Drought

A drought occurs in the U.S. resulting in direct economic losses greater than $1 billion.

Data Summary

In the following table, note that the low and high likelihoods do not correspond to the low and high impacts. In addition, low and high impacts are not necessarily correlated with each other between different impact categories.

Category	Description	Metric	Low	Best	High
Health and Safety	Fatalities	Number of Fatalities	0[1]		
	Injuries and Illnesses	Number of Injuries or Illnesses			
Economic	Direct Economic Loss	U.S. Dollars (2011)[2]	$2 Billion	$8.7 Billion	$38 Billion
Social	Social Displacement[3]	People Displaced from Home ≥ 2 Days	0[4]		
Psychological	Psychological Distress	Qualitative Bins	0[5]		
Environmental	Environmental Impact	Qualitative Bins	N/A[6]		
LIKELIHOOD	Frequency of Events	Number of Events per Year[7]	0.50	0.63	1.0

This table shows the minimum, average, and maximum values for frequencies and impacts associated with the direct impacts of national-level droughts.[8] The event set evaluated was from 1980 to 2014 and contained a total of 22 droughts that met the $1 billion threshold. This analysis did not specifically include consideration for climate scenarios often associated with drought events (e.g. heat waves, reduction in precipitation and snowpack).

Event Background

The SNRA Drought National-level Event was originally developed by the DHS Office of Policy for the 2012–13 Homeland Security National Risk Characterization (HSNRC) project, a

[1] There are no significant human health implications resulting from a drought in the United States. To avoid double counting of impacts between hazard events, for drought and heat wave incidents which overlapped in time or which were reported together in historical data sets the SNRA counted human fatalities and injuries under the Heat Wave event, while direct economic losses were counted under the Drought event. As both property damage (e.g., damage to physical infrastructure) and crop damage were reported by the primary data sources used for these events in the 2015 SNRA as combined totals, this raises the possibility of over-reporting the direct economic losses for Drought. Non-crop damages to physical infrastructure by heat events can be substantial. However, previous DHS analysis conducted for the 2013 Homeland Security National Risk Characterization (HSNRC) Drought National-level Event indicated that these property damage costs were generally insignificant in comparison to the economic value of lost crops which were orders of magnitude greater.

[2] Low, best, and high estimates for direct economic loss are the historical minimum, average, and maximum for the event set. Adjusted from 2014 dollars of NCDC source to 2011 dollars for comparison with existing SNRA events.

[3] See discussion.

[4] See text for further description.

[5] No reported human health or displacement impacts. (The SNRA Psychological Distress Index is calculated from fatality, injury/illness, and displacement estimates. For Drought/Heat Wave events, non-economic impacts were reported under the Heat Wave event.)

[6] Environmental impact estimates were elicited from subject matter experts in 2011, prior to the addition of the Drought hazard event (2015).

[7] Historical lowest, average, and maximum number of events per year (calculated from inter-arrival times).

[8] Direct economic loss data was gathered from the National Oceanic and Atmospheric Administration (NOAA)'s National Climatic Data Center (NCDC) Billion Dollar Disaster List.

cooperative effort of the DHS analytic enterprise, to expand the 2011 SNRA risk knowledge base to additional threats and hazards relevant to national preparedness. The HSNRC data and analysis were updated and revised by Argonne National Laboratory in support of the 2015 SNRA.

The National Weather Service (NWS) defines drought as a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. Drought is a temporary aberration from normal climatic conditions; thus it can vary significantly from one region to another.[9] It is a normal, recurrent feature of climate that occurs in virtually all climate zones. However, drought conditions can be caused by human interaction with the natural world.

Drought characteristics include large-scale drying trends in precipitation, streamflow, and soil moisture fields. The impacts of a drought result from the interplay between the natural event (less precipitation than expected) and the demand people place on the water supply.

While droughts and heat waves can occur at the same time, they are separate meteorological events and are treated as separate hazard events in the SNRA.

The duration of droughts can vary greatly. For instance, there are cases when drought conditions develop relatively quickly and lasts a very short period of time, exacerbated by extreme heat and/or wind, and there are other cases when drought spans multiple years, or even decades.

Drought differs from other natural hazards in at least two significant ways:

- The onset and end of a drought can be difficult to determine. The effects of a drought can accumulate slowly, and may linger even after the apparent termination of an episode.
- Unlike most natural hazards, drought impacts are less obvious, and are spread over a larger geographic area.

During severe droughts, agricultural crops do not mature, wildlife and livestock are undernourished, land values decline, and unemployment increases. Droughts can cause a shortage of water for human and agricultural consumption, hydroelectric power, recreation, and navigation. Water quality may decline and the number and severity of wildfires may increase.[10]

Assumptions

- For the purpose of the SNRA, a national-level drought is defined as a drought producing direct economic loss in excess of $1 billion dollars.
- A 35-year time period, from Jan 1, 1980 to Dec 31, 2014, was used to estimate the inter-arrival rates/frequencies and impacts for droughts exceeding the $1 billion threshold. A full list of aggregated drought events used for this report is located in Table 1.
- The Data Summary table reports the maximum, average, and minimum frequency with which such droughts occurred in the United States, and the maximum, average and minimum impacts for fatalities, injuries, and direct economic losses associated with droughts in the data set.

[9] National Weather Service (2008, May). Drought: Public Fact Sheet. At http://www.nws.noaa.gov/om/brochures/climate/DroughtPublic2.pdf (retrieved December 2012).

[10] This section is substantially adapted from Chapter 15 of Federal Emergency Management Administration (1997), Multi-Hazard Identification and Risk Assessment (MHIRA): A Cornerstone of the National Mitigation Strategy. FEMA Mitigation Directorate. At https://www.fema.gov/media-library/assets/documents/7251?id=2214 (retrieved April 2013).

- Mean global drought conditions were not directly considered in this assessment. The focus of this analysis was limited to the climatic regions within the contiguous United States.

Frequency

For purposes of the SNRA, drought risk is based on historical weather and climate disasters reported by the National Oceanic and Atmospheric Administration (NOAA)'s National Climatic Data Center (NCDC) for the Billion Dollar Disaster List.[11] The best-estimate frequency is the average frequency of occurrence of droughts in the selected 35-year period. The low frequency is the inverse of the longest inter-arrival time in the data set (the longest number of years that two droughts are spaced apart); the high frequency is the inverse of the shortest inter-arrival time in the data set (the shortest number of years that two incidents are spaced apart).

Health and Safety

There were no fatalities or illness/injuries directly linked to the droughts in this data set.[12] In the developed world, widespread drought-related deaths are rare in the modern era. However, increasing drought conditions in developed countries such as the United States can have significant direct and indirect impact to food supplies which may put populations at risk.[13]

Economic Impacts

Direct Economic Impacts

Direct economic impacts as defined in the SNRA include decontamination, disposal, and physical destruction costs including property (structure, contents, physical infrastructure, and other physical property) and crop damage; one year's lost spending due to fatalities; medical costs; and business interruption directly resulting from the impacts of an event. The direct economic loss estimates of the Billion Dollar Disaster List were used for the 2015 SNRA without modification because of the close similarity of its direct economic loss estimation methodology with that of the SNRA.[14]

In performing these disaster cost assessments, NCDC gathers the statistics from a wide variety of sources.[15] The total estimated costs of these events are the costs in terms of dollars that would not have been incurred had the event not taken place. Insured and uninsured losses are included in damage estimates. Sources include the NWS, FEMA, U.S. Department of Agriculture, other U.S. Government agencies, individual state emergency management agencies, state and regional climate centers, media reports, and insurance industry estimates.[16]

[11] NCDC (2015). Billion-dollar U.S. weather/climate disasters 1980–2013. NOAA: at http://www.ncdc.noaa.gov/billions/events.
[12] To avoid double counting of impacts between hazard events, for drought and heat wave incidents which overlapped in time or which were reported together in historical data sets the SNRA counted human fatalities and injuries under the Heat Wave event, while direct economic losses were counted under the Drought event.
[13] Franke, R. W.; Chasin B. H. Seeds of famine: Ecological destruction and the development dilemma in the West African Sahel. Rowman/Allanheld: Towtowa, New Jersey, 1980.
[14] Smith et al (2013, June). U.S. billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases. *Natural Hazards* 67(2) 387-410. At http://www.ncdc.noaa.gov/billions/docs/smith-and-katz-2013.pdf (retrieved 18 January 2014).
[15] In 2012, NCDC reviewed its methodology how it develops Billion-dollar Disasters and examined possible inaccuracy and biases in the data sources and methodology used in developing the loss assessments. As a result, NCDC temporarily rounded their loss estimates to the nearest billion dollars while implementing the newest research to define uncertainty and confidence intervals surrounding these loss estimates. The current methodology for the production of this loss data set is described in Smith et al (2013), *op. cit.* This document highlights its strengths and limitations including sources of uncertainty and bias. The Insurance Services Office/Property Claims Service, the FEMA National Flood Insurance Program and the U.S. Department of Agriculture's crop insurance program are key sources of quantified disaster loss data, among others. The methodology uses a factor approach to convert from insured losses to total direct losses, one potential limitation.
[16] NCDC (2015). Billion-dollar disaster list, Overview: http://www.ncdc.noaa.gov/billions/overview.

For the NCDC source list, economic drought damages were inflated to a 2014 dollar value using average changes in the Consumer Price Index. In total, 22 droughts exceeding the $1 billion threshold are aggregated in the findings of this report. Low, best, and high estimates for direct economic loss are the historical minimum, average, and maximum for the event set, adjusted to 2011 dollars for comparison with the existing SNRA data set.[17]

The total loss for the 22 events was $201 billion (see Table 1 for a full breakdown of cost per event). The historical high for economic losses was the 1988 drought at $38 billion [2014 $40 billion], which was rated as one of the nation's worst in the past 100 years. The 1988 drought impacted large portions of the U.S. with very severe losses to agriculture and related industries. Barge traffic on the lower Mississippi River was stopped during June and July 1988 as a result of record low flows caused by drought conditions throughout most of the Mississippi Basin.[18] Five separate drought events (1993, 1996, 2005, 2006, and 2014) all reported the historical low for economic loss at $2 billion. The average economic impact is $8.7 billion [2014 $9.1 billion] per event. The largest gap between drought events of two years occurred twice during the event set—between 1980 and 1983, and again between 1993 and 1996.

Indirect Economic Impacts[19]

Direct economic losses alone do not represent the full picture of the economic impacts to the Nation from a disaster or attack. Indirect and induced economic losses can be substantially larger than the direct economic losses that occur in the aftermath of an event.

- **Indirect economic impacts** include costs incurred by the suppliers and vendors in the associated expenditure sectors for the industries impacted by the direct costs. Indirect impacts also include positive offsets due to increased spending within sectors impacted by the direct costs.[20]
- **Induced economic impacts** include those incurred due to reduced spending by households with members employed in any of the directly or indirectly affected industries. Induced impacts can also include substitution effects or likely transfers of economic activity from one set of sectors to another set, such as avoidance of air or other travel or altered transportation mode preferences to other sectors following an attack on the commercial air transport sector.

Highly mature economic models exist for calculating estimates of indirect and induced economic losses for natural disasters, human and animal pandemics, technological accidents, terrorist attacks, and cyber events. However, there is at present no generally agreed or practical method for translating estimates produced by these disparate models into a single measure which can be meaningfully compared across all of the threats and hazards of the SNRA in a defensible fashion. Because such a measure would yield data of great value for multiple purposes beyond the context of the SNRA and similar assessments, it has been among the highest risk research priorities for DHS and its academic Centers of Excellence for over a decade. Should these efforts prove successful in coming years, the next iteration of the SNRA will include comparisons of total economic loss to the Nation across all of its threats and hazards.

[17] CPI-U 2014–2011, 0.950.
[18] Chagnon, Stanley A. (1989, September). The 1988 drought, barges, and diversion. *Bulletin of the American Meteorological Society* 70(9) 1092-1104: available at http://journals.ametsoc.org/doi/abs/10.1175/1520-0477%281989%29070%3C1092%3ATDBAD%3E2.0.CO%3B2 (accessed on March 25, 2015).
[19] The SNRA's taxonomy of indirect and induced economic impacts comes from the DHS Terrorism Risk Assessments and so is retained here for consistency across DHS assessments. However, both combined will be referred to as 'indirect economic impacts' where it is not expected to impede clarity.
[20] These may include the waste management, environmental consulting, mortuary services, and medical industries, among others.

Social Displacement

For the purposes of the SNRA, social displacement was defined as the number of people forced to leave home for a period of two days or longer. By this measure, social displacement was assessed to be zero as a result of national level droughts.[21]

Note that there are limitations to this measure of social displacement, as permanent migration due to job loss or lack of opportunities from a hazard such as drought are not captured through this measure. For instance, during the Dust Bowl in the 1930's, millions of people migrated from the drought areas, often heading west, in search of work.[22]

Psychological Impacts

Psychological impacts for the SNRA focus on significant distress and *prolonged distress*, which can encompass a variety of outcomes serious enough to impair daily role functioning and quality of life. An index for significant distress was created that reflected empirical findings that the scope and severity of an event is more important than the type of event. The equation for this index uses the fatalities, injuries, and displacement associated with an event as primary inputs.[23]

Fatalities and injuries associated with historical heat wave/drought events were counted under the Heat Wave event by definition, and as noted above the assessed displacement was zero. As the SNRA psychological distress index is derived from the human health and displacement impact estimates, this measure reflects *de minimus* psychological distress impacts for the SNRA 2015 Drought event.

Environmental Impacts

The environmental impact estimate, which was assessed for the 23 original national-level events of the 2011 SNRA by subject matter experts from the U.S. Environmental Protection Agency (EPA), could not be assessed for the Drought event which was added to the SNRA in calendar year 2015. A future iteration of the SNRA will assess the environmental impacts of this event.

Potential Mitigating Factors

According to the National Drought Mitigation Center, studies over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature.

Scientists do not know how to predict drought a month or more in advance for most locations. Predicting drought depends on the ability to forecast two fundamental meteorological parameters, precipitation and temperature. Historical record reinforces that climate is inherently variable, and anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on air-sea interactions, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of dynamically unstable weather systems at the global scale.[24]

[21] For the purposes of the SNRA, social displacement was defined as the number of people forced to leave home for a period of two days or longer. To estimate social displacement for the SNRA, U.S. drought data from the Emergency Events Database (EM-DAT) maintained by the World Health Organization Collaborating Centre for Research on the Epidemiology of Disasters with support from the United States Agency for International Development, provides estimates of the "total number affected" by disaster events. The data from EM-DAT suggest that there were no displacements as a direct result of drought events.
[22] Reported by the National Drought Mitigation Center, http://drought.unl.edu/DroughtBasics/DustBowl/DroughtintheDustBowlYears.aspx.
[23] See Appendix G for references and additional discussion of the SNRA Psychological Distress metric.
[24] National Drought Mitigation Center is based in the School of Natural Resources at the University of Nebraska-Lincoln; http://drought.unl.edu/Home.aspx.

Additional Relevant Information

Although a variety of weather related phenomena have the potential to cause great economic and personal losses in the US, drought has historically had the greatest impact on the largest number of people. On a broad scale, the 1980s and 1990s were characterized by unusual wetness with short periods of extensive droughts, the 1930s and 1950s were characterized by prolonged periods of extensive droughts with little wetness, and the first decade of the 2000s saw extensive drought and extensive wetness.

Table 1: Drought Events[25]

Event	Begin Date	End Date	DE $B[26] (2014)	Summary
Western Drought 2014	01/01/14	12/31/14	$2	Severe drought CA, TX, OK.[27]
Western/Plains Drought/Heat Wave Spring-Fall 2013	03/01/13	11/30/13	$11	Moderate to extreme drought AZ, CA, CO, IA, ID, IL, KS, MI, MN, MO, ND, NE, NM, NV, OK, OR, SD, TX, UT, WA, WI, WY.[28]
U.S. Drought/Heatwave 2012	01/01/12	12/31/12	$31	Moderate to extreme drought CA, NV, ID, MT, WY, UT, CO, AZ, NM, TX, ND, SD, NE, KS, OK, AR, MO, IA, MN, IL, IN, GA.[29]
Southern/Plains/Southwest Drought Spring-Summer 2011	03/01/11	08/31/11	$13	Drought and heat wave conditions created major impacts across Texas, Oklahoma, New Mexico, Arizona, southern Kansas, and western Louisiana.[30]
Southwest/Great Plains Drought 2009	01/01/09	12/31/09	$4	Drought conditions with agricultural losses during much of the year across parts of the Southwest, Great Plains (TX, OK, KS, CA, NM, AZ), largest losses TX and CA.
U.S. Drought 2008	01/01/08	12/31/08	$8	Severe drought and heat caused agricultural losses across a large portion of the U.S. Record low lake levels also occurred in areas of the southeast.
Western/Eastern Drought/Heat Wave Summer-Fall 2007	06/01/07	11/30/07	$3	Severe drought with periods of extreme heat over ND, SD, NE, KS, OK, TX, MN, WI, IA, MO, AR, LA, MS, AL, GA, NC, SC, FL, TN, VA, WV, KY, IN, IL, OH, MI, PA, NY.[31]
Midwest/Plains/Southeast Drought Spring-Summer 2006	03/01/06	08/31/06	$2	Rather severe localized drought causes significant crop losses (especially for corn and soybeans) in the states of AR, IL, IN, MO, OH, and WI.
Midwest Drought Spring-Summer 2005	03/01/05	08/31/05	$2	Rather severe localized drought causes significant crop losses (especially for corn and soybeans) in the states of AR, IL, IN, MO, OH, and WI.
Western/Central Drought/Heat Wave Spring-Fall 2003	03/01/03	11/30/03	$6	2003 drought across western and central portions of the U.S. with losses to agriculture.
U.S. Drought Spring-Fall 2002	03/01/02	11/30/02	$11	Moderate to extreme drought over large portions of 30 states, including the western states, the Great Plains, and much of the eastern U.S.
Western/Central/Southeast Drought/ Heat Wave, Spring-Fall 2000	03/01/00	11/30/00	$7	Western/Central/Southeast Drought/Heatwave.
Eastern Drought/Heat Wave Summer 1999	06/01/99	08/31/99	$3	Very dry summer and high temperatures, mainly in eastern U.S., with extensive agricultural losses.
Southeast Drought/Heat Wave Summer 1998	06/01/98	08/31/98	$6	Severe drought and heat wave from Texas/Oklahoma eastward to the Carolinas.
Southern Plains Drought Spring-Summer 1996	03/01/96	08/31/96	$2	Severe drought in agricultural regions of southern plains--Texas and Oklahoma most severely affected.
Southeast Drought/Heat Wave Summer 1993	06/01/93	08/31/93	$2	Drought and heat wave across Southeastern U.S.
U.S. Drought Spring-Summer 1991	03/01/91	08/31/91	$5	Drought conditions over parts of the West, Central and eastern U.S. most affected the states IL, IN, KS, MN, OH, OR, PA, SD, and WA.
Northern Plains Drought Summer-Fall 1989	06/01/89	11/30/89	$4	Severe summer drought over much of the northern plains with significant losses to agriculture.
U.S. Drought/Heat Wave Summer 1988	06/01/88	08/31/88	$40	1988 drought across much of the U.S., very severe losses to agriculture and related industries. Combined direct & indirect deaths due to heat stress estimated at 5,000.
Southeast Drought/Heat Wave Summer 1986	06/01/86	08/31/86	$4	Severe summer drought in parts of the southeastern U.S. with severe losses to agriculture.
Southeast Drought Summer 1983	06/01/83	08/31/83	$6	1983 flash drought in the southeastern U.S. with losses to agriculture, most notably corn and soybeans.
Central/Eastern Drought/Heat Wave Summer-Fall 1980	06/01/80	11/30/80	$29	Central & eastern U.S. drought/heat wave damaged agriculture & related industries. Combined direct & indirect deaths due to heat stress estimated at 10,000.

[25] Table based on information reported by NOAA's NCDC. This table reflects the 2014 dollars reported by the NOAA source. The final SNRA estimates in the Data Summary table are converted to 2011 dollars for comparison with existing SNRA events (CPI 2014–2011, 0.950).
[26] Direct economic loss. Cost estimates are rounded to nearest billion-dollars. Ongoing research is seeking to define uncertainty and confidence intervals around the cost of each event.
[27] Historic drought conditions affected majority of CA for all of 2014 making it the worst drought on record for the state. Surrounding states and parts of TX, OK also experienced continued severe drought conditions. Continuation of drought conditions that have persisted for several years.
[28] The 2013 drought slowly dissipated from the historic levels of the 2012 drought, as conditions improved across many Midwestern and Plains states. However, moderate to extreme drought did remain or expand into western states. In comparison to 2011 and 2012 drought conditions, the U.S. experienced only moderate crop losses across the central agriculture states.
[29] The 2012 drought is the most extensive drought to affect the U.S. since the 1930s. Moderate to extreme drought conditions affected more than half the country for a majority of 2012. Costly drought impacts occurred across the central agriculture states resulting in widespread harvest failure for corn, sorghum and soybean crops, among others. The associated summer heatwave also caused 123 direct deaths, but an estimate of the excess mortality due to heat stress is still unknown.
[30] In Texas and Oklahoma, a majority of range and pastures were classified in "very poor" condition for much of the 2011 crop growing season.
[31] Severe drought with periods of extreme heat over most of the southeast and portions of the Great Plains, Ohio Valley, and Great Lakes area, resulting in major reductions in crop yields, along with very low stream-flows and lake levels.