Drought History

for Texas' 10 Regions

Prepared by the South Central Climate Science Center in Norman, Oklahoma

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What is drought?

Defining drought can be difficult because the impacts associated with drought are often far-reaching and devastating. A *meteorological drought* is a prolonged period when precipitation is below "normal" for the location (Heim 2002). An *agricultural drought* occurs when soils are too dry to grow healthy vegetation, particularly crops or forests. As water becomes scarce in rivers, lakes, and other water bodies, a *hydrological drought* develops. If, at any time, the water demands of society (e.g., water for drinking, maintaining lawns and gardens, washing clothes) exceed the availability of good-quality water, then a *socioeconomic drought* has occurred. A socioeconomic drought may arise even during times of normal precipitation because of increased water demand from a growing population, increased temperatures and wind speeds, new businesses, or other societal changes.

Why be prepared for drought?

Since 2000, the National Oceanic and Atmospheric Administration has identified nine droughts nationwide as *billion-dollar* weather disasters based on both damages and costs, such as from crop loss. The 2012 drought, which at its height affected over 80% of the contiguous U.S., resulted in estimated damages and costs of over $50 billion from both direct and indirect impacts. Drought can result in crop, pasture, and forest damage; increased livestock and wildlife mortality; increased fire hazard; threats to aquatic and wildlife habitats; increased water demand; and reduced water supplies.

Proper management of water resources is necessary to protect supplies for drinking water, sanitation, and fire protection as well as to maintain economic activity and environmental sustainability. ***Because disasters affect families, neighbors, and businesses locally, community-level planning is necessary to reduce the vulnerability to drought in Texas***.

The "Droughts-of-Record" in Texas

For purpose of planning, we consider the "drought-of-record" to be the drought with the worst environmental conditions rather than the drought with the worst recorded impacts on the High Plains of Texas. Hence, a shorter and less severe drought with high monetary losses in our recent past (e.g., during 2011) will <u>not</u> outweigh a long and severe drought in our early history, when fewer people lived in the region. We choose to prepare for the worst.

We compared Palmer Drought Severity Indices for these droughts, as well as the most recent (hence, memorable) drought of 2011 to present (December 2012) in Tables 1-9. Using these indices, the drought of the 1950s exceeds the duration and intensity of all other droughts.

How to be prepared for drought?

Local officials and other key stakeholders in Texas will be better prepared for drought when they complete the following: (1) have assessed their vulnerability to drought, (2) understand past droughts and the local climate, (3) monitor drought, (4) prepare a thorough set of actions to be taken before, during, and after a drought, and (5) educate citizens on this plan.

Having a plan in place will enable these individuals to understand key factors to monitor so they may respond proactively to drought conditions early. Following this plan helps reduce the risk such that, when drought conditions occur, water resources do not run out. This report will help government officials and resource managers by overviewing the climate and drought history in Texas since record-keeping began in the late 19th century.

How is drought measured?

To quantify drought severity, the scientific community has developed several methods to assess drought, including departure from normal precipitation, the Palmer Drought Severity Index, and the Standardized Precipitation Index. All three use weather observations to diagnose drought conditions. The simplest of these is the annual departure from normal precipitation, which is the actual precipitation total for the year subtracted from the annual normal. Large negative values indicate a precipitation deficit for that year.

The Palmer Drought Severity Index uses observations or estimates of precipitation, temperature, and soil water content. Values typically range from +4 representing extremely wet conditions to –4 representing extremely dry conditions. Values less than –1 indicate some level of drought, and the values become more negative with less rainfall and hotter temperatures.

The Palmer Drought Severity Index helps to diagnose agricultural drought because it is sensitive to soil moisture conditions and works well at relatively long time scales. The index does not account for reservoir levels and streamflow, so it has drawbacks for diagnosing hydrological drought.

The Standardized Precipitation Index is based solely on precipitation but has the advantage of multiple time scales (e.g., 3 months, 6 months, 1 year) to better highlight short-term versus long-term droughts. Values typically range from +2 as extremely wet to –2 as extremely dry, with values less than –1 representing drought.

A more recent method to measure drought intensity is the U.S. Drought Monitor (Figure 1). This product depicts weekly drought conditions for the United States on a drought intensity scale of D0 to D4, with D0 representing areas that are abnormally dry and D4 representing areas of exceptional drought. Although the levels are subjectively determined, they are established through expert review of weather and water data, including local observations, as well as reports of drought impacts from local, tribal, state, and federal officials as well as the public and media. Figure 1 displays the weekly percentage of each of Texas' regions affected by D0 through D4 drought since 2000[1].

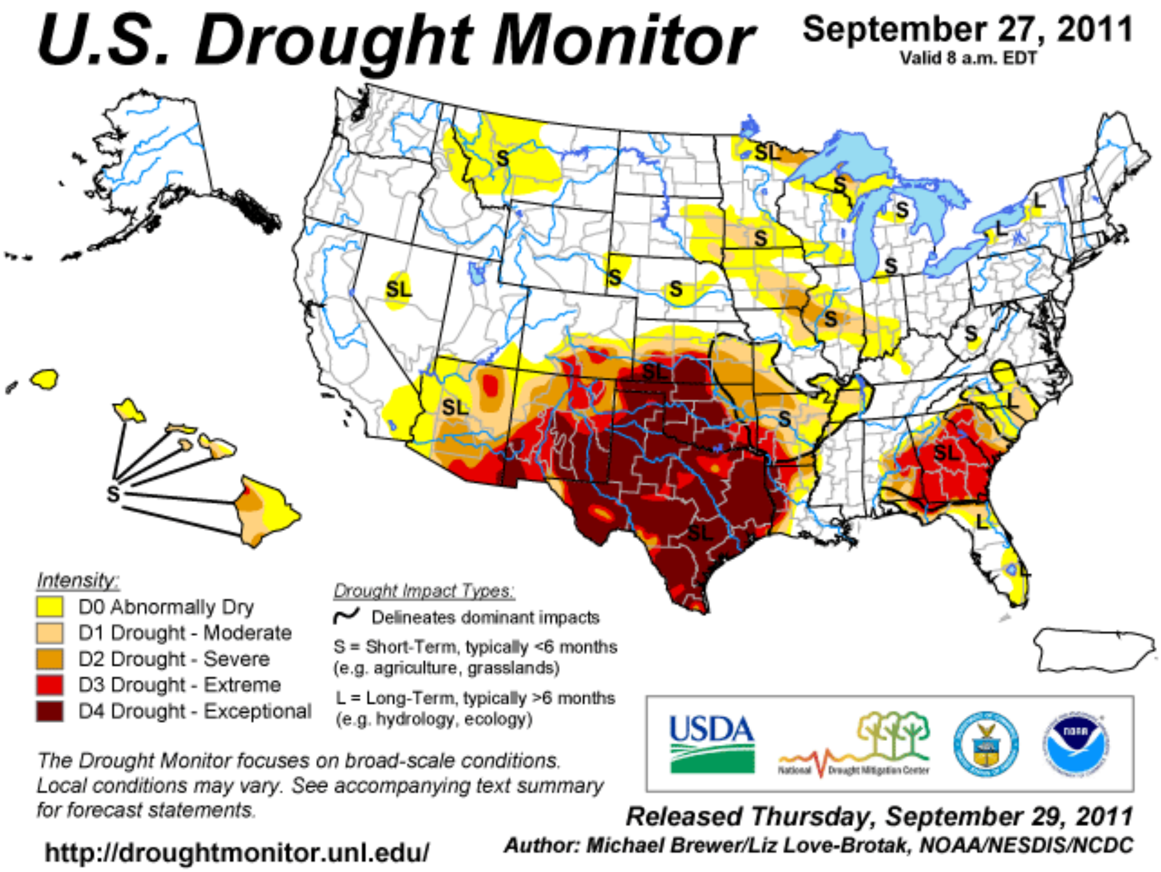


Figure 1*. Example map of the U.S. Drought Monitor from the drought assessment issued for the week preceding September 27, 2011. The color scale (yellow to dark red) displays the level of drought from D0 (abnormally dry) to D4 (exceptional drought). Significant regional impacts on agriculture are designated with an "***S***" and regional impacts on water supply are designated with an "***L***". The maps are released each Thursday at 8:30 a.m. Eastern Time. Courtesy of the National Drought Mitigation Center.*

[1] Data provided by the National Drought Mitigation Center.

Has Texas experienced drought?

Drought is a recurring condition in Texas, and is part of our climate. Our climate history can provide us insight into what we may see in the future. Being "drought ready" means, in part, that we recognize how our climate has changed over time. Let's examine our past.

The Climate of Texas

Temperature and precipitation are the two main elements of our climate. Because Texas is located in the middle latitudes, and northwest of the Gulf of Mexico, its citizens experience a wide range of weather conditions. Hence, our climate is highly variable, from year to year, season to season, and month to month.

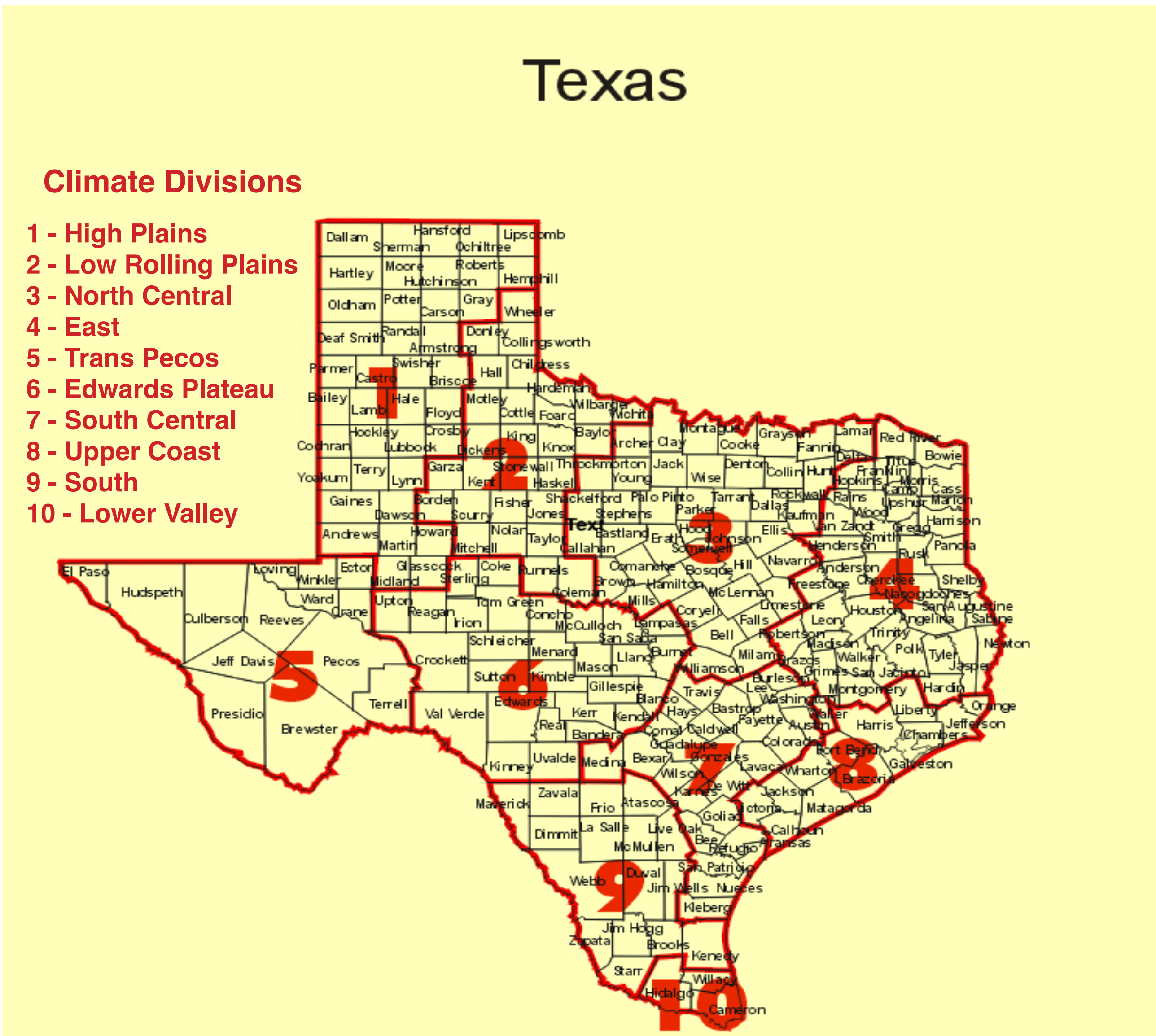


Figure 2. *Map of the climate divisions of Texas.*

Region 1: High Plains

Texas' High Plains region has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 3 shows the annual temperature (top) and annual precipitation (bottom) in the High Plains of Texas since 1895.[2] The annual temperature for the High Plains of Texas averages 58.4 degrees Fahrenheit, while precipitation averages 18.81 inches. Warmer-than-average periods have spanned the 1930s, the 1950s, and the late 1990s through the early 2010s. Significant periods of drier-than-average conditions include the early 1910s, the 1930s, the 1950s, the 1960s, and the early 2010s.

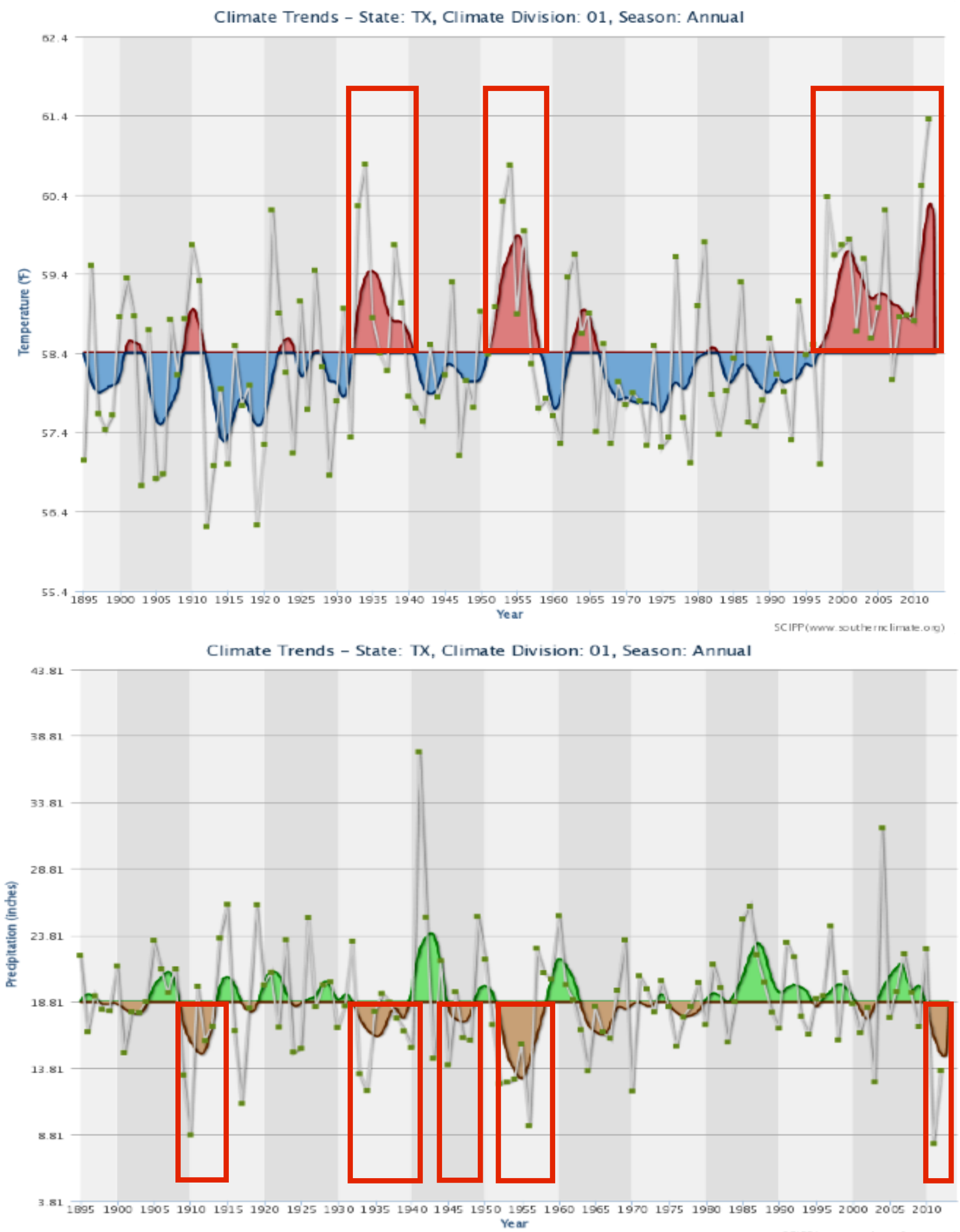


Figure 3. *The average annual temperature (<u>top graph</u>) and total annual precipitation (<u>bottom graph</u>) in the High Plains of Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the 1930s and the 1950s. The longest period of dry conditions was undoubtably was during the 1950s. Table 1 compares Palmer Drought Severity Indices for these droughts and others. Using these indices, the drought of the 1950s exceeds the duration and intensity of all other droughts; hence, ***the period from January 1950 to February 1957 is the drought-of-record for the High Plains of Texas***.

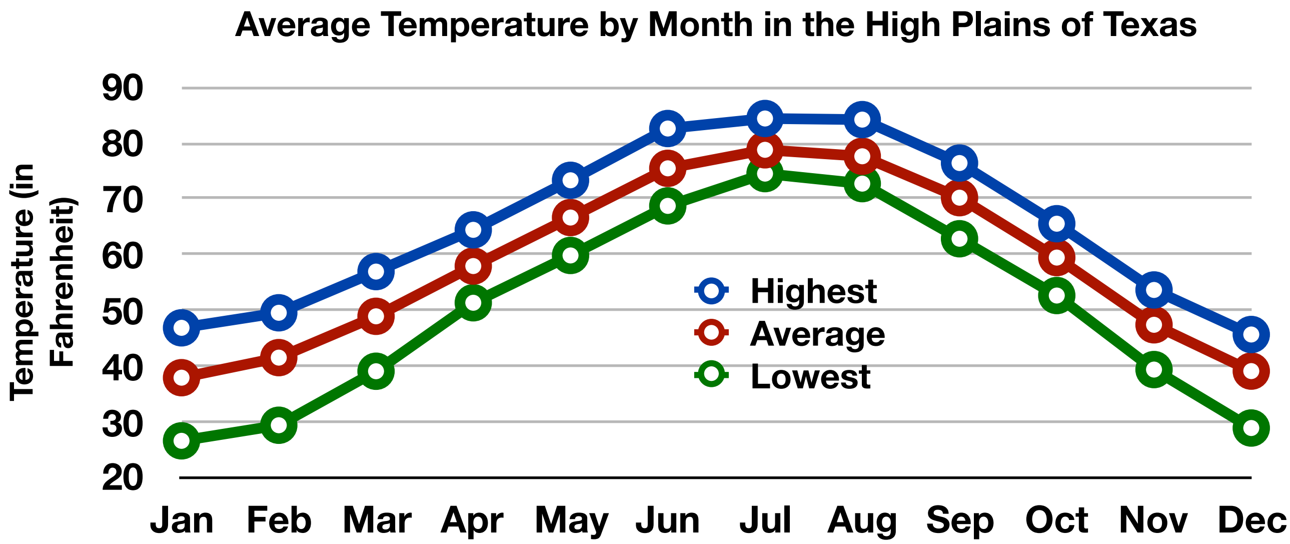
Because of its intense heat combined with a period of PDSI less than -4, ***June 1933 to October 1940 comes in second for the drought-of-record for the High Plains of Texas.***

Table 1: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting the High Plains of Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
February 1909 – June 1911	29 (of 29 months)	10 consecutive plus 1 other	–5.31
June 1933 – October 1940	62 (of 89 months)	10 consecutive	–5.01
January 1950 – February 1957	77 (of 86 months)	10 consecutive plus 12 others	–5.86
March 1963 – July 1971	64 (of 101 months)	1	-4.19
December 2010 – December 2012*	25 (of 25 months)	8 consecutive plus 7 consecutive	-6.79

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for the High Plains of Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 4. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during June, July, and August (top of Figure 4).



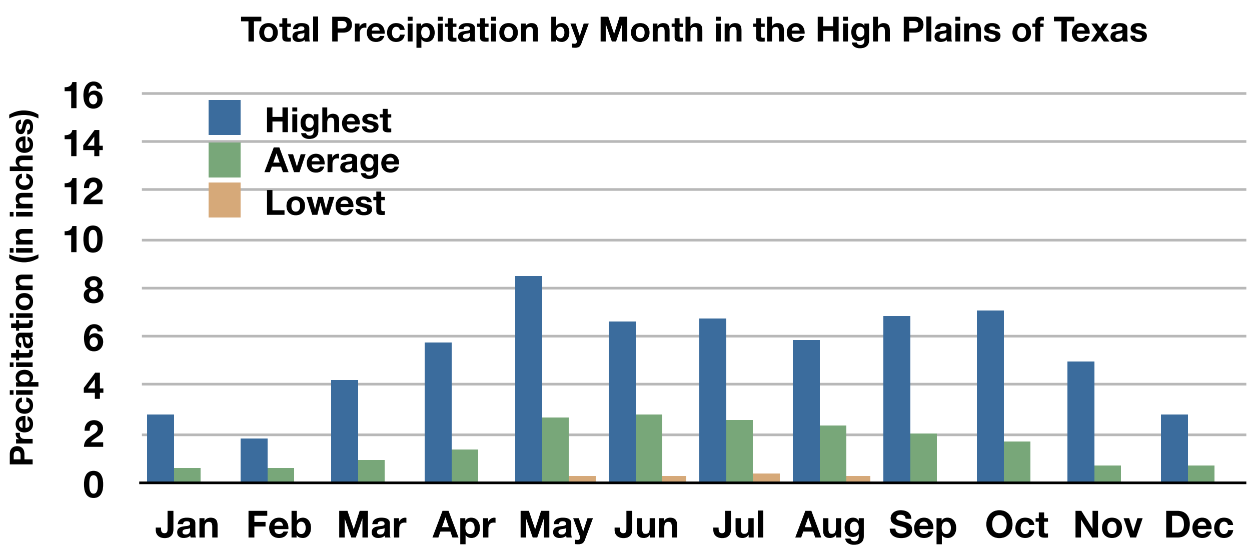


Figure 4. *Top graph: The monthly average temperature (in degrees Fahrenheit) across the High Plains of Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. Bottom graph: The average total precipitation (in inches) by month across the High Plains of Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during January, February, March, September, October, November, and December.] The peak precipitation in May is clearly visible.*

The High Plains of Texas has experienced long and extreme droughts in its past. Figure 5 displays the departure from normal precipitation, and Palmer Drought Severity Index, for the High Plains of Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 3.

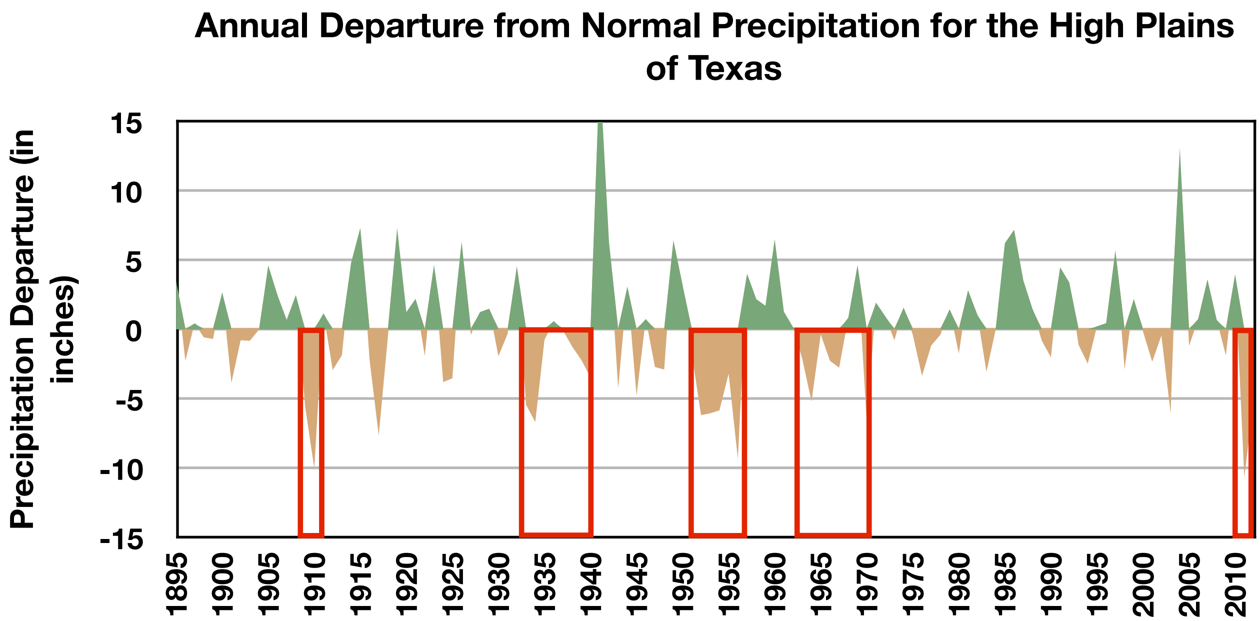


Figure 5a. Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for the High Plains of Texas from 1895 to 2012.

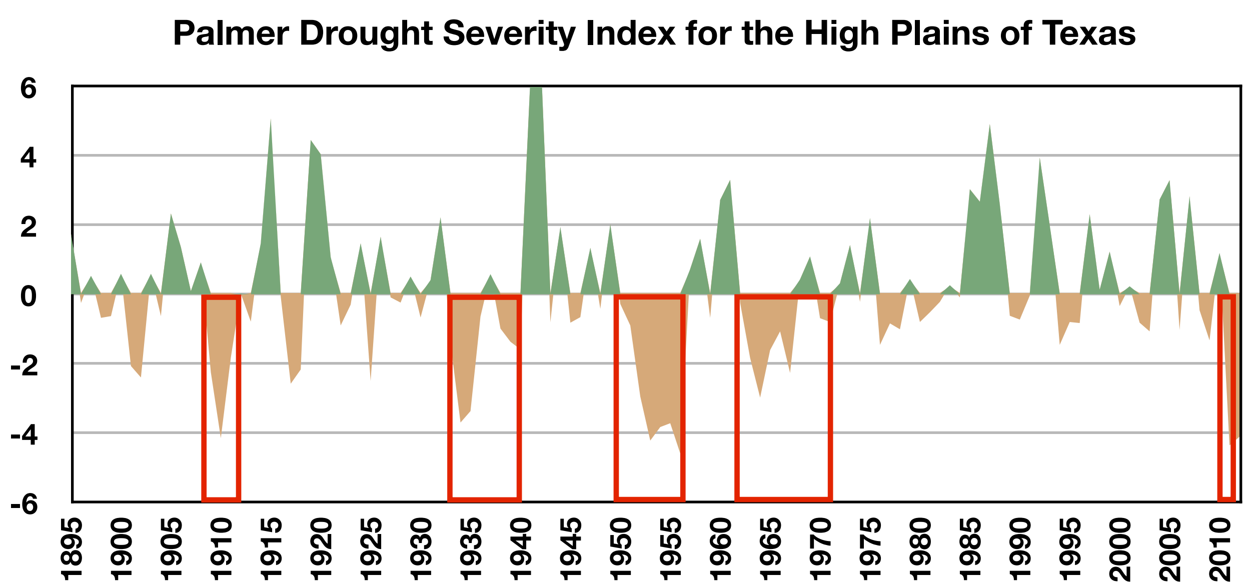


***Figure 5b**. Palmer Drought Severity Index for the High Plains of Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 6 we look at drought designation in the High Plains of Texas and see that from 2000-2004 abnormally dry to extreme conditions covered up to 100% of the region. In 2011 to 2013 the region experienced extreme to exceptional drought also covering 25 to nearly 100% of region.

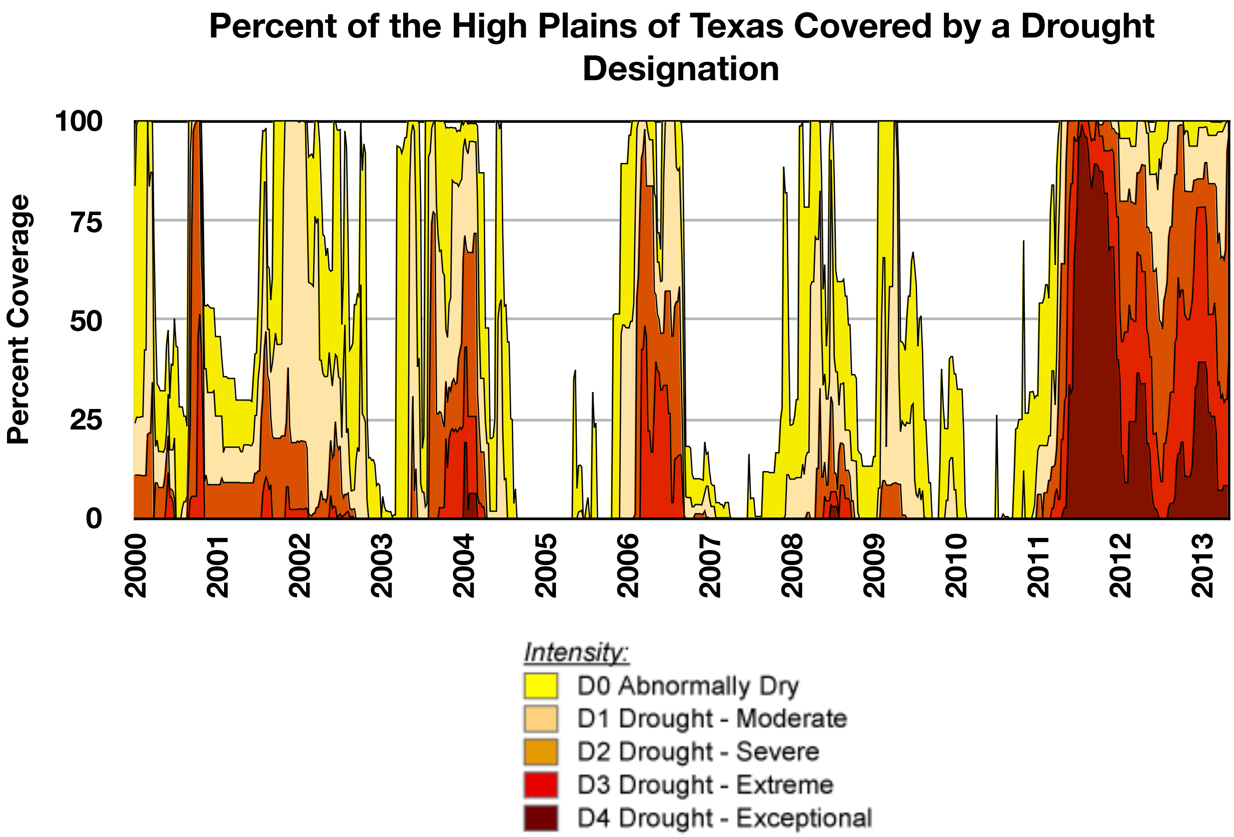


Figure 6 *Drought history for the High Plains of Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that the High Plains of Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the climate division during much of 2006 and 2011 to present (data through March 2013).* Data courtesy of the National Drought Mitigation Center.

For more information on the sources of drought information, see Table 11 on page 57.

Region 2: Low Rolling Plains

The Low Rolling Plains region of Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 7 shows the annual temperature (top) and annual precipitation (bottom) in the Low Rolling Plains of Texas since 1895.[3] The annual temperature for the Low Rolling Plains of Texas averages 62.8 degrees Fahrenheit, while precipitation averages 23.5 inches. Warmer-than-average periods have spanned the 1920s, the 1930s, the 1950s, and the late 1990s through the 2000s. Significant periods of drier-than-average conditions include the 1910s, the mid-1920s through the early 1940s, the 1950s, the mid-1960s, and the early 2010s.

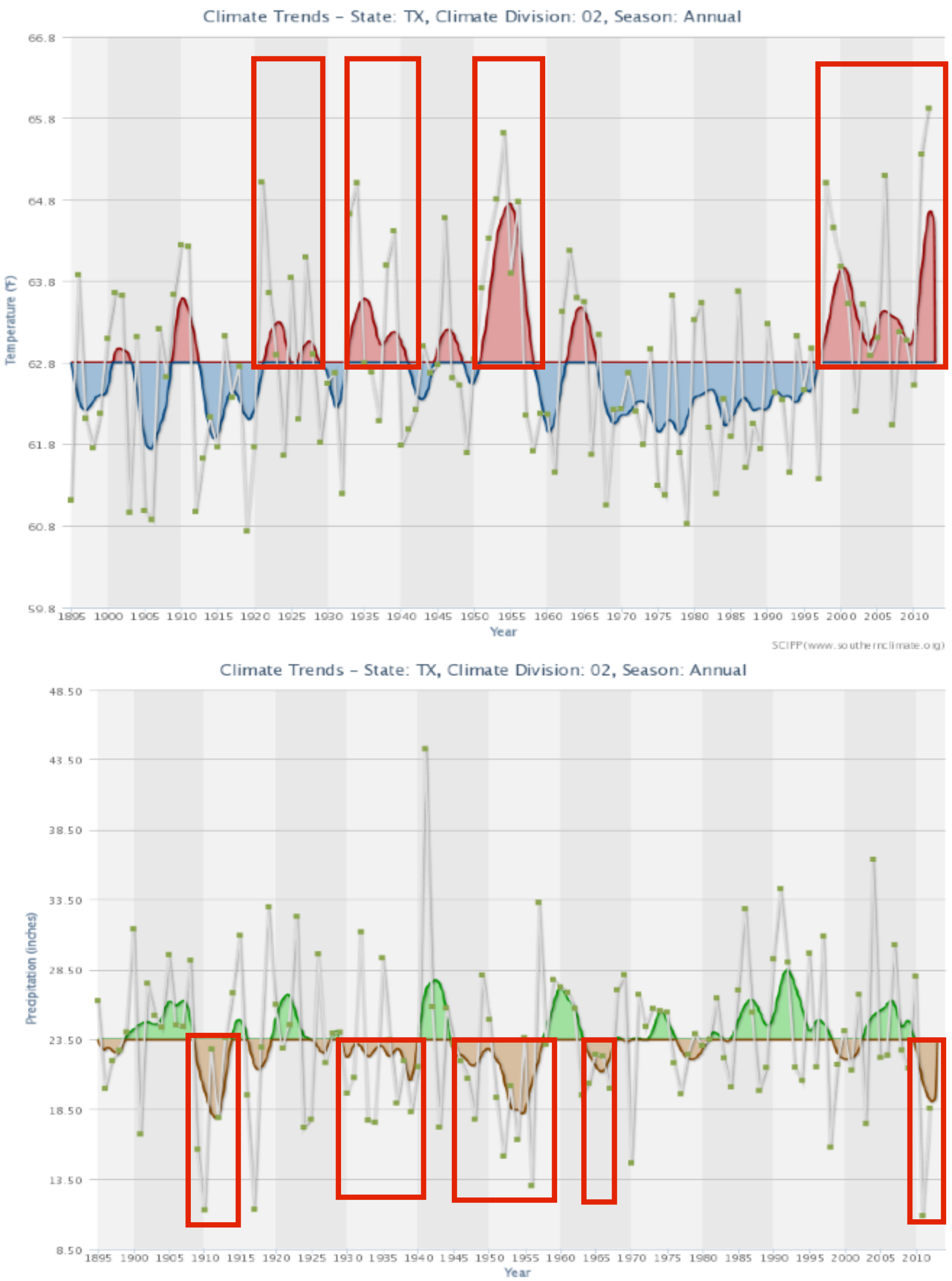


Figure 7. *The average annual temperature (top graph) and total annual precipitation (bottom graph) in the Low Rolling Plains of Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the 1910s, the 1930s, and the 1950s. The longest period of dry conditions undoubtably was during the 1950s. Table 2 compares Palmer Drought Severity Indices for these droughts. Using these indices, the drought of the 1950s exceeds the duration and intensity of all other droughts; hence, ***the period from January 1950 to February 1957 is the drought-of-record for the Low Rolling Plains of Texas***.

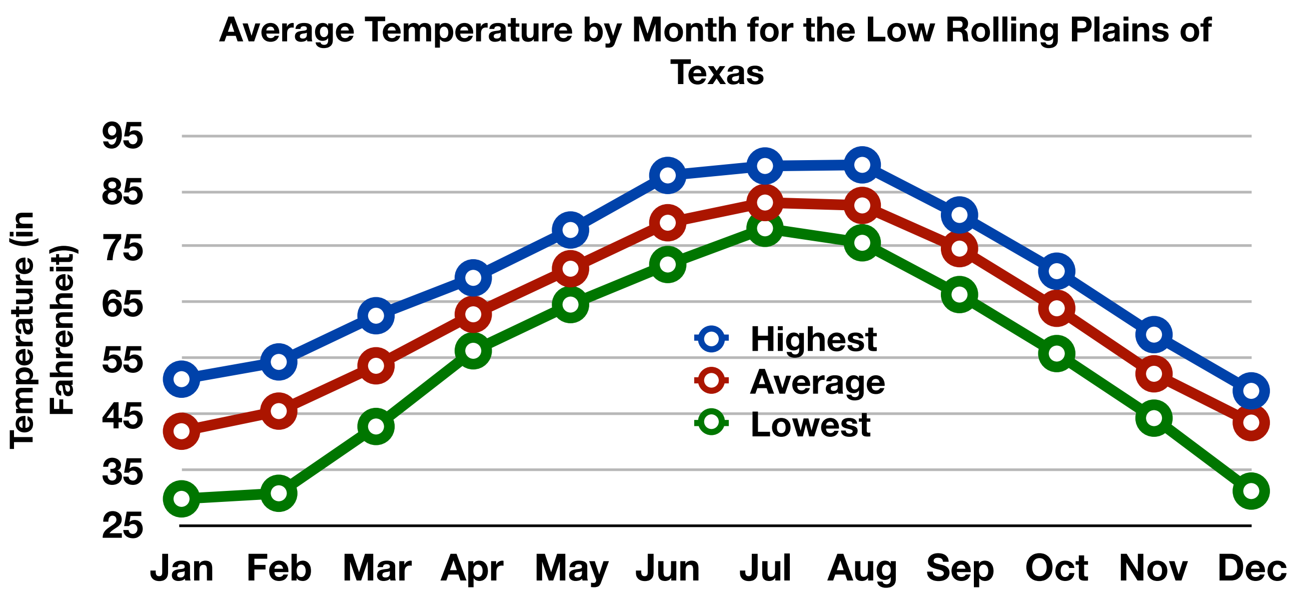
Because of its intense heat combined with non-stop dry conditions, ***February 1909 to August 1913 comes in second for the drought-of-record for the Low Rolling Plains of Texas.***

Table 2: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting the Low Rolling Plains of Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
February 1909 – August 1913	53 (of 55 months)	10 consecutive plus 3 other	–5.66
June 1933 – October 1940	62 (of 89 months)	10 consecutive	–5.01
January 1950 – February 1957	77 (of 86 months)	10 consecutive plus 12 others	–5.86
March 1963 – July 1971	64 (of 101 months)	1	-4.19
December 2010 – December 2012*	25 (of 25 months)	8 consecutive plus 7 consecutive	-6.79

****Note****: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for the Low Rolling Plains of Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 8. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during June, July, and August (top of Figure 8).



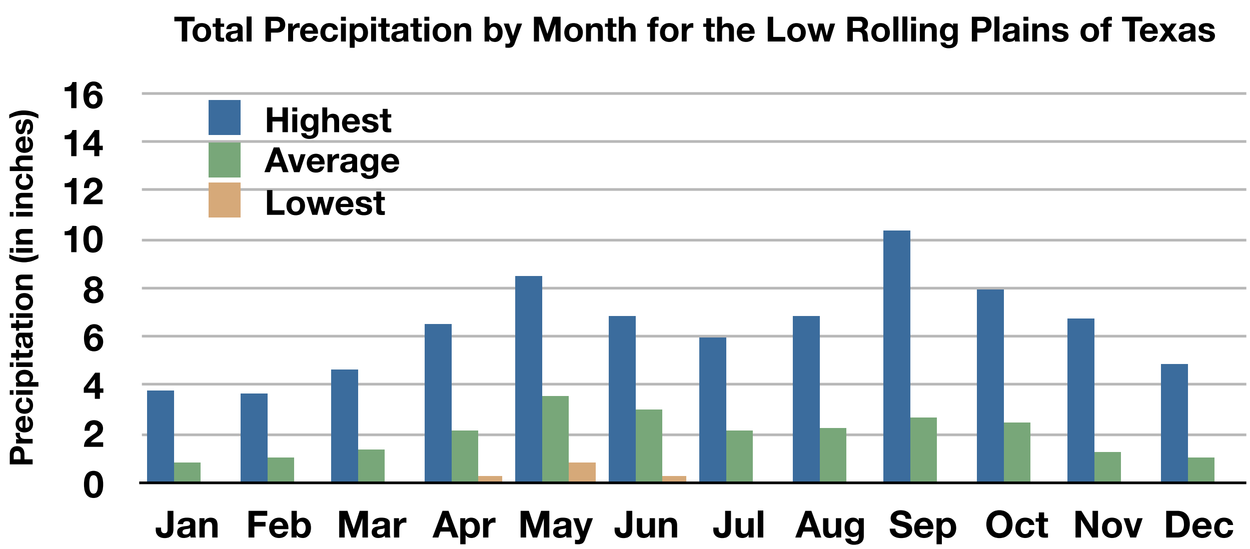


***Figure 8**. <u>Top graph</u>: The monthly average temperature (in degrees Fahrenheit) across the Low Rolling Plains of Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. <u>Bottom graph</u>: The average total precipitation (in inches) by month across the Low Rolling Plains of Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during January, February, September, October, November, and December.] The two peaks in precipitation, first in May, then in September, is clearly visible.*

The Low Rolling Plains of Texas has experienced long and extreme droughts in its past. Figure 9 displays the departure from normal precipitation, and Palmer Drought Severity Index for the Low Rolling Plains of Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 7.

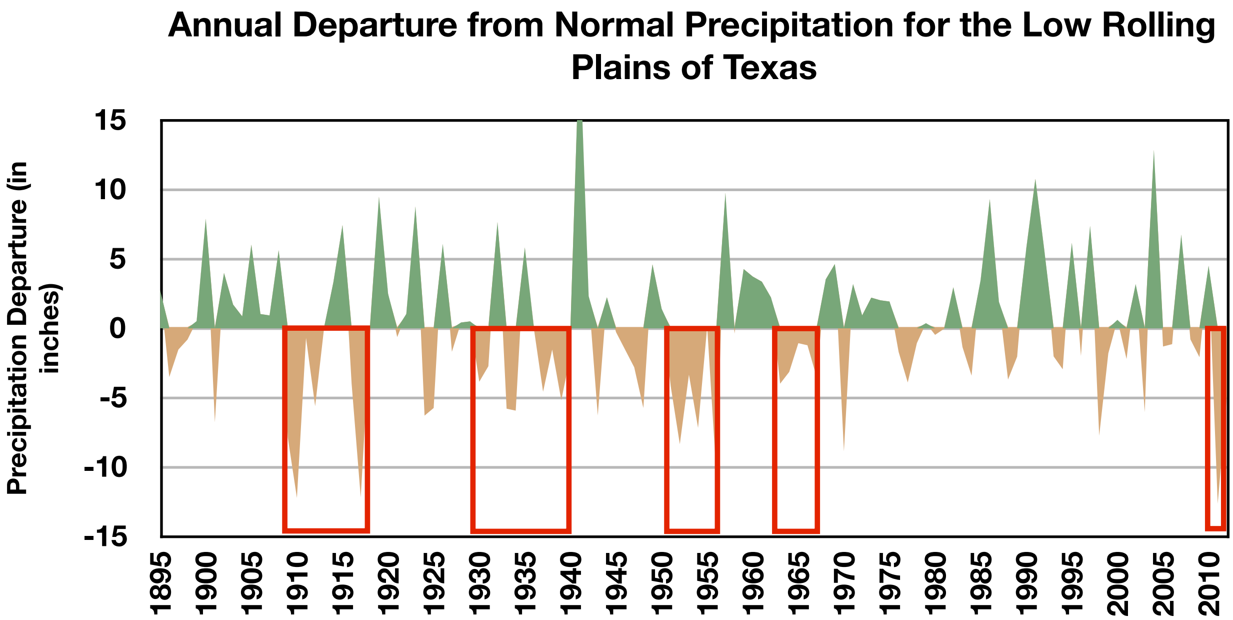


***Figure 9a**. Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for the Low Rolling Plains of Texas from 1895 to 2012.*

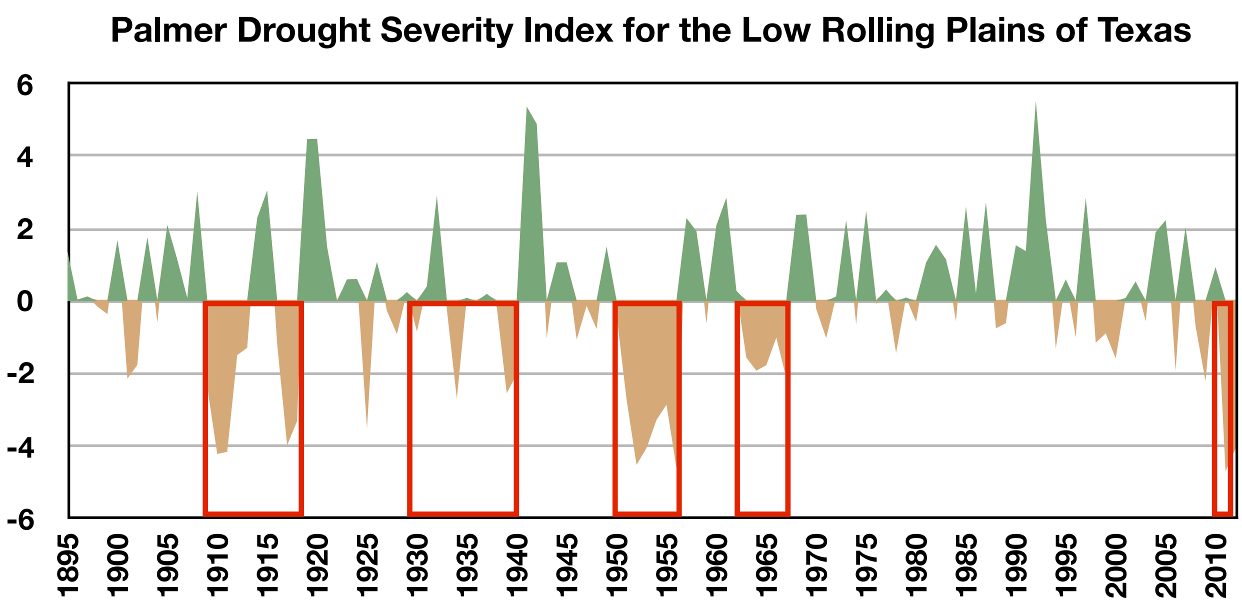


***Figure 9b**. Palmer Drought Severity Index for the Low Rolling Plains of Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 10 we look at drought designation in the Low Rolling Plains of Texas and see that from 2000-2004 abnormally dry to extreme conditions covered up to 100% of the region. In 2011 to 2013 the region experienced extreme to exceptional drought also covering 25 to nearly 100% of region.

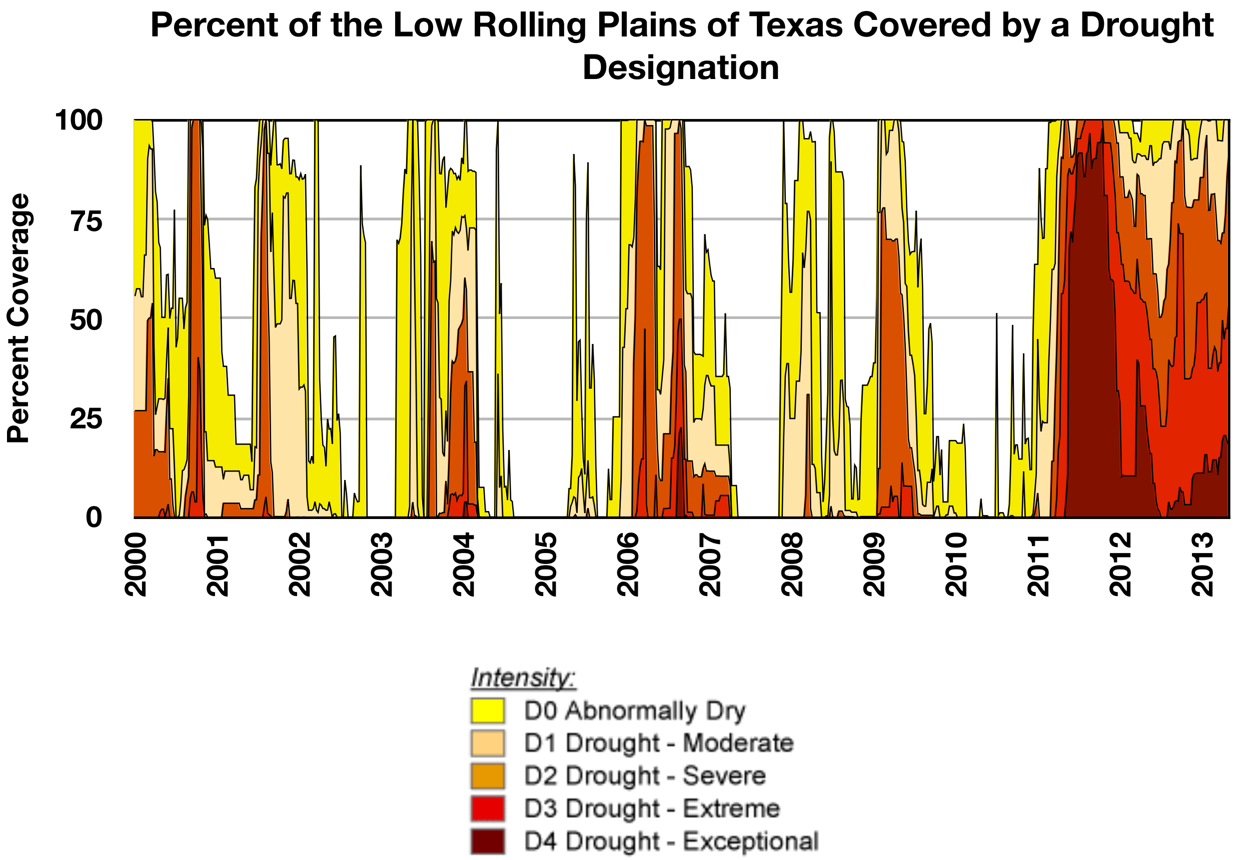
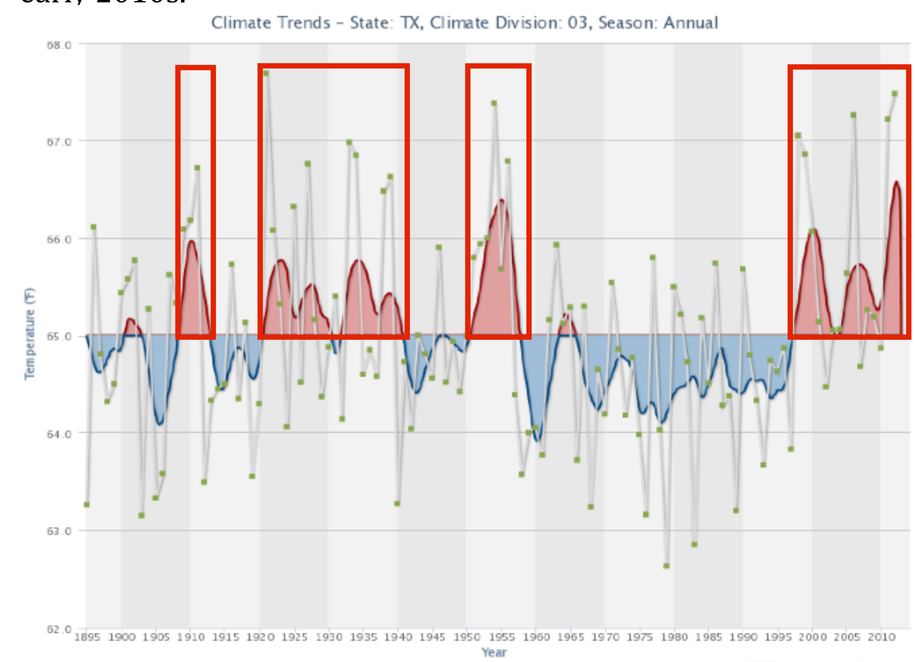


Figure 10. *Drought history for the Low Rolling Plains of Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that the Low Rolling Plains of Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the climate division during much of 2006 and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 3: North-Central Texas

North-Central Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 11 shows the annual temperature (top) and annual precipitation (bottom) in north-central Texas since 1895.[4] The annual temperature for north-central Texas averages 65.0 degrees Fahrenheit, while precipitation averages 32.3 inches. Warmer-than-average periods have spanned the late 1900s, the 1920s through the 1930s, the 1950s, and the late 1990s through the early 2010s. Significant periods of drier-than-average conditions include the 1910s, the 1930s, the 1950s, the late 1970s, and the early 2010s.



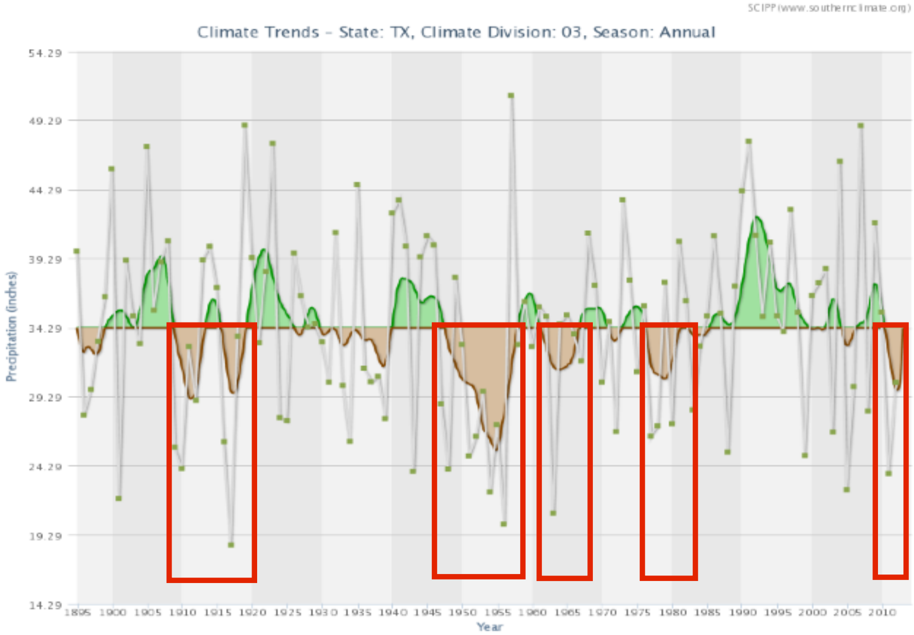


Figure 11. *The average annual temperature (top graph) and total annual precipitation (bottom graph) in north-central Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the 1910s, late 1930s, and mid-1950s. The longest period of dry conditions undoubtably was during the 1950s. Table 3 compares Palmer Drought Severity Indices for these droughts,.. Using these indices, the drought of the 1950s exceeds the duration and intensity of all other droughts; hence, ***the period from November 1950 to February 1957 is the drought-of-record for north-central Texas***.

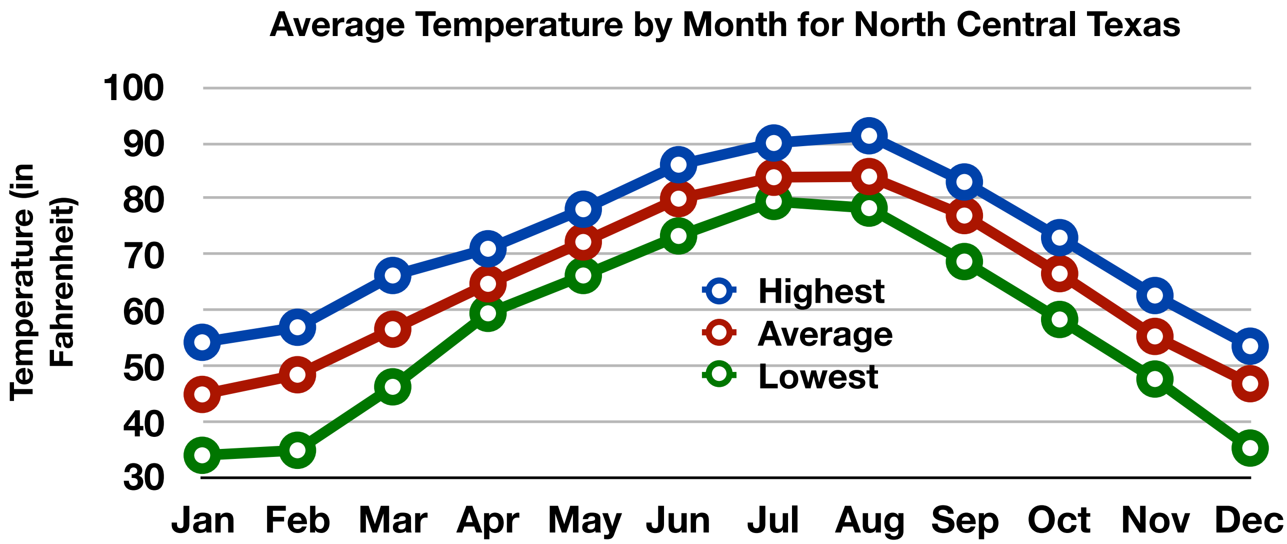
Because of its intense heat combined with non-stop dry conditions, ***January 1909 to August 1918 comes in second for the drought-of-record for north-central Texas.***

Table 3: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting North-Central Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
January 1909 – August 1918	81 (of 116 months)	15 consecutive plus 1 other	–6.03
November 1950 – February 1957	76 (of 76 months)	12 consecutive plus 11 others	–6.92
February 1963 – August 1967	32 (of 43 months)	4	–4.56
November 1975 – February 1981	35 (of 64 months)	1	-4.24
June 2010 – December 2012*	19 (of 31 months)	3 consecutive	-5.28

****Note****: *Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for north-central Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 12. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during July and August (top of Figure 12).



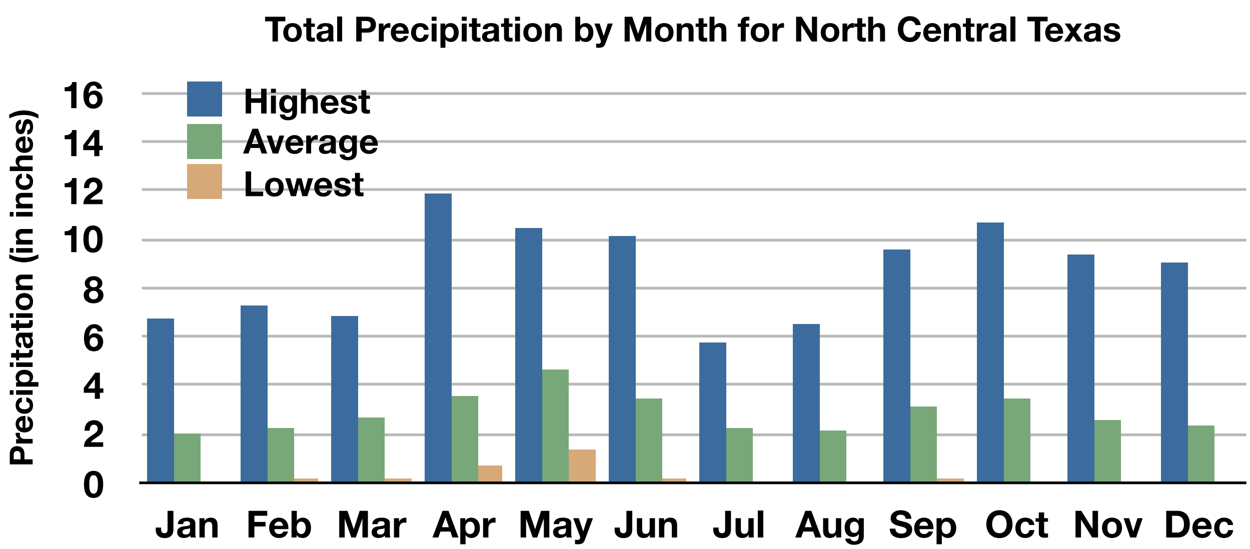


Figure 12. *Top graph: The monthly average temperature (in degrees Fahrenheit) across north-central Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. Bottom graph: The average total precipitation (in inches) by month across north-central Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during December.] The peak in precipitation in April is clearly visible.*

North-central Texas has experienced long and extreme droughts in its past. Figure 13 displays the departure from normal precipitation, and Palmer Drought Severity Index for north-central Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 11.

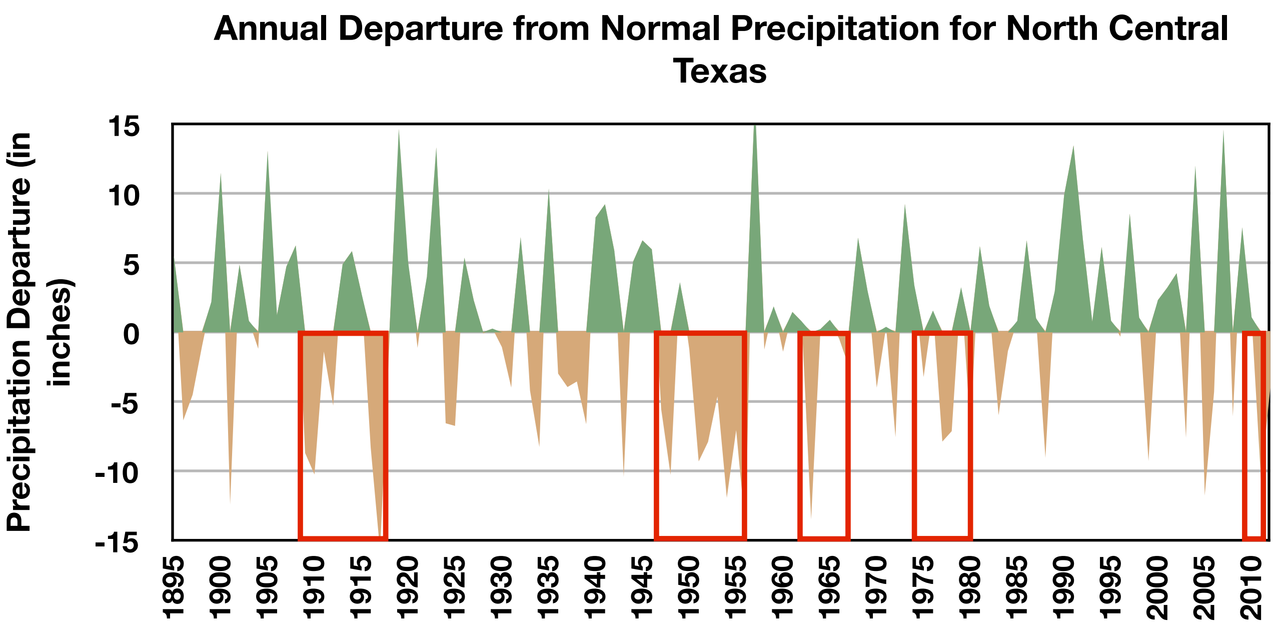


Figure 13a. *Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for north-central Texas from 1895 to 2012.*

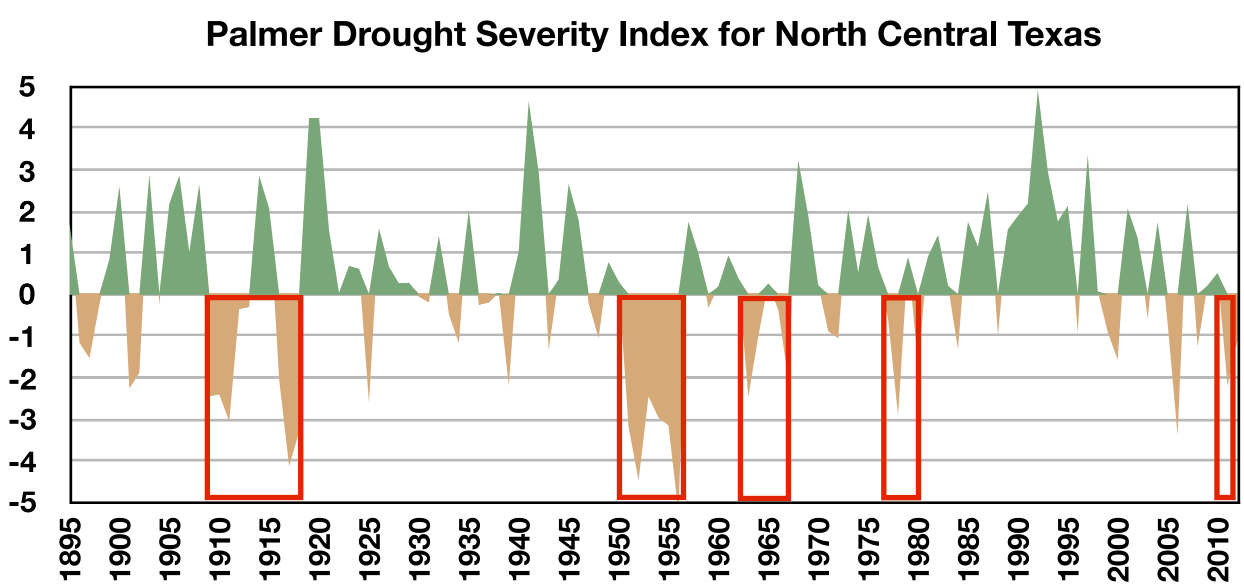


Figure 13b. *Palmer Drought Severity Index for north-central Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 14 we look at drought designation in north-central Texas and see that from 2005-20027 severe to extreme conditions covered up to 100% of the region. In 2011 to 2013 the region experienced severe to exceptional drought covering nearly 100% of region.

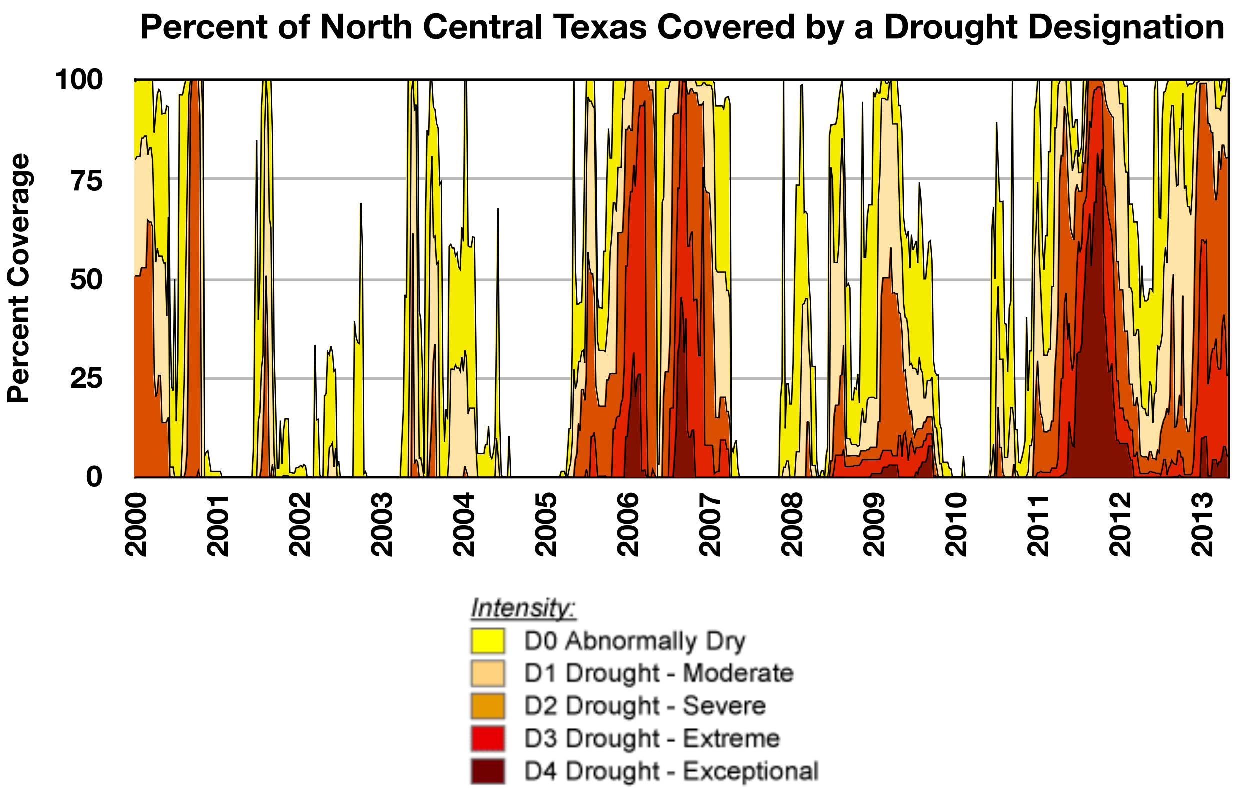


Figure 14. *Drought history for north-central Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that north-central Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the climate division during much of 2005 through 2006 and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 4: East Texas

Northeast Oklahoma has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 15 shows the annual temperature (top) and annual precipitation (bottom) in eastern Texas since 1895.[5] The annual temperature for eastern Texas averages 65.8 degrees Fahrenheit, while precipitation averages 46.32 inches. Warmer-than-average periods have spanned the late 1900s through the early 1910s, the 1920s through the late 1950s, and the late 1990s through the early 2010s. Significant periods of drier-than-average conditions include the late 1890s through the early 1900s, the 1910s, the 1930s, the 1950s, the 1960s through the early 1970s, and the early 2010s.

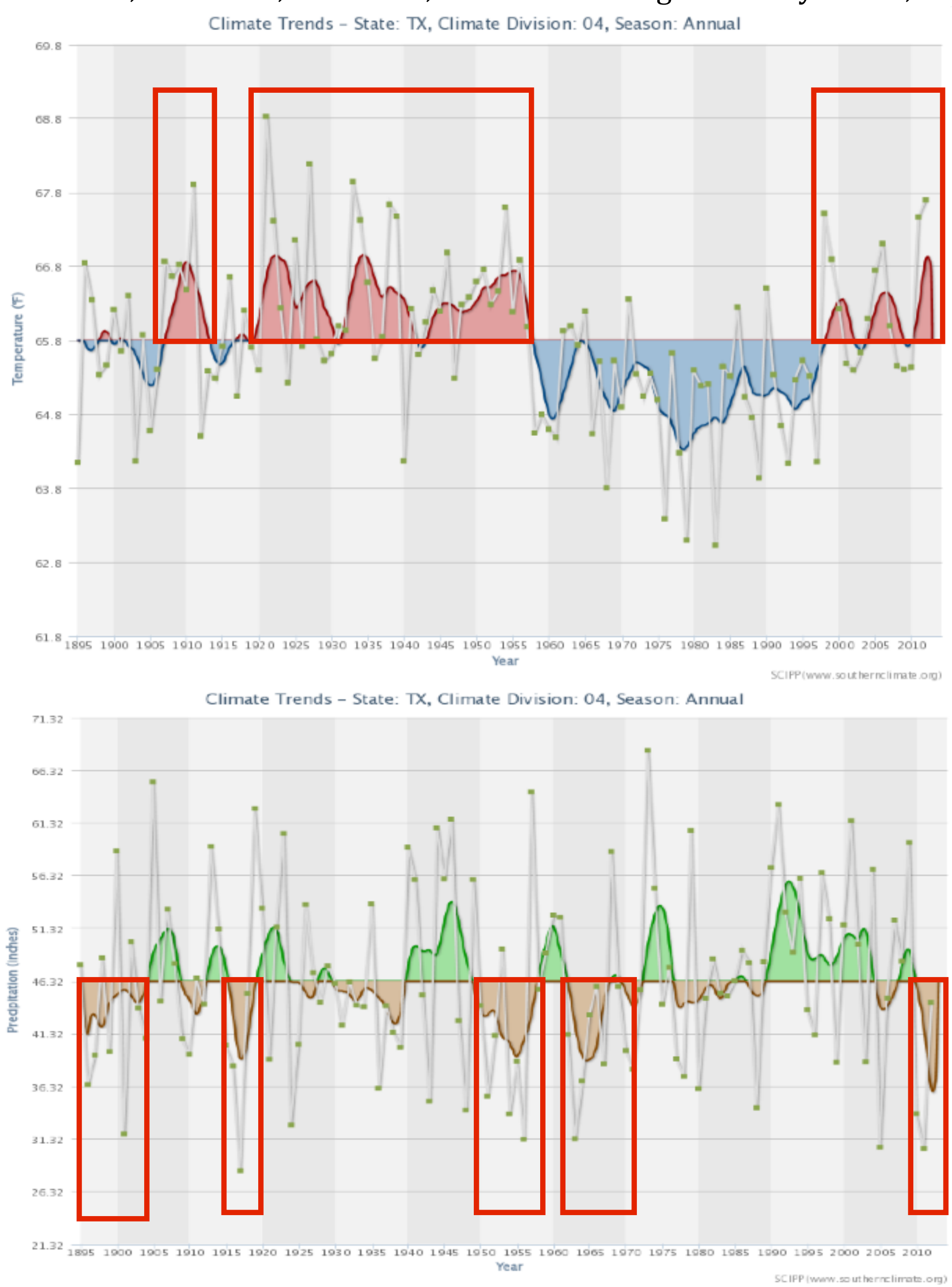


Figure 15. *The average annual temperature (<u>top graph</u>) and total annual precipitation (<u>bottom graph</u>) in eastern Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

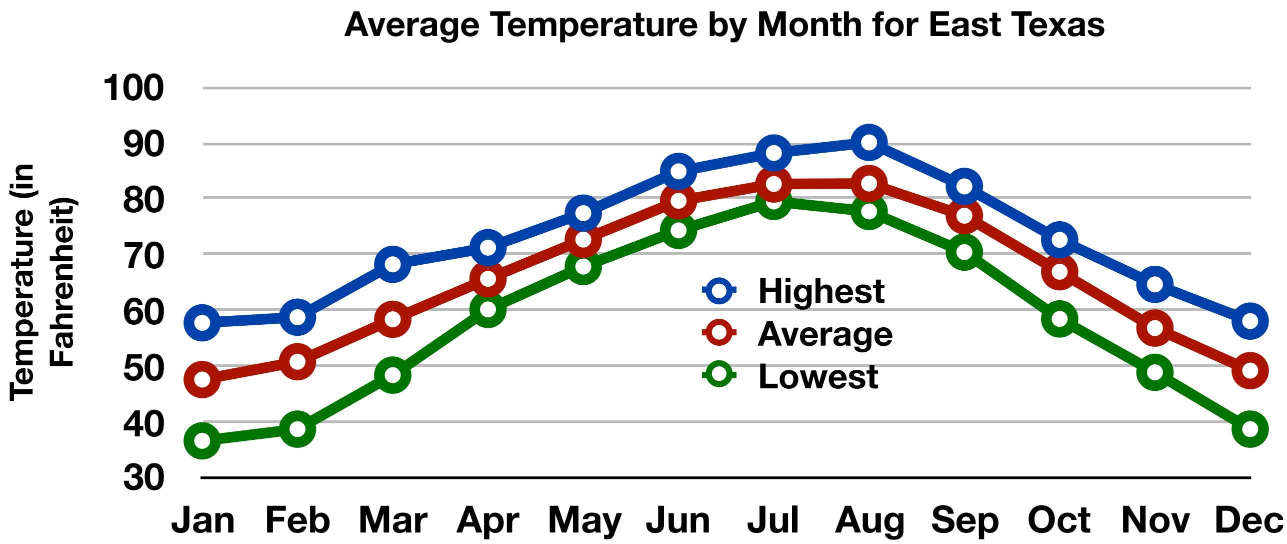
Options for the drought-of-record for the region include the droughts in the 1910s, the late 1930s, and the mid-1950s. The longest period of dry conditions undoubtably was during the 1950s. Table 4 compares Palmer Drought Severity Indices for these droughts. Using these indices, the drought of the 1950s exceeds the intensity of most other droughts; hence, ***the period from November 1950 to February 1957 is the drought-of-record for eastern Texas***.

Table 4: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting East Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
May 1896 – August 1902	48 (of 88 months)	0	–3.82
December 1915 – September 1918	27 (of 35 months)	10 consecutive	–5.99
November 1950 – February 1957	49 (of 76 months)	6 consecutive plus 2 others	-4.54
December 1962 – May 1972	77 (of 114 months)	0	-3.78
May 2010 - December 2012*	29 (of 29 months)	11 consecutive	-6.5

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for eastern Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 16. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during August in eastern Texas (top of Figure 16).



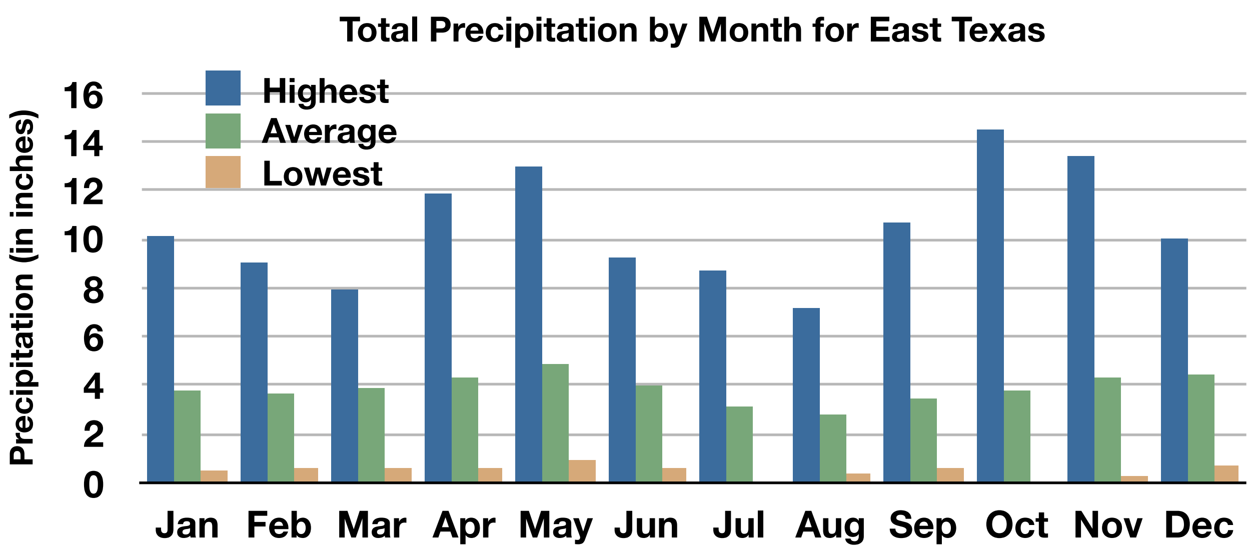


Figure 16*. Top graph: The monthly average temperature (in degrees Fahrenheit) across eastern Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. Bottom graph: The average total precipitation (in inches) by month across eastern Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during July and October] The three peaks of precipitation, first in May, then in October, and finally in November, is clearly visible.*

Eastern Texas has experienced long and extreme droughts in its past. Figure 17 displays the departure from normal precipitation, and Palmer Drought Severity Index for eastern Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 15.

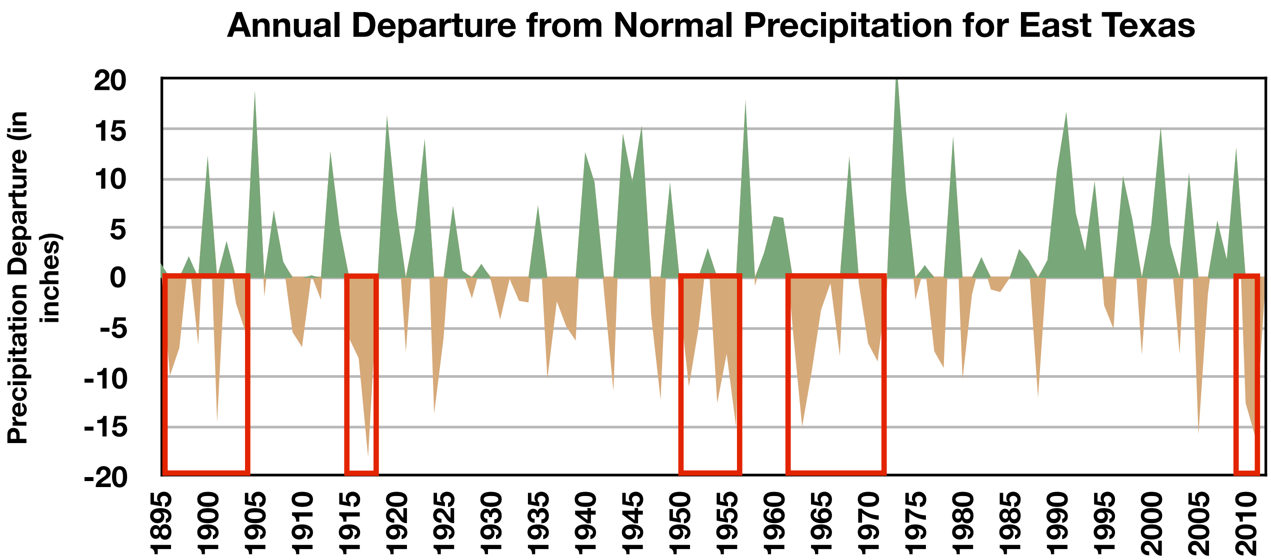


***Figure 17a**. Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for eastern Texas from 1895 to 2012.*

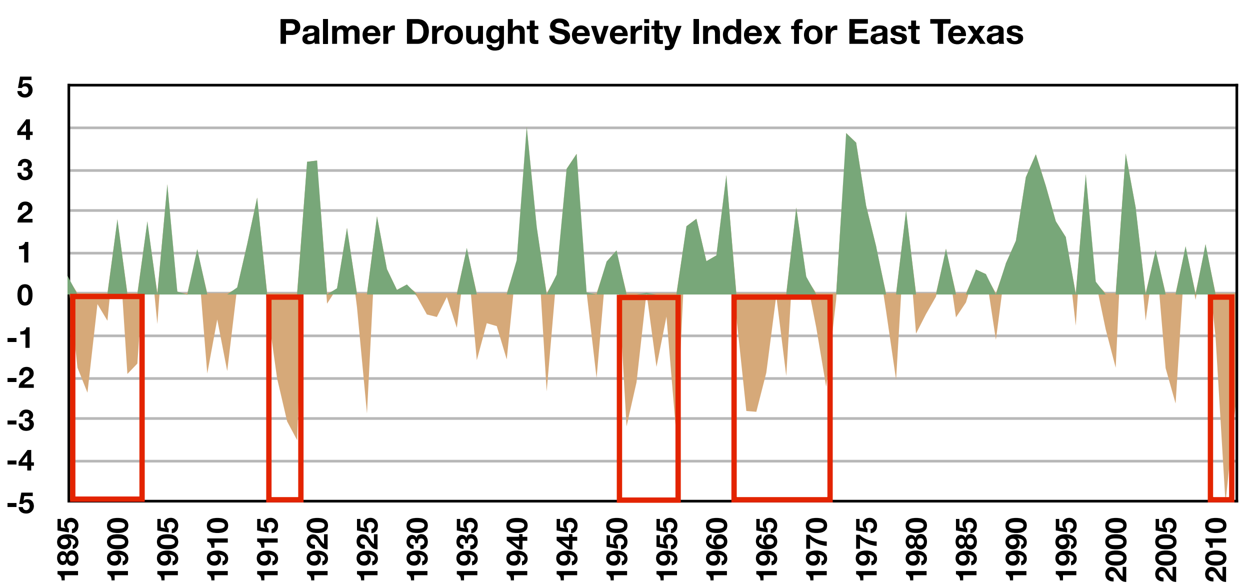


***Figure 17b**. Palmer Drought Severity Index for eastern Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 18 we look at drought designation in east Texas and see that from 2005-2007 abnormally dry to extreme conditions covered 15 to 100% of the region. In 2011 to 2013 the region experienced extreme to exceptional drought also covering 25 to nearly 100% of region.

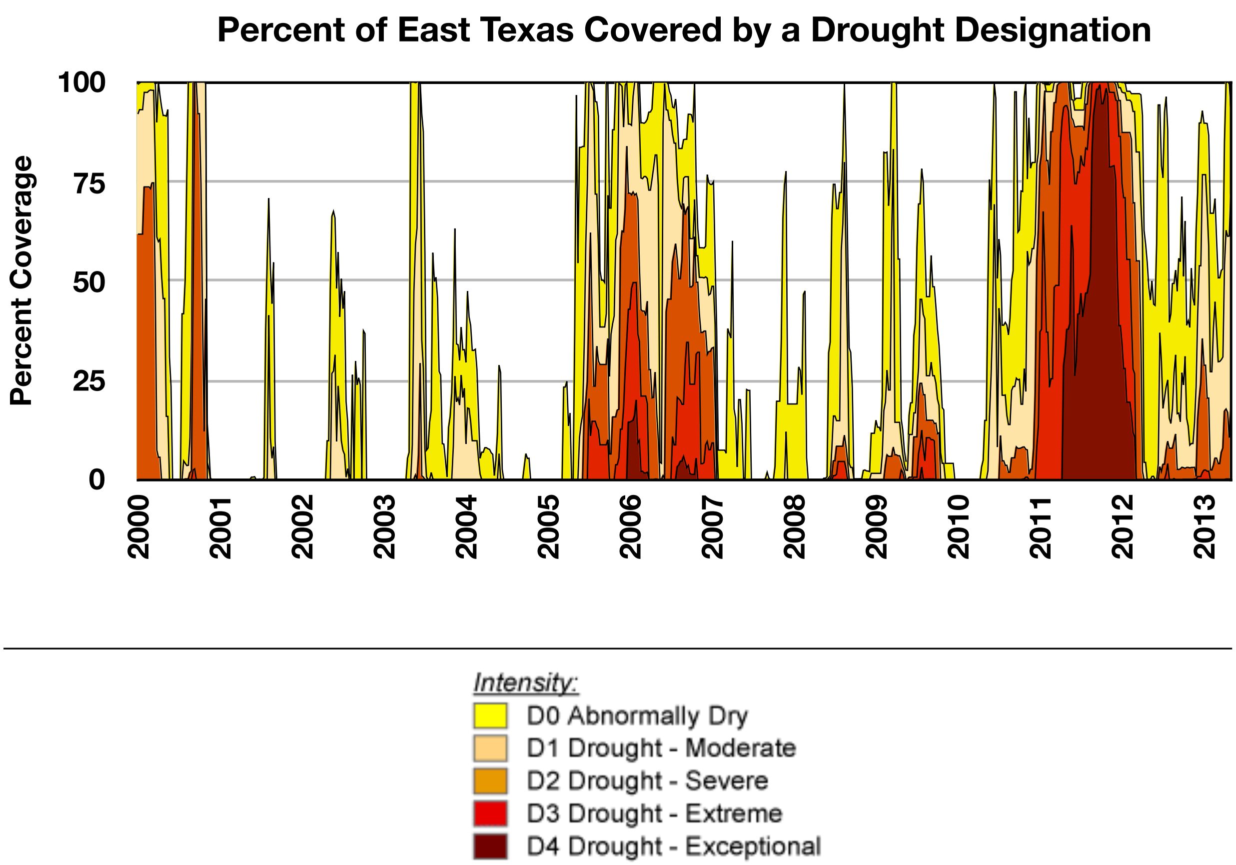


Figure 18. *Drought history for eastern Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that eastern Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the climate division during much of 2005 through 2006 and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 5: Trans Pecos of Texas

The Trans Pecos region of Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 19 shows the annual temperature (top) and annual precipitation (bottom) in the Trans Pecos of Texas since 1895.[6] The annual temperature for the Trans Pecos of Texas averages 63.8 degrees Fahrenheit, while precipitation averages 12.42 inches. Warmer-than-average periods have spanned the 1900s, and the mid-1990s through the early 2010s. Significant periods of drier-than-average conditions include the early 1910s, the mid-1920s to the mid-1930s, the mid-1940s through the late 1960s, the mid-1990s through the mid-2000s, and the early 2010s.

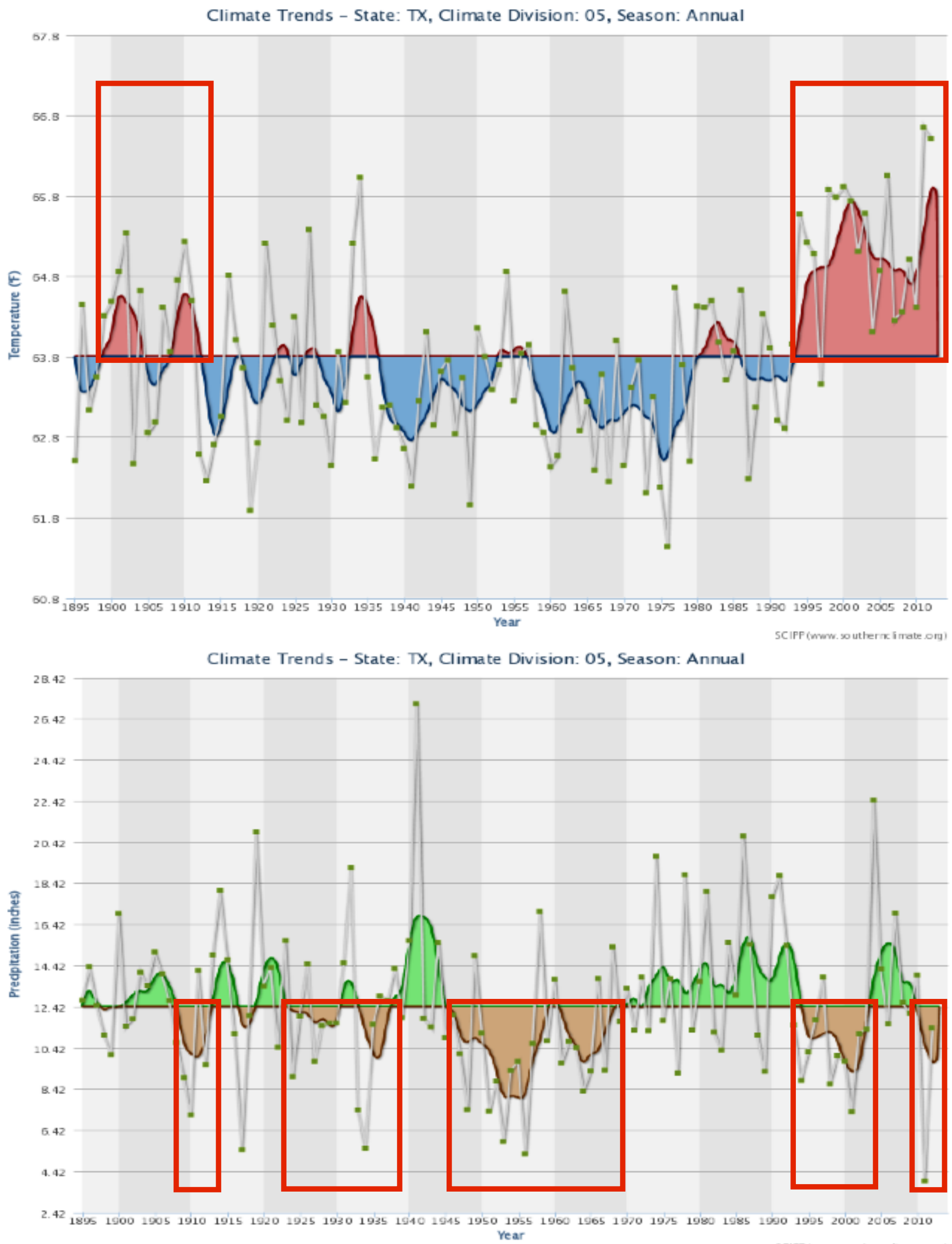


Figure 19 *The average annual temperature (<u>top graph</u>) and total annual precipitation (<u>bottom graph</u>) in the Trans Pecos of Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the 1920s to the 1930s, the 1940s to the 1960s, and the 1990s to the early 2000s. The longest period of dry conditions undoubtably was during the 1940s through the 1960s. Table 5 compares Palmer Drought Severity Indices for these droughts. Using these indices, the drought of the 1940s through the 1960s well exceeds the duration and intensity of all other droughts; hence, ***the period from February 1943 to November 1967 is the drought-of-record for the Trans Pecos of Texas***.

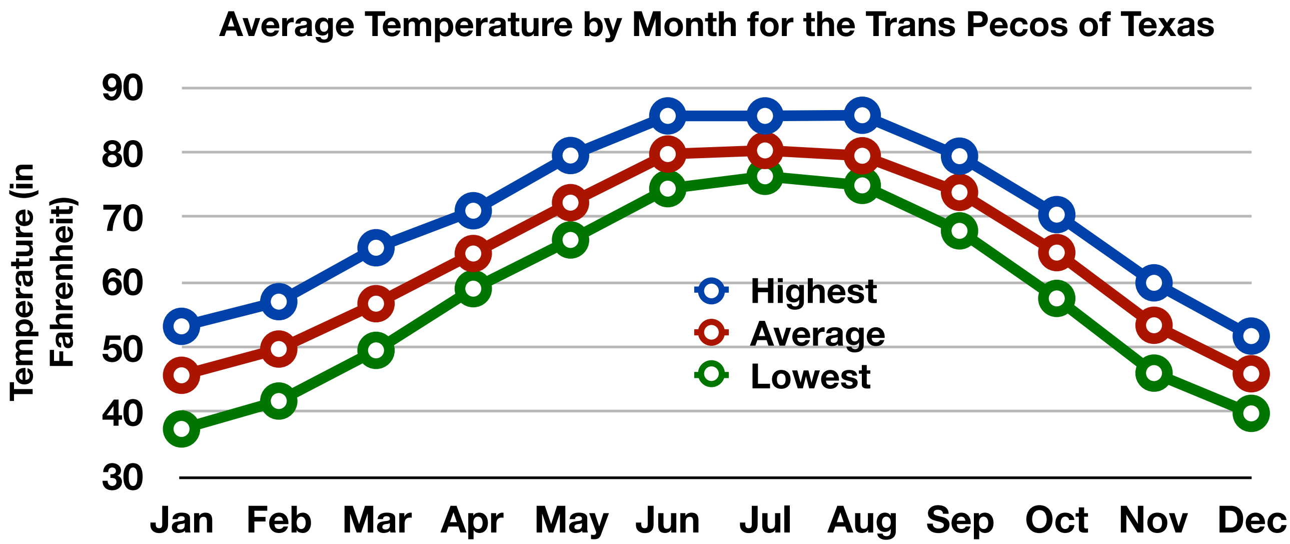
Because of its intense heat combined with non-stop dry conditions, ***October 1992 through December 2003 comes in second for the drought-of-record for the Trans Pecos of Texas***.

Table 5: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting the Trans Pecos of Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
March 1907 – August 1913	40 (of 78 months)	3 consecutive plus 1 other	–4.49
February 1921 – August 1936	102 (of 187 months)	9 consecutive	–5.38
February 1943 – November 1967	185 (of 298 months)	10 consecutive plus 6 consecutive	-5.1
October 1992 – December 2003	108 (of 135 months)	7	-5.12
October 2010 - December 2012*	27 (of 27 months)	12 consecutive	-6.47

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for the Trans Pecos of Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 20. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during June, July, and August (top of Figure 20).



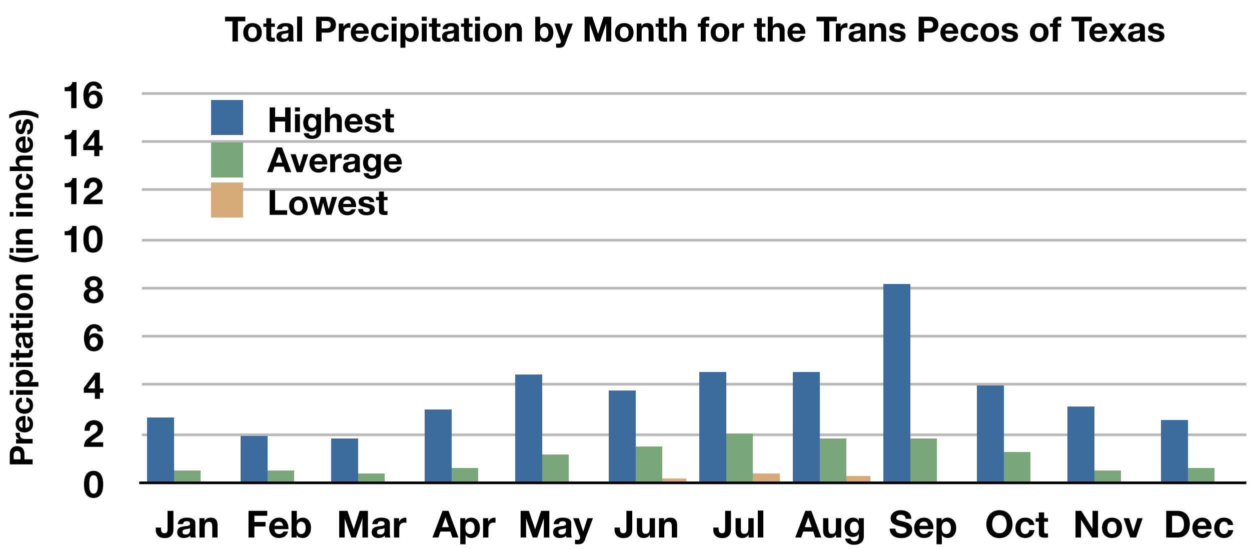


***Figure 20**. <u>Top graph</u>: The monthly average temperature (in degrees Fahrenheit) across the Trans Pecos of Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. <u>Bottom graph</u>: The average total precipitation (in inches) by month across the Trans Pecos of Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during January, February, March, April, November, and December.] The peak precipitation in September is clearly visible.*

Trans Pecos of Texas has experienced long and extreme droughts in its past. Figure 21 displays the departure from normal precipitation, and Palmer Drought Severity Index for the Trans Pecos of Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 19.

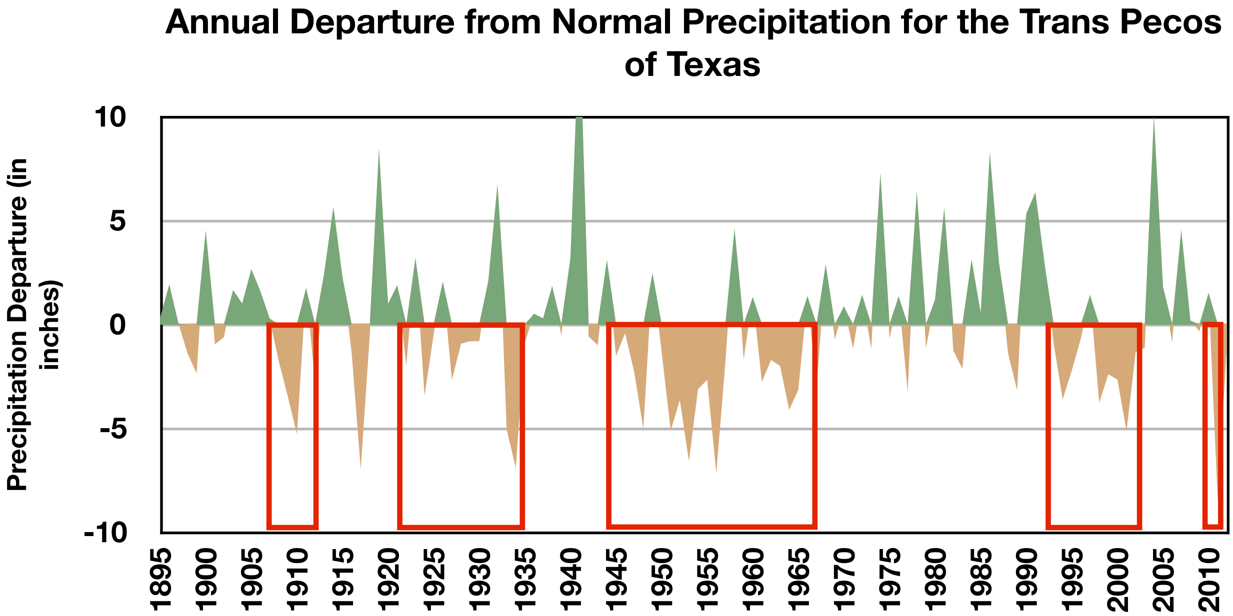


***Figure 21a**. Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for the Trans Pecos of Texas from 1895 to 2012.*

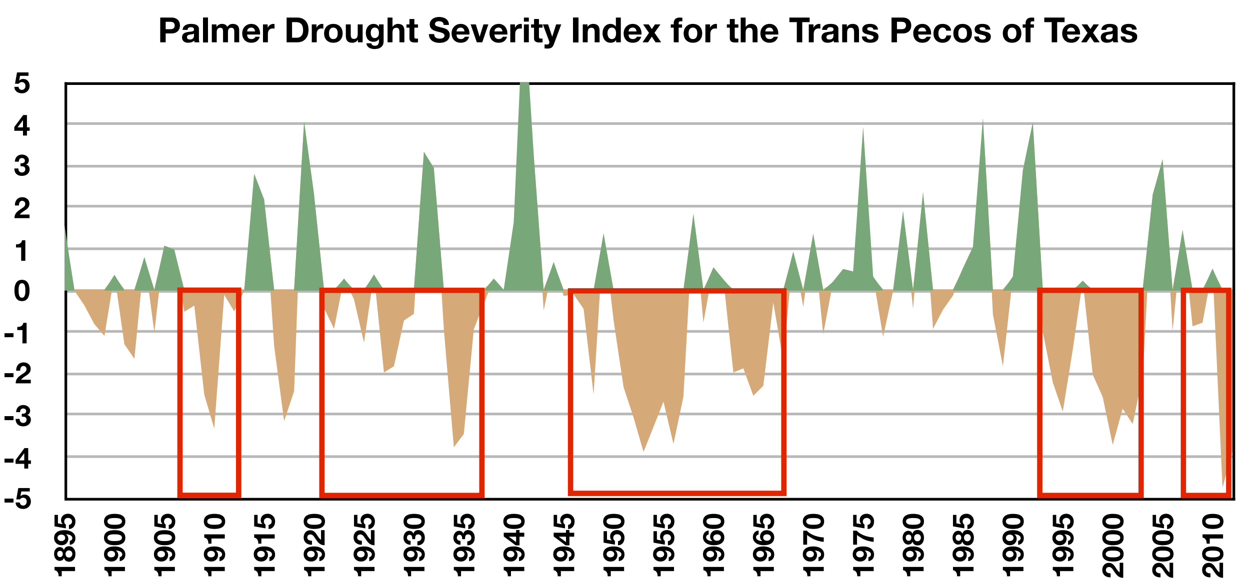


***Figure 21b**. Palmer Drought Severity Index for the Trans Pecos of Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 22 we look at drought designation in the Trans Pecos of Texas and see that from 2000-2004 abnormally dry to extreme conditions covered up to 100% of the region. In 2011 to 2013 the region experienced extreme to exceptional drought also covering nearly 60 to 100% of region.

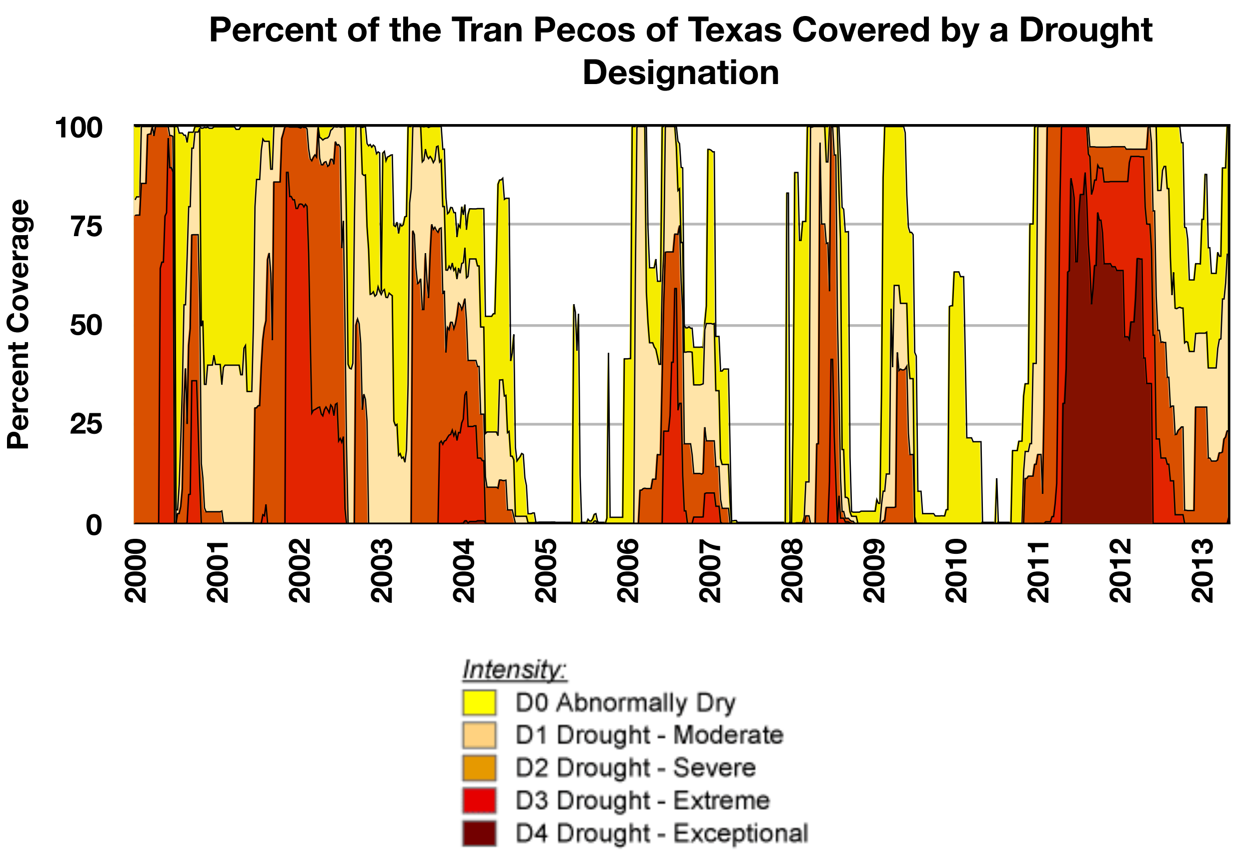


Figure 22. *Drought history for the Trans Pecos of Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that the Trans Pecos of Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the climate division during much of 2001, 2003, and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 6: Edwards Plateau of Texas

The Edwards Plateau has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 23 shows the annual temperature (top) and annual precipitation (bottom) in the Edwards Plateau of Texas since 1895.[7] The annual temperature for the Edwards Plateau of Texas averages 66.0 degrees Fahrenheit, while precipitation averages 25.24 inches. Warmer-than-average periods have spanned the late 1900s through the mid-1910s, the 1920s through the 1930s, the mid-1950s, the mid-1990s through the early 2000s, and the early 2010s. Significant periods of drier-than-average conditions include the early 1910s, the late 1910s, the 1950s, the 1960s, and the early 2010s.

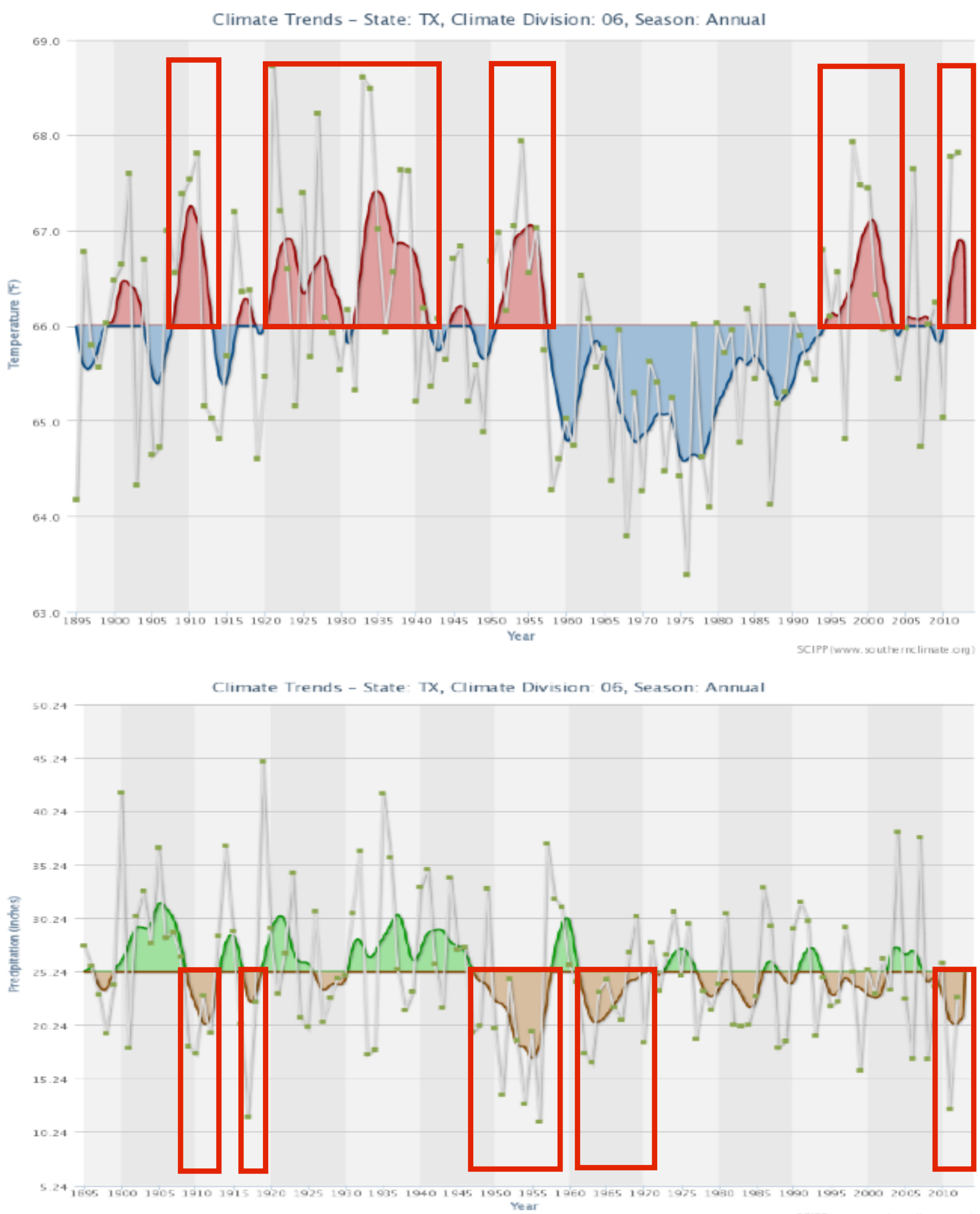


Figure 23. *The average annual temperature (<u>top graph</u>) and total annual precipitation (<u>bottom graph</u>) in the Edwards Plateau of Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the mid-1910s and 1950s. The period with the longest duration is undoubtably the 1950s. Table 6 compares Palmer Drought Severity Indices for these droughts and others. Using these indices, the drought of the 1950s well exceeds intensity of all other droughts; hence, ***the period from October 1950 to February 1957 is the drought-of-record for the Edwards Plateau of Texas***.

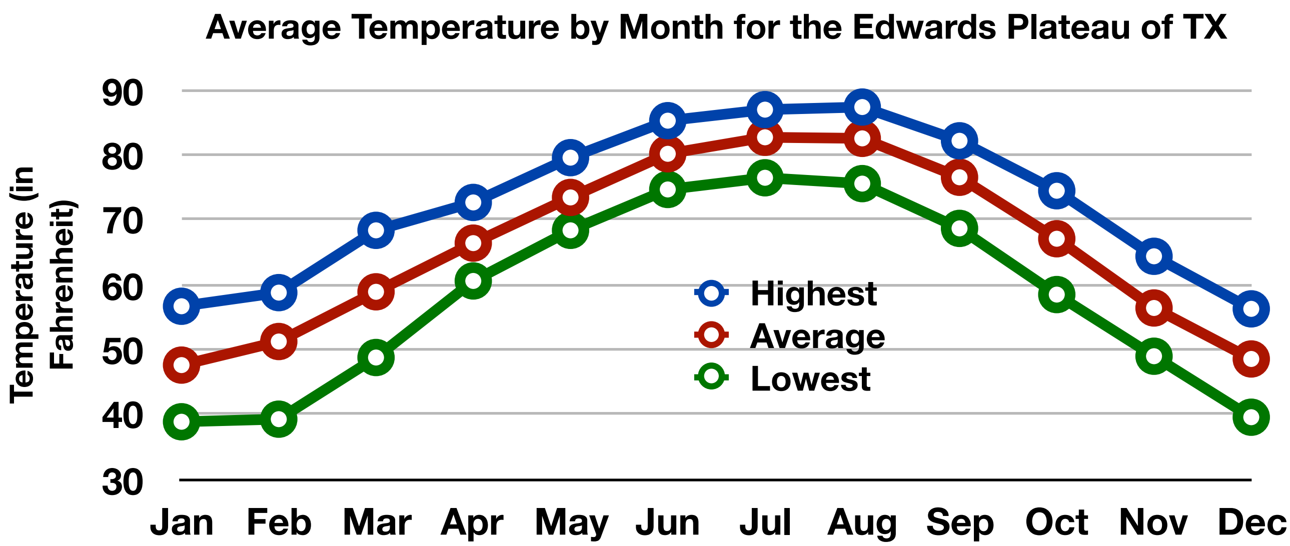
Because of its non-stop dry conditions combined with a period of PDSI less than -4, ***January 1916 to October 1918 comes in second for the drought-of-record for the Edwards Plateau of Texas***.

Table 6: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting the Edwards Plateau of Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
January 1909 - August 1913	53 (of 56 months)	3 consecutive	–4.23
January 1916 - October 1918	33 (of 33 months)	14 consecutive plus 1 other	–5.25
October 1950 - February 1957	77 (of 77 months)	11 consecutive, 7 consecutive, plus 11 other	–6.08
January 1962 - July 1964	31 (of 31 months)	4 consecutive	–4.54
November 2010 - December 2012*	26 (of 26 months)	8 consecutive	–6.13

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for the Edwards Plateau of Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 24. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during July and August (top of Figure 24).



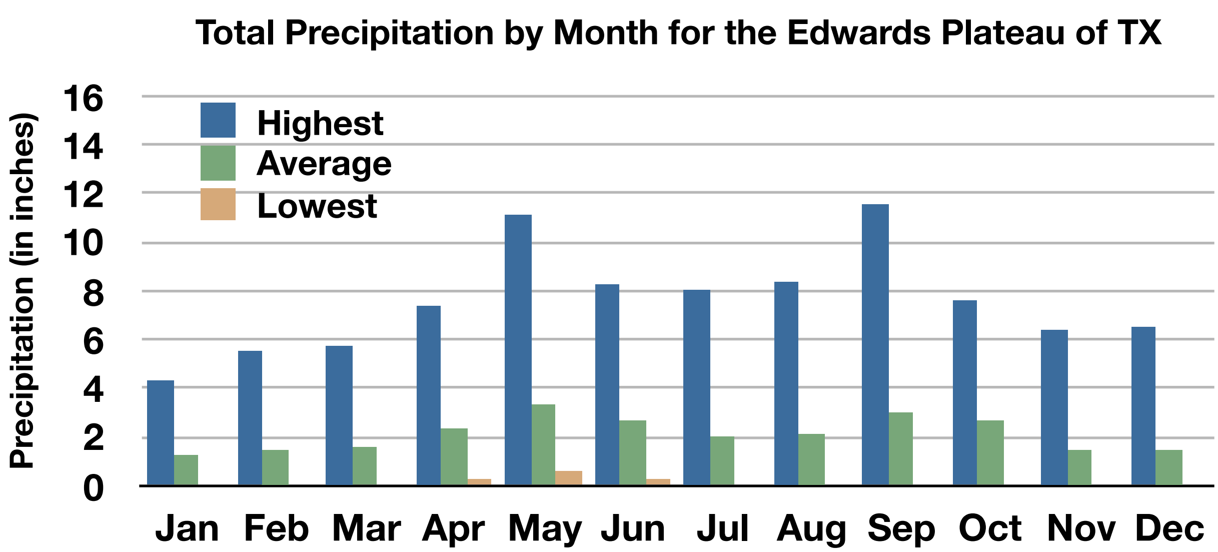


***Figure 24**. <u>Top graph</u>: The monthly average temperature (in degrees Fahrenheit) across the Edwards Plateau of Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. <u>Bottom graph</u>: The average total precipitation (in inches) by month across the Edwards Plateau of Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during January, February, August, November, and December] The two peaks of precipitation, first in May, then in September, are clearly visible.*

The Edwards Plateau of Texas has experienced long and extreme droughts in its past. Figure 25 displays the departure from normal precipitation, and Palmer Drought Severity Index for the Edwards Plateau of Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 23.

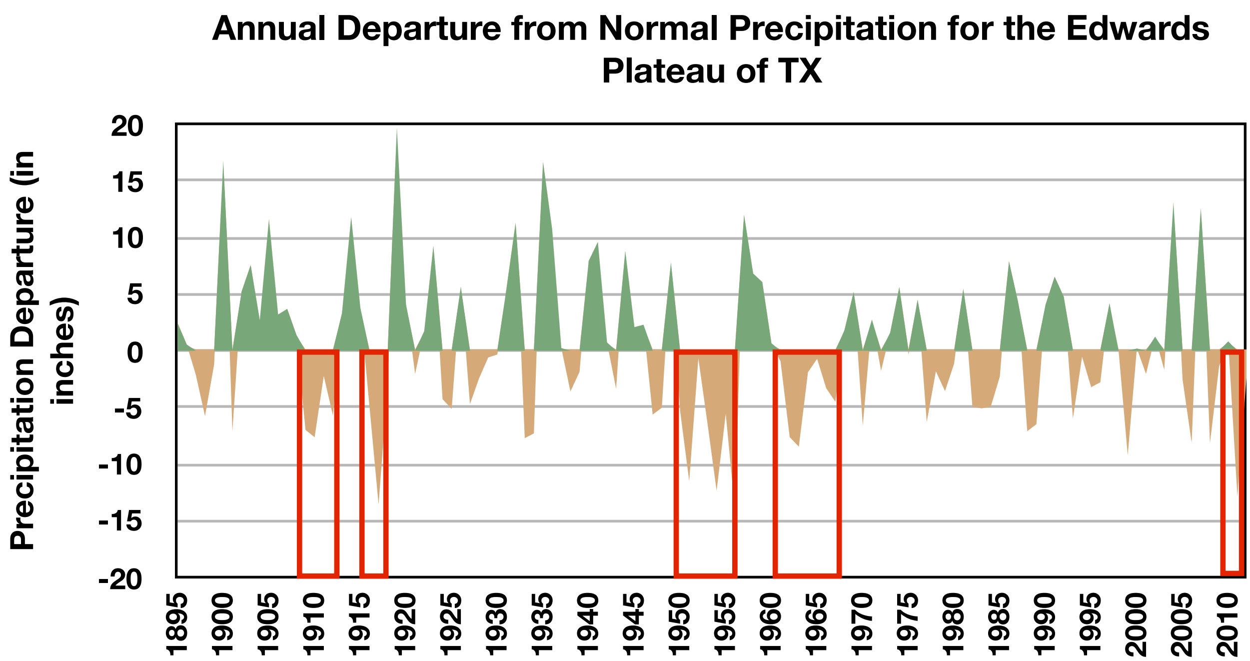


Figure 25a. *Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for the Edwards Plateau of Texas from 1895 to 2012.*

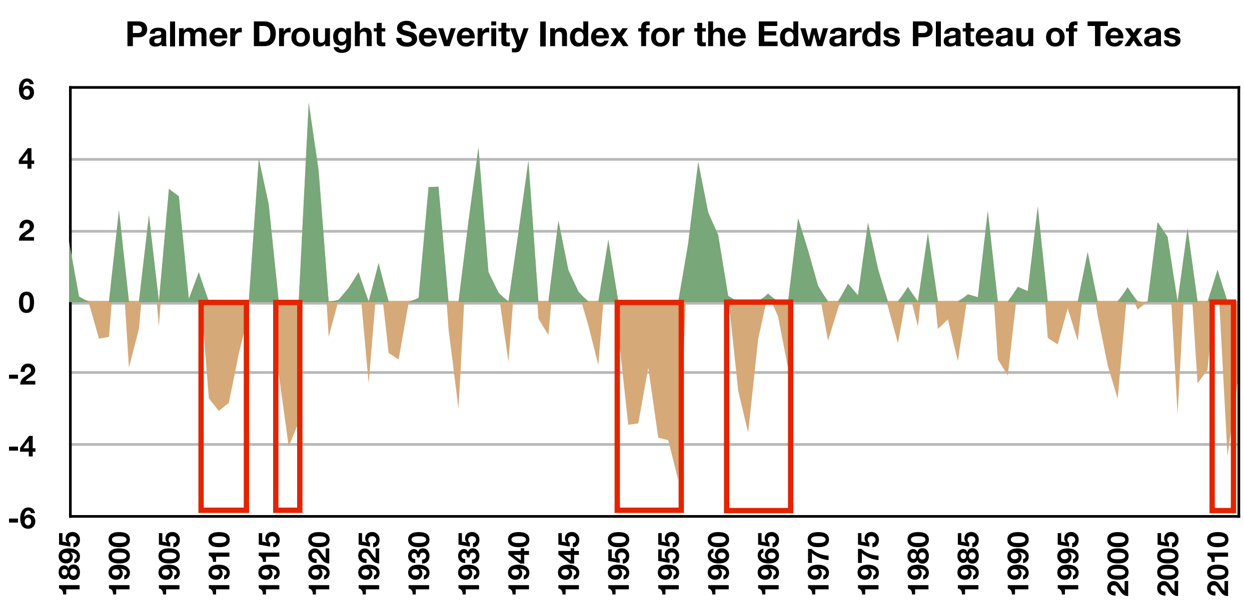


Figure 25b. *Palmer Drought Severity Index for the Edwards Plateau of Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 26 we look at drought designation in the Edwards Plateau of Texas and see that from 2000-2001 severe to extreme conditions covered up to 100% of the region. 2006 to 2007 as well as 2011 to 2013 the region experienced extreme to exceptional drought also covering 25 to 100% of region.

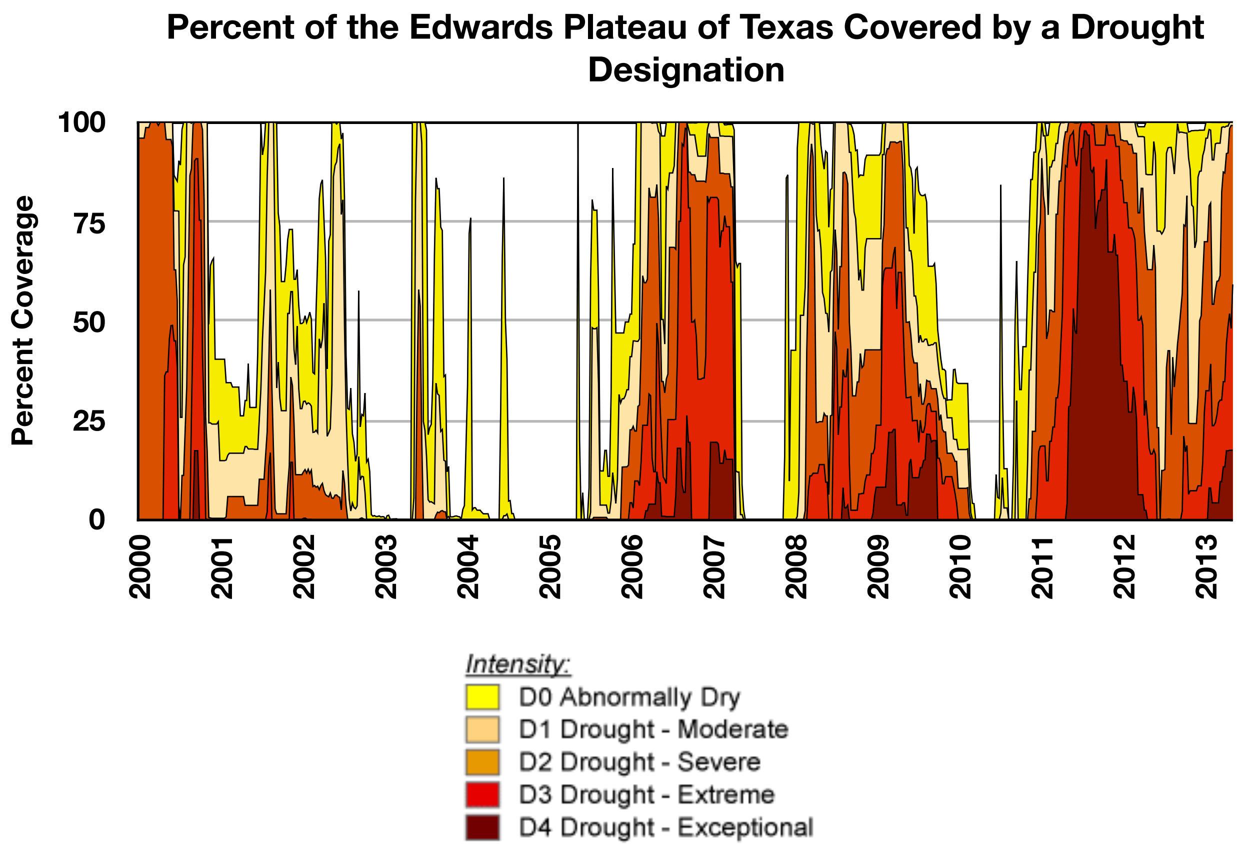


Figure 26*. Drought history for the Edwards Plateau of Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that the Edwards Plateau of Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the area during much of 2006, 2008 through 2009, and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 7: South Central Texas

South Central Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 27 shows the annual temperature (top) and annual precipitation (bottom) in south-central Texas since 1895.[8] The annual temperature for south-central Texas averages 69.4 degrees Fahrenheit, while precipitation averages 34.54 inches. Warmer-than-average periods have spanned the late 1900s through the mid-1910s, the 1920s, the 1950s, and the late 1990s through the early 2010s. Significant periods of drier-than-average conditions include the late 1910s, the 1950s, the 1960s, and the early 2010s.

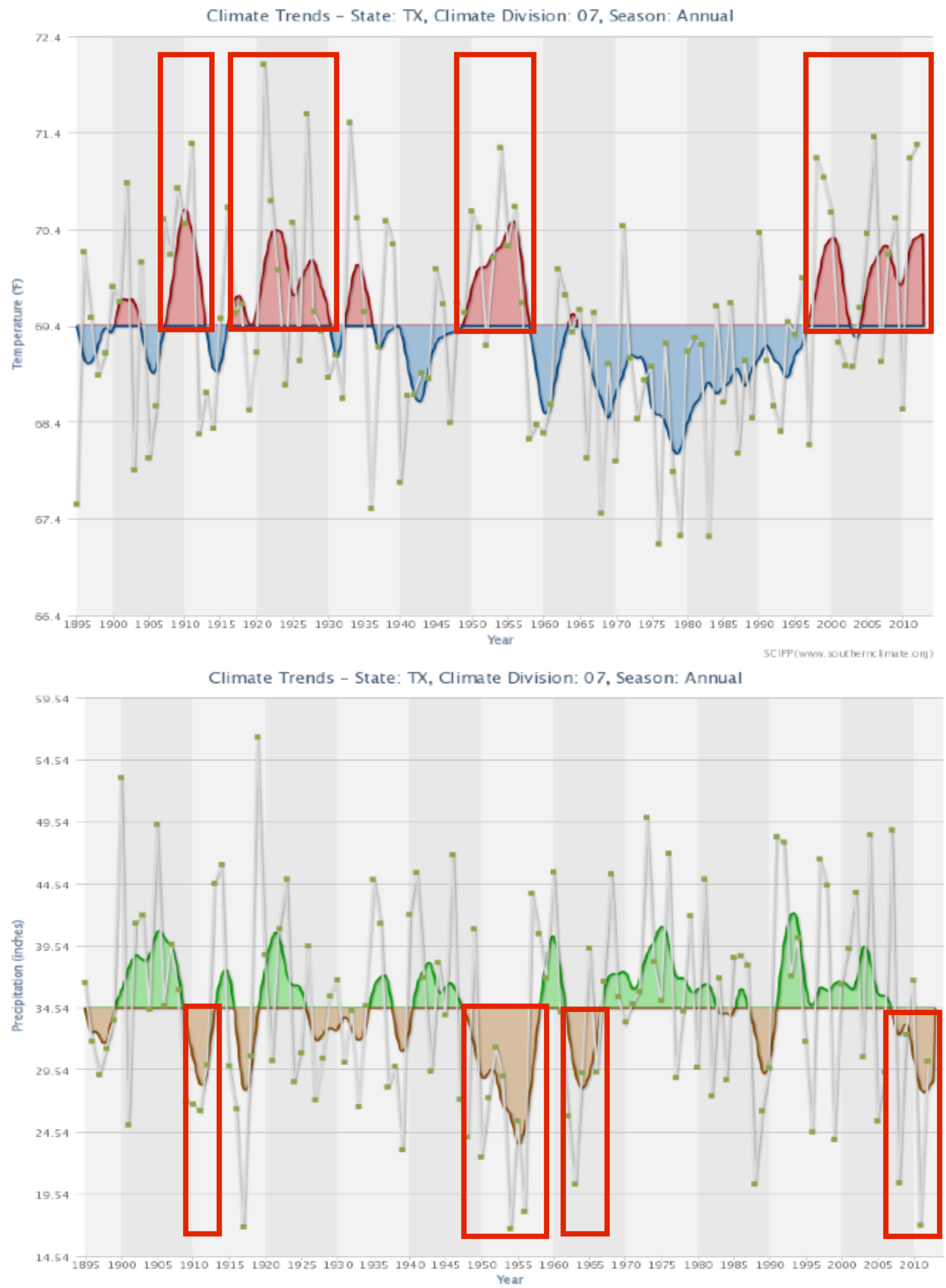


Figure 27. *The average annual temperature (top graph) and total annual precipitation (bottom graph) in south-central Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the mid-1910s and 1950s. The period with the longest duration is undoubtably the 1950s. Table 7 compares Palmer Drought Severity Indices for these droughts and others. Using these indices, the drought of the 1950s well exceeds intensity of all other droughts; hence, ***the period from January 1951 to February 1957 is the drought-of-record for south-central Texas***.

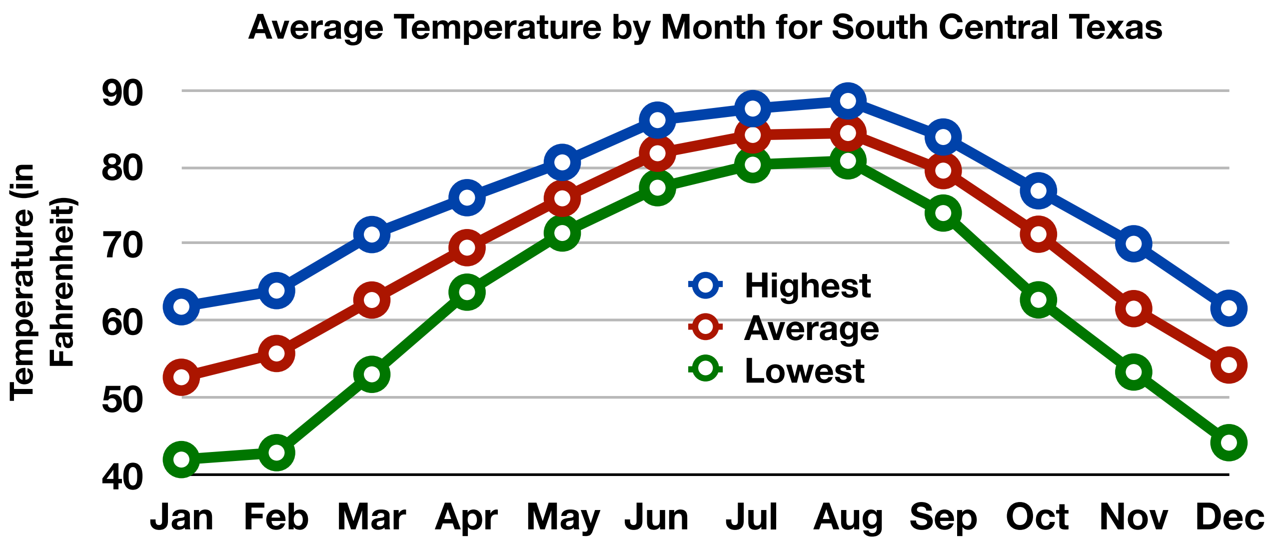
Because of its non-stop dry conditions combined with a period of PDSI less than -4, ***June 1915 to September 1918 comes in second for the drought-of-record for south-central Texas***.

Table 7: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting South-Central Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
January 1909 - December 1911	36 (of 36 months)	4 consecutive	–4.91
June 1915 - September 1918	39 (of 40 months)	20 consecutive	–6.16
January 1951 - February 1957	74 (of 74 months)	32 consecutive plus 4 other	–6.67
February 1962 - December 1964	35 (of 35 months)	7 consecutive	–5.04
December 2010 - December 2012*	24 (of 25 months)	7 consecutive	–5.75

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for south-central Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 28. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during July and August (top of Figure 28).



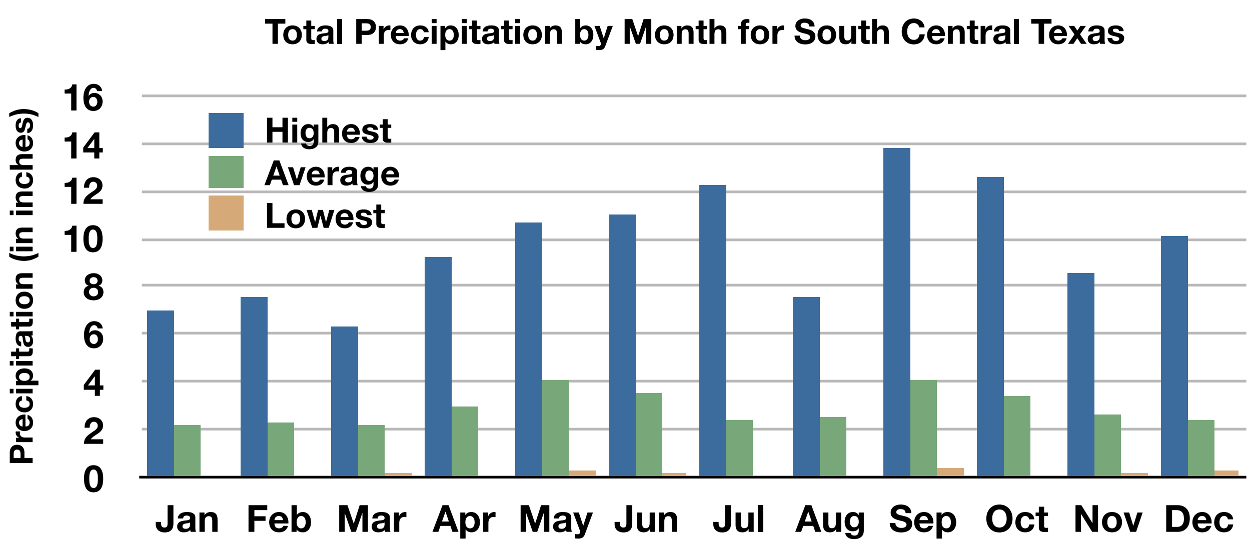


***Figure 28**. Top graph: The monthly average temperature (in degrees Fahrenheit) across south-central Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. Bottom graph: The average total precipitation (in inches) by month across south-central Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during February, July, and August] The three peaks of precipitation, first in July, then in September, and finally in December, are clearly visible.*

South-central Texas has experienced long and extreme droughts in its past. Figure 29 displays the departure from normal precipitation, and Palmer Drought Severity Index for south-central Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 27.

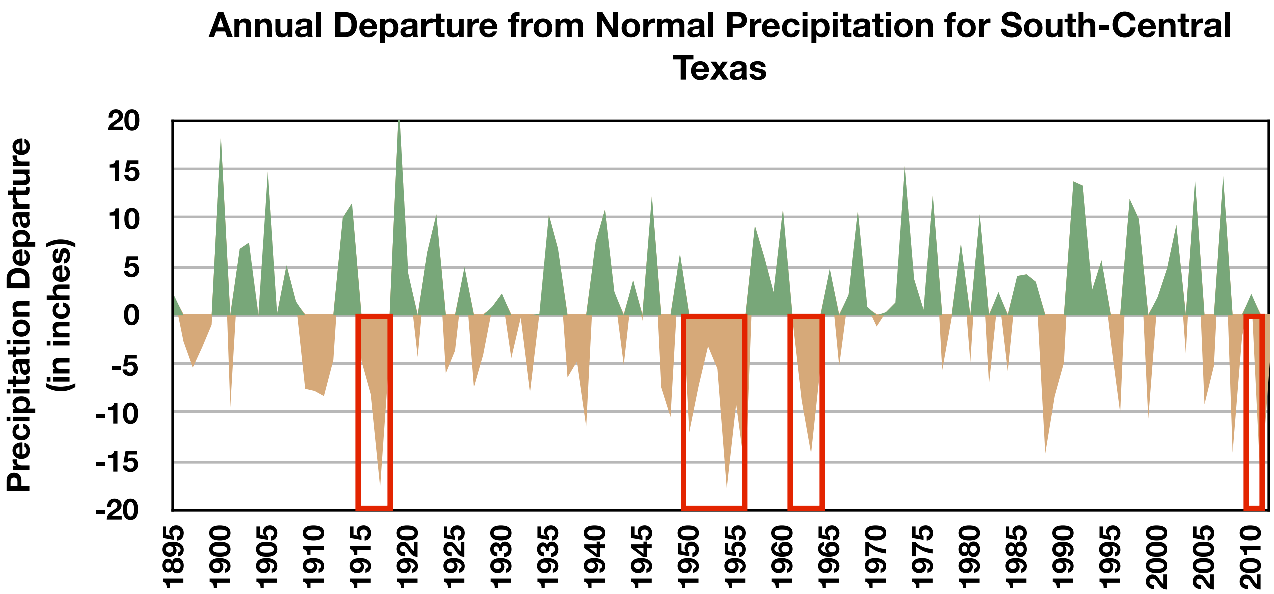


Figure 29a. *Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for south-central Texas from 1895 to 2012.*

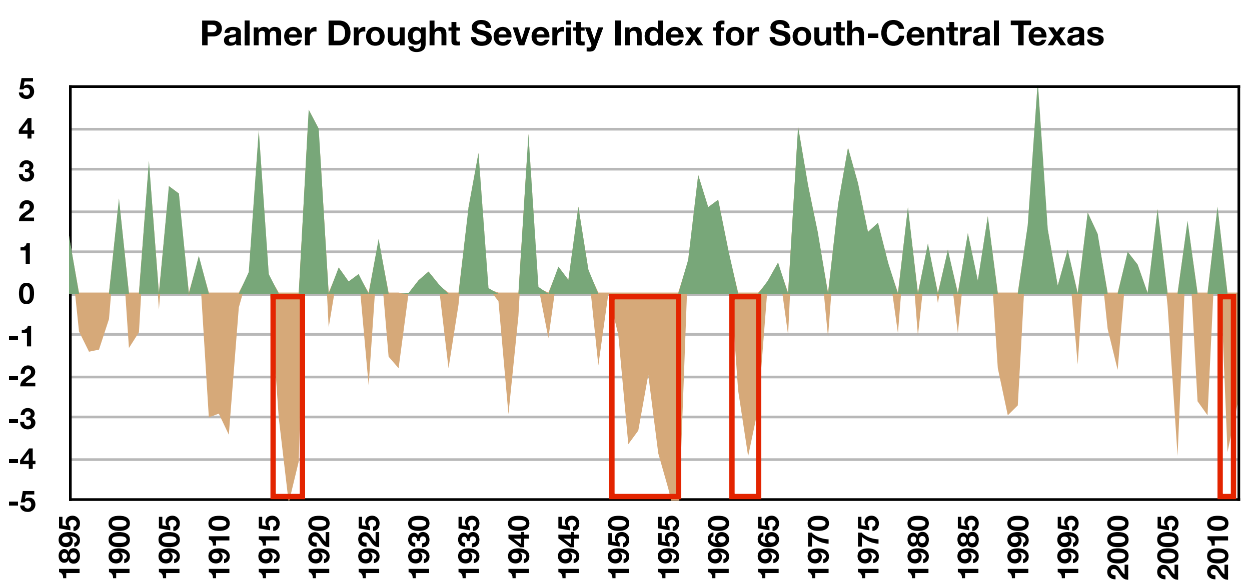


Figure 29b. *Palmer Drought Severity Index for south-central Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 30 we look at drought designation in the South Central Texas and see that from 2008-20010 the regions experienced extreme to exceptional conditions covering up to 100% of the region. In 2011 to 2013 the region experienced the same conditions spanning longer periods of time.

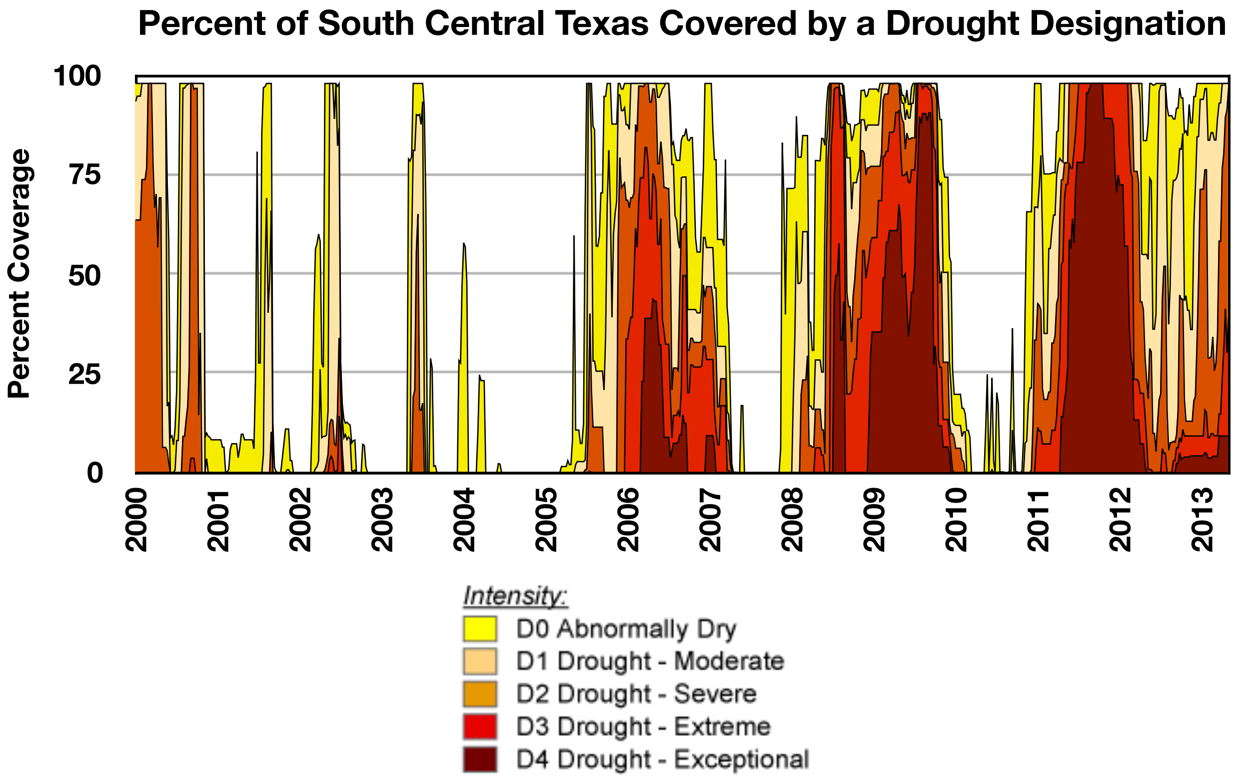


Figure 30*. Drought history for south-central Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that south-central Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the area during much of 2006, 2008 through 2009, and 2011 to present (March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 8: Upper Coast

The Upper Coast of Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 31 shows the annual temperature (top) and annual precipitation (bottom) in the Upper Coast of Texas since 1895.[9] The annual temperature for the Upper Coast of Texas averages 69.5 degrees Fahrenheit, while precipitation averages 47.67 inches. Warmer-than-average periods have spanned the late 1900s through the early 1910s, the 1920s, the 1950s, and the late 1990s through the early 2010s. Significant periods of drier-than-average conditions include the late 1910s, the 1950s, the 1960s, and the early 2010s.

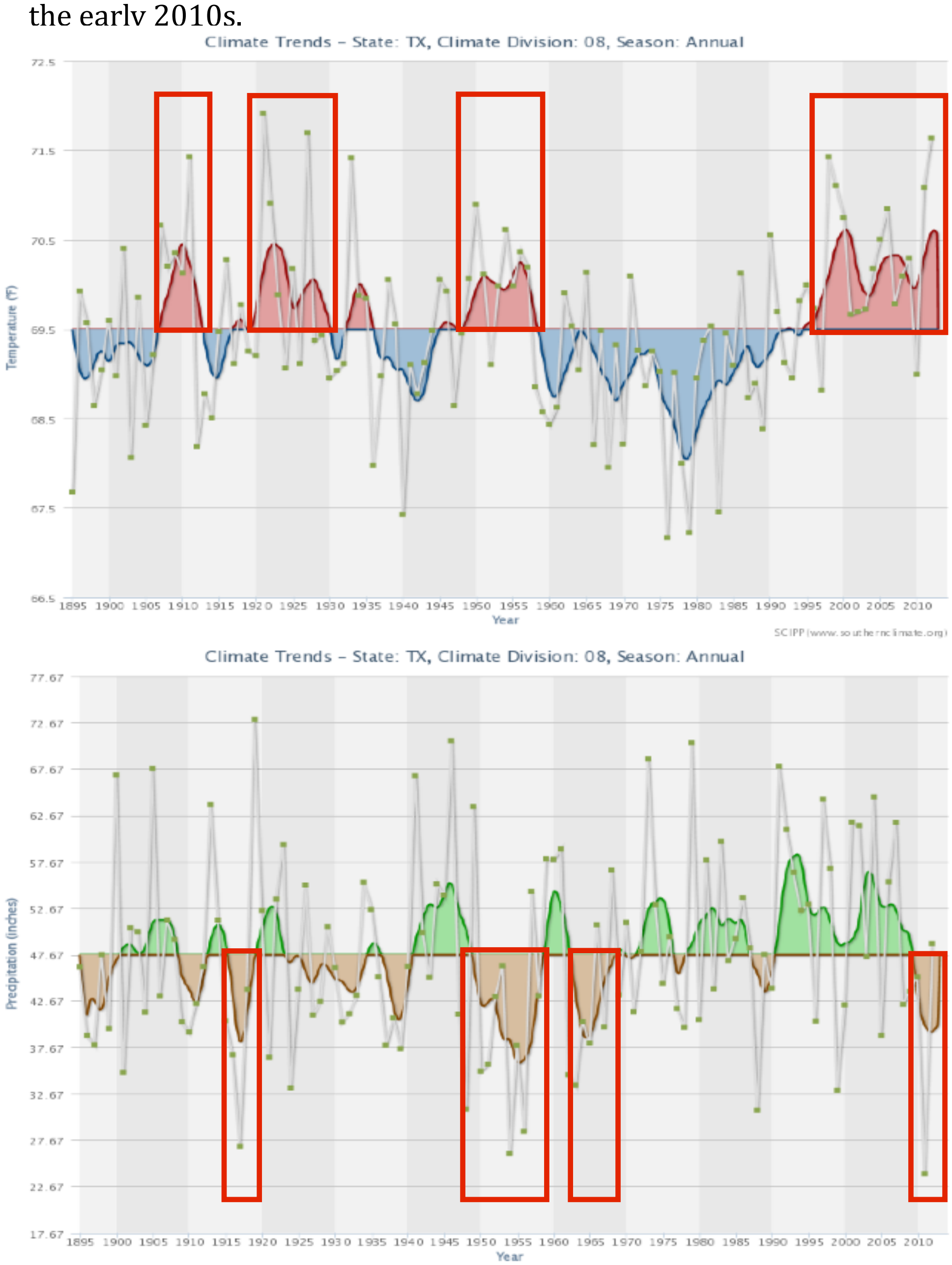


Figure 31. *The average annual temperature (<u>top graph</u>) and total annual precipitation (<u>bottom graph</u>) in the Upper Coast of Texas. from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

Options for the drought-of-record for the region include the droughts in the mid-1910s and 1950s. The period with the longest duration of PDSI less than -4 is undoubtably the mid-1910s. Table 8 compares Palmer Drought Severity Indices for these droughts and others. Using these indices, the drought of the mid-1910s well exceeds intensity of all other droughts; hence, ***the period from June 1915 to September 1918 is the drought-of-record for the Upper Coast of Texas***.

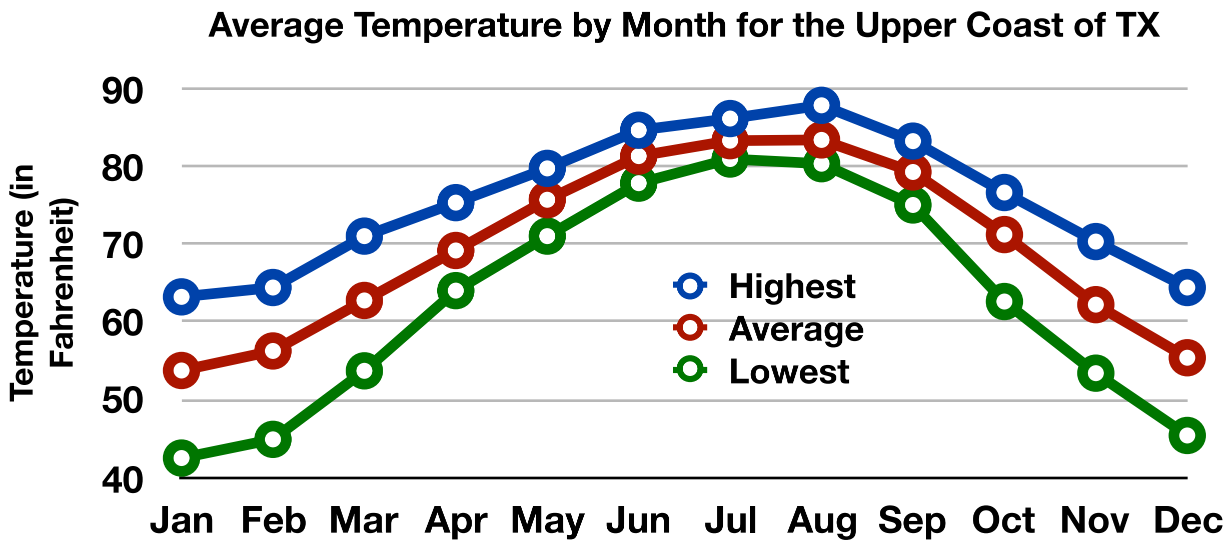
Because of its intense heat combined with non-stop dry conditions, ***October 1950 to July 1957 comes in second for the drought-of-record for the Upper Coast of Texas***.

Table 8: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting the Upper Coast of Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
June 1915 - September 1918	40 (of 40 months)	13 consecutive plus 1 other	–5.91
October 1950 - July 1957	69 (of 83 months)	10 consecutive plus 2 other	–5.45
February 1962 - November 1965	46 (of 46 months)	2	–5.09
December 2010 - December 2012*	24 (of 25 months)	7 consecutive	–5.29

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for the Upper Coast of Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 32. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during June, July and August (top of Figure 32).



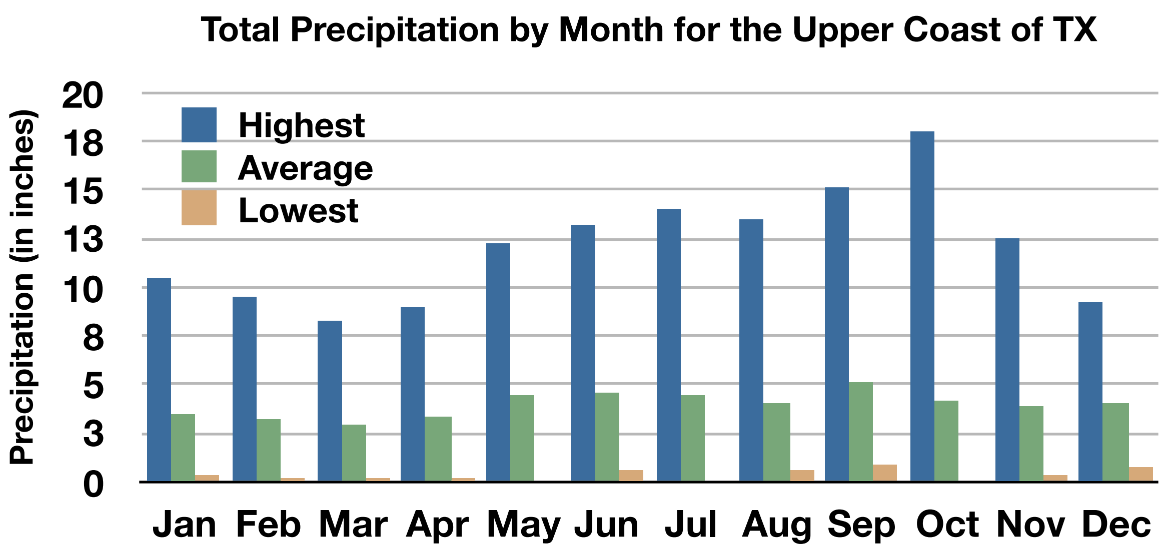


***Figure 32**. Top graph: The monthly average temperature (in degrees Fahrenheit) across the Upper Coast of Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. Bottom graph: The average total precipitation (in inches) by month across the Upper Coast of Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during July and October] The three peaks of precipitation, first in July, then in September, and finally in October, are clearly visible.*

Figure 33 displays the departure from normal precipitation, Palmer Drought Severity Index, and two-year Standardized Precipitation Index for the Upper Coast of Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 31. ***It is evident from these three drought indicators that the Upper Coast of Texas has experienced long and extreme droughts in its past***.

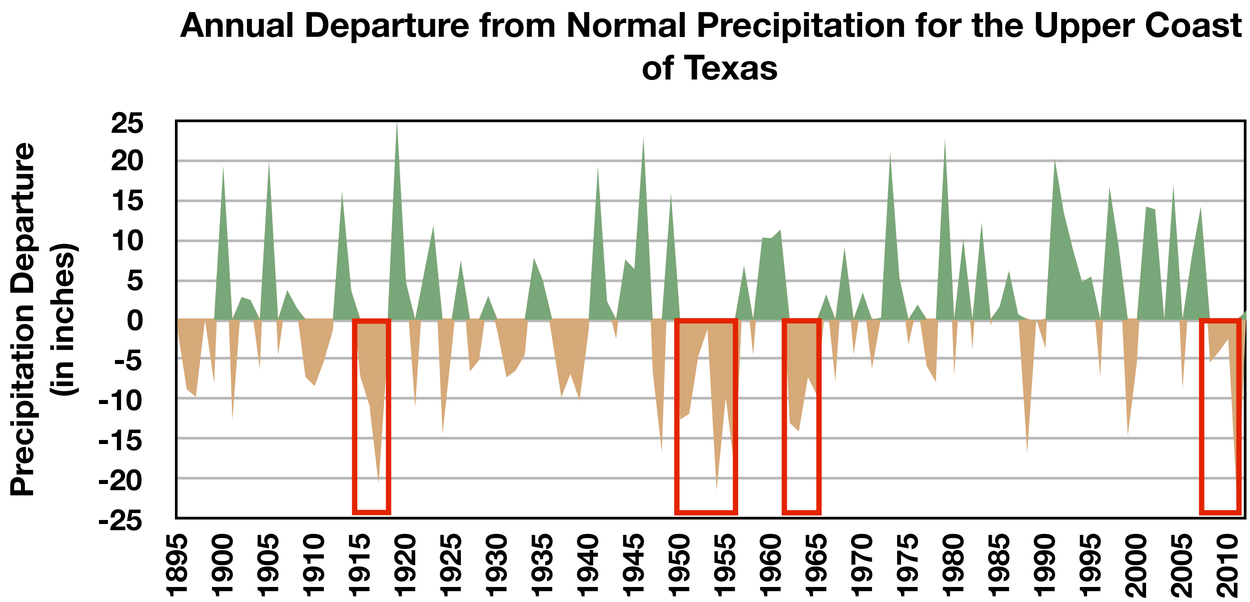


Figure 33a. *Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for the Upper Coast of Texas from 1895 to 2012.*

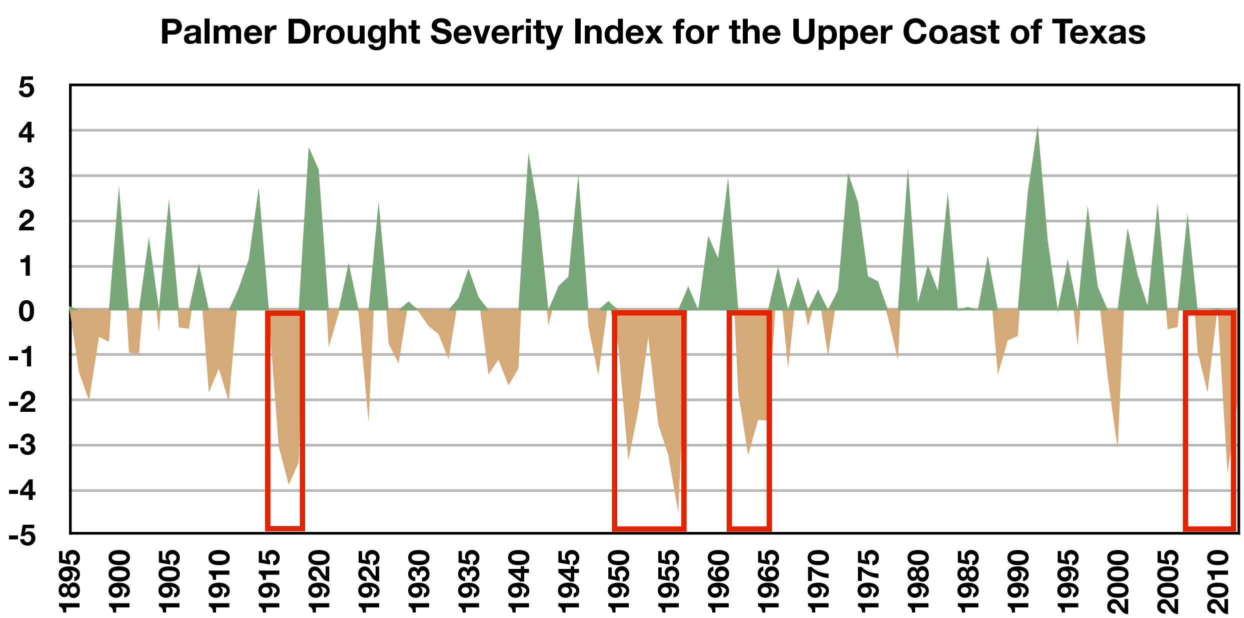


Figure 33b. *Palmer Drought Severity Index for the Upper Coast of Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 34 we look at drought designation in the upper coast of Texas and see that from 2008-2010 abnormally dry to extreme conditions covered 25-100% of the region. In 2011 to 2013 the region experienced extreme to exceptional drought also covering 50-100% of region.

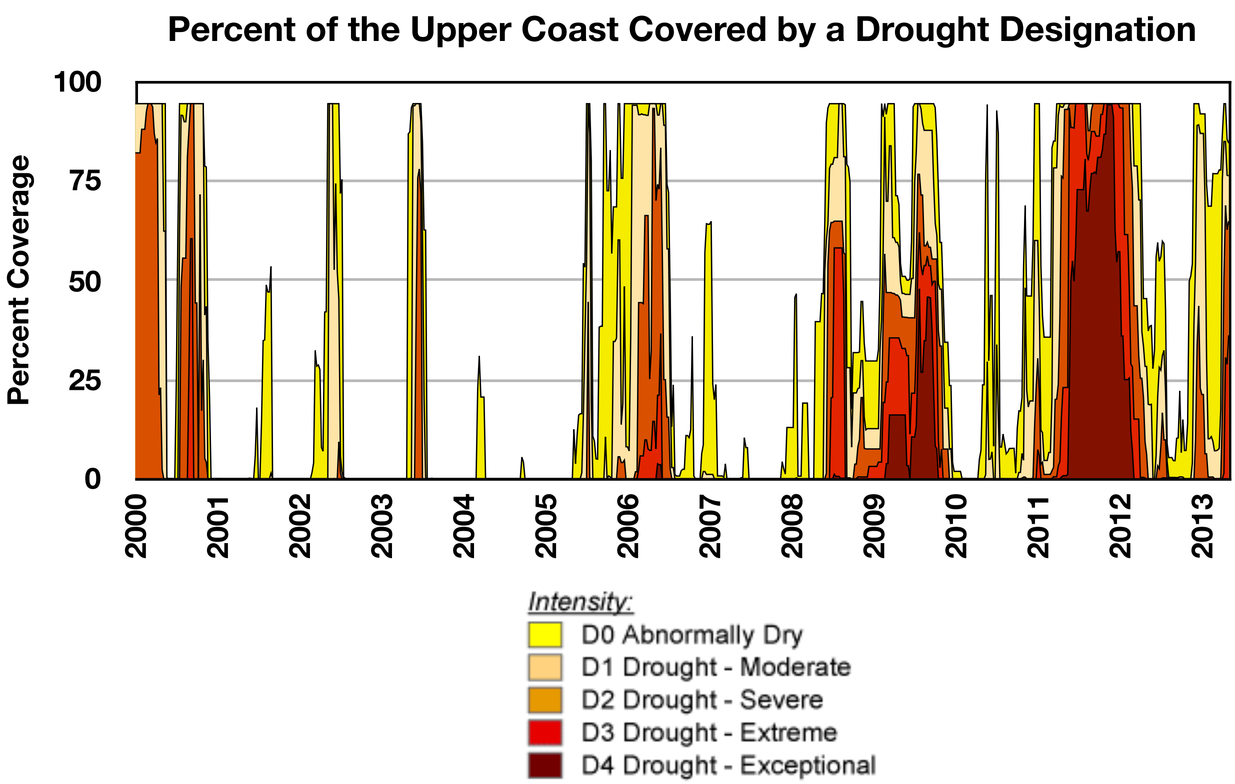


Figure 34. *Drought history for the Upper Coast of Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that the Upper Coast of Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the area during much of 2006, 2009, and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 9: South Texas

South Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 35 shows the annual temperature (top) and annual precipitation (bottom) in south Texas since 1895.[10] The annual temperature for south Texas averages 71.9 degrees Fahrenheit, while precipitation averages 23.29 inches. Warmer-than-average periods have spanned the late 1900s through the early 1910s, the late 1910s through the 1920s, the 1950s, and the mid-1990s through the early 2010s. Significant periods of drier-than-average conditions include the early 1910s, the late 1910s, the mid-1940s through the 1950s, the 1960s, and the early 2010s.

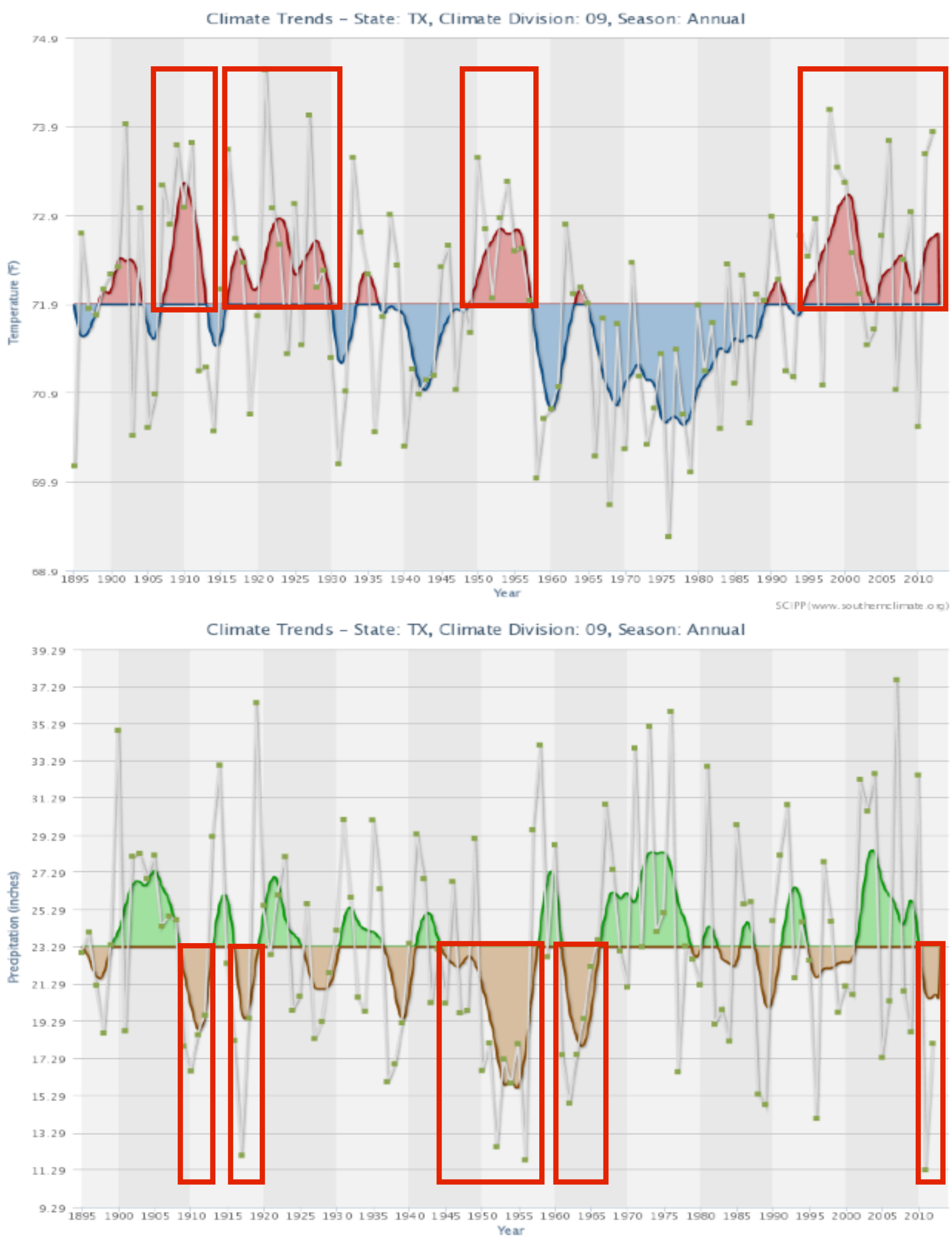


***Figure 35.** The average annual temperature (top graph) and total annual precipitation (bottom graph) in south Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation* are outlined in red boxes.

Options for the drought-of-record for the region include the droughts in the mid-1910s and the 1950s. The period with the longest duration is undoubtably the 1950s. Table 9 compares Palmer Drought Severity Indices for these droughts and others. Using these indices, the drought of the 1950s well exceeds intensity of all other droughts; hence, ***the period from February 1950 to February 1956 is the drought-of-record for south Texas.***

Because of its non-stop dry conditions combined with a period of PDSI less than -4, ***January 1916 to October 1918 comes in second for the drought-of-record for south Texas***.

Table 9: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting South Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
January 1909 - August 1913	55 (of 56 months)	0	–4.00
January 1916 - October 1918	34 (of 34 months)	8 consecutive	–4.43
February 1950 - February 1957	85 (of 85 months)	8 consecutive, 6 consecutive, plus 6 other	–4.55
October 1961 - September 1965	45 (of 48 months)	0	–3.91
December 2010 - December 2012*	24 (of 25 months)	4 consecutive	–4.88

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for south Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 36. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during June, July and August (top of Figure 36).

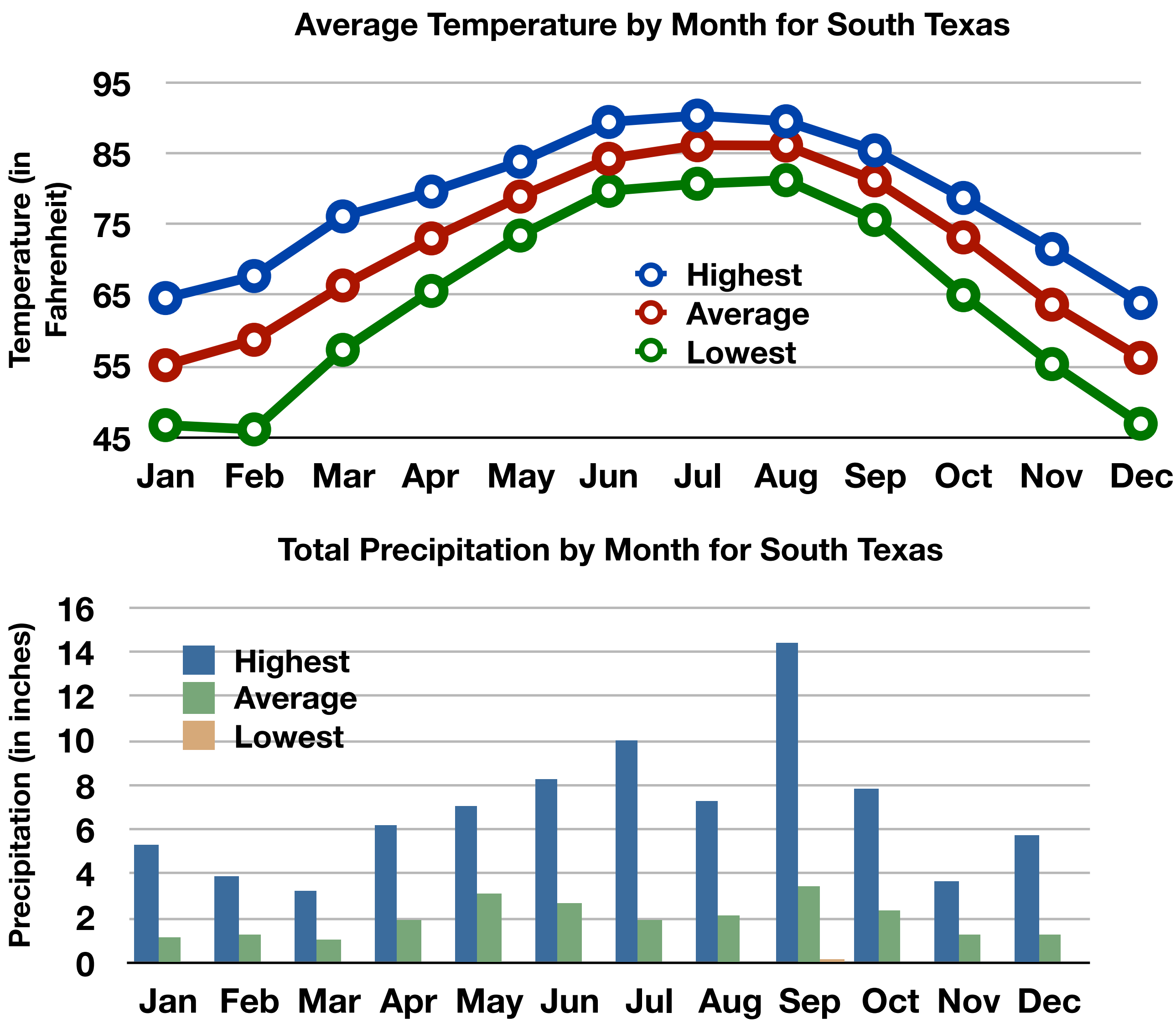


***Figure 36**. <u>Top graph</u>: The monthly average temperature (in degrees Fahrenheit) across south Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. <u>Bottom graph</u>: The average total precipitation (in inches) by month across south Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during January, February, July, August, October, November, and December] The two peaks of precipitation, first in July, then in September are clearly visible.*

South Texas has experienced long and extreme droughts in its past. Figure 37 displays the departure from normal precipitation, Palmer Drought Severity Index, and two-year Standardized Precipitation Index for south Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 35. ***It is evident from these three drought indicators that.***

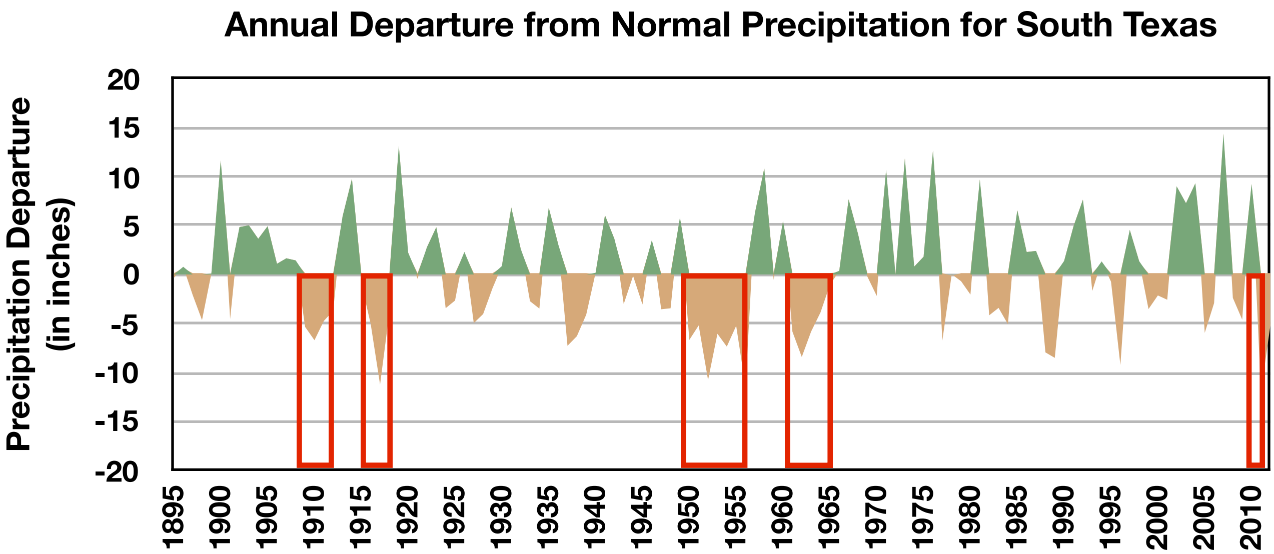


Figure 37a. Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for south Texas from 1895 to 2012.

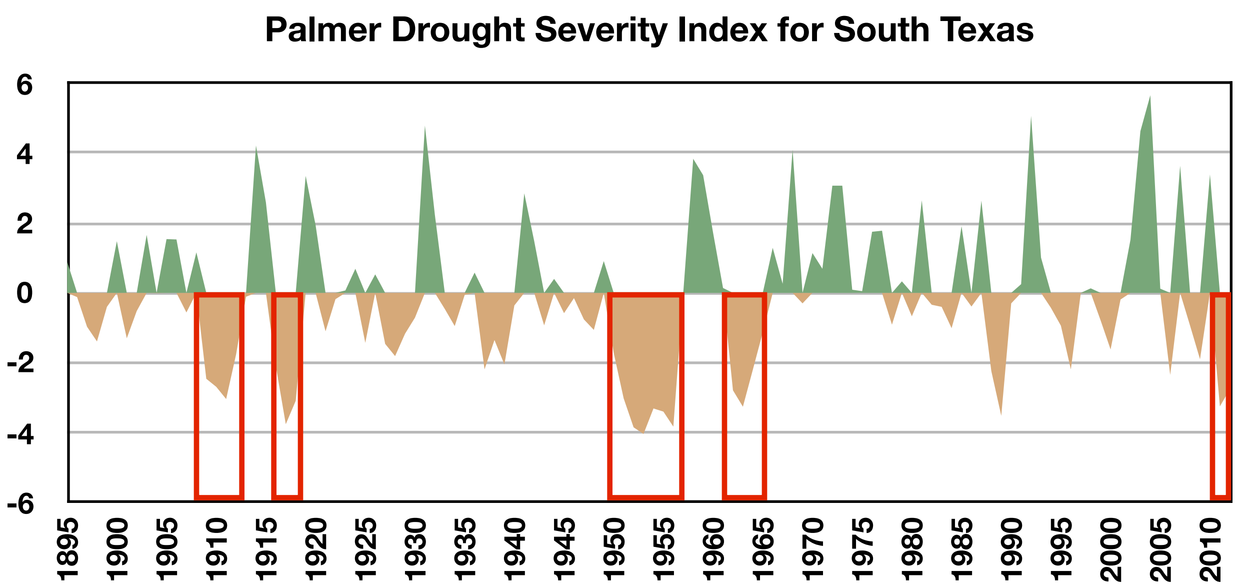


***Figure 37b**. Palmer Drought Severity Index for south Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 38 we look at drought designation in south Texas and see that abnormally dry to exceptionally dry conditions covered more than 25% of the region in 2006, 2009, and 2011.

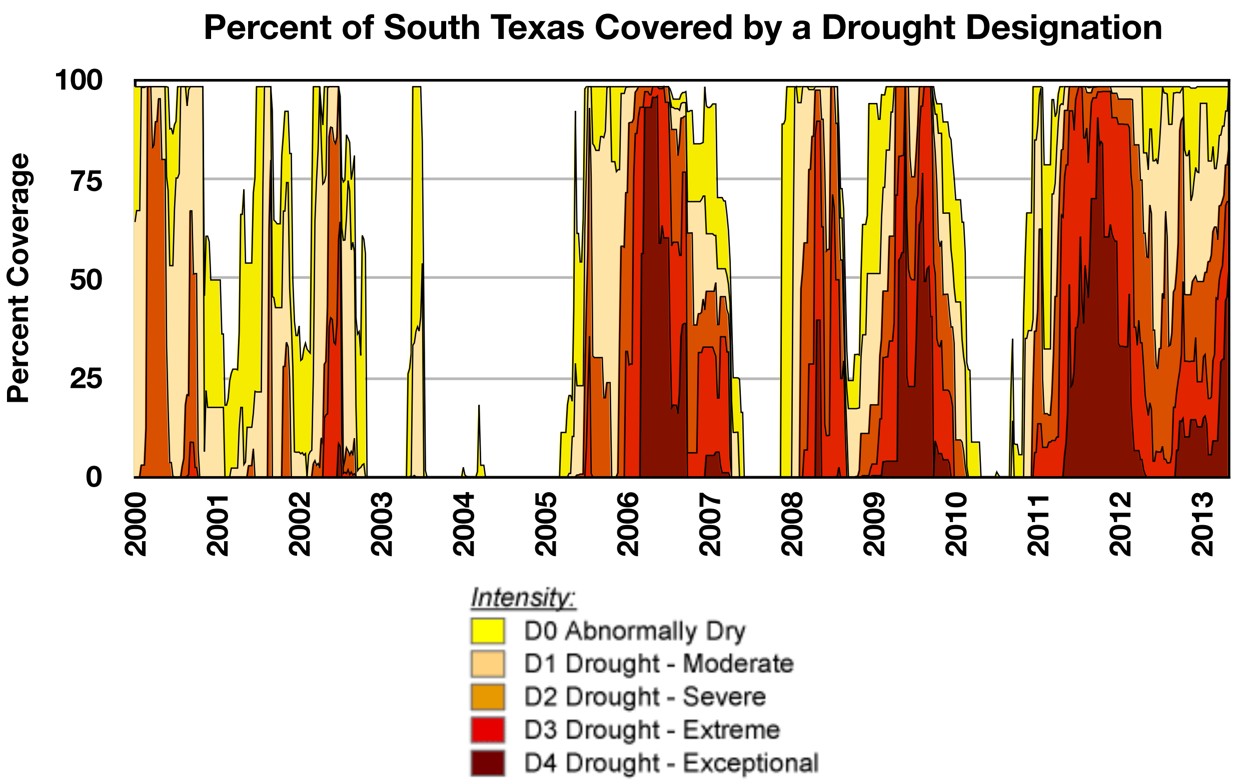


Figure 38. *Drought history for south Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that south Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the area during much of 2006, 2008 through 2009, and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Region 10: Lower Valley

The Lower Valley of Texas has experienced a wide range of temperatures and precipitation over the past several decades. Abnormally hot and dry conditions have occurred multiple times since the early 1900s. Figure 39 shows the annual temperature (top) and annual precipitation (bottom) in the Lower Valley of Texas since 1895.[11] The annual temperature for the Lower Valley of Texas averages 74.0 degrees Fahrenheit, while precipitation averages 24.86 inches. Warmer-than-average periods have spanned the late 1900s through the early 1910s, the late 1910s through the 1920s, the mid-1940s through the 1950s, and the mid-1990s through the early 2010s. Significant periods of drier-than-average conditions include the mid-1940s through the 1950s, the early 1960s through the mid-1960s, and the early 2010s.

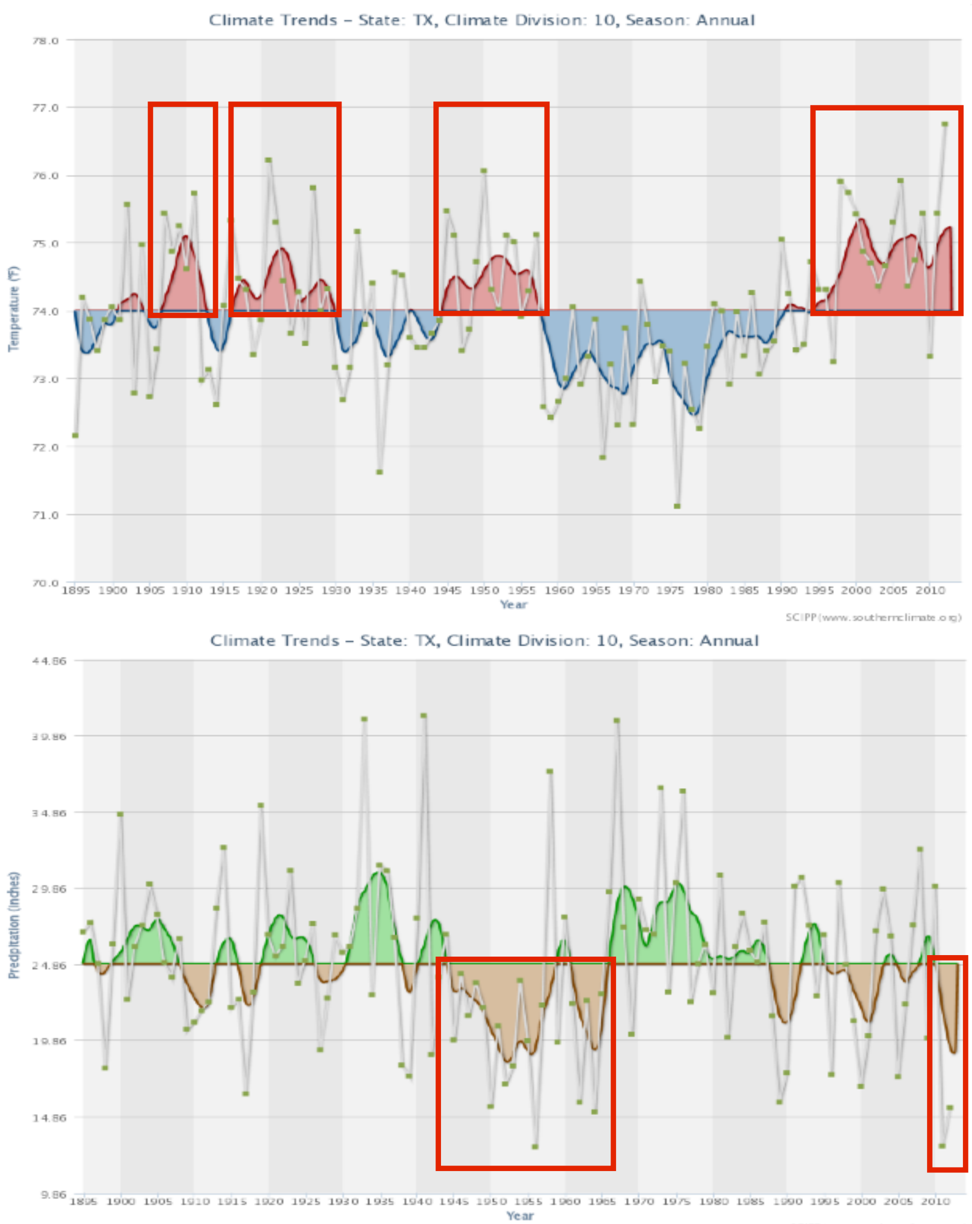


Figure 39. *The average annual temperature (top graph) and total annual precipitation (bottom graph) in the Lower Valley of Texas from 1895 to 2012. To highlight warmer, cooler, wetter, or drier periods, 5-year moving averages are shaded. On the top graph, red shading (above the horizontal line) indicates warmer periods and blue shading (below the line) notes cooler periods than average. Similarly, on the bottom graph, green shading (above the horizontal line) highlights wetter periods and brown shading (below the line) highlights drier periods than average. Extended periods of relatively warm temperatures or low precipitation are outlined in red boxes.*

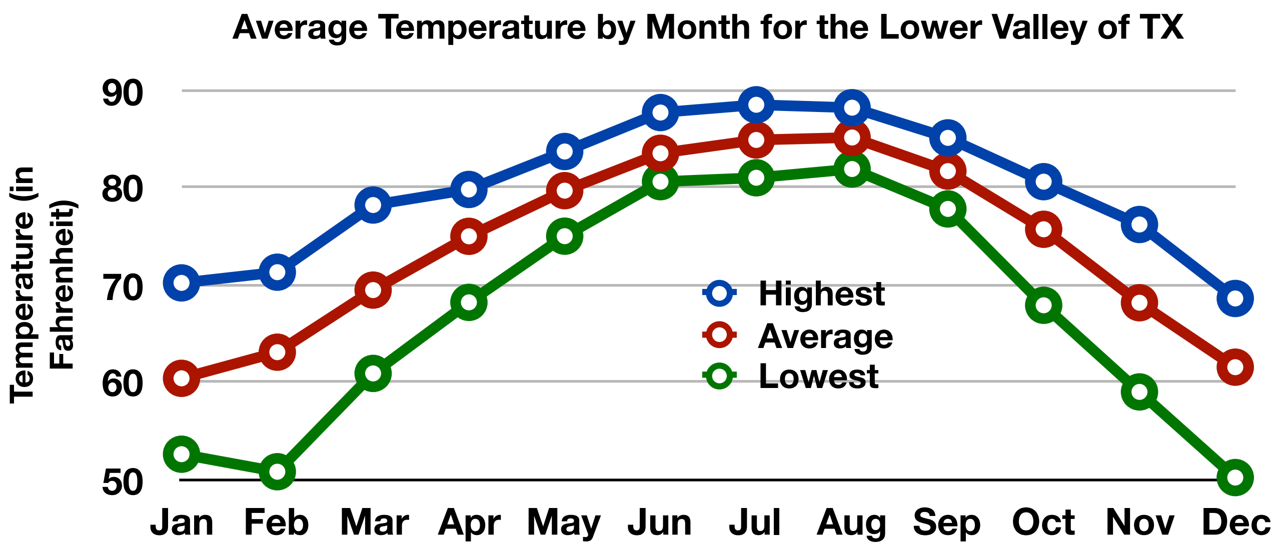
An option for the drought-of-record in the region includes the drought in the mid-1940s through the 1950s. The period with the longest duration is undoubtably this period at 152 months. Table 10 compares Palmer Drought Severity Indices for this drought and others, as well as the most recent (hence, memorable) drought of 2011 to 2012. Using these indices, the drought of the mid-1940s through the 1950s well exceeds intensity of all other droughts; hence, ***the period from March 1945 to October 1957 is the drought-of-record for the Lower Valley of Texas***.

Table 10: Comparison of Palmer Drought Severity Indices (PDSI) for Several Droughts Affecting the Lower Valley of Texas

Time Period	Months with PDSI less than –1	Months with PDSI less than –4	Lowest PDSI Value
March 1945 - October 1957	133 (of 152 months)	3 consecutive plus 2 other	–4.89
November 1999 - August 2002	34 (of 34 months)	2	–4.23
November 2010 - December 2012*	26 (of 26 months)	3 consecutive, plus 2 other	–4.43

**Note*: Data only available through December 2012; drought conditions may have continued past this date.*

To understand when there is the greatest stress on water availability for the Lower Valley of Texas, the average monthly temperature and precipitation, as well as their average highest and lowest monthly values, are shown in Figure 40. Warmer temperatures result in greater water loss by evaporation and transpiration. The warmest temperatures typically occur during June, July and August (top of Figure 40).



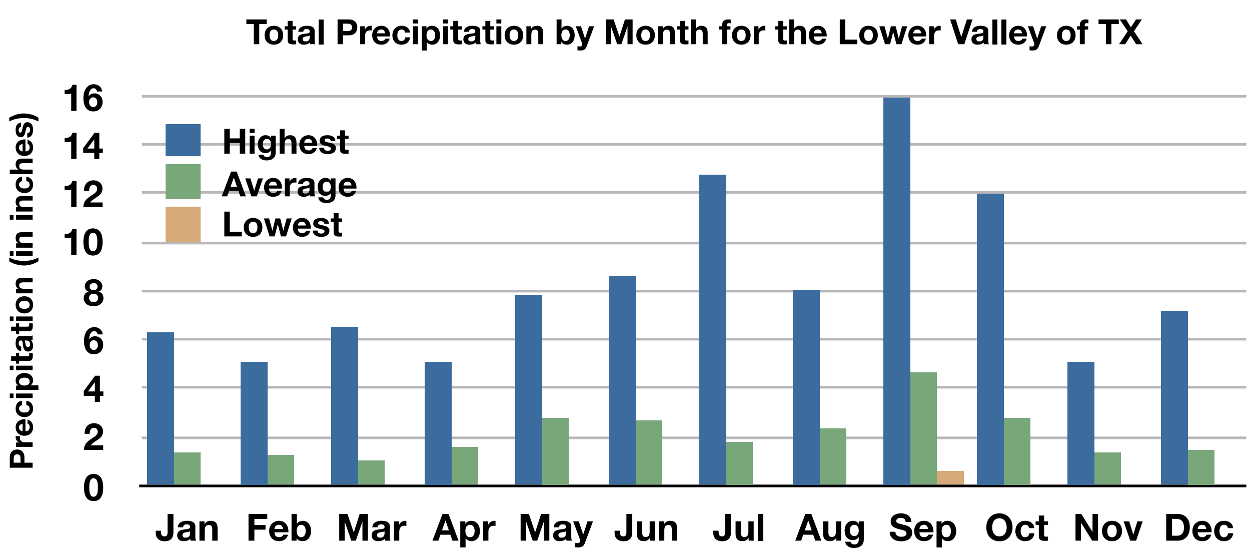


Figure 40. *<u>Top graph</u>: The monthly average temperature (in degrees Fahrenheit) across the Lower Valley of Texas using data from 1895 to 2012. The red (middle) line is the average of all climate-division average temperatures for that time period. The blue (top) line is the highest monthly average and the green (bottom) line is the lowest. <u>Bottom graph</u>: The average total precipitation (in inches) by month across the Lower Valley of Texas using data from 1895 to 2012. The blue (leftmost of each monthly cluster) bar is the highest monthly precipitation; the green (middle of the cluster) is the average precipitation total recorded for that month; the gold (rightmost) is the lowest precipitation total recorded for that month. [Note that zero precipitation has occurred at least once during April, May, July, August, October, and December] The three peaks of precipitation, first in July, then in September, then in October, are clearly visible.*

Lower Valley of Texas has experienced long and extreme droughts in its past. Figure 41 displays the departure from normal precipitation, and Palmer Drought Severity Index for the Lower Valley of Texas from 1895 to 2012. Red boxes outline the same drier-than-average periods highlighted in Figure 2.

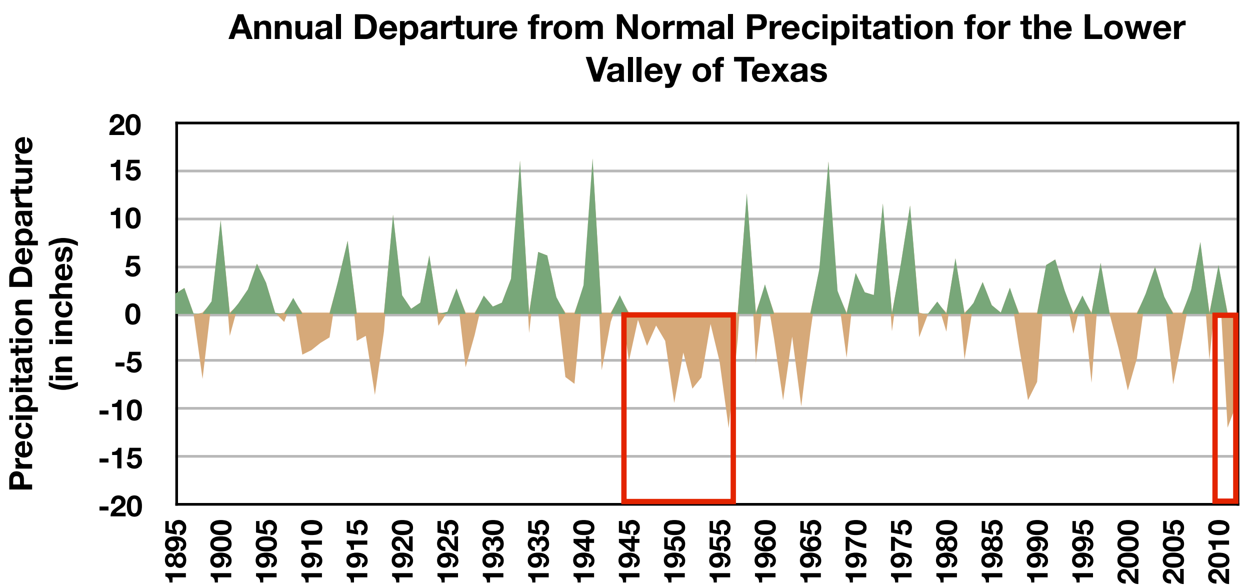


Figure 41a*. Annual departure from normal precipitation (actual precipitation total for the year subtracted from the annual normal) for the Lower Valley of Texas from 1895 to 2012.*

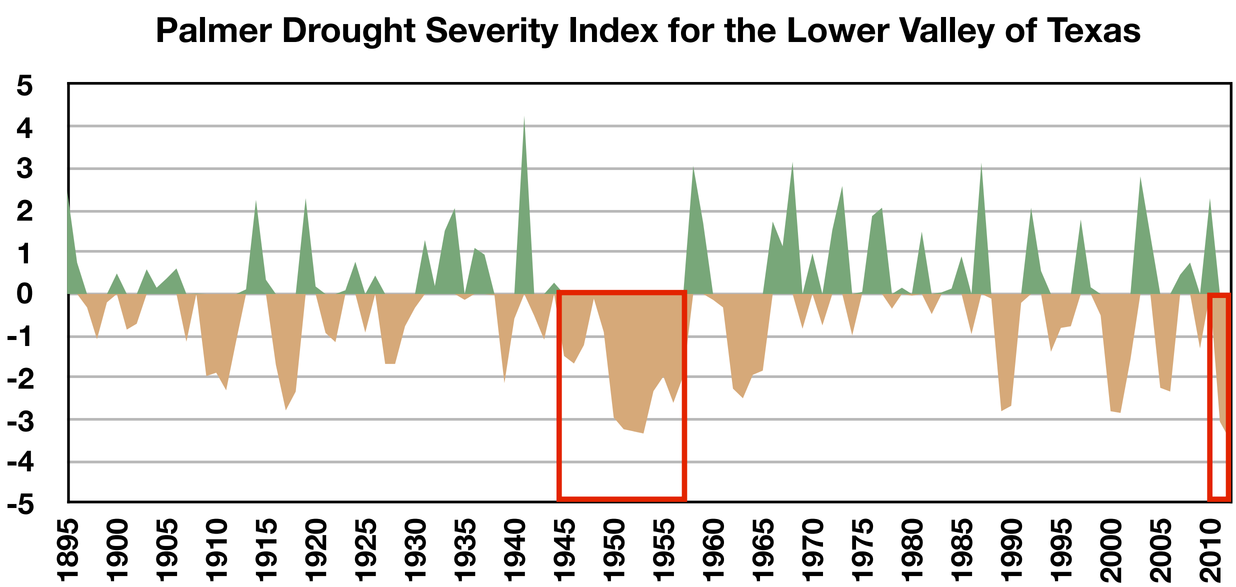


Figure 41b*. Palmer Drought Severity Index for the Lower Valley of Texas from 1895 to 2012.*

The region has experienced dry conditions from 2000 to 2013. In Figure 42 we look at drought designation in the Lower Valley region of Texas and see that from 2000-2002 moderately dry to extreme conditions covered up to 100% of the region. In 2011 to 2013 the region experienced extreme to exceptional drought covering 25 to 100% of region.

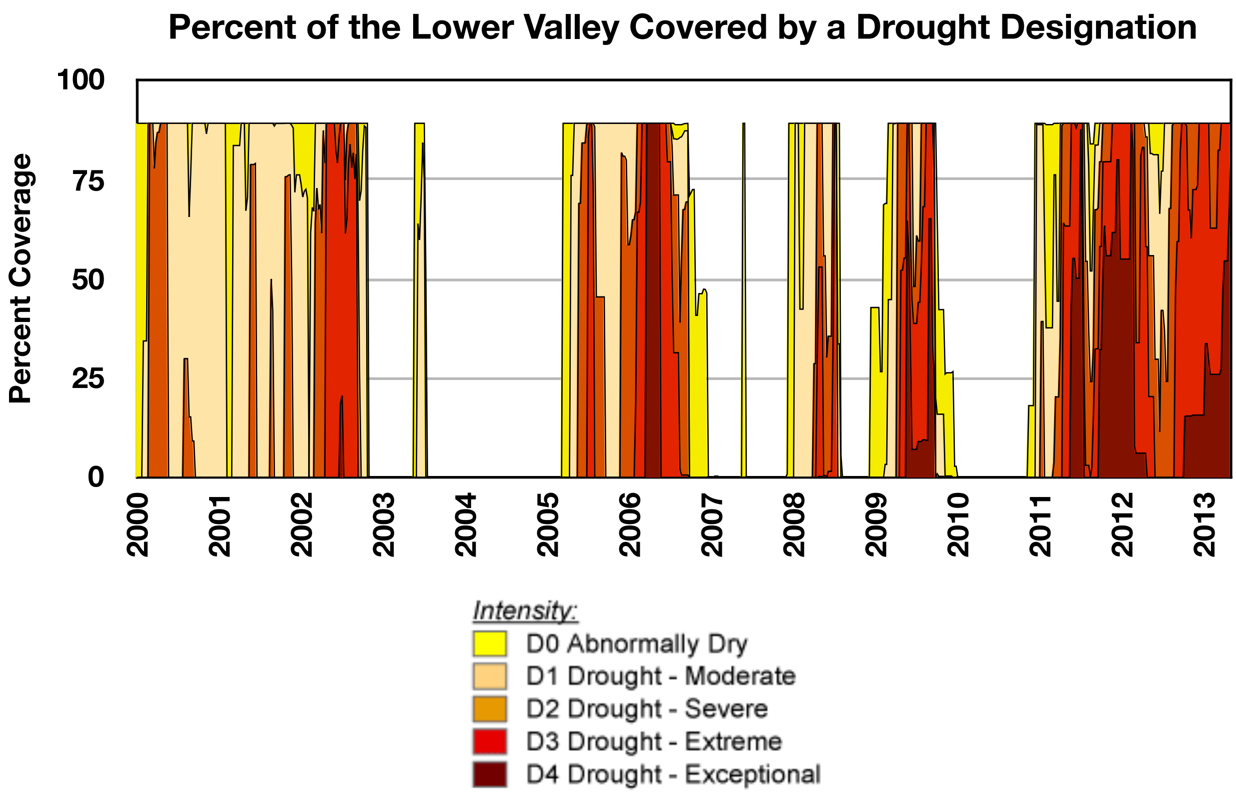


Figure 42. *Drought history for the Lower Valley of Texas as designated by the U.S. Drought Monitor. The color scale is identical to that in Figure 1. Note that the Lower Valley of Texas was experiencing extreme (bright red) to exceptional drought (dark red) across most of the area during much of 2002, 2006, 2009, and 2011 to present (data through March 2013). Data courtesy of the National Drought Mitigation Center.*

For more information on the sources of drought information, see Table 11 on page 57.

Drought Resources

There are several excellent sources of information for drought monitoring and reporting, ranging from national to local (Table 10). These resources are designed to help you pan and prepare for drought conditions in you region.

Table 11 summarizes several excellent sources of information for drought monitoring and reporting, ranging from national to local.

Table 11: Sources of Drought Information & Tools

Source	Web Address	Uses
	Major Sources of Information	
National Integrated Drought Information System	www.drought.gov	Consolidated source of drought information, monitoring & reporting tools, including many of the other sources listed below
National Drought Mitigation Center	drought.unl.edu	Consolidated source of drought information, including drought planning, monitoring reporting, risks, and impacts
State Climate Office - Texas	climatexas.tamu.edu	Consolidated source of Texas climate information
West Texas Mesonet	www.mesonet.ttu.edu/	Regional weather observing network specific to west Texas
	Specific Drought-Related Tools	
U.S. Drought Monitor: *National Drought Mitigation Center*	droughtmonitor.unl.edu/	Current and past diagnoses of drought conditions, both nearby and across the United States
Texas Drought Monitoring Website: *Office of the State Climatologist*	climatexas.tamu.edu/ index.php/drought	Current drought conditions and research on previous drought impacts within Texas
U.S. Seasonal Drought & Precipitation Outlooks: *Climate Prediction Center*	www.cpc.noaa.gov	Large-scale trends in drought across the U.S. for the next few months; Expert assessments (not forecasts) of possible changes in precipitation conditions over a range of times (6-10 days, 8-14 days, 1 month, & 3 months)

The Southern Climate Impacts Planning Program provides a drought monitoring web site at http://www.southernclimate.org/data.php. The products on this site depict changes in precipitation and temperature across the Southern United States (including Texas). Tables summarize the current precipitation totals to past years across a variety of time scales (e.g., last 30 days, last 90 days), as shown in Figure 43.

30-Day Precip For TX - Apr 27, 2013 through May 26, 2013

Climate Division	Total Rainfall	DFN	% of Normal	Driest Rank	Driest on Record	Wettest on Record	SPI	Similar Season In Last 30 yrs (Score)
CD 1	0.62	-1.72	26.6	14/122	0.00(1893)	8.16(1941)	-1.42 D2	1987(9.26)
CD 10	3.08	0.6	124	98/134	0.00(1899)	9.11(1941)	0.59	1992(8.23)
CD 2	1.33	-1.72	43.6	15/118	0.70(1984)	10.05(1957)	-1.30 D2	2008(9.45)
CD 3	3.01	-1.49	66.9	37/132	0.38(1886)	12.71(1957)	-0.52 D0	2003(9.11)
CD 4	3.87	-0.98	79.8	56/121	0.60(1886)	11.55(1953)	-0.16	2003(8.70)
CD 5	0.51	-0.55	48.3	21/117	0.00(1896)	4.51(1914)	-0.84 D0	2009(9.43)
CD 6	3.66	0.49	115.5	83/121	0.48(1998)	8.91(1914)	0.40	2003(8.90)
CD 7	4.43	0.12	102.8	85/127	0.24(1998)	10.23(1972)	0.51	1997(8.38)
CD 8	4.27	-0.31	93.2	89/143	0.00(1874)	9.60(1972)	0.36	2005(8.99)
CD 9	4.99	2.12	173.7	107/116	0.08(1998)	8.04(1941)	1.22	2004(8.61)

Figure 43*. Example of a drought monitoring product from the Southern Climate Impacts Planning Program (http://www.southernclimate.org/). This example provides an assessment of the past 30 days ending on May 26, 2013 and includes the following information: total rainfall for the period, departure (difference) from normal rainfall for the period, the percentage of normal precipitation for the period, how wet or dry the period has been compared to previous years, the precipitation amount for the driest similar period on record (and its year), and the precipitation amount for the wettest similar period on record (and its year).*

Acknowledgments

Weekly U.S. Drought Monitor data were provided by Brian Fuchs of the National Drought Mitigation Center, and climate division data were supplied by Monica Deming of the Oklahoma Climatological Survey. Texas drought photos courtesy of the San Angelo, TX National Weather Service Weather Forecast Office (http://www.srh.noaa.gov/sjt/?n=drought).

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