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FOCUS ON GEOGRAPHY

Land-Use and Land-Cover Change in Three Corn Belt Ecoregions: Similarities and Differences

by

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Photographs by the Authors Unless Otherwise Noted

Introduction

The term "Corn Belt" in the United States evokes a vision of corn and soybean fields that stretch unbroken from Ohio to Nebraska and Missouri to Minnesota, dotted with farmsteads and communities of varying sizes, connected to one another via river, rail, or road (Figure 1). The first known usage of "Corn Belt" was printed in *The Nation* in 1892 (Warntz 1957, 40), and the first academic use of the term was by Harvard economist T.N. Carver, where he wrote of "a tolerably compact strip where corn is the principal crop, and which may therefore properly be called the corn belt" (Carver 1903a, 4132). Later that same year, he referred to the region as "the most considerable area in the world where agriculture is uniformly prosperous" (Carver, 1903b, 4233).

In the late 1920s and early 1930s, in a lengthy series of papers in *Economic Geography*, geographer and agricultural economist O.E. Baker set out to delineate agricultural regions in North America - one of which being the Corn Belt (Baker 1927). Baker's regions were based mostly on environmental thresholds that determined where certain crops could best be grown (e.g.: average summer temperatures, rainfall total, soil, and topography). In 1950, the U.S. Department of Agriculture using Baker's work as a model, created a map of the U.S. where each county – based on the most common agricultural practice – was placed into one of ten regions (USDA 1950). Region V, "Feed Grains and Livestock" (a.k.a, the Corn Belt), encompassed Baker's definition entirely, and detailed the region's expansion into the spring wheat region of north-central Minnesota and eastern South Dakota, and the corn and winter wheat regions of eastern Kansas, western Missouri, and along the Wabash River Valley on the Illinois/Indiana border.

The Corn Belt again gained exposure when John Fraser Hart (1986) revealed that cash-grain farming had replaced mixed/general farming throughout most of the region. John Hudson's (1994) work, *Making the Corn Belt*, offers arguably the most thorough examination of this region's history and ever-changing geography, tracing corn's 200-year journey from the east coast to its present-day range. More recently, Laingen and Craig (2011) reported on the Corn Belt's continued transition north and west of the 1950 USDA delineation. This work led to Laingen's (2012) creation of a new-and-improved Corn Belt boundary, based on thresholds related to agricultural land use, production totals, and economic returns, that again describe this region's continual change over the past half-century (Figure 2).

Like "Midwest" or "Dixie", the Corn Belt, however it is defined, has indeed become a part of America's vernacular. While corn can be found nearly uninterrupted across this region, both human and natural forces have created at least three distinct sub-regions within the Corn Belt.

Figure 1. *A summer picture of rural land use in the Corn Belt taken in west-central Iowa; corn growing on the left side of a gravel road and a little further ahead, soybeans on the right.*

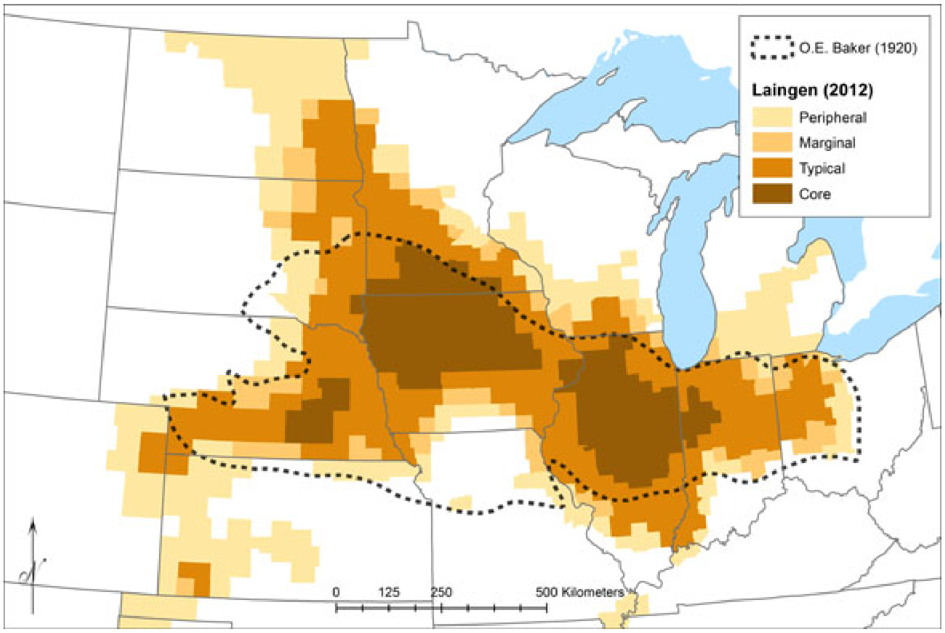

Figure 2. *Corn Belt definitions from Baker (1927) and Laingen (2012).*

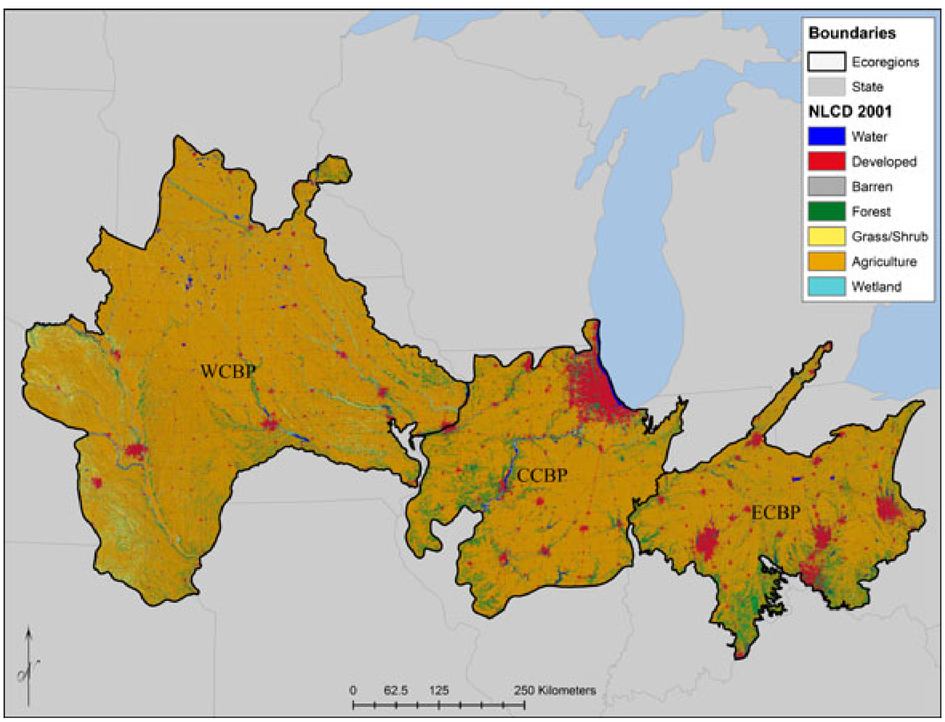

Figure 3. *The U.S. Environmental Protection Agency's three "Corn Belt" Level III Ecoregions (1999) shown with 2001 National Land Cover Dataset land covers with a Anderson I (Anderson et al. 1976) classification system.*

The U.S. Environmental Protection Agency identifies three Corn Belt ecoregions: the Eastern Corn Belt Plains (ECBP), the Central Corn Belt Plains (CCBP), and the Western Corn Belt Plains (WCBP) (Omernik 1987; U.S. Environmental Protection Agency 1999) (Figure 3). Dividing the Corn Belt into three distinct ecological regions was done largely because of differences in pre-settlement land cover and other biophysical conditions (Wiken et al. 2011). The ECBP had dense natural tree cover (beech and elm-ash forests) growing in alfisol soils. The CCBP was a mosaic of extensive prairie communities and oak-hickory forests, while tallgrass prairies covered the drier WCBP almost entirely – with mollisol soils acting as the foundation for the vegetation of the CCBP and WCBP. Wetlands, ranging from herbaceous marshes and "wet prairies" to forested bottomlands and swamps, have also led to variations in how these three regions' land uses have evolved. Also important in distinguishing among the three sub-regions are factors such as precipitation (which generally decreases from east to west) and slope/topography (which generally becomes more irregular from east to west, as the gently rolling till plains give way to wind-blown loess hills) (Wiken et al. 2011).

The subtleties of these prior (and subsequent) biophysical conditions, along with the legacies of Euro-American settlement and continued anthropogenic drivers of change, have created, sustained, and influenced the types and amounts of contemporary land use and land cover change (LULCC) found across this region. While indeed the majority of the Corn Belt is used to produce agricultural commodities, there are also enough differences within the Belt to warrant further investigation as to why this commonly perceived uniform region is much more than seemingly endless fields of corn and soy. This paper utilizes data that report trends and trajectories in how humans have changed these sub-regions' rural and urban landscapes.

Data and Methods

Land use/cover data and results were gleaned from interpretations of satellite imagery, specifically, data from the U.S. Geological Survey's (USGS) Land Cover Trends project, hereafter "Trends" (Loveland et al. 2002; Auch et al. 2012). The bookend dates for this study were 1973 and 2000. These dates coincide with the beginning of the Landsat satellite era, and conclude with what was then the end of the initial Trends study period (Loveland et al. 2002). Although there are other periodic assessments of land use that may be more current, they are typically based on individual thematic sectors or land ownership while Trends is the most inclusive and comprehensive assessment to date for the conterminous U.S. (Sleeter et al. 2013). The Trends project analyzed satellite imagery that fell within approximately forty 10x10 kilometer sample blocks that were randomly selected from within the bounds of an ecoregion for the dates of 1973, 1980, 1986, 1992, and 2000, using a revised version of the Anderson Level I LULC classification scheme (Anderson et al. 1976; also see http://landcovertrends.usgs.gov for more in-depth – and technical – details on Trends, as well as the appendices in Sleeter et al. 2012).

In simplified terms, 60x60 meter pixels within each 10x10 km sample block were manually classified into LULC categories such as developed (urban/built up), agriculture (crops, pasture), grassland/shrubland, wetlands, and so on. After each of the five dates was analyzed, change statistics were calculated by comparing one year to another. For example, the creation of a new residential subdivision may have led to pixels classified in 1992 as "agriculture" to be changed to "developed" in 2000. Not surprisingly, the vast majority of land in the three Corn Belt ecoregions fell into four of the eleven Anderson-based LULC categories: agriculture, forest, developed (urban), and grassland/shrubland. Ancillary data including county-scale population characteristics and slope/topographic information were also used to place the numeric change values being measured via the satellite image interpretation into a more comprehensive geographical context. The overall goal of the project was not simply to measure change, but to tell the complete story of that change, which meant uncovering why variations in change trajectories occurred driven by forces both human and natural. The integration of both socioeconomic and biophysical datasets was necessary to further describe not only how much change had occurred, but also the possible reasons why.

Land-Use and Land-Cover Change Results, 1973-2000

Compared to human changes occurring on the landscapes in other parts of the country, the Corn Belt is a rather boring place. The overall spatial change (where a land parcel changed at least once from 1973 to 2000) ranged from 3.2 percent (± 0.8 percent) in the WCBP to 6.3 percent (± 2.7 percent) in the ECBP (Figure 4). While little LULCC occurred during the 30-year study period, a more in-depth look at land use changes at a finer temporal scale revealed distinct differences in what types of changes occurred. The pattern of these temporal changes suggest the three distinct Corn Belt sub-regions (i.e. WCBP, CCBP, and ECBP) do indeed exist and can be identified using land use change data.

The ECBP and CCBP, though more diverse in pre-settlement vegetation compared to the CCBP and WCBP, had similar patterns of contemporary land change (Figure 5). In the ECBP and CCBP ecoregions, an increase in the amount of developed land cover at the expense of agricultural land and some forestland was the leading aspect of change when compared to the WCBP. In the WCBP, gains in grassland/shrubland land cover, specifically a spike during the 1986-1992 interval, was unique to this ecoregion.

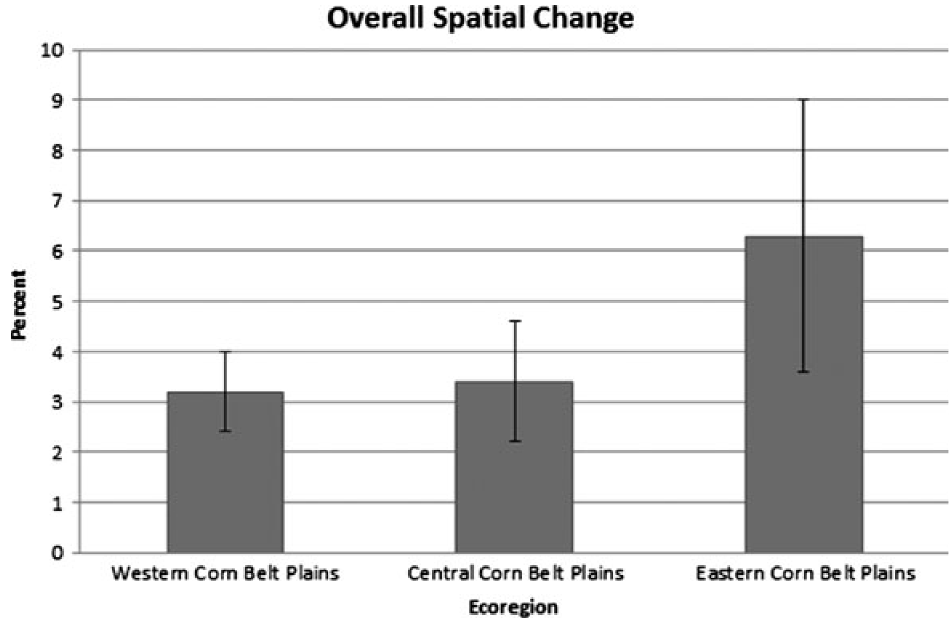

Figure 4. *Overall estimated percent land-use land-cover change between 1973 and 2000 among the Corn Belt ecoregions.*

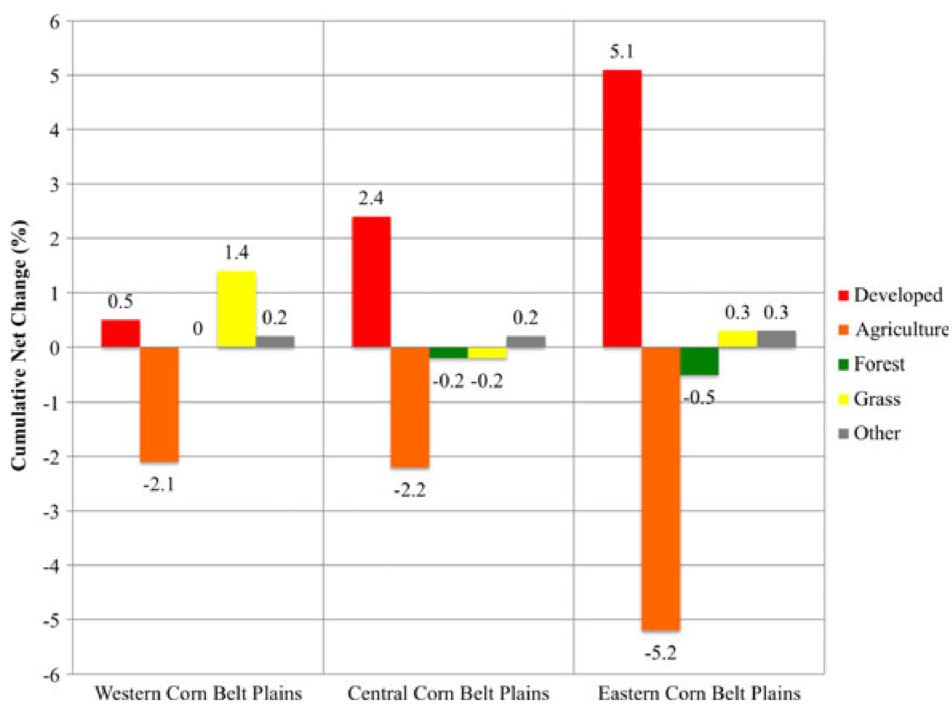

Figure 5. *Cumulative (1973-2000) net change by ecoregion and by class. Bars below zero indicate land uses/covers that decreased from 1973 to 2000, while bars above zero indicate the type of land uses/covers that gained from those losses.*

Agricultural land cover had the largest net declines during the study period in all three regions. The type of change(s) found in the ECBP and CCBP, however, were more permanent (unidirectional) types of change (agriculture to developed) than the potentially reversible (multidirectional) change of agriculture to grassland/shrubland conversions found in the WCBP. Forest land cover also had minor net declines in both the ECBP and CCBP, as it was being converted to development and agricultural uses. The WCBP had very little forested land overall, and it experienced almost no change at the ecoregion scale. These results provide a mixed regional picture of both similarities and differences among the three ecoregions. The Corn Belt was not monotone with regard to land change during the 1973 to 2000 era. We will now explore why the differences in land change may have occurred across this region.

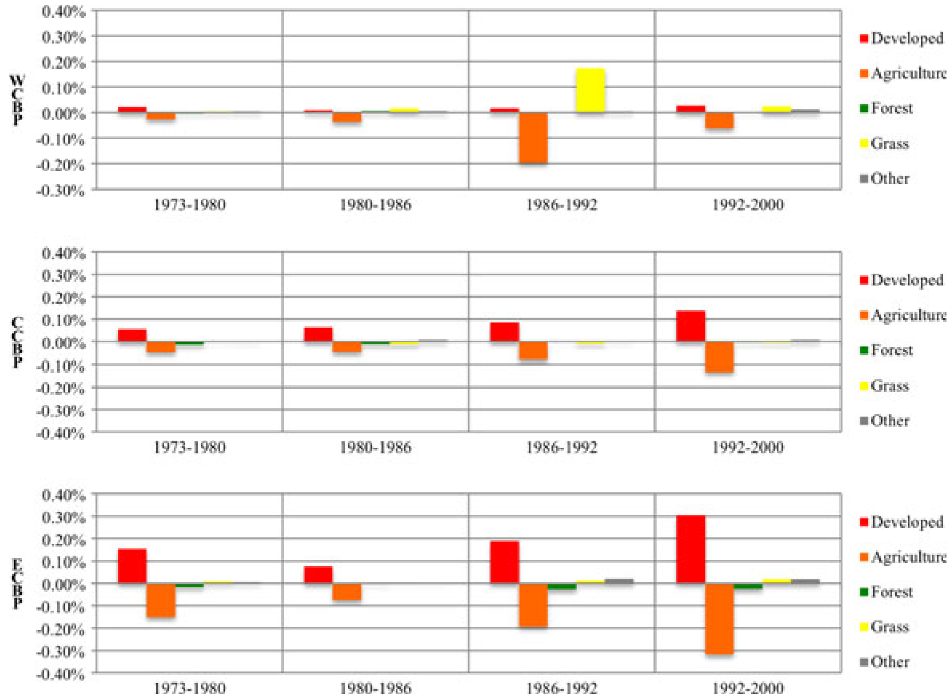

Figure 6. *Estimated land use / land cover change in all three Corn Belt ecoregions. Bars below zero indicate uses/covers lost and that were replaced by uses/covers shown in the bars above zero. Data shown are normalized to annual rates of change.*

Agriculture to Grassland/Shrubland Change

The most noticeable anomaly among the three Corn Belt ecoregions during the study period was the statistically significant agriculture to grassland/shrubland change in the WCBP– a change that was, more or less, absent in the other two ecoregions (Figure 6). Agriculture to grassland/ shrubland change was most prominent during the 1986-1992 interval, when federal farm policy initiated the Conservation Reserve Program (CRP) (U.S. Dept. of Agriculture 2013). The 1992-2000 interval witnessed the CRP renewed as a federal policy, although agriculture to grassland/ shrubland conversions were less prevalent as most CRP participants had already entered into their 10-year contracts. As a federal program, the CRP was available to land owners across the country (e.g. all three Corn Belt ecoregions), but there appears to have been several factors that made CRP enrollment more attractive (or available) to landowners in the WCBP.

The CRP was part of the 1985 federal farm bill, with the primary purpose of helping to remove highly erodible land from crop production (U.S. Department of Agriculture 2013). A secondary benefit was the removal of excess cropping capacity and associated financial stress towards the end of the 1980s "Farm Crisis" – primarily in the WCBP and continuing further west into the Great Plains (Harl 1990; Dicks 2005).

Eligibility for CRP enrollment was initially based on soil erodibility. Several important factors that influence erosion potential are soil conditions (Figures 7, 8) and the slope of the land (Figures 9, 10). These variables can be incorporated into an erodibility index to identify highly erodible lands. Unfortunately, a spatially explicit index is not publically available and slope analysis was used as a surrogate for erosion potential. It revealed greater values in the WCBP for mean degree of slope than were found in the ECBP or CCBP (Figure 11). As a percentage of ecoregion area, the CCBP and ECBP had 80 percent of their land in the lowest class of mean degree of slope (0.0 to 0.5), while the WCBP has only about 55 percent in that class. The WCBP was the leading Corn

Figure 7. *Soil types can greatly influence the erodibility. Loess-derived soils, as seen from a roadside in eastern Nebraska, tend to be finer grained, friable, and more easily worked by water and wind actions.*

Figure 8. *Soil types can greatly influence the erodibility. Heavier soils, such as clay-loams found in southwest Minnesota, tend to be less affected by erosion.*

Figure 9. The amount of slope can also impact erosion potential. The overall slope on this parcel of land in east-central Iowa has dictated its land use, with moderate slope still being cropped whereas the more broken and higher sloped areas were kept in pasture.

Figure 10. This more gently sloped field found in a north-central Illinois has less erosion potential and is entirely cropped.

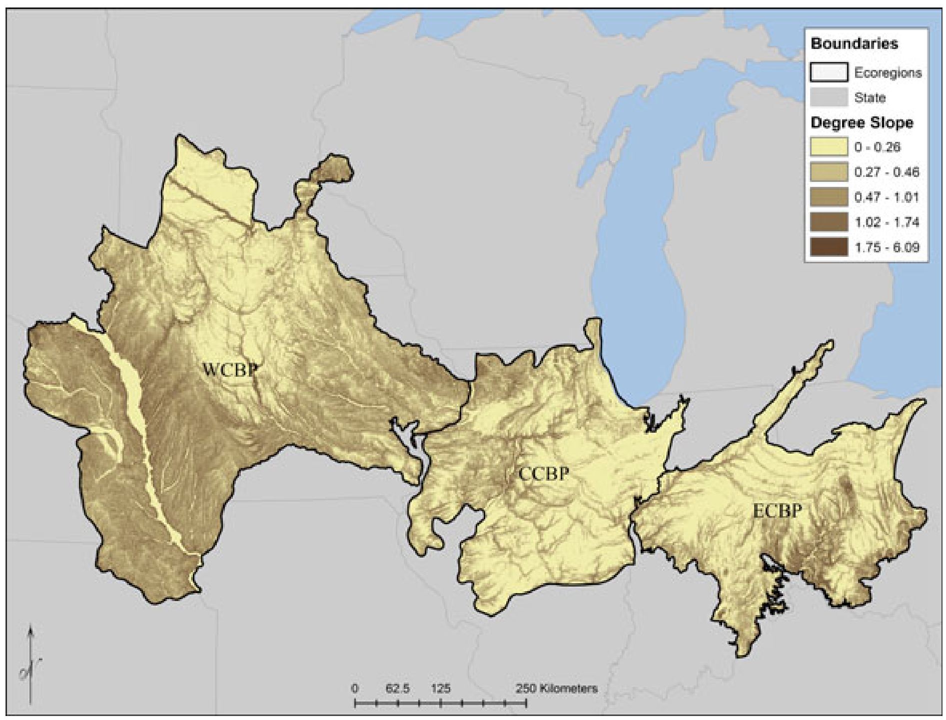

Figure 11. Mean degree of slope across the three Corn Belt Ecoregions at a 500-meter grid resolution using USGS's National Elevation Dataset.

Belt ecoregion in the next two higher-sloped classes (0.51 to 1.0 and 1.01 to 1.5). Water erosion potential, based on terrain conditions, appears to be the highest in the WCBP, but other socioeconomic and land policy factors likely played a role as to why CRP was used more by landowners there than in the other two ecoregions.

The mid-1980s were tough economic times for U.S. farmers. During the 1970s, high commodity prices and an era of inflation encouraged farmers to expand their operations and incur large amounts of financed debt (Harl 1990). The agricultural bubble had burst by the early 1980s as economic conditions changed with lower consumer demand for American farm products. Many Corn Belt farmers were in difficult cash-flow situations as loans taken out at high interest rates became increasingly difficult to service with much lower commodity prices. Credit dried up as the value of the most widely-used agricultural collateral – land – quickly dropped (Anderlik and Walser 1999). Corn and soy producers were hit the hardest, with Iowa and Minnesota (the main WCBP states) having the highest number of financially stressed (technically insolvent) farms by 1984. At that time eight percent of Iowa farms were financially stressed and ten percent of Minnesota farms were in the same financial predicament. On the other hand, only four percent of Illinois farms were considered financially stressed (Hanson, Parandvash, and Ryan 1991) (Figure 12). Though the CRP was not intentionally designed to help struggling farmers, most believe that it helped some agricultural operators remain viable by guaranteeing a fixed income from a portion of their land (Hodur, Leistritz, and Bangsund, 2002; Iowa Official Register, 1999-2000; Nowak, Schnepf, and Barnes 1990; Sullivan et al., 2004).

By the late 1980s, the number of financially stressed farms in the Corn Belt had declined (Hanson et al 1991). In 1992, the WCBP was eighth of 84 Level III ecoregions in the percentage of its area enrolled in the CRP, whereas the ECBP ranked 18^{th} and the CCBP was in 25^{th} place when county data found here were aggregated up to the ecoregion scale for comparison (U.S. Dept. of Agriculture 2012). The subsequent farm bills of the 1990s renewed the CRP, but the emphasis changed to include more diverse types of environmentally sensitive lands (Sullivan et al. 2004). The spatial dynamics of the CRP reinforces that this LULCC (agriculture to grassland) was then and remains potentially ephemeral for any given area that is different than the more permanent change that

Figure 12. *Crowd and auctioneer's wagon at farm equipment auction on a farm near Cresco, Iowa (WCBP), December 19, 1985. (Photographer: Bill Gillette. Used with permission from the State Historical Society of Iowa).*

occurred in the other major land use categorical changes that were happening across the Corn Belt (Figures 13, 14).

Developed Land Change

The leading type of LULCC in the ECBP and CCBP during the study period was the conversion of agricultural land cover to developed (urban) land. Although contemporary drivers of urbanization played a role in creating newly developed land cover within the three Corn Belt ecoregions, historic settlement patterns across the region played a substantial role as well.

By 2000, a regional map showed that the ECBP and CCBP contained more urban places than the WCBP when counties were classified as metropolitan, micropolitan, or rural. Metropolitan counties are defined as those containing or linked to urban places with populations of 50,000 or greater whereas micropolitan counties contain or are linked to urban places with populations of 10,000 to 50,000 in size. Rural counties have population centers of less than 10,000 people (U.S. Bureau of Labor Statistics 2011; U.S. Census Bureau 2012) (Figure 15). In terms of the percentage of counties placed within this classification system, the ECBP was slightly more dominated by urban places (metropolitan and micropolitan counties combined) than the CCBP, while the WCBP was more dominated by rural counties. The spatial and temporal variations in the placement and patterns of these urban (and rural) systems accounted for the differences in developed land-cover change among the Corn Belt ecoregions for the 1973 to 2000 era.

The WCBP had fewer urbanized areas because its urbanized areas lacked the temporal legacy of growth that was found in the ECBP and CCBP. Chicago (CCBP) was a burgeoning railroad hub and Cincinnati (ECBP) was the leading producer of finished pork by the time that the Minnesota, Iowa, and eastern Nebraska prairies (WCBP) were first being converted to farmland (Biles 2005; Cayton 2002; Cronon 1991; Francaviglia 2002; Olson and Naugle 1997). Chicago claimed its national "second city" status by 1900 while Des Moines had only 62,000 residents (Biles, 2005; Cronon 1991; Sage 1974). Minnesota's largest metropolitan area, Minneapolis-St. Paul, lay just outside of the WCBP in a transitional ecoregion to the north. Metropolitan areas that grew within or on the ecoregion's periphery were subordinate to larger cities outside of the WCBP, such as Chicago and Minneapolis-St. Paul, and certain larger regional/national economic activities would primarily remain there (Borchert 1967; Borchert, 1987).

Intra-regional variations between urbanization in the ECBP and CCBP also existed. Metropolitan Chicago became (by far) the most dominant urbanized area within the CCBP (Biles 2005), whereas no overall leader emerged in the ECBP.

Figure 13. *An example of a probable Conservation Reserve Program (CRP) field within the Corn Belt, and its semi-ephemeral existence, is shown in this tall grassy field in rolling topography found in northeastern Nebraska that was photographed in 2002.*

Figure 14. *Another example of probable CRP land as seen in this more level field found in south-central Illinois in 2009. Both fields shown in Figures 13 & 14 had the potential to be returned to agricultural production in subsequent years.*

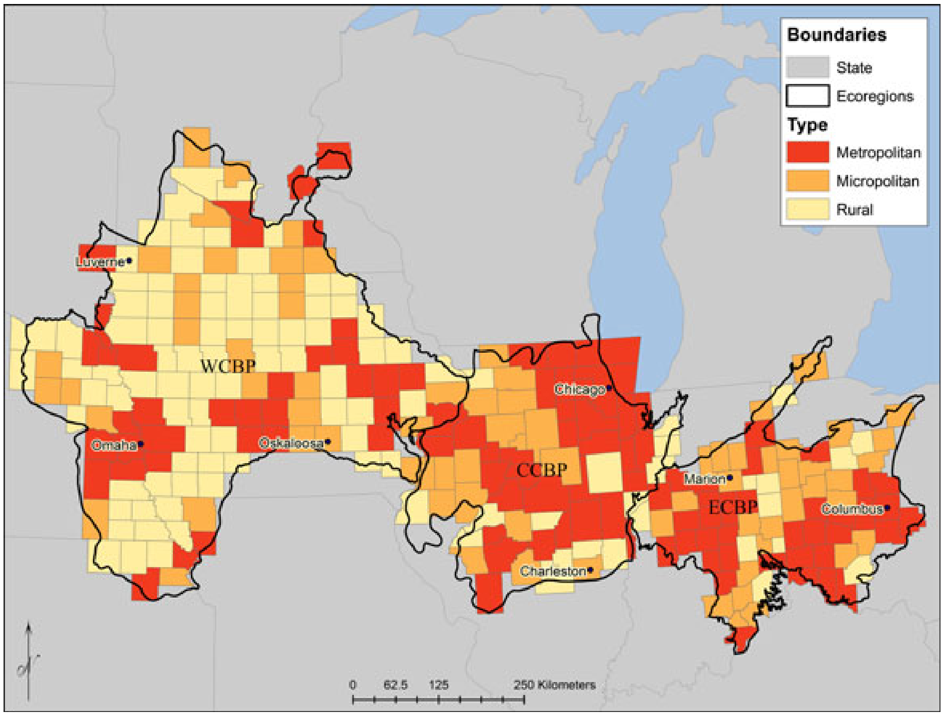

Figure 15. *Corn Belt ecoregions counties classified as metropolitan, micropolitan, or rural in 2000 (based on state maps produced by the U.S. Bureau of Labor Statistics, 2011).*

Figure 16. *Typical suburban growth resulting in advancing land-use change can be seen as a newer housing subdivision borders a crop field within the greater Chicago metropolitan area.*

Metropolitan Indianapolis dominated the Indiana side of the ecoregion, along with Cincinnati-Dayton and Columbus on the Ohio side (Cayton 2002; Furlong 2001). The manufacturing sector of the economy was a major driver of urbanization during the latter 19th and first half of the 20th centuries. Although the Chicago area was the location of a majority of the CCBP's industrial output (Biles 2005), the same situation did not hold true for the ECBP. Indiana's manufacturing did not become concentrated in Indianapolis. Instead, it was spread across smaller developing metropolitan (e.g. Fort Wayne, Lafayette) and micropolitan centers (e.g. Marion, Decatur) (Peckham 2003). A similar pattern developed in Ohio, with Columbus never becoming a large manufacturing center when compared to Dayton and to a lesser extent Cincinnati, as well as smaller Ohio cities in the ecoregion (Cayton, 2002).

Though metropolitan Chicago was the manufacturing heavyweight for the CCBP, smaller urbanized places downstate also grew because of specific manufacturing endeavors, along with growth in the services and educational sectors (e.g. Peoria, Bloomington-Normal, Champaign-Urbana) (Petterchak, 2005). Starting before, and continuing through the study period, large metropolitan urbanization was heavily influenced by the growth of the tertiary (services) and quaternary (information and knowledge) sectors of the economy. The new locations of these activities, as well as the majority of residential growth, were found most pronounced in a ring of suburban or "collar" counties around the central cities (Biles 2005; Furlong 2001; Cayton 2002) (Figure 16). Developed land cover also increased around smaller metropolitan and micropolitan core cities as similar tertiary economic growth occurred, as well as the relocation and retooling of manufacturing often spurred on by aggressive state and local policies (Cayton 2002, Furlong 2001; Petterchak 2005; Waisanen 2003) (Figure 17). Small urban places with little economic diversification often had limited new developed land use (Figure 18).

More "newly developed land" was measured in the ECBP than in the CCBP, largely due to the fact that urbanization was much more "evenly spread" across the ECBP landscape. Instead of urbanization occurring around the fringes of one or two large metropolitan areas, urbanization (along with sub- and exurbanization) in the ECBP was occurring around dozens of smaller yet growing nodes of development – increasing the ECBP's potential for development to continue.

A New Look On a Familiar Region

The findings presented in this paper indicate that the Corn Belt should not be viewed as a singular, monolithic region. Rather, three distinct sub-regions exist, and have been shown to have significantly different rates and trends of LULCC conversions. The major change in the ECBP and CCBP was agricultural to permanent developed land conversion, while in the WCBP the dominant trend was often temporary agricultural to grassland conversion. While conversions to both developed or grassland

Figure 17. *Smaller micropolitan centers continued to expand their own core or had exurban development spring up around them, such as this rural subdivision found approximately five miles north of Marion, Indiana.*

Figure 18. *A farming-dominated smaller community in east-central Illinois that witnessed little growth in developed land cover in recent years.*

uses resulted in a loss of agriculturally productive cropland across the Corn Belt, the potential for that changed land to change again differs among the three regions. Agricultural land that has been changed to grassland has the potential to be quite easily converted back to cropland as the economics of conservation versus production change might dictate. However, agricultural land that was converted to a developed use (e.g. housing subdivisions, roads, golf courses) will likely never revert back to its former use/cover.

Though overall spatial change was low in all three regions, the challenges created by those changes have linked this Corn Belt region to a larger-scale issue that affects nearly every American – competition for its major agricultural commodities. Pollan (2006) described how corn has been transformed into many of the basic components of modern manufactured food. That, along with corn's traditional use as livestock feed, as well as emerging uses such as biofuel and other non-food based products, increases the demand for its production (which may lead to further LULCC). Less obvious consequences of agricultural intensification also remain, such as groundwater degradation due to excess nutrient runoff and infiltration, as well as the continued threat of erosion, although monitoring changes in these conditions takes a different suite of techniques than just detecting land conversions. The questions then become whether to increase the intensity of production in this already agriculturally-focused region, create new agricultural lands in more marginal regions elsewhere, or do both? Recent analysis may indicate that we are following the last pathway (Wright and Wimberly 2013).

While the Corn Belt region can indeed be held together by the notion of its unrivaled ability to produce food, fuel, and fiber, it has been shown that biophysical and socioeconomic conditions have created three distinct sub-regions. The intersection of socioeconomic and biophysical factors was, and continues to be, responsible for these unique divergences of LULCC trajectories.

The Corn Belt remains – and likely will for decades to come – a distinct American region. And while only a small amount of actual land area has changed uses (e.g. agriculture to urban), the real story of change is the intensity of its use. How long these patterns of LULCC continue into the future, as socioeconomic trends evolve and the potential for biophysical changes to the landscape loom (e.g.: climate change), is still uncertain.

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