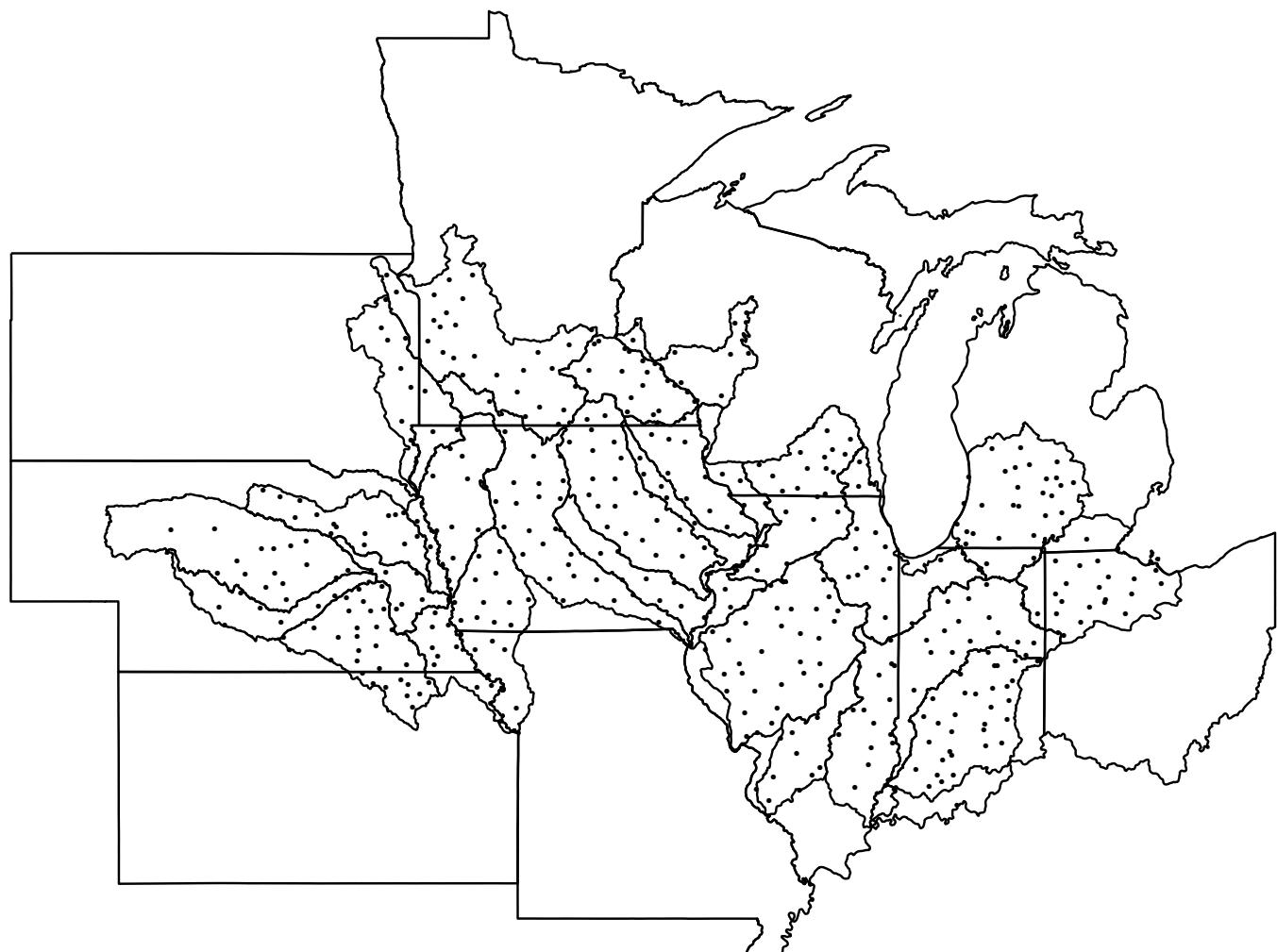


8 Weather

In this section weather variables that were constructed to supplement the survey data are presented. The construction of these weather variables is discussed, then summaries of these variables by watershed are presented.

Weather Variable Definitions

The weather variables were constructed from the National Weather Service (NWS) Cooperative Observer (COOP) data archive, which includes daily values of minimum temperature, maximum temperature, precipitation, and snowfall. The data archive constructed for the CSCAP-U2U survey includes all available data from January 1, 1971 through December 31, 2011. Data were downloaded from the Iowa Environmental Mesonet (<http://mesonet.agron.iastate.edu/>).



Map 63. Locations of the National Weather Service Cooperative Observer Network (NWS COOP) stations in the HUC6 watersheds included in the CSCAP-U2U survey.

Several of the weather variables were based on station-specific percentiles computed from this historical record. Daily percentiles are month-specific; for example, the 99th percentile of daily precipitation for June was defined by combining all daily precipitation for June across all 41 years. Seasonal or monthly summaries (percentiles, means, standard deviations) were computed from the record of 41 seasonal or monthly totals.

Below we define the weather variables included in this report:

Seasonal Precipitation

Seasonal precipitation was computed as the total precipitation for April 1 through September 30. The empirical cumulative distribution (CDF), often based on 41 values for a station, was computed to yield a percentile rank for each year. The percentile rank for a year is a rank divided by the total number of years, or the percentage of years with as much or less precipitation than the chosen year. A value of 50% would indicate the median seasonal precipitation and that half of all years would have as much or less precipitation than the selected year. In this report, we include this median value and the average of these percentages for the five-year period from 2007–2011.

Daily Precipitation Extremes

Heavy precipitation events are counted as any days when the daily precipitation exceeded the 99th percentile of daily precipitation for a given month. The 99th percentile was defined separately for each station and each month. As an example, the 99th percentile for May precipitation is found by assembling all daily precipitation in May from 1971–2011 for a particular station. Then the 99th percentile of this empirical distribution of about $31 \times 41 = 1271$ values is found. We consider the proportion of days with precipitation exceeding the 99th percentile for the five-year period 2007–2011. Note that one would expect this to be about 0.01 by chance.

Cumulative Drought Index

The U.S. Drought Monitor (<http://droughtmonitor.unl.edu/>) is a subjective analysis of drought conditions produced weekly. Table 12 highlights the drought severity categories used in this product.

Table 12. Drought monitor categories

Category	Name	Possible Impacts
None		
D0	Abnormally dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered
D1	Moderate drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested
D2	Severe drought	Crop or pasture losses likely; water shortages common; water restrictions imposed
D3	Extreme drought	Major crop/pasture losses; widespread water shortages or restrictions
D4	Exceptional drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams and wells creating water emergencies

Since the Drought Monitor is produced weekly, the archive can be used to identify areas with prolonged drought conditions. To quantify long-term drought exposure, we constructed a variable $d_{i,t}$ defined for location i in week t , with

$$d_{i,t} = \begin{cases} 0 & \text{if location } i \text{ is not in a drought area in week } t \\ 1 & \text{if location } i \text{ is in D0 in week } t \\ 2 & \text{if location } i \text{ is in D1 in week } t \\ 3 & \text{if location } i \text{ is in D2 in week } t \\ 4 & \text{if location } i \text{ is in D3 in week } t \\ 5 & \text{if location } i \text{ is in D4 in week } t \end{cases}$$

This variable not only reflects whether a location is in drought conditions, but also takes on increasingly large values for more severe drought conditions.

To obtain watershed-level summaries, we took the median of the summed $d_{i,t}$ values over the last five years for each watershed. This cumulative drought index reflects both the length of drought conditions as well as the severity of prolonged drought conditions.

Aridity Index

The aridity index is a composite weather index that has been linked with crop yield. The index combines standardized precipitation and maximum temperature anomalies. Let $T'_{i,j}$ be the average maximum temperature and $P'_{i,j}$ be the total precipitation in month i of year j . Then $T'_{i,j}$ and $P'_{i,j}$ are the standardized maximum temperature and precipitation anomalies in month i and year j .

$$\begin{aligned} T'_{i,j} &= \frac{T_{i,j} - \bar{T}_i}{s_{T,i}} \\ P'_{i,j} &= \frac{P_{i,j} - \bar{P}_i}{s_{P,i}} \end{aligned}$$

The aridity index is defined as the difference in the standardized anomalies

$$A_{i,j} = T'_{i,j} - P'_{i,j}$$

Thus, a hot and dry month will have a positive index value while a cool and wet month will have a negative index value.

Heat Stress Degree Days

Accumulated heat stress degree days (SDD) is one weather variable that characterizes the cumulative impact of hot weather. SDD are computed as the sum of maximum temperatures over some threshold, with 86°F (30°C) often used for corn. If $T_{m,t}$ is the maximum temperature on day t , the season SDD are

$$SDD = \sum_{t=1}^n I(T_{m,t} > 86)(T_{m,t} - 86)$$

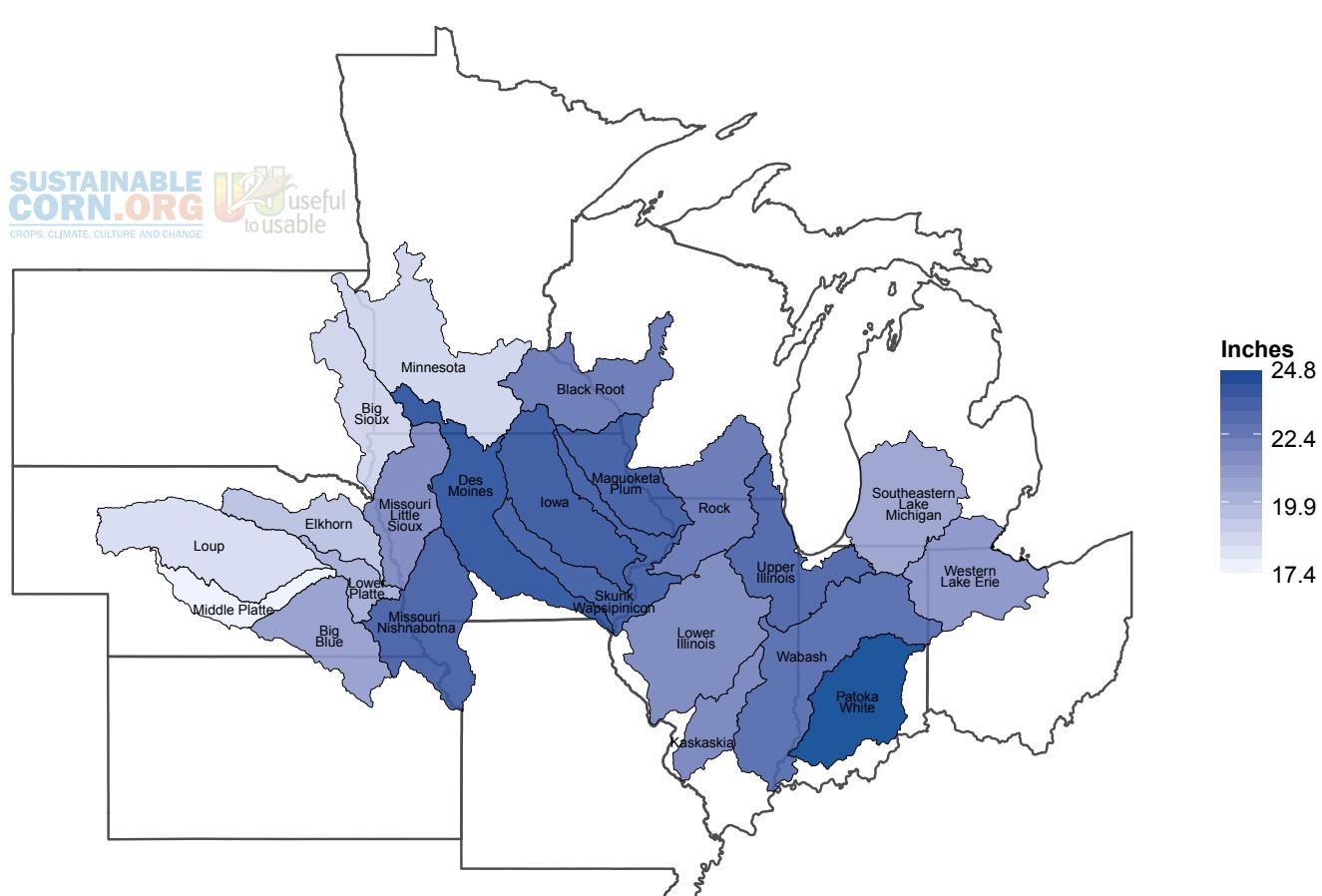
To characterize recent trends in heat stress, we compute a standardized SDD for each station i and year j

$$z_{i,j} = \frac{SDD_{i,j} - \bar{x}_i}{s_i},$$

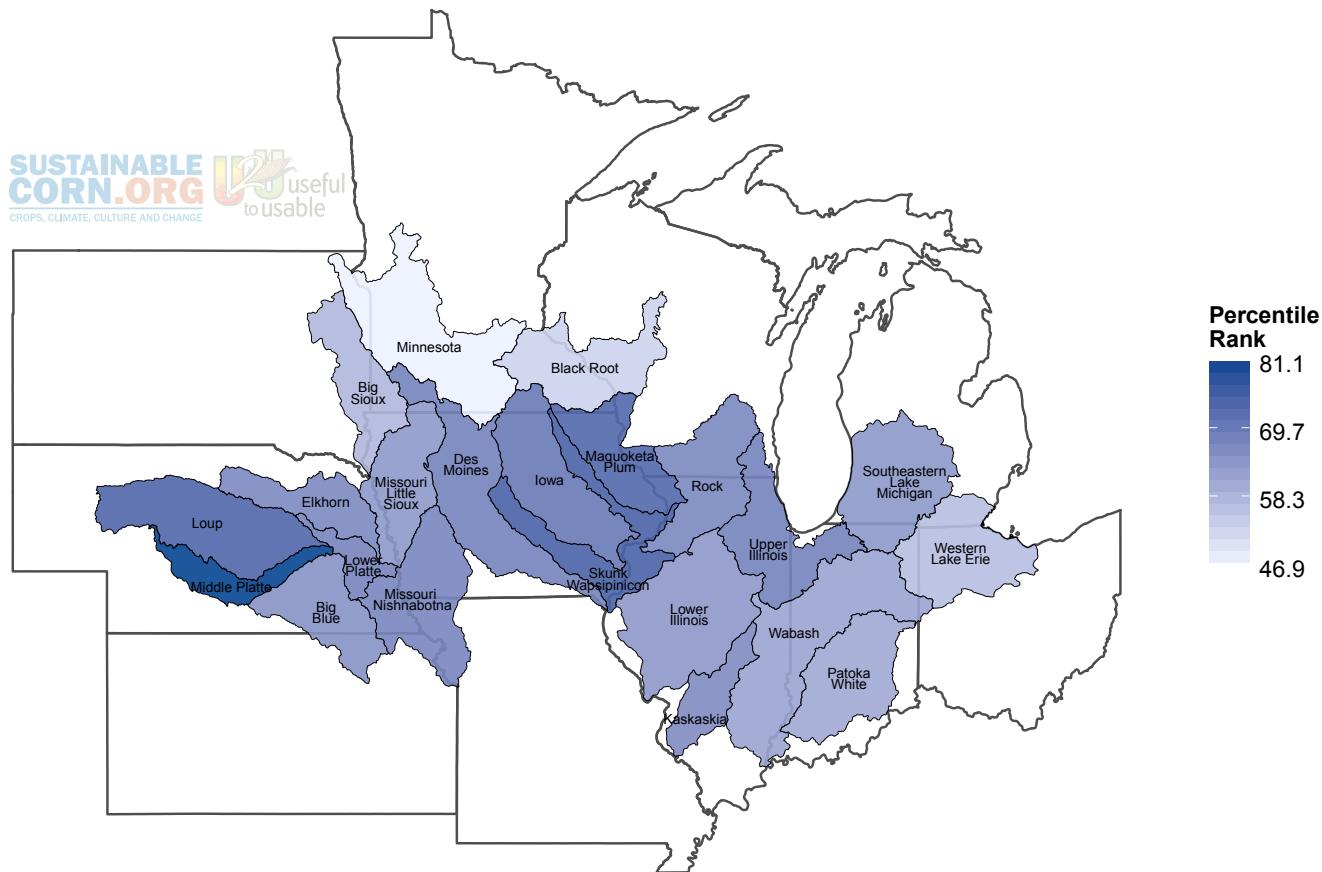
where \bar{x}_i and s_i are the 41-year average and standard deviation at station i . In this report we consider the average of these standardized values over the last five years. To aggregate to the watershed-level, the median of this measure for all stations within a watershed was calculated.

Table 13. Median seasonal April to September precipitation from 1971–2011, percentile rank of seasonal precipitation from 2007–2011, and average percentage of extreme daily April to September precipitation for 2007–2011

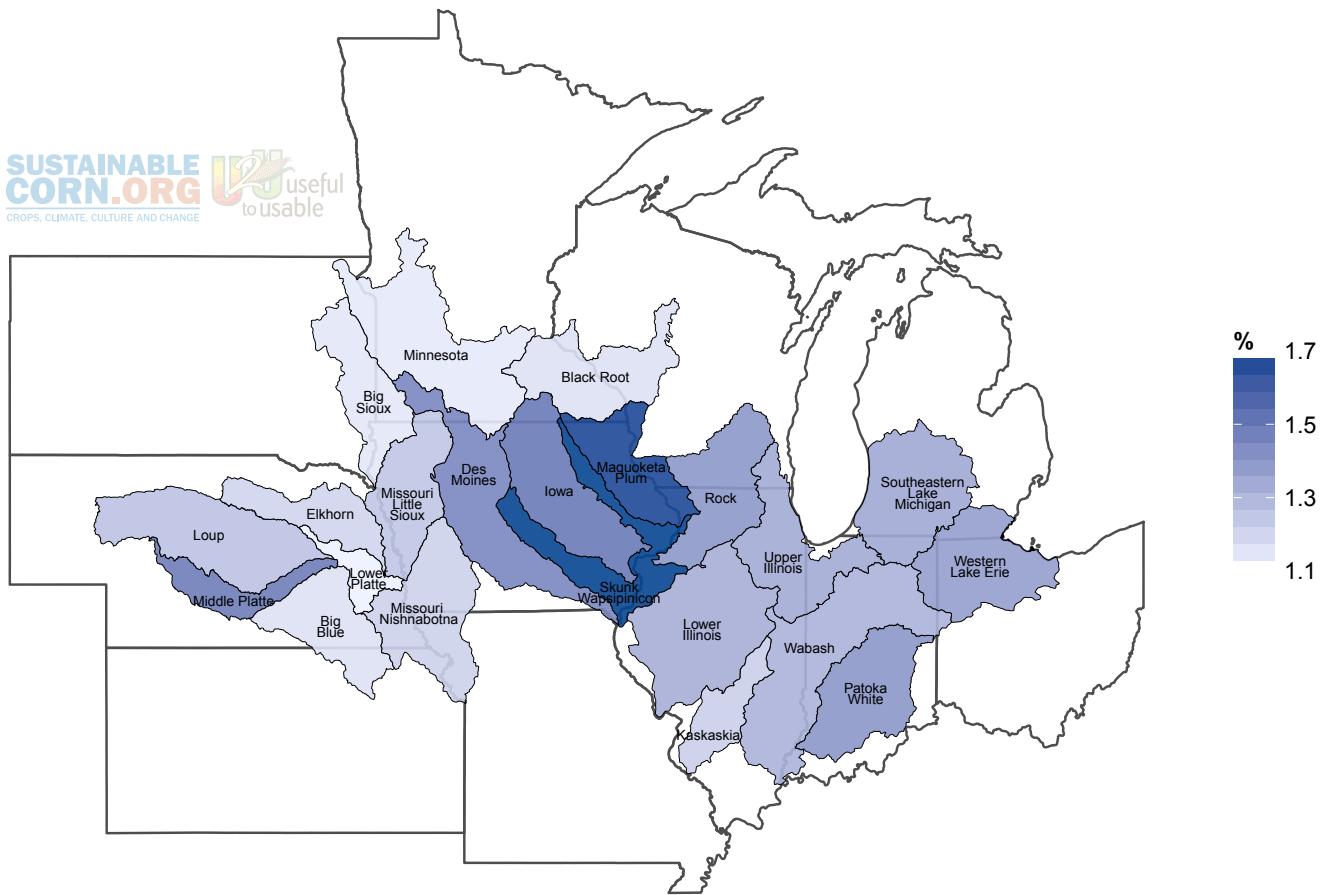
Watershed (HUC6)	Median Seasonal Precipitation	Seasonal Precipitation Percentile Rank	Extreme Daily Precipitation Frequency
Loup.....	19.1	75.8	0.013
Middle Platte.....	17.8	81.2	0.015
Elkhorn	19.6	69.8	0.011
Big Blue	20.7	63.4	0.012
Lower Platte.....	20.2	67.1	0.011
Big Sioux	18.8	60.5	0.010
Missouri-Little Sioux	21.8	67.8	0.013
Missouri-Nishnabotna.....	24.1	67.5	0.011
Minnesota.....	20.1	46.3	0.010
Des Moines.....	23.6	65.4	0.015
Iowa.....	24.2	73.4	0.013
Black Root	23.0	52.7	0.011
Skunk Wapsipinicon	23.9	73.2	0.018
Maquoketa Plum.....	24.5	75.1	0.016
Lower Illinois.....	22.2	64.4	0.013
Rock	23.2	66.8	0.015
Kaskaskia	22.3	66.3	0.010
Upper Illinois.....	23.0	69.3	0.013
Wabash	23.4	63.4	0.011
Patoka-White	24.7	60.0	0.013
Southeastern Lake Michigan.....	20.7	66.1	0.013
Western Lake Erie	21.4	56.6	0.013



Map 64. Median total April to September precipitation from 1971–2011.



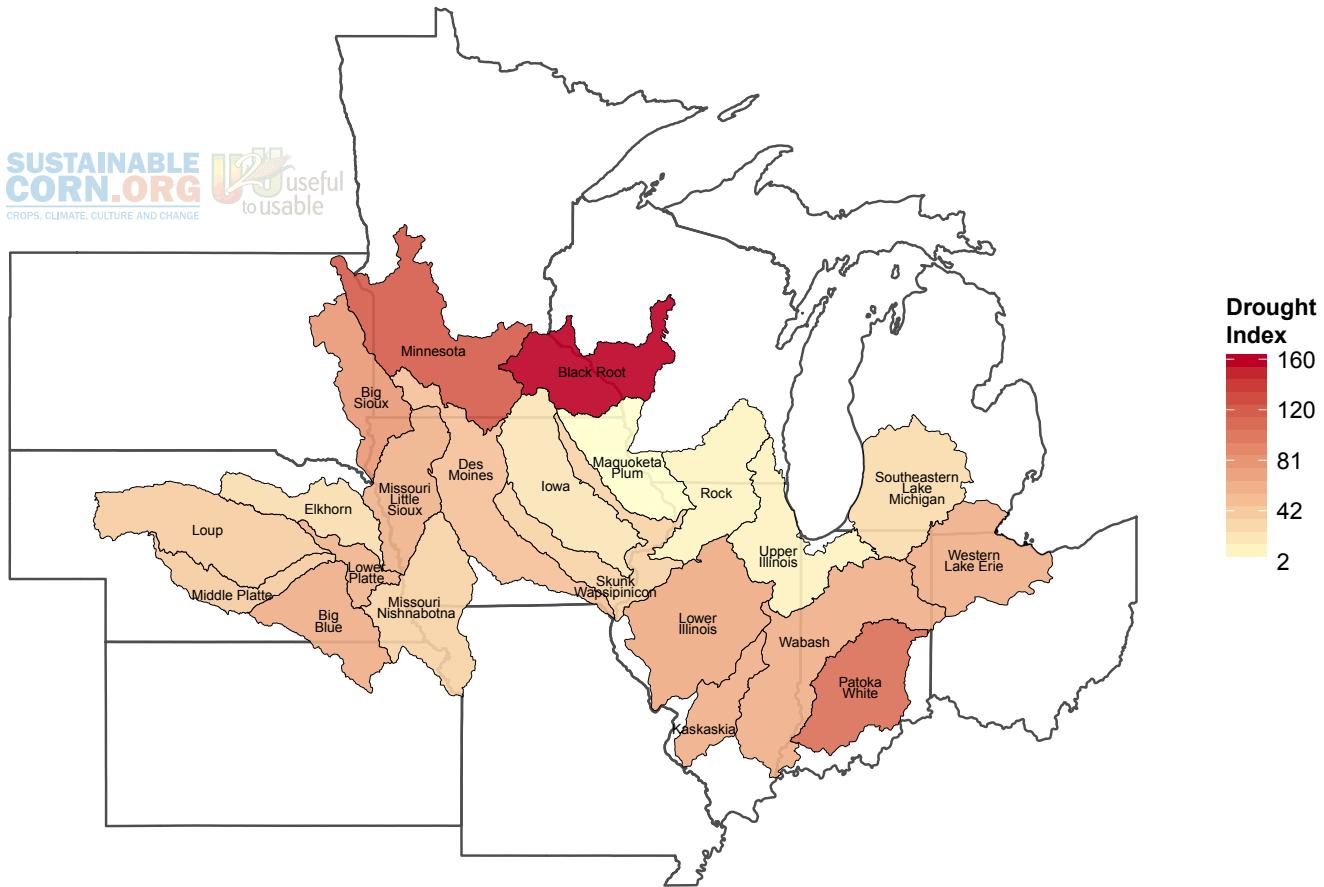
Map 65. Percentile rank of total April to September precipitation for 2007–2011 (compared to all data from 1971–2011).



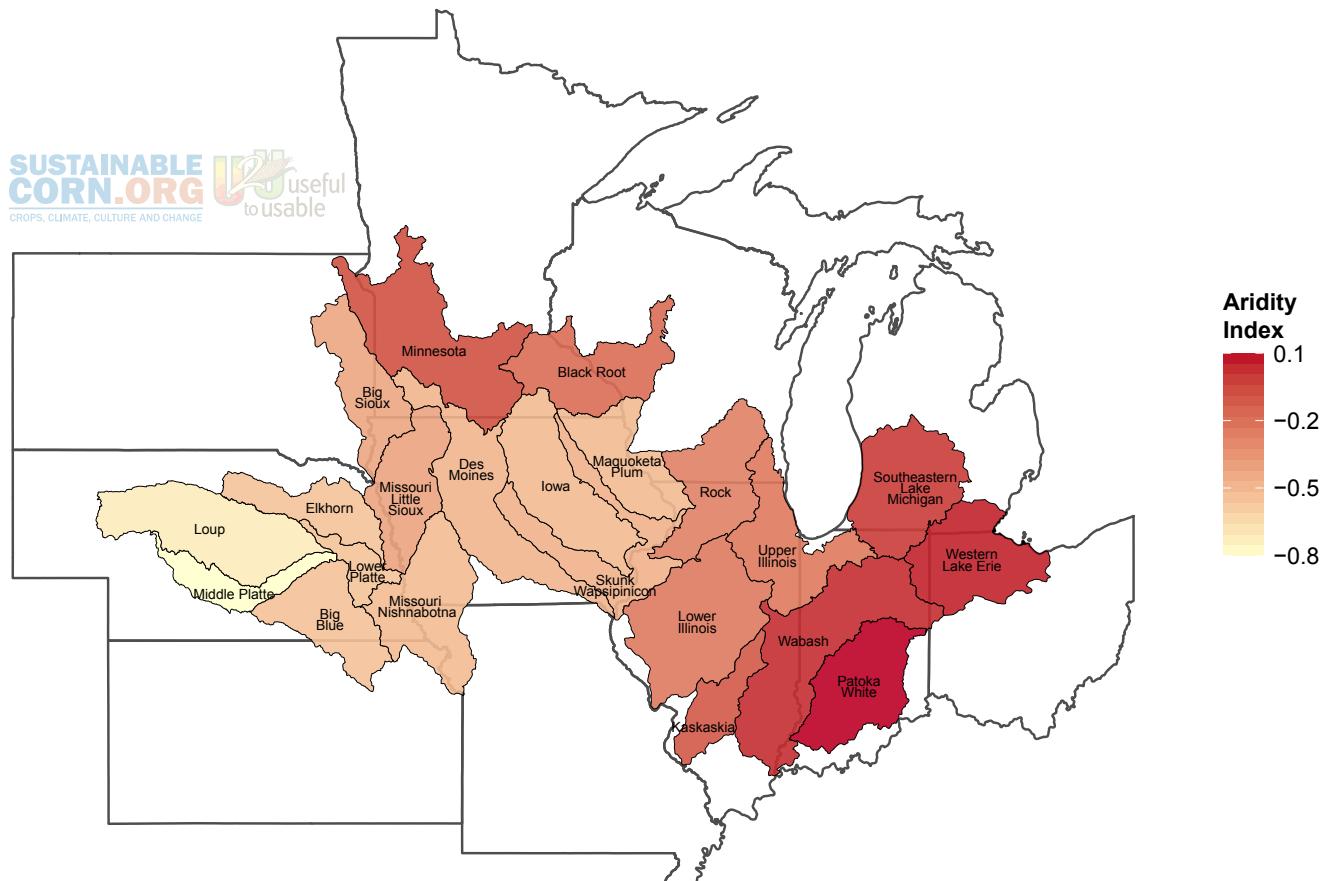
Map 66. Average percentage of extreme daily April to September precipitation from 2007–2011.

Table 14. Median cumulative drought index, aridity index, and standardized annual heat stress degree days from 2007–2011

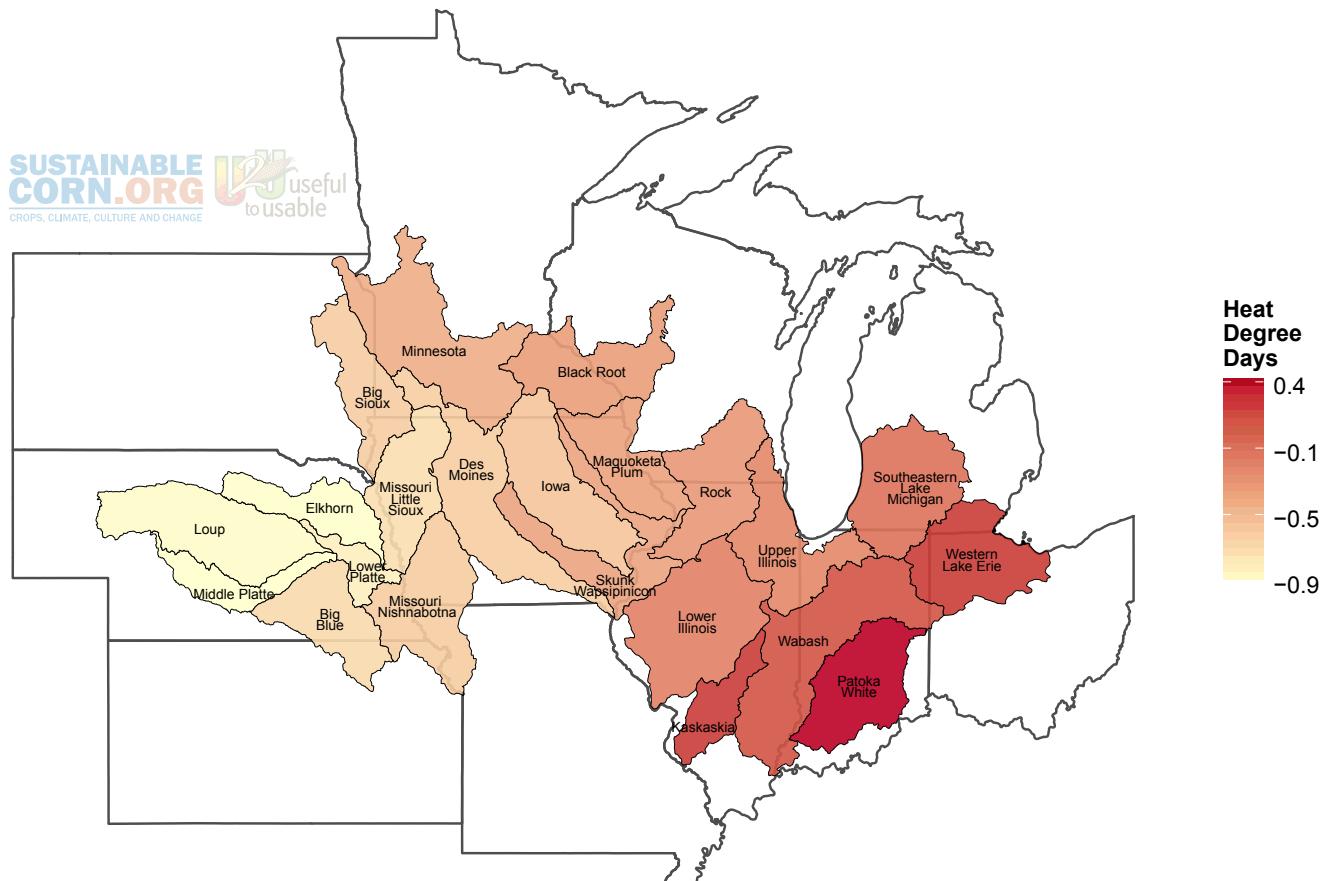
Watershed (HUC6)	Cumulative Drought Index	Average Aridity Index	Annual Heat Stress Degree Days
Loup.....	39	-0.74	-0.87
Middle Platte.....	40	-0.82	-0.89
Elkhorn	27	-0.56	-0.88
Big Blue	61	-0.55	-0.67
Lower Platte.....	57	-0.56	-0.79
Big Sioux	78	-0.43	-0.60
Missouri-Little Sioux	58	-0.42	-0.70
Missouri-Nishnabotna.....	35	-0.53	-0.59
Minnesota.....	121	-0.07	-0.42
Des Moines.....	48	-0.50	-0.61
Iowa.....	21	-0.52	-0.55
Black Root	160	-0.18	-0.32
Skunk Wapsipinicon	35	-0.48	-0.36
Maquoketa Plum.....	2	-0.52	-0.35
Lower Illinois.....	64	-0.24	-0.16
Rock	10	-0.26	-0.29
Kaskaskia	60	-0.10	0.20
Upper Illinois.....	11	-0.23	-0.19
Wabash	60	0.05	0.08
Patoka-White.....	108	0.13	0.36
Southeastern Lake Michigan	28	0.01	-0.08
Western Lake Erie	60	0.08	0.19



Map 67. Median cumulative drought index for 2007–2011.



Map 68. Median aridity index for April to September from 2007–2011.



Map 69. Median standardized annual heat stress degree days from 2007–2011.

