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An online, peer-reviewed journal
published in cooperation with the
Texas Water Resources Institute

TEXAS WATER JOURNAL

Volume 3, Number 1
2012

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ISSN 2160-5319

texaswaterjournal.org

THE TEXAS WATER JOURNAL is an online, peer-reviewed journal devoted to the timely consideration of Texas water resources management and policy issues. The journal provides in-depth analysis of Texas water resources management and policies from a multidisciplinary perspective that integrates science, engineering, law, planning, and other disciplines. It also provides updates on key state legislation and policy changes by Texas administrative agencies.

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Texas Water Resources Institute
make every drop count

Cover photo: Located in far east Texas and stretching into Louisiana, Caddo Lake is known for its extensive forests of baldcypress trees draped with Spanish moss. This famous lake is home to a rich ecosystem and a wide variety of wildlife. The cover photo was taken during normal water levels, but in 2011 the lake's levels dropped significantly during the drought. Photo credit: Texas Water Resources Institute

Texas Water Resources Institute
Texas Water Journal
Volume 3, Number 1, Pages 59–95, November 2012

The 2011 Texas Drought

John W. Nielsen-Gammon[1]

Abstract: The 2011 drought in Texas was unprecedented in its intensity. Beginning in October 2010, most of Texas experienced a relatively dry fall and winter, but the record dry March 2011 brought widespread extreme drought conditions to the state. The 12-month rainfall total for October 2010 through September 2011 was far below the previous record set in 1956. Average temperatures for June through August were over 2 °F above the previous Texas record and were close to the warmest statewide summer temperatures ever recorded in the United States.

As the drought intensified, the previous year's relatively lush growth dried out, setting the stage for spring wildfires. Conditions were so dry during the spring planting season across much of the state that many crops never emerged from the ground. Continued dry weather through the summer led to increasing hardship for ranchers, who generally saw very little warm-season grass growth while stock tanks dried up. By early fall, trees in central and eastern Texas were showing widespread mortality, and dry and windy conditions allowed forest fires to burn intensely and spread rapidly in Bastrop and elsewhere.

Near-normal rainfall across Texas in October–December improved short-term conditions, but almost the entire state remained in drought.

Keywords: drought, Texas, rainfall, records, SPI

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Citation: Nielsen-Gammon JW. 2012. The 2011 Texas Drought. The Texas Water Journal. 3(1):59-95. Available from: https://doi.org/10.21423/twj.v3i1.6463.

Terms used in paper

Short name or acronym	Descriptive name
FNEP	Full network estimated precipitation
NCDC	National Climatic Data Center
PDSI	Palmer Drought Severity Index
SPI	Standardized Precipitation Index
USHCNv2	U.S. Historical Climatology Network, Version 2

INTRODUCTION

Drought is a condition of hardship due to lack of water caused by unusual meteorological conditions. Drought affects both society and the natural environment. Society attempts to use water to maximum benefit, and hardship results when sufficient water is unavailable for the normal types and amounts of water uses. Natural ecosystems have adapted to occasional drought, though human interactions with the environment have sometimes reduced natural resilience.

The severity of a drought depends on its intensity and duration. Differences in drought duration make it difficult to compare various droughts. A short-term drought, one lasting less than 6 months or so, will have a large impact on the agricultural industry but cause relatively few water supply problems. In contrast, a long-lasting drought of low intensity may have relatively little agricultural impact but may cause major problems for water suppliers because of steadily declining reservoir and aquifer levels.

As shown in this report, the 2011 drought in Texas has been unprecedented in its intensity. After barely more than a year of below-normal rainfall, the lack of rainfall was so profound that many water supplies throughout the state were seriously affected.

This report considers the Texas portion of the 2011 drought. In 2011, drought conditions extend almost continuously across the southern United States from Arizona to North Carolina and from parts of the Northern Plains into central Mexico (NCDC 2011). However, the exceptional drought conditions in 2011 disproportionally affected Texas and Oklahoma along with neighboring parts of New Mexico, Colorado, Kansas, Arkansas, Louisiana, and the country of Mexico.

It is essential to understand the present drought in a historical context in order to design policy to mitigate the impacts of present or future droughts. A drought so rare as to be unlikely to recur in the next thousand years might require a one-time intervention, while a drought likely to repeat itself within our lifetimes may require a greater emphasis on permanent mitigation or adaptation measures.

This report focuses on the meteorological aspects of the 2011 Texas drought. The second section of this report describes the conditions leading up to the onset of the 2011 Texas drought. Section 3 illustrates how dry conditions developed across the state during fall of 2010 and winter, spring, summer, and early fall of 2011. The fourth section considers the 2011 drought's place in the meteorological record books on a statewide, climate division, and local scale. Finally, section 5 briefly considers the outlook for the present and future droughts over the next year, the next decade, and beyond.

We refer to the "2011 Texas drought" even though the drought is persisting at least into 2012 and has affected areas from Arizona to North Carolina and from Nebraska to central Mexico. The term reflects the limited spatial and temporal scope of this paper.

An earlier version of this report was published as a briefing packet for the Texas Legislature in 2011.

SETTING THE STAGE: RAINFALL PATTERNS THROUGH SEPTEMBER 2010

During the past 15 years, Texas has experienced a succession of droughts interspersed by relatively wet years. This period of frequent drought followed the wettest 10 to 20 years in the Texas climate record (Nielsen-Gammon 2011). Unless otherwise stated, all weather records quoted in this report reference a period of record extending from 1895 to the present.

The drought of 1995–1996 broke the string of wet years and partly influenced major water planning legislation enacted in many states, including Texas. A brief drought in 1998 was followed by the drought of 1999–2002, which reached its peak in most of Texas with record-setting temperatures in early September 2000 but which lingered in far west Texas for 2 more years. The 2005–2006 drought was widespread across most of Texas but never really achieved historical proportions. The 2007–2009 drought was relatively localized when it reached its peak intensity in 2009, but for some locations in south-central and south Texas, it may well have been the worst drought on record up to that point (Nielsen-Gammon and McRoberts 2009).

This section and the next will evaluate rainfall shortages using a drought index called the Standardized Precipitation Index (SPI). The SPI has become one of the most popular drought indices, in part, because of its simplicity and flexibility. The SPI takes a particular value of accumulated precipitation (such as precipitation over the past 6 months) at a given location and rescales it based on the historical record of precipitation variability at that location. The result is an index value that is negative when present conditions are drier than expected based on historical values and positive when present conditions are wetter than expected. The more negative the SPI value, the more unusually dry the weather conditions are. Table 1 shows some sample values of SPI and their interpretation. However, assessments of actual drought severity should not be based exclusively on a single measure.

SPI values below -2.5 are unlikely to have occurred previously on a given date in the historical record. SPI values below -3.0 have an expected return period for a given date of once every 1,000 years in an unchanging climate, though the historical record is too brief to allow such low probabilities to be calculated with much accuracy.

This report presents SPI maps from the online archives of the Office of the State Climatologist, Texas. The maps are accessible through http://climatexas.tamu.edu and the method of map generation is described in McRoberts and Nielsen-Gammon (2012). The input data is the 4-kilometer resolution daily precipitation analysis produced by the National Weather Service's River Forecast Centers, calibrated using long-record stations in the Cooperative Observer Network. These maps provide an excellent guide to the distribution of drought conditions across Texas in space and time, but the quality of the maps is occasionally hampered by uncorrected errors in the radar estimation of precipitation. The color gray designates areas with insufficient radar coverage for accurate precipitation estimation.

The 2007–2009 drought was most severe in south-central and south Texas (Figure 1). The short-term dryness was most acute in the Coastal Bend area, where at least one county experienced a total failure of its cotton crop, while longer-term drought was most intense along and just southeast of the Balcones Escarpment in central and south-central Texas. Extreme drought conditions in the Lower Valley and east Texas were largely mitigated by the rainfall from hurricanes Dolly and Ike and tropical storm Edouard.

The distribution of drought in August 2009 is shown here for two reasons. First, it indicates which portions of the state were most seriously affected in 2007 and 2009 and which may not have recovered prior to the 2011 drought. Second, it provides a useful point of comparison by which to indicate the much greater severity of the 2011 drought.

The date of onset of the 2011 drought can be stated with remarkable precision: September 27, 2010. On that date, a storm system bringing widespread rain to Texas left the state.

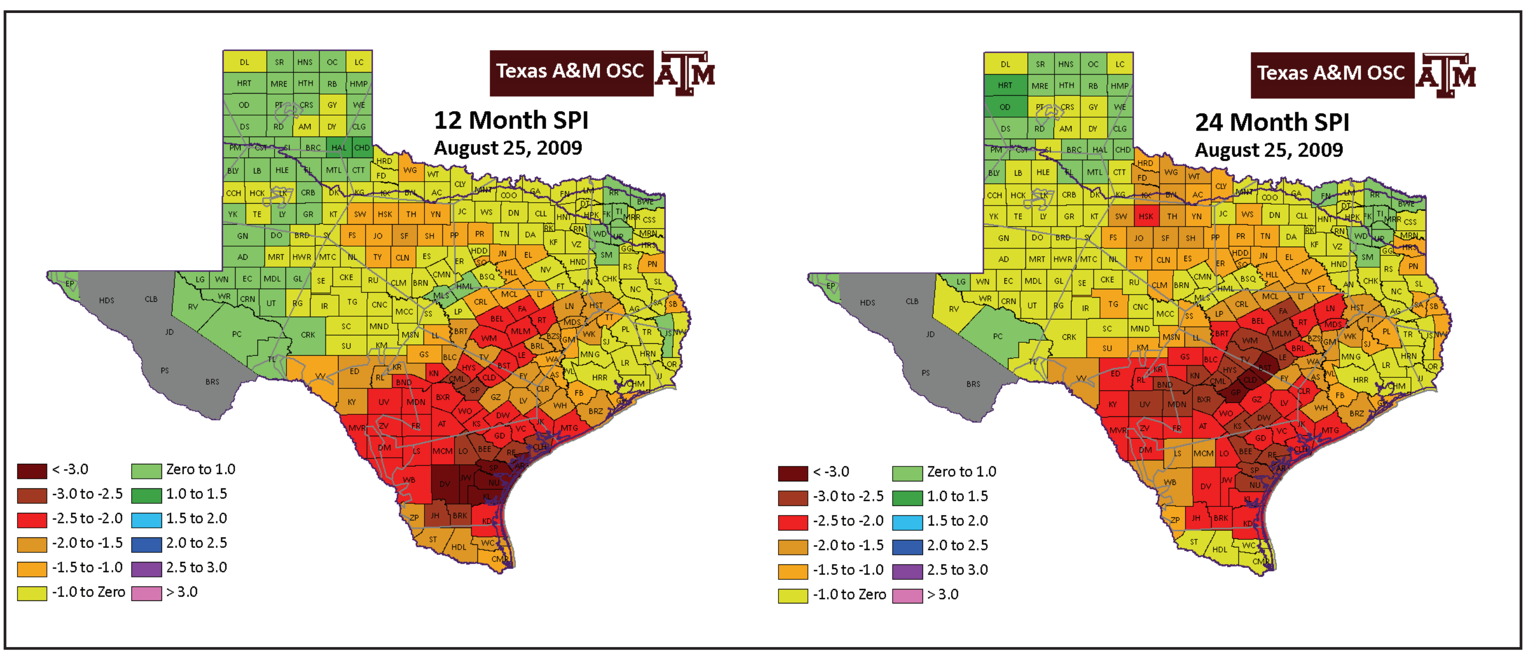


Figure 1. SPI values for accumulated precipitation over 12 months (left) and 24 months (right), at the height of severity of the 2007–2009 drought.

Table 1. Interpretation of various ranges of values of the Standardized Precipitation Index (SPI). Source: modified after http://droughtmonitor.unl.edu/classify.htm (cited 2011 October 30).

SPI range	Expected frequency	Designation
0.5 to -0.5	About 40% of the time	Near Normal
-0.5 to -0.7	About 10% of the time	Abnormally dry
-0.8 to -1.2	About 10% of the time	Moderate drought
-1.3 to -1.5	About 5% of the time	Severe drought
-1.6 to -1.9	About 3% of the time	Extreme drought
-2.0 to -2.5	About 1.5% of the time	Exceptional drought
Below -2.5	About 0.5% of the time	Exceptional drought

Though it could not be known at the time, 13 of the next 14 months would bring below-normal precipitation to Texas.

The September 2010 conditions reflected a relatively wet winter, spring, and summer caused, in part, by an El Niño event in the tropical Pacific. Based on rainfall over the preceding 12 months, most of the state was above or near normal (Figure 2), with the driest conditions found along the Louisiana border. When 2009 is factored in, the 2-year accumulations averaged near-normal across the state, with the lowest 2-year totals (compared to normal) found in scattered pockets in the southern and eastern portions of the state.

Parts of eastern Texas could rightfully take exception to the claim that the drought started at the end of September 2010. As Figure 2 shows, moderate drought conditions already existed at both 1- and 2-year time scales in Newton County, and other parts of eastern Texas had just finished a summer with below-normal rainfall and relatively little hay production. However, for the state as a whole, the end of September represents the "high water mark" prior to the onset of widespread drought conditions. The U.S. Drought Monitor (http://droughtmonitor.unl.edu) classified only 2.4% of the state as being in drought at the end of September.

DRIER AND DRIER: DEVELOPMENT OF THE 2011 TEXAS DROUGHT

This section tells the evolution of the 2011 Texas Drought using 4 separate SPI indices. The 2-month SPI characterizes precipitation shortages (and excesses) for the 2-month period ending on the date specified. This index is most useful for monitoring the month-to-month variations in rainfall and for characterizing short-term drought stress during the warmer parts of the year. The 6-month SPI characterizes the rainfall amounts during the preceding half-year and is most useful for characterizing shallow soil moisture available to agricultural crops and forage grasses. The 12- and 24-month SPI maps are most useful for characterizing precipitation on time scales relevant to the recharge of reservoirs and some aquifers, as well as deep soil moisture available to trees.

Tables 2 and 3 list monthly statewide average values of precipitation and temperature, compared to normal and ranked against the historical record.

Already by the end of October 2010, the dry conditions in eastern Texas were becoming increasingly obvious, as some

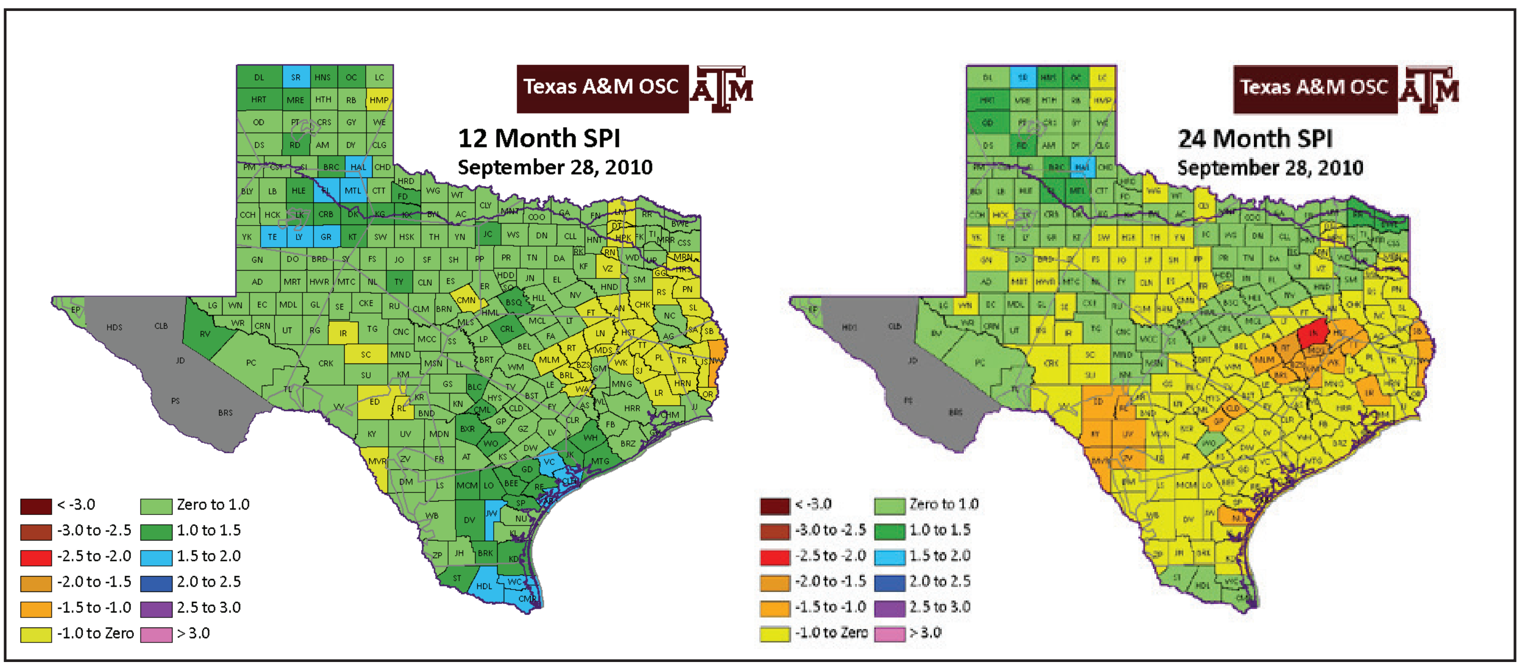


Figure 2. SPI values for accumulated precipitation over 12 months (left) and 24 months (right), just prior to the onset of the 2011 drought.

Table 2. Monthly precipitation values (inches) and rank among historical values, based on Texas statewide average precipitation calculated from FNEP data set (McRoberts and Nielsen-Gammon 2011) and from official National Climate Data Center climate division data set. Normal values are an average for the 1981–2010 period. The period of record is 1895–2011. Average precipitation is defined as the total precipitation at each station for the month, averaged within each climate division, and then spatially averaged across Texas.

Month	FNEP Precipitation	FNEP Normal	Ranking since 1895	NCDC Precipitation
October 2010	0.83	2.61	8th driest	0.82
November 2010	1.10	1.88	31st driest	1.03
December 2010	0.79	1.79	17th driest	0.74
January 2011	1.59	1.65	49th wettest	1.63
February 2011	0.75	1.83	20th driest	0.74
March 2011	0.29	2.18	Record driest	0.29
April 2011	0.81	2.04	6th driest	0.77
May 2011	1.63	3.32	9th driest	1.60
June 2011	0.99	3.51	5th driest	1.03
July 2011	0.71	2.45	3rd driest	0.73
August 2011	0.71	2.42	5th driest	0.72
September 2011	1.13	2.87	7th driest	1.17
October 2011	2.23	3.10	62nd driest	2.21
November 2011	1.38	2.12	49th driest	1.34
December 2011	2.96	1.87	18th wettest	2.95

Table 3. Monthly average temperature values and rank among historical values, based on official National Climate Data Center climate division data set. Normal values are an average for the 1981–2010 period. The period of record is 1895–2011. Average temperature is defined as the average of the maximum and minimum temperatures at each station for the month, averaged within each climate division, and then spatially averaged across Texas.

Month	Average Temperature (°F)	Normal Average Temperature (°F)	Rank
October 2010	67.0	66.25	41st warmest
November 2010	56.5	56.06	46th warmest
December 2010	48.7	47.30	43rd warmest
January 2011	44.8	46.62	38th coolest
February 2011	48.7	50.49	44th coolest
March 2011	61.7	57.63	18th warmest
April 2011	70.1	65.18	5th warmest
May 2011	73.8	73.21	32nd warmest
June 2011	85.0	79.73	Record warmest
July 2011	86.9	82.37	Record warmest
August 2011	88.1	82.06	Record warmest
September 2011	77.8	75.65	18th warmest
October 2011	67.0	66.25	48th warmest
November 2011	56.5	56.06	45th warmest
December 2011	45.8	47.30	28th coldest

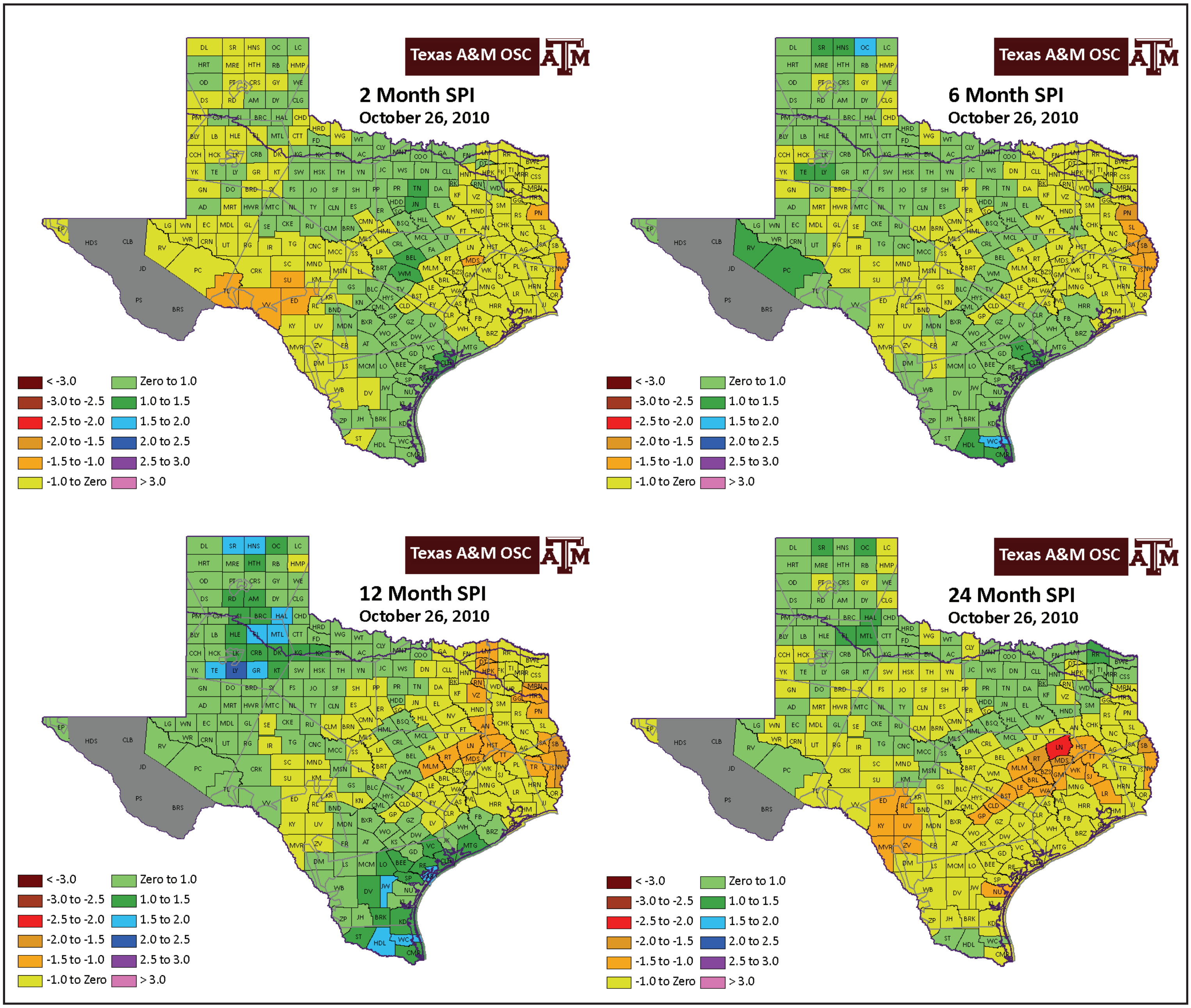


Figure 3. SPI drought index values as of October 26, 2010. The more negative values indicate more severe drought conditions.

rainfall events prior to the summer no longer contributed to the short-term SPI values shown in Figure 3. The 2-month SPI reflected a combination of a wet September, with multiple tropical disturbances bringing rain to south Texas and the I-35 corridor, and an October that was the eighth driest month on record for the state as a whole.

At the end of November, the 2-month SPI was based on 2 consecutive dry months, and Figure 4 shows that the fall dryness was exceptional in parts of central and south Texas. The Panhandle had actually received above-normal precipitation for the 2-month period, due almost entirely to rain from a single storm system on November 11–12.

December was the third consecutive drier-than-normal month for Texas. The November 11–12 Panhandle rain event was all that kept the entire state from receiving below-normal precipitation for the November–December period. The 3 months of dry weather had thrown most of eastern Texas into drought conditions according to the 6- and 12-month SPI maps (Figure 5). The year 2009 had been the 11th wettest on record for the East Texas climate division (#4), but the year 2010 was the eighth driest. The 12- and 24-month SPI maps in Figure 5 indicates that 2010 was driest toward the

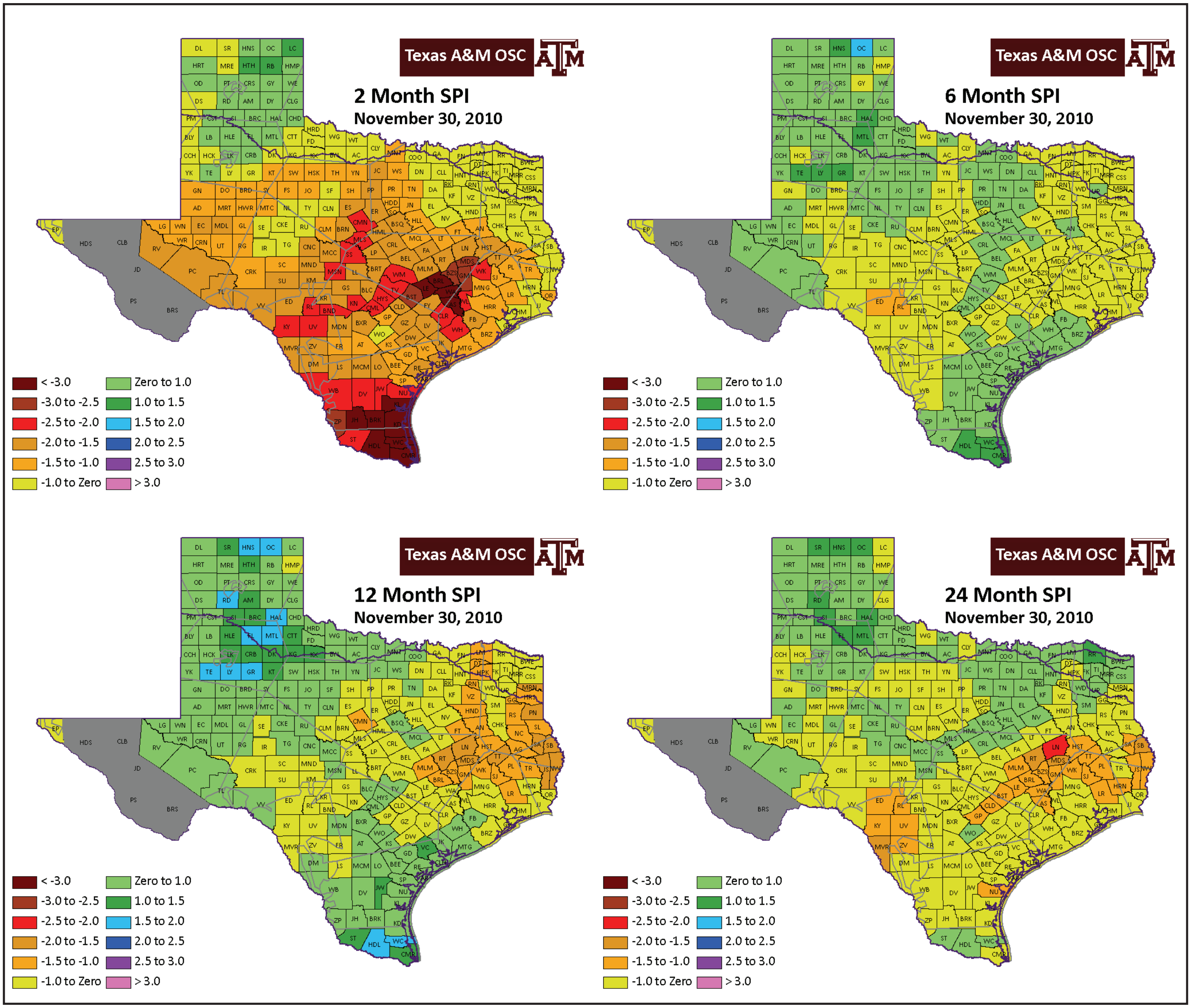


Figure 4. SPI drought index values as of November 30, 2010. The more negative values indicate more severe drought conditions.

Louisiana border, while 2009 was apparently wettest near the Oklahoma border. This left the southern half of the Louisiana border in drought conditions for all depicted time scales, based on the SPI.

Both short- and long-term drought were also already present in east-central Texas, in an area centered on Bryan/College Station, and in the western Winter Garden area of southwestern Texas east of Del Rio. In the rest of the state, the wet summer was still substantially reducing the potential impact of the dry fall. However, the combination of a wet summer and dry fall provided substantial fuel for wildfires. Potential wildfire danger is indicated by those areas in which the 2-month SPI is much drier than the 6-month SPI.

Three months into what would become the 2011 drought, the U.S. Drought Monitor was indicating short-term drought across most of Texas (Figure 6). Already, 69.4% of the state was classified as being in at least moderate drought. However, exceptional drought had not yet made an appearance, and only 9.6% of the state was in extreme drought.

January was the only month within the period in which statewide average rainfall (barely) exceeded its long-term average. The precipitation was sufficient to bring the 2- and 6-month

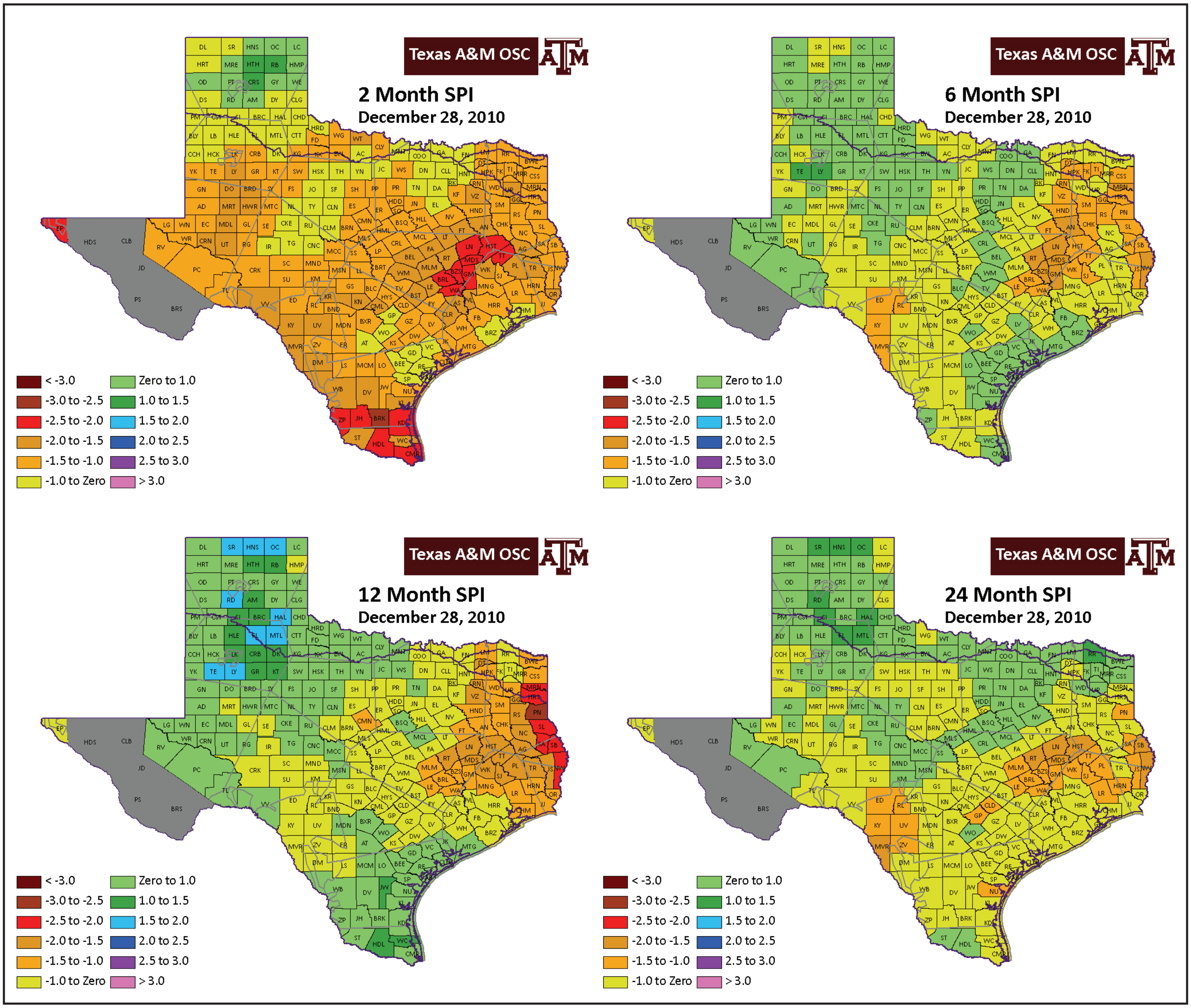


Figure 5. SPI drought index values as of December 28, 2010. The more negative values indicate more severe drought conditions.

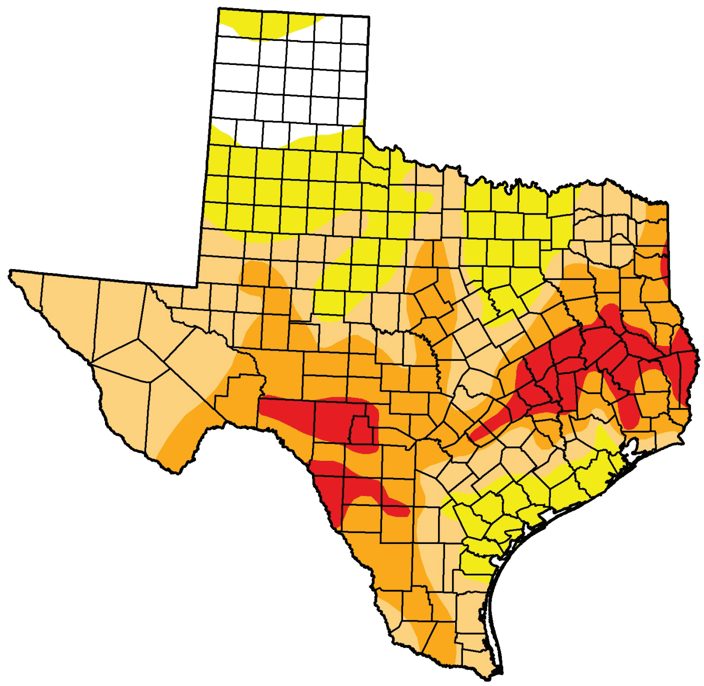
U.S. Drought Monitor

December 28, 2010
Valid 7 a.m. EST

Texas

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	7.89	92.11	69.43	37.46	9.59	0.00
Last Week (12/21/2010 map)	13.61	86.39	73.68	38.41	9.66	0.00
3 Months Ago (09/28/2010 map)	75.57	24.43	2.43	0.99	0.00	0.00
Start of Calendar Year (12/29/2009 map)	72.90	27.10	6.98	2.32	0.00	0.00
Start of Water Year (09/28/2010 map)	75.57	24.43	2.43	0.99	0.00	0.00
One Year Ago (12/22/2009 map)	72.27	27.73	8.14	2.32	0.00	0.00



Intensity:

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

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

http://drought.unl.edu/dm

Released Thursday, December 30, 2010
D. Miskus, CPC/NOAA

Figure 6. U.S. Drought Monitor for Texas for December 28, 2010. Available online at http://droughtmonitor.unl.edu.

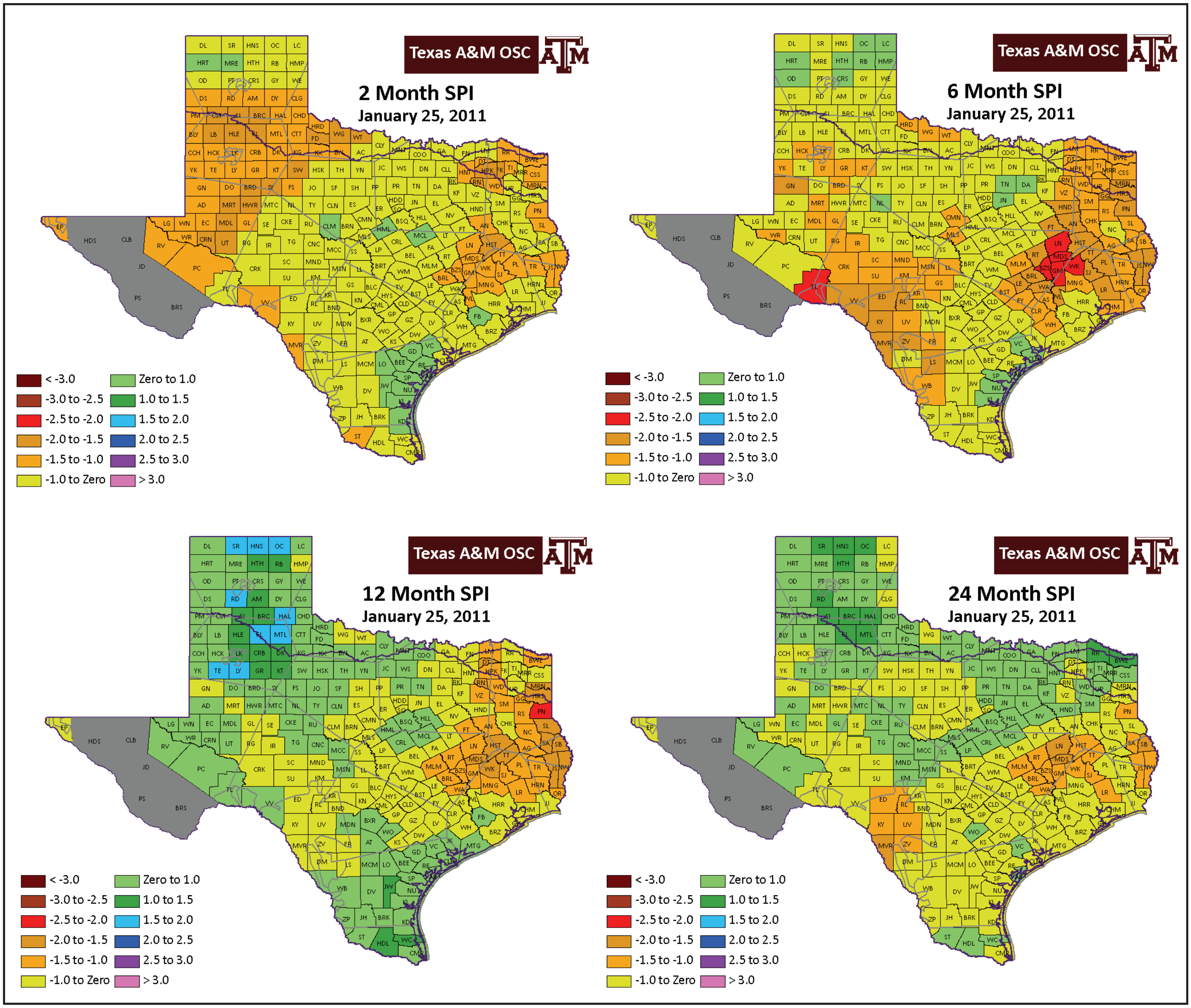


Figure 7. SPI drought index values as of January 25, 2011. The more negative values indicate more severe drought conditions.

totals to above normal in the Coastal Bend area (Figure 7); this rain was extremely beneficial for establishing suitable conditions for crop planting and seed germination. Most of the rest of the state also benefited temporarily from the rainfall (or, in northern Texas, snowfall). However, less than a tenth of an inch of precipitation was recorded in most of western Texas, and the lack of midseason precipitation and snow cover would have serious implications for much of the winter wheat crop.

By the end of January, the area around Bryan/College Station had crossed the exceptional drought threshold at the 6-month accumulation period. However, environmental and societal water demands are minimal in that region during the wintertime, so the impacts of the drought were still far short of exceptional. Terrell County in southwest Texas had also crept into exceptional drought based on 6-month precipitation.

February was again a dry month, but not exceptionally so. The SPI maps (Figure 8) showed little change from the end of January. At this point, 6 months into the drought, true drought conditions were present throughout east Texas, extending westward almost as far as Dallas, Austin, and Houston. Drought conditions also prevailed across southwestern Texas and parts of western and northern Texas as well. According-

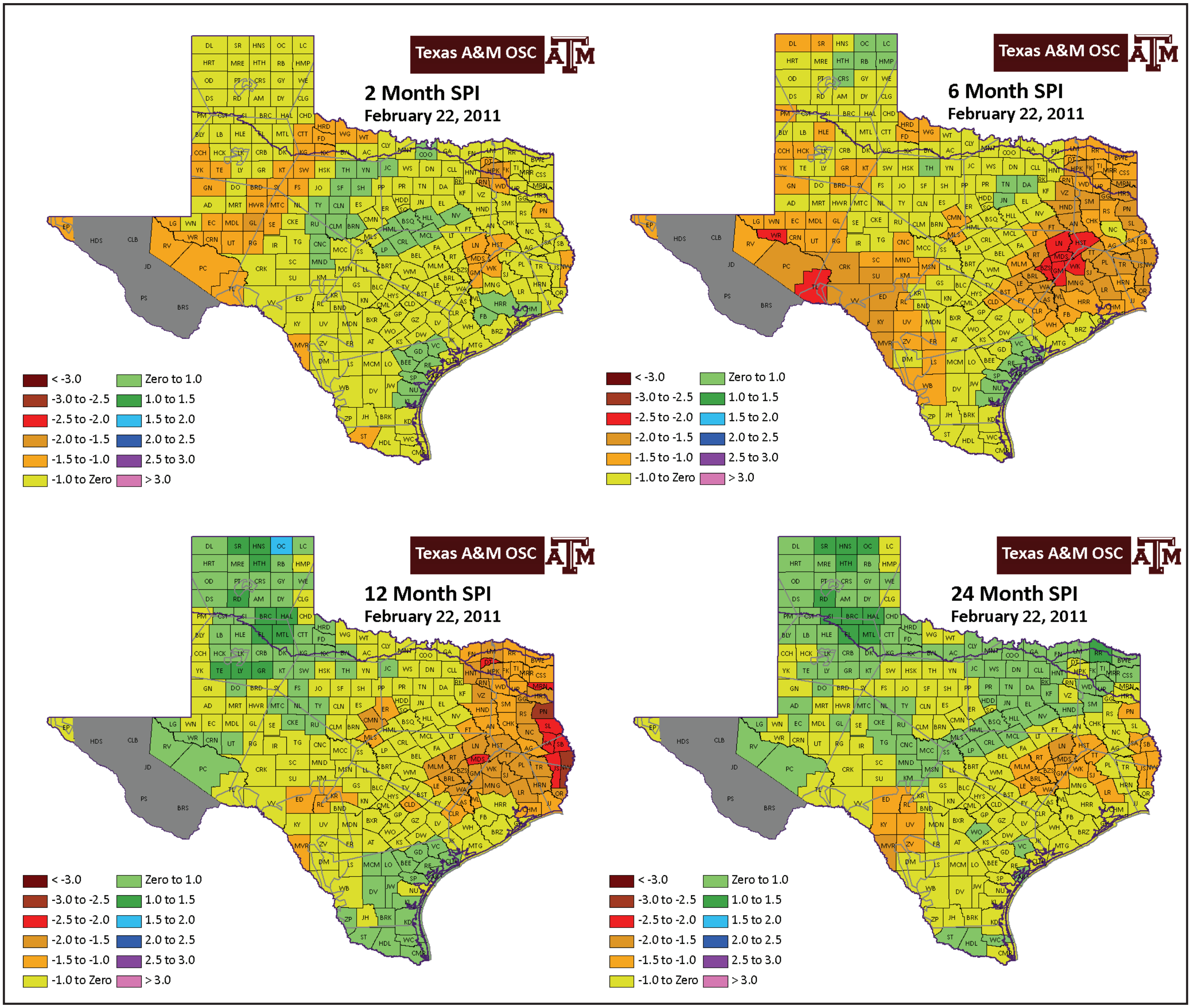


Figure 8. SPI drought index values as of February 22, 2011. The more negative values indicate more severe drought conditions.

ing to the U.S. Drought Monitor (not shown), the fraction of the state suffering under drought was about the same size it was at the end of December.

While Texas was already in serious drought at the end of February 2011, the upcoming months were disastrous for farmers and ranchers. If ample rain had begun in March, the most serious drought impacts might have been limited to the winter wheat crop and excess winter-feeding costs for ranchers.

Instead, the opposite happened. March 2011 was the driest March on record for the state of Texas as a whole. Below-normal precipitation for the February–March period occurred everywhere except parts of western Texas, where rainfall in February and March is normally light (Figure 9).

The record dry March combined with the removal of September from the 6-month precipitation accumulation period combined to allow the 6-month SPI to depict terrible drought conditions across the state. Many counties in east-central, south, and west Texas had SPI values below -2.5, implying a lack of cool-season rainfall that was probably unprecedented in the historical record. The only portion of the state with positive SPI values at the 6-month time scale was in the Pan-

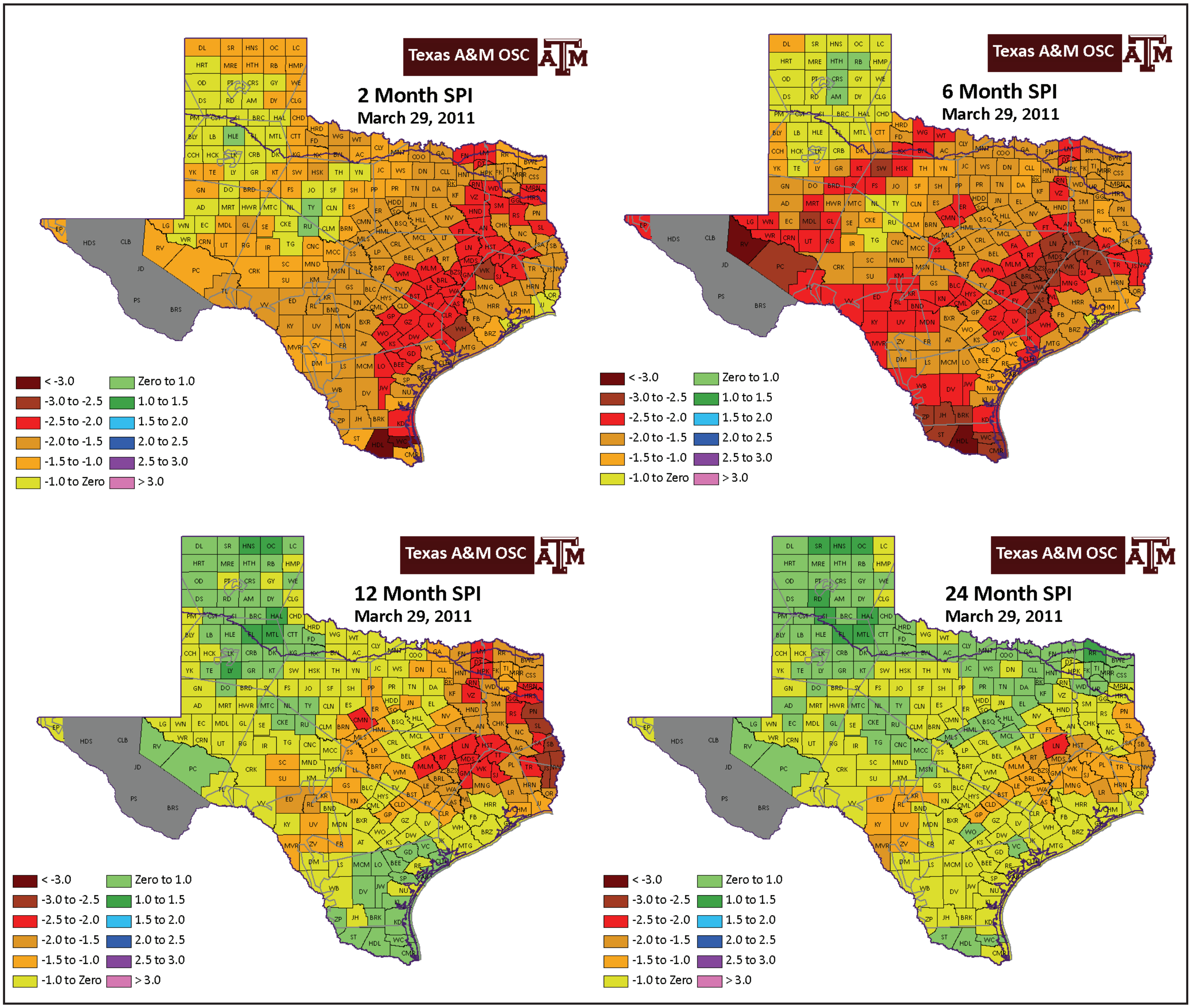


Figure 9. SPI drought index values as of March 29, 2011. The more negative values indicate more severe drought conditions

handle because of the storm in November.

Throughout the rest of Texas, the remarkable lack of rainfall, combined with springtime warmth, dried out the previous year's growth of grasses. Because the previous growth season had been relatively wet, there was ample dry grass available to serve as fuel for wildfire, especially in central and western Texas where absolute precipitation amounts were smallest and winds tended to be stronger. By early April, wildfires were burning in many parts of western and west-central Texas. Table 4 provides information on the 20 largest wildfires in Texas in 2011.

The U.S. Drought Monitor indicated prevalent dry conditions throughout Texas at the end of March 2011 (Figure 10). More significantly, over 43% of the state was classified as D3, extreme drought, the second most severe drought category.

The U.S. Drought Monitor began in 2000, and in its existence, only 2 weeks during August 2006 had a greater portion of Texas been in extreme or exceptional drought. That record would be broken during the first week of April 2011. The record for the greatest percentage of Texas in severe or worse drought would be broken during the third week of April, as would the record for the greatest percentage of Texas in at least moderate drought (the new record would be 100%). The record for the greatest percentage of Texas in exceptional drought would be broken during the fourth week of April.

So, according to the U.S. Drought Monitor, the 2011 Texas drought by April was already the most severe Texas drought in recent memory.

The dry weather continued throughout April, and the SPI values tracked with the U.S. Drought Monitor in showing worsening conditions (Figure 11). The 2-month SPI showed that only the very northeastern part of Texas received more precipitation than the historical norm. Elsewhere, precipitation was well below normal, providing insufficient moisture for development of warm-season dryland crops or initiation of warm-season forage growth.

Besides east-central, south, and west Texas, a new area of especially dry conditions emerged in west-central Texas, extending from the Midland-Lubbock area to the Red River between Childress and Wichita Falls. In all but a handful of counties, the wet weather at the beginning of the previous 12-month period was overshadowed by the more recent dry weather.

Table 4. List of 20 largest (acres burned) fires during 2011 in Texas, listed in chronological order. Source: Texas Forest Service (April Saginor, personal communications, June 2012)

Fire Name	Primary County	Start Date	Days Until Controlled	Acres Burned	Homes Lost
Matador West Fire	Motley	Feb. 27	7	41,000	2
Tom Fire	Adams	Feb. 27	2	65,000	0
Swenson Fire	Stonewall	Apr. 6	15	122,500	2
Killough Fire	Garza	Apr. 9	7	32,000	1
Roper Fire	Brewster	Apr. 9	2	41,000	0
Crawford Ranch Fire	Moore	Apr. 9	2	35,096	0
PK Complex	Palo Pinto	Apr. 9	33	126,734	168
Rockhouse Fire	Jeff Davis	Apr. 9	33	314,444	23
Wildcat Fire	Coke	Apr. 10	20	158,308	0
Pierce/Sutton Fire	Crockett	Apr. 11	5	30,814	0
Cooper Mountain Ranch Fire	Kent	Apr. 11	12	162,625	4
Cannon Complex	Pecos	Apr. 11	7	63,427	0
Frying Pan Fire	Andrews	Apr. 14	2	80,907	0
Deaton Cole Fire	Val Verde	Apr. 25	17	175,000	n/a
Dickens Complex	Dickens	May 6	9	89,200	0
Schwartz Fire	Brewster	May 7	13	83,995	0
Iron Mountain Fire	Brewster	May 9	13	87,401	0
White Hat Fire	Nolan	June 20	11	72,473	8
Bear Creek Fire	Cass	Sept. 4	50	41,050	92
Bastrop County Complex	Bastrop	Sept. 4	36	34,068	1660

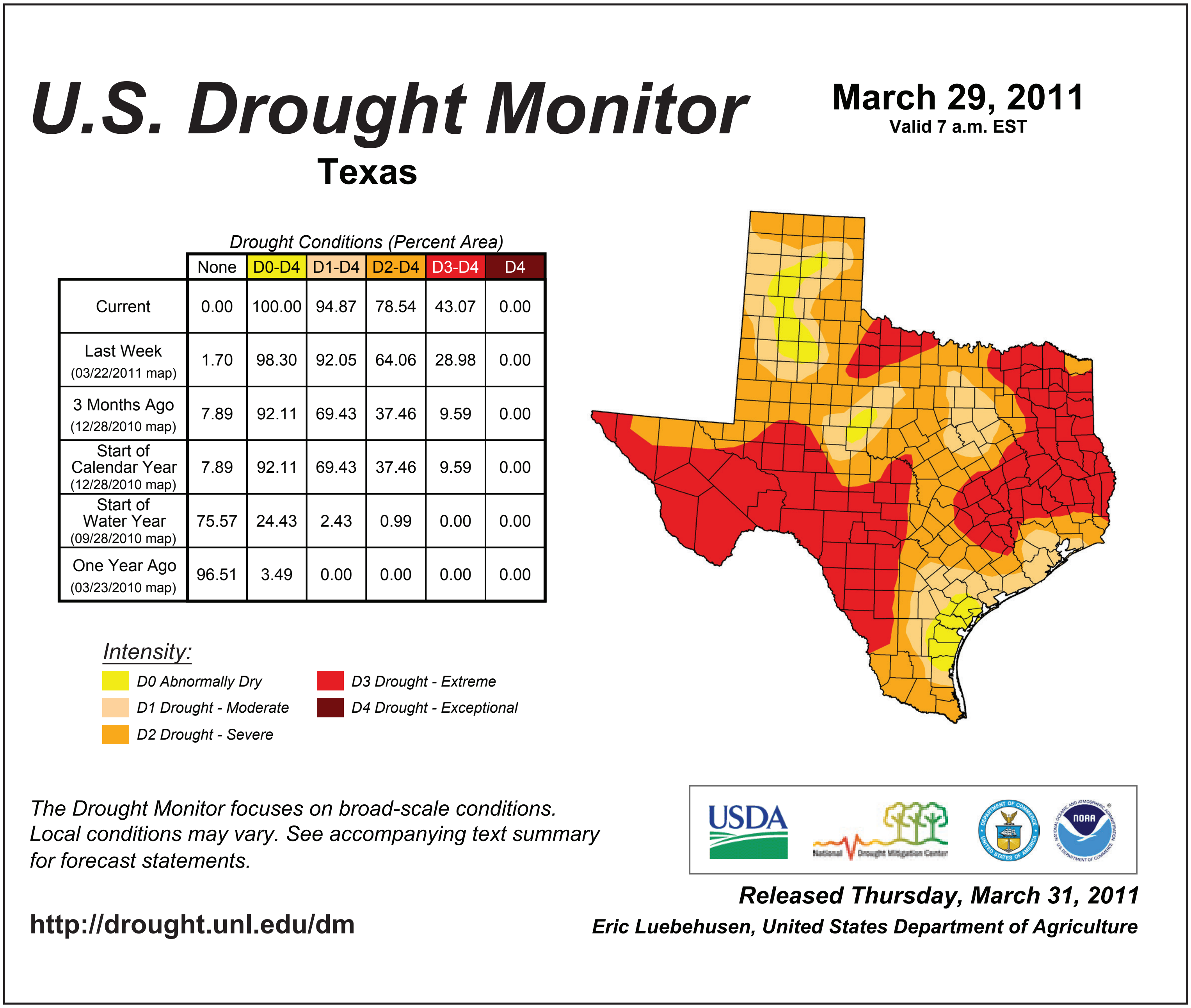


Figure 10. U.S. Drought Monitor for Texas for March 29, 2011. Available online at http://droughtmonitor.unl.edu.

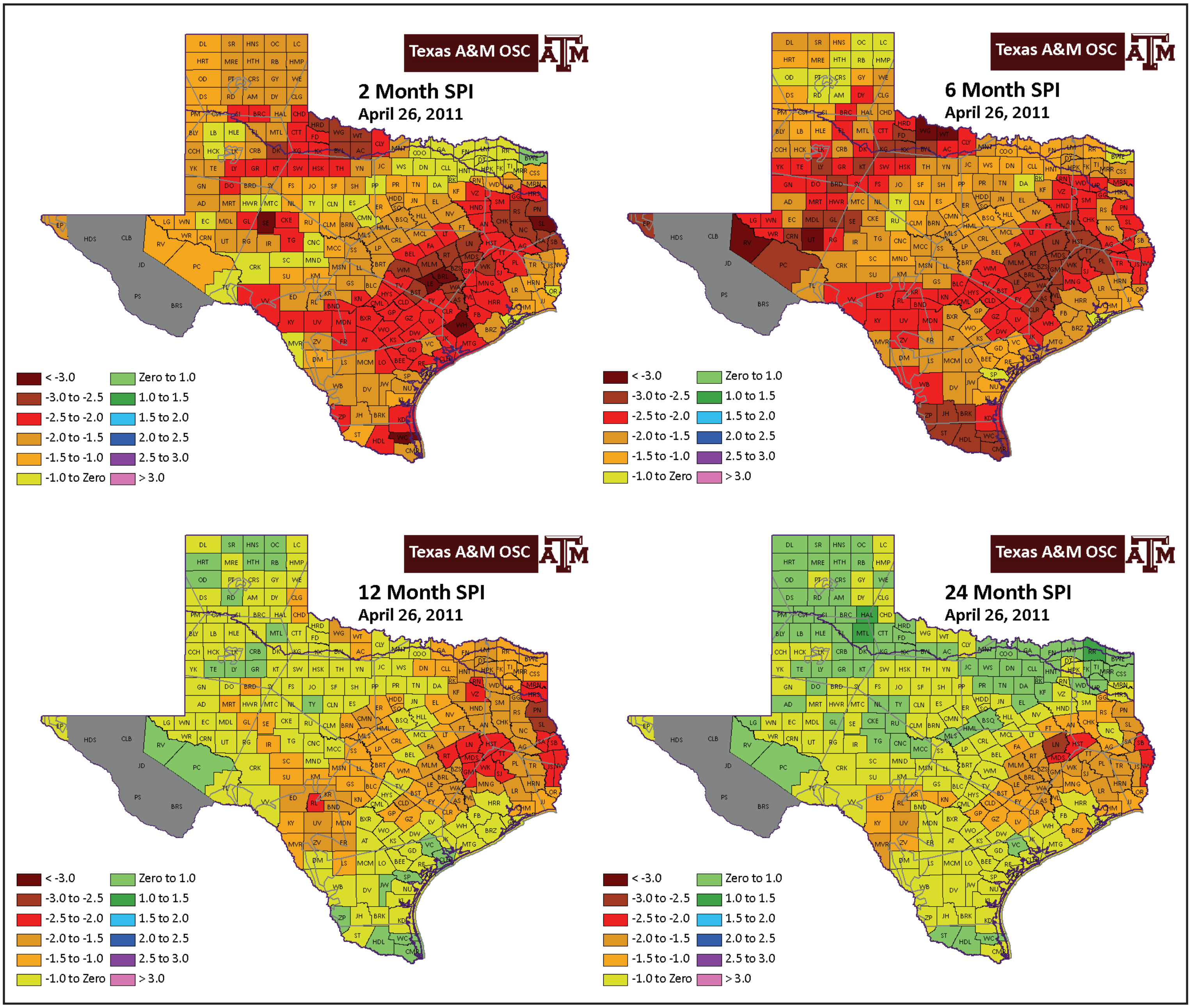


Figure 11. SPI drought index values as of April 26, 2011. The more negative values indicate more severe drought conditions.

Statewide, May and June normally average more precipitation than any other months (Table 2). May 2011 turned out to be the ninth driest May on record, and the 3-month period from March through May was the driest March–May on record. For all of the state, except parts of north-central and northeast Texas, the dry March–May, on the heels of an already dry winter, guaranteed very low to nonexistent dryland crop yields for the 2011 growing season, irrespective of potential future rainfall. In the drier areas, warm-season forage had yet to emerge.

The wetter conditions in northeast Texas were on the edge of a region of flood-producing rainfall extending from eastern Oklahoma and Arkansas northeastward into the Ohio River Valley. In general, if one region of the country is unusually dry, another region will be unusually wet, so the floods can be thought of as being caused by the same set of circumstances that produced the drought.

With the November Panhandle storm no longer part of the 6-month accumulation period, the 6-month SPI (Figure 12) showed a remarkably broad area of -3.0 or worse drought across much of western Texas. This part of Texas is normally dry during the wintertime, but the rains become more plentiful during May as squall lines and severe thunderstorms typically form along the dryline. In 2010–2011, many areas had received less than 10% of their meager normal rainfall, and a large swath of the state west of Midland had not received any measurable precipitation whatsoever during December through May.

The near-total absence of dryline thunderstorm activity continued through June (Figure 13). Thus the Panhandle, which had benefited from a November storm that missed the rest of the state, now suffered through spring weather not merely much drier than normal, but much drier than any previous record. In the High Plains climate division (#1), May–June precipitation averaged 0.57 inch, roughly 8% of the long-term average for those 2 months and less than half of the previous record set in 1999. The 1.63 inches average for the first 6 months of the year was likewise less than half the previous record set in 1954. Most counties west of a San Angelo-Wichita Falls line had 6-month SPI values below -3.0, indicating an agricultural drought far worse than anything previously experienced in the area.

Despite the particular severity of the drought there, west Texas received little attention because the drought was extremely bad elsewhere. Most of the area within 75 miles of Interstate 10, from the western border to the eastern border, had 6-month SPI values below -2.0, and the timing seemed designed to produce maximum impact on ranchers. In most of the state, warm-season grasses were still very slow to develop, and stock tanks and streamflows were rapidly declining because of the lack of precipitation combined with the excessive heat.

Because the more recent lack of rainfall had occurred at precisely the time of year when rain was needed the most, the U.S. Drought Monitor showed that drought conditions had rapidly worsened during the 3 months ending in June 2011 (Figure 14). Three months before, 43% of the state had been in extreme drought; by the end of June, 72% of the state was depicted as being in exceptional drought. The only portion of the state not shown as abnormally dry was the region near and north of Dallas, where several counties had received adequate rain during May and June.

Amplifying the severity of the drought was the excessive heat that had developed across the state. June was the warmest June on record (Table 3) and the fourth warmest month on record up to that point. Unusually warm weather is common during summertime droughts in Texas because the lack of available soil moisture causes almost all of the energy in sunlight to go into heating up the ground and the adjoining air and the lack of low-level clouds allows most of the sunlight to reach the ground in the first place. The high temperatures, in turn, produce greater drought stress in most plants and accelerate evaporation from streams, reservoirs, and stock tanks.

The dry weather continued into July, which was the third driest July on record despite the occurrence of a landfalling tropical depression (Don). The 6-month SPI (Figure 15) showed that extremely severe drought conditions (SPI < -2.5) had spread from west Texas across the Edwards Plateau into central and south-central Texas. With rains during June and July 2010 now a distant memory, the 12-month SPI had plummeted, with SPI values below -2.5 in many parts of the state.

At the same time, temperatures continued to set records. July was not just the warmest July on record for Texas but the warmest month ever in the state. The number of triple-digit-temperature days threatened to break previous records.

The prolonged dry and hot weather began to have a serious impact on trees, as well. Normally, trees are able to tolerate short-term drought because their root systems penetrate deeper into the soil. By the end of July, many months of remarkably dry and hot weather across central and eastern Texas had caused even deep-soil moisture to become seriously depleted.

In August, scattered rains in parts of west Texas had reduced the severity of drought conditions in some areas, but elsewhere conditions worsened (Figure 16). The 2-month SPI indicated that July and August had been especially dry almost precisely where the previous summer's rainfall had been most beneficial: along a line from Corpus Christi through Austin and nearly to Dallas. Over the 6 months from March through August, rainfall in that area was so small that the 6-month SPI was below -3.0, and similar conditions were found near Houston, in much of the Hill Country, and almost the entire region north and west of Abilene.

The record for warmest month in Texas, set during July,

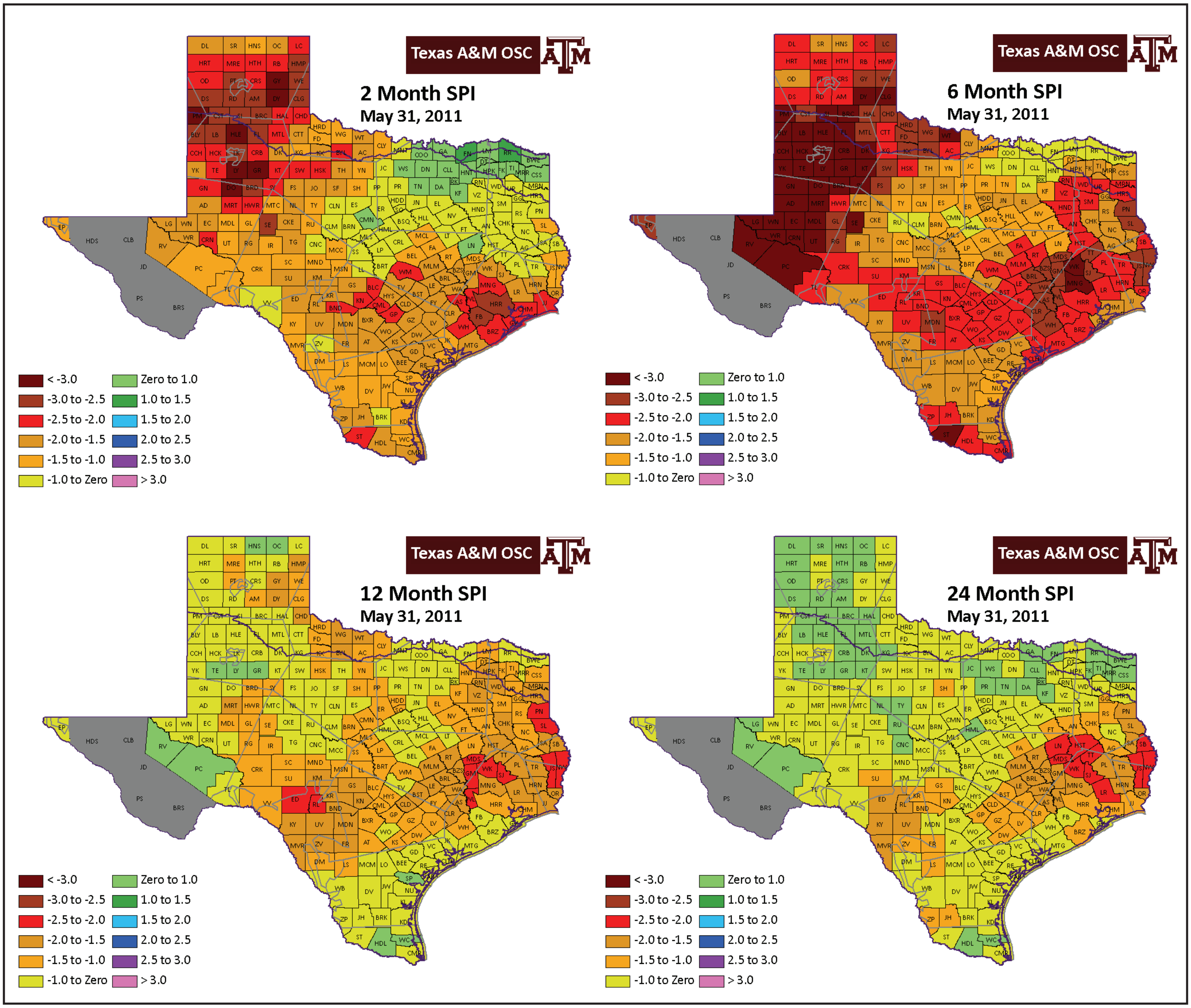


Figure 12. SPI drought index values as of May 31, 2011. The more negative values indicate more severe drought conditions.

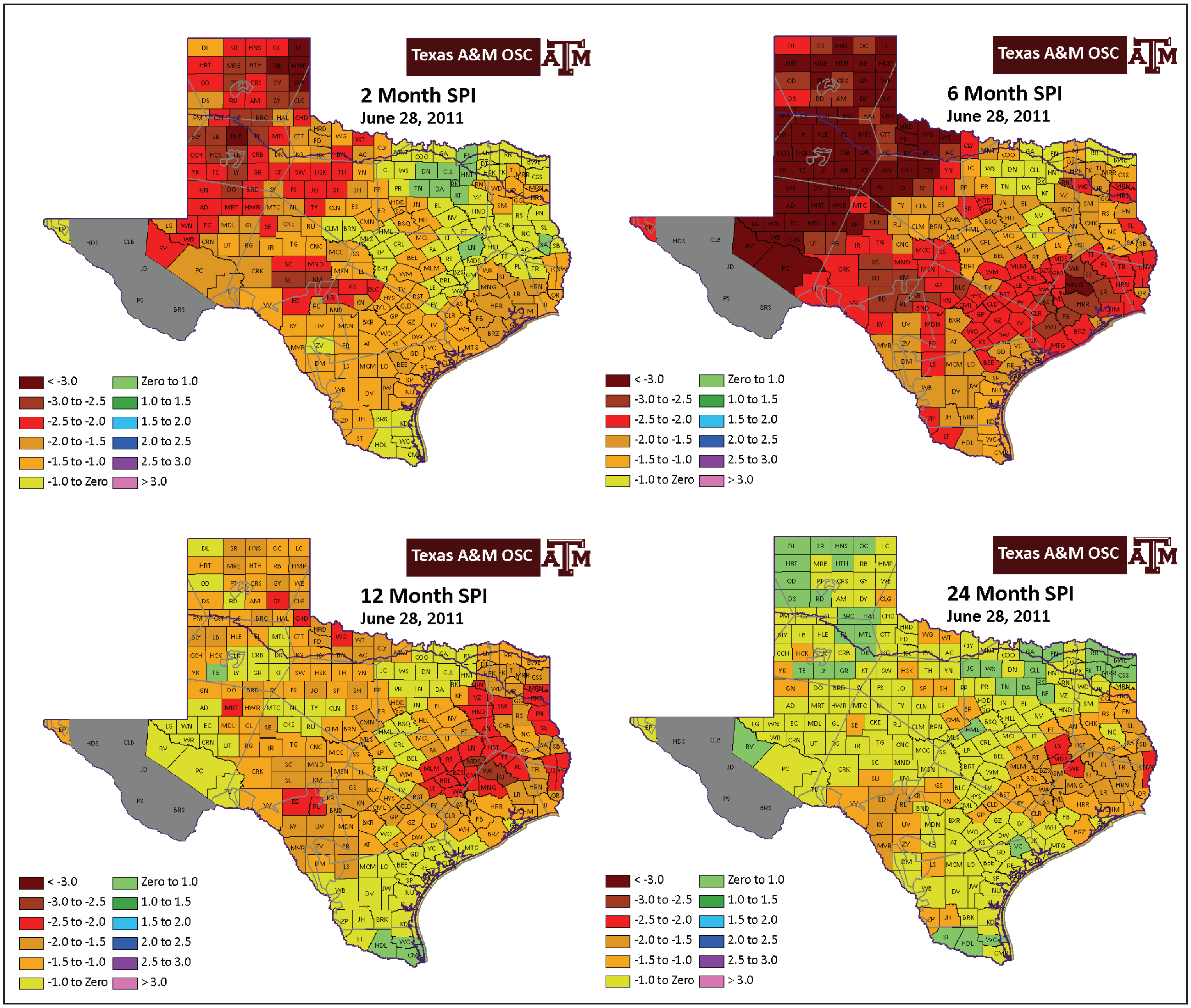


Figure 13. SPI drought index values as of June 28, 2011. The more negative values indicate more severe drought conditions.

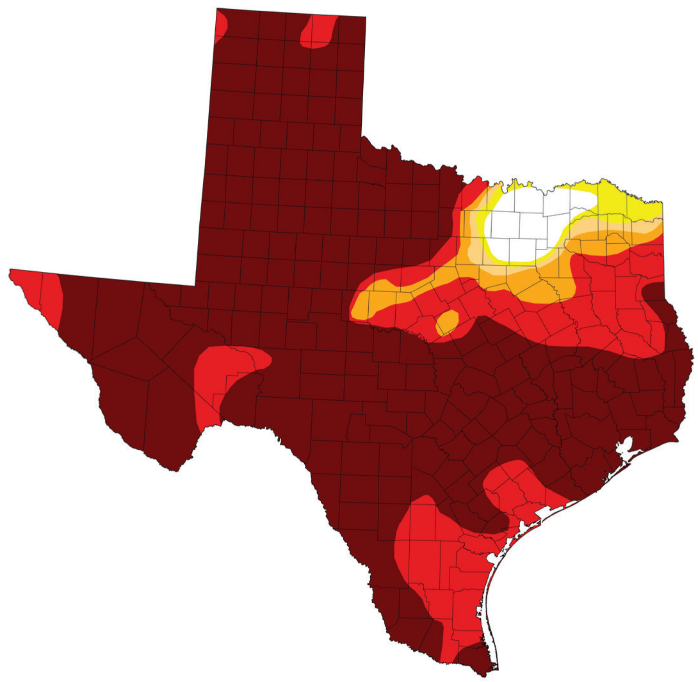
U.S. Drought Monitor

Texas

June 28, 2011
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.68	97.32	95.71	94.52	90.62	72.32
Last Week (06/21/2011 map)	3.33	96.67	95.71	94.52	91.31	70.61
3 Months Ago (03/29/2011 map)	0.00	100.00	94.87	78.54	43.07	0.00
Start of Calendar Year (12/28/2010 map)	7.89	92.11	69.43	37.46	9.59	0.00
Start of Water Year (09/28/2010 map)	75.57	24.43	2.43	0.99	0.00	0.00
One Year Ago (06/22/2010 map)	51.78	48.22	13.00	0.00	0.00	0.00



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

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

http://drought.unl.edu/dm

Released Thursday, June 30, 2011
Richard Heim/Liz Love-Brotak, NOAA/NESDIS/NCDC

Figure 14. U.S. Drought Monitor for Texas for June 28, 2011. Available online at http://droughtmonitor.unl.edu.

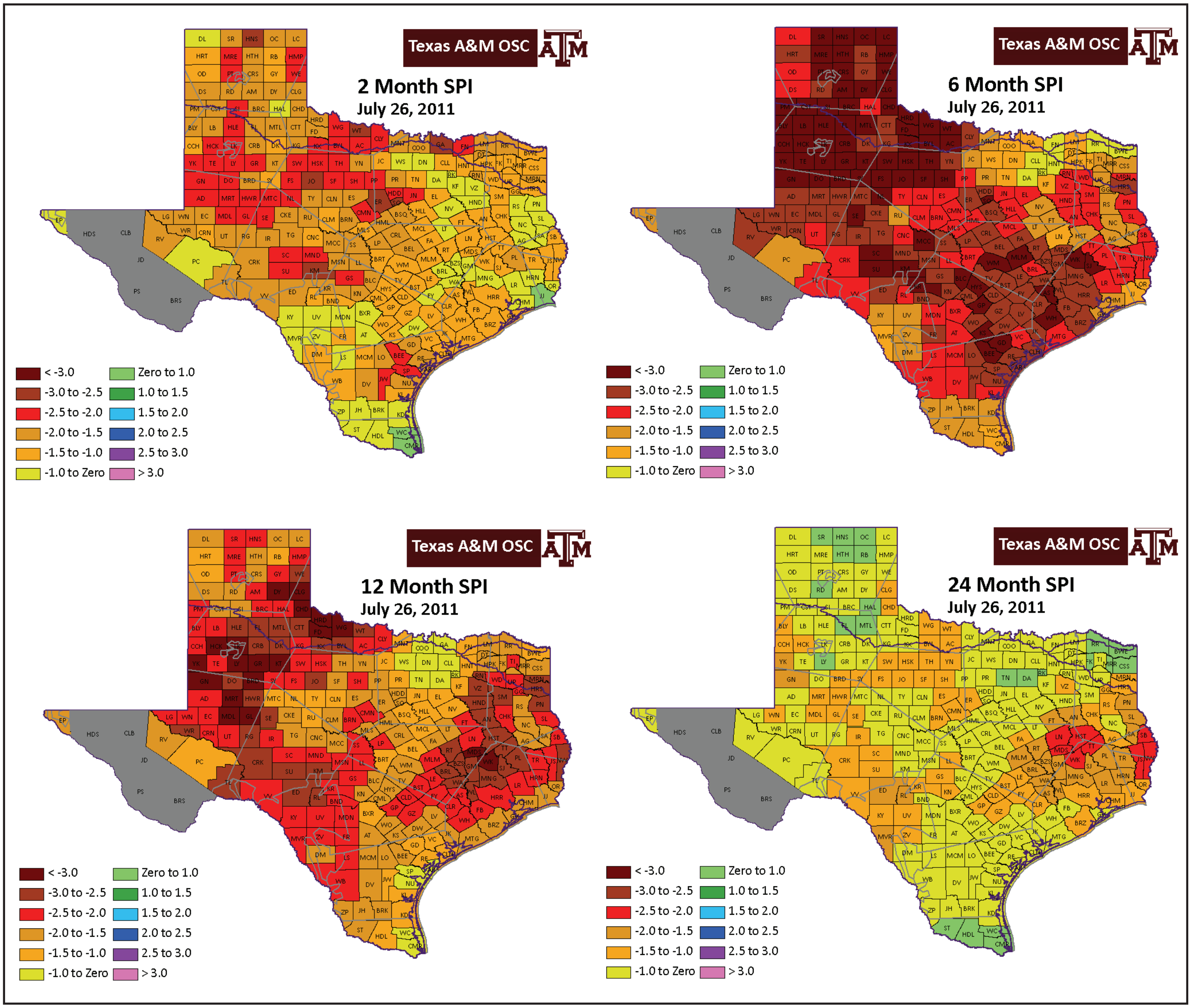


Figure 15. SPI drought index values as of July 26, 2011. The more negative values indicate more severe drought conditions.

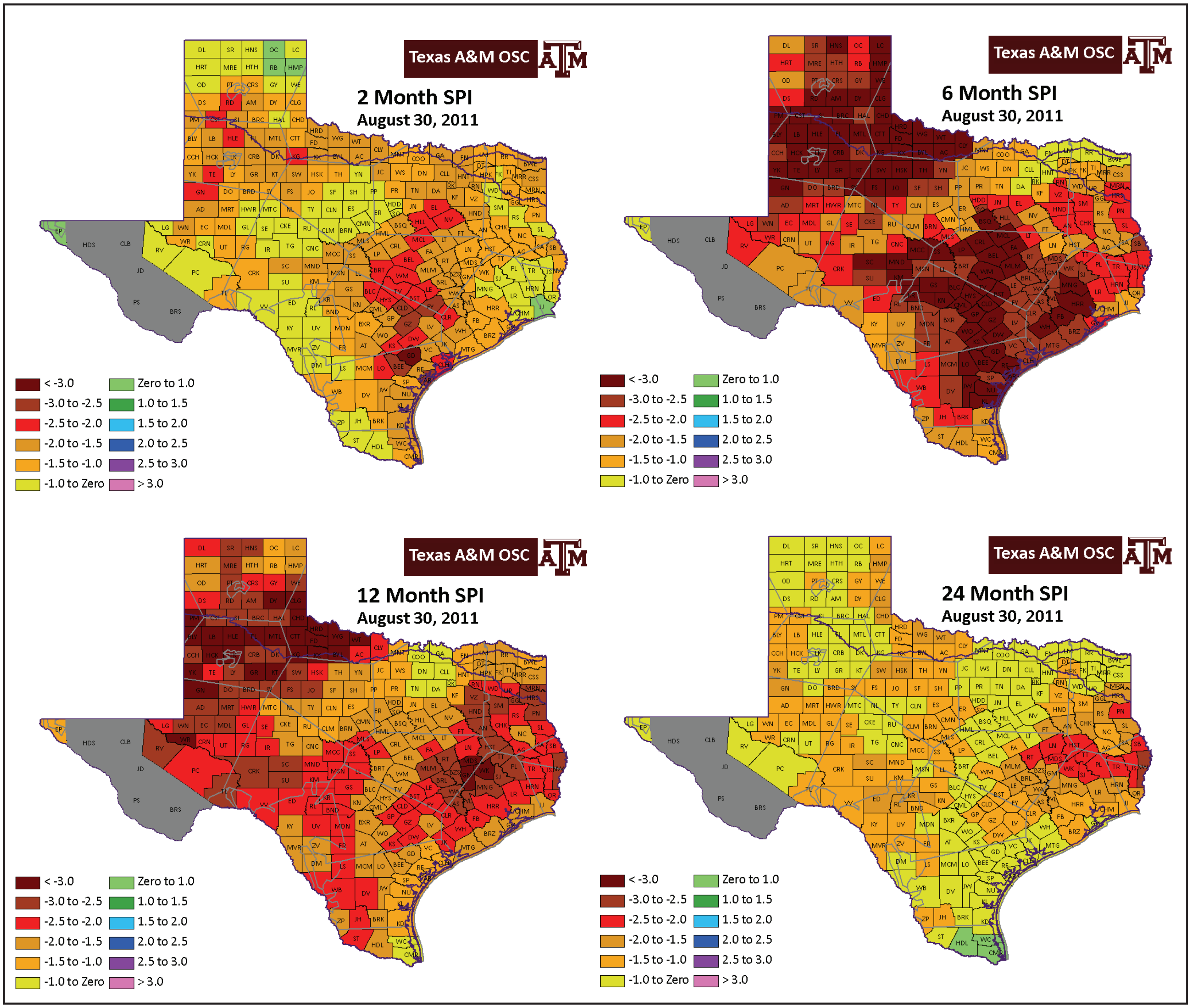


Figure 16. SPI drought index values as of August 30, 2011. The more negative values indicate more severe drought conditions.

stood for exactly one month. August averaged 1.2 °F warmer than July (Table 3). The combined June–August temperatures were statistically even with those of Oklahoma, and both states shattered the previous record for warmest summer (June–August) in the contiguous 48 states, set by Oklahoma in 1934. The data available as of early September had Texas holding the new record, and this information was widely reported, but by the time the data archive was complete at the National Climatic Data Center (NCDC) a few months later, Oklahoma possessed the final record for the 3-month period. Nonetheless, Texas now holds the national records for warmest June and warmest August.

The continued record warm and dry weather had caused most Texas forests to become extremely dry, and the near-approach of Tropical Storm Lee, making landfall in Louisiana, provided the high winds necessary to produce a widespread outbreak of rapidly growing forest fires. Many forest fires burned large areas of timber and some homes in northeast Texas and northwest of Houston. In central Texas, the most devastating fire of the entire year, the Bastrop Fire Complex, ignited.

The Texas Forest Service (April Saginor, personal communication 2012) lists the Bastrop Fire Complex as the third most devastating fire ever in the United States in terms of residences destroyed, but that only includes fires for which an official total exists. Based on historical accounts, I estimate the Bastrop Fire Complex, with 1660 homes destroyed, to be the sixth most destructive fire in the history of the United States, behind the April 1906 San Francisco fire, the October 1871 Great Chicago fire, the October 1918 Cloquet (Minnesota) fire, the October 1991 Oakland (California) firestorm, and the October 2003 Cedar (California) fire (Nielsen-Gammon 2012).

By the end of September, the drought was 1 year old, and the 12 consecutive months of precipitation from October 2010 through September 2011 were the driest 12 consecutive months on record for the state. Texas averaged slightly more than 11 inches for the 12 months, much less than the 27-inch average value, and roughly 2.5 inches less than the previous 12-month record set during the 1950s drought. The dry statewide conditions are reflected in the 12-month SPI map (Figure 17), which depicts most of the state at -2.5 or below and only a few corners of the state with SPI values better than -1.5.

The U.S. Drought Monitor map for October 4, 2011 (Figure 18) depicts the most severe drought conditions ever depicted for Texas. Only 3% of the state was not classified in at least extreme drought, and almost 88% of Texas was classified as exceptional drought. If the U.S. Drought Monitor depicted conditions corresponding to D5 or D6, they would probably have been widespread across Texas.

October was yet another month with below-normal precipitation for Texas (Figure 19), despite an early October rain event that brought over 6 inches of rainfall to parts of the central and north-central Texas. The rain alleviated much of the shorter-term dry conditions in central Texas, but 12-month rainfall deficits continued to be daunting. As the drought continued, longer-term rainfall shortages began to emerge. Twelve counties in eastern Texas were below -2.5 on the 24-month SPI map (Figure 19), including one county along the Louisiana border below -3.0. This implies long-term issues for streamflow and reservoir levels in eastern Texas. In west and central Texas, where other reservoirs were at or near historic lows, the magnitude of the lack of rainfall during the past year was extreme. There, 2-year SPI values totals generally fell within the -1.0 to -1.5 range, which is less unusual than in eastern Texas where almost no values are above -1.5.

November was the tenth consecutive month with below-normal rainfall for Texas. Drought patterns (Figure 20) had changed little from the previous month. December broke the string, with well-above-normal rainfall for the month as a whole (Figure 21). Parts of west Texas and the Coastal Bend (near Corpus Christi) had avoided substantial rainfall, but the rest of Texas finally had some decent topsoil moisture. This was good news for winter wheat crops and ranchers with winter fields. Across central and eastern Texas, reservoir levels at last began to climb, but were still far below typical lake levels for this time of year. West Texas reservoirs failed to respond. Unlike the previous year, there was an active subtropical jet stream upon which upper-level disturbances flourished.

The U.S. Drought Monitor (Figure 22) continued to show much of Texas in exceptional drought, but a few patches of D0 (abnormally dry) had developed in northern Texas. The only substantial portions of the state in merely moderate drought included the El Paso area, parts of the Panhandle, and parts of north-central and northeast Texas.

HISTORICAL PERSPECTIVE

Temperatures

The June–August average temperature across Texas was roughly 2.5 °F warmer than any previous Texas summer and over 5 °F above the long-term average. The public's attention was captured by the unusually high number of days reaching or exceeding 100 °F.

The final tally for stations in the south-central United States is shown in Figure 23. This interpolation does not take into account topographic features, so the analysis will misrepresent the actual pattern in regions of large topographic relief such as far west Texas.

Many parts of the state achieved the "double-triple": at least 100 days of at least 100 °F. Such areas include a large portion of south Texas surrounding Laredo, parts of north Texas near and west of Wichita Falls, and stations along the Rio Grande

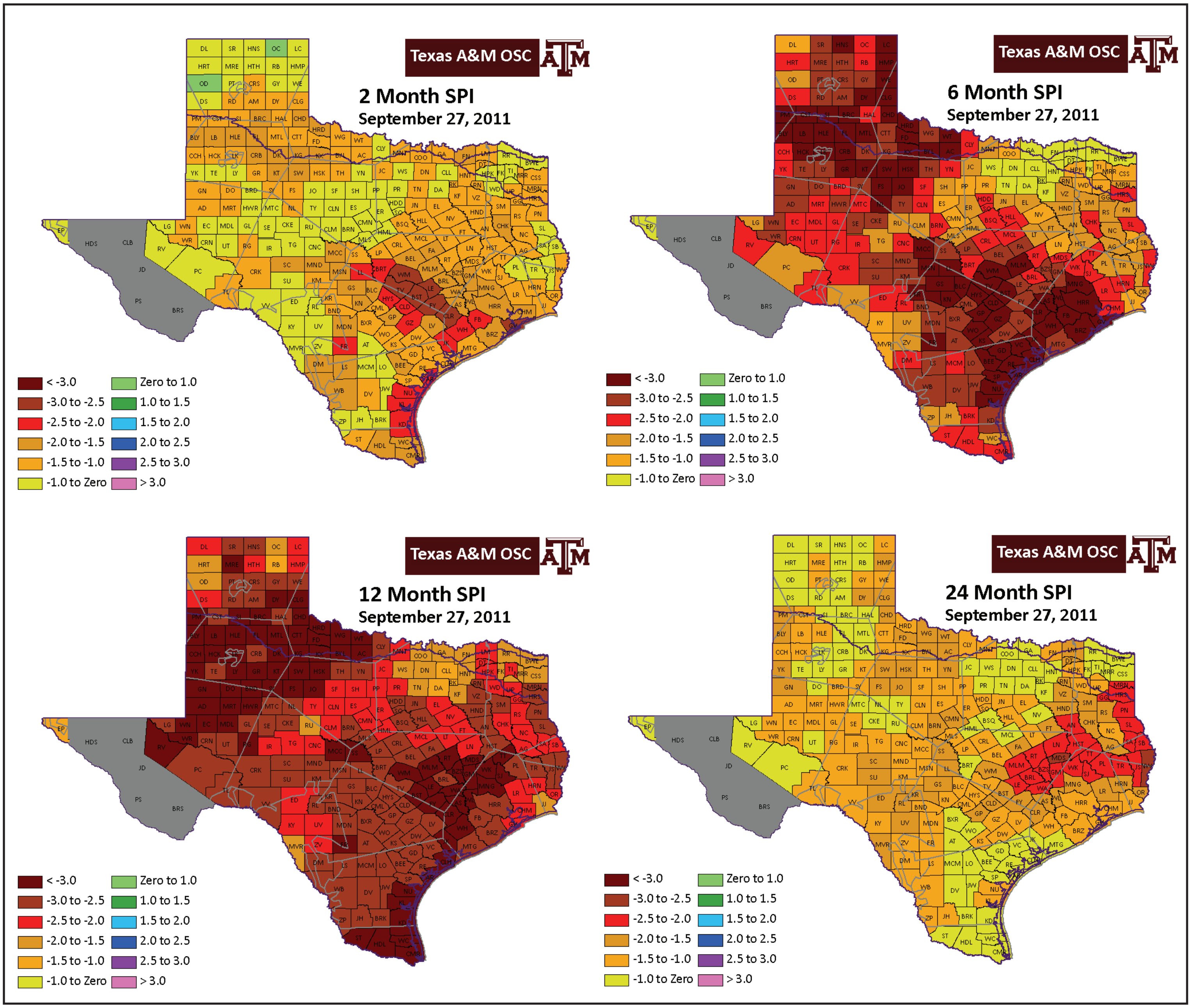


Figure 17. SPI drought index values as of September 27, 2011. The more negative values indicate more severe drought conditions.

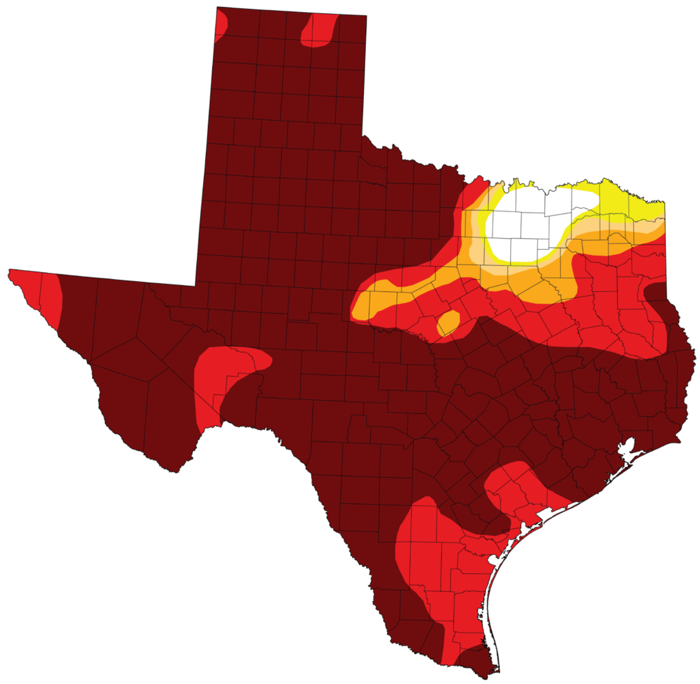
U.S. Drought Monitor

June 28, 2011
Valid 7 a.m. EST

Texas

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	2.68	97.32	95.71	94.52	90.62	72.32
Last Week (06/21/2011 map)	3.33	96.67	95.71	94.52	91.31	70.61
3 Months Ago (03/29/2011 map)	0.00	100.00	94.87	78.54	43.07	0.00
Start of Calendar Year (12/28/2010 map)	7.89	92.11	69.43	37.46	9.59	0.00
Start of Water Year (09/28/2010 map)	75.57	24.43	2.43	0.99	0.00	0.00
One Year Ago (06/22/2010 map)	51.78	48.22	13.00	0.00	0.00	0.00



Intensity:

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

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

http://drought.unl.edu/dm

Released Thursday, June 30, 2011
Richard Heim/Liz Love-Brotak, NOAA/NESDIS/NCDC

Figure 18. U.S. Drought Monitor for Texas for September 27, 2011. Available online at http://droughtmonitor.unl.edu.

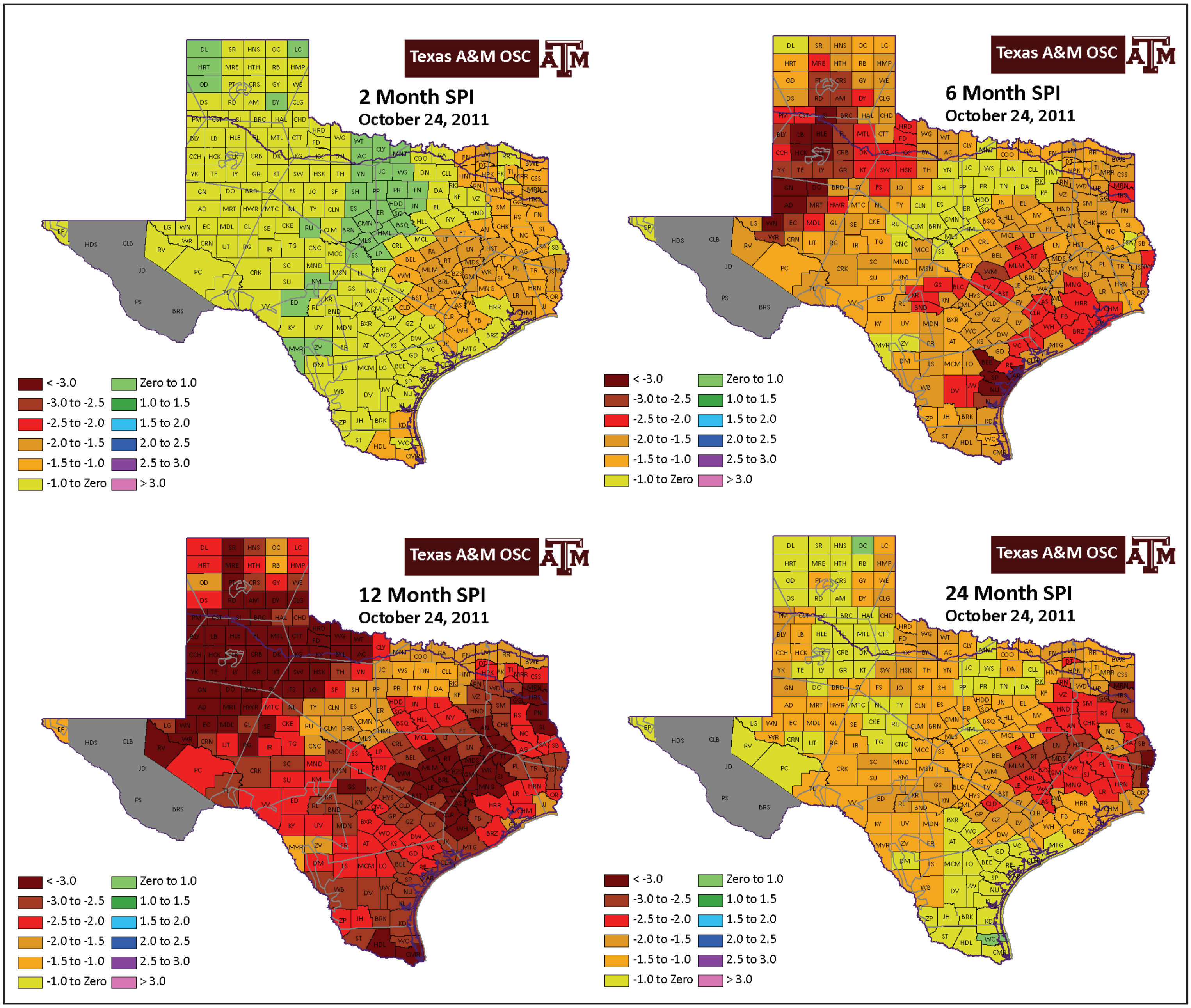


Figure 19. SPI drought index values as of October 24, 2011. The more negative values indicate more severe drought conditions.

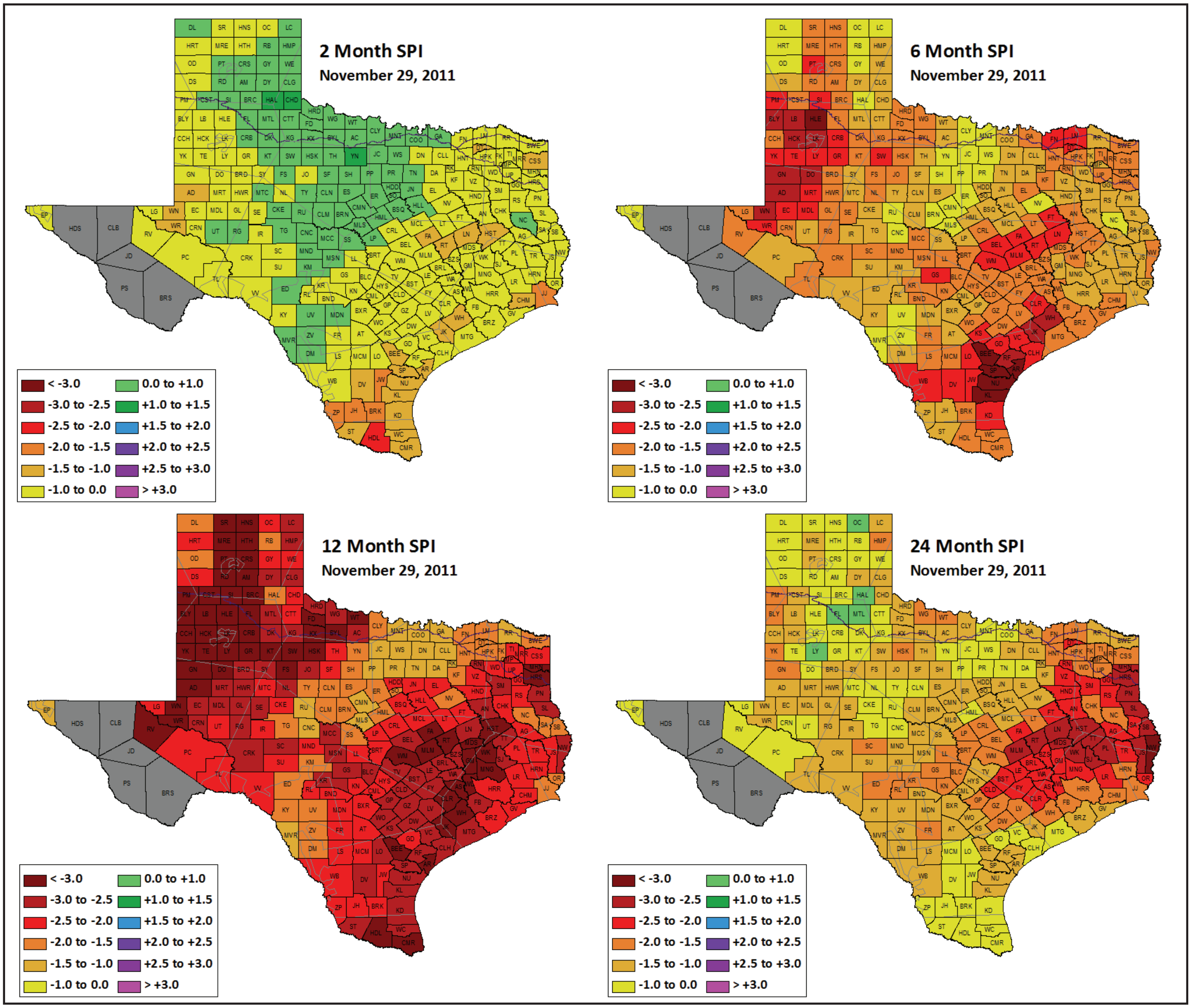


Figure 20. SPI drought index values as of November 29, 2011. The more negative values indicate more severe drought conditions.

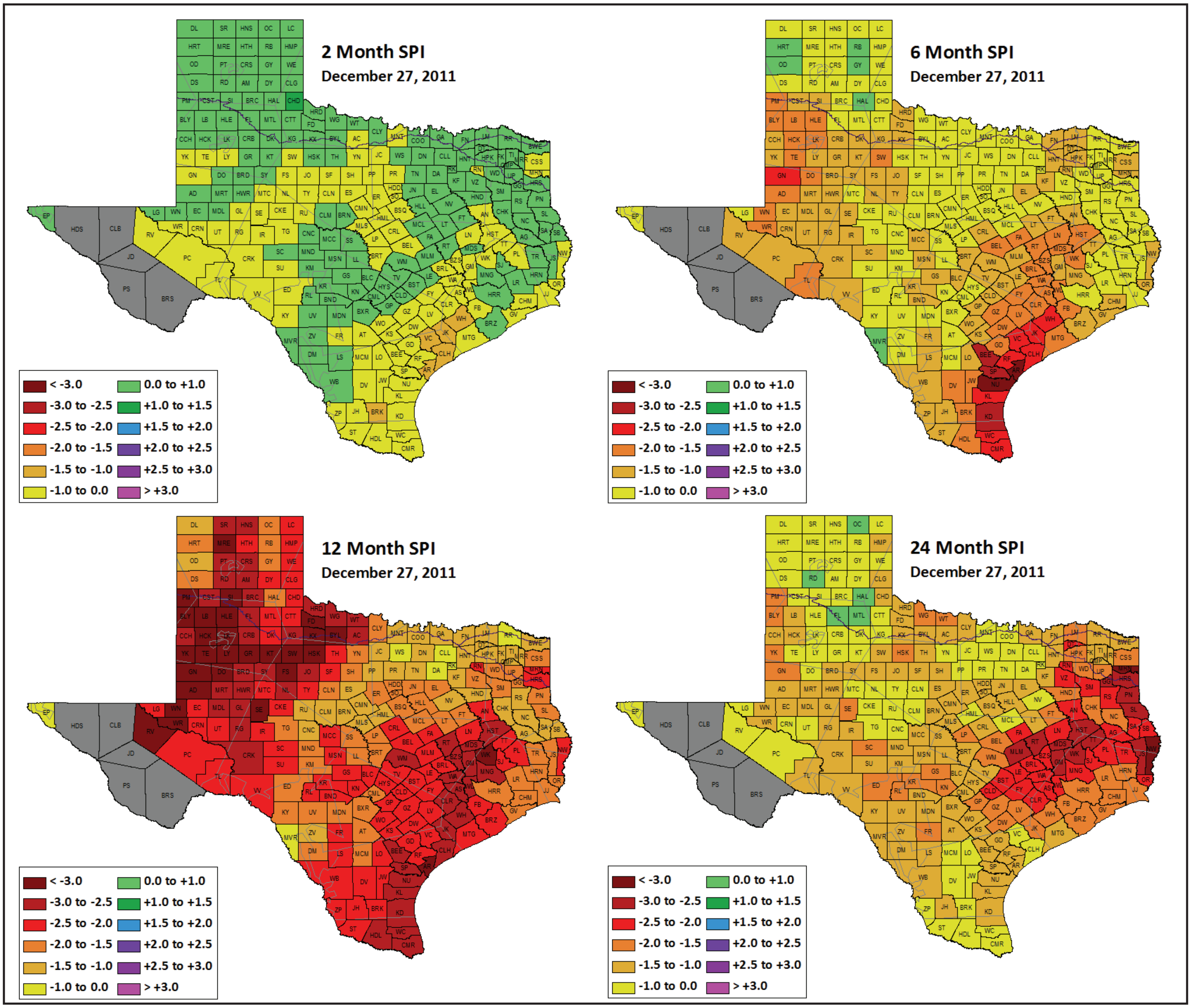


Figure 21. SPI drought index values as of December 27, 2011. The more negative values indicate more severe drought conditions.

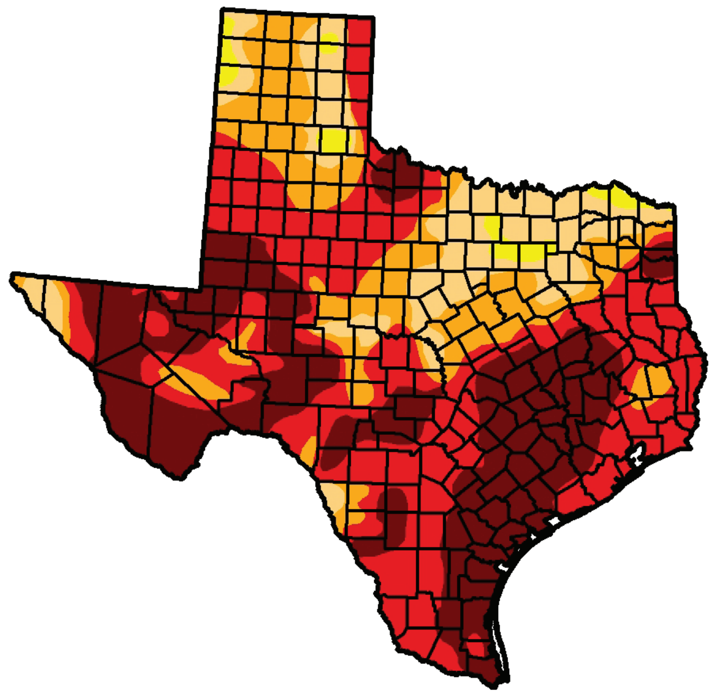
U.S. Drought Monitor

December 27, 2011
Valid 7 a.m. EST

Texas

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.01	99.99	97.83	84.81	67.32	32.36
Last Week (12/20/2011 map)	0.01	99.99	97.85	84.81	69.35	38.84
3 Months Ago (09/27/2011 map)	0.00	100.00	100.00	99.16	96.65	85.75
Start of Calendar Year (12/28/2010 map)	7.89	92.11	69.43	37.46	9.59	0.00
Start of Water Year (09/27/2011 map)	0.00	100.00	100.00	99.16	96.65	85.75
One Year Ago (12/21/2010 map)	13.61	86.39	73.68	38.41	9.66	0.00



Intensity:

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

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

http://droughtmonitor.unl.edu

USDA National Drought Mitigation Center

Released Thursday, December 29, 2011
Brad Rippey, U.S. Department of Agriculture

Figure 22. U.S. Drought Monitor for Texas for December 27, 2011. Available online at http://droughtmonitor.unl.edu.

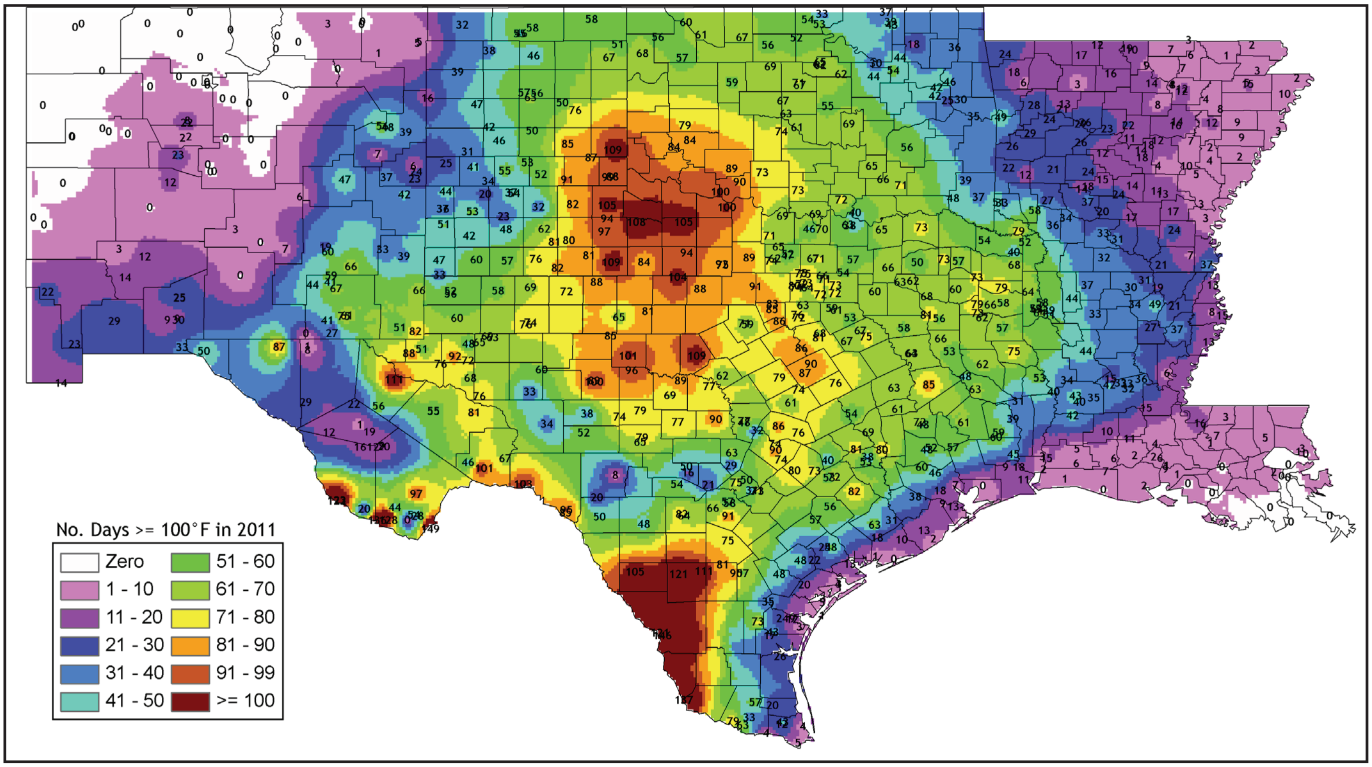


Figure 23. Number of days with maximum temperatures equaling or exceeding 100 °F in calendar year 2011 (through October 17, 2011). Graphic created by Brent McRoberts, Office of the State Climatologist, from Applied Climate Information System data.

upstream at least as far as Big Bend. Much easier to count are the 4 stations that did not have a single day reach 100 °F: 2 of them are along the Gulf Coast, while the other 2 are in far west Texas at altitudes exceeding 5,000 feet above sea level.

Gauge-Based Precipitation

The SPI analysis in the preceding section is based on National Weather Service precipitation analyses that use radar estimates of precipitation as a starting point and a statistical analysis of regional precipitation records (McRoberts and Nielsen-Gammon 2011). A much more direct assessment of drought severity may be made by directly analyzing the long-term climate records from the U.S. Historical Climatology Network, Version 2 (USHCNv2).

Figure 24 shows that, across much of western and south-central Texas, the 12 months ending in September 2011 were the driest 12 consecutive months on record. About one-third of all Texas USHCNv2 stations set their all-time 12-month record, and over half of the stations experienced their driest October–September on record. The lowest measurement was a remarkable 8% of normal at the McCamey USHCNv2 station. It was as though McCamey received 1 month of rainfall instead of 1 year of rainfall.

The 12 months were among the driest 5% throughout the state except for parts of Texas near, north, and east of Dallas. Though the lack of precipitation near Dallas was not as extreme as in the rest of the state, Dallas suffered through the exceptionally high temperatures caused by the dryness across the rest of the state, exacerbating evaporative stresses on plants and water supplies.

Figure 25 provides another perspective on the drought in a historical context, by showing which year out of the past 100 experienced the smallest percentage of normal precipitation prior to and during the growing season. For most of the state, 2011 had the driest growing season conditions, as indicated by the pink shading. The year 2011 was worst for almost every location in the western half of Texas, as well as for many locations in central, south, southeast, and northeast Texas. In many parts of central and east Texas, the 1925 drought surpassed the 2011 drought in short-term intensity. Elsewhere, record-setting years were 2009 in the Coastal Bend area, 1917 in parts of south Texas, 1956 in many parts of central Texas, and 1918 in parts of central and eastern Texas. Various other years establish the driest observed conditions in north-central and northeast Texas, where the current 2011 drought was not as severe as elsewhere.

Except for the Coastal Bend and parts of north-central and northeast Texas, most of the state has not experienced an agricultural drought as severe as this one for 55 years, and more than half of the state has never experienced a growing-season drought so severe.

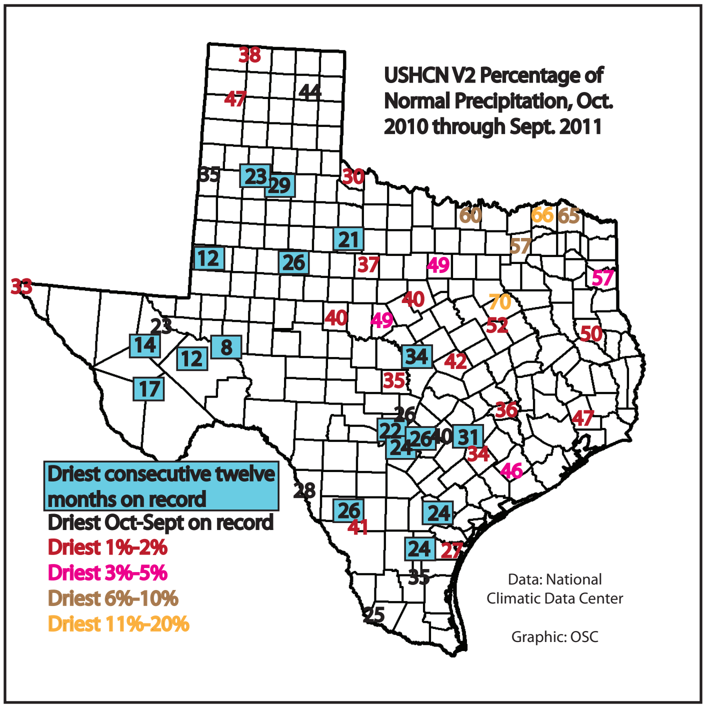


Figure 24. Percentage of normal precipitation for the 12-month period October 2010 through September 2011, as observed by the USHCNv2 station network. An additional station (Nacogdoches) has been added to fill a gap in the distribution of stations in eastern Texas. The colors indicate the ranking of the observed precipitation relative to previous October–September periods or, for exceptionally dry stations, all previous 12 consecutive month periods regardless of starting month.

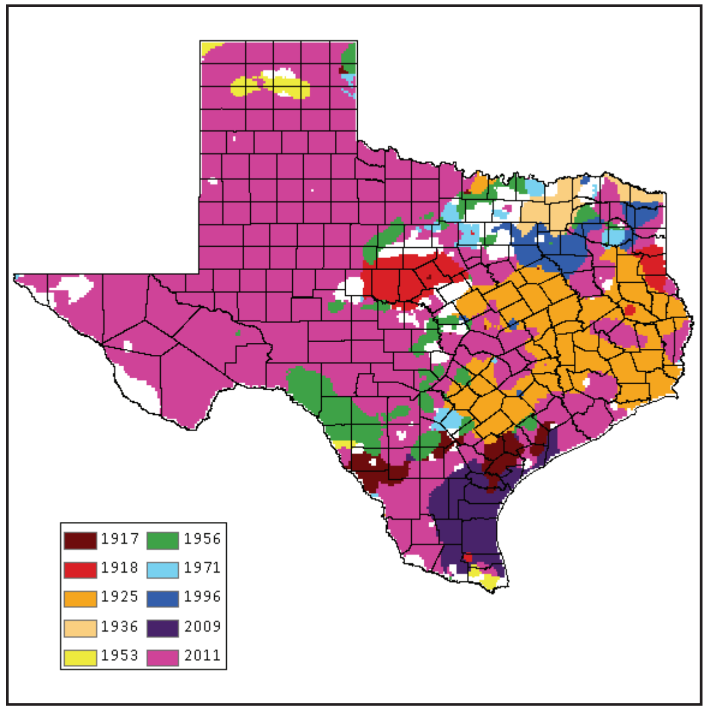


Figure 25. Year experiencing the lowest percentage of normal precipitation for the period prior to and during the growing season, defined here as the 9-month period ending June, July, or August, based on spatial analysis of Cooperative Observer Network data. Only the 10 years having the greatest coverage are indicated. Only the 100 years since 1911 are analyzed.

Though the drought has been most intense at time scales of 1 year or less, the lack of precipitation has been so extreme that the multiyear precipitation totals are also unusually dry. The 4 years since October 2007 includes a 2-year drought (2008–2009) and a relatively wet year (2010) in addition to the current 2011 drought.

Figure 26 shows the 4-year 2008–2011 accumulated precipitation as a percentage of normal, color-coded as in Figure 24. At a few stations in south and east Texas, the past 4 years were drier than any previous corresponding 4-year period, including any similar period during the drought of the 1950s. The current drought may well be considered worse than the 1950s drought in these areas.

The long-term drought was least severe in northeast Texas, extreme south Texas, and parts of western Texas. In these locations, the lack of rain by itself did not imply a long-term water shortage, but the relatively warm temperatures during the period enhanced evaporation and made available water worse than the numbers in Figure 26 would indicate.

Statewide Records

Because the drought was widespread throughout the state of Texas, its overall evolution and intensity is well represented by statewide average conditions. Table 2 shows the historical ranks of monthly statewide precipitation since the beginning of the drought. The statewide precipitation values represent area-weighted averages of values within each of the 10 Texas climate divisions. Precipitation data are obtained from the NCDC and are adjusted to correct for changes in network configuration (McRoberts and Nielsen-Gammon 2011). The rankings indicate that the dry fall and winter of 2010 were followed by an exceptionally dry spring and summer and a near-normal fall in 2011.

When unusually dry months occur one after the other, multimonth precipitation records are likely to be broken. Tables 5–7 show records established for 3-month, 6-month, and 9-month periods.

The records tend to become more extreme as the time spans become longer. As shown in Table 5, the driest March through May on record was immediately followed by the driest June

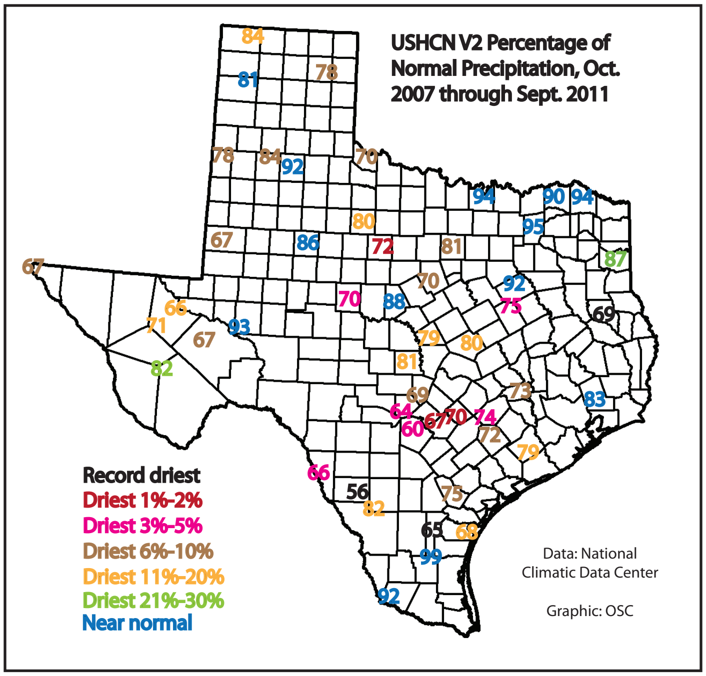


Figure 26. Percentage of normal precipitation for the 4-year period October 2007 through September 2011, as observed by the USHCNv2 station network. An additional station (Nacogdoches) has been added to fill a gap in the distribution of stations in eastern Texas. The colors indicate the ranking of the observed precipitation relative to previous October–September periods.

through August on record. The 9-month precipitation totals in Table 7 are much lower than any other 9-month precipitation totals for any time of year.

Table 8 shows the overall ranking of nonoverlapping 12-month precipitation totals. (Nonoverlapping means that a particular month cannot be part of more than one 12-month period.) The record driest 12-month period was the 12-month period from October 2010 to September 2011. The previous record, set in 1956, was broken by a comfortable 2.35 inches.

Two other aspects of Table 8 deserve comment. First, the driest 4 periods are substantially drier than the remaining periods. For statewide 1-year precipitation deficits, 2010–2011, 1955–1956, 1917–1918, and 1924–1925 are by far the most extreme events since records began in 1895. Second, it was necessary to continue the list to period number 14 to ensure that the list included another drought from the past 30 years. This means that while there have been several severe 1-year droughts in the past, it had been many decades since Texas had experienced a 1-year drought even remotely as severe as 2011.

Regarding the calendar year records, the full network estimated precipitation (FNEP) values (McRoberts and Nielsen-Gammon 2011) indicate that Texas received 15.20 inches of rainfall during 2011, ranking second all-time behind the 14.59 inches of rainfall in 1917 and just ahead of the 15.40 inches of rainfall in 1956. Average temperature also ranked second all-time highest at 67.18 °F, behind 1921 (67.48 °F) and just ahead of 1998 (67.10 °F), according to NCDC data.

Palmer Drought Severity Index

The information presented so far has focused on the lack of rainfall, with some additional discussion of unusually high temperatures. The most common measure of drought intensity in the United States is the Palmer Drought Severity Index (PDSI). The PDSI attempts to assess the relative amount of water available in the soil, based on precipitation, an estimate of evaporation based on temperature, and information regarding soil type. Because it combines temperature and precipitation information, it is a more comprehensive measure of drought intensity than the SPI. Unlike the SPI, the PDSI has its own intrinsic time scale, so a single numerical value characterizes the overall drought intensity.

Drought is considered to be present when the PDSI value is below -2, and extreme drought is present when the PDSI value is below -4. The NCDC calculates PDSI values for each climate division as well as a statewide PDSI value. In Figure 27, the evolution of statewide PDSI values for all 14 previous extreme droughts are plotted on a common time scale. As Fig-

Table 5. Ranking of 3-month precipitation among historical values, based on FNEP Texas statewide average precipitation (McRoberts and Nielsen-Gammon 2011).

Months	Precipitation Amount (in.)	Ranking
February–April 2011	1.85	Record driest
March–May 2011	2.74	Record driest
April–June 2011	3.44	2nd driest
May–July 2011	3.34	2nd driest
June–August 2011	2.42	Record driest
July–September 2011	2.56	2nd driest

Table 6. Ranking of 6-month precipitation among historical values, based on FNEP Texas statewide average precipitation (McRoberts and Nielsen-Gammon 2011).

Months	Precipitation Amount (in.)	Ranking
November 2010–April 2011	5.34	2nd driest
December 2010–May 2011	5.87	Record driest
January–June 2011	6.07	Record driest
February–July 2011	5.19	Record driest
March–August 2011	5.16	Record driest
April–September 2011	6.00	Record driest
May–October 2011	7.42	Record driest
June–November 2011	7.16	2nd driest

Table 7. All-time rankings of 9-month accumulated precipitation, based on FNEP Texas statewide average precipitation (McRoberts and Nielsen-Gammon 2011).

Months	Precipitation Amount (in.)	Rank
December 2010–August 2011	8.29	#1
January–September 2011	8.64	#2
November 2010–July 2011	8.68	#3
October 2010–June 2011	8.80	#4
February–October 2011	9.27	#5
June 1917–February 1918	9.62	#6
March–November 2011	9.90	#7

Table 8. All-time rankings of 12-month accumulated precipitation, based on Texas statewide average precipitation. Periods are constrained to be non-overlapping.

Months	Precipitation Amount (in.)	Rank
October 2010–September 2011	11.36	#1
October 1955–September 1956	13.71	#2
February 1917–January 1918	14.50	#3
July 1924–June 1925	15.80	#4
February 1910–January 1911	17.60	#5
January 1954–December 1954	17.87	#6
March 1901–February 1902	18.21	#7
June 1970–May 1971	18.40	#8
October 1908–September 1909	18.54	#9
November 1951–October 1952	18.62	#10
October 1950–September 1951	18.96	#11
May 1977–April 1978	19.33	#12
November 1962–October 1963	19.41	#13
September 2005–August 2006	19.56	#14

ure 27 shows, the September 2011 PDSI value for the 2011 drought (shown in black) is a record low value for statewide PDSI, surpassing the previous record set in 1956 (orange). However, the 1950–1957 drought is generally regarded as a much worse drought overall because it lasted for so many years. The most intense year of that drought, in 1956, immediately followed 5 other consecutive drought years. The 1915–1918 drought might also arguably be worse than the 2010–2011 drought overall. The 1915–1918 drought was the third most intense, according to the PDSI, but it maintained values below -5 from June 1917 through September 1918. In contrast, the 2010–2011 drought only had 8 months below -5.

Ultimately, all droughts are different, and it is not possible to say at what point a particular drought surpasses another in overall severity. As of the end of 2011, the 2010–2011 drought was easily the most severe 1-year drought on record and was clearly among the top 5 overall. Whether it would last long enough and remain intense enough to surpass the 1908–1911, 1961–1966, 1915–1918, and 1950–1957 droughts (or whether it already has surpassed some of them) would depend on both future weather and the means by which one drought is compared against another.

The previous sections discussed the overall statewide intensity of the drought as well as the severity of the drought recorded at specific rain gauges. In this section, the historical ranking of the 2011 drought within the various climate division of Texas is considered.

Climate Division Perspective

Texas is divided into 10 climate divisions (Figure 28). Nine are approximately equally sized, while climate division #10

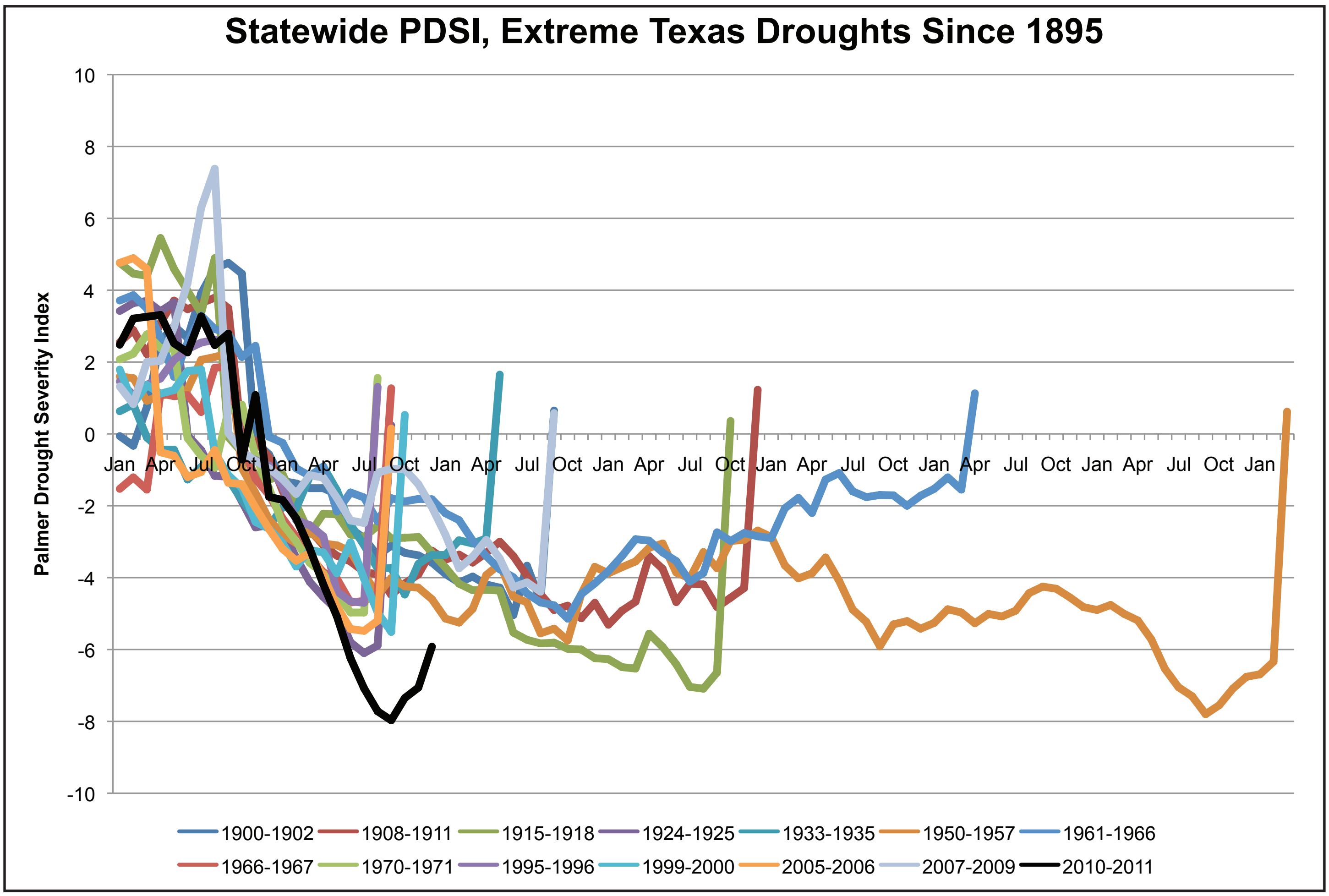


Figure 27. Texas statewide Palmer Drought Severity Index (PDSI) values for all previous droughts attaining a PDSI value of -4 or lower. Droughts are plotted on a common time scale, beginning in January of the year in which the run of negative PDSI values first appeared and ending when the PDSI value again became positive. Drought endings appear abrupt because the PDSI jumps suddenly from a characterization of dry conditions to a characterization of wet conditions. Thus, the PDSI is ill-suited for monitoring recovery from drought.

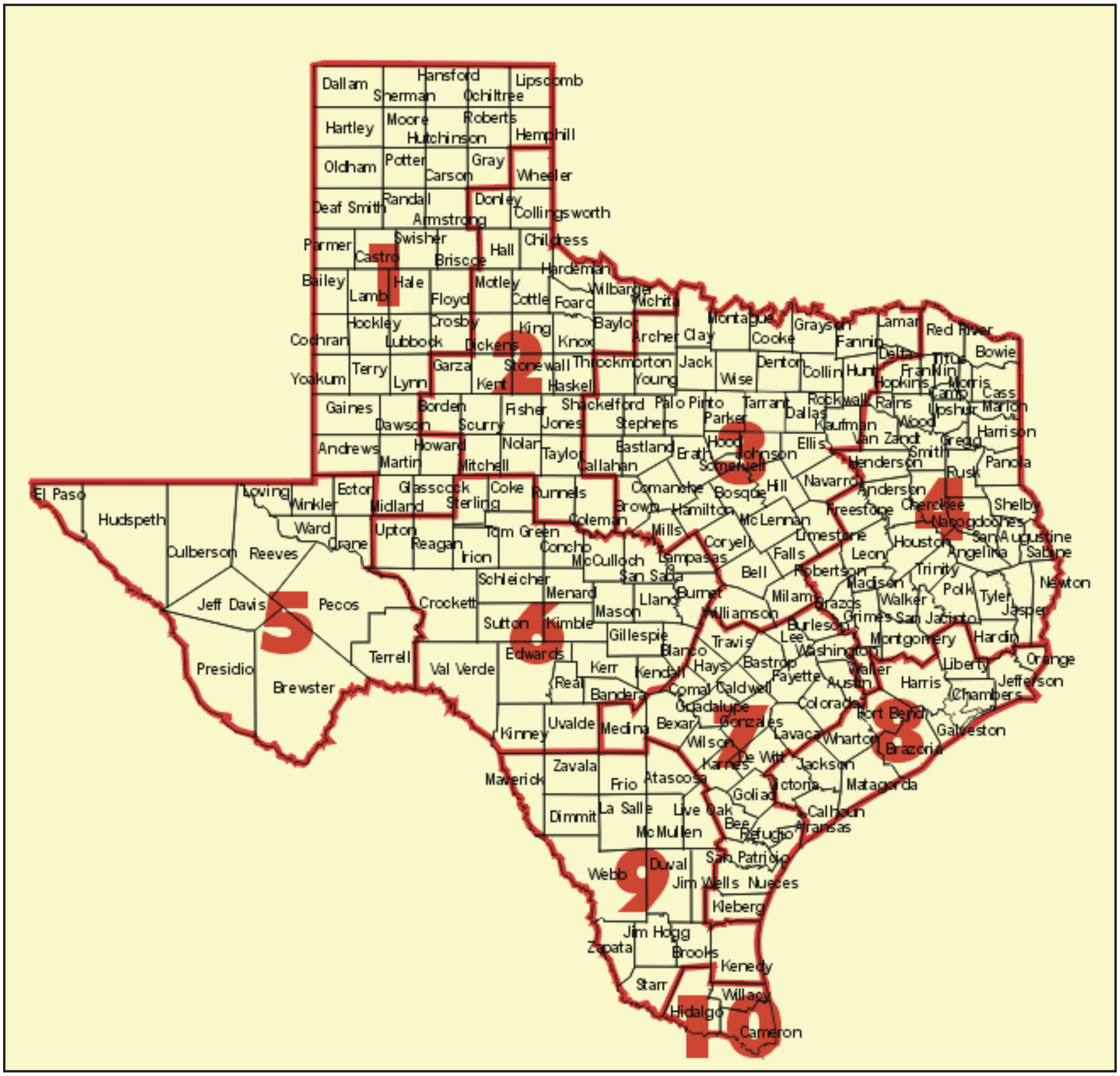


Figure 28. U.S. Boundaries of Texas climate divisions. Figure from NOAA's Climate Prediction Center.

Table 9. Droughts surpassing -4 PDSI in 3 or more climate divisions. Shown are the minimum PDSI value, the number of months at or below -4 PDSI, and the number of months at or below -2 PDSI. Data through December 2011.

	High Plains	Low Rolling Plains	North Central Texas	East Texas	Trans-Pecos	Edwards Plateau	South Central Texas	Upper Coast	South Texas	Lower Valley
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1908–1911	-5.31 11 26	-5.66 14 40	-4.29 1 30	13	-4.49 4 24	-4.23 3 33	-4.91 4 34	12	34	18
1915–1918	-4.04 1 19	-5.61 16 22	-6.03 15 27	-5.99 **10** 27	-4.33 4 20	-5.25 15 28	-6.16 20 33	**-5.72** **14** 34	-4.43 8 30	25
1924–1925	11	-4.81 4 13	-5.61 5 10	-5.99 7 13	9	-4.90 3 10	-5.19 3 10	-5.38 6 12	6	3
1933–1935	-5.01 10 32	-4.03 1 13	4	4	-5.23 9 29	-4.57 2 17	3		1	
1950–1957	-5.86 **24** **58**	-6.33 **25** **71**	**-6.92** **22** **71**	-4.54 8 **40**	-5.10 **16** **74**	-6.08 **29** **66**	**-6.67** **36** **67**	-5.45 12 **55**	**-5.73** **20** **77**	**-4.89** **5** **79**
1961–1966	-4.19 1 24	11	-4.00 1 14	27	28	-4.54 4 25	-5.04 7 32	-4.14 2 34	35	30
1966–1967	8	8	-4.56 3 8	7	3	-4.33 3 8	-4.63 2 7	5	4	1
1970–1971	10	-4.67 2 9	-4.18 1 5	8	5	7	-4.84 2 7	6	5	5
1974	-4.39 1 4	-4.25 1 6	3		5	5				4
1995–1996	5	4	-4.07 1 6	5	-4.06 1 23	-4.12 1 6	-4.31 1 6	2	10	7
1999–2002	5	7	9	10	-5.12 7 56	-5.06 6 13	-4.09 1 10	-4.69 6 13	8	-4.23 2 31
2005–2006	-4.38 2 7	-4.78 3 8	-4.47 3 14	-4.11 5 16	4	-4.04 1 11	-4.95 8 14	6	-4.42 3 11	-4.42 3 16
2007–2009		9	3		1	16	-6.51 3 16	8	-4.77 3 12	4
2010–2011	**-6.79** 7 9	**-7.02** 8 10	-5.28 3 7	**-6.50** **10** 17	**-6.47** 8 13	**-6.13** 8 11	-5.75 7 10	-5.29 6 9	-4.88 4 9	-4.43 2 10

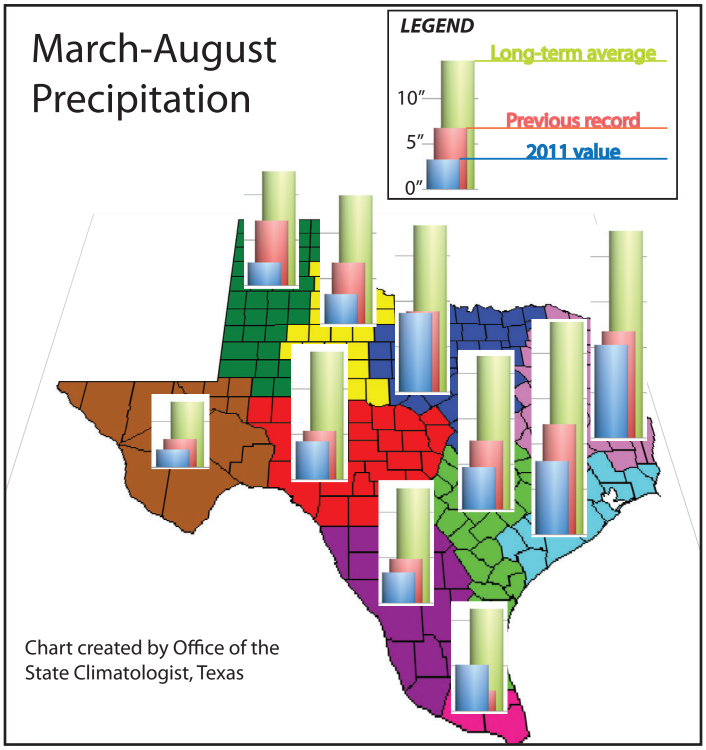


Figure 29. Climate division average precipitation for March–August 2011 (blue), compared to the long-term average for March–August (green), and the previous record for driest March–August (red). See legend for scale.

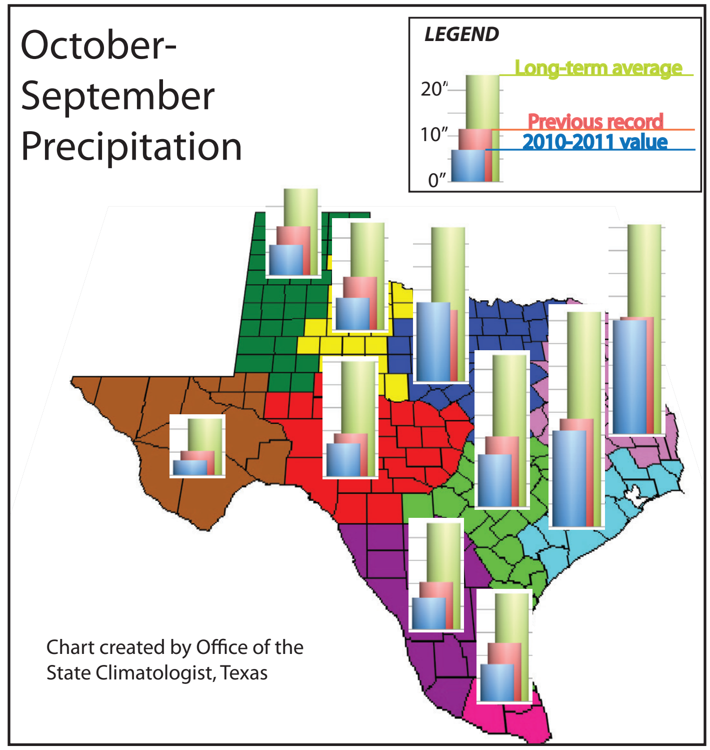


Figure 30. Climate division average precipitation for October 2010–September 2011 (blue), compared to the long-term average for 12 months (green), and the previous record for driest October–September (red). See legend for scale.

separately reflects conditions within the farming region of the Lower Valley.

Table 9 shows the PDSI values and drought durations within each of the 10 climate divisions during the major Texas droughts of the past and present. The table allows one to compare the intensity and duration of the present drought to past droughts in the same portion of the state.

Only 2 droughts have reached extreme (PDSI below -4) status in all 10 climate divisions: the 1950–1957 drought and the current drought. The PDSI attains its lowest value in the current drought within four climate divisions: #1, #2, #4, and #5. From a historical perspective, the current drought is worst in East Texas (climate division #4). The current drought far exceeds the 1950–1957 drought in intensity (though not in duration), has already surpassed the 1924–1925 drought by all measures, and is most strongly rivaled by the 1915–1918 drought. Based on the combination of precipitation and temperature incorporated into the PDSI, the present drought is already at least the third-worst drought on record in East Texas.

Figure 29 is a graphical depiction of the driest 6-month period of the 2011 drought. The 6-month rainfall was below the previous record in all but climate division #10 (see Figure 28 for climate division identification). In climate divisions #1 and #2, the total rainfall was less than half the previous record and less than a quarter of normal precipitation. Even the "wettest" climate division received less rainfall than normally occurs everywhere but climate division #5.

The 12-month totals (Figure 30) are no less staggering. East Texas received the normal rainfall of the Low Rolling Plains. South Central Texas received the normal rainfall of the Trans-Pecos. Only North Central Texas managed to receive more precipitation than its previous record. Most climate divisions received much less than half of their normal precipitation.

COSTS

The final estimate for Texas agricultural losses due to the 2011 drought was $7.62 billion, according to Texas AgriLife Extension Service economists (Fannin 2012). In current dollars, it was the costliest agricultural drought on record. The losses broke down as follows: livestock $3.2 billion, cotton $2.2 billion, wheat $0.3 billion, corn $0.7 billion, grain sorghum $0.4 billion, and hay $0.8 billion. Neither additional losses from smaller cash crops nor indirect costs were tallied, which would add several more billion dollars to the total.

An estimated $669 million worth of merchantable and premerchantable timber succumbed to the drought, and an additional $97 million of timber was destroyed by drought-related wildfires (Texas Forest Service 2012). Other fire-related losses include an estimated $535 million in insured property losses (Hanna 2011, Hanna 2012) and at least $203 million in firefighting costs (Dexheimer 2011). The above numbers, which include only a portion of all drought losses, add up to over $9 billion, so it seems highly likely that the total cost of the 2011 drought to Texas exceeded $10 billion.

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