MAPPING COVER CROPS ON CORN AND SOYBEANS IN ILLINOIS, INDIANA AND IOWA, 2015–2016

AUTHORS
Soren Rundquist,
EWG Director of Spatial Analysis

Sarah Carlson,
Midwest Cover Crop Director
for Practical Farmers of Iowa

Image Source: Practical Farmers of Iowa

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ABOUT EWG

The Environmental Working Group is the nation's most effective environmental health research and advocacy organization. Our mission is to conduct original, game-changing research that inspires people, businesses and governments to take action to protect human health and the environment. With your help—and with the help of hundreds of organizations with whom we partner—we are creating a healthier and cleaner environment for the next generation and beyond.

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HEADQUARTERS

1436 U Street N.W., Suite 100
Washington, D.C. 20009
(202) 667-6982

CALIFORNIA OFFICE

500 Washington Street, Suite 400
San Francisco, CA 94111

MIDWEST OFFICE

103 E. 6th Street, Suite 201
Ames, IA 50010

SACRAMENTO OFFICE

1107 9th Street, Suite 625
Sacramento, CA 95814

INTRODUCTION

In the Midwestern Corn Belt, residents are increasingly concerned about poor water quality and other environmental problems caused by modern agricultural systems. Because crops grow for only a few months and living cover is missing for most of the year, the region's dominant cropping systems "leak" nitrate-nitrogen, phosphorus, sediment and other pollutants into the water and surrounding environment.

From 1985 to 2005, for example, nitrogen loads to the Gulf of Mexico ranged from 893,000 to 2,436,000 tons (810,000 to 2,210,000 metric tons) and phosphorus loads ranged from 88,956 to 198,400 tons (80,700 to 180,000 metric tons) per year. On average, 39 percent of the total nitrogen and 26 percent of the total phosphorus load from corn and soybean fields came from the Upper Mississippi sub-basin.

Three states within the Upper Mississippi sub-basin—Iowa, Illinois and Indiana— publish strategies that identify the most effective agricultural practices farmers can implement to reduce the loss of nitrogen and phosphorus from their fields. **Research shows that adding a cover crop to the corn-soybean rotation is one of the most effective in-field practices.** Cover crops are so effective at cutting losses of nitrogen, phosphorus and sediment because they keep living roots in the ground between corn and soybean crops, which hold down soil and absorb nutrients during the winter months.

Cover crops grown in the Corn Belt are typically cool-season plants like cereal rye, winter wheat and oats. The cover crops are planted in the fall and protect the soil with living cover over the winter and into

the spring when no other living roots are present. Oats and some other cover crops grow only in the fall and die off by January, while other plants like cereal rye and winter wheat persist throughout the winter and continue to cut losses of nitrate when heavy rains fall in early spring.

According to the **Iowa Nutrient Reduction Strategy**, cover crops "reduce soil erosion and limit the amount of nitrate-N leaching from the system," and when coupled with other conservation practices also have "the potential to substantially reduce phosphorus-P loss" from agricultural fields. On average, cover crops can cut the amount of nitrate-nitrogen leaching from fields by 35 percent and reduce soil erosion by more than half. They also soak up potential pollutants and provide a protective cover for the soil throughout the winter. Although applying cover crops is a proven and effective practice to reduce nitrogen and phosphorus losses from fields, adoption remains low.

The Environmental Working Group, or EWG, and Practical Farmers of Iowa, or PFI, have developed a method to map the presence of cover crops in Illinois, Indiana and Iowa to better understand how often cover crops are being used by farmers in these three states, which together produce a third of all corn and soybeans grown in the U.S. To our knowledge, this is the first use of aerial imagery to survey cover crops at this scale.

METHODS

EWG used multi-spectral satellite data over several periods during the fall of 2015 and the spring of 2016 to detect cover crops in the three states. The Normalized Difference Vegetation Index, or NDVI, derived from Landsat 8 satellite imagery, was used to

measure the emergence of vegetation on acres classified as corn and soybean fields in the 2015 U.S. Department of Agriculture Cropland Data Layer. EWG modeled multiple cover crop emergence scenarios in fall 2015 and spring 2016, when data were available to account for different cover crop species and planting windows across the three states (see Appendix 2). Fall imagery was available and analyzed between late September and early December, and spring imagery between late February and the middle of May.

NDVI thresholds used to identify cover crop fields were checked against fields in Iowa visited through windshield surveys. Fields of 10 acres or more were included and counted as cover crop fields for the purposes of this report. Fields smaller than 10 acres were excluded.

Results in Iowa were also validated using known locations of 2015 cover crop contracts received through the Iowa Department of Land Stewardship, or IDALS, cost-share program. Fields detected on satellite images were compared to these known cover crop locations from the IDALS data at the Public Land Survey System Section level. If a cover crop field was detected on satellite imagery within a section that received cost share in 2015, it was deemed a match. In all, EWG results matched the cost-share data 72 percent of the time (see Figure 1 below).

FIGURE 1: Validation of Cover Crops with State Government Data

☐ Match - Cost Share & Detected Cover Crop
☐ No Match - Cost Share & Undetected Cover Crop
■ Cover Crop Plantings
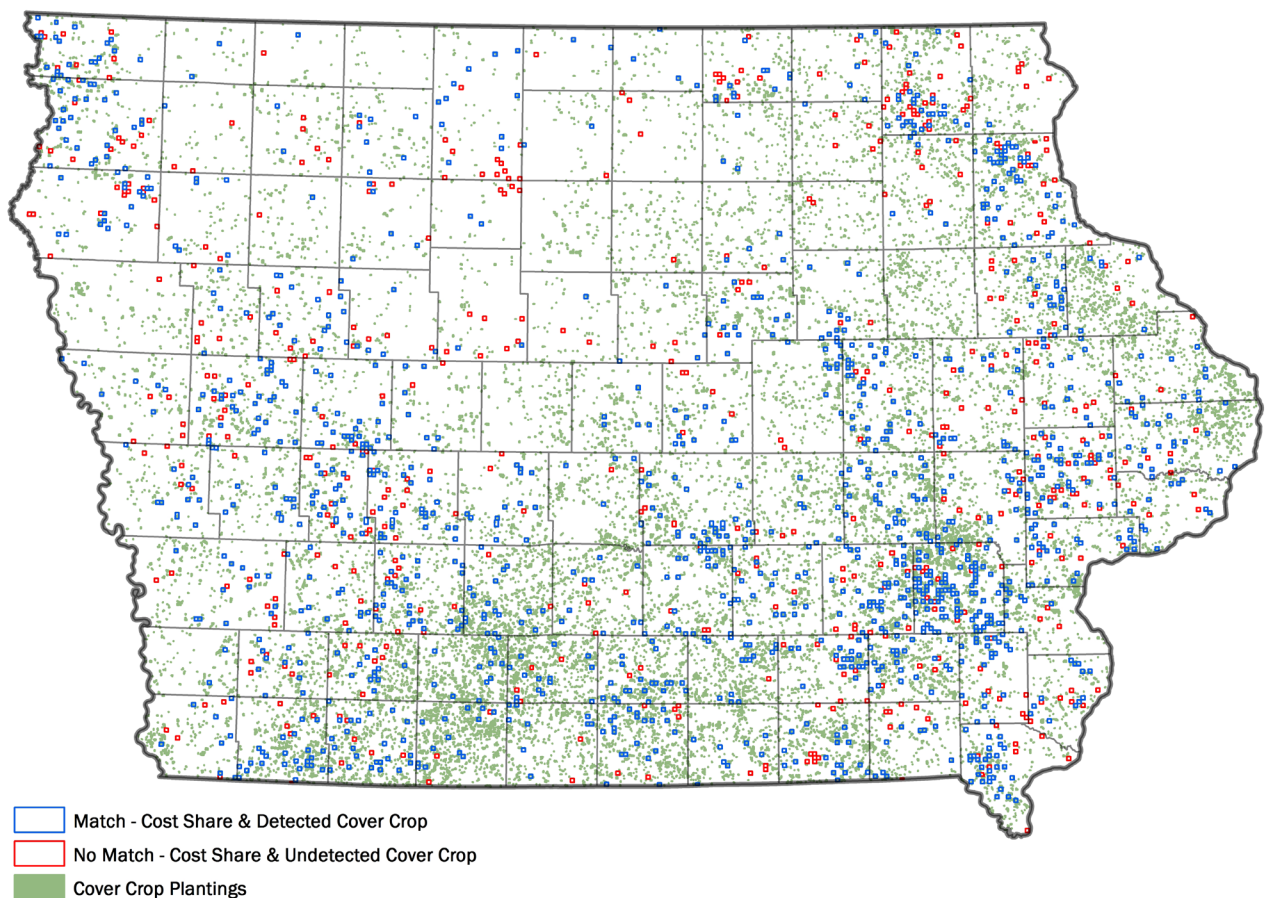
Four reasons could account for a failure to match imagery with IDALS data: 1) cover crop emergence occurred after a satellite passed an area and therefore no detection occurred, 2) the cover crop failed to emerge, 3) the producer terminated the cover crop before the satellite image could capture emergence, or 4) clouds obstructed cover crop fields when a satellite was present.

Interestingly, on average, 40 percent of the cover crops in sections that received cost-share funding from IDALS between 2012 and 2014, but not in 2015, were detected in fall 2015 or spring 2016 satellite imagery (see Table 1 below). **This suggests that about 40 percent of farmers that got cost-share funding kept using cover crops without ongoing financial support.** Sixty percent of farmers, however, appear to have stopped using cover crops once the financial support ended. Some of those farmers could have received a cost share from federal USDA programs, which we could not validate because USDA prohibits revealing the exact location of funded practices.

RESULTS

Almost 800,000 acres of cover crops (7.1 percent of all corn and soybean acres) were detected in Indiana (see Table 2 below). Only 2.6 percent of corn and soybean acres in Iowa, and 2.3 percent of such acres in Illinois, were planted with cover crops, despite the fact that far more acres are planted with corn or soybeans in those two states. County-by-county maps of cover crops are provided in the Appendix. In addition to cover crops for corn and soybeans, about 4 percent of the agricultural area in Indiana is planted with winter wheat, which provides environmental functions similar to those of cover crops. In Illinois, winter wheat is planted on two percent of the agricultural area, and in Iowa winter wheat production is negligible.

Table 1: 2012 to 2014 IDALS Cost-Shared Cover Crop Acres Detected in 2015 but Not Paid for by Iowa Department of Agriculture and Land Stewardship
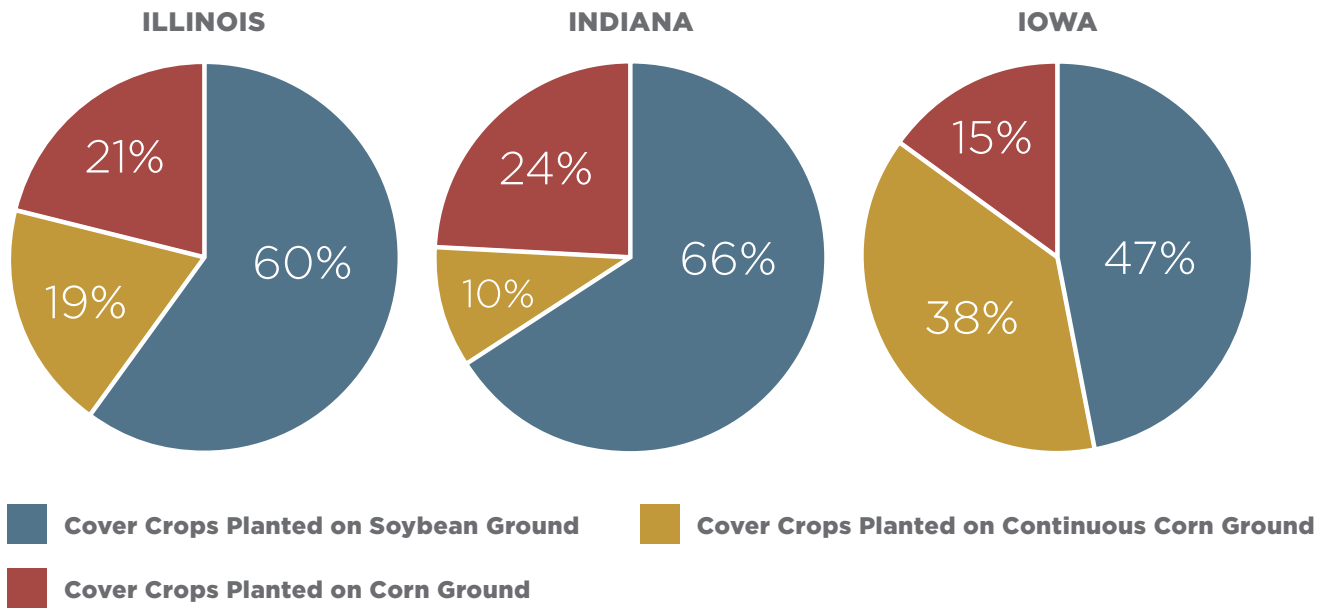
Year	IDALS Funded Cover Crops Sections	Previously Funded IDALS Sections (not 2015) and Detected on Satellite Data	Percent Persistence
2014	918	366	40%
2013	1,554	582	37%
2012	269	112	42%

Table 2: Acres of Cover Crops by State

State	Cover Crops Detected on Corn & Soybeans (Acres)*	2015 Corn & Soy (Acres)*	Percent Cover Crops
Illinois	488,626	20,795,277	2.3%
Indiana	794,724	11,136,683	7.1%
Iowa	591,880	22,651,703	2.6%

*Acres of corn and soybeans taken from the 2015 USDA Cropland Data Layer

Figure 2: Distribution of Cover Crops Following Soybeans, Continuous Corn and Rotational Corn

ILLINOIS

60%
21%
19%

INDIANA

66%
24%
10%

IOWA

47%
38%
15%

■ Cover Crops Planted on Soybean Ground

■ Cover Crops Planted on Continuous Corn Ground

■ Cover Crops Planted on Corn Ground

The 2015 USDA Cropland Data Layer was used to determine which cash crop was followed by a cover crop. Cover crops tended to follow soybeans in Illinois (60 percent) and Indiana (66 percent), but followed corn more often in Iowa (53 percent; see Figure 2 above). Additionally, Iowa had the highest percentage of cover crops following continuous corn—acres planted with corn two years in a row—at 38 percent, followed by Illinois (19 percent) and Indiana (10 percent).

Cover crops were often planted on land designated by the USDA as Highly Erodible Land, meaning it is extremely vulnerable to soil loss. Fifty-four percent (318,391 acres) of cover crops in Iowa, 35 percent (171,443 acres) of those in Illinois and 29 percent (230,460 acres) of those in Indiana were planted on Highly Erodible Land (see Table 3 below).

Table 3: Distribution of Cover Crops on Highly Erodible Land Tracts

State	Cover Crops Detected on Highly Erodible Lands (Acres)*	Cover Crops Detected on Corn & Soybeans (Acres)**	Percent Cover Crops on Highly Erodible Lands
Illinois	171,443	488,626	35%
Indiana	230,460	794,724	29%
Iowa	318,391	591,880	54%

*Acres determined by the Common Land Unit boundaries classified as highly erodible

**Acres of corn and soybeans taken from the USDA Cropland Data Layer

Figure 3: Percent of Annual EQIP Spending for Cover Crop Practices by Fiscal Year


Iowa   Indiana   Illinois
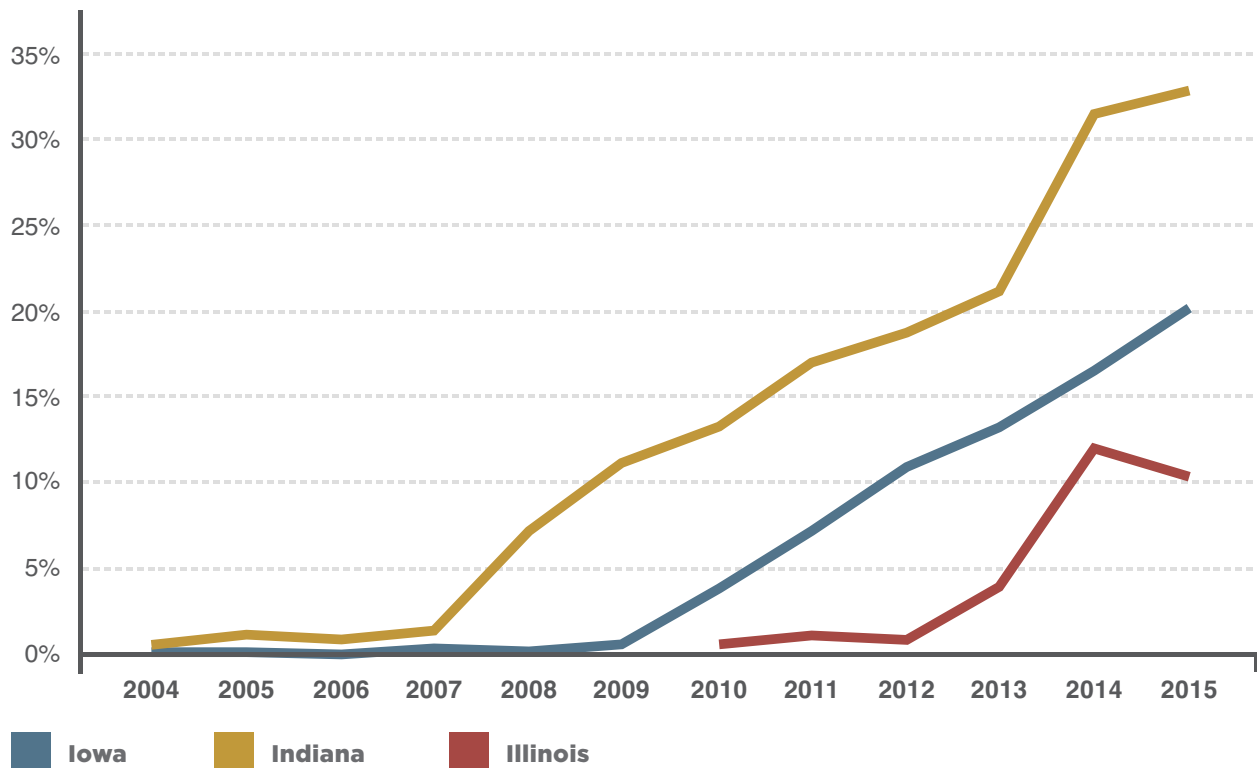
TAXPAYER INVESTMENT IN COVER CROPS

The Environmental Quality Incentives Program, or EQIP, provides technical and financial help for farmers who want to implement cover crops and many other conservation practices. Since 1997, EQIP has invested $235 million in Iowa, $140 million in Indiana and $126 million in Illinois to encourage famers to add conservation practices to their operations.

In recent years, EQIP spending on cover crops has increased dramatically. Support for cover crops in Indiana grew from 1 percent of EQIP funding in 2007 to 33 percent in 2015. Iowa's investment in cover crops grew from 1 percent in 2009 to 20 percent in 2015, and Illinois' spending increased from 1 percent in 2010 to 10 percent in 2015 (see Figure 3 above).

Cover crops also account for an increasing share of the acres treated by all practices supported by EQIP. In 2007, for example, 7,807 acres of cover crops accounted for less than 1 percent of the 504,192 acres treated with practices such as residue management or nutrient management through EQIP in Indiana (see Figure 4 on the following page). By 2015, Indiana's share of acres devoted to cover crops had grown almost 19 percent—164,736 out of 898,944 acres affected by all practices. Illinois and Iowa experienced similar increases in acres supported by EQIP. As of 2015, Iowa's 92,480 acres of cover crops supported through EQIP accounted for 18 percent of all acres treated. In Illinois, 14 percent of all acres treated were accounted for by cover crops (30,738 acres).
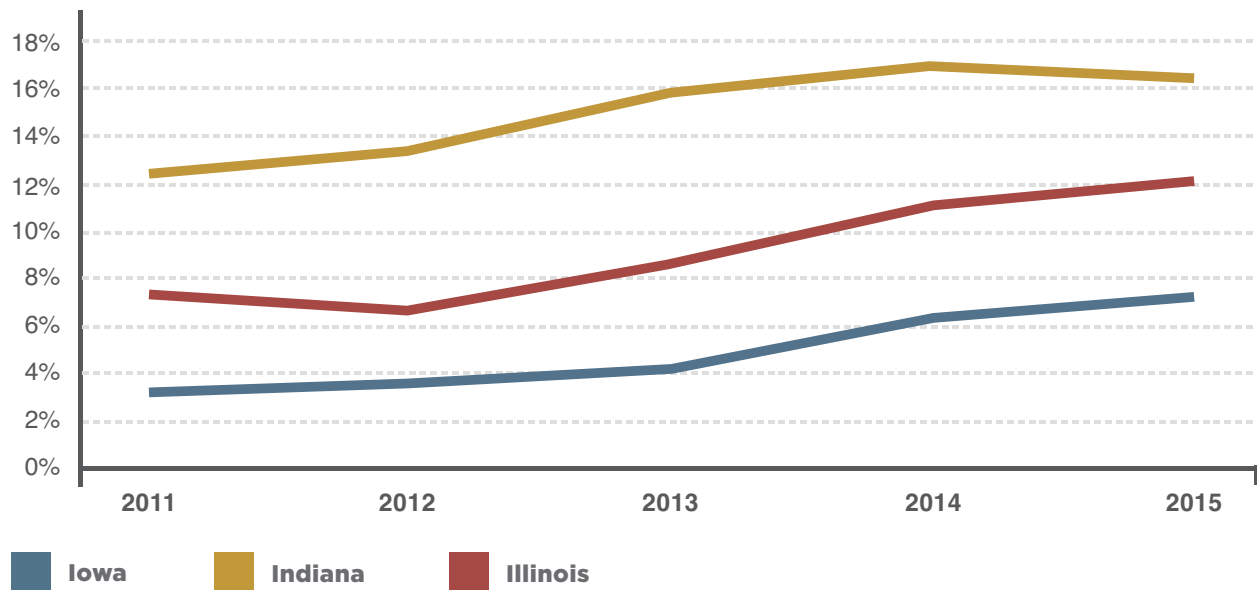
Figure 4: Percent of Annual EQIP Acre Quantity for Cover Crop Practices by Fiscal Year

Iowa Indiana Illinois
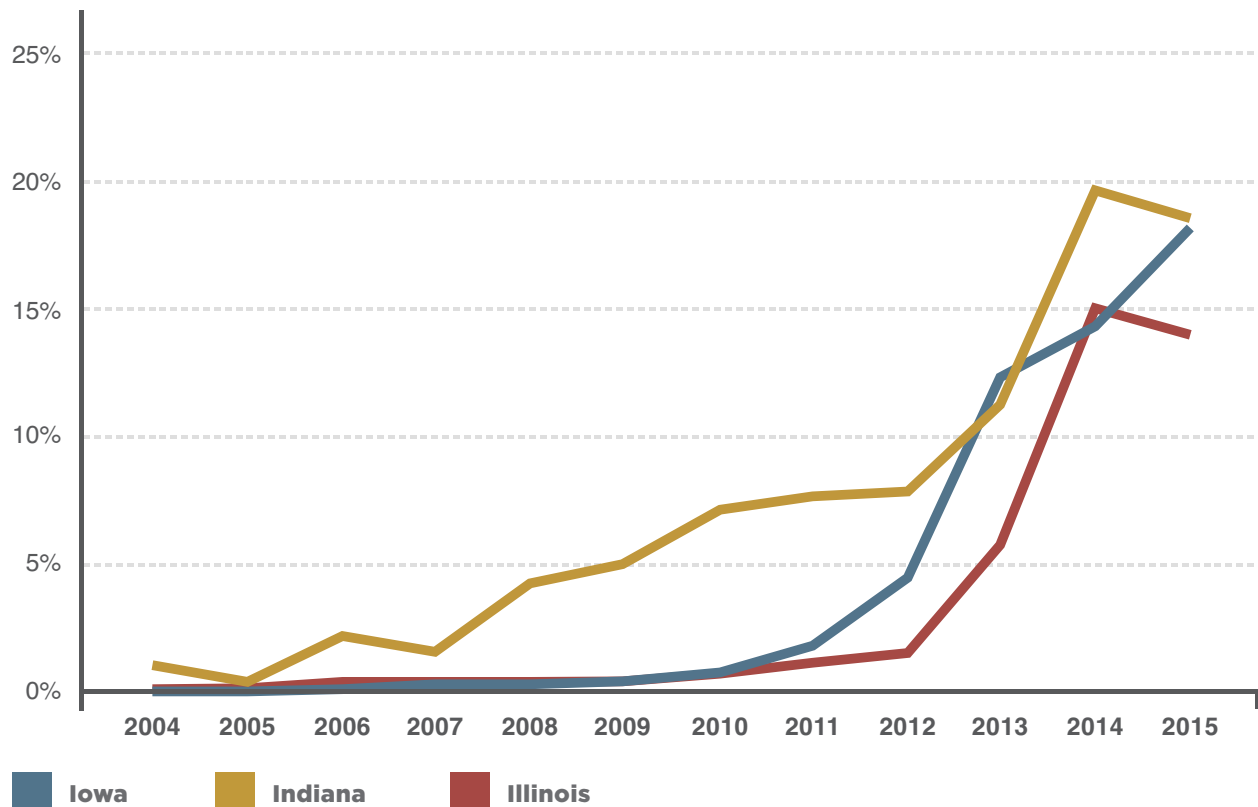
The USDA's Conservation Stewardship Program, or CSP, also promotes cover crops. However, data on the number of cover crop acres installed and amount of funding devoted to cover crops is not available for CSP. To measure a change in cover crop adoption within the CSP program, we measured the percentage of CSP contracts with the following CSP practice enhancements that require the use of cover crops: ENR12, PLT20, SQL02, SQL04, SQL05, SQL08, SQL11, SQL12, WQL10 and 340. Since 2011, the number of contracts that included these enhancements increased steadily in all three states (see Figure 5 on the following page). The share of CSP contracts that included these enhancements in Indiana increased from 12 percent in 2011 to 17 percent in 2015, from 7 to 12 percent in Illinois, and from 3 to 7 percent in Iowa.

Lastly, all three states have also appropriated state funds to farmers adopting cover crops. In 2016, Indiana dedicated **$2.9 million** to its **Clean Water Indiana** program. The program offers financial assistance to farmers and Soil and Water Conservation Districts to implement conservation practices, including cover crops. In 2016, **Iowa budgeted** $4.4 million in taxpayer funds to the **Water Quality Initiative**, a program similar to Indiana's program. Illinois does not currently have a stand-alone program designed to help cost-share conservation practices, but previously allocated financial cost shares to farmers adopting cover crops. Currently, Illinois is only state appropriating funds in the form of individual grants to Soil and Water Conservation Districts working on priority watershed projects.

According to data from IDALS, state-funded acres of cover crops have increased from only 159 acres in 2007 to 175,000 acres in 2015.

Illinois does not maintain any state level cost-share or records of cover crops acres.

Indiana has the most robust measurement of its cover crop acres. Field transects have been established across the state, and are used to track the use of cover crops and other conservation practices. The state reports that cover crop usage jumped from 2 percent of acres planted on corn and soybean cropland in 2011 to 10 percent in 2015.

While dramatic growth in federal and state spending to promote cover crops has resulted in greater adoption, the scale at which cover crops must be used to meet water quality goals is daunting. Some nutrient-reduction scenarios require cover crops on nearly 60 percent of the cropland in order to resolve water quality issues. Current cover crop acres of 2 and 7 percent of the corn and soybean cropland, respectively, took 11 years of investment. At that rate, target cover crop rates won't be achieved for hundreds of years. Use of cover crops must expand far faster to realize landscape-level reductions in pollution and environmental degradation before irreparable damage has been done.

IOWA GROWTH PROJECTION

Since Iowa was the only state to maintain publicly available cost-share data and a cover crop goal, it was modeled to establish rough estimates of how much money and time will be required to meet targets for cover crops. Our projections are based on current rates of adoption, and investment of federal and state conservation dollars to promote cover crops.

The Iowa Nutrient Reduction Strategy provides several scenarios that could achieve the state's goals for cutting

nitrate-N and phosphorus pollution. One of the published scenarios estimates that planting cover crops on 12.6 million corn and soybean acres, coupled with restoring wetlands on 27 percent of Iowa's agricultural land and installation of bioreactors on 60 percent of tile-drained cropland, would achieve a 42 percent reduction from baseline conditions in nitrate losses and a 30 percent reduction in phosphorus losses. This scenario was chosen because it had the lowest percentage of acres for cover crops and would achieve both the nitrogen and phosphorus target reductions.

In 2015, Iowa state funding for cover crops was $4.4 million and $3.8 million in federal EQIP funds was spent to promote cover crops. Based on the frequency with which cover crops appeared in CSP contracts, we estimate that about $2.4 million was devoted to cover crops in 2014, which was the most recent funding data available. Acres of cover crops funded through CSP contracts were calculated using total CSP spending ($39.9 million) multiplied by the frequency for cover crop enhancements, which was 6 percent (see Figure 5 on the previous page). Together, federal and state cover crop funding is an annual investment of $10.6 million in the state of Iowa. Finally, we employed the state cost share for cover crops of **$25 an acre**—federal cost-share rates have a much wider range, from $18 an acre to nearly $100 an acre.

Assuming $10.6 million is available each year and that every farmer who tries cover crops continues to use cover crops after the cost-share payments end, the level of public investment could add 424,000 cover crop acres annually. At this rate, it would take 30 years (at $25 an acre) and

a total investment of $315 million—not accounting for inflation—to reach the 12.6 million acres of cover crops proposed in the NRS scenario. This assumes that all of every year's cost share would lead to permanent adoption.

Table 4: Example Statewide Combination Scenarios that Achieve Both the Targeted Nitrate-N and Phosphorous Reductions from the Iowa Nutrient Reduction Strategy

Name	NCS1
Practice/ Scenario**	Combined Scenario (MRTN Rate, 60% Acreage with Cover Crop, 27% of ag land treated with wetland and 60% of drained land has bioreactor)
% Reduction from baseline[xx]	
Nitrate-N	42
Phosphorus	30
Cost of N Reduction from baseline (%/lb)	2.95
Initial Investment (million $)	3,218
Total EAC* Cost (million $/year)	756
Statewide Average EAC Costs ($/acre)	36

*EAC stands for the Equal Annualized Cost (50 year life and 4% discount rate) and factors in the cost of any corn yield impact as well as the cost of physically implementing the practice. Average cost based on 21.009 million acres, costs will differ by region, farm and field.

**Scenarios that include wetlands, bioreactors, controlled drainage and buffers have substantial initial investment costs.

***N paractices and cost of N reduction are the same as NCS7 (Section 2.2). Reducing P application meets the P reduction goal and lowers the cost of the scenario.

[xx]Baseline load includes both point and nonpoint sources.

Source: Iowa Department of Agriculture and Land Stewardship et al., Iowa Nutrient Reduction Strategy, Table 5.

Not all farmers, however, continue to use cover crops after initially being paid to try them.

An **IDALS survey** reports that "75% of cover crop applicants through WQI in 2015 indicated they are planning to continue" to use cover crops. If 25 percent of farmers fail to make cover crops a permanent part of their operation after the trial period, it would take almost 40 years—at $25 an acre—and a total investment of $420 million to get to 12.6 million acres consistently protected by cover crops.

PFI's and EWG's analysis of remotely sensed cover crop adoption in Iowa, however, suggests that only about 40 percent of farmers who received cost share to try out cover crops continued to use them (see Table 1 above). At that rate of adoption, it would take more than 74 years—at $25 an acre—and $787 million to reach the 12.6 million-acre goal.

All three scenarios show that at current rates of spending, it will take a long time and a large amount of money to get 12.6 million acres consistently protected by cover crops—whether farmers adopted cover crops at 100 percent (30 years and $315 million), 75 percent (40 years and $420 million) or 40 percent (74 years and $787 million).

PUTTING IT IN PERSPECTIVE

This investment may look daunting, but it is a small fraction of the money taxpayers already spend on farm subsidies and crop insurance. The USDA's Farm Service Agency reports that in 2015 alone, farmers in Iowa were paid $660 million through the **Agriculture**

Risk Coverage (ARC) and Price Loss Coverage (PLC) subsidy programs**. That same year, the USDA Risk Management Agency reported that farmers in Iowa benefited from $378 million in **crop insurance premium subsidies**. The $10.6 million invested in cover crops annually in our scenario calculations is only 1 percent of the $1.04 billion spent on farm and insurance subsidies in 2015.

In Illinois, farmers received $914 million in farm subsidies and $388 million in insurance subsidies for total of $1.3 billion. Total subsidies in Indiana were $1.27 billion—$738 in farm subsidies and $532 million in insurance subsidies. Combined with spending in Iowa, that adds up to $3.6 billion in taxpayer funding spent to support farmers' income in just one year. Favorable federal and state tax treatment adds to the remarkable support farmers enjoy.

CONCLUSION

By pursuing the methods in this study, we found that satellite imagery is a useful tool for tracking and monitoring the existence of cover crops, and should be routinely used to provide insight for farmers, policymakers and advocates engaged in efforts to evaluate the adoption rate of cover crops. Collecting this data over time will create a solid foundation for a shared conversation on changes in investments and policies needed to achieve meaningful improvements in water quality and soil health.

The data show that the use of cover crops and investments to promote cover crops are on the rise. That is very good news and shows that more and more farmers are willing to make cover crops an integral part of their operations. The increased

investment of public dollars over the past five years also indicates a growing understanding of the water quality improvement cover crops can provide and a growing commitment to improving water quality.

The data also show, however, that a dramatic increase in initial upfront funding for cover crops and/or other changes in policy will be needed to meaningfully improve water quality within a reasonable timeframe. At current rates of progress, it will take decades to get use of cover crops at the scale needed to make a real difference. **That's too long to wait.**
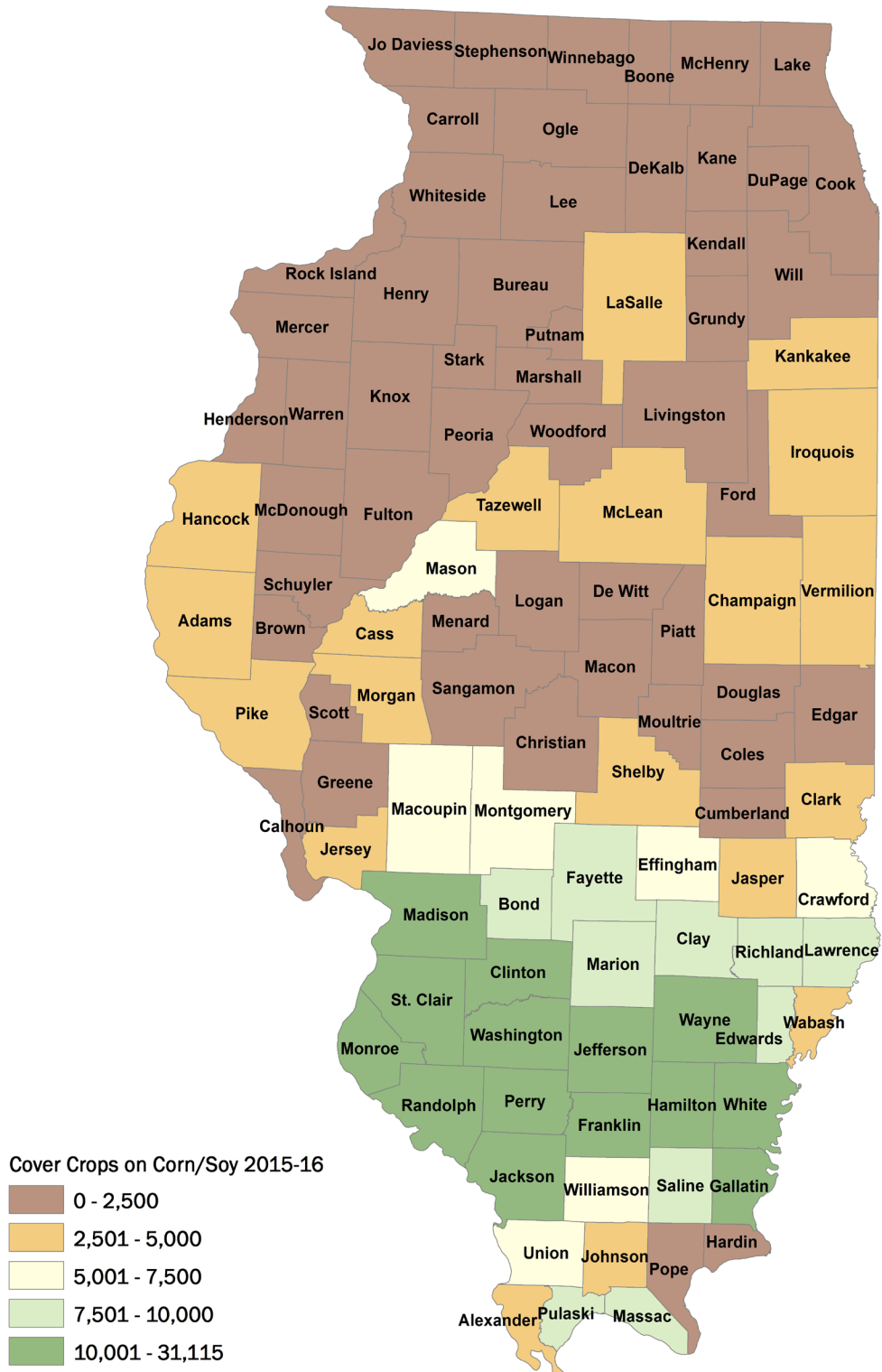
EWG believes that shifting a small allocation of ARC, PLC and crop insurance premium subsidies to water quality would provide enough stimulus to seriously jump start progress on tackling water quality issues. Farming and clean water can go hand-in-hand. But business as usual will not get us clean water for decades. Farmers are ready to be rewarded for providing this public benefit, and allocating funds from the current USDA subsidy programs to farmers who use cover crops could spur real changes.
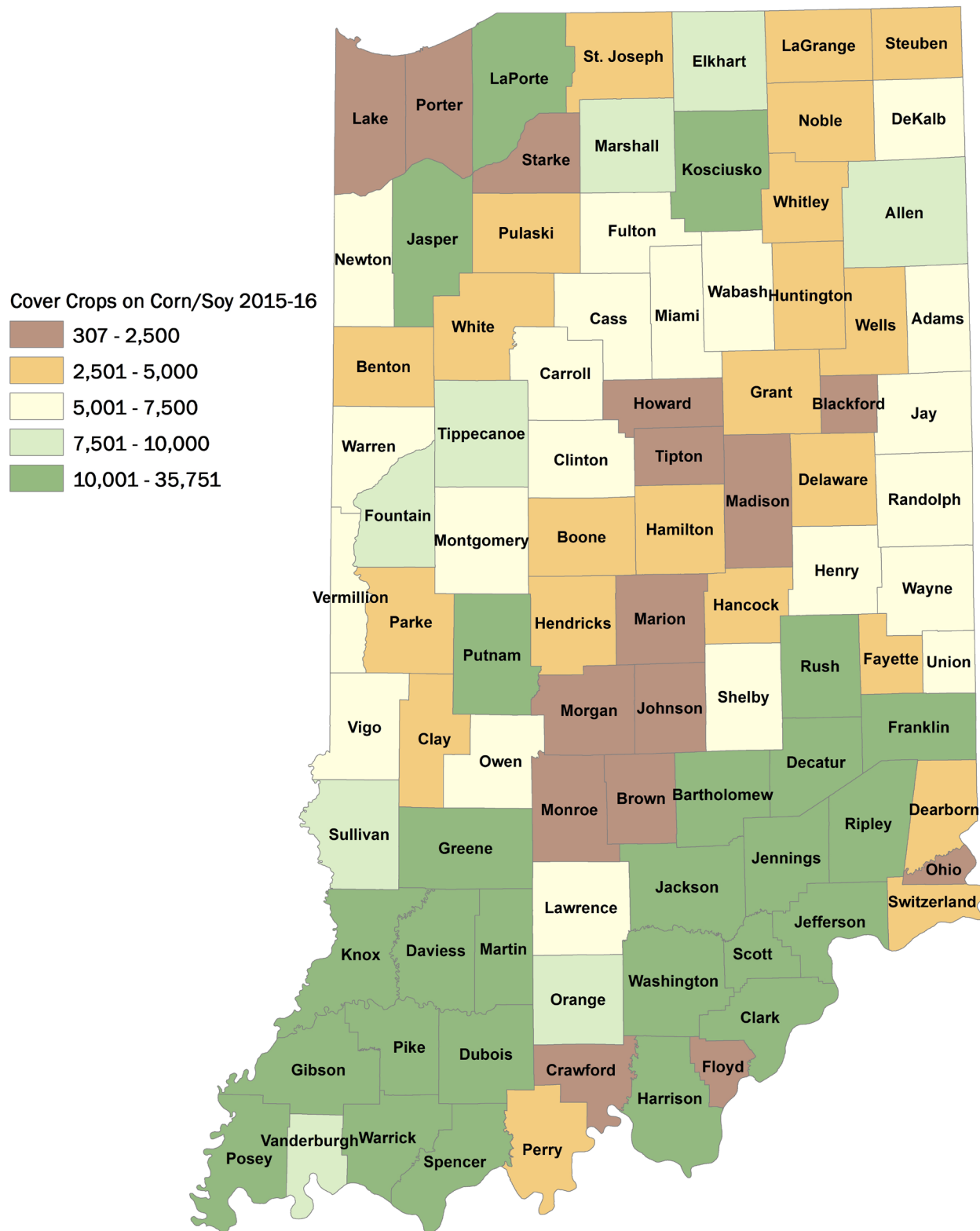
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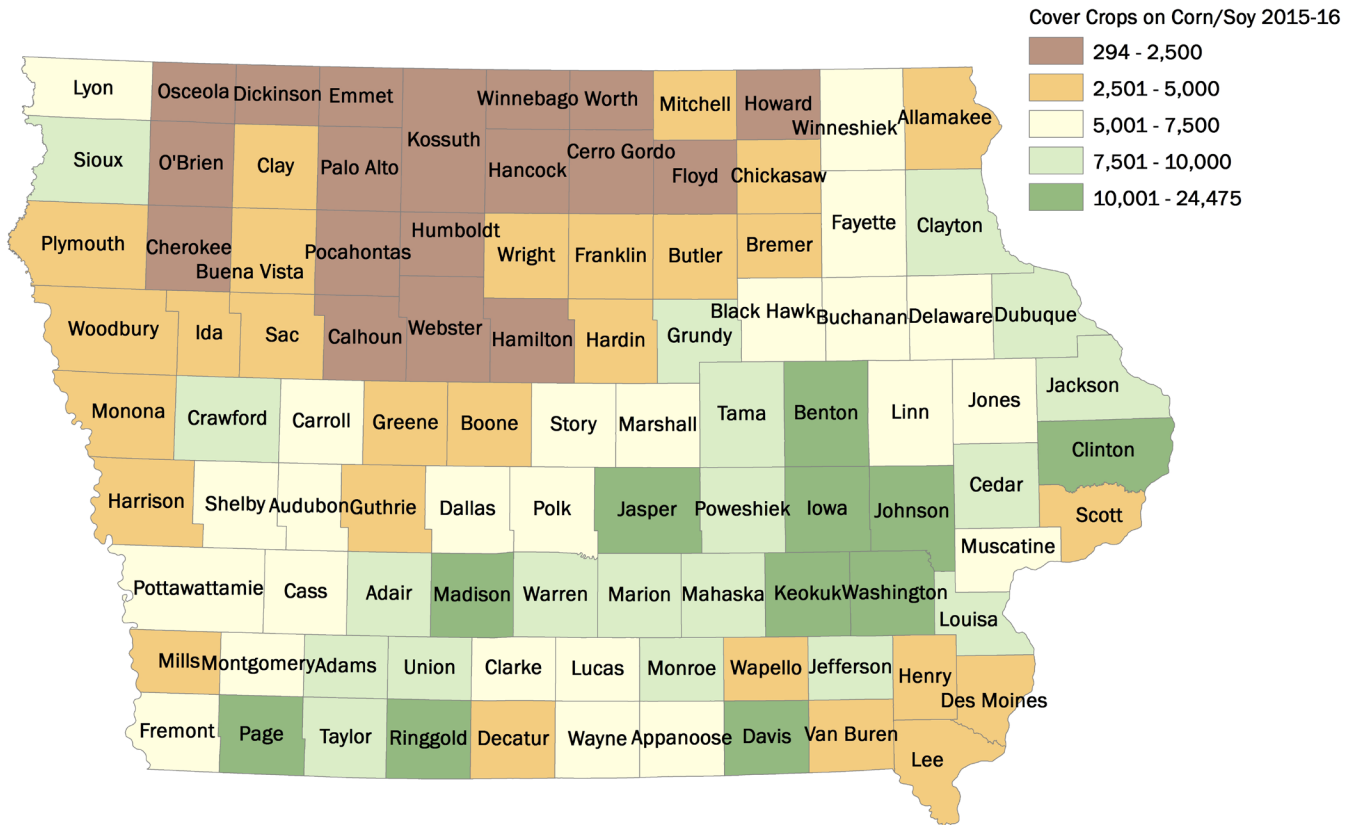
MAPPING COVER CROP ACRES BY COUNTY:

ILLINOIS

Cover Crops on Corn/Soy 2015-16

- 0 - 2,500
- 2,501 - 5,000
- 5,001 - 7,500
- 7,501 - 10,000
- 10,001 - 31,115

Cover Crops on Corn/Soy 2015-16

- 307 - 2,500
- 2,501 - 5,000
- 5,001 - 7,500
- 7,501 - 10,000
- 10,001 - 35,751

IOWA

Cover Crops on Corn/Soy 2015-16

- 294 - 2,500
- 2,501 - 5,000
- 5,001 - 7,500
- 7,501 - 10,000
- 10,001 - 24,475

CENTRAL IOWA COVER CROP DETECTION WITH LANDSAT

Soren Rundquist, Remote Sensing and Landscape Analyst
May 2015

Image Source: Practical Farmers of Iowa

KEY FINDINGS

It Is Possible To Detect Cover Crops Using Landsat Imagery

Within Central Iowa, we found that a clear distinction exists between cover crops and all other fall cover types. On average, cover crops maintain a higher Normalized Difference Vegetation Index (NDVI) throughout the fall, winter and spring. Moreover, the steep decline in NDVI between August and October for all cover types confirms that the field is planted to row crops rather than perennial vegetation. Cover crops also exhibit a higher photosynthetic emergence in the spring months. These findings are essential to separating cover crop from all other fall land cover types and for modeling various cover crop emergence scenarios.

Methodology Tested

Originally, EWG intended to collect data for the fall of 2014 and the spring of 2015 from two Landsat scenes; path26row31 and path27row31. Both scenes cover a large portion of west and central Iowa. Frequent cloud cover inhibited our ability to analyze the original area of interest. Instead we created a smaller area of interest that focused on the overlapping areas between the two Landsat scenes (15 counties in central Iowa). The overlapping area provided the most usable times steps possible for fall and spring analysis.

Cover crops emerge at different times across the area of interest and even within an individual field because of varying field characteristics. To account for this variability in emergence, we used NDVI thresholds established from the ground control to develop seven emergence scenarios (Figure 5) to dynamically capture cover crop growth. The ground control enabled us to establish NDVI thresholds indicating: (1) suppression caused by tillage or harvesting of the crop, (2) crop or cover crop emergence and (3) sustained growth of the crop or cover crop. Each one of the seven scenarios follows a pattern of suppression, emergence and sustained growth that indicates the presence of a cover crop. EWG evaluated each pixel to determine if that pixel followed one or more of these seven scenarios.

Once a pixel was classified into one of the above-mentioned emergence scenarios, it was recorded and then aggregated into a cover crop footprint for further analysis. The finished footprint was then filtered to capture contiguous features that were greater than five acres. Also, if the detected cover crop within an entire boundary of a field (as defined by the USDA common land units) was greater than or equal to 60 percent of the entire tract area was preserved into the footprint.

Test Results

We analyzed over 1.5 million acres of corn and soybeans found within the area of

interest. We detected 9,690 acres of cover crops on about 0.6 percent of the cropland in the area of interest. This percentage is similar to the state level estimate made by Iowa NRCS that 1 percent of planted acres in Iowa are using cover crops.

Cover crops were evenly distributed between corn and soybean acres. Fifty-one percent of the detected cover crops were on acres that had been planted to corn and 49 percent on acres planted to soybeans according to the 2014 Cropland Data Layer.

Going Forward
The most important limitation to detecting cover crops is our reliance on publicly available and free imagery. Landsat is by far the best option, but one is forced to hope that the satellite passes over the landscape at the right time of year and when there is no cloud cover.

The good news, however is that based on the acreage collected from each unique emergence scenario, 72 percent of cover crop emergence happens in the spring months of March and April. Early August to the end of October captured almost all of the rest of the cover crop emergence (27 percent).

This means that we can focus on a more targeted time of year to detect cover crops, which is an important advantage.

Having the resources to purchase or contract for imagery at the critical times of year would substantially increase the capacity to feasibly and accurately track cover crops.

INTRODUCTION

Cover crops have long been touted as a real-world solution for dealing with soil erosion and nutrient runoff. Increasing the presence of vegetation on producing fields

throughout the year enhances yields and maintains soil health. While many producers in Iowa have adopted the practice, a vast majority of fields are still exposed. **Recent estimates peg current planting of cover crops at around 300,000 acres**, approximately 1 percent of all planted acres in Iowa (24,955,000 USDA NASS 2014).

EWG is working to create a method to use remote sensing of satellite data to detect fields that are treated with cover crops. Our goal is to develop a process that would make it possible to determine how many acres on which cover crops are being used, where those acres are located, the quality of cover crop vegetation and trends in use of cover crops over time.

AREA OF INTEREST AND DATA COLLECTION

According to Practical Farmers of Iowa—a nonprofit organization promoting cover crop adoption through outreach, partnership and resources—**fall and winter cover crops are usually planted between August 1st and October 15th**, but the exact date on which cover crops are seeded depends on the specific plant species and weather.

EWG chose to use Landsat 8-OLI satellite data and when necessary fill in gaps with data from Landsat 7-ETM. These sensors were chosen for a variety of practical reasons. Most important, Landsat data is a free product from the USGS/NASA, it revisits the earth's surface every 16 days, and maintains a pixel resolution ideal for detecting large scale agriculture, 30m.

Originally, EWG intended to collect data for the fall of 2014 and the spring of 2015 from two Landsat scenes; *path26row31* and *path27row31*. Both scenes cover a large

Figure 1: Area of Interest
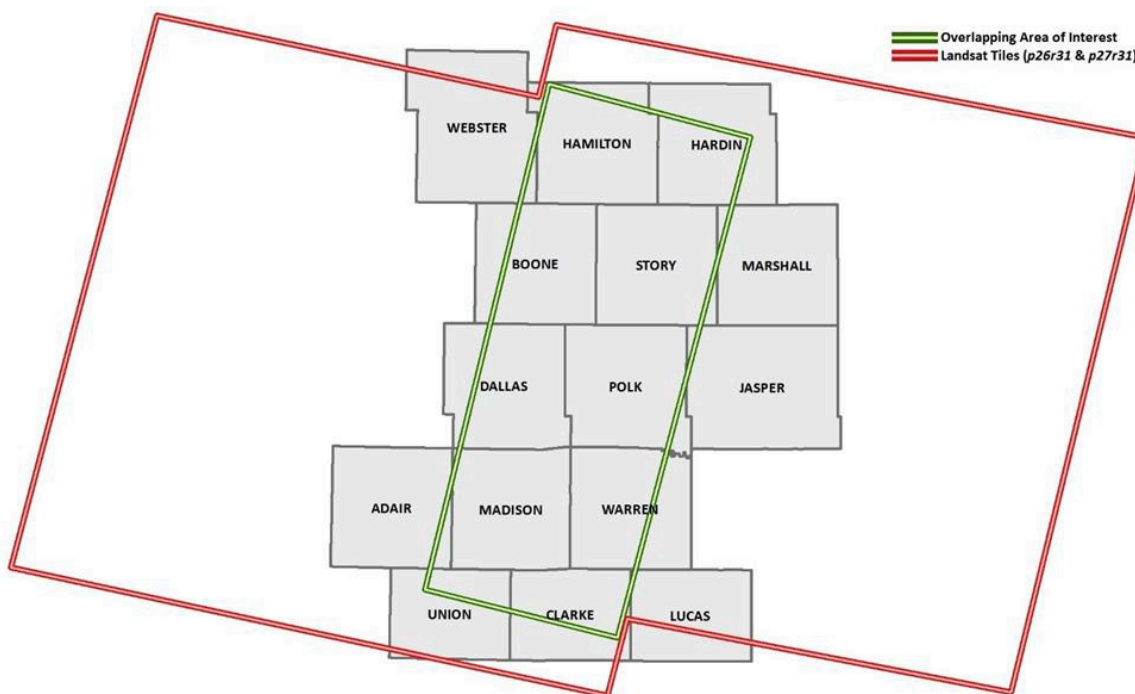
portion of west and central Iowa. Frequent cloud cover inhibited our ability to analyze the original area of interest. Instead we created a smaller area of interest (see green box in Figure 1) focused on the overlapping areas between the two Landsat scenes (15 counties in central Iowa). The overlapping area provided the most usable times steps possible for fall and spring analysis.

Using two, rather than one sensor meant we had to scale the Landsat 7-ETM data to the similarly dated Landsat 8-OLI visit. This was necessary to maintain consistent values between sensors. The scaling factors we used are shown in Table 1.

The following Landsat scene time steps (Table 2) were clipped within the area of interest and used as the base data for the investigation. Because cloud free data in the spring was hard to acquire, maximum value NDVI composites were created from three time steps in late March and mid-April.

NORMALIZED DIFFERENCE VEGETATION INDEX

EWG's approach to tracking cover crop emergence is based on persisting photosynthesis throughout the fall and spring. The Normalized Difference

Table 1: Scaling Factors

	ETM–March 31 & OLI–March 30	**ETM–April 16 & OLI–April 15**
ETM Band4 to OLI Band5	$y=147.8x1 + 4577.1$ $R^2=0.9453$	$y=174.37x + 4427$ $R^2=0.9621$
ETM Band3 to OLI Band4	$y=58.998x + 4708.1$ $R^2=0.9878$	$y=64.805x + 5068.8$ $R^2=0.9592$

Date	Source
August 18, 2014	Landsat 8-OLI
October 21, 2014	Landsat 8-OLI
October 30, 2014	Landsat 8-OLI
November 6, 2014	Landsat 8-OLI
December 17, 2014	Landsat 8-OLI
March 14, 2015	Landsat 8-OLI
March 22, 2015 March 30, 2015 March 31, 2015	Late March: Maximum NDVI Composite Landsat 8-OLI & Landsat 7-ETM
April 15, 2015 April 16, 2015 April 23, 2015	Mid-April: Maximum NDVI Composite Landsat 8-OLI & Landsat 7-ETM

Vegetation Index (NDVI) is commonly used to monitor plant growth and determine phenologic signatures for many agricultural cover types. The NDVI is calculated using near infrared (NIR)

and red (RED) bands in Landsat imagery. Specifically, NDVI is the ratio of NIR minus RED divided by NIR plus RED, which creates a normalized scale ranging from +1 to -1. Positive 1 indicates vigorous plant growth, while negative 1 indicates the absence of plant growth.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Our approach was to use NDVI as an indicator of cover crop emergence. We eliminated pixels obscured by clouds before calculating NDVI for every time step using the quality assessment band in Landsat 8.

GROUND CONTROL

To discriminate between the various fall cover types and their phenologic signatures, a ground survey was conducted by EWG in the middle of November 2014. Ground control results were used to establish baseline NDVI thresholds

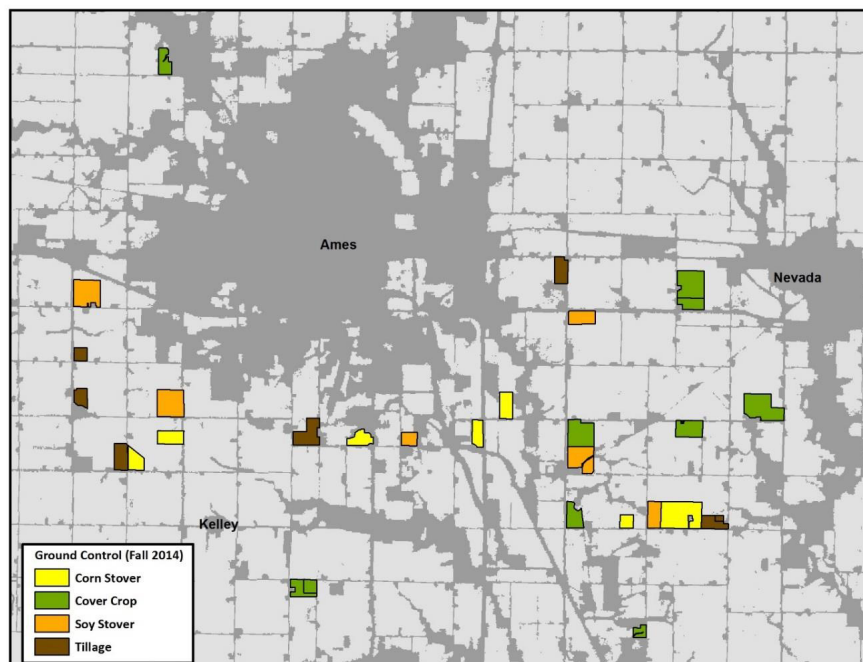**Figure 2: Ground Truth Locations**

Figure 3: Internal Buffered Boundary

over a time frame for tillage, corn stover, soy stover and cover crops. In all EWG captured 29 tracts encompassing 1,200 acres in Boone and Story counties near Ames, Iowa (Figure 2).

Field mean NDVI values were calculated for each ground control field boundary at each time step. Field boundaries were internally buffered by -100 feet, about one pixel width, to reduce noise or edge of field effects (i.e. grass, roads) that were diluting the actual cover value (Figure 3).

Once calculated, the NDVI field means were summarized by cover type and plotted to visualize their phenologic signature (Figure 4). We found that a clear distinction exists between cover crops and all other fall cover types. On average, cover crops maintain a higher NDVI throughout the fall, winter and spring. They also exhibit a higher photosynthetic emergence in the spring

months (green line). In contrast, the barren soil or fields that were tilled between the early November and mid-December (brown line) produced the lowest NDVI values throughout the time frame. Corn and soybean residue showed similar signatures, with corn stover producing slightly higher values (yellow & orange lines). These thresholds will be essential to separating cover crop from all other fall land cover types and for modeling various cover crop emergence scenarios.

The steep decline in NDVI between August and October for all cover types confirms that the field is planted to row crops rather than perennial vegetation.

ANALYSIS

We used USDA's most recent Cropland Data Layer (CDL) to distinguish between cover crops and fields planted to

Figure 4: NDVI Field Means by Scene Date and Cover Type

Legend:
- Corn Stover
- Cover Crop
- Soy Stover
- Tillage (November 14, 2014)
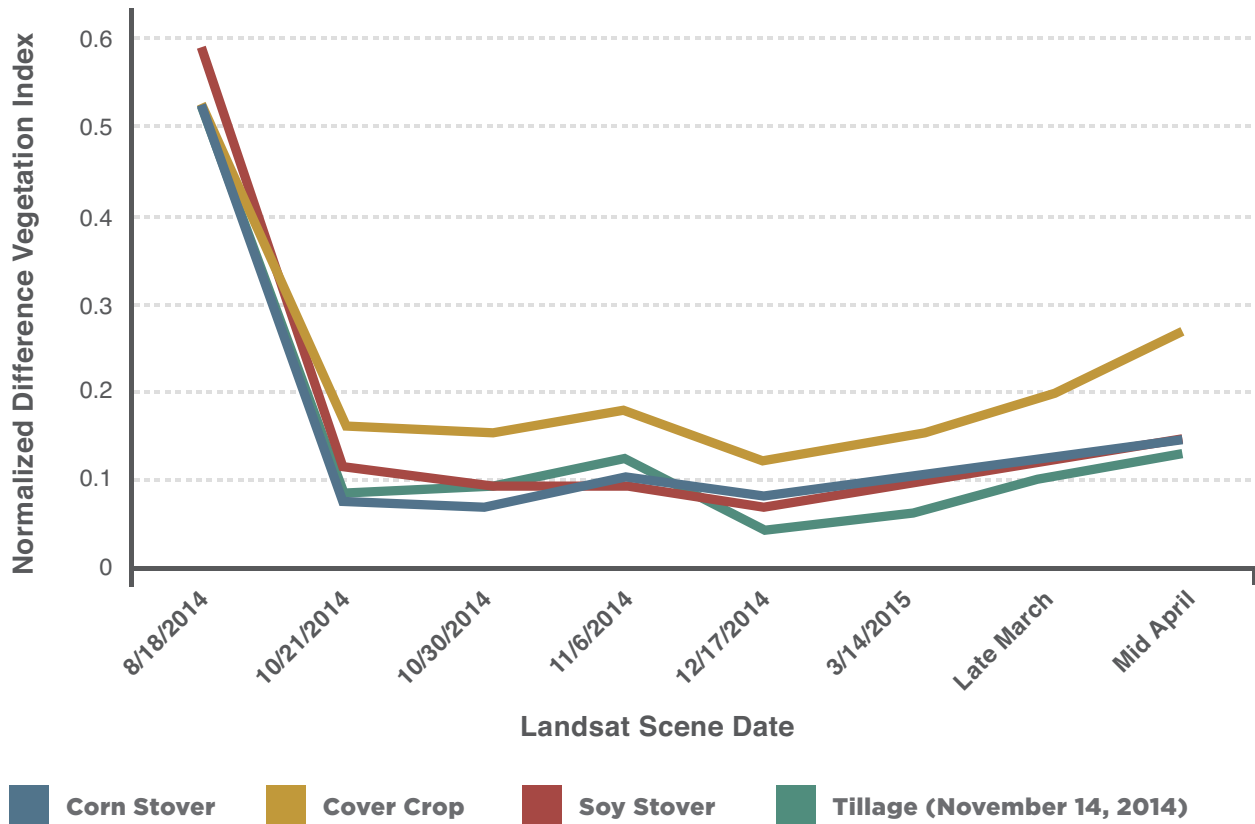
perennial grasses. Only pixels that were classified in the 2014 CDL as either corn or soybeans were used in our analysis. In addition, we filtered out all contiguous pixels of corn or soybean that were less than five acres in size.

Cover crops emerge at different times across the area of interest and even within an individual field because of varying field characteristics. To account for this variability in emergence, we used NDVI thresholds established from the ground control to develop seven emergence scenarios (Figure 5) to dynamically

capture cover crop growth. The ground control enabled us to establish NDVI thresholds indicating: (1) suppression caused by tillage or harvesting of the crop, (2) crop or cover crop emergence and (3) sustained growth of the crop or cover crop. Each one of the seven scenarios follows a pattern of suppression, emergence and sustained growth that indicates the presence of a cover crop. EWG evaluated each pixel to determine if that pixel followed one or more of these seven scenarios.
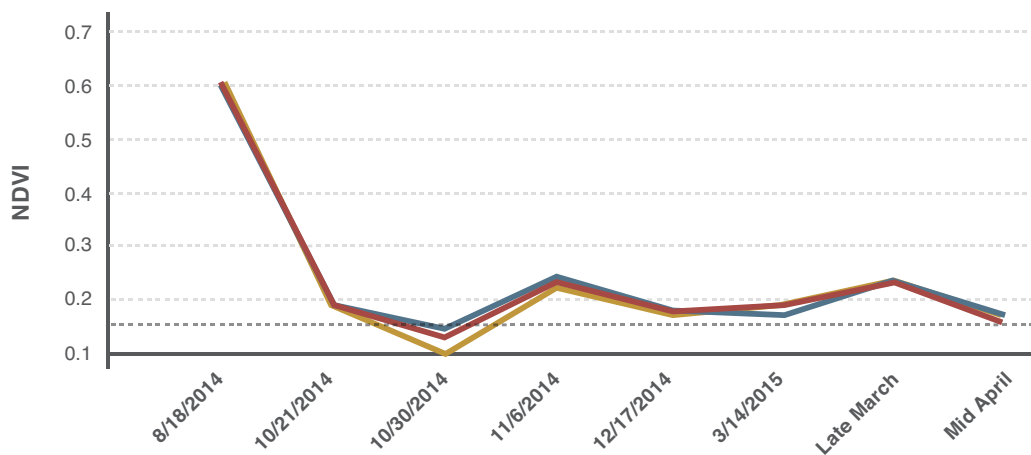
## Figure 5: Seven NDVI Emergence Scenarios
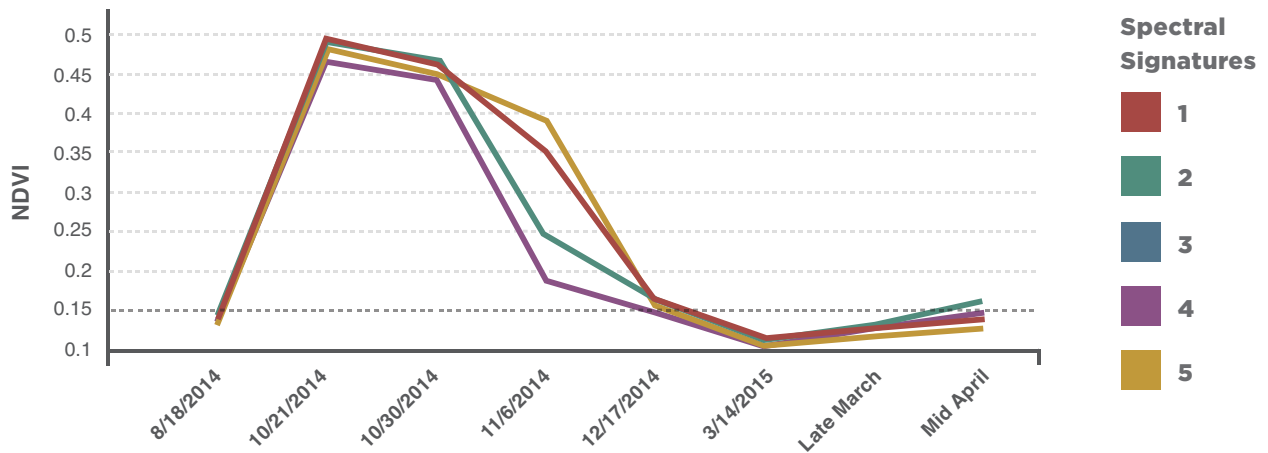
Late summer emergence scenario: August 18th, 2014 NDVI suppression with an October 21st NDVI emergence with sustained greening into October 31st accounted for 9 percent of the total detected emergence.
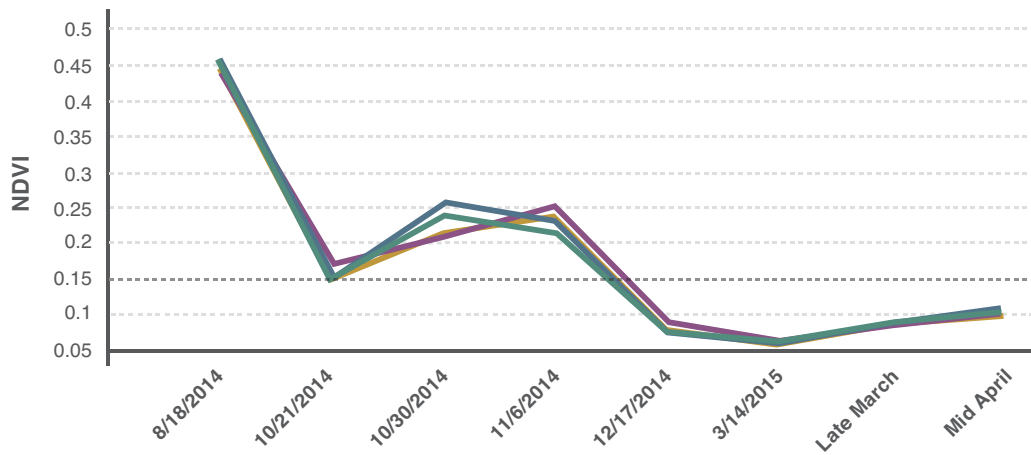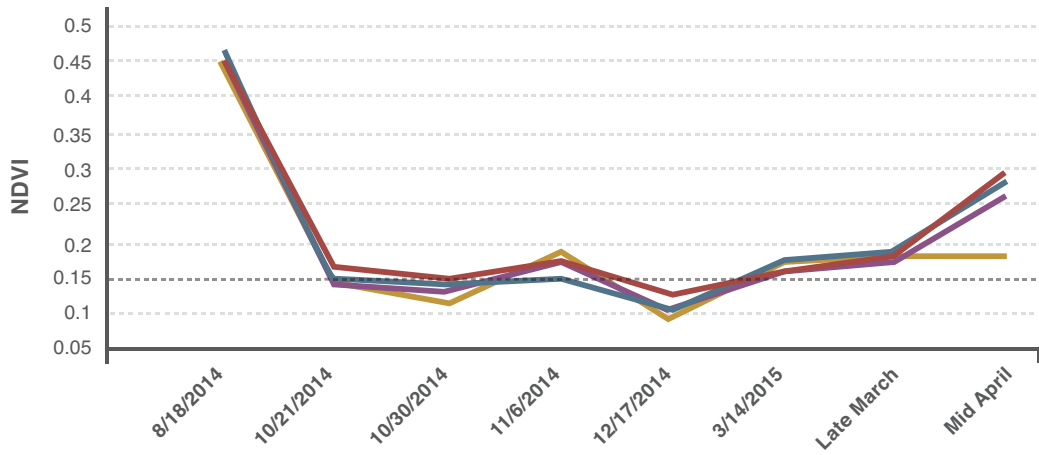

Fall emergence scenario: October 21st, 2014 NDVI suppression with an October 30th NDVI emergence with sustained greening into November 6th accounted for 10 percent of the total detected emergence.
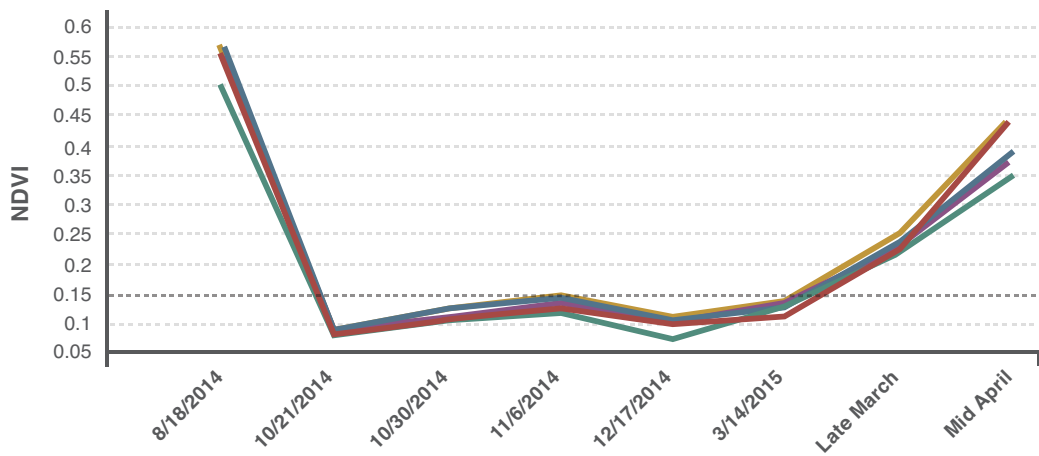

Mid-fall emergence scenario: October 30th, 2014 NDVI suppression with a November 6th NDVI emergence with sustained greening into December 17th accounted for 8 percent of the total detected emergence.

Spectral Signatures
- 1
- 2
- 3
- 4
- 5
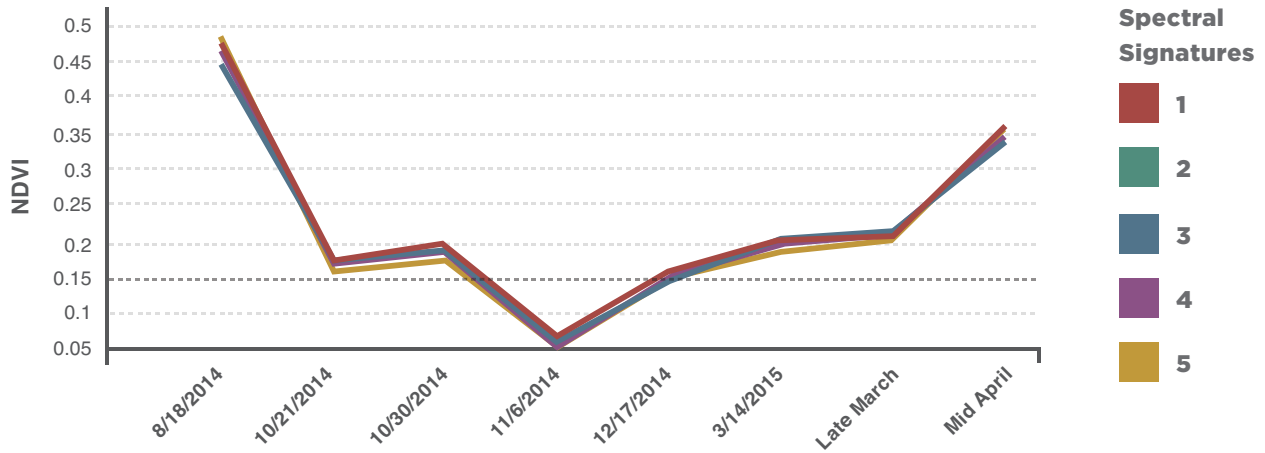
Late fall emergence scenario: November 6th, 2014 NDVI suppression with a December 17th NDVI emergence with sustained greening March 14th, 2015 accounted for 1 percent of the total detected emergence.

Winter emergence scenario: December 17th, 2014 NDVI suppression with a March 14th, 2015 NDVI emergence with sustained greening into March 22nd/30th/31st (Late March) accounted 12 percent of the total detected emergence.

Early spring emergence scenario: March 14th, 2015 NDVI suppression with a March 22nd/30th/31st (Late March) NDVI emergence with sustained greening into April 15th/16th/23rd (Mid-April) accounted for 19 percent of the total detected emergence.
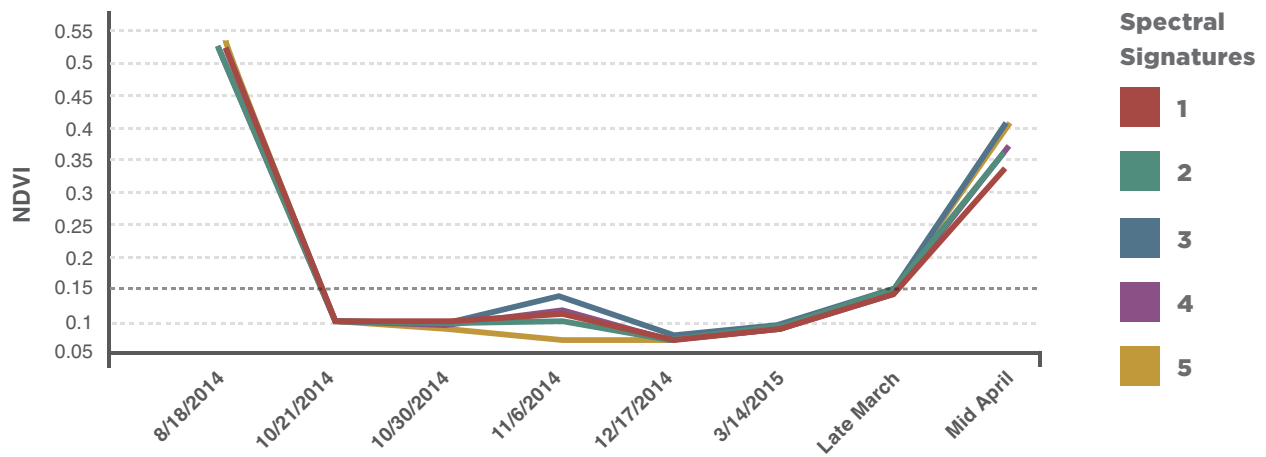
Spring emergence scenario: March 22nd/30th/31st (Late March), 2015 NDVI suppression with an April 15th/16th/23rd (Mid-April) NDVI emergence accounted for 41 percent of the total detected emergence.

Once a pixel was classified into one of the above-mentioned emergence scenarios, it was recorded and then aggregated into a cover crop footprint for further analysis. The finished footprint was then filtered to capture only contiguous feature that were greater than five acres. Also, if the detected cover crop within an entire boundary of a field (as defined by the USDA common land units) was greater than or equal to 60 percent of the entire tract area was preserved into the footprint. This increased the total universe by 134 acres (1 percent).

Based on the acreage collected from each unique emergence scenario, 72 percent of cover crop emergence happens in the spring months of March and April. Early August to the end of October captured almost all of the rest of the cover crop emergence (27 percent). Only 1 percent of the total cover crop footprint emerged in late November to mid-December.

The map below (Figure 6) details how at field and regional level emergence is not uniform, this can be attributed to a variety of factors such as soil health, standing water, inconsistent planting and so forth.

RESULTS

We analyzed over 1.5 million acres of corn and soybean found within the area of interest. We detected 9,690 acres of cover crop on about 0.6 percent of the cropland in the area of interest. This percentage is similar to the state level estimate made by Iowa NRCS that 1 percent of planted acres in Iowa are using cover crops. Ninety-three percent of the cover crop acres were in those counties in which 45 percent (Table 3) or more of the county was included in the area of interest. Boone County had the fewest acres treated with cover crops (533 acres) within the area of interest and Story County the most (1,806 acres). Clarke County, however, had the largest percent of cropland acres with cover crops (2 percent) while Hamilton County had the smallest percent of acres with cover crops (0.2 percent).

Cover crops were evenly distributed between corn and soybean acres. Fifty-one percent of the detected cover crops were on acres that had been planted to corn and 49 percent on acres planted to soybean according to the 2014 Cropland Data Layer.
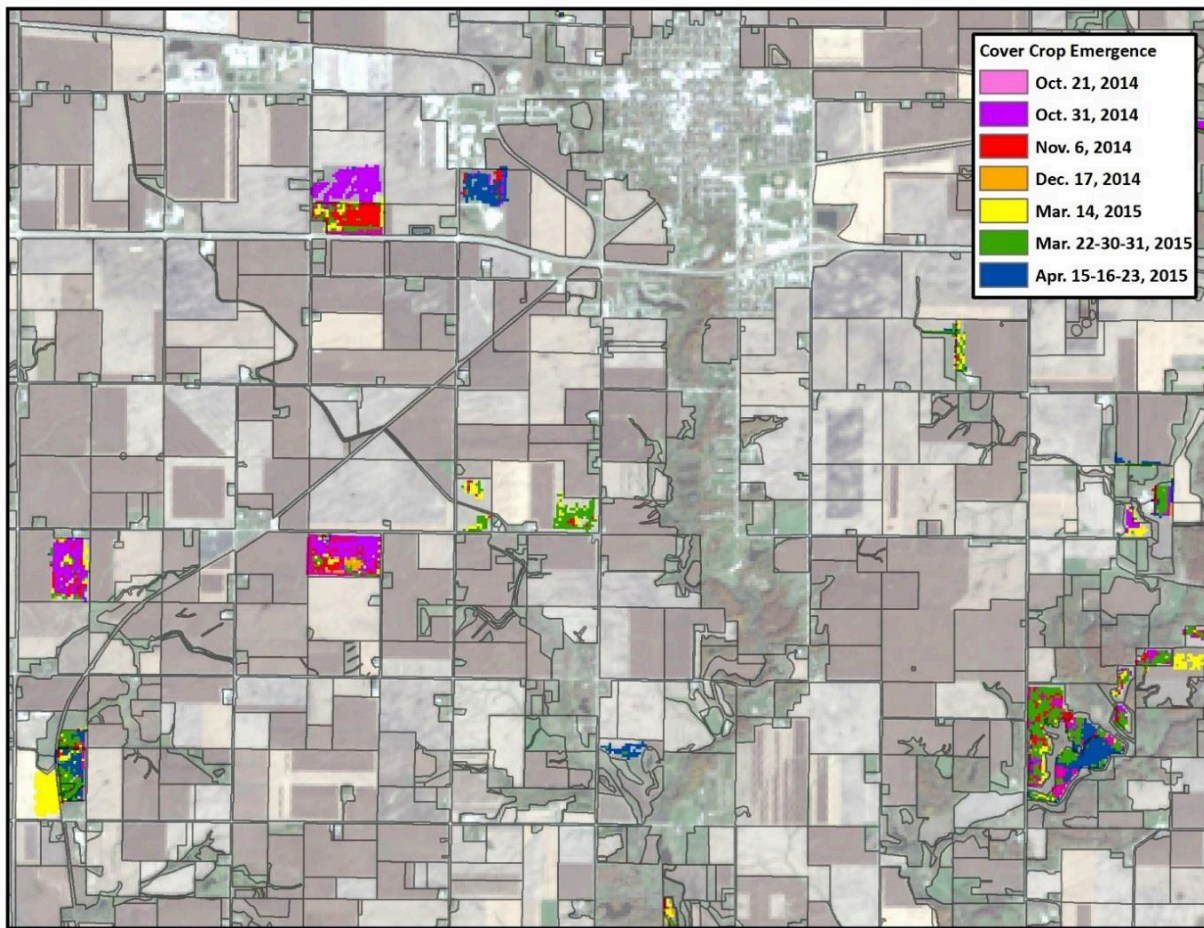
Figure 6: Variation in Emergence Scenarios

Table 3: Cover Crop Acres by County

County	EWG Cover Crop (Acres)	Corn & Soy Within AOI (Acres)	Pct. Of County Sampled	Cover Crop Detected
Clarke	922	47,033	58.5%	2.0%
Madison	1,673	153,102	99.3%	1.1%
Warren	793	88,522	68.3%	0.9%
Polk	1,076	140,443	93.6%	0.8%
Story	1,806	263,651	96.3%	0.7%
Dallas	1,023	173,292	76.2%	0.6%
Hardin	558	136,497	46.8%	0.4%
Boone	533	184,989	75.5%	0.3%
Hamilton	598	256,961	86.1%	0.2%
TOTAL	**8,983**	**1,444,491**	**78.4%**	**0.6%**

Counties with more then 45 percent of the county area assessed by EWG

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