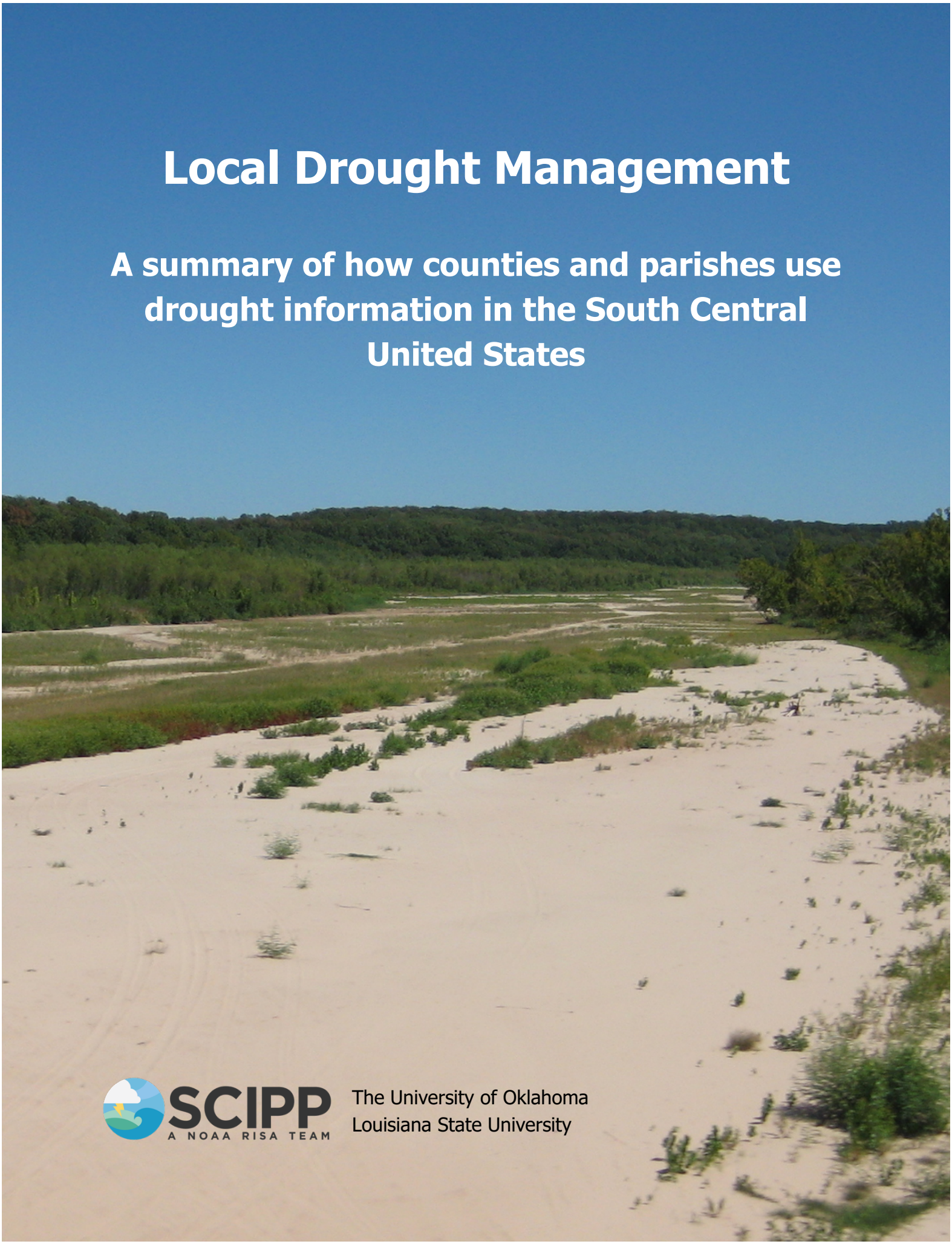
Local Drought Management

A summary of how counties and parishes use drought information in the South Central United States



SCIPP
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The University of Oklahoma
Louisiana State University

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Louisiana State University

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July 2017

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Introduction

The National Integrated Drought Information System (NIDIS) was established in 2006 to improve the use of drought information and improve management and planning practices across the United States. While great strides have been made among national partners, federal agencies, and state governments, less is known about how these improvements connect to local communities. For example, does the weekly depiction in the U.S. Drought Monitor, which draws upon many new and improved data sources supported in part by NIDIS, accurately correspond with perceptions of drought in local communities?

To examine the relationship between national coordination and local challenges, the Southern Climate Impacts Planning Program (SCIPP) designed and administered a survey that was distributed electronically to county officials in the six-state region served by SCIPP: Texas, Oklahoma, Arkansas, Louisiana, Mississippi, and Tennessee. The survey was distributed in the Fall of 2014 and drew 331 respondents. These included representatives from counties and parishes, including Natural Resources Conservation Service, Farm Service Administration, Cooperative Extension, Emergency Management, and Water Districts.

The survey included four categories: perceptions and actions related to drought; monitoring drought, managing drought, and communicating drought information. The survey design included Likert Scale rankings for quantitative assessment, such as the relevance of various drought indicators, data sources, and communication methods, and qualitative responses to identify common themes related to management decisions and the U.S. Drought Monitor performance.

Survey Participants

A majority of responses to the survey came from Texas (n=110, 33%) and Oklahoma (n=106, 32%). This was primarily because of an extreme, multi-year drought that had begun in 2010 and was still ongoing at the time the survey was administered. Because of the drought, awareness and engagement in drought management-related activities was higher in these states than in the other states in the region, improving response rates. While not as high, the other states did have adequate representation, sufficient to draw some comparative conclusions (Figure 1). Response rates for the remaining states were Arkansas (n=37, 11%), Mississippi (n=31, 6%), Tennessee (n=27, 8%) and Louisiana (n=20, 6%). Combined, these response rates provide a sufficient sample to compare responses between the climatologically drier, multi-year drought region and the climatologically wetter region that was affected by only periodic, shorter-duration droughts in the preceding several years.

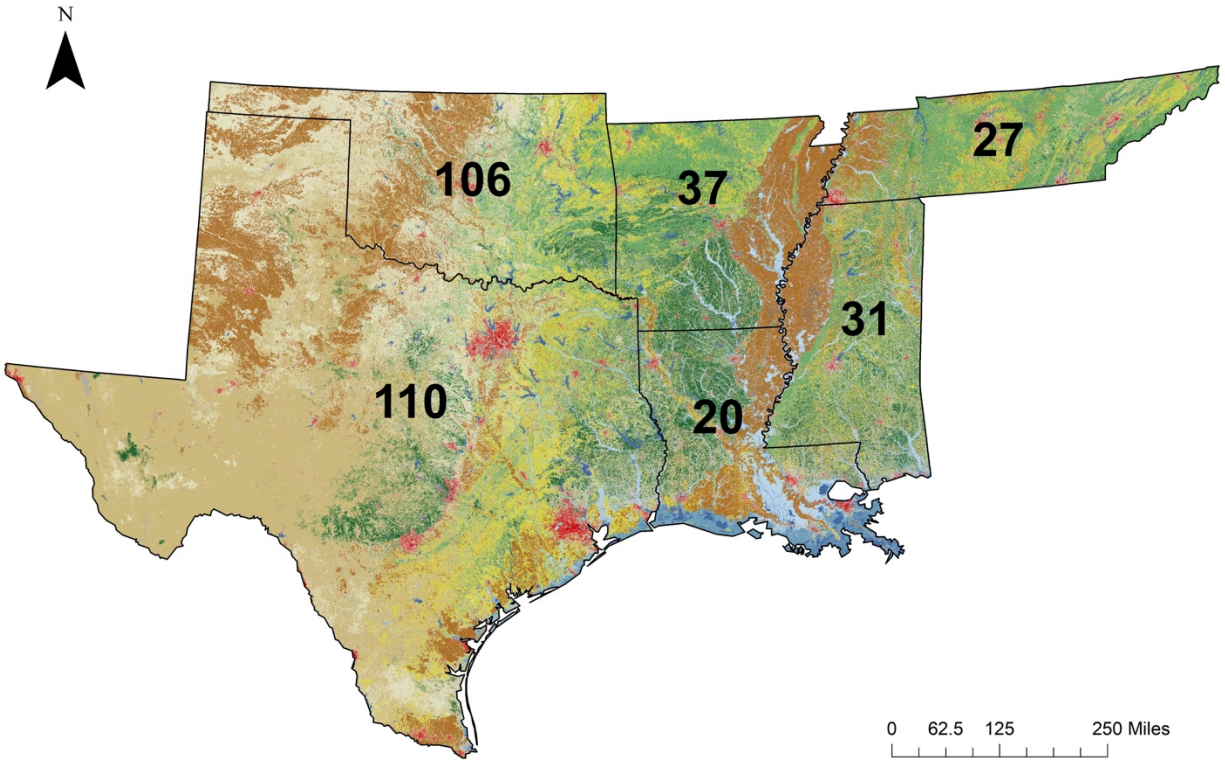

Figure 1. States represented in the survey. Map shows number of responses for each state.

The target audience for the survey were city and county offices, particularly in more rural areas of the states. This objective was achieved. The majority of respondents served populations of between 5,000 and 29,999 people (n=137, 41%) or 30,000 to 99,999 people (n=102, 31%). Fourteen of the 17 respondents serving a population of 1,000,000 or greater were from state agencies or federal government; the other three were from government agencies or universities in cities. Eighty-four percent (n=278) of respondents identified themselves as working in a county or parish.

Table 1. Respondents' jurisdiction sizes.

Population	Number of Responses	Percentage of Responses
Fewer than 1,000	2	1%
1,000-4,999	31	9%
5,000-29,999	137	41%
30,000-99,999	102	31%
100,000-999,999	42	13%
1,000,000 or greater	17	5%

Most respondents were either from universities or extension (n=124, 37%), federal agencies (n=95, 29%), or city/county/parish conservation district or USDA offices (n=41, 12%). The latter categories would include county extension, NRCS and FSA offices. Such offices are most involved in drought management activities, such as filing for and administering aid from USDA, and consequently more likely to respond to a survey about drought management. There was representation from other governmental sectors (Figure 2). Unfortunately, there were no respondents from the private sector, direct agricultural producers, trade associations, or the media. Consequently, results should be viewed as primarily addressing issues managed by USDA or agricultural-related county services offices and cannot necessarily be generalized to other sectors.

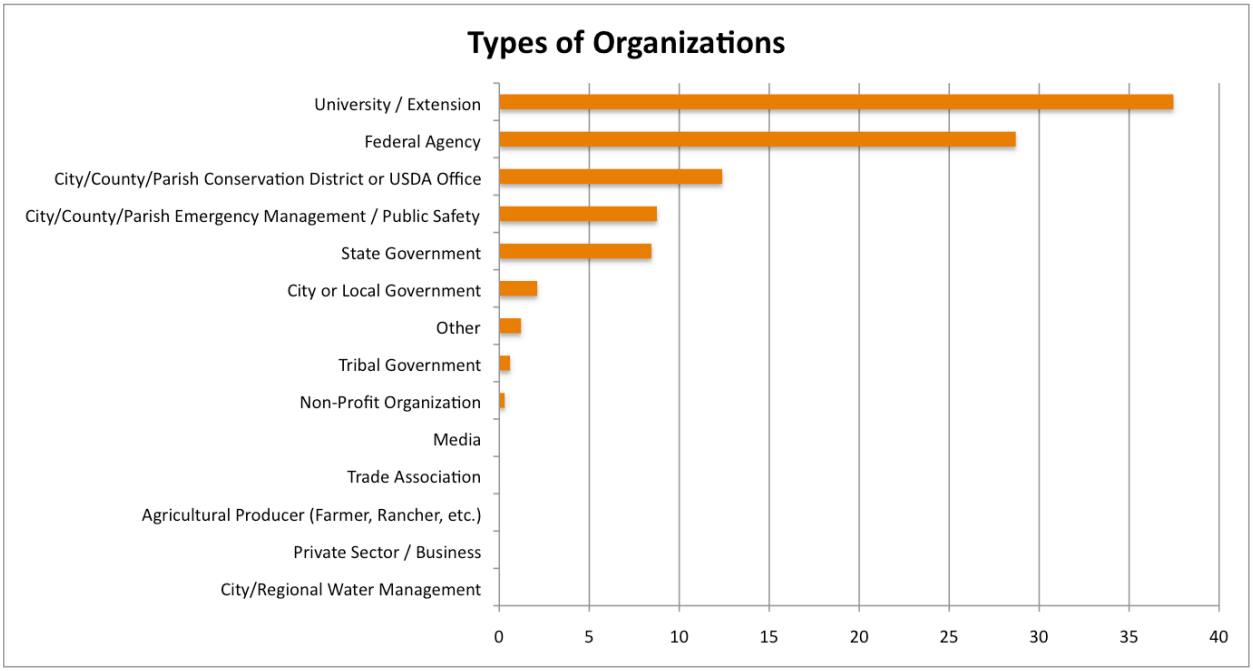

Figure 2. Types of organizations responding to the survey.

Perceptions and Actions Related to Drought

The following discussion relates to overall findings based on all six states. Comparisons between states and within-region differences are discussed later.

For reference, respondents were asked about how the ongoing drought at the time compared to their prior experience with drought. Thirty-five percent (n=104) responded that they experienced few or no impacts, while 6% (n=19) responded that they were the worst impacts on record. The majority indicated either moderate (n=98, 33%) or extreme (n=79, 26%) impacts. Most of those indicating few or no impacts (n=77) or moderate impacts (n=27) were from the eastern part of the region where drought conditions had been shorter duration or sporadic.

Few respondents (n=38, 13%) reported having a formal role in drought management, such as determining water rationing or monitoring indices. Of those who did, most responsibilities related to monitoring (n=11), reporting or collecting information (n=10), or coordination (n=10). Few had formal authority over programs such as water rationing or implementing crop or livestock management funds. Several (n=5) reported additional education or outreach activities during drought.

Respondents were asked to provide examples of types of impacts related to increasing severity of drought, using the U.S. Drought Monitor scale from D0 to D4. This was to assess whether their perceptions of impacts matched the types of things drought experts often consider when producing the weekly U.S. Drought Monitor maps. It also provides an opportunity to examine the degree of differentiation local officials make in assessing impacts. Most (n=132, 49%) equated D2 as a stage at which their agency would begin drought management options (Figure 3). Those who responded that they do not take action until D4-level impacts generally associated few impacts with drought conditions below a D4 level; some D4-level impacts mentioned were herd liquidations, crop losses, dry ponds, and poor grass.

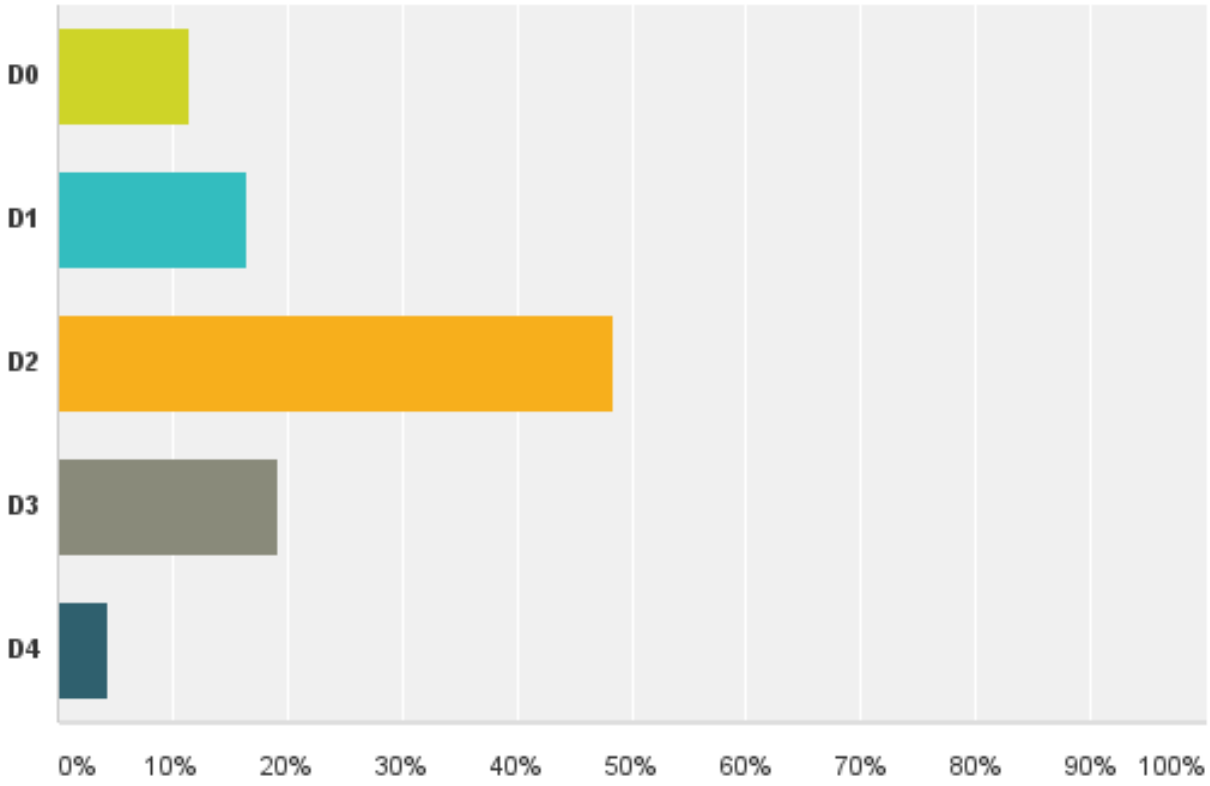

Figure 3. Drought stages at which respondents indicated their agency would begin taking drought management actions (n=272).

Respondents were asked to indicate conditions or actions associated with the U.S. Drought Monitor level of severity. A consensus of perceived conditions or actions is

presented by topic and drought level below. These were separated into different types of impacts to the extent possible, although there was some overlap (e.g., wells going dry requiring alternative water sources for cattle would be both water resources and agriculture).

Table 2. Conditions or actions associated with the U.S. Drought Monitor level of severity, according to respondents. Actions are separated by type of impact or activity: water resources, agriculture, wildfire, education, monitoring, financial, and other.

Level	Example Impacts (Water Resources)
D0	Decrease in base flows in streams
	Pond levels dropping
	Water loss tracking
	Infrastructure maintenance and improvement
D1	Creeks, ponds, and wells low, dropping rapidly
	Voluntary water rationing
	Slight increase in groundwater use
	Limited lawn watering
D2	Dry ponds
	Lake and well levels dropping
	City water restrictions
	Limitation on lawn and commercial watering
	Alternative water sources identified
	More irrigation for livestock
D3	Rural water systems have insufficient supply, adding interconnections
	Creeks and Wells go dry
	Mandatory water restrictions
	Ponds less than 40% of water holding capacity
	Water quality poor
	Subsoil moisture very low
	Use of recycled water
	Providing water for people on private wells
D4	Ponds, tanks, streams, irrigation wells dry
	Urban water rationing
	Water quality degradation
	Severe drawdown of local aquifers
	Development of additional wells, new water sources
	Areas entirely without water

Level	Example Impacts (Agriculture)
D0	Dry soils Crop growth slows Reduced hay / pastures beginning to go dormant Poor weight gain for cattle; weaning and selling calves earlier Implement more efficient irrigation methods Timber growth slows
D1	Pastures rated poor Provide water for livestock; stocking rates reduced Crops and grass wilting / yield reduction Irrigation needs increasing Reduced fertility (cattle)
D2	Wells begin to fail / alternative water sources needed Pastures / grass dormant Supplemental feed for grazing animals required Complete loss of non-irrigated crops Switch to drought-tolerant crops Herd reductions Insect infestations Seedling mortality
D3	Irrigated crops brown and wilted / extreme damage, major crop loss Farmers planting less Animals totally dependent on supplemental feed and water Transporting hay Herd reductions Clean out ponds Animal mortality Abandoned crops Severe overgrazing
D4	Crops will not emerge Cattle sold or shipped to another part of the country Complete loss / farmers not planting anything High livestock mortality No livestock water in above-ground ponds Farm closures / years to recover Grass and Tree plantations die

Level	Example Impacts (Wildfire)
D0	Increased frequency of fire Drier fuels Burn bans
D1	Increased fire danger Very dry fuels Burn bans in more locations Increased fire awareness
D2	High fire danger Numerous fires Fines and jail time for arson
D3	Extreme fire danger Extensive wildfires Some forest fires
D4	Exceptional fire danger Forest fires, wildfires

Level	Example Impacts (Education)
D0	Education of water users and landowners Increased programming efforts to educate public Educational programs on impacts Articles in county newspapers
D1	More detailed articles Encourage producers to stretch water resources Education on producer options Provide water saving tips
D2	Meetings with ranchers about drought management, planning Educational programs on herd culling Teaching about capturing and saving water
D3	Technical assistance and financial assistance Programs on herd liquidation
D4	Long-term decisions Locating forage for livestock Infrastructure management Water-saving tips

Level	Example Impacts (Monitoring)
D0	Increase monitoring Increased number of phone calls and farm visits
D1	Technical assistance on grass management Meeting and reporting
D2	Need ground-truthing for percent loss Stepped-up monitoring Well level monitoring
D3	Review water rationing plans Increased monitoring of water sources and use
D4	-

Level	Example Impacts (Financial)
D0	-
D1	Begin Livestock Feed Program and Crop Disaster Program Crop insurance income Financial loss
D2	Livestock Feed and Crop Disaster Programs automatic eligibility Increased supplemental feed costs Programs to assist livestock and crop producers Emergency loans Disaster programs Restructure debt
D3	All available drought programs implemented by USDA FSA Emergency loans Restructure debt Increase payments Drought cost-share assistance programs Business losses (agricultural)
D4	Long-term financial loss, decisions Disaster payments and emergency loans Impacts on the economy

Level	Example Impacts (Other)
D0	Some wind erosion and blowing dust Grass going dormant (urban) Higher than normal ozone levels
D1	Reduced wildlife production Soil erosion, more blowing dust Elevated ozone and particulate pollution Occasional dust and smoke issues Impacts to homeowners and small cities Ground starting to crack
D2	Pray for rain Hot, dry and dusty; dust storms Frequent ozone pollution and particulate events Erosion becomes a big problem Cracks in ground easily seen Soil quality degradation Situational awareness
D3	Loss of vegetative cover Soil erosion, dust storms Intense heat Protracted, widespread ozone pollution Young pine tree mortality
D4	High plant and tree mortality Loss of wildlife Loss of human life Disaster declaration Producers going out of business People moving out of area / land abandonment Livelihoods affected Structural damage from soil shrinking

Despite a range of impacts, nearly 80% of respondents (n=224, 79%) reported that they did not have any specific triggers to spur action. Of those who did (n=57), a variety of indicators were mentioned. Note that the total does not equal 57 because some people indicated that they used multiple measures:

- Reservoir levels (17)
- Drought Monitor (14)

- Weather data / precipitation departures (8)
- Well or aquifer levels / new well requests (7)
- Available forage quantity / quality / supplemental feed / cattle sales (6)
- Stream flow (6)
- Water use (5)
- Soil moisture (5)
- Water restrictions / demand (4)
- Plant / crop health (4)
- Fire danger / burn bans (3)
- Pond levels (2)
- Producer requests for assistance (2)

Respondents were asked if there were any particular groups, businesses or geographical areas that were particularly susceptible to drought. Agricultural producers and agri-business were frequently mentioned, including livestock and poultry producers. Other specific groups affected included the rice and sugarcane industries, aquaculture, water districts, conservation districts, fire departments, wildlife management, river and lake-related recreation, forestry and tree nurseries, municipalities, hydropower, large industry, and homeowners

Ceremonial sites and The Nature Conservancy lands were also mentioned as being affected. Elderly and other vulnerable citizens may struggle with higher water bills. One respondent also mentioned an increase in air quality issues from smoke and dust. One other respondent mentioned coastal salinity issues affecting domestic wells and community supply systems.

Monitoring Drought

Even though few mentioned having specific triggers, most (75%; n=221) who responded to the question indicated that they monitor drought conditions directly. Respondents were then asked to rate the importance of a variety of weather indicators and impact indicators.

Among weather indicators, soil moisture, the U.S. Drought Monitor and Precipitation were viewed as the most important indicators, with more than 80% of respondents ranking those indicators as critical or highly relevant. Temperature departures, the U.S. Drought Outlook, the Palmer Drought Severity Index, five-day forecasts, and Keetch-Byrum Drought Index were rated as critically or highly relevant by more than 50% of respondents.

Table 3. Weather indicators used in drought monitoring. Participants were asked to rank these as a critical indicator, highly relevant, somewhat relevant, or not relevant. Columns show the percentage of participants giving that ranking for each indicator. Percentages may not add up to 100 because of rounding.

Indicator	Not Relevant	Somewhat Relevant	Highly Relevant	Critical Indicator	Number of Respondents
Soil Moisture	2	11	44	42	205
U.S. Drought Monitor	1	15	45	38	209
Precipitation Departures from Normal	1	17	51	31	210
Temperature Departures from Normal	2	25	52	20	205
U.S. Drought Outlook	6	34	44	15	204
Palmer Drought Severity Index	13	29	42	16	197
5-Day Forecasts	10	37	42	11	203
Keetch-Byrum Drought Index	17	32	36	15	192
Precipitation Ranks	8	50	31	10	202
Standardized Precipitation Index	13	39	39	8	191
8-14 Day Forecasts	12	46	32	11	205
30-Day Forecasts	14	41	35	10	204
Temperature Ranks	9	51	33	7	201
Seasonal Forecasts	15	45	31	9	202

Among impact indicators, only crop status had 80% or more of participants ranking it as a highly relevant or critical indicator. All other impacts other than streamflow and media reports received at least 50% or respondents ranking as highly relevant or a critical indicator. This suggests that while there are some clear weather-based indicators, there is not a clear consensus on impact indicators.

Table 4. Impact-based indicators used in drought monitoring. Participants were asked to rank these as a critical indicator, highly relevant, somewhat relevant, or not relevant. Columns show the percentage of participants giving that ranking for each indicator. Percentages may not add up to 100 because of rounding.

Indicator	*Not Relevant*	*Somewhat Relevant*	*Highly Relevant*	*Critical Indicator*	*Number of Respondents*
Crop Status	2	15	55	28	212
County Burn Bans	7	25	42	26	211
Reported Drought Impacts	4	26	53	17	207
Groundwater Depth	10	27	38	25	210
Vegetation Health Index	7	29	46	18	205
Vegetation Greenness	7	29	47	17	207
Reservoir Storage	13	25	40	22	208
Water Use (Demand)	9	37	35	18	209
Wildfire Locations / Reports	12	31	41	16	208
Water Quality	13	32	40	16	206
Stream Flow	16	36	34	14	208
Media Reports	22	51	22	5	204

The most frequently-cited source of information for drought was the National Weather Service while the least frequently-cited source was the U.S. Bureau of Reclamation. State or local Mesonets were frequently used, however these do not exist in much of the region. State Climate Offices were seen as an important source by nearly half the respondents, who indicated using them as a source on at least a monthly basis during drought. The NIDIS drought portal was not a particularly important source.

Table 5. Frequency of use of various information sources. Columns show the percentage of participants giving that ranking for each source. Percentages may not add up to 100 because of rounding.

Source of Information	*Daily or Weekly*	*About Once a Month*	*Every Few Months*	*Do Not Use*	*Number of Respondents*
National Weather Service	65	23	5	7	211
USDA	41	39	10	10	210
State or Local Mesonet	39	14	9	38	202
State Climate Office	21	25	17	37	204
USGS Stream Gauges	12	17	16	55	200
US Army Corps of Engineers	8	19	19	54	203
NIDIS Drought Portal	8	20	13	59	200
CoCoRaHS	12	14	9	65	199
Bureau of Reclamation	2	6	8	84	202

Availability of weather information was a primary characteristic that made sources most useful. Characteristics that respondents noted as important was the availability of forecast information, current conditions, past data over a variety of variables they monitor, easy navigation of the website, and clear and concise descriptions. Many forecast offices provide information from the Drought Monitor during events as well.

Other characteristics of the data provided included timeliness, ease of access, availability, and relevance of local data. Trust and accuracy were also characteristics that respondents mentioned. One respondent mentioned using a local source because they "have first hand relationship with the drought conditions since they live here." This suggests that, for at least this one respondent, distant, national sources may not be perceived as accurate or as trustworthy. Personal relationships were mentioned by a few respondents.

The Drought Monitor

Respondents were asked for their perspectives on accuracy of the U.S. Drought Monitor and who they would contact if they felt that the depiction was not accurate. Only 45% of respondents (n=128 of 283 total respondents to the question) considered the Drought Monitor to be usually accurate. Twenty-four percent (n=67) felt that it frequently under-represents local conditions while 6% (n=16) thought it over-represented local conditions. Eight percent (n=23) felt that it is inconsistent in its accuracy and direction. Seventeen percent (n=49) either did not know or were not familiar with the Drought Monitor.

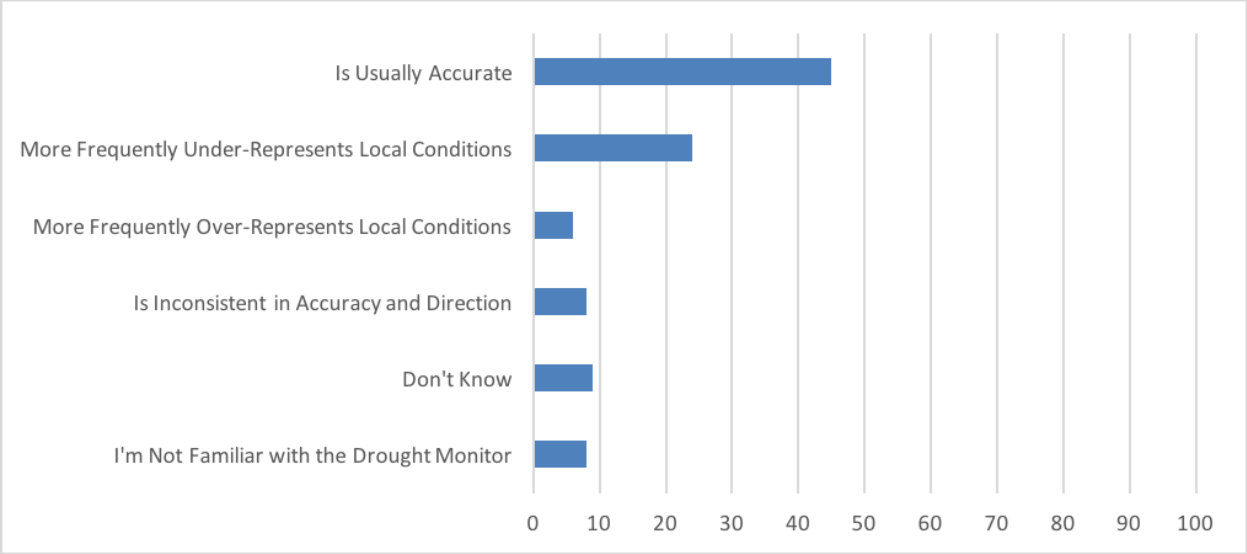

Figure 4. Respondents' perceptions of the accuracy of the U.S. Drought Monitor.

Respondents were asked, "if you suspected there were some emerging drought issues in your area or the Drought Monitor was not accurately portraying local conditions, who would you contact to investigate?" Organizations included state offices (20% of respondents, n=34), the National Weather Service (14%, n=24), USDA (13%, n=21), a local water organization (5%, n=8), the Mesonet (4%, n=6), or the Drought Monitor (3%, n=5). NOAA, USGS, county judges, Farm Service Agency County Emergency Board, water quality enforcement engineer, and extension specialists were also mentioned. Among state offices, 12 respondents mentioned the State Climate Office.

Agency Actions

Actions agencies could take to reduce impacts on their operations were asked as an open-ended response. Responses fell into general categories of education, financial instruments, water use restrictions, technical assistance, and USDA programs. Education included promoting information on water conservation practices, awareness

of drought information and financial assistance, demonstrations for local producers and clientele regarding water usage, and preparations farmers and ranchers can take.

Financial assistance mentioned includes funding for pipelines, irrigation water management, rehabbing dams and ponds, developing water wells, reservoirs maintenance, heavy use area protections, and water saving practices. Financial assistance includes assistance to producers, primarily through USDA programs, and water hauling for livestock.

Water management strategies included implementing irrigation efficiency strategies, augmenting water supplies, improving water infrastructure for wildlife and habitats, restricting use, providing incentives for well owners to reduce use, and providing emergency water supplies. Land management practices to improve retention of moisture (such as no-till) were mentioned as potential water management strategies. Some respondents mentioned re-allocating use under riparian use doctrines.

Other responses included improved monitoring and reporting, preparing staff and clients to reduce work load, making program determinations sooner, and prayer.

Communications

A slight majority (55%, n=149) indicated that they do not receive notification of drought conditions from other individuals or agencies. Among those who indicated that they do receive notification, sources included the USDA (46%, n=49), the National Weather Service (14%, n=15), a state agency (11%, n=12), a state Mesonet (9%, n=10), farmers (8%, n=9), NOAA (6%, n=6), the Drought Monitor (5%, n=5), and the media (2%, n=2). Other sources mentioned by a single respondent included the state climatologist, conservation districts, supervisory officials, U.S. Forest Service, Tennessee Valley Authority, the Southern Regional Climate Center, the city, the county, and local fire departments. [Note: some respondents indicated multiple sources.]

Most respondents (62%, n=171) reported that they communicated drought status to other individuals, organizations, or agencies. These include various USDA offices (n=61), producers or clients (n=54), local organizations (n=33), the public (n=15), water districts (n=8), state agencies (n=9), federal agencies (n=3) or others (n=9). USDA agencies mentioned include Cooperative Extension, Farm Service Agency, Natural Resources Conservation Service, National Agricultural Statistics Service, and Rural Development (FSA and Extension were most frequently mentioned). Local organizations included county judges or commissioners, fire departments, conservation districts, emergency management, county emergency boards, and local government leaders. State agencies included agriculture, forestry, environmental quality, and natural resources. Federal agencies included the National Weather Service and U.S. Geological

Survey. Others mentioned included tribal government, universities, and other agency staff.

A majority of respondents (61%, n=168) indicated that they provide written materials (including web-based posts) to the community about water conservation or thresholds for action. Preferred sources included newspapers (96% considered somewhat or very effective), radio (88% somewhat or very effective), or television (80% somewhat or very effective). Direct mail (81%) and email (84%) were also mentioned as generally effective, although not as highly ranked as very effective. Social media posts (77%) and website message (73%) were also used, although these also rated higher as not effective (15% and 21% respectively). Town hall meetings (52% somewhat effective) and utility bill inserts (41% somewhat effective) were also used. Respondents also mentioned using billboards, fact sheets, flyers in agricultural businesses, mass notification systems, general education, and word of mouth.

Other Drought Information

There is a lot of information and a lot of indicators available related to drought, but several respondents offered suggestions for improvements or new sources of information. More localized information that captures small-scale (sub-county) variations of drought, additional indicators, historical context, and improved forecasts were mentioned by multiple respondents. In particular, observing stations may record a heavy rainfall that misses other parts of the county, affecting eligibility for assistance or insurance. There were also suggestions for monitoring groundwater depth and lake levels relative to water intakes, crop and pasture conditions, a "pond index" to measure smaller, local water sources, and deep soil moisture that can affect moisture reserves for plants.

Although climate services organizations cannot necessarily improve forecasts, there are opportunities to improve the use an applicability of forecasts. In particular, less technical language associated with assessment and forecast products, forecasts of specific variables such as groundwater, and how much moisture is needed to end the drought and recovery vegetative stability were viewed as useful. Respondents also mentioned longer-term forecasts extending several years in advance.

Respondents also mentioned that products relating to the water budget would be useful as guidance on how much water is needed for irrigation or storage. Relating rainfall departures to drought categories would be useful guidance in understanding how the Drought Monitor is applied. Information regarding alternative crops and markets for low-water crops, cloud seeding, and rain barrels (water capture) were viewed as useful.

Other comments relating to management strategies and information access included:

- conservation districts are in every county (parish) but may not be involved in drought assistance
- promotion of rain water capturing
- an easier way for local input for describing current crop, pasture, livestock water, and loss conditions
- more local reporting in addition to existing automated networks
- during long-lasting drought, soil moisture depletion can occur more rapidly than under normal conditions
- would like a user-friendly website with access to historic rainfall records capable of producing a graph or table outputs of a weather station
- information should be more specific to a location based upon their basin and water sources (i.e., water sources away from the community may be low even if it has been raining in the community and vice-versa)
- information from the National Weather Service was limited, vague, and hard to understand
- groundwater conservation districts need to be more involved in drought coordination
- monitoring in mountain communities (southern Appalachian area) is limited

Regional Variations

There is a large variation in average annual precipitation across the region, ranging from more than 60 inches along the Gulf Coast in Louisiana and Mississippi to less than 15 inches in far west Texas. The abrupt transition from wet (east) to dry (west) across central Texas and Oklahoma make these states particularly susceptible to drought.

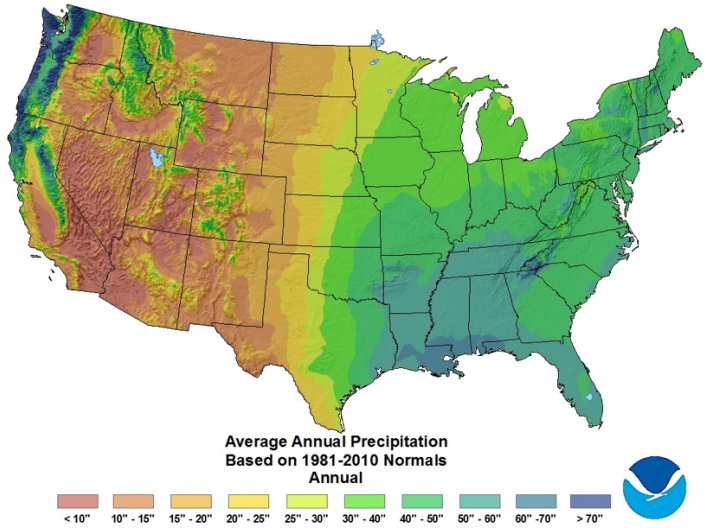

Figure 5. Average annual precipitation. Source: National Centers for Environmental Information.

Evapotranspiration (water loss due to evaporation and use by plants) exceeds annual precipitation in arid areas of west Texas and Oklahoma, while precipitation usually exceeds evapotranspiration to the east. Consequently, intense, long-lasting droughts are more common in Oklahoma and Texas, although all areas are susceptible to intense flash droughts. Because of the differing frequency and intensity of drought across the region, responses were subdivided between "wet states" (Louisiana, Mississippi, Tennessee and Arkansas) and "dry states" (Texas and Oklahoma). Eastern Texas and Oklahoma share characteristics similar to states further to the east, but data collection did not allow subdivision of responses within a state.

All drought indicators and forecasts were viewed as more relevant in dry states compared to wet states. The preference among indicators was similar between the two regions, with soil moisture, the U.S. Drought Monitor, and precipitation departures ranking among the top 3 in both areas. All except Palmer Drought Severity Index showed a double-digit increase in high rankings in the dry states. The largest differences were with Keetch-Byrum Drought Index (25 points), temperature ranks (23), U.S. Drought Outlook (22), and precipitation and temperature departures from normal, Standardized Precipitation Index, and seasonal forecasts (21 points each).

Table 6. Percentages of respondents who ranked the indicators as Highly Relevant or Critical Indicator in the "Wet States" (AR, LA, MS, TN) and the "Dry States" (OK, TX). Columns show the percentage of participants giving that ranking for each indicator. Percentages may not add up to 100 because of rounding.

Indicator	*"Wet States"*	*"Dry States"*
Soil Moisture	75	92
U.S. Drought Monitor	76	86
Precipitation Departures from Normal	67	88
Temperature Departures from Normal	57	78
Palmer Drought Severity Index	53	59
U.S. Drought Outlook	44	66
5-Day Forecasts	42	58
Keetch-Byrum Drought Index	33	58
Standardized Precipitation Index	33	54
30-Day Forecasts	35	50
8-14 Day Forecasts	32	47
Precipitation Ranks	31	46
Temperature Ranks	24	47
Seasonal Forecasts	25	46

There was more variation among impact indicators between the sub-regions. Crop status was ranked as most important in both regions, but there was less emphasis in the "dry states" than in the "wet states" on reported drought impacts (8 percentage points lower) and media reports (10 points lower). This may be attributable, in part, to a more aggressive inclusion of drought impacts and media coverage in the Drought Monitor process in Oklahoma and Texas; therefore drought impacts are already incorporated into the U.S. Drought Monitor which is among the most widely-used indices. Other notable differences were a greater emphasis on water-based impact indicators in the dry states – reservoir storage (39 percentage points higher), water quality (23), and groundwater depth and water use (demand) (21 points each).

Table 7. Percentages of respondents who ranked the impact indicators as Highly Relevant or Critical Indicator in the "Wet States" (AR, LA, MS, TN) and the "Dry States" (OK, TX). Columns show the percentage of participants giving that ranking for each indicator. Percentages may not add up to 100 because of rounding.

Indicator	*"Wet States"*	*"Dry States"*
Crop Status	79	85
Reported Drought Impacts	76	68
County Burn Bans	56	73
Vegetation Greenness	59	66
Vegetation Health Index	59	65
Groundwater Depth	48	69
Wildfire Locations / Reports	49	61
Reservoir Storage	34	73
Water Quality	39	62
Water Use (Demand)	39	60
Stream Flow	48	48
Media Reports	34	24

Outside of National Weather Service, which was by far the most frequently-used source in both sub-regions, there was quite a bit of variation in preferred sources. State or Local Mesonets (47 points) and State Climate Offices (17 points) were more commonly used in the "dry states". Oklahoma and Texas have very well-established State Climate Offices and Oklahoma is the only state in the region that possesses a real-time statewide Mesonet observation system. Arkansas and Mississippi have smaller, less active state climate offices and Tennessee does not have an official state climate office. CoCoRaHS was used more frequently in the "wet states" (25 points), in part because

not having state Mesonets, these states have been more active in the CoCoRaHS program. Surprisingly, the U.S. Army Corps of Engineers (-13 points) and USGS Stream Gauges (-8 points) were consulted less frequently in the "dry states", even though water-based impact indicators were rated as higher importance

Table 8. Percentages of respondents who indicated frequent use (daily, weekly, monthly) of sources of information in the "Wet States" (AR, LA, MS, TN) and the "Dry States" (OK, TX). Columns show the percentage of participants giving that ranking for each indicator. Percentages may not add up to 100 because of rounding.

Source of Information	*"Wet States"*	*"Dry States"*
National Weather Service	82	91
USDA	68	78
State or Local Mesonet	20	67
State Climate Office	34	51
U.S. Army Corps of Engineers	37	24
CoCoRaHS	43	18
USGS Stream Gauges	34	26
NIDIS Drought Portal	25	29
Bureau of Reclamation	5	8

The U.S. Drought Monitor seeks to synthesize all of these indicators and sources into a weekly composite. This weekly analysis is in part dependent upon local sources of information and expertise, provided through its listserve discussion group. Oklahoma and Texas, and to a somewhat lesser extent Louisiana, all have a noticeable presence in the weekly discussions; less local input is provided from Arkansas, Mississippi, and Tennessee. Not surprisingly, respondents from the states with more frequent input rated the accuracy of the U.S. Drought Monitor more highly than states with less frequent input. However, even the best-performing state (Texas) achieved only 55% of respondents rating it as "usually accurate", suggesting there may be local variations and impacts that are not adequately captured in the weekly depiction. Respondents from Tennessee, in particular, viewed the drought monitor as frequently underestimating drought severity (37%) or inconsistent (17%), while respondents from Louisiana and Mississippi were most likely to view the U.S. Drought Monitor as crying "wolf" more often (11% each). Respondents from Arkansas (38%), Mississippi (37%) and Louisiana (28%) were most likely to be unfamiliar with the Drought Monitor or not have enough information to make an assessment of its validity. Nearly all respondents from Tennessee (96%) were familiar with the Drought Monitor enough to have an opinion of its accuracy.

The number of respondents who were able to accurately identify a contact who could provide input into the weekly U.S. Drought Monitor discussion reflects the substantial effort put forth by the state climate offices and other providers in Oklahoma and Texas. Of the 85 respondents from Oklahoma who responded to the question, 27 of them (32%) could report a concern to someone who could raise the issue with the Drought Monitor authors. Similar percentages in Louisiana (38%) and Arkansas (28%) indicate that those who responded to the survey could reach someone to report a concern. The low percentage in Texas (13%) who were able to accurately identify a contact may be indicative of the higher percentage (55%) who perceived the U.S. Drought Monitor as usually being accurate; thus they may not have needed searching out a contact to express a concern. Tennessee and Mississippi appear to be the least-connected to the Drought Monitor process and express substantial concerns about its accuracy.

Table 9. Perceived accuracy of the U.S. Drought Monitor, by state and the number of respondents in each state who could accurately identify an appropriate contact for reporting problems to the Drought Monitor.

State	Number of Responses	Usually Accurate	More frequently underestimates	More frequently overestimates	Inconsistent	Don't Know / Not Familiar	Accurately Identify Contact
TX	100	55%	19%	6%	10%	10%	13
OK	85	47%	28%	4%	7%	14%	27
AR	29	31%	24%	3%	4%	38%	8
LA	18	44%	17%	11%	0%	28%	7
MS	27	26%	19%	11%	7%	37%	3
TN	24	38%	37%	4%	17%	4%	1

* 3 in Oklahoma mentioned the State Climatologist (Gary McManus) specifically by name.

Summary

This project examined the connection between national efforts to improve drought monitoring, management, and communication with local use of drought information. A survey, distributed to county offices within a 6-state region of the South Central U.S., found that few local respondents had a formal role in drought management and most did not have specific triggers for action, although a substantial majority did monitor conditions directly. Most indicated action for their agency or organization would likely be initiated when the U.S. Drought Monitor indicated severe drought (D2).

Soil Moisture, the U.S. Drought Monitor, and precipitation indices were the most-preferred indicators. Use of indicators across-the-board were higher in the drier states

of Texas and Oklahoma than in the wetter states of Arkansas, Louisiana, Tennessee, and Mississippi. Crop status was overwhelmingly the most important impact indicator. Other important indicators included county burn bans and reported drought impacts. Stream flows and media reports were least used. There was less emphasis on reported impacts in the drier states, perhaps because of aggressive efforts to include impact information in the U.S. Drought Monitor process from local state climate offices, but water-based impacts were a much more important source in the drier states. The National Weather Service was by far the primary source of information across the region. Other frequently-assessed sources were USDA, state or local Mesonets (where available) and state climate offices. Availability of weather information was the primary characteristic that these sources were sought. Mesonets and state climate offices were more used in the drier states; CoCoRaHS was more important in the wetter states. In contrast to the importance of water-based indicators, direct sources of water information were less frequently consulted in the drier states.

Fewer than half of respondents perceived the U.S. Drought Monitor as usually accurate. Texans viewed it as more accurate (55%) while few respondents from Mississippi (26%) perceived it to be accurate. More thought it under-represented (24%) rather than over-represented (6%) local conditions. About one-third of respondents in Oklahoma, Louisiana, and Arkansas could properly identify a contact for the U.S. Drought Monitor who could investigate or relay concerns about its inaccuracy; Tennessee and Mississippi appeared least connected to the U.S. Drought Monitor process.

Actions that agencies could take in response to drought included education (promoting water conservation practices, awareness of technical and financial assistance), financial (emergency funding, USDA assistance programs), and water management strategies (habitat protection, restricting use, providing conservation incentives, and emergency supplies).

Nearly half (45%) received some kind of notification from other individuals or agencies about drought status. Most (62%) relayed information to other individuals, organizations, or agencies. Preferred methods included newspaper articles, radio, and television. Direct mail or email were also viewed as effective. Social media posts and website messages were used but were not seen as very effective.

The greatest needs for additional information included: more localized information, historical context, additional indicators (such as groundwater and local water sources), improved forecasts (less technical, forecasts of specific variables like groundwater, and longer lead times), and products related to the water budget (irrigation and storage).

This project revealed an active local network, especially in the drier states in the western part of the region, working to help their communities, businesses, and individuals manage drought. Those in the network had access to a wealth of information, but there are opportunities to improve their connection, particularly

through the U.S. Drought Monitor process and representing local conditions. The National Weather Service and state climate offices appear to be significant links between national monitoring efforts and local use of that information.

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