Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

Western Water and Working Lands Framework for Conservation Action

Coordinated action must be focused on a watershed or landscape scale to gain the greatest positive and sustainable conservation outcomes.

– H.H. Bennett, 1st Chief of the Soil Conservation Service

Frameworks for Conservation Action

USDA's Natural Resources Conservation Service (NRCS) uses frameworks for conservation actions (frameworks) to coordinate and track progress on addressing defined conservation concerns across large geographic areas. These frameworks provide a shared vision for targeting vulnerable landscapes that cross state boundaries and for voluntary conservation benefiting both agriculture and the environment.

Through frameworks, NRCS assesses issues across these large geographic areas and identifies landscapes with natural resource vulnerabilities and conservation challenges. NRCS further identifies opportunities to help individuals, entities, and communities voluntarily conserve natural resources and build resiliency to emerging threats.

Frameworks also provide a consistent way to track NRCS assistance that supports the objectives of the strategy. For each strategy, NRCS identifies measures to track progress and then establishes goals. With clear goals, NRCS leaders and managers can better identify the agency resources needed to put business plans into action and achieve desired results for each targeted area.

NRCS supports state and local operations through activities at National Headquarters and National Centers. The Areawide Planning Branch of the Conservation Planning and Technical Assistance Division in NRCS's National Headquarters Conservation Programs Deputy Area supports the development and use of frameworks.

Developing the Western Water and Working Lands Framework for Conservation Action

On December 17, 2020, NRCS hosted a public listening session and opened a 30-day public comment period to gather feedback on how the agency could better address water quantity and related issues in the West.[1] Analysis of the comments identified several key issues that cross state lines, Agency organizational levels, and program authorities. Development of this framework is one of the followup actions NRCS is taking to address comments and concerns raised during the public listening session.

[1] For this framework, the West refers to the 17 adjoining states that are west of the climatic divide where annual water precipitation equals evapotranspiration: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

After analyzing water-related issues, national and regional experts identified different types of vulnerable landscapes and the associated water and working lands management challenges across the West. NRCS state-level experts, working in collaboration with their partners, then verified which concerns were relevant to their state.

Modelled after successful Working Lands for Wildlife Frameworks, the water and working lands framework supports strategic targeting, goal setting, and performance reporting by NRCS states across the West. It also enables consistent tracking of NRCS investments and related outcomes across large geographic areas. It likewise helps NRCS executives to communicate (1) cross-cutting issues; (2) actions by state, regional, and national executives taken to address them; (3) business needs for supporting these actions; and (4) desired outcomes for improving the management of water and working lands, conserving natural resources, and building resiliency across the West.

Executive Summary

We all have a stake in using water wisely to ensure its continued availability for all purposes, including drinking water, agricultural water for irrigation or livestock, industrial uses, and water for wildlife and ecosystems. Agricultural producers in dry climates across the West cannot grow crops without a reliable supply of water. These producers also manage over two-thirds of the Nation's land resources through which water flows into the reservoirs that supply us with water for our everyday needs.

Water supply in sufficient quantity and quality is declining in many areas of the West as it is increasingly threatened by growing demand and the impacts of climate change. Declining water supply threatens water and working land resources that sustain agricultural productivity and environmental quality in these areas. These interrelated threats increase challenges encountered by water resource managers and producers as well as the opportunities for NRCS to deliver conservation assistance where it can make a greater impact.

Through the water and working lands framework, NRCS has identified six major management challenges:

- Forecasting water supply
- Sustaining agricultural productivity
- Protecting groundwater availability
- Protecting surface water availability
- Managing and restoring rangelands and forestlands
- Responding to disruptions from catastrophic events

NRCS takes a wide variety of actions to help individuals, entities, and communities respond to each of these major management challenges. For example, the agency installs and maintains snow survey sites, directly assists farmers in improving irrigation efficiency, and provides technical and financial assistance to communities recovering from disasters like floods. The framework categorizes responses into the following 13 strategies:

1. Improve reliability of water supply forecasts
2. Improve soil moisture and irrigation water management
3. Improve water and nutrient management in crop fields and pastures
4. Modernize water infrastructure
5. Improve community water supply by completing watershed projects
6. Increase reuse of wastewater for agriculture and conservation
7. Prolong aquifer life
8. Complete managed aquifer recharge projects
9. Reduce surface water withdrawals
10. Install conservation systems that protect water quality
11. Restore and protect streams and wetlands
12. Manage and restore rangelands and forestlands
13. Increase resilience during disaster recovery

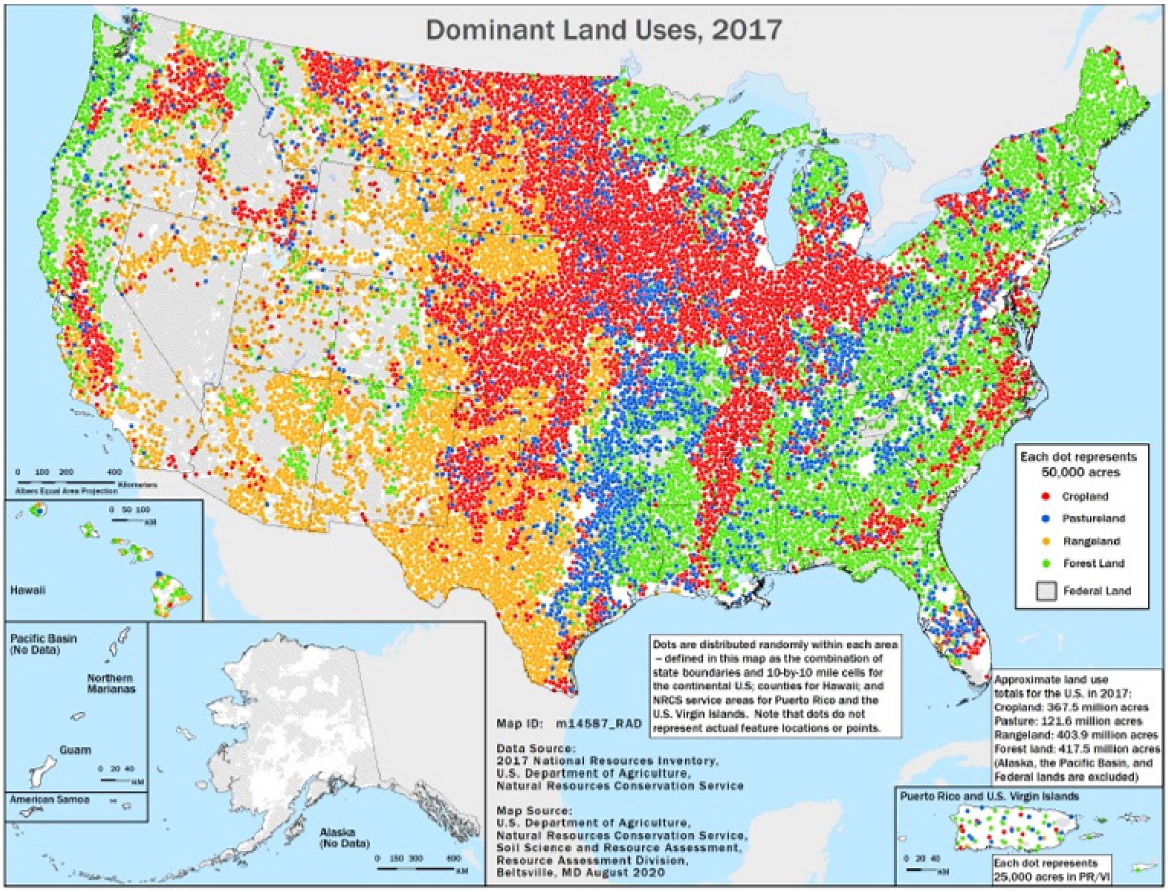
These strategies enable NRCS leaders and managers across the West to set comparable goals for effective program delivery. NRCS will use this framework to coordinate and track progress on helping individuals, entities, and communities across the West.

Farmers, ranchers, irrigation districts, groundwater management entities, municipalities, tribes, and others across the West are working together to attain clean and available water supplies, healthy soils, resilient landscapes, and thriving agricultural communities now and in the future. NRCS is working to assist them to accelerate voluntary conservation of water and working land resources.

Introduction: Two Major Threats

Using water wisely is important to everyone. Agricultural producers need reliable water supplies to produce the food and fiber that consumers rely on. Moreover, these producers manage over two-thirds of the continental United States (Figure 1.0), influencing the availability of the water used by other sectors.

Figure 1.0. The Nation's working lands. (Source: USDA 2020)



These agricultural lands consist of active crop fields, pastures, range sites, and forest stands as well as linked areas in the surrounding landscape, including surface waters, wetlands, and fallow fields. Proper management of our Nation's working lands sustains agricultural productivity and the flow of freshwater over that vast ground into streams, rivers, and eventually the ocean or down into the aquifers below the surface. Natural and constructed reservoirs supply freshwater for agriculture and provide a myriad of uses in every community. In this way, agricultural landscapes sustain not only our food supply but our water supply as well (Robertson 2015).

A reliable supply of water in sufficient quantity and quality to sustain the accustomed standards of living in the West is increasingly in jeopardy. Unreliable supply of water to irrigate crops limits agricultural productivity in much of the dry climates of the West, and naturally available soil moisture is insufficient to grow many crops.

Livestock, fish, and wildlife depend on reliable water supplies. People in cities and towns need potable water and industries such as manufacturing, energy, and mining often depend on the same water sources.

A major threat to water and working lands resources across the West is the increased demand from all users for a limited supply of water. This is leading to more individuals, entities, and communities experiencing a scarcity of adequate water to meet their needs (Schaible 2017).

Another major threat to water and working lands across the West is the impact of climate change. Agricultural productivity is threatened by temperature extremes rising above normally hot conditions, water supply disruptions from longer and more intense droughts, and changes to the landscape in response to catastrophic disturbances. The increasing frequency, duration, and intensity of droughts, extreme storms, flooding, landslides, and wildfires is altering the water cycling function of the landscape, degrading water quality and habitat, and damaging water infrastructure. These impacts exacerbate water supply challenges already being faced by individuals, entities, and communities.

These two major threats to water and working land resources across the West (increased demand and climate change) are interrelated and are increasingly challenging for resource managers. In addition, local communities may be experiencing other threats to water and land resources such as urbanization, pests damaging forest health, or invasive species altering plant communities on ranges.

Many public and private sector organizations have technical or financial resources to help address water and land resource management challenges. Although NRCS does not establish water allocation policies or regulate water or land resources, NRCS does coordinate with local, state, and Federal authorities to ensure that voluntary conservation actions are considered in such decisions. NRCS uses a locally led model to direct agency resources to vulnerable areas where those resources will address community priorities and have a greater impact.

NRCS is already helping—and can do more to help—address ongoing water and working lands management challenges. The following sections describe the scientific basis of the two foremost and interrelated threats to the accustomed standards of living in the West.

Threat 1: Increasing Demand for Water

The West contains rapidly growing urban areas (Figure 1.1) and is home to much of the Nation's agriculture, manufacturing, energy, and mining industries. It is also home to the majority of the 574 federally recognized tribal nations and 100 million acres of land that make up tribal lands (Figure 1.2).

According to the U.S. Census of 2020, the population of western states grew by 9.4 percent over the prior decade outpacing the national average of 6.6 percent. Competition for water is already stressing water resources in some communities, and water supply is insufficient to meet demand, a situation also known as water scarcity (GAO 2019). The growing need for more food, feed, and fiber from agriculture, as well as competition from all sectors in society for increasingly scarce water, continues to increase pressure on agriculture and water availability (Box 1.0), especially for irrigation uses in the dry climates of the West. Disputes over water supply have been an issue for a long time in some areas and have resulted in interstate and regional river basin compact agreements to apportion water between states (Appendix 2).

Figure 1.1. Areas used as urban and built-up lands. Red dots highlight areas with over 50 percent of urban land use. Grey shading shows the location of Federal lands. (Source: USDA 2020)

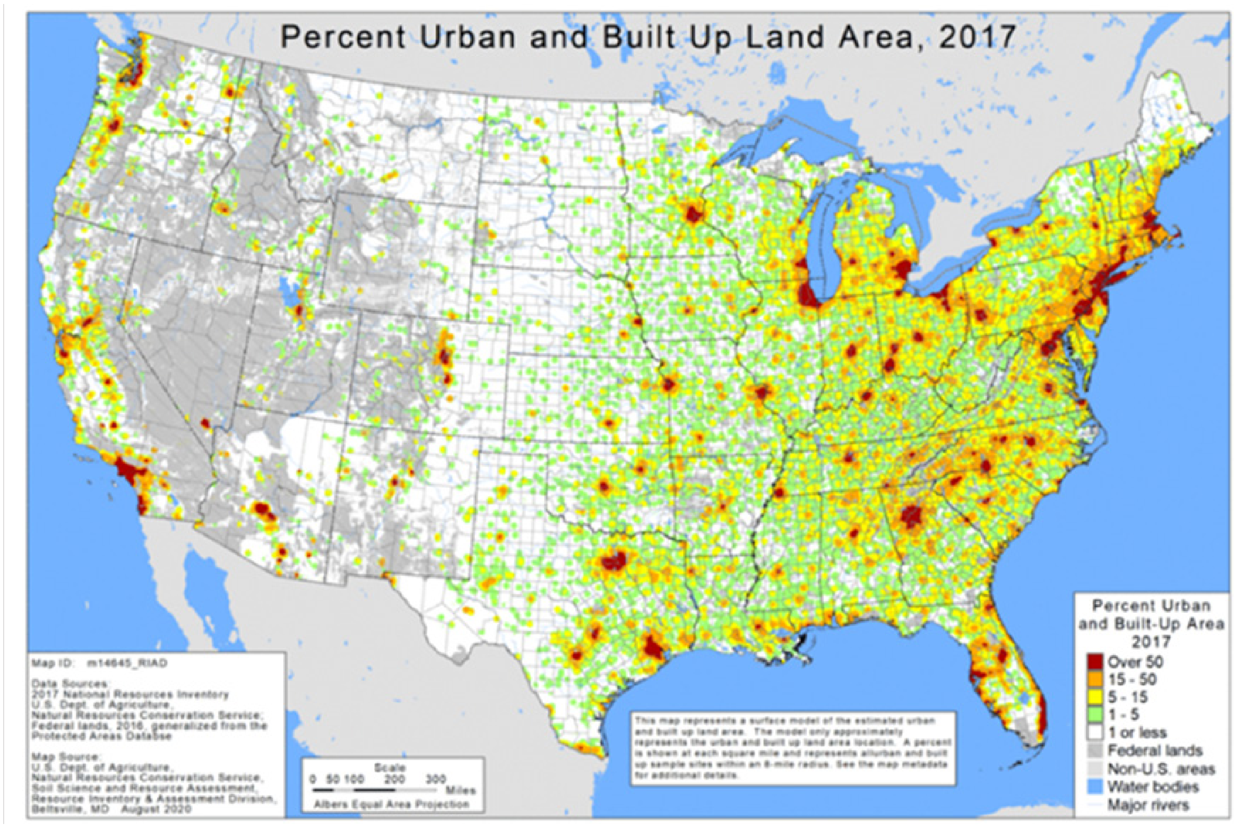
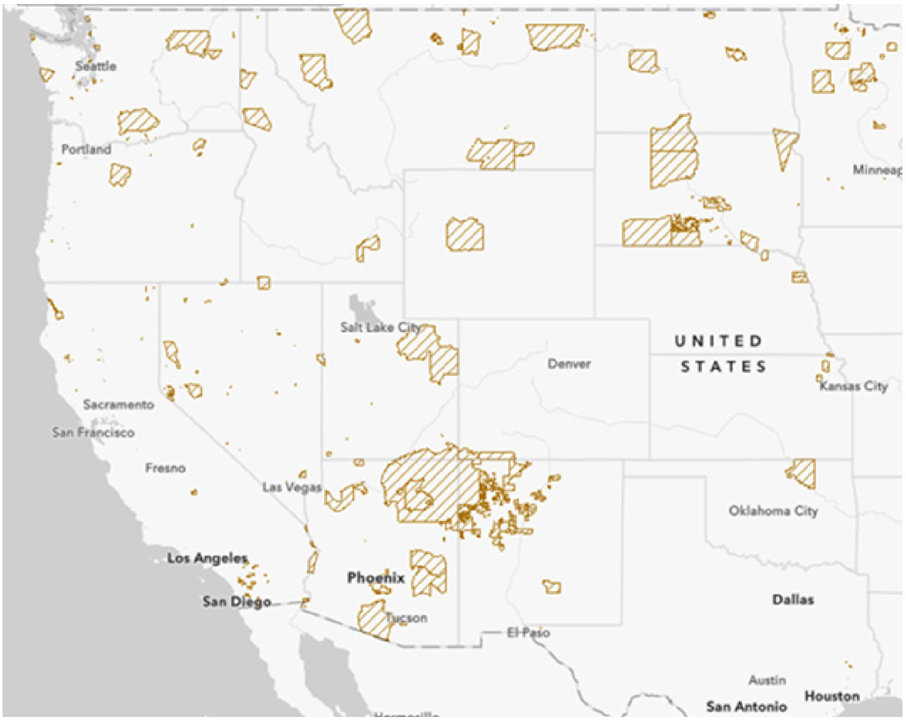


Figure 1.2. American Indian nation lands across the West. (Source: U.S. Forest Service Tribal Connections Viewer accessed 2022)



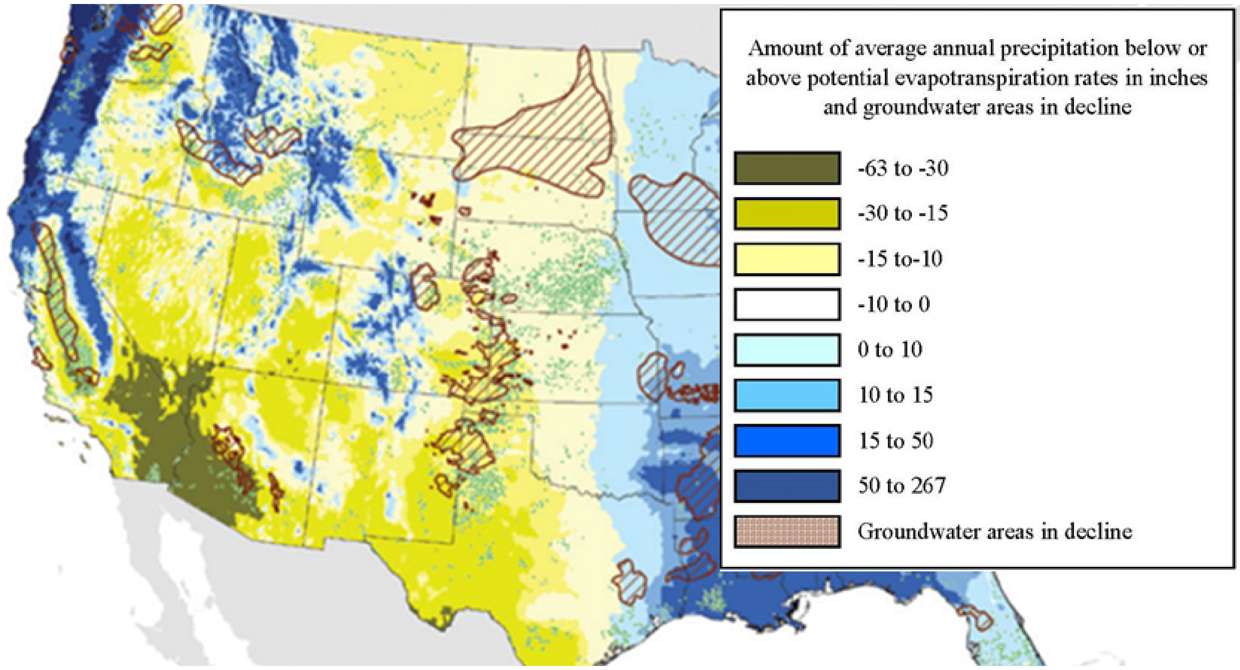
Box 1.0. What is water availability?

The 2018 National Water Census completed by the United State Geological Society (USGS) defines water availability as "Water in the broadest sense, water availability having four components: (1) the need for a certain volume of water to meet the intended purpose, (2) the timing characteristic with which water is delivered, (3) the adequate quality of the water for the intended purpose, and (4) the need for water to meet both human and environmental/ecological uses." (Source: USGS 2018)

Water resources available for irrigated agriculture are indicated by three trends: (1) the amount of average annual precipitation exceeding the potential rate of evapotranspiration over the year,(2) the presence of snowpack runoff from high elevations in intermountain regions of the West, and (3) aquifers (Figure 1.3). The 17 states west of the climatic divide (shown in Figure 1.3 as a boundary in the center of the Nation between a blue color ramp and a yellow one) generally receive less precipitation than the potential for evapotranspiration to return water to the atmosphere. In these dry climates, moisture in the soil quickly dries out, and in areas with high water tables, capillary action can cause water to rise from deeper in the ground and be lost to the dry air. Surface water bodies are also at risk for water loss due to high rates of evaporation in these dry climates.

NRCS's National Resources Inventory (NRI) program is a critical component to monitoring water availability in the West. This program monitors the status, condition, and trends of land, soil, water, and related natural resources on the Nation's non-Federal lands, including irrigated cropland. The NRI supports efforts to protect, restore, and enhance the lands and waters of the United States. Reports are published every 5 years and used by Congress, conservation programs, technology, and operational managers across NRCS and USDA, other Federal agencies, academia, and special interest groups.

Figure 1.3. Three indicators of water availability: (1) the yellow color ramp indicates where potential evapotranspiration (PET) exceeds annual average precipitation, (2) the blue color ramp indicates where annual average precipitation exceeds PET, and (3) cross-hatching indicates aquifers in decline. (Source: USDA 2011)

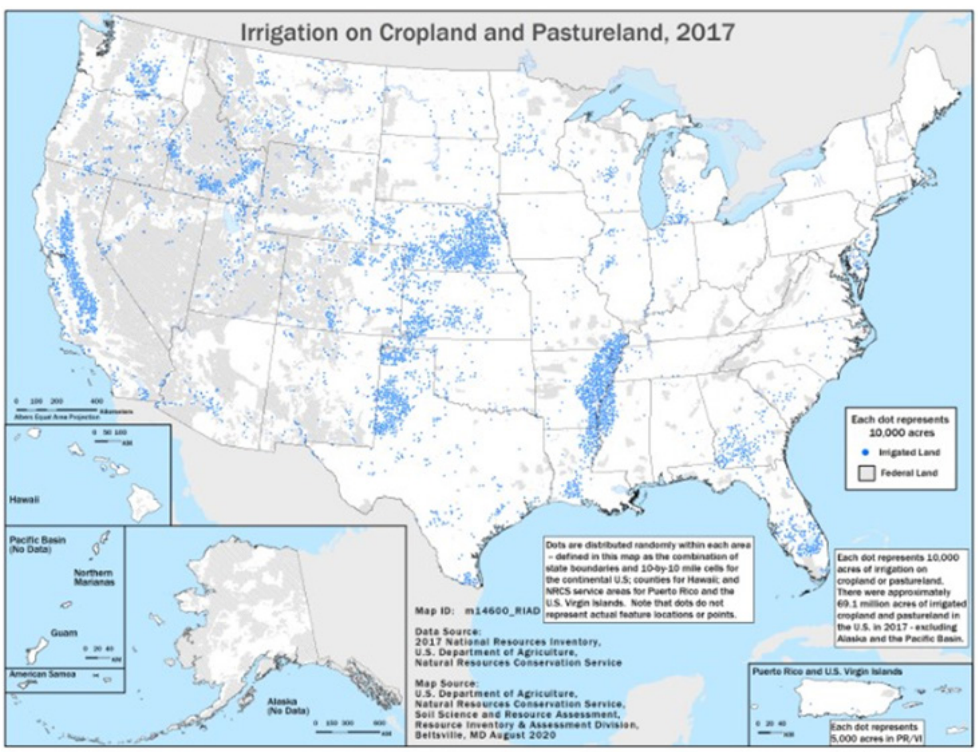


The most recent NRI summary report (USDA 2020) for the period of 2012 to 2017 shows that 3 percent of the surface of land area in the lower 48 States (52 million acres) is covered by water, 6 percent is land developed as urban and built-up areas or for rural transportation (116 million acres), and 21 percent is Federal land (405.6 million acres). The remaining 70 percent is non-Federal rural land (1,370 million acres), and within this swath, 417.5 million acres is forestland, 403.9 million range-land, 367.5 million cropland, 121.6 million pasture, 15.9 million enrolled in the Conservation Reserve Program (CRP), and 43.8 million acres is other rural land that includes farmsteads, farm structures, barren land, marshland, or permanent snow-ice.

The 367.5 million acres of cropland is further categorized into irrigated, non-irrigated, cultivated, and non-cultivated cropland. Croplands irrigated from water supplied through ditches, pipes, or other conduits are counted, whereas water spreading is not considered irrigation. Cultivated cropland is land in close-grown, row crops or hay or pasture in rotation. Non-cultivated cropland is permanent hay or horticultural crops. Land covered for at least 5 years by introduced grasses, legumes, or forbs suitable as forage for grazing livestock is considered pasture, regardless of whether it is grazed or not. Pasture may also be irrigated, and a special NRI Report on Pastureland found that 47 percent of non-Federal pastureland in the West is irrigated (USDA 2018).

Cropland is considered irrigated if there is evidence it has been irrigated during the year of the inventory or at least 2 of the prior 4 years. There are 50.8 million acres of irrigated cultivated crop-land, of which 64 percent is in the West, and 14.1 million acres of irrigated non-cultivated cropland, of which 90 percent is in the West. Figure 1.4 shows the location of irrigation on crop and pasture lands in the United States. According to USDA's 2017 Census of Agriculture, U.S. farmers irrigated 58 million acres that year demonstrating that not all land capable of being irrigated is irrigated in any given year. In 2017, most irrigated cropland was used to produce hay, corn, and soybeans. Even though just a fraction of total land in crop and pasture, irrigated agriculture contributed about 27 percent of the Nation's farm sales—over $103 billion—due to irrigating higher value crops such as fruits, vegetables, and other horticultural crops.

Figure 1.4. The location of irrigation on cropland and pastureland. (Source: USDA 2020)



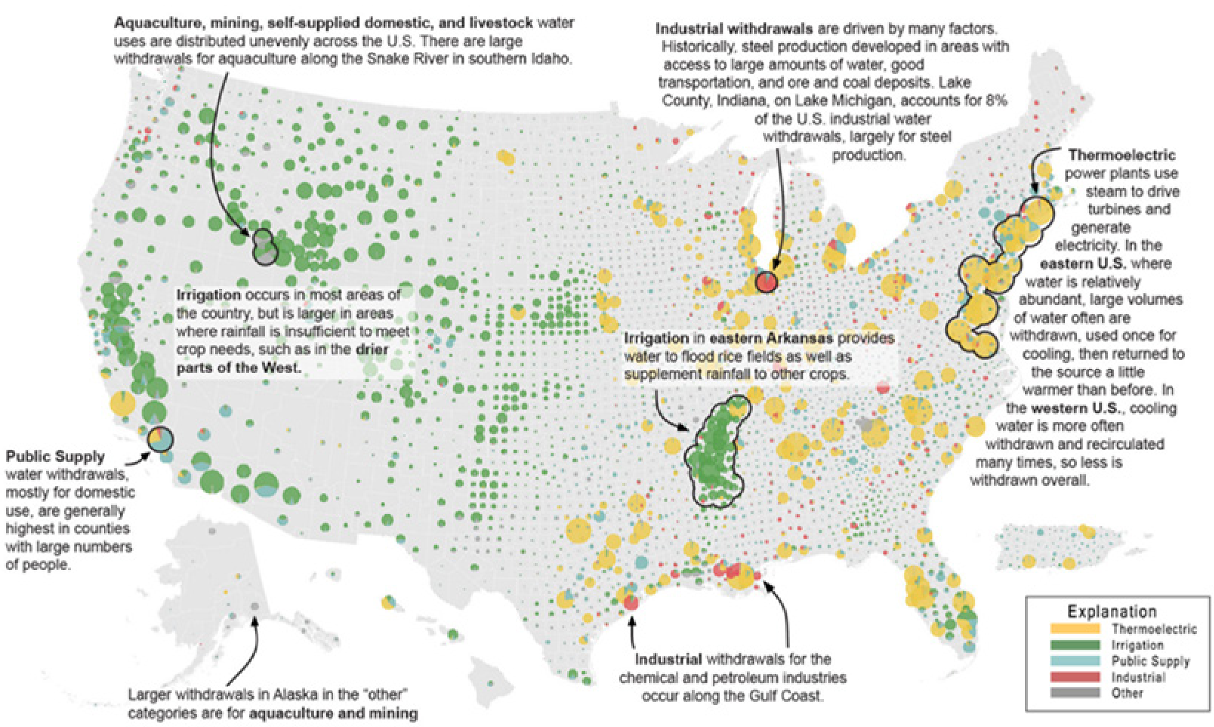
Recent findings by USDA's Economic Research Service show that the share of U.S. irrigated cropland located within the Mountain region (eight states), or Pacific region (three states) has decreased significantly from 77 to 44 percent since the middle of the last century, while the share of irrigated cropland in the Mississippi Delta region (three states) and Northern Plains region (four states) has increased from 8 percent to 34 percent over the same period (Hrozencik 2021). The 17 contiguous states in the West accounted for nearly three-quarters of U.S. irrigated farmland in 2007 (Schaible 2013).

A United States Geological Survey (USGS) report, "Estimated Use of Water in the United States in 2015," shows that irrigation water used for both agriculture and recreation withdraws 37 percent from our Nation's total water resources (fresh and saline water removed from the ground or diverted from a surface water source such as a river or reservoir); this amount is second only to thermoelectric power (41 percent) and significantly more than public water supply (12 percent), self-supplied/industrial (4.6 percent) or any other category of user (see Figure 1.5). For 2015, total irrigation withdrawals were 118 billion gallons per day, mostly from freshwater sources. The West accounted for 81 percent of total irrigation withdrawals, and 74 percent of the total irrigated lands in the United States (USGS 2018).

In addition to monitoring water withdrawal rates, water resource managers must also consider how water is used, what the source is, and how much is returned. Of the water withdrawn for irrigation, 62 percent is "consumed" and no longer available to return to the water source for other users. Consumed water is the part of a water withdrawal that is evaporated, transpired, incorporated into crops, and consumed by livestock or otherwise not available for immediate use.

In summary, a major threat to water and working lands resources in the West is the increased demand for water from all users—urban populations needing it for potable water, agricultural water users for irrigation or livestock watering, and high-tech manufacturing, energy, and mining industries needing it for production processes. An increasing demand for water is leading more individuals, entities, and communities to experience a scarcity of adequate quality water to meet their needs.

Figure 1.5. Where and how water was used during 2015. (Source: USGS 2018)



Threat # 2: Climate Change Impacts to Water Supply and Quality

As average temperatures increase globally, the atmosphere is holding more water vapor, and precipitation patterns around the world are changing. Much of the West is experiencing higher temperatures, longer and more intense meteorological droughts, and increased frequency of catastrophic impacts from unusually severe storms (USGCRP 2018). Under a changing climate, demand on water for all uses is increasing due to longer and more intense droughts while surface water supply is simultaneously decreasing, a condition referred to as hydrologic drought in the National Integrated Drought Information System, For example, more water is needed to offset additional water loss in agriculture caused by increased evapotranspiration in crops and in the hydroelectric power industry by increased evaporation from water reservoirs. These changing weather and climatic conditions are shifting the balance of water supply and demand and resulting in cascading impacts across the landscape, especially on the quantity and quality of water available for use (Box 1.1).

The balance of water supply and demand on any given day, month, or year is calculated from a water budget (Box 1.2), like calculating cash flow in a household budget. Too much or too intense rainfall saturates soils, increases stormwater runoff, and can lead to excessive flooding; too little rain or snow dries out soils, reduces streamflow, and leads to declining surface and groundwater levels. Not enough surface water supply increases demand for groundwater. Excess withdrawal of groundwater risks lowering the water table in surface waters and wells.

Box 1.1. More information about climate change impacts to water quantity and quality

The National Climate Assessment summarizes the effects of climate change on the United States, now and in the future. Produced by a team of more than 300 experts guided by a 60-member Federal Advisory Committee and extensively reviewed by the public, the report is delivered to Congress and the President no less than every 4 years as mandated by the Global Change Research Act of 1990.

The Fourth National Climate Assessment (NCA4), published in 2018, is the most recent effort to advance our collective understanding of how climate change poses risks to things of value to society. The report links scientific knowledge of cascading impacts, risks, and vulnerabilities associated with a changing global climate and informed decision making across the United States. Chapter 3 reports the state of the water sector and impacts on water quantity and quality. (Source: USGCRP, 2018).

Box 1.2. What is a water budget?

A water budget is an estimate of water supply and demand based on the hydrologic cycle of a specific area. The quantity of water available for use is what remains—or is deficient—when accounting for inflows of precipitation, streams, groundwater, and aquifer withdrawals on the supply side, as well as outflows of water loss through evaporation from soil and land covers, snowpack, lakes, and reservoirs; transpiration through plants; and flows leaving the area through streams, canals, rivers, shallow groundwater, and deep percolation on the demand side. (Source: USGS, 2007)

Higher Temperatures Alter the Water Cycle

The average annual temperature is expected to increase 2 to 3 degrees Fahrenheit (F) across the United States by the end of the century, which will alter the water cycle by increasing the average rate of annual evaporation and contribute to altering precipitation patterns. Figures 1.6 and 1.7 show the changes in temperatures and precipitation patterns that have already occurred and are expected under a high emissions scenario. Direct impacts from the higher temperatures particular to the West, increase the chance of droughts, warmer surface water temperatures, decreasing amounts of snowpack, earlier snowmelt, and increasing frequency of extreme weather and climate events. Cascading impacts include increased risk of erosion and flooding, decreased soil moisture, variable surface water supply, reduced streamflow, increased demand for groundwater, lower water tables, and countless other adversities. (USGCRP 2018).

Figure 1.6. Historic (since 1950) and projected (up until 2100) average summer maximum temperatures for the West under a high emissions scenario. Source: https://ClimateToolbox.org

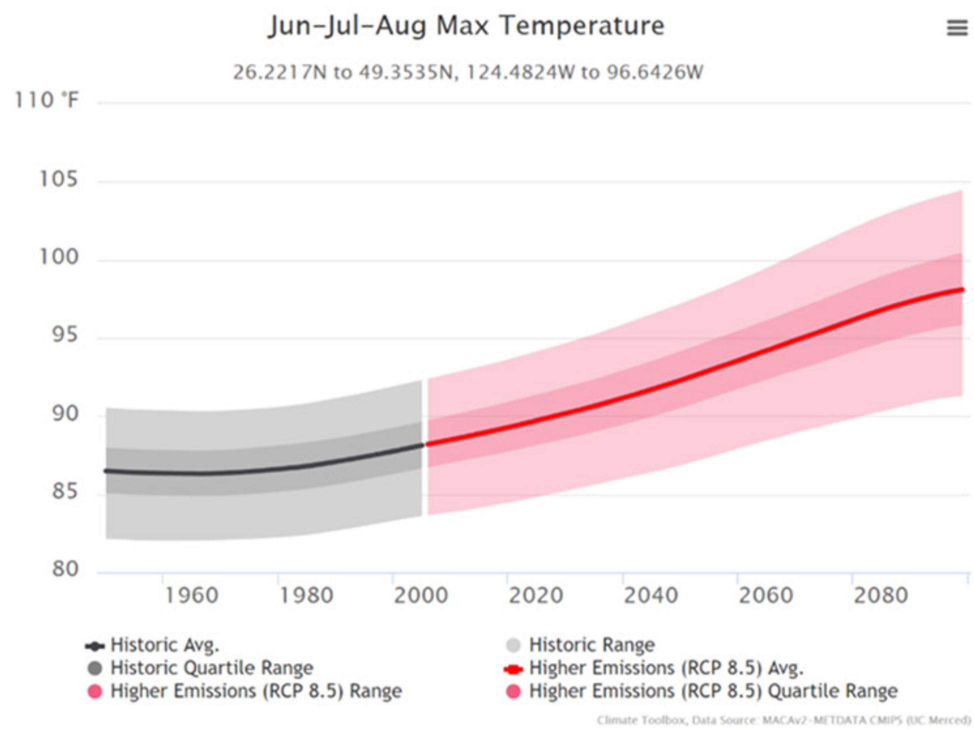
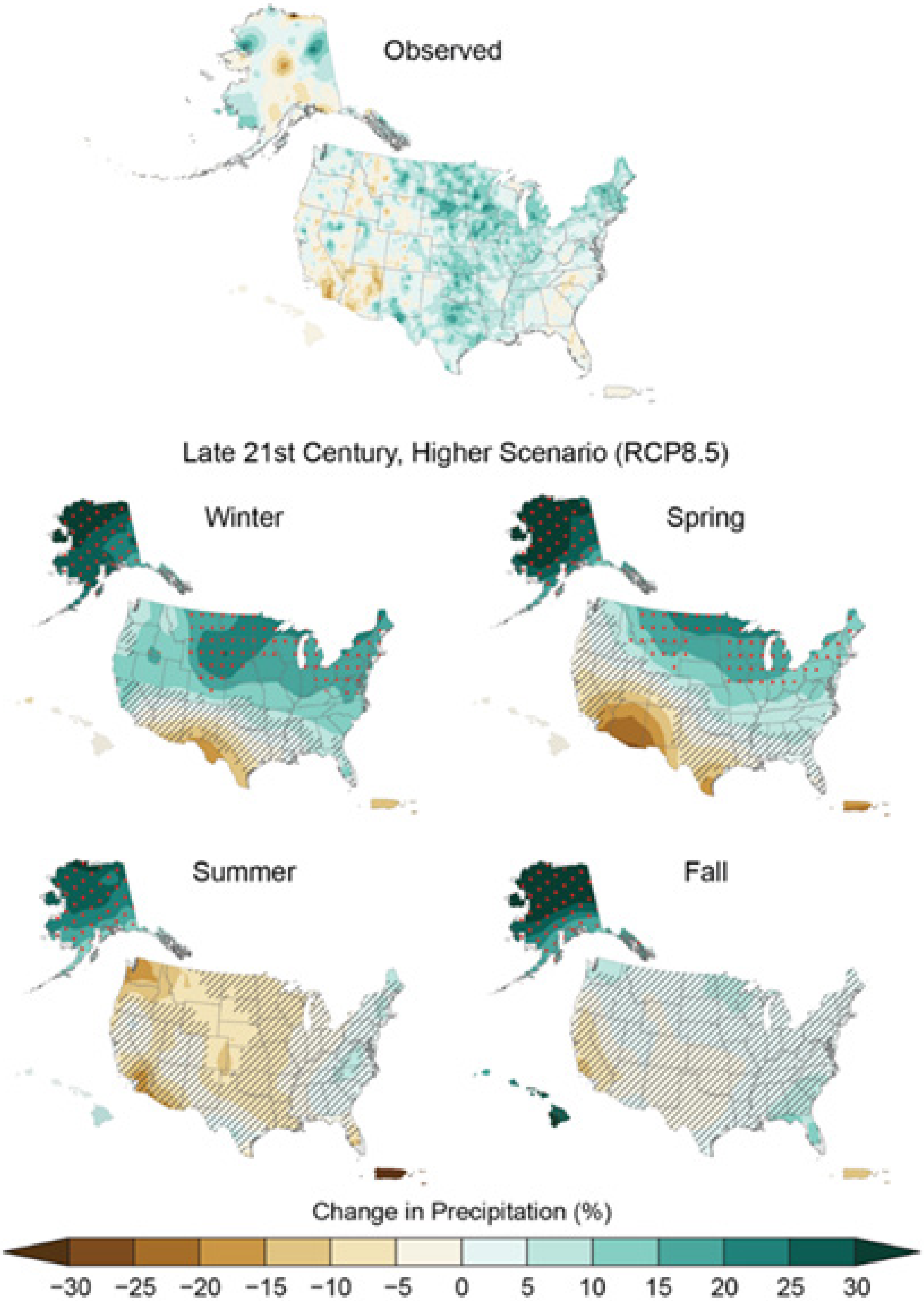


Figure 1.7. Observed and projected precipitation changes. Image shows variations observed by region (top) and projected by season (bottom) under the high emissions scenario. Areas with red dots show where projected changes are large compared to natural variations; areas that are hatched show where changes are small and relatively insignificant. (Source: USGCRP 2018)



Altered Precipitation Patterns Reduce Snowpack and Seasonal Streamflow

Most of the West is already experiencing altered precipitation patterns (Figure 1.7) resulting in more intense and longer drought, less snowpack, and earlier spring runoff in basins supplied predominantly by snowmelt. This altered timing of water supply to stream and river flows exacerbates the impact of increased demand for water by making the supply less available during the growing season when demand by irrigated agriculture is higher (USGCR 2018). Snowpack typically acts as a natural reservoir, providing water throughout the drier summer months. Lack of snowpack (often referred to as snow drought) or a shift in timing of snowmelt are challenges for hydrologic drought planning.

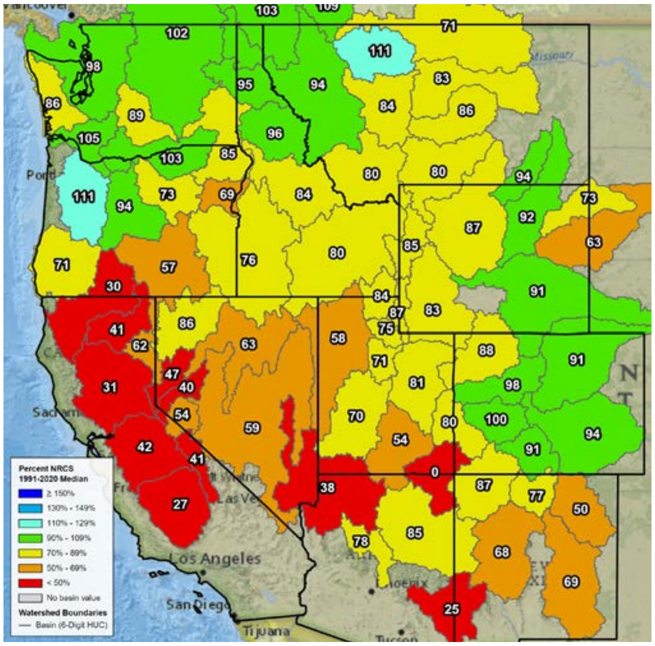
In some areas, such as the western side of the Cascade Mountains, the east slope of the southern Rocky Mountains, and in the Southwest, snowmelt is not as dominant, and winter, spring, and summer rainfall supplies a significant amount of the streamflow volume (USDA 2021).

Long-term droughts are drying up rivers and contributing to aquifer depletion in the Southern Plains, the Southwest, and California (Figure 2.3). Depletion of groundwater also weakens the buffer between drought and scarcity of surface water supplies (USGCRP 2018). These changing precipitation patterns impact regional water supply in different ways but generally there is, and will be, less water available to continue current agricultural productivity in the West.

The primary impact of climate change for water resources in much of the West is a decrease in the proportion of wintertime snowfall in comparison to rainfall. With less snowfall there is less snowpack, it melts earlier, and the seasonal runoff timing shifts to earlier winter dates, rather than in spring and summer when it is most needed for agriculture, communities, and wildlife.

Figure 1.8 shows the percent of liquid water contained within snowpack (known as snow water equivalent) across the West at the end of the day on April 15th, 2022, as compared to the median of all values on the same day between 1991 and 2020 measured by the NRCS Snow Survey and Water Supply Forecasting Program.

Figure 1.8. Percent of snow water equivalent observed on April 15, 2022, as compared to the NRCS median observations between 1991 and 2020. (Source: USDA 2022).



Climate change has various additional effects on snow accumulation and melt, such as potential moderate increases or decreases in winter precipitation in the northern and southern parts of the West, respectively. The influence of climate change on landcover also affects snowpack dynamics such as direct conversion to water vapor (sublimation) and other water cycle factors and processes, which can be seen in a cycle initiated by the declining water levels in lakes and reservoirs that results in exposing soil, leading to more dust blown onto snowpack, where it further accelerates snowmelt.

Increasing Frequency of Catastrophic Events

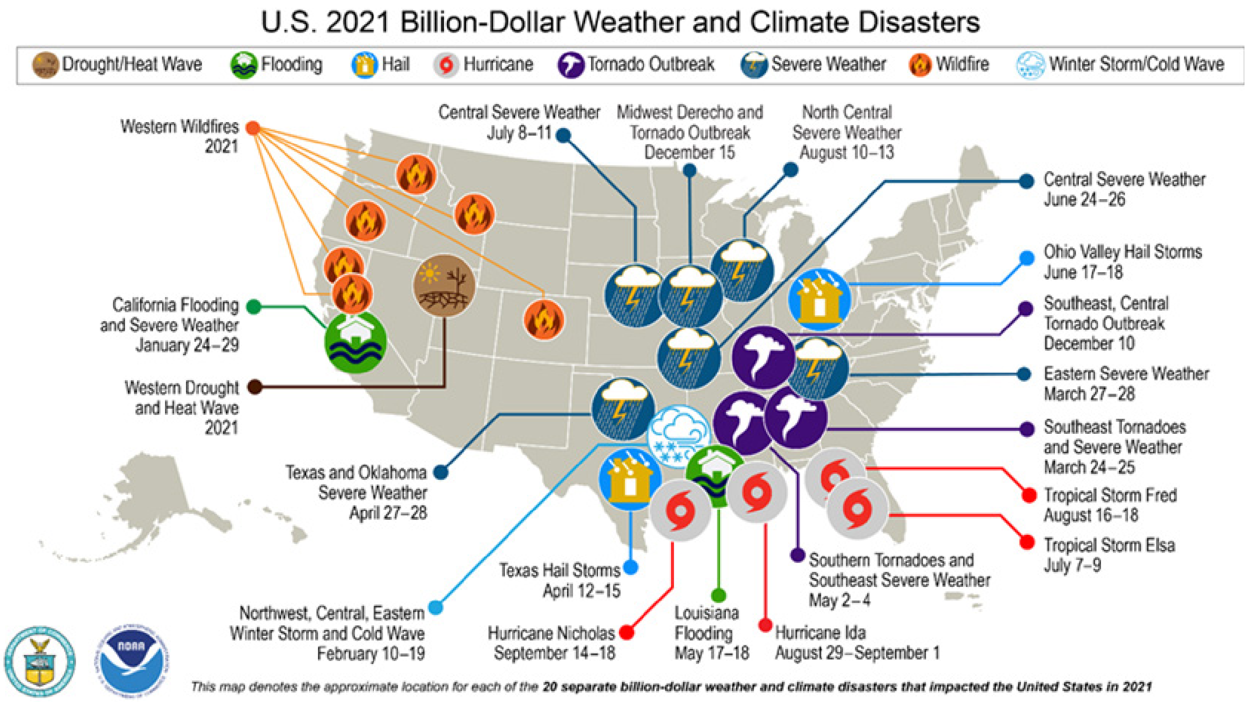
Another impact from the rise in temperature and shift in precipitation patterns is the increasing frequency of extreme weather and climate events, such as more severe storms and more intense and longer droughts between storms, resulting in more frequent catastrophic losses. Megadroughts (intense droughts lasting for decades or longer) historically occur in the Desert Southwest and are expected to increase in the future because of climate change (Cook 2021). Atmospheric rivers (large, narrow streams of water vapor traveling through the air) are normally beneficial as they transfer moisture from the tropical Pacific Ocean, which supplies anywhere from 30 to 50 percent of water to coastal areas. However, the warmer the air, the more water vapor it can carry, increasing the volumes and intensity of rain or snow releases that are possible as it reaches landfall.

Severe droughts decrease soil moisture and increase evapotranspiration in cropping systems, resulting in declining productivity in dryland agriculture, increased water demand in irrigated agriculture, increased risk of large wildfires, and major shifts in plant communities. Shifts may occur in the extent and quality of wetlands, riparian areas, lakes, and estuaries, as well as associated habitats. When precipitation returns, it increasingly results in extreme rainfall or snowfall, which can lead to severe and even catastrophic damage especially after intense droughts or wildfires.

When storms become more severe and vegetative cover becomes drastically degraded from more intense and extended periods of droughts and wildfires, more water contaminants (such as sediment and nutrients) are mobilized and transported to waterbodies. Droughty soils are unstable and unable to absorb intense precipitation events, resulting in bigger floods, erosion, landslides, and sudden releases of contaminants. Disturbances from drought, wildfire, or extreme storms also alter plant communities, presenting opportunities for woody and invasive plant encroachment to further alter the water cycling function of the land. Decreasing quantity and degrading quality of water and general degradation of soil, water, and related natural resources leads to more challenges for water land managers.

Extreme weather and climate events are resulting in more frequent catastrophic losses as demonstrated in the increasing number and total cost of disasters exceeding $1 billion dollars each year since 1980 (adjusted for inflation). In 2021, 20 weather or climate disasters occurred (Figure 1.9) continuing the recent trend of high frequency and a large diversity of extreme events resulting in high costs. Many factors contribute to the catastrophic losses, including where and how structures are built, the value of the developed environment, and impacts from a changing climate.

Figure 1.9. U.S 2021 Billion-Dollar Weather and Climate Disasters (Source: NOAA 2022)



Management Challenges and Conservation Opportunities

The convergence of major interrelated threats to water and working lands resources in the dry climates across the West increase the following management challenges in vulnerable landscapes:

- Forecasting water supply,
- Sustaining agricultural productivity,
- Protecting groundwater availability,
- Protecting surface water availability,
- Managing and restoring rangelands and forestlands, and
- Responding to disruptions from catastrophic events.

Working agricultural lands and connected waters on or under the surrounding landscape have interrelated vulnerabilities. Surface and ground water resources in dry climates are vulnerable to changes in natural water supplies, increasing rates of pollution, aging infrastructure or operational equipment and facilities, and other conditions (USGCRP 2018). Agricultural land resources in dry climates are vulnerable to insufficient water available to grow crops either from naturally available soil moisture or from irrigation. NRCS has the capacity to help individuals, entities, and communities manage water and working lands, conserve natural resources, and build resilience across vulnerable landscapes in the West.

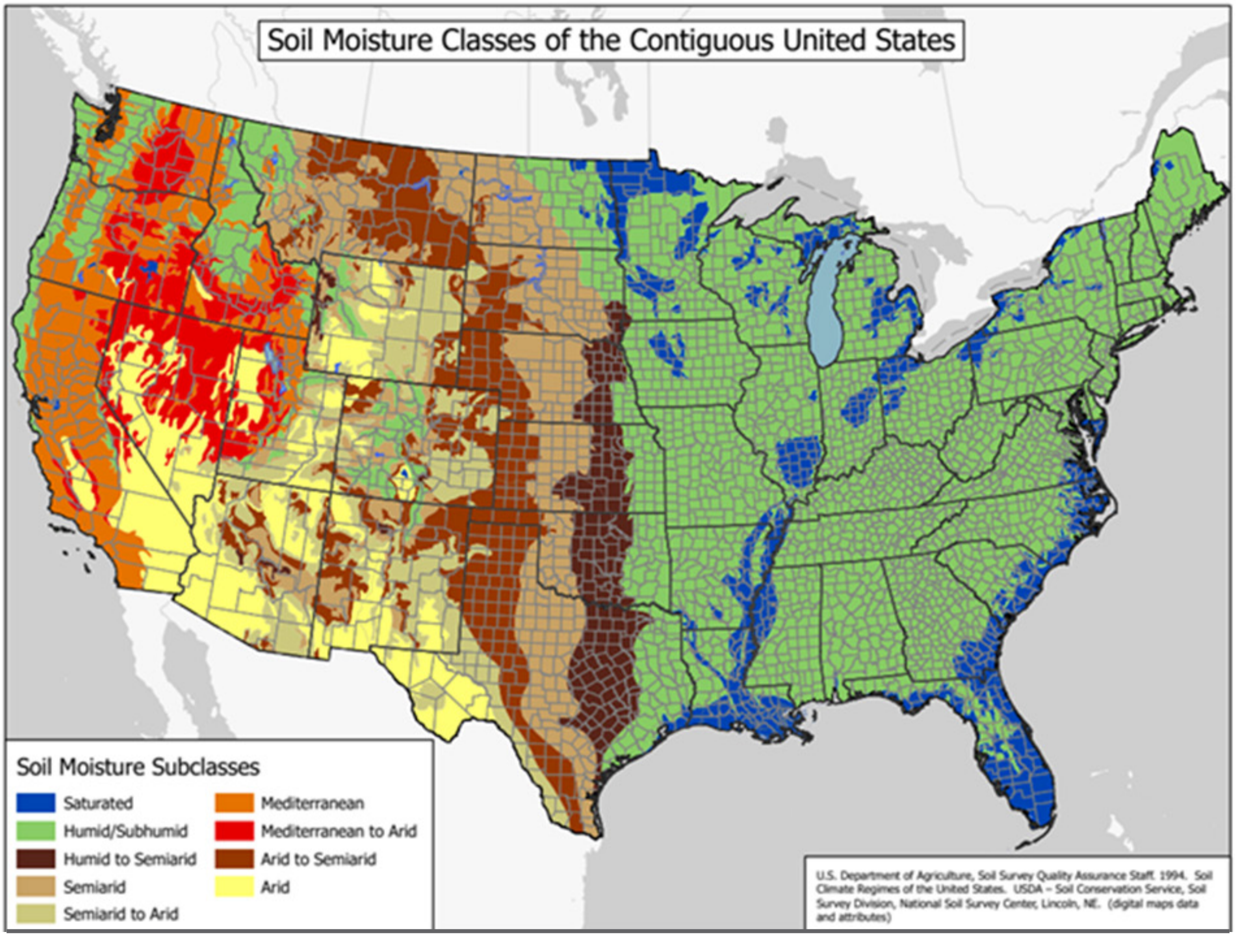
NRCS's role is to take a science-based and locally-led approach in determining where it can make the greatest impact when addressing these major interrelated threats and the resulting management challenges in vulnerable landscapes.

Forecasting Water Supply

To a great extent, surface water supplies in the West rely on precipitation that falls as rain or snow during the cool, wet seasons for use in warmer, drier times of the year. Forecasts of water supply provided by precipitation and meltwater from snowpack is critical to effective water management. Increasing demand for water makes accurate forecasting more important while climate change is making water forecasting more difficult. To respond to this challenge, NRCS can improve the network of sites for monitoring snowpack and invest in innovative technology, methods, and models to inform water forecast products. NRCS provides water supply forecasts and data used by other entities for their forecasts (USDA 2021).

Figure 2.1 shows (1) the location of a vast portion of the West with landscapes under arid and semiarid climates (brown to yellow color ramp) where there is insufficient soil moisture year round, and irrigation is always required to grow common agricultural crops; (2) another portion with landscapes under Mediterranean-like climates (red to orange) where precipitation falls mostly outside of the growing season and irrigation is still required to grow common crops; (3) small pockets of wetter climates (green) in the Rockies and Pacific Coast mountain ranges where snowpack dominated watersheds supply surface water for a myriad of water users in other landscapes; and (4) a narrow sliver of wetter landscape conditions found along the Pacific coast where rainfed agriculture can be practiced as is commonly done across the eastern United States (USDA 1994).

Figure 2.1. The locations of soils having a general presence or absence of plant-available moisture in any given year. (Source: USDA 1994)



The natural network of streams and rivers in the West carrying spring snowmelt and rainwater from the mountains to the sea (and to all the communities in between) are complemented by a complex network of dams and canals built since the early 1900s to collect, store, and distribute water for irrigation, hydroelectric power, and other uses (USDOI 2016). Where water runoff is predominantly from snowmelt, the delay between snow accumulation and snowmelt makes it possible for experts to predict spring and summer streamflow based on measurements of winter snowpack. Uncertainty from water supply forecasts is higher in areas where snowmelt is not as dominant. Innovative data gathering and forecasting for modeling water supply is still needed.

Although large Federal, state, or municipal water projects manage the supply of surface water across the West, irrigated agriculture in these landscapes relies on local irrigation organizations (such as irrigation districts, ditch companies, and acequias) to deliver water to the farm (Hrozencik 2021). Individuals, entities, and communities across the West need accurate and reliable surface water forecasts to make decisions related to the supply and delivery of water from increasingly scarce surface water resources.

Vulnerable landscapes: Agricultural landscapes across 11 states in the West (Washington, Oregon, California, Idaho, Nevada, Arizona, Montana, Wyoming, Utah, Colorado, and New Mexico) where naturally available soil moisture is normally insufficient to grow crops and irrigated agriculture depends on reliable water supply forecasts.

Conservation opportunity to improve reliability of water supply forecasts: NRCS can improve the network of sites for monitoring snowpack and invest in innovative technology, methods, and models to inform water forecast products.

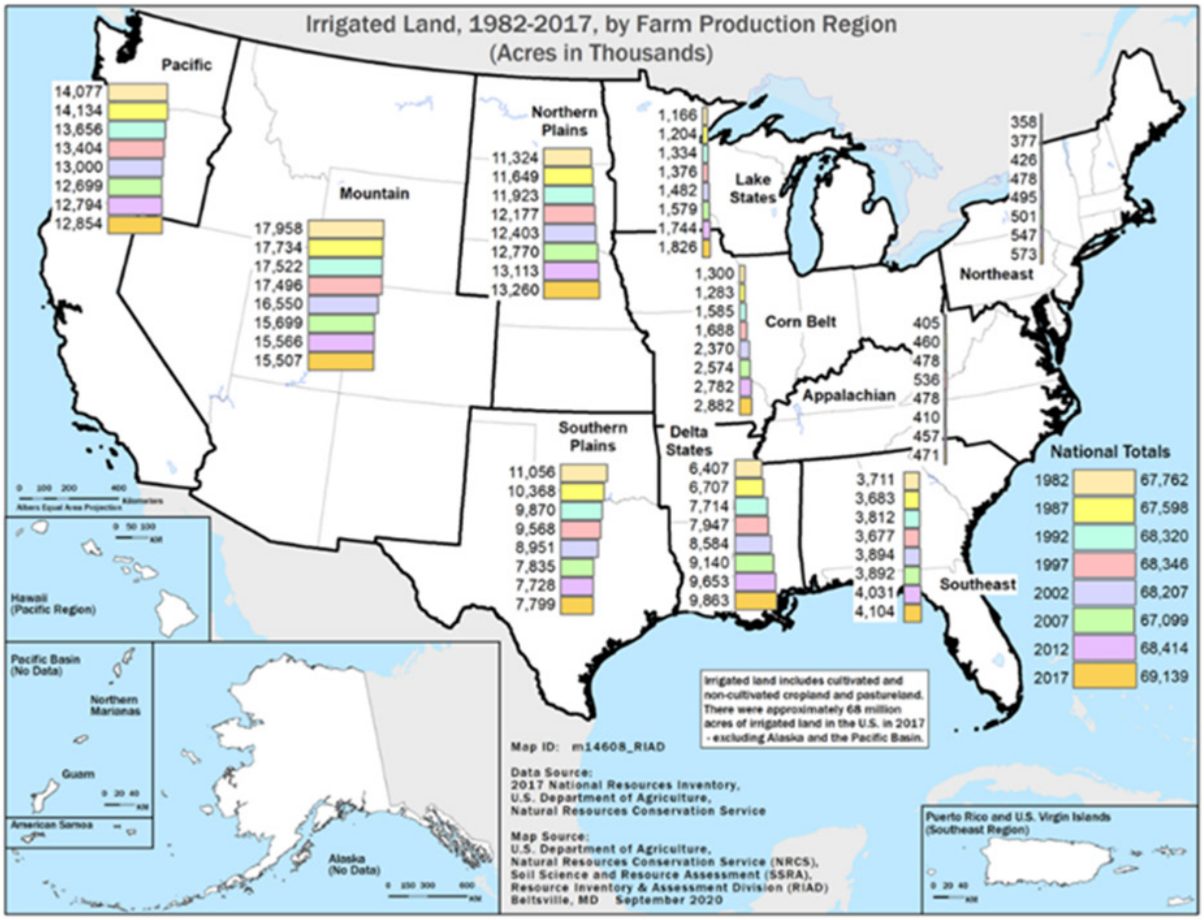
Sustaining Agricultural Productivity

Farmers and ranchers in the West face a unique set of resource concerns as they produce food and fiber in the region. Irrigation is essential to crop production in much of the West, so efficient delivery of irrigation water to farms and efficient use of irrigation water on farms is critical to making the best use of limited water supplies. Managing soil moisture resources is vital to sustaining agricultural productivity for irrigated and non-irrigated crop production. The management of nutrients and soil health is unique for both irrigated and dryland production in the region. NRCS can provide voluntary assistance to individuals and communities as they strive to address conservation challenges while producing food and fiber under scarce water conditions.

Irrigation water mitigates the lack of naturally available soil moisture and high salt concentration stressors in dry climates. Therefore, on-farm irrigation improvements increase the economic value of land in the West (Sun Ling Wan, et al., 2022). However, without an on-farm source of water to supply irrigation needs, farms depend on a network of well-maintained infrastructure and local irrigation organizations to deliver water (Hrozencik 2021). Farms often rely on withdrawing water from a mix of off-farm surface and on-farm groundwater sources to supply their needs. In areas with declining aquifers, farms may be limited to allocations regulated by local or state groundwater management agencies. In some communities, the economic value of water can exceed that of the irrigated crop and farmers are making an economic choice to sell water to urban users rather than grow crops. The loss of irrigated agriculture lands in these communities lowers agricultural productivity and leads to new conservation issues from fallowed land, such as wind erosion and invasive species.

Figure 2.2 shows that irrigated land across the Nation has grown overall and has shifted east since 1982. Average irrigation costs are lower in eastern states where the depth of groundwater is generally shallower and therefore cheaper to pump. In parts of the West where groundwater is unavailable or insufficient to meet year-round needs, costs to purchase water from off-farm surface water sources are much higher than pumping from groundwater.

Figure 2.2. Irrigated lands have grown overall and shifted eastward since 1982. (Source: USDA 2020)



Irrigated agriculture is the predominant consumer of water in the West; however, dryland agriculture is the most extensive cropping system. Dryland crop productivity is vulnerable to altered rainfall patterns because irrigation water is not used to mitigate the lack of naturally available soil moisture. Longer periods of seasonal drought punctuated by intense periods of rainfall increase the risks of soil loss by water erosion. Increasingly higher temperatures also impact the length of the frost-free season, the frequency and intensity of heat waves, and plant hardiness zones. Consequently, there is a shift from dryland agriculture to irrigated agriculture throughout the Great Plains to sustain agricultural productivity in that region (USGCRP 2018).

Healthy soils improve the efficient use of soil moisture that is naturally available during periods of low precipitation while water control structures manage the flow of water during extreme storm events. Water control structures and an effective nutrient management program can help to avoid the loss of soluble nutrients below the root zone and enable the safe transport of sediment and unused nutrients across the field to areas where they can be trapped and prevented from harming water quality (USDA 2022).

Crop productivity in irrigated agriculture is vulnerable to unreliable water supply especially in basins dominated by snowmelt. Historically, increases in water demands have been met by improvements in irrigation efficiency through irrigation water management and other technology advancements (GAO 2019). Irrigation efficiency helps to characterize the potential of water conservation and is measured at the field, farm, water delivery project, or the entire water supply area scale (Hrozencik 2021). It is important to accurately measure efficiency at the scale that the challenges occur to address water supply and demand concerns.

Water demand increases under intense and longer meteorological drought conditions, which consequently increases the risk of agricultural drought in dryland agriculture systems and leads to more water loss through evaporation in irrigated agriculture. To sustain crop productivity in irrigated agriculture, increasing demand for irrigation water further increases the risks of depleting surface water sources in the wider region, which is already threatened by hydrologic drought. Aquifers may be used to buffer against hydrologic drought until their useable life is depleted. Only one-fifth of irrigation organizations use a formal drought plan to mitigate the risk of water supply disruptions to their customers (Wallander, et al., 2022).

Vulnerable landscapes: Landscapes dominated by dryland agriculture and irrigated crop and pasture production

Conservation opportunities: Five opportunities exist for NRCS to help sustain agricultural productivity in states across the West.

1. **Improve soil moisture and irrigation water management:** NRCS can help farmers in dry climates efficiently use soil moisture and irrigation water to sustain productivity and build resilience to agricultural drought in dryland or irrigated crop fields and pastures.
2. **Improve water and nutrient management in crop fields and pastures:** NRCS can help farmers in dry climates apply soil health management, nutrient management, and water control practices within crop fields and pastures to (1) sustain productivity, (2) avoid nutrient loss and control sediment and nutrient transport to areas where they can be trapped, and (3) protect groundwater and surface water quality. (Also see the "Protecting Groundwater Availability" and "Protecting Surface Water Availability" challenges for opportunities to help with installing irrigation or livestock watering systems that reduce withdrawals of water at a farm or project scale, irrigation tailwater recovery systems for increasing water reuse, and conservation systems that protect water quality through the avoid, control, and trap approach. The "Managing and Restoring Rangelands and Forestlands" challenge identifies other opportunities to help manage water and sustain agricultural productivity.)
3. **Modernize water infrastructure:** NRCS can help irrigation districts, groundwater management organizations, and other water management entities modernize the water storage and delivery infrastructure needed to (1) supply irrigation or livestock water to farms and ranches, and (2) build drought resilience across a water delivery project area.
4. **Improve community water supply by completing watershed projects:** In a water supply emergency arising from a sudden impairment caused by wildfire or another natural occurrence, NRCS can help communities design, construct, rehabilitate, or modernize agricultural water storage and delivery infrastructures to build drought resilience or protect a watershed. (Also see the "Protecting Groundwater Availability" and "Protecting Surface Water Availability" challenges for opportunities to meet diminished water supplies by reducing water withdrawals.)
5. **Increase reuse of wastewater for agriculture and conservation:** NNRCS can help individuals, academic institutions, non-Government organizations, tribes, and local or state governments develop innovative water and land conservation tools, technologies, and approaches, including reusing treated wastewater for agricultural and conservation applications where feasible.

Examples of help for individual farmers include (1) selecting less water-demanding (or drought-tolerant) crops, species, or varieties; (2) rotating crops; (3) converting irrigated crop production to less water intensive agricultural uses; (4) reducing salt concentrations that limit agricultural productivity; (5) increasing efficiency in irrigation water applications; (6) adapting irrigation water management plans to changing climatic conditions; and (7) improving soil health and nutrient management practices (e.g., fertigation), and (8) treating agricultural wastewater for reuse.

Examples of help for water management entities and communities include lining irrigation canals, replacing irrigation canals with pipelines, installing water flow meters and other automation devices.

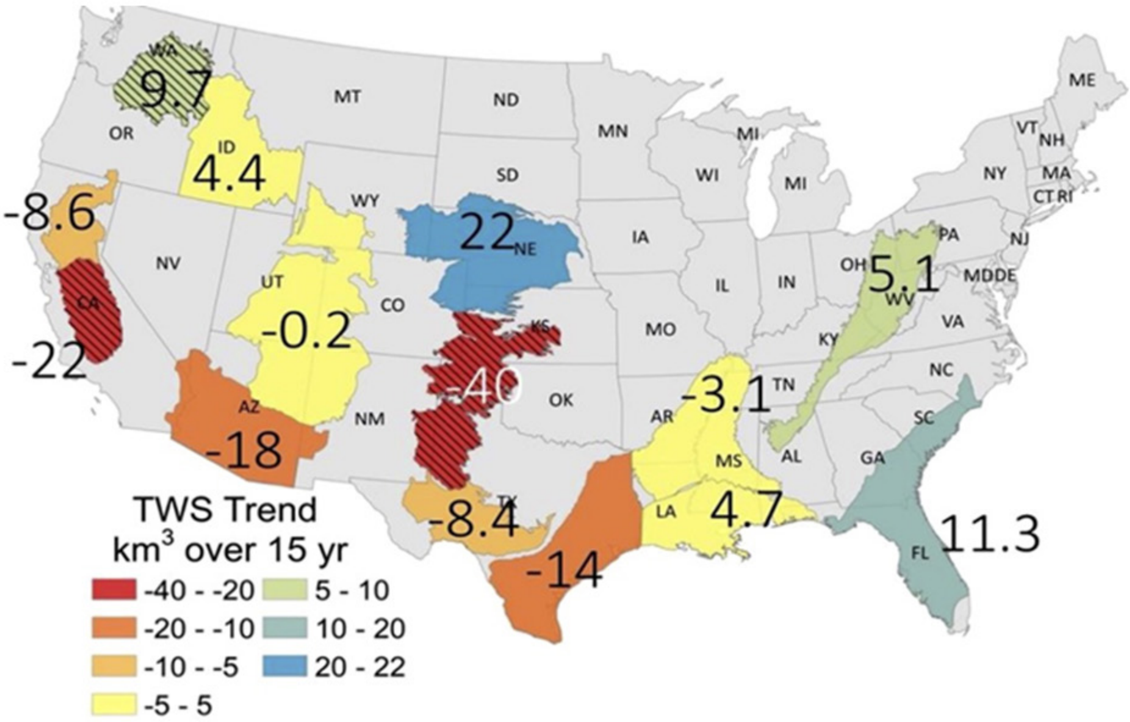
Protecting Groundwater Availability

Groundwater is an important source of water for agriculture, municipal and other uses, but the availability of this resource can be diminished by withdrawals exceeding recharge and by contamination. Increased demand for water, exacerbated by climate change, is putting additional strain on groundwater resources across the West. The decisions of water managers and the regulation of groundwater, as well as the absolute availability, may also reduce availability of water to agricultural producers. NRCS can assist producers in making more efficient use of groundwater and in supporting aquifer recharge in ways that do not risk reducing the quality of those resources.

Groundwater supplies irrigation or livestock watering needs to many communities across the West. In California, Nebraska, Texas, Kansas, South Dakota, and Oklahoma, groundwater is a more significant source of irrigation than surface water (USGS 2015). Regional aquifer systems (termed principal aquifers by USGS) yield groundwater to numerous communities and users, often crossing state lines as in the case of the Ogallala or High Plains aquifer system. Each aquifer within the system has its own geologic characteristics influencing how water moves and which management practices are best for protecting the availability of groundwater.

In places such as the Northern Plains, groundwater recharge is increasing not only due to geology, increases in precipitation, the resulting shifts in streamflow, and the extent of wetlands under climate change, but also from irrigation enhanced recharge, resulting in an increase in total volume of water stored in the region's aquifers (Figure 2.3). In other places such as the Southern Plains, the Southwest, and California, long-term droughts and irrigation withdrawals exceeding natural recharge rates (groundwater overdraft) are depleting aquifers.

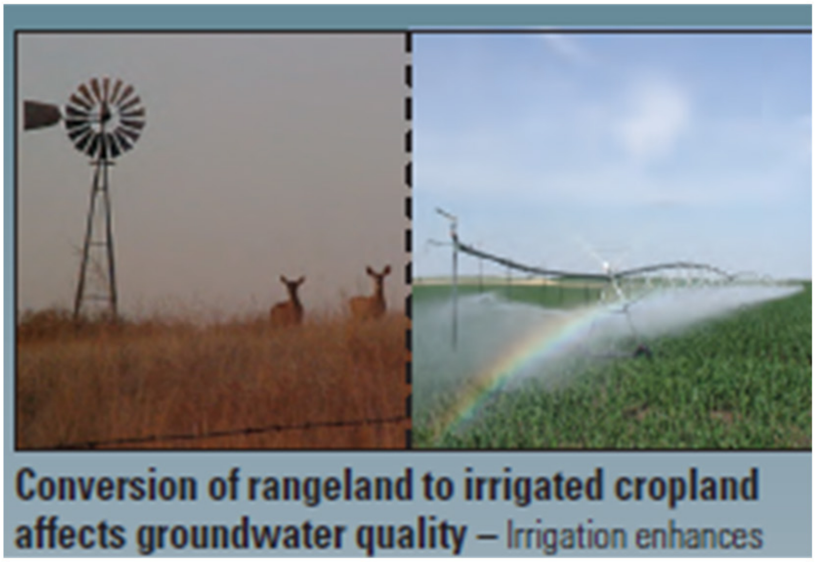
Figure 2.3. The effects of climate and irrigation on the total water storage of 12 major U.S. aquifers. Cross-hatching identifies aquifers where the trends greatly exceed year to year variations. (Source: Scanlon and others 2021)



Groundwater overdraft can increase land subsidence and salt concentration in aquifers. Saltwater intrusion from the sea can occur in aquifers along coastal areas. When water becomes too salty for its intended use, water wells may be decommissioned or reconstructed. Depletion of groundwater also weakens the buffer against droughts or scarce surface water supplies (USGCRP 2018). In addition to the challenge that groundwater overdraft poses to the sustainability of groundwater resources for economic uses, ecological functions of surface waters and other ecosystems that interact with groundwater systems are also at risk.

In places where irrigation-enhanced recharge is helping to increase groundwater volume, there is an increased risk of transporting nitrates and salts into the aquifer, which limits the availability of untreated groundwater for use as drinking water (USGS 2009). Where managing irrigation water applications cannot address the groundwater quality concern, conversion of irrigated cropland to non-irrigated uses may be necessary. Figure 2.4 illustrates how converting rangeland to irrigated cropland increases the recharge ability of the land and the risk of degrading groundwater quality. Groundwater quality in these irrigated areas may also be at risk of contamination from the waste of confined livestock feeding operations found in the same area.

Figure 2.4. Converting rangeland to irrigated cropland. (Source: USGS 2009)



In places where wetlands are a focal point for groundwater recharge, conserving wetlands helps to protect available groundwater (see the section on "Protecting Surface Water" for more information and Figure 2.6 for the prevalence of wetlands across the West). Collecting stormwater to manage aquifer recharge through water control basins or through distribution over suitable farmland is a conservation innovation currently being piloted and demonstrated in several locations.

In some communities, farmers and ranchers do not have private control over how much groundwater they can withdraw and are limited by local or state regulations as to how much is allocated for irrigation. Local groundwater management organizations monitor and manage groundwater conditions and may assist with aquifer recharge or other projects (Hrozencik 2021).

Vulnerable landscapes: Principal aquifers existing within or crossing multiple western states where water is less available due to groundwater depletion.

Conservation opportunity to prolong aquifer life: NRCS can help farmers and ranchers prolong aquifer life by reducing groundwater withdrawals to rates that correspond to natural recharge or comply with local or state groundwater withdrawal regulations. Where groundwater influences surface water, NRCS can help address concerns related to both water sources. (Also see the "Sustaining Agricultural Productivity" challenge for opportunities to help avoid loss of nutrients below the root zone to groundwater.)

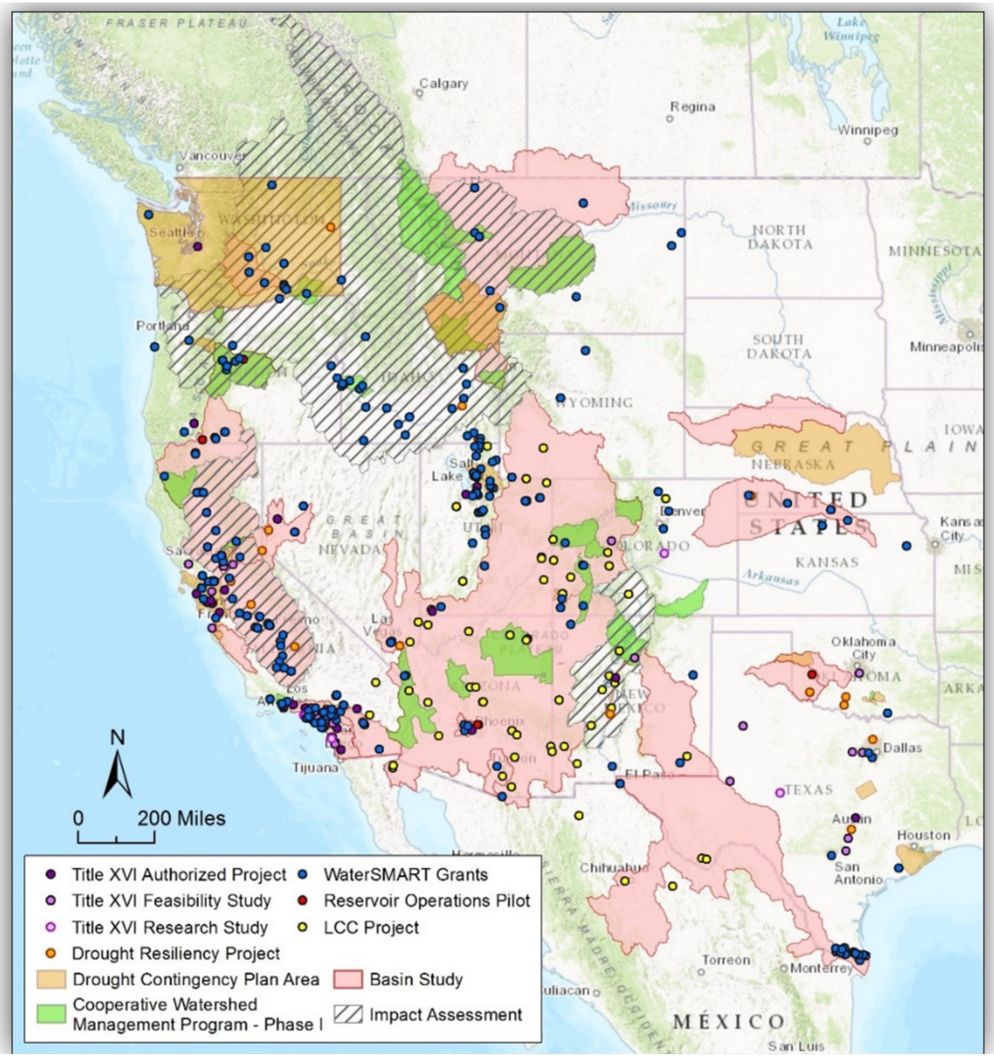
Conservation opportunity to complete managed aquifer recharge projects: NRCS can help farmers, ranchers, groundwater management entities, and communities prolong aquifer life by assisting with design and installation of managed aquifer recharge projects where surface water runoff or delivered water is available. (See also the "Protecting Surface Water Availability" challenge for opportunities to restore wetlands and streams that may also recharge aquifers).

Protecting Surface Water Availability

Surface water is the primary source of irrigation water in the driest parts of the West and is similarly important for other water users. Climate change is affecting the absolute amount of surface water available as well as the timing of that availability. The decisions of water managers and regulation of surface water, as well as the absolute availability, may reduce availability of water to agricultural producers. Pollutants from agricultural runoff can reduce the quality of surface water, making it less available for use by people and wildlife. NRCS can assist producers with (1) reducing surface water withdrawals to rates that correspond with diminished supply or meet local or state requirements, (2) reducing losses of nutrients and other potential contaminants to surface water, and (3) restoring streams and wetlands in watershed or groundwater recharge areas. NRCS can also assist water management entities with improving water distribution systems to reduce loss and use alternative water sources such as water reuse.

Protecting surface water availability requires collaboration between Federal, state, and local water supply managers and users in each community, as well as the wider region from which the surface water is collected. Figure 2.5 shows large areas in the West where water supply and demand have been evaluated to support water management planning activities. The Federal Department of Interior's Bureau of Reclamation provides WaterSMART funding to states, tribes, and local entities to evaluate water supply and demand for planning and managing cooperative watersheds.

Figure 2.5. Large areas in the West where water supply and demand have been evaluated for planning and implementation projects funded by the Bureau of Reclamation's WaterSMART program. (Source: DOI 2016).



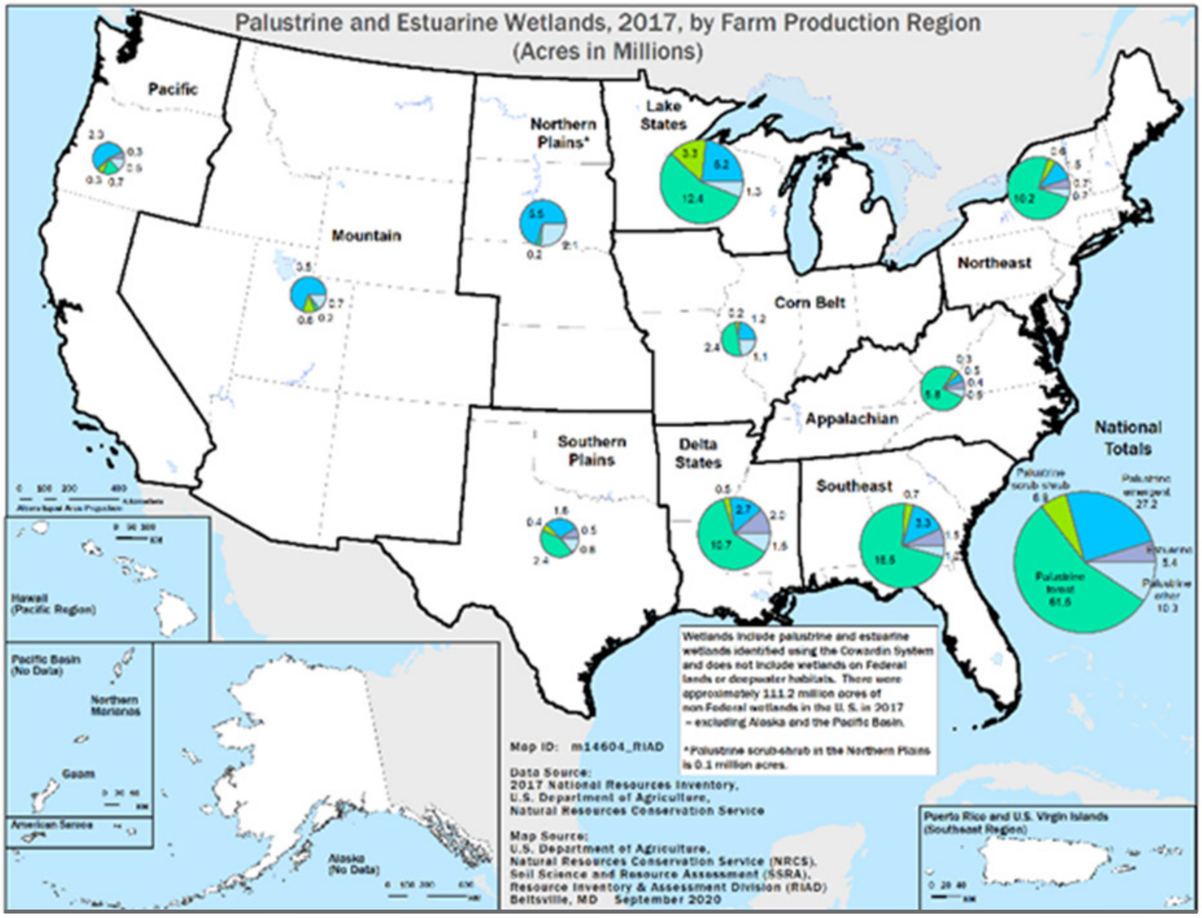
Farmers and ranchers with insufficient sources of irrigation or livestock water on their land lack control over their water supply. Although many people in the West withdraw groundwater from their own private property within applicable local or state groundwater regulations, more are dependent on allocations from surface water sources subject to the laws governing their state's water rights (USGS 2018). Others may have ponds or irrigation reservoirs to supplement their principal source of water. See Appendix 2 for more information about how water resources are allocated and managed within water rights laws across the West.

Where surface water is the primary source of water used by a community, that water is usually collected, stored, and transferred through a network of natural streams, rivers, and lakes (nature's water infrastructure), which is complemented by an extensive network of canals and reservoirs (the constructed water infrastructure). Water infrastructure may be managed by large Federal, state, or local water projects and often crosses state lines, requiring the cooperation of multiple public and private entities.

These large water infrastructure projects are vulnerable to droughts and the risk of declining water levels. As surface water levels decrease, water must be lifted higher to reach the land surface, which requires more energy and increases costs to drive the pump that withdraws the water. Production of crops and livestock, residential and municipal needs, and wildlife habitats are all at risk when the available water supply can no longer meet user demand.

Another impact of surface water depletion is a decrease in the quantity of water available for natural aquifer recharge. With less water entering the aquifer, the water table in the aquifer is susceptible to decline, leading to groundwater availability issues. Freshwater marshes, other types of wetlands, riparian areas, and floodplains found across the landscape contribute significantly to streamflow, groundwater recharge, and water quantities in permanent open water bodies (USDA 2008). In landscapes where water bodies are connected by flowing water (with or without a defined channel), there may be additional benefits to plant and animal communities when the water bodies are stable and connections between them are free of barriers. Some landscapes have geographically isolated depressional wetlands (e.g., playas, prairie potholes), which can be the focal point for groundwater recharge and may contribute to the availability of groundwater. In general, freshwater, and saltwater marshes are less extensive in the West than in the East (Figure 2.6). Although the economic value of these water sources may be difficult to determine, the social and environmental values may rank higher in decision making.

Figure 2.6. The prevalence of freshwater and saltwater marshes on rural lands by region. (Source: USDA 2020)



During periods of surface water depletion, the normal dilution of nutrients in the water is reduced, which can lead to a dense growth of algae or other plants removing oxygen from the water and a sudden die-off of fish or other water-dependent life. Surface waters impaired by excess nutrients, sediments, and other sources of pollution are costly to treat and use for their intended purposes. Just as there are a myriad of water users, sources of pollution are equally countless and can be broadly categorized as urban, agricultural, residential, industrial, etc. In irrigated agriculture, water applied through irrigation is easier to manage than water from precipitation; however, inefficient irrigation water applications can lead to excess nutrients in irrigation tailwater, nutrient loading to tributaries, water quality impairments, and in some cases, even algal blooms in lakes. Protecting source water from contamination helps to reduce treatment costs for private and public drinking water (USDA 2003).

As communities across the West encounter increasing challenges to meet their long-term water needs, they are considering alternative sources of water, such as collecting and using stormwater, desalinating seawater, or groundwater high in salt, and reusing treated wastewater. While reusing wastewater can be a more reliable source of water supply than traditional raw water sources, it may also come with challenges such as contamination by pharmaceuticals or other substances (EPA 2020).

To manage and deliver water used for irrigation, farmers and ranchers must depend on local organizations such as irrigation districts, ditch companies, acequias, and groundwater districts (Hrozencik 2021). These irrigation organizations construct and manage local infrastructure to transport, store, and deliver surface water to farms and ranches for irrigation. Many of the organizations are also involved in managing groundwater and other water-related activities.

Open canals, reservoirs, and turnouts are susceptible to water loss from evaporation, and aging water delivery infrastructure has increased the risk of water loss to seepage. About one-fifth of irrigation organizations use a formal drought plan to mitigate the risk of water supply disruptions to their customers (Hrozencik 2021). Infrastructure projects may take significant time to plan as there is the need to carefully assess potential environmental impacts, such as total maximum daily loads and base flows to protect threatened and endangered fish and wildlife habitat or drinking water supply.

Vulnerable landscapes: Surface water drainage areas existing within or crossing multiple western states where water availability is reduced due to depletion or degraded quality of surface water.

Conservation opportunity to reduce surface water withdrawals: NRCS can help farmers and ranchers protect the availability of surface water by reducing withdrawals to rates that correspond with diminished supply or that meet requirements of local or state regulations. (Also see the "Sustaining Agricultural Productivity" challenge for opportunities to help modernize water storage and delivery infrastructure and reuse wastewater for agriculture and conservation. See the "Protecting Groundwater Availability" challenge for opportunities to use stormwater that is not supplying a surface water body.).

Conservation opportunity to install conservation systems that protect water quality: NRCS can help farmers and ranchers protect surface water availability by installing conservation systems that protect water quality by reducing losses of sediment, nutrients, and other materials at the edges of fields and pastures. Where surface water bodies interact with ground water, NRCS can help manage both water resources. (Also see "Sustaining Agricultural Productivity" for opportunities to improve water and nutrient management within crop fields and pastures).

Conservation opportunity to restore and protect streams and wetlands: NRCS can help individuals, entities, and communities restore and protect floodplains, riparian areas, wetlands, and streams flowing through agricultural lands to increase available surface water supply, build hydrologic drought resilience, and protect water quality in small watersheds or other areas.

Examples of help for farmers and ranchers include (1) reducing surface water withdrawal rates; (2) converting to other sources of water for irrigation or livestock; (3) replacing aging water conveyance infrastructure; (4) installing flow meters to monitor water use; (5) converting flood irrigation to pressurized or micro-irrigation; (6) converting high pressure sprinklers to low pressure systems; (7) recovering irrigation tailwater for reuse; (8) installing edge of field practices to trap lost sediment, nutrients, pesticides, salts, or other potential contaminants; (9) creating or enhancing wetlands; and (10) restoring and protecting wetlands, floodplains, and streams.

Examples of help for individuals, entities, and communities include wetland creation or enhancement, stream and wetland restoration and protection, and floodplain and riparian area restoration and protection.

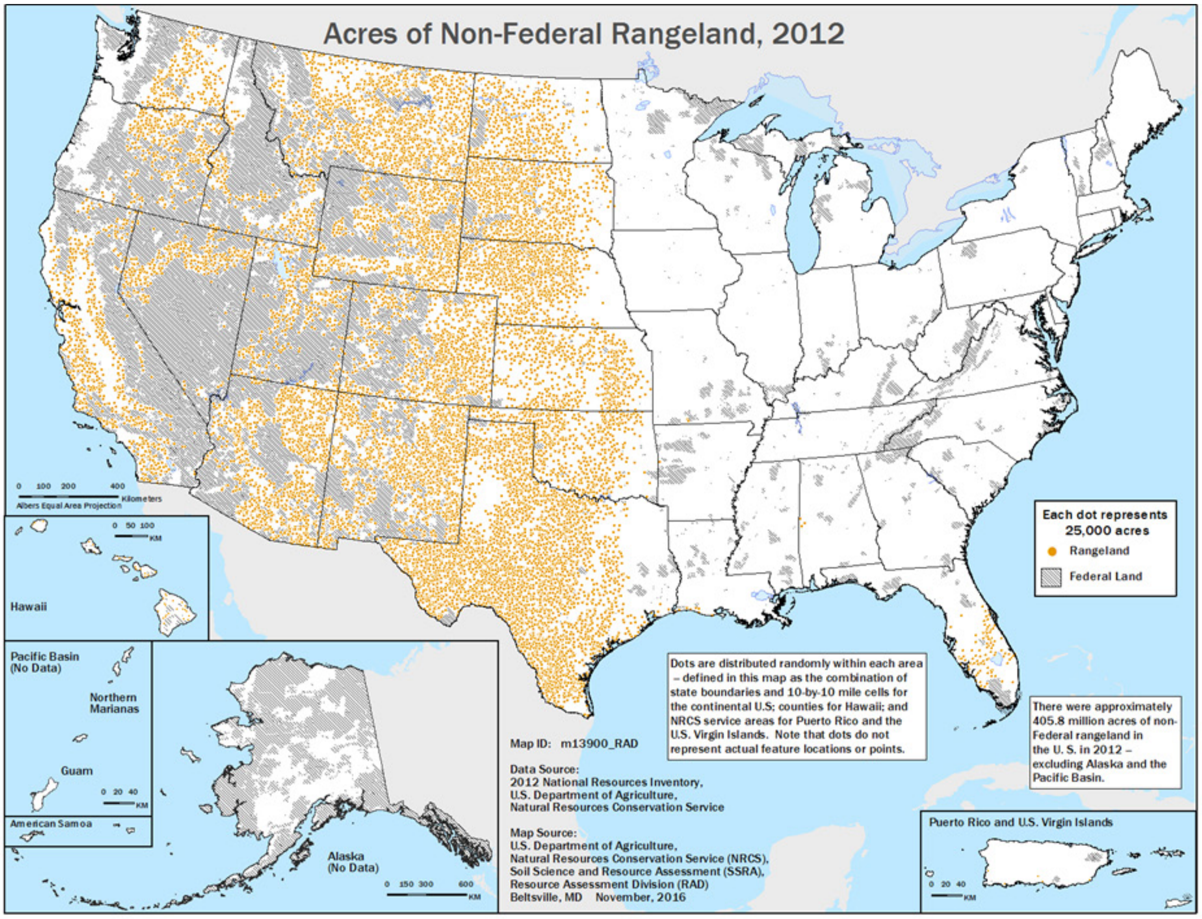
Managing and Restoring Rangelands and Forestlands

Many watersheds in the West are predominantly made up of rangelands and forests. These landscapes are sensitive to climate impacts like fires, floods, and drought that may reduce their productivity for food and fiber production as well as their water cycling function. Degradation of rangelands and forests can lead to reduced quality and quantity of the water in watersheds. NRCS can assist landowners and managers with improving the condition and resilience of these ecosystems.

Unlike crop and pasture lands, agricultural productivity for rangelands and forests does not depend on irrigation or an off-farm source of water; however, productivity is susceptible to more intense and longer droughts, increasing frequency of extreme weather events, and cascading impacts such as lower plant productivity and health, increased risk of erosion, lower water tables, more wildfires, etc. Climate change impacts also increase the risk of disrupting the water cycling function of rangelands and forestlands.

Through the NRI program, NRCS estimates the status, conditions, and trends of natural resources on the Nation's non-Federal land including rangeland (USDA 2018). Non-Federal rangeland makes up 21 percent of the lower 48 states and most of it is found in the West (Figure 2.7). The primary vegetation produced on these lands is herbaceous plants and shrubs, and they provide forage for domestic livestock to graze as well as habitat for a wide range of wildlife. Rangeland may be part of a multiple land use grazing system that includes grazed forest, crop, and pasture lands.

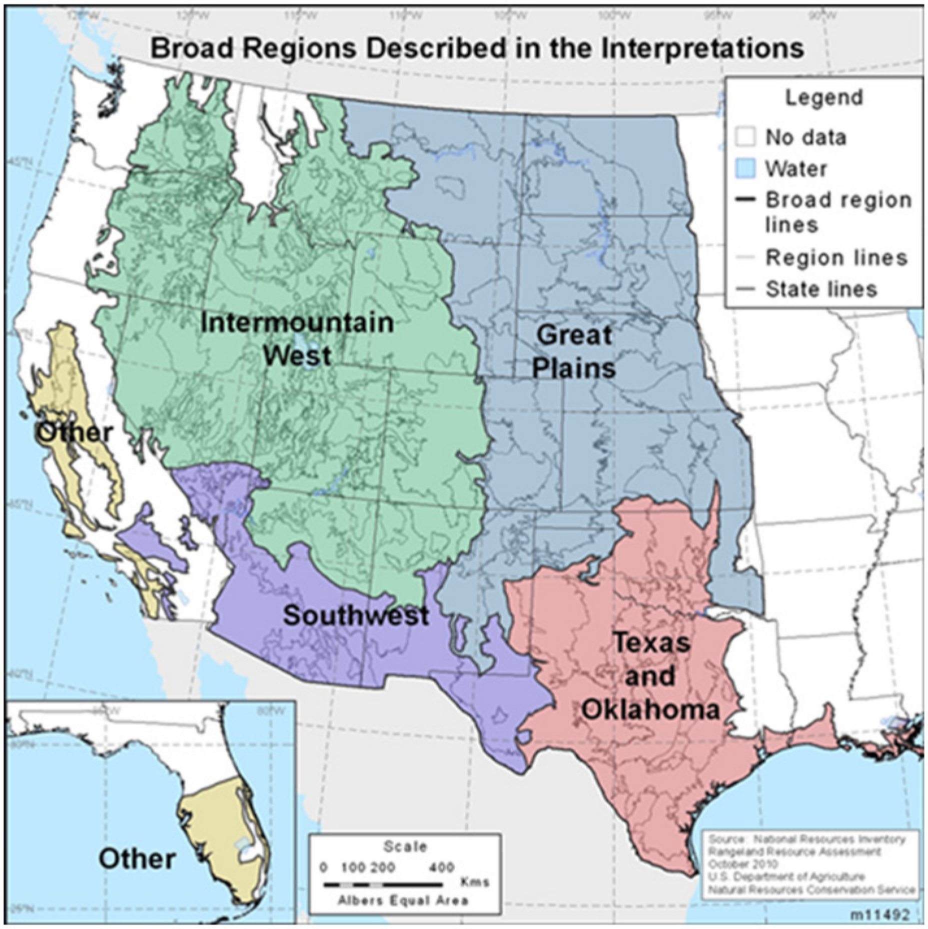
Figure 2.7. Location of the Nation's 405.8 million acres of non-Federal rangeland in 2012. (Source: USDA 2018).



Rangeland health is measured by its soil and site stability (its capacity to resist redistribution of nutrients, organic matter, and other soil resources by water and wind erosion), its biotic integrity (the health of plants, animals, and microbial communities), and its hydrologic function (water cycling). Water cycling is determined by rills, water flow patterns, pedestals and small ridges, bare ground, gullies, litter movement, soil resistance to erosion, soil surface loss or degradation, plant composition relative to infiltration, soil compaction, and litter amount.

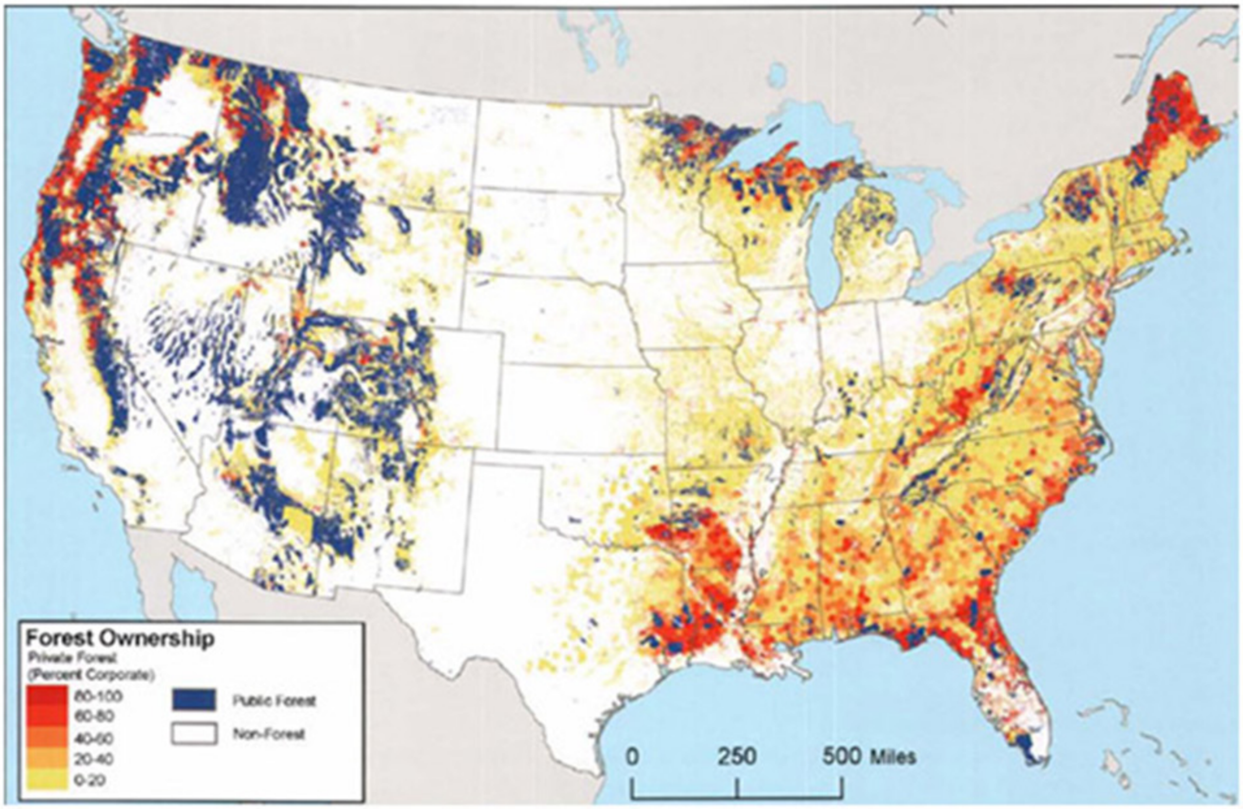
The general trend in water cycling on rangelands in the West has been interpreted at five regional scales (Figure 2.8): Great Plains; Texas and Oklahoma; Southwest; Intermountain West; and the annual grasslands of California. These regional interpretations document plant communities and climatic trends, including periodic droughts during the historic period. Rangeland conservationists use these interpretations to help ranchers conserve grazing land resources including water availability.

Figure 2.8. Broad regions used in rangeland interpretations. (Source: USDA 2018)



The United States Forest Service leads USDA research activities for estimating the status, conditions, and trends of natural resources on public forestlands and in cooperation with states for private forestlands (Figure 2.9). NRCS coordinates with the United States Forest Service at the national level and NRCS foresters work with their counterparts in state and private forestry to address technical forestry matters. Planning considerations for carrying out forestry activities include applying sound forest management principles such as tree cover, which is a watershed protection function. Water-related challenges in forest management include flood producing storm runoff, soil erosion, sediment load in streams, streamflow during dry periods, water infiltration and percolation for feeding permanent springs, streamflow, and replenishing the water table (USDA 2004). In forests where soil, water, air, plant, and animal needs can be met, proper management can produce forage for livestock, placing these forests in an important role for distributing livestock across a multiple land use grazing system.

Figure 2.9. Location of forests by public or private ownership. (Source: Hines 2011)



The water cycling function of the landscape is sensitive to changes in land use and cover (USGCRP 2018). Changes in regional water supply and demand may lead to shifts in land use and management across a watershed or groundwater management area. Shifts in land use may also be caused by increasing market values around urban areas. Shifting land use alters the water cycling function of the landscape by altering plant communities and the movement of stormwater across the surface or into the soil. For example, invasive plant encroachment such as junipers on rangelands or forestlands can intensify water runoff, erosion rates, and sediment transport. The amount of water that flows in a stream is particularly sensitive to changes in land cover in the headwaters area of a watershed, especially where such flows are primarily the result of snowpack quantity and rate of snow melt. The quality of stream water, especially its temperature, is also sensitive to changes in land cover in headwater areas.

Changing land use (such as clearing a forest to establish a pasture, converting rangeland by removing sod to cultivate small grains or row crops, or selling cropland to put up a shopping mall parking lot) decreases the amount of plant cover on the land and alters the flow of water across the landscape, increasing the risk of transporting sediment, nutrients, or chemicals to surface water bodies or aquifers where they can cause harm. Poor water quality can limit how much untreated water is available and negatively affect the drinking water quality for human communities, as well as degrade habitats of water-dependent and terrestrial wildlife. For example, the conversion of rangeland to irrigated cropland affects groundwater quality (Figure 2.4).

Vulnerable landscapes: Rangelands and forestlands across the West.

Conservation opportunity to manage and restore rangelands and forestlands: NRCS can help ranchers and forest owners improve the condition and resilience of these lands by making them less vulnerable during intense and longer droughts and extreme weather events. Vulnerabilities are reduced through improved grazing and forest management systems that sustain the agricultural productivity of rangelands and forestlands and increase the supply of water available to communities. (Also see the “Protecting Groundwater” and “Protecting Surface Water” challenges for opportunities to help recharge groundwater and improve surface water supply by restoring floodplains, riparian areas, wetlands, and streams.).

NRCS Plant Material Centers and the National Plant Materials Program can also support restoration projects to improve and care for plant communities across the West.

Examples of help for ranchers and forest owners include: any practice that improves naturally available moisture use, snow drifts, water temperature, plant productivity and health, plant community structure and composition, livestock water quantity, quality and distribution, feed and forage balance, livestock shelter, wildfire hazard from biomass accumulation condition, aquatic habitat for fish and other organisms, and terrestrial habitat for wildlife and invertebrates.

Responding to Disruptions From Catastrophic Events

Disasters such as droughts, fires, floods are increasing in frequency and intensity across the West and some cause catastrophic damage. These events can have immediate impacts on water delivery infrastructure and conservation structures as well as long term effects on water supply. NRCS helps individuals, entities, and communities in recovering from these disasters and can build resilience to climate stressors into recovery measures.

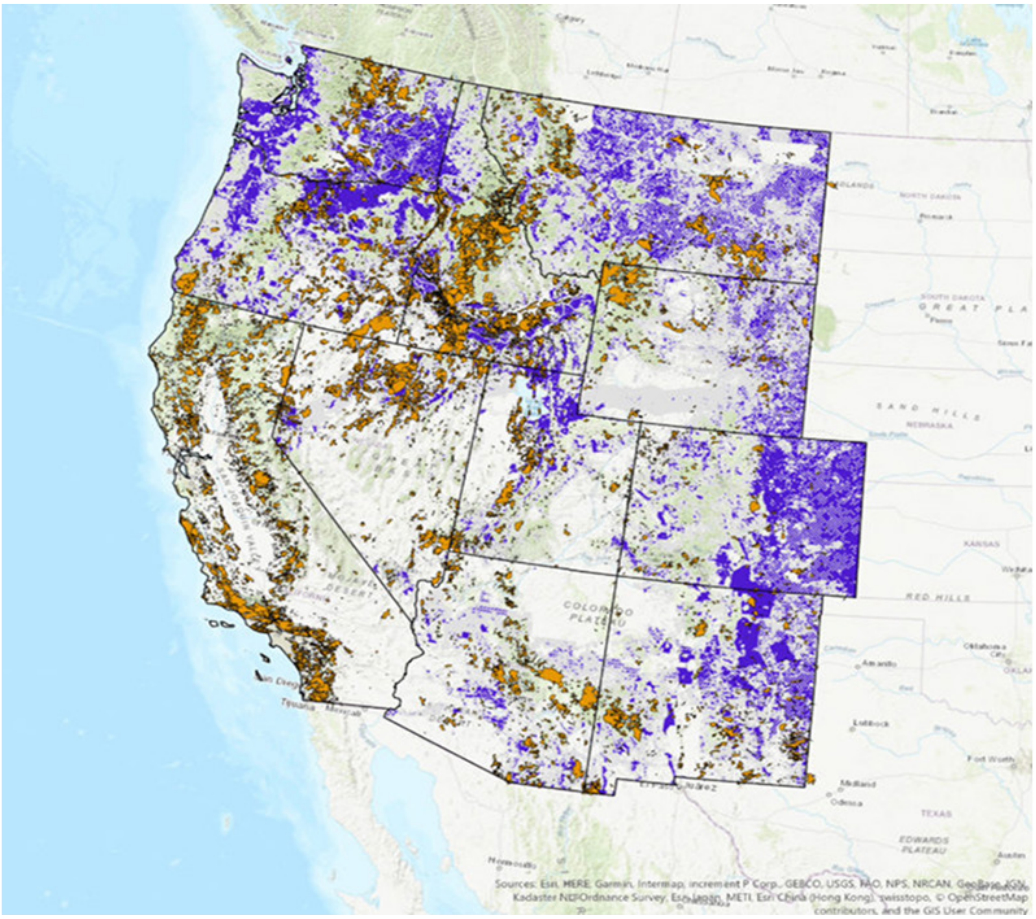
The increasing frequency and intensity of catastrophic events (e.g., megadroughts, devastating wildfires, extreme weather events, etc.) is resulting in major shifts in vegetation, land use changes, declining water supplies, and degraded water quality and habitat (USGCRP 2018). Catastrophic events also threaten communication, transportation, water, and other infrastructure needed for agricultural communities to thrive. Communities have limited resources to use in response to natural disasters of any scale and most cannot cope with catastrophic losses. Achieving social resilience to these challenges requires increased adaptive capacity for improving shared community resources.

While drought is a normal part of life in the West, the 22-year ongoing megadrought in the southwest is the driest in at least 1,200 years (Williams 2022). Water in Lake Mead, which sits behind the iconic Hoover Dam and is the Nation’s largest constructed reservoir, supplying water for at least 40 million people, reached a record low in August 2021 according to NASA observations. Under these conditions, less water is available to supply needs in 2022.

When water availability in a natural plant and animal community becomes too low for too long, plants die and local species disappear or may even go extinct if already rare, transforming the community to another type of vegetation altogether. In turn, this may reduce the amount of water available in the soil or for supplying water to streams and water bodies across the landscape. This intermittent deficit in water availability that drives plant community transformation is a phenomenon known as ecological drought (Crausbay 2017).

Over the last decade, wildfires in the West have grown and have burned more acreage than in the central or eastern United States (Congressional Research Service 2021). Of the acreage burned in the West, 75 percent was on Federal land managed primarily by either the United States Forest Service or the Department of Interior. Eleven percent of western lands have burned since 1950 (Figure 2.10). Only a small fraction of wildfires become catastrophic, but they account for most of the acres burned and have devastating impacts, including damage to infrastructure.

Figure 2.10. Since 1950, 11 percent of the area west of the Great Plains has burned (orange). Private lands are shown in purple while areas with no color are public lands. (Source: NASA 2018)



Heavy rains delivered by atmospheric rivers cause flooding, erosion, and mudslides, which damage homes, vehicles, business, and infrastructure. These same impacts can compound the damage that has already occurred when hitting the same area burned by a recent wildfire (NASA 2018). Services are often interrupted during extreme weather and climate events or when aging infrastructure fails because there are inadequate resources to replace, rehabilitate, or modernize them.

In agricultural communities across the West, aging water infrastructure (e.g., canals, ditches, flood control structures, ponds, reservoirs) and conservation practices that have outlived their lifespan (e.g., grass waterways, stream crossings, manure lagoons) are at greater risk of failure. Most of the infrastructure and conservation practices currently in use were designed based on criteria for climate conditions and service life that are no longer adequate.

Vulnerable landscapes: Wherever natural disasters (or related emergencies) are declared.

Conservation opportunity to build resilience during disaster recovery: NRNRCS can help individuals, entities, and communities repair damage from natural disasters (including wildfire, ecological drought, and related emergencies). Where opportunities exist, NRCS can also provide long-term support for adding resilience measures such as conserving water resources, recovering from wildfires, and improving livestock access to water.

Examples of disaster and emergency assistance include help with repairing watershed infrastructure and conservation structures damaged by severe erosion, drought, flooding, debris-clogged waterways, or downed timber, as well as help with relieving imminent threats to life and property in a watershed impaired by floods, fires, windstorms, or other natural disasters. Designs may consider adding resilience measures to prepare for increased impacts from volatile weather and a changing climate. Emergency haying and grazing or emergency water conservation measures may be employed in areas affected by severe or exceptional drought or similar natural disasters.

Western Water and Working Lands Strategies

Western Water and Working Lands Strategies enable NRCS leaders and managers to set program delivery goals and plan supporting business activities. These strategies may be incorporated into the deliberations of State Technical Advisory Committees and local working groups to complement the locally led conservation model. The strategies are also program neutral and may be supported though the various conservation programs that NRCS delivers. See Appendix 1 for more information about the kind of assistance NRCS may be able to provide through applicable USDA Conservation Programs.

The following strategies support NRCS efforts to direct assistance for conserving water and working land resources across the West:

1. Improve reliability of water supply forecasts
2. Improve soil moisture and irrigation water management
3. Improve water and nutrient management in crop fields and pastures
4. Modernize water infrastructure
5. Improve community water supply by completing watershed projects
6. Increase reuse of wastewater for agriculture and conservation
7. Prolong aquifer life
8. Complete managed aquifer recharge projects
9. Reduce surface water withdrawals
10. Install conservation systems that protect water quality
11. Restore and protect streams and wetlands
12. Manage and restore rangelands and forestlands
13. Increase resilience during disaster recovery

Table 3.1 identifies the need for each of these strategies and how NRCS will help customers achieve them. Table 3.2 identifies which strategy primarily addresses each challenge. NRCS will establish goals for each strategy and track accomplishments annually

Table 3.1. Western Water and Working Lands Strategies, Needs, and How NRCS Will Help

Strategy	Purpose and need:	How NRCS Will Help)
1. Improve reliability of water supply forecasts	Under increased demand for water and with climate change impacts, supply from surface water sources to a myriad of users is increasingly unreliable. Forecasting expected streamflow is an important aid in planning water storage and release as well as irrigated agriculture planting decisions.	NRCS will improve the network of sites for monitoring snowpack and invest in innovative technology, methods, and models to inform water forecast products
2. Improve soil moisture and irrigation water management	Soil moisture may be supplied by precipitation or irrigation. Irrigation water mitigates the lack of soil moisture and high salt concentrations. Naturally available soil moisture needs to be managed in dryland agriculture, and both soil moisture and irrigation needs to be managed in irrigated agriculture to achieve economical production of common and high value crops in dry climates	NRCS will help farmers in dry climates efficiently use soil moisture and irrigation water to sustain productivity and build resilience to agricultural drought in dryland or irrigated crop fields and pastures.
3. Improve water and nutrient management in crop fields and pastures	Water movement across the surface and down into the soil profile can transport sediment and nutrients within crop fields and pastures reducing plant productivity and health and degrading water quality. Healthy soils and an effective nutrient management program are needed to improve water infiltration and holding capacity, avoid nutrient loss below the root zone and from water runoff, and improve crop productivity and health. Water control practices further reduce the risk of excessive leaching, soil loss by water erosion, and nutrient transport by safely moving water runoff and sediment to trapping practices.	NRCS will help farmers in dry climates apply soil health management, nutrient management, and water control practices within crop fields and pastures to (1) sustain crop productivity; (2) avoid nutrient losses and control sediment and nutrient transport to areas where they can be trapped; and (3) protect groundwater and surface water quality.
4. Modernize water infrastructure	Water infrastructure such as canals, reservoirs, turnouts, and automation devices are needed to transport, store, and deliver surface water or manage groundwater. Only one-fifth of irrigation organizations use a formal drought plan to mitigate the risk of water supply disruptions.	NRCS will help irrigation districts, groundwater management organizations, and other water management entities modernize water storage and delivery infrastructure needed to (1) supply irrigation or livestock water to farms and ranches and (2) build drought resilience across a water project delivery area.
5. Improve community water supply by completing watershed projects	Local government agencies, tribal organizations, and other organizations need help during emergencies arising from a sudden watershed impairment caused by wildfire or other natural occurrences. Eligible organizations may sponsor small watershed projects that include agricultural water management, drought resilience, or emergency protection related to community water supply.	NRCS will help communities design, construct, rehabilitate, or modernize agricultural water storage and delivery infrastructure to build drought resilience or protect a watershed.
6. Increase reuse of wastewater for agriculture and conservation	Alternative sources of water such as treated wastewater are being considered to meet long- term needs. While reuse of wastewater can be a more reliable source of water supply than traditional water sources, it may also come with other challenges such as contamination by pharmaceuticals or other substances	NRCS will help individuals, academic institutions, non-Government organizations, tribes, and local or state governments develop innovative water and land conservation tools, technologies, and approaches, including reusing treated wastewater for agricultural and conservation applications where feasible.

Table 3.1. Western Water and Working Lands Strategies, Needs, and How NRCS Will Help—continued

Strategy	Purpose and need:	How NRCS Will Help)
7. Prolong aquifer life	Groundwater supplied by principal aquifer systems is a significant source of agricultural water in many places, and the only source in a few. In some places, long-term droughts and irrigation withdrawals are depleting aquifers. Where the aquifer is the only source of water, irrigated agriculture will cease when it is gone. In areas fortunate to have both groundwater and surface water, depleting the aquifer reduces the buffer against declining surface water supply.	NRCS will help farmers and ranchers prolong aquifer life by reducing groundwater withdrawals to rates that correspond with natural recharge or comply with local or state groundwater withdrawal regulations.
8. Complete managed aquifer recharge projects	In some places managed aquifer recharge is feasible due to geology, topography, and available surface water sources	NRCS will help farmers, ranchers, groundwater management entities, and communities prolong aquifer life by assisting with design and installation of managed aquifer recharge projects where surface water runoff or delivered water is available.
9. Reduce surface water withdrawals	When surface water volume is sufficiently depleted there is not enough water available for all users. In some cases, increased irrigation efficiencies can result in less water available for downstream users.	NRCS will help farmers and ranchers protect the availability of the surface water by reducing withdrawals to rates that correspond with diminished supply or that meet requirements of local or state regulations.
10. Install conservation systems that protect water quality	Extreme storm events in dryland agriculture can exceed the capacity of water control practices to safely convey water runoff, which could result in soil erosion and water quality impairments. Inefficient irrigation water applications can lead to excess nutrients in irrigation tailwater, nutrient loading to tributaries, water quality impairments, and in some cases, even algal blooms in lakes.	NRCS will help farmers and ranchers protect surface water availability by installing conservation systems that protect water quality by reducing losses of sediment, nutrients, and other materials at the edges of fields and pastures
11. Restore and protect streams and wetlands	Streams, wetlands, riparian areas, and floodplains contribute significantly to surface water supply and groundwater recharge.	NRCS will help individuals, entities, and communities restore and protect floodplains, riparian areas, wetlands, and streams to increase available surface water supply, build hydrologic drought resilience, recharge aquifers, or protect water quality in small watersheds or other areas.
12. Manage and restore rangelands and forestlands	Rangelands and forestlands play a critical role in the regional balance of water supply and demand. These lands are sensitive to more intense and longer droughts, increasing frequency of extreme weather events, increased risk of erosion, lower water tables, wildfires, changes in land use and cover. Rangelands supply the greatest amount of forage for domestic livestock and grazed forests may be an important part of a multiple land use grazing system.	NRCS will help ranchers and forest owners improve the condition and resilience of rangelands and forestlands by making them less vulnerable during intense and longer droughts and extreme weather events. Vulnerabilities are reduced through improved grazing and forest management systems that sustain agricultural productivity of rangelands and forestlands and increase the supply of water available to communities.
13. Increase resilience during disaster recovery	The increasing frequency and intensity of catastrophic events is resulting in major shifts in vegetation (ecological drought), land use changes, declining water supplies, and degraded water quality and habitat. Communities have limited resources to respond to natural disasters and most cannot cope with catastrophic events (e.g., megadroughts, devastating wildfires, extreme weather, epic flooding, massive landslides, etc.).	NRCS will help individuals, entities, and communities repair damage from natural disasters (including wildfire, ecological drought, and related emergencies). Where opportunities exist, NRCS will provide long-term support for adding resilience measures, such as conserving water resources, recovering from wildfires, and improving livestock access to water.

Table 3.2. Management Challenges Addressed by Western Water and Working Lands Strategies

Management Challenges		Western Water and Working Lands Strategies (1-7)						
#	Name	1. Improve reliability of water supply forecasts	2. Improve soil moisture and irrigation water management	3. Improve water and nutrient management in crop fields and pastures	4 Modernize water infrastructure	5. Improve community water supply by completing watershed projects	6. Increase reuse of wastewater for agriculture and conservation	7. Prolong aquifer life
1	Forecasting water supply	P						
2	Sustaining agricultural productivity	S	P	P	P	P	P	
3	Protecting groundwater availability	S	S	S	S	S	S	P
4	Protecting surface water availability	S	S	S	S	S	S	S
5	Managing and restoring rangelands and forestlands	S						
6	Responding to disruptions from catastrophic events	S						

P denotes the primary challenge addressed by the strategy, S the secondary challenge also addressed.

Table 3.2. Management Challenges Addressed by Western Water and Working Lands Strategies—continued

Management Challenges		Western Water and Working Lands Strategies continued (8-13)					
#	Name	8. Complete managed aquifer recharge projects	9. Reduce surface water withdrawals	10. Install conservation systems that protect water quality	11. Restore and protect streams and wetlands	12. . Manage and restore rangelands and forestlands	13. Increase resilience during disaster recovery
1	Forecasting water supply						
2	Sustaining agricultural productivity						S
3	Protecting groundwater availability	P		S	S	S	S
4	Protecting surface water availability		P	P	P	S	S
5	Managing and restoring rangelands and forestlands					P	S
6	Responding to disruptions from catastrophic events		S		S	S	P

P denotes the primary challenge addressed by the strategy, S the secondary challenge also addressed.

Through voluntary conservation efforts individuals, entities, and communities in the West can conserve water and working lands resources for future generations, feed a growing world, and provide public benefits including clean and available water supplies, healthy soils, resilient landscapes, and thriving agricultural communities.

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Appendix 1—NRCS Assistance for Conserving Water and Working Lands Resources

NRCS delivers conservation assistance to agricultural producers, entities, and communities that voluntarily improve the health of working agricultural lands while also protecting natural resources in the environment, including water. Coordinating with other USDA agencies, NRCS works to ensure the sustainability of American agriculture and an environment full of clean and abundant water, healthy soils, resilient landscapes, and thriving economies now and in the future.

There are over 2400 local NRCS field offices across the Nation delivering conservation assistance to customers in all states and territories of the United States. The National Headquarters office, NRCS national centers (listed at the end of this appendix), and NRCS area, state, and regional offices support field office operations. Individuals, entities, and communities can partner with NRCS through contracts, grants, and agreements managed at the state, regional, or national levels of the agency.

Conservation assistance is available through a suite of USDA conservation programs (listed at the end of this appendix), each with their own approach to conserving natural resources. General approaches to advancing natural resource conservation include conservation technology innovation development, field demonstrations, stakeholder engagement, education and outreach events, locally led delivery of financial and technical assistance benefiting agricultural producers and the wider public, targeted funding for landscapes in the greatest need of conservation treatment, public works improvement projects for watershed protection, disaster and emergency response assistance, land retirement, and agricultural conservation easements to protect the conservation values of the land. Each of these approaches are applicable to conserving water and land resources anywhere.

NRCS categorizes soil, water, air, plants, animals, and energy as the natural resources used in production agriculture and environmental management. Science-based natural resource conservation assessments and plans that consider socioeconomic factors (the human factor) are the basis for decision making and providing conservation assistance.

Conservation plans are developed through assessing site vulnerabilities, identifying natural resource concerns or problems, assessing conservation opportunities for each unit of land under the customer's control, and evaluating alternative solutions. Criteria used for planning determine if conservation treatment is needed to solve a natural resource use problem in a particular area. These criteria are established in accordance with Government programs and local, state, and Federal regulations, and they also take into consideration ecological, economic, and social impacts. Once the customer decides on a conservation alternative and voluntarily agrees to a plan, NRCS can also help them put their plan into action by delivering technical and financial assistance for carrying out a schedule of conservation practices or activities.

Examples of the conservation assistance that is available to address water and land resource conservation include (1) helping farmers and ranchers design, construct, and manage irrigation systems while protecting water availability and quality, which benefits related natural resources and complies with applicable water laws and environmental regulations; (2) helping water management entities (such as state irrigation districts, ground water management districts, acequias, or other entities) improve water delivery infrastructure and management; (3) helping local and tribal agencies or non-profit organizations restore and protect watersheds; and (4) working with state or local government agencies and non-Government organizations to drive public and private sector innovation.

NRCS measures and annually tracks its progress in delivering assistance for conservation of natural resources on working agricultural lands. NRCS determines improvement in environmental quality by counting each land unit where a conservation practice has been applied through an NRCS Conservation Program for a specific purpose and land use (crop, grazing, etc.) during the fiscal year, and totals the number of acres for each land unit receiving assistance in each state as well as nationally.

Practice purposes related to conserving water and working land resources include (1) conservation on cropland to reduce soil erosion, improve soil quality, health, and sustainability or address poor soil health through management principles; (2) conservation on grazing land to improve the resource base or achieve a sustainable forage-animal balance; (3) conservation on forest land; (4) conservation to improve irrigation water use efficiency, management, and water conservation; (5) conservation of wetlands; (6) conservation to improve water quality; and (7) conservation to improve fish and wildlife habitat quality and management. Some practices contribute to more than one performance measure. Changes in land unit acres receiving conservation assistance by program and fiscal year can be visualized at the NRCS Resource Conservation Act (RCA) data viewer (see Box A1.1 for additional information).

NRCS also quantifies the environmental effects of conservation practices and programs and works with USDA's Agriculture Research Service to develop the science base for managing the agricultural landscape for environmental quality through its Conservation Effects Assessment Project (CEAP). Project findings are used to guide USDA conservation policy and program development and help conservationists, farmers and ranchers make more informed conservation decisions.

Box A.1. About the RCA

NRCS cooperates with other Federal agencies, state agencies, and partners to collect and analyze natural resource data. As new information becomes available, it is used to conduct analyses of policy options and strategies for improving conservation efforts.

The Soil and Water Resources Conservation Act of 1977 (Pub. L. No. 95-192) provides broad natural resource strategic assessment and planning authority for the USDA. The purpose of the RCA is to ensure that USDA programs for the conservation of soil, water, and related resources are responsive to the long-term needs of the Nation.

The 2011 RCA appraisal provides an overview of (1) land use and the U.S. agricultural sector; (2) the status, condition, and trends of natural resources on non-Federal lands; and (3) USDA's program for soil and water resources conservation. It also examines interrelated issues that have implications for U.S. agriculture in the 21st Century including climate change challenges and conservation opportunities related to water resources (USDA 2011).

Conservation data can be visualized at the RCA Data Viewer. Users can graph, map, and download customized datasets based on practices applied through NRCS programs and survey data on land use, soil erosion, and prime farmland in the NRI. State and national data on conservation practices cover fiscal years 2005-2021. NRI data are available at 5-year intervals from 1982-2017 for the state and national levels.

1. **NRCS National Centers**

    - National Geospatial Center of Excellence
    - National Soil Survey Center
    - National Water and Climate Center
    - National Water Management Center
    - National Design, Construction, and Soil Mechanics Center
    - Plant Materials Centers
    - National Agroforestry Center
    - East National Technology Support Center
    - Central National Technology Support Center
    - West National Technology Support Center

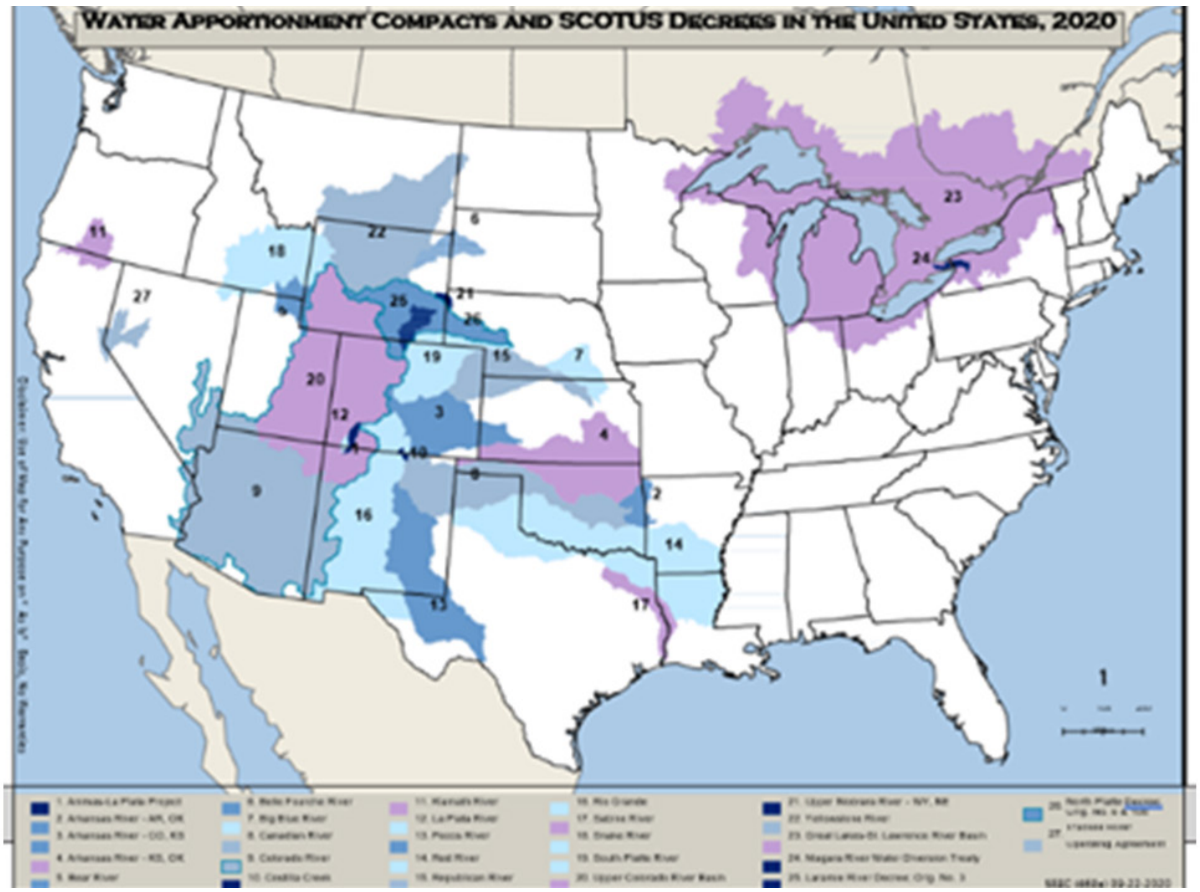
2. **USDA Conservation Programs that Address Western Water and Working Lands Resources**

    - Agricultural Conservation Easement Program (ACEP)
    - Agricultural Conservation Easement Program Wetland Reserve (ACEP – WRE)
    - Agricultural Management Assistance (AMA)
    - Colorado River Basin Salinity Control (CRBSCP)
    - Conservation Effects Assessment Project (CEAP)
    - Conservation Innovation Grants (CIG)
    - Conservation Reserve Program (CRP)
    - Conservation Stewardship Program (CSP)
    - Conservation Technical Assistance (CTA)
    - Emergency Watershed Protection Program (Recovery) (EWP)
    - Emergency Watershed Protection Program (Floodplain Easements) (EWP – FE)
    - Environmental Quality Incentives Program (EQIP)
    - Environmental Quality Incentives Program WaterSMART Initiative (EQIP – WSI)
    - Environmental Quality Incentives Program National Water Quality Initiative (EQIP – NWQI)
    - Healthy Forest Reserve Program (HFRP)
    - National Resources Inventory (NRI)
    - Regional Conservation Partnership Program (RCPP)
    - Snow Survey and Water Supply Forecasting Program (SSWSFP)
    - Soil Survey Program (SSP)
    - Urban Agriculture and Innovative Production (UAIP)
    - Water Bank Program (WBP)
    - Watershed Protection and Flood Prevention Operations Program (WPFO)
    - Watershed Rehabilitation Program (REHAB)
    - Wetland Mitigation Banking Program (WMBP)

Appendix 2—Interstate Water Apportionment Compacts and Water Rights

In the American West, there are more than 20 interstate and regional river basin compacts, most of which have authority for the equitable apportionment of water between states (Figure A2.1). Many of the western compacts have commissions that may only meet one or two times per year and do not have staff. Allocations of water resources between states for some river basins occurs through U.S. Supreme Court Original Jurisdiction Decrees when states are not able to agree on compact terms (e.g., the Laramie River between Colorado and Wyoming, and the North Platte River between Colorado, Wyoming, and Nebraska

Figure A2.1. Location of Water Apportionment Compacts in the United States and the associated SCOTUS decrees. (Source: Interstate Council on Water Policy, 2021)



Water rights directly affect land values, so understanding them is critical for motivating landowners to adopt conservation practices. In the West, water rights are known as "Appropriative Water Rights." Appropriative water rights confer diversion privileges (generally to stream flow) in the order of the claim so that the earliest claimant has the highest priority. There are senior rights and junior rights and differences in how water is managed within those contexts. Agricultural users typically hold the more senior water rights. All water assigned must be used under the beneficial use doctrine. Any remaining water is freed for subsequent claimants. Under the prior appropriation doctrine, there is a ladder of water rights on each stream that ranges from highest to lowest priority, and the highest priority claim gets first access to the water. Therefore, senior water right holders are more certain to receive water delivery and their water rights are more valuable. Consequently, there is more incentive for investment in their water infrastructure than in the infrastructure for junior water right holders.

Not only do water rights vary from state to state but there can be substantial differences in how water is managed and allocated within different basins in the same state. Some states allow for a water right to be forfeited if it is not used within a certain timeframe, or the state requires a new application if the water usage changes. If a water rights holder does not use their allotment (according to historical rates), they may lose future access to that right (volume). One of the barriers to adopting water conservation and efficiency measures is that a reduction in the volume of water used may result in forfeiture of future rights.

Key Water Rights Principles

1. Prior appropriation grants priority based on the date use begins ("first in time, first in right").

2. Water rights may be forfeited if not applied to a beneficial use ("use it or lose it").

More information about water rights in the western United States may be found in the six-part series of articles Water Law 101 found at the University of Nebraska – Lincoln.