Estimating the Impact of Swine Feedlots on Residential Values in Southern Minnesota

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Abstract

A hedonic analysis, or revealed preference analysis, was used to estimate the effect of hog barn proximity on prices of rural residents' real estate in the southern region of Minnesota using Minnesota Pollution Control Agency (MPCA) and county home sales data. Explanatory variables in the dataset include number of bedrooms and bathrooms, lot size, age of home, year sold, feedlot characteristics, and proximity calculated using GIS software. This analysis included 2,795 observations in Blue Earth County, Jackson County, and Freeborn County from 2017 to 2020 and reveals that homes located between one-half to one mile away from swine feedlots were associated with an increase in value, whereas a distance of less than one-half mile away was not found to have an effect.

INTRODUCTION

Minnesota has an estimated 18,000 livestock feedlots registered under the state's feedlot rule, and the Minnesota hog industry is one of the largest in the nation with over $2.7 billion in annual hog sales in 2019. Hog farms also support their local communities; the average hog farm contributed roughly $33,000 in state and local taxes in 2019 (Hadrich, Roberts, and Tuck, 2020). Swine farms have also been a point of contention in the recent past, with nuisance lawsuits providing a precedent to limit construction, expansion, and renovation. Livestock owners are seeking solutions to these problems and concerns posed by community members. Researchers have conducted studies on feedlots and the effect they have on home prices, but these studies are applicable only to the area where they took place. The last study evaluating Minnesota feedlots and home values was completed in 1996. The study examined this relationship in two counties, Redwood and Renville, using a total of 292 residential sale observations. Since 1996, the number of residential sales near production agriculture has increased as urban sprawl continues to expand, even in more rural areas. Updating the 1996 studying using home sales transactions and feedlot proximity will provide a comparison to the earlier study while also giving additional insight on the potential relationship between production agriculture and rural communities. Further, this study collects data from 2017 to 2021 that results in 2,795 observations of residential home sales within a one-mile proximity of livestock feedlots. This results in an expanded dataset that includes variables that were not previously available or easy to collect, such as school districts.

Since 1990, there have been several studies completed across North America seeking to assess the impact of feedlots on residential property values. Most of these

studies have concluded that proximity to feedlots is statistically negatively associated with home values (Abeles-Allison and Connor, 1990; Hamed, Johnson, and Miller, 1999). Some of these studies discuss limitations of their results due to concerns surrounding potential biases associated with unobservable variables, such as the spatial correlation of houses, and overall market differences across regions and studies. Researchers at the University of Missouri (Massey and Horner, 2021) completed a meta-analysis of previous studies to find that the impact of feedlots on housing values is still unknown due to the complexity of the question but estimate the effect is likely negative. A study evaluating farms in Indiana (Indiana Business Research Center, 2008) found that homes within half a mile of a feedlot decrease in value, but values increase from one-half mile to three miles. These results were a combination of all livestock, but negative effects were observed when studying swine exclusively. Taff, Tiffany, and Weisberg (1996) conducted a study of homes sold in rural areas for two counties in southern Minnesota in 1996 and found that nearby feedlots increased housing prices. They did not include factors for homes downwind, animal density, or spatial correlation.

This study's objective is to provide the scientific findings of the impact that swine feedlots have on home prices in southern Minnesota. As previously mentioned, the staff paper conducted at the University of Minnesota by Taff, Tiffany, and Weisberg attempted to answer this same question in 1996. Although this paper has its merits, the study was conducted in counties with lower hog density than other Minnesota counties and had a low sample size of only 292. This paper improves on the last Minnesota study by expanding the number of observations used by utilizing GIS to calculate the distance from homes to feedlots as well as including three of the largest swine producing counties in the state in the dataset.

MODEL AND METHODS

This study uses a regression analysis, known as hedonic price analysis, to determine the impact that house characteristics, feedlot and proximity characteristics, and school district have on the sale price of a home. Ordinary least squares (OLS) is used to estimate the impact of the independent variables on the dependent variable. OLS minimizes the sum of the squared residuals in the model (Wooldridge, 2015). The model for this study is

$$y_i = \beta X_i + \gamma X_i + \delta X_i + \varepsilon_i, \qquad (1)$$

where y_i represents the quarter root of the sales price of the home i divided by 1000, β is a vector of home and sale characteristics, γ is a vector of feedlot characteristics and proximity to the nearest feedlot, δ is a school district dummy variable (used only for individual county datasets), and ε_i is the error term for the house sale.

Following Taff, Tiffany, and Weisberg (1996), a Box-Cox transformation was used on the dependent variable—selling price—to transform the home sale price into a normally distributed variable. The results of the Box-Cox transformation in SAS (SAS Institute, 2022) indicated that the quarter root of selling price would yield the most normally distributed variable. Normal distribution aids in the applicability of the model and sets the mean predicted error near zero, making the OLS parameter significance more reliable. This study was therefore focused on the sign associated with each parameter estimate rather than magnitude. Results are displayed as positive or negative, with asterisks corresponding to the significance levels. Outliers within the home characteristic data are addressed using studentized residuals. Any observations with a studentized residual less than negative two and greater than positive two are removed. To remove the outliers, a regression of the three counties was run just using home characteristics and year sold as independent variables. This resulted in only one observation being removed that was within one mile of a feedlot.

Distance (the proximity variable) was created using ArcGIS geocoding. Home sale addresses as well as feedlot addresses were geocoded. Proximity was determined by multiple buffer rings at 0.25, 0.5, and 1.0 miles around each feedlot, as illustrated in Figure 1. These distances were chosen based on findings by previous studies that showed little to no impact on sale prices after one mile (Bayoh, Irwin, and Roe, 2004; Herriges, Secchi, and Babcock, 2005; Ready and Abdalla, 2005). These rings were centered on the address and may not be centered directly over the feedlot or buildings containing livestock. These overlapping feedlots were then spatially joined with the home sale data. Another distance variable, one-mile boundary, was created to capture any homes within one mile of a feedlot as shown in Figure 2. School district areas were also overlaid on the house sales and spatially joined together with the home sales in Blue Earth, Freeborn, and Jackson Counties (Figures 3–5).

DATA

Home sale data and its corresponding housing characteristics from 2017 to 2021 were compiled from three southern Minnesota counties. A five-year timespan was used to account for the variation in home sale prices due to market conditions impacting home sales over this time period (COVID-19, increased housing demand, etc.). Home data was collected through Beacon (https://beacon.schneidercorp.com), a public online tool that contains property information that participating cities and counties provided. County data that was not available in Beacon was gathered through the county assessor's office. Home characteristics and sales prices were collected. These include number of bedrooms, number of bathrooms, lot size, date of the sale, and age of the home at time of the sale. Blue Earth data was available only from 2017 to 2020. Homes that sold for less than $70,000 were removed from the data, as were home sales that included more than 80 acres since they were not considered to be arm's length transactions. Other variable outliers were removed utilizing studentized residuals.

Blue Earth County and Martin County are part of the top 20 hog producing counties in the United States. This study captures 827 observations in Blue Earth County but is not able to utilize any home sale data from Martin County due to missing variables and lack of consistency within their data reporting processes. Counties examined for this study had differing levels of home sale information available in Beacon and from county assessors, with some counties in Beacon providing only three of the variables needed to conduct the analysis. Of 11 counties that were intended for this study, only three (Blue Earth, Freeborn, and Jackson) had data with all the required variables. The other two counties used in this study, Freeborn and Jackson, supplied the remaining 1,968 observations and are both high swine producing counties located in southern Minnesota.

Publicly available feedlot information was collected through the Minnesota Pollution Control Agency (MPCA). MPCA maintains a database within ArcGIS that contains the geospatial data and accompanying data for each feedlot in Minnesota. The MPCA is the governing body for these livestock feedlots and regulates the handling of animal manure. MPCA feedlot rules apply to location, design, construction, operation, and management of feedlots. Owners of feedlots are required to register when the feedlot meets one of two conditions: an animal feedlot capable of holding 50 or more animal units, or an animal feedlot capable of holding 10 or more and fewer than 50 animal units that is located within shoreland (Minnesota Legislature, 2014). One animal unit is equivalent to the amount of manure produced by a steer or heifer. One head of swine that is over 400 pounds is equivalent to 0.4 animal units. Between 55 pounds and 300 pounds is equivalent to 0.3 animal units. Under 55 pounds is 0.05 animal units (Minnesota Legislature, 2019). This data contains the number of animal units, a dummy variable for primary animal, and a yes/no variable if liquid storage is used. For this study, only feedlots that are required to register were considered.

Another key variable for analyzing individual counties was the school district sold homes were located in. School district areas were collected through ArcGIS utilizing shape files generated at the University of Minnesota in February 2022 (Crosson, 2022). Dummy variables were created for each of the 21 school districts and were used only in individual county analyses.

The resulting dataset contains house sales from 2017 to 2021 and includes 2,795 observations with averages: sale value of $170,938, roughly three bedrooms, two bathrooms, and one acre (see Table 1). Age of homes at the time of sale ranged from less than a year to 151 years old.

In this dataset, only two primary animal types, swine and beef, were within a mile of home sales. Eleven swine feedlots had an average of 551 animal units or 1,837 head (0.3 hogs per 1 animal unit). Table 2 shows the number of feedlots within proximity of a home sale by livestock type. Of the 11 swine feedlots within a mile of a home sale, nine homes are one-half to one mile away. Ten of the swine feedlots also have liquid manure storage on the farm. The 10 remaining feedlots in the study area had beef as their primary livestock, so a dummy variable was created for the category. The majority of these beef feedlots are also from one-half to one mile away. Only two of the beef feedlots have liquid manure storage.

Table 3 shows the frequency of home sold in a particular school district in that county. Albert Lea School District, located in Freeborn County, makes up a large percentage of total observations for the entire sample at 57.78%, followed by Mankato School District in Blue Earth County with 12.31%.

RESULTS

In conjunction with ArcGIS (Esri, 2022), SAS software (SAS Institute, 2022) was used to run OLS regressions

for the three-county dataset and for the individual counties. Table 4 displays the regression results for the full dataset of three counties using home characteristics, the multiple buffer rings at a quarter mile, half mile, and one mile away from the feedlot address, and the group of all home sales within one mile of a feedlot.

Home characteristics and year sold, in comparison to the omitted year of 2021, are statistically significant in explaining variation in the selling price. Increasing the number of bedrooms, bathrooms, or acreage, holding all else equal, is associated with a higher selling price. Older homes are associated with a lower selling price when holding other parameters constant. Sales from 2017 to 2019 are associated with lower sales prices compared to 2021. Additionally, home sales in 2020 are not statistically different from sales in 2021.

The second column of Table 4 presents results including the home characteristics as well as multiple ring buffers around the feedlot as explanatory variables in the regression. The magnitude and significance of the home and sale parameters did not change. As for the feedlot characteristics, only the swine feedlot distance parameter of one-half to one mile was significant. Shockingly, swine feedlots within this distance are associated with an increase in selling price This finding is similar to the previous Minnesota study (Taff, Tiffany, and Weisberg, 1996) where nearby feedlots increase the value of the home and should be a valuable asset in supporting producers when disputes arise regarding the impact feedlots will have on the community and home values. The other swine feedlot parameters—quarter to one-half mile, animal units, and liquid manure storage—were not statistically significant at the 10% level. There were no homes sold within a quarter mile of a feedlot, so only quarter-mile to one-half mile and one-half to one-mile distances were used in this buffer ring analysis. Beef feedlot parameters were included to isolate the effects that each type of primary livestock had on home sales. One of the buffer ring distance parameters for beef feedlots was statistically significant at the 1% level as well as the animal unit count at the 5% level.

The last column of Table 4 uses a different distance parameter, a dummy variable that equals one if the home was within a mile of a feedlot, rather than the multiple buffer rings. Once again, home and sale characteristics were significant and did not differ in magnitude from the first regression. With the new distance, dummy variable results show that home sales within a mile of a swine feedlot are associated with a higher selling price and statistically significant at the 10% level. Parameter estimates for swine lagoon and number of animal units differ slightly in magnitude from the previous regression but are not statistically significant from zero and are not associated with a change in selling price. This differs from Taff, Tiffany, and Weisberg (1996), who found that the number of animal units and liquid manure storage had a significant and positive effect on home sale prices. Within a mile of a beef feedlot results in a positive and significant effect on home sales price at the 5% level. The beef animal unit count also changes signs from positive to negative and is significant at 1%. The three-county dataset was divided into individual county datasets to incorporate school district dummy variables into the regression. Table 5 displays regressions for each county, one with home, sale year, and feedlot characteristics and the other including all of the former regressions and school districts. Although the three-county models used two distance parameters, these county-level regressions use the ring distance variables since no difference was found between using the multiple rings and distance dummy variable on the county level. Parameters signified with # were dropped due to the low sample size of feedlots when separating the counties apart.

Jackson County

Jackson County had only one of the home characteristics significant at the 1% level (age of home); number of bathrooms and acres were significant at the 5% and 10% level, respectively. There were no swine feedlots located within this county's dataset. Adding school districts into the regression in Table 5, home characteristic parameters did not change in significance or magnitude but the R-squared increased by 1.5 percentage points. The school district variables are compared to Jackson County Central and are not significant.

Freeborn County

Freeborn County had statistically significant home attribute variables as well as sale years, with price decreases associated with older homes and selling prior to 2021. Swine feedlot parameters are insignificant but biased due to sample size. Analyzing the school district regression section of Table 5, Freeborn home and sale parameters had no sign changes or significance level changes.

Freeborn County feedlot parameters are consistent with the findings in the previous section. The parameter estimates for sales within one-half to one mile are positive but insignificant and biased. School district estimates were in comparison to Albert Lea, and R-squared increased by 0.8 percentage points.

Although adding these school districts did not change parameter estimates from the feedlot regression, they did add explanatory information on sales price.

Blue Earth County

Similar to Freeborn County, Blue Earth County had statistically significant home attribute variables as well as sale years (Blue Earth did not have data for 2021, so 2020 is dropped). Number of bedrooms, bathrooms, and acres are all associated with an increase in home price. Swine feedlots with lagoons were associated with a decrease in sales price, and the parameter estimate is significant at the 10% level. The swine animal unit count parameter estimate was positive and significant, meaning that one additional animal unit is associated with an increase in the home selling price. Adding school districts results in similar findings. There were no sign changes or significance level changes regarding the home and sale parameter estimates for Blue Earth County. The parameter estimates for swine lagoons and swine animal unit counts were still marginally significant and hold the same signs as the feedlot characteristics regression. Blue Earth County School District parameters are in comparison to the Mankato School District and increased the R-squared 5.1 percentage points to 74%.

CONCLUSION

The results from this study differ based on the granularity of the dataset used. The three-county dataset shows that homes sold within one mile of swine feedlots are associated with an increased selling price. This increase may be limited to the one-half to one-mile range, as demonstrated by the multiple buffer ring regression. The effect on home sales closer to swine feedlots was not determined since there were no home sales recorded within a quarter mile of a swine feedlot. Liquid storage and the number of animal units on swine feedlots were not found to have an effect on a home's selling price. Individual county level results differ, with Blue Earth County homes having a higher selling price with the addition of swine animal units and a lower selling price when the swine feedlot uses a lagoon. Home sale prices were not affected when considering distance to the nearest swine feedlot in these three counties. Feedlot effects differ from region to region, and southern Minnesota is an outlier with swine feedlots increasing home prices—unlike in many other states.

This research could be extended by looking at the magnitude of parameter estimates and using spatial correlation measures to test for bias within neighborhoods. Overall, this study emphasizes the need for accurate public data and standardization so that questions similar to this can be answered. Minnesota collects thousands of data points on feedlots and home sales every year. Over 8,000 additional home sale observations covering eight additional counties could have been used in this analysis if the data collection methods were standardized across counties. The results of this study show that this type of research needs to be conducted not only to provide evidence in support of farmers for nuisance suits and permitting meetings but also to provide more information about the effects of agriculture on different communities.

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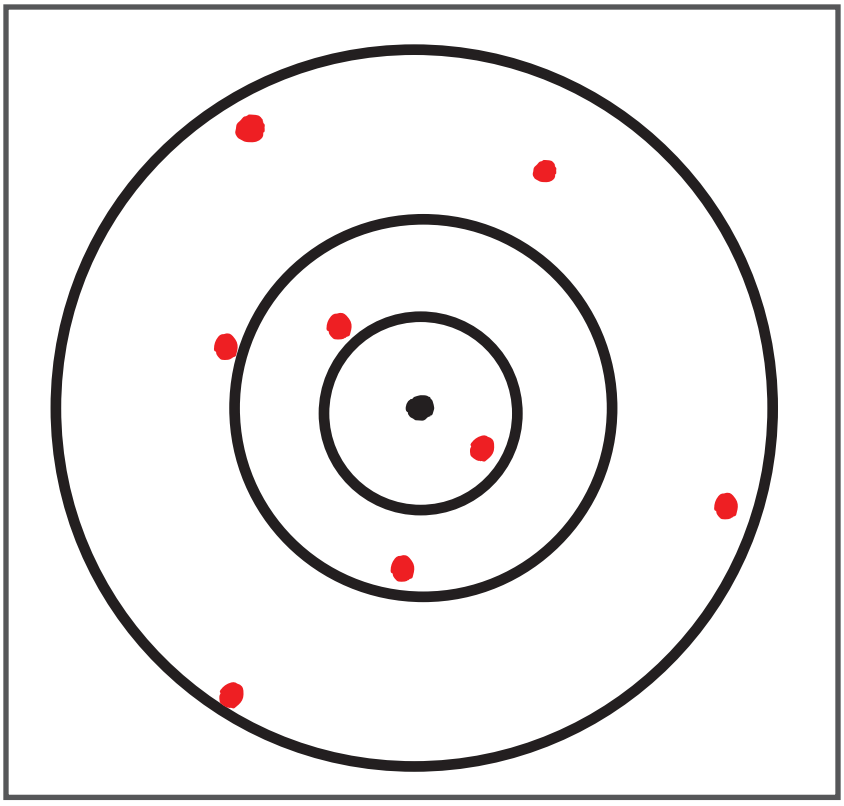

Figure 1. Multiple ring buffer

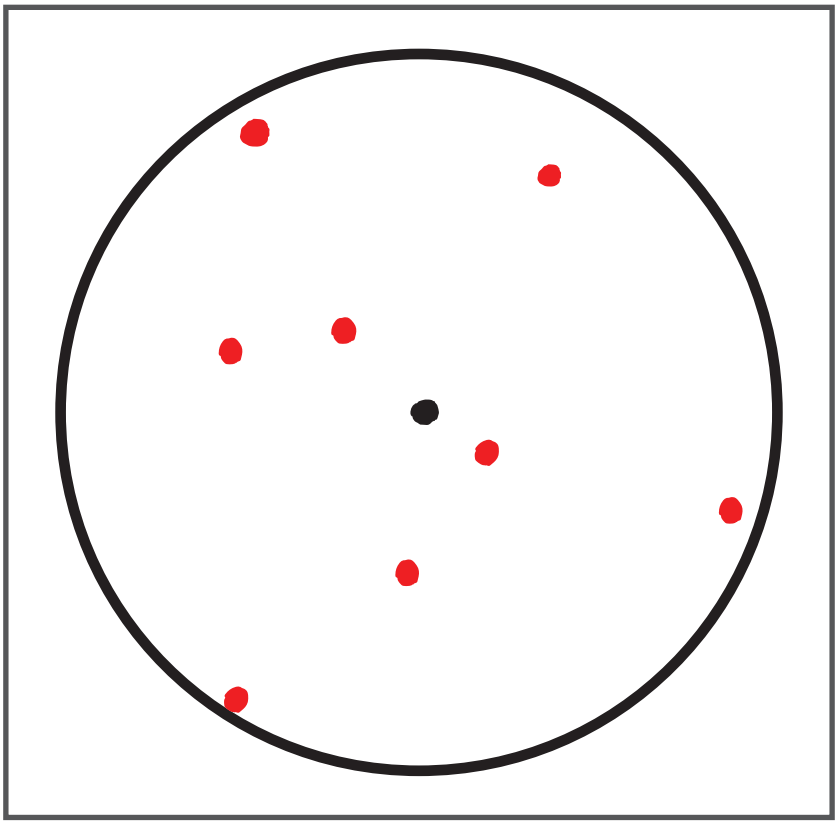

Figure 2. One-mile boundary

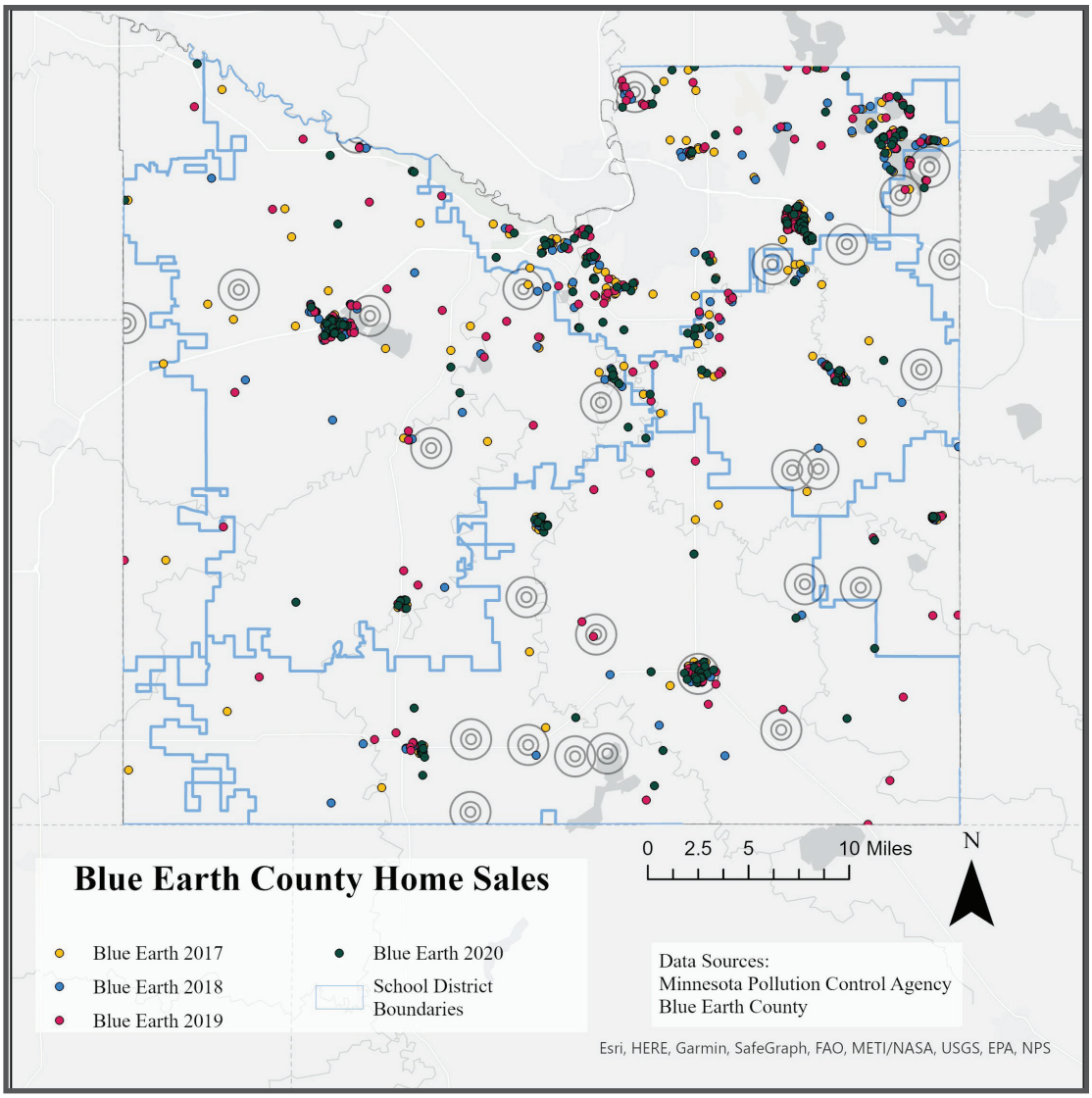

Figure 3. Blue Earth County in ArcGIS, 2017–2020. (Note: Buffer rings indicate feedlot locations.)

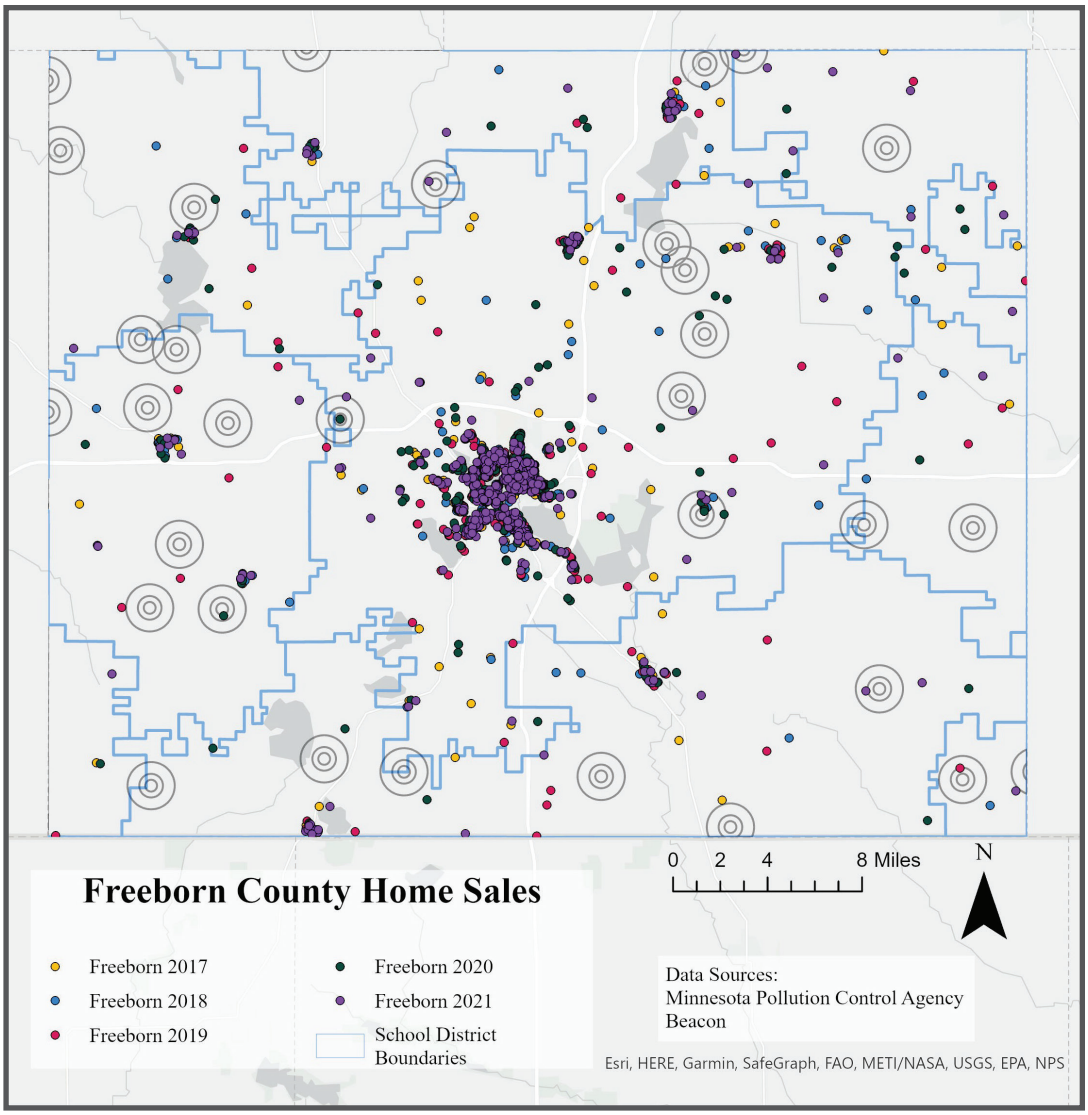

Figure 4. Freeborn County in ArcGIS, 2017–2021

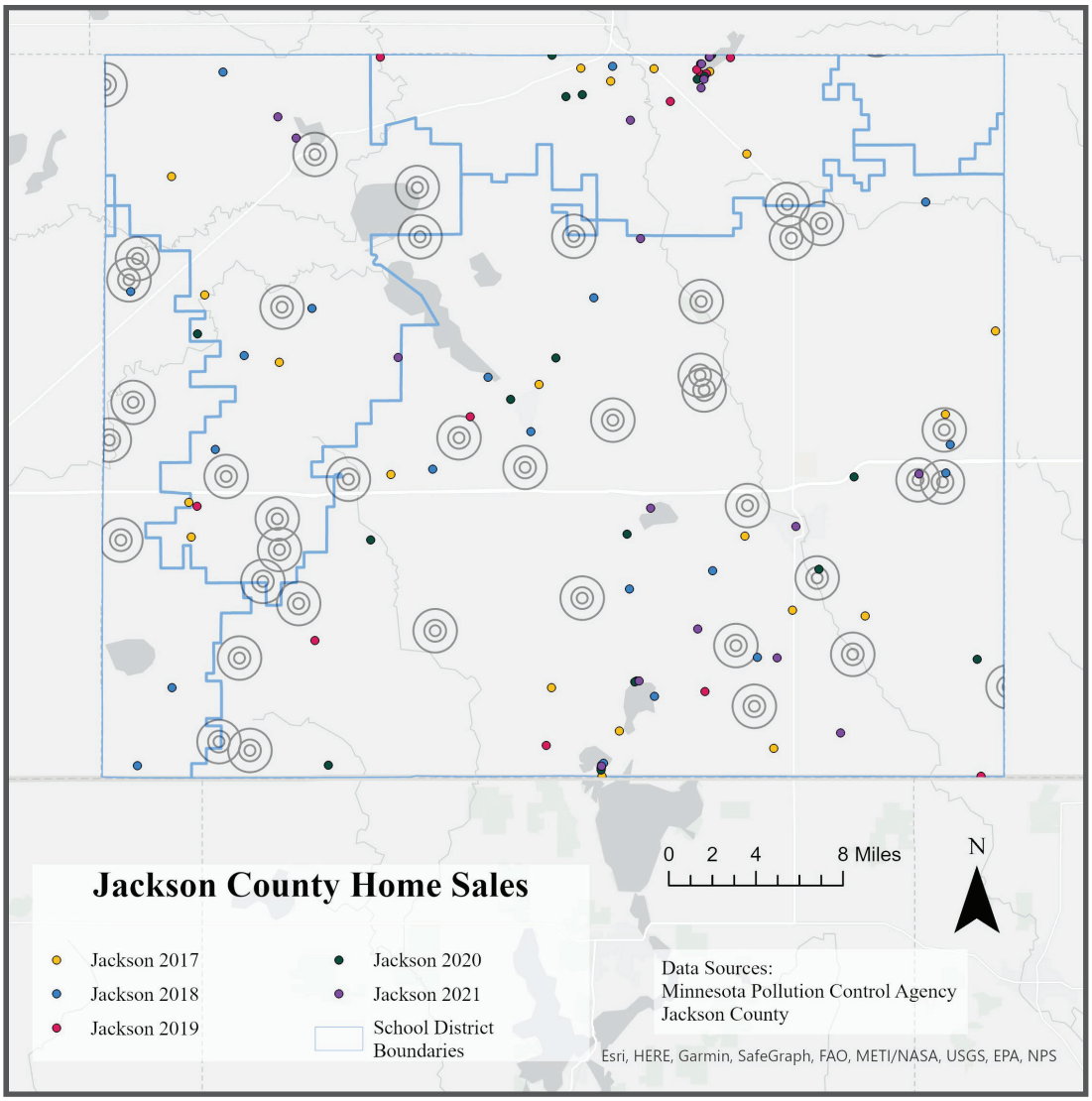

Figure 5. Jackson County in ArcGIS, 2017–2021

Table 1. Descriptive Statistics, Three-County Model, 2017–2021					
Variable	**Obs.**	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
Home Characteristics					
Sale Amount	2795	$170,938	$83,174	$70,000	$535,000
Number of Bedrooms	2795	3.16	0.85	1.00	7.00
Number of Bathrooms	2795	1.95	0.69	0.75	4.50
Age of Home	2795	59.44	32.85	0.00	151.00
Acres	2795	1.02	2.98	0.00	45.08
Feedlot Characteristics					
Swine AU Count	11	551.08	452.39	94.40	1500.00
Beef AU Count	10	74.05	90.20	13.55	249.90
Year Sold					
2017	597				
2018	583				
2019	594				
2020	602				
2021	419				

Table 2. Descriptive Statistics, Feedlot Proximity Characteristics by Livestock Type, 2017–2021				
	Beef		**Swine**	
Variable	**Obs.**	**Percent of Obs.**	**Obs.**	**Percent of Obs.**
Total Observations	10		11	
Distance Half	2	20.00%	2	18.18%
Distance One	8	80.00%	9	81.82%
Lagoon	2	20.00%	10	90.91%

Table 3. Descriptive Statistics, School Districts by County, 2017–2021		
School District	**Obs.**	**Percent of Total Obs.**
Blue Earth County	827	29.59%
Cleveland	3	0.11%
Janesville-Waldorf-Pemberton	21	0.75%
Lake Crystal-Wellcome-Memorial	213	7.62%
Madelia	3	0.11%
Mankato	344	12.31%
Maple River	161	5.76%
New Ulm	1	0.04%
St. Clair	80	2.86%
Truman	1	0.04%
Jackson County	67	2.40%
Heron Lake-Okabena	12	0.43%
Jackson County Central	36	1.29%
Round Lake-Brewster	3	0.11%
Windom	16	0.57%
Freeborn County	1901	68.01%
Albert Lea	1615	57.78%
Alden-Conger	49	1.75%
Austin	14	0.50%
Blooming Prairie	20	0.72%
Glenville-Emmons	86	3.08%
Lyle	3	0.11%
NRHEG	85	3.04%
United South Central	29	1.04%
Total	**2795**	**100%**

Table 4. Regression Results for Three-County Model, 2017–2021						
Variable	**Home Characteristics**		**Home & Multiple Buffer Rings**		**Home & One-Mile Boundary**	
Intercept	0.9846	***	0.9854	***	0.9855	***
Home & Sale Characteristics						
Age of Home at Sale	–0.0015	***	–0.0015	***	–0.0015	***
Number of Bedrooms	0.0272	***	0.0270	***	0.0272	***
Number of Bathrooms	0.0762	***	0.0763	***	0.0761	***
Acres	0.0124	***	0.0123	***	0.0123	***
Sale in 2017	–0.0511	***	–0.0512	***	–0.0516	***
Sale in 2018	–0.0337	***	–0.0344	***	–0.0343	***
Sale in 2019	–0.0204	***	–0.0214	***	–0.0214	***
Sale in 2020	–0.0073		–0.0073		–0.0072	
Swine Feedlot Characteristics						
Within Quarter to Half Mile of Swine Feedlot			0.0687			
Within Half to One Mile of Swine Feedlot			0.1439	*		
Within One Mile of Swine Feedlot					0.1407	*
Swine AU Count			0.0000		0.0001	
Swine Lagoon			–0.0851		–0.1192	
Beef Feedlot Characteristics						
Within Quarter to Half Mile of Beef Feedlot			–0.6981	***		
Within Half to One Mile of Beef Feedlot			0.0027			
Within One Mile of Beef Feedlot					0.0886	**
Beef AU Count			0.0024	**	–0.0010	***
Beef Lagoon			–0.0204		0.1015	
Number of Observations	**2795**		**2795**		**2795**	

Note: *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%.

Table 5. Regression Results for County Level Multiple Buffer Rings, 2017–2021												
	Feedlot Characteristics						Feedlot Characteristics & School Districts					
Variable	Blue Earth		Freeborn		Jackson		Blue Earth		Freeborn		Jackson	
Intercept	1.0283	***	0.9958	***	1.1223	***	1.0607	***	1.0001	***	1.1075	***
Home & Sale Characteristics												
Age of Home at Sale	−0.0013	***	−0.0015	***	−0.0017	***	−0.0011	***	−0.0014	***	−0.0018	***
Number of Bedrooms	0.0279	***	0.0190	***	0.0106		0.0284	***	0.0185	***	0.0129	
Number of Bathrooms	0.0691	***	0.0824	***	0.0578	**	0.0609	***	0.0817	***	0.0555	**
Acres	0.0102	***	0.0130	***	0.0041	*	0.0103	***	0.0122	***	0.0045	*
Sale in 2017	−0.0511	***	−0.0746	***	−0.0452		−0.0501	***	−0.0737	***	−0.0397	
Sale in 2018	−0.0345	***	−0.0581	***	−0.0030		−0.0377	***	−0.0571	***	0.0126	
Sale in 2019	−0.0229	***	−0.0448	***	0.0451		−0.0244	***	−0.0447	***	0.0464	
Sale in 2020			−0.0272	***	0.0066				−0.0268	***	0.0085	
Swine Feedlot Characteristics												
Within Quarter to Half Mile of Swine Feedlot	0.1079						0.114					
Within Half to One Mile of Swine Feedlot	0.1196		0.0091				0.1118		0.0409			
Swine Lagoon	−0.1832	**		#			−0.1471	*		#		
Swine AU Count	0.0002	**		#			0.0002	**		#		
Beef Feedlot Characteristics												
Within Quarter to Half Mile of Beef Feedlot					0.0152						0.0209	
Within Half to One Mile of Beef Feedlot	−0.0305						−0.0311					
Beef Lagoon												
Beef AU Count	−0.0022	**				#	0.0027	***				#
School Districts												
Cleveland							0.0888	**				
Janesville-Waldorf-Pemberton							−0.0927	***				
Lake Crystal-Wellcome-Memorial							−0.0368	***				
Madelia							−0.0673					
Maple River							−0.0802	***				
New Ulm							0.0292					
St. Clair							−0.0132					
Truman							−0.0356					
Alden-Conger									−0.0313	***		
Austin									0.0398	*		
Blooming Prairie									0.0634	***		
Glenville-Emmons									−0.0311	***		
Lyle									−0.0093			
NRHEG									0.0009			
United South Central									−0.0081			
Heron Lake-Okabena											0.0083	
Round Lake-Brewster											−0.0450	
Windom											0.0277	
Number of Observations	**827**		**1901**		**67**		**827**		**1901**		**67**	
R-Squared	**0.6896**		**0.5659**		**0.5355**		**0.7406**		**0.5742**		**0.5500**	

Note: *** indicates significance at 1%; ** indicates significance at 5%; * indicates significance at 10%; # indicates a dropped parameter.