



Climate Change and Resilient Communities Along the U.S.-Mexico Border:

The Role of the Federal Agencies

Seventeenth Report of the Good Neighbor Environmental Board to the President and Congress of the United States



Environmental Advisors Across Borders

December 2016

A satellite image of the Earth, showing the Americas. The image is oriented with North to the left. The title 'About the Board' is overlaid on the right side of the image, with a white horizontal bar below it.

About the Board

The Good Neighbor Environmental Board (GNEB or the Board) was created in 1992 by the Enterprise for the Americas Initiative Act, Public Law 102-532. The purpose of the Board is to “advise the President and the Congress on the need for implementation of environmental and infrastructure projects (including projects that affect agriculture, rural development, and human nutrition) within the states of the United States contiguous to Mexico to improve the quality of life of persons residing on the United States side of the border.”

The Board is charged with submitting an annual report to the U.S. President and Congress. Management responsibilities for the Board were delegated to the Administrator of the U.S. Environmental Protection Agency (EPA or the Agency) by Executive Order 12916 on May 13, 1994.

GNEB does not carry out border region activities of its own, nor does it have a budget to fund border projects. Rather, its unique role is to serve as a nonpartisan advisor to the President and the Congress and recommend how the federal government can most effectively work with its many partners to improve conditions along the U.S.-Mexico border.

The Board operates under the provisions of the Federal Advisory Committee Act, and membership on the Board is extremely diverse. By statute, GNEB comprises representatives from:

- (1) the U.S. government, including a representative from the Department of Agriculture and representatives from other appropriate agencies;
- (2) the governments of the states of Arizona, California, New Mexico and Texas; and
- (3) private organizations, including community development, academic, health, environmental, and other nongovernmental entities with experience on environmental and infrastructure problems along the Southwest border.

The Board also includes representatives from tribal governments with lands in the border region.

The recommendations in this report do not necessarily reflect the official positions of the federal departments and agencies that are represented on the Board, nor does the mention of trade names, commercial products, or private companies constitute endorsement. The states of Arizona, New Mexico and Texas have recused themselves from this report.

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*Transmittal Letter to
the President From
the Good Neighbor
Environmental Board*

President Barack Obama
Vice President Joseph Biden
Speaker Paul Ryan

On behalf of your Good Neighbor Environmental Board, I am submitting to you our 17th Report, *Climate Change and Resilient Communities Along the U.S.-Mexico Border: The Role of the Federal Agencies*. In our report, the Board summarizes the effects that climate change is having in the U.S.-Mexico border region, identifies possible future impacts based on current trends, and makes a series of recommendations that the federal government can take in concert with state, local and tribal governments and partners in the private sector to mitigate and adapt to climate change along our southern border.

Our report deals with a number of the issues in the border region that we have examined in the past—including air quality, water quality and availability, human health, energy, and vulnerable populations—but in this case focuses on the cumulative impacts climate change will bring in all of these areas. Our recommendations emphasize the essential role that the federal government plays in addressing the effects of a changing climate along our shared border with Mexico. The many national, subnational and international programs to deal with the effects of climate change along the border will not succeed without strong and unwavering support from the federal departments and agencies whose expertise and resources are crucial.

One area we have particularly tried to highlight is the disproportionate effects of climate change that will be borne by the poor, the disadvantaged and tribal nations in the border region that already are underserved and challenged economically. Many of these communities will be increasingly challenged to cope with rising temperatures, decreased supplies of potable water, an increased prevalence of infectious diseases, and extreme weather events. In many cases, these communities and the people in them lack the financial means to partially shield themselves from these impacts of climate change and will suffer the consequences in ways the more affluent will not.

Our past reports have noted the unique characteristics of the U.S.-Mexico border region. As a whole, it is one of the hottest, driest and poorest areas of the country, yet it is growing rapidly and is vital to the U.S. economy. Mexico is the United States' third largest trading partner, and the stream of commerce crossing our shared border is essential to the economic prosperity of both countries. The Board's hope is that its report and recommendations have identified actions that the U.S. federal government can take to help protect and preserve the communities, environment and economy of the border region.

Sincerely,



Paul Ganster, Ph.D.
Chair
Good Neighbor Environmental Board



Executive Summary

Climate change models project increasing economic, social, human health and environmental impacts on the diverse and vulnerable communities along the U.S.-Mexico border. Overall, the border region is one of the poorest in the United States, with many disadvantaged Hispanic and tribal communities in urban and rural areas especially vulnerable to climate change impacts. An added complexity for U.S. border communities is that Mexican cities sharing the same bioregion contain millions of inhabitants and have different governance systems. Although the effects of climate change flow both ways across the international boundary, mitigation and adaptive measures do not.

This report explores how U.S. border communities can partner with existing federal programs to build sustainable communities in the face of climate change impacts. At the same time, it addresses the important issue of coordination across the international border for collaborative actions with Mexico. Finally, the report provides recommendations for federal agencies to work more effectively with border communities to increase local resilience in the face of climate change.

The U.S.-Mexico border area generally is characterized by a hot, dry climate, and evidence indicates that periods of decades-long droughts have occurred throughout the region. Climate change is projected to, among other effects, increase temperatures, decrease precipitation, produce more extreme weather events, decrease snowpack and runoff, reduce renewable surface and ground water resources, and bring about more frequent and intense wildfires and intense storm surges in the region. Traditional infrastructure systems are ill-equipped to allow border communities to mitigate these extremes, which will affect many sectors, including water, energy, trade, transportation and public health. The often-disadvantaged populations of border communities, including tribal populations, are particularly vulnerable to the health effects of climate change. Animal and plant species in the border region also are at risk.

Climate change on the U.S.-Mexico border region is projected to contribute to, and make it more difficult to manage, rising levels of infectious and chronic disease; harmful, cumulative effects on humans and the environment caused by fire, flood, heat, pollution and health disparities; and complexity and risk posed by a globalized economy with increasing food-energy-water security problems.

As demonstrated by examples throughout this report, U.S. federal agencies are committed to addressing climate change. Federal and state agencies are investing significant financial and human resources in the border region to reduce pollution and environmental degradation; these agencies also are investing in programs to mitigate climate change impacts and increase the resiliency of local communities. Challenges, however, exist in ensuring that these programs and investments are accessible to border communities, whether they are urban or rural, small or large. The Board provides a series of recommendations to address these challenges.

The recommendations described in this report fall within three themes. The first theme is outreach. Many federal programs can assist all types of border communities in addressing climate change impacts. Many smaller and poorer communities, however, lack the administrative support and technical expertise to effectively access these programs. Federal agencies should increase their outreach and organize information regarding federal programs for border communities. The binational North American Development Bank and Border Environment Cooperation Commission have a presence along the border, have worked in most border communities, and have experience in Mexican communities as well; this binational agency can play an important outreach role with border communities regarding climate change.

Another important theme of the report and recommendations is that many groups in the border region are disadvantaged and characterized by low income. Many of these groups are primarily Hispanic and live in *colonias* with substandard infrastructure and public services. Others are tribal peoples in rural areas that depend on natural resources affected by climate change. All of these groups are disproportionately affected by climate change and need special attention by federal programs.

A third important theme is that federal agencies addressing climate impacts in the border region should make a concerted effort to coordinate with counterpart agencies in Mexico. The Good Neighbor Environmental Board firmly believes that climate change-related issues that have origins and effects on both sides of the international boundary require solutions that also span the border.

Introduction

Climate change and variability already affect the economic, social, human health and environmental conditions of diverse and vulnerable communities along the U.S.-Mexico border. The border region is one of the poorest in the United States, with disadvantaged communities in urban and rural areas that are vulnerable to the effects of climate change. The border location creates additional challenges for U.S. border communities because Mexican cities with millions of inhabitants share the same bioregion but have different governance systems. Although the effects of climate change flow both ways across the international boundary, mitigation and adaptive measures do not.

The Good Neighbor Environmental Board (GNEB or Board) has developed this report to explore how U.S. border communities can partner with existing federal programs and their state and local partners to build sustainable and resilient communities in the face of climate change impacts. It also addresses collaboration across the international border with Mexico.

Chapter 1 describes the primary consequences of a changing climate for communities along the U.S.-Mexico border, based on the best science available. Changes are occurring and pose a growing concern in the border region. Although the geographical focus of this report is on the zone between the border and 100 kilometers (62.1 miles) north of the international boundary, the discussion is relevant to wider regions—such as major river basins, airsheds or adjacent oceans—including binational effects.

Chapter 2 highlights groups in the border region that are especially vulnerable to the potential negative effects

of climate change in their region. Poor rural and urban groups and tribal peoples are characterized by low income, substandard housing and lack of public services while being disproportionately affected by many effects of a changing climate.

Chapter 3 discusses government programs that address climate change and consequences for border communities and how these programs can build resiliency and mitigate climate change impacts for the border populations. This chapter includes information that should be of use to border stakeholders, including binational, state and local government partners.

Chapters 4 to 7 address specific climate change impacts related to water, air, energy and resiliency and include examples of actions and programs that respond to these effects to improve environmental resilience in the border region. **Chapter 4** examines how climate change affects water resources, which is critical to almost all facets of border life. **Chapter 5** highlights climate risks related to trade, transportation and air pollution in the border zone, as well as promotion of resilience and risk mitigation in border communities. **Chapter 6** discusses the nexus between energy and greenhouse gases (GHGs) relative to the built environment. **Chapter 7** details current and possible future climate change impacts on public health.

Chapter 8 presents a summary of recommendations for federal actions to aid border communities in response to these climate change challenges.



Chapter

1

The Impacts of Climate Change Along the U.S.-Mexico Border

The U.S.-Mexico border region overall is characterized by a hot, dry climate, although the Lower Rio Grande region has greater precipitation and humidity. The paleoclimate record, which goes back thousands of years before regular recorded measurements, indicates past periods of extended drought lasting several decades. Changes in global climate are projected to result in a variety of environmental, social and economic vulnerability issues for the region, including temperature increases in the atmosphere, on land and in the ocean; decreased total precipitation and increased evapotranspiration; more extreme weather events; decreased snowpack and runoff; more frequent insect outbreaks; more frequent and intense wildfires; and sea-level rise and more intense storm surges, resulting in worse flooding, saltwater intrusion and erosion in coastal areas.

1.1 How is climate expected to change in the region?

Global annual average temperature, as measured over both land and ocean surfaces, warmed roughly 1.53°F (0.85°C) from 1880 to 2012.¹ **Figure 1** illustrates the general increase in average temperatures in the Southwest United States, whereas **Figure 2** compares average changes in temperature and dryness between the 20th and 21st centuries throughout the United States. U.S. average air temperature has increased by 1.3°F to 1.9°F (0.7°C to 1.1°C) since recordkeeping began in 1895, and most of this increase has occurred since about 1970. Continued warming of the planet is projected to occur as a result of GHG emissions, although natural variability still will play a role.² Recent research has indicated that another

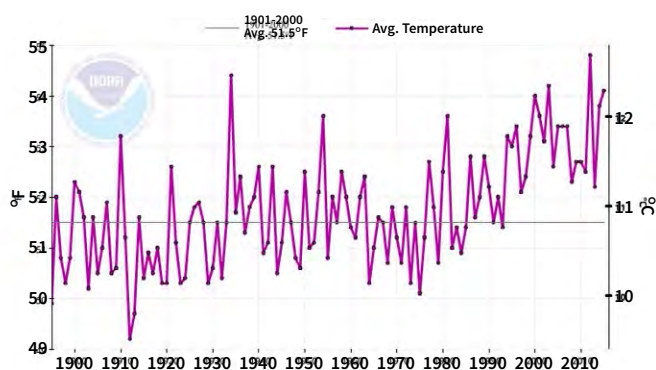


Figure 1. Southwest average yearly temperatures.

Source: National Oceanic and Atmospheric Administration (NOAA) *Climate at a Glance*, ncdc.noaa.gov/cag/time-series/us/107/0/tavg/ytd/12/1895-2016?base_prd=true&firstbaseyear=1901&lastbaseyear=2000. Temperatures reflect data from the Southwest region as defined by NOAA, which includes the states of Arizona, New Mexico, Colorado and Utah.

0.5°F (0.28°C) increase is projected during the next few decades even if all GHG emissions are stopped.³ Recorded past and projected future temperature increases also have affected and are projected to affect the climate of the border region, with the greatest increases inland from the coasts. The projected magnitude of temperature increase is expected to be greatest during the summer, with a greater number of extreme heat days above 100°F (38°C) and more frequent high nighttime temperatures. The average annual temperature is projected to increase 2°F to 7°F (1.1°C to 3.9°C) by the middle of the 21st century.⁴ Recently, the U.S. Desert Southwest experienced record-breaking heat, including record daily high temperatures set on June 19, 2016, in Phoenix

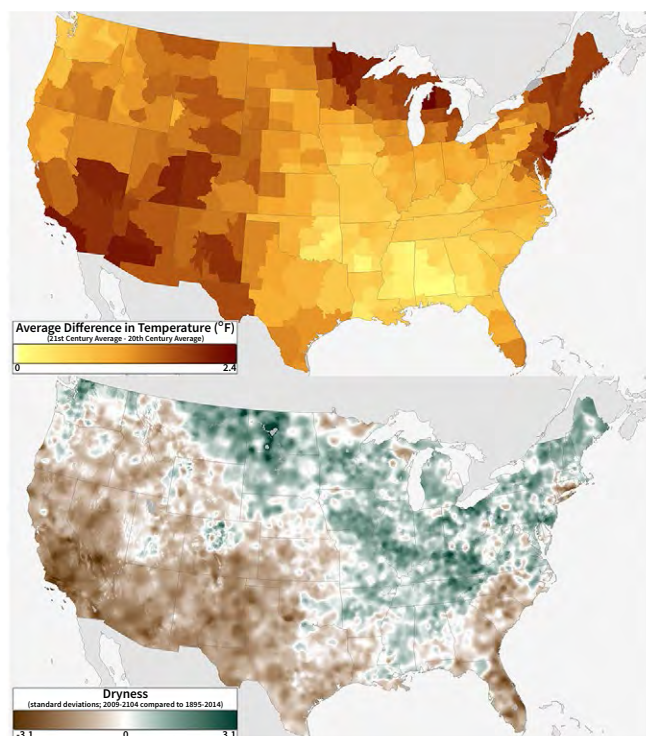


Figure 2. Comparison of average differences in temperature and dryness in the United States between the 20th and 21st centuries.

Top: Difference in Temperature from 20th Century Average to 21st Century Average. Bottom: Dryness 2009–2014 Compared to 1895–2014.

Source: National Oceanic and Atmospheric Administration U.S. Climate Resilience Toolkit, toolkit.climate.gov.

(118°F/48°C), Tucson (115°F/46°C), Yuma (120°F/29°C) and Flagstaff, Arizona (93°F/34°C).⁵

The most recent decade (2001–2010) was the warmest on record.⁶ In 2013, 46 record-high temperatures were matched or exceeded in the Southwest. If global emissions continue to grow, projections suggest that the Southwest regional average annual temperature will increase by 2.5°F to 5.5°F (1.4°C to 3.1°C) between 2041 and 2070 and by 5.5°F to 9.5°F (3.1°C to 5.3°C) between 2070 and 2099. Reducing emissions dramatically would lower these projected increases to only 2.5°F to 4.5°F (1.4°C to 2.5°C) between the years 2041 and 2070, and 3.5°F to 5.5°F (1.9°C to 3.1°C) between the years of 2070 and 2099.⁷ **Figure 3** depicts the projected temperature increases in the Southwest region based on different emission levels.

Toward the end of the century (2077–2099), the number of hot nights also is projected to increase significantly compared to the timeframe between 1971 and 2000 (**Figure 4**). Such changes will affect the Texas and New Mexico border regions most intensely.

Precipitation is projected to be more variable with decreases on the Pacific coast and parts of the Arizona-Sonora border. **Figure 5** highlights the changes in average precipitation

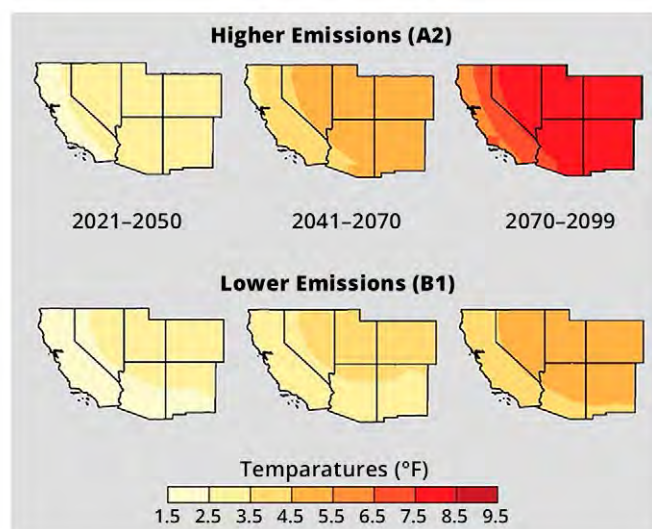


Figure 3. Projected temperature increases in the Southwest.

Source: Adapted from Melillo et al. 2014.⁸

in the Southwest United States during the last century. Models project that the Lower Rio Grande Basin area of the border (downstream of Fort Quitman in Hudspeth County, Texas) will experience decreased precipitation and increased evapotranspiration, contributing to an estimated 700,000 acre-feet per year (8.6 million cubic meters per year) surface water shortfall by 2060, exacerbated by increased population growth in the region.¹⁰ Although limited water resources and periodic droughts have been major issues historically in the region, with future increasing temperatures and changes in precipitation projected to exacerbate drought consequences, it also should be noted that the reluctance to deliver water according to treaty also has worsened matters.^{11,12} Paleoclimate records for the area show that severe

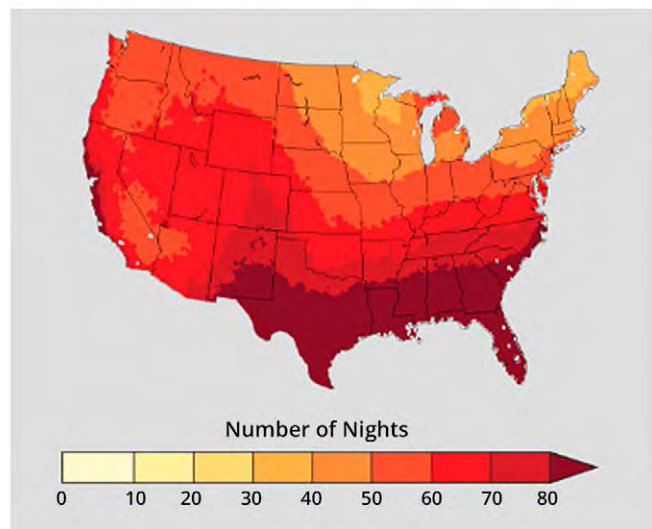


Figure 4. Projected change in the number of hot nights.

Source: Adapted from Melillo et al. 2014.⁹

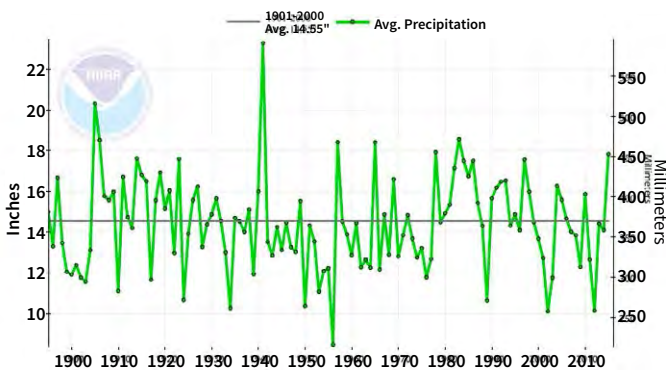
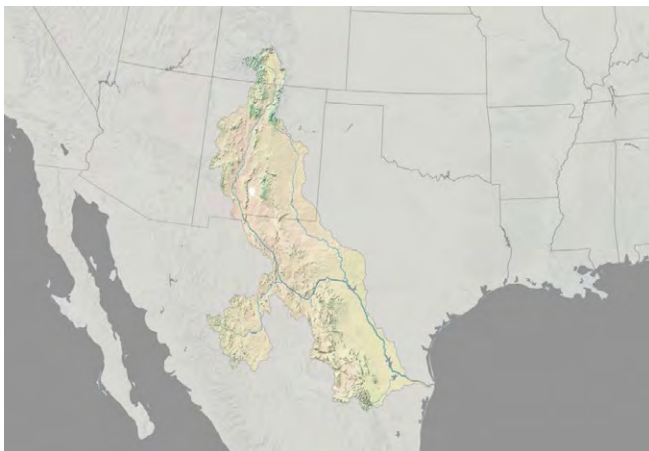


Figure 5. Southwest annual precipitation.

Source: National Oceanic and Atmospheric Administration (NOAA) *Climate at a Glance*, ncdc.noaa.gov/cag/time-series/us/107/0/pcp/ytd/12/1895-2016?base_prd=true&firstbaseyear=1901&lastbaseyear=2000. Temperatures reflect data from the Southwest region as defined by NOAA, which includes the states of Arizona, New Mexico, Colorado and Utah.

“mega-droughts” have lasted for 50-year periods.¹³ The decade of 2001 to 2010 was the warmest in the 110-year instrumental record for the Southwest, with temperatures almost 2°F (1.1°C) higher than historic averages, fewer cold air outbreaks, and more heat waves.¹⁴

Droughts and heat waves along the U.S.-Mexico border region are projected to become more intense and cold waves less intense, affecting precipitation, runoff and recharge, food and energy security, and ecosystem and species health. For example, dry conditions coupled with overgrazing can lead to increased erosion, the spread of invasive plants, and reduced productivity of crops such as fruit trees.⁶ Some cacti in the Desert Southwest have experienced no or reduced reproduction with overall population declines beginning in the 1990s. It is not clear whether climate change is the driving factor in these declines, but increased temperatures and reduced precipitation certainly could affect species such as the endangered acuña cactus (*Echinomastus erectocentrus* var. *acunensis*).¹⁵

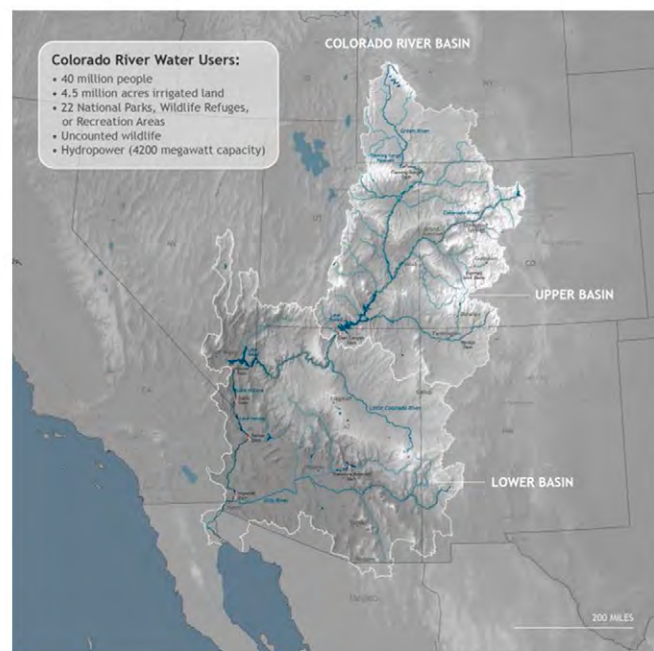


The Rio Grande provides water for more than 5 million people in Colorado, New Mexico, Texas and Mexico. In New Mexico, it supplies a substantial portion of water for urban needs and irrigation, among other uses. **Source:** climate.gov/news-features/features/drought-rio-grande.

In addition to generally decreased precipitation, the border region may experience an increasing number of extreme drought and flood events because of climate change. Traditional stormwater management systems (commonly known as gray infrastructure) are ill-equipped to mitigate either of these extremes. Gray infrastructure redirects rainfall into channels and pipes, making it unavailable for storage, irrigation, natural cleansing or infiltration into the ground water supply.

Extreme rain events come with their own challenges. The *Assessment of Climate Change on the Southwest United States* (2013) reports that highly structured and in-filled cities have limited capacity to adapt to increasing stormwater flows and may be vulnerable to extreme flooding.¹⁶ Enhanced, intensified water flows will increase suspended sediments and other pollutants in the runoff, degrading water quality. Altered flow regimes, polluted urban stormwater and degraded water quality have significant implications for downstream ecosystems.

The frequency of 2-day heavy rainfall spells has nearly doubled in Texas during the past century.¹⁷ Rainfalls of 4 to 6 inches (10 to 15 centimeters) are becoming more common in the Rio Grande Valley. The increasingly urbanized border cities experience special challenges as a result of the intensity of storm events. As more and more areas of the Rio Grande Valley watershed become paved, and thus impervious, rainfall runoff discharges peak faster and higher, resulting in increased damage to homes and businesses. This also can lead to decreased dry weather flows in streams because less ground water is being recharged.¹⁸ In terms of development



Colorado River Basin. Source: National Oceanic and Atmospheric Administration U.S. Climate Resilience Toolkit, toolkit.climate.gov.

and stormwater management, Federal Emergency Management Agency (FEMA) flood maps usually are used to understand flood hazards for an area. This process needs to be readdressed because these maps often are produced from decades-old stream flow data. As the U.S. Climate Resilience Toolkit has noted: “Floodplain managers need new peak streamflow data to update flood frequency analyses and flood maps in areas with recent urbanization.”¹⁹

1.2 Reduced water supply and intensifying drought

Declines in total basin runoff have been observed in the Colorado River and Rio Grande River watersheds.²⁰ Snowpack and stream flows are projected to diminish across the Southwest, decreasing surface water supply available to cities, agriculture and ecosystems.⁶ Climate change, coupled with the area’s natural variability (i.e., the extensive and severe droughts now documented in the historical record), could amplify these past extreme conditions.²⁰ Droughts already affect estuarine ecosystems along the U.S.-Mexico border, such as the Tijuana River Estuary in California and the Rio Grande and Lower Laguna Madre of South Texas. Estuarine ecosystems depend on adequate water flow for normal habitat function and biological productivity in and during extended droughts. Conflict among water users could reduce water allocated to ecosystems and increase existing severe drought stresses. Drought and reduced water supply in the two transboundary basins of the Colorado River and Rio Grande River can affect compliance by the United States and Mexico with mutual water delivery obligations established by treaty. Climate projections for 2050 indicate that 32 percent of counties in the United States could be at high or extreme risk of water shortages (compared to 10% of counties today), with the greatest concentration of extreme conditions occurring along the U.S.-Mexico border.²¹ Reduced stream flows and snowpack will affect tourism and recreation in the Southwest’s rivers and lakes, with economic effects on businesses that depend on these activities. Soil moisture is projected to decline with higher temperatures and faster evapotranspiration rates in the Southwest.²⁰ **Figure 6** illustrates changes in terrestrial water storage trends from 2002 to 2015.

The U.S. Bureau of Reclamation’s *2016 SECURE Water Report* projects several increased risks to western United States water resources during the 21st century, including:

- A temperature increase of 5°F to 7°F (2.8°C to 3.9°C) by the end of the century.
- A precipitation increase over the northwestern and north-central portions of the western United States and a decrease over the southwestern and south-central areas of the western United States.

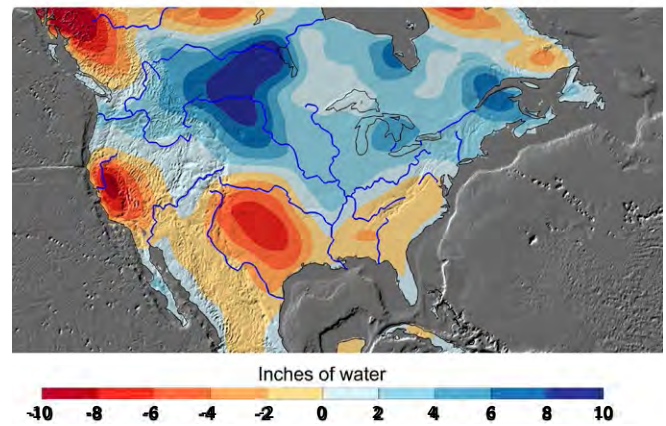


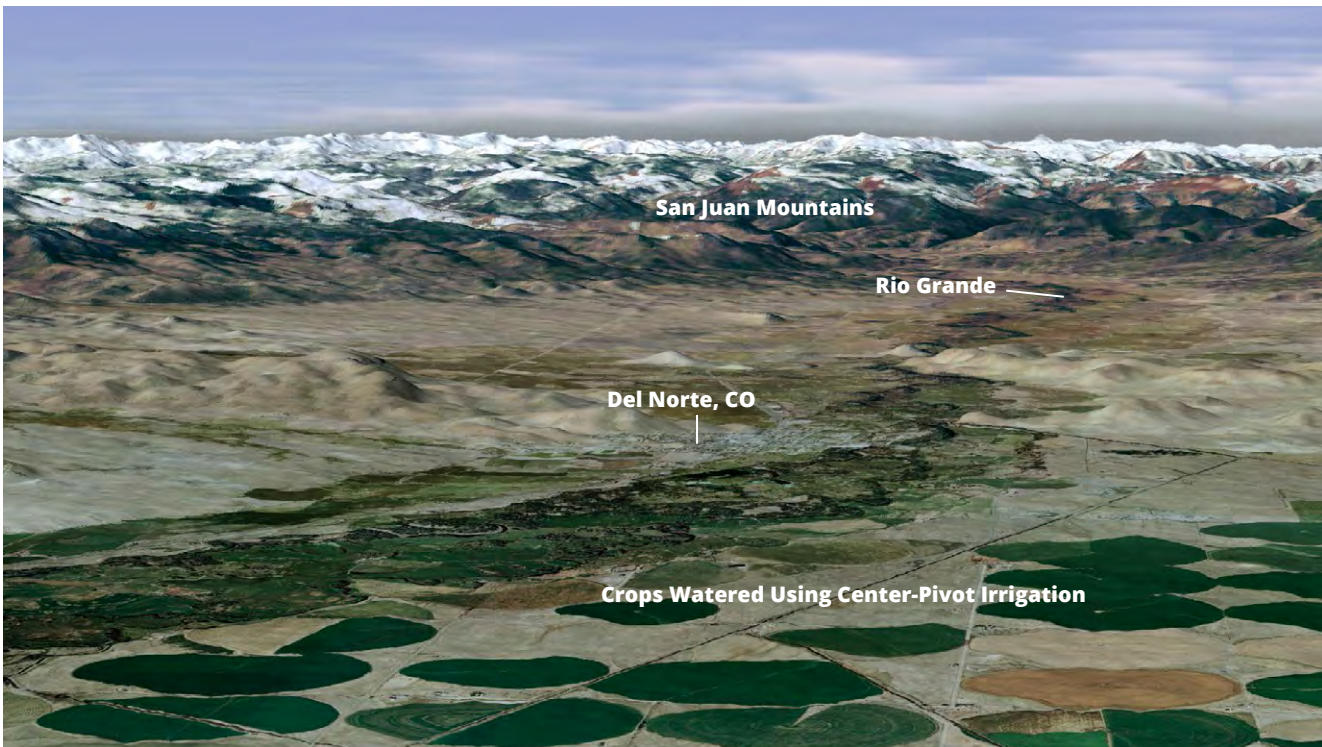
Figure 6. Gravity Recovery and Climate Experiment (GRACE) total water storage trends from 2002 to 2015.

Source: National Aeronautics and Space Administration Jet Propulsion Laboratory GRACE data/California Institute of Technology.

- A decrease for almost all of the April 1 snowpack, a standard benchmark measurement used to project river basin runoff.
- A 7 to 27 percent decrease in April to July stream flow in several river basins, including those of the Colorado, Rio Grande and San Joaquin rivers.²²

A recent detailed study of the Colorado River Basin, which supplies critical amounts of water to the border regions of California, Arizona, Baja California and parts of Sonora, concludes that by 2060, there will be an annual shortfall between water production and water demand ranging from 0 and 6.8 million acre-feet (8.4 billion cubic meters), with a median of 3.2 million acre-feet (3.9 billion cubic meters), leading to the curtailment of water deliveries to all users of the river’s waters.^{22,23} The projected shortfall will have significant economic, social and policy implications for the U.S.-Mexico border region.

Renewable surface and ground water resources along the U.S.-Mexico border likely are being reduced by climate change, posing a major concern to energy security, as water, energy and food are closely intertwined. Energy is needed to purify and distribute water, and water is needed to generate energy.²⁴ Thermoelectric power production is the single largest user of water in the United States, accounting for more than 45 percent of total water withdrawals in 2010²⁵ (although actual water use is much less, as most cooling water is returned to the source). Thermoelectric power plants use water for steam production and cooling to generate electricity.²⁶ The growing demand for limited water supplies places increasing pressure on the energy sector to seek alternative approaches. The water-energy nexus is becoming increasingly important, especially along the U.S.-Mexico border, which faces growing water scarcity challenges exacerbated by climate change, population growth and industrial expansion.



A view looking west into the San Juan Mountains of southern Colorado, the headwaters of the Rio Grande, from near the town of Del Norte. Snowmelt is the primary water source for the river. Visualization by Hunter Allen, based on multiple data sources: National Aeronautics and Space Administration Advanced Spaceborne Thermal Emission and Reflection Radiometer from the U.S. Geological Survey (USGS) Global Data Explorer (gdex.cr.usgs.gov); USGS Global Visualization Viewer (glovis.usgs.gov) landsat image from April 5, 2011; and aerial imagery from the National Agriculture Inventory Program via the U.S. Department of Agriculture Natural Resources Conservation Service Geospatial Data Gateway (<https://gdg.sc.egov.usda.gov/>). **Source:** climate.gov/news-features/features/drought-río-grande.

Water use can be defined in terms of withdrawal and consumption. Water consumption is the use of water that is not returned to the environment, usually by evaporation.²⁷ Withdrawal is the total amount of water that is removed from a ground or surface water source, some of which may get returned to its source, consumed or made available for use elsewhere. Water withdrawn by thermoelectric power plants for cooling that is not consumed sometimes is returned to the environment at a higher temperature (occasionally exceeding 90°F/32°C), which can harm fish and wildlife.²⁷ Nearly three-quarters of the total amount of water withdrawn by thermoelectric power plants is fresh water.²⁸ According to the Texas Water Development Board, which conducts an annual survey of water, and a 5-year state of Texas water plan, steam electric power plants in Texas consumed 410,000 acre-feet (506 million cubic meters) of water in 2014, or roughly three percent of all water used in the state that year. In its 2017 plan, the Texas Water Development Board projects that steam electric consumption could increase to as much as 1.7 million acre-feet (2.1 billion cubic meters) by 2070 as population and electricity needs increase.^{29,30}

The Southwest faces rapid population growth, rising electricity demand and declining water resources.³¹ Continued reliance on thermoelectric power plants under a business-as-usual scenario, for example, would reduce

the amount of water stored in Lake Mead (in Nevada and Arizona) and Lake Powell (in Utah and Arizona) by 50 percent below the long-term historical average (1971–2007) by 2050.³²

One of the consequences of the energy-water nexus is that it may bring challenges to the stability and reliability of the electrical grid. The extreme drought in Texas in 2011 caused a 6 percent increase in electricity generation and a 9 percent increase in water consumption for electricity.³³ Water shortages and higher water temperatures caused by ongoing drought in the Southwest are revealing the vulnerability of thermoelectric power plants and grids. On average, a 1°C (1.8°F) rise in ambient cooling water temperature can cause power output to drop by as much as 0.5 percent.³⁴ Hydroelectricity generation in California has dropped nearly 50 percent since 2013, as the state continues to be affected by the worst drought in memory. In 2015, hydroelectricity provided less than 7 percent of California's overall electricity generation, down from 13 percent in 2013. From October 2011 through the end of 2015, California experienced a reduction of around 57,000 gigawatts of hydroelectricity, which caused electricity costs to increase by approximately \$2 billion. Replacing the reduction in hydroelectricity with natural gas also led to a 10 percent increase in carbon dioxide (CO₂) emissions and other pollutants.³⁵

1

Human consumption and use of ground water has benefited society in terms of improved public health, agricultural productivity, economic development and food security. Ground water extraction, however, has surpassed recharge rates in numerous locations around the world, including the southwestern United States and the U.S.-Mexico border region. As energy demand increases with population growth, other uses of water—such as agriculture, manufacturing, drinking water and sanitation services for cities—face increasing competition for limited water resources.

1.3 Demographic change and high social vulnerability

Almost all border climate and environmental issues are binational, as most of the U.S. border population lives in sister cities separated from adjacent Mexican urban areas only by the international boundary, forming more than a dozen transboundary metropolitan regions. These range in size from the greater San Diego, California-Tijuana, Baja California, area, with 5 million people, to the area of Naco, Arizona-Naco, Sonora, with slightly more than 6,000 people.³⁶ Each sister city pair shares an ecosystem with common environmental issues, such as air and water pollution. All of these communities, even wealthier San Diego, are characterized by large numbers of low-income residents who are especially vulnerable to climate effects.

The challenges of responding to the consequences of regional climate change are exacerbated by these prevalent socioeconomic conditions of communities along the border region. With the exception of San Diego, U.S. residents along the border have fewer financial resources than residents of other U.S. regions; three of the poorest 10 counties in the United States can be found within 100 miles (161 kilometers) of the U.S.-Mexico border,³⁷ and in 2013, nearly 30 percent of the U.S. population residing in 23 counties along the border was below the poverty level.³⁸ The cultures and languages are more diverse along the border than many areas elsewhere in the country, as approximately one-half of all people residing in U.S. counties along the border speak Spanish as a first language.^{39,40} With a changing climate, federally recognized tribes and tribal communities along the border face the loss of traditional foods and medicines, culturally important animal species, and plant resources.⁴¹ Historic land settlement patterns and high rates of poverty—more than double that of the general U.S. population⁴²—complicate tribes' and other disadvantaged populations' abilities to respond to environmental challenges.

1.4 Significant border economy

Persistent U.S.-Mexico border poverty notwithstanding, the region is critical for the prosperity of the U.S. economy. Mexico is the third-largest trading partner of the United States.⁴³ U.S. goods and services trade with Mexico totaled

an estimated \$583.6 billion in 2015. Most of the trade moves through the land ports of entry located on the southern border in truck and rail containers.^{43,44} Some border regions are areas of significant economic activity in addition to trade, such as the biotechnology cluster in San Diego; aerospace in Arizona; petroleum and natural gas in Texas; and intensive irrigated agriculture—especially fresh fruits and vegetables—in Imperial County, California, adjacent areas in Arizona, and in Texas' Lower Rio Grande Valley.

Although the benefits of U.S.-Mexico trade are spread widely throughout the country, many of the costs associated with the flow of goods are borne by border communities in the form of a saturated transportation infrastructure and heavy truck traffic through communities with its associated air pollution, which is exacerbated by excessive waiting times for northbound crossings at the border.⁴⁵ Although transnational trade creates jobs in both the U.S. and Mexico border regions in transportation and warehousing, these tend to pay low wages without benefits and so fail to address the border-wide issue of low *per capita* income.⁴⁶

Climate change and air pollution are closely linked. When energy from the sun reaches the earth, the planet absorbs some of this energy and radiates the rest back to space as heat. The surface temperature depends on this balance between incoming and outgoing energy. Atmospheric GHGs, such as CO₂ and methane, can trap this energy and prevent the heat from escaping. Ozone, composed of three oxygen atoms, is formed by the combination of volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. Weather and climate play a key role in the formation of ozone in urban areas, with ozone levels generally higher during hot, dry summers; these levels will increase with global warming.⁴⁷ Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOCs. Breathing ozone can trigger a variety of health problems, particularly for children, the elderly and



Photo Credit: Leterman / Shutterstock.com.

people of all ages who have lung diseases such as asthma. Ground-level ozone also can have harmful effects on sensitive vegetation and ecosystems.⁴⁸

Ports of entry are a major source of pollution as a result of the high volume of personal vehicle and diesel truck traffic crossing the border. The large number of vehicles crossing through the ports of entry located in dense urban U.S. and Mexican border cities, combined with long waiting times to cross, produce elevated levels of criteria pollutants, including carbon monoxide and nitrogen dioxide. Also present in high concentrations are benzene, black carbon and ultrafine particles, the very small nanoparticles that are implicated in cardiovascular, neurological and other health effects.⁴⁹

Thus, efforts to reduce pollution from transportation, local businesses, power plants, and oil and gas production, as well as other sources of NO_x and VOCs, will be important in the border areas to allow communities to keep ozone levels down and protect populations in the likelihood of hotter, drier summers. In addition, a particular issue confronting some U.S. border communities is the challenge of controlling pollution when a significant amount can come from sources within Mexico. Particulate matter (PM)—specifically PM_{2.5} (PM less than or equal to 2.5 micrometers in diameter)—is a criteria pollutant. The U.S. Environmental Protection Agency (EPA) establishes National Ambient Air Quality Standards (NAAQS) for each criteria pollutant.⁵⁰

1.5 Human health

Low-income rural and urban residents of border communities, especially communities of color, are more vulnerable to climate risks.^{11,51,52} The U.S.-Mexico Border Health Commission identified eight border populations highly vulnerable to climate-related health effects: low income, homeless, uninsured and underinsured, limited and non-English speakers, elderly, migrant laborers and farmers, newer immigrants, and undocumented immigrants.⁵³ Poorer residents of U.S. border communities most often live in substandard housing that is more vulnerable to climate extremes. Poor residents may not be able to afford air conditioning, and their homes may be located in areas more prone to flooding or adjacent to major transportation routes and ports of entry that have poor air quality.⁴⁹ With less access to medical care relative to the general population, disadvantaged urban and rural communities along the border experience a greater burden from a changing climate.

Temperature changes may understate the likely consequences of climate change along the border resulting from a projected increase in the number of extreme heat days and high nighttime temperatures. In the summer of 2011, for example, large areas of the inland U.S.-Mexico border region set records for the highest number of days with temperatures exceeding 100°F (38°C) in recorded history. In some



Photo Credit: David Litman / Shutterstock.com.

areas, temperatures exceeded 100°F (38°C) on more than 100 days.¹¹ During the 2011 heat event, rates of water loss resulting in part from evaporation were double the long-term average. Depleted water resources contributed to more than \$10 billion in direct losses to agriculture alone.⁵⁴ In January 2012, customers of 1,010 Texas water systems were asked to restrict water use, and mandatory water limits were in place in 647 water systems.⁵⁵ Similarly, because of drought, in April 2015, California's governor ordered mandatory water-use reductions of 25 percent annually by 400 local water supply agencies.⁵⁶

The primary cause of weather-related deaths in the United States is heat, and excessive heat leads to high morbidity, particularly for low-income and minority populations. For example, the Arizona Department of Health Services documented 1,535 deaths from heat between 2000 and 2012. Of the nearly 586 Arizona residents who died from heat-related causes, more than one-half were Hispanic, one-half were older than 57 years, and many died within their homes.⁵⁷

Climate change is projected to increase the presence and range of disease vectors—such as mosquitoes or rodent populations—in the border region, which will increase the transmission of the West Nile, dengue, chikungunya and Zika viruses. Valley fever, plague and Hanta pulmonary syndrome occurrences also are linked to climate change in the Southwest, although the direction and impacts of the changes are specific to diseases and locations. Climate change may increase PM stemming from additional wildfires with negative implications for respiratory health, particularly for the elderly, children, infants and those with pre-existing pulmonary and cardiovascular conditions.⁵⁸

1.6 Ecosystem and species health

The border region contains more than 6,500 plant and animal species, including 148 species listed as endangered in the United States.⁵⁹ Approximately a dozen transboundary rivers and aquifers provide water to cities, tribes and farms in the two countries—including two major rivers, the Colorado

The Sky Island Region and Climate Change



The Sky Island Alliance survey of spring sites in Arizona included stakeholders from the U.S. Forest Service, the U.S. Geological Survey, the Arizona Geological Survey, private landowners, and others. This photo shows Turkey Creek in the Chiricahua Mountains of southeast Arizona, summer 2015. Credit: Sky Island Alliance.

The Sky Island Region and Climate Change

The Sky Island region is a globally recognized center of biocultural diversity that sprawls across the U.S.-Mexico border, mainly in the states of Arizona and Sonora, but with parts in New Mexico and Chihuahua. Sky Islands are forested mountains surrounded by grasslands or desert. Several biotic influences converge here across 55 mountain ranges that support a staggering diversity of life: more than 4,000 plants, more than one-half of all species of birds found in North America, thousands of species of invertebrates, nearly 100 reptiles, and 25 native amphibians. Because the Sky Islands are isolated from each other, the number of unique (endemic) species in the region is impressive. The Sky Island region faces threats related to climate change. Annual average daily maximum temperatures in Arizona have increased by as much as 5.4°F (3°C) from 1901 to 2010 in some areas, the Southwest is experiencing unusually severe drought,⁶⁷ and winter precipitation in Arizona has become more variable, with a trend toward increasing frequency of both extremely dry and extremely wet winters.⁶⁸ Water resources are becoming increasingly scarce in the arid Sky Island region of southern Arizona and northern Sonora as the area experiences continued urban and rural population growth.

Sky Island Alliance is a binational conservation organization that works to protect and restore the rich natural heritage of native species and habitats in this binational region.^{69,70} During the past 5 years, the organization has taken a comprehensive approach to addressing both current and anticipated climate change impacts on human and natural communities in southeastern Arizona. A number of climate adaptation projects have been organized by Sky Island Alliance and implemented with federal, state and local agencies; tribal

authorities; private landowners and nongovernmental organizations; and hundreds of volunteers. These projects include:

Adaptation Planning for Natural Resources of the Sky Island Region

From 2010–2013, Sky Island Alliance conducted a regional climate change adaptation workshop series that brought together diverse stakeholders. Workshop participants developed a shared understanding of current climate science and key vulnerabilities and prioritized implementable adaptation strategies. Outcomes included forging an inclusive group of stakeholders for the region, identifying a key study topic (springs in priority ground-water basins), and scaling of restoration work to a watershed scale.

Response to Wildfire Impacts

Severe fire followed by intense monsoon precipitation is altering streams, springs and entire watersheds in rapid and sometimes catastrophic ways. Burned areas that receive no rehabilitative treatment experience destructive erosion resulting from a lack of ecosystem recovery; wildlife and pollinator corridors may suffer as a result. Sky Island Alliance worked with partners to restore two watersheds in the Chiricahua Mountains, one burned and one unburned. This work was designed to inform future ecological restoration in arid lands in the context of climate change impacts. Treatments



Location of the Sky Island region. Credit: Samantha Hammer, Sky Island Alliance.



A rock erosion-control structure provides a localized increase in water infiltration in the Chiricahua Mountains. **Credit:** Sky Island Alliance.

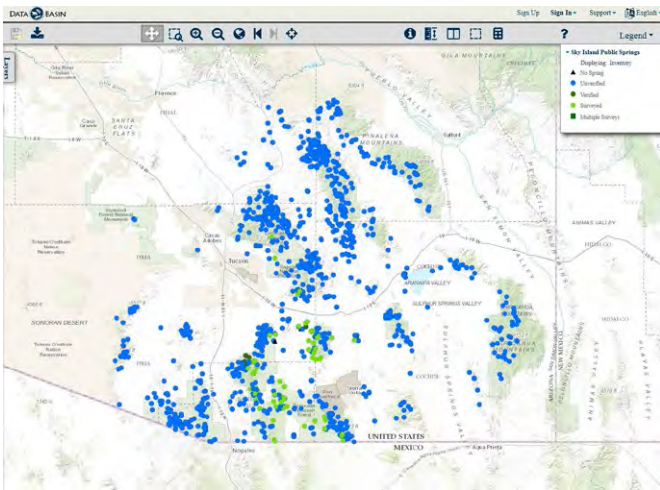
included installation of more than 700 loose rock erosion control structures in drainages to facilitate creation of microclimates that are likely to be resilient to future fires and a drying climate, benefitting both native vegetation and wildlife.

Documenting, Protecting and Restoring Spring Ecosystems

Approximately 1,300 springs exist in the Arizona portion of the Sky Island region. Springs are keystone ecosystems and known to be

biodiversity hotspots; however, they are poorly documented and suffer from extensive human modification. Sky Island Alliance worked with multiple partners to develop new information on the location, management context, and biological, hydrological and ecological characteristics of springs. Restoration at spring sites has focused on the organization working with agencies, landowners and grazing permittees to find creative ways to both make water available to as wide a variety of wildlife as possible while not interrupting current land uses.

River and the Rio Grande River—and many smaller sources, such as the Tijuana and New rivers in California and Baja California and the Santa Cruz and San Pedro rivers in southern Arizona and northern Sonora. Major transboundary aquifers include the Hueco Bolsón and the Mesilla-Conejo-Médanos in the Paso del Norte region and the Mimbres-Los Muertos aquifer and drainage system in New Mexico. Major desert ecosystems include the Mojave (Imperial Valley, California), Sonoran (southern Arizona and Sonora), and Chihuahuan (eastern Arizona, western New Mexico and western Texas) deserts. Coastal zones at the eastern and western ends of the border contain important marine and freshwater habitats.^{11,60}



This is a compilation of springs data in the Sky Islands of southern Arizona. Data were imported from the National Hydrology Dataset database, the Arizona State Land Office, and the Arizona Department of Water Resources. Additional data were contributed by Springs Stewardship Institute and Sky Island Alliance.

Source: databasin.org/datasets/a1f0dd6d51e34ff1bf6d3abe07c985a6

As air temperature increases, so will the temperature of streams and rivers. Some species—such as the Gila, Apache and Rio Grande cutthroat trout—are dependent on cold water. Increases in stream temperature will affect oxygen levels, food resources and the ability of these native

cold-water species to compete with nonnative fishes.¹⁵ The border region of southeast Arizona and northern Sonora—including the Santa Cruz, Gila and San Pedro rivers and the Río Yaqui and Río Concepción—is the habitat for 16 of the 21 species of fish native to the region. Three native frogs, a salamander and several species of garter snakes depend on aquatic habitat in these drainages. Although current modeling cannot reliably predict specific changes several decades in advance, projected warmer temperatures with more variable precipitation will result in greater stress for species in the coming decades.⁶¹

Coupled with nonclimatic factors such as population growth and development pressure, the higher temperatures, more extensive and severe droughts, and decreases in precipitation create challenges for protected natural areas, birds and wildlife, and riparian systems.¹¹

For example, in recent years demand has exceeded the supply of water from the transborder Colorado River system, which serves 40 million people, irrigates 3 million acres (1.2 million hectares) in the United States, and supplies 1.5 million acre-feet (1.9 billion cubic meters) of water annually to Mexico by treaty.^{62,63} The health of wetland ecosystems that are bountiful sources of biodiversity are affected by these increasing pressures.¹¹ The border fence marking the international boundary between the two countries fragments wildlife habitats and migration corridors and can limit species' ability to access food and mates on the other side of the fence.^{11,39}

1.7 Ecosystem services and carbon sequestration

Land-use and land-cover choices can influence the degree to which human communities and natural systems are vulnerable to climate change. The *Third National Climate Assessment* (2014) includes a discussion of sectors—including agriculture, forestry and other land use—that emit approximately one-quarter of all anthropogenic GHG emissions.⁷

In the case of the U.S.-Mexico border region, land-use and land-management choices can reduce atmospheric GHG releases; enhance resilience to a changing climate and related hazards; improve food, water and energy security; and improve human health. The 16th GNEB report, *Ecological Restoration in the U.S.-Mexico Border Region*, highlights some of these connections by drawing attention to the importance of green infrastructure, ecosystem services and human health, and the role that biomass and soil play in carbon sequestration on local, regional and global scales.⁶⁴ Key carbon capture targets include forests and wetlands as well as strategies to sustainably couple human and natural systems in human settlements using biotic and green infrastructure across local and bioregional scales. Coastal wetlands, for example, sequester and store significant amounts of carbon, up to 10 times more carbon per equivalent area than tropical forests.⁶⁵

Preventing further destruction or degradation of wetlands, forests and other natural areas in the U.S.-Mexico border region can limit future loss of natural vegetation and capture carbon through plant growth. Although the fraction of global emissions from the destruction of ecosystems is not as large as those from the burning of fossil fuels, the global emissions from degraded or destroyed coastal ecosystems alone can be substantial. Estimates of emissions from conversion and degradation of coastal wetlands amount to the equivalent of up to 19 percent of tropical deforestation emissions on an annual basis globally.⁶⁶

1.8 Wildfire frequency

The trend toward longer, hotter and drier summer seasons appears to be contributing to the significant increase in large wildfires in the western United States and those burning across the international U.S.-Mexico boundary.^{71,72} Increased warming and drought will further stress forest areas and result in more devastating insect infestations. The accumulation of woody fuel and the spread of nonnative grasses also have made the region more vulnerable to intense wildfires.⁷³ Increased temperatures also will contribute to a longer fire season; California, for example, now has a fire season that lasts all year.^{74,75} Fire models project more wildfires and increased risks to communities across extensive border areas.⁶

1.9 Coastal risk and vulnerability

Rising sea levels along the Gulf of Mexico and Pacific coasts will increase the likelihood of flooding and potentially compromise water quality and ecosystem health. Based on tide-gauge data, the past 100-year trend for sea-level rise is 0.68 feet (0.21 meters) near San Diego and 1.24 feet (0.38

meters) near Port Isabel, Texas.⁷⁶ Intermediate-low scenario projections of the increase in local relative sea level from 2015 to 2050 for these two locations (taking into account ocean thermal expansion but not melting ice) suggest an additional 0.49 feet (0.15 meters) and 0.70 feet (0.2 meters), respectively.^{77,78}

With elevated sea levels, the potential for coastal flooding—as well as erosion of bluffs, beaches and barrier islands—increases. The risk of damage and chronic, recurrent shallow coastal flooding from higher daily tides, as well as storm surge and destructive wave action from tropical storm events, will increase. Texas' Gulf Coast averages approximately three tropical storms or hurricanes every 4 years,⁷⁹ generating coastal storm surge and sometimes bringing heavy rainfall and damaging winds hundreds of miles inland. Sea-level rise creates the potential for greater damage from storm surge along both the Texas and California coasts. Coastal estuaries and marsh complexes may become inundated as sea level rises. In addition, saltwater intrusion into coastal aquifers can damage potable water sources.

Episodic and chronic coastal flooding could put at risk critical coastal infrastructure in San Diego and southeastern Texas, including ports, roads, bridges, energy production, and water and sewage treatment facilities, as well as urban beachfront development. Port Isabel, Texas, has seen a 547 percent increase in the number of recurrent (nuisance) flood days during the past 50 years (from 2.1 per year in 1960 to 13.9 per year in 2010).⁸⁰ In Texas, 26 percent of insured commercial and residential property lies in coastal counties, totaling \$1.2 trillion in 2013.⁸¹ Shorter term climate fluctuations, such as those caused by El Niño, can further stress the productivity, integrity and rebound capacity of economic, social and environmental systems.

In the U.S.-Mexico border region, human health, ecosystems and the water supply already are at risk. Climate changes and fluctuation may increase the severity and magnitude of these risks. Coupled with the poverty and social vulnerability of the region, federal agency action to help citizens adapt to and mitigate climate risks could improve the quality of life, livelihoods and security of border communities.

Following a discussion of border groups vulnerable to climate change in Chapter 2, the remainder of this report details current efforts by federal programs and reviews case studies of the impacts from climate risks. It culminates with recommendations to the U.S. President and Congress. ■



Chapter

2

Vulnerable Populations and Environmental Justice and Climate Change

2.1 Disadvantaged communities

A cross-cutting theme of this report is the impact of climate change on the vulnerable populations and disadvantaged communities—both rural and urban—present throughout the entire border region. Previous GNEB reports have underscored the intersection of disadvantaged communities and environmental impacts in the border region.³⁹ This GNEB report makes clear that these disadvantaged border communities are likely to be disproportionately affected by the projected impacts of climate change and that addressing their needs by federal agencies is a priority for environmental justice.

Native communities, many of which depend on tribal resources on reservation lands, are exposed to the threats of climate change on many levels. The border is replete with disadvantaged communities, often characterized as poor, without adequate urban services, and primarily Hispanic. The population of the U.S.-Mexico border has *per capita* incomes well below average U.S. *per capita* income levels.³⁹

Many of these disadvantaged border residents are found in *colonias* in Texas, New Mexico, Arizona and California, with both the largest number of *colonias* and the largest colonia population in Texas.⁸² *Colonias* are residential areas in rural and sometimes urban areas in the border region that lack basic urban infrastructure and services and are mainly Hispanic in population. The development of Texas *colonias*

dates back to at least the 1950s when developers divided surplus land in floodplains with low agricultural value into small lots with little or no infrastructure or urban services, such as potable water supply, seepage treatment, paved roads or public lighting. These lots were sold for low-cost housing sites. At one point, more than 400,000 residents in Texas lived in these *colonias* along the border with Mexico. As of 2014, 369,000 residents lived in 1,854 *colonias* in the six largest Texas border counties with *colonias*.⁸³ Today, Texas colonia residents continue to have incomes significantly lower than the state average, with a median income of \$28,900 compared to \$51,000 for the state as a whole. In the six largest counties with *colonias* in Texas, 96 percent of the population is Hispanic, with 94 percent of residents under 18 born in the United States.⁸⁴

It should be noted, however, that of the 369,000 colonia residents in Texas' six largest counties with colonia populations, only 38,000 lack water and sewer—a result of state, federal and binational agencies working together to fund this infrastructure.⁸³ As a result of the substantial efforts by many local, state and community representatives, much progress has been made during the last 25 years to improve the infrastructure, including laws that require counties along the border to adopt model subdivision rules to prevent future colonia development and new programs through the Texas Water Development Board. The Economically Distressed Areas Program provides financial assistance to provide water



Stepping stones in front of a colonia home reflect chronic flooding problems. **Credit:** EPA Office of Environmental Justice.

and wastewater services to economically distressed areas where services do not exist or systems do not meet minimum state standards, and through August of 2016, more than \$624 million in Economically Distressed Areas Program funds—including dedicated EPA funds through the binational North American Development Bank (NADB) and Border Environment Cooperation Commission (BECC)—have been provided throughout the state for completed projects, with some 300,000 residents benefited, most of them in border communities.⁸⁵

Colonias and low-income areas are present in large neighborhoods in the more prosperous cities of the border, including El Paso (Texas), Las Cruces (New Mexico), Brownsville



Many colonia homes are self-constructed from readily available used and new materials. **Credit:** EPA Office of Environmental Justice.

(Texas) and San Diego (California), where income disparities often are significant. For example, in 2010, San Diego County was the wealthiest area along the border, with a median household income of \$62,771 and a population that was 32 percent Hispanic. In contrast, the city of San Diego's San Ysidro Community Planning Area, which is adjacent to the port of entry, had a 2010 population that was 93 percent Hispanic with a median household income of \$35,993.⁸⁶ San Ysidro's socioeconomic characteristics were more similar to populations elsewhere along the border than to those in the rest of San Diego County.

A limited supply of adequate, affordable housing in cities and rural areas along the Texas-Mexico border, coupled with the rising need for such housing, has contributed to the development of new *colonias* and the expansion of existing ones. People often buy property lots through a contract for deed, a financing method whereby developers offer a low down payment and low monthly payments but no title to the property until the final payment is made. Houses in *colonias* generally are constructed in phases by their owners and may lack electricity, plumbing and other basic amenities.

The *colonias'* growth has challenged residents, as well as county, state and federal governments, to provide basic water and sewer services and improve the quality of life in the *colonias*.⁸⁷ Local public funds and other resources often are limited and unable to provide services to the current and growing colonia population. Hidalgo County, which has the most *colonias* and largest number of colonia residents in Texas, is typical of many border counties. For basic health



Without piped-in municipal water, washing clothing requires significant effort. **Credit:** Federal Reserve Bank of Dallas.



Pit privies are the norm in colonias without municipal sewage systems and often contaminate adjacent shallow wells. **Credit:** Federal Reserve Bank of Dallas.

and human services, environmental services and capital improvements, colonia residents must rely on an often confusing combination of local, state and federal programs, many of which come and go depending on the political and economic climate.

2.2 Environmental justice

Executive Order 12898, signed by President Bill Clinton in 1994, requires each federal agency to work to achieve environmental justice in agency policies and regulations. Although the executive order is not enforceable in court, federal agencies have subsequently incorporated considerations of environmental justice in their operations. Environmental justice concerns the inequitable exposure of poor and minority communities to environmental hazards.⁸⁸ Environmental justice is required to be considered in federal planning as described in Executive Order 12898⁸⁹ and has been an issue along the border for environmental agencies and others.^{90,91} A significant body of scientific literature exists about environmental justice in the United States and worldwide, with numerous critical appraisals of its research methodologies and conclusions; however, the U.S. federal mandate for consideration of environmental justice issues within the United States by the executive order is quite clear.^{92,93}

In the border region, many neighborhoods with high poverty rates are especially vulnerable to climate change impacts such as drought, rising temperatures that intensify health effects of air pollution, and extreme weather events. The many challenges faced by residents of poor neighborhoods detailed in Chapter 1 exacerbate health effects in these underserved communities. For example, disparities in exposure to traffic have been documented and are considered an environmental justice issue in the U.S.-Mexico border region. In California, Hispanic children have been shown to be more likely to live in areas with higher traffic density than non-Hispanic whites.⁹⁴ Despite health risks posed by traffic exposure, some schools in California are located close to traffic sources, and these schools are more likely to be poor and serve Hispanic students.⁹⁵

2.2.1 Ports of entry and environmental justice

The border ports of entry are vital to U.S. trade and the national economy, but most of these are located in the U.S. cities adjacent to residential and commercial areas whose residents and workers are mainly low income. In these areas, the location near the port of entry amplifies the environmental justice issue. As described in Chapter 1, proximity to heavy trucks and large numbers of idling vehicles can expose border crossers to toxic air pollutants. Traffic pollutants concentrations are much higher very near the source as compared to further away, and exposure to near-traffic environments is associated with a host of harmful health effects, including cardiovascular and adverse birth outcomes.⁴⁹ Short-term high exposures and long-term exposures have been linked with health effects.⁹⁶ Exposures from being near traffic at border crossings come in addition to background exposures to the generally poor air quality



Solar panels along the shore of Lake Powell. Credit: Susan Schmitz / Shutterstock.com.

along the U.S.-Mexico border.⁹⁷ At the U.S.-Mexico border crossings, the existing infrastructure was not designed to consider the effects of air contamination by idling vehicles. At many crossings, for example, pedestrians wait in long lines adjacent to idling vehicles, and they only escape the direct exposure when entering an air-conditioned pedestrian inspection facility after crossing into the United States. As the U.S. economy improves, cross-border commercial and noncommercial vehicular traffic and pedestrian crossing through the ports of entry will grow, which will increase concerns regarding wait times and health effects.

The infrastructure and administrative resources for the ports of entry along the Mexican border have always lagged behind demand that was driven by international trade and by population growth in the border region. Investment in efficient borders has always had as a first priority the facilitation of movement of commercial cargo. A second priority has been improving the flow of passenger vehicles. The very last priority, until recently, has been improvement of pedestrian crossings.

Reducing border wait times also is an obvious measure to limit people's exposures when waiting to cross at ports of entry. This would directly benefit vehicle drivers and passengers as well as pedestrians crossing the border, and air quality near the crossing would be improved. Even though recent border infrastructure improvements at San Ysidro have significantly reduced vehicle wait times, the pedestrian waits are still often 1 hour or longer.⁹⁸ Lack of shade, hot and cold weather extremes in the desert regions, and the deliberate avoidance of liquid intake by crossers because of the lack of public toilet facilities can exacerbate the adverse

effects of pollution exposures. Many of the pedestrians are from low-income groups and cannot afford the expedited crossing permits or to cross in a vehicle. Thus, the pollution exposure is greater at the border crossings for low-income residents of the region.

2.3 Native communities and climate change: Protecting tribal resources as part of national climate policy

Native American communities are among the most vulnerable groups in the U.S.-Mexico border region. Tribes often are the first to see and feel changes in the natural environment. Traditional tribal practices and relationships with the natural world form the spiritual, cultural and economic foundation for many Native American nations—foundations that will be, and in some cases already are, threatened by climate change. For example, many Native Americans reside in rural regions that are particularly exposed to the growing threat of wildfires, enhanced by climate change impacts. For centuries, the Colorado River and its tributaries have been the lifeblood of southwestern tribes, including the Hopi, Navajo, Mohave, Apache and Tohono O'odham. Historically, plentiful waters enabled tribes to survive in this arid region by growing crops and raising livestock, traditional subsistence practices that many tribes still follow today. A dramatic increase in the population of the Southwest has placed a severe strain on the water resources in the Colorado River Basin. Today's users place such high demand on the river system that in most years the Colorado River does not reach its outflow into the Gulf of California, nor does this trend show signs of stopping. The populations of Nevada and Arizona alone are projected to double in the next 25 years.

Although tribes often hold federal reserved water rights that are among the most senior in the prior appropriation scheme of water allotment in the West, many tribal water rights remain unquantified, and tribal access to water rights often is impeded by the lack of infrastructure. In a warmer and drier Southwest, competition for water resources will only become fiercer, posing significant challenges for tribes and also threatening the already unstable and delicate allocation for all Southwest residents. Increased demand for decreasing water supplies will have serious implications for tribes, as competition between tribal and nontribal users will make water adjudication and negotiation more difficult.

The federal trust responsibility requires the federal government to protect tribal land and resources. This authority is rooted in numerous treaties, statutes, executive orders and judicial opinions that recognize the very tribal rights at risk from climate change. Consequently, federal agencies play a key role in partnering with Native communities to address the challenges of climate change.

2.3.1 Alternative energy development for tribes

Because fossil fuel emissions are such a major contributor to GHGs and climate change, development of alternative energy technologies will be an important component of any future strategy. Tribes have some of the greatest resources (e.g., wind and solar power) for helping the United States with renewable energy development. At the same time, they are among the most vulnerable to climate change impacts caused in large part by conventional fossil fuel-based energy development. Helping tribes develop alternative energy technologies both on reservations and as part of a national renewable energy program can help overcome this contradiction. Alternative energy projects take investment capital, infrastructure and technical capacity that tribes often lack. Development of renewable energy resources by tribes on their own will do little to mitigate the impact from climate change on their communities. Tribes, however, can play an important role in any national or international solution. For this reason, any renewable energy program at the federal level, including the binational NADB-BECC, should include opportunities and incentives for tribes. Such a program should include technical assistance and subsidies for individual projects on reservations. The government also should

provide financial assistance to establish transmission lines to connect tribal projects to the national energy infrastructure.

2.4 Recommendations

1. Vulnerable and disadvantaged border communities will be disproportionately affected by climate change impacts. These groups also often lack the expertise to access available federal programs that assist border communities to develop resiliency to these impacts. An immediate priority should be to coordinate federal agencies to proactively perform outreach to disadvantaged border communities to assist in addressing the effects of climate change.
2. The NADB-BECC, through consultations with border tribes and coordination with U.S. federal and state programs, should develop a specific program to facilitate the development of renewable energy by border tribes.
3. Every federal agency with an emergency preparedness mission should use its existing programs to support vulnerable and disadvantaged communities in establishing infrastructure and building capacity for fire suppression, emergency management implementation, and hazard mitigation for natural disaster events. For example, federal agencies should facilitate wildland fire management specific to rural disadvantaged tribal and other vulnerable communities.
4. EPA should continue to support the La Paz Agreement and Border 2020 initiatives to enhance emergency response coordination with its federal, state and local partners, with special attention to tribal communities and underserved populations. As GNEB recommended in its 11th report, *Natural Disasters and the Environment Along the U.S.-Mexico Border*, emergency response must be more closely coordinated across the border with Mexico. Most importantly, the 1980 U.S.-Mexico Agreement on Cooperation During Natural Disasters needs to be updated to enable the immediate and targeted responses required when a natural disaster affects the shared geographical region on both sides of the border. ■



Chapter

3

Existing Federal Programs and Resources

Federal agencies are committed to addressing climate change. On February 19, 2015, President Barack Obama signed Executive Order 13693,⁹⁹ which commits the United States to reduce GHG emissions by 40 percent during the next decade from 2008 levels, saving taxpayers up to \$18 billion in avoided energy costs. The federal government agreed to increase the share of electricity that it consumes from renewable sources to 30 percent. Both federal and state agencies are investing significant financial and human resources in the border region to reduce pollution and environmental degradation; address water and air quality, energy and health issues; and facilitate the movement of goods and people. These agencies also are investing in programs to mitigate climate change impacts and increase the resiliency of local communities. Regular transboundary consultation between the United States and Mexico can empower cooperative local responses and enhance border resiliency through careful planning and bilateral collaboration with local and international partners. Federal leadership in transborder cooperation through increased use of the Border Liaison Mechanism (a local binational meeting that U.S. and Mexican consuls convene to address cross-border issues), the U.S. and Mexican sections of the International Boundary and Water Commission (IBWC), and other means is critical in developing regional approaches to binational issues. It is beyond the scope of this chapter or report to describe all federal programs in the U.S.-Mexico border region that can mitigate climate risks and improve community adaptation to climate fluctuation and change. Instead, this chapter seeks to describe some of the programs and provide case studies of

successful agency actions. [Table 1](#) alphabetically lists federal agencies and the scope of their climate-related responses. Included are two binational institutions—the NADB-BECC—and the IBWC.

3.1 Agriculture

The Natural Resources Conservation Service (NRCS), a nonregulatory agency under the U.S. Department of Agriculture (USDA), works with private landowners and land managers to plan and implement conservation efforts within the diverse variety of ecosystems, critical habitats and treasured landscapes along the U.S.-Mexico border, ranging from deserts and mountains to natural waterways such as rivers, streams and creeks. Through its guiding principles of “service, partnership and technical excellence,” the NRCS provides technical and financial assistance in an effort to protect, restore and enhance impaired natural ecosystems at risk from climate change, extreme weather, land fragmentation and urban encroachment. The NRCS partners with state and local governments, as well as private organizations, to sustain and restore ecosystems to improve water quality and quantity and air quality as well as enhance soil productivity and the diversity of healthy plant and wildlife communities.¹⁰⁰

For example, in fiscal year 2016, the NRCS’ priorities included soil health, nitrogen management, livestock partnership, grazing and pasture, energy efficiency, and private forests. Two climate change mitigation opportunities are being offered along the Texas border. A Rio Grande project near Fort Quitman, just downstream of El Paso,

Table 1. Scope of Climate-Related Responses for Border Communities of Federal and Binational Agencies

Agency	Scope of Climate-Related Response						
	Air	Emergency Preparedness	Energy	Health	Movement of Goods	Water Infrastructure	Ecology
U.S. Department of Agriculture	◆		◆				◆
U.S. Department of Commerce, National Oceanic and Atmospheric Administration	◆	◆			◆	◆	◆
U.S. Department of Health and Human Services	◆	◆		◆			
U.S. Department of Homeland Security		◆	◆		◆	◆	
U.S. Department of Interior	◆	◆	◆			◆	◆
U.S. Department of State	◆	◆	◆	◆	◆	◆	
U.S. Environmental Protection Agency	◆	◆	◆	◆	◆	◆	◆
International Boundary and Water Commission, U.S. Section		◆	◆		◆	◆	
North American Development Bank-Border Environment Cooperation Commission	◆	◆	◆	◆		◆	◆

promotes carbon sequestration in soil on both rangeland and cropland. A Southern Texas Rio Grande project promotes soil health and grazing on pasturelands to increase carbon sequestration. In both projects, the NRCS also works closely with the Texas State Soil and Water Conservation Board in promoting conservation practices. The NRCS' Migratory and Shore Bird Habitat Initiative involves conservation planning for migrating, shorebird and grassland nesting bird habitats in Texas' southernmost border counties. Funding has been provided for brush management, grass planting, prescribed burning and prescribed grazing to emulate open prairie and savannah-type ecosystems that support grassland bird species. These practices also create habitat for a number of migratory insect, bird and animal species, such as the Monarch butterfly and neotropical migratory bird populations.

During fiscal year 2015, the USDA's national StrikeForce for Rural Growth and Opportunity provided relief for Texas, New Mexico and Arizona counties with persistent poverty, 85 percent of which are in rural areas. The NRCS collaborated closely with other USDA agencies, partners, community-based organizations, stakeholders and communities to reach underserved populations and rural communities; improve access to and participation in USDA

programs; enhance economic opportunities and benefits to these areas; and enable farmers, ranchers and private landowners to operate more sustainably while their conservation practices promote clean air and water, healthy soil, wildlife habitat and resistance to extreme weather events, such as drought. The NRCS' Texas program provided \$1.2 million through its Environmental Quality Incentives Program to farmers and ranchers in StrikeForce counties.

3.2 North American Development Bank/Border Environment Cooperation Commission

In 1993, in the context of negotiations of the North American Free Trade Agreement, sister U.S.-Mexico binational institutions, NADB and BECC, were established. The institutions were funded in equal parts by the United States and Mexico and are mandated to preserve, protect and enhance the environment of the border region to advance the well-being of the people of the United States and Mexico. The joint NADB-BECC Board of Directors comprises representatives from the U.S. Department of State (State Department), U.S. Department of Treasury, and EPA and their Mexican federal counterparts, as well as state and local representatives from the border region. The State

Department also directly funds BECC operations in the amount of approximately \$2.4 million annually.

The close coordination between NADB and BECC, including the integration of their respective boards of directors into a single board in 2006, has resulted in significant benefits to the projects these two institutions support. Realizing the benefits of closer integration, the board of directors in 2014 approved a resolution recommending the merger of the two organizations into one. The merger process continues in 2016.

NADB, located in San Antonio, Texas, and BECC, located in Ciudad Juárez, Chihuahua, constitute an innovative, binational approach to environmental infrastructure development and financing in the border region. NADB and BECC offer comprehensive support to public entities and private companies in planning, development, implementation, supervision and results measurement of environmental infrastructure projects. NADB is authorized to make loans to public and private sector borrowers operating within the United States and Mexico. Any project, regardless of community size or project cost, is eligible for financing and other forms of assistance from NADB if it meets all three of the following eligibility criteria: (1) it is a remedy to an environmental and/or human health problem; (2) it passes the BECC certification process; (3) it is located within 100 kilometers (62 miles) north of the international boundary in one of the four U.S. states of Texas, New Mexico, Arizona or California or within 300 kilometers (186 miles) south of the border in one of the six Mexican states of Tamaulipas, Nuevo León, Coahuila, Chihuahua, Sonora or Baja California.

NADB and BECC provide technical assistance and institutional strengthening efforts through community grants for project development activities, including feasibility and engineering studies, urban and regional planning, infrastructure needs assessments, and credit ratings for potential borrowers. They also facilitate capacity building through studies and various workshops on climate change and basic infrastructure. To date, NADB is participating in 225 BECC-certified environmental infrastructure projects with \$2.72 billion in loans and grants, of which 89 percent has been disbursed for project implementation.¹⁰¹

Many of these projects have addressed issues that increase border community resiliency in the face of climate change impacts and include projects for water conservation and efficiency, energy efficiency, cleaner and alternative energy, air pollution reduction, and green infrastructure. BECC partnered with EPA and the Center for Climate Strategies on a climate-change initiative coordinated with Mexico's National Institute of Ecology and Climate Change. GHG inventories completed in 2010 for the six Mexican border

states concluded that by 2025, these states would generate 31 percent of Mexico's total GHG emissions with only 19 percent of the national population residing in these states. Following the completion of these inventories, BECC—with support from Border 2020, the U.S. Agency for International Development (USAID), the Latin American Regional Climate Initiative, and El Colegio de la Frontera Norte—continued work with the Mexican states of Baja California, Sonora, Chihuahua, Coahuila and Tamaulipas to complete state climate action plans, which identify mitigation policies. NADB and BECC also support many projects in energy efficiency and alternative energy to reduce GHG emissions.

Since 1997, the U.S.-Mexico Border Water Infrastructure Program, funded by the U.S. Congress through EPA, has awarded grants to border-region water and wastewater systems through the Project Development Assistance Program for project development and design and the Border Environment Infrastructure Fund (BEIF) for construction programs administered by NADB-BECC. EPA and NADB-BECC have contributed more than \$47 million in Project Development Assistance Program technical assistance grants for project development in more than 160 communities. The BEIF has committed \$642.3 million to implement 115 water and wastewater projects in the United States and Mexico. Of that amount, \$597.4 million has been disbursed for project implementation, which represents 93 percent of the funds contracted for projects. The BEIF selection process requires that every project, whether located in the United States or Mexico, document an environmental and human health benefit for the United States.¹⁰²



Water infrastructure construction for new development.

Credit: Muratart / Shutterstock.com.

In 2015, NADB and BECC expanded promotion of green infrastructure along the border to document how green strategies and technologies—such as reinstating native flora, redesigning street medians and sidewalks to capture stormwater onsite, and using permeable paving materials—can be gradually incorporated into existing urban infrastructure.

BECC hosted five green infrastructure events in 2015, including the second annual Border Green Infrastructure Forum in Tucson, Arizona, and an interactive webinar to explore the current legal framework for promoting green infrastructure projects in Mexico. Two workshops involving a hands-on demonstration project also were hosted in San Luis Río Colorado, Sonora, and Ramos Arizpe, Coahuila. The exercise focused on passive rainwater harvesting and reuse systems and the importance of planting native vegetation for restoring regional ecosystems.^{103–105}

NADB and BECC also encourage public-private cooperation to conduct climate change adaptation planning; conduct scientific studies; advocate for management and conservation strategies that address the threat of climate change; engage volunteers in critical monitoring, protection and restoration activities; and advocate for sustainable policy. One example of this engagement is the Sky Island Alliance in Tucson, which involves a range of nongovernmental organizations and local, state and federal government agencies. One of Sky Island Alliance's focus areas is climate change, and the organization conducts climate change adaptation planning and scientific studies; advocates for management and conservation strategies that address the threat of climate change; engages volunteers in critical monitoring, protection and restoration activities; and advocates for good policy. Working on landscape issues, Sky Island Alliance has convened a series of climate change workshops to address natural resource management, planning and conservation and has published its adaptation methods and results to promote strategies that safeguard ecological systems and the wildlife and human populations that depend on them.

3.3 Commerce

Scientists are increasingly called on to address the most pressing challenges of our time. They also are asked to articulate the societal impact of their work and communicate research findings to broader audiences. Researchers in all disciplines must not only communicate their research to the public, but also they must work with the public to develop an effective research agenda that authentically addresses the concerns and

needs of communities. The National Academies of Sciences, Engineering, and Medicine Committee on Science Literacy and Public Perceptions of Science argues that science literacy is desirable not only for individuals but also for the health and wellbeing of communities and society. Science literacy in public decision making is increasingly important.¹⁰⁶ This presents special challenges in transboundary regions that span international borders. The type of efforts described in this report thus merit ongoing evaluation and support.

For instance, the National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce manages science and stewardship programs that advance the understanding of and ability to anticipate changes in the environment, improve society's ability to make scientifically informed decisions, and conserve and enhance ocean and coastal resources. NOAA's observations, tools and information enable people to understand and prepare for climate variability and change as well as monitor climate and environmental fluctuations as they occur in real time. NOAA is an important resource for research results, data and analysis to help border communities develop capacity to respond to the effects of climate change.

For example, the [Climate.gov](https://climate.gov) website provides timely and authoritative scientific data and information about climate to promote public understanding of climate science and climate-related events, as illustrated by the report *Drought on the Rio Grande*.¹⁰⁷ NOAA's National Hurricane Center also provides storm surge forecasts, which are of increasing interest to Pacific and Gulf of Mexico border communities.¹⁰⁸ NOAA's U.S. Climate Resilience Toolkit provides scientific tools, information and expertise to help people manage climate-related risks and opportunities to improve resilience to extreme events, such as the Boosting Ecosystem Resilience in the Southwest's Sky Islands case.¹⁰⁹ [Table 2](#) lists site resources.

NOAA leads the interagency National Integrated Drought Information System (NIDIS), which improves the country's capacity to manage drought-related risks by providing the

Table 2. The National Oceanic and Atmospheric Administration's U.S. Climate Resilience Toolkit

Component	Content
Steps to Resilience	Steps that users can follow to initiate, plan and implement projects to become more resilient to climate-related hazards.
Case Studies	Real case studies of climate risks affecting communities and steps they are taking to plan and respond to improve resilience.
Tools	Free software to access, analyze and visualize climate data; estimate climate trends and hazards; and enable resilience-building efforts.
Climate Explorer	A visualization tool to create maps of climate stressors and impacts and interactive graphs of daily observations or long-term averages from thousands of weather stations.
Self-Guided Learning and Access to Expertise	Narratives explaining how climate variability and change can affect regions and economic sectors, pointers to free training courses, locations of centers for regional climate information, and search tools for accessing federal climate science domains.

best available information and tools to prepare for and mitigate the effects of drought. NIDIS operates a Drought Early Warning System to make climate and drought science readily available to a wide range of federal, tribal, state, local and academic partners and to improve the capacity of stakeholders to monitor, forecast, plan for and cope with the impacts of drought. The North America Drought Monitor is a cooperative Canadian, Mexican and U.S. effort to monitor drought across the continent.¹¹⁰ The system allows each country's drought experts to coordinate and integrate data collection and monitor droughts across the continent monthly. NOAA's Digital Coast provides coastal social and economic data, satellite and Lidar imagery, hydrography data sets, land cover and land cover-change databases, and digital elevation models, as well as decision-support tools and training for coastal managers to help communities address climate resiliency issues and other topics, such as adaptation.

The Global Ecosystem Center used NOAA's Coastal Change Analysis Program to integrate land-cover data sets with Landsat imagery from 1984 and 2011 to evaluate land cover over 26 years to visualize urban growth in the region between Los Angeles and San Diego and illustrate fire risks so as to develop land-use and natural-resource management strategies to address fire vulnerabilities. Another example is the San Diego Regional Climate Collaborative, a partnership of local and regional organizations working together to protect the county's approximately 70 miles of coastline from vulnerabilities to sea-level rise, coastal flooding and extreme weather events and help participating cities in California (Oceanside, Carlsbad, Encinitas, Solana Beach, Del Mar, San Diego and Imperial Beach) coordinate sea-level rise

vulnerability assessments and integrated coastal resilience strategies to reduce the region's risks and vulnerabilities and build regional coastal resilience. A third example is the Gulf of Mexico Alliance, whose partners will seek to help 10 Gulf of Mexico coastal communities enhance their resilience to future hazards through pilot projects and regional coordination, including in Texas.



Tijuana estuary in San Diego, California, the largest undivided, intact coastal wetland in Southern California.

Credit: Sherry V. Smith / Shutterstock.com.

3.4 Energy

The U.S. Department of Energy (DOE) seeks to ensure America's security and prosperity by addressing its energy and environmental challenges through transformative science and technology solutions. As part of its initiatives related to climate change and energy, the DOE works collaboratively with its counterparts in Mexico and Canada. In May 2015,

San Diego Climate Collaborative (National Oceanic and Atmospheric Administration [NOAA] Regional Coastal Resilience Program)

The San Diego Climate Collaborative, founded in 2012, is a member-based network supporting public agencies in the San Diego region to advance comprehensive solutions to reduce greenhouse gas emissions and prepare for climate impacts. In February of 2016, the collaborative received a \$689,500 grant from NOAA (matched with nearly \$350,000 from nonfederal partners) for protecting the region's coastline. As storms and flooding from El Niño and sea-level rise have threatened the San Diego region's coastline, infrastructure and economy, this partnership managed by seven San Diego public agencies has extended its efforts to improve regional resilience and urban protection. The project provides new data on flood mapping and shoreline bluff surveys, developing

additional legal, economic and scientific expertise and helping cities with outreach and communication. Along with 70 miles of beaches that attract millions of visitors each year, San Diego's coastal region contains key infrastructure such as major transportation arteries, including Amtrak rail lines and highways; seven major military installations; and water and energy infrastructure, including power plants and a new desalination plant.

Specific goals of the collaborative include the coordination of sea-level rise vulnerability assessments for the five contiguous Californian coastal cities of Oceanside, Carlsbad, Encinitas, Del Mar and San Diego and legal and cost benefit analyses of

potential coastal protection strategies that could be incorporated into land use, regulatory policies and capital improvement programs. As a result, local coastal plans will be updated to account for coastal storm and sea-level rise hazards. The large number of NOAA Regional Coastal Resilience Grants Program proposals devoted to building resilience in coastal communities in the face of climate change impacts and hazards indicate both the extraordinary level of nationwide need and the realization that communities, in addition to facing current impacts, are concerned about the future impacts that will potentially have greater negative consequences to their environmental, social and economic sustainability.

the energy ministers from the three countries established a Working Group on Climate Change and Energy to support implementation of clean energy and climate change goals. Areas for collaboration include energy efficiency, low-carbon electricity grids, and climate change adaptation and resilience. In February 2016, the three countries signed a Memorandum of Understanding Concerning Climate Change and Energy Collaboration, which expanded areas of cooperation addressing climate change associated with energy production, transmission and use. Bilateral discussions between the United States and Mexico also encourage the development and implementation of initiatives to foster cooperation in the energy sector between the two countries.

3.5 Environmental Protection Agency

EPA is the U.S. lead agency for protecting human health and the environment, including promulgation, enforcement and rule development related to the Clean Air Act and hazardous materials responses during declared disasters or emergencies, such as major storms and other climate-related incidents. The EPA-led binational Border 2020 Program, an implementation program of the 1983 La Paz Agreement, empowers federal environmental authorities in the United States and Mexico to implement cooperative initiatives through multiyear binational programs. In collaboration with Mexico's environment ministry, Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT)—as well as help from EPA's partners in state government, industry, academia, tribes and local communities—Border 2020 builds on progress already made on climate change and other environmental issues under the program. Border 2020 emphasizes regional, bottom-up approaches for decision making, priority setting and project implementation to protect and improve the environment and public health along the border. Many of the activities under Border 2020, as well as other EPA programs, respond directly to climate change issues in border communities.

Border 2020 has established five environmental and public health goals: (1) reduce air pollution; (2) improve access to clean and safe water; (3) promote materials management, waste management and clean sites; (4) enhance joint preparedness for environmental response; and (5) enhance compliance assurance and environmental stewardship.¹¹¹ Within each goal, EPA has defined specific priority activities that program partners will undertake to protect the environment and public health in the U.S.-Mexico border region through “conservation-oriented social and economic development that emphasizes the protection and sustainable use of resources, while addressing both current and future needs, and present and future impacts of human actions.”¹¹² Task forces devoted to EPA's Border 2020 Goal 4 regularly discuss, plan, prepare and conduct exercises for potential

emergency responses because of the increased potential for floods, fire and severe storms resulting from climate change. EPA coordinates closely with FEMA, NOAA, and the U.S. Coast Guard—as well as with other federal, state and local agencies (e.g., Protección Civil, county emergency managers, emergency management departments)—through the Goal 4 task forces and EPA Regional Response Teams.

EPA works with partners along the U.S.-Mexico border to address binational environmental challenges and disproportionate health effects that burden border communities. Health effects include poor indoor and outdoor air quality, mismanagement of pesticides, misuse of chemicals and other waste, poor water quality, and binational chemical emergencies. Increasing temperatures that have accompanied climate change have exacerbated many of these problems, particularly the health effects of poor air quality in border communities. One example of EPA efforts to improve air quality is through the Imperial County (California) Air Pollution Control District. Region 9 has provided funding for the last 5 years to allow the district to implement a campaign that discourages the use of fireworks and open burning; public service announcements are aired on local television, and outreach materials are distributed to local schools.

EPA has been working with many partner organizations along the border to protect children's health in communities by funding a dozen organizations during the past 3 years to support capacity building through training for child care and school personnel, environmental home assessments, education for farm workers about take-home pesticide exposures, and training for those who train others. Many of these activities address issues related to children's health and the effects of climate change. These efforts have affected about 25,000 people directly; when a community health promoter (*promotora*) carries the message about children's health protection into a community or physicians hear about children's health protection in grand rounds or via online training, long-term, multiplicative effects within a community may result. For example, with partners such as the Southwest Center for Pediatric Environmental Health, Texas Tech University Health Sciences Center in El Paso, the White House “Strong Cities, Strong Communities” initiative, and the University of Texas Rio Grande Valley, EPA has cohosted three successful children's environmental health symposia in the border region. During these symposia, experts from the United States and Mexico presented on a variety of important topics, including asthma and air pollution, lead and mercury exposure, climate change effects on children's health, diabetes and obesity, and vector-borne illnesses. Participants included health professionals, *promotoras*, community-health workers and academics, as well as representatives from federal, state and local governments.



Measuring station for air quality and weather. **Credit:** Grafxart / Shutterstock.com.

EPA has addressed mobile source emissions and impacts from U.S.-Mexico trade ports of entry as a major source of pollution resulting from the high volume of personal vehicle and diesel truck traffic that crosses the border, as described in Chapters 1 and 2. For example, the San Ysidro Port of Entry in California is the busiest land port in the world, accounting for almost 20 percent of all personal vehicle and pedestrian crossings on the U.S.-Mexico border. The San Diego Air Pollution Control District, with funding from EPA Region 9, installed an air quality monitor at the San Ysidro Port of Entry for $PM_{2.5}$ in 2015 to gather data about air quality and likely impacts on the local community. $PM_{2.5}$ consists of ultrafine particles that are absorbed deep into the respiratory tract. They are generated to a significant degree by motor vehicles, and they affect the air quality adjacent to motor ways.

Using a methodology developed by the Federal Highway Administration (FHWA) that estimates emissions from vehicles crossing the ports of entry, EPA also has provided funding to estimate emissions at the Calexico, California, and the Mariposa, Arizona, ports of entry. For the Mariposa study, researchers used historical information from the U.S. Department of Transportation's Bureau of Transportation Statistics and field data to establish a simulation model. The results from the model are input to the Motor Vehicle Emission Simulator, state-of-the-art emission modeling software developed by EPA to analyze emissions. For the Calexico study, researchers utilized methodologies developed by FHWA.¹¹³ Emissions were estimated using a model used by California state and local governments to meet Clean Air Act requirements that calculates air pollution vehicle emissions factors. The Motor Vehicle Emission Simulator also was used for this study to develop an adjustment factor to account for conditions that the California model cannot directly analyze. The results of these studies can be used by local, state and federal agencies responsible for planning new ports or expanding existing ports to minimize emissions.

With funding from EPA, the California Air Resources Board is operating two $PM_{2.5}$ monitors in Mexicali, Baja California, for the next 2 years. Air quality from these monitors will help inform both countries of the international transport of $PM_{2.5}$. Imperial County (California) is in nonattainment for $PM_{2.5}$ and has been successful in demonstrating, pursuant to Clean Air Act Section 179B International Border Areas, that it would have been in attainment but for emissions emanating from Mexico. With funding from EPA, the state of Arizona recently completed 2 years of PM_{10} (PM less than or equal to 10 millimeters in diameter) monitoring in Nogales, Sonora. Air quality data from these monitors will help inform both countries of the international transport of PM_{10} in the region.

In 2015, with EPA funding, the Texas Commission on Environmental Quality contracted with the Texas A&M Transportation Institute to generate border-specific drive cycles for cross-border transit buses at the El Paso-Ciudad Juárez Port of Entry. The commission analyzed the data following federal emissions models to develop a more refined on-road mobile emissions inventory. In addition, as vehicle traffic at border crossings contributes to total on-road mobile-source emissions in border cities—and there was no methodology to estimate this impact—the Texas Commission on Environmental Quality contracted with the Transportation Institute to develop a robust estimation methodology to allow analysis of cross-border vehicle activity and accurate calculations of the potential effect of control strategies. The estimation tool was completed in 2013 and facilitates modeling at other inland ports along the entire length of the U.S.-Mexico border, especially Laredo-Nuevo Laredo, the inland port in the United States with the highest commercial volume.

In recent years, as part of implementation of the Clean Air Act, EPA has been targeting climate change more directly by targeting GHG emissions—first through engine and fuel economy standards in the transportation sector—but also



In 2015, the Border Health Commission and U.S. Environmental Protection Agency Regions 6 and 9 cooperated with governmental and nongovernmental organizations to train *promotoras* in cities throughout the border region. **Credit:** Pema Garcia, Texas A&M University.

requiring large newly constructed power plants to obtain a GHG air permit. Most recently, EPA adopted a new rule on August 3, 2015, known as the Clean Power Plan (CPP), which would eliminate significant amounts of power plant carbon pollution, and the resulting health-harming pollutants, by requiring existing power plants to reduce CO₂ emissions by 30 percent in the next 15 years. The CPP offers clean energy innovation, development and deployment and lays the foundation for the long-term strategy needed to tackle the threat of climate change.

One of the key programs of the CPP, known as the Clean Energy Investment Program, would provide—as part of the way to comply with the CPP Rule—extra incentives for states, tribes and local communities to invest in energy efficiency and renewable energy accessible to communities. By providing states and utilities ample flexibility and the time needed to achieve these pollution cuts, the CPP offers the power sector the ability to optimize pollution reductions while maintaining a reliable and affordable supply of electricity. The CPP will allow fossil fuel-fired power plants to continue to operate more cleanly and efficiently while expanding the capacity for zero- and low-emitting power sources. EPA is establishing interim and final statewide goals. These goals will reduce sulfur dioxide and NO_x and lower missed work days, premature deaths, asthma attacks and premature deaths related to pollution. The CPP has been challenged in court and was recently stayed by the U.S. Supreme Court while the CPP is under review. Some border states have continued to plan for implementation of the CPP, whereas others are awaiting the results of the review by the Court of Appeals.¹¹⁴

3.6 Health and Human Services

The Border Health Commission (BHC) within the U.S. Department of Health and Human Services (HHS) provides international leadership to improve health and the quality of

life along the U.S.-Mexico border by convening stakeholders to promote health and prevent diseases. For example, the BHC has established a collaborative partnership with EPA to coordinate activities that support the BHC's Healthy Border 2020 initiative and EPA's Border 2020 program. In 2015, the BHC and EPA Regions 6 and 9 cooperated with governmental organizations and nongovernmental organizations to train *promotoras* in cities throughout the border region, covering topics such as air quality, carbon monoxide, asthma, lead exposure, pesticides, household chemicals, water quality and drought within the Texas-Chihuahua region. In regard to climate change, participants in those sessions considered measures that their communities and organizations are taking to address climate fluctuation and change risks. The BHC and EPA collaborated on three children's health symposia in 2015 and 2016 in El Paso, San Diego and Brownsville. All included discussions on climate change and its effects on children's health, especially with regard to infectious diseases, respiratory illness and heat-related illnesses.¹¹⁵

3.7 Interior

The U.S. Department of the Interior (DOI) protects and manages the country's natural resources and cultural heritage, provides scientific and other information about those resources, and honors its trust responsibilities and special commitments to American Indians, Alaska Natives and affiliated island communities. To implement President Obama's 2013 Climate Action Plan, DOI's Bureau of Reclamation, the U.S. Fish and Wildlife Service, the National Park Service, and the U.S. Geological Survey (USGS) have developed and implemented programs to enhance the resiliency of U.S. border communities.

For example, USGS manages eight Climate Science Centers, providing scientific vulnerability assessments, estimation of climate effects on natural resources, monitoring, and data

sharing for making decisions on mitigating and adapting to the effects of climate change.¹¹⁶ DOI's Landscape Conservation Cooperatives operate at the regional and field levels to partner with federal, state, tribal and local entities to apply Climate Science Center findings. For example, one Climate Science Center-Landscape Conservation Cooperative effort (the Southwest Tribal Climate Adaptation Workshop convened in San Diego in 2015¹¹⁷) helped southern California tribes learn about climate change impacts on tribal resources and vulnerabilities and possible ways of adapting to these impacts.

USGS supports 48 Water Science Centers in the United States that collect, analyze and disseminate hydrological data used to manage water resources. Since 2007, the Arizona Water Science Center, in coordination with Mexico, has conducted transboundary aquifer assessments of the U.S.-Mexico transboundary aquifers, such as the Hueco Bolsón-Mesilla Aquifer in New Mexico and Texas and the Upper Santa Cruz and San Pedro River Basin aquifers in Arizona. Objectives include a comprehensive assessment of the status of the aquifer, ground water flow models, and extensive monitoring of hydrologic conditions, as well as preparation of findings and sharing of information with land managers in the United States and Mexico.¹¹⁸

3.8 The U.S. Department of State, U.S. Agency for International Development, and International Boundary and Water Commission

3.8.1 U.S. Department of State

The State Department supports bilateral and trilateral (with Canada) policies to further the administration's climate change objectives, including signing and ratifying the Paris Agreement and implementing the National Determined Contributions under the Paris Agreement. A major example of this cooperation is the formation of the North American Climate, Clean Energy, and Environment Partnership, announced at the June 2016 North American Leaders Summit, which outlines specific climate change goals agreed to by all three countries. Several federal agencies on both sides of the border are involved with implementing these objectives. The State Department plays a coordinating, support role in some cases and directly runs other programs.

3.8.2 U.S. Agency for International Development

USAID supports Mexican national and subnational policy development to implement energy reform and Mexico's 2012 General Law on Climate Change. Mexico's climate change programs focus on switching to cleaner energy sources and increasing energy efficiency. USAID supports Mexican efforts to achieve its goal of a low-carbon future through the following: (1) reducing GHG emissions from its energy, forestry and land use sectors; (2) establishing robust systems for monitoring, reporting and verifying emission rates and reductions; (3) strengthening its institutional and technical capacities; and (4) creating a sustainable source of financial support for climate change mitigation programs. **Table 3** lists some key recent USAID achievements that relate to the U.S. border because they enable Mexico's efforts to prevent pollution and mitigate climate risks.

Table 3. Key U.S. Agency for International Development Achievements in 2016

Provided technical assistance for the development of Mexico's Climate Change Strategy.
Assisted Mexico to formulate mitigation cost curves for greenhouse gas abatement strategies.
Assisted development of social and environmental safeguards for reducing emissions from deforestation and degradation.
Helped Mexico plan for integrating renewable energy into Mexico's electrical grid.
Fostered peer-to-peer learning, training and exchanges of technical experts in climate change and energy.
Supported creation of a clean energy certificate system as an incentive for renewable power generation.

Although the State Department and USAID initiatives do not focus exclusively on the border region, the implementation of climate change goals nationally in Mexico will affect the border.

3.8.3 International Boundary and Water Commission

The IBWC is a binational international organization comprising separate U.S. and Mexican sections tasked with joint responsibility for managing the two countries' various

Border Sanitation and Stormwater Issues in Mexicali, Baja California, affecting New River in California

The United States and Mexico have made significant progress to address stormwater and wastewater problems in Mexicali, Baja California, that affect New River water quality in California. Key wastewater treatment

infrastructure in Mexicali, however, is either now well past its useful life or highly inefficient energy-wise; stormwater infrastructure to handle extreme storm events in Mexicali needs to be upgraded to prevent adverse

water quality effects on the New River in California. The New River is a tributary to the Salton Sea, California's largest inland surface water.

water and boundary agreements. The U.S. Section of the IBWC is a federal agency that receives its budget as part of the State Department's Foreign Operations and Related Programs appropriation. The State Department provides the U.S. Section with foreign policy oversight and guidance. Commissioners appointed by each country's president head both sections, which are administered and funded independently.

The IBWC's mission relates to climate change through the execution of its water distribution and flood control responsibilities, transboundary water distribution in the watersheds of the Rio Grande and Colorado rivers, operation and maintenance of water storage reservoirs and hydroelectric dams on the Rio Grande, and flood protection along the principal boundary rivers through levee and interior floodway projects. The Commission's border sanitation and water quality mission includes the operation of wastewater treatment plants in San Diego and Nogales (Arizona), both the responsibility of the IBWC's U.S. Section. Its Mexican Section manages a wastewater treatment plant in Nuevo Laredo, Tamaulipas, on the Rio Grande.

Two principal agreements between the United States and Mexico guide the IBWC's water management mission: the 1906 Convention on the Equitable Distribution of the Waters of the Rio Grande and the 1944 Treaty for the Utilization of Waters of the Colorado and Tijuana rivers and the Rio Grande. Implementation of the IBWC's treaty responsibilities frequently requires specific agreements for the planning, construction, operation and maintenance of joint works and projects, as well as for changes and adjustments to operational matters. Major decisions of the IBWC are subject to the approval of the two governments and are recorded as formal "Minutes," 320 of which have been concluded as of August 2016. Text boxes describe the Commission's two most recent Minutes concerning various aspects of Colorado River and Tijuana River Basin water management.

3.9 Recommendations

1. A wealth of federal agency programs exists to help border communities respond to the challenges of climate change. Navigating the complex federal structure to connect with specific programs, however, often is a complicated and difficult task. Larger border

IBWC Minute 319 and Colorado River Water Resource Management

Minute 319 was adopted in 2012 to promote, on a 5-year pilot basis, binational cooperation in countering the impact of protracted drought in the U.S. Southwest and northern Mexico. The Minute established mutual obligations to improve management of the Colorado River and guide U.S. and Mexican authorities for managing challenges of regional climate change. It established adaptive approaches to cooperate, within the strictures of the two countries' 1944 Water Treaty,

on the diminishing water supply and growing demand in the border region. Mexico agreed to share the loss of potential water usage reductions with U.S. states under specified conditions, while gaining a right to any eventual surplus water in the system. The Minute also provided for investment in water conservation projects in Mexico by U.S. governmental and private entities to improve the efficiency of the conveyance of the 1.5 million acre-feet (1.85 billion cubic meters) of Colorado

River water delivered to Mexico annually under the treaty. Minute 319 also addressed environmental restoration of the Colorado River delta by authorizing a first-ever release of a "pulse flow" through the river system, a long-standing goal of environmentalists in both countries. In 2016, U.S. and Mexican officials engaged in intensive consultations that seek to design an agreement to succeed Minute 319 once it sunsets at the end of 2017.

IBWC Minute 320 and Tijuana River Basin Cooperation

The United States and Mexico approved Minute 320 in 2015 to manage flood control, wastewater, solid waste, sediment and stormwater flows containing sediment, trash, and high concentrations of industrial, agricultural and urban pollutants in the transboundary Tijuana River Basin that extends across a 1,750-square mile (4,532-square kilometer) area in San Diego County and the Baja California municipalities of Tijuana, Tecate, and Ensenada. Responsible technical authorities in the United States and Mexico (e.g., U.S. Environmental

Protection Agency, U.S. Army Corps of Engineers, state and local governmental entities such as the Regional Water Quality Control Board and the city of San Diego), along with other stakeholders (e.g., Surfrider and Wild Coast), are cooperating to protect the Tijuana River Basin's natural resources despite the growing population and urbanization on both sides of the boundary. Minute 320 created a consultative mechanism for jointly identifying and addressing sustainable management of the basin that also encourages enhanced

civic participation in the process. A Binational Consultative Group, chaired by the U.S. and Mexico sections of the International Boundary Water Commission, serves as a clearinghouse for recommending cooperative measures under the Minute 320 process. This Minute's example of binational cooperation in addressing the transboundary impact of climate change could pave the way for joint management of other shared watersheds along the border.

communities, with well-trained and numerous staff, generally interface well with federal agencies. Smaller urban and rural communities, however—especially disadvantaged communities—often lack the human resources to initiate contact with appropriate federal programs. Consequently, it is recommended that federal agencies facilitate the flow of information on climate change programs for the border region to border communities of all types. The NADB-BECC would be an appropriate agency to organize this information as part of its regular outreach to border communities. NADB-BECC has a history of cooperation with many different federal agencies, and BECC would be able to effectively facilitate this information sharing across the international border to communities and agencies at all levels because it is a binational organization with headquarters in Mexico.

2. EPA should begin working with the State Department and other federal and state partners and nongovernmental organizations to directly engage with Mexico to reduce CO₂ emissions from the Carbon I and II electrical generating units near Nava, Coahuila, 20 miles south of Eagle Pass, Texas. These two coal-fired power plants generate 1.2 and 1.4 gigawatts of energy, respectively, and Carbon I emitted 7.5 million tons (6.8 million metric tonnes) of CO₂ in 2005 alone.
3. A range of local communities along the border recognize the direct economic, social, human health and environmental effects caused by climate change. This leads to more local conversations on initiatives that can be implemented or recommended to mitigate climate change impacts. This bottom-up approach is a key to Border 2020's success. Federal agencies, particularly EPA, should continue to support Border 2020, which helps build on the expertise within communities to identify priorities and implement projects.

Supporting these local initiatives is an infrastructure of regional and border-wide workgroups further targeting resources based on priorities identified by the United States and Mexico.

4. Agencies should increase the frequency and depth of binational coordination. For example, as a result of the GNEB meetings in February 2016, the sister cities of Brownsville (Texas) and Matamoros (Tamaulipas) participated jointly in the World Urban Campaign: Urban Lab in September 2016. The Urban Lab dialogues are being led by ONU-Habitat Mexico and Urban Campus by the Colegio Nacional de Jurisprudencia Urbanística. Leading up to this important meeting, the cities of Brownsville and Matamoros participated in co-working meetings to plan and decipher topics of valuable concern. Through careful facilitation from federal officials and presentation of background materials, the two cities agreed on two topic areas: (1) transportation and mobility and (2) flood mitigation and resiliency. Both cities highlighted current local ordinances, areas of federal support, and future initiatives. The mayors and staff from both cities officially participated in the meetings.
5. The Border Liaison Mechanism is an agreement of the U.S.-Mexico Binational Commission to empower the consuls general of border cities to convene public and other stakeholders from both sides of the border to address common interests of regional concern. The Border Liaison Mechanism has become less active in recent years as a result of the economic downturn and border violence. This mechanism now needs to be re-energized with appropriate levels of resources to facilitate cross-border cooperation at the local level on climate change-related issues and other shared concerns in the diverse regions of the border. ■



Chapter

4

Water-Related Issues and Climate Change

The combination of increased temperatures, reduced precipitation and ongoing drought associated with climate change threatens surface and subsurface water supplies for residential, commercial, agricultural and ecosystem maintenance purposes in many areas of the border region. Growing scarcity of water also has negative implications for energy production in the border region. The intensification of storms that is one effect of climate change is projected to increase runoff that is magnified by expanding urban areas, exacerbating stormwater and flood management challenges for border communities. Many of the resultant risks are transboundary in nature and can be most effectively addressed through bilateral cooperation in the border region. The most obvious challenges are effective management of the binational Rio Grande River and Colorado River systems and support of state aquifer management programs.

Many factors, from urbanization to urban tree cover to high energy demand, affect water quantity and quality in the U.S.-Mexico border region. Cities along the border have started implementing programs and policies to help combat these negative effects; however, much more can and should be done. Many of these efforts also address the effects of climate change. Federal agencies provide support and leadership for many of these activities, in concert with state, local and binational agencies.

4.1 Effect of urban development on water flows and flood risk

Extreme rain events that are projected to increase with climate change come with their own challenges. The *Assessment*

*of Climate Change on the Southwest United States*¹⁶ reports that highly structured and in-filled cities have little capacity to adapt to increasing stormwater flows and may be especially vulnerable to extreme flooding. Urban development has significantly affected natural water flows and hydrological patterns. Construction generally involves removing native vegetation and soil, which alters the natural landscape and vegetation that help to slowly capture and filter stormwater, provide air purification benefits, and provide habitat for animals. As development changes the landscape from “green” or natural to “gray,” there often is a loss in permeable surfaces, which can lead to an acceleration of stormwater runoff into low-lying areas. This affects the natural stormwater flow and changes expectations of “flood zones” and preparations for extreme weather events, which are projected to increase as the climate changes (Figure 7).

The potential for extreme precipitation events is important for urban planners and engineers to consider because the amount of rain and duration of these events determine the needed design capacity of the stormwater infrastructure. Substantial increases in extreme precipitation events driven by climate change may result in the failure of stormwater systems if new extreme precipitation levels are outside their design envelope.

As indicated in Chapter 1, FEMA flood maps depict flood hazards for the border area derived from decades-old data. In addition, for areas that share a watershed with Mexico, data from south of the border often are not harmonized with those for U.S. communities. New flood maps that are

updated with changes in runoff resulting from urbanization on both sides of the border and incorporate projected climate change impacts will help manage flood hazards in border communities.¹⁹

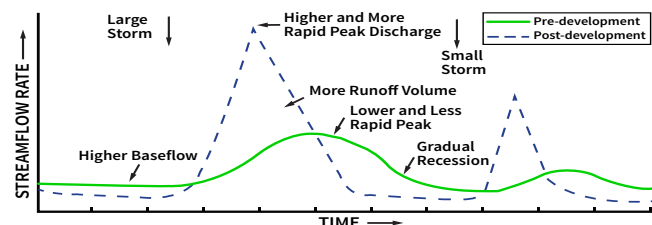


Figure 7. Altered hydrograph that indicates runoff volume and peaks in response to urbanization.

Source: Adapted from Schueler, 1987.¹¹⁹

The amount of land urbanized in the border region continues to increase, exacerbating runoff from the more intense storm events associated with climate change. From 2006 through 2015, the three major urban areas along the Texas-Mexico border lost 18,389 acres (7,445 hectares) of land to urban development, representing a 5 percent increase in urbanized or developed land (Table 4). In the Lower Rio Grande Valley and El Paso areas, the land lost was primarily cropland. The land use changed as a result of urbanization around Laredo, Texas, was mainly former rangeland (Figure 8).

4.2 Green infrastructure

Traditional stormwater management systems, or gray infrastructure, are ill-equipped to mitigate the increasing number of extreme drought and flood events associated with climate change. Gray water infrastructure redirects rainfall into channels and piping, making it unavailable for storage, irrigation, natural cleansing or infiltration. Sizing for larger flood events would require costly overhauls of existing storm management systems.

Green infrastructure provides a cost-effective alternative to traditional gray infrastructure that revives ecosystem services, adding to the border's resiliency. Green infrastructure is defined by EPA as a set of products, technologies and practices that use natural systems or constructed systems that mimic natural processes to improve overall environmental quality and provide public services.^{120,121} BECC has done

much to increase border communities' understanding of these principles and techniques through its many educational forums.

Green stormwater infrastructure helps slow runoff in developed and undeveloped areas, reduces surface erosion (resulting in improved water quality), and filters the water slowly into the soil. In addition, roots from trees and shrubbery help to anchor soil, which minimizes erosion, and the vegetation helps build organic soil that allows for filtration and keeps nutrients in the ground. Green stormwater infrastructure supports improved human health and air quality, reduced energy demand, increased carbon storage, increased property values of up to 30 percent, increased recreation space, reduced ambient temperatures, flood prevention, and additional habitat for wildlife:

*"[T]he value of green infrastructure actions is calculated by comparison to the cost of 'hard' infrastructure alternatives, the value of avoided damages, or market preferences that enhance value (e.g., property value). Green infrastructure benefits generally can be divided into five categories of environmental protection: (1) Land-value, (2) Quality of life, (3) Public health, (4) Hazard mitigation, and (5) Regulatory compliance."*¹²²

Green stormwater infrastructure, including bioswales and rain gardens, can help to capture and filter water onsite instead of diverting it into stormwater systems or onto roads or property. Tucson is a leader in terms of green stormwater infrastructure implementation, and research has shown the numerous benefits:

"Results from modeling show GSI [green stormwater infrastructure] can have a significant impact on both large and small storm events. GSI resulted in reducing the 100-year 3-hour event peaks by 24%, 19% and 10% in the Valencia, El Vado and Santa Clara watersheds, respectively. GSI implemented throughout these watersheds in our 25-year scenario will result in over \$2.5 million of annual community benefits as a result of flood reductions, water conservation, property value increases, reduced urban heat island impacts,

Table 4. Developed Land in the Three Major Urban Areas Along the Texas-Mexico Border (2006–2015)

	Lower Rio Grande Valley	Laredo, Texas	El Paso, Texas	Combined
2006 acres	218,896	32,497	102,605	353,998
2015 acres	227,698	36,429	108,260	372,387
Difference	8,802	3,932	5,655	18,389
Percentage increase	4%	12%	6%	5%

Source: National Geospatial Data Asset 2006 National Land Cover Database; National Agricultural Statistics Service 2015 Cropland Data Layer.

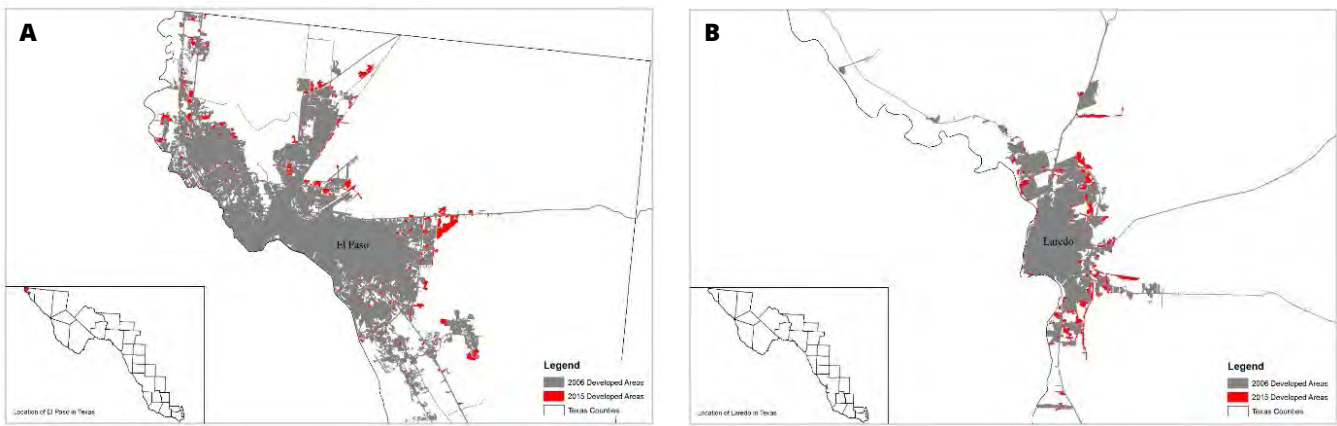


Figure 8. Developed areas in (A) El Paso and (B) Laredo, Texas, in 2006 (gray) and 2015 (red). From 2006 to 2015, El Paso's urban footprint increased 6 percent and that of Laredo 12 percent.

Source: National Geospatial Data Asset 2006 National Land Cover Database and National Agricultural Statistics Service 2015 Cropland Data Layer.



An example of green infrastructure. Water from an adjacent parking lot in Las Cruces, New Mexico, is directed to a rain garden, where it slowly soaks into the ground while natural bacteria in the soil help to break down pollutants.

Credit: Cathy Mathews, Landscape Architect, City of Las Cruces, New Mexico.

improved stormwater quality, reduced heating and cooling needs, air quality improvements, and the energy associated with pumping Central Arizona Project water and ground water in Tucson.”¹²³

The Lower Rio Grande Valley Texas Pollutant Discharge Elimination System Stormwater Management Task Force is an organization that promotes green stormwater infrastructure and less intense development through education and workshops. The Lower Rio Grande Valley Stormwater Task Force and its many conferences, trainings, demonstration projects and research are partly funded by an EPA 319(b) grant through the Texas Commission on Environmental

Quality. The organization assists 17 municipalities and counties across the Rio Grande Valley in complying with state and federal stormwater regulations and permits.¹²⁴

Decreased precipitation is likely to stress already fragile local water supplies. Capturing or storing stormwater runoff when it rains can help communities increase water supply reliability. Organizations such as the San Diego Climate Collaborative already advocate for infiltration-based green infrastructure practices (e.g., rain gardens, green streets) that allow rainwater to soak into the ground, replenishing local ground water reserves. Rainwater harvesting techniques (e.g., rain barrels, cisterns) can reduce demand for potable

Brownsville Resaca Restoration Program



Floating dredger from IMS Dredges® is self-propelled and has a 9-foot cutterhead. Sediment is transported via floating pipe to an offsite dewatering system. **Credit:** Brownsville Public Utilities Board.



Segments of the Brownsville resaca system that were dredged during Phase 1 of the resaca restoration project. **Credit:** Brownsville Public Utilities Board.

An innovative green infrastructure project is underway in the City of Brownsville that will improve urban resiliency to climate change impacts. Brownsville Public Utilities Board's *resaca* restoration program, in cooperation with state and federal agencies, is restoring these natural

wetlands to improve ecological functioning, increase urban recreation areas, and capture stormwater to reduce flooding. The Brownsville landscape is characterized by a broad, fanshaped delta at a river's mouth that has been dissected by multiple meandering channels. These channels

carried river flows with heavy sediment loads through the delta to the Gulf of Mexico. Today, these deltaic channels have been abandoned to form finger-lakes throughout Brownsville, which are referred to as "resacas" and are classified as wetlands. The *resaca* system eventually flows into the Brownsville Ship Channel and the Gulf of Mexico.

Over time, agriculture and urban development contributed to substantial deposits of sediment and trash resulting in decreased water depth, water quality and water circulation. Water depths are no longer sufficient to provide habitat for many native species of fish that once lived in the *resacas*, algal blooms and fish kills are becoming a more common occurrence, and the *resaca* are no longer able to capture sufficient quantities of runoff from the intense storms of the region to avoid urban flooding.

Initiated in 2013, by December 2015, the restoration program had dredged nearly 116,000 cubic yards (89,000 cubic meters) of sediment from three *resacas* along with significant quantities of solid waste, including scrap tires. Removal of this material increased the capacity of stormwater retention of these three *resacas* by 23.3 million gallons (88.2 million liters). Accomplishments to date, along with the ongoing dredging and restoration projects conducted in partnership with the U.S. Army Corps of Engineers, will increase Brownsville's ability to address flood events, which will likely become more intense with the effects of climate change.

Source: brownsville-pub.com/about-us/projects/resaca-restoration; Mariscal, R. 2016. Resaca Restoration and Southmost Regional Water Authority Update to the Good Neighbor Environmental Board, epa.gov/node/142511/revision/353653.

water for landscape irrigation in public parks and municipal buildings or for nonpotable uses such as toilet flushing and cooling systems. According to a joint Issue Brief by the Natural Resources Defense Council and the Pacific Institute:

"In southern California and the San Francisco Bay Area, capturing runoff using these approaches can

*increase water supplies by as much as 630,000 acre-feet each year. Capturing this volume, roughly equal to the amount of water used by the entire City of Los Angeles annually, would increase the sustainability of California's water supplies while at the same time would reduce a leading cause of surface water pollution in the state."*¹²⁵

Urban Forestry

Project Desert Canopy is funded by the U.S. Department of Agriculture's U.S. Forest Service to enable communities to improve air quality through urban forestry. Urban forestry and expansion of tree cover helps offset climate change impacts in border cities. The Desert Canopy study completed in 2014 indicates that Phoenix, Arizona, has a 9 percent tree cover that has an annual benefit of \$6.11 million in terms of stormwater capture and filtering. El Paso, Texas, has a 5.1 percent tree cover that has an annual benefit of \$2.1 million. Albuquerque, New Mexico, has a 13.3 percent tree cover that has a \$3.42 million annual benefit in terms of avoided stormwater runoff. Las Cruces, New Mexico, has a 3.7 percent tree cover, which has an annual benefit of \$58,900 per year in terms of stormwater filtration and capture.^{128,129} By adopting smart tree canopy and green stormwater infrastructure policies, the U.S.-Mexico border cities not only can become more resilient in terms of flash flooding and extreme heat but also improve air quality through increased carbon sequestration, increase walkability through reduced urban heat island effects, and reduce peak energy demand while increasing property values: "[A] 20-percent tree canopy over a house results in annual cooling savings of 8 to 18 percent and annual heating savings of 2 to 8 percent."¹³⁰

During the past century in Texas, the frequency of 2-day heavy rainfall spells has nearly doubled,¹⁷ with 4- to 6-inch rainfalls becoming more common in the Rio Grande Valley. In lieu of developing oversized stormwater infrastructure to combat these deluges, Brownsville, Texas, is using *resacas* or historic river channels to help buffer the effects of extreme flooding events. Efforts are underway to restore, enhance and improve the natural services of flood protection and water supply in the *resacas* through sedimentation removal. In phase one alone, the community has increased its storage capacity by 23.3 million gallons (88.2 million liters).¹²⁶

If all area *resacas* are restored, the city could direct up to 727 million gallons (2.8 billion gallons) into these channels. As promising as this strategy appears for this coastal city, the unmet restoration costs moving forward are almost \$170 million.¹²⁷ The adjacent Mexican city of Matamoros, Tamaulipas, had filled in most of its *resacas* with urban development, and storm events produce considerably more flooding there than in Brownsville. This contrast across the international border in the same ecoregion illustrates the value of green infrastructure.

Green infrastructure implemented at a broad scale has the potential to reduce stormwater pollution from the "first flush," the first 0.5 inch (1.3 centimeters) of rain that liberates the oils, grease, animal feces, brake dust, metals and sediment that accumulate on roofs, streets and other impermeable surfaces between storm events. As water infiltrates roots and soil, bacteria break down hydrocarbons

and other urban contaminants carried across impermeable surfaces. For cities such as Las Cruces, New Mexico—which is soon to have its National Pollutant Discharge Elimination System stormwater permitting program adopt green stormwater infrastructure as its primary management strategy to address water quality impairments—building professional and economic capacity to address health and environmental concerns is imperative.

4.3 Nogales water quantity and quality issues

Binational water, wastewater and stormwater issues are very complex in the Ambos Nogales region, comprising the sister cities of Nogales, Arizona, and Nogales, Sonora. Ambos Nogales has long presented a microcosm of the type of water and sanitation issues that arise when close proximity, explosive population growth and a particular topography combine at the U.S.-Mexico border. The United States and Mexico, through the IBWC, have cooperated in wastewater treatment since the 1950s to handle effluent from Mexico that flows from the much larger and faster growing city of Nogales, Sonora. Currently, the Nogales International Wastewater Treatment Plant (NIWTP), located near Nogales, Arizona, treats much of the wastewater from the Mexico side of the border. The treated effluent is discharged into the Santa Cruz River, where it maintains critical riparian habitat downstream (in the United States) for many miles and recharges aquifers that supply potable water to surrounding communities.

Stormwater management also constitutes a major challenge. A combination natural wash and manmade tunnel system conveys floodwaters through the two municipalities during the brief but intense summer monsoon season but is proving increasingly inadequate for the task. Greatly diminished rainfall absorption capacity by the ground in the rapidly urbanizing territory of Nogales, Sonora, has combined with the more intense rainfall events associated with climate change to greatly overload the system, leading to blown manhole covers and street flooding in both cities. Stormwater challenges that have arisen as a result of climate change in Ambos Nogales have been the focus of the IBWC, which has approached the issues from a binational perspective.

4.3.1 Climate change impacts on limited water supply

The water supply of Nogales, Arizona, relies mainly on micro-ground water basins located along the Santa Cruz River, located east of the city, that are recharged by ephemeral runoff. The city also depends on the Potrero well field located east of the Nogales Wash. The main water supply of Nogales, Sonora, is the Los Alisos well field, located south of the Nogales watershed divide. Supply is supplemented by

ground water infiltration galleries located along the Santa Cruz River in Sonora and wells located within the Nogales subwatershed.

In the Upper Santa Cruz River Basin in Arizona, climate change is projected to increase the frequency of dry summers and the frequency of both wet and dry winters.¹³¹ This will complicate management decisions for the water utilities that serve Ambos Nogales and will have significant implications for water quality and quantity and the ecosystem services supported by the Santa Cruz River in Arizona. The following issues are of concern:

- Drier summers coupled with wetter winters could shift the distribution of Nogales sanitary sewer overflows to the winter months. This may augment infiltration of contaminated stormwater on downstream water supplies while affecting ecosystems.
- Drier summer and winter seasons could negatively affect the Santa Cruz River microbasins in Arizona, forcing the U.S. municipality to rely on lower quality water from the Potrero well field.
- IBWC Minute 276, a binational agreement between the United States and Mexico adopted in 1988, established the conditions for wastewater treatment of effluent from Nogales, Sonora, in the United States. The Minute further established that Mexico would retain the right to eventually treat such effluent in its own national territory, as well as the right to reclaim wastewater volumes treated in the United States. Seasonal uncertainties in rainfall may encourage diminished wastewater deliveries to Arizona via treatment at the Los Alisos Wastewater Treatment Plant for recharge of Sonoran water supplies.
- Reduced wastewater deliveries to the NIWTP in Arizona will affect recharge of downstream Arizona water supplies, the perennial flow of the Santa Cruz

River, and the sustainability of established and rare ecosystems that the river currently supports (Figure 9).

4.3.2 Climate change impacts on ecosystem services

Surface flows in the Santa Cruz River provide many ecosystem services, such as vegetation and habitat for wildlife, as well as recharge to ground water resources for water provisioning. The USGS has mapped and quantified the biophysical and socioeconomic effects resulting from various scenarios associated with diminished deliveries of Sonoran wastewater to the NIWTP in Arizona. Based on various effluent release scenarios from Sonora, the USGS Santa Cruz Ecosystem Portfolio Model summarizes the effects on Arizona community real estate values; the effects on Tumacácori National Historical Park, an Audubon Society Important Bird Area that hosts endangered birds; and the extent of the Santa Cruz River's perennial flow, which hosts the endangered Gila topminnow (*Poeciliopsis occidentalis*).¹³²

Declining precipitation and annual distribution of storms associated with climate change, in combination with urban expansion and water scarcity in Nogales, Sonora, however, likely will reduce treated water discharge to the Santa Cruz River. As Nogales, Sonora, reuses more of its wastewater, a lower volume will be conveyed across the border to the binational sewage treatment plant. The USGS predicts that a 17 percent reduction in wastewater deliveries to the NIWTP will negatively affect real estate values in the downstream community of Tubac by \$1 million, impair the downstream Important Bird Area, and affect the perennial extent of the river by at least 2 miles (3.2 kilometers). The worst-case scenario considers no further deliveries of wastewater from Sonora. In this case, real estate values in Tubac and Tumacácori are affected by more than \$11 million

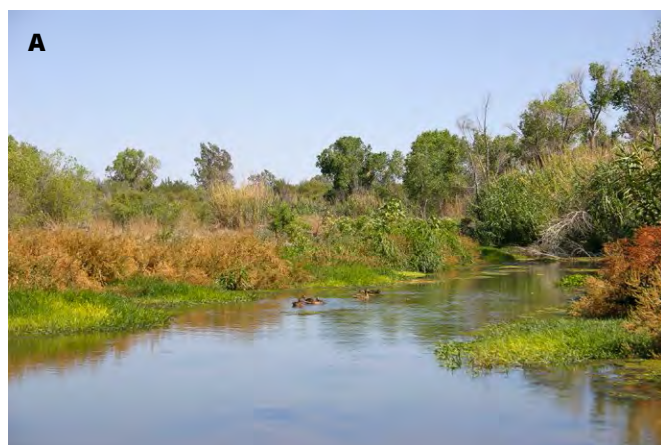


Figure 9. Santa Cruz River at the Chavez Siding Road Crossing before (A) and after (B) the Nogales International Wastewater Treatment Plant upgrade and Los Alisos diversions (June 2004 and May 2014, respectively).

Source: John Shasky, Friends of the Santa Cruz River Volunteer.

combined, perennial flows through the Tumacácori National Historical Park are eliminated, and at least 12 miles (19.3 kilometers) of Santa Cruz River perennial habitat is lost.

Most recently, the perennial extent of the Santa Cruz River has diminished as a result of improved recharge of effluent. This resulted from decreased ammonia concentrations associated with an upgrade to the NIWTP in 2009. Although perennial reach has been lost, improved effluent quality also has resulted in the rediscovery of the endangered Gila topminnow downstream of the NIWTP, thus putting more at stake if the river is entirely lost.¹³³

4.4 Wetlands

Wetlands serve many important functions, from acting as natural water filters to preserving and protecting the country's aquatic and terrestrial species. Wetlands also provide a useful tool for control of stormwater. EPA defines wetlands

as “areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.”¹³⁴ Wetlands also can be community assets and offer ecotourism and economic benefits: “When all else is equal, the price of a home located within 300 feet from a body of water increases by up to 27.8%.”¹³⁵ When properly designed and implemented, a wetland can not only provide habitat for animals but also play a very important role in urban stormwater management.

There are many successful examples of wetland creation along the U.S.-Mexico border. In El Paso, the Rio Bosque Wetland receives treated effluent water from the Bustamante Wastewater Treatment Plant year-round. The University of Texas at El Paso manages the wetland and organizes bird watching tours and other outdoor activities in the wetland. The BJ Bishop Wetland in Presidio, Texas, also is an example

Climate Change and Endangered Desert Fish Response to Drought at Leslie Canyon National Wildlife Refuge



Gila topminnow. Credit: U.S. Fish and Wildlife Service.

The southwestern border region of the United States has always been challenged by the availability of water. Historic droughts have sometimes extended for decades. In response to these conditions, aquatic species in the area have very restricted distribution and also have been challenged by introductions of invasive fish species. At Leslie Canyon National Wildlife Refuge in southeast Arizona, wildlife managers are collaborating with private landowners to help desert fish adapt to rapidly changing climatic conditions. The 2,765-acre (1,119-hectare) refuge was established

in 1988 to protect the Yaqui topminnow (*Poeciliopsis sonoriensis*) and the Yaqui chub (*Gila purpurea*), two mosquito-eating fish that are in danger of extinction because of loss of their wetland habitat and competition with nonnative species.

Perennial flow in Leslie Creek is dependent on an ample winter snowpack on the adjacent 9,796-foot (2,986-meter) Chiricahua Mountains, which slowly melts and provides a steady source of fresh water. Ongoing long-term drought conditions now affect this region, and future climate

change is projected to further reduce available water. For example, the annual snowpack has been more than 50 percent below normal, resulting in less stream flow and sometimes even zero perennial water.

To help sustain the native fish populations, the U.S. Fish and Wildlife Service has worked with ranchers upstream from the refuge to purchase conservation easements, establish a Safe Harbor Agreement, and introduce the rare fish into suitable wetlands on the private ranches that are less threatened by reduced water. This formal process is a “win-win” situation for everyone involved. It provides for landscape protection and conservation of rare animals on private property, which remain on local tax rolls instead of being owned by the federal government. It enables ranchers to restore endangered species on their private lands without any risk imposed by laws that might otherwise negatively affect their management activities and use of their property. Finally, it helps build positive relationships between wildlife managers and ranchers as they work together to keep large areas of the landscape intact and healthy during adverse environmental conditions. Through this cooperation, desert fish that have lived in these harsh conditions for millennia will have a chance to survive the expected changes in climate.

of how treated wastewater can be diverted to a wetland to enhance habitat for migrating and local birds and provide recreation opportunities for community members. Presidio has agreed to donate water for as long as the supply lasts.

Shallow marsh systems are a viable option for stormwater management because they act as a hybrid system for retention, detention and pollutant removal. They can temporarily store stormwater runoff in shallow pools and include design elements such as trees, native grasses, wildflowers, waterfalls (for aeration) and aquatic life. Shallow marshes or constructed wetlands are considered a “highly effective” management practice in terms of water quality treatment.¹³⁶ Incorporating more wetlands into urban areas and into the design of retention ponds can lead to reduced concentrations of trace metals, trash and debris, oil and grease, and toxins in the water system. The effective use of *resacas* by Brownsville for flood control and other environmental benefits, described above, is an example of the value of wetlands and the services they provide.

4.5 The water-energy nexus

Water and energy are closely intertwined. As discussed in Chapter 1, the energy supply that is critical to the economic dynamism, social wellbeing and health of U.S. border residents is likely to be stressed by the effects of climate change on a number of fronts, including limited water supplies for hydropower generation and cooling of thermoelectric power plants.

4.5.1 Water-stressed areas along the border

Although the United States and Mexico in general are not considered water-scarce countries, unequal water distribution, pollution, population growth and overuse have led to significant water stress along the U.S.-Mexico border. The water stress on both sides of the border will only be exacerbated by the higher temperatures and declining precipitation brought by climate change.

Climate change is reducing renewable surface and ground water resources along the U.S.-Mexico border, posing a major concern to energy security. Arizona and California are two of seven U.S. states that share the Colorado River with Mexico. Recent droughts have affected the water supply across the West, with reservoir levels along the Colorado River dwindling to 40-year lows.¹³⁷ The border region of southern New Mexico, far west Texas and Chihuahua (Mexico) is challenged by limited surface and ground water supplies that are becoming increasingly saline; increasing water demands resulting from a growing population and demand from irrigated agriculture; water quality effects from agricultural, municipal and industrial discharges to the river; and rising temperatures and increased frequency and intensity of drought and extreme weather events.¹³⁸ According to

Mexico’s National Water Commission, much of northern and central Mexico are under high or very high levels of water stress, with 40 percent to 132 percent of the region’s renewable water resources already having been allocated.¹³⁹

Table 5 contrasts water withdrawal for different uses in the United States and Mexico.

Table 5. Water Withdrawal for Different Uses in the United States and Mexico

United States (2010)	
Type	Percentage of Total
Thermoelectric*	45
Irrigation	32
Industrial	4
Public Supply	12
Other	7
Mexico (2009)	
Type	Percentage of Total
Agriculture	77
Municipal	14
Thermoelectric	5
Industrial	4

*Total withdrawals for cooling; does not reflect cooling water that is returned to source after use. **Source:** U.S. data: Maupin et al. 2014²⁵; Mexico data: UN-Water 2013.¹⁴⁰

Renewable energy sources, such as solar photovoltaic systems and wind, have an advantage over hydroelectric and thermodynamic energy as they do not require fuel processing and associated water inputs to generate electricity and are consequently more resilient to extreme weather events and severe droughts than hydro and thermoelectric sources. Solar photovoltaic and wind power systems can improve access to and sustainability of water supply for agriculture and other uses.

In its *World Energy Outlook 2012*, the International Energy Agency concluded that energy sector scenarios with higher shares of renewable energy require much less water. The American Wind Energy Association estimated that electricity generated from wind energy in the United States avoided the consumption of more than 130 billion liters (34 billion gallons) of water in 2013, equivalent to the annual water consumption of more than 320,000 U.S. households (**Figure 10**).¹⁴¹

4.5.2 Solar photovoltaic power case study

Solar photovoltaic power uses up to 300 times less water¹⁴³ than conventional energy by directly converting sunlight to electricity without the use of water. On average, U.S. thermoelectric power plants withdraw 19,000 gallons (72,000 liters) to produce 1 megawatt-hour of electricity,¹⁴⁴ compared

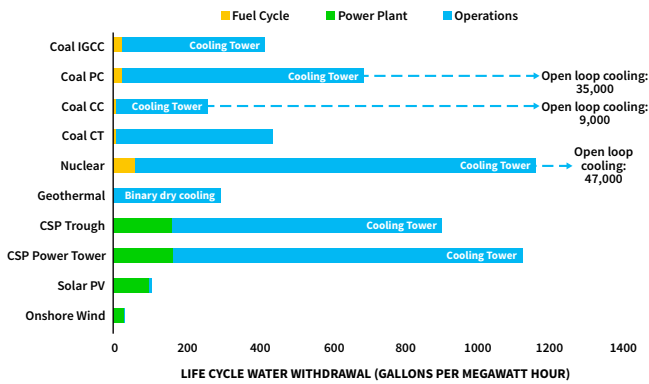


Figure 10. Median life cycle water withdrawal by energy source.

Source: Meldrum et al. 2013.¹⁴² *Note:* CSP = concentrating solar power; CT = combustion turbine; CC = combined cycle; IGCC = integrated gasification combined cycle; PC = pulverized coal. The life cycle water withdrawal of selected electricity generating technologies depicted in the graph above is based on median harmonized estimates and includes component manufacturing, fuel acquisition, processing, transport, and power plant operation and decommissioning.

to photovoltaic power systems, which withdraw approximately 5 gallons (19 liters) per megawatt-hour or less during operation.¹⁴⁵ Solar photovoltaic power water consumption during operation is associated with cleaning modules. By displacing conventional grid electricity, a photovoltaic array in the U.S. Southwest border region can save up to 5,600 liters (1,500 gallons) of life-cycle water withdrawal per megawatt-hour.¹⁴⁶ In California, 25 First Solar, Inc. photovoltaic power plants in various stages of development, construction or operation (total capacity of 3.6 gigawatts) are projected to save more than 1.8 billion liters (475,000 gallons) of water per year in operational water consumption (equivalent to approximately 730 Olympic-sized swimming pools). Solar photovoltaic power is ideally suited to meet the energy needs of arid regions of the U.S. border and northern Mexico. Communities that generate a significant amount of electricity from renewable energy can be less susceptible to electricity disruption during droughts.

According to a study by the Union of Concerned Scientists, an electric system that relies on renewable sources such as wind, solar and geothermal systems to supply 80 percent of electricity demand and cuts energy use with energy efficiency programs would withdraw 50 percent less water by 2030 and 90 percent less by 2050 than the business-as-usual scenario in the power sector.³¹ In addition, renewable energy can help to address the trade-offs between water, energy and food, bringing security of supply to all three sectors. Although the study uses very optimistic projections for increases in energy efficiency and decreases in energy use and does not consider grid reliability, it underlines the important connection between renewable energy and water withdrawals for power production.

4.6 Recommendations

1. Stormwater engineers and floodplain managers along the U.S.-Mexico border should utilize real-time data from streamflow-gauging stations when new development is being considered in an area. This will enable development guidelines consistent with climate change impacts. At the same time, streamflow data from portions of shared watersheds in Mexico also should be incorporated into new flood maps. Agencies should consider how future—or modifications to existing—infrastructure investments in floodplains will be informed by the new Federal Flood Risk Management Standard. The new flood standard describes various approaches for determining the higher vertical flood elevation and corresponding horizontal floodplain for federally funded projects and establishes the level to which a structure or facility must be resilient. This may include using structural or nonstructural methods to reduce or prevent damage; elevating a structure; or, where appropriate, designing it to adapt to, withstand and rapidly recover from a flood event. In addition, agencies should consider the use of natural systems, ecosystem processes and nature-based approaches in the development of alternatives for actions.
2. U.S. and Mexico officials should work with federal agencies; the Colorado River Basin states of Arizona, California, Colorado, New Mexico, Nevada, Utah and Wyoming; and local stakeholders to reach an agreement to succeed Minute 319, once it sunsets at the end of 2017, that would continue binational cooperation under the 1944 Water Treaty. The agreement should continue to address the effects of climate change on water supplies, as well as how the two countries can participate in water conservation efforts and drought planning.
3. The combination of increased temperatures, reduced precipitation and ongoing drought associated with climate risks threaten surface and subsurface water supplies for residential, commercial, agricultural and ecosystem maintenance purposes. Many of the resultant risks are transborder in nature and can be most effectively addressed through bilateral cooperation in the border region. U.S. and Mexico federal agencies should enhance their work together, in concert with public and private stakeholders from both countries, for effective management of the binational Rio Grande River and Colorado River systems and support of state aquifer management programs.

Solar Case Study: Campo Verde Solar Facility—Imperial County, California



The Campo Verde Solar Facility (139-megawatt alternating current) is located in Imperial County, California, less than 10 miles from the U.S.-Mexico border.

Credit: The 111th Group, Inc., courtesy of First Solar, Inc.

Located along the U.S.-Mexico border, Imperial County, California, is an example of a border community where utility-scale solar power is booming. High solar insolation; available land, including more than 1.3 million acres of Bureau of Land Management public land; proximity to transmission; and supportive local, state and federal renewable energy policies have helped drive the development of more than 1,000 megawatts of utility-scale solar capacity in the county. This is more solar capacity than most U.S. states, with 60 percent sited on or crossing over federal lands.^a

The Campo Verde Solar Facility is a 139-megawatt alternating current utility-scale solar photovoltaic project located less than 10 miles from the U.S.-Mexico border. The facility, which became operational in October 2013, was the first Bureau of Land Management-approved project in the

county to reach commercial operation.^a The project was developed and constructed by First Solar, Inc., using its advanced thin-film photovoltaic modules. The facility was sold to Southern Power and Turner Renewable Energy and has a 20-year power purchase agreement with San Diego Gas & Electric Company, helping the San Diego company to reach state of California-mandated renewable portfolio standards of 33 percent by 2020 and 50 percent by 2030.

Campo Verde generates enough clean electricity to power nearly 48,000 homes, displacing 80,000 metric tons of carbon dioxide per year, the equivalent of taking 15,000 cars off the road. In addition to producing clean, renewable electricity, the facility's photovoltaic technology uses no water to generate electricity, saving more than 28 million gallons of water per year.

Imperial County has a 2015 population of about 180,000 individuals. The population is 80 percent Hispanic, and three-quarters speak a language other than English at home. Although one of the top 10 agricultural counties in the United States, with about \$2 billion in annual production, the valley has a *per capita* income one-half of that of California or the United States, poverty and unemployment rates of more than 20 percent, and low levels of education attainment.^b The economic activity that development of solar facilities brings is welcomed in this disadvantaged border community. According to an independent study conducted for Imperial County, the Campo Verde Solar Facility will have an economic impact to the Imperial County area totaling about \$239 million during the estimated 30-year project life. During construction, the facility contributed approximately \$17.5 million in local tax revenue and employed an average of 250 workers during the construction phase.

The growth of solar in Imperial County was fueled by federal and state renewable energy policies, including the Federal Investment Tax Credit and California's aggressive renewable portfolio standards.

^a Bureau of Land Management. 2016. "Renewable Energy Projects Approved Since the Beginning of Calendar Year 2009." Last updated August 2. www.blm.gov/wo/st/en/prog/energy/renewable_energy/Renewable_Energy_Projects_Approved_to_Date.html

^b Census Reporter. 2016. "Imperial County, CA." Accessed October 1. censusreporter.org/profiles/05000US06025-imperial-county-ca

4. Federal or binational agencies with responsibility for addressing water problems and needs along the border (including EPA, USGS, NADB-BECC and the U.S. Section of the IBWC) should build on existing programs, such as EPA's Border 2020 Program and the IBWC's Minutes 319 and 320, to engage with Mexico and its agencies to address climate change related to shared water problems.
5. Federal water agencies and the binational NADB-BECC should enhance their existing efforts to

compile and share information on local and state water conservation programs on both sides of the border to promote community resilience in the face of climate change impacts. They should convene a bilateral conference to learn what actions U.S.-Mexico border communities are taking to conserve water, share successful practices, and engage the private sector in the discussion and implementation of best practices. The agencies ought to use existing program funds to encourage state and local government agency staff, staff from environmental utilities, appropriate

private sector stakeholders, and Mexican counterparts to meet and discuss practical ways to prevent water pollution of transboundary surface water and ground water resources as well as watershed management approaches to enhance border water quality. In shared water bodies where such discussion has been occurring (e.g., through the Transboundary Aquifer Assessment Program), implementation of solutions to identified problems should commence.

6. Federal agencies (including EPA, IBWC, USGS, USDA, the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers) should implement or support ground water recharge for vulnerable and/or disadvantaged communities through existing water programs. Ground water recharge efforts provide a mechanism to create stable ground water storage areas, which in turn allow surface water to flow to storage areas with reduced losses. Federal agencies should implement and/or support stormwater runoff programs to utilize recycled water for surface water-dependent municipalities and facilitate funding through existing programs to establish and/or enlarge

surface water storage impoundments and/or reservoirs, where appropriate and cost effective. Federal agencies should enhance their engagement with local officials and planners to develop or support community design solutions that prevent water contamination, such as infrastructure for wastewater capture and treatment. To protect tribal resources and meet the federal government's trust responsibilities to tribes, the DOI and its Bureau of Indian Affairs should operate U.S. government programs to protect treaty and other tribal rights as the climate changes.

7. The USDA's NRCS could allocate funds under PL-566, the Small Watershed Program, to rehabilitate aging stormwater infrastructure and complete watershed plans in the U.S.-Mexico border region to prevent and mitigate flooding. The U.S. government could provide financial assistance for water conservation projects that target shared resources (e.g., the Colorado River, ground water) in such areas as California-Baja California, where people and ecosystems are already experiencing negative climate-related impacts. ■



Chapter

5

Transit, Trade and Air Pollution: Climate Risks and Promoting Environmental Resiliency

This chapter discusses a number of risks for border communities associated with climate change. It highlights examples for preventing damage and improving resilience, emphasizing the role of federal agencies. Trade, transit and air pollution are the core case studies examined here.

5.1 Air pollution and the border region

Under the Clean Air Act, EPA is charged with oversight on ensuring that communities throughout the United States, including the border areas, comply with health-based safeguards for certain air pollutants. The NAAQS are the standards that determine whether or not areas comply with basic standards for PM, ozone, sulfur dioxide, lead, nitrogen dioxide and carbon monoxide. The NAAQS, continually reviewed on a 5-year cycle, have become more restrictive through the years, making compliance a challenge for local communities. The increasing temperatures in the border region associated with climate change, as well as increasing urbanization and economic activities, provide significant air quality management challenges. The location of many U.S. border communities adjacent to large Mexican border cities that have less restrictive air pollution requirements than U.S. standards provides an added challenge for regional air quality control.

For example, in 2008, EPA set the ozone standard at 75 parts per billion over an 8-hour time period. Under that standard, several communities near the U.S.-Mexico border in Arizona and California do not meet this 2008 standard

(**Figure 11**). Recently, EPA lowered the ozone standard from 75 to 70 parts per billion. Although compliance is based on a 3-year average, it is likely that both the current nonattainment areas in California and Arizona and some additional border communities, including El Paso, will have difficulty meeting this standard. Indeed, a preliminary proposal from Texas would declare El Paso in nonattainment for ozone, with final designations due in 2017. Efforts taken today to reduce air pollution at the local level will help keep border populations healthy, lower ozone levels, allow areas to remain in compliance with EPA standards, and ultimately allow communities to better face the challenges of hotter, drier climates that will accompany climate change. For many border communities, an ongoing air quality challenge is pollution transport and generation related to regional and international commerce, ports of entry, and adjacency of large urban areas across the border in Mexico.

5.2 Southern border entry volume and wait times

U.S. and Mexican air quality monitoring along the border traditionally has measured regional averages for San Diego, Tijuana, El Paso, Ciudad Juárez and other border cities. Government scientists and academic researchers, however, have understood that ports of entry generate significant levels of air contaminants resulting from long lines of idling vehicles crossing the border.⁴⁹ The poor air quality near these ports of entry not only affects workers at the facilities and individuals crossing but also the surrounding communities,

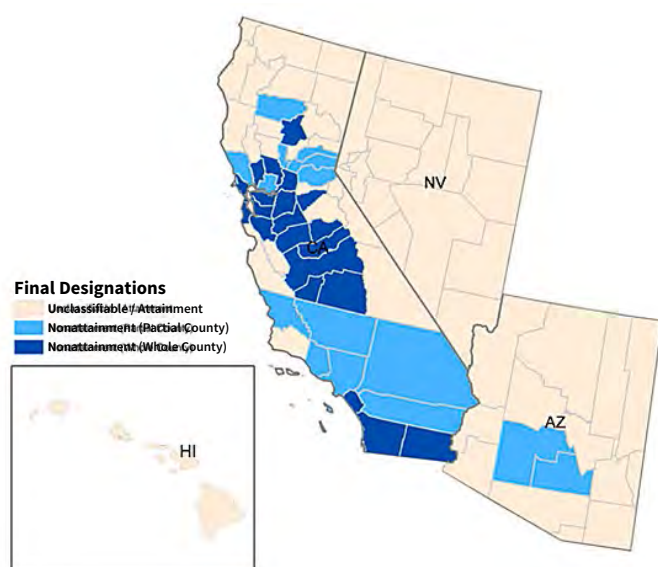


Figure 11. Current nonattainment areas under the 2008 ozone National Ambient Air Quality Standards.

Source: U.S. Environmental Protection Agency.

which often are primarily Hispanic and poor. EPA has initiated programs to monitor air quality specifically at ports of entry and to develop methodologies to accurately estimate emissions at the ports of entry. These efforts are designed to develop policies to help mitigate air pollution impacts on border communities and make them more resilient in the face of climate change.

As described in Chapter 3, with funding from EPA Region 9, the San Diego Air Pollution Control District installed a PM_{2.5} air quality monitor at the San Ysidro crossing, which will operate for 2 years, ending January 2017, to provide data on the air quality impact to the local community. The monitoring of ports of entry will produce important information on human health impacts and environmental justice for the surrounding low-income neighborhood. EPA also collaborates with the Department of Homeland Security's U.S. Customs and Border Protection (CBP), Mexico's Aduanas, and the trade community to reduce wait times at ports of entry.

As discussed in Chapter 3, using a methodology developed by the FHWA that estimates emissions from vehicles crossing the ports of entry, EPA has provided funding to estimate emissions at the Calexico (California) and the Mariposa (Arizona) ports of entry. The results of these studies will be used by local, state and federal agencies responsible for planning new ports or for expansion of existing ports to minimize emissions.

El Paso County and Ciudad Juárez have implemented a mandatory vehicle emissions inspection test. Building on results from 23 years of the Ciudad Juárez Vehicle Emissions Inspection Program, the state of Chihuahua implemented

a similar program statewide in 2014. Throughout Juárez, Chihuahua, and El Paso County, gasoline stations provide oxygenated fuel during colder months and low Reid-vapor-pressure gasoline during the hot summer.

To reduce emissions, California promulgated regulations requiring diesel trucks and buses operating in California to be upgraded or replaced with air pollution filters beginning in January 2012. By January 2015, certain older trucks also had to be replaced. By January 2023, nearly all trucks and buses will need to have 2010 model-year engines or equivalent. This regulation applies to all heavy-duty diesel-fueled trucks and buses that cross at California ports of entry. California has an active enforcement program at the two commercial ports to ensure compliance with these requirements.

To support emissions reductions from transportation, the NADB is financing the Border Wide Transportation Project, which provides loans to public bus companies in Mexico for the purchase of new buses that meet diesel emission requirements that will improve air quality in the binational airsheds along the border. NADB also has provided \$205 million in loans to local and state governments in Baja California and Sonora to pave roads, thereby reducing PM emissions. EPA also works with the Brownsville Metropolitan Planning Organization and Juárez Planning Institute to improve transit mobility by evaluating traffic needs and planning future construction that will mitigate congestion resulting from economic growth.¹⁴⁷

Although not related to mobile sources, the use of fireworks and open burning is a known contributor of GHG emissions and PM during the holiday season in Mexicali. As discussed in Chapter 3, for the past 5 years, EPA has funded the Imperial County Air Pollution Control District to implement a campaign that discourages such practices through public announcements on local television and distributing outreach materials in schools. This is projected to reduce PM_{2.5} emissions in the binational basin.

5.3 Commercial vehicles at southern border crossings

Commercial vehicles frequently are delayed at border crossings. The commercial volumes are high and require CBP to employ different screening methods than they do for personally owned vehicles (POVs). Trip delays increase transportation costs and affect national security and the environment. Air quality is a special concern, and increasing ambient temperatures will only exacerbate the air pollution effects of border delays on human health in the areas surrounding the ports of entry. Border crossings are potential bottlenecks in the freight transportation network. Meanwhile, a query of the U.S. Department of Transportation's Bureau of Transportation Statistics shows

that slightly less than 500,000 (loaded/unloaded) commercial trucks entered at various southern ports of entry from January through March 2016. Year-end totals are summarized in **Table 6**. The totals for 2016 are projected to meet or exceed 2015 totals.

Table 6. 2015 Commercial Truck Entry at Ports of Entry

Rank	Port Name	Trucks
1	TX: Laredo	2,015,773
2	CA: Otay Mesa	829,581
3	TX: El Paso	747,702
4	TX: Hidalgo	546,259
5	CA: Calexico East	337,474
6	AZ: Nogales	319,747
7	TX: Brownsville	205,159
8	TX: Eagle Pass	141,592
9	NM: Santa Teresa	102,315
10	TX: Del Rio	70,009
11	CA: Tecate	52,090
12	TX: Progreso	36,940
13	AZ: San Luis	33,712
14	AZ: Douglas	32,104
15	TX: Rio Grande City	30,890

Source: U.S. Bureau of Transportation Statistics.¹⁴⁸

Efforts are underway by several agencies to improve processes (e.g., inspection, queuing, just-in-time delivery), as well as programs to fund and improve infrastructure, at ports of entry to reduce delays and increase security. The objective of these studies is to provide a baseline of border crossing wait times by measuring border crossing times for commercial trucks at each of the border crossings. These baseline data then will be used to help measure the success of improvement projects and strategies. The goal is to have 95 percent of commercial truck traffic included in the monitoring and have near real-time dissemination of border wait times and cross-border wait times along the entire U.S.-Mexico border.

In late July 2016, a pilot program was initiated at the Mariposa Port of Entry in Nogales for joint inspections of cargo by CBP and Mexico's Tax Administration Service. The inspections are conducted by both U.S. and Mexico personnel for shipments of Customs-Trade Partnership Against Terrorism-certified companies. A similar program is being undertaken in Mexico at the Mesa de Otay Port of Entry. Though the Mariposa project still is in its proof-of-concept pilot phase, initial reductions in wait times and emissions from commercial vehicles have been impressive. In its first week of implementation alone, processing times were reduced by up to 85 percent. What used to take 3.5 to 8 hours to process because of separate inspections now currently takes an average of 25 minutes.^{149,150}

5.4 Private vehicles at southern border crossings

The volume and wait times for POVs vary greatly at different ports of entry along the southern border. San Ysidro is the busiest POV port of entry. The U.S. Department of Transportation's Bureau of Transportation Statistics end-of-year totals for the southern border for the year 2015 are presented in **Table 7**.

Table 7. 2015 Personal Vehicle Entry at Ports of Entry

	Port Name	Personal Vehicles
1	CA: San Ysidro	14,435,252
2	TX: El Paso	12,258,192
3	CA: Otay Mesa	6,933,472
4	TX: Laredo	5,224,056
5	TX: Hidalgo	4,594,298
6	TX: Brownsville	4,340,461
7	CA: Calexico	4,294,156
8	CA: Calexico East	3,622,215
9	AZ: Nogales	3,470,471
10	AZ: San Luis	3,106,744
11	TX: Eagle Pass	2,683,168
12	AZ: Douglas	1,591,184
13	TX: Del Rio	1,438,570
14	TX: Progreso	1,070,550
15	CA: Tecate	908,482

Source: U.S. Bureau of Transportation Statistics.¹⁴⁸

The POV totals for 2016 are on track to meet or exceed those of 2015. A POV traffic border wait time system has been implemented at the Ysleta, Texas-Zaragoza, Chihuahua Port of Entry in both directions (southbound and northbound).¹⁵¹

Efforts are underway at many ports of entry to determine whether Bluetooth-enabled devices, such as smartphones, can be used to accurately measure wait times at the border.⁴⁹ Accurate and real-time measures of wait times will assist individuals crossing the border and also will facilitate efforts of U.S. and Mexican authorities to reduce wait times, thereby reducing air quality effects at the border. Similar approaches are underway to examine pedestrian and bicycle border crossing times.

5.5 Pedestrian traffic at southern border crossings

San Ysidro followed by El Paso are the busiest pedestrian ports of entry, each processing slightly fewer than 600,000 pedestrians each month from January through March 2016.¹⁴⁸ In the past, managers of the ports of entry have focused on reducing wait times of commercial vehicles and

5

POVs, largely ignoring pedestrians, who often were forced to wait in long lines for hours, without shade or restroom facilities, and often adjacent to lines of waiting traffic. At many ports of entry, the paths that pedestrians must follow in crossing the border are excessively long, especially if connecting from Mexican public transport on one side to U.S. public transport on the other. This raises concerns regarding vulnerable populations, including disabled people, in terms of health effects in the face of increasing regional temperatures and air pollution. Border crossing is a greater burden for low-income people, who often cannot afford the expense of a personal vehicle.

Currently, studies are underway at the San Luis, Arizona-San Luis Río Colorado, Sonora Port of Entry to evaluate existing conditions and current needs of pedestrian and bicycle border crossing. The reconfiguration of the San Ysidro border crossing includes addition of a new pedestrian crossing on the west side of the facility that separates pedestrians from traffic and increases the number of inspection stations.

5.6 Current efforts to improve transportation planning and reduce pollution

The U.S.-Mexico Joint Working Committee for Transportation Planning, co-chaired by FHWA and the Mexican Secretariat of Communication and Transportation, analyze various ways that border wait-time data can be used for planning, operations, traffic information and design, as well as what methods and formats are needed for dissemination of the information. Most of the information currently is being collected through the Border Crossing Information System and being disseminated at the system's website.¹⁵² The system includes near real-time and archived data, mainly for commercial and some POV traffic for the Texas ports of entry.

The Joint Working Committee has created a number of border-wide regional master plans with a comprehensive and prioritized assessment of transportation needs along the border, including at the ports of entry. Regional border master plans provide the next logical step in a comprehensive, binational transportation planning process. The master plans include land use, environment, population and socioeconomic data. These data are used to adequately evaluate growth and future capacity needs at the border and to more realistically forecast future conditions in the border region. These data can be utilized to evaluate the existing binational transportation and port of entry system, its current and future demand, and the infrastructure necessary to handle the projected growth. The master plans foster consistency among the individual agency planning processes, which creates documentation that feeds back into the periodic updates of the plans. It considers short-, mid- and long-term needs.

The comprehensive list and prioritized assessment of the transportation and port of entry needs support international trade and improve cross-border travel and the quality of life for the residents of and visitors to each region.

Border master plans can be incorporated as a component of federal, state and local strategic plans. Additionally, the outcome of the planning process should be accepted and embraced by stakeholders throughout the border region. Stakeholders should make the border master plan part of their overall planning and forecasting process. Border master plans should be regularly updated (every 3–5 years) with new data, policy issues, and economic and infrastructure changes, as planned by the stakeholders. As of October 2015, border master plans have been completed for all six regions: California-Baja California (2008 and 2014 update); Arizona-Sonora (2013); West Texas-New Mexico/Chihuahua (2013); Lower Rio Grande Valley-Tamaulipas (2013);

California Integrated Border Approach Study

The California Integrated Border Approach Study is an ongoing, multiyear study aimed at exploring an innovative multiagency integrated border systems-based approach to project delivery strategies at the California-Mexico border. This research effort aims to provide advice to address solutions related to multiagency planning and innovative project delivery to overcome funding shortages and individual agency limitations to improve multimodal regional mobility at communities abutting the state's international border with Mexico. Although a number of federal, state and local agencies work in border communities, no formalized, collaborative strategies exist to implement projects that go "beyond the mandate" of individual agencies. The California border region needs a multi-institutional border mechanism to serve as the lead coordinating entity for strategic planning, project delivery and funding partnerships to address regional mobility needs at California's border communities.

The California Integrated Border Approach Study will:

- Describe the existing mobility conditions and challenges at each of California's border communities abutting international land ports of entry.
- Review best practice case studies from other areas along the U.S.-Mexico border.
- Propose to the state of California different alternatives of intra-agency collaboration to serve California's international border with Mexico.
- Propose the required legal operating frameworks for a future intra-agency structure.
- Develop innovative joint mechanisms for planning, funding, financing and project delivery at California's border communities.
- Provide a 5-year concept of operations for a new intra-agency border collaboration mechanism.

Laredo District in Texas-Tamaulipas/Nuevo León/Coahuila (2012); and New Mexico-Chihuahua (2015).

In an effort to provide accurate short-, medium- and long-term traffic projections for cross-border travel, forecast modeling of cross-border and port of entry travel demand is desired, including information to populate travel demand models. Current examples of this include the Arizona-Sonora Binational Travel Demand Model Phase I and a project in California-Baja California. The Joint Working Committee will support the completion of the Scenario Planning of Future Freight and Passenger Traffic Flows across the U.S.-Mexico and U.S.-Canada borders project. This project will model traffic and produce projections through the year 2045. The committee's support will help guide the modeling effort and the project's success. These projections will provide additional tools for future border master plan updates.

These border master plans and modeling efforts with federal leadership and strong state and local participation, as well as the active collaboration of Mexican agencies, are outstanding examples of transborder cooperation. The border-spanning efforts of this transportation planning provides a useful

example for the type of multilevel and multiagency trans-border collaboration required to enhance the resilience of border communities in the face of challenges such as climate change.

Many federal, state and local agencies are involved at the ports of entry along the U.S.-Mexico border. Coordinating these agencies in efforts to improve infrastructure and rationalize administration to facilitate trade and serve local communities is a complex task, especially when the participation of Mexican stakeholders is essential.

An innovative study similar to the California Integrated Border Approach Study is ongoing on the Arizona-Sonora border with the Southern Arizona to Central Mexico Freight Corridor Study and Needs Analysis. This study will focus on Interstate 19 from Tucson to Nogales, Arizona, and Carretera Federal 15 from Nogales, Sonora, to central Mexico. The goal of the analysis is to identify ways by which Arizona's transportation entities (e.g., state and departments of transportation, regional planning agencies) may leverage performance improvements or the creation of new freight movement capacity within the state's transportation network to garner economic development benefits. Modes analyzed

General Services Administration and Customs and Border Protection: Investing in Green Infrastructure at San Ysidro

The San Ysidro Land Port of Entry is the busiest land border crossing in the Western Hemisphere, currently processing an average of 50,000 northbound vehicles and 25,000 northbound pedestrians per day. The San Diego Association of Governments projects an 87 percent increase in vehicle traffic in San Ysidro by the year 2030. To accommodate that growth and better meet the changing needs of the tenant agencies and the traveling public, the General Services Administration is conducting a complete reconfiguration and expansion of the port. The scope includes the demolition and construction of the land port of entry, including primary and secondary inspection areas, administration and pedestrian buildings, and all other support structures. The project will expand pedestrian processing facilities, including a new pedestrian crossing on the east side of the land port of entry that will connect with a new multimodal transportation hub in Mexico and expanded northbound inspection facilities. Additionally, there will be a new north- and southbound crossing at El Chaparral/Virginia Avenue with an associated transit center.

Once all three phases are complete, the new port will boast 62 northbound vehicle primary inspection booths, one dedicated bus lane, and inspection booths spread across 34 lanes, as well as improved processing facilities for bus travelers and travelers participating in the Secure Electronic Network for Travelers Rapid Inspection program. The land port of entry will have more than 110,000 square feet of new primary and secondary vehicle inspection canopy utilizing state-of-the-art materials that will both conserve and produce energy. In addition, a portion of the Interstate 5 South freeway will be realigned and expanded from the current five lanes to 10 lanes, which will connect to Mexico's new El Chaparral facility. A corresponding southbound inspection canopy will be constructed to support U.S. Customs and Border Protection (CBP) southbound vehicle inspection efforts.

In designing the new San Ysidro Land Port of Entry, the General Services Administration is committed to build the "Port of the Future" and strives to build a facility that is sustainable and operationally scalable and will

dramatically reduce the port's carbon footprint, while at the same time enhancing CBP's ability to conduct its mission. With the innovative applications of energy production projects, as well as sustainable energy and water-saving features, the San Ysidro Land Port of Entry aspires to receive the Leadership in Energy and Environmental Design (commonly known as LEED) Gold certification.

The General Services Administration currently is collaborating with local agencies to develop a plan for improvements at Virginia Avenue to support northbound and southbound pedestrian crossing on the west side of the port. The proposed design includes 10 northbound and two reversible pedestrian processing lanes and conveniently serves the traveling public on the west side of San Ysidro. The concept includes an intermodal transit center for buses and taxis in addition to a pedestrian drop-off and pickup area that was completed in July of 2016.



Vehicles lined up to enter into the United States from Tijuana, Mexico. Credit: James Steidl / Shutterstock.com.

will include both commercial motor carrier and freight rail. The corridor of interest spans from Tucson along Interstate 19 to Nogales, Arizona, and Nogales, Sonora, before extending southward along Carretera Federal 15 to Guaymas, Mazatlán, Guadalajara, and eventually Mexico City. The primary aim of the study is to determine the deficiencies of the transportation network on Carretera Federal 15 and Interstate 19 from Central Mexico to Tucson.

The active participation of federal agencies is central to both of these studies to facilitate close coordination with Mexican agencies at all levels. These processes provide U.S. border communities with mechanisms to participate actively in policy discussions that have great importance for quality of life at the local level, as well as regional and national economic impact.

As described in Chapter 3, a federal program that has empowered border community participation in development of border programs is Border 2020, the latest environmental program implemented under the 1983 La Paz Agreement. Border 2020 focuses on regional areas where environmental improvements are needed most, establishing thematic goals, supporting the implementation of projects, considering new fundamental strategies, and encouraging the achievement of more ambitious environmental and public health goals. Border 2020 has been important in building capacity in local border communities to meet the challenges of climate change in the border region.

Under Border 2020, Goal 1 is to reduce air pollution. This is being accomplished through initiatives to boost energy efficiency and renewable energy generation, including 20 renewable energy projects supported by NADB-BECC and under a 2-year plan to increase air monitoring along the border. Several air quality monitoring projects currently are underway, including PM monitors at two sites in Mexicali

and at the San Ysidro Port of Entry in San Diego, which will aid in understanding PM_{2.5} transport through the adjacent areas.

5.7 Transportation and air quality

The transportation sector is the largest source of air pollution in the border region, and the movement of trade and people across the U.S.-Mexico boundary exacerbates this problem because delayed movement resulting from U.S. and Mexican security measures has the unintended consequence of increased emissions of particulates and ozone as well as VOCs and NO_x, which contribute to ozone formation.

The U.S. Department of Transportation and CBP can take a number of actions to address transportation and air quality issues, such as reducing GHG releases and air pollution at border crossings with Mexico by decreasing border wait times, creating amenities for pedestrians waiting in line, improving border crossing traffic-flow designs, and identifying innovative technologies to better predict and reduce border wait times. Some design options include creation of buffer zones between roadways and communities, re-routing trucks through commercial areas and away from residential zones, and encouraging clean diesel programs for commercial vehicles.⁴⁹ Of course, many of these solutions require coordination of all levels of U.S. government, as well as Mexican authorities. The Mariposa Port of Entry in Arizona is an example of effective design and smart border management to increase energy efficiency and reduce vehicular pollution.¹⁵² Some changes to reduce excessive border crossing delays involve infrastructure and design issues that will require years for implementation; however, there are immediate actions, such as joint inspections, that the relevant federal agencies can implement widely to decrease border wait times.

In 2014, for example, 11.9 million passenger vehicles (21.1 million passengers) and 7.9 million pedestrians crossed into San Diego at the San Ysidro port of entry.¹⁴⁸ During the times when most crossings took place, wait times often were 1 to 2 hours for passenger vehicles and more than 1 hour in the pedestrian line, resulting in significant human exposure to ozone, carbon monoxide and PM_{2.5}, as well as considerable distress to waiting individuals, especially in the pedestrian line.^{49,153} An executive order mandating that U.S. border authorities prioritize reallocating staff to inspection booths and positions at busy crossing times could significantly reduce vehicular and pedestrian wait times, reducing ozone and air contaminant production and the negative health effects on passengers, pedestrians and workers at the ports of entry and residents of the surrounding communities. The economic benefits of shorter wait times for both commercial and noncommercial traffic at the ports of entry also would be significant.¹⁵⁴

5.8 Recommendations

1. The U.S. Department of Transportation and CBP should reduce GHG releases and air pollution at border crossings with Mexico by decreasing border wait times, create amenities for pedestrians waiting in line, improve border crossing traffic-flow designs, and identify innovative technologies to better predict and reduce border wait times. Some design options, in which the General Services Administration will play a role, include creation of buffer zones between roadways and communities, re-routing trucks through commercial areas and away from residential zones, and encouraging clean diesel programs for commercial vehicles. Of course, many of these solutions require coordination of all levels of U.S. government, as well as Mexican authorities.
2. An executive order should be implemented mandating that U.S. border authorities prioritize reallocating staff to inspection booths and positions at busy crossing times. Such a mandate could significantly reduce vehicular and pedestrian wait times, reducing ozone and air contaminant production and their resulting negative health effects on passengers, pedestrians, workers at the ports of entry, and residents of the surrounding communities. This executive order also should address recruitment, training and retention issues for CBP employees. The economic benefits of shorter wait times for both commercial and non-commercial traffic at the ports of entry also would be significant.
3. The unified cargo inspection project being piloted in Nogales should be evaluated for its reduction in emissions from commercial vehicles, in addition to wait times, and modeled at other land ports of entry in the border region. The selection of one methodology for obtaining emissions reduction also should be included so that data evaluations are consistent.
4. Agencies should provide commensurate staffing levels whenever infrastructure improvements are made at land ports of entry in the border region. ■



Chapter

6

Energy, Greenhouse Gases and Climate Change

Energy production through the burning of fossil fuels, both globally and in the U.S.-Mexico border region, is the leading source of CO₂, the most important of the GHGs that contribute directly to global warming and climate change. Fossil fuels are the main source of electricity generation and dominate the transportation sector as well. The burning of fossil fuels also produces air pollution, with significant human health effects that will only intensify with climate change and higher temperatures in the border region. Efforts to reduce GHGs as a means of combating climate change are integral to most federal, state and local border community climate action plans. Energy efficiency, a shift to cleaner burning fossil fuels, and growing use of nonpolluting alternative and renewable energy sources, such as solar photovoltaic and wind, are important components of efforts to address the causes of climate change. U.S. border communities will continue to be faced with the challenge of transitioning away from traditional fossil fuel sources while both fortifying the grid against new threats from climate change and minimizing human health impacts.

6.1 Energy, human health and climate change

As of 2015, the primary fuel sources supplying the energy grid in the four U.S.-Mexico border states were fossil fuels such as coal (Arizona: 36%, New Mexico: 63%) or natural gas (California: 57%, Texas: 49%).^{155,156} These fuel sources help to establish an affordable and reliable energy grid critical to delivering many of the services that form the pillars of community stability and health, including access

to clean water, sanitation and modern health services. In analyzing the relationship between climate change and energy production in this region, however, two key human health consequences must be considered: (1) how reliance on fossil fuels for energy production directly affects human health and climate change and (2) how climate change may indirectly affect human health by disrupting energy production required to maintain community health and stability. By devising a comprehensive energy strategy that addresses a primary cause of and adverse impacts from climate change, the U.S.-Mexico border region also can address these two energy-related threats to human health.

6.2 Energy resources and climate change

Located in one of the hottest and driest regions in the United States, the population of the U.S.-Mexico border region relies heavily on the energy grid as a lifeline to maintain habitable communities and, therefore, is especially vulnerable to disruptions in electricity supply. As discussed in Chapter 1, the southwestern United States is predicted to experience higher temperatures, more heat waves, more droughts and more extreme weather events (e.g., storms, floods, wildfires) during the next century,^{16,157} which will serve to increase energy demand and magnify this vulnerability. Each of these climate impacts poses unique threats to the energy grid and community stability and health.

Higher temperatures affect thermal power plants (burning both nuclear and fossil fuels) by raising the temperature of water sources required for energy production and cooling.

6

Insufficiently cool water sources can cause unsafe conditions and reduce efficiency of the plants that require high temperature differentials to operate. Either of these conditions can force a plant to temporarily curtail production or shut down.¹⁵⁸ Additionally, high temperatures can cause damage to the physical structure of the power grid by lowering power-carrying abilities and increasing wear and tear on components. A 2012 report by the DOE states that high temperatures cause power system stress, which increases the vulnerability of the system to failure, by:

- Lowering the power-carrying capability of system elements such as transmission lines, transformers, circuit breakers and so forth.
- Accelerating the deterioration of dielectric materials, operating mechanisms, supporting structures and cooling/insulating liquids used in power apparatus.
- Inducing greater overall wear and tear effects on apparatus, which leads to increased vulnerability to faults and cascading failures.
- Shortening the life of batteries that are crucial in supporting uninterruptible power supply and emergency response systems.
- Significantly reducing the efficiency of photovoltaic solar panels.
- Reducing the capacity and efficiency of gas and combustion turbines.¹⁵⁸

Power plants, such as hydroelectric and thermal plants, that rely on surface water for energy production and cooling are especially vulnerable to drought conditions, as water resources in the Southwest likely will become increasingly scarce during the next century. In a 2012 report by the DOE, approximately 61 percent of installed energy capacity in the Southwest was considered at “high-risk” for capacity loss from drought conditions.¹⁵⁸ The DOE also released a report in 2015 providing a summary of climate change impacts on the energy sector and resilience solutions for various regions, including those along the U.S.-Mexico border region.¹⁵⁹

Insufficient water resources can cause problems for power plants in several ways. In hydroelectric plants, the generation of electricity depends on the flow of large volumes of water to spin turbines. Drops in reservoir levels cause decreased energy generation.¹⁶⁰ For example, in 2014 severe drought conditions in California caused in-state hydropower generation to decrease by 50 percent.¹⁶¹ In thermal plants, drought conditions also may affect the availability of water needed for cooling purposes. Lack of cooling water can cause unsafe conditions and lead to a shutdown of plants.

Floods, wildfires and storms with high winds or lightning routinely damage electrical infrastructure. In a 2014 report by Climate Central, severe weather was determined to have caused 80 percent of large-scale power outages in the United

States between 2003 and 2012, and the average annual number of weather-related power outages has doubled since 2003.¹⁶²

General consensus indicates that these extreme weather events and natural disasters are projected to continue to increase in frequency and intensity in the U.S.-Mexico border region as global temperatures rise. Much of the U.S. energy infrastructure is located aboveground and vulnerable to severe weather. Even power lines that are buried underground, however, can be damaged during floods.

If the electricity grid is unable to withstand the increasing constraints brought by climate change, then power outages may occur more frequently. Beyond powering residences, electricity powers many important services that are critical to community health and stability, including water and sewer systems, communications systems, hospitals and emergency response systems, and refrigeration that preserves food and medicines. Recent studies estimate the annual cost of major weather-related power outages in the United States to be between \$20 and \$55 billion.¹⁶³ Power blackouts lasting days, weeks or even longer could have catastrophic effects on community stability and health in the U.S.-Mexico border region.

The 2011 Southwest Blackout—in which power was lost in the San Diego-Tijuana area; southern Orange County; the Imperial, Mexicali and Coachella valleys; and parts of Arizona and Sonora—serves as an example of how power blackouts can affect community health and stability. The blackout, although caused by human error rather than climate effects, lasted for 11 hours and left nearly 7 million people without power.¹⁶⁴ The 11 hours without power caused an estimated \$12 to \$18 million in food losses from spoilage, traffic gridlock and some sewage pumping systems to fail, resulting in contaminated water supplies and beach closures.^{165,166} Millions were left without air conditioning on a day when temperatures in some border cities reached dangerously high levels (e.g., 113°F/45°C in Yuma, Arizona).

Power blackouts amplify risks to vulnerable border populations as a result of extreme heat. As stated in Chapter 1, excessive heat is the leading cause of U.S. weather-related deaths.¹⁶⁷ California suffered a massive heat wave in 2006 that caused the deaths of an estimated 300 to 450 people.¹⁶⁸ Many low-income households in the U.S.-Mexico border region may not have access to air conditioning and are especially at risk of heat stroke or death during power outages. Chapter 7 provides more information on the effects of heat on human health.

6.3 Energy and climate resilience

To meet the energy needs of the growing population in the border region and enhance climate resiliency, the border



The 200-megawatt Los Vientos I Windpower Project is in Lyford, Willacy County, Texas. Together with its sister project Los Vientos II, it powers about 280,000 homes. Credit: Duke Energy Renewables.

states have begun to transition to a cleaner energy economy powered by energy efficiency and renewable energy programs and policies. The federal government can continue to play a vital role through education and outreach programs, as well as providing support for the adoption of energy efficiency and renewable energy technologies.

During the next decade, the U.S.-Mexico border region will need to continue to invest in improvements that will ensure that the energy system can withstand the new demands brought on by climate change impacts. Building a more resilient energy grid should be a key part of the climate change strategy for the region and will help mitigate energy-related impacts of climate change to human health.

Investing in low-carbon energy sources is an important part of both building grid resiliency and ensuring community health and stability. In 2013, 37 percent of energy-related U.S. CO₂ emissions stemmed from burning coal, natural gas and oil to produce electricity.⁵⁰ Using fossil fuels for energy production not only contributes to the greenhouse effect but also releases air pollutants that have documented

health effects (e.g., mercury, PM and sulfur dioxide) into the air. Increased use of renewable energy not only reduces these negative health effects, but also certain technologies, such as wind and solar photovoltaic power, can enhance grid resiliency by reducing dependency on fuel supplies and water for operation.¹⁶⁹ Wind and solar technologies also are increasingly cost competitive with conventional fuel sources (based on an unsubsidized leveled cost-of-energy comparison)¹⁷⁰ and are even more cost competitive when negative health and environmental effects from fossil fuels are taken into consideration.¹⁷¹ Transition from fossil fuels to renewables poses significant challenges, such as energy storage and improvements to the grid, to ensure that energy supply is available to meet demand; currently, these are areas of significant research and development.

Solar photovoltaic power is most efficient in areas with high insolation (solar radiation that reaches the earth's surface),¹⁷² and solar photovoltaic power uses no water to generate electricity, making the technology well-suited for deployment in the U.S.-Mexico border region. An additional benefit of solar photovoltaic power is that it can be easily scaled for either residential, commercial, community or utility use. Employing a combination of distributed generation and community- or utility-scale generation will increase grid resiliency in the most cost-effective manner.

The United States, Mexico and Canada are working on these issues at the federal level and solidified the trilateral commitment with the North American Climate, Energy and Environment Partnership announced by President Obama, President Enrique Peña Nieto and Prime Minister Justin Trudeau at the 2016 North American Leaders Summit. The partnership's goals include 50 percent clean power generation across the three countries by 2025, a 40 to 45 percent reduction in methane emissions from the oil and gas sector from the 2012 level by 2025, and more alignment of energy efficiency standards. An example of the federal-level cooperation related to this partnership already occurring is the program by the DOE and Mexico's Secretaría de Energía (Energy Secretariat), which is expanding power sector cooperation to include peer dialogues for grid planning and operation to include integration of renewable energy, supporting establishment of renewable energy zones in Mexico, and launching programs to enable business and investor partnerships to scale up investment in low-carbon power infrastructure. High-level government-to-government engagement, including through the U.S.-Mexico Clean Energy and Climate Policy Task Force, can continue to further these efforts.

The DOE also has established the Partnership for Energy Sector Climate Resilience, including electric utilities located throughout the United States and in the U.S.-Mexico border



The Newman Solar, LLC facility in northeast El Paso, Texas, generates clean energy to power more than 3,800 homes. Credit: El Paso Electric.

region. The Partnership for Energy Sector Climate Resilience is an initiative to enhance energy security by improving the resilience of energy infrastructure to extreme weather and climate change impacts. The goal is to accelerate investment in technologies, practices and policies that will enable a resilient 21st century energy system. Under this partnership, owners and operators of energy assets will develop and pursue strategies to reduce climate and weather-related vulnerabilities. Collectively, these partners and the DOE will develop resources to facilitate risk-based decision making and pursue cost-effective strategies for a more climate-resilient energy infrastructure.

Along the border, electricity transmission connections cross the border in numerous locations, and electric power is moved back and forth across the boundary. With the reform of Mexico's energy sector, new investment is moving into electrical energy production and renewables. As the cross-border linkages increase and promote development of regional, binational power grids, the reliability of the grid for border communities will improve.

EPA's RE-Powering America's Land Initiative encourages renewable energy development on previously contaminated properties, such as landfills, mines and industrial developments. This initiative addresses the need that renewables have for large areas to site solar or wind projects and provides a better alternative to converting farm or range land or natural areas to energy production. In addition to maintaining an inventory of these properties, the DOE's National Renewable Energy Laboratory and EPA collaborate to conduct feasibility studies for selected properties, examining both technical remediation of the site, as well as an economic assessment.

Currently, 13 landfill methane capture projects exist in the border region, with three more either planned or under construction, where landfill gas is used for power generation on-site or transferred to off-site industrial users.¹⁷³ Most of these projects are located in California or Arizona.

EPA has identified several benefits to siting solar photovoltaic power systems at Deming, New Mexico, and other Brownfield sites. In addition to mitigating climate change by reducing GHG emissions, solar power generation can be developed in place of limited greenfields, preserving the land carbon sink, especially as these sites often are located near existing roads and energy transmission or distribution infrastructure. This advances cleaner and more cost-effective energy technologies while building community resiliency.¹⁷⁴

The binational agencies, the NADB and BECC, are supporting initiatives to increase solar photovoltaic and wind projects in the border region and also climate change action planning in Mexico's northern border region. NADB has provided loans that finance almost \$500 million for nine solar and wind projects within Arizona and California, totaling about 271 megawatts generated. BECC facilitated the Baja California Climate Change Action Planning process, which resulted in an estimate of costs and benefits of different mitigation and adaptation options.

BECC has supported border efforts to address air risks posed by climate change. For example, as described in Chapter 3, BECC collaborated to help the Mexican border states develop GHG emissions inventories and forecasts in 2010. The resulting state climate action plans developed by the Mexican states of Baja California, Sonora, Chihuahua, Coahuila and Tamaulipas identified mitigation policies and

the economic impacts of implementing these public policies. In Baja California, Coahuila and Chihuahua, the action plans also include socioeconomic micro- and macroanalyses of mitigation policies, as well as the quantification of reduction and costs and the cost savings of the GHG inventory.¹⁷⁵

The macroeconomic analysis showed that the recommended policies identified to lower GHGs have, as a group, a positive effect on the economy through increases in employment and gross domestic product. A great disparity also exists among the individual policies. For example, in Baja California, “Finance Incentives for Machinery Energy Efficiency” showed the greatest economic gain in the analyses based on the reduction of production costs and the economic stimulus from the investment in new equipment and machinery. “Energy Supply Diversification” is seen to have the highest negative effect in Baja California because of high capital costs of the generation of renewable energy. Future initiatives may include the review of four of the 17 policies in the Coahuila state climate action plan to identify implementation strategies.

6.4 Energy efficiency and public education initiatives

Encouraging the adoption of energy-efficient technologies and behaviors in the public sector also will help promote grid resiliency. By reducing overall electricity demand, especially during critical times like extreme heat events, the grid will be better able to serve communities and enhance community resiliency in the face of climate change. The federal government can encourage adoption of conservation and energy efficiency technologies to benefit low-income families and border communities, including updated energy building codes for new construction, which will increase resiliency of these residents in the face of higher temperatures in the future.

The DOE and the National Science Foundation held a series of joint workshops in 2015 and 2016 to stimulate dialogue and accelerate the wide-scale advent of advanced water resource recovery facilities (also known as wastewater treatment plants).¹⁷⁶ An opportunity exists for collaboration and coordination with BECC on applying this work to small water and wastewater utilities along the border, including those of tribal governments. Most water and wastewater facilities have large pumps, drives, motors and other equipment operating 24 hours per day, and these facilities can be among the largest individual energy users in a community. Communities that operate water and wastewater treatment plants along the border can improve energy efficiency and cost savings through the use of variable speed pumps/aeration equipment and incorporating solar power systems. Facilities also can use other approaches to

improve energy efficiency by shifting energy usage away from peak demand times to times when electricity is cheaper. Wastewater treatment facilities that incorporate anaerobic digesters can use the generated biogas end product as a source of energy to operate facility booster and process transfer pumps, blowers and heating units. The use of more energy-efficient motors and pumps will reduce further the amount of electricity needed to operate these facilities. These actions can reduce the power generation requirements of the electric power utility, thereby reducing GHG emissions.

In coordination with the National Weather Service, the Climate Prediction Center can use existing programs to develop methods to predict more accurately the location, length and severity of extreme heat weather events, including events with above-average nighttime temperature, which are projected to have energy-use effects. Public education about energy efficiency and safety during these events could help prevent blackouts and heat deaths. Existing grant programs of the DOE, the U.S. Department of Housing and Urban Development (HUD), and EPA can be used to provide emergency shelters for extended periods of extreme temperatures in vulnerable communities and subsidize air conditioning for vulnerable populations.

6.5 Greenhouse gas reduction

Some border state and local community efforts to address climate change include legal mandates to reduce GHG production, subsidies for alternative energy, and development of climate action plans. The combination of federal and state subsidies and tax credits stimulated significant growth of residential and commercial solar photovoltaic power systems in border cities such as San Diego. The *Shining Cities 2016* report indicates that San Diego at the end of 2015 had installed solar photovoltaic power capacity of 189 megawatts, ranking second nationally behind Los Angeles.¹⁷⁷ That same report also ranked San Diego as fourth nationally in terms of *per capita* solar photovoltaic power capacity.

The two largest border cities, San Diego and El Paso, had adopted climate action plans by 2016. In 2009, El Paso released its *Sustainability Plan*, which includes community-wide goals for climate and clean energy action. El Paso releases periodic report cards in accordance with this plan. In addition, on August 2, 2016, El Paso Electric, which serves parts of southern New Mexico as well as El Paso County, announced the sale of its share of the coal plant and that it had become the first utility in Texas or New Mexico to be a coal-free energy provider, in part by making further investments in solar energy.¹⁷⁸ In California, both San Diego and Imperial counties have climate action plans, whereas a number of incorporated cities within each jurisdiction have city-based climate action plans.

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6.6 Energy and resilient border communities

Throughout the border region, communities are becoming more climate-resilient with local renewable, energy-efficiency and demand-response programs. In some cases, these are local or state initiatives, but the federal government has played and can play a role through the DOE, NADB-BECC, EPA, Federal Energy Regulatory Commission, and other federal agencies. With projected changes in weather and climate indicating more extreme weather, it will be important for border communities to have a resilient energy system that can operate efficiently and encourage local generation. The DOE has specific renewable energy and energy resiliency programs for federally recognized tribes, including those in the border region.¹⁹¹ At the same time, many of these solutions also reduce the need to run larger central power stations or natural gas peaker plants that can negatively affect air quality.

6.7 Efficient new buildings

Cities and states along the U.S.-Mexico border have different codes or standards related to energy use and consumption within both residential and commercial buildings. Although the federal government does not play a direct role in energy code adoption or enforcement along the border or in states in general, the DOE is a participant in the development of the codes through the International Code Council and other groups, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers. In addition, the DOE analyzes codes through its national laboratories and provides resources and training for states on building sciences and building code compliance. Thus, the DOE reviews the latest codes to ensure that they will lead to more energy-efficient homes and buildings.

The DOE provides grant funding to states for energy planning and other activities, and that funding is contingent on states showing compliance with certain energy-efficient building code measures, including having considered and adopted more recent energy codes. Thus, to certify compliance with Title III of the Energy Conservation and Production Act, states must provide evidence that they have adopted or have begun a process to adopt the latest International Energy Conservation Code (IECC) and are actually enforcing or ensuring compliance with that code. The DOE also can work on its own code if it believes that the most recent version of the IECC does not make new buildings more efficient. These federally encouraged standards can benefit local communities along the border through improvements in energy efficiency.

Texas, New Mexico and California set minimum energy codes with which all builders are required to comply, although actual implementation and enforcement is left up to local municipalities. Since 2001 in Texas, the State

Renewable Energy Border State Facts

U.S. states bordering Mexico have taken significant steps in renewable energy, leading to decreased emissions of air pollutants and a reduction in fossil fuels use. Because energy sources are connected by an electrical grid, it is difficult to disaggregate energy production location from geographic usage; that is, energy generated in one place in the state could be consumed anywhere in a large region.

California

- California leads the nation in generation capacity for geothermal, biomass, solar photovoltaic and solar thermal electric projects.¹⁷⁹
- California has the largest advanced energy industry in the nation, with one in every five advanced energy workers nationwide. California employment in the advanced energy industry grew 18 percent in 2015.¹⁸⁰
- As of December 2015, California leads the country in cumulative solar capacity installed, with 13.2 gigawatts—enough energy to power 3.3 million homes.¹⁸¹

Arizona

- With 2.3 gigawatts of solar power as of December 2015, Arizona has the second most installed solar electrical watts per capita¹⁸² and the second-highest solar energy capacity in the United States, with enough solar energy installed in the state to power 327,000 homes.¹⁸¹
- The state ranked second in the nation in utility-scale electricity generation from solar energy and third in solar employment, with an estimated 9,200 jobs (2014).¹⁸²
- Arizona's Renewable Portfolio Standard requires regulated electric utilities to generate 15 percent of their energy from renewable resources by 2025.¹⁸³

New Mexico

- In 2014, New Mexico ranked sixth nationally in utility-scale electricity generation from solar energy.¹⁸⁴
- As of June 2016, New Mexico has 400 megawatts of solar energy installed (34 megawatts residential, 51 megawatts commercial and 316 megawatts utility-scale), enough to power 91,000 homes.¹⁸⁵
- A major portion of the SunZia Corridor—a 515-mile (830-kilometer) transmission corridor being developed by federal and state agencies to allow renewable development on and across federally held lands in Arizona and New Mexico—lies in New Mexico.¹⁸⁶

Texas

- Texas ranks first in the nation for wind energy capacity, with 17.9 gigawatts of wind power capacity as of December 2015. In 2015, wind generation in Texas powered the equivalent of 4.1 million homes.¹⁸⁷
- On March 23, 2016, wind power at one point accounted for 48 percent of Texas' electricity.¹⁸⁸
- Renewable energy accounted for 16 percent of the state's electrical generating capacity as of April 2016.¹⁸⁹

San Diego's Climate Action Plan

Some state and local governments along the U.S.-Mexican border have begun to respond to challenges posed by climate change, most frequently through development of a climate action plan that recognizes the link between greenhouse gas (GHG) emissions and global warming. San Diego, the largest border city in the United States, with more than 1.3 million residents, has been a leader on climate-related matters for the last decade. In December 2015, the city council unanimously approved Mayor Kevin Faulconer's ambitious new *City of San Diego Climate Action Plan* that called for cutting the city's carbon footprint in one-half by 2035.¹⁹⁰ The plan, championed by a Republican mayor, was endorsed by a broad cross section of stakeholders, including the business community and environmentalists. In May 2016, Mayor Faulconer released a report that identified \$130 million in new monies for the fiscal year 2017 budget for transportation, renewable energy, water, infrastructure and other investments that support the goals of the plan.

The *City of San Diego Climate Action Plan* recognizes potential effects of a changing climate—higher seasonal temperatures, worsening air quality, negative health effects such as increased asthma and vector-borne diseases, diminished water supplies, and increased wildfires—that will have great consequences not only for the built and natural environment but also for the community's health and economic vitality. The plan also commits to improve resilience to potential future impacts of climate change.

The *City of San Diego Climate Action Plan* is driven by California's legislation (Assembly Bill 32) and Governor Jerry Brown's Executive Order B-30-15, which set aggressive statewide

GHG emissions reduction targets to reduce emissions to 40 percent below 1990 levels by 2030, setting the state on a trajectory to reach 80 percent below 1990 levels by 2050. San Diego calculated an interim goal for 2035 to eventually achieve the 2050 target (Figure 12).

The city has identified five strategies to achieve the 2035 targets:

1. 100 percent clean and renewable energy citywide.
2. 50 percent of people commuting by bicycling, walking and transit.
3. Zero waste.
4. Energy and water efficient buildings.
5. Climate resiliency and adaptation.

Although the *City of San Diego Climate Action Plan* links to regional, state and federal efforts regarding climate change within the United States, the plan does not link to efforts in Mexico's border region nor refer to realities

south of the international boundary. The focus on areas within the city limits is understandable because of data availability and the geographical limits of San Diego's jurisdiction. The plan, however, and the next level of all climate action planning in states and at the federal level likely could benefit from increased cross-border collaboration. There is a potential for greater positive effects if San Diego partners with neighboring Tijuana and its 2 million residents to expand their climate action efforts. For example, GHG reduction at the two ports of entry would benefit both San Diego and Tijuana and provide air quality co-benefits for the residents and workers in the area. Also, the benefits of enhancing quality of life through actions such as improved public transit and increased urban tree canopy of each city will serve the entire region, beyond city boundaries.

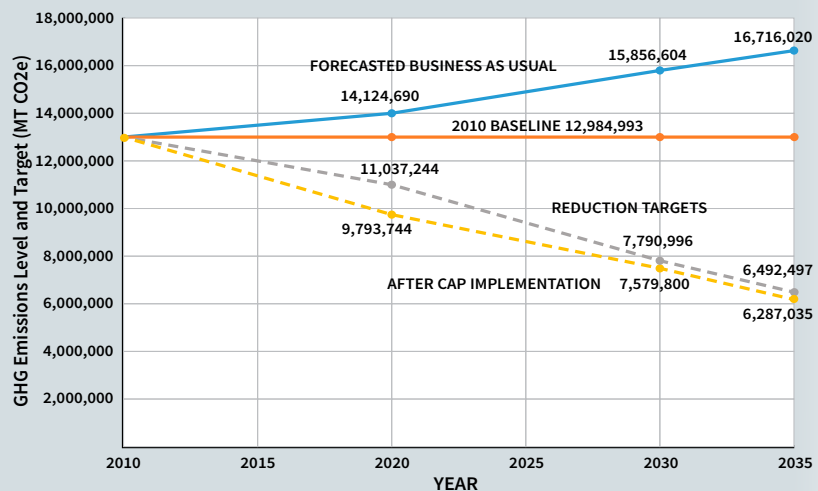


Figure 12. San Diego's projected greenhouse gas emission levels and reduction targets.

Source: *San Diego Climate Action Plan*, 2015.¹⁹⁰

Energy Conservation Office, a state department within the Texas Comptroller of Public Accounts, has required that more energy efficient codes be adopted. Most recently, following the passage of Texas House Bill 1736, the State Energy Conservation Office adopted the 2015 IECC—or its equivalent—for all state-funded buildings, as well as residential and commercial construction, beginning in 2016. Cities throughout Texas now are required to implement these new codes for new construction, although local amendments are allowed. Cities considered to lie in a nonattainment or

near-nonattainment area because of concerns of ground-level ozone can only make the minimum codes more energy efficient, not less. El Paso recently adopted the 2015 IECC from its current code, which is based on the 2009 IECC. Independent analysis by the Texas Energy Systems Laboratory has shown that the average home built to the 2015 IECC will save between nine and 20 percent energy depending on the climate zone and size of the home.¹⁹²

The state of California mandates minimum building code standards for new construction, which are continually

6

updated through a rulemaking process. The California Building Codes can be found in Title 24 and generally are among the most energy efficient in the country. In fact, they are the only state code to require compliance with a “Green Construction Standard.” Recently, California approved the new 2016 Energy Efficient Standards, which build on the previous California standards. In addition to requiring that new homes and buildings be energy efficient with better windows, insulation and roofs and less duct leakage, the California requirements, also under Title 24, require all buildings (with some exceptions) to be “solar ready”; that is, easy to add solar panels if future occupants want them. Thus, some communities, such as San Diego, already require new homes and businesses to be solar ready, which helps spur the adoption of solar technology.

In New Mexico, no process currently is in place to adopt the 2015 IECC, although since January 1, 2012, builders are required to comply with the 2009 IECC. The Construction Industries Division of the Regulation and Licensing Department is the state agency charged with analyzing and adopting new versions of the code. In Arizona, no state minimum codes exist, although individual cities have for the most part adopted either the 2009 or 2012 IECC.

Financing availability is important for border communities to address energy-related issues related to climate change and the critical role that energy plays. In 2010, the DOE issued guidelines for pilot Property-Assessed Clean Energy (PACE) financing programs.¹⁹³ Several states—including California, New Mexico and Texas—have adopted legislation that allows local governments to create PACE districts. In Texas, border counties—including Willacy, El Paso and Cameron—have passed resolutions to create new PACE districts, although programs just began in 2015.

In addition to PACE, some utilities, municipal utilities or electric cooperatives have offered either “on-bill repayment” or “on-bill financing” that allows residential and commercial customers to borrow money for local storage, solar and energy efficiency projects and pay the funds back over time. Recently, in Texas, the Pedernales Electric Cooperative began offering such loans through its billing systems, utilizing startup funding obtained from the USDA’s Rural Utilities Service.

6.8 Energy storage solutions

A more recent development has been the growth in the use of energy storage as a solution to create a more resilient and flexible electric grid. Because solar photovoltaic arrays do not work at night and have reduced output during cloudy weather conditions, and wind generation often is erratic, it is necessary to balance the regional electric grids so that peak demands can be met. Energy storage meets this need, and 2015 represented the largest growth in energy storage technology in the United States. Energy storage

technologies—including batteries, flywheels, compressed air energy storage, and thermal storage such as chilling stations and hydrological storage systems—take electricity generated at another site, store it and then release it at a later time.

In many electricity markets, electric consumers and utilities are considering how to incorporate energy storage into the country’s mix of energy resources. In California, under Assembly Bill 2514, all large investor-owned utilities are required to meet goals to purchase energy storage technology. In Texas, there is no requirement to add electric storage, but new rules are being developed on how storage can participate in electric and operating reserve markets. Recently, several large-scale battery projects have been developed and are mainly providing “ancillary” services. Along the border, American Electric Power, a large private electric company, added a large battery of 4 megawatts to its transmission system as a backup power source at the end of a large transmission line near Presidio, Texas.

The federal government plays a role in the development of storage technology. Through its Energy Laboratories, the DOE provides important funding and research for the integration of storage technology, and it also provides direct funding to utilities and others. The Federal Energy Regulatory Commission established a comment period in 2016 under Docket No. AD16-20-000 so that the public could provide input on how storage technology can be more seamlessly integrated into markets and transmission systems.

6.9 Waste-to-energy technologies

Under EPA’s Border 2020 Program, the Texas-New Mexico-Chihuahua Regional Workgroup Joint Advisory Committee partner, Cementos de Chihuahua in Ciudad Juárez, has been using more than 1.2 million scrap used tires annually for energy cogeneration. Recently, Cementos de Chihuahua submitted and received authorization from Mexico’s SEMARNAT to utilize nonhazardous municipal waste as a source of energy to supplement consumption at the Juárez Cement Plant. Cementos de Chihuahua cogenerates energy using an average of 120 metric tonnes (132 tons) of waste daily, constituting up to 33 percent substitution of combustible energy consumed in a single cement plant.¹⁹⁴ The waste used for energy generation included used tires, pecan shells, sawdust, plastics and industrial trash such as carton, paper and automobile upholstery, averaging 40 metric tonnes (44 tons) daily.

EPA Region 6 has conducted several energy management workshops for water and wastewater utilities along the U.S.-Mexico border to promote a reduction in energy consumption and costs by using the ISO 50001 Energy Management Systems framework and EPA’s ENERGY STAR Guidelines for Energy Management. Utilities along the border, however, have not yet adopted these energy

Property-Assessed Clean Energy (PACE) Programs

Initiated in 2010 and updated in 2016, the PACE program, when authorized by states, enables property owners to finance clean energy projects by attaching the obligation to repay the cost of improvements to the property, not to the individual borrower. Recently, many states, including both Texas and California, have passed statewide legislation that authorizes the creation of PACE Districts. PACE Districts are entities that can assess a loan on a property for energy efficiency, water conservation or renewable energy improvements and then allow the loan to be paid back through the property taxes by adding a special fee that is paid back over time. In this way, energy efficiency and renewable energy can be financed and are much more accessible to low-income border residents and small businesses. Although these programs are statewide, they are important for the border region as a tool for homeowners.

The federal government has a unique role to play in promoting PACE. Recently, the Federal Housing Authority approved new guidance that would allow homes that it helps finance with existing PACE loans to proceed. Stakeholders, however, still are awaiting final rulemaking or guidance from the Federal Housing Finance Agency to determine how that agency would allow residential PACE to proceed while protecting the agency and the federal mortgage market.

management practices, usually because they require an initial monetary investment.¹⁹⁵

6.10 Recommendations

1. Since its 14th report in 2011, GNEB has asked the federal government to encourage the adoption of cost-effective conservation and energy efficiency technologies that benefit low-income families in the border region currently paying high prices for energy. For example, EPA can encourage U.S. border states utilizing the Clean Energy Incentive Program as part of the CPP to support renewable energy projects and energy efficiency in low-income communities. HHS can use its Low-Income Home Energy Assistance Program to target tribal and other poor communities in the border area, especially considering the increased number of extreme heat events and the growing need for air conditioning for vulnerable populations. In the border region of San Diego-Tijuana, cooperative efforts are underway between HUD and Mexico's Secretaría de Desarrollo Agrario, Territorial y Urbano (Secretariat of Agrarian, Territorial and Urban Development) to mitigate and adapt to climate change through regional planning and green building.
2. Federal agencies should take the lead in assisting border communities in the development of climate action plans. Federal agencies, EPA and NADB-BECC should organize information-sharing technical workshops on climate action plans with U.S. and Mexican sister cities.
3. The Federal Housing Finance Authority should finalize its guidelines and rules on the participation of homes with federally backed mortgages to participate in PACE programs. Finalizing this guidance and rulemaking would help local communities decide to what extent residential PACE programs can be implemented in border communities.
4. EPA should finalize the details of the Clean Energy Incentive Program, and then, if and when the CPP Rule becomes effective, work with NADB-BECC, tribes, states and local communities in best practice design of programs that could take advantage of the incentives available under the program.
5. The DOE should continue to monitor the implementation of more efficient energy codes at the state and local levels and provide funding, technical assistance and guidance in compliance with these more advanced energy codes.
6. The DOE should increase outreach to border communities on climate change and clean and efficient energy technologies, best practices, costs and benefits, and how to determine the potential economic and job creation effects from implementing energy efficiency and photovoltaic solar, including utility-scale, rooftop and community solar. Photovoltaic power plants are the most technically and financially viable renewable energy solution for increasing the border region's climate resiliency. Energy efficiency and photovoltaic solar projects are proven to provide significant economic benefits, are developed in reasonably short timeframes, and displace CO₂ and water used by more traditional energy sources. In another example, EPA—in collaboration with NADB-BECC and the DOE and through Border 2020—can undertake a regional assessment of opportunities to promote energy efficiency and distributed solar for small water and wastewater utilities along the border, including those of tribal governments.
7. In coordination with the National Weather Service, the Climate Prediction Center should use existing programs to develop methods to predict more accurately the location, length and severity of extreme weather events, including events with above-average nighttime heat. Existing DOE, HUD and EPA grants programs can be used to provide emergency shelters for extended periods of extreme temperatures in vulnerable communities and subsidize air-conditioning for vulnerable populations. ■



Chapter

7

Climate Change Impacts on Public Health in the Border Region

Climate change on the U.S.-Mexico border region is projected to contribute to, and make it more difficult to manage, rising levels of infectious and chronic disease; harmful, cumulative effects on humans and the environment caused by fire, flood, heat, pollution and health disparities; and complexity and risk posed by a globalized economy with increasing food-energy-water security problems. Changes in health issues related to climate change are driven by rising daytime and nighttime temperatures, increasing frequency and intensity of wildfires, changes in precipitation and storm intensity, changes in the distribution and numbers of infectious disease vectors, and other factors.

The U.S.-Mexico border region encompasses a large range of geographic landscapes and climate zones; large portions of it in each of the four U.S. border states (California, Arizona, New Mexico and Texas) are desert, however, with high temperatures in the spring and summer and a dry climate throughout the year. Many people find the year-round warm weather more attractive and head south either permanently or temporarily as seasonal “snow birds”; as temperatures continue to rise, however, the extreme heat can put people, especially older populations, at risk. As populations increase in these areas, so will air pollution as commerce also increases and cities expand to meet population needs, potentially leading to increased rates of respiratory and heat-related illnesses.^{196–198} Furthermore, increasing temperatures may have a more significant effect on other climate zones in the border region, including coastal areas, which are traditionally milder but experience higher humidity.

Scientists have recognized the strong impact of climate variability on infectious diseases in the southwestern United States.¹⁹⁹ Pertinent infectious diseases to the Southwest border region of the United States include dengue and valley fever. Zika (**Figure 13**) and chikungunya are emerging infectious diseases in the region. These likely will become more widespread from temperature increases and the spread of disease vectors, notably the *Aedes aegypti* mosquito that is now present throughout the border region.

Four dengue virus serotypes exist, and the *Aedes* mosquito serves as the vector for dengue, which results in high fevers, rash, nose/gum bleeds, severe headaches, and pain in the joints, muscles and bones.²⁰⁰ Any four of the serotypes can lead to dengue hemorrhagic fever, a potentially fatal clinical syndrome found when more than one serotype is present.

A fungus, *Coccidioides immitis*, found in the soil of the southwestern United States and parts of Mexico, is responsible for valley fever (coccidioidomycosis). Individuals exposed to these fungal spores may never develop any symptoms, but those who do can experience fatigue, cough, fever, and muscle and joint pain, among other symptoms.²⁰¹ Early diagnosis is essential to preventing medical complications and death for all of these diseases.

7.1 Border region infectious disease outbreaks

Dengue is typically imported to the United States by travelers visiting endemic countries. Dengue currently is prevalent

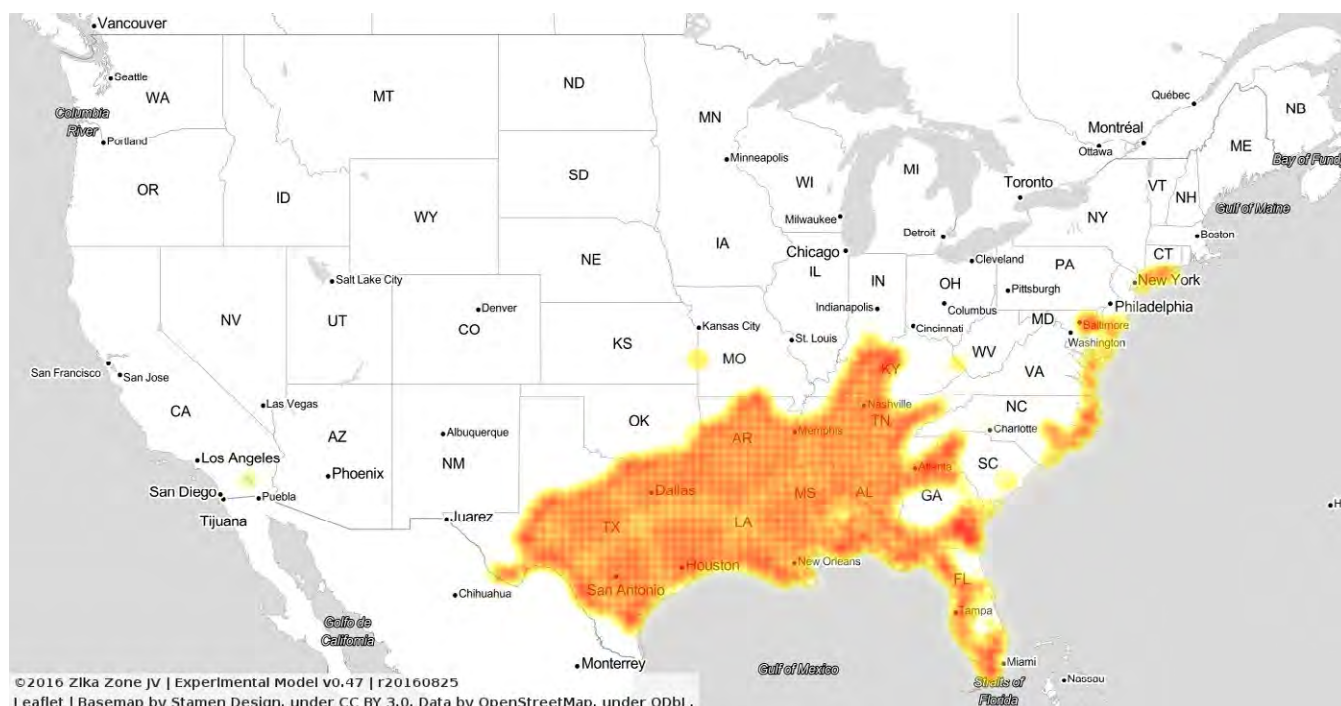


Figure 13. Weekly maps show where conditions are prime for the Zika-spreading mosquito to breed, bite and potentially infect humans with the Zika virus.

Source: zikazoneusa.com.

in northern Mexico, increasing potential exposure among U.S. border region residents. In 2005, the sister border cities of Brownsville (Texas) and Matamoros (Tamaulipas) experienced a dengue virus type 2 epidemic that caused several cases of the deadly dengue hemorrhagic fever.²⁰² A study assessed the roles of temperature, precipitation and El Niño Southern Oscillation and found that for every 1°C/1.8°F increase in sea surface temperature, a 19.4 percent increase in dengue incidence followed.²⁰³ An abundant winter population of *Aedes* mosquitoes and mosquito-infested water containers (e.g., discarded waste tires, buckets) contributed to the outbreak in both cities. Incidence was higher in Matamoros, where household infrastructure that limits dengue transmission was less available (e.g., lack of air conditioners, small residential lot size). It is not clear whether the epidemic in Brownsville largely resulted from cross-border traffic or whether dengue now is endemic in this U.S. border city.²⁰² Increased incidence and distribution of this vector-borne disease, however, may occur along the U.S. border region because of high rates of cross-border travel and low levels of economic resources (e.g., inability to afford air conditioning or insect repellants).²⁰⁴ Some researchers maintain that dengue is underreported on both sides of the border, and a study suggests that dengue fever is endemic in the Brownsville-Matamoros border region, with past infection detected in 40 percent of Brownsville residents and 78 percent of Matamoros residents.²⁰⁵

A more recent cross-border dengue outbreak was reported for Yuma County (Arizona) and San Luis Río Colorado

(Sonora) during the fall season of 2014.²⁰⁶ As shown in **Table 8**, 122 cases of laboratory-confirmed dengue were reported in this border region: 52 in San Luis Río Colorado and 70 in Yuma County. Most (86%) of the diagnosed individuals in Yuma County reported travel to Mexico within the 2 weeks preceding their illness onset. Jones et al., however, caution that high travel frequency to Mexico increases the probability that infections will be automatically misclassified as travel-associated, obscuring actual rates of infection occurring within Yuma County.

The study by Jones et al. included household-based cluster investigations near (within a 50-meter/164-foot radius) the residences of laboratory-confirmed dengue cases in Yuma

Table 8. Demographic, Health, and Behavioral Characteristics of Laboratory-Confirmed Dengue Cases in Yuma County, Arizona, and San Luis Río Colorado, Sonora (October–December 2014)

Characteristic	San Luis Río Colorado (n = 52)	Yuma County (n = 70)
	No. (%)	No. (%)
Female	32 (62)	42 (60)
Hospitalized	11 (21)	37 (53)
Dengue hemorrhagic fever	3 (6)	0 (0)
Travel to Mexico <14 days before illness onset	n/a	60 (86)

Source: Jones et al. 2016²⁰⁶

County. The study revealed that nearly 80 percent reported travel to Mexico at least once in the prior month, and very few (16%) reported using mosquito repellent.²⁰⁶ The entomologic assessments confirmed a significant proportion of *A. aegypti*. This mosquito carrier was found to be colonized water containers (24 per 100 houses; Breteau index),²⁰⁷ indicating increased risk for dengue virus transmission. Buckets and other plastic water containers were the most common types of infested containers.

Coccidioides, the fungus that causes valley fever, is endemic along the U.S.-Mexico border region²⁰⁸ (Figure 14). The incidence of valley fever has risen dramatically in the past two decades and infections are appearing more frequently outside of the endemic zones.²⁰⁹ This fungus grows best in soil following heavy rainfall and disperses in the air during hot, dry conditions. Seasonal peaks of valley fever infections in Arizona have been associated with climatic changes, with hot, dry conditions demonstrating the strongest association with incidence.²¹⁰ A strong correlation also was identified between variations in seasonal precipitation and incidence of coccidioidomycosis reported in Arizona.²¹¹ A separate study found that men, persons older than 65 years, immunosuppressed individuals, Hispanics, Native Americans, and residents of California or Arizona were at greatest risk of coccidioidomycosis-associated deaths.²¹²

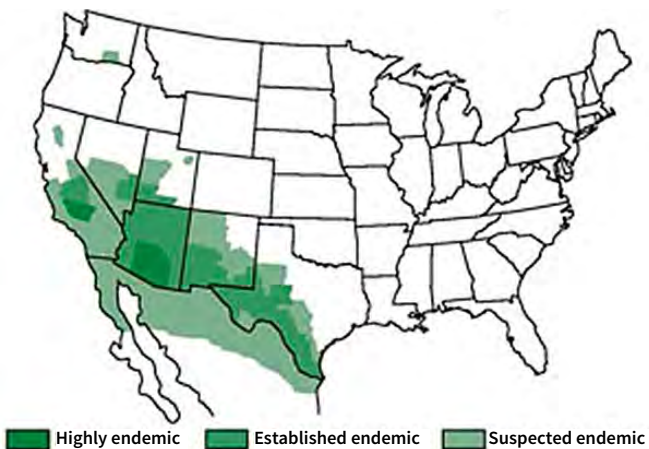


Figure 14. Areas endemic for *Coccidioides*.

Source: Centers for Disease Control and Prevention, cdc.gov/fungal/diseases/coccidioidomycosis/causes.html.

7.2 Emerging infectious diseases

Emerging infectious diseases that pose a risk along the U.S.-Mexico border region include the Zika and chikungunya viruses. Climate change and rising temperatures contribute to a greater presence of the primary vector for these diseases, *A. aegypti*, in the U.S. border region from Brownsville to San Diego.²¹³ Border community risk for new and well-established infectious diseases is compounded by high levels of poverty and related poor quality housing and lack of air conditioning. Adjacency to densely populated urban areas

across the international boundary in nearby Mexico and high volumes of cross-border travel are additional considerations in the spread of infectious diseases.²¹⁴

Zika virus is transmitted via *A. aegypti* mosquito bites, directly from mother to fetus during pregnancy and at birth, through blood transfusion, and through sexual contact with an infected man.²¹⁵ Most individuals infected with Zika will exhibit mild or no symptoms and therefore may never realize they were infected.²¹⁶ Clinical illness occurs in approximately 20 percent of infected people, with common symptoms that include fever, rash, muscle and joint pain, conjunctivitis, and headache. The most significant risk posed by Zika virus is its ability to lead to microcephaly and other severe fetal brain defects, making its transmission of particular concern during pregnancy.

Zika virus was first introduced in the Americas to Brazil in 2015 and now is pandemic in some areas of Latin America. Cases have been reported in most Central and South American countries as well as the United States. Mexico is a designated country with active Zika virus transmission reported.²¹⁷ Bidirectional cross-border traffic makes the U.S.-Mexico border region a high-risk region for travel-associated infections, particularly if increased cases of Zika infections are identified in northern Mexico.

As of September 9, 2016, 50 cases of Zika virus infections were identified in the border counties (Table 9). The fact that there have been no locally acquired vector-borne cases reported in the U.S. border states²¹⁸ may be the result of a bias in algorithms used to test for Zika, which are largely targeting those individuals who have traveled abroad to infected areas.^{219,220} As indicated above by Jones et al. (2016) in discussing dengue, caution should be taken against misclassifying travel-related cases in a population with a high frequency of cross-border travel. Because some areas of the border are highly suitable year-round for the *A. aegypti*

Table 9. Zika Infection in U.S. Border Counties (September 9, 2016)

County	State	Zika Cases	
		Travel Acquired (n = 50)	Locally Acquired (n = 0)
San Diego ^a	CA	36	0
Pima ^b	AZ	5	0
Yuma ^b	AZ	1	0
Cochise ^b	AZ	3	0
Dona Ana ^c	NM	1	0
El Paso ^d	TX	3	0
Val Verde ^d	TX	1	0

Sources: ^aCalifornia Department of Public Health, 2016.²²¹

^bArizona Department of Health Services, 2016.²²²

^cNew Mexico Department of Public Health, 2016.²²³

^dTexas Department of State Health Services, 2016.²²⁴

7 mosquito, and it is present throughout the border region, it is likely that locally acquired vector-borne cases will become common in the border region. High poverty rates in many communities in this region also increase susceptibility of human exposure to *A. aegypti* and its viral transmission.

The chikungunya virus was discovered in the Americas in 2013. As with the Zika and dengue viruses, the *A. aegypti* mosquito is the primary vector in the transmission of the chikungunya virus. Unlike Zika, however, chikungunya is rarely transmitted from mother to a newborn. Although infection with chikungunya rarely results in death, it can lead to severe and disabling symptoms.²²⁵ For example, one of its most common symptoms, joint swelling and pain, may persist for months following infection. It also is important to note that, unlike with Zika, most people infected with chikungunya develop symptoms, which occur within 3 to 7 days of initial infection.

In 2015, 896 cases of new chikungunya-related illness were reported in the United States; all except one case were attributed to travelers returning from affected areas.²²⁶ Among the border states, a significant number of travel-associated cases have occurred in California (276 cases), Texas (54 cases) and Arizona (24 cases), accounting for 40 percent of all laboratory-confirmed U.S. cases of chikungunya-related illness in 2015 (Figure 15).²²⁷ As of September 6, 2016, all four border states had reported cases of new chikungunya-related illness.²²⁸

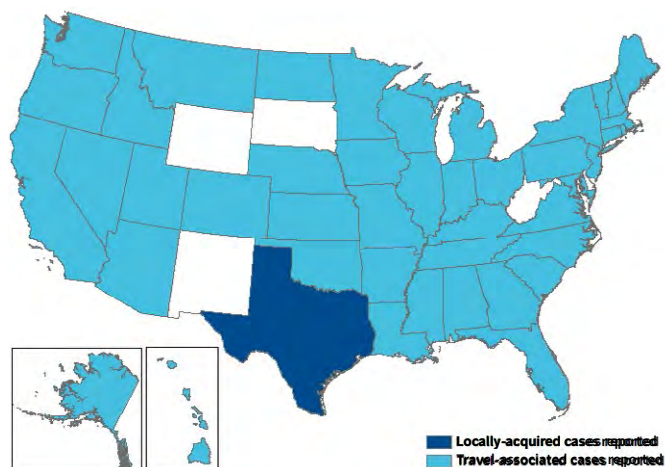


Figure 15. States reporting chikungunya virus disease cases in the United States in 2015.

Source: Centers for Disease Control and Prevention, cdc.gov/chikungunya/geo/united-states-2015.html.

7.3 Heat waves, public health and climate change

Globally, there is a relationship between climate change and the frequency, intensity and duration of extreme heat events.²²⁹ Extreme heat is defined as temperatures that are significantly higher than the average temperature in a specific place during a specific period of time.²³⁰ An extreme heat

event is described as having stationary masses of warm air with successive nights of high minimum temperatures. In the United States, higher temperatures along with urbanization and an aging population will lead to a “significant public health problem.”²²⁹

The Southwest border is the hottest and driest region in the United States, with climate change contributing to increased temperatures throughout the 20th century and projected temperatures for the 21st century, as discussed in Chapter 1 of this report. Already, this region experiences a large portion of the year with days above 95°F/35°C (Figure 16). The increasing temperatures related to climate change have clear effects on human health in the border region. Exposure to high heat can affect the body’s ability to regulate temperature, and this results in physiologic strain, which can lead to death.²³¹ Extended exposure to high heat can lead to multiple health issues, including heat exhaustion, heat stroke, heat syncope and death.²²⁹ Warmer temperatures will result in higher incidences of dehydration and renal diseases, as well as asthma, hay fever and other allergy-related diseases brought on by climate change impacts on pollen seasons.¹⁹⁸ Heat stress is a leading cause of death in the Southwest, and as heat waves increase in number, length and intensity, heat-related death rates will increase.¹⁵⁷

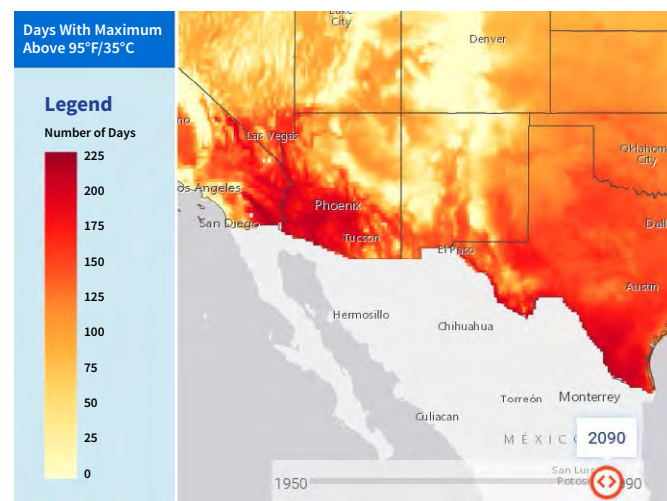


Figure 16. The total number of days per year with maximum temperature above 95°F (35°C) in the last decade of the 21st century.

Source: National Aeronautics and Space Administration Earth Exchange Downscaled Climate Projections at 30 arc-seconds (NEX DCP30) showing number of days per year whose temperature would exceed 90°F in the 2090s under RCP 8.5. Taken from Climate Explorer: toolkit.climate.gov/climate-explorer2/variables.php?id=days_tmax_abv_35.0&zoom=6¢er=-122.29924,52.56282&2C3916021.83310615&year=2090.

Those at highest risk for heat stress include vulnerable residents such as Hispanics and Native Americans, children, people living in rural areas, low-income residents, older adults, people without air conditioning in their homes, and people with pre-existing health conditions (e.g., cardiovascular disease, diabetes, hypertension, obesity).²³¹ Approximately

25 percent of residents living on the U.S. side of the border are living at or below the poverty level, whereas 28 percent of residents in the Mexican border states are living in poverty.²³² People with asthma and other respiratory illnesses also are vulnerable because high temperatures contribute to poor air quality, including the formation of ground-level ozone.¹⁵⁷ Finally, people suffering from mental illness exhibit triple the risk of death during heat waves.⁵²

Disruptions to urban and rural electricity and water supplies may further aggravate health problems in the Southwest. For example, increased energy use for cooling during heat waves may place additional strain on the electric grid ultimately resulting in brownouts or power outages.⁶ Greater water demand in growing cities along the border and reduced water availability also could affect access to drinking water. Shallow wells in rural border regions are drying up and reducing drinking water supplies available to rural border residents, including Native Americans and Hispanics.

7.4 Respiratory problems

Increasing historic temperatures in the border region as well as projected increases for the 21st century will exacerbate the health effects of air pollution. In many cities along the U.S.-Mexico border, air pollution is a growing concern. As discussed in previous chapters, a critical challenge to air quality along the border includes international ports of entry and associated traffic emissions from idling vehicles. A positive association has been found between high temperatures (32°C/90°F) and ground-level ozone production, and increasing evidence suggests that ozone and high temperature affect mortality synergistically. Heat wave mortality is greatest on days with high PM₁₀.²²⁹ Because ozone formation is temperature dependent, surface ozone concentration is projected to increase with a warmer climate. Ozone damages lung tissue, causing particular problems for people with asthma and other lung diseases. Even modest exposure to ozone may encourage the development of asthma in children.

Combustion of fossil fuel for energy production and transportation and biomass fuel for energy production and trash burning also affects the health of individuals. Household burning of solid fuel such as wood exposes border residents, increasing their mortality and morbidity from respiratory and cardiovascular diseases. Dust also is a consequence of climate change and drought, leading to inhalation of pollutants attached to dust.

In some regions, changes in temperature and precipitation are projected to increase the frequency and severity of fire events. Large wildfires release large amounts of PM_{2.5} and concentrations can reach levels as high as 10 to 20 times the NAAQS in adjacent populated areas. Wildfires also release large amounts of VOCs and semi-VOCs, which contribute to the formation of secondary organic aerosols. Elevated

concentrations of PM_{2.5} and secondary organic aerosols caused by wildfires are usually accompanied by an increase in the number of people with respiratory problems, such as asthma and chronic obstructive pulmonary diseases, who seek treatment at a hospital.²³³

7.5 Food and waterborne disease

Climate change is likely to worsen surface and ground water scarcity and quality both regionally and globally.²³⁴ Contamination of reduced water sources through untreated sewage discharges or hazardous materials releases will only exacerbate existing water quality problems. Poor water quality for domestic and agricultural uses can increase infectious diseases, including gastrointestinal diseases. Climate change, particularly events of extreme precipitation, has been associated with increases in the incidence of food- and waterborne diseases as well.²⁰⁴ Human exposure to waterborne pathogens may occur via ingestion, inhalation and dermal absorption of microbial organisms. Water quality, sanitation and hygiene also play significant roles in human exposure. Gastrointestinal illness is particularly dangerous to vulnerable populations and can cause chronic conditions or fatalities in the elderly, infants, pregnant women, immune-compromised individuals and people with other chronic illnesses such as diabetes.²³⁵ Waterborne diseases, especially gastrointestinal diseases, are a leading cause of infant death in Mexico and an ongoing problem in rural and poor urban areas of the U.S. border. Gastroenteritis originates from viral, bacterial and protozoan agents, whereas other pathogens, such as *Escherichia coli* and *Salmonella*, are important causes of food-borne illnesses.²⁰⁴ Cholera poses the greatest climate change threat among waterborne diseases. Such increased risk is associated with warming water temperatures.²⁰⁴

7.6 Climate change and mental health

Although the effects of climate change on physical health are well documented in the medical literature, research on climate change as a determinant of mental health outcomes is limited. Climate change may affect mental health directly, as found in conditions of extreme heat or natural disasters leading to acute stress or post-traumatic stress disorder. It also may affect mental health indirectly, such as through displacement from one's home and socioeconomic effects leading to extended stress, depression and suicide.²³⁶

7.7 Climate change impact on chronic diseases

Climate change in the border likely will exacerbate infectious disease, as detailed in previous sections of this report. The impact of climate change in the border region on chronic disease, however, may be more difficult to discern. Nonetheless, it is likely that increasing temperatures affect the obesity, diabetes and nonalcoholic fatty liver disease epidemics that particularly afflict Hispanic Americans and

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Native Americans, as well as Mexican populations across the border.^{237–241} With their genetic predisposition, their susceptibility is compounded by the harsh reality that many Hispanic and Native Americans live in poor areas, including sites along the U.S.-Mexico border, with high rates of obesity, poverty, poor nutrition, health disparities and exposure to toxicants—all of which constitute cumulative effects that increase the risk of getting cancer.

How does climate change factor into high toxicant-associated steatohepatitis rates along the border region? In the Southern California-Northern Baja California border region, places like Imperial County's poverty-stricken rural and urban areas—already among the disadvantaged communities hardest hit by climate change (resulting from such factors as heat, dust and economic challenges associated with water scarcity and food insecurity)—are known to experience significant environmental exposures, especially pesticides in farm-working communities. These rural communities likely are at a higher risk of toxicant-associated steatohepatitis because of their higher exposure to environmental toxicants, higher rates of obesity, unhealthy diets, health disparities and genetic susceptibility. The same can be said of rural communities in Mexico.

Rising temperatures and persistent, as well as more frequent, heat waves have been correlated to asthma, diabetes, acute renal failure and cardiovascular diseases. Temperature inversions, occurring in the vicinity of warm fronts and often seen during winter months, also can trap pollutants close to the ground, creating and triggering adverse health effects, especially for young children and adults already prone to such diseases. In addition, extreme heat, severe weather and air pollution can have direct and indirect effects on chronic diseases, therefore making it critical to understand how climate change can affect public health.⁵² All of these concerns are important in the border region, and addressing the impacts to vulnerable populations remains a challenge for federal, state and local authorities. The underlying stressors—low-education and low-income levels—decrease residents' ability to prepare as needed (i.e., purchase fans or air conditioning units).

7.8 Increased frequency and severity of storms

Increased intensity of storm events related to climate change in the border region will have implications for public health in addition to physical infrastructure and property implications. Flood deaths are a problem as a result of flash floods on the western part of the border, whereas the Lower Rio Grande region experiences damaging inundations from tropical storms. Damage to the electric grid, water treatment and wastewater treatment facilities affects the resiliency of communities to respond to storm impacts. Flooding brings increased risk of waterborne disease, dehydration from decreased access to potable water, and exposure to mosquitoes and other vectors.²⁴²

7.9 Food security, soil and food waste

Food security, loss of productive soils, and food waste are emerging global and national issues related to climate change that are of growing concern in the border region.^{243,244} President Obama signed into law the 2016 Global Food Security Act (S. 1252), which requires the development and implementation of a Global Food Security Strategy to promote global food security, resilience and nutrition. In the case of the U.S.-Mexico border region, as already noted in Chapter 1 of this report, scientists project that droughts, heightened intensity of storm events, and heat waves are likely to worsen negative effects on food security, ecosystems and health. For example, dry conditions coupled with overgrazing in the border region can lead to increased erosion, the spread of invasive plants, and reduced productivity of crops such as fruit trees.

The United Nations designated 2015 as the International Year of Soils. In response, the White House Office of Science and Technology Policy issued a national Call to Action in August 2016 to protect America's soil: "Climate change is expected to increase pressure on soil as the frequency of extreme weather events increases, bringing forceful rain and flooding, which can strip away soil. Without coordinated action, the United States is on track to run out of topsoil—the medium upon which crop production depends—before the end of the 21st century."²⁴⁵ The loss of vegetative cover (biomass) and top soil is an acute problem for parts of the U.S.-Mexico border region. For instance, in the San Diego-Tijuana binational metropolis, rapid urbanization along Tijuana's steep canyons lacking adequate infrastructure has led to serious erosion with negative effects on wetlands and waterways.²⁴⁶

A recent University of California report also recommends interventions focused on soil and biomass, in a way that advocates for food waste reduction and recovery. One recommendation of the report is to implement "food waste reduction programs and energy recovery systems to maximize utilization of food produced and recover energy from food that is not consumed."²⁴⁷ The Food and Agriculture Organization of the United Nations estimates that as much as one-third of all food produced for human consumption is lost or wasted as a result of supply chain inefficiencies (e.g., failure to harvest crops in time, damage to the food during processing or transport) and food waste (e.g., edible items discarded for a variety of reasons, such as imperfections in appearance, spoilage and too-large portions).^{248,249}

The CO₂ emitted in producing and distributing this food accounts for 10 percent of the global CO₂ emissions. The magnitude of this problem suggests that much can be gained from establishing food waste reduction and recovery systems that maximize utilization of food resources while significantly reducing emissions of CO₂ and methane. Most

food waste ends up in landfills, where it off-gases methane as it decomposes, making it one of the waste sector's largest sources of GHG emissions.^{250,251} The Food and Agriculture Organization's report argues that food waste reduction has multiple benefits. It can mitigate climate change, reduce pressure on scarce natural resources, and make it easier to meet the rapidly rising demand for food. Between 2013 and 2050, the Food and Agriculture Organization estimates that global food production may have to increase by 60 percent to meet worldwide demand.

7.10 Recommendations

1. The Centers for Disease Control and Prevention (CDC) should modify current Zika testing algorithms that are biased toward detection of travel-related infection rates. The current testing approach is inappropriate and ineffective in distinguishing between travel and locally acquired Zika cases along the U.S.-Mexico border, particularly because of the high cross-border traffic and shared ecological environment.
2. Public health campaigns to increase awareness and education of infectious diseases pertinent to the U.S.-Mexico border region are essential to prevention, especially concerning vulnerable populations at increased risk from climate change and other factors for development of these diseases. Prevention education should focus on the importance of emptying/disposing of water containers that can serve as mosquito breeding sites and sealing water containers that cannot be emptied. In addition, the public can be educated in the prevention of mosquito bites through the application of mosquito repellents, use of protective clothing, installation of window screens, and use of air conditioning when indoors. U.S. agencies should coordinate these efforts with Mexican authorities to reduce risk regionally in the binational border region.
3. Greater surveillance of vectors and analysis of the mediating mechanisms/processes between climate change (e.g., increases in precipitation and temperature) and disease outbreak is needed. Surveillance of disease vectors should be systematic and well-distributed along and across the U.S.-Mexico border, particularly cities with high cross-border traffic, to accurately determine prevalence of infected vectors/hosts, prevent and manage outbreaks, and tailor warning messages to border communities at risk for infection. Understanding how climate-related variations in vector habitats and human behavior (e.g., water storage and irrigation, pollution, migration, travel) contribute to disease outbreaks in the border region also is important.
4. The U.S.-Mexico border region is a contiguous landscape where vector and zoonotic pathogens thrive and circulate across political borders. To mitigate the health burden of these infectious diseases effectively, surveillance systems must follow a shared border region perspective and a "One Health" approach. Sharing of surveillance strategies and data can help to facilitate timely detection of cross-border outbreaks.
5. NOAA should deploy an early heat warning system for the binational Paso del Norte region to assist early responders and community members to better prepare for extreme heat events that are increasing in intensity and frequency with climate change. The system should be deployed in cooperation with Mexican authorities. Once piloted, the system should be extended to the rest of the binational border region.
6. Federal agencies should guide and support local governments in identifying tree planting areas, installing irrigation, purchasing and planting native shade-providing trees, installing three-tier water fountains, and providing benches and other shade structures.
7. Federal agencies should increase training and continuing education for primary care providers and mental health professionals, highlighting the relation of climate change to mental health, particularly targeting those providers working with underserved populations. Agencies should incorporate mental health training among emergency and disaster response teams.
8. EPA should improve air quality monitoring and warning systems along the border, moving beyond region-wide air values to specifically monitoring areas with vulnerable populations and hot spots such as ports of entry. EPA also should increase efforts to promote air quality awareness and education to vulnerable populations along the U.S.-Mexico border in their preferred language.
9. The CDC, in cooperation with state and local authorities and Mexican agencies, can use existing public health infrastructure programs to strengthen transboundary disease surveillance, educate the public regarding prevention and transboundary vector prevention and control efforts, control insect vectors and animal reservoirs of disease, and respond rapidly to border public health outbreaks.²⁰⁴ The CDC should coordinate public education campaigns that emphasize protective behaviors to reduce risk to vector-borne diseases and promote access to cooling centers, particularly for the elderly, infirm and economically disadvantaged people. ■



Chapter

8

Recommendations

8.1 Summary of recommendations

The U.S.-Mexico border region is projected to experience challenging economic and social impacts resulting from climate risks across a spectrum—from water and energy to health and transportation. This report outlines specific recommendations for positive actions that federal government agencies should implement in this fiscal year to build climate resilience in the border region. Executive actions on the following can be implemented during the current fiscal year:

1. Convene stakeholders from both sides of the border to share information on responses to threats to water supplies.
2. Enhance stormwater harvesting, ground water recharge and ecological water flows to respond to both flood and drought risks.
3. Facilitate flood mitigation and watershed management efforts, especially systems with cross-border causes and effects.
4. Promote efforts to advance integrated wastewater resource management, innovative technologies, and green infrastructure along the border with the goal of providing clean, reliable and affordable water, wastewater and stormwater services.
5. Promote and incentivize green infrastructure and prioritize its financing for both domestic and binational projects.
6. Promote the understanding of ecosystem services and co-benefits of nature-based and carbon mitigation options in water infrastructure projects (e.g., green infrastructure) and coastal adaptation measures (e.g., living shorelines).
7. Coordinate efforts across and along the border to prepare for new vectors and vector-borne diseases, as well as other potential health effects related to temperature increases and other climate risks.
8. Using existing executive orders, and reflecting community concerns, continue to support, plan and design for the reduction of wait times at the border crossings from Mexico into U.S. border communities—initially through management efforts and full staffing and in the longer term through physical infrastructure improvements.
9. Target border urban and rural communities to enhance and increase support for their energy efficiency and security in the face of growing energy demand risks.



10. Provide federal leadership to enhance the ability of border communities to respond to emergencies such as heat waves, flooding, coastal inundation and wildfires, especially when U.S. and Mexican border communities are affected. An important first step is to modernize and make relevant to border realities the 1980 U.S.-Mexico Agreement on Cooperation During Natural Disasters.

8.2 Complete report recommendations by chapter

The recommendations from the different chapters of this report are listed below. Collectively, they address what federal agencies can do better with existing resources and programs to address climate change impacts and enhance the resilience of border communities. A number of themes run through these recommendations.

The first theme is that many federal programs within numerous agencies can assist border communities, large and small, urban and rural, in addressing climate change impacts. Many smaller and poorer communities, however, lack the administrative support and technical expertise to effectively access these programs. The Board recommends that agencies increase outreach to the diverse border programs. In addition, GNEB suggests that NADB-BECC organize information regarding federal programs for border communities. NADB-BECC has a presence along the border, has worked in most border communities, and has experience in Mexico's communities.

Another important theme of the report and recommendations is that many groups in the border region are disadvantaged and characterized by low income. Many of these are primarily Hispanic and live in *colonias* with substandard infrastructure and public services. Others are tribal peoples in rural areas that depend on natural resources affected by climate change. All of these groups are disproportionately affected by climate change and need special attention by federal programs.

A third important theme is that federal agencies that address climate impacts in the border region should make a concerted effort to coordinate with counterpart agencies in Mexico. GNEB firmly believes that climate change-related issues that have origins and effects on both sides of the international boundary require solutions that also span the border.

Chapter 2. Vulnerable Populations and Environmental Justice and Climate Change

1. Vulnerable and disadvantaged border communities will be disproportionately affected by climate change impacts. These groups also often lack the expertise

to access available federal programs that assist border communities to develop resiliency to these impacts. An immediate priority should be to coordinate federal agencies to proactively perform outreach to disadvantaged border communities to assist in addressing the effects of climate change.

2. The NADB-BECC, through consultations with border tribes and coordination with U.S. federal and state programs, should develop a specific program to facilitate the development of renewable energy by border tribes.
3. Every federal agency with an emergency preparedness mission should use its existing programs to support vulnerable and disadvantaged communities in establishing infrastructure and building capacity for fire suppression, emergency management implementation, and hazard mitigation for natural disaster events. For example, federal agencies should facilitate wildland fire management specific to rural disadvantaged tribal and other vulnerable communities.
4. EPA should continue to support the La Paz Agreement and Border 2020 initiatives to enhance emergency response coordination with its federal, state and local partners, with special attention to tribal communities and underserved populations. As GNEB recommended in its 11th report, *Natural Disasters and the Environment Along the U.S.-Mexico Border*, emergency response must be more closely coordinated across the border with Mexico. Most importantly, the 1980 U.S.-Mexico Agreement on Cooperation During Natural Disasters needs to be updated to enable the immediate and targeted responses required when a natural disaster affects the shared geographical region on both sides of the border.

Chapter 3. Existing Federal Programs and Resources

1. A wealth of federal agency programs exists to help border communities respond to the challenges of climate change. Navigating the complex federal structure to connect with specific programs, however, often is a complicated and difficult task. Larger border communities, with well-trained and numerous staff, generally interface well with federal agencies. Smaller urban and rural communities, however—especially disadvantaged communities—often lack the human resources to initiate contact with appropriate federal programs. Consequently, it is recommended that federal agencies facilitate the flow of information on climate change programs for the border region to border

communities of all types. The NADB-BECC would be an appropriate agency to organize this information as part of its regular outreach to border communities. NADB-BECC has a history of cooperation with many different federal agencies, and BECC would be able to effectively facilitate this information sharing across the international border to communities and agencies at all levels because it is a binational organization with headquarters in Mexico.

2. EPA should begin working with the State Department and other federal and state partners and nongovernmental organizations to directly engage with Mexico to reduce CO₂ emissions from the Carbon I and II electrical generating units near Nava, Coahuila, 20 miles south of Eagle Pass, Texas. These two coal-fired power plants generate 1.2 and 1.4 gigawatts of energy, respectively, and Carbon I emitted 7.5 million tons (6.8 million metric tonnes) of CO₂ in 2005 alone.
3. A range of local communities along the border recognize the direct economic, social, human health and environmental effects caused by climate change. This leads to more local conversations on initiatives that can be implemented or recommended to mitigate climate change impacts. This bottom-up approach is a key to Border 2020's success. Federal agencies, particularly EPA, should continue to support Border 2020, which helps build on the expertise within communities to identify priorities and implement projects. Supporting these local initiatives is an infrastructure of regional and border-wide workgroups further targeting resources based on priorities identified by the United States and Mexico.
4. Agencies should increase the frequency and depth of binational coordination. For example, as a result of the GNEB meetings in February 2016, the sister cities of Brownsville (Texas) and Matamoros (Tamaulipas) participated jointly in the World Urban Campaign: Urban Lab in September 2016. The Urban Lab dialogues are being led by ONU-Habitat Mexico and Urban Campus by the Colegio Nacional de Jurisprudencia Urbanística. Leading up to this important meeting, the cities of Brownsville and Matamoros participated in co-working meetings to plan and decipher topics of valuable concern. Through careful facilitation from federal officials and presentation of background materials, the two cities agreed on two topic areas: (1) transportation and mobility and (2) flood mitigation and resiliency. Both cities highlighted current local ordinances, areas of federal support, and future initiatives. The mayors and staff from both cities officially participated in the meetings.

5. The Border Liaison Mechanism is an agreement of the U.S.-Mexico Binational Commission to empower the consuls general of border cities to convene public and other stakeholders from both sides of the border to address common interests of regional concern. The Border Liaison Mechanism has become less active in recent years as a result of the economic downturn and border violence. This mechanism now needs to be re-energized with appropriate levels of resources to facilitate cross-border cooperation at the local level on climate change-related issues and other shared concerns in the diverse regions of the border.

Chapter 4. Water-Related Issues and Climate Change

1. Stormwater engineers and floodplain managers along the U.S.-Mexico border should utilize real-time data from streamflow-gauging stations when new development is being considered in an area. This will enable development guidelines consistent with climate change impacts. At the same time, streamflow data from portions of shared watersheds in Mexico also should be incorporated into new flood maps. Agencies should consider how future—or modifications to existing—infrastructure investments in floodplains will be informed by the new Federal Flood Risk Management Standard. The new flood standard describes various approaches for determining the higher vertical flood elevation and corresponding horizontal floodplain for federally funded projects and establishes the level to which a structure or facility must be resilient. This may include using structural or nonstructural methods to reduce or prevent damage; elevating a structure; or, where appropriate, designing it to adapt to, withstand and rapidly recover from a flood event. In addition, agencies should consider the use of natural systems, ecosystem processes and nature-based approaches in the development of alternatives for actions.
2. U.S. and Mexico officials should work with federal agencies; the Colorado River Basin states of Arizona, California, Colorado, New Mexico, Nevada, Utah and Wyoming; and local stakeholders to reach an agreement to succeed Minute 319, once it sunsets at the end of 2017, that would continue binational cooperation under the 1944 Water Treaty. The agreement should continue to address the effects of climate change on water supplies, as well as how the two countries can participate in water conservation efforts and drought planning.
3. The combination of increased temperatures, reduced precipitation and ongoing drought associated with



climate risks threaten surface and subsurface water supplies for residential, commercial, agricultural and ecosystem maintenance purposes. Many of the resultant risks are transborder in nature and can be most effectively addressed through bilateral cooperation in the border region. U.S. and Mexico federal agencies should enhance their work together, in concert with public and private stakeholders from both countries, for effective management of the binational Rio Grande River and Colorado River systems and support of state aquifer management programs.

4. Federal or binational agencies with responsibility for addressing water problems and needs along the border (including EPA, USGS, NADB-BECC and the U.S. Section of the IBWC) should build on existing programs, such as EPA's Border 2020 Program and the IBWC's Minutes 319 and 320, to engage with Mexico and its agencies to address climate change related to shared water problems.
5. Federal water agencies and the binational NADB-BECC should enhance their existing efforts to compile and share information on local and state water conservation programs on both sides of the border to promote community resilience in the face of climate change impacts. They should convene a bilateral conference to learn what actions U.S.-Mexico border communities are taking to conserve water, share successful practices, and engage the private sector in the discussion and implementation of best practices. The agencies ought to use existing program funds to encourage state and local government agency staff, staff from environmental utilities, appropriate private sector stakeholders, and Mexican counterparts to meet and discuss practical ways to prevent water pollution of transboundary surface water and ground water resources as well as watershed management approaches to enhance border water quality. In shared water bodies where such discussion has been occurring (e.g., through the Transboundary Aquifer Assessment Program), implementation of solutions to identified problems should commence.
6. Federal agencies (including EPA, IBWC, USGS, USDA, the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers) should implement or support ground water recharge for vulnerable and/or disadvantaged communities through existing water programs. Ground water recharge efforts provide a mechanism to create stable ground water storage areas, which in turn allow surface water to flow to storage areas with reduced losses. Federal agencies should implement and/or support stormwater

runoff programs to utilize recycled water for surface water-dependent municipalities and facilitate funding through existing programs to establish and/or enlarge surface water storage impoundments and/or reservoirs, where appropriate and cost effective. Federal agencies should enhance their engagement with local officials and planners to develop or support community design solutions that prevent water contamination, such as infrastructure for wastewater capture and treatment. To protect tribal resources and meet the federal government's trust responsibilities to tribes, the DOI and its Bureau of Indian Affairs should operate U.S. government programs to protect treaty and other tribal rights as the climate changes.

7. The USDA's NRCS could allocate funds under PL-566, the Small Watershed Program, to rehabilitate aging stormwater infrastructure and complete watershed plans in the U.S.-Mexico border region to prevent and mitigate flooding. The U.S. government could provide financial assistance for water conservation projects that target shared resources (e.g., the Colorado River, ground water) in such areas as California-Baja California, where people and ecosystems are already experiencing negative climate-related impacts.

Chapter 5. Transit, Trade and Air Pollution: Climate Risks and Promoting Environmental Resiliency

1. The U.S. Department of Transportation and CBP should reduce GHG releases and air pollution at border crossings with Mexico by decreasing border wait times, create amenities for pedestrians waiting in line, improve border crossing traffic-flow designs, and identify innovative technologies to better predict and reduce border wait times. Some design options, in which the General Services Administration will play a role, include creation of buffer zones between roadways and communities, re-routing trucks through commercial areas and away from residential zones, and encouraging clean diesel programs for commercial vehicles. Of course, many of these solutions require coordination of all levels of U.S. government, as well as Mexican authorities.
2. An executive order should be implemented mandating that U.S. border authorities prioritize reallocating staff to inspection booths and positions at busy crossing times. Such a mandate could significantly reduce vehicular and pedestrian wait times, reducing ozone and air contaminant production and their resulting negative health effects on passengers, pedestrians, workers at the ports of entry, and residents of the

surrounding communities. This executive order also should address recruitment, training and retention issues for CBP employees. The economic benefits of shorter wait times for both commercial and non-commercial traffic at the ports of entry also would be significant.

3. The unified cargo inspection project being piloted in Nogales should be evaluated for its reduction in emissions from commercial vehicles, in addition to wait times, and modeled at other land ports of entry in the border region. The selection of one methodology for obtaining emissions reduction also should be included so that data evaluations are consistent.
4. Agencies should provide commensurate staffing levels whenever infrastructure improvements are made at land ports of entry in the border region.

Chapter 6. Energy, Greenhouse Gases and Climate Change

1. Since its 14th report in 2011, GNEB has asked the federal government to encourage the adoption of cost-effective conservation and energy efficiency technologies that benefit low-income families in the border region currently paying high prices for energy. For example, EPA can encourage U.S. border states utilizing the Clean Energy Incentive Program as part of the CPP to support renewable energy projects and energy efficiency in low-income communities. HHS can use its Low-Income Home Energy Assistance Program to target tribal and other poor communities in the border area, especially considering the increased number of extreme heat events and the growing need for air conditioning for vulnerable populations. In the border region of San Diego-Tijuana, cooperative efforts are underway between HUD and Mexico's Secretaría de Desarrollo Agrario, Territorial y Urbano (Secretariat of Agrarian, Territorial and Urban Development) to mitigate and adapt to climate change through regional planning and green building.
2. Federal agencies should take the lead in assisting border communities in the development of climate action plans. Federal agencies, EPA and NADB-BECC should organize information-sharing technical workshops on climate action plans with U.S. and Mexican sister cities.
3. The Federal Housing Finance Authority should finalize its guidelines and rules on the participation of homes with federally backed mortgages to participate in PACE programs. Finalizing this guidance and rulemaking would help local communities decide to what extent residential PACE programs can be implemented in border communities.
4. EPA should finalize the details of the Clean Energy Incentive Program, and then, if and when the CPP Rule becomes effective, work with NADB-BECC, tribes, states and local communities in best practice design of programs that could take advantage of the incentives available under the program.
5. The DOE should continue to monitor the implementation of more efficient energy codes at the state and local levels and provide funding, technical assistance and guidance in compliance with these more advanced energy codes.
6. The DOE should increase outreach to border communities on climate change and clean and efficient energy technologies, best practices, costs and benefits, and how to determine the potential economic and job creation effects from implementing energy efficiency and photovoltaic solar, including utility-scale, rooftop and community solar. Photovoltaic power plants are the most technically and financially viable renewable energy solution for increasing the border region's climate resiliency. Energy efficiency and photovoltaic solar projects are proven to provide significant economic benefits, are developed in reasonably short timeframes, and displace CO₂ and water used by more traditional energy sources. In another example, EPA—in collaboration with NADB-BECC and the DOE and through Border 2020—can undertake a regional assessment of opportunities to promote energy efficiency and distributed solar for small water and wastewater utilities along the border, including those of tribal governments.
7. In coordination with the National Weather Service, the Climate Prediction Center should use existing programs to develop methods to predict more accurately the location, length and severity of extreme weather events, including events with above-average nighttime heat. Existing DOE, HUD and EPA grants programs can be used to provide emergency shelters for extended periods of extreme temperatures in vulnerable communities and subsidize air-conditioning for vulnerable populations.

Chapter 7. Climate Change Impacts on Public Health in the Border Region

1. The CDC should modify current Zika testing algorithms that are biased toward detection of travel-related infection rates. The current testing approach is inappropriate and ineffective in distinguishing



between travel and locally acquired Zika cases along the U.S.-Mexico border, particularly because of the high cross-border traffic and shared ecological environment.

2. Public health campaigns to increase awareness and education of infectious diseases pertinent to the U.S.-Mexico border region are essential to prevention, especially concerning vulnerable populations at increased risk from climate change and other factors for development of these diseases. Prevention education should focus on the importance of emptying/disposing of water containers that can serve as mosquito breeding sites and sealing water containers that cannot be emptied. In addition, the public can be educated in the prevention of mosquito bites through the application of mosquito repellents, use of protective clothing, installation of window screens, and use of air conditioning when indoors. U.S. agencies should coordinate these efforts with Mexican authorities to reduce risk regionally in the binational border region.
3. Greater surveillance of vectors and analysis of the mediating mechanisms/processes between climate change (e.g., increases in precipitation and temperature) and disease outbreak is needed. Surveillance of disease vectors should be systematic and well-distributed along and across the U.S.-Mexico border, particularly cities with high cross-border traffic, to accurately determine prevalence of infected vectors/hosts, prevent and manage outbreaks, and tailor warning messages to border communities at risk for infection. Understanding how climate-related variations in vector habitats and human behavior (e.g., water storage and irrigation, pollution, migration, travel) contribute to disease outbreaks in the border region also is important.
4. The U.S.-Mexico border region is a contiguous landscape where vector and zoonotic pathogens thrive and circulate across political borders. To mitigate the health burden of these infectious diseases effectively, surveillance systems must follow a shared border region perspective and a “One Health” approach. Sharing of surveillance strategies and data can help to facilitate timely detection of cross-border outbreaks.
5. NOAA should deploy an early heat warning system for the binational Paso del Norte region to assist early responders and community members to better prepare for extreme heat events that are increasing in intensity and frequency with climate change. The system should be deployed in cooperation with Mexican authorities. Once piloted, the system should be extended to the rest of the binational border region.
6. Federal agencies should guide and support local governments in identifying tree planting areas, installing irrigation, purchasing and planting native shade-providing trees, installing three-tier water fountains, and providing benches and other shade structures.
7. Federal agencies should increase training and continuing education for primary care providers and mental health professionals, highlighting the relation of climate change to mental health, particularly targeting those providers working with underserved populations. Agencies should incorporate mental health training among emergency and disaster response teams.
8. EPA should improve air quality monitoring and warning systems along the border, moving beyond region-wide air values to specifically monitoring areas with vulnerable populations and hot spots such as ports of entry. EPA also should increase efforts to promote air quality awareness and education to vulnerable populations along the U.S.-Mexico border in their preferred language.
9. The CDC, in cooperation with state and local authorities and Mexican agencies, can use existing public health infrastructure programs to strengthen transboundary disease surveillance, educate the public regarding prevention and transboundary vector prevention and control efforts, control insect vectors and animal reservoirs of disease, and respond rapidly to border public health outbreaks.²⁰⁴ The CDC should coordinate public education campaigns that emphasize protective behaviors to reduce risk to vector-borne diseases and promote access to cooling centers, particularly for the elderly, infirm and economically disadvantaged people. ■

Appendices

Glossary of Acronyms

BECC	Border Environment Cooperation Commission
BEIF	Border Environment Infrastructure Fund
BHC	Border Health Commission
CBP	U.S. Customs and Border Protection
CDC	Centers for Disease Control and Prevention
CO ₂	carbon dioxide
CPP	Clean Power Plan
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GHG	greenhouse gas
GNEB	Good Neighbor Environmental Board
GRACE	Gravity Recovery and Climate Experiment
HHS	U.S. Department of Health and Human Services
HUD	U.S. Department of Housing and Urban Development
IBWC	International Boundary and Water Commission
IECC	International Energy Conservation Code
NAAQS	National Ambient Air Quality Standards
NADB	North American Development Bank
NIDIS	National Integrated Drought Information System
NIWTP	Nogales International Wastewater Treatment Plant
NOAA	National Oceanic and Atmospheric Administration
NO _x	nitrogen oxides
NRCS	Natural Resources Conservation Service
PACE	Property-Assessed Clean Energy
PM	particulate matter
PM _{2.5}	particulate matter less than or equal to 2.5 micrometers in diameter
PM ₁₀	particulate matter less than or equal to 10 micrometers in diameter
POV	personally owned vehicle
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOC	volatile organic compound

Glossary of Terms

acre-foot: A unit of volume equal to the volume of water required to cover 1 acre (0.405 hectare) in area and 1 foot (30.48 centimeter) in depth; 43,560 cubic feet (1233.5 cubic meters).

Ambos Nogales: Meaning “both Nogales,” this is a common name for the adjacent border towns of Nogales, Arizona, and Nogales, Sonora.

anaerobic digester: A sealed vessel, or series of vessels, in which microorganisms break down biodegradable material in the absence of oxygen; commonly used as part of wastewater treatment.

bioswale: Landscape elements designed to remove silt and pollution from surface runoff water. They consist of a swaled drainage course with gently sloped sides (less than 6%) and filled with vegetation, compost and/or riprap.

colonias: An unregulated settlement/residential area along the U.S.-Mexico border that may lack some of the most basic living necessities such as potable water and sewer systems, electricity, and safe and sanitary housing.

ecosystem services: Benefits derived by humans from ecosystems, such as provisions (production of food and water), regulation (control of climate and disease), support (nutrient cycles and crop pollination), and cultural (spiritual and recreational benefits).

endemic species: Species of plants or animals that occur only in a restricted location.

ephemeral runoff: Water that flows for a short period of time after a precipitation event or snowmelt.

evapotranspiration: The sum of evaporation and plant transpiration from the Earth’s land and ocean surface to the atmosphere.

gray infrastructure: Human-engineered solutions that often use concrete and steel for stormwater management and urban development.

green infrastructure: An approach to stormwater management that protects, restores or mimics the natural water cycle.

greenfield: Previously undeveloped sites for commercial development or exploitation.

greenhouse gas: A gas that contributes to the greenhouse effect, the warming of Earth’s lower atmosphere, by absorbing infrared radiation.

Glossary of Terms (continued)

hydrography: The applied science of surveying, charting and describing the physical features of bodies of water and coastal areas and predicting their change over time.

insolation: The solar radiation that reaches the Earth's surface. It is measured by the amount of solar energy received per square centimeter per minute. Much of the border region has high values.

Lidar: A detection system that works on the principle of radar, but uses light from a laser.

neotropical: A zoogeographical region comprising Central and South America, including the tropical southern part of Mexico and the Caribbean. Distinctive animals include edentates, opossums, marmosets and tamarins.

outflow: The outward flow of air from a weather system, associated with wind shift and temperature drop.

paleoclimate: Past climate that existed prior to humans collecting instrumental measurements of weather.

peaker plants: Power plants that generally run only when there is a high (peak) demand for electricity.

PM_{2.5}: Fine particulate matter; microscopic solid or liquid matter suspended in the Earth's atmosphere with a diameter of 2.5 micrometers or less. They can enter the lungs, potentially causing serious health problems.

PM₁₀: Coarse particulate matter; microscopic solid or liquid matter suspended in the Earth's atmosphere with a diameter of 2.5 to 10 micrometers. They can enter the lungs, potentially causing serious health problems.

promotoras: A community member who receives specialized training to provide basic health education in the community without being a professional health care worker.

rain garden: A planted depression or a hole that allows rainwater runoff from impervious urban areas—such as roofs, driveways, walkways, parking lots and compacted lawn areas—the opportunity to be absorbed.

recharge: A hydrologic process where water moves downward from surface water to ground water; the primary method through which water enters an aquifer.

resacas: A type of oxbow lake that can be found in the southern half of Cameron County, Texas. They are former channels of the Rio Grande and are naturally cut off from the river, having no inlet or outlet.

riparian system/habitat: The interface between land and a river or stream.

runoff: The draining away of water (or substances carried in it) from the surface of an area of land, a building or structure, or so forth.

snowpack: Layers of snow that accumulate in geographic regions and high altitudes where the climate includes cold weather for extended periods during the year; they are an important water resource that feed streams and rivers as they melt.

water-energy nexus: The relationship between the water used for energy production (including electricity and sources of fuel such as oil and natural gas) and the energy consumed to extract, purify, deliver, heat/cool, treat and dispose of water and wastewater.

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