



# Drought in the United States: Causes and Issues for Congress

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## Summary

Drought is a natural hazard with often significant societal, economic, and environmental consequences. Public policy issues related to drought range from how to identify and measure drought to how best to prepare for, mitigate, and respond to drought impacts, and who should bear associated costs. Severe drought in 2011 and 2012 fueled congressional interest in near-term issues, such as current (and recently expired) federal programs and their funding, and long-term issues, such as drought forecasting and various federal drought relief and mitigation actions. Continuing drought conditions throughout the country contribute to ongoing interest in federal drought policies and responses.

As of April 2013, drought has persisted across approximately two-thirds of the United States and is threatening agricultural production and other sectors. More than 1,180 counties so far have been designated as disaster areas for the 2013 crop season, including 286 counties contiguous to primary drought counties. In comparison, in August 2012, more than 1,400 counties in 33 states had been designated as disaster counties by the U.S. Secretary of Agriculture. Most attention in the 112<sup>th</sup> Congress focused on the extension of expired disaster assistance programs in separate versions of a 2012 farm bill. Attention in the 113<sup>th</sup> Congress again is expected to focus on farm bill legislation; however, other bills addressing different aspects of drought policy and response have also been introduced. (For information regarding drought disaster assistance for agricultural producers, see CRS Report RS21212, *Agricultural Disaster Assistance*. For information on the 2012 bill, see CRS Report R42552, *The 2012 Farm Bill: A Comparison of Senate-Passed S. 3240 and the House Agriculture Committee's H.R. 6083 with Current Law*.)

Although agricultural losses typically dominate drought impacts, federal drought activities are not limited to agriculture. For example, the 2012 drought raised congressional interest in whether and to what extent other federal agencies have and are using authorities to address drought. Similarly, the President in August 2012 convened the White House Rural Council to assess executive branch agencies' responses to the ongoing drought. The Administration shortly thereafter announced several new administrative actions to address the drought.

While numerous federal programs address different aspects of drought, no comprehensive national drought policy exists. A 2000 National Drought Policy Commission noted the patchwork nature of drought programs, and that despite a major federal role in responding to drought, no single federal agency leads or coordinates drought programs—instead, the federal role is more of “crisis management.” Congress may opt to revisit the commission's recommendations. Congress also may consider proposals to manage drought impacts, such as authorizing new assistance to develop or augment water supplies for localities, industries, and agriculture—or providing funding for such activities where authorities already exist. Congress also may address how the two major federal water management agencies, the U.S. Army Corps of Engineers and the Bureau of Reclamation, plan for and respond to drought.

This report describes the physical causes of drought, drought history in the United States, and policy challenges related to drought. It also provides examples of recurrent regional drought conditions. For information on federal agricultural disaster assistance and related legislation, see the CRS reports noted above.

This report will not be updated. For further information about the causes and current understanding of drought in the United States, see CRS Report R43407, *Drought in the United States: Causes and Current Understanding*.

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## Introduction

This report discusses how drought is defined (e.g., why drought in one region of the country is different from drought in another region), and why drought occurs in the United States. How droughts are classified, and what is meant by moderate, severe, and extreme drought classifications, are also discussed. The report briefly describes periods of drought in the country's past that equaled or exceeded drought conditions experienced during the 20<sup>th</sup> century. This is followed by a discussion of the future prospects for a climate in the western United States that might be drier than the average 20<sup>th</sup>-century climate. The report concludes with a primer on policy challenges for Congress, such as the existing federal/nonfederal split in drought response and management and the patchwork of drought programs subject to oversight by multiple congressional committees.

Following are brief answers to frequently asked questions related to drought.

*What is drought?* Drought is commonly defined as a lack of precipitation over an extended period, usually a season or more, relative to some long-term average condition. History suggests that severe and extended droughts are inevitable and part of natural climate cycles. While forecast technology and science have improved, regional predictions remain limited to a few months in advance.

*What causes drought?* The physical conditions causing drought in the United States are increasingly understood to be linked to sea surface temperatures (SSTs) in the tropical Pacific Ocean. Studies indicate that cooler-than-average SSTs have been connected to the severe western drought in the first decade of the 21<sup>st</sup> century, severe droughts of the late 19<sup>th</sup> century, and precolonial North American "megadroughts." The 2011 severe drought in Texas is thought to be linked to La Niña conditions (cooler-than-average SSTs) in the Pacific Ocean.

*What is the future of drought in the United States?* The prospect of extended droughts and more arid baseline conditions in parts of the United States could suggest new challenges to federal programs and water projects, which were conceived or constructed largely on the basis of 20<sup>th</sup>-century climate conditions. Some studies suggest a transitioning of the American West to a more arid climate, possibly resulting from the buildup of greenhouse gases in the atmosphere, raising concerns that the region may become more prone to extreme drought than it was in the 20<sup>th</sup> century. Some models of future climate conditions also predict greater fluctuations in wet and dry years; however, the net effect of such fluctuations is difficult to predict.

*What is federal drought policy?* Although drought impacts can be significant, no comprehensive national drought policy exists. Developing a national policy would be challenging because of split federal and nonfederal responsibilities; the existing patchwork of federal programs; and differences in regional conditions, risks, and available responses. In 2000, the National Drought Policy Commission provided recommendations to Congress to improve drought policy. Congress has acted on some of the recommendations (e.g., authorizing the National Integrated Drought Information System), but not others (e.g., creation of a National Drought Council and a fund to support drought planning). Given current conditions, Congress may review the functioning and adequacy of existing federal responses and programs (e.g., access to and level of assistance provided, incentives for mitigation of drought risk, and preparedness of federal facilities).

## Drought in the United States—Overview

The likelihood of extended periods of severe drought, similar to conditions experienced centuries ago, and its effects on 21<sup>st</sup>-century society in the United States raise several issues for Congress. These issues include how to respond to recurrent drought incidents, how to prepare for future drought, and how to coordinate federal agency actions. For example, drought often results in agricultural losses, which can have local, regional, and national effects. It also can affect other industries and services, including power and energy resource production, navigation, recreation, municipal water supplies, and natural resources such as fisheries, aquatic species, and water quality. How to address these impacts is an often recurring issue for Congress. Addressing drought on an emergency basis is costly to individuals, communities, and businesses. Additionally, millions and sometimes billions of dollars in federal assistance can be expended in response to drought's social consequences. Thus, another recurrent policy issue is how to prepare and mitigate future drought impacts and how to do so efficiently across the many federal agencies with various and sometimes overlapping drought responsibilities.

Drought has afflicted portions of North America for thousands of years. Severe, long-lasting droughts may have been a factor in the disintegration of Pueblo society in the Southwest during the 13<sup>th</sup> century, and in the demise of central and lower Mississippi Valley societies in the 14<sup>th</sup> through 16<sup>th</sup> centuries.<sup>1</sup> In the 20<sup>th</sup> century, droughts in the 1930s (Dust Bowl era) and 1950s were particularly severe and widespread. In 1934, 65% of the contiguous United States was affected by severe to extreme drought,<sup>2</sup> resulting in widespread economic disruption and displacement of populations from the U.S. heartland.

Drought conditions are broadly grouped into five categories: (1) abnormally dry, (2) moderate, (3) severe, (4) extreme, and (5) exceptional.<sup>3</sup> Some part of the country is almost always experiencing drought at some level. Since 2000, no less than 6.6% of the land area of the United States has experienced drought of at least moderate intensity each year.<sup>4</sup> The land area affected by drought of at least moderate intensity varies by year and also within a particular year. For example, since 2000, the total U.S. land area affected by drought of at least moderate intensity has varied from as little as 6.6% (July 6, 2010) to as much as 55% (September 25, 2012). Based on weekly estimates of the areal extent of drought conditions since 2000, the average amount of land area across the United States affected by at least moderate-intensity drought has been 26%.

While the previous percentages refer to the extent of drought nationally, there is particular concern about those locations experiencing the most intense drought conditions. Nearly every year, *extreme drought*<sup>5</sup> affects some portion of the country. Since 2000, extreme drought or drier

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<sup>1</sup> Edward R. Cook, et al., "North American drought: reconstructions, causes, and consequences," *Earth-Science Reviews*, vol. 81 (2007): pp. 93-134. Hereafter referred to as Cook et al., 2007.

<sup>2</sup> Donald A. Wilhite, et al., *Managing Drought: A Roadmap for Change in the United States* (Boulder, CO: The Geological Society of America, 2007), p. 12; at <http://www.geosociety.org/meetings/06drought/roadmap.pdf>.

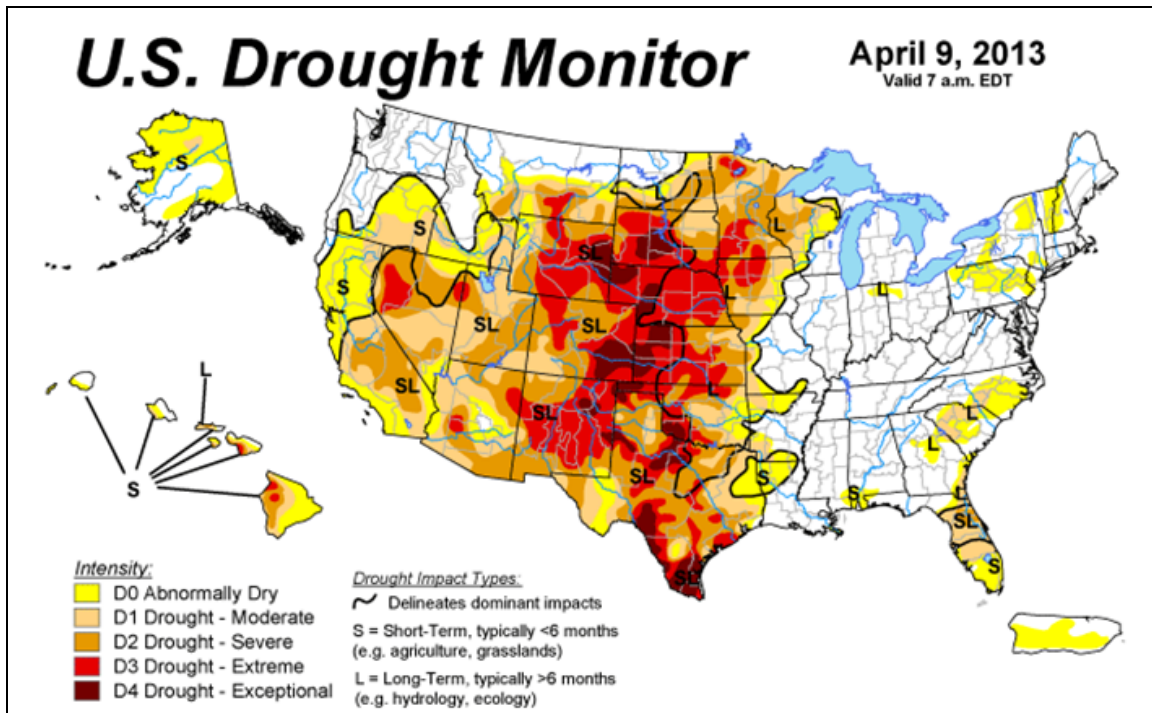
<sup>3</sup> These are the categories used by the National Drought Mitigation Center (NDMC). The NDMC helps prepare the U.S. Drought Monitor and maintains its website.

<sup>4</sup> NDMC data collected since 2000. U.S. Drought Monitor at the NDMC in Lincoln, NE. See [http://droughtmonitor.unl.edu/DM\\_tables.htm?archive](http://droughtmonitor.unl.edu/DM_tables.htm?archive).

<sup>5</sup> Extreme drought is the fourth of five categories indicating drought conditions, ranging from abnormally dry to exceptional drought, according to the National Drought Mitigation Center.

conditions have affected approximately 6.4% of the nation on average.<sup>6</sup> During August 2012, extreme drought extended over 20% of the country. Since 2000, *exceptional drought* conditions have affected approximately 1.4% of the nation on average. Of particular note were the conditions between June and October 2011; exceptional drought occurred over the largest land area—greater than 9%—during those months, with the affected areas concentrated in Texas. This year, 2013, is likely to be another exceptional year in terms of the breadth of drought conditions throughout the country, particularly in the Great Plains and eastern portions of the Midwest. The severe to exceptional drought conditions throughout the central and western parts of the United States appear to be persisting during spring 2013. (See Figure 1.)

Figure 1. Extent of Drought in the United States



**Source:** U.S. Drought Monitor, <http://droughtmonitor.unl.edu/monitor.html> for April 9, 2013.

**Notes:** The areas delineated on the map as “drought impact types” depict regions where reports of specific impacts (e.g., short term (S) or long term (L) impacts) have been reported and tallied. For more information, see <http://www.cpc.ncep.noaa.gov/products/predictions/tools/edb/droughtblends.php>.

## Drought in North America: Summer 2012 into 2013

In mid-August 2012, the extent of the drought conditions was significant: over 70% of the land area of the United States (including Alaska and Hawaii) was affected by abnormally dry and drought conditions.<sup>7</sup> The percentage of land area affected by abnormally dry or drought

<sup>6</sup> In some years or months, however, no part of the country was under extreme or exceptional drought. For example, from January 2000 through early April 2000, extreme or exceptional drought did not affect any portion of the country.

<sup>7</sup> For the contiguous United States, 80% of the land area was affected by abnormally dry or drought conditions. U.S. Drought Monitor, [http://droughtmonitor.unl.edu/DM\\_tables.htm?conus](http://droughtmonitor.unl.edu/DM_tables.htm?conus).

conditions stayed at or above 65% through February 2013, and remains above 60% as of mid-April, 2013. The intensity of the drought varied across the country, but the regions of extreme and exceptional drought were clustered across the Midwest, Great Plains, Southwest, and in the Southeast, particularly Georgia in 2012. The widespread nature of drought and excessive heat conditions in the Midwest and Great Plains in the summer of 2012 contributed to sharply lower yields for major crops, including corn and soybeans. For example, the average U.S. corn yield was 123.4 bushels per acre, down more than 40 bushels from expectations before the onset of drought. For all crops, crop insurance indemnities for 2012 losses totaled \$16 billion. In 2013, continuation of drought in the Great Plains and western parts of the Midwest is affecting prospects for wheat and other crops as well as pasture and forage conditions for livestock producers.

**Figure 2** shows that Texas and portions of Florida and Georgia experienced exceptional drought conditions (the worst category of drought) in early 2012, while the upper Midwest, including most of the Mississippi Valley experienced normal conditions. A year later, in early 2013, the drought had eased somewhat in portions of Georgia and Florida, but intensified throughout the center of the country from Texas to the Canadian border. Nearly 12% of the contiguous United States was in exceptional drought conditions from late June 2011 through October 2011, compared to approximately 6% of the country the following year.<sup>8</sup> However, exceptional drought conditions persisted over nearly 6% of the contiguous United States from mid-August 2012 through mid-February 2013. Although less severe for portions of the country, such as Texas and Florida, the 2012-2013 drought affected broader swaths of the agricultural heartland compared to 2011 (**Figure 2**). The 2012-2013 experience illustrates that the extent, timing, and particular features of areas affected by drought—dryland versus irrigated farm regions, or regions that are still recovering from previous droughts—are important in addition to the relative severity of drought conditions.

## Origin of the 2012-2013 Drought

**Figure 2** shows a snapshot of drought conditions for March in North America for 2010-2013. In 2010 most of North America and the United States were experiencing near-normal conditions. The extent and severity of the 2012-2013 drought raised questions regarding its origin, and whether the drought was consistent with the range of natural variability in the U.S. Midwest and Plains, or whether it was linked to longer-term changes in the Earth's climate system, such as human-induced global warming.

Although the images presented in **Figure 2** may seem to indicate a steady progression of drought in the middle portion of the country from near-normal conditions in 2010 to widespread and intense drought in 2012-2013, a March 2013 analysis concludes that the 2012 intense drought was a discrete extreme event.<sup>9</sup> The report states that “the event did not appear to be just a progression or a continuation of the prior year’s record drought event that developed in situ over the central U.S.”<sup>10</sup> Instead, the report asserted that the drought developed suddenly, with near normal precipitation during winter and spring 2012 over the Great Plains. The drought resulted

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<sup>8</sup> U.S. Drought Monitor, *Drought Monitor Archive Tables*, [http://droughtmonitor.unl.edu/dmtabs\\_archive.htm](http://droughtmonitor.unl.edu/dmtabs_archive.htm).

<sup>9</sup> Martin Hoerling et al., *An Interpretation of the Origins of the 2012 Central Great Plains Drought*, National Oceanic and Atmospheric Administration, Assessment Report: NOAA Drought Task Force Narrative Team, March 20, 2013, <ftp://ftp.oar.noaa.gov/CPO/pdf/mapp/reports/2012-Drought-Interpretation-final.web-041113.pdf>.

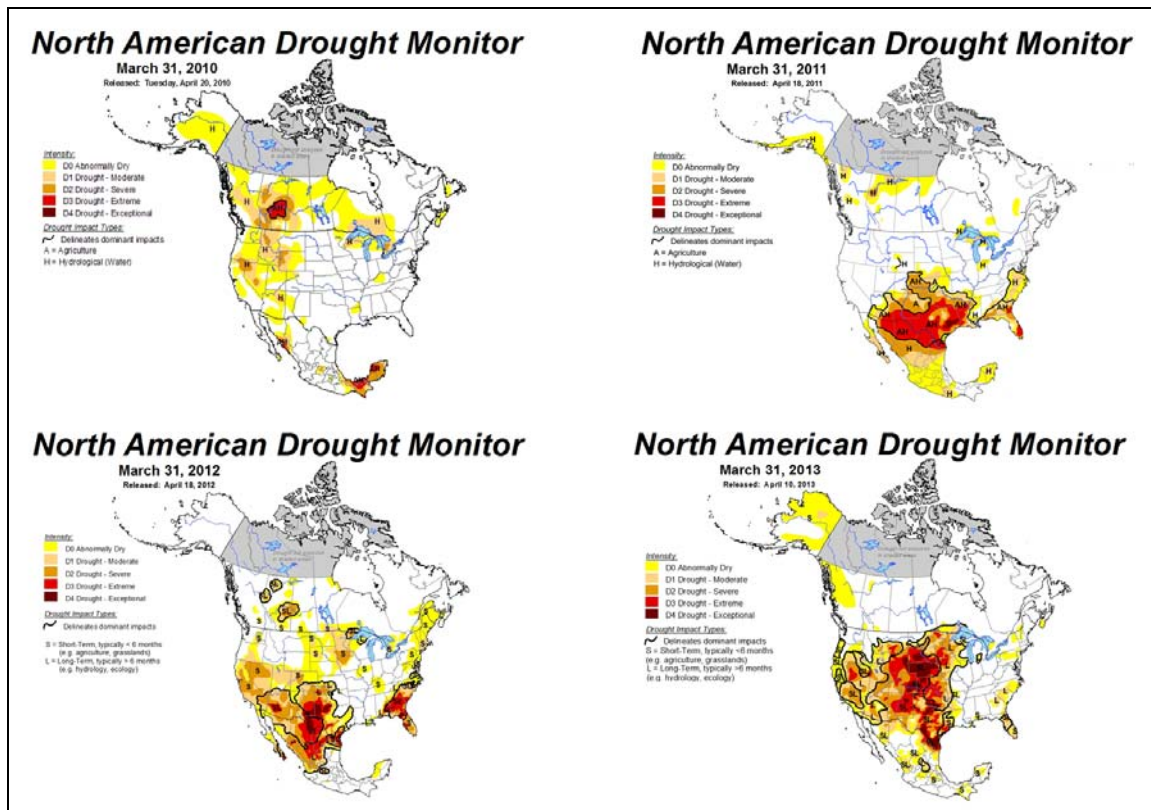
<sup>10</sup> *Ibid.*, p.1.



from an extreme lack of precipitation during the summer months: 2012 was the driest summer in the historical record for the region, experiencing even less rainfall than the years 1934 and 1936, when the central Great Plains were about 0.5° C warmer than 2012.<sup>11</sup> Essentially the rains abruptly stopped in May over the central Great Plains, and did not return for the summer.

The report further stated that the 2012 summer drought was a “climate surprise,” because summertime Great Plains rainfall has been trending upward since the early 20<sup>th</sup> century, and the last major drought occurred 25 years ago in 1988.<sup>12</sup> Further, the report concluded that neither sea surface temperatures, which have been rising generally due to global warming, nor changes in greenhouse gases in the atmosphere, were responsible for producing the anomalously dry conditions over the central Great Plains in 2012.<sup>13</sup> (A brief discussion of climate change and drought is below.)

**Figure 2. Drought Conditions in North America, Comparing March 2010, 2011, 2012, and 2013**



**Source:** North American Drought Monitor, <http://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/>.

**Notes:** These drought intensity classifications represent broad-scale conditions. Local conditions may vary. The drought intensity classifications are discussed in detail in the text. Drought conditions are not analyzed in the gray shaded areas of northern Canada. Regions in northern Canada outside of the gray shaded area may not be as accurate as other regions in North America due to limited information.

<sup>11</sup> Ibid., p. 4.

<sup>12</sup> Hoerling et al., 2013, p. 10.

<sup>13</sup> Ibid., p. 22.

## What Is Drought?

Drought has a number of definitions; the simplest may be a deficiency of precipitation over an extended period of time, usually a season or more.<sup>14</sup> Drought is usually considered relative to some long-term average condition, or balance, between precipitation, evaporation, and transpiration by plants (evaporation and transpiration are typically combined into one term: evapotranspiration).<sup>15</sup> An imbalance could result from a decrease in precipitation, an increase in evapotranspiration (from drier conditions, higher temperatures, higher winds), or both. It is important to distinguish between drought, which has a beginning and an end, and aridity, which is restricted to low rainfall regions and is a relatively permanent feature of an area's climate (e.g., deserts are regions of relatively permanent aridity).<sup>16</sup>

Higher demand for water for human activities and vegetation in areas of limited water supply increases the severity of drought. For example, drought during the growing season would likely be considered more severe—in terms of its impacts—than similar conditions when cropland lies fallow. For policy purposes, drought often becomes an issue when it results in a water supply deficiency: Less water is available than the average amount for irrigation, municipal and industrial supply (M&I), energy production, preservation of endangered species, and other needs. These impacts can occur through multiple mechanisms: decreased rainfall and soil moisture affecting dryland farming; low reservoir levels decreasing allocations for multiple purposes (including irrigation, navigation, energy production, recreation, fish and wildlife needs, and other water supplies); low stream flows limiting withdrawals for multiple purposes, including municipal and industrial supplies, among others; decreased exchange of water in lakes resulting in water quality problems limiting recreation (e.g., blue-green algae restrictions in multiple lakes in Oklahoma and Texas during 2011 and 2012 drought conditions). At the national level, drought is monitored and reported by the National Drought Mitigation Center in an index known as the U.S. Drought Monitor, which synthesizes various drought indices and impacts, and represents a consensus view of ongoing drought conditions between academic and federal scientists. Drought can also relate and contribute to other phenomena, such as fires and heat waves.<sup>17</sup>

## Drought Is Relative

Drought and “normal” conditions can vary considerably from region to region. For example, the U.S. Drought Monitor shows that the southern tip of Texas, including Corpus Christi, faced extreme to exceptional drought in early April 2013 (**Figure 1**). Similarly, the city of Albuquerque, New Mexico, was in extreme drought during the same time period. However, Corpus Christi receives on average a total of 5.19 inches of precipitation over the three-month period January through March.<sup>18</sup> In contrast, Albuquerque receives on average 1.54 inches of precipitation over

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<sup>14</sup> NDMC, <http://www.drought.unl.edu/DroughtBasics/WhatisDrought.aspx>.

<sup>15</sup> Evapotranspiration may be defined as the loss of water from a land area through transpiration from plants and evaporation from the soil and surface water bodies such as lakes, ponds, and manmade reservoirs.

<sup>16</sup> Permanently arid conditions reflect the *climate* of the region, which is the composite of the day-to-day weather over a longer period of time. Climatologists traditionally interpret climate as the 30-year average. See NDMC, <http://www.drought.unl.edu/DroughtBasics/WhatisClimatology.aspx>.

<sup>17</sup> For more on fire, see CRS Report RL30755, *Forest Fire/Wildfire Protection*, by (name redacted).

<sup>18</sup> NOAA, National Climatic Data Center, <http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmlprcp.html>.

the same period.<sup>19</sup> Both cities faced extreme drought in early April 2013, but what was normal for Corpus Christi was very different for what was normal for Albuquerque.

To deal with these differences, meteorologists use the term meteorological drought—usually defined as the degree of dryness relative to some average amount of dryness and relative to the duration of the dry period. Meteorological drought is region-specific because atmospheric conditions creating precipitation deficiencies vary from region to region, as described above for Corpus Christi and Albuquerque.

## **Drought Is Multifaceted**

In the past, U.S. Drought Monitor maps used an “A” to indicate that the primary physical effects are agricultural (crops, pastures, and grasslands) and an “H” to indicate that the primary impacts of drought are hydrological (to water supplies such as rivers, groundwater, and reservoirs). When both effects are apparent, the letters are combined, appearing as “AH.” In the newer versions of the maps, such as the one shown in **Figure 1**, the “A” and “H” are replaced with an “S” and “L.” These are experimental designations, according to the National Drought Mitigation Center, which produces the U.S. Drought Monitor maps.<sup>20</sup> The “S” designation is intended to indicate a combination of drought indices that reflect impacts that respond to precipitation over several days up to a few months (short-term effects). These would include impact to agriculture, topsoil moisture, unregulated streamflows, and aspects of wildfire danger. The “L” designation approximates responses to precipitation over several months up to a few years (long-term effects). These would include reservoir levels, groundwater, and lake levels. **Figure 1** shows that for early April the nation, predominantly the western half, was experiencing a combination of all three types, S, L, and SL.

The U.S. Drought Monitor maps also indicate the intensity of a drought, ranging from abnormally dry (shown as D0 on the maps) to exceptional drought (shown as D4). How these conditions are assessed and how drought is classified is discussed below.

## **Drought Classification**

To assess and classify the intensity and type of drought, certain measures, or drought indices, are typically used. Drought intensity, in turn, is the trigger for local, state, and federal responses that can lead to the flow of billions of dollars in relief to drought-stricken regions.<sup>21</sup> The classification of drought intensity, such as that shown in **Figure 1** for April 9, 2013, may depend on a single indicator or several indicators, often combined with expert opinion from the academic, public, and private sectors. The U.S. Drought Monitor uses five key indicators,<sup>22</sup> together with expert

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<sup>19</sup> Ibid.

<sup>20</sup> The complete designations are referred to as experimental objective blends of drought indicators, <http://www.cpc.ncep.noaa.gov/products/predictions/tools/edb/droughtblends.php>.

<sup>21</sup> For example, the Palmer Drought Index has been widely used by the U.S. Department of Agriculture to determine when to grant emergency drought assistance. See NDMC, <http://drought.unl.edu/Planning/Monitoring/ComparisonofIndicesIntro/PDSI.aspx>.

<sup>22</sup> The five key indicators include the Palmer Drought Index, the Climate Prediction Center soil moisture model, U.S. Geological Survey weekly streamflow data, the Standardized Precipitation Index, and short- and long-term drought indicator blends. For a discussion of drought indices, see NDMC, <http://droughtmonitor.unl.edu/current.html>.

opinion, with indices to account for conditions in the West where snowpack is relatively important, and with other indices used mainly during the growing season.<sup>23</sup> The U.S. Drought Monitor intensity scheme—D0 to D4—is used to depict broad-scale conditions but not necessarily drought circumstances at the local scale. For example, the large regions depicted as red in **Figure 1** faced extreme to exceptional drought conditions for the week of April 9, 2013, but they may contain local areas and individual communities that experienced less (or more) severe drought.<sup>24</sup>

## Recent Examples: Texas, California, and Colorado River Basin

### Drought in Texas, 2011-2013

In early April 2011, over 80% of Texas was experiencing severe to extreme drought, and nearly 10% of the state was in exceptional drought, the most severe level of drought intensity published by the National Drought Mitigation Center.<sup>25</sup> The 2011 drought in Texas represented a dramatic shift compared to the same time period in 2010, when approximately 4% of the total land area in Texas was experiencing drought conditions, with no exceptional drought conditions anywhere in the state. (See **Figure 3**, comparing 2010, 2011, 2012, and 2013.)

#### **Drought and Electricity: Texas and the Pacific Northwest at Particular Risk**

A December 2011 assessment of the drought vulnerability of electricity in the western United States revealed two regions whose electric generation was at risk—the Pacific Northwest and Texas. The Pacific Northwest was shown to be vulnerable because of its heavy reliance on hydroelectric power generation.

In the summer of 2011, high heat in Texas resulted in increased demand for electricity, and power plants were operated for extended periods at maximum capacity. The operator of the grid that covers 75% of the state and 23 million people put into effect its emergency action alert system, which at first recommended conservation by customers but eventually deemed customer conservation critical to avoid rotating outages (rolling blackouts). In the end, only one plant on the Texas grid had curtailed generation due to water constraints; others were nearing curtailment when the weather conditions improved. The Texas grid was vulnerable because of heavy dependence on thermoelectric generation that relied on surface water for cooling and the region's high drought climate hazard.

**Source:** C.B. Harto et al., *Analysis of Drought Impacts on Electricity Production in the Western and Texas Interconnections of the United States*, Argonne National Laboratory, Oak Ridge, TN, December 2011, <http://energy.sandia.gov/wp/wp-content/gallery/uploads/Drought-Analysis-Report-Final.pdf>.

Drought conditions worsened in Texas through the beginning of October 2011, when 88% of the state experienced exceptional drought conditions (and only 3% of the state was not classified as extreme or exceptional drought).<sup>26</sup> Drought conditions generally improved throughout the rest of 2011, but large portions of the state were still affected by extreme or exceptional drought until

<sup>23</sup> U.S. Drought Monitor, <http://www.drought.unl.edu/dm/classify.htm>.

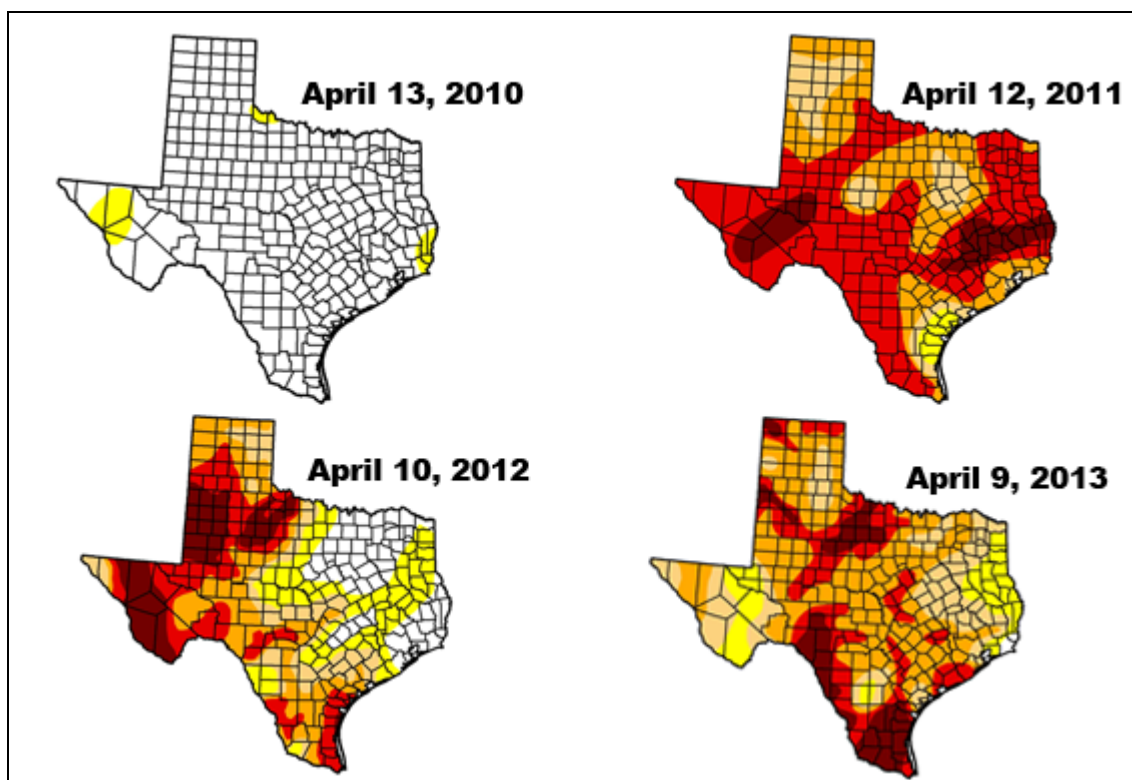
<sup>24</sup> The “S” and “L” terms in **Figure 1** give information on the nature of the drought in the affected region. For more information on the reasoning behind the classification schemes, see <http://droughtmonitor.unl.edu/classify.htm>.

<sup>25</sup> U.S. Drought Monitor, [http://droughtmonitor.unl.edu/DM\\_tables.htm?TX](http://droughtmonitor.unl.edu/DM_tables.htm?TX).

<sup>26</sup> See the U.S. Drought Monitor, Texas, on October 4, 2011, <http://droughtmonitor.unl.edu/archive.html>.

late winter and early spring of 2012, when the eastern portion of the state recovered to normal or abnormally dry conditions (the least severe category) because of above-normal rainfall from December 2011 through February 2012.<sup>27</sup>

**Figure 3. Comparison of Drought Conditions in Texas in 2010, 2011, 2012, and 2013**



**Source:** U.S. Drought Monitor, <http://droughtmonitor.unl.edu/>, Modified by CRS.

**Notes:** See **Figure 1** for explanation of colors shown on maps.

In April 2012 the drought in Texas had eased somewhat; slightly more than 50% of the state was experiencing severe drought or worse, down from 80% a year before. Conditions in April 2013 have worsened compared to a year earlier, however; approximately 70% of the state was experiencing at least severe drought in April 2013, and extreme and exceptional drought were 30% and 12%, respectively.<sup>28</sup> (See **Figure 3.**)

According to Texas state climatologist John Nielsen-Gammon, 2011 may have been the worst one-year drought on record for Texas.<sup>29</sup> Compounding the effects of abnormally low precipitation, the June-August average temperature in Texas was approximately 2.5 degrees Fahrenheit greater than any previous Texas summer since 1895 and 5 degrees Fahrenheit (F)

<sup>27</sup> “Climate Abyss: Weather and Climate Issues with John Nielsen-Gammon,” *Texas Drought Update*, March 23, 2012, <http://blog.chron.com/climateabyss/2012/03/texas-drought-update/>.

<sup>28</sup> U.S. Drought Monitor, Drought Condition (Percent Area): Texas, [http://droughtmonitor.unl.edu/DM\\_tables.htm?TX](http://droughtmonitor.unl.edu/DM_tables.htm?TX).

<sup>29</sup> Office of the Texas State Climatologist, “Texas Drought Officially the Worst Ever,” August 4, 2011, <http://tamunews.tamu.edu/2011/08/04/texas-drought-officially-the-worst-ever/>.

greater than the long-term average.<sup>30</sup> The 2011 U.S. Drought Monitor showed that Texas had been experiencing both hydrological and agricultural drought, indicating that the drought had caused deficiencies in water supplies as well as deficiencies of water to crops, plants, and grasses.<sup>31</sup>

### **Drought Conditions Affecting the Rio Grande Project in 2011 and 2012**

The 2011-2013 drought conditions in Texas and the Southwest have affected the amount of water in the Rio Grande river, which flows south from Colorado through New Mexico to form the U.S. border between Texas and northern Mexico. The U.S. Bureau of Reclamation's Rio Grande Project, which furnishes irrigation water for approximately 178,000 acres in New Mexico and Texas, as well as electric power, includes the Elephant Butte dam and reservoir and the Caballo dam and reservoir. Both dams and reservoirs are in New Mexico, and about 60% of the lands receiving irrigation water are in New Mexico. Elephant Butte dam and reservoir provide year-round electric power generation and water during the irrigation season. Water released from Elephant Butte during winter power generation is stored downstream in the Caballo reservoir for irrigation use during the summer. About 40% of the lands receiving water from the project are in Texas, and water is also provided per a treaty with Mexico to irrigate about 25,000 acres in the Juarez Valley. The timing of the water releases in 2012 for delivery to Mexico and their potential impacts on U.S. regional interests (e.g., potential conveyance losses because releases for Mexico would not be timed with deliveries to U.S. water districts) raised concerns among some U.S. stakeholders about how scarce regional water resources are to be managed during dry conditions. Mexican growers sought the surface water deliveries because pumping problems had impaired their ability to start the agricultural season using groundwater.

Inflow to Elephant Butte reservoir in 2011 was less than 15% of the 30-year average for March through July and is expected to be 39% for 2013; however, due to low runoff averages since 2008, reservoir storage is extremely low. For example, combined Elephant Butte and Caballo reservoir storage is 189,342 acre-feet—8.5% of combined capacity. The 2011-2013 drought conditions have exacerbated low flows into the reservoir; flows into the reservoir have exceeded average runoff values only three times in the past 15 years (1997, 2005, and 2008). Further, more than half the current available storage is "credit water" owned by upstream users and therefore not available for downstream use. Thus, only 4% of the current combined storage capacity will be available for downstream use. In 2011, water deliveries from the Rio Grande Project to the irrigation district in Texas (El Paso County Water Improvement District No. 1) as well as to the city of El Paso were stopped a month earlier than normal and the New Mexico portion of the project, operated by the Elephant Butte Irrigation District, stopped taking surface water deliveries in mid-July 2011. Most of these farmers turned to groundwater withdrawals to offset lost surface water supplies. Rio Grande Project water users were receiving a 20% allocation of water supplies as of April 1, 2012, and ended the year with a 38.7% allocation for the year. However, the preliminary allocation for 2013 is 4.2% as of March 31, 2013.

The dry conditions in the basin along with efforts to try to restore the populations of the endangered silvery minnow in some New Mexico reaches of the Rio Grande have focused attention not only on Bureau of Reclamation facilities and efforts in the basin, but also on whether a more comprehensive recovery implementation plan for the species might augment storage at other facilities to increase the flexibility of releases to the river. The Army Corps of Engineers also operates federal projects in the basin that currently are principally operated for flood control.

**Sources:** U.S. Bureau of Reclamation, Rio Grande Project, [http://www.usbr.gov/projects/Project.jsp?proj\\_Name=Rio+Grande+Project](http://www.usbr.gov/projects/Project.jsp?proj_Name=Rio+Grande+Project); Texas Agrilife Research Center at El Paso, "Drought Watch on the Rio Grande," September 2, 2011, May 1, 2012, and February 8, 2013; email from Dionne Thompson, Chief, Congressional and Legislative Affairs, U.S. Bureau of Reclamation, September 15, 2011; personal communication with Filiberto Cortez, Division Manager, El Paso Field Office, U.S. Bureau of Reclamation, May 2, 2012, and April 18, 2013; letter from Patrick R. Gordon, Texas Commissioner, Rio Grande Compact Commission, to Edward Drusina, Commissioner, United States Section, International Boundary and Water Commission, April 9, 2012; Texas Agrilife Research Center "Drought Watch, February 2013.

<sup>30</sup> John W. Nielsen-Gammon, *The 2011 Texas Drought: A Briefing Packet for the Texas Legislature*, October 31, 2011, p. 29, [http://climatexas.tamu.edu/files/2011\\_drought.pdf](http://climatexas.tamu.edu/files/2011_drought.pdf).

<sup>31</sup> Office of the Texas State Climatologist, "Texas Drought Officially the Worst Ever," August 4, 2011, <http://tamunews.tamu.edu/2011/08/04/texas-drought-officially-the-worst-ever/>.

The most severe Texas drought overall occurred from 1950 to 1957, and had substantial impacts on water supplies across the state because it lasted over many years. Because of the longevity and severity of the 1950s drought, municipal water supplies in Texas today are designed to withstand a drought of similar magnitude, according to the state climatologist. Long-term precipitation patterns in Texas are influenced by a configuration of sea surface temperatures known as the Pacific Decadal Oscillation (PDO). Similar conditions also prevailed from the 1940s through the 1960s, encompassing the Texas drought of record (1950-1957).

## **The 2007-2009 California Drought and Outlook for 2013**

The 2007-2009 California drought<sup>32</sup> was complicated by decades of tension over water supply deliveries for irrigation and M&I uses, and the preservation of water flows to protect threatened and endangered species. Dry conditions that began in 2007 continued through the 2009 water year (October 2008 through September 2009) and into the fall of 2009. According to the California Department of Water Resources, the 2007-2009 drought was the 12<sup>th</sup>-driest three-year period in California history since measurements began.<sup>33</sup> Although hydrological conditions were classified as below normal in 2010 and “wet” (well above average) in 2011, the 2012 water year was classified as “below normal” for the Sacramento River basin and “dry” for the San Joaquin River basin.<sup>34</sup> Above-average reservoir storage at the end of 2011 mitigated reductions to water users. Although the drought was declared over<sup>35</sup> in spring 2011, by August 2012, the U.S. drought monitor again showed increasing severity of drought in the eastern portion of the state. Water deliveries to state and federal water project contractors were restricted again in 2012.<sup>36</sup>

California’s dry conditions from 2007 through 2009 exacerbated an already tight water supply, where federal and state water deliveries had been reduced in response to a court order to prevent extinction of the Delta smelt.<sup>37</sup> Similar factors are still in play today. Water deliveries from state and federal water projects for 2013 are restricted due to legal actions to protect threatened and endangered species, water quality requirements, and hydrological factors. Some federal agricultural water supply contractors are projected to receive just 20% of contract water supplies from the Bureau of Reclamation’s Central Valley Project as of April 5, 2013, while some municipal and industrial contractors are scheduled to receive 70% of contract supplies.<sup>38</sup> The April 9, 2013, drought monitor shows abnormally dry to severe drought conditions in almost every corner of the state. (For more information on project water deliveries, see CRS Report R40979, *California Drought: Hydrological and Regulatory Water Supply Issues*, by (name redacted), (name redacted), and Cynthia Brougher.)

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<sup>32</sup> For more information about the hydrology and policy issues involved in the 2007-2009 California drought, see CRS Report R40979, *California Drought: Hydrological and Regulatory Water Supply Issues*, by (name redacted), (name redacted), and Cynthia Brougher.

<sup>33</sup> California Department of Water Resources, *California’s Drought of 2007-2009—An Overview*, September 2010, <http://www.water.ca.gov/waterconditions/drought/docs/DroughtReport2010.pdf>.

<sup>34</sup> <http://cdec.water.ca.gov/cgi-progs/iudir/WSIHIST>.

<sup>35</sup> Office of Governor Edmund G. Brown, Jr., “A Proclamation by the Governor of the State of California—Drought,” <http://gov.ca.gov/news.php?id=16997>.

<sup>36</sup> For information on current water supply conditions and historical water allocations to federal water contractors in California, see <http://www.usbr.gov/mp/PA/water/>.

<sup>37</sup> The Delta smelt is a species of fish listed as threatened under the federal Endangered Species Act and as endangered under the California Endangered Species Act. *Natural Resources Defense Council v. Kempthorne*, No. 1:05-cv-1207 OWW GSA (E.D. Cal., December 14, 2007).

<sup>38</sup> See [http://www.usbr.gov/mp/cvo/vungvari/water\\_allocations\\_historical.pdf](http://www.usbr.gov/mp/cvo/vungvari/water_allocations_historical.pdf).

## Conditions in the Colorado River Basin

Spanning parts of Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming, the Colorado River basin is a critical water supply for the West and portions of northwestern Mexico. Based on inflows observed over the last century, the river is over-allocated, and some contend that supply and demand imbalances are likely to increase in the future.<sup>39</sup> The March 2013 forecast is for flows below average for 2013, as has been the case for 10 of the last 13 years. The 2013 forecast for Lake Powell, the basin's largest reservoir, was for half of its normal inflow as the result of below average snowpack; that is, the inflow is anticipated at 5.3 million acre-feet. As called for in the water compact and interim guidelines that prescribe water sharing in the basin, the Bureau of Reclamation will most likely release from Lake Powell 8.2 million acre-feet from the reservoir for downstream purposes, thus resulting in a net drop in the lake level by the end of the water year. The dry conditions in 2013 are following the dry conditions of 2012. If forecasted conditions transpire, the basin will have storage levels in September 2013 near the historic lows of 2005. Reclamation predicts that Lake Powell storage levels will be 44% of capacity—10.78 million acre-feet—at that time.<sup>40</sup>

Drought in part of the basin, particularly the upper basin, which is the source of most of the river's flow, exacerbates tensions over the sharing of the resource and results in difficult tradeoffs among the multiple uses of water (e.g., municipal, agricultural, hydropower, energy, recreation, and ecosystem and species demands). How water resources are allocated among these uses within a state is largely determined by state water law, compliance with federal and state laws (including interstate compacts, and environmental and resource management laws and regulations), and court decisions. In the case of the Colorado River, apportionment of water supplies among the seven basin states is done in accordance with the Colorado River Compact and a body of law known as the "Law of the River."<sup>41</sup>

Low water availability in the Colorado River basin has effects beyond the basin boundaries. For example, Colorado River water is transported from Colorado's Western Slope to the state's Front Range; this water represents a significant contribution to the water available for agricultural and municipal uses in many eastern Colorado counties. Similarly, much of the lower basin allocation (4.4 million acre-feet) is diverted to southern California under the Colorado River Compact.

## What Causes Drought in the United States?

The immediate cause of drought is:

the predominant sinking motion of air (subsidence) that results in compressional warming or high pressure, which inhibits cloud formation and results in lower relative humidity and less precipitation. Regions under the influence of semi permanent high pressure during all or a major portion of the year are usually deserts, such as the Sahara and Kalahari deserts of Africa and the Gobi Desert of Asia.<sup>42</sup>

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<sup>39</sup> U.S. Department of the Interior, Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study*, December, 2012, p. SR-3.

<sup>40</sup> See description at <http://www.usbr.gov/uc/water/crsp/cs/gcd.html>. (Accessed April 17, 2013.)

<sup>41</sup> For more information on the Law of the River, see <http://www.usbr.gov/lc/region/g1000/lawofrvr.html>.

<sup>42</sup> See NDMC, at <http://drought.unl.edu/DroughtBasics/PredictingDrought.aspx>.



Prolonged droughts occur when these atmospheric conditions persist for months or years over a certain region that typically does not experience such conditions for a prolonged period.<sup>43</sup>

Predicting drought is difficult because the ability to forecast surface temperature and precipitation depends on a number of key variables, such as air-sea interactions, topography, soil moisture, land surface processes, and other weather system dynamics.<sup>44</sup> Scientists seek to understand how all these variables interact and to further the ability to predict sustained and severe droughts beyond a season or two in advance, which is the limit of drought forecasting abilities today.

In the tropics, a major portion of the atmospheric variability over months or years seems to be associated with variations in sea surface temperatures (SSTs). Since the mid- to late 1990s, scientists have increasingly linked drought in the United States to SSTs in the tropical Pacific Ocean. Cooler than average SSTs in the eastern tropical Pacific region—“la Niña-like” conditions—have been shown to be correlated with persistently strong drought conditions over parts of the country, particularly the West.<sup>45</sup> A number of studies have made the connection between cooler SSTs in the eastern Pacific and the 1998-2004 western drought,<sup>46</sup> three widespread and persistent droughts of the late 19<sup>th</sup> century,<sup>47</sup> and past North American “megadroughts” that occurred between approximately 900 and 1300 A.D.<sup>48</sup> The precolonial megadroughts apparently lasted longer and were more extreme than any U.S. droughts since 1850, when instrumental records began. Some modeling studies suggest that within a few decades the western United States may again face higher base levels of dryness, or aridity, akin to the 900-1300 A.D. period.<sup>49</sup>

Although the relationship between cooler than normal eastern tropical Pacific SSTs (La Niña-like conditions) and drought is becoming more firmly established, meteorological drought is probably never the result of a single cause. Climate is inherently variable, and accurately predicting drought for one region in the United States for more than a few months or seasons in advance is not yet possible because so many factors influence regional drought. What is emerging from the scientific study of drought is an improved understanding of global linkages—called teleconnections by scientists—between interacting weather systems, such as the El Niño-Southern Oscillation, or ENSO. (See box for a description of ENSO.) For example, some scientists link La Niña conditions between 1998 and 2002 with the occurrence of near-simultaneous drought in the southern United States, Southern Europe, and Southwest Asia.<sup>50</sup>

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<sup>43</sup> Ibid.

<sup>44</sup> Ibid.

<sup>45</sup> Cook et al., 2007.

<sup>46</sup> Hoerling, Martin and Arun Kumar, “The perfect ocean for drought,” *Science*, vol. 299 (January 31, 2003), pp. 691-694. Hereafter referred to as Hoerling and Kumar, 2003.

<sup>47</sup> Herweiger, Celine, Richard Seager, and Edward Cook, “North American droughts of the mid to late nineteenth century: a history, simulation and implication for Mediaeval drought,” *The Holocene*, vol. 15, no. 2 (January 31, 2006), pp. 159-171. Hereafter referred to as Herweiger et al., 2006.

<sup>48</sup> Cook et al., 2007.

<sup>49</sup> Richard Seager et al., “Model projections of an imminent transition to a more arid climate in southwestern North America,” *Science*, vol. 316 (May 25, 2007): pp. 1181-1184.

<sup>50</sup> Hoerling and Kumar, 2003.

### **El Niño-Southern Oscillation (ENSO)**

Under normal conditions, the trade winds blow toward the west in the tropical Pacific Ocean, piling up the warm surface waters so that the ocean surface off Indonesia is one-half meter higher than the ocean off Ecuador. As a result, deep and cold water flows up to the surface (upwelling) off the west coast of South America. The upwelling waters are 8 degrees Celsius (14.4 degrees Fahrenheit) cooler than waters in the western Pacific. During El Niño, the trade winds relax, upwelling off South America weakens, and sea surface temperatures rise. The El Niño events occur irregularly at intervals of 2-7 years, and typically last 12-18 months. These events often occur with changes in the Southern Oscillation, a see-saw of atmospheric pressure measured at sea level between the western Pacific and Indian Ocean, and the eastern Pacific. Under normal conditions, atmospheric pressure at sea level is high in the eastern Pacific, and low in the western Pacific and Indian Oceans. As implied by its name, the atmospheric pressure oscillates, or see-saws, between east and west; and during El Niño the atmospheric pressure builds up to abnormally high levels in the western tropical Pacific and Indian Oceans—the El Niño-Southern Oscillation, or ENSO. During a La Niña, the situation is reversed: Abnormally high pressure builds up over the eastern Pacific, the trade winds are abnormally strong, and cooler-than-normal sea surface temperatures occur off tropical South America. Scientists use the terms ENSO or ENSO cycle to include the full range of variability observed, including both El Niño and La Niña events.

**Source:** Tropical Ocean Atmosphere Project, Pacific Marine Environmental Laboratory, at [http://www.pmel.noaa.gov/tao/proj\\_over/ensodefs.html](http://www.pmel.noaa.gov/tao/proj_over/ensodefs.html).

## **Prehistorical and Historical Droughts in the United States**

Some scientists refer to severe drought as “the greatest recurring natural disaster to strike North America.”<sup>51</sup> That claim stems from a reconstruction of drought conditions that extends back over 1,000 years, based on observations, historical and instrumental records where available, and on tree-ring records or other proxies in the absence of direct measurements.<sup>52</sup> What these reconstructions illustrate is that the coterminous United States has experienced periods of severe and long-lasting drought in the western states and also in the more humid East and Mississippi Valley. The drought reconstructions from tree rings document that severe multidecadal drought occurred in the American Southwest during the 13<sup>th</sup> century, which anthropologists and archeologists suspect profoundly affected Pueblo society. Tree ring drought reconstructions also document severe drought during the 14<sup>th</sup>, 15<sup>th</sup>, and 16<sup>th</sup> centuries in the central and lower Mississippi Valley, possibly contributing to the disintegration of societies in that region.<sup>53</sup>

More recently, a combination of tree ring reconstructions and other proxy data, historical accounts, and some early instrumental records identify three periods of severe drought in the 19<sup>th</sup> century: 1856-1865 (the “Civil War drought”), 1870-1877, and 1890-1896.<sup>54</sup> The 1856-1865 drought, centered on the Great Plains and Southwest, was the most severe drought to strike the region over the last two centuries, according to one study.<sup>55</sup> The 1890-1896 drought coincided with a period in U.S. history of federal encouragement of large-scale efforts to irrigate the relatively arid western states under authority of the Carey Act.<sup>56</sup> Congressional debate also

<sup>51</sup> Cook et al., 2007.

<sup>52</sup> Proxies are indirect measurements typically used where direct measurements are unavailable. Tree rings can be used as a proxy for measuring dryness and drought. Similarly, ice cores from glaciers and polar caps can be used as proxies for measuring atmospheric temperatures and carbon dioxide concentrations from thousands of years ago.

<sup>53</sup> Cook et al., 2007.

<sup>54</sup> Herweiger et al., 2006.

<sup>55</sup> Ibid.

<sup>56</sup> The Carey Act, signed into law on August 18, 1894 (Chapter 301, Section 4, 28 Stat. 422), initially made available up to 1 million acres of federal land in each state, provided that the state met several requirements for the eventual (continued...)

occurred over a much larger federal role in western states irrigation, which led to the Reclamation Act of 1902.

In the 20<sup>th</sup> century, the 1930s “Dust Bowl” drought and the 1950s Southwest drought are commonly cited as the two most severe multiyear droughts in the United States.<sup>57</sup> (The 1987-1989 drought was also widespread and severe, mainly affecting the Great Plains but also instigating extensive western forest fires, including the widespread Yellowstone fire of 1988.) According to several studies, however, the 19<sup>th</sup> and 20<sup>th</sup> century severe droughts occurred during a regime of relatively less arid conditions compared to the average aridity in the American West during the 900 to 1300 A.D. megadroughts. One study indicates that the drought record from 900 to 1300 A.D. shows similar variability—drought periods followed by wetter periods—compared to today, but the average climate conditions were much drier and led to more severe droughts.<sup>58</sup>

## Drought and Climate Change

The relationship between climate change and future trends in droughts is complex and its scientific understanding appears to be evolving. In 2007 the Intergovernmental Panel on Climate Change (IPCC) released its Fourth Assessment Report, which stated that, globally, very dry areas have more than doubled since the 1970s due to a combination of El Niño-Southern Oscillation (ENSO)<sup>59</sup> events and global surface warming.<sup>60</sup> The IPCC report added that very wet areas declined by about 5% globally. The report asserted that documented trends in severe droughts and heavy rains show that hydrological conditions are becoming more intense in some regions.

In 2012, however, the IPCC issued a new report that noted: “There are still large uncertainties regarding observed global-scale trends in droughts.”<sup>61</sup> The new report noted that its earlier assessment, that very dry areas have more than doubled since the 1970s, was based largely on only one study, which relied on a measurement largely related to temperature, not moisture. A different study, which looked at soil moisture simulations, found that trends in drought duration, intensity, and severity predominantly were *decreasing*, not increasing, but with strong regional variation.<sup>62</sup>

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(...continued)

development of water resources for reclamation. Some observers have suggested that the failure of the Carey Act to foster irrigation projects in all the land made available, compounded in part by the 1890-1896 drought, led to the Reclamation Act of 1902 and the emergence of the Bureau of Reclamation in the 20<sup>th</sup> century. (See Marc Reisner, *Cadillac Desert* (New York, New York, Penguin Books, 1986)).

<sup>57</sup> Fye, F., D.W. Stahle, and E.R. Cook, “Paleoclimate analogs to twentieth century moisture regimes across the United States,” *Bulletin of the American Meteorological Society*, 2003, vol. 84, pp. 901-909.

<sup>58</sup> For example, one report showed that 42% of the area studied in the American West was affected by drought during the years 900 to 1300, versus 30% between 1900 and 2003, a 29% reduction in the average area affected by drought between the two periods. See Cook et al., 2007.

<sup>59</sup> A discussion of ENSO is provided elsewhere in this report.

<sup>60</sup> S. D. Solomon et al., “Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,” 2007, Cambridge University Press, Cambridge, United Kingdom and New York, NY.

<sup>61</sup> C. B. Field et al., IPCC, “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation,” 2012, Cambridge University Press, Cambridge, United Kingdom and New York, NY, p. 170.

<sup>62</sup> C.B. Field et al., IPCC, 2012, p. 170.

The 2012 IPCC report assigned medium confidence<sup>63</sup> that there has been an overall slight tendency toward *less* dryness in North America (i.e., a wetting trend with increasing soil moisture and runoff). It noted that the most severe droughts in the 20<sup>th</sup> century occurred in the 1930s and 1950s, where the 1930s drought was the most intense and the 1950s drought was the most persistent. In comparison to the severe megadroughts that occurred in North America hundreds and thousands of years ago, as documented using paleoclimate evidence (discussed elsewhere in this report), these recent droughts were not unprecedented, according to the 2012 IPCC report.

The report concluded that despite new studies that have furthered the understanding of mechanisms leading to drought, there is still limited evidence to attribute observed changes. The IPCC assessed that there was medium confidence that anthropogenic influence has contributed to changes in drought patterns in the second half of the 20<sup>th</sup> century, but gave low confidence to the attribution of changes in drought patterns at the regional level.<sup>64</sup> The report noted that some regions of the world have experienced trends towards more intense and longer droughts, such as southern Europe and West Africa. But in other regions, such as central North America and northwestern Australia, droughts have become less frequent, less intense, or shorter. How the 2011-2012 drought in the central United States may change that assessment in the forthcoming IPCC report (2014) remains to be seen.

Further adding to the complexity and challenge to the scientific understanding of what causes drought was work presented at the European Geosciences Union meeting in April 2013 that attempted to simulate megadroughts that occurred in the past.<sup>65</sup> The simulations produced a number of megadroughts that lasted for decades; however, they did not match the timing of the past documented megadroughts. The scientists presenting their work at the meeting concluded that the model they used seemed to miss some of the dynamics that drive large droughts.

## **Responding to and Planning for Drought**

Several recent droughts triggered federal responses. When a drought is declared for a locality or region by the U.S. President, U.S. Secretary of Agriculture, or a state governor, it sets in motion a series of alerts, recommendations, activities, and possible restrictions at the local, regional, or state level, depending on the drought length and severity. Ultimately, a drought could initiate a federal response and transfer of federal dollars to the affected area.

Before drought severity reaches a level triggering a federal response, many states take action. The National Drought Mitigation Center posts online copies of drought management, mitigation, or response plans for states and localities, nationwide.<sup>66</sup> The California and Texas governors also have in recent years issued state drought emergency declarations triggering state drought assistance. Some states have also instituted water banks and water transfer mechanisms to deal with water supply shortages (e.g., California, Idaho, and Texas).

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<sup>63</sup> According to the report, confidence in the validity of a finding is based on the type, amount, quality, and consistency of evidence and on the degree of agreement. Confidence is expressed qualitatively: low, medium, high.

<sup>64</sup> C.B. Field et al., IPCC, 2012, p. 172.

<sup>65</sup> Quirin Schiermeier, "Climate Models Fail to 'Predict' US Droughts," *Nature*, vol. 496, no. 7445 (April 16, 2013), <http://www.nature.com/news/climate-models-fail-to-predict-us-droughts-1.12810>.

<sup>66</sup> For more information, see <http://drought.unl.edu/Planning/PlanningInfobyState.aspx>.

## Federal Aid

When a state's resources are lacking, a state governor may request drought disaster assistance through the U.S. Secretary of Agriculture, who can declare an agricultural disaster due to drought and make available low-interest loans for qualified farmers and ranchers and other emergency assistance. However, under a new Farm Services Agency (FSA) streamlined process, any portion of a county experiencing severe drought according to the U.S. Drought Monitor for eight consecutive weeks can receive a "nearly" automatic USDA disaster declaration.<sup>67</sup> Further, any county for which a portion is identified in the U.S. Drought Monitor as undergoing severe drought (or worse) may also be declared a disaster area.

As of August 13, 2012, more than 1,400 U.S. counties in 33 states had been designated as drought disaster areas by the Secretary.<sup>68</sup> As of April 17, 2013, more than 1,180 counties had been designated as drought disaster areas for the 2013 crop loss purposes (primary and contiguous county designations).<sup>69</sup> For more on emergency assistance, see the box "USDA Emergency Assistance: Status and Legislation."

In addition, if the effects of a drought overwhelm state or local resources, the President, at the request of the state governor, is authorized under the Stafford Act (42 U.S.C. 5121 et seq.) to issue major disaster or emergency declarations resulting in federal aid to affected parties.<sup>70</sup> However, the last presidential drought or water shortage disaster declaration in the continental United States was for New Jersey in 1980. More recent drought declarations have been issued for U.S. territories in the Pacific. The infrequency of presidential domestic drought declarations increases the uncertainty about the circumstances under which such a declaration is likely to be made. The de facto policy since the 1980s has been that the U.S. Secretary of Agriculture is the lead in responding and declaring drought and eligibility for drought assistance.

Although agricultural losses typically dominate drought impacts, congressional interest in federal drought assistance is not limited to the USDA. For example, the 2012 drought raised interest in whether and to what extent other federal agencies have and are using authorities to assist with managing drought. For example, in addition to operations of federal water resource facilities (discussed below), the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation also have limited emergency drought authorities and funding; the drought response and recovery authorities for the Corps, Reclamation, and the Farm Service Agency are provided in **Appendix A**. While the Corps and Reclamation authorities have experienced some use, the frequency, impact, and coordination of their use with other federal and state drought efforts have not been monitored and assessed. Most of the Corps drought response and recovery authorities are limited to providing limited and temporary water from its reservoirs for a fee. The exception is its

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<sup>67</sup>[http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=pfs&newstype=prfactsheet&type=detail&item=pf\\_20120720\\_insup\\_en\\_ed\\_desigp.html](http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=pfs&newstype=prfactsheet&type=detail&item=pf_20120720_insup_en_ed_desigp.html)

<sup>68</sup>[http://usda.gov/wps/portal/usda/usdahome?contentid=2012/08/0271.xml&navid=NEWS\\_RELEASE&navtype=RT&parentnav=LATEST\\_RELEASES&edeployment\\_action=retrievecontent](http://usda.gov/wps/portal/usda/usdahome?contentid=2012/08/0271.xml&navid=NEWS_RELEASE&navtype=RT&parentnav=LATEST_RELEASES&edeployment_action=retrievecontent)

<sup>69</sup> See the USDA FSA crop disaster map (accessed April 17, 2013); [http://www.fsa.usda.gov/Internet/FSA\\_File/disaster\\_map\\_cropr\\_2013.pdf](http://www.fsa.usda.gov/Internet/FSA_File/disaster_map_cropr_2013.pdf)

<sup>70</sup> For more information about the Stafford Act, see CRS Report RL33053, *Federal Stafford Act Disaster Assistance: Presidential Declarations, Eligible Activities, and Funding*, by (name redacted); and CRS Report R41981, *Congressional Primer on Major Disasters and Emergencies*, by (name redacted) and (name redacted).

authority to assist with well construction and transport of water to drought-distressed farmers, ranchers, and political subdivisions; the construction costs are a nonfederal responsibility, while the transport costs can be federally funded. Congress has provided Reclamation with a broader set of authorities that allow it to assist with drought response and recovery; these authorities, however, are limited to the 17 western states<sup>71</sup> and Hawaii.

### **USDA Emergency Assistance: Status and Legislation**

Under current U.S. farm policy, financial losses caused by drought and other natural disasters are mitigated primarily by the federal crop insurance program (administered by USDA's Risk Management Agency). From 2000 to 2011, the federal contribution to the crop insurance program averaged about \$4.6 billion per year, mostly in premium subsidies. In crop year 2012, when drought adversely affected many growing regions, crop producers were reimbursed for losses totaling \$16 billion (as of April 1, 2013). (The total premium subsidy to farmers was nearly \$7 billion.)

Since the severe drought of 1988 and until passage of the 2008 farm bill (P.L. 110-246), Congress regularly made supplemental financial assistance available to farmers and ranchers (in addition to crop insurance), primarily in the form of crop disaster payments and emergency livestock assistance. Crop disaster payments, paid to any producer who experienced a major crop loss caused by a natural disaster, totaled \$22.34 billion from FY1989 to FY2009.

More recently, under the 2008 farm bill (P.L. 110-246), Congress authorized a \$3.8 billion trust fund to supplement crop insurance and cover the cost of making agricultural disaster assistance for losses from droughts and other causes available on an ongoing basis over four years (FY2008-FY2011). Among the programs operating from FY2008 through September 30, 2011, the Livestock Forage Disaster Program (LFP) assisted ranchers who graze livestock on drought-affected pastureland or grazing land. As of March 5, 2013, payments under LFP totaled more than \$565 million for losses caused by weather events on or before September 30, 2011.

The expired status of these disaster payment programs received significant congressional attention in 2012 as drought conditions spread across the country. The 112<sup>th</sup> Congress considered but did not pass omnibus farm legislation, including extension of certain agricultural disaster programs that expired in September 2011. The Senate passed its version of the omnibus 2012 farm bill (S. 3240, the Agriculture Reform, Food, and Jobs Act of 2012) in June 2012. The Senate bill would have retroactively extended the livestock disaster and tree assistance programs, thereby potentially covering losses associated with the 2012 drought. In the House, on July 11, 2012, the House Agriculture Committee passed its farm bill (H.R. 6083, the Federal Agriculture Reform and Risk Management Act of 2012), which included the same combination of disaster programs as in the Senate bill. The bill, however, did not reach the House floor. Other attempts in the 112<sup>th</sup> Congress to reauthorize and fund the disaster programs were not successful. At the end of the 112<sup>th</sup> Congress, on January 2, 2013, the five-year 2008 farm bill was extended one year as part of the American Taxpayer Relief Act of 2012 (ATRA; P.L. 112-240). Under ATRA, Congress provided authority to appropriate funds (but no actual funding) for the three livestock programs and the tree assistance program. Neither discretionary funding authority nor resources were provided for the crop disaster program (the Supplemental Revenue Assistance Payments Program or SURE). With farm bill programs expiring in 2013, the 113<sup>th</sup> Congress may consider the reauthorization of an omnibus farm bill.

In response to the 2012 drought, USDA took a variety of administrative actions. For example, it reduced the interest rate for emergency loans from 3.75% to 2.25%. Also, USDA authorized emergency haying and grazing use of Conservation Reserve Program (CRP) acres for 2012 due to drought conditions. USDA announced a smaller reduction (10% instead of 25%) on rental payments made to producers on CRP lands used for emergency haying and grazing in 2012. The agency also announced a purchase of up to \$170 million in livestock and fish products to help ease the financial effects of drought on meat and catfish producers.

For analysis of agricultural disaster and emergency assistance, see CRS Report RS21212, *Agricultural Disaster Assistance*. For more on crop insurance, see CRS Report RL34207, *Crop Insurance and Disaster Assistance in the 2008 Farm Bill*, and CRS Report R40532, *Federal Crop Insurance: Background*. For more information on the 2012 omnibus farm legislation, see CRS Report R42552, *The 2012 Farm Bill: A Comparison of Senate-Passed S. 3240 and the House Agriculture Committee's H.R. 6083 with Current Law*.

<sup>71</sup> Per the Reclamation Act of 1902, as amended, the 17 Western states often referred to as "Reclamation States" include the following: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Other federal agencies are also reviewing drought response actions and committing resources or temporarily changing policies that may ease drought burdens. For example, the President in early August 2012 convened a White House Rural Council to review and assess federal agency activities and capabilities. Shortly following the gathering, the Administration announced new measures to address drought impact, as well as a listing of ongoing federal agency efforts to address the 2012 drought.<sup>72</sup> Among the new efforts announced were waivers for federal trucking regulations and additional emergency funding for crop and livestock producers.<sup>73</sup>

## Federal Facilities and Drought

Operations of federal water resource facilities, particularly reservoirs behind dams, can both assist in meeting water supply needs during droughts and be vulnerable to droughts. Federal dams, particularly in the West, were constructed in part to provide multi-year storage to help with variations in seasonal and annual precipitation.<sup>74</sup> Sustained hydrological drought nonetheless affects operations of federally managed reservoirs, dams, locks, hydroelectric facilities, and other components of the nation's water infrastructure. For example, numerous Corps reservoirs have drought management plans that result in the curtailing of some benefits (e.g., navigation, hydropower) in order to maintain other benefits (e.g., in-stream flows to support water quality, aquatic species, and river withdrawals for electric power cooling and municipal and industrial water supplies). The Corps' operations of its facilities in the Apalachicola-Chattahoochee-Flint River system during 2007-2008 illustrate management tradeoffs during drought (see box below).

### Federal Reservoir Operations During Southeast Droughts

An example of hydrological drought was the 2007-2008 drought in the southeastern United States. A severe drought in the region, beginning with below-average rainfall in spring 2006, exacerbated an ongoing interstate dispute involving Alabama, Florida, and Georgia over water sharing in the Apalachicola-Chattahoochee-Flint (ACF) river system. During the drought, Atlanta's municipal and industrial water users in the upper basin were concerned over the potential loss of their principal water supply, Lake Lanier, a surface water reservoir behind a U.S. Army Corps of Engineers operated dam. Their concern resulted from the decision by the Corps to draw down Lake Lanier in the fall of 2007. The Corps drew down the reservoir to maintain minimum flows in the lower basin Apalachicola River to support species protection, energy production (e.g., power plant cooling), and lower basin municipal withdrawals.

During and after the 2007-2008 drought, additional actions were taken and considered at the state level to manage water demand in droughts. The extent to which similar activities may be implemented or necessary again revives policy questions of what actions should be taken by whom and when in a shared basin to adapt to dry conditions.

For more on the ACF 2007-2008 drought and tri-state conflict, see CRS Report RL34326, *Apalachicola-Chattahoochee-Flint (ACF) Drought: Federal Water Management Issues*, coordinated by (name redacted); and CRS Report RL34440, *Apalachicola-Chattahoochee-Flint Drought: Species and Ecosystem Management*, by (name redacted), (name redacted), and (name redacted).

**Source:** NOAA, National Weather Service, Southeast River Forecast Center, *When Did the Drought Begin, a Focus on the North Georgia and Atlanta Areas*, November 16, 2007.

<sup>72</sup> See <http://www.whitehouse.gov/the-press-office/2012/08/07/fact-sheet-president-obama-leading-administration-wide-drought-response>.

<sup>73</sup> Ibid.

<sup>74</sup> Reclamation is a central player in water resource management in the West. A devastating drought at the end of the 19<sup>th</sup> century probably was a factor leading to the 1902 Reclamation Act that launched the federal reclamation effort and Reclamation itself. See Marc Reisner, *Cadillac Desert* (New York: Penguin, 1986), pp. 108-109. Other research suggests that failures of some late 19<sup>th</sup> century private irrigation projects, undertaken following passage of the Carey Act (see footnote 56), may have occurred in part due to drought conditions.

Similarly, drought conditions in California from 2007 to 2009, coupled with declining fish species, resulted in operational changes to Reclamation facilities, including significantly reduced water deliveries to Central Valley Project contractors, as well as to California's State Water Project (SWP) contractors. Reclamation, whose facilities currently serve over 31 million people in the West and deliver a total of nearly 30 million acre-feet of water<sup>75</sup> annually, faces operational challenges because of conflicts among its water users during drought in states it serves.

For example, severe drought conditions in 2001 in the Klamath River basin, on the Oregon-California border, exacerbated competition for scarce water resources among farmers, Indian tribes, commercial and sport fishermen, other recreationists, federal wildlife refuge managers, environmental groups, and state, local, and tribal governments. Reclamation's decision in April 2001 to withhold water from farmers for in-stream flows for three fish species listed as endangered or threatened under the Endangered Species Act sparked congressional debate that continues today. The Klamath basin again experienced drought conditions in 2010 and again in 2012. Project water flows to Klamath refuges were halted from December 2011 through March 2012. Dry conditions contributed to a cholera outbreak among migrating birds during this time, resulting in the death of thousands of birds that visit the refuges. Early spring precipitation improved hydrological conditions such that Reclamation projected full irrigation deliveries for 2012.<sup>76</sup> However, low lake levels and inflows by April 1, 2013, have resulted in Reclamation postponing spring water deliveries by one to two weeks.<sup>77</sup> Final water deliveries are also affected by flows necessary to protect federally listed Coho salmon and two sucker species. A new biological opinion on project operations through February 2014 is expected in April 2013, which may again affect water deliveries.

The droughts in California, the Southeast, and the Klamath River basin underscore an underlying difficulty of managing federal reservoirs to meet multipurpose water needs. In the future, the United States might face severe and sustained periods of drought not experienced in the 20<sup>th</sup> century. If so, disputes over federal infrastructure management like those in California, the ACF basin, and Klamath River basin may increasingly determine short-term actions by Reclamation and the Corps, and result in long-term consequences for congressional oversight and funding.

### **Droughts and Navigation: The 2012-2013 Experience**

The dry conditions of 2012 contributed to low flow conditions in portions of the Mississippi River into early 2013. While a full shutdown of barge navigation on the river did not materialize, the risk to navigation and the industries that rely on that navigation (e.g., agriculture, and energy) resulted in intense political interest and the Army Corps of Engineers taking emergency actions (e.g., blasting of rocks in areas with shallow depths) to avoid disruptions. The situation resulted in increased interest among Mississippi River stakeholders in having federal infrastructure on the Missouri River and its tributaries operated to support Mississippi River navigation; this has prompted introduction of legislative proposals (e.g., S. 565, Mississippi River Navigation Sustainment Act). Water management issues in the Missouri River basin have also been debated among upper basin and lower basin interests for decades; the intensified interest of Mississippi River stakeholders further complicates the Corps efforts to balance the needs of a diverse mix of basin stakeholders (e.g., agricultural and municipal and industrial water supply users, hydroelectric power users, navigation interests, and species that rely on certain water flows and timing of water releases).

<sup>75</sup> One acre-foot is enough water to cover one acre of land one foot deep. An acre-foot is equivalent to 325,851 gallons.

<sup>76</sup> U.S. Bureau of Reclamation, *Klamath Project 2012 Operations Plan*, April 6, 2012, p. 5, [http://www.usbr.gov/mp/kbao/docs/summer\\_operations.pdf](http://www.usbr.gov/mp/kbao/docs/summer_operations.pdf).

<sup>77</sup> U.S. Bureau of Reclamation, press release, *Reclamation Announces Delay in Water Deliveries for Klamath Project*, April 2, 2013.



## Drought Forecasts for the United States

Predicting the severity and duration of severe drought over a specific region of the country is not yet possible more than a few months in advance because of the many factors that influence drought. Nevertheless, some modeling studies suggest that a transition to a more arid average climate in the American West, perhaps similar to conditions in precolonial North America, may be underway.<sup>78</sup> Some studies have suggested that human influences on climate, caused by emissions of greenhouse gases, may be responsible for a drying trend,<sup>79</sup> however, other studies appear to indicate an opposite trend or possibility (see above section on “Drought and Climate Change”).<sup>80</sup> Whether future greenhouse gas-driven warming can be linked to La Niña-like conditions, or other phenomena related to the El Niño-Southern Oscillation, is unclear.

A likely consequence of higher temperatures in the West would be higher evapotranspiration, reduced precipitation, and decreased spring runoff.<sup>81</sup> These impacts would result from an “acceleration” of the hydrologic cycle, due to increased warming of the atmosphere, which in turn increases the amount of water held in the atmosphere.<sup>82</sup> A possible consequence is more frequent, and perhaps more severe, droughts and floods. However, these changes are unlikely to occur evenly across the United States. Observations of water-related changes over the last century suggest that runoff and streamflow in the Colorado and Columbia River basins has been decreasing, along with the amount of ice in mountain glaciers in the West, and the amount of annual precipitation in the Southwest.<sup>83</sup> Yet the understanding of hydrologic extremes, such as drought, is confounded by other effects such as land cover changes, the operation of dams, irrigation works, extraction of groundwater, and other engineered changes. Forecasting drought conditions at the regional scale, for example for river basins or smaller, is difficult because current climate models are less robust and have higher uncertainty at smaller scales.<sup>84</sup> (For example, see box below on the Colorado River’s Lake Mead.)

Even though forecasting drought at the regional scale is difficult, understanding potential changes in long-term trends is important for water managers at all levels—federal, state, local, and tribal. Water project operations and state water allocations are typically based on past long-term hydrological trends; significant deviations from such trends may result in difficult challenges for water managers and water users alike.<sup>85</sup> An example of such a dilemma can be observed in the Colorado River basin.

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<sup>78</sup> Richard Seager et al., “Model projections of an imminent transition to a more arid climate in southwestern North America,” *Science*, vol. 316 (May 25, 2007), pp. 1181-1184.

<sup>79</sup> Tim P. Barnett, et al., “Human-induced changes in the hydrology of the western United States,” *Science*, vol. 319 (February 22, 2008), pp. 1080-1082.

<sup>80</sup> C.B. Field, et al., IPCC, 2012, p. 170.

<sup>81</sup> Research results are emerging, however, that suggest that local and regional patterns of precipitation may be variable, and parts of a region or a state could receive higher precipitation than the current average, even if the overall trend over the broader area is towards less precipitation. See K. T. Redmond, “Climate Change in the Western United States: Projections and Observations,” *Eos Trans. AGU*, 90(52), Fall Meet. Suppl., Abstract U11D-02, 2009.

<sup>82</sup> National Research Council, Committee on Hydrologic Science, *Global Change and Extreme Hydrology: Testing Conventional Wisdom*, Washington, D.C., 2011, p. 3.

<sup>83</sup> *Ibid.*, p. 7.

<sup>84</sup> *Ibid.*, p. 9.

<sup>85</sup> P.C.D. Milly et al., “Stationarity Is Dead: Whither Water Management?,” *Science*, vol. 319 (February 4, 2008), p. 574.

### **Colorado River's Lake Mead**

A 2008 study asserted that water storage in Lake Mead has a 50% probability by 2021 to “run dry” and a 10% chance by 2014 to drop below levels needed to provide hydroelectric power under current climate conditions and without changes to water allocation in the basin. This study raised awareness of the vulnerability of western water systems but drew criticism that global climate models are insufficient to forecast climate change effects at the regional scale. Some western water officials were especially critical of the report’s assertions. One explained that Reclamation and other agencies had recently developed new criteria for the allocation of Colorado River water in times of shortages (shortage criteria), including drought, and commented that the likelihood that Lake Mead would run dry was “absurd.” The study was based on predictions of future warming in the West without increased precipitation.

In a 2009 follow-up study, the same authors acknowledged that the ability of the Colorado River system to mitigate drought could be managed if the users found a way to reduce average deliveries, thereby maintaining water levels in Lake Mead and Lake Powell at consistently higher elevations. Maintaining higher water levels would increase the capacity of the Colorado River system to buffer itself against low precipitation years. Even so, the authors noted, global climate models are in broad agreement that the southwestern United States is likely to become warmer and more arid, especially in the Colorado River drainage basin. In addition, paleoclimate studies suggest that the 20<sup>th</sup> century was the wettest or second-wettest century for at least 500 years and possibly over the past 1,200 years. Notwithstanding potential climate change, the paleoclimate data suggest that average future precipitation in the Colorado River basin is unlikely to match what hydrologists believe were relatively wet 20<sup>th</sup>-century levels, and upon which water allocation decisions were made.

In December 2012, the Bureau of Reclamation and basin state agencies released the Colorado River Basin Water Supply and Demand Study, which was undertaken to address uncertainties over Colorado River water supplies. The study assessed future water supply and demand imbalances under several different supply and demand scenarios in order to provide background information and data for decision makers. Although the study also solicited water supply and demand management solutions, it did not provide recommendations for future management. Key findings echoed concerns noted in earlier studies. Notably, the study confirmed that the Colorado River is over-allocated given existing and projected water supply levels and that “the long-term projected imbalance in future supply and demand [based on median projections of each] is about 3.2 million acre-feet by 2060.” The authors note that this figure does not take into account reservoir storage and management and that factors contributing to the supply and demand projections are highly variable. This disparity makes planning even more difficult for basin water managers. Management of reservoir operations and future agreements among basin states will continue to play a large role in the system’s viability. Although the system was able to meet all downstream water requests in recent years despite experiencing the worst drought in a century, there is no guarantee that a longer-term drought or successive low water years will not become the new norm. That said, the current system has enormous capacity to recover if there are above normal water years given its 60 million acre-feet storage capacity—a resilience that was demonstrated over the recent 11-year drought.

**Sources:** Tim P. Barnett and David W. Pierce, “When Will Lake Mead Go Dry?” *Water Resources Research*, vol. 44 (March 29, 2008), p. W03201, DOI:10.1029/2007WR006704; Felicity Barringer, “Lake Mead could be within a few years of going dry, study finds,” *New York Times* (February 13, 2008); Jenny Dennis, “Stunned Scientists: ‘When Will Lake Mead Go Dry?’” *Rim Country Gazette* (February 28, 2008), quoting Larry Dozier, Central Arizona Project deputy general manager; Timothy P. Barnett and David W. Pierce, “Sustainable Water Deliveries from the Colorado River in a Changing Climate,” *Proceedings of the National Academy of Sciences*, vol. 106, no. 18 (May 6, 2009); U.S. Dept. of the Interior, Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study* (December 2012).

Conditions in the Colorado River basin over the last decade, including recent low reservoir levels in Lake Mead and Lake Powell, and low flows in the Upper Basin, raise the issue of what is the baseline for average hydrologic cycles now and in the future. The allocation of Colorado River water supplies was agreed upon by lower and upper basin states in the early part of the 20<sup>th</sup> century based on hydrologic data from what scientists now know was a relatively wet period in the history of the Colorado River basin.<sup>86</sup> If long-term reduced runoff predictions for the basin are

<sup>86</sup> The Colorado River basin is somewhat unusual in that the Secretary of the Interior acts as water “master” for the river, and apportionment of water supplies among the basin states is done in accordance with the Colorado River Compact and a body of law known as the “Law of the River.” For more information on the Law of the River, see (continued...)

borne out (see box above on Colorado River’s Lake Mead and earlier section on “Conditions in the Colorado River Basin”), then water allocation policies for regions like the Colorado River basin may again need to be revisited.<sup>87</sup> In the meantime, Colorado River basin states have negotiated “shortage criteria” and “interim guidelines” for managing Colorado River water supplies during times of shortages.<sup>88</sup> Additionally, Reclamation in December 2012 released a new Colorado River basin supply and demand study, which examined several different future water supply and demand scenarios.<sup>89</sup>

## Policy Challenges

Severe drought can cause significant economic harm, affect nearly all areas of the country, and exacerbate water competition. Nonetheless, several key factors make comprehensive drought policy at the national level a challenge, including:

- the gradual, or “creeping,” nature of drought;
- split federal and nonfederal drought response and management responsibilities;
- a patchwork of federal programs and oversight with little coordination; and
- differences in regional conditions and drought risk in terms of the drought hazard, vulnerability, and potential consequences.

Drought conditions often develop slowly, are not easily identified initially, and are challenging to forecast beyond 30 to 90 days. Consequently, drought declarations are made well after onset—typically once impacts are felt. This situation makes it difficult to mitigate or prevent drought impacts. Further, even though drought generally is continuously occurring somewhere in the United States, the unpredictability of its location, duration, and severity complicates preparation for implementation of responses.

When severe meteorological drought affects a region, the supply of available water often shrinks before use is reduced. Adjusting down the use of water as drought persists and supplies shrink can be difficult. Actually, droughts can increase demand on water supplies (e.g., lower soil moisture results in increased demand for irrigation and landscape watering). The lack of flexibility of existing water access and use arrangements sometimes limits the scope and speed of some

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(...continued)

<http://www.usbr.gov/lc/region/g1000/lawofrvr.html>.

<sup>87</sup> Tim P. Barnett and David W. Pierce, “When Will Lake Mead Go Dry?” *Water Resources Research*, vol. 44 (March 29, 2008), p. W03201, DOI:10.1029/2007WR006704. Note: Colorado River inflow is highly variable. Although inflow has been below average for 10 of the last 13 years, reservoir storage in the basin had increased by more than 8 million acre-feet between 2005 and 2012, reaching nearly 63% of capacity by April 3, 2012. Hydropower production continued under 2007 “interim guidelines” for managing water shortages in the Lower Colorado River basin. Reservoir management is similarly dynamic reflecting ever-changing basin hydrological conditions and predictions. See also U.S. Dept. of the Interior, Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study*, December 2012, <http://www.usbr.gov/lc/region/programs/crbstudy/finalreport/study rpt.html>.

<sup>88</sup> For more information on 2012 operations, see [http://www.usbr.gov/uc/water/crsp/studies/24Month\\_03.pdf](http://www.usbr.gov/uc/water/crsp/studies/24Month_03.pdf), accessed May 2, 2012. CRS has not determined to what degree recent scenarios are similar to those considered in studies supporting the new shortage criteria for Colorado River water allocations under the Colorado River Compact.

<sup>89</sup> U.S. Dept. of the Interior, Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study* (December 2012).

drought responses. Federal, state, and local authorities make water resource decisions within the context of multiple and often conflicting laws and objectives, competing legal decisions, and entrenched institutional mechanisms, including century-old water rights and long-standing contractual obligations (i.e., long-term water delivery and power contracts). Typically, how access to and competition for water is managed (e.g., permitting of water withdrawals) and how reductions in water supply are managed (e.g., shared reductions under a riparian system of water rights versus reductions based on the priority in time of a water right) is determined by state law and at times through interstate compacts. Additionally, state and local laws can determine how easily water can be transferred among users. These access, reduction, and transfer arrangements can significantly affect the behavior, incentives, and opportunities available to water users during droughts. Fundamental changes to the access, reduction, and transfer arrangements are largely outside of the realm of federal action, and are largely determined by each state; however, such activities might be directly or indirectly influenced by changes in federal policies and activities.

A mismatch between supply and demand during droughts underscores the responsibility of stakeholders to anticipate the influence of drought and plan and act accordingly. The federal government has several drought monitoring and response programs. While drought planning and mitigation responsibilities lie largely at the state and local level, the federal government also provides some drought planning assistance. Much of this assistance historically has been concentrated on the West. Additionally, the federal government often provides emergency funding for drought relief that is primarily aimed at easing the economic impacts. The National Drought Commission and others have noted, however, that federal relief programs and emergency funding provide little incentive for state and local planning and efforts to reduce social and economic vulnerability to drought. A policy issue particularly relevant to state and local decision makers is the role and types of demand management tools to employ during a drought (e.g., lawn watering restrictions, incentives to curtail irrigation during droughts, scarcity pricing). How a state distributes and administers its waters among competing uses can affect what drought response tools are available to it and to water users.

A further challenge is lack of a cohesive national drought policy at the federal level, and lack of a lead agency coordinating federal programs. Rather, several federal programs have been developed over the years, often in response to specific droughts. Additionally, occasional widespread economic effects have prompted creation of several federal relief programs. These programs are overseen by different congressional committees. Whether this fragmentation results in duplication, waste, and gaps, or whether it reflects the complexity of preparing and responding to drought and the different responses needed by a wide range of stakeholders (e.g., irrigated agriculture, dry land farming, municipal water utilities) is part of the debate about how to proceed with cost-effective management of the nation's drought risk and who bears the consequences of drought. (See box below for an example of how water access and transfer arrangements played a significant role in shaping Australia's drought resilience and adaptation.)

The 2012 drought, like other recent severe weather events, has contributed to the ongoing public and policy discussion about the influence of human actions on climate and the future of U.S. actions on climate change mitigation. For a discussion of climate change science and policy, see CRS Report RL34266, *Climate Change: Science Highlights*, by (name redacted); and CRS Report R41973, *Climate Change: Conceptual Approaches and Policy Tools*, by (name redacted), respectively.

### **Australia's Drought Experience: Water Markets as Drought Management**

Australia experienced a historic drought from 1997 to 2009, known as the Millennium Drought. The drought tested a preexisting multi-pronged national water reform initiative; one aspect of the reform was the development of water markets. To develop water markets, the initiative had promoted reform of state law to clarify the property right associated with a water right and facilitated the means to buy and sell perpetual water rights and short-term allocations in basins that were fully allocated. Water trade increased significantly during the later years of the drought as allocations fell and markets matured. Allocations in some sub-basins during the worst of the drought reached as low as 20% of a full allocation. While gross domestic production dropped by \$2 billion-\$3 billion in Australia's most significant agricultural basin during each of the worst drought years, the ability to trade water is estimated to have reduced losses by roughly \$1 billion during each drought year. The market's ability to move scarce water to uses with higher economic value is credited with assisting Australia's rural economy to ride out the drought as well as it did by getting more value per unit of water used. For example, some dairy farmers sold their water rights and purchased fodder, rather than growing it themselves. Agricultural businesses increasingly used buying and selling in the water market as a coping mechanism as the drought persisted. With water availability high in many basins since 2009, market water prices have fallen, and rice and cotton production, which had declined during the drought, have picked back up.

Water markets were not established in Australia without controversy and criticism. While not solely responsible, water rights trading contributed to trends producing significant economic adjustment, particularly in rural agricultural communities. Nonetheless, contemplating the consequences for Australia, especially its agricultural communities and businesses, of such a severe drought under a less flexible water rights regime has increased internal support for the use and further improvement of water markets.

The broader water reform initiative produced some disappointments, as well as successes. The broader reform is criticized for falling short of achieving ecologically sustainable levels of surface water withdrawals. Consequently, the recent discourse about the next steps in Australian water policy has focused on how to establish sustainable levels of withdrawals that can maintain ecosystems and support regional economies and how to cost-effectively secure the water for the environment. Australia's government uses the water markets to transition water out of existing uses for use in meeting environmental flow goals; to date, the Australian government's purchase of water rights for the environment using the market has been less expensive than obtaining the water through infrastructure efficiency improvements.

**Source:** National Water Commission (Australia), *The Impacts of Water Trading in the Southern Murray-Darling Basin Between 2006-07 and 2010-11*, April 2012.

## **Legislative Action**

Congress has long recognized the lack of coordinated drought planning and mitigation activities among federal agencies and the predominance of a crisis management approach to dealing with drought. Over the last 15 years, legislative action has focused on the question of whether there is a need for a national drought policy. For example, in 1998, Congress passed the National Drought Policy Act (P.L. 105-199), which created the National Drought Policy Commission. In 2000, the commission submitted to Congress a comprehensive report that included policy recommendations. Congress has considered recommendations from the commission's 2000 report; to date, it has enacted one part of the recommendations (the National Integrated Drought Information System, discussed below). Congress also considered, but did not enact, legislation creating a National Drought Council during deliberations on the 2008 farm bill. Recent congressional deliberations focused on the 2012 reauthorization of the farm bill, which was given a one-year extension (through 2013) in January 2013, although other legislation is also pending.<sup>90</sup>

<sup>90</sup> For example, reauthorization of NIDIS, S. 376, and reauthorization of the Reclamation States Emergency Drought Relief Act, H.R. 518.

The commission findings, the proposed council, and the 2008 and 2013 farm bills are discussed below.

## **The National Drought Policy Act of 1998**

In passing the National Drought Policy Act of 1998, Congress found that “at the Federal level, even though historically there have been frequent, significant droughts of national consequences, drought is addressed mainly through special legislation and ad hoc action rather than through a systematic and permanent process as occurs with other natural disasters.”<sup>91</sup> Further, Congress found an increasing need at the federal level to emphasize preparedness, mitigation, and risk management. Those findings are consistent with a recognition of the inevitability, albeit unpredictability, of severe drought occurring. The act created the National Drought Policy Commission, and required it to conduct a study and report to Congress on

- what is needed to respond to drought emergencies;
- what federal laws and programs address drought;
- what are the pertinent state, tribal, and local laws; and
- how various needs, laws, and programs can be better integrated while recognizing the primacy of states to control water through state law.

In May 2000, the commission submitted its report.<sup>92</sup> The commission concluded that the United States needed to embrace a national drought policy with preparedness at its core. It recommended that Congress enact a National Drought Preparedness Act, which would establish a federal-nonfederal partnership through a National Drought Council. The council would function to further national drought policy goals. The commission’s report provided 29 specific recommendations to achieve the goals of national drought policy. Most of the specific recommendations were targeted at the President and federal agencies, coupled with calls for Congress to fund drought-related activities in support of the recommendations. (**Appendix B** of this report lists the five goals and illustrative recommendations from the commission’s report.) As background for its recommendations, the commission noted the patchwork nature of drought programs, and that despite a major federal role in responding to drought, no single federal agency leads or coordinates drought programs—instead, the federal role is more of “crisis management.”<sup>93</sup>

## **National Drought Preparedness Legislation and the 2008 Farm Bill**

National Drought Preparedness Act bills were introduced in 2002 (107<sup>th</sup> Congress), 2003 (108<sup>th</sup> Congress), and 2005 (109<sup>th</sup> Congress), but were not enacted. Similar stand-alone legislation was introduced in the 110<sup>th</sup> Congress; however, the House-passed version of H.R. 2419, the Farm, Nutrition, and Bioenergy Act of 2008 (also known as the 2008 farm bill), contained a section creating a National Drought Council. This section of the 2008 farm bill would have charged the council with creating a national drought policy action plan, which would have incorporated many

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<sup>91</sup> The National Drought Policy Act of 1998, P.L. 105-199 (42 U.S.C. 5121 note).

<sup>92</sup> Available at <http://govinfo.library.unt.edu/drought/finalreport/fullreport/ndpcfullreportcovers/ndpcreportcontents.htm>.

<sup>93</sup> *Ibid.*, p. 1.

of the components recommended in the commission's report; however, it was not included in the conference agreement. Although the Senate version of H.R. 2419 did not contain a similar section, the Senate bill authorized permanent disaster payments in hopes of precluding the need for ad hoc disaster payments. The conference agreement on the 2008 farm bill (P.L. 110-246, enacted June 18, 2008) included a new \$3.8 billion trust fund to cover the cost of making agricultural disaster assistance available on an ongoing basis over the following four years. The assistance was available for disasters occurring on or before September 30, 2011. In January 2013, as part of a one-year extension of the 2008 farm bill, four of the five disaster programs were reauthorized through FY2013, but Congress provided no funding. With farm bill programs expiring in 2013, the 113th Congress is expected to consider the reauthorization of an omnibus farm bill, including agricultural disaster programs (see box on page 18).

## **National Integrated Drought Information System**

Although Congress has not enacted comprehensive national drought preparedness legislation, it acted on the second of five commission goals by passing the National Integrated Drought Information System (NIDIS) Act of 2006 (P.L. 109-430). That goal called for enhanced observation networks, monitoring, prediction, and information delivery of drought information. P.L. 109-430 established NIDIS within the National Oceanic and Atmospheric Administration (NOAA) to improve drought monitoring and forecasting abilities.<sup>94</sup> The NIDIS authorization expired in 2012. A NIDIS reauthorization bill, S. 376, has been introduced in the 113<sup>th</sup> Congress.

## **Conclusion**

Drought is a natural hazard with potentially significant economic, social, and ecological consequences. History suggests that severe and extended droughts are inevitable and part of natural climate cycles. Drought has for centuries shaped the societies of North America and will continue to do so into the future. Current understanding is that the physical conditions causing drought in the United States are linked to sea surface temperatures in the tropical Pacific Ocean. For example, the 2011 severe drought in Texas is thought to be linked to La Niña conditions in the Pacific Ocean. Increasingly, studies are projecting the long-term role that droughts may play in regional climate patterns. Nonetheless, available technology and science remains limited to forecasting specific drought a few months in advance for a region. The prospect of extended droughts and more arid baseline conditions in parts of the United States represents a challenge to existing public policy responses for preparing and responding to drought, and to federal water resource projects in particular, because their construction was based largely on 19<sup>th</sup>- and 20<sup>th</sup>-century hydrologic conditions.

Over time, Congress has created various drought programs, often in response to specific droughts and authored by different committees. Crafting a broad drought policy that might encompass the jurisdiction of many different congressional committees is often difficult. Additionally, although many water allocation and other water management responsibilities largely lie at the state or local level, localities and individuals often look to the federal government for relief when disasters occur. This is similar to the situation for flood policy, and water policy in general, at the national level. The National Drought Policy Commission recognized these patterns, and they underlie

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<sup>94</sup> NOAA allocated \$12.1 million for NIDIS in FY2012. For more NIDIS information, see <http://www.drought.gov>.

many of its recommendations to Congress.<sup>95</sup> The currently fragmented approach can be costly to national taxpayers; however, it is not certain that increased federal investment (especially vis-à-vis the potential for tailored local and state investment) in drought preparation, mitigation, and improved coordination would produce more economically efficient outcomes.

The overall costs to the federal government and the nation as a result of extreme drought, apart from relief to the agricultural sector, are difficult to assess in part because of the broad nature of drought's impacts. Drought can result in water restrictions affecting municipal and industrial users, decreased hydropower generation and power plant cooling efficiency, navigation limitations and disruptions, harm to drought-sensitive species (benefits to other species), and increased fire risk, among other effects.

Congress may opt to revisit the commission's recommendations and reevaluate whether current federal practices could be supplemented with actions to coordinate, prepare for, and respond to the unpredictable but inevitable occurrence of drought. Given the daunting task of managing drought, Congress also may consider proposals to manage drought impacts, such as assisting localities, industries, and agriculture with developing or augmenting water supplies. This could take multiple forms: construction or permitting of reservoirs, the reallocation of water supplies at existing facilities, promotion of alternative water sources (e.g., reuse, desalination), or water conservation and efficiency. Congress also may move to examine how the two major federal water management agencies, the Corps and Reclamation, plan for and respond to severe drought and account for its impacts.

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<sup>95</sup> *Infra*, note 52.



## Appendix A. Drought-Related Federal Response and Recovery Authorities

**Table A-1. Drought-Related Federal Response and Recovery Authorities**

Army Corps of Engineers, Bureau of Reclamation, and Farm Service Agency  
(not including USDA crop insurance programs)

Agency	Program Name and Brief Description	Primary Authorities
Army Corps of Engineers	Temporary water withdrawal, for a fee, from Corps facilities during drought for municipal and industrial purposes. Administration policy limits application to governor-declared drought emergencies and to 99 acre-feet.	Flood Control Act of 1944, as amended (33 U.S.C. 708)
Army Corps of Engineers	Construction of wells for and transport of water to drought-distressed farmers, ranchers, and political subdivisions. Non-transport costs are nonfederal.	Disaster Relief Act of 1974 (33 U.S.C. 701n)
Army Corps of Engineers	Contracts for temporary sale of surplus water for municipal and industrial use from Corps reservoirs at a fee determined by the Secretary of the Army.	Flood Control Act of 1944 (33 U.S.C. 708)
Army Corps of Engineers	Interim use for irrigation of un-contracted water designated for municipal and industrial use at Corps reservoirs for a fee.	Water Resources Development Act of 1986 (43 U.S.C. 390)
Bureau of Reclamation (17 Western States and Hawaii)	Temporary construction, management, and conservation activities (well construction can be permanent but must be designed to address drought impacts). Costs incurred by Reclamation performing or contracting for the work are federal (nonreimbursable); other costs are to be repaid to the federal government (reimbursable).	Reclamation States Emergency Drought Relief Act of 1991, as amended (43 U.S.C. 2201, et seq.) <sup>a</sup>
Bureau of Reclamation (17 Western States and Hawaii)	Loans with interest to water users (that demonstrate an ability to pay within the terms of the loan) for construction of temporary facilities and permanent wells, conservation activities, and acquisition of water to mitigate droughts.	Reclamation States Emergency Drought Relief Act of 1991, as amended (43 U.S.C. 2201, et seq.) <sup>a</sup>
Bureau of Reclamation (17 Western States and Hawaii)	Authorizes Reclamation to facilitate water purchases and transfers through nonfinancial assistance, and to provide financial assistance for contingency plans. Cost for purchasing, storing, and conveying water are generally nonfederal (reimbursable).	Reclamation States Emergency Drought Relief Act of 1991, as amended (43 U.S.C. 2201, et seq.) <sup>a</sup>
Bureau of Reclamation (17 Western States and Hawaii)	Authorizes Reclamation purchases of water from its project contractors and sold under temporary contracts at full cost recovery.  Authorizes Reclamation's participation in state water banks.	Reclamation States Emergency Drought Relief Act of 1991, as amended (43 U.S.C. 2201, et seq.) <sup>a</sup>
Bureau of Reclamation (17 Western States and Hawaii)	Temporary procurement (not to exceed two years) of Reclamation project and non-project water for managing fish and wildlife impacts due to drought or the operation of a Reclamation project during drought conditions. Price charged for water is to recover the federal costs of the Reclamation facilities.	Reclamation States Emergency Drought Relief Act of 1991, as amended (43 U.S.C. 2212)

Agency	Program Name and Brief Description	Primary Authorities
Bureau of Reclamation	Emergency fund established to assure continuous operation of Reclamation facilities. Also, other site or drought specific authority.	Act of June 26, 1948, as amended (43 U.S.C. 502) P.L. 95-18, as amended (43 U.S.C. 502 note)
Farm Service Agency	<i>Noninsured Assistance Payments (NAP)</i> - provides direct payments to crop producers who experience a significant crop loss, but are not eligible for federal crop insurance.	7 U.S.C. 1501 et seq. and 7 U.S.C. 1509
Farm Service Agency	<i>Emergency Loans</i> - low-interest government loans to producers suffering from production and physical losses located in or adjacent to a county that has been declared a disaster by the President or USDA Secretary.	7 U.S.C. 1961 et seq.
Farm Service Agency	<i>Livestock Forage Program (LFP)</i> provides financial assistance to producers who suffered grazing losses due to drought or fire between January 1, 2008, and September 30, 2011. Authorization is extended (but not funded) through September 30, 2013.	7 U.S.C. 1531
Farm Service Agency	<i>Livestock Indemnity Program (LIP)</i> compensates ranchers at a rate of 75% of market value for livestock mortality caused by a disaster between January 1, 2008, and September 30, 2011. Authorization is extended (but not funded) through September 30, 2013.	7 U.S.C. 1531
Farm Service Agency	<i>Tree Assistance Program (TAP)</i> provides financial assistance to qualifying nursery tree growers and orchardists to replant or rehabilitate eligible trees, bushes and vines damaged by natural disasters, including floods, occurring on or after January 1, 2008, and before October 1, 2011. Authorization is extended (but not funded) through September 30, 2013.	7 U.S.C. 1531
Farm Service Agency	<i>Emergency Assistance for Livestock, Honey Bees, and Farm-Raised Fish Program (ELAP)</i> compensates producers for disaster losses not covered under other disaster programs. Authorization is extended (but not funded) through September 30, 2013.	7 U.S.C. 1531
Farm Service Agency	<i>Emergency Conservation Program (ECP)</i> - Provides emergency funding and technical assistance to producers to rehabilitate farmland damaged by natural disasters, including implementing emergency water conservation measures in response to severe droughts.	16 U.S.C. 2201-2205
Farm Service Agency	<i>Emergency Forest Restoration Program (EFRP)</i> provides payments to eligible owners of nonindustrial private forest (NIPF) land in order to carry out emergency measures to restore land damaged by a natural disaster, including drought.	16 U.S.C. 2206

**Source:** CRS.

**Notes:** For a discussion of USDA crop insurance programs see CRS Report R40532, *Federal Crop Insurance: Background*, by (name redacted).

- a. For the draft agency policy on implementation, see Bureau of Reclamation, Draft Reclamation Manual: Directives and Standards, Title I, Reclamation States Emergency Drought Relief Act of 1991, as amended, 2002, <http://www.usbr.gov/drought/title1.pdf>.

## **Appendix B. Excerpts from the 2000 National Drought Policy Commission Report to Congress**

In 2000, the National Drought Policy Commission published its report to Congress, *Preparing for Drought in the 21<sup>st</sup> Century—A Report of the National Drought Policy Commission*.<sup>96</sup> The commission concluded that the United States needed to embrace a national drought policy with preparedness at its core. It recommended that Congress enact a National Drought Preparedness Act, which would establish a federal-nonfederal partnership through a National Drought Council. The council would function to further national drought policy goals. The council's recommended duties included promoting cooperation and effective delivery of drought programs, evaluation of regional needs and opportunities, and assessments of drought-related assistance and initiatives, and post-drought impact assessments.

The commission also recommended five broad national policy goals and a number of recommendations for furthering each of the goals. Below are the five goals and below those are some examples of the types of recommendations accompanying each of the goals; many more recommendations are proposed in the commission's report. To date, Congress has enacted legislation furthering Goal 2 on improved observation. Congress also has taken action on insurance and financial strategies; their effect on improving drought preparedness (i.e., reducing drought vulnerability) versus increasing the relief for the impacts of drought has not been evaluated. This type of assessment potentially would fall under the duties of a National Drought Council as recommended by the commission.

### **Policy Statement<sup>97</sup>**

- Favor preparedness over insurance, insurance over relief, and incentives over regulation.
- Set research priorities based on the potential of the research results to reduce drought impacts.
- Coordinate the delivery of federal services through cooperation and collaboration with nonfederal entities.

### **Goals<sup>98</sup>**

Goal 1. Incorporate planning, implementation of plans and proactive mitigation measures, risk management, resource stewardship, environmental considerations, and public education as the key elements of effective national drought policy.

Goal 2. Improve collaboration among scientists and managers to enhance the effectiveness of observation networks, monitoring, prediction, information delivery, and applied research and to foster public understanding of and preparedness for drought.

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<sup>96</sup> Available at <http://govinfo.library.unt.edu/drought/finalreport/fullreport/ndpcfullreportcovers/ndpcreportcontents.htm>.

<sup>97</sup> Ibid., p. i.

<sup>98</sup> Ibid., p. vi.

Goal 3. Develop and incorporate comprehensive insurance and financial strategies into drought preparedness plans.

Goal 4. Maintain a safety net of emergency relief that emphasizes sound stewardship of natural resources and self-help.

Goal 5. Coordinate drought programs and response effectively, efficiently, and in a customer-oriented manner.

#### **Illustrative Recommendations for Goal 1: Planning and Mitigation<sup>99</sup>**

- Congress should adequately fund existing drought preparedness programs.
- President should direct appropriate federal agencies to effectively meet the drought planning needs of those areas not traditionally served (e.g., eastern United States).
- The President should direct all appropriate federal agencies to study their programs for potential impacts on drought.
- The president should direct all appropriate federal agencies to develop and implement drought management plans for federal facilities (e.g., military bases, federal office complexes, federal prisons).

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<sup>99</sup> Ibid., p. 36.

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