# Measuring the Impacts of Confined Animal Feeding Operations: Technical Issues and Policy Implications

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**Abstract**

Input-output and spatial hedonic models are developed to estimate the economic impacts and public costs of confined animal feeding operations, at the spatial scale of hog farms and neighboring houses. The results show that the positive economic impacts of hog farms on a local economy may outweigh the public costs to nearby property owners and that this difference is more pronounced when farms are located in less populated areas. The methodology and findings can be valuable to planners and policymakers and to those interested in economic development as they look toward or away from livestock as a source of growth.

**Key Words**: public costs, economic impact, input-output, spatial hedonic, confined animal feeding operations, CAFOs, property values

# Measuring the Impacts of Confined Animal Feeding Operations: Technical Issues and Policy Implications

## 1. Introduction

One of the most common value added opportunities for rural communities has historically been, and continues to be, livestock production. In the modern setting livestock production has become a double-edged sword providing critical economic activity on the one hand yet causing conflict over the use of rural amenities such as clean air and clean water. For livestock businesses to continue to be part of the rural economy the community, producers, and policymakers need more factual information about the impact of these businesses on rural economies.

The conceptual framework for this study is that livestock farms generate public and private impacts, each of which can be positive or negative (Figure 1). From an economic perspective these might be thought of as "goods" and "bads." Private impacts which are positive are the rents that accrue to the owners of the assets and the benefits received by consumers of pork products. Private negative impacts are costs that could be born by the public but are internalized and born by the farm operation. An example is refuse production and its removal by a licensed refuse company. Public positive economic impacts are the indirect and induced benefits arising from economic activity undertaken by the farmer. Examples are impacts to suppliers from purchased inputs, governments from taxes paid, and recipients of spending by employees. Public negative impacts are the externalities arising from the firm such as odor and water pollution. This

study attempts to compare the public negative impacts with the positive public impacts resulting from hog farming.

Recent work has documented, at the county level, the impacts from hog farming in terms of jobs, taxes, and economic activity of livestock level by species (see Goldsmith and Hedris, 2001; Goldsmith and Kim, 2002). Several studies have examined the environmental impacts of livestock production on neighboring communities (Abeles-Allison, 1990; Taff et al., 1996; Palmquist, Roka, and Vukina, 1997; Hamed, Johnson, and Miller, 1999; Ansine et al., 2003; Herriges, Secci, and Babcock, 2003; Kim and Goldsmith, 2004; Kim, Goldsmith, and Thomas, 2005).

This article is the first attempt to combine both types of studies and analyze the economic impacts and public costs of confined animal feeding operations (CAFOs) at the spatial scale of individual hog farms and houses. The economic impacts of hog farms will be assessed using an economic input-output model. The input-output model provides an assessment of how specific economic activity (livestock in our case) impacts the local economy in terms of jobs, taxes, and spillovers.

The public costs of swine production will be derived indirectly by measuring livestock's neighboring property values. This will be accomplished using a spatial hedonic model, explicitly taking into account spatial autocorrelation of individual property values.

The two assessments, one economic impacts and the other public costs, are then compared to provide a more complete economic assessment of swine production on a community. This information would be valuable for community stakeholders, livestock producers, and government policymakers to better understand the full impact of livestock

on communities and would provide the basis for sound decision-making when incorporating livestock production into economic development.

## 2. Literature Review

Compared with a rich literature on the negative impact of noxious facilities such as landfills on property values (see Farber, 1998 for an overview), swine production facilities have received less attention on how they affect neighboring property values. Several studies have examined the economic benefits of hog farms on local economy (Abeles-Allison, 1990; Goldsmith and Hedris, 2001; Goldsmith and Kim, 2002; Grant and Kulshreshtha, 2002; Serecon Management Consulting, Inc.). To date, there is no study that integrates both the economic impacts and public costs of such facilities at the parcel level, or at the spatial scale of hog farms and houses. Spatial scale is important to identify who are affected, how much harmed parties should be compensated, and where livestock facilities should be located to maximize net public benefits.

Abeles-Allison (1990) first examined the economic impacts and costs of hog operations at the local level in Michigan. The impacts were calculated from local input expenditures and the public costs were estimated from a hedonic model. Local expenditures per hog, $69.09 for a small farm and $45.87 for a large farm, were calculated as direct impacts to the local economy (Table 1). Following Otto (1987), Abeles-Allison employed a multiplier of 1.5 to estimate the indirect and induced economic impacts. Property tax losses were counted as the public cost of hog farms because these farms were assumed to reduce property values. A negative coefficient from a hedonic model was applied to township tax rate to calculate a loss in tax revenue. The author found that the ratios of economic impacts to public costs (EI/C ratios) ranged

between 2.63 and 8.47 for a 500 head farm and between 2.43 and 5.79 for a 5,000 head farm, depending on the ratio of local input purchase and multiplier effects of input expenditure.

Grant and Kulshreshtha (2002) estimated the economic impact of new hog farms in Manitoba, Canada. The authors surveyed six farm owners and twenty-seven farm employees and gathered information on employment, expenditure, and income. The impacts were generated from two phases, the investment phase and the production phase. The investment phase spans the purchase of machinery and equipment and the construction of the buildings. The production phase covers the ongoing operation of facilities. Using an input-output model, they estimated that the six hog farms would generate economic impacts of $10 million for the local region and $19 million for the Province of Manitoba.

Finally, forty-four hog producers in Alberta, Canada, were surveyed to obtain information on capital assets, input purchase, wages, and spending patterns (Serecon Management Consulting, Inc.). Employment and income multipliers were applied to estimate the economic impact of hog operations. The study estimated that the economic impact of an average size of the survey sample (316 sow equivalent) would range from $1.3 million to $1.5 million for the local economy and $1.6 million and $1.8 million for the provincial economy. In addition, the development cost of a 1,000 sow-equivalent operation was estimated at $4.3 million, about 80% of which could be purchased within the region (50 km radius). In both of the Canadian studies the cost of economic bads was not addressed.

## 3. Methodology

### *3.1 Estimation of Economic Impacts*

The economic impacts of hog farms are estimated by using the IMPLAN software program. The IMPLAN model estimates the direct effects, indirect effects, and induced effects of an economic activity. Direct effects refer to a production change associated with a change in demand for the good itself. In the case of hog farms, direct effects are the dollar value of hog farms' production, which is the initial impact to the economy. Indirect effects refer to secondary impact on affected industries caused by input purchases of hog farms. Induced effects are caused by changes in household spending due to the additional employment generated by direct and indirect effects.

In this way using IMPLAN software distinguishes among the direct, indirect, and induced effects, and its taxonomy corresponds to the notion of private and public benefits. That is, direct effects in output are private in the sense that they benefit hog farm business, whereas indirect and induced effects benefit the public. In addition to output estimates, IMPLAN estimates value-added by the economic enterprise. The value-added consists of employee compensation, labor income for the self-employed such as doctors and lawyers, other property-type income such as rent and corporate profits, and indirect business taxes. Each component in the value-added category includes direct, indirect, and induced effects. Wages and business taxes are included in public benefits for the analysis.

### *3.2 Cost Estimation*

The public costs of hog farms are estimated by a spatial hedonic model that takes into account spatial autocorrelation in property values. The choice of the hedonic model for our

purposes is an attempt to capture the negative externality of a livestock operation by looking at the impact of farms on housing values in the community. It is assumed that a significant component of the public concerns about odor, light pollution, water pollution, increased traffic, etc., will in part be captured by a devaluation of houses in the impact shed. A hedonic model employs physical, locational, and environmental attributes as explanatory variables of a house's value. An example of a physical attribute is the number of bathrooms, which would positively contribute to a house's value. A locational attribute might be proximity to the central business district, which generally is thought to be positive. Finally, an example of an environmental attribute is the house's proximity to a livestock facility. This may be positive, if a housing shortage exists in the area, thereby limiting options for farm employees. On the contrary, it may be negative if communities believe the neighboring farm creates health risks to neighboring residents. Or the coefficient may be insignificant if the farm is thought to be environmentally benign.

The coefficients in a hedonic model represent the marginal contribution of the attribute to housing value. Assessed property values are used as the dependent variable. The dependent variable is Box-Cox transformed, and spatial autocorrelation in property values is captured by incorporating spatially lagged dependent variable, analogous to lagged dependent variable in time-series.[1] To be specific, a spatial-lag hedonic model is estimated as follows:

$$\begin{aligned} \mathrm{VTF} = \beta_0 + \rho\, W \cdot \mathrm{VTF} + \beta_1\, \mathrm{BASEAREA} + \beta_2\, \mathrm{ROOM} + \beta_3\, \mathrm{BATHROOM} \\ + \beta_4\, \mathrm{LOTSIZE} + \beta_5\, \mathrm{AGE} + \beta_6\, \mathrm{INCOME} + \beta_7\, \mathrm{DCBD} + \beta_8\, \mathrm{DOPEN} \\ + \beta_9\, \mathrm{DSCHOOL} + \beta_{10}\, \mathrm{HOG\_D} + \beta_{11}\, \mathrm{SIZE} \end{aligned}$$

where VTF is Box-Cox transformed assessed property values, $\rho$ is the spatial autoregressive parameter, *W* is the *k*-nearest neighbor weights matrix, BASEAREA is the base area of a house, ROOM is the number of rooms, BATHROOM is the number of bathrooms, LOTSIZE is lot size, AGE is house age, INCOME is median household income by census block groups, DCBD is the distance to CBD, DOPEN is the distance to nearest open space, DSCHOOL is the distance to the nearest school, HOG_D is the number of hogs in the nearest farm divided by the distance, and SIZE is a dummy variable for farm size (= 1 if greater than 2,500 head[2]).

*3.3 Study Area and Data*

Craven County located in southeastern North Carolina is chosen as the study area: First, the county maintains geographically coded real estate (N = 25,684 housing values). Second, the State of North Carolina maintains geographically coded swine industry data (N = 26 farms and 85,000 pigs). The availability of livestock data is important because it is hypothesized that livestock facilities, an environmental variable, may impact the value of residential properties. Third, land use is heterogeneous where neither agriculture nor non-agriculture rural residents dominate. The county therefore provides a sufficiently complex spatial setting to explore what drives market value and possible differences between valuation techniques.

Three phases of data collection are involved in this study. These data include: (1) assessed property values, (2) general neighborhood characteristic, and (3) hog operation and location.

Data on assessed property values are available from the Craven County GIS Website. For the purpose of analysis, rural houses are identified from the Craven parcels map with the following procedures: first, since the Craven parcels map includes every parcel including residential, commercial, agricultural, and open space, only parcels whose building type and land use are residential are deemed to be residential parcels with houses. Second, only houses with at least one bedroom and bathroom, including mobile homes, are selected. Third, houses in urban areas (N = 12,799) are excluded as they, because of their higher population density, may swamp the data compared to the sparsely populated rural areas. As a result, 1,100 houses (9%), defined as urban in the U.S. census, are not included within 2 miles of the nearest farm.[3] Additionally, 91 houses defined as rural in the U.S. Census, but located in the same blocks with urban houses are deemed to be urban and excluded from the sample[4]. Houses in the two townships (Township 5 and 6) with no hog farms are also excluded from the sample, as the minimum distance from the two townships to the nearest farm is about 7.25 and 19 miles, respectively. Houses with lot size over 10 acres are considered outliers and excluded as houses with farm or timber tracts, following Palmquist, Roka, and Vukina (1997).[5] These selection procedures reduced the data set to 5,352 rural houses.

Information on the general neighborhood characteristic is available from the 2000 Census. The Census Bureau reports the median household income by the census block-group level. The spatial information on the census block-groups is available in the form of the Census 2000 TIGER (Topologically Integrated Geographic Encoding and Referencing System) Shapefiles.

Data on the 26 hog operations are acquired from the North Carolina Department of Environment and Natural Resources, Division of Water Resources, and Craven County Appraisal Office. North Carolina hog data include: farm name, design capacity, steady-state live weight, owner's name, and mailing address. The steady-state live weight represents the collective weight of all animals at a facility and is a more accurate means of size comparison.[6] The steady-state live weight is divided by an average hog weight (135 lb.) to get an average number of animal "units" for an operation. The locations of the farms are identified by comparing owners' names and parcel IDs from Craven County Appraisal Office records.

## 4. Estimation Results

### *4.1 Countywide Economic Impacts*

IMPLAN estimates that the swine industry in Craven County produced a direct private output of $21,175,000 ($249/hog) and hired 292 employees in 2001 in a county with a total of $4.6B of direct economic output of and 60k employees.

The output of the Craven swine industry generates economic impact across the economy in addition to its direct output (sales). IMPLAN estimates that the Craven swine industry has total economic impact of $27,144,000 ($319/hog) in output and 337 jobs in employment. The total impact includes indirect impact[7] ($4.1 million) that ripples across other related industries and induced impact ($1.8 million) from increased household spending. The indirect and induced employment impacts are 57 and 27 jobs, respectively.[8] The industry paid $3,171,000 ($37.30/hog) as workers' wages and salaries and $890,000 ($10.47/hog) as excise and sales tax.

*4.2 Countywide Costs*

Recent research using a spatial-lag hedonic model indicates hog farms in Craven County negatively impact neighboring property values (see Kim and Goldsmith, 2004.) The impact decays with distance and is measurable up to 1.75 miles from the farm. Specifically, the impact on property loss on a per hog basis is -$0.47 at 0.75 mile, -$0.52 at 1 mile, and -$0.42 at 1.25 mile.[9] Thus, the impact on the value of the median house ($63,520) 1 mile from a swine facility with 10,000 head is -$5,200, or 8.2%.

## 5. Application of Results

*5.1 Economic Impacts/Public Costs Analysis*

Two actual contrasting hog farms located in Craven County are selected to illustrate how an economic impact/public cost analysis can be conducted at the property tract level. . One farm (Farm A) is small with 853 hog units and located in a typical rural area (Figure 3). There are 13 houses within 1.25 miles of the farm. The other farm (Farm B) is large with 12,590 hog units and located near the urban-rural fringe (Figure 4). There are 43 houses within 1.25 miles of the farm.

The estimated property loss for each house in the impact sheds due to proximity to the hog farms is estimated using the spatial hedonic model results (Tables 3 and 4). The property values of the 13 houses surrounding Farm A decline by -$5,400, or -0.7% of assessed values, while the 43 houses within 1.25 miles of Farm B suffer a loss of property value of -$536,200, or -8.6% (Table 5). The public costs of Farm B are about 100 times those of Farm A due to four factors: greater number of hogs, higher population density, closer proximity of houses, and higher value of houses in proximity. The last three

factors correspond to public costs from livestock farms, while the first factor, hog number, affects both benefits and costs. Optimal citing policy and livestock industry development should focus on these four factors.

The economic impact of Farm B is about $1.5 million, or about 15 times the economic impact of Farm A.[10] Though both farms have EI/C ratios greater than 1, it would be incorrect to suggest that the economic impacts of hog farms is greater than the public costs, as captured through changes in housing value. The question is discussed more completely below. Caution is needed because the ratio is a narrow measure whose application is in ordinal ranking, not measures of social welfare.

Also of importance may be different time frames that could be applied when estimating impacts versus costs. The economic impacts recur annually. In contrast, the public costs of reduced valuations are one-time losses.

Though smaller, Farm A has an EI/C ratio of 18.76, far greater than that of Farm B with 2.79. It may be counterintuitive that a smaller farm can contribute more net benefits to a local economy than a larger farm. Yet the different factors discussed above produce much lower EI/C ratios for Farm B. Our EI/C ratios are comparable to those of Abeles-Allison (1990). For a small farm, EI/C ratios are similar (2.79 vs. 2.43). For a large farm, our EI/C ratio is 3.24 times as much as his ratio (18.76 vs. 5.79).

The implications for planning and economic development purposes are twofold: first, capturing both "goods" and "bads" can significantly affect a project's assessment; and second, utilizing an EI/C ratio test can provide an objective initial assessment of a project's viability.

*5.2 Ranking Economic Impacts/Costs of Hog Farms*

The EI/C ratio for all 26 hog farms are ranked in descending order (Table 6). Impacts are estimated for each farm and costs are estimated for surrounding houses within 1.25 miles of each farm (N = 731). The EI/C ratios range from 179.93 to 0.64. All farms except one have the EI/C ratio above one. Overall, the impacts are greater than the costs by about five to one.

Very significant in the case of Craven County is the number of houses near a hog farm. For example, the farm with the highest EI/C ratio has 1,156 hog units, but only two houses within 1.25 miles. This results in minimal public externality costs of $763. The annual economic impacts of the farm, however, are $137,341. In contrast, there is a farm with 5,200 hogs near the urban-rural fringe. It has 153 houses within 1.25 miles, resulting in public costs of $962,507. Though four times larger in terms of impacts, the magnitude of the cost reduces the EI/C ratio to 0.64, the lowest in Craven County.

*5.3 Optimal Siting*

To investigate how the location of a hog farm affects the EI/C ratio, a scenario is presented in which the two farms (Farm A and B) switch their locations. Following the scenario, Farm A is now located near the urban-rural fringe, surrounded by 43 houses within 1.25 miles. And Farm B, the larger farm, is located in a rural setting with only 13 houses within 1.25 miles. Losses increase 15-fold for farm A to $79,749, while public costs for Farm B fall 93% to only $36,323. Farm A, the small farm, in its new location sees its EI/C ratio fall from 18.76 to 1.27. Farm B's ratio jumps to 41.19, compared with 2.79 when it was located in a more urban area.

## 6. Conclusion and Policy Implications

This article presents the economic impacts/costs analysis of hog farms in Craven, North Carolina, at the spatial scale of hog farms and neighboring houses. An Input-Output model is used to measure the economic impacts hog farms contribute to the local economy. Spatial hedonics are used to estimate public costs of hog farms on property values. The value of the analysis is not the specification of the EI/C ratio, but the establishment of the ordered ratios for analysis and planning purposes. Clearly, our hedonic model does not capture all of the public costs associated with hog farming, and while economic impact is an important measure of economic vitality, it does not measure the collective benefits from pork production. This would require estimating both consumer and producer surplus. However, the approach presented in this paper does help to rank farms by their contribution to the local economy, accounting for a significant portion of their public cost. The spatial nature of the models permits one to analyze where poor EI/C ratios may occur in a county and where improved siting choices may be found. The results show the significance of farm location is when looking at more complete assessments of local impacts.

Social welfare theory in economics, underscored by the concepts of consumer and producer surpluses and system dead weight losses, encompasses all costs and benefits and the efficiency and equity tradeoffs that result from a specific solution. Measuring full benefits and costs is in practice very difficult, but the concept of comparing benefits and costs, compensating harmed parties, and redistribution are important lessons to help resolve policy impasses, such as are common with respect to the livestock industry. The EI/C ratio suggested in this research, while not capturing full costs and full benefits, is

tractable. It allows policy makers, regional planners, and those involved in economic development to address the benefits and costs of economic activity. A natural extension of this research, consistent with social welfare theory, is capturing more of the benefits and costs associated with economic activity balanced against the real needs of stakeholders.

One extension of the approach described in this research is the development of schemes to compensate harmed parties. Economic beneficiaries (say, taxing authorities) could choose to compensate parties who had seen their property values adversely affected by lowering their property tax rates. Central to such a scheme would be whether farming or residential living was the original activity in the setting. If hog farms existed before the construction of the houses, then new home owners would be receiving a discount on a per square foot basis because of the proximity to a livestock facility. If the farm followed the residences, or expansion occurred expanding the impact shed, then homeowners would be suffering losses as noted above. A third situation may occur where shifting land use norms (informal) or even zoning (formal) give preference to one side or the other[11]. This may happen when areas become so densely populated that they become suburban in nature or, alternatively, agricultural zones are established to provide some legal legitimacy to livestock production.

Compensation of harmed parties as part of livestock siting policy is now possible using this approach. The methodology employed herein allows policymakers to know not only who is being harmed, but by how much and by whom. It appears to be worthwhile for communities to try to balance the economic impacts of livestock production while at the same time compensating harmed parties through tax reductions or

direct payments. While the negative impacts on housing values may be non-trivial, they may in fact be only one-time effects. The economic impacts of a well-managed large livestock operation are annual and under certain circumstances appear to exceed the public costs.

**Figure 1. Economic Impacts and Costs of Hog Production**

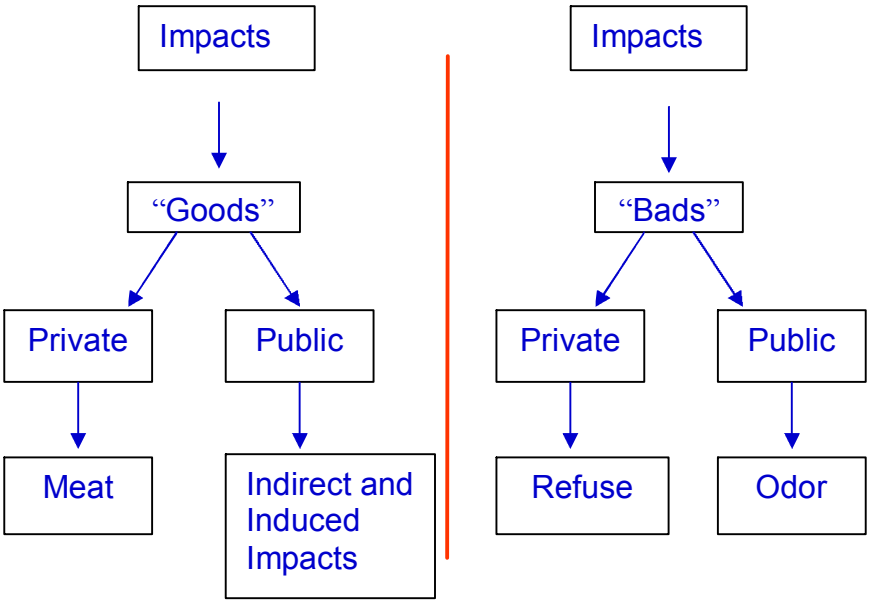
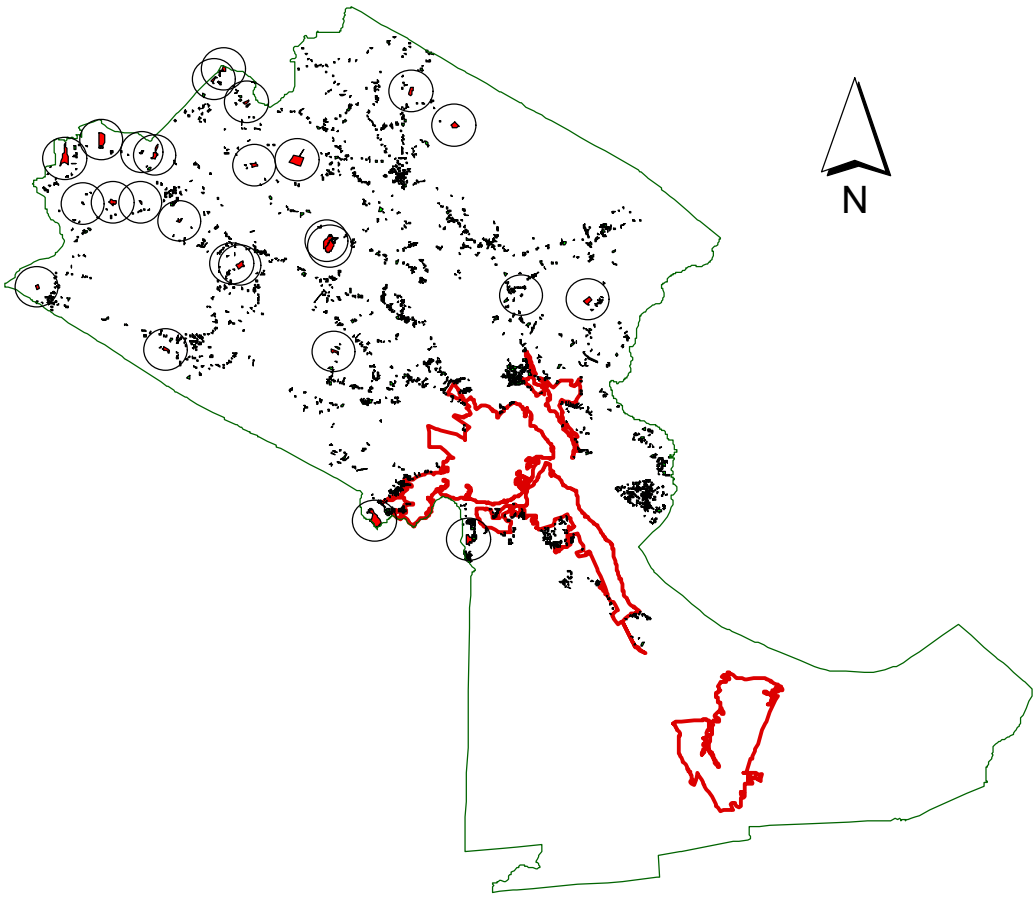
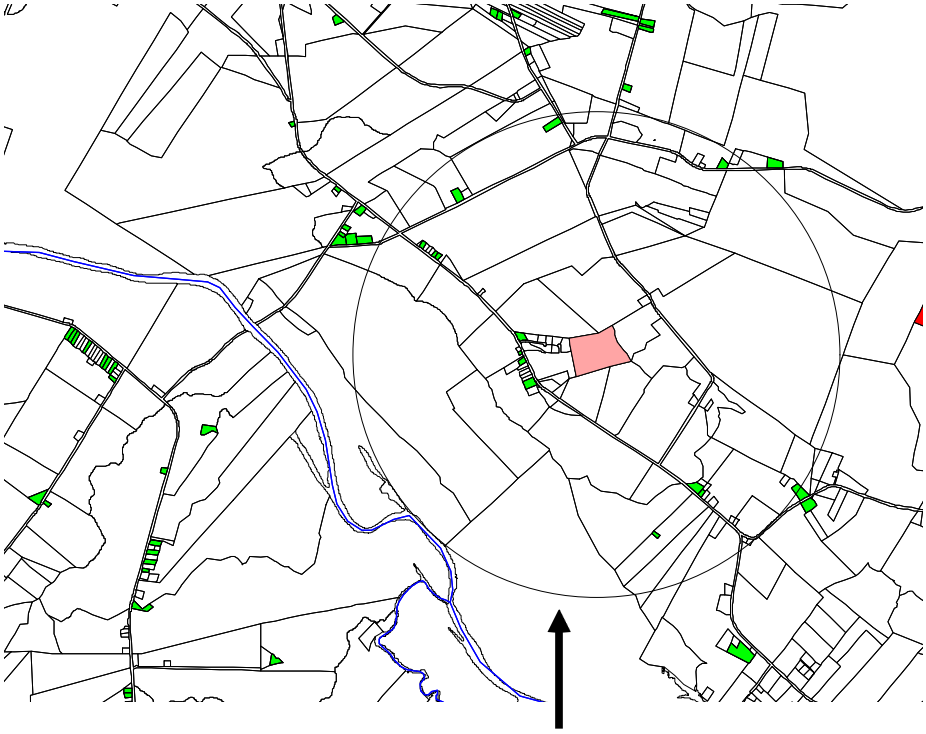


**Figure 2. Craven County Rural Homes and Hog Farms**




Note: Circles represent 1-mile radius from hog farms, and thick lines within the county represent urban census areas.

**Figure 3 Hog Farm (853 hogs) and Surrounding Houses**



**1.25 mile radius (13 houses)**

**Figure 4 Hog Farm (12,590 hogs) and Surrounding Houses**

**Table 1. Economic Impact of Swine Production**

| | Unit | Impact or Expenses | Public Cost | EI/C |
|---|---|---|---|---|
| Abeles-Allison (1990) | 8 farms | $69.09 per hog for 500 hog farm<br>$45.87 per hog for 5,000 hog farm | $0.43 per hog | 2.63-8.47 for 500 hog farm<br>2.43-5.79 for 5,000 hog farm |
| Grant and Kulshreshtha (2002) | 6 farms | $10 million (local)<br>$19 million (province) | | |
| Serecon Management Consulting, Inc. | 44 farms | $1.3-1.5 million (local)<br>$1.6-1.8 million (province) | | |

**Table 2. Top Industries Impacted by the of Swine Industry in Craven County (ranked by indirect effects)**

| IMPLAN Sector | Direct Effect | Indirect Effect | Induced Effect | Total Effect |
|---|---|---|---|---|
| Real estate | $0 | $654,992 | $96,103 | $751,095 |
| Wholesale trade | $0 | $549,489 | $79,879 | $629,368 |
| Truck transportation | $0 | $303,980 | $20,708 | $324,688 |
| Agriculture and forestry support activities | $0 | $254,241 | $249 | $254,490 |
| Automotive repair and maintenance | $0 | $217,295 | $76,025 | $293,320 |
| Other federal government enterprises | $0 | $101,790 | $72,528 | $174,318 |
| Monetary authorities and depository credit intermediation | $0 | $94,463 | $78,547 | $173,010 |
| Rail transportation | $0 | $91,997 | $2,515 | $94,512 |
| Power generation and supply | $0 | $85,078 | $14,683 | $99,761 |

**Table 3. Estimated Cost of Small Farm to Surrounding Property Values**

| House No. | Assessed Value | Distance to a Farm (Mile) | Estimated Impact | % Change |
|---|---|---|---|---|
| 1 | $37,690 | 0.40 | -$620 | -1.6% |
| 2 | $31,510 | 0.41 | -$538 | -1.7% |
| 3 | $36,690 | 0.41 | -$590 | -1.6% |
| 4 | $29,490 | 0.42 | -$501 | -1.7% |
| 5 | $28,920 | 0.86 | -$239 | -0.8% |
| 6 | $43,140 | 0.90 | -$303 | -0.7% |
| 7 | $44,070 | 0.97 | -$287 | -0.7% |
| 8 | $25,500 | 0.99 | -$190 | -0.7% |
| 9 | $100,770 | 0.99 | -$503 | -0.5% |
| 10 | $35,260 | 1.07 | -$222 | -0.6% |
| 11 | $128,020 | 1.09 | -$542 | -0.4% |
| 12 | $66,990 | 1.16 | -$322 | -0.5% |
| 13 | $146,350 | 1.19 | -$544 | -0.4% |
| Sum | $754,400 | | -$5,401 | -0.7% |

**Table 4. Estimated Impact of Large Farm on Surrounding Property Values**

| House No. | Assessed Value | Distance to a Farm (Mile) | Estimated Impact | % |
|---|---|---|---|---|
| 1 | $177,220 | 0.43 | -$25,499 | -14.4% |
| 2 | $44,470 | 0.45 | -$9,142 | -20.6% |
| 3 | $259,680 | 0.53 | -$27,390 | -10.5% |
| 4 | $218,310 | 0.54 | -$23,534 | -10.8% |
| 5 | $230,280 | 0.57 | -$23,313 | -10.1% |
| 6 | $337,810 | 0.58 | -$30,061 | -8.9% |
| 7 | $157,890 | 0.61 | -$16,679 | -10.6% |
| 8 | $226,170 | 0.61 | -$21,439 | -9.5% |
| 9 | $281,450 | 0.63 | -$24,251 | -8.6% |
| 10 | $160,540 | 0.65 | -$15,840 | -9.9% |
| 11 | $55,600 | 0.68 | -$7,135 | -12.8% |
| 12 | $135,660 | 0.68 | -$13,266 | -9.8% |
| 13 | $252,300 | 0.69 | -$20,459 | -8.1% |
| 14 | $92,450 | 0.69 | -$9,954 | -10.8% |
| 15 | $133,510 | 0.70 | -$12,782 | -9.6% |
| 16 | $70,850 | 0.71 | -$8,046 | -11.4% |
| 17 | $168,000 | 0.73 | -$14,373 | -8.6% |
| 18 | $48,090 | 0.75 | -$5,797 | -12.1% |
| 19 | $53,010 | 0.77 | -$6,053 | -11.4% |
| 20 | $256,420 | 0.77 | -$18,478 | -7.2% |
| 21 | $349,380 | 0.79 | -$22,396 | -6.4% |
| 22 | $58,330 | 0.82 | -$6,086 | -10.4% |
| 23 | $194,280 | 0.86 | -$13,563 | -7.0% |
| 24 | $120,450 | 0.87 | -$9,602 | -8.0% |
| 25 | $49,920 | 0.87 | -$5,110 | -10.2% |
| 26 | $119,750 | 0.89 | -$9,346 | -7.8% |
| 27 | $27,890 | 0.90 | -$3,269 | -11.7% |
| 28 | $134,400 | 0.91 | -$9,918 | -7.4% |
| 29 | $58,950 | 0.92 | -$5,455 | -9.3% |
| 30 | $123,430 | 0.92 | -$9,180 | -7.4% |
| 31 | $55,390 | 0.93 | -$5,163 | -9.3% |
| 32 | $130,520 | 0.95 | -$9,341 | -7.2% |
| 33 | $151,120 | 0.95 | -$10,312 | -6.8% |
| 34 | $72,390 | 0.97 | -$6,018 | -8.3% |
| 35 | $56,560 | 0.97 | -$5,044 | -8.9% |
| 36 | $54,810 | 0.99 | -$4,812 | -8.8% |
| 37 | $139,370 | 1.02 | -$9,079 | -6.5% |
| 38 | $63,370 | 1.11 | -$4,748 | -7.5% |
| 39 | $200,960 | 1.12 | -$10,713 | -5.3% |
| 40 | $271,150 | 1.15 | -$12,925 | -4.8% |
| 41 | $216,280 | 1.18 | -$10,674 | -4.9% |
| 42 | $201,310 | 1.20 | -$9,980 | -5.0% |
| 43 | $203,400 | 1.21 | -$9,977 | -4.9% |
| Sum | $6,413,120 | | -$536,203 | -8.36% |

**Table 5. Economic Impact/Cost Analysis of Two Selected Farms**

| | | | | Output | | | | Value Added | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cost (public) | Economic Impact | EI/C | Direct | Indirect | Induced | Output Total | Wages | Self-employment Income[1] | Other Income[2] | Business Taxes[3] | Valued Added Total |
| Farm A | $ (5,401) | $101,343 | 18.76 | $211,792 | $41,836 | $18,416 | $272,044 | $32,009 | $18,521 | -$2,071 | $9,082 | $57,541 |
| Farm B | $ (536,203) | $1,496,258 | 2.79 | $3,126,977 | $617,677 | $271,899 | $4,016,553 | $472,595 | $273,450 | -$30,576 | $134,087 | $849,556 |
| Sum | $ (541,604) | $1,597,601 | 2.95 | $3,338,769 | $659,513 | $290,315 | $4,288,597 | $504,604 | $291,971 | -$32,647 | $143,169 | $907,097 |

Notes
[1] Consists of payments to self-employed persons as income, such as private business owners, doctors, and lawyers.
[2] Consists of rent payments, contracts royalties, dividends, and corporate profits.
[3] Includes excise and sales taxes paid to businesses but does not include taxes on profit or income.

**Table 6. Ranking Economic Impact/Cost for the 26 Farms in Craven County**

| Farm No. | Hog Number | Number of Houses Within 1.25 Miles | Cost | Impact | EI/C |
|---|---|---|---|---|---|
| 1 | 1,156 | 2 | ($763) | $137,341 | 179.93 |
| 2 | 11,226 | 3 | ($13,991) | $1,333,730 | 95.33 |
| 3 | 1,500 | 3 | ($2,115) | $178,210 | 84.26 |
| 4 | 3,100 | 5 | ($6,008) | $368,302 | 61.30 |
| 5 | 658 | 9 | ($2,589) | $78,176 | 30.19 |
| 6 | 2,630 | 8 | ($12,282) | $312,463 | 25.44 |
| 7 | 3,672 | 7 | ($17,900) | $436,259 | 24.37 |
| 8 | 1,743 | 10 | ($10,224) | $207,081 | 20.25 |
| 9 | 7,698 | 9 | ($45,273) | $914,579 | 20.20 |
| 10 | 853 | 13 | ($5,401) | $101,343 | 18.76 |
| 11 | 711 | 3 | ($5,926) | $84,472 | 14.25 |
| 12 | 4,320 | 17 | ($37,923) | $513,247 | 13.53 |
| 13 | 2,448 | 7 | ($23,120) | $290,840 | 12.58 |
| 14 | 3,520 | 19 | ($33,981) | $418,200 | 12.31 |
| 15 | 1,760 | 25 | ($26,242) | $209,101 | 7.97 |
| 16 | 4,896 | 25 | ($74,461) | $581,681 | 7.81 |
| 17 | 2,400 | 23 | ($37,416) | $285,137 | 7.62 |
| 18 | 2,629 | 33 | ($41,115) | $312,344 | 7.60 |
| 19 | 1,156 | 34 | ($19,607) | $137,341 | 7.00 |
| 20 | 853 | 20 | ($17,566) | $101,343 | 5.77 |
| 21 | 3,144 | 54 | ($83,628) | $373,530 | 4.47 |
| 22 | 1,400 | 50 | ($39,180) | $166,330 | 4.25 |
| 23 | 1,707 | 102 | ($58,022) | $202,803 | 3.50 |
| 24 | 12,594 | 43 | ($536,288) | $1,496,258 | 2.79 |
| 25 | 2,309 | 54 | ($99,563) | $274,290 | 2.75 |
| 26 | 5,200 | 153 | ($962,507) | $617,798 | 0.64 |
| | 85,283 | 731 | ($2,213,092) | $10,132,199 | 4.58 |

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Endnotes

[1] See Kim and Goldsmith (2004) and Kim, Goldsmith, and Thomas (2004) for a complete discussion of the Spatial-Lag Hedonic Model and the Box-Cox Hedonic Swine Impact Model.

[2] Grouping corresponds to a recent EPA ruling (December 2002) defining a CAFO.

[3] There are 12 and 317 urban houses within 1 mile and 1.5 mile distance of the nearest farm, respectively.

[4] See Kim, 2004 for details.

[5] An additional outlier was identified and excluded from the sample. See Kim, 2004 for details.

[6] Division of Water Resources website, "Important Facts about Lists of Animal Operations", ftp://h2o.enr.state.nc.us/pub/Non-Discharge/Animal%20Operations%20Info/

[7] Table 2 lists top ten industries in Craven ranked by the size of indirect effects.

[8] The direct employment impact is less than the number of jobs in the swine industry in Craven because the regional purchase coefficient (RPC) was set to 0.876. IMPLAN assumes that a portion of employment (1-RPC) is imported from outside of Craven County.

[9] See Kim and Goldsmith (2004) on how to derive marginal prices for spatial hedonic models.

[10] The economic impact of a hog farm is assumed to be linearly proportionate to its hog inventories.

[11] Agricultural "right-to-farm" laws that zone for agricultural use provide only limited protection from nuisance lawsuits. They provide relief when the agricultural activity has not changed in any substantial way. Modern livestock expansion, as an example, might therefore breach the capability of safe-haven zoning ordinances.