11.1 DETERMINING DROUGHT SEVERITY AND EXTENT: THE U.S. NATIONAL DROUGHT MONITOR

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1. INTRODUCTION

In August 1999, a new product providing a weekly assessment of drought conditions for the United States was released for the first time. This product is called the Drought Monitor. Since then, the Drought Monitor map and accompanying text have received a large amount of attention. The original goal of the Drought Monitor was to provide a relatively "simple" classification of drought severity over a large scale based on a variety of indicators that could be easily interpreted by users such as the public, media, decision- and policy-makers, and the scientific community. The Drought Monitor does not attempt to capture local conditions that may vary considerably from the larger scale, nor is it a "forecast" but rather a weekly "snapshot" of the current conditions (Svoboda et al. 2002).

The Drought Monitor began as a partnership of three agencies. Now, nine authors from four agencies take turns developing the Drought Monitor map each week. The four agencies are: NOAA's Climate Prediction Center, NOAA's National Climatic Data Center, USDA, and the National Drought Mitigation Center (NDMC). Each author develops the map for a two- or three-week period, and then it rotates to a different author. In addition, there is a very important group of "local experts" that provide input to the Drought Monitor author each week. This group of experts has now grown to more than 150, and their input is critical in validating the Drought Monitor's accuracy across the country.

2. DROUGHT MONITOR MAP

Figure 1 shows the Drought Monitor map for August 6, 2002. The map shows four levels or categories of drought severity ranging from moderate drought (D1) up to exceptional drought (D4). There is also a fifth category labeled as "abnormally dry" (D0) that works to 1) alert officials that recent dryness could be sending them into a drought situation, and 2) help identify those areas coming out of a drought event but are still experiencing some lingering impacts. The categories were established to roughly align with possible return periods for droughts: moderate drought might occur every couple of years; severe drought about every 10 years, extreme drought every 20-25 years, and exceptional drought every 50 years or so.

The maps are released every Thursday morning before the agricultural markets open in the United States. However, the maps portray the drought conditions up through 8 am Eastern Time Tuesday mornings. Any precipitation that may change a drought situation and falls on Tuesday or Wednesday does not get incorporated until the next week's map.

The Drought Monitor maps also try to give an indication of the major impacts that are occurring with each drought event, particularly if one sector is affected more than another. Three impacts qualifiers exist: "A" for agricultural impacts, "W" for hydrological impacts, and "F" for wildfire impacts. Usually these qualifiers are added if one or two of the sectors is being affected more than the other(s). If all three sectors are being affected at approximately the same level, either no qualifier is added, or sometimes all three are added depending on what might make the map clearer for the user. Unfortunately, impacts blur between these qualifiers and so the qualifiers should be viewed as a rather imperfect generalization. The Drought Monitor map in Figure 1 shows that wildfire impacts related to the drought are not as big an issue in southeastern Arizona and southern New Mexico, and so the qualifiers "A" and "A, W" are added in these areas.

The Drought Monitor map is available on a web site hosted by the NDMC (http://drought.unl.edu/dm/). This site also contains the narrative that accompanies the text, as well as the indicators that are used to develop the maps and any supplemental information or forecasts that might be helpful for a user interested in the information behind the creation of the map or how a drought situation might evolve in the coming weeks and months.

3. DROUGHT CLASSIFICATION SCHEME

One of the first tasks in creating the Drought Monitor product was to develop a drought classification scheme that identified the important drought indicators used to create the Drought Monitor map and the associated severity levels that correspond to the Drought Monitor severity levels. Table 1 shows the current drought classification table. Several of the indicators, except for the Palmer Drought Severity Index (PDSI) and percent of normal rainfall, are organized by percentiles, which makes them more closely correspond with the rough return periods of the Drought Monitor categories. Additional indicators are also very important in the development of the Drought Monitor maps including snowpack information, radar-estimated rainfall totals, and agricultural statistics from the state and national Agricultural Statistics Service offices such as the condition of rangelands and the top and subsoil moisture levels.

4. ASSOCIATED PRODUCTS

As mentioned, the Drought Monitor is an assessment of the current drought conditions. In March 2000, a Climate Prediction Center (CPC) product was first released that provides a 3-month "outlook" of what drought conditions could potentially be. This CPC

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product is called the Seasonal Drought Outlook or SDO. The SDO is created and released on the third Thursday of each month and is based on the Drought Monitor for that week. The SDO is available at the CPC web site [http://www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html].

Another suite of new products created as a result of the Drought Monitor effort are called the experimental Objective Blends of Drought Indicators (OBDI). These experimental products are an attempt by the authors of the Drought Monitor, and particularly Rich Tinker at CPC, to blend a variety of relevant indicators into objective long-term, short-term, and "unified" (combined short- and long-term) drought products. The relevant indicators and their associated weighting factors were initially discussed and selected by the authors and other scientists at a forum for Drought Monitor issues held in Lincoln, Nebraska in November, 2000. Since that time, they have been adjusted, tested, and compared to reported ground conditions and related impacts.

All of the OBDI products are generated using CPC's real-time daily and weekly climate division data and NCDC's monthly archive of indices for 1932-2000. Tables 2 and 3 show the indicators used in calculating the raw versions of both the short- and long-term blends, along with their weighting factors. The "raw" unified blend product is simply the average of the short- and long-term blends. The "finished" unified product actually plots the percentile of the current raw values relative to the 1932-2000 distribution of values generated from NCDC's monthly climate division data archive.

More details about the methodology, all of the OBDI products, and their archives can be found on a web site at CPC [http://www.cpc.ncep.noaa.gov/products/predictions/experimental/edb/access.html].

In addition to the OBDI maps, a table is generated describing the proportion of the country currently below or above selected percentile thresholds. The areal extent of drought conditions, the anomaly, and the percentile are each generated for the short-term, long-term, and "unified" blend index percentiles. This allows for a quick summary of how much area is being affected by drought each week, how that extent compares to historical occurrences, and whether things are getting better or worse nationally. Table 4 provides an example of the weekly update for the unified blend for August 3, 2002.

As part of a different project, additional efforts are underway on a prototype interface that allows a user to calculate a weekly SPI and PDSI [http://nadss.unl.edu] value on a station-by-station basis for the High Plains using real-time data obtained from the Unified Climate Access Network (UCAN) (Pasteris et al. 1997). The next step is to take this interface to the national level, which would be very beneficial for the Drought Monitor product.

5. NEXT STEPS

The Drought Monitor product continues to evolve. One of the next steps the product will undergo is the creation of a partner product called the North American Drought Monitor that will involve both Mexico and Canada. The Drought Monitor itself will still be created and released weekly as it has been. However, starting in November 2002, a continental product will be available on a monthly basis, with a new map likely released near the start of each month.

As part of the move to a North American product, the Drought Monitor will also evolve more into a GIS environment, so that the creation and analysis of the Drought Monitor, and related indicators, could be done with GIS. The hope would be that the Drought Monitor would provide the large-scale situation, with a user being able to use GIS to access more local-scale information from a variety of sources and indicators.

The Drought Monitor also continues to influence the improvement of various indicators and the development of new indicators that are helpful in the creation of drought maps. It is likely that during 2003, a new "Basin Water Index" (BWI) being developed through NRCS might start being tested for various areas of the western United States, as well as other locations in the country. It is hoped that this BWI will help improve the ability to assess water supply conditions for all basins and large watersheds across the country as this has currently been very difficult to accomplish. Reservoir and groundwater information has been particularly difficult to monitor, and it is hoped that the creation of the BWI will also help improve the assessment of these two indicators individually as well.

Finally, the Drought Monitor authors and the large group of local experts associated with the product are trying to find ways to tap into existing national, regional, and state soil moisture monitoring networks. The soil moisture component is one of the most neglected components in efforts to monitor drought across the United States.

6. CONCLUSION

The use of the Drought Monitor product has increased significantly since it was first released in August 1999. In 2001, the Drought Monitor web site received two million hits, and this number is projected to top five million hits during 2002. Other nations have expressed interest in developing a product similar to the Drought Monitor, and the involvement of Mexico and Canada in a North American version will provide an important multi-national model as well.

7. REFERENCES

Pasteris, P., R. Reinhardt, K. Robbins, and C. Perot, 1997. UCAN - climate information now for the next century. First Symposium on Integrated Observing Systems, Long Beach, CA, 2-7 February, 1997. American Meteorological Society, Boston, MA, 113-116.

Svoboda, M., D. LeComte, M. Hayes, R. Heim, K. Gleason, J. Angel, B. Rippey, R. Tinker, M. Palecki, D. Stooksbury, D. Miskus, and S. Stephens, 2002. An introduction to the drought monitor. Bulletin of the American Meteorological Society (accepted).

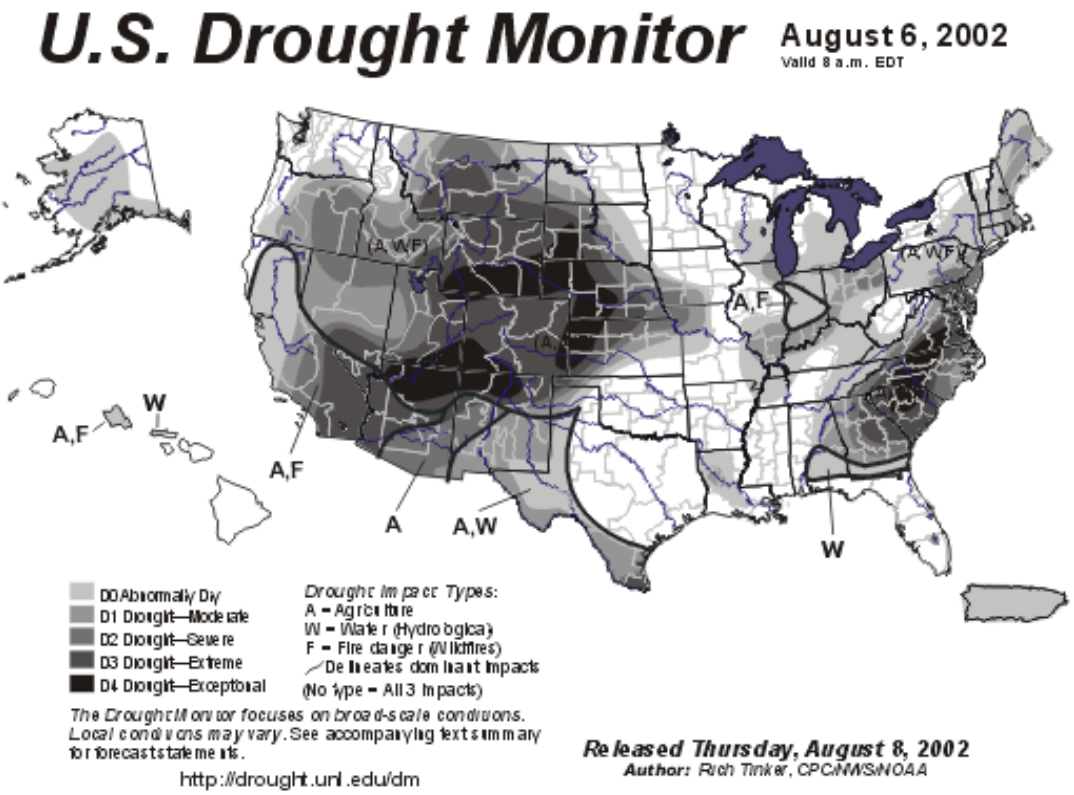

Figure 1. The U.S. Drought Monitor map for August 6, 2002.

Table 1. Drought Monitor Drought Severity Classification System.

Drought Monitor Classification							
Drought Type		Associated Ranges of Objective Indicators					
Category	**Description**	**Palmer Drought Index**	**CPC Soil Moisture Model (Percentiles)**	**USGS Weekly Streamflow (Percentiles)**	**Percent of Normal Precipitation**	**Standardized Precipitation Index (SPI)**	**Satellite Vegetation Health Index**
D0	Abnormally Dry	-1.0 to -1.9	21-30	21-30	<75% for 3 months	-0.5 to -0.7	36-45
D1	Moderate Drought	-2.0 to -2.9	11-20	11-20	<70% for 3 months	-0.8 to -1.2	26-35
D2	Severe Drought	-3.0 to -3.9	6-10	6-10	<65% for 6 months	-1.3 to -1.5	16-25
D3	Extreme Drought	-4.0 to -4.9	3-5	3-5	<60% for 6 months	-1.6 to -1.9	6-15
D4	Exceptional Drought	-5.0 or less	0-2	0-2	<65% for 12 months	-2.0 or less	1-5

Table 2. Experimental Short-term Objective Blend Indicators and Weighting Factors.

Short-term Objective Blend	
Indicator	**Weighting**
Palmer Z-index	35%
3-Month Precipitation	25%
1-Month Precipitation	20%
CPC Soil Moisture Model	13%
Palmer (Modified) Drought Index	7%

Table 3. Experimental Long-term Objective Blend Indicators and Weighting Factors.

Long-term Objective Blend	
Indicator	**Weighting**
Palmer Hydrologic Drought Index	30%
12-Month Precipitation	20%
6-Month Precipitation	15%
Palmer (Modified) Drought Index	10%
24-Month Precipitation	10%
60-Month Precipitation	10%
CPC Soil Model	5%

Table 4. Percent of the U.S. Mainland in Selected Ranges for the Unified Drought Index Blend for August 3, 2002.

Percentile Range	Unified Blend			
	Current %	Anomaly*	Percentile*	Change
0-30 (D0)	63.57	+33.74	95.91	-0.03
0-20 (D1)	53.94	+34.22	97.88	+1.93
0-10 (D2)	41.15	+31.57	98.74	+2.83
0-5 (D3)	28.95	+24.40	99.00	+2.68
0-2 (D4)	17.86	+16.14	99.05	+1.99

*Anomalies and percentiles based on end-of-month 1932-2000 data dosest to valid date, from National Climatic Data Center.