

WESTERN WATER ASSESSMENT WHITE PAPER

Tracking Socioeconomic Impacts of Drought with
Rapid Analytics and Dashboards

by William R. Travis and Zachary Johnson

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Introduction

In response to a need in the Western Water Assessment (WWA) region¹ for socioeconomic data and tools that can aid climate adaptation strategies, especially with regard to drought, the WWA funded an effort to explore the potential for expanding drought impact assessment beyond current information available through the National Drought Information System (NIDIS, see: <http://www.drought.gov/drought>) and associated outlets like the National drought Mitigation center at the University of Nebraska-Lincoln (see: <http://drought.unl.edu>). NIDIS is developing regionally-specific impact indicators in its regional early warning programs (e.g., the Colorado River Basin, California, and the Southeast pilot drought early warning system), and we explore options for such measures in this white paper. We also prototype national and local economic impact indicators, and develop visualizations and analytics that could provide users with more power to track the socio-economic effects of drought.

Strategic Goals

Following the findings and recommendations from two previous WWA white papers (Travis et al. 2011; Travis and Klein, 2012) and in light of expressed need from groups like the Western Governors' Association (WGA, 2011) and the State of Colorado (Klein et al., 2011), we first developed a strategic list of objectives and indicator goals. The overall objectives were to:

- Review current indicators, explore options for enhancing socio-economic impacts tracking and assessment
- Explore options for new indicators and impacts measures and products, and experiment with analytics and visualizations via dashboards.

We identified these challenges to measuring drought impacts:

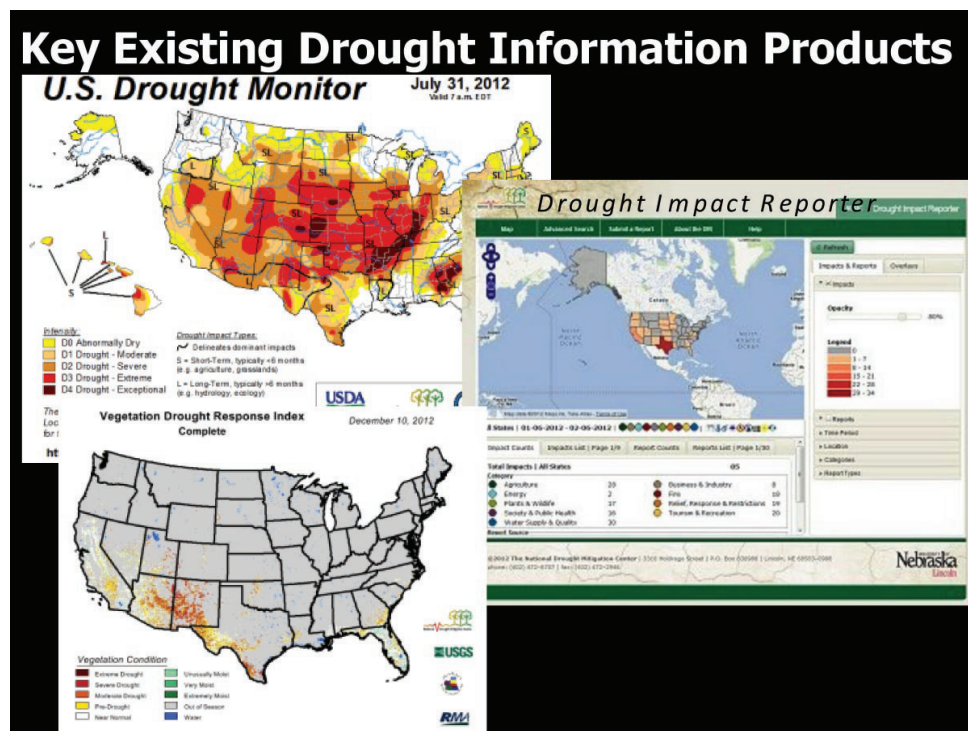
- No central database for losses, no accepted time series of losses
- Losses not measured in fatalities or obvious property damage (though hurricane, flood and tornado loss data series are not so great either)
- Little insurance data (outside of agriculture)
- Few “disaster” declarations
- Not even a unified roster of drought events
- Difficult to define spatially and temporally
- Yet: drought is frequently cited as most pervasive and among most costly hazards in U.S.---in 2012 many media stories about impacts, and calls for loss estimates.

We further recognized that not only does NIDIS already provide near-real-time drought data (Fig. 1), but that extensive climate, hydrological and agricultural data is available, some of it in dashboard and user-friendly formats. So we committed to exploring options for enhancing

¹ WWA is one of several Regional Integrated Sciences and Assessment (RISA) programs funded through NOAA. The WWA region includes Colorado, Utah and Wyoming.

socio-economic impacts tracking and assessment that go beyond current, mostly geo-physical, indicators.

Figure 1. Example products from NIDIS.



To that end, we set these strategic goals for developing new indicators:

- Put drought impacts in geographical perspective
- Normalizing and indexing for comparison over time and space
- Quantifying vulnerability
- Prototype: leading, current, and following indicators
- Develop region-specific indicators
- Develop early warning indicators
- Explore experimental measures that reflect national impacts
- Explore experimental local-to-national economic impact projection and assessment.

We also explored the role that analytics and dashboards might play in drought decision support systems.

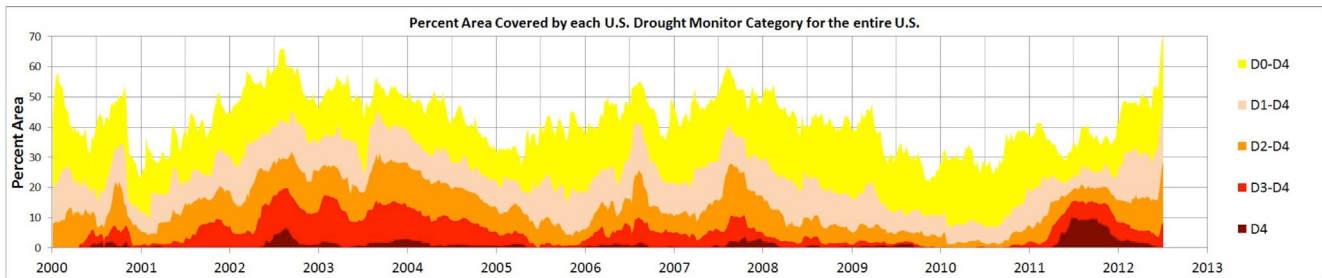
Results

This white paper briefly illustrates and describes a set of analytics and dashboards that address each of the goals, except for the last which, as noted in Travis and Klein (2012), needs much more development and investment.

Putting drought impacts in geographical perspective

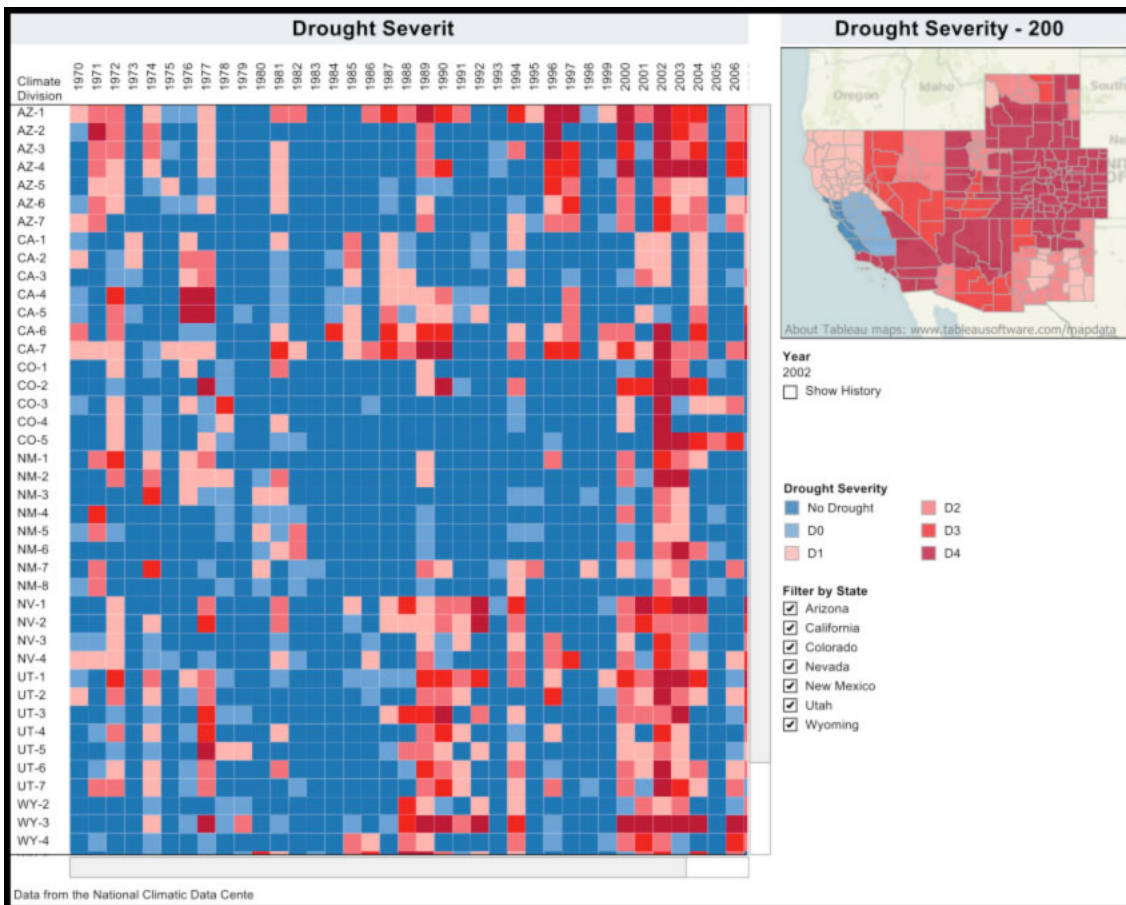
The US Drought Monitor provides a geographical footprint of drought that is now tracked as a national indicator of “area in drought” (Fig. 2). Several organizations, such as the *New York Times*, have produced user-friendly versions of this time series, and the USDA now routinely maps crop areas under different drought intensities.

Figure 2. One version of the US Drought Monitor expressed as a time series of area in different magnitudes of drought. (This version appeared on the New York Times web site).



We experimented with two variations on this geographical theme, first creating a cartogram that reveals patterns of intensity and time abstracted from geographical location (Fig. 3), and then creating the drought-area time series as a proportion of the resident population (rather than land area) affected by different drought intensities (Fig. 4).

Figure 3. A cartogram of drought intensity over time (left panel) and the data mapped onto climate divisions for the Southwest Climate assessment area.



The “affected population” indicator allows a more socially-relevant assessment of the number of people experiencing a certain level of drought on a monthly basis (though the underlying population will be up-dated only annually). We plotted the value as a whole number to illustrate that, compared to the land area index, the population index changes over time (growing in most regions). The indicator can also be calculated as a proportion (percent). In some cases one can imagine a rather extensive drought in the “percent area” index showing up as a smaller event in the affected population index (or vice versa).

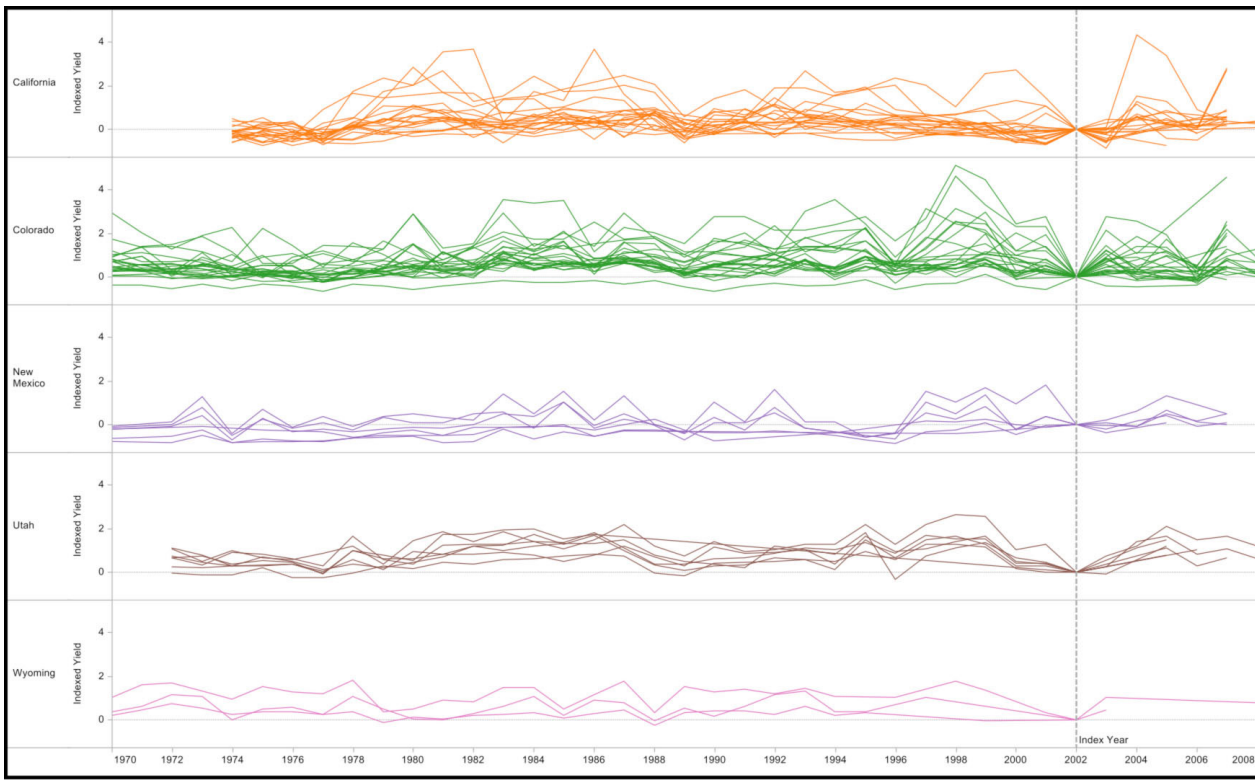
Figure 4. A dynamic dashboard showing affected population rather than land area (for the SWCA five-state region), with user able to select details of intensity, state, or time.



Analytics: Normalization and indexing for comparison over time

Next we explored the potential for developing dashboard analytics that allow the user to specify, for example, a point in time and then normalize all other data to that value. This was in response to efforts especially in Colorado to compare previous and more recent droughts with conditions in the seminal year 2002. In the example shown in Fig. 5 we provide time series for dryland wheat yields for southwestern US counties and allow the user to select a year and re-calculate all other data as a proportion of that year. Switching years or using a slider to shift through the time series gives quick assessment of the relative impacts for a given year, and makes counties that consistently over- or under-perform the others stand out. We also developed similar normalized dashboards for western state wildfire numbers and area (see final, combined dashboard).

Figure 5. Wheat yield time series with a moveable reference year set by the user. As the reference year is changed, the yields in other years are re-calculated as a proportion of the selected year.

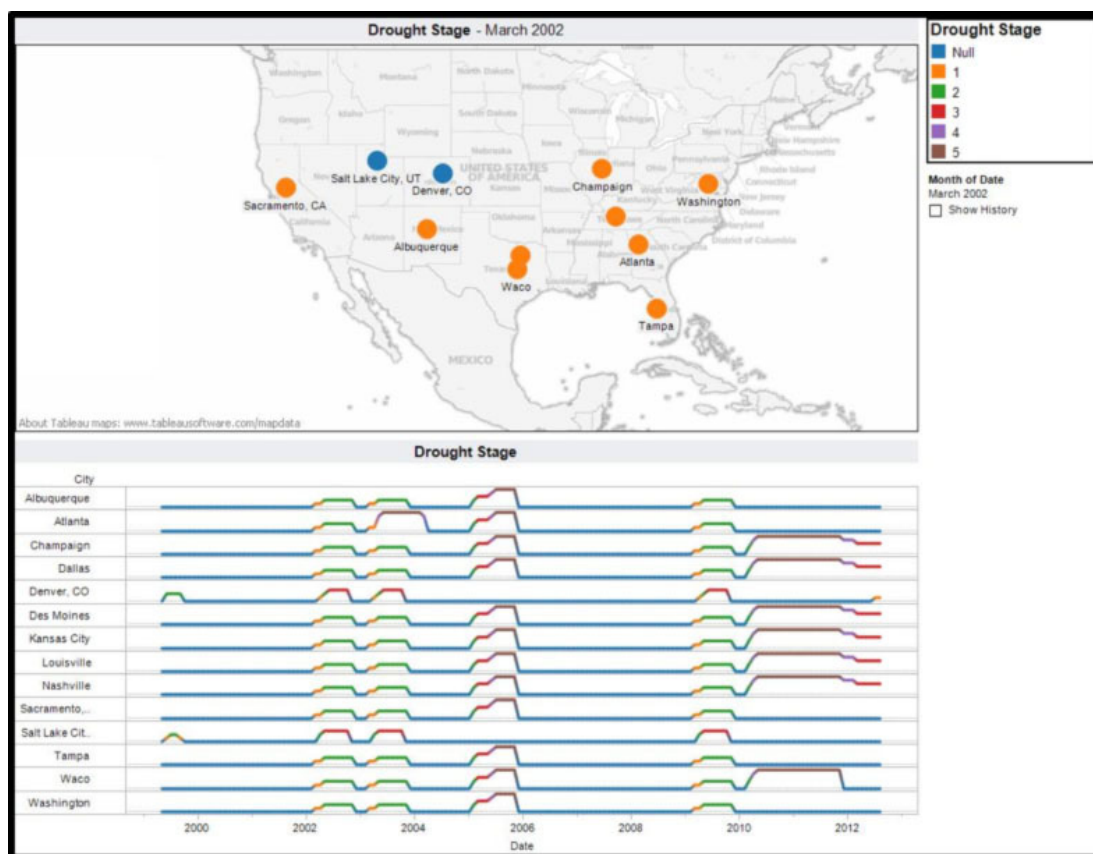


Prototype real-time measures

We developed a sample of real time indicators that reflect local-to-national drought impacts. Some regional indicators we explored are based on previous droughts and track impacts known to have caused problems in the past, such as barge traffic on the Mississippi River, cooling water availability to power plants, Great Lakes levels/shipping restrictions, groundwater pumping restrictions, and cattle sales. Such indicators can nicely reflect local to regional impacts, but for the most part they are not archived, nor are they collected with a view toward tracking of drought impacts. An effort would be needed to gather them and create useful visualizations for regional and national assessors.

The example we illustrate here deserves that investment, we believe. Because a common drought declaration system has come to be adopted by many municipal (some some rural) water systems, and because declarations are up-dated over short time periods by local officials as conditions change (and disseminated to local publics via municipal websites), we believe it would be possible collect and track (at a monthly time-step) a relatively large and representative sample of drought declarations for water systems across the nation. (Fig. 6)

Figure 6. A prototype drought declarations dashboard. The declarations time series can be animated and explored by the user.



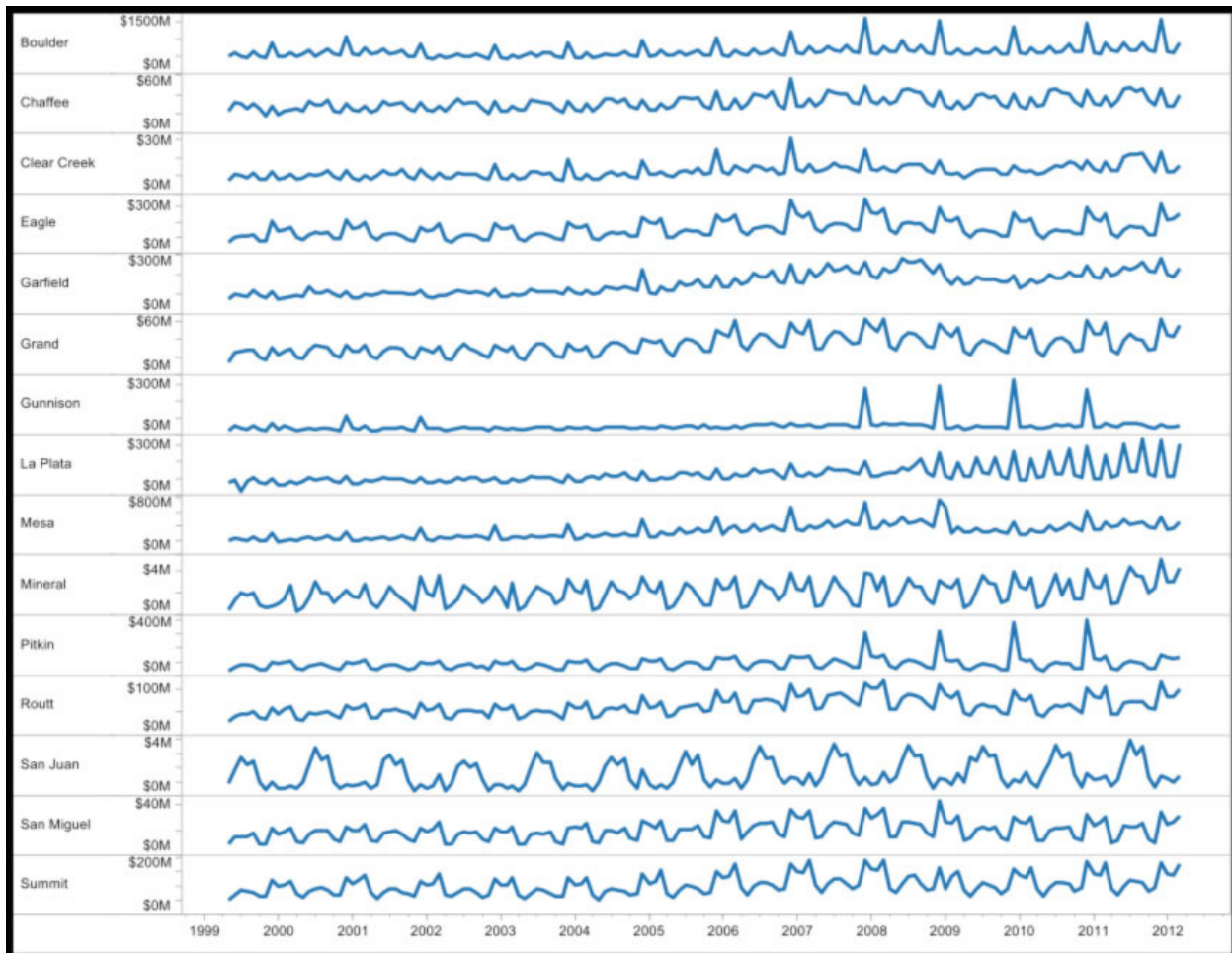
The challenge in generating new indicators is the necessary commitment to gathering the data and maintaining the archive as well as the publicly accessible dashboard. Thus care is needed in choosing a few key measures to develop as part of the national drought impact assessment structure. Water utilities drought stage declarations is a high priority that deserves attention as a regularly-collected indicator. A few other measures we examined that have the potential also to act as early-warning of worsening drought impacts include insurance claims, cattle sales activity, outdoor recreation, and activity in the landscaping and other green industries (e.g., horticulture, lawn care, and landscape services). The challenge with these potentially-useful drought impact indicators is that the data are often in the private sector, not archived, or simply not collected.

Economic Indicators

The only significant regular efforts to calculate the economic impacts of drought are associated with agriculture: crop and livestock effects are translated into farm income loss, and other impacts (e.g., consumer prices). Even these economic impacts are not calculated in a consistent fashion, made available for additional analysis, archived, nor aggregated to the national scale. Estimate of impacts in other sectors appear occasionally, especially for serious droughts with state-wide or regional-to-national impacts, such as the 2010-11 drought in Texas. Yet qualitative and narrative, anecdotal reports often refer to economic impacts of water shortages, impacts on the green industries, forestry, recreation and other sectors. Costs associated with wildfire are reasonably well measured, but are not always associated with drought.

We explored alternative socio-economic indicators. One that might offer some indication of drought impacts, and is widely available, is business tax receipts, especially sales taxes, and taxes associated with recreational activities, including lodging in resort areas. Sales tax data are often available at the county scale, monthly, and broken into useful categories such as retail sales, lodging, restaurant, etc. We added monthly retail sales taxes for several counties in the Colorado to examine their seasonality and to search for effects of the 2002 drought (Fig. 7). We have not yet analyzed these data for drought patterns.

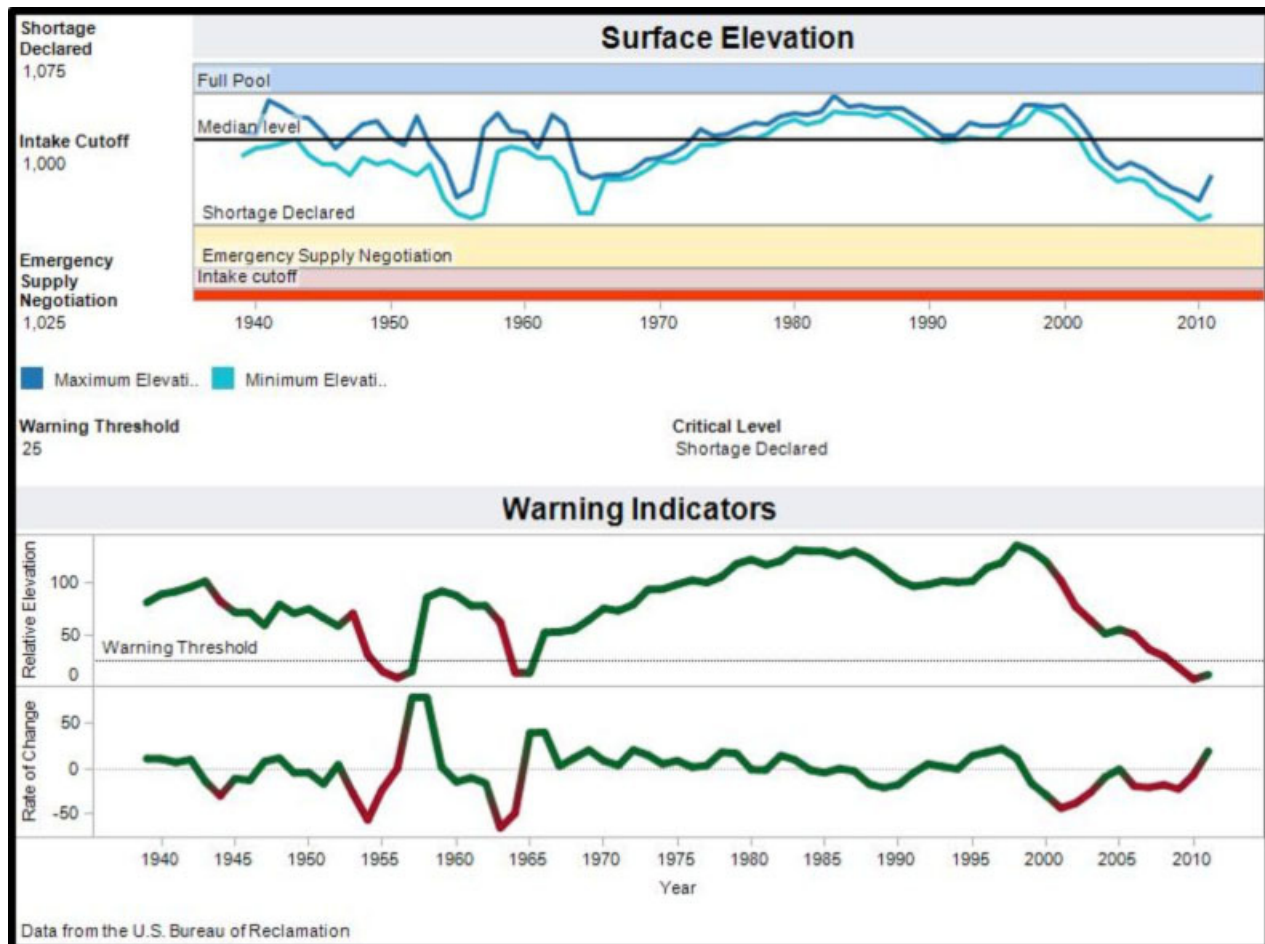
Figure 7. Monthly retail sales tax receipts, Colorado mountain counties.



Early Warning Indicators

Many of the indicators mentioned above can be collected, analyzed, and visualized so as to act as early warning or leading indicators of drought impacts. Leading indicators can be considered those that reflect impacts in an early stage within a given sector or activity, or that presage impacts spreading into other areas and sectors. The analytics/dashboard tool that we use, *Tableau*, is employed especially in the business sector to track, dashboard, and warn about changes in business conditions. In Fig. 8 we illustrate a hybrid time-series/early warning system for a major water resource reservoir.

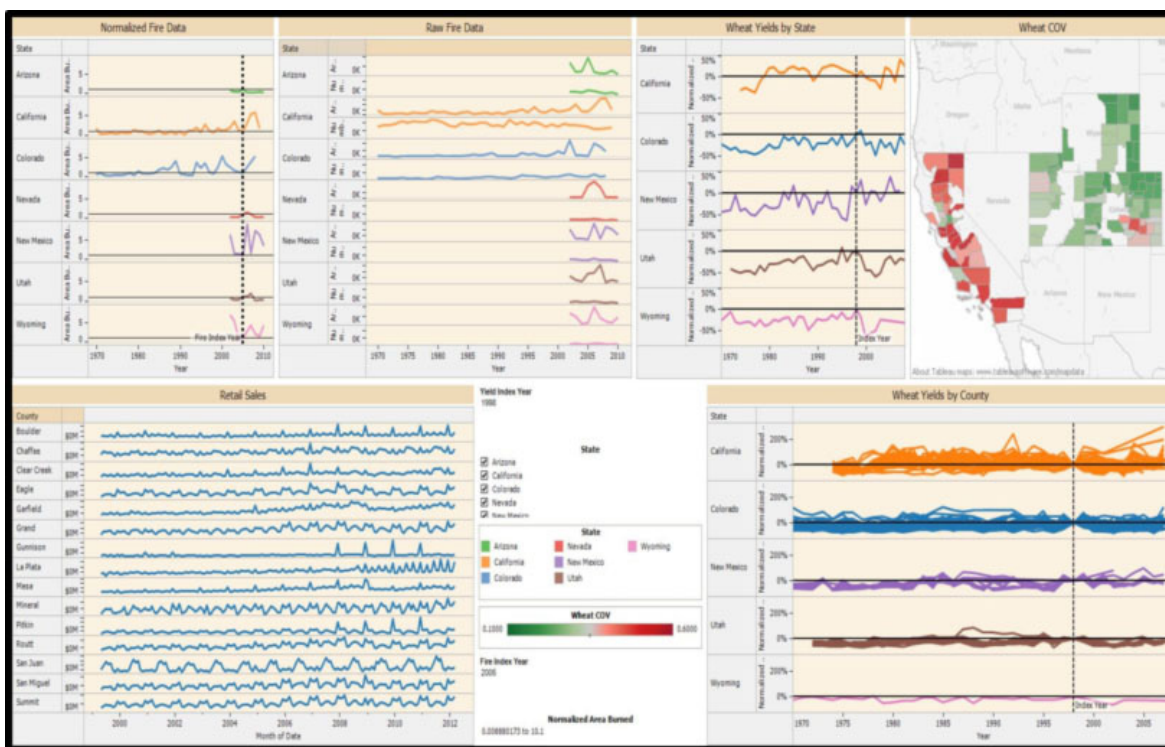
Figure 8. Dashboard views for a time series of reservoir contents with regulatory and physical thresholds (top panel), and a real-time indicator of approach or departure from a key threshold using the traditional spectrum from green (good) to red (bad) as the warning visualization. The user can set the “warning threshold”, rate of change, and other parameters.



Combined and Customizable Drought Impact Dashboards

Drought impact indicators can be combined in dynamic dashboards to allow quick assessments and analysis. While the main goal of our efforts is to better measure the often under-reported socio-economic effects of drought, there is some value in trying to make the indicators visually compelling and to allow manipulation by the user. In Fig. 9 we combine several types of indicators, including a measure of vulnerability (coefficient of variation of dryland crop yields) and normalized values for crop yields, wildfire number and area, and county-level retail sales tax receipts to reflect local economic activity.

Figure 9. Several drought impact indicators combined into a dynamic, customizable dashboard. Such dashboards can be served on the web.



Conclusions and Recommendations

Improved assessment of the socio-economic effects of drought will require investing in development of new indicators, data collection, visualization and dissemination. Indicators can reflect vulnerability, impacts, or relative effects, and can be used to judge response needs as well as provide early warning of worse impacts to come. As we found in WWA white paper No. 11 on quantifying drought socio-economic impacts, we lack measures that can judge the overall gross or net economic effects of drought at the regional to national scale; outside of agricultural effects, little effort has been expended to measure the costs of drought. Although we explore several different measures here, including some that would reflect only regional conditions (e.g., barge traffic on the Mississippi River), it is possible as we suggest in the previous white paper, and as proposed by Ding et al. (2010), that we could model and assess regional and national drought impacts with a national input-output model like IMPLAN. The multiple inputs and outputs of such a model could be managed in an analytics software such as used here to produce drought impact indicators. We also found cases where available proprietary data (for example, daily to weekly cattle sales across the country or end-of-season ski area data surveys) could be purchased and fed into the drought indicators dashboard.

The other great weakness in the nation's drought impact assessment skills is in the area of ecosystem services. Beyond water supply and agricultural yields, little effort is made to assess the short- and long-term ecological effects of drought, and how those effects translate into socio-economic impacts. This is true of all natural hazards, but the pervasive and cumulative effects of drought suggest that it is the hazard most under-measured by the few indicators currently available.

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