The Effect of Regulated Livestock Operations on Property Values in Selected Indiana Counties

IBRC

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Key Words: CAFO, CFO, Regulated Livestock Operation, property values, hedonic modeling

Executive Summary

Regulated livestock operations, contrary to many perceptions, can have a small positive effect on nearby residential property values in rural areas. Regulated livestock feeding operations have, on average, a negative effect on nearby town residential properties. The effect of these operations on either town or non-town residences depends on the concentration of livestock, the distance to the closest regulated livestock operation and the prevailing wind direction. This conclusion is based on statistical analysis using transactions data for three Indiana counties.

"The Effect of Regulated Livestock Operations on Property Values in Selected Indiana Counties," a report by the Indiana Business Research Center (IBRC), presents the findings of a research project designed to answer the question: does proximity to a concentrated animal feeding operation (CAFO) or a confined feeding operation (CFO) affect property values?

The Indiana Business Research Center conducted the study on behalf of the Indiana Soybean Alliance. The research used two methods of investigation: (1) a survey of real estate professionals and other community leaders to ascertain their perception about the effect that regulated livestock operations (RLOs) have on property values and (2) statistical analysis using real estate transactions data to quantify the effect, if any, that RLOs had on real estate prices.

Both CAFOs and CFOs are regulated large-scale animal production facilities. CAFOs are federally regulated and CFOs are regulated at the state level. Both types of regulated livestock operations have come under scrutiny in recent years. In the last year, over 50 local and regional news articles in Indiana have reported about the local dynamics associated with the regulation and placement of RLOs. Most of these articles reported negative public attitudes about RLOs.

The IBRC selected Decatur, Hancock and Shelby counties for this study because those counties had a sufficient concentration of RLOs and electronic transactions records of property sales to conduct a rigorous statistical analysis.

The IBRC research team surveyed real estate professionals and community leaders in the three selected counties to determine perceptions about RLOs and their influence on property values. A majority of the respondents thought that RLOs reduced nearby residential property values, although real estate agents perceived that RLOs had a greater negative effect than real estate appraisers. The perceptions of the survey respondents were consistent with recent reports in the media, namely, that proximity to an RLO has a substantially negative effect on residential property values.

The transactions data, however, yielded more complex and nuanced results. All other considerations equal, proximity of a non-town residence to an RLO did not necessarily have a negative effect on sale price. This conclusion is based on a data set of 7,849 real estate transactions records compiled for the period of 2000 through 2006 for Decatur, Hancock and Shelby counties. There were a total of 197 farm property transactions in the period.

Averages Can Be Deceiving

The statistical analysis first evaluated the relative price of traditional property characteristics. For example, the statistical model estimated the effect of such traditional real estate characteristics like square footage, a fireplace, an attached garage or central air conditioning on the sale price. The next step in the modeling process estimated the relative benefit of a property located in a rural area versus the same property in a town. The attributes associated with proximity to an RLO—distance to the nearest RLO, number of surrounding RLOs within certain distances, type of livestock, concentration of livestock and wind direction—were also considered and modeled. In the third and final step, the research team evaluated the model that best predicted the effects of all traditional residential characteristics and effects of the RLO attributes on sales price. As the analysis progressed from the first step to the last, the model and modeling techniques became more sophisticated.

The simplest intermediate model used a measure from several previous studies that estimated the effect of an RLO on residential property values. The animal distance measure summarizes—or in a way, averages—all the attributes of the closest RLO to the property. The model using this summary showed that proximity to an RLO does not affect non-town properties, and town properties are negatively but mildly affected by RLO proximity.

In sum:

- It could not be statistically established that the number of animals on an RLO one mile away from a non-town residential property had a negative effect on sale price
- A town property lost, on average, $140 in sale price for the animal unit equivalent of 100 market-mature hogs (250 pounds) on an RLO that is 1 mile away

This simple model, however, was a guide for additional analysis. This summary measure is something like a swimming pool that is, on average, one-inch deep; it says nothing about how deep the deepest part of the pool is or whether there are parts of the pool, such as fountains, above the water's surface. The summary measure accounts only for the closest RLO, treats all livestock types the same and does not measure important attributes such as wind direction.

To make the executive summary easier to understand, the unit of analysis is reported in terms of mature head of livestock. The detailed report, however, compares livestock types based on a standard equivalent animal unit (AU). An AU represents 1,000 lbs of live weight.

The U.S. Department of Agriculture developed the animal unit of measure. The measure standardizes the comparison of livestock species. About 4 market-mature hogs equals 1.0 AU, but those hogs averaged about 60% of their market weight while maturing. A mature head of dairy cattle is 1.4 AUs and a mature head of beef cattle is 1.2 AUs.

Main Findings

When all statistically relevant RLO attributes are considered together, the model and the effects of the attributes become more complex. Considered together, some attributes have a positive effect and others have a negative effect. The positives and negatives need to be added together to calculate the overall net effect.

For non-town residential properties:

- Each RLO within one mile of a residence increased sale price by $12,700
- Each RLO between one and three miles of a residence increased value by $1,070
- Every 100 market-mature hogs on RLOs within 1 mile reduced sale price by $550

For town residential properties:

- Each RLO within three miles of a residence increased sale price by $2,560
- Having the closest RLO upwind of the residence reduced sale price by $4,980
- Every 100 market-mature hogs on RLOs within 3 miles reduced sale price by $120

The statistical analysis thereby implies that calculating the magnitude of the effects of proximity to an RLO should be based on a case-by-case analysis. Those who wish to delve into the details of the statistical analysis of all the RLO attributes that can have an effect on residential property values, as well as advice on interpreting statistical relationships, are encouraged to read the full report that is available at www.ibrc.indiana.edu/studies/RLOs_and_Indiana_Property_Values.html.

The type of livestock is also important. Hogs had a mildly negative effect on both non-town and town residential properties. A surrounding RLO with beef cattle had a strongly positive effect on the sale price of a town residential property, but one with dairy cattle had a strongly negative effect. Typically, however, cattle operations in this region have both types of livestock, blurring the net effect. There were too few RLOs with chickens or turkeys for a statistical assessment.

For town residential properties:

- Dairy cattle at the closest RLO reduced sale price by $32,340 for every 100 mature head, if the closest RLO was 1 mile away
- Beef cattle at the closest RLO increased sale price by $12,960 for every 100 mature head, if the closest RLO was 1 mile away
- Beef cattle on RLOs within three miles increased sale price by $2,880 for every 100 mature head

The analysis separated town (incorporated areas) from non-town residences because, true to the opinions of real estate professionals, non-town properties carry a premium. All other property characteristics equal, rural properties enjoyed a premium of $12,050 compared to a town property.

Properties in Hancock were more highly valued, all other things equal, than properties in Shelby and Decatur counties. Hancock residences were also more sensitive to the effects of RLOs. Expensive properties were more sensitive to wind direction than lower- and mid-range properties.

There were only 197 farm property transactions in these three counties from 2000 through 2006. This dataset is not nearly as rich as that for residential properties. There was only one statistically significant result: farms carried a premium of over $55,000.

Are perceptions about the effect of RLOs on residential property values consistent with real data? Not necessarily. The effect that RLOs have on rural properties depends on several factors, as reflected in the transactions data. RLOs negatively affect town property values.

All told, the answer to the question of whether RLOs affect residential property values is more complicated than a simple yes or no. The transaction data and statistical analysis do not support an unambiguous answer. The presence of an RLO can have a positive effect on property values in a rural area. Close proximity to an RLO most likely has a negative effect on property values for town residences, once all factors like livestock density and type are considered. The relative sensitivity of rural versus town properties to the presence of an RLO is also noteworthy.

These results advance the discussion about the impact that RLOs have on property values by highlighting the nature and source of the economic effects associated with the placement and size of regulated livestock operations.

Introduction

"Livestock farms grow in Indiana along with neighbors' complaints and concerns"
—Associated Press wire headline dated March 6, 2007. Filed from Indianapolis.

In Randolph County, hog output increased by an astonishing 400 percent from 2003 to 2007, according to a report by Ball State University.[1] Statewide, Indiana hog production has also increased, although at rates similar to several Midwestern neighbors.[2] The increase in hog production has been attributed to the increase in size and number of concentrated animal feeding operations (CAFOs) and confined feeding operations (CFOs).[3] With the expansion of CFOs and CAFOs—two types of regulated livestock operations (RLOs)—public resistance has also intensified.

Public resistance to the placement of RLOs has been registered at the county level and in the corridors of the state capitol. Before 2003, local and regional newspapers published few articles related to the permit process and operations of RLOs. Over the last two years, dozens of articles from all corners of the state have reported on the proposed placement, public resistance to those proposed placements and changes in the legal framework for regulating large livestock operations.

Key interests in the state are currently clashing over the rights to operate animal farms at a scale that is profitable, over the alleged economic benefits of those operations, and over the alleged economic and environmental drawbacks of those operations. Since January 2007, several bills have been introduced in the state legislature, ranging from a three-year moratorium on new large-scale livestock operations farms to a bill granting counties the right to enforce local ordinances on RLOs.

A sampling of local and regional newspaper articles would find that most of the reports present the potential negative aspects of RLOs. That said, public perception about RLOs does not seem to revolve around a singular issue. One random selection of articles found that odor and public health concerns topped the list of direct references to CAFOs. One in three of the sampled articles mentioned property setbacks as a means to mitigate some of the concerns. In a random selection of 25 articles, only five directly mentioned the negative effects on property values resulting from proximity to an RLO.

If there are negative environmental effects—such as odor, well contamination or traffic noise—as a result of being close to an RLO, one would suspect reductions in property values as a result. This study was commissioned to determine whether the perceived presence of negative effects on property values exist and, to the degree possible, to measure the magnitude of the effects on property values.

This study is not the first of its kind. In 1997, Palmquist et al. published a paper about the effect of large-scale hog operations on property values in North Carolina. In the early 1990s, North Carolina led the country in moving toward the concentration and streamlining the hog production pipeline.

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[1] Slabaugh, Seth. "Randolph County Pork Output Grows 400 Percent in 4 Years." Star Press, June 26 2007.
[2] According to the National Agricultural Statistics Service of the United States Department of Agriculture, Indiana, Iowa, Minnesota and Ohio have all increased their inventories of hogs and pigs by between 18 percent and 22 percent from 2003 to 2007. See http://www.nass.usda.gov.
[3] For more information, please see Thompson, Michael "Major Livestock Operations Across Indiana" *InContext* (March 2008): www.incontext.indiana.edu/2008/march/1.html. According to the USDA NASS, percentage of hog and pig inventory in Indiana RLOs of over 5,000 head has increased from 27 percent to 47 percent from 1997 to 2007.

In 1993, Hurt and Zering stated that 13 percent of hog producers accounted for 95 percent of the state's swine output. Palmquist et al. found that in the nine southeastern North Carolina counties, proximity within one mile of an RLO negatively affected residential property values.

Since that time, studies measuring the effect of large-scale livestock operations on property values have been conducted in Colorado, Iowa, Illinois, Missouri, Michigan, North Carolina, Ohio and Pennsylvania. All of these studies found that the large-scale livestock operations negatively affected residential property values. Only one study, written for the Minnesota state legislature, found that large feedlot operations could have a positive effect on residential property values. This report, however, was never published in a peer-reviewed journal.

While the preponderance of evidence from studies conducted in other states would indicate that proximity to large-scale livestock operations has a negative effect on residential property values, the studies have not used a consistent method for measuring that effect. Indeed, the inconsistent nature of the data in different states (and counties) and the lack of a statistical standard to model the effects make it irresponsible to consider the question answered. Moreover, these studies focused on residential property values, leaving the question about effects on farm property values unanswered.

The Indiana Soybean Alliance (ISA) commissioned the Indiana Business Research Center (IBRC) of Indiana University's Kelley School of Business to use the best practices of previous quantitative research and extend previous work in two ways. One, augment quantitative, data-driven analysis by pursuing a qualitative approach to assess the *perceptions* real estate professionals and community leaders have regarding the effects of RLOs on property values. Two, assess the effect of proximity of an RLO on *farm*[4] property values to the degree possible. Following the traditional hedonic pricing model methodology used in a majority of previous studies, the IBRC research team collected and processed sales transactions data for three contiguous counties in southeastern Indiana: Decatur, Shelby and Hancock. In laymen's terms, the hedonic model estimates the price associated with a property characteristic. For example, the model estimates the relative price of characteristics such as a bathroom, a fireplace, a basement, a good school district or the negative price associated with a septic system rather than city sewer service. The research team also surveyed real estate professionals and community officials to ascertain their perceptions of the effect that RLOs have on property values.

The following maps show the three counties under study. The research team selected these three counties because the IBRC could gain access to a multi-year series of transactions data that reported all real estate sales in the area together with the property characteristics and precise location. Because the different series of data were collected and stored by several government and business entities, developing a consistent set of parcel data on transactions for both residential and farm properties was the most burdensome aspect of the project.

Figure 1 shows the location of each RLO within the three counties, as well as the location of RLOs just outside the county borders if that farm might affect a property. **Figure 2** shows the number of transactions for residential and farm properties by zip code within ten miles of an RLO by zip code.

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[4] For the purposes of this study and report, the term "farm" refers to crop and smaller, unregulated livestock operations. The Indiana Department of Local Government Finance classified 197 transactions as agricultural, in other words, as farms.

Figure 1: Regulated Livestock Operations within 10 Miles of Decatur, Hancock and Shelby Counties
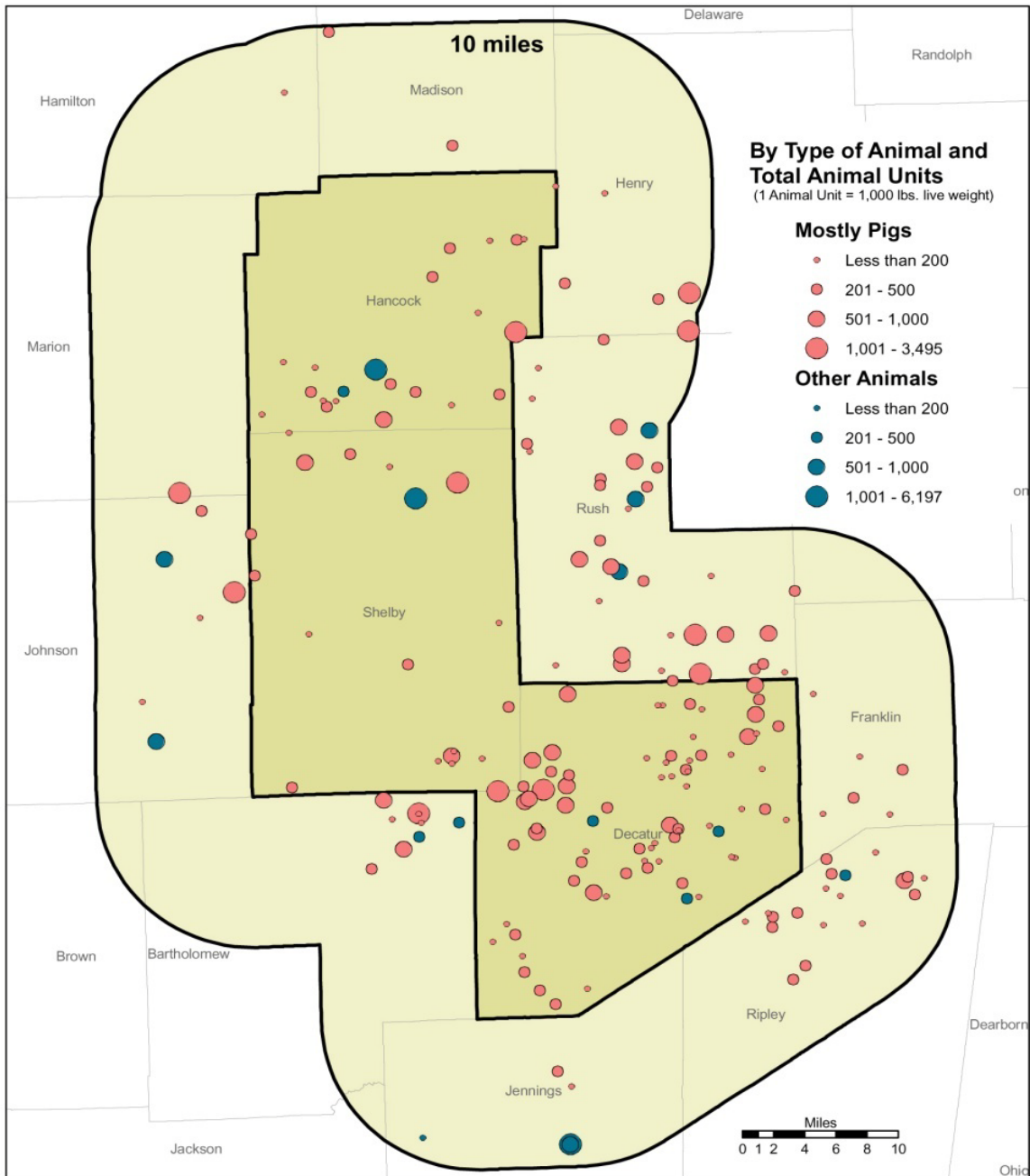
Source: Indiana Business Research Center, using data from the Indiana Department of Environmental Management as of January 1, 2008

Figure 2. Number of Decatur, Hancock and Shelby County Real Estate Transactions by ZIP Code within 10 Miles of an RLO, 2000 to 2006

Source: Indiana Business Research Center, using data from the Indiana Department of Local Government Finance, the Indiana Department of Environmental Management and the Metropolitan Indianapolis Board of Realtors
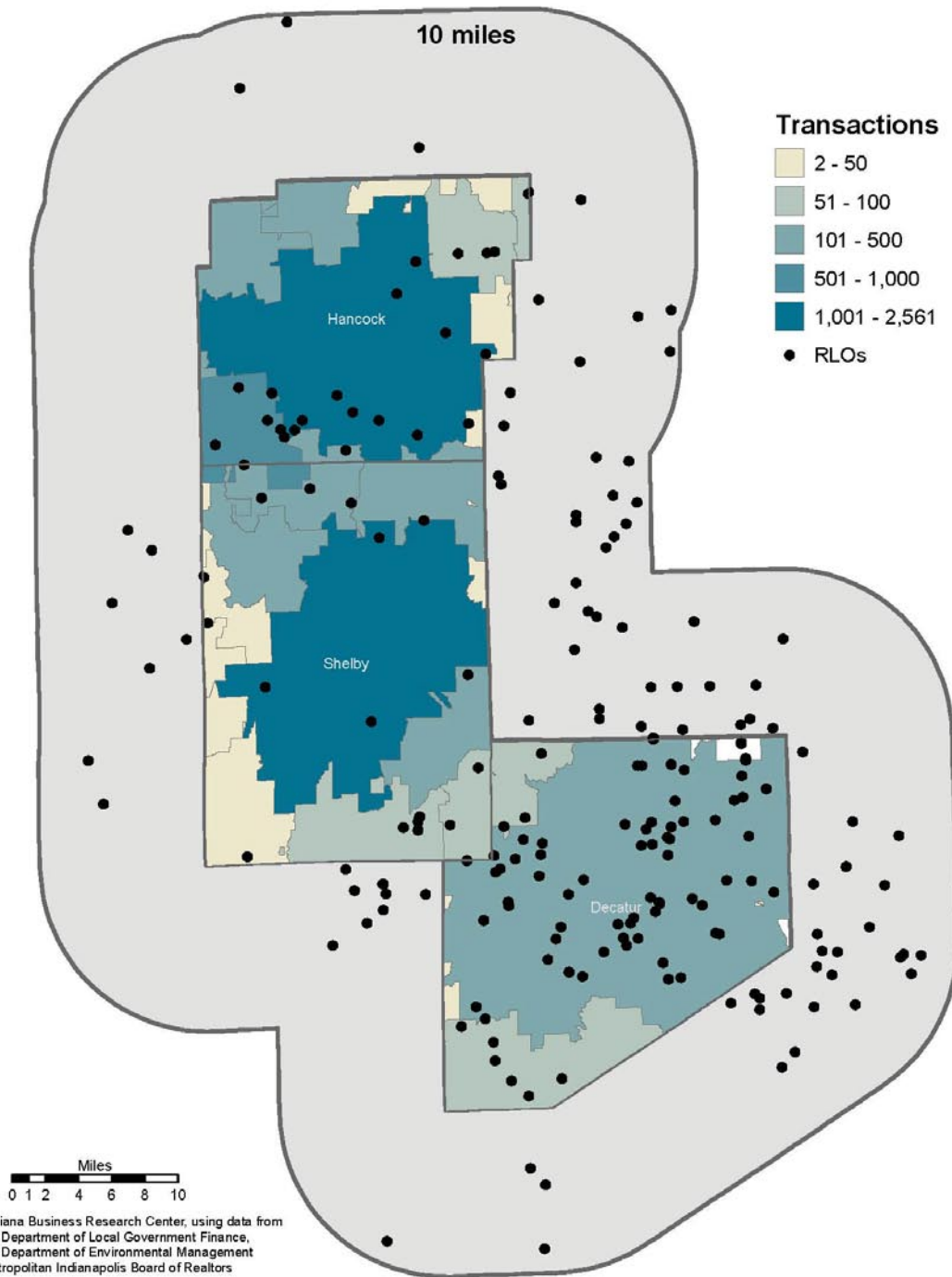
Scope of Work and the Organization of the Report

As stipulated in the scope of work, the IBRC designed and implemented a qualitative and quantitative research methodology.

Few would argue that the perceptions of a non-standard product do not influence price. Whether or not large-scale animal operations produce documented environmental effects is irrelevant if a prospective buyer perceives proximity to an RLO as negative. This report leads with the qualitative analysis of people's perceptions about large-scale livestock operations. In this way, we see whether perceptions correspond to the overwhelmingly negative sentiments expressed in the media. In the qualitative analysis section, the interview and survey methods are presented together with the key findings.

The qualitative analysis is followed by the quantitative analysis. This section reviews studies conducted in other states and brings together the best methodological elements of those studies for the Indiana study. After a brief overview of the statistical method and the collected transactions data, the report presents the estimated effect proximity to RLOs has on residential and farm property values. The report concludes with an overview of the results of the two tracks—qualitative and quantitative—and outlines avenues for future research.

Qualitative Analysis: Interviews and Surveys

Survey Methodology

To gather information about the opinions of real estate professionals, the research team developed a web-based survey that targeted those who had a role in the transaction of a property that may have been affected by the proximity to an RLO. A "real estate professional" included any occupation with a role in real estate transactions. In addition to agents, brokers and appraisers, real estate professionals included those who help facilitate the financing of commercial, farm and residential properties. The survey instructions also stipulated that only those who had been involved in property transactions potentially affected by an RLO were to complete the survey.

The survey asked a range of questions about the relative effect RLO distance, animal type and animal density would have on property values. The research team developed categories and questions based on important variables identified in previous studies. For residential property values, the survey solicited opinions about the effect proximity would have based on the value of the property as well as the relative value of property characteristics—such as the number of bedrooms, type of construction, or whether the house had such amenities as a fireplace or central air conditioning. For farm properties, the survey included questions about the average value per acre without consideration of the value of outbuildings and residential structures.

Because of the detailed nature of the questions related to property characteristics, and the relative price associated with those characteristics, the survey was lengthy. Approximately 105 real estate professional were invited via email to participate in the online survey. Few elected to do so. Those who accepted the invitation tended to complete the survey, despite its length. The number of completed surveys was not sufficient to be able to draw conclusions from the survey instrument. As a result, the results of the online survey were blended with the results of the interviews to present a more complete picture about real estate professionals' opinions on the property value effects of RLOs.

Interview Methodology

Given the disappointing rate of online survey participation, the research team engaged a more personal approach to soliciting opinions. Using a greatly truncated survey instrument, the research team conducted over 100 interviews with individuals from both the public and private sectors. All interviews were confidential. While in-person interviews were preferred, the research team conducted telephone interviews when circumstances would not allow a personal meeting. Ninety-two interviews were complete enough to be tabulated and included in this study.

Following the study design, interviews focused on individuals who worked and lived in the southeastern Indiana counties of Decatur, Hancock and Shelby. Because concerns related to large-scale livestock operations are statewide and because the research team used referrals and introductions to foster greater participation among real estate professionals, the team interviewed persons residing or working in eleven other Indiana counties. In this way, the study incorporated opinions from a wide range of individuals knowledgeable about RLOs and their actual or perceived influence on the local community.

Responses are reported in three categories: residential real estate appraisers, residential real estate agents and other non-realty professionals with interests in the effects of RLOs. The latter category included Purdue University extension agents, township assessors, county commissioners, bankers,

farm credit field office staff and other farm service agency staff. Given the nature of their occupations, the interviewees were likely to have greater knowledge of RLOs than the average citizen. In the interviews, participants shared their views and anecdotal information on community perceptions of RLOs. The interviews were slightly longer for residential appraisers and real estate agents in order to ask them about the degree to which proximity to an RLO may affect residential property values. In addition to recording the responses to the formal interview questions, the team recorded respondent opinions, if offered, about how other emerging agricultural or rural land-use trends such as ethanol plants, wind farms, the high cost of fuel or other factors that may affect farm and residential property values.

Nearly all respondents were candid and impressed upon the interviewer that their opinion was not necessarily the opinion or the official position of their employer. Township assessors were the most reticent concerning their opinions. This may be because their positions had been under scrutiny by the state legislature. Another explanation for their reticence may be possible future regret for sharing their opinions if they received subsequent requests for re-assessment, confidentiality of the interviews notwithstanding. Despite possible concerns, no surveyed assessor had been asked to reassess any property that was located near or adjacent to an RLO.

Findings from Interviews and Surveys

Given the central question about the relative effect of large-scale livestock operations on the value of residential property, realtors differed slightly from appraisers. Realtors tended to ascribe a greater negative effect of RLOs on property value than did appraisers. When asked to compare similar, rural houses, one within a mile of an RLO and one that was not close to an RLO, more realtors than appraisers thought it would reduce the property's value. Non-realty participants, like agricultural extension agents and bankers, tended to have the same response pattern on these questions as did appraisers.

When asked how distance affects property value reduction, realtors and appraisers had distinctively different opinions, as shown in **Figure 3**. (Because they did not have direct experience with the specifics of property valuation, non-realty participants were not asked how distance affects value.)

Figure 3: Differences in Perceptions: Realtors and Appraisers

The Perceived Effect of RLO Distance on Residential Property Values
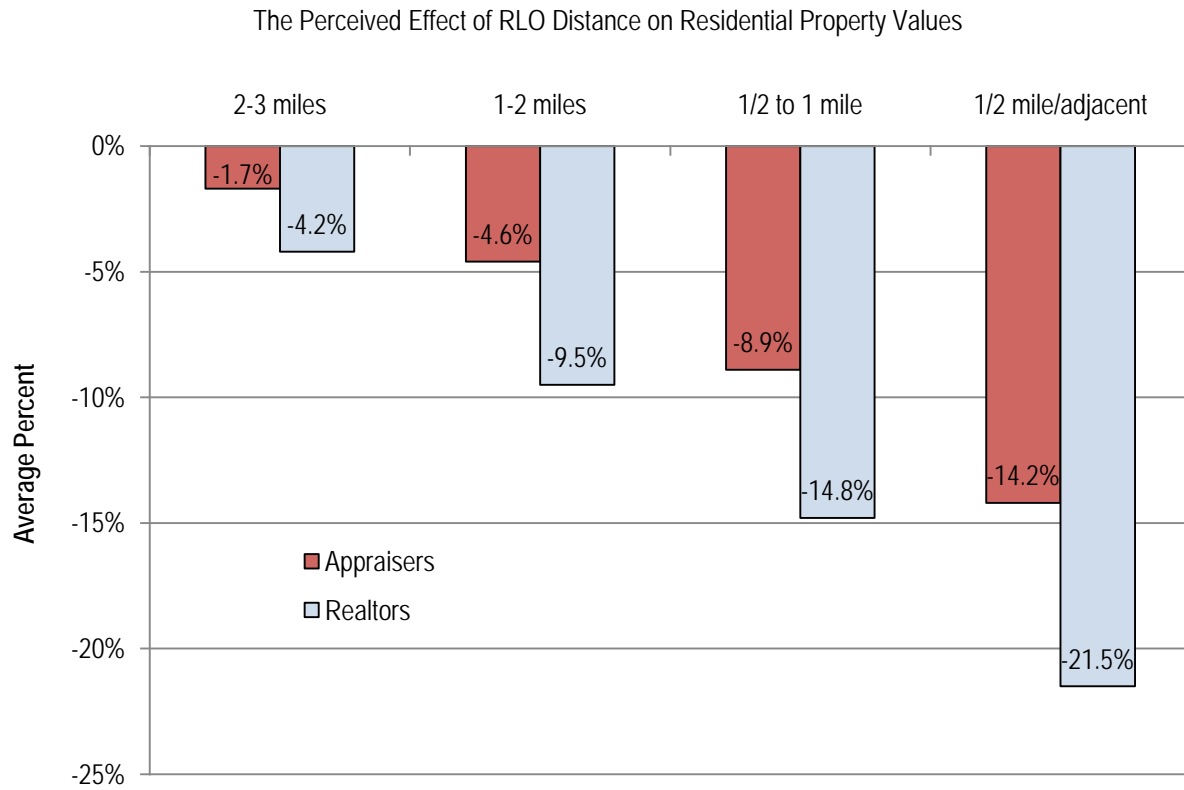
As **Figure 4** shows, all three categories of respondents considered distance from a large-scale livestock operation to be the most important factor in determining the effect on property value.

The second most important factors may be the most interesting. There was a divergence in relative importance among the three categories of respondents.

Figure 4: The Perceived Effect of an RLO on Residential Property Values

"Most Important Factor" by Respondent Occupation
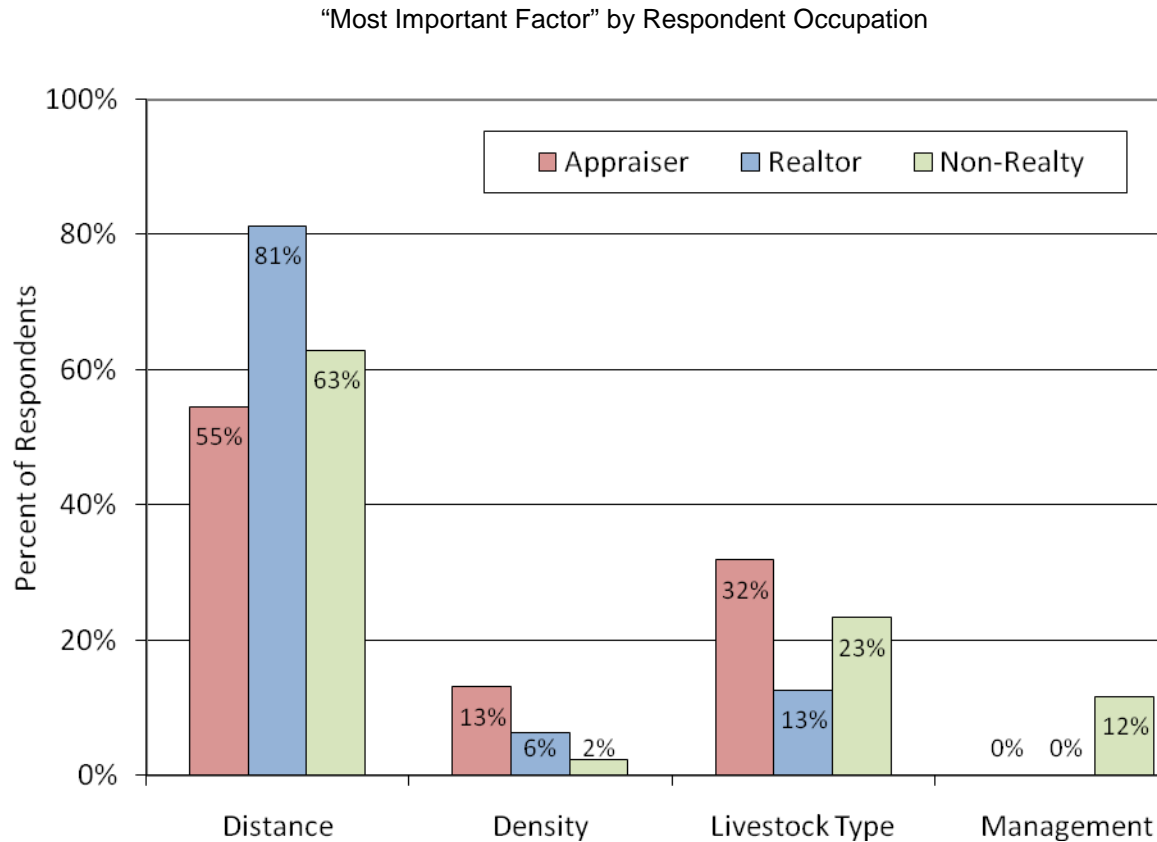
The difference in opinions between appraisers and agents is noteworthy. A vast majority of real estate agents (81 percent) considered distance the most important factor affecting residential property value whereas a relatively small majority of appraisers (55 percent) considered distance the most important RLO attribute. Neither agents nor appraisers considered the management of the RLOs—waste handling equipment or sanitary practices, for example—to be the most important factor. Remarks made during the interview process suggest that appraisers were less vested in the valuation result and more objective in their observations. (Appraisers are paid a flat fee for their work regardless of value). Real estate agents, on the other hand, seemed more inclined to associate greater stigma with proximity to an RLO, regardless of other circumstances like sight lines and wind direction.

As shown in **Figure 5**, there was a greater dispersion among the respondents in terms of the second most important factor perceived as affecting residential property values. Perhaps one of the more interesting results is how strongly realtors felt that animal type was more important than density. This is interesting because RLOs in these three counties are comprised largely of swine. Their opinions may be influenced by a small but powerful number of anecdotes about non-swine RLOs.

Figure 5: The Perceived Effects of RLOs on Residential Property Values

Second Most Important Fact by Respondent's Type of Occupation
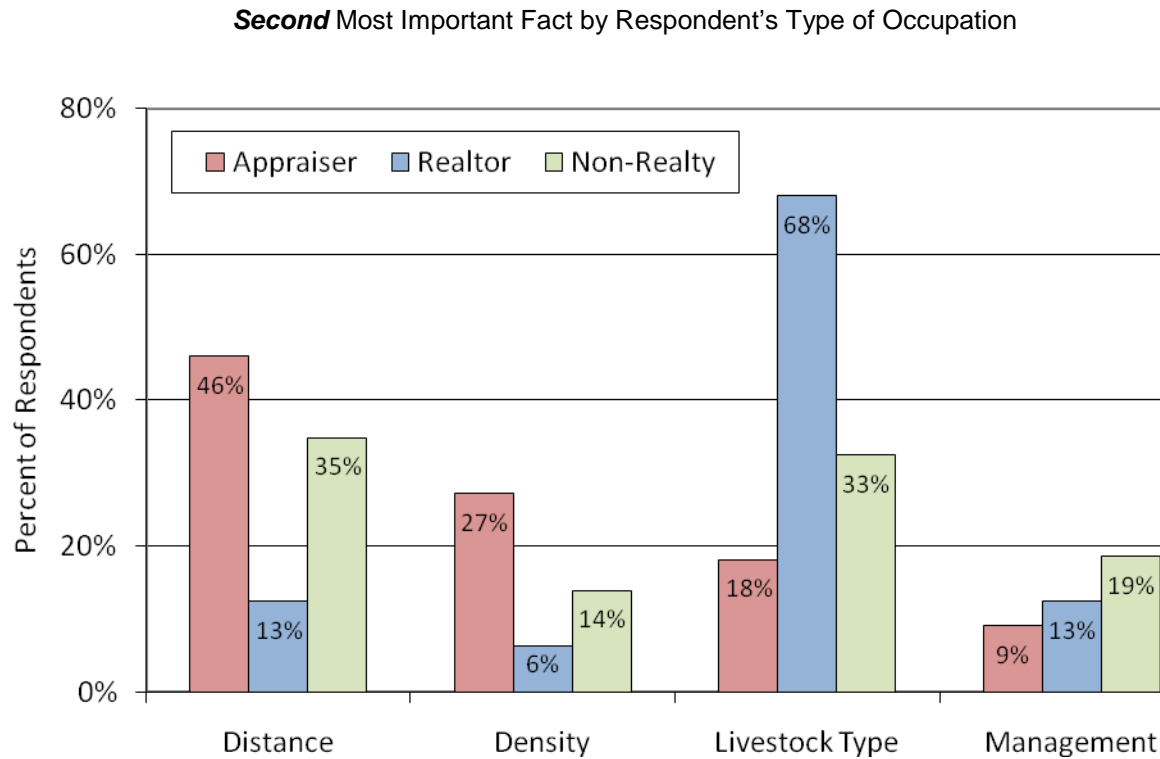
There were several other conclusions to draw from the interviews. A vast majority of non-realty persons registered the opinion that RLOs positively contribute to the county in terms of tax revenues and employment. While majorities of both appraisers and realtors also thought that RLOs make a positive contribution to the county, it appears that realtors are less convinced. In the interviews, residential realtors registered their sentiments that RLOs, while making a contribution, also carried a stigma.

Both appraisers and realtors had little direct experience with RLOs. Less than one in five appraisers and residential realtors had visited an RLO. On the other hand, a vast majority (93 percent) of community members not directly involved in a real estate occupation have visited an RLO. Of those interviewed, two-thirds of those in non-realty occupations had attended a public meeting about the effect of RLOs on residential property values. Of the residential realtors interviewed, 25 percent have attended such public meetings, while a mere 18 percent of appraisers admitted to attending them. Several participants mentioned that they were unsure whether the public forum had been devoted to residential property values in particular or property values in general. When prompted, no participant could recall whether the magnitude of the effect, in either dollar or percentage terms, was mentioned at the public forum.

An unintended consequence of the questions asked in the personal interviews was the relative valuation of a rural residence in contrast to the same house located in the largest city in their counties.[5] A large majority (over 80 percent) of respondents in all occupations valued properties in a

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[5] See the Appendix for the interview questions.

rural locale more highly than the same property in the largest city in their county. (See questions 5, 6 and 7 in the survey.) The data *seem* to indicate that county living is more highly valued than "city" living, even if one were within a mile of an RLO. The majority of respondents considered properties a mile from an RLO as having a greater value than an identical property in the largest city in their respective county.[6] The presence of the RLO a mile or less away from the rural residence did tend to reduce the perceived value of the property according to all the occupational categories, but the residential realtors seemed to sense a greater negative effect.

Were respondent perceptions informed by empirical evidence? The answer seems to be no. The general consensus of the 92 respondents is that there is a dearth of hard sales data. Many appraisers and realtors noted that there are too few sales near RLOs to draw firm conclusions about effects. In addition, there may be extenuating circumstances based on wind direction and topography. Several appraisers intimated that proximity to an RLO might have a greater effect on the length of time on the market than on sales price. Finally, several appraisers noted that the negative effects of a residence's proximity to an RLO would be similar to proximity to a slaughterhouse, ethanol plant or even an auto parts salvage yard.

The following anecdotes from the interviews provide some context for the opinions expressed in the interviews.

- A Shelby County property adjacent to (and downwind of) an RLO was listed for $179,900 in 2005. According to the listing realtor, the traditional brick house, built in 1935, sits on more than two acres and is well-maintained. It was on the market for two years and sold for $135,000. The realtor attributed both the extended marketing time and reduction in value to the proximity to the RLO. The realtor estimated that the property probably would have sold for $20,000-$35,000 more in a different location. An appraiser familiar with the property noted that while the RLO likely had some affect on the sale, the house's age and its location in southeastern Shelby County reduced the number of potential buyers. In addition, the property may be unusual as neither the realtor nor the appraiser could find comparable properties that sold in the $155,000-$180,000 range at the time the property was listed.

- A Miami County appraiser cited the foreclosure of a 100-year-old home that was within one-half mile of a large RLO. The property had been neglected and its physical state certainly affected the market value. But which had the greater effect, the deteriorated condition or the proximity to the RLO? The appraiser was uncertain whether the owner let the property fall into disrepair because of financial problems or because he did not think investing in maintenance made sense given the nearby RLO. The property sold for $45,000, a fair price according to the appraiser given its neglected physical condition.

- In Carroll County in 2007, two modular homes one mile east of an RLO both sold relatively quickly and within the price range of similar houses that were not proximate to large-scale livestock operations. The appraiser opined that the presence of an RLO has a less significant effect on the value of houses in the lower price ranges. After all, reflected the appraiser, home buyers of low-and-moderate incomes do not have as many purchase options.

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[6] This question did not ask about wind direction and the location of residence relative to the CAFO.

- One appraiser speculated that the effect of CAFOs on residential values will diminish over time. Production and waste disposal technologies will likely improve and that will reduce concerns about odor and water contamination. The appraiser cited I-465 as an example. When I-465 was built around Indianapolis, there was great concern by homeowners their home values would decrease due to pollution and traffic noise. However, the installation of sight and sound barriers eliminated most of the negative effects of the noise and new emissions technology reduced the pollution. Conversely, easy access to the interstate is often seen as a positive by many potential buyers. After the barriers were erected and the dust settled, property values were not negatively affected and, in some cases, those properties appreciated at a faster rate than comparable homes in the same areas or townships.

- A Pulaski County farm appraiser related a story about a man who learned that an RLO was going to be constructed a mere 1,200 feet from his $500,000 house. He wanted to sue the RLO owner(s) for damages. While the appraiser thought there would be a negative effect on the property value, he declined to testify in court on behalf of the homeowner for a couple of reasons. One, the cost to construct the house may well have been $500,000, but this cost may not correspond to market value. The value is the price someone is willing to pay for a property, regardless of cost. Two, there is no way of knowing the RLO effect until the house is sold. Unless the homeowner was willing to move, he wouldn't learn the magnitude of the effect.

These anecdotes are a representative sample of the qualitative support for the perceptions recorded in the personal interviews. Nearly all the individuals interviewed thought that residential properties adjacent to, or within sight or smell of, an RLO would have some reduction in value. That said, translating a perception into a dollar or percentage amount is almost impossible because each house is different and the relative magnitude of the RLO environmental effect is also different.

Fortunately, economists have developed statistical techniques that can be used to estimate the relative costs and benefits of a house's characteristics. Several studies conducted in other states have attempted to estimate the effects the proximity of RLOs on residential property values. Those studies are summarized below.

Quantitative Analysis: Transaction Data and the Hedonic Pricing Model

Review of the Literature

Livestock production in the United States has undergone many changes in the last 15 years. Since 2000, those changes in the size and structure of farms have gained momentum in Indiana. North Carolina led Indiana and many other states in the transformation of livestock production, especially swine production. From 1991 to 1994, hog production increased 250 percent in North Carolina. In recent years, parts of Indiana have also seen dramatic increases in hog output. In Randolph county, for instance, hog output increased 400 percent from 2003 to 2007.[7]

The transformation of swine production and the rapid expansion of output have led to increasing public concern about the potential environmental and health effects related to large-scale animal operations. Many homeowners claimed that the tangible value of their property declined due to close proximity to large-scale animal feeding operations, but few had hard data to support this assertion. Before Palmquist et al. (1997) published their seminal study on the effects of hog operations on residential property values in North Carolina, few studies had been conducted. At the same time that Palmquist et al. were conducting their published research, Taff et al. (1996) studied the effects of feedlots on residential property values in two Minnesota counties using a "hedonic approach" similar to Palmquist et al.[8] Contrary to expectations, Taff et al. found that proximity to an RLO had a mildly positive effect on value. The only other study that Palmquist et al. had to reference that used a hedonic valuation approach was Abeles-Allison and Conner (1990). Their unpublished study measured the effect of hog operations on house values for properties around eight Michigan hog operations. They found that the operations had a negative effect, but because the study used sales data only for affected properties that had registered multiple odor complaints, the results could not be generalized to a larger universe of properties.

Before the mid-1990s, the occasional property impact study was probably motivated by the occasional flare up of local resistance to large-scale livestock operations. By the mid-1990s, however, local public interests and environmental activist groups seemed to coalesce around the negative effects of RLOs. With such a dramatic increase in livestock operation size and output, and having weathered several manure lagoon ruptures, North Carolina became something of the epicenter for protest. In 1997, North Carolina passed a moratorium on large-scale hog operations that only recently expired. Thus, it comes as no surprise that more studies have been completed in North Carolina than any other state. The motivation for this type of applied research is to determine *if* large-scale operations have an effect on the value of residential properties that are close by and, if so, *the magnitude* of those effects. There was probably little motivation to estimate the effects RLOs had on farm values.

 The North Carolina study by Palmquist et al. (1997) found that values were especially affected within one mile of a large-scale livestock operation. They examined 237 rural house sales between January 1992 and July 1993 in nine southeastern counties in North Carolina. Because of confidentiality rules in North Carolina, the authors did not have *specific* location data for large-scale

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[7] Slabaugh, Seth. "Randolph County Pork Output Grows 400 Percent in 4 Years." *Star Press,* June 26 2007.
[8] The hedonic method is explained in detail below. In general terms, the method measures the economic value of each characteristic of a product, service or property.

hog operations. That said, State Veterinarian's Office did supply data that allowed the authors to place the large-scale livestock operations within three rings around the home sales. The authors also used a manure index based on the type and number of animals. Depending on the distance and volume of manure produced by the large-scale operation, proximity can negatively affect the value of the house by as much as 9 percent.

Since the seminal work of Palmquist et al, studies have used the hedonic approach and attempted to include as many relevant large-scale livestock operation attributes that could affect residential property valuations. All the subsequent studies concluded that proximity had a negative effect. Researchers found that several important RLO attributes affected residential property values: distance from the operation(s) to the property, the number of RLOs close to the affected property, the number of livestock, the type of livestock, wind direction and the modernity of the operation. The following discussion catalogues the salient findings of the studies.

Hamed, Johnson and Miller (1999), in an unpublished study, examined transactions that occurred in Saline County, Missouri between January 1, 1996 and December 31, 1997 for possible large-scale livestock operation proximity effects. Using a linear measure of distance to the nearest RLO, the authors found that land parcels with houses within 3 miles from an RLO suffered a loss in value. RLOs did not affect the value of vacant land.

Bayoh, Irwin and Roe (2004) studied transactions data from five townships within Mercer County, Ohio. The data consisted of 3,476 residential property sales from 1999 to 2001. Using a hedonic model, they found that proximity could have both a positive and negative effect. As distance from livestock increased, house values also increased, but *adjacent* livestock operations increased the value of a house. The authors speculated that the relative value-effect of changes in the size and location of large-scale livestock operations depends on existing livestock levels. Residential parcels that are already proximate to a RLO may see their value increase with the increase in the local livestock concentrations. On the other hand, parcels initially isolated from livestock operations would find their property prices decline with the commencement of a nearby large-scale livestock operation.

Park, Seidl and Davies (2004) used a total of 3,345 residential transactions for a three-year period in Weld County, Colorado. A large majority of the 184 livestock operations were cattle (beef and dairy). Like previous studies, the researchers drew three rings around each housing unit to estimate the effect of distance. Size and location data were defined for each livestock type. As expected, irrespective of species, the effect of more operations or larger operations becomes weaker and less statistically significant as distance increases. Park et al. also found that the magnitude and nature of the effects are different based on the value of the residence. Hog operations, for example, have a positive effect for less expensive homes, possibly because of the employment effect. For the more expensive home market segment, there was a large decrease in value based upon proximity and hog concentrations.

Herriges, Secchi, and Babcock (2005) examined transactions that occurred between 1992 and 2000 in five Iowa counties for the effects of proximity to 550 livestock facilities. The number of transactions, 1,145 house sales, combined with the using data from five counties provided the authors a rich data set. The authors used several types of measures for the effects of RLOs: distance to the nearest RLO, RLO density, animal concentration, a manure index and seasonal wind direction. Perhaps contrary to expectations, larger RLOs had a smaller negative effect than smaller RLOs. This may be, the authors posit, because larger RLOs can afford more advanced odor

abatement technology. The authors also found that wind direction (especially in the winter) has a particularly negative effect.

Kim, Goldsmith and Thomas (2005) used the assessed values for 25,684 properties in Craven County, North Carolina. Craven County updated assessed property values in 2002 and made them public on the county website in January 2003. They found that houses with average (or "median") characteristics were negatively affected if the RLO was within 1.75 miles. As farm size decreased or relative distance increased, the effects declined. That said, the researchers found that at some point, even as hog concentration (RLO size) increased, the animal unit effect on property values diminished. They posit that larger RLOs may have a lesser effect on value on a *per hog-unit* basis because there may be economies of scale for abatement.

Milla, Thomas and Ansine (2005) conducted a similar study for Craven County, North Carolina. They selected Craven County because of the publically available, GIS database of assessed property values and features. Unlike the study by Kim et al., parcel data were selected based on transactions that took place between January 2000 and July 2001, yielding a final dataset of 810 observations. Milla et al. constructed a variable that, in their view, captures the affect of both distance and hog concentration. The model showed that concentration/proximity has a negative coefficient. In other words, there is an inverse relationship between home prices and the number of hogs or the proximity to an RLO.

In a published study, Ready and Abdalla (2005) estimated a hedonic house price model using 8,090 residential properties sold between 1998 and 2002 in Berks County, Pennsylvania. The researchers used house sales prices, not assessed values, in constant (2002) dollars; the database contained an extensive array of house characteristics. While most previous studies tended to focus on hogs, this study includes all species of livestock. Ready and Abdalla found that the negative effects occurred within 1.6 miles of the large-scale livestock operation. Poultry had the most significant effect, while swine and cattle were not statistically different. The researchers found that farm size did not affect house price consistently. Medium-sized operations had a larger effect on price than larger-sized operations. Herriges et al. found a similar result and suggested that larger operations may be managed better or have more modern abatement equipment. Even more interesting, Ready and Abdalla found that the smaller, unregulated operations may have a relatively larger effect than regulated operations.

Few studies have examined the effects of RLOs on farm property values. Hamed et al., did not focus on farm values, but did find that that RLOs did not decrease non-residential property values. More recently, Huang, Miller, Sherrick and Gomez (2006) examined average farm property values at the county-level in Illinois. This study used county-level data for transactions between 1979 and 1999. The study found that counties with more large-scale hog operations showed a decrease in average property values. They also found that the average size of these operations did not have a significant effect on average county farmland property values. While Huang et al. used state of the art modeling techniques, their data were dated. The more recent trends in farm values would probably stand in stark contrast to trends observed in the Illinois county-level data from the 1990s.

Isakson and Ecker (2008) studied the affect of 39 large-scale hog farms in Black Hawk County, Iowa. The transactions data totaled 5,822 and were compiled with variables that captured the effects of prevailing winds within concentric circles around each RLO. Isakson and Ecker also accounted for "selection bias," the phenomena that low land values attract both RLOs and inexpensive homes. The degree to which RLOs and lower-priced homes "co-locate" has been an important topic of

discussion in some earlier studies. If selection bias is present, then there should be more RLOs located near lower-priced houses than higher-priced houses. Isakson and Ecker did not find evidence for selection bias. They also found that there are large negative effects for houses within 2.5 miles and directly downwind from an RLO.

Statistical Methodology

Economists have used hedonic techniques to measure the value of product attributes or the effect of environmental attributes for decades. The strength of these models is that they allow one to simultaneously compare many diverse real estate properties (thousands in the case of this study) to understand which property characteristics are significantly more likely than others to increase or decrease a property's value. The model assesses the effect on sale price of each attribute (e.g., the effect of having an upwind regulated livestock operation or not) for properties that otherwise share similar characteristics (bedrooms, acreage, age, etc.). Since no two properties are exactly the same, hedonic models provide a statistically defensible method to make comparisons.

Transactions Data. The IBRC complied transactions data for Decatur, Hancock and Shelby counties for the period 2000 through 2006—a challenging task considering the inconsistent recording of transactions data among Indiana's numerous local government agencies.[9] After two months of contacting county assessor offices across the state, the research team could not identify a county that had a substantial concentration of RLOs with detailed electronic files of sales transactions data. The Indiana Department of Local Government Finance (DLGF) had the most comprehensive listings of property sales across the state, but many records were missing important characteristics (e.g., the number of bathrooms, type of heating, etc.). Local realtor associations that use the Multiple Listing Service (MLS) had more detailed property information but tended to favor counties without a significant presence of RLOs. By necessity, the research team chose counties for which, by mixing multiple data sources, it could assemble both sales values and property characteristics. This task was made even more difficult because different data sources used different methods to identify a particular property. To improve the accuracy of parcel matches, the team employed GIS-based matching techniques (using the longitude and latitude of each parcel) to identify whether different groups of parcels belonged together as part of the same recorded sale.

Decatur, Hancock and Shelby counties were used for this study because these were among the few counties whose DLGF transaction data *and* MLS property files were complete enough for consistent data assembly. These counties are close to Indianapolis and MLS data was available through the Metropolitan Indianapolis Board of Realtors (MIBOR) database. In addition, these counties had substantial numbers of regulated livestock operations. The IBRC has a close working relationship with both DLGF and MIBOR. As a result, analysts from all three agencies routinely ironed-out issues related to data integrity.

As of the first quarter of 2007, there were 53,041 parcels in Decatur, Hancock and Shelby counties. Among these, initial queries identified 9,753 sales during the 2000-2006 period with valid 'matches,' that is, verifiable sale, parcel and characteristics data. After several iterations, the team scrubbed that data of duplicates, sales data with errors, or records with incomplete information on year of sale, price, acreage or square footage. The final dataset contains 7,849 sales with sufficient property information for hedonic analysis.

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[9] For more information about the challenges of collecting property transactions data, please see Brown, Mark. 2005. "Statewide Property Tax Equalization Study: Policy Report." *Indiana Fiscal Policy Institute*: Available at: www.indianafiscal.org/REPORT.pdf.

Data on regulated livestock operations (RLOs). The Indiana Department of Environmental Management (IDEM) provided data on all regulated feeding operations in Indiana, including the 203 RLOs within 10 miles of the borders of the three counties. Because the state agency regulates CFOs within Indiana, and monitors CAFOs that are regulated at the federal level by the Environmental Protection Agency, IDEM maintains a database of all RLOs in the state. IDEM not only provided geocoded location data for all RLOs, but also the number and type of animal for which a particular RLO has a permit. IDEM also provided guidance regarding the unit of measure for animal concentration at an RLO, namely the U.S. Department of Agriculture measure calculating animal units based on live weight (1 animal unit = 1,000 lbs; see Appendix Table 13 for more details).

Coding and Measurement. The following section explains the major coding decisions for the main 16 traditional housing variables and 23 RLO variables constructed and tested for use in this study (other variables were also prepared but not used in this analysis). These variables are summarized in **Tables 1A** and **1B**.

- Dependent Variable. The sales price served as the dependent variable for all analyses, rather than assessed or appraised value. (The logged sales price was used to estimate the factor or percentage effect of different RLO attributes at different levels of property value).

Table 1A: Property Pricing Variables based on Traditional Housing Characteristics for Properties Sold in Selected Indiana Counties, 2000 to 2006. Labels & Descriptive Statistics, N=7849

Variable	Description (units)	Mean	Std. Dev.	Min.	Max.
A: Dependent Variable					
priceth	Price when Sold (thousands of dollars)	129.52	68.94	15.00	879.00
B: Traditional Housing Characteristics (Independent Variables)					
	<u>Characteristics of all Sold Property</u>				
county	County variables: *decatur* (533 sales, 6.79%); *hancock* (4397, 56.02%); *shelby* (2919, 37.19%)				
town	1=within a town/incorporated area; 0=not	0.54	0.50	0.00	1.00
saleyear	Year of Sale variables: *y00* (847 sales, 10.79%); *y01* (988, 12.59%); *y02* (963, 12.27%); *y03* (1135, 14.46%); *y04* (1372, 17.48%); *y05* (1469, 18.72%); *y06* (1075, 13.70%)				
age	Age (years)	43.94	35.82	2.00	208.00
newacre	Lot Acreage	2.44	10.47	0.00	243.84
area	Area within Property (square feet)	1918.94	872.61	320.00	8089.00
farm	1=Farm (197 sales, 2.51%); 0=Residential Dwelling (7652, 97.49%)	0.03	0.16	0.00	1.00
multilevel	0=One Level; 1=Two or More Levels	0.25	0.43	0.00	1.00
bed	Number of Bedrooms	3.09	0.70	0.00	8.00
fbath	Number of Full Bathrooms	1.71	0.61	0.00	8.00
hbath	Number of Half Bathrooms	0.33	0.51	0.00	4.00
centair	1=Central Air Heating/Cooling System; 0=other	0.80	0.40	0.00	1.00
fplace	Number of Fireplaces	0.56	0.59	0.00	5.00
detgar2	1=Detached Garage; 0=Other Garage or No Garage	0.19	0.39	0.00	1.00
othgar	1=Attached or Unknown Garage; 0=No Garage	0.67	0.47	0.00	1.00

Source: Indiana Business Research Center, using data from the Indiana Department of Local Government Finance and the Metropolitan Indianapolis Board of Realtors. Residential properties of less than $15,000 were not used for this study. Several dozen transactions were recorded with a zero or nominal value. These may have been "sales" within a family and probably did not reflect market value. The $15,000 threshold was used because that is the lowest cost of a pre-manufactured, modular housing structure (without the value of land).

- **Traditional Housing Variables**. The variables summarized in **Table 1A** represent a traditional set of characteristics used in hedonic models for property values, except for two:

- town. This variable indicates whether or not a sold property was within the city or town limits of an incorporated area, as defined by U.S. Census Bureau TIGER/Line files.[10]

- newacre. Whereas other traditional housing characteristics were generally coded (with minor modifications) directly from DLGF and MIBOR sources, the total acreage was often not available. To fill in the gaps, the research team performed GIS-based computations of sold property parcel sizes.

- RLO Variables. **Table 1B** summarizes variables that describe the attributes of all RLOs within a 10-mile radius of each sale. In order to produce these variables, the research team computed the distance (miles) and direction (eight cardinal points, e.g. West, Southwest) of all 203 RLOs from each of the 7,849 property sales. These data were then condensed to produce summary statistics concerning the permitted animal type and number of the closest RLO and the collective features of all RLOs within one-half mile, one mile, three miles, and 10 miles of each sale. Some additional information on these variables is as follows:

- totdist. This measure takes into account both the number of animal units at the closest RLO to the sold property and the distance of the operation from this property. It does so by dividing the number of animal units by the distance in miles so that operations with more animals have a larger index score than those with fewer animals and, simultaneously, operations that are closer would have larger index figures than those further away. The variables *pigdist*, *beefdist*, *dairydist* and *birddist* were similarly constructed for the animal units of pigs, beef, dairy and poultry, respectively.[11]

- upwindmin. This variable indicates whether the residential property is downwind from the closest RLO. Wind direction is predominantly from the West, Southwest or South. The research team analyzed data from the National Climatic Data Center and found that prevailing winds blew from these three directions in 79.8% of all months and in 86.4% of all months in which the wind blew at above-average speed.[12] Research by *Global Energy Concepts* in 2004 and the first quarter of 2005 also indicated that prevailing and most powerful winds also come from the southwest in Central Indiana.[13]

Analysis. An ordinary least squares (OLS) regression of hedonic pricing models has been the traditional method of analysis to investigate the effect of feeding operations and traditional housing characteristics on property value. This investigation used a wide variety of OLS models to assess the effects of different types of regulated feeding operations on property sales price. These models were independently tested for the statistical significance of individual predictors (*t*-tests) and groups of predictors (*F*-tests). Rather than simply relying on the improvements in the overall predictive power

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[10] These boundaries were defined with GIS precision. For more information on Indiana incorporated boundaries, please see Justis, Rachel. "Increasing Incorporation" *InContext* (March 2008): www.incontext.indiana.edu/2008/march/2.html

[11] These variables were constructed in a similar manner to the hog distance/density variable used by Milla, K., Thomas, M. H., & Ansine, W. (2005). "Evaluating the Effect of Proximity to Hog Farms on Residential Property Values: A GIS-Based Hedonic Price Model Approach". *URISA Journal*, 17(1), 27-32.

[12] These assessments used measurements recorded at Shelbyville Municipal Airport in Shelby County throughout the 2000-2006 period. Please see Appendix Figures 2 and 3 for the frequency charts.

[13] This measurement was made in Carthage, Indiana which is just east of Hancock County. Please see Appendix.Figure 1 for the wind rose diagram from the Global Energy Concepts report.

of each model (through the 'R-squared' statistic), models were compared using well-established Bayesian model selection strategies.[14]

Preferred models were selected based on the lowest levels of statistical uncertainty, that is, they were least likely due to chance. Preferred models produced the most negative primed Bayesian Information Criterion (BIC') scores, that is, property characteristics (independent variables) that did not contribute to the model's ability to predict sales price were weeded out.[15] To reduce the influence of heteroskedastic errors (error that is correlated with the independent variables), robust standard errors—specifically the MacKinnon-White Jackknifed Adjustment—were used for all models to improve the accuracy of statistical tests.

Results are summarized in bar charts with solid bars and labeled coefficients for findings that are statistically significant at the $p<0.05$ level. Lightly shaded bars with labels are marginally significant at the $p<0.10$ level, while lightly shaded bars without labels are not statistically significant. Detailed results are contained in the appendix tables.

The first round of statistical analysis indicated that the price of residential properties in towns were substantially different from those outside of incorporated areas. As a result, subsequent analysis evaluated town and non-town properties both jointly and separately. Similarly, pricing models for farms were also evaluated separately since traditional housing characteristics (such as number of bedrooms and garages) were less likely to predict the value of farm properties than for residential properties. It is important to note that separate analysis of farms is prone to greater error since there are far fewer farm sales (197 or 2.51 percent).

For final verification, a spatially-correlated error (SCE) model using Maximum Likelihood estimation was conducted (with Huber/White robust standard errors) to evaluate the potential effect of location-based errors in the preferred model for residential and farm properties. While this type of statistical error was likely to be minimal in this study since the OLS models controlled for the number of RLOs within several distance rings, there was concern that large clusters of properties were affected by the same RLO. This condition potentially violated the key statistical assumption that statistical errors are randomly distributed. The SCE model was not substantially different from the OLS model. As a result, the findings are not due to location-based biases.[16]

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[14] For more information on this model selection procedure, please see Raftery, Adrian E. 1995. "Bayesian Model Selection in Social Research." *Sociological Methodology* 25: pp. 111-163.

[15] c.f Raftery, Adrian E. 1995. "Bayesian Model Selection in Social Research." *Sociological Methodology* 25: pp. 111-163.

[16] Due to software limitations, SCE models were estimated for a randomly selected sample of 700 sold properties. This allowed inversion of a 700x700 matrix with standardized weightings for the extent to which each pair of properties were neighbors–within 2.75 miles of each other. The OLS model for the smaller sample reproduced all significant RLO impacts found in the larger preferred model, except for wind direction. Comparing the small sample's OLS and SCE models, the impact of the number of RLOs within one mile was the only RLO impact that seemed somewhat influenced by geographic location though no impact changed in statistical significance or order of magnitude. Please see Appendix Table 12 for full results. For more information on the statistical strategy of these models, please see Dubin, Robin A. 1998. "Spatial Autocorrelation: A Primer." *Journal of Housing Economics* 7: pp. 304-327

Table 1B: Property Pricing Variables based on Attributes of Surrounding Regulated Livestock Operations (RLOs) for Properties Sold in Selected Indiana Counties, 2000 to 2006.

Variable	Description (units)	Mean	Std. Dev.	Min.	Max.
Attributes of Closest RLO					
andist	All Animal Units / distance of closest RLO	243.46	279.76	11.90	5862.45
pigdist	Pig Animal Units / distance of closest RLO	169.43	245.95	0.00	5862.45
beefdist	Beef Animal Units / distance of closest RLO	27.85	66.85	0.00	633.72
dairydist	Dairy Animal Units / distance of closest RLO	16.96	43.65	0.00	453.40
birddist	Poultry Animal Units / distance of closest RLO	16.65	42.82	0.00	446.69
upwindmin	1=Closest RLO is in upwind direction (West/Southwest/South); 0=not	0.48	0.50	0.00	1.00
Attributes of RLOs within three miles					
farm3mile	Number of RLOs within three miles	1.75	2.38	0.00	14.00
efarm3mile	Number of RLOs between one and three miles away	1.65	2.30	0.00	14.00
nupwind3	Number of RLOs that are upwind and within three miles	0.73	0.99	0.00	6.00
tot3mile	Total Animal Units within three miles	647.52	835.32	0.00	11695.21
pig3mile	Pig Animal Units within three miles	478.64	713.13	0.00	11695.21
beef3mile	Beef Animal Units within three miles	71.66	166.90	0.00	880.80
dairy3mile	Dairy Animal Units within three miles	35.73	93.31	0.00	436.80
bird3mile	Poultry Animal Units within three miles	35.04	91.60	0.00	274.48
Attributes of RLOs within one mile					
farm1mile	Number of RLOs within one mile	0.10	0.36	0.00	4.00
efarm1mile	Number of RLOs between half a mile to one mile away	0.09	0.33	0.00	4.00
nupwind1	Number of RLOs that are upwind and within one mile	0.06	0.25	0.00	3.00
tot1mile	Total Animal Units within one mile	31.09	157.21	0.00	3461.50
pig1mile	Pig Animal Units within one mile	29.68	151.39	0.00	3461.50
beef1mile	Beef Animal Units within one mile	0.64	14.82	0.00	522.00
dairy1mile	Dairy Animal Units within one mile	0.28	8.89	0.00	278.60

bird1mile	Poultry Animal Units within one mile	0.28	8.76	0.00	274.48
Miscellaneous Distance Variables, Distance to RLO					
farmhmile	Number of RLOs within half a mile	0.01	0.12	0.00	2.00
efarm10mile	Number of RLOs between three and 10 miles away	17.56	11.92	1.00	69.00
farm10mile	Number of RLOs within 10 miles	19.31	13.34	1.00	75.00

Source: Indiana Business Research Center, using data from Indiana Department of Environmental Management, Indiana Department of Local Government Finance and the Metropolitan Indianapolis Board of Realtors

Key Findings from Hedonic Model Estimation

Traditional Hedonic Model

Before considering the effects of RLOs, one must examine the influence that traditional property characteristics have on property values (see **Figure 6**).[17] Each characteristic is considered independently; in other words, all characteristics are held constant save the one characteristic under evaluation.

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[17] Full regression results are available in Appendix Table 1.

Figure 6: The Effect of Traditional Housing Characteristics on Property Value ($1,000s) in Selected Indiana Counties, 2000 to 2006
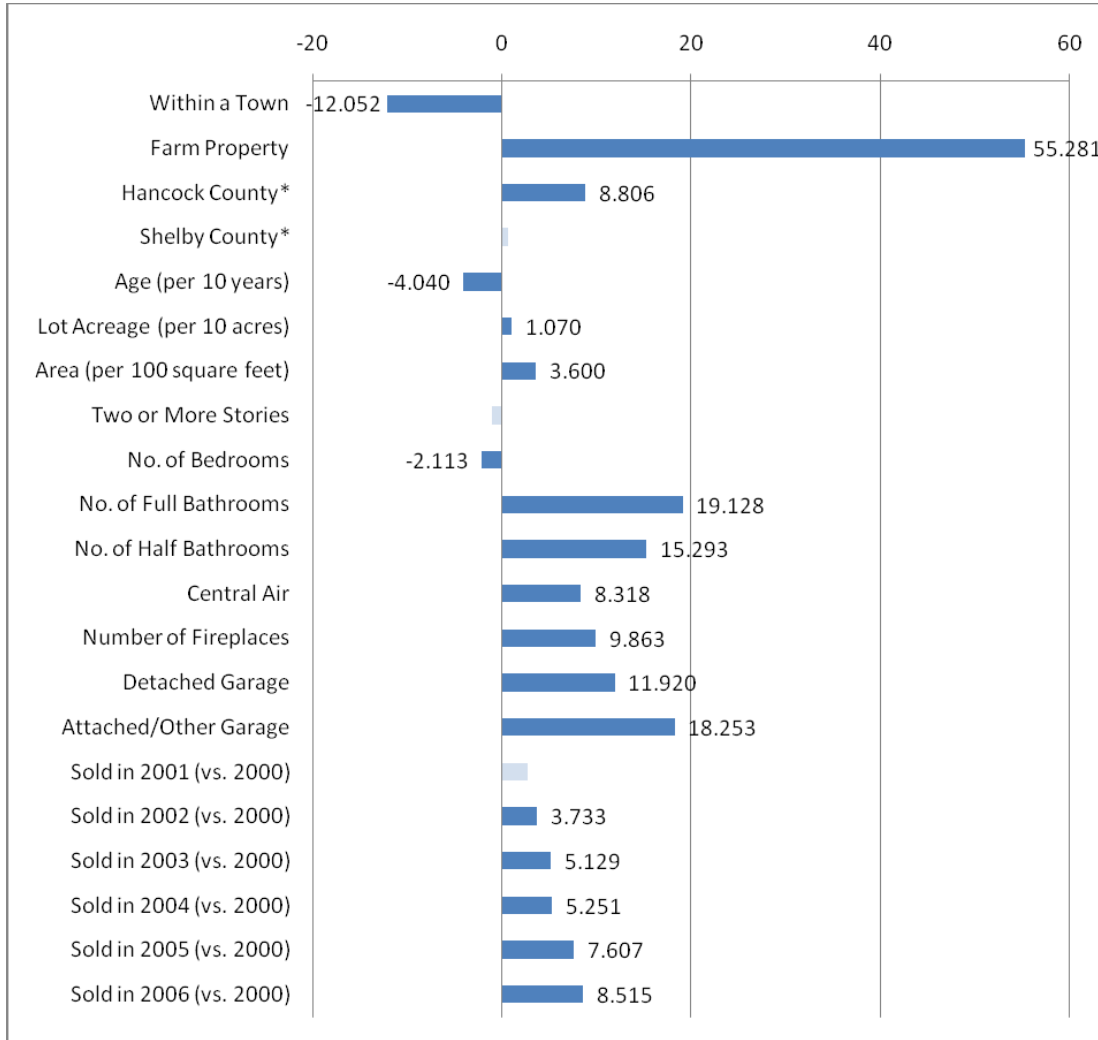
*Reference county is Decatur County

The three-county transactions data show that property values are largely determined by several conventional characteristics, notably:

- **Location of property.** Properties in Hancock County, which includes more wealthy Indianapolis suburbs, were valued $8,806 higher than those in more rural Decatur County. Hancock's property sale prices were not significantly higher than those in Shelby County.

- **Bathrooms.** Each additional full bathroom increases the sales price by $19,128; half bathrooms by $15,293.

- **Age.** For every ten years that a property ages, the sales price decreases by $4,038.

- **Area within property buildings (square footage).** Each additional 100 square feet of building space increases property value by $3,626.

- **Garages:** Detached garages increase sales price by $11,920 while attached and other types of garages increase property value by $18,253.

There were a few results that go against common expectations of how particular characteristics affect property values:

- **Number of bedrooms.** Each additional bedroom would decrease a property's value by $2,113. However, one should remember that this occurs for properties that are the same on all other measured characteristics, including square footage. As a result, this outcome may be explained by the fact that a property with an additional bedroom would have substantially smaller bedroom sizes.

- **Farm vs. residential properties.** Farms have income-earning capacity. One would expect that farms would have higher property value than residential properties. That said, the large difference of $55,281 exceeded expectations, suggesting that there may be other influential factors (perhaps type of agricultural business) that are beyond the scope of this study.

- **Town locations.** Properties in towns or incorporated areas have lower property values than non-town properties—a difference of $12,052. While one may expect that urban conveniences (e.g. government services, local entertainment) may increase a property's value, one should note that most towns in this three-county region are quite small and without the amenities of a large city. This result is in keeping with the opinions of realtors provided in the interviews and surveys. The data and the opinions of realtors seem to show that there is a premium associated with living in a rural setting.

- **Lot acreage.** The effect of acreage is smaller than one may have expected. Every 10-acre increase in residential property acreage increased sales value a mere $1,073. This outcome may be explained by the fact that residential lot acreage increases the property tax bill without adding to income potential. This finding also suggests that the effect of lot acreage is not a simple matter of raw size. The lot acreage effect may depend on the soil type and usage of available land (crop growth, grazing etc.) or the tax treatment of land classified as agricultural. These features were beyond the scope of this study.

The important differences between farm and residential properties as well as between town and non-town residential properties made the case for separate hedonic models for each property type. The separate models yielded slightly different results for several traditional housing characteristics:[18]

- Less significant effects for farm properties. Several of the significant effects noted in **Figure 6** are not statistically significant for farm properties, including age, lot acreage, central air, number of fireplaces and garages. While part of the explanation for these fewer significant effects may be the small number of farms (197) sold over the 2000-2006 period, it is more likely that farms are valued in very different ways than residential properties.

- The effect of multi-level properties depends on property type and location. Among residential properties in towns, single-story ('ranch-style') properties have higher sale prices ($5,276) than comparable properties with two or more levels. Multiple levels have no effect on residential sale prices in unincorporated areas. Among farm properties, multi-level properties were valued at $29,149 higher than single-level farm properties that were otherwise similar.

- Price increases due to year of sale depend on property type and location. **Figure 7** shows that property values are fairly flat for town residential properties from 2000 to 2006. Non-town and farm properties, however, showed higher sale prices as the years progressed.

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[18] Please see Appendix Table 1 for more details.

Figure 7: The Effect of Selected Housing Characteristics on Sale Price for Different Types of Property in Selected Indiana Counties, 2000 to 2006 (controlling for other property characteristics)
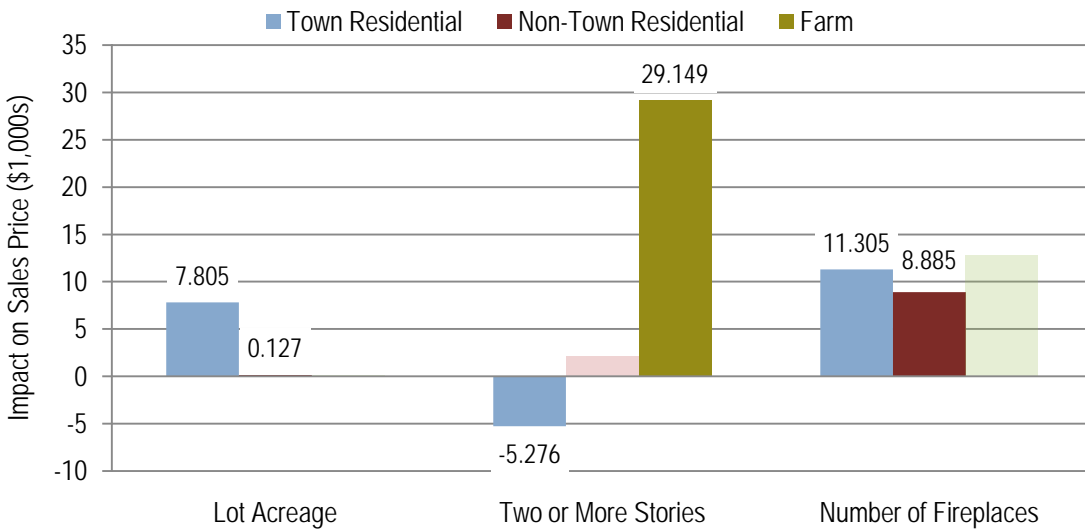
Figure 8: The Effect of Year of Sale (compared to 2000) on Sale Price ($1,000s) for Different Types of Property in Selected Indiana Counties, 2000 to 2006 (controlling for other characteristics).
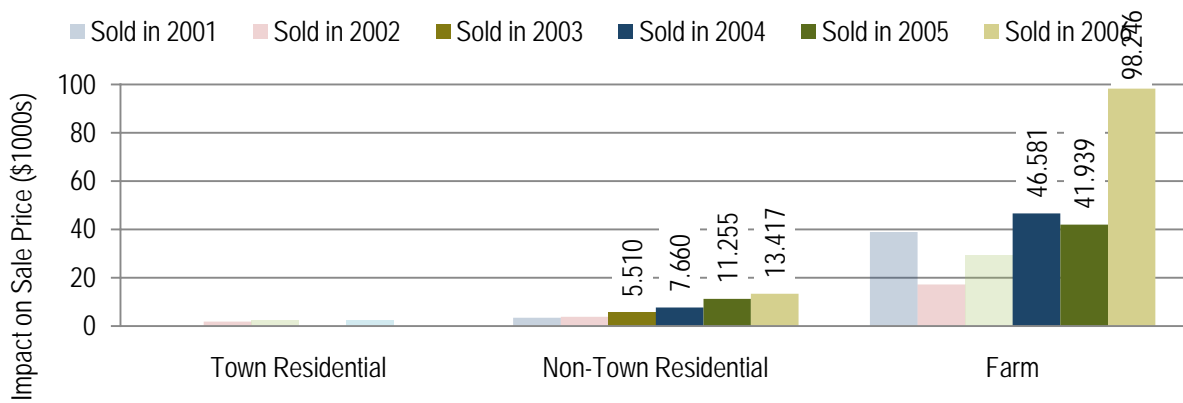
Beyond Traditional Residential Property Characteristics: Exploring the Effects of RLOs

The previous section of this report documented the valuation of traditional property characteristics for the selected counties. The next section documents the intermediate steps the research team took to determine the potential effects that RLOs may have on property values while controlling for traditional characteristics. There are three sets of potential effects, namely:

- the direction, distance and animals at the closest RLO;
- the number of RLOs within different distances;
- the total number of animals on surrounding RLOs.

These different sets of effects cannot be considered in isolation since they interact with each other. Presenting these models separately allows one to understand the influential characteristics of RLOs that can inform the selection process for the 'preferred' models.

Effect of the Closest RLO—Animal Distance. **Figure 9A** focuses simply on the animal distance index and considers the effect of only the closest RLO in isolation. The animal distance index measures the 'inseparable' effects of both the distance and animal quantity of the closest RLO. As presented in **Figure 9A**, there are statistically significant effects for town residential properties of -0.559. This means that among comparable town residential properties (same number of bedrooms, etc.) and all other things equal, each additional 100 animal units reduces the sale price by $559 if the closest RLO is one mile away. (The effects of animal distance on non-town residential and farm properties is not significant at the $p < 0.05$ level)

Figure 9A: Estimated Effect of Closest RLO's Animal Distance Index on Sale Price ($1,000s) for Different Types of Property in Selected Indiana Counties, 2000-2006 (controlling for other property characteristics).
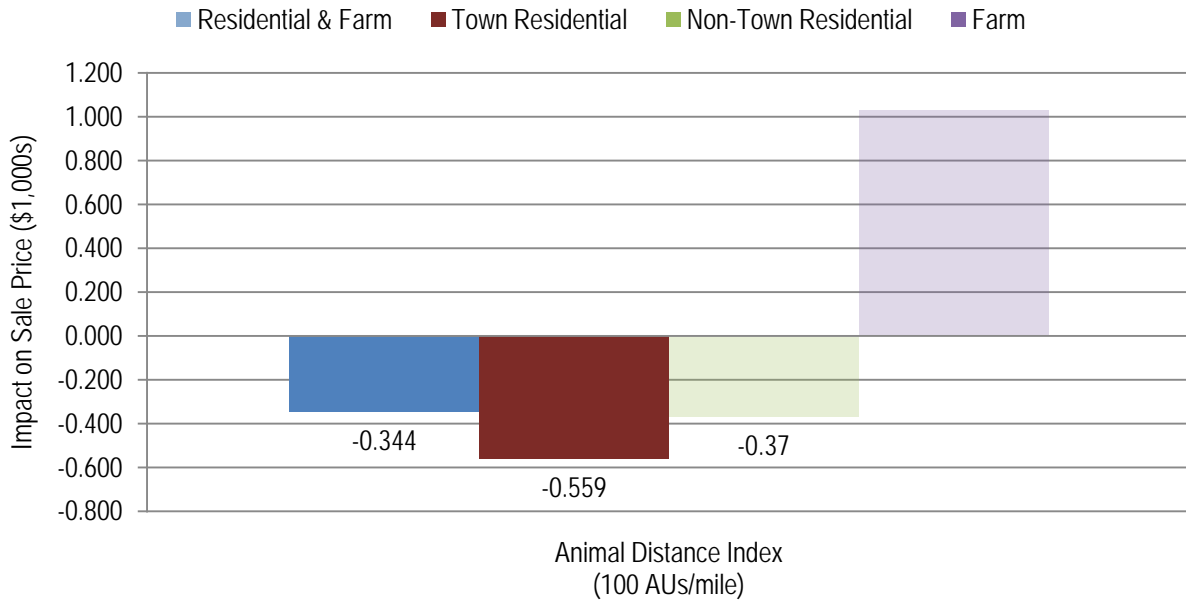
The Effect of the Closest RLO—Animal Distance by Animal Type and Wind Direction

- Animal Distance Indices by Animal Type. These indices measure the joint effect of distance and animal quantity at the closest RLO and distinguish between animal types. **Figure 9B** shows that only for dairy is there an animal distance index that has a statistically significant effect on property value when residential and farm properties are aggregated together. In this case, each additional 100 dairy animal units (equivalent to approximately 71 dairy cattle) reduces the sale price by $5,417 if the closest RLO is one mile away. Overall, the sale price of town residential properties appears to be more sensitive to the effect of different types of animal indices than other types of properties.

- Wind Direction. If the closest RLO is upwind, or in other words, if the property is downwind, its value declines by an average of $3,311 (controlling for property characteristics and the animal distance indices). This effect is more acute among comparable town residential properties. A town property loses $6,225 if it is downwind of the closest RLO. (For non-town residential properties there is negative effect of $2,332 but this effect was only marginally significant at the $p<0.10$ level).

Figure 9B: Estimated Effect of Closest RLO's Animal Distance Indices and Wind Direction on Sale Price ($1,000s) for Different Types of Property in Selected Indiana Counties, 2000 to 2006 (controlling for other property characteristics).
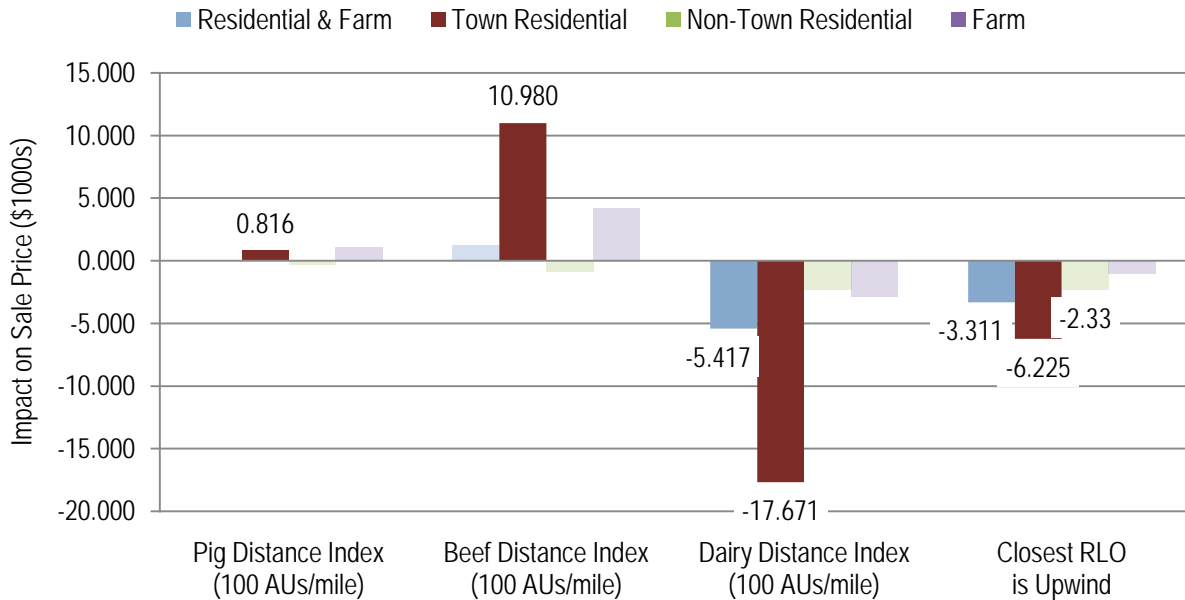

Note: One Animal Unit (AU) = 1,000 lbs of live weight

Effect of the Number of Surrounding RLOs. The closest RLO may not be as influential to a property's sale price as the overall concentration of feeding operations—especially if several RLOs are in close proximity. **Figure 10** summarizes the concentration effect, that is, the number of RLOs within half-a-mile; between half-a-mile and one mile; between one mile and three miles; and from three miles to 10 miles away from a property. The figure shows positive effects on property values where there are RLOs between half-a-mile and one mile (increase of $3,971) and between one mile and three miles away from a property (increase of $1,953).

These results point to a conclusion that rests in stark contrast to the perceptions of real estate professionals and county officials: the housing market benefits from having large-scale feeding operations nearby. Some potential answers as to why may be that RLOs spur local economic activity or may increase demand for housing by the owners or employees. The results, however, are not unambiguous. There is a small but significantly negative effect of $134 for each farm that is between three to 10 miles away. The negative effects for properties three to 10 miles away may counterbalance the positive effects. For the typical residential sale, there are only one or two RLOs within three miles (positive effects), but there may be a sufficient number of RLOs between three to 10 miles away (negative effects) to overwhelm the positive influence.

Figure 10: The Effect of Number of Surrounding RLOs on Sale Price ($1,000s) for Different Types of Property in Selected Indiana Counties, 2000 to 2006 (controlling for number of RLOs that are upwind within one mile and three miles and other property characteristics)
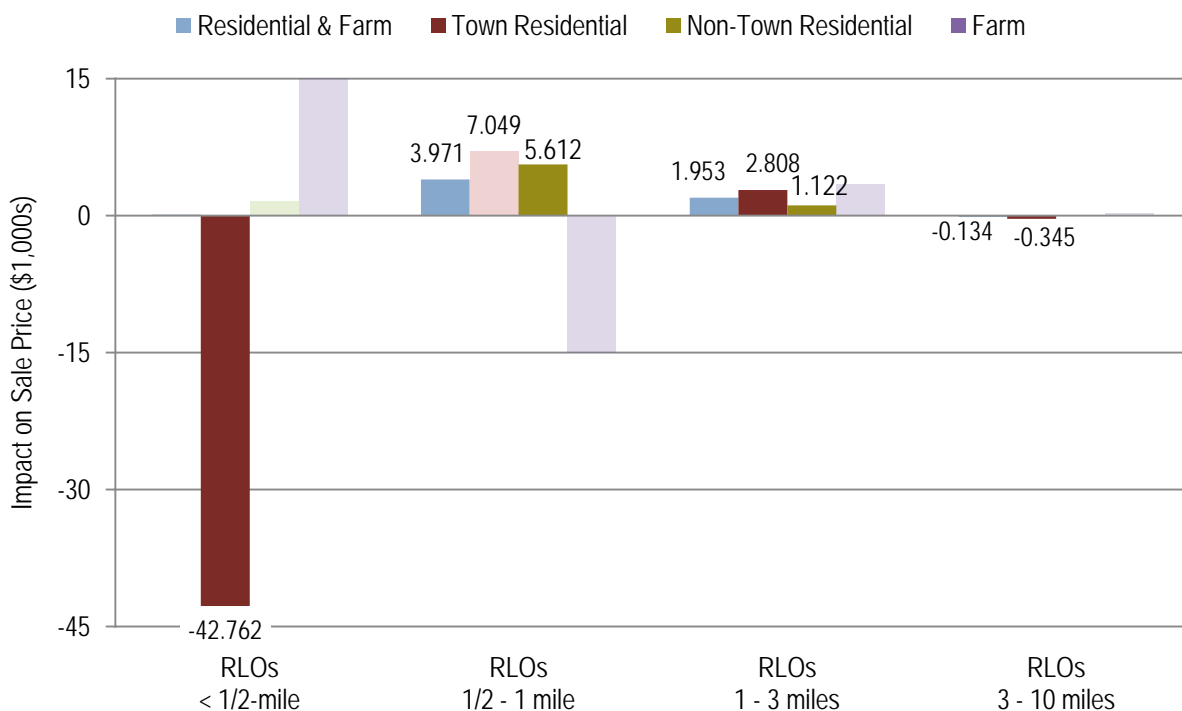
Once again, town residential properties seem most influenced by the concentration of RLOs within certain distances of influence. There is a $42,762 reduction in property values for each RLO within half-a-mile, a marginal positive effect between half-a-mile and one mile (marginal because it was significant at the p<0.1 level), a positive effect of $2,808 between one to three miles and then a negative effect of $345 for each feeding operation in the outermost ring of influence. This pattern is complex and may strike one as contradictory. On the other hand, most town residential sales occurred within three miles of at least one RLO, but only five sales (0.12 percent) occurred within half-a-mile.

Effect of the Number of Animals on Surrounding RLOs. The number of proximate RLOs, as important a factor as that is, may pale in comparison to the concentration of animals around a residential sale. In short, animal concentration may be the most important factor in the valuation equation. **Figure 11** reveals that, when considering both residential and farm properties, the effect of animal density is far stronger within a mile of a property than within three miles. Within one mile, each beef animal unit is estimated to increase property value by $119.76 (the equivalent of $143.71 per mature bull) while each dairy animal unit is expected to decrease property value by $211.21 (roughly $295.69 per mature cow). Within three miles, both town and non-town residential property values have significant reductions in property values ($77.48 and $26.55, respectively) associated with each additional dairy animal unit. Beef animal units have a positive effect overall, particularly for town residential properties ($52.01 per animal unit). Pig density has little effect on sales price.

One may speculate that this small effect is due to ubiquitous presence of pigs in the region. In other words, it is difficult to not be proximate to pigs in the region so this is not a discriminating factor in the model.

Figure 11: The Effect of Surrounding RLO Animals on Sale Price ($) for Different Types of Property in Selected Indiana Counties, 2000 to 2006 (controlling for other property characteristics).
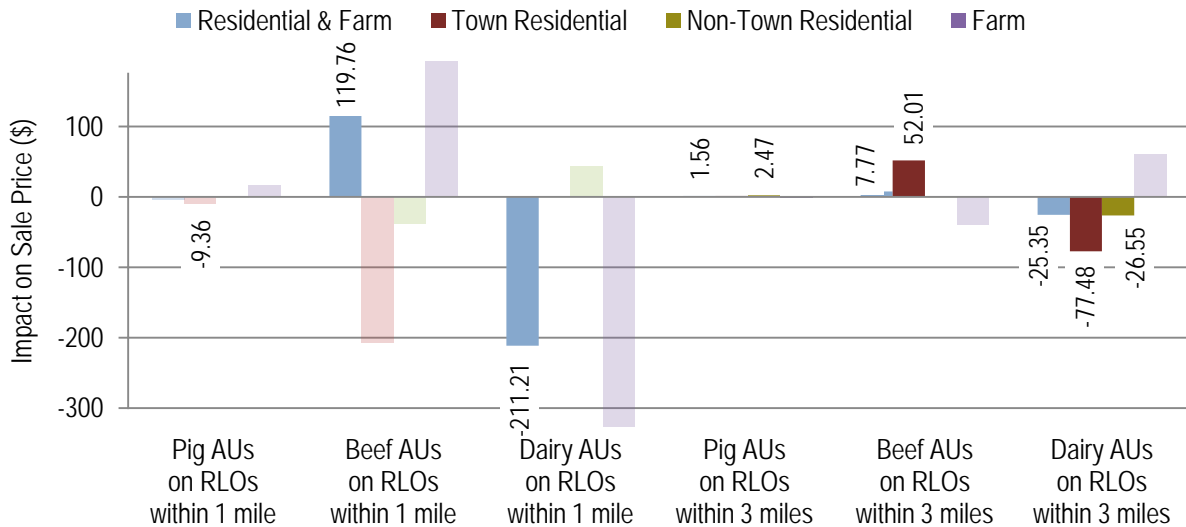

Note: One Animal Unit (AU) = 1,000 lbs of live weight

The Final Results: The Preferred Models for Measuring the Effects of RLOs

The following section presents the models that estimate the effects of large-scale livestock operations on residential property values given the characteristics and their effects already discussed in the previous sections. While all three sets of influential RLO attributes are important in isolation, some have far more substantial effects than others. Moreover, other residential characteristics no longer have significant effects when selecting the model with the most predictive power and the least statistical uncertainty. Which features of surrounding RLOs have the greatest effect (both positive and negative) also depends enormously on the type of residential property under consideration. Residential properties in towns are affected far more than those in unincorporated areas. Attributes of RLOs like animal type and animal concentration may have no measured effects on farm properties.

Residential and Farm Property Values

Table 2 presents the Ordinary Least Squares (OLS) regression coefficients for each of the three intermediate models discussed earlier and then the final preferred model for all properties. The preferred model indicates that when all potential effects are considered, RLOs have five statistically significant effects on the property value of residential and farm properties:

- A $3,579 decrease if the closest RLO is upwind (residence is downwind)
- An $11,378 increase for each RLO within one mile
- A $2,150 increase for each RLO between one to three miles away

- A $17 decrease for each animal unit on RLOs within one mile (plus additional $3 decrease since these animal units are also within 3 miles)
- A $3 decrease for each animal unit on RLOs within three miles (Note: this $3 also applies to each AU within 1 mile)

The results indicate that the effect of RLOs on property values is an intricate balance of negative and positive effects. These effects vary within each of the three counties. If an RLO is upwind (residence downwind), it has a major negative effect on the residence's sale price. Owing to the overwhelming presence of pigs in this region (over 80 percent of all RLO animal units), there are significant effects for number of animals in general, but not for particular species. While these five factors are significant across sales in all three counties, sale prices within Hancock County are more sensitive to the effects of neighboring RLOs, particularly if downwind from the closest RLO. Sale prices for Decatur and Shelby properties are less influenced by RLOs and are more likely to be positively influenced.[19] To place these results in perspective, consider that two-thirds of all property sales are within three miles of an RLO, but few properties (707 or 9.0 percent) are within one mile. The closest RLO was upwind (residential property downwind) for 48.5 percent of transactions.

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[19] Please see Appendix Table 9 for full results of the preferred model for residential and farm properties by county.

Table 2: OLS Regression Coefficients of the Effect of RLOs on Residential and Farm Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=7,849 (controlling for traditional housing characteristics)

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Pig Distance Index	0.000			
Beef Distance Index	0.013			
Dairy Distance Index	-0.054**			
Closest RLO is Upwind	-3.311**			-3.579**
Number of RLOs within half-mile		0.174		
Number of RLOs between half-mile & 1 mile away		3.971*		
Number of RLOs between 1 mile & 3 miles away		1.953**		2.150**
Number of RLOs between 3 miles & 10 miles away		-0.134*		
Number of RLOs Upwind & within 1 mile		3.375		
Number of RLOs Upwind & within 3 miles		-1.259*		
Pigs on RLOs within 1 mile (Animal Units)			-0.004	
Beef Cattle on RLOs within 1 mile (Animal Units)			0.120**	
Dairy Cattle on RLOs within 1 mile (Animal Units)			-0.211**	
Pigs on RLOs within 3 miles (Animal Units)			0.002*	
Beef Cattle on RLOs within 3 miles (Animal Units)			0.008*	
Dairy Cattle on RLOs within 3 miles (Animal Units)			-0.025**	
Number of RLOs within 1 mile				11.378**
Animals on RLOs within 1 mile (Animal Units)				-0.017**
Animals on RLOs within 3 miles (Animal Units)				-0.003**

Statistically significant results: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors
Please see Appendix Table 2 for a more detailed version of this table

Based on the foregoing analysis, one can postulate that the negative and positive effects on the value of a residential property are based on the number, type and proximity (all taken together) of surrounding RLOs. Consider the case of a property that is downwind of a single RLO with over 600 animal units (the equivalent of about 4,000 finishing hogs) situated less than a mile away. In this scenario, potential wind-driven odors may make this property less valuable, but having a nearby farm increases local sale prices to counter this negative effect ($11,378 - $3,579 = $7,799). This isn't the entire equation, however. There are negative effects associated with the animal density. Each animal unit above the 390 threshold for a regulated operation would start introducing a negative effect of $20 per animal unit, adding the effects of within one mile with the effects of three miles ($17 + $3), leading to an overall decline of approximately $4,200 in property value.

On the other hand, one can consider a residential property that is upwind of a 300 animal unit RLO less than a mile away. In this case, the large positive effect of having a nearby RLO ($11,378) is countered only by the negative effect of the animals. In this case, the animal density effect is relatively small because it has relatively few animals (300 x -$20 = -$6,000) and yields a net property value gain of $5,378.

Figure 12 allows one to compare the effects associated with RLOs and with traditional housing characteristics. The five main effects of RLOs are significant, but they are substantially smaller than the traditional determinants of residential sales price, such as number of full bathrooms (an increase of $19,163 each) or having an attached garage (increase of $17,564). Only the number of RLOs within 1 mile is similar in magnitude to traditional property characteristics and, as explained earlier, only 9 percent of properties were this close to an RLO.

Figure 12: The Effect of Surrounding RLOs (red bars) and Traditional Housing Characteristics (blue bars) on Residential & Farm Property Value ($1,000s) in Selected Indiana Counties, 2000 to 2006

Category	Value
Closest RLO is Upwind	-3.579
No. of RLOs < 1 mile	11.378
No. of RLOs 1 - 3 miles	2.150
Animals on RLOs < 1 mile (100 AUs)	-1.734
Animals on RLOs < 3 miles (100 AUs)	-0.263
Within a Town	-9.962
Farm Property	55.997
Hancock County*	18.026
Shelby County*	11.288
Age (per 10 years)	-3.954
Lot Acreage (per 10 acres)	1.121
Area (per 100 square feet)	3.600
Two or More Stories	
No. of Bedrooms	-2.153
No.of Full Bathrooms	19.163
No.of Half Bathrooms	14.854
Central Air	8.156
Number of Fireplaces	9.428
Detached Garage	11.580
Attached/Other Garage	17.564
Sold in 2001 (vs. 2000)	3.105
Sold in 2002 (vs. 2000)	3.984
Sold in 2003 (vs. 2000)	5.287
Sold in 2004 (vs. 2000)	5.710
Sold in 2005 (vs. 2000)	7.914
Sold in 2006 (vs. 2000)	9.095

*Reference county is Decatur

While these models look at all property transactions jointly, one of the most profound RLO effects depended upon whether a residence is in a town or not.[20] As a result, subsequent analysis considered three main property types—town, non-town and farm—separately to better understand the different and specific effects that RLOs have on sales price based on the location of the residential property.

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[20] Interaction models confirmed that the lower prices of town properties compared to non-town properties was not attributable to the fact that they were simply around fewer CFOs/CAFOs. Please see Appendix Table 8 for results.

Non-Town Residential Property Values

There is a substantial premium for non-town (or unincorporated area) residential properties, all other residence characteristics equal. **Figure 13** shows that the relative magnitude of the positive effect of an RLO within one mile is comparable to several traditional characteristics of property value (notably number of fireplaces or having central air).

Overall, only three RLO attributes influence the sale prices of non-town residential properties, and these effects occur almost exclusively in Hancock County:[21]

- A $12,703 increase for every RLO within one mile
- A $1,073 increase for every RLO between one and three miles
- A $2,207 decrease for every 100 pig animal units (approximately 666 finishing hogs) within one mile

While the effects for properties in close proximity are positive, this positive effect does not apply to many properties. There are few properties are within one mile of a feeding operation (15.4 percent), while there are many within three miles (73.7 percent). One can deduce that a typical rural property with one RLO between one and three miles away would have a higher sale price by $1,073 than a similar property without a feeding operation within this range. That positive effect, however, would be offset by a reduction in value depending on animal density (and type). For example, the expected increase of $12,703 in sale price for the non-town residence within one mile of an RLO would be mitigated by the 400 pig animal units that would reduced the property value $8,828 (4 x $2,207). The net benefit of proximity to the RLO falls to $3,875.

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[21] Please see Appendix Table 4 for more detailed results of the intermediate and preferred models and Appendix Table 11 for the preferred model applied to sales within each county.

Figure 13: The Effect of Surrounding RLOs (red bars) and Traditional Housing Characteristics (blue bars) on Non-Town Residential Property Value ($1,000s) in Selected Indiana Counties, 2000 to 2006

Category	Value
RLOs < 1 mile	12.703
RLOs < 3 miles	1.073
Pigs on RLOs < 1 mile (100 AUs)	-2.207
Hancock County*	10.294
Shelby County*	
Age (per 10 years)	-3.677
Lot Acreage (per acre)	0.116
Area (per 100 square feet)	3.782
Two or More Stories	
No. of Bedrooms	
No.of Full Bathrooms	19.140
No.of Half Bathrooms	14.985
Central Air	8.315
Number of Fireplaces	8.209
Detached Garage	17.803
Attached/Other Garage	25.564
Sold in 2001 (vs. 2000)	3.89
Sold in 2002 (vs. 2000)	4.368
Sold in 2003 (vs. 2000)	5.835
Sold in 2004 (vs. 2000)	8.391
Sold in 2005 (vs. 2000)	11.824
Sold in 2006 (vs. 2000)	14.125

* Decatur is the reference county.

Finally, **Figure 14** shows that mid-priced and higher-priced non-town residential properties are positively affected by the number of RLOs within one mile. Only mid-priced properties are negatively affected by the number of pig animal units.[22]

Figure 14: Effect of RLO Attributes on Sale Price ($1,000s) for Low, Middle & High-Value Non-Town Residential Properties in Selected Indiana Counties, 2000 to 2006 (controlling for other characteristics)
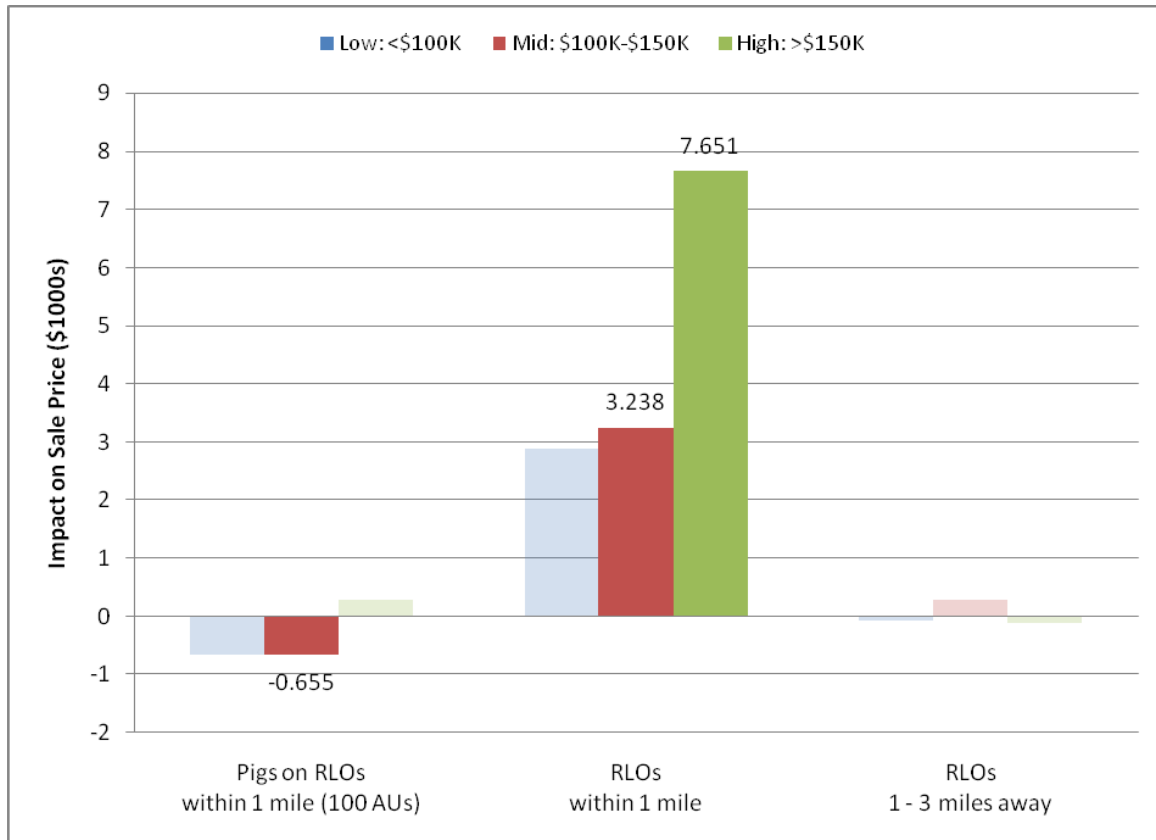
Town Residential Property Values

The sale price of residential properties in town (incorporated) areas is more acutely affected by the attributes of surrounding RLOs than other types of property.[23]

Ultimately, the preferred model estimates that town residential property value is affected by surrounding large feeding operations in six ways:

- A $10,796 increase for every 100 beef animal units (approximately 83 mature head) at the closest RLO, assuming that it is one mile away
- A $23,140 decrease for every 100 dairy animal units (approximately 71 mature head) at the closest RLO, assuming that it is one mile away
- A $4,976 decrease if the closest RLO is upwind
- A $2,561 increase for every RLO within three miles

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[22] Please see Appendix Table 7 for more detailed results of the preferred models applied to different value properties.
[23] Please see Appendix Table 3 for detailed results of the intermediate and preferred models for town residential properties.

- A \$482 decrease for every 100 pig animal units (approximately 666 finishing hogs) on RLOs within three miles
- A \$2,403 increase for every 100 beef animal units on RLOs within three miles

These effects, most notably being downwind of the closest RLO, are acute for Hancock County and Shelby County town residential properties, but less so in Decatur County. In Decatur County, sale prices are mostly affected by the number of feeding operations and number of pig animal units within three miles.[24]

Figure 15 compares the significant RLO effects together with the traditional house characteristics for the 4,236 town residential properties examined in this study. If calculated in 100s of animal units present at an RLO, the number of beef and dairy animals at the closest feeding operation is comparable to the number of bathrooms or having a garage.

For the typical town residential property, the combination of positive and negative RLO effects yields a net decrease in property value. The majority of town residential property sales are closest to an RLO that has a population of pigs (negative effect). The mixture of both beef cattle (positive effect) and dairy cattle (negative effect) on the typical cattle RLO yields a net loss of property value. As an illustration, consider a scenario in which a property is downwind of an RLO that is two miles away with 300 pig animal units. Based on the model, the RLO proximity increases the sale price by \$2,561, but this is more than offset by the negative effects of 300 pig animal units two miles away (3 x -\$481) and the RLO's upwind direction (-\$4,976). All other house characteristics equal, this property would lose \$3,858 of value.

Figure 16 shows that mid-priced town residential properties (between \$100,000 and \$150,000) were the most likely to have their sale price influenced by surrounding RLOs, particularly the kind of animals.[25] For every 100 beef animal unit increase on the closest RLO (one mile away, with all other factors equal), property value increased by \$10,449. However, every 100 dairy animal units lead to a decline of \$16,272. Lower-priced town properties (under \$100,000) do not appear to be affected much by proximity to an RLO, except they appear to be mildly affected by the number of pigs within three miles (a decrease of \$228 per 100 animal units).

Wind direction seems to exclusively affect higher-priced properties. All other things equal, downwind properties suffer a decrease of \$10,590.

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[24] Please see Appendix Table 10 for more detailed results of the preferred town residential model by county.
[25] Please see Appendix Table 6 for more detailed results of the preferred models applied to different value properties.

*Figure 15: Effect of Surrounding RLOs and Traditional Housing Characteristics on Town Residential Property Value ($1,000s) in Selected Indiana Counties, 2000 to 2006*

	Value
Beef Distance Index (100 AUs/mile)	10.796
Dairy Distance Index (100 AUs/mile)	-23.140
Closest RLO is Upwind	-4.976
No. of RLOs < 3 miles	2.561
Pigs on RLOs < 3 miles (100 AUs)	-0.482
Beef on RLOs < 3 miles (100 AUs)	2.403
Hancock County*	19.829
Shelby County*	11.795
Age (per 10 years)	-3.913
Lot Acreage (per acre)	
Area (per 100 square feet)	3.192
Two or More Stories	-5.156
No. of Bedrooms	
No. of Full Bathrooms	16.310
No. of Half Bathrooms	13.401
Central Air	8.852
Number of Fireplaces	10.619
Detached Garage	8.744
Attached/Other Garage	15.155
Sold in 2001 (vs. 2000)	
Sold in 2002 (vs. 2000)	
Sold in 2003 (vs. 2000)	
Sold in 2004 (vs. 2000)	
Sold in 2005 (vs. 2000)	
Sold in 2006 (vs. 2000)	

*Reference county is Decatur

Figure 16: The Effects of RLO Attributes on Sale Price ($1,000s) for Low, Middle & High-Value Town Residential Properties in Selected Indiana Counties, 2000 to 2006 (controlling for other characteristics).
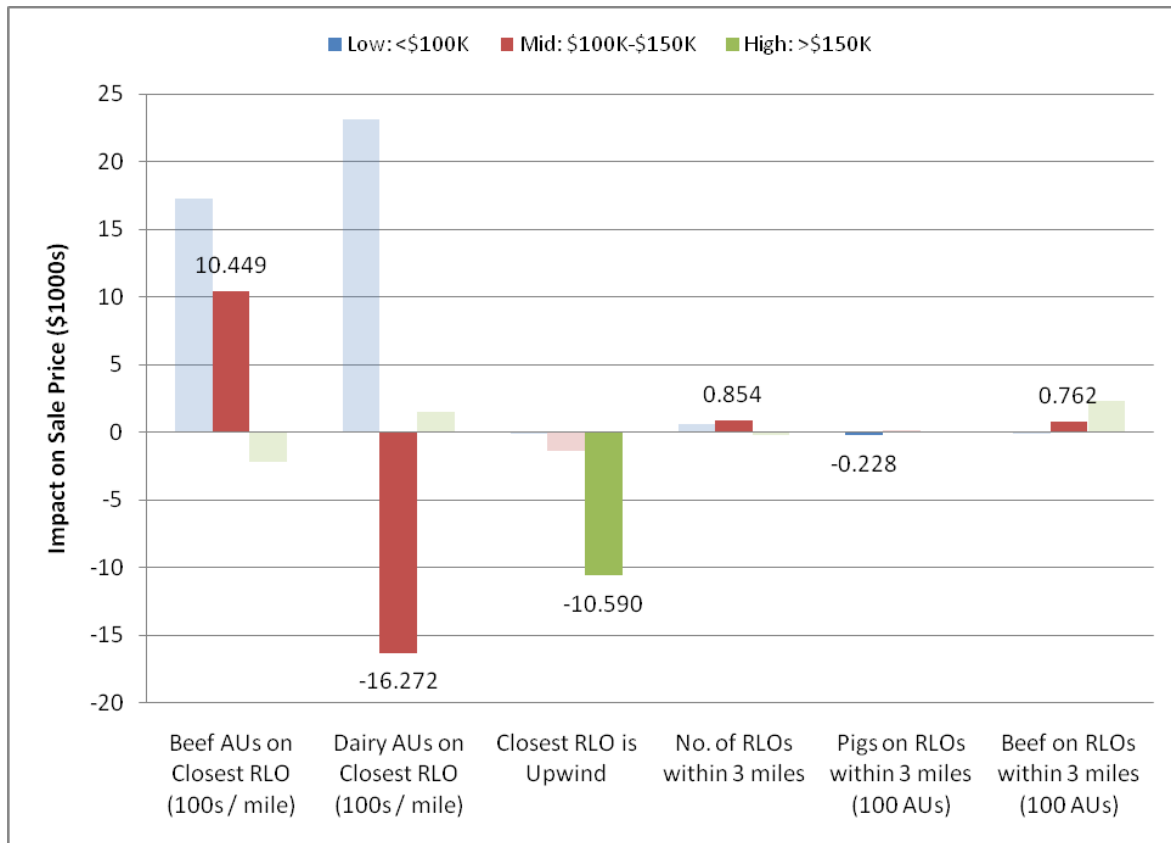
Farm Property Values

Unlike residential properties, the sale price of farm properties does not appear to be affected (positively or negatively) by neighboring RLOs. **Table 3** shows that only one variable in the "intermediate model" was significant. (See column labeled "Surrounding RLOs.") This outcome, however, did not carry through once other RLO attributes such as the concentration and type of animals were taken into account. (See "Preferred Model" column.)

The lack of statistically significant results may indicate that the effects of neighboring RLOs on farm property values are more complex than simply the proximity, animal type and animal concentration. It is also possible that the relative lack of farm sale data (197 sales) compared to residential sale data (7,652 sales) may hinder the robust measurement of potential RLO effects.

Table 3: OLS Regression Coefficients of the Effect of RLOs on Farm Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=197 (controlling for traditional housing characteristics)

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model[a]
Pig Distance Index	0.011			
Beef Distance Index	0.042			
Dairy Distance Index	-0.029			
Closest RLO is Upwind	-1.039			
Number of RLOs within half-mile		15.033		
Number of RLOs between half-mile & 1 mile away		-15.049		
Number of RLOs between 1 mile & 3 miles away		3.395		
Number of RLOs between 3 miles & 10 miles away		0.257		
Number of RLOs Upwind & within 1 mile		52.309*		
Number of RLOs Upwind & within 3 miles		-12.022		
Pigs on RLOs within 1 mile			0.016	
Beef Cattle on RLOs within 1 mile			0.192	
Dairy Cattle on RLOs within 1 mile			-0.327	
Pigs on RLOs within 3 miles			-0.002	
Beef Cattle on RLOs within 3 miles			-0.040	
Dairy Cattle on RLOs within 3 miles			0.061	

[a] There is no preferred model that includes statistically significant effectss of RLOs
Statistically significant results: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors
Please see Appendix Table 5 for more a detailed version of this table

Conclusion

This research study answered two questions. One, what are the perceptions about the effect of property values on the presence of RLOs? Two, what do the sales transactions data reveal about the effect of RLOs on property values?

The IBRC research team surveyed real estate professionals and community leaders in three selected Indiana counties—Hancock, Shelby and Decatur—to answer the first question. The research team also compiled transactions data from 2000 through 2006 for the three counties and statistically modeled effects that RLOs had on real estate sales.

The perceptions of those interviewed were consistent with recent reports in the media, namely, that proximity to an RLO has a substantially negative effect on residential property values. The transactions data, however, yielded more complex and nuanced results. Proximity of a residence to an RLO did not have an unambiguously negative effect on a property's value.

The effect of proximity to an RLO depended upon whether the residence was located in a rural area or in an incorporated area. All other property characteristics equal, rural residences enjoyed a premium compared to a town (incorporated area) property.

Depending on the distance to the RLO and the concentration and type of animal at the RLO, rural property values could be positively associated with proximity to an RLO. Rural properties that were downwind of an RLO were affected negatively. Animal type was also a factor. Proximity to beef cattle had a positive value on a rural property. Swine had a moderately negative effect while dairy cattle had a stronger negative effect. The degree of this negative effect depended on the number and distance of those animals. All told, the positive effect of proximity to an RLO could be offset by wind direction and animal concentration.

Proximity to an RLO had an unambiguously negative effect on town residences, especially if the residence was downwind of an RLO. While beef cattle had a positive effect on value, beef and dairy are typically produced jointly and the presence of the dairy cattle reduces the value more than the positive contribution of the beef. Pigs had a negative effect.

Properties in Hancock were more highly valued, all others things equal, than properties in Shelby and Decatur counties. Hancock County residences were also more sensitive to the effects of RLOs.

There were only 197 farm property transactions in these three counties from 2000 through 2006. This dataset is not nearly as rich as that for residential properties. As a result, there was only one statistically significant outcome of the modeling efforts, namely, farms carried a premium of over $55,000.

Are people's perceptions about the effect of RLOs on residential property values consistent with real data? Not necessarily. The effect that RLOs have on rural properties depends on several factors, as shown by the transactions data and statistical analysis. RLOs do have a negative effect on town properties. Real estate professionals probably overestimated the negative effects of proximity to an RLO, based on the survey and the transactions data. That said, the survey respondents were correct in their perceptions of the premium associated with rural properties versus town properties.

All told, the answer to the question of RLO effects on residential property values is more complicated than a simple yes or no. The transaction data do not support an unambiguous answer. The presence of an RLO can have a positive effect on property values in a rural area. Close proximity to an RLO most likely has a negative effect on property values for town residences, once all factors like animal density and type are taken into consideration. The relative sensitivity of rural versus town properties to the presence of an RLO is also noteworthy. These results should advance the discussion about the impact of RLOs on residential properties as they highlight the nature and source of the economic effects associated with the placement and size of regulated livestock operations.

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Appendices

Figure 1: Annual Wind Rose for Carthage, Indiana
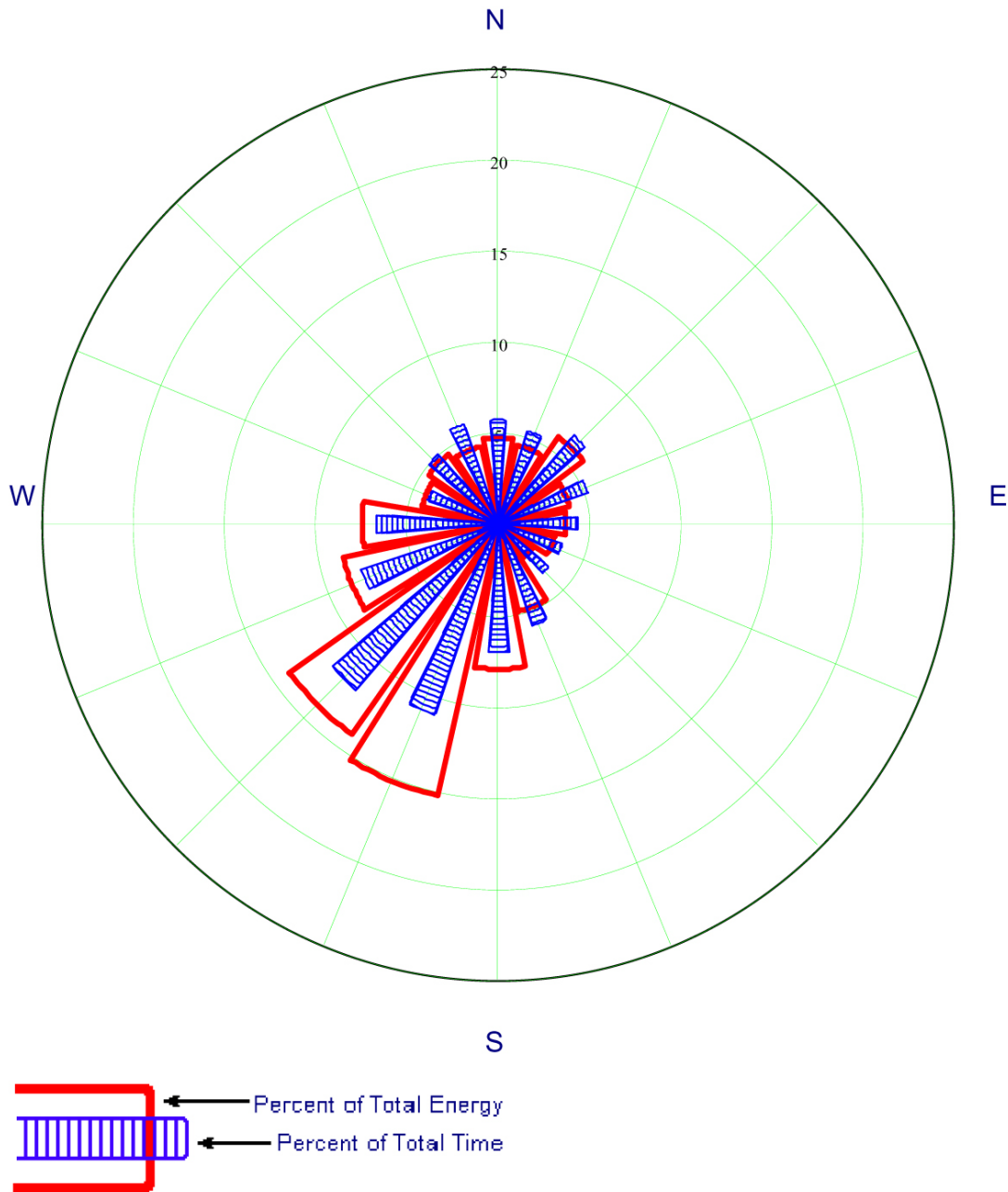
Source: Global Energy Concepts 2005

*Figure 2. Percentage of Months for Each Prevailing Wind Direction at **All Wind Speeds**, recorded at Shelbyville Municipal Airport, 2000 to 2006*
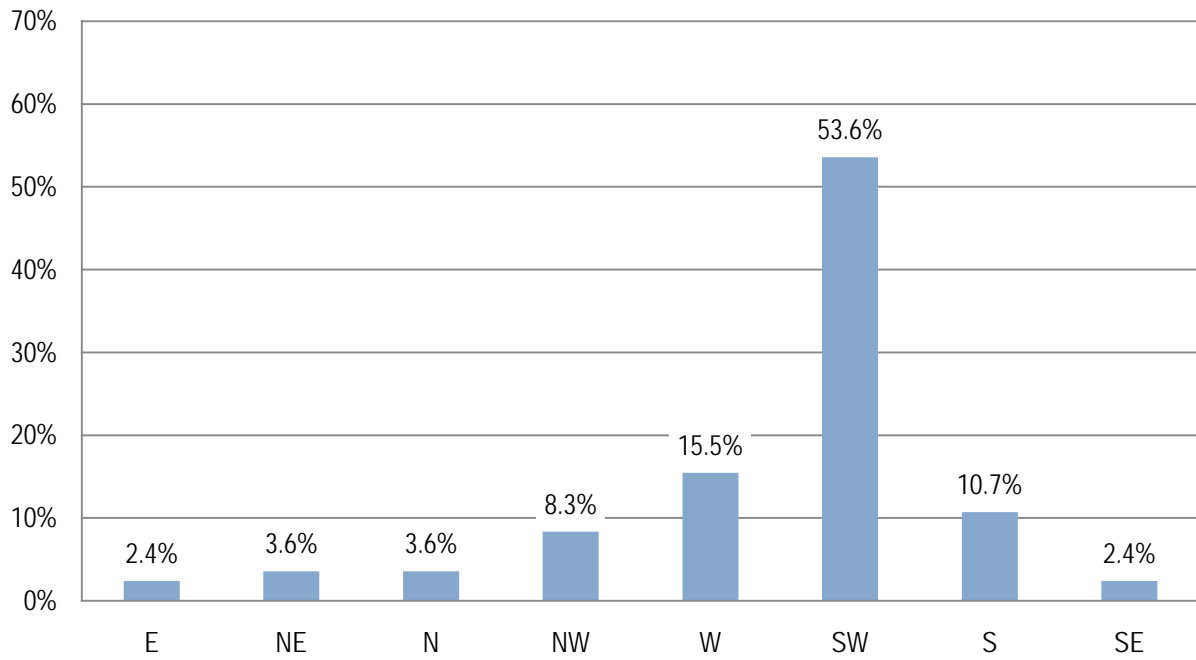
Source: Indiana Business Research Center, using data from the National Oceanic and Atmospheric Administration (NOAA) / National Climatic Data Center (NCDC)
Available at: http://cdo.ncdc.noaa.gov/ulcd/ULCD?state=IN&callsign=GEZ

Figure 3. Percentage of Months for Each Prevailing Wind Direction at **Above Average Wind Speeds***,
recorded at Shelbyville Municipal Airport, 2000 to 2006*
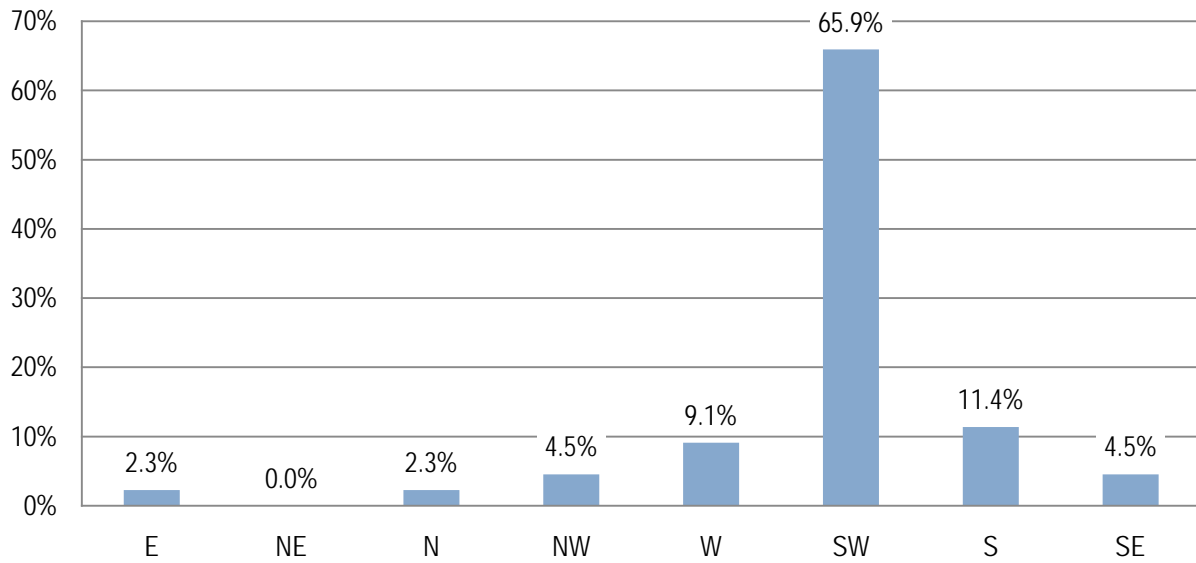
Source: Indiana Business Research Center, using data from the National Oceanic and Atmospheric Administration (NOAA) / National Climatic Data Center (NCDC).
Available at: http://cdo.ncdc.noaa.gov/ulcd/ULCD?state=IN&callsign=GEZ

A Note on Appendix Tables

The following appendix tables provide details of key statistical analyses that support the results presented in the report.

For Tables 2, 3, 4, 5, 8 and 12, only the column labeled 'preferred model' contains significant results for the model with the best statistical fit (lowest BIC ' scores), while controlling for property characteristics. Other models, such as intermediate or interaction models, are displayed for informational purposes only and should not be used out of context.

For more information, please contact researchers at the Indiana Business Research Center (www.ibrc.indiana.edu / 317-274-2979 or 812-855-5507).

Table 1: OLS Regression Coefficients of Traditional Pricing Measures on Different Types of Property Value ($1,000s) in Selected Indiana Counties, 2000 to 2006 (This table spans two pages)

Type of Property:	Residential and Farm	Town Residential	Non-Town Residential	Farm
Farm or Agricultural Property	55.281**			
	(20.06)			
Hancock County (compared to Decatur County)	8.806**	6.726**	5.824+	54.833**
	(5.01)	(3.74)	(1.69)	(2.62)
Shelby County (compared to Decatur County)	0.695	-1.707	0.009	24.390
	(0.39)	(0.94)	(0.00)	(1.15)
Within a Town/Incorporated area	-12.052**			-6.443
	(13.91)			(0.23)
Age	-0.404**	-0.409**	-0.377**	-0.334+
	(24.27)	(21.64)	(13.11)	(1.89)
Lot Acreage	0.107**	7.805**	0.127**	0.107
	(2.60)	(8.58)	(2.66)	(0.48)
Area within Property (square feet)	0.036**	0.033**	0.038**	0.032**
	(51.83)	(37.80)	(35.75)	(5.12)
Two or More Levels/Stories	-1.014	-5.276**	2.124	29.149*
	(0.85)	(3.64)	(1.18)	(2.00)
Number of Bedrooms	-2.113**	-2.675**	0.081	-3.920
	(2.84)	(3.20)	(0.06)	(0.46)
Number of Full Bathrooms	19.128**	16.638**	18.988**	34.411**
	(18.65)	(13.47)	(11.69)	(4.10)
Number of Half Bathrooms	15.293**	13.721**	15.266**	36.292**
	(14.89)	(11.05)	(9.77)	(2.88)
Central Air	8.318**	8.929**	8.336**	16.583
	(7.29)	(6.93)	(4.44)	(1.28)
Number of Fireplaces	9.863**	11.305**	8.885**	12.869
	(11.77)	(11.16)	(6.97)	(1.42)
Detached Garage	11.920**	8.880**	18.139**	-4.578
	(8.32)	(5.90)	(6.93)	(0.25)

Type of Property:	Residential and Farm	Town Residential	Non-Town Residential	Farm
Attached or Unknown Type of Garage	18.253**	15.308**	26.196**	-15.498
	(12.95)	(9.56)	(10.97)	(0.91)
Year of Sale (reference year is 2000 for each)				
Sold in 2001	2.712	-0.372	3.474	39.021+
	(1.61)	(0.19)	(1.31)	(1.92)
Sold in 2002	3.733*	1.894	3.877	17.215
	(2.20)	(0.96)	(1.45)	(0.77)
Sold in 2003	5.129**	2.371	5.510*	29.323
	(3.14)	(1.25)	(2.15)	(1.54)
Sold in 2004	5.251**	-0.020	7.660**	46.581*
	(3.33)	(0.01)	(3.04)	(2.39)
Sold in 2005	7.607**	2.203	11.255**	41.939*
	(4.86)	(1.23)	(4.51)	(2.31)
Sold in 2006	8.515**	-0.154	13.417**	98.246**
	(5.04)	(0.08)	(4.87)	(4.17)
Constant	14.683**	20.904**	-3.588	-13.954
	(4.30)	(5.56)	(0.63)	(0.39)
Observations	7849	4236	3416	197
R-squared	0.73	0.74	0.70	0.66

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center, using data from Indiana Department of Local Government Finance, Metropolitan Indianapolis Board of Realtors

Table 2: OLS Regression Coefficients of RLOs and Traditional Housing Characteristics on Residential and Farm Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=7,849 (This table spans two pages)

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Pig Distance Index	0.000			
	(0.25)			
Beef Distance Index	0.013			
	(1.25)			
Dairy Distance Index	-0.054**			
	(3.04)			
Closest RLO is Upwind	-3.311**			-3.579**
	(3.72)			(3.99)
Number of RLOs within half-mile		0.174		
		(0.05)		
Number of RLOs between half a mile and one mile away		3.971*		
		(2.14)		
Number of RLOs between one mile and three miles away		1.953**		2.150**
		(6.55)		(6.83)
Number of RLOs between three miles and 10 miles away		-0.134*		
		(2.44)		
Number of RLOs Upwind and within one mile		3.375		
		(1.27)		
Number of RLOs Upwind and within three miles		-1.259*		
		(2.00)		
Pigs on RLOs within one mile			-0.004	
			(1.41)	
Beef Cattle on RLOs within one mile			0.120**	
			(2.76)	
Dairy Cattle on RLOs within one mile			-0.211**	
			(2.93)	
Pigs on RLOs within three miles			0.002*	
			(2.06)	
Beef Cattle on RLOs within three miles			0.008*	
			(2.11)	

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Dairy Cattle on RLOs within three miles			-0.025**	
			(3.76)	
Number of RLOs within one mile				11.378**
				(6.01)
Animals on RLOs within one mile				-0.017**
				(4.23)
Animals on RLOs within three miles				-0.003**
				(3.29)
Hancock County (compared to Decatur County)	11.138**	13.052**	12.207**	18.026**
	(6.14)	(4.76)	(5.78)	(6.94)
Shelby County (compared to Decatur County)	1.474	5.946*	3.023	11.288**
	(0.83)	(2.05)	(1.47)	(4.18)
Within a Town/Incorporated area	-10.553**	-10.672**	-11.153**	-9.962**
	(11.59)	(12.07)	(12.36)	(10.28)
Other Traditional Housing Characteristics (see Table 1)				
Constant	14.250**	9.816*	11.400**	4.642
	(4.13)	(2.16)	(3.10)	(1.02)
BIC'	-10048.47	-10064.26	-10020.58	-10130.02
R-squared	0.730	0.731	0.730	0.733

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors

Table 3: OLS Regression Coefficients of RLOs and Traditional Housing Characteristics on Town Residential Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=4,236 (This table spans two pages)

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Pig Distance Index	0.008**			
	(3.15)			
Beef Distance Index	0.110**			0.108**
	(3.93)			(2.91)
Dairy Distance Index	-0.177**			-0.231**
	(4.46)			(4.80)
Closest RLO is Upwind	-6.225**			-4.976**
	(5.00)			(3.85)
Number of RLOs within half a mile		-42.762**		
		(2.95)		
Number of RLOs between half a mile and one mile away		7.049+		
		(1.80)		
Number of RLOs between one mile and three miles away		2.808**		
		(7.82)		
Number of RLOs between three miles and 10 miles away		-0.345**		
		(5.61)		
Number of RLOs Upwind and within one mile		-3.610		
		(0.72)		
Number of RLOs Upwind and within three miles		-1.818*		
		(2.43)		
Pigs on RLOs within one mile			-0.009+	
			(1.67)	
Beef Cattle on RLOs within one mile			-0.207	
			(0.76)	
Dairy Cattle on RLOs within one mile			0.000	
			(.)	
Pigs on RLOs within three miles			0.001	-0.005*
			(1.29)	(2.38)
Beef Cattle on RLOs within three miles			0.052**	0.024**
			(7.40)	(3.43)

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Dairy Cattle on RLOs within three miles			-0.077**	
			(8.16)	
Number of RLOs within three miles				2.561**
				(4.83)
Hancock County (compared to Decatur County)	12.416**	9.180**	10.177**	19.829**
	(6.58)	(2.85)	(4.17)	(7.12)
Shelby County (compared to Decatur County)	0.617	-0.580	1.372	11.795**
	(0.33)	(0.16)	(0.60)	(3.54)
Other Traditional Housing Characteristics (same as Table 1)				
Constant	18.395**	23.795**	17.421**	9.365+
	(4.90)	(4.62)	(4.34)	(1.95)
BIC'	-5639.38	-5640.21	-5605.25	-5719.39
R-squared	0.748	0.749	0.746	0.753

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%

Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors

Table 4: OLS Regression Coefficients of RLOs and Traditional Housing Characteristics on Non-Town Residential Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=3,416 (This table spans two pages)

Models of RLO Effect	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Pig Distance Index	-0.003			
	(1.25)			
Beef Distance Index	-0.008			
	(0.68)			
Dairy Distance Index	-0.024			
	(0.80)			
Closest RLO is Upwind	-2.332+			
	(1.74)			
Number of RLOs within half a mile		1.541		
		(0.38)		
Number of RLOs between half a mile and one mile away		5.612*		
		(2.53)		
Number of RLOs between one mile and three miles away		1.122*		1.073**
		(2.26)		(3.39)
Number of RLOs between three miles and 10 miles away		0.091		
		(0.84)		
Number of RLOs Upwind and within one mile		2.387		
		(0.71)		
Number of RLOs Upwind and within three miles		-0.450		
		(0.44)		
Pigs on RLOs within one mile			-0.002	-0.022**
			(0.41)	(5.03)
Beef Cattle on RLOs within one mile			-0.038	
			(0.37)	
Dairy Cattle on RLOs within one mile			0.043	
			(0.30)	
Pigs on RLOs within three miles			0.002*	
			(2.22)	
Beef Cattle on RLOs within three miles			-0.001	
			(0.27)	

Models of RLO Effect	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model
Dairy Cattle on RLOs within three miles			-0.027*	
			(2.05)	
Number of RLOs within one mile				**12.703****
				(6.42)
Hancock County (compared to Decatur County)	4.818	12.555**	9.513*	**10.294+**
	(1.37)	(2.68)	(2.52)	**(1.91)**
Shelby County (compared to Decatur County)	-1.142	7.989+	3.051	**6.051**
	(0.33)	(1.75)	(0.81)	**(1.11)**
Other Traditional Housing Characteristics (same as Table 1)				
Constant	-0.777	-14.973*	-7.902	**-10.200**
	(0.13)	(1.98)	(1.29)	**(1.43)**
BIC'	-3929.76	-3936.39	-3918.77	**-3976.48**
R-squared	0.700	0.702	0.701	**0.704**

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%

Table 5: OLS Regression Coefficients of RLOs and Traditional Housing Characteristics on Farm Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=197 (This table spans two pages)

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model[a]
Pig Distance Index	0.011			
	(0.97)			
Beef Distance Index	0.042			
	(0.62)			
Dairy Distance Index	-0.029			
	(0.17)			
Closest RLO is Upwind	-1.039			
	(0.09)			
Number of RLOs within half a mile		15.033		
		(0.46)		
Number of RLOs between half a mile and one mile away		-15.049		
		(0.89)		
Number of RLOs between one mile and three miles away		3.395		
		(0.71)		
Number of RLOs between three miles and 10 miles away		0.257		
		(0.32)		
Number of RLOs Upwind and within one mile		52.309*		
		(2.16)		
Number of RLOs Upwind and within three miles		-12.022		
		(1.37)		
Pigs on RLOs within one mile			0.016	
			(0.72)	
Beef Cattle on RLOs within one mile			0.192	
			(1.50)	
Dairy Cattle on RLOs within one mile			-0.327	
			(1.05)	
Pigs on RLOs within three miles			-0.002	
			(0.28)	
Beef Cattle on RLOs within three miles			-0.040	
			(1.02)	

Models of RLO Effects	Closest RLO	Surrounding RLOs	Animals on RLOs	Preferred Model[a]
Dairy Cattle on RLOs within three miles			0.061	
			(0.56)	
Hancock County (compared to Decatur County)	58.484**	67.548*	55.762*	
	(2.70)	(2.29)	(2.32)	
Shelby County (compared to Decatur County)	27.408	35.774	28.843	
	(1.23)	(1.21)	(1.17)	
Other Traditional Housing Characteristics (same as Table 1)				
Constant	-16.273	-23.447	-11.753	
	(0.43)	(0.46)	(0.30)	
BIC'	-84.919	-79.837	-77.412	
R-squared	0.659	0.668	0.664	

[a] There is no preferred model that includes statistically significant impacts of RLOs
Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from Indiana Department of Local Government Finance, Indiana Department of Environmental Management, Metropolitan Indianapolis Board of Realtors

Table 6: OLS Regression Coefficients[a] for Low, Middle and High-Priced Town Residential Properties Values in Selected Indiana Counties, 2000 to 2006

Property Value Category:	Low: <$100K		Mid: $100K-$150K		High: >$150K	
	$1000s	factor	$1000s	factor	$1000s	factor
Beef Distance Index	-0.173	-0.002	0.104**	0.001**	-0.022	-0.000
Dairy Distance Index	0.231	0.002	-0.163**	-0.001**	0.015	0.000
Closest RLO is Upwind	-0.012	-0.007	-1.404	-0.013+	-10.590*	-0.044*
Number of RLOs within three miles	0.639	0.014+	0.854*	0.007*	-0.219	-0.002
Pigs on RLOs within three miles	-0.002**	-0.000*	0.001	0.000	0.001	0.000
Beef Cattle on RLOs within three miles	-0.001	-0.000	0.008*	0.000*	0.023	0.000
Hancock County (compared to Decatur County)	-0.215	0.010	7.707**	0.061**	15.984	0.069
Shelby County (compared to Decatur County)	-2.836	-0.034	5.790*	0.047*	19.047+	0.068+
Observations	2092	2092	1364	1364	780	780
R-squared	0.42	0.37	0.37	0.37	0.63	0.63

[a]These models include controls for other traditional housing characteristics (same as Table 1)
+ significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from Indiana Department of Local Government Finance, Indiana Department of Environmental Management, Metropolitan Indianapolis Board of Realtors

Table 7: OLS Regression Coefficients[a] for Low, Middle and High-Priced Non-Town Residential Properties Values in Selected Indiana Counties, 2000-2006

Property Value Category:	Low: <$100K		Mid: $100K-$150K		High: >$150K	
	$1000s	factor	$1000s	factor	$1000s	factor
Number of RLOs within one mile	2.887	0.051	3.238*	0.025*	7.651*	0.042**
Pigs within one mile (on RLOs)	-0.007	-0.000	-0.007*	-0.000*	0.003	-0.000
No. of RLOs between one mile and three miles away	-0.077	0.002	0.279	0.002	-0.106	0.000
Hancock County (compared to Decatur County)	2.499	0.097	4.082	0.032	-27.985*	-0.115**
Shelby County (compared to Decatur County)	0.505	0.054	1.685	0.011	-27.607*	-0.111**
Observations	804	804	1204	1204	1408	1408
R-squared	0.27	0.26	0.19	0.19	0.55	0.54

[a]These models include controls for other traditional housing characteristics (same as Table 1)
+ significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from Indiana Department of Local Government Finance, Indiana Department of Environmental Management, Metropolitan Indianapolis Board of Realtors

Table 8: OLS Regression Coefficients for RLOs and Traditional Housing Characteristics for Residential and Farm Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. Comparing Preferred Model to Interaction Model of Rural Variable with RLO Variables. N=7,849*

Models of RLO Effect	Preferred Model	Interaction Model
Closest RLO is Upwind	-3.579**	-9.288**
	(3.99)	(9.04)
Number of RLOs between one mile and three miles away	2.150**	1.658**
	(6.83)	(3.74)
Number of RLOs within one mile	11.378**	3.994
	(6.01)	(0.7)
Animals on RLOs within one mile	-0.017**	-0.008
	(4.23)	(0.33)
Animals on RLOs within three miles	-0.003**	-0.002
	(3.29)	(1.54)
Rural (Not within a Town/Incorporated area)	9.962**	
	(10.28)	
Rural × Closest RLO is Upwind		10.364**
		(6.83)
Rural × Number of RLOs between one mile and three miles away		0.987
		(1.63)
Rural × Number of Animals on RLOs within one mile		10.390+
		(1.7)
Rural × Animals on RLOs within one mile		-0.013
		(0.53)
Rural × Animals on RLOs within three miles		-0.001
		(0.36)
Hancock County (compared to Decatur County)	18.026**	19.138**
	(6.94)	(6.64)
Shelby County (compared to Decatur County)	11.288**	13.081**
	(4.18)	(4.43)
Other Traditional Housing Characteristics (see Table 1)		
Constant	4.642	-2.649
	(1.02)	(0.59)
BIC'	-10130.02	-10067.53
R-squared	0.733	0.732

*Supplement to Table 2
Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors

Table 9: OLS Regression Coefficients for RLOs and Traditional Housing Characteristics on Residential and Farm Property Values ($1,000s) by County, 2000 to 2006

Models of RLO Effect	All Counties	Decatur County	Hancock County	Shelby County
Closest RLO is Upwind	-3.579**	7.567	-6.654**	0.210
	(3.99)	(1.44)	(5.27)	(0.16)
Number of RLOs within one mile	11.378**	5.066	12.341**	10.795+
	(6.01)	(0.73)	(5.45)	(1.88)
Number of RLOs between one mile and three miles away	2.150**	3.089**	1.932**	1.061
	(6.83)	(2.89)	(4.96)	(0.89)
Animals on RLOs within one mile	-0.017**	-0.007	-0.018**	-0.022
	(4.23)	(0.40)	(4.19)	(1.55)
Animals on RLOs within three miles	-0.003**	-0.004	-0.001	-0.002
	(3.29)	(1.33)	(1.17)	(1.28)
Hancock County (compared to Decatur County)	18.026**			
	(6.94)			
Shelby County (compared to Decatur County)	11.288**			
	(4.18)			
Within a Town/Incorporated area	-9.962**	-20.452**	-6.998**	-13.875**
	(10.28)	(3.62)	(5.88)	(9.32)
Farm or Agricultural Property	55.997**	23.121	61.717**	45.004**
	(9.60)	(1.40)	(7.97)	(4.76)
Other Traditional Housing Characteristics (see Table 1)				
Constant	4.642	5.193	15.229*	28.411**
	(1.02)	(0.29)	(2.34)	(5.86)
Observations	7849	533	4397	2919
R-squared	0.73	0.62	0.75	0.70

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors

Table 10: OLS Regression Coefficients for RLOs and Traditional Housing Characteristics on Town Residential Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006. N=4,236

Models of RLO Effect	All Counties	Decatur County	Hancock County	Shelby County
Closest RLO is Upwind	-4.976**	5.452	-8.602**	-3.841**
	(3.85)	(1.19)	(3.08)	(2.77)
Number of RLOs within three miles	2.561**	4.219**	5.606**	8.147**
	(4.83)	(3.89)	(3.15)	(4.60)
Beef Distance Index	0.108**	-0.164	-0.019	0.209**
	(2.91)	(0.74)	(0.67)	(5.23)
Dairy Distance Index	-0.231**	-	-	-
	(4.80)	(.)	(.)	(.)
Pig AUs on RLOs within three miles	-0.005*	-0.007*	-0.024*	-0.006**
	(2.38)	(2.15)	(2.52)	(3.15)
Beef AUs on RLOs within three miles	0.024**	0.032	0.020**	-
	(3.43)	(0.64)	(3.24)	(.)
Hancock County (compared to Decatur County)	19.829**			
	(7.12)			
Shelby County (compared to Decatur County)	11.795**			
	(3.54)			
Other Traditional Housing Characteristics (same as Table 1)				
Constant	9.365+	9.611	26.981**	19.458**
	(1.95)	(0.63)	(4.06)	(3.39)
Observations	4236	365	2268	1603
R-squared	0.753	0.74	0.77	0.75

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%
Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors

Table 11: OLS Regression Coefficients for RLOs and Traditional Housing Characteristics on Non-Town Residential Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006

Models of RLO Effect	All Counties	Decatur County	Hancock County	Shelby County
Number of RLOs within one mile	12.703**	-3.634	13.515**	10.688
	(6.42)	(0.17)	(6.51)	(1.44)
Number of RLOs between one mile and three miles away	1.073**	1.037	1.414**	-0.693
	(3.39)	(0.62)	(4.08)	(0.72)
Pigs on RLOs within one mile	-0.022**	0.014	-0.028**	-0.017
	(5.03)	(0.29)	(6.29)	(0.95)
Hancock County (compared to Decatur County)	10.294+			
	(1.91)			
Shelby County (compared to Decatur County)	6.051			
	(1.11)			
Other Traditional Housing Characteristics (same as Table 1)				
Constant	-10.200	-113.887	-4.687	17.150*
	(1.43)	(0.98)	(0.61)	(2.19)
Observations	3416	149	2000	1267
R-squared	0.704	0.60	0.73	0.68

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%

Source: Indiana Business Research Center using data from Indiana Department of Local Government Finance, Indiana Department of Environmental Management, Metropolitan Indianapolis Board of Realtors

Table 12: Comparing Preferred and Spatially-Correlated Error Models for RLOs and Traditional Housing Characteristics on Residential and Farm Property Values ($1,000s) in Selected Indiana Counties, 2000 to 2006

Models of RLO Effect	Preferred Full Model[a]	Small Sample Model[a]	Small Sample SCE Model[b]
Closest RLO is Upwind	-3.579**	-1.029	-0.750
	(3.99)	(0.33)	(0.22)
Number of RLOs within one mile	11.378**	17.388**	13.781*
	(6.01)	(2.78)	(2.06)
Number of RLOs between one mile and three miles away	2.150**	2.822**	1.809
	(6.83)	(2.60)	(1.31)
Animals on RLOs within one mile	-0.017**	-0.026*	-0.022*
	(4.23)	(2.12)	(2.12)
Animals on RLOs within three miles	-0.003**	-0.004	-0.001
	(3.29)	(1.32)	(0.44)
Hancock County (compared to Decatur County)	18.026**	19.846**	20.102*
	(6.94)	(3.04)	(2.50)
Shelby County (compared to Decatur County)	11.288**	11.173	10.850
	(4.18)	(1.61)	(1.26)
Within a Town/Incorporated area	-9.962**	-13.065**	-14.343**
	(10.28)	(4.28)	(4.07)
Farm or Agricultural Property	55.997**	56.200**	52.254**
	(9.60)	(3.04)	(3.17)
Other Traditional Housing Characteristics (see Table 1)			
Constant	4.642	-4.228	-2.658
	(1.02)	(0.34)	(0.20)
Observations	7849	700	700
R-squared	0.73	0.74	

Absolute value of t statistics in parentheses: + significant at 10%; * significant at 5%; ** significant at 1%

[a]Both the Preferred Model and Small Sample Models use Ordinary Least Squares (OLS) Regression Estimation with robust errors (McKinnon-White Jackknifed Adjustment)

[b]The Small Sample SCE Model uses Maximum Likelihood (ML) Regression Estimation with robust errors (Huber/White/Sandwich Adjustment)

Source: Indiana Business Research Center using data from: Indiana Department of Local Government Finance; Indiana Department of Environmental Management; Metropolitan Indianapolis Board of Realtors

Table 13: Equivalent Animal Units (AUs) based on Live Weight

Animal Name	Average Live Weight (lbs)	Animal Unit (1 Animal Unit is 1,000 lbs live weight)
Nursery Pigs	20.0	0.0200
Finishing Hog	150.0	0.1500
Sows	425.0	0.4250
Boars	425.0	0.4250
Market-mature Hog§	*250.0*	*0.2500*
Beef Calves	450.0	0.4500
Beef Cattle	1,200.0	1.2000
Dairy Calves	150.0	0.1500
Dairy Heifers	750.0	0.7500
Dairy Cattle	1,400.0	1.4000
Veal Calves	250.0	0.2500
Pullets	1.5	0.0015
Broilers	3.0	0.0030
Layers	3.5	0.0035
Turkeys	15.0	0.0150
Ducks	3.5	0.0035
Sheep	100.0	0.1000
Horses	1,000.0	1.0000

Source: US Department of Agriculture data provided by the Indiana Department of Environmental Management (IDEM), courtesy Michael Dunn (environmental manager)

§ This measure was not provided by USDA. Market-mature animal unit weight was created and used by the authors to provide a common understanding of the size of a finishing hog at the time it goes to market. Finishing hogs arrive at less than 15 pounds and average around 150 pounds. The typical person who has attended a state or county fair is familiar with the size of a market-mature hog. Conveniently, at 250 pounds, four market-mature hogs equal one animal unit.

Sows and boars are given the same capacity as "Breeding/Gestation Sows"

Beef cattle are given the same capacity as "mature cows (beef)"

RLO Interview Questionnaire

Preface: The IBRC conducted over 100 interviews with individuals from both the public and private sectors about the possible effects that a regulated livestock operation have on property values. All interviews were confidential. Respondents were encouraged to share their personal opinions and provide background and rationale for their opinion. If an interview could not be done in person, a member of the research team administered the questionnaire by phone. A total of ninety-two interviews were sufficiently complete for statistical analysis.

Selection of Individuals: Individuals from Hancock, Shelby and Decatur Counties were targeted for interviews. That said, persons residing and/or working in eleven other Indiana counties also participated. The broader scope of interviews was considered legitimate because media markets are more broad than the three counties that were selected for the quantitative analysis and the media reports on public resistance to RLOs help form opinion statewide. In other words, individuals in other areas are not likely to have considerably different opinions than those living or working in the three county area. In addition, one participant may have referred the IBRC to other real estate professional professionals as sources of information.

One goal of the qualitative analysis was to measure the perceptions of a wide range of individuals who may be knowledgeable about RLOs and their actual or perceived effects on their local communities. While the term "RLO" is used throughout this study as an abbreviation for both CAFO and CFO concepts together, the term CAFO was used in the survey because it is the term used in the media. Those included:

- **Purdue Extension Agents** familiar with the scope of concentrated feeding operations in their respective (and in many cases, adjacent) counties.
- **Township Assessors** who might have been requested to perform reassessments upon residential properties due to perceived adverse effects.
- **County Commissioners** as they are both familiar with county zoning and planning, the economic value of RLOs to their county as well as both positive and negative public perception of such operations.
- **Residential real estate appraisers** (as opposed to strictly farm/land appraisers) who might have real-world experience of valuing homes sold adjacent or near to RLOs.
- **Residential real estate agents** (as opposed to farm and land brokers) who might have knowledge of the effect (if any) on sales of homes due to location near RLOs.
- **Commercial bankers** known for making residential home mortgages in rural communities/areas regarding rural underwriting standards.
- **Farm Service Agency** county field office directors with knowledge of RLOs operations and community perceptions.
- **Farm Credit Services** county field office directors/personnel with knowledge of RLOs (perhaps including housing) in rural areas.

Core Questions: All respondents had some degree of knowledge of RLOs and were, most likely, better informed than the average citizen. (The only way of knowing if this was the case would have been a large-scale survey of all individuals which was far outside the scope of this study.) Each

participant was encouraged to share her or his opinions on RLOs and any anecdotal information on community perceptions. In addition, they were given the opportunity to express any opinions on other emerging agricultural or rural trends, such as ethanol plants, wind farms, mega-farms or the continued erosion of the number of small family farms.

A research team member asked each participant a series of eight questions regarding RLO potential effects. The questions were asked in the following order. *[The motivation for the question is in brackets and italics.]*

- Have you ever visited a concentrated animal feeding operation whether CFO or CAFO? [This to get a general feel as to actual familiarity as opposed to perceived knowledge.]

- In general, do you believe that CAFO's provide a positive contribution to the county's well being? [This to measure whether property tax revenues and jobs created outweighed negative perceptions of such operations and an indicator of overall community support for CAFO presence and/or expansion.]

- Do you believe there is a marked difference in the effects between dairy, cattle, hog or poultry operations upon nearby residential property values? *[This is a perception question. Respondents who answered "yes" were not asked to rate the different kinds of operations but simply asked which type they thought had the best and worst image.]*

- Have you ever attended a public meeting where the question of CAFO impact upon residential property values has been raised? [The intent was to discover not only how many individuals had been involved in the CAFO decision-making process but if potential property value impact had been part of that process.]

- Hypothetically think of two typical median-priced homes that are exactly alike except for location, one within the city limits of your county seat and one in a rural location but far away from the closest CAFO. Would the rural property be worth more, the same or less than the one in the city? *[Intent was to ascertain urban vs. rural values specific to the county of the respondents.]*

- Think of that same rural home located one mile from a CAFO. Would it be worth more, the same as or less than the same home in the city? *[Intent here was to derive some type of location measure as well as a value measure.]*

- Now think of that same home located one-half mile or less from a CAFO. Would the property value be more than, the same as or less than the one located in the city? *[Intent same as question #6.]*

- Please rate the importance of the effect, if any, of a CAFO upon nearby—say two miles or less—residential property values for:

- Distance from the CAFO

- Number of livestock

- Type of livestock

- The effort of the CAFO owner to operate a professional and environmentally concerned operation

As most important, second most important, third most important and least important from your personal viewpoint.

In addition, residential appraisers and real estate agents were asked their views on the effect of RLO distance from a residential property. These two participant groups were asked the effect of RLO-to-residence distance in percentage terms.

- In percentage terms, if a CAFO were 2 to 3 miles from a residential property, what effect would its presence have residence's sales price?
- If the CAFO were 1 to 2 miles from the residence?
- If the CAFO were ½ to 1 mile from the residence?
- If the CAFO were ½ mile to adjacent to the residence?