Number 387
February 1, 2013

1. Fallow efficiency: Measuring the value of fallow

Fallow periods are perceived by some to be an inefficient use of land in western Kansas cropping systems. Others view fallow as a valuable means of ensuring dryland crop yields. Taking a long-term view, what is the overall value of fallow? How is fallow efficiency (precipitation storage efficiency) determined?

Fallow efficiency is simple to define. It is the gain in soil water over the fallow period -- that is, from crop harvest to planting of the following crop -- divided by the total precipitation received during that time. Soil water is normally measured to the depth of 5 feet to determine fallow efficiency. Additionally, measurements of fallow efficiency are best taken in silt loam soils. Sandy soils do not store enough water to be effective in typical rotations that include fallow, and poor water infiltration is often a confounding problem on clay soils.

Fallow efficiency is not one set number. It will vary among different areas because of soil types and precipitation patterns, and for different tillage systems and crop rotations.

Determining fallow efficiency: Step 1 – Precipitation records

The first step in estimating fallow efficiency for your particular situation is to add up the total amount of precipitation that occurs during the fallow months of the rotation you're in, using long-term precipitation averages for your county.

To illustrate this, we can use the average precipitation totals by month for 1895-2012 at Goodland:

Goodland, Kansas 6/1/1895 to 4/30/2012: Average precipitation (inches)												
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
0.33	0.47	1.05	1.63	2.83	2.88	2.89	2.47	1.37	1.13	0.61	0.47	18.14

Which months should we use to calculate the amount of precipitation during fallow periods? Two common types of fallow rotations are used below as examples: wheat/summer row crop/fallow and wheat/fallow. In this example, corn is used as the summer row crop. Similar results would be obtained with other summer row crop choices, such as grain sorghum or sunflowers.

A. Wheat/Corn/Fallow (3 years)

Wheat, growing crop	October – June	9 months	11.40 inches
Fallow (no crop)	July – April	10 months	12.42 inches
Corn, growing crop	May – mid-Sept	4.5 months	11.755 inches
Fallow (no crop)	Mid-Sept – September	12.5 months	18.825 inches
3-year total			54.40 inches

Inches of precipitation during fallow = (12.42 + 18.825) = 31.245
% of precipitation during fallow = 31.245/54.4 = 57.4%
% of precipitation during crop = 23.155/54.4 = 42.6%

B. Wheat/Fallow (2 years)

Wheat, growing crop	October – June	9 months	11.40 inches
Fallow (no crop)	July through the following September	15 months	24.87 inches
2-year total			36.27 inches

Inches of precipitation during fallow = 24.87
% of precipitation during fallow = 24.87/36.27 = 68.6%
% of precipitation during crop = 11.40/36.27 = 31.4%

In comparing these two fallow-based rotations, surprisingly the percentage of time the land is in fallow and in growing crops with the two rotations is the same.

Wheat/corn/fallow:
% of months in fallow: (10 + 12.5)/36 = 62.5%
% of months in crop: (9 + 4.5)/36 = 37.5%

Wheat/fallow:
% of months in fallow: 15/24 = 62.5%
% of months in crop: 9/24 = 37.5%

But the growing crops in the wheat/corn/fallow rotation receive 42.6 percent of the total precipitation during the 3-year period. In the wheat/fallow rotation, the growing crop received only 31.4% percent of the total precipitation during the 2-year period. This is one positive contributor to the fact that the wheat/corn/fallow rotation often has more total crop productivity than the wheat/fallow rotation.

Determining fallow efficiency: Step 2 – Water storage research results

Fallow efficiency is calculated by dividing the inches of soil water stored during fallow by the average inches of precipitation received during the fallow period, so the next step is to come up with a good number to use for the amount of water stored during the fallow period. There have been many years of research on this at different locations and using different tillage systems, and the results have contained much variability. Because of this variability, fallow efficiency is an estimate and not a definite number. However, water storage efficiency patterns are evident.

The inches of soil water stored during fallow in one given location depends largely on the tillage system used, the amount of residue on the soil surface, the crop rotation, soil type, precipitation pattern, and length of fallow phases. Water storage during fallow is also affected by weed growth and the presence of plow pans and compacted zones.

The following chart shows the average soil water storage during fallow in a stubble mulch tillage system at four locations in the western Great Plains, and at four levels of initial surface mulch after wheat harvest, based on USDA-ARS research data.

Soil water storage during fallow as influenced by surface mulch level after harvest					
		Tons of surface mulch per acre after harvest			
		0	1	2	3
Location	No. of years tested	Inches of soil water stored during fallow			
Bushland, Tex.	3	2.8	3.9	3.9	4.2
Akron, Colo.	6	5.3	5.9	6.5	7.3
North Platte, Neb.	7	6.5	7.6	8.5	9.2
Sidney, Mont.	4	2.1	2.7	3.7	4.0
Average		4.2	5.0	5.7	6.2

Source: “Reducing Drought Effects on Croplands in the West Central Great Plains,” USDA Agriculture Information Bulletin No. 420, 1979

Here is how we would calculate fallow efficiency in a wheat/fallow system at Goodland, using the average water storage figures above:

* 0 tons surface mulch (tillage and no surface mulch): The average gain in stored soil water during the fallow period is 4.2 inches. The amount of precipitation received during the 15 months of fallow in a wheat/fallow rotation is 24.87 inches.
Fallow efficiency = 4.2/24.87 = 17%

* 3 tons per acre surface mulch (tillage and initial surface mulch of 3 tons per acre): The average gain in stored soil water during the fallow period is 6.2 inches.
Fallow efficiency = 6.2/24.87 = 25%

* No-till: Additional research, explained below, has determined that the average gain in stored soil water during fallow is about 8.2 inches.
Fallow efficiency = 8.2/24.87 = 33%

The figure of 8.2 inches of stored soil water gain in no-till is derived from a paper by K-State researchers Loyd Stone and Alan Schlegel (Stone, L.R. and A.J. Schlegel. 2006.

Yield-water supply relationships of grain sorghum and winter wheat. Agron. J. 98:1359-1366). This paper cited studies from the west central Great Plains showing that the additional gain in soil water during fallow in a no-till system compared with a stubble-mulch tilled system is about 2.0 inches at planting (in a wheat/fallow cropping system).

If the 2.0 inches of additional gain with no-till is added to the 6.2 inch value of the stubble mulch tillage system, the profile soil water gain would be 8.2 inches with no-till.

So at Goodland, fallow efficiency in a wheat/fallow system could be expected to range from 17 to 33 percent, depending on the amount of residue cover and tillage system.

Fallow efficiency, water storage, and yields

Although the estimated fallow efficiency for wheat/fallow in our example is "only" 17 to 33 percent, that still represents between 4.2 (with tillage and no residue) and 8.2 inches (with no-till and residue maintained) of available soil water for the next wheat crop. This can add considerably to the wheat yield.

Figuring long-term wheat yield response to available soil water at emergence of 3.7 bushels per acre per inch (as determined in the Stone and Schlegel Agronomy Journal article noted earlier), those 4.2 and 8.2 inches of stored soil water would translate to an additional grain yield of about 15 bushels per acre in clean till and 30 bushels in no-till.

Of course, if rainfall is limited in a particular growing season, the grain yield increase from the stored available soil water would likely be less than the long-term data would indicate.

Other considerations regarding water use and fallow

The maximum storage efficiency during fallow even if all conditions were perfect in a wheat/fallow cropping system is only about 40%, being ultimately controlled by the water storage capacity of the soil profile. A silt loam soil can hold about 2 inches of available water per foot of soil. In a 5-foot profile, that would be 10 inches of water. In the no-till wheat/fallow example above from Goodland, the gain in stored soil water during the fallow period is 8.2 inches out of the 24.87 inches it received (33%). At most, the soil could store 10 inches out of the 24.87 inches it received (40%).

That means that at least 60%, and almost surely more, of the precipitation during the fallow period is lost to evaporation, transpiration, leaching, or runoff. To utilize part of that lost moisture, a cash crop or cover crop could be grown in a continuous cropping system instead of wheat/fallow. But cash crops in the continuous cropping system would likely have lower yields (or possibly no yield at all). Also, the additional or second-year wheat crop in a continuous cropping system will utilize soil water as opposed to a fallow period which increases soil water. The ultimate comparison of profitability of these two systems (fallow vs. continuous cropping) will depend on predicted rainfall amounts and patterns, expected yields, and variable costs of productions -- and is beyond the scope of this article.

Cover crops can be used as a fallow replacement, but they also use up soil moisture through transpiration. K-State research at the Southwest Research-Extension Center by John Holman, and earlier research by Alan Schlegel and John Havlin, has found that all cover crops among those tested resulted in reduced soil available soil water at wheat planting time in western Kansas, and reduced wheat yields compared to wheat/fallow systems. In Holman's research, he found that certain cover crops can still increase profits compared to wheat fallow, but only if the cover crops are harvested for forage.

The bottom line

The main take-home message is that although the fallow period in a no-till wheat/fallow system stores only about 33 percent of the precipitation received in western Kansas, this still increases soil water storage enough to increase wheat yields every other year considerably, at least with somewhat normal rainfall amounts.

If we were to go back through the analysis above and calculate fallow efficiency and inches of stored water during fallow for a wheat/summer crop/fallow rotation instead of wheat/fallow, we would find that on the average the fallow efficiency is greater for the wheat/summer crop/fallow system.

That is a primary reason for reducing the length of the fallow phase, as is done in shifting from wheat/fallow to wheat/summer crop/fallow. It may not always be successful, however, since extreme heat and drought during the summer crop phase of that rotation can severely reduce yields of the summer crop, as happened in many cases in 2011 and 2012. There are no guarantees in farming.

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2. Next generation soybean breeding: Phenotyping using spectral analysis

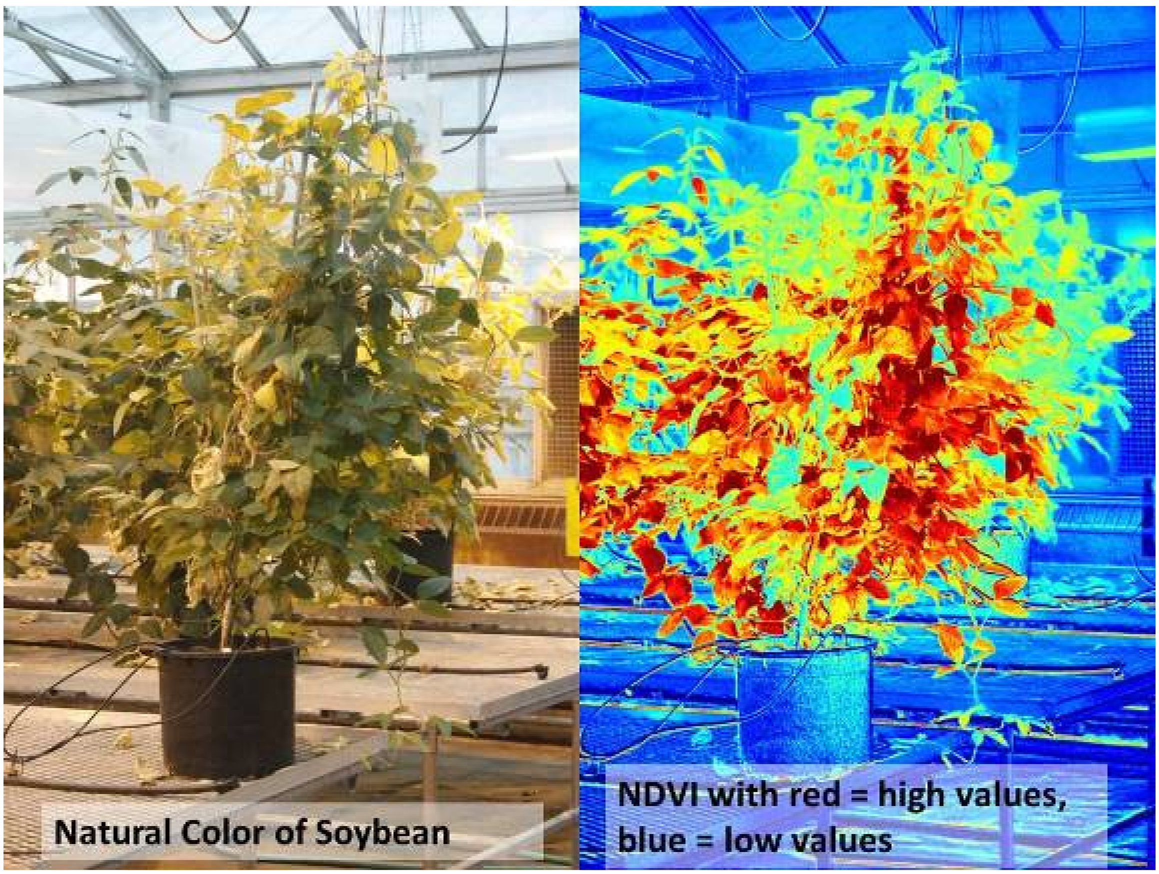
The K-State soybean breeding program has teamed up with the spectral analysis lab of Dr. Kevin Price, professor of agronomy, to explore ways to increase the efficiency of the soybean breeding line selection process.

The most time-consuming and expensive aspect of our breeding program at K-State is in harvesting the many thousands of early generation lines, weighing the seed, and determining yield. The early screening stage of the breeding process also takes up a lot of acreage.

If we can find a way to separate out 50 percent or more of the very-low-yielding lines without the need to combine harvest and weigh the seed, that would reduce the time and cost of our breeding program considerably.

Spectral analysis is being used in the Agronomy Department at K-State to determine the level of photosynthetic activity of vegetation in many different situations. We decided to work with Dr. Price's spectral analysis team to try using this new technology in our soybean breeding nursery. The goal was to find out how effective this technology might be in predicting yields, stress tolerance, and disease resistance as a way to eliminate unpromising lines early in the process.

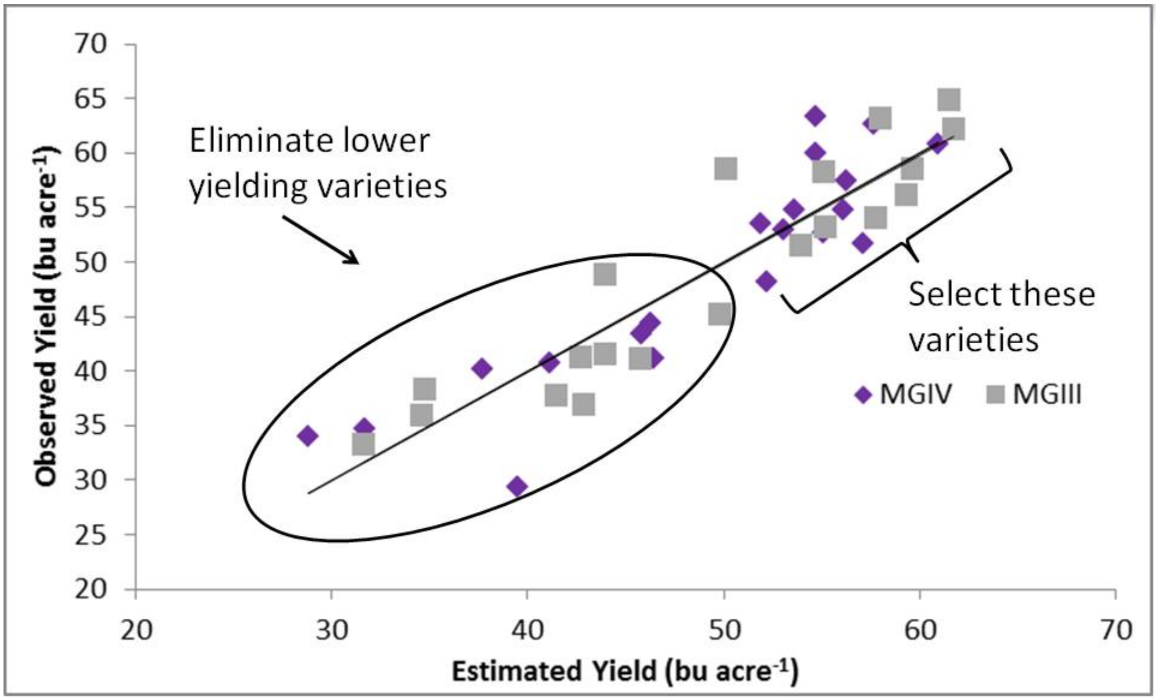
To do this, we used a ground-based spectroradiometer to gather spectral data at various stages of growth, and correlated the results with actual yield data. We have spent the last two years trying to determine exactly what data to collect and how often, and whether any of the spectral regions being measured would have a good correlation to yield. Spectral analysis doesn't have to be accurate enough to separate lines with a yield difference of just 1 or 2 bushels per acre. If it can separate lines with a yield difference of 5 to 10 bushels, that would be a great help in the preliminary stages of line evaluation.



The image above illustrates the difference between what a person sees when looking at a soybean plant (left), and one of the ways spectral analysis can present the same plant. In this case, the plant on the right is presented using NDVI readings. NDVI is a ratio: (Near Infrared – Red)/(Near Infrared + Red). Photo by Kevin Price, K-State Research and Extension.

With financial support from the Kansas Soybean Commission, during the past two years, we have been testing this technology. A ground-based spectroradiometer has been gathering wavelength data in both the visible and infrared spectrums, resulting in thousands of pieces of data on each genotype.

We have a “training” population of different soybean varieties we are using to develop models from the spectral data we have collected to help us predict the phenotype, or performance of a variety. We intentionally selected varieties known to have a large difference in yield potential for this initial testing phase.



Bill Schapaugh, Nathan Keep, Brent Christenson, Kevin Price, Nan An, Vara Prasad, Hatice Aslan
Agronomy Dept.

K·STATE Research and Extension
Kansas Soybean Commission
Knowledge for Life

The graph above is the result of one model that graduate student Brent Christensen has developed comparing actual yields to yields predicted by the model. On the X axis is estimated yield based only on spectral data using the model. On the Y axis is the actual seed yield at harvest. Each box on the graph represents a Group III variety. Each diamond represents a Group IV variety.

If the model was predicting yields perfectly using the spectral data, all the boxes and diamonds would fall on the line. They don’t, but in most cases the estimated yield is fairly close to the predicted yield.

With this model, and using only the spectral data taken at the seed fill stage to make selections, we would have retained all of the highest yielding varieties by selecting the best half.

If we can repeat the kind of results we have achieved in the training population with experimental varieties from other populations, the precision should be accurate enough to cull out lines having a low yield potential at the earliest stage of evaluation. If we can discard low-yielding lines without having to harvest them and weigh the seed for yields, this will have tremendous value to the breeding program in terms of saving time, space, and money.

We only have two years of data so far. We are expanding our research into this new technology, developing more robust models, using different types of sensors, adding genotypes, and evaluating the methods of measurement. Also, this summer, we will test the use of aerial sensors in addition to the ground-based sensors.

Our goal is to be able to use spectral analysis to achieve a dramatic reduction in the cost of producing a unit gain in yield potential, and the results so far are promising.

This technology is also being evaluated for its ability to detect yield differences in wheat genotypes, in the program of USDA-ARS wheat geneticist Dr. Jesse Poland.

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3. Regional Sorghum Schools scheduled at six locations in February

Sorghum production and profitability will be the focus of six regional in-depth Sorghum Schools around the state. The one-day schools will cover a number of issues facing sorghum growers: sorghum for risk management; importance of sorghum for the ethanol industry; sorghum irrigation management (at selected locations); weed control strategies, herbicide resistant weeds; and planting, fertility, and insect management.

The schools, sponsored by the Kansas Grain Sorghum Commission and the United Sorghum Checkoff Program, and supported by Bayer CropScience and KFRM 550 AM Radio, each begin with registration at 9 a.m. The program starts at 9:30 a.m. Lunch is included at each location. The program will wrap up by mid-afternoon.

Regions, dates, and locations include:
Central/North Central – Feb. 5, Saline County Fairgrounds 4-H Building, Salina
South Central – Feb. 6, Kiowa County Fairgrounds, 720 North Bay St., Greensburg
Central – Feb. 7, United Methodist Church, 905 East D Street, Hillsboro
Northwest – Feb. 12 NW KS Educational Service Center, 703 West 2nd St., Oakley
West Central – Feb. 13, Greeley County Fairgrounds 4-H Building, Tribune
Southwest – Feb. 14 Grant Co. Civic Center, 1000 West Patterson, Ulysses

Certification credits have been approved for:

* CCA credits: 2 Crop Management, 2 IPM, 1 Nutrient Management, 1 Water Management, and 0.5 Professional Development
* Commercial Applicator Pesticide Recertification Credits: 2

Participants are asked to register for the sorghum school of their choosing by two days before the school they plan to attend, either by contacting their local K-State Research and Extension office or online at:
http://2013sorghumschools.eventbrite.com

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4. Comparative Vegetation Condition Report: January 15 – 28

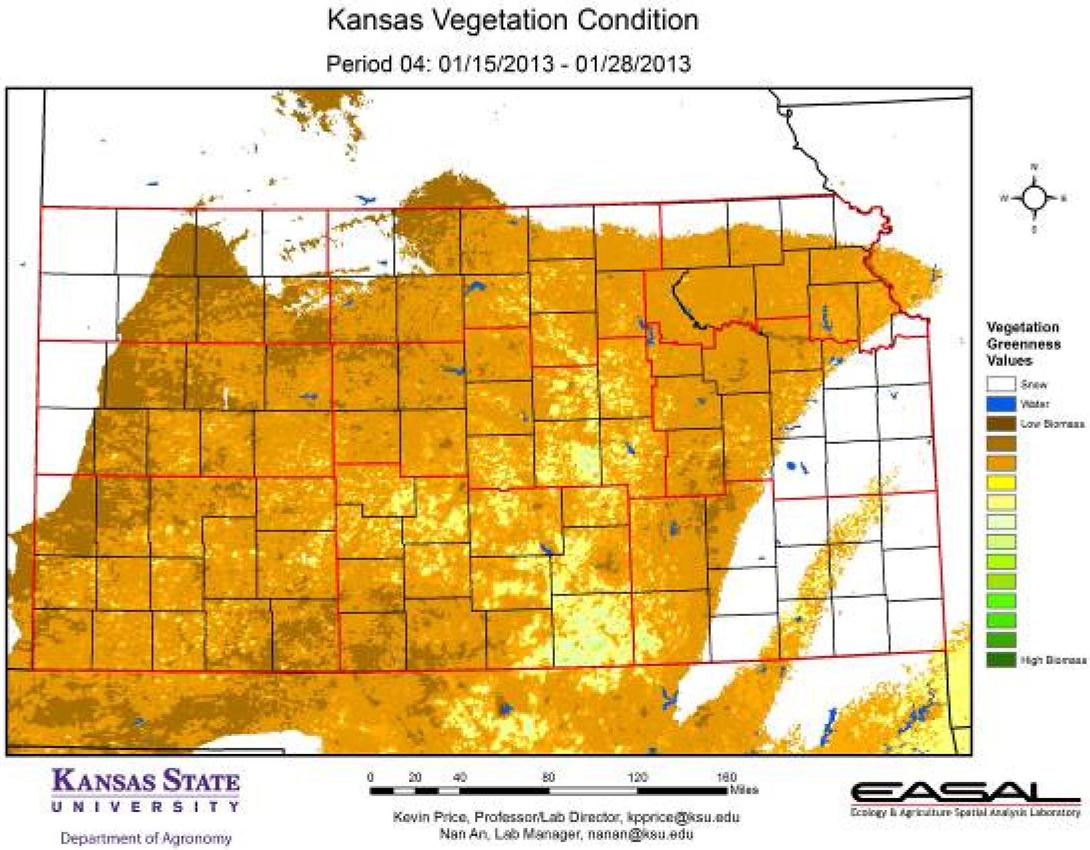
K-State's Ecology and Agriculture Spatial Analysis Laboratory (EASAL) produces weekly Vegetation Condition Report maps. These maps can be a valuable tool for making crop selection and marketing decisions.

Two short videos of Dr. Kevin Price explaining the development of these maps can be viewed on YouTube at:
http://www.youtube.com/watch?v=CRP3Y5NIggw
http://www.youtube.com/watch?v=tUdOK94efxc

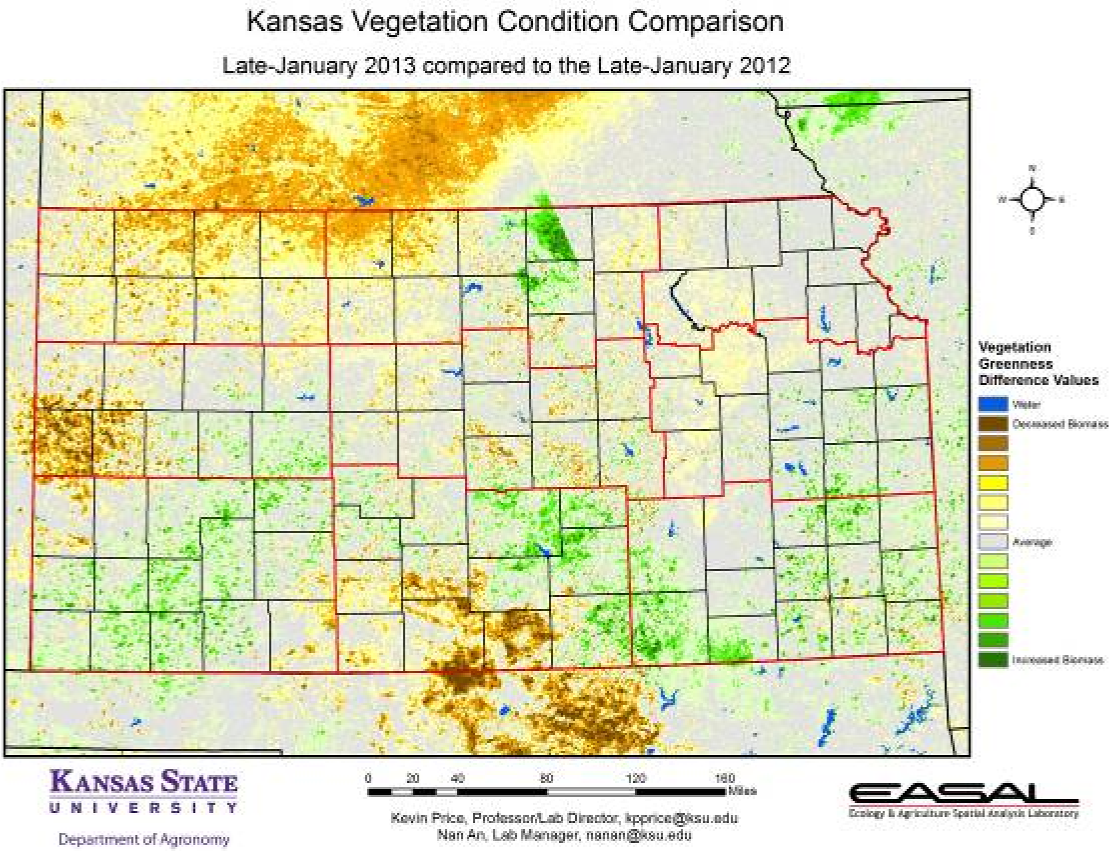
The objective of these reports is to provide users with a means of assessing the relative condition of crops and grassland. The maps can be used to assess current plant growth rates, as well as comparisons to the previous year and relative to the 24-year average. The report is used by individual farmers and ranchers, the commodities market, and political leaders for assessing factors such as production potential and drought impact across their state.

NOTE TO READERS: The maps below represent a subset of the maps available from the EASAL group. If you'd like digital copies of the entire map series please contact Kevin Price at kpprice@ksu.edu and we can place you on our email list to receive the entire dataset each week as they are produced. The maps are normally first available on Wednesday of each week, unless there is a delay in the posting of the data by EROS Data Center where we obtain the raw data used to make the maps. These maps are provided for free as a service of the Department of Agronomy and K-State Research and Extension.

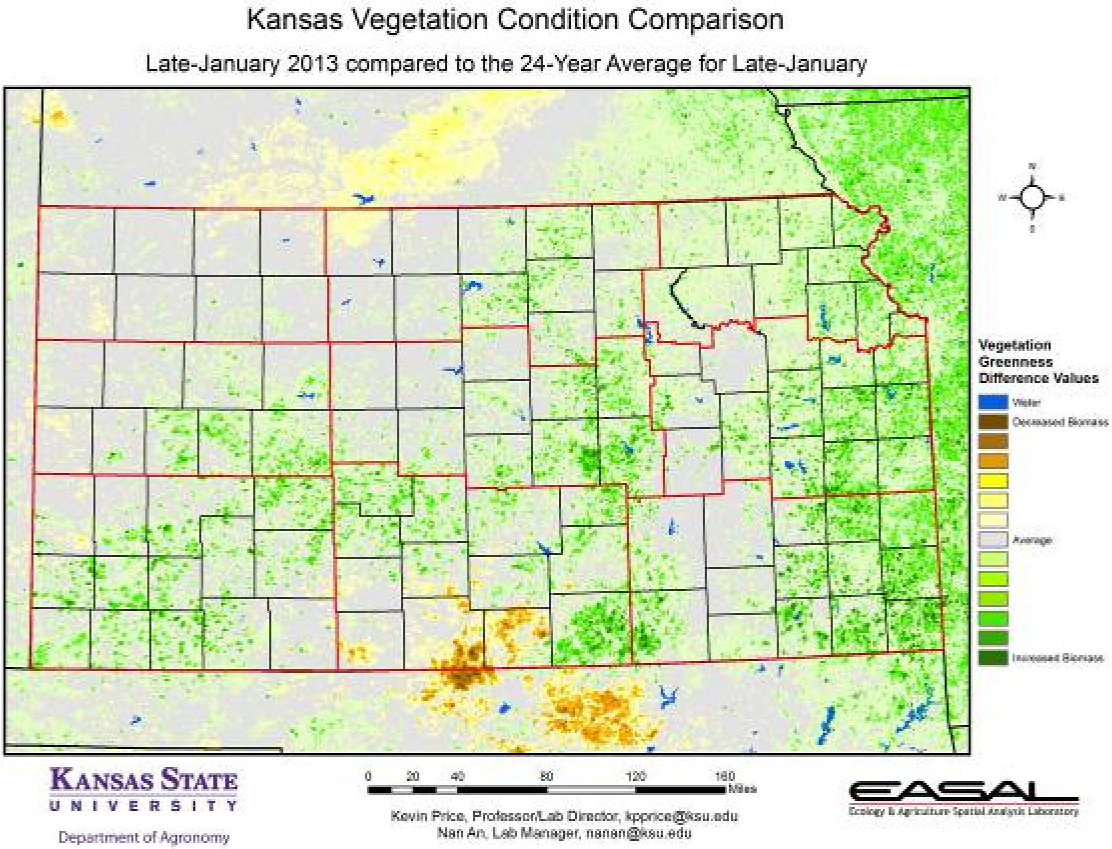
The maps in this issue of the newsletter show the current state of photosynthetic activity in Kansas, the Corn Belt, and the continental U.S, with comments from Mary Knapp, state climatologist:



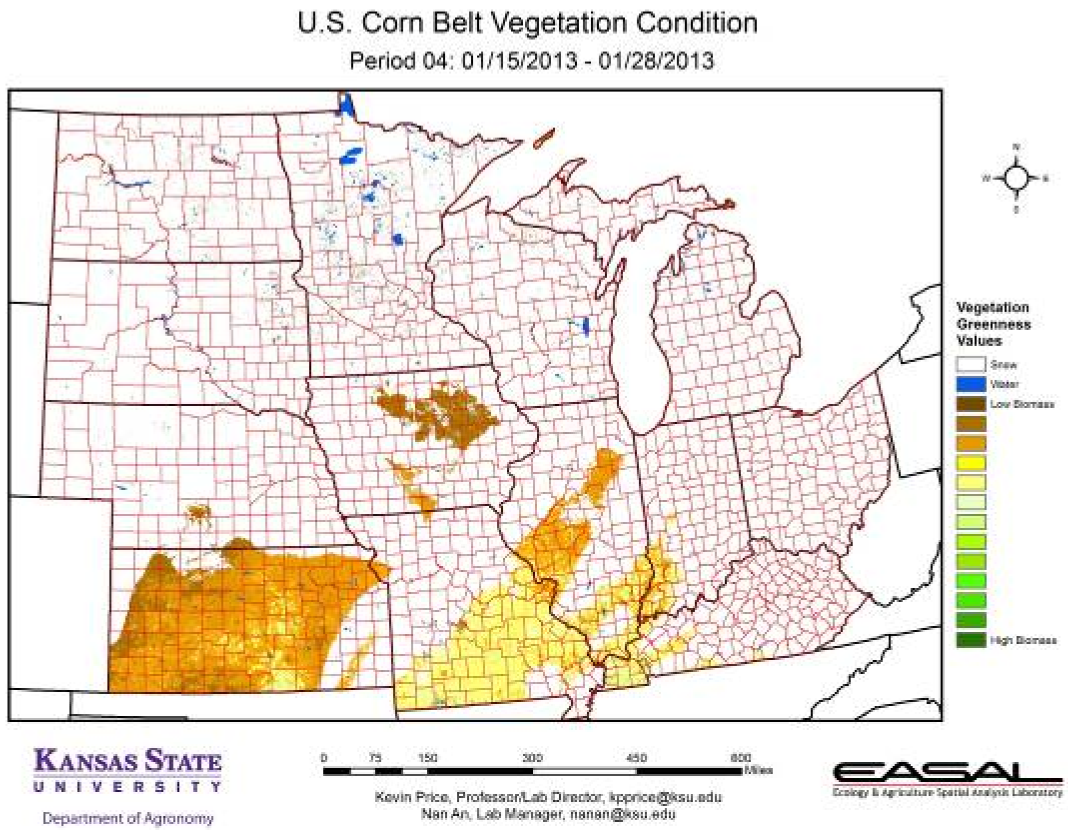
Map 1. The Vegetation Condition Report for Kansas for January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that the fringes of the state had the snow during this two-week period. In most cases, the snow totals were light and contributed little to the overall moisture. It is interesting to note the very narrow slot from south central to east central Kansas which did not have snow during the period.



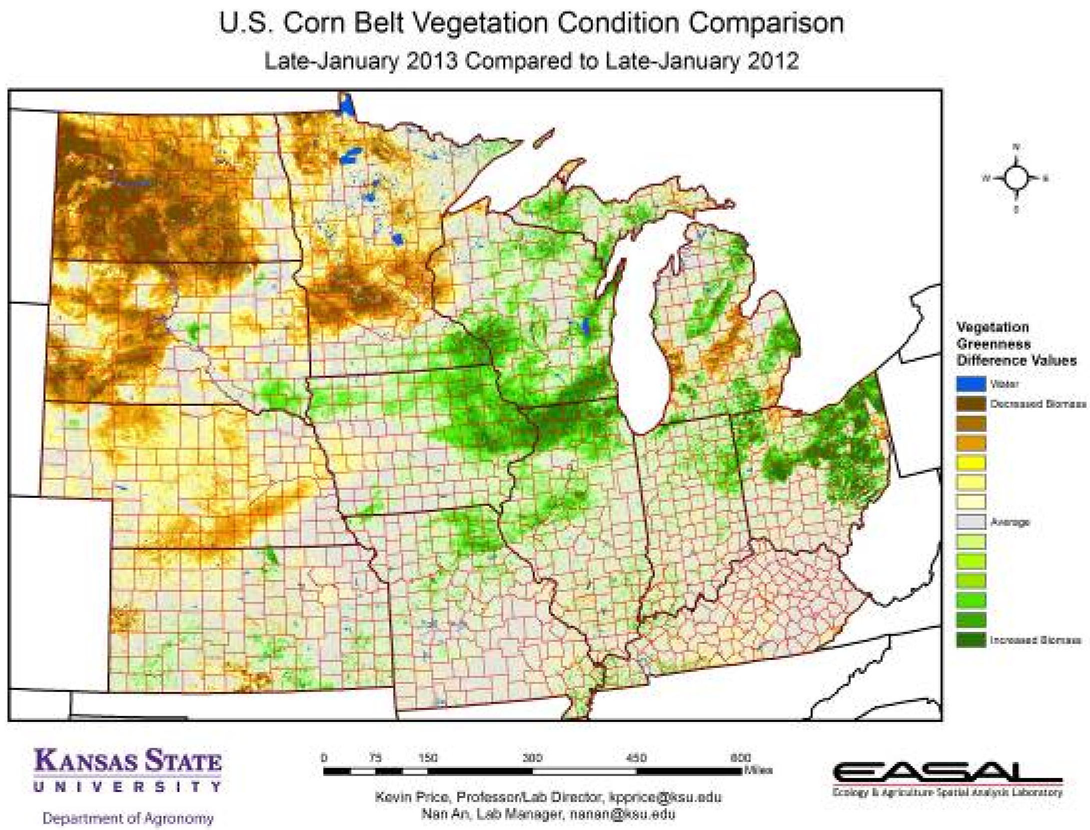
Map 2. Compared to the previous year at this time for Kansas, the current Vegetation Condition Report for September January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that the greatest departures can be seen in Greeley and Wichita counties in west central Kansas, as well as Barber and Harper counties in south central Kansas. Low moisture levels continue to dominate these areas.



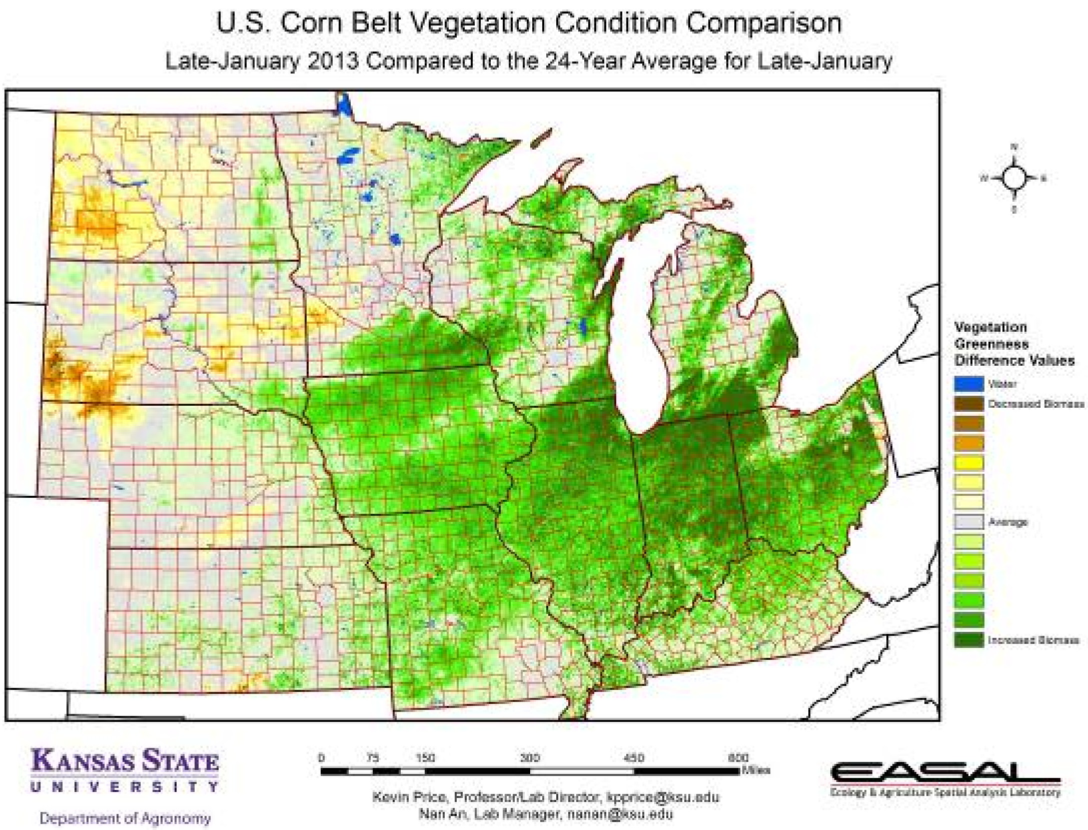
Map 3. Compared to the 24-year average at this time for Kansas, this year's Vegetation Condition Report for January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows much of the state has above average NDVI values. This continues to follow a southwest to northeast gradient. Warmer-than-average temperatures have predominated south of that line. Harper and Barber counties continue to be exceptions, due mainly to their continued dryness. This lower photosynthetic activity is beginning to develop in Comanche County as well.



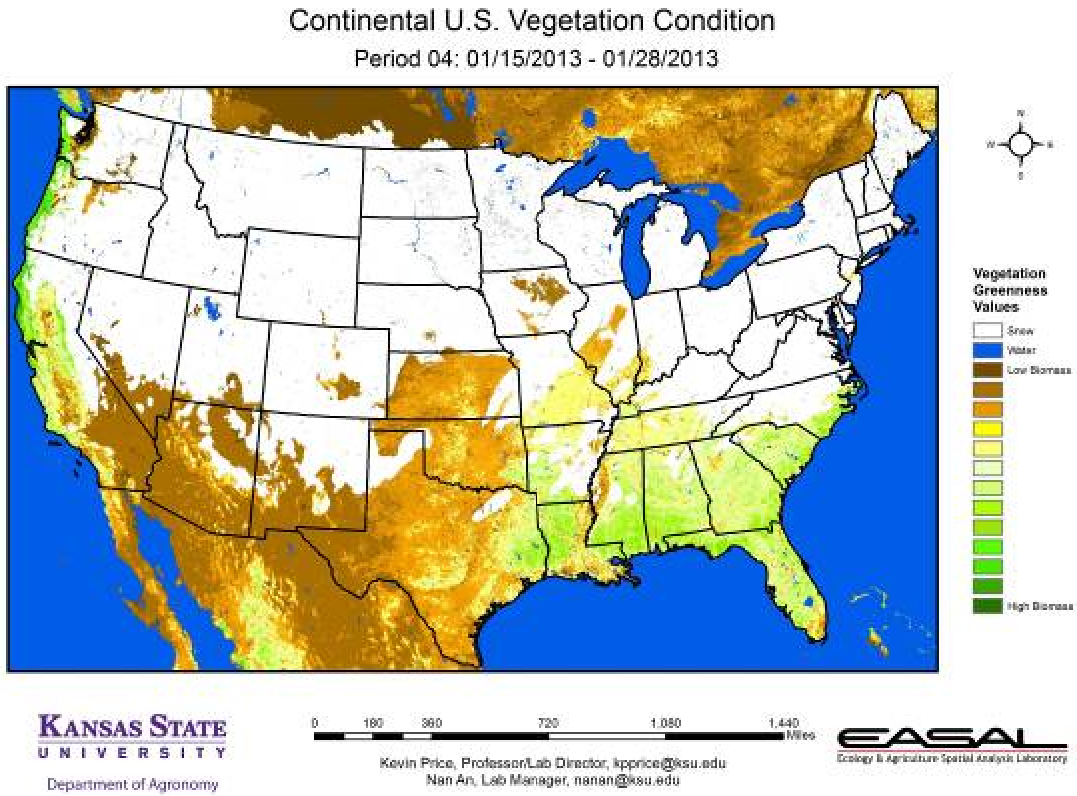
Map 4. The Vegetation Condition Report for the Corn Belt for January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that a significant area of north central Iowa remained snow-free during the period. That is unusual for the region. Snow-free areas from central Illinois to southwestern Missouri are less uncommon. Despite the lack of snow, these areas did experience significant moisture.



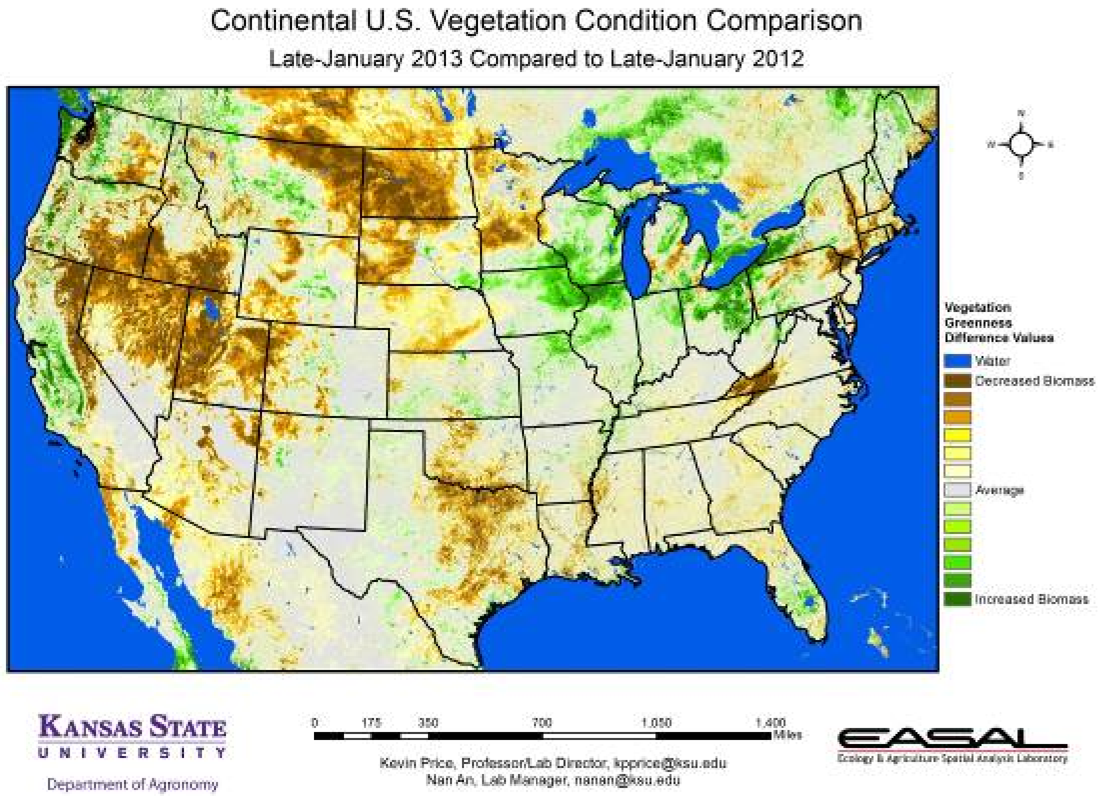
Map 5. The comparison to last year in the Corn Belt for the period January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows much lower NDVI values in the northwestern areas of the region. In these areas, cold temperatures and persistent snow have reduced photosynthetic activity. In Nebraska, the biggest deterrent has been the extremely dry conditions.



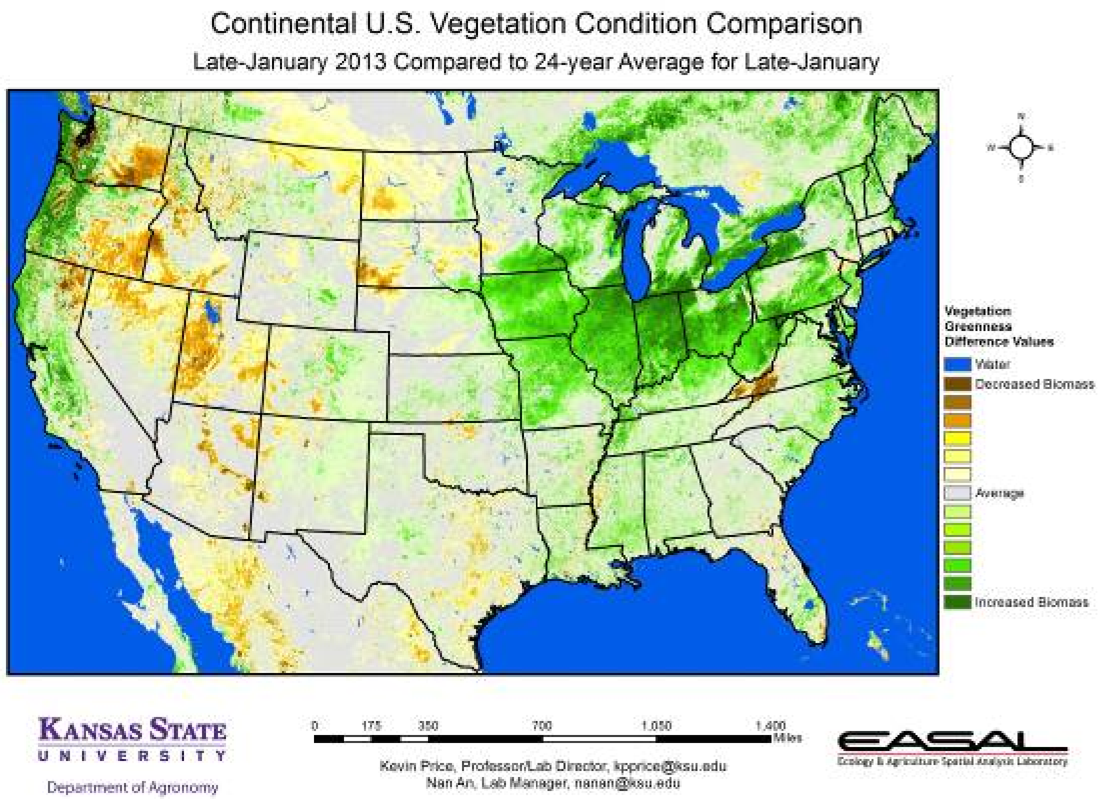
Map 6. Compared to the 24-year average at this time for the Corn Belt, this year's Vegetation Condition Report for January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows much-above-average NDVI values in the eastern Corn Belt. In these areas milder-than-average temperatures plus adequate moisture has favored higher-than-average photosynthetic activity.



Map 7. The Vegetation Condition Report for the U.S. for January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that snow dominated the northern half of the continental U.S. Slight amounts were seen in the higher elevations of Arkansas, northern Alabama, and Georgia.



Map 8. The U.S. comparison to last year at this time for the period January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that central Texas has less biomass production. Meanwhile, higher NDVI values can be seen along the Pacific Northwest into central California. These regions have experienced favorable moisture for much of the season.



Map 9. The U.S. comparison to the 24-year average for the period January 15 – 28 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that the Pacific Northwest into central California have much-above-average photosynthetic values, as does the Upper Midwest. In Central Illinois, January precipitation is as much as 4 inches above average, while temperatures averaged almost 2 degrees above normal.

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Steve Watson, 785-532-7105 swatson@ksu.edu, Jim Shroyer, Crop Production Specialist 785-532-0397 jshroyer@ksu.edu, or Curtis Thompson, Extension Agronomy State Leader and Weed Management Specialist 785-532-3444 cthompso@ksu.edu.