Determinants of Change in the Intermountain West

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Abstract

The future operating environment and planning context for the Intermountain West is highly uncertain. Driven by powerful forces including climate, shifting economics, population demography, and technology, (among others), the region is changing in many ways simultaneously. Dynamic interrelationships among these factors means that we cannot ever know what the future will be like with any certainty, and this challenges our ability to set assumptions for long term planning within the region.

Fortunately, there are long-term planning methods that are better suited for situations that are both highly uncertain and complex. In particular, formal scenario planning as developed at Royal Dutch Shell in the 1970s has been shown to be useful under such circumstances. As a result, the Western Lands and Communities has initiated a series of projects to promote the adoption of scenario planning techniques. Western Lands and Communities' first foray into scenario thinking, compiling a list of key determinants of change in the Intermountain West, is the subject of this working paper.

About the Authors

Josef Marlow is the Sonoran Institute's senior economist, working for the organization since 2007. He conducts research and analyses on resource conservation, land-use and development economics in the West; prepares reports on research results and serves as a spokesperson, explaining economic trends and concepts. He is currently leading the scenario planning efforts at the Institute, with recent/ongoing projects including developing a set of key change drivers in the Intermountain West, conducting an exploratory scenario planning workshop in support of organizational strategic planning, and initiating a scenario planning component of a comprehensive land-use planning process. Before joining the team at Sonoran Institute, Joe was a faculty member at a tribal college for five years, teaching economics, mathematics, statistics, weather/climate and earth science. Previously he was a principal in a resource economics consulting firm involved in quantitative mineral resource assessment, mineral economic analyses, geographic information system design and programming, and satellite image analysis. Other professional employment experience involved extensive project management and fieldwork in mineral, oil and gas exploration, as well as geotechnical and civil engineering. Joe holds a doctorate in mineral economics with a minor in remote sensing, a master's in mineral economics with a concentration in finance, and a bachelor's degree in earth science.

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Stephen Aldrich is the founder of Bio Economic Research Associates LLC (bio-eraTM), an independent research and consulting firm specializing in complex issue analysis at the intersection of our emerging knowledge of biology and the economy. He lives in Stockbridge, Vermont with his family, where he produces excellent maple syrup and fine apple cider.

Steve studied evolutionary biology at Harvard (1978) before entering business. In 1984, he joined Cambridge Energy Research Associates (CERA) where he co-founded the firm's natural gas practice and served as a senior consultant on energy industry strategies. In 1995, he was appointed to the North American Natural Gas Council.

While at CERA, Steve had the great privilege to learn scenario methods directly from Ted Newland, one of the original developers of formal scenario planning techniques at Royal Dutch Shell, and subsequently launched bio-era as an independent research and consulting firm on the social and economic consequences of human-induced change to biological systems in 2003.

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Introduction

The future operating environment and context for the Intermountain West (IMW) is highly uncertain. The current situation in the region is evolving with respect to many important determinants of change, including climate, and water, regional economies, population demographics, and technology (among many others). Dynamic interrelationships among these factors means that we cannot ever know what the future will be like with any certainty, and this challenges our ability to set assumptions for long term planning within the region.

Fortunately, there are long-term planning methods that are better suited to prepare for situations that are both highly uncertain and complex. In particular, formal scenario planning has been shown to be useful under such circumstances. This is true for Western Lands and Communities, a joint venture of the Lincoln Institute of Land Policy and the Sonoran Institute, internally as well as for communities, other organizations and stakeholders across the IMW. As a result, Western Lands and Communities has initiated a series of projects to further our understanding of and capabilities to use and promote the adoption of scenario planning thinking techniques. Western Lands and Communities' first foray into scenario thinking, compiling a list of key determinants of change in the Intermountain West, is the subject of this working paper.

Background

There are two types of scenario stories commonly used in planning: exploratory and normative. (van Notten 2006; Davis 2002; Börjeson et al. 2005; Thomas 2012).

Normative scenarios describe a desired future, what an organization wants to happen or wants to be. This type of scenario can also be thought of as a goals or vision statement (Thomas 2012). Scenario planning that uses normative scenarios is concerned with developing strategies for achieving a desired future.

Exploratory scenarios focus on what might occur in the future. These scenarios are often driven by external forces. When exploratory scenarios are used in scenario planning, the process is concerned with developing strategies that will perform well across multiple scenarios. The objective is to develop plans that will be robust across a range of plausible futures.

The scenario planning work being conducted by the Western Lands and Communities joint program is of the exploratory type. This initial effort is focused on developing a set of key determinants of change in the IMW. These determinants comprise the principal drivers of change, the major uncertainties and predetermined elements, that is, factors that are predetermined to be true. In scenario planning, the key determinants of change are used to construct specific scenarios. The particular determinants of change for the IMW developed by

Western Lands and Communities will be used to inform more issue-specific and downscaled scenario planning projects with collaborating parties in the West.

To elicit key determinants of change in the IMW, a workshop was conducted in Phoenix on April 22–23, 2013. Prior to the workshop, 33 experts in a range of disciplines were interviewed regarding change in the IMW. Eighteen people, many selected from the interviewees, attended the workshop. Please see appendix A for a list of workshop participants. At the workshop a lengthy list of change determinants was developed.

For the purposes of this document, the IMW is defined as the states of Idaho, Montana, Wyoming, Nevada, Utah, Colorado, Arizona and New Mexico, as well as the portions of Washington, Oregon east of the Cascade Range and the part of California east of the Sierra Nevada. The time horizon under consideration is the 25 years into the future (to approximately 2040).

Population Changes in the Intermountain West

Population growth and changing demographics are a key set of change determinants. Four particular components of population change significant for the future of the IMW are:

- Increasing population
- Growing urbanization
- Aging population
- Increasingly Hispanic population

The West has been one of the fastest growing regions of the nation for several decades. Recent data indicate the IMW continues to lead the country in population growth rate, but that the rate of growth is decreasing. In other words, the population of the IMW has grown more slowly over the last decade compared to the previous one, as can be seen in figure 1. This trend of population growth with a slowing rate of increase is projected to continue.

The spatial pattern of population growth in the IMW clearly indicates a trend towards increasing urbanization of the population, also apparent in figure 1. Of course, one of the interesting characteristics of the West is the juxtaposition of the wide open spaces with a highly urbanized population. As can be seen in figure 2, populations of states in the IMW have become increasingly urban over the last 60+ years, although Wyoming and Montana have bucked the trend the last two decades. It is the general expectation that the IMW population will continue to urbanize in the future.

The aging population in the U.S. is another key component of demographic changes that will continue to occur. Figure 3 shows projections of the percentage of US population age 65 and older. The percentage is projected to increase steadily until about 2035 after which it levels out due to the decline of influence on the percentage from the Baby Boomer generation. A map of the county-level current spatial distribution of people age 65 and older in the IMW is shown in figure 4. This map shows there are sharp differences in population aging across western counties.

Another significant demographic shift occurring in the IMW is an increasing Hispanic population, a trend that has been occurring for many years and which has accelerated in the last few decades. Figure 5 is a series of maps highlighting this phenomenon. Initially, Hispanic population increases were concentrated primarily in border states, but in recent years the trend has extended further into the interior West.

As these four components of population change play out over the coming decades, they will have a wide array of impacts. As such, population changes are important determinants of change in the IMW.

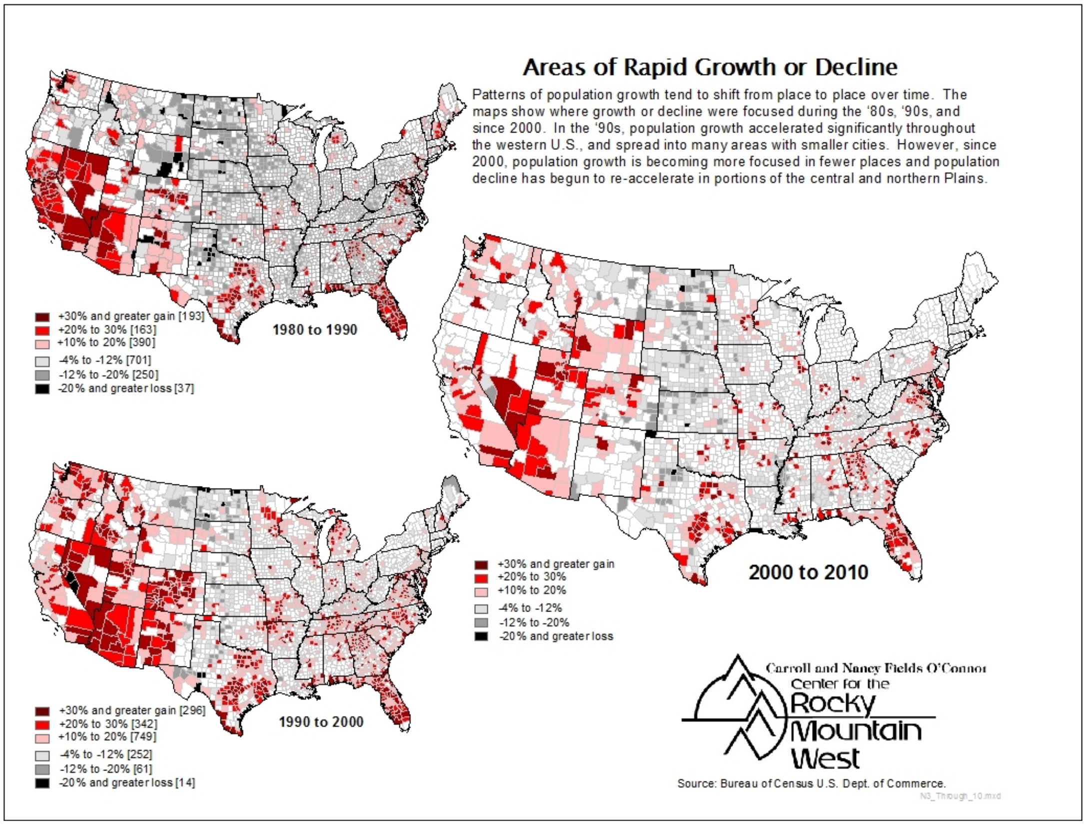
The amount and form of land development will be affected by the magnitude and location of population growth. Much of the new development will be focused in and near towns and metropolitan areas. The types and locations of housing demanded by aging Baby Boomers and Hispanic will likely be different from trends of the recent past.

Local and regional economies will evolve significantly as a result of changing population and demographics. Health care for an aging population will become an increasingly larger economic sector.

Requirements for water, energy and transportation infrastructure will change in response to slowing population growth. As population is concentrated more into urban areas water and energy will need to be moved from sources to these demand centers, necessitating additional pipelines and electrical transmission lines. Growing populations will need roads, rail and various forms of public transit.

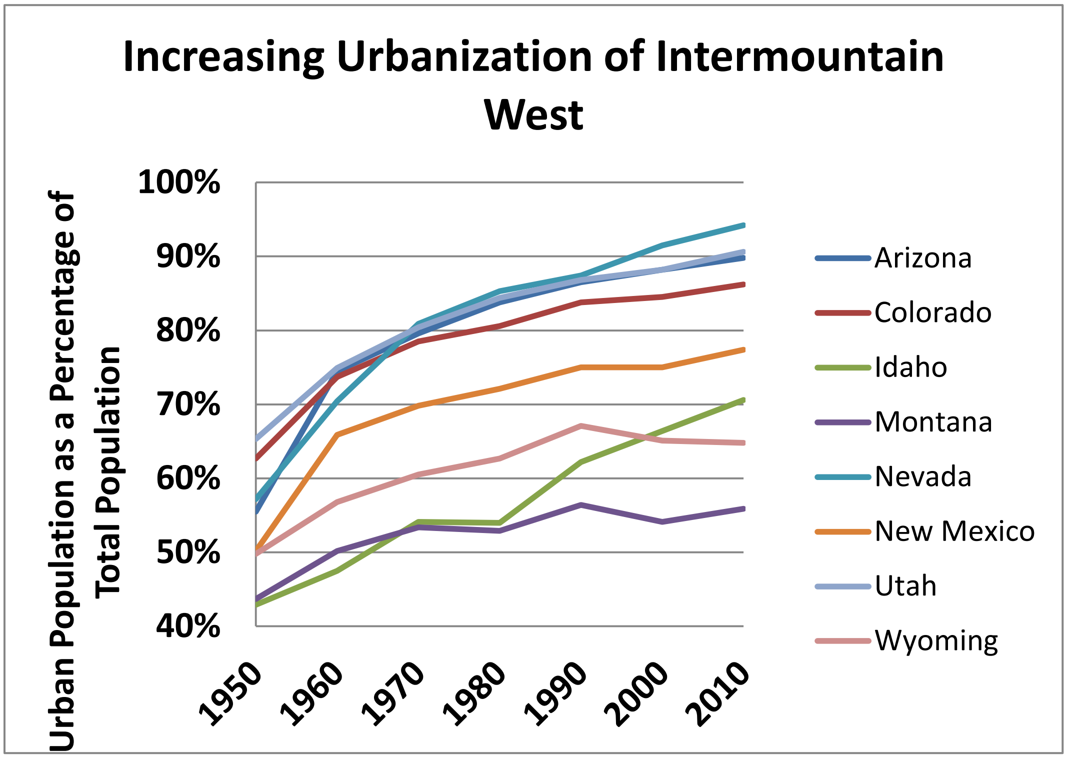
Major shifts in demand for various types of social services will occur. Already mentioned above, additional health care will be demanded by an aging population. Shifts in education needs and other social services will need to occur to accommodate an increasingly Hispanic population.

Figure 1: U.S. Decadal County Population Growth Maps, 1980–2010



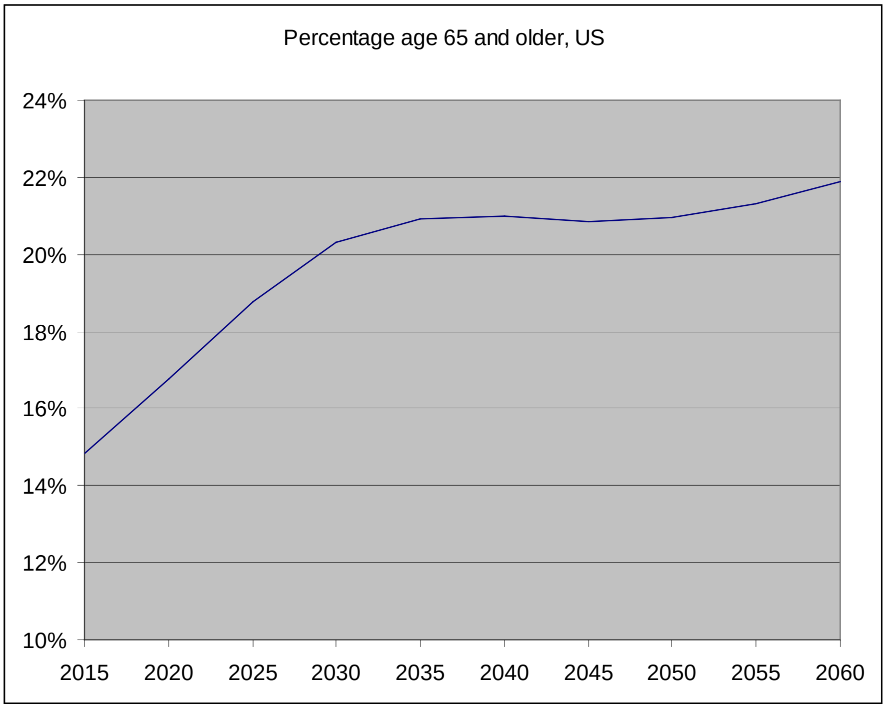
Source: U.S. Census Bureau data aggregated by Carroll and Nancy Fields O'Connor Center for the Rocky Mountain West

Figure 2: Urban Population in the IMW



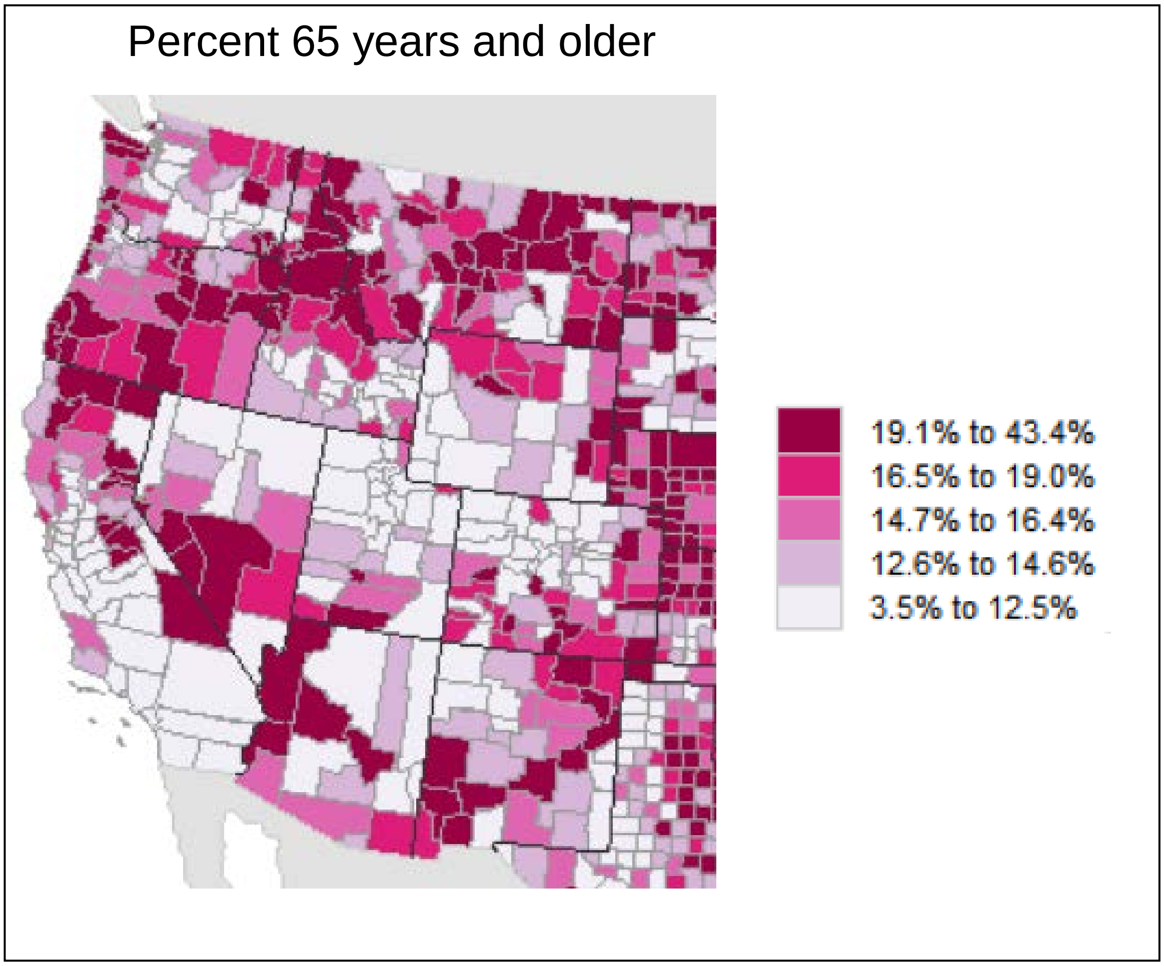
Source: U.S. Census Bureau

Figure 3: Aging Population Projection for the U.S.



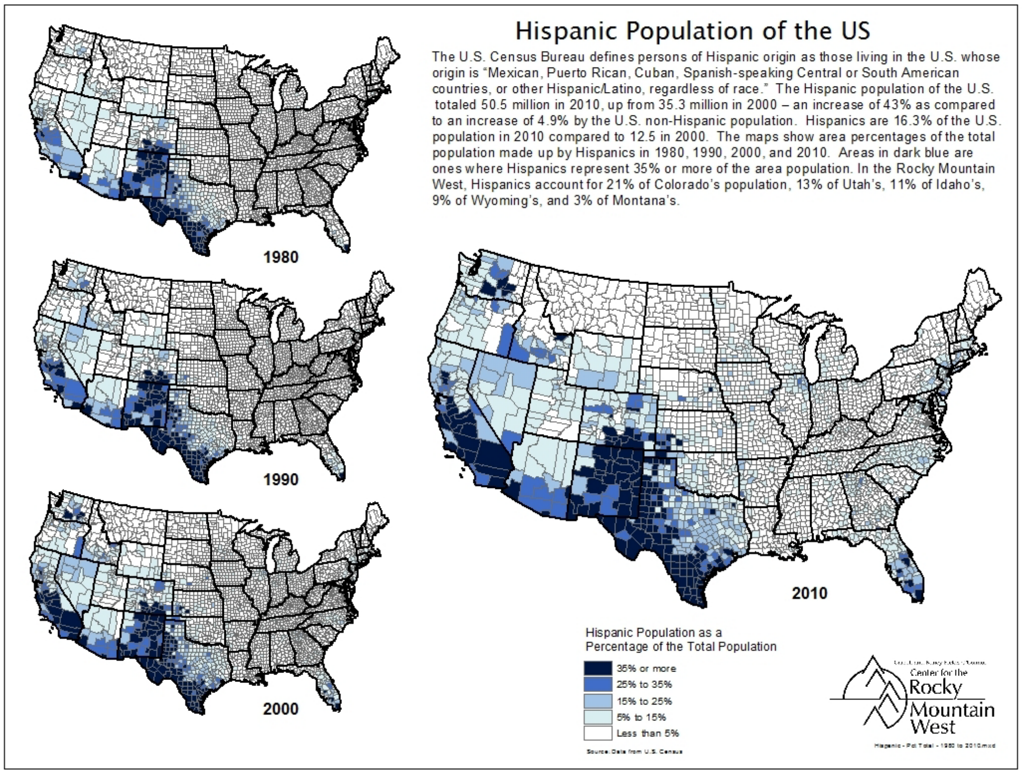
Source: U.S. Census Bureau

Figure 4: Distribution of Age 65 and Older



Source: U.S. Census Bureau

Figure 5: Distribution of Hispanic Population



Source: U.S. Census Bureau data aggregated by Carroll and Nancy Fields O'Connor Center for the Rocky Mountain West

Increasing Water Scarcity

One of the hallmarks of the IMW is its aridity. Long before significant population migration into the IMW, in 1878 John Wesley Powell presented to the U.S. Congress his "Report on the Lands of the Arid Region of the United States", describing the scarcity of water in the region and providing series of recommendations regarding development of the IMW, which were mostly ignored. One hundred thirty-five years later the issue of water scarcity is still with us and increasing.

The most well-known example of western water scarcity is the Colorado River, whose basin extends into six of the IMW states (Wyoming, Colorado, Utah, Nevada, Arizona, and New Mexico) plus California and Mexico. Figure 6 shows the results of the Colorado River Basin Water Supply and Demand Study, released by the U.S. Bureau of Reclamation in December, 2012. As can be seen in the graph, water demand in the basin now outstrips supply and this is expected to extend well into the future. The study projects an average imbalance between supply and demand of 3.2 million acre-feet by the year 2060, with the largest component of demand increase arising due to population growth.

Of course, water scarcity issues in the IMW extend beyond the Colorado River basin, to include many other river basins, including the Rio Grande, North Platte, Yellowstone, Snake, Walker and Truckee, among others. Also, the issue is not limited to surface water; groundwater supplies are also part of the water scarcity problem. Many water sources throughout the IMW are over allocated.

Although approximately 75 percent of western water demand is for agriculture, the increasing water demand in the IMW is being driven primarily by increasing municipal and industrial demand, which is mainly a function of an increasing population.

Water supply in the IMW is projected to diminish, as a result of expected climate change, with its accompanying effects on temperature and precipitation. In the Colorado River Basin Water Supply and Demand Study, under the scenario that incorporated downscaled global climate model impacts, the basin was projected to experience a nine percent mean stream flow decrease by 2060.

This all adds up to increasing water scarcity across the IMW, with likely far-reaching impacts in many dimensions.

As noted above, agriculture accounts for about three-quarters of total water demand in the IMW. Decreasing water availability will affect agriculture production in many ways, including the location and magnitude of agricultural production; how the crops are watered (surface, sprinkler, drip); the mix of food, feed and fiber crops; as well as the specific species and varieties grown. Increasing water scarcity will necessitate changes in allocation of water among the myriad users, which has the potential to create conflicts among upstream and downstream water users, as well as among various water-using sectors—agriculture, municipal and industrial, recreational and environmental.

Changing water availability and allocation will affect the structure and health of local and regional economies, displacing some economic sectors (such as agriculture) in some places and creating new opportunities in others. Uncertainty regarding water availability may create challenges for economic development as firms and individuals decide where to locate and expand operations.

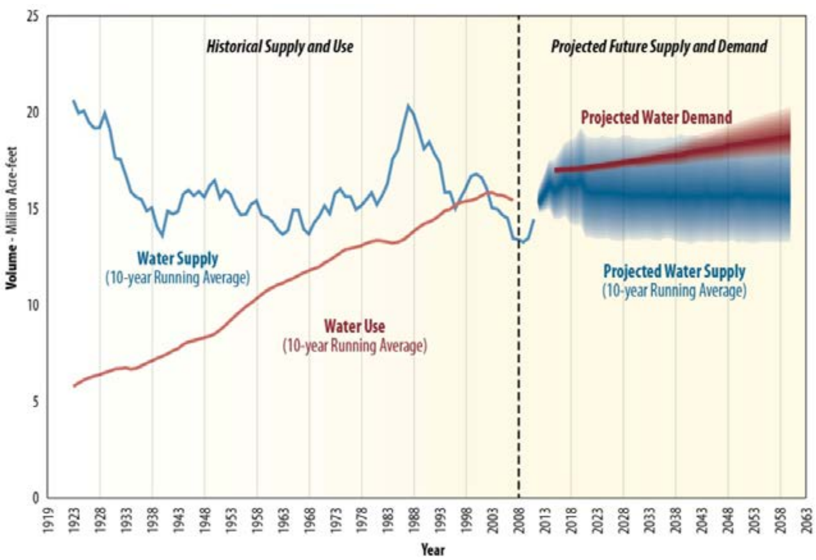
One economic sector likely to be strongly affected by increasing water scarcity is land development, in both the rural and urban settings. The need for an assured water supply for all forms of land development will affect the locations and types of development, as well as the overall amount of development that occurs.

A significant portion of western energy supply is hydroelectric power. If decreasing runoff results in lower reservoir levels, less electricity will be generated using hydropower. Of course, water and energy are interrelated as electricity, including hydroelectric power, is used to pump water and water is used for cooling thermoelectric power plants.

Water is essential in mineral and energy extraction, used for process water in mining and ore concentration, as well as in hydrofracturing for oil and gas production. As water scarcity increases, mineral and energy extraction costs will likely increase and some projects may not be developed due to lack of water. This may affect the IMW economy as well.

Increasing water scarcity will extensively affect plant and animal habitat, especially in riparian corridors, which have high levels of biodiversity, but also across the landscape. Many species that are currently threatened and/or endangered will continue to have their habitat reduced or degraded.

Figure 6: Colorado River Basin Supply and Demand Study



Source: U.S. Bureau of Reclamation, Colorado River Basin Water Supply and Demand Study, 2012

Real Energy Prices

Real (inflation-adjusted) energy prices are fundamental to the future of the IMW. Should the real cost of energy rise, so would the value of exploitable energy resources in the region, along with the financial incentives to further expand their development. While energy resource development might become a significant driver of the regional economy under such conditions, at the same time, rising real costs for transporting people, goods and services between Western population centers and higher costs for other forms of energy beyond transportation could significantly dampen overall regional economic activity and result in low growth, or even a regional recession—depending on the extent and speed of real energy price inflation. Should real energy prices decline in the future, the reverse effects might be expected: a depressed resource development sector, accompanied by a more robust general environment for economic growth. So the net effect of future energy prices is both important and complex—but fundamentally uncertain for the region. The U.S. Department of Energy's Energy Information Administration (EIA) notes the following relevant trends in its Annual Energy Outlook (AEO) for 2013:

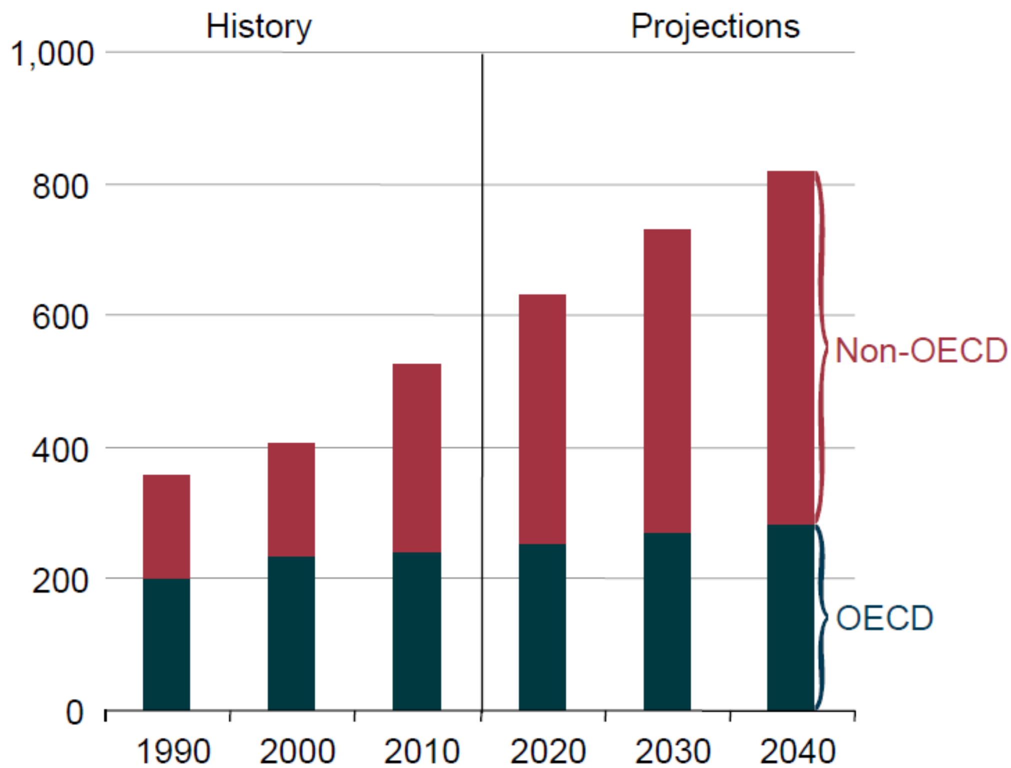
- U.S. oil production will rise over the next decade, leading to a reduction in net-import dependence;

- The United States will become a net exporter of natural gas as growth in productive capacity outstrips domestic consumption;

- Coal's share of U.S. electric power generation will fall. (U.S. Energy Information Administration 2013)

With more efficient light-duty vehicles, motor gasoline consumption will decline while diesel use will grow, even as more natural gas is used in heavy-duty vehicles The EIA also issues a bi-annual International Energy Outlook (IEO). The most recent IEO was issued in July 2013. In the *IEO2013* Reference case, which does not incorporate prospective legislation or policies that might affect energy markets, world marketed energy consumption is projected to grow by 56 percent from 2008 to 2040. Global energy use is projected to rise from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and 820 quadrillion Btu in 2040 (Figure 7). Much of the growth in energy consumption is expected to occur in countries outside the Organization for Economic Cooperation and Development (non-OECD nations), where demand growth is expected to be driven by high economic growth. Energy use in non-OECD nations increases by 90 percent in the Reference case compared to an increase of 17 percent for OECD economies.

Figure 7: World Energy Consumption, 1990–2040 (Quadrillion Btu)

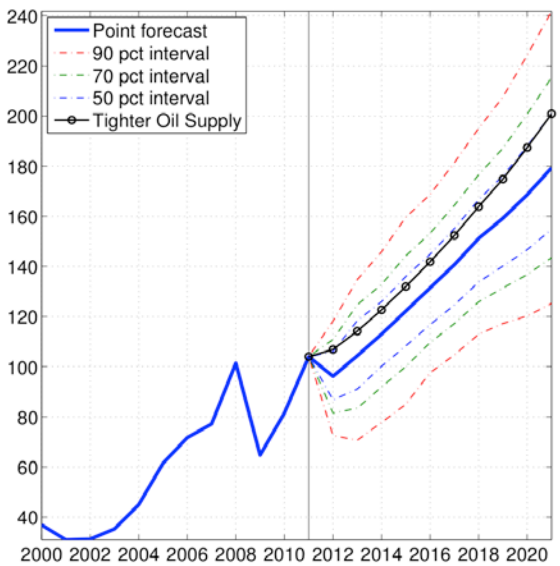


Source: (U.S. Energy Information Administration 2011)

While new technologies are providing substantial assistance in bringing energy to market, demand growth from developing countries will continue to place upward pressure on real energy prices despite near-term fluctuations in supply and pricing.

A recent working paper "The Future of Oil: Geology versus Technology" (Benes et al. 2012) published by the International Monetary Fund illustrates how difficult it will be to simultaneously realize healthy global economic growth (3–5 percent per year), while limiting increases in the price of oil. The paper presents a forecast of real oil prices through 2020 (Figure 8) based upon analysis aimed at reconciling the countervailing influences posed by traditional geological limitations governing recoverable reserves, and the confounding impact of advancing recovery technologies.

Figure 8: World Oil Price International Monetary Fund 2012 (in 2011 dollars)



Source: (Benes et al. 2012)

The authors clearly state "there is substantial uncertainty about these future trends that are rooted in our fundamental lack of knowledge, based on current data, about ultimately recoverable oil reserves, and about long-run price elasticities of oil demand and supply," yet, even so, the model forecasts a "near doubling of real oil prices over the coming decade," with a global average growth rate of between 3–5 percent. The authors conclude:

> Our data and analysis suggest that there is at least a possibility that we may be at a turning point for world oil output and prices. A key concern going forward is that the relationship between higher oil prices and GDP may become nonlinear if oil prices become sufficiently high. (Benes et al. 2012, 15)

An equally plausible interpretation might be that we are at a turning point not for oil prices, but for the global economy. Given the requirements of that economy for oil, we cannot sustain a 3–5 percent global economic growth rate—and the associated oil demand—for very long. Either interpretation is critically important to the future of the IMW because both highlight the likelihood of growing economic incentives for accelerating the development of the region's energy resources, and the critical importance of continuous improvement in energy efficiency and conservation across all sectors of the region's economy.

Drought and Wildfire

Along with general aridity, frequent drought conditions are a persistent characteristic of the IMW. Current drought conditions in the West are shown in figure 9; nearly 85 percent of the West is experiencing some degree of drought right now and almost half of the region is in severe or worse drought. Drought conditions have been widespread for over 10 years, beginning in the early 2000s in most of the West.

Historically, the West has experienced many periods of 25 or more continuous years of drought, as can be seen in figure 10, which shows drought conditions as reconstructed from tree ring data. It is clear from these data that the west is highly likely to see periods of drought as it moves into the future, without even considering climate change.

Future drought conditions in the IMW are likely to affect stream flow, agriculture, forest health, wildlife habitat, water scarcity and associated effects, air quality, snowmelt, invasive species distribution and human, animal and plant disease outbreaks, among others.

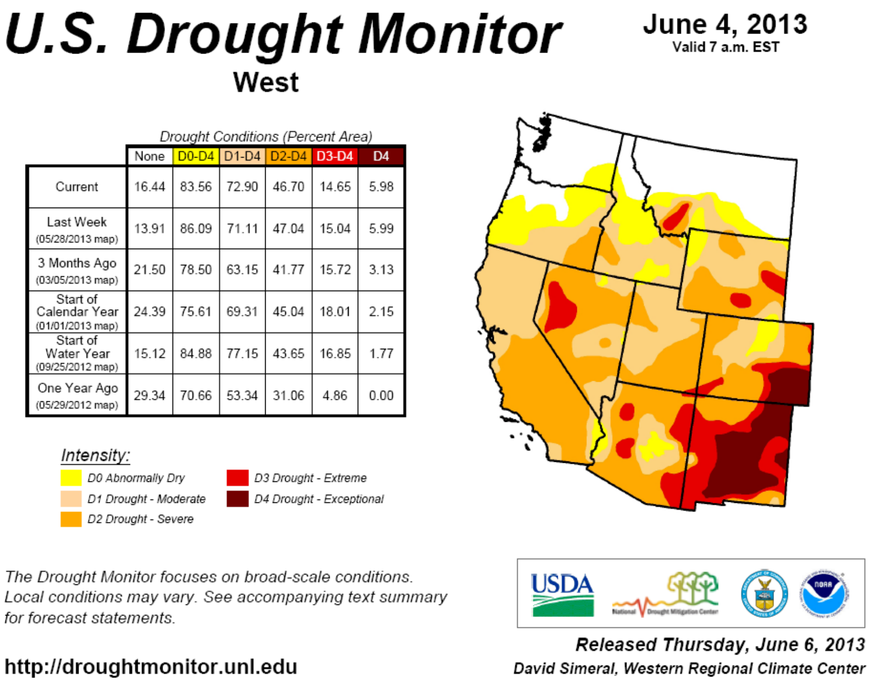
Drought conditions are a key factor in wildfires. Drought not only creates dry fuel conditions, but promotes bark beetle infestations that leave millions of acres of dead and dying trees that are prone to wildfire. The number of acres burned by wildfire in the U.S. is shown in figure 11, much of which is in the IMW. The trend has been increasing for the last 15 years or so and will likely continue as climate change exacerbates drought conditions and further facilitates the spread of bark beetles.

Wildfires result in extensive property losses as homes and infrastructure are destroyed. As such, increasing number of wildfires will change how land development occurs in the wildland-urban interface.

Costs of fighting wildfire are primarily borne by the Federal government and in an era of static or decreasing budgets for Federal agencies, these costs significantly impact the ability of those agencies to carry out other land management activities. These costs plus the human cost in lives lost will likely lead to changing policies regarding fighting wildfire.

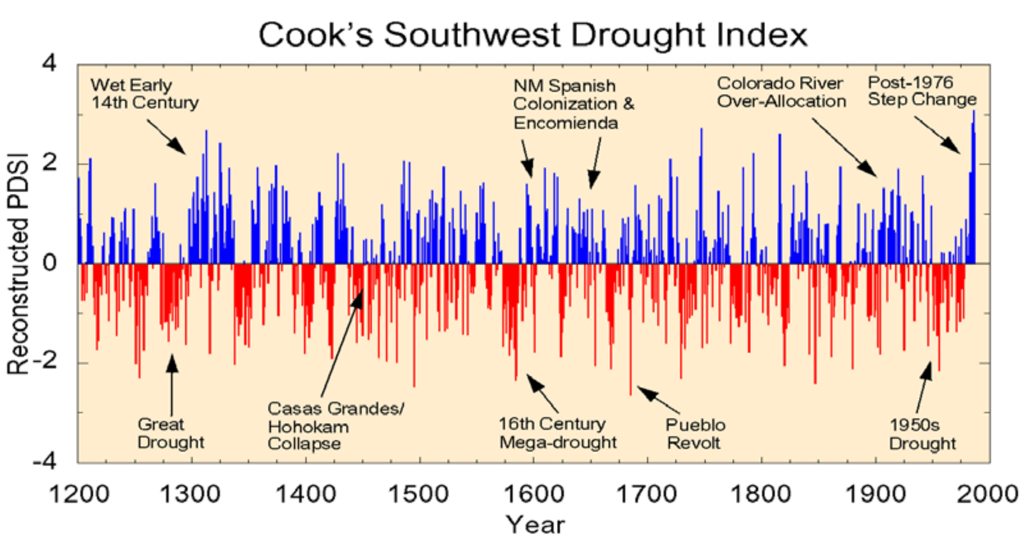
As watersheds are devastated by intense wildfires, flooding in these watersheds is often exacerbated, leading to compromised water supply infrastructure in the form of sediment-choked reservoirs and streams. These conditions will increasingly affect agricultural and municipal water supplies.

Figure 9: Current Drought Conditions



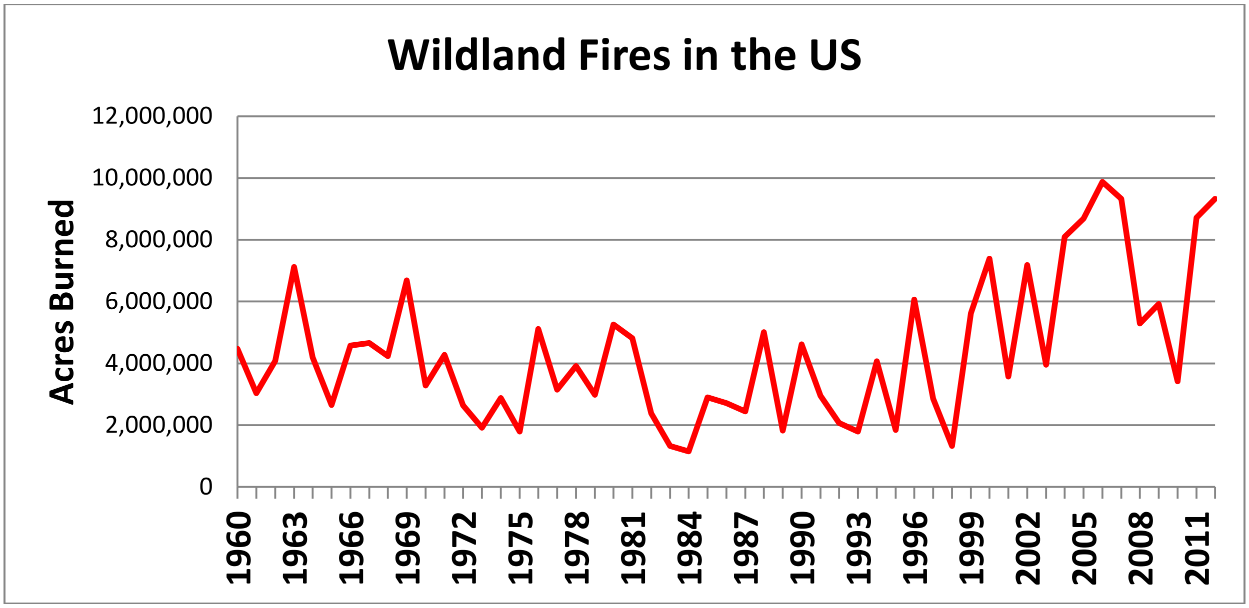
Source: University of Nebraska-Lincoln

Figure 10: Long-term Colorado River Basin Drought Conditions from Tree-ring Data



Source: J.L. Betancourt, U.S. Geological Survey, based on (Cook 2000)

Figure 11: Acres Burned in Wildfire in the U.S.

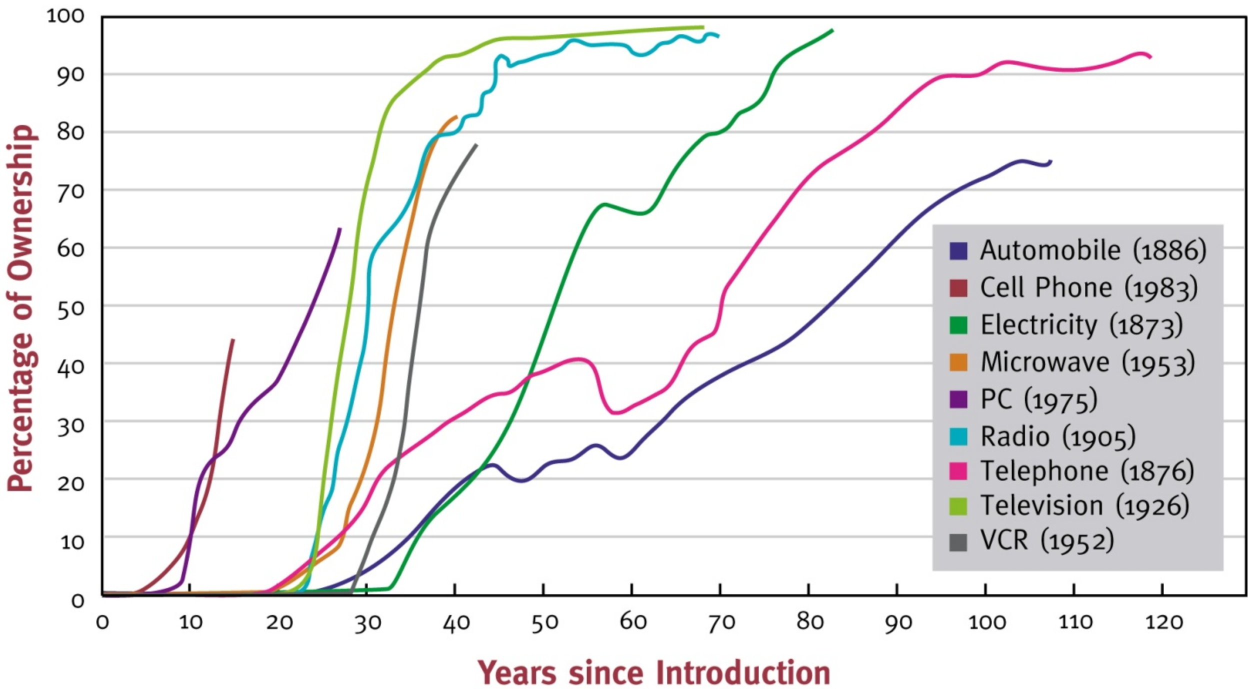


Source: (National Interagency Fire Center)

Technological and Process Innovation

Over the coming 25 years, technological change will reshape the Intermountain West in countless ways. While 25 years is only a fraction of a human lifetime, it is a long horizon over which to contemplate the impacts of new technological and process innovations. We should keep in mind however, that truly disruptive or transformative technological change requires much more than the technical innovation itself—it also requires what economist W. Brian Arthur has called "arrangements of use"—those myriad ancillary and institutional adjustments that must occur to support and enable the widespread diffusion and adoption of any particular technological innovation—and putting all the required "arrangements of use" in place may take considerable time. A disruptive innovation is one that creates a new market and disrupts an existing market by displacing an existing technology. An example of this is mass-produced automobiles, such as the Ford Model T, which fundamentally changed the transportation market. As a point of reference, figure 12 traces the time required for a number of 20th century technical innovations to achieve high degrees of market penetration.

Figure 12: Time 20th Century Tech Innovations Take to Achieve High Market Penetration



Source: (Aldrich et al. 2007)

Keeping this experience in mind, for the purposes of thinking about the future of the IMW, we draw attention below to technological innovations in a few key areas that are likely to drive fundamental changes over our 25 year time horizon within the Intermountain West:

Energy

Advances in energy technology, both for production and use, have critical bearing on the future availability and cost of energy in the West, and the quality of the overall environment. On the supply side, advances in horizontal drilling, the hydraulic fracturing of oil and gas-bearing shale (*fracking*), and the thermal recovery of hydrocarbons from oil-bearing sands, continues to lower the technical and cost barriers for the exploitation of previously marginal resources. Over the next 25 years, these trends could create pressures to open new areas of Western land for resource development. On the one hand, this bodes well for the future of the gas, oil and coal industries as significant contributors to the future economy of the region. On the other, environmental degradation due to an expanding and accelerating development of the region's oil, natural gas and coal resources could threaten historic scenic landscapes or traditional recreational land-uses, and is sure to increase conflict over access to (and use of) public lands.

Advances in power generating technologies will also be important. If costs and efficiencies of solar and wind generation continue to improve, solar and wind installations may become more attractive. And if natural gas continues to prove regionally abundant and relatively cheap, smaller distributed combined cycle systems, along with modular, solar and wind generation might play a larger role in power generation over the coming 25 years.

Finally, growth in the production of advanced biofuels could conceivably impact the future of land-use in the West. Of the many advanced biofuel production technologies under development, one in particular has important land use implications for the region, namely the conversion of cellulose from plants into smaller sugars, and then into fuels using centralized, refinery-like facilities. These 50–100 million gallon a year facilities typically call for the surrounding area of land (up to 20 miles in diameter) to be dedicated to the cultivation of cellulosic energy crops (such as switchgrass or miscanthus) as feedstock for the plant. Open range and grasslands in the West could be attractive potential siting areas for the construction of these kinds of advanced biofuels facilities.

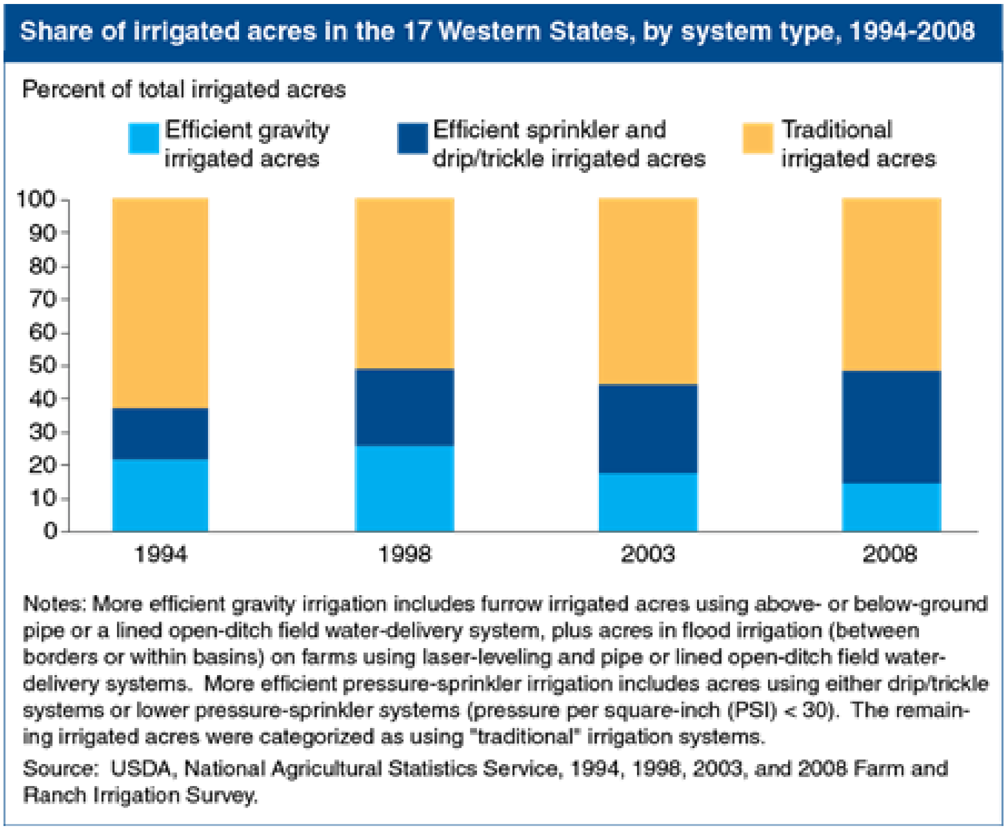
On the demand side, increasing energy efficiency driven by technological innovation could, over a 25 year time horizon, redefine transportation energy use in the IMW. The barriers to development posed by high-transportation costs could become less formidable with advances in engine, road, and piloting technologies. Already, hybrid passenger cars like the Prius enjoy 2–3 fold operating cost advantages over earlier, less efficient engine designs—and Daimler AG's smart cars offer consumers both low capital ($12–$15,000 for a new car) and low operating costs (70–85 miles per gallon). Google's driverless smart car initiative also carries the promise of fully automated, pilotless driving for short- and long-haul transport by 2018. Smarter transportation infrastructure is also under development, and new, interactive roads offering a variety of benefits are likely to be adopted within the next 25 years.

The redevelopment of the electric transmission and distribution infrastructure as a "smart grid" also promises regional efficiencies and cost savings—enabling lower cost "wheeling" of power into and around the region, while affording businesses and homeowners the ability to monitor their specific uses and costs for power in real time, and to tailor their purchase decisions accordingly.

Water

Clean, fresh water is a limiting and constraining resource in much of the Intermountain West. Over the next 25 years, new innovations in water pumping, purification, metering, and conservation technologies will play a crucial role in ensuring the availability of clean water throughout the region. On the supply side, while desalinization technologies continue to advance, they will remain a very expensive option for supplementing existing fresh water resources. Recent multibillion dollar commitments to add new desalinization capacity in California to meet expected future water demand will be watched closely as a bellwether for additional investment in desalinization facilities. If the region is to continue to grow in the face of limited and expensive options for expanding water supplies, major advances in the conservation and reuse of existing water resources must be achieved. On the demand side, metering, conservation, and efficiency innovations will be important determinants of future water availability. Smarter, more efficient agricultural irrigation and industrial process technologies could have significant impacts on the future of regional clean water resources (Figure 13).

Figure 13: Impact of Efficient Agricultural Irrigation on Regional Clean Water Resources



Source: (Schaible and Aillery 2012)

Information and Telecommunications

On-going innovation and growth of digital information processing and telecommunications infrastructure will continue to transform human life in the Intermountain West over the next two and a half decades, redefining where and how we work, how we socialize, how we learn, and how we procure and provide all types of goods and services. The internet is still a very young technology and we are just beginning to discover and build out its disruptive potential.

Unfortunately, making predictions in advance about what will prove to be truly transformative is rarely possible. Fortunately, imagining the possibility of disruptive and transformative change to most existing processes is possible. If you can imagine leveraging advances in digital technologies to create a particular transformation, it most probably can happen. This is how most internet business applications begin—as a realization of someone's creative imagination. For example, twenty five years ago almost all mass fundraising was done via door-to-door solicitation, direct mail or over the phone. The growth of the internet in conjunction with the advent of smart phones and mobile devices has ushered in a new and wholly unforeseen era of fundraising that leverages these new networks.

At root, it is a combination of technological and economic trends that taken together are driving these transformative changes, including:

- Continuing exponential improvement in the underlying enabling technologies of information processing, storage, and transmission (Moore's Law continues to hold and computing and information storage devices continue to get better, faster, and cheaper!)

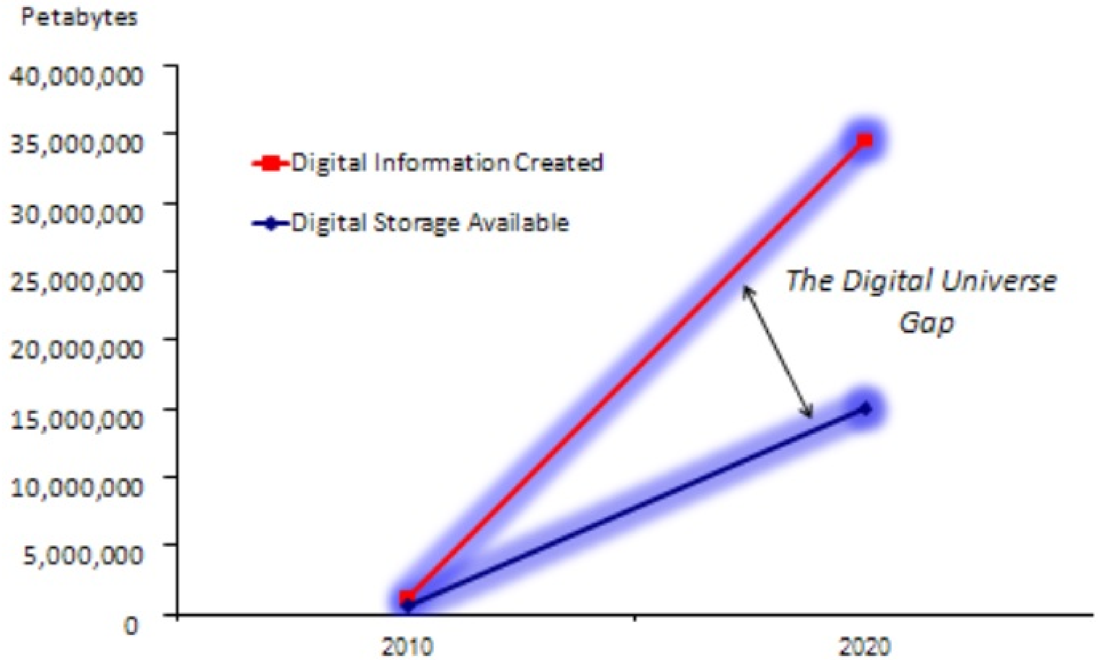
- Continuing build-out of network infrastructure to support the massive growth of the internet and mobile telecommunications networks.

- Diffusion of information processing capacity into more and more manufactured goods, enabling interactive "smart" networks to operate independent of human operators (i.e., the internet of things, which refers to digitally connected devices such as appliances and automobiles).

- An exploding array of new economic opportunities for distributed manufacturing in which the substitution of immediately available digital information and instruction sets coupled with better, faster, cheaper, and smaller manufacturing "facilities" overcome the traditional advantages and economies of scale captured through centralized, scaled manufacturing and distribution—a fast approaching future in which the manufacture and distribution of many common goods and services—even those derived from ancient and conservative processes like food production—are subject to radical transformation. For example, meals could end up being "printed" in your kitchen, rather than grown, transported, processed and re-assembled via today's convoluted global agricultural supply chain (NASA).

- Exponential growth in the volume of data our continually improving information landscape is generating, and hence, growing requirements for information processing and storage at huge scales (i.e., big data). See figure 14.

Figure 14: Estimated Data Growth—Worldwide



Source: (Gantz and Reinsel 2010)

Health Care

As the U.S. population both ages and continues to grow, so will healthcare spending. On the one hand, healthcare industries will become larger, more important contributors to local, state, and regional economies in the West. On the other, the number of people suffering from chronic, expensive-to-treat diseases and disabilities will increase due to an aging population and population growth, and will further burden strained health-care systems and state and federal budgets—especially in states with large numbers of retirees.

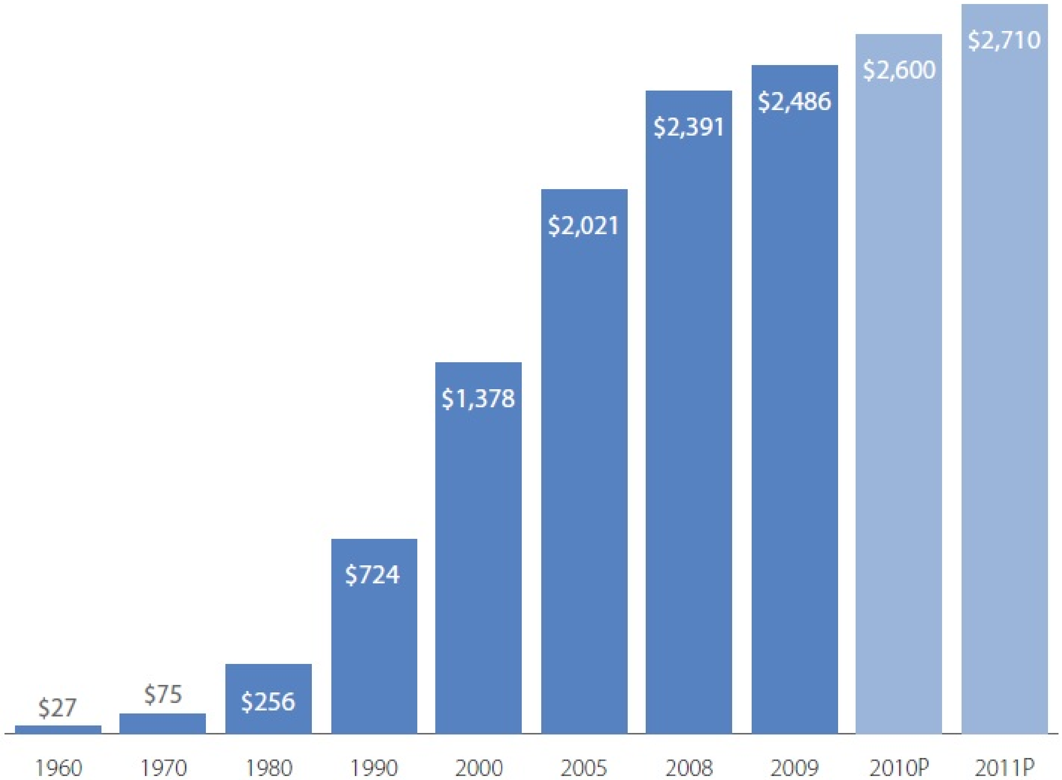
Without adequate preparation, shortages of health care workers could develop, along with the need to triage health care services at the end of life. Shortages in primary care physicians and rising costs may also shift the current balance of who is treating patients—with more emphasis on nurse practitioners, physician's assistants, and the delivery of virtual diagnostic and treatment services over the internet. While what we spend on treating illness will increase, so will spending on wellness and illness prevention. More dollars will be spent on ways to help prevent or reduce the incidence and severity of serious diseases (e.g. cancers) and chronic conditions (e.g. obesity-related illnesses such as diabetes). See figure 15.

Within this context of rising spending on the provision of healthcare and wellness services, technological and process innovation will play a central role. New, early diagnostic and treatment intervention technologies are constantly emerging, and will play a major role in mitigating the overall cost of delivering health-related services. For example, the cost and time required to sequence individual genomes continues to fall dramatically, as radically new sequencing technologies come to market. As a consequence, the market for genome sequencing in developed countries is expected to explode over the next few years, and portends the dawn of a complex new era in providing information intensive, personalized medicine—an era accompanied by an equally complex set of privacy and cost-benefit concerns. The U.S.-based consulting firm, Accenture, notes:

> As healthcare information technology evolves, the transformational opportunities it presents continue to grow exponentially. The penetration of Internet access, mobile technologies and social networks collectively offer a future in which it is possible to deliver highly personalized care without necessarily having to do it in person, or even with a doctor. Three technology trends—size and scale, personalization and social—are all impacting the future of healthcare. For example, healthcare professionals have begun to exploit people's natural tendency to play games in order to improve their cognitive skills and change their behaviors. Tele-health offers patients remote access to healthcare professionals and also has major advantages over traditional methods of delivery. Healthcare-specific social networks can help practitioners to deliver services, but they also enable patients to play a more active role in their care. (Accenture)

Technological innovation will also play a critical role in combating emerging infectious diseases. While the world has become more sophisticated in recent years in coping with potential pandemics, growing human and livestock populations, continued urbanization, travel, and inadequate public health infrastructure in poorer countries ensures that infectious disease will remain a serious threat to human and animal populations—and to regional economies—for many years to come. In this context, new vaccine manufacturing technologies capable of responding quickly to emerging threats will play an increasingly central role.

Figure 15: Total U.S. Healthcare Costs, 1960–2011

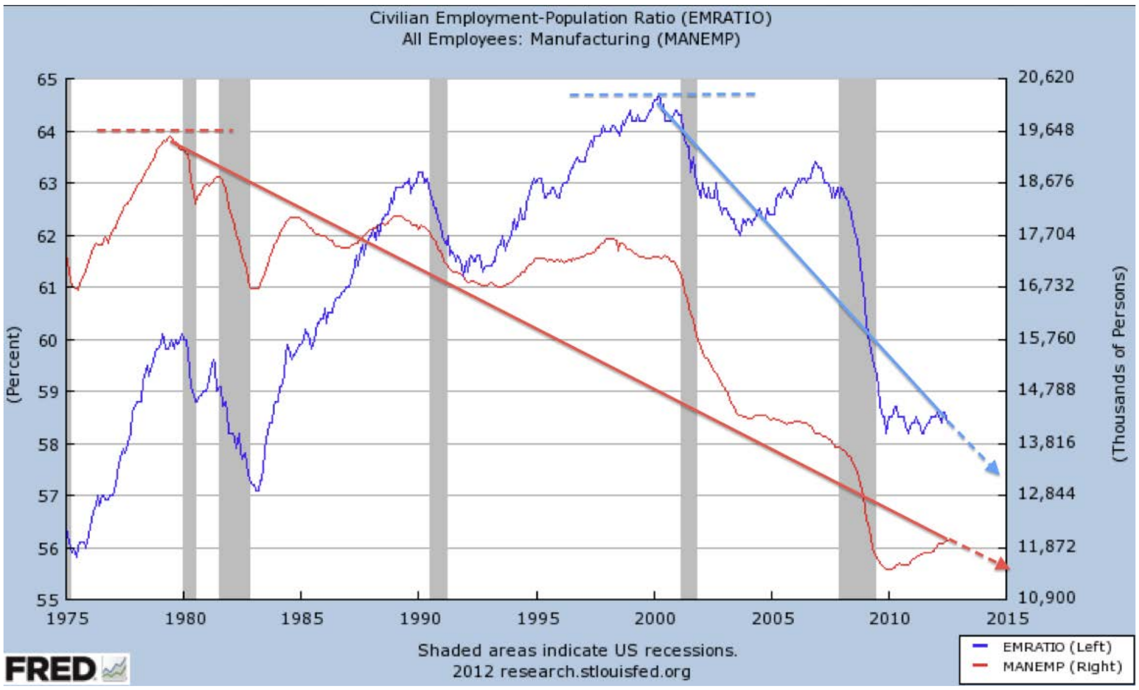


Source: (California Healthcare Foundation 2011)

Manufacturing

Advances in artificial intelligence, sensing, and control technologies are creating major growth opportunities for robotics and automated manufacturing systems. According to recent findings from IMS Research, the U.S. and Chinese markets will lead growth in a global industrial automation market expected to expand by more than 20 percent in just three years—from $160 billion in 2012, to more than $200 billion by 2015. Factories are becoming more automated, and are leveraging advances in robotics, remote sensing, artificial intelligence, cloud computing, and mobile communications to more effectively and seamless integrate real-time information flows between the marketplace, the factory floor, management, and the rest of the enterprise supply chain. Over the next 25 years, North America should have many opportunities to modernize and upgrade old manufacturing infrastructure—and to retool existing factories to better align production with global and regional demands. This may mean further restructuring and realignment in Western U.S. labor markets, with fewer traditional blue-collar manufacturing jobs, and more jobs for highly trained IT, electronic and automation support service providers (Figure 16).

Figure 16: Civilian Employment-Population Ratio; All Employees: Manufacturing

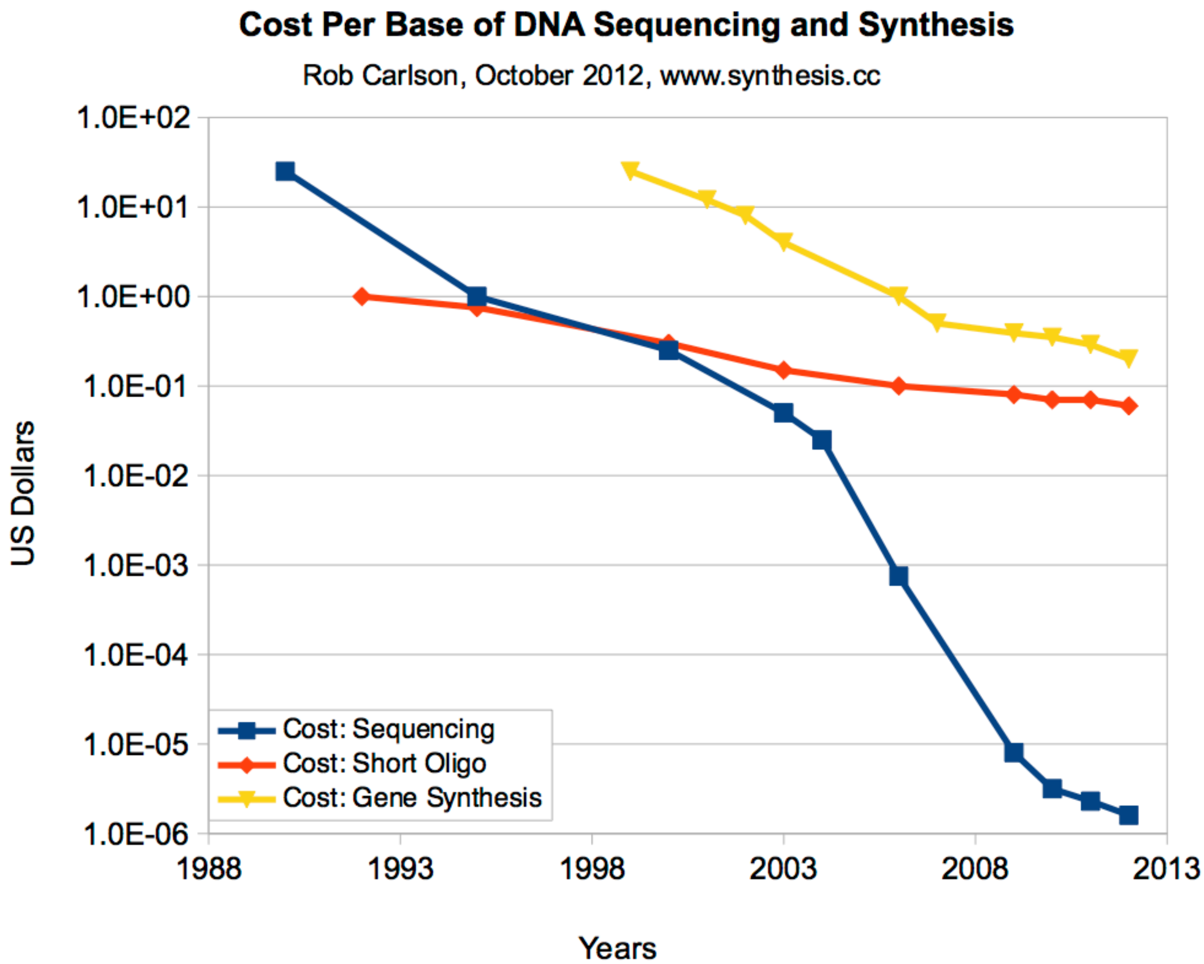


Source: (Federal Reserve Bank of St. Louis)

Biotechnology

Rapid advances in biological engineering portend dramatic impacts on the future of daily life and the economy in the Intermountain West. Exponential improvements in the cost and performance of key enabling biotechnologies—in particular, methods and tools for sequencing and synthesizing DNA—are opening the door to a new era of genome engineering and design that could prove as far-reaching as the revolution in information and computing technologies that preceded and enabled it (Figure 17). In addition to the impacts in the healthcare industry, other industries, such as petrochemicals, are witnessing the rise of radically new, more environmentally friendly, production platforms in which genetically engineered bacteria or yeast ferment renewable feedstocks like ordinary sugar to produce needed chemicals using processes more akin to brewing beer than refining crude oil—displacing older, less efficient, and dirtier production facilities. The impact of these developments is only just beginning, but is sure to transform much of our production economy in coming years. Already, open-source libraries of interoperable genetic "parts" and "circuits" are well underway, and a "DIY—Do It Yourself" culture of garage and hacker biologists is in full flower… Efforts are even underway to bring back to life now extinct animals leveraging developments in stem-cell biology, cloning, and genome synthesis.

Figure 17: Cost per Base of DNA Sequencing and Synthesis

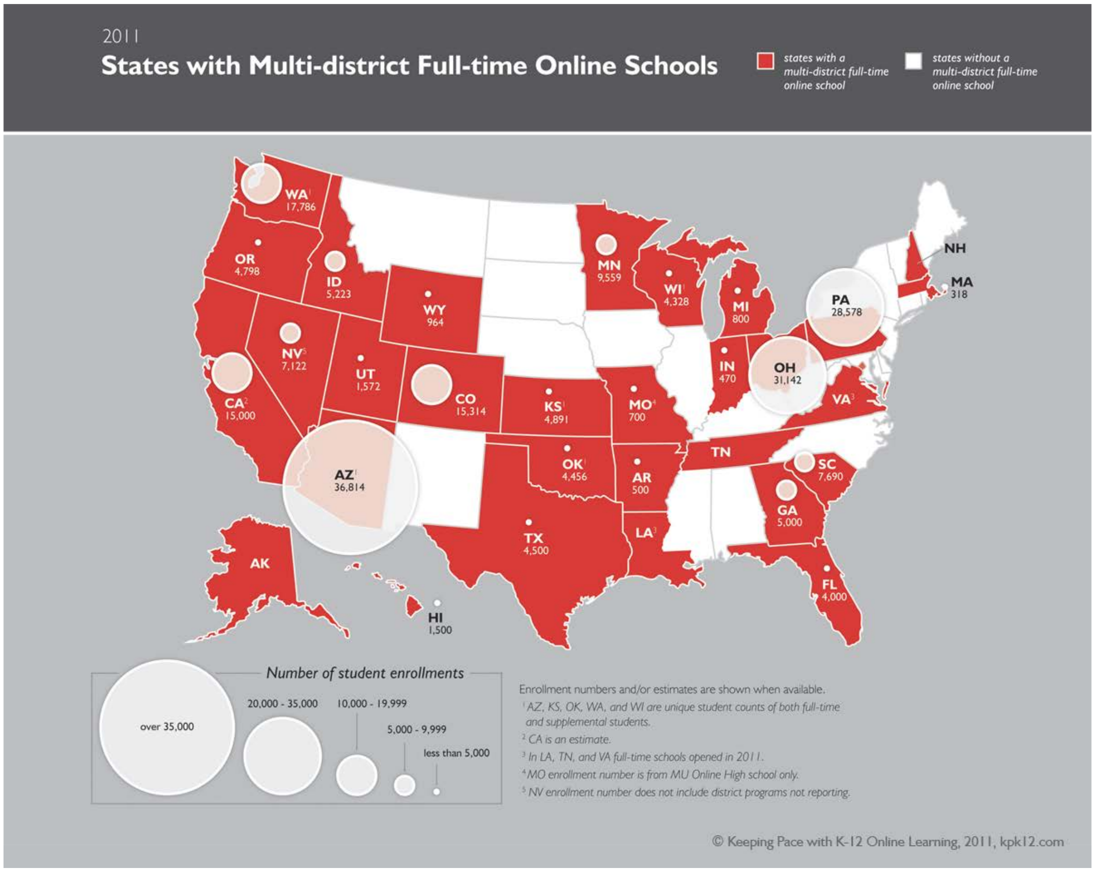


Source: (Synthesis 2012)

Education

Over the past decade or so, the on-going revolution in internet technology and mobile computing has sparked the beginnings of a revolution in U.S. education. As the cost of educating students continues to rise despite the poor economy and constrained budgets, educational systems are under increasing pressure to adopt new, more efficient educational processes. First and foremost among the alternatives has been online educational services and technologies (Figure 18). Already, growth in online education in the U.S. (and especially in some Western states) has been explosive, but the results over the next 25 years should be nothing short of revolutionary. Already, the ever climbing costs of public and private secondary education are driving an onslaught of internet-based educational innovations that are challenging the traditional U.S. model of age-based student cohorts sharing physical space as they progress through a shared cirriculum. The amazing growth and success of freely available on-line course providers such as the Khan Academy are fundamentally reshaping what is being done in the classrooms. Progress through the educational system is being reshaped to accommodate individual capacities and appetites for learning as certified by the demonstrable competency of the student whenever they are ready. In short, the entire educational system is being slowly reshaped around the desire and capacity of individuals to achieve competency in a given subject or discipline. This profound trend has important implications for the future of all educational institutions and systems.

Figure 18: States with Multi-district Full-time Online Schools



Source: (Watson et al. 2012)

Economic Growth

The economy is one of the most fundamental determinants of change in any region and this is also true in the IMW. The essential uncertainties about the economy are whether or not it will grow, to what extent, and what will be the contributions of the various economic sectors. Figure 19 captures how the IMW economy has evolved over the last 40 or so years. Key components of this evolution are the rise of the service economy, increasing importance of non-labor income and the decreasing relative contributions of the agriculture, extractive industries and manufacturing sectors. With some variation, these general trends are likely to continue.

Factors affecting the service economy are population growth, how well the IMW economy competes in the global economy, workforce needs, higher education and how well it supports innovation, trade with Mexico and Canada, economic development in the IMW metropolitan areas, and the ability of the region to continue to attract high-wage and high-skill professionals.

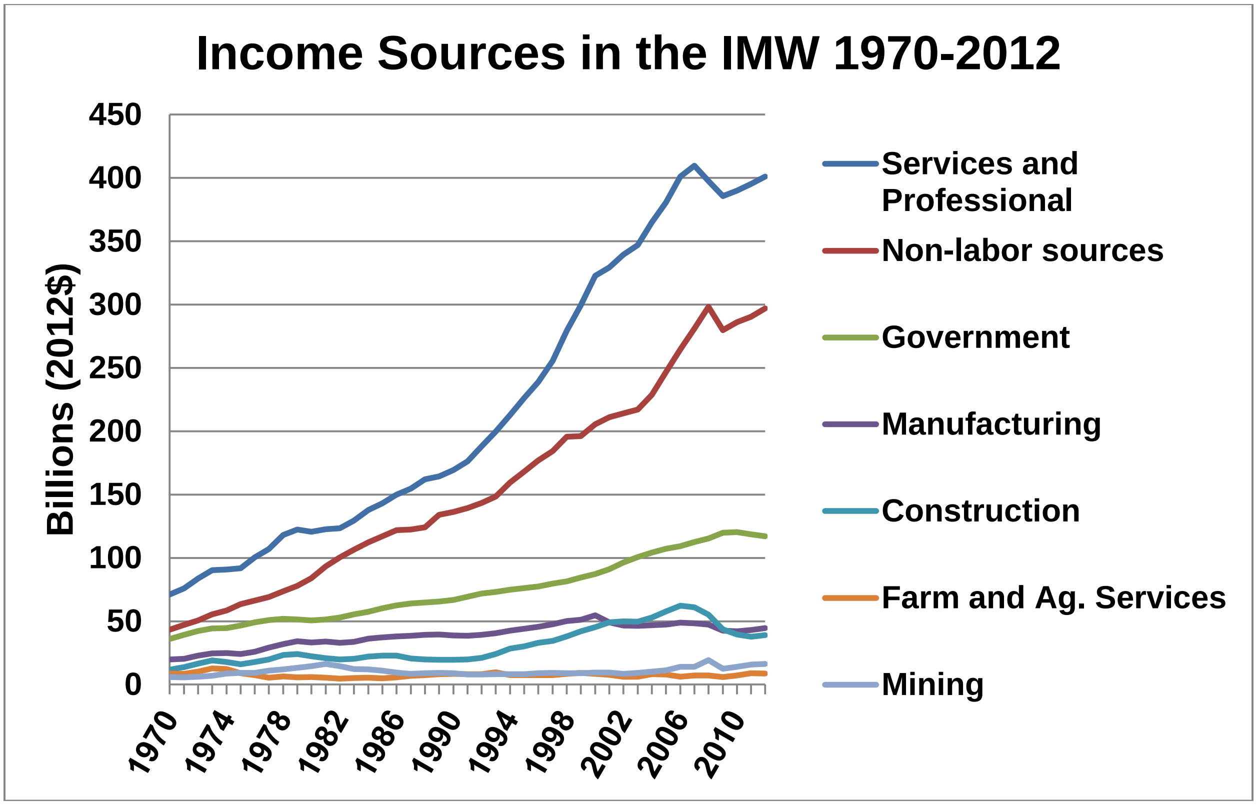
The agricultural sector, although a relatively small component of the overall economy, affects a significant percentage of the western land area and consumes approximately 75 percent of the water supplies in the region. It is generally assumed that water will transition out of agriculture into municipal and industrial usage as these sectors are able to pay higher prices for the water, but this raises important questions about food production, water for environmental flows and the cultural importance of agriculture to the IMW.

The extractive sector is likewise a relatively small component of the regional economy, but global commodity demand and pricing could significantly change that, especially regarding coal and metals. Montana and Wyoming contain very large coal resources that could move into world markets should transportation infrastructure be developed, especially port facilities in the Pacific Northwest and British Columbia. Changes in oil and gas extraction have already radically altered the petroleum sector and may continue to do so. If the immense oil reserves disseminated within the Green River Shale in Colorado, Utah and Wyoming were to be developed, the extractive sector would become a much larger proportion of the IMW economy.

Renewable energy is currently a very minor component of the western economy, but extensive and abundant resources in the form of wind and solar exist in the IMW. Continued development of these resources will depend on development of adequate transmission capacity, whether or not carbon pricing becomes prevalent and sustained demand for renewable energy.

The tourism and outdoor recreation sector is another small component of the IMW economy, but one that is growing in importance. Its growth will depend on whether or not environmental amenities in the IMW are protected, maintained and/or restored.

Figure 19: Income Sources in the West



Source: Bureau of Economic Analysis, U.S. Department of Commerce

Intermountain West Natural Resources

More than 263 million acres of land across the IMW are managed by the four major land management agencies (U.S. Forest Service, Bureau of Land Management, National Park Service, and Fish and Wildlife Service) and the Department of Defense. This is approximately 48 percent of the total land area of the eight IMW states (Gorte, et al. 2012).

Paradoxically, the region is marked by both abundance and scarcity of natural resources. Forests, grasslands, energy and mineral resources, including significant reserves of oil, natural gas, coal, uranium, silver, copper and other mineral resources are relatively abundant, while supplies of other common resources, such as water, are constrained.

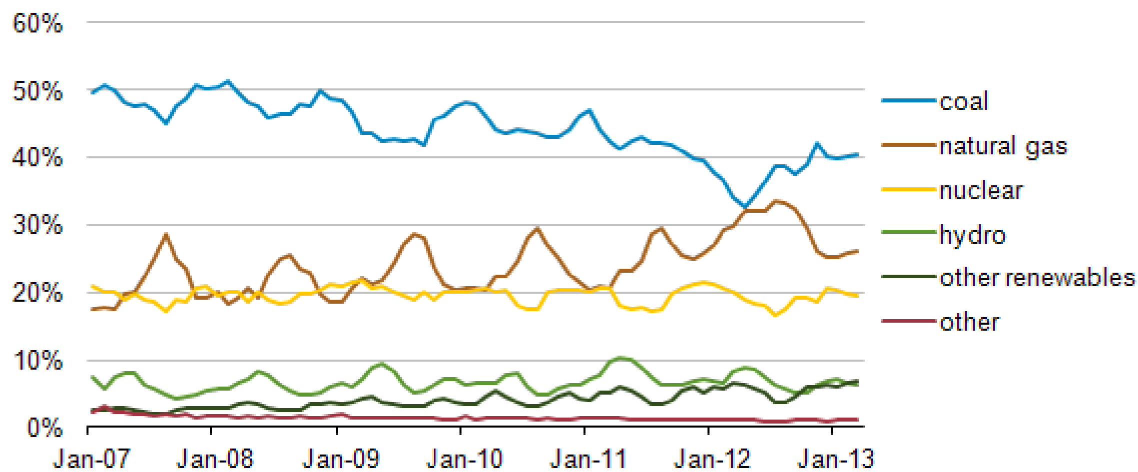
In addition, five IMW states (Nevada, Utah, Arizona, Idaho, and Colorado) top the nation in population growth, with growth rates over the past decade of over 20 percent. Across the region, but particularly in these states, access to natural resources for recreation and commerce is often cited as a significant determinant for residents and businesses settling in the area. Much of the new population growth is occurring near preservation land in these states, enabling new opportunities for human and wildlife disruption and increasing forest-fire risks to private lands and property.

In the coming years, these trends are expected to continue. Increasing population and economic development pressures, coupled with changing climatic conditions, will increase the challenges of managing the Intermountain West's natural resources. Greater vulnerability to wildfires, floods, storms, insect outbreaks and other disturbances will unfold within a context of constrained government budgets.

Within the energy sector, oil and natural gas extraction will continue to grow as demand for both domestic uses and exports increases. The extent of this growth may be constrained by pipeline availability and expansion.

Coal, by comparison, is an energy source with more clearly defined transportation infrastructures and export channels. The U.S. holds the world's largest estimated recoverable reserves of coal and is a net exporter. Currently (2013) approximately 42 percent of the country's nearly four trillion kilowatt hours of electricity used coal as its source of energy (Figure 20). As shown in figure 21, much of the remaining reserve base is in the IMW (U.S. Energy Information Administration 2012). The top 10 coal producing mines in the U.S. are all in Wyoming and Montana (Figure 22).

Figure 20: U.S. Monthly Net Electric Power Generation, January 2007–March 2013, (Percent Share)



Source: (U.S. Energy Information Administration)

Figure 21: U.S. Coal Mining Areas

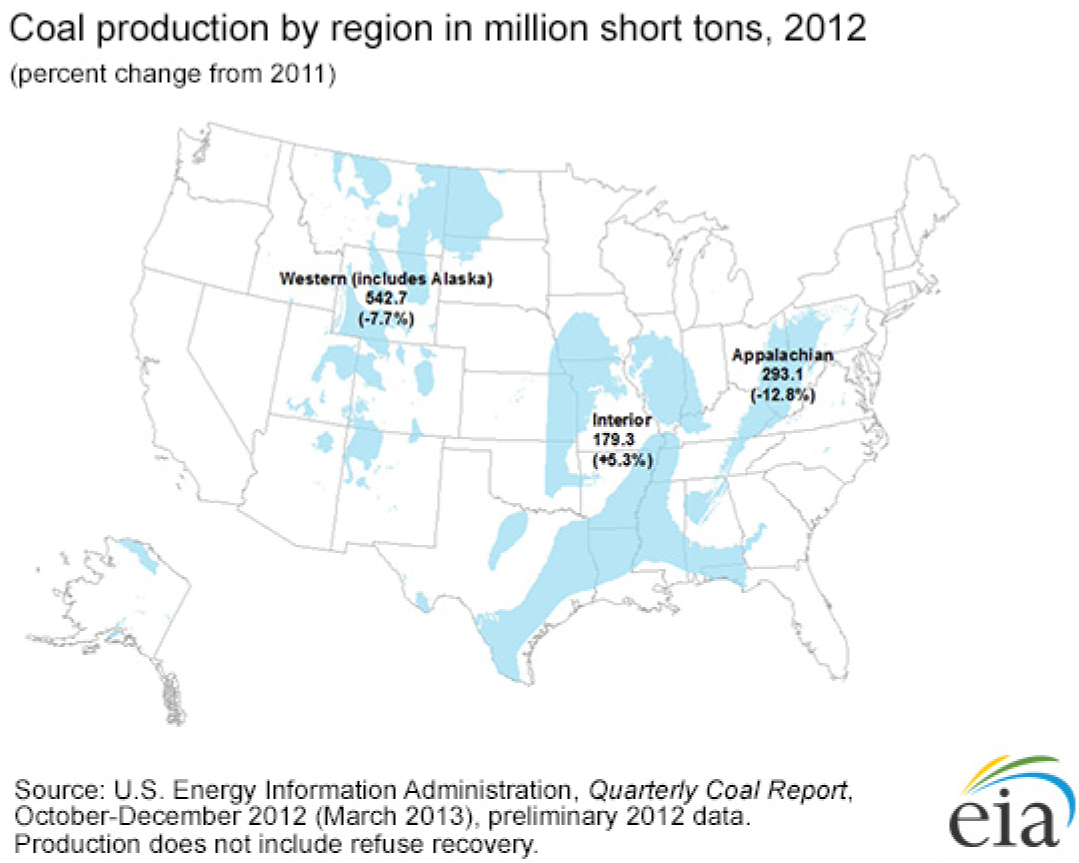
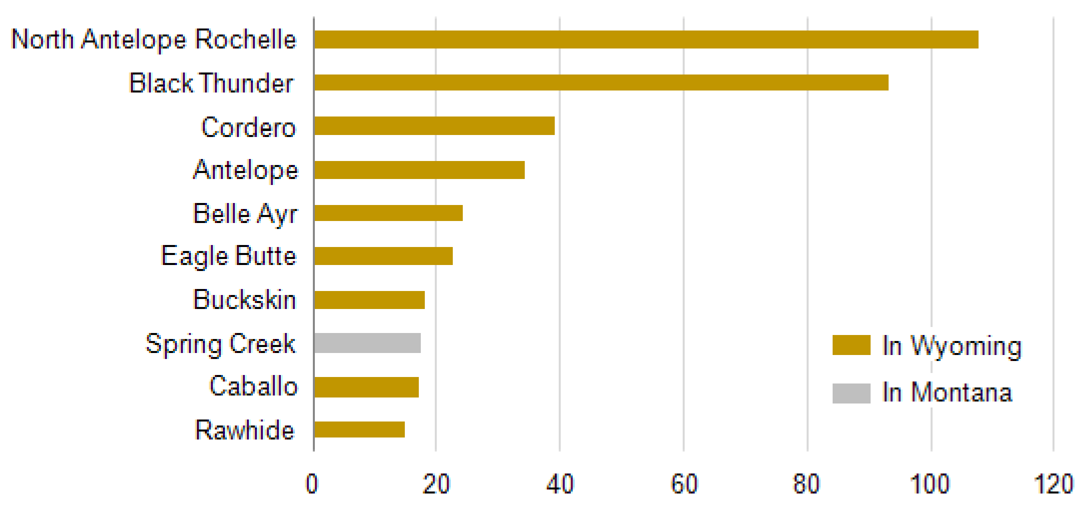


Figure 22: Top 10 Producing Coal Mines in the U.S. by Tonnage, 2012 (Million Short Tons)



Source: (U.S. Energy Information Administration)

Looking ahead, there may be sufficient supply in the U.S. to continue coal extraction for some time. The U.S. Energy Information Administration (EIA) projects sufficient reserves in its standard outlook to last for several decades. However, some sources suggest that coal extraction and use may be hampered by environmental and societal concerns related to pollution and safety of the miners engaged in coal extraction, as well as the evolving regulation of carbon.

Copper is another important natural resource present in the IMW. Of the world's currently known reserves of copper, approximately 6 percent (39 million metric tons) is in the U.S., most of which is in the IMW. Mine production in the U.S. in 2012 was about 1.15 million tons, 99 percent of which was produced in the IMW (Arizona, Utah, New Mexico, Nevada, and Montana) (Edelstein 2013).

Interestingly, although copper is continuously mined and put into use, the estimated U.S. reserve base has stayed relatively constant in recent years. It has increased fourfold from estimates made in 1952 as new deposits have been found, and, even more importantly, because better extraction techniques have allowed leaner deposits to be added to the reserve base. It seems reasonable to expect that these dynamics will continue in the years to come.

Overall, we see a number of social and economic factors contributing to natural resource demand across the IMW. The future for extractive industries in the region is uncertain, but industrial and consumer demand appears likely to increase for the two primary commodities that we've identified—coal and copper.

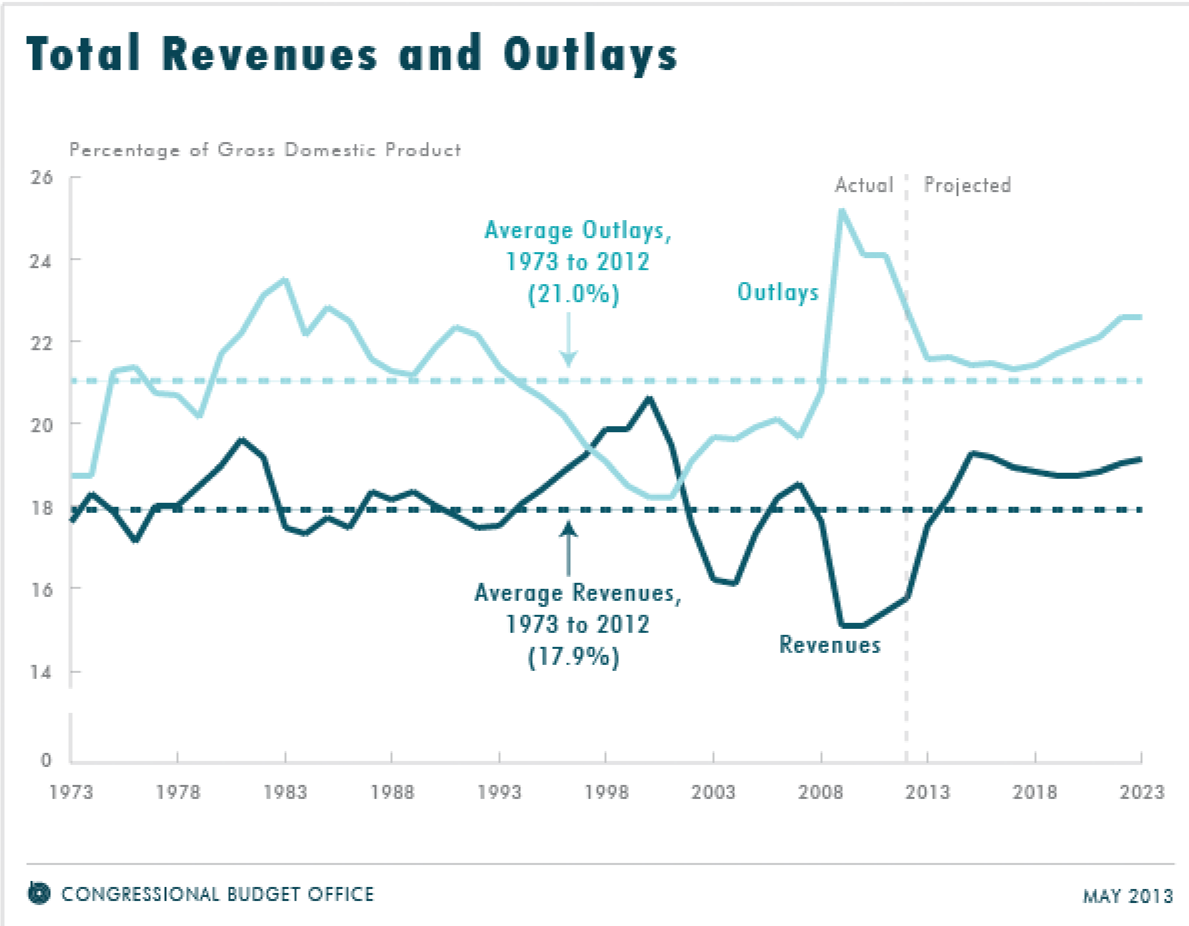
Role of Government

The role of government at all levels, federal, state and local is a critically important determinant of change in the IMW. Governmental policies, activities and interaction with individuals, private enterprise, other governmental entities and non-governmental organizations have effects on all aspects of the IMW.

Uncertainties in three areas bear particular consideration: government finances, land management/land use and environmental/natural resource policies/regulation.

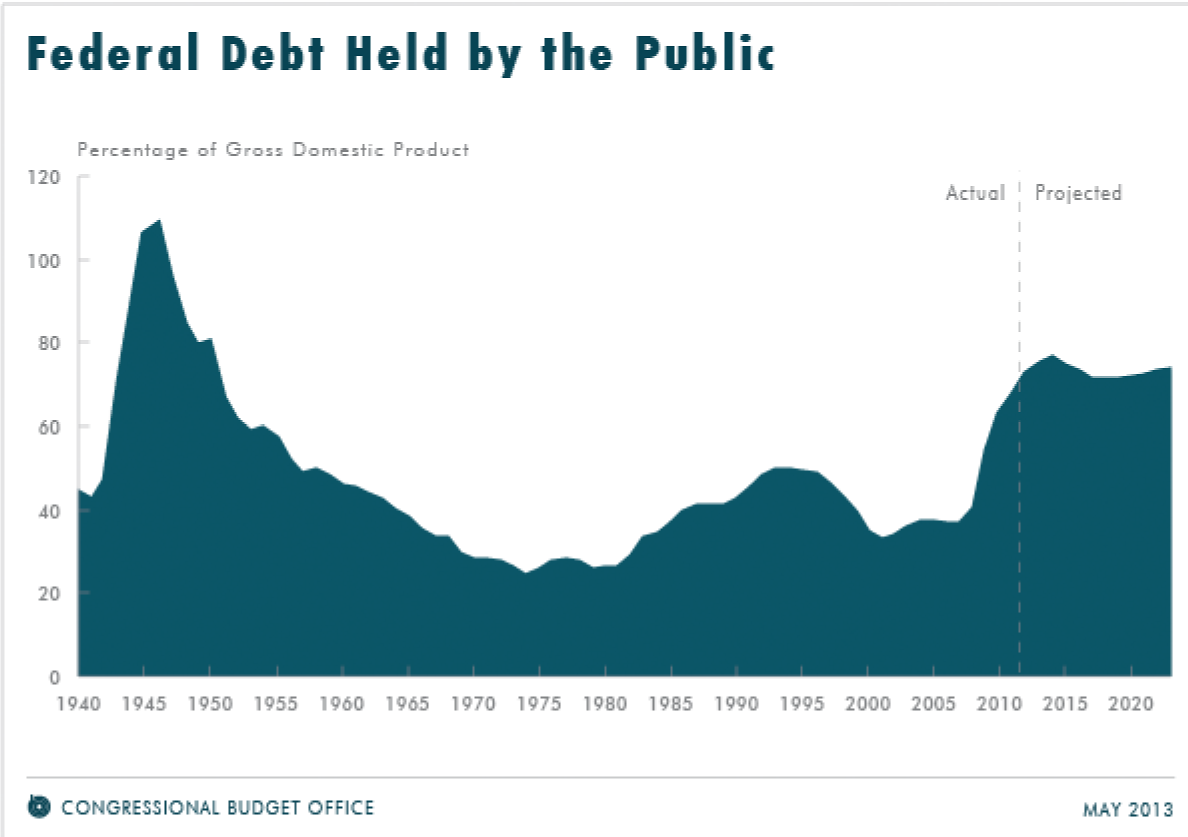
How governments generate revenues and how those monies are spent will continue to have far-reaching consequences in the future. Recently released Congressional Budget Office federal budget projections project a shrinking budget deficit over the next few years (Congressional Budget Office 2013). But deficits are projected to increase later in the next decade (Figure 23) due to increasing health care costs, health insurance subsidies, an aging population and rising interest on the federal debt. Total deficits for the ten-year period 2014 and 2023 are projected to be $6.3 trillion, which will result in very high public debt levels—above 70 percent of GDP (Figure 24). If these trends continue, public debt levels will continue to rise.

Figure 23: Projected Revenues and Outlays, U.S. Federal Budget



Source: (Congressional Budget Office 2013)

Figure 24: Federal Debt



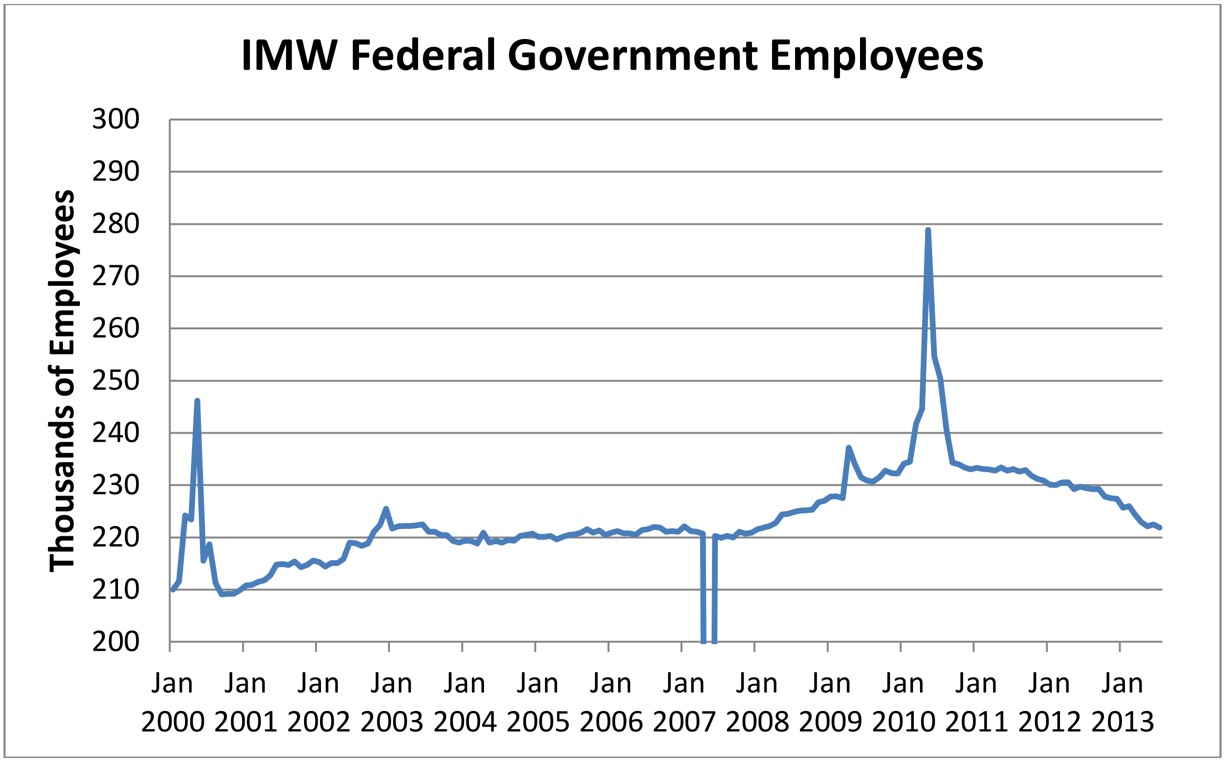
Source: (Congressional Budget Office 2013)

The impacts of such high debt levels that continue to rise include sharply increased costs of interest on the debt, more constrained government spending for all types of programs and an increased risk of severe fiscal crisis.

Uncertainties around how the deficit/debt will be managed and sources of the necessary revenue will constrain and shape the level of federal investments for managing the vast western federal land base, constructing and maintaining transportation and water-supply infrastructure and operating military bases located throughout the west, among other federal government activities.

Federal employment levels in the IMW can be seen in figure 25. Federal employment in the region has been decreasing since the end of the decadal census federal employment spike in 2010 and are currently nearly the same as immediately before the beginning of the global financial crisis and recession. How federal employment levels will change in the face of the federal fiscal situation is another uncertainty that will have implications for land management and many other federal government functions in the IMW.

Figure 25: Federal Government Employment in the IMW



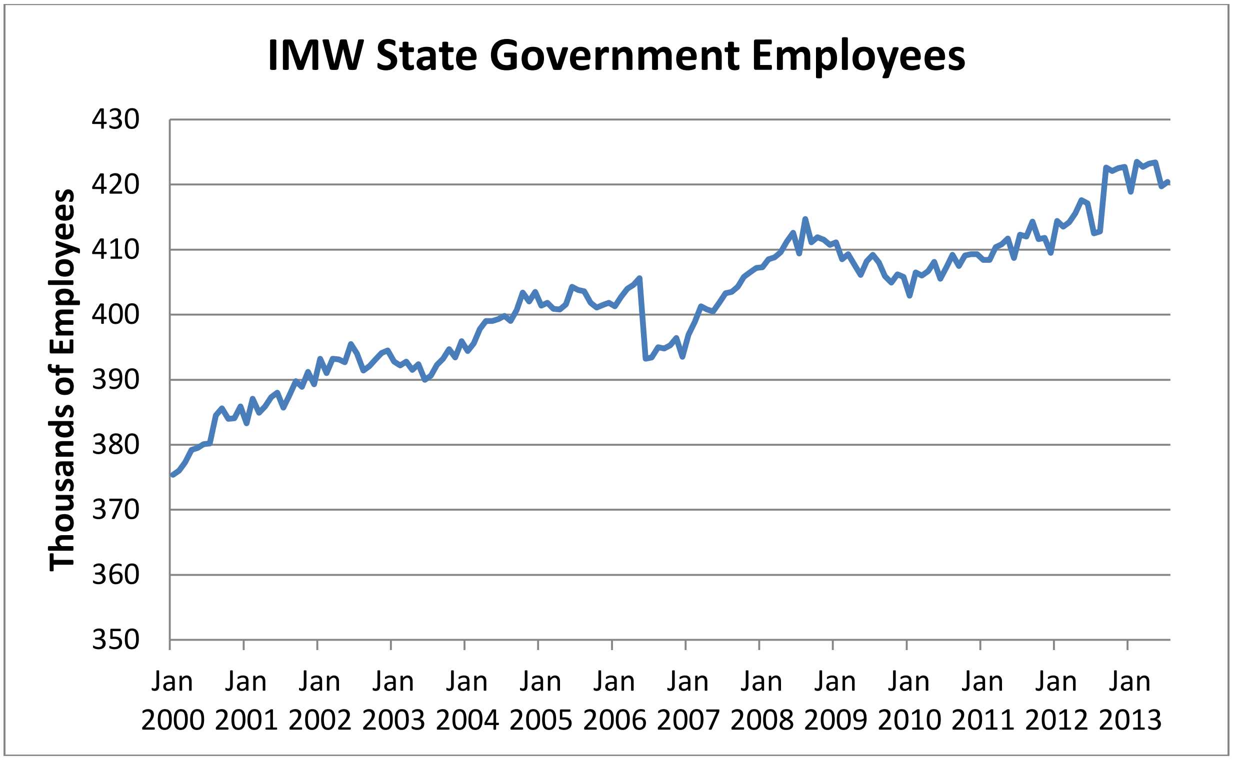
Source: Bureau of Labor Statistics

Across the IMW there is great variation in fiscal health of state and local governments. In general, as the region recovers from the global recession, the fiscal strain affecting local and state governments is slowly receding.

How IMW states' fiscal situations were affected by the recession was a complex function of each state's economic structure, tax policies and spending priorities. Depending on tax structures, some state's revenues have become more volatile and sensitive to economic cycles as personal income, sales and property values change (National Association of State Budget Officers 2013). How the fiscal balance evolves going forward will greatly affect primary and secondary education, colleges/universities, public safety, health and welfare services, transportation infrastructure and economic development activities.

In general, overall state government employment in the IMW contracted significantly immediately after the global financial crisis began in 2008 and started to recover with the economy in 2010 continuing to rise since then (Figure 26) to eclipse pre-recession levels. However, state government employment trends vary considerably from state to state. For example, Colorado has seen state government employment growing strongly throughout the recession period and continuing to do so currently, while in Arizona government employment decreased sharply from 2008 through 2010, recovering slightly in the last two years.

Figure 26: State Government Employment in the IMW

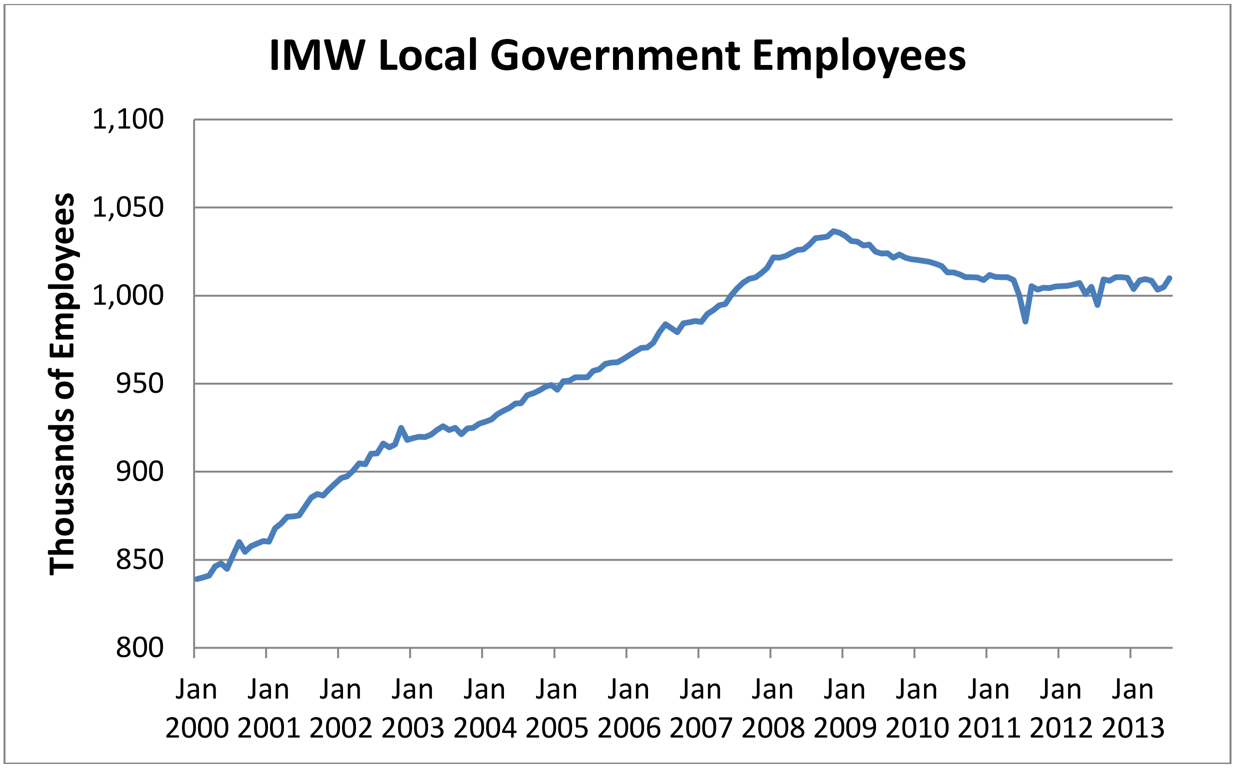


Source: Bureau of Labor Statistics

In contrast to the situation with state government employment, total local government employment in the IMW decreased from 2009 through 2011 and has been essentially flat since then (Figure 27). This is mirrored in the individual states in the region with the exception of Utah, which has seen local government employment increase gradually throughout the recession and recovery with only a partial-year, slight decrease in 2012.

Future trends in state and local fiscal health and government employment will affect the ability of government entities to the deliver the full range of functions needed by citizens. These trends will also impact how these government entities interact with private citizens, businesses and non-government organizations in various forms of partnerships to address public needs.

Figure 27: Local Government Employment in the IMW



Source: Bureau of Labor Statistics

How federal and state lands are managed will significantly affect regional and local economies, water supplies, natural resource development, tourism and recreation activity, agriculture, and energy development. A key uncertainty is what will be the balance among management of federal and state lands for extractive purposes, other forms of development and conservation.

The role of government in setting environmental policies and regulations is another important uncertainty to consider. These decisions, made primarily at the federal and state level, will have wide-reaching impacts on sustainability, land development, conservation, water supply and demand, human health, and ecosystem services.

Conclusion

The determinants of change examined in this working paper comprise a subset of the key change drivers for the future of the IMW. Many of the most significant drivers are represented here and this compilation should prove useful for communities and organizations contemplating the future and considering using exploratory scenario planning methodologies as they prepare for an uncertain and complex future.

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Appendix A—Determinants of Change Workshop Participants

First Name	Surname	Affiliation	Expertise
Stephen	Aldrich	Bio-Economic Research Associates	Scenario planning
Maria	Baier	Sonoran Institute	State trust land
Martin	Buchert	University of Utah	Spatial, transportation, housing
Armando	Carbonell	Lincoln Institute of Land Policy	Land-use planning
Charles	Coughlin	HighGround Public Affairs Consultants	Politics, governance, AZ
Susan	Culp	Sonoran Institute	State trust land
Craig	Groves	The Nature Conservancy	Conservation
Carly	Jerla	U.S. Bureau of Reclamation	Water, Colorado River
Holway	Jim	Sonoran Institute	Water, land-use planning
Rob	Lang	Brookings Institution	Urban, policy
Ron	Lehr	Western Grid Group	Energy, policy
Joe	Marlow	Sonoran Institute	Economics
Hannah	Oliver	Sonoran Institute	Land-use planning, climate
Peter	Pollock	Lincoln Institute of Land Policy	Land-use planning
Dave	Richins	Sonoran Institute	Policy
John	Shepard	Sonoran Institute	Policy
Larry	Swanson	University of Montana	Economics
Carol	Whiteside	California Strategies LLC, Lincoln Institute of Land Policy	Scenarios