Delineating the 2007 Corn Belt Region

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1. INTRODUCTION

A continuous region of concentrated corn production emerged over 150 years ago in the states of Illinois, Indiana, Kentucky, Missouri, Ohio, and Tennessee (Warntz, 1957). The first printed use of the term “Corn Belt” was published in 1882 when *The Nation* summarized the week’s news and discussed “some discouraging accounts of the prospects in the corn belt” (Warntz, 1957, 40). The term was first utilized in an academic study in 1903 by a Harvard professor of economics, T.N. Carver. In his report, published in *The World’s Work*, 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). One month later, in the same publication, he wrote an article entitled, “Life in the Corn Belt”, where he concluded that “the corn belt is the most considerable area in the world where agriculture is uniformly prosperous” (Carver, 1903b, 4233).

Agricultural economist O.E. Baker (1927) produced one of the earliest statistically based maps depicting the Corn Belt as a region. His map consisted of climate-, soil-, and topographically-based thresholds that outlined the geographic extent of where corn could best be grown. In 1950 the U.S Department of Agriculture (USDA), in an attempt to better understand the physical and economic forces driving agricultural practices, produced a map of agricultural regions, including the Corn Belt (Figure 1). Their county-level analysis placed counties in the Corn Belt based on “general farming” practices, where corn was the dominant crop, but where raising livestock and rotating corn production with oats, wheat, soybeans, and pasture/hay crops was observed (USDA, 1950).

![FIGURE 1](image-url)
PREVIOUS DEFINITIONS OF THE CORN BELT BY BAKER AND THE U.S. DEPARTMENT OF AGRICULTURE

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Geographers (Hart, 1986; Hudson, 1994) have written about changes in Corn Belt agriculture, such as intensification and specialization, yet no one, including the USDA, has offered a contemporary spatial definition. While maps of various agricultural commodities are produced for the USDA’s Census of Agriculture that is conducted every five years (most recently in 2007), the maps do not provide statistically- or geographically-based boundaries of agricultural regions. Understanding why the Corn Belt’s regional boundaries have and continue to change will shed light upon some of the possible implications and consequences to both human and natural systems in the places where the Corn Belt’s regional boundary has changed.

2. SPATIAL TRENDS AND DRIVERS OF CHANGE

Myriad socioeconomic, technologic, and political driving forces have caused the geography of corn production to shift. The spatial distribution of areas where corn was grown in 2007\(^1\) compared to 1950 illustrates the need for a revised regional definition of the Corn Belt (Figure 2). Using the USDA’s 1950 Corn Belt boundary for reference (shown in white), one can note the loss of corn from the southeast as described by Hart (1968), as well as northern Missouri and southern Iowa where physical limitations of soil and topography have diminished the productive capacity of the land (Laingen and Craig, 2011). Conversely, corn production has increased in areas of western Kansas, North and South Dakotas, and along the region’s northern fringe. Many of these counties experienced an increase of more than 200 square miles (128,000 acres) of corn production since 1950. Richland County, the southeastern-most county in North Dakota, with over 800,000 acres of cropland in 2007, experienced a 30 percent increase in acres of corn harvested between 1969 and 2007. In 1950 only 45 acres of corn were harvested in Stevens County, in southwest Kansas. By 2007, that number had increased to over 140,000 acres. Both of these counties had well over 30 percent of their cropland (or land that became cropland) producing a crop that only decades ago was rarely ever found in those counties – corn.

\(\text{FIGURE 2}
\)
CHANGE IN AREA OF CORN HARVESTED FROM 1950 TO 2007

\(\text{\begin{tabular}{|c|c|} \hline
Square Miles Gained & Square Miles Lost \\
\hline
1 to 50 & 1 to 50 \\
51 to 100 & 51 to 100 \\
101 to 200 & 101 to 200 \\
Over 200 & Over 200 \\
\hline
\end{tabular}}\)

\(1\) Data acquired from the USDA Census of Agriculture from 1950 to 2007 (http://www.agcensus.usda.gov/index.php).
Spatial and temporal trends in the geography of U.S. corn production can be visualized by calculating the geographic centers of harvested corn acres (Figure 3). The initial movement of corn production was northward, as cropland in the south was lost (Hart, 1968) and new corn acreage was planted in and along the region’s northern periphery (Roepke, 1959). Faster maturing hybrids made it possible to grow corn in areas with short growing seasons (such as central Wisconsin and Minnesota) (Bray and Watkins, 1964). In the early 1970s, corn production shifted to the west as irrigation allowed the expansion of corn production to the western plains (Kromm and White, 1991; MacLeod, 2011). Pasturelands in the Corn Belt’s core were converted to cropland (Hudson, 2001) while new corn acreage was planted in the western plains to support cattle feedlots (Hart, 2003). Most recently, from 1997 to the present, cropland planted to corn has continued to shift to the west and to the north, as harvested corn acreage increased along the region’s northwestern periphery. In the late 20th Century, ethanol facilities were constructed in northern Iowa, southern Minnesota, and eastern South Dakota (Laingen and Craig, 2011), enticing farmers to grow more corn. Along with ethanol, restrictions in farm program and crop insurance regulations, that had limited the types and amounts of crops that farmers could grow, were loosened. This allowed farmers, especially those in the Dakotas, to plant whatever type of crop they wished (Johnson, 2009). Because of these changes, farmers who once grew a variety of row crops, small grains such as wheat and oats, and raised livestock are today transitioning to strictly corn and soybeans.

Corn has become a more financially lucrative crop than many of the small grains historically grown in North and South Dakota due to emerging international grain markets in Asia. The South Dakota Wheat Growers Co-op is one of the largest farmer cooperatives in the country with over 5,300 owner-members. They have renovated twelve of their grain elevators

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2 Geographic centers for 2010 and 2011 (shown in gray) were calculated using data from the National Agricultural Statistical Service’s annual agricultural survey (http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats_1.0/index.asp). While these data are not interchangeable with data from the USDA’s Census of Agriculture, they are similar enough to show general trends.
in the James River Valley region of North and South Dakota to handle increasingly large quantities of corn production (Schmit, 2010) in a program called “Connecting to Tomorrow”. These massive facilities will be linked to Pacific Northwest ports and eventually to Asian markets by new loop rail lines. Much of the new corn acreage comes from farmers transitioning from small grain farming to corn and soybean farming. However, some of the new production is a result of declining participation in the USDA’s Conservation Reserve Program (Laingen, 2008). It has become economically advantageous for farmers to grow crops instead of idling lands in grassland conservation programs and hundreds of thousands of acres of cropland have been reopened for production in the past five years (USDA, 2011).

The dynamic nature of land use in this region and the myriad human and natural forces that drive such changes are topics for continued research. This brief introduction to these topics does, however, illustrate the limitations of continued use of the USDA’s 1950 Corn Belt boundary when discussing contemporary issues related to the environmental and socioeconomic changes that have occurred in the region, and justifies the need for a revised Corn Belt boundary.

3. METHODS

The USDA created its 1950 Corn Belt boundary by taking into consideration general farming practices and interpretations of those practices by state-level agricultural experts (USDA, 1950, 1). Those multiple (and variable) interpretations were then sent to Washington D.C., aggregated, and re-interpreted in a process that was never fully operationalized. Therefore, duplicating USDA methods proved impossible. Moreover, even if the USDA’s methods were available, the results would be suspect due to differences between today’s cash-grain agricultural systems and general farming systems of the 1950s. Corn Belt farmers in the 1950s also grew wheat, oats, and alfalfa, and they devoted notable acreages to pasture. Today’s Corn Belt landscape is much less diverse. Farmers focus on growing two crops (corn and soybeans), and much of the land that was once devoted to pasture has been converted to cropland (Napton, 2007). This research offers up new, and more importantly, replicable methods that will allow for future updates of the spatial limits of this dynamic region.

To define the Corn Belt without the help of a prior descriptive rationale, one must first select appropriate agricultural data, and more importantly understand how those data “appear” on the actual rural landscape in which they occur. Three common variables reported in the Census of Agriculture for crops are area (acres), production (bushels), and value (dollars). Acres of harvested corn (used alone, and also in calculations with other area-related variables such as acres of total cropland) was a key measure, as the actual amount of land used for a crop signals a farmer’s intent of how they plan to utilize their land (Hudson, 2012). More often than not, these are long-term decisions carrying with them significant investments in land, machinery, and other agricultural inputs.

Six tests, each consisting of three thresholds, were devised to map the 2007 Corn Belt (Figure 4). To calculate these tests, four sets of county-level data were downloaded in tabular format for use in ArcMap: 1) acres of harvested corn, 2) bushels (bu) of harvested corn, 3) value of harvested corn, and 4) acres of total cropland. These data were obtained from the 2007 USDA Census of Agriculture using their online data query tool3 and were joined (using state and county FIPS codes) to a GIS shapefile of all U.S. counties in the contiguous forty-eight states. The total area (in square miles) of each county was also calculated using the “calculate geometry” tool in ArcMap.


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Thresholds for tests involving normalized areas (Tests 3, 4, and 5) were set using basic, easy-to-understand breakdowns of agricultural land units (based on 80 acre increments). Corn is commonly cultivated in rotation with soybeans; therefore, approximately 50 percent (or 320 acres of each square mile) of a typical Corn Belt county’s cropland should be corn. Test 3 (corn per square mile) and 4 (corn per square mile of cropland) determined this. The former tested for acres of corn against all land area in a county and the latter against only cropland area. Test 5 (Total cropland per square mile) measured how much of a county’s total area was cropland. This variable was assigned greater importance to counties with large proportions of agricultural land. For example, using Test 4 a county could score high if a small ratio of cropland to total land area was planted almost entirely to corn. This small ratio of cropland to total land area would be caught using Test 5. Three other variables – Test 1 (bushels of corn harvested), 2 (acres of corn harvested), and 6 (value of corn harvested) – were non-normalized data. The thresholds for these were set by displaying the data in ArcMap and determining logical breakpoints using even, easily understandable numbers (e.g., 10-20 million bushels, $25-$50 million).

Rarely do regions have precise boundaries where one region ends and another region begins. Rather, as one travels from the core of a region out towards its periphery, the variable(s) that hold the region together tend to fade. With this in mind, as one looks at a map showing “acres of harvested corn” (Figure 5) it becomes clear that drawing a border around a group of “similar” counties could prove difficult because of the salt and pepper-like appearance of the map. To remedy this, the six datasets (from Figure 4 above) that were tested were “smoothed” by implementing a spatial join.

The spatial join function calculates the average value for a county using that county’s value and those of its intersecting neighbors. This “data averaging” helps create more spatially cohesive regions by reducing the number of “outliers”. Common examples of “outliers” (found
in the Corn Belt) are those that may contain large urban areas or sizeable lakes and rivers, or simply counties whose size is much smaller or larger than their adjacent neighbors. Though these counties may not have corn acreage that rivals their neighbors, they should, nevertheless, be considered as being “in” the broader region.

Before the spatial join was run, to take the data smoothing and outlier removal a bit further, each county was given a 20-mile buffer\(^4\). Now, instead of a county’s value being influenced only by its adjoining neighbors, any county intersecting the 20-mile buffer was included in the averaging. The 20-mile buffer surrounding Watonwan County, Minnesota is displayed in Figure 6. The border of Watonwan County intersects with five other counties. If only the spatial join had been run, data from those five counties (and its own) would have been averaged. Use of the 20-mile buffer increased that number to ten counties. When one compares the regional maps in Figures 5 and 6, the smoothing effect produced by the buffering and spatial join becomes evident. While the raw numeric values of each county were changed, the smoothing techniques were successful in creating a more spatially cohesive visualization of the region.

![FIGURE 6](image)

**FIGURE 6**
**EXAMPLE OF DATA (ACRES OF CORN) PRIOR TO BUFFER AND SPATIAL JOIN USING TEN COUNTIES IN SOUTHERN MINNESOTA**

After the county-level data had been downloaded, joined to the county-level shapefile, had calculations, buffers, and spatial joins run on them, they were ready to be assigned values (0 to 3) based on the test thresholds. This was done in ArcMap by using the “select by attributes” function, querying for the upper and lower thresholds of the data and test in question, and assigning the selected counties a value of 0, 1, 2, or 3. When completed, the resulting scores, corresponding to each of the six tests for each county, were summed. This produced scores for each county ranging from 0 to 18.

4. RESULTS

Over 3,000 counties were analyzed. A total of 2,268 counties received a score of 0. These were counties where corn production, row-crop agriculture, or agriculture in general was virtually non-existent. A total of 222 counties received a score of 1. They met the lowest threshold in only one of the six tests. These counties were not considered to be part of the Corn Belt. Many were found in areas quite distant from the Corn Belt (e.g., Arkansas, west Texas, central Kansas, Washington, and Montana), and met only the lowest threshold for Test 5 (total cropland per square mile). These counties have cropland, but not at the same density as counties within the Corn Belt. Test 2 (corn acreage harvested) also revealed that very little of

\(^4\) Twenty miles was chosen because most counties in the Corn Belt are anywhere from 18 to 30 miles tall/wide. This would allow the inclusion of additional counties within the 20-mile radius, further “smoothing” the data.
that cropland was used for corn production. Other areas with scores of 1 included counties along the east coast, as well as a ring of counties along the region’s eastern and northern borders (southern Indiana, central Ohio, Michigan, and Wisconsin). These counties met only the lowest threshold for Test 4 (corn per square mile of total cropland). Cropland and corn production are indeed found in these counties, but only 25 to 38 percent of cropland was planted to corn.

Counties were then grouped into more meaningful classes (Figure 7). After excluding counties with scores of 0 or 1, those remaining (2 to 18) were grouped into categories that represented the importance and intensity of both corn and overall agricultural production. The first grouping of counties, those scoring 2, 3, or 4, were identified as being “Peripheral” to the Corn Belt. While most of these counties were physically adjacent to counties with higher scores (which is likely a product of the buffering and spatial join techniques that were utilized), their scores were too low (meeting only one maximum threshold or two to three minimum thresholds) to be considered a viable part of the Corn Belt.

**FIGURE 7**
MAP OF THE NEW CORN BELT
CORN BELT INCLUDES THOSE THAT SCORED 5-18 POINTS

Counties that attained a score of 5 were deemed to be “Marginal”, and in the final analysis were included in the 2007 Corn Belt. A step closer (spatially) to the region’s core, these counties were found in areas with recent increases in corn production (North Dakota, South Dakotas, Nebraska) or, as in Ohio and Indiana, where corn production has always been important, but not overwhelmingly so. The continued inclusion of these counties within the boundaries of the Corn Belt will likely depend upon annual variability of environmental factors (namely weather) and/or technological and socioeconomic forces that influence the abundance and intensity of continued corn production (e.g., enhancements in infrastructure, changes to export markets, costs of production, value of production, local-regional markets, and changes in agricultural practices of adjacent regions).
The next grouping consisted of counties scoring 6 to 12. These were considered typical “Corn Belt” counties. They met either the minimum threshold (a score of 1) on each of the six tests, or met higher thresholds (scores of 2 or 3) on two to four of the tests. These counties were either within or in close proximity to the USDA’s 1950 boundary. It also included recent additions to the region such as counties in northeast South Dakota, southeast North Dakota, southern Illinois, counties along the region’s northern periphery, and an island of four counties in southwest Kansas that have emerged with continued use of center-pivot irrigation (Kromm and White, 1991).

The final class was comprised of counties that scored from 13 to 18 that included a total of 120 counties that served as the “Core” of the Corn Belt. Twenty-two counties (ten in Illinois and twelve in Iowa) scored 16 or higher. The core consisted of three separate sub-regions labeled in Figure 7 as A, B, and C: the Grand Prairie of central Illinois (A), the Des Moines Lobe glacial region of north-central Iowa and southern Minnesota (B), and an area of irrigated corn found in east-central Nebraska along the Platte River (C). Interestingly, two of these areas attained “Core” status by draining excessive water from the land through tiling and ditching during much of the 20th Century while the third achieved it through irrigation. Indeed, much of what helped to create the Corn Belt was based on the region’s physical geography (namely climate, slope, and soil quality), but humans, both in the region’s core and along its periphery, have played an ever-increasing role in changing this region’s geographic limits (Reganold et al., 2011).

5. CONCLUSION

“Anyone who ventures forth to explore the real world soon discovers that it is equal parts fearfully untidy and extraordinarily fascinating, and the search for order in its apparent chaos and confusion is a challenging but rewarding experience” (Hart, 1982, 22). Regions are rarely discrete physical entities (Oldstad, 2012); more often they are conceptualizations that reflect people’s perceptions of spatial patterns of how land is organized and used. The Corn Belt is no different. As Hart (1982) stated thirty years ago, “The purpose of regional geography is to understand areas, not merely to draw lines around them.” This exercise has shown that a basic understanding of the Corn Belt’s regional history, the driving forces that helped to create that history, along with proper application of data analyses and mapping techniques, can create a product that helps us better understand a dynamic region such as the Corn Belt.

Results from this work will be used to analyze data from earlier agricultural censuses to:
1. determine the applicability of using the set thresholds on older data (testing for repeatability of the techniques used), and
2. to create a time-series of maps that shows the region’s changing boundary over the past half-century.

Similar methods will also be applied to forthcoming data from the 2012 Census of Agriculture that is currently being administered and whose results will be released in February 2014.

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