Chapter 10

Dry Periods and Drought Events of the Edwards Plateau, Texas

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Introduction

The purpose of this chapter is to describe dry periods that have occurred and to identify possible drought events in the Edwards Plateau physiographic province and the Edwards Plateau climatic division. Several approaches are used that will identify dry periods.

A climatic division represents a region within a state that is generally climatically homogeneous. It is used by the National Oceanic and Atmospheric Administration to report climatic data such as drought indices (NCDC, 1983) The Edwards Plateau climatic division encompasses the eastern portion of the Edwards Plateau physiographic province, excluding the Stockton Plateau. The climatic division includes the Central Texas Uplift. The 28 counties included in this division are Bandera, Blanco, Burnet, Coke, Concho, Crockett, Edwards, Gillespie, Irion, Kendall, Kerr, Kimble, Kinney, Lampasas, Llano, McCulloch, Mason, Menard, Reagan, Real, San Saba, Schleicher, Sterling, Sutton, Tom Green, Upton, Uvalde, and Val Verde (Figure 10-1).

The Edwards Plateau is a high limestone plain in southwest Texas that covers about 23.1 million acres that merges with the High Plains on the northwest and merges with the Low Rolling Plains to the north. Valley floors range from 800 to 1,500 feet lower than the surrounding divides, and the hills and plateaus range in elevation form 1,300 to 4,000 feet

Today, the average annual precipitation varies from 14 to 35 inches and is mostly rainfall. About three-quarters of the rainfall comes during the growing season (Greiner, 1982). The average annual temperature varies from 57 to 70 ˚F with summer temperature reaching around 100 ˚F.

According to the Thornwaite (1931) climate classification, the Edwards Plateau is a meso-thermal, semiarid to arid climate. The vegetation classification is a forest/steppe to steppe region (Budyko, 1974). These classifications indicate a semiarid to arid climate, and therefore the region is “dry”.

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“Dry” is characterized by little or no rain, such as a “dry climate,” or being marked by the absence of natural or normal moisture, such as “a dry month” (Houghton Mifflin, 2002). The second definition represents a long period of abnormally low rainfall, especially one that adversely affects growing or living conditions.

Most drought studies have not defined drought sufficiently and have used inconsistent methods of analysis. The first step should be defining drought. However, most scientists have used general definitions of drought (Hisdal and Tallaksen, 2000).

One general definition suggested by Beran and Rodier (1985) is “The chief characteristic of drought is a decrease of [normal] water availability in a particular period”. This formalization represents the dryness in a physical drought that occurs due to a lack of rain, soil moisture, streamflow, or recharge depending on the part of the hydrological cycle under evaluation.

The scope of this investigation is to present an analysis and description of the physical droughts and dry periods that have occurred in the Edwards Plateau region from various viewpoints of dryness and drought.

Precipitation

One technique to analyze dryness is to look at the inputs to the hydrological cycle, and precipitation is the primary input to this cycle. The amount of precipitation determines regional characteristics, such as what crops can be grown.

Precipitation can be analyzed by plotting the distribution of rainfall for a daily, monthly, or yearly pattern. From this pattern a "normal" range for a region can be determined. Based on a method by the Joint Agricultural Weather Facility (USDA, 1987), "Normal precipitation" is here defined as the range of values between the 30th and 70th percentile for each station record that was evaluated. Values above the 70th percentile indicate wet years and values below the 30th percentile indicate dry years. To determine precipitation patterns for the region, five weather stations with long -term records were selected that lie within the Edwards Plateau. The selected stations are Menard (Menard County), San Angelo (Tom Green County), Sanderson (Terrell County), Harper (Gillespie County), and Blanco (Blanco County) (Figure 10-1; NCDC, 2003a). Selection of these stations is because of the good records that span most of the 20th Century. Missing data were filled in with one-degree quadrangle precipitation data developed by the TWDB Surface Water Division (TWDB, 2003).

The stations reflect the variability of the precipitation pattern over the vast Edwards Plateau region. Because of this variability in precipitation from station to station across the region, a threshold was set at the 30th percentile position in the rainfall distribution to represent the point where “dryness” occurs in a serious condition that might be the start of a drought event.

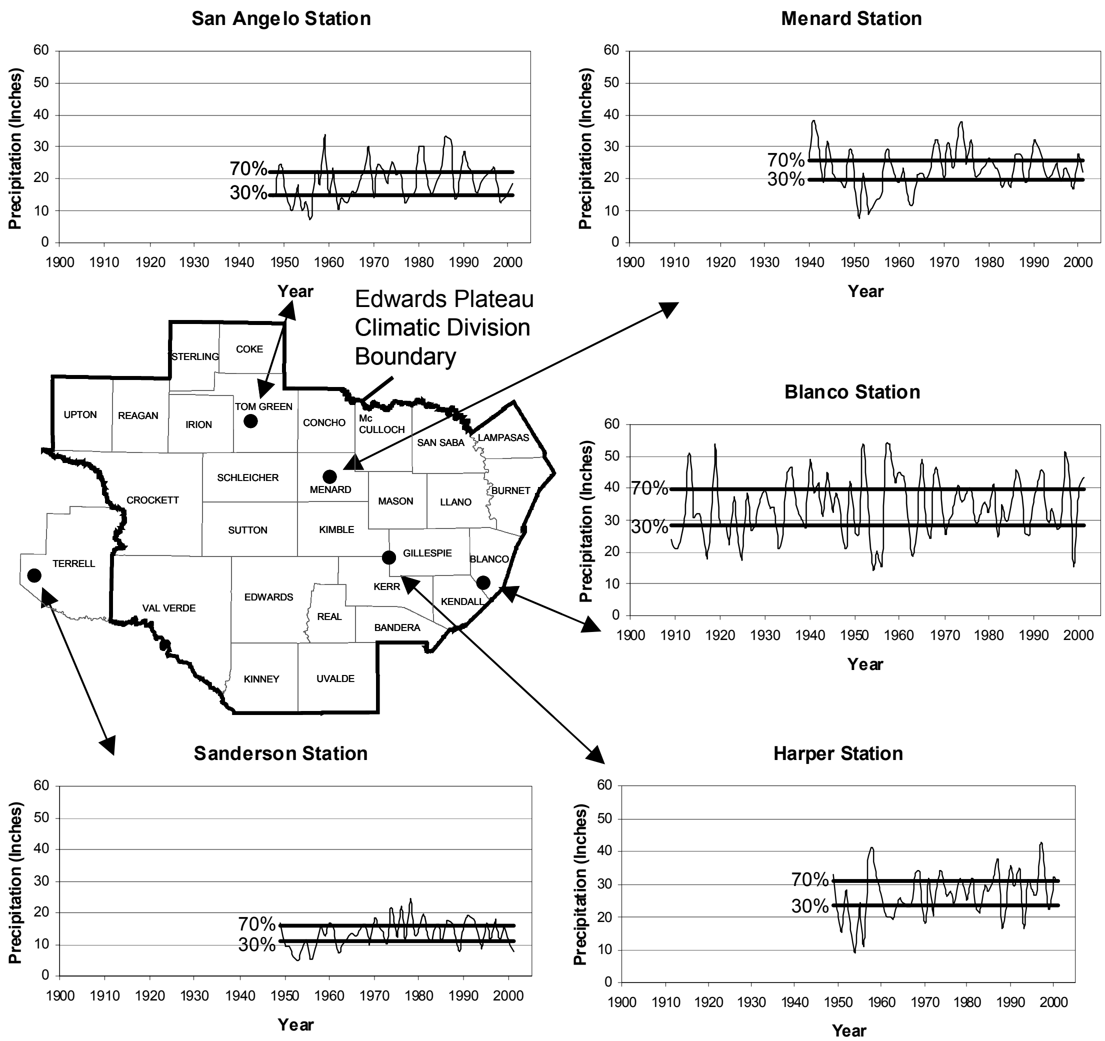

Figure 10-1: The Edwards Plateau Climatic Division and precipitation stations of the Edwards Plateau area (NCDC 1983; NCDC, 2003a).

The dryness threshold (30th percentile) value for each station is listed in Table 10-1. Severe precipitation shortages occurred at all of the stations in the 1950s (Figure 10-1). Several short-term shortages occurred throughout each record, typically lasting about two years.

Table 10-2 shows the number of years that each station was below this threshold between the years 1950-1959.

According to Table 10-2, the "drought-of-record" was not uniform in its distribution on the Edwards Plateau. The number of years below the dryness threshold varies, and the total impact is the period is generally dryer from east to west. The use of precipitation

Table 10-1: Precipitation station statistics for the period of record

Station	Central Average (Inches)	Tendency Median (Inches)	70^{th} Percentile (Inches)	30^{th} Percentile (Inches)
Blanco	33.81	32.76	39.67	28.50
Harper	26.80	27.76	31.20	23.45
Menard	22.95	22.07	25.50	19.88
San Angelo	19.19	18.35	22.89	14.83
Sanderson	13.41	13.13	15.84	11.13

Table 10-2: Years of above and below 30^{th} percentile precipitation point between 1950 and 1959

Station	Years Below 30^{th} Percentile	Years Above 30^{th} Percentile	Comment
Blanco	4	6	3 dry yrs in a row
Harper	5	5	2 dry yrs in a row
Menard	5	5	4 dry yrs in a row
San Angelo	5	5	3 dry yrs in a row
Sanderson	8	2	8 dry yrs in a row

as a drought measurement is not perfect. However, it is a good indicator of the presence of drought conditions.

Historical Droughts

After the drought events of the 1950s, the Texas Board of Water Engineers published Bulletin 5914, “A Study of Droughts in Texas” by Lowry (1959). The author described nine drought events between 1889 and 1957 on the Edwards Plateau. Moreover, the most severe episode occurring on the plateau occurs with the combination of last two droughts of 1950 to 1952 and 1954 to 1956.

The events were determined by plotting the average annual rainfall deficiency expressed as a percentage of the long-term mean rainfall. Here is a summary of these events.

1891-1893

This event affected the southeastern portion of the Edwards Plateau Region. It encompassed an area bounded on the southwest by eastern Val Verde County and Kinney County and extended up to McCulloch and San Saba counties.

1896-1899

Drought conditions affected most of Kinney County and the western half of Uvalde County. It also affected portions of northern Pecos County.

1909-1912

This episode affected the entire region, with more severe conditions described in all or part of Andrews, Martin, Howard, Ector, Midland, Glascock, Sterling, Coke, Tom Green, Irion, Regan, and Upton counties.

1916-1918

This event affected the entire region with less severe conditions noted for Uvalde, Real, and Bandera counties.

1924-1925

This event affected the eastern portions of the Edwards Plateau and extended roughly from McCulloch County on the north, out west to Regan County, and to Kinney County to the south.

1933-1934

This event affected the entire Edwards Plateau region. This particular drought event represents the eastern extension of one of the most severe droughts known as the "Dust Bowl" era.

1937-1939

This event affected the southeastern plateau region south of a line from Terrell County to Bandera County.

1950-1952

This event affected the entire region with less severe conditions, with the most severe conditions occurring in Sutton, Kimble, and northern Edwards counties.

1954-1956

This is the most severe drought event recorded for the Edwards Plateau. It affected the entire region and was more severe in the north-central plateau region. The eastern parts of the region recorded a cumulative rainfall deficit of more than 20 inches over the three-year period.

Water Balance over a Region

Precipitation is only part of the hydrological cycle. The hydrological cycle can be described by a basic equation in which storage equals inputs minus outputs for a control area. Examples of inputs are precipitation and stream flow into an area. Outputs can be stream flow out of the area, evaporation, transpiration of plants, and drainage to aquifers.

Here is a simple example of this type of equation:

$$\Delta s/\Delta t = p(t) - q(t) - e(t)$$

where:
s = storage,
t = time,

p = precipitation,
q = discharge, and
e = evaporation.

The time interval used can be any unit. Generally, time measurements equal to or greater than a year are preferable. Additionally, the input and output data should be averaged over the same period. This will allow the storage variable to equal to zero. The evaluation of dryness of an area is possible with this equation.

The most commonly used drought index is based on a water-balance technique that uses a ratio of demand to supply.

Palmer Drought Severity Index

Discussions about agricultural, meteorological, or hydrological drought typically look at various parts of the hydrological cycle. A misconception is that a particular drought index is the only means to define a drought event. A drought index is often a single number characterizing the general dryness conditions at a measurement site.

A drought event is a definition that is applied to select events in a time series to demonstrate the beginning and end of droughts. The most frequently applied quantitative definition of a drought is based on defining a threshold below which a measurement is considered being in a "drought" range (Hisdal and Tallaksen, 2000).

The Palmer Drought Severity Index (PDSI), which is one of three deviated indices using Palmer's base index to calculate drought, is used by federal, state, and local agencies to monitor drought conditions. Palmer's base index uses the ratio demand over supply as the main concepts used in the water-balance equation. This approach takes into account more than just the precipitation deficit at specific locations (Palmer, 1965). This index was to present measurements of moisture conditions that were consistent so comparisons between different months and locations can be made (Palmer 1965). The PDSI uses the deviation from the small center condition (-0.49 to 0.49) as its threshold point.

The Palmer Drought Severity Index is the most used drought index in the United States. In Texas, it is the standard "Drought Index" for determining dry or drought conditions. However, due to the spatial extent the PDSI is calculated, the index is not suitable for determining local drought conditions.

The Palmer Index series ranges roughly from -6.0 to +6.0. The base index of the Palmer Index series is called the "Z" index, which is assumed to represents moisture conditions. The Palmer selected the classification scale of moisture conditions based on study areas in Iowa, Kansas, and Texas (Palmer, 1965).

The Long-Term PDSI has been calculated for the entire United States from 1895 to the present (NCDC, 2003b). The PDSI used is for the Edwards Plateau NOAA Climatic Division. The monthly values are graphed as 20-year periods, starting with 1900 (Figure 10-2).

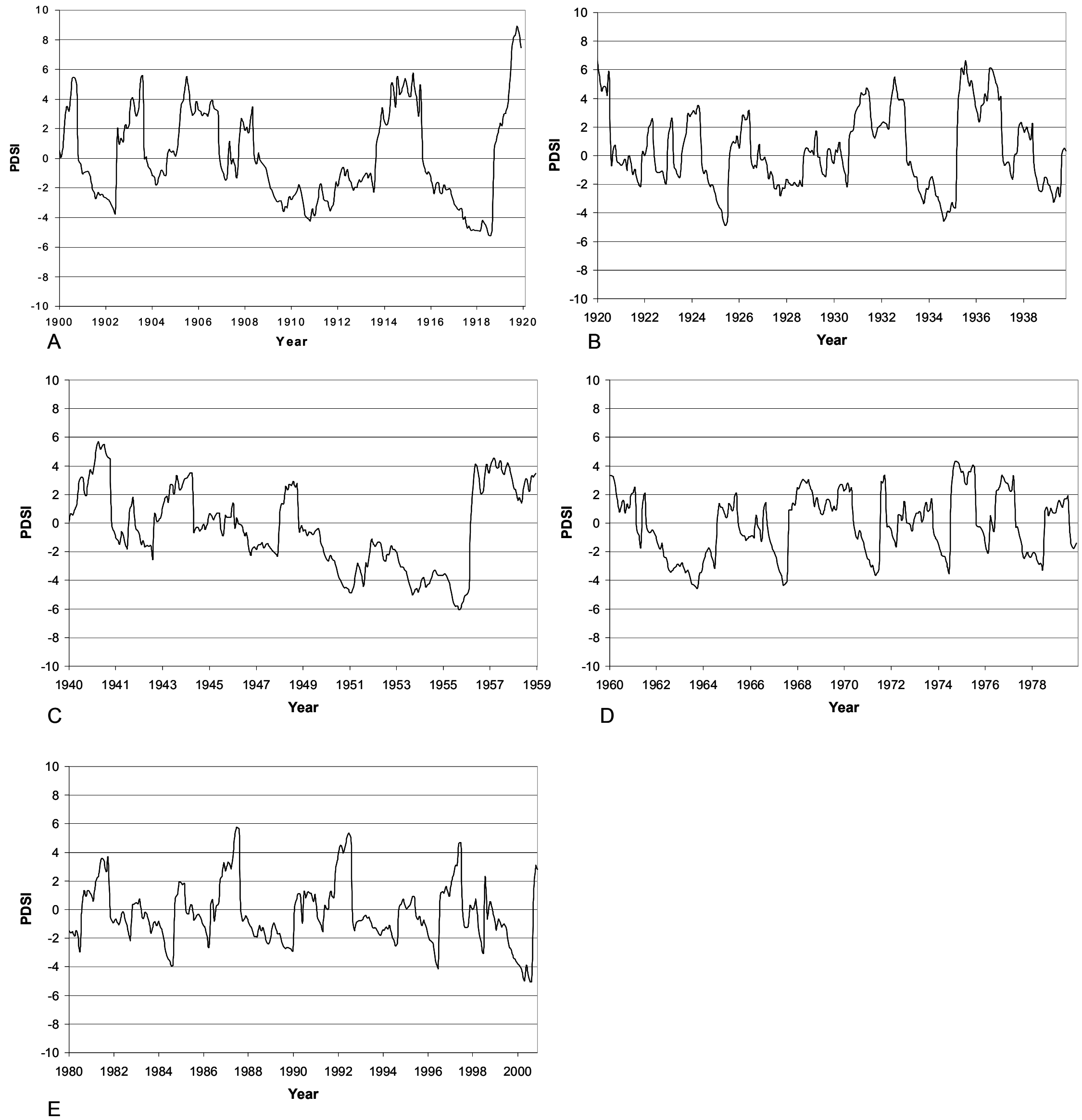

Figure 10-2: The Long-Term Palmer Drought Severity Index, 1900 to 2002 (data from NCDC, 2003b).

For the analysis of the PDSI, the ranges are from the Texas Drought Preparedness Council's (DPC) drought evaluation process (Texas Drought Preparedness Council, 2001). The PDSI classification, drought evaluation process ranges, and associated stage descriptions are in Table 10-3.

The DPC stages are used as the threshold for each dry period identified from the PDSI data. Events shorter than six months in duration were not used to eliminate short periods

Table 10-3: Classifications of the Palmer Drought Severity Index and Texas Drought Preparedness Council drought evaluation process.

Palmer Classifications		DPC Classifications			
Range	Description	Range	Description	Stage	Stage No.
4.00 or more	Extremely Wet				
3.00 to 3.99	Very Wet				
2.00 to 2.99	Moderately Wet				
1.00 to 1.99	Slightly Wet				
0.50 to 0.99	Incipient Wet Spell				
0.49 to -0.49	Near Normal				
-0.50 to -0.99	Incipient Dry Spell				
-1.00 to -1.99	Mild Drought	-1.00 to -1.99	Abnormally Dry	Advisory	1
-2.00 to -2.99	Moderate Drought	-2.00 to -2.99	First-Stage Drought	Watch	2
-3.00 to -3.99	Severe Drought	-3.00 to -3.99	Severe Drought	Warning	3
-4.00 or less	Extreme Drought	-4.00 to -4.99	Extreme Drought	Emergency	4
		-5.00 or less	Exceptional Drought	Disaster	5

of dryness that are a normal pattern for Texas. Based on this classification, twenty-four dry periods are identified (Table 10-4).

The periods range in duration from 6 to 77 months with the median event lasting 13 months. Generally, these events start and end at anytime during the year (Table 10-4).

The most severe event occurred from October 1950 to February 1957. This event had eight months in which the PDSI values were equal to or less than -5.0. These values occurred in September 1954 and in the period June through December 1956. “Severe Drought” to “Extreme Drought” conditions characterized most of the period (43 months) based on the PDSI classification. Moreover, based on the DPC stages, this event ranged from “Severe Drought” to “Exceptional Drought” conditions as classed by the DPC. The second longest period occurred between January 1909 and February 1912. This event lasted for 38 months with most of the time being in the “Moderate Drought” condition.

The second most intense event, based on duration and severity, occurred between January 1916 and September 1918 and lasted 38 months. During this event, the PDSI was below -5.0 for two months in July and August of 1918. “Extreme Drought” conditions characterized most of the period (13 months).

The most recent event occurred from May 1999 to September 2000 and lasted 17 months. For the last two months of this period, the PDSI was less than -5.00.

Table 10-4: Dry period evaluation based on DPC stage.

Period		DPC Stage Duration (months)					
Start	End	1	2	3	4	5	Total
May 1901	June 1902	1	10	3			14
January 1909	February 1912	7	18	10	3		38
July 1912	August 1913	12	2				14
January 1916	September 1918	5	8	5	13	2	33
August 1922	January 1923	6					6
August 1924	August 1925	3	4	3	3		13
May 1927	October 1928	7	11				18
June 1933	April 1935	6	6	9	2		23
September 1938	September 1939	4	8	1			13
February 1943	August 1943	6	1				7
September 1947	December 1948	12	4				16
October 1950	February 1957	11	15	22	21	8	77
January 1962	July 1964	6	8	13	4		31
November 1966	August 1967	2	3	2	3		10
November 1970	July 1971	2	3	4			9
December 1973	July 1974	3	4	1			8
August 1977	July 1978	1	10	1			12
October 1979	July 1980	8	2				10
February 1984	September 1984	2	2	4			8
February 1988	February 1989	11	2				13
April 1989	January 1990	3	7				10
August 1993	September 1994	11	3				14
December 1995	July 1996	2	3	2	1		8
May 1999	September 2000	4	2	5	4	2	17

Eight of the events (Table 10-4) do not have PDSI values that are in the "Severe Drought," "Moderate Drought," or "Extreme Drought" conditions. These events may represent minor drought events; however, the best classification for these events should be "dry periods".

Conclusions

There are many ways to view dryness in a region like the Edwards Plateau. In this discussion, precipitation and the Long-Term PDSI were used to indicate possible dry periods and drought events. Thresholds were used to show when "dryness" occurs and to indicate dry periods and drought events. Analysis of precipitation showed that, based on a 30th percentile threshold, all five stations showed significant precipitation shortages in the 1950s. The severity was not uniform across the Edwards Plateau. However, it was generally dryer from east to west during this period.

Based on the regionally extensive PDSI, the most severe event occurred from October 1950 to February 1957. "Severe Drought" to "Extreme Drought" conditions dominated the Edwards Plateau during this period. Another severe event occurred between January 1916 and September 1918 and lasted thirty-eight months. The most recent event occurred from May 1999 to September 2000. Through the analysis of these data sets, the 1950s sustained a serious event, known as the "drought of record". The current trend of the Edwards Plateau is toward a wet period with occasional dry periods or short drought events.

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