

## The Science of Droughts: Preparing for the Future

### Understanding Drought through Science

Drought is defined by the National Drought Policy Commission as “a persistent and abnormal moisture deficiency having adverse impacts on vegetation, animals, or people.” Drought, however, is not an uncommon occurrence. A drought takes place somewhere in the U.S. every year, regardless of the climate zone. In the past century, parts of the U.S. suffered the effects of multi-year droughts in 1930-1939, 1950-1956, 1961-1966, 1976-1977, mid-1980s to mid-1990s, and again in the late 1990s. Scientists consider drought a normal feature of any climate region, even semi-desert areas. It differs from aridity in that it is temporary, lasting from a few months to several years. Quantifying drought requires measuring rainfall relative to averages for season and year; assessing declines in water supplies in rivers, lakes, reservoirs, and aquifers; measuring soil moisture content; and tracking the increase in forest fire frequency.

Several indices are used to calculate drought conditions. Among them, the Palmer Drought Severity Index (PDSI) is a popular drought-monitoring tool used by scientists and government agencies to determine when extreme weather conditions—abnormally wet or abnormally dry periods—begin and end (Figure 1). The purpose of the index is to measure deviations from average amounts of rain precipitation. The severity of the drought is influenced by temperature, winds, humidity, and the drought’s coincidence with persistent large-scale global climate patterns.

One such pattern is ENSO, the El Niño-Southern Oscillation, a cyclic pattern of sea surface temperatures and surface air pressure in the tropical Pacific Ocean. During El Niño conditions, warm waters persist along the coast of Peru. These warm surface waters affect global climate and are associated with warmer winters and higher precipitation in the southwestern United States. The other extreme of the southern oscillation, La Niña, is associated with a cooling of eastern tropical Pacific waters and is correlated with warmer and drier conditions in the southwest, the northern plains, and southeast coast of the U.S. as well as greater variability in temperature. Those areas felt the effects of La Niña from

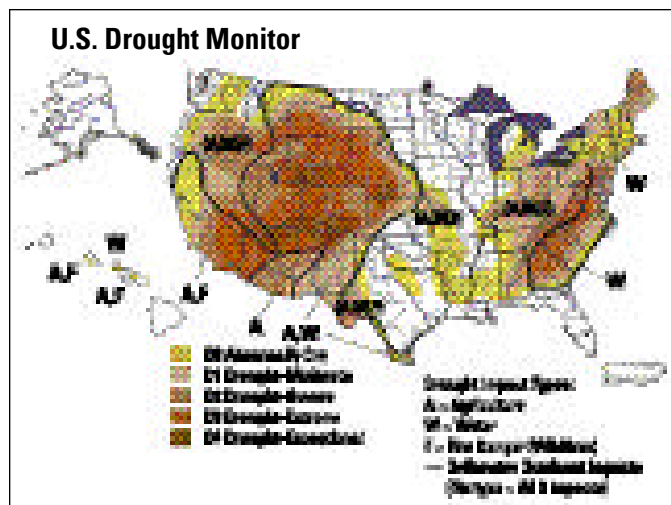


Figure 1. Map of the U.S. indicating drought conditions as of September 17, 2002. Source is <http://drought.unl.edu/dm>

1998 until mid-2002. Knowledge of the relationship between prevailing “long-term” climate conditions and the daily or seasonal variation in weather is crucial to our understanding of droughts past, present, and future.

### Drought History

Drought history is collected from 20th-century weather station data, tree ring analysis, and paleo-climate records. Tree ring data, gathered from living trees or trunks of dead trees, provide strong evidence for past climate conditions and have revealed some startling information. Dr. Lisa Graumlich of Montana State University and colleagues were able to reconstruct an 8000+ year record of precipitation using tree ring data from bristlecone pine in California. The Palmer Drought Severity Index (PDSI), when applied to this data, indicates evidence of a drought in the 16th century that exceeded the Dust Bowl drought of the 1930s in duration, intensity, and total area affected. In other work conducted by Dr. Scott Stine (California State University) and researchers in the high lakes of the Sierra Nevada, radio-carbon ( $C^{14}$ ) analysis of ancient tree stumps exposed by lowering water levels provides evidence of 20+ year dry

cycles or “mega-droughts” in 1000 A.D. and again in 1300 A.D. It therefore appears likely that long and unrelenting droughts are a recurring aspect of climate in North America. Obviously, given water use in the U.S. today, a drought as bad as, or worse than, that of the Dust Bowl would place extreme demands on our country’s infrastructure.

### Impacts of Drought

Drought conditions, regardless of duration and intensity, place stress on water supplies. Indirectly, drought also affects agriculture, fire risk, recreation, energy production, water quality, air quality, and species preservation. The impacts differ in type and intensity across the U.S.

In the Southwest and Central Plains, water is a highly valued resource because it is rarely plentiful, even in non-drought times. Consumption of water in relation to the amount of precipitation received is higher in these areas, due to agricultural demands and the needs of rapidly growing communities. The Lower Colorado River and Rio Grande River basins appear to be particularly susceptible as illustrated in Figure 2. This portion of the country is typically affected by periods of drought related to La Niña conditions, and it is currently experiencing drought. Clearly, long-term drought management is critical for these affected river basin regions.

In many parts of the country, particularly in the West, drought also has a direct impact on forests (Figure 3). Lack of precipitation stresses plants as they compete for diminished water supplies. Plants under physiological stress have less resistance to insects and disease. These

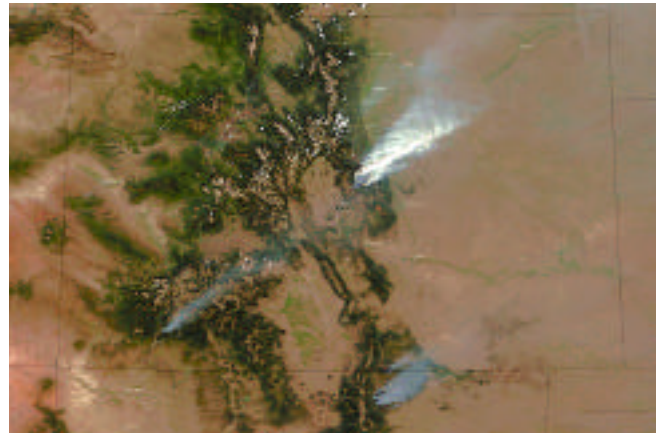
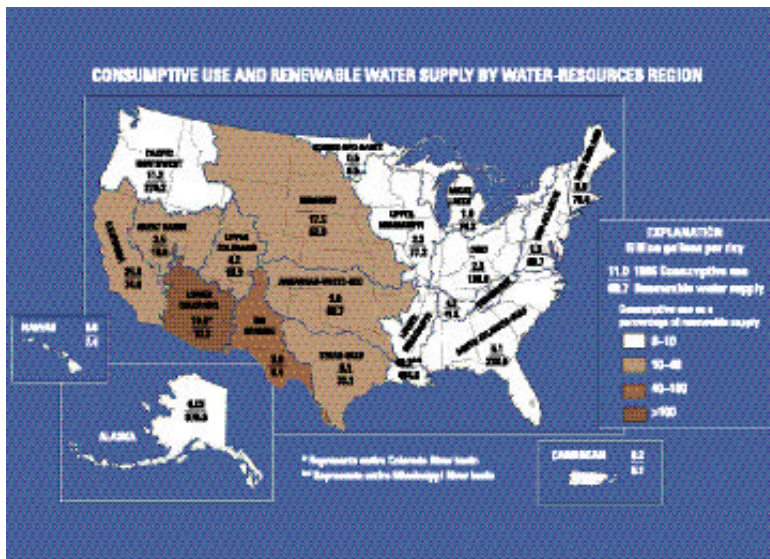


Figure 3. Aerial map of fires in Colorado on June 10, 2002. From presentation to the Drought Congressional Briefing June 14, 2002, by Timothy Killeen, Director, National Center for Atmospheric Research. (Courtesy NASA Goddard Space Flight Center.)

maladies increase tree mortality and leave behind vast stands of dead timber—fuel for forest fires.

According to Dr. Steven W. Running, the Director of the Numerical Terradynamic Simulation Group at the University of Montana, the number of acres burned in 11 Western states has dramatically increased in the past 15 years, as have the expenditures associated with fighting the fires. Costs are related to the destruction of homes and other structures, the death of livestock, and the resources needed for firefighting and suppression. The value of wildlife and human lives lost to wildland fire is incalculable. In an attempt to reduce these impacts, fire managers need to accurately assess potential fire danger in order for trained personnel and firefighting resources to be readily available in drought-affected areas. Advancement in drought prediction will only serve to improve our preparedness for potential forest fires.

Figure 2. Map of the U.S. indicating Consumptive Use and Renewable Water Supply, by Water-Resources Region. Source is <http://water.usgs.gov/watuse>



### Classroom Activity: Is Your Water Supply at Risk?

1. As a group, have students identify the sources of their water supply using USGS water-use maps (<http://ga.water.usgs.gov/edu/mapgallery.html>), then ask them to identify the severity of drought in their region by studying the current map of the Palmer Drought Severity Index (<http://drought.unl.edu/dm/current.html>).
2. In smaller groups, have students identify the potential risks to their water supply (such as increased water demand, drought, pollution, etc.) and discuss ways of conserving or increasing efficiencies of water use.
3. Return to the large group and compile a list of risk factors and a list of action items.

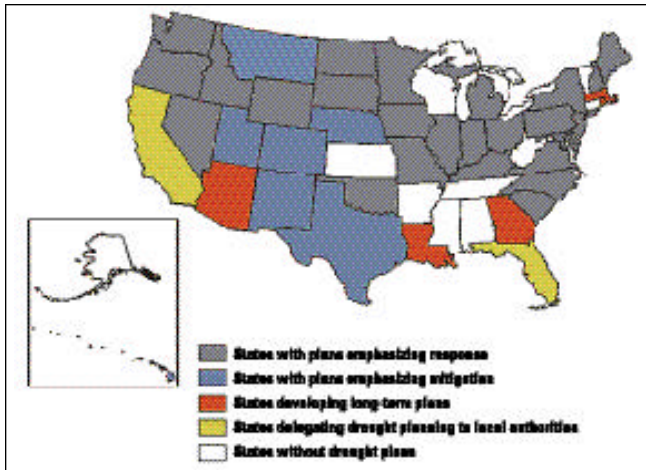


Figure 4. Map of U.S. indicating the Status of Drought Planning: May 2002. Presentation to the Drought Congressional Briefing June 19, 2002, by Donald Wilhite, Director of the National Drought Mitigation Center and the International Drought Information Center, and Associate Director, School of Natural Resource Sciences, University of Nebraska. (Courtesy National Drought Mitigation Center.)

## Predicting Droughts

Scientific study in the cause and nature of drought is revealing that, contrary to popular belief, drought is not an anomaly but is part of the natural variability in the Earth system. Research indicates that severe multi-year drought events have occurred regularly in the climate history of North America, leading scientists to suggest that such events can occur at any time. Now is the time to plan for that eventuality.

The National Drought Mitigation Center (NDMC), located at the University of Nebraska at Lincoln, is dedicated to mitigating the impacts of drought by the development and promotion of risk management techniques. Dr. Donald A. Wilhite, NDMC Director, stresses that drought mitigation is an “investment in sustainable resource management.” Mitigation involves making risk assessments of drought based on evaluating the hazard (or natural events) and

vulnerability (or social factors). Planning to anticipate future droughts remains an immense challenge. Scientists at the National Center for Atmospheric Research, interested in long-term climate patterns, are striving to predict drought occurrence and duration using climate models.

Improvements in computing power, understanding of the physical mechanisms affecting global climate patterns, and increases in the amount and quality of observational data will enhance the prognostic abilities of scientists. In the meantime, planning is vital. Most states currently have drought plans, but not all of them are comprehensive enough to include monitoring, assessments to reduce risk, and response strategies for fostering recovery (Figure 4). Increasing demands on limited water supply requires greater short- and long-term planning involving collaborative efforts of government resource managers, decision makers, and scientists to ensure the resiliency of communities to the droughts tomorrow.

### Web-based Resources:

#### Drought Watch at the National Drought Mitigation Center Web site:

Maps, current drought conditions, and links.  
<http://drought.unl.edu>.

#### Understand ENSO and Forecasting Drought Web site:

For information and links to ENSO.  
[http://enso.unl.edu/ndmc/enigma/el\\_nino.htm](http://enso.unl.edu/ndmc/enigma/el_nino.htm)

#### El Niño Educational Web sites:

Various educational resources including El Niño related activities.  
[http://www.el\\_nino.noaa.gov/edu.html](http://www.el_nino.noaa.gov/edu.html)

#### UCAR's Web site:

Regularly updated information on ENSO.  
<http://www.esig.ucar.edu/signal/index.html>

#### Fire Education Links:

Numerous helpful educational links on forest fires.  
<http://www.fs.fed.us/oonf/ozark/fire/education>

*Science Now* is jointly published by the Walter Orr Roberts Institute of the University Corporation for Atmospheric Research and SIRS Publishing, Inc. (Social Issues Resources Series). *Science Now* is published three times during the school year and is distributed to SIRS subscribers. Comments and questions should be directed to Susan Foster via Internet at [susanf@ucar.edu](mailto:susanf@ucar.edu). You can also contact your SIRS representative or write to SIRS Publishing, Inc., P.O. Box 272348, Boca Raton, FL 33427-2348.

Editors: Laura Curtis, Susan Foster, Bob Henson  
Writer: Susan Parks Halabrin

UCAR is a consortium of over 65 universities in the U.S. and Canada with doctoral programs in atmospheric and related sciences. UCAR manages and operates the National Center for Atmospheric Research under the sponsorship of the National Science Foundation. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the

views of the National Science Foundation. Anyone who undertakes any of the activities described herein shall do so at their own risk; UCAR and SIRS Publishing, Inc. assume no liability, whatsoever, for any injury or harm, which may result therefrom.

© COPYRIGHT2002 UNIVERSITYCORPORATION FOR  
ATMOSPHERIC RESEARCH.  
ALLRIGHTS RESERVED.

**Note to Teachers:** Permission is hereby granted to copy all or any portion of this publication for distribution to third parties provided such copying and distribution occur for the benefit of research, scientific, and educational purposes and for no other purposes including, but not limited to, commercial exploitation purposes. In the event copying occurs or derivative works, as defined under U.S. Copyright Laws, are created, all notices and/or credits recited herein must remain intact on any copies made or derivative works created.

## RESOURCES

### EXPAND YOUR RESEARCH WITH SIRS RESOURCES

SIRS award-winning reference databases offer a variety of informative full-text articles on the science of droughts. Titles of related articles include:

“The New Dust Bowl” (from *TIME Magazine*)

“El Niño Expect to Impact Atlantic Hurricane Season” (from *National Oceanic and Atmospheric Administration [NOAA] Magazine*)

“New Research Site Established in Australia to Help Predict Climate” (from *Department of Energy News*)

“The Great Drying” (from *U.S. News & World Report*)

“Nationwide Drought in 2001 Foretells More Dry Years Ahead” (from *Canadian Press*)

“Spreading Drought Threatens Nation” (from *Miami Herald*)

“U.S. Seasonal Drought Outlook from NOAA’s Climate Prediction Center” (from *NOAA Magazine*)

“Tree Rings: Timekeepers of the Past” (from *Geological Survey*)

SIRS articles are well-suited to the science curricula of schools and colleges. In addition, thousands of carefully-selected articles and Web sites on topics such as social issues, health, history, government, the

arts & humanities and more can be found on SIRS databases.

**SIRS Researcher**<sup>®</sup> is an online/CD-ROM reference database with thousands of articles and graphics from 1,500 worldwide publications. Articles examine social issues, science, history and more.

**SIRS Government Reporter**<sup>®</sup>, an online/CD-ROM reference database, contains information published by the U.S. government.

**SIRS Renaissance**<sup>®</sup>, an online and CD-ROM database, provides dynamic information on the arts and humanities.

**SKS WebSelect**<sup>™</sup> is an online database of quality Web sites on vital issues and topics, which are evaluated for relevance and credibility.

**SIRS Interactive Citizenship**<sup>™</sup> utilizes interactive electronic books that align with national and state standards, and links to appropriate Web sites and articles on SIRS databases.

**SIRS Discoverer**<sup>®</sup> is an online/CD-ROM, age-appropriate, full-text general reference database for 1st-9th graders.

**SIRS Enduring Issues**<sup>™</sup> is an 8-volume print reference set showcasing the best articles published during the preceding year. Topics include social issues, science, government and more.

For more information about SIRS products, visit [www.sirs.com](http://www.sirs.com) or call 1-800-232-7477.