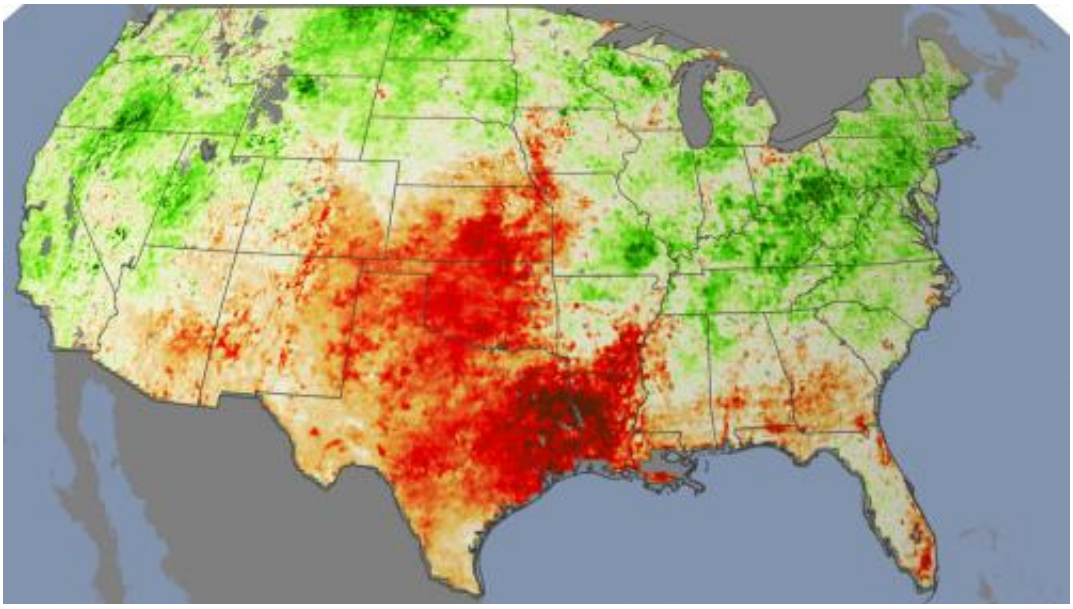
Plant stress paints early picture of drought

December 5 2012



Plant stress on June 24, 2011, (top) indicated significant drought in southern US states. Credit: NASA/Goddard Scientific Visualization Studio/USDA-ARS

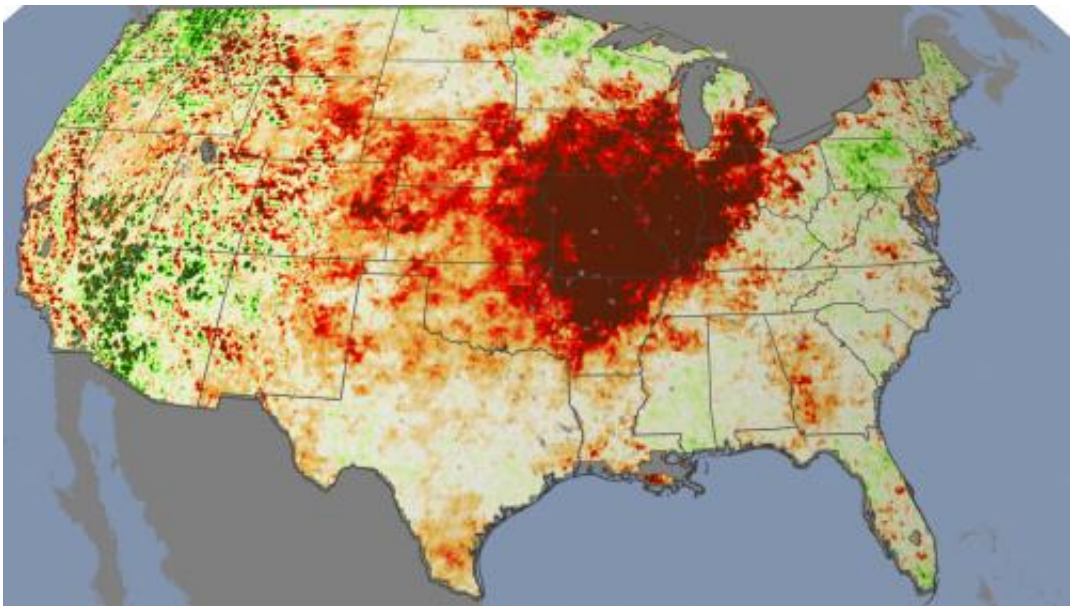
In July 2012, farmers in the U.S. Midwest and Plains regions watched crops wilt and die after a stretch of unusually low precipitation and high temperatures. Before a lack of rain and record-breaking heat signaled a problem, however, scientists observed another indication of drought in data from NASA and NOAA satellites: plant stress.

Healthy vegetation requires a certain amount of water from the soil every day to stay alive, and when soil moisture falls below adequate levels, plants become stressed. Scientists with the U.S. Department of

Agriculture's Agricultural Research Service (USDA-ARS) have developed a way to use satellite data to map that plant stress. The maps could soon aid in drought forecasts, and prove useful for applications such as crop yield estimates or decisions about crop loss compensation.

"Crop drought monitoring is of high practical value, and any advance notice of drought conditions helps the farmer make practical decisions sooner," says Steve Running, an ecologist at University of Montana in Missoula.

A new animation of plant stress (top) shows how drought evolved across the United States from January 2010 through September 2012. In spring 2010, satellites measured cool leaf temperatures, indicating healthy plants and wetter-than-average conditions (green), over many areas across the country. By summer 2011, satellites saw the warming of stressed vegetation, indicating significantly lower-than-usual water availability (red) in many areas, most notably in Texas. Crops were either dead or would soon be dead.



Plant stress on Aug. 28, 2012, indicated significant drought in the US Midwest.

Credit: NASA/Goddard Scientific Visualization Studio/USDA-ARS

Drought in 2012 was the most severe and extensive in at least 25 years, according to the USDA's Economic Research Service. By August 60 percent of farms were in areas experiencing drought, and by mid-September USDA had designated more than 2,000 counties as disaster areas. "2012 was record-breaking, this was just a huge event," says Martha Anderson with USDA-ARS in Beltsville, Md., who is working with a team to develop the plant stress indicator for drought and presented the research Dec. 5, at the American Geophysical Union meeting in San Francisco.

The 2012 event is what experts call a flash drought, meaning that it evolved quickly and unexpectedly. Low soil moisture was further depleted by the heat wave that started in May, and drought abruptly followed. By about May 5 the core regions of drought began to appear on the plant stress map – earlier than the signs of drought appeared in other indicators, such as rainfall measurements.

"We think there's some early-warning potential with these plant stress maps, alerting us as the crops start to run out of water," Anderson says. Signals of plant stress may often appear first in satellite-derived maps of vegetation temperature before the crops have actually started to wilt and die. "The earlier we can learn things are turning south, presumably the more time we have to prepare for whatever actions might be taken."

For example, farmers may decide they need to buy supplemental feed from outside the drought-affected area to support their livestock, or they may need to adjust contract or insurance decisions.

The U.S. Drought Monitor already uses a combination of indices, such

as rainfall, to describe drought conditions each week. The monitor currently does not include plant stress, but the potential is being explored. "Plant stress is one representation of drought impacts, and the drought monitoring community agrees that you can't do this with just one tool – you need a lot of different tools," Anderson says.

Plant stress information has the potential to improve the skill of existing forecasts that predict drought out to weeks or months. Also, because the plant stress information is derived from satellites, it can describe drought conditions in areas where rain gauge and radar networks are sparse—and it can do so at the scale of individual fields.

To produce the maps of plant stress, scientists start with the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites. Images are processed to distinguish between land surfaces covered by soil and surfaces covered with vegetation.

Narrowing their focus to vegetated areas, scientists set out to measure moisture availability. Plants cool themselves by sweating water extracted from the soil by their roots. When access to water is limited, plants lessen their consumption and reduce evapotranspiration from leaf surfaces. As a result, leaves heat up and produce an elevated leaf or canopy temperature, which can be detected by thermal sensors on NOAA's geostationary weather satellites. Hotter plants imply limited water in the soil.

"This is not a drought forecast. It's a map of what's going on right now," Anderson says. "Is there more or less water than usual?"

What is "usual" or normal, however, can depend on the season or even the year. Scientists currently define normal by calculating and mapping plant stress averaged over periods of 1-3 months, from the start of MODIS data collection in 2000 to present. The mean of these historic

maps is considered normal. Compare a current map with the longer-term "normal" map, and scientists get a picture of the magnitude by which current conditions deviate from normal.

"What was normal back in 1920 is not what's normal now, so the more years we have under the belt the better we can define normal," Anderson says. "But this year is so far out of line with respect to previous years, it is unusual regardless of the period of record used as the baseline."

Provided by NASA's Goddard Space Flight Center