Long-Term Weather Trends and Implications for Grazing Operations in the Mid-South

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Weather plays a large role in determining our agricultural production and management-related decisions throughout the growing season. In a couple examples, it controls when we can cut hay or when we are able/not able to graze (drought 2019). The short-term shift in the weather pattern is always on the back of any farmers mind and how it'll impact their own operation, but what about long-term changes? These can be just as important. This can be tracked by looking at our climate, which is the average weather conditions over a specific period of time (usually 30 years). Unlike weather, which tells us what we will get, climate shows us what we can expect at any point throughout the year. Climate tells us what we can and cannot grow in the Bluegrass State, when we can plant, and long-term sustainability.

Changes in our climate can be seen by comparing climate 'normals'. What is a normal? It's essentially the 30-year average of a particular weather variable. Just as an example, 'normals' show us that the average high temperature on May 28th in Bowling Green is 82 degrees. In another example, the state averages 50.38 inches on an annual basis. These climate 'normals' are updated every ten years. In 2021, the 1981-2010 climate normals were replaced with the 1991-2020 normals. This update showed some notable changes to our climate over the past decade, which could prove impactful to our forage production and grazing practices across the state of Kentucky. The hope is this article and presentation will help prompt some thoughts about how a warmer and wetter climate could impact your livestock operation in the years ahead.

In starting out, the past decade ran extremely warm across the Commonwealth. In fact, Kentucky saw four of its top-10 warmest years on record, which includes 2012, 2016, 2017, and 2019 (Table 1). What makes this data significant is the fact that it runs back to 1895. When comparing to our most recent set of normals, this uptick in temperatures has increased our annual mean temperature about a half to one degree across the state. This same trend has been seen across much of the United States (Map 1).

Precipitation has shown a similar increase across the state of Kentucky. In fact, the eastern half of the state is showing some of the largest changes in precipitation across the entire country (Map 2). Just like temperatures, the state saw a number of its wettest years on record over the past decade. 2011, 2018, 2019, 2015, and 2020 all sit in the top-10 wettest years on record (Table 2). When comparing the 1981-2010 climate normals to 1991-2020, we see that annual precipitation averages have increased more than 2 inches for number of locations across the state (Table 3). In one case, Lexington has seen its precipitation average increase by over 4.5 inches. Looking at the state as a whole, our state annual precipitation average has increased from 47.9 inches (1981-2010) to 50.38 inches (1991-2020).

How will this increase in temperature and precipitation impact grazing and forage operations in the Mid-South?

Seasons trending warmer and wetter

Not only has the state been trending warmer and wetter on an annual scale, but also on a seasonal scale. I included a look at four time-series scatterplots in (Figures 1-4). Each scattered plot represents a meteorological season, which is divided by the three coldest months of the year (winter) and three warmest (summer). Each year was plotted on the graph based on the annual state average temperature and precipitation accumulation for that respective year. The plot was then divided into four windows, separated by the average temperature and precipitation accumulation, which is based on the 1991 to 2020 climate normals for each season. Any years showing up in the upper right quadrant would contain years with above normal temperatures and precipitation. Top left: below normal temperatures and above normal precipitation. Bottom left: below normal temperatures and precipitation. Bottom right: above normal temperatures and below normal precipitation. I then highlighted the past five years in red.

Do you notice a trend? Most of the past five years show up in the upper right-hand box: above normal precipitation and temperatures. It's not the case 100% of the time, but it does happen more times than not in recent years. The wetter and warmer climate will lead to a fair share of positives and negatives throughout the year, some of which I will discuss in the paragraphs below, including expanded grazing seasons, less baling days, and less drought.

Longer grazing seasons (Table 4)

Looking at the latest set of freeze normals, the warmer climate of the Ohio Valley is causing a lengthening of our growing season. Our average first freeze of the fall season is occurring later in the year, usually falling somewhere over the last week of October. In some cases, this is over a week later in the fall season than what was seen in the 1971-2000 climate normals. Our average last freeze during the spring season is also occurring earlier in the year. Once again, several locations have seen their average last freeze date pushed about a week earlier in the year compared to the 1971 to 2000 normals. Combining the earlier start to the growing season and a later end equates to a longer freeze-free period throughout the year in Kentucky. It's not to say we won't see some late freezes in spring or early freezes in fall, but on average, our growing seasons are getting longer. Ultimately, this can lead to more forage growth earlier and later in the year.

Drought

The wetter pattern has obviously led to a lower threat of drought conditions, but they have not been non-existent. We've seen more in the way of "flash droughts" or droughts that can rapidly develop over the course of several weeks. You can see these short-term droughts in the Kentucky Drought Time Series in Figure 5. Our last major drought occurred back in 2012, but since then, all droughts have been relatively short-lived. Saying that, they can still have very detrimental impacts. Two of the more notable flash droughts occurred in fall of 2016 and more recently, September of 2019. The latter set the record for the all-time driest September on record for the Bluegrass State with an average of only 0.22 inches. In addition, high temperature records were broken over several days. Burnt up pastures led to producers feeding hay very early-on in the fall months, which then led to concerns of winter supplies moving forward. In a sense, it was also a double-edged sword combined with the lack of available grazing. Bottom line, while we have been trending wetter over the recent decade, droughts can still happen.

Baling days decreasing

Looking at baling days, we've seen a decrease in recent years with the wet pattern in place, most notably during the spring and early summer months. In Table 5, I calculated the number of baling days for three cities across the state, based on a typical four-day window of dry conditions that is needed in spring (cut on day 1 and bale on day 4). Day 4 would be considered a baling day and any consecutive dry day thereafter. While other factors affect the drying process (relative humidity, winds, solar radiation, etc.), I strictly only took into account precipitation with this data (days with no rainfall accumulations). In doing so, I compared the average amount of baling days on a monthly and seasonal basis between 2000 and 2021, to the average amount over the past five years (2017-21). Just as an example, Lexington has only averaged 4 baling days in May over the past five years. Looking at the deviation, any numbers shown in red signal a decrease in the number of baling days over the past 5 years, while green would signal an increase. All stations have shown a loss on the annual side (May through September), but the most notable losses on the monthly scale have occurred in May and June.

Focusing on May (graph 6) and June (graph 7), I included a look at the number of baling days on an annual basis since 2000, also comparing to the monthly average across the three locations. The most recent five years generally showed total baling days staying under 6 in May and 8 in June. All and all, the wetter climate is narrowing our dry windows across the state.

In conclusion, these are just a few of the impacts related to a warmer and wetter climate in the Ohio Valley, but this list can be expanded. What about pests overwintering farther north with warmer winters, making Kentucky more susceptible to northern migrations on an annual basis. While warmer temperatures will extend the growing season, they may also put certain forage species at risk to freeze damage as plants break dormancy earlier in the year.

Weather always get most of the attention when we manage our farming operation, but it doesn't hurt to occasionally look at the long-term changes too. In monitoring both the weather and climate across the state of Kentucky, I've created the Ag Weather Update. This is a weekly newsletter sent throughout the year where I focus on the current climate conditions, weekly forecast, and long-range outlooks. Using the link above, you can sign-up with an email address and have the Update sent to you direction on a weekly basis. Also, the Kentucky Climate Center host a monthly webinar series titled the "Kentucky Monthly Perspective on Drought and Hydrologic Conditions". In this webinar, we focus on the current climate conditions seen across Kentucky, in addition to any related short- or long-term impacts. Each webinar is held on the first Thursday of the month at 2PM Eastern, 1PM Central and can be accessed by signing up using the link above or the Kentucky Climate Center's YouTube page.

Charts and Figures

Table 1 & 2 – Top ten wettest and warmest years across the state of Kentucky.

Kentucky Top-10 Warmest Years on Record (1895 - 2020)

Rank	Year	Avg.	Normal	Dep.
1	1921	58.7	56.3	2.4
2	2012	58.4	56.3	2.1
3	1998	58.2	56.3	1.9
4	2016	57.9	56.3	1.6
5	2017	57.8	56.3	1.5
5	1931	57.8	56.3	1.4
7	2007	57.7	56.3	1.4
8	1938	57.5	56.3	1.2
8	2019	57.5	56.3	1.1
10	1933	57.4	56.3	1.1
10	1991	57.4	56.3	1

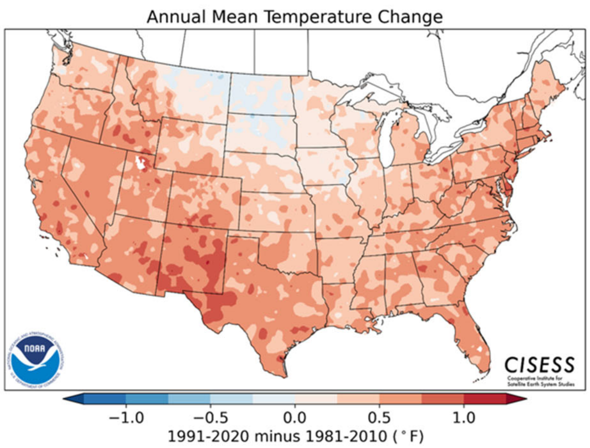
Data Courtesy: Midwestern Regional Climate Center cli-MATE toolkit: *https://mrcc.purdue.edu/CLIMATE/*

Kentucky Top-10 Wettest Years on Record (1895 - 2020)

Rank	Year	Total	Normal	Dep.	%Norm
1	2011	64.35	50.38	13.97	128
2	2018	63.74	50.38	13.36	127
3	1950	62.63	50.38	12.25	124
4	1979	62.58	50.38	12.2	124
5	2019	61.32	50.38	10.94	122
6	1935	58.38	50.38	8	116
7	2015	58.31	50.38	7.93	116
8	2020	58.11	50.38	7.73	115
9	1989	57.74	50.38	7.36	115
10	1972	57.08	50.38	6.7	113

Data Courtesy: Midwestern Regional Climate Center cli-MATE toolkit: *https://mrcc.purdue.edu/CLIMATE/*

Maps 1 & 2 – Annual mean temperature and precipitation change between the 1991-2020 and 1981-2010 climate normals. Courtesy: CISESS, Cooperative Institute for Satellite Earth System Studies, *https://www.ncei.noaa.gov/news/noaa-delivers-new-us-climate-normals*



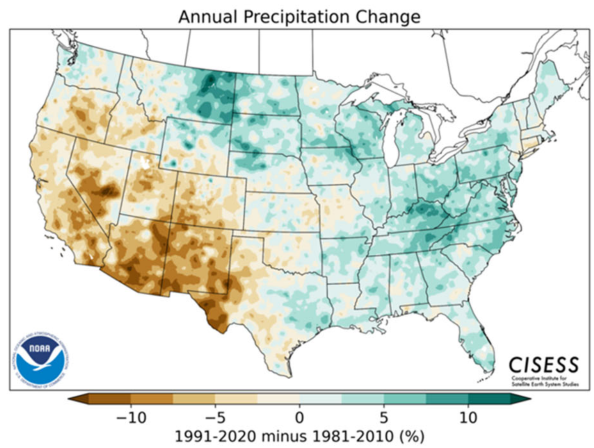


Table 3 – City-specific temperature and precipitation differences between the 1991-2020 and 1981-2010 climate normals.

	Temperature Normals			Precipitation Normals		
Stations	1981 to 2010	1991 to 2020	Difference	1981 to 2010	1991-2020	Difference
Bowling Green Warren Co AP	58	59.1	1.1	49.89	50.12	0.23
Lexington Bluegrass AP	55.6	56.3	0.7	45.17	49.84	4.67
Paducah *	57.9	58.8	0.9	49.08	50.32	1.24
Louisville Int AP	58.2	58.9	0.7	44.91	48.34	3.43
Cincinnati/Northern KY Int AP	54.4	54.7	0.3	42.52	45.26	2.74
Jackson *	56.6	57.2	0.6	48.34	51.89	3.55
Data Courtesy: National Centers for Environmental Information, 1991-2020 U.S. Climate Normal Quick Access - https://www.ncei.noaa.gov/access/us-climate-normals/, Data Tools: 1981-2010 Normals, https://www.ncdc.noaa.gov/cdo-web/datatools/normals						
*Same location, different station. Same station not available for both datasets.						

Figure 1 – Temperature and precipitation time-series scatterplot of the winter season in Kentucky, based on the years 1991 to 2020.

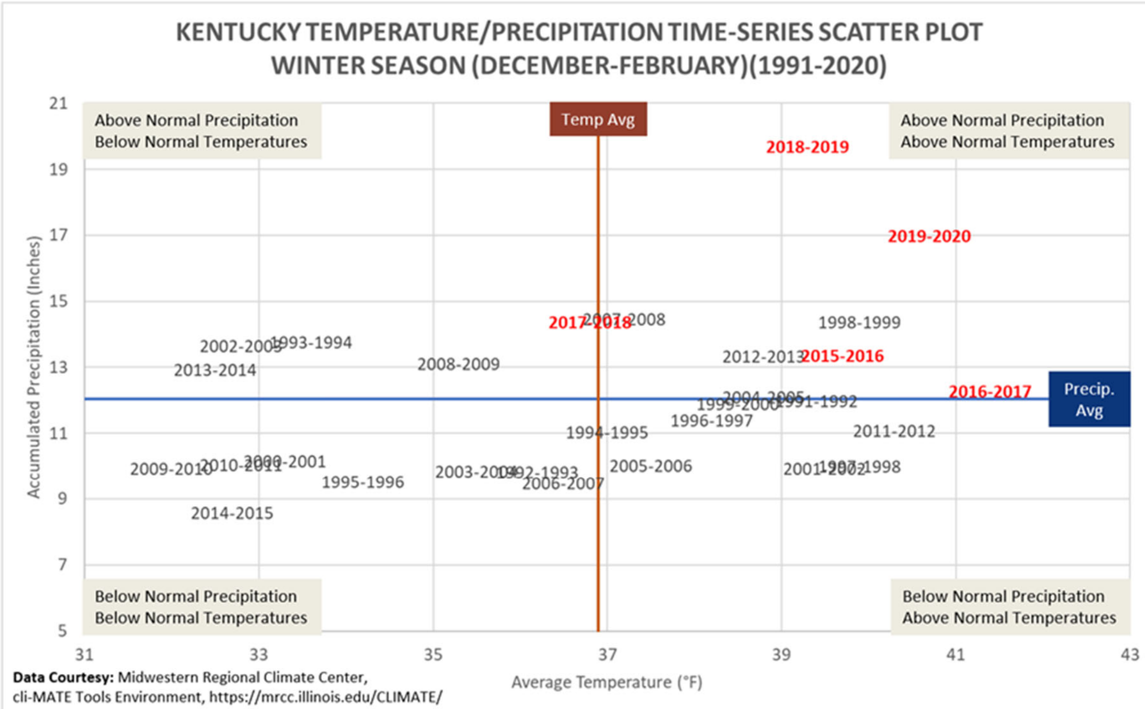


Figure 2 – Temperature and precipitation time-series scatterplot of the spring season in Kentucky, based on the years 1991 to 2020.

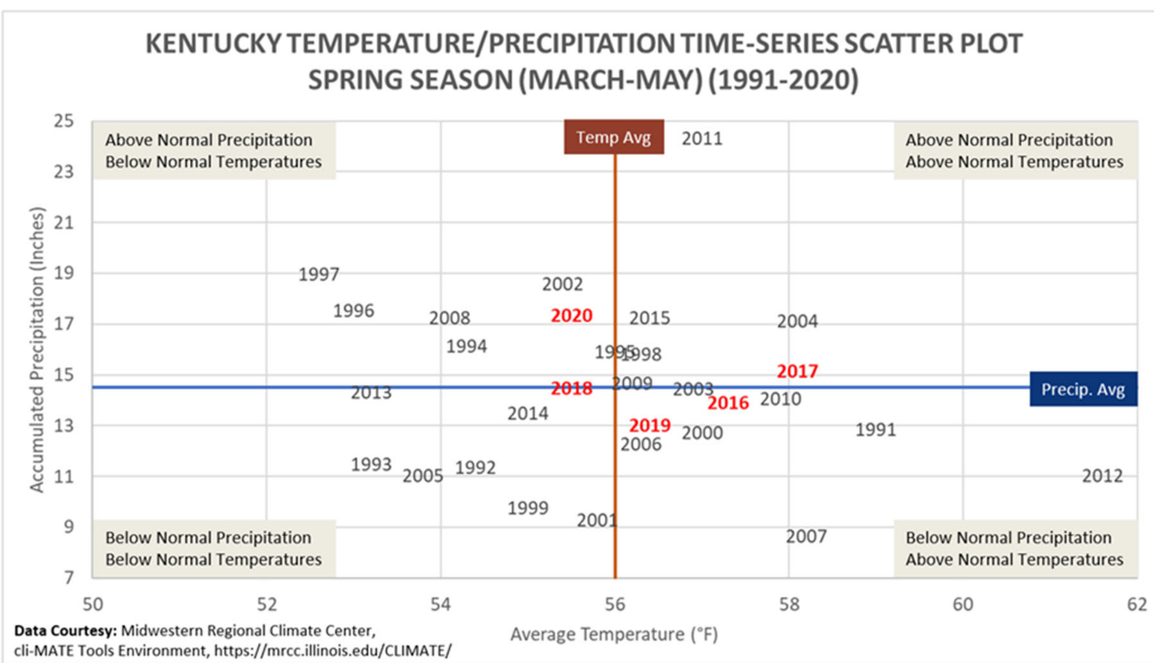


Figure 3 – Temperature and precipitation time-series scatterplot of the summer season in Kentucky, based on the years 1991 to 2020.

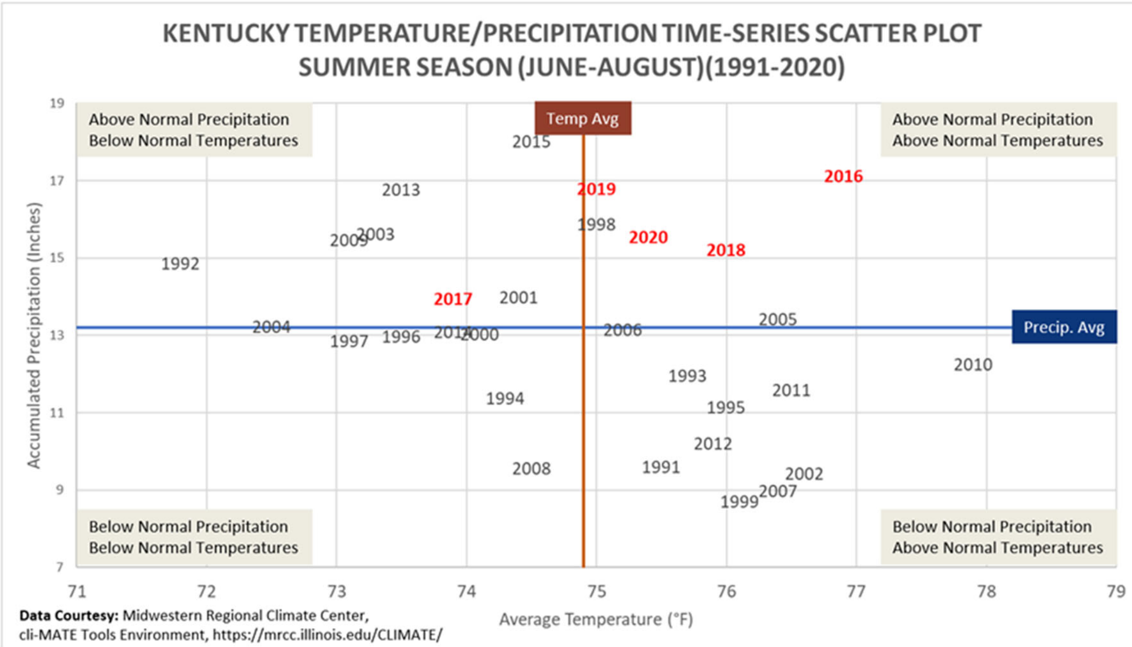


Figure 4 – Temperature and precipitation time-series scatterplot of the fall season in Kentucky, based on the years 1991 to 2020.

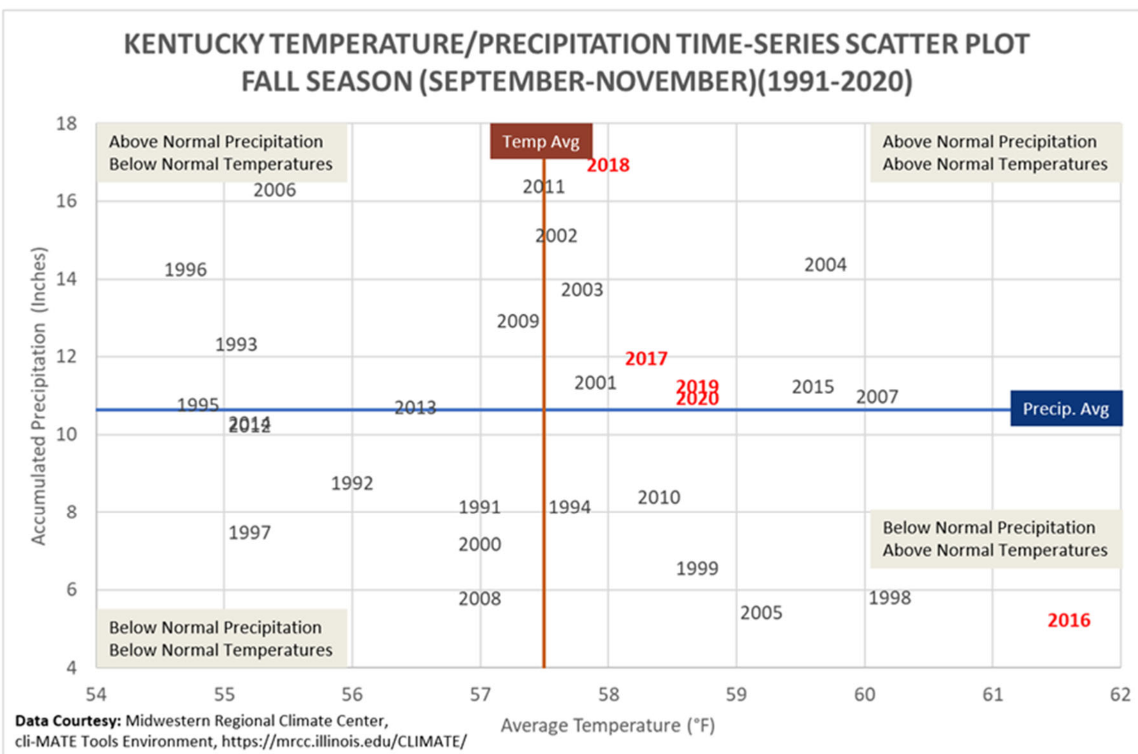


Table 4 – Comparison of the average freeze date during the fall and spring seasons among three sets of climate normals. Data Courtesy: National Centers of Environmental Information, ncei.noaa.gov

Comparison of Kentucky Freeze Normals

	Fall Freeze 50%		
Station	**1971-2000**	**1981-2010**	**1991-2020**
LEXINGTON BLUEGRASS AP, KY	25-Oct	27-Oct	28-Oct
LOUISVILLE INTL AP, KY	30-Oct	4-Nov	7-Nov
CINCINNATI NORTHERN KENTUCKY INTL AP, KY	17-Oct	24-Oct	25-Oct
PADUCAH BARKLEY REGIONAL AP, KY	25-Oct	26-Oct	28-Oct
LONDON CORBIN AP, KY	16-Oct	22-Oct	25-Oct
BOWLING GREEN WARREN CO AP, KY	23-Oct	27-Oct	31-Oct

	Spring Freeze 50%		
Station	**1971-2000**	**1981-2010**	**1991-2020**
LEXINGTON BLUEGRASS AP, KY	15-Apr	14-Apr	13-Apr
LOUISVILLE INTL AP, KY	8-Apr	3-Apr	31-Mar
CINCINNATI NORTHERN KENTUCKY INTL AP, KY	20-Apr	16-Apr	18-Apr
PADUCAH BARKLEY REGIONAL AP, KY	7-Apr	8-Apr	5-Apr
LONDON CORBIN AP, KY	19-Apr	16-Apr	15-Apr
BOWLING GREEN WARREN CO AP, KY	11-Apr	9-Apr	5-Apr

	Average Freeze-Free Period		
Station	**1971-2000**	**1981-2010**	**1991-2020**
LEXINGTON BLUEGRASS AP, KY	193	196	198
LOUISVILLE INTL AP, KY	205	215	221
CINCINNATI NORTHERN KENTUCKY INTL AP, KY	180	191	190
PADUCAH BARKLEY REGIONAL AP, KY	201	201	206
LONDON CORBIN AP, KY	180	189	193
BOWLING GREEN WARREN CO AP, KY	195	201	209

Figure 5 – Kentucky Drought Time Series, courtesy of the U.S. Drought Monitor

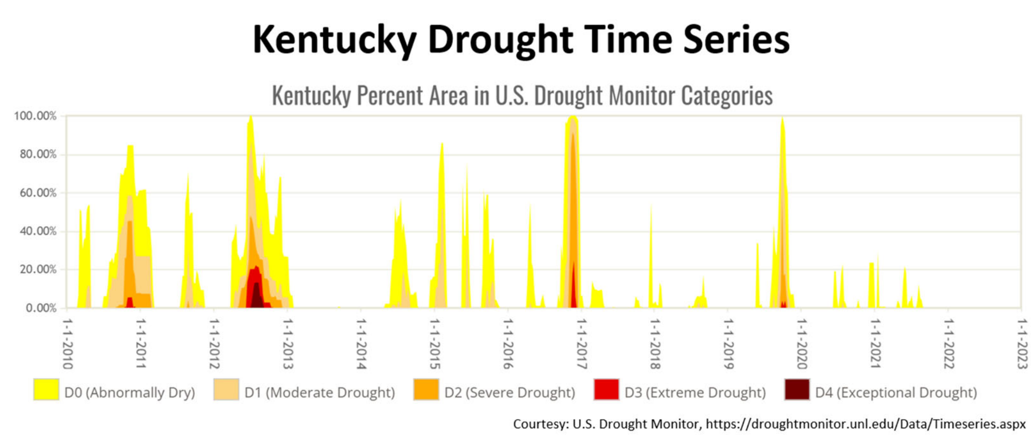


Table 5 – Available number of baling days as a monthly and annual average for Lexington, Bowling Green, and Paducah. Based on a four-day window (cut day 1, bale day 4) and solely on precipitation (dry days). Each consecutive dry day after day 4 is also counted as a baling day.

Available Baling Days *						
Lexington						
	May	**June**	**July**	**August**	**September**	**Annual**
2000-2021 Avg	5.5	6.5	6.2	8.2	12.5	38.9
2017-2021 Avg	4.0	5.0	6.2	7.0	13.2	35.4
Deviation	**-1.5**	**-1.5**	**0.0**	**-1.2**	**0.7**	**-3.5**
Bowling Green						
	May	**June**	**July**	**August**	**September**	**Annual**
2000-2021 Avg	6.4	7.4	6.7	9.2	11.7	41.4
2017-2021 Avg	5.2	7.4	8.4	6.0	11.0	38.0
Deviation	**-1.2**	**0.0**	**1.7**	**-3.2**	**-0.7**	**-3.4**
Paducah						
	May	**June**	**July**	**August**	**September**	**Annual**
2000-2021 Avg	5.8	9.1	10.3	10.7	13.0	49.0
2017-2021 Avg	3.8	8.0	11.2	10.0	14.0	47.0
Deviation	**-2.0**	**-1.1**	**0.9**	**-0.7**	**1.0**	**-2.0**
* Based on 4-day window.						
Data Courtesy: Midwestern Regional Climate Center cli-MATE toolkit: https://mrcc.purdue.edu/CLIMATE/						

Figure 6 – Available number of baling days in May for the cities of Paducah, Bowling Green, and Lexington. Data Courtesy: MRCC, Midwestern Regional Climate Center cli-MATE toolkit, https://mrcc.purdue.edu/CLIMATE/