FOOD

Monitoring Crops from Space: A Decades-Long Partnership

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From George Washington to Abraham Lincoln, early U.S. presidents struggled to determine the value and extent of U.S. agriculture—then the country's primary economic engine. Despite Washington's best efforts, the U.S. did not have an annual agricultural survey until Abraham Lincoln established the Department of Agriculture in 1862. In the Department's first agricultural status report, issued on July 10, 1863, chief statistician Isaac Newton explained the need for crop information:

"Ignorance of the state of our crops invariably leads to speculation, in which oftentimes, the farmer does not obtain just prices…and the consumer is not benefited." (Quoted in The Story of U.S. Agricultural Estimates, pg. 23)

Today, the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) continues to publish regular crop reports to "provide objective and unbiased statistics on a preannounced schedule that is fair and impartial to all market participants," according to its mission statement.

"Since the agency was established in 1863, we have been mandated to determine agricultural production to feed the population and maintain food security," says Rick Mueller, head of the spatial analysis research division at NASS. "Today, the crop reports encourage calm in the market place and fair and equal play for all."

From the beginning, the challenge in producing the monthly crop reports lay in collecting consistent, accurate crop figures from farmers (who underestimated crop production in fear of higher taxes) and, later, designated county-level agriculture representatives. For this reason, NASS became an early proponent of launching a satellite to observe Earth's land. A satellite can provide an entirely impartial accounting of crop ▸

Photo Information

Below: US farmers produce about $100 billion in crops every year making food more affordable in the US than in any other developed country. Credits: previous full page photo, samott; below Natalie Maynor; above, USDA.

Image Information

Landsat 5 acquired this image of farms near Garden City, Kansas on August 14, 2011. Traditional rectangular fields are being overtaken by the circles formed by center-pivot irrigation.

area and health. The service formed a remote sensing branch in 1968—four years before NASA launched the nation's first land-observing satellite, Landsat 1. In the decades since, the U.S. Department of Agriculture has been one of Landsat's primary users.

Landsat and Agriculture

"Landsat is beneficial to NASS because it provides a mechanism to enhance the statistics. We blend information from the satellite data with survey data," says Mueller. Using Landsat data, crop analysts can estimate the aerial extent of fields planted with corn, soybeans, hay, wheat, rice and other crops.

Landsat is useful to crop analysts because of the wavelengths of light it records and because of its resolution. The Landsat satellites measure reflected visible light just like our eyes do, but the satellites also record additional wavelengths of infrared light that people can't see. Each crop reflects light uniquely, giving analysts the ability to differentiate crops. In addition, reflected infrared light provides information about the water content and physiological status of plants, allowing analysts to assess crop health and productivity.

Landsat's resolution [level of detail] is also critical for crop monitoring. Like choosing between a zoom lens and a wide-angle lens on a camera, satellites can observe the Earth in detail while seeing a narrow swath of ground, or they can see a wider area in less detail. Landsat splits the difference. Each pixel in a Landsat image shows an area about the size of a baseball diamond, 30 meters by 30 meters, and each image shows a swath of ground that is about 185 kilometers wide—a wide enough area to make regional crop monitoring feasible. This means that Landsat data can be used to estimate how large an area has been planted in specific crops.

Production, the amount of a particular crop harvested, is calculated by multiplying crop area by yield. Landsat provides area, while other satellite instruments, such as the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua and Terra satellites, can measure daily crop health, from which yield can be calculated.

USDA also uses other Landsat-like satellites to calculate area, but Landsat provides a unique historical record. "Landsat has a known predicted orbit that systematically repeats," says Mueller. This means that a single point on the ground will be in the same place in every Landsat scene, making it possible to track change in agricultural land from year to year since 1972. Landsat 8 is continuing that record into the future.

The Power of Free Data

While Landsat provides a powerful tool, it took time for NASS to use the information extensively because of the computing power required to process and composite Landsat scenes. In addition to the effort involved, Landsat data once cost several hundred dollars per scene, forcing NASS to focus their efforts on key crop-growing regions in the Midwestern United States. All of that changed in early 2009 when the United States Geological Survey, which archives and distributes Landsat data, began distributing the data free of charge.

"When the USGS announced the free data policy, that was a game changer. It allowed us to expand our monitoring program across the whole country," says Mueller. In January 2011, NASS released CropScape, an interactive web visualization portal that shows where crops were grown in the continental US during the previous year. Based partly on Landsat data, the annual crop maps are available in select states dating back to 1997, providing an easy method to make comparisons. "Now we can provide Landsat-based crop data for the entire country to anyone anywhere in the world," says Mueller. It is the most extensive, detailed geospatially based ▸

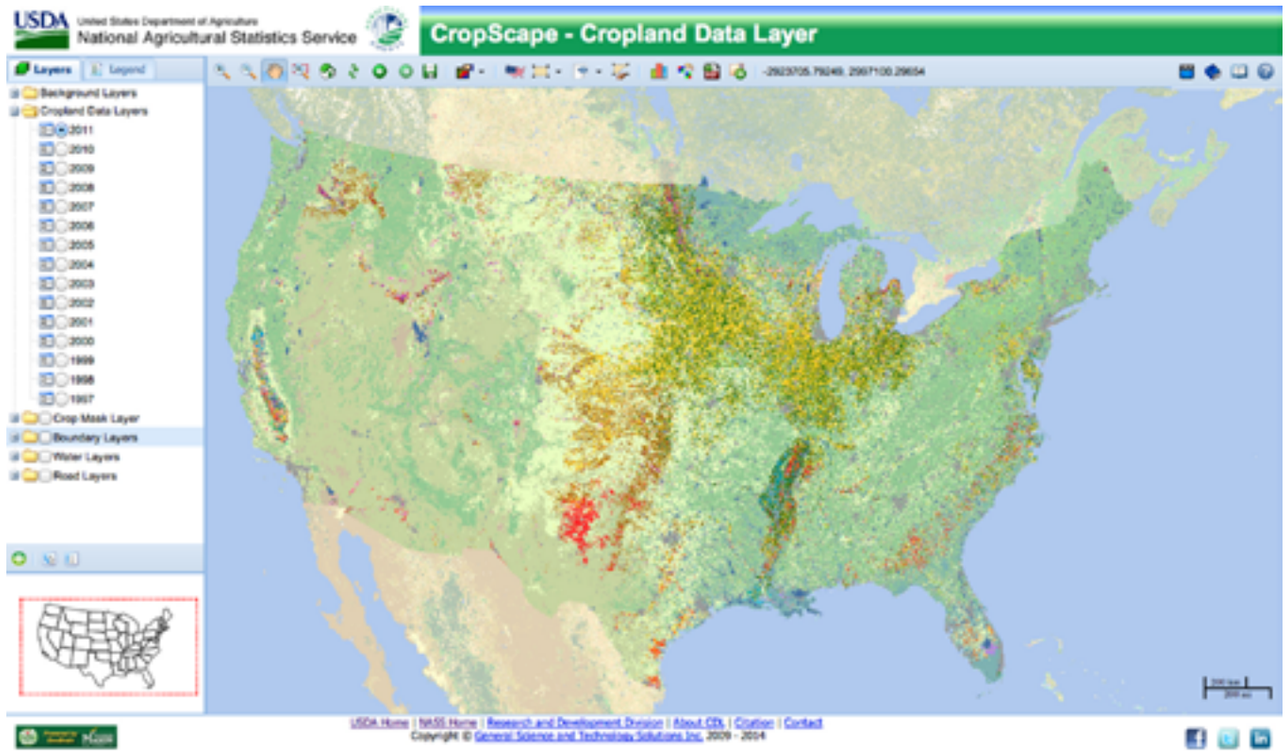
crop map produced by any nation, and it is available three months after harvest.

The Landsat-based crop maps are compared to ground-based observations reported through surveys, providing robust validation, says Mueller. Outside the United States, where little ground data are available, satellite observations become even more critical. The necessity of independent satellite observations became starkly clear in the 1970s.

Foreign Agricultural Service

In the early 1970s, world wheat harvests failed. But in the United States, crops were very productive, leading to a large stockpile. Before the United States realized that there was a global shortage, the Soviet Union bought 15 million tons of wheat at low prices. This left the United States and other countries with a shortage and drove up the cost of wheat 200 to 350 percent.

Determined to not to be blindsided again, the USDA established a global crop surveillance and reporting system in the Foreign Agricultural Service. Using satellites allowed them to monitor crops globally, even in Russia and China during the Cold War. The information provides price stability. ▸



CropScape displays crop production data in a map interface.

Photo Information

Above: In the early 1970s, U.S. wheat farms were productive, while in Asia they failed. The Soviet Union took advantage of low prices to purchase a large amount of wheat, upsetting world markets and giving the U.S. a significant disadvantage in the price it could charge for its wheat.

Left: Subsequently the USDA established a global crop surveillance and reporting system that now utilizes satellites to monitor crop production around the world and keep prices stable for consumers.
Credit: Above, Grecaud Paul; Immediate Left, Amy Jeffries; Following full-page photo, Bob Nichols, USDA.

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That price stability matters because agriculture is still the base of world economies. Food prices affect each of us—from the leader of a nation trying to grow a national economy to the small-time family farmer trying to make a living or the parent trying to feed a family.

Learn More:

Landsat - Protecting the Price of Bread
http://landsat.gsfc.nasa.gov/news/news-archive/soc_0010.html

CropScape
http://nassgeodata.gmu.edu/CropScape/

Meet Rick Mueller, Spatial Analyst with the U.S. Department of Agriculture

Rick Mueller
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Rick Mueller sees the world in pictures. As a mapmaker, he joined the National Agricultural Statistics Service just as the group was starting to use satellite images and geospatial data to supplement large data tables of crop statistics. "Seeing the potential of satellite imagery to communicate crop extent was inspiring," says Mueller.

Mueller graduated from the University of Maryland College Park with a degree in geography. He began his career at the National Oceanic and Atmospheric Administration as a cartographer working on aeronautical charts. After six and a half years, he returned to school to get a master's degree in business from Johns Hopkins University.

When Mueller began working for the National Agricultural Statistics Service (NASS) in 1993, it was natural for him to think about transforming the table-based crop statistical reports into graphical mapping products. "I was interested in developing a product that leveraged the power of the GIS (geographic information systems) to the world."

As Mueller moved from analyst to manager while at NASS, he saw technology develop enough to make his vision possible. Computer processing power advanced, satellite data became more abundant and now freely accessible, and mapping software became more powerful and sophisticated. Working with a team of geographers, statisticians, and information technology experts, Mueller led the development of CropScape, a powerful online mapping tool that allows anyone to explore crop information by location.

"We now have a cool way of disseminating data. No other country is doing this quite like us!" says Mueller.

Satellite Data Requirements:

- 8-day revisit (5-7 day preferred)
- 30 m resolution
- Vis, NIR, SWIR
- Global coverage
- Archive continuity & consistency
- Rapid delivery of free, unrestricted data
- Coregistered geolocation