State of the Science FACT SHEET

U.S. Drought

Droughts are among the most damaging of all natural hazards, with annual economic losses for the U.S. often in the billions of dollars. Droughts differ from most other hazards because of their gradual onset and accumulation of impacts over months, seasons, and years. Droughts can devastate crops, pastures, and ecosystems while severe heat waves that often accompany summer droughts can increase demands for energy and water resources, heighten wildfire risks, and contribute to large numbers of fatalities.

How is Drought Defined?

Drought is defined by a prolonged deficiency in precipitation and runoff, usually over a season, several years or longer, that leads to water shortages having adverse impacts on vegetation, animals, energy production, commerce and people. Temperature increase can also result in reductions in water supply, especially in snowmelt driven systems, due to evaporation, sublimation and water uptake by heat stressed vegetation. Droughts occur in virtually all climate zones. Because droughts can have profound societal and environmental impacts, several definitions of drought have been found useful. These include meteorological drought, which is defined by the magnitude of precipitation departures below long-term average values for a season or longer; agricultural drought, which is defined as the soil moisture deficit that impacts crops, pastures, and rangelands; and hydrological drought, which is defined by significant impacts on water supplies. NOAA provides information on all three types of droughts in its U.S. drought products.

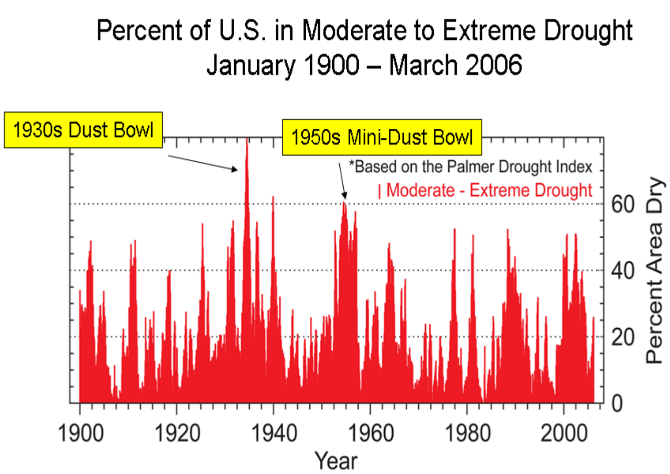

Figure 1. Percent of U.S. in Moderate to Extreme Drought

How is Drought Severity Defined?

Drought severity is defined by the frequency, magnitude and duration of reductions in precipitation and runoff that result in water supply shortages and for meeting human and environmental needs. Three important categories are:

- *Moderate drought* is associated with some crop damage and scattered water shortages.
- *Severe drought* is characterized by serious crop and pasture losses, water shortages and water use restrictions.
- *Extreme drought* causes major crop and pasture losses and widespread water shortages.

For any given part of the US, moderate droughts have been experienced on average once every 5-10 years, severe droughts once every 10-20 years, and extreme droughts once every 20-50 years.

How Have Droughts Varied Over the U.S. During the Past Century?

- Droughts are a common feature of U.S. climate. The fraction of the country in moderate or greater drought varies tremendously over time, averaging about 20 percent but ranging from less than 5 percent to as much as 80 percent.
- Widespread drought can affect the country for many years, such as during the 1930s “Dust Bowl.”
- Drought frequency varies considerably from year-to-year and over decades and longer. There is little evidence for any systematic trend toward either more or fewer droughts in the U.S. over the past century.
- The most extensive drought over the continental U.S. in the modern observational record occurred from 1933 to 1938. In July 1934, 80 percent of the U.S. was gripped by moderate or greater drought (Figure 1), and 63 percent experienced severe to extreme drought. During 1953-1957, severe drought covered up to 50 percent of the country.
- Of the 62 weather-related disasters over the period 1980-2004 having impacts over $1 billion, approximately one quarter were related to droughts. The costliest recent drought was in 1988, which devastated crops in the Corn Belt, causing a $15 billion loss in agricultural output and much larger additional indirect economic impacts.
- NOAA paleoclimate research has found that over the past two thousand years the climate of the western U.S. was usually more arid than at present, and within the past millennium severe droughts occurred in the western U.S. and Midwest that lasted for multiple decades (Figure 2).

What are the Primary Causes for Droughts?

- A strong and persistent blocking weather pattern is a common feature of many droughts. Blocking patterns are associated with sinking air and shifts of storm tracks away from the affected region that can lead to prolonged dry conditions. Such patterns also favor abundant sunshine, higher daytime temperatures and increased evaporation, increasing drought impacts.

- Large-scale sea surface temperature patterns are an important factor in producing many U.S. droughts.
  - The El Niño-Southern Oscillation, a coupled ocean-atmosphere phenomenon that has its origins in the equatorial Pacific, plays a significant and potentially predictable, role in drought development and persistence, especially during winter and spring.
  - NOAA research indicates that a warming trend in the tropical Indo-Pacific region together with a strong, three-year La Niña event (characterized by unusually cold sea surface temperatures over the central and eastern equatorial Pacific) were important factors in producing the severe, sustained Western drought of 1999-2004. Droughts over the U.S. also occur independently of sea surface temperature patterns in the Pacific.
  - The roles of multi-decadal oscillations of sea surface temperature (SST) patterns in the Pacific and the Atlantic in droughts are less certain but are being actively investigated.
- Once droughts have been initiated, the associated below-normal conditions in soil moisture, vegetation cover and snow cover spur feedbacks that both prolong the drought and increase its severity and/or regional extent
- Most climate models used in the recently completed Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report project a general trend toward drying in the semi-arid subtropics and increased precipitation in sub-polar latitudes over this century. Several studies suggest a trend toward increasing aridity in the Southwest U.S. during this period. Confidence in projections of regional precipitation and river runoff trends is much lower than for temperatures, and further research will be required to reduce the uncertainty in these projections and determine the implications for future U.S. droughts.

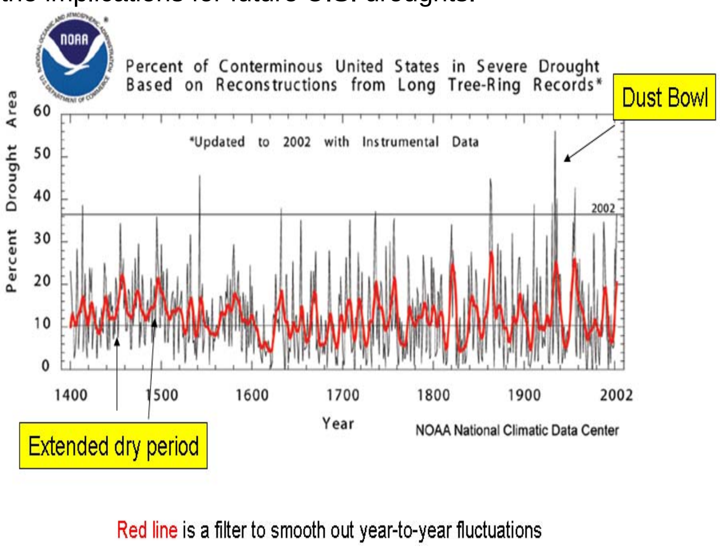

Figure 2. Percent of Conterminous United States in Severe Drought Based on Reconstructions from Long Tree-Ring Records

NOAA Priorities

- Applying advances in ocean/land/atmospheric observations, data assimilation, and modeling to improve drought outlooks.
- Improving understanding of the causes of droughts, as well as effects of land surface and vegetation feedbacks.
- Improving drought monitoring, especially estimates of soil moisture and snow water storage.
- Incorporating real-time analysis and monitoring of precipitation, temperature, soil moisture, snowpack, vegetation/crop stress, and river levels into the drought early warning system.
- Improved understanding of the effects of increasing emissions of greenhouse gases and changing aerosol concentrations on drought frequency, severity, and projections of long-term trends in aridity.
- Incorporating paleo-hydrologic records into resource management and drought planning.
- Determining effects of long-term temperature changes on drought severity and impacts.
- Reducing uncertainty in climate model predictions and projections of regional precipitation and stream flow changes.
- Creating a drought early warning capability to better serve the public and decision-makers through development of the National Integrated Drought Information System (NIDIS). NOAA leads NIDIS in collaboration with other federal agencies, state and local governments.

NOAA Resources for Additional Information

NWS Climate Prediction Center and Environmental Modeling Center – Intraseasonal to interannual climate variability modeling and outlooks; diagnostic studies of major climate anomalies; real time monitoring of climate; seasonal drought outlooks.

NWS River Forecast Centers, Office of Hydrological Development and National Operational Hydrological Remote Sensing Center – current river levels and flow volumes, plus their outlooks from days to months, and current U.S. snowpack conditions.

National Environmental Satellite, Data, and Information Service (NESDIS) National Climatic Data Center – Official archive for drought data sets; analyses of climate trends, monitoring and historical perspective on current seasons, and paleoclimatic reconstructions of drought.

NESDIS/ Center for Satellite Applications and Research – Global satellite vegetation indices for monitoring plant health.

Office of Oceanic and Atmospheric Research (OAR) Geophysical Fluid Dynamics Laboratory – Studies of long-term climate variability and change; development of climate models for use in multi-decadal climate projections and projections of climate change for the next 50 to 100 years.

OAR Earth System Research Laboratory – Research on causes of droughts and other high impact climate events; methods for improving climate analyses and forecasts; impacts assessments and regional applications of climate information.

OAR Air Resources Laboratory – Research on the bidirectional exchange of water between the land and atmosphere to improve models; high quality precipitation observations to detect trends.

OAR NOAA Climate Program Office – Competitive research support for developing a predictive understanding of the climate system and observational capabilities required for advancing NOAA climate services. Coordinates and supports the development of the NIDIS through the NIDIS Project Office. The NIDIS drought information portal is at www.drought.gov.