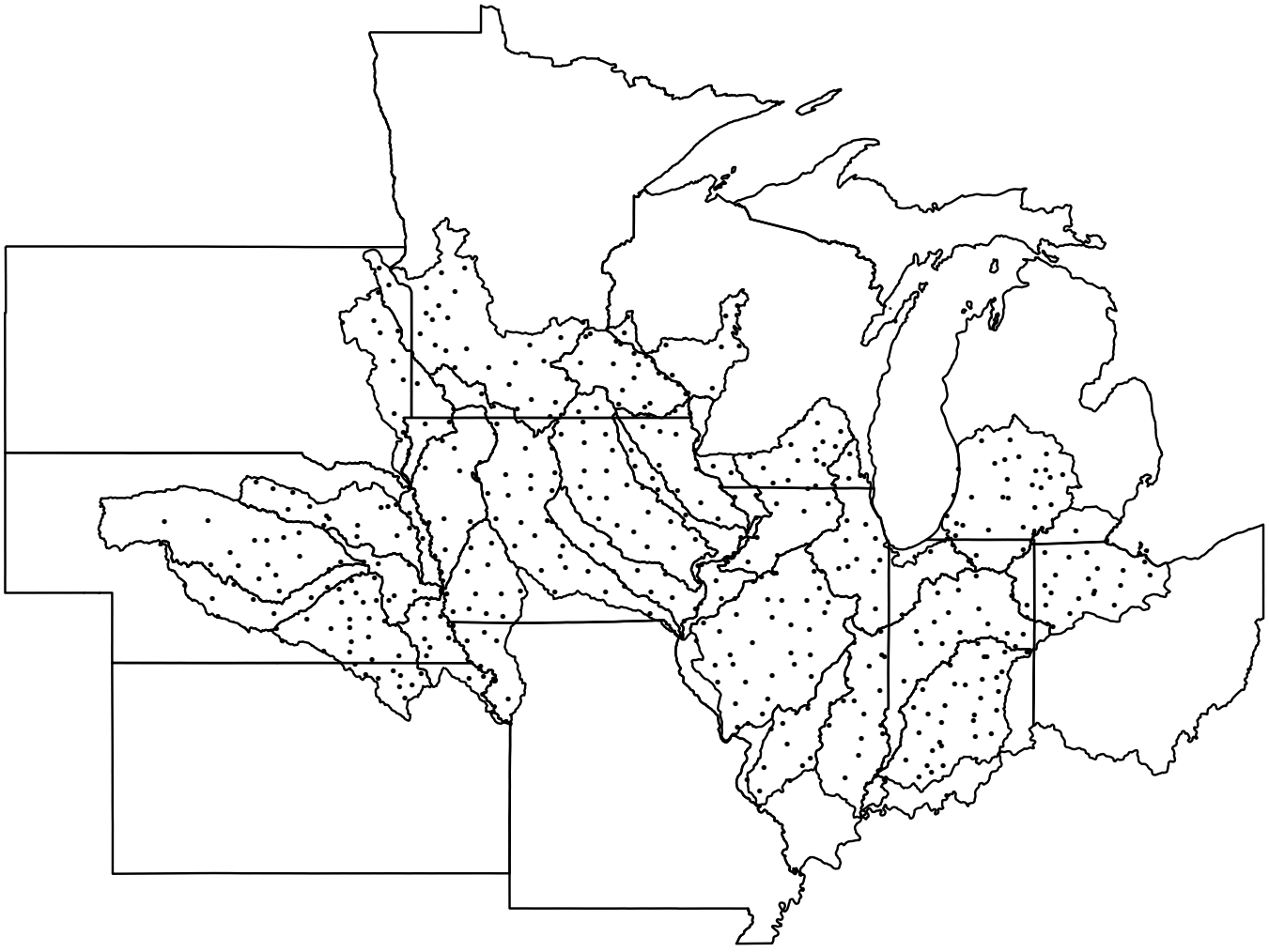
8 Weather

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.

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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 31x41=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

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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.

$$T'_{i,j} = \frac{T_{i,j} - \overline{T}_i}{s_{T,i}}$$

$$P'_{i,j} = \frac{P_{i,j} - \overline{P}_i}{s_{P,i}}$$

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

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

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

$$z_{i,j} = \frac{\mathrm{SDD}_{i,j} - \overline{x}_i}{s_i},$$

where $\overline{x}_i$ 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[1]	Seasonal Precipitation Percentile Rank[2]	Extreme Daily Precipitation Frequency[3]
Loup	19.1	75.8	1.3
Middle Platte	17.8	81.2	1.5
Elkhorn	19.6	69.8	1.1
Big Blue	20.7	63.4	1.2
Lower Platte	20.2	67.1	1.1
Big Sioux	18.8	60.5	1.0
Missouri-Little Sioux	21.8	67.8	1.3
Missouri-Nishnabotna	24.1	67.5	1.1
Minnesota	20.1	46.3	1.0
Des Moines	23.6	65.4	1.5
Iowa	24.2	73.4	1.3
Black Root	23.0	52.7	1.1
Skunk Wapsipinicon	23.9	73.2	1.8
Maquoketa Plum	24.5	75.1	1.6
Lower Illinois	22.2	64.4	1.3
Rock	23.2	66.8	1.5
Kaskaskia	22.3	66.3	1.0
Upper Illinois	23.0	69.3	1.3
Wabash	23.4	63.4	1.1
Patoka-White	24.7	60.0	1.3
Southeastern Lake Michigan	20.7	66.1	1.3
Western Lake Erie	21.4	56.6	1.3

[1] Median seasonal precipitation is the median total precipitation (in inches) for April to September from the historical record. Half of all years had seasonal precipitation less than this median value.

[2] Percentile rank is the percentage of years in the historical record with precipitation less than the amount in each of the years from 2007-2011. Large values indicate that the five-year period was unusually wet relative to the historical record.

[3] Extreme daily precipitation frequency is the percentage of days from 2007-2011 with heavy daily precipitation greater than the 99th percentile of all daily precipitation in the historical record. Values above 1% indicate more heavy precipitation events than expected by chance.

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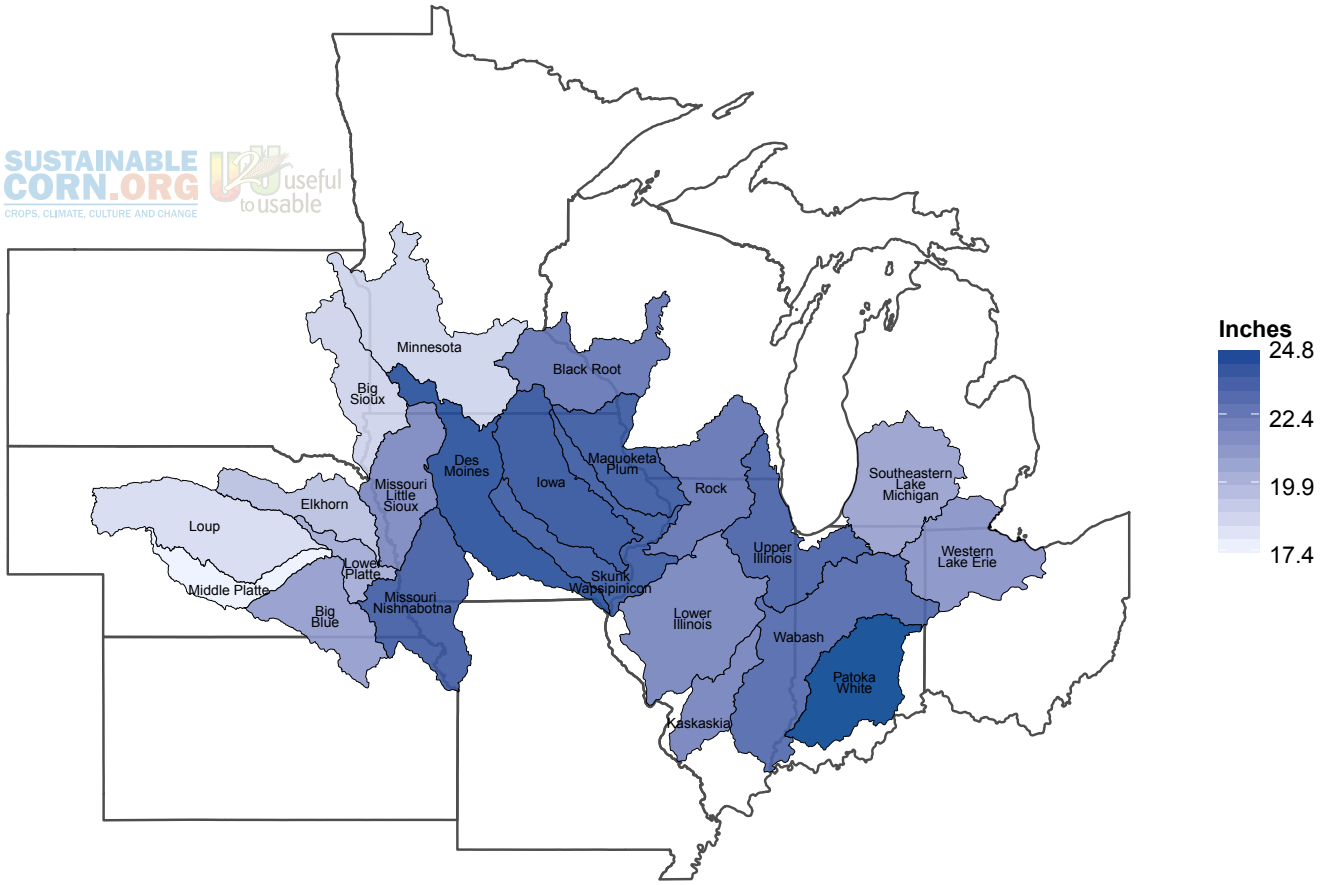

Map 64. Median total April to September precipitation from 1971–2011.

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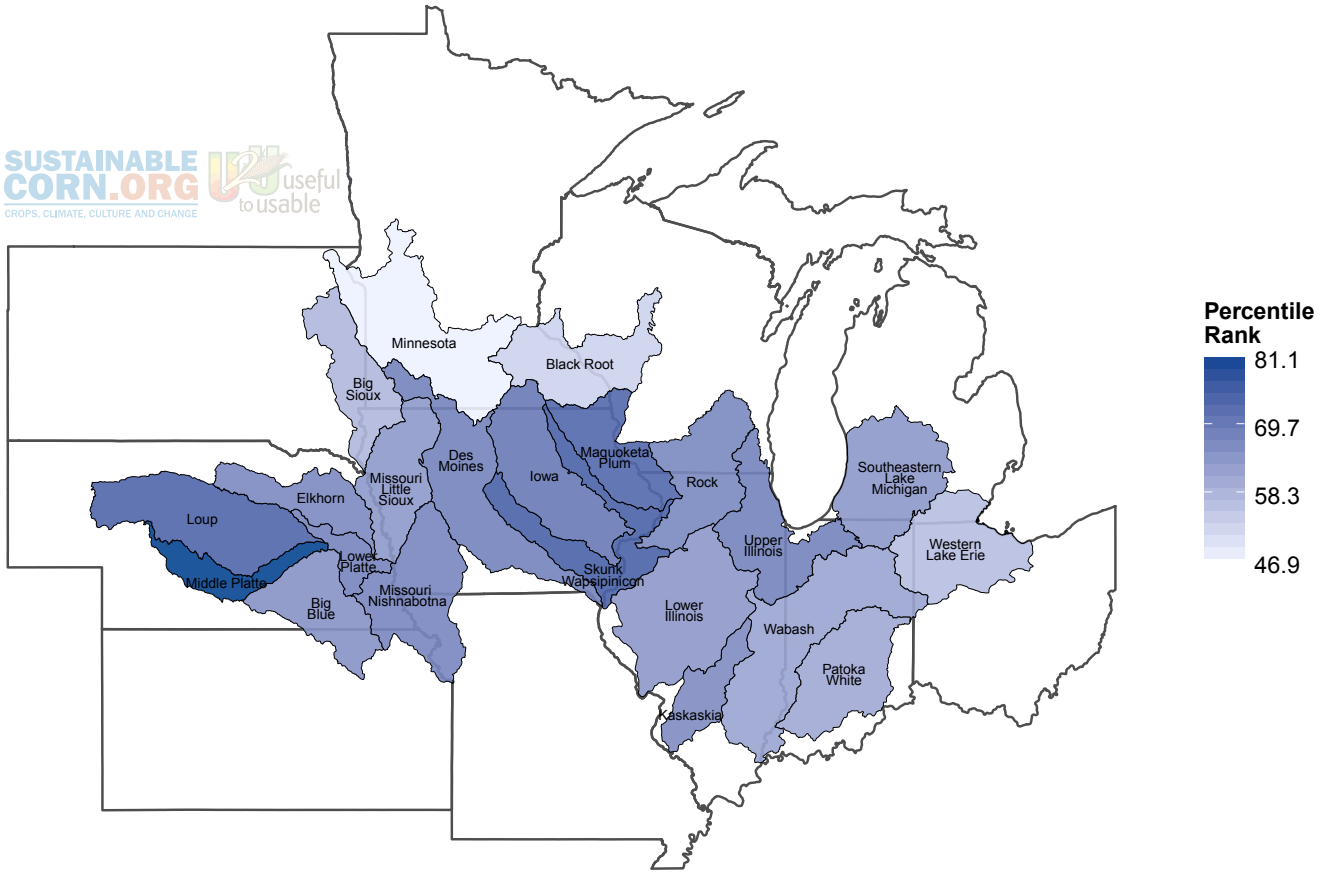

Map 65. Percentile rank of total April to September precipitation for 2007–2011 (compared to all data from 1971–2011).

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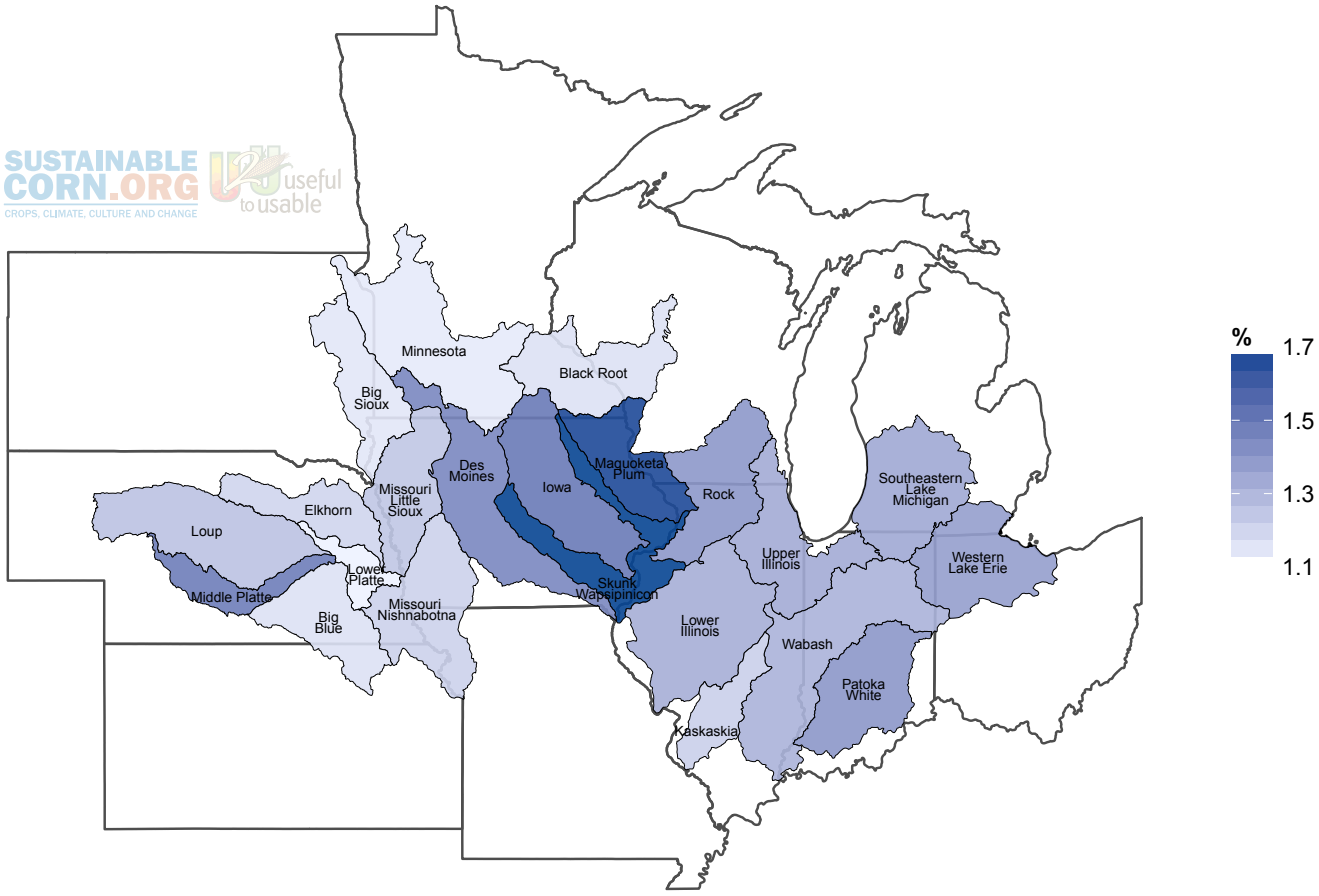

Map 66. Average percentage of extreme daily April to September precipitation from 2007–2011.

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

Watershed (HUC6)	Cumulative Drought Index[1]	Average Aridity Index[2]	Annual Heat Stress Degree Days[3]
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

[1] Cumulative drought index is the total length of time (in weeks) in drought conditions from 2007-2011, weighted by the magnitude of drought conditions. Large values indicate prolonged periods of especially severe drought conditions.

[2] Average aridity index is the average of a combined precipitation and temperature index for April to September of 2007-2011. Negative values indicate cool and wet conditions relative to the historical record, and positive values indicate hot and dry conditions.

[3] Annual heat stress degree days represent the deviation of heat stress conditions for 2007-2011 from the historical record. Negative values indicate relatively few heat stress events while positive values indicate more heat stress events than average.

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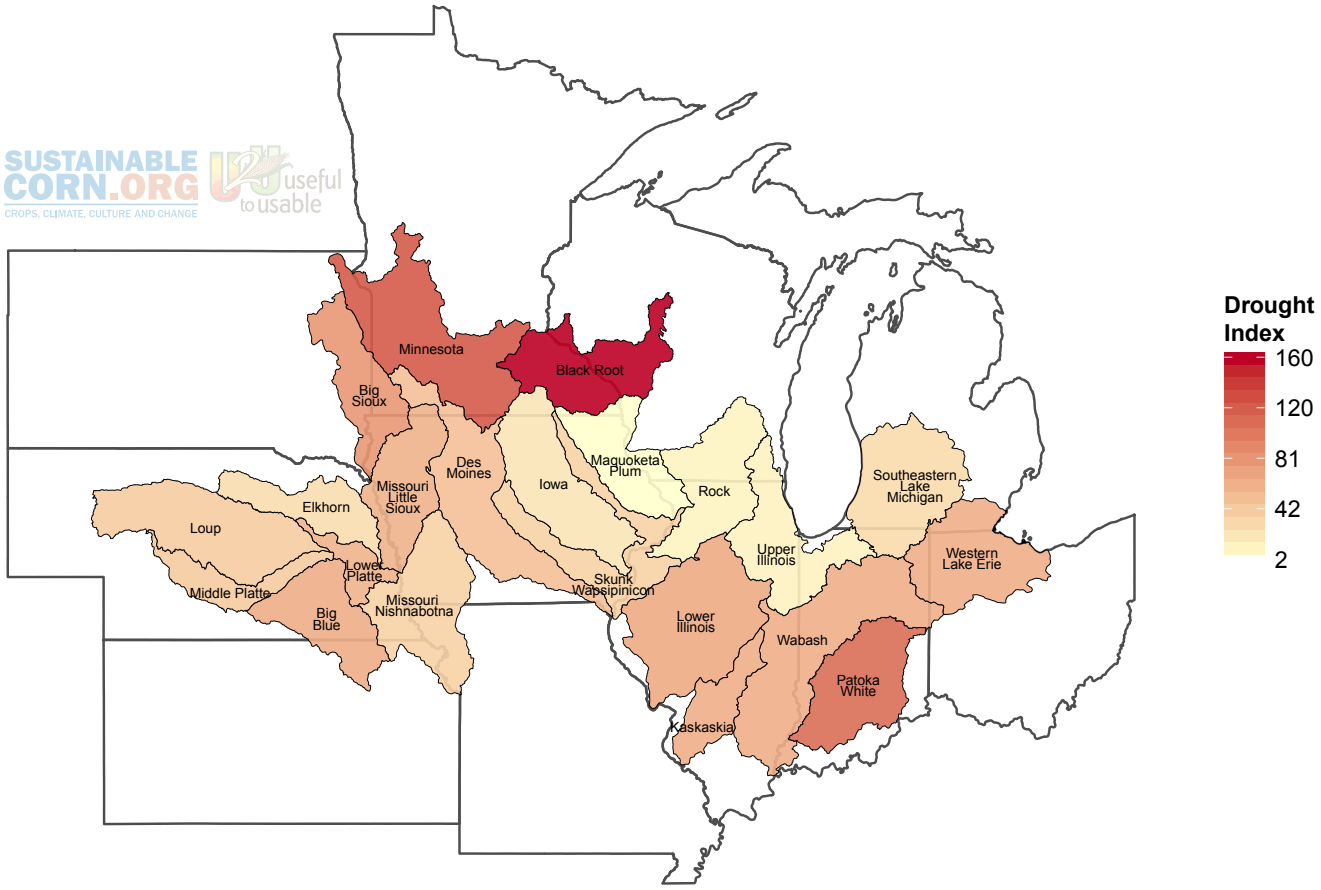

Map 67. Median cumulative drought index for 2007–2011.

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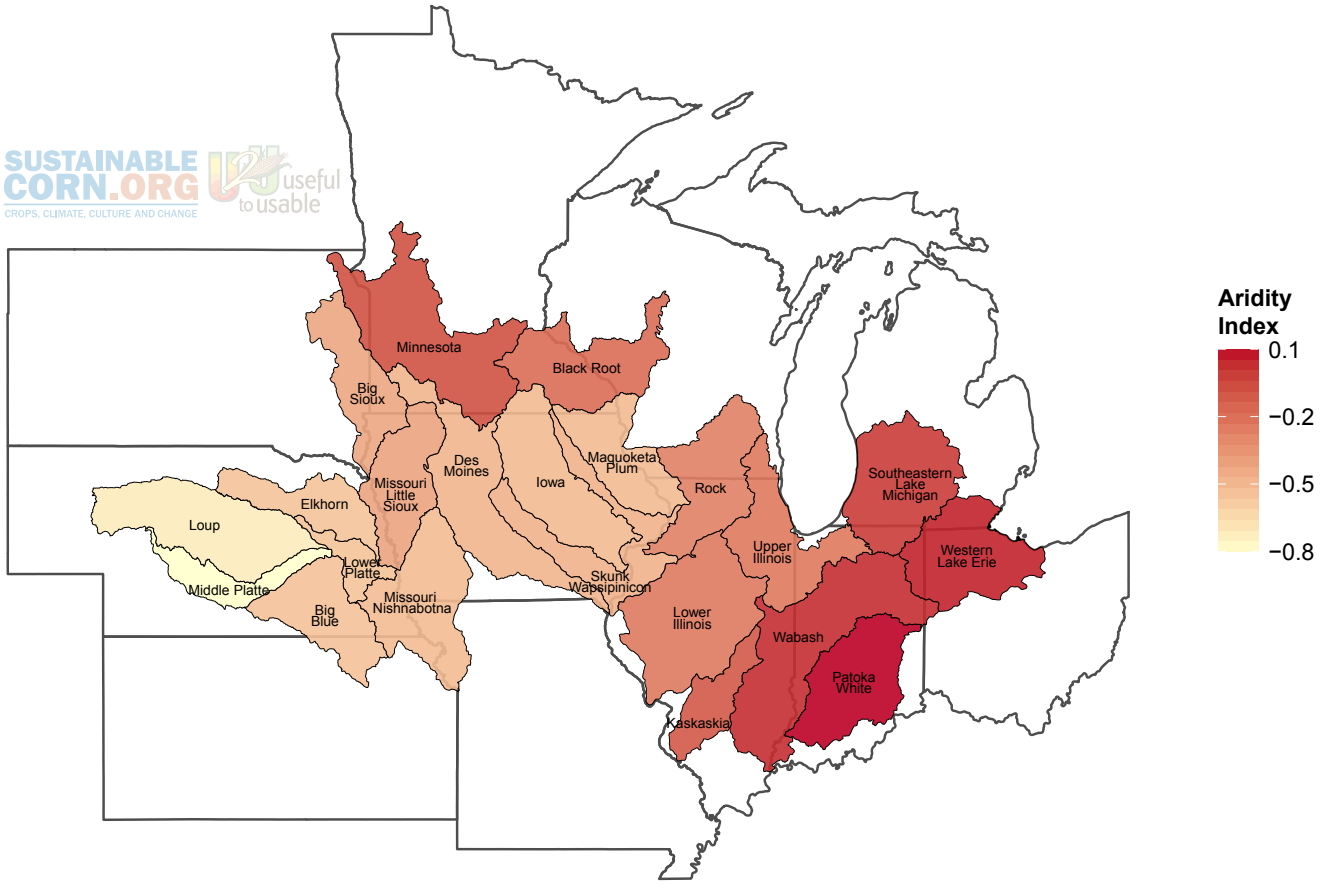

Map 68. Median aridity index for April to September from 2007–2011.

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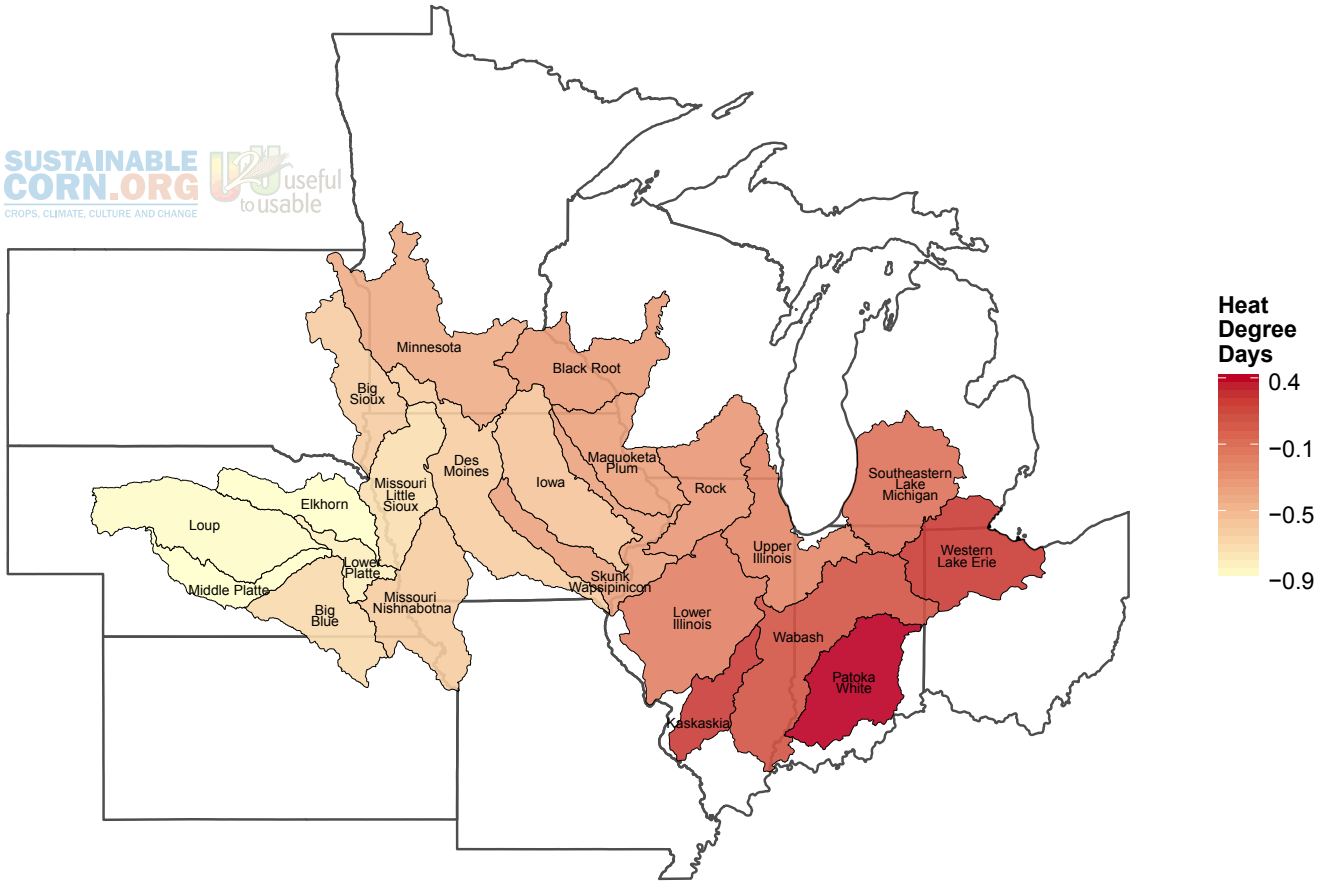

Map 69. Median standardized annual heat stress degree days from 2007–2011.

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