

IBS

INSTITUTE OF BEHAVIORAL SCIENCE ■

**RESEARCH PROGRAM ON
ENVIRONMENT and BEHAVIOR ■**

University of Colorado at Boulder
Boulder CO 80309-0484

***WORKING PAPER* EB2003-0004 ■**

The Geography of Development and Water in the American West

William R. Travis

November, 2003

Working Paper:

The Geography of Development and Water in the American West

William R. Travis
Department of Geography
and
Institute of Behavioral Science/ Program on Environment and Behavior
260 UCB, University of Colorado
Boulder, CO 80309-0260
wtravis@colorado.edu voice 303-492-6312 fax 303-492-7501

[Paper prepared for the USFS/University of Montana Water Synthesis Project]

Abstract

This paper offers an overview of the geography of demographics, development, land use and water in the American West, providing a geographic context to the Water Project Synthesis Papers. It touches lightly on topics to be elaborated in other papers and delves more deeply into a few key interactions among regional development, water and associated resources, especially changes in agricultural and urban land uses, and water needs in recreation and species protection. The current facts of Western development speak to a building tension among resource uses. The region is gaining population faster than any other part of the country, with growing rural and urban land uses, including irrigated agriculture, energy extraction, and sprawling residential and commercial development. This volatile mix is further leavened by increased demands for recreational and environmental uses of both land and water. Instead of the West's scarce water guiding or limiting land development, development (for both traditional uses like irrigation and the region's burgeoning urbanization) drives water use. This is illustrated by water development plans of the fastest-growing cities in the U.S., like Las Vegas and the Denver metro-area, which have successfully provided water to their rapidly growing populations and have stratagems in place to meet foreseeable future needs. The optimism evinced in such plans is supported by the simple fact that the vast majority of water use in the West is in agriculture,

and cities plan to acquire some of this water as needed, at prices that, in the past, have enticed farmers to sell. Still, and surprisingly, irrigated land is not declining as much as conventional wisdom suggests, has even increased in most western states in recent years (according to some data), and is expected to hold its ground.

Just how sustainable is this pattern of regional development and its demands on water? Record population growth now accompanies record amounts of natural gas and coal production. Sub-divisions squeeze out farms and ranches, which themselves reduced natural grasslands, predators, and streamflows. Growing human population adds to recreational demands, while the effort to preserve bio-diversity places its own demands on water and related habitat. Experienced observers of the West are alarmed, and their prescriptions for regional development are hopeful but may be tough medicine for a development-minded system. Larry MacDonnell (1999) lays out the needed shift in western water development:

The task occupying our attention for the past 150 years---establishing human control over water resources to meet human needs---is now largely complete. The primary task ahead is to integrate changing human water needs and interests and to restore and maintain ecological functionality of water-dependent natural systems. (p. 286).

A tall order, indeed, for a region perpetually focused on creating the next boom.

Introduction

This paper offers an overview of the geography of demographics, development, land use and water in the West, providing a geographic context to the Water Project Synthesis Papers. It touches lightly on topics to be elaborated in other papers and delves more deeply into a few key interactions between regional development, water and associated resources, especially changes in agricultural and urban land uses. As an assessment of the state-of-the-art, the paper also evaluates what we know about

demographic and land use trends, and our ability to project them into the future and assess their effects on water resources.

Logic suggests that the geography of water resources strongly shaped, and continues to influence, development in the American West, the driest region of the country. And certainly the location of early development---the first settlements and resource extraction outposts---was affected by water availability and this paper briefly describes that relationship. But we have only to note that the two fastest-growing cities in the United States today, Las Vegas and Phoenix, are also the driest large cities in the nation, to realize that the relationships among water, demography, and development are not simple, nor are they uni-directional. Since the 1902 Reclamation Act, under which the first major project was a water supply system for Phoenix, huge investments have reduced the strictures that water, or at least the geography of water, place on western development. Indeed, the century-long effort to store water in high elevation watersheds or along the major rivers, and to transport it to agricultural and population centers, has had its desired effect: more agriculture and more settlement, in some very dry landscapes, than many early appraisals envisioned or thought possible; more than some analysts today feel is sustainable

Socio-economic trends in the modern West further complicate the interaction of water and development, especially the rise of an economy less tied to natural resources extraction and the region's increasing attractiveness to people and jobs. But contemporary discourse about the relationship between the geography of water and of development still reflects two broad, countervailing views: (1) water strongly shapes and limits development in this semi-arid zone, and will limit future development, or (2) water is just one of the many resources that must be, and routinely are, marshaled, moved, processed and distributed to support regional growth and development.

Hydraulic Essentialism: No Water, No Development

Obviously, native and early European inhabitants of the West, lacking technologies to drill tunnels under mountain ranges or to store millions of acre feet of water in reservoirs, were tied to the region's limited and spotty surface water supplies, on something of a rather short leash at that. About half of the area west of the 100th

meridian receives only 10-20 inches of precipitation on average annually, and most of the West's terrain produces little or no runoff (Vale, 1995). Riparian zones probably account for only 1% or less of the landscape in places like Wyoming (Knight, 1994) and only some 5% of higher-elevation, forested landscapes (Southern Rockies Ecosystem Project, 2000). Runoff is highly variable. Precipitation in arid and semi-arid regions is negatively-skewed, meaning that the average annual precipitation is generally wetter than the median or modal value---westerners cannot rely on averages! Much of the West, even its wetter sections, also shows large intra-annual (seasonal) variation in precipitation and runoff, so that water is not always naturally available as runoff when it is desired for various uses. Most problematically, western precipitation is affected by multi-year swings in Pacific Ocean conditions, like the *el nino* warming. This causes runs of wet or dry years that are especially difficult to mitigate because their effects accumulate in both managed resource systems and natural ecosystems (see, for example, Miller, 1997; Redmond and Koch, 1991 for details of climate and runoff variability in the West).

Certainly water availability shaped early land uses. Native population densities are generally assumed to have reflected precipitation patterns or, more accurately, the endowments of vegetation and wildlife that are linked to precipitation. Native population nodes, some of which later became towns and cities, were at water sources (e.g., along major waterways like the Missouri River and Columbia Rivers; at springs like Flagstaff; or along the shores of freshwater lakes, like Walker Lake in Nevada). Early Euro-American incursions into the region, up the Rio Grande River and on the Santa Fe and Oregon trails for example, either followed water courses or traversed from water source to water source (Beck and Haase, 1989, pp. 32-33). Lewis and Clark essentially floated across the West. The first gold rushes were based on placer deposits in stream beds, and much gold was recovered through hydraulic mining ("hydraulicking"), a practice that left degraded riparian landscapes still visible today in both the Rockies and the Sierra Nevada (Rohe, 1995; Wohl, 2001). Early Euro-American permanent settlements, such as the Spanish colonization of the Upper Rio Grand, Mormon settlement in the Salt Lake Valley, and the first permanent towns along the Rocky Mountain front ranges, were essentially all on rivers or streams (Beck and Haase, 1989; Hornbeck, 1990;

Westcoat, 1990; Wohl, 2001). Even some settlements that seem hydrologically illogical today had water at their base: Las Vegas began as a stop on the Salt Lake to Los Angeles freight trail instituted by Mormon leader Brigham Young to provide ocean access to his mostly-inland “State of Deseret.” About half way along this mostly dry route, the site offered several springs and marshes. Of course, those springs are totally inadequate to southern Nevada water demands today, but they anchored the primal Vegas Strip.

Lack of water left its mark on the cultural landscape. Trails avoided larger deserts and playas in Utah, Nevada and California, though various short-cuts and “cut-off’s” did entice some immigrants across these truly arid landscapes, often with disastrous results. Readers of Historian Patricia Limerick’s stories of travelers caught without water will appreciate having a cool glass of the stuff on hand (Limerick, 1989). Every early party crossing the Interior West thought a lot about water; Wallace Stegner recounts the Mormon’s 1847 indecision at Sublette’s cut-off in southwestern Wyoming, where they would leave the Big Sandy River and face “a forty-three mile waterless *jornada* to the Bear River.” (Stegner, 1964, p. 154). But even true desert could not thwart early development. Prehistoric cultures of the Southwest built urban-like settlements in quite dry landscapes, most notably the Anasazi/Chacoans in the San Juan Basin (Lekson, 1993) and the Hohokam around what is now Phoenix (Lekson, 1993; Westcoat, 1990). The Anasazi at Mesa Verde apparently managed mostly with rainfed agriculture, though they did channelize the runoff and even stored some rainwater. The Chacoans used rainfed irrigation, but may also have enjoyed a perennial water source in Chaco Wash, now a deeply-incised arroyo that rarely carries water. (More about this apparent hydrological degradation below.) But the Hohokam diverted the Salt and Gila Rivers, through:

“miles and miles of canals, many as large as 10 meters wide and 6 meters deep... Impressive even by today’s engineering standards, each canal had its own hierarchy of settlements strung along its length.” (Lekson, 1993 p. 47).

Water obviously shaped the early built environment, and may have affected the fortunes of entire cultures. Stephen Lekson, a leading Anasazi/Chaco researcher, argues that

Anasazi and Chacoan cultures developed and receded in an irregular pattern, but that the Hohokam prospered longer and remained more stable because of their water engineering (Lekson, 1999).

The hydro-essentialist view of western development also explains the demise of cultures, via drought. Conventional wisdom holds that the Anasazi civilization fell apart because of a major drought after about 1200AD, though more recent archaeological interpretations place less stress on climate factors (Cordell and Gumerman, 1989; Cordell, 1994). Tree-ring re-constructions also reveal Southwestern droughts in the 1500s and 1600s that are worse than any in the instrumental record (Meko and Boggess, 1995). And modern Cassandras, citing past as prologue, warn not only that deep, multi-year, region-wide droughts are possible, even likely, in the West's future, but that they will challenge the sustainability of our current urban-oasis civilization.

Yet, a careful reading of the results of a major study on the likely effects of a severe, sustained drought in the Colorado River Basin suggest that current physical and institutional systems are actually fairly resilient and would not fail in even a worse-case scenario (see especially Lord et al., 1995, and The Powell Consortium, 1995). Dire views die hard while this relatively optimistic assessment caught little public attention.

Another common theme in the environmental history of the West runs something like the Garden of Eden myth: early inhabitants enjoyed lush landscapes later degraded by over-grazing and other human impacts. Visitors to Chaco National Cultural Park learn that development and climate change altered a perennial stream into a mostly dry arroyo, a story repeated across the Southwest (see Bahre, 1991).

Other early western resource assessments turn this story on its head. Zebulon Pike and Stephen Long's uninhabitable "Great American Desert" became, in John Wesley Powell's (1878) assessment, a zone for extensive irrigation. Powell estimated in 1878 that, for example, California's water supplies could support over 10 million irrigated acres (the eventual total was close, around 9 million).

The environmental conditions of water also fundamentally affect, if you buy the social critics' view, the society that manages it, transforming the very structure of that society. This thinking harkens to Karl von Wittfolgel's (1981) analysis of what he termed

“hydraulic civilizations” in Asia. Von Wittfolgel argued that the managerial requisites of large irrigation systems led inevitably to despotic government. Historian Donald Worster (1985) transferred von Wittfolgel’s model to the American West, arguing, in *Rivers of Empire*, that the West was “a culture and a society built on, and absolutely dependent on, a sharply alienating, intensely managerial relationship with nature.” (p. 5). OK, so far this is the conventional environmentalist critique of modern, technocratic society. But Worster went on to argue that the American West is a “hydraulic society...a social order based on the intensive, large-scale manipulation of water and its products in an arid land.” (p. 7). As such, this society is coercive, monolithic and hierarchical, characteristics that emanate from the command and control authority needed to deploy large water systems. This extreme form of determinism, that a whole society is shaped by its engineering and managerial approach to a natural resource, is ludicrous, but it illustrates the bedrock hydraulic essentialism that informs a good deal of thinking about the West, its water and its future.

The contemporary version of hydro-essentialism is expressed in modern environmentalism, and in arguments that development is outstripping water supply and threatening the ecological health and sustainability of the West’s natural resources and ecosystems. Journalist Marc Reisner’s (1993) *Cadillac Desert: The American West and Its Disappearing Water*, is the best general expression of this view, but it also forms the basis of, or is at least prominent in, several technical and scientific assessments (e.g., Sedell, et al., 2000; Western Water Policy Review Advisory Commission, 1998; Minckley, 1997). Most recent assessments also stress the importance of water for non-human uses, especially for aquatic species protection like salmon in the Northwest and native fish recovery in the Colorado (Wilkinson, 1996, chapter 5; Volkman, 1997; Pontius, 1997). The essential notion here is that Western development has degraded water resources compared to their “natural” baseline. The prescription emerging from this view—loosely under the rubric of ecosystems management—is that something more closely approximating natural (e.g., pre-development) water conditions should be re-created, and that human use should adapt to these more natural boundary conditions. This implies, among other things, in-stream flows, reservoir re-regulation to recreate the “natural” hydrograph, and even dam removal. Most of these prescriptions

conflict with the basic goal of water development: to engineer systems that meet, first and foremost, humans needs and wants in terms of amount, quality, timing, and location.

Hydraulic Exceptionalism: Build It Because They Will Come

The other, more dominant but less strident, view holds that water is a resource, like land, labor and capital, to be marshaled for development. In fact, water resources had better be developed because the region is growing. It might be scarcer in the West than elsewhere, but conscientious efforts can overcome this scarcity. The hydraulic essentialist who muses that Western urban growth, especially in places like central Arizona and southern Nevada, simply cannot continue because of limited water, ignores history, politics, and the power of modern engineering and urban economics. Powell, sometimes viewed as an early Western environmentalist because he was bold enough to suggest that the region's climate did impose some limits on development, was actually more of a development booster, envisioning dams, canals, and, to his prognostic credit, about as much irrigation as in fact exists today. The evolution of modern water resources engineering made the rest of Western history surprisingly like Powell's vision except for one big discrepancy: the urban and suburban culture that grew right along with the agrarian development he envisioned, and that used similar tools to get the water it needed. Urbanism was part of Western water resource development from early on, exhibited in the likes of the aforementioned Phoenix, a dusty, desert railroad stop that boomed with both suburbs and orange groves after promoters talked congress into damming the Salt River as the first major project under the Reclamation Act (Wilkinson, 1999). Western cities and farms have jointly developed water ever since.

Past and current pessimists, expecting aridity to dampen regional growth, also neglect a key feature of the West's physical geography: its mountains. In short, while much of the West is arid, and much of its landscape produces little runoff, the mountains, accounting for perhaps less than 20 percent of the region's surface area, exhibit precipitation and runoff values that are "eastern-like" or humid. According to Vale (1995):

The mountainous basin of the Northern Rocky Mountains, for example, generate as much or more runoff (11.3 to 21.7 inches per acre) than most of the hydrologic basins in the east (7.8 to 21.4 inches per acre), and several of those in Southern Rockies produce runoff (9.4-11.6 inches per acre) comparable to the upper Mississippi River Valley and Great lakes (7.8 and 10.5 inches per acre). (p. 146).

Vale goes on to point out that watersheds in the Cascade mountains are the wettest in the U.S. These runoff zones are more limited than comparable watersheds in the East, but they supply water to larger landscapes that, on the whole, are less populated than equivalent areas in the East, making the West, in a sense, fairly well-watered.

Most of this country, the runoff-producing zones, is federal land, especially National Forests, and, thus, National Forests provide much of the West's surface water (Table 1). Indeed, concern over future flows of clean water led to the creation of the National Forest system (Vale, 1995; Sedell, et al., 2000). Because most western cities reach into higher-elevation, forested catchments for their water, the majority of Westerners end up being supplied by National Forest runoff. While only 20% of the California is National Forest lands, they provide 50% of the state's surface water supplies (Sedell, et al., 2000).

[Table 1 about here]

The geographic gap between where the water is and where people live in the West is bridged by engineering systems that collect, store and transfer (often for long distances) water. In addition to the elaborate engineering systems now in place, the region is overlain with a complex institutional structure that allocates access to and control over water in ways that encourage its transfer from wetter to drier areas (see Van de Wetering synthesis paper). But there is no need to recount here the West's engineered water systems. Suffice to say that most of the 61.4 million people living in the eleven western states are served by centralized water systems that reach into local and distant catchments. And most of these systems use water running directly off of Forest Service and other federally-owned lands. Even Las Vegas, which gets most of its water now from Lake Mead, claims rights on the Virgin River, which drains the Dixie

National Forest and Zion National Park, rights it plans to develop eventually (Southern Nevada Water Authority, 1997; see also Weissenstein, 2001).

California's State Water Project alone serves 20 million municipal and industrial (M&I) users, in addition to 600,000 acres of irrigated land. It derives essentially all of its water from the Sacramento-the San Joaquin river systems draining the Sierra Nevada mountains. Some of this water is moved over 400 miles to users in Southern California (via a 444-mile aqueduct, the longest continuous water conveyance in the West).

Water is moved from mountain catchments to urban distribution systems for most western cities, whether they are in wet or dry settings, including Seattle, San Francisco, Phoenix, Denver, Los Angeles, and even smaller cities like Cheyenne, Wyo. (population 73,000), which reaches two mountain ranges away for some of its supply. In all of these cases local watersheds and aquifers are insufficient; yet, in all of these cases, lack of geographically-proximate water has not limited urban development. Instead of water driving land use, land use appears to drive water development, and thus affects the entire water geography of the West.

The Modern Geography of Western Development

Accepting the argument that development now drives the water geography of the West instead of the reverse, it make sense to examine the trajectory and patterns of that development.

Rapid Regional Growth

The 2000 Census substantiated the feeling that many Westerners had in the 1990s: their region was growing fast. The eleven Western states grew by 10.2 million people in the 1990s, or by 20% (the national rate was 13.2%). The Interior West topped the national charts of population growth, with Nevada, Arizona, Utah, Colorado and Idaho making up the five top-growing states in the United States (Figure 1).

This continues a historical trend that put the West ahead of national growth rates for four consecutive decades. These five states grew from 10.8

million to 14.9 million residents (4.1 million additional people, or 37% increase—almost three times the national rate) during 1990-2000.

Population growth occurred almost everywhere in the Interior West (Figure 2), with only a baker's dozen of counties showing flat or negative growth. In most of these cases one can identify the proximate cause of decline, and most declines are associated with failure of a traditional extractive industry (e.g., closed silver mines in Northern Idaho; the weakened mineral and ranching economy of Sweetwater County in southern Wyoming; a closed lumber mill in Jackson County, CO). Still, many of the nation's fastest-growing areas were Western rural counties, like Summit County, Utah or exurban counties adjacent to metro areas, like Douglas County, CO. Indeed, rural counties in the West grew an average of 20.7%, a bit faster than the metro area rate of 19.6% in the 1990s—both the fastest in the nation. Of course, rural areas grew from a smaller base population, but rate of growth is an important indicator of its impacts, and several rural areas are feeling pressed by rapid change. Indeed, rural counties in the West grew an average of 20.7%, a bit faster than the metro area rate of 19.6% in the 1990s—both the fastest in the nation.

[Figures 1 and 2 about here]

Still, the vast majority of Westerners, including those added in the last decade, live in urban and suburban settings (some 82% in 2000, compared to a national average of 78%). This has long been true; even during the gold rushes and subsequent early settlement, cities dominated the economic and social landscape of the West, a fact rarely portrayed in the region's much-told agrarian creation myth, with its isolated homesteaders, but well documented by serious historians (White, 1991; Abbott, 1991).

The region is growing rapidly for a number of reasons: it lures more domestic and international immigrants than other parts of the country, and it exhibits the highest fertility rates in the nation (Cromartie, 1999). Demographers, economists and geographers all cite a common litany of forces driving growth, including: dispersion of business and jobs away from the coasts as business

activity de-centralizes; increased mobility of capital; a natural fit between the services and high-technology economy; the region's newness as an economic development pole; and a quality of life that attracts increasingly footloose businesses and individuals (e.g., Power, 1996; Case and Alward, 1997; Vias, 1999 and 2001; Riebsame et al., 1997). Most observers expect the West to grow faster than the country as a whole for the foreseeable future, even if the economy slows.

Will this boom bust, too, just like past gold rushes and oil booms? Hard to say. The current national and global economic slowdown would certainly seem to presage lessened growth in the region, but some the West's population increase derives from forces that can be considered counter to the business-cycle: relatively young population with high fertility; international immigration; attraction to retirees and other foot-loose non-wage income earners. Some analysts suggest that the West has turned the old industrial-employment growth model around, so that people are drawn initially not by jobs but by quality of life; once here they create an economy that supports their locational choice (Power, 1999). Alexander Vias, a geographer at the University of Northern Colorado, has cast light on this chicken-or-egg question (which comes first, jobs or people?) through econo-demographic modeling; he says the people increasingly appear to drive job growth rather than vice versa (Vias, 1999; 2001). In any case, the West seems positioned to continue to grow rapidly.

The 1990s demographic and economic boom in the West has created a triad of conflicting water resource demands: (1) growing urban/suburban demand; (2) stable, perhaps slightly declining, resource extraction (energy, agriculture, mining) demand; and (3) a growing, but unfilled, demand for water for environmental quality, recreation, and species protection. Each, of course, is wrapped up in some ways with the others, creating a complex water resource geography.

Today's Water Resources Geography

Even though the first project under the Reclamation Act was water supply for Phoenix, and urban demand has grown ever since, the majority of water stored, transferred, and used in the West is still for irrigation (from 81% of all water use in California to 98% in Idaho; Table 2). Thus it makes sense to examine the irrigated landscape first.

[Table 2 about here]

The Irrigation Landscape

Though there is irrigated land essentially wherever surface water supplies are available in the West, the great swaths of irrigation in the West are concentrated in several large projects, especially on the Columbia Plateau, the Snake River Plain, California's Central and Imperial valleys, and the Colorado High Plains, all in relatively dry landscapes. Limited irrigated areas also line the upland rivers and streams, even in the highest mountain valleys, some of which are famous for the quality of their hay production.

Irrigation accounts for most of the water extracted and put to use in the West. Even with its large urban population, and associated public water supply systems, California's water is still mostly (85%) used in agriculture. The State Water Project supplies irrigation water to some 600,000 acres and the federal Central Valley Project irrigates roughly another 2 million acres; connections among the projects puts it among the very largest integrated irrigation projects in the nation.

Most of the large projects have a similar history, and face similar tensions today. I looked at one of the early, large irrigation projects---the Bureau of Reclamation's Minidoka Project---in a report to the Western Water Policy Review Advisory Commission (Riebsame, et al. 1997). Water extraction from the Upper Snake and its tributaries for irrigation began in the late 19th Century, as the area was settled as the northern extension of Mormon culture, a theocracy founded on irrigation agrarianism (see Stegner, 1942). It had the right ingredients: rich, lava-derived soils, flat lands and available water---the Snake River, though running

through an arid plain, drains the Teton and Yellowstone sections of the Rocky Mountains, with a recent (last ten years) annual mean flow of over 5,000 cubic feet per second (ft^3s^{-2}) at Minidoka, the first major reservoir site.

Like elsewhere, Snake River irrigators, having created modest local systems, sought federal support to expand. The first dribs of federal money, labor, equipment and engineering flowed westward during the 1890s and early 1900s under the 1884 Carey Act. But, on the Snake and elsewhere, these primordial federal efforts could not meet the rapidly growing demand for expanded irrigation. Of course, it was a demand subsidized by federal money, often to grow crops already produced in abundance elsewhere (e.g., potatoes in Maine vs. the soon-to-be-famous Idaho spuds), but it furthered the nation's long-standing goal of developing the West, and so federally-supported irrigation was seen as net national good, and as something approaching a miracle that made the deserts bloom (MacDonnell, 1999). On the Snake, additional storage facilities were developed under the 1902 Reclamation Act: Minidoka Dam in 1904 and Jackson Lake Dam in 1907. Today, six Bureau of Reclamation dams exist in the upper basin primarily for irrigation, with a seventh primarily for flood control and recreation. These projects provide active storage for about 4 million acre-feet of water, which irrigates almost 1.1 million acres of land. Other sources of water, along with the Minodoka, allow a total of about 2.5 million acres to be irrigated in the area.

Overall, this would seem a successful and stable irrigation scheme that anchored the agricultural settlement of the Snake River Plain and does not appear to be much affected by contemporary development or environmental protection policy. In that previous report (Riebsame, et al. 1997) I found little evidence of water transfers to development in this area, despite Idaho's rapid population growth. Certainly M&I demand is increasing, but is so small compared to the water available that its supply plays only a minor role in Snake River Plain urbanization. I believe this may be true of most of the large projects, as discussed later. Upper Snake irrigated acreage is remarkably stable over time (Figure 3). However, like many large water projects in the West, the Minodoka is

now increasingly affected by species protection and other environmental demands. The key environmental management problem in the Upper Snake is the need for it to provide a share of water for salmon. I pick up this thread again in the section on species protection below.

[Figure 3 about here]

The big geographical surprise of Western irrigation is just how stable it is. Conventional wisdom holds that a variety of forces, from urbanization to environmental protection, are forcing irrigation (and agriculture in general) into decline. But the statistics are not as convincing. Of course, there are uncertainties in agricultural census and other land use data---the U.S. simply lacks consistent, reliable land use data, so any land use assessment relies on data of limited quality collected for various reasons. I will refer to the Census of Agriculture here because it is the standard source for agricultural lands, but will note that the National Resources Inventory (NRI) data, collected by the Natural Resource Conservation Service, sometimes differs from the census data.

According to the census, irrigated land in the western states has bounced around between 23 and 27 million acres over the last quarter century (Table 3). For some reason, it grew in all the states during the 1990s, after declining in all but one (Utah) during the 1980s.¹ A look at individual irrigated areas in the West yields a similar picture: decline in some cases, but stability, even expansion in others. In his study of four major irrigation projects in the West, MacDonnell (1999) claims that irrigated land is in retreat, yet only one of his case studies has actually experienced a significant decline (the Lower Arkansas Valley in Colorado), the others appear stable and one (the Yakima Basin) has expanded irrigation in recent years. The major irrigation projects, even those in areas where water is switching to urban use and where changes have been made to provide for species and habitat, exhibit relatively stable bases of irrigated land (as in the Upper Snake) or have experienced only slight declines for a variety of reasons

¹ This differs from the trend reported by Brown (1999) in his RPA assessment because his "West" includes the Great Plains states where aquifer draw-down has, indeed, caused a significant decline in irrigated area.

(in the Central Valley Project)—nothing approaching, say, 10% loss in the last few decades, at least not that I can find.

[Table 3 about here]

The one major exception to this that I can find is on the Arkansas River in eastern Colorado, where, as MacDonnell reports, substantial dry-up of irrigated land occurred with urban transfers and a legal conflict between Colorado and Kansas (MacDonnell, 1999). In just a few major water sales in the late 1980s, some 50,000 acres were dried up; the county hardest hit, Crowley, went from some 37,000 irrigated acres in 1976 to 11,000 in 1997.

But even with this loss, Colorado's total irrigated land has increased since the mid-1980s (Table 3). How can this be in an area known for water transfers and for enlarging urban and suburban development? The answer lies in a finer-scale analysis.

The greatest extent of irrigated land in Colorado is served by the Colorado-Big Thompson (C-BT) project, which transports water from the Colorado Basin to the South Platte Basin. The Northern Colorado Conservancy District (NCWCD) manages the project and distributes the water. The district's own statistics illustrate the complex interaction of agricultural and urban water use. First, more than half of the water in the project is now owned by urban supplies (Figure 4a). Actual deliveries (Figure 4b) show that agricultural users still receive most of the water, some in lease arrangements with the cities. Finally, the land actually irrigated in the district boundaries shows that the sale of most of the water contracts to cities, and even the physical delivery of more than a third of it to cities (Figure 4b), has not significantly reduced irrigated area (Figure 4c). How can this be? Obviously, efficiency gains make a difference, but so does the fact that farmers have other water supply options, say from a local ditch company.

[Figure 4 about here]

What about the growing Front Range cities? Has their growth reduced irrigated land? Here again, the story is not as many might think. By tracking annual crop reporting data (instead of relying on the 5-year agricultural census), we found that irrigated land in the urban and near-urban counties along the Front Range is relatively stable, not unlike the Snake River Plain, and is actually increasing in rural eastern Colorado (Parton et al., in review). As an example, dryland and irrigated cropland trends for Douglas County, CO, the nation's fastest-growing county during the 1990s (Figure 5), show that while dryland cropland is declining, presumably developed for residential or commercial use, irrigated area remains relatively stable or even increases in the 1980s and 1990s, while the county's population grew rapidly. Some of the persistence of irrigation near urbanizing areas is due to a uniquely cis-urban phenomenon: the increase in hay demand associated with the increased population of horses near the cities (including in low-density residential fringe around the cities, the "horse properties").

[Figure 5 about here]

Again, one must be skeptical of land use data---a real weak spot among U.S. environmental data bases---but my personal experience in Colorado suggests that even large irrigated regions encompass significant un-irrigated lands that might actually be preferred for residential and commercial development (my own sub-division was carved out of a dry-land wheat farm).

The Urban Landscape

Irrigation may account for the vast majority of Western water development, but cities and urban water systems attract a lot of attention because, while Western irrigation is relatively stable, urban water demand is increasing.

Geography and history have put most western cities in relatively low-elevation, quite dry settings. Western cities exhibit archetypal American urban sprawl. As the country's newer urban areas, the West's cities were designed around the automobile---LA practically invented and perfected the auto-based urban society, and other cities like Phoenix, Salt Lake, and Denver have followed

suit. But, in strict land use terms, cities are small blips on the Western landscape, even in California. Very little land in the American West is urban *per se*, that is, built up with high densities of buildings and pavement. Estimates vary among data sources and measurement approaches. Analysis by me and others at the Center of the American West (see www.centerwest.org/futures) finds that in 2000 some 18.4 million acres of the eleven western states was developed at urban and suburban densities, out of slightly over 325 million acres that reasonably could be built on (meaning the land is not public, covered with water, or too steep). This is 5.6% of the buildable land, which is less than half of all land. Using a different method, the U.S.D.A.'s National resources Inventory (NRI) estimated that in 1997 about 4.2% of the non-federal land in the eleven western states was "built-up."

The direct ecological impact, the *in situ* effects, of cities is thus limited in a landscape sense, paling in comparison to more widespread land uses like agriculture. Yet, the larger landscape that can be called "urbanized," including the suburbs, emerging "edge cities," and shrinking open spaces between cities and towns in urbanizing swaths is probably quadruple this development footprint. Urbanizing zones, like Colorado's Front Range or Utah's Wasatch Front, might encompass from 500 to 1,000 square miles of landscape, parts of which are still quite rural-like and open, but all of which is dominated by urban uses and economics, rather than by rural conditions.

Still, the urban "footprint" in the West is a very small proportion of the region's private land area, and opponents of urban growth boundaries and other tools for reining in the spread of urban land uses use this fact to argue that we need not fear running out of open land, that there is no real "urban sprawl" problem (see, for example, O'Toole, 2001).

Of course, cities have impacts far past their suburban fringes, the most notable, and frequently lamented, being their reach for water. The stories of urban water development in the West are somewhat repetitive, and cast the cities as aggressive "water buffaloes" able to bring money and political power to

bear on the job of obtaining water, often from quite distant sources. Certainly Los Angeles's surreptitious reach, starting in the early 1920s, into the Owens Valley for water is the most notorious (Kahrl, 1982; Reisner, 1993), but similar stories, with less drama, come from Denver, Salt Lake, Phoenix and Las Vegas. In all of these cases cities reach into their hinterlands, sometimes out hundreds of miles, to distant rivers, reservoirs, and aquifers, for water. Denver bought water rights and built reservoirs on the other side of the continental divide, creating the largest trans-basin diversion (between the Colorado and South Platte basins) in the nation. Salt Lake City now gets water, via the Central Utah Project, that would otherwise have drained off of the Uintah Mountains down the Green River into the Colorado. Phoenix, and Tucson both obtain water from the Colorado River via the Central Arizona Project (Riebsame et al., 1997).

Urban development, especially of the green-lawn suburbs that dominate Western cities, strikes many observers as ultimately limited by the West's scarce water resources (Reisner, 1993; Stegner, 1994). But urban planners and city leaders evince little sense of a boundary on their visions and expectations. Even as the fastest growing city in the country, and a desert city at that, Las Vegas and Clark County leaders and planners do not see water as a serious limit on development (Southern Nevada Water Authority, 1997; Weissenstein, 2001). Clark County's population is expected to more than double by 2030, and its water needs to grow from .29 billion gallons per day (bgd) to .5 bgd. The metropolitan water system will be using all of its Colorado River allotment in less than 15 years, and planners thus have proposed several far-flung efforts to obtain supplies for additional growth. For example, in 1993 the city proposed building a reservoir in Colorado (on Roan Creek) so that it could lease (for 50 years at some \$200 an acre foot) part of that state's Upper Colorado River allotment that it was not yet using (Maddock and Hines, 1995). Colorado rejected the idea, and the governor fired the state water engineer who seemed to take it seriously.

Next, the planning authority (then the Las Vegas Valley Water District which has now, for most purposes, been absorbed into the Southern Nevada Water Authority, see Weissenstein, 2001) sent a land use shock wave into its

rural hinterlands with its Cooperative Water Project proposal to phase in, over two decades, pumping of up to .22 bgd from some 200 rural basins north of Las Vegas. The response was sufficiently negative and loud that the Authority's revised plan (Southern Nevada Water Authority, 1997) now gives priority to meeting future needs with additional Colorado River water and diversions from the Virgin River, on which it owns substantial rights. The Authority floated the idea of leasing Arizona's "unused apportionment" in the Colorado River, but can more reasonably expect a mixture of new groundwater and Virgin River supplies, plus conservation, to meet its needs until sometime after about 2025, when what they call the "least preferred" projects may be needed. These are ones on which they again expect significant protests, like tapping groundwater in distant rural areas, or major legal wrangling, like re-allocation of Colorado River water. Like most other western cities, the plan does not include altered land use planning or comprehensive growth limits and, thus, water conserved through lower per capita use is expected to be consumed by a growing population. The plan makes it very clear that the Authority will meet rapidly growing demand with firm supplies, that the authority will "continue to aggressively pursue long-term resources."

Cities represent a huge fixed investment in the western geography, and they command most of the economic, and a growing share of the political, muscle in the region, as historian Carl Abbott ably shows in his modern history of the urban West (Abbott, 1993). Thus, the pattern of urban water transfers is likely to endure, and even enlarge, as the region develops. The great question then is: just how sustainable is urban growth in the West? Is the optimism so evident in Las Vegas water planning a groundless arrogance? Western city water plans I reviewed in 1997 impressed me with the confidence permeating their vision of the future. Yes, many identified a point when current supplies would be inadequate, but this was addressed not as a crisis but as a planning milestone for installing additional supplies and for obtaining greater efficiencies (Riebsame, et al., 1997).

But maybe I am too credulous. A more demanding assessment, by water engineers, of urban supply plans for the Colorado Front Range cities comes to

mixed conclusions: some cities have reasonable plans in place while others do not and may end up short (Hydrosphere et al., 1999). Another review by the University of Colorado's Natural Resource Law Center, based on seven different assessments of Colorado water supplies, concludes that future demands appear to be larger than "relatively certain projected future supplies" (Nichols et al., 2001, p. 20). But that review also points out that the studies use high estimates of growth and low estimates of supply (part of the engineering practice of risk-averse planning) and that only the cities who put off serious water until recently will face shortages because the bigger cities, especially the Denver metro-area, have planned and acquired water aggressively for decades.

Nevertheless, it seems to me that the bigger picture still offers no insuperable water supply problems in most of the rapidly-growing urban areas since total M&I water demand in all of the projections I have reviewed still fall far short of agricultural use in those areas. For various physical and legal reasons a unit of water in agriculture cannot simply be translated into a unit for M&I use, but water is a fungible resource, mostly private property that can be legally and physically conveyed to new users when conditions warrant. Yes, there is a finite amount of water available, but much of the currently developed supply is in relatively low-value agricultural use and will shift as growth demands. Furthermore, Western cities have not only been successful at obtaining water as they grew, but at reducing their per capita use (Maddock et al., 1995).

I take up the question of sustainability in the conclusions. Perhaps, though, a worthwhile step here is to ask a slightly different question in keeping with a state-of-the-art review paper: how good are we at projecting future regional development patterns?

Future Development Trends

As an attempt to assess the state-of-the-art, and because what we can surmise about future water use depends on regional development projections, it makes sense here to assess how well we do at projecting population and land use trends.

Western Population Projections

The most reliable projections of future population come from demographic models that take into account fertility, mortality, and domestic and international migration. This approach is used by the U.S. Census Bureau, which produces 30 year population projections for states based on the decadal censuses. The bureau creates high, medium and low projection series, allowing for uncertainties in all of these factors (specially international immigration, which is politically-determined), putting the onus on the user to assessing the likelihood, say, of increased or decreased immigration. Most users, in my experience, choose the “middle range” projections (as did Brown, 1999, in his national freshwater use assessment for the U.S. Forest Service Resources Planning Act—RPA--report), though recent growth rates might recommend the higher estimates for the Interior West. The latest projections currently available extend to 2100 for the entire U.S. and 2025 for each state. The state projections were made in the mid-1990s using the 1990 census, and I have not yet seen a census Bureau announcement on when they will up-date these projections with 2000 census data.²

Now that we have the 2000 counts we can assess at least some of projection track record. Table 4 gives projected population for each of the eleven Western states, plus the actual count for 2000. The projections were released in 1993 based on the 1990 census. Seven of the eleven states were underestimated, probably due to higher-than-expected immigration (both international and domestic). Since demography exhibits long-term trends, the 2000 counts probably means that the next set of projections will be higher for the West.

The current projections have the population of the eleven western states growing by about 24 million people during 2000-2025 (Table 5), about 46% of the nation’s total population increase. The 1990s experience would suggest that this is an underestimate. The Census Bureau also projects national population to 2100, so the intrepid extrapolator could step these numbers down to regions or

² Details on the census methodology are available at: www.census.gov.

even to states by also projecting the proportion of national population in that region or state over time. Brown (1999) used a similar approach to turn national projections into state and county projections for his RPA freshwater use projections. He allowed the ratios of national and state totals to change as the West grew---the West has accounted for a steadily increasing proportion of national population, doubling from 11% in 1940 to 22% in 2000---but I suspect his apportionment of national population to the West is still conservative).

[Tables 4 and 5 about here]

Other population projections are made by private firms (some sell the data for marketing and other purposes) and other governmental agencies. Rural population analyses useful to understanding rural development and resource use are analyzed by the Rural Development Division of the U.S.D.A.'s Economic Research Service (see: <http://www.ers.usda.gov/briefing/Population>). Many states make their own projections: the Colorado state demographer adjusts Census Bureau projections with economic data because he has found that the Census Bureau tends to underestimate population growth in areas (counties) with certain economic profiles (e.g., high tech or resort).

All of these projections are based on reasonably sound understanding of fertility and mortality rates---demographers know quite well how many people will be born and die over the next few decades. The great uncertainty in future Western population is migration, both domestic and international. How many people will move to the West in future decades? How will they distribute themselves within the West? The uncertainties here are illustrated in California's demographic dynamics. A recent review of population projections for the state found that migration factors account for much of the difference among forecasts (Johnson, 1999), which runs about 50% over the next fifty years, from low estimates of about 49 million in 2050 to high estimates of 70 million. Keeping in mind that interstate migration in the West is greatly affected by California, then obviously projections for the rest of the West are at least as uncertain as those for California alone. In the mid-1990s California grew due to fertility and high

rates of international immigration, while simultaneously maintaining a net domestic out-migration (more folks leaving than entering from other states; Johnson, 1999). Most of those leaving California end up in one of the other Western states, and a few, like Oregon, Colorado, and Montana are especially affected by this stream of ex-Golden Staters (Masnick, 2001). So, we need to know more about California's population dynamics to better understand growth in the Interior West. We also need to know more about other streams of domestic migration, like the long-standing "rust-belt" to "sunbelt" movement—how enduring will it be—as well as mobility trends in an aging population.

Next we need to know more about international immigration. Demographers are confident of their fertility/mortality estimates, less sure about their domestic migration projections, and very uncertain of their international immigration estimates. As U.S. Census Bureau demographers Hollmann, et al. (2000) point out, this demographic variable, more than the others, is affected by politics and policy. The U.S. has relatively liberal immigration policy now, but immigration became a political hot-potato in the 1990s. Any limits on it would especially affect the West. Immigration uncertainties are one of the main reason the Census Bureau issues a range of estimates, and Census analysts admit that they know less about it than other components of population change. It is worth noting, however, that Census Bureau demographers expect international immigration to increase by about 40% by 2030 (their current horizon for state-level projections). In terms of uncertainty, the range is largest at 2010, from a low of 592,000 net international immigrants to a high of 1,036,000.

California further illustrates the problem. Migration is the key factor in differences among California population projections. Right now, most demographers expect international immigration to remain strong (Johnson, 1999), but if they are wrong, then many other elements of their demographic models, especially fertility and domestic out-migration, will also be wrong. How wrong? Immigration accounts for slightly more than half of projected population growth each year by about 2010, so the error can add up, but would presumably

be something less than half of the population increment in any given year, and only a very small percent of total population.

Finally, both un-documented aliens and second-home owners “reside” in the West without showing up in census counts. The former raise a host of questions about labor, social services, and equity, and the latter have the simple effect of building more houses and requiring more infrastructure and services than the simple “resident population” numbers from the Census would suggest. In this way, and because the West hosts a disproportionate share of both types of residents, census counts underestimate the actual land and resource use of population on the region.

Land and Water Use Projections

Water resource projections are mostly based on raw population plus coefficients of demand in the municipal and agricultural sectors. Some attention is paid to land use: where people live, where development occurs, etc. Urban sprawl and rural development affect water resources in several ways that change the type, location, and timing of demand, but most water planning is divorced from land use planning (Western Water Policy Review Commission, 1997). Urban development, of course, creates domestic and commercial water demand, but it also affects the amount and location of agricultural demand. So, two major land use questions confront us in assessing water resource conditions in the future American West. First, how much irrigated land will exist? And second, what will be the patterns of urban, suburban and exurban growth?

Irrigation: Still Here in Fifty Years?

Since irrigation still uses most water in the West, water resource projections must grapple with trends in irrigated land and irrigation efficiency. Brown (2000) used national trends for most of his predictions, but he projected irrigation for each water resources region, with perhaps somewhat surprising results for the West. He projects a slow expansion of irrigated land to 2040, and stable or slightly decreasing total water withdrawn for irrigation (Brown, 2000: pp.

14-15). Key assumptions behind Brown's analysis include increasing demand for agricultural products, growing personal income, and inter-regional shifts of irrigated land that favor parts of the West.

Such projections are maybe a bit heroic, but taking them at face value obviously raises doubts about arguments that urbanization is taking, and will take, significant water and land from agriculture in the West. Readers of this paper should be aware that there is a significant debate on-going over trends in farmland. It is widely assumed that urban and suburban growth nationally and in the West will infringe on agricultural land, especially irrigated land (American Farmland Trust, 1997). But, as I argued above, the geographical story is more complicated.

Agricultural Census data, deemed reliable by some sources, tend to show a loss of "land in farms" but little change in cropland, especially irrigated land. Data from the Natural Resource Conservation Service (NRCS) show greater loss of "agricultural land," at least according to their every-five-year National Resources Inventory (NRI). Certainly less and less "farmland" shows up nationally in the Census of Agriculture (though the rate of decline has lessened, from 6.2% decline in the 1960s to a 2.7% decline in the 1990s; see Staley, 2000). And "farmland" has declined slowly in most western states since about the mid-1960s (though it grew in Wyoming in the 1990s). But "cropland," which is more carefully assessed, and tracked annually in most states, has not shown a net decline nationally, nor in the West, as illustrated earlier for irrigated cropland land in Table 3.

A skeptical literature exists as to the causes of agricultural land use change (Staley, 2000). According to one long-time agriculture analyst, when cropland has been converted in the U.S. over the past five decades, only about 26% of it went to urbanization, while the rest shifted among forest, pasture and other open space uses (Tweeten, 1998). A recent U.S.D.A. review concludes that farmland and cropland loss are not likely to be significant problems in terms of future agricultural productivity, essentially the same conclusion of studies

conducted in the 1970s during an earlier episode of concern over a farmland crisis (Heimlich and Anderson, 2001).

For our purposes, it is simply worth noting that Western cropland loss, especially irrigated cropland loss, is not necessarily as great as some commentators would argue. It may well be that Brown is on solid ground suggesting little overall change in irrigated land use over the next fifty years (as was actually observed during the last 25 or so).

Still, the inexorable logic that population growth and sprawl must, eventually, make a serious dent in irrigated land in some parts of the West deserves some attention. One area subjected to more careful projections has been the Central Valley of California, which encompasses the West's largest irrigation project, and the country's most productive agricultural area, with 11 key agricultural counties in the Valley producing some \$13 billion in crops annually. The valley holds a sixth of all irrigated land in the U.S., 3/4ths of California's irrigated land.

The American Farmland Trust (AFT) projected land use trends in the Central Valley as part of their effort to raise concerns about farmland loss (American Farmland trust, 1995). The area's non-agricultural population is growing quickly and the valley is developing in the traditional Californian (and Western) style of sprawling suburbanization. The AFT studied argued that the Valley, an area growing faster than the state average, should about double its 1992 study-baseline population by 2020 (from 4.29 million to 8.46 million people), and almost triple it by 2040 (to 12.24 million). Their projected land development (assuming three dwelling units per acre of all non-agricultural or open space lands, or roughly an average lot size of .25 acres, similar to the valley's historic average) would consume some 1.04 million acres of farmland by 2040. Essentially all of this land can be assumed to be irrigated, meaning that a about a sixth of the valley's irrigated land could be lost over a 50 year period.

So, one-sixth of the irrigated land gone in 50 years. Big Deal? The dispassionate economic analysts tend to down-play such losses (Heimlich and

Anderson, 2001), pointing out that there seems little threat to overall food supply and that it makes sense for land to move to higher economic uses. Others, like the AFT, see land use changes of this order as tragic. I return to these disparate views in the conclusions, after addressing two other growing uses of land and water in the West: recreation and species protection.

Other Demands on Western Land and Water

Besides agricultural and urban development, land and water in the American West is also increasingly in demand for two widespread uses: recreation and species protection. Here I briefly review these two issues in terms of the role played by western development.

Recreational Demand

Although I am not an expert in recreation, the recreation and water focus of this series of synthesis papers demands an assessment of the relationship between regional development and recreation, especially water-based recreation. The first and obvious implication of the region's rapid population growth and urbanization in recent years is that it creates more recreational demand, especially near population centers (Case and Alward, 1997; Flather and Cordell, 1995). Of course, some significant proportion of recreation use of Western lands and waters is associated with destination (long-distance) tourism, both domestic and international, so extra-regional trends are important too. For example, the proportion of anglers who were non-resident in 1996 was 27% in Colorado, 43% in Idaho, and 53% in Montana (U.S. Fish and Wildlife Service, 1997). That is, more than half the anglers in Montana in 1996 were from out of state (though they accounted for only 32% of user-days, and many of those were probably from other western states). The West, and its waters, have long been the destination of long-distance tourists, since before the first stage coaches entered Yellowstone National Park. Fishing has been part of this tourist tradition all along, too.

Still, most outdoor recreation user-days are generated today by visitors who travel relatively short distances from nearby urban areas. For example, most fishing trips in the U.S. in 1991 (the last time the travel distance question was asked in the USFWS national survey) were less than 25 miles from home, and most anglers report traveling less than 25 miles to fish their favorite spots (USFWS, 1993). Thus, urban and rural population growth in an area is a big driver of increases in recreation demand in that area.

It is also widely reported in the recreational literature that per capita outdoor recreation demand increases as leisure time, education, and income increases—points made strongly by the 1962 report of the Outdoor Recreation Resources Review Commission, and re-enforced by the President’s Commission on Americans Outdoors in 1987. I don’t keep up with the recreation literature in detail, but the little I know indicates that this has not changed, though more attention is also now paid to issues of ethnicity, family structure, etc. (Cordell et al., 1999). I do know that several Western states, especially Colorado, Utah and Idaho, saw the greatest growth of personal income among all states in the 1990s, and thus per capita demand for outdoor recreation probably also grew, though there may be a negative correlation between income and leisure time! Presumably this also means some shift in recreational behavior, with more demand for activities like downhill skiing (demand for which nevertheless remains flat), river rafting, vehicle-supported bicycle touring, and the region’s burgeoning vacation (or second) home market. So, recreational demand in the West is growing for a number of reasons: simple population growth and socio-economic trends.

Still, recreational demand is hard to predict. The 1989 U.S.D.A. Forest Service RPA Assessment on outdoor recreation found demand growing in proportion to population growth (U.S.D.A. 1989). And the assessment concludes that the supply of recreational opportunities has generally kept pace with demand except in a few areas. But the latest surveys by the Outdoor Recreation Coalition (www.funoutdoors.com/index.html) indicate that per capita participation is now increasing. And the USDA’s RPA assessment in 1989 did raise concerns about

meeting demand for dispersed, un-developed recreation (which requires open-lands) and for some snow and water based recreation over the next several decades.

In the West this means increasing demand for access to water bodies, and for winter use like cross-country skiing and snowmobiling. Among the recreational demands of direct importance to water resources, the case of downhill skiing remains a bit odd. Skier-days have been flat at most western resorts over the last decade, even declining in several recent years. But the ski industry has added more terrain, facilities, and, important to this assessment, snowmaking, even as use has stabilized, under the marketing theory that quality of the skiing experience will attract new skiers, keep current ones, and support higher ticket prices. Snowmaking will increase and become more controversial as it cuts into the limited winter runoff of mountain watersheds. A critic of Vail Resorts, Inc. claims that they have acted like the western cities, acquiring water rights in the Eagle watershed through the usual tactics, a mixture of attractive purchase offers and aggressive legal maneuvers (Glick, 2000). An assessment by Colorado Trout Unlimited cites snowmaking as a serious threat to in-stream flows (Trout Unlimited, 2002).

Resorts have also expanded base properties lately, and real estate sales, as well as some retail activities, are increasing even as skier numbers decline. The future of this sport, important to the economy and ecology of the western mountains, remains difficult to fathom, but its land and water impacts seem destined to increase, at least in the near term.

Other outdoor recreation trends are mixed, too. The USFWS national hunting and fishing survey, and some other assessments, suggest that per capita participation in hunting and fishing is declining and will continue to decline over the coming decades. The number of anglers remained stable between 1991 and 1996, though the number of fishing trips increased (USFWS, 1997). In areas of rapid population growth, like the Interior West, arrival of new anglers overrides the flat or declining trend in per capita participation so that the total number of

anglers and fishing trips increases, placing more demands on freshwater aquatic systems (e.g., Loftus and Flather, 2000). In fact, Bowker et al. (1999) predict that the USDA Forest Service Rocky Mountain region will see the largest proportional increase in fishing by 2020, growing 59%.

Surveys and marketing data from the Outdoor Recreation Retailers Council show that other water uses, especially rafting and kayaking, are increasing rapidly. Even wildlife watching, a growing segment of outdoor activity, can be closely associated with water resources in the West---birding especially, but also for some larger mammals, like moose.

Projecting recreational demand is like any other forecasting, an uncertain business. Some of that uncertainty comes from the poor quality of empirical data. English et al. (2001) report on the design of the USFS's new "National Visitor Use Monitoring" (NVUM) system that:

The credibility of recreational visitation estimates reported by the Forest Service has been questioned both by Congress and the General Accounting Office.The methods that have been used to estimate recreation use are inconsistent across reporting units and often yield results of questionable validity. (P. 1)

Some data from NVUM is available, by national forest, and my quick perusal of a few western forests showed that it will include some useful water-related information, especially for fishing, and use of motorized and non-motorized water travel, as well as for use of developed sites like boat ramps. The survey also includes significant demographic information. The need now, of course, is to develop the consistent time-series of data needed to assess trends, which was a big weakness with the original Recreation Information Management System (RIMS) system used up until 1996.

Overall, Western development would seem likely to continue to push demand for outdoor recreation, especially relatively near the growing population centers. The last two USDA Forest Service RPA assessments of future recreation needs evince confidence that developed recreational facilities, both

public and private, can keep up with this demand, but worry about meeting wildland recreation needs. But it seems obvious, to me at least, that recreation growth has created its greatest problems and conflicts nearer to settlement, in the urban-wildland interface, and over specific issues, like access and in-stream flows. Finally, while attention might be on the land-base for recreation, clearly the future crunch is more likely to center on water, given its attractiveness to recreationists and relative scarcity in western landscapes. Obviously, the Forest Service and other agencies must constantly assess their role in recreation and tourism (Kline, 2001), and given the centrality of water to recreation, the availability of the resource itself.

Development, Water and Species Protection

There is little point in adding to the already large literature on water and species protection, but it may be useful to look at this issue more from the point of view of regional growth and land use. Obviously, water development for agriculture, hydropower, and settlement in the West caused the decline of several aquatic species (MacDonnell, 1999). Timbering, cropping, grazing, roads, housing, and other land uses further affected aquatic species, and terrestrial species that needed riparian habitat (Stein et al., 2000).

Species protection, especially via the Endangered Species Act, thus further complicates the relationship between regional development and water. It is commonly argued that species protection has changed land and water use and thwarted development in some places, an argument advanced especially by property right advocates and some politicians, but also by some more objective analysts (Mann and Plummer, 1992; Feldman and Brennan, 1997).

Unfortunately, few dispassionate assessments of the impacts of species protection on development have been conducted, to my knowledge. Houck (1995) concludes that the threat perceived by land-owners is much worse than any documented regulatory actions, and Duffy-Duno (1997), in a study of 333 non-metropolitan counties in the West, found no evidence that threatened and endangered species affected economic growth rate. Studies of the economic

effects of critical habitat designation for the Lower Colorado fish recovery program found negligible effects (less than .2%) on variables such as income, tax revenues and employment (Shogren and Hayward, 1998). Unfortunately, the lack of development and land use effects of species protection may be a sign of ineffective protection. Houck (1995) and others (e.g., Feldman and Brennan, 1998) argue that most species recovery plans go out of their way to avoid reducing private property development potential, so much so that some become biologically ineffective.

Overall, evidence of significant limits on land use and development due to species protection is weak. It was my assessment in 1997 that species protection had not yet had demonstrable effects on land uses, even uses involving significant water, like irrigation (Riebsame et al., 1997). This is not to say that it had not caused some re-allocation of water and re-working of water management plans (as described below). But as MacDonnell (1999) shows, these efforts are mostly in the planning stage or very early implementation across the West---measurable effects on actual land use and development are simply not yet manifest.

Let us first return to the Upper Snake River, one of the three largest irrigated landscapes in the West. Under its agreement with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, the Bureau of Reclamation provides 427,000 acre feet of water in the Snake system for salmon flow augmentation (Bureau of Reclamation 1996). The agreement was fought by farmers in the Upper Snake who feared loss especially of dry-year supply. But, as of now the BOR has had to purchase only 22,400 acre feet of storage from irrigators in the upper basin to meet this goal; the remaining water was derived from improved systems operations. Thus, salmon water has not required less irrigation in the Upper Snake, but has affected some of the details of water storage and management.

Indeed, a common approach to species obligations in all of the big irrigation projects in the West has been to re-work reservoir operations, often to

take better advantage of high flow years, rather than to infringe on agricultural water shares (Western Water Policy Review Advisory Commission, 1998, pp. 3-25-32; see also Nichols et al., 2001, p.135). This strategem may spread to urban supply systems, too. Other efforts plan to employ conservation, re-use and conjunctive use to free up water for species (e.g., Riecke, 1996).

But now, from the dry summer of 2001 in the Klamath Basin, comes what might be the first significant water lock-down for species protection, and I do mean lock-down as in head-gate controls literally locked to stop farmers from opening them illegally (Clarren, 2001). A National Research Council panel is looking into the Klamath situation, so judgement is best postponed, but news reports suggest that, at least in the Klamath case, the strategy of fine-tuning reservoir operations rather than re-allocating water out-right tends to concentrate the risk of not meeting either species or irrigation needs in drought years. And since much of the West has been relatively wet since the 1976-77 drought, there is reason to expect more cases like the Klamath. Such clashes may bring about significant changes in land use and development.

An example of a more integrated solution to species and other water problems is provided by the Sacramento-San Joaquin Delta accord, called the "CALFED" agreement; it required changes in water management in both the State Water Project and the Federal Central Valley Project. (Rieke, 1996), including changes in policy, actual uses and re-uses, reservoir management, and a host of other components to assure water for the largest estuary in the West—the San Francisco Bay delta. Many of these changes are just now being implemented, and it makes sense that they will reduce the water available from the San Joaquin-Sacramento system for irrigation and municipal use, but I am unaware of any attempt to estimate what this could mean for development and land use.

According to MacDonnell (1999), water rights acquisition for tribal rights and fish needs in the Truckee-Carson Basin and Newlands irrigation project also appears to be on the verge of actually reducing irrigated area in order to protect

wetlands and the cutthroat trout of Pyramid Lake (MacDonnell, 1999). But the land use effect is still in the future. This seems to be the case for fish and crane protection on the South Platte (Nichols et al., 2001). And I could find few actual land use effects of fish recovery in the Upper Colorado (Riebsame et al., 1997).

This is not to say that species recovery will have no effect on land use and development potential in the future. Certainly development interests argue that it will, but a series of innovations in habitat conservation planning (e.g., ‘safe harbor’ and ‘no surprises’) during the 1990s and a more collaborative approach by the current administration, should lessen the imposed effects. Additionally, many resource issues in the West are beginning to yield to more collaborative solutions. A water and development example includes tensions between east and west slope interests in Colorado (Kenney, 2001). Feeling pinched by diversions to east-slope cities and potential requirements to recover endangered fish, west-slope entities began to worry about water for their own development, including rapid growth around ski resorts in Eagle, Pitkin and Garfield counties. After years of legal battles there is some indication that interests on both sides of the divide will collaborate to accommodate both environmental and development needs for water. Perhaps the growing, collaborative ‘watershed movement’ will manage to reduce battles over water, species, and development (see, for example, Rieke and Kenney, 1997).

The Water Resource for Recreation and Species

What are the water resource needs implied by recreational trends and by efforts to protect bio-diversity—and how does development affect them? The most obvious, and most focused on, is stream flow. A great deal of effort has been placed by federal agencies and others on maintaining instream flows for habitat and recreation (Neuman and Blumm, 1999; Sedell et al., 2000). Several studies illustrate the basic value of flows to recreation (e.g., Shelby et al., 1992; Whittaker et al., 1993), and the importance of water and riparian habitat to Western species is well-documented (Flather et al., 1994). In view of this, the USFS mounted an effort in recent years to assure instream flows through its own

land planning process and by participating in hydroelectric dam permitting and licensing processes (Neuman, and Blumm, 1999). Sedell, et al. (2000) conclude that enhanced Forest Service participation in the re-licensing of hydropower dams could have a cost-benefit ratio of 30 to 1, largest of all FS programs (p. 15). They do not specify how this was calculated, but presumably they are comparing the benefits to ecosystems and recreation to the costs of the agency being involved aggressively in the re-licensing. The actual experience thus far suggests that this potential remains unfulfilled. Trout Unlimited (2001) reviewed one of these cases, a hydropower plant on the South Arkansas River near Salida, Colorado, concluding that the benefits, while positive on paper, are too few and too slow in coming. Neuman et al. (1999) conclude that the Forest Service efforts in the early 1990s to make in-stream flows (AKA “by-pass” flows) part of special use permits was mostly unsuccessful.

What do regional land development trends suggest for streamflows and riparian areas? On streamflows, the picture is mixed, I think. If urban development takes water from irrigation supplies, the net effect may be small. But the cities are also searching out and developing new supplies (e.g., Las Vegas and the Virgin River), which could reduce stream flows. Even when they obtain already-developed supplies, urban systems may store and transfer it in different manner than did farmers, thus changing the hydrograph. Perhaps the worst case in terms of water available for recreation and ecosystems would be for cities to develop new supplies while irrigation maintains its hold on most Western water. Several analysts argue that relatively easy transfers of water rights from agricultural to urban use would aid both development and environment, as opposed to continuing a regulatory regime that tends to maintain inefficient uses (MacDonnell, 1999; Sedell, et al., 2000; Brown, 1999; see also Van de Wetering paper).

Finally, of course, growing recreational demand and tourism will pressure jurisdictions to dedicate water to recreation. Water parks are springing up in and near Western cities. Denver developed the recreational potential of the South Platte (including a kayaking course adjacent to Recreational Equipment Inc.’s

new mega-store), and worked to ensure flows useful for recreation (Nichols et al., 2001, pp. 52-52). More controversy erupted when Golden, CO, wanted to ensure Clear Creek flows for its kayak park, and so far they have not been successful at getting Colorado water courts to accept kayaking as a beneficial use. Indeed, though some western states have made progress in designating in-stream flows for environmental purposes, recreation has not been recognized as a legitimate use (e.g., for Colorado see Nichols et al., 2001). Similar efforts in Reno, Boise, Missoula, and even near Phoenix, suggest that the growing cities will play a larger role in allocation of western water for recreation, including especially in-stream uses.

What of water for species? Major efforts are underway, especially in basins with large reservoirs and irrigation demand, like the Upper Colorado and Green Rivers (U.S. Fish and Wildlife Service, 1993a), the South and North Platte rivers, and the San Juan, where the species protection effort is wrapped up with a rare thing in the modern West: the last big federal water project still on the drawing boards, the Animas-La Plata (Gosnell, 2001). For the most part, these efforts are still tied to irrigation land uses, though there are cases where urban development plays an increasing part in aquatic species endangerment and recovery (e.g., in the San Francisco Bay delta, the Truckee-Carson Basin, the Middle Rio Grand and the South Platte; see Western Water Policy Review Advisory Commission, 1998).

Even if in-stream flows are protected, riparian habitats may not be. Private land and settlement in the West naturally gravitated toward valley-bottom, streamside locations. Towns and cities occupy streamside sites, and rural development, especially in the mountainous West, increases streamside building (Riebsame et al., 1996; Theobald et al., 1996). Rivers and streams, even on public lands, also provided logical alignments for railroads and automobile roads. A third of all perennial streams in the Southern Rockies are within 500 feet of a primary or secondary road, even though much of the higher elevation is protected as wilderness (this analysis also neglects many dirt roads; see Southern Rockies Ecosystem Project, 2000). Several governmental and non-

governmental assessments raise concerns about development and roads along riparian areas (e.g., Sierra Nevada Ecosystems Project, 1996; Greater Yellowstone Coalition, 1991; 2001).

Regional development also implies other growing needs, like access to land and water for recreation. Low density rural development near, and adjacent to, federal lands suggest worsened access problems. Subdivided ranches tend to cut off traditional access to public lands across private land, especially given the high-end types of developments occurring throughout the mountain west (Riebsame et al., 1993; Collins, 2000). Riverside developments restrict access to streambanks and owners may enforce, where they can, limits on stream navigation.

The potential for species needs to change water development patterns is still nascent. One very experienced analyst of western water, Law Professor David Getches (2001), concludes that the ESA still has the greatest potential of all political and legal forces to bring about an ecologically-positive change in western water development. But Gosnell (2001) concludes that the Fish and Wildlife Service (FWS) unduly limited the options it considered for protecting native fish in the San Juan River. She concludes that actually to manifest ESA's ability to protect species, "the range of choice for the FWS has to be expanded to include the ability to say 'No.'" (p. 626). Perhaps the proverbial half-filled glass is the right metaphor here, except, that in terms of actually devoting water to effective species protection, it seems to me more a glass one-quarter filled, with lots of room for improvement, for saying "No" to the next straw.

Conclusion: Approaching Sustainable Development?

The American West is in transition. Its economy shifting from its roots in resource extraction to a post-industrial "new economy" built on the technology and services sectors. The West's population is also growing quickly. In the first quarter of the 21st century the eleven states that comprise the majority of the American West will gain 20.5 million additional residents, one-third of the total United States population growth. The region grew faster than the rest of the

country during the past 25 years, indeed for most of the 20th century, and appears destined to outstrip the nation in rates of population growth and development into the foreseeable future.

Just how sustainable is western development? Sustainability is a vague concept, and assessments of it are strongly affected by the historical moment in which they are made. Recall that a team of serious-minded resource modelers forecast, in the 1970s, that much of the world's population would starve by the year 2000, and that fossil fuels would be mostly depleted (Meadows et al., 1972). Perhaps my own personal and professional experience of this 1960s and 1970s "doom-saying", and actual events over the subsequent quarter-century, make me view current water and development issues with rose-colored glasses, or at least to steer a course somewhere between Cassandra and Pollyanna.

Certainly modern development adds new burdens to environments already stressed by a century and a half of extraction and development. Record population growth now accompanies record amounts of natural gas and coal production. Sub-divisions squeeze out farms and ranches, which themselves reduced natural grasslands, predators, and streamflows. The Pacific Northwest salmon runs, for example, were decimated by dams, over-fishing, logging and grazing. And now every new road, culvert, and stream of sediment eroding from individual construction sites further reduces the species' ability to recover. Every subdivision, new or widened highway, and big-box retail center adds to this cumulative burden, enlarging the footprint of development in the West. Our failure to apply cumulative impact assessment may make us more optimistic than the facts suggest. And surely careful observers have been alarmed. Charles Wilkinson's (1992) still-very-relevant analysis in *Crossing the Next Meridian* found a West mired in out-dated institutions fashioned to push development and forget the ecological and social consequences. Re-reading his last chapter, "Crossing the Next Meridian" I am struck by how much sustainability requires---effective land use planning, slowed population growth, revised resource laws---a big order indeed. Larry MacDonnell (1999) lays out an equally big agenda in his

last Chapter, "Getting There," for shifting western water to sustainability, concluding that:

The task occupying our attention for the past 150 years---establishing human control over water resources to meet human needs---is now largely complete. The primary task ahead is to integrate changing human water needs and interests and to restore and maintain ecological functionality of water-dependent natural systems. (p. 286)

I think filling the next three-quarters of the glass will be a long, hard task in a West where land development still drives water development.

References

Carl Abbott, 1993, *The Metropolitan Frontier: Cities in the Modern American West*. Tucson: University of Arizona Press.

American Farmland Trust. 1997. Farming on the Edge. American Farmland Trust, Washington, D.C.

Bahre, Conrad J. (1991) A Legacy of Change: Historic Human Impact on the Vegetation of the Arizona Borderlands. (Tucson: University of Arizona Press).

Beck, Warren A., and Ynez D. Haase (1989) Historical Atlas of the American West. (Norman: University of Oklahoma Press).

Bowker, J.M., English, Donald B.K., Cordell, H. Ken (1999) Projections of Outdoor Recreation Participation to 2050. In Cordell, et al., eds. *Outdoor Recreation in American Life: A National Assessment of Demand and Supply Trends*. Champaign, IL: Sagamore Publishing: 323-351.

Clarren, Rebecca (2001) "No Refuge in the Klamath Basin." High Country News vol. 33, no. 15 (August 13): 1, 8-12.

Collins, Katherine (2000) "Locked out of the public lands." High Country News 32 (8), April 24: 6.

- Cordell, H. Ken, et al., eds. (1999) Outdoor Recreation in American Life: A National Assessment of Demand and Supply Trends. Champaign, IL: Sagamore Publishing: 323-351.
- Cordell, Linda S. 1994. Ancient Pueblo Peoples. Washington, DC: Smithsonian Institution Press. 176 pp.
- Cordell, Linda S. and George J. Gumerman, eds. 1989. Dynamics of Southwest Prehistory. Washington: Smithsonian Institution Press. 395 pp.
- Cromartie, John (1999) "Migrants Settling Far and Wide in the Rural West." Rural Development Perspectives 14 (2): 2-8.
- Duffy-Duno, K.T. (1997) Economic Effect of Endangered Species Preservation in the Non-Metropolitan West. Growth and Change 28: 263-288.
- English, Donald B. K, Susan M. Kocis, Stanley J. Zarnoch, and J. Ross Arnold (2001) Forest Service National Visitor Use Monitoring Process: Research Method Documentation. USFS Southern Research Station, Athens, GA.
- Feldman, M.D. and M.J. Brennan (1997) Judicial Application of the Endangered Species Act and the Implications for Takings of Protected Species and Private Property. In J.F. Shogren, ed. Saving Habitats, Protecting Homes: Private Property and the Endangered Species Act. (Austin: University of Texas Press).
- Flather, C.H. and Cordell, H.K. 1995. Outdoor recreation: Historical and Anticipated trends. In R.L. Knight and K.J. Gutzwiller, eds., Wildlife and Recreationists. (Washington, DC: Island Press).
- Flather, C.H., L.H. Joyce, and C.A., Bloomgarden (1994) Species Indangerment Patterns in the United States. General Technical Report RM-241. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture.
- Gosnell, Hannah (2001) "Section 7 of the Endangered Species Act and the Art of Compromise: The Evolution of a Reasonable and Prudent Alternative for the Animas-La Plata Project." Natural Resources Journal 41: 561-626.

- Greater Yellowstone Coalition (1991) An Environmental Profile of the Greater Yellowstone Ecosystem. Bozeman, MT.
- Greater Yellowstone Coalition (2001) Saving the Yellowstone River. Bozeman, MT.
- Heimlich, Ralph E., and William D. Anderson (2001) Development at the urban fringe and beyond: Impacts on Agriculture and Rural Land. Report No. 803. Economic Research Service. Washington, DC: , U.S. Department of Agriculture.
- Hollmann, Frederick W., Tammany J. Mulder, and Jeffrey E. Kallan (2000) Methodology and Assumptions for the Population Projections of the United States: 1999 to 2100. Population Working Paper No. 38. Population Projections Branch, Houck, O.A. (1995) Reflections on the Endangered Species Act. Environmental Law 25: 689-702.
- Bureau of the Census, U.S. Department of Commerce, Washington, DC.
- Hornbeck, D., 1990. Spanish Legacy in the Borderlands. In M.P. Conzen (ed.) The Making of the American Landscape, pp. 51-62. Boston: Unwin Hyman.
- Hydrosphere Resource Consultants, Inc., HRS Water Consultants, Inc., Mulhern MRE, Inc., and Spronk Water Engineers, Inc. (1999) Metropolitan Water Supply Investigation. Prepared for the Colorado Water Conservation Board, Denver.
- Johnson, Hans P. (1999) "How many Californians? A review of population projections for the state." California Counts: Population Trends and Profiles vol. 1, no. 1 (San Francisco: Public Policy Institute of California).
- Kahrl, William L. (1982) Water and Power: The Conflict Over Los Angeles' Water Supply in the Owens Valley. (Berkeley: University of California Press).
- Kenney, Douglas S. (2001) Collaborative Water Development in Colorado: The Eagle River Assembly Case study prepared for the "Workshop on Collaborative Resource Management in the Interior West," Red Lodge, Montana, October 18-22.

- Kline, Jeffrey D. (2001) Tourism and natural resource management: a general overview of research and issues. General Technical Report PNNW-GTR-506. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.
- Las Vegas Water District (1987) Water Resources Plan. (now the Southern Nevada water Authority).
- Lekson, Stephen H. (1993) "Chaco, Hohokam, and Mimbres: The Southwest in the 11th and 12th Centuries." Expedition 35-51.
- Lekson, Stephen H. (1999) The Chaco Meridian: Centers of Political Power in the Ancient Southwest. (Walnut Creek, CA: AltaMira Press)
- Limerick, Patricia N. (1989) Desert Passages: Encounters with the American Deserts. (Niwot, CO: University Press of Colorado).
- Loftus, Andrew J., and Curtis H. Flather (2000) Fish and Other Aquatic Resource Trends in the United States: A Technical Document Supporting the 2000 USFS Forest Service RPA assessment.
- Lord, William B., James F. Booker, David M. Getches, Benjamin L. Harding, Douglas S. Kenney, and Robert A. Young. 1995. Managing the Colorado River in a severe sustained drought: an evaluation of institutional options. Water Resources Bulletin 31: 939-944.
- MacDonnell, Lawrence J. (1999) From Reclamation to Sustainability: Water, Agriculture, and the Environment in the American West. (Niwot, CO: University Press of Colorado).
- Maddock, Thomas S., and Walter G. Hines (1995) "Meeting Future Public water Supply Needs: A Southwest Perspective." Water Resources Bulletin 31: 317-329.
- Masnack, George (2001) "America's Shifting Population: Understanding Migration Patterns in the West." The Rocky Mountain West's Changing Landscape 2 (Winter/Spring): 8-15.

- Meadows, D.H., D.L. Meadows, J. Randers, and W.W. Behrens, III (1972) The Limits to Growth: A Report on the Club of Rome's Project on the Predicament of Mankind. (New York: New American Library).
- Miller, Kathleen A. 1997. Climate Variability, Climate Change, and Western Water. Report to the Western Water Policy Review Advisory Commission, U.S. Bureau of Reclamation, Denver, CO. 54 pp.
- Nichols, Peter D., Megan K. Murphy, and Douglas S. Kenney. 2001. Water and Growth in Colorado: A review of Legal and Policy issues. Natural Resources Law Center, University of Colorado School of Law, Boulder. 191 pp.
- Neuman, Janet C. and Michael C. Blumm. 1999. "Water for National Forests: The Bypass Flow Report and the Great Divide in Western water Law." Stanford Environmental Law Journal 3.
- O'Toole, Randall. 2001. The Vanishing Automobile and Other Urban Myths. (Bandon, OR: the Thoreau Institute). 454 pp.
- Parton, William J., William R. Travis, and Myron P. Gutman (in review) "Historical land use Change in Eastern Colorado." Submitted to Land Use Policy.
- Pontius, Dale. 1997. Colorado River Basin Study. Report to the Western Water Policy Review Advisory Commission, U.S. Bureau of Reclamation, Denver. 132 pp.
- Powell, John W. (1878) Report on the Lands of the Arid Regions. (Washington, DC: Geographical and Geological Survey); see also Wallace Stegner's edition of this report: Stegner, Wallace, ed. (1962) Report on the Arid Region of the United States. (Cambridge, MA: Harvard University Press).
- Powell Consortium. 1995. Severe Sustained Drought: Managing the Colorado River System in Times of water Shortage. Issue No. 1. Arizona Water Resources Research Center, University of Arizona, Tucson, AZ.
- Power, T.M. 1999. *Lost Landscapes and Failed Economies*. Washington, DC: Island Press.

- Redmond, K.T. and R.W. Koch. 1991. "Surface climate and streamflow variability in the Western United States and their relationship to large-scale circulation indices." Water Resources Research 27: 2381-2399.
- Reisner, Marc (1993) Cadillac Desert: The American West and Its Disappearing Water. (New York: Penguin Books).
- Riebsame, William E., Hannah Gosnel and David M. Theobald, eds. (1997) Atlas of the New West: Portrait of a Changing Region. (New York: W.W. Norton and Co.). 192 pp.
- Rieke, Elizabeth A. 1996. The Bay-Delta Accord: A Stride Toward Sustainability. University of Colorado law review 67 (2): 341-369.
- Rieke, Betsy and Douglas S. Kenney (1997) Resource Management at the Watershed Level. Report to the Western Water Policy Review Advisory Commission (available from NTIS, Springfield, VA).
- Rohe, Randall (1995) Environment and Mining in the Mountainous West. In William Wyckoff and Lary M. Dilsaver, eds., The Mountainous West: Explorations in Historical Geography, pp. 169-193. Lincoln: University of Nebraska Press)
- Sedell, James, Maitland Sharpe, Daina Dravneiks, Max Copenhagen, and Mike Furniss (2000) Water and the Forest Service. Washington, DC: U.S.D.A. Forest Service.
- Shelby, Bo, Thomas C. brown and Jonathan G. Taylor (1992) Streamflow and Recreation. General Technical Report RM-209, Rocky Mountain Forest and range Experiment Station, Fort Collins, CO.
- Sierra Nevada Ecosystems Project (1996) Final Report to the Congress: State of the Sierra Nevada. (Davis: Center for Waster and Wildland Resources, University of California).
- Staley, Samuel R. (2000) The Vanishing Farmland Myth and the Smart-Growth Agenda. Policy Brief No. 12. Los Angeles: Reason Public Policy Institute.

- Stegner, Wallace (1994) The American West as Living Space. (Ann Arbor: University of Michigan Press.). 89 pp.
- Stegner, Wallace (1942) Mormon Country. (Lincoln: University of Nebraska Press). 362 pp.
- Stein, Bruce A., Lynn S. Kutner, and Jonathan S. Adams, eds. (2000) *Precious Heritage: The Status of Biodiversity in the United States*. (New York: Oxford University Press).
- Tweeten, Luther (1998) Competing for Scarce Land: Food Security and Farm Preservation. Occasional paper ESO #2385. Department of Agricultural, Environmental, and Development Economics, Ohio State University, Columbus.
- U.S. Fish and Wildlife Service (1993a) Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. (Denver).
- U.S. Fish and Wildlife Service (1993b) *1991 National Survey of Fishing, Hunting and Wildlife-Associated Recreation*. Washington, DC.
- U.S. Fish and Wildlife Service (1997) *1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation*. Publication No. FAW-96 NAT. Washington, DC.
- Vale, Thomas R. (1995) Mountains and Moisture in the West. In William Wyckoff and Larry M. Dilsaver, eds., The Mountainous West: Explorations in Historical Geography, pp.141-165. (Lincoln: University of Nebraska Press). 420 pp.
- Vias, Alexander C. 1999. Jobs follow people in the rural Rocky Mountain West. *Rural Development Perspectives* 14 (2): 14-23.
- Vias, Alexander C. 2001. Demographic and economic forces shaping land use and development in the West. Presentation at the Tenth Annual Land Use Conference, Rocky Mountain Land Use Institute, University of Denver. April.

- Volkman, John M. 1997. A River in Common: The Columbia River, the Salmon Ecosystem, and Water Policy. Report to the Western Water Policy Review Advisory Commission, U.S. Bureau of Reclamation, Denver. 206 pp.
- Weissenstein, Michael (2001) "The Water Empress of Vegas." High Country News Vol. 33, no. 7 (April 9): 1, 8-10.
- Western Water Policy Review Advisory Committee (1998) Water in the West: Challenge for the Next Century. (Springfield, VA: National Technical Information Service)
- Wescoat, James. L., Jr. (1990) Challenging the Desert. In Michael P. Conzen, ed., The Making of the American Landscape, pp. 186-203. (Boston: Unwin Hyman).
- White, Richard. 1991. It's Your Misfortune and None of My Own: A New History of the American West. (Norman: University of Oklahoma Press).
- Whittaker, Doug, Bo Shelby, William Jackson, and Roberta Beschta (1993) Instream Flows for Recreation: A Handbook on Concepts and Research Methods. (Alaska Region, National Park Service, Anchorage, AK).
- Wilkinson, Charles. W. (1999) "Phoenix." Chapter 9 of Fire on the Plateau: Conflict and Endurance in the American Southwest. Washington, DC: Island Press.
- Wittfogel, Karl von (1957) Oriental Despotism: A Comparative Study of Total Power. New Haven: Yale University Press.
- Wyckoff, William. 1999. Creating Colorado: The Making of a Western American Landscape, 1860-1940. New Haven: Yale University Press.
- Wohl, Ellen E. 2001. Virtual Rivers: Lessons from the Mountain Rivers of the Colorado Front Range. New Haven: Yale University Press. 210 pp.

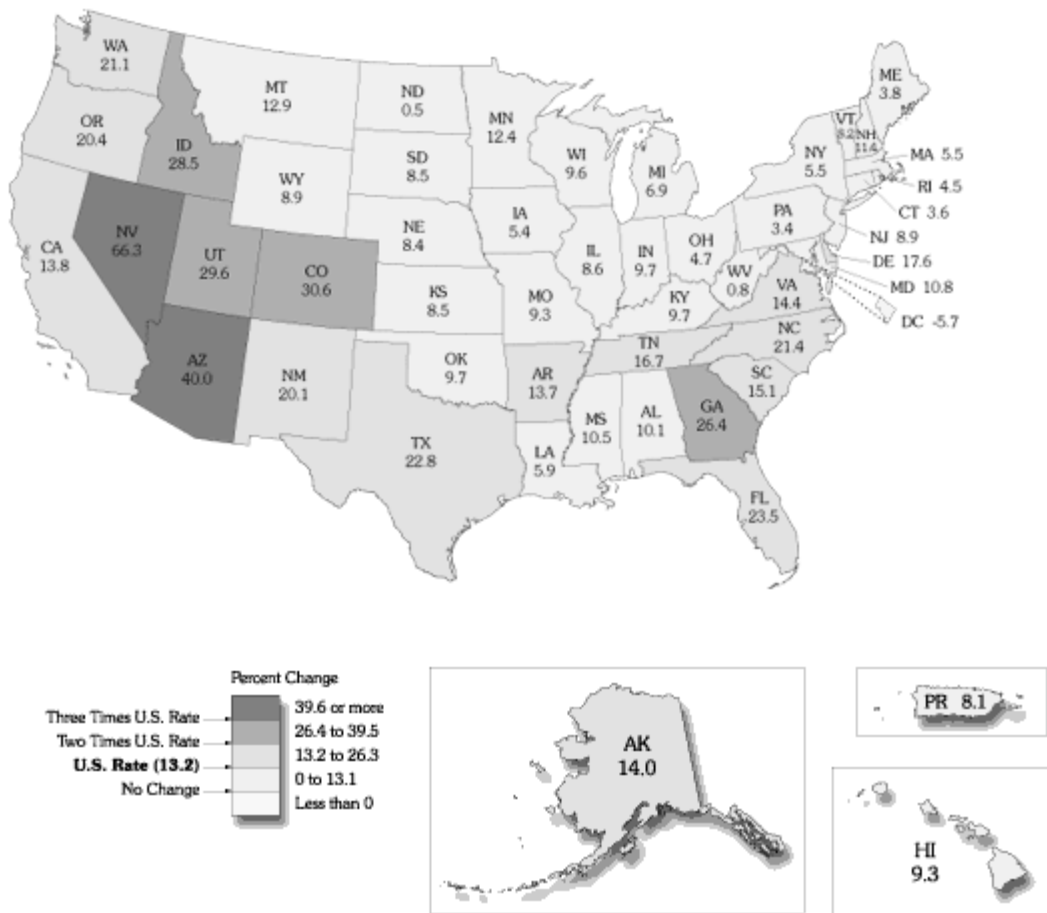


Figure 1: State population growth rates, 1990-2000. Source: U.S. Census Bureau.

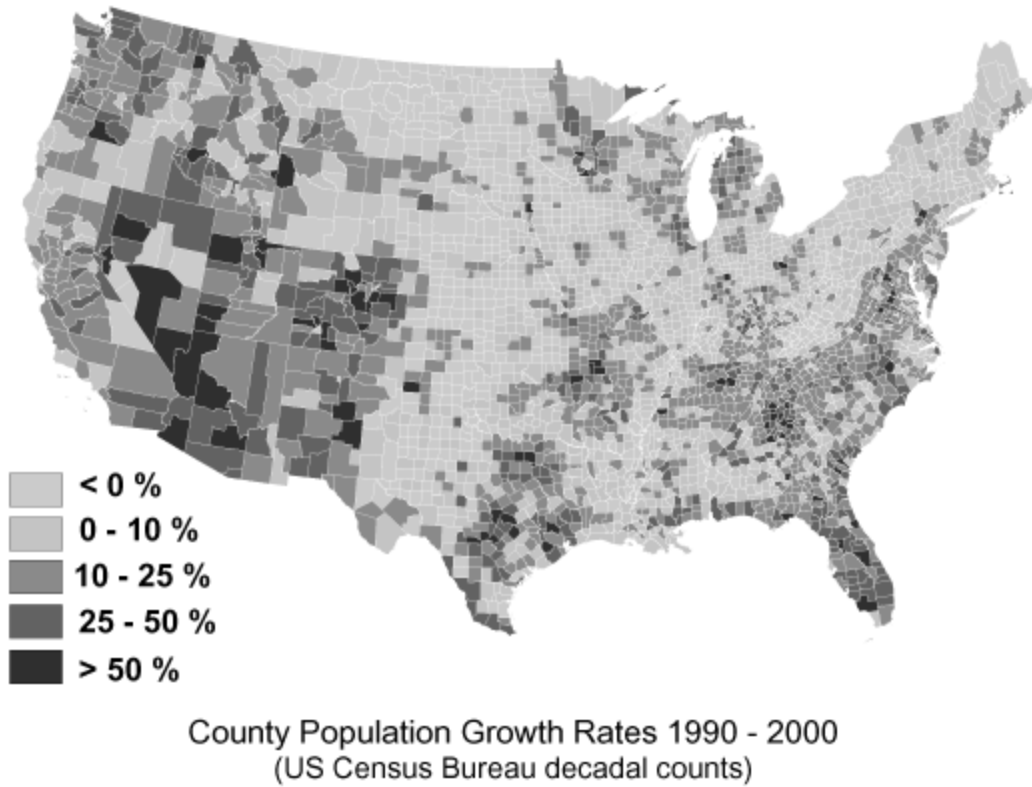


Figure 2: County population growth rates, 1990-2000. Source: U.S. Census Bureau.

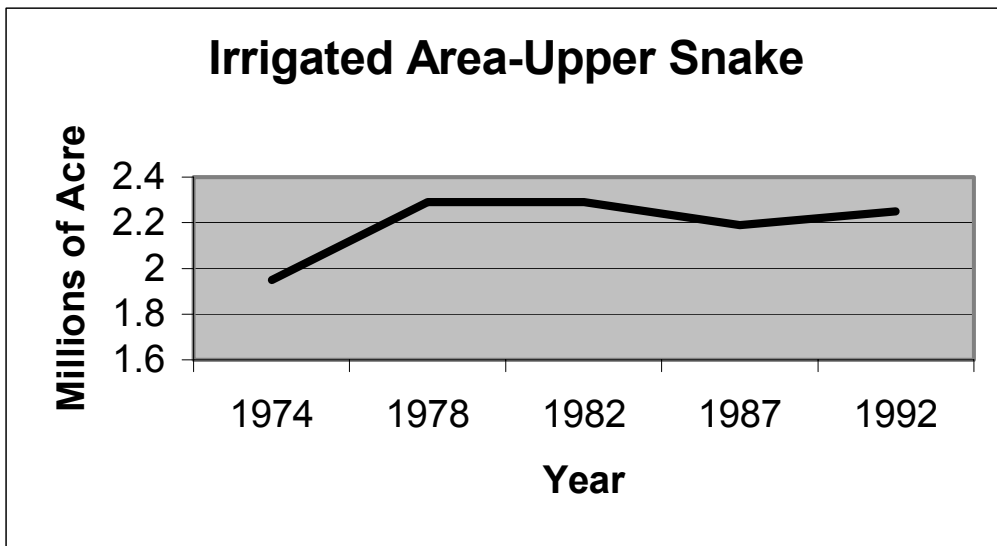


Figure 3: Irrigated land in the Upper Snake River Basin. Source: Census of Agriculture.

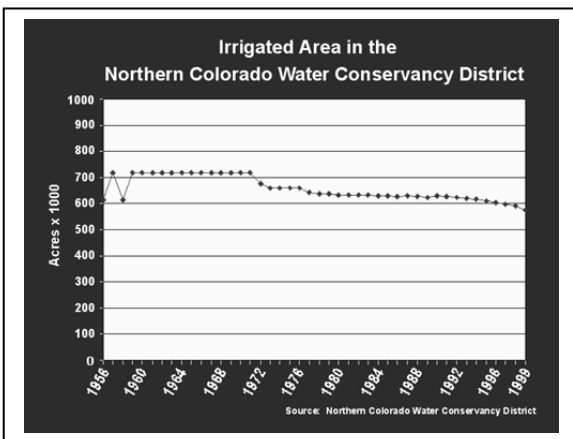
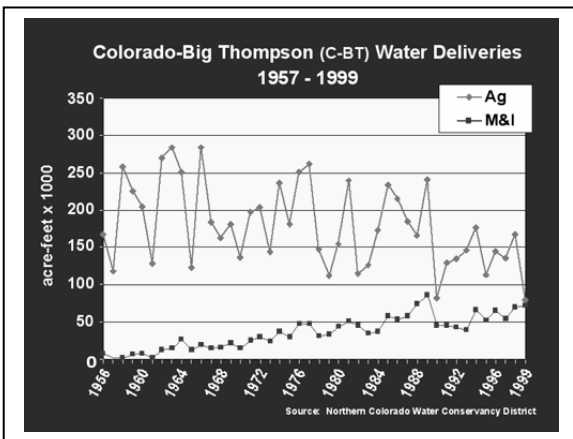
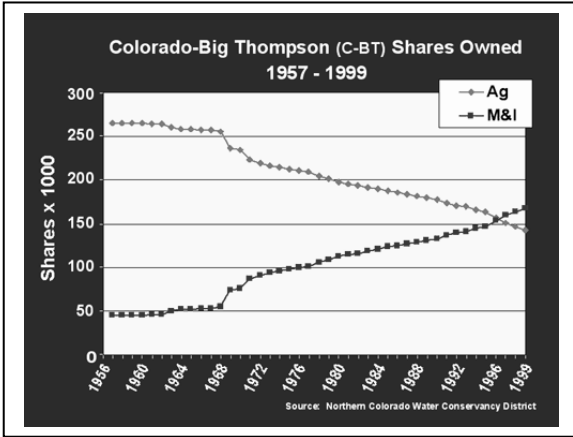


Figure 4: Water ownership (a), deliveries (b) and area irrigated (c) for the Colorado-Big Thompson Water Project. Source: Northern Colorado Water Conservancy District.

Irrigated vs. Non-Irrigated

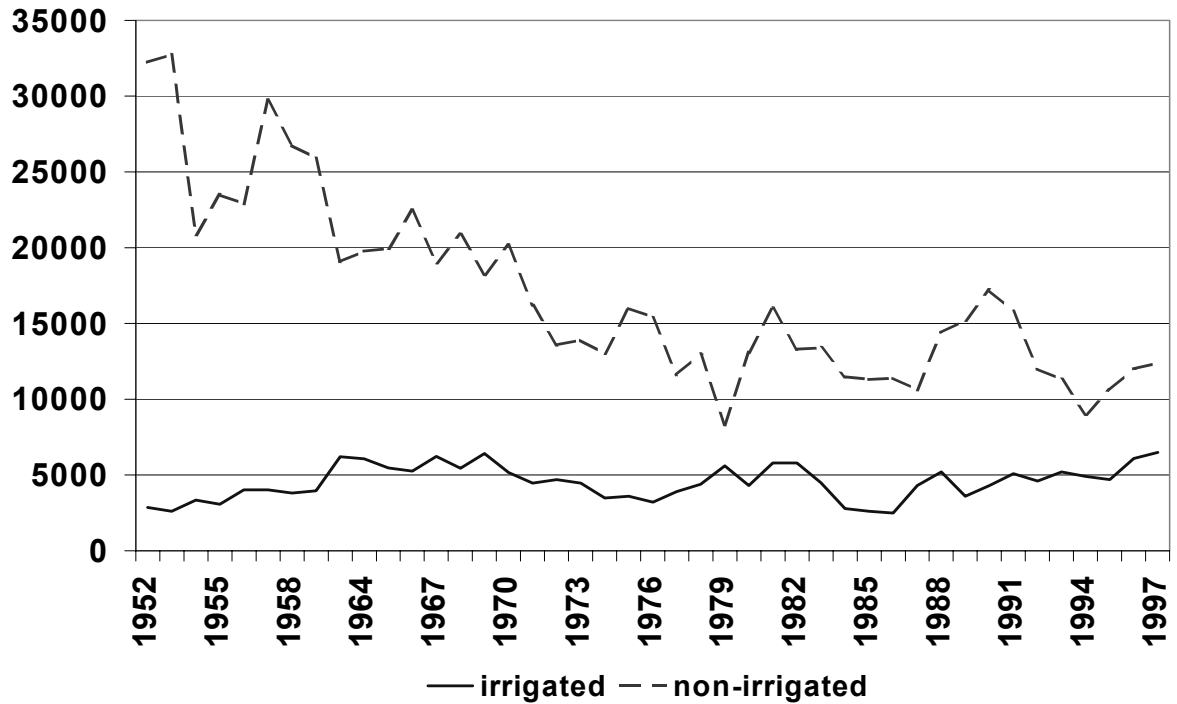


Figure 5: Cropland in Douglas County, CO. Source: Colorado Department of Agriculture and national Agricultural Statistics Service.