Chapter 3

The Changing Southwest

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Executive Summary

This chapter describes important geographical and socio-economic characteristics and trends in the Southwest—such as population and economic growth and changes in land ownership, land use, and land cover—that provide the context for how climate change will likely affect the Southwest. The chapter also describes key laws and institutions relevant to adaptive management of resources.

- The Southwest is home to a variety of unique, natural landscapes—mountains, valleys, plateaus, canyons, and plains—that are both important to the region's climate and respond uniquely to changes in climate. Potential adaptation of human and natural systems will face challenges due to a complex pattern of land ownership, which crosses political and management jurisdictions and transverses significant elevational gradients. This decreases the adaptive capacity of the region because it makes it more difficult to coordinate decision making across landscapes. (medium-low confidence)

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- The Southwest has experienced rapid population increases and urban expansion for the past 150 years or so, and rapid population growth will likely continue to be an enduring feature, especially in urban areas. Indeed, the region will likely grow by an additional 19 million people by 2030 (from 2010). These changes will make it more difficult to manage natural resources because of the additional demand for and reliance on natural resources (e.g., water supply). (medium-high confidence)
- The coordination of climate-change adaptation strategies will be challenging because environmental management decisions will be made at many geographic scales, over different time frames, and by multiple agencies pursuing numerous associated policies and management goals. Adaptive capacity may be bolstered through lessons learned from emerging assessment projects (see Chapter 18). (medium-high confidence)

3.1 Lay of the Land: Geographical Themes and Features

Regions can be defined in many ways, but an important lesson from decades of geographical research is that the definition depends on the theme or topic being studied, the manner in which it is being studied, and the intended outcome of such a study. An assemblage of states provides the National Climate Assessment a way to divide assessment activities regionally. The "Southwest"—defined as the six contiguous states of Arizona, California, Colorado, Nevada, New Mexico, and Utah—rests on the certain logic of proximity and on the fact that states are important governmental units that must respond to the effects of climate variation and change. Beyond this basic political geography are several "critical zones" that are important to highlight because of their vulnerability to climate change, such as the coastal zone (see Chapter 9), the wildland-urban interface (see Chapter 13), the U.S.-Mexico borderlands (see Chapter 16), and the lands of Native nations (see Chapter 17).

Natural features

Two common geographical features tie the six states together. First, the states collectively span the most extensive arid and semi-arid climates and lands in the United States. Each state also touches and makes use of the waters of the Colorado River Basin. On the other hand, the six-state region, covering nearly 700,000 square miles, encompasses a variety of topography and landscapes, from the highest mountains in the conterminous United States (Mt. Whitney at 14,505 feet in California and Mt. Elbert at 14,440 feet in Colorado) to the lowest terrestrial point in the western hemisphere (Bad Water Basin in Death Valley at 282 feet below sea level). Significant physiographic and hydrologic features (Figure 3.1) include: a 3,400-mile shoreline along the Pacific Ocean that varies from cliff and rocky headlands to low-gradient coastal and brackish marshlands; the Central Valley of California; the Sierra Nevada; a southern reach of the Cascade Range; the extensive Basin and Range province; the Colorado Plateau; the Southern Rocky Mountains; and the western Great Plains (or "high plains") that skirt the region's eastern edge in Colorado and New Mexico (Hunt 1974). This natural landscape is also broken into hydrological basins, most notably the Sacramento-San Joaquin, Colorado, and Rio Grande, as well as

a large (260,000-square-mile) interior drainage—the Great Basin—which covers nearly one-fifth of the six-state region.

Figure 3.1 Important physiographic and ecoregional features of the Southwest. Water basin names are in upper-case, ecoregional names in lower-case. Source: ESRI ArcDate v10.

The juxtaposition of mountains, valleys, plateaus, canyons, and plains increases the degree to which the region will be affected by climate change. For example, the higher elevations produce the net annual runoff that provides water resources to the drier valleys, piedmonts, and plains where most of the region's human settlements are located. As a result, important sources of water for many urban areas are often quite far away (Southern California partially relies on water from the Colorado River, for example). As a result, potential feedbacks in the water resources system (in this case between the water users and their water sources) may be fairly weak or even "decoupled." Also, at a local scale the topographic variability of the Southwest is important because it may provide a buffer to climate change by conserving biodiversity (Ackerly et al. 2010). Yet many public and private land ownership boundaries occur in areas of steep elevational changes (Travis 2007), coinciding with boundaries between ecological systems (i.e., ecotones).

The land covers (Figures 3.2 and 3.3, and Table A3.1) draped on this topography are principally grassland and shrubland (55.3% of the region's land cover), marked by California chaparral and Great Plains grasslands as well as by extensive sagebrush and desert shrub and cacti mixes (such as found in the Sonoran and Mojave Deserts). Nearly one-quarter of the Southwest is covered by forests in a diverse array of mountain and high-plateau settings, including: extensive lodgepole pine in the Southern Rockies (notable for experiencing a significant die-off in recent years; see Bentz et al. 2010); topographically controlled forest islands in otherwise desert landscapes (the "Sky Islands" of southern New Mexico and Arizona); moist coastal and redwood and inland sequoia forests in California; park-like forests of ponderosa pine skirting the southern Colorado Plateau and eastern slopes of the Southern Rockies; and extensive pinyon-juniper at middle elevations in the Colorado Plateau and Great Basin (with pinyon also experiencing a significant die-off early this century; see Chapter 8). At the highest elevations are mountain peaks and alpine tundra (0.7%). About 6.6% of the Southwest has been converted to cropland agriculture, and another 2.3% has been developed as urban areas.

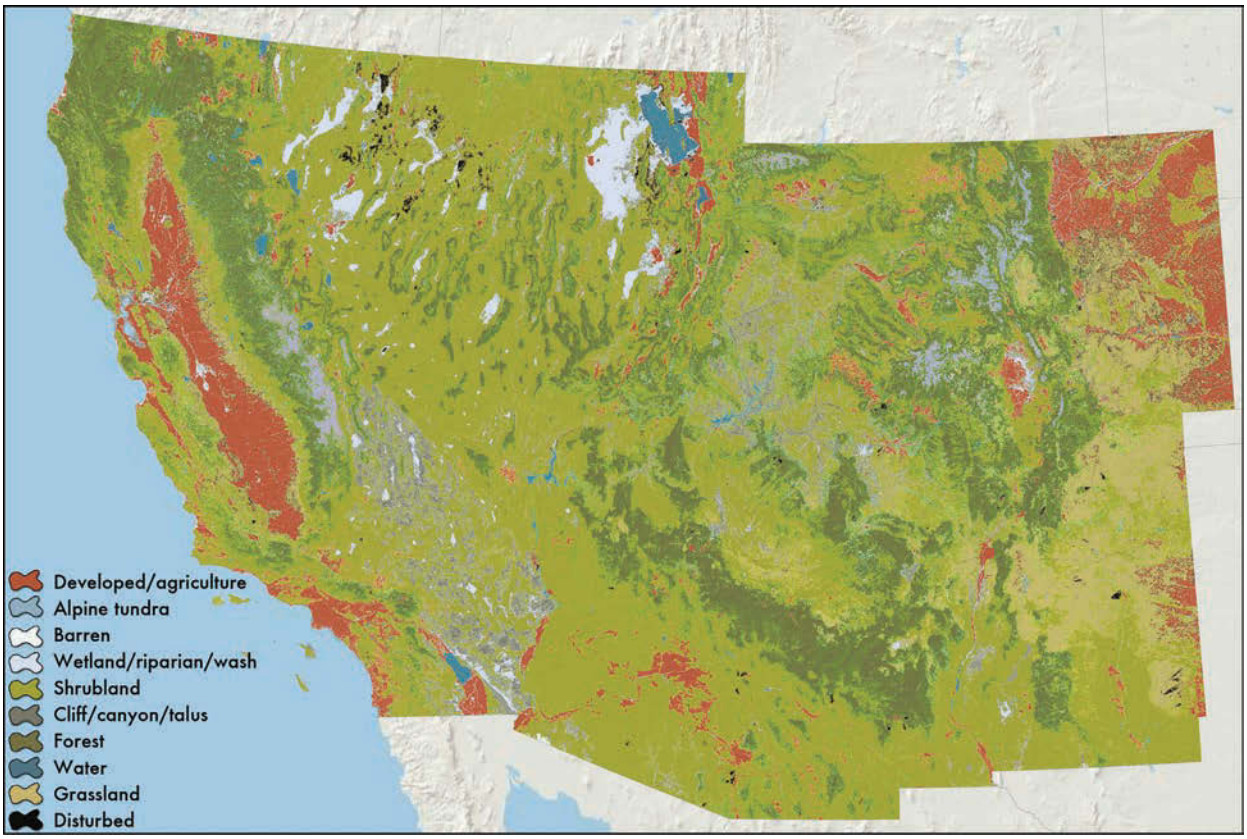

Figure 3.2 Land cover types in the Southwest. See Appendix Table A3.1 for classifications. Source: USGS (2010).

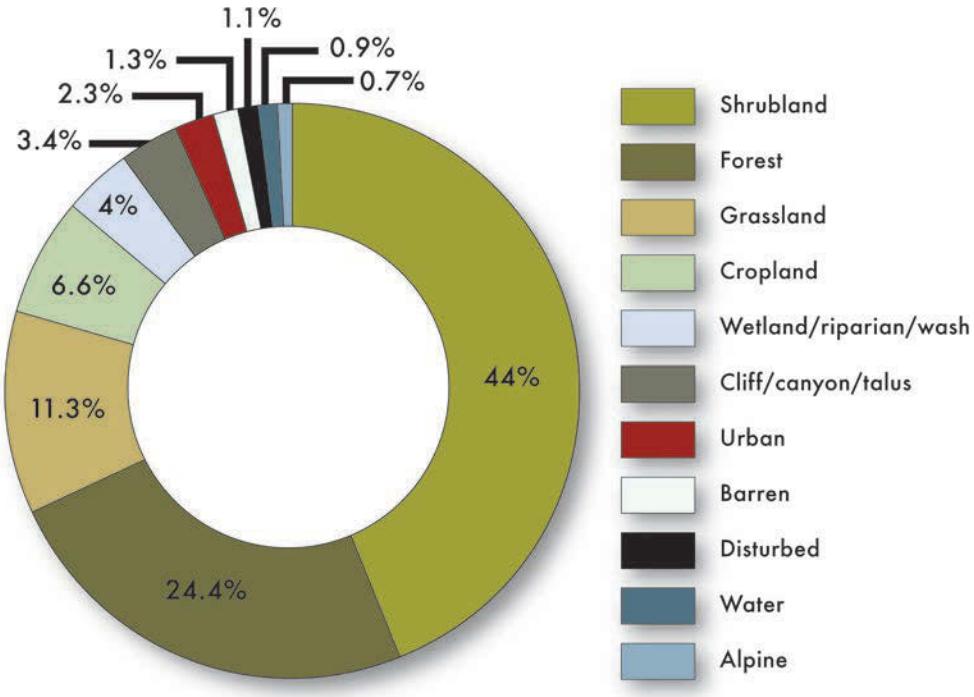

Figure 3.3 The proportion of land cover types found in the Southwest. See Appendix Table A3.1 for classifications. Source: USGS (2010).

Human geography

The human landscape of the Southwest is marked by a few large cities, some comprising sprawling metropolitan swaths, embedded in a predominantly rural landscape and in some places wilderness (Theobald 2001; Lang and Nelson 2007). The most notable metropolitan footprints include the Southern California conurbation around Los Angeles and San Diego; the San Francisco Bay Area; the string of cities marking California's Central Valley (from Redding to Bakersfield); Phoenix to Tucson; the Wasatch Front (anchored in Salt Lake City); and the Colorado Front Range centered on Denver. Smaller urban-suburban footprints in the region include Las Vegas, Reno, and Albuquerque. All told, there are thirty-nine metropolitan planning organizations centered on urban areas in the Southwest (these are described more fully in Chapter 13). Nearly all of these urban areas have grown significantly in the last few decades in both population and extent (Theobald 2001; Theobald 2005; Travis 2007) and many are surrounded by exurban development, much of which can be described as the "wildland-urban interface" (Radeloff et al. 2005; Theobald and Romme 2007). Beyond the exurban fringe, the region's rural landscapes include areas of dryland and irrigated agriculture, extensive rangelands (see Chapter 11), and isolated small towns and resorts. Although infrastructure is rather thinly dispersed across this rural landscape, areas of intense energy development and pockets of earth-transforming hard-rock mining also mark the landscapes.

A dominant feature of the region's rural geography is its extensive public lands, mostly federal, that encompass fully 59% of the six-state region's land surface (Figures 3.4 and 18.1). The federal lands are divided among agencies with different management mandates and goals, chiefly the Bureau of Land Management (BLM), Forest Service

(USFS), National Park Service (NPS), and Fish and Wildlife Service (USFWS). Each agency has efforts underway to plan for and adapt to climate change (Smith and Travis 2010). The lands of Native nations occupy another 7% of the region. Nearly five million acres of privately owned lands have been conserved in the past decade through land trust conservation (a 65% increase over that period). Especially relevant to climate vulnerability and adaptation in the Southwest is the mixture of ownership that occurs along the elevational gradients (Figure 3.4), which hints at the complexities of managing and cooperating for possible latitudinal and upward shifts of climates and migration of species. (For further discussion about the potential responses of plant and animal species to climate change, see Chapter 8).

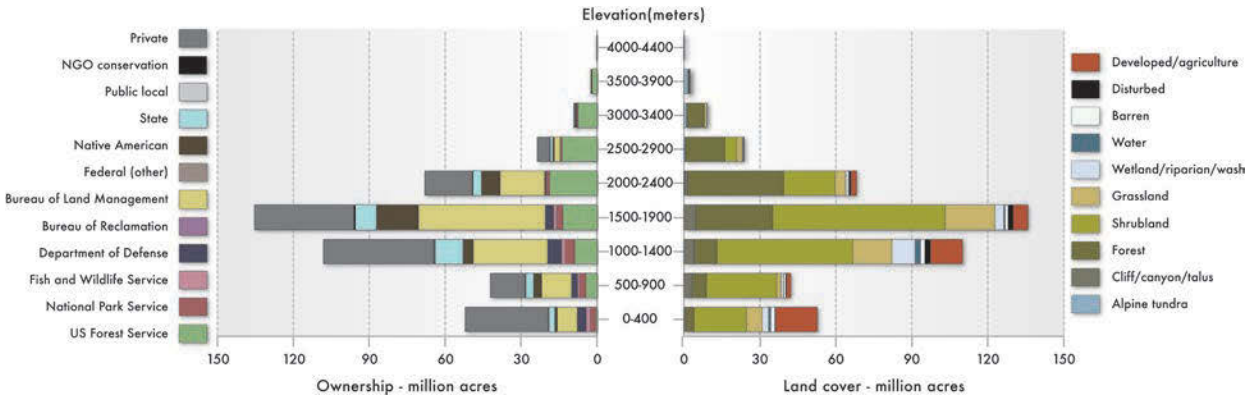

Figure 3.4 Spatial patterns of ownership and land cover types, arrayed along elevation gradients, are two critical aspects that hint at the complexities of coordinating adaptation strategies in the Southwest. All data up to 2010 taken from the US Census Bureau, with state specific projections from: AZ Dept. of Economic Security, CA Dept. of Finance, CO State Demographer's Office, NV State Demographer's Office, NM Bureau of Business and Economic Research, UT Governor's Office of Planning and Budget, and UT State Demographer's Office.

Public lands

The federal lands in the Southwest comprise 22 national parks, 74 national wildlife refuges, nearly 66 million acres of national forests, and 120 million acres under the jurisdiction of the BLM (see Figure 18.2). A patchwork of federal laws governs resource management policies on these lands (Table 3.1). For example, BLM policies are set under the Federal Land Policy and Management Act of 1976, which codified public ownership of BLM-managed lands and prescribed "multiple-use" management intended to direct resource use to "best meet the present and future needs of the American people" (Public Law 94-579). BLM lands are often managed for grazing, mineral and hydrocarbon extraction, and recreation, among other uses. The Department of Agriculture's USFS oversees National Forests through policies developed in accordance with the 1976 National Forest Management Act. This law requires National Forest System managers to develop integrated management plans intended to balance multiple intended uses while

maintaining forest resources for future generations. Primary uses of National Forests include timber harvesting, grazing, mineral extraction, and recreation. National Wildlife Refuges are administered by the USFWS, under the Department of the Interior. Refuges are managed under the National Wildlife Refuge System Administration Act of 1966 with the stated goal of establishing a network of lands for conservation, management, and restoration of fish and wildlife resources. Although primarily managed for species conservation and restoration, refuges may also host extractive industries and recreation, including hunting and fishing. The NPS was created under the 1916 National Park Service Act, which instructed NPS to manage scenery and natural and historic resources "unimpaired for the enjoyment of future generations." Individual units are managed under the terms of specific laws establishing each park.

A number of federal laws prescribe policies relevant to federal and other lands. The Wilderness Act of 1964, the Antiquities Act of 1906, and the National Landscape Conservation System Act of 2009 all provide additional legal authority to protect public lands. The National Environmental Policy Act of 1969 requires agencies to review environmental impacts of major environmental actions, while the Endangered Species Act of 1973 prohibits government and private actors from destroying habitat critical to the survival of threatened and endangered species.

Extractive resource use on federal lands is further guided by a number of laws, including the Surface Mining Control and Reclamation Act of 1977 (regarding coal extraction), the General Mining Act of 1872 (regarding hardrock mining), the Mineral Leasing Act of 1920 (regarding oil and gas resources) and the Taylor Grazing Act of 1934 (regarding sheep and cattle grazing).

A central difficulty of the patchwork of laws, policies, and regulatory agencies is that it poses a significant challenge to coordinate adaptation to climate change (although Landscape Conservation Cooperatives have recently been developed to address this issue under the auspices of the USFWS). The problem is further compounded by the relatively high levels of uncertainty associated with climate model predictions. A key is to develop proactive strategies to anticipate change and to adaptively manage resources throughout changing circumstances.

Population

The Southwest hosted a permanent resident population of 56.2 million in 2010 (Table 3.2). It has been the fastest-growing region of the nation for several decades as part of the so-called Sun-Belt Migration that began in earnest in the 1970s. The Interior West topped the national charts of population growth over the last two decades (1990–2010), with Nevada, Arizona, Utah, and Colorado comprising the four fastest-growing states in the country. The Southwest grew by 37%, from 41.2 to 56.2 million residents, during 1990–2010, compared to a national growth rate of 24% (1.2% annualized).

Growth in the region is concentrated in the metropolitan areas, and several Southwestern cities (most notably Las Vegas and Phoenix) have been among the fastest growing in the United States over the past two decades. The region is slightly more urbanized than much of the nation, with 82% of the population residing in urban areas compared to a national average of 78%. (See further discussion of the Southwest's urban areas in Chapter 13.)

Table 3.1 Federal laws and policies relevant to federal and other lands in the Southwest

Federal Law (Year Enacted)	Land Base or Resource Covered	Relevant Agency	Overarching Goal
POLICIES GUIDING FEDERAL LAND MANAGEMENT AGENCIES			
National Park Service Organic Act (1916)	National Parks and other park units	NPS	"Conserve the scenery and natural and historic objects and wild life … unimpaired for the enjoyment of future generations"
National Wildlife Refuge System Administration Act (1966)	National Wildlife Refuges	USFWS (on-shore resources); NOAA (offshore resources)	Conservation, management, and restoration of species
Federal Land Policy and Land Management Act (1976)	BLM Lands	BLM	Multiple use to best meet the present and future needs of the American people
National Forest Management Act (1976)	National Forests	USFS	Integrated planning for sustained multiple uses of renewable resources
ADDITIONAL LAWS PROTECTING PUBLIC LANDS			
Antiquities Act (1906)	National Monuments	Primarily NPS, also including USFS and BLM	Preservation of resources of "historic or scientific interest"
Wilderness Act (1964)	Specified federal public lands	Primarily USFS, BLM, and NPS	Preservation of lands with wilderness characteristics
National Landscape Conservation System Act (2009)	Specified federal public lands	NPS, USFS, and BLM	Conservation, protection, and restoration of nationally significant western public lands with outstanding natural, cultural, or scientific values
LAWS PROTECTING WILDLIFE AND RESOURCE MANAGEMENT POLICIES			
National Environmental Policy Act (1969)	Any major federal action	All federal agencies	Requires review of environmental impacts resulting from any major federal action
Endangered Species Act (1973)	Threatened and endangered species	USFWS, although applies to all federal agencies	Conservation, protection, and recovery of threatened and endangered species

Table 3.1 Federal laws and policies relevant to federal and other lands in the Southwest (Continued)

Federal Law (Year Enacted)	Land Base or Resource Covered	Relevant Agency	Overarching Goal
LAWS GOVERNING RESOURCE EXTRACTION AND GRAZING			
General Mining Act (1872)	Minerals found on federal lands	All federal land management agencies	Set policies for the discovery, claim, and recovery of hardrock resources under federal lands
Mineral Leasing Act (1920)	Oil and gas extraction	All federal land management agencies	Set policies for the extraction of oil, gas, phosphate, sodium, and coal on federal lands
Taylor Grazing Act (1934)	Rangeland	Federal agencies that manage grazing (primarily BLM and USFS)	Prevent overgrazing and provide for the permitting of grazing on public lands
Surface Mining Control and Reclamation Act (1977)	Coal on federal lands	All federal land management agencies	Ensure appropriate regulation of mining and reclamation on federal lands

Most analysts expect the West, and especially the Southwest, to continue growing in population faster than the nation as a whole for the foreseeable future (Travis 2007). This prediction is based on positive trends in all of the demographic components of population change: natural growth (births over deaths), domestic net in-migration, and international net in-migration. The Census Bureau's population projections to 2030 (Table 3.2) reflect this scenario. Arizona and Utah likely will grow by about 50% of their 2010 populations, and Colorado and New Mexico are expected to add another third to their populations (Figure 3.5). Even California, building on a large base (37.2 million in 2010), is projected to grow by nearly a third. In all, some 18.8 million more people likely will live in the West by 2030 than did in 2010. Most states extend their projections even further in time; linear extrapolation to each state's extended population projection suggests a regional population in 2050 of around 94.8 million, a 69% (1.37% annualized) increase over the 2010 census.

Natural resource economy

Two trends are clear with respect to the Southwest's natural resource-based economy (Figure 3.6). First, the iconic Western economies of agriculture, ranching, fishing, hunting, and mining have lost ground, and now contribute only a small fraction of the overall gross domestic product or GDP of the region, averaging around 4.5% for the past three decades and never reaching higher than 7% per year during that period. Second,

Table 3.2 Trends in population growth in the Southwest (in thousands of people)

State	1990	2000	2010	Total Growth 1990–2010	% Growth 1990-2010	Projected Pop. 2030	% Growth 2010–2030	Total Growth 2010–2030
Arizona	3,665	5,130	6,392	2,726	74	9,480	48	3,088
California	29,760	33,871	37,253	7,493	25	48,380	30	11,127
Colorado	3,294	4,301	5,029	1,734	53	6,564	31	1,535
Nevada	1,201	1,998	2,700	1,498	125	3,363	25	663
New Mexico	1,515	1,819	2,059	544	36	2,825	37	767
Utah	1,722	2,233	2,763	1,041	60	4,394	59	1,631
TOTAL	**41,159**	**49,353**	**56,198**	**15,039**	**37**	**75,010**	**33**	**18,811**

Sources: U.S. Census sources [for pre-2010] and state demographer's projections [for 2010 and beyond].

after a period of relative stability or small increases from the 1970s to the mid-1980s (averaging 5.4% over that 15-year period), the contribution of these natural resource sectors has declined by a third in the past 15 years (now averaging 2.9% per year). Finance, professional services, and the like now contribute a large majority of GDP, followed by construction and manufacturing.

3.2 Land Use and Land Cover

The pace and types of land-use and land-cover change (from one type of land use or land cover to another) from 1973 to 2000 varied across the Southwestern states (Figure 3.7, and Table A3.2). The average annual rate of the combined changes ranged from <0.1% of the total area of Nevada to 0.4% of neighboring California. Annual rates of change were consistently higher in Colorado and California, although the amount of change in New Mexico tripled beginning in the mid-1980s. Numerous factors contributed to the state-by-state variability, including the mix of land ownership, population changes, government policies and regulations, and climate variability.

The arid states with extensive public lands that limit land use options—Arizona, Utah, and Nevada—have some of the lowest rates of land-use and land-cover change in the nation. These states and other areas of warm deserts (i.e., the Chihuahuan, Sonoran, and Mojave) also lack the large extent of agricultural land cover fluctuation (such as occurs in the Great Plains of eastern Colorado, New Mexico, and California's Central Valley) and intensive forest harvesting that contribute to higher rates of land-use and

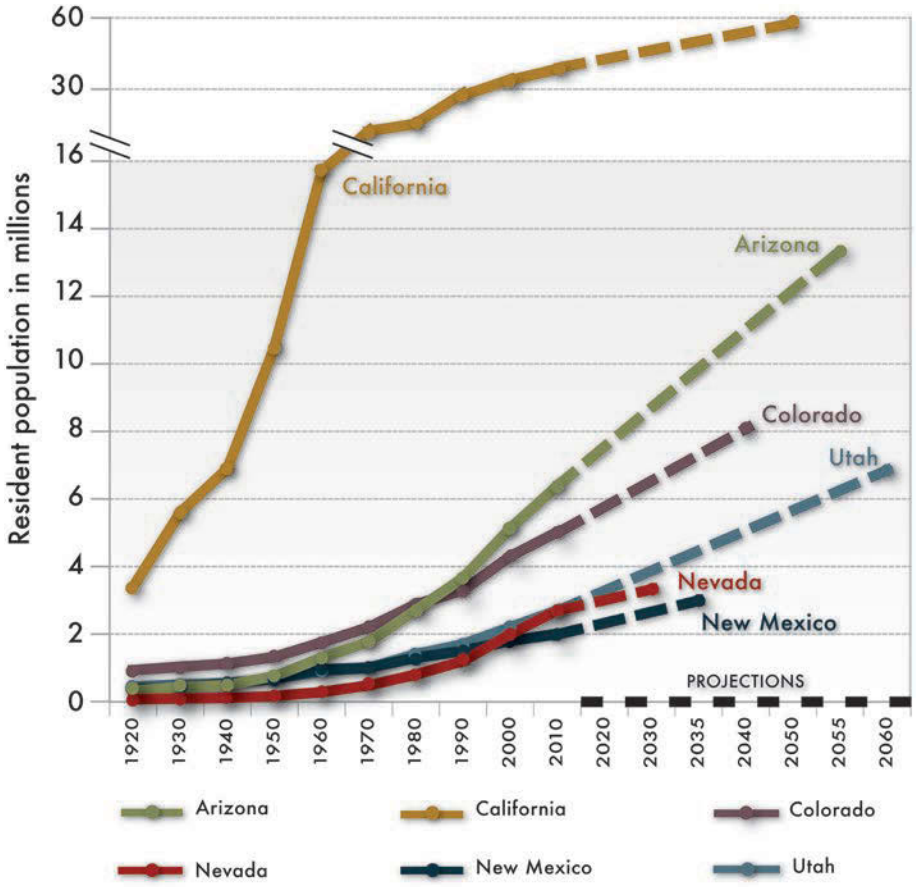

Figure 3.5 Rapid population growth in the Southwest is expected to continue. The current (2010) population is 56 million, and an additional 19 million people are projected to be living in the region by 2030. Source: US Department of Commerce, Bureau of Economic Analysis (http://www.bea.gov/regional/index.htm).

land-cover changes in other U.S. regions. However, lower rates of land-use change do not preclude important change-related effects, such as irreversible or slow recovery of disturbed lands. For example, in Nevada, although low rates of change occurred, disturbed forested areas were slow to recover and grasslands/shrublands converted for urban development and mining contributed to the net decline of natural cover types.

Other trends between 1973 and 2000 are notable. The extent of urban development, mining, fire, and other natural land disturbance increased across all Southwestern states. Urban land cover increased by an estimated 45%, affecting 0.5% of the total area. Most of the growth in urban and other developed lands occurred on grassland/shrubland (56%), although more than one-third of the expansion was at the expense of cropland agriculture and maintained pasture (34%). Nearly 90% of the agricultural land converted to urban areas was in California and Colorado. The loss of agriculture to development and other causes in California's Central Valley is offset by expansion of new cultivated areas; however, other types of conversions cumulatively resulted in a small net loss of agricultural land cover in the state. California's developed lands increased overall by an estimated 40% between 1973 and 2000. This increased land-use conversion and development in the Southwest generates increased pressure and need for a coordinated land management approach for successful adaptation to climate change.

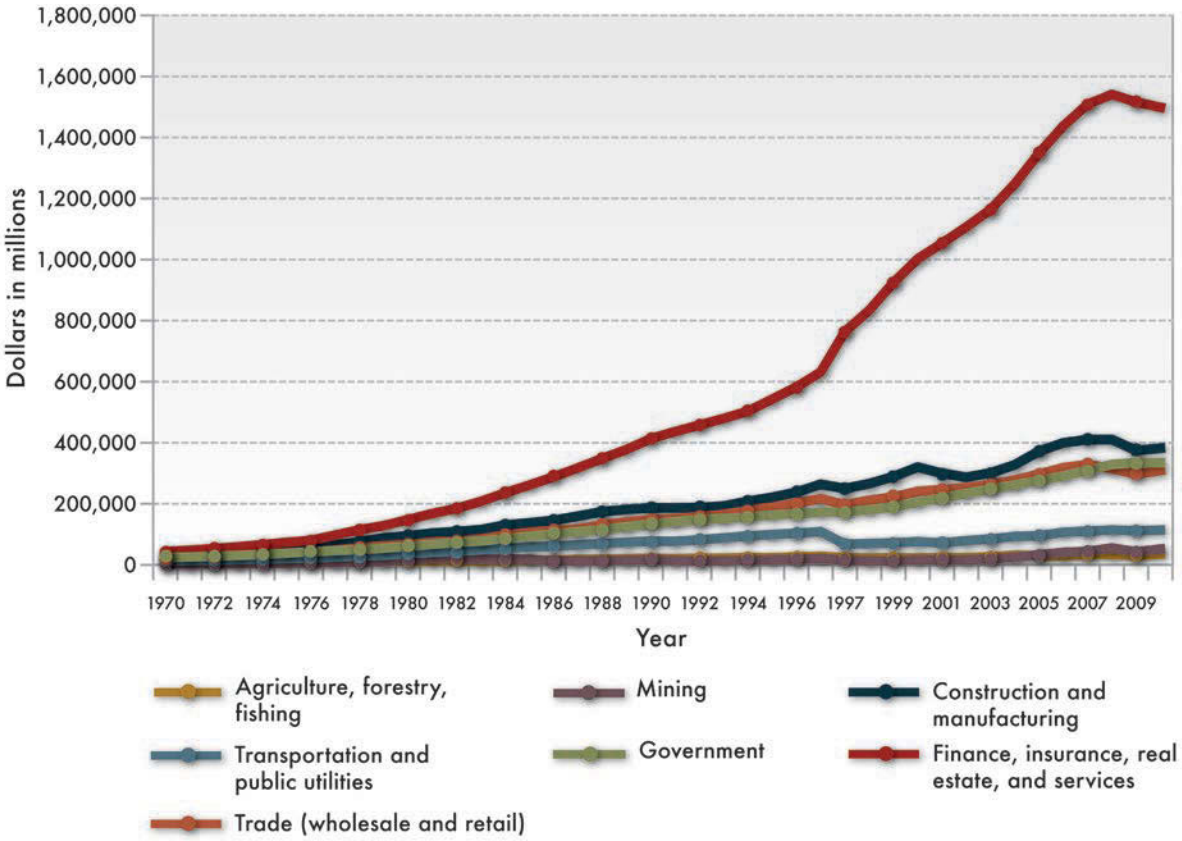

Figure 3.6 The Southwestern economy grew rapidly from the 1970s through 2008, with a decline commencing with the recession. The strongest economic sectors were finance, insurance, real estate, and services, followed by construction and manufacturing, trade, and government. The more traditional natural resource economies remain important but provide only a small portion of the GDP of the region (shown in millions of dollars). Note that previous to 1998 income by industry were defined using the Standard Industrial Classification, and in 1998 and after were defined using the North American Industry Classification System. This definitional change resulted in a slight down-tick in Construction and manufacturing, Agriculture, forestry, and fishing, and Transportation and public utilities, and the up-tick in Finance, insurance, real estate, and services. Longer-term trends (>5-10 years) remain robust to this definitional change. Source: U.S. Department of Commerce, Bureau of Economic Analysis (http://www.bea.gov/regional/index.htm).

Forest cover declined in all states by a combined 2.2% (0.5% of the region) due primarily to mechanical disturbance (e.g., timber harvest) and fire, although some of the decrease occurred on land with potential for eventual tree regrowth following fire or post-harvest replanting. The extent of mechanical disturbance was highest in the mountains and foothills of California, central Arizona, and New Mexico. However, Colorado and other states may see an increase in timber harvest related to insect-related forest die-off exacerbated by changing climatic conditions.

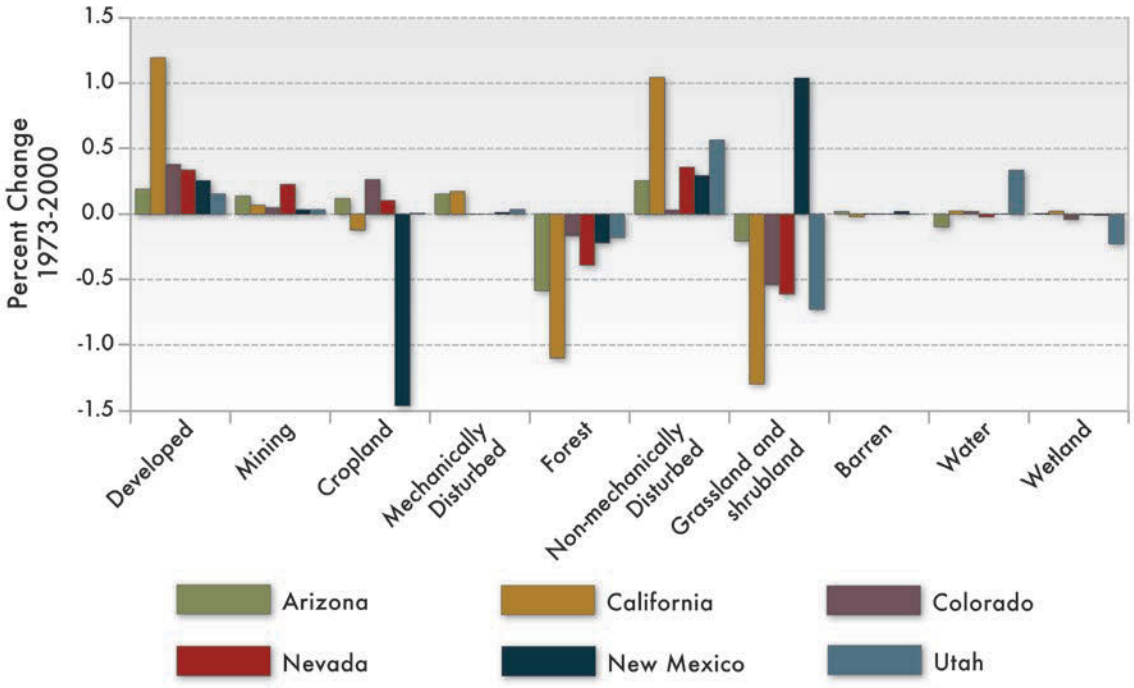

Figure 3.7 Percent of total state area affected by net change in land use and land cover types from 1973 to 2000 for the six Southwestern states. See Appendix Table A3.2 for class descriptions. Source: USGS land cover trends project (http://landcovertrends.usgs.gov); Loveland et al. (2002).

Changes in agricultural land cover, which declined by 3.5% (0.2% of the region), often show a reciprocal relationship with grassland/shrubland changes (0.6% decline, 0.4% of the region), although the extent of exchange between the two types of cover is often uneven. Conversions from grassland and shrubland to agriculture were more extensive in Colorado, Arizona, and Nevada, resulting in small net increases in agriculture. A substantial net decline in agricultural land cover occurred in New Mexico, where a significant amount of cropland was returned to grassland cover in response to incentives of the Conservation Reserve Program to set aside environmentally sensitive land. The overall decline in grassland/shrubland (except in New Mexico) is tied to agricultural expansion, as well as to urban growth and development, expansion of mining, and other disturbance.

Trends for urban and exurban development

Associated with rapid population growth in the Southwest, the extent of urban land (housing density greater than one unit per 2.5 acres) and exurban land (one unit per 2.5–40 acres) will continue to increase (Figure 3.8; Table 3.3). The extent of urban land is forecast to double (from 4.1 to 8.1–9.3 million acres) by 2050, while lower-density exurban lands will expand by 33% to 41% (from 13.6 to 18.2–19.1 million acres) (Bierwagen et al. 2010).

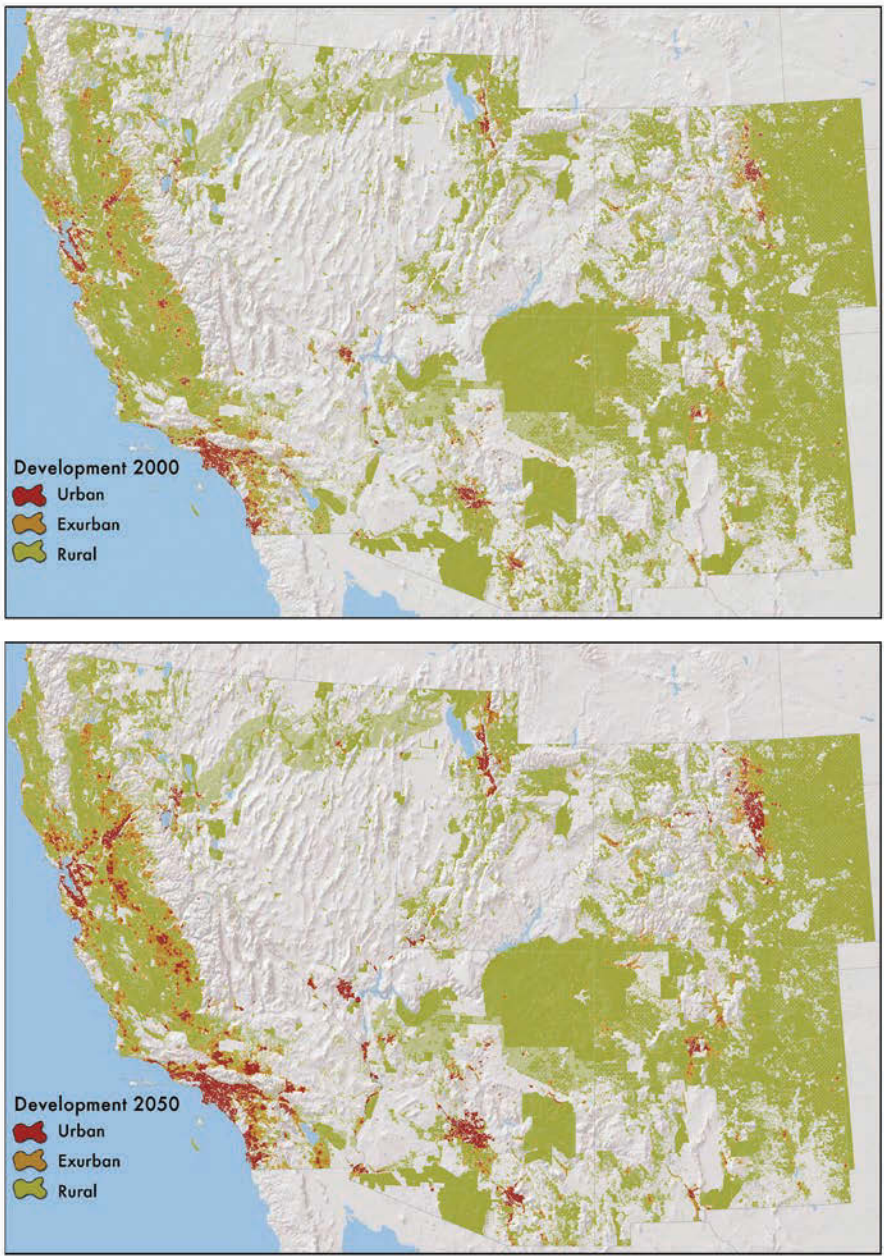

Figure 3.8 The pattern of urban, exurban, and rural residential development for 2000 and forecast for 2050. Source: Bierwagen et al. (2010).

Both the rapid pace and patterns of population growth and ensuing land use change provide both challenges and opportunities for adapting to climate change. A near-doubling of population from 2000 to 2050 will increase already stressed water resources in particular. Although most of the population in the Southwest lives in urban areas, the footprint of these areas is likely to more than double, from about 4 million acres to 8–9 million acres. An additional 10–11 million acres of low-density (exurban) housing density (see Table 3.3) is likely to contribute significantly to the number of miles travelled in vehicles.

Table 3.3 Historical, current, and forecasted expansion of urban and exurban lands in the Southwest (data expressed as thousands of acres [kac])

Geography	Historical (1950)		Current (~2000)		Forecast (~2050)	
	Urban developed (kac)	Exurban developed (kac)	Urban developed (kac)	Exurban developed (kac)	Urban developed (kac)	Exurban developed (kac)
STATES						
Arizona	30	224	544	1,441	1,255	1,967
					1,448	1,818
					1,054	1,928
					1,163	1,884
California	597	2,334	2,516	7,962	4,995	11,727
					5,349	11,374
					4,874	10,555
					5,058	10,384
Colorado	68	355	402	1,690	1,024	2,204
					1,003	2,202
					785	2,311
					766	2,333
New Mexico	24	237	191	1,328	324	1,730
					348	1,812
					277	1,841
					287	1,925
Nevada	8	65	179	428	562	510
					500	521
					463	516
					419	521
Utah	33	235	224	655	696	863
					580	965
					599	938
					485	1058
Southwest	767	3,477	4,083	13,563	8,894	19,074
					9,270	18,762
					8,092	18,158
					8,218	18,174
WATER RESOURCE REGIONS						
Rio Grande	21	208	161	1,035	291	1,361
					314	1,386
					241	1,407
					250	1,456

Table 3.3 Historical, current, and forecasted expansion of urban and exurban lands in the Southwest (data expressed as thousands of acres [kac]) (Continued)

Geography	Historical (1950)		Current (~2000)		Forecast (~2050)	
	Urban developed (kac)	Exurban developed (kac)	Urban developed (kac)	Exurban developed (kac)	Urban developed (kac)	Exurban developed (kac)
Upper Colorado	7	112	79	889	150	1,118
					144	1,146
					118	1,183
					114	1,198
Lower Colorado	34	269	677	1,665	1,691	2,161
					1,879	2,006
					1,393	2,182
					1,496	2,144
Great Basin	37	259	283	835	899	1,199
					738	1,306
					769	1,222
					629	1,335
California	596	2311	2495	7874	4908	11,582
					5250	11,248
					4818	10,413
					4991	10,254

Source: Bierwagen et al. (2010).

Note: These reflect the storylines used in the IPCC's Special Report on Emissions Scenarios (Nakićenović and Swart 2000): A1, A2, B1, and B2, from top to bottom.

A remaining question of importance for this region is how well emerging "green design" strategies will be able to diminish or reduce resource demands for energy and water. Much of the development of alternative resources such as wind and solar energy has occurred remotely from the urban areas to be served, as has water-supply infrastructure. This geographical decoupling can be useful in some settings, but further removes social systems from natural system feedbacks. This can be a positive thing, but also can hinder the development of adaptive strategies because of a perceived lack of need to change behavior.

With environmental management decisions taking place at many geographic scales, over different time frames, and by multiple agencies, the coordination of climate change adaptation strategies will be a particular challenge.

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Appendix

See following page.

Table A3.1 List of ecological systems and groups, modified from USGS Southwest region

Group (L1)	Ecological systems
Alpine	Alpine sparse/barren
	Alpine grassland
Cliff-canyon-talus	Cliff, canyon and talus
Developed	Urban/built-up
	Cropland
Disturbed	Mining
	Recently burned
	Introduced vegetation
	Other disturbed or modified
Forest	Deciduous-dominated forest and woodland
	Mixed deciduous/coniferous forest and woodland
	Conifer-dominated forest and woodland
Grassland	Montane grassland
	Lowland grassland and prairie
	Sand prairie, coastal grasslands and lomas
	Wet meadow or prairie
Shrubland	Scrub shrubland
	Steppe
	Chaparral
	Deciduous-dominated savanna and glade
	Conifer-dominated savanna
	Sagebrush-dominated shrubland
	Deciduous-dominated shrubland
Sparse-barren	Beach, shore and sand
	Bluff and badland
	Other sparse and barren
Water	Rivers, lakes, reservoirs
Wetland-riparian	Playa, wash, and mudflat
	Salt, brackish & estuary wetland
	Freshwater herbaceous marsh
	Freshwater forested marsh or swamp
	Bog or fen
	Depressional wetland
	Floodplain and riparian

Source: USGS (2010).

Table A3.2 List of USGS land cover trends class descriptions

Land Cover Class	Description
Agriculture (cropland and pasture)	Land in either a vegetated or unvegetated state used for the production of food and fiber, including cultivated and uncultivated croplands, hay lands, pasture, orchards, vineyards, and confined livestock operations. Forest plantations are considered forests regardless of their use for wood products.
Barren	Land comprised of soils, sand, or rocks where <10% of the area is vegetated. Does not include land in transition recently cleared by disturbance.
Developed (urban and built-up)	Intensive use where much of the land is covered by structures or human-made impervious surfaces (residential, commercial, industrial, roads, etc.) and less-intensive use where the land-cover matrix includes both vegetation and structures (low-density residential, recreational facilities, cemeteries, utility corridors, etc.), and including any land functionally related to urban or built-up environments (parks, golf courses, etc.).
Forest and Woodland	Non-developed land where the tree-cover density is >10%. Note cleared forest land (i.e. clear-cuts) is mapped according to current cover (e.g. mechanically disturbed or grassland/shrubland).
Grassland/Shrubland (including rangeland)	Non-developed land where cover by grasses, forbs, or shrubs is >10%.
Mechanically Disturbed	Land in an altered, often unvegetated transitional state caused by disturbance from mechanical means, including forest clear-cutting, earthmoving, scraping, chaining, reservoir drawdown, and other human-induced clearance.
Mines and Quarries	Extractive mining activities with surface expression, including mining buildings, quarry pits, overburden, leach, evaporative features, and tailings.
Non-mechanically Disturbed	Land in an altered, often unvegetated transitional state caused by disturbance from non-mechanical means, including fire, wind, flood, and animals.
Open Water	Persistently covered with water, including streams, canals, lakes, reservoirs, bays, and ocean
Wetland	Land where water saturation is the determining factor in soil characteristics, vegetation types, and animal communities. Wetlands can contain both water and vegetated cover.

Source: USGS (2010).