extension AGRONOMY e-Updates

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1. Liming no-till soils

Before producers convert a field to long-term no-till, they often apply and incorporate lime if the soil test shows a need for it. That's because it is not possible to incorporate lime after the field has been converted to no-till, unless the producer is willing to do some rotational tillage.

But several years after the initial lime application, it is not unusual for the soil pH to decline again, especially in the upper 2 to 3 inches of soil. Why is that?

Some of the factors include rainfall and root activity, which is related to crop productivity. But these factors act relatively slowly over time, and have very little short-term effect on pH. The most significant factor that causes soil acidity is the process of nitrification. The article below (No. 2) goes into more detail on this process.

In no-till, all or part of the nitrogen fertilizer is often surface-applied. As nitrification occurs year after year in the upper layers of the soil, this will lower the pH significantly. As a general rule, for every 100 pounds of N fertilizer applied, 500 pounds of "typical" agricultural lime will be needed to neutralize the acidity produced from nitrification.

When the pH gets too low for optimal crop production, lime must be applied to reduce the effect of toxic aluminum on plant roots, to maintain good conditions for microbial activity, and to get the best performance from some of the soil-applied herbicides. Most growers prefer to surface-apply the lime if the ground is to remain in long-term no-till. How effective will surface-applied lime be, and how long will it take to start increasing the soil pH?

Lime applied on the soil surface reacts as quickly in the soil as lime incorporated by tillage, but only in the upper surface inch or so of the soil. Surface-applied lime moves down through the soil at a very slow rate, so changes in pH occur very slowly below that surface inch, if at all.

K-State research on liming rates and methods on no-till soils

No-till lime research was done by Chad Godsey and Ray Lamond of K-State from 2000 through 2004. They applied lime to two soils in Cowley County and one in Marshall County. All of the soils had been in long-term no-till production, and had a pH less than 6.0 in the top 6 inches of soil. Both agricultural lime and pelletized lime, at equivalent ECC rates, were surface-applied to these soils. The rates were based on the amounts needed to raise the pH in the top 6 inches to 6.8, using the SMP buffer, as determined by soil tests at the K-State Soil Testing Laboratory. Lime was applied in the following amounts:

* Full rate, one-time application
* Full rate, applied in four consecutive years using a quarter-rate each year
* Half-rate, one-time application
* Quarter-rate, one-time application
* None

Individual limestone rates were on an ECC basis at all sites. The ECC of the commercially available limestone was 55% and that of the pelletized limestone was 86%.

Over the five years of the studies, surface application of limestone was effective in raising the soil pH in the surface 2 to 3 inches of soil, but not at lower depths. Below 3 inches, there was no significant change in pH after 5 years. The observed downward movement of limestone was largely dependent on the amount of limestone applied to the surface, and did not differ between the two types of lime. When the full rate was applied, the change in soil pH was about the same whether the lime was applied all in one application, or in four annual applications of a quarter-rate each.

Although the soil pH was increased by the lime applications, the application treatments failed to increase the pH to 6.8, when measured by a 0-to-6-inch soil sample, which was the goal. However, the pH of the top inch of the soil was increased to over 6.8 at all the sites when full rates of lime were applied. It should be noted that this research was conducted in areas with an average annual rainfall of 32 to 40 inches.

Final comments

It is critical to closely monitor soil pH in no-till systems. The top few inches of soil may become extremely acidic due to the surface application of N fertilizer. However, soil surface pH can also become too high if a large amount of lime is applied at one time and left on the soil surface. This can affect nutrient availability in the upper soil levels, microbial activity, and herbicide performance or carryover. It is best to apply small amounts of lime more frequently to maintain soil pH in a no-till system.

How often should lime be applied in a no-till situation? A general guideline for lime applications in no-till is: half the rate, twice as often. This depends on several factors. A coarse-textured soil with a low CEC does not require a lot of lime to correct soil pH, but may need to be limed frequently. A finer-textured soil with a high CEC requires a large amount of lime to initially correct pH, but it may be several years before another lime application is needed due to its high buffering capacity.

The frequency of lime applications needed also depends in part on how much nitrogen fertilizer is being applied and the yield level of crops being produced. In general, the higher the nitrogen rates and yield levels, the more frequently lime will be needed. Due to the variation in buffering capacity of soils, lime applications should always be guided by soil tests.

The bottom line is that there are beneficial effects of surface application of limestone to acidic no-till soils even though the immediate effect may only be in the top 1 to 2 inches.

-- Dave Mengel, Soil Fertility Specialist
dmengel@ksu.edu

-- Dorivar Ruiz Diaz, Nutrient Management Specialist
ruizdiaz@ksu.edu

2. The role of nitrogen fertilizer in soil pH levels

Acid soils are becoming an important issue in Kansas, even in the western reaches of the state where most people think of high pH as a bigger issue. The primary reason for our soils becoming more acid over time is the use of nitrogen (N) fertilizers containing ammonium-N, including mono and diammonium phosphates, 11-52-0 and 18-46-0. As the ammonium-N in fertilizers nitrifies, acidity is released.

One common way to express the relative acidifying effects of N fertilizers is the pounds of Effective Calcium Carbonate, ECC, required to neutralize the acidity from 1 pound of actual N. That value varies from 3.6 to 7.2 for the fertilizers we commonly use. The table below shows the actual pounds of ECC needed to neutralize the acidity produced by the N from common fertilizer materials.

Amount of ag lime (ECC) required to neutralize the acidity created by nitrogen fertilizer.

Fertilizer	N Concentration	Pounds of ECC needed as lime to neutralize the acidity from 1 lb. of actual N
Ammonium nitrate	34% N	3.6
Anhydrous ammonia	82% N	3.6
Urea	46% N	3.6
UAN Solutions	28-32% N	3.6
Ammonium Sulfate	21%N	7.2
Monoammonium Phosphate	11% N	7.2
Diammonium Phosphate	18% N	5.4

How nitrification increases soil acidity

To understand the acidification potential of various nitrogen fertilizers, it is helpful to understand how the process of nitrification increases soil acidity. In the first step of nitrification, ammonia-oxidizing bacteria oxidize ammonia to nitrite according to the following equation:

* $NH_3 + O_2 \rightarrow NO_2^- + 3H^+ + 2e^-$

Nitrosomonas is the most frequently identified genus associated with this step.

In the second step of the process, nitrite-oxidizing bacteria oxidize nitrite to nitrate according to the following equation:

* $NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$

Nitrobacter is the most frequently identified genus associated with this second step.

Hydrogen (H^+) is released in the process of nitrification, and free hydrogen ions increase acidity. The higher the percentage of ammonium (or urea) in the fertilizer, the greater the acidification potential.

Another reason that NH_4^+ increases acidity has to do with plant uptake. As plant roots absorb NH_4^+ they secrete H^+ ions into the soil solution to maintain a chemical charge balance.

Acidification potential of nitrogen fertilizers

* *Acidification potential: Neutral*
Potassium nitrate (13% N)
Calcium nitrate (15.5% N)

> Because all of the nitrogen in these fertilizers is in the nitrate form, these fertilizers are not acidifying so there is no need to apply lime to neutralize acidity.

* *Acidification potential: Moderate*
Anhydrous ammonia (82% N)
Urea (46% N)
Ammonium nitrate (34% N)
Urea ammonium nitrate solutions (32% and 28% N)

> These products are acidifying because they contain ammonium, or produce ammonium when applied to the soil. But they are less acidifying than DAP, MAP, or ammonium sulfate. Unlike DAP and MAP, anhydrous ammonia and urea do not leave any phosphoric acid residue remaining after they dissolve in soil solution. Ammonium sulfate leaves sulfuric acid residue as it dissolves. With ammonium nitrate and UAN solutions, only part of the total N is in the ammonium form, so these products result in less nitrification than fertilizers in which all the N is in the ammonia or ammonium form.

* *Acidification potential: Moderately high*
Diammonium phosphate (DAP) (18% N, 46% P_2O_5)

> Diammonium phosphate has a moderate acidifying effect when applied.

* *Acidification potential: High*
Ammonium sulfate (21% N, 24% S)
Mono-ammonium phosphate (MAP) (11% N, 52% P_2O_5)

> These fertilizers are very acidifying. Ammonium sulfate not only results in acidification through the process of nitrification, but one of the dissolution byproducts in sulfuric acid.

This may raise some other questions, though, such as:

A. Why is anhydrous ammonia less acidifying than MAP and DAP if they are all applied at the same N rate?

When anhydrous ammonia (NH3) is applied to the soil, it reacts with water to form ammonium-N and the hydroxide ion, which is basic.

* $NH_3 + H_2O \rightleftarrows NH_4^+ + OH^-$

This reaction initially raises the pH of the soil. It is only after the NH_4^+ undergoes nitrification that it begins to acidify the soil (through the release of H^+). These two reactions (the basic effect of ammonia reacting with water vs. the acidifying effect of nitrification) don't entirely balance each other out. The end result is an acidifying effect.

B. Why is urea less acidifying than MAP and DAP, if they are all applied at the same N rate?

In soil solution, urea first reacts with water and free H+ ions to form ammonium-N and bicarbonate.

* (1) $CO(NH_2)_2 + 2H_2O + H^+ \rightarrow 2NH_4^+ + HCO_3^-$

This reaction is immediately followed by another reaction that takes H+ ions out of soil solution:

* (2) $HCO_3^- + H^+ \rightarrow CO_2 + H_2O$

Both these reactions "soak up" free H^+ ions in soil solution, which reduces acidity. This reduction in acidity is more than balanced out by the acidifying reaction of the nitrification of ammonium-N. As with anhydrous ammonia, the overall net effect is acidifying.

C. Why is MAP slightly more acidifying than DAP when applied at the same N rate?

Ammonium phosphates, such as MAP and DAP fertilizers, are extremely soluble in soil solution, and dissolve easily. Knowing what happens to each product after it dissolves helps explain this effect.

MAP -- The pH of MAP in saturated solution is 3.5. MAP contains one ammonium-N and one $H_2PO_4^-$ ion. The reaction in soil solution is:

* $NH_4H_2PO_4 \rightleftarrows NH_4^+ + H_2PO_4^-$

This reaction does not use up any H+ ions in soil solution, so the full acidifying effect of nitrification impacts the soil pH level.

DAP -- The pH of DAP in saturated solution is 8.0. DAP contains two ammonium-N ions and one HPO_4^{-2} ion. In soil solution, DAP initially undergoes the following reaction:

* (1) $(NH_4)_2HPO_4 \rightleftarrows 2NH_4^+ + HPO_4^{2-}$

If the soil solution pH is greater than 7.0, the orthophosphate ion will be stable and not react any further. If the soil solution pH is less than 7.0, the orthophosphate ion will react with the free hydrogen ions and reduce the acidity somewhat.

* (2) $HPO_4^{2-} + H^+ \rightleftarrows H_2PO_4^-$

To the extent that it occurs, the second reaction balances some of the acidifying effect of the nitrification of the ammonium-N ions. That's why DAP has a slightly less dramatic acidifying effect on the soil than MAP.

Soil acidity and aluminum toxicity

We should also note that strictly speaking, soil acidity is a measure of the concentration of H^+ ions in the soil solution. But the greatest injury to crop growth from low pH soils comes not from the H^+ ions, but from the release of aluminum into the soil solution at low pH levels.

As the pH decreases below 5.5, the availability of aluminum and manganese increase and may reach a point of toxicity to the plant. Excess Al in the soil solution interferes with root growth and function, as well as restricting plant uptake of certain nutrients, namely, Ca and Mg. Liming acid soils reduces the activity of Al and Mn.

-- Dave Mengel, Soil Fertility Specialist
dmengel@ksu.edu

-- Dorivar Ruiz Diaz, Nutrient Management Specialist
ruizdiaz@ksu.edu

3. Winter/spring fertilization of tall fescue and smooth bromegrass pastures

Much of the nitrogen (N) applied to tall fescue and smooth bromegrass hay meadows and pastures goes on in January or February in eastern Kansas. The amount and timing of N depends on whether the field is hayed or grazed; how much, if any N was applied in the fall; the price of N and hay; and the growing conditions since last fall.

While January and February is normally the driest time of the year, there is still adequate moisture most years to move the N down into the root zone and stimulate early season growth of tall fescue and smooth bromegrass.

Hay

Normal N fertilization rates for established fescue and bromegrass hay fields are 90 to 120 pounds actual N per acre, or about 30 pounds of N per ton of expected yield. A recent summary of fescue and bromegrass N response data shows that across nearly 100 experiments, the average yields for unfertilized plots was 1.35 tons of hay per acre, while maximum yields averaged 3.15 tons of hay with 140 pounds of N.

N Rate (lbs N/acre)	Hay Yield (tons dry matter/acre)	Hay Yield Increase From 20 pounds N (tons dry matter/acre)
0	1.35	-------
20	1.80	0.45
40	2.20	0.40
60	2.52	0.32
80	2.78	0.26
100	2.97	0.19
120	3.10	0.13
140	3.15	0.05
160	3.14	-0.01

Doing some simple cost-and-return calculations, using a long-term average value of $60 per ton as the value of the hay produced and $0.50 per pound of N, the normal rates of N mentioned above (90 to 120 lbs/acre) are appropriate to maximize profit in most years. It will be important to watch N costs, however, as they continue to be volatile.

The other issue is hay price and supply. With the drought, prices for grass hay have been considerably above the long-term average of $60 per ton. With the reduced hay supplies on many farms and current lack of soil moisture in many parts of the state, there is a good chance hay prices may continue to remain high in 2013. If that is the case, applying N rates at the upper end of the 90 to 120 pound range should be most profitable.

If N prices for urea continue in the $0.50-per-pound range, and at a hay price of $100 per ton, the response data would suggest that the last 20 pounds of N between 100 and 120 pounds N per acre would return a $3 per acre profit. But going beyond that 120-pound N rate would still not be cost effective.

One issue these calculations don’t consider is hay quality. Protein levels will be increased at the higher N fertilizer rates. So in cases where producers are relying on high-quality hay as their primary protein source, they may want to push N rates a little higher, or add supplemental protein to rations at the lower N rates.

Pasture

Under normal conditions, tall fescue and smooth bromegrass pastures that are grazed in both spring and fall should receive about 100 pounds total N per acre, with 60% applied in the winter or early spring and 40% in late August or early September, along with any needed P and K. So producers should plan on applying 60 to 70 lbs N per acre in winter or early spring, starting as early as January or February.

In any type of fertilizer management program for tall fescue and smooth bromegrass, for best results, needed phosphorus and potash should be applied in the late summer, along with a light application of N. Rates should be based on soil tests. Phosphorus will help the grass develop a good root system for the winter, and develop buds for new tillers the next spring. P and K applied in winter or early spring won’t provide the same benefits.

Other considerations

One additional nutrient producers should consider watching for tall fescue and smooth bromegrass pastures or hayfields is sulfur (S). If the pasture or hayfield is receiving adequate nutrients and precipitation, but is dropping off in production, it could be deficient in S. Sulfur deficiency will cause a general reduction in forage production long before it results in visual deficiency symptoms. An application of S to a tall fescue or smooth bromegrass pasture or hayfield that is deficient in S can result in forage yield increases of as much as 500 to 800 lbs per acre.

To determine whether P, K, S, and lime are needed on tall fescue and smooth bromegrass fields, producers should consider soil sampling. The best time to sample is 30 days prior to fertilizer application. Samples for a P and K soil test should be taken to a 6-inch depth. A profile N test to a depth of 24 inches should be used to evaluate S needs.

-- Dave Mengel, Soil Fertility Specialist
dmengel@ksu.edu

4. Winter Canola Risk Management Schools planned in Anthony, McPherson

Winter Canola Risk Management schools are scheduled in Anthony on Feb. 22 and McPherson on Feb. 28. Both schools will begin at 10 a.m.

K-State Research and Extension is dedicated to helping producers make informed management decisions to minimize their production and marketing risks. Industry experts will be on hand to provide updates on the latest marketing prospects for canola in Kansas.

Two of the most experienced canola agronomists in the southern Great Plains will be available to answer questions and provide knowledge about growing the crop.

Canola is a crop that requires attention in the spring. Producers who attend one of the schools will have the necessary tools to successfully scout their fields for disease and potential pest problems.

Topics to be presented at both schools include:

- Canola varieties;
- Winter survival in a drought year;
- Pest management in late winter and spring;
- Winter canola establishment strategies;
- Harvest risk management;
- Update on winter canola insurance; and
- Update on marketing strategies.

Representatives of the Great Plains Canola Association will give an update on what the GPCA has been doing to promote the benefits of canola in a wheat-based cropping system.

The schools are free to attend and will include a complimentary lunch. Organizers ask, however, that attendees pre-register to allow for enough food.

The Friday, Feb. 22 school in Anthony will be held at the Bank of Kansas meeting room. Call the K-State Research and Extension Harper County office at 620-842-5445 for more information or to register.

The Thursday, Feb. 28 school in McPherson will be at the McPherson County Extension office. Call 620-241-1523 for more information or to register.

-- Mike Stamm, Canola Breeder
mjstamm@ksu.edu

5. Weed Resistance and Cultural Practices survey

Kevin Bradley, associate professor of weed science at the University of Missouri, is soliciting information from growers and retailers regarding glyphosate-resistant weeds via an online survey.

Bradley will be giving a talk at a symposium at the upcoming Weed Science Society of America meeting on some of the impacts of glyphosate-resistant weeds on farming practices in the Midwest. He would like input from those in states other than just Missouri, so he has developed a short 12-question online survey. This information will help him deliver a talk that more accurately reflects what is happening in the entire Midwest area. The link to the survey is below:

https://www.surveymonkey.com/s/59GJBCX

-- Dallas Peterson, Weed Management Specialist
dpeterso@ksu.edu

6. Comparative Vegetation Condition Report: January 8 – 21

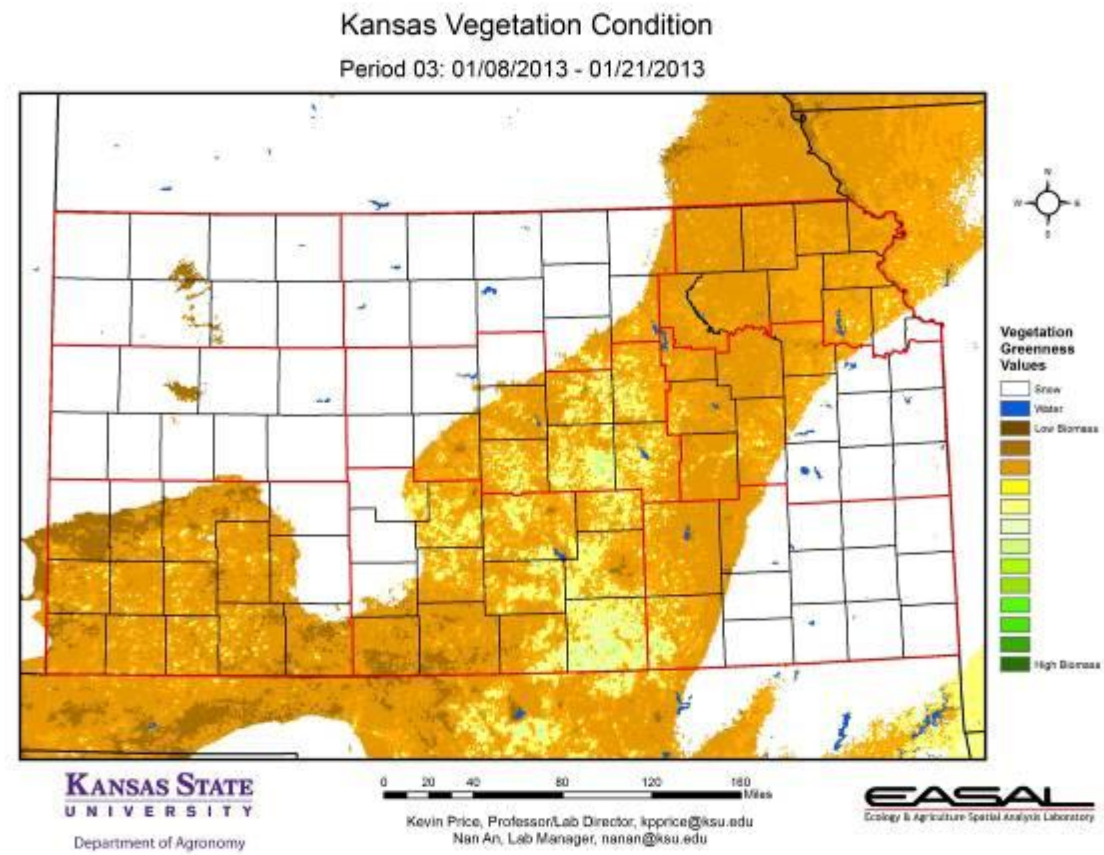
K-State's Ecology and Agriculture Spatial Analysis Laboratory (EASAL) produces weekly Vegetation Condition Report maps. These maps can be a valuable tool for making crop selection and marketing decisions.

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

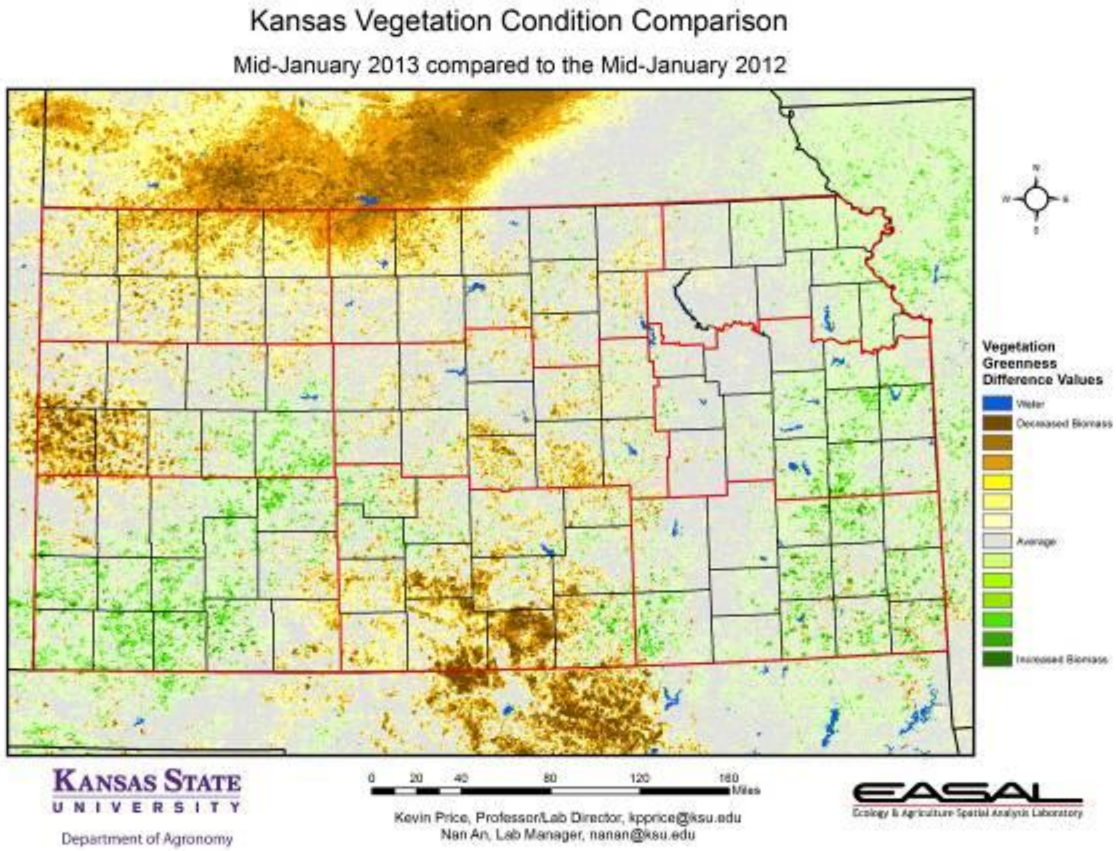
The objective of these reports is to provide users with a means of assessing the relative condition of crops and grassland. The maps can be used to assess current plant growth rates, as well as comparisons to the previous year and relative to the 24-year average. The report is used by individual farmers 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.

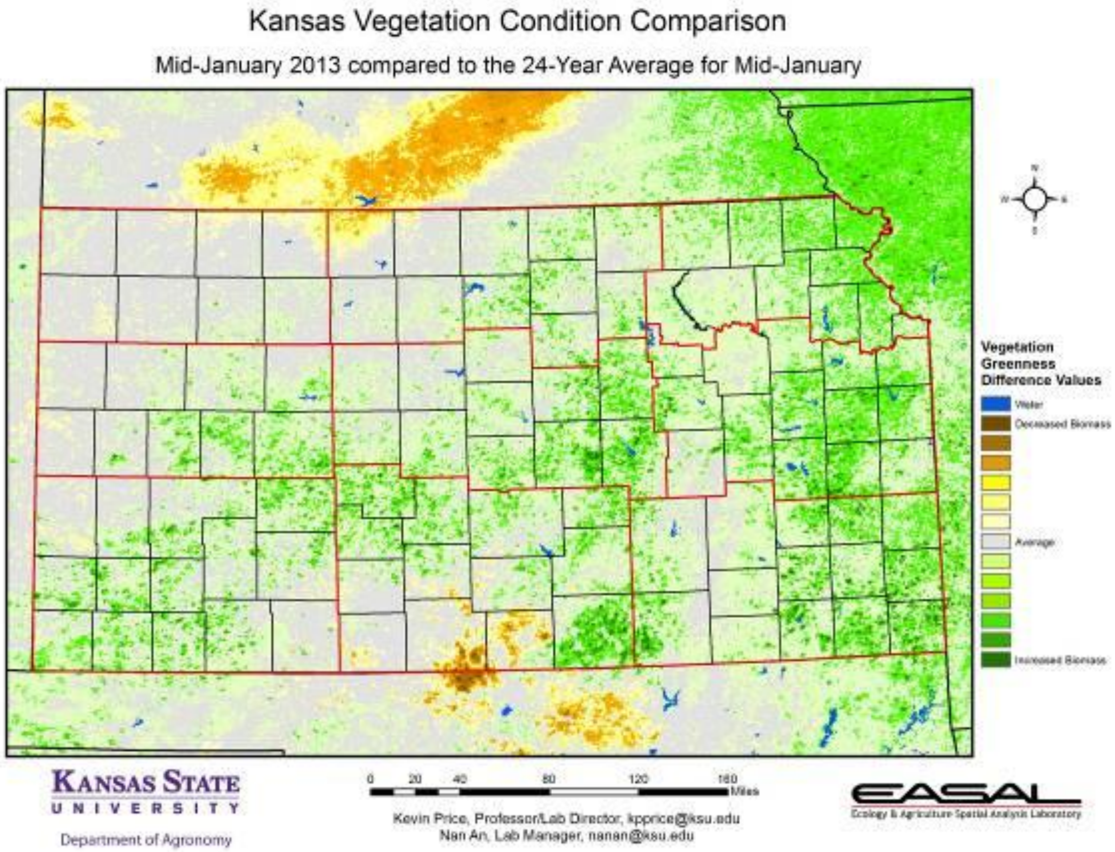
The maps in this issue of the newsletter show the current state of photosynthetic activity in Kansas, the Corn Belt, and the continental U.S, with comments from Mary Knapp, state climatologist:



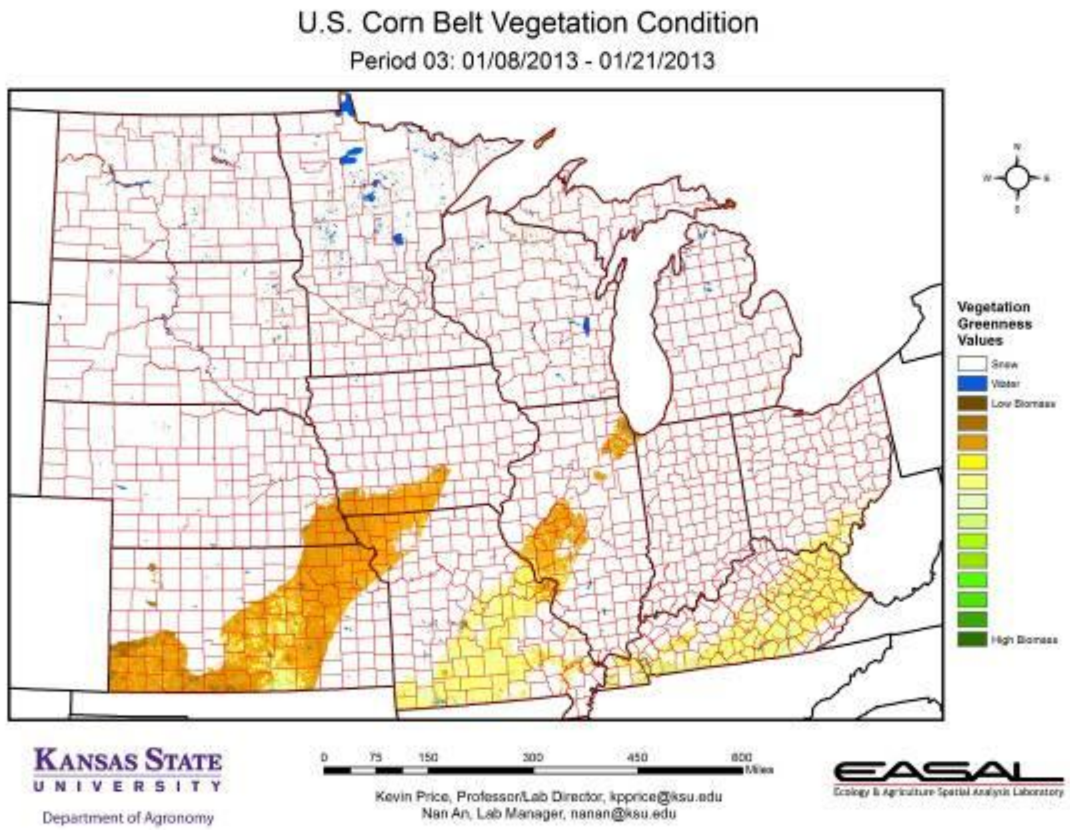
Map 1. The Vegetation Condition Report for Kansas for January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that the snow coverage during this two-week period was split across the state. In most locations the amounts were less than 2 inches, and the moisture content was minimal.



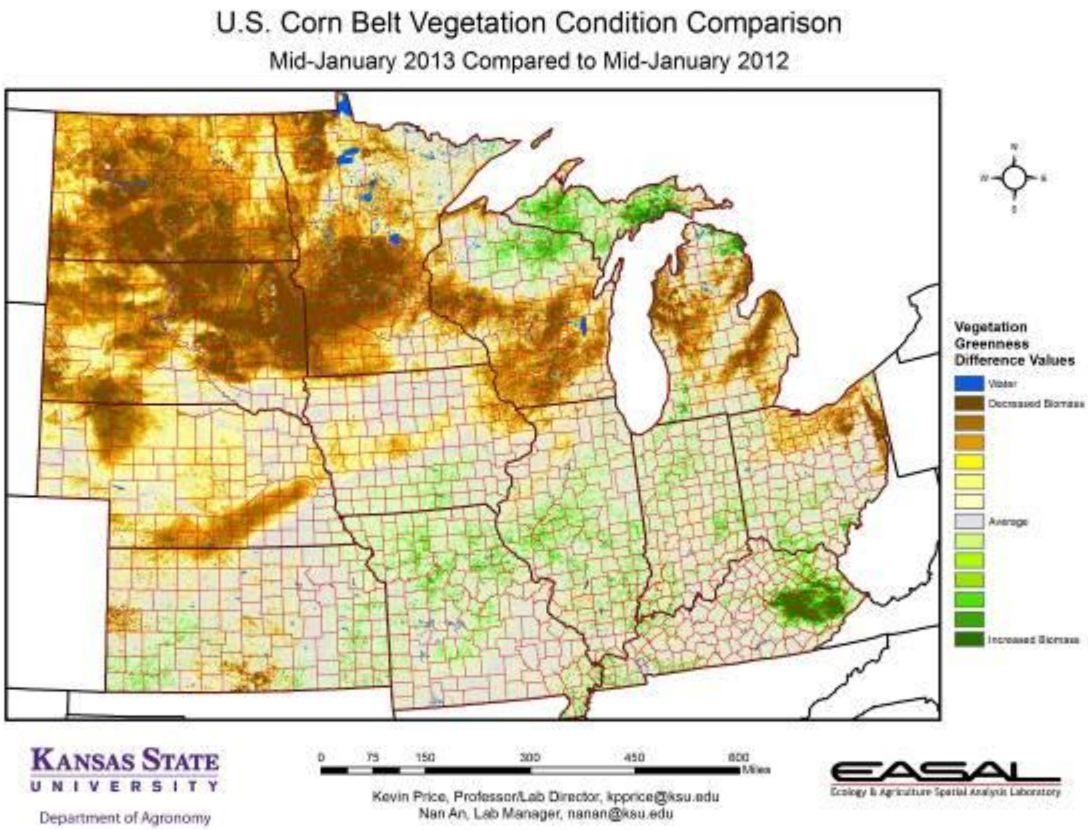
Map 2. Compared to the previous year at this time for Kansas, the current Vegetation Condition Report for September January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that parts of south central and west central Kansas continue to have much lower NDVI values than last year at this time. Barber and Harper counties in south central Kansas and Greeley and Wichita counties in west central Kansas have missed out on much of the winter moisture.



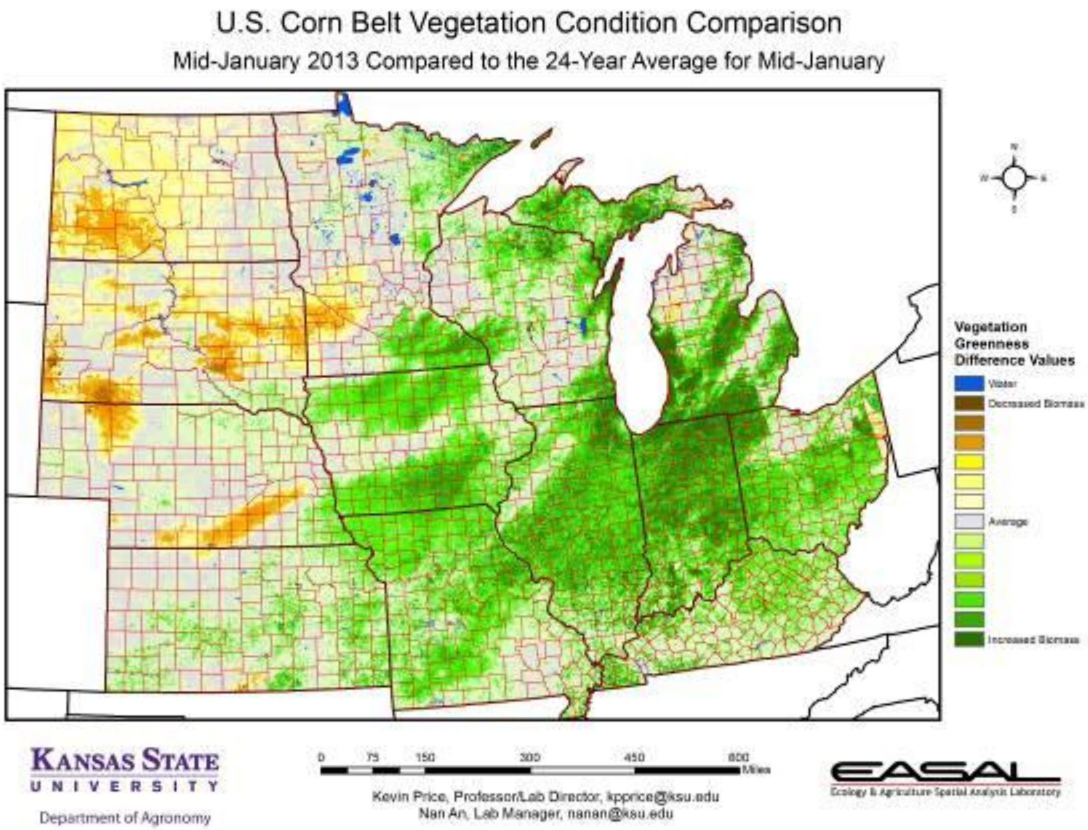
Map 3. Compared to the 24-year average at this time for Kansas, this year's Vegetation Condition Report for January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows higher-than-average photosynthetic activity along a line from southwest to northeastern Kansas. North of that line, temperatures have been below average, with soil temperatures below freezing. This has kept most vegetation in dormancy. South and east of the line, milder temperatures have allowed for some photosynthetic activity. This makes the dry conditions in Barber and Harper counties even more evident.



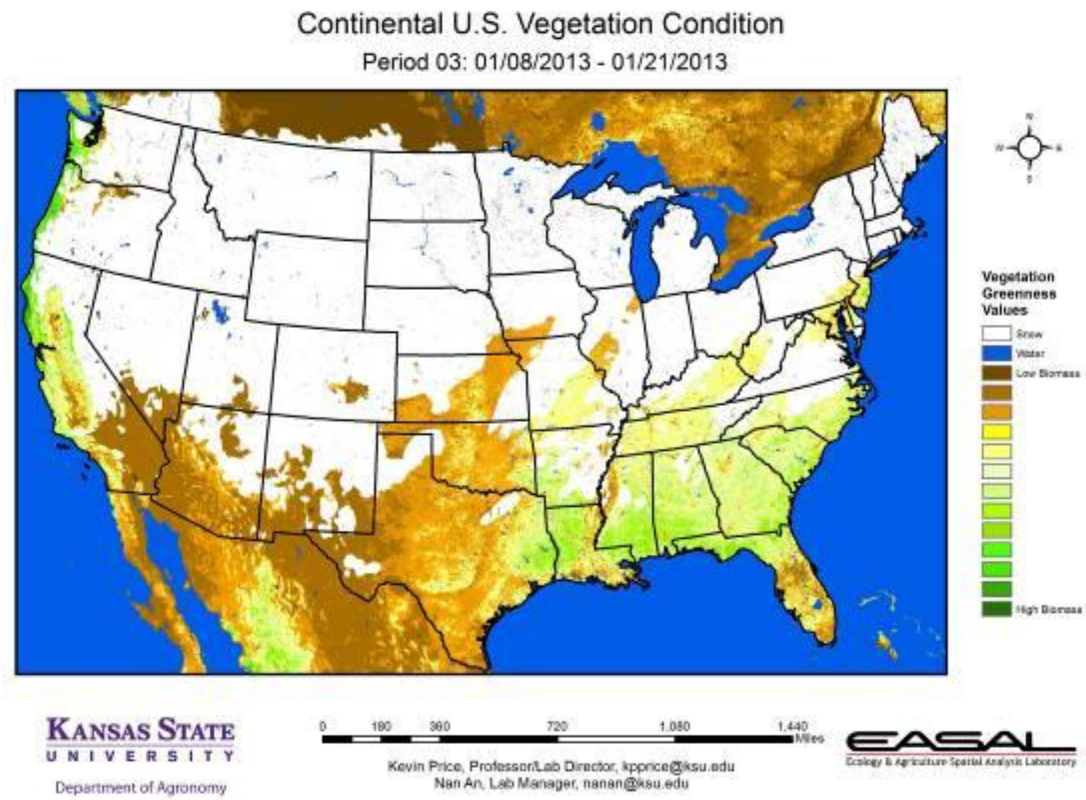
Map 4. The Vegetation Condition Report for the Corn Belt for January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that an area from southwestern Iowa to southwest Kansas missed out on the snow. A smaller area across Illinois into southern Missouri also saw little in the way of snowfall.



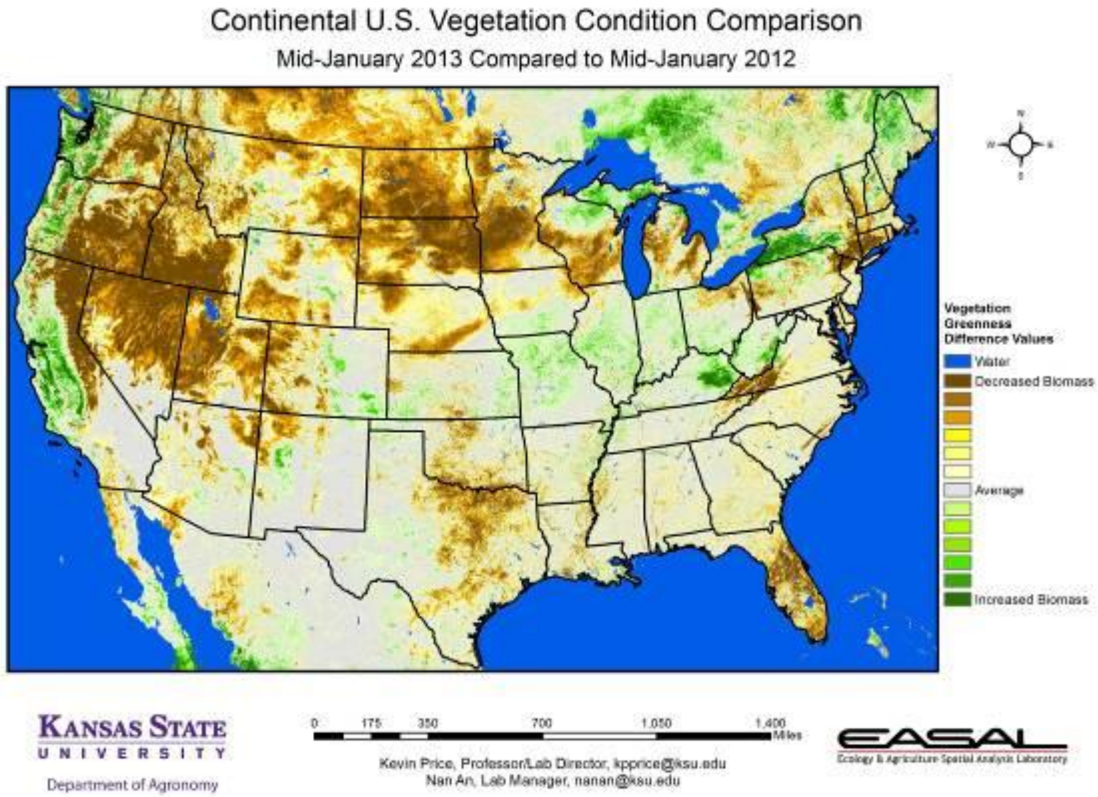
Map 5. The comparison to last year in the Corn Belt for the period January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows a lower level of photosynthetic activity across most of the northern Corn Belt. This area has seen much more in the way of snowfall this season.



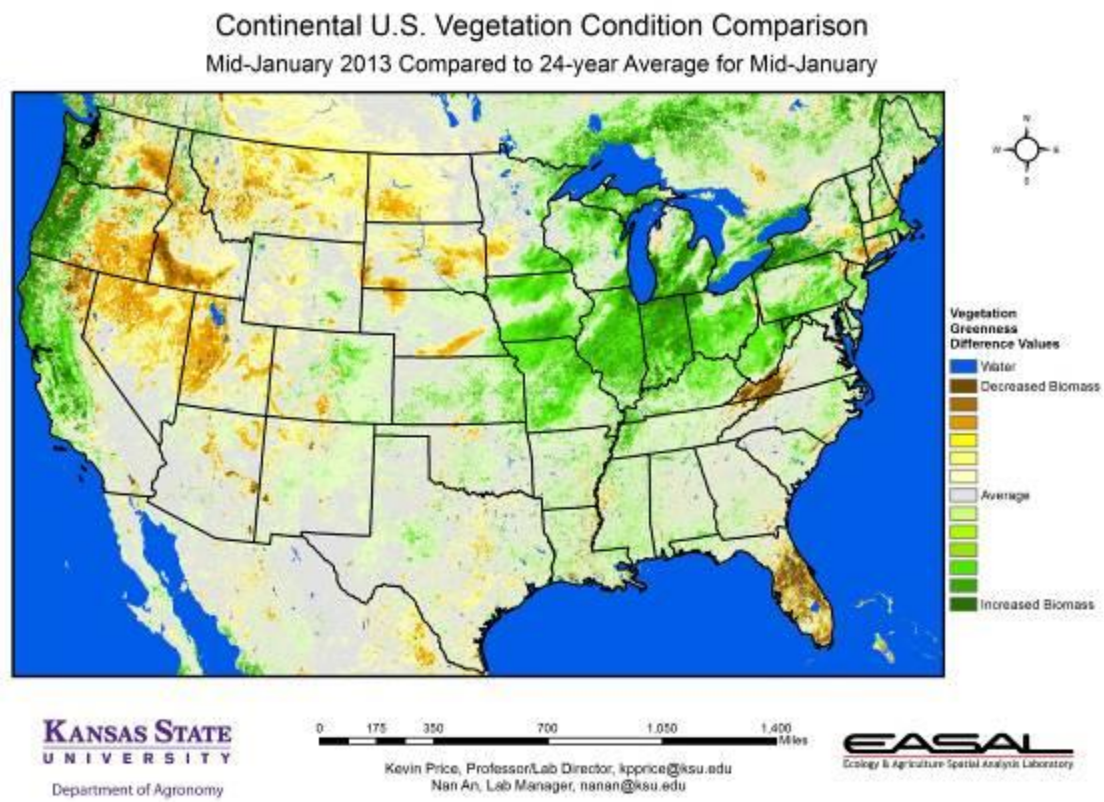
Map 6. Compared to the 24-year average at this time for the Corn Belt, this year's Vegetation Condition Report for January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that photosynthetic activity is above average across the eastern half of the Corn Belt. Favorable moisture has occurred in that area over the last two weeks. In Illinois, last week's Drought Monitor had a little more than 60 percent of the state as drought free. This week's drought monitor has 80 percent of the state as drought free.



Map 7. The Vegetation Condition Report for the U.S. for January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows the snow line has pulled further north, although some snow was seen in parts of Arkansas and into the South. Amounts in the southern areas were light.



Map 8. The U.S. comparison to last year at this time for the period January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that much of the Intermountain West and Northern Plains are showing lower photosynthetic activity than last year. Snow amounts in these areas are higher than last year at this time.



Map 9. The U.S. comparison to the 24-year average for the period January 8 – 21 from K-State's Ecology and Agriculture Spatial Analysis Laboratory shows that the Midwest and the Pacific Coastal areas have the greatest increase in photosynthetic activity. Dryness is increasing in Florida.

-- Mary Knapp, State Climatologist
mknapp@ksu.edu

-- Kevin Price, Agronomy and Geography, Remote Sensing, Natural Resources, GIS
kpprice@ksu.edu

-- Nan An, Graduate Research Assistant, Ecology & Agriculture Spatial Analysis Laboratory (EASAL)
nanan@ksu.edu

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.