THE DROUGHT MONITOR

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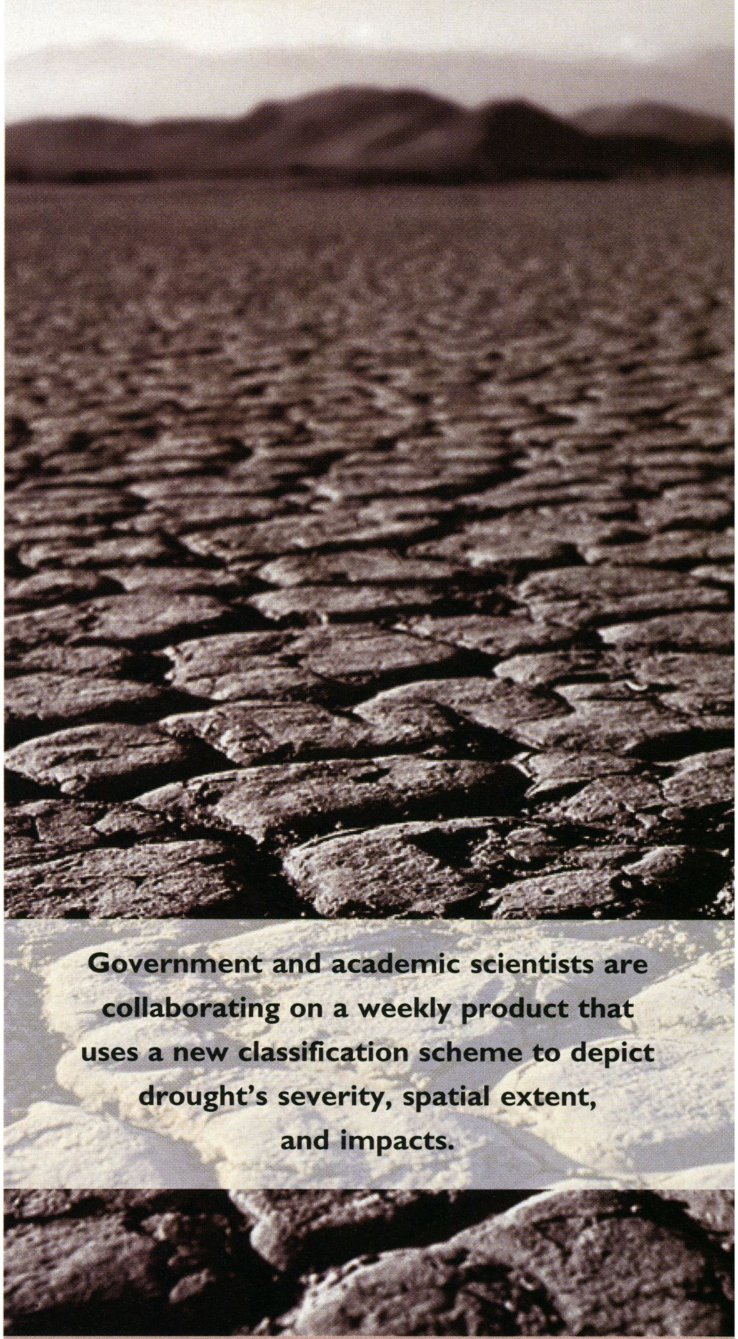

Government and academic scientists are collaborating on a weekly product that uses a new classification scheme to depict drought's severity, spatial extent, and impacts.

There is a need for improved drought monitoring and assessment methods in the United States. Drought is the most costly natural disaster [Federal Emergency Management Agancy (FEMA 1995; Wilhite 2000)], but it is often neglected by developers of assessment and forecast products. Drought is more nebulous than other disasters and does not lend itself to traditional assessments or forecast methods. Its relatively slow onset and the complexity of its impacts are reasons for the new assessment methodology. Improvements in drought monitoring and forecasting techniques will allow for better preparation, lead to better management practices, and reduce the vulnerability of society to drought and its subsequent impacts.

The Drought Monitor (additional information available online at http://drought.unl.edu/dm) was created with the goal of tracking and displaying the magnitude and spatial extent of drought and its impacts across the United States. The Drought Monitor is produced weekly and classifies drought severity into four major categories, with a fifth category depicting "abnormally dry" conditions. The category thresholds assigned to locations on a map are determined from a number of indicators, or tools, blended with subjective interpretation.

A strength of the Drought Monitor is its inclusion of input from climate and water experts across the country. This gives the national product a unique and

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necessary feeling of reality at the state and local level. The product also serves as an example of interagency cooperation. The National Drought Mitigation Center, located at the University of Nebraska—Lincoln, and the Departments of Commerce and Agriculture have worked together, with the collaboration of many outside experts, to compile and provide drought information in a simple, timely, and effective manner using Internet technologies.

ORIGINS. Drought is a major natural hazard with serious impacts on society. Riebsame et al. (1991) estimated that the 1987–89 drought in the United States caused $20 billion in agricultural and forest production losses, with an additional $10 billion loss associated with increased food costs. These totals do not factor in losses experienced by other sectors of the economy during this drought. As a result of recent droughts in the United States (e.g., the widespread events of 1995–96 in the southwest and southern Great Plains; 1998 in the south; 1999 in the northeast; 2000 in the south, midwest, and Great Plains; 1998–2002 in the southeast; and 2002 in the east), there is heightened interest in better defining, monitoring, and predicting drought.

Until recently, there was no comprehensive nationwide effort to consolidate or centralize the drought monitoring activities conducted by federal, regional, or state entities. In the summer of 1998, a dialogue began between the National Drought Mitigation Center (NDMC) and the National Oceanic and Atmospheric Administration's Climate Prediction Center (NOAA/CPC). Both were concerned about improving drought monitoring in the United States. What emerged was a plan to develop a classification system for droughts that would be as recognizable to the public as the Fujita tornado intensity scale (F0–F5) and the Saffir–Simpson hurricane intensity scale (categories 1–5). Early in the process, the U.S. Department of Agriculture's World Agriculture Outlook Board (USDA/WAOB) joined the effort. As a result of meetings held during spring 1999, an agreement was reached between NOAA, USDA, and the NDMC to produce and maintain a drought monitoring product that would incorporate weather data coupled with input from local, state, regional, and federal levels. An initial draft of a drought classification scheme was formulated by CPC scientists and submitted to the NDMC and staff of the USDA chief meteorologist. These groups worked together to further refine the criteria for the new drought classification scheme, associated maps, and text products. The new experimental product was named the Drought Monitor.

The determination of drought magnitude in real time can be as complicated as the definition of drought. Not only is drought arguably differentiated from other natural disasters by its many and diverse impacts, but it is also gauged by it spatial extent, intensity, magnitude, and duration. All of these properties must ultimately be taken into account in understanding and portraying drought on a map.

When tracking and assessing the severity of droughts, some basic questions are usually asked. One such recurrent question is "How severe is this drought?" For purposes of understanding vulnerability or risk, another commonly posed question is "How rare is this event?" Translated into the language of science, this asks "What is the frequency of a drought of a certain magnitude?" This approach follows along the lines of a probability of nonexceedance analysis to determine if the drought is usual, or unusual.

Concern over the impacts of drought in the Northeast during the summer of 1999 increased the momentum for the project and raised the visibility of the initial Drought Monitor products. The Drought Monitor was officially launched at a White House press conference conducted jointly by the Departments of Commerce and Agriculture in August 1999. The Drought Monitor had developed from an experimental biweekly prototype to an operational product within a few months. With the support of USDA's chief meteorologist, the NDMC (http://drought.unl.edu) at the University of Nebraska—Lincoln agreed to set up and maintain the Web site for the Drought Monitor. During spring 2001, the National Climatic Data Center (NOAA/NCDC) in Asheville, North Carolina, joined in coauthoring the Drought Monitor. Their experience brings additional expertise to this product.

Since its unveiling, the Drought Monitor has experienced widespread public interest and has been accessed by a broad user base. More than 1.25 million page views were registered on the Web site in 2000 (its first full year), with that number nearly doubling to 2 million in 2001. The media have been especially quick to use the new product, but it is also being used by a variety of agricultural producers, commodity brokers, congressional delegations, and state/federal agencies. Most users like the straightforward classification system and the simplicity of the map product. A Drought Monitor map is shown in Fig. 1.

COLLECTING AND CLASSIFYING THE EVIDENCE. No single definition of drought works in all circumstances (Wilhite 2000). For example, water planners and agricultural producers may rely on

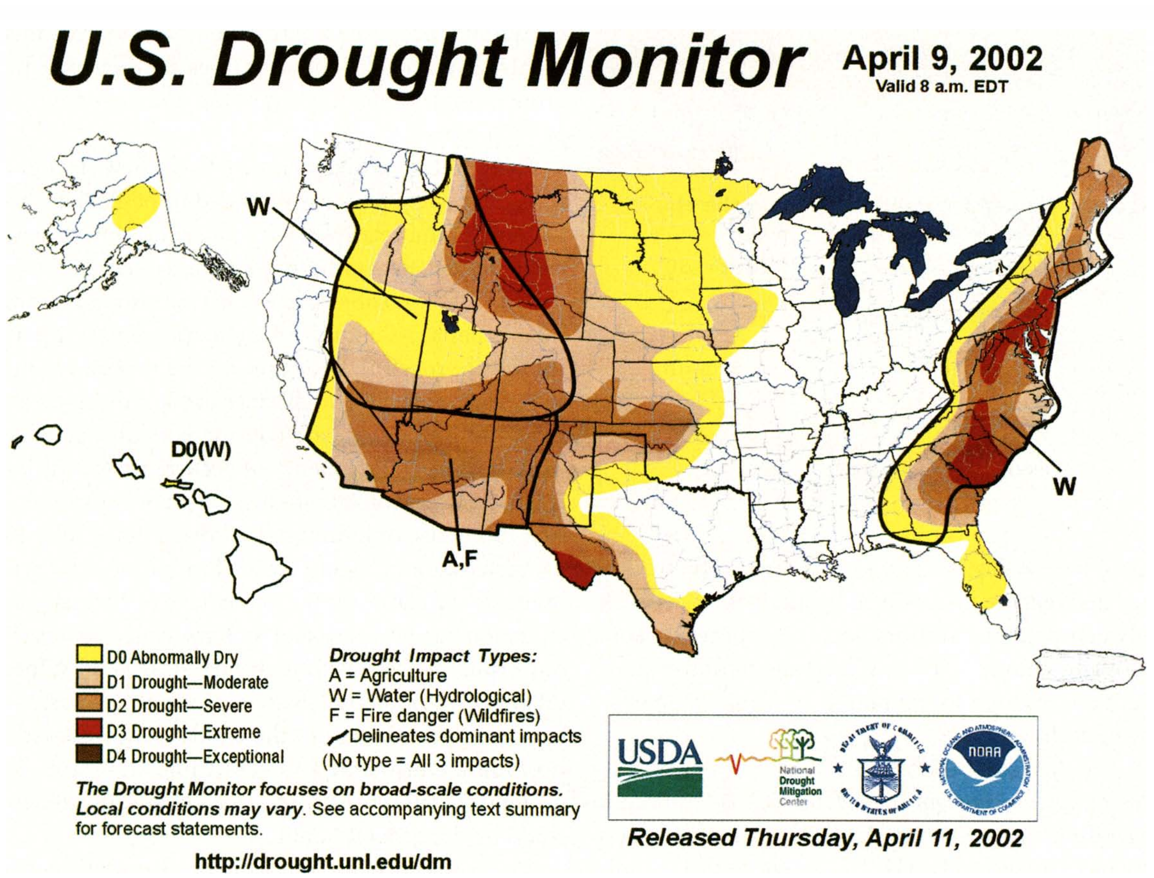

Fig. 1. The U.S. Drought Monitor map for 9 Apr 2002.

completely different sets of indicators. These are most often depicted in map or graphic form in order to ascertain the spatial distribution of drought conditions. The Drought Monitor authors also rely on a number of key and ancillary indicators from different agencies. The final map fuses these indices, using human expertise from across the United States, into an easy-to-read image presenting a current status of drought conditions. The Drought Monitor process is evolving as new, or better, indicators and information sources become available.

The Drought Monitor consists of a map depicting areas of the country that are experiencing drought, accompanied by a narrative of drought conditions and impacts. The product is an assessment of current conditions and should not be confused with CPC's Seasonal Drought Outlook product (www.cpc.ncep.noaa.gov/products/expert_assessment/seasonal_drought.html). The Drought Monitor itself is not an index, nor is it based on a single index, but rather is a composite product developed from a rich information stream, including climate indices, numerical models, and the input of regional and local experts around the country. It is particularly well suited for use by the media because it packages the expertise into a timely, colorful, and simple map. Currently, the World Wide Web is the main means of distributing the Drought Monitor, but NOAA also distributes the product through its weather wire channels. Some advantages of the Internet are minimal distribution costs and the instant availability of information. Admittedly, there are those who lack Internet access, but the Drought Monitor map is often duplicated in newspapers and displayed in other media sources, especially in drought-affected areas. Our focus to this point has been to disseminate the product in the most timely and cost-efficient manner.

The lead responsibility for preparing the Drought Monitor rotates among nine authors from the NDMC, USDA, CPC, and NCDC, who sequentially take 2–3 week shifts as the product's lead author. Every Monday the other authors and nationwide experts respond to the lead author's first draft when it arrives by Internet and through a Drought Monitor e-mail list-server and a secure NOAA ftp site. This first draft of the week is checked against the previous week's map to be sure that it reflects any changes in drought status occurring since the previous Tuesday

Table 1. The categories of drought magnitude used in the Drought Monitor. Each category is associated with its percentile chance of happening in any given year out of 100 yr.

Category	Drought condition	Percentile chance
D0	Abnormally dry	20 to ≤30
D1	Drought—moderate	10 to ≤20
D2	Drought—severe	5 to ≤10
D3	Drought—extreme	2 to ≤5
D4	Drought—exceptional	≤ 2

(the effective day of each week's map). The weekly map and text are then refined by interactive feedback between primary authors and the expert advisors across the country. The final map and narrative summary are released to the public on Thursday morning of each week.

Classification of drought magnitude: D0–D4. Drought magnitude is classified in the Drought Monitor into one of four levels: D1, D2, D3, or D4, with D1 indicating areas with moderate drought and D4 identifying regions with exceptional drought (Table 1). A fifth category, D0, designates those areas experiencing either "abnormally dry" conditions that may precede a drought or depicts lingering impacts after a drought event.

Droughts are generally slow to emerge and slow to recede, so the Drought Monitor usually changes incrementally, at most one level per week, during an intensifying or waning drought. However, there are cases, like the consecutive hurricanes on the northeast Atlantic coast during the summer of 1999 or tropical storms like Allison in 2001, when a drought-breaking type of event can accelerate the recovery process. Likewise, there are cases of "flash drought," which refers to rapid crop deterioration due to the adverse effects of a severe heat wave and short-term dryness, leading to a rapid onset of drought and associated impacts in agriculture, fire potential, livestock health, and other areas. Even after the physical cause of a drought (e.g., anomalous atmospheric circulation pattern) in a region has been eliminated, an area can often still experience lingering hydrological impacts for months or years, depending on the timing, duration, and intensity of the drought.

The Drought Monitor uses a percentile approach for magnitude category thresholds (Table 1) to answer the question from the introduction, "How rare is this event?" This enables the user to easily interpret the drought magnitude in terms of the number of events per 100 years.

It should be noted again that this new drought classification system was intended to be flexible, allowing for the relatively easy incorporation of new technologies and data as they evolve, as well as adjustments based on subjective impact assessments from local experts. As a guideline, the system uses a percentile approach in determining the thresholds for each severity level, and all data used in drought severity determinations are considered with reference to their historical frequency of occurrence for the location and time of year in question. The only exception to the use of locally standardized percentiles in characterizing drought is the adoption of some nationwide standards for the percentage of normal precipitation during a period of time associated with various drought levels. Although these threshold values do not correspond exactly to the appropriate percentiles at all locations across the United States, they still provide a consistent and replicable standard for drought classification utilizing a variable easily understood by the general public.

These objective inputs, and subjective adjustments based on local impacts and vulnerability, result in a drought indicator based on a convergence of evidence that can be interpreted easily in terms of return periods. Of course, attempts at full objectivity will only go so far and will eventually break because of the complexity of drought and the various return periods impacting multiple sectors.

For instance, Table 1 shows that D0 (abnormally dry) conditions have a 21%–30% chance of occurring in any given year at a given location, while D1 (moderate drought) events, or worse, occur 11%–20% of the time. A D2 (severe) drought would mean that a similar level of dryness would be expected 6%–10% of the time. The chances of D3 (extreme) or D4 (exceptional) droughts happening are even more remote, at 3%–5% and 2% or less, respectively. The percentiles are standardized for time of the year, rather than for all times of the year at once. They are not meant to imply an average areal extent value for the United States at any given time. Understanding that all drought situations cannot be captured by any one classification system, we acknowledge that the percentiles are used only as guidelines in generating the product. The resulting level designations are qualitative complications of both objective and subjective indicators to create a simplified index of a complex hazard.

TABLE 2. The association of the six key objective drought indicators with the magnitude of drought severity in the Drought Monitor.

Drought Monitor classification							
Drought type		**Associated ranges of objective indicators**					
Category	**Description**	**Palmer drought**	**CPC soil moisture**	**USGS weekly**	**Percent of normal**	**Standardized precipitation**	**Satellite vegetation**
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

Drought indicators. The Drought Monitor's severity categories are based on six key physical indicators and many supplementary indicators. The indicators are the Palmer Drought Severity Index (PDSI) (Palmer 1965), CPC Soil Moisture Model Percentiles (CPC/SM; Huang et al.1996), U.S. Geological Survey (USGS) Daily Streamflow Percentiles (http://water.usgs.gov.waterwatch/), Percent of Normal Precipitation (Willeke et al. 1994), Standardized Precipitation Index (SPI; McKee et al. 1993), and remotely sensed Satellite Vegetation Health Index (VT; Kogan 1995). Table 2 shows the relationships between the six indicators and the current drought magnitude classification system. This system of relationships is not permanent but is designed to be flexible, allowing for future incorporation of the latest technologies and data for drought monitoring.

Ancillary indicators include the Palmer Crop Moisture Index (CMI; Palmer 1968); the Keetch–Bryam Drought Index (KBDI; Keetch and Byram 1968); the U.S. Forest Service Fire Danger Index (www.fs.fed.us/land/wfas/); evaporation-related observations such as relative humidity and temperature departure from normal, reservoir and lake levels, and groundwater levels; USDA/National Agricultural Statistics Service (USDA/NASS) field observations of surface soil moisture (expressed as the percent of a state short to very short); and soil moisture measurements from USDA/Natural Resources Conservation Service's (NRCS) Soil Climate Analysis Network (SCAN) and other mesonet sites. In the western United States, additional indicators may be used, such as NRCS's Snowpack Telemetry (SNOTEL) observations of snow water equivalent for remote mountain sites, SNOTEL percent of normal snowpack observations, and the Surface Water Supply Index (SWSI; Shafer and Dezman 1982). Some of these indices and indicators are computed for point locations, and others are computed for climate divisions, drainage (hydrological) basins, or other geographical regions. Some are available on a national or regional scale; others are available sporadically (both in space and time).

One analysis tool developed specifically for the Drought Monitor is the Objective Blend of Drought Indicators (OBDI). The OBDI is not purely objective in that subjective decisions were made by the authors in deciding which measures to include and what weights to give them in the analysis. The basic premise is to automatically generate a consistent and replicable base layer of drought on a climate division level. This weekly operational tool consists of a "raw" number that is simply the weighted average of the percentiles for the observed modified Palmer Drought Index (PDI or PMDI; Heddinghaus and Sabol 1991), CPC/SM, and 30-day precipitation, weighted 5/12, 5/12, and 1/6, respectively. The raw value is then analyzed with respect to its historical frequency of occurrence, rendering an OBDI percentile that is released to the public (www.cpc.ncep.noaa.gov/soilmst/drought.html).

The OBDI values are computed on a climate division basis each Monday with the intent of consistently assessing drought severity for each climate division as averaged across multiple (long- and shorter-term) timescales, since the input values respond to precipitation on different timescales. McKee et al. (1995) found an inherent timescale of 10–14 months within the PDSI when comparing it to the SPI. The CPC/SM, based on work done at CPC, averaged across all climate divisions and time of the year, is most highly correlated with precipitation anomalies of 5–7 months' duration. Similar work at CPC shows that PDI values are best correlated with 7–10 month precipitation anomalies. However, the time periods to which both the PDI and CPC/SM best respond exhibit substantial temporal and areal variability, so their best-correlated precipitation anomaly periods cannot be assumed to apply to all locations, nor in all circumstances. Both indices, for instance, tend to correlate best with 2–4 month precipitation anomalies in the northern Ohio River valley during July, but with 6–10 month anomalies in this same region for periods ending in February.

The OBDI drought severity indicator is beneficial in determining current drought severity averaged across many timescales, thus aiding the Drought Monitor author in determining a single "average" drought designation for the current week's map, which presents a composite of short- and long-term conditions (placing more weight on those indices that are most relevant to the observed impacts).

However, at times when long- and short-term precipitation anomalies are diametrically opposed (which, for instance, happened several times in the Southeast during 1999–2001), the OBDI will average these conditions into a near-normal depiction that does not accurately assess, for instance, 1 or 2 months of heavy rainfall after 1 or 2 yr of persistently below-normal precipitation. In such an instance, substantial hydrological problems will coexist with much improved agriculture- and wildfire-related impacts. For this reason, various combinations of drought indices and precipitation anomalies of varying durations are being used in experimental blends that attempt to assess short- and long-term drought severity separately. This next generation of the blended product has shown better potential in responding to and differentiating drought on a temporal level, specifically distinguishing between different characteristics seen in agricultural and hydrological droughts.

Classification of drought impact types: A, W, and F. The Drought Monitor also attempts to depict impact types by giving a label of A, W, or F to areas on the map where these impacts may be occurring or impending (Table 3). The labels are used only when impacts differ within a delineated region. The first label (A) rep-

Table 3. The categories of drought magnitude used in the Drought Monitor and associated impacts in the agriculture (A), water (W), and fire (F) categories.

Category	Agriculture (A)	Water (W)	Fire (F)
D0	Slows farm activity, and crop and pasture growth	Steamflow below average	Fire risk above average
D1	Some damage to crops and pastures	Streamflow, reservoir, and well levels are low; some water shortages develop	Fire risk high
D2	Crop and pasture losses likely	Water shortages common; water restrictions imposed	Fire risk very high
D3	Major crop/pasture losses	Widespread water shortages and restrictions	Fire risk extreme
D4	Exceptional and widespread crop/pasture losses	Shortages of water in stream, reservoirs, and wells creating emergencies	Fire risk exceptionally dangerous

resents agricultural effects, such as impacts on crops, livestock, and range or pasture conditions. Water (W), or hydrological impacts are labeled when a region is experiencing a drought impact on some part of the water supply system, including streamflow, snowpack, groundwater, and reservoirs. Finally, the fire category (F), is noted when abnormally high risks of fire danger (wildfires) are observed coinciding with drought in the region. When no symbol type accompanies the shading on the map, then impacts of all three types are being experienced. Other impacts may also be occurring, but these three types are fairly distinct and, in the case of agricultural (A) and hydrological (W), may represent different timescales. The map displays this information as a label attached to specific areas of drought delineated by a heavy dark line (e.g., the northwest and southwest United States in Fig. 1).

Crop stress is often among the earliest indicators of a developing drought situation, because plants rely on frequent rainfall and need moderate temperatures during critical phases of development, such as pollination. The CMI was, in part, designed to depict short-term (up to 4 weeks) dryness during the growing season and, thus, is used as an ancillary indicator for the Drought Monitor.

In contrast, hydrological drought sometimes goes beyond the timescale limits of many of the Drought Monitor indicators, except the Standardized Precipitation Index and a derivative of Palmer's work, the Hydrological Drought Index (PHDI; Palmer 1965). The best field indicators of hydrological drought include streamflow, and reservoir, lake, and groundwater levels, while one of the best statistical indicators is the accumulation of long-term precipitation deficits.

Hydrological impacts of a major drought often linger for months or years after agricultural concerns disappear. But effects of the drought can still be measured by persistently low streamflows, the rapid return of river levels to "base flow" after a heavy precipitation event, and below-normal subsoil moisture and reservoir supplies. The West presents a special problem with respect to hydrological concerns, since many of the water systems are managed and designed to handle a multiyear drought, such as the one that affected key watersheds of the Sierra Nevada from 1986–87 to 1991–92. And unlike most of the remainder of the United States, much of the west's water is stored as seasonal snowpack before reaching reservoirs each spring, resulting in a lag time between observed precipitation and reservoir recharge. As a result, emphasis is placed on winter and spring snow water–equivalent measurements in the western mountains.

Another impact type often governed by short-term weather changes is wildfire danger. However, unlike the agricultural situation, the threat of wildfires is complicated by a number of factors that can include the underlying effects of an earlier long-term drought on the health of an ecosystem, fire management practices, thunderstorm and lightning activity, abundant moisture in an earlier season (month, year, or even decade), and the presence of freeze-browned grasses and underbrush. The wildfire picture is further clouded by the fact that a high risk of wildfires is normal at certain times of year in many locations, such as the Florida peninsula during the dry season (before the late-spring onset of seasonal rainfall), or much of the West during the late summer and early autumn. As a result, the authors rely on a suite of fire products issued by the Forest Service, the National Weather Service, and the National Interagency Fire Center (www.nifc.gov/).

Narrative. The narrative accompanying the Drought Monitor map is used to clarify what changes have been made to the map over the past week and describes the nature of current impacts associated with droughts in different regions of the country. A brief discussion regarding forecasts, potential trends, and changes on the map for the following week is also included. The narrative also fills a crucial role by incorporating expert opinion from the field, which reflects the impacts being experienced. In some cases, more specific details are given that may fall through the cracks on the generalized map. In short, the section helps to account for the qualitative aspects of drought, which are not easily quantifiable on a map.

REGIONAL AND LOCAL PARTICIPATION.

The first experimental Drought Monitor map was produced for internal review and comment in May 1999. Soon afterward, the map production process was ready for outside input, and an e-mail list-server was set up and is maintained at the NDMC. The Internet allows participating experts nationwide and the primary Drought Monitor authors to discuss and share their observations, viewpoints, and concerns rapidly and effectively.

A key to the success of the weekly Drought Monitor is this process of gleaning information from many experts located across the country. Their input and verification of impacts is critical in both the creation of the Drought Monitor and in establishing the credibility of the product. These experts (including regional and state climatologists, agricultural and water resource managers, hydrologists, National

Weather Service field office employees, and others) help to ground-truth the product with their professional knowledge of regional and local drought conditions and impacts. The list of expert reviewers has grown to more than 130 in the last two years. Much of their input also serves to verify whether or not the indicators are correctly capturing drought impacts.

The six regional climate centers (RCCs) of NOAA (www.ncdc.noaa.gov/regionalclimatecenters.html) provide both resource capabilities and expert input to the main Drought Monitor authors. The Western Regional Climate Centers provide access to timely monthly updates of a suite of Standardized Precipitation Index products that are exceedingly useful for developing both a spatial and temporal picture of drought in the United States, especially in the west (www.wrcc.dri.edu/spi/spi.html). The SPI pages (updated early each month) are fully interactive and have a variety of tools to allow for manipulation and display of the historical national climate divisions database. The Southeastern Regional Climate Center provides in near–real time an analysis of the effects of tropical storms (e.g., Allison in June 2001) on precipitation departures in the Southeast. They also help in providing information on the status of drought in Puerto Rico.

The Midwestern Regional Climate Center provides the Drought Monitor authors an account on the Midwestern Climate Information System (MICIS; Kunkel et al. 1990). This system generates precipitation departure maps based on gridded cooperative observer data for any user-selected period of time (up to the day in question) with full U.S. coverage (Kunkel et al. 1998). In addition, for the Midwest, an operational soil moisture model can provide an additional perspective on soil moisture impacts of drought (Kunkel 1990).

The High Plains Regional Climate Center is collocated with the NDMC and cooperates fully with the data and information needs of the Drought Monitor authors. The Northeastern, Southern, and High Plains Regional Climate Centers are leading the development of the Unified Climate Access Network (UCAN), an advanced climate data access system (Pasteris et al. 1997) that will provide even more climate data analysis options for the Drought Monitor authors. The value here lies in a distributed access system that is strongly driven by needs expressed by users for interactively created products. Additionally, staff at the RCCs also contribute expert opinions regarding drought magnitude and spatial distribution in their regions to the Drought Monitor authors, news on drought impacts in their regions, and feedback on the initial and subsequent drafts of the Drought Monitor map and text products each week.

The contributions of the state climatologists to the Drought Monitor are threefold. First, they provide unique data sources and insights into the local climate that are not always available at the regional or national level. For example, the Illinois State Water Survey operates a long-term soil moisture network of 18 sites across the state (Hollinger and Isard 1994). The soil moisture at these sites is measured with a neutron probe once a month in winter and twice a month during the growing season. This rather unique dataset provides the status of soil moisture down to 2 m, something that is not captured by looking at the normal suite of drought indicators.

The second contribution of the state climatologists is possible because of their close ties with state and local officials and a wide variety of stakeholders. As a result, they can provide valuable insights on the local impacts of drought that can help guide the determination of the appropriate level of drought. For example, the impacts of a short but intense dry period during the growing season may show up first in feedback from farmers before precipitation-based drought indices indicate a problem.

In addition, state climatologists can bring extensive knowledge about the unique political and geographical characteristics of water resources in their respective states. For example, southern Georgia depends on groundwater while northern Georgia relies on local surface water. In particular, metropolitan Atlanta depends on Lake Lanier, which is located about 50 mi north of the "official" rain gauge at Hartsfield International Airport. Therefore, someone could mistakenly use just the airport data to assess drought conditions within the city.

CONCLUSIONS AND FUTURE DEVELOPMENTS. Perhaps the idea of having a meaningful drought classification process is a utopian concept. The many variables involved and their complex interactions continually force the Drought Monitor to adapt. The simplicity of the map, while useful for public consumption, masks many of the complex interactions going on at different spatial and temporal scales. The ultimate goal, however, is to have a system in place that works by providing timely, relevant, and helpful information on drought.

Some of the evolutions anticipated in the future include integrating more USDA and other observational soil moisture data into the Drought Monitor, as well as more complete groundwater information from the USGS. It is likely that better reservoir- and lake-level information will become available in near-real time over the Internet as the various federal and state agencies responsible for this information make it more accessible. In addition, although it is strictly an assessment product, it is possible as the accuracy and confidence in the forecasts improves for all timescales that more predictive information could be incorporated into the Drought Monitor product.

The Drought Monitor will also become a better product as the data networks monitoring all aspects of the hydrological cycle improve the quality, timeliness, and spatial availability of data. Support for these networks is critical to the Drought Monitor product. This includes the operational collection of daily soil moisture and reservoir, lake, groundwater, and streamflow levels, as well as critical climate data such as precipitation and temperatures. Efforts are also under way to explore the possibility of developing a regional SWSI tool for the West.

Support is also necessary for the networks [Cooperative Observer Program (COOP), stream gauge, SNOTEL, various mesonets, etc.] and organizations (NOAA, USGS, USDA) that make these data available. There is an essential and continual need for a greater density of data and observations coupled with the ability to place them in historical context. Upgrades are needed in climate observing standards, including improved coordination of climate monitoring efforts and better integration of atmospheric, hydrologic, and natural resources data. Presently, we simply do not have sufficient information or resources to monitor as well as we need to at all scales. The Drought Monitor will continue to strive to be a complete drought monitoring system. In the future, the online version of the map will be made clickable, linking the user to drought data and impacts information on many spatial levels at the point.

The Drought Monitor is a working example of a cooperative effort between federal and nonfederal entities, which provides timely assistance to decision makers faced with a potential natural disaster. The product serves as a tool in helping them depict the intensity, spatial extent, and potential impacts of drought across the country. Ultimately, management and application decisions must be made by the users. The goal, however, has been to provide the best available product in a timely fashion to describe the complex nature of drought and its impacts in a simple way so that it can be understood by the users. The increasing visibility and use of the product illustrates that the Drought Monitor is on its way to achieving that goal.

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