THE CONCRETE STAVE SILO LANDSCAPE: DIFFUSION OF AGRICULTURAL TECHNOLOGY IN NORTHEASTERN SOUTH DAKOTA

BY

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AGRICULTURAL TECHNOLOGY IN NORTHEASTERN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a
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requirements for this degree. Acceptance of this thesis does not imply that the
conclusions reached by the candidate are necessarily the conclusions of the major
department

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ABSTRACT

THE CONCRETE STAVE SILO LANDSCAPE: DIFFUSION OF AGRICULTURAL TECHNOLOGY IN NORTHEASTERN SOUTH DAKOTA

James D. Sampson

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Geographic diffusion of agricultural landscape features gives us a picture of our state history. This thesis is a geographic analysis of the business history (1937-1967) of Watertown Cement Products Company, based in Watertown, South Dakota. It examines how the constructed products of a single company gave a unique character to the landscape of a large portion of the state of South Dakota and a picture of the importance of silage and silos. The research applies GIS technologies to map and analyze the spatial patterns over this landscape. Cultural landscape change and diffusion models were used to define the spread of Watertown Cement Products concrete stave silos over time. The results show that there were multiple influences that determined the diffusion of concrete stave silos across the state of South Dakota.

Keywords: silo, silage, agricultural landscape, GIS, diffusion
Chapter 1 - Introduction and Literature Review

Introduction

The red barn with cows, chickens, a field, and silo symbolizes the American family farm. The farm silo is an especially visible landscape element, and has come to define agricultural landscapes in many parts of the United States, but especially in the Midwestern corn belt. The silo is representative of a complex of structures belonging to the mixed crop-livestock farm of the early and mid-twentieth century United States (Hudson, 2010). The silo, visible from a great distance, often outlasts barns and other farm buildings. It stands as a relic to changing agricultural economies and technologies. The silo and another Midwest landscape feature, the shelter belt of deciduous and coniferous trees, are sometimes the only way to distinguish a farm location. It is a remnant of the past embedded in today's landscape and demands documentation (Conzen, 2010). Study of the introduction and spread of the concrete stave silo in northeastern South Dakota will contribute to our understanding of how landscapes are created and changed through time.

Agricultural landscapes of the Midwest

Geographers John Fraser Hart, John Hudson, and Michael Conzen have had a long and abiding interest in the making of farmlands in the Midwest. The first change to the upper Midwest and South Dakota farm landscape was the plowing of the grassland and planting of wheat in the late 19th and the early 20th centuries. Shortly after, railroads and grain elevators spread across the plains for transportation and storage of the wheat crop (Conzen, 2010). The wheat frontier was part of western settlement progress.
Railroad based settlements with grain elevators, grain bins, and silos for cattle feed were visible in the spread to the west across the plains (Hudson, 2010). Many of the patterns of towns across South Dakota are as dependent upon the railroads as they are on the roads in the state. Corn replaced wheat across Wisconsin and Minnesota when farmers found their land conducive to dairy production. With increased dairy production, the use of silage became common, and silos to contain silage were built (Hart and Ziegler, 2008). Another landscape feature of the Midwest is the grid system of surveying initiated by Thomas Jefferson. In eastern South Dakota we have roads every mile both east to west and north to south. The thought at the time was that one square mile of land would be sufficient for any farmer. This type of thinking assumed that land fertility and moisture remain constant throughout the region (Jackson, 1994). Other landscape traits such as water towers, courthouses, and grain elevators have also engaged the interest of cultural geographers.

**Farm Silos as Landscape Elements**


Landscape characteristics are the tangible evidence of the activities and habits of the people who occupied, developed, used, and shaped the land to serve human needs; they may reflect the beliefs, attitudes, traditions, and values of these people. (United States. National Park Service. Interagency Resources Division, 1990)

The farm silo, the subject of this work, is a prominent and lasting icon on the South Dakota landscape. South Dakota silos have been constructed from wood, brick, tile, poured concrete, fiberglass lined steel, and concrete staves. The introduction of silos around the turn of the twentieth century allowed farmers to have nutritious feed available
year round. A silo became an important farm feature when a better way to keep silage or ensilage was needed. It was discovered that keeping chopped green feed in a partially fermented state without exposure to outside air would provide a nutritious and palatable feed for cattle. The dairy industry was most interested in having a consistent form of nutrition year round. A beef cow-calf operation only needs winter feed of sufficient quantity and quality to maintain the cow until spring calving. A dairy farmer produces milk all winter and needs feed that will provide excess nutrition to produce a constant milk supply. The first attempts at silage storage were pits in the ground where silage was piled and packed. These trench silos were not completely air tight, and had problems with contaminants from the surrounding soil. The solution was found in the vertical cylindrical silo.

This research is a study of the concrete stave silo landscape of northeastern South Dakota. It is a geographic analysis of the business history (1937-1967) of Watertown Cement Products Company, based in Watertown, South Dakota. It examines how the constructed products of a single company gave a unique character to the landscape of a large portion of the state of South Dakota. It also looks at diffusion of an agricultural innovation through time and space using GIS mapping and analysis techniques.

Some driving questions of the research are:

- How has silage technology changed over time and how has this change impacted the agricultural landscape of South Dakota?
- What factors have influenced the decline of silo construction in South Dakota?
• Why was the Watertown Cement Products Company (WCPC) so historically successful, or was it?

• What is the geography of silo adoption and which diffusion theories best fit silo adoption in South Dakota?

• Is there a genuine clustering of silo construction in northeastern South Dakota? If so, what explains the clustering?

**Diffusion Literature**

This section of the thesis looks at the fundamentals of diffusion theory and how it applies to agricultural innovation. The remainder of the chapter defines study areas in northeastern South Dakota.

The spread of the concrete stave silo across northeastern South Dakota is most likely driven by diffusion theory. The main types of diffusion are expansion and relocation (Jordan and Rowntree, 1990). Expansion diffusion is important in this study since it occurs when neighbor influences neighbor and innovators educate receptive future adopters. Relocation diffusion is less valuable to this study because it involves the transfer of knowledge accompanied with a move from a distant location. The placement of the first silos in the area of study was not the focus of this thesis. Expansion diffusion is commonly separated into three types: contagious, hierarchical, and stimulus. In a silo study, stimulus diffusion would apply if the end user would change the type of silage or silo to use on his farm after being inspired by a different usage. An example would be a farmer that fills his silo with alfalfa instead of corn since he is not able to grow corn because his climate is too dry. Stimulus diffusion was not observed in northeastern South Dakota. In the following figures, each circle represents an entity that might influence or
be influenced by neighboring entities. Contagious diffusion begins at one point, spreads to all neighbors, and continues out in all directions (Figure 1).

Contagious diffusion was rarely observed during this study and only in small areas that would be difficult to differentiate from hierarchical diffusion. Hierarchical diffusion (Figure 2) also begins at a single point, but does not necessarily move to the closest neighbors.

Hierarchical diffusion was always observed in the silo study areas. One of the driving questions in this thesis is finding the possible reasons for those jumps to distant farms.
The most influential diffusion innovator was Thorsten Hägerstrand, who focused on agricultural innovation and diffusion in Sweden (Hägerstrand, 1952). Hägerstrand decided that information was the key factor in the diffusion of innovations. In 1977, James Blaut expanded on some of Hägerstrand’s theories pointing out that key innovators can drive diffusion along with information agencies such as agricultural extension services common in the United States (Blaut, 1977). DeTemple's local study of Harvestore silo diffusion in Iowa analyzed and discounted the Hägerstrand innovative farmer centric model of diffusion (DeTemple, 1971). The Harvestore Company kept detailed records of silo construction dates and locations to assist with the study accuracy. DeTemple decided that the influence of local cultural centers was more important than the innovative farmer. I will call DeTemple’s results a “Space Preference” theory.
Study Areas in Northeastern South Dakota

This thesis will focus on four study areas that either show high numbers of silos or a diverse cluster of silo diffusion. The main study area is around the city of Watertown, South Dakota where the headquarters of the Watertown Cement Products Company (WCPC) was located (Figure 3). The basis of this diffusion study are the sales records of Watertown Cement Products Company. The second study area is Brookings County which has the distinction of having the highest concentration of WCPC silos in the study area. The third study area is centered on Hoven, in northern Potter County. The Hoven area has a fairly large concentration of silos considering the distance from the headquarters in Watertown. A fourth study area is located in eastern Brown County near Groton.

The areas and counties close to the company headquarters in Watertown are an obvious area of study. Early sales would normally start close to the company's home base. The silos constructed in the first three years of operation were mostly located around Watertown (Figure 3-Box 1). The study area centered in western Brookings County and encompasses part of Kingsbury County began expanding around 1940 and eventually becomes the area with the highest concentration of WPCP silos (Figure 3-Box 2). According to interviews with the company salesman, Bob Kirby, sales were influenced by a prominent Brookings Banker, Horace Fishback (Kirby, 2012).

Study area number three is the farm community surrounding Hoven on the northern border of Potter County (Figure 3-Box 3). Hoven is 145 road miles west of Watertown and silos began spreading out in the area around 1950, near the peak of the company's sales years. The reasons for diffusion in the Hoven area may involve the
influence of important innovators. The final diffusion study area is in southeastern Brown County centered on the community of Groton (Figure 3-Box 4). This area is closer to Watertown than Hoven, but shows a cluster of silos separated from the large group of Watertown/Brookings silos.

In later maps (Figures 8-37) other clusters of silos appear in the study area, but probably occur because of similar reasons as the main study areas.

Figure 3: Main Study Areas
Chapter 2 - Changing Agricultural Technologies

History of Silos and Silage

Silage

The role of the silo is to produce and store silage. The history of silage is not fully documented, though M. Auguste Goffart from France is given the most credit for early publicity (Shaw, 1910). Goffart spent many years experimenting with the science of silage and wrote *The Manual of the Culture and siloing of Maize* in 1877. But the origins of silage are even earlier than 1877. In 1842 in a publication *Transactions of the Baltic Association for the Advancement of Agriculture*, from the University of Griefswald, a long description of the process shows that there is an earlier history to be found. The French origin of the word 'ensilage' combines *en* - *in* and *silo* - *pit* (Stevens, 1881).

Silage would be generally described as a green feed packed firmly into an air tight container and left to ferment. Any introduction of outside air that would allow oxidation causes the silage to spoil. Early descriptions mention layering and packing the feed in pits lined with bricks and/or cement, covering the silage with boards and adding weight to the top to compress the material and reduce air contamination (Shaw, 1910).

In the late 1800s, silage fell out of favor for a while when George Fry insisted that the farmer should produce sweet silage to make the feed more palatable to the cattle. This process required some air exposure early in the process that caused the silage to heat to over 120 degrees Fahrenheit. The silage was sweeter, but not as digestible so few farmers felt that it was worth the trouble (Watson and Smith, 1956). Another feature of silage that slowed usage was the fermentation quality. Some claimed that the silage would get the
cows drunk and a number of dairies refused to buy milk from farmers that fed silage
(Allen George Noble and Willhelm, 1995).

**Silos in the United States**

Farm silos and their diffusion have not been studied to the extent as other
agricultural innovations. In his book *Diffusion of Silos*, geographer Allen G. Noble
observed how the silo was distributed across the United States in the late 1800s. The first
silo in the United States was built in 1875 by Manly Miles at the University of Illinois for
research purposes (Allen G Noble, 1981). From there the early silos spread east to New
England, being mostly used by university researchers. F. Morris of Maryland was
credited with building a silo in 1876 (Shaw, 1910) and from there common usage spread
to New England and then west to Nebraska and Minnesota by 1884. Commercial use was
instituted by dairy farmers near major population centers that needed a reliable winter
feed source. The first silo may have been used in South Dakota as early as the 1890s.

In his doctoral thesis describing the diffusion of Harvestore Silos in Iowa, Blaut
states that diffusion of agricultural innovation needs an information source, either an
innovative farmer or a trusted local agriculture extension agency (Blaut, 1977). The
agriculture extension system which disseminates valuable information to farmers is
unique to the United States. The information provided is well researched by local
universities. U.S. government information in a USDA publication explains how a silo
should be built to fit the individual farmer's needs. The farmer determines how many tons
of feed are needed by the number of cows he/she will be feeding, possibly 100 pounds
per cow per day (McCalmon, 1960). Since two inches of silage should be removed each
day to prevent spoilage, the tonnage per day decides the diameter of the silo. The height of the silo is figured by deciding how many days the cows will be fed. Other information provided in the pamphlet describes the advantage of a silo roof and alternate silage storage methods. Similar, but possibly not as reliable information was also provided by the concrete industry (Portland Cement Association, 1957; Universal Portland Cement Company, 1914). Silage containers come in a wide variety of sizes and types. The earliest types only are mentioned as pits in the ground (Picture 1). They were either built of earth only or lined with brick, tile, or cement. The next structure in transition was the square wooden building (Allen G. Noble, 1980). There were problems with square silos because of the difficulty in packing the silage in the corners. To prevent this spoilage issue, the first attempt was to build 45 degree angles across each corner. This eventually led to the round wooden silo (Picture 2).

Wooden silos were built with either vertical staves or wooden hoops. Neither type were able to resist rot or high winds, but the materials were inexpensive.
Other common early silo materials were stone, brick, tile, and poured concrete (Pictures 3 - 6).

Picture 2: Wood silo - Kingsbury County

Picture 3: Stone silo
Picture 4: Brick silo

Picture 5: Tile silo
Picture 6: Poured concrete silo
The most common silo and the type key to this study is the concrete stave silo. The staves could be precast at a manufacturing plant, hauled to the farm, and built in a short period of time (Pictures 7 - 9).

Picture 7: Stave silo construction

Source: Portland Cement Association

Picture 8: WCPC Plant - Watertown

Source: Irene
In South Dakota, a number of companies other than Watertown Cement Products built concrete stave silos. Numerous issues of Dakota Farmer from the 1940s, 1950s, and 1960s show advertisements for concrete stave silos built by Korok Silo, Norling Brothers, Hanson Silo Company (Picture 10), Madison Silo (Picture 11), Steel Rock Silo, along with Watertown Cement Products (Picture 12) (Dakota-North Plains Corp).

Picture 9: Concrete stave silos

Picture 10: Hanson Silo
Picture 11: Madison Silo

Picture 12: Watertown Silo advertisement

Source: Dakota Farmer Magazine – May 2, 1953
The stave is the basic building block of a concrete stave silo. A common concrete stave is ten inches wide, thirty inches long, and two and a half inches in thickness (Picture 13). The longest edges are convex on one side and concave on the other. This modified tongue and groove configuration allows the staves to fit tightly and can be adjusted for any diameter of silo.

Picture 13: Silo stave
Each joint is sealed with cement and the inside of the silo is coated with a thin cement mixture to make the silo waterproof. An example of this cement mixture is shown on the bottom staves in Picture 14. In the starting course of staves, every other stave used is shorter to stagger the joints and make a stronger structure (Picture 14). At the top end of the concrete construction, staves coated with the same white cement mixture are arranged in a unique pattern that distinguishes one company from another (Pictures 10-12).

Picture 14: Silo construction detail
The crowning piece for most silos is a roof made from either galvanized steel or aluminum (Picture 15). A roof is not always necessary (Picture 11), but a roof helps add stability to the silo, retard freezing, reduce spoilage, protect an unloader from the elements, and discourage damage from birds (McCalmont, 1960). If a roof is not included, a tripod is positioned at the top to support loading and unloading equipment.

Picture 15: Silo roof
A chute on the side of the silo covers a series of doors that can be opened for unloading purposes (Picture 16). Handles on the doors also serve as a ladder to enter the silo at the top of the stored silage.

Picture 16: Silo unloading chute
The common method of silage production during the era of concrete stave silos is chopping the green forage in the field (Picture 17) and filling the silo with a forage blower (Picture 18). Corn is the most common form of silage, but silage can also be made from grass, alfalfa, and sorghum. The green silage needs to be evenly distributed in the silo and firmly packed to reduce air exposure. A common packing technique involved...
having the largest child in the family walk and tamp down the silage as it was being unloaded.

An automatic unloader for a silo speeds up the unloading process because the farmer does not have to break up and pitch the silage down the unloading chute by hand. A concrete stave silo uses an unloader that is placed on top of the silage pile.

![Automatic silage unloader](http://patzcorp.com/better-silage-management-could-mean-a-better-bottom-line/)

August, 2011
Chapter 3 - Sources and Methods

Chapter 3 details the history of the Watertown Cement Products Company, company sales records compilation, and methods used in locating and mapping silos. I have selected this company to study because I am the son-in-law of a Watertown Cement Products Company president and have access to thirty years of company sales records.

Watertown Cement Products Company

Watertown Cement Products Company (WCPC) was founded in 1903. The main company product was precast concrete blocks and ready-mix concrete. In 1937 the company began building concrete stave silos. The distinctive pattern of a WCPC silo are three staggered white staves that give the look of a 'chevron' from a distance. The chevron is topped by a band of circles that resemble a 'bull’s eye' or target (Pictures 8, 9, 12, 15). Another feature usually included was the farm name and date of construction (Pictures 9, 12, 20). This personalization may have kept some silos from being torn down after they were no longer of use because of the silo's new duty as a welcome sign.

Since the company only manufactured the Picture 20: Farm Name and Date
concrete parts of a silo, they needed to buy roofs, doors, and other metal accessories from other parts manufacturers. One of those manufacturers was Railoc Company of Plainfield, Illinois. This company made steel and aluminum roofs and other silo components (Pictures 21-22). In the mid-1950s, Watertown Cement Products Company owed a considerable amount of money to the Railoc Company because of extended credit on parts purchases. Peter Rutten, a partner in Railoc, felt that the only way to recover his investment required the purchase of WCPC and the installation of his son-in-law, Henry Esser as company president (Esser, 2013). The same method was used to acquire and control silo construction companies in Hutchinson, MN, Morris, IL, Joliet, IL, and Cherokee, IA. WCPC continued to sell silos and concrete products until 1967 when it had to be
sold for owner health reasons. A new competing company had just started up in Watertown, so the company assets had to be auctioned since a new buyer could not be found.

The majority of WCPC silo sales were made in northeastern South Dakota by a traveling salesman. Some sales were made to farmers as far away as Rapid City, Newell, and Hermosa in western South Dakota. These western South Dakota farmers were referred by traveling reporters that worked for farm and ranch magazines (Kirby, 2012), and were rewarded with a small finder's fee.

Sales Records Compilation

The sales records of WCPC were compiled into a database from written notes in 2006 as a family history project. The records had been kept since 1937 by the company salesman, Bob Kirby. A sample of the data (Figure 4), shows that details were kept of the

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<th>Year</th>
<th>County</th>
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<td>DaSmat</td>
<td>SD</td>
<td>14 x 30.0</td>
<td>$888.50</td>
<td>1955</td>
<td>Kingsbury</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flandreau</td>
<td>SD</td>
<td>16 x 35.0</td>
<td>$1,230.32</td>
<td>1951</td>
<td>Moody</td>
<td></td>
<td></td>
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<tr>
<td>Vienna</td>
<td>SD</td>
<td>20 x 50.0</td>
<td>$3,386.65</td>
<td>1963</td>
<td>Clark</td>
<td>3' extension</td>
<td>Playford, extension 636.65 x 2950</td>
</tr>
<tr>
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<td>SD</td>
<td>16 x 32.5</td>
<td>$731.00</td>
<td>1944</td>
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<td>SD</td>
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<td>$643.00</td>
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<td>SD</td>
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<td>$5,318.00</td>
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<td>14 x 30.0</td>
<td>$888.50</td>
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<td>Arlington</td>
<td>SD</td>
<td>16 x 35.0</td>
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<tr>
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<td>SD</td>
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<td>1942</td>
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<td>$1,241.10</td>
<td>1951</td>
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Figure 4: Sales Records and Silo Data Sample
farmer or farm name, nearest town or postal town, silo size, cost, year constructed, accessories included, and notes on stave or roof type.

For this study, any records that were not related to construction of a silo or silo extension were excluded. An important area of this study is that of silage volume. Records that would have no numbers in any volume calculation needed to be eliminated. Records with missing data were either eliminated or estimates were made for the missing pieces. After excluding unusable records, 3674 total silos or silo extensions were left to analyze. If a cost was not included, it was possible to estimate that cost by comparing silos constructed close by in both location and date. Some extensions were missing dimensions. The diameter could usually be determined by noting the size of the silo that farmer had previously purchased. The height could be determined if a cost was available by using the proximity and date method.

**Locating Silos**

The silo sales records from the Watertown Cement Products Company contained the buyer's name, nearest town, silo size, cost, year built, and notes related to accessories purchased (Kirby, 2006). To find the location of each silo, county atlases by Midland Atlas Company, Thomas O. Nelson, and Farm and Ranch Guides were used to find the township, range and section of the farm (Farm and ranch directory, 1970; Midland Atlas Company., 1975; Nelson (Thomas O.) Company Fergus Falls Minn. [from old catalog], 1963). GIS layers of townships and sections overlaid on recent imagery from the U.S. Department of Agriculture was used to verify if the silo still existed. Bing Maps and Google Earth were also helpful with the silo verification process. Bing Maps often
included Pictometry high resolution oblique imagery that could help verify whether a silo was made by WCPC or a competitor. If the farm was located on a major highway, Google Earth Street View could also be used to identify the maker of a silo. Some assumptions were made concerning inherited farm ownership. The farm may have passed down to a son with the same last name when the original farmer could not be found. Atlases close to the year of purchase were not always available. When the original farmer

![Voronoi Diagram of City Points](image)

**Figure 5: City Points and Polygons**

or a possible relative could not be found, the silo was placed randomly at a farmstead within a Voronoi polygon surrounding the town associated with the farmer (Figure 5). Voronoi polygons were generated using the ArcGIS Theissen polygon tool.
The same Voronoi diagrams of Theissen polygons were used to determine the count and density of the silos in the area of influence around each town (Figure 6). A point density interpolation map (Figure 7) helped find important cluster areas. Zooming into a map area with an important original silo can determine if the diffusion spreads from that farm or if the local town became the center as was noted in a study of Iowa Harvestore silos by David DeTemple (DeTemple, 1971).
Phone interviews with farmers in Brookings County, in the area around the Hoven cluster of silos, and Groton were used to try and determine the reasons for the purchase of a WCPC silo and the history of silo use. Farmers were asked why the farm might have needed a silo, why Watertown Cement Products was selected over other companies, how the silo was used, and how many years it was used.
Identification of Assumptions

When observing the distribution and diffusion of silos in northeastern South Dakota, this thesis attempts to determine if this diffusion follows any of the previously referenced diffusion models.

If the diffusion of WCPC silos follows the Hägerstrand model, then new silos should appear around the farm of an early innovator in an area that previously did not have silos (Blaut, 1977). If the diffusion follows the “Space Preference” approach of the study by DeTemple (DeTemple, 1971), then new silos should appear around a central place (town) that is near the location of any early innovator.

Considering that this study only deals with the sales and distribution of silos from one company, then the influence of silos from any other companies will have to be ignored. Additionally the competition from other stave silo companies or other types of silos could not be determined when observing the decline of silo sales.

Methods of Display

The maps in Chapter 4: Results and Analysis portray a general picture of silo diffusion. Data are mapped using a GIS by placing silo points at their exact or estimated geographic latitude/longitude in a series by the year in which they were built. Years with low numbers were sometimes combined. As each new year was added to the map, the previously displayed points were colored light blue and the new year's points were displayed a dark blue. The local cluster analysis maps that are presented later in the chapter generally have multiple years combined. The first set of maps have major cities,
county boundaries, and U.S. highways represented. The Interstate highway system was not included since it did was not complete at the time most of the silos were constructed.
Chapter 4 - Results and Analysis

Silo Expansion through Time

Thirty maps were produced and analyzed. Figures 8 and Appendix figures 44-46 show maps during the first four years of WCPC silo construction when sales stayed in the counties close to Watertown with two silos built in Brown County and one silo near Mitchell in Davison County in 1941.

Figure 8: Distribution of Silos 1937-38
The war and post war years from 1942 through 1946 (Appendix Figures 47-50) (Figure 9) kept the expansion and diffusion in the Watertown and Brookings areas with a few more silos to the west in Brown and Spink Counties and one silo southwest of Sioux Falls in Minnehaha County.

Figure 9: Distribution of Silos 1946
The years of 1947 and 1948 (Appendix Figure 51) (Figure 10) show the northwest spread of silos past Brown County nearing the Missouri River. A cluster begins forming in Beadle County around the major population center of Huron.

Figure 10: Distribution of Silos 1948
In 1949 (Figure 11) the first WCPC silos appear west of the Missouri River and in 1950 (Appendix Figure 52) a cluster begins to form near Hoven in Potter County. WCPC silos are also built as far south as Springfield near the southern border of South Dakota (Appendix Figure 52).
From 1951 to 1954 (Appendix Figures 53-55) (Figure 12) a few silos are built in far western South Dakota and a cluster starts forming around Mitchell. The region from Watertown to Brookings continues to fill in with a high silo density.
Years 1955 through 1958 (Appendix Figures 56-58) (Figure 13) show a general decline in WCPC silo sales except for a brief increase in 1958. Sales records in 1958 show a large number of small twenty foot tall silos built that were used for grain storage (Belden, 2012).
The final nine years of WCPC silo construction (Appendix Figures 59-66) (Figure 14) continue to demonstrate the decline of silo sales with no new large clusters of silos forming. Many of the later sales appeared next to existing silos as the farmers expanded their storage capacity with additional structures or extending existing silos.
Four areas are studied in detail to observe the effects of diffusion. The first area is in Codington County around Watertown (Figure 15), centered on the company headquarters and one of the first areas where WCPC silos were built. The second area of interest is Brookings and Kingsbury Counties (Figure 16) which had the greatest density of silo construction. The third area of study is around Hoven, SD (Figure 17). This is an area of moderate silo density, but separated from the main concentration of silos in the eastern part of the state. The fourth area is in southeastern Brown County focused on

Figure 15: Codington County
Groton (Figure 18). The four areas were studied primarily with maps of silo placement. Personal interviews in person or by phone were conducted with people associated with Watertown Cement Products and farmers that were either end users or related to the original silo purchaser. Finding an original owner of a silo built even as late as 1960 was difficult. The silos of most interest in this study were built before 1951. The sons and daughters of those farmers are now in their 60s and 70s.
Figure 17: Hoven Area

Figure 18: Southeast Brown County
**Codington County**

Codington County is an important area to analyze because of the possible influence of the company headquarters in Watertown. The Watertown area also has some of the first silos built by WCPC. Two early adopters were north of Watertown and southeast of Watertown (Figure 19) and three others southwest of Watertown. A Hägerstrand style diffusion should show new silos being constructed around these early innovators. Figures 20 and 21 show that subsequent silos are positioned closer to Watertown than the two early adopters. There may have been some influence by those early adopters, since silos appear between those early farms and the manufacturing center.
in Watertown (Figure 22). The influence of the city of Watertown would lean more toward the cultural center theory favored by DeTemple (DeTemple, 1971).
Figure 21: Codington 1940

Figure 22: Codington 1941
**Brookings - Kingsbury Counties**

The Brookings - Kingsbury Counties study area shows a single early innovator in Kingsbury County between Erwin and Badger (23). Silos built in that area in 1940 (Figure 24), show a cluster of silos near the early innovator, but also show that the town

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**Figure 23: Brookings/Kingsbury 1938**

**Figure 24: Brookings/Kingsbury 1940**
of Lake Preston may have been an influencing factor since the silos built appear between the first silo and Lake Preston. Other scattered silos were built between the early innovator and the Volga/Sinai region in southeastern Brookings County. Figure 25 shows the silos built during the next five years. Three areas show interesting clustering on Figure 48. The grouping of silos in northeastern Kingsbury County appears to have the town of Badger as a center. The silos that were built northeast and southwest of Sinai in 1940 both show a pattern of early innovator influence over the following five years.

Figure 25: Brookings/Kingsbury 1941-45
A possible explanation for the high volume of silos in the Brookings - Kingsbury area comes from the company salesman, Bob Kirby. Kirby stated that a local Brookings banker, Horace Fishback, felt that a silo was an important piece of any farm operation. He made the purchase of a silo a requirement for any loan from his bank. He also referred farmers to Watertown Cement Products as a recommended silo company (Kirby, 2012). Interviews with Brookings County farmers did not completely confirm this story, but many understood why it could be true. Larry Diedrich stated that his father always listened when Horace Fishback spoke (Diedrich, 2012). Jim Kleinjan said that Horace Fishback was a “farmer's banker” (Kleinjan, 2012). An interview with Horace Fishback's son Van confirmed that Horace was committed to agriculture in the area even though he could not confirm the 'silos and loans' story (Fishback, 2013). One interviewed farmer, Perry Sutton, had heard the same story and always wondered if Horace Fishback had been an investor in Watertown Cement Products (Sutton, 2012). This possible connection in a local community may have been as influential in the diffusion of silos as an innovative silo owning neighbor.
Hoven

The third area of interest centered on Hoven, included parts of four counties, Potter, Walworth, Edmunds, and Faulk. The first silos were constructed east of Hoven in southwest Edmunds county in 1947 (Figure 26). Two years later, two silos were constructed farther east near Loyalton, and one was constructed on the south edge of Hoven on the Richard Simon farm now owned by Randy Simon (Figure 27), circled in orange. In the following years (Figures 28, 29), the diffusion of silos is either around the Simon silo, or the town of Hoven. The influence of family connections is important in this area (Harner, 2012). Eight other silos were built in subsequent years by Simons.
The first two silos in southwest Edmunds County were built by Elmer Holweger and J. R. Voegele, who were related by marriage (Harner, 2012). Another brother-in-law, John
Binder, purchased a silo in 1950. This family connection accounts for five silos in southwest Edmunds County.

Figure 29: Hoven 1952-53

Dennis Arbach, a farmer north of Hoven, and related by marriage to the Simon family, pointed out an important factor in the need for silos. In his immediate area, a group of farmers worked together and shared expensive silage chopping and filling equipment (Arbach, 2012). The group his father worked with were mostly relatives and neighbors. They shared two corn choppers and one blower. This social organization was observed by Kimball where silo filling 'companies' with five to ten members shared equipment and were organized by a company manager (Kimball, 1949). The reduced expense and shared labor of these groups would be a contributing factor that would promote silo purchases.
Groton

The fourth and last area of interest is around Groton in eastern Brown County. The first silos constructed from 1941 to 1945 do not show any particular pattern (Figures 30, 31). The years 1946 through 1951 (Figure 32), show community centered diffusion surrounding many of the towns in the area. In 1958 there is a large volume of construction, mostly north of Groton (Figure 33). After viewing aerial imagery of the farmland south of Groton, there seems to be a different land type. There is more wetland than north of Groton, fewer farmsteads, and even fewer farmsteads with silos from any company. Interviews with area farmers show a somewhat different picture than those in the other study areas.

Figure 30: SE Brown County 1941
Figure 31: SE Brown County 1941-45

Figure 32: SE Brown County 1951
Gilbert Hinkelman still feeds silage to cattle, but does not store silage in silos anymore because their volume needs are too high (Hinkelman, 2012). Hinkelman stated that his family was convinced that a silo was important when Olson's Dairy in Groton built a silo in the 1930s and they were able to produce milk all winter. The Rix family were important silo customers north of Groton. WCPC sales records show twelve out of the 103 sales in the area were sold to a member of the Rix Family. Since two of their purchases were in 1944 and 1946, they might be considered an early innovator that might influence other farmers to purchase silos. An interview with another north Groton farmer, Mrs. Delbert Leonhardt stated that their silo purchases "would not have been influenced by the Rix family" (Leonhardt, 2012). Tom Belden said that Watertown Cement Products

Figure 33: SE Brown County 1958
was the closest local dealer and no other companies tried to sell in the Groton area (Belden, 2012). Belden also pointed to the high volume of twenty foot silos that were built to be used as grain storage and not for silage. Twenty-six out of the 103 Groton area silos match the description of a grain storage structure, including five at the Ferney Farmer's Elevator. Four of the twelve Rix silos were probably grain storage structures and twenty-one out of the thirty-four sales in 1958 could have been used for grain storage only.

Observations in these four areas tend to show more influence from a community than from an early innovator. The Hoven area is problematic since an early silo is built on the south edge of the town. It would be impossible to separate the influence of the early innovator from the community. The other study areas where the early silos are miles away from the local cultural center give more value to the community/cultural center theory posited by DeTemple (DeTemple, 1971). The high number of silos in the Brookings area that may have been promoted by the Brookings banker Horace Fishback could not be confirmed by interviews. The type of farming and the ability to grow quality silage during the right time period and latitude may have as much influence on the high numbers of silos.
**Silo Decline**

The decline of silo numbers is almost as interesting as the expansion and diffusion of stave silos. The reasons for the decline in WCPC silo numbers may be the result of a wide range of reasons. Cattle numbers, the improvements in pit silage methods, competition, and/or corn as an important cash crop are all probably partially responsible for declining silo sales. Even when silo numbers began declining after 1951 (Figure 34), the volume of silage storage did not fall as fast since the size of silos was increasing in the late 1950s and 1960s (Figure 35). A standard silo sold before 1950 was 14 feet in diameter and 30 feet high (14 x 30). In 1960, a more common size was 20 x 50. The 14 x
30 silo holds 4618 cubic feet of feed, while a 20 x 50 silo can hold more than three times as much with 15,707 cubic feet of storage volume.

When cattle numbers increase (Figure 36) and farm numbers decrease (Figure 37), then the number of cattle on each farm are increasing also. Since the rate of silage available from even a silo with an unloader is limited, the practicality of a vertical silo
declines with higher cattle numbers if the farmer wishes to finish his feeding in a reasonable amount of time each day. Wayne Berkland in Brookings County started storing silage in pits because the process of feeding from a silo was too slow (Berkland, 2012). Depending on the size of the loader bucket, a farmer can move one-half to three quarters of a ton of silage with each load.

Early pit silage had problems with spoilage from soil contamination when using a hole in the ground or a notch cut into a hillside. Modern pit silage systems are generally made with concrete walls and floors. An efficient system has a drainage system that keeps liquids from collecting in the bottom of the pit and the pit is long and narrow to keep the air exposure of silage to a minimum. A pit system requires large, heavy equipment for building and packing the pile (Wilkinson, 2005). Fresh chopped silage is emptied onto a concrete pad in front of the pit which prevents soil contamination. Large tractors with blades or loaders push the silage up the pile in thin layers and pack the feed tightly (Picture 23). A medium-large silage pile with concrete walls is shown in a Google

Earth aerial image in Picture 24. The width of this pile in the area highlighted is 80 feet and the pile is 180 feet in length. If the average depth of the silage is ten feet, then the total cubic feet of silage is 144,000. The largest vertical silos are usually around sixty feet tall and twenty-four feet in diameter holding a little over 27,000 cubic feet of silage. To hold the same amount of silage as the pictured pit would require five vertical silos at a much higher cost. In my travels around the area viewing silage storage methods, I find that most modern dairies build piles of silage taller than ten feet and forego the concrete side walls (Picture 25).
Competition from other silo companies may have been an important factor in the decline of WCPC silo production. In northeastern South Dakota, silos built after 1960 are mostly built by Hanson Silo Company of Luverne, Minnesota, Madison Silo with the closest plant in Detroit Lakes, Minnesota, or Appleton Silo in Marshall, Minnesota. It is not clear whether these companies increased their sales because of the closing of Watertown Cement Products in 1967 or if they were able to offer a better product at a lower price and were partly responsible for declining WCPC sales. The fiberglass lined steel silos (Picture 26) most commonly sold by the Harvestore Company were an expensive but popular competitor to the stave silo.
The ability of South Dakota farmers to grow corn for grain sales has increased dramatically during the period of this study. With a valuable cash crop available, farmers would be inclined to reduce their cattle numbers and dedicate more time and land to the production of corn. In 1936, South Dakota State College compared hybrid corn with non-hybrids in field tests (Hume, Franzke, and South Dakota Agricultural Experiment, 1936). The non-hybrid corn yields ranged from 6.9 to 18.9 bushels per acre and the hybrid varieties yielded 7.9 to 21.8 bushels per acre. In just six years, the results were improved to the point of making corn a viable crop. The 1942 South Dakota Hybrid Corn Yield Test ranged from 23.6 bushels per acre in Codington County, 49 bushels per acre at Brookings, 53.7 bushels per acre at Milbank, and 64.9 bushels per acre in Clay County in the southeast part of the state (Hehn, Grafius, and South Dakota Agricultural Experiment,
Modern yields are generally over 100 bushels per acre even during dry years (USDA, 2013). Figures 38, 39, and 40 compare the corn for grain harvests in 1940, 1960, and 2007 in the most common corn producing counties in eastern South Dakota. The maps also indicate testing sites used in the previously mentioned studies. The bushels per acre numbers are calculated by dividing the total harvest of each county by the total acres of land in that county. These numbers are lower than actual crop yields, but offer an accurate comparison over the years studied. The lowest producing counties in 2007 produce more corn than the highest production counties in 1940.
Figure 38: Corn Production

Figure 39: Corn Production 1960
Figure 40: Corn Production 2007
As the silos were abandoned as silage storage, other uses for the structure were sometimes found. The most common use was storage for high moisture shelled corn that was also used for a cattle feed (Diedrich, 2012). Since WCPC silos were a prominent structure in the farmyard with the farmer or farm name boldly displayed with large white letters, the farmer may have kept them intact for advertising purposes. Many farms still take the time to repaint the letters and date to keep them visible even though the silo is not currently used. A Hoven area farmer spread hay and straw in the bottom of his silo every year for the pigeons to use for nesting material (Arbach, 2012).

When the farmer no longer needs his silo, he may choose to have it torn down. The Kleinjan farm north of Volga carefully dismantled a silo and used any undamaged staves to extend the height of another silo by twelve feet (Kleinjan, 2012). A more common method involves pulling the silo over with a caterpillar tractor and burying the debris in the ground (Diedrich, 2012) (Picture 27). After many years of standing in South Dakota, the chance of a tornado tearing the silo down is good. Two of the farmers interviewed reported having a tornado destroy their silo (Hope, 2012; Naef, 2013).
Picture 27: Silo Destruction
Source: SD Agriculture Museum 1992
South Dakota Agricultural Economies

An important factor in the makeup of farms in South Dakota is the change in farm size and organization over the period of this study. From 1937 to 1967 the number of farms in the study counties has fallen sharply (Figure 41). Assuming that the number of acres being farmed in these counties remains constant, then the size of each farm must be increasing. As farm size increases, then the farm is able to support a larger herd of cattle. If the farmer is keeping dairy cattle, or trying to fatten beef cattle over the winter months, then it would make sense to have a way to keep high quality feed during the winter.
Figures 42 and 43 show the trends in cattle over the period of this study. Dairy cattle showed some decline until 1950 and a more rapid decline in numbers after 1950. At the same time, total cattle numbers were on the rise which points to either larger numbers.
of cow/calf pairs or the more likely use of the farm as a feedlot to fatten cattle for sale to
a processing company. When dairy cattle numbers have been reduced, and cattle numbers
are rising, feeding operations are the only way to account for the increase in cattle sales.
A South Dakota State University economics report from 1983 stated the following:

The dairy production industry has been transformed in 20 years

from a large number of farms each milking a few cows to relatively few

highly specialized dairy farms. (Janssen and Edelman, 1983)
Chapter 5 – Discussion and Conclusions

Driving Questions Revisited

This chapter addresses the questions posed in Chapter 1 and presents some conclusions of the complete thesis.

How has silage technology changed over time and how has this change impacted the agricultural landscape of South Dakota?

Storage of silage has transitioned from pits in the ground to vertical silos of various types and back to horizontal storage in concrete lined pits and large piles that are now found in the large dairy operations in eastern South Dakota. Silage is still an important animal feed source, and is seen in large quantities in the scattered dairies that generally milk 3000 to 5000 cows. The visual landscape of the area is still dominated by the now mostly empty vertical stave silo. New construction of vertical silo of any type has essentially stopped. The most recently constructed silo encountered during this study was a Hanson concrete stave silo built in 2010, but it appears to be a rare occurrence.

What factors have influenced the decline of silo construction in South Dakota?

The main factors reducing vertical silo construction are the changes in farm size and the type of crop production available to the modern farmer. The importance of corn and possibly soybeans as a cash crop has reduced the need for the farmer to want or need to deal with cattle.
Why was the WCPC so historically successful, or was it?

Watertown Cement Products Company was conveniently situated to take advantage of the need for silage storage when the popularity of silo was on the rise in the state. A concrete stave silo built from precast staves was probably the most economical and rapid method of silo construction during the thirty years of this study. The building of over 3500 large farm structure in thirty years would qualify WCPC as a successful business.

What is the geography of silo adoption and which diffusion theories best fit silo adoption in South Dakota?

The spread of WCPC silos shows an obvious spread out from the company headquarters in Watertown with multiple cluster expansions in various neighboring counties. The diffusion tendencies appear to be a combination of the innovator centered Hägerstrand model and the local cultural centered DeTemple model. Family connections favor the innovator model in the Hoven cluster while much of the expansion in Codington and Brookings counties tends to occur in the space between the early innovator and a local community.

Is there a genuine clustering of silo construction in northeastern South Dakota?

This study focused on four varied clusters, but could have selected many other clusters of various sizes. Clusters appeared and grew over various time periods, later clusters tended to be farther from the Watertown center. The Silo Point Density map
(Figure 9) shows over a dozen clusters of various densities that were available for analysis.

When traveling in time from 1937 to 1967 observing the spread of silos out from the headquarters at Watertown, cluster patterns are obviously more than just random placement.

In the Codington County analysis, the early silo construction appears to have a similar or equal influence on subsequent silo placement. Small communities in the area show a similar clustering influence.

The Brookings/Kingsbury County analysis demonstrates a similar pattern as shown near Watertown. The early important cultural center appears to be Lake Preston, but a wider view might give that status to the town of Arlington. A wider and later view of the area cluster shows the center closer to Brookings.

The observation of the Hoven area cluster is different than the first two studies. The first two silos built begin as the center of the three silos constructed two years later. From 1950 on, those two early silos stay on the edge of the cluster and the town of Hoven becomes the new center. The 1949 silo built by Richard Simon within the city limits of Hoven may have been an important influence in the clustering process.

Southeastern Brown County cluster patterns are similar to those observed in Codington County. Groups of silos form between early innovators and the communities of Groton and Stratford. The first silo constructed near Ferney stands alone for a few years until a number of silos are built on the opposite side of Ferney.
**Conclusions**

If you drive the roads of northeastern South Dakota, you can hardly miss the presence of the concrete stave silo. Small, old, abandoned or large and still in use, silos are found on almost every square mile in South Dakota farm country. Even some of the western South Dakota ranches have a silo or two next to the barn. One hundred years ago, a silo was a rare sight in the upper Midwest. This study shows the possible reasons for silo appearance and dominance on the South Dakota farm landscape.

Watertown Cement Products Company silos along with those of other companies have been an important fixture in a changing agricultural way of life. The diffusion of these silos on the plains has demonstrated the influence of both innovative farmers and local cultural centers. The changing farm moving to mostly grain production or large scale dairy operations has made most vertical silo use obsolete.

New silo construction does not appear to be a current farming practice. Old decaying silos will continue to be removed rather than be repaired. If our picture of the northeast South Dakota farm landscape needs a silo in the frame, then we had better record our images now.

**Future Study**

To validate the diffusion of silos observed during this study, it may be interesting to look at sales by other silo companies in the upper Midwest. The ability to get comparable results would depend on the quality of sales records. Many of the silo companies mentioned early in this thesis are no longer in business and may have lost those sales records.
Since the cultural centers appear to be an important diffusion influence, an analysis of each of those areas would be interesting. The analysis would try to find the institution in those cultural centers that provides the social structure that is important to the diffusion process. That institution might be the local cafe, grain elevator, feed store, or church.

Similar farm structures that are no longer being regularly used on the farm may be of interest. Corn cribs were used when storing dried ears of corn was common. There are many still in farm yards, but few are still being used. Most have vines or trees growing in or around them. Another common farm structure no longer used in northeastern South Dakota, but commonly used farther west is the windmill. Many farms still have the windmill tower still standing, but the wind blades and vane are rarely intact.
Figure 44: Distribution of Silos 1939
Figure 45: Distribution of Silos 1940
Figure 46: Distribution of Silos 1941
Figure 47: Distribution of Silos 1942
Figure 48: Distribution of Silos 1943
Figure 49: Distribution of Silos 1944
Figure 50: Distribution of Silos 1945
Figure 51: Distribution of Silos 1947
Figure 52: Distribution of Silos 1950
Figure 53: Distribution of Silos 1951
Figure 55: Distribution of Silos 1953
Figure 56: Distribution of Silos 1955
Figure 58: Distribution of Silos 1957
Figure 59: Distribution of Silos 1959
Figure 61: Distribution of Silos 1961
Figure 62: Distribution of Silos 1962
Figure 63: Distribution of Silos 1963
Figure 66: Distribution of Silos 1966
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