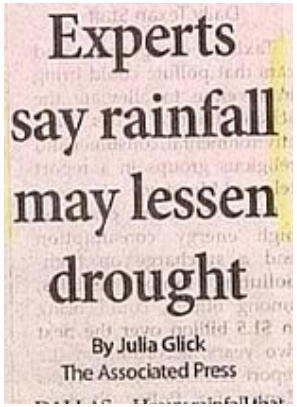
Defining Drought


Experts say rainfall may lessen drought

By Julia Glick
The Associated Press

Chad McNutt
NOAA, National Integrated Drought Information System (NIDIS)

Improving Drought Resilience – Forest to Valley Bottom
March 14-16, 2017
Choteau, MT

Our guide

Redmond, K.T. 2002. The Depiction of Drought: A Commentary

1. Definitional Issues
2. Tracking and Depicting Drought
3. Impact Information

THE DEPICTION OF DROUGHT

A Commentary

BY KELLY T. REDMOND

This issue of *BAMS* contains several articles that emphasize how we describe the status of drought. Interest in this topic has risen because of a combination of natural and human factors. The Southwest–southern Great Plains drought of 1995–96 led to the establishment of the Western Drought Coordination Council (WDCC) by the Western Governors Association. The subsequent National Drought Policy Commission (NDPC) expanded on WDCC recommendations distilled from the western experience. Both groups emphasized climate monitoring as a necessity. In May 1999, drought in an area of tremendous climatic significance—Washington, D.C.—led to the establishment of the Drought Monitor. A small cadre of climatologists, originally in the West—the Climate Prediction Center, the National Climatic Data Center (NCDC), and the National Drought Mitigation Center—were involved in every step in this sequence, and participation has gradually grown since.

The Drought Monitor is both a product and an activity. An extended e-mail "conversation" takes place for about 2–3 days each week, and the results are assimilated by the "author of the week" into a consensus product in the form of a national map. During a typical week about 15–20 out of a total distribution of around 140 individuals participate, mostly from affected areas. The article by Svoboda et al. captures the flavor of the Drought Monitor very well. The discussions, ranging widely as conditions and issues unfold, have proven to be a rich source of provocative thought. It is from these and numerous earlier WDCC discussions, and other experiences over the prior 15 years, that the personal perspective has been acquired to offer the observations and comments that follow.

DEFINITIONAL ISSUES. In depicting the status of

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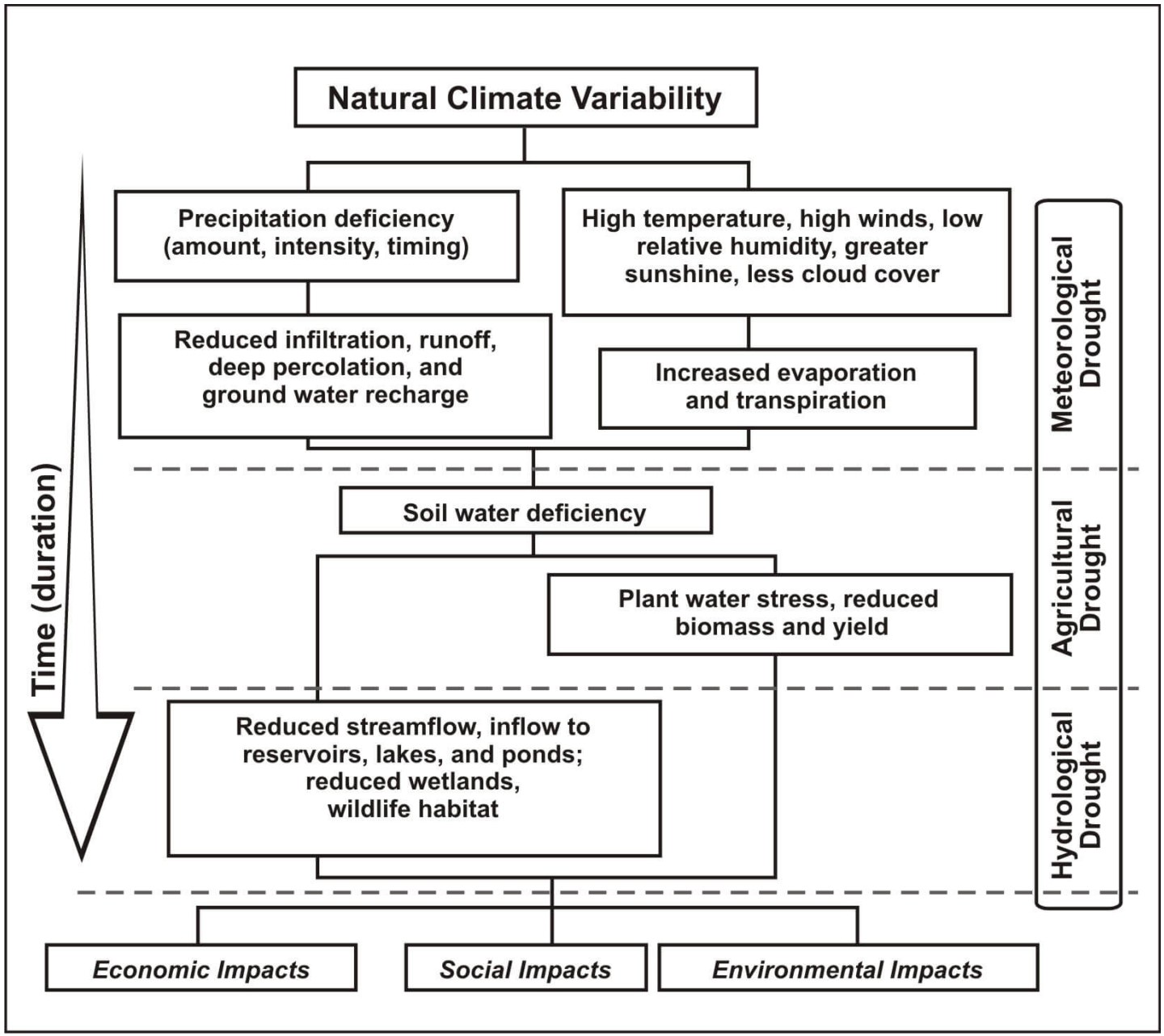
question, "What is meant by drought?" The problem of defining drought is longstanding and has never been resolved to the satisfaction of all. This fact alone surely tells us something. Drought means many different things to many different audiences. Early defi-

Drought Definitions

- **Meteorological:** degree of dryness over a defined period of time
- **Agricultural:** linking meteorological drought w/ ag impacts
- **Hydrologic:** precipitation deficits and their effect on the hydrologic system
- **Socio-economic:** demand for an economic good exceeds supply as a result of a weather/climate induced related shortfall in water supply

Wilhite, D.A. and Glantz, M.H., *Understanding the Drought Phenomenon: The Role of Definitions* (1985)


Natural Climate Variability
Precipitation deficiency (amount, intensity, timing)
High temperature, high winds, low relative humidity, greater sunshine, less cloud cover
Reduced infiltration, runoff, deep percolation, and ground water recharge
Increased evaporation and transpiration
Soil water deficiency
Plant water stress, reduced biomass and yield
Reduced streamflow, inflow to reservoirs, lakes, and ponds; reduced wetlands, wildlife habitat
Time (duration)
Meteorological Drought
Agricultural Drought
Hydrological Drought
Economic Impacts
Social Impacts
Environmental Impacts

Definitional Issues

"In my opinion, the preferred definition would be that which has the most universal range of application, the one that works in the largest number of circumstances."

"Most concepts of drought involve a water balance. This implies that both supply and demand must be considered, as well as the question of whether there is "enough" (and, enough for what?). Thus, through time I have come to favor a simple definition; that is, **insufficient water to meet needs**."

Drought: Supply and Demand

- Supply = physical climate system (biological feedbacks complicate this),
- Demand = ecosystems, human interactions, subject to manipulation/intervention to smooth supply variation

"It is mostly because of this demand side and the properties and causes of its variability that I feel we cannot escape consideration of impacts in how we characterize and describe drought. **This approach in effect defines drought in terms of its impacts**"

Tracking and Depicting Drought

"In developing an index to assess drought status, we quickly discover that we cannot escape from the issue of defining drought itself"

Index development: "A typical sequence is as follows. Someone hatches an idea for a new index; an algorithm and code are created; requisite observational input data (time series) are assembled, usually at considerable travail and effort, often based on different periods of record, not always homogeneous, and many times exhibiting unusual statistical properties."

Developing & Evaluating Indices

Evaluation: "Such intensive evaluations, especially once an index is in use, take a great deal of effort and are difficult to justify in the operational environment of an agency…. The evaluations often involve activities that such agencies rarely seek: **follow up on a past activity, with risk of an unfavorable outcome**."

- What is the purpose of the index?
- Who is the audience?
- What info. does the index convey and at what timescale?

Handbook of Drought Indicators and Indices

Integrated Drought Management Programme

WORLD METEOROLOGICAL ORGANIZATION

WMO-No. 1173

WEATHER CLIMATE WATER

Global Water Partnership

Towards a water secure world

Meteorology	Page	Ease of use	Input parameters	Additional information
Aridity Anomaly Index (AAI)	11	Green	P, T, PET, ET	Operationally available for India
Deciles	11	Green	P	Easy to calculate; examples from Australia are useful
Keetch–Byram Drought Index (KBDI)	12	Green	P, T	Calculations are based upon the climate of the area of interest
Percent of Normal Precipitation	12	Green	P	Simple calculations
Standardized Precipitation Index (SPI)	13	Green	P	Highlighted by the World Meteorological Organization as a starting point for meteorological drought monitoring
Weighted Anomaly Standardized Precipitation (WASP)	15	Green	P, T	Uses gridded data for monitoring drought in tropical regions
Aridity Index (AI)	15	Yellow	P, T	Can also be used in climate classifications
China Z Index (CZI)	16	Yellow	P	Intended to improve upon SPI data
Crop Moisture Index (CMI)	16	Yellow	P, T	Weekly values are required
Drought Area Index (DAI)	17	Yellow	P	Gives an indication of monsoon season performance
Drought Reconnaissance Index (DRI)	17	Yellow	P, T	Monthly temperature and precipitation are required

Soil moisture	Page	Ease of use	Input parameters	Additional information
Soil Moisture Anomaly (SMA)	25	Yellow	P, T, AWC	Intended to improve upon the water balance of PDSI
Evapotranspiration Deficit Index (ETDI)	26	Red	Mod	Complex calculations with multiple inputs required
Soil Moisture Deficit Index (SMDI)	26	Red	Mod	Weekly calculations at different soil depths; complicated to calculate
Soil Water Storage (SWS)	27	Red	AWC, RD, ST, SWD	Owing to variations in both soil and crop types, interpolation over large areas is challenging

Hydrology	Page	Ease of use	Input parameters	Additional information
Palmer Hydrological Drought Severity Index (PHDI)	27	Yellow	P, T, AWC	Serially complete data required
Standardized Reservoir Supply Index (SRSI)	28	Yellow	RD	Similar calculations to SPI using reservoir data
Standardized Streamflow Index (SSFI)	29	Yellow	SF	Uses the SPI program along with streamflow data
Standardized Water-level Index (SWI)	29	Yellow	GW	Similar calculations to SPI, but using groundwater or well-level data instead of precipitation
Streamflow Drought Index (SDI)	30	Yellow	SF	Similar calculations to SPI, but using streamflow data instead of precipitation
Surface Water Supply Index (SWSI)	30	Yellow	P, RD, SF, S	Many methodologies and derivative products are available, but comparisons between basins are subject to the method chosen

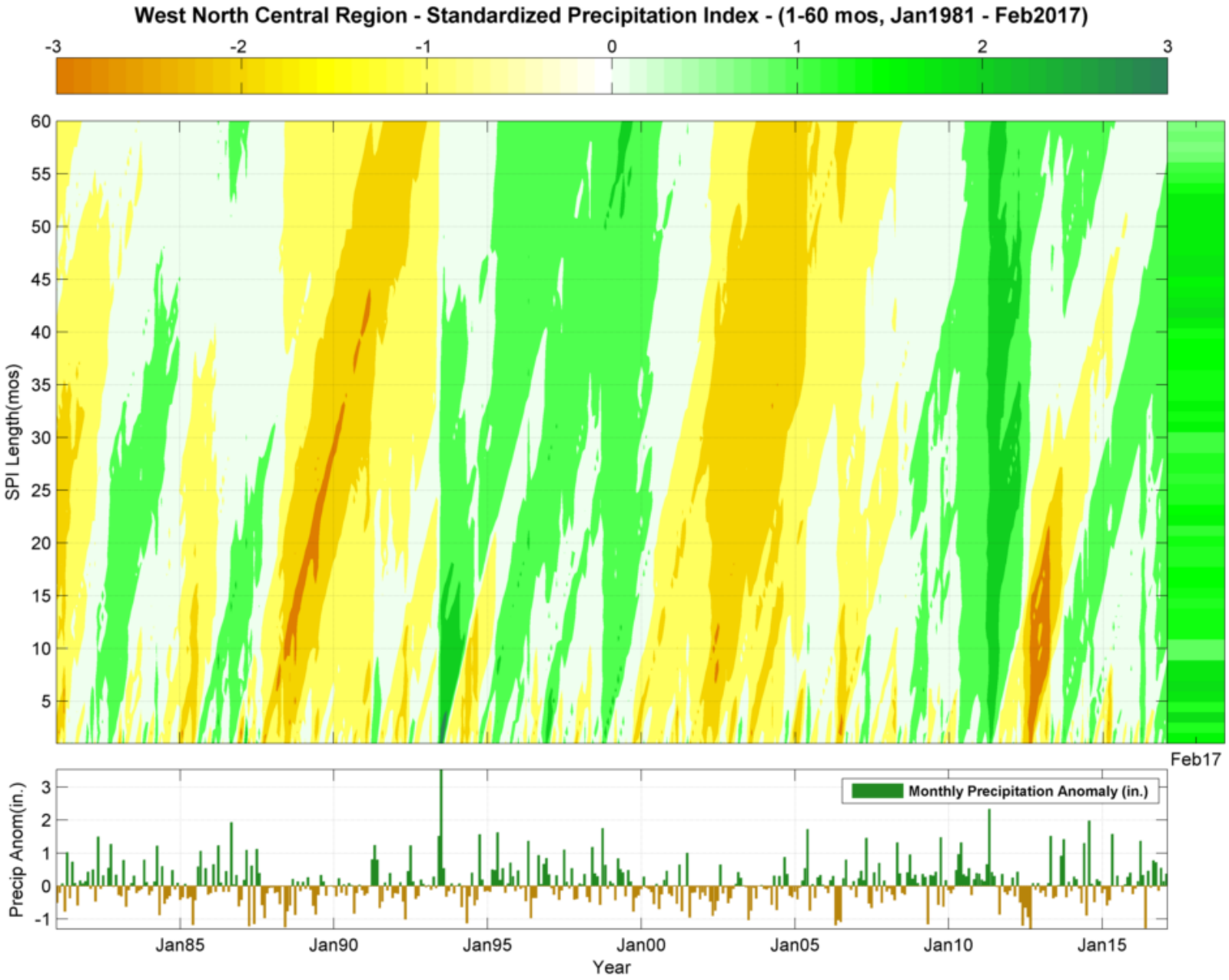
Remote sensing	Page	Ease of use	Input parameters	Additional information
Enhanced Vegetation Index (EVI)	32	Green	Sat	Does not separate drought stress from other stress
Evaporative Stress Index (ESI)	33	Green	Sat, PET	Does not have a long history as an operational product
Normalized Difference Vegetation Index (NDVI)	33	Green	Sat	Calculated for most locations
Temperature Condition Index (TCI)	34	Green	Sat	Usually found along with NDVI calculations
Vegetation Condition Index (VCI)	34	Green	Sat	Usually found along with NDVI calculations
Vegetation Drought Response Index (VegDRI)	35	Green	Sat, P, T, AWC, LC, ER	Takes into account many variables to separate drought stress from other vegetation stress

Composite or modelled	Page	Ease of use	Input parameters	Additional information
Combined Drought Indicator (CDI)	38	Green	Mod, P, Sat	Uses both surface and remotely sensed data
Global Integrated Drought Monitoring and Prediction System (GIDMaPS)	38	Green	Multiple, Mod	An operational product with global output for three drought indices: Standardized Soil Moisture Index, SPI and Multivariate Standardized Drought Index
Global Land Data Assimilation System (GLDAS)	39	Green	Multiple, Mod, Sat	Useful in data-poor regions due to global extent
Multivariate Standardized Drought Index (MSDI)	40	Green	Multiple, Mod	Available but interpretation is needed
United States Drought Monitor (USDM)	41	Green	Multiple	Available but interpretation is needed

Standardized Precipitation Index

"recognize and even emphasize that accumulated precipitation can be simultaneously in excess and deficit on different timescales"

1. What is the absolute amount of precipitation that has fallen?
2. What is the departure from average?
3. What is the departure in percentage terms?
4. What is the value in frequency space (percentile)?
5. What is a single number that best encompasses this information?



Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate

Data source: NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv
Base Period= 1900-2017 Date created: 08-Mar-2017

Issues with Depicting Drought

- Regional differences (wet area in drought vs. dry areas in drought)
- Lags in the system (e.g. hydrological drought, snow drought?)
- Seasonality differences
- Flash droughts

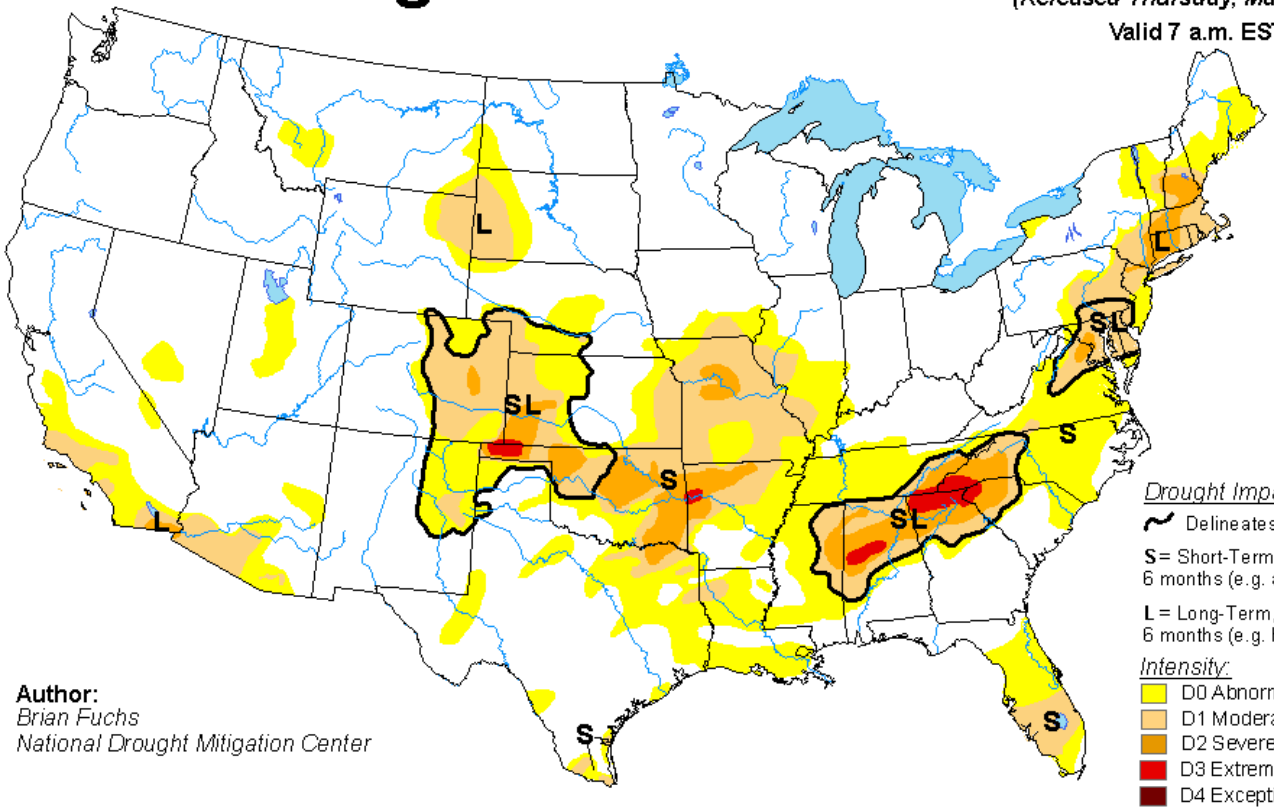
"Water supply regions for agriculture, human consumption, recreation, power, navigation, fish, and wildlife can be hundreds or thousands of miles from demand regions. As a result, severe and substantial drought impacts in one location can occur as a result of **climate events far away, or long ago, or both."**

U.S. Drought Monitor

March 7, 2017

(Released Thursday, Mar. 9, 2017)

Valid 7 a.m. EST



Author:
Brian Fuchs
National Drought Mitigation Center

Drought Impact Types:

Delineates dominant impacts

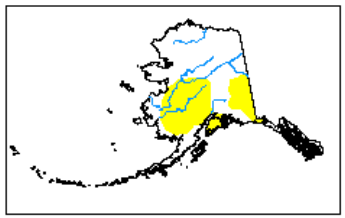
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)

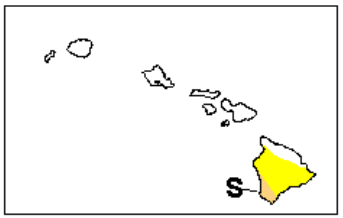
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)

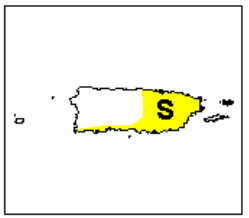
Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.







USDA

National Drought Mitigation Center

http://droughtmonitor.unl.edu/

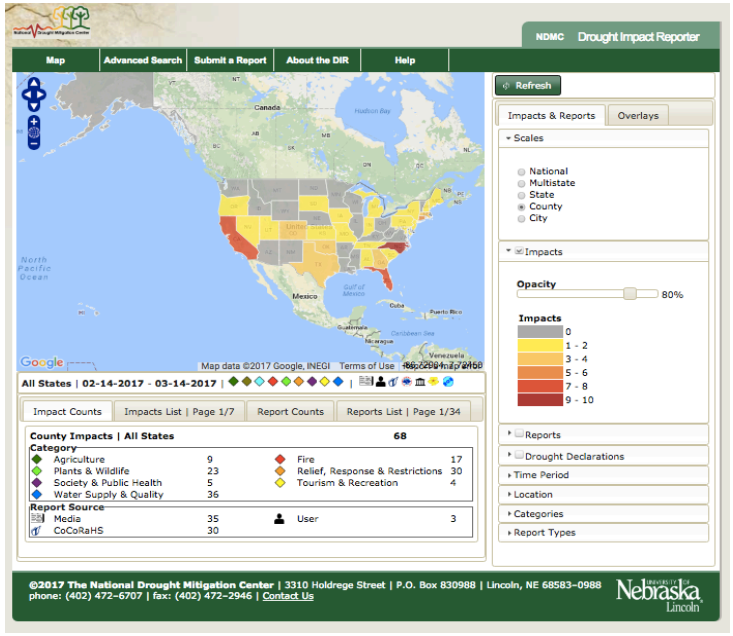
U.S. Drought Monitor

- Assessment of **current** conditions
- The U.S. Drought Monitor is ***NOT*** a model
- The U.S. Drought Monitor is ***NOT*** interpreting just precipitation
- The U.S. Drought Monitor is ***NOT*** a forecast or drought declaration
  - Can be used in this way though
- Identifying **impacts**
  - "**S**" short-term impacts, "**L**" long-term impacts or "**SL**" for a combination of both
- Incorporate **local expert** input
  - Accomplished via email and impact reports
- Authors try to be as **objective** as possible (using the percentiles methodology)
  - The data ***must*** support the depiction on the map
- ***"Convergence of evidence"*** approach

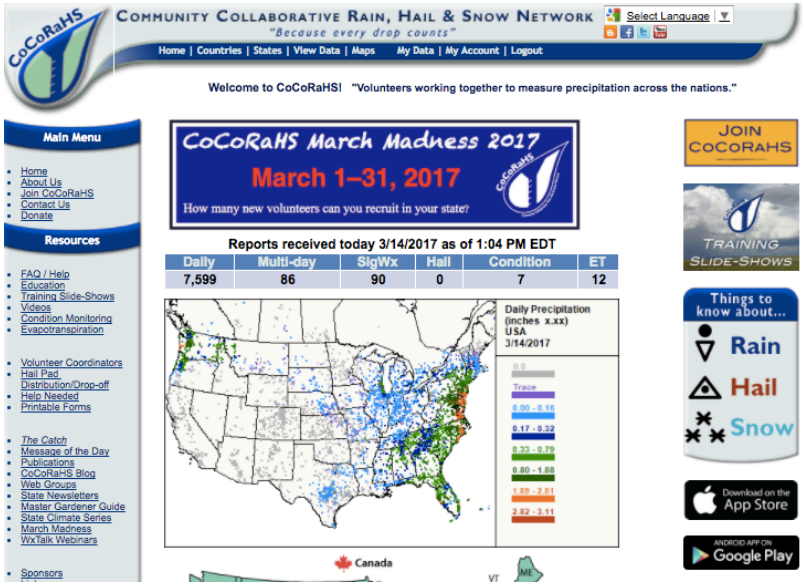
"It is not likely that there is an easy way out of this depiction dilemma. Drought is a many-headed creature, and its full description requires an equally diverse menagerie of indices and indicators."

Impact Information

"The effect of drought varies widely, and the same physical climate sequence can easily produce very different impacts to a wide variety of economic sectors, ranging from none to extreme. **In essence, as with rainbows, each person experiences their own drought."**



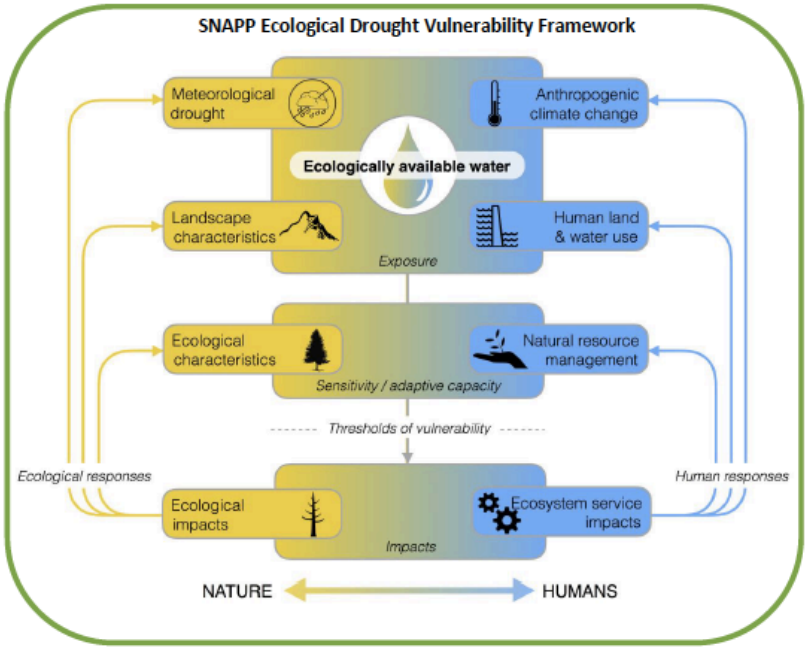
Drought Impact Reporter



CoCoRaHS Condition Reports

5-Practical Issues for Indicators and Ecological Drought

1) time scale
2) probability
3) precipitation deficit
4) application of eco drought to precipitation and to EAW
5) the relationship of the definition to the impacts.



McKee et al. 1993

THANK YOU