Changing Cropland Combinations in Wisconsin
1949-1992

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Abstract
Utilizing Weaver's methodology for classifying crop combinations, this paper examines changes in agricultural land use in Wisconsin between the 1940s and the early 1990s. According to Weaver, in 1949 a Corn-Oats-Hay crop combination predominated throughout most of the state, with 57 counties so classified. Hay or Hay-Oats were predominant in eleven counties of northern Wisconsin, while a Corn-Hay-Oats-Barley combination dominated in three east-central Wisconsin counties. In 1992 only two counties in the state displayed the Corn-Hay-Oats combination, with 49 counties being predominantly Corn-Hay. Statewide, the cropland devoted to oats had declined by 2.26 million acres. The expansion of soybeans resulted in eight counties in southern or eastern Wisconsin having either the Corn-Hay-Soybeans or Corn-Soybeans crop combination in 1992. The production of specialty crops, particularly of vegetables, potatoes, and cranberries, increased substantially during the period being investigated, while the production of rye and tobacco declined sharply.

Introduction
Agricultural production and land use in Wisconsin have undergone tremendous change in the half century since the first meeting of the Wisconsin Council for Geographic Education, the forerunner of today's Wisconsin Geographical Society, in the mid-1940s. Data provided by the U.S. Department of Commerce and the Wisconsin Agricultural Statistics Service for various years show substantial change in both the overall pattern of land-use, and relative change in the contributions of specific agricultural sub-sectors to the total farming "picture" of the state.

In 1945, for example, Wisconsin had 177,745 farmers. Fifty years later the state had 80,000 farmers. In 1950 Wisconsin had 116,500 dairy farms, down from 154,156 in 1945. By early 1996, the number of Wisconsin farmers with producing dairy cows had dropped to 26,046. California overtook Wisconsin as the nation's leading milk producer in 1993. Whereas fifty years ago more than eighty percent of Wisconsin's farmers reported milk sales (81.2 percent in 1949), by 1996 this figure had fallen to one third (32.5 percent).

The acreage of cropland harvested also fell over the period from the 1940s to the 1990s, although not as precipitously as did dairy farming. According to the 1950 Census of Agriculture, 10,112,027 acres of cropland were harvested in 1949, down from the all-time high of 10,544,975 in 1944, but still 296,063 acres more than in 1939. In contrast, the 1992 Census of Agriculture reported 8,843,649 acres of cropland harvested in Wisconsin in 1992.

Although the declining number of active dairy barns is conspicuous evidence that many Wisconsin farmers have left dairying, what other major changes can be identified in the state's agricultural production over the past several decades? With fewer cows and fewer active dairymen, have farmers altered their mix or crops? Additionally, what changes have occurred in the state's crop production and regional agricultural patterns?

Regionalization of Agriculture: The Literature
More than forty years ago John C. Weaver published his seminal "Crop Combination Regions of the Middle West" (1954a), which was the most detailed approach to U.S. agricultural regionalization ever attempted. Going much farther than the notion of "one crop regionalization," which he viewed as an oversimplification, Weaver developed a system which examined the complex pattern of crop combinations at the local level. Weaver's crop combination classification schema accounted for the greatest acreage of cropland in a particular county, while allowing minimal possible deviation among the various possible theoretical combinations, ranging from one-crop monocultures to seven-crop combinations. For example, according to Weaver the combination for Winnebago County in 1949 was Corn-Oats-Hay (1954a).

Using the statistically determined cropland combination for each county, Weaver produced maps of crop combination patterns for 1919, 1929, 1939, and 1949, permitting temporal shifts in the regionalization
of agricultural production to be analyzed (1954a 1954c).

Weaver's methodology was not without its critics. For example, Gregor (1970 115) wrote,

The difficulty of determining the boundaries of the different field combinations, even in localized areas, is shown by the almost-confusing variety of regions mapped by Weaver for the American Midwest.

Furthermore, in some circumstances the "least squares" methodology results in a multiple crop combination which failed to indicate a single crop which may have been dominant. Nevertheless, Henshall (1967 440) argued that "the area in which Weaver developed his method, the Midwestern United States, was particularly suited to this type of classification."

**Methodology**

The methodology utilized in the present project is virtually identical to that outlined by Weaver, permitting comparisons to be made between his results and those obtained from 1992 Census of Agriculture data. Data for all crops which occupied at least one percent of the total harvested cropland in each of Wisconsin's counties were arranged in rank-order, from the largest percentage to the smallest. The grouping of one or more crops to characterize the cropland combination in each county was statistically determined, by noting which grouping had "actual percentages that showed the smallest deviation from the theoretical curve" (Weaver 1954a 180).

The theoretical curve used by Weaver assumed that if one crop was grown it would account for 100 percent of the acreage; if two crops were grown each would account for 50 percent; if three crops were grown each would account for 33.3 percent, and so forth. For each grouping of crops, the sum of the squared differences (between the theoretical percent of cropland and the actual percent of cropland) was calculated and divided by the number of crops in the grouping. Thus:

$$ s^2 = \frac{\sum d^2}{n} $$

where \( d \) is the difference between actual crop percentage in a given county and the appropriate percentage in the theoretical curve, and \( n \) is the number of crops in a given combination (1954a 180).

The combination which had the smallest deviation was used to classify each county, and Weaver mapped a small number of counties as being transitional between two or more crop combination regions, drawing the boundaries through several counties rather than following county boundaries as typified most of his mapping. Because it was unclear to the present writer what criteria Weaver utilized for such splitting of counties, statistics from the 1950 Census of Agriculture were utilized to reclassify those few counties into single crop combination regions, permitting a more consistent comparison of the 1949 crop combination regions with the 1992 regions. Computations using agricultural sales data were conducted in a manner similar to those using cropland harvested. However, because such sales data is not reported by the U.S. Census Bureau for all crops or livestock products, but rather, for only seventeen key items, plus three catch-all miscellaneous categories (e.g.: "other grains", "other crops", and "other livestock"), certain slight adjustments became necessary.

**Cropland Combination Patterns in Wisconsin - 1949**

A Corn-Oats-Hay combination was most common in Wisconsin counties in 1949, with 57 counties being so classified (Figure 1). In the northern third of the state, where corn was far less frequently grown, the cropland combination was either Hay-Oats, noted in four counties (Taylor, Lincoln, Oneida, and Forest), or simply Hay, which predominated in all the counties along Lake Superior, plus Vilas, Price and Florence. Within these northern counties, the proportion of cropland devoted to hay ranged from 68.2 to 78.7 percent. Weaver identified a Corn-Hay-Oats-Barley crop combination for three counties of east-central Wisconsin (Calumet, Door, and Kewaunee). In addition, he mapped the aforementioned combination as being transitional in parts of adjacent Brown and Manitowoc counties, which should statistically classify as Corn-Hay-Oats. Recalculations using the 1949...
Crop Combination

- Hay
- Hay - Oats
- Corn - Hay
- Corn-Hay-Oats
- C-H-O-Barley
- C-H-Soybeans
- Corn - Soybeans
- No cultivation

Specialty crops:  
P = potatoes  
R = rye  
T = tobacco  
Tf = tree fruits and berries  
V = vegetables

Note: Crop combinations based upon Weaver (1954).

Figure 1. Crop Combination Patterns, 1949
census data indicates that Weaver's Corn-Hay-Oats-Barley classification is not justified in Kewaunee County (which should be classified Corn-Oats) and that a Corn-Hay-Oats combination has a slightly lower least squares calculation in Calumet county (114.54 versus 115.10, probably caused by my calculations using production data to the nearest tenth of a percent, versus Weaver's apparent rounding to the nearest percent). Nevertheless, barley, the fourth crop in the combination, accounted for 6.8 to 9.6 percent of the cropland in these counties.

Hay was the most widely grown crop in 54 of Wisconsin's 71 counties in 1949. Corn held the leading position in 12 counties and oats held that position in five counties. Hay held the second place position in nine counties where either corn or oats led. Oats was the most common second-rank crop, having this position in 43 counties.

Specialty crops, defined as those exceeding 2.5 percent of the harvested cropland in a county, were noted in 29 of Wisconsin's 71 counties in 1949. Corn held the leading position in 14 counties, and soybeans held the third position in 12 counties. Hay held the second place position in nine counties where either corn or oats led. Oats was the most common second-rank crop, having this position in 43 counties.

In contrast to 1949, a Corn-Hay combination predominated across most of Wisconsin in 1992, with 49 of the state's counties displaying this two-crop combination (Figure 2). To a large degree, the counties displaying the Corn-Hay combination in 1992 had displayed the Corn-Hay-Oats combination in 1949. Only two counties in the state, Langlade and Door, had the Corn-Hay-Oats combination in 1992, and in Door county the strong presence of two specialty crops entered the calculations of the minimum least squares.

Six counties in southeastern Wisconsin, plus Winnebago county, displayed a Corn-Hay-Soybeans crop combination in 1992, a combination which did not exist in the state in the 1940s. An additional county, Racine, exhibited the two crop Corn-Soybeans combination. Indeed, in Racine county soybeans accounted for 31.2 percent of the harvested cropland.

Two counties, Oneida and Vilas, both of which are in northern Wisconsin, were mapped as having the Hay-Oats combination in 1992, down from four counties so classified in 1949. Ten counties in northern Wisconsin had the single crop Hay classification in 1992, an increase of three additional counties since 1949. Hay acreage in these counties averaged 84.0 percent of the harvested cropland. Hay occupied the largest acreage of any crop within 46 Wisconsin counties in 1992. Corn held the primary rank in 24 counties, and soybeans held this position in one county. Corn occupied the second largest proportion of cropland in 39 counties, oats in five counties, and soybeans in four counties. Cranberries, potatoes, and vegetables each occupied the second rank in a single county.

Thirty-five counties devoted at least 2.5 percent of their harvested cropland to a specific specialty crop in 1992, an increase of six counties since 1949. Although the domination of the counties of eastern Wisconsin in the production of specialty crops continued, significant changes can be noted in the role of vegetable and potato production. For example, in Adams county of central Wisconsin, the production of potatoes and vegetables together accounted for more than forty percent of the harvested cropland. Although Weaver's classification methodology shows Adams county as having a Corn-Hay crop classification for 1992, the acreage of both potatoes and vegetables, individually, were nearly twice that of hay. Thus, the proportion of cropland devoted to specialty crops in some counties rose substantially. Besides vegetables and potatoes, mapped as specialty crops in 29 and nine counties, respectively, tree fruits and berries exceeded the 2.5 percent harvested acreage threshold in four counties in
Crop Combination

- Hay
- Hay - Oats
- Corn - Hay
- Corn-Hay-Oats
- C-H-O-Barley
- C-H-Soybeans
- Corn - Soybeans
- No cultivation

Specialty crops:  M = mint  N = nursery crops  P = potatoes  Tf = tree fruits and berries  V = vegetables

Figure 2. Crop Combination Patterns for 1992
A comparison of the 1949 and 1992 crop combination patterns clearly demonstrates that while corn and hay continued as mainstays of Wisconsin agriculture, new crops arrived and the importance of several "older" crops declined. The decline of oats and barley was particularly significant. For example, 27.2 percent of the state's harvested cropland was devoted to oats in 1949. In 1992 this figure was 5.5 percent, a decrease of 2,262,452 acres. During this same time period, the acreage of barley harvested declined from 169,689 to 64,255. Rye production was locally important in 1949 and was mapped by Weaver as a specialty crop in seven counties. Statewide, 90,849 acres of rye were threshed or combined in 1949. In 1992 only 13,148 acres of rye were harvested for grain and no county had even two percent of its cropland devoted to its production.

While the cultivation of oats, barley, and rye declined precipitously, the acreage devoted to the cultivation of corn and soybeans increased dramatically. The cropland devoted to corn production increased by 1,103,162 acres, from 26.3 percent of Wisconsin's total harvested cropland in 1949 to 42.6 percent of the state's total harvested cropland in 1992. This increase represented a near-doubling of the acreage of corn harvested for grain, as the acreage devoted to corn silage decreased by 118,083 acres. Soybeans, which were harvested from 56,705 acres statewide in 1949, were harvested from 575,087 acres in 1992, at which time it represented 6.5 percent of the state's harvested cropland. However, unlike corn production, which occurred throughout most of the state -- with the exception of the northernmost counties -- the introduction of soybeans was much more regionalized into portions of southeastern, south-central, and east-central Wisconsin.

Not only did oats fall from the rankings as the first or second crop within many Wisconsin counties, but the proportion of the harvested acreage devoted to the leading crop actually increased within the majority of counties (Table 1). With oats dropping out of the Corn-Oats-Hay combination and being replaced by Corn-Hay in most areas, fewer crops accounted for the preponderance of the state's cropland in 1992.

### Changing Specialty Crop Production 1949-1992

Specialized production of vegetables (exclusive of potatoes) grew from 234,456 acres in 1949 to 347,581 acres in 1992, with the increases highly regionalized. Besides central Wisconsin's Adams and Waushara counties, where vegetable production accounted for 27.4 and 21.5 percent of harvested cropland, respectively, in 1992, vegetable fields exceeded 7.5 percent of the harvested cropland in eight additional counties (Columbia, Dodge, Fond du Lac, Green Lake, Oneida, Ozaukee, Portage, and Sheboygan).

Potatoes, although exceeding the 2.5 percent harvest threshold in nine counties, were particularly prominent in Adams and Langlade Counties (22.7 and 18.9 percent of harvested cropland, respectively). Statewide, the acreage devoted to potatoes increased 36.7 percent between 1949 and 1992.

Tree-fruit and berries were mapped as a specialty crop in only one county (Door) in 1949. At that time Door county had 11,861 acres of fruit trees, mostly apple and cherry. By 1992 Door county's orchards had declined to 4,436 acres, 5.3 percent of its harvested cropland. However, three new counties boasted a tree-fruit and berries specialty crop. In these northern or central Wisconsin counties (Oneida, Vilas, and Wood), the production of berries, particularly cranberries, has

### Table I. Number of Wisconsin Counties* in Various Crop Combination Regions

<table>
<thead>
<tr>
<th>Crop Combination Region</th>
<th>1949</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Corn-Hay</td>
<td>0</td>
<td>49</td>
</tr>
<tr>
<td>Corn-Soybeans</td>
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<td>1</td>
</tr>
<tr>
<td>Hay-Oats</td>
<td>4</td>
<td>2</td>
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<td>Corn-Oats-Hay</td>
<td>57</td>
<td>2</td>
</tr>
<tr>
<td>Corn-Soybeans-Hay</td>
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<td>7</td>
</tr>
<tr>
<td>Corn-Oats-Hay-Barley</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

*Excludes Menominee County, which had no measurable cultivation.

Source: Compiled from data supplied by the U.S. Census of Agriculture (various years)

Specialized production of tobacco has declined in significance in Wisconsin in recent decades. Statewide 19,719 acres of tobacco were harvested in 1949, and tobacco production in Vernon county, with 8,073 acres, accounted for 4.3 percent of that southwestern Wisconsin county's harvested cropland. In 1992 Wisconsin's total tobacco harvest was 7,379 acres, less than Vernon county's acreage forty-three years previously. By 1992, tobacco accounted for only 1.5 percent of Vernon county's cropland, well below Weaver's specialized crop threshold. On the other hand, a new specialized crop exceeded his reporting threshold in Marquette county (central Wisconsin). There, in 1992 mint was grown on 3,927 acres or 5.9 percent of the county's harvested cropland. Statewide, 16,132 acres were devoted to production of mint for oil. Although ginseng is another new crop, of which 1,234 acres were harvested in Marathon county in 1992, that figure was less than one percent of the harvested cropland in Wisconsin's largest county -- the county which figured in 86.4 percent of Wisconsin's ginseng production in 1992. However, the total acreage devoted to ginseng cultivation was several times greater than the acreage harvested because of the lengthy time period between planting and harvest of that crop.

Continued Reliance on Dairying for Farm Income

Weaver's least squares methodology is less successful when considering farm income, largely because for most counties milk sales account for approximately half of farm income, with the second most important product being responsible for only a sixth to a quarter of farm sales. In such circumstances, the more items which are entered into the least squares equation, the lower the deviation. Thus, for nearly half the counties, the resultant multiple farm product combinations would mask the dominant role of dairying. Therefore, the methodology was slightly modified by excluding additional sales once either the first dip in least squares had been reached or at least eighty percent of total farm sales were accounted for by the products listed.

Dairy products, or a combination of dairy products and livestock sales -- chiefly beef cattle or "dairy beef"-- provided the farm sales "least squares" combination classification for 43 of Wisconsin's counties in 1992. As can be seen in Figure 3, the main exception to this categorization was a belt of counties extending from southeastern Wisconsin, through central Wisconsin into north-central Wisconsin. Nevertheless, even in most of these counties, milk played a major role in farm sales. In southeastern Wisconsin, a variety of field crops (particularly corn and soybeans), specialty crops, and other livestock sales all supplemented dairying. In central Wisconsin, specialty crops (especially potatoes, vegetables, cranberries, and in Marathon county, ginseng) each provided over ten percent of farm sales. Only in four counties did dairying not figure into the classification. These were Menominee, Milwaukee, Oneida, and Vilas. Menominee county -- all of which is an Indian reservation -- had no harvested cropland nor dairying in 1992. Highly urbanized Milwaukee county had only two commercial dairy farms, with most farm revenue coming from greenhouses or nursery crops (Cross 1995). Mostly forested Oneida county likewise had only two dairy farmers, and Vilas county, adjacent to Michigan's Upper Peninsula, had none.

The proportion of Wisconsin's total farm income derived from the sale of dairy products remained relatively unchanged over the past half century, rising slightly from 52.0 percent in 1949 to 54.2 percent in 1992, even though -- as has been noted -- the proportion of farmers milking cows dropped sharply. Nevertheless, the spatial pattern of dairy sales was highly variable across the state (Figure 4), ranging from some counties which had no dairy farms (and relatively little other farming) to other counties where agriculture was a major business, in which dairying did, or did not, provide the bulk of farm income. For example, Adams county, with large sales of vegetables and potatoes, obtained only 11.8 percent of its 1992 farm income from the sale of dairy products. Conversely, dairy product sales provided 78.5 percent of Clark county's agricultural income. Furthermore, in most counties sales of cattle and calves ranked second to
Figure 3. Farm Sales Combination Patterns for 1992

Significant specialty crop and livestock sales: G=ginseng H=hogs L=livestock N=nursery P=potatoes Pe=poultry+eggs Tf = tree fruits and berries V= vegetables
Figure 4. Percent of Farm Sales From Dairying, 1992
dairying in total sales. In four additional counties either poultry or "other livestock" held this second position, strengthening the conclusion that most of Wisconsin's agricultural economy is livestock based.

Summary/Conclusions

As has been shown in the preceding discussion, Weaver's nearly half-century-old crop combination methodology provides a useful tool for examining Wisconsin's changing pattern of crop production. Most of the state shifted from a predominately Corn-Oats-Hay crop combination to a Corn-Hay classification between the late 1940s and the early 1990s. However, the trends of change in Wisconsin's agriculture over the past half century have been contradictory.

Although fewer crops account for more cropland in most counties and the dominance of hay and cornfields have increased, more areas have noteworthy production of specialty crops. Moreover, although a much smaller proportion of Wisconsin's farmers milk cows, overall milk sales accounts for a larger share of the state's farm sales. Wisconsin is not alone in witnessing tremendous agricultural change. Moreover, the entire "Corn Belt", which overlaps into a small portion of Wisconsin, has witnessed the rise of soybeans (Hart 1986). Likewise, the development of new hybrids and a strengthening world market caused the production of cash corn crops to expand northwards (Hudson 1994). Given the observations of Napton (1989) that there is a "persistent theme among rural geographers to describe and interpret the changing distributions of crops and livestock", one can only speculate about the conditions which will characterize Wisconsin's agricultural scene when members gather to celebrate the centenary of the Wisconsin Geographical Society in the year 2046.

Literature Cited


