

Chapter 18

Climate Choices for a Sustainable Southwest

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Executive Summary

The Southwest faces many stresses from current climate variability and is projected to become a hotspot for climate change. A century of economic and population growth has placed pressures on water resources, energy supplies, and ecosystems. Yet the Southwest

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also has a long legacy of adaptation to climate variability and of environmental management that has enabled society to live within environmental constraints and to protect large parts of the landscape for multiple uses and conservation. Many different types of organizations and individuals in the Southwest have already taken a variety of steps to respond to climate change; and a wide range of choices are available for those choosing to reduce greenhouse gas (GHG) emissions or implement preparedness and adaptation measures to manage the risks from climate variability and change in the region. Others are pursuing energy and water efficiency, renewable energy, or sustainable agriculture for other reasons but these can also reduce emissions or assist with adaptation.

This chapter features the following key findings:

- The U.S. Southwest is a region with great capacity both to respond to environmental stress and to steward its abundant natural resources. Past efforts to develop its water resources and protect its public lands are indicative of this capacity, and while viewed as successes by many, they also illustrate challenges and trade-offs in policy and actions that can increase resilience for some while increasing vulnerability for others. (medium-high confidence)
- Local and state governments, tribes, private-sector entities, non-profit organizations, as well as individuals are already taking steps to reduce the causes of climate change in the Southwest—though often not solely for climate-mitigation purposes—and there are many lessons to learn from the successes and failures of these early efforts. Few systematic studies have been undertaken to date to evaluate the effectiveness and impacts of the choices made in the Southwest to reduce GHG emissions. (medium-high confidence)
- If the Southwest decides to reduce a proportional share of the emissions recommended (50% to 80% by 2050) by the U.S. National Academy of Sciences and others, the carbon budget for the region between 2012 and 2050 would only be 150–350 million metric tons per year (NRC 2010d). This would be a very challenging but not impossible target to meet. (medium-low confidence)
- There are low-cost, cost-saving, or revenue-generating opportunities for emission reductions in the Southwest, especially in energy efficiency and renewable energy. (medium-high confidence)
- A range of stakeholders are already planning how to prepare for and respond to climate risks in the Southwest, but few have begun implementing adaptation programs due to financial, institutional, informational, political, and attitudinal barriers. Various adaptation options exist in every sector, including many that help society respond to current risks of climate variability and extreme events. (medium-high confidence)
- Many response options simultaneously provide adaptation and mitigation “co-benefits,” reducing the causes of climate change while also increasing the preparedness and resilience of different sectors to climate change. Other response options involve trade-offs between increasing emissions or reducing resilience

- More research and monitoring is needed to track and evaluate decision outcomes and to understand the balance and effectiveness of these choices especially under financial constraints. (high confidence)

18.1 Introduction

This chapter provides an integrated overview of solutions and choices for responding to climate change in ways that reduce risks and support sustainable development in the Southwest. The goal is to illustrate the range of choices for responding to climate change, along with some of the relevant trade-offs and opportunities, to inform policy options and decisions. In the context of climate change, risk reduction includes: reducing global GHG emissions to limit global changes; limiting activities locally or regionally (e.g. land use choices) that increase unwanted local or regional climatic changes; taking action now to accommodate and adapt to climate changes to date; and increasing capacity to respond effectively and adapt to future changes.

The chapter begins with a discussion of how the Southwest might choose to secure a sustainable future in the context of climate change. The Southwest has a long history of adapting to environmental stresses and managing resources, which demonstrate the ability of the region to make choices that promote sustainability of ecosystems and natural resources, the economy, and society, but also to minimize some of the risks.

Because some studies have identified the Southwest as a potential hotspot of climate change (see Chapter 5) where changes may start to occur rapidly or unfold particularly severely, this chapter also examines some of the options for transformational adaptation to climate change—rather than make more incremental adjustments to climate risks—in the event it becomes necessary to make significant changes in resource allocation or technology, or to relocate people, ecosystems and infrastructure. The co-benefits and trade-offs in linking mitigation and adaptation are also discussed.

National choices about responding to climate change were recently presented by the National Research Council's *America's Climate Choices* study (NRC 2010a, 2010b, 2010c, 2010d). This study is used as a starting point for identifying some of the options for limiting emissions and adapting to climate change, and analyzing what these options might mean for the Southwest in terms of social, technological, economic, behavioral, and institutional structures and choices.

The chapter also reviews some of the choices and solutions that are already being implemented in the Southwest in response to climate change. These efforts include: regional activities by federal agencies; the plans and activities of states, cities, and communities; key regional collaborations such as those in major river basins; and solutions that have been chosen by businesses, tribes, and civil society organizations.

Finally, we discuss options for integrating mitigation and adaptation activities in ways that mutually support each other, rather than produce difficult trade-offs, and focus on the challenges communities and organizations face in planning and implementing solutions. We also raise the question of what actions may be needed if both global mitigation and regional adaptation fail to minimize climate change and resulting impacts to acceptable levels.

18.2 Defining a Sustainable Approach to Climate Change in the Southwest

For the purposes of this chapter, a “sustainable” Southwest is defined as one where the choices we make in responding to climate change assist in the long-term maintenance of economic, social, and environmental well-being—in other words, in meeting the needs of the present without compromising future generations (Wiek et al. 2012). These choices include reducing the risks of climate change by limiting emissions and making it easier to adapt to the impacts of climate changes that are occurring or will occur. Sustainable solutions endure in the face of continuing climate change and other stresses. The Southwest alone cannot mitigate all global GHG emissions, but the region can choose from many options to reduce its proportional contribution to the global causes of climate change and reduce the region’s own vulnerability to climate change.

Climate change is not the only threat to sustainability in the Southwest, so pathways to sustainability involve managing multiple risks to the region. This requires considering not just environmental, economic, and social goals, and addressing climate mitigation and adaptation, but also managing risks and opportunities for the well-being of the region’s residents and the Earth system (MacDonald 2010). The best pathways will be those that maximize the benefits for environment, economy, and society while minimizing costs and environmental risks, especially for the most vulnerable. One of the greatest challenges is to be prepared for and able to act in the face of uncertainty while being aware of the possibility of reaching thresholds where conditions deteriorate rapidly (Lempert and Groves 2010; Westley et al. 2011). A sustainable Southwest will need early warning of such risks and plans for responding if and when they occur.

18.3 Making a Sustainable Living in the Southwest: Lessons from History

The history of the Southwest demonstrates a remarkable ability to adapt to the climatic and geographic extremes of the region. Tapping into this ability is key to developing sustainable solutions to future climate change.

Throughout human history, water—in particular the ability to move it across the landscape—has been critical to the growth of societies (Worster 1992). Many of the pre-historic peoples of the Southwest found ways to harvest rainwater and runoff and even developed sophisticated water conveyance systems and other techniques for living in a desert climate. The European settlers who came later established water infrastructure and institutions for the development of cities and agriculture. The development of water resources is one of the most notable stories of settling and living in the Southwest. Key to the rapid population expansion in the Southwest was the construction of massive water projects, especially following the passage of the federal Reclamation Act of 1902 (Hundley 1991) (Figure 18.1). By taming the highly variable flow of rivers such as the Colorado and Rio Grande and creating a vast network of canals and ditches capable of moving water between basins, settlers and the federal government did more than just adapt to the necessities of life in an arid climate—they made it a thriving corner of the nation.

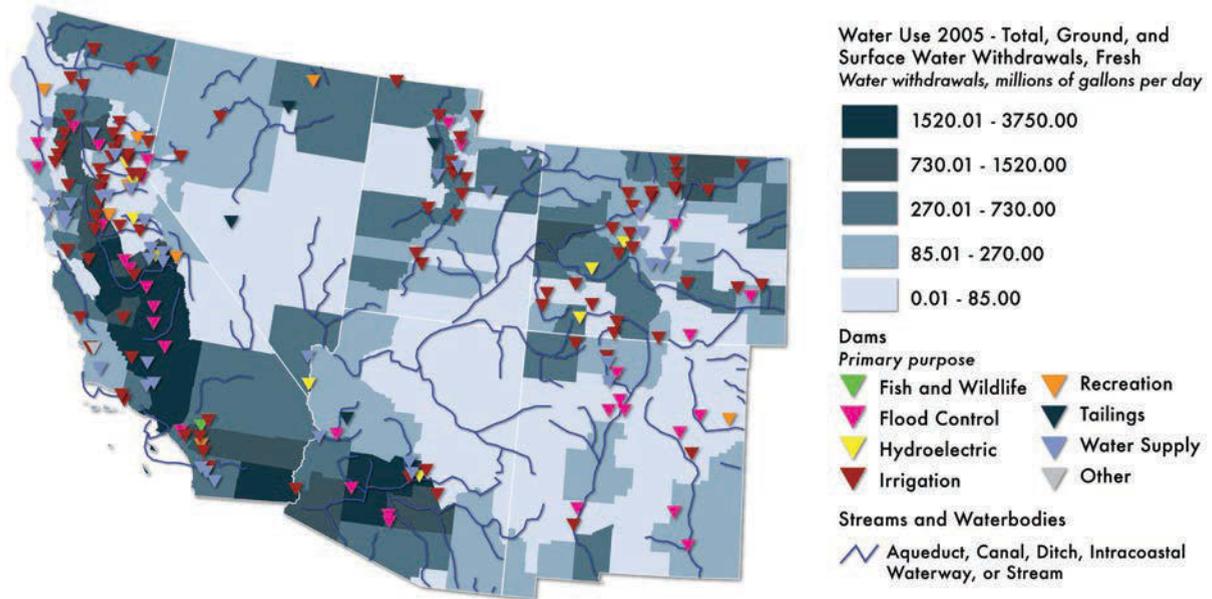


Figure 18.1 Water resource development in the Southwest: 2005 surface-water withdrawals for irrigation and dams. The massive development of water resources stands as one of the grand stories of settling the Southwest. Although this has created its share of environmental and social problems, and there are legitimate questions as to the long-term sustainability of water supply interventions, the systems of dams (shown here), diversions, and management institutions is a testament to the region's ability to invest in managing its environment for economic and social well-being. In light of these incredible efforts to make the Southwest habitable, meeting the new climate challenges of the twenty-first century seems less daunting. Map from *The National Atlas of the United States of America* (<http://www.nationalatlas.gov>; see also <http://www.nationalatlas.gov/mapmaker?AppCmd=CUSTOM&LayerList=wu2005%3B5&visCats=CAT-hydro,CAT-hydro>; accessed October 8, 2012).

Water development in the West certainly also created a number of environmental and social problems, and there are legitimate questions as to the long-term ecological, social, and economic sustainability of water demand and use in the region. Fundamental changes to the natural flow of water have had profound consequences for the natural environment. The waters of the Colorado River now rarely reach its mouth at the Gulf of California, drying up a critical and unique wetland (Glenn et al. 1996). The complex plumbing of the Central Valley Project and the State Water Project in California has changed fish communities, water quality, and habitat structure in the Sacramento-San Joaquin Delta (Nobriga et al. 2005). Water availability allowed for massive increases in population throughout the West, in turn increasing the vulnerability of population centers to drought and increased competition between water users (Reclamation 2005).

Despite these consequences, the settlement and watering of the Southwest stands as a reminder of the remarkable effort and funds mustered to transform a dry landscape into one with booming urban centers and extensive and productive agricultural lands.

A second example of choices that created a more sustainable Southwest were the decisions of federal, state, and local governments, as well as private landowners and

conservation groups, to set aside vast areas of the West to conserve extractive commodities such as timber and protect scenic beauty, wildlife, habitat, and open space. Twenty-two national parks, nearly 66 million acres of national forests, 74 wildlife refuges, and other protected areas cover more than 165 million acres of the Southwest, conserving natural resources, and providing income to users such as ranchers, loggers, miners, and tourist operators and recreation to millions of residents and tourists (Clawson 1983; Wilkinson 1992) (see also Chapter 3, Section 3.1.3). The Southwest is also home to 120 million acres under the jurisdiction of the Bureau of Land Management (Figure 18.2). While the vast majority of federal public lands were originally created to conserve natural resources for uses in the public interest, such as timber and grazing lands, an environmental protection movement in the 1960s and 1970s led to stronger laws, guiding the management and protection of public lands, and also recognized a number of non-utilitarian uses for the federal domain (Hardt 1994). The Wilderness Act of 1964, Wild and Scenic Rivers Act of 1968, Endangered Species Act of 1973, National Forest Management Act of 1976, Federal Land Policy and Management Act of 1978, and a host of other laws and regulations helped ensure that public lands could be managed and conserved for years to come and that biodiversity would be protected.

This federal land ownership system, which covers nearly 30% of the entire United States (Loomis 2002), helps protect habitat and ecosystem services, facilitates sustainable management of resources, and provides an “insurance policy” for climate adaptation, as land-based resources and economies (such as forestry, tourism, and recreation) as well as species and ecosystems consequently have significant space to migrate to and adjust to the changing conditions. As federal climate-change adaptation response becomes increasingly coordinated, this large area of land can be managed for adaptation and multiple uses in an integrated fashion although multiple jurisdictions can present some barriers.

As with water development, protection of public lands has its challenges. Extractive users, ranchers, recreationalists, and environmentalists struggle with each other and with land-management agencies over appropriate uses of these areas. Yet the wealth of publicly owned land across the United States, especially in the Southwest, is a testament to the willingness of Americans to take proactive steps to prevent the exploitation of resources for the benefit of current and future generations: a sign of a spirit more than capable of tackling the challenges of future climate change.

The Southwest is also leading the economic transformation that has become known as the “green economy,” with investments in business ventures that increase energy security, promote sustainability, and reduce environmental impacts (Jones 2009). Colorado and California in particular have supported moves to a green economy where jobs and profits are associated with renewable energy. Colorado has targeted public policy at green energy, attracting venture capital to clean technology of \$800 million, and hosting an estimated 17,000 green jobs (see Box 18.5). In Colorado, New Mexico, and Utah, green job growth has outpaced overall job growth (Headwaters Economics 2010). In California, Roland-Holst (2008) estimates that energy efficiency has already generated income savings and created 1.5 million jobs, while redirecting consumption to in-state supply chains. He further estimates that AB 32 (the California Global Warming Solutions Act) will encourage innovation, increase income, and create more than 400,000 new jobs.

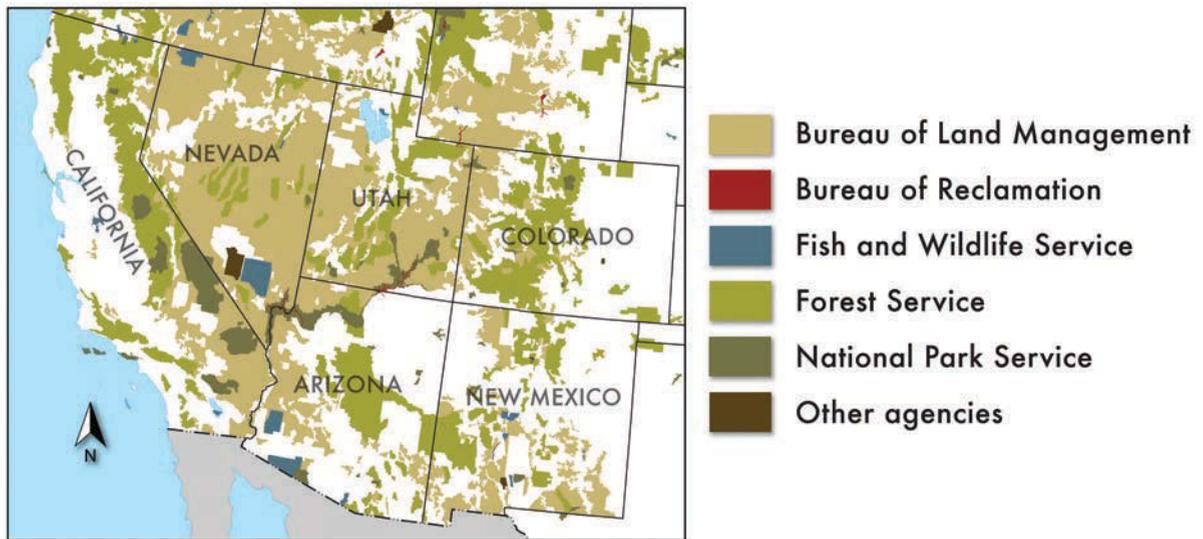


Figure 18.2 Extensive federal lands in the Southwest: A legacy for the future. This map illustrates the legacy of federal land ownership in the Southwest, covering nearly 30 percent of the entire United States. Protected habitat and ecosystem services ensure sustainable management of resources and may be the greatest insurance policy against losses in the future, because natural resource use and biological species can more easily adapt to rapidly changing climatic conditions. Modified from *The National Atlas of the United States of America* (<http://www.nationalatlas.gov>; see also <http://nationalatlas.gov/printable/images/pdf/fedlands/fedlands3.pdf>; accessed October 8, 2012).

Other examples of sustainable choices in the Southwest include those cities and communities that have broken with the western model of sprawl, energy-intensive buildings, and dependence on the automobile, to plan more sustainable communities. Sustainable urbanism in the Southwest has included downtown infill, dry landscaping, water reuse, renewable energy development, green-building standards, and public transport to reduce water and energy use, protect green space, and create more livable cities (see, for example, http://www.lgc.org/freepub/healthy_communities/index.html; Garde 2004; Farr 2007; and Chapter 13). Examples of large developments focused on a new sustainable urbanism in the region include Mesa Del Sol, New Mexico; Civano in Tucson, Arizona; Stapleton, Colorado; Mountain House in San Joaquin County, California; and Santa Monica, California.

18.4 Limiting Emissions in the Southwest

To keep human-caused climate change below dangerous levels, the National Research Council (2010d) suggested that the United States and other industrial countries should reduce GHG emissions by 50% to 80% by 2050 compared to 1990 levels. This would give a reasonable chance of keeping atmospheric GHG concentrations below 450 parts per million and limiting overall temperature increases to 3.6°F (2°C) above preindustrial levels. Because annual U.S. carbon dioxide emissions in 1990 were estimated to be 6

gigatons (Gt), a 50% reduction by 2050 would mean reducing emissions to 3 Gt a year, and an 80% cut would be to 1.2 Gt. The NRC estimated that this gives the United States a total carbon budget of 170 Gt to 200 Gt for 2012 to 2050. (The study relied on a wide range of peer reviewed studies and estimated 2008 U.S. emissions to be the equivalent of about 7 Gt of carbon dioxide.) While its recommendation is highly ambitious and challenging, the NRC believes achieving this goal is possible, and more easily so if begun immediately. The study also offers a basket of options for reaching this goal, including choices such as: putting a price on carbon; increasing the energy efficiency of electricity production and transport; moving toward low carbon fuels; increased research and development for carbon capture and storage and new-generation nuclear power generation; and the retirement or retrofit of emission-intensive infrastructure (NRC 2010c, 4–5).

The latest emissions data for CO₂ from fossil fuels in the Southwest shows the region is responsible for 13.4% of the U.S. total in 2009, dominated by emissions from California, which ranks second to Texas in overall emissions (see also Chapter 12). The recently released GHG data reported by large facilities (EPA 2012a) shows that the largest emitters in the Southwest are power-generating plants and oil refineries, with only thirty facilities producing 50% of the emissions from all large facilities (EPA 2012b) (Table 18.1).

Table 18.1 Greenhouse gas emissions by state in the Southwest, shown as CO₂ equivalent emissions (in million metric tons [MMT])

State	CO ₂ emissions in MMT (2009)	Percent of Region	Percent of U.S.
Arizona	94	12.95	1.74
California	377	51.93	6.96
Colorado	93	12.81	1.72
Nevada	40	5.51	0.74
New Mexico	58	7.99	1.07
Utah	64	8.82	1.18
Region	726	100	13.4
U.S. total	5,417	—	100

Source: <http://www.epa.gov/statelocalclimate/state/activities/ghg-inventory.html>.

Since data for projections of regionally specific carbon emissions scenarios are not available, an estimate of possible regional emission reductions is provided based on the NRC study cited above (NRC 2010d). Assuming global “business-as-usual” emissions were to increase at 3% per year as assumed in several studies (Nakićenović and Swart 2000; Garnaut 2008), the Southwest would have emissions of about 1,000 million metric

tons (MMT) in 2020 and 2,400 MMT in 2050.¹ Alternatively, using the lower observed U.S. emissions growth rate of 1.2% per year (1990–2007) (<http://epa.gov/climatechange/emissions/index.html>), the region would have emissions of around 810 MMT in 2020, and approximately 1,090 MMT in 2050.

For the Southwest to contribute its fair share to reducing emissions by 2050, as NRC recommends, the region would need to reduce emissions to about 150 MMT to 350 MMT per year by 2050. Since this is much lower than projected business-as-usual emissions discussed above—as much as a 90% cut by 2050—we conclude that meeting higher emission reduction goals in the Southwest would be very challenging, but not impossible. Any delay in beginning serious emission reductions would make achieving the region’s goal of reducing its proportional share that much harder.

Of the states in the region, only California and Colorado have made commitments to reduce their emissions in line with the 50% to 80% reduction recommended by the NRC. California’s goal is to reduce emissions by 80% below 1990 levels by 2050 (State of California, Executive Order S-3-05) and Colorado’s is to reduce to 80% below 2005 levels by 2050 (State of Colorado, Executive Order D-004-08). Other states have made more modest or non-binding emission reduction commitments—for example, through the 2007 Western Climate Initiative’s target of 15% below 2005 levels by 2020—but some of these commitments have been rescinded or not implemented (<http://www.c2es.org/states-regions>).

Significant emission reductions can be made at low cost or can save money (see Chapter 12). One estimate for the United States showed that significant emissions reductions could be achieved at a cost of less than \$50 per ton of avoided emissions and that almost half of these reductions would actually involve money savings especially from energy efficiency (McKinsey 2007) (Figure 18.3). Many of the money-saving options are relevant to the Southwest and are already being implemented through individual and corporate choices or through government incentives and regulation (see, for example, case studies of local communities at <http://www.lgc.org/freepub/energy/index.html>). Options include reducing overall energy consumption by driving less or adjusting thermostats, more efficient lighting, more efficient electronic equipment, building insulation, more efficient automobiles, power plant retrofits, and methane management at mines. California has adopted many energy-efficiency strategies over the past several decades, and its economy grew by 80% between 1960 and 2008, with no change in per capita electricity use and a savings of \$1,000 per household (Kammen, Kapadia and Fripp 2004; Engel and Kammen 2009; Wei, Patadia, and Kammen 2010).

Some researchers also suggest that the Southwest has a comparative advantage and real opportunities in certain areas of emission reductions, which include solar energy, energy-efficiency savings, and low-carbon electric vehicles (Zweibel, Mason, and Fthenakis 2008; Fthenakis, Mason, and Zweibel 2009). New commercial installations of solar concentrating or solar photovoltaic facilities have been located in the Southwest or are under review in California, Colorado, Arizona, and Nevada. These states lead the country with installed solar photovoltaics and concentrated solar (Gelman 2010). The combination of ample cloud-free days and large areas of land, including abandoned industrial sites, farmland, and public land, represent a regional opportunity for this energy supply. Large solar facilities are not without controversy, however, as they can displace native species, disturb the soil, and may conflict with other human uses of the land.

Box 18.1*Case Studies of Climate Choices for a Sustainable Southwest**Federal Lands and Agency Planning in the Southwest*

Federal land and resource management agencies are beginning to incorporate climate change considerations into planning, although efforts are not consistent across agencies (Jantarasami, Lawler, and Thomas 2010). A 2009 Secretarial Order issued at the Department of the Interior spurred individual agencies to begin to incorporate adaptation into individual decisions. The National Park Service's Climate Change Response Program aims to protect park resources from climate change impacts while also using parks to develop knowledge about ecosystem impacts from climate change. A survey of federal land managers in three states in 2011 (Colorado, Wyoming, and Utah) showed that only 6% of their offices were carrying out adaptation plans, but another 25% percent were in the process of

developing plans (Archie et al. 2012). A majority were either not currently planning for climate change adaptation (47%) or did not know the status of adaptation planning in their office (24%). Preliminary data indicate that there is some difference in the level of planning among agencies, with the U.S. Fish and Wildlife Service planning at a significantly higher rate than its sister agencies, but it is too early to say why this may be the case. The National Park Service has adopted a range of actions to meet the challenges of climate change in the Southwest region including efforts to reduce energy consumption with a goal of carbon neutrality and through the Climate Friendly Parks program which provides parks with tools to address climate change, including emissions inventories, action plans, and outreach support.

This section focuses on adaptation and basic approaches to it and provides examples of activities already being undertaken. *America's Climate Choices* (NRC 2010a) provides a starting point to lay out a fundamental way of thinking about adaptation to climate change. In it, adaptation is essentially viewed as a challenge in risk management. The Southwest is no stranger to climate-related risks, such as drought, heat extremes, floods, high-wind storms, wildfires, heavy snowfall in the mountains, and cold snaps (Chapters 4, 7, and 8). To reduce the risks from these events in the past, the region's residents, businesses, and planners devised a number of mechanisms, including early warning systems, emergency planning, irrigation systems, building codes, and insurance policies. As the historical patterns of extreme weather events change with a warmer, drier regional climate, the Southwest will need these and additional risk-management tools to prepare for the future so that disruptive events do not become disasters.

Risk management in the face of an uncertain future climate—as defined and discussed in detail in *America's Climate Choices* (NRC 2010a, 2010c)—entails a number of characteristics and iterative, inclusive processes to implement over time. These characteristics and processes are summarized here as generic components that will apply to many if not most adaptation strategies as they are implemented in different sectors:

- **Risk identification, vulnerability assessment, and evaluation.** Scientists and stakeholders jointly identify projected changes in the climate and relevant consequences for particular regions or sectors in light of existing or expected social, economic, and ecological vulnerabilities.
- **Development and assessment of adaptation strategies.** Stakeholders, decision makers, scientists, and engineers assess the costs, benefits, feasibility, and limits of a range of adaptation options.
- **Iterative decision making and deliberate learning.** Many pro-active adaptation decisions will need to be made without “perfect” knowledge of what the future may hold, thus requiring frequent revisiting of decisions and making deliberate efforts at monitoring outcomes and reevaluating them in light of changing knowledge, changing climate, non-climatic stressors, and policy contexts. (This idea and many of those that follow are addressed further in Chapter 19.)
- **Maximizing flexibility.** Whenever decisions with long-term (greater than 30 years) implications can be made incrementally, future risks will be minimized if options for course changes are not foreclosed immediately.
- **Enhancing robustness.** Whenever decisions with long-term implications are being made that can be reversed only at major expense (if at all), future climate risks (and the odds of investing in the wrong option) will be minimized if the considered option(s) will work under a range of plausible future scenarios.
- **Ensuring durability.** To avoid or minimize a perception of economic and social uncertainty, investors, homeowners, and others require some stability to make decisions. Some degree of durability of decisions is needed, with rational adjustments allowed over time.
- **Having a portfolio of approaches.** In a rapidly changing, complex environment, simplistic “fixes,” narrow sectoral approaches, or reliance on only a small set of options used in the past are typically insufficient to meet future challenges.
- **Focusing on “no-regrets” options whenever possible.** While any adaptation strategy may involve benefits for some and disadvantages for others, “no-regrets” options are understood as those that would—regardless of the exact unfolding of future climate change—provide the benefit of reducing vulnerability or increasing resilience. For example, improving access for poor, less mobile populations to cooling centers during heat waves would already be beneficial, and will be even more beneficial if and when heat extremes become more common, even if there is some cost involved in providing this service to those currently disadvantaged populations.
- **Focusing on “low-hanging fruit.”** Such options are those that are useful for reducing climate risks, are relatively easy to implement, and may not cost much. Examples are avoiding placing more people and assets at risk, improving early-warning or disaster preparedness and response systems, and building climate-change considerations into existing plans for ecosystem restoration or floodplain management.
- **Focusing on building adaptive capacity.** Another very useful strategy already being pursued by a number of institutions and governments in the Southwest—is

to build the capacity to address climate change impacts in the future, including improving understanding of the problem, educating and building awareness among citizens, establishing collaborative ties with others, improving data sharing and communication, setting up stakeholder engagement processes, and developing funding mechanisms.

Box 18.2

Case Studies of Climate Choices for a Sustainable Southwest

Private Sector Responses in the Southwest: Levi Strauss

Levi Strauss & Co. (LS&CO) is a retail company based in California that has started to take steps to mitigate its contribution to climate change. It groups its climate-related goals under three categories: (1) reducing climate-change impacts resulting from production (supply chain focus); (2) reducing impacts from its facilities; and (3) promoting environmentally friendly use and disposal of its products. Since 2007, LS&CO has reduced carbon emissions by 5.84%; this reduction came despite a 6% increase in its real-estate portfolio. The company launched a “Levi’s® Water<Less™” jeans product line that reduces both water and

energy consumption. LS&CO was also active in supporting The California Global Warming Solutions Act (AB 32) and joined the campaign against Prop 23 that aimed to overturn AB 32 (see also Box 18.4). LS&CO supports a non-profit program focused on teaching irrigation and rainwater-capture techniques in India, Pakistan, Brazil, and Central Africa. Currently 5% of the cotton used in its jeans production is grown using sustainable methods and the company aims to increase this to 20% by 2015.

Source: <http://www.levistrauss.com/about/public-policy/environment>.

Table 18.2 identifies some of the many options for adapting to climate change in the Southwest, many of which are mentioned in earlier chapters of this report. In addition to adaptation options for specific sectors, any jurisdiction can take steps to develop integrated adaptation plans. This is already being pursued by several entities in the Southwest, including the Western Governors Association, stakeholders in San Diego Bay, the cities of Los Angeles, Salt Lake, San Francisco, and Tucson, the state of California, and a number of regional water utilities.

The actual and potential capacity to adapt to climate variability and change exists at a variety of scales and involves a number of institutions across the Southwest. At a local scale, efforts like watershed protection and restoration conducted by non-governmental organizations and other institutions could minimize potential climate impacts to habitats and ecosystem services (e.g., Carpe Diem West 2011). More formally, a number of municipalities and counties have developed climate adaptation assessments or plans aimed at preparing for future impacts. For example, eight municipalities in the Southwest have formed the Regional Climate Adaptation Planning Alliance to develop

a common approach for individual adaptation efforts. Local water providers in Phoenix and Denver have been downscaling climate model data to estimate potential impacts on streamflow, and thus on their long-term water supplies. They are now beginning to explore flexible and incremental actions to respond to such changes if they occur (Quay 2010).

Table 18.2 Adaptation options relevant for the Southwest

Sector	Example Adaptation Strategies
Agriculture	Improved seeds and stock for new and varying climates (and pests, diseases), increase water use efficiency, no-till agriculture for carbon and water conservation, flood management, improved pest and weed management, create cooler livestock environments, adjust stocking densities, insurance, diversify or change production.
Coasts	Plan for sea level rise—infrastructure, planned retreat, natural buffers, land use control. Build resilience to coastal storms—building standards, evacuation plans. Conserve and manage for alterations in coastal ecosystems and fisheries.
Conservation	Information and research to identify risks and vulnerabilities, secure water rights, protect migration corridors and buffer zones, facilitate natural adaptations, manage relocation of species, reduce other stresses (e.g., invasives)
Energy	Increase energy supplies (especially for cooling) through new supplies and efficiency. Use sustainable urban design, including buildings for warmer and variable climate. Reduce water use. Climate-proof or relocate infrastructure.
Fire management	Use improved climate information in planning. Manage urban-wild land interface.
Forestry	Plan for shifts in varieties, altered fire regimes, protection of watersheds and species.
Health and emergencies	Include climate in monitoring and warning systems for air pollution, allergies, heat waves, disease vectors, fires. Improve disaster management. Cooling, insulation for human comfort. Manage landscape to reduce disease vectors (e.g., mosquitos). Public health education and training of professionals.
Transport	Adjust or relocate infrastructure (coastal and flood protection, urban runoff), plan for higher temperatures and extremes.
Urban	Urban redesign and retrofit for shade, energy, and water savings. Adjust infrastructure for extreme events, sea-level rise.
Water management	Enhance supplies through storage, transfers, watershed protection, efficiencies and reuse, incentives or regulation to reduce demand and protect quality, reform or trade water allocations, drought plans, floodplain management. Use climate information and maintain monitoring networks, desalinate. Manage flexibly for new climates not stationarity.

Source: Smith, Horrocks et al. (2011); Smith, Vogel et al. (2011).

Box 18.3*Case Studies of Climate Choices for a Sustainable Southwest**Cities Responding to Climate Change in the Southwest*

Cities are emerging as the leaders in setting policies, preparing risk assessments, and setting targets for the reduction of GHG emissions (Rosenzweig 2010; see also Chapter 13). Organizations such as ICLEI, the World Mayors Council on Climate Change, and the C40 Cities Climate Leadership Group have provided successful venues for cities to raise awareness and disseminate best practices (Zimmerman and Faris 2011). Nationwide most of the climate action at the city level is still focused on mitigation (Wheeler 2000; <http://www.icleiusa.org/>) and recent assessments of these mitigation efforts have been critical of their likelihood to reach stated goals (Willson and

Brown 2008). In the Southwest, more than 140 cities are members of ICLEI. Success stories include Fort Collins, Colorado, which has not increased its annual GHG emissions since 2005 despite 5% population growth. Fort Collins is hoping to reduce emissions by 80% below 2005 levels by 2050 (Karlstrom 2010). Salt Lake City, Utah, reduced its GHG emissions by 31% between 2005 and 2009 (Zimmerman and Faris 2011). Cities such as Los Angeles; Boulder City, Nevada; and Pleasanton, California, are also promoting initiatives to expand locally based renewable energy initiatives (Zimmerman and Faris 2011).

Several states have also begun adaptation planning efforts (see Center for Climate and Energy Solutions 2012; Georgetown Law Center 2012). Although California is the only state in the region to have completed a state adaptation plan (see Box 18.4), climate action plans in Arizona, New Mexico, and Colorado call for the development of statewide adaptation activities, and in some sectors—such as water management—adaptation activities are already underway (Chou 2012). Many local governments are also engaging in adaptation planning; to date more than 140 cities in the Southwest are members of ICLEI—Local Governments for Sustainability.ⁱⁱⁱ To facilitate such adaptation planning, nine western utilities—together with several from other U.S. regions—have formed the Water Utility Climate Alliance and have been funding research on adaptation strategies for water utilities. This includes a study on advancing climate modeling (Barsugli et al. 2009) and methods for planning adaptation under uncertainty (Means et al. 2010).

18.6 Linking Mitigation and Adaptation

To move toward greater sustainability, both adaptation and mitigation efforts are needed and in some organizations (and households) the same person or group of decision makers are responsible for both activities. While both types of activities have distinct goals, their interaction has four possible outcomes: (1) mitigation positively supports the achievement of adaptation goals; (2) mitigation undermines the achievement of adaptation goals; (3) adaptation supports the achievement of mitigation goals (emission

Box 18.4*Case Studies of Climate Choices for a Sustainable Southwest**California's Climate Policy History and AB 32*

The history of climate-change policy making in California is longer than in most other states (Franco et al. 2008). Beginning in 1988, Assembly Bill 4420 (AB 4420) called on the California Energy Commission to lead the preparation of the first scientific assessment of the potential impacts of climate change and of policy options to reduce GHG emissions. It took until 2000 before the first steps were taken to regulate GHG emissions, when Senate Bill 1771 created the non-profit California Climate Action Registry (CA Registry), allowing state organizations to register and track their voluntary emission reductions. Shortly thereafter in 2002, the assembly passed the so-called "Pavley bill" (AB 1493), a ground-breaking law which led to the regulation of GHG emitted from automobiles. After an executive order was signed by Governor Arnold Schwarzenegger in

June 2005 (S-3-05), the California state assembly then passed the California Global Warming Solutions Act (AB 32) in 2006, committing the state to reduce GHG emissions statewide by 80% below 1990 levels by mid-century, with an interim goal of capping emissions at 1990 levels by 2020. Several additional laws have been passed since in support of these policy goals, including requirements to generate a growing percentage of electricity from renewable energy and to develop integrated land use and transportation strategies (Franco et al. 2008; NRC 2010c, Box 2.1). Contrary to widespread concerns, the climate-policy initiatives in California appear to have positive economic impacts on the state economy in terms of jobs generated and technological innovation spurred (Roland-Holst 2008; Berck and Xie 2011).

reductions); and (4) adaptation undermines the achievement of mitigation goals. Because funding is often limited and alternatives are not always feasible, in some instances adaptation may have to be chosen even though it increases emissions, or one type of effort must be focused on one rather than the other because of mandates. For example, heat wave response may require extra air conditioning in public buildings or extra groundwater pumping, even when this increases emissions because other options such as desalination are too expensive or simply not available in the near-term. Some renewable energy options may require more water use, thus adding to adaptation challenges. It is important to examine the interaction of mitigation and adaptation in the Southwest because it can help maximize potential co-benefits and reduce potential trade-offs if they cannot entirely be avoided (Scott and Pasqualetti 2010). To the extent trade-offs are perceived by interested stakeholders, they can pose barriers to progress, and thus need careful consideration (Moser 2012). Table 18.3 lists examples of activities particularly relevant in the Southwest region that illustrate these interactions.

While trade-offs should be avoided, stand-alone climate policies that pursue only mitigation or adaptation goals should not be disfavored if they are well indicated and demonstrably useful even if they do not have explicit co-benefits for other policy goals. This may entail difficult political challenges, as it is reasonable to expect that there will

be times when true sustainability and successful adaptation require hard choices, including convincing stakeholders that what they perceive as harmful to them could be beneficial to them and the larger community and environment in the long term.

Box 18.5

Case Studies of Climate Choices for a Sustainable Southwest

Colorado's Green Economy

Colorado has a strong focus on the fast-growing clean-energy economy. Between 1998 and 2007, jobs in the U.S. clean-energy sector grew by 9.1%, while those in Colorado's clean-energy sector grew by 18.8% (Pew Charitable Trusts 2009). Colorado has one of the most aggressive Renewable Portfolio Standards (RPS)—a requirement to produce a certain amount of energy from renewable sources—with 30% of energy to be sourced from renewable energy by 2020, according to Headwaters Economics (2010). This RPS was doubled from its previous target when lawmakers observed the ease with which it was being met,

together with an influx of jobs in rural areas. Colorado has provided a variety of incentives to promote its clean-energy growth, including direct funding for renewable energy development targeted at residential and commercial buildings. In 2009 Colorado implemented an Energy Efficiency Resource Standard with the goal of achieving 11.5% energy savings by 2020 for investor-owned utilities. Colorado was ranked fifth nationally in terms of total venture capital investment in clean energy between 2006 and 2008, with almost \$800 million invested in clean technologies.

18.7 Barriers to Planning for and Implementing Climate Solutions

As adaptation has become a focus of public policy, many states, local governments, tribes, for-profit and non-profit organizations, and individuals have encountered impediments to the development and implementation of mitigation and adaptation efforts. At the same time, researchers have made progress in documenting and examining these impediments, including in the Southwest.

The National Research Council distinguished four basic groups of barriers to climate action: (a) inadequate information and experience, (b) inadequate institutional support, (c) lack of resources and technology, and (d) behavioral impediments (NRC 2010a). These barriers were also found for mitigation (NRC 2010d) and are echoed in other studies (e.g., Post and Altman 1994; Verbruggen et al. 2009; Gifford, Kormos, and McIntyre 2011). More recent studies provide much more detailed insights into the range of impediments that decision makers encounter (e.g., Amundsen, Berglund, and Westskog 2010; Burch 2010; Storbjörk 2010; Ekstrom, Moser, and Torn 2011; Measham et al. 2011; McNeeley 2012; Moser and Ekstrom 2012).

Table 18.3 Examples of synergies and trade-offs between regionally relevant mitigation and adaptation activities and climate-change impacts

	Reforestation increases carbon storage and improves water resources.	Jimenez et al. 2009
Mitigation supports Adaptation	Moving from water-cooled concentrating solar power plants in California and Nevada toward dry cooling helps reduce water needs for the energy sector and leaves resources available for other users.	Schultz, Shelby, and Agogino 2010
	Increased urban tree cover increases carbon storage and shading, resulting in lower cooling-energy demand and fewer heat-related health risks.	Blate et al. 2009
	Installation of renewable energy systems in homes, farms, and tribal land, as well as building retrofits to increase insulation and energy efficiency reduce emissions and produce high-quality jobs, thus increasing income-generating opportunities for communities and lowering their vulnerability to change.	Averyt et al. 2011; Nowak, Crane, and Stevens 2006; Pataki et al. 2006; Chen et al. 2011
	Carbon capture and storage from coal-burning power plants increases demand on and creates greater competition for regionally scarce water resources.	Averyt et al. 2011
Mitigation undermines Adaptation	As hydroelectric power generation declines because of decreased precipitation, water supplies may become insufficient to meet all human and environmental needs, and the power deficit may be made up from CO ₂ -emitting sources.	Giridharan et al. 2007
	Power generation has occasionally depleted aquifers in the Southwest.	
	Power plants dependent on water cooling will release warmed waters into already warmer rivers and streams, adding further stress on aquatic plants and animals and reducing water quality.	
	The move to renewable energy can be water intensive: U.S. nuclear power plants may require as much as eight times more freshwater than natural gas plants per unit of electricity generated and 11 % more than coal plants. Some concentrating solar power plants consume more water per unit of electricity than the average coal plant.	
	More compact coastal urban design (to reduce transportation-related emissions) may increase the urban heat island effect and could concentrate development in hazardous areas (such as floodplains).	
Adaptation supports Mitigation	Improved forest fuel management (and reduction) decreases the risk of devastating wildfires (and thus large releases of carbon into the atmosphere), and thus maintains watershed health, reduces the risk of landslides, soil erosion, and destruction of infrastructure, and better preserves scarce water resources.	Carpe Diem West 2011

Table 18.3 Examples of synergies and trade-offs between regionally relevant mitigation and adaptation activities and climate-change impacts (Continued)

Adaptation supports Mitigation	<p>Efforts to increase rainwater infiltration on the land to improve water security and reduce the risk of sewer overflows and flooding during extreme rainfall events also reduces the need for energy-intensive sewage treatment and pumping.</p> <p>Coastal seagrass bed and wetland restoration increases carbon uptake and increases coastal protection against storms [1].</p>	Borel 2009; Waterfall 2006; PWA 2010; DeLaune and White 2011
Adaptation undermines Mitigation	<p>Desalination of seawater to increase local water security during drought years is a highly energy-intensive adaptation options, thus increasing CO₂ emissions (unless the desalination plant is solar-powered).</p> <p>Increased pumping for groundwater and increased recharge of depleted groundwater aquifers is energy-intensive and thus, typically, increases CO₂ emissions.</p> <p>Relocation of residents out of floodplains in ways that increase the overall need for driving increases one-time relocation-and rebuilding-related emissions and possibly increases transportation-related emissions.</p> <p>Extensive fortification of coastlines against sea-level rise and coastal flooding with seawalls also increases CO₂ emissions from cement.</p>	DOE 2006; Stokes and Horvath 2006; Lofman, Petersen, and Bower 2002 Biesbroek, Swart, and van der Knaap 2009 Boden, Marland, and Andres 2011

Note: [1] Additional benefits and cost savings may arise if sediment trapped in nearby bays or channels is used to help wetlands build up vertically; carbon storage benefit may be smaller if coastal storms cause severe damage to wetlands.

For example, in a survey of over 600 federal public land managers in Colorado, Wyoming, and Utah (Dilling 2012), lack of funding and lack of information (including both the uncertainty of information and its usefulness) were both ranked highly as barriers in moving forward to plan or implement adaptation strategies for climate change. Lack of specific agency direction was also mentioned as a key barrier. Public perception, including the perceived lack of importance and lack of demand from the public to take action on climate change may also act as hurdles in preparing for climate change. A perhaps unique challenge for public lands and other resources governed by federal law such as interstate water compacts (i.e., the Colorado River Compact) is that they have a decision process and legal framework that was developed under an assumption of climate stationarity—the concept that patterns of past climate provide a reasonable expectation of those of the future—an assumption that is no longer valid (Milly et al. 2008; Ruhl 2008). The legal framework defining decision making on public lands is likely to be another barrier to making adaptive decisions.

Box 18.6*Case Studies of Climate Choices for a Sustainable Southwest**Energy and Climate in the Southwest*

With all states in the Southwest implementing Renewable Portfolio Standards (RPS), the development of renewable energy sources is thriving across the region. Taking advantage of its unique position at the intersection of three of the country's ten major electrical grids as well as its natural resources, New Mexico has the potential to become a major hub for renewable energy with a proposed Tres Amigas "superstation" linking to the Electric Reliability Council of Texas, the Southwest Power Pool, and the Western Electricity Coordinating Council. New Mexico's RPS requires 10% of its energy to be generated from renewable sources by 2011, with an increase to

20% by 2020. The state is capitalizing on its diverse renewable energy potentials, including wind, solar, geothermal, and biofuels. To encourage the increased production and demand for alternative and renewable energy, New Mexico is implementing a variety of tax credits, tax deductions, and innovation funds. In addition, the state is expanding green-job training as well as research and development of clean technology across the state (as through the new North American Wind Research and Training Center, which partners with Sandia National Laboratories and New Mexico State University) (Thorstensen and Nourick 2010).

Box 18.7*Case Studies of Climate Choices for a Sustainable Southwest**Salt Lake City's Emission Reduction Efforts*

Salt Lake City is striving to reduce GHG emissions from municipal operations by 3% per year for the next ten years. By 2040, the city aims to reduce emissions by 70% (EPA n.d.). EPA and DOE have awarded an ENERGY STAR Award for Excellence to the Utah Building Energy Efficiency Strategies (UBEES), a coalition of government agencies, members of the building industry, and stakeholders, for their energy efficiency and renewable energy goals (Energy Star Program n.d.). Utah aims to source 20% of its energy from renewable energy sources by 2025. The state also

aims to improve energy efficiency 20% by 2015 (Energy Star Program n.d.). Utah's first commercial wind power project generates nearly 19 MW of energy through an urban wind turbine installation. Located in Spanish Fork, a city of 32,000 located fifty miles south of Salt Lake City, the project is a remarkable example of small-scale renewable energy production that faced many political, market, and social barriers and overcame them successfully through a transparent and patient stakeholder engagement process (Hartman, Stafford and Reategui 2011).

A detailed study on barriers to adaptation focused on four local coastal communities (two cities and two counties) and a regional process in San Francisco Bay (Moser and Ekstrom 2012). Its findings were extended through a survey of coastal communities along the entire California coastline (Hart et al. 2012), thus allowing for verification and generalization. The case study found institutional- and governance-related barriers to be the leading impediments to greater adaptation planning and implementation, followed by attitudinal and motivational barriers among the individuals and groups involved. Economic barriers mattered also, even in some of the wealthiest communities in that region (and the nation). Multiple lines of evidence confirmed the importance of institutional, individual, and economic barriers, which is also echoed in the broader literature. At the same time, the study revealed that communities have significant leverage over the barriers they face in the “here and now,” as well as many important advantages, and assets that either help avoid barriers in the first place, or help overcome them if they are encountered. To move beyond barriers created through decisions made in the past or at other levels of governance, as well as to manage obstacles resulting from entrenched local political dynamics and pressures, communities need assistance from higher levels of governance (see also Chapter 9, Section 9.5).

To help overcome the barriers that prevent communities, organizations, and businesses from planning for a climate-altered future or that pose time-consuming and costly obstacles to those ready to implement mitigation and adaptation actions, several critical steps can be taken. Much of the adaptation activity to date can be characterized as building capacity (including gathering relevant information, assessing risks, educating decision makers and affected stakeholders, and improving communication and cross-sectoral and cross-scale collaboration) (Moser and Ekstrom 2010, 2012). Several categories of supporting activities can be broadly categorized into cooperation and collaboration (across scales, agencies, public/private), market mechanisms (e.g., trading systems, pricing, valuing ecosystem services), legal reforms, mandates and standards, education, information and decision support, and—to move any and all of these forward—both technical and political leadership. Framing responses in terms of water conservation or energy efficiency, for example, may be more effective than making explicit links to climate change for some Southwest residents who are confused by the debate over climate science (Nisbet 2009; Resource Media 2009).

18.8 Coping with the Risks of Rapid Climate Changes

There is a risk that climate change might bring unacceptably large, sudden, or abrupt changes to the Southwest (see Chapter 7) and elsewhere, such as multi-decadal droughts, shifts to significantly higher temperatures (e.g., +3°F) in less than ten years, sea-level rise that is much faster than what has historically occurred, dramatic shifts in ecosystems (crossing of local- or larger-scale tipping points), or significant increases in the incidence of climatic extremes (Lindenmayer et al. 2010; Park et al. 2011; Smith, Horrocks et al. 2011). Even if such changes prompted steep emission reductions globally, the lags in the climate response would make it difficult to immediately stabilize the climate. Should such a scenario unfold, the Southwest may need to consider more dramatic and transformational adaptations to a changed climate (Smith, Horrocks et al. 2011; Kates, Travis and Wilbanks 2012; O’Brien 2012) or push for large-scale manipulations of the climate (also called geoengineering).

In conditions of water scarcity, for example, choices would need to be made about water-allocation priorities that would challenge traditional water rights in the West. Agriculture and ranching might need to shift into different places or species. Desalination and water reuse might become much more viable and socially acceptable options and urban areas might need to transform water use (Larson et al. 2005). Coastal settlements and infrastructure, as well as valued ecosystems, might need to be relocated on short timescales and thus possibly at considerable cost. Southwestern residents would need to consider their positions and choices on geoengineering options, which involve intentional interventions in the carbon cycle or in solar radiation to cool the planet (Victor et al. 2009; Caldeira and Keith 2010).

Box 18.8

Case Studies of Climate Choices for a Sustainable Southwest

Private Sector Responses in the Southwest: Freeport McMoRan mining

Multinational mining corporation Freeport McMoRan, based in Phoenix, operates eight copper mines in Arizona, Colorado, and New Mexico and has responded to environmental concerns, including climate change, by developing solar energy facilities in two Arizona mining communities, Bagdad and Ajo, and completing GHG inventories. Most of its emissions are from materials transport and the company states it is

focusing on improved fuel consumption. As a global business, Freeport McMoRan report to the Global Reporting Initiative and Carbon Disclosure Project. In 2010 the company reported worldwide emissions of 10 MMT; it is working on overall emission reduction plans, energy efficiency, and carbon offsets (http://www.fcx.com/envir/wtsd/pdf-wtsd/2010/WTSD_Bk_2010.pdf).

18.9 Research Gaps

A significant amount of general knowledge about mitigation and adaptation options is available to Southwest stakeholders. Few of these options have specifically assessed the costs, legal feasibility, or possible trade-offs of climate solutions with other policy goals. Thus, the practical basis for informed decision making is still relatively weak, even if much is known in general about possible climate responses. Tracking and evaluation of mitigation and adaptation activities is missing. Research on private sector actions is especially difficult and therefore largely missing. In addition, little has been done to evaluate plans and responses already underway and to assess the effectiveness of secondary actions that indirectly contribute to climate responses. For example, claims of climate action undertaken for other reasons such as energy or food security need to be assessed for their impacts. Other key research gaps include the analysis of trade-offs and of the long-term implications of choices on environmental impacts, vulnerability, and economic well-being.

The least developed or understood solutions are generally those that require deeper intervention in the various systems, such as through legal changes (for example, to water rights) or large-scale market mechanisms (for example, a functional regional carbon-trading scheme). Similarly, understanding the potential impacts of geoengineering interventions on many systems—regional climate, crop production, water availability, and human well-being—is a considerable challenge.

With key agencies, collaborative projects, and universities actively engaged in use-inspired⁴ climate research, the Southwest is uniquely endowed with research centers that have considerable expertise in developing effective relationships with stakeholders and decision makers and in developing decision-relevant information (Table 18.4). A fair amount is understood about how to do this well, and the Southwest may well lead the nation in this regard. The demand for use-inspired research and decision support is growing rapidly, and there is a growing need to expand the expertise and capacity to deliver on this need. Scaling up the capacity-building efforts among decision makers to understand and meet the challenges involved in risk management in the face of rapid changes must also be a priority.

Table 18.4 Climate science and assessment example activities in the Southwest

Type of Organization	Specific Programs in the Southwest	Geographic Scope of Program	Description and Mission
Regional Integrated Sciences and Assessments (RISAs; funded by NOAA)	Western Water Assessment <i>wwa.colorado.edu</i>	CO, UT	Identifying regional vulnerabilities to and impacts of climate variability and change, and developing information, products, and processes to assist decision makers throughout the Intermountain West.
	Climate Assessment for the Southwest <i>climas.arizona.edu</i>	AZ, NM	Improving the region's ability to respond sufficiently and appropriately to climatic events and climate changes.
	California-Nevada Applications Program <i>meteora.ucsd.edu/cap</i>	CA, NV	Developing and providing better climate information and forecasts for decision makers in California, Nevada, and the surrounding region.
Climate Science Center (CSC; funded by Department of the Interior)	<i>doi.gov/csc/southwest</i>	Entire Southwest	Providing scientific information, tools, and techniques that land, water, wildlife, and cultural-resource managers and other interested parties can apply to anticipate, monitor, and adapt to climate and ecologically driven responses at regional-to-local scales.

Table 18.4 Climate science and assessment example activities in the Southwest (Continued)

Type of Organization	Specific Programs in the Southwest	Geographic Scope of Program	Description and Mission
Landscape Conservation Cooperatives (LCCs; funded by Dept. of the Interior)	California LCC <i>californialcc.org</i>	Portions of CA	LCCs are public-private partnerships that complement and build upon existing science and conservation efforts—such as fish habitat partnerships and migratory bird joint ventures—as well as water resources, land, and cultural partnerships as part of the Department of the Interior’s collaborative, science-based response to climate change.
	Desert LCC <i>usbr.gov/WaterSMART/lcc/desert.html</i>	Portions of AZ, CA, NM, NV	
	Southern Rockies LCC <i>doi.gov/lcc/Southern-Rockies.cfm</i>	Portions of AZ, CO, NM, UT	
	Great Plains LCC <i>greatplainslcc.org</i>	Portions of CO and NM	
	Great Basin LCC <i>blm.gov/id/st/en/prog/Great_Basin_LCC.html</i>	Portions of CA, NV, and UT	
	North Pacific LCC <i>fws.gov/pacific/Climatechange/nplcc/</i>	Portions of CA	
NOAA Regional Climate Services	NOAA Western Region RCSD <i>noaaideacenter.org/rcsd/west/</i>	Entire Southwest	Building and strengthening regional partnerships to better assess and deliver regionally focused climate science and information products and services to help people make informed decisions in their lives, businesses, and communities.
	Great Northern LCC <i>nrmcs.usgs.gov/gnlcc</i>	Portions of CO and UT	
Bureau of Reclamation	Colorado River Basin Water Supply & Demand Study <i>www.usbr.gov/lc/region/programs/crbstudy.html</i>	Colorado River Basin	Defining current and future imbalances in water supply and demand, and developing and analyzing adaptation and mitigation strategies to resolve those imbalances.

Table 18.4 Climate science and assessment example activities in the Southwest (Continued)

Type of Organization	Specific Programs in the Southwest	Geographic Scope of Program	Description and Mission
The Nature Conservancy	Southwest Climate Change Initiative <i>conserveonline.org/workspaces/climateadaptation/documents/southwest-climate-change-initiative-0/view.html</i>	AZ, CO, NM, UT	Providing guidance to conservation practitioners and land managers in climate change adaptation planning and implementation on more local scales.
Northern Arizona University Institute for Tribal Environmental Professionals	Southwest Tribal Climate Change Network <i>www4.nau.edu/itep/climatechange/tcc_SWProj.asp</i>	AZ, NM	Identifying existing tribal climate change efforts being undertaken in Arizona and New Mexico; assessing tribal research and information needs regarding climate change issues; and developing strategies for meeting those needs.
University of Arizona Institute of the Environment	Southwest Climate Change Network <i>southwestclimatechange.org</i>	AZ, NM	Fostering a dialog and exchange of science and policy information among climate experts, other scientists, natural resource managers, utility providers, policy and decision makers, community groups, the public, and the media about climate-change issues in the Southwest.
Desert Research Institute	Western Regional Climate Center <i>wrcc.dri.edu</i>	Entire Southwest	Tracking and disseminating high quality climate data and information for the Western United States; fostering better use of climate data in decision making; conducting applied climate research; improving the coordination of climate-related activities.
Multi-university	Southwest Climate Alliance <i>southwestclimatealliance.org</i>	Entire Southwest	Working with the Southwest Climate Science Center to help regional stakeholders meet the needs of climate variability and change.
Multi-agency	Western Mountain Initiative <i>westernmountains.org</i>	Entire Southwest	Scientists from USGS and U.S. Forest Service working to understand responses of Western mountain ecosystems to climate variability and change.
Arizona State University	Decision Center for a Desert City <i>http://dcdc.asu.edu/</i>	AZ	Conducting climate, water, and decision research and developing innovative tools to bridge the boundary between scientists and decision makers and put this work into the hands of those whose concern is for the sustainable future of Greater Phoenix.

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Endnotes

- i Observed global emissions have accelerated from an increase of 1.1% per year in the 1990s to 3.5% per year from 2000–2007 (see McMullen and Jabbour 2009). The global recession produced only a slight drop in emissions in 2009 with the overall trend now upward again (Friedlingstein et al. 2010; Peters et al. 2011).
- ii Definition adapted from NRC 2010a.
- iii See <http://www.icleiusa.org/about-iclei/members/member-list>.
- iv The concept of “use-inspired” basic research was originally introduced by Stokes (1997); it refers to research that seeks basic understanding while considering social needs and potential usefulness.
- v The company website is at <http://www.fcx.com>.