2017 Multi-State Land Use Study Update: Estimated Land Use Changes 2007-2016

Prepared for:

Minnesota Farm Bureau

Missouri Farm Bureau

Iowa Farm Bureau — People. Progress. Pride.

Missouri Agriculture

Kansas Farm Bureau — The Voice of Agriculture

Illinois Farm Bureau — Farm. Family. Food.

Indiana Farm Bureau

Nebraska Farm Bureau

Michigan Farm Bureau

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Decision Innovation Solutions — Bridging Your Research Needs.

October 2017

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Table 1, Acronyms

Acronym	Description
USDA/NASS	United States Department of Agriculture, National Agricultural Statistics Service
USDA/FSA	United States Department of Agriculture, Farm Service Agency
CRP	Conservation Reserve Program
CDL	Cropland Data Layer

Executive Summary

This 2017 Multi-State Land Use Study Update was commissioned by eight state Farm Bureau organizations in the Midwest. The states included in this analysis are shown below.

The primary purpose of this study is twofold: 1) provide estimates of the degree to which land use changes have occurred in many Midwestern states; and 2) identify potential factors contributing to these land use changes. To accomplish this twofold purpose, this analysis has utilized a variety of analytical techniques, tools, and datasets and was performed with the time period 2007-2016 as the frame of reference.

Given the importance associated with a critical limited resource such as land, context is of utmost importance when undertaking a study such as this. Understanding what is happening contextually allows those seeking to understand changes in land use patterns to not only grasp what has actually occurred, but what may have contributed to that change. Since approximately 2005, focus on land use issues has centered on the extent to which land is being converted to the production of crops, and even more specifically, the major program crops and those crops for which there is crop insurance coverage.

The issue of land use change is of great importance in the Midwest. Due to its prime location and possession of some the most productive soils in the world, the issue will certainly continue to be relevant and increase in frequency of discussion as time progresses. In order to adequately address land use challenges, it is imperative to have an accurate understanding of what has occurred, as well as what influencing factors impacted the myriad of land use changes leading to up to the present time.

The 2017 Multi-State Land Use Study Update yielded many interesting results with significant public policy implications. The spatial analysis yielded results that support the perception that land use

continues to evolve in the Midwest, just as it has done for centuries. The table below shows a summary of estimates of net land use change during the 2007-2016 timeframe based on satellite imagery. As shown, the total net change across the entire 8-state study area was 19.848 million acres.

The majority (sixty-seven percent) of this net change was toward Non-Perennial Crops (Corn, Soybeans, Small Grains and Other Oilseeds). A combined 4.390 million acres (twenty-two percent) designated as "Perennial Crops and Habitat" (woody habitat, alfalfa and other ag) were net recipients of grassy habitat acres. The remaining 2.117 million acres (eleven percent) went to what has been classified as Non Ag.

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Grassy Habitat to Perennial Crops & Habitat	Net Grassy Habitat to Non-Perennial Crops	Net Grassy Habitat to Non-Ag	Net Total Grassy Habitat Change
Nebraska	997,367	3,404,295	823,796	5,225,458
Minnesota	733,925	1,624,783	332,711	2,691,420
Iowa	722,805	1,746,538	359,498	2,828,842
Illinois	28,195	878,796	301,767	1,208,758
Indiana	184,636	521,662	183,104	889,402
Michigan	1,187,012	574,910	171,827	1,933,749
Kansas	334,132	2,672,972	(164,265)	2,842,839
Missouri	201,885	1,916,976	108,810	2,227,671
8-State Total	4,389,958	13,340,932	2,117,249	19,848,138

One of the key findings of this research with regards to spatial implications is the degree of value gained from using CDL data for decision making. While the CDL data have been improving over time and continues to increase its ability to guide the policy decision making process, there are still errors in how certain types of land covers are identified, particularly those which are either comparatively observed less frequently or are grassier in nature. To base policy decisions solely upon results from CDL data can lead to less than optimal outcomes with regard to land use patterns.

A key finding of this research with regards to econometric implications is that the study of land use has embedded within it many intertwining issues which cannot be reduced to a few simple variables. One of these issues in particular is that our economic research does not support the notion that crop insurance subsides and net returns alone are the dominant factors contributing to loss of Grassy Habitat, especially when observed from a regional perspective.

Both spatial and econometric results have led to questions that could be the subject of additional research in the realm of understanding Midwestern land use patterns. These areas for further consideration include: 1) the expansion of crop production beyond traditional growing areas; 2) the impact of elevated crop prices and returns on land use change; and 3) the future of land stewardship efforts and programs.

Introduction

Project Scope

This 2017 Multi-State Land Use Study Update was commissioned by eight state Farm Bureau organizations in the Midwest1. The states included in this analysis are shown in Figure 1.

Figure 1, 8-state Study Area

The primary purpose of this updated study is twofold: 1) provide estimates of the degree to which land use changes have occurred in many Midwestern states, particularly in more recent years; and 2) identify potential factors contributing to these land use changes. To accomplish this twofold purpose, this analysis has utilized a variety of analytical techniques, tools, and datasets and was performed with the time periods 2007-2012, 2012-2016 and 2007-2016 as the frames of reference.

Contextual Overview

Given the importance associated with a critical limited resource such as land, context is of utmost importance when undertaking a study such as this. Understanding what is happening contextually allows those seeking to understand changes in land use patterns to not only grasp estimates of what has occurred, but what may have contributed to that change, and thus inform public and private policy decisions.

As in other geographies and time periods throughout the history of the United States, land use continues to evolve in the Midwest. During early colonization years prior to the expansion west in the 19th century, the Midwest's primary land cover was prairie grassland. As westward expansion occurred,

[1] The original study included South Dakota, but not Kansas and Missouri. This update includes the 2007-2012 timeframe for Kansas and Missouri to provide a complete, comparable analysis.

a large share of this native prairie was converted to other uses, such as urbanization along with crop and livestock production.

Since approximately 2005, much of the focus on land use issues has centered on the extent to which land is being converted to the production of crops. In some cases it is argued that the conversion of non-cropland has come at the expense of native prairie, while other sources of converted cropland has been land which has historically been used at some point for producing crops (i.e., pasture, acreage enrolled in the Conservation Reserve Program, etc.).

Conservation Reserve Program[2]

Figure 2, shows the cumulative total acreage enrollment in CRP from its inception in 1986. The trend of late is a decline in total acreage enrolled in the overall CRP program, but an increase in continuous CRP. This trend coincides with both a large number of acres reaching contract expiration and elevated economic returns for producing crops. Current total CRP acreage is at the lowest level since 1988. Total CRP acreage peaked in 2007 at 36.8 million acres. Acreage enrolled in the CRP program in 2016 was 23.5 million acres. With such a large reduction in CRP acres from 2007 to 2016 (13.3 million acres), the policy decision (2014 Farm Bill lowered acreage cap to 24 million acres) to reduce the number of CRP acres is a major reason for acreage leaving grassy habitat for something else.

Also demonstrated in Figure 2 is that, while total CRP acreage has been declining since 2007, continuous CRP is increasing both in terms of acreage and share of total acreage. In 1997 (the first year acreage was enrolled), continuous CRP represented just 1.7% (555,000 acres) of the total; the share of total in 2016 was 9.4% (7.023 million acres). While total CRP acreage has significantly declined since 2007, it can be argued that the acreage remaining in the program is more environmentally sensitive and are thus higher quality acres from a sustainability standpoint. Alternatively stated, whole farm enrollments in the early years of the CRP program removed acreage from production that was in large part suitable for crop production.

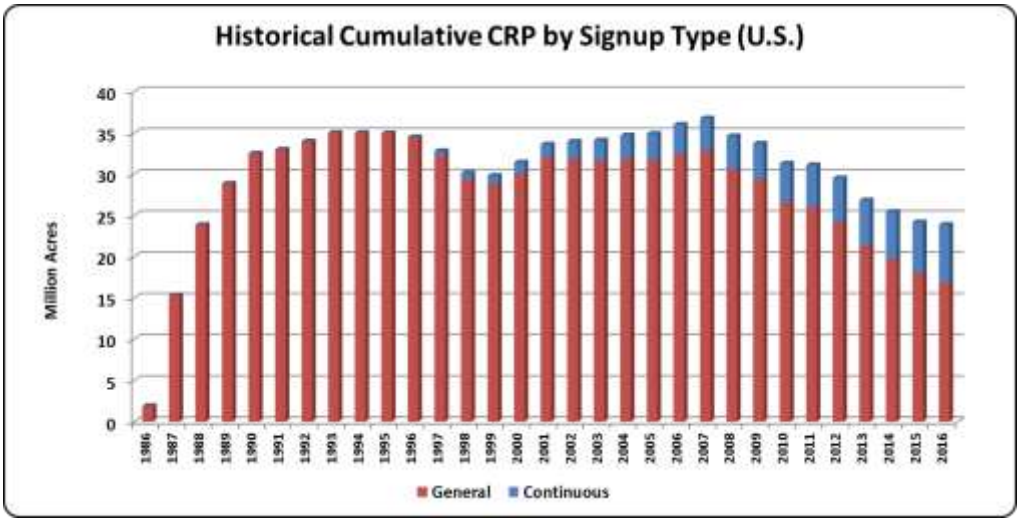


Figure 2, Historical Cumulative CRP Acreage (U.S.)

[2] Much of the language regarding CRP that was included in the original report has been moved to Appendix B, Conservation Reserve Program.

There are many, and often significant factors (i.e., water rights, water availability, returns from competing agricultural endeavors such as livestock production, etc.), influencing landowners' decision-making process regarding the use of their land. However, for the purpose of this study, we have chosen to better understand the role crop production economics plays in land use decisions. We have chosen this as our focus because upon closer inspection it appears to be the most influential factor affecting agricultural land use decisions.

Methodology

The 2017 Multi-State Land Use Study Update consists of two major components: 1) Spatial Analysis, and 2) Econometric Analysis. Below are details regarding the methodology employed, data used, and implications surrounding the choice of methodology and data used in this analysis.

Spatial Analysis

The spatial analysis component of the 2017 Multi-State Land Use Study Update seeks to answer the question of what types of land use change have occurred for three periods: 1) 2007 to 2012, 2) 2012-2016, and 3) 2007-2016. Specific data have been identified and used to answer this question and is detailed below.

Data Description

The single most important data source for the spatial component of the 2017 Multi-State Land Use Study Update is the USDA/National Agricultural Statistics Service (USDA/NASS) Cropland Data Layer (CDL) dataset. Depending on the state in question, there are varying degrees of historical data available. In order to accurately compare states across time, the identification of a common time frame was necessary. For purposes of this analysis, the periods selected were 2007-2012, 2012-2016 and 2007-2016, which allows for the analysis of ten annual land use category totals and three period changes in land use.

Annual data in the USDA/NASS CDL has historically provided estimates of land use in about 130 possible land cover types across the United States. Geography necessarily precludes any one area from having all possible land cover types present in a given area. Because the degree to which the CDL data are classified is computationally intensive, we have aggregated the universe of land use types into nine categories, which are detailed in Appendix A, Land Use Types. The land use type aggregation scheme followed in this update is the same as in the original study. Below are the nine land use categories used in this analysis:

1. Corn
2. Soybeans
3. Other Oilseeds
4. Alfalfa
5. Small Grains
6. Other Ag
7. Grassy Habitat
8. Woody Habitat
9. All Non-Ag

Spatial Analysis Methodology

Change Data

Beginning in 2007, all Midwest states have had annual data from the USDA/NASS CDL collected. Because the USDA/NASS began to make available universal coverage in 2007 for the states under study, this remains the starting year of the analysis. The resolution of the annual data was not consistent, so all years were resampled to 100-meter resolution to get a consistent resolution across all states and years.

Using ArcGIS, the USDA/NASS CDL data were re-classed to the above listed nine aggregation categories from over 130 land types in the CDL data. Once this was completed for the 2007, 2012 and 2016 (i.e., the "endpoint years") raster sets, the 2012 values were subtracted from the 2007 values to determine the land use change, if any, which occurred during the six-year period. Similar calculations were made for the 2012-2016 and 2007-2016 periods. Doing this created 73 possible land use changes. Once the raster datasets were combined to determine change, the raster was converted to a polygon dataset to calculate the areas of each individual land use change.

To determine individual county data, each county was clipped out of the statewide polygon for each endpoint year to determine changes. Individual county files were summarized according to each possible land use change and then exported to be used in a SAS software application for the summarization of county-specific change data. State change totals were also calculated.

Annual Data

To aid in the econometric analysis component of the study, ArcGIS and the USDA/NASS CDL data were again used to re-class the data for the non-endpoint years (2008-2011 and 2013-2015) into the above listed nine aggregation categories. Annual data totals did not determine the "change" as was done for the three periods mentioned previously. Each year's annual totals were summarized by the nine aggregation categories and the total area for each category was determined for each county in each state.

An important point worth mentioning regarding the spatial analysis methodology is that, whereas some analyses have endeavored to understand habitat acreage changes from a "converted from habitat" basis, we have analyzed land use changes on a net basis. In other words, our expectation for this research assumed that land use changes can move both directions (both to and from habitat). To not account for land use changes on a net basis, in our opinion, would produce research and results that could be biased, marginalized and rendered useless, or worse yet, lead to inaccurate conclusions regarding the magnitude of land use changes that are occurring and the drivers of land use change. Our goal has been to provide a rigorous analysis that withstands scrutiny.

Alternative Aggregation

Between the time the original study was completed (2007 through 2012) and this update (through 2016), a different kind of sensing result has been detected with regard to grassy and woody habitat aggregation categories. A flag was raised when large amounts of grassy habitat moving to woody habitat were noticed over the course of the ten-year study period. For example, in Michigan, one third of the

net change in acreage from grassy habitat went to what we'd termed woody habitat (see Figure 3). In some instances, particularly northwestern Nebraska, the share was much higher than one third. The 8-state study area total acreage estimated to have moved to woody habitat from 2007-2016 was 2.279 million acres, or 11.5% of the total acreage shift (19.8 million acres)

Respective shares of the movement of grassy habitat to all other categories can be seen in Figure 4. While a few states such as Minnesota and Illinois didn't see as much of an impact on a percentage basis (two percent or less), the remaining states studied had at least eight percent of their net movement from grassy habitat to woody habitat.

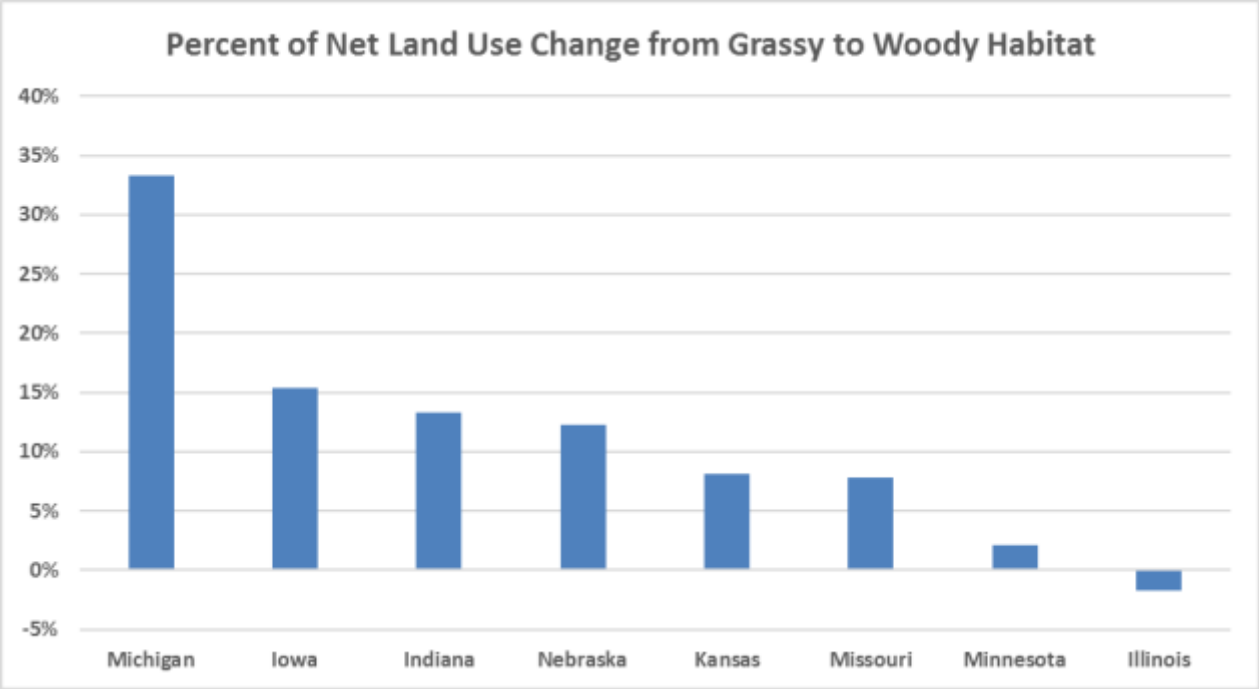


Figure 3, Percent of Net Land Use Change from Grassy to Woody Habitat (2007-2016)

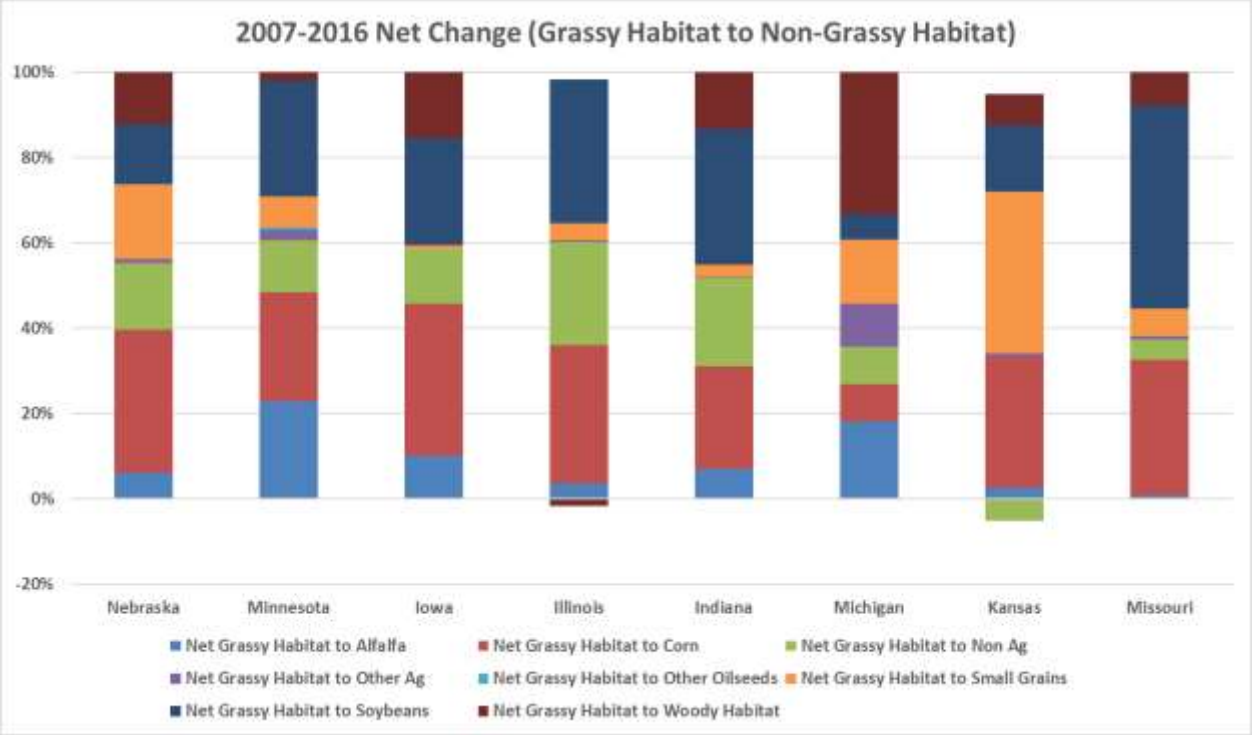


Figure 4, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)

Because of the large impact of this sensing result, areas that were flagged as moving to woody habitat from grassy habitat were plotted on a terrain map to see where they were located. While results for all points for all eight states were derived and plotted, three are shown in this report for demonstration purposes. These examples follow.

Boyne City, MI in Charlevoix County near Lake Michigan

Crawford, NE in Dawes County in northwest Nebraska

Kanopolis, KS in Ellsworth County, KS (central KS)

What is very apparent in the three maps above is that, with few exceptions, the affected points on the map are near tree lines, filter/buffer strips, streams and rivers. A few thoughts and potential explanations for this:

1. Over the course of ten years, natural growth of trees has caused the satellites which sense land cover to sense differently
2. CRP and other idle or minimally-used lands have had small trees (cedars, sycamores, etc.) begin to grow to a point which has caused them to be sensed differently

If a premise for conducting this study is determining if habitat acreage is being lost to production agriculture, one could argue that movement to what has been defined as woody habitat is a positive movement. Because the passage of time has likely caused these particular areas to be sensed differently, we have chosen to adjust how results from this update are presented. We have also restated the original results in a similar way so as to remain comparable to the latest data. To allow for a backward comparison, we provide the current results under the same reporting structure as in the original study and have included these results in Appendix D.

Using the nine aggregation categories mentioned in the Data Description section previously results will be presented as shown below. Similar to woody habitat, Alfalfa and Other Ag (berries, fruit trees and other less-intensively-farmed ground) provides habitat benefits and have thus been included in the "Perennial Crops and Habitat" category. We invite readers to visit Appendix A, Land Use Types, for a more complete breakdown of what is in each of these categories.

- **Grassy Habitat**
- **Perennial Crops and Habitat**
    - Woody Habitat
    - Alfalfa
    - Other Ag
- **Non-Perennial Crops**
    - Corn
    - Soybeans
    - Small Grains
    - Other Oilseeds
- **Non-Ag**

Movement of Grassy Habitat to Non-Ag

The methodology and aggregation scheme adopted for this analysis estimated a net total of 2.117 million acres moving from grassy habitat to non-ag (see Appendix A, Land Use Types for what is classified as "Non-Ag"). This represents nearly 10.7% of the total 19.8 million acres estimated to move from grassy habitat on a net basis. Because this shift category is nearly as large as the shift toward woody habitat, further context is warranted. To provide additional context, an example from each of Nebraska, Iowa and Illinois are used.

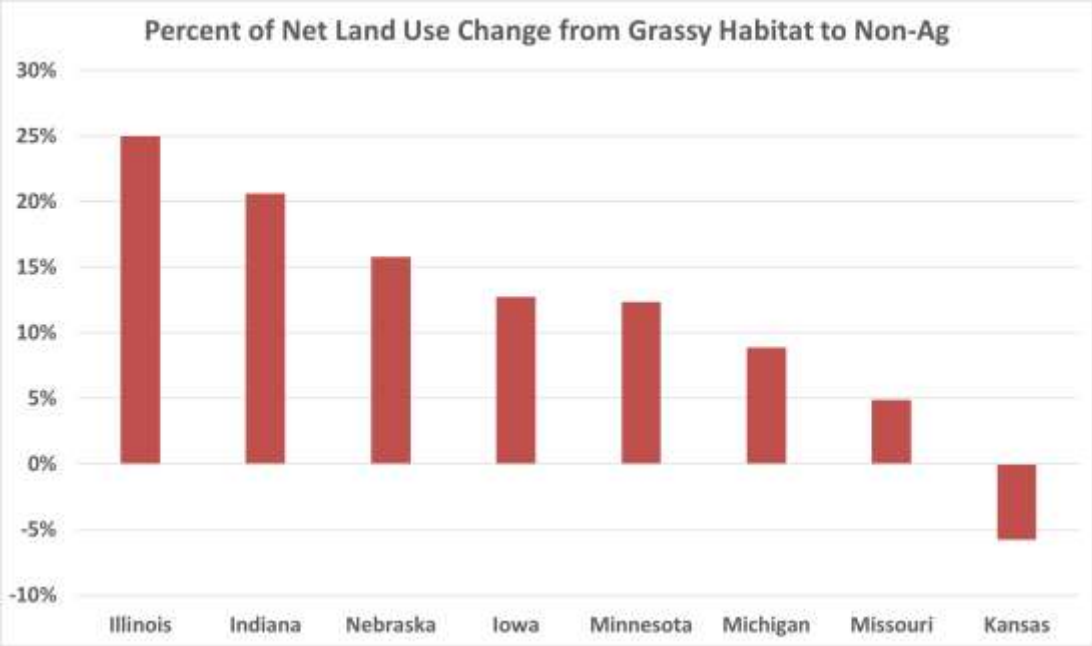
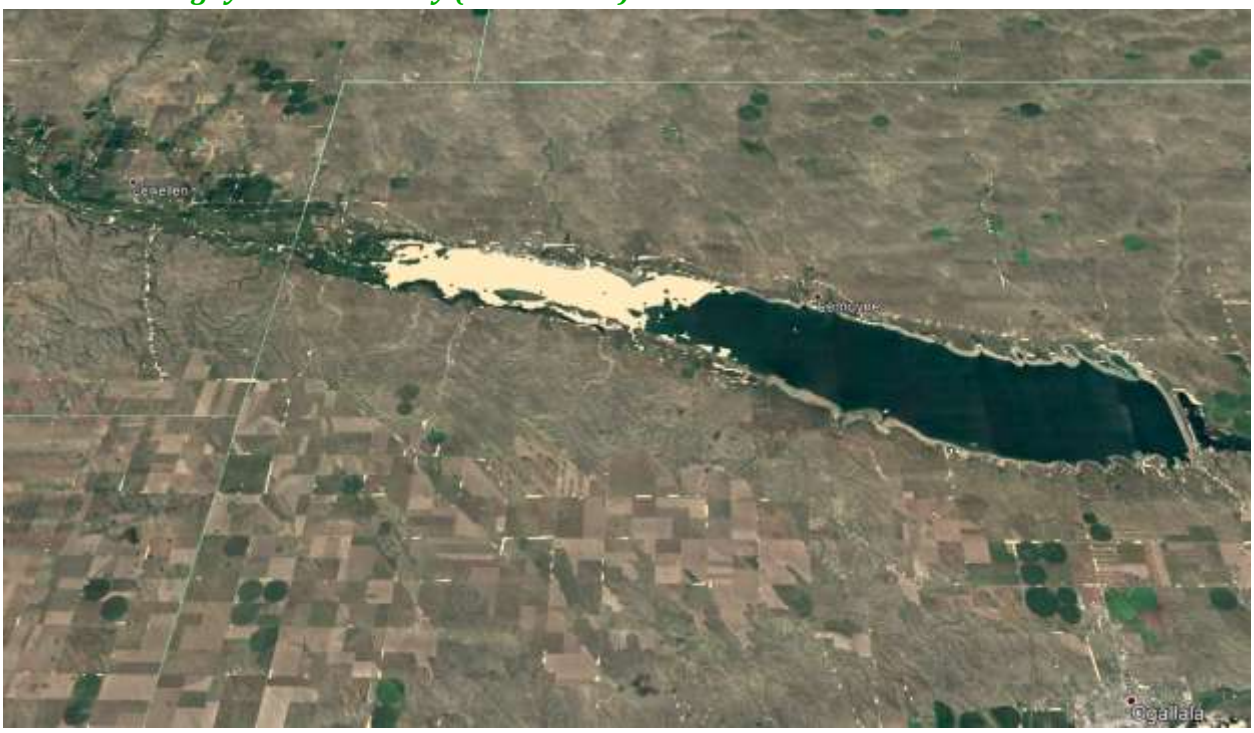
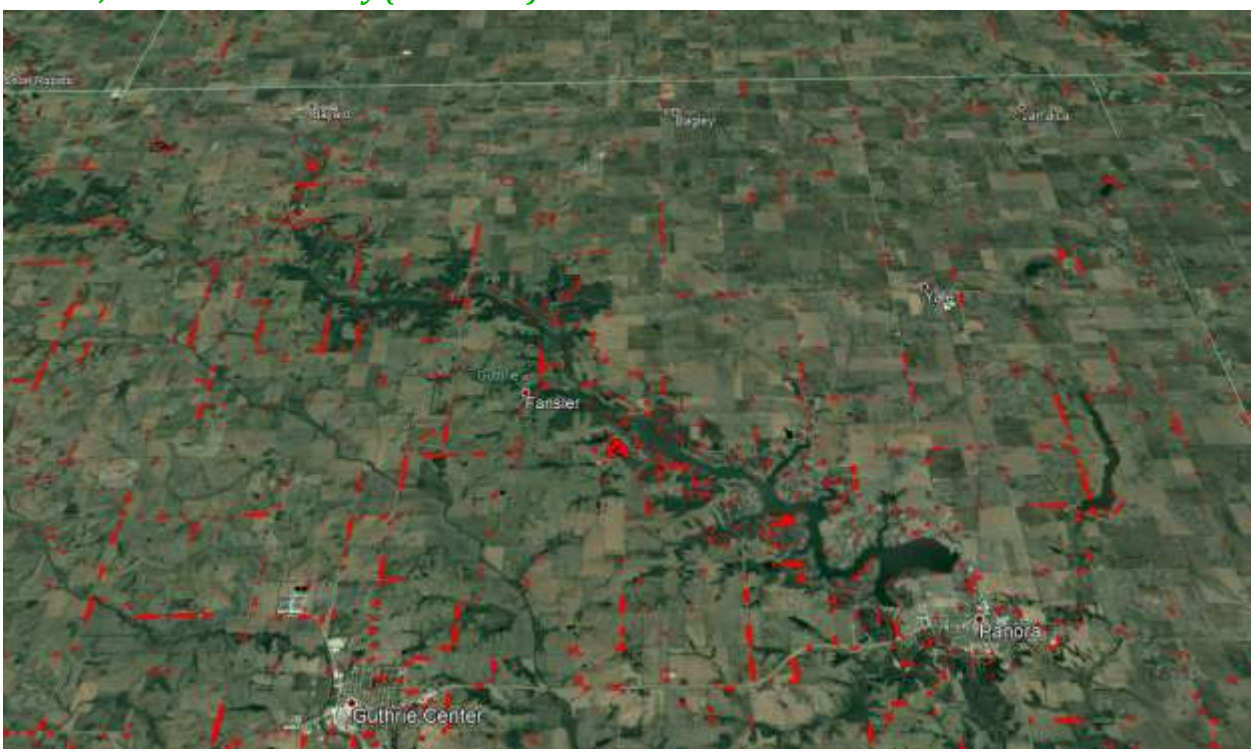


Figure 5, Percent of Net Land Use Change from Grassy to Woody Habitat (2007-2016)

Lake McConaughy in Keith County (Western NE)



Panora, IA in Guthrie County (Central IA)



Grantfork, IL in Madison County (Southwestern IL)

What is apparent in the maps from the three states above is that, with few exceptions, the affected points on the map are near or include roads, right-of-way's and bodies of water such as lakes, streams and rivers. A few thoughts and potential explanations for this:

1. Over the course of ten years, the way roads are sensed has changed.
2. Fluctuations in water body size (i.e., Lake McConaughy in NE) from year to year cause additional acres to be sensed as covered by water, which is classified as "non-ag".

Given the premise for commissioning this study (understanding shifts of grassy habitat to non-perennial crops) and because of the patterns of where and under what circumstances it occurs, the acreage that shifted from grassy habitat to non-ag should be understood, but do not materially change the results.

Grassy Habitat Acreage Estimates

A second underlying issue is with the overall acreage classified as Grassy Habitat within the CDL data. This issue was discussed at length in the original report; we provide an update here. To reconcile the two data sources (CDL and USDA/NASS), all 106 CDL land use codes were aggregated into the same groups as for the rest of this study. Acreage summaries by state by year were calculated. Known USDA/NASS acreage survey data for corn, soybeans, alfalfa and small grains were used in place of the estimates of the same from the CDL data source. Combining the two sources of data in this way allows the data with the lower error rate (USDA/NASS) to take precedence over the data with a higher error rate (CDL). In so doing, we solved for the "implied" Grassy Habitat for each state by each year.

By adopting this approach, Figure 6 shows that over the study period (2007-2016) errors in Grassy Habitat acreage estimates have occurred, but appears the errors are improving as the ability to remotely sense land cover improves. In the year 2007, for example, all studied states except Michigan had a Grassy Habitat overstatement of at least 2.2 million acres.

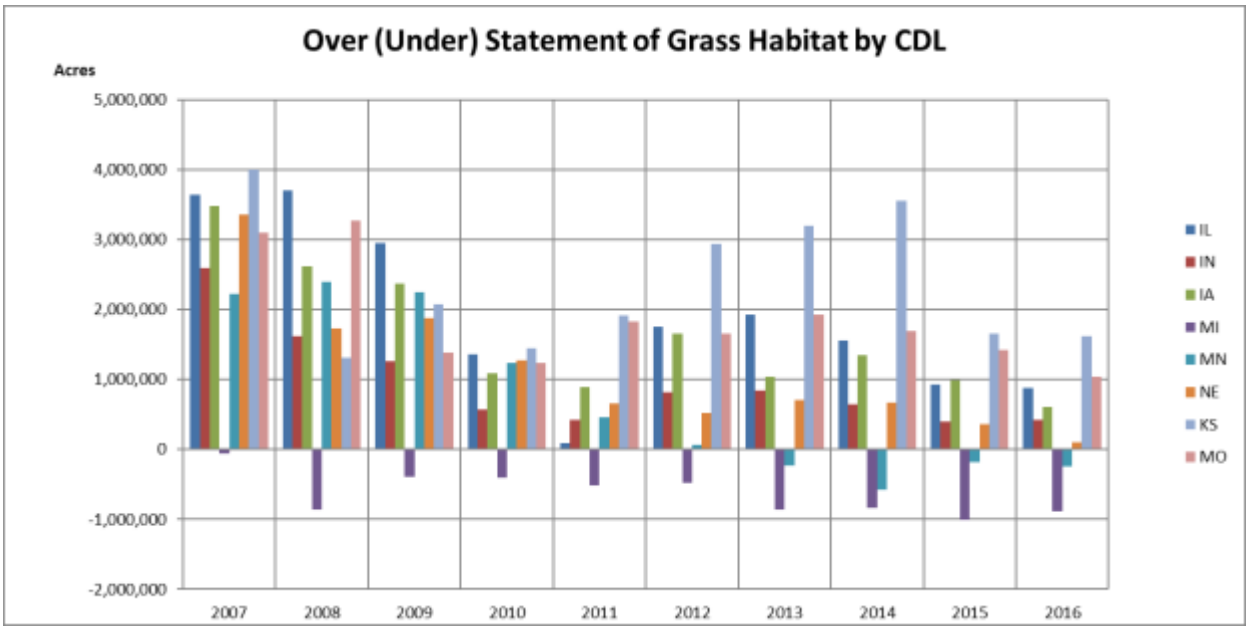


Figure 6, Overstatement of Grassy Habitat by the CDL

Drilling down to various crops within both sets of data sheds further light on how remote sensing has improved over time. Corn and soybeans are widely grown in the 8-state study area so are used as an example. Table 2 (corn/sorghum) and Table 3 (soybeans) were created to demonstrate how the error rate in CDL data has changed over time. These tables show the percent difference in the total acreage for corn (and sorghum) and soybeans between the CDL data and the NASS survey data. A negative number means CDL acreage is lower than the NASS survey data. As shown in these two tables, it is apparent that the CDL data is getting more accurate over time.

Table 2, CDL Percent Difference from NASS (Corn/Sorghum)

Corn/Sorghum	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ILLINOIS	-11.7%	-9.6%	-7.5%	-2.7%	2.0%	-4.2%	-3.9%	-3.1%	-1.2%	-1.1%
INDIANA	-10.9%	-8.2%	-6.4%	-2.2%	-1.4%	-2.5%	0.8%	-2.6%	2.7%	2.0%
IOWA	-10.7%	-7.3%	-7.9%	-1.3%	-2.6%	-5.5%	-3.1%	-4.5%	-3.2%	-1.9%
KANSAS	-16.3%	-5.7%	-6.7%	-7.0%	-6.9%	-9.8%	-16.2%	-13.1%	-4.3%	-2.8%
MICHIGAN	5.8%	19.9%	10.3%	8.0%	1.4%	3.3%	8.8%	10.9%	14.0%	7.0%
MINNESOTA	-10.2%	-8.3%	-10.9%	-3.6%	0.4%	1.0%	1.5%	0.6%	-0.5%	-1.0%
MISSOURI	-24.6%	-27.8%	-8.4%	-10.7%	-15.8%	-12.1%	-5.8%	-10.2%	-10.3%	-4.1%
NEBRASKA	-12.6%	-4.5%	-7.2%	-4.0%	0.3%	0.2%	-1.0%	-1.2%	1.0%	2.0%
Average	**-11.4%**	**-6.4%**	**-5.6%**	**-2.9%**	**-2.8%**	**-3.7%**	**-2.4%**	**-2.9%**	**-0.2%**	**0.0%**

Table 3, CDL Percent Difference from NASS (Soybeans)

Soybeans	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ILLINOIS	-17.1%	-18.2%	-14.5%	-6.5%	-4.8%	-9.0%	-10.4%	-8.1%	-5.7%	-5.2%
INDIANA	-14.9%	-12.3%	-10.3%	-5.5%	-4.8%	-4.8%	-8.6%	-4.3%	-3.0%	-2.5%
IOWA	-10.3%	-5.9%	-3.5%	-1.6%	-2.1%	-5.0%	-1.8%	-3.9%	-2.6%	-2.8%
KANSAS	-35.7%	-21.3%	-23.2%	-15.3%	-17.6%	-22.8%	-17.2%	-28.1%	-21.6%	-22.9%
MICHIGAN	0.5%	19.7%	6.1%	3.5%	0.6%	-2.1%	2.1%	-3.9%	14.7%	11.5%
MINNESOTA	-5.8%	-2.3%	-1.2%	0.3%	0.5%	-2.9%	5.1%	6.7%	2.6%	2.5%
MISSOURI	-28.1%	-29.5%	-14.3%	-12.1%	-17.6%	-15.2%	-17.0%	-15.1%	-13.1%	-8.9%
NEBRASKA	-17.0%	-8.1%	-8.3%	-7.6%	-6.9%	-5.1%	-4.3%	-4.3%	-3.1%	-3.9%
Average	**-16.1%**	**-9.7%**	**-8.7%**	**-5.6%**	**-6.6%**	**-8.4%**	**-6.5%**	**-7.6%**	**-4.0%**	**-4.0%**

From a multi-year approach, Figure 7 shows the cumulative change in Grassy Habitat change from 2007-2016. For example, according to the CDL data, Iowa lost 2.5 million acres of Grassy Habitat from 2007-2016. On the other hand, the combination of CDL and USDA/NASS survey data implies that 360,000 acres of Grassy Habitat were *gained* during the same time. Iowa had the largest difference (2.9 million acres) between the CDL data and combined CDL/NASS data. Michigan had the smallest difference (824,000 acres acres) between the CDL data and combined CDL/NASS data. Notably, according to the combined CDL/NASS data, three states (Illinois, Indiana and Iowa) had an implied positive movement to Grassy Habitat.

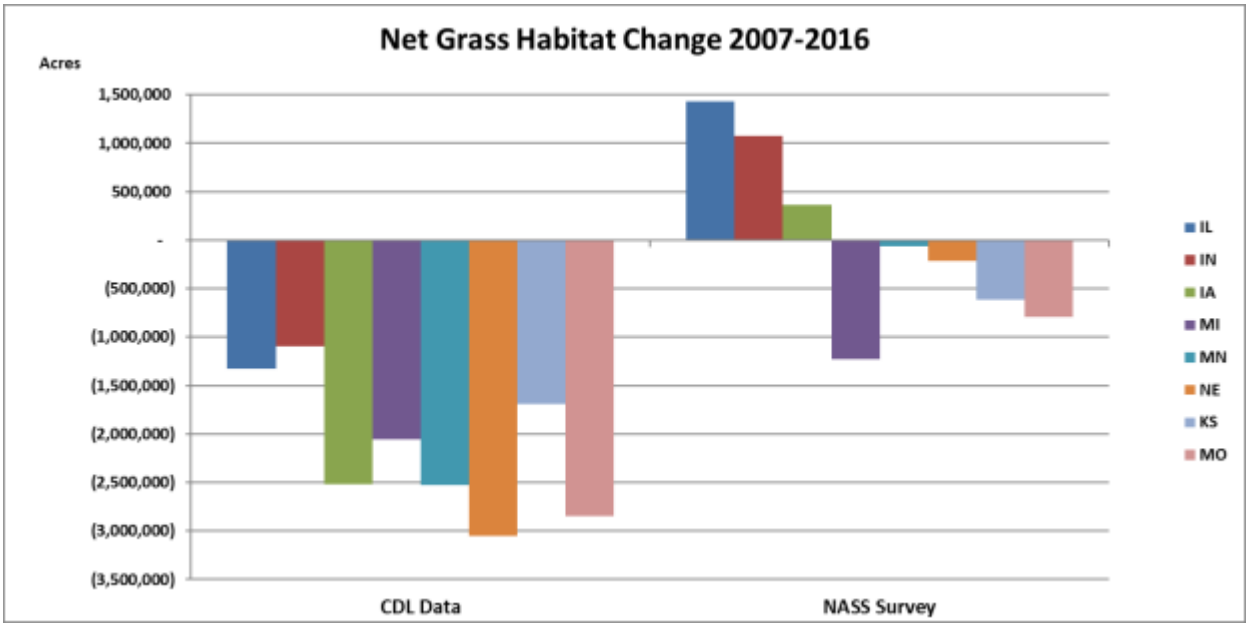


Figure 7, Grass Habitat Change (2007-2012)

While the improvement in the ability to remotely sense land cover is certainly a good thing, this may cause an analysis based solely on CDL data to give inaccurate and/or misleading results and lead to less than optimal policy decisions. The issue with an overstatement of grasslands is that as land cover is more accurately categorized as something other than a grassy-type category, data users are led to believe that more change is taking place than there may actually be. Therefore, one of our primary findings is that great care should be taken in drawing conclusions based upon early CDL datasets, particularly if CDL datasets are the sole source of data.

Econometric Analysis

Data Description (annual data from 2007 to 2016)

Data for the econometric portion of this study come from sources listed in Table 4.

Table 4, Data Sources

Data Source	Purpose
Annual data from spatial analysis	Quantification of annual estimated land use patterns
Relevant crop production budgets, various sources	Estimation of returns to crop producers
USDA/Risk Management Agency crop insurance database	Estimation of subsidy rates for federal crop insurance
Iowa Environmental Mesonet	Calculation of Growing Degree days
Iowa Environmental Mesonet	Calculation of Precipitation

Econometric Analysis Methodology

In preparation for conducting this econometric analysis, an updated literature review of a recent Agricultural and Applied Economics Association publications was conducted. As appropriate, methodology was adapted and used for this purpose. This study assesses the impacts of several variables on land use change in the study area with the following model:

$$Y_{it} = \beta_0 + \beta_1 RET_{it} + \beta_2 CIS_i + \beta_3 GDD_{it} + \beta_4 Precip + \varepsilon_{it}$$

Here Y_{it} is the share of land devoted to the Grassy Habitat land use category in county *i* and year *t*; RET_{it} represents a weighted average (by area) net return for cropland; CIS_i represents crop insurance subsidies per acre; GDD_{it} represents total growing degree days; $Precip_{it}$ represents total precipitation; and ε_{it} is the random error term, which can be serially correlated or heteroscedastic. $\beta_0, \dots, \beta_4$ are parameter estimates. The share of Grassy Habitat is derived by dividing total Grassy Habitat area by the total land area in a county for each year.

We assume a key factor that determines Grassy Habitat's share of total acreage is cropland's relative profitability. The profitability of cropland is affected by prices, yields, and production costs. We calculate cropland profitability as weighted average net returns for primary study area cropland (i.e. revenue minus operating costs, weighted by share of cropland devoted to corn, soybeans, and wheat). Expectations are that higher weighted average net returns to the cropland should mean more acreage devoted to cropland and less to Grassy Habitat.

Another key variable of interest is government support as measured by federal crop insurance subsidies. We assume that increased government support increases the share of cropland and hence decreases the share of habitat. Due to the economic environment present during our analysis time period, many traditional (i.e., counter-cyclical, ACRE, etc.) government payments were not paid. Other government payments such as direct payments were unchanged across the analysis time period and were therefore excluded from the analysis.

We applied an Ordinary Least Squares (OLS) modeling method to construct the regression model specified above. Grassy Habitat's share for each county is linked to weighted average net returns for crops, crop insurance subsidies, growing degree days, and total precipitation.

In the regression equation described above, expectations of the estimated sign for explanatory variables are as follows:

- Net returns for crops would possess a negative coefficient, as higher net returns for cropland would induce higher demand for planting acreage for cropland, causing a decrease of Grassy Habitat acreage.
- The coefficient for crop insurance subsidies would likely have a negative sign, given that a higher government payment tends to encourage more acreage for cropland, causing a decrease of Grassy Habitat acreage.
- The coefficient for the total growing degree days would be negative as higher growing degree days tend to increase crop acreage, which would in turn dampen total Grassy Habitat acreage.
- The coefficient for the total precipitation would be negative as higher precipitation tends to increase crop acreage, which would in turn dampen total Grassy Habitat acreage.

Results

Historically, land use across the 8-state study area is very diverse. Michigan, for example, is one of the most agriculturally-diverse states in the country. Many fruits, vegetables, row and tree crops are produced in Michigan. Missouri, Nebraska, and Iowa, on the other hand, have a larger proportion of their land devoted to grains and oilseeds. As a result of this diversity across the study area, one would expect results which were as varied as the states themselves.

For the "Results" section of this report, we begin by exploring the 8-state study area as a whole to give readers a sense for what has occurred during the 2007-2012, 2012-2016 and 2007-2016 time periods – the spatial analysis. Following the discussion regarding the 8-state area, we provide similar content for each of the individual eight states under study, but include an updated analysis of what may have contributed to the land use changes which have occurred during the overall time period (2007-2016) – the econometric analysis.

8-State Study Area Results

Acreage to Principal Field Crops

In terms of a historical perspective on the land use in the 8-state study area, acreage devoted to principal field crops (varied by state) for the area has ranged from a low of 138.0 million acres in 1995 to a high of 144.5 million acres in 1998. Estimated acreage farmed in 2016 (142.2 million) is the fifteenth highest total since 1993, the first year data of this type were available. Referring to Figure 8, four of the five highest planted acreage amounts occurred during the consecutive years 1997-2000.

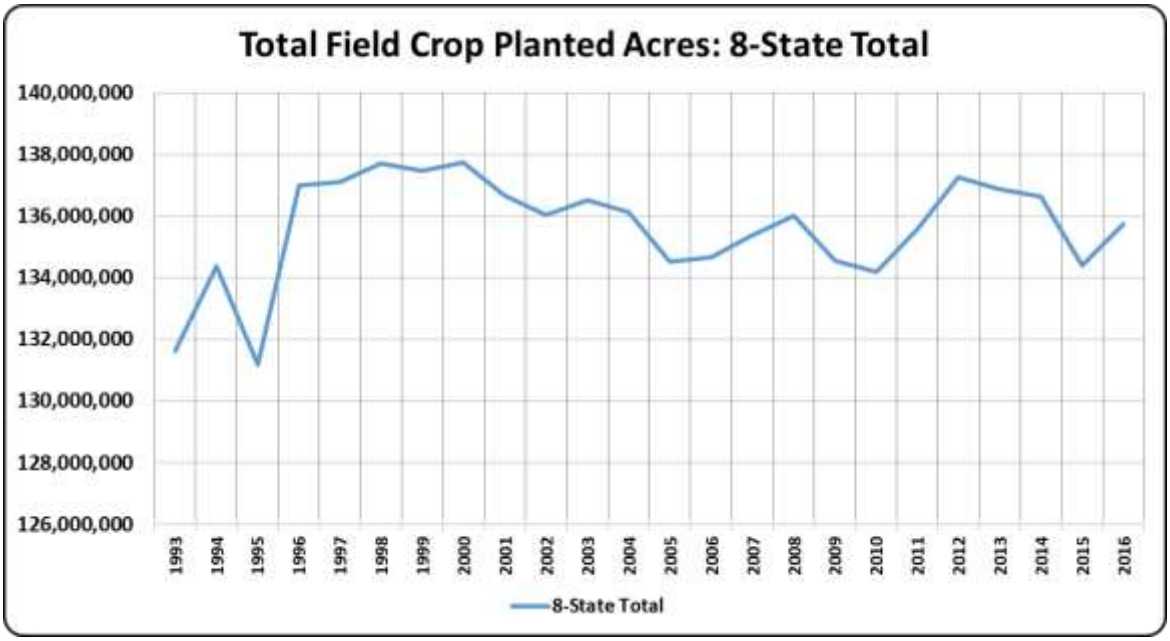


Figure 8, Total Field Crop Planted Acres: 8-state Total

Conservation Reserve Program

Since the CRP program first reached a degree of stability in 1990, acreage in the 8-state study area has fluctuated between a high of 11.7 million acres to a low of 7.9 million acres. In 2016, the 8-state study area total CRP acreage was approximately 8.0 million acres. Current acreage enrollment trends suggest that CRP acres in the 8-state study area will continue to decline as they have done since 2008. Historical total CRP enrollment is shown in Figure 9.

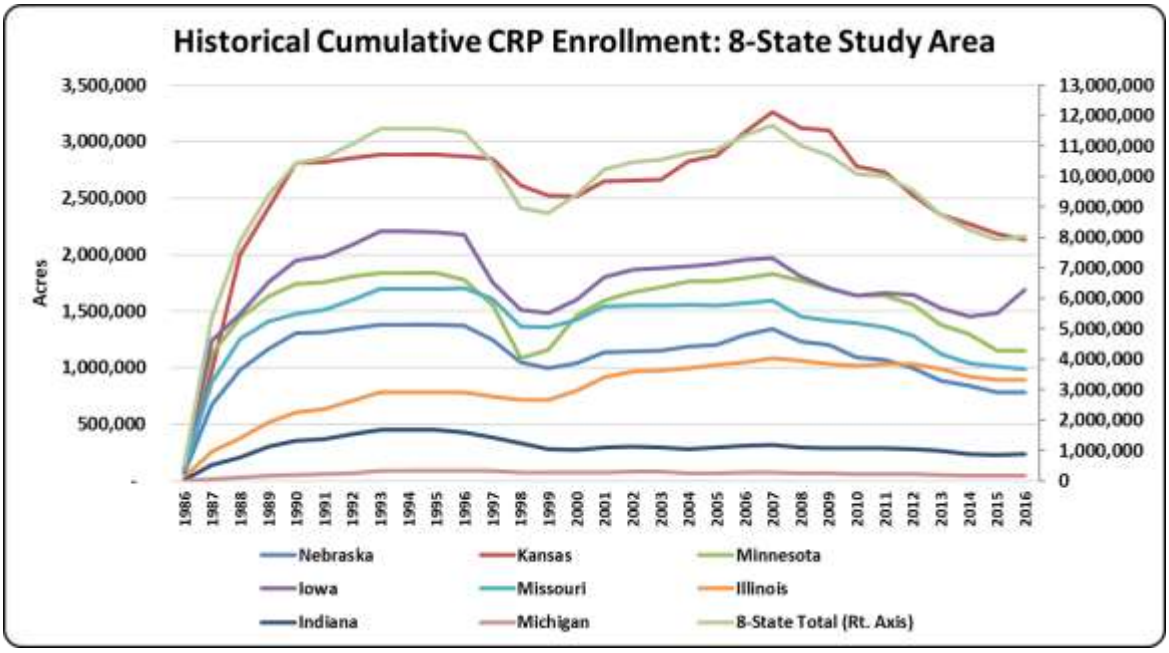


Figure 9, Historical Cumulative CRP Enrollment: 8-state Study Area

Spatial Results

Given some of the challenges addressed earlier (and in the original study) pertaining to relying solely upon CDL data, all spatial results discussed in this section are what would be considered the most accurate interpretation of such data. We acknowledge that there may still be issues with the data (primarily overstatement of grassland), but we believe this impact has been minimized due to our method of aggregation. The spatial analysis for the 8-state study area yielded some interesting results in terms of total acreage according to the nine-class aggregation scheme. Figure 10 shows the 8-state acreage totals for all ten years during the study period.

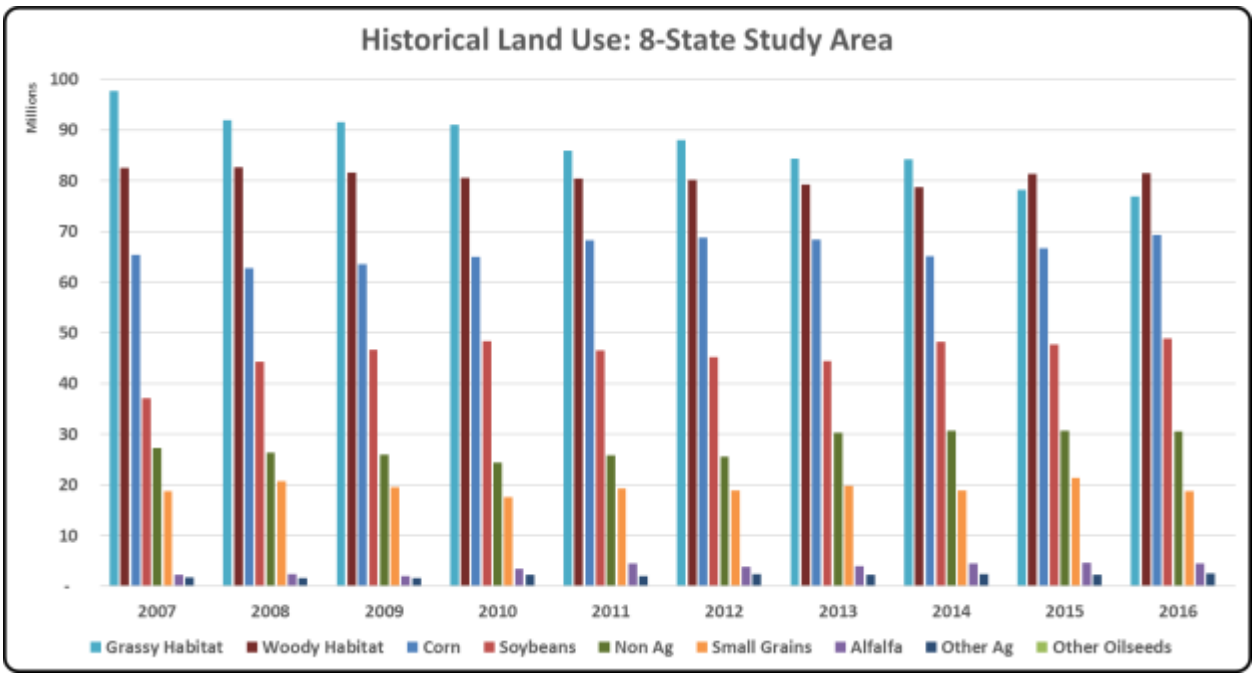


Figure 10, Historical Land Use: 8-state Study Area (2007-2016)

Also of interest are the 8-state net land use changes for each of the eight possible outcomes. Table 5 shows a summary of net land use changes estimates for the study area as a whole by type of change. Table 6 shows these same estimates by state. As shown in Table 5 and Table 6, the total net change across the entire 8-state study area was 19.8 million acres. The majority of this net change was toward Corn (5.914 million), Soybeans (4.550 million), Small Grains (2.849 million) and Non-Ag (2.117 million), or "Perennial Crops" as defined in this update. A combined 4.390 million acres designated as "Perennial Crops and Habitat" (woody habitat, alfalfa and other ag) were net recipients of grassy habitat acres.

Table 5, 2007-2016 Net Change by Type: 8-state Study Area

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): 8-States	Net Change
Net Grassy Habitat to Alfalfa	1,770,083
Net Grassy Habitat to Corn	5,913,655
Net Grassy Habitat to Non Ag	2,117,249
Net Grassy Habitat to Other Ag	340,859
Net Grassy Habitat to Other Oilseeds	28,011
Net Grassy Habitat to Small Grains	2,848,792
Net Grassy Habitat to Soybeans	4,550,474
Net Grassy Habitat to Woody Habitat	2,279,016
Net Change FROM Grassy Habitat	19,848,138

Table 6, 2007-2016 Net Change by State: 8-state Study Area

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change
Nebraska	5,225,458
Kansas	2,842,839
Minnesota	2,691,420
Iowa	2,828,842
Missouri	2,227,671
Illinois	1,208,758
Indiana	889,402
Michigan	1,933,749
8-State Total	19,848,138

By providing an update of the original study, three time periods are available for study. These study periods are: 2007-2012, 2012-2016 and 2007-2016. Recall that to account for land use changes for both to and from the Grassy Habitat land use category, all land use changes are expressed on a net basis. Consequently, negative numbers can and do appear in tables and charts associated with the data. A negative number is interpreted as a net movement to Grassy Habitat (i.e., time period 2007-2012 for Michigan). High level summaries for all states and all time periods are shown in Figure 11.

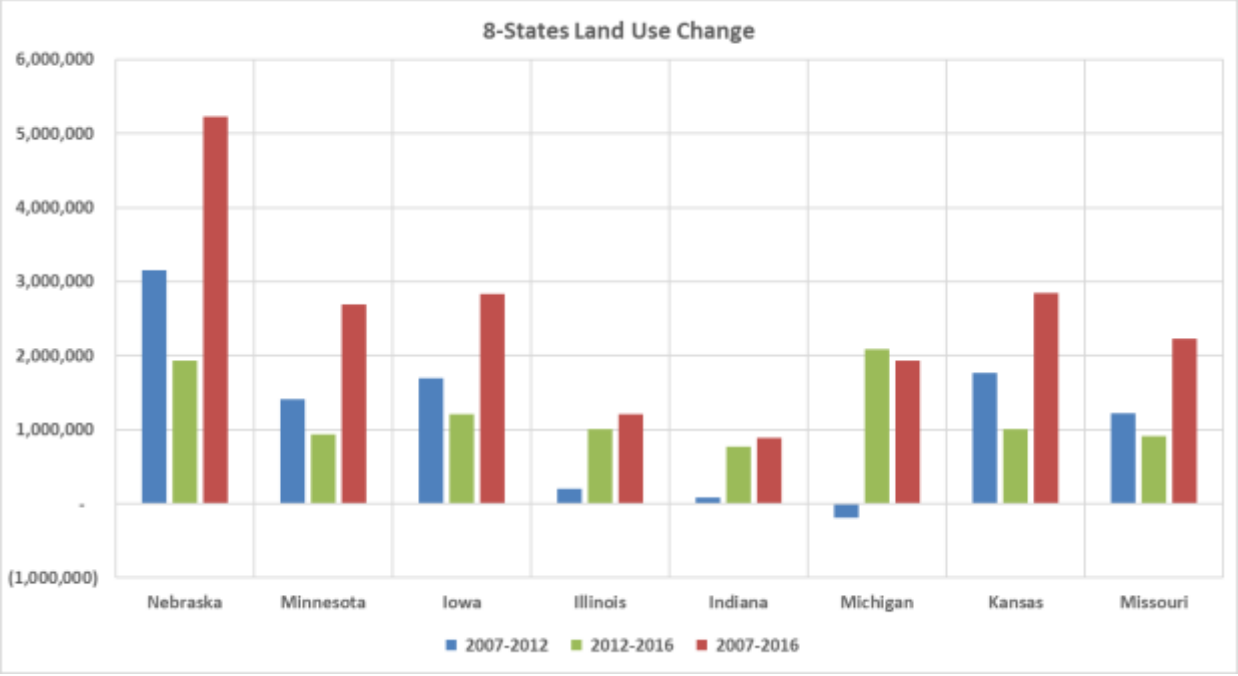


Figure 11, Study Period Totals

Figure 12, Figure 13 and Figure 14 are charts which show the estimated aggregated land use change for the time periods 2007-2012, 2012-2016 and 2007-2016, respectively. As one moves from the western to eastern edges of the study region patterns emerge. Patterns are also manifest from a time period standpoint.

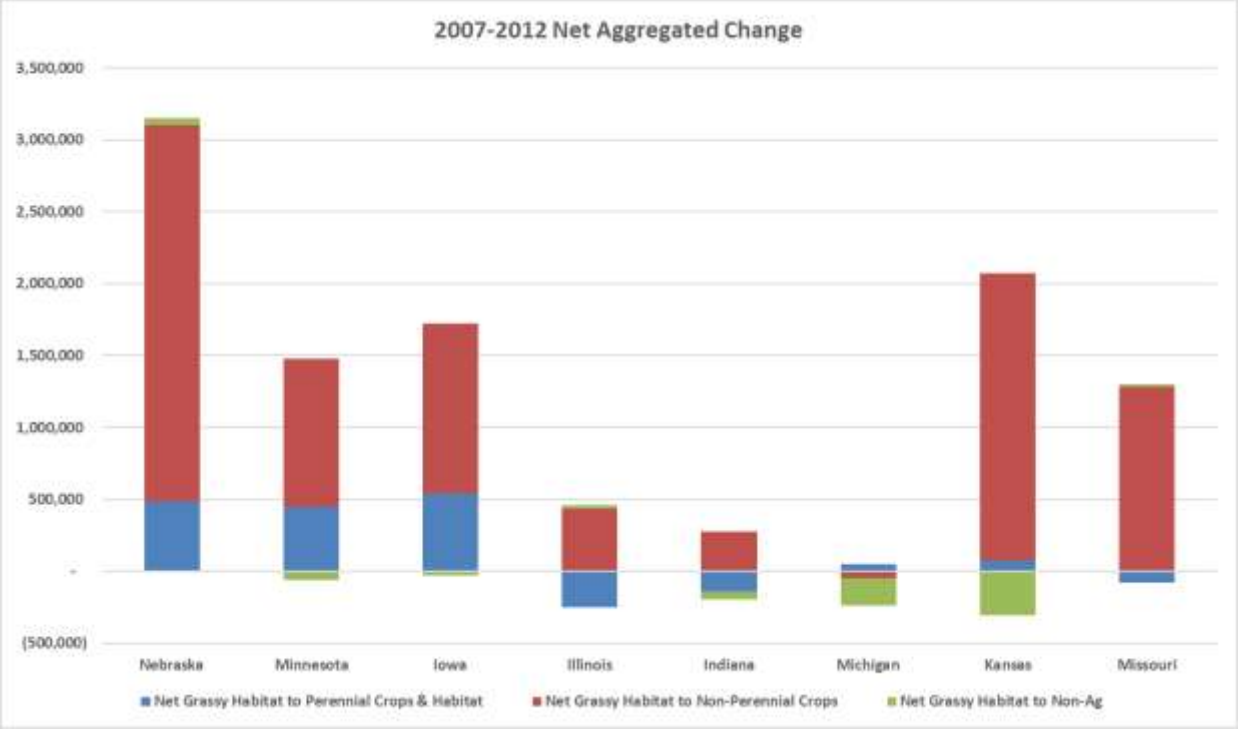


Figure 12, 2007-2012 Net Change by Aggregated Type

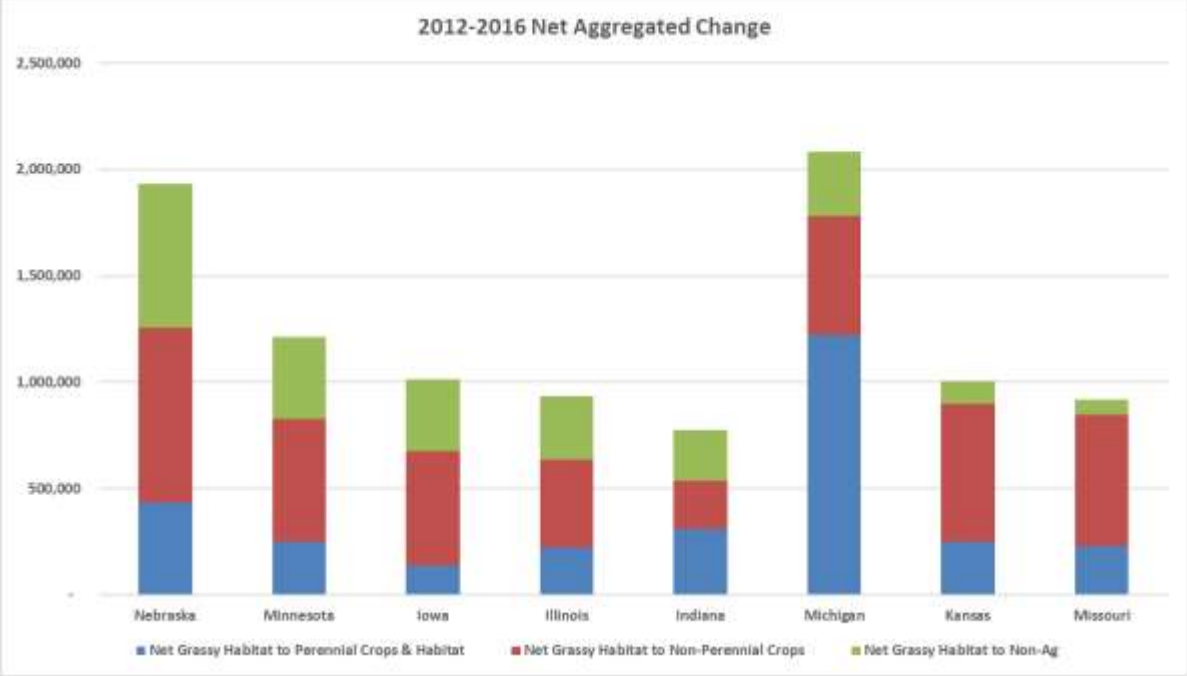


Figure 13, 2012-2016 Net Change by Aggregated Type

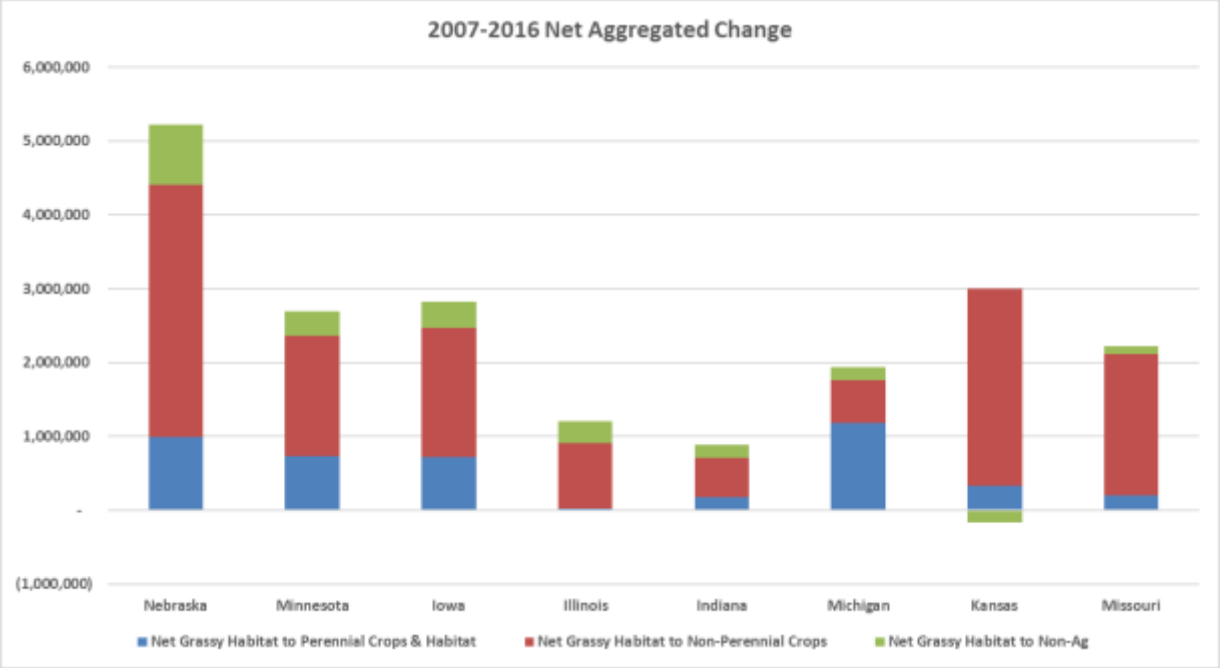


Figure 14, 2007-2016 Net Change by Aggregated Type

Figure 15, Figure 16 and Figure 17 are gradient maps which show the estimated total net change from grassy habitat for the 8-state region for the 2007-2012, 2012-2016 and 2007-2016 time periods, respectively.

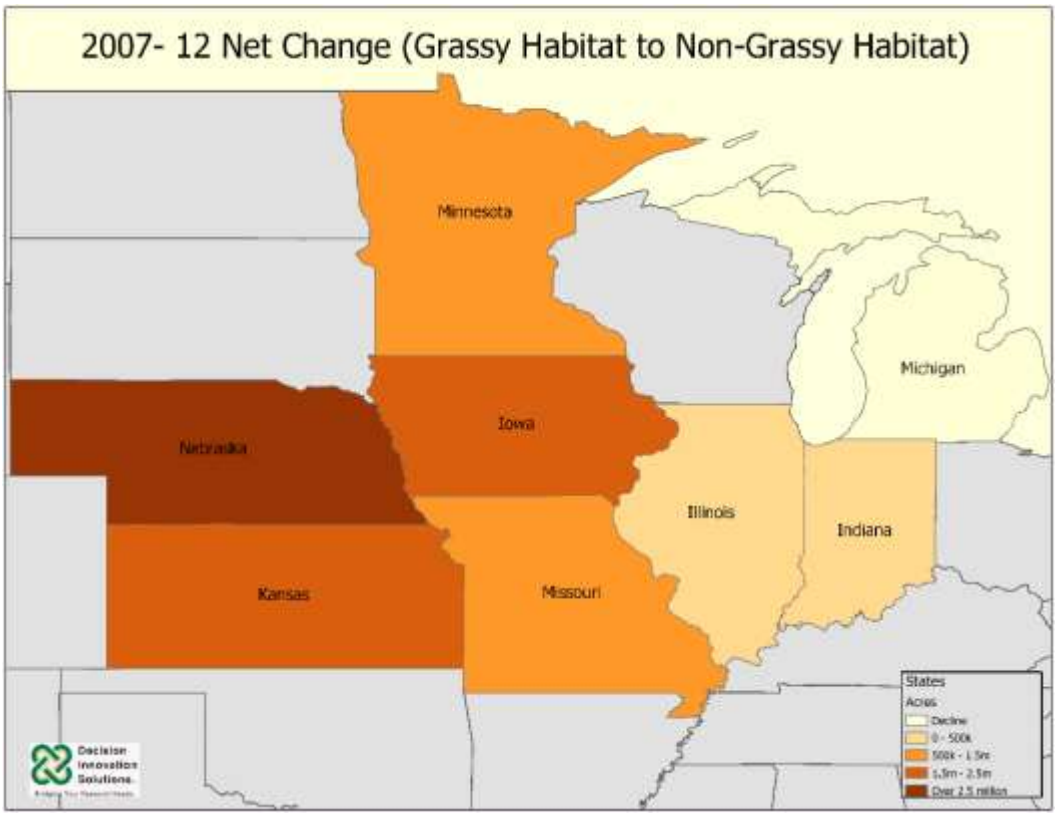


Figure 15, 2007-2012 Total Net Change (8-State Region)

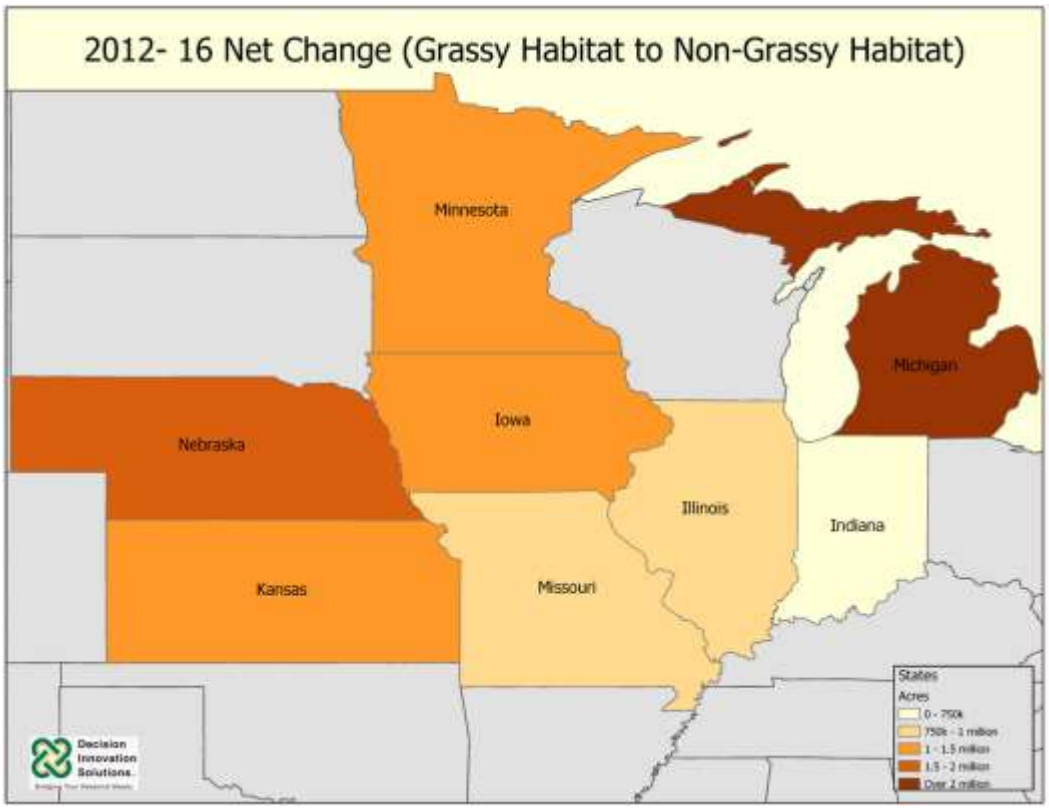


Figure 16, 2012-2016 Total Net Change (8-State Region)

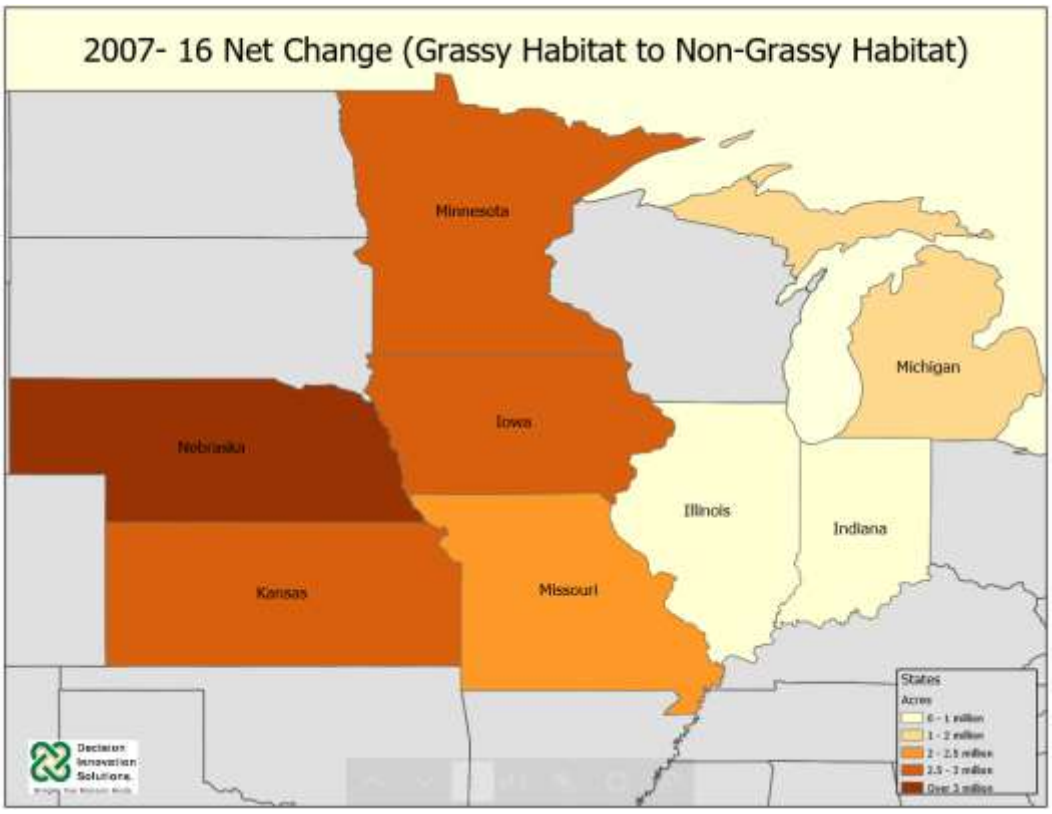


Figure 17, 2007-2016 Total Net Change (8-State Region)

Figure 18, Figure 19 and Figure 20 are gradient state level maps which show the estimated total net change from grassy habitat to perennial crops and habitat for the 2007-2012, 2012-2016 and 2007-2016 time periods, respectively.

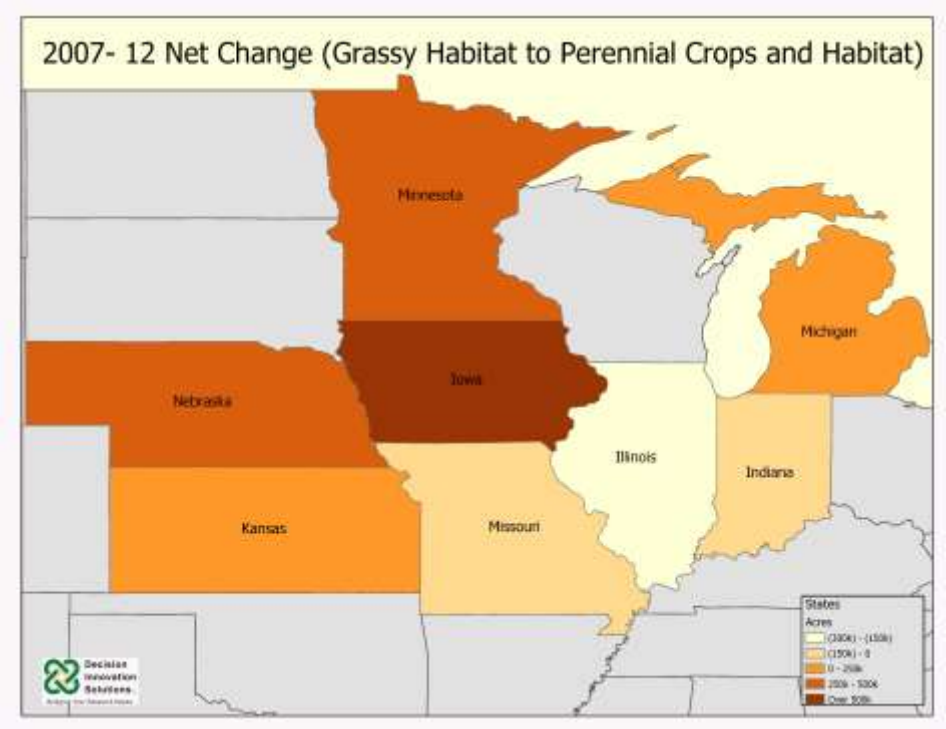


Figure 18, 2007-2012 Net State Change (Grassy Habitat to Perennial Crops and Habitat)

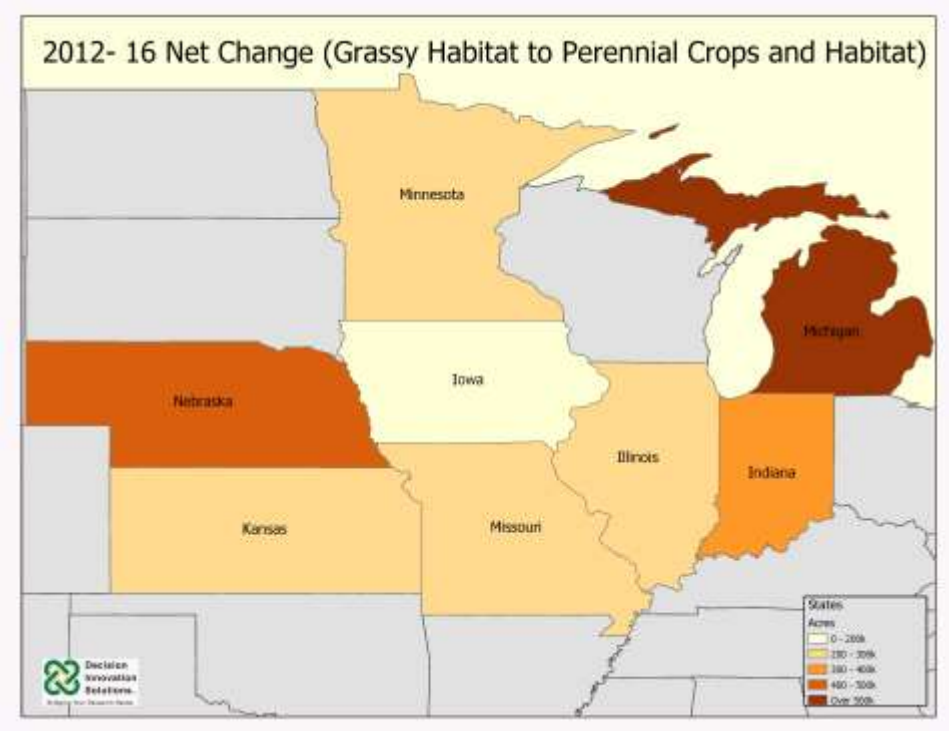


Figure 19, 2012-2016 Net State Change (Grassy Habitat to Perennial Crops and Habitat)

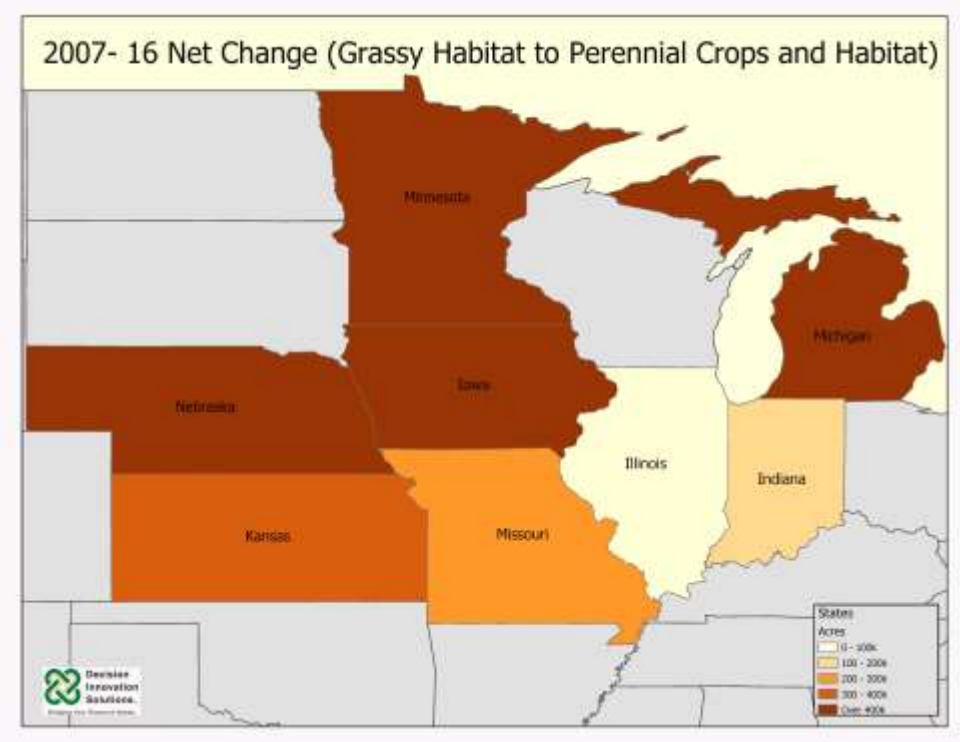


Figure 20, 2007-2016 Net State Change (Grassy Habitat to Perennial Crops and Habitat)

Figure 21, Figure 22 and Figure 23 are gradient county level maps which show the estimated total net change from grassy habitat to perennial crops and habitat for the 2007-2012, 2012-2016 and 2007-2016 time periods, respectively.

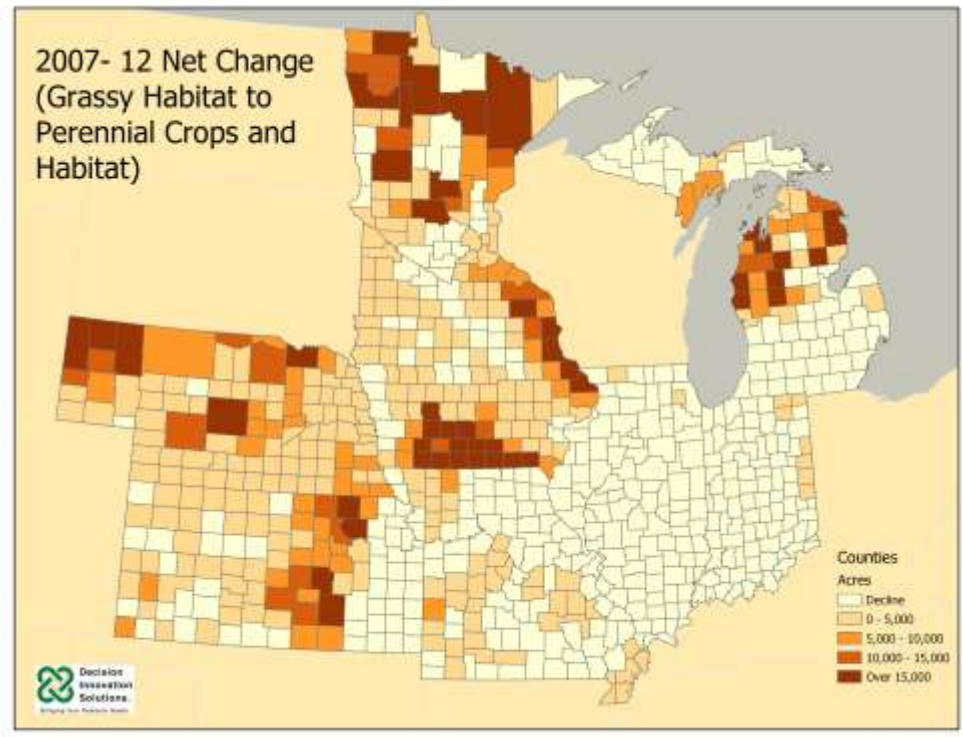


Figure 21, 2007-2012 Net County Change (Grassy Habitat to Perennial Crops and Habitat)

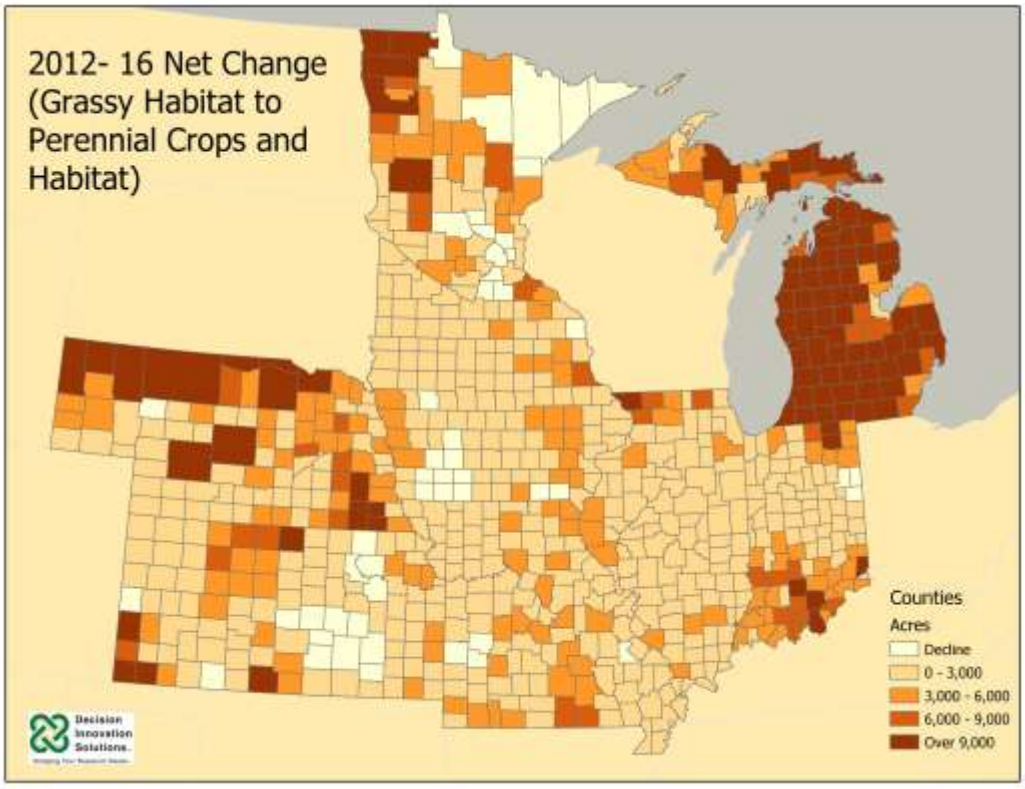


Figure 22, 2012-2016 Net County Change (Grassy Habitat to Perennial Crops and Habitat)

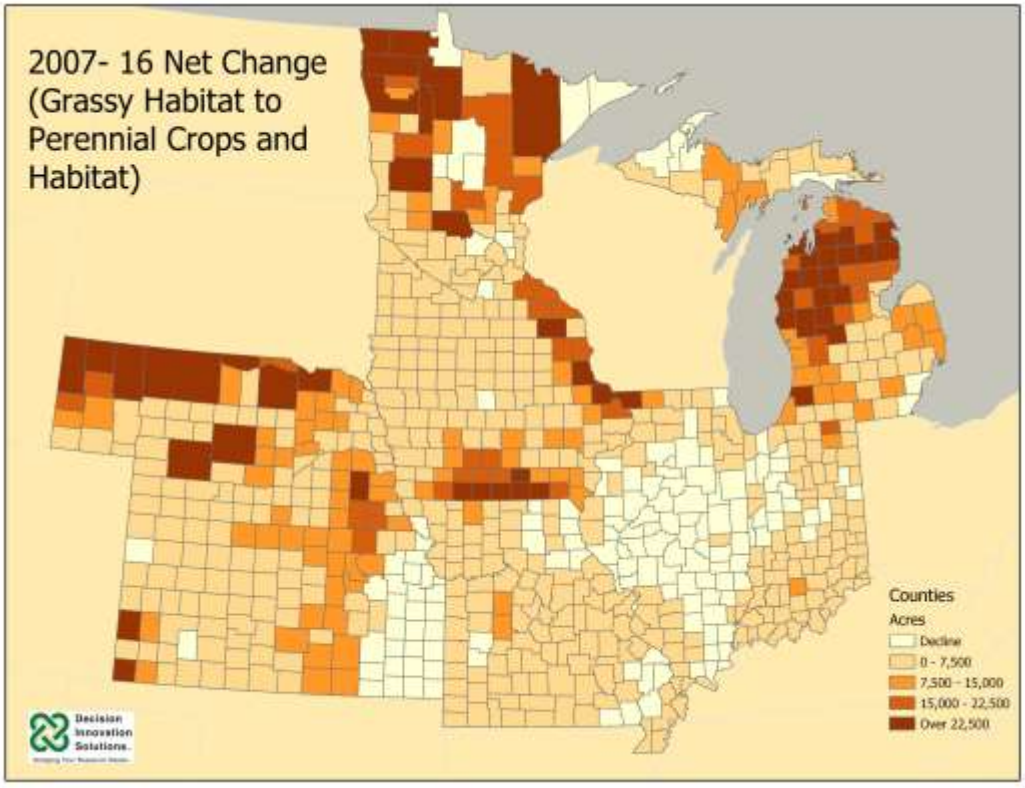


Figure 23, 2007-2016 Net County Change (Grassy Habitat to Perennial Crops and Habitat)

Farm Policy

Because part of the econometric analysis addresses the concern that farm policy has contributed to loss of habitat, we have provided a subset of results for what may be termed "program crops". This subset is what we've aggregated to "Non-Perennial Crops" and includes: Corn, Soybeans, Small Grains and Other Oilseeds. These results are shown in Table 7 and Figure 24. On a net basis, an estimated total of 13.341 million acres have shifted from the Grassy Habitat land use category to a combination of Corn, Soybeans, Small Grains and Other Oilseeds, the bulk of which is in the western portion of the study area.

Table 7, 2007-2016 Net Change (Grassy Habitat to Program Crops): 8-state Study Area

2007-2016 Net Change (Grassy Habitat to Program Crops)	NE	MN	IA	IL	IN	MI	KS	MO	8-State
Net Grassy Habitat to Corn	1,752,429	682,683	1,006,005	405,314	213,504	169,382	975,444	708,893	5,913,655
Net Grassy Habitat to Other Oilseeds	8,730	15,594	32	(2)	49	1,029	2,458	122	28,011
Net Grassy Habitat to Small Grains	908,047	198,016	26,928	51,935	25,783	290,284	1,199,935	147,863	2,848,792
Net Grassy Habitat to Soybeans	735,089	728,490	713,573	421,550	282,325	114,215	495,134	1,060,097	4,550,474

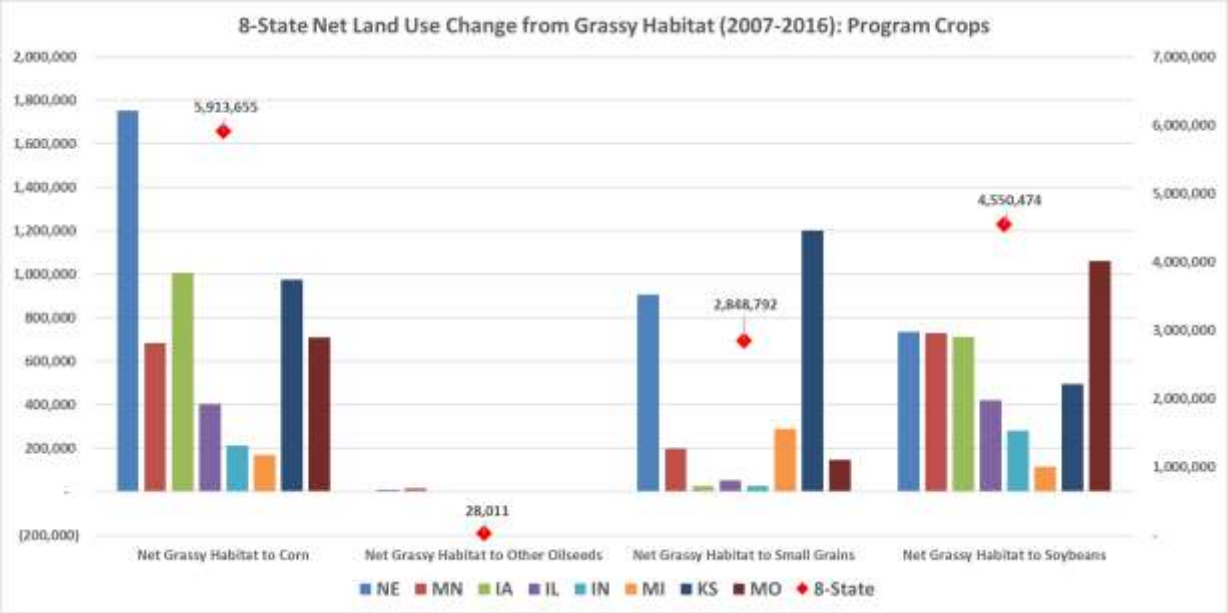


Figure 24, 2007-2016 Net Change (Grassy Habitat to Program Crops): 8-state Study Area

Figure 25, Figure 26 and Figure 27 are gradient state level maps which show the estimated total net change from grassy habitat to non-perennial crops for the 2007-2012, 2012-2016 and 2007-2016 time periods, respectively.

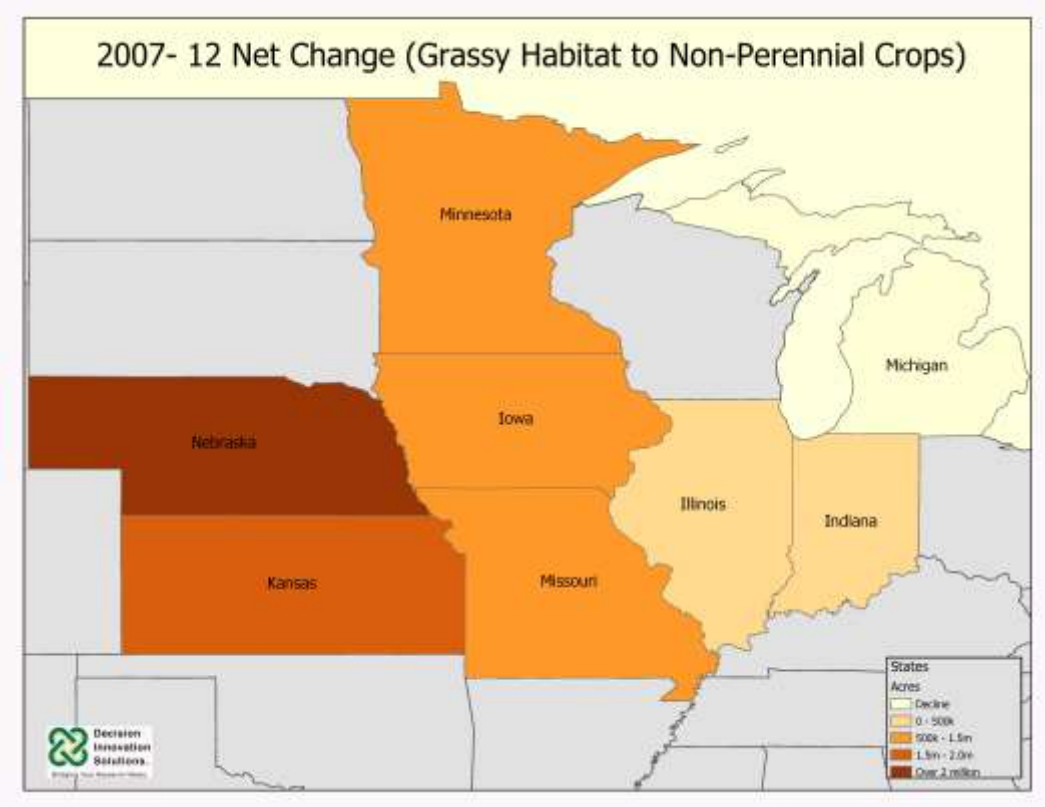


Figure 25, 2007-2012 Net State Change (Grassy Habitat to Non-Perennial Crops)

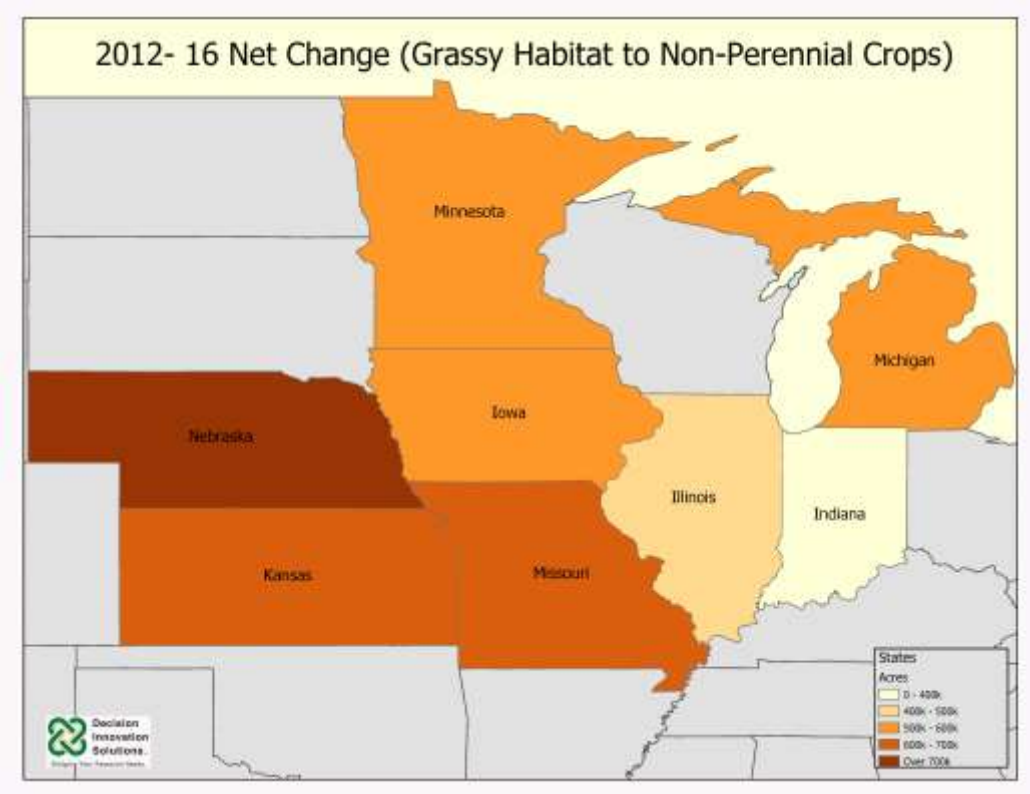


Figure 26, 2012-2016 Net State Change (Grassy Habitat to Non-Perennial Crops)

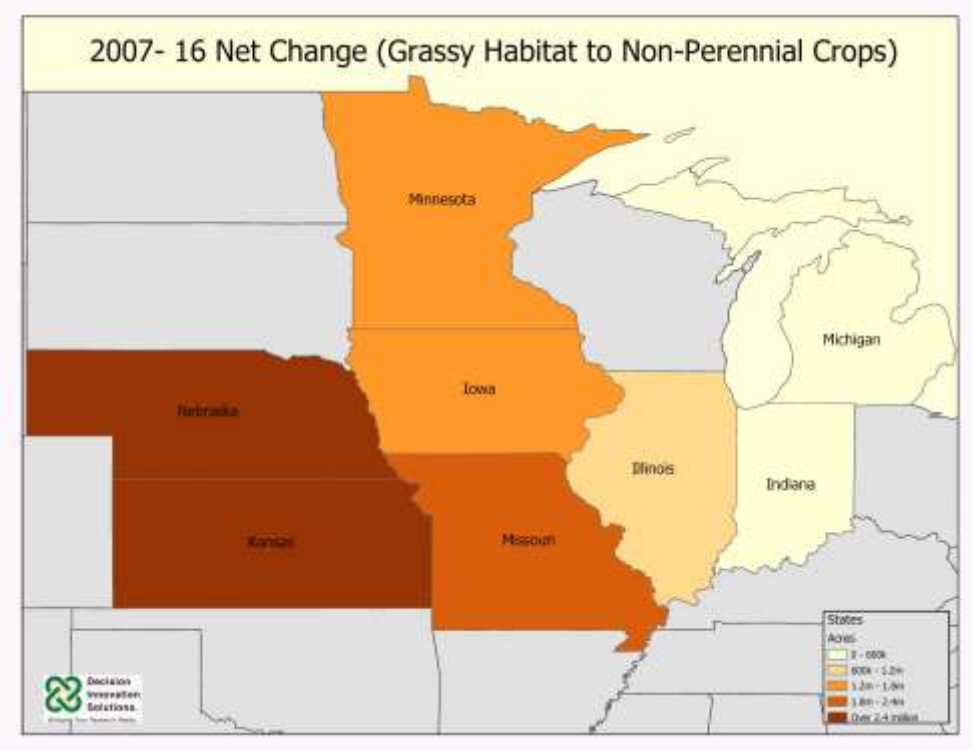


Figure 27, 2007-2016 Net State Change (Grassy Habitat to Non-Perennial Crops)

Figure 28, Figure 29 and Figure 30 are gradient county level maps which show the estimated total net change from grassy habitat to non-perennial crops for the 2007-2012, 2012-2016 and 2007-2016 time periods, respectively.

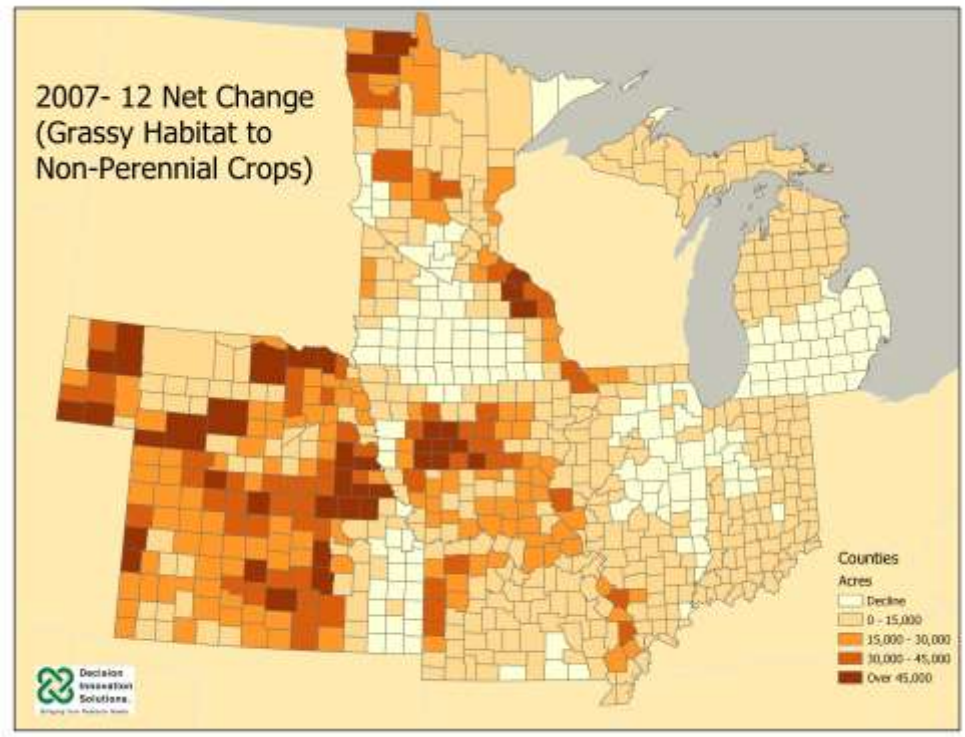


Figure 28, 2007-2012 Net County Change (Grassy Habitat to Non-Perennial Crops)

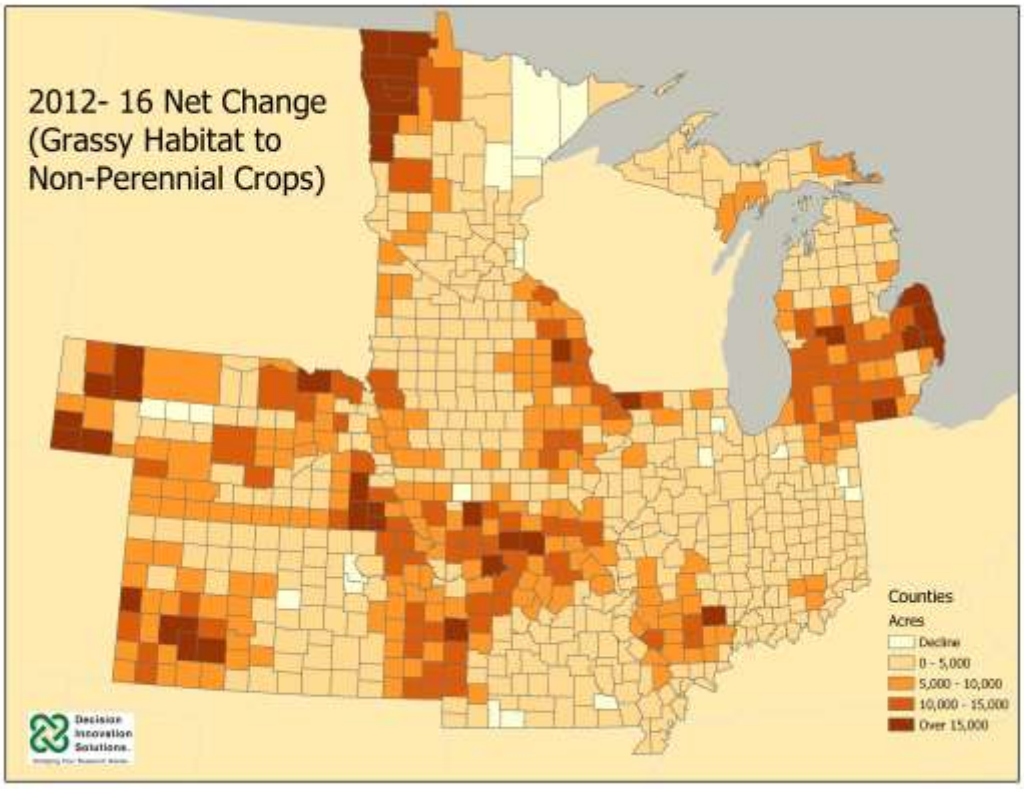


Figure 29, 2012-2016 Net County Change (Grassy Habitat to Non-Perennial Crops)

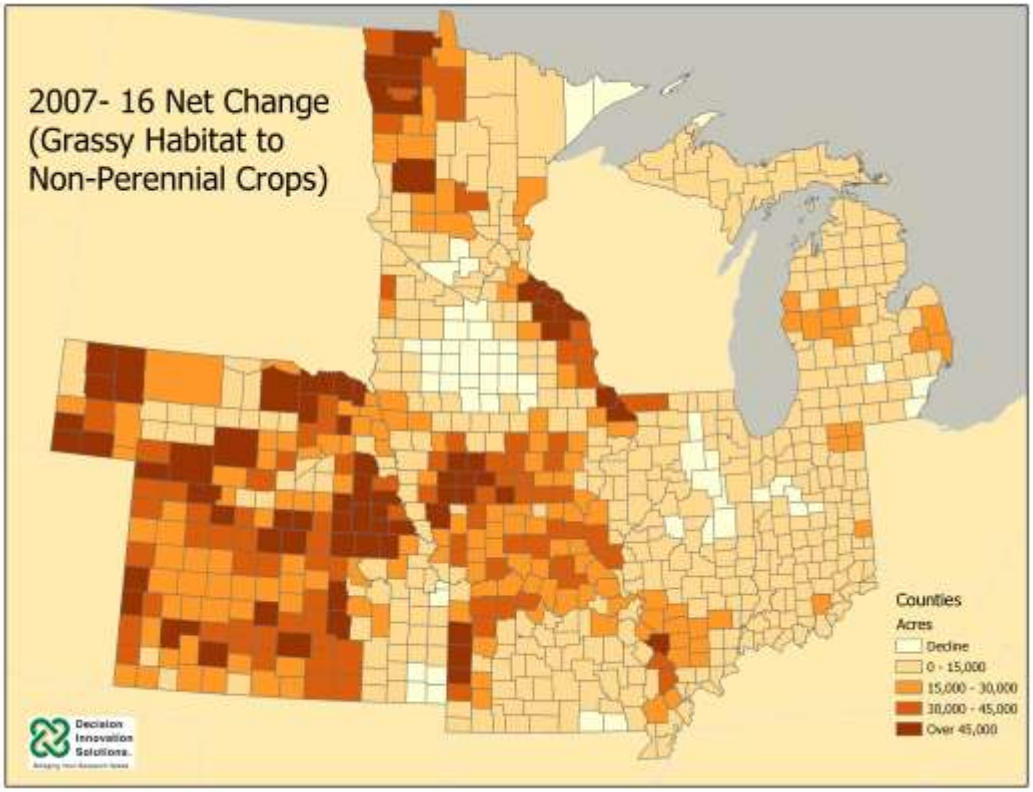


Figure 30, 2007-2016 Net County Change (Grassy Habitat to Non-Perennial Crops)

NEBRASKA

Background

In terms of a historical perspective on the land use in Nebraska, acreage in farms for the area has ranged from a low of 18.3 million acres in 1995 to a high of 19.7 million acres in 2012. Estimated acreage devoted to principal field crops in 2015 is the highest total since 1993, the first year data of this type were available. Referring to Figure 31, after having fairly consistent declines in acreage devoted to field crops since 1999, the trend reversed in 2007 and has generally (except for 2016) climbed steadily higher since.

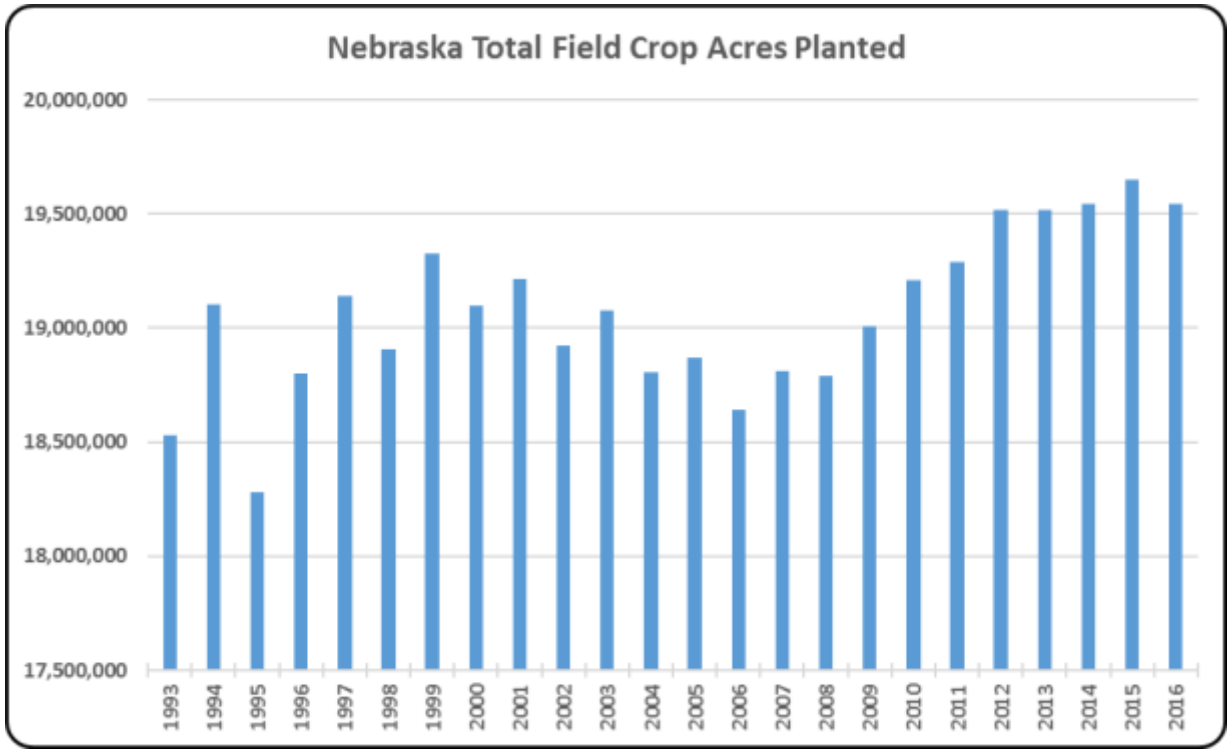


Figure 31, Nebraska Total Field Crop Planted Acres

Referring to Figure 32, by 1990 Nebraska reached 1.3 million acres enrolled in the CRP program and held fairly steady until the first round of 10-year contracts starting expiring. Since then, the acres enrolled in the program grew slightly until 2007, but has since seen the effects of higher prices crop prices and the need for usable farmland. There were nearly 782,000 acres enrolled in the CRP program in 2016 in Nebraska.

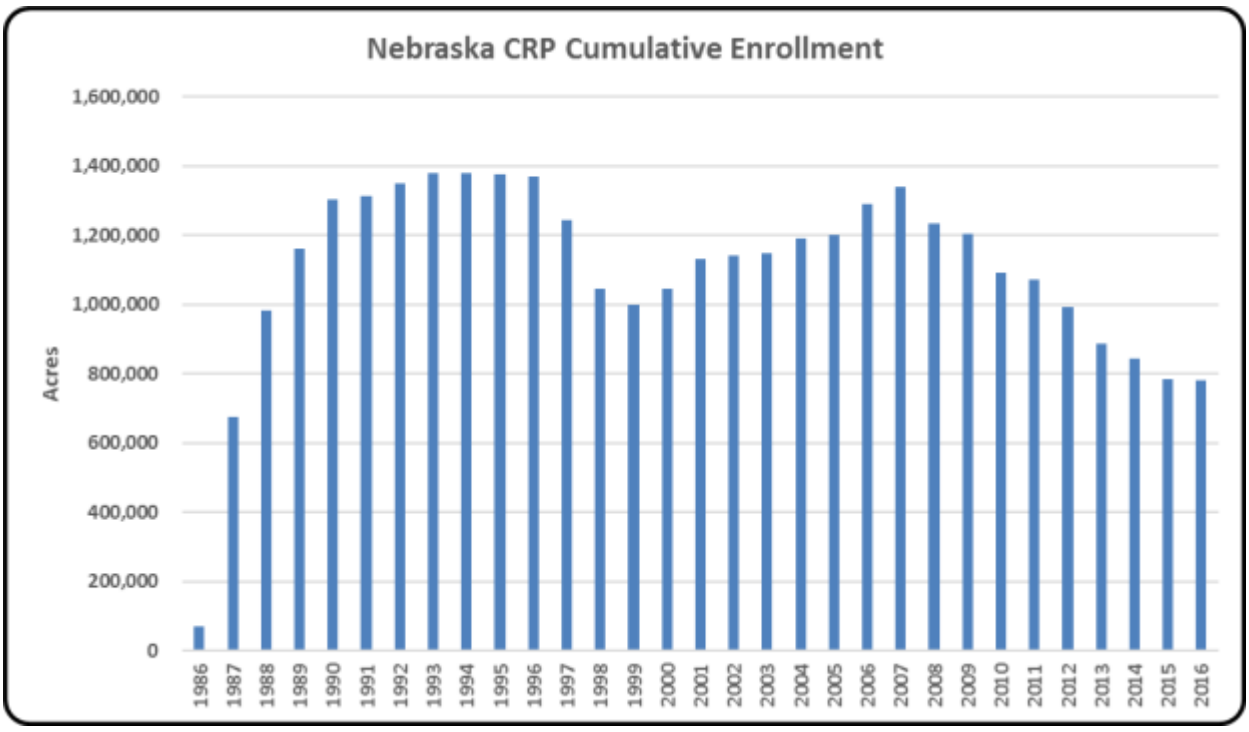


Figure 32, Nebraska CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 33, Figure 34, Figure 35 and Table 8, the spatial analysis for the Nebraska study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Nebraska, there was a positive net land use change from the Grassy Habitat land use category to other categories.

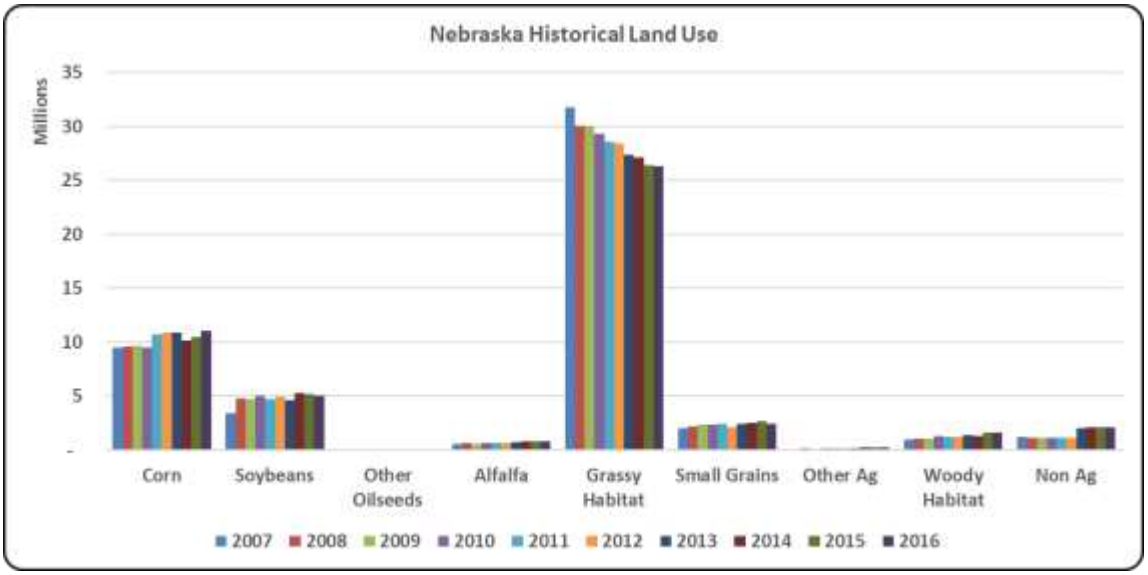


Figure 33, Historical Land Use (2007-2016): Nebraska

Table 8, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Nebraska

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	313,305	6%
Grassy Habitat to Corn	1,752,429	34%
Grassy Habitat to Non Ag	823,796	16%
Grassy Habitat to Other Ag	41,651	1%
Grassy Habitat to Other Oilseeds	8,730	0%
Grassy Habitat to Small Grains	908,047	17%
Grassy Habitat to Soybeans	735,089	14%
Grassy Habitat to Woody Habitat	642,411	12%
Net Change FROM Grassy Habitat	5,225,458	100%

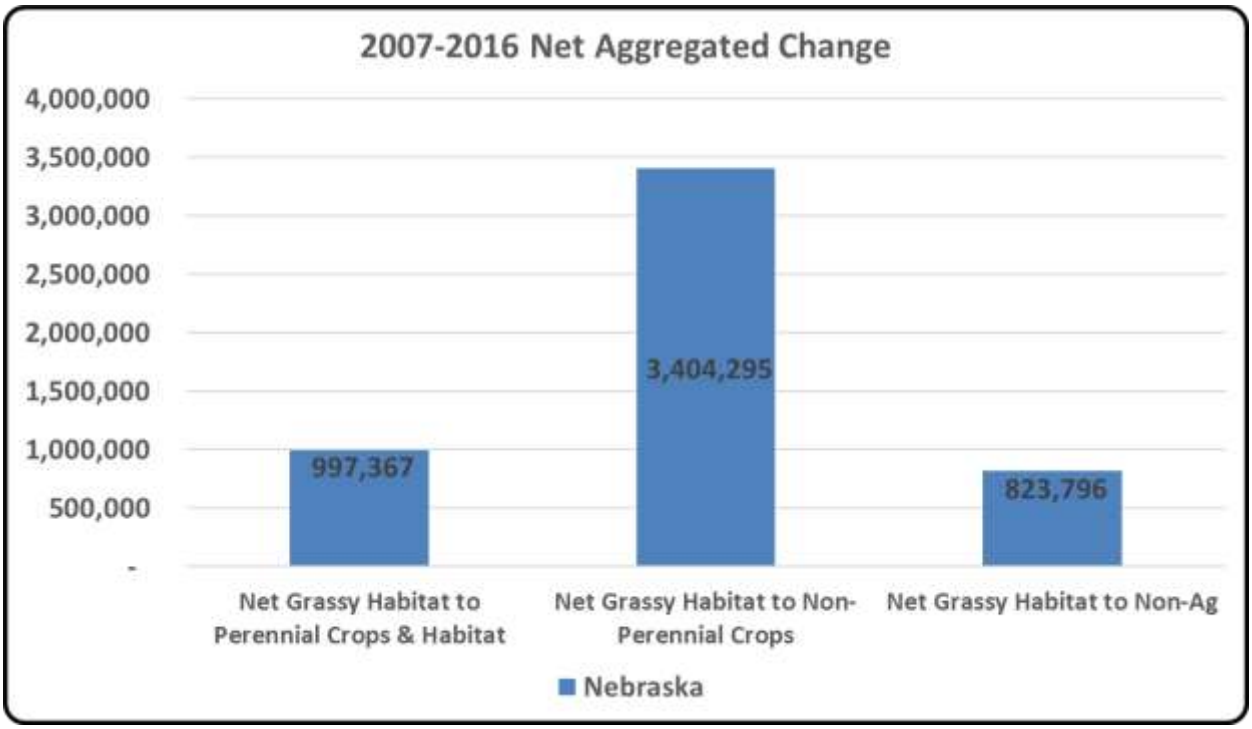


Figure 34, 2007-2016 Net Change (from Grassy Habitat): Nebraska

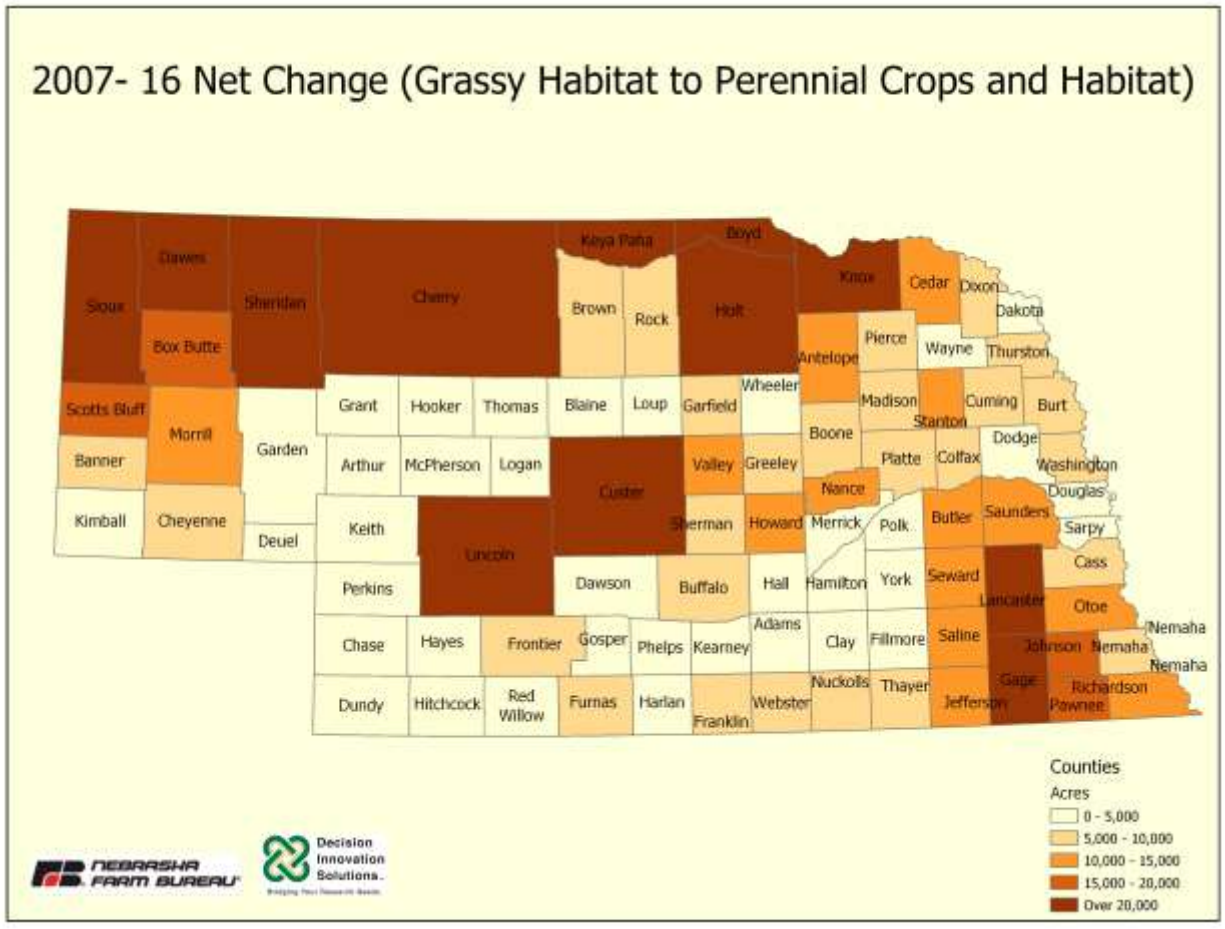


Figure 35, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Nebraska Counties

Observations

Ninety-three percent of this net land use change from Grassy Habitat was toward Corn, Small Grains, Non-Ag and Soybeans. Woody Habitat was also a large recipient of acreage from Grassy Habitat. Figure 34 shows that under the revised aggregation scheme, nineteen percent (nearly one million acres)of net land use change was toward perennial crops and habitat. Notably about 824,000 acres moved from Grassy Habitat toward Non-Ag.

Net land use changes in Nebraska were larger when compared to other states in the 8-state study area. As shown in Figure 35, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the northern and northwestern parts of the state. The central and southeastern parts of the state also saw significant shifts toward Perennial Crops and Habitat.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of “program crops”. These additional crops (generally minor oilseeds) have been included as “program crops” in this update. We again provide a subset of results for

this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as “Non-Perennial Crops”.

These results are shown in Figure 36 and Figure 37. On a net basis, sixty-five percent (about 3.4 million acres) of net land use change went toward non-perennial crops. This represents 6.9 percent of total land area in Nebraska. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Nebraska Results section.

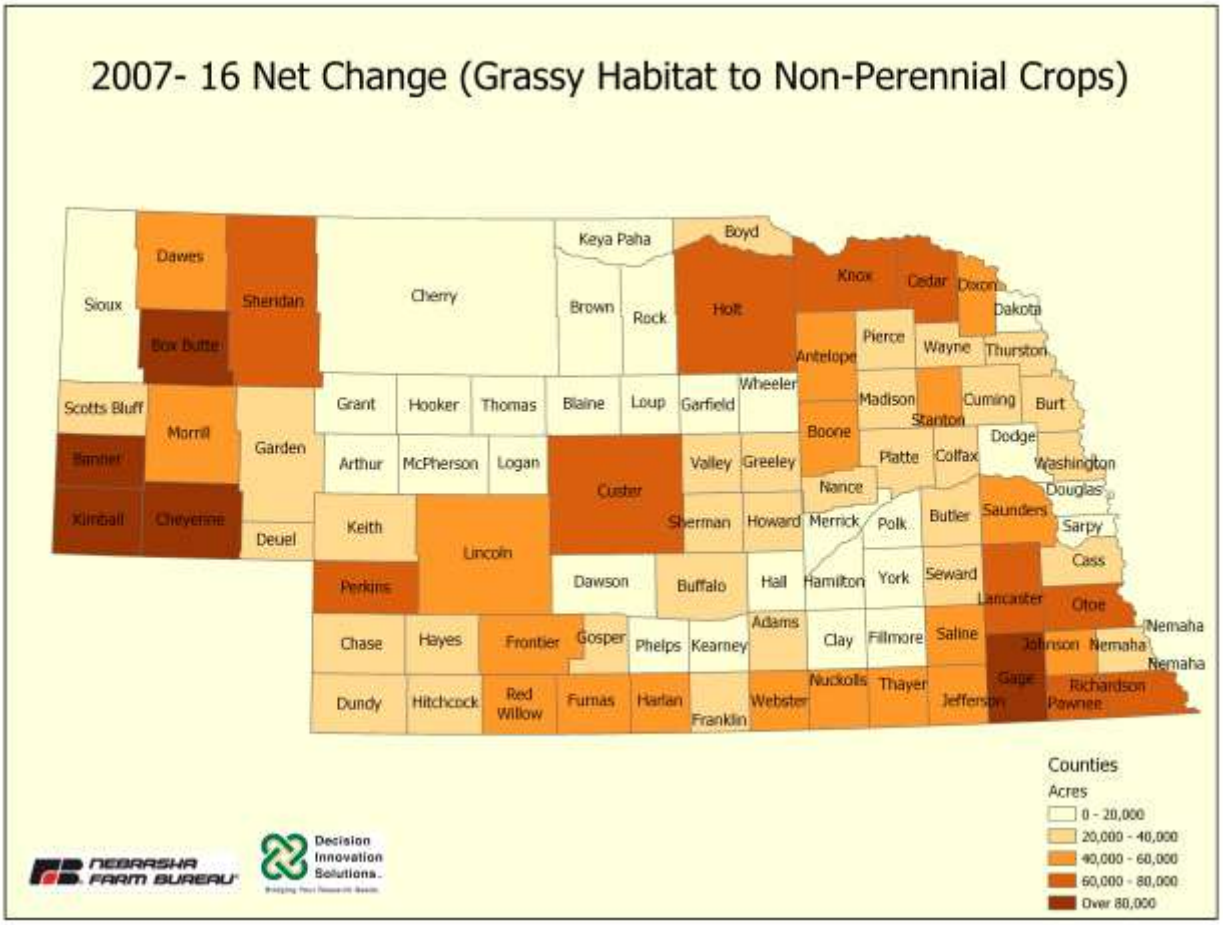


Figure 36, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Nebraska Counties

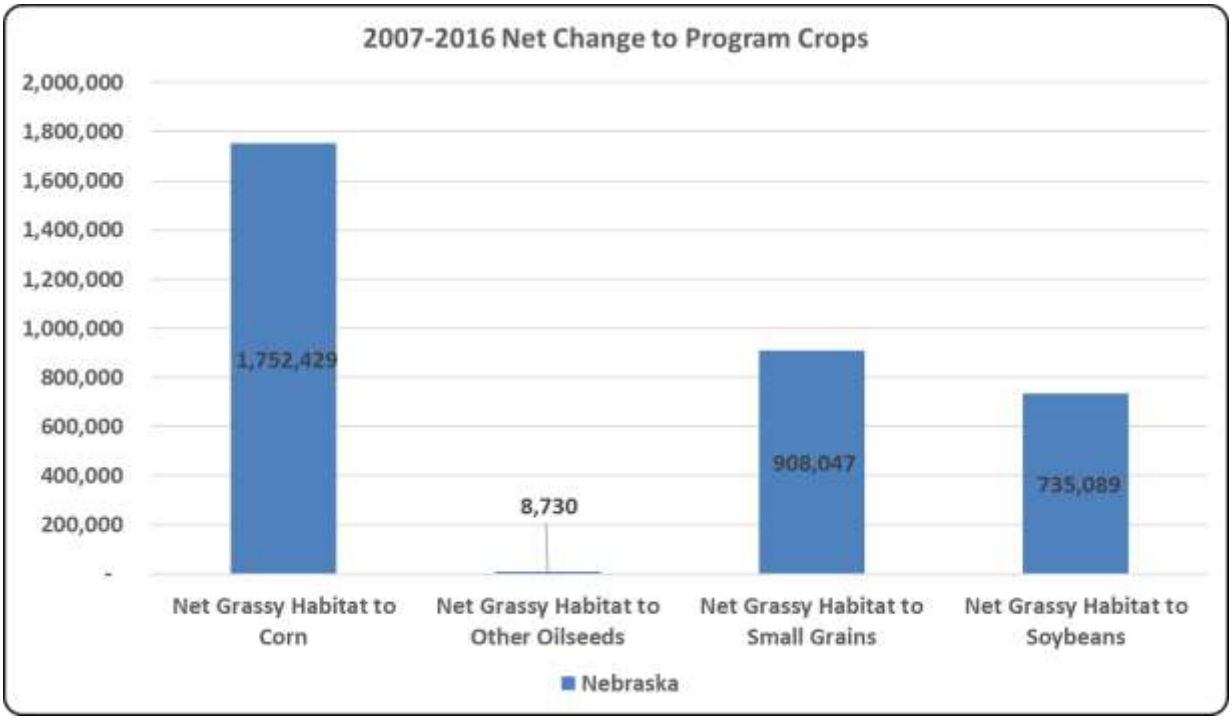


Figure 37, 2007-2016 Net Change (Grassy Habitat to Program Crops): Nebraska

Econometric Results

Table 9 provides results for Nebraska. A summary of econometric results with regard to the explanatory variables for Nebraska is provided below.

- **Crop Insurance Subsidies**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the higher the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is not significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the lower the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the lower the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is significant at the 95% level and exhibits the expected sign (-).

- Result suggests that the higher the Precipitation, the lower the share of land devoted to Grassy Habitat.

Table 9, Econometric Results: Nebraska

Variable	Coefficients	Standard Error	t Stat
Intercept	1.0397	0.0987	10.5294
Crop Insurance Subsidies	0.0132	0.0012	11.1511
Net Returns for Crops	0.0000	0.0001	-0.1660
Growing Degree Days	-0.6634	0.0777	-8.5361
Precipitation	-0.2781	0.0298	-9.3248
Adjusted R2	0.3904		
Observations	883		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The above results show that in Nebraska, Growing Degree Days and Precipitation are key variables of interest in this study. We can conclude that that the higher the Growing Degree Days, the lower the share of land devoted to Grassy Habitat. We can also can conclude that the higher the Precipitation, the lower the share of land devoted to Grassy Habitat in Nebraska.

KANSAS

Background

In terms of a historical perspective on land use in Kansas, acreage in farms has ranged from a low of 21.9 million acres in 1993 to a high of 24.2 million acres in 1996. Estimated acreage devoted to principal field crops in 2016 (23.6 million) is the third highest total since 1993, the first year data of this type were available. Referring to Figure 38, three of the top five years of acres being devoted to the planting of field crops have occurred since 2008.

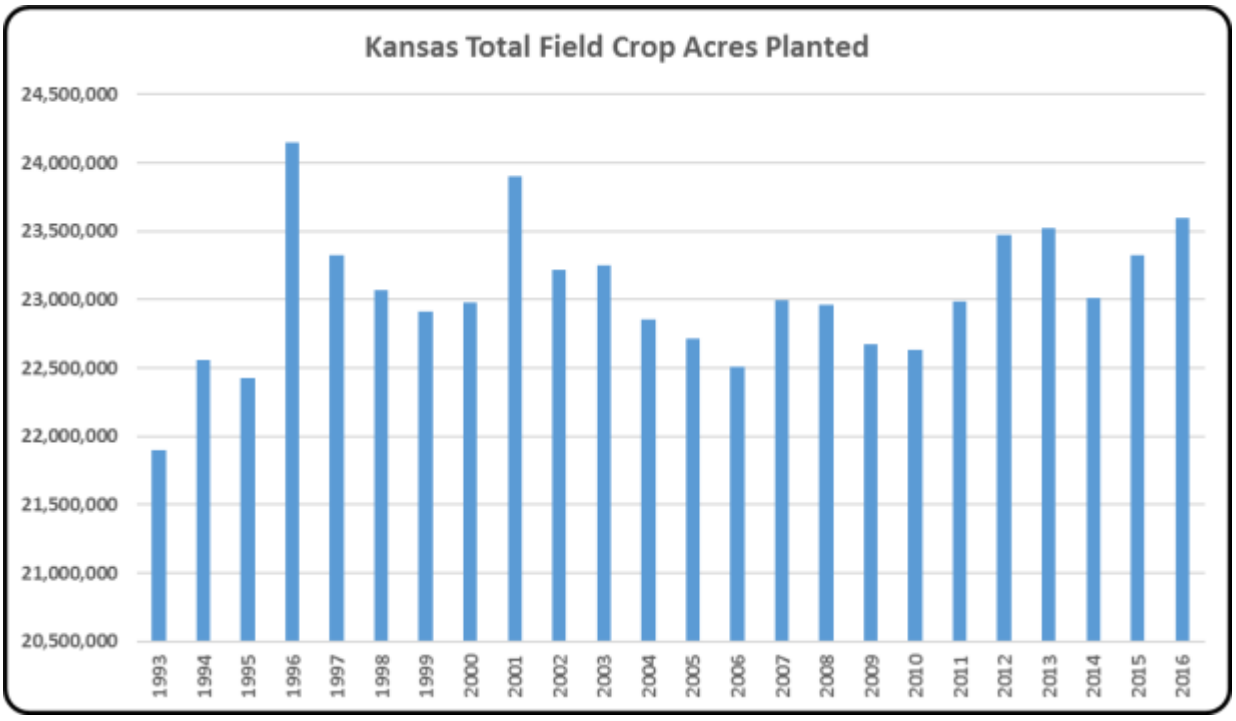


Figure 38, Kansas Total Field Crop Planted Acres

Referring to Figure 39, Kansas quickly reached 2.8 million CRP acres by 1990. It held steady for the next eight years, until the first round of 10-year contracts began to expire. Since 2000, there were slight increases until 2007, but the total never exceeded 3.3 million acres. Since 2007, the number of acres enrolled in Kansas has dropped off and is now near 2.1 million acres.

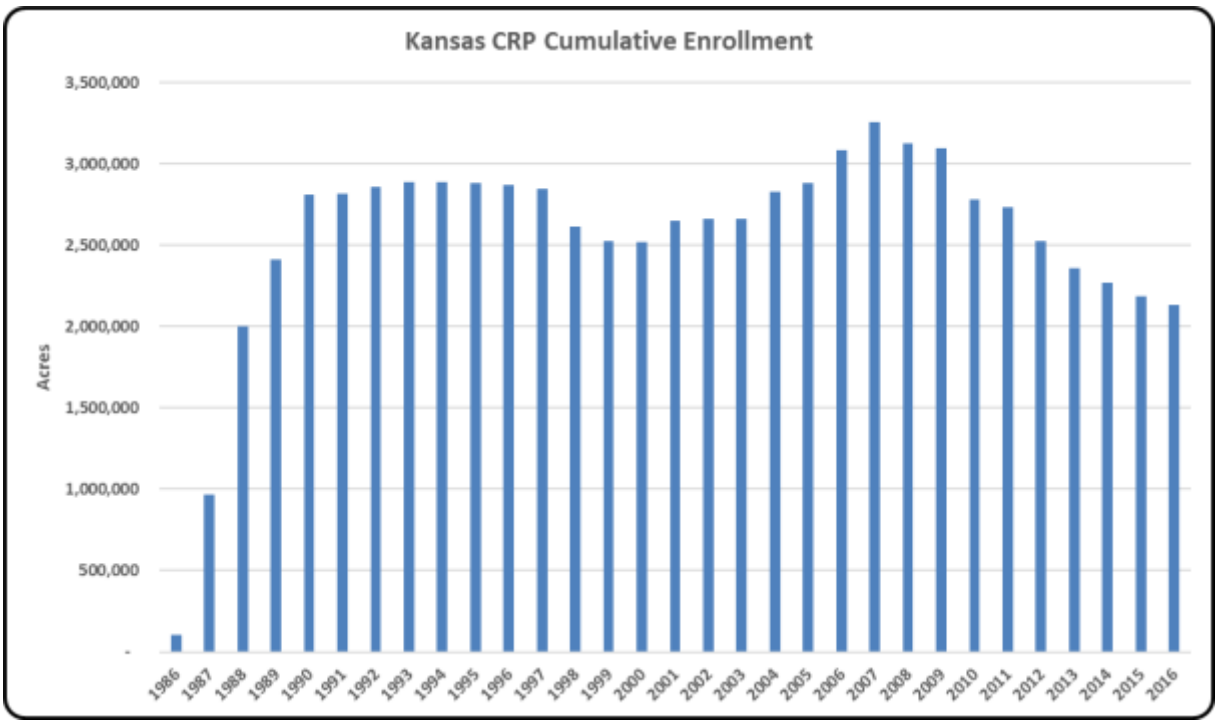


Figure 39, Kansas CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 40, Figure 41, Figure 42 and Table 10, the spatial analysis for the Kansas study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Kansas, there was a positive net land use change from the Grassy Habitat land use category to other categories.

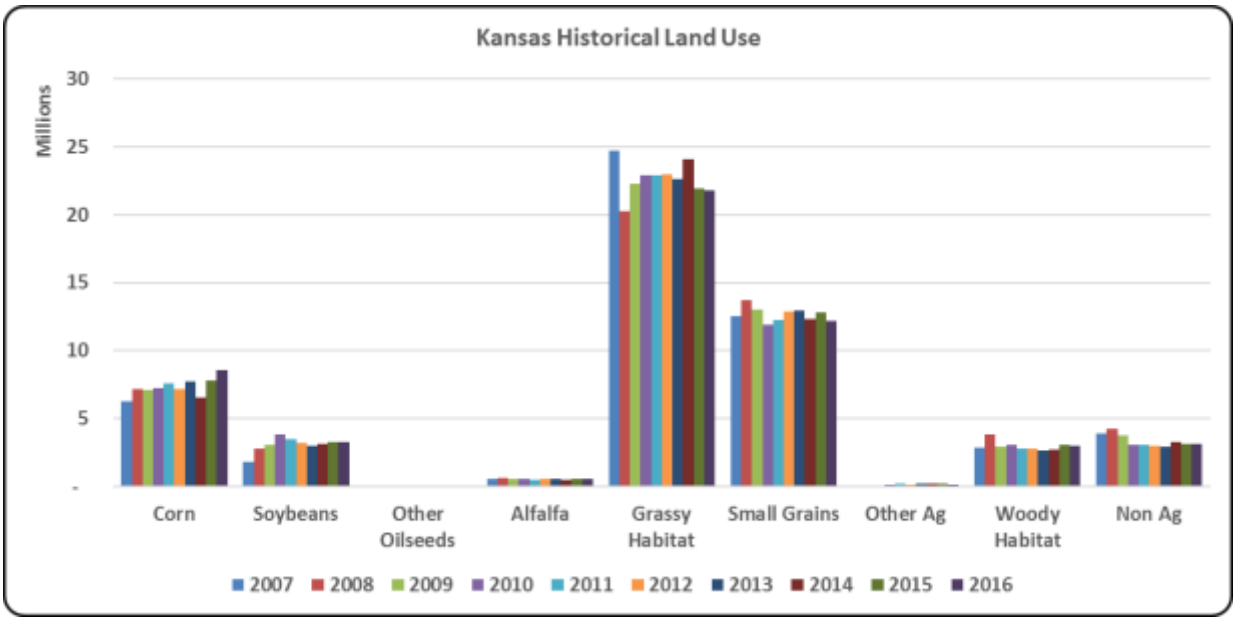


Figure 40, Historical Land Use (2007-2016): Kansas

Table 10, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Kansas

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	83,142	3%
Grassy Habitat to Corn	975,444	34%
Grassy Habitat to Non Ag	(164,265)	-6%
Grassy Habitat to Other Ag	20,498	1%
Grassy Habitat to Other Oilseeds	2,458	0%
Grassy Habitat to Small Grains	1,199,935	42%
Grassy Habitat to Soybeans	495,134	17%
Grassy Habitat to Woody Habitat	230,493	8%
Net Change FROM Grassy Habitat	2,842,839	100%

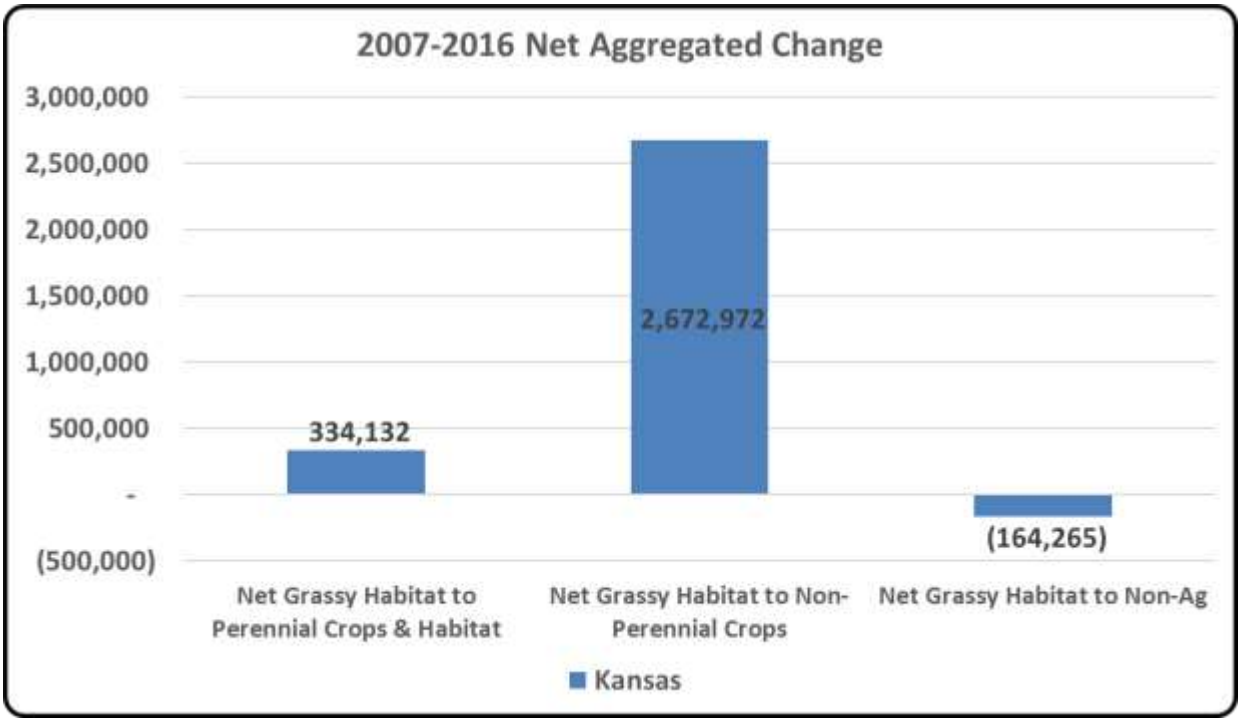


Figure 41, 2007-2016 Net Change (from Grassy Habitat): Kansas

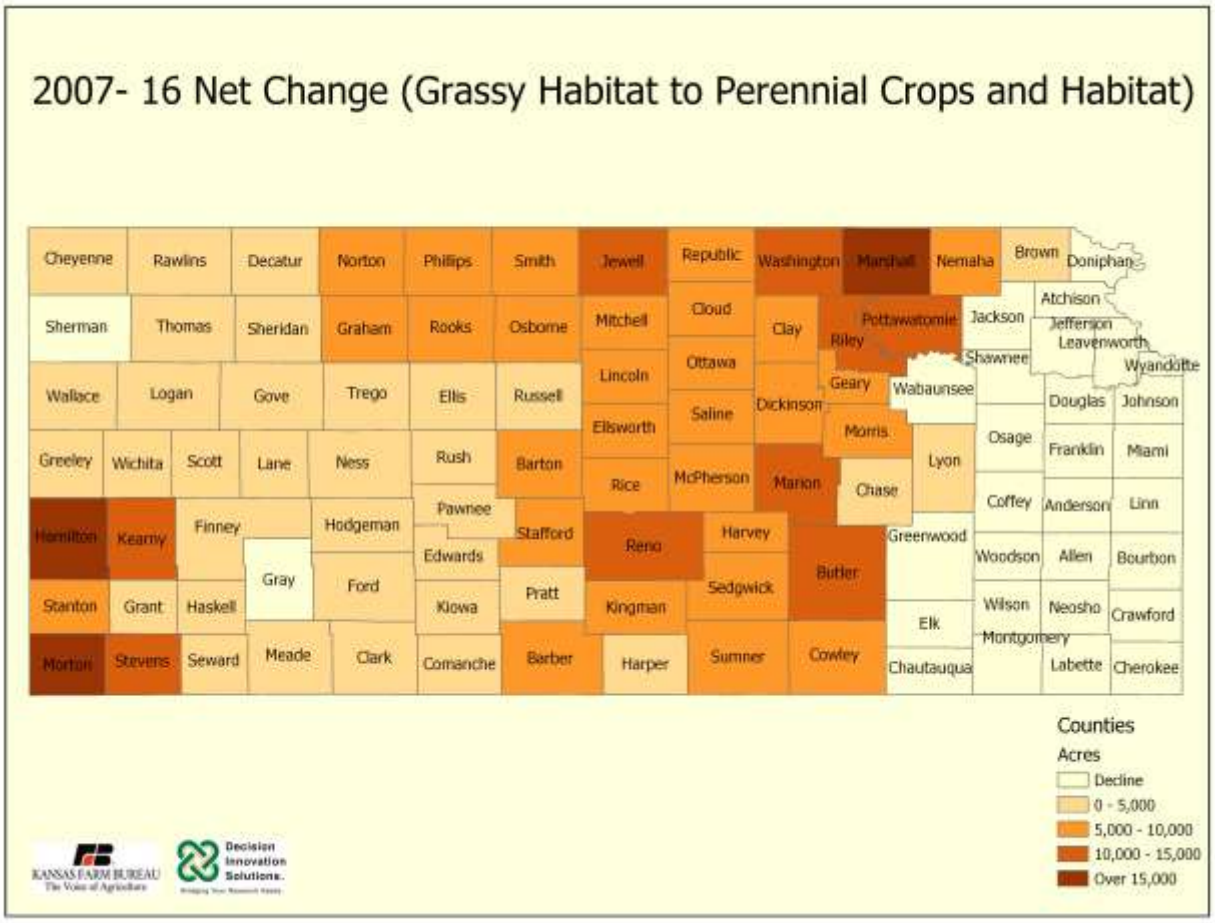


Figure 42, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Kansas Counties

Observations

Due to the relatively low acreage of Other Oilseeds, Alfalfa and Other Ag within Kansas, we did not anticipate much of a shift from Grassy Habitat to these land use categories. Ninety-four percent of this net land use change from Grassy Habitat was toward Small Grains, Corn and Soybeans. Figure 41 shows that under the revised aggregation scheme, the majority of net acreage changes went toward non-perennial crops (about 2.7 million acres) Approximately 334,000 acres moved to perennial crops and habitat. As shown in Figure 42, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the western two-thirds of the state.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of “program crops”. These additional crops (generally minor oilseeds) have been included as “program crops” in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as “Non-Perennial Crops”.

These results are shown in Figure 43 and Figure 44. On a net basis, ninety-four percent (about 2.7 million acres) of net land use change went toward non-perennial crops. This represents 5.1 percent of total land area in Kansas. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Kansas Results section.

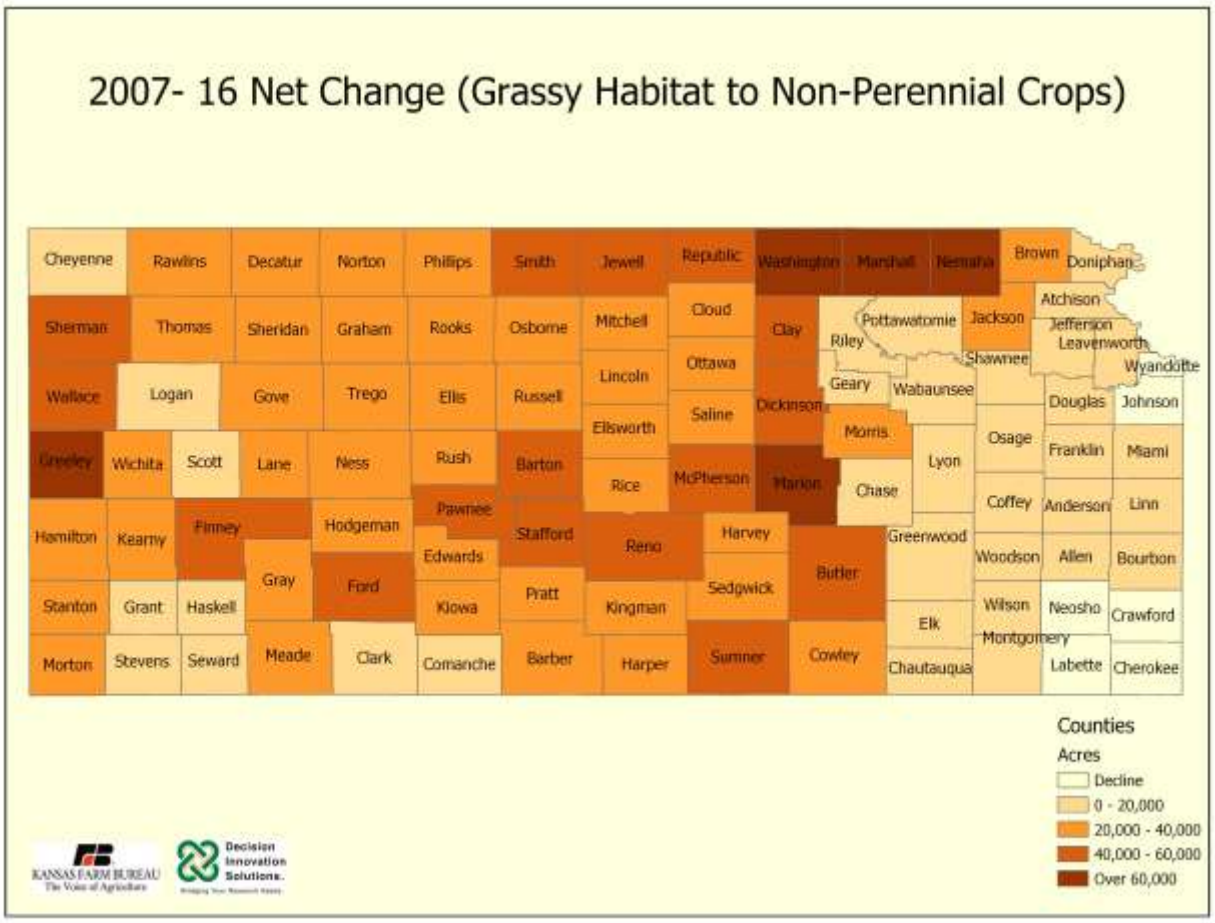


Figure 43, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Kansas Counties

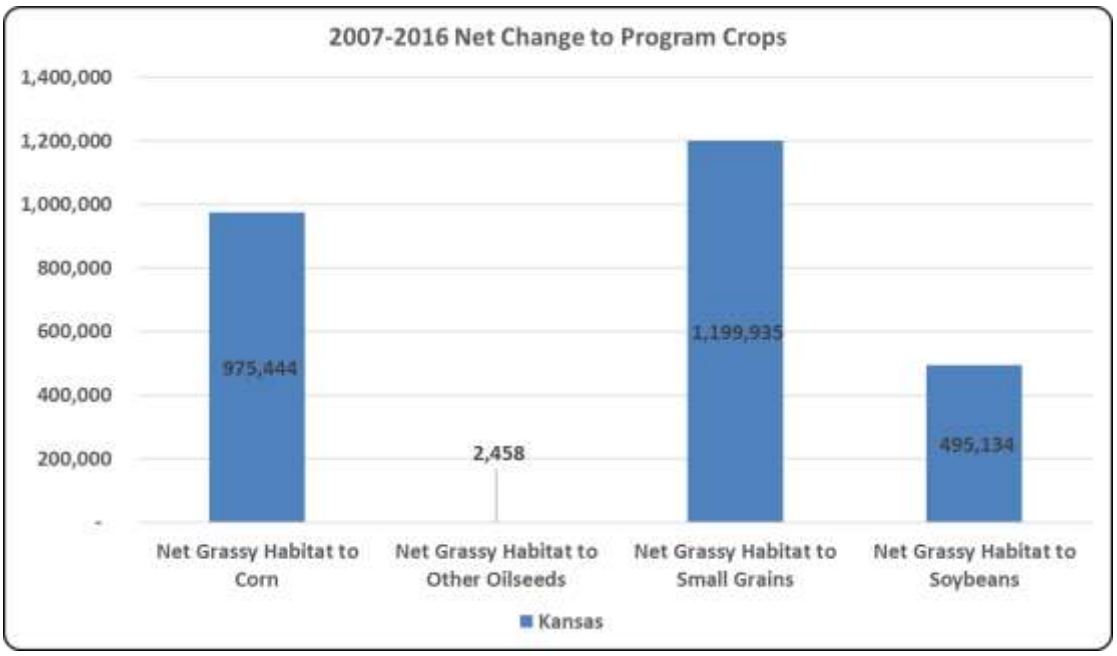


Figure 44, 2007-2016 Net Change (Grassy Habitat to Program Crops): Kansas

Econometric Results

Table 11 provides econometric results for Kansas. A summary of econometric results with regard to the explanatory variables for Kansas is provided below.

- **Crop Insurance Subsidies**
  - Variable is significant at the 90% level and exhibits the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the lower the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is not significant at the 95% level, but does not exhibit the expected sign (-).
    - Result suggests that the higher the net Returns, the higher the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level, but does not exhibit the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the higher the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is significant at the 95% level, but does not exhibit the expected sign (-).
    - Result suggests that the higher the Precipitation, the higher the share of land devoted to Grassy Habitat.

Table 11, Econometric Results: Kansas

Variable	Coefficients	Standard Error	t Stat
Intercept	0.0144	0.0927	0.1551
Crop Insurance Subsidies	-0.0013	0.0007	-1.8297
Net Returns for Crops	0.0002	0.0001	1.3874
Growing Degree Days	0.3623	0.0751	4.8216
Precipitation	0.0658	0.0146	4.4961
Adjusted R2	0.0631		
Observations	1040		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The results show that net returns for crop, total growing degree days, and total precipitation have the theoretically wrong sign, even though the estimated parameters are statistically significant. Therefore, we cannot conclude any of these variables have had a significant effect on changes in grassy habitat during the study period. However, the regression results point out that crop insurance subsidies in Kansas have contributed to the change in grassy habitat during the study period.

MINNESOTA

Background

In terms of a historical perspective on the land use in Minnesota, acreage in farms has ranged from a low of 19.3 million acres in 1993 to a high of 20.5 million acres in 1998. Estimated acreage devoted to principal field crops in 2016 (19.9 million acres) is the eleventh highest total since 1993, the first year data of this type were available. Referring to Figure 45, not since 2003 have more than 20 million acres been devoted to the planting of crops.

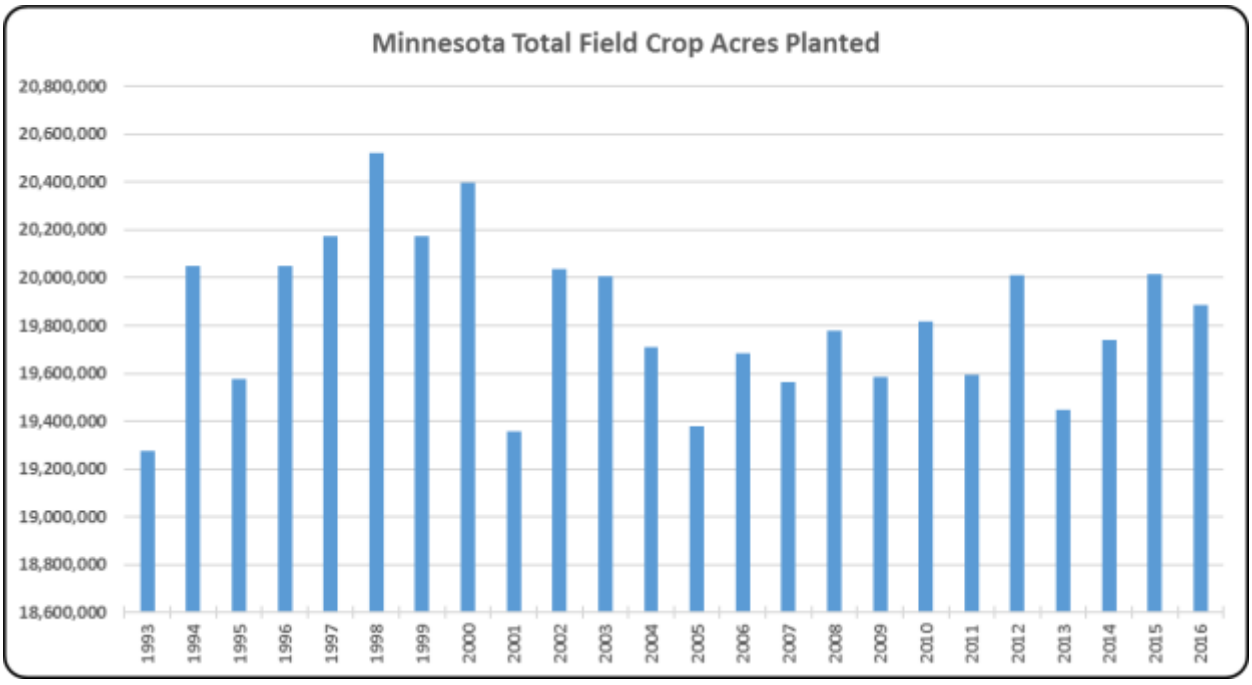


Figure 45, Minnesota Total Field Crop Planted Acres

Referring to Figure 46, when CRP was implemented in 1986, Minnesota enrolled 0.130 million acres in the program. The following year it increased more than one million acres and steadily increased until 1993 and 1994 when there was record enrollment of 1.837 million acres. In 1996 and 1997, Minnesota saw decreases in CRP acreage due to the expiration of 10-year contracts, some of which were not being renewed, or no longer eligible for renewal due to changes in CRP program criteria. During the next decade, cropland enrolled in the CRP program increased, reaching a new peak in 2008. Higher crop prices resulting in higher net returns for crop production have made CRP rental rates less competitive in recent years and have most likely been a reason for the decline in CRP-enrolled acreage since 2008. There were 1.2 million acres enrolled in the CRP program in 2016 in Minnesota.

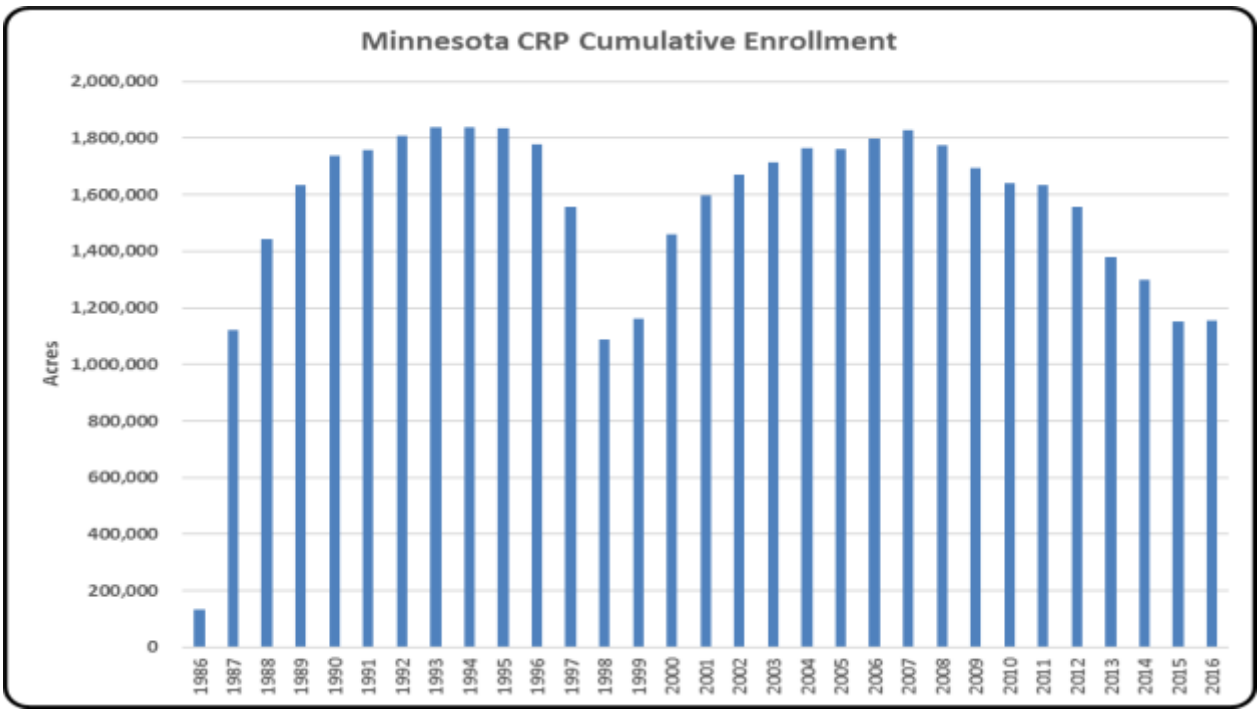


Figure 46, Minnesota CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 47, Figure 48, Figure 49 and Table 12, the spatial analysis for the Minnesota study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Minnesota, there was a positive net land use change from the Grassy Habitat land use category to other categories.

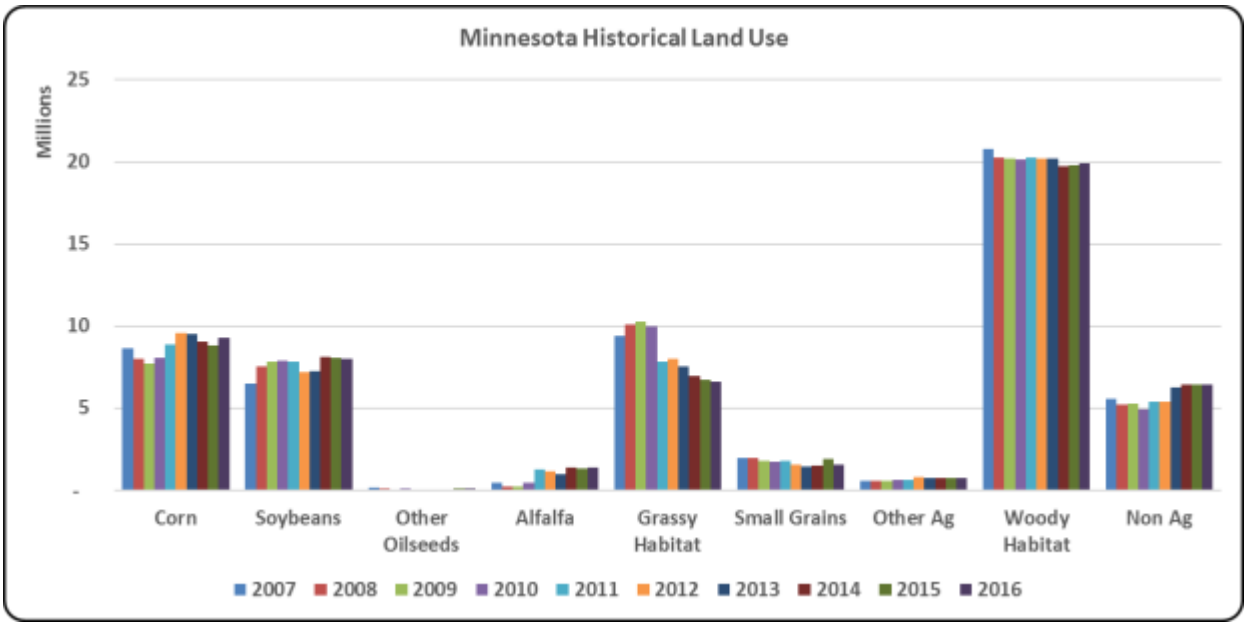


Figure 47, Historical Land Use (2007-2016): Minnesota

Table 12, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Minnesota

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	616,531	23%
Grassy Habitat to Corn	682,683	25%
Grassy Habitat to Non Ag	332,711	12%
Grassy Habitat to Other Ag	61,836	2%
Grassy Habitat to Other Oilseeds	15,594	1%
Grassy Habitat to Small Grains	198,016	7%
Grassy Habitat to Soybeans	728,490	27%
Grassy Habitat to Woody Habitat	55,558	2%
Net Change FROM Grassy Habitat	2,691,420	100%

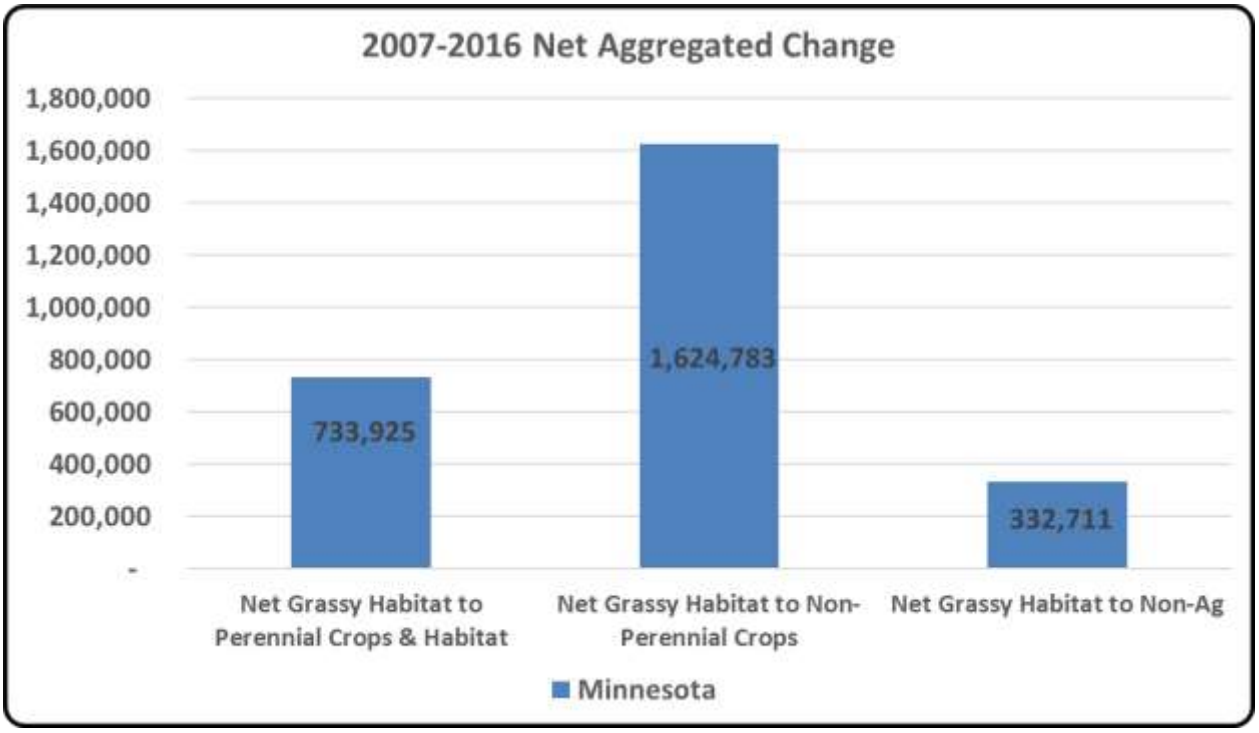


Figure 48, 2007-2016 Net Change (from Grassy Habitat): Minnesota

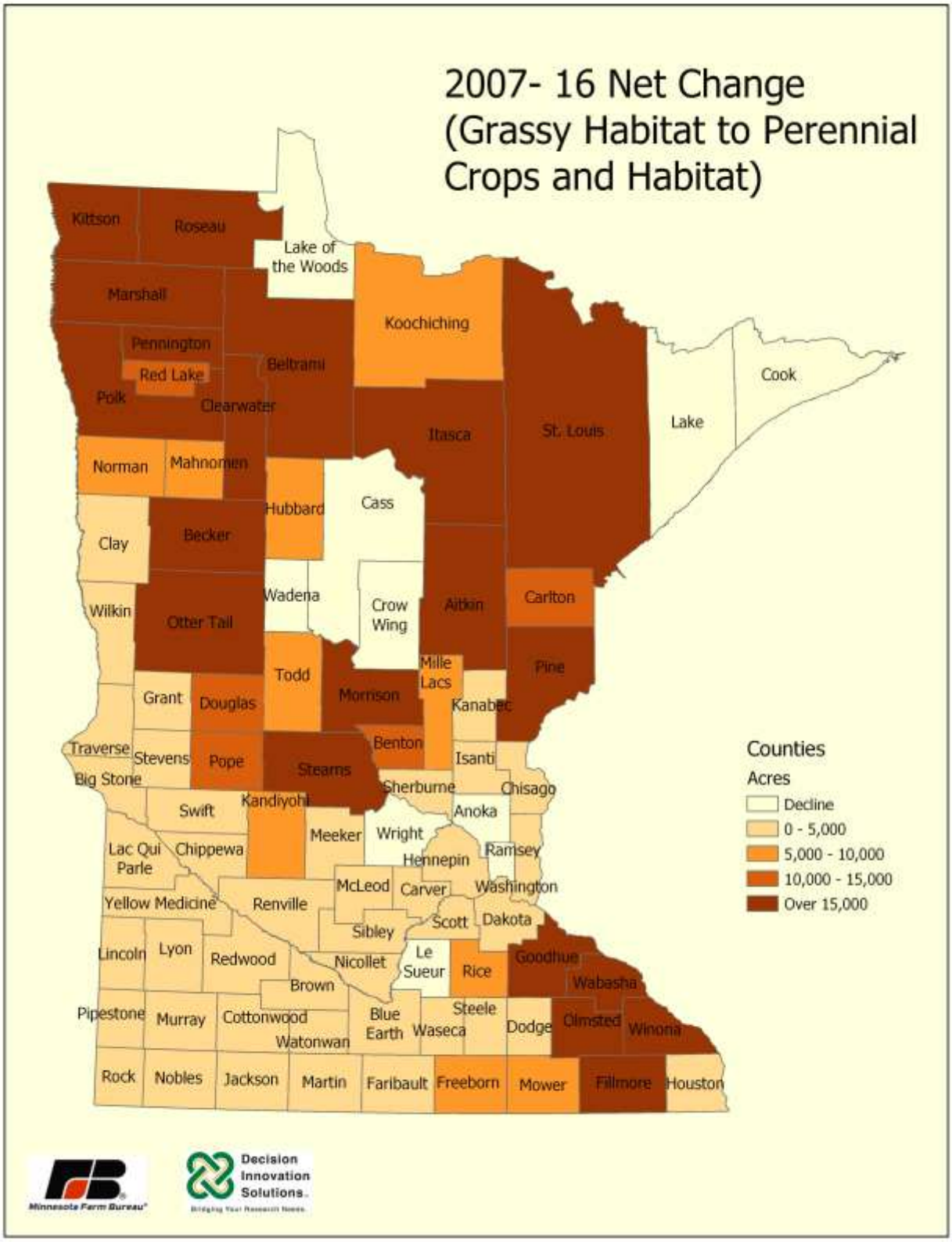


Figure 49, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Minnesota Counties

Observations

Due to the results from the original study related to Other Oilseeds and Other Ag within Minnesota, we again did not anticipate much of a shift from Grassy Habitat to these land use categories. Eighty-eight percent of estimated net land use change from Grassy Habitat was toward Soybeans, Corn, Alfalfa and Non-Ag. Figure 48 shows that under the revised aggregation scheme, twenty-seven percent (about 734,000 acres) of net land use change was toward perennial crops and habitat. Notably about 333,000 acres moved from Grassy Habitat toward Non-Ag. As shown in Figure 49, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the northern half of the state. The southeastern part of the state also saw a significant shift toward Perennial Crops and Habitat.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of "program crops". These additional crops (generally minor oilseeds) have been included as "program crops" in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as "Non-Perennial Crops".

These results are shown in Figure 50 and Figure 51. On a net basis, sixty percent (about 1.6 million acres) went toward non-perennial crops) of net land use change went toward non-perennial crops. This represents 3.0 percent of total land area in Minnesota. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Minnesota Results section.

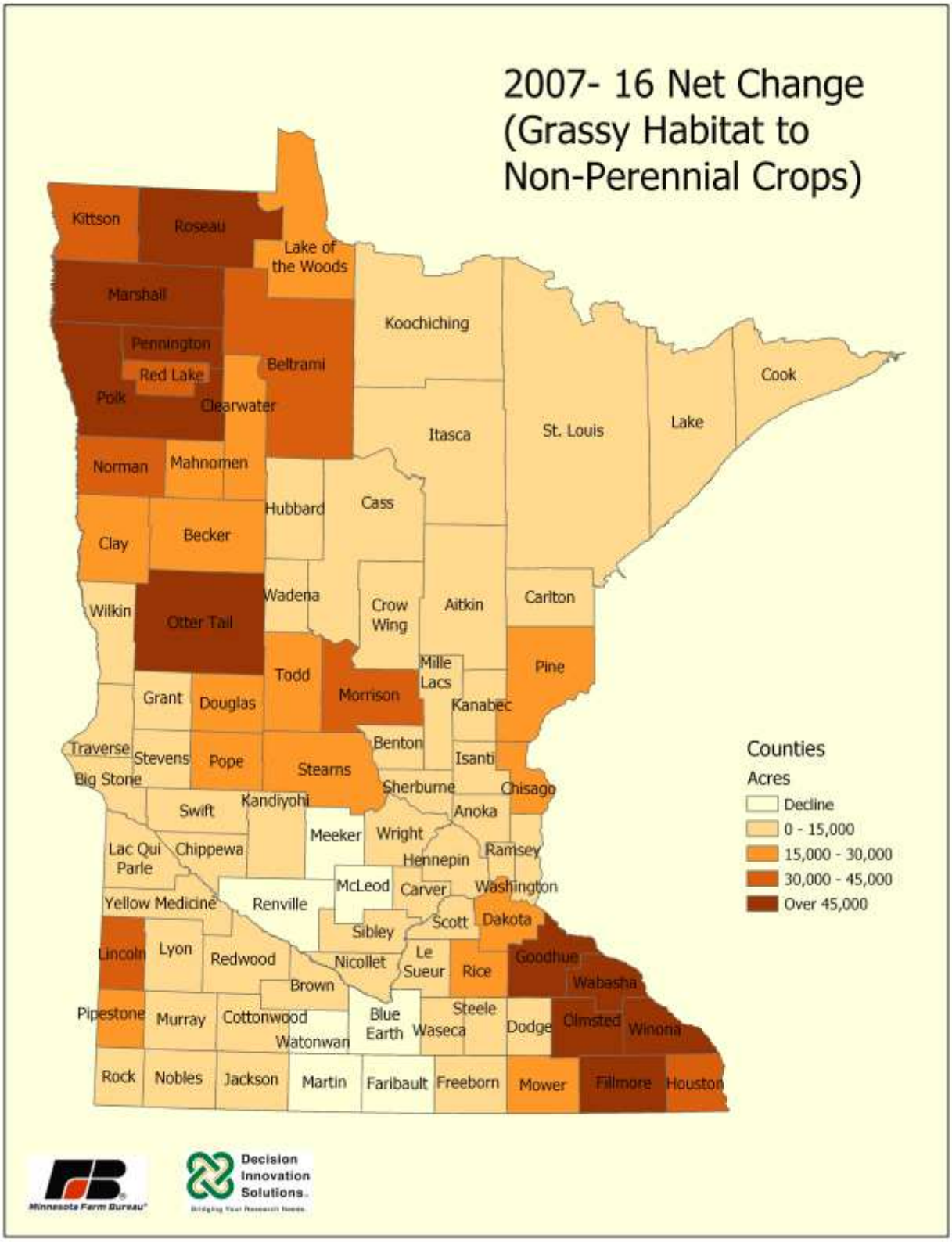


Figure 50, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Minnesota Counties

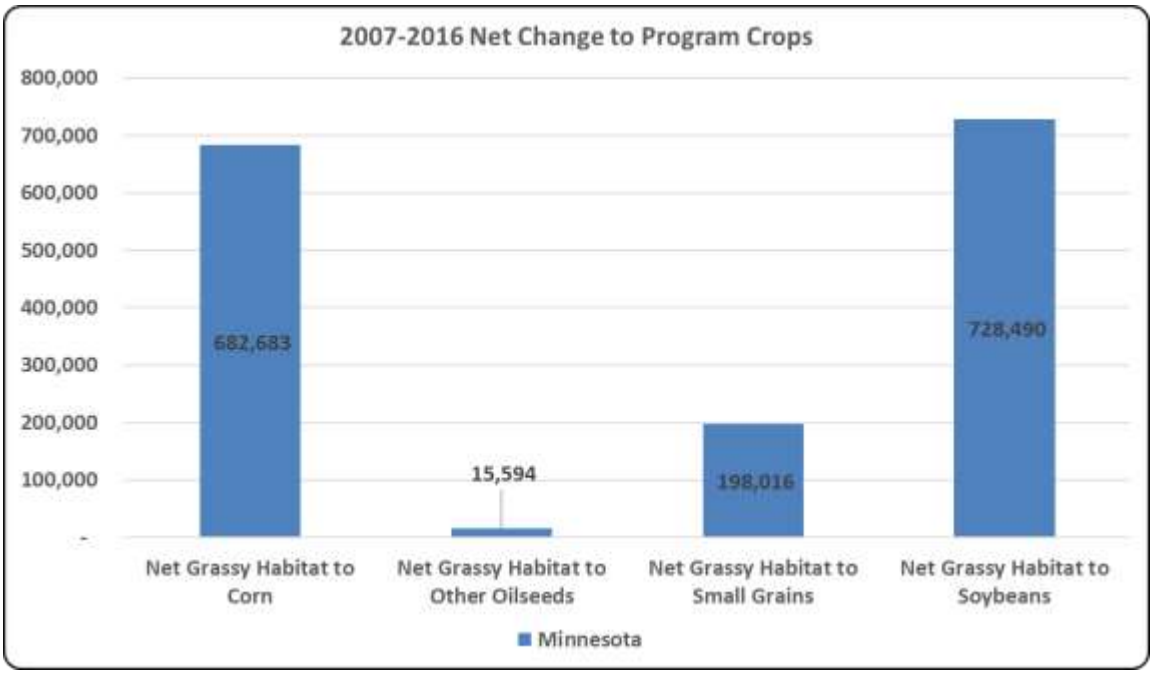


Figure 51, 2007-2016 Net Change (Grassy Habitat to Program Crops): Minnesota

Econometric Results

Table 13 provides econometric results for Minnesota. A summary of econometric results with regard to the explanatory variables for Minnesota is provided below.

- **Crop Insurance Subsidies**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the higher the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is not significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the lower the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the lower the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Precipitation, the higher the share of land devoted to Grassy Habitat.

Table 13, Econometric Results: Minnesota

Variable	Coefficients	Standard Error	t Stat
Intercept	0.1774	0.0439	4.0387
Crop Insurance Subsidies	0.0023	0.0004	5.2717
Net Returns for Crops	0.0000	0.0000	-0.2272
Growing Degree Days	-0.1134	0.0382	-2.9701
Precipitation	0.0550	0.0168	3.2782
Adjusted R2	0.0716		
Observations	807		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The results show that crop insurance subsidies, net returns for crops, and precipitation did not play any role in the grassy habitat lands in Minnesota during the study period. Growing degree days have played a significant role in changes of grassy habitat in Minnesota.

IOWA

Background

In terms of a historical perspective on the land use in Iowa, acreage in farms for the area has ranged from a low of 23.6 million acres in 1995 to a high of 25.0 million acres in 2000. Estimated acreage devoted to principal field crops (corn, soybeans, hay, oats, and wheat) in 2012 (24.8 million acres) is the third highest total since 1993, the first year data of this type were available. Referring to Figure 52, after a temporary decline from a recent peak in 2008, acreage has began a moderately increasing trend, but has since fallen since 2012.

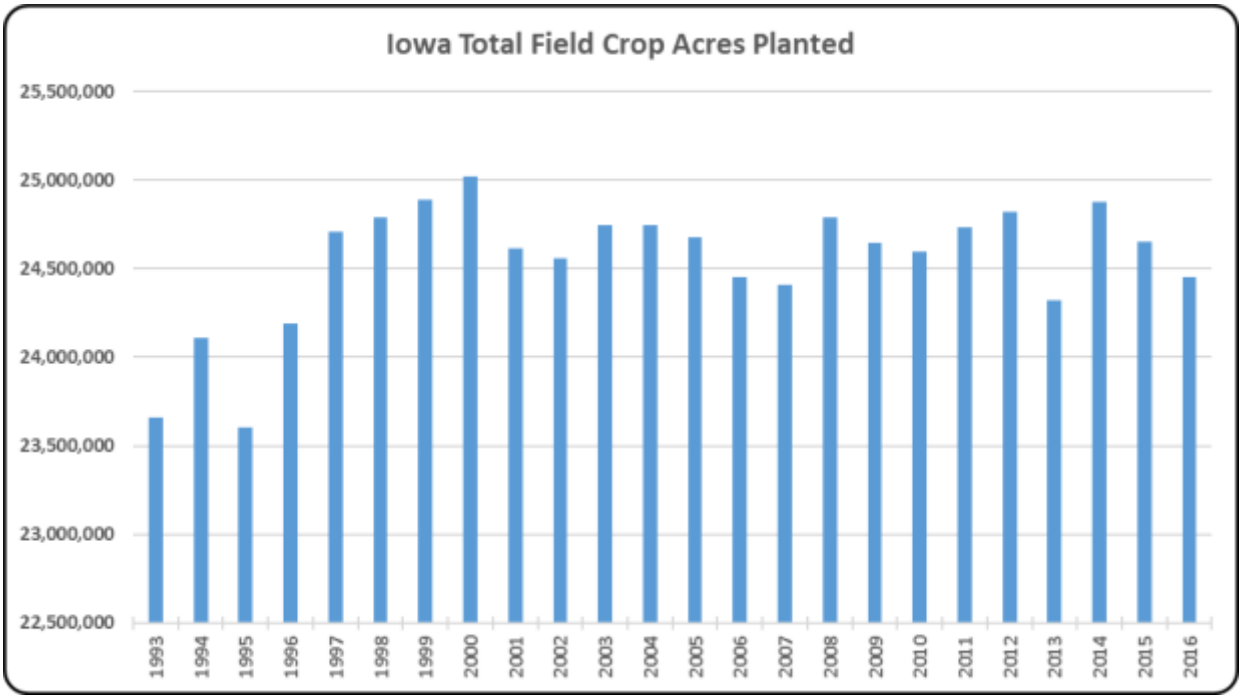


Figure 52, Iowa Total Field Crop Planted Acres

Referring to Figure 53, CRP caught on quickly in Iowa as enrolled acres exceeded 2.0 million in the eighth year of the program. In 1996 the first of the ten-year contracts began to expire; acres enrolled subsequently dropped to around 1.5 million. There had been a steady increase since then until 2007, but never to exceed the highs of the early 1990s. Higher crop prices and the need for suitable land to be farmed are reasons for the decline over the past few years. There are currently 1.7 million acres enrolled in the CRP program in Iowa.

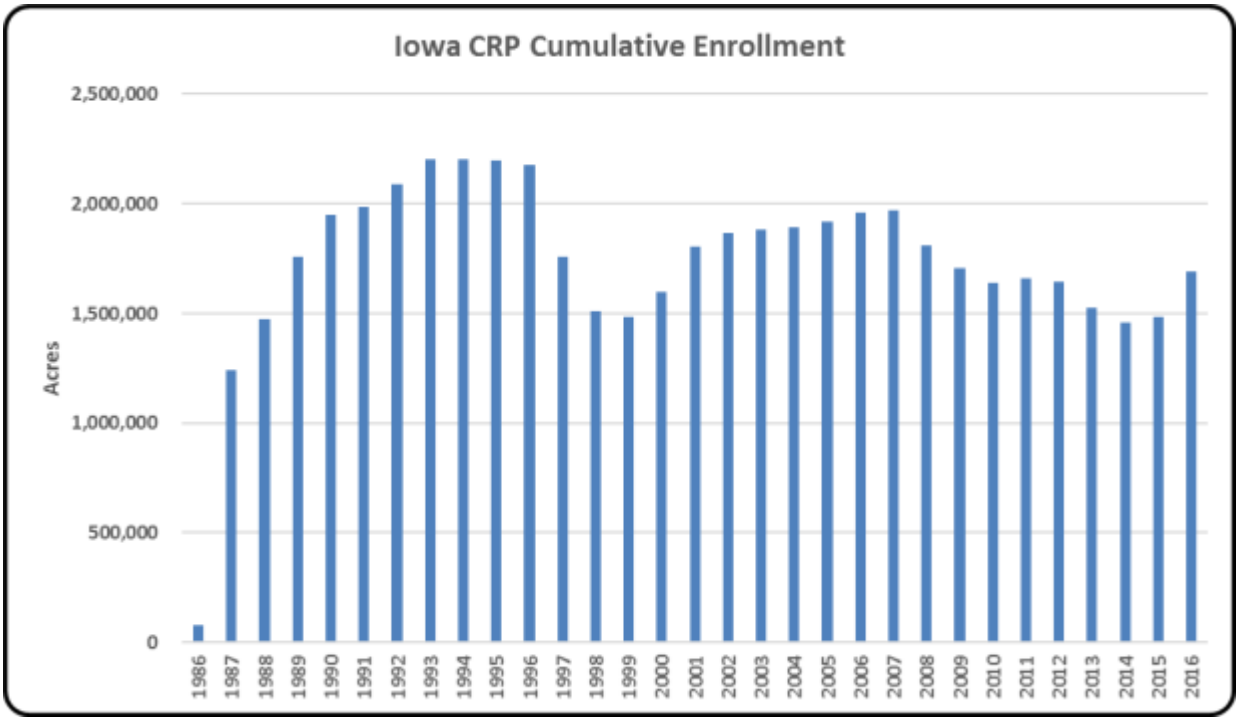


Figure 53, Iowa CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 54, Figure 55, Figure 56 and Table 14, the spatial analysis for the Iowa study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Iowa, there was a positive net land use change from the Grassy Habitat land use category to other categories.

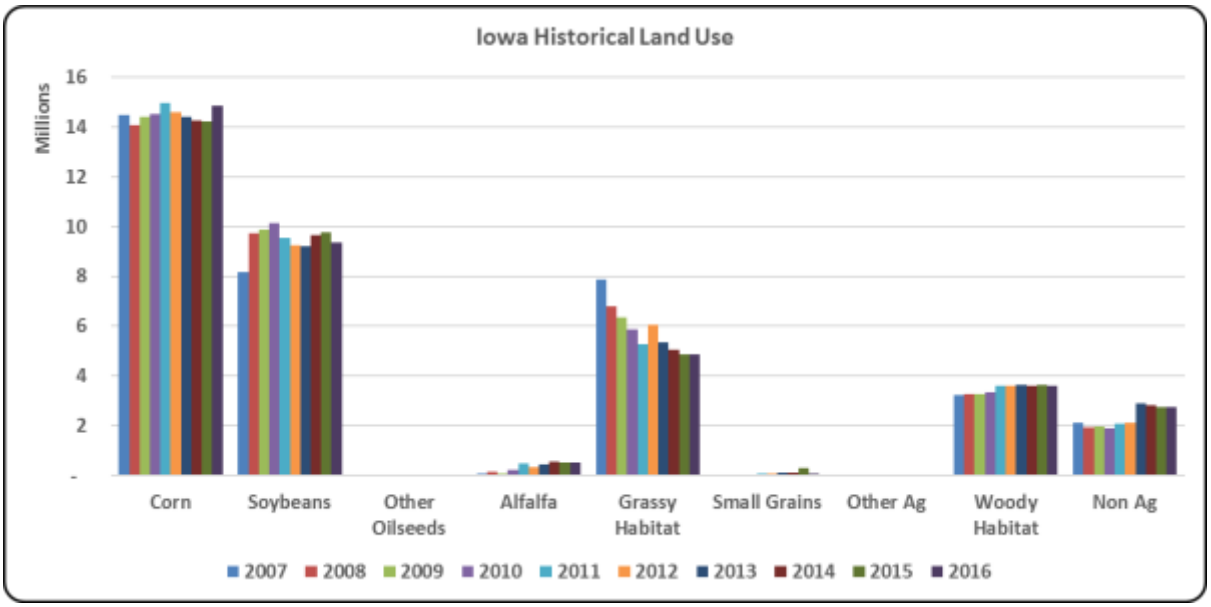


Figure 54, Historical Land Use (2007-2016): Iowa

Table 14, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Iowa

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	285,732	10%
Grassy Habitat to Corn	1,006,005	36%
Grassy Habitat to Non Ag	359,498	13%
Grassy Habitat to Other Ag	1,511	0%
Grassy Habitat to Other Oilseeds	32	0%
Grassy Habitat to Small Grains	26,928	1%
Grassy Habitat to Soybeans	713,573	25%
Grassy Habitat to Woody Habitat	435,562	15%
Net Change FROM Grassy Habitat	2,828,842	100%

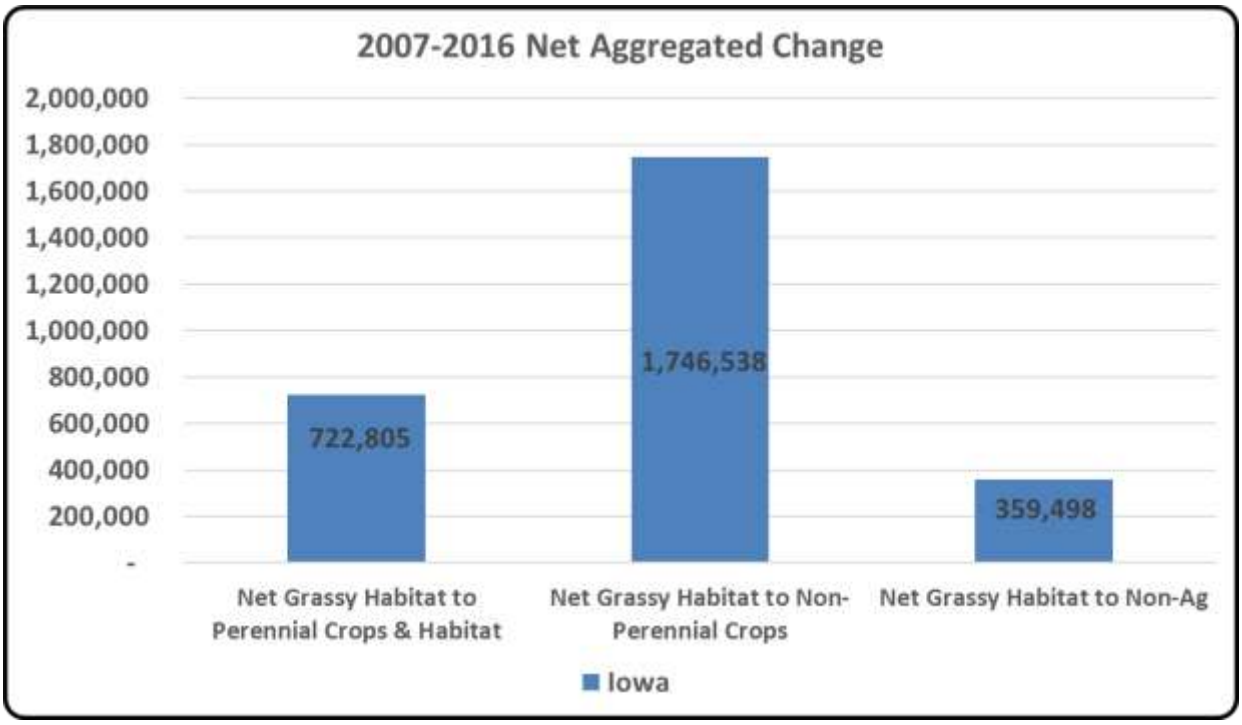


Figure 55, 2007-2016 Net Change (from Grassy Habitat): Iowa

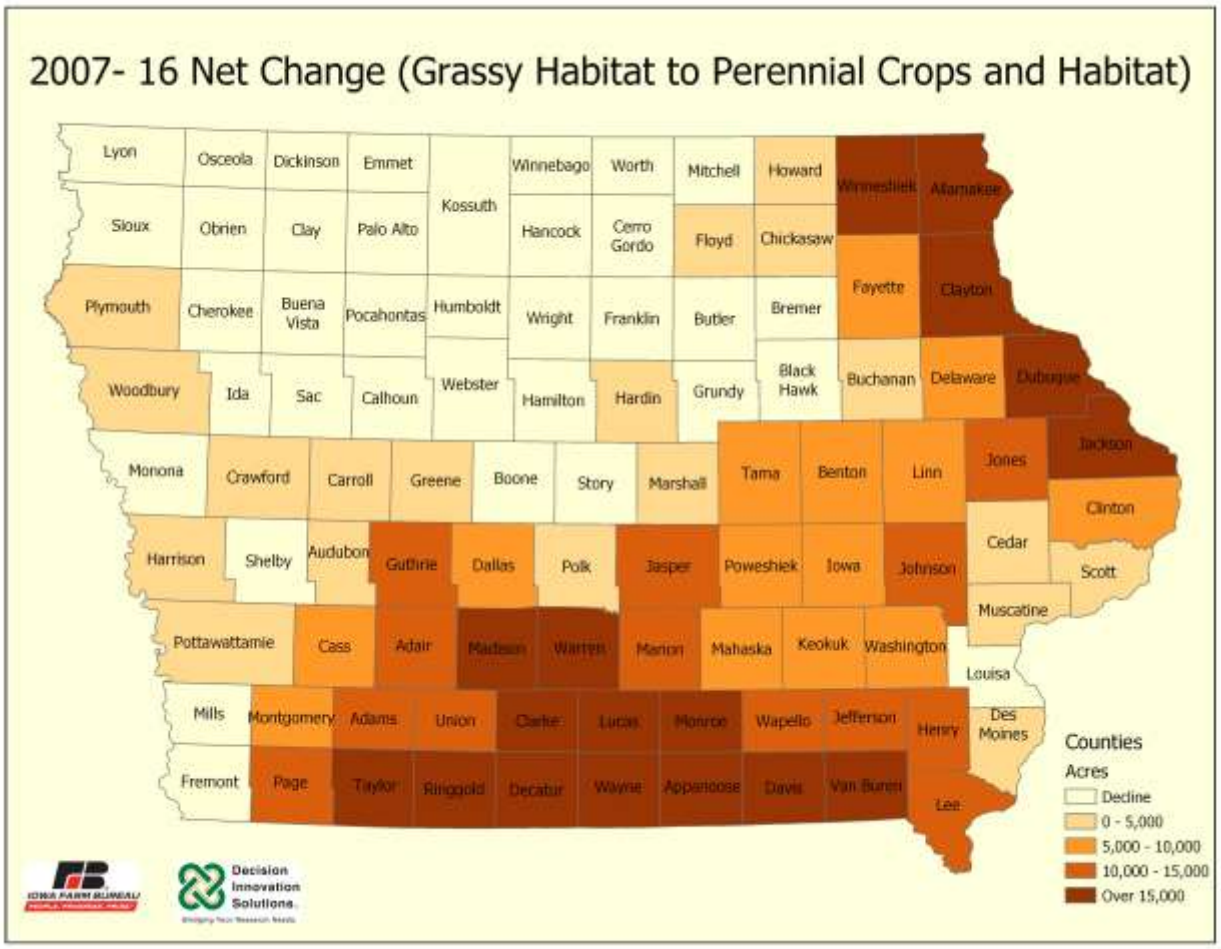


Figure 56, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Iowa Counties

Observations

Due to the results from the original study related to Other Oilseeds and Other Ag within Iowa, we again did not anticipate much of a shift from Grassy Habitat to these land use categories. Eighty-nine percent of estimated net land use change from Grassy Habitat was toward Corn, Soybeans, Woody Habitat and Non-Ag. Figure 55 shows that under the revised aggregation scheme, twenty-six percent (about 723,000 acres) of net land use change was toward perennial crops and habitat. Notably more than 359,000 acres moved from Grassy Habitat toward Non-Ag. As shown in Figure 56, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the southern part of the state. The northeastern part of the state also saw a significant shift toward Perennial Crops and Habitat.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of “program crops”. These additional crops (generally minor oilseeds) have been included as “program crops” in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as “Non-Perennial Crops”.

These results are shown in Figure 57 and Figure 58. On a net basis, sixty-two percent (about 1.7 million acres) of net land use change went toward non-perennial crops. This represents 4.8 percent of total land area in Iowa. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Iowa Results section.

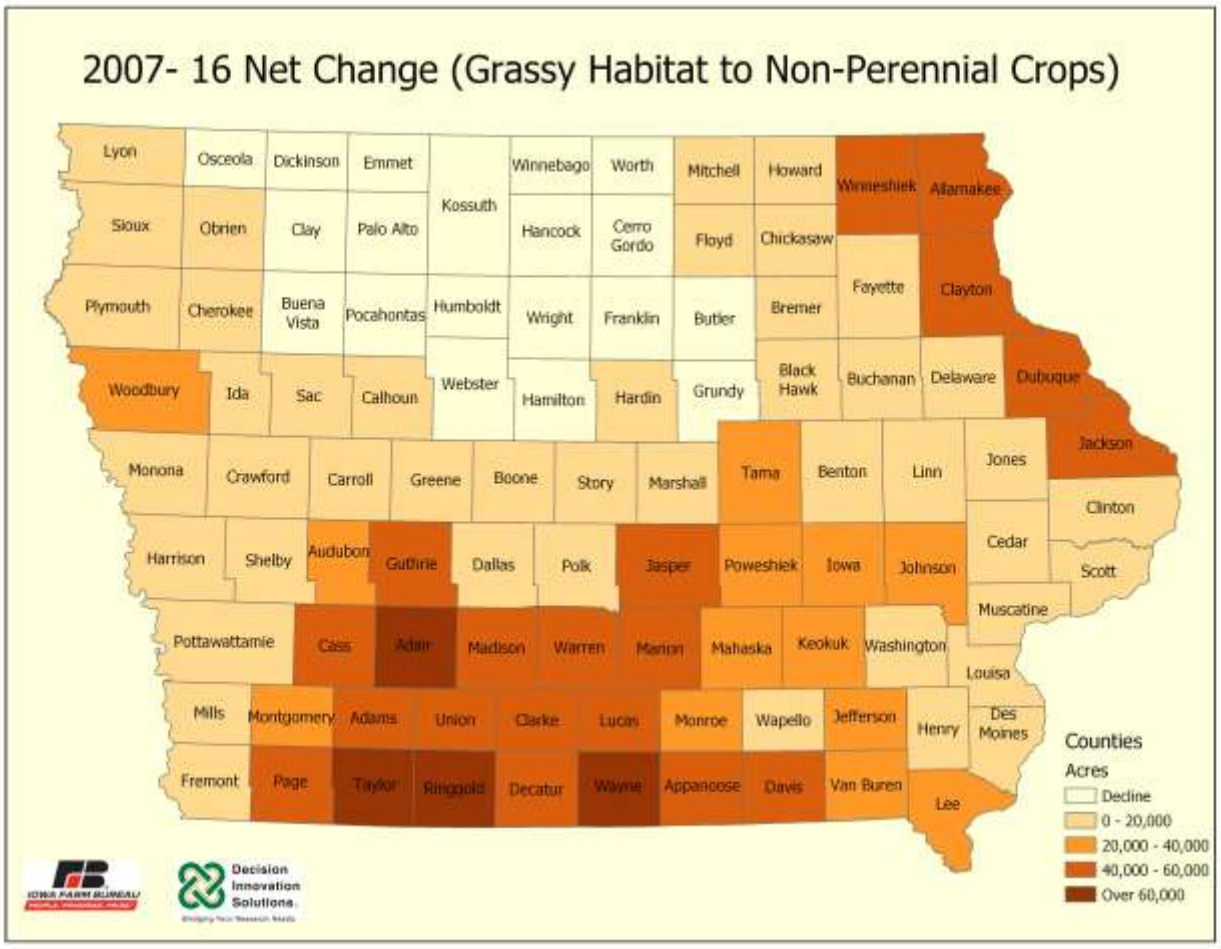


Figure 57, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Iowa Counties

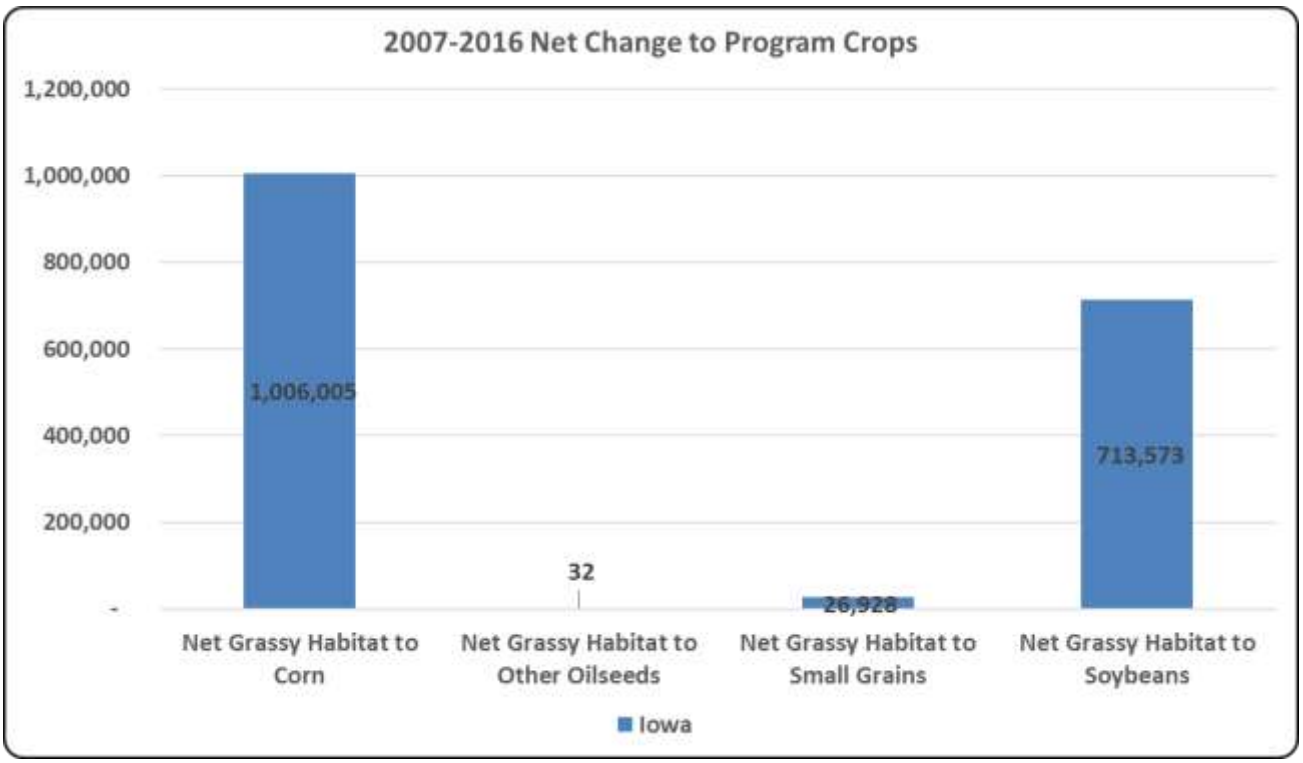


Figure 58, 2007-2016 Net Change (Grassy Habitat to Program Crops): Iowa

Econometric Results

Table 15 provides results for Iowa. A summary of econometric results with regard to the explanatory variables for Iowa is provided below.

- **Crop Insurance Subsidies**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the higher the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the lower the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the higher the share of land devoted to Grassy Habitat. This may be due to the dominance of physical characteristics of the landscape in the southern part of the state, which tends to have higher Growing Degree Days than does the northern part of the state.

- **Precipitation**
    - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
        - Result suggests that the higher the Precipitation, the higher the share of land devoted to Grassy Habitat.

Table 15, Econometric Results: Iowa

Variable	Coefficients	Standard Error	t Stat
Intercept	-0.5627	0.0330	-17.0629
Crop Insurance Subsidies	0.0096	0.0005	20.3084
Net Returns for Crops	-0.0001	0.0000	-7.2172
Growing Degree Days	0.3307	0.0284	11.6610
Precipitation	0.2012	0.0126	16.0003
Adjusted R2	0.4245		
Observations	990		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The model results for Iowa show that all variables were significant. But, net returns is the only variable which exhibited both significance and the expected sign. A possible explanation for unexpected signs for crop insurance subsidies, growing degree days, and precipitation lies in how Iowa's landscape changes spatially. As one moves from north to south, growing degree days increase. As one moves from northwest to southeast, precipitation increases. Additionally, the landscape in southern Iowa is considerably hillier than the rest of the state, which has implications for the magnitude of crop insurance subsidies that are available to crop producers. We would expect the combination of these three unique characteristics to have an impact, both in terms of significance and the type of impact (expected sign). Further, the "overstatement of grassland by CDL" issue explored earlier may also be confounding these results.

MISSOURI

Background

In terms of a historical perspective on the land use in Missouri, acreage in farms has ranged from a low of 12.1 million acres in 2015 to a high of 14.6 million acres in 2013. Estimated acreage devoted to principal field crops in 2016 (13.4 million acres) is the seventeenth highest total since 1993, the first year data of this type were available. Referring to Figure 59, acreage devoted to crops in Missouri has been quite stable over the years.

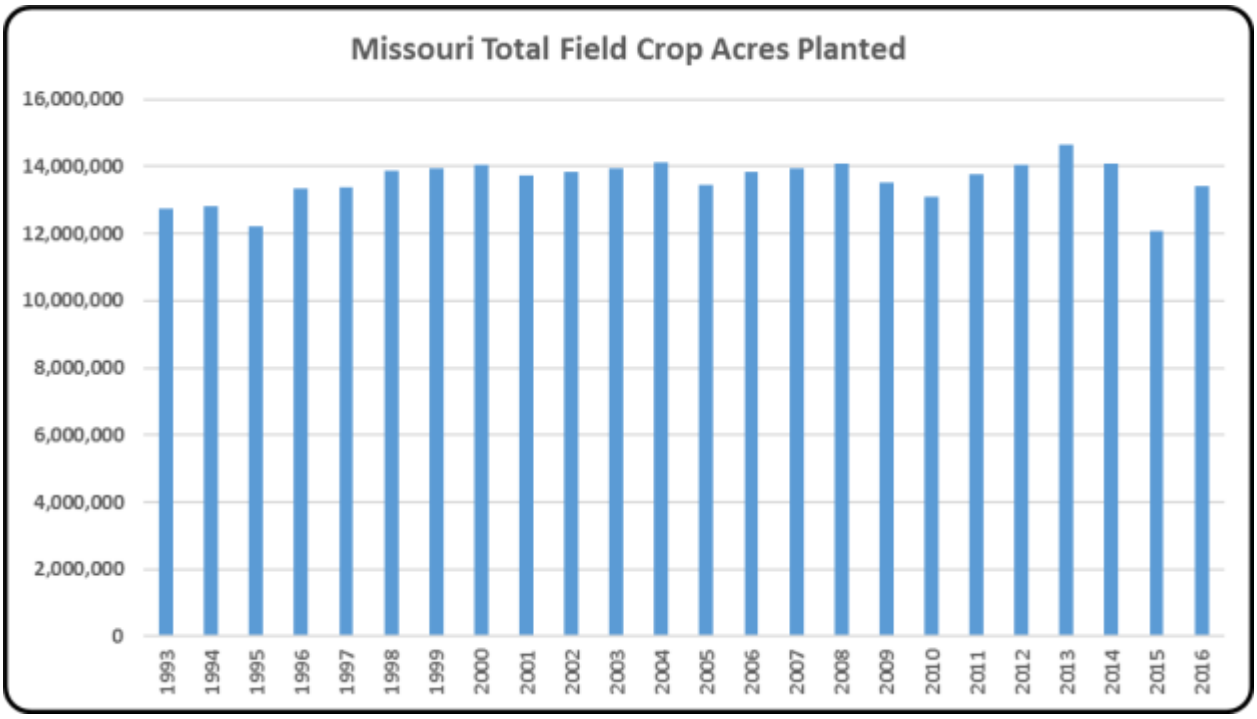


Figure 59, Missouri Total Field Crop Planted Acres

Referring to Figure 60, when CRP was implemented in 1986, Missouri enrolled 0.101 million acres in the program. The following year saw a nearly nine-fold increase. Large increases continued until 1997 and peaked at about 1.7 million acres at which point acreage declined slightly and remained stable until 2007. Since 2007, CRP acreage in Missouri has continued to decline and currently stands at about one million acres.

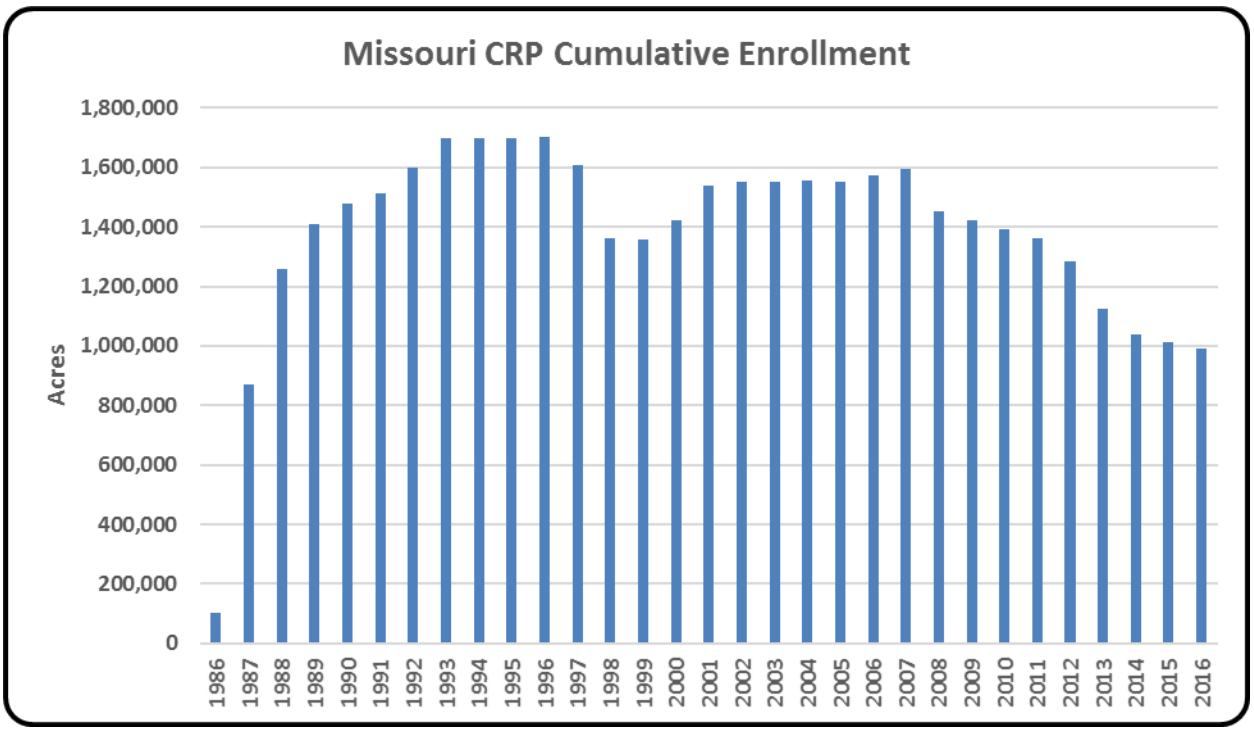


Figure 60, Missouri CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 61, Figure 62, Figure 63 and Table 16, the spatial analysis for the Missouri study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Missouri, there was a positive net land use change from the Grassy Habitat land use category to other categories.

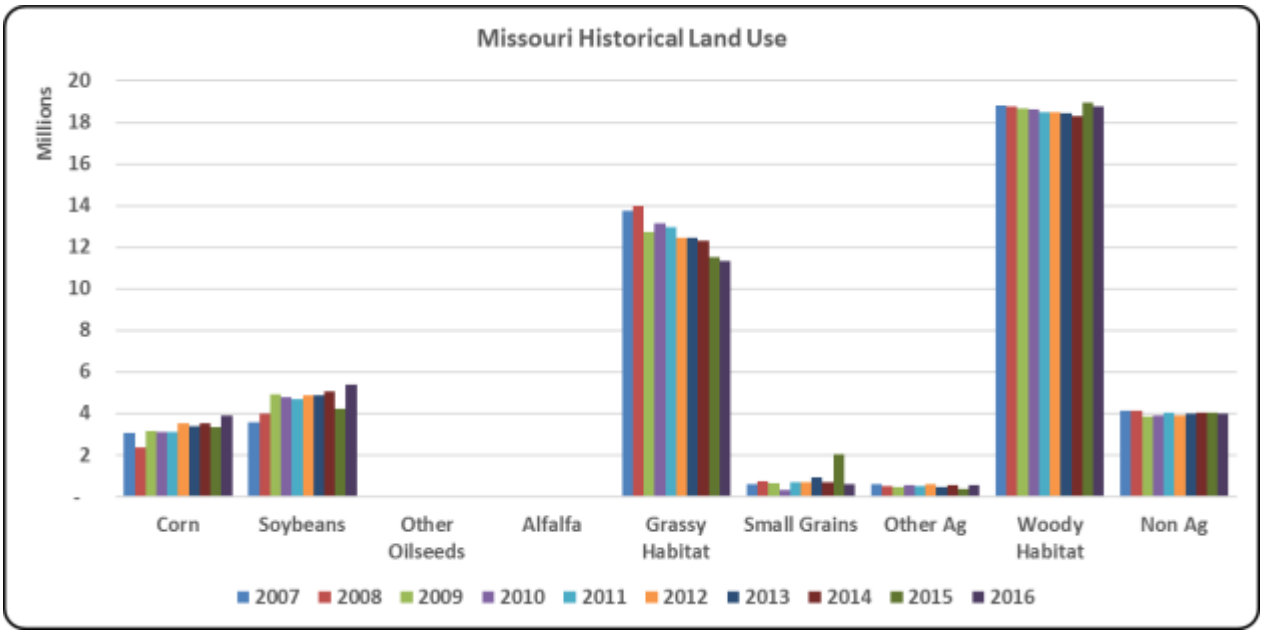


Figure 61, Historical Land Use (2007-2016): Missouri

Table 16, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Missouri

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	15,094	1%
Grassy Habitat to Corn	708,893	32%
Grassy Habitat to Non Ag	108,810	5%
Grassy Habitat to Other Ag	13,624	1%
Grassy Habitat to Other Oilseeds	122	0%
Grassy Habitat to Small Grains	147,863	7%
Grassy Habitat to Soybeans	1,060,097	48%
Grassy Habitat to Woody Habitat	173,168	8%
Net Change FROM Grassy Habitat	2,227,671	100%

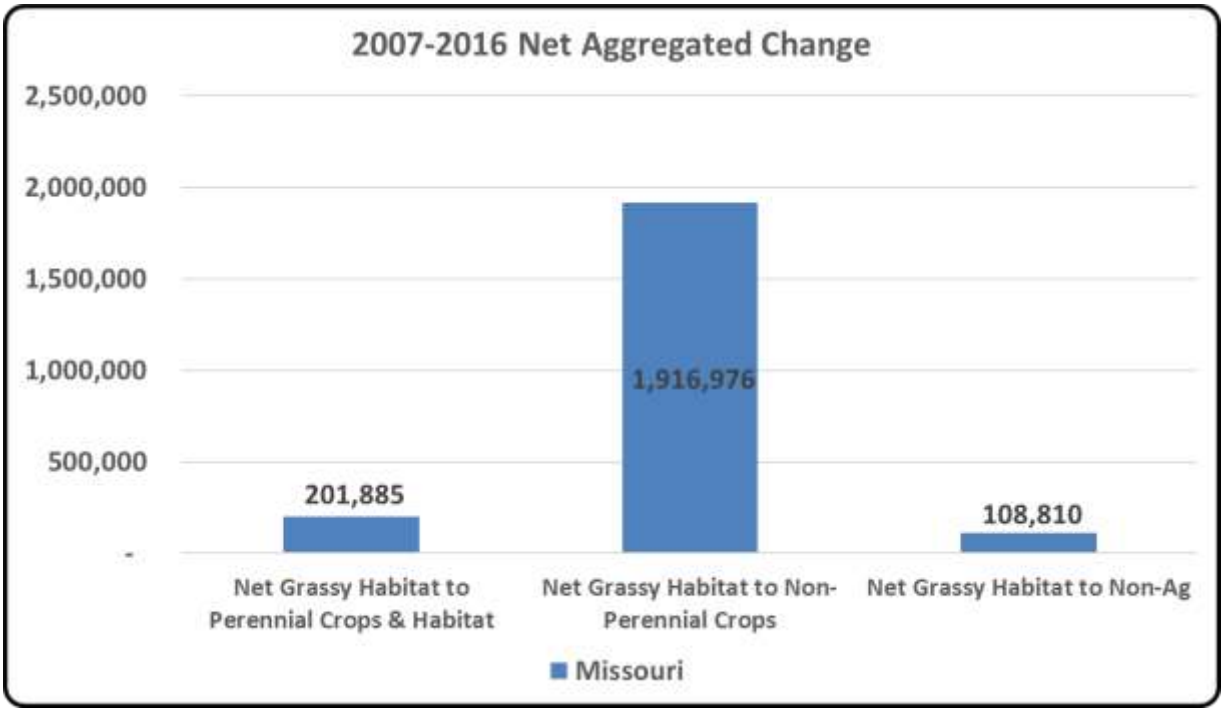


Figure 62, 2007-2016 Net Change (from Grassy Habitat): Missouri

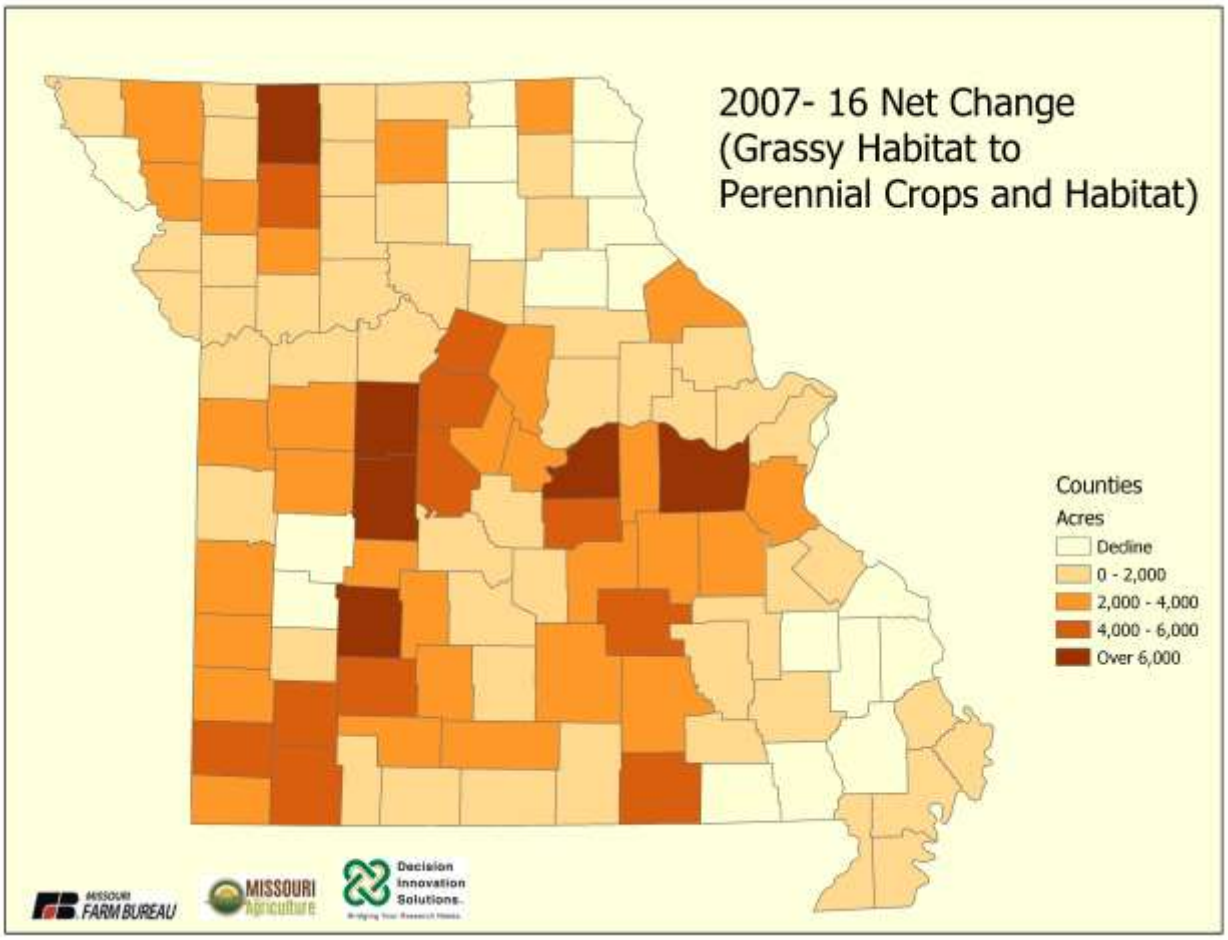


Figure 63, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Missouri Counties

Observations

Due to the relatively low acreage of Other Oilseeds and Other Ag within Missouri, we did not anticipate much of a shift from Grassy Habitat to these land use categories. Ninety-four percent of estimated net land use change from Grassy Habitat was toward Soybeans, Corn, Woody Habitat and Small Grains. Figure 62 shows that under the revised aggregation scheme, nine percent (about 202,000 acres) of net land use change was toward perennial crops and habitat. As shown in Figure 63, the central part of the state saw a somewhat significant shift toward Perennial Crops and Habitat.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of “program crops”. These additional crops (generally minor oilseeds) have been included as “program crops” in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as “Non-Perennial Crops”.

These results are shown in Figure 64 and Figure 65. On a net basis, eighty-six percent (about 1.9 million acres) of net land use change went toward non-perennial crops. This represents 4.3 percent of total land area in Missouri. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Missouri Results section.

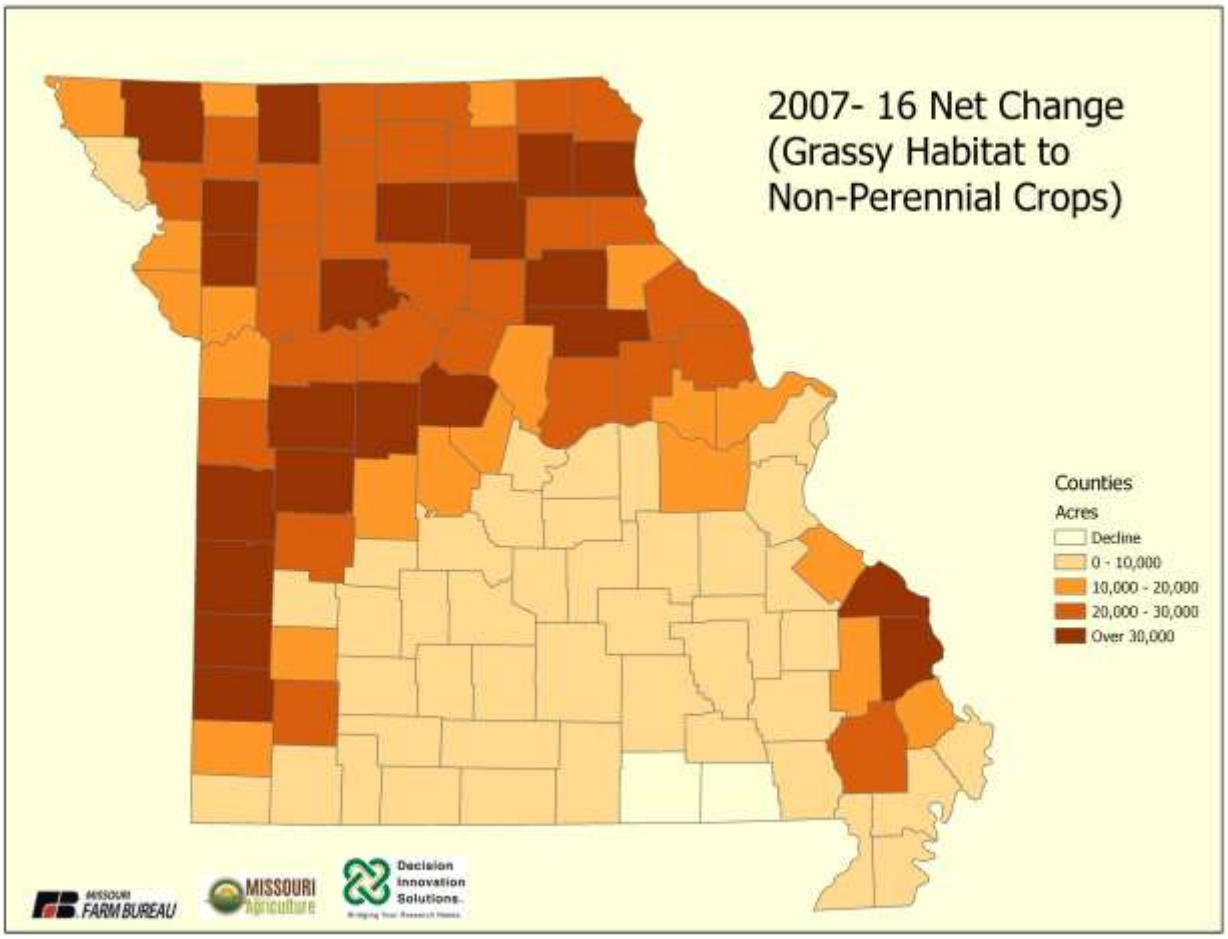


Figure 64, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Missouri Counties

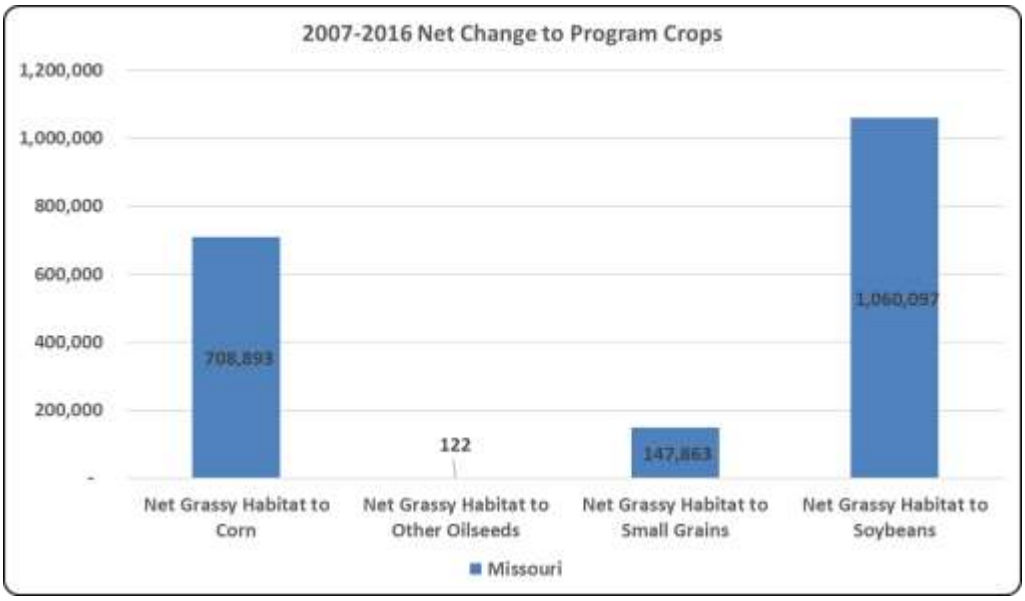


Figure 65, 2007-2016 Net Change (Grassy Habitat to Program Crops): Missouri

Econometric Results

Table 17 provides results for Missouri. A summary of econometric results with regard to the explanatory variables for Missouri is provided below.

- **Crop Insurance Subsidies**
  - Variable is not significant at the 95% level, but exhibits the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the lower the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is significant at the 95% level, but does not exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the higher the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the lower the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is not significant at the 95% level and *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Precipitation, the higher the share of land devoted to Grassy Habitat.

Table 17, Econometric Results: Missouri

Variable	Coefficients	Standard Error	t Stat
Intercept	0.8323	0.0766	10.8687
Crop Insurance Subsidies	-0.0010	0.0007	-1.3864
Net Returns for Crops	0.0001	0.0000	2.4785
Growing Degree Days	-0.5006	0.0561	-8.9309
Precipitation	0.0029	0.0234	0.1230
Adjusted R2	0.09		
Observations	868		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The results show growing degree days is the only variable affecting the change in grassy habitat during the study period. The other three variables don't show any theoretical impact on the change in grassy habitat during the study period.

ILLINOIS

Background

In terms of a historical perspective on the land use in Illinois, acreage in farms for the area has ranged from a low of 22.6 million acres in 2015 to a high of 23.8 million acres in 1996. Estimated acreage devoted to principal field crops in 2016 (22.8 million acres) is the twenty-second highest total since 1993, the first year data of this type were available. Referring to Figure 66, the overall trend since 1996 in terms of land devoted to the planting of field crops has been a steady decline.

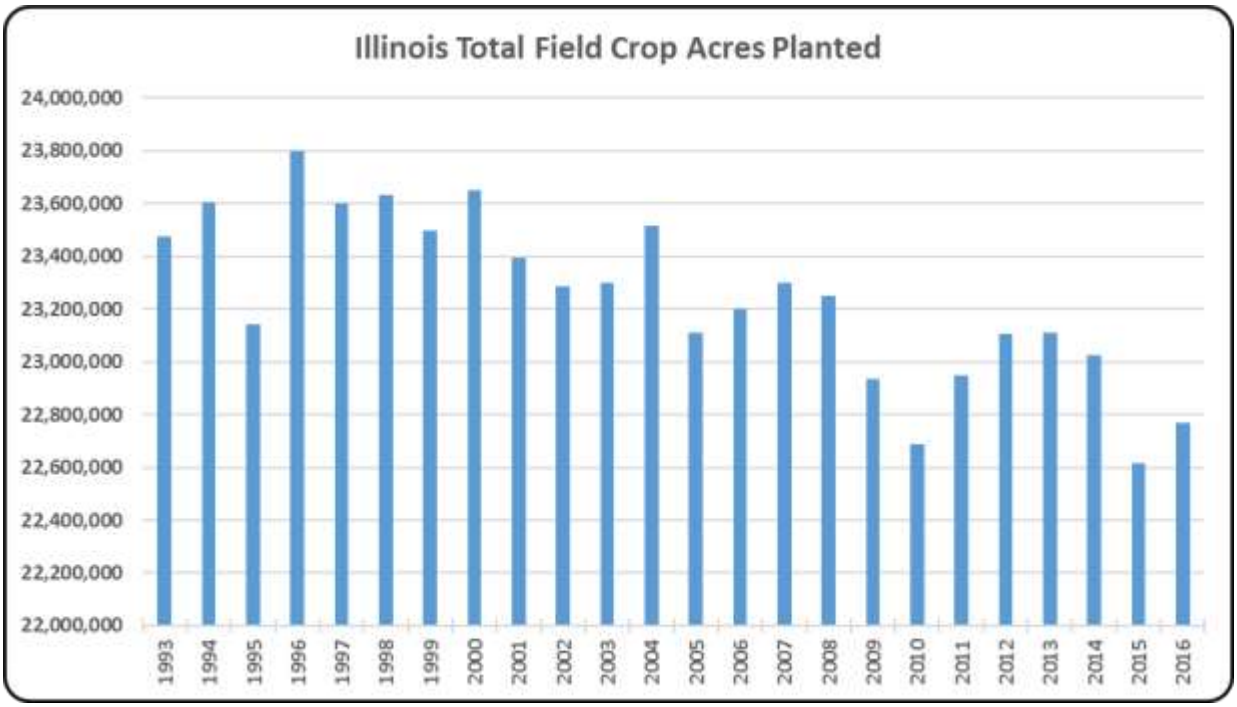


Figure 66, Illinois Total Field Crop Acres Planted

Referring to Figure 67, Illinois has seen a steady increase from the implementation of the CRP program until the mid-1990s. There was a slight decline to around 0.7 million acres as the first round of 10-year contracts expired, but since then Illinois has continued to increase the number of acres enrolled until 2007. The past few years' enrollment has suffered and have recently fallen to less than 0.894 million acres.

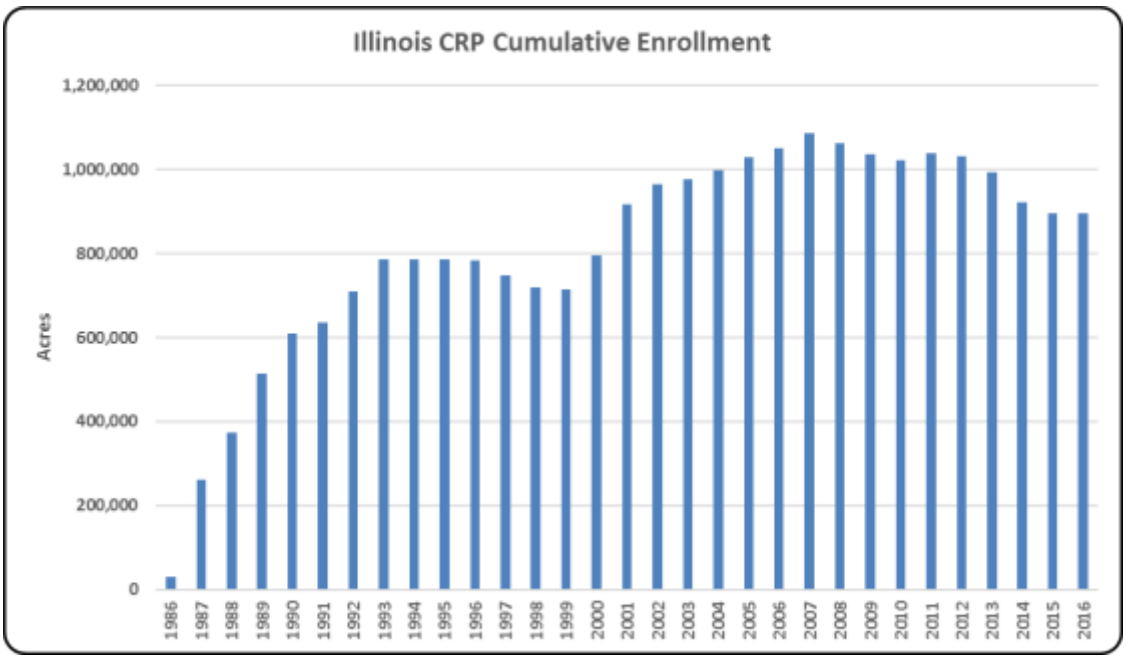


Figure 67, Illinois CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 68, Figure 69, Figure 70 and Table 18, the spatial analysis for the Illinois study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Illinois, there was a positive net land use change from the Grassy Habitat land use category to other categories. Recall that to account for land use changes for both to and from the Grassy Habitat land use category, all land use changes are expressed on a net basis. Consequently, negative numbers can and do appear in both tables and charts associated with the Indiana data. A negative number is interpreted as a net movement to Grassy Habitat.

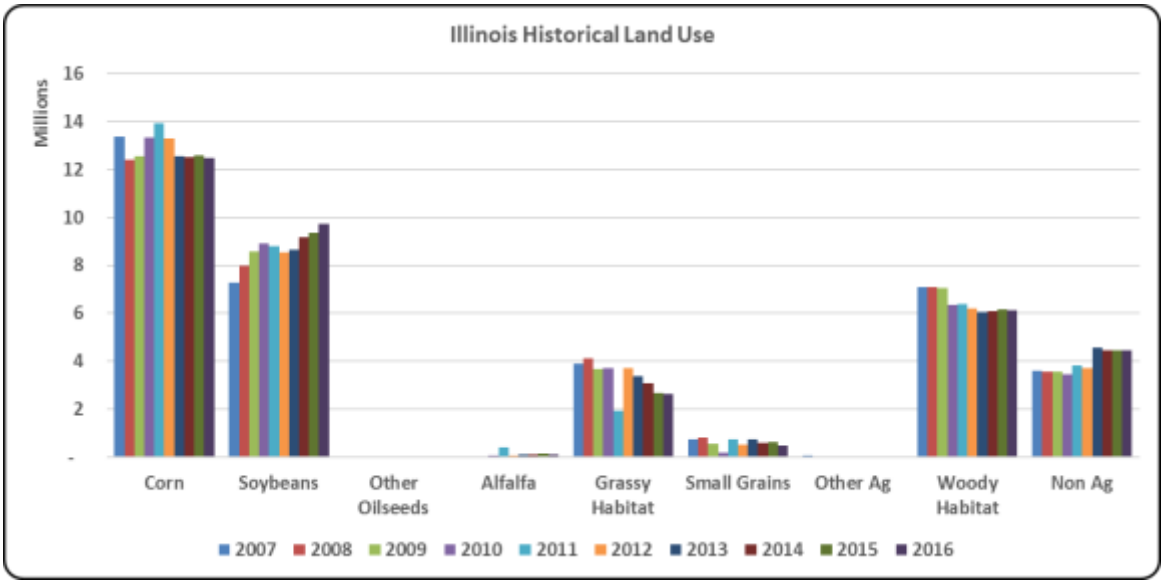


Figure 68, Historical Land Use (2007-2016): Illinois

Table 18, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Illinois

Grassy Habitat to Alfalfa	44,483	4%
Grassy Habitat to Corn	405,314	34%
Grassy Habitat to Non Ag	301,767	25%
Grassy Habitat to Other Ag	4,781	0%
Grassy Habitat to Other Oilseeds	(2)	0%
Grassy Habitat to Small Grains	51,935	4%
Grassy Habitat to Soybeans	421,550	35%
Grassy Habitat to Woody Habitat	(21,069)	-2%
Net Change FROM Grassy Habitat	1,208,758	100%

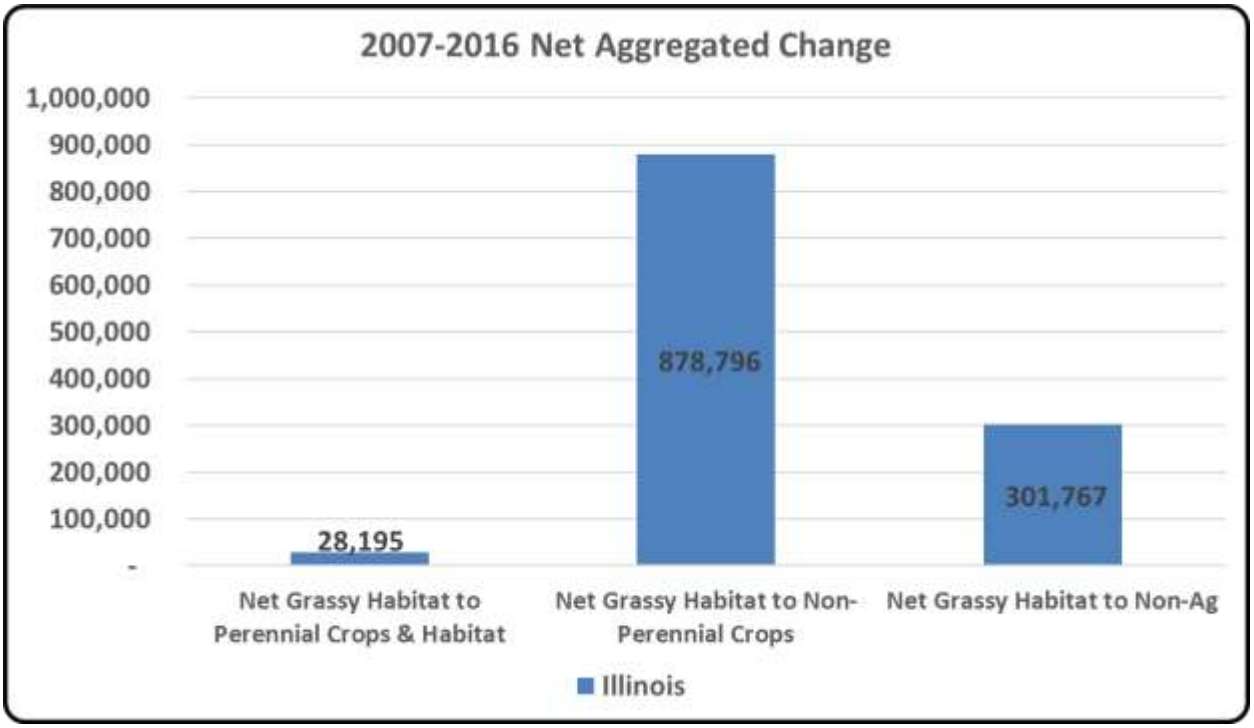


Figure 69, 2007-2016 Net Change (from Grassy Habitat): Illinois

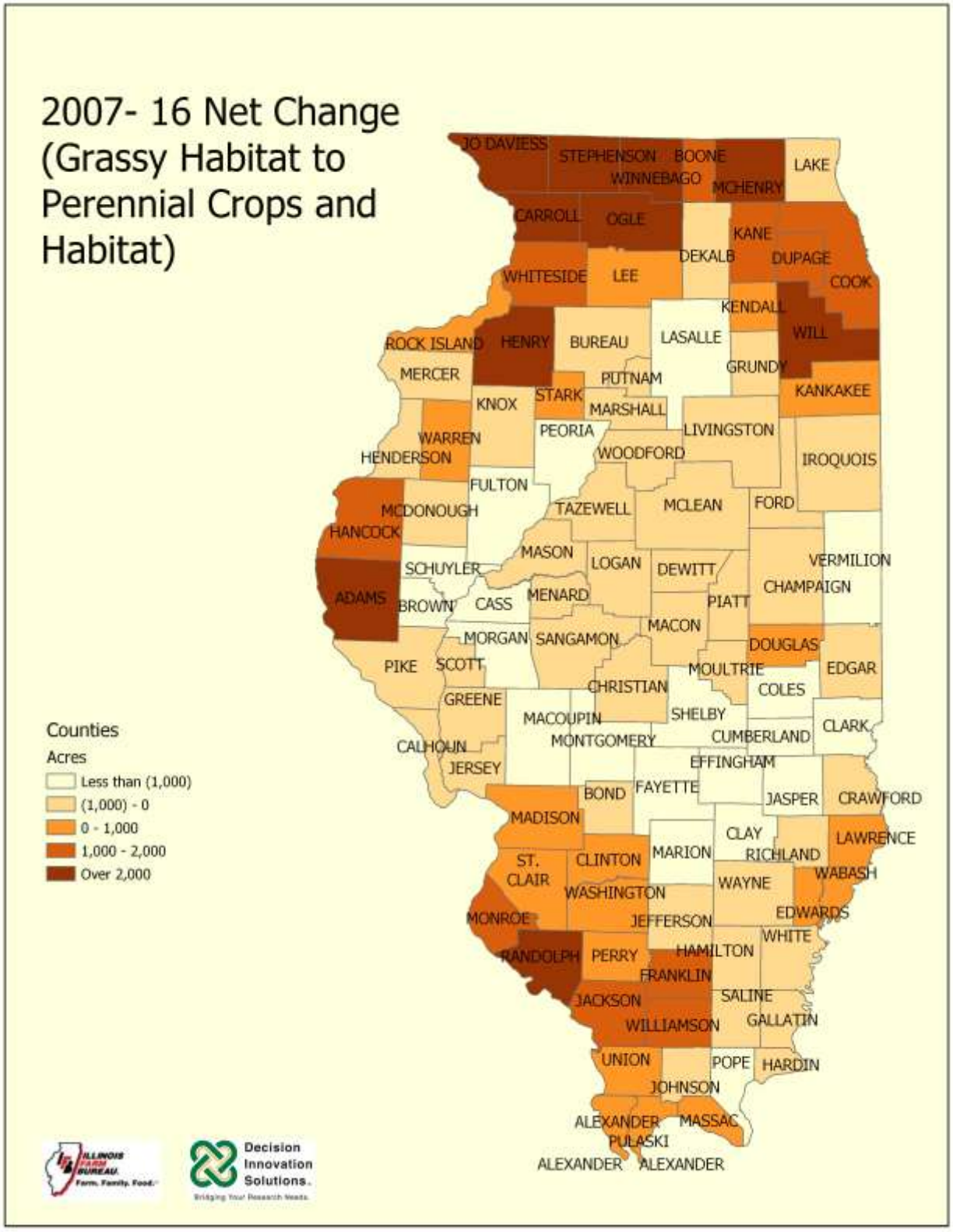


Figure 70, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Illinois Counties

Observations

Due to the results from the original study related of Other Oilseeds and Other Ag within Illinois, we again did not anticipate much of a shift from Grassy Habitat to these land use categories. However, net land use changes in Illinois from Habitat to other categories were on a smaller scale when compared to other states in the 8-state study area; Illinois had the second fewest acres move from Grassy Habitat on a net basis. Ninety-eight percent of estimated net land use change from Grassy Habitat was toward Soybeans, Corn, Non-Ag and Small Grains.

Figure 69 shows that under the revised aggregation scheme, two percent (about 28,000 acres) of net land use change was toward perennial crops and habitat. Notably about 302,000 acres moved from Grassy Habitat toward Non-Ag. As shown in Figure 70, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the northern and southwestern parts of the state. The western part of the state also saw a somewhat significant shift toward Perennial Crops and Habitat.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of “program crops”. These additional crops (generally minor oilseeds) have been included as “program crops” in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as “Non-Perennial Crops”.

These results are shown in Figure 71 and Figure 72. On a net basis, seventy-three percent (about 879,000 acres) of net land use change went toward non-perennial crops. This represents 2.4 percent of total land area in Illinois. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Illinois Results section.

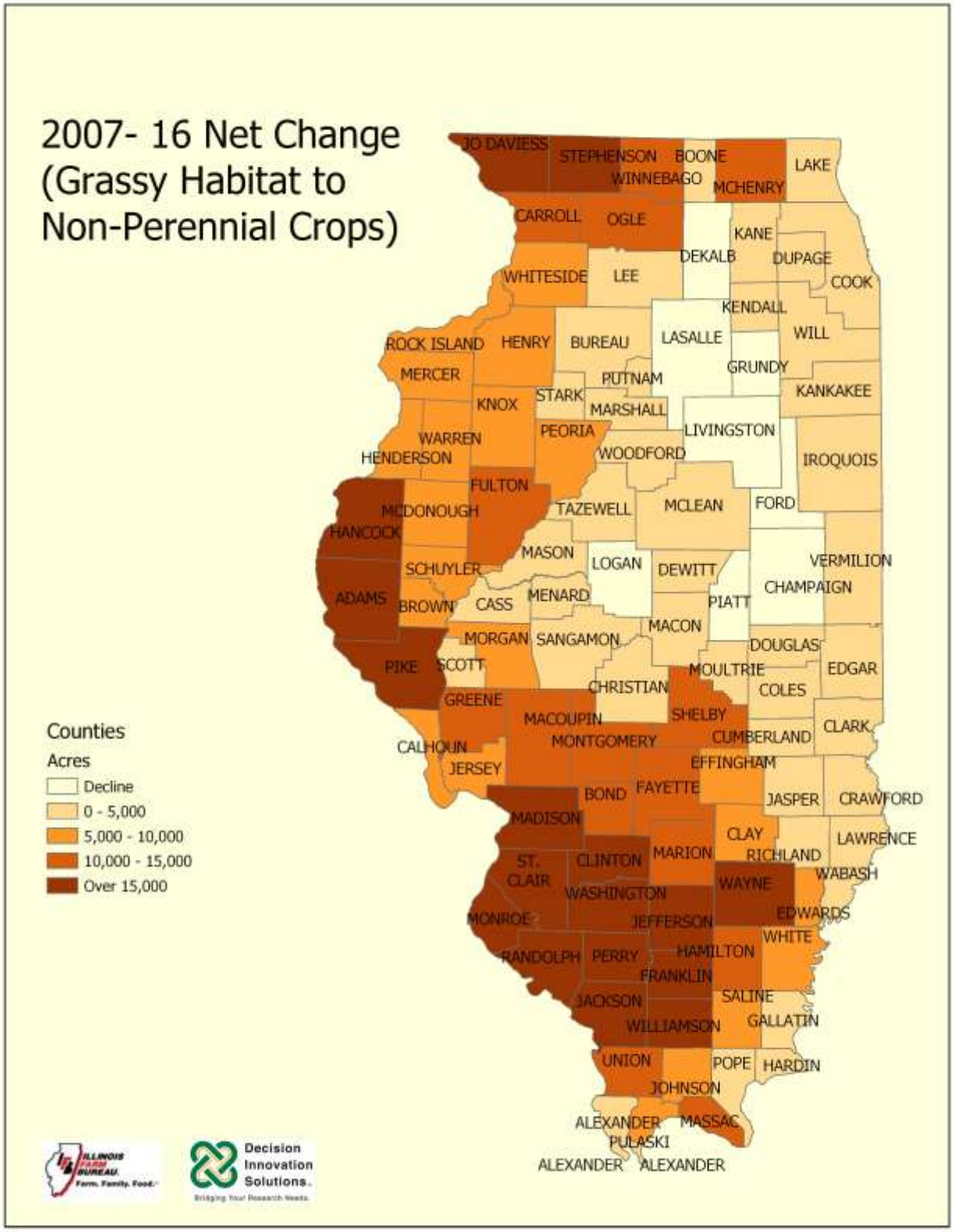


Figure 71, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Illinois Counties

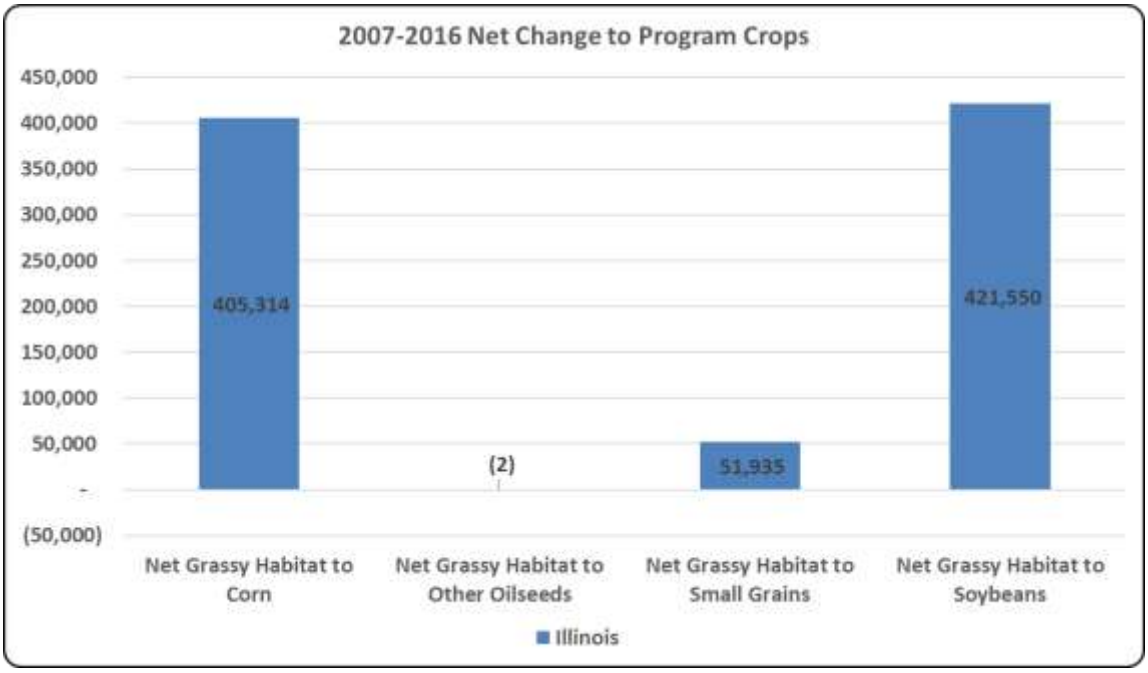


Figure 72, 2007-2016 Net Change (Grassy Habitat to Program Crops): Illinois

Econometric Results

Table 19 provides results for Iowa. A summary of econometric results with regard to the explanatory variables for Iowa is provided below.

- **Crop Insurance Subsidies**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the higher the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the lower the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the higher the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Precipitation, the higher the share of land devoted to Grassy Habitat.

Table 19, Econometric Results: Illinois

Variable	Coefficients	Standard Error	t Stat
Intercept	-0.0618	0.0200	-3.0947
Crop Insurance Subsidies	0.0016	0.0002	6.6343
Net Returns for Crops	-0.0001	0.0000	-2.8454
Growing Degree Days	0.0846	0.0177	4.7768
Precipitation	0.0381	0.0094	4.0358
Adjusted R2	0.1102		
Observations	1005		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The model results for Illinois show that all variables were significant. But, net returns is the only variable which exhibited both significance and the expected sign. This indicates higher net returns for cropland would induce higher demand for planting acreage for cropland, causing a decrease of grassy habitat acreage.

INDIANA

Background

In terms of a historical perspective on the land use in Indiana, acreage in farms for the area has ranged from a low of 11.9 million acres in 1995 to a high of 12.9 million acres in 1998. Estimated acreage devoted to principal field crops in 2016 (12.1 million acres) is the twenty-first highest total since 1993, the first year data of this type were available.

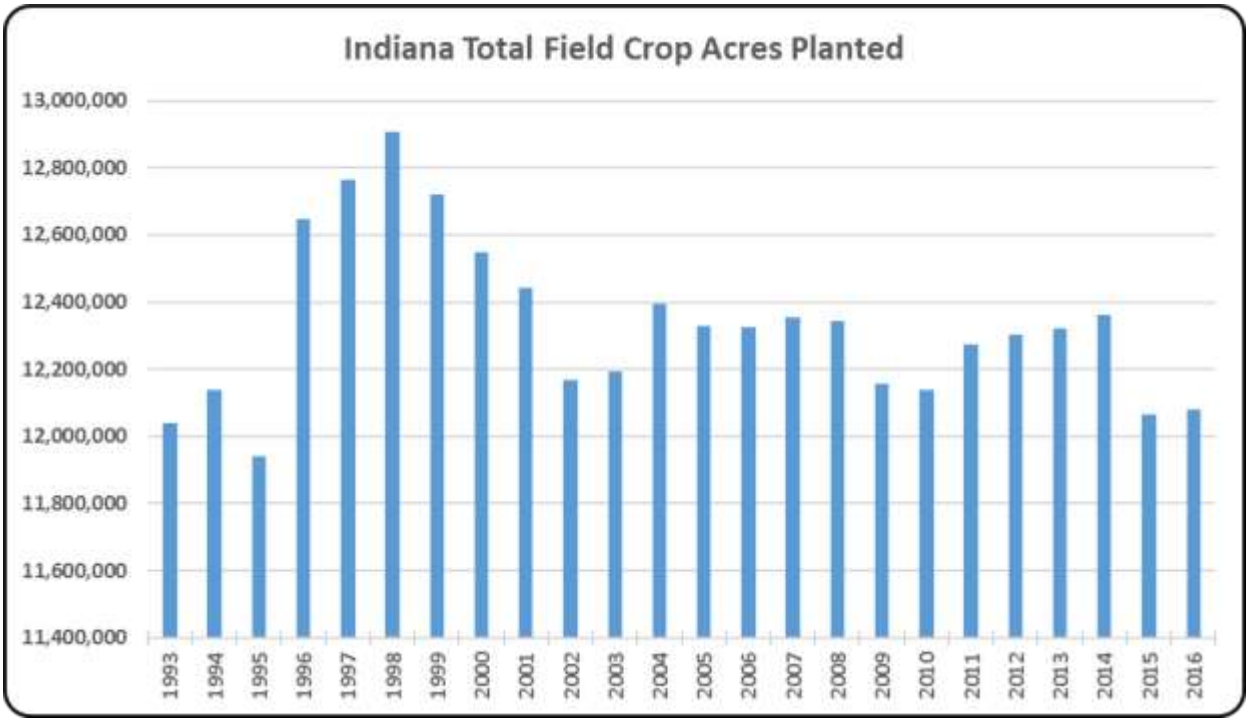


Figure 73, Indiana Total Field Crop Acres Planted

Referring to Figure 74, Indiana has not seen the level of enrollment in the CRP program as other states such as Iowa, Nebraska and Illinois. Since the implementation of the program, Indiana had steady increases until the mid-1990s and reached 0.453 million acres. Since the first round of 10-year contracts expired, the enrollment in the program has held fairly steady around the 0.300 million mark. There are currently 0.236 million acres enrolled in CRP in Indiana.

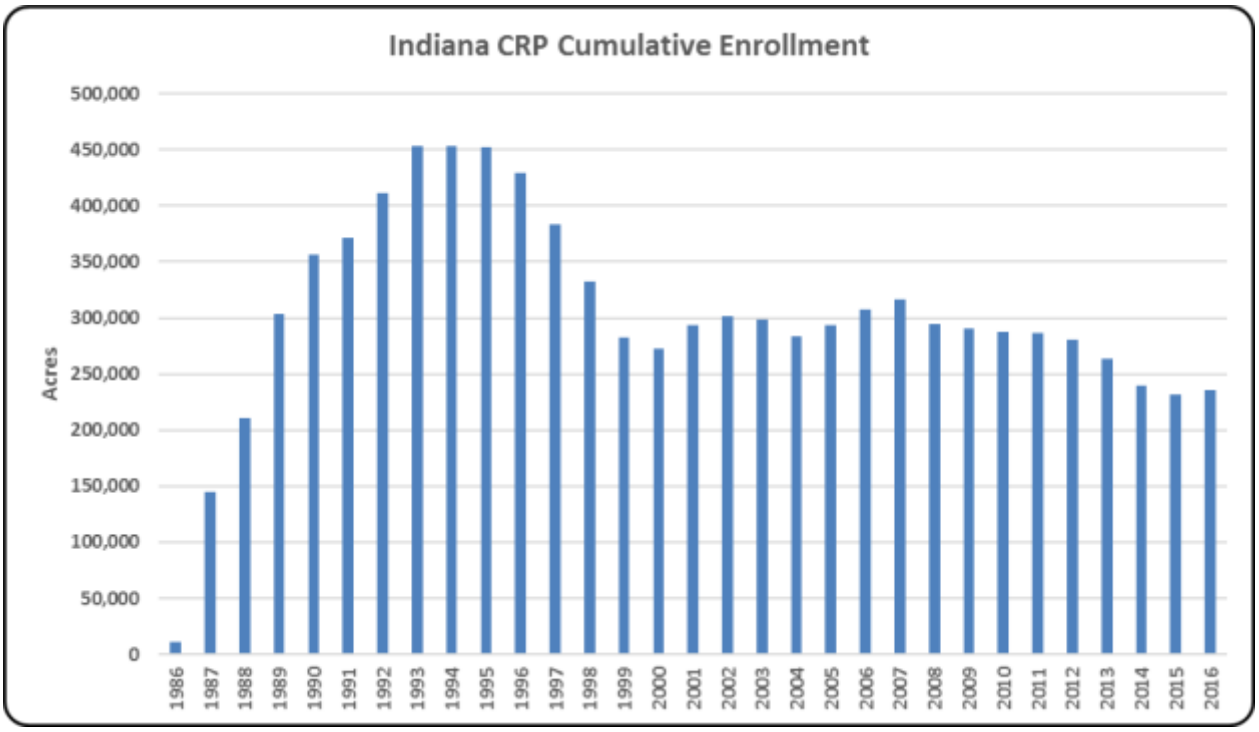


Figure 74, Indiana CRP Cumulative Enrollment

Spatial Analysis

Referring to acreage totals in Figure 75, Figure 76, Figure 77 and Table 20, the spatial analysis for the Indiana study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Indiana, there was a positive net land use change from the Grassy Habitat land use category to other categories.

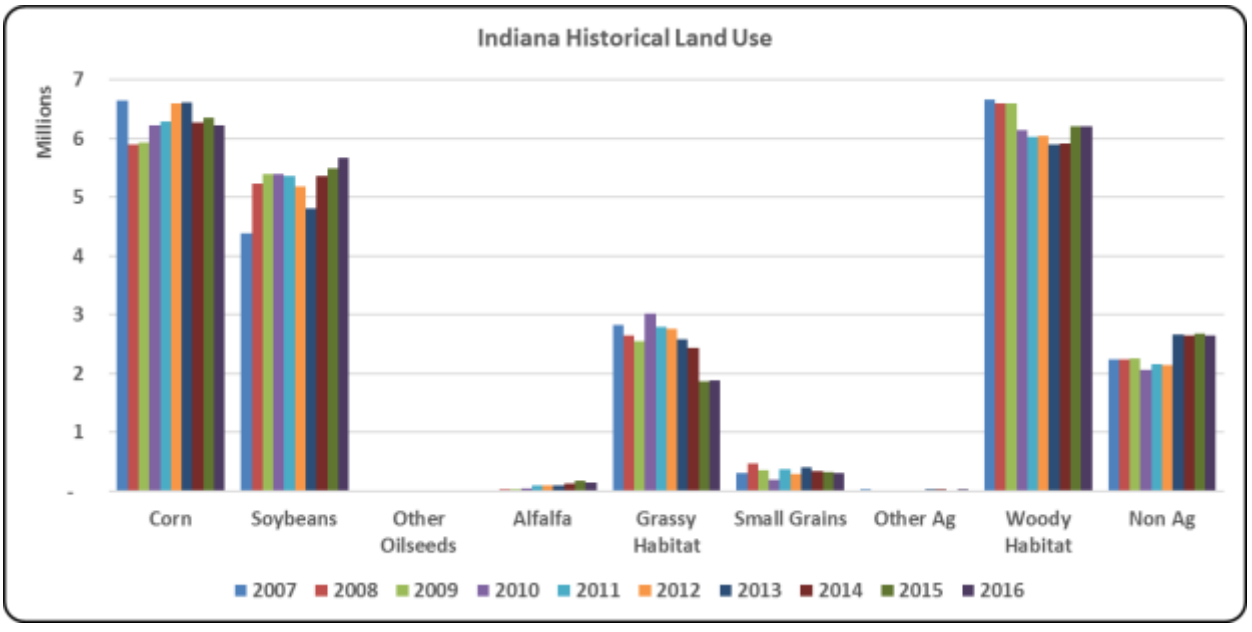


Figure 75, Historical Land Use (2007-2016): Indiana

Table 20, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Indiana

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	63,194	7%
Grassy Habitat to Corn	213,504	24%
Grassy Habitat to Non Ag	183,104	21%
Grassy Habitat to Other Ag	2,777	0%
Grassy Habitat to Other Oilseeds	49	0%
Grassy Habitat to Small Grains	25,783	3%
Grassy Habitat to Soybeans	282,325	32%
Grassy Habitat to Woody Habitat	118,665	13%
Net Change FROM Grassy Habitat	889,402	100%

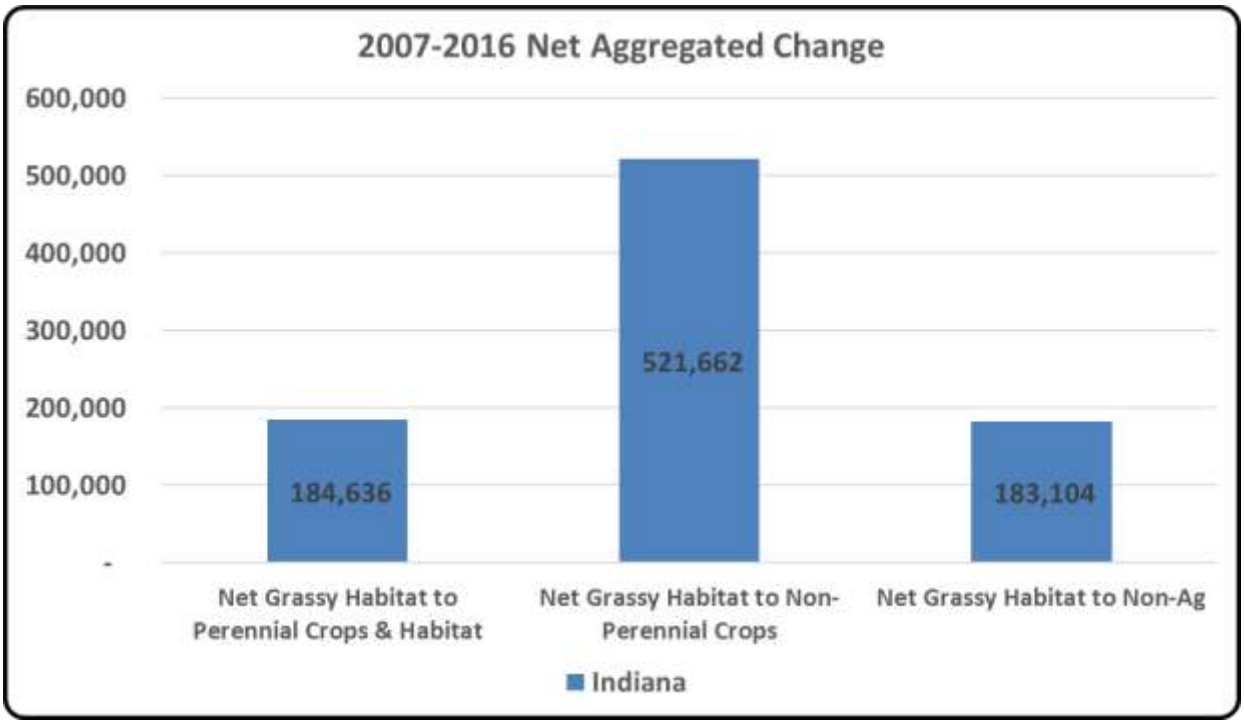


Figure 76, 2007-2016 Net Change (from Grassy Habitat): Indiana

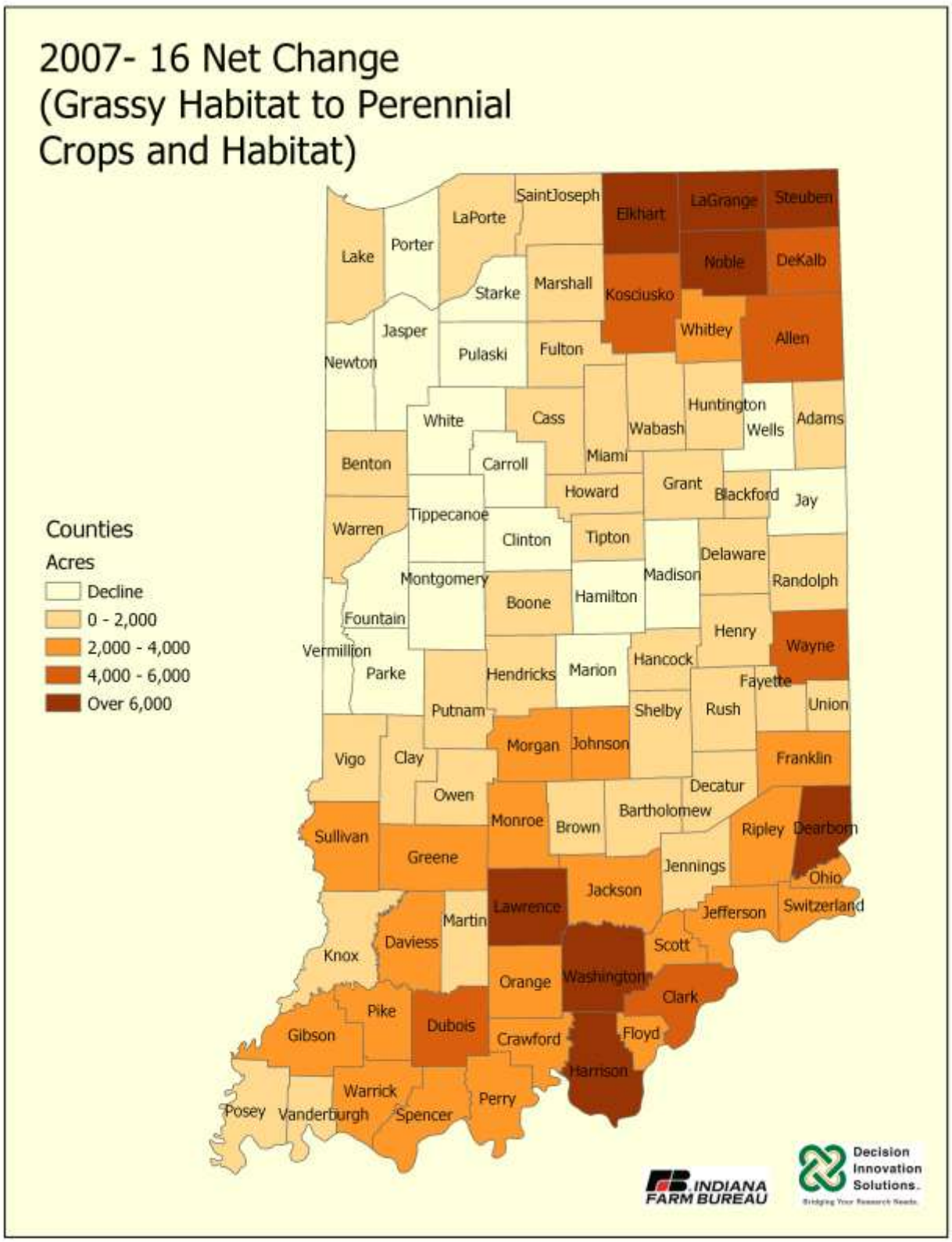


Figure 77, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Indiana Counties

Observations

Due to the results from the original study related of Other Oilseeds and Other Ag within Indiana, we again did not anticipate much of a shift from Grassy Habitat to these land use categories. However, net land use changes in Indiana from Habitat to other categories were on a smaller scale when compared to other states in the 8-state study area; Indiana had the fewest acres move from Grassy Habitat on a net basis. Ninety percent of estimated net land use change from Grassy Habitat was toward Soybeans, Corn, Non-Ag and Woody Habitat.

Figure 76 shows that under the revised aggregation scheme, twenty-one percent (about 185,000 acres) of net land use change was toward perennial crops and habitat. Notably about 183,000 acres moved from Grassy Habitat toward Non-Ag. As shown in Figure 77, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the northeastern and southern parts of the state.

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of “program crops”. These additional crops (generally minor oilseeds) have been included as “program crops” in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as “Non-Perennial Crops”.

These results are shown in Figure 78 and Figure 79. On a net basis, fifty-nine percent (about 522,000 acres) of net land use change went toward non-perennial crops. This represents 2.3 percent of total land area in Indiana. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Indiana Results section.

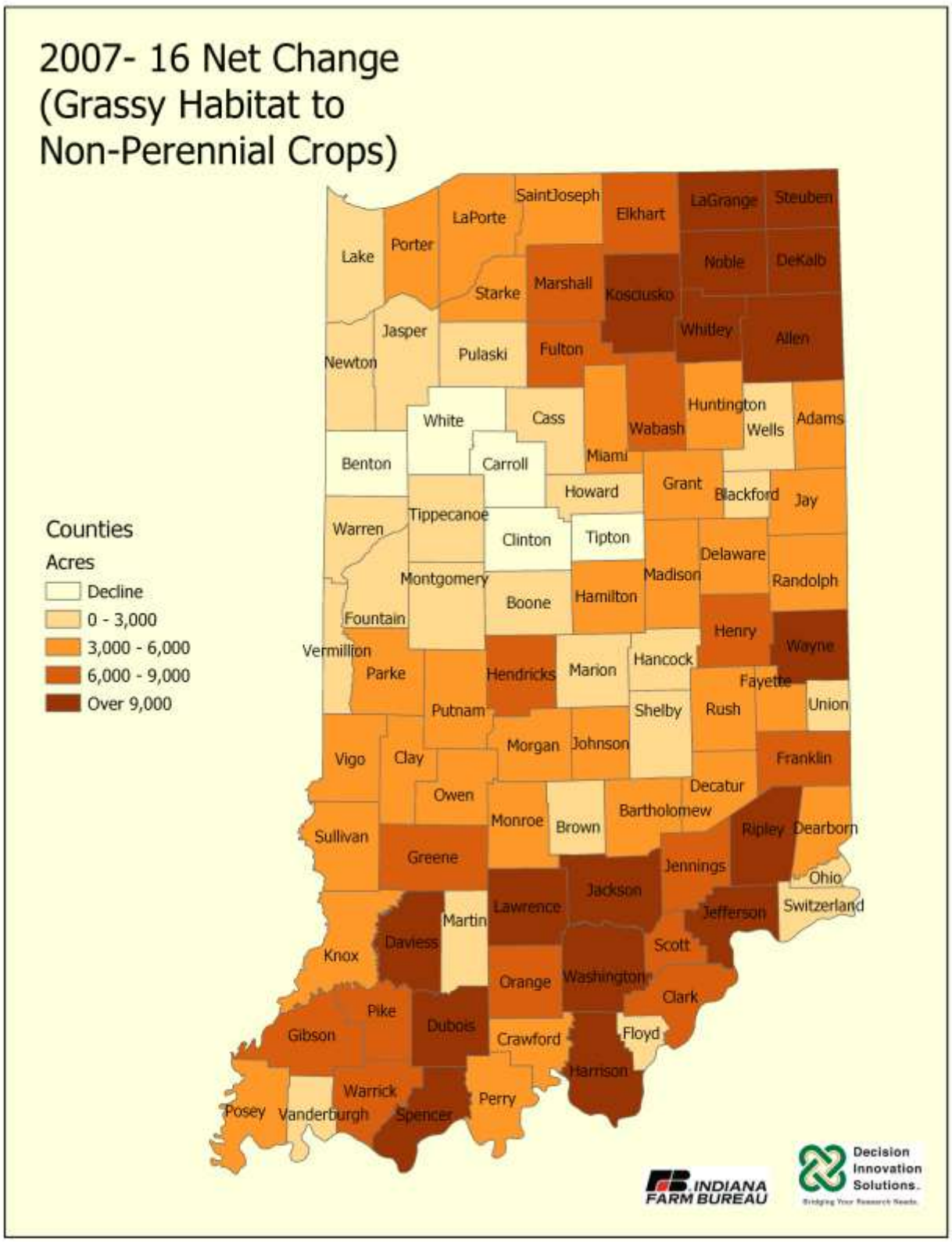


Figure 78, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Indiana Counties

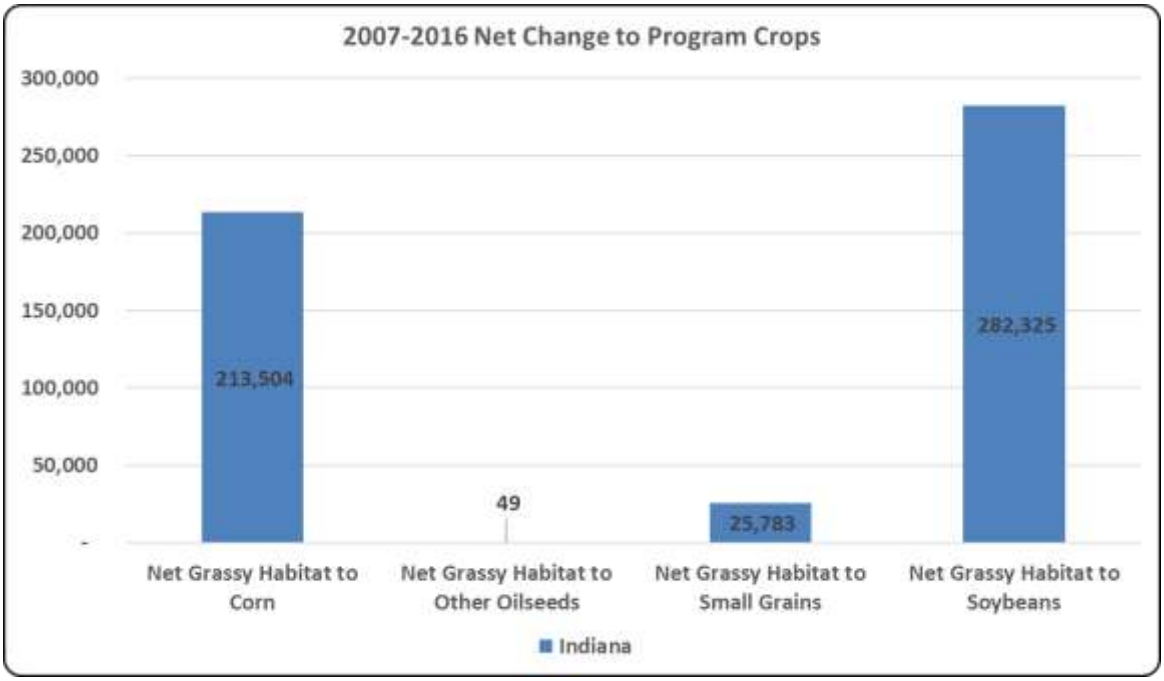


Figure 79, 2007-2016 Net Change (Grassy Habitat to Program Crops): Indiana

Econometric Results

Table 21 provides results for Indiana. A summary of econometric results with regard to the explanatory variables for Iowa is provided below.

- **Crop Insurance Subsidies**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the higher the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the lower the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is not significant at the 95% level and *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the higher the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is significant at the 90% level and exhibits the expected sign (-).
    - Result suggests that the higher the Precipitation, the lower the share of land devoted to Grassy Habitat.

Table 21, Econometric Results: Indiana

Variable	Coefficients	Standard Error	t Stat
Intercept	0.0570	0.0218	2.6133
Crop Insurance Subsidies	0.0024	0.0003	8.1466
Net Returns for Crops	-0.0001	0.0000	-2.9362
Growing Degree Days	0.0246	0.0211	1.1683
Precipitation	-0.0221	0.0115	-1.9231
Adjusted R2	0.09		
Observations	893		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

Other than growing degree days, the model results for Indiana show that all variables were significant. But, net returns and precipitation are the only variable which exhibited both significance and the expected sign. We can conclude that higher net returns and precipitation for cropland would induce higher demand for planting acreage for cropland, causing a decrease of grassy habitat acreage.

MICHIGAN

Background

In terms of a historical perspective on the land use in Michigan, acreage in farms for the area has ranged from a low of 6.4 million acres in 2009 to a high of 7.0 million acres in 1994. Estimated acreage devoted to principal field crops in 2016 (6.4 million acres) is the twenty-third highest total since 1993, the first year data of this type were available. Referring to Figure 80, Michigan is at an almost historic low since 1993, rebounding only slightly since 2015.

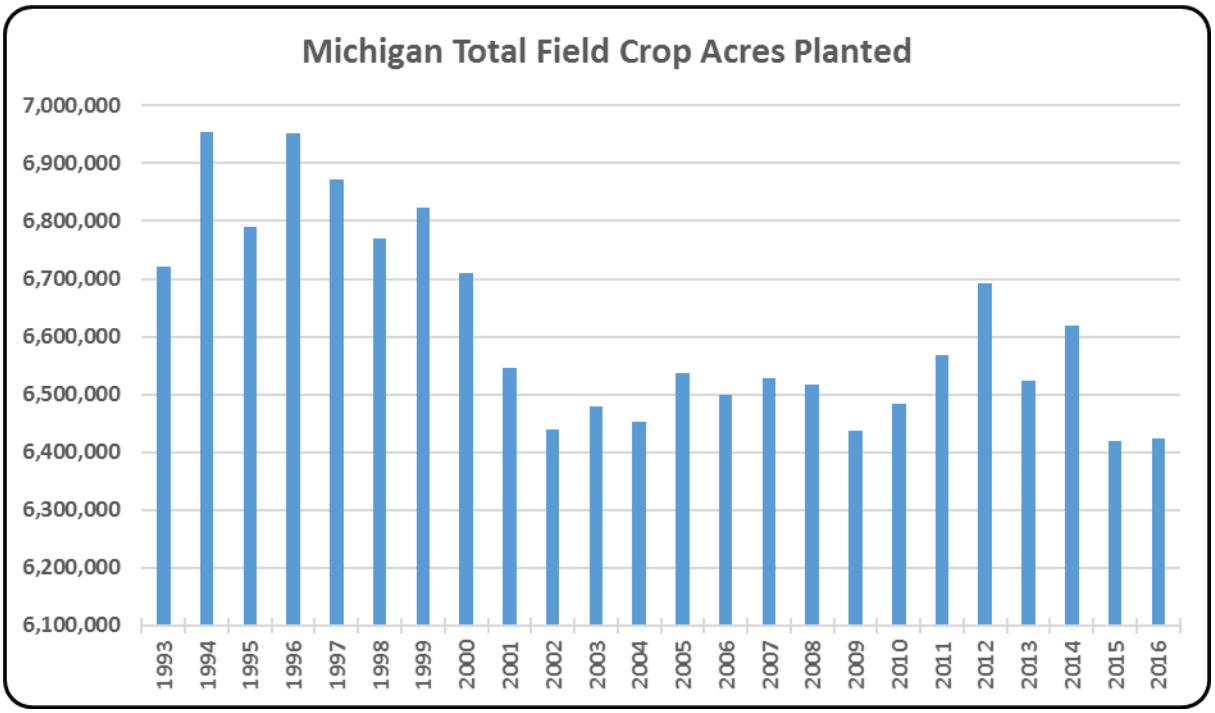


Figure 80, Michigan Total Field Crop Acres Planted

Referring to Figure 81, participation in the CRP program in Michigan is similar to Indiana. Neither of these states has had as many acres enrolled in the CRP program as other states such as Nebraska, Iowa, and Illinois. In 1996 the acres enrolled reached 0.335 million. Since the drop off in acres around 1998 and 1999, there was a small jump in 2002 and 2003, but acreage has since decreased to 0.158 in 2012.

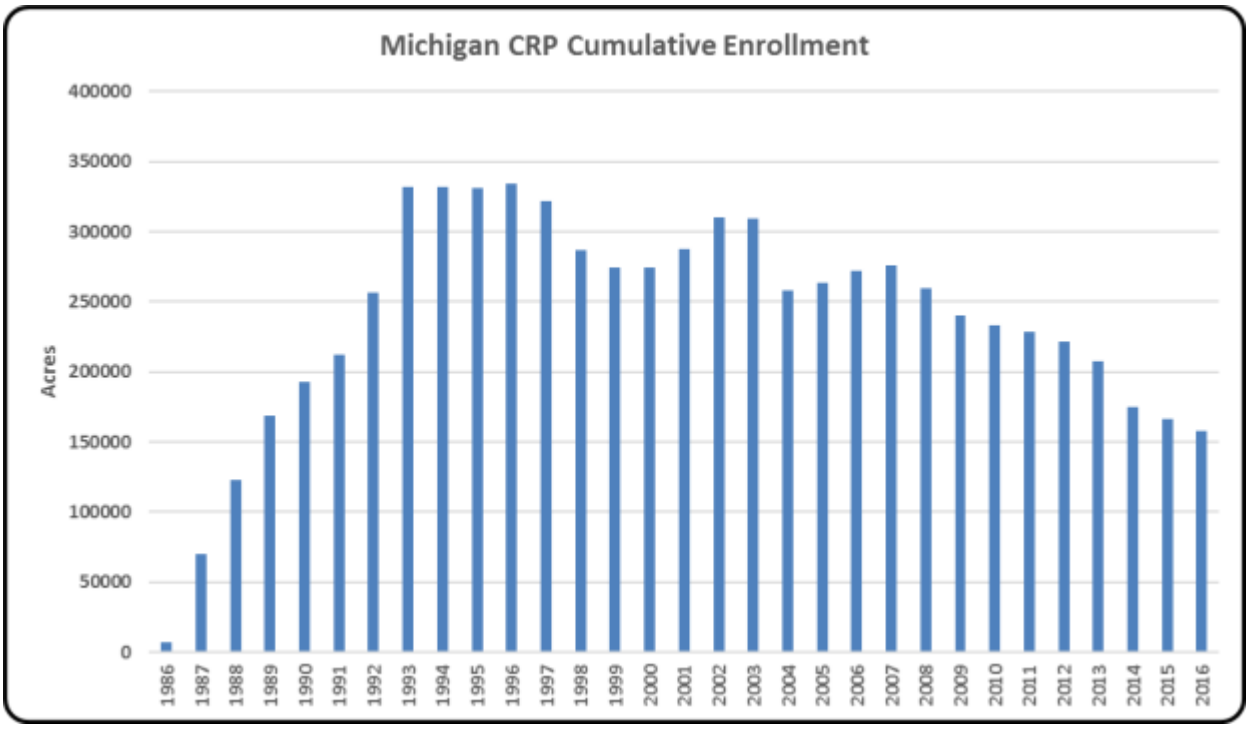


Figure 81, Michigan CRP Cumulative Enrollment

Spatial Results

Referring to acreage totals in Figure 82, Figure 83, Figure 84 and Table 22, the spatial analysis for the Michigan study area yielded some interesting results in terms of the degree to which the net change in habitat occurred across the study area from 2007-2016. In Michigan, there was a positive net land use change from the Grassy Habitat land use category to other categories.

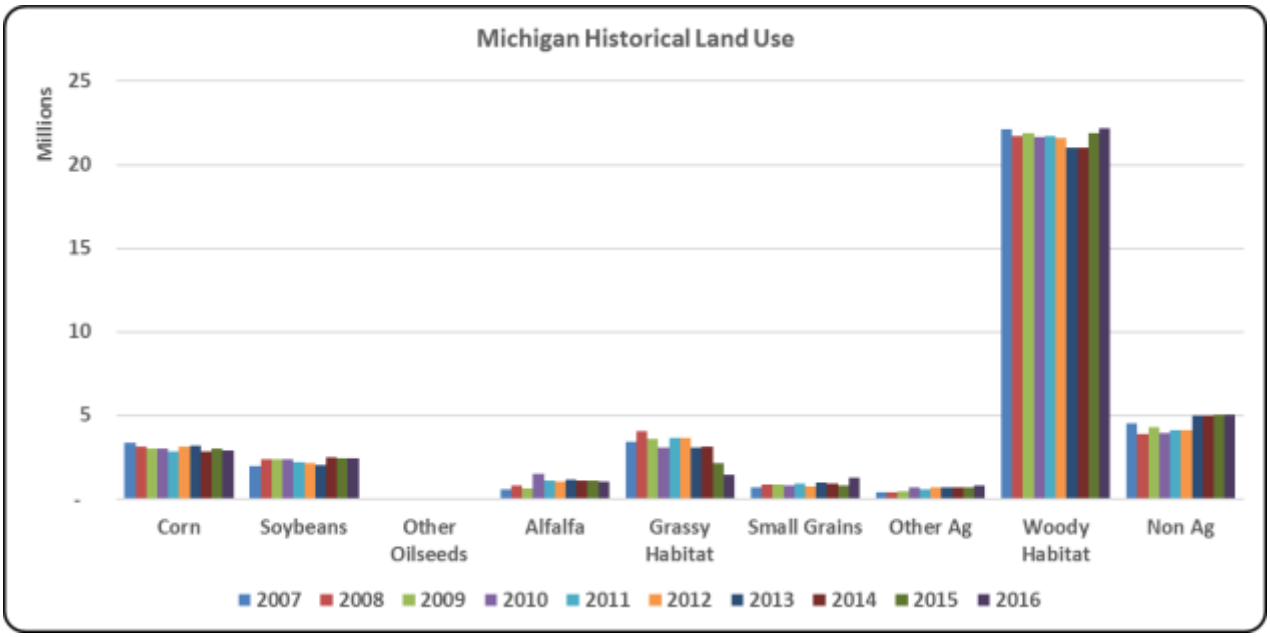


Figure 82, Historical Land Use (2007-2016): Michigan

Table 22, 2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat): Michigan

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Net Change	Percent of Total
Grassy Habitat to Alfalfa	348,603	18%
Grassy Habitat to Corn	169,382	9%
Grassy Habitat to Non Ag	171,827	9%
Grassy Habitat to Other Ag	194,182	10%
Grassy Habitat to Other Oilseeds	1,029	0%
Grassy Habitat to Small Grains	290,284	15%
Grassy Habitat to Soybeans	114,215	6%
Grassy Habitat to Woody Habitat	644,228	33%
Net Change FROM Grassy Habitat	1,933,749	100%

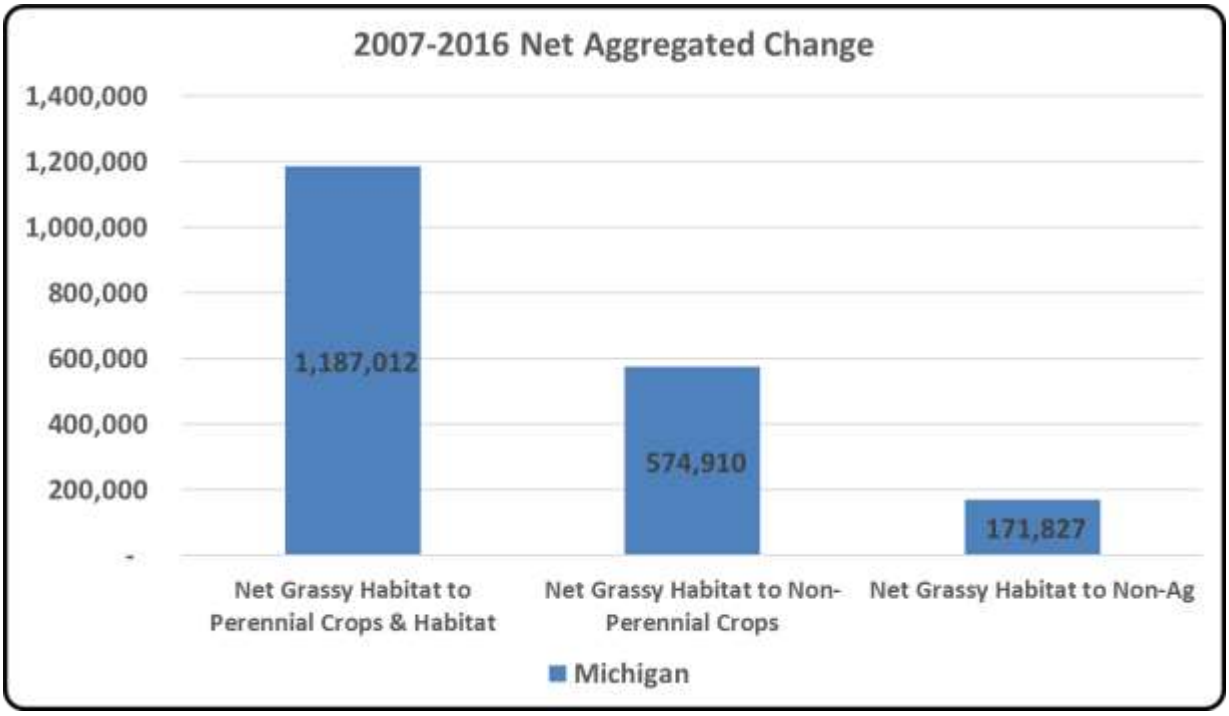


Figure 83, 2007-2016 Net Change (from Grassy Habitat): Michigan

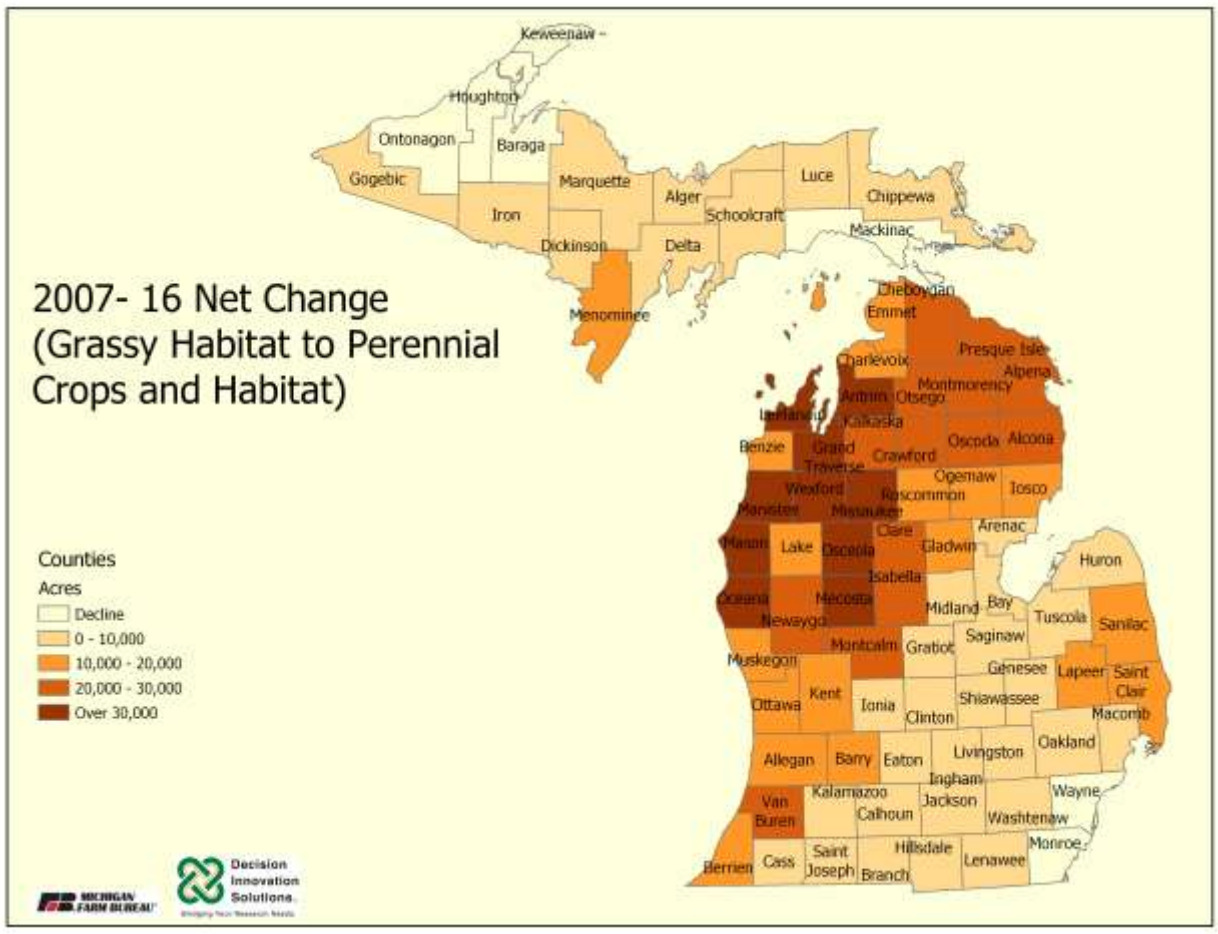


Figure 84, 2007-2016 Net Change (Grassy Habitat to Perennial Crops and Habitat): Michigan Counties

Observations

Due to the results from the original study related of Other Oilseeds and Other Ag within Michigan, we again did not anticipate much of a shift from Grassy Habitat to these land use categories. Seventy-six percent of estimated net land use change from Grassy Habitat was toward Woody Habitat, Alfalfa, Small Grains and Other Ag. Figure 83 shows that under the revised aggregation scheme, sixty-one percent (about 1.2 million acres) of net land use change was toward perennial crops and habitat. Notably about 172,000 acres moved from Grassy Habitat toward Non-Ag. As shown in Figure 84, the majority of the shift from Grassy Habitat to Perennial Crops and Habitat occurred in the northwestern part of the "mitten".

Farm Policy

As with the original 2013 study, we again include an econometric analysis which aims to address the concern that farm policy has contributed to loss of habitat. Since the original study was completed, the 2014 Farm Bill expanded its definition of "program crops". These additional crops (generally minor oilseeds) have been included as "program crops" in this update. We again provide a subset of results for this group of land use categories, which includes: corn, soybeans, small grains and other oilseeds. Please note that this aggregation is referred to throughout this document as "Non-Perennial Crops".

These results are shown in Figure 85 and Figure 86. On a net basis, thirty percent (about 575,000 acres) of net land use change went toward non-perennial crops. This represents 1.5 percent of total land area in Michigan from Grassy Habitat to Corn, Soybeans, and Small Grains was the only state in the 8-state study area which saw a net movement of the combination of these crops to Grassy Habitat. Additional context regarding the degree, if any, to which farm policy has influenced land use changes is discussed in the Econometric Analysis sub-section of the Michigan Results section.

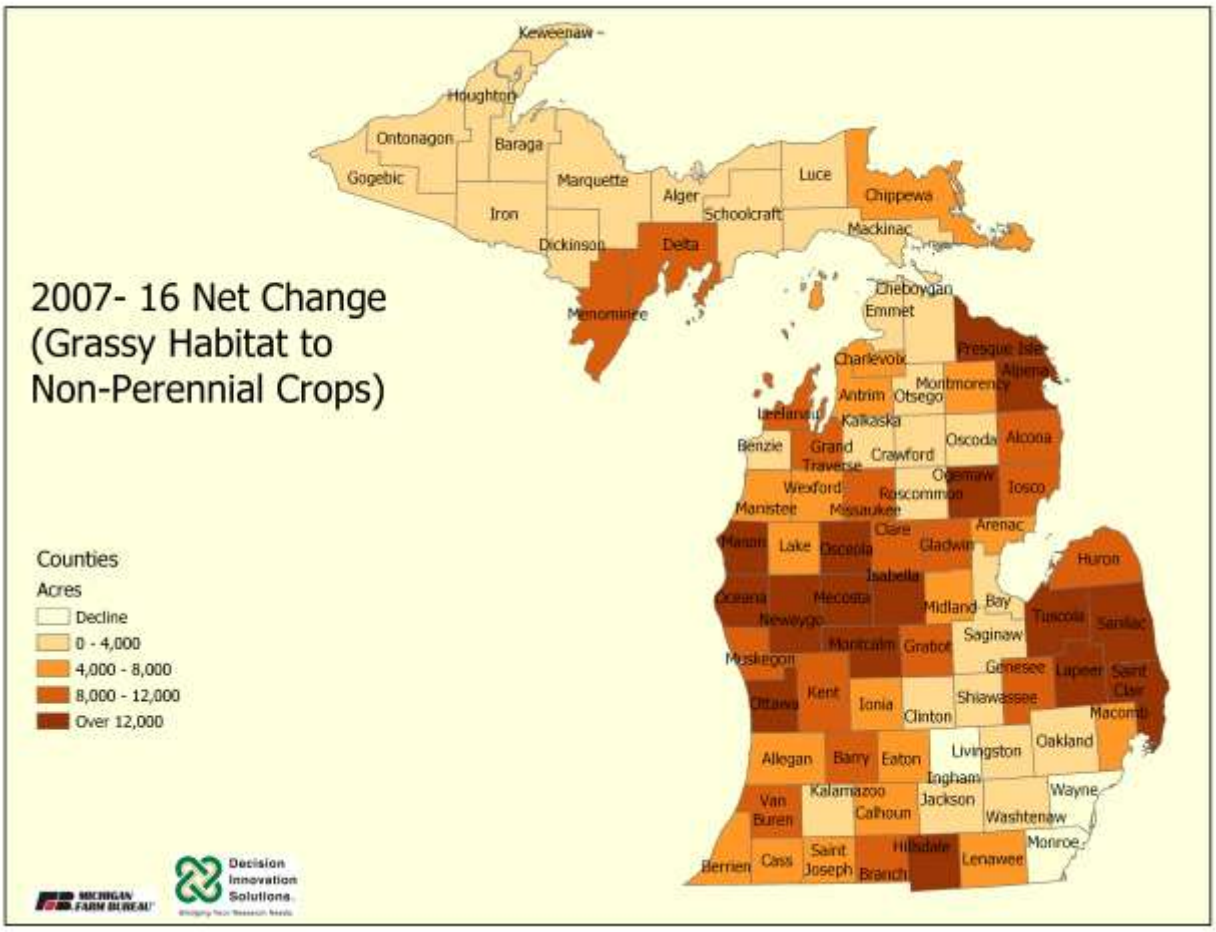


Figure 85, 2007-2016 Net Change (Grassy Habitat to Non-Perennial Crops): Michigan Counties

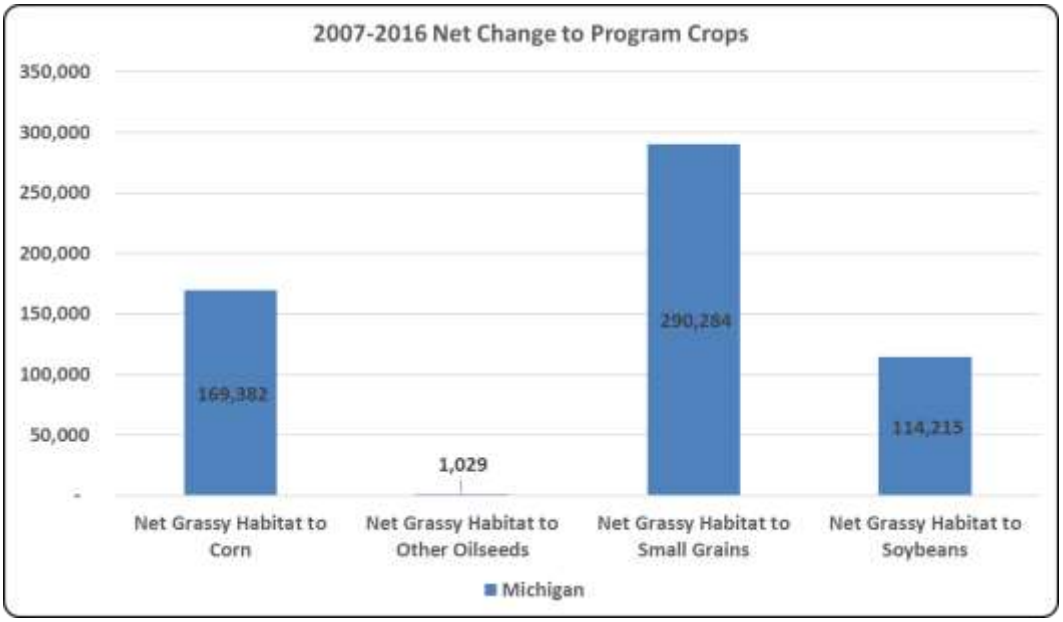


Figure 86, 2007-2016 Net Change (Grassy Habitat to Program Crops): Michigan

Econometric Results

Table 23 provides results for Michigan. A summary of econometric results with regard to the explanatory variables for Michigan is provided below.

- **Crop Insurance Subsidies**
  - Variable is not significant at the 95% level, but exhibits the expected sign (-).
    - Result suggests that the higher the Crop Insurance Subsidy, the lower the share of land devoted to Grassy Habitat.
- **Net Returns to Crops**
  - Variable is not significant at the 95% level and does not exhibit exhibits the expected sign (-).
    - Result suggests that the higher the net Returns, the higher the share of land devoted to Grassy Habitat.
- **Growing Degree Days**
  - Variable is significant at the 95% level and exhibits the expected sign (-).
    - Result suggests that the higher the Growing Degree Days, the lesser the share of land devoted to Grassy Habitat.
- **Precipitation**
  - Variable is significant at the 95% level, but *does not* exhibit the expected sign (-).
    - Result suggests that the higher the Precipitation, the higher the share of land devoted to Grassy Habitat.

Table 23, Econometric Results: Michigan

Variable	Coefficients	Standard Error	t Stat
Intercept	0.0654	0.0289	2.2607
Crop Insurance Subsidies	-0.0003	0.0002	-1.3153
Net Returns for Crops	0.0000	0.0000	1.7782
Growing Degree Days	-0.0421	0.0214	-1.9684
Precipitation	0.0789	0.0110	7.1528
Adjusted R2	0.08		
Observations	547		

Note: Dependent variable is the share of land devoted to the Grassy Habitat land and annual data from 2007 to 2016

The model results for Michigan show that only growing degree days and precipitation were significant. But, growing degree days is the only variable which exhibited both significance and the expected sign. These results indicate that higher growing degree days in Michigan tend to increase crop acreage, which would in turn decrease total grassy habitat acreage.

Research Implications/Suggestions for Further Research

The 2017 Multi-State Land Use Study Update yielded many interesting results with policy implications. Additionally, the results have led to questions that could be the subject of additional research in the realm of understanding Midwestern land use patterns. The primary purpose of the 2017 Multi-State Land Use Study Update was to: 1) provide estimates of the degree to which land use changes have occurred in eight of twelve Midwestern states; and 2) identify potential factors contributing to these land use changes.

Spatial Implications

Without question, our spatial analysis yielded results that support the perception that land use continues to evolve in the Midwest, just as it has done for centuries. In our research we found the assumption by some regarding the large degree to which net land use changes away from habitat as a foregone conclusion is not entirely accurate, especially on a regional basis. When looking at various states and/or sub-Midwestern regions, certain areas exhibited more net land use change away from Grassy Habitat than others. South Dakota and Nebraska are examples of this type of net land use change away from Grassy Habitat.

On the contrary, many states showed very low net movement from Grassy Habitat (Illinois and Indiana) or, in one case (Michigan), a net increase in habitat acreage. In our assessment, this marks a significant departure from the belief that all areas in the Midwest are suffering net losses in Grassy Habitat. Our spatial results stand in direct conflict to this assumption.

In using an aggregated measure such as “Net Land Use Change (Grassy Habitat to Non-Grassy Habitat)”, certain types of land use changes can be masked, particularly when the change is within a land use category. As explained, aggregation was done in such a way to minimize the effects of either misclassified land cover types by the CDL data and/or improvement in remote sensing technology.

One of the key findings of this research with regards to spatial implications is the degree of value gained from using CDL data for decision making. While the data have been improving over time and continues to increase its ability to guide the policy decision making process, there are still errors in how certain types of land covers are identified, particularly those which are either comparatively observed less frequently or are more grassy in nature. To base policy decision solely upon results from CDL data can lead to less than optimal outcomes with regard to land use patterns.

Econometric Implications

Surprisingly, the econometric results associated with this study showed that the majority of states in the study area were not significantly impacted by crop insurance subsidies. However, Kansas is the only state showing that crop insurance subsidies have played a statistically significant role in changing grassy habitats during the study period (See Table 24).

The econometric results suggest that net returns for crops in Iowa, Indiana, and Illinois have contributed to the changes in grassy habitat lands during the study period. The rest of the five states did not show any conclusive evidences of net returns for crops contributing to the changes in grassy habitats.

With some exceptions, as shown in Table 24, precipitation and growing degree days were statistically significant variables when explaining the share of acreage devoted to Grassy Habitat, but in some cases exhibited an unexpected sign. While this result was expected, something worth considering is what would be the impact of a reduction or even unavailability of water in those states that are heavily reliant upon irrigation. Those crop producers who irrigate, no doubt, factor the costs of irrigation when considering an alteration of traditional crop rotations.

Growing degree days in Nebraska, Minnesota, Missouri, and Michigan have contributed to the change in grassy habitat lands during the study period as seen in Table 24. The results from Nebraska and Indiana show that precipitation has played significant role in changing in the grassy habitat lands during the study period.

A key finding of this research with regards to econometric implications is that land use is a very complex issue that cannot be reduced to a few variables. In particular, our economic research does not support the notion that crop insurance subsides are the dominant factor contributing to loss of grassy habitat, especially when observed from a regional perspective.

Table 24, Sign and Statistical Significant of Estimated Parameters for Each Variable of Each State.

State	Parameter	Crop Insurance Subsidies	Net Returns to Crops	Growing Degree Days	Precipitation
Nebraska	Expected Sign	No	Yes	**Yes**	**Yes**
	Significance	Yes	No	**Yes**	**Yes**
Kansas	Expected Sign	**Yes**	No	No	No
	Significance	**Yes**	No	Yes	Yes
Minnesota	Expected Sign	No	Yes	**Yes**	No
	Significance	Yes	No	**Yes**	Yes
Iowa	Expected Sign	No	**Yes**	No	No
	Significance	Yes	**Yes**	Yes	Yes
Missouri	Expected Sign	Yes	No	**Yes**	No
	Significance	No	Yes	**Yes**	No
Illinois	Expected Sign	No	**Yes**	No	No
	Significance	Yes	**Yes**	Yes	Yes
Indiana	Expected Sign	No	**Yes**	No	**Yes**
	Significance	Yes	**Yes**	No	**Yes**
Michigan	Expected Sign	Yes	No	**Yes**	No
	Significance	No	No	**Yes**	Yes

Suggestions for Further Research

Technological Advancements in Aerial Surveying

This study has primarily relied on Cropland Data Layer to evaluate changes in land use. However, this system is inadequate for evaluating recent conservation and soil health practices such as cover crops. It is feasible today to use Landsat and other remote input to tabulate advancements in these practices. Depending on locale, the use of cover crops creates a temporary shift from crop use to grassy habitat. Integrating this technology in future studies will help in validating CDL data and introduce another view of land use during a given year.

Change in Traditional Growing Areas

As the traditional growing area for corn and soybeans expanded west and north in an elevated return situation, how "durable" were these acres with regard to the ability to consistently be used for producing these crops, especially now that marginal returns to crop producers have returned to past levels? At what point and to what extent have these acres reverted to their use prior to increases in net returns? If the land use immediately prior to producing crops was CRP, will these acres be resubmitted for enrollment?

Elevated Commodity Prices

Additional research regarding the cause(s) of higher commodity prices and resulting net returns is a topic worthy of additional consideration. Because our results suggest crop production economics have significant influence on the decision to produce crops, returns from competing land use options will have influence on responsible land owners' decision-making process. A statistical analysis of the interaction of variables such as, supply and demand, policy, and international monetary swings over time may provide insight on commodity price expectations.

CRP Decision

Because of the nature and degree to which CRP has influence on land use decisions, the topic of CRP has been an integral component to this research. Despite lowering the cap to twenty-four million acres in the 2014 Farm Bill, for the foreseeable future, CRP will continue to be viewed as an alternative land use to crop production. However, whole farm signups have and will continue to give way to more targeted land conservation programs and/or land stewardship techniques. Given the degree to which technological and agronomic advances have been made since CRP was first implemented in 1986, we would expect the use of either federal programs such as the Continuous CRP and other state level incentives to increase.

Change in Study Area Definition

To maintain comparability to the original study, study areas were defined by state boundaries. One finding from this research has been that landscape again had implications for econometric results. Within each state are different types of landscape. For example, Nebraska exhibits large changes in precipitation from west to east, Illinois has large difference in growing degree days from north to south, and Iowa's landscape becomes hillier as one moves south. While not certain, we believe this, again, had implications for econometric results being either insignificant and/or exhibiting the theoretically

incorrect sign. Additional research in this area may benefit from study areas not confined to political boundaries such as states. At the least, additional insight may be gained from an analysis based on groups of crop reporting districts without regard to state, as defined by USDA and to explore the use of additional variables.

Appendix A, Land Use Types

Corn

"1" Corn
"4" Sorghum
"12" Sweet Corn
"13" Pop or Ornamental Corn

Soybeans

"5" Soybeans

Other Oilseeds

"6" Sunflower
"31" Canola
"32" Flaxseed
"33" Safflower
"34" Rape Seed
"35" Mustard

Alfalfa

"36" Alfalfa

Grassy Habitat

"37" Other Hay/Non Alfalfa
"62" Pasture/Grass
"87" Wetlands
"171" Grassland Herbaceous
"181" Pasture/Hay
"195" Herbaceous Wetlands

Woody Habitat

"63" Forest
"64" Shrubland
"141" Deciduous Forest
"142" Evergreen Forest
"143" Mixed Forest
"152" Shrubland
"190" Woody Wetlands

Small Grains

"21" Barley
"22" Durum Wheat
"23" Spring Wheat
"24" Winter Wheat
"25" Other Small Grains
"26" Dbl Crop Winter Wheat/Soybeans
"27" Rye
"28" Oats

"29" Millet
"30" Speltz
"61" Fallow/Idle Cropland

Other Ag

"2" Cotton
"3" Rice
"10" Peanuts
"11" Tobacco
"14" Mint
"38" Camelina
"39" Buckwheat
"41" Sugarbeets
"42" Dry Soybeans
"43" Potatoes
"44" Other Crops
"45" Sugarcane
"46" Sweet Potatoes
"47" Misc Vegs & Fruits
"48" Watermelons
"49" Onions
"50" Cucumbers
"51" Chick Peas
"52" Lentils
"53" Peas
"54" Tomatoes
"55" Caneberries
"56" Hops
"57" Herbs
"58" Clover/Wildflowers
"59" Sod/Grass Seed
"60" Switchgrass
"66" Cherries
"67" Peaches
"68" Apples
"69" Grapes
"70" Christmas Trees
"71" Other Tree Crops
"72" Citrus
"74" Pecans
"75" Almonds
"76" Walnuts
"77" Pears
"92" Aquaculture
"204" Pistachios
"205" Triticale
"206" Carrots
"207" Asparagus

"208" Garlic
"209" Cantaloupes
"210" Prunes
"211" Olives
"212" Oranges
"213" Honeydew Melons
"214" Broccoli
"216" Peppers
"217" Pomegranates
"218" Nectarines
"219" Greens
"220" Plums
"221" Strawberries
"222" Squash
"223" Apricots
"224" Vetch
"225" Dbl Crop Winter Wheat/Corn
"226" Dbl Crop Oats/Corn
"227" Lettuce
"229" Pumpkins
"230" Dbl Crop Lettuce/Durum Wheat
"231" Dbl Crop Lettuce/Cantaloupe
"232" Dbl Crop Lettuce/Cotton
"233" Dbl Crop Lettuce/Barley
"234" Dbl Crop Durum Wheat/Sorghum
"235" Dbl Crop Barley/Sorghum
"236" Dbl Crop Winter Wheat/Sorghum
"237" Dbl Crop Barley/Corn
"238" Dbl Crop Winter Wheat/Cotton
"239" Dbl Crop Soybeans/Cotton
"240" Dbl Crop Soybeans/Oats
"241" Dbl Crop Corn/Soybeans
"242" Blueberries
"243" Cabbage
"244" Cauliflower
"245" Celery
"246" Radishes
"247" Turnips
"248" Eggplants
"249" Gourds
"250" Cranberries
"254" Dbl Crop Barley/Soybeans

Non-Ag

"65" Barren
"81" Clouds/No Data
"82" Developed
"83" Water

"88" Nonag/Undefined
"111" Open Water
"112" Perennial Ice/Snow
"121" Developed/Open Space
"122" Developed/Low Intensity
"123" Developed/Med Intensity
"124" Developed/High Intensity
"131" Barren

Appendix B, Conservation Reserve Program

Land use change is driven by a variety of factors. However, it has been postulated that a primary driver of land use change in the last decade or so is elevated crop prices and associated economic returns for landowners. Returns to landowners for the production of crops, in many cases, exceeds returns from the receipt of annual Conservation Reserve Program (CRP) rental payments or the receipts that can be derived from alternative uses such as pasture. Given the fact that much of the currently enrolled CRP acreage was used in an active crop production environment prior to the creation of the CRP program in 1986, it is a reasonable assumption that a portion of this land is suitable once again for producing crops.

The original form of the CRP program was designed for "whole farm" enrollment, which means that whole sections of land, regardless of the variation of the land's characteristics, were submitted for enrollment. Oftentimes, a significant portion of the land from these whole farm parcels was suitable to continue in active production. Given technological advances in crop production techniques and improved land stewardship practices, this is especially true in 2017.

If elevated prices and returns persist, economic pressure will continue to have an influence on the decision to enroll or re-enroll acres in the CRP program, especially those acres which are less environmentally sensitive. However, due to the extreme environmentally-sensitive nature of some acres enrolled in the CRP program, some acres will likely never be suitable for actively producing crops, regardless of their crop production history.

CRP as a Commodity Supply Control Mechanism

In 1986, toward the end of the acute part of the farm crisis in the early to mid-1980s, the Conservation Reserve Program (CRP) began with a two-fold mission: 1) act as a commodity supply control mechanism and 2) protect environmentally-sensitive lands.

In the mid-1980s, farmers were experiencing depressed commodity prices and had endured severe financial hardship from the farm crisis of the early 1980s. By allowing farmers to "set aside" their farms in exchange for regular monetary payments for a specified period of time, supply of excess commodities were reduced and prices for major commodities found a degree of support. Most notable during this time period were the 1986 and 1987 sign-ups in which more than 21 million acres of cropland were enrolled.

CRP as an Environmentally-Sensitive Land Protection Mechanism

According to the USDA/Farm Service Agency (2010):

> "Title XII of the Food Security Act of 1985 established the Conservation Reserve Program (CRP) to assist owners and operators in conserving and improving soil, water, and wildlife resources on their farms and ranches by converting highly erodible and other environmentally sensitive cropland and marginal pasture to long-term resource conserving covers.
>
> In exchange for annual rental payments and cost-share assistance of up to 50 percent of cover establishment costs, agricultural landowners and operators agree to establish and maintain an approved permanent cover on enrolled acreage for 10 to 15 years. The 1985 Act directed the Department of Agriculture to enroll 40 to 45 million acres by 1990 with a primary goal to reduce soil erosion on highly erodible cropland. Secondary objectives included; protecting the Nation's long-run capability to produce food and fiber, reducing sedimentation, improving water quality, fostering wildlife habitat, curbing production of surplus commodities, and providing income support for farmers."

As the CRP program has matured, the cap on number of acres nationally has varied, as well as the requirements which must be satisfied for admission into the program. The first general CRP sign-up period was in early 1986. Since that time, there have been forty-nine sign-up periods for CRP. The general sign-up for CRP is a competitive process, which means that not all land offered for enrollment in CRP will be accepted. The length of a CRP contract is generally ten years unless the land will be devoted to certain wildlife practices, in which case a participant may select a 15-year contract. The most recent general sign-up (sign-up 45) was for the May 20, 2013 through June 14, 2013 time period.

Beginning in 1997, landowners have had the option of submitting acres for inclusion in continuous CRP, which is a targeted (from a sustainability standpoint) program designed to protect the most sensitive lands from degradation. The continuous CRP program addresses the whole farm issue present in the general CRP program in that only lands that merit a higher degree of environmental protection are accepted. Notably, the annual rental payments for the continuous CRP program are typically higher than their general CRP counterparts.While there are stiff financial penalties for breaking a CRP contract (at a minimum, all prior payments received under the contract must be repaid), there are opportunities for exiting the program upon contract expiration. As noted earlier, contracts are typically ten years in length.

Appendix C, Data Accuracy[3]

The spatial analysis was initially undertaken with the assumption that sampling errors in the CDL data were similar to other data collection methods undertaken by USDA/NASS. After reaching preliminary conclusions regarding the degree to which land use had changed within the study area, the accuracy of CDL data was called into question. In particular, it became apparent that some types of land covers were sensed and/or classified inconsistently or inaccurately. The classification process improved over the course of our study period. For instance, in our first round of spatial analysis we had included a CDL-designated land cover called "Pasture/Grass" in our "Habitat" aggregation category. Michigan data shown in Table 2 illustrates that this land cover type was brought to zero by 2009.

State	CDL_Code	Aggregation	Land Cover	2007	2008	2009	2010	2011	2012
MI	36	Alfalfa/Hay	Alfalfa	671,209	778,738	637,698	1,457,712	1,094,902	1,049,819
MI	37	Alfalfa/Hay	Other Hay/Non Alfalfa	1,516	309,771	-	642,689	514,988	480,695
MI	181	Alfalfa/Hay	Pasture/Hay	-	1,724,395	2,039,218	1,313,221	2,075,090	1,977,482
MI	63	All Non-Ag	Forest	6,573	-	-	-	-	-
MI	141	All Non-Ag	Deciduous Forest	10,795,549	10,389,263	10,566,998	10,435,082	10,781,017	10,718,263
MI	142	All Non-Ag	Evergreen Forest	2,041,096	2,078,341	1,989,809	2,070,077	2,072,168	2,047,809
MI	143	All Non-Ag	Mixed Forest	952,960	1,051,176	1,035,364	1,074,605	922,361	959,037
MI	1	Corn	Corn	2,801,323	2,875,388	2,588,115	2,711,864	2,530,563	2,783,077
MI	62	Habitat	Pasture/Grass	1,522,507	579,726	-	-	-	-
MI	87	Habitat	Wetlands	7,154	-	-	-	-	-
MI	152	Habitat	Shrubland	126,893	134,216	155,183	132,199	168,349	181,314
MI	171	Habitat	Grassland Herbaceous	2,100,013	1,589,035	1,743,411	1,357,636	1,283,438	1,387,088
MI	190	Habitat	Woody Wetlands	7,311,234	7,247,943	7,240,056	7,151,604	7,022,087	6,917,869
MI	195	Habitat	Herbaceous Wetlands	330,586	327,249	328,553	329,001	339,622	396,392
MI	5	Soybeans	Soybeans	1,809,113	2,274,335	2,122,230	2,211,190	1,961,451	1,958,305

Table 25, CDL Data Inconsistencies: Michigan

While not certain, we believe the land in Pasture/Grass land cover type in 2007-2008 was re-classed to a CDL-designated land cover called "Pasture/Hay" in 2009, which was in our "Alfalfa/Hay" aggregation category. We believe this was the case because of the closeness of totals in each of the CDL-designated land covers. This change in classification led our original analysis to erroneously conclude that there was a more than 1.5-million-acre shift of land from "Habitat" to "Alfalfa/Hay", even though much, if not all, of the land was likely being used for the same purpose in 2012 as in 2007.

Remote sensing errors were found in other states in addition to Michigan. For instance, Minnesota data in Table 3 shows how a CDL-designated land cover called "Deciduous Forest" was reduced by more than

[3] Due to a desire to remain comparable to the original study released in 2013, we have adopted the same aggregation scheme and associated methodology for the 2017 update.

4 million acres from 2007-2012. At the same time, a CDL-designated land cover called "Woody Wetlands" was increased by approximately the same amount. Due to how we aggregated CDL-designated land cover types in our original analysis, this led us to conclude that more than 4 million acres had been converted from a "Non-Ag" use to a "Habitat" use, even though the land was likely being used for the same purpose in 2012 as in 2007. Similar results were observed in several other states in the study area during the 2007-2012 timeframe.

Table 26, CDL Data Inconsistencies: Minnesota

State	CDL_Code	Aggregation	Land Cover	2007	2008	2009	2010	2011	2012
MN	36	Alfalfa/Hay	Alfalfa	477,554	299,083	275,174	522,047	1,260,820	1,157,765
MN	37	Alfalfa/Hay	Other Hay/Non Alfalfa	-	-	187,889	114,242	1,028,978	909,692
MN	181	Alfalfa/Hay	Pasture/Hay	-	5,108,894	5,062,816	4,487,898	-	-
MN	63	All Non-Ag	Forest	10,841	10,162	17,599	19,532	-	-
MN	**141**	**All Non-Ag**	**Deciduous Forest**	**13,362,536**	**13,067,912**	**12,913,236**	**12,969,208**	**9,287,577**	**9,259,276**
MN	142	All Non-Ag	Evergreen Forest	3,266,572	3,234,944	3,203,482	3,215,628	1,337,127	1,356,630
MN	143	All Non-Ag	Mixed Forest	15,030	14,297	16,244	15,699	1,343,544	1,326,146
MN	1	Corn	Corn	7,542,827	6,990,791	6,711,205	7,335,567	8,038,260	8,727,601
MN	62	Habitat	Pasture/Grass	2,032,729	1,865,261	1,755,555	2,183,486	-	-
MN	87	Habitat	Wetlands	225,664	12,398	19,435	17,935	-	-
MN	152	Habitat	Shrubland	283,498	185,233	231,422	211,846	607,114	596,711
MN	171	Habitat	Grassland Herbaceous	2,862,900	848,009	971,063	862,428	2,398,777	2,360,833
MN	**190**	**Habitat**	**Woody Wetlands**	**3,040,201**	**3,005,450**	**3,083,934**	**3,101,105**	**7,269,476**	**7,298,791**
MN	195	Habitat	Herbaceous Wetlands	5,387,225	3,297,838	3,392,780	3,194,419	5,248,211	5,491,894
MN	5	Soybeans	Soybeans	5,982,741	6,887,052	7,114,633	7,419,199	7,400,229	6,848,061

After determining the primary causes for our inconsistent spatial results, we determined that it was necessary to adjust our methodology for how we aggregated CDL-designated land cover types. Instead of including forests in a "Non-Ag" category and subjectively dividing CDL-designated land cover types that gave the impression of a cropping aspect (i.e., Pasture/Hay, Other Hay/Non-Alfalfa), we determined to group all "grassy" land cover types together[4]. Hence, we determined that a "Grassy Habitat" and "Woody Habitat" aggregation was the best course of action. By so doing, we were able to address and correct the issue causing misleading results in several states (i.e., Michigan and Minnesota). Further, because our hypothesis is that the habitat acres most susceptible to conversion to crop production are of the grassy-type, we have used the Grassy Habitat aggregation category as our primary area of study.

[4] Please see Appendix A for complete documentation on revised aggregation methodology.

Appendix D, Comparability to 2013 Study

As discussed in main body of this report, an alternative aggregation was adopted in this update. Justification for this change in aggregation can be found in the Alternative Aggregation section in this report. While the change in aggregation was justified, the structure of the results in this update renders them not fully comparable to the original results. This appendix provides state results for all time periods under the original aggregation scheme. While not presented here, all results can be made available at the county level.

Figure 87, Figure 88 and Figure 89 show, by aggregation type, the change in land use for 2007-2012, 2012-2016 and 2007-2016, respectively.

Table 27, Table 28 and Table 29 show, by aggregation type, the change in land use for 2007-2012, 2012-2016 and 2007-2016, respectively.

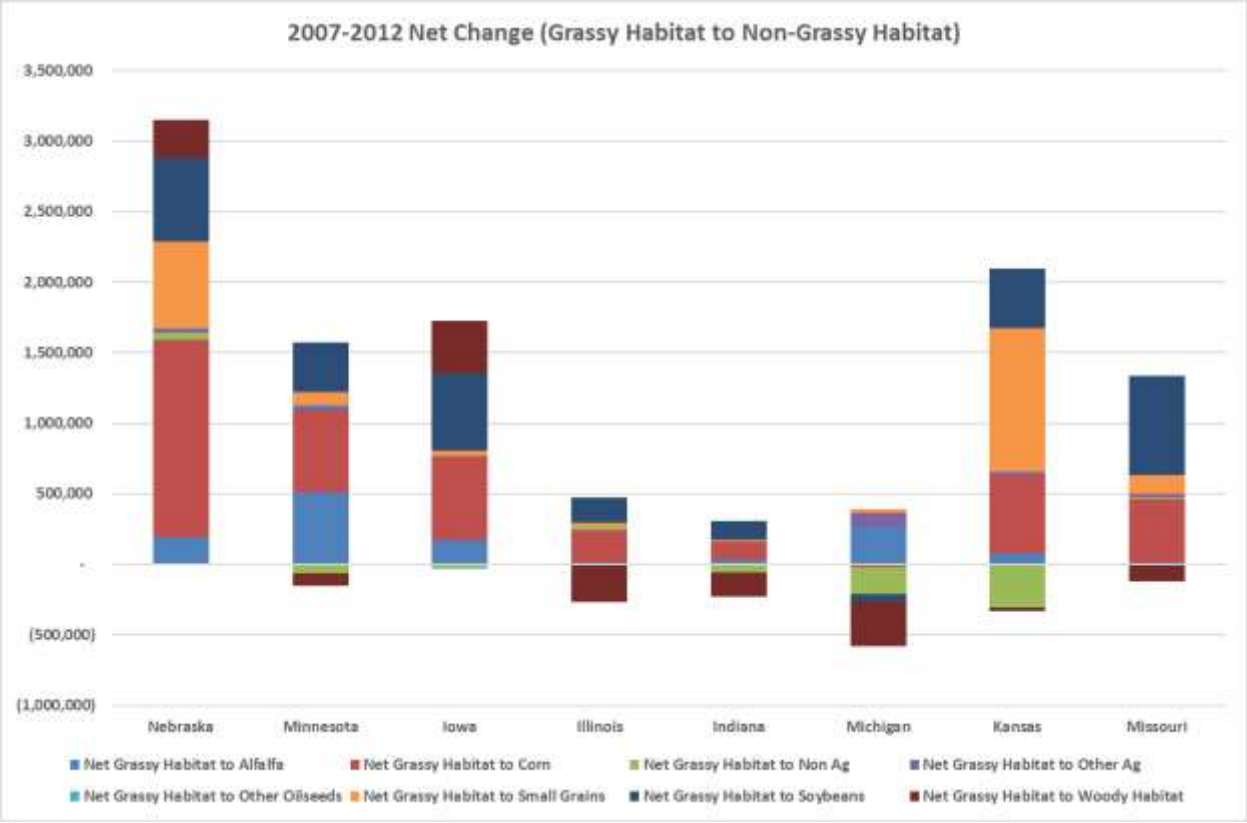


Figure 87, 2007-2012 Net Change by Type

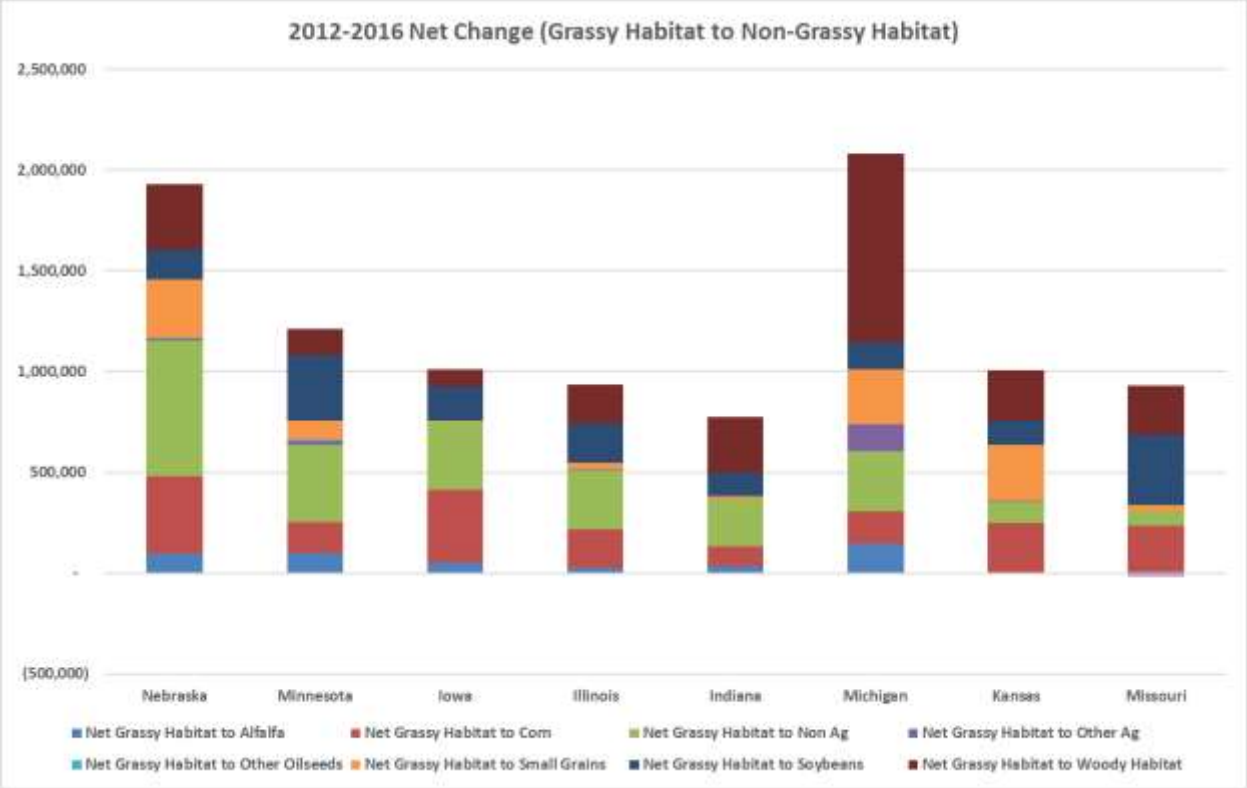


Figure 88, 2012-2016 Net Change by Type

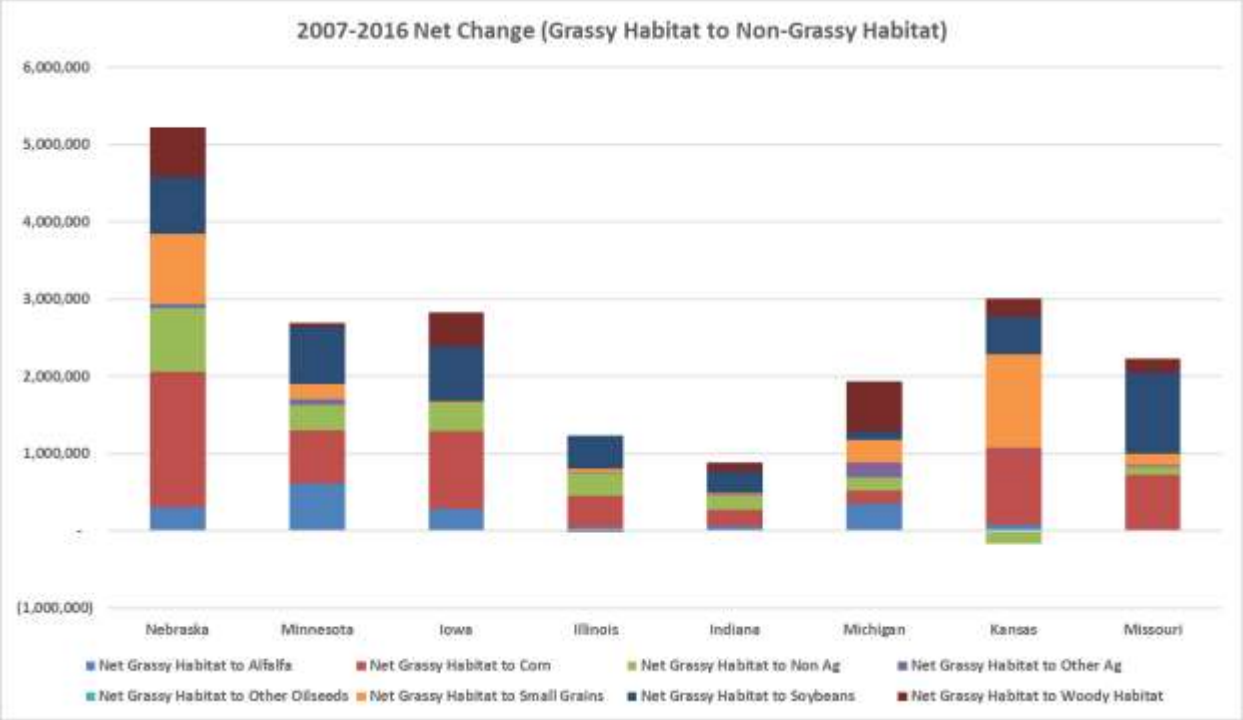


Figure 89, 2007-2016 Net Change by Type.

Table 27, Net Land Use Change by State by Aggregation Type (2007-2012)

2007-2012 Net Change (Grassy Habitat to Non-Grassy Habitat)	Nebraska	Minnesota	Iowa	Illinois	Indiana	Michigan	Kansas	Missouri
Net Grassy Habitat to Alfalfa	191,155	511,791	170,640	15,266	30,834	271,467	75,718	14,027
Net Grassy Habitat to Corn	1,400,212	582,108	598,692	230,435	127,991	(17,328)	558,294	444,221
Net Grassy Habitat to Non Ag	49,625	(61,389)	(26,500)	25,714	(56,231)	(194,757)	(305,861)	16,824
Net Grassy Habitat to Other Ag	27,043	26,211	1,061	(640)	808	93,026	20,118	24,737
Net Grassy Habitat to Other Oilseeds	5,422	8,606	(10)	(1)	-	350	3,221	35
Net Grassy Habitat to Small Grains	617,025	93,175	33,364	23,758	10,950	23,631	1,016,473	132,720
Net Grassy Habitat to Soybeans	594,305	347,651	553,597	179,657	136,234	(51,702)	419,786	703,916
Net Grassy Habitat to Woody Habitat	265,887	(91,519)	366,385	(267,445)	(170,574)	(314,393)	(23,105)	(120,002)
Total	3,150,675	1,416,635	1,697,229	206,744	80,013	(189,706)	1,764,644	1,216,477

Table 28, Net Land Use Change by State by Aggregation Type (2012-2016)

2012-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Nebraska	Minnesota	Iowa	Illinois	Indiana	Michigan	Kansas	Missouri
Net Grassy Habitat to Alfalfa	98,506	101,043	52,811	26,592	32,809	147,044	(3,108)	(2,200)
Net Grassy Habitat to Corn	383,601	150,285	361,178	190,148	98,890	157,485	249,175	234,235
Net Grassy Habitat to Non Ag	672,813	385,766	338,170	296,816	236,408	299,426	105,393	69,937
Net Grassy Habitat to Other Ag	9,450	17,441	563	4,284	1,628	135,569	4,485	(11,293)
Net Grassy Habitat to Other Oilseeds	2,557	6,931	16	-	42	549	207	33
Net Grassy Habitat to Small Grains	288,250	96,397	4,501	30,780	10,284	272,576	278,096	31,597
Net Grassy Habitat to Soybeans	149,112	323,114	171,241	193,192	119,079	133,360	121,565	348,764
Net Grassy Habitat to Woody Habitat	325,896	129,519	83,543	192,414	274,509	935,465	248,697	244,791
Total	1,930,184	1,210,496	1,012,022	934,226	773,649	2,081,475	1,004,511	915,864

Table 29, Net Land Use Change by State by Aggregation Type (2007-2016)

2007-2016 Net Change (Grassy Habitat to Non-Grassy Habitat)	Nebraska	Minnesota	Iowa	Illinois	Indiana	Michigan	Kansas	Missouri
Net Grassy Habitat to Alfalfa	313,305	616,531	285,732	44,483	63,194	348,603	83,142	15,094
Net Grassy Habitat to Corn	1,752,429	682,683	1,006,005	405,314	213,504	169,382	975,444	708,893
Net Grassy Habitat to Non Ag (2007-2016)	823,796	332,711	359,498	301,767	183,104	171,827	(164,265)	108,810
Net Grassy Habitat to Other Ag	41,651	61,836	1,511	4,781	2,777	194,182	20,498	13,624
Net Grassy Habitat to Other Oilseeds	8,730	15,594	32	(2)	49	1,029	2,458	122
Net Grassy Habitat to Small Grains	908,047	198,016	26,928	51,935	25,783	290,284	1,199,935	147,863
Net Grassy Habitat to Soybeans	735,089	728,490	713,573	421,550	282,325	114,215	495,134	1,060,097
Net Grassy Habitat to Woody Habitat	642,411	55,558	435,562	(21,069)	118,665	644,228	230,493	173,168
Total	5,225,458	2,691,420	2,828,842	1,208,758	889,402	1,933,749	2,842,839	2,227,671