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# AIRCURRENTS: THE 2012 U.S. DROUGHT WORSENS, EXPECTED TO SURPASS 1988 DROUGHT IN INDUSTRY LOSSES

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**EDITOR'S NOTE:** In this article, Dr. Gerhard Zuba and Dr. Oscar Vergara discuss the causes of meteorological, agricultural, and hydrological droughts, how the 2012 U.S. drought developed, what effects it has had on U.S. agriculture, and how it compares with previous droughts.

The U.S. agricultural sector is being affected by the worst drought in a quarter century. The 2012 drought meets the criteria for all three types of drought: meteorological, agricultural, and hydrological,<sup>1</sup> but the primary focus of this article will be on the 2012 agricultural drought, its causes, how it compares with other historic droughts, and what its financial impacts are likely to be. First, though, we begin by defining some terms.

## WHAT CAUSES DROUGHT?

Determining the cause of a drought seems easy—lack of precipitation, which is the main source of soil moisture. Heavy and prolonged rain builds up moisture in the soil, saturating it, then creates runoff that accumulates in lower lying areas, causing floods; lack of precipitation sets in motion a complex reverse process of evaporation and slow depletion of soil moisture.

Time is also an important factor. A brief period without rainfall will not cause plants with deeper roots, such as bushes, trees and most field crops, to suffer negative side effects because they can draw moisture from deeper levels of the soil. But when lack of precipitation is combined with exceptionally high temperatures—which cause increased evaporation from the soil as well as increased plant transpiration (loss of water vapor)—a prolonged dry spell can establish severe drought. The basic ingredients of the general water cycle with respect to plants is depicted in Figure 1.

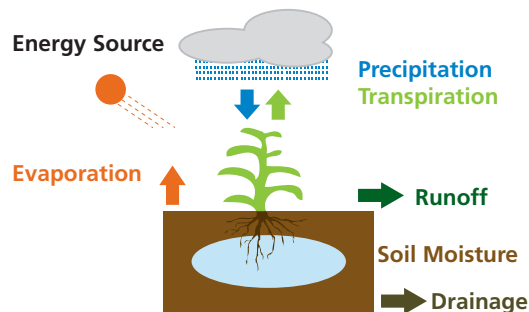


Figure 1. Diagram of the water cycle

**THE ARTICLE:** Describes the meteorological factors that caused the extent of the 2012 U.S. drought and the drought's agricultural and financial impacts.

**HIGHLIGHTS:** Compares this year's drought with those of 1956 and 1988 and discusses the estimated range of insured loss based on take-up rates in the Corn Belt, as well as expected yields for corn and soybeans.

A meteorological drought is defined by the degree of dryness compared to a normal state. The element of time is important here also. Precipitation spread out during a period of months is beneficial to plants, whereas concentrated precipitation within a short period, followed by no precipitation for months can lead to a deficit in soil moisture.

A hydrological drought is defined by the effect of precipitation shortfalls on whole watersheds and streamflows. Water resources become depleted and rivers and reservoirs drop to lower than normal levels. This type of impact is measured by the Palmer Drought Severity Index (PDSI), available from the US Drought Monitor.<sup>2</sup> For the PDSI to return to normal levels, the soil moisture needs to be completely replenished—not only the moisture content of the top soil.

Determining what constitutes an agricultural drought requires the quantification of various linked meteorological characteristics and their impact on agriculture. These characteristics include precipitation shortfalls, high temperatures, soil water deficits, and groundwater levels. The Crop Moisture Index (CMI) available from the National Weather Service Climate Prediction Center (CPC) is based on these parameters.<sup>3</sup> Even though the PDSI is derived from

the CMI, the CMI better reflects moisture supply in the short-term across major crop-producing regions, which makes it more suitable for quantifying potential drought conditions related to agricultural production.

### DEVELOPMENT OF THE 2012 U.S. DROUGHT

The establishment of a severe drought like this year's is a long process. The 2012 drought really began back in the spring of 2011, when conditions in major agricultural regions were the opposite of what they are now. Soil moisture levels at the beginning of the 2011 crop growing season were excessive, so farmers had difficulty getting their machinery into the fields to plant. This resulted in a delayed start to planting, which shortened the 2011 growing season and led to lower-than-expected production.

In Figure 2, the CMI indicates that the Corn Belt had just come out of abnormally wet conditions in July 2011. Later that summer, however, conditions turned dry, causing moisture stress in corn plants. This resulted in below-normal overall corn production for 2011. Figure 2 also shows the exceptional drought that affected Texas in 2011, which resulted in one of the worst years for crop production in the state. It also generated total agricultural losses of USD 7.62 billion<sup>4</sup> and a total payout from crop insurance of USD 2.58 billion, which corresponds to a gross underwriting loss ratio for the industry in Texas of 236%.<sup>5</sup>

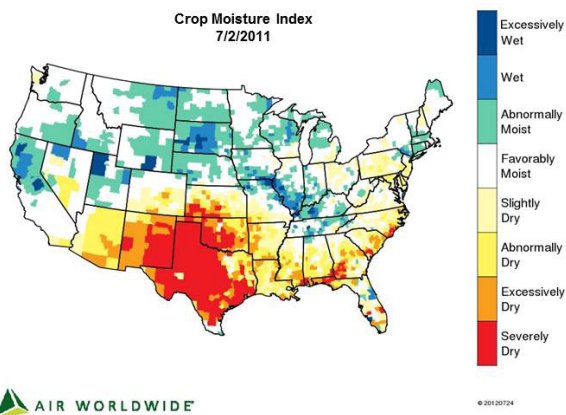


Figure 2. Crop Moisture Index for mid-July 2011 (Source: CPC and AIR)

The dry conditions persisted throughout the winter of 2011/2012 for most of the U.S. The exceptionally warm winter, which brought very little precipitation, meant that soil moisture was not completely replenished in large swaths of the country. Among the corn-producing states, Minnesota was especially hard hit. However, spring rains compensated for the below-normal winter precipitation, and Minnesota now has one of the best outlooks for this season's crop production.

The rest of the country has not fared as well. The warm spring with above normal temperatures led to an early start to the growing season and the chance to extend it, thereby increasing crop production and offsetting 2011's shortfall. But the setup for a perfect 2012 growing season was ruined by lack of further precipitation, which exacerbated the moisture deficit carried over from the dry winter. In combination with below-normal precipitation, temperatures were exceptionally high during the late spring/early summer of 2012, which increased water evaporation and plant transpiration.

Then, July 2012 was recorded as the hottest July since recordkeeping began in 1895.<sup>6</sup> The lack of soil moisture during the late spring and summer set in motion a negative feedback mechanism: lack of evaporating moisture resulted in less humid air, which reduced the development of thunderstorms—part of the natural water cycle. (The lack of thunderstorms also caused fewer tornados as one of the few benefits of very dry conditions.<sup>7</sup>)

Figure 3 shows the current CMI as of August 4, 2012. Interestingly, large parts of Texas and the whole southeastern U.S.—where thunderstorm activity *has* occurred—show normal or even wet conditions. The rest of the country, especially the Corn Belt and the Great Plains states, currently show severe dryness.

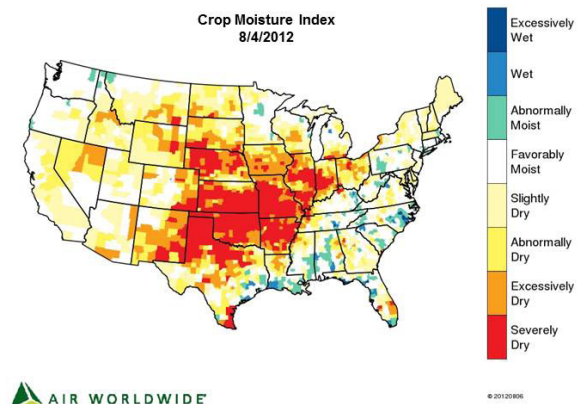


Figure 3. Crop Moisture Index for August 4, 2012 (Source: CPC and AIR)

The drought in the agricultural heartland will not only reduce the crop harvest substantially but will also have a broad ecologic and economic reach. The Mississippi River has dropped more than 40 or 50 feet in some places from near-record high levels during the 2011 Mississippi River Flood.<sup>8</sup> (For more on the 2011 Mississippi River Flood, see CropAlert™ for Week Ending May 20, 2011.) When river levels drop this low, ships cannot load to their full capacity. The river has also narrowed to the point that in some areas only one-way traffic is allowed.

## COMPARING THE 2012 DROUGHT WITH THE DROUGHTS OF 1956 AND 1988

By the end of July 2012, the area of the contiguous U.S. affected by severe to extreme drought increased to 42%, ranking this year's drought the fifth worst since 1895.<sup>9</sup>

The last time there was a drought this severe was in December 1956, when 43% of the contiguous U.S. was in severe to extreme drought.<sup>10</sup> But the 1956 drought had a limited impact on crop production in the Corn Belt. Figure 4 shows how the 1956 drought only fully developed late in the year, at a time when crops had already been harvested.

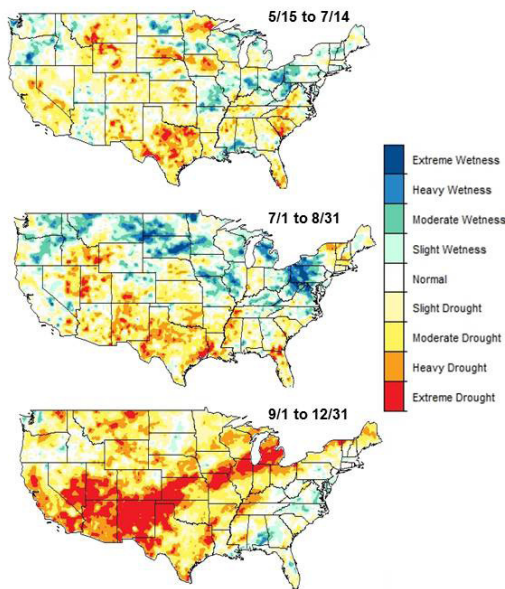


Figure 4. Precipitation Anomalies during 1956, May-July (top), July-August (middle) and September-December (bottom) (Source: CPC and AIR)

The 1988 agricultural drought depicted in Figure 5 was by far the most severe that the U.S. agricultural sector had experienced in the last quarter century—until now. In 1988, precipitation became erratic early in the summer and by mid-July moisture levels were severely depleted in the major corn-producing states, such as Illinois, Indiana, and Minnesota. This is in contrast to 2012 when Minnesota still shows less impact from the current drought. By mid-August the dry conditions also heavily impacted Iowa (Figure 5) and continued to affect the Corn Belt, leading to the worst result of the last 25 years.

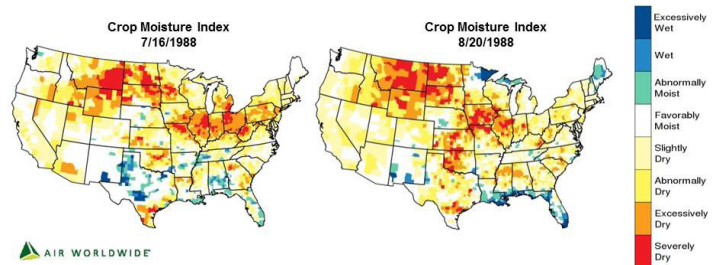


Figure 5. CMI in 1988 mid-July (left panel), mid-August (right panel) (Source: CPC and AIR)

The economic loss of the 1988 drought due to drought/heat was USD 77.6 billion (adjusted to 2012 dollars), making it the second most expensive U.S. weather disaster since 1980. The associated heat wave caused 7,500 deaths.<sup>11</sup>

According to the USDA's Risk Management Agency (RMA), indemnities totaled nearly USD 1.1 billion (in 1988 dollars) and the gross loss ratio for the crop insurance industry was 245%.<sup>12</sup>

## ASSESSING CROP PROGRESS UNDER CURRENT CONDITIONS

There are multiple techniques to monitor crop progress in real time. One technique is to use the Normalized Difference Vegetation Index (NDVI), a satellite-derived measure of how much visible light plants absorb and how much infrared light they reflect. Drought-stressed plants reflect light differently than plants in normal conditions.<sup>13</sup> The advantage of the NDVI is its very high resolution. Another means to assess plant conditions is through surveys such as those performed by the USDA's National Agricultural Statistics Service (NASS) in the form of weekly crop progress reports<sup>14</sup> on a state level resolution. The obvious advantage of this method is that it is a direct measure of plant health and not an indirect one arrived at through modeling deduced value.

AIR uses its Agricultural Weather Index (AWI)<sup>15</sup> model for the assessment of crop progress and yield potential on a local level. The AWI model uses basic input parameters, such as temperature, precipitation, and soil conditions, and their progress during the growing period. The basis of the AWI is a water balance model. For estimating crop yields, the surplus/deficit of soil moisture during the growing season is compared to plant needs and correlated to plant health, then further translated into crop yield potential for corn and soybeans at harvest. Figure 6 shows the AWI-based spatial distribution of corn yield shortfalls as percent of normal for this season (current as of August 4). It is not surprising that the pattern corresponds to the drought monitor's PDSI values as the season-long moisture and heat stress takes its toll on corn plants.

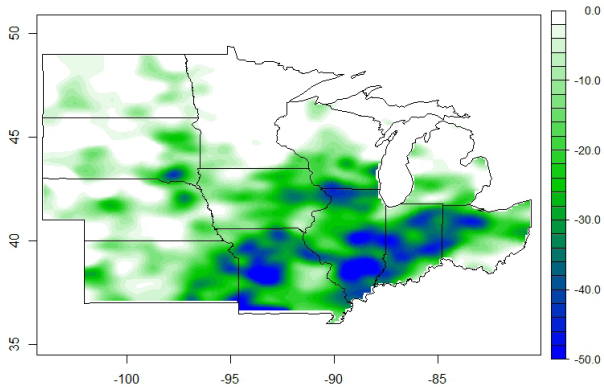


Figure 6. AIR corn yield estimates at harvest as percent deviation from normal in the Corn Belt, as of August 4. White areas are estimated to produce at normal or above normal levels for any corn acreage present in the area (Source: AIR)

### POSSIBLE INFLUENCE OF CLIMATE CHANGE ON DROUGHT FREQUENCY

The relationship between climate change and the frequency of agricultural droughts affecting North America is a topic of lively scientific debate but remains inconclusive. A recent report by the Inter-Governmental Panel on Climate Change (ICPP) states that it is likely that there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights in North America. The report continues by indicating that there is medium confidence that in central North America droughts have become less frequent, less intense, or shorter. The report also indicates that there is medium confidence that droughts will intensify in the 21st century in central North America due to reduced precipitation and/or increased evapotranspiration.

Another report by the Association of British Insurers (ABI) indicates that climate change for the most part may bring benefits to the North American agricultural sector by shifting crop production ranges further north and potentially increasing cereal production by 6 to 9%. Nevertheless, the report also points to an increased potential for droughts in the Great Plains states.

### CROPALERT GROWING CONDITIONS REPORT

During every growing season, AIR issues a monthly CropAlert newsletter that describes the current growing conditions and estimates expected corn and soybean yields at harvest based on the AWI model.

As of August 4, given weather observations, current soil moisture levels and the outlook for the next two weeks, our crop yield model shows a U.S. corn yield estimate at harvest between 131 and 135 bushels per acre. Our current U.S. soybean yield estimate at harvest is between 33.4 and 39.4 bushels per acre.

Figure 7 depicts the deviation of the AWI-based corn and soybean yield estimates from normal values. In this case, “normal” is defined as the median of the detrended time series of historical yield data for eight Corn Belt states and the entire U.S.

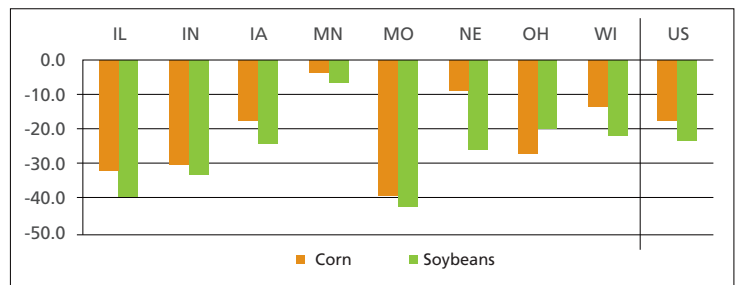


Figure 7. AIR estimates for deviations from normal for corn and soybean yields for selected states and U.S. total

The CropAlert newsletter also includes weather maps of key agro-meteorological variables accumulated on a weekly basis. Figure 8 shows the current (as of August 4) CMI, weekly accumulated precipitation, accumulated growing degree days, and the weekly average temperature anomaly.

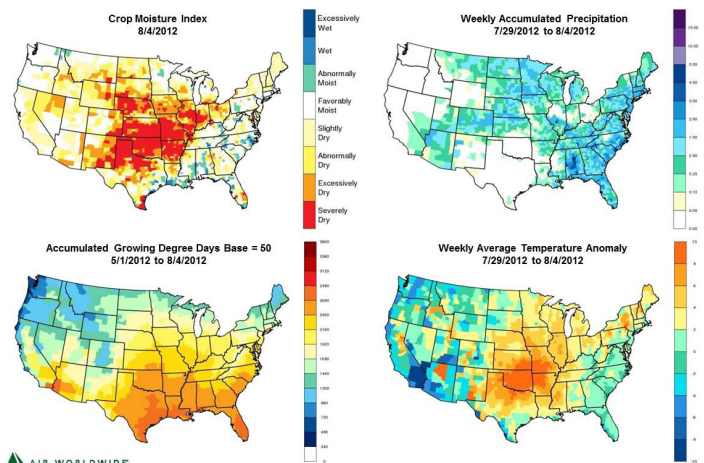


Figure 8. CropAlert agro-meteorological variables for the week of August 4, 2012

## POTENTIAL LOSSES FOR THE CROP INSURANCE INDUSTRY

The drought of 2012 will greatly reduce the harvest of major crops such as corn and soybeans. The AIR model indicates yields as low as 40% below normal. These low yields and the expected shortage at harvest have already increased prices for these commodities. Since planting this spring, corn prices have risen by 142% and soybeans by 127% (as of August 4).

Insurance take-up rates in the Corn Belt are as shown in Table 1. With high prices and high-take-up rates, most farmers will not suffer a loss, as they bought a product that protects them against yield shortfalls; their monetary compensation will be calculated based on the final harvest price in the fall. Typical deductibles with respect to yield shortfalls are between 15 and 50% of their normal production level, but most farmers have a deductible of about 20 to 25%.

Table 1. Typical take-up rates of crop insurance in some of the Corn Belt states (obtained by combining planted acres from NASS and insured acres from RMA for major field crops, values for 2011)

STATE	TAKE-UP RATE
ILLINOIS	79%
INDIANA	74%
IOWA	91%
KANSAS	84%
MICHIGAN	71%
MINNESOTA	94%
MISSISSIPPI	92%
MISSOURI	82%
NEBRASKA	91%
OHIO	74%
OKLAHOMA	70%
WISCONSIN	68%

Insurers will not fare so well. Given the overall reduction in yields, as indicated in Figure 7, many of this year's corn and soybean policies will trigger a loss. Current estimates range from USD 8.8 billion for corn and soybeans alone<sup>16</sup> to USD 20 billion or more for the whole program.<sup>17</sup>

AIR's current (as of August 4) estimate for this year's crop insurance losses for corn and soybeans are calculated by matching this year's (as of August 4) price increases since planting and expected yield shortfalls to those of simulated years from the stochastic catalog of the AIR US MPCI model. These "like events," which also include losses or gains from other regions of the U.S. outside the Corn Belt as well as other crops besides corn and soybeans, point to a gross loss ratio for the whole industry of 120-180%, which translates to payouts of USD 13-20 billion assuming USD 11 billion in total premiums. The exact value of the total premiums for 2012, however, are not yet available. After government recoveries, the total responsibility for the insurance companies will be about USD 11.5-14 billion, again on the basis of USD 11 billion of assumed total premiums for 2012. The upper range is the equivalent of the impact of the drought of 1988 under today's MPCI program.

## CONCLUSION

Although the 2012 growing season began on a very promising note, it became clear by the end of June that the crop insurance industry was facing one of the worst agricultural droughts since 1988. After the hottest July on record, the 2012 drought is now expected to surpass the 1988 drought in terms of industry losses.

Of course, we do not yet know what September will bring. The Agricultural Risk Modeling Team continues to monitor the situation closely and will be issuing CropAlerts with updated information for the remaining months of the 2012 crop growing season.

- <sup>1</sup> [HTTP://WWW.PDC.ORG/WEB/DROUGHT.JSP?SUBG=1](http://www.pdc.org/web/drought.jsp?subg=1)
- <sup>2</sup> [HTTP://DROUGHTMONITOR.UNL.EDU/](http://droughtmonitor.unl.edu/)
- <sup>3</sup> [HTTP://WWW.CPC.NCEP.NOAA.GOV/PRODUCTS/ANALYSIS\\_MONITORING/REGIONAL\\_MONITORING/CFI.GIF](http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/cmi.gif)
- <sup>4</sup> [HTTP://AGECOEXT.TAMU.EDU/FILEADMIN/USER\\_UPLOAD/DOCUMENTS/RESOURCES/PUBLICATIONS/BRIEFINGPAPER09-01-11.PDF](http://agecoext.tamu.edu/fileadmin/user_upload/documents/resources/publications/briefingpaper09-01-11.pdf)
- <sup>5</sup> [HTTP://WWW3.RMA.USDA.GOV/APPS/SOB/CURRENT\\_WEEK/STATE2011.PDF](http://www3.rma.usda.gov/apps/sob/current_week/state2011.pdf)
- <sup>6</sup> [HTTP://WWW.WEATHER.COM/NEWS/NOAA-REPORT-JULY-20120808](http://www.weather.com/news/noaa-report-july-20120808)
- <sup>7</sup> [HTTP://NEWS.YAHOO.COM/DROUGHT-HELPS-SET-JULY-RECORD-FEWEST-TORNADOES-173943151.HTML](http://news.yahoo.com/drought-helps-set-july-record-fewest-tornadoes-173943151.html)
- <sup>8</sup> NATIONAL WEATHER SERVICE-ADVANCED HYDROLOGIC PREDICTION SERVICE
- <sup>9</sup> [HTTP://WWW.WUNDERGROUND.COM/BLOG/JEFFMASTERS/COMMENT.HTML?ENTRYNUM=2157](http://www.wunderground.com/blog/jeffmasters/comment.html?entrynum=2157)
- <sup>10</sup> [HTTP://WWW.NCDC.NOAA.GOV/BILLIONS/](http://www.ncdc.noaa.gov/billions/)
- <sup>11</sup> GLAUBER, JOSEPH W. 2004, "CROP INSURANCE RECONSIDERED," AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS, 5, 1179-1195
- <sup>12</sup> [HTTP://EARTHOBSERVATORY.NASA.GOV/IOTD/VIEW.PHP?ID=78553](http://earthobservatory.nasa.gov/iotd/view.php?id=78553)
- <sup>13</sup> [HTTP://WWW.NASS.USDA.GOV/PUBLICATIONS/NATIONAL\\_CROP\\_PROGRESS/INDEX.ASP](http://www.nass.usda.gov/publications/national_crop_progress/index.asp)
- <sup>14</sup> [HTTP://AGECONSEARCH.UMN.EDU/BITSTREAM/35613/1/SP05ZU01.PDF](http://ageconsearch.umn.edu/bitstream/35613/1/SP05ZU01.pdf)
- <sup>15</sup> [HTTP://INSIGHT.MILLIMAN.COM/ARTICLE.PHP?CNTID=8130](http://insight.milliman.com/article.php?cntid=8130)
- <sup>16</sup> [HTTP://WWW.HARTFORDBUSINESS.COM/APPS/PBCS.DLL/ARTICLE?AID=/20120803/NEWS02/120809916](http://www.hartfordbusiness.com/apps/pbcs.dll/article?aid=/20120803/NEWS02/120809916)

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