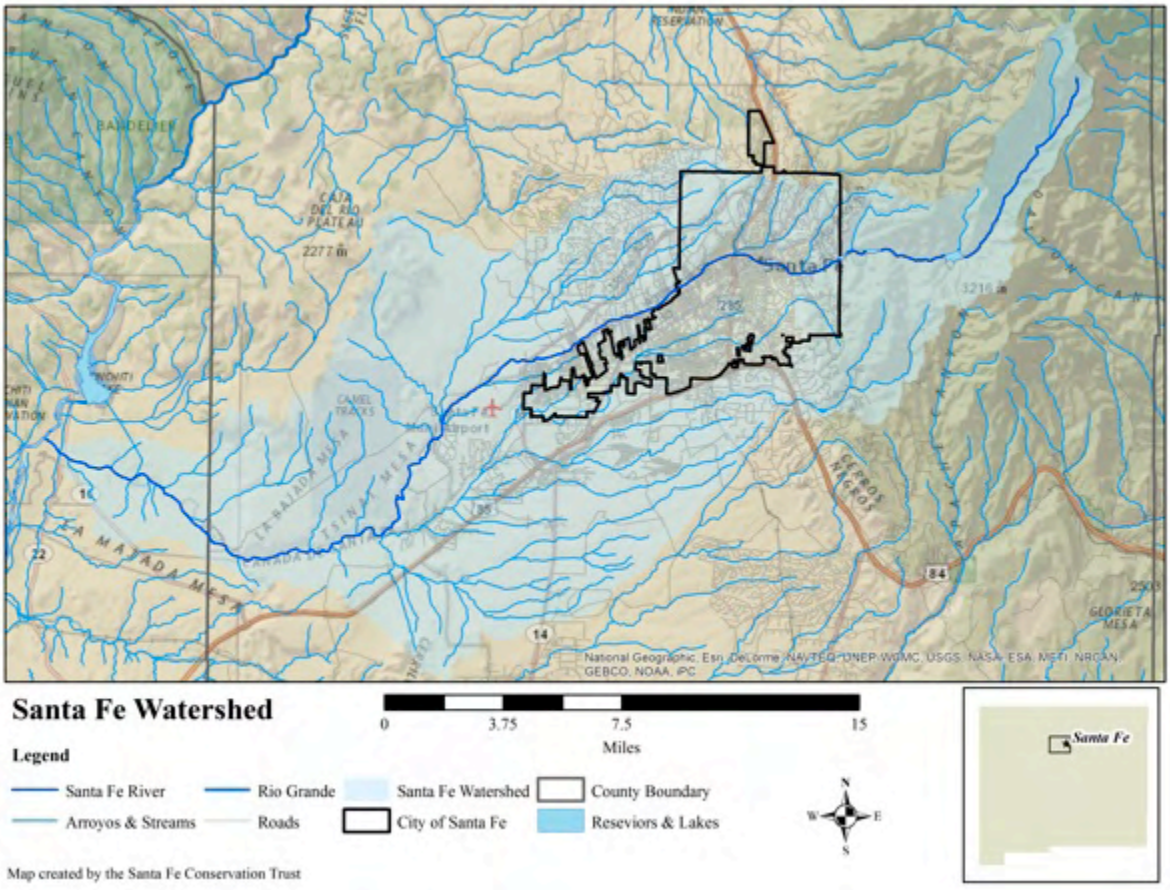
Photo 9: Hikers learn about the upper watershed on a guided tour led by the Santa Fe Watershed Association, the U.S. Forest Service and the City of Santa Fe. The rubber boots seen in the foreground are used by the elementary school kids who visit the Watershed as part of the *My Water, My Watershed* program run by the SFWA. *Source: Esha Chiocchio.*

The Santa Fe Watershed: Water Sources and Use

The Santa Fe watershed exists in an arid land where water is scarce and precious. The watershed area comprises 285 square miles that drain into the 46 mile length of the Santa Fe River from its beginning at Lake Peak (12,408') to its final outfall at the Rio Grande in Cochiti Pueblo (5,220') (Grant 2002). In between these two points are three distinct areas, each with their own characteristics and complexities: the upper watershed, a 17,400 acre area

Photo 10: The Santa Fe River in downtown Santa Fe. *Source: Esha Chiocchio.*

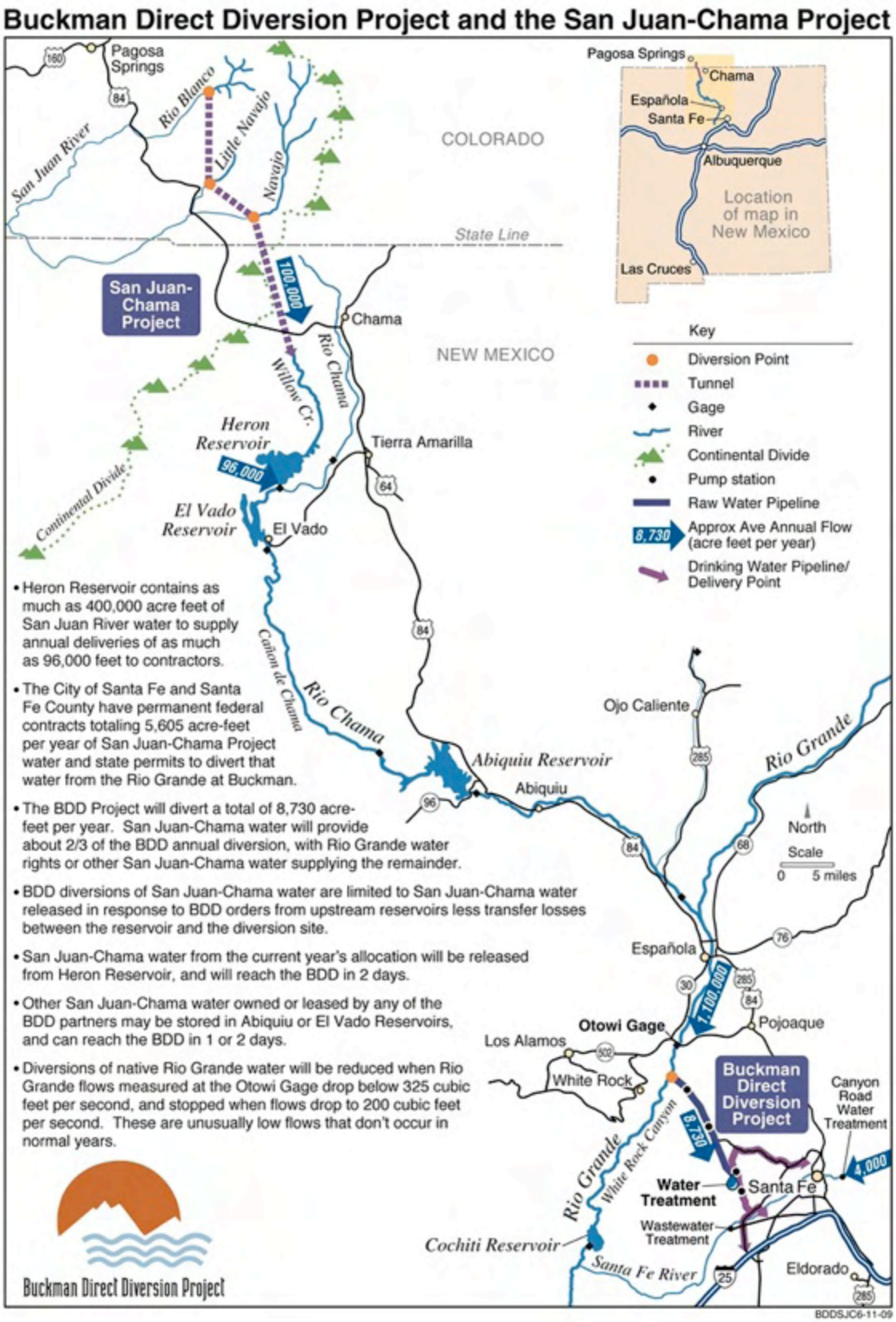
mostly contained within the closed Santa Fe National Forest; the middle watershed, an area that is occupied by the City of Santa Fe between the Canyon Road water storage tank and the wastewater treatment plant; and the lower watershed, comprised of the area between the wastewater treatment plant discharge and the Rio Grande River.



Map 1: Map of the Santa Fe Watershed with the City of Santa Fe city limits and river and arroyo paths identified. *Source: Santa Fe Conservation Trust.*

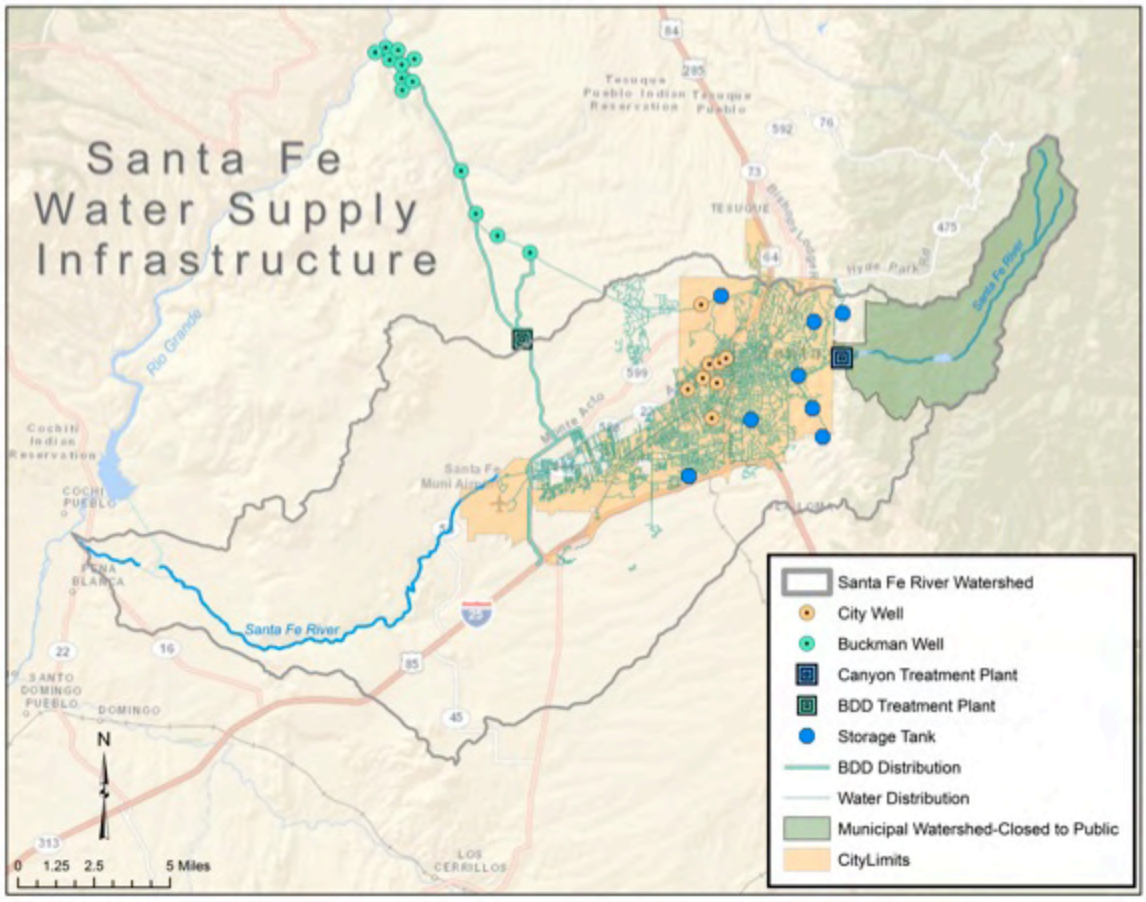
Over the course of Santa Fe's history, four dams have been built along the Santa Fe River and two remain today forming the Nichols Reservoir (capacity 2,500 acre feet) and McClure Reservoir (capacity 4,000 acre feet). Santa Fe has rights to 5,040 acre-feet of water per year from these reservoirs, which supply approximately 40% of the City's drinking water. Until 2011, the remaining 60% of Santa Fe's water supply was pumped from the City and Buckman well fields. In 2011, the water supply was diversified to include water sourced from the Colorado River System via the Buckman Direct Diversion (BDD) project, with water rights of 5,605 acre feet per year originating from the San Juan-Chama Project. This project diverts Colorado River system water from the San Juan Mountains in Colorado via a series of tunnels that carry it through the Continental Divide into Willow Creek. The imported water is stored in Heron Reservoir, and released down the Chama River, which flows through El Vado Reservoir and Abiqui Reservoir before it reaches its confluence with the Rio Grande. It then flows in the Rio Grande until the

BDD siphons it about 1000 feet uphill to the BDD water processing facility. The finished water is then piped throughout the City and County via the municipal water supply system. The map below shows the trajectory of BDD sourced water.



Map 2: Illustration of the Buckman Direct Diversion Project water flows. *Source: bddproject.org.*

In addition to these surface supplies, the City of Santa Fe continues to use the Buckman and City well fields to enhance its water supply portfolio with rights to an additional 10,000 acre feet per year. The map below illustrates the location of Santa Fe's current water supply infrastructure.



Map 3: Map of the City of Santa Fe water supply infrastructure in 2013.
Source: City of Santa Fe Water Department.

To summarize, the City of Santa Fe has a diversified water portfolio that utilizes surface water from the Santa Fe River (5,040 af) and the Colorado River (5,605 af) (via the San Juan Chama Project and the Rio Grande) as well as ground water from the City and Buckman well fields (10,000 af). The diversity of this portfolio is essential for managing through periods of drought, which can significantly decrease surface water supplies. The City of Santa Fe Water Division supplies approximately 10,000 acre-feet of water annually, with 9,850 af delivered to City customers and 155 af delivered to County customers (Borchert 2013).

The National Weather Service recently confirmed the 24 months between August 2010 and August 2012 were the hottest and driest in the U.S. southwest since record-keeping started in the 1890s. Despite two years of persistent and severe drought conditions pushing peak daily demands to all-time highs, Santa Feans used an average of 107 gallons per person per day in 2011, well below the national average of 150 gallons per person per day and lower than use in most other similar western cities. The gallon-per-capita–per-day (GPCD) calculation includes not only

Photo 11: The Nichols Reservoir in July 2012. *Source: Esha Chiocchio.*

residential but also commercial, industrial, institutional and irrigation water use. Residential indoor use in Santa Fe accounts for 58 gallons per person per day, while the remaining 49 gallons is used for commercial, industrial, multi-family (such as apartment complexes) and public facilities (Water Conservation page of Santa Fe website).

Water conservation measures throughout the City have helped to reduce this rate over the past fifteen years. In a study conducted by the Santa Fe Water Division that compares water usage rates from 2007/2008 to those in 1998, water usage rates fell dramatically across residential, commercial and community categories. A few of the highlights include:

- Water use in single family dwelling units fell 31%
- Water use in full-service restaurants fell 50%
- Water use in hotels fell 58%
- Water use in neighborhood centers fell 70%

These reductions are due in large part to the City's water conservation measures, the most effective of which required that all new demand on the water utility be offset by replacing high flow toilets with 1.6 gallon or less flush toilets. Through this program, the city gave away 5,508 residential toilets and 2,559 commercial toilets during the ten-year period analyzed in the report. Other ongoing measures include a rebate program for high-efficiency washing machines, low water use commercial dishwashers and rain barrels; commercial landscape irrigation audits and low water use landscaping recommendations; posting of advertisements encouraging water wise practices in local businesses; and the replacement of hotel towels and sheets only upon request (King, 2009).

Clearly we have made great strides in reducing our per-capita water usage. Simultaneously, however, our population has continued to grow: between 2000 and 2011, the population of Santa Fe grew 9.2% from 62,203 to 67,909 (U.S. Department of Commerce 2000 and 2012b). As mentioned above, we are already experiencing hotter and dryer weather patterns and will need to continue to improve upon our water conservation efforts in the years to come.

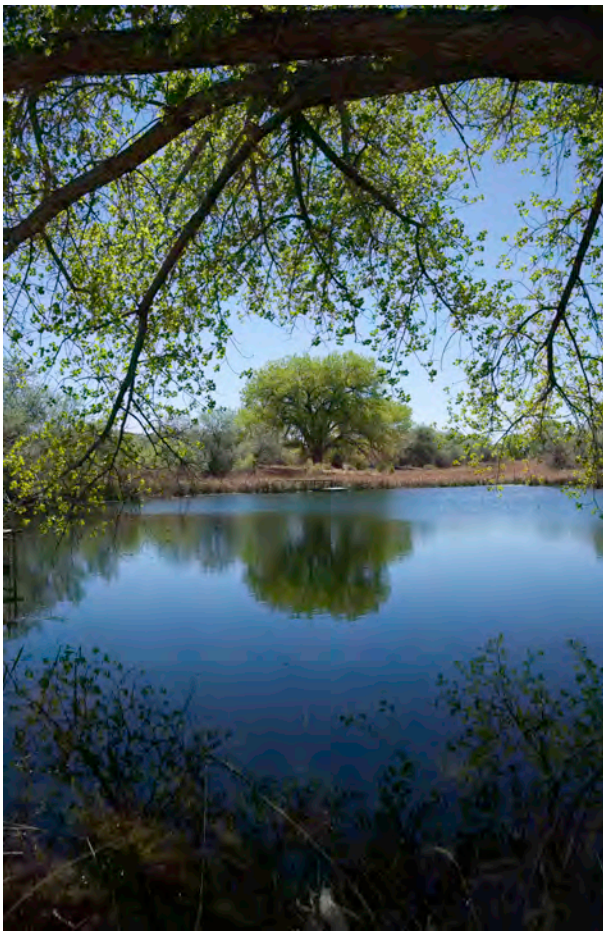


Photo 12: Spring at Los Golondrinas in La Cienega.
Source: Esha Chiocchio.

In addition to ensuring adequate water supply for the City of Santa Fe, water use within the City impacts water availability downstream. Much of the potable water used throughout the City enters the sewer system and is treated at the Wastewater Treatment plant on the West side of town. Some of this treated effluent is used for irrigation in parks and is sold to contractors for construction purposes. The remaining water, about 4,000 acre-feet, is released back into the Santa Fe River where it flows through the traditional agricultural communities of La Cieneguilla, La Cienega, La Bajada and, on a good day, to Cochiti Pueblo where it flows into the Rio Grande (Borchert 2013).

Over the years, this water has been the source of tension between the City and the downstream communities who have seen significant declines in their surface flows, springs and wells. Several perennial springs exist within the Santa Fe River watershed, importantly those that support irrigation in La Cienega and base-flows in the Santa Fe Canyon above the Village of La Bajada.

The situation occurring downstream of the urban community could be perceived as foreshadowing of future vulnerabilities. Growing population, declining supply, and increasing demand for water can lead to the perfect storm with regards to water equity and social justice. In a proactive response, a broad array of representatives has convened regularly for two years in a collaborative effort to address the incredibly complex issues of geography, conflicting water uses, law, demand, history, and culture. The collaboration represents a growing momentum for communal problem solving that we believe is an integral part of any future endeavor regarding climate change adaptation.

Water Impact Findings

Land Use:

Land use patterns are a critical factor in the health of a watershed. With the development of Santa Fe over the past four centuries, land within the watershed has undergone a shift to increased percentages of pavement and structures that have reduced the water absorption capacity of the land and increased the speed and volume of runoff during rainfall events. This, in turn, has reduced groundwater recharge rates and increased the erosion of our arroyos and riverbeds.

Even a slight increase in impervious surfaces can greatly affect water quality. Natural environments filter water, slow drainage and store water in the ground. Urban environments encourage faster runoff that can wash away topsoil, degrade arroyos, channelize rivers and wash pollutants directly into streams and rivers.

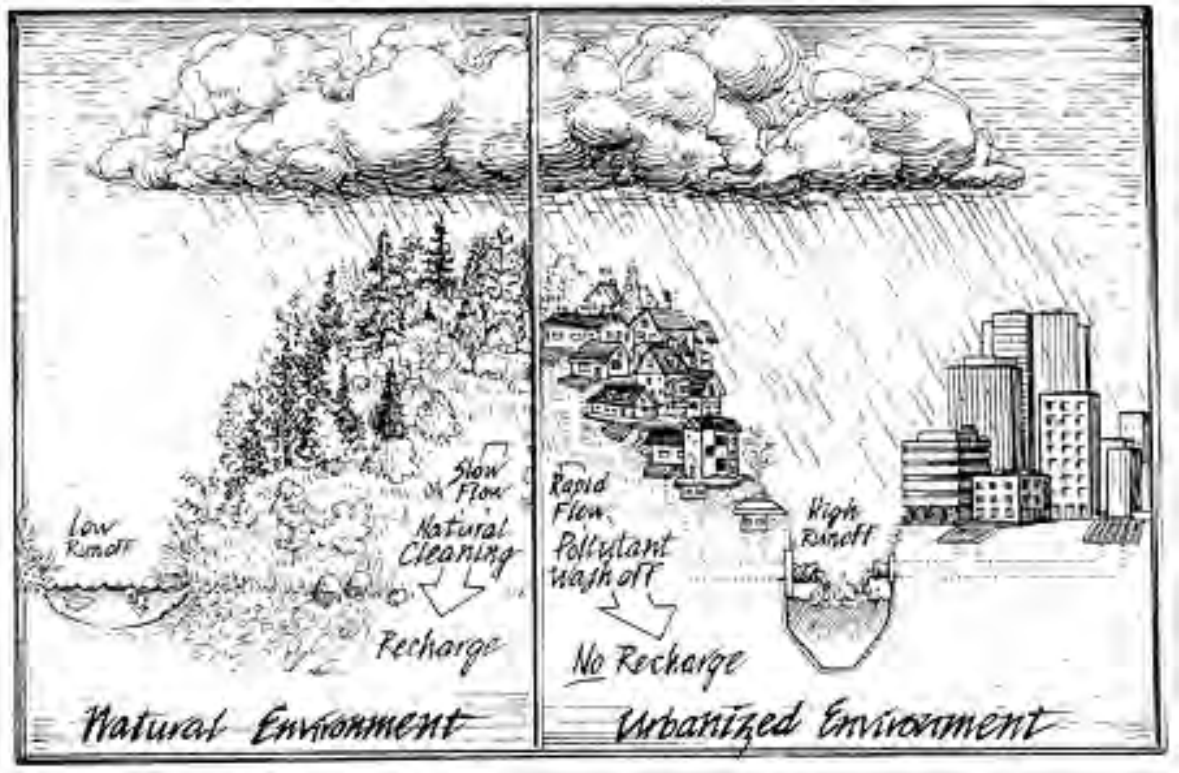


Figure 11: Illustration of storm water runoff in natural vs. urbanized environments.
Source: Rogue Valley Council of Governments website.

One of the more striking examples of the shift from a natural environment to an urban one can be seen just behind the St. Francis Cathedral in downtown Santa Fe. In the late 1800s, Santa Fe had springs in the heart of the city, one of which fed the carp pond in the Archbishop's garden. Over the years, this pond was filled in and turned into a cemetery and then an asphalt parking lot, which remains today.


Photo 13 (left): Carp pond in the Archbishop's garden near Saint Francis Cathedral, Santa Fe, NM.
Source: Courtesy of the Palace of the Governors Photo Archives, image number 015264.

Photo 14 (right): View of the parking lot that is now in the place of the former spring, 2013.
Source: Esha Chiocchio.

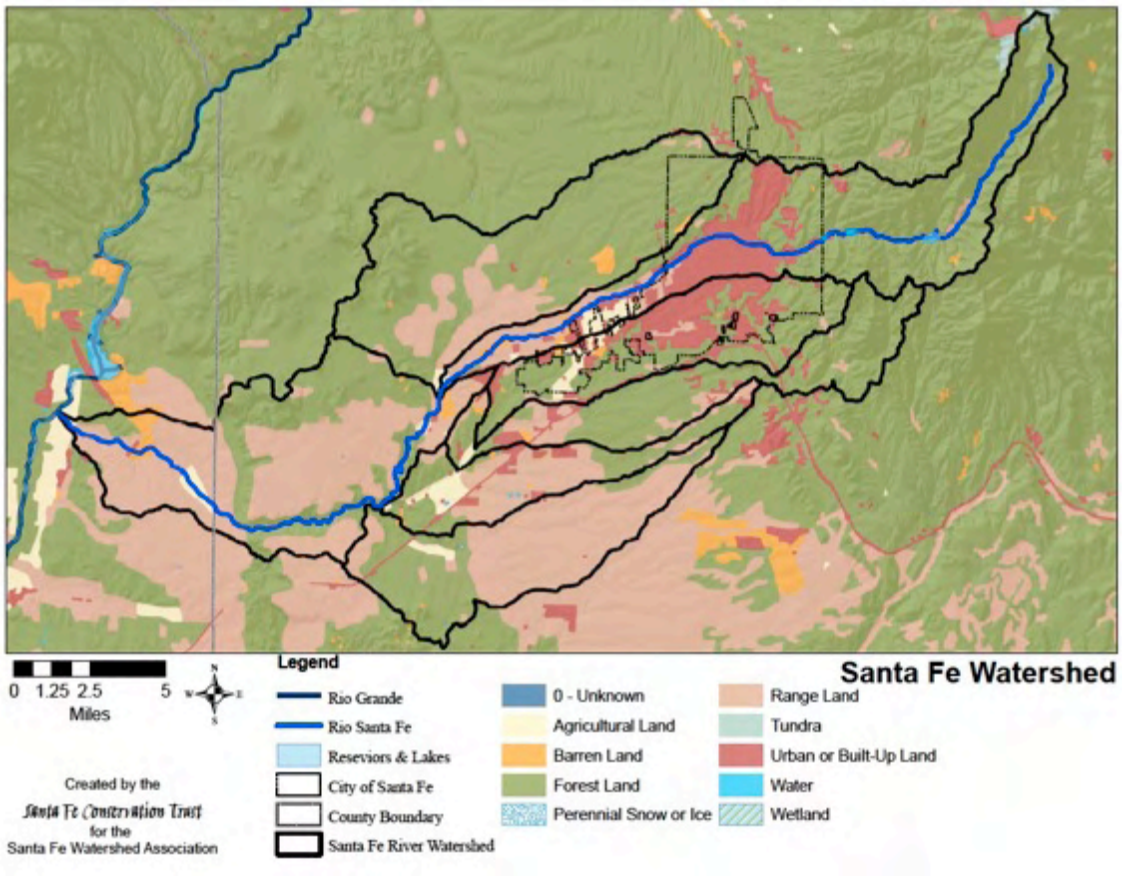
Land use in the area has gradually shifted to increased development and impermeable surfaces. Beginning from the highest and most northerly point of the watershed, and moving southwesterly and downslope, the chart below identifies the land use distribution within the Santa Fe Watershed (areas approximate) (Grant 2002):

Area	Acreage
Pecos Wilderness: most restrictive land use, no use of motorized equipment, no roads.	7,000
Municipal watershed (exclusive of wilderness): managed to protect quality of City water supply – land ownership mostly Santa Fe National Forest, +/-10% City and private land, minimal dirt roads.	10,000
City of Santa Fe within Santa Fe River watershed: mixed density urban development, including 11,640 acres of open space (parks as well as public and private undeveloped land). Population 67,981 (2010 census). Extensive paved roads and relatively densely built environment.	22,991
Santa Fe County within Santa Fe River watershed: mixed density development and open land. Population 144,169, inclusive of City (2010 census). Numerous paved roads and buildings in a variety of density patterns.	159,409
Caja del Rio grazing lands within Santa Fe River watershed: ownership almost 50:50 BLM and Forest Service, minimal roads.	27,368
Acequia-irrigated agricultural land in La Cienega and La Bajada, several paved and dirt roads with homes dotting the landscape.	100
Cochiti Pueblo, grazing land and wetlands, minimal dirt roads.	20,181

Effects of this can be seen throughout the watershed and would be best addressed through both active and passive rainwater harvesting systems that reduce the rate of flow and encourage water to soak into the ground. Such techniques have multiple benefits for the overall health of the watershed including the recharge of groundwater supplies, the natural filtration and purification of water, the increase of soil moisture to support stabilizing vegetation, a reduction in soil loss and arroyo/river degradation, and a reduction in the amount of potable water used for outdoor irrigation.

Photo 15: Curb cut with infiltration basin along West Alameda Street in Santa Fe.
Source: Esha Chiocchio.

Current efforts are underway to increase the permeability of some pavement and to direct storm water flows to infiltration basins. This "rainwater harvesting," based on Brad Lancaster's work in Tucson, directs rainwater into roadside basins where it can slowly soak into the ground and irrigate nearby vegetation (Lancaster and Marshall 2006). Such strategies reduce the overall storm water flows that rush into arroyos and riverbeds and cause excessive erosion. Simultaneously, these basins irrigate road-side vegetation and filter contaminants from storm water, thereby reducing the irrigation needs and improving storm water quality.



Map 4: Land use patterns of the Santa Fe Watershed. *Source: Santa Fe Conservation Trust.*

Arroyo (ə-roi ō): A small, deep gully or channel of an ephemeral stream. Arroyos usually have relatively flat floors and are flanked by steep sides consisting of unconsolidated sediments. They are usually dry except after heavy rainfall.

Source: American Heritage Science Dictionary, 2005.

Arroyos

Arroyos are one of the most important (and typically overlooked) landscapes in the Santa Fe Watershed. These tributaries hold an important key to a future of water security as storm water harvesting and infiltration areas. Typically dry except during rain events, they are subject to flooding and erosion during intense rainfall. The potential for slowing down this rain water, spreading it out across the arroyo landscape, and encouraging infiltration for recharge of the more surface aquifers, is a recent area of development toward progressive water management.

In 2012, the Santa Fe Watershed Association conducted an assessment of the ten major arroyo systems to determine their health and where immediate action is needed. Many high-priority

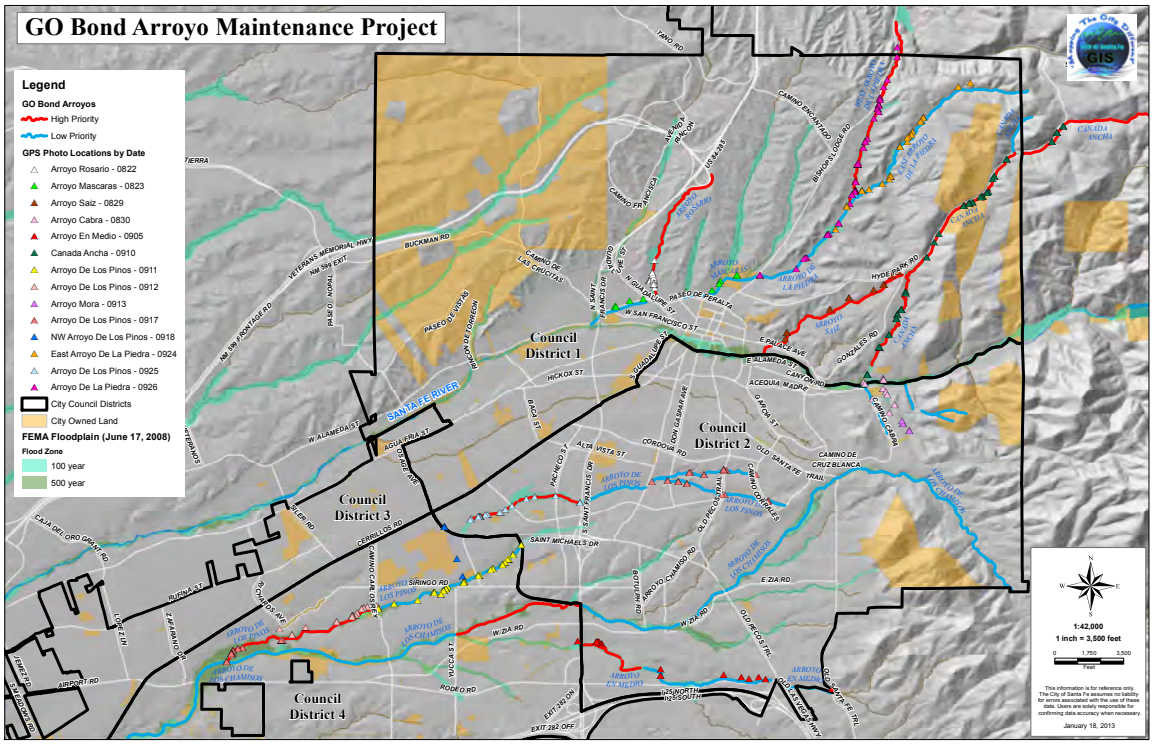
reaches require well-designed restorative actions to help stabilize, protect, and secure the infrastructure that runs through them (SFWA 2012).

Photo 16: View of a healthy arroyo with a flat bed, minimal erosion of sidewalls and vegetated riparian areas. *Source: Keely Jackson Kennemore, SFWA 2012.*

Arroyos are eroding close to trails, roads, bridges and homes and have exposed pipes and electrical cables. However, because each arroyo is unique, there isn't one approach to fixing them. These highly erodible systems are intricately affected by impervious surfaces, extended periods of drought that kill stabilizing vegetation and large volumes of water flowing down them in flash flood scenarios. In the photo below, the banks of the arroyo have eroded to the fence line, exposing cables and threatening the house nearby (SFWA 2012).

Photo 17: Arroyo de los Chamisos eroding the land close to a property line and exposing cables. *Source: Keely Jackson Kennemore, SFWA 2012.*

In 2012, a bond was passed to fund a $2 Million arroyo restoration project. While this project will help build a few demonstration sites that showcase the potential for green infrastructure, it is the small tip of a very large iceberg. We have hundreds of miles of arroyos in the Watershed, thus, the scope of restoration needed is much greater and will likely require millions of dollars and a long-term maintenance strategy to fully remedy. Below is a map of the areas to be addressed with the GO Bond Arroyo Maintenance Project. While the GO Bond will fund this initial pilot project, a long-term financing system is needed to restore and maintain these fragile ecosystems.



Map 5: Map of the Santa Fe Watershed arroyos that are in need of restoration. Those marked in red are listed as high-priority sections and those in blue are lower-priority sections. *Source: SFWA 2012.*

Wetlands

Within the Santa Fe Watershed, there are three wetlands that provide critical ecosystem services and habitat for the area. Numerous bird, amphibian and mammal species dependent upon wetland vegetation will be negatively impacted unless they are maintained, improved and re-established, where possible.

Generally, wetlands comprise approximately 3%-7% of a given watershed. However, in dryland areas, such as the Santa Fe Watershed, this percentage is at the lower end of, or below, this range. According to Jan-Willem Jansens, "wetlands in Santa Fe County are scattered and most wetlands seem to be in functional decline" (Jansens 2013). This is due, in part, to the reduced water infiltration capacity of the land and in part due to the increase in well-pumping throughout the watershed. Both the wetlands and the arroyos would benefit greatly from increased infiltration.

Governance

As with many watersheds within the United States, there are multiple agencies, non-profits, and community groups that are working to protect our land and water. Each entity has its specific focus, and though there is significant overlap and coordination they are not always in sync with one another. The chart below identifies some of the water governance policies, their related agencies and their planning schedule for the coming years.

Plan / Process	Stressor or Risk or Resource Focus	Schedule	Agency(ies) Responsible	Stakeholders
CWA 303(d) & 305(b) reports	Water quality	2013 (every 5 years)	NM Water Quality Control Commission	State wide
CWA Section 404 permit procedure updates	Wetlands and waters of the US	Unsure	US Army – Corps of Engineers	State wide
BLM	General BLM land management	Updated RMP (2012) being implemented	BLM	Northern NM (Taos) region, includes Santa Fe
BOR WaterSMART Program with City of SF	Climate impacts	2014	City of Santa Fe Sangre de Cristo Water Management Division	City SF residents and SF watershed residents
FEMA Map updates	Flood control	Every several few years (probably again around 2016)	FEMA and City and County	State wide
US Forest Service water planning initiatives	Water delivery from the mountains	Ongoing process (very slow due to staff shortages)	US Forest Service	Santa Fe National Forest, SF Watershed residents
State wetland mapping and assessments in SF County	Wetland mapping and assessments	Ongoing (completed by early 2014)	NMED – SWQB – Wetlands Program	SF County residents; watershed residents
SF County Sustainable Land Development Code	Growth management ordinance (including a new storm water ordinance and new flood management ordinance)	Ongoing (scheduled for completion in late 2013 or 2014, if ever)	SF County Planning, Legal, and BCC	SF County residents
SF County well inventory	Groundwater diversion point mapping and inventory	Published Sept. 2013	SF County Public Works	SF County residents
Various water studies (e.g., waste water recovery and	Wastewater use; water infiltration; water conservation	Ongoing by City, Wastewater published April	City of SF, Sangre de Cristo Water Division	City of SF residents; watershed

reuse plan)		2013		residents
Establishment of a County Water Policy Advisory Commission	Providing info to BCC on water, waste water and water management	Being established – will look at feasibility of a regional water authority	SF County	SF County residents
SF Pojoaque Soil & Water Conservation District	Water conservation and use for ag users ("cooperators")	Ongoing: annual series of projects and initiatives	SF-Pojoaque SWC District	District cooperators
County Water Line extension	Constructing piped water to rural communities	Ongoing (e.g., NM Detention Center just recently placed on County water line; Eldorado and Cañoncito to follow soon)	SF County Public Works	Rural SF County residents (who want to be served and don't care about possible development it entails)
Update of SF Watershed Based Plan	EPA endorsed watershed planning document	TBD	EPA/NMED – SFWA	Watershed residents
City arroyo restoration program	Stabilization of degraded City arroyos per City and SFWA priority plan	2013-2014	City Public Works (Streets & Drainage) and SFWA	Watershed residents
City NPDES storm water permit	City process to complete water quality scorecard	Annual	City/State/EPA	Watershed residents
City Urban Forest Plan	Urban forest plan	2014	City Urban Forest/Parks Dept.	City residents

Table 2: Planning process chart that identifies the various authorities and planning processes underway within the Santa Fe Watershed.

Potential Water Solutions and Strategies for Climate Resilience

In order to address our water issues in a manner that will stand the test of time in a changing climate, solutions must be locally based, culturally appropriate, multi-functional and adhere to the guiding principles of sustainability (environmental stewardship, economic health and social justice) to the greatest degree possible. They should also address the root cause of the problem, rather than providing a short-term fix that will ultimately need fixing again. Below are several potential water solutions that have been identified by the core planning team.

• **Develop a Regional Water Authority**. Currently, there are numerous regulatory agencies and organizations that are involved in the management of our waters. In order to increase coordination and streamline the process of making necessary changes, a Regional Water Authority should be developed to coordinate all of the many water regulation organizations. An example of this are the Dutch Water Boards in the Netherlands. These regional government bodies are charged with management, water barriers, waterways and water quality in their regions.

• **Increase Infiltration**. Many of the challenges within the watershed are a result of years of decreased water infiltration. When water is unable to infiltrate (due to roads, buildings and other impervious surfaces), a cascade of events follows: groundwater recharge rates are decreased, soil moisture for trees/shrubs/plants is reduced, and water velocity is increased leading to erosion, channelization, increased risk of flooding, etc.

- **Soil study analysis**. Analyze soil studies to determine where infiltration techniques will be most effective.
- **Arroyo restoration**. Many arroyos should have more space to allow water to spread out. When roads and buildings are built too close to arroyos, their ability to function properly is decreased, leading to excessive erosion.
- **Require gutters with passive/active water harvesting**. Reducing the rate of water runoff during storm events will in turn reduce the stress to receiving arroyos and rivers. This technique also provides water for irrigation in between rain events, thereby reducing the potable water demand for outdoor irrigation. In addition, this can boost the local economy by creating jobs while reducing City/County expenses for arroyo and road maintenance.
- **Encourage beaver activity**. Beaver dams help slow and spread water over a greater area creating habitat, regulating the rate of flow and increasing infiltration. Of crucial importance is the placement of beaver habitats within the watershed. Any efforts to implement this strategy must be considered by a broad range of stakeholders.
- **Establish a Managed Aquifer Recharge program**. Evaporation of surface water supplies accounts for about 90% of surface water losses within the Santa Fe Watershed. By storing water in aquifers, we can reduce these evaporative losses (Morore 2011).

• Increase water and energy efficiency: establish water reuse retrofit and energy efficiency programs.

- **Pilot projects for retrofitting neighborhoods**. Launch a pilot project to retrofit one to three neighborhoods with grey/black water reuse systems that promote the reuse of this water for irrigation within the neighborhood. Determine the best strategies for social buy-in/management and physical construction and then encourage more retrofits.
- **Integrate job training and business development to support workforce personnel and skills needed to implement retrofit projects**.
- **Establish a climate adaptation working group**. Create an ongoing working group to evaluate how to create incentives for people to make climate adaptations to homes/businesses.
- **Establish a financial working group.** Create a financial working group to create financing systems in order to make money available for climate adaptation retrofits.
- **Encourage retrofits.** Create regulatory incentives to allow and encourage people to address one retrofit project (water/energy/etc.) without mandating an upgrade of the entire house (plumbing/electrical systems). (This is intended to reduce the financial burden of complete retrofits).

• **Support continued catastrophic fire reduction techniques** (USFS). For the past 10 years, the U.S. Forest Service has been thinning and using prescribed burns to reduce fuel loads in the upper watershed. These techniques can greatly reduce the risk of catastrophic fire and increase watershed health and should be continued and funded appropriately.

• **Support the urban forest.** The City of Santa Fe is working to develop a 75-year urban forest plan. Trees help to slow, spread and sink water, cycle nutrients and provide shade and habitat among other beneficial uses. Invasive trees, however, can crowd out natives and deplete water supplies. By assessing the entire urban forest and working to increase the native tree canopy we can slowly bring the watershed back into balance.

• **Manage invasive tree species**. Along many arroyos and riparian areas, Siberian Elms, Salt Cedars, Tree of Heaven, and Russian Olive trees have crowded out native species. There are current efforts throughout the County to remove them to allow natives to reestablish themselves. Invasive species that are known to crowd out natives should be banned from all nurseries in the County.

• **Modify the QWEL program**. Adapt the Qualified Water Efficient Landscaper (QWEL) certification course to arid southwest best management practices that take into consideration predicted climate shifts. Provide regular local access for completing the certification course.

• **Establish a Triple Bottom Line Impact Report form**. Develop and approve a City-wide assessment form that accompanies City actions like purchases, ordinances, contracts, resolutions, plans, etc. and requires staff to evaluate the impacts of actions based on a triple bottom-line of

people, profit and planet. This form would encourage behaviors that are sustainable given long-term climate predictions.

Chart 3 was created by the planning team to identify solutions that would mitigate the identified water stressors and climate-related impacts.

Water Stressor/ Impact	Solutions	Responsible Parties	Comments
Drought: reduced water supplies	Water conservation program (retrofits, incentives, workshops)	Water Cons. Committee	Public Education Campaign
Wildfire	Forest thinning/controlled burns, WUI development controls	USFS	Ongoing
Increased temperatures	Locate Nursing homes in cooler parts of city, increase home insulation, green roofs or white reflective roofs through building codes, retrofit incentives,	City planning, building codes	
Extreme rain events: flooding	Rehabilitate Arroyos, Increase tree cover, Increase infiltration and catchment	SFWA, City of SF,	
Invasive species	Support the 75 year Urban Forest Plan, Support down-stream invasive tree removal programs	City of SF Parks Dept., County	
Drought: Increased tree mortality	75 year urban forest plan, encourage grey/black water reuse	Parks Dept., City, Building codes	
Decreased groundwater supplies	Increase water infiltration through passive rainwater harvesting and Managed Aquifer Recharge.	Streets & Drainage, homeowner incentives, County	See below
Decreased water supplies	Continue and expand water conservation programs	City Water Dept.	
Increased temperatures	Strengthen social systems, neighborhoods and collaboration	Neighborhood Associations	Have neighbors check on elderly
Drought	Est. cultural information exchange with Cities with similar climate	Sustainable SF, Western Adaptation Alliance	Sister Cities for arid environments
Increased erosion	Update the QWEL program, encourage rainwater harvesting	Melissa McDonald	
Decreased water/energy	City triple-bottom-line form for all City actions/purchases	City of SF, SF County	

Table 3: This Climate Risks and Solutions Chart identifies some of the risks and solutions that have been identified to address the changing climate in the Santa Fe Watershed.

The Contemporary Landscape

Photo 18: Hikers on the Aspen Vista Trail in the Santa Fe Forest. *Source: Esha Chiocchio.*

The Sangre de Cristo Mountains and the forests that covers them, provide incalculable ecosystem services for the entire Santa Fe Watershed: the high altitude mountains encourage precipitation and are cold enough to host snow-pack; they provide geological formations that funnel water to reservoirs; and the trees slow precipitation and stabilize soils to reduce runoff and provide a continuous supply of moisture-preserving mulch with their fallen needles and leaves. They are the heart that keeps water circulating through the land.

However, climate change presents new challenges for these critical landscapes. As temperatures rise, evaporation accelerates, stripping both the soil and the vegetation of moisture. This reduction in moisture levels stresses the trees, making them more susceptible to insect infestations and wildfires. Simultaneously, a century-long policy of fire suppression, has left our forests overgrown. This increased tree density presents three risks for the forest: 1) a higher demand for groundwater to support the greater number of trees, 2) higher fuel loads that encourage hotter and faster-burning fires and 3) the smaller and mid-sized trees provide "ladders" for fire to move from low-level grassland fires to crown fires that kill the larger and more established trees that would have survived a low-lying fire.

Regional tree ring data indicate that fire historically swept through the area in low-grade wildfires that fostered a diversity of meadows and tree density patterns. These fires provided a keystone disturbance process that kept the forest functioning optimally (Allen et al.). Now that the forests have grown into dense stands and humans have built their homes and businesses in and around forested areas, we are faced with new challenges. In order to reduce the risk of losing the forest altogether, we must now try to mimic the beneficial effects of wildfire through selective thinning and controlled burns.

Significant research has been conducted in New Mexico forests that lends great insight into future needs for forest management. The following passage is an excerpt from *Climate Change in the Santa Fe Watershed: A Preliminary Assessment.*

Southwestern US Forests

A particularly arresting example of the potential for cascading impacts of climate change is the projected effect of increasing temperatures on Southwestern forests. Dr. Park Williams, has been studying how forest fires correlate with rates of water use by plants, winter snowpack, drought indices, and pine beetle outbreaks (Williams et al., 2012a and 2012b). He found that all of these factors are strongly correlated; dry winters coupled with dry, hot summer conditions stress the trees, making them more susceptible to pine beetles and more prone to forest fires.

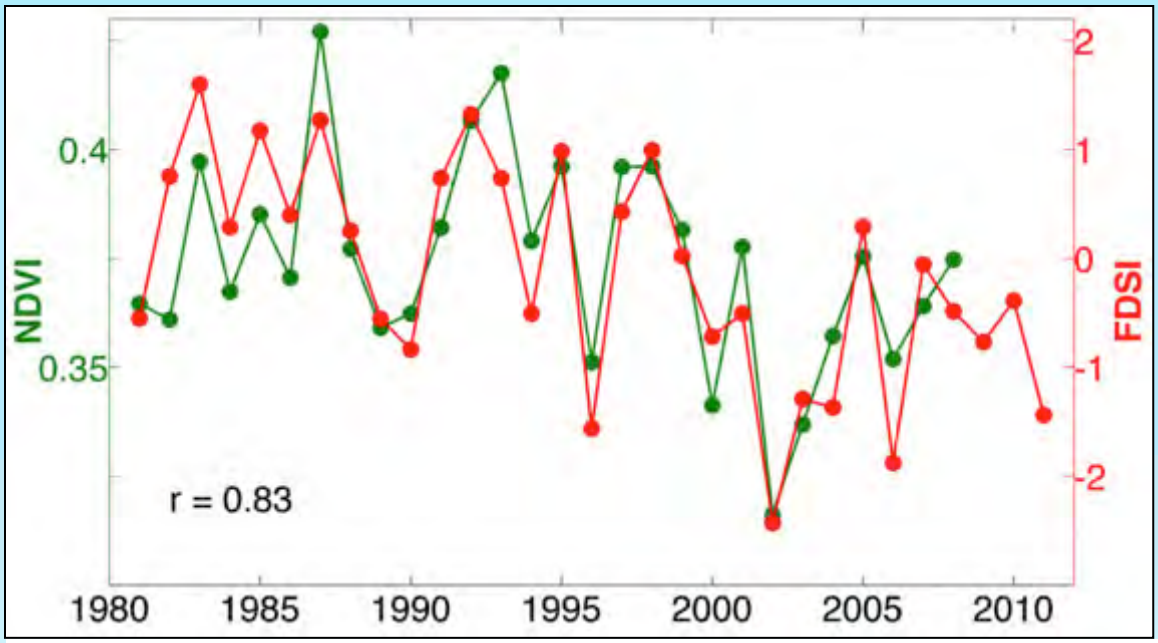


Figure 12: Correlation between summer vegetation greeness index (NDVI) and the Forest Drought Stress Index (FDSI). *Source: Williams et al., 2012a.*

Dr. Williams used this information, combined with historical data from tree rings, to develop a "forest drought stress index" (Figure 11). Low index values indicates conditions prime for forest fires. The index was particularly low in northern New Mexico in 2002, 2006, and 2011, all years with particularly high fire activity in this region. New Mexico experienced the worst fire season on record in 2011, when the Las Conchas fire burned 150,000 acres in the Jemez Mountains. The Pacheco fire burned about 10,000 acres in June 2011 and came within two miles of the Santa Fe watershed.

Drought-induced forest fires are normal in New Mexico. For example, tree-ring data suggest that regionally extensive droughts in the late 1200s and late 1500s caused increased forest fires throughout the Southwestern U.S. Dr. Williams' research also calculated low forest drought

severity indices during these periods. Furthermore, Dr. Williams predicts that index values in the future will become more negative (drier), and that by about 2050, FDSI values for even the wettest, coolest years will equal or exceed the values experienced during the 1200 and 1500

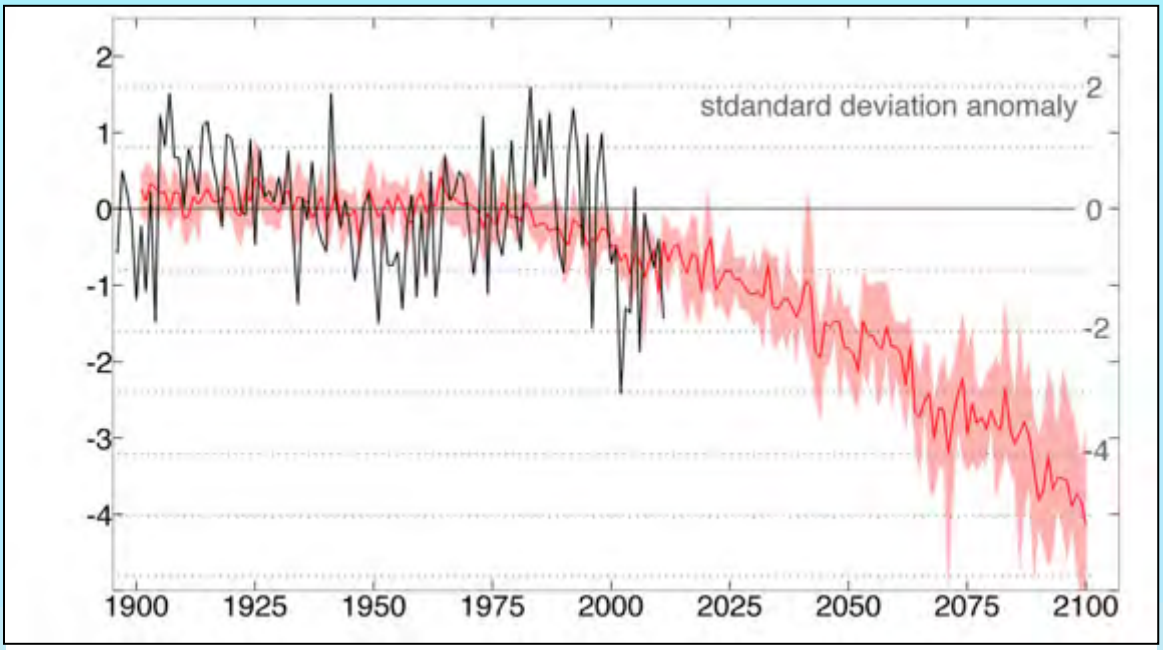


Figure 13: Projected and historic Forest Drought Stress Index (FDSI) derived from measured data (black) and projected data (red). *Source: Williams et al., 2012a.*

"mega-droughts", the 1950s drought, and the recent 2002, 2006 and 2011 summers. In other words, by 2050, average conditions will equal that of the worst drought years that the Southwestern U.S. has experienced in the past 1000 years (Figure 12).

In the near future, forest fires are likely to become more frequent, and possibly larger (depending on how the basin's forests are managed). These forest fires in turn affect the stability of the landscape. The more intense rainstorms that are expected are likely to increase erosion, and cause the accumulation of ash and sediment in streams and rivers.

As in 2011, with the severe erosion following the Las Conchas fire, these changes may prevent the use of surface water for drinking water by communities such as Santa Fe for many months.

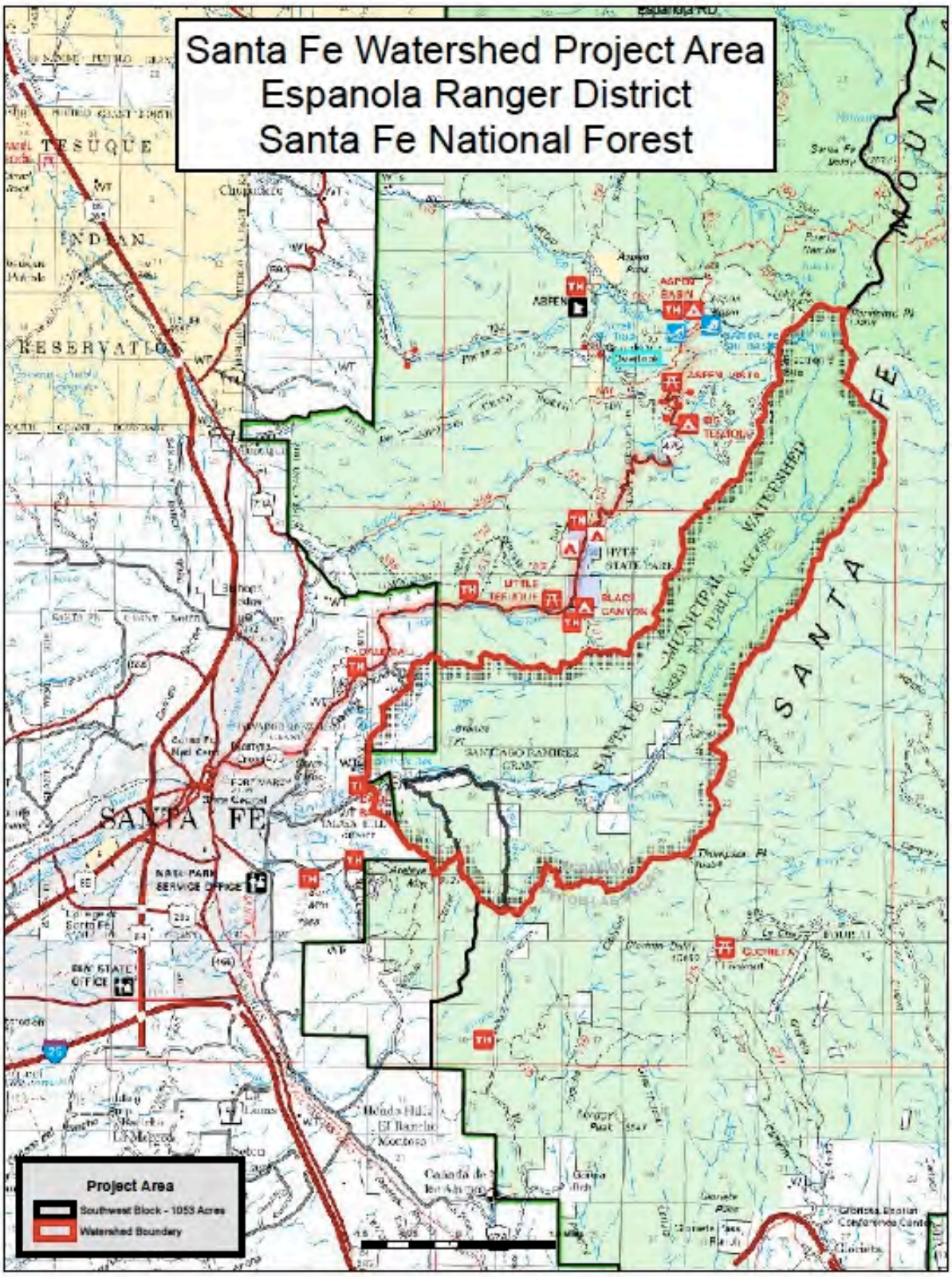
Within a few decades, maintaining ecosystems as forests, rather than allowing conversion to scrublands or grasslands, if desired, may only be possible in wetter or otherwise milder climatic niches. Most other currently forested areas may transition to non-forest vegetation ecosystems.

The Sangre de Cristo Mountains

Throughout the 1800s, heavy livestock grazing, homesteading, logging and recreational activities such as swimming, fishing and camping occurred in the forested section of the upper watershed, known as the Municipal Watershed. By the 1920s, the lower slopes were depleted of trees and ground vegetation, which led to severe soil erosion and water pollution. In 1932, the Secretary of Agriculture closed the Watershed to public access in order to protect the water supply for the City. During the early 1900's a wildfire burned the forest between what is now Hyde State Park and the Santa Fe Ski Basin. Today, the majority of the burned area is covered with a large Aspen forest. The composition of the remainder of the forest is predominately populated by conifers with the following species distribution according to elevation in feet above sea level (abs):

- ~ 7000' abs: Piñon/Juniper complex
- 7000'-8500': Ponderosa Pine intermingled with Aspens
- 8500'-10,000': Engelmen Spruce and Douglas Fir

The map below delineates the closed Municipal Watershed area and shows its relationship with the City and surrounding camping and recreational areas of the Santa Fe National Forest. Although the scope of this climate adaptation plan is limited to the Santa Fe Watershed itself and the forest of the Santa Fe Watershed is closed to the public, it should be noted that the adjacent areas are open to the public and threaten the Upper Santa Fe River with accidental wildfire caused by users of the Santa Fe National Forest and Pecos Wilderness. This area includes residential areas (Hyde Park Estates), recreational areas (the Santa Fe Ski Basin, Hyde State Park, numerous hiking trails and the Pecos National Wilderness), and businesses (Ten Thousand Waves, Cottams, etc.). Moreover, the lingering drought conditions existing in Northern New Mexico have resulted in additional stress on forest health, especially in the lower elevations where the Piñon/Juniper complex dominates. This lower elevation forest complex has been devastated by invasions of Pine Bark Beetles during the past ten years. In addition, homeless people living in the urban wildland interface (UWI) just north of the City of Santa Fe have caused wildfire threats and there are current efforts underway to relocate them out of the forest to reduce the risk of accidental wildfires that might be initiated by these temporary campsites.



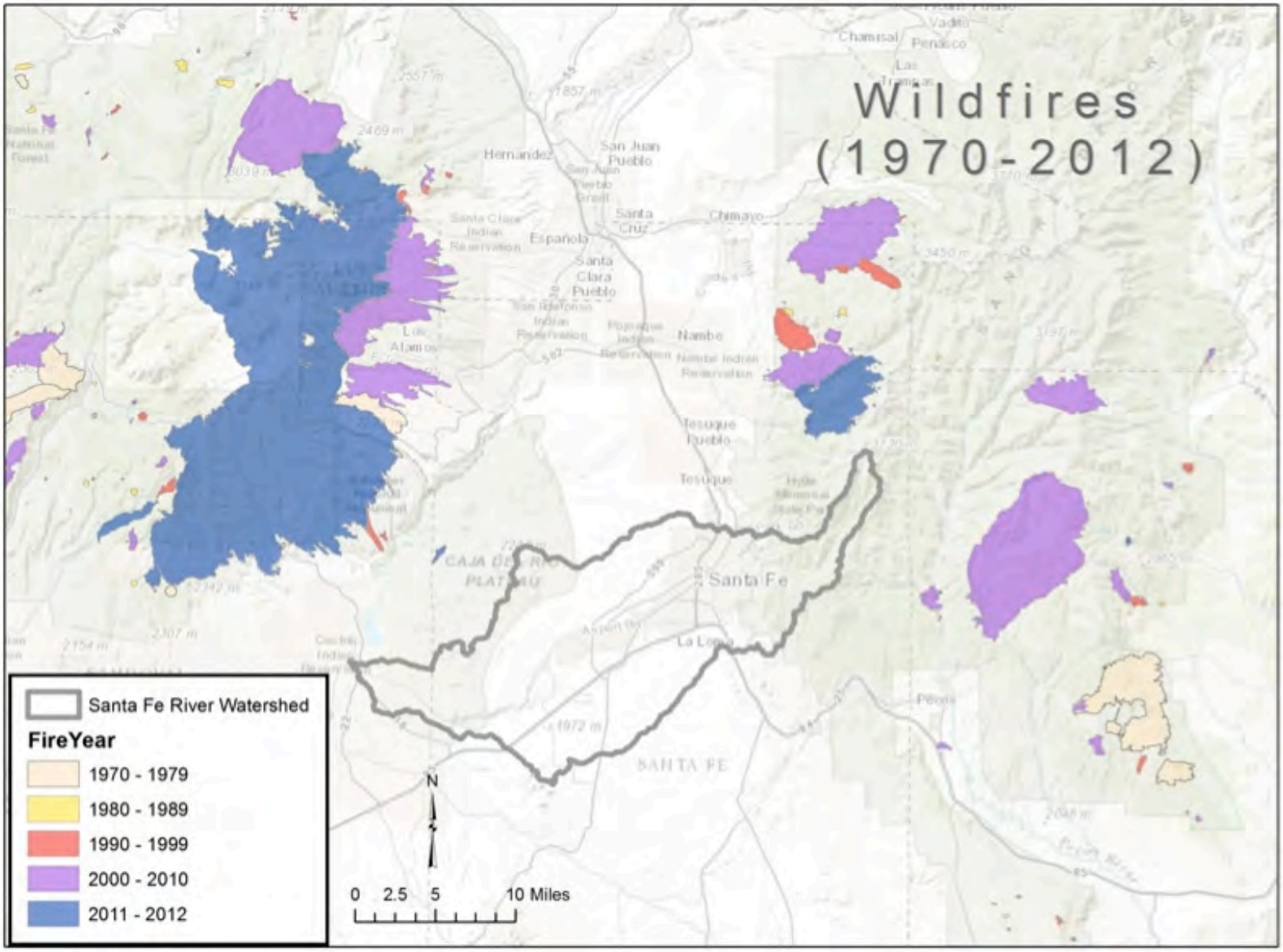
Map 6: The Santa Fe Municipal Watershed in relation to the City, Santa Fe National Forest and recreational areas. *Source: Jon Boe, USFS.*

Forests and Fires

A healthy forest is critical to the health and quality of the water in the Santa Fe River. For the past 100 years, the forestry management strategy throughout the United States was to suppress fires. This has left the forests overcrowded, vulnerable to pests and prone to "stand replacement fires" that destroy the vegetation that normally protects the soil. This became frighteningly clear in 2000 when the Cerro Grande Fire near Los Alamos, NM severely burned one-third of the basin's forest. When an area has not burned in numerous years, the accumulated vegetation burns much hotter than it would in an area that has been naturally thinned by fire over time. The resultant extreme heat has a tendency to kill the larger trees that would have survived a lower-temperature burn. In addition, it burns the sand in the soil, creating a less-permeable, glass-like hydrophobic surface. With the trees and other vegetation no longer available to slow surface runoff and the soil less able to absorb water, precipitation events send water downhill at a higher velocity and with much higher percentages of sediment (Margolis *et al.* 2009). If this were to occur within our Municipal Watershed, the two reservoirs would fill with sediment, ash and other debris rendering them incapable of storing water.

Photo 19: View of Frijoles Canyon, photographed in March 2013, almost two years after the June 2011 Las Conchas Fire. *Source: Esha Chiocchio.*

Over the past forty years, New Mexico has seen significant wildfire activity, much of which has occurred close to the Santa Fe Watershed but, fortunately, not within its geographic boundaries. In 2011's drought, fires burned 650,000 acres, including the Las Conchas Fire, which burned more than 150,000 acres and threatened the Los Alamos National Laboratory. In 2012, the Whitewater-Baldy fire burned over 259,000 acres, nearly twice the size of Las Conchas (Repetto, 2012). The map below shows the history of wildfire activity in the region since 1970 and identifies the Santa Fe Watershed with a gray outline.



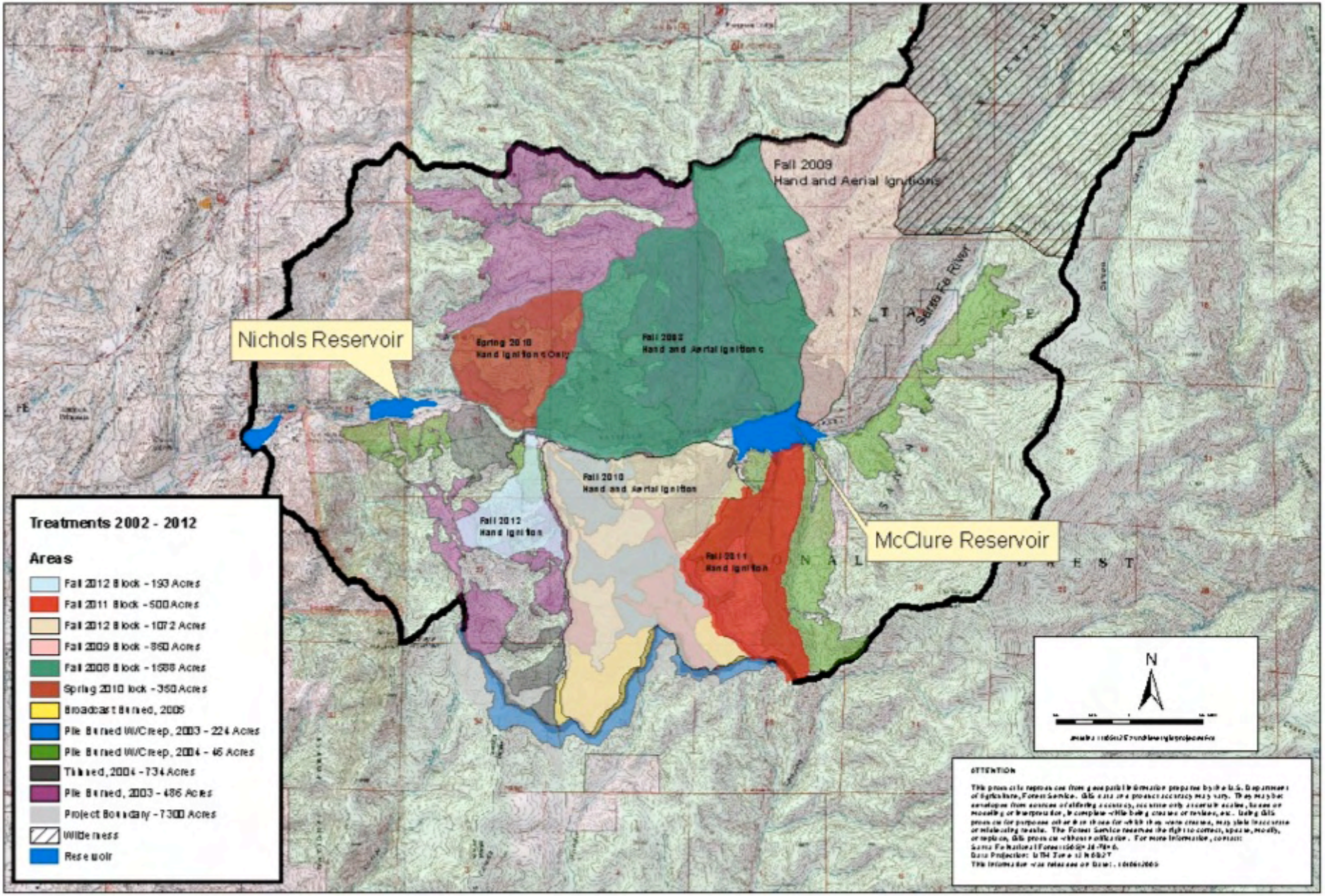
Map 7: Wildfire activity near the Santa Fe Watershed from 1970 to 2012. *Source: City of Santa Fe Water Department.*

In an attempt to avoid such catastrophic fires in the Santa Fe Watershed, the Espanola Ranger District of the Santa Fe National Forest (SFNF), City of Santa Fe Water Division, the Santa Fe Watershed Association (SFWA), the City of Santa Fe Fire Department, and the Nature Conservancy (TNC) developed the Santa Fe Municipal Watershed Project Final Environmental Impact Statement (EIS). The EIS established a plan to mechanically thin the forest and use a system of prescribed burns to reduce the risk of stand replacement fires. Over the past ten years, the USFS has implemented this treatment plan throughout the lower portion of the Santa Fe Municipal Watershed.

The initial implementation work was financed with federal appropriated funds, specific to the work. The ongoing maintenance is financed through a small fee for ecosystems services that is financed by the public through their water bills.

The following map shows the ten-year history of fuel treatments in the lower portion of the Santa Fe Watershed.

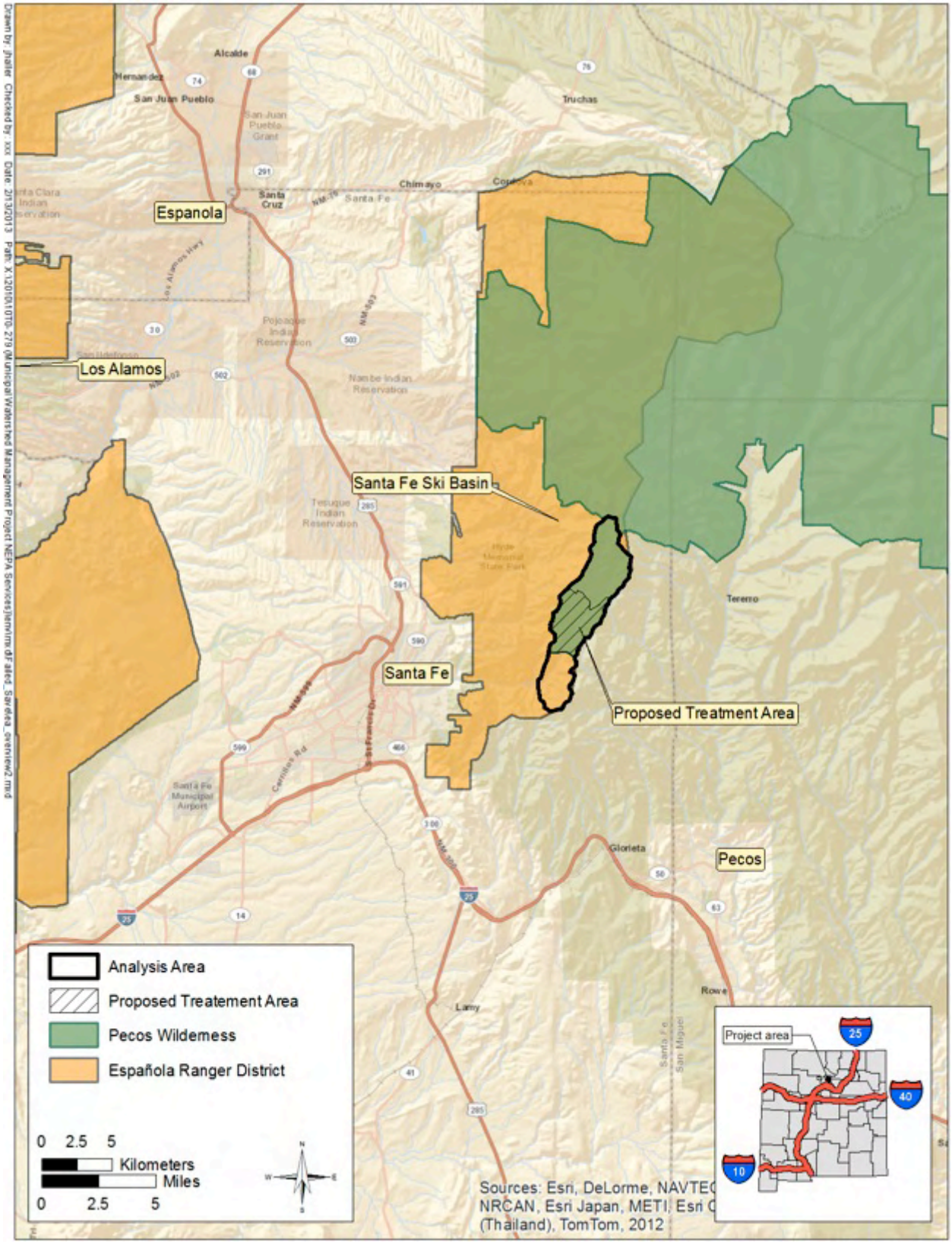
Photo 20: Prescribed burns are often conducted in the Upper Watershed during winter months, when soil moisture levels are high and wind speeds are low, to reduce the risk of spreading.
Source: USFS.



Map 8: Map showing the 10-year history of fuel treatments in the lower portion of the Santa Fe Watershed. *Source: Jon Boe of the USFS.*

Photo 21: A Ponderosa Pine stand in the Upper Watershed that has been treated with thinning and prescribed burns to reduce the fuel load and stabilize the soils. *Source: Esha Chiocchio.*

Due to the designation as a Wilderness Area, the upper portion of the Municipal Watershed has not yet been accessible for treatments. Currently, the USFS is proposing a series of options for a treatment regime in approximately 6,520 acres of ponderosa pine and mixed conifer stands within the Pecos National Wilderness Area. The plan calls for treatment of the area marked with diagonal lines in the following map (USDA 2013).

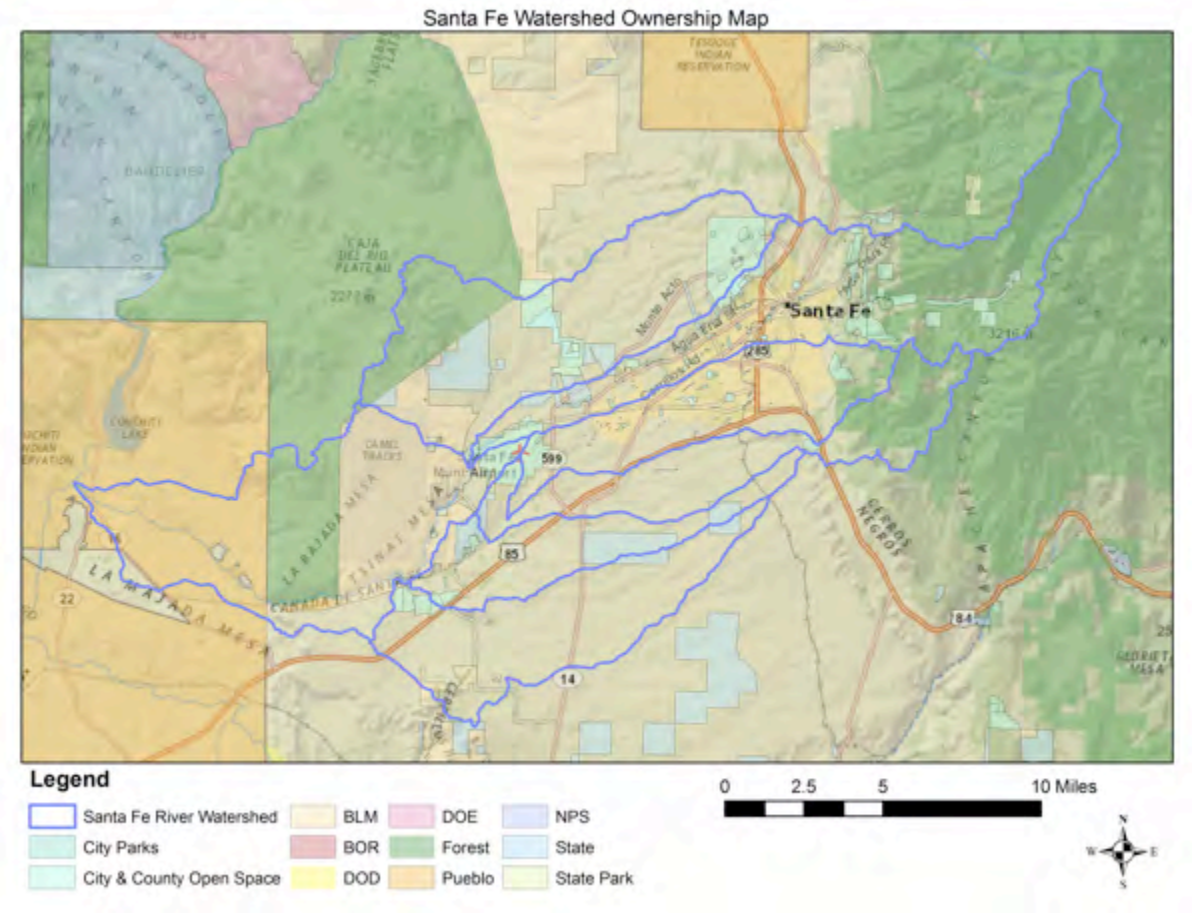


Map 9: USFS proposed treatment areas. *Source: Draft Environmental Assessment, USDA 2013.*

The current proposal, *Santa Fe Municipal Watershed Pecos Wilderness Prescribed Burn Project – Final Environmental Assessment* (EA), suggests three treatment options:

- Alternative A – The No-Action Alternative
- Alternative B – The Proposed Action: Prescribed Fire with Aerial Ignitions and Hand Ignitions Where Practical
- Alternative C – Mechanical Pre-treatments Using Chainsaws/Prescribed Fires with Aerial Ignition and Hand Ignitions Where Practical.

The goal of intervention is to reduce the likelihood of catastrophic fires within the Santa Fe watershed. Please see Appendix 1 for the analysis summary of each of the proposed alternatives.



Map 10: Ownership map of the Santa Fe area with the watershed defined in blue.
Source: Santa Fe Conservation Trust.

The main forested area described above can be seen in green on the East (right) side of Santa Fe on the map above. While this is the main forest of the watershed, there are other trees that provide critical ecosystem services within the greater watershed. Several initiatives are underway to improve forest health throughout the area. The land ownership of the greater Santa Fe Watershed consists of the municipal watershed (described above), the urban area within the City limits, and

the more rural communities downstream (La Cienaga, La Cienegilla, La Bajada and Cochiti Pueblo). The ownership map above delineates the overarching ownership pattern of the area with the watershed outlined in blue.

Forestry Initiatives within the City of Santa Fe

Over the past 40 years, the overall canopy cover of the Santa Fe Watershed has been reduced, leaving the soil exposed and susceptible to excessive evaporation and erosion. In recent years, significant strides have been made throughout the watershed to reforest the Santa Fe River basin. In an effort to maximize water infiltration, reduce erosion, increase shading, improve wildlife corridors and generally improve the overall health of the Santa Fe River, the City embarked on a river restoration project that included inducing the meander and widening the river's path, installing one-rock dams and other rock structures designed to slow and direct flow, and planting thousands of native willow and cottonwood trees along the banks of the river bed. The following photo-illustration shows the areas that have been planted through this program as marked in green with a red outline.

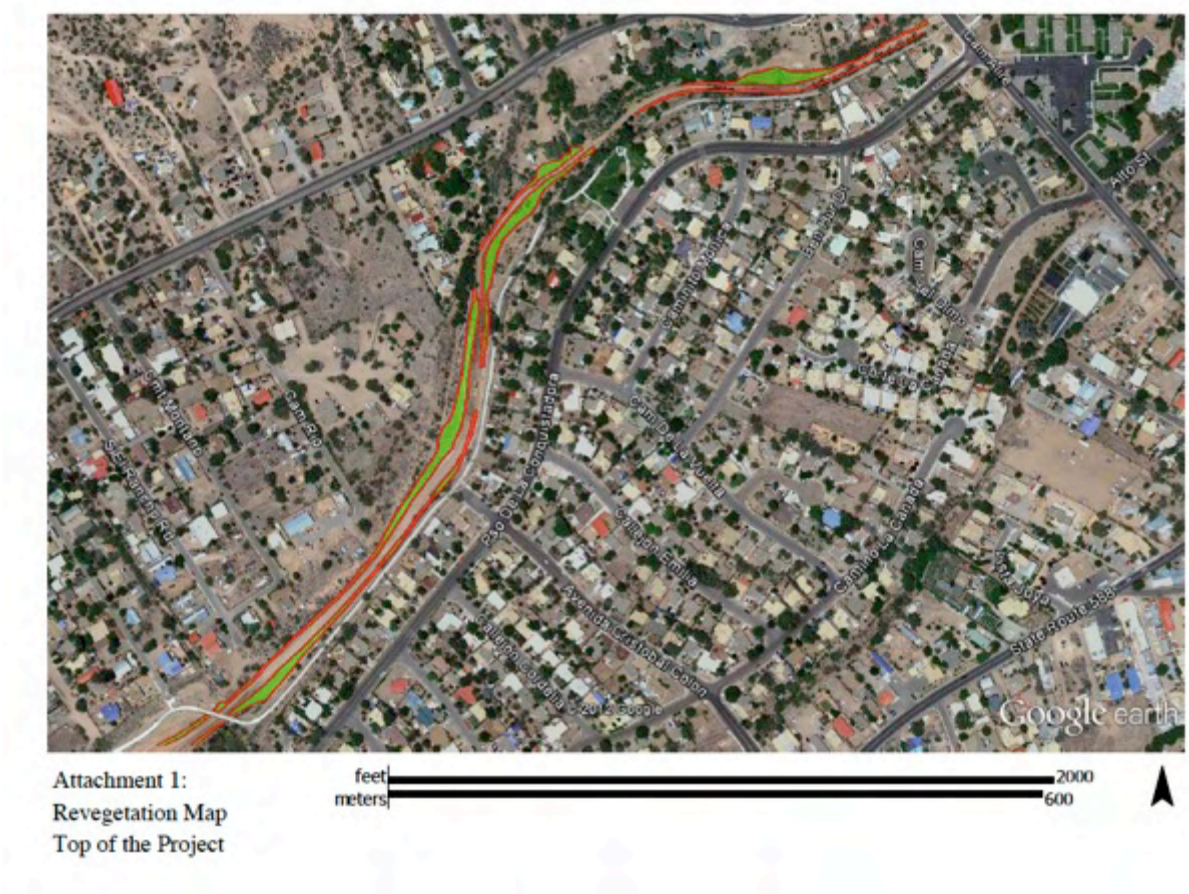


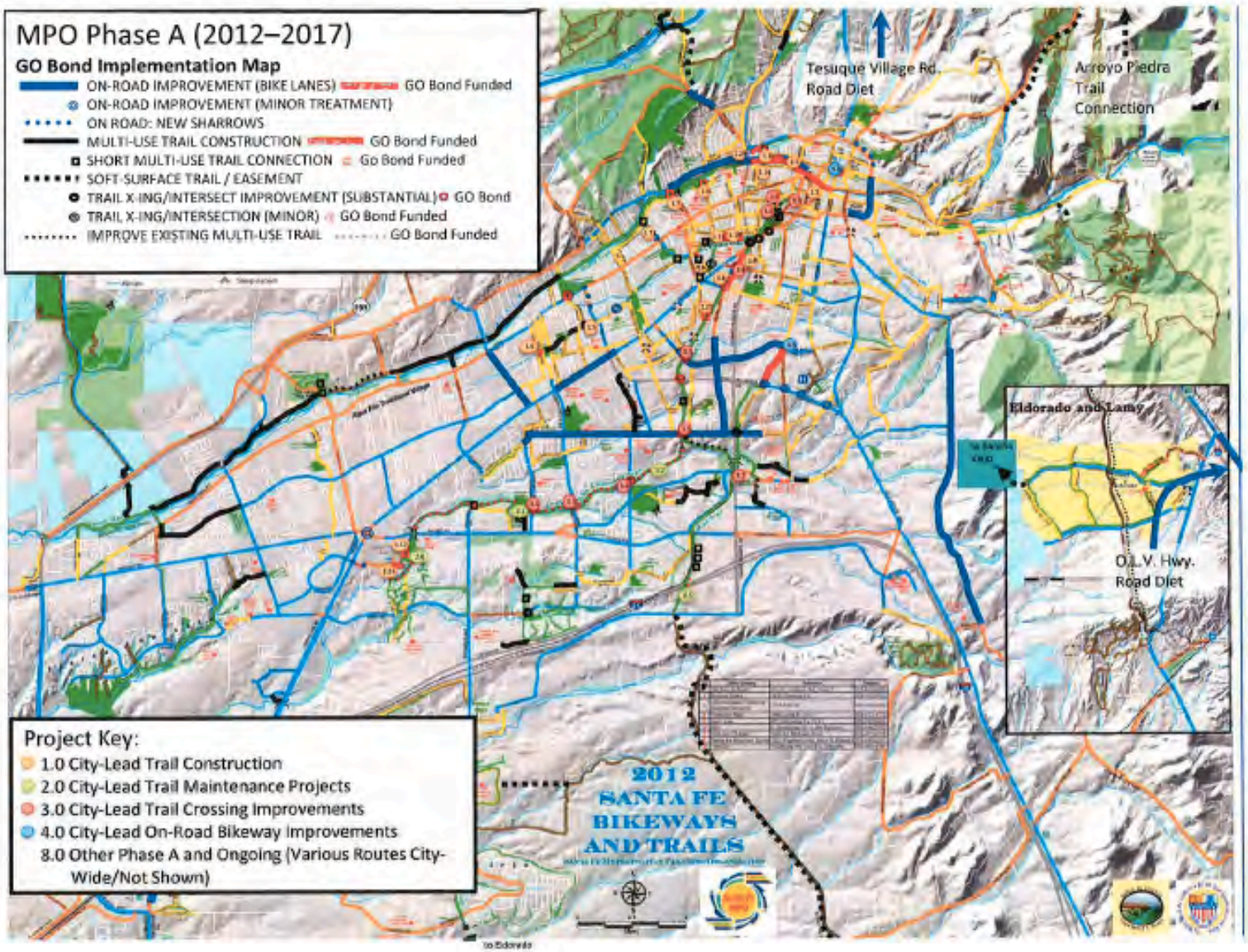
Photo 22: Photo-illustration of the Santa Fe River with the restoration and re-vegetation project identified in red and green. *Source: Brian Drypolcher, City of Santa Fe.*

In addition to this tree-planting effort, the Santa Fe Parks department has been working for the past several years to assess the overall tree coverage and health, reduce water-intensive turf areas and increase the tree canopy throughout the City. They are currently working on a pilot project with Youth Works to use the iTree application on iPads in conjunction with Tree Keepers software to map all of the trees between Cerro Gordo and Frenchie's Park. Once this pilot project is complete, they hope to expand it to the entire city. This system will provide information about the exact location (via GPS), the species (via leaf and bark identification), the age and health of the tree (via photographs to determine the size and percentage of live vs. dead branches) and will help the City Forester, Robert Wood, determine if there are trees that should be replaced and/or identify areas that have inadequate tree cover. In order to ensure adequate and healthy tree cover throughout the City over time, they are working on acquiring funding to contract with Davey Tree to create a 75-year Master plan for the urban forest. As this project is in its infancy, there is limited data on the urban forest. The following map shows the parks and trails of the City to give a sense of the number of vegetated parks within the City limits.

Photo 23: Mother and children planting a cottonwood tree in the Santa Fe River bed during one of the community tree-planting days.
Source: SFWA.

Another initiative that is currently in process is an Urban Forest Roundtable that has been organized by the Railyard Stewards. The first two and a half-day Roundtable focused on the main attributes participants would like to see in an urban community forest and the challenges that will hinder them from achieving the ideal community forest. Their second Roundtable identified the actions they can take to overcome those challenges. They are currently seeking funding to implement their plan (Railyard Stewards 2013, Railyard Stewards 2013b).

In order to rebalance the ecosystem, collaboration among non-profits, City and County staff, landscapers and individual homeowners will be critical to achieve appropriate tree-cover and increased infiltration. The Urban Forest Roundtable provided the environment for people from each of these sectors to discuss the issues and explore solutions to improve the urban forest.



Map 11: The Santa Fe parks, bikeways and trails to show the City's public vegetated spaces.
Source: Santa Fe Parks Division.

Forestry Initiatives Downstream from Santa Fe

Other initiatives are underway West of the City limits (downstream) that work in conjunction with the upstream efforts. Similar to the City tree planting initiatives, the County is also planting native Willows and Cottonwoods along the streambed Southwest of the city limits. In addition, the Santa Fe-Pojaque Soil and Conservation District has worked with homeowners along the Santa Fe River to remove invasive species (mostly Russian Olive, Tamarisk and Siberian Elm trees) so that the native species (mostly willows and cottonwoods) can thrive.

Photo 24: The Santa Fe River basin in the La Bajada area, downstream from Santa Fe.
Source: Esha Chiocchio.

Governance

The following governance chart was developed by the planning team to identify each of the entities that govern the forests of the Santa Fe Watershed.

Type of Entity	Specific Entity(ies)	What Does Entity Do That Impacts Resources?	Significance in the Community (Subjective)
Land Owners	City of Santa Fe	Processes reservoir water for City Supply, manages land around reservoirs.	Supplies City Water.
	USFS	Implements actions under various National Forest System laws, and other applicable laws like ESA and CWA.	Reduces risk of catastrophic fire and protects the functioning of the reservoirs.
	The Nature Conservancy	Manages TNC Conservation area adjacent to the Audubon.	Preserves open space and habitat along the Santa Fe River.
	The Randal Davey Center (Audubon)	Manage the Audubon Center and promotes preservation of the natural environment.	Preserves open space and habitat along the Santa Fe River.
Land Owners (cont.)	Private Wells within City and County under State Engineer's office	Depletes groundwater supplies.	Wells are not metered/monitored and can draw more water than is technically allotted.
Land Management Agencies	USFS	Implements actions under various National Forest System laws, and other applicable laws like ESA and CWA.	Controls 90% of land base in upper/closed watershed.
	BLM	Implements actions under various National Forest System laws, and other applicable laws like ESA and CWA.	
	State of NM (DNR, parks dpt.)	Manages parks and open space. Can lease mineral and/or grazing rights.	
	Cochiti and Keva Pueblos	Owns and manages land in the lower reaches of the SF River Basin.	

Regulatory Agencies	U.S. EPA via the NMED	Implements CWA by approving rules and permits by state WQ agency.	
	USFWS	Implements ESA, may impact activities on forests of ALL owners.	
	State water quality agency: NMED	Adopts and implements WQ rules and permits.	Actions need to be taken so that the TMDLs remain to be done with WQ standards not met due to shade/temperature problems in the forest.
	Santa Fe County	Regulates land use—uses, subdivisions, riparian buffers, critical areas, etc.	
	Soil and Water Conservation Districts	Provides education to forest landowners on how to protect ecosystem services.	
	City of Santa Fe Water Department	Manages water supply: 2 Reservoirs, 2 well fields and BDD.	Critical to the functioning of the City.

Table 4: Governance chart for the forests of the Santa Fe Watershed.

Potential Forest Solutions and Strategies for Climate Resilience

Throughout the Santa Fe Watershed, initiatives are underway to protect and improve the health, quality and quantity of trees as we shift to hotter and dryer climate conditions. The balance of tree cover and water use to support those trees is perhaps the most challenging aspect of these endeavors. While forest conditions in the upper, forested watershed are dense and susceptible to catastrophic fires, thereby necessitating mechanical thinning and prescribed burns to reduce fuel loads, the opposite situation exists in the lower section of the watershed. Here, there is a need to increase the overall native tree canopy, which has been reduced due to a variety of factors, including development, competition from invasive species, reduced river flows, decreased soil moisture and lower groundwater levels. Trees provide shade (and therefore cooling), reduce erosion, provide habitat, filter water, help to complete the hydrological cycle, and absorb carbon, among other things. For innumerable reasons they are essential to a healthy environment.

Trees, however, need water. In order to increase tree-cover in the lower stretches of the watershed, water is necessary in the soils and streambeds (at least periodically). For many years, the Santa Fe River did not have rights to its own water and virtually all of its water was held in the reservoirs and distributed throughout the City via the municipal water distribution system. This lack of water and the resulting desiccation of the riparian vegetation led to its designation as

America's Most Endangered River in 2007. The sounding of this alarm bell led the community to pass a resolution to dedicate 1,000 acre feet of water per year to the Santa Fe River (subject to water availability). This periodic release of water is intended to irrigate the newly planted willows and cottonwoods that stabilize the river bed, hydrate groundwater and sub-surface flows and increase groundwater levels that will benefit plant life during the dryer periods of the year (City of SF Resolution No. 2012-28). In addition, the parks and recreation department is employing sophisticated, weather-tied, efficient irrigation systems to keep trees and other plantings alive with a minimum amount of water.

Photo 25: Re-vegetation sign to inform the community of new plantings along the Santa Fe River as part of the 2012 river restoration project. *Source: Esha Chiocchio.*

For the long-term success of trees in this area, however, infrastructure changes are needed to increase the water storage capacity of the land through improved storm water management techniques. Several projects are underway to replace conventional asphalt with permeable pavement combined with directional subsurface piping and below-grade planting areas to encourage the irrigation of street-side or median plantings. In essence, we need to increase the "sponge factor" of our landscape and embrace the Permaculture technique of water harvesting through the water management goal of "slow it, spread it, sink it" (Lancaster 2006). This is perhaps the area of maximum potential for the watershed and can be extended through education to reach the municipal infrastructure departments, home and business owners, landscape design companies and anyone else who influences how land is used and contoured.

Progressive forest management projects are being implemented throughout the Santa Fe Watershed and numerous individuals and agencies are working to build upon these efforts. Climate predictions for the region indicate that we can expect increased temperatures in the years to come, in effect shifting our traditional gardening zone to a lower elevation. Simultaneously, we

can expect less predictable weather patterns and more intense storms. With the development of the 75 year urban forest plan, the retrofitting of numerous storm water drains and green building codes that encourage water harvesting, we have the opportunity to take into consideration the effects of climate change and plan accordingly through species selection, percentage of canopy cover and advanced planting techniques that better utilize storm water to irrigate trees and other plantings and to distribute and store in the landscape to reduce the risk of flooding.

When considering these changes and what can be done to mitigate the impacts of climate change, the planning team considered several areas of focus and created the following chart to identify some of the solutions.

Function at Risk	Stressors & Risks	Solutions	Responsible Parties	Comments
Forest (in upper USFS and private forests)	Increased fire/Wildland Urban Interface issues (WUI)	Land use regulation to prohibit or control development in WUI.	County, state fire agency, F.S., City,	Need good economic analysis to help "sell" the idea to landowners and county; reducing incentives might require change in state law.
		Realtor education (Create Disclosure requirements for NM & local homebyers).		
		Private landowner education		
		Fire management / controlled burns		
		Forest thinning programs		
Hydrological (storage, release, filtration, flood control, infiltration, soil stability, soil conservation, etc.)	Loss of urban forest land to development	Ecosystem service valuations for business case for conservation in light of forest projections	City Urban forest plan (Bob Wood), County; easement purchase	Politically difficult and/or expensive; use ecosystem services to make case and possibly find ways to pay or make politically tenable.
		Improve the urban canopy cover and species selection through the 75-year plan development and implementation.		
		Land use/zoning changes		
		LEED-ND Neighborhood Development		
		Land acquisition for conservation		
		Update Building Codes.		
		Arroyo/acequia/SF River zone requirements		
		Ecological overlay zone		
		Conservancy programs to keep large tracts of land intact.		
		Incentives to create natural over-story		

Habitat	Degraded habitat (fragmentation, noise, size, species diversity, structural diversity, etc.)	Habitat dedication requirements	County, F.S. on federal land, City of SF	Develop Climate Adaptation Standards Checklist for all projects to ensure water infiltration, habitat preservation, soil conservation, over-story maximization, etc.
		Habitat connectivity		
		Watershed clearing limitations		
		Road management plan		
		Stream crossing requirements		
		Storm water rules		
		Habitat Restoration		
		Soil building		
		Program of objections checklist of criteria for habitat optimization for all projects (Climate Adaptation Standards).		
	Drought	Promote the concept of the forest as a sponge to increase soil moisture and health.	USFS, City, County,, Streets and drainage dept.	
		Increase the use of permeable pavement, curb cuts and other infrastructure changes that slow, sink and spread water.		
		Tree thinning to reduce insect damage and risk of fire.		
Recreation		Limit off-road vehicle use.		
		Design hiking/biking trails to reduce erosion.		

Table 5: Forest solutions chart.

ANALYSIS AND RECOMMENDATIONS

The Santa Fe community greatly appreciates its natural resources, both for economic and intrinsic values. Citizens are engaged in policies and land management and are doing their part to reduce water use. There is an opportunity to bring together the spirit of the community and the expertise of agencies and non-profits to be a leader in preparation and adaptation for climate change.
A business as usual approach will put many of the beloved aspects of Santa Fe at risk. Rather than waiting for impacts and responding, the potential impacts should be assessed and specific adaptation strategies implemented. Climate change is happening and the impacts will continue to intensify. However, there are many opportunities in the Santa Fe Watershed to implement measures for adapting to climate change that can simultaneously increase ecosystem and community resiliency, improve the economy and strengthen community relationships. Outreach and education is needed through groups like the Santa Fe Watershed Association, The Sustainable Santa Fe Commission and the Nature Conservancy. Project implementation is needed through municipal entities like the Water Department and Streets and Drainage, and monitoring is necessary to continually update adaptation strategies as needed, and for accountability and trust.

Photo 26: Forester Bill Armstrong explains the long-term rainfall patterns of the area during a guided tour of the Santa Fe Municipal Watershed.
Source: Esha Chiocchio.

This Climate Adaptation and Action Plan is one step toward preparing for climate change and increasing resiliency in the Santa Fe Watershed. This is an iterative process, and this plan will need to be continually updated and modified as conditions change and monitoring informs. This is a step toward bringing the community together to have the agility and capacity to adapt to climate change, increase resiliency, and serve as a model for other regions to prepare for changes in the climate.

The following chart was created by the core team to prioritize the areas of concentration in climate adaptation planning.

Table 6: Identification of the risks and stressors to various systems and the risk value associated with them.

Planning Area	Non-climate Stressors	Current Climate Risks / Impacts	Consequence (L,M,H)	Probability (L,M,H)	Ability to respond (L,M,H)	Risk Value (L,M,H)
Forest						
Catastrophic, stand-replacement fire	Overgrown forest due to decades of fire suppression.	Hotter/dryer climate with less snow pack.	High: Destabilization of soils can cause ash/debris can clog water treatment facility (40% loss of water supply); reduced infiltration/ groundwater recharge.	High: Catastrophic fires have already occurred in neighboring forests.	Medium: 10 years of thinning and controlled burns have reduced the risk in the upper watershed, however, surrounding forests have had no treatment due to wilderness designation and resistance by private property owners.	High
Insect-induced tree mortality	Overgrown forest due to decades of fire suppression.	Hotter/dryer climate with reduced soil moisture.	High: tree mortality, increased fire risk, reduced water cycling, reduced soil stabilization.	High: Thousands of acres of trees have already died due to bark beetle.	Low: Cannot effect rainfall or temperature without significant global carbon reductions, thinning can reduce trees per acre to improve water supplies for remaining trees.	High

Invasive tree species throughout the Watershed	Russian Olive, Siberian Elm, Tamarisk, Ailanthus, and other invasives have pushed out native species.	Climate change is increasing temperatures and reducing available water, thereby shifting the species dynamic in the region.	Medium: Theses changing habitats and food sources negatively affect wildlife populations thereby increasing the importance of preserving native plant species.	High: Many native species have already been pushed out of their habitats.	Medium: Invasive tree removal is underway throughout the watershed but it is expensive.	Medium
Urban forest loss and deterioration	Increased impermeable surfaces, reduction of canopy cover, proliferation of invasive tree species that create intolerable soil conditions.	Climate change is creating increased competition for available water.	Medium: Increased heat island effect, reduced animal forage, exposed/wind blown soil.	High: The urban forest is already experiencing several of these impacts.	Medium/ High: The 75-year urban forest plan is being developed, homeowners can be educated to improve forest health on private property.	Medium
Soil deterioration and im-permeability	Increased impermeable surfaces, loss of available water through runoff, decreased tree canopy cover.	Increased temperatures are drying the soils through evaporation, thereby decreasing microbial life, increasing erosion (gullying) and exposing them to wind loss.	High: Infrastructure damage (increased City expenditures); reduction of soil productivity, infiltration capacity, and water table levels.	High: Already happening to a greater or lesser degree throughout the watershed.	Low to Medium: Can be remedied with available techniques in green technologies however these require labor, funding and the widespread application of techniques.	High

Planning Area	Non-climate Stressors	Current Climate Risks / Impacts	Consequence (L,M,H)	Probability (L,M,H)	Ability to respond (L,M,H)	Risk Value (L,M,H)
Water						
Catastrophic fire	Overgrown forest due to decades of fire suppression in the Ponderosa Pine; natural fire cycle of spruce-fir ecosystem.	Hotter/dryer climate with less snow pack; increased likelihood, intensity, and frequency of fires.	High: Ash/debris clog reservoirs; no or reduced water supply available.	High: Catastrophic fires have already occurred in neighboring forests.	Medium: 10 years of thinning and controlled burns have reduced the risk in the ponderosa pine upper watershed, however, surrounding forests have had no treatment due to wilderness designation; resistance by private property owners; no money.	High
Surface water supply	More demand (water rights) than availability.	Reduced snow-pack/shifting precipitation patterns; increased evaporation; decreased soil moisture content; decreased runoff; earlier runoff.	High: Reduced water-storage; decreased infiltration; need to supplement water supplies; increased impact on local ecosystem.	High: Snow-pack is already reduced and storm patterns are changing.	Medium: Land can be contoured and arroyos managed for better infiltration; increase green infrastructure; increase water absorption capacity of watershed to improve overall health.	Medium-High

Groundwater	Impervious surfaces have reduced groundwater recharge, well-pumping has reduced groundwater supplies; little recharge.	Greater demand on groundwater; reduction in groundwater recharge from reduced snow, earlier snow-melt, increased impermeable surfaces and increased storm intensity.	High: Wells go dry; increased cost of water; individual domestic wells will go dry earlier; City/Co well fields will need to be drilled deeper; riparian areas will dry up which will lead to vegetation conversions, downstream users will share greater % of impacts .	High for those on the West/Southwest parts of the downstream portions of the river. Lower for those upstream.	High: City/County can do more conservation and regulatory changes. State engineer can limit domestic wells to .25 acre feet per year.	High for those on domestic wells and low to medium for those on City/County utility water.
Watershed health	Historical overgrazing, impervious surfaces, sand and gravel mining, arroyo degradation, water diversions that have desiccated riparian vegetation.	Hotter and dryer conditions will lead to increased desiccation; severe storm events will cause erosion and infrastructure damage.	High: Accelerated land degredation .	High: This is already being seen throughout the watershed.	Medium:	High
Accelerated Runoff	Elevated percentages of impermeable surfaces.	More intense storm events, more precipitation as rain than snow.	High: increased runoff can compromise infrastructure.	High: Effects can already be seen in arroyos throughout the watershed.	Stormwater management, rainwater harvesting.	High

Potable water supplies	Inefficient uses of water.	Reduced water supplies due to increased temperatures and reduced precipitation.	High: As increased temperatures and drought conditions take hold, we will have to use water very wisely to survive.	High: This region has seen a steady decline in ground and surface water supplies.	High: Incorporate more water reuse to increase the productivity per gallon.	High
Planning Area	**Non-climate Stressors**	**Current Climate Risks / Impacts**	**Consequence (L,M,H)**	**Probability (L,M,H)**	**Ability to respond (L,M,H)**	**Risk Value (L,M,H)**
Economics						
Catastrophic fire	Overgrown Ponderosa Pine forest due to decades of fire suppression.	Hotter/dryer climate with less snow pack.	High: Reduced recreation and tourism revenues; reduced building; increased fire fighting costs.	High: The ski season is already starting later and hiking trails/campgrounds have been closed for several weeks of the summer.	Low: Proactive advertising and communication strategy.	High
Insurance		Greater risk of fire/ flooding can increase the amount of money that insurance companies have to pay for damages.	Medium: Increased rates, greater restrictions with regard to which properties can be covered.	Medium:	Medium: Investments in the kind of climate adaptation measures suggested in this plan can reduce the risks of climate-related damages.	Medium

Tourism	Recession or gas prices reduce travel for tourism.	Ski season has been shortened due to reduced snow pack; a loss of forest would greatly reduce City aesthetics and recreation opportunities.	High: Tourism and the related services industries provide the majority of the jobs and income for the City.	High: Tourism decreased after the neighboring Cerro Grande and Las Conchas fires and would be significantly impacted by a watershed fire.	Medium: 10 years of thinning and controlled burns have reduced the risk in the ponderosa pine upper watershed, however, surrounding forests have had no treatment due to wilderness designation; resistance by private property owners; no money.	High
Construction and home sales	The recession has caused a reduction in home sales.	A wildfire or flood would damage the natural beauty and ecological functioning of the area making it a less desirable location, thereby reducing home sales.	High: Significant reductions in home sales would negatively impact the overall economy.	The probability depends upon our ability to adapt to and mitigate the climate changes.	Medium: This is dependent upon the implementation of this plan to reduce the risk of wildfire and flooding.	High

Food system	Water supplies in the agricultural areas of the lower SF Watershed are already diminished due to over-pumping and a reduction in groundwater recharge.	Increased temperatures and extended drought will exacerbate water shortages and reduce the agricultural production capacity of the watershed.	High: Many of the people living in the lower portion of the watershed are dependent on agriculture for their livelihoods.	High: Climate predictions for the area indicate a continued warming trend.	Medium: Water conservation in the upper reaches of the watershed can increase water availability in the lower reaches. Increased storm water infiltration in the urban areas can increase groundwater supplies in the basin.	Medium - High
Flood control/storm water	Arroyos are channelized, culverts are clogged.	Weather patterns are projected to intensify with longer periods of drought between more intense precipitation events that release increased volumes of water in shorter periods of time.	High: Flooding could cause significant damage to infrastructure, homes, buildings and the natural environment.	High: Climate projections for the area indicate an increase in heavy rainfall events and our current arroyos and infrastructure needs updating to accommodate such flows.	Medium: In order to rehabilitate our arroyos, redesign our roads and storm water management systems, and integrate increased rainwater harvesting on all properties, we will need significant capital.	High
Water-intensive businesses (bottling, beer brewing, ice making, etc.)		Increased cost to process and deliver water will effect supply chain expenses.	Low: This is a relatively small sector of Santa Fe businesses, however the impact to them individually will be great.	High: Already, Santa Fe's largest nursery closed, in part, due to expensive water.	Medium: The businesses will need to negotiate with the City Water Department to determine tailored solutions.	Low

Electricity generation	Utility scale energy production (mostly coal) is required to reduce emissions (costly).	Reduced water supplies for cooling; general need to reduce GHG emissions to reduce climate impacts.	Medium: Fossil fuel based energy (coal, natural gas and nuclear) require large amounts of water for cooling. As water supplies in the State are reduced due to increased temperatures, we will need to reduce non-essential water use.	High: Water supplies in the state are expected to decrease as the temperatures rise and cause increased evaporation.	High: Technology is available to shift to increased percentages of renewable energy (PV, wind, etc.) that will require little to no water and have no GHG emissions.	High

DEVELOPING AN ADAPTATION ACTION PLAN

In order to develop an adaptation action plan, the team listed all of the stressors and/or impacts for the watershed that were identified during the assessments and wrote them onto orange sticky notes. We then moved them into groups that could be addressed by the minimum number of goals. We then began brainstorming goals that would address each of the stressors to create a more resilient environment, economy and society and wrote a couple of the goals onto purple sticky notes. While many of the stressors are addressed by multiple goals, it was our objective to address all of the stressors through the development of our goals for the plan. During the process, we considered the following stressors:

- → Decreased ground water supplies
- → Decreased surface water supplies
- → Erosion of arroyos
- → Erosion of the Santa Fe River
- → Increased evaporation
- → Soil desiccation
- → Drying wetlands
- → Drying wells
- → Drying springs
- → More intense storms (harder/faster rainfall patterns)
- → Energy intensive water sources
- → Brain drain (educated youth moving elsewhere to find work)
- → Invasive tree species
- → Fragmented wildlife corridors
- → Reduced agricultural capacity
- → Economic impacts to water processing facilities
- → Increased risk of Catastrophic forest fires
- → Wildland Urban Interface (WUI) fire risks
- → Economic impacts to insurance companies
- → Economic impacts to building and home sales
- → Flooding
- → Higher temperatures
- → Bark beetle/insect infestations
- → Decreased tourism revenues
- → Later snowfall
- → Earlier snow melt
- → Decreased snow pack
- → Water intensive energy production

Photo 27: Climate Adaptation Planning Team brainstorming activity to identify goals that would address the stressors that threaten the Santa Fe Watershed.
Source: Esha Chiocchio.

Over the following weeks, we continued to evaluate each of the stressors and refine our goals through discussions, emails and consultations with experts in the area. Through this process, we identified several additional stressors to the watershed. These included the need for improved financing mechanisms and increased services for the young working class (public transportation, recreation opportunities, workforce training, etc.).

Ultimately, we identified the following goals:

GOAL 1: Increase the water security and ecological integrity of the Santa Fe Watershed through conservation, infiltration, groundwater recharge, and reuse.

GOAL 2: Improve forest and ecosystem health for resilience in the face of climate change.

GOAL 3: Expand and develop the workforce-training programs needed to implement this plan.

GOAL 4: Increase energy efficiency and renewable energy (EERE) to reduce the use of fossil fuel-derived and water consumptive energy sources.

GOAL 5: Establish financing systems that facilitate investments, emergency funds, and cash flow availability to fund climate adaptation and innovation initiatives.

ANTICIPATED OUTCOMES

As the strategies for this plan are implemented, we hope to decrease our vulnerabilities from the identified risks associated with climate change. The five stated goals address areas of high impact that reflect the greatest possibilities for tangible results. Accordingly, our anticipated outcomes correspond to each goal as outlined below:

GOAL 1: Increase the water security and ecological integrity of the Santa Fe watershed through water conservation, infiltration, groundwater recharge and reuse.

The future of human habitation in Santa Fe depends upon an adequate water supply. In this high desert environment, the projections indicate decreased precipitation, increased groundwater dependence, hotter temperatures, and an increase in severity of storm events. Therefore, the outcomes we anticipate from this goal are:

a) Increased groundwater recharge and storage
b) Increased capacity for stormwater capture and infiltration
c) Increased coordination among water planning entities
d) Increased productivity of existing wastewater supplies
e) More reliable water supply for the agricultural communities in the lower watershed
f) Capacity for population and economic growth in the watershed with available water supply without compromising ecological health

GOAL 2: Improve forest and ecosystem health for resilience in the face of climate change.

Our forests and water supplies are intimately linked. Without healthy, functioning forests, our water supplies would be significantly compromised. In addition to their contribution to the water cycle, the Santa Fe forests provide habitat, beauty and recreation opportunities and are an essential grounding element for the region. Through the implementation of this goal, we expect the following outcomes:

a) Increased percentages of treated forest areas to reduce the risk of catastrophic wildfire and pest infestation
b) Expanded management of invasive tree species
c) Increased resilience of the urban forest
d) Increased soil health
e) Mutually beneficial collaborations between the city, USFS, and SFWA that support financial resources, on-the-ground projects, and monitoring for forest health
f) Sustainable healthy headwater streams in the upstream national forest lands
g) Forest ecosystems that flourish long term without damage from catastrophic wildfire

GOAL 3: Expand and develop the workforce-training programs needed to implement this plan.

In order to implement the goals identified in this plan, as well as expand the diversity of job opportunities in the area to both retain and attract working families, the development and coordination of workforce training will be necessary. Through this effort we expect:

a) Increased diversity of job training and opportunities
b) Local workers will increase their economic status with greater job skills and income levels
c) Successful restoration projects to result in a healthy watershed and attract more economic development to the region
d) Investments in local restoration projects to generate a positive return on investment for the entire community resulting in greater revenues from recreation and tourism and increases in property values and tax revenue

GOAL 4: Increase energy efficiency and renewable energy (EERE) to reduce the use of fossil fuel-derived and water consumptive energy sources.

As the combination of drought and higher temperatures reduce water supplies, it is increasingly necessary to conserve water across all sectors. Many energy production technologies use and pollute significant quantities of water. By increasing efficiency to reduce energy demand and integrating non-polluting, water thrifty renewable energy into the State's energy portfolio, we can increase water availability. By carrying out the objectives of this goal, we hope to:

a) Shift regulatory structures to expedite integration of EERE
b) Decrease water use for energy production
c) Decrease the carbon footprint from energy production
d) Increase energy efficiency and renewable energy use
e) Merit recognition for climate leadership in both mitigation and adaptation initiatives
f) Ensure that long term energy sources will not be subject to rising prices for either fossil fuels or declining water sources
g) Support abundant sustainable energy sources to drive economic growth in the region
h) Ensure that Santa Fe and Northern New Mexico are more able to meet water demands for cities and nature far into the future
i) Reduce the magnitude of climate impacts by reducing greenhouse gas emissions

GOAL 5: Establish financing systems that facilitate investments, emergency funds and cash flow availability to fund climate adaptation and innovation initiatives.

In order to achieve any of the goals in this plan, funding will be necessary. By developing new financing structures that enable long-term and emergency fund availability, the community will be more able to invest in climate adaptation strategies and weather the storms ahead. The benefits of this goal include:

a) Newly developed financing structures create accessible capital for climate adaptation initiatives
b) The development of a virtuous cycle where restoration investments bring positive economic returns through the increase of jobs, property values, and sustainable ecosystem services
c) Natural disaster costs will be reduced and insurance rates can remain reasonable

IMPLEMENTATION OF THE PLAN

Implementation of the plan will be conducted through the actions of several key organizations involved in the stakeholder planning team:

The Santa Fe Watershed Association will help coordinate ongoing team interactions and will focus their activities around energy and water conservation initiatives, with a particular focus on education and community outreach.

The U.S. Forest Service will integrate recommendations, where appropriate, into their forest management plans and track their results through the national forest climate scorecard process. The national forest short term priorities will center on continuation of prescribed burns, community education and outreach, integrating climate projections in all planning processes, and securing financing and garnering support for expanded treatment areas.

The City of Santa Fe Water Utility will focus on implementing the Reclaimed Water Use Plan. The City's Water Conservation Program will incorporate this Climate Adaptation plan into their 2014 planning activities. The City of Santa Fe's River and Watershed Coordinator will incorporate these goals into the 2014 work plan with an emphasis on rainwater harvesting and infiltration.

The Santa Fe County Water Policy Advisory Committee will research and review the concept of regional water authorities and will make recommendations to the board of County Commissioners. They will also research and evaluate possibilities for Aquifer Storage and Recovery within the County and present them to the County Commissioners.

The short-term implementation priorities for 2014 include the following activities:

- The planning team will meet on a quarterly basis to monitor progress and ensure that the goals of this plan are being carried forward. These meetings will be facilitated by the Santa Fe Watershed Association and the Jemez y Sangre Regional Water Planning Council.

Near term windows of opportunity that can work in synergy with the plan include:

- Development and implementation of the Santa Fe 75-year urban forestry plan
- The recent passage of updated county building codes that will increase water and energy efficiency in all new construction.
- Potential adoption of recommendations in the *Santa Fe municipal watershed Pecos Wilderness prescribed burn project – final environmental assessment* that would permit the treatment of wilderness areas in the Santa Fe Watershed to reduce the risk of wildfire.
- The Interstate Stream Commission recently updated their guidebook in which they call for an update to the Jemez y Sangre Regional Water Plan. This new update will incorporate the goals of this Climate Adaptation plan thereby integrating our action steps into their larger regional plan.
- River Source will be installing water harvesting earth works into several Santa Fe locations, thereby increasing infiltration and reducing runoff.
- The Sustainable Santa Fe Commission Energy Committee will pursue the development of

community solar and will work with solar installation companies, financial institutions and citizens to encourage investments in rooftop solar.
- The City of Santa Fe will restore ten arroyo segments as funded through the GO Bond.

The longer-term implementation of adaptation strategies will proceed as funding, resources, and organizational capacity allows. Each party will support ongoing tracking of progress and monitoring of conditions according to agreed-upon cooperative efforts.

As implementation proceeds, progress will be assessed and the adaptation plan will be modified as needed to stay on track with progress toward climate resilience and economic stability.

Climate Adaptation Plan Table

In the following section, we have listed each of these goals with the objectives, strategies and actions we feel will be necessary to achieve the identified goals. Monitoring will be necessary to provide feedback and help those implementing the goals to refine their strategies over time.

GOAL 1: **Increase the water security and ecological integrity of the Santa Fe Watershed through water conservation, infiltration, groundwater recharge, and reuse.**					
OBJECTIVE 1- 1: Increase Aquifer Storage and Recovery (ASR).					
Strategy 1-1a: Work with the City and County of Santa Fe to secure funding for analysis, feasibility and implementation of Aquifer Storage and Recovery (ASR).					
Measure: Funding secured.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Review funding sources and seek partnerships for ASR.	TBD	M (1-2 yrs.)	Hire an intern to research funding opportunities.	Funding secured.	See Goal 5 for funding possibilities.
Strategy 1-1b: Conduct an analysis of the Watershed's soil and hydrological modeling to determine the best areas for water infiltration.					
Measure: Watershed map is available to define best areas for water infiltration.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Compile and review the existing hydrological and soil studies.	Contract Scientists TBD.	M	Review existing studies.	Inventory of studies.	Possibilities: Peggy Johnson, Neil Williams, Paige Grant.
2. Map watershed according to potential for water infiltration and groundwater recharge.	Contract Scientists TBD.	M-L	GPS mapping.	Complete site map.	Possibilities: Peggy Johnson, Neil Williams, Paige Grant.
Strategy 1-1c: Conduct a feasibility study to determine the possibilities and priorities for ASR.					
Measure: Feasibility study is complete and identifies a plan of action for implementation.					
1. Engineering firm conducts feasibility study.	TBD	L 3-5 years	City and County send out RFP for study.	Complete feasibility study.	

Strategy 1-1d: Implement ASR projects.					
Measure: ASR projects implemented					
1. Utilize information in preceding action steps to implement project.	TBD	L			Dependent upon success of previous steps.
OBJECTIVE 1-2: Optimize water infiltration from the full range of precipitation events, up to and including runoff from a 500-year storm event.					
Strategy 1-2a: Develop joint City/County codes involving City/County Pubic Works, City/County Planning, and other relevant local government resources to increase water infiltration from runoff from buildings, roads, and parking lots.					
Measure: New codes are in place and being implemented.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Establish a joint City/County working group to review existing codes and suggest amendments to improve water infiltration from runoff from buildings, roads, and parking lots.	TBD	Spring 2014	Draft new codes and requirements.	New building and road drainage plan.	Review existing County Sustainable Land Use code.
2. Ensure that code amendments are adopted by City/County local governments.	Working group	Winter 2014	City/County Agenda.	New codes for building and roads.	
Strategy 1-2b: Incorporate new codes into the City/County Capital Improvement Plan (CIP) projects to increase infiltration of runoff from buildings, roads, parkings lots, etc.					
Measure: Number of green infrastructure (GI) projects that have been implemented.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Coordinate with City/County Public Works Departments to integrate new codes into CIP projects.	TBD	S-M	Set initial meeting to develop initiative.	Comprehensive list of CIP projects.	Dependent upon review from 1-2a.
2. Improve public awareness of City/County initiatives to increase water infiltration by publishing information on CIP projects.	TBD	S-M	News Media Release.	News articles published.	

Strategy 1-2c: Develop City/County guidelines for remodeling, repair, and maintenance projects to optimize the number of projects that incorporate green infrastructure (GI).					
Measure: Published guidelines for integration of GI for remodeling, repair, and maintenance projects.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Establish a joint City/County Working Group to integrate GI for remodeling, repair, and maintencance projects within the watershed.	City/County Public Works	S	Coordinate initial joint meeting.	Draft guidelines for integration of GI.	
2. City and County Public Works Departments adopt final guidelines.	City/County Public Works	S	City/County Public Works Approval.	Final guidelines for integration of GI.	
Strategy 1-2d: Design and construct GI into the prioritized reaches of the ten major arroyo systems of the Santa Fe Watershed.					
Measure: Identified arroyo GI projects are implemented.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Monitor the GO Bond funded arroyo restoration pilot projects for success and lessons learned to use for subsequent arroyo GI.	Arroyo Working Group	M	Establish monitoring benchmarks and monitor progress.	Identified best management practices	This project is funded and RFP will be released imminently.
2. Integrate the lessons learned in 1-2d-1 for future arroyo restoration projects.	Arroyo Working Group	M-L	TBD	TBD	

OBJECTIVE 1-3: Promote the creation of a Regional Authority to focus water planning and management on a Santa Fe basin-wide scale to maximize efficiency (eg. Water, Waste Water, Storm Water, and Energy).					
Strategy 1-3a: Work with City/County/State governments to create a Regional Authority for the Santa Fe Basin by December 1, 2015.					
Measure: Regional Water Authority is in place by December 1, 2015.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Create a Working Group to develop draft legislation to create the statute for the development of Regional Water Authorities and provide educational support materials & events.	TBD	Fall 2013	Establish initial City/County meeting.	Draft legislation.	Nylander, Leigland
2. Identify New Mexico Legislative sponsor for introduction of legislation in the 2014 session.	TBD	Fall 2013	Contact potential legislative sponsor.	Legislative sponsor.	Sen. Wirth?
3. Ensure that Regional Authority legislation is passed in the 2014 session.	TBD	Winter 2014	Lobby legislators to garner support.	Bill passed.	Nylander, Leigland
OBJECTIVE 1-4: Work with the City and County of Santa Fe to increase the use of reclaimed waste water.					
Strategy 1-4a: Increase the use of reclaimed waste water for non-potable uses.					
Measure: Acres of land that are being irrigated by reclaimed waste water above 2013 levels.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Refer to "Implementing Actions" in the Reclaimed Wastewater Resource Plan http://www.santafenm.gov/index.aspx?NID=2576.					Borchert, April 2013

Strategy 1-4b: Increase the use of reclaimed waste water for potable uses.					
Measure: Please refer to the Borchert April 2013 report. Note that this is beyond to scope of this plan but we would like to recognize that this is within the foreseeable 20-year future of the desert southwest.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Refer to "Implementing Actions" in the Reclaimed Wastewater Resource Plan.					Borchert, April 2013
Objective 1-5: Safeguard the groundwater supply in the La Cienega, La Cieneguilla and La Bajada communities.					
Strategy 1-5a: Convert residential well-users to Santa Fe County water supply.					
Measure: One-third of identified residents are connected to County water supplies by 2016 with another third connected by 2019.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Finalize negotiations with the county public utilities.	La Cienega Valley Association	Ongoing	Organizing community meetings with County.	Homeowner and County agreement.	
2. Secure financing to build the infrastructure necessary to connect homeowners to County water supplies.	Santa Fe County	M	Apply for federal funding.	Funding secured.	BOR WaterSmart grant
3. Build infrastructure and connect area residents.	Santa Fe County Public Works Dept.	L	Planning, design and construction.	Infrastructure complete	

GOAL 2: **Improve forest and ecosystem health for resilience in the face of climate change.**					
OBJECTIVE 2-1: Reduce the risk of catastrophic wildfire.					
Strategy 2-1a: Promote understanding of methods and benefits of forest thinning and prescribed burning.					
Measure: number of talks, PSAs, letters, blogs posts, etc.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Meet with various community, political and business groups, to inform the public about forestry practices as tied to the water cycle.	USFS, SFWA, TNC, etc.	Ongoing	Contacting groups and presenting material.	Presentations	
2. Media outreach: PSAs (radio, TV, newspapers, movie theaters, etc.), letters to the editor, blogs, public presentations, etc.	USFS, SFWA, TNC, etc.	Ongoing	Creating media outreach products.	Media products	
Strategy 2-1b: Encourage forest treatment projects for the areas bordering the Santa Fe Watershed (Pecos Wilderness, the greater Tesuque drainage area and Glorieta/Thompson Ridge areas).					
Measure: Forest treatments are implemented in adjacent forests.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Explore funding opportunities (grants, NMED, insurance companies, cooperative funds for landowners, etc.).	Community organizations, non-profits, USF, NRCS, etc.	Ongoing	Research.	Data base/list of available funds.	See goal 6 for funding strategies.
2. Establish a volunteer cadre to help citizens to treat private forested land.	USFS, City of SF and private citizens	M	Community volunteer contact person.	Volunteer cadre trained and organized.	
3. Encourage land/homeowners in the WUI to put land into conservation easement and to use funds to leverage grant opportunities to thin and treat private lands.	Land owners, Conservation Trust, Quivera Coalition	Ongoing	Contact potential land owners.	Number of acres placed in conservation.	

OBJECTIVE 2- 2: Reduce the risk of disease and pest infestation.

Strategy 2-2a: Encourage proper forestry practices on private lands to ensure healthy tree spacing, adequate irrigation, and treatment/removal of pest infested trees.

Measure:

Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Gather public education materials and disseminate to owners of forested land.	State and Federal forestry departments.	Ongoing	Compile materials and make availability known through libraries, websites, PSAs, etc.	Materials compiled and disseminated.	

OBJECTIVE 2-3: Reduce invasive tree species and replace with natives and non-invasive ornamentals.

Strategy 2-3a: Pass an ordinance to ban the selling and planting of invasive tree species (Russian olive, Siberian Elm, Ailanthus (Tree of Heaven), Salt Cedar, etc.)

Measure: Ordinance is in place and enforced.

Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Propose ordinance to City Council.	Bob Wood	S	Presentation to City Council.	Ordinance passed.	Ask Bob if in place.

Strategy 2-3b: Remove non-native invasive tree species from City and County property, where appropriate.

Measure: Removal of non-native invasive tree species.

Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Earmark funding to be spent annually for a 3-5 year period to remove invasive tree within the City and County.	Bob Wood, County counterpart	S-M	Work with City Council and County Commissioners to secure funding.	Funding mechanism established	
2. Coordinate and implement invasive tree removal program.	Bob Wood, County Counterpart	M-L	Tree removal.	Map of treated areas	Dependent upon financing.

OBJECTIVE 2-4: Develop a healthy urban forest.					
Strategy 2-4a: Support the development and implementation of the 75-year urban forest plan. Measure: 75-year urban forest plan is written and being implemented.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Encourage City support of financing and implementation of the 75-year urban forest plan.					Bob Wood is leading this effort.
Strategy 2-4b: Educate homeowners and landscapers about appropriate plantings and landscape design techniques to maximize urban forest health. Measure: Landowners and landscapers are implementing updated techniques.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Ensure QWEL, Master Gardener, and other information sources provide information appropriate to changing climate limitations for successful urban forest health.	Melissa McDonald, Master Gardener Program Lead, Nurseries	S-M	Integrate climate prediction information into training seminars.	Lectures and published materials.	
2. Develop a landscaping guide to be distributed to homebuyers through the SF Realtor Assn.	County Ag Extension Service, Master Gardener Program, SFCC, etc.	M	Develop landscaping guide.	Landscaping guides distributed to homebuyers.	
OBJECTIVE 2-4: Increase soil health in public and private land and urban forest cover to improve the water absorption capacity of soils and support the flora of the area.					
Strategy 2-4a: Develop and expand composting programs throughout the City and County. Measure: Composting programs in place and compost is spread on public lands to improve soil health.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Work with hotels, restaurants, grocery stores, schools, etc. to collect food waste for composting.	City Solid Waste Management	M-L	Work with Solid Waste Management Department.	Composting program established.	

2. Develop public education campaign to encourage residential composting and mulching.	SFCC, Farmer's Market Institute, Carbon Economy Series	Ongoing	Coordination among various entities, development of programs.	Public Education campaign developed.	Master Gardener Program, SF Women's Club.
3. Establish an annual residential chipping service to shred yard waste in the fall and create mulch for residential gardens and landscapes.	City Solid Waste Department	M-L	Trucks, equipment, personnel, advertising.	Program established.	Reduces risks and impacts of flooding.
4. Work with Parks department to utilize compost on public lands.	City Parks, Solid Waste Dept.	L	Trucks.	Compost being utilized.	

GOAL 3: **Expand and develop the workforce-training programs needed to implement this plan.**					
OBJECTIVE 1: Efficiently develop training capacity across the range of sectors identified in this plan.					
Strategy 1: Provide workforce training for the jobs needed to implement this Plan.					
Measure: Number of participants in selected and developed training programs.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Convene a gathering of City and County Economic Development leaders and Institutions of Higher Education to identify training needs to both prepare for the jobs needed to implement the plan (skills needed to improve forest health and provide water and energy security) and to meet the goals of diversifying the economy.	Plan Implementer (yet to be identified or funded)	S	Pre-meetings with City and County Economic Development staff, Event organization.	Training and education plan designed to meet the needs of the jobs identified, including a funding strategy.	
2. Implement training and education plan developed in Action Step 1.	Local institution of higher education and possibly some non-profits, depending on plan	M	Submit grant applications and other instruments to obtain necessary funding/and tuition assistance.	New and updated training programs developed that meet training needs identified.	
3. Conduct a periodic review of the programs and evolving training needs and make appropriate adjustments to the training programs.	To be assigned in the Training and Education Plan.	L	Annual assessment and possible convening of partners.	Recommenda-tions for program adjustments.	SFCC, NNMC, Highlands, UNM, St. Johns, Center for Higher Education, Youth Works

GOAL 4: **Increase energy efficiency and renewable energy (EERE) to reduce the use of fossil fuel-derived and water consumptive energy sources.**					
OBJECTIVE 1: Participate in the Georgetown University Energy Prize (GUEP) (http://www.guep.org/) to develop and implement a comprehensive EERE program.					
Strategy 1a: Work with the GUEP advisor to refine the goals, objectives, strategies and actions steps listed below to achieve maximum EERE by 2016.					
Measure: Full action plan is developed and being implemented.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Submit letter of intent to GUEP to participate in their 2 year program.	John Alejandro	S: Dec. 2013	Draft letter.	Letter of intent.	
2. Work with assigned advisor and participating parties to create a full action plan.	SFCEA, Got Sol, SSFC, SFGCC, County	S: Winter 2014	Draft action plan.	Action Plan, buy-in from participating entities.	NEE, SFCC, GCC, SC, SSFC, PNM, Legis., City, County, etc.
OPTION 4-1: Establish a City/County municipal electric utility, called Santa Fe Public Power (SFPP).					
OBJECTIVE 4-1-1: Conduct preliminary assessments and engage in community outreach.					
Strategy 4-1-1a: Develop a working group to carry out the steps necessary to shift from PNM to Santa Fe Public Power.					
Measure: Working group in place and carrying out the steps necessary to make the transition to a municipal electric utility.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Consult with those currently working on this effort to establish a working group.	Mariel Nanasi, Paul Campos	S: Winter 2014	Contact necessary parties and set up meeting.	Commitment of participants.	

Strategy 4-1-1b: Launch an educational campaign to inform the public about the pros and cons of a municipal electric utility.					
Measure: Number of attendees, number of articles in papers, public opinion assessment results, etc.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Establish a working group to design and produce an educational campaign.	Mariel Nanasi, Paul Campos	Already in place?		Action Plan	
2. Public Education Forum.	New Energy Economy	9/18/13 Forum, more?	Venue, speakers, etc.	# of attendees?	
3. Conduct a public opinion assessment to gage the level to which the public understands the issues and to what extent they support the project.	Municipal utility working group	M	Create poll, distribute to City/County residents.	Polling results	
Strategy 4-1-1c: Conduct a technical-level engineering analysis of PNM's load profile in the County, the location, age and condition of PNM's distribution system and the extent to which SFPP could acquire and pay for a sustainable power supply sourced entirely from natural gas, solar and wind.					
Measure: Analysis results indicate whether or not this is a feasible endeavor.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Designate funds to pay for a full feasibility analysis.	Municipal utility working group	M: 2014	Approval by City Council/ County Commissioners .	Funding secured.	
2. Contract with a firm to conduct a full analysis of the feasibility of a shift to a municipal utility.	Municipal utility working group	M: 2014	Need all technical data from PNM.	Full engineering analysis report.	

Strategy 4-1-1d: Conduct an analysis of the wholesale energy markets for near-term availability of natural gas-derived electricity and renewables and the constraints of the regional transmission system.					
Measure: Analysis results indicate the possibilities and constraints of purchasing wholesale energy on the open market.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Consult with turnkey developers on the availability of long-term supply contracts for Santa Fe in the range of 100 MW of daily capacity.	Municipal utility working group	M-L	Research and contact potential developers.	Developers contacted and data compiled.	
Strategy 4-1-1e: If the results of the technical analysis are favorable, secure funding to transition to a municipal utility.					
Measure: Funding proposal chosen and supported.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Establish a working group to evaluate funding possibilities (bonds, tax levees, lease agreement with PNM, etc.).	Municipal utility working group	M	Evaluation of funding possibilities.	Analysis of funding options.	
2. Work with community to support the suggested funding proposal.	Municipal utility working group	M-L	Public education and outreach.	Funding supported and secured.	
Strategy 4-1-1f: Transition to SFPP from PNM.					
Measure: Full transition is complete.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Purchase electrical infrastructure from PNM.	City/County	L	Financing	Transaction complete.	
2. Contract with RE developers to provide electricity to SFPP.	City/County	L	Negotiate with independent utility scale developers.	RE contracts.	
3. Establish aggressive energy conservation incentive program.	City/County	L	Plan development and imple-mentation.	Plan and outreach efforts.	
4. Begin construction on SFPP gas fired power plant.	City/County	L	Financing.	Plant complete.	

5. Install solar panels at all municipal facilities.	City/County	Ongoing	Financing, City/ County approval.	Installations complete.	
6. Encourage the installation of solar panels at homes/businesses through financing incentives.	City/County, Home Wise	Ongoing	Public education and outreach.		
OPTION 4-2: Within the PNM (electric) and NM Gas Co. (natural gas) statutory/regulatory structure, encourage a transition to increased energy efficiency and renewable energy (EERE).					
OBJECTIVE 4-2-1: Make regulatory and legislative changes to state energy policies and requirements to encourage the development of EERE.					
Strategy 4-2-1b: Implement decoupling legislation to increase utilities' incentives to improve EERE for electricity, natural gas, and other non-renewable, water intensive energy forms.					
Measure: Decoupling legislation is in place.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Develop a public education campaign to help citizens and legislators understand decoupling and the need for this legislation.	SSFC Energy Committee and affiliates	S	Funds for PSAs, letters to editor, radio interviews, etc.	Public education campaign in place.	Review examples from other states (CA, AZ, VT, etc.).
2. Work with legislators to draft decoupling legislation.	SSFC Energy Committee and affiliates	M	Meet with legislators and write legislation.	Drafted and submitted legislation.	Egolf, Soules, Wirth?
2. Ensure passage of decoupling legislation in 2015 legislative session (Jan-March).	SSFC Energy Committee and affiliates	M: 2015 session	Lobbying, public outreach.	Legislation passed.	PRC, PNM, Legis., Gov. lobbying efforts.
Strategy 4-2-1a: Revise the NM Efficient Use of Energy Act and the Renewable Energy Act to increase the EERE targets.					
Measure: EERE targets are revised and implemented.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Draft and pass legislation to increase the RPS to 30% renewables by 2020 and 40% by 2030; and replace the "Reasonable Cost Threashold" provision with "Reasonable Market Price" provision.	TBD	M-L	Draft and pass legislation.	Renewable Energy Act revised.	

2. Draft and pass legislation to increase requirements in the Efficient Use of Energy Act to 20% by 2020.	TBD	M-L	Draft and pass legislation.	Efficient Use of Energy Act revised.	
OBJECTIVE 4-2-2: Enhance renewable energy education and outreach efforts.					
Strategy 4-2-2a: Establish an education and outreach campaign to inform public of the benefits of renewable energy and the options available for financing their RE projects. Measure: Number of people who switch to RE and who take advantage of the financing options.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Create an education and outreach plan.	City, County, Home Wise, PNM	Spring 2014	Plan, outreach materials.	Plan developed and financing secured.	
2. Host community meetings, create PSAs, distribute information, etc.	City, County, Home Wise, PNM	Fall 2014	Distribute info., host community meetings, etc.	Documenta-tion of efforts.	
OBJECTIVE 4-2-3: Increase energy efficiency for residential, business and municipal buildings.					
Strategy 4-2-3a: Launch aggressive energy efficiency incentive programs for residential and business customers. Measure: Percentage of reduction in overall energy load.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Procure financing to expand the energy efficiency incentive programs as stated in updated Efficient Use of Energy Act.	City, County, Home Wise, PNM	M-L	Financing, program development.	Program developed and implemented.	To be done after the EUE Act is revised.
2. Promote and implement incentive program	City, County, Home Wise, PNM	L	Public education and outreach.	Measurable decreases in energy use.	

OBJECTIVE 4-2-4: Increase financing options for energy-related projects.					
Strategy 4-2-4a: Expand and promote financing options for residential and commercial customers to increase energy efficiency and shift to renewable energy.					
Measure: Number of customers utilizing the proposed financing options.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Promote Home Wise's home improvement financing offers for those with household incomes under $103,050.	Home Wise, City, County	Ongoing	Public education and outreach.	Increase in Home Wise participants.	
2. Develop low-interest, long-term (15-20 years) on-bill financing option through the City of Santa Fe Water Department for solar installations and energy efficiency projects.	Sangre de Cristo Water Division	M	Development of program, dedicated financing.	Program established and in place.	
3. Develop low-interest financing options for solar installations and energy efficiency projects through local financing institutions.	City, County, Local Financial Institutions	M-L	Negotiations with financing institutions.	Financing options developed and offered.	Credit unions, LANB, other banks? See Goal 5 for more financing options.
OBJECTIVE 4-2-5: Encourage third-party solar development.					
Strategy 4-2-5a: Encourage the establishment of LLCs to lease solar arrays to homeowners through Power Purchase Agreements (PPA).					
Measure: LLCs established and PPAs in place.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Encourage private sector investment in LLCs through information dissemination.	Dan Baker, Private sector enterprise	S-M	Compilation of financial data.	Establishment of PPAs to develop rooftop PV.	This is becoming less feasible as the REC payments decrease.

Strategy 4-2-5b: Encourage the establishment of a 2-5 MW community solar (CS) array in Santa Fe County.					
Measure: Size of array and number of customers who have purchased panels.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Work with PNM to design CS agreement and send out an RFP (Request for Proposal).	SSFC Energy Committee	S-M	Negotiations with PNM.	CS approved and RFP released.	PNM is negotiating with SF team.
2. Work with PRC to change current rules so that CS is permissible.	SSFC Energy Committee	S-M	Negotiations with PRC, Public outreach.	CS development approved.	
3. Third party installer installs CS system.	County, City, project developer, insatallation company	M	Determination of site, financial specifics.	Installation of CS.	Project developer and installation company will be determined through RFP process.
4. Launch education/outreach campaign to encourage business owners, renters and homeowners to purchase CS panels.	SSFC, City, County, Green Chamber of Com.	M-L	Program specifics, development of campaign.	Education/ outreach campaign in place.	
OBJECTIVE 4-2-6: Increase energy efficiency and renewable energy utilization at local government facilities.					
Strategy 4-2-6a: Shift >50% of the entire municipal energy load to renewable sources by 2025 (fire stations, schools, administrative buildings, etc.).					
Measure: Percentage of energy produced by renewable energy exceeds 50% of the total energy load.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Work with City Council to earmark 3% of all City tax revenues for renewable energy projects.	SSFC, Green Chamber	S-M	Develop proposal, public outreach, petitions, etc.	Financing established.	Albuquerque has adopted this with great success.
2. Install solar panels on all City and County buildings/parking lots.	City, County	Ongoing	Funding, political will.		Dependent upon financing.
3.Evaluate the use of biomass to heat municipal buildings	City, County	S-M			Conduct feasibility assessment.

4. Identify sources of waste-derived bio-CNG to be used in CNG fleet vehicles.	City, County	M-L			Conduct feasibility assessment.
OBJECTIVE 4-2-7: Adopt and meet the requirements of the 2030 Challenge.					
Strategy 4-2-7a: City and County adopt ever-increasing water and energy requirements for new buildings.					
Measure: Codes updated and on track to meet the 2030 Challenge.					
Action Step	Responsible Party	Timing (SML)	Requirements	Deliverables	Notes
1. Increase energy efficiency requirements for the City incrementally according to the City Building Codes and the 2030 Challenge.	K. Mortimer (City), K. Shanahan (SFAHBA)	M	Update the City Codes to adhere to the 2030 Challenge.	Codes updated and implemented.	Strict energy and water building codes are already in place in the City and are scheduled to be updated according to the 2030 Challenge.
2. Update County building codes to mirror those of the City.	County	S	Update County Codes to City code standards.	Codes updated and implemented.	Passed on 12/10/13.

GOAL 5: Establish financing systems that facilitate investments, emergency funds, and cash flow availability to fund climate adaptation and innovation initiatives.

OBJECTIVE 5-1: Establish a financial institution (or financial institutions) specializing in (1) holding and distributing funds for ecosystem conservation and restoration programs (e.g., similar to already existing eco-finance banking institutions in some parts of the country); (2) holding revolving loan funds and distributing low/no-interest loans to members for cash flow purposes related to ecosystem restoration and conservation initiatives that require upfront cash outlays before being eligible for reimbursement by government programs or other funding sources; and (3) acquiring and distributing equity investment funds for economic and ecological innovation and stimulus initiatives and for accumulating and distributing disaster relief funds and emergency financing in case of catastrophic events.

Strategy 5-1a: Identify additional financing systems and programs available through Federal, State, and local governments, and seek to adapt and list them in a directory to support the financing needs for programs identified in the Climate Adaptation Plan for the Santa Fe Watershed area (see for example: http://www.ca-ilg.org/document/financing-local-sustainability-efforts).

Measure: Number of government financing systems/program found that can be listed in a directory for our local area

Action Step	Responsible Party	Due Date	Requirements	Deliverables
1 Research, identify, and describe existing governmental financing programs	TBD	mid 2014	funds to pay researchers	report
2 List and describe them in a directory for the area	TBD	late 2014	funds to establish directory	directory (web-driven)

Strategy 5-1b: Research and use (link to) sources of information and examples to establish local and state-wide financing mechanisms, based on a variety of sources of information already identified

Measure: Realization of each phase (of a series of phases for the realization of the above listed financing systems/programs for Objective 5.1.

Action Step	Responsible Party	Due Date	Requirements	Deliverables
1 Establish a phased process plan for establishment of financing systems/ institutions, and the necessary resources and information (sources) needed to realize the plan	TBD	TBD: mid 2014	Funding to compensate the initiator's work	Report/Plan (Prospectus)
2 Begin working through each step (phase) of the process plan	TBD	late 2014	Funding to compensate the initiator's work	Reports on each phase

OBJECTIVE 5- 2: Establish financing programs tailored to soil conservation and soil improvement, local food production, water management, stream and wetland (i.e., water source) restoration, forest management and restoration, and local/community-driven economic development				
Strategy 5-2a: Start at the smallest feasible scale and follow the most desirable up-scaling scenarios through adaptive management, collaboration, and marketing				
Measure: One program established (number of programs established; one by one)				
Action Step	Responsible Party	Due Date	Requirements	Deliverables
1 As in 5-1				
2 As in 5-1				
OBJECTIVE 5-3: Educate target groups (i.e., the community and environmental and community development/innovation organizations) about the availability of the funds, investment options, and fund utilization opportunities and conditions. Grow membership in case of member-driven financing programs.				
Strategy 5-3a: TBD ; e.g., publication of funding directory; offering presentations; launching pilot projects				
Measure: TBD: e.g., number of information/education sources and events launched				
Action Step	Responsible Party	Due Date	Requirements	Deliverables
1 TBD				
2 TBD				

APPENDICES

Appendix 1: The effects analysis summary for the Santa Fe Municipal Watershed Pecos Wilderness Prescribed Burn Project. *Source: USDA 2013.*

Resource/Issue	Alternative A, No Action	Alternative B, Proposed Action	Alternative C, Proposed Action with Mechanical Pre-treatment
Forest Vegetation, Fuels, and Fire Behavior	A catastrophic crown fire would have an adverse impact on forest vegetation, fuels would be eliminated, and fire behavior would be uncontrolled.	Beneficial impact on forest vegetation, fuels would be reduced, and fire behavior would return to a more natural regime.	Fire behavior the same as for Alternative B, with the added benefit of providing for a wider range of burning opportunities.
Soil and Water Resources	Following a catastrophic crown fire, the erosion potential for soils would be high, soils would be lost, and the Santa Fe River would be subject to high levels of sedimentation.	Minimal impacts to soils and low risk for sedimentation in the the Santa Fe River.	Same as Alternative B.
Aquatic Habitat and Biota	High risk of adverse impacts from sediment and ash runoff.	Minimal risk for impacts, no treatments would occur near the Santa Fe River, and buffer zones between treated areas and the river would be established.	Same as Alternative B.
Riparian Ecosystems and Jurisdictional Wetlands	High risk of adverse impacts.	Minimal risk for impacts, no treatments would occur in riparian areas, and buffer zones between treated and riparian areas would be established.	Same as Alternative B.

Resource/Issue	Alternative A, No Action	Alternative B, Proposed Action	Alternative C, Proposed Action with Mechanical Pre-treatment
Terrestrial Habitat and Associated Wildlife	High risk of adverse impacts.	Temporary reduction in habitat following treatment. Beneficial impact as increased ground cover develops.	Same as Alternative B.
Special Status Species	High risk of adverse impacts.	No impacts from treatment. Beneficial impacts from more favorable tree densities, an increased number of snags in open areras, and development of increased groundcover.	Same as Alternative B.
Wilderness	A catastrophic fire, either originating in the Wilderness or spreading from non-Wilderness areas into the Wilderness, would have an adverse impact on the Wilderness.	Beneficial impact because fire conditions would return to a more natural fire regime and ecological processes would be restored.	Same as Alternative B.
Air Quality/Smoke	A catastrophic crown fire would have a long duration and smoke production that would have a severe adverse impact on air quality.	Air quality would be temporarily impacted by a moderate amount of smoke.	Similar to Alternative B with slightly less smoke production and the added benefit of providing for a wider range of burning opportunities.
Economics	Fighting a catastrophic crown fire, removing sediment from reservoirs, and Watershed restoration would be far more expensive than both Alternatives B and C.	Least expensive, depending on amount of hand ignitions.	Similar to Alternative B, with added expense from labor-intensive mechanical pre-treatment.

Resource/Issue	Alternative A, No Action	Alternative B, Proposed Action	Alternative C, Proposed Action with Mechanical Pre-treatment
Heritage Resources	High risk of adverse impacts.	Minimal chance of impact because heritage sites would be avoided.	Same as Alternative B.
Recreation and Scenery	Adverse impacts if a crown fire started in the Watershed and spread to surrounding areas open to recreation.	No impact to recreation because the Watershed is closed to the public. Moderate and temporary impacts to scenery.	Similar to Alternative B with long-term impacts from mechanical thinning.
Facilities	A catastrophic crown fire would have adverse impacts on municipal reservoirs and the water treatment plant, as well as monitoring facilities.	Beneficial impact because facilities would be less at risk.	Same as Alternative B.

REFERENCES

Allen, C., Anderson, R., Jass, R., Toney, J., and Baisan, C. (date unknown) Paired charcoal and tree-ring records of high-frequency Holocene fire from two New Mexico bog sites. http://www.ltrr.arizona.edu/~cbaisan/Allen%20et%20al.%20Paired%20Fire%20History.pdf

American Heritage Science Dictionary (2005) *Definition of arroyo*. Published by Houghton Mifflin Company. http://www.thefreedictionary.com/arroyo

Borchert, C. (2013) *2012 Annual Water Report*. City of Santa Fe Water Division. http://www.santafenm.gov/DocumentCenter/View/41745

Borchert, C. (April 2013) Reclaimed Wastewater Resource Plan. City of Santa Fe. http://www.santafenm.gov/index.aspx?NID=2576

Business Green (March 13, 2012) *Report: solar, wind and biofuel markets smash revenue records*. http://www.businessgreen.com/bg/news/2159031/report-solar-wind-biofuel-markets-smash-revenue-records

City of Santa Fe Resolution No. 2012-28 (February 29, 2012) *Adopting administrative procedures for the Santa Fe River target flow ordinance, Article 25-13 SFCC 1987*. Introduced by Mayor Coss and Councilor Bushee.

Lancaster, B., & Marshall, J. (2006). *Rainwater harvesting for drylands : Guiding principles to welcome rain into your life and landscape. vol. 1* (1st ed.). Tucson, Ariz: Rainsource Press.

Derr, T. (Ed.) Margolis, E., Savage, M., Lyons, D., Dupzyk, P., and McCarthy, L. (2009) *Santa Fe Municipal Watershed Plan 2010-2029*. Prepared with funding from the Collaborative Forest Restoration Program.

Hansen, E., Mulvaney, D. and Betcher (October 30, 2013) *Water resource reporting and water footprint from Marcellus shale development in West Virginia and Pennsylvania*. Downstream Strategies and San José State University for Earthworks Oil and Gas Accountability Project. http://www.downstreamstrategies.com/documents/reports_publication/marcellus_wv_pa.pdf

Grant, P. (2002) *Santa Fe River watershed restoration action strategy (WRAS).* Santa Fe Watershed Association.

Grant, P. (2009) *Community forestry in the Santa Fe Municipal Watershed*.

Gutzler, D. and Robbins, T. (2010) *Climate variability and projected change in the western United States: regional downscaling and drought statistics*. DOI 10.1007/s00382-010-0838-7 http://epswww.unm.edu/facstaff/gutzler/manuscripts/ClimDyn_10Jun.pdf

Gutzler, D. (2012) *Climate variability and change in the Santa Fe Watershed*. Presented at the Santa Fe Watershed Climate Change Workshop, March 6, 2012. http://www.santafenm.gov/DocumentCenter/Home/View/10402

Hay, K. (July 25, 2013) *Climate change may ruin SF tourism, speakers say*. Journal North. http://www.abqjournal.com/225401/north/climate-change-may-ruin-sf-tourism-speakers-say.html

Hook, A. (April 2013) *2012 annual water report*. City of Santa Fe Water Division. http://www.santafenm.gov/DocumentCenter/View/40782

Hurd, B.H. and Coonrod, J. (2008). *Climate Change and Its Implications for New Mexico's Water Resources and Economic Opportunities*, New Mexico State University, Agricultural Experiment Station, Technical Report 45, Las Cruces, NM. 28 p. http://agecon.nmsu.edu/bhurd/HurdHome/HURD PUBS//Published Reports/PR-11 Hurd and Coonrod (2008) Climate Chng and NM Water Resources - AES-TR45.pdf

Jansens, J-W. (2013) *Keeping Santa Fe County wetlands viable and functioning: A wetlands action plan for Santa Fe County*. Ecotone.

Jemez y Sangre Water Planning Council (2003) *Jemez y Sangre regional water plan, volume 1: report*. Prepared by Daniel R. Stephens and Associates, Inc. and Amy Lewis, consultant. http://www.ose.state.nm.us/Planning/RWP/region_03.php

King, A. (2009) *Water use in Santa Fe: A study of residential and commercial water use in the Santa Fe urban area*. Water Division, City of Santa Fe, New Mexico. http://www.santafenm.gov/DocumentCenter/Home/View/10629

Lancaster, B., & Marshall, J. (2006). *Rainwater harvesting for drylands : Guiding principles to welcome rain into your life and landscape. vol. 1* (1st ed.). Tucson, Ariz: Rainsource Press.

Lewis, A., MacClune, K., Tyler, K., Borchert, C., Llewellyn, D., Torres, K. (October 2012) *Climate change and the Santa Fe watershed: A preliminary assessment.* Prepared for Bureau of Reclamation, City of Santa Fe, Santa Fe County. http://www.santafenm.gov/DocumentCenter/View/38596

Marin County Watershed Program. *What is a healthy watershed? http://www.marinwatersheds.org/healthy_watershed.html*

Moore, S. (Jan. 26, 2011) *Managed Aquifer Recharge in the middle Rio Grande basin, New Mexico*. Abstract and Powerpoint presentation at the Managed Aquifer Recharge Symposium, Irvine, CA. Daniel B. Stephens & Associates, Inc. http://www.nwri-usa.org/pdfs/MoorePresentationFinal.pdf

Natural Resources Defense Council (NRDC) (2008) *Preparing for global warming: a framework for protecting community health and the environment in a warmer world*. http://www.nrdc.org/globalWarming/files/preparedness.pdf

New Mexico Environment Department (NMED) (2012) *Santa Fe River from Nichols Reservoir to the outfall of the Santa Fe Wastewater Treatment Facility Use Attainability Analysis*. ftp://ftp.nmenv.state.nm.us/www/HearingOfficer/12-07(R)/NMED_NOI_Exhibits/17-UAA-SantaFeRiver.pdf

PNM Website. Water management: San Juan Generating Station. http://www.pnm.com/environment/sj_water.htm

Rogue Valley Council of Governments website. http://rvcog.org/MN.asp?pg=NR_Stormwater_General

Railyard Stewards (March 5-7, 2013) *A different forest for the city different: A stakeholders' policy roundtable to explore the future of Santa Fe's community and community forest meeting report*. Prepared by Americans for Indian Opportunity (AIO).

Railyard Stewards (May 30, 2013) *A different forest for the city different: a stakeholders' policy roundtable to explore the future of Santa Fe's urban and community forest – developing an action plan meeting report*. Prepared by Americans for Indian Opportunity (AIO).

Repetto, R. (2012) New Mexico's rising economic risks from climate change. Demos. http://www.demos.org/publication/new-mexicos-rising-economic-risks-climate-change

Santa Fe County (2013) *Santa Fe County National Pollution Discharge Elimination System: Notice of intent Ms4 stormwater management plan and program description*. Originally written in 2009 and revised in March 2013. http://www.santafecountynm.gov/userfiles/SFC_MS4_Rev3-28-2013.pdf

Santa Fe Watershed Association (SFWA) (2012) *Arroyo assessment surveys of 10 major arroyos in the Santa Fe watershed*. Report to the Public Works Department, City of Santa Fe 2012.

U.S. Census Bureau (2010) Santa Fe (City), New Mexico). Retrieved from: http://quickfacts.census.gov/qfd/states/35/3570500.html

USDA (2001) *Santa Fe municipal watershed project final environmental impact statement*. United States Department of Agriculture (USDA) Forest Service Southwest Region, Santa Fe National Forest.

USDA (2013) *Santa Fe municipal watershed Pecos Wilderness prescribed burn project – final environmental assessment (EA)*. United States Department of Agriculture (USDA) Forest Service Southwest Region, Santa Fe National Forest, Santa Fe County, New Mexico.

U.S. Department of Commerce (2000) *Census Bureau*. Systems Support Division, Washington, D.C.

U.S. Department of Commerce (2012a) Bureau of Economic Analysis, Regional Economic Information System, Washington, D.C.

U.S. Department of Commerce (2012b) Census Bureau. American Community Survey Office, Washington, D.C.

U.S. Global Change Research Program (2009) *Global climate change impacts in the United States 2009 Report*. U.S. Global Change Research Program. Graphics can be found at http://nca2009.globalchange.gov/projected-changes-water-cycle and http://nca2009.globalchange.gov/category/image-galleries/southwest

Water Conservation section of the Santa Fe City Website. http://www.santafenm.gov/index.aspx?NID=2684

Yulsman, T. (September 12, 2013) *Colorado deluge: Could be classified as a 1,000-year event*. Discover Magazine online blog ImaGeo. http://blogs.discovermagazine.com/imageo/2013/09/12/colorado-deluge-could-be-classified-as-a-1000-year-event/#.UmAAwihgk0w