Journal of
Applied Remote Sensing

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Changes of crop rotation in Iowa determined from the United States Department of Agriculture, National Agricultural Statistics Service cropland data layer product

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Abstract. Crop rotation is one of the important decisions made independently by numerous farm managers, and is a critical variable in models of crop growth and soil carbon. In Iowa and much of the Midwestern United States (US), the typical management decision is to rotate corn and soybean crops for a single field; therefore, the land-cover changes each year even though the total area of agricultural land-use remains the same. The price for corn increased from 2001 to 2010, which increased corn production in Iowa. We tested the hypothesis that the production increase was the result of changes in crop rotation in Iowa using the annual remote sensing classification (the cropland data layer) produced by the United States Department of Agriculture, National Agricultural Statistics Service. It was found that the area planted in corn increased from 4.7 million hectares in 2001 to 5.7 million hectares in 2007, which was correlated with the market price for corn. At the county level, there were differences in how the increase in corn production was accomplished. Northern and central counties had little land to expand cultivation and generally increased corn production by converting to a corn–corn rotation from the standard corn–soybean rotation. Southern counties in Iowa increased corn production by expanding into land that was not under recent cultivation. These changes affect the amount of soil carbon sequestration. © *2012 Society of Photo-Optical Instrumentation Engineers (SPIE).* [DOI: 10.1117/1.JRS.6.063590]

Keywords: land-use change; land-cover classification; agriculture; corn; biofuels; ethanol production; economics; Conservation Reserve Program.

Paper 11246 received Nov. 14, 2011; revised manuscript received Sep. 17, 2012; accepted for publication Sep. 25, 2012; published online Oct. 30, 2012.

1 Introduction

For the USA in 2008, Iowa ranked first among states in corn and soybean production.[1] In recent years, ethanol plants were built in Iowa in order to use corn for biofuel production. The production capacity of ethanol plants in Iowa increased from 227 million liters in 2000 to 6.3 billion liters in 2007 and to 12.1 billion liters in 2009 (Ref. 2). As ethanol production has increased, so has the demand for corn, thereby increasing its market price[3,4] and leading to more corn production.[5,6] Furthermore, as the prices for corn increased, there was less incentive for keeping land in the Conservation Reserve Program (CRP).[7,8] Agricultural land-use and land-cover are critical variables for crop growth and soil carbon models such as Environmental Policy Integrated Climate Model (EPIC),[9] Voluntary Reporting of Greenhouse Gases-Carbon Management Evaluation Tool (Comet-VR),[10] and contraction of carbon-sequestration (CQESTR).[11] Determining where in Iowa the additional corn was planted is important for economic and environmental policies, such as carbon sequestration.

Most land-use and land-cover changes occur over many years: growth of cities,[12,13] deforestation,[14,15] and other causes.[16] Therefore, one image every few years is usually sufficient to

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determine trends in land-use and land-cover change. What, when, and where crops are planted are important decisions made independently by each farm manager. In Iowa and much of the Midwestern US, the typical management decision is to alternate corn and soybean crops in consecutive years for a single field (called a corn–soybean rotation). Therefore, the land-cover changes each year, even though the total area of agricultural land-use remains the same. Determining changes in crop rotation by remote sensing provides important information for the estimation of soil-carbon sequestration over agricultural areas at low cost.

One method to detect change is to create a land-use classification each year, and then note changes from one year to the next. Classification of different crop types with high accuracy is based on the phenological differences in planting date and crop growth rate.[17] Since 2001, the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) used remote sensing to produce a land-use land-cover data product for Iowa called the Cropland Data Layer (CDL). Over time, NASS has expanded the number of states for which a CDL was created.

Other land-cover datasets are not useful for determining changes in crop rotation. The National Land Cover Database (NLCD) is used to determine the trends over intervals of years (1992, 2001, 2006), but does not differentiate crop types in areas of agricultural land-use.[18] The MODerate resolution Imaging Spectroradiometer (MODIS) on the National Aeronautics and Space Administration (NASA) Terra and Aqua satellites provide time-series data over a growing season for determining phenology.[19–22] Overall accuracies of MODIS crop classifications ranged from 50.8% to 73.9%, depending on the data source used for the accuracy assessment.[23–25] Estimates of planted area using MODIS land-cover classifications may be sufficient for some purposes, but not for determining crop rotation.

We hypothesized that increased corn production in Iowa was the result of changes to the rotation of corn and soybean. We tested this hypothesis by determining two and three-year crop rotations using USDA-NASS CDL's of Iowa from 2001 to 2010 (Fig. 1). Alternatively, areas enrolled in the USDA Farm Services Agency (FSA) CRP were removed from the program and returned to cultivation. Collectively, these two possibilities may have occurred uniformly over the state or may have varied from county to county depending on soil type or other land-use.

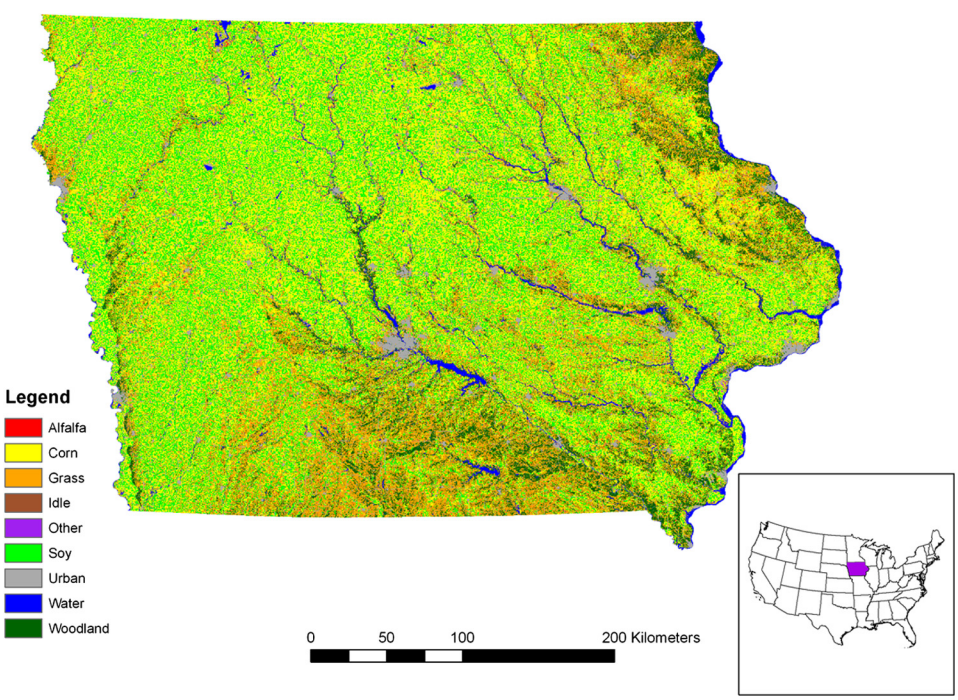

Fig. 1 United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) cropland data layer of Iowa for 2010.

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2 Methods

2.1 *Data Sources*

Five sources of data were used to investigate land-cover change associated with the increase of corn production in Iowa. The first set was the price per kilogram of each crop from USDA NASS.[3] The second set was the "Annual Planted Areas by County" data for corn and soybeans from 2001 through 2010 produced by NASS.[4] The third set of data was the USDA NASS CDL for Iowa from 2001 through 2010 (Ref. 26). The fourth set was the amount of land enrolled in the USDA NRCS CRP.[27] Lastly, weekly NASS reports, "Crop Progress and Status" (personal correspondence, Teresa Green, Jan 3, 2012) were used to determine when the corn was planted during the spring of each year.

CDLs from 2001 to 2005 were created using Landsat Thematic Mapper (TM) and Landsat Enhanced Thematic Mapper Plus (ETM+) imagery. The NASS classification process used a modified iterative self-organizing data analysis (ISODATA) clustering algorithm applied to the ground data, and a maximum likelihood algorithm for classifying the entire scene, with an in-house NASS program called "Peditor" (Ref. 28). CDLs from 2007 through 2010 were created using Indian Resourcesat-1 Advanced Wide Field Sensor (AWiFS, 56-m pixel resolution at nadir) imagery (Fig. 1). CDLs for 2006 were created using both AWiFS, Landsat TM data, and Landsat ETM+. A different classification process was used starting in 2006 with See 5.0 (Rulequest Research, St. Ives NSW, Australia) to create classification rules based on ground data. These rules were then implemented in a decision tree classification using Erdas Imagine (Erdas Inc, Norcross, Georgia).[29,30]

Most of Iowa was composed of three classes: corn, soybean, and grass (Fig. 1). Corn and soybean areas fluctuated between 56% and 64% of the state's total land area during the study period. Grasslands and pastures tended to be about 20% of the land area and were located in the south-central and north-eastern parts of the state (Fig. 1). All other crops combined had a maximum of 5% of the state's total area. Idle cropland fell from a high of 6% in 2001 to less than 1% in 2010.

The ground data used to create and validate the CDL data products were from annual surveys conducted by the USDA FSA. For nonagricultural lands, NLCD data were used for training and validation data. From 2001 to 2006, there were a variable number of Landsat TM and ETM+ images covering a single scene; each scene was assessed independently and the results were combined for the entire state. For 2007 to 2010, the whole state was processed using a mosaic of all AWiFS data. The CDL metadata lists producer accuracies and user accuracies (starting in 2007) for each crop, and provides an overall accuracy (Table 1). The accuracies for corn and soybean are very high for each year (Table 1), so crop rotations based on these data would be accurate.

Iowa is divided into 99 counties. USDA NASS calculated acreage estimates for each crop by county using surveys conducted by NASS in June.[31] NASS uses the CDL as supplementary data using regression models to determine acreages based on CDL.[32] Thus, for this study, the reported planted acres were used rather than pixel counting from the CDLs. However, the acreage estimates could not be used to determine crop rotation. Remotely sensed land-cover classifications tended to overestimate the total area for major crops, because features smaller than the image pixel size would not be determined.[32,33] However, small differences in land area estimates would not affect the determination of crop rotation. Annual CDLs for Iowa were used to determine land-cover changes at the pixel scale and then consolidated to the county scale in order to compare changes in rotation with changes in acreage.

2.2 *Determination of Crop Rotations*

Crop rotation refers to the sequence of crops from year to year for a single field. In Iowa, the standard rotation is to switch between planting corn and soybeans in consecutive years. Alternatively, some farm managers choose to plant corn year after year in the same field, which is called continuous corn. Analysis of crop rotations is difficult because minor changes in land-cover can create large amounts of complexity. For example, with four years and two crops, there

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Table 1 Producer accuracy (prod. acc.) and user accuracy (user acc.) for corn and soybean, and overall accuracy classifications by year for the Iowa cropland data layer (CDL).

Year	Prod.Acc.corn (%)	User Acc.corn (%)	Prod.Acc.soybean (%)	User Acc.soybean (%)	Overall Acc. (%)
2001	89.6	—[a]	91.0	—[a]	81.3
2002	96.3	—	95.0	—	88.6
2003	92.5	—	93.0	—	88.5
2004	97.4	—	98.7	—	93.2
2005	94.0	—	95.4	—	88.0
2006	87.5	—	86.9	—	83.2
2007	97.5	97.6	97.0	96.7	97.2
2008	96.6	97.9	96.2	95.8	95.7
2009	97.9	98.1	97.0	97.7	95.5
2010	96.6	97.6	95.8	97.3	93.2

[a]User accuracies not provided in CDL metadata from 2001 to 2006.

are 16 possible permutations, with 10 years there are 1024 permutations. The CDL classes were consolidated into nine land-cover types: corn, soybean, alfalfa, fallow, grass, urban, woodland, water, and everything else. With nine land-cover types and 10 years, there are more than 3 billion possible combinations. While many combinations will not occur except as classification errors (e.g., corn-urban-corn), the complexity made direct crop rotation analysis nearly impossible for each field at the county or state level. For the purpose of this study, continuous corn means that corn was grown either two or three years in a row depending on the analysis.

CDLs were combined in two ways to determine changes in crop rotation. The first method was to determine only the changes in area with a continuous corn rotation. A binary classification was created where pixels classified as corn were labeled 1 and other land-cover types were labeled 0. Three years were added sequentially so that seven images were created: 2001 to 2003, 2002 to 2004, 2003 to 2005, 2004 to 2006, 2005 to 2007, 2006 to 2008, and 2008 to 2010. If all three years were classified as corn then that pixel was considered to have a continuous corn rotation. The percent of pixels that were continuous corn was calculated based on the total number of pixels in each county. The three year period with the highest percentage of continuous corn area was determined for each county. In addition, the percentage area for each county was calculated and divided into four groups (approximately quantiles) of either 24 or 25 counties to track the number of counties for each three year period.

The second method was to determine changes in crop rotation over two-year intervals. To simplify the analysis, two consecutive years were combined, for example 2001 to 2002, and the number of pixels were calculated that were either corn in both years, soybean in both years, or in a standard rotation (either corn followed by soybean, or soybean followed by corn). Other combinations, such as corn followed by grass were not counted. The percent area of each rotation was calculated based on the number of pixels in a particular rotation divided by the sum of the three rotations. The year in which a county had its highest fractional area in continuous corn rotation was determined.

2.3 *Land Enrolled in the Conservation Reserve Program*

While the primary focus of this study is on changes from a corn–soy (soy–corn) rotation, there is also cropland which is coming into and out of productions. Some of this land is sitting idle because the farmer has reasons for not farming it. Some land is in the CRP in which, the USDA FSA contracts with farmers to conserve erodible land identified by the USDA Natural

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Resources Conservation Service by planting perennial grasses. The amount of land enrolled in the CRP is determined by the amount of money appropriated for the CRP. As prices for corn increased, farmers unenrolled some land from the CRP and put the land back into crop production.[7,8] Unfortunately, land-use classification can't determine which land is within the CRP program and which land is sitting idle for other reasons. Thus, for this analysis, statistics from the CRP are used to determine which areas are losing or adding land to the program.

3 Results and Discussion

3.1 *Area Planted and Annual Production*

Using the NASS statistics for prices received and acreages planted by county, various trends can be analyzed. Both corn and soybean prices reached a maximum in 2010, with other peaks in 2003 and 2007 (Fig. 2). Prices for soybean were higher than for corn for all years. However, corn has higher yields than soybean, thus the worth of the corn per hectare was higher. The maximum worth of corn and soybean also peaked in 2010 (Fig. 3). In Fig. 4, the area of the crop planted versus the price per kilogram showed a positive correlation with corn (Pearson's $r = 0.77$), while soybeans had a negative correlation (Pearson's $r = -0.74$).

An analysis of the area in corn and soybean cultivation at the state level showed the total area planted increased from a low of 9.1 million hectares in 2002 to 9.4 million hectares in 2010. Corn planted area increased from a low of 4.7 million hectares in 2001 to a peak in 2007 of 5.7 million

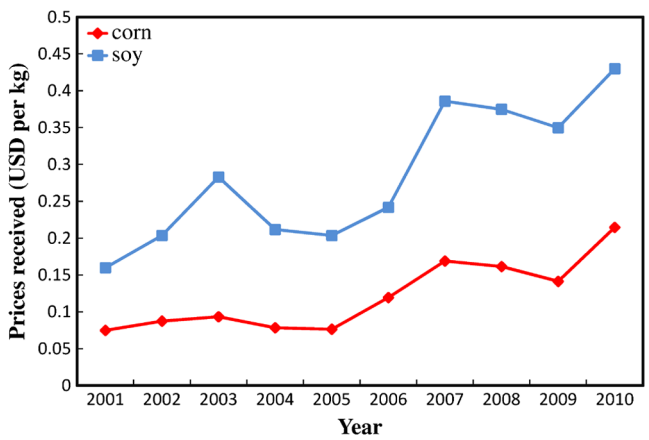

Fig. 2 Prices in US dollars (USD) for corn and soybean in Iowa.

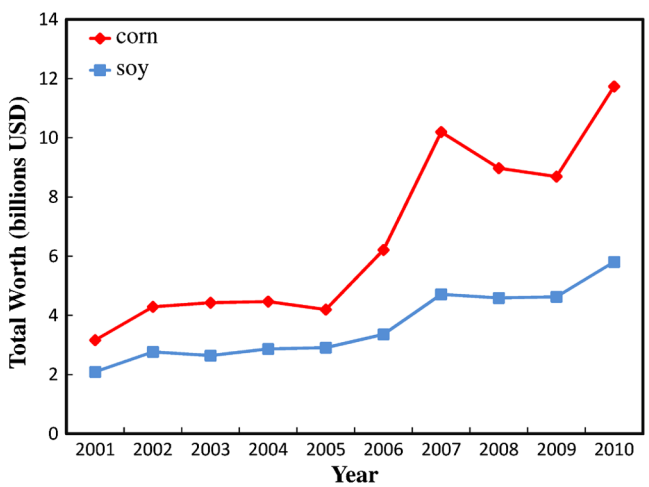

Fig. 3 Total worth of corn and soybean production in Iowa from 2001 to 2010.

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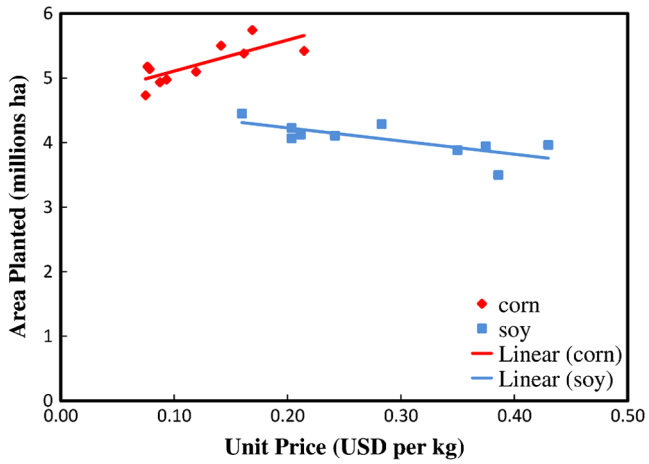

Fig. 4 Area planted corn or soybean in Iowa for given price received.

hectares before falling slightly from 2008 through 2010. Soybeans showed the reverse trend, the maximum of 4.4 million hectares occurred in 2001, falling to a low of 3.5 million hectares in 2007 before rebounding slightly.

The planting of corn generally precedes the planting of soybeans, and usually does not start until mid-April, due to insurance considerations. In Iowa, corn planted prior to April 11th are not eligible for replanting payments.[34] When comparing the week at which 70% of the corn is planted from the Crop Progress Reports versus the amount of corn planted in each agricultural district, Pearson's r ranged from 0.008 to 0.308. At the state level Pearson's r was 0.195. Thus, the planting date is not associated with the increased acreages of planted corn.

These increases in corn supply may be attributed to the demand created by the increasing capacity of ethanol plants.[5,6] In 2000, there was 227 million liters of ethanol capacity available while in 2009 (the last year data was available) that capacity had grown to 12,117 million liters. The correlation between corn prices and ethanol capacity has a Pearson's r of 0.79 from 2000 to 2009 and a Pearson's r of 0.90 if 2009 was not included. However, there did not appear to be localized effects on production created by proximity to new ethanol plants.[35] Thus, it was largely price that drove the increased corn production.

At a county scale, the trends were more variable, 34 of 99 counties reached a maximum area of both combined corn and soybean acres in 2010 and 15 of 99 reached a maximum in 2009 (Fig. 5). However, 26 of 99 counties had their maximum in 2001 (Fig. 5). These 26 counties tended to be in the central and north central parts of the state, in a physiographic region called the Des Moines Lobe.[36] These differences were largely based on the amount of land in each county under cultivation in 2001, and whether there was land available that could be converted to agricultural use. Counties with the maximum area in corn and soybean cultivation from 2001 to 2003 had 61% to 78% of the total county area already being farmed for either corn or soybeans during those years. In contrast, counties that had their maximum area of corn and soybeans during 2008 to 2010 had an average of 52% to 64% of their total area planted in corn and soybeans.

An additional source of information considered was the fraction of land planted in corn compared to the total area under corn and soybean cultivation. At the state level in 2001, 51.5% of the land in corn and soybean cultivation was planted in corn, which increased to 62.1% in 2007, before falling slightly. The year with the highest percentage of corn occurred in 2007 for 95 of 99 counties (Fig. 6), the year in which there was a large increase in the market price (Fig. 2). The three counties which peaked after 2007 were all found in the southwestern part of the state (Fig. 6). In 2007, all counties had greater than 50% corn in the corn and soybean areas. The highest percentages in 2007 were found in the northeast, while the lowest percentages were in the south of the state (Fig. 7). Neither the northeast nor the south originally had large cropped areas in corn and soybean compared to the central and north central areas of the state, so small changes in area planted may have created large swings in percentages. All of the counties had increases in the percent of the area under corn cultivation from 2001 to 2007.

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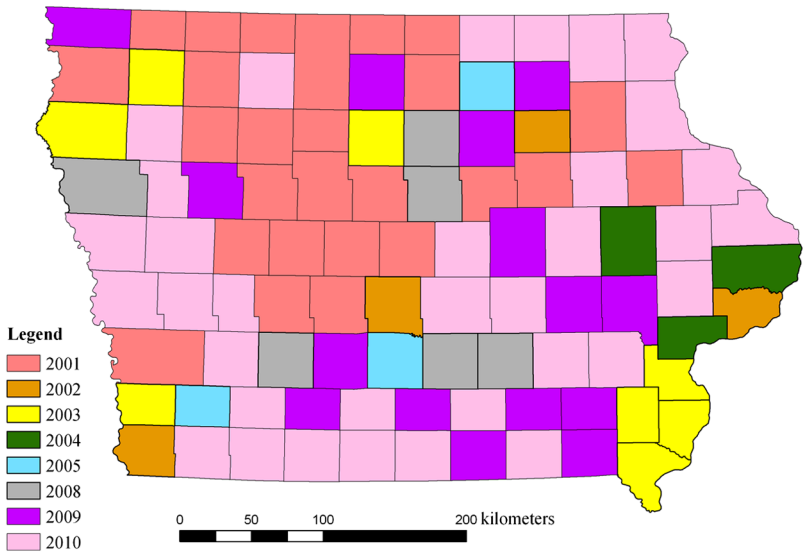

Fig. 5 Year of maximum land area in each county used for combined corn and soybean production. Area of corn and soybean are combined because most fields were in the standard corn–soybean rotation.

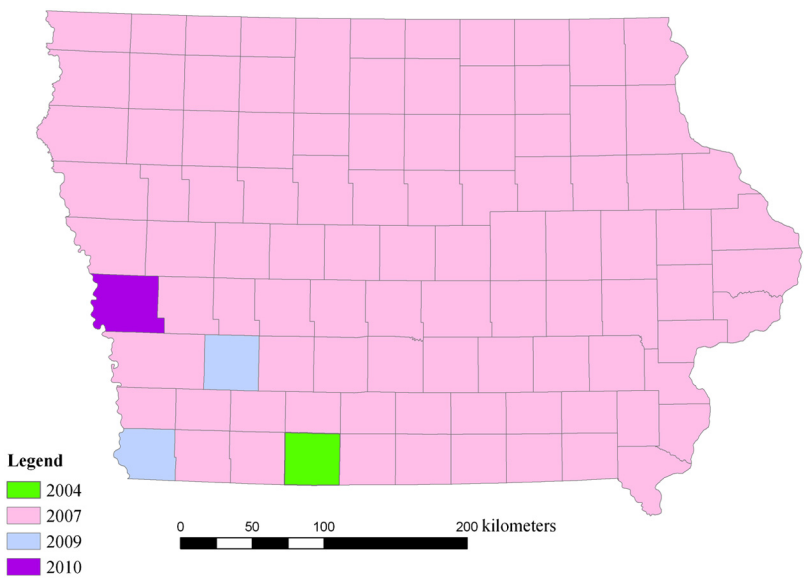

Fig. 6 Year with highest percentage of corn in fields that were either corn or soybean during 2001 to 2010.

In 2001, on a county basis, the USDA NASS reported yield and the percent of corn in the corn and soybean area were weakly correlated with a Pearson's r of 0.56. In 2007, the correlation was unchanged. However, there are five counties in the northeast section (Fig. 8) of the state that have highly erodible soils with clay percentages less than 25% (Ref. 37). For these five counties, corn is generally favored over soybeans, because there is more residue left on the soil after harvesting corn, which protects the soil somewhat from erosion. If these five counties are excluded from the analysis, the correlation (Pearson's r) between yield and the fractional area of corn is 0.72 in 2001 with a linear regression equation of $\text{yield} = (179.7 \times \%\text{corn area}) - 52.8$ but the correlation drops to 0.62 in 2007 and the equation changes to $\text{yield} = (90.6 \times \%\text{corn area}) + 5073.7$ (Fig 9). The decrease in correlation may be attributed to expanding corn production into marginal areas, where: 1. soils which are not as productive, and 2. changing to a continuous corn rotation, which initially may reduce yield.

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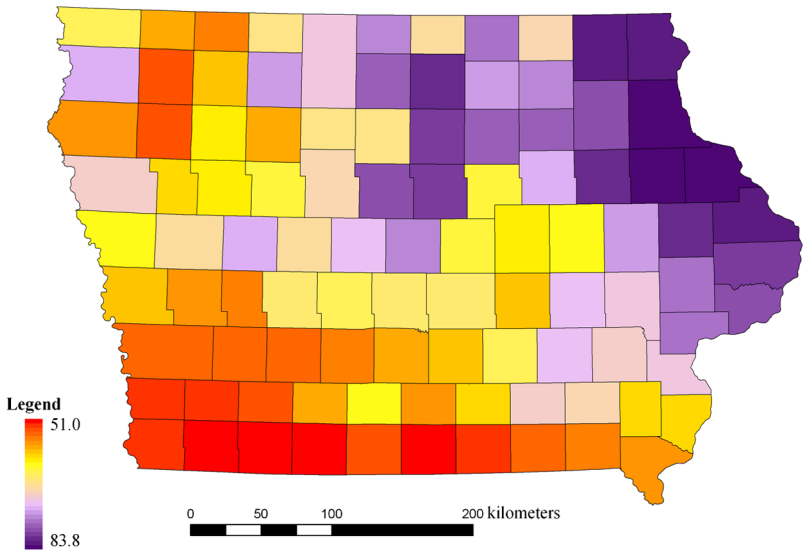

Fig. 7 Percentage of county area in corn compared to the area of land used for both corn and soybean production during 2007.

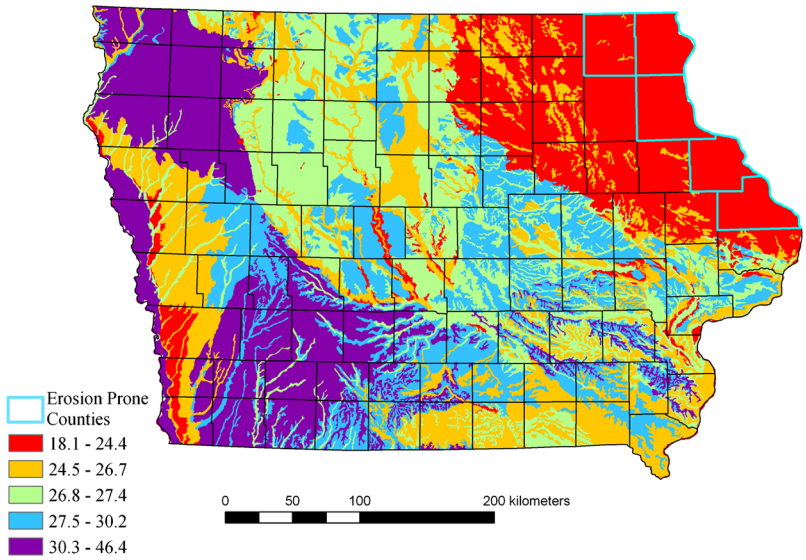

Fig. 8 Percent of clay in top 20 cm of soil. The five categories represent data quantiles. Low clay content indicates the soil is more prone to erosion. The five counties outlined in cyan (in the northeast) have the largest amount of soils prone to erosion.

3.2 *Analysis of Crop Rotation*

With any land-use land-cover classification, there is always an issue about the classification's accuracy. In Fig. 10, the effect of misclassifications can be seen when comparing rotations. Using Landsat TM imagery, single pixels are misclassified and show up as corn–corn, usually along field or road edges. Using AWiFS which has a larger pixel size, tends to minimize the "speckle" effect but misclassifications along field boundaries still persist. However, the area of these misclassifications is relatively small when compared to the total area being analyzed.

At the state level, overall accuracies are always greater than 80% (Table 1). Corn and soybean accuracies are always greater than 85%. These accuracies are similar or better than the National Land Cover Data (NLCD) for 2001 (Ref. 38). Since this study focused only on identifying corn and soybean rotations, only misclassifications of corn or soybean pixels would potentially alter

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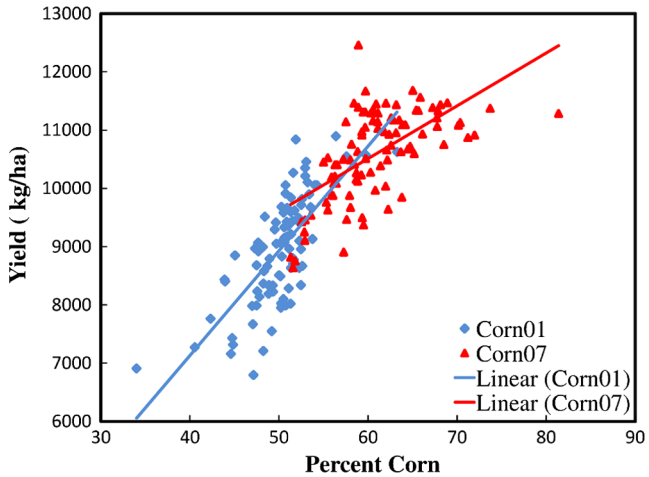

Fig. 9 Percentage of corn land-cover type in land-use areas of corn and soybean production versus average corn yield by county for 2001 and 2007.

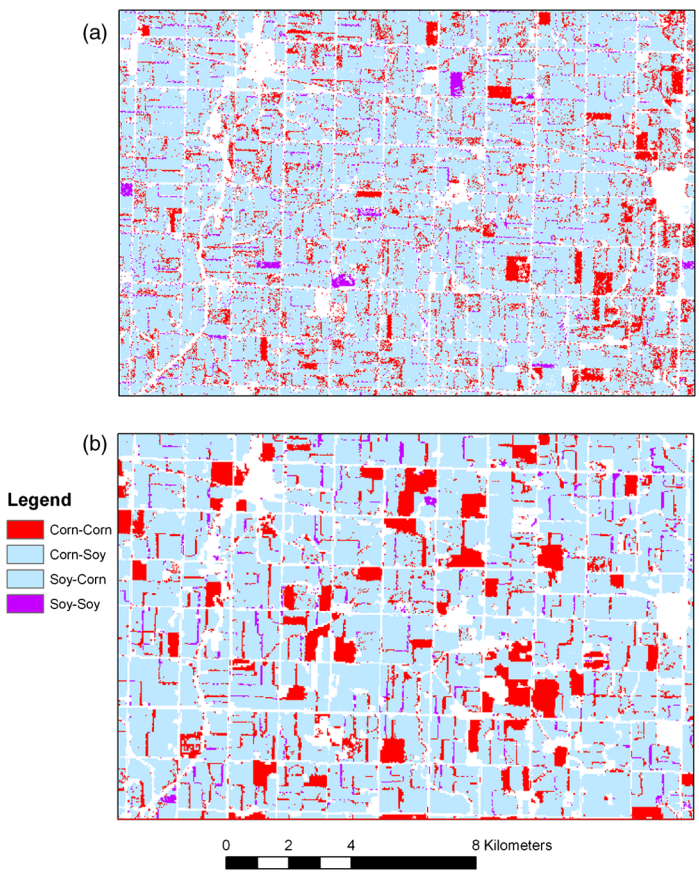

Fig. 10 (a) Corn and soybean rotations in (a) 2001 to 2002 and (b) 2009 to 2010, section of Calhoun County in the Des Moines Lobe.

the analysis. In addition, since this study looked at trends, unusual spikes were ignored. Lastly, since most of the changes in rotation took place after 2005, when accuracies were better, the impact of misclassification was probably not large.

In the first methodology, pixels with three consecutive years were considered to be continuous corn. Only 18 counties had the greatest percentage area planted in continuous corn during 2002 to 2004, primarily in the eastern and southern part of the state (Fig. 11). Over half the

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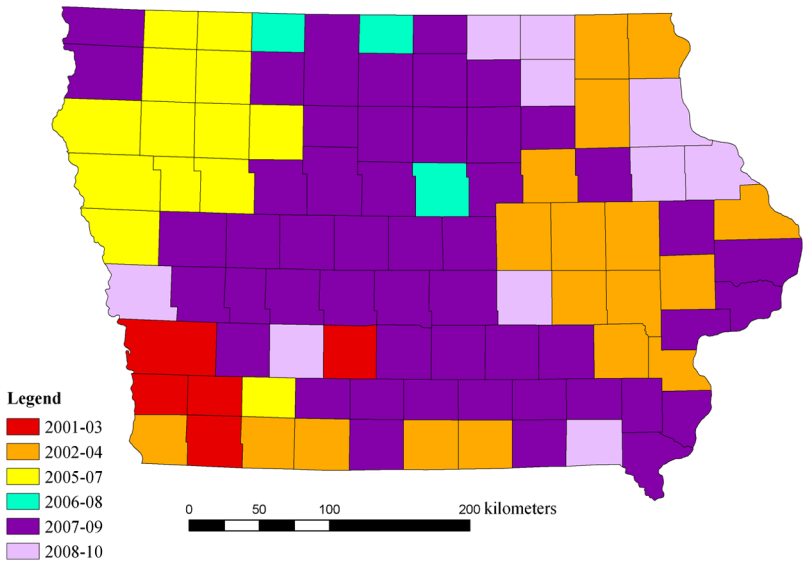

Fig. 11 Three year period with the highest percentage of area planted in continuous corn.

counties (50 of 99) had the greatest percentage of area planted in continuous corn during 2007 to 2009. The counties were predominately in the central part of the state (Fig. 11), with an additional ten counties that had their maximum percentage in 2008 to 2010. Thirteen counties (twelve of which are contiguous) in the north-west part of the state had their maximum in 2005 to 2007. Seventy six out of ninety nine counties had their maximum period from 2005 onwards.

In Fig. 12, the first quantile (continuous corn <2.9%) had the highest number of counties (56) occur during 2003 to 2005, and dropped to a low of 20 counties during 2007 to 2009. In contrast, the fourth quantile (continuous corn > 6.6%) had its lowest number of counties (5) in 2001 to 2003 and peaked with 48 counties in 2007 to 2009. The second quantile (2.9% to 4.6%) had a general downward trend with the exception of 2004 to 2006. Generally, the third quantile (4.6% to 6.6%) remained constant through the study period.

In the second methodology, the interplay of a corn–soy (or soy–corn) rotation was compared with a corn–corn and soy–soy rotation for a two year period. The maximum corn–corn percentages of 46 of 99 counties occurred in 2007 to 2008, mostly located in the central and northern part of the state (Fig. 13). Nineteen counties had the maximum corn–corn in 2006 to 2007, primarily in the northwestern part of the state. Areas in the southern part of the state had

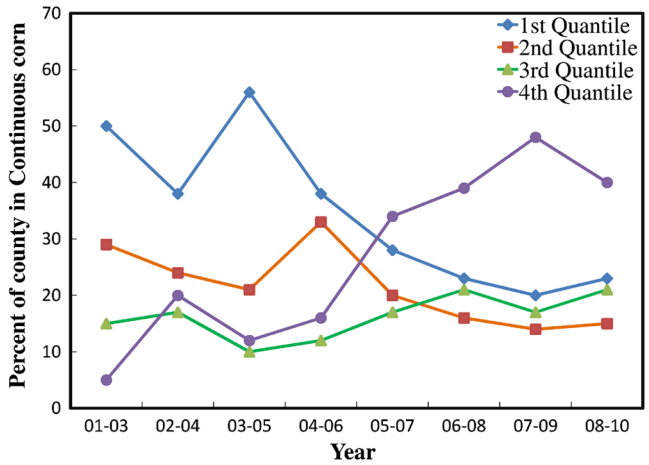

Fig. 12 Number of counties in each quantile of the percent of county in continuous corn. Quantile classes are: 1st (<2.9%), 2nd (2.9% to 4.6%), 3rd (4.6% to 6.6%), and 4th (>6.6%)

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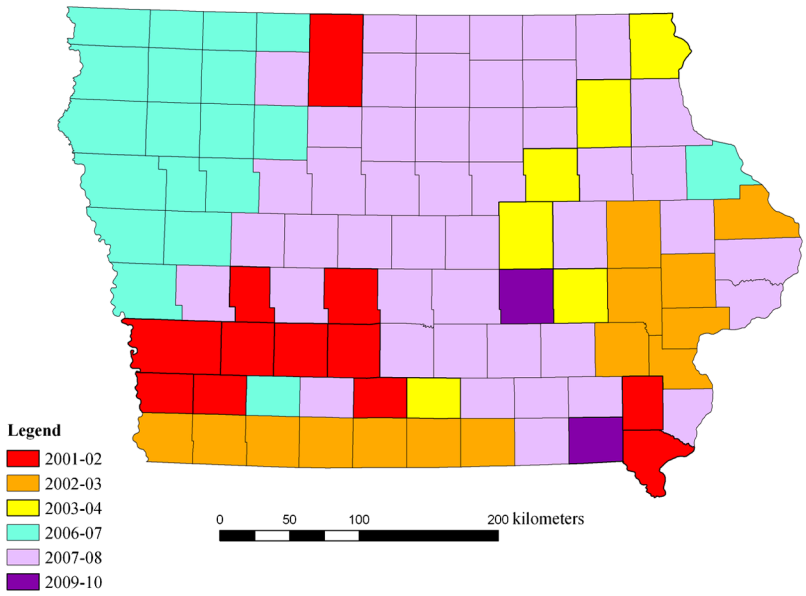

Fig. 13 Two year period with the highest percentage area in a corn–corn rotation of area growing corn and soybean.

their maximum corn–corn percentages either in 2001 to 2002 or 2002 to 2003 (Fig. 13). Only two counties had their maximum corn–corn percentages in 2009 to 2010.

For the two-year period 2007 to 2008, the counties with the lowest percentage of area planted in a continuous corn rotation were found in southern Iowa, while the counties with the highest percentages were found in northeast Iowa (Fig. 14). Furthermore, the standard rotation (corn–soybean or soybean-corn) had the lowest percentages in the northeast and the highest percentages in the west—nearly opposite to the areas with the highest percentages in a continuous corn rotation.

The range of percentages of the corn–corn rotation for 2007 to 2008 was from 8.2% to 59.0% (Fig. 14). Percentages of area planted in the standard rotation were from 39.2% to 86.1%. The soy–soy rotation percentages were highest in the south and lowest in the east and north central. The percentages range of the soy–soy rotation was from 1.3% to 18.9%. The percentage of continuous corn in 2007 to 2008 (Fig. 14) correlated very highly with the percent of corn in the corn and soybean area in 2007 with a Pearson's r of 0.96. Furthermore, the patterns

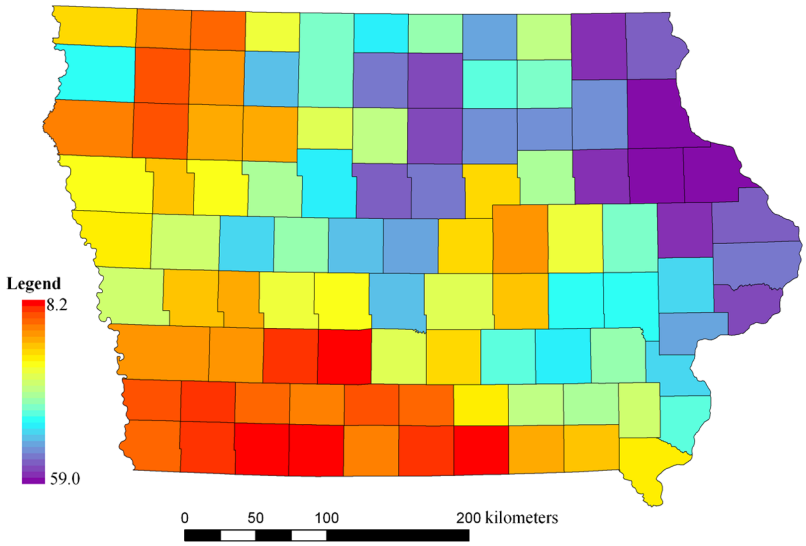

Fig. 14 Percentage of corn and soybean area in corn–corn rotation in 2007 to 2008.

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of crop rotations during 2001 to 2002 were much less correlated to the fractional areas planted in either corn or soybeans with a Pearson's r of 0.62. In general, counties with the lowest percentages of continuous corn rotation were found in areas where expansion of corn production could occur by expanding into uncultivated lands, and the highest percentages of continuous corn rotation were where there was very little area of available land for expansion.

Based on the total county area with the land-use of corn and soybean production, an increase in one rotation type has to correspond with a decrease in one of the two other rotation types. The legend of Fig. 15 shows the six possible changes in rotation type: 1. the continuous corn rotation (cc) and the standard rotation (st) decreased while continuous soybean rotation (ss) increased (cc−, st−, ss+); 2. the continuous corn rotation decreased, the standard rotation increased, and the continuous soybean rotation decreased (cc−, st+, ss−); 3. the continuous corn rotation decreased while both standard rotation and continuous soybean rotation increased (cc−, st+, ss+); 4. the continuous corn rotation increased, while standard rotation and continuous soybean rotation decreased (cc+, st−, ss−); 5. the continuous corn rotation increased, the standard rotation decreased, and the continuous soybean increased (cc+, st−, ss+); and 6. the continuous corn rotation and the standard rotation increased while the continuous soybean rotation decreased (cc+, st+, ss−). Changes of rotation type are assessed by comparing the periods of 2001 to 2002 and 2007 to 2008. Fifty-four of 99 counties have the fourth combination (cc+, st−, ss−); a combination in which area planted in continuous corn rotation increased at the expense of the standard rotation and the continuous soybean rotation (Fig. 15). These 54 counties are located mostly in northern Iowa where there was little room to increase the area under cultivation for corn and soybean. Thus, increases in total corn production were from changing to a continuous corn rotation. The third combination (cc−, st+, ss−) in which the standard rotation increased at the expense of continuous corn and soybean rotations was the second most common change in rotation types, which occurred mostly in the southeast and southwestern parts of the state, where uncultivated land could be brought into corn and soybean production.

3.3 *Changes of Enrollments in the Conservation Reserve Program*

When comparing the percent of a county in CRP from 2001 to 2010 (Fig. 16), it was found that most counties which started with 4% or more of their land in CRP, decreased the amount of land in CRP. Conversely, most counties with less 4% of their land in CRP tended to add land to the program. Pearson's r was 0.86.

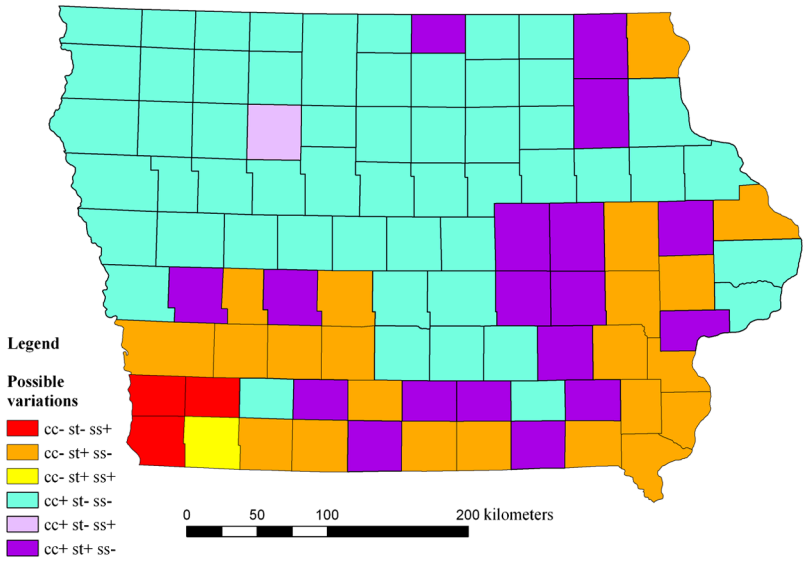

Fig. 15 Pattern of increase (+) or decrease (−) among corn–corn rotations (cc), standard rotations (st), and soy–soy rotations (ss) from 2001 to 2002 through 2007 to 2008.

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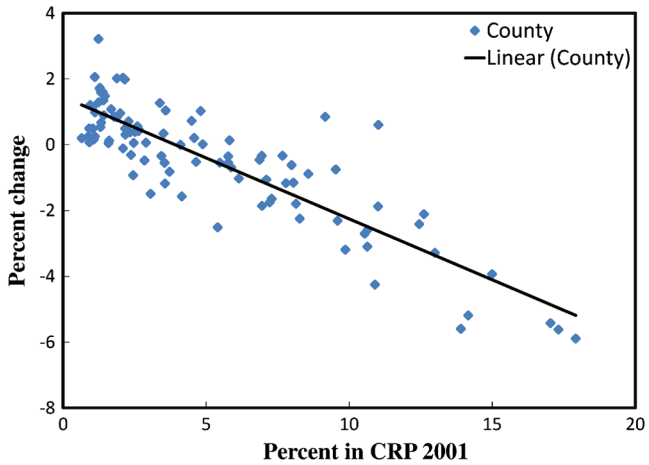

Fig. 16 Percent of county area in CRP in 2001 versus percentage change by 2010.

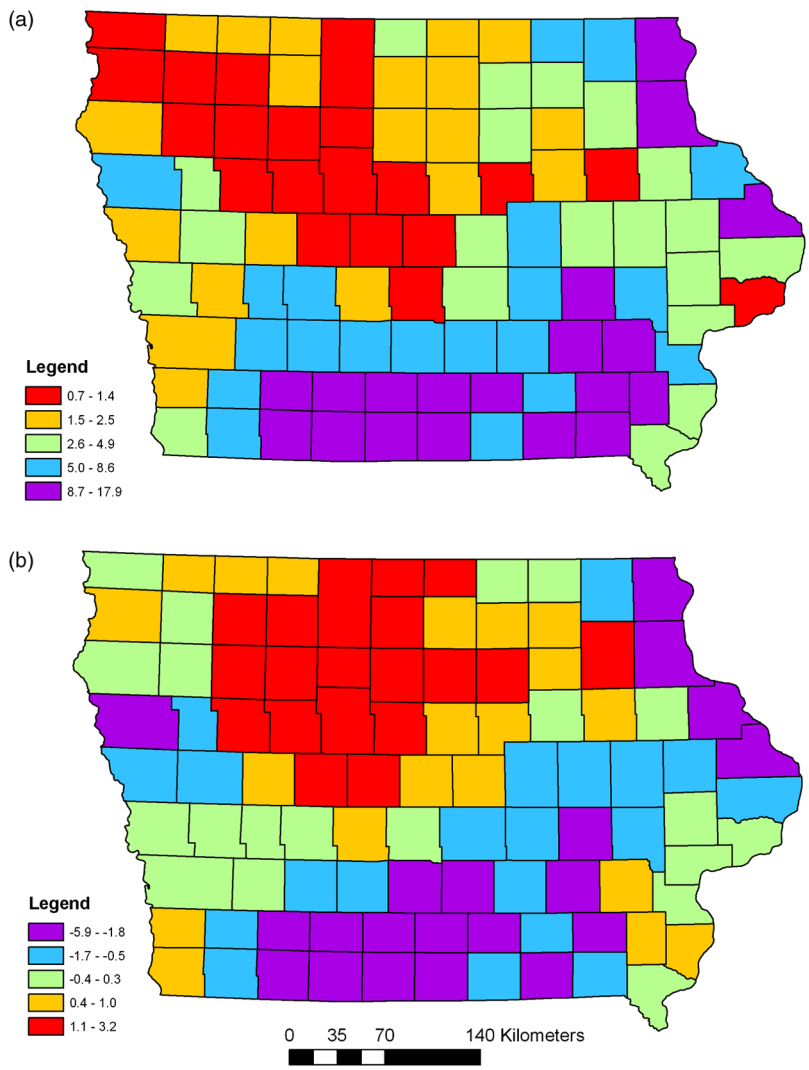

Fig. 17 (a) Percent of county in CRP land in 2001 and (b) percent change in land in CRP land by 2010. The color schemes have been reversed to emphasize areas with the most CRP land tended to lose the most.

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Geographically, the areas that started with very little land in CRP tended to be in the north and these were the counties that also added some land to the CRP (Fig. 17). The southern and eastern counties had more land in CRP and took that land out of the CRP program.

4 Conclusions

From 2001 to 2010, ethanol production has increased in Iowa. As ethanol production has increased the price for corn has also increased, probably from increased demand. Using NASS CDL, it was possible to observe changes in crop rotation due to price increases in corn. Many of the changes in rotation peaked in 2007, which was the same year as the second highest price for corn, which was circumstantial evidence that the rotation changes were the result of corn prices. At the state level, the area used for corn cultivation increased while the area used for soybeans decreased. In addition, idle land was brought into corn or soybean cultivation. However, at the county level, changes in land-use were more variable. In the central and north-central corn cultivation increased largely due to a shift from a corn–soybean (or soybean-corn) rotation to a corn–corn rotation.

Counties in other parts of the state expanded into areas previously not used, such as idle cropland. In general, a standard corn–soybean rotation was used in this expansion. Bringing recently uncultivated land, such as land enrolled in the CRP into corn and soybean production is likely to have different environmental impacts than changing from a standard rotation of corn–soybean to continuous corn.

Acknowledgments

We thank Ms. Teresa Green at the NASS-Iowa State office (Des Moines, IA) for the historic crop progress data. The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

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