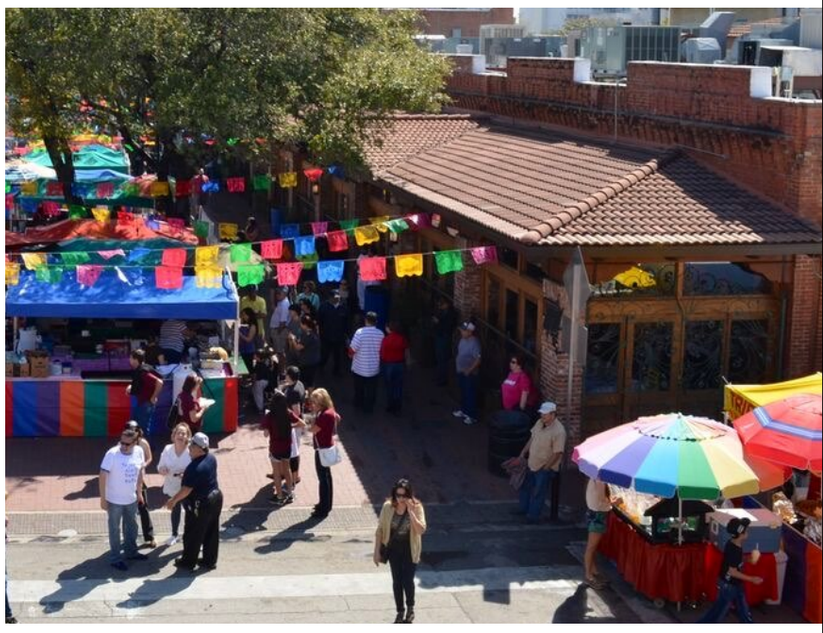
City of San Antonio

Sustainability Plan



San Antonio launched its SA Tomorrow planning effort to guide the City toward smart, sustainable growth as it prepares for a million more people by 2040.

Adopted by the City of San Antonio City Council
August 11, 2016

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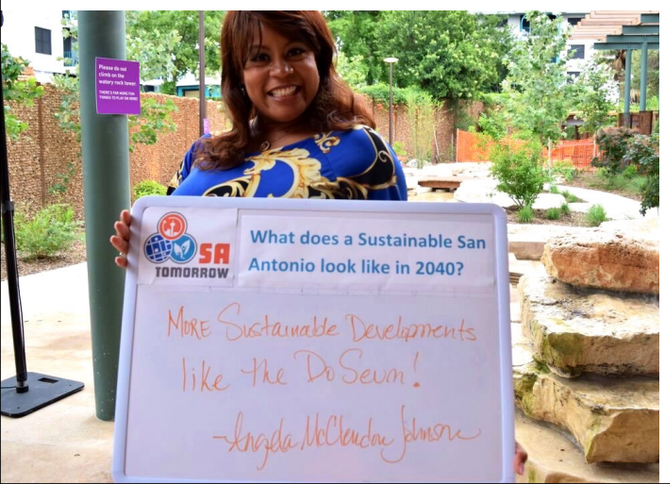


INTRODUCTION

San Antonio holds a special place for residents and visitors alike. From serving as Military City, USA to being home to the San Antonio Spurs, we love San Antonio for its history, culture, natural beauty, and most importantly its people. It's at this point in time, however, that we need to take a step back and acknowledge that our community is changing at an exceedingly quick pace. New development downtown and at our fringes, more traffic, reduced air quality, increasing rents and housing prices, pressure on our historic resources, and a changing climate are just some of the things we see occurring today. The question now is what does the future hold and more importantly, what do we want it to look like. What do one million more residents in the San Antonio region by 2040 mean for our long term sustainability?

To address current and future opportunities and challenges associated with this growth, the City of San Antonio launched a community-based planning process, SA Tomorrow, in 2014. SA Tomorrow is a three-pronged planning effort designed to guide San Antonio towards smart, sustainable growth and to meet and build upon the collective vision articulated for San Antonio through the SA2020 visioning process in 2011.

The Sustainability Plan focuses on the three pillars of sustainability (economic, environmental, and social) and is the roadmap for both the community and the municipal government to achieve the overall vision of a sustainable San Antonio.

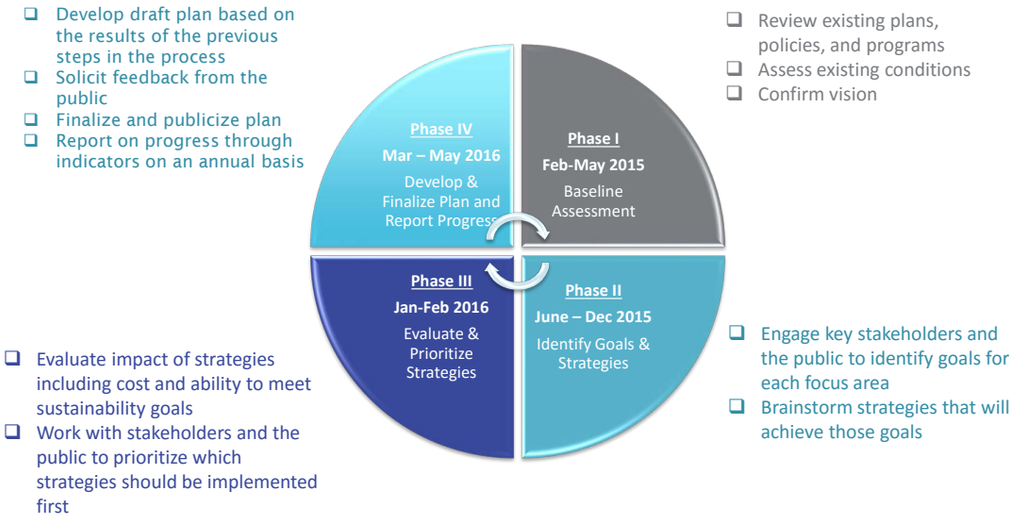
A sustainable San Antonio has a thriving economy, a healthy environment, and an inclusive and fair community.

WHAT IS A SUSTAINABLE SAN ANTONIO?

Working with the public and stakeholders, a sustainable San Antonio was identified as a community that has a thriving economy, a healthy environment, and an inclusive and fair community. To meet this definition of sustainability, the Sustainability Plan highlights seven focus areas and five cross cutting themes. Each focus area has its own vision, outcomes, strategies, and measures of success. The cross cutting themes were identified through a process of reviewing past surveys and current plans and policies, coupled with public input, in order to identify and highlight key priorities for San Antonio. These priorities create the framework by which every identified strategy was evaluated to ensure that upon implementation, the state of these priority areas is improved or, at a minimum, not negatively impacted. Additionally, these cross cutting themes will allow for strategy prioritization based upon current and future needs and objectives.

THE PLANNING PROCESS

The SA Tomorrow Sustainability plan was developed from an evaluation of past plans, such as Mission Verde and SA2020, as well as through engagement with the public, an expert steering committee, subject matter experts, key members of City leadership, and the SA Tomorrow comprehensive and transportation planning teams, along with best practice research from around the country.



Throughout this 14 month planning process, the City of San Antonio engaged more than 4,000 people in the development of the sustainability plan through online engagement, in-person meetings, and public events, including San Antonio's first annual Sustainability Forum. The Sustainability Plan team strived to achieve a balance in its public engagement efforts by establishing a goal of engaging a representative sample of San Antonians. The Sustainability Planning Team focused its resources for in-person meetings on those traditionally disenfranchised members of the community including the low-income, Hispanic, and young adults.

The Sustainability Steering Committee consisted of 31 professionals representing a diverse group of organizations. The Steering Committee met in-person four times and maintained ongoing communication through an online portal. The focus of the Steering Committee was to help the City identify appropriate goals, strategies, and targets for measures of success for each of the Plan focus areas.

The City of San Antonio Leadership Team, which consisted of all the Directors and Deputy Directors within each municipal department, was engaged in the sustainability planning process through two in-person meetings, an online survey, and one on one interviews. Their input was instrumental in developing the Leading By Example strategies that comprise the Municipal Sustainability Plan.

CLIMATE AND RESILIENCE

In order to develop a robust, comprehensive sustainability plan that is a roadmap to the envisioned future, it is essential to assess greenhouse gas emissions and understand the impacts of a changing climate on San Antonio's people and environment. Changing climate conditions are relevant to city planning in that they will affect the way the city plans for changes in temperatures (planning for cooling/heating, ensuring public safety, and protecting public health); changes in precipitation (preparing for droughts, planning for municipal water use or designing infrastructure to reduce the impacts of flooding); and increases in other extreme weather events (enhancing emergency management and preparedness efforts).

A key strategy to address our changing climate is to improve San Antonio's resilience. Resilience of a city is measured as the capacity for individuals, neighborhoods, and whole systems to not only survive but thrive despite disruptions and stresses. These stresses can be extreme weather events such as flooding, extreme heat, and unexpected economic downturns or other social disruptions. Knowing where vulnerabilities exist and identifying ways to adapt to predicted changes is essential to enhancing resilience.

Through the sustainability planning process, a greenhouse gas emissions inventory, a climate trends and projections analysis, and a climate change vulnerability assessment were completed to better understand the current and potential future impacts and opportunities associated with greenhouse gas emissions and the impacts of a changing climate.

GREENHOUSE GAS EMISSIONS INVENTORY

Why is it important to track and reduce greenhouse gas emissions?

As greenhouse gas emissions from human activities increase, they build up in the atmosphere and warm the climate, leading to many local and global impacts—in the atmosphere, on land, and in the oceans. These changes have both positive and negative effects on people, society, and the environment. Because many of the major greenhouse gases stay in the atmosphere for tens to hundreds of years after being released, their warming effects on the climate persist over a long time and can therefore affect both present and future generations.

The Greenhouse Gas Emissions Inventory assessed greenhouse gas (GHG) emissions generated from both the community and the government operations for the calendar year 2014. The results of this assessment indicate the best opportunities to reduce emissions within the community are within buildings (homes and offices) and transportation. San Antonians can reduce demand for electricity by installing energy efficient lighting and appliances in buildings and switching to more renewable energy supplies, such as wind and solar. To reduce the amount of gasoline that is burned by cars, there needs to be a targeted effort to create more opportunities for San Antonians to walk, ride bikes, and take public transit to their destinations.

For the government operations, the best opportunity to reduce emissions is from the generation of electricity. Actions to reduce in this area include installing more renewable energy sources from solar and wind and promoting additional energy efficiency programs. The Final Executive Summary of the GHG Inventory can be found in the Appendix section of this Plan.

CLIMATE TRENDS AND PROJECTIONS

A Climate Trends and Projections Analysis was completed for San Antonio by world renowned climate scientist, Texas Tech professor, and Texas native, Dr. Katharine Hayhoe. The report provided by Dr. Hayhoe and her team highlighted what scientists know about why climate is changing, and what this means for the future. They analyzed observed trends in San Antonio and compare them with those seen across Texas and the South Central region. Finally, they summarized qualitative projected future changes across the South Central region. The final Climate Trends and Projections Report can be found in the Appendix section of this Plan.

CLIMATE VULNERABILITY ASSESSMENT

The Climate Vulnerability Assessment was developed by bringing together the best available science with a multi-departmental, multi-organizational team of experts from across the city to identify key concerns and evaluate the potential vulnerability of assets, resources, and segments of the community. A focus of this assessment was to identify what current and future changing climate conditions and extreme weather events mean to San Antonio. By combining the best available science with the knowledge and expertise of the people who work on these issues locally, it is possible to gain real insight into how the community could be affected by future events. Results of this work include: relative climate and weather related vulnerability rankings for Key Areas of Concern, detailed descriptions of those rankings; and a list of strategies that could be used to address these vulnerabilities. The final Climate Vulnerability Assessment can be found in the Appendix section of this Plan.

HOW TO READ THE SA TOMORROW SUSTAINABILITY PLAN

The SA Tomorrow Sustainability Plan is divided into seven focus areas or categories each representing a component of the community. Each focus area includes highlights on the current state of the focus area and the outcomes, strategies, and targets for the measures of success identified through this process.

Vision

the long-term state which the community aspires towards related to each focus area.

By the Numbers

Select highlights about the current state of the focus area.

Measure of Success & Targets

An indicator or a measurable factor that provides insight on an existing condition with a specified level of achievement to track progress towards accomplishing an outcome.

HOW TO READ THE SA TOMORROW SUSTAINABILITY PLAN

Leading by Example

The strategies identified for the City of San Antonio to implement related to their government operations.

Outcomes

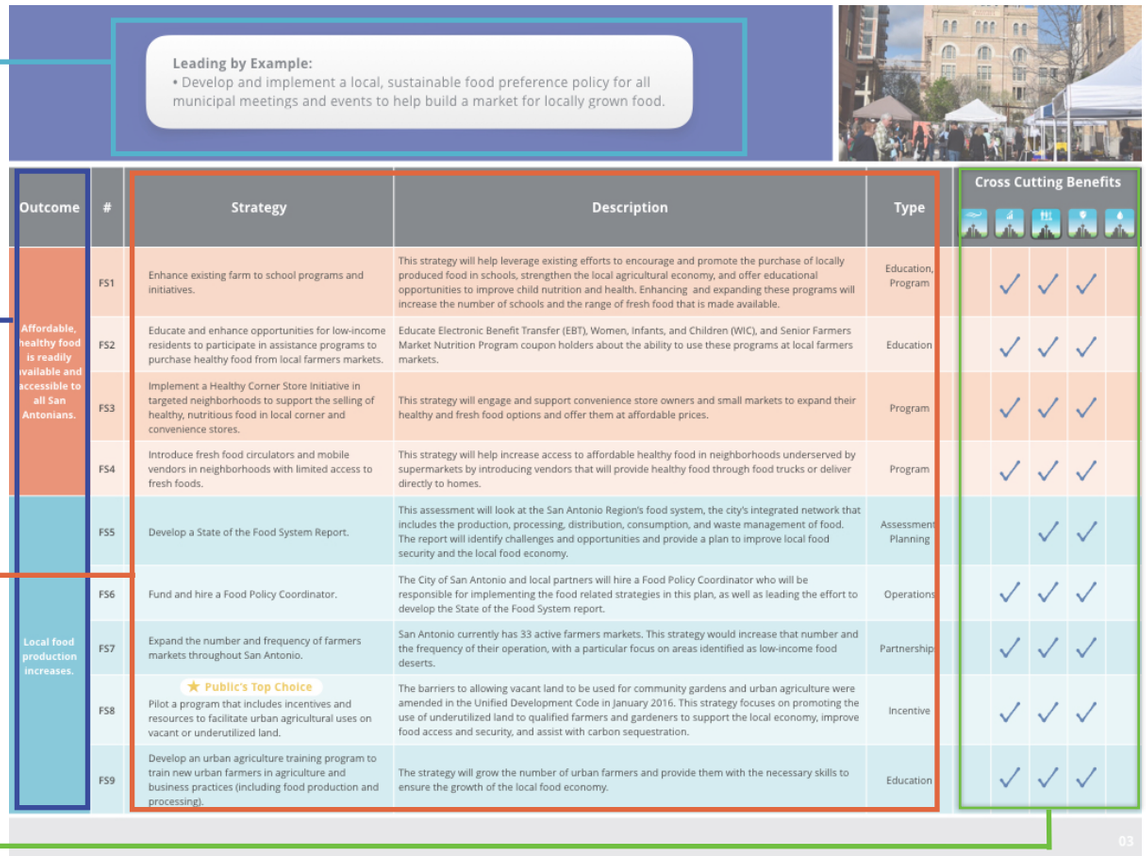
The objectives identified for the Sustainability Plan. Each focus area has between two and five outcomes.

Strategies

Those specific actions proposed to achieve an outcome.

Cross-Cutting Themes

Identifies the high priority issues that specific strategies impact.



Leading by Example:
• Develop and implement a local, sustainable food preference policy for all municipal meetings and events to help build a market for locally grown food.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits
Affordable, healthy food is readily available and accessible to all San Antonians.	FS1	Enhance existing farm to school programs and initiatives.	This strategy will help leverage existing efforts to encourage and promote the purchase of locally produced food in schools, strengthen the local agricultural economy, and offer educational opportunities to improve child nutrition and health. Enhancing and expanding these programs will increase the number of schools and the range of fresh food that is made available.	Education, Program	✓ ✓ ✓
	FS2	Educate and enhance opportunities for low-income residents to participate in assistance programs to purchase healthy food from local farmers markets.	Educate Electronic Benefit Transfer (EBT), Women, Infants, and Children (WIC), and Senior Farmers Market Nutrition Program coupon holders about the ability to use these programs at local farmers markets.	Education	✓ ✓ ✓
	FS3	Implement a Healthy Corner Store Initiative in targeted neighborhoods to support the selling of healthy, nutritious food in local corner and convenience stores.	This strategy will engage and support convenience store owners and small markets to expand their healthy and fresh food options and offer them at affordable prices.	Program	✓ ✓ ✓
	FS4	Introduce fresh food circulators and mobile vendors in neighborhoods with limited access to fresh foods.	This strategy will help increase access to affordable healthy food in neighborhoods underserved by supermarkets by introducing vendors that will provide healthy food through food trucks or deliver directly to homes.	Program	✓ ✓ ✓
Local food production increases.	FS5	Develop a State of the Food System Report.	This assessment will look at the San Antonio Region's food system, the city's integrated network that includes the production, processing, distribution, consumption, and waste management of food. The report will identify challenges and opportunities and provide a plan to improve local food security and the local food economy.	Assessment Planning	✓ ✓
	FS6	Fund and hire a Food Policy Coordinator.	The City of San Antonio and local partners will hire a Food Policy Coordinator who will be responsible for implementing the food related strategies in this plan, as well as leading the effort to develop the State of the Food System report.	Operations	✓ ✓ ✓
	FS7	Expand the number and frequency of farmers markets throughout San Antonio.	San Antonio currently has 33 active farmers markets. This strategy would increase that number and the frequency of their operation, with a particular focus on areas identified as low-income food deserts.	Partnership	✓ ✓ ✓
	FS8	★ Public's Top Choice Pilot a program that includes incentives and resources to facilitate urban agricultural uses on vacant or underutilized land.	The barriers to allowing vacant land to be used for community gardens and urban agriculture were amended in the Unified Development Code in January 2016. This strategy focuses on promoting the use of underutilized land to qualified farmers and gardeners to support the local economy, improve food access and security, and assist with carbon sequestration.	Incentive	✓ ✓ ✓
	FS9	Develop an urban agriculture training program to train new urban farmers in agriculture and business practices (including food production and processing).	The strategy will grow the number of urban farmers and provide them with the necessary skills to ensure the growth of the local food economy.	Education	✓ ✓ ✓

CROSS CUTTING THEMES

In order to ensure that the identified strategies of the Sustainability Plan were specific to the needs of San Antonio, five cross cutting themes were identified that address high priority issues for the community. These priorities create the framework by which every identified strategy was evaluated to ensure that these priorities are considered through prioritization, implementation, and future re-evaluation.

Air Quality

Continuously finding opportunities to improve air quality is a priority for the City of San Antonio, as air quality impacts health and the local economy.

Economic Vitality

A thriving economy is key to long-term sustainability and it is essential that San Antonio has a diverse, resilient, and growing economy that benefits the entire community.

Equity

A fair and just community ensures equal opportunities for all of its members. Strategies identified through this planning process should be able to demonstrate value to all of San Antonio's people, with a particular focus on those underserved communities.

Resilience

Like all cities, San Antonio has a set of vulnerabilities that could weaken it. Flooding and high heat days are just two examples. Measuring the value an identified strategy provides towards reducing those vulnerabilities and enhancing resilience to all social, environmental, and economic vulnerabilities is essential to ensure a sustainable future.

Water Resources

Water is essential to all life. In San Antonio the availability and quality of this resource, whether for human consumption or as part of our natural systems, is expected to be a challenge for years to come. Strategies identified through this planning process will be evaluated based on their ability to protect, preserve, and improve the quality of San Antonio's water.

FOCUS AREAS

The people of San Antonio require certain elements to survive and thrive, now and in the future, like water, energy, food and transportation. Since these elements are so vital to our community, we need to find ways to conserve and optimize them. The SA Tomorrow Sustainability Plan, includes seven “Focus Areas” that were assessed for current conditions and that contain actionable strategies.

Energy

The Energy Focus Area encompasses all direct components of energy generation including generation and distribution, efficiency, renewable energy, demand response, and green power purchasing.

Food System

The Food System Focus Area includes the production, processing, distribution, and consumption components of the food cycle. Disposal is covered in Solid Waste Resources.

Green Buildings and Infrastructure

The Green Buildings & Infrastructure Focus Area seeks to incorporate more sustainable practices within the physical structures of the city’s built environment, specifically buildings, water and sewer lines, stormwater systems, wastewater treatment facilities, and other infrastructure.

Land Use & Transportation

The Land Use & Transportation Focus Area focuses on sustainable land use patterns and modes of transportation and an improved infrastructure, including smart, mixed-use, and transit oriented development practices and bicycle and pedestrian infrastructure, alternative fuels, transit options, and complete streets.

Natural Resources

The Natural Resources Focus Area emphasizes the value and quality of existing natural resources, including air, surface and ground water, tree canopy, open space, and biodiversity from an ecosystem standpoint.

Public Health

The Public Health Focus Area includes overall public health and well-being and addresses various conditions, including obesity and diabetes, and promotes general physical activity and wellness.

Solid Waste Resources

The Solid Waste Resources Focus Area assesses the solid waste cycle and current facilities to promote approaches that reduce the negative impact on the environment and public health.

IMPLEMENTATION

The key to success for any plan is its ability to be implemented. The Sustainability Plan contains several measures to assure that the plan brings about real change.

- As you cannot manage what you don't measure, the Sustainability Plan will have an online dashboard that highlights plan indicators and targets that enable the public and decision makers to track progress of the plan's metrics.
- Plan strategies have been cross-referenced with the SA Tomorrow Comprehensive and Strategic Multi-Modal Plans to ensure consistency, as well as the ability to leverage resources for common plan outcomes.
- An implementation matrix was developed that identifies strategies as short, mid, or long-term, and identifies a lead agency and partner agencies and organizations.
- An annual sustainability report will be prepared and made publicly available to provide transparency regarding plan implementation, as well as allow for plan adjustments to be made depending upon updated priorities and circumstances.
- The SA Tomorrow Sustainability Plan will be updated every five years to address changing social, environmental, and economic opportunities, challenges, and priorities.
- Sustainability Plan goals and strategies will be integrated into the overall SA Tomorrow Implementation Strategy to ensure that sustainability is considered in future budget, capital improvement, and policy decisions.
- To ensure continued public engagement through sustainability plan implementation, the Office of Sustainability will hold an annual Sustainability Forum, as well as implement an ongoing program of engagement through online and in-person meetings and events.

City of San Antonio SA Tomorrow Sustainability Plan

Energy

The Energy Focus Area encompasses all direct components of energy generation including generation and distribution, efficiency, renewable energy, demand response, and green power purchasing.

Vision: San Antonio leads the nation in the generation and delivery of clean, reliable, affordable energy.

What is Electricity Generation Capacity?

The maximum output an electricity generator can produce under ideal conditions. Electricity Generation is the actual amount produced at a specific time.

State of Energy by the Numbers

352

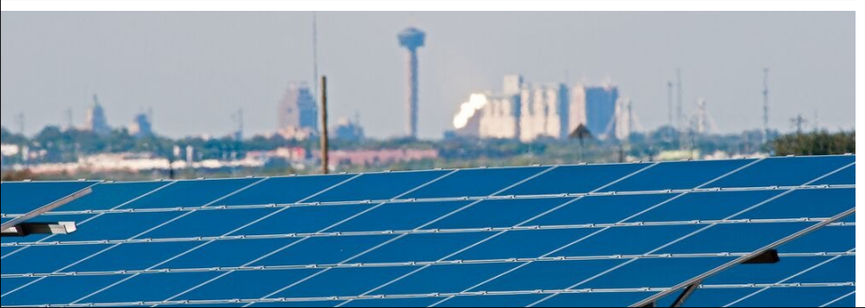
The megawatts reduced from 2009-2014 through CPS Energy's Save for Tomorrow Program.

194

The number of solar installations throughout San Antonio as of 2014.

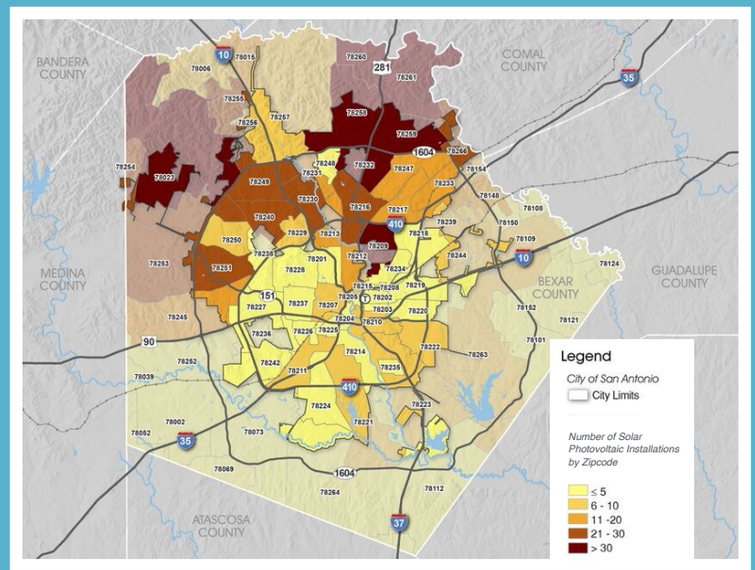
1,059.1

The megawatts of wind-generated electricity purchased by CPS Energy.



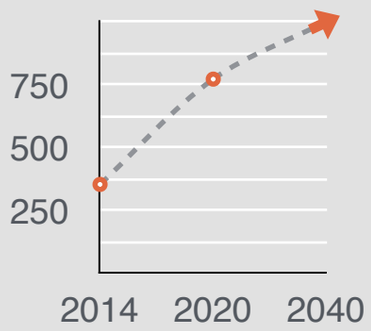
Solar Photovoltaic Installations by Zip Code

This map indicates the number of solar installations by zip code. The areas in **light to medium yellow** will be targeted for engagement in CPS Energy's Simply Solar program.



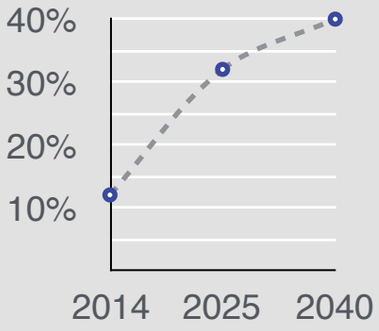
Measures of Success

Reduction in Energy demand in megawatts (MW)



Base Year	**2014**
Baseline	**352 MW Reduced**
2020 Target	**771 MW Reduced**
2040 Target	* This target will be identified during CPS Energy's upcoming Beyond 2020 strategic planning process.

% of total electricity generation capacity from renewable energy (solar, wind)



Base Year	**2014**
Baseline	**12%**
2040 Target	***40%**

* This target will be confirmed or adjusted during CPS Energy's upcoming Beyond 2020 strategic planning process.

Leading by Example:
- Purchase renewable energy for government operations.
- Explore renewable energy distributed generation and battery storage opportunities at critical municipal facilities.
- Develop and implement an Energy Policy for city buildings and operations.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
San Antonio continues to be a leader in renewable energy generation.	**EN1**	Support a Property Assessed Clean Energy (PACE) financing program in Bexar County.	PACE programs allow the costs of energy efficiency, clean energy, and water efficiency improvements to be privately financed through a property tax bill and run with the property rather than a specific property owner.	Policy, Program	✓	✓		✓	✓
	EN2	Develop partnerships to fund research and development of energy efficiency and renewable energy generation technology and innovations.	This strategy will support efforts that advance research and development of new energy efficiency and renewable energy generation options.	Incentives, Partnerships		✓			
	EN3	Engage the State of Texas to consider additional tax incentives for renewable energy generation.	Through this strategy the City/CPS Energy and key stakeholders will play active roles in encouraging the State to provide more incentives and support for renewable energy.	Partnerships	✓	✓			
Solar power becomes part of the fabric of the community.	**EN4**	★ Public's Top Choice Expand participation in the CPS Energy Simply Solar Initiative programs, with a particular focus on low income and affordable housing units.	This strategy will actively engage community members, particularly those in low income and affordable housing units, to participate in the existing CPS Energy Simply Solar Initiative, which includes the Roofless Solar and Solar Hosting programs. Education about the benefits these programs bring to individuals and the entire community, such as improved air quality and greenhouse gas emission reductions, will be highlighted.	Education, Program	✓	✓	✓	✓	✓
	EN5	Launch a pilot "Resilient Neighborhoods" program to identify critical facilities within vulnerable neighborhoods and establish renewable energy back-up power systems for emergencies.	This strategy will help ensure that critical facilities have power during emergency situations. The "Resilient Neighborhoods" program is also discussed in the Public Health Focus Area.	Program		✓	✓	✓	
	EN6	Host neighborhood meetings/workshops for customers to learn about energy efficiency, receive energy saving tips, and explore aggregating neighborhood demand for renewables (e.g. bulk power purchasing).	These meetings will be held by the City/CPS Energy and other key stakeholders in neighborhoods throughout San Antonio and will focus on how community members and businesses can leverage existing programs to realize energy and cost savings.	Education	✓		✓		
	EN7	Develop a solar map to provide residents and businesses a tool to evaluate the solar potential of their building rooftops.	An online solar map will increase solar installations by providing public information regarding the solar potential for all public and private buildings in San Antonio. By simply providing an address through an online portal, people will be able to determine the size of the solar panel system and energy generation capacity, and the approximate financial return.	Program	✓	✓			
San Antonio drives a new energy economy through technology and innovation.	EN8	Identify opportunities to leverage technology to deliver effective demand response and other energy use reduction programs.	Demand response programs pay users to reduce their energy use when demand is at its highest. This strategy will focus on ways to increase building energy efficiency across sectors, as well as use technology to improve delivery of these programs. Energy efficiency programs help improve air quality and reduce greenhouse gas emissions.	Assessment, Program	✓			✓	

City of San Antonio SA Tomorrow Sustainability Plan

Food System

The Food System Focus Area includes the production, processing, distribution, and consumption components of the food cycle. *Disposal is covered in Solid Waste Resources.*

Vision: All San Antonians benefit from a thriving food system that is accessible, secure, nutritious, and affordable.

What is a Food Desert?

The SA Tomorrow Sustainability Plan defines a Food Desert as an area of the community where a significant number of low-income residents are more than 1 mile from a “full-service” grocery store, supermarket, farmer’s market, or other healthy food outlet.

State of the Food System by the Numbers

24 The current number of farmers markets in San Antonio

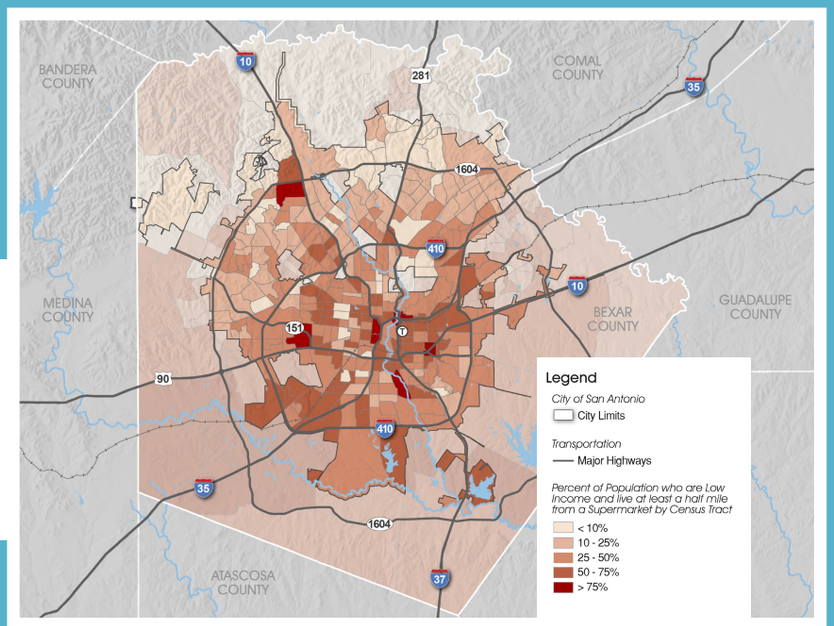
32 % of low-income San Antonians that lived in a food desert in 2010

2nd hungriest state in America

(meaning that a large number of citizens within Texas do not have access at all times to food that promotes a healthy lifestyle)

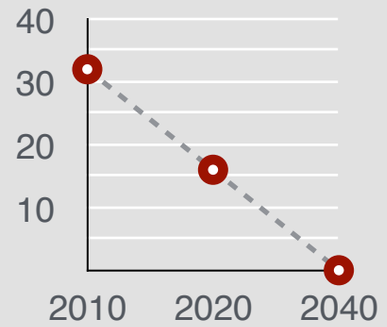
Percentage of Low Income Residents Living in a Food Desert

This map shows the current percent of low-income San Antonians that live in a food desert. The City will first seek to address those neighborhoods in the **darkest red.**



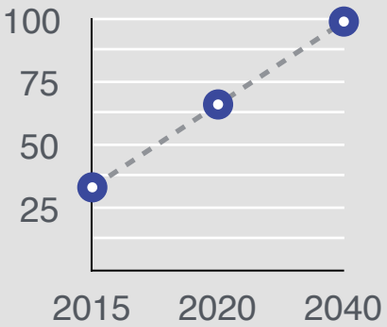
Measures of Success

% of Low-Income San Antonio Residents Living in a Food Desert



Base Year	**2010**
Baseline	**32%**
2040 Target	**0%**

# of Schools Participating in the USDA’s Fresh Fruit and Vegetable Program



Base Year	**2015**
Baseline	**33 out of 99**
2040 Target	**99+**

Leading by Example:
• Develop and implement a local, sustainable food preference policy for all municipal meetings and events to help build a market for locally grown food.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
Affordable, healthy food is readily available and accessible to all San Antonians.	FS1	Enhance and expand existing farm to school programs and initiatives.	This strategy will help leverage existing efforts to encourage and promote the purchase of locally produced food in schools, strengthen the local agricultural economy, and offer educational opportunities to improve child nutrition and health. Enhancing and expanding these programs will increase the number of schools and the range of fresh food that is made available.	Education, Program		✓	✓	✓	
	FS2	Educate and enhance opportunities for low-income residents to participate in assistance programs to purchase healthy food from local farmers markets.	Educate Electronic Benefit Transfer (EBT), Women, Infants, and Children (WIC), and Senior Farmers Market Nutrition Program coupon holders about the ability to use these programs at local farmers markets.	Education		✓	✓	✓	
	FS3	Implement a Healthy Corner Store Initiative in targeted neighborhoods to support the selling of healthy, nutritious food in local corner and convenience stores.	This strategy will engage and support convenience store owners and small markets to expand their healthy and fresh food options and offer them at affordable prices.	Program		✓	✓	✓	
	FS4	Introduce fresh food circulators and mobile vendors in neighborhoods with limited access to fresh foods.	This strategy will help increase access to affordable healthy food in neighborhoods underserved by supermarkets by introducing vendors that will provide healthy food through food trucks or deliver directly to homes.	Program		✓	✓	✓	
Local food production increases.	FS5	Develop a State of the Food System Report.	This assessment will look at the San Antonio Region's food system, the city's integrated network that includes the production, processing, distribution, consumption, and waste management of food. The report will identify challenges and opportunities and provide a plan to improve local food security and the local food economy.	Assessment, Planning			✓	✓	
	FS6	Fund and hire a Food Policy Coordinator.	The City of San Antonio and local partners will hire a Food Policy Coordinator who will be responsible for implementing the food related strategies in this plan, as well as leading the effort to develop the State of the Food System report.	Operations		✓	✓	✓	
	FS7	Expand the number and frequency of farmers markets throughout San Antonio.	San Antonio currently has 33 active farmers markets. This strategy would increase that number and the frequency of their operation, with a particular focus on areas identified as low-income food deserts.	Partnerships		✓	✓	✓	
	FS8	★ Public's Top Choice Pilot a program that includes incentives and resources to facilitate urban agricultural uses on vacant or underutilized land.	The barriers to allowing vacant land to be used for community gardens and urban agriculture were amended in the Unified Development Code in January 2016. This strategy focuses on promoting the use of underutilized land to qualified farmers and gardeners to support the local economy, improve food access and security, and assist with carbon sequestration.	Incentive	✓	✓	✓	✓	✓
	FS9	Develop an urban agriculture training program to train new urban farmers in agriculture and business practices (including food production and processing).	The strategy will grow the number of urban farmers and provide them with the necessary skills to ensure the growth of the local food economy.	Education		✓	✓	✓	

City of San Antonio SA Tomorrow Sustainability Plan

Green Buildings & Infrastructure

The Green Buildings & Infrastructure Focus Area seeks to incorporate more sustainable practices within the physical structures of the city's built environment, specifically buildings, water and sewer lines, stormwater systems, wastewater treatment facilities, and other infrastructure.

Vision: San Antonio is a leader in high performance and resilient buildings and infrastructure.

What is meant by Green Buildings and Green Infrastructure?

Green buildings are designed to amplify the positive and mitigate the negative effects that the built environment has on the natural environment, as well as the people who inhabit buildings every day. Green infrastructure is an approach to water management that allows natural features, like trees and wetlands to manage water rather than adding more impervious surfaces and increasing the risk of flood and adding contaminants to the waterways.

State of Green Buildings & Infrastructure by the Numbers

58

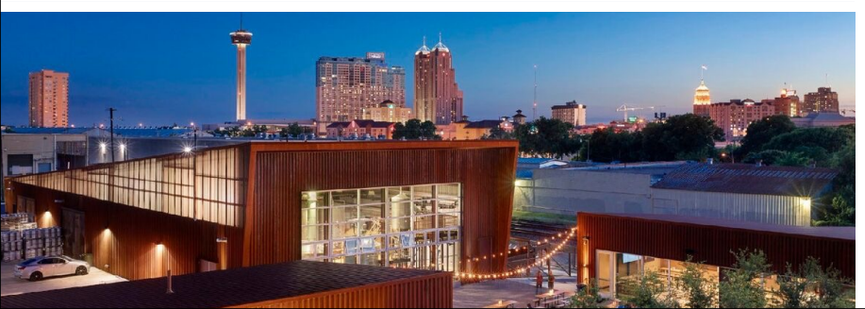
The percent of San Antonio's greenhouse gas emissions from the Building sector.

5,150

The number of homes that have been certified green by Build San Antonio Green.

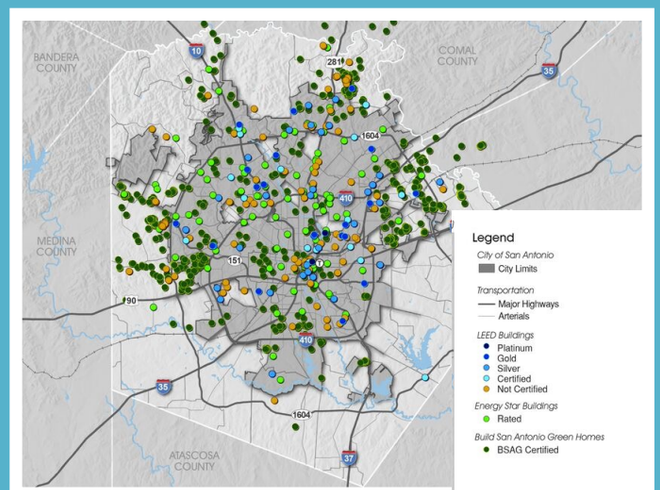
17 days

The projected average increase in number of days over 100 degrees F per year due to a changing climate.



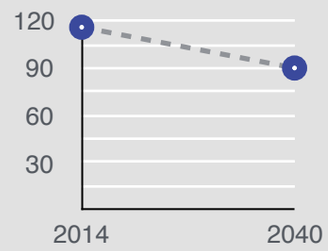
Green Buildings

This map shows how various green building types are distributed throughout San Antonio.



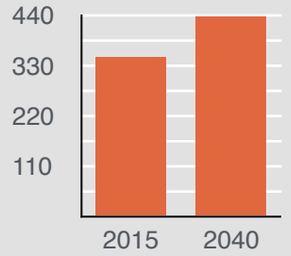
Measures of Success

Average Building Energy Use per Square Foot (all building types)



Base Year **2014**
Baseline **116 kBTU/ square foot**
2040 Target **90 kBTU/square foot**

Number of green buildings (LEED/ Energy Star)

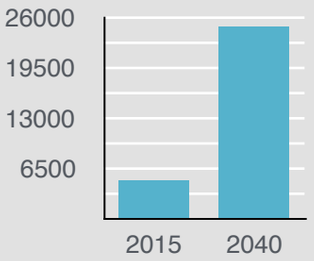


Base Year **2015**
Baseline **349**
2040 Target **436.25**

Urban/Rural Temperature Differential

Base Year **2008**
Baseline **8-12°F**
2040 Target **5-9°F**

Number of homes certified through the BSAG program



Base Year **2015**
Baseline **5,150**
2040 Target **25,000**

Leading by Example:
- Update city facility design guidelines to require new construction and significant renovations to meet and receive EPA Energy Star Certification within the 80th percentile.
- Develop a building and facility energy management system for real-time data and operational control.
- Require all appropriate City-funded infrastructure projects be designed to deliver no net runoff/or provide for an increase in net natural areas.
- Assess city-owned buildings and install green or cool roofs to reduce building energy consumption and mitigate urban heat island impact.
- Ensure all essential City assets and systems are assessed for their preparedness and ability to recover from current and future extreme weather events.
- Support the development of the San Antonio 2030 District.
- Pilot the use of Sustainable Return on Investment (SROI) analysis for city building and infrastructure projects.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
All buildings meet or exceed high performance building standards.	GB1	Collaborate with developers and community stakeholders to develop and adopt a high performance building standards program with education and technical assistance.	Through collaboration with developers and the construction industry, establish a process to encourage development of high performing efficient buildings that minimize environmental impact and have reduced operating costs.	Education, Incentives, Policy	✓	✓		✓	✓
	GB2	Pilot a building energy benchmarking and disclosure program.	This strategy will work with stakeholders to develop and pilot a program that will save energy in building operations by reducing related costs and environmental pollution through tracking and analyzing a building's energy use and sharing the results. The program will provide necessary resources to building owners to access utility data.	Policy, Program	✓	✓			✓
	GB3	Launch a Better Building Challenge.	The Better Building Challenge is a program of the US Dept. of Energy that collaborates with public and private sectors to make homes, commercial buildings and industrial facilities more energy efficient by sharing best practices and accelerating investment.	Program	✓	✓		✓	✓
	GB4	Develop a program that includes incentives, training, and support to retrofit existing buildings to a high performance building standard.	Working with partner organizations, a program of financial incentives and technical assistance will be developed for property owners of existing buildings to reduce the upfront costs and payback period of energy efficiency, resilience, and other performance enhancing retrofits. Additionally, educate the public on the benefits of adaptive reuse and preserving the embodied energy of existing buildings. Additionally, educate the public on the benefits of adaptive reuse and preserving the embodied energy in existing buildings.	Education, Incentives, Program	✓	✓		✓	✓
Water quality is improved due to the implementation of stormwater best management practices throughout the city, particularly within the San Antonio River watershed.	GB5	Create incentives, and provide training and recognition opportunities for existing developments to manage stormwater onsite.	This strategy creates an incentive within the existing stormwater fee structure to encourage onsite management of stormwater to reduce the risks of flooding and runoff of contaminants into San Antonio's waterways. This can be through reductions in impervious surfaces, and through the installation of rain gardens and rain barrels.	Education, Incentives	✓	✓		✓	✓
	GB6	★ Public's Top Choice Expand education, outreach, and technical assistance associated with the low impact development (LID) voluntary program to encourage significant onsite stormwater management for all new development and substantial retrofits and to encourage LID as the standard for San Antonio.	This strategy establishes a standard of development that reduces the environmental pollution that runs into San Antonio rivers, streams, and waterways through targeted education and outreach of the benefits of low impact development. Low Impact Development has multiple benefits including stormwater and flood management, reducing urban heat island impacts, and enhancing biodiversity.	Education, Incentives	✓			✓	✓

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
Water quality is improved due to the implementation of stormwater best management practices throughout the city, particularly within the San Antonio River watershed.	**GB7**	Pilot the use of the Envision™ Rating System or equivalent, for all public infrastructure projects and determine the benefit for use on future projects across all sectors.	Envision™ is a sustainability rating system for horizontal infrastructure, such as water pipes, roads, bridges, power transmission lines, etc. It addresses all infrastructure in the city, except buildings. The rating system provides guidance to help ensure that capital infrastructure projects include all stakeholders in the planning process and take into account the broader range of community impacts to air, water, and other essential environmental and social community assets.	Policy, Incentives	✓	✓		✓	✓
San Antonio demonstrably reduces the impact of urban heat island effect.	**GB8**	Launch an urban heat island mitigation program in priority areas to address opportunities for new and existing developments to minimize their contribution to excessive heat associated with the urban heat island effect.	An urban heat island program will encourage the use of cool roofs, tree plantings, shade structures, etc. to mitigate the impact of extreme heat, decreased air quality and related health impacts.	Program	✓	✓	✓	✓	
	GB9	Complete the LED Streetlight Conversion Project.	LEDs are significantly more efficient than traditional bulbs used in streetlights. Four years ago, the City launched a project replacing existing streetlights with LEDs. To date, 25,000 streetlights have been replaced with LEDs and an additional 30,000 will be installed by mid-2018 out of 70,000 total streetlights. This strategy aims to complete this project.	Program	✓	✓			
	GB10	Working with a broad stakeholder group, study and consider whether to update San Antonio's Dark Sky Ordinance.	The current ordinance only applies to areas around military bases. An update to this ordinance, if deemed necessary through a broad stakeholder process, could expand the reach and leverage newer technology to promote energy savings in addition to the other environmental and health benefits associated with dark skies.	Policy	✓				
Existing buildings are retrofit and new buildings are designed to be resilient to projected changes in climate.	**GB11**	Initiate a climate education campaign for businesses and property owners, including details about how to make built and natural infrastructure more resilient to existing and projected changes in climate.	This strategy will educate business owners and residents about the impacts of climate change and the strategies to enhance their resilience. Resources will be offered to help the community understand potential risks and the appropriate actions needed to prepare themselves.	Education	✓	✓		✓	
	GB12	Develop and pilot questionnaire in the building development review process to assess how climate change could impact new development and major renovations and encourage and provide support to developers to design their buildings to be resilient to these impacts.	The questionnaire will support the incorporation of climate change considerations into the design and review process, to help create more resilient buildings, developments, and landscapes by requesting that developers consider specific questions related to how climate change could impact their project. Education and technical support will be made available. Resources should be identified to maintain existing review and approval timelines.	Education, Operations		✓		✓	
	GB13	Join FEMA's Community Rating System (CRS) program.	CRS is a voluntary incentive program that recognizes floodplain management activities that exceed requirements. Benefits of engaging in this program include reduced flood insurance premium rates for policyholders and general enhancements to public safety through reductions in damages to people, property and public infrastructure, the economy, and the environment	Partnerships			✓	✓	

City of San Antonio SA Tomorrow Sustainability Plan

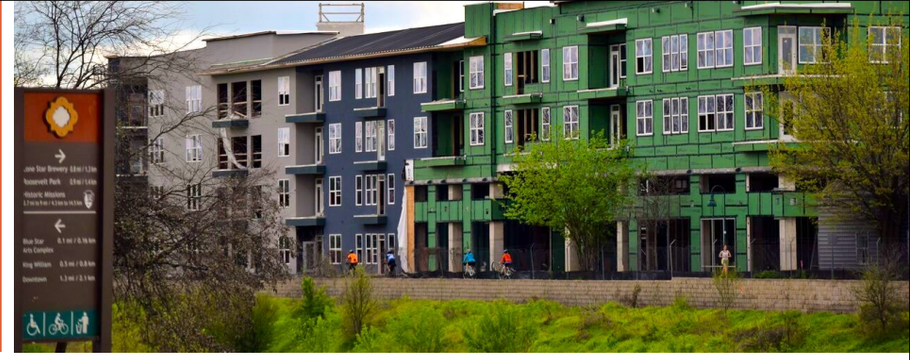
Land Use & Transportation

The Land Use & Transportation Focus Area focuses on sustainable land use patterns and modes of transportation and an improved infrastructure, including smart, mixed-use, and transit oriented development practices and bicycle and pedestrian infrastructure, alternative fuels, transit options, and complete streets.

Vision: San Antonio's future growth is sustainable and efficient, focusing on strategic development that is compact, mixed-use, economically-inclusive, and multi-modal.

What is the Housing and Transportation Index?

The Housing & Transportation Index measures the costs of housing and transportation as a percentage of income to provide a more comprehensive understanding of the affordability of a community. The lower the percentage the more affordable a place is.



State of Land Use & Transportation by the Numbers

612

The miles of bike facilities in San Antonio as of 12/31/2015.

37th

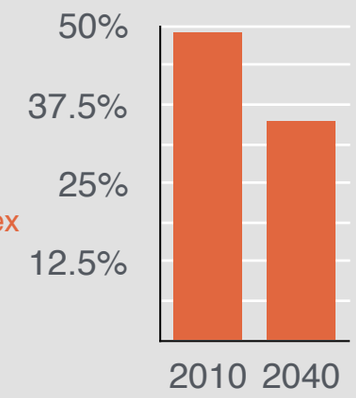
San Antonio's ranking among the most walkable large cities in the US.

80%

The percent of San Antonians that drive alone to get to work as of 2013.

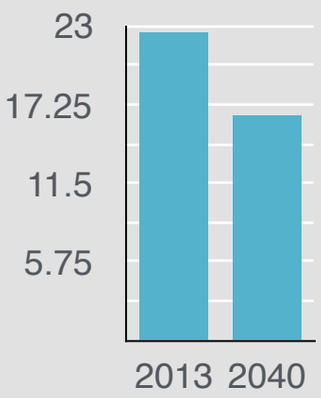
Measures of Success

Housing and Transportation Index



Base Year	**2010**
Baseline	**49%**
2040 Target	**35%**

Vehicle Miles Traveled Per Capita

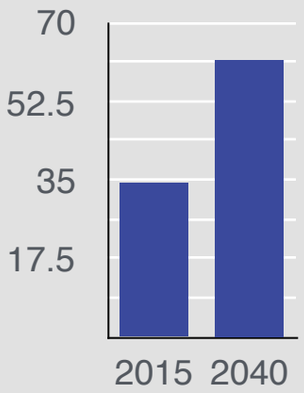


Base Year	**2013**
Baseline	**22.4**
2040 Target	**16.5**

Bicycle Friendly Community Score

Base Year	**2015**
Baseline	**Bronze**
2040 Target	**Platinum**

Average Walk Score (2010)



Base Year	**2015**
Baseline	**34**
2040 Target	**61.6**

Leading by Example:
• Provide incentive programs and shower and storage facilities for all COSA employees who commute to work utilizing clean sources (bike, walk, carpool, transit, alternative fueled vehicle), as well as provide options for flex scheduling/ telecommuting to reduce congestion and emissions during AM/PM peak hours).
• Green the city fleet to reduce fuel use (EV's, efficient vehicles, rightsizing, telematics, and behavior change).

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
New development is affordable, mixed-use, transit oriented and is designed for walking, biking, and electric vehicle infrastructure.	LT1	★ Public's Top Choice Incentivize new development to provide bike and pedestrian facilities, and infrastructure for electric and other alternative or technologically advanced vehicles.	This strategy will encourage development that provides pedestrian, bicycle, and transit - oriented infrastructure with a priority focus on projects that connect to major employment centers via transit. These amenities can help increase physical activity, reduce air pollution, and improve property values.	Policy	✓			✓	
	LT2	Evaluate and assess existing parking space requirements and identify innovative parking strategies to encourage walkability and alternative modes of transportation.	Minimum parking requirements can create excess parking and impervious cover that contribute to a car-dependent community, as well as the urban heat island effect and excessive stormwater runoff. By evaluating the existing parking requirements and identifying innovative strategies to minimize new, and existing parking, San Antonio can minimize flooding, reduce heat islands, foster more walkability and promote the use of transit or bicycles.	Assessment, Policy	✓				✓
	LT3	Create incentives to guide employment and housing (including affordable housing) to transit rich and targeted areas throughout the city.	This strategy encourages private developers to develop affordable housing in targeted areas.	Incentives	✓	✓	✓		
	LT4	Launch an incentive program and educational campaign to encourage private developers to develop mixed-use and walkable communities.	This strategy helps incentivize and educate the development community and the public regarding the social, economic, and environmental benefits of walkable, mixed-use development.	Education, Incentives			✓	✓	
Existing neighborhoods are enhanced to allow for mixed uses and increased access to jobs, services, and transportation options.	LT5	Work with public and private employers to design and implement employee transportation demand management (TDM) programs.	This strategy will help develop plans to reduce travel demand (specifically that of single-occupancy private vehicles), or to redistribute this demand in space or in time, with the result of reducing vehicle miles traveled and improving air quality.	Assessment, Policy, Program	✓	✓	✓		
	LT6	Participate in the Great Streets program and other public improvement programs to create complete streets that enhance economic development, improve commercial and civic life, decrease retail vacancy rates, and enhance safety.	A Great Streets Program provides a mechanism to improve the quality of streets and sidewalks, aiming ultimately to transform the public right-of-ways into great public spaces. It provides incentives to encourage implementation of streetscape standards that go above and beyond the City's minimum requirements.	Program	✓	✓	✓	✓	✓

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
Existing neighborhoods are enhanced to allow for mixed uses and increased access to jobs, services, and transportation options.	LT7	Continue to explore the feasibility and eventual development of high capacity transit options such as Bus Rapid Transit, Light Rail, or Street Car within San Antonio, as well to regional destinations.	This strategy will help assess what type of high capacity transit options are best suited to San Antonio and can help to significantly reduce congestion, improve air quality, encourage transit use, and support transit-oriented development.	Assessment, Planning	✓		✓		
	LT8	Expand infrastructure and promote policies that encourage the use of electric vehicles (EV) and anticipate new technology and innovation in the transportation sector.	As electric vehicles provide positive air quality benefit, develop a program to increase electric vehicle use through the expansion of EV infrastructure on public and private property, updated policies, incentives, education, and partnerships with developers and auto dealers. New innovations, such as driverless cars and E-Bikes, should be assessed for their potential benefits.	Policy, Program	✓	✓			
	LT9	Evaluate underutilized commercial and industrial land use and zoning designations in the core of the City, major employment centers, and primary transit corridors to determine areas that could be converted to residential or mixed-use.	Promote and incentivize compact, mixed-use development in existing underutilized commercial and industrial areas, as the reuse of previously developed land has significantly more social, economic, and environmental benefits than greenfield development.	Assessment, Incentives, Policy		✓	✓		
	LT10	Develop and implement a Priority Bike Facility Action Plan.	This strategy will allow the City of San Antonio to develop a plan to create a priority bike network that connects existing bike infrastructure to trails, recreational areas, neighborhoods, and service and employment centers.	Program	✓	✓			
	LT11	Pilot a Sprawl Repair Study.	This strategy identifies opportunities to retrofit existing suburban neighborhoods to provide more options for walkability and bikability to transit, schools, and recreational and commercial facilities.	Assessment	✓	✓			
All neighborhoods within San Antonio have appropriate amenities to support safe walking and biking.	LT12	Develop a Bike Living Lab Pilot Program.	The City of San Antonio will work with the community and partner organizations to provide opportunities to install a variety of temporary bicycle facilities aimed at creating safer streets and to determine if they are appropriate for the community.	Program				✓	
	LT13	Develop a program to encourage private employers to install shower and storage facilities for employees that commute via alternative modes.	Workplace shower and storage facilities promote biking and walking to work, which promotes active lifestyles and reduces single-occupancy vehicle traffic.	Incentives, Program	✓				

City of San Antonio SA Tomorrow Sustainability Plan

Natural Resources

The Natural Resources Focus Area emphasizes the value and quality of existing natural resources, including air, surface and ground water, tree canopy, open space, and biodiversity from an ecosystem standpoint.

Vision: San Antonio serves as a national model for respectful stewardship of the city's natural resources and values them for their social, ecological, and economic benefits.

How can we protect the Edwards Aquifer?

The Edwards Aquifer is a unique groundwater system and one of the greatest natural resources on Earth. As the San Antonio area continues to grow, we need to take action to protect the areas within and around the aquifer to ensure safe, reliable, secure drinking water sources are available for generations to come.

State of Natural Resources by the Numbers

1st

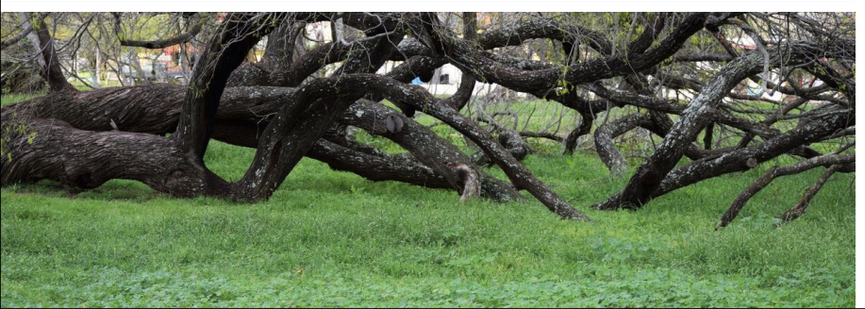
San Antonio is the first community in the nation to have their Mayor sign on to the Monarch Butterfly Pledge to commit to meet all 24 actions .

7

The number of endangered species in the Edwards Aquifer system.

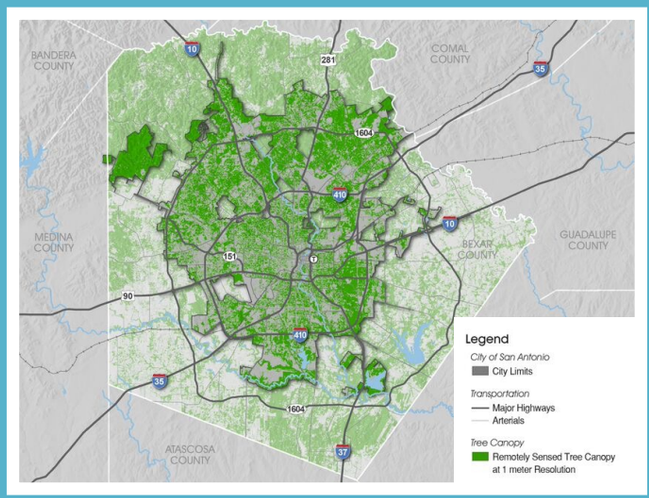
135,954

acres protected in the Edwards Aquifer Protection Program



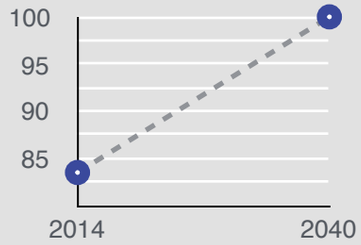
Tree Canopy

This maps shows the overall tree canopy coverage in San Antonio. The areas in **dark grey** in between the dark green tree canopy will be targeted for tree planting.



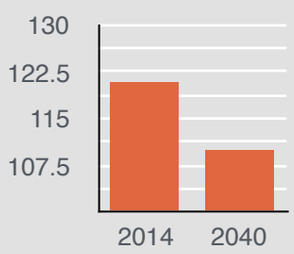
Measures of Success

% of Bexar County's Total Assessed Stream Miles that meet TCEQ Primary Contact Recreation Standards



Base Year	**2014**
Baseline	**83.5%**
2040 Target	**100%**

Water Use Per Person Per Day



Base Year	**2014**
Baseline	**121 gallons/person/day**
2040 Target	**110 gallons/person/day**

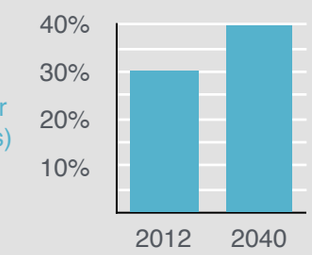
Concentration of Criteria Air Pollutants

Base Year	**2015**
Baseline	

PM 2.5: 8.9 ug/m3 (Weighted Annual Mean)
PM 10: 22 ug/m3 (Annual Mean)
Ozone: 78 parts per billion (8-hour)

2040 Target **Attainment of Federal Standards**

Tree Canopy Cover (not including parks)



Base Year	**2012**
Baseline	**30%**
2040 Target	**40%**

Leading by Example:
- Enhance the water conservation program at municipal buildings and facilities.
- Develop and enforce a no idling policy for all applicable municipal vehicles and employees.
- Consider the use of native milkweed and nectar plants at city properties where appropriate to create habitat for the Monarch Butterfly and other pollinators.
- Utilize sustainable, adaptive landscaping and have onsite stormwater management at all applicable municipal facilities.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
San Antonio's water bodies meet or exceed all state and federal regulations.	NR1	Explore incentive, voluntary, and other implementation programs for Low Impact Development (LID) and the development of Conservation Subdivisions.	A voluntary Low Impact Development Program and an updated Conservation Subdivision Ordinance were adopted by the San Antonio City Council in February 2016, which promote the use of Low Impact Development and conservation development practices, as well as buffer zones around valuable water or natural resources, to reduce flooding, protect water quality, and ensure they are able to deliver on their necessary ecosystem functions. This strategy evaluates and identifies implementation opportunities.	Assessment, Policy	✓			✓	✓
	NR2	Through a representative stakeholder process, conduct a science-based assessment of the impact of increased impervious cover and determine if development standards are needed to address flooding, water quality, and urban heat islands.	Impervious surfaces can exacerbate flooding as water is not able to infiltrate. Pervious surfaces, such as grass, soil, or porous pavement allow water to infiltrate, helping reduce the impacts of flooding. Working with a broad group of stakeholders, determine whether it is necessary to update impervious cover standards outside of the Edwards Aquifer Recharge Zone and, if needed, identify standards that would reduce flooding, improve water quality, and reduce urban heat islands.	Assessment, Planning	✓		✓	✓	✓
	NR3	Educate landscapers and the development community on integrated pest management and the benefit of the reduced use of conventional pesticides and insecticides.	Integrated pest management (IPM) techniques will reduce pesticides and insecticides entering and contaminating the water system. This strategy will focus on educating the community on the benefits of IPM and encourage the use of it.	Education					✓
Water use in San Antonio is efficient and per capita consumption does not increase over time.	NR4	★ Public's Top Choice Assess and develop new pilot programs, and expand existing programs, to phase large commercial buildings off of potable water use for landscaping.	These programs will include strategies and incentives for encouraging commercial buildings to use drought tolerant landscaping, rainwater harvesting, and recycled water from building systems for landscaping.	Incentives, Program	✓				✓
	NR5	Expand and promote incentives for native plants and low-water use landscaping and other residential water conservation strategies.	Incentives will be designed to promote residential water conservation and enhance onsite stormwater management with native and other sustainable plants.	Incentives					✓
San Antonio meets or exceeds attainment status for all measured criteria air pollutants.	NR6	Implement the City of San Antonio Potential Emissions Control Strategies Report.	Developed in 2015, this report identified a list of possible municipal actions that have the potential to reduce ozone in San Antonio. This strategy would move forward with implementing appropriate actions from this report.	Program	✓				

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
San Antonio meets or exceeds attainment status for all measured criteria air pollutants.	**NR7**	Partner with public and private organizations to promote a voluntary anti-idling campaign around schools, hospitals, and other areas with vulnerable populations.	The voluntary initiative will provide limits for how long a parked car can idle its engine around certain areas that tend to have vulnerable populations, such as schools and hospitals. Emissions from vehicles have been linked to respiratory illness and other diseases.	Program	✓		✓		
	NR8	Coordinate with significant point source emitters to reduce emissions during high ozone days.	This strategy will create a program whereby those with direct and significant air pollution emissions would work with the City to identify opportunities to reduce emissions and during high ozone days would receive an alert to activate those reduction actions.	Partnership, Program	✓			✓	
Tree canopy is enhanced and coverage is increased.	**NR9**	Develop a Street Tree Strategic Plan focused on high urban heat island areas with high pedestrian activity.	This strategy focuses on planting street trees in targeted urban heat island priority areas or underserved zones. This will focus primarily on the right-of-way and assess incentives for private property owners in those areas. Street trees have multiple benefits including shade, improved air quality, stormwater management, and increased property values. This plan will complement the City of San Antonio's Urban Ecosystem Analysis and Urban Forestry Plan.	Assessment, Planning	✓		✓	✓	✓
San Antonio is a leader in the preservation of critical habitat for native and migratory species.	**NR10**	Continue to promote the use of bonds for the development of bike trails, sidewalks, paths, greenways, and other open spaces that allow for density while also protecting natural areas and significant aquifer recharge areas.	Increased bike trails, sidewalks, paths, greenways, and other open spaces will enhance the walkability, bikeability, and overall livability of San Antonio and help to promote more active, healthy lifestyles, and protect significant natural areas, such as essential recharge areas conserved through the Edwards Aquifer Protection Program. This strategy will ensure that the City continues to keep bike paths, greenways, etc. as high funding priorities.	Assessment, Policy, Program	✓		✓	✓	✓
	NR11	Meet the requirements of and apply to become a National Wildlife Federation (NWF) certified Wildlife–Friendly Community.	Wildlife-Friendly Community Certification involves education and outreach, along with a certain number of homes, schools, and common areas becoming NWF Certified Wildlife Habitats by providing the 4 basic elements that all wildlife need: food, water, cover and places to raise young.	Education, Program				✓	✓
	NR12	Develop and implement a strategy to protect and enhance native habitat (i.e. milkweed) of the monarch butterfly and other migratory or endangered species.	The strategy will develop new strategies and utilize existing plans, such as the Edwards Plateau Habitat Conservation Plan, to promote biodiversity in San Antonio and preserve critical habitats.	Assessment, Program				✓	

City of San Antonio SA Tomorrow Sustainability Plan

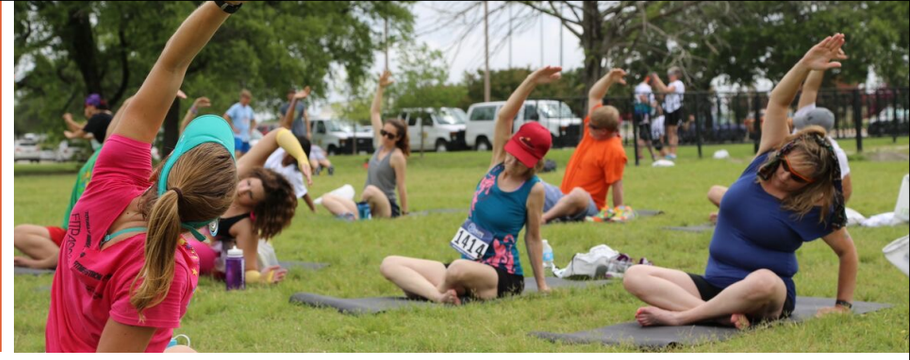
Public Health

The Public Health Focus Area includes overall public health and well-being and addresses various conditions, including obesity and diabetes, and promotes general physical activity and wellness.

Vision: All San Antonians regardless of income, ability, or employment, benefit from a safe environment that inspires healthy, active lifestyles.

Why is Community Resilience Important?

Resilience refers to the ability of people, the places where they live, and the infrastructure they rely upon to withstand and quickly recover from a natural or other hazard. Healthy, physically fit, socially connected San Antonians will be in a much better position to withstand and recover from a disaster.



State of Public Health by the Numbers

58

The percentage of San Antonians that live within 1 mile of a park or open space.

29.8% / 10.4%

The number of uninsured adults / children in the City of Antonio in 2014.

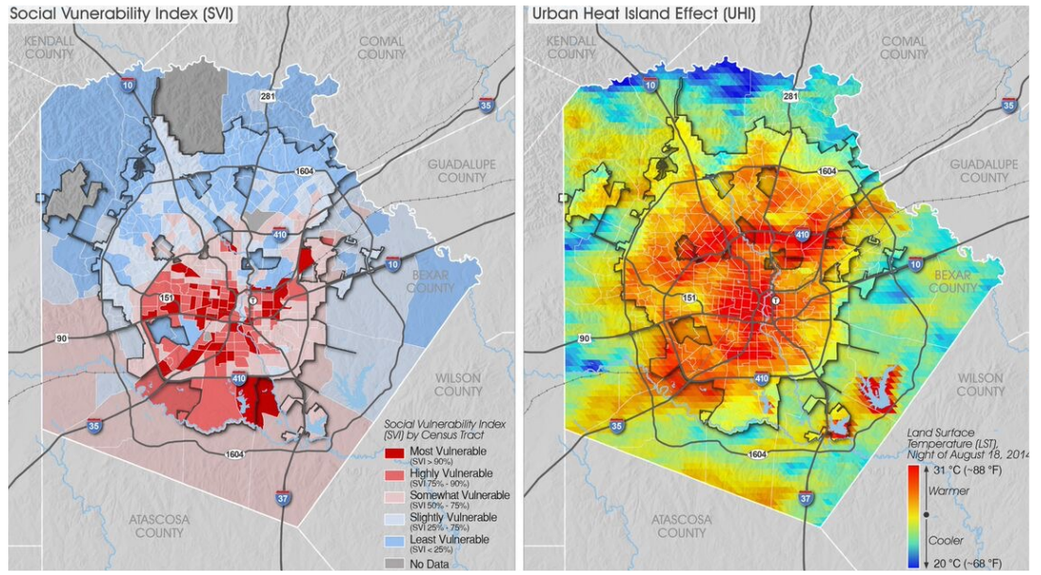
6.6%

The rate at which adult obesity decreased between 2010 and 2012.

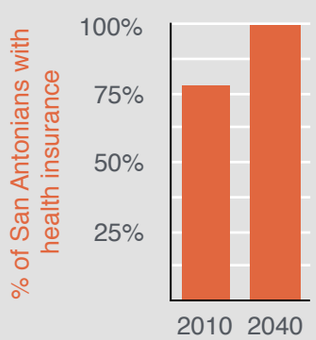
Social Vulnerability Index & Urban Heat Island

This map shows a side by side comparison of the social vulnerability index rankings and the urban heat island effect for Bexar County.

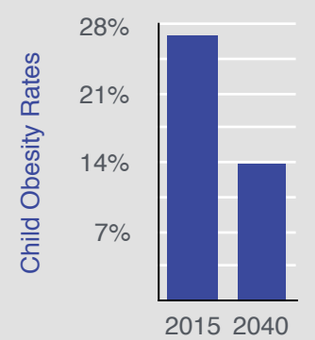
On both maps the areas in the **darkest red** indicate those areas of greatest concern of a heat related illness, as they contain a high concentration of vulnerable populations (children, seniors, etc.). These areas are subject to intense heat, with minimal opportunities for shade, respectively.



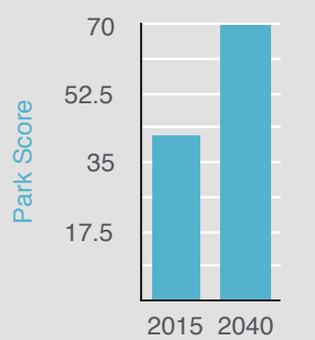
Measures of Success



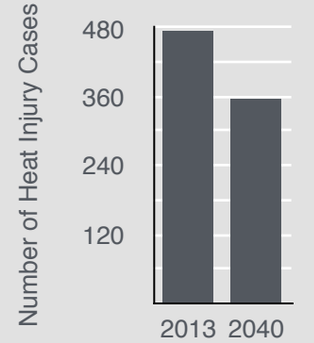
Base Year	2010
Baseline	78%
2040 Target	100%



Base Year	2015
Baseline	27.7%
2040 Target	13.8%



Base Year	2015
Baseline	42/100
2040 Target	70/100



Base Year	2013
Baseline	473
2040 Target	355

Leading by Example:
- Pilot healthy vending machines in select municipal facilities to increase the availability of locally sourced, fresh fruit and vegetables.
- Expand incentives and essential infrastructure for employees to regularly engage in physical activity and make healthy choices.
- Ensure that all relevant departments have plans in place for extreme weather events and that all City employees are prepared.
- Develop a Climate Action Plan, including a study of future San Antonio-specific climate projections.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
All San Antonians have access to affordable health care.	**PH1**	Provide mobile health clinics to underserved areas of the community.	This strategy will involve partnering with the County or private service providers to expand their existing services and ensure that those most in need are receiving the services.	Assessment, Program			✓	✓	
Youth of all ages are engaged and provided the resources needed to maintain an active, healthy lifestyle.	**PH2**	★ Public's Top Choice Partner with the school districts to increase physical activity before, during, and after school to meet the national recommendations for physical activity.	Physical activity for youth is critical to their health, and has been shown to improve educational attainment. This strategy could open school yards to all children after school to increase access to areas for physical activity.	Partnerships, Program			✓	✓	
	PH3	Enhance existing public park access, programming, and infrastructure to promote healthy lifestyles and physical exercise.	The City will review accessibility to existing parks and programming and identify opportunities to enhance accessibility and expand programming options through partnerships.	Assessment, Program			✓	✓	
San Antonio promotes well-being by providing healthy and affordable food choices, convenient access to green spaces and recreational facilities, and a robust network of physical and mental healthcare designed to eliminate existing health disparities in the community.	**PH4**	Increase and expand the number and quality of parks and recreational amenities city-wide, with a particular focus on areas of the city considered as underserved.	The City will develop a strategy for public and private entities to provide complete and equitable access to parks, playgrounds, trails, and linear greenways.	Assessment, Incentives, Program	✓		✓	✓	✓
	PH5	Develop a "Healthy by Design" program for all new affordable housing projects.	The program will provide guidelines for site design, walkability, open space, and green building techniques to create healthy environments that promote active lifestyles, social connectedness, and access to healthy food.	Education, Program	✓		✓	✓	
	PH6	Launch a public education campaign to promote the benefits of active, healthy lifestyles.	This public education campaign will be designed to target populations most at risk of obesity, and/or diabetes, to help promote active, healthy lifestyles.	Education			✓	✓	

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
									
San Antonians are prepared for changes in climate and weather.	PH7	Pilot a “Resilient Neighborhoods” program, including identifying “block captains” focused on enhancing the safety of all community members during and after an extreme event or disaster.	This strategy will establish a preparedness program that is focused on creating or enhancing social interactions and cohesion within neighborhoods. Block captains would be trained and activated to go door to door to check on the health of high risk neighbors during or after a disaster. The block captains could be existing or emerging neighborhood leaders who will play a critical role in immediate post-disaster recovery, to ensure the health and safety of all San Antonians. This program is also mentioned in the Energy Focus Area.	Education, Partnerships, Program			✓	✓	
	PH8	Develop a communications program for areas at high risk of vector borne health issues due to flooding.	Partner with public health agencies and pest management and control agencies to determine at-risk areas for vector borne health issues due to flood management issues and create informational materials for potentially impacted residents.	Assessment, Education, Partnership			✓	✓	
	PH9	Review effectiveness of cooling centers and other high heat day strategies and identify underserved areas for increased expansion of existing strategies or new strategies to mitigate the effects of high heat days.	Assess the effectiveness of existing cooling centers and other high heat day strategies, and develop a plan for implementing new high heat mitigation strategies or relocating centers to areas most in need.	Assessment, Planning			✓	✓	

City of San Antonio SA Tomorrow Sustainability Plan

Solid Waste Resources

The Solid Waste Resources Focus Area assesses the solid waste cycle and current facilities to promote approaches that reduce the negative impact on the environment and public health.

Vision: All residents and businesses have access to and receive ongoing benefits from innovative recycling and solid waste diversion programs.

What is Pay as You Throw?

Pay as You Throw is a program that allows residents to pay for waste collection services based on the amount of garbage they throw away.

State of Solid Waste Resources by the Numbers

30%

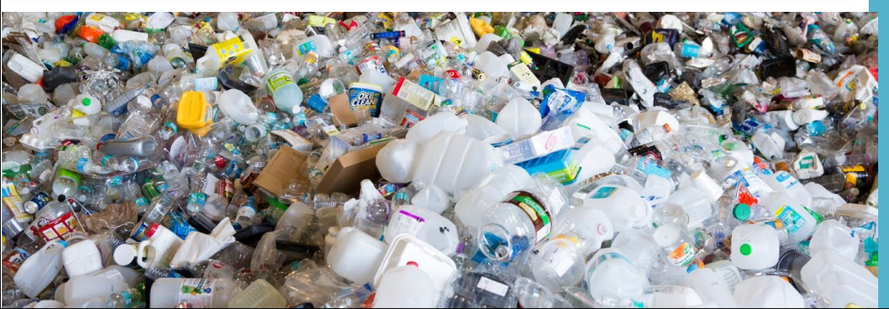
The amount of waste sent to the landfill decreased by between 2005 and 2015.

13%

The current residential recycling rate in San Antonio.

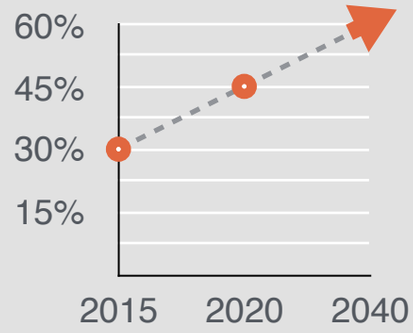
17%

The current residential brush mulching and composting rate.



Measures of Success

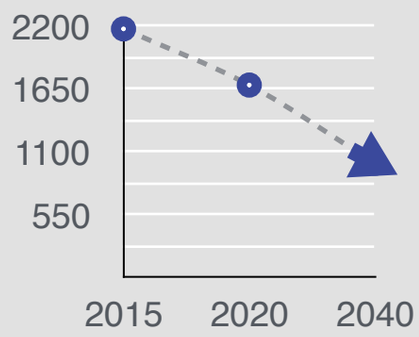
Residential Waste Diversion Rate (Combined Recycling & Composting Rates)



Base Year	2015
Baseline	30%
2020 Target	45%
2040 Target	*

* This target will be identified during the COSA Solid Waste Management Department's Recycling & Resource Recovery Plan Update

Residential Solid Waste Generation per Household Annually



Base Year	**2015**
Baseline	**2,177 lbs./year/ household**
2020 Target	**1,685 lbs./year/ household**
2040 Target	*

* This target will be identified during the COSA Solid Waste Management Department's Recycling & Resource Recovery Plan Update

Leading by Example:
• Ensure that all municipal facilities have appropriate recycling, diversion, and waste minimization programs.
• Increase spending on and seek to minimize waste from products purchased through CoSA's Environmentally Preferred Purchasing Policy.
• Partner with other Texas municipalities to improve statewide recycling framework.
• Convene a national working group to discuss the potential development of a standard methodology for calculating zero waste.

Outcome	#	Strategy	Description	Type	Cross Cutting Benefits				
Increased composting, recycling, and diversion opportunities for all sectors of the community.	SW1	Design and implement an effective commercial business waste reduction and recycling program.	Waste from commercial businesses in San Antonio is collected by private haulers and very little information is available on the amount and types of waste coming from that sector. This strategy will further develop the City's engagement with commercial businesses, such as through a comprehensive Green Business Program, to identify how they can be part of the solution to reduce overall waste that is sent to the landfill.	Program	✓	✓			
	SW2	★ Public's Top Choice Identify opportunities to foster markets for commercial recycling and organic material composting.	This strategy focuses on making connections between the materials that are being recycled and composted and those businesses that use the recycled materials as a resource for their products.	Partnerships	✓	✓			
	SW3	Conduct a waste characterization study.	A waste characterization study identifies the type and amount of disposed waste and helps identify areas of improvement for diversion programs.	Assessment					
	SW4	Identify opportunities to improve technology and processes at waste management facilities to expand the types of materials that can be recycled and composted.	This strategy will help make more items available to be recycled or composted.	Assessment	✓	✓			
	SW5	Develop a program to work with developers to reduce the amount of construction and demolition (C&D) waste sent to landfills.	With the expected increase in population, there will continue to be significant new development within San Antonio. It will be important to ensure that the waste associated with this new development is reused or recycled.	Program	✓	✓			
Enhanced outreach for the curbside recycling and composting programs.	SW6	Expand outreach and education on recycling and composting at City events.	The City can support the education of the community through ensuring all City-sponsored events provide facilities and signage to properly dispose of waste.	Education	✓		✓		
	SW7	Develop new outreach and education materials specifically targeted at those audiences/neighborhoods with the lowest recycling rates to encourage proper recycling and composting through clear, multi-lingual messages.	This strategy will provide a targeted marketing and education campaign focused specifically on those neighborhoods that are underperforming in terms of recycling and composting.	Education	✓		✓		

City of San Antonio SA Tomorrow Sustainability Plan

Community Indicators

STAR COMMUNITIES | Sustainability Tools for Assessing & Rating Communities

An indicator is a measurable factor that provides insight on an existing condition with a specified level of achievement to track progress towards accomplishing an outcome.

Focus Area	Indicator	Baseline Year	Baseline	2040 Target	Geographic Area	Source
Energy	Percent of total electricity generation capacity from renewable enegry	2014	12%	40% *	N/A	CPS Energy
	Reduction in Energy Demand in megawatts (MW)	2014	352 MW	771 MW (2020)*	CPS Service Area	CPS Energy
Food System	Number of schools participating in the USDA's Fresh Fruit and Vegetable Program	2015	33 out of 99	99	San Antonio ISD	SAISD Fresh Fruit and Vegetable Program Info, 2015. http://nova.saisd.net/storage/uploads/Foodnutrition/FFVP%202015-2016
	Percentage of low-income residents living in a food desert	2010	32%	0%	City of San Antonio	USDA ERS Food Access (based on Census 2010 data) http://www.ers.usda.gov/data-products/food-access-research-atlas/download-the-data.aspx.
Green Buildings & Infrastructure	Average Building Energy Use per Square Foot (all building types)	2014	116 kBTU/ square foot	90 kBTU/ square foot	City of San Antonio	2014 City of San Antonio Greenhouse Gas Emissions Inventory; Square footage from Bexar County Appraisal District (BCAD; 2014)
	Number of green buildings (LEED, Energy Star)	2015	349	464	City of San Antonio	Bexar County Appraisal District (BCAD; 2014); USGBC 2015
	Number of homes certified by Build San Antonio Green (BSAG)	2015	5,150	25,000	City of San Antonio	Build San Antonio Green
	Urban/Rural Temperature Differential	2008	8-12°F	5-9°F	City/Rural	Assessing the long-term urban heat island in San Antonio, Texas based on moderate resolution imaging spectroradiometer/Aqua Data. Journal of Applied Remote Sensing, Vol. 4, 043508 (6 February 2010) https://www.researchgate.net/publication/249516837_Assessing_the_long-term_urban_heat_island_in_San_Antonio_Texas_based_on_moderate_resolution_imaging_spectroradiometerAqua_Data
Land Use & Transportation	Housing & Transportation Index	2010	49%	35%	City of San Antonio	Housing and Transportation Index. http://htaindex.cnt.org/fact-sheets/?lat=29.4241219&lng=-98.49362819999999&focus=place&gid=8457#fs
	Vehicle Miles Traveled per Capita	2013	22.4	16.5	City of San Antonio	SA2020/FHWA
	Walk Score	2015	34	61.6	City of San Antonio	https://www.walkscore.com/TX/San_Antonio
	Bicycle Friendly Community Score	2015	Bronze	Platinum	City of San Antonio	http://www.bikeleague.org/sites/default/files/BFC_Master_Fall2015.pdf

Focus Area	Indicator	Baseline Year	Baseline	2040 Target	Geographic Area	Source
Natural Resourcea	% of Bexar County's Total Assessed Stream Miles (Assessment Units) that meet TCEQ Primary Contact Recreation Standards for activities such as wading, swimming, kayaking and canoeing.	2014	83.5%	100%	Bexar County	2014 Texas Integrated Report.- https://www.tceq.texas.gov/waterquality/assessment/14twqi/14txir; SARA 2012 position paper - https://www.sara-tx.org/wp-content/uploads/2015/07/SARA-Position-Statement-PRC-F.pdf
	Water use per person per day (gallons per day)	2014	121 gpd	110 gpd	City of San Antonio	SAWS
	Concentration of Criterial Air Pollutants	2015	PM 2.5: 8.9 ug/m3 (Weighted Annual Mean) PM 10: 22 ug/m3 (Annual Mean) Ozone: 78 parts per billion	Attainment of Federal Standards	Bexar County	EPA: https://www3.epa.gov/airdata/ad_rep_con.html; TCEQ: https://www.tceq.texas.gov/airquality/sip/eighthour.html
	Tree Canopy Cover (not including parks)	2014	30%	40%	City of San Antonio	National Agriculture Imagery Program (NAIP) 2014, 1m NIR; Zhang, Y. (2001). Texture-integrated classification of urban treed areas in high-resolution color-infrared imagery. Photogrammetric Engineering and Remote Sensing, 67(12), 1359-1366.
Public Health	% of San Antonians with health insurance	2010	78%	100%	Bexar County	http://www.countyhealthrankings.org/app/texas/2016/rankings/bexar/county/outcomes/overall/snapshot
	Child Obesity Rates	2015	27.7%	15.1%	Bexar County	https://issuu.com/wittemuseum/docs/hebba_year_1_report_final_082115__1
	Park Score	2015	42.5 out of 100	70	City of San Antonio	http://parkscore.tpl.org/city.php?city=San%20Antonio
	Number of Heat Injury Cases	2013	473	355	City of San Antonio	(STRAC) Rescuenet; SAMHD
Solid Waste Resources	Residential Waste Diversion Rate (Combined Recycling & Composting Rates)	2015	30%	45% (2020) #	City of San Antonio	City of San Antonio SWMD
	Residential Solid Waste Generation per Household Annually	2015	2,177 lbs./year/household	1,685 lbs./year/household (2020) #	City of San Antonio	City of San Antonio SWMD
Climate	Greenhouse Gas Emissions (metric tons of carbon dioxide equivalent)	2014	14,498,864 mtCO2e	TBD	City of San Antonio	City of San Antonio 2014 Greenhouse Gas Emissions Inventory

* This target will be confirmed or adjusted during CPS Energy's upcoming Beyond 2020 strategic planning process.
# This target will be identified during the COSA Solid Waste Management Department's Recycling & Resource Recovery Plan Update.

ACKNOWLEDGMENTS

Thank you to the many people who provided content, input and feedback to develop the City of San Antonio's SA Tomorrow Sustainability Plan, and who continue to work together to increase the sustainability and resiliency of our community.

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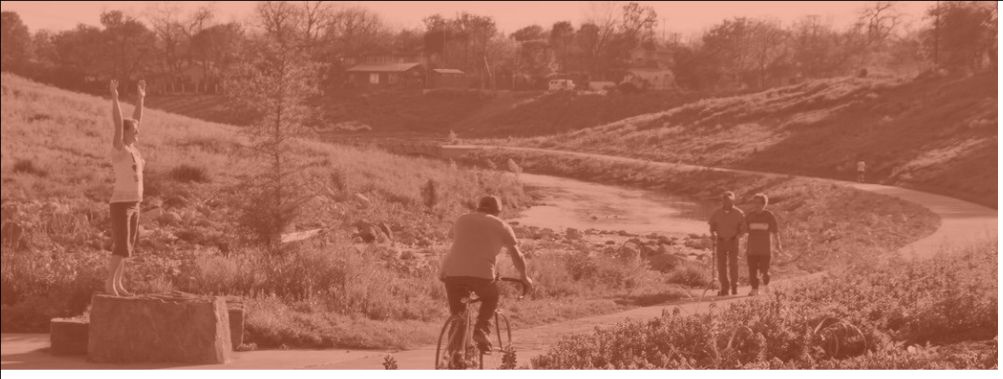
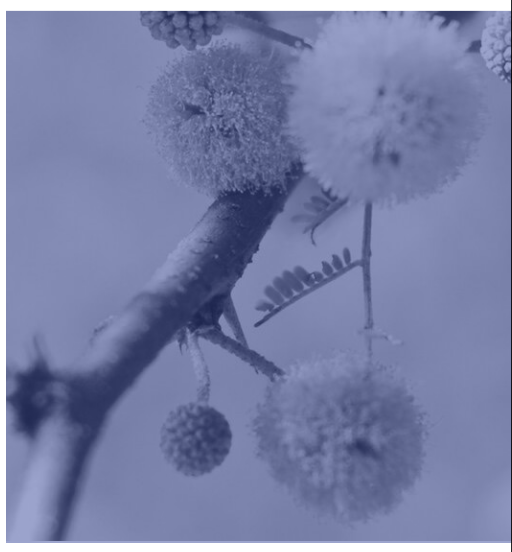


Appendix A

City of San Antonio

2014 Greenhouse Gas Emissions Inventory, March 2016



San Antonio launched its SA Tomorrow planning effort to guide the City toward smart, sustainable growth as it prepares for a million more people by 2040.

A sustainable San Antonio has a thriving economy, a healthy environment, and an inclusive and fair community.

The SA Tomorrow Sustainability Plan is a roadmap for enhancing the community's quality of life and overall resilience while balancing the impact of our expected growth with existing economic, environmental, and social resources.

Our Objective

One of the Sustainability Plan's primary goals is to provide an initial framework to allow the City to set a greenhouse gas (GHG) emission reduction target from all sources by 2050. To understand current greenhouse gas emissions levels, and their sectors and sources, the City has completed a GHG emissions inventory that assesses sources within government operations and throughout the community. This GHG emissions inventory measures and reports 2014 GHG emissions by the sector (Buildings, Transportation) and source (electricity, gasoline) they represent in government operations or the community. The City utilized the Local Government Operations Protocol (LGOP) to quantify GHG emissions from municipal operations, and the U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions (UCSP) for all community sectors except Solid Waste, where the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) was utilized.

Why Greenhouse Gas Emissions Matter

Greenhouse gases are essential to life on Earth and having the natural amount helps regulate the Earth's temperature. Human activities, like how we get around and the buildings we live and work in, have increased the level of greenhouse gases (GHGs) in our atmosphere and have led to disruptions in the Earth's climate. While scientists focus on six GHGs that result from various human activities, the most significant GHG is carbon dioxide (CO_2). Humans produce more CO_2 than any other GHG and when counting emissions of all GHGs, scientists use what is called the CO_2 equivalent (CO_2e). Each GHG has its own degree to which it contributes to the warming of our atmosphere and in order to compare apples to apples, we must convert the emissions of each GHG based on how they compare to CO_2. For example methane, which is another GHG that is produced as trash breaks down in landfills, has 22 times more warming power than CO_2. Therefore when looking at the emissions of methane, 1 ton of methane would be reported as 22 tons of CO_2e.

The increase in GHGs in the atmosphere leads to an increase in the number and the intensity of extreme weather events, the degradation of our air quality, and limits the amount of available drinking water in Texas. Extreme weather events, like torrential rains contribute to flooding and destroy homes and infrastructure. An increase in temperatures results in an increase in "bad" ozone which is the primary ingredient in smog, which contributes to poor air quality and impacts the health of San Antonians, specifically the young and those with existing asthma or other respiratory issues. Finally, one of the projected impacts of a changing climate for Texas is an extended drought, which could negatively impact our drinking water supply. Therefore, it is essential that a city like San Antonio takes action to both understand and reduce its contribution to increasing GHG emissions into the air.

San Antonio Government Operations GHG Emissions

The delivery of government services to San Antonio residents, workers, and visitors resulted in the emission of approximately 583,000 metric tons of CO2e in 2014, which is equivalent to the emissions offset by 14,957,077 new seedling trees growing for 10 years. **Table 1** provides a breakdown of the GHG emissions by sector for San Antonio's government operations.

Table 1

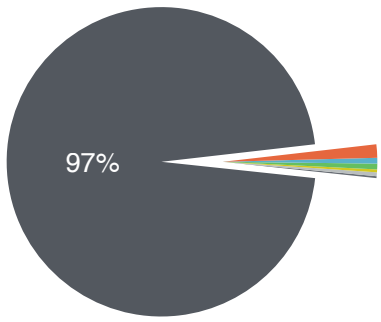
Sectors	Total GHG Emissions (metric tons of carbon dioxide equivalent)
Closed Landfills	231,103
Building and Facilities	102,158
Water Supply	98,441
Wastewater Treatment	61,388
Vehicle Fleet	55,574
Streetlights and Traffic Signals	34,662
Electricity Generation (provided as an information point only, not included in total)	16,351,643.86
Total	**583,326**

San Antonio Government Operations GHG Emissions

The Government Operations GHG Emissions Inventory assesses the emissions associated with all of the buildings and equipment the City owns as well as the various treatment and operational processes, with one exception. The City of San Antonio owns and operates a municipal utility that generates and distributes electricity to San Antonio and to surrounding communities.

The GHG emissions that result from electricity generation are nearly as much as the entire San Antonio community profile, with more than 16 million metric tons of CO2 emitted in 2014. Including these GHG emissions in the government operations inventory total would completely overshadow all other sources and would not provide a useful assessment of GHG emissions from government operations, as seen in **Figure A.**

Figure A



Therefore, GHG emissions from electricity generation are reported as an information item only and not included in the government operation total provided in this Inventory.

Due to the fact that methane is a more potent GHG than carbon dioxide, the emissions from the closed landfill represent the largest individual sector at 40%. Energy used to cool and power buildings, pump and treat water and wastewater, and power streetlights and traffic signals together comprise 50% of all sector emissions. The last 10% is captured by the municipal vehicle fleet.

Similarly, electricity and methane comprise the vast majority of source emissions at a combined 85% with gasoline and diesel representing another 9%.

Details of the GHG emissions for San Antonio's government operations by sector and source are shown in **Figures B and C.**

Figure B

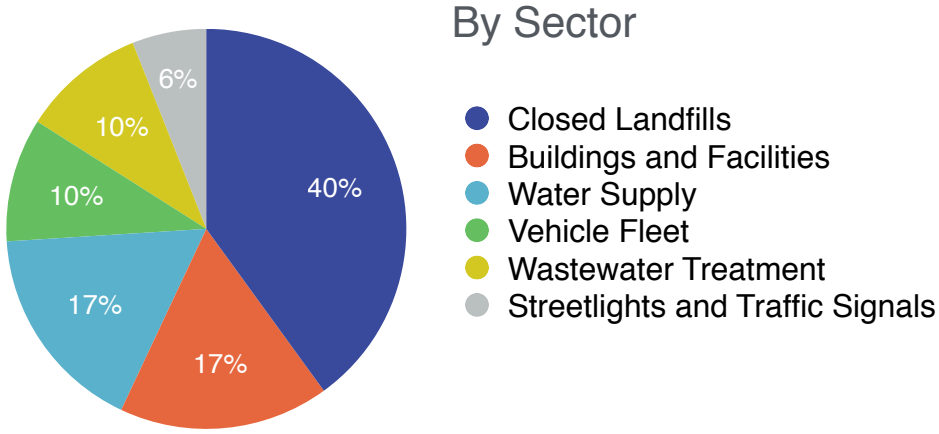
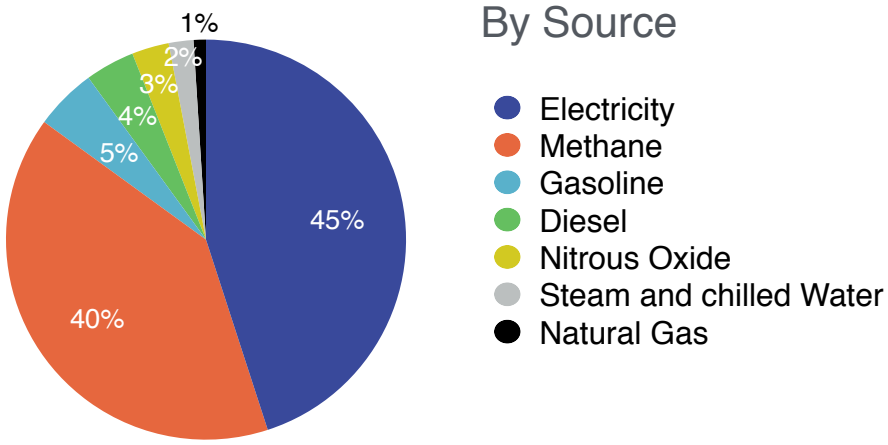


Figure C



San Antonio Community GHG Emissions

Activities by residents, visitors, and workers in San Antonio resulted in the emission of more than 16,498,864 metric tons of CO_2e in 2014, which is equivalent to the emissions offset by 423,047,795 new seedling trees growing for 10 years. A breakdown of these emissions by sector is shown in **Table 2.**

Table 2

Sectors	Total GHG Emissions (metric tons of carbon dioxide equivalent)
Buildings	9,801,806
Transportation	5,882,395
Solid Waste Management	584,834
Water Supply and Wastewater Treatment	159,829
Total	**16,498,864**

San Antonio Community GHG Emissions

Emissions are reported by both the sector (Buildings, Transportation) and source (electricity, gasoline) they represent. Slightly more than half of community emissions are a result of energy used to cool, light, and power the homes, offices, and industrial facilities throughout San Antonio. The second highest sector, at more than a third of all community emissions is transportation, which includes fuel used to power cars, trucks, and buses.

When looking at the sources of emissions, the fuel used to generate electricity within the city accounted for half of all GHG emissions. Gasoline was responsible for almost a third of all GHG emissions. Diesel fuel for transportation, natural gas for building space heating and hot water, and methane from solid waste disposal and wastewater treatment each accounted for less than 10% of GHG emissions, respectively.

Details of the GHG emissions for the San Antonio community by sector and source are shown in **Figures D and E.**

Figure D

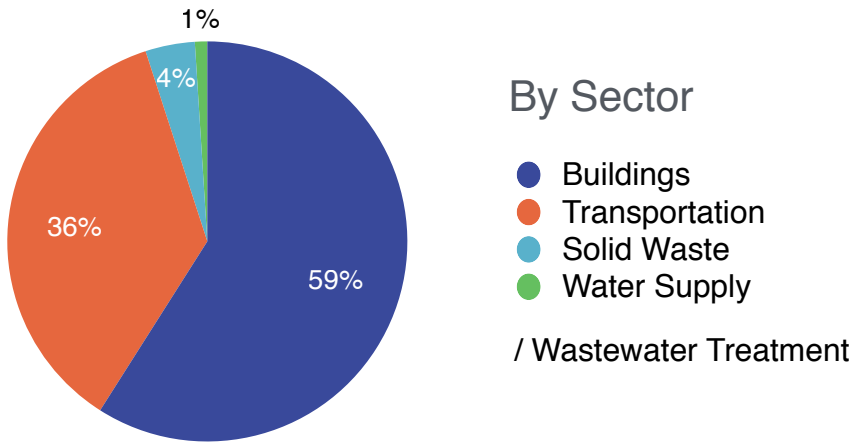
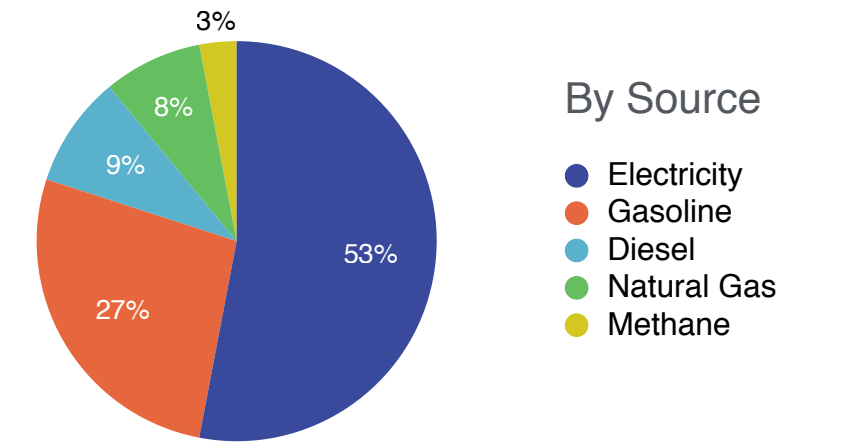


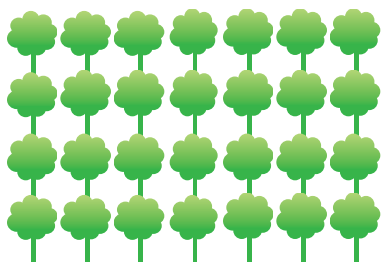
Figure E



Government Operations

Emissions offset by 14,957,077 new seedling trees growing for 10 years = 583,326 metric tons of CO2e

Community



Emissions offset by 423,047,795 new seedling trees growing for 10 years = 16,498,864 metric tons of CO2e

What is emission offset?

A carbon offsets let you help build projects in communities across the country that reduce greenhouse gas (GHG) emissions beyond what you can achieve through individual action. Carbon offsets are purchased to fund these projects and diminish the impact of your own GHG emissions, even though the projects are located elsewhere."

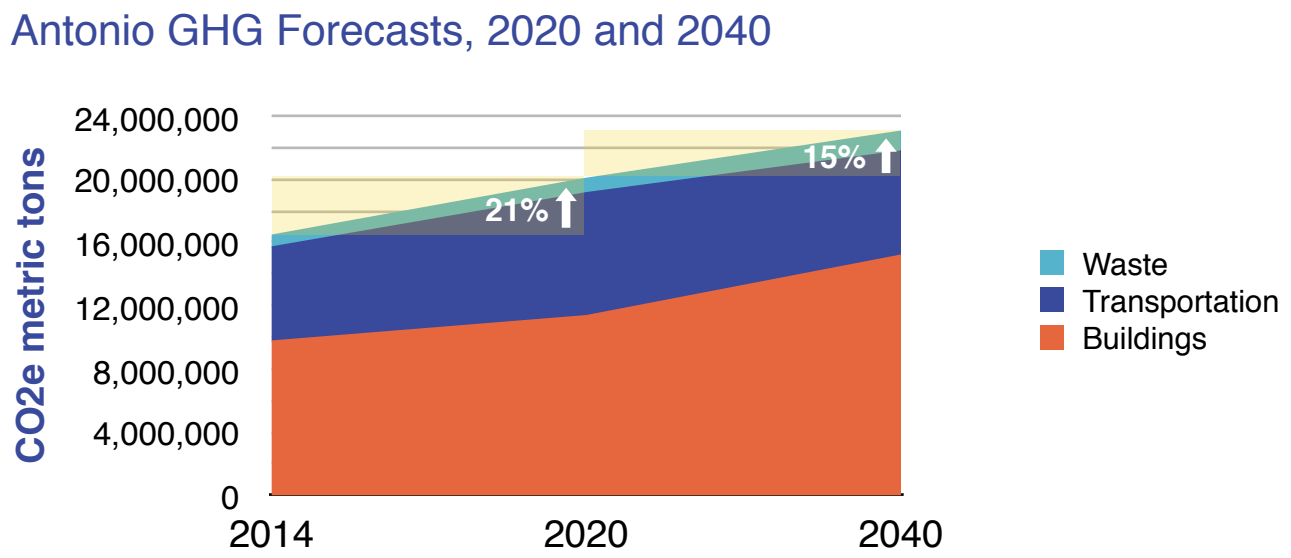
San Antonio GHG Forecast

As part of the development of the GHG Emissions Inventory, a forecast of emissions was prepared. For San Antonio, a forecast of emissions under a Business As Usual (BAU) scenario was developed for both the long-term target year of 2040 and an interim year, 2020, to inform the identification of an emissions reduction target. The City of San Antonio has identified a 50% reduction target for 2040. The BAU scenario used the following assumptions:

- Population increases by 1,000,000 by 2040
- Energy use per person remains constant
- Waste generation per person remains constant
- Vehicle fuel efficiency improves per compliance with federal requirements
- Ten percent more renewable energy is added to the electricity supply per compliance with the federal Clean Power Plan mandates

The results of this BAU scenario show GHG emissions rising approximately 21% in 2020 and then rising approximately another 15% in 2040. The BAU scenario suggests that in 2040 the Buildings sector will continue to be the largest contributor to GHG emissions, but Transportation's contribution to total emissions will increase the by more than 7%, the most of any sector analyzed. **Figure F** below shows the forecasts and the breakdown of how each sector is expected to contribute to this growth.

Figure F



Conclusion

Based on the GHG data, to reach a 50% reduction of 2014 emission levels by 2040, San Antonio will need to focus heavily on reducing overall electricity and gasoline consumption, which make up 80% of the community GHG emissions. Reducing demand for electricity by installing energy efficient lighting and appliances in buildings and switching to more renewable energy supplies, such as wind and solar, will help ensure emissions per person stay at or below the current level of 12 tons CO2e per person.

Additionally, to reduce the amount of gasoline that is burned by cars, there needs to be a targeted effort to create more opportunities for San Antonians to walk, ride bikes, and take public transit to their destinations. The SA Tomorrow Sustainability Plan has identified a number of strategies that can help reduce emissions from electricity and gasoline consumption, among other areas.

Appendix B

City of San Antonio Sustainability Plan: Climate Vulnerability Assessment

February 2016

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1.0 Executive Summary

Building climate resilience and becoming sustainable is a process and not an outcome. It takes time to diversify and grow the economy of the region so that everyone in the community has access to the jobs and resources they need to live healthy and productive lives. It takes time to transform the energy and transportation systems to enable them to meet the needs of residents and businesses while maintaining flexibility in the face of extreme weather events. It takes time to protect the natural, historic, and cultural resources that make the City of San Antonio a unique and attractive place to live. The City of San Antonio started this journey with a commitment to building a sustainable city while continuing to grow and increase prosperity for its current and future residents. This climate vulnerability assessment is part of the *SA Tomorrow* planning process and an important part of this journey.

For many decades, individual departments such as public works, emergency management, CPS Energy, and others, have been working to serve the City of San Antonio's residents. Working closely with other organizations such as the San Antonio Water System (SAWS), the San Antonio River Authority (SARA), and Bexar County (health department, flood control district, etc.), the City ensures that the region and its residents have the resources they need to thrive and stay safe during extreme weather events. Efforts by the City and these organizations have included:

- *SA 2020,* which helps set the vision for a growing region;
- SAWS' *Water Management Plan* that helps guide the conservation and water supply diversification efforts and ensure water availability for the region;
- *Bexar County Community Health Improvement Plan* that sets a vision for the health of the community; and
- The *Hazard Mitigation Plan* that evaluates the potential risk of different hazards and identifies actions to reduce those risks.

The *SA Tomorrow Plan* is the latest step on the path towards sustainability and resilience. It is an ambitious effort that builds on all of these previous efforts and works to unify them under a shared vision, set of goals, and actions for a sustainable community. This climate vulnerability assessment is one piece of this *SA Tomorrow* planning effort.

The goal of this climate preparedness process is to shift the focus from the past and consider how extreme weather events and changing climate conditions could affect the city in the future. The recently completed *Hazard Mitigation Plan* (2015) identifies both natural and human events that could affect the city, but the assessment is based solely on historical events. As climate conditions change, those historical events are not necessarily adequate predictors of the future. Said another way, planning for these past events may not go far enough to prepare the city for new and emerging threats. Changing climate conditions are relevant to city planning in that they will affect the way the city plans for changes in temperatures (planning for

cooling/heating, ensuring public safety, and protecting public health); changes in precipitation (preparing for droughts, planning for municipal water use or designing infrastructure to reduce the impacts of flooding); and increases in other extreme weather events (enhancing emergency management and preparedness).

One example of these potential vulnerabilities can be seen by comparing the relative social vulnerability index (SVI) with an overview of the observed urban heat island effect. The SVI is calculated by census tract and combines 14 variables including persons aged 65 and older, persons aged 17 and younger, single parent households with children under 18, minority status, and persons living in group quarters, to identify areas that are more sensitive and likely less able to prepare for or respond to extreme weather events. The urban heat island map indicates the urban areas that are often much hotter, and stay hotter throughout the night, than rural areas.

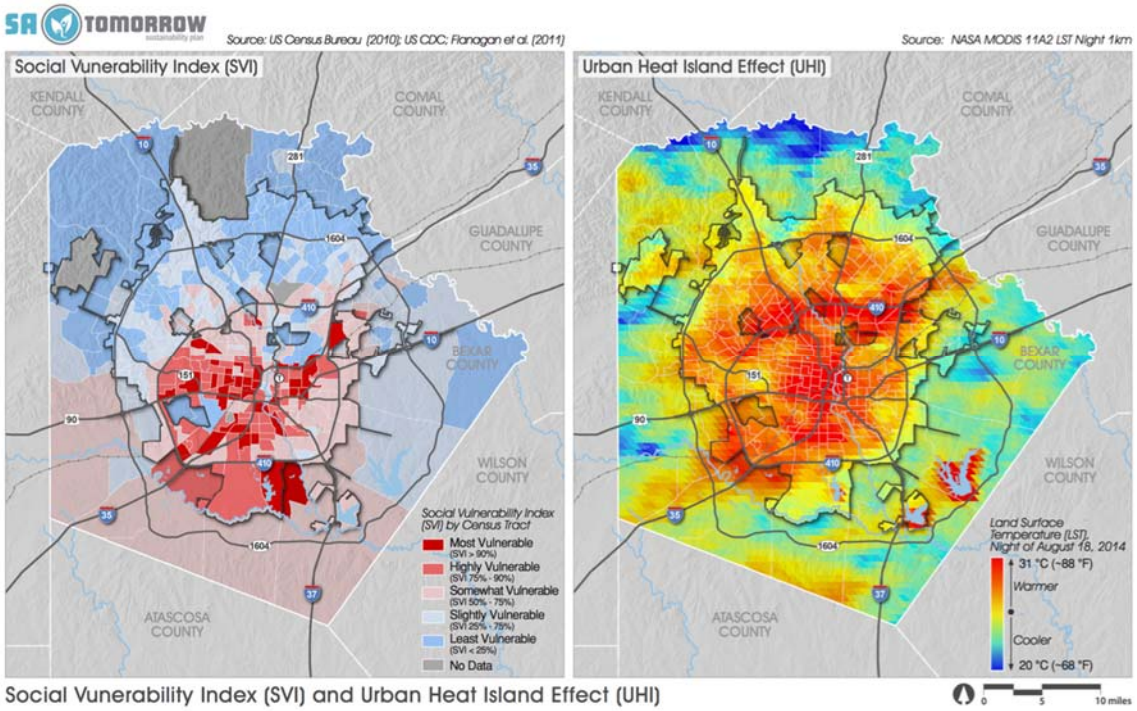


Figure 1: Side by side comparison of the relative social vulnerability index rankings and the urban heat island effect for Bexar County. Comparison can be used to identify areas of enhanced vulnerability to extreme heat events based on increased exposure and higher sensitivity (or lower ability to respond) to those events.

This report describes a process that brought together the best available science with a multi-departmental, multi-organizational team of experts from across the city to identify key concerns and evaluate the potential vulnerability of assets, resources, and segments of the community. A focus of this assessment was on changing climate conditions and extreme weather events. By combining the best available science with the knowledge and expertise of the people who work on these issues, it is possible to gain some insight into how the community could be affected by future events.

Results of this work include: relative climate and weather related vulnerability rankings for Key Areas of Concern *(Section 4.3)*, detailed descriptions of those

rankings *(Section 5)*; and a list of strategies that could be used to address these vulnerabilities *(Section 6)*. The table below provides examples of key resilience strategies being reviewed as part of the broader *SA Tomorrow* planning process.

Table 1: Example strategies from the SA Tomorrow Sustainability Plan that could be used to build climate resilience. Listed along with the weather or climate impact they are designed to address and focus area from the SA Tomorrow Sustainability Plan. Additional strategies are provided in Section 6.

Impact Addressed	Key strategies from the SA Tomorrow Plan	Focus Area
Flooding	Adopt a low impact development standard requiring 100% of onsite stormwater management for all new development and significant retrofits.	Green Buildings & Infrastructure
	Initiate a climate education campaign for businesses and property owners, including details about how to make built infrastructure more resilient to existing and projected changes in climate.	Green Buildings & Infrastructure
	Evaluate and adopt ordinances to create buffer zones around floodplains, riparian areas, and other natural priority areas	Natural Resources
	Adopt conservation development friendly ordinances that minimize development in natural greenways, floodplains, near waterways in order to protect watershed and allow for more greenspace	Natural Resources
	Establish a network of "block captains" that can be activated to go door to door to check on the health of high risk neighbors during or after a disaster.	Public Health
Extreme Heat	Review effectiveness of cooling centers and other high heat day strategies and identify underserved areas for increased expansion of existing strategies or new strategies to mitigate the effects of high heat days.	Public Health
	Expand the number of publicly accessible parks and open space areas within the city.	Public Health
	Develop a “Healthy by Design” program for all new affordable housing projects.	Public Health
	Adopt an urban heat island mitigation ordinance for all new developments and major renovation projects.	Green Buildings & Infrastructure
Drought	Update water efficiency standards in city building codes.	Green Buildings & Infrastructure
	Adopt a program to phase large commercial buildings off of potable water use for landscaping.	Natural Resources
	Expand incentives for native plants/low-water use landscaping and other residential water conservation strategies	Natural Resources

Planning for the future is a critical aspect of any sustainability planning effort. It is not enough to look at current conditions. We must look to the future in order to continue to build a safe, healthy, prosperous, and resilient community for all the residents of San Antonio.

2.0 Introduction

The City of San Antonio has been engaging in a process to coordinate the development of their Comprehensive, Strategic Multimodal Transportation, and Sustainability Plans. Known as "SA Tomorrow," the process builds upon previous planning efforts, such as the SA 2020 Plan, to outline key goals for the next 25 years, as the expected population of the county will nearly double, adding an additional 1.1 million people[1]. This expected population growth creates many challenges and opportunities for San Antonio, and the collective planning for these expected changes demonstrates the city's commitment to, "*preserve the San Antonio culture and increase livability through ensuring housing and transportation choices as our city grows*[1]."

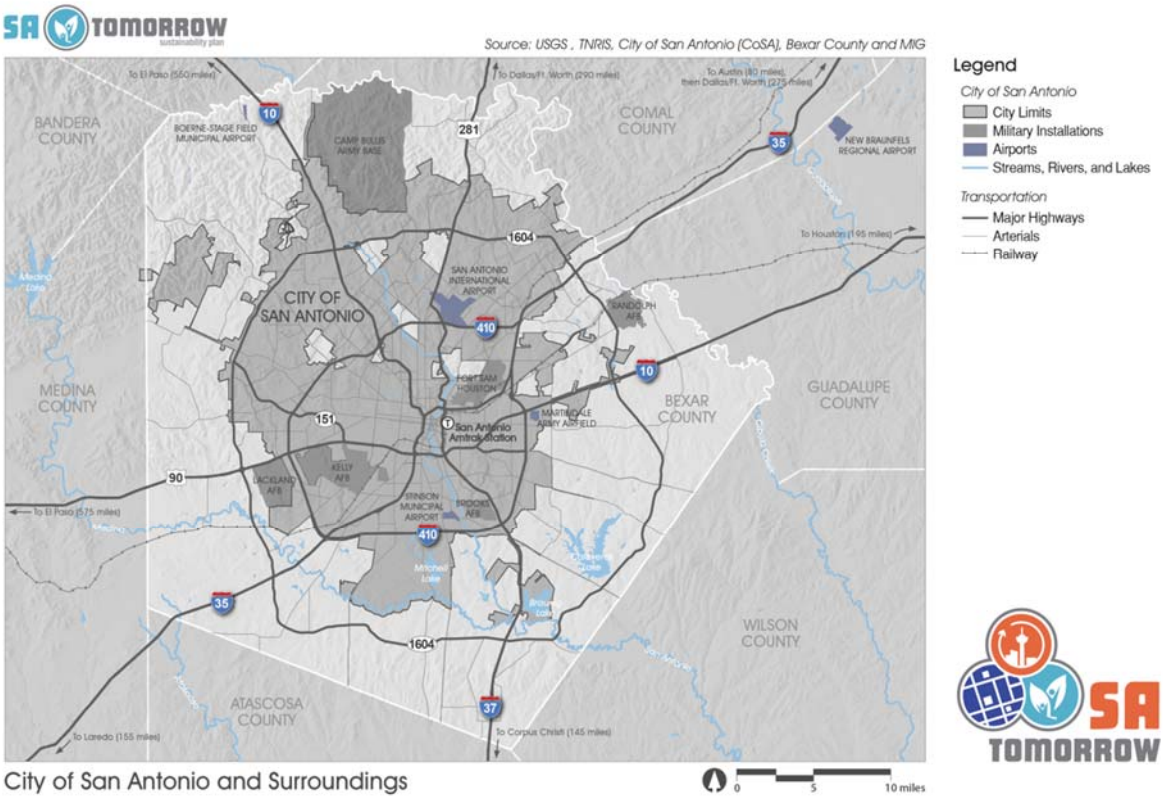


Figure 2: Map of the City of San Antonio, major waterways, and surrounding areas.

The City of San Antonio wants to ensure that all goals outlined under the three plans consider sustainability as it prepares for both current and future conditions. As part of the sustainability planning process, Adaptation International and Kim Lundgren Associates, Inc. (KLA) led a climate change vulnerability assessment to support the City's commitment to building resilience to changing climate conditions and expected increases in extreme weather events.

To support this effort, the City convened a *Resilience Advisory Committee (RAC)*, a diverse committee of city, county, state, private sector, and non-profit agency representatives, to work together and conduct the vulnerability assessment. This report summarizes these efforts to determine where the city is most vulnerable to

current and future extreme weather events and begin discussing strategies for how the city might reduce these vulnerabilities and build resilience. The report also highlights some promising practices being used across the country that the city could use, adapt, or build on to be better prepared in the future.

3.0 Climate and the City of San Antonio

The climate is changing around the globe and these changes affect how cities manage themselves and prepare for the future. As part of the Sustainability Plan, ATMOS Research completed an analysis of the past and projected future climate for San Antonio[2]. Climate is relevant to city planning in that it impacts the way in which cities plan for **changes in temperatures** (planning for cooling/heating, ensuring public safety, and protecting public health); **changes in precipitation** (preparing for droughts, planning for municipal water use or designing infrastructure to limit the impacts of flooding); and **increases in other extreme weather events** (enhancing emergency management and preparedness). The analysis by ATMOS Research shows the following *observed* and *projected* climate changes for San Antonio (Table 2).

Table 2: Observed climate trends and projections for San Antonio and the South Central Region[2].

Climate Changes	Observed Changes	Future Projections
Temperature Averages	Warmed +0.5°F (summer) to +0.7°F (winter) per decade from 1960-2014 (**Figure 3**).	*"The number of hot days and warm nights occurring on average each year will continue to increase, with greater increases under a higher as compared to a lower future emissions scenario." (page 17)*
Temperature Extremes	Increases in the number of days over 80°F, 90°F, and 100°F from 1960-2014 (**Figure 4**).	Increases in frequency of the historically hottest days and warmest nights by the end of the century (**Figure 5**).
Precipitation Averages	Increases in the average number of dry days per year, average rainfall intensity (the average amount of rain falling on any given wet day during the year), and the amount of rainfall in the wettest 5 days of the year.	*"Average winter and spring precipitation will decrease towards the end of the century, accompanied by increased risk of dry conditions in spring and longer periods of consecutive dry days." (page 17) (**Figure 6**)*
Precipitation Extremes	Increased variability in precipitation starting in the 1980s.	*"The frequency of heavy precipitation and/or average precipitation intensity may increase across some parts of Texas, although projected increases are likely to be small." (page 17)*

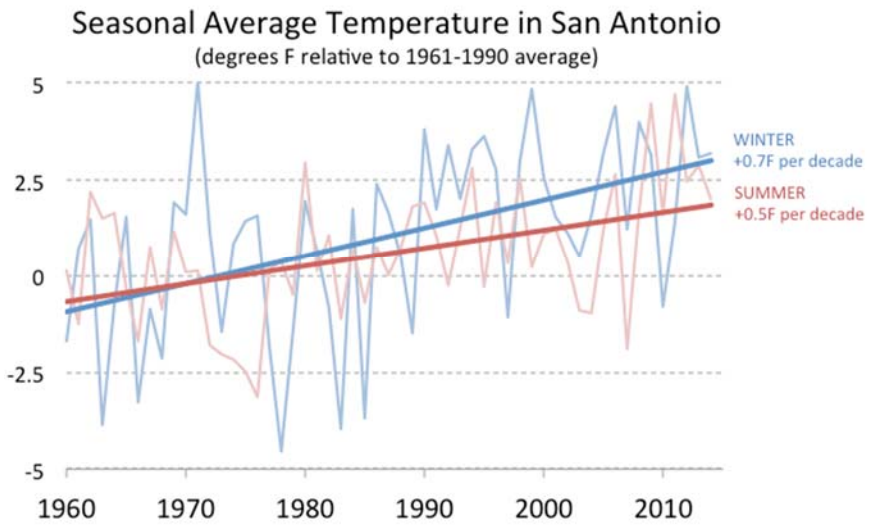


Figure 3: Observed year-to-year values (thin lines) and long-term trends (thick lines) in winter and summer average temperature by season at the San Antonio International Airport weather station from 1960 to 2014. The y-axis shows degrees in Fahrenheit where numbers above zero are warming/positive trends while negative numbers below zero are cooling/negative trends. The x-axis shows time from 1961-2014. All trends are significant[2].

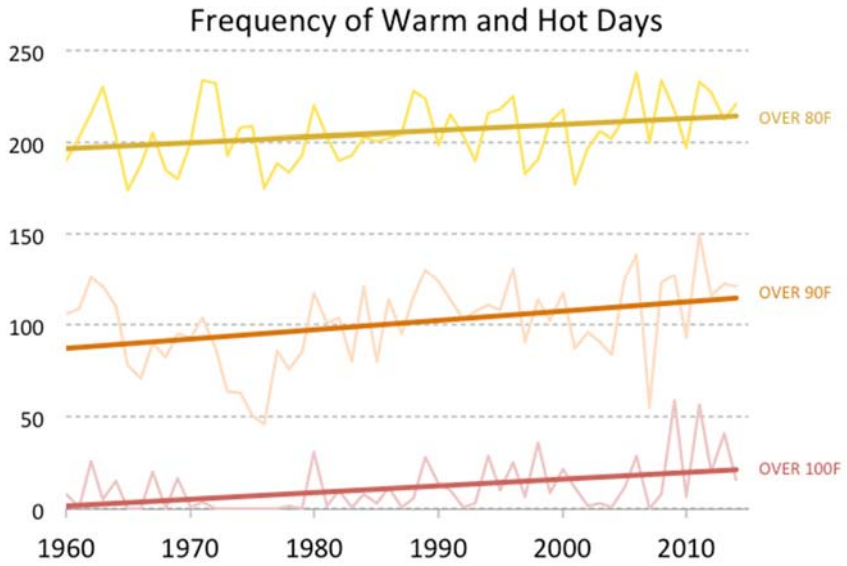


Figure 4: Observed year-to-year values (thin lines) and long-term trends (thick lines) in the number of days per year with maximum temperatures exceeding 80°F, 90°F, and 100°F at the San Antonio International Airport weather station from 1960-2014. The y-axis shows the number of days a year while the x-axis shows time from 1960-2014. All trends are significant[2].

Hot Days **Warm Nights**

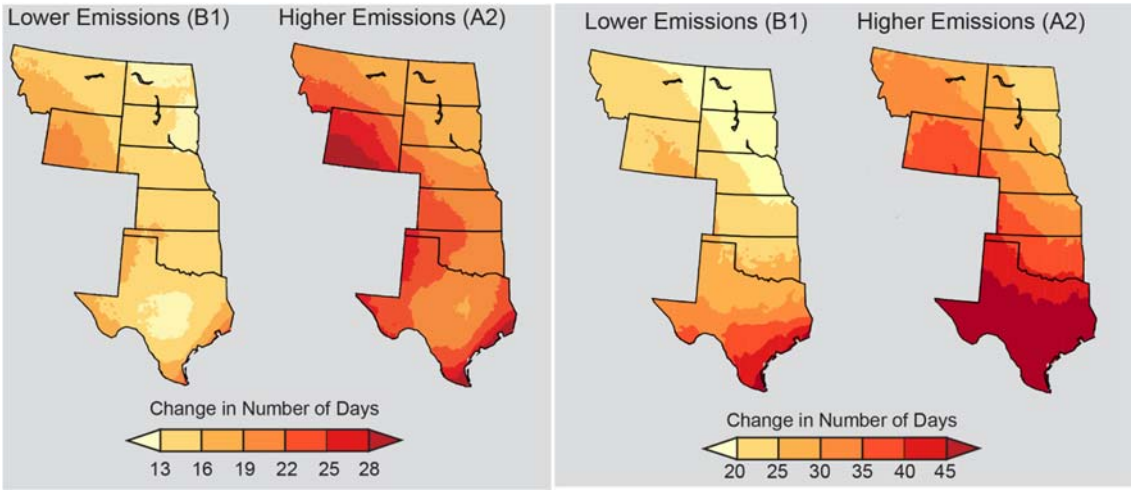


Figure 5: Projected future changes in the frequency of the seven hottest historical days (left) and the seven warmest historical nights (right) of the year for the period 2070-2099 relative to 1971-2000. The lighter yellow and orange colors correspond to smaller annual increases while the darker red colors are larger increases. Each panel of this figure compares projections of what would be expected under a lower greenhouse gas emissions scenario and a higher emissions scenario[3].

Wet Days **Dry Days**

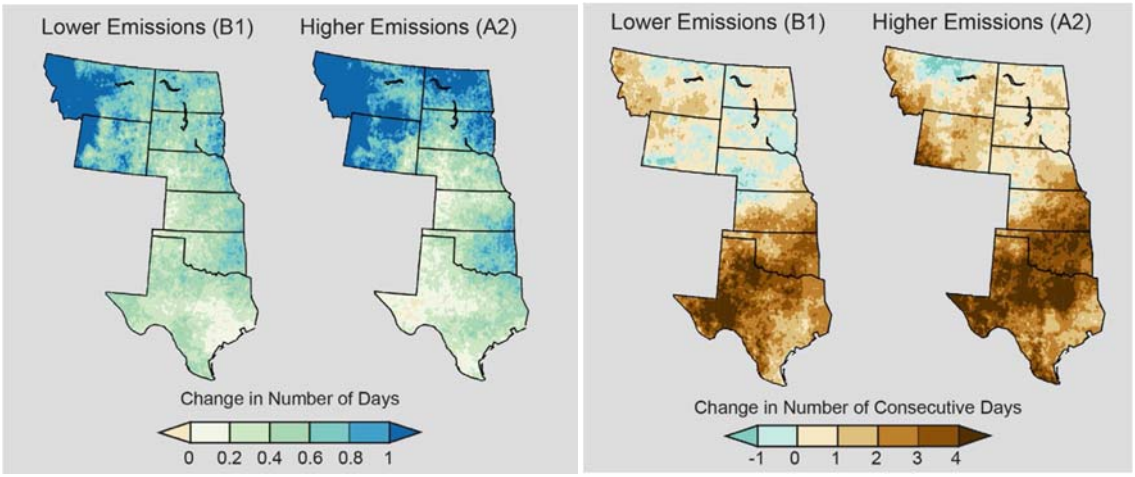


Figure 6: Projected future changes in the frequency of the seven historically wettest days per year (left) and the total number of dry days per year (right) for the period 2070-2099 relative to 1971-2000. For the wet days, the darker blue color represents a greater change in the number of wet days. For the dry days the darker brown represents a greater change in the number of consecutive dry days. Each panel of this figure compares projections of what would be expected under a lower greenhouse gas emissions scenario and a higher emissions scenario[3].

4.0 Collaborative Project Process with the Resilience Advisory Committee

The City of San Antonio formed a Resilience Advisory Committee (RAC) to gain insights into how changing climate conditions and extreme weather events would affect various key facets of the City's operations and assets, as well as the community at-large. For a full list of the Resilience Advisory Committee Members see Appendix 2. The committee participated in a four-step process. First, they participated in an introductory web-based meeting describing the sustainability planning and vulnerability assessment process. Second, committee members received an online survey through the SA Tomorrow "MindMixer" dashboard as a way to solicit initial thoughts about key areas of concern for San Antonio. Third, the project team conducted individual phone calls to RAC members to generate and expand the list of of concerns as well as to engage in discussions about potential extreme weather-related thresholds. These discussions provided valuable information about the specific temperature and precipitation-related thresholds to be considered in the assessment, as well as any future climate work. An "extreme weather event" is:

> *"[An] event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile.* ***By definition, the characteristics of what is called extreme weather may vary from place to place*** *[emphasis added][4]."*

Because of the regional differences for extreme weather events, integrating local knowledge about climate and weather related impacts and thresholds provided the opportunity to hone in on the weather-related events that are most important to San Antonio. Finally, the RAC participated in a one-day workshop on June 25, 2015 to collaboratively conduct the vulnerability assessment.

4.1 Online survey to develop initial list of Key Areas of Concern

The consultant team surveyed local subject matter experts from a variety of sectors (e.g. planning, public health, emergency management, and sustainability) regarding how weather affects their work. A majority of those interviewed felt that extreme weather is a concern. Comments from respondents included:

> *"Extreme weather conditions can have adverse affects on the transportation system—recent heavy rains caused significant damage to the roadways."*

> *"Drought will deplete water supplies and create problems with potable water distribution systems."*

When asked what the chief climate-related concerns were for the city, responses aligned well with issues already being addressed through some of the City of San Antonio planning documents (Figure 7).

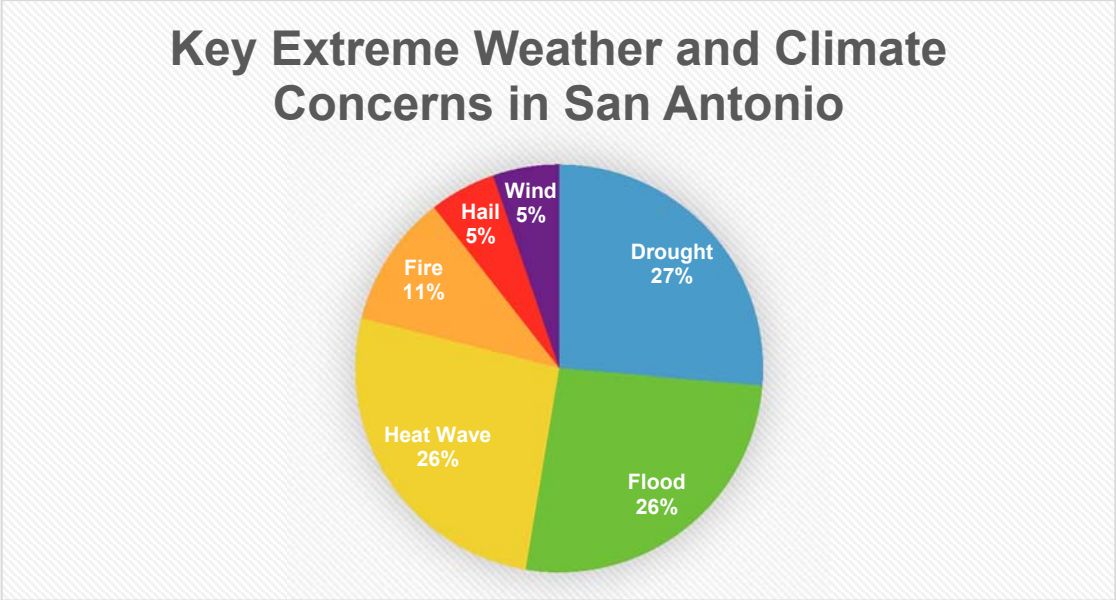


Figure 7: Respondents' chief climate-related concerns for San Antonio from the survey conducted June 8, 2015. Size of the pie wedge shows the percentage of respondents concerned about each extreme weather event listed. Droughts, floods, and heat waves were the top three concerns for the respondents.

Many respondents stated that their departments or organizations are already taking action to address extreme weather and climate-related impacts. For example, SAWS already has a water management plan and Bexar County already has an extreme heat response plan. Respondents also identified various obstacles to fully addressing climate change. These obstacles included: *1)* limited time and budget*; 2)* competing priorities; and *3)* lack of information about what to do or how to move forward. This vulnerability assessment process can be used to address both items 2 and 3 above. It can help prioritize the issues of concern and increase the sharing of information between departments and organizations so that they can better coordinate their efforts to prepare for, respond to, and recover from extreme weather events. Developing a shared understanding and list of concerns won't necessarily solve the budget related issues, but it could be used to prioritize spending on the most critical issues that face the City and the region.

Further, in a survey of City Leadership conducted as part of the larger sustainability planning process, the majority (60%) of respondents agreed that the City should consider climate change and resilience in the development of city polices (Figure 8).

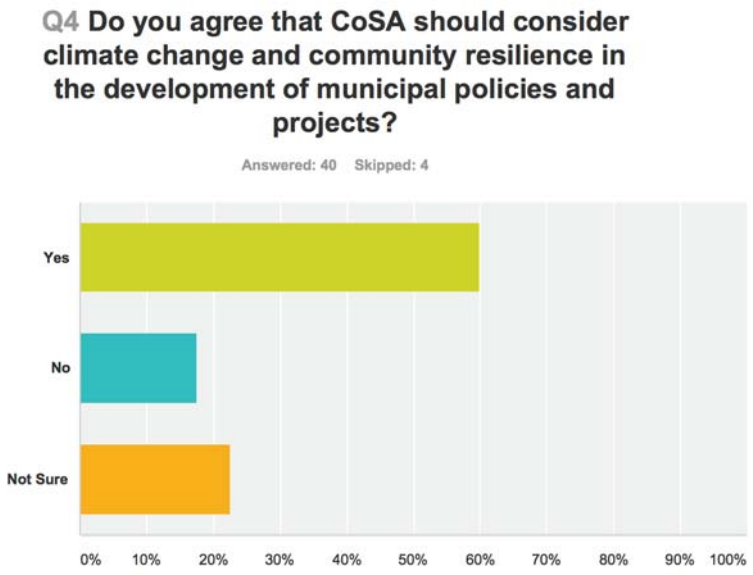


Figure 8: SA Tomorrow Sustainability Plan Leadership agreement on considering climate change and including resilience in the development of municipal policies and projects.

4.2 Collaborative Workshop

On June 25, 2015, at the San Antonio Food Bank, the Resilience Advisory Committee members came together to conduct the vulnerability assessment. The goals for the day were to 1) refine a list of Key Areas of Concern; and 2) conduct a climate vulnerability assessment for these items.

The group began by discussing how climate and extreme weather events impact their work and their concerns about how San Antonio is affected by these events both currently and in the future. The project team gave a presentation of the results of the Climate Analysis conducted by Dr. Katharine Hayhoe specific to San Antonio (results summarized in *Section 3.0: Climate and the City of San Antonio*). Following the climate data presentation, the project team provided a detailed review of existing conditions relevant to Key Areas of Concern generated from the survey results.

The committee generated a refined list of Key Areas of Concern (Table 3) grouped under three categories: increasing temperatures, water (flooding and drought), and other extreme weather events. These are the final areas of concern, which were evaluated for the vulnerability assessment. These categories parallel the top four hazards identified in the *2015 Hazard Mitigation Plan*.

Table 3: Key Areas of Concern Generated by the Resilience Advisory Committee

Temperature	Water	Extreme Weather Events
Poor Air Quality • Impacts to public health due to increases in air pollutants • Potential for non-attainment due to increases in ground level ozone with higher temperatures	**Structures in the 100-year floodplain** • Residences • Multi-family/commercial • Critical/public infrastructure and assets	**Wildfires** – urban/wild land interface including impacts to public health and infrastructure
Extreme heat events and their impacts on the health of vulnerable populations *(elderly, children, poor, chronically ill, homeless & homebound, outdoor workers, pregnant)*	**Critical transportation infrastructure** *(flooding)*	
Extreme heat effects on native species and the tree canopy	**Low water crossings** - high call rescue sites *(flooding)*	
	Wastewater treatment and sewage overflow *(flooding)*	
	Vector borne disease *(drought and flooding)*	
	Geographic distribution of water supply *(drought)*	
	Meeting municipal peak water demand *(drought)*	
	Cooling water availability for power plants *(drought)*	
	Municipal Water quality *(drought)*	
	Local food security *(drought)*	

There are many other ways that extreme weather events can affect the City of San Antonio. Those other events are described in detail in the *2015 Hazard Mitigation Plan*. These other events include (statistics from HMP 2015):

- Tornadoes *(65 events recorded in Bexar County from 1950-2014 ranging from gale force winds to F4 tornadoes);*
- Extreme winds *(impacts deemed to be minor injuries and limited structural damage to mobile homes and wood buildings);* and
- Hail *(common – 208 events in San Antonio between 1955 and 2014 causing an estimated almost $170 million in damages (2014 Dollars))*[5].

While these other extreme weather events are not insignificant for the city, the role of this assessment is to identify the highest priority events affected by changing

climate conditions. It is unclear how changing climate conditions could affect tornadoes and hail events and these events were not deemed critical for consideration by the Resilience Advisory Committee.

Additionally, there are other ways that changing climate conditions and extreme weather can affect the city. For example: extreme heat events have the potential to stress the energy grid by requiring more energy for cooling homes and businesses; drought could affect surrounding crop lands and the agricultural yields of farms around San Antonio; and flooding may destroy habitat in riparian corridors. These issues could be explored in more detail in future studies. Based on the expert judgment of the Resilience Advisory Committee, these additional potential impacts did not rise to the top as key concerns for San Antonio at this time.

4.3 Vulnerability Assessment Process

The vulnerability of an asset, resource, or segment of the community depends on its exposure to climate and weather, sensitivity to that exposure, and ability to adapt (Figure 9). The Resilience Advisory Committee members engaged in a guided exercise to complete the vulnerability assessment for each area of concern during the workshop. The use of *sensitivity* (how susceptible the system or asset is to changing climate conditions) and *adaptive capacity* (ability of a system or asset to respond to changing climate conditions) is an internationally recognized means for assessing climate change related vulnerabilities[6]. To see the process of the scoring from the guided activity, go to Appendix 3.

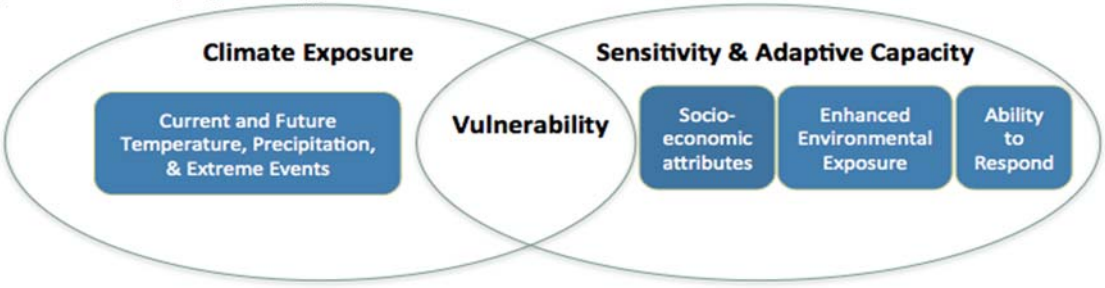


Figure 9: Climate change vulnerability of a system, asset, or resource depends on the climate exposure, sensitivity, and adaptive capacity of that system.

The relative vulnerability rankings identify areas that will need immediate attention and those that can simply be monitored for future changes. Based on the results of the vulnerability assessment, there are clearly three groups of concerns: those with high vulnerability (items in red), those with medium or medium high vulnerability (items in yellow and orange), and those with low vulnerability (items in green). Based on this qualitative assessment, the groups of items that rise to the top are the ones that will require immediate and urgent attention, while those in the last group (such as *impacts on cooling water available for power plants)* are not a pressing need for the city at this time. See Figure 10 for the results of the assessment.

Relative Vulnerability Assessment Ranking

	S0	S1	S2	S3	S4
AC0				• Vector borne diseases	
AC1				• Critical/public infrastructure and assets in the 100-year floodplain (communications, power, etc.) • Critical transportation infrastructure • Low water crossings high call rescue sites	• Extreme heat and impacts to vulnerable populations
AC2			• Single family residences in 100-year flood plain	• Non-attainment due to increased ozone • Impacts to multifamily housing in the 100-year flood plain	• Local food security
AC3			• Municipal water quality during droughts	• Extreme heat impacts on native species • Geographic distribution of the water supply	• Wildfires
AC4			• Cooling water available for power plants	• Waste water treatment and sewage overflow • Meeting municipal water peak demand	

Figure 10: The relative vulnerability ranking of each of the Key Areas of Concern based on their *sensitivity* and *adaptive capacity* rankings. Colors show vulnerability rankings for the different items: red = high vulnerability, dark orange = medium-high vulnerability, light-orange = medium vulnerability, yellow = medium-low vulnerability, and green Items = low vulnerability. Sensitivity ranking vary from S0 = will not be affected to S4 = greatly affected by the exposure. Adaptive Capacity rankings vary from AC0= no ability to adapt to the impact to AC4 = able to accommodate or adjust to the impacts in a beneficial way.

5.0 Results of the Vulnerability Assessment

5.1 High Vulnerability Areas of Concern

5.1.1 Extreme Heat Impacts to Vulnerable Populations

Extreme heat can impact the public's health, particularly for those who are most vulnerable. These impacts are not unfamiliar to the City of San Antonio, which has a long history of dealing with prolonged extreme heat. Extreme heat is identified as a key hazard in the *2015 Hazard Mitigation Plan* and the Metropolitan Health District developed a *Heat Emergency Response Plan* in 2015[7]. The public health effects of exposure to extreme heat are well understood:

- Increases in heat-related morbidity (cramps, rash, exhaustion, fainting, stroke)
- Increases in heat-related mortality (cardiovascular disease, renal failure, respiratory deaths, strokes)[8,9]

These conditions are more pronounced among ***vulnerable populations***, which include the elderly (over age 65), children, low income, chronically ill, pregnant, disabled, socially isolated (homeless, homebound), and outdoor workers[9]. According to the Hazard Mitigation Plan, "*Due to its geography, and its warm, muggy semitropical climate with hot summers, the City of San Antonio can expect an extreme heat event each summer* (HMP, Section 6 page 3)[5]."

The *Hazard Mitigation Plan* does not tell the whole story when it comes to changing climate conditions. As with many of the concerns identified in this vulnerability assessment, analysis of historical occurrences will not accurately guide future projections of these events as the San Antonio climate changes. With observations that the seasonal average temperatures in the summer have increased 0.5°F per decade from 1960-2014, and that there is increased frequency of days over 80°F, 90°F and 100°F from 1960-2014, there is reason to be concerned.

> *"In the summer of 1998, the National Weather Service declared numerous communities in North and South Texas to be under an extreme heat advisory. Throughout Texas, high humidity coupled with temperatures in the high 90's and above caused significant elevations in the heat indices. In addition to the extremely hot and sultry afternoons, the ambient overnight temperatures rarely dropped below 80°F during the summer of 1998. These conditions produced critical heat waves and pushed the heat index into the Extreme Hot Classification which entails a heat index of 130°F or greater. According to the Associated Press, 124 Texans died during this heat wave of which 3 were from Bexar County. History has shown that these conditions are common for South Central Texas (Heat and Emergency Response Plan, 2015, Page 1)[7]."*

One recent extreme heat event cited in the *Hazard Mitigation Plan* occurred in 2009 and resulted in two confirmed fatalities (HMP, Section 6 page 6)[5]. Projections of increases in the historically hottest days and warmest nights by the end of the century for the city are likely to exacerbate already challenging circumstances. There are high

numbers of people living in the city that may be vulnerable to this increased frequency of extreme heat events.

Bexar County has an aging population with ***residents over the age of 65*** accounting for 11.3%, or a total of 209,713 residents[10], and projected to reach 14% of the total population by 2020[11]. This is significant because often people of advanced age can be in declining health, may live on a fixed income, and/or may be isolated from the rest of their community or homebound. Because of this, they are at an increased risk from extreme heat events.

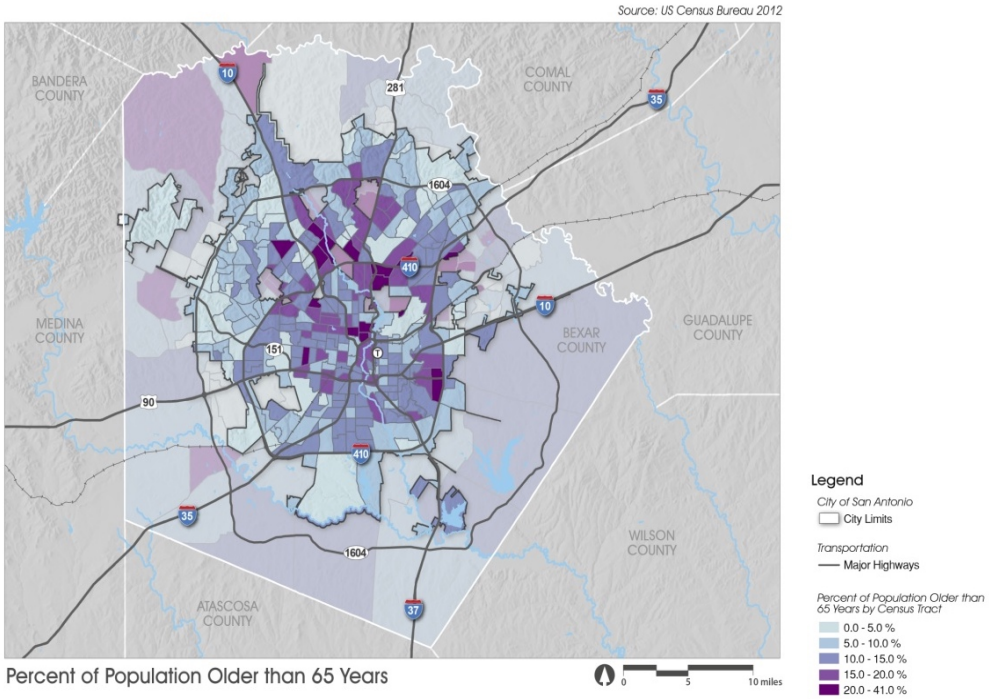


Figure 11: Percent of the population of the City of San Antonio over the age of 65 years by census tract. People over 65-years old are more sensitive to extreme heat events.

> *"A prolonged heat wave from the end of June through early July [2009] brought record temperatures and heat advisories to South Central Texas. 82 year old twins died in their home in San Antonio. The cause of death was heatstroke according to the medical examiner. The twins did not want to use a fan or air conditioning stating that they were on a fixed income and were trying to save money. High temperatures were at or near 100 degrees in San Antonio that day and previous days as well (HMP, Section 6 page 6)[5]."*

Children are considered vulnerable to extreme heat events as well. 133,622 residents, or 7.2% of the population, in 2014 were children 5 years and younger11. Children spend more time outdoors than adults, often being active, and their body's surface area makes up a greater proportion of their overall weight as compared to an adult making them more vulnerable to heat exposure.

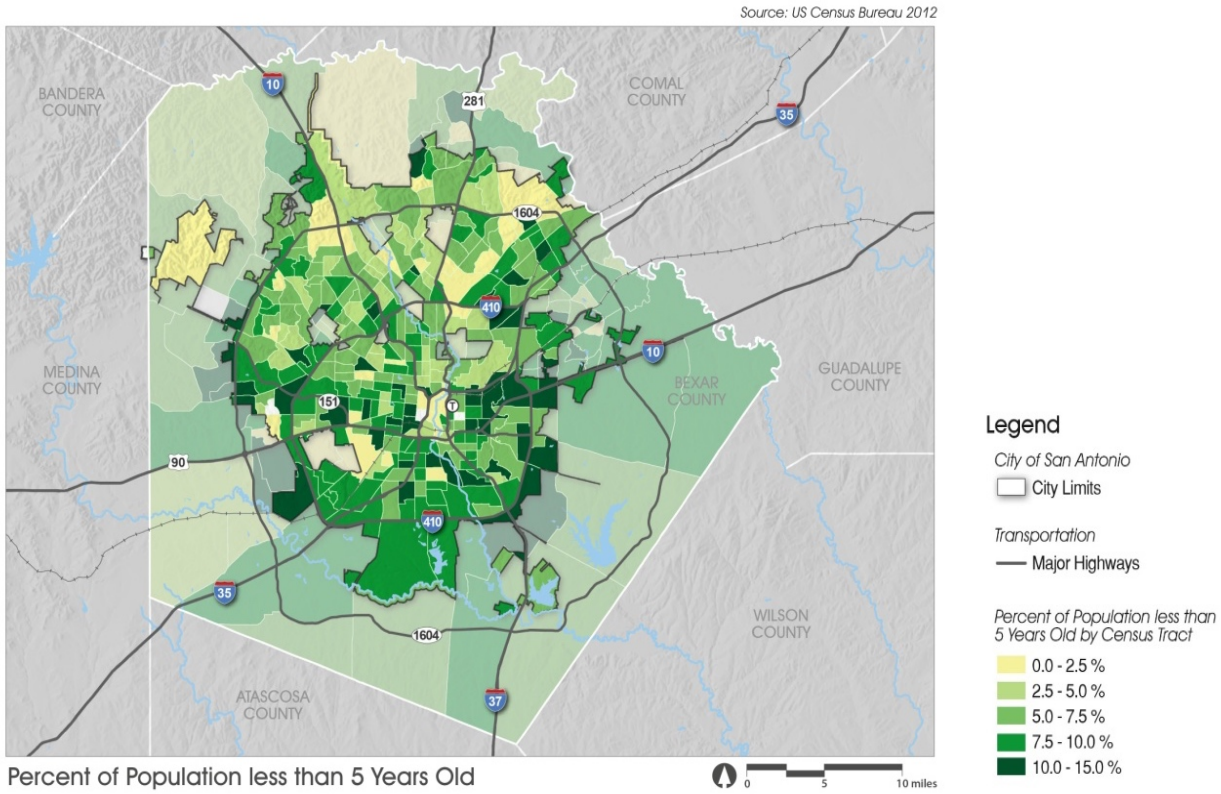


Figure 12: Percent of the population of San Antonio under the age of 5 years by census tract. Children are more sensitive to extreme heat events.

Poverty is another indicator of increased vulnerability as it relates to a lack of overall resources to adapt to a changing climate or deal with extreme events. The poverty rate for the city was 9% in 2000 and 19% in 2010 (3% higher than in the entire metropolitan statistical area), implying a growing challenge for the city (Chapter 2, pages 3-6)[10]. Income is unevenly distributed across the city with some parts of the city experiencing extreme poverty (e.g. Eastside and Southeast/Southwest) as shown in Figure 13. Further, the number and availability of health access points within certain portions of San Antonio is a challenge. During emergencies, access to healthcare, especially for the poor, can be diminished (page 224)[11].

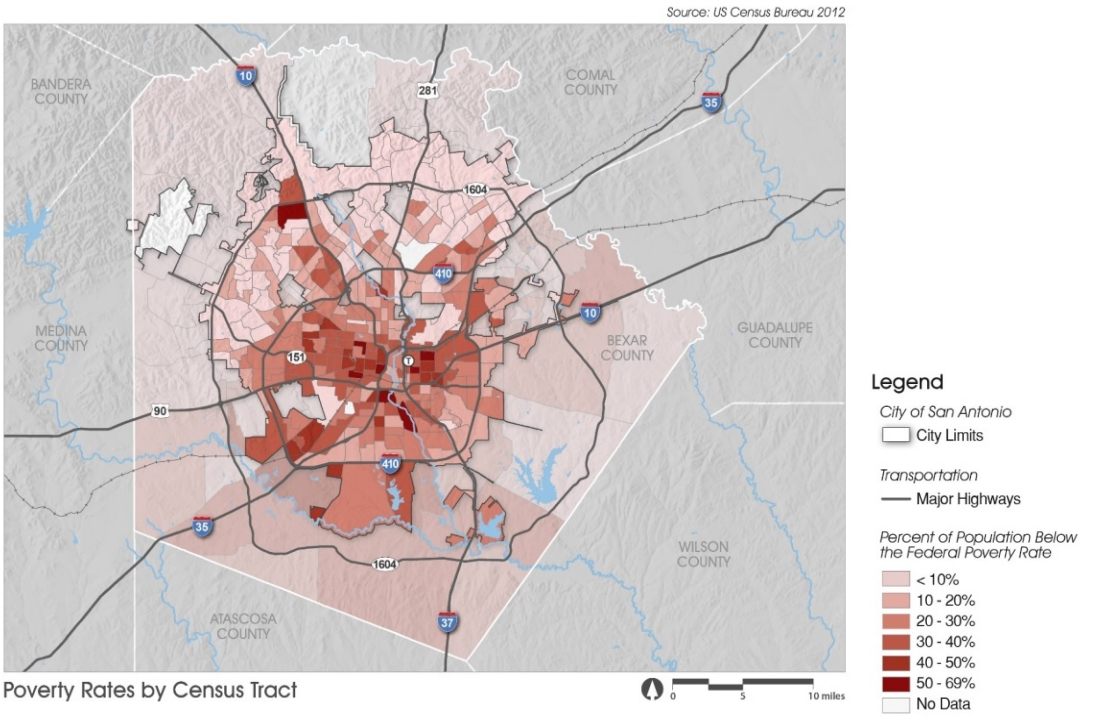


Figure 13: Percent of the population of San Antonio living below the Federal Poverty Rate by census tract. Low-income segments of the population have fewer resources to prepare for and respond to extreme heat events.

The presence of **chronic diseases** can increase the risk from extreme heat. The city has been grappling with a high obesity rate among its residents and according to the 2013 Bexar County Community Health Assessment report, "*a higher proportion of Bexar County adults (68%) than adults in Texas (65%) were overweight or obese in 2012* (page 58)[12]." The rates of **diabetes** in 2013 for Bexar County are 11.4%, down from 14% in 2010 and similar to the rate in the state of Texas[12]. In 2012, 6% of adults in Bexar County reported having **heart disease** and *"…chronic heart disease accounted for the largest proportion of deaths among Bexar County adults age 75 and older in 2011* (page 148)12". These poor health conditions make residents with chronic disease more vulnerable to extreme heat events[9].

The convergence of these social, economic, and health factors may create enhanced vulnerability to changes in climate, and specifically to extreme heat events. To understand the combined effect of these factors, a map of the relative "social vulnerability index" was created using the Agency for Toxic Substances and Disease Registry's Social Vulnerability Index, or SVI[9]. Figure 14 shows the SVI for each of Bexar County's census tracts for 2010. The SVI combines 14 variables including persons aged 65 and older, persons aged 17 and younger, single parent households with children under 18, minority status, and persons living in group quarters. Dividing the data into five groups, the darker red portions depict the areas of the county at the highest social vulnerability, while the darkest blue portions indicate the least vulnerable portions of the county. This information could be used to guide the City as it looks to make decisions about next steps and help target efforts in the more vulnerable areas of the city that are less able to adapt to changing climate conditions.

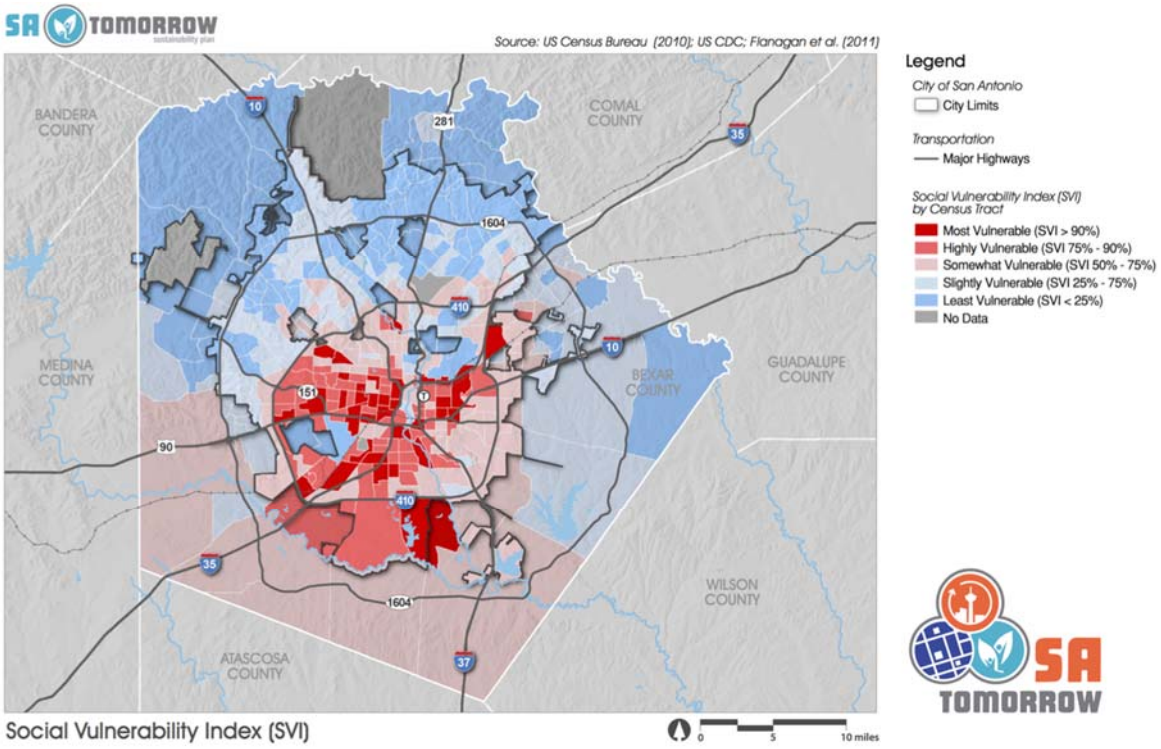


Figure 14: Social Vulnerability Index by Census Tract within Bexar County for 2010.

Finally, a significant contribution to the vulnerability of the residents of the city is due to the "Urban Heat Island Effect" (Figure 15) wherein temperatures in urban areas are often much hotter, and stay hotter throughout the night, than rural areas.

> *"Cities can be up to 10°F warmer than surrounding rural areas and can maintain warmer temperatures throughout the night. Concrete and asphalt in cities absorb and hold heat. Tall buildings reduce potentially cooling airflows. Urban environments may lack trees and other vegetation that provide shade and increase cooling through evaporation. As a result, city-dwellers may experience longer and more severe periods of extreme heat compared to rural or suburban dwellers (page 5)*[9]*."*

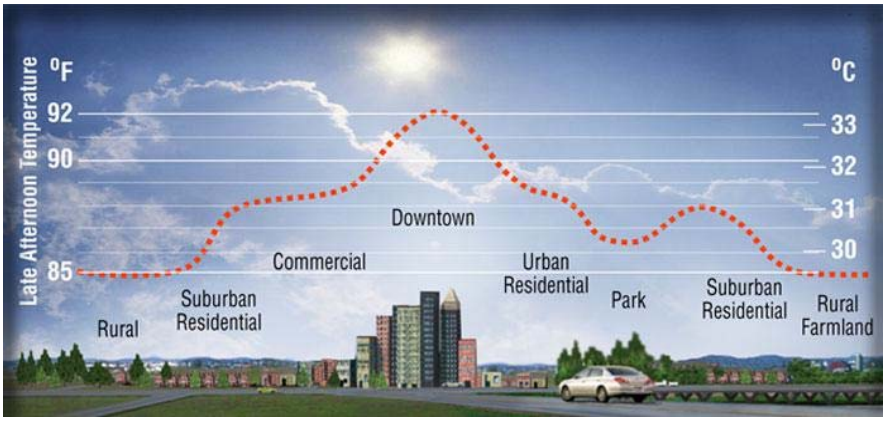


Figure 15: Urban Heat Island Effect[13].

Although roughly equivalent to the national average, the San Antonio's 2012 rate of 17.6 acres of open space per 1,000 residents is a reduction from the 2010 of 20.7 acres per 1,000 residents (Chapter 7, pages 4-7)[11]. This is important because decreases in open space correlate with increases in the urban heat island effect (i.e. open space/tree cover can reduce the urban heat island effect). Heat islands raise air conditioning demand, air pollution levels (particularly smog), and greenhouse gas emissions associated with the energy production required to meet that demand. They also increase the incidence of heat-related illness and mortality[14].

The analysis of the urban heat island effect for the city confirms that the more densely developed areas are "hotter" while the areas of crop or grasslands with forest cover are cooler (Figure 16).

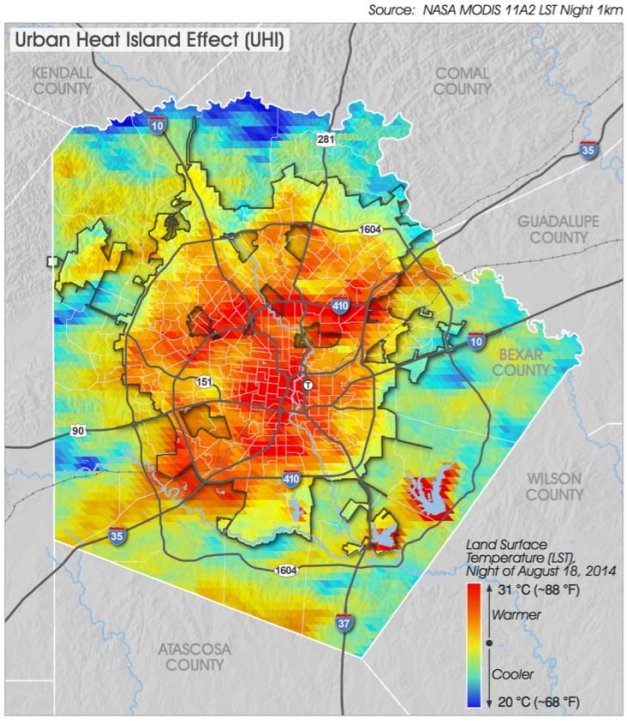


Figure 16: Urban Heat Island Effect for the City of San Antonio.

Looking at the relative SVI rankings alongside the Urban Heat Island map can be a good way to identify areas of enhanced vulnerability to extreme heat events based on increased exposure and higher sensitivity (or lower ability to respond) to those events.

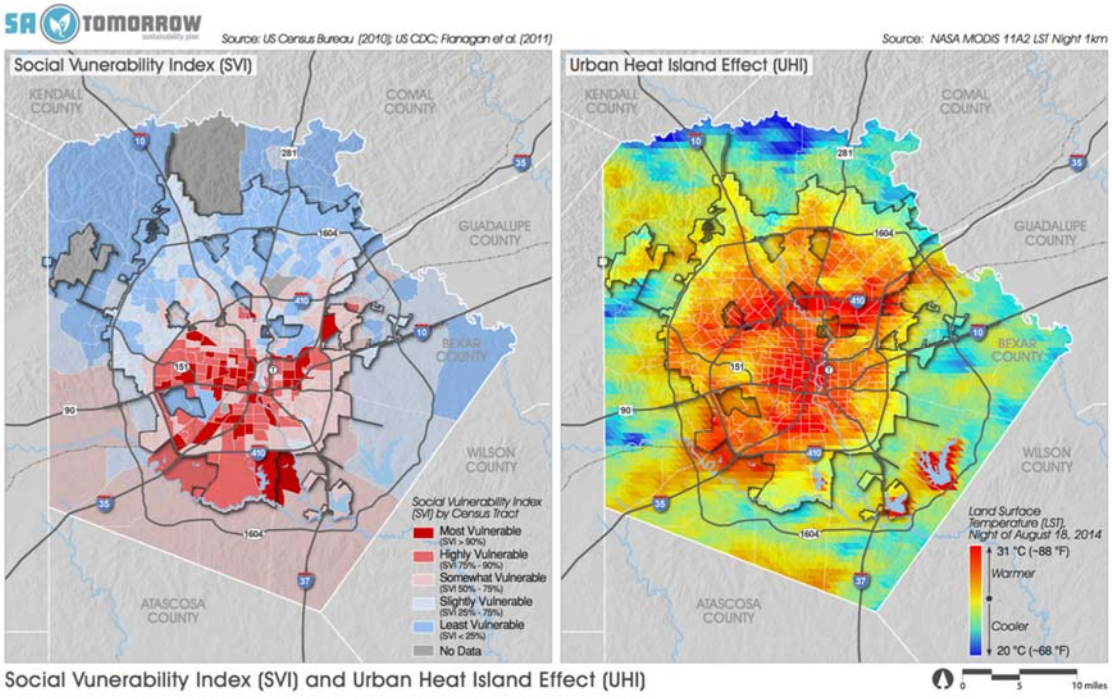


Figure 17: Side by side comparison of the relative social vulnerability index rankings and the urban heat island effect for Bexar County. Comparison can be used to identify areas of enhanced vulnerability to extreme heat events based on increased exposure and higher sensitivity (or lower ability to respond) to those events.

As mentioned, tree cover and green space reduce the urban heat island effect. According to the American Forests Report, San Antonio has a 38% overall tree canopy[15], while the project team's analysis of 2014 data found tree canopy cover of over 34% for Bexar County (excluding the City of San Antonio) and 32% for San Antonio (Figure 18).

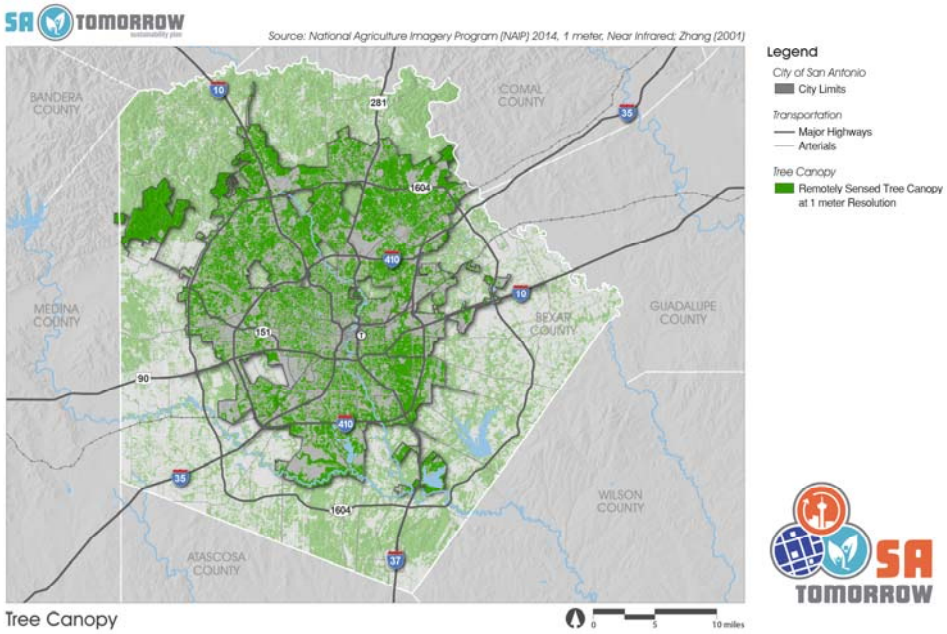


Figure 18: Urban Canopy for San Antonio and surrounding areas.

Importantly, between 2001-2006, San Antonio lost 1,800 acres (3.4%) of tree canopy and 7,600 acres (6.8%) of open space/grasslands while gaining 7,400 acres (5.8%) of additional urban area. The most dramatic tree canopy loss trend occurred in the Edwards Aquifer Recharge and Transition Zone. 3,200 acres (6.0%) of tree canopy and 4,400 acres (10.7%) of open space and grasslands were removed while almost 6,000 acres (20.2%) of urban area were added[15]. The inherent cooling affect of trees is evident in the satellite data used to create the urban heat island maps (Figure 16).

Overlaying the urban tree canopy with the relative social vulnerability index is another way to identify target locations for future tree planting that can be used to cool areas where the populations may be more susceptible to extreme heat events.

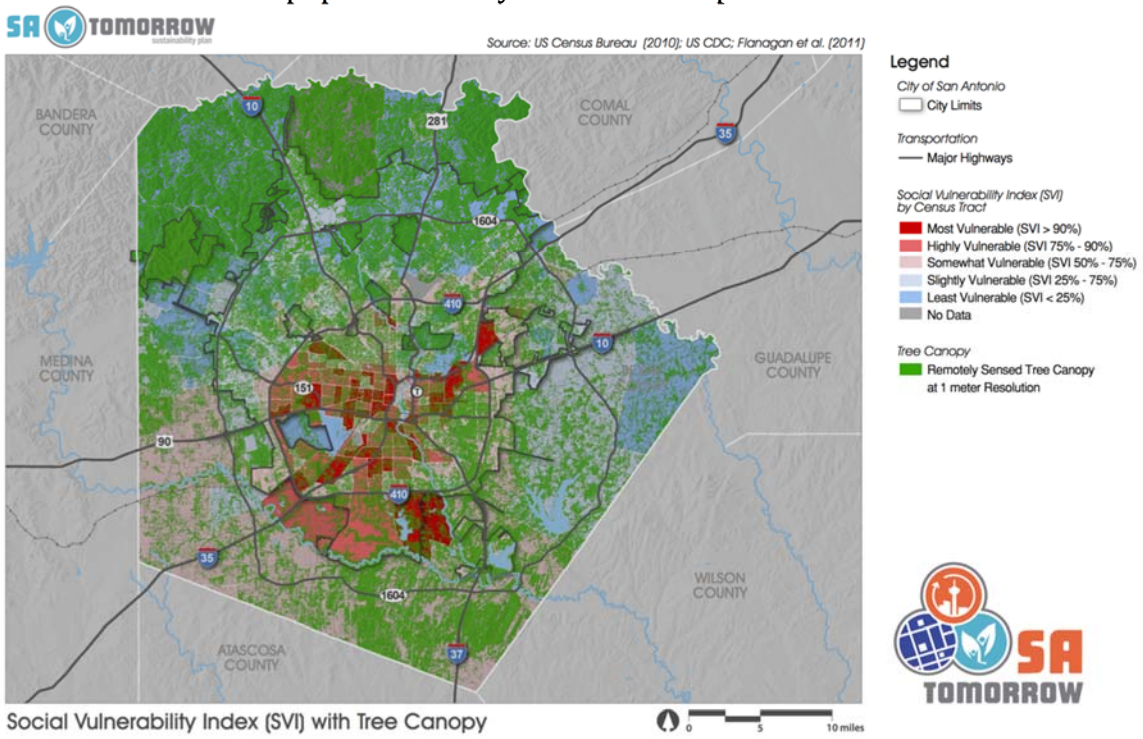


Figure 19: Tree Canopy and relative social vulnerability index for Bexar County.

Social cohesion of a community can have a significant impact on how sensitive that community is to a climate or weather event and the ability of that portion of the community to come together and respond to the climate and weather related challenges[16]. This can be particularly important for low-income communities, though income itself is not the only predictor of social cohesion[17]. A recent study on the impacts of Super Storm Sandy found that *"Communities where residents had stronger and more active social ties were better able to utilize these social networks to adapt, respond, and recover from Sandy* [18] *."* These connections can come through neighborhood involvement and are frequently tied to community and faith based organizations in the neighborhoods. Thus, as described in Section 4.3 it is not only the climate related exposure, but also the sensitivity and adaptive capacity of the affected community that determines the vulnerability.

Based on all the data presented, the RAC determined that extreme heat impacts to human health were a high vulnerability and in need of additional attention. For example, the San Antonio Metro Health District's *Heat Emergency Response Plan* is well developed, and adequately prepares the city to respond during these times of need. However, there was recognition that these events will continue to stress the existing emergency response systems (police, fire, emergency) and require expanding or enhanced educational and outreach programs (some of these systems are already in place) on the part of the San Antonio Metro Health District and partner agencies to ensure that residents receive ample notification and support to deal with them when they arise.

5.1.2 Vector Borne Diseases and Impacts to Public Health

Vector borne diseases are often cited as an emerging or imminent climate-related health effect. Vector borne diseases typically influenced by changing climate conditions are mosquito-related (e.g., West Nile) and tick-related (Lyme disease), as those are the predominant vectors, or organisms, capable of transmitting diseases across species[19]. According to the San Antonio Metro Health District, the vector borne diseases of concern transmitted by mosquitos are West Nile, St. Louis and Eastern Encephalitis, Chikungunya and of those transmitted by ticks is Lyme Disease. In addition to climate effects, because of increased travel to and from the area, and increases in the supply of host animals (e.g. birds and non-human mammals), the potential for the spread of these diseases is heightened.

The key climate concerns affecting the spread of these diseases are the projected increasing winter temperatures, which, according to past trends, would continue to increase 0.7°F per decade during the winter. These changes will result in diminished die-off of vectors during the cold winter months, thereby increasing overall numbers of mosquitos and ticks. Further, already high levels of flooding within the city could increase in intensity, expanding the number of vector habitats and breeding sites, such as standing water from heavy rain or flooding[19]. According to the World Health Organization, *"West Nile Fever has resurged in Europe subsequent to heavy rains and flooding, with outbreaks in Romania in 1996-97, in the Czech Republic in 1997 and Italy in 1998[19]."* From 2002-2013 there were a total of 4,253 cases in Texas with a record high number of 1,868 cases reported in 2012[20]. There were two human cases of West Nile Fever recorded in Bexar County in 2014[20].

It is frequently assumed that mosquito-related illnesses increase only during flooding (more water = more mosquitos), however drought conditions can actually increase vector-borne illnesses. When natural water sources dry up, two species critical to carrying out the transmission of these vector borne illness—birds and mosquitos—concentrate in more urban areas where humans provide water and food during drought. As these drought conditions occur, birds may flock to more urban areas due to the fact that humans store more water and food scraps and waste can be a food source for birds. Because of this, there is increased interaction between birds and mosquitos which breed in these water storage areas. It is this increased interaction that enhances the ability for vector-borne diseases to thrive[21]. In sum, it is the

weather extremes (both too much and not enough water) that allow for potential increases in vector-borne diseases.

Table 4: Incidence of cases of Vector Borne Diseases per 100,000 residents of San Antonio[22].

Condition	2010	2011	2012	2013	2014
Chagas, chronic indeterminate	0.000	0.000	0.000	0.110	0.108
Chagas, chronic symptomatic	0.000	0.000	0.000	0.055	0.000
Chikungunya non-neuroinvasive disease*	0.000	0.000	0.000	0.000	0.379
Dengue**	0.000	0.000	0.000	0.331	0.000
Encephalitis, West Nile	0.000	0.000	0.953	0.000	0.216
Malaria*	0.058	0.171	0.056	0.000	0.054
West Nile Fever	0.000	0.000	0.672	0.000	0.108
Lyme Disease	0.000	0.000	0.000	0.000	0.000

Although the prevalence of these diseases is relatively low, this was rated a high vulnerability for San Antonio because of the limited staffing and funding currently available to conduct surveillance efforts and respond to or combat these illnesses in the face of a future changing climate.

5.2 Medium-High Vulnerabilities

5.2.1 Critical infrastructure in the 100-year floodplain

Many of the Key Areas of Concern relate to flooding. According to the Hazard Mitigation Plan:

> *"Texas is prone to extremely heavy rains and flooding with half of the world record rainfall rates (48 hours or less). Central Texas, known as Flash Flood Alley, is particularly vulnerable because storms tend to stall out along the Balcones escarpment. While the City of San Antonio is susceptible to a wide range of natural and human-caused hazards, including flooding, tornadoes and wildfires,* ***San Antonio is considered one of the most flash-flood prone regions in North America*** *(HMP, Section 1 page 2)*[5]*."*

The city regularly deals with and focuses on being prepared for extreme flooding events. With increases in extreme wet periods projected for the city by the end of the century, flooding is expected to increase. *"Based on recorded historical occurrences and extent, flooding is highly likely, meaning an event will occur within the next year (HMP, Section 7 page 13)*[5]*."*

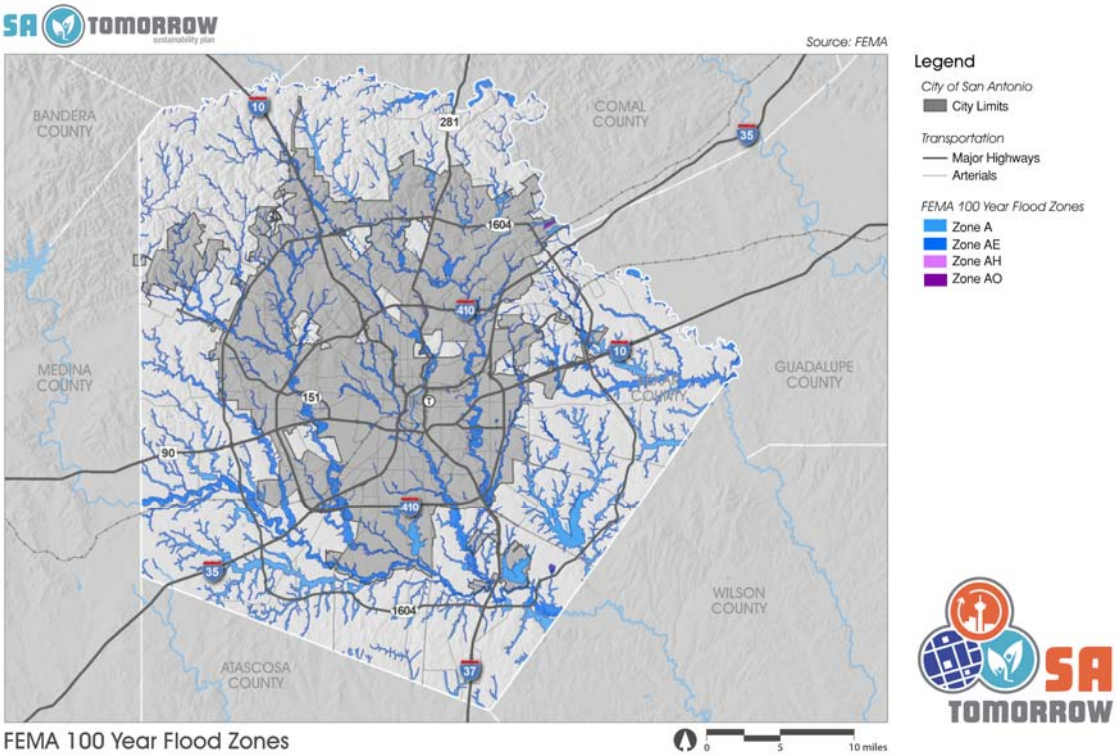


Figure 20: 100-year Flood Zones for San Antonio and surrounding areas.

At a high level, Figure 20 shows the potential flooding areas for the city where the high-risk zones are A and AE (shown in the two blue colors)[23], which cover a significant portion of the city.

These flooding events can be devastating to the city in terms of loss of life, destruction of property, disruption of the economy, and overall quality of life impacts. In San Antonio's recorded 129 flood events over the years 1993-2014, there were 16 deaths, 507 reported injuries, property damage totaling almost $14.7 million and $228,662 of crop damage (2014 Dollars). In the flooding event in May 2013 affected 350 residences, 15 of which were destroyed and 27 suffered major damages. There were also 200 citizen rescues and 3 casualties during that event[5].

> *"According to the NWS [National Weather Service], the City of San Antonio and Bexar County area hold the highest number of fatalities resulting from flash flooding in Texas, with at least 26 fatalities attributed to flooding/flash flooding since 1996. Additionally, more than 852 injuries have been attributed to flooding in the same time period (HMP, section 7 page 17)[5]."*

Floods also increase exposure to contaminated water requiring an emergency response to decrease exposure or contact with contaminated water and creating the potential need for widespread immunization. The flood events in May 2013 required this response[5].

Combining critical socio-economic factors indicative of increased vulnerability, the relative social vulnerability index was again applied to the issue of flooding for the census tracts of Bexar County (Figure 21). The red census tracks indicate higher relative vulnerability and red tracts that overlay with flood zones could be used as a way to focus efforts to reduce vulnerability and build resilience.

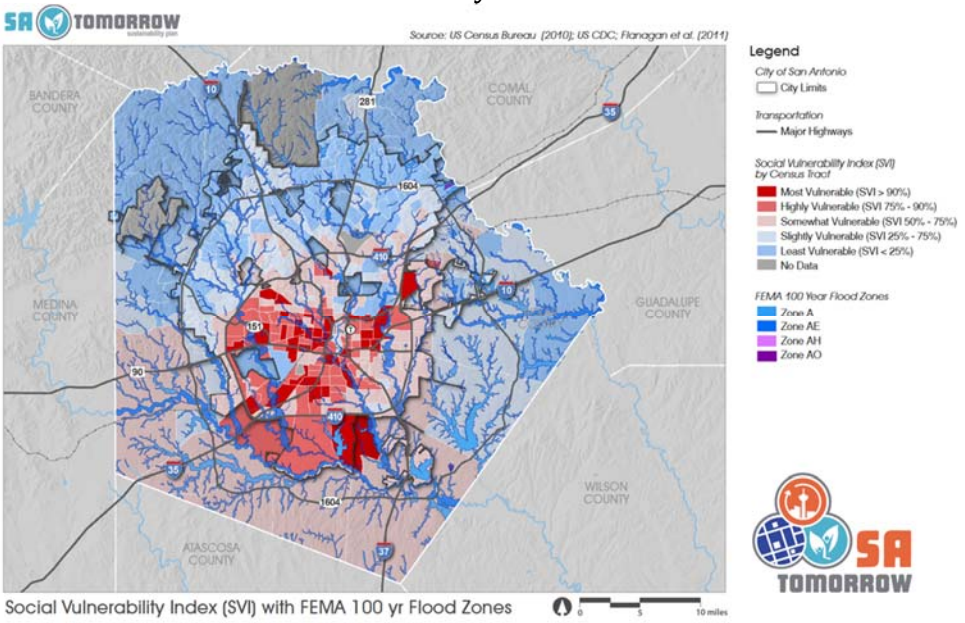


Figure 21: Relative Social Vulnerability Index using 2010 data for all census tracts in Bexar County overlaid with the FEMA 100-year flood zones.

Critical infrastructure concerns for flooding relate to the ability of the City to provide regular power, ensure that communications systems are not affected, keep the water supply from being contaminated, protect health and emergency services, and ensure that transportation systems are still functioning. According to the *Hazard Mitigation Plan*, there are 197 critical facilities located within the floodplain (Section 7 page 16)[5]. Though these facilities are very broadly defined and the City could work to better define the specific "critical infrastructure" that needs to be studied, where those facilities are, and then require specific building codes/regulations of those facilities. Further, the City is making strides through its efforts to reduce repetitive losses as part of the National Flood Insurance Program. According to the Hazard Mitigation Plan, the City is preparing materials to apply to join the Community Rating System (CRS):

> *"…including documenting tasks and projects to prevent and reduce flood losses. These include measures such as updating codes as a preventative measure, acquisition of flood-prone structures, and implementation of other structural flood control projects. The city has acquired over 300 flood-prone or repetitive flood loss properties in previous years and has plans to acquire additional structures that have previously experienced one or more floods, in an effort to protect open space adjacent to floodplains. Additionally, they have identified and included over 85 flood mitigation projects in the current hazard mitigation plan underway (HMP, Section 7 Page 26)[5]."*

5.2.2 Critical Transportation Infrastructure

Concerns were also raised by the Resilience Advisory Committee with respect to the impacts of flooding on transportation infrastructure, which includes damage in the form of washed out roads, water infiltration into roads (damaging the pavement), sediment build up at bridges (degrading the stability of the structures over time), and improperly maintained stormwater systems. These impacts could result in road closures, limit mobility, and affect emergency response efforts. Most major roadways can withstand large-scale flooding but smaller roads can be significantly damaged causing high clean up costs[24].

The *Hazard Mitigation Plan* identifies a number of specific locations that have been affected by past flooding events.

> *"The **San Antonio River at Loop 410** had floodwaters reach 34.21 feet in May 2013" (Section 7 Page 71)[5]."*

> *"Thunderstorms produced heavy rain that caused flash flooding in and around San Antonio and Bexar County. There was record rainfall in the San Antonio area with the San Antonio International Airport recording 9.87 inches of rain (2nd highest 24-hour total record)…Most of the rain fell in six hours with four inches in one hour between 6:00 and 7:00am. A USGS stream and rain gauge on Olmos Creek and Dresden Drive reported 2.58 inches in 15 min between 6:15 and 6:30am…A 24hr total at this gauge was 17 inches of rain. This led to **massive flooding in the Olmos Basin/Creek just inside Loop 410** near the Quarry (Section 7 Pages 11-12)[5]."*

> *"**Most of the flooding across the city was in north central and northwest San Antonio along and just inside Loop 410**…**There were many roads closed including Hwy 281 at Olmos Creek** which remained closed for several days. At 10:00 a.m., there was one foot of water over Ingram and Callaghan Rds.…Areas [in the south portion of Bexar County] that were hit the hardest included the Espada Rd area near the San Antonio River and Loop 410 intersection (Section 7, Page 12)*[5] *[emphasis added]."*

One specific area of concern that was discussed at the workshop was the VIA Transportation facility. It is located near the source of the San Pedro springs and built over the San Pedro creek. The facility is low lying, sometimes flooded, and central to VIA's ability to maintain its vehicles and offer transportation services to the region.

As discussed in section 5.2.1, flooding is a critical problem for the city and with projections of increasing intensity of precipitation events the committee scored potential critical transportation infrastructure a medium-high vulnerability.

5.2.3 Low water crossings high call rescue sites

Another important effect of increased flooding in the city is the impacts of flooding on low water crossings and high call rescue sites. (See section 5.2.1 for flooding impacts to the city.) According to the *Hazard Mitigation Plan*,

> *"Flood-related rescues often occur at swift water and low water crossing. Swift water rescues are rare, since most calls for assistance are related to stalled or stranded vehicles in or near low water crossings.* ***New low water crossings may and do emerge as a result of increased development or changes to the hydrology/floodplain of an area*** *(Section 7 Page 17)*[5]*."*

As flood frequency decreases and intensity increases, so too might residents become less vigilant in their awareness of their surroundings, placing themselves at increased risk and potentially requiring emergency response. Further, changes to floodplains may introduce new areas where low water crossings are an issue. According to the discussions with the RAC, this is particularly true as more people move to the area. These new residents will need additional flood education to ensure public safety.

5.2.4 Local food security

The issue of food security emerged through discussions with the Resilience Advisory Committee. The U.S. Department of Agriculture defines food security as, *"access by all people at all times to enough food for an active, healthy life*[25]*."* In these discussions, concerns focused on how climate could affect local solutions to deal with "food deserts" such as the San Antonio Food Bank's community gardens[26] and the San Antonio Housing Authority's fruit orchard[27], as some city residents have a limited ability to access their local grocery store. According to a 2012 report by the San Antonio Metropolitan Health District and the University of Texas, Bexar County's food system has deficiencies despite programs such as WIC and SNAP to enhance access to food, and it is clear that in certain parts of the city there is a substantial food-based need[28]. Figure 22 shows the percentage of the population by zip code that lives within one mile of a grocery store, super market, or farmers market. The darker red zip codes are places where a large percentage of the residents do not live within 1 mile of these healthy food options.

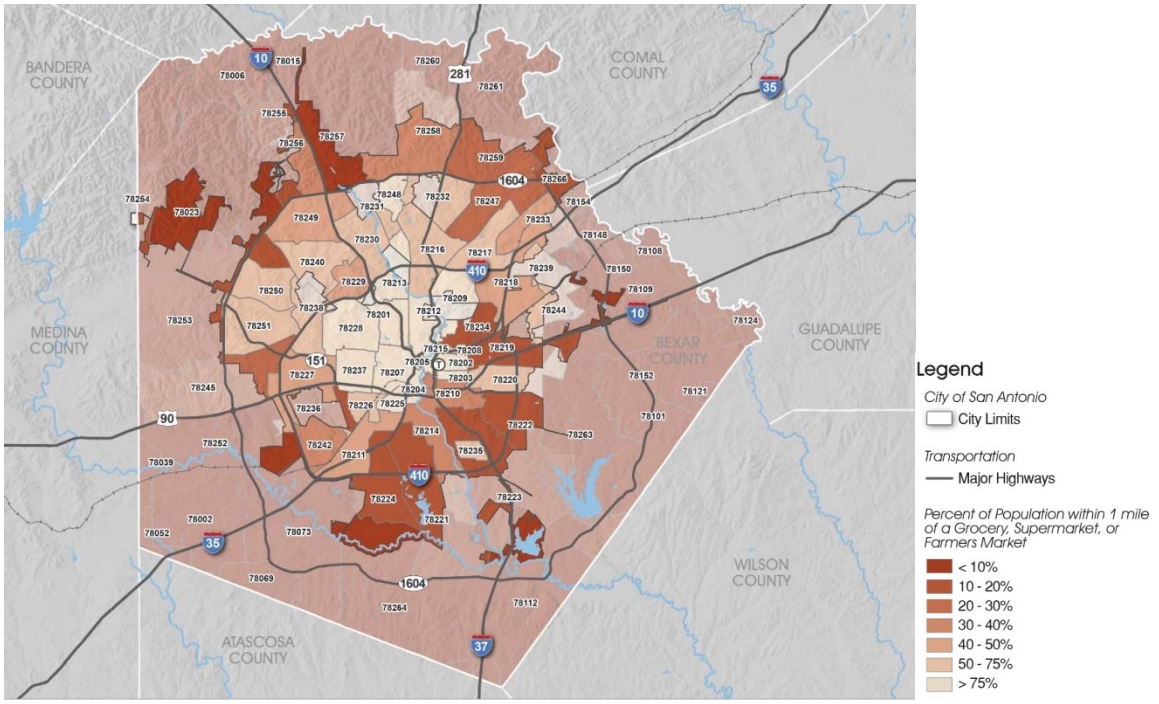
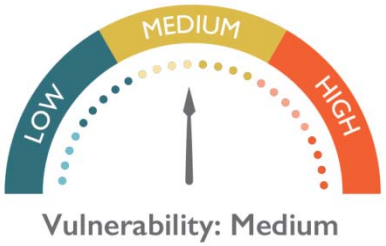


Figure 22: Percent of the Population living within 1 mile of a grocery store, supermarket or farmer's market by zip code in San Antonio.

Within Bexar County there are a total of 160,770 acres classified as improved farm or ranch (58,858 of those acres are within San Antonio city limits). As temperatures continue to warm and the number of hot days and warm nights occurring on average each year increase, agriculture and livestock production may be affected. Further, livestock are affected by extreme heat in that it can make them vulnerable to diseases, threaten feed supplies, and affect their fertility/reproduction[29]. According to the Texas A&M agricultural program, during the 2011 drought, ranchers provided supplemental feeding for livestock or began to liquidate herds (HMP, Section 5 Page 6)[5]. Diminished agricultural and livestock production could have economic impacts on the city.

The Resilience Advisory Committee rated this a medium-high vulnerability due to the fact that any efforts to create a more localized food economy would be affected by changes in climate. Further, as changing climate conditions affect the greater national and international food system, those who already lack access to healthy food choices due to their lower socio-economic status might be further affected if those changes increase the price of food that is brought into the city.



5.3 Medium Vulnerabilities

5.3.1 Poor Air Quality and Potential Non-Attainment Due to Ozone

San Antonio is already near the non-attainment threshold for ground level ozone. The U.S. Environmental Protection Agency's definition of "non-attainment" states, *"any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant* [30] *."* Ground level ozone has known human health effects, such as exacerbating asthma, reducing lung function, and creating lung inflammation [31]. Ground level ozone forms when sunlight comes into contact with vehicular emissions. Studies have shown that ground level ozone levels increase when temperatures increase[32]. Thus, higher temperatures result in higher levels of ozone. The projected growth of the city and increase in the number of vehicles (and thus emissions) will also increase ozone levels. There are direct financial implications to consumers, businesses, and industry along with increases in ground level ozone leading to increased school absences, medication use, visits to physicians, emergency room visits, and hospitalizations[31].

Data from 2005-2007 showed an increase in the number of unhealthy days due to ozone for Bexar County, which was higher than the state of Texas overall (Figure 23). Effective December 28th, 2015, The EPA reduced the 8-hour ozone standard from 75 parts per billion to 70 parts per billion[33]. The San Antonio area attainment status is "pending" (based on information from the Texas Commission on Environmental Quality[34]) while the EPA updates the implementation rules and guidance around the new standard. Increasing temperatures, 1.1 million more people moving to the region by 2040, and the increased transportation service needs for those people all have the potential to increase ground level ozone in the region.

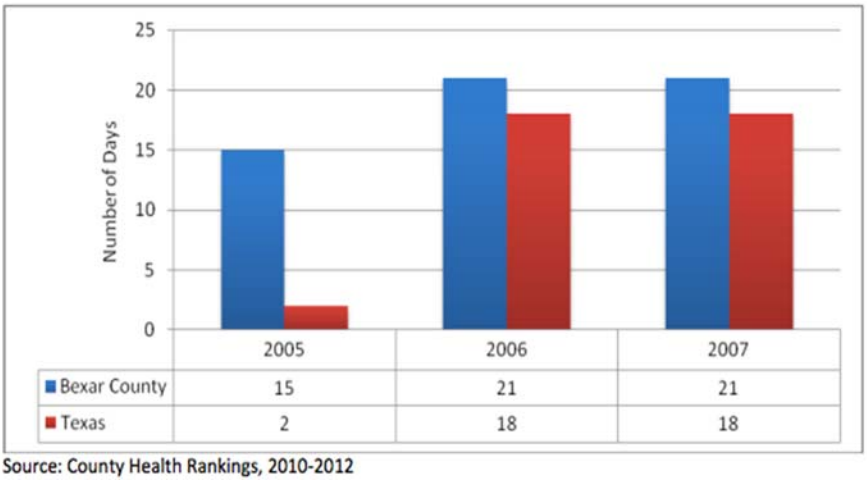


Figure 23: Annual number of poor air quality days due to ozone, Texas and Bexar County, 2005-200712[12].

The concerns raised by the committee were that transportation projects to enhance capacity for the growing population could be stalled due to restrictions and funding requirements related to a "non-attainment" designation. As a result, the City might need to find new modes of transportation to increase capacity (e.g. public transit) and work to increase emissions controls to reduce baseline ozone levels.

5.3.2 Wildfires

Although wildfire threat within most of the city is relatively low, continuing development in the north and northwest portion of San Antonio expands the wildland urban interface deeper into more fire prone areas. According to the *Hazard Mitigation Plan*, 22% of the population lives along this wildland urban interface[5]. Figure 24 demonstrates this higher risk in the north, northwest region of the city[35].

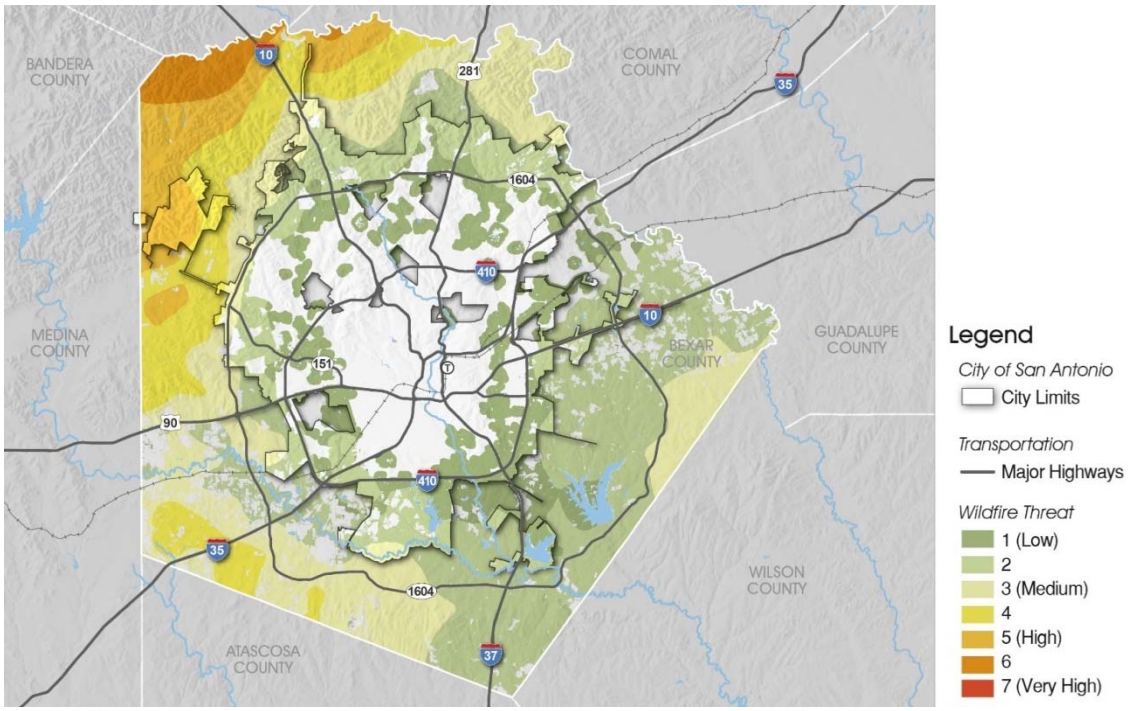


Figure 24: Wildfire risk for San Antonio and surrounding areas[35].

Economic impacts of wildfires can be large. For example, the Bastrop Complex Wildfire in 2011, itself a result of severe drought conditions, resulted in estimated losses of over $209 million[36]. Wildfires do not tend to have much direct impact on transportation infrastructure, though indirect impacts from disruption of evacuation routes, as well as decreased soil stability and subsequent erosion and sedimentation accumulation, can be significant. Further, wildfires could create bottlenecks in the transportation system interfering with wildfire evacuation and thus threatening public health/safety[36].

> *"The San Antonio Fire Department reported 83 wildfire events between 2007 and October 2014 and two wildfire events reported by the National Climatic Data Center (NCDC) in 2011 and 2014, which resulted in $250,000 of property damages. (Section 8 Page 2)[5]."*

Changing climate conditions are likely to increase temperatures and increase the likelihood of dry conditions, further exacerbating wildfire risk. The Resilience Advisory Committee members felt that the city would be more vulnerable to wildfires in the face of these projected changes to climate. Further, as the population increases and there is more development along the wildland urban interface, more property and people will be at risk. This could stress the emergency response systems.

5.3.3 Multi-family residences in 100-year floodplain

The flooding impacts have been outlined thoroughly in Section 5.1.1, and with projections for increased severity of these events, the committee rated these impacts to multi-family housing in the floodplain a medium vulnerability. The committee decided that people living in multi-family residents, while sometimes part of strong social networks in their communities, generally had lower "adaptive capacity" due to generally lower incomes and less access to transportation than those living in single-family homes. The sheer number of people in a single multi-family complex create challenges communicating with and relocating residents during emergency events.

On the positive side, there are efforts underway to identify and reduce flood risk. The city participated in an effort to redraw the flood risk maps as part of a partnership known as the Bexar Regional Watershed Management (BRWM) partners, consisting of Bexar County, the San Antonio River Authority (SARA) and 20 other suburban cities in Bexar County. The result of this effort are interactive online maps, housed by SARA, that allow residents to see where their homes are within the floodplain[37]. The BRWM partnership has also developed a three year rolling capital improvement project plan to prioritize and fund $500 million worth of regional drainage projects over ten years[38].

5.4 Medium-Low Vulnerabilities

5.4.1 Single-family residence in 100-year floodplain

Although facing similar flood risk as multi-family residents, the committee felt that the city had a greater capability to help people living in single-family residences prepare for and respond to flood events. This is largely due to the number of residents and the ability to communicate with these residents.

Further, both the City of San Antonio and Bexar County have taken steps to stop development of additional residences from the floodplain with the aforementioned SARA flood risk maps, a unified development code to ensure appropriate permitting for the floodplain, and other efforts. For these reasons, despite a recognition that flood intensity and severity will increase with changing climate conditions, the committee ranked this Key Area of Concern a medium-low vulnerability.

5.4.2 Extreme heat impacts on native species (trees)

Trees can be vulnerable to extreme heat and preserving the urban tree canopy is a concern. The City Landscaping and Tree Preservation Ordinance requires developers who intend to remove trees or vegetation to obtain a tree preservation permit from the City. In addition, the ordinance has requirements for landscaping, buffers, streetscape planting, and fences[39, 40].

Increasing average temperatures and more hot days and warm nights combined with projections of increasing risk of dry conditions may create drought conditions that will kill trees, especially in circumstances where planting and landscaping practices may not have been up to standard (i.e. root health and depth of planting may not be adequate). The workshop discussion centered on the need for more training and certification for those planting trees as a way to support tree health and preserve and expand the city's canopy.

5.4.3 Geographic distribution of the municipal water supply

The San Antonio Water System (SAWS) has developed a water conservation program that is one of the best in the country[41]. Because of this, and some excellent planning and coordination efforts, the city has been able to provide water for its residents even during times of drought. Yet, as the city continues to grow and a changing climate continues to affect both the supply and demand for water, San Antonio will be increasingly challenged. These challenges will include expanding water supply capacity to meet the projected needs of new residents and newly developed areas, especially under drought conditions. Incorporating changing climate conditions will require enhancing strategic planning to ensure that there is enough water to carry the city through future dry periods.

SAWS has a demographer who utilizes all of the best available information in order to estimate and project the number of people using SAWS water, both for the entire service area, and on much smaller scales. SAWS is working to develop a new pipeline in 2016 to bring water from southern Bexar County to the western side of its service area, to supplement the existing pipeline that services the eastern side of its service area (Figure 25). In addition to the existing innovative Aquifer Storage & Recovery project and existing Local Carrizo project at SAWS Twin Oaks facility in southern Bexar County, SAWS is also developing a brackish groundwater desalination program and additional production from the Carrizo Aquifer in Bexar County, to further diversify its water provision efforts. Phase 1 of the desalination program will be complete in 2016, and the project eventually expects to provide the city with an additional 30 million gallons of water per day[42]. This is the largest planned inland desalination project currently in the United States.

Figure 25: Proposed new pipeline that will bring water from southern Bexar County to the eastern and western sides of its service area, to enhance flexibility[42].

In addition, another proposed water solution, the Abengoa Vista Ridge project, would transport water from Burleson County to San Antonio. The unique aspect of this project is its diversification in supply away from the Edwards Aquifer (Figure 26).

Figure 26: Map of Proposed Vista Ridge Pipeline[43].

While SAWS *2012 Water Management Plan* does not explicitly include projections of changing climate conditions, it does plan for drought using the drought of record from the 1950s. Figure 27, below, shows water demand for a series of nine years (dark black line) along with available water supplies (colored bars). The demand line is sloped upward to account for population growth coupled with a sustained conservation program. The colored bars represent water that would be available if the seven-year drought that occurred during the 1950s were to reoccur in the future. As seen in the figure, it isn't until the 2030s, and the seventh year of the drought, that there is a projected gap between water supply and water demand.

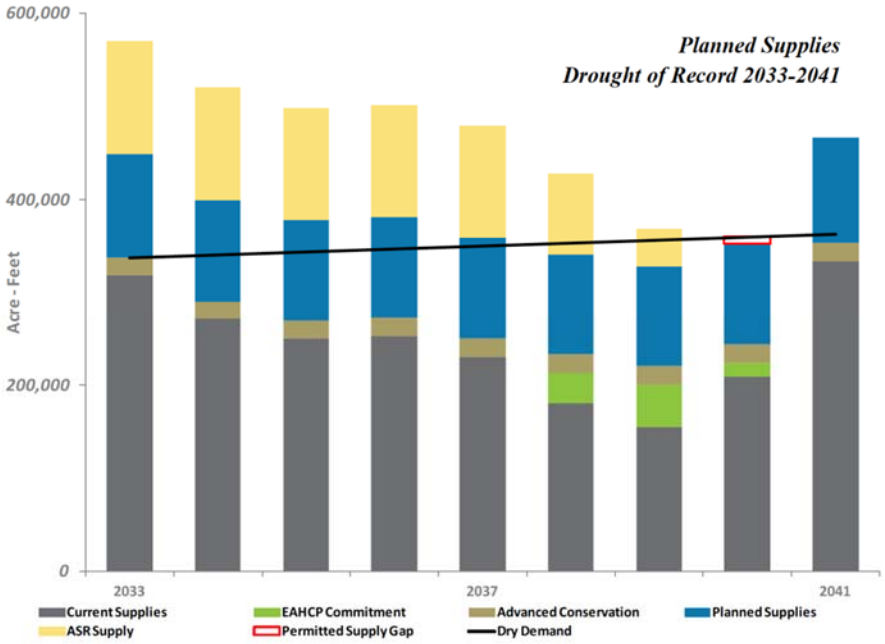


Figure 27: SAWS 2012 Water Management Plan supplies for the years 2033-2041. Dark black line shows water demand by year based on population growth. Colored bars show water supply in the event that the drought of the 1950s was to reoccur[41].

Recognizing the fact that extreme droughts have the potential to occur in the future and considering the ongoing efforts to diversify water supply resources and enhance conservation efforts, the committee rated this Key Area of Concern a medium-low vulnerability.

5.5 Low Vulnerabilities

5.5.1 Municipal water quality during droughts

Another issue raised by the Resilience Advisory Committee was the challenge of ensuring water quality that meets standards during times of drought. According to the *Hazard Mitigation Plan*:

> *"Based on 31 recorded drought events over seven extended time periods within an 18 year reporting period, the City of San Antonio averages two droughts every year. This lends to a highly likely frequency of occurrence, meaning* ***a drought can be expected on an annual year cycle*** *(HMP, Section 5 page 7)*[5]*."*

Working under the assumption that droughts are inevitable events to plan for, concerns arose during discussions with the Resilience Advisory Committee about the potential for increased water main breaks and their potential to affect water quality. In particular, water quality can be an issue in dead-end water lines where water remains stagnant for longer periods of time. The committee felt that this is a low vulnerability due to the diversification of supply and overall system redundancy. SAWS has acquired and preserved 135,000 acres as part of San Antonio's Aquifer Protection Program in an effort to protect water quality. Thus, while overall vulnerability is low, there are recommendations to consider connecting dead end mains and create codes against cul-de-sacs (one of the sources of dead end mains) to ensure continued water quality during times of drought.

5.5.2 Waste water treatment and sewage overflow

The issue of wastewater treatment and sewage overflow is a potential concern. Heavy precipitation events have led to infiltration of stormwater into the sewer system, even though SAWS does not have a combined sewer-stormwater system. This has been a problem in the past, resulting in a number of sewage overflows including ones in May and October of 2015. A consent decree with the U.S. Environmental Protection Agency was passed to work to mitigate these issues. SAWS has invested funds to fix the collection system, remove obstructions, and is in the process of developing a new sewer system model to better prepare for, track, and respond to these events. This project represents a major investment in the sewer infrastructure over the next 10 years that could greatly decrease the number of sewer overflow events. It is important however that future climate projections be incorporated to ensure these modifications are effective.

5.5.3 Municipal water peak demand

Per capita water use has been decreasing in the City. In 2011, residents used 143 gallons of water per person per day in 2011. That number fell to 126 gallons per person per day in 2013 and 121 gallons per person per day in 2014. These per capita improvements, although significant and important, could be challenged by annual extreme temperatures and drought-like conditions. Consecutive days without rain and high heat conditions, especially when combined with the projected populations growth of 20,000 new residents a year, have the potential to increase peak water demand. Accordingly, despite SAWS aims to continue to set more progressive conservation goals in the next update of its Water Management Plan, the committee felt that this was a Key Area of Concern to consider. According to the Draft Conservation Plan:

> *"There are time periods when SAWS has an excess of water supply needed for the community and time periods when curtailed permits and drought reduce the Edwards supply by up to 44%. The combination of rapidly growing population, a growing economy, prolonged drought periods and decreased water source permits has required San Antonio to be innovative in its approach to water planning (page 2)[41]."*

To plan for a future where more municipal water will be needed, especially during dry months or years, SAWS uses the drought of record (1950-1958) in their simulations of water supply needs. SAWS currently relies solely on historical experience, rather than climate projections, which may not be sufficient to guide preparedness efforts over the longer term. Figure 27 above shows how SAWS uses historic drought conditions to plan for the future. By 2020, SAWS will have developed more water supplies, including the implementation of its brackish groundwater desalination program. Further, they are connecting themselves to other water sources through a regional pipeline network, thereby providing redundancy in the system and creating the ability to shift water from one location to another, enhancing overall resilience within the system.

Resulting from far-reaching efforts to conserve water, municipal water use is on the decline (Figure 28). Because of this, and other forward-thinking efforts on SAWS and the City of San Antonio, the committee rated this Key Area of Concern a low vulnerability.

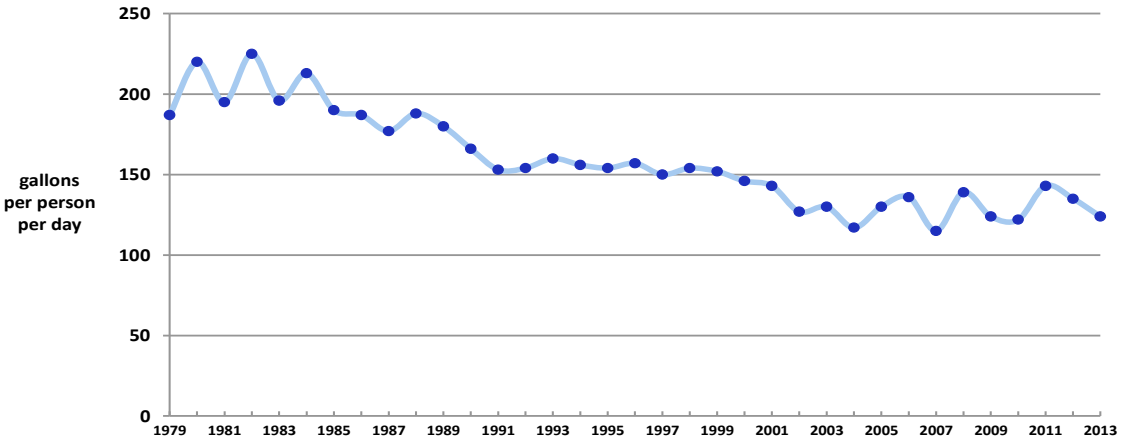


Figure 28: Daily Per Capita Water Use in gallons per person per day in San Antonio from 1979-2013[44].

5.5.4 Cooling water available for power plants

According to the *Hazard Mitigation Plan*, during times of drought,

> *"The service that will be the most directly impacted will be utilities, both water delivery and electric (for those producers that rely on hydroelectric production or nuclear power generation methods, as some providers in the region do). Without a steady supply of water, utilities may cut back energy generation and service to their customers and possibly to prioritize the service that they are able to provide (Section 5 pages 9 -10)[5]."*

One climate related concern is that increasing temperatures will increase evaporation rates for Lake Calaveras and Lake Braunig, two critical water sources for cooling power plants. Without either sufficient water for cooling, or if cooling water temperatures are too high, power production can be reduced or limited. CPS Energy's ability to divert water for cooling is limited by the Texas Commission on Environmental Quality. This could create a potential vulnerability, as there is increasing competition for surface water. Despite this, the committee felt that the vulnerability was low and discussion centered on the need to:

- Develop a direct pipeline from SAWS Dos Rios Water Recycling Center to CPS Energy;
- Increase investment in renewable energy sources to obviate the need for diversion of water; and
- Develop larger or variable speed pumps so that diversions can be better timed with diurnal availability.

6.0 Actions and Next Steps

There are many ways that the City, community organizations, and partners throughout the region can work together to prepare for extreme weather events and anticipate the impacts of a changing climate. When done well, these efforts can greatly reduce the climate related vulnerability of the region and help San Antonio continue to be an attractive and vibrant community far into the future.

When it comes to building resilience, there is no silver bullet or one size fits all strategy that can be used everywhere. The strategies shown below are based on a combination of best practices from other communities as well as input from residents of San Antonio, the Resilience Advisory Committee, the Sustainability Plan Steering Committee, and the City's leadership team. These strategies represent some of the most promising approaches to building resilience to the identified weather and climate related risks. Under each theme, the table highlights key sustainability strategies currently under review as part *SA Tomorrow* planning process and the bulleted list identifies additional relevant practices from other communities.

6.1 Flooding

Flooding 1: Flood Risk Management

Key strategies from the SA Tomorrow Plan	Focus Area
Integrate a climate change questionnaire in the building development review process to assess how climate change could impact new development and major renovations and encourage developers to design their buildings to be resilient to these impacts.	Green Buildings & Infrastructure
Adopt a low impact development standard requiring 100% of onsite stormwater management for all new development and significant retrofits.	Green Buildings & Infrastructure
Create a stormwater utility and produce incentives for existing developments to manage 100% of stormwater onsite.	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- "Identify appropriate flood risk acceptance and develop supporting standards and guidelines. Three options include:
  - *Informed Science Approach*: Use the best available climate science data to determine future flood conditions, and elevate structures above that future flood level.
  - *Freeboard Value Approach*: Elevate structures and facilities two feet for standard projects and three feet for critical projects above the 100-year flood level.
  - *500-Year Elevation Approach*: Elevate structures to the 500-year flood level (a flood with a 0.2 percent chance of occurring in any given year). *FEMA, North Olympic Peninsula, WA.*

- Adopt and enforce updated building codes. Stricter building codes for new construction and existing facilities may help the city protect its building stock from flooding as well as wind, and prolonged power outages. Targeted strategies include building code legislation/regulation changes, adjustments to zoning regulations, incentive programs, and best practices guides. *Salem, MA, Durham, NC, and Lafourche Parish, LA.*
- Limit or restrict development in future flooding areas. The first step is to review the existing regulations and zoning ordinances, review historical flood events and insurance claims, review future flooding levels, and determine implications to tax base and private property rights. *Salem, MA and Seabrook, NH.*
- Retrofit existing structures and study and implement zoning changes to encourage construction only of new resilient buildings in the 100-year floodplain. *New York City, NY* ***or*** Retrofit or elevate structures to the 500-year flood level (a flood with a 0.2 percent chance of occurring in any given year). *Durham, NH and Chester, PA.*
- Establish new road and street grade and building first floor elevation and infrastructure requirements covering the life-cycle of such construction based on the flood elevations projected in this study to 2050 and 2100 (i.e. preferably an elevation that exceeds current city, state, and FEMA standards). *Portsmouth, NH.*
- Improve on-site stormwater management practices such as: creating monetary & non-monetary incentives for stormwater management or re-use, including within Low Impact Development (LID) projects or creating pilot projects to demonstrate the value of on-site stormwater management (examples include green roofs, rain gardens, cisterns, and bioswales). *North Olympic Peninsula, WA*.

Flooding 2: Utilize FEMA's Community Rating System

Key strategies from the SA Tomorrow Plan	Focus Area
Join FEMA's Community Rating System program.	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- Dedicate a staff person to learn more about what is involved in participation in the FEMA Community Rating System (CRS - http://www.fema.gov/national-flood-insurance-program-community-rating-system).
- Assess and review opportunities for continuing education courses offered by FEMA's Emergency Management Institute (EMI), including courses on floodplain management and the NFIP's CRS.
- Evaluate and, if needed, develop more stringent regulations for homeowners in flood zones, so that the community is eligible for a reduction in insurance rates. *North Olympic Peninsula, WA, San Diego, CA, Swinomish, WA, Chester, PA, Lewes, DE, and Dorchester, MD.*

Flooding 3: Outreach to those living within floodplains

Key strategies from the SA Tomorrow Plan	Focus Area
Initiate a climate education campaign for businesses and property owners, including details about how to make built infrastructure more resilient to existing and projected changes in climate.	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- Develop and distribute outreach and educational materials for building owners and tenants about the risk of living in areas vulnerable to floods. *San Diego, CA and Somerset, MD.*
- Mail flood safety information, including evacuation zones and routes, and "turn around, don't drown" key messages about flash flooding, to all residents within the city. *Waveland, MS and Durham, NH.*
- Establish a homeowner education program on flood mitigation measures to encourage owners of repetitive and severe repetitive loss properties citywide to participate in mitigation activities such as flood proofing, elevation, or buyout programs, and prepare a floodplain management plan for the repetitive loss areas. *Waveland, MS and Lafourche Parish, LA.*
- Enhance efforts to educate home and business owners on the value of on-site water conservation, retention, and catchment. *North Olympic Peninsula, WA.*

Flooding 4: Acquire and remove high-risk structures in flood zones

Key Strategies from Other Communities:

- Identify sources of funding, such as FEMA, to purchase high-risk structures for demolishment or flood proofing.
- Explore creative financing programs or cheaper insurance structures to help incentivize residents to move out of vulnerable areas.
  North Olympic Peninsula, WA.

Flooding 5: Floodplain restoration

Key strategies from the SA Tomorrow Plan	Focus Area
Evaluate and adopt ordinances to create buffer zones around floodplains, riparian areas, and other natural priority areas	Natural Resources
Adopt conservation development friendly ordinances that minimize development in natural greenways, floodplains, near waterways in order to protect watershed and allow for more greenspace	Natural Resources

Key Strategies from Other Communities:

- Protect, restore, and enhance floodplains, thereby increasing the ability of the aquatic systems to hold high flows, filter sediment, and allow replenishment of groundwater stores and to address health concerns related to flooding such as controlling disease vectors. *San Luis Obispo, CA and Flagstaff, AZ.*

- Restore proper function to floodplains and stream channels. By reconnecting, re-vegetating, and re-contouring floodplains and stream channels, these systems should be used to provide water storage, groundwater recharge, sediment capture, and flood abatement and also provide essential habitat for aquatic and terrestrial species. *Dane County, WI.*

Flooding 6: Protect Wastewater Treatment

Key Strategies from Other Communities:

- Provide flood protection for key water treatment facilities and assets. Reduce flooding hazard potential along creeks, rivers, or other flowing water intake sources; flood-proof structures or features at water department sites; and protect vulnerable assets in low lying areas. *Santa Cruz, CA.*
- Continue working to reduce inflow and infiltration to wastewater systems. This could include: working to identify current inflow and infiltration to wastewater system and enhancing funding to accelerate repairs and replacement of critical areas. *North Olympic Peninsula, WA.*

Flooding 7: Update Emergency Management and Response Planning

Key strategies from the SA Tomorrow Plan	Focus Area
Establish a network of "block captains" that can be activated to go door to door to check on the health of high risk neighbors during or after a disaster.	Public Health

Key Strategies from Other Communities:

- Prior to a hazard event, identify lead contacts serving vulnerable populations and coordinate actions to maximize safety and information sharing. Leads can assist and provide support during hazard events.
- Establish a network of "block captains" that can be activated to go door to door to check on the health of high-risk neighbors. Some examples of other neighborhood emergency management outreach materials are available from Seattle (here and here) or for Baltimore City.
- Continue to work with residents to create a home emergency kit that ensures that all residents have the resources they need to survive during an event. This kit should include back-up medications, rations of food, and secondary communication technologies.
- Expand training and education of health and social services systems/providers to identify and treat mental health problems after extreme climate events.
  North Olympic Peninsula, WA; Seattle, WA; Baltimore, MD.

6.2 Extreme Heat

Heat 1: Coordinate Social Services for Extreme Heat Events

Key strategies from the SA Tomorrow Plan	Focus Area
Review effectiveness of cooling centers and other high heat day strategies and identify underserved areas for increased expansion of existing strategies or new strategies to mitigate the effects of high heat days.	Public Health
Expand the number of publicly accessible parks and open space areas within the city.	Public Health
Develop a "Healthy by Design" program for all new affordable housing projects.	Public Health
Expand the solar hosting program, increasing installations at low income and affordable housing units.	Energy
Create incentives to encourage the development of affordable housing in transit rich areas throughout the city.	Land Use & Transportation

Key Strategies from Other Communities:

- Facilitate networking and coordination of social services to vulnerable populations in anticipation of extreme heat events. *Chester, PA, Lee County, FL, and New York City, NY.*
- Evaluate and enhance the cooling plan for extreme heat events for each community, with special attention to vulnerable populations, through the expansion and provision of cooling stations throughout the city. Ensure that planning includes provision of transportation services for those who need them. *Chester, PA, Confederated Salish and Kootenai Tribes, and Lee County, FL, Baltimore, MD, Metropolitan Washington Council of Governments, and Benton County, OR.*
- Strengthen and expand the notification system for residents, schools and businesses during extreme heat events. *Chula Vista, CA, Swinomish, WA, and Benton County, OR.*
- Develop public health surveillance programs to monitor heat-related illness. *Chester, PA.*

Heat 2: Decrease the Urban Heat Island Effect

Key strategies from the SA Tomorrow Plan	Focus Area
Adopt an urban heat island mitigation ordinance for all new developments and major renovation projects.	Green Buildings & Infrastructure
Expand the number of publicly accessible parks and open space areas within the city.	Public Health
Develop a Street Tree Strategic Plan.	Natural Resources

Key Strategies from Other Communities:

- Identify "heat island" areas of the community and increase ground cover and shade by creating or expanding urban forests, community gardens, parks, and native vegetation-covered open spaces. Other strategies include green roofs, cool roofs, and cool pavements. *Lee County, FL, Austin, TX, Baltimore, MD, and Metropolitan Washington Council of Governments.*

6.3 Drought

Drought 1: Residential Water Conservation

Key strategies from the SA Tomorrow Plan	Focus Area
Update water efficiency standards in city building codes	Green Buildings & Infrastructure
Pilot a building energy and water disclosure and benchmarking program.	Green Buildings & Infrastructure
Adopt a program to phase large commercial buildings off of potable water use for landscaping.	Natural Resources

Key Strategies from Other Communities:

- Extend or enhance incentives (rebates or grants) to use of drip irrigation, rain barrels and cisterns, and other residential conservation methods. *North Olympic Peninsula, WA.*

Drought 2: Landscaping with Native and Drought Tolerant Plants

Key strategies from the SA Tomorrow Plan	Focus Area
Expand incentives for native plants/low-water use landscaping and other residential water conservation strategies	Natural Resources

Key Strategies from Other Communities:

- Enhance existing outdoor planting incentives (rebates or grants) program for native, drought tolerant plants, and rainwater-capturing landscapes.
- Partnerships with the City of San Antonio's arborists could be strengthened to maintain genetic diversity and make climate resilient and drought tolerant tree species publicly available, especially under the City's Landscaping and Tree Preservation Ordinance.
- Develop financial, regulatory, or other incentive program to promote greater use of native plants at homes and at industrial/commercial sites.
- Provide incentives for removing lawns and invasive species and replacing them with native plans.
  North Olympic Peninsula, WA.

Drought 3: Education on Water Conservation, Retention, and Catchment

Key strategies from the SA Tomorrow Plan	Focus Area
Adopt a low impact development standard requiring 100% of onsite stormwater management for all new development and significant retrofits.	Green Buildings & Infrastructure
Enhance incentives for existing developments to manage 100% of stormwater onsite	Green Buildings & Infrastructure

Key Strategies from Other Communities:

- Create outreach materials to explain to home and business owners the value of on-site stormwater retention, rainwater catchment, availability of incentives, and value to the community and ecosystems.
- Educate on the broader issue of the need for water conservation, retention, and catchment.
  North Olympic Peninsula, WA.

6.4 Wildfire

Wildfire 1: Address the Wildland-Urban Interface

Key Strategies from Other Communities:

- Manage forest density for reduced susceptibility to drought stress. This includes developing a strategy to reduce biomass fuel in the wildland-urban interface. *Jamestown S'Klallam Tribe, WA, and Santa Cruz, CA.*
- Monitor trends in forest condition and climate to proactively identify areas with high susceptibility to wildfire. *Jamestown S'Klallam Tribe, WA.*
- Develop wildfire management overlay zones for high-risk areas that control new development regarding density, building location, and design and fuel management. This may require adding additional staffing to implement these strategies. *La Plata, CO and Boulder County, CO.*
- Adopt and maintain FireWise community standards and fire buffer zones. *Swinomish Indian Tribe, WA.*
- Regulate development in and adjacent to the wildland-urban interface to require new development in high-risk areas to be responsible for fire prevention activities (visible house numbering, use of fire-resistant and fire-retardant building and landscape materials) and to also provide a defensible zone to inhibit the spread of wildfires. *Santa Cruz, CA.*

6.5 Climate Information

In many cases, it can be valuable to obtain climate projections, information, or analysis that is tailored to be useful in specific decisions. For example, some communities (such as Boulder, CO; Chicago, Il; Las Cruces, NM; Miami, OK; and San Angelo, TX) have identified key climate or weather related thresholds of concern and then had analysis done to identify potential changes to the frequency that those thresholds will be crossed in the future given different climate scenarios. This information can be useful in making decisions related to human health, water supplies, emergency management, and other city operations. ***The City, and other local and regional organizations partners who have participated in this assessment, should consider having this additional climate analysis done to help make the climate information more useful and usable by the departments and organizations across the county.***

7.0 Appendices

Appendix 1: Comprehensive Key Areas of Concern List

Temperature

1. Poor air quality/non-attainment due to increased ozone from increased temperatures (specifically affecting transportation projects that could increase capacity).
2. Decreased air quality due to increases in temperatures.
3. Increased rainfall and increased heat index resulting in increase health effects (specifically to vulnerable populations, such as the elderly, chronically ill, young, low income, etc.).

Water

1. Housing development affected by increased precipitation (building deadlines) and drought (landscaping).
2. Drought impacts:
    a. In combination with increased precipitation resulting in erosion/soil shifting
    b. Meeting peak demand for municipal water use (economic effects).
3. Water quality impacts with flooding.
4. Wastewater impacts due to increases in peak flow with flooding and drought cycles (the total costs of the Consent Decree between SAWS and the U.S. EPA is $1.2 Billion and this investment, while not driven by climate change, will likely have some co-benefits that help with reducing infiltration during heavy rainfall events).
5. Drainage costs to deal with flooding.
6. Flooding and drought impacts on crops (especially in dealing with food insecure populations).
7. Storm water pollution prevention during flooding especially during construction (2" rain=2-year storm).
8. Evacuation plans with increases in flooding.
9. Respiratory impacts due to flooding/mold.
10. Project delays due to flooding/extreme rain (Floods of 1998 and 2002 are examples), and building confidence in the flood forecasting system.
11. Economic costs/staffing to deal with increased maintenance of parks due to increases in rain (increased need to mow).
12. City Police Department staffing strains/risks during times of flooding/road closures.
13. Metro Transportation interruptions and impacts to evacuations due to flooding.
14. Drought and the economic effects to drawing new business to City.
15. Drought and fire impacts/incidence.
16. Drought and financial impacts to deal with conservation.
17. Flooding and revenue shortfalls for municipal water usage: less use by the public equates to less money for SAWS.
18. Lots of variability in the impacts due to flooding in the city:
    a. "Significant intersections"
    b. Woodlawn
    c. 281 Basin
    d. Watershed Master Plans' Damage Centers
    e. Floodplain—15,000 structures within the 100-year flood plain
    f. Leon Creek
    g. East Side

h. Plumb Mobile Home Community
i. Low Water Crossings (220 within the city)

Other Extreme Weather Events

1. High winds and their impacts on power supply and resulting oil spills.
2. Ice and transportation impacts (e.g. bridge structures and road closures).
3. Wildfires and secondary impacts from hurricanes and micro-bursts.
4. Extreme/High Winds.

Appendix 2: Resilience Advisory Committee Members

Resilience Advisory Committee Members	
Name	**Organization**
Donovan Agans	University Health System
Leroy Alloway	Alamo Area MPO
Jose Banales	San Antonio Police Department
Robert Brach	Bexar County Public Works
Alison Buck	VIA Metropolitan Transit
Anthony Chukwudolue	City of San Antonio (CoSA) Transportation & Capital Improvements
Steven Clouse	San Antonio Water System
Kyle Coleman	Emergency Management Coordinator, Bexar County OEM
Adam Conner	San Antonio Water System
Rene Dominguez	CoSA Economic Development Office
John Dugan	CoSA Planning & Community Development
Gregg Eckhart	San Antonio Water System
Karen Guz	San Antonio Water System
Nathaniel Hardy	Bexar County Flood Control
Terry Kannawin	CoSA Development Services
Beth Keel	San Antonio Housing Authority
Rachelle Littlefield	San Antonio Office of Emergency Management
Elizabeth Lutz	Bexar County Health Collaborative
James Mendoza	San Antonio Office of Emergency Management
Roger Pollok	CoSA SAMHD
Abigail Rodriguez	VIA
Darcie Schipull	Texas Department of Transportation
Kim Stoker	CPS Energy
Lawrence Trevino	San Antonio Office of Emergency Management
Wayne Tschirhart	SARA
Xavier Urrutia	CoSA Parks and Recreation
Carl Wedige	CoSA Fire
Paul Yura	National Weather Service

Appendix 3: Sensitivity and Adaptive Capacity Levels

The relative vulnerability of the Key Areas of Concern depends on the combination of the *sensitivity* and *adaptive capacity* scores.

Sensitivity Levels	
S0	System will not be affected by the impact
S1	System will be minimally affected by the impact
S2	System will be somewhat affected by the impact
S3	System will be largely affected by the impact
S4	System will be greatly affected by the impact

Adaptive Capacity Levels	
AC0	System is not able to accommodate or adjust to impact
AC1	System is minimally able to accommodate or adjust to impact
AC2	System is somewhat able to accommodate or adjust to impact
AC3	System is mostly able to accommodate or adjust to impact
AC4	System is able to accommodate or adjust to impact in a beneficial way

Appendix 4: Vulnerability Assessment Worksheet Instructions

Vulnerability and Adaptive Capacity Exercise

Instructions

Column 1 **Key Area of Concern –** This lists the Key Area of Concern to analyze and consider for this activity.

Column 2 **Changing Climate Condition –** Input the climate condition that would impact that key area of concern listed in Column 1.

Column 3 **Current Climate/Weather Impacts –** Identify how existing and historic changes in weather and climate have affected or are currently affecting the key area of concern listed in Column 1.

Column 4 **Possible Future Impacts** – Identify possible impacts to the key area of concern if the projected changes in climate (Column 2) take place.

Column 5 **Non-Climate Stressors –** Record any non-climate factors that currently affect (positively or negatively) the key area of concern.

Column 6 **Assign Sensitivity –** Using the orange *Exposure & Sensitivity Levels* table (below) decide how sensitive you believe this key area of concern is to the changing climate condition and input this number into column 6 (i.e.: S4).

Column 7 **Ability to Adapt -** Identify existing attributes or assets of the key area of concern that will help it adapt to the changing climate condition.

Column 8 **Resources Needed -** Identify any external resources or actions that the key area of concern will need to adapt to the changing climate condition.

Column 9 **Assign Adaptive Capacity -** Using the purple *Adaptive Capacity Levels* table, assess how much capacity you believe the key area of concern has to adapt to the changing climate condition and input this number into column 9 (i.e.: AC2).

Repeat steps for each Key Area of Concern

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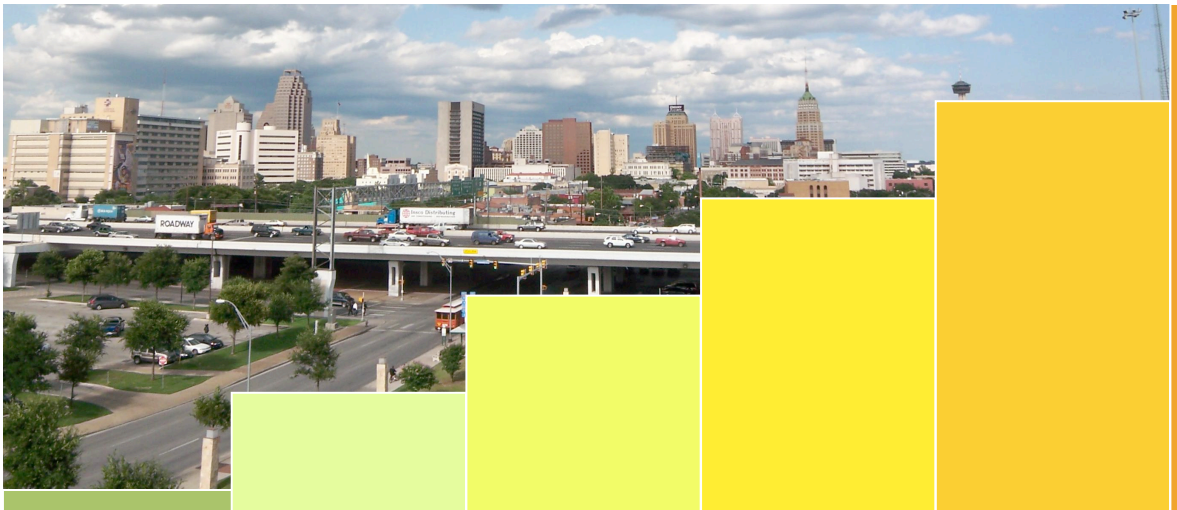

Appendix C

Climate trends in San Antonio

and an overview of climate projections for the South Central region

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ATMOS Research & Consulting

MAY 2015, REVISED

EXECUTIVE SUMMARY

In this report, we discuss what scientists know about why climate is changing, and what this means for the future. We analyze observed trends in San Antonio and compare them with those seen across Texas and South Central region. Finally, we summarize qualitative projected future changes across the South Central region as described in the U.S. National Climate Assessment.

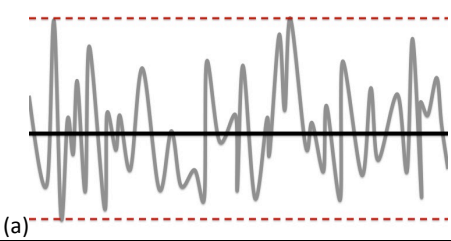
Why does climate matter?

For cities, states, and agencies charged with managing and maintaining public infrastructure and services, climate is important because it dictates the range of conditions that might be expected in a given location. Climate is typically defined as the long-term average of weather over multiple decades. It encompasses a host of relevant variables relevant to city planning, including:

- average winter and summer temperatures, which in turn can be translated into demand for heating and cooling;
- the frequency of heat waves and cold snaps that affect public health as well as the integrity of energy systems and infrastructure;
- the growing season, which determines the types of trees and plants that can grow in a given place, as well as which invasive species and pests might be expected;
- average rainfall amounts and how they vary from year to year, which help cities plan for water availability and drought; and
- rainfall extremes that affect transportation infrastructure and buildings, and determine the frequency of events such as the hundred-year flood.

When planning for the future, it is often assumed that past climate will serve as a reliable guide for future conditions, as illustrated in Figure 1a. Today, however, climate is changing: here in Texas, across the United States, and around the world. This is affecting average conditions and the risk of many types of weather extremes both now and in the future. Today, climate looks more like Fig. 1b.

Infrastructure, building codes and many other types of planning require information on climate conditions to meet performance standards. Most such planning assumes *stationarity* – that climate will be stable, or stationary, over multiple decades despite variations in temperature, rainfall, and other aspects of climate from year to year. Climate change matters to cities because it introduces *non-stationarity* into our systems. If long-term climate is changing, it no longer stable. This means that historical conditions are no longer a reliable predictor for the future. In fact, in a changing climate, relying on historical conditions to predict the future could give us the wrong answer to many of our questions.



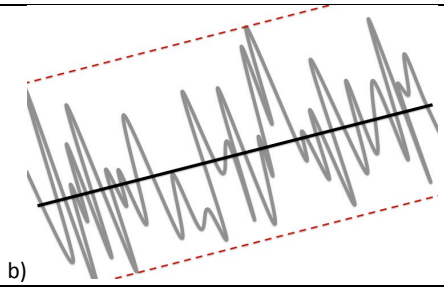


Figure 1. A conceptual illustration of year-to-year average temperature in (a) a stable climate versus (b) a changing climate. *Source: K. Hayhoe*

Why is climate changing?

Over the last 150 years, long-term weather station records have documented a 1.5°F increase in the Earth's average temperature. At the global scale, each decade has successively been warmer than the decade before, and 2014 was the warmest year on record to date. Although 1.5°F may not sound like much, over the course of western civilization the Earth's temperature has been as stable as that of the human body. Just as a small increase in our body's temperature serves as a warning of a possible fever, in the same way a small increase in the Earth's temperature also warns us that climate is changing.

Climate has changed before, as a result of natural causes. These natural causes are well-known. They include: (1) changes in amount of energy the Earth receives from the Sun, (2) natural cycles like El Niño that exchange heat between the ocean and atmosphere, (3) periodic cycles in the Earth's orbit that bring the ice ages and the warm interglacial periods like we are in right now, and (4) the cooling effects of dust clouds from powerful volcanic eruptions.

When we see climate changing today, the first place to look is these "usual suspects". Could the Earth's temperature be warming because of natural causes?

- **The Sun.** For the Sun to be responsible for the observed increase in the Earth's temperature, the energy from the Sun should be increasing. However, the Sun's energy has been going down, not up, since the mid-1970s. Hence, if the Sun were responsible for climate change today, the planet would be getting cooler, not warmer (Figure 2, top).
- **Natural Cycles.** Natural cycles like El Niño occur inside the Earth's climate system. These cycles do not create or destroy heat – they just move it back and forth, from east to west, or north to south, or between the ocean and atmosphere. So if the Earth's near-surface air temperature were warming all around the entire planet due to a natural cycle like El Niño, that heat would have to be coming from somewhere else within the Earth system, like the ocean. Measurements of the heat content of the entire Earth system, however, have shown that every part of the climate system is warming: the atmosphere, the land surface, the cryosphere (ice), and the ocean. In fact, the ocean is absorbing 20 times more heat than the rest of the climate system put together. This means that the observed warming can't be due to a natural cycle within the Earth system, because that cycle can only move heat around, it can't create extra heat. The warming has to be coming from somewhere else.
- **The Earth's Orbit**. Slow, periodic changes in the shape of the Earth's orbit and the tilt of the Earth's axis of rotation alter how the Sun's energy falls on the Earth. These changes in turn can trigger the advance of the ice sheets, or the end of the ice ages and the beginning of the warm interglacial periods such as we are in today. Could the Earth still be warming since the last ice age? According to long-term climate records, the warming after the last ice age peaked around

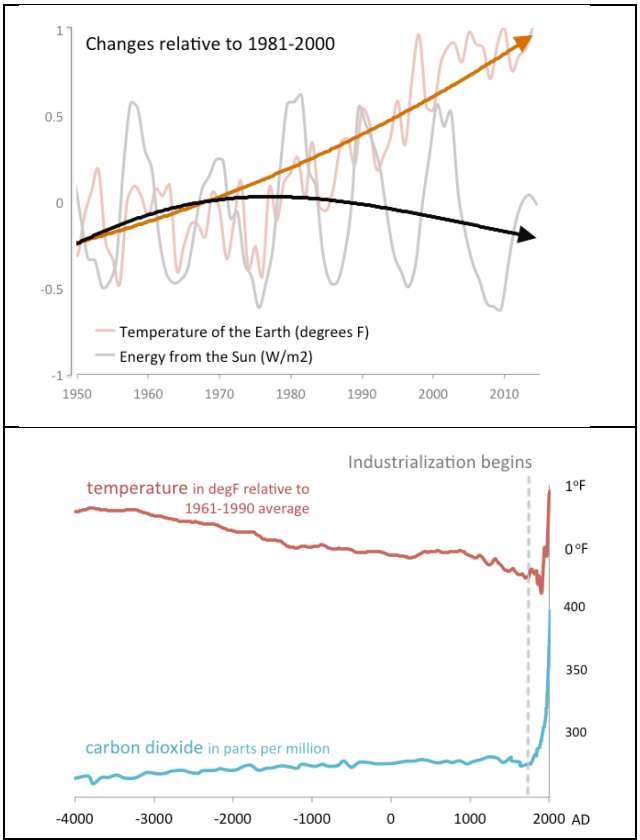


Figure 2. (TOP) Observed changes in the Earth's temperature (red) and energy from the Sun (black) from 1950 to present. Thin lines show the year-to-year values, while thick lines show the long-term trends. (BOTTOM) Observed changes in the Earth's temperature (red) and carbon dioxide levels in the atmosphere (blue) over the last 6,000 years. *Source: K. Hayhoe, with data from NASA GISS, Lean et al., PMOD, Marcott et al., Mauna Loa, and Epica.*

8,000 years ago. Since then, the Earth has been cooling gradually in preparation for the next ice age – until just recently, that is. (Figure 2, bottom)

- **Volcanoes**. When volcanoes erupt, they spew dust, ash and soot high up into the atmosphere. If the volcano is powerful enough, these particles can reach all the way to the stratosphere, where they can circle the globe for months and even years. There, they act as an umbrella, reflecting the Sun's energy back to space and cooling the Earth. Because they have a cooling effect, they cannot be causing the planet to warm.

Figure 2 provides a clue as to why climate may be changing today. Since the Industrial Revolution, atmospheric levels of heat-trapping gases such as carbon dioxide and methane have been rising due to the burning of fossil fuels such as coal, oil, and natural gas. Other activities, such as agriculture, wastewater treatment, and extraction and processing of fossil fuels also produce heat-trapping gases and particles that affect climate. Volcanoes produce some carbon dioxide and methane as well; however, emissions from natural geologic sources are less than 10% of emissions from human sources.

These heat-trapping gases exist naturally in the atmosphere, where they act like a blanket, trapping the heat given off by the Earth that would otherwise escape to space. The trapped heat keeps the Earth nearly 60°F warmer than it would be otherwise. However, artificially adding more of these gases in the atmosphere is like wrapping an extra blanket around the planet. This extra blanket traps too much of the heat given off by the Earth. This extra heat is what's increasing the temperature, and the heat content, of the atmosphere and ocean.

Recent studies have concluded that human influence, specifically the increases in emissions of carbon dioxide and other heat-trapping gases from human activities, is responsible for most of the warming over the last 150 years. A number of studies conclude that humans are responsible for *more than 100%* of the warming over the last 60 years, since the Sun and orbital cycles would be causing the planet to get cooler, not warmer, over this time. Surveys of the scientific literature and of climate scientists studying this topic have found that over 97% of scientists agree that humans are the primary reason climate is changing today.[1,2]

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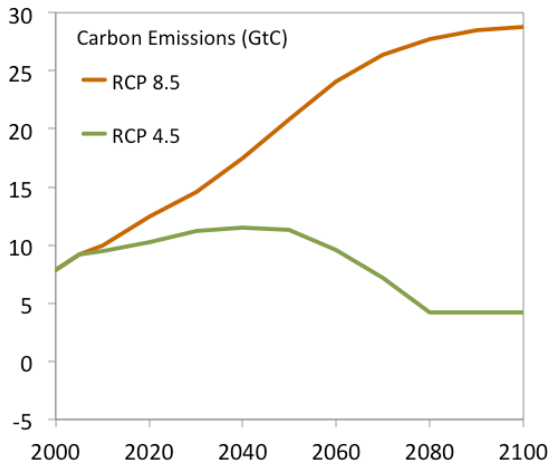


Figure 3. Climate change projections used in the U.S. National Climate Assessment and other regional analyses typically contrast the climate change expected under a higher scenario (red), where human emissions of carbon dioxide and other heat-trapping gases continue to rise, with a lower scenario (green), where emissions peak and then begin to decline by mid-century. This figure compares the carbon emissions corresponding to each scenario, in units of gigatons of carbon per year (GtC). *Source: K. Hayhoe, with data from IIASA*

Even if humans are causing climate to change, why does it matter what or who is responsible? Can't we just look at past trends and use those as a guide to the future?

The reason why climate is changing matters, because it affects our future projections. If climate is changing due to natural causes, we would base our future projections on those causes: the Sun, or natural cycles. However, if climate is changing due to human activities, then we must base our future projections on how much heat-trapping gases we produce from human activities.

Over the next few decades, climate will continue to change regardless of how much carbon we are putting into the atmosphere. This is due to two reasons: first, the inertia of the climate system in responding to human emissions, and second, the inertia of the global economy in transitioning from carbon-emitting to clean sources of energy. The further out we go, however, the more the amount of future climate change depends on human emissions of carbon dioxide and other heat-trapping gases occurring now and over the next few decades. By the 2050s, there is a noticeable difference between the amount of climate change projected under a higher versus a lower emissions scenario.

Higher scenarios of carbon emissions (Figure 3, red line), that assume continued dependence on fossil fuels such as coal, gas, and oil, produce greater amounts of temperature change. Lower scenarios (Figure 3, green line), that envision a transition from fossil fuels to non carbon-emitting renewable energy sources, result in smaller amounts of temperature change. To quantify the range of future climate change that might result from human choices over this century, the projections used by the National Climate Assessment usually compare the climate changes that would be expected under a higher versus a lower scenario.

For more information, see the Third National Climate Assessment's Climate Science Appendix and Frequently Asked Questions, available online, and Katharine Hayhoe's TEDx talk, "What if climate change is real?".

[2] Doran P & M. Zimmerman. 2009. Examining the scientific consensus on climate change EOS Trans. Am. Geophys. Union 90 22–3

How is climate changing in Texas and the United States?

In the United States, average temperature has increased by 1.5°F since 1900, with most of the increase occurring in the last 30 years (Figure 4, top). The Third National Climate Assessment (NCA3) highlights a number of observed changes in climate, including:

- More frequent heavy precipitation events, particularly in the Northeast and Midwest, but also over the South-Central region that includes Texas
- Increasing risk of heat waves across the U.S.
- Increased risk of floods (particularly in the Midwest and Northeast), droughts and wildfire risk (particularly in the western U.S.)
- Decreases in Arctic sea ice, earlier snow melt, glacier retreat, and reduced lake ice
- Sea level rise and increased storm surge risk
- Warming oceans and stronger hurricanes
- Poleward shifts in many animal and plant species, as well as a longer growing season

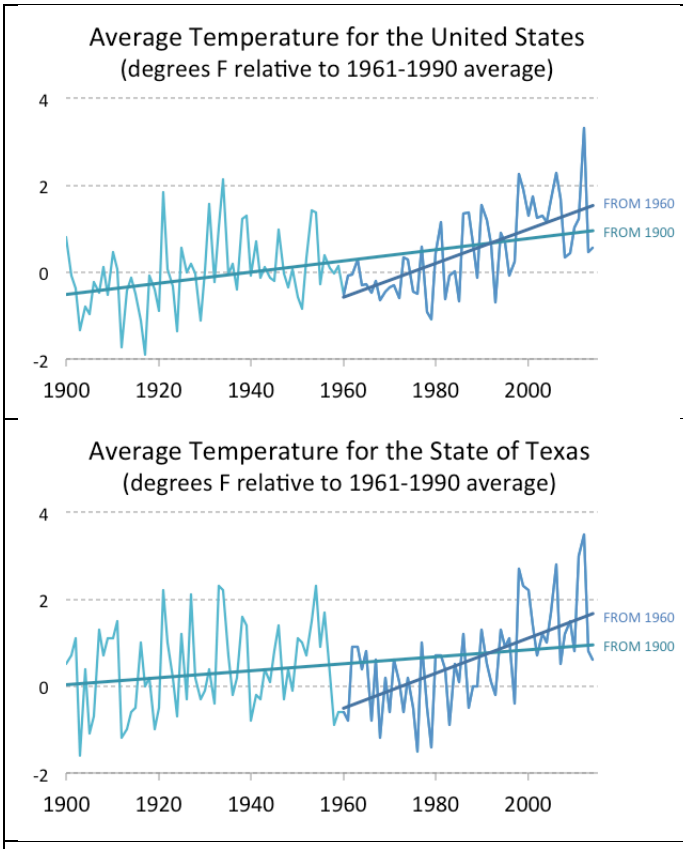


Figure 4. Observed change in annual mean temperature for the contiguous United States (top) and the state of Texas (bottom), in degrees F relative to the 1961–1990 average. Year-to-year values are indicated by the jagged lines, and long-term trends by the straight lines. *Source: K. Hayhoe, based on data from NOAA*

In Texas, annual average temperature has increased by slightly less than the national average, 0.9°F since 1900 (Figure 4, bottom). Trends at individual weather stations are more variable, as they reflect both long-term regional trends as well as more localized influences such as land use change. Despite their variability, station-based analyses show that seasonal average temperatures are increasing in both winter and summer at many locations across Texas (Figure 5, top), and there are also consistent trends in the number of nights per year below freezing at most locations (Figure 5,

bottom). For more information on this analysis, see Gelca et al., "Observed trends in air temperature, precipitation, and water quality for Texas reservoirs: 1960-2010".

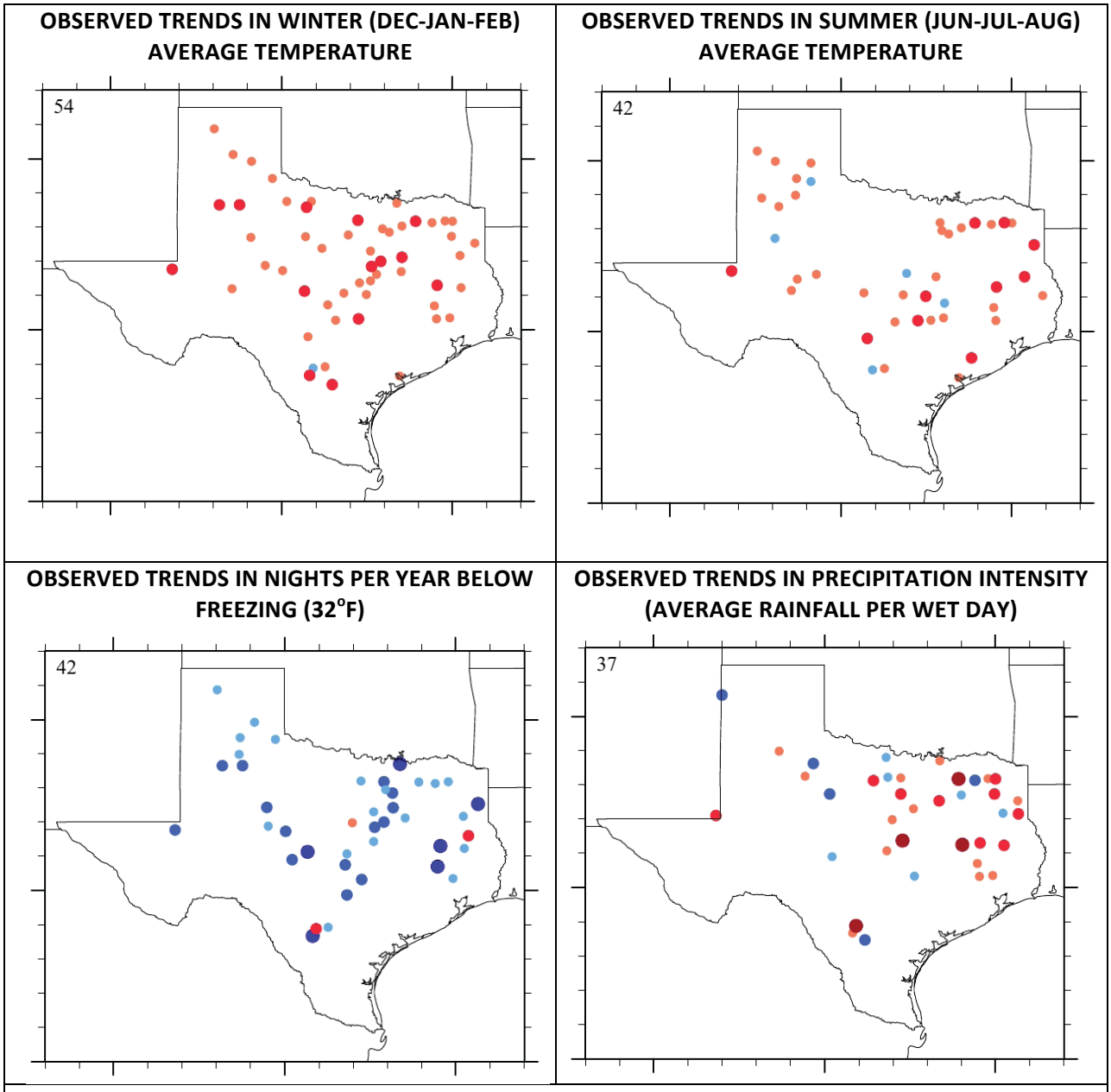


Figure 5. This map shows observed trends from 1960 to 2010 for individual weather stations across the state of Texas. Each dot indicates one weather station. The color and size of each dot shows the direction and strength of the trend. Blue dots indicate decreasing trends while red dots indicate increasing trends. Larger dots with darker colors show stronger trends.

The four maps show observed trends in four different variables: (1) average winter (Dec-Jan-Feb) temperature (top left), (2) average summer (Jun-Jul-Aug) temperature (top right), (3) the number of nights per year with minimum temperature below 32°F (bottom left) and (4) precipitation intensity, measured as annual average rainfall divided by the number of wet days per year (bottom right). Only trends that are **significant** (with a p-value equal or less than 0.1, indicating that there is a 99% or greater chance that the trend is real) are shown. *Source: Gelca, Hayhoe & Scott-Fleming (2014)*

Annual precipitation trends vary by geographic region and season. In general, wet areas are becoming wetter, while dry areas experience more frequent dry conditions. This axiom is borne out in the state of Texas, which has experienced a slight increase in rainfall over the eastern half and a slight decrease over the western half of the state over the past century (Figure 6 top).

As air temperatures warm, more water evaporates out of soils, oceans, lakes, rivers and streams. This leaves behind drier conditions, but also means that when a storm comes along, this means that there is more water vapor available for the storm to pick up and dump as precipitation.

This simple relationship explains both the increasing risk of stronger droughts *and* the simultaneous increase in heavy precipitation events that is being observed across many parts of the United States and around the world. At the global scale, the increase in heavy precipitation has been formally attributed to human-induced warming. While trends at the local scale are more variable, they are still consistent with the relationship between warmer temperatures and more frequent extreme precipitation (Figure 6, bottom).

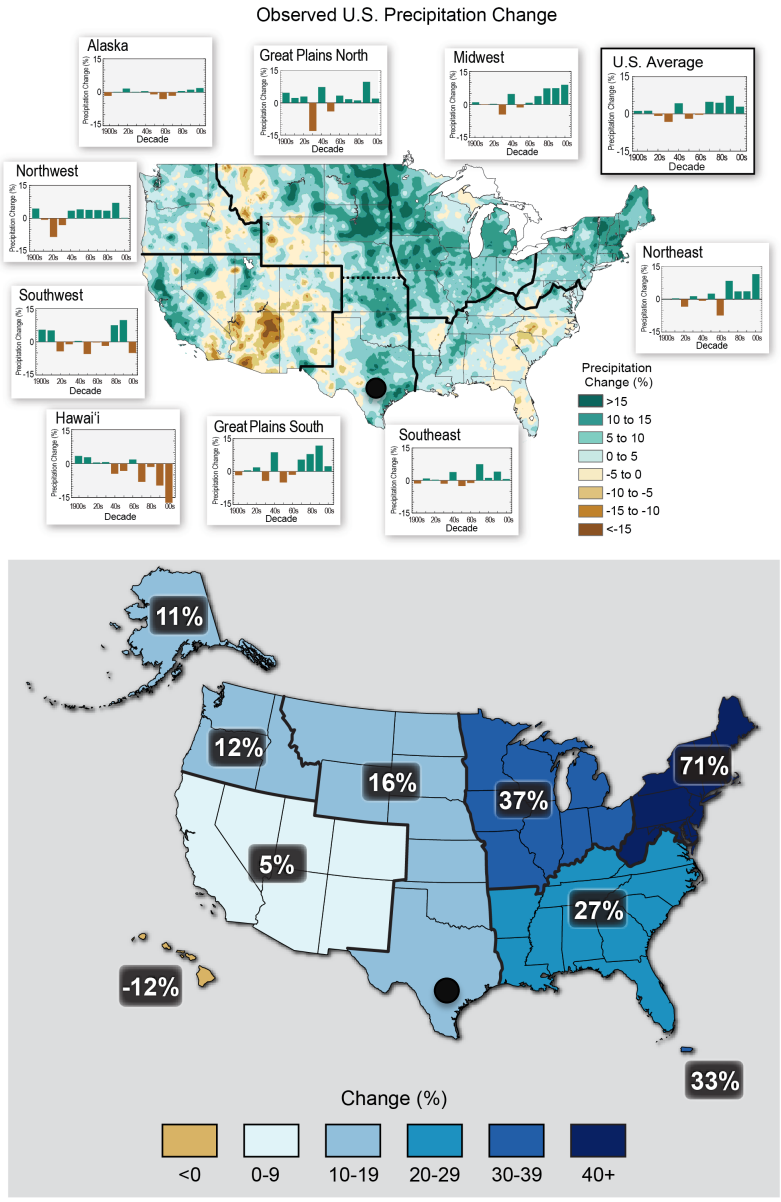


Figure 6. Observed change in (top) average annual precipitation for 1991-2012 compared to the 1901-1960 average, and (bottom) for very heavy precipitation events (defined as the heaviest 1% of all daily events) from 1958 to 2012. Black dots indicate the approximate location of San Antonio. *Source:* NCA3

At the level of the individual weather station, precipitation intensity can be affected by many factors, including local sources of water such as irrigation or reservoirs. Even so, analysis of long-term weather stations across Texas show significant increases in precipitation intensity across central and eastern Texas, where average rainfall has also increased (Figure 5, bottom right).

How has San Antonio's climate changed?

At the San Antonio International Airport weather station, analysis of observed daily temperature and rainfall records shows trends that are consistent with those observed over the United States and Texas, as described above.

For temperature, we found significant[3] and positive (increasing) trends in every temperature indicator tested. This includes:

- Average winter and summer temperature
- The number of "warm and hot days" per year, with maximum daytime temperatures greater than 80, 90, and 100°F
- The number of "warm nights" per year, with minimum nighttime temperatures above freezing

The magnitude of the trend for each of these indicators is summarized in Figure 7, while Figure 8 compares the long-term trend with year-to-year variations.

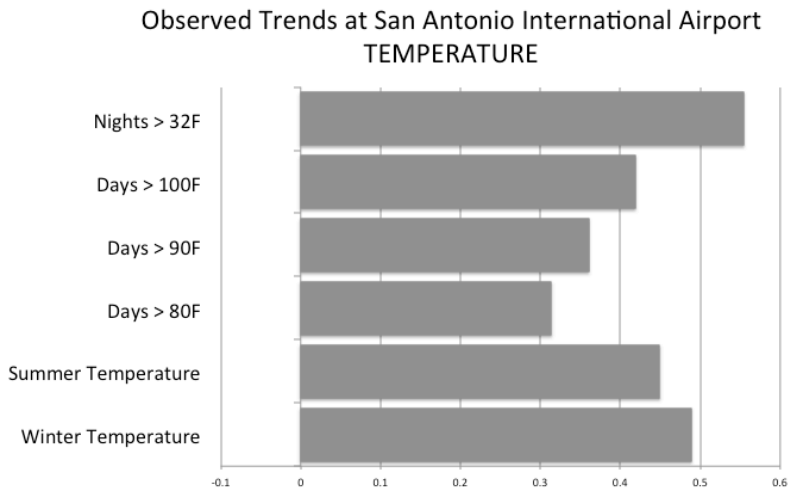
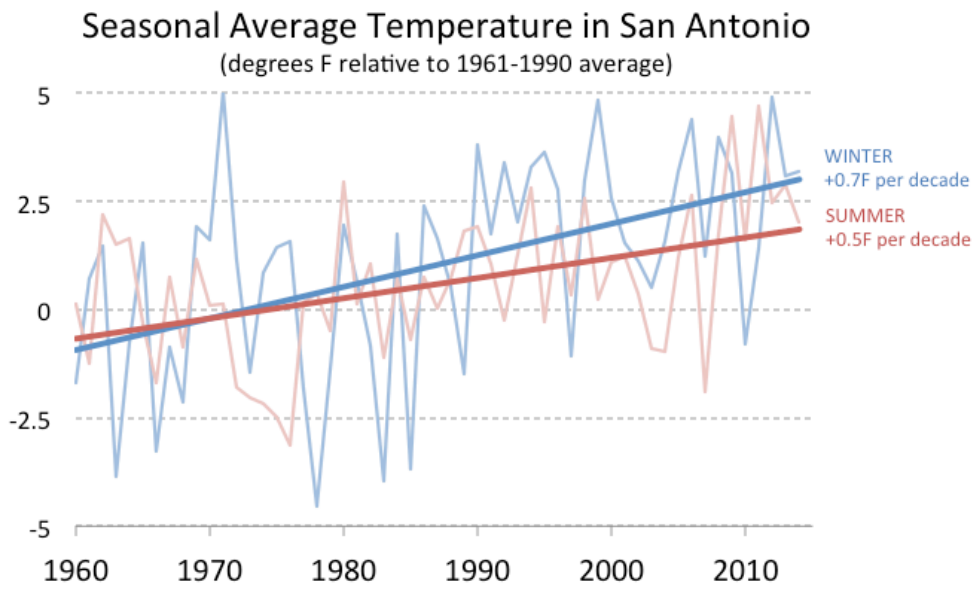


Figure 7. Observed trends in temperature indicators at the San Antonio International Airport weather station, from 1960 to 2014. All of the trends are significant trend ($p<0.1$). Values are the Pearson correlation coefficient; higher values indicate stronger trends. *Source: K. Hayhoe*

[3] Throughout this report, the word "significant" is used in its formal statistical sense, to denote trends that are significant at or above the 99th percentile – in other words, that there is a 99% or greater chance that the trend is real. Significance is measured by p-value; for significant trends, the p-value must be equal to or below 0.1. A variable may have a trend, but if the trend is not yet strong enough and/or if the data is very noisy, the trend will not be significant according to the formal statistical definition.



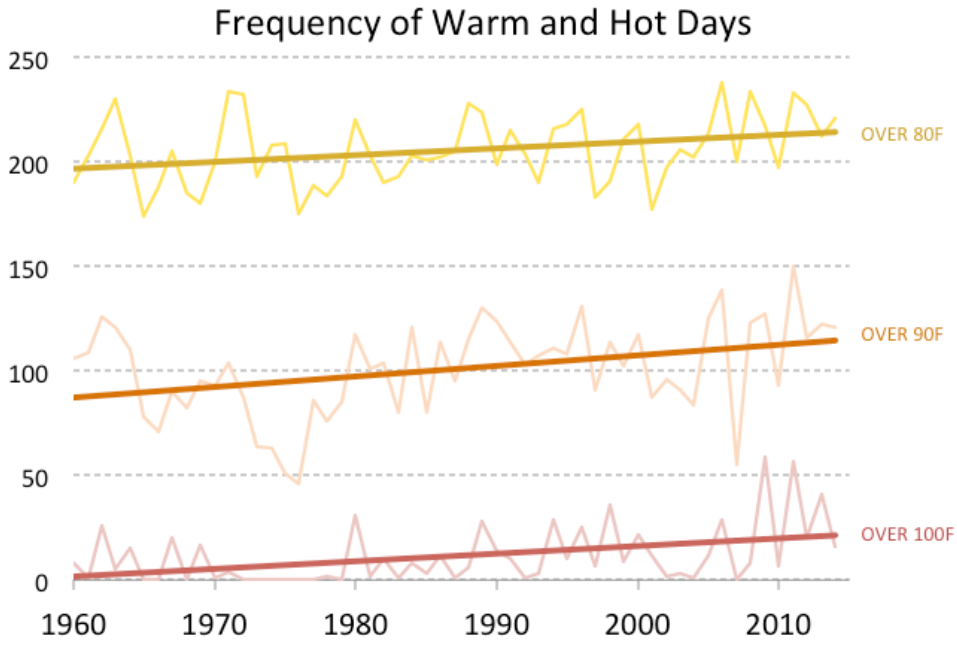


Figure 8. Observed year-to-year values (thin lines) and long-term trends (thick lines) in winter and summer mean temperature (top), and in the number of days per year with maximum temperature exceeding 80, 90, and 100°F (bottom) at the San Antonio International Airport weather station from 1960 to 2014. All trends are significant. *Source: K. Hayhoe*

There were trends in many of the precipitation indicators tested here as well (Figure 9). However, none of the trends were significant in the formal statistical sense.[3] Lack of significance may mean that a trend was not yet strong enough, or the data was too noisy, or a trend was spurious.

Of the non-significant trends in observed precipitation from 1960 to 2014, small increases in spring and fall rainfall were offset by small decreases in winter and little change in summer. Overall, there was a small increase in average annual precipitation. This trend is consistent with the broader regional trend shown in Figure 6 (top).

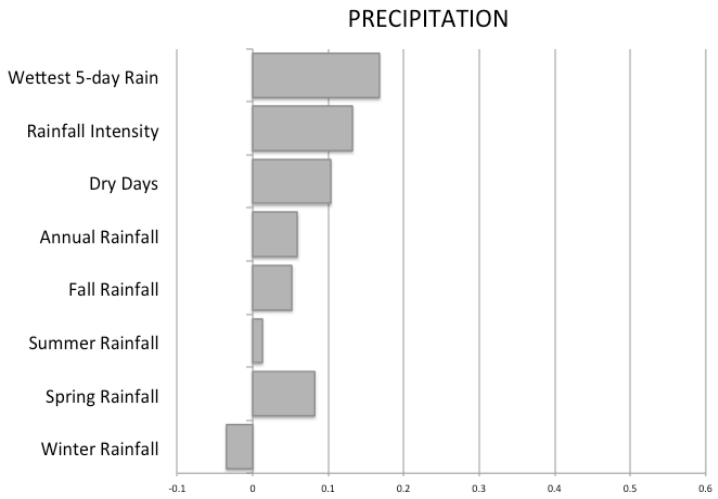


Figure 9. Observed trends in precipitation indicators at the San Antonio International Airport weather station, from 1960 to 2014. None of the trends are significant ($p<0.1$). Values are the Pearson correlation coefficient; higher values indicate stronger trends. *Source: K. Hayhoe*

Larger (but still not statistically significant) trends were observed in measures of rainfall intensity. Specifically, we found increases in the average number of dry days per year, as well as in average rainfall intensity (the average amount of rain falling on any given wet day during the year) and the amount of rainfall in the wettest 5 days of the year. These positive trends in both rainfall extremes and dry days are consistent with little change in annual average rainfall. If the total amount is not changing by much, but it is becoming more intense, then by definition there must be longer dry periods in between the rain. These trends are also consistent with the broader regional trends discussed in the previous section, and summarized in Figure 6 (bottom).

Analysis of the year-by-year values shows that annual rainfall has become more variable from one year to the next. From 1960 to the 1980s, the standard deviation (a measure of the average difference between one year to the next) was 7 inches. This value increased to 10 inches between the 1980s and now (Figure 10, top). Similar changes in year-to-year variability are seen in precipitation intensity (Figure 10, middle) and in the amount of rain falling during the wettest 5 days of the year. In terms of the rain falling during the wettest 5-day period of the year, the standard deviation increases from 1.5 to 3.5 inches between the same two time periods (Figure 10, bottom). Based on this analysis, it is not possible to determine whether this change is consistent with long-term trends in climate, or whether it is simply a natural variation in the precipitation record.

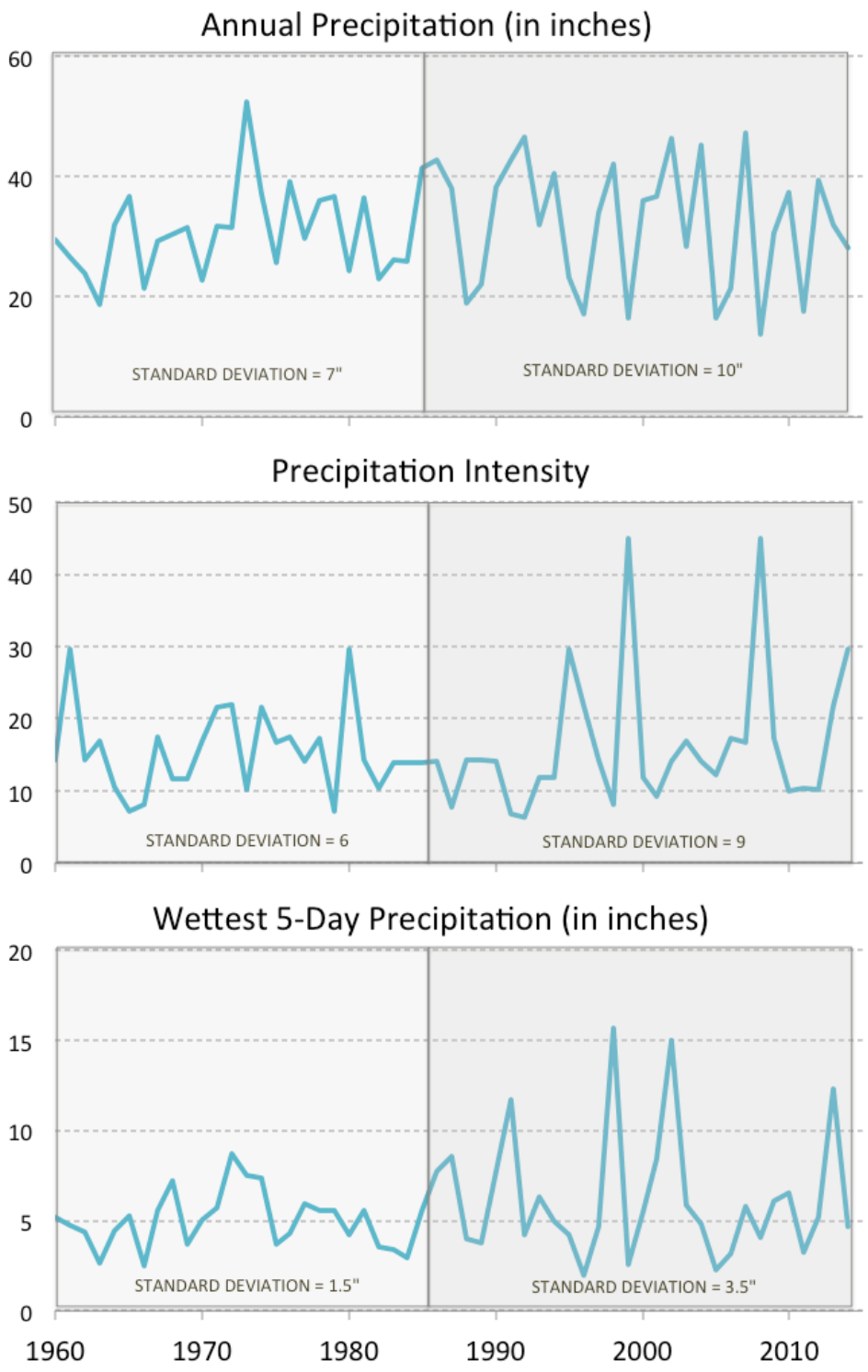


Figure 10. Observed year-to-year values in annual precipitation (top), in precipitation intensity (middle), and in the amount of rain falling during the wettest consecutive 5 days of the year (bottom) at the San Antonio International Airport weather station from 1960 to 2014. None of these variables are significant according to the formal statistical definition. However, there is some indication of a shift in variability in the mid-1980s. Whether this is natural or related to long-term climate trends remains to be decided. *Source: K. Hayhoe*

What do we expect for the future?

Although the future is uncertain, scientists can break down the uncertainty in future climate change into three specific sources:

1. **Internal (natural) variability of the climate system** is the result of interactions between different components of the climate system, such as the exchange of heat energy between the ocean and the atmosphere. It is most important over the short term (from year to year) and at smaller spatial scales. Beyond these time frames, long-term climate trends become meaningful. In NCA3, we[4] accounted for natural variability by comparing projected climate changes averaged over 30 years in the future (e.g. 2041–2070) to historical climate conditions averaged over a similar 30-year period (e.g. 1971–2000).
2. **Scientific uncertainty** arises because scientists' ability to model and predict the response of the climate system to global change is limited and incomplete. To account for scientific uncertainty, in NCA3 we used simulations from a broad range of different climate models, as the average of a large set of simulations is nearly always closer to reality than any individual model or sub-set of models.
3. **Scenario uncertainty** is the result of not being able to predict human behavior. Future emissions of heat-trapping gases will be driven by human choices including population, technology, and policy. This uncertainty becomes most important past mid-century. To encompass the range of possible futures, in NCA3 we compared projections of what would be expected under a higher as compared to a lower future scenario.

At the global scale, additional temperature increases between 2°F and 9°F are expected by end of century, depending on the amount of carbon emissions humans produce. This is expected to be accompanied by increases in extreme heat and heavy precipitation events. For most temperature and some heavy precipitation indicators, a higher emissions scenario is expected to result in greater amounts of change; lower emissions, in comparatively smaller amounts of change.

NCA3 projections for the United States show increases in average temperature across the country, with greater increases under a higher as compared to a lower future scenario (Figure 11, top). By the end of the century, average temperature is projected to increase by an average of 4–5°F under a lower scenario and 7–8°F under a higher scenario across central Texas.[5] NCA3 projections also show increases in the frequency of hot days and warm nights, defined as the hottest 7 days or nights during the historical period. Across central Texas, there are expected to be between 2 to 3

[4] I developed the high-resolution climate projections used throughout NCA3 and served as a lead author for Chapter 2 and the Climate Science and Frequently Asked Questions Appendices.

[5] In this report, "central Texas" refers to the region encompassing San Antonio and central Texas. It is not possible to be any more specific without generating climate projections for the city.

more weeks' worth of hot days by mid-century, depending on the scenario, and 4 to 7 more weeks' worth of warm nights (Figure 11, bottom).

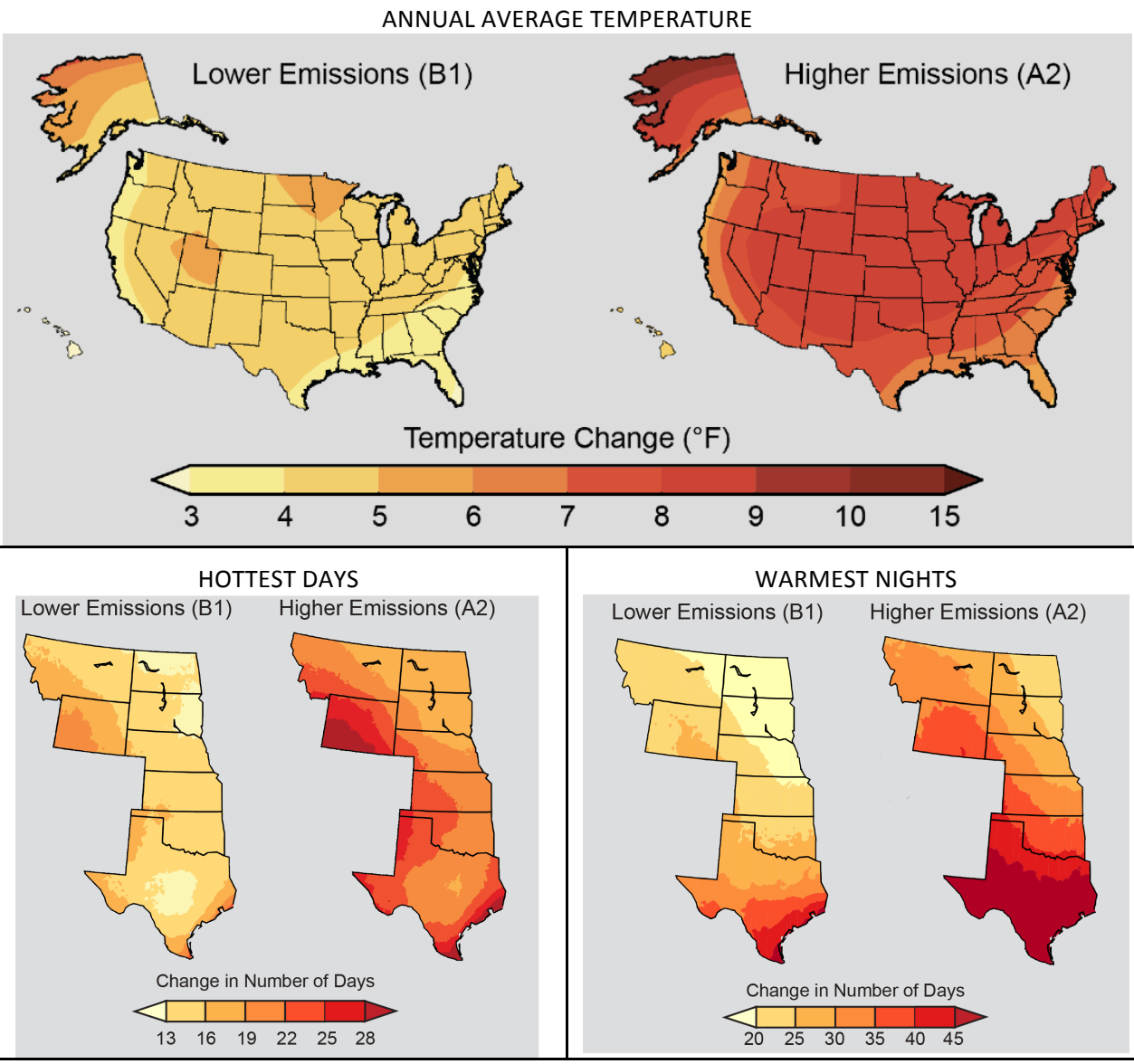


Figure 11. Projected future changes in average annual temperature (top) and in the frequency days where temperatures are greater than the seven hottest historical days (bottom right) or greater than the seven warmest historical nights (bottom left), for the period 2070-2099 (top) and 2041-2070 (bottom) relative to 1971-2000. All maps compare projections of what would be expected under a lower versus a higher scenario of human emissions. Source: NCA3, data from K. Hayhoe

In terms of precipitation, global projections as well as projections across North America show a general pattern of "wet regions becoming wetter and dry regions becoming drier". The largest changes in seasonal annual precipitation are projected for winter and spring, when much of Texas, along with the Southwest, is projected to become drier on average (Figure 11, top). NCA3 projections also show a fractional increase in the frequency of wet days per year, around 1 more day every 3 to 5 years, and an increase in the average length of dry periods of around 1 to 4 days

per year. It is not possible to provide any further detail without developing customized projections for San Antonio.

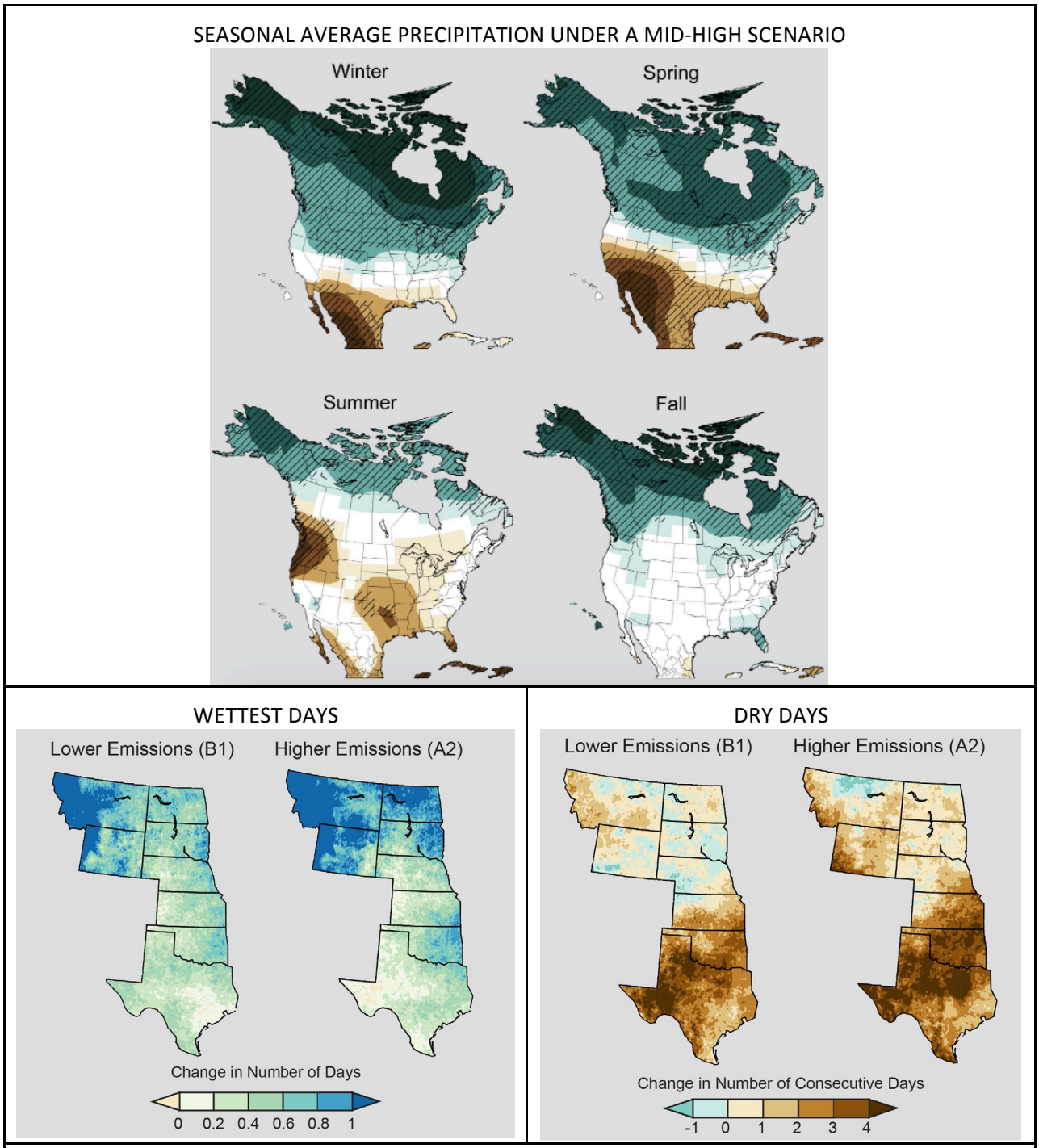


Figure 12. Projected future changes in annual precipitation (top), in the number of future days per year with more precipitation than on the seven wettest historical days per year (bottom right), and the longest stretch of consecutive dry days per year (bottom right) for the period 2070–2099 (top) and 2041–2070 (bottom) relative to 1971–2000. All maps compare projections of what would be expected under a lower versus a higher scenario of human emissions. Source: NCA3, data from K. Hayhoe

The 2011 U.S. National Research Council report, Warming World: Impacts by Degree, quantifies some of the impacts that would be expected to increase per degree of global warming. For example, for each degree-Celsius (or 1.8°F) that global temperature increases, we would expect:

- An increase the amount of rain falling during heavy precipitation events of 3 to 10 percent
- A decrease the amount of streamflow and runoff averaging around 7% across the Texas Gulf region and 12% across the Rio Grande region
- A reduction in the yields of common crops including wheat and maize by 5 to 15 percent worldwide
- An increase the area burned by wildfire in the western United States by 70 to 400 percent

Using this same approach of quantifying future impacts by degree, we calculated the risk of future drought conditions, as defined by the seasonal mean Standardized Precipitation Index. As global temperature increases by 1, 2, 3 and 4°C, the risk of dry conditions across much of Texas is projected to increase in spring. In summer, central Texas initially shows little change. By the time the world warms by +3°C, however, dry conditions are projected to become more frequent in summer as well (Figure 13).

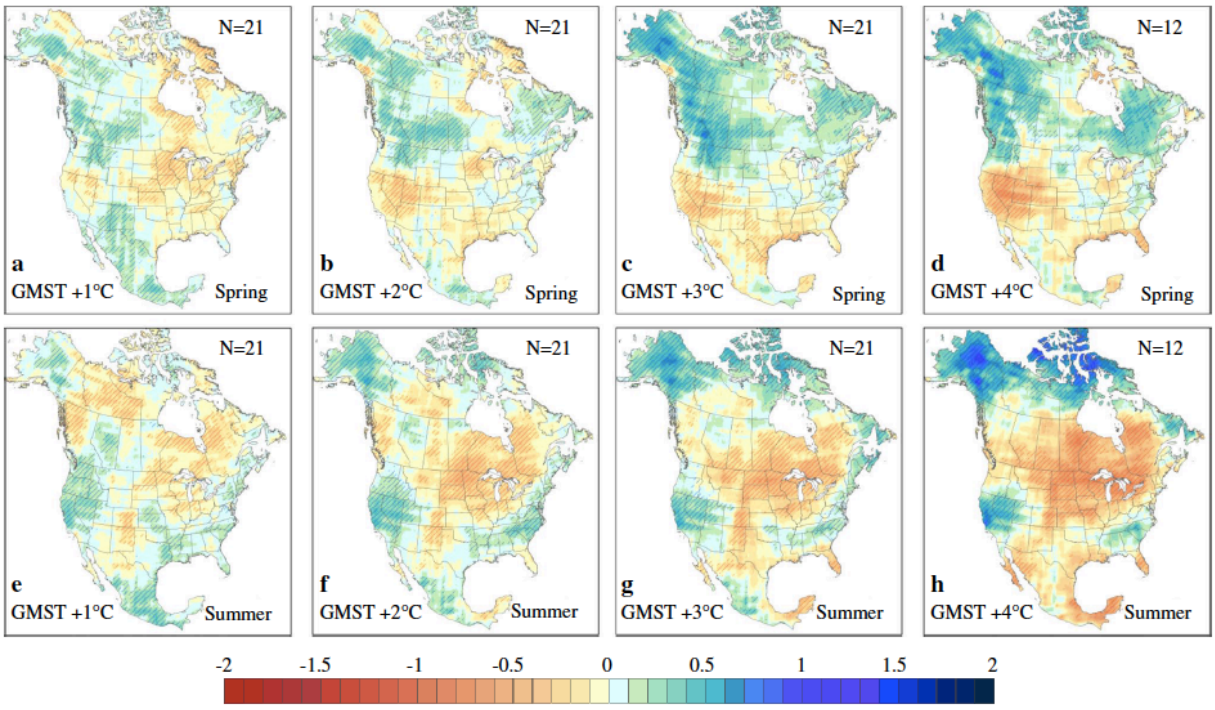


Figure 13. Projected change in Standardized Precipitation Index for a +1, 2, 3, and 4°C increase in global mean surface temperature (GMST) relative to the historical period 1971–2000. The top row shows projections for spring, while the bottom row shows projections for summer. Green and blue areas are projected to experience wetter conditions while brown areas are projected to experience drier conditions compared to the historical base period. *Source: Swain & Hayhoe (2014)*

The Bottom Line

For projected changes occurring over *climate timescales* (averaging over 20–30 years or more), based on the observed trends analyzed here and the future projections provided in NCA3 there is:

- *High confidence* that average temperatures will continue to warm, with greater increases under a higher as compared to a lower future scenario.
- *High confidence* that the number of hot days and warm nights occurring on average each year will continue to increase, with greater increases under a higher as compared to a lower future scenario.
- *Moderate confidence* that average winter and spring precipitation will decrease over the long term, towards the end of the century, accompanied by increased risk of dry conditions in spring and longer periods of consecutive dry days. Also towards the end of the century, there is some indication these changes may be greater under a higher as compared to a lower future scenario, or under a greater amount of global temperature change as compared to a lesser.
- *Moderate confidence* that the frequency of heavy precipitation and/or average precipitation intensity may increase across some parts of Texas, although projected increases are likely to be small and trends at individual locations, such as San Antonio, will be strongly influenced by local factors.

Statements of confidence simply reflect how certain the science is, in our expert judgment, that these changes will occur. The degree of scientific confidence says nothing about the vulnerability of San Antonio's infrastructure, services, or people to such impacts. In fact, sometimes the greatest vulnerabilities can have the lowest levels of confidence associated with them. For example, the recent rain in May 2015 was at least a 1-in-2000 year event, according to early estimates. Vulnerability to this event, in terms of impacts on people, infrastructure, and the economy, was very high. However, this event is exceedingly rare. As such, scientific confidence in how soon and how often this event might recur will be quite low. Low confidence, however, does not mean low impact.

The projections presented in this report provide qualitative guidance regarding the likely direction of future trends in average climate indicators and certain temperature and precipitation extremes. These projections **should not be used to generate specific numbers for the city of San Antonio**, as local and regional factors not included in these projections can modify projected values.

Finally, as discussed above, these projections are **subject to uncertainty** due to natural variability, scientific uncertainty, scenario uncertainty, and the influence of regional land use and topography on local climate. More information on climate science, regional climate change, and the origin of the information presented in this report is available from the linked references highlighted throughout the report.