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The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model in Southeastern Pennsylvania

Richard Ready
Assistant Professor of Agricultural and Environmental Economics
E:mail; RReady@psu.edu
Telephone: 814-863-5575

Charles Abdalla
Associate Professor of Agricultural and Environmental Economics
E-mail: CAbdalla@psu.edu
Phone: (814) 865-2562

Department of Agricultural Economics and Rural Sociology
Pennsylvania State University
Armsby Building
University Park, PA 16802
Fax: 814-865-3746

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and Charles Abdalla

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Department of Agricultural Economics and Rural Sociology
The Pennsylvania State University
University Park, PA 16802

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The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model in Southeastern Pennsylvania

I. Introduction

Traditional analysis of agricultural land has focused on the outputs of commodities that are easily measured by their market values. Increasingly, non-marketed outputs of farmland have been recognized and become important to public policy discussions about agriculture and land use. These outputs, or externalities, can be both positive, including environmental amenities such as open space, wildlife habitat and groundwater recharge or negative. Examples of the latter include water degradation from nutrient and pesticide runoff, soil erosion, and odors. In addition to these amenity and disamentity impacts from agricultural lands may generate other non-marketed outputs that contribute to rural development or are social and cultural (Hellerstein et al, 2002). The inability of markets to adequately provide incentives for decision-makers to take into account externalities has led to under or overproduction of these outputs. It has also led to enactment of farmland protection and land use/environmental policies at the national, state and local level.

Urbanization over the last several decades has given rise to a set of inter-related issues and concerns, sometimes called "sprawl". The urbanization/suburbanization process is related to transportation and communication technologies, housing/lifestyle preferences and economic factors, but it is fundamentally driven by population growth and household formation. When unplanned urban development occurs on the edges of cities and in rural areas, it impacts rural residents and businesses, and local governments. These impacts include loss of farmland and open space, higher infrastructure and public service provision costs, and congestion. Often piece-meal individual and public decisions result in longer term outcomes that no one in the community desires (Heimlich and Anderson, 2001). While not a threat to the nation's food supply, the direct and indirect impacts of loss of farm and other rural lands to unplanned growth are critical concerns facing land use decision-makers in most regions of the US.

The amenity or positive externality effects of agricultural lands, such open space, wildlife habitat, bio-diversity, and contribution to viable rural communities, have been discussed in national farm policy in the US. In Europe, national policy has been re-aligned to link production payments to account for the multifunctional character of agriculture. In the US, the amenity benefits of agriculture have been discussed under the auspices of "green payments" in the last farm bill. (Batie and Horan, 2001). However, relatively few multifunctionality concepts were incorporated in the 2002 Farm Bill.

Local conflicts over negative externalities from farming, especially animal agriculture, have been increasingly evident and difficult. Farm structure has generally evolved from a situation of many diversified crop-livestock farms that were spread out to fewer specialized larger farms that are geographically concentrated. Poultry and livestock producers are more closely integrated into marketing functions and tend to be located in clusters near processing or infrastructure specialized to their needs. As the scale of operations have increased and production has become geographically concentrated, the potential impacts upon neighbors and the environment have

increased. In some locations, this led to neighbor and community concern and conflict with producers over disamenities from animal production, including water pollution, odors and other issues (Abdalla, 2002). A study of conflicts over intensive livestock operations completed in Pennsylvania identified eight areas of concern: health and safety, environmental use (e.g. water degradation or diminution of supply, air quality, odors), role of government officials, decision making processes, economic impact, and community conflicts about farming and food supply (Abdalla et al, 2002).

Neighbors and rural residents have increasingly voiced concern and, in some areas, opposed the siting or expansion of intensive agricultural operations, particularly large hog farms. Since state policies often address water quality only, local governments have enacted other ordinances to protect residents. In addition, most states have some form of right-to-farm law that limits the ability of parties to sue farmers for nuisance related complaints. The issue of local government involvement in decisions about agricultural land use and nutrient management has become divisive itself, leading to pre-emptive state legislation, court challenges, uncertainty and higher costs (Abdalla and Shaffer, 1997, Abdalla and Dodd, 2002). Moreover, in a number of states both the potential disamenties from animal agriculture and the legality of local government responses to address them have become contentious issues.

A fundamental point of disagreement is whether externalities beyond water quality degradation addressed by current state law actually exist or are of sufficient magnitude to be relevant to decision-makers. Some groups have offered anecdotal evidence of property value declines, suggesting some the disamenities of agricultural land are in fact reflected in markets. Further, the groups argue that reflection of these externalities in markets provides evidence that such effects are real and of sufficient magnitude for consideration in public policy decisions. Relatively little research has been conducted by agricultural economists on this issue.

The objective of this study was to measure, in monetary terms, both the amenity and the disamenity impacts of agricultural practices. This was done by estimating a hedonic price function for single family homes in Berks County, Pennsylvania, a county characterized by a mix of urban, suburban, and rural land uses, and by productive and, in some cases, intensive agriculture. Amenity impacts of agricultural open space are estimated by including in the hedonic price function measures of land use surrounding the home. Disamenity impacts from agriculture are estimated by including measures of proximity to concentrated animal production and to mushroom production. These disamenity impact estimates are compared to estimates generated for other potential local disamenities, including landfills and an airport.

II. A Review of Theory and Previous Research

The Theory Behind Hedonic Pricing Analysis

The following discussion of the theoretical foundation for hedonic property price models follows closely that of Palmquist (1991). Hedonic property price models stem from the work of Sherwin Rosen (1974). Rosen's model treats any market good (in our case, a single family home) as a collection of attributes. In a competitive market, similar houses will exist with slightly different

levels of these attributes. The market price of a particular house will depend on its levels of those attributes, which can be characterized as a vector, **z**. Houses with more attractive levels of the attributes will sell at a higher price.

In a hedonic pricing analysis, the hedonic price function (also called the implicit price function), P(**z**), is an empirical relationship that predicts the market price of a given house as a function of the levels of its attributes. This function describes the equilibrium set of house prices that results given the population of house buyers and the available housing stock. House buyers search the set of available houses, and choose the house that maximizes their indirect utility function, given by V(W-P(**z**),**z**), where W is the wealth of the household. If houses with sufficient variability in **z** are available in the market, then each household will choose a house that maximizes their utility. For each single house attribute, z_i, the first order condition for this maximization is

$$\partial P/\partial z_i = \frac{\partial V/\partial z_i}{\partial V/\partial W} .$$

The left hand side of this equality is called the marginal implicit price of attribute z_i. The right hand side is the household's marginal rate of substitution between attribute z_i and money. For marginal changes in z_i, then, the marginal implicit price of z_i measures the household's marginal willingness to pay for additional z_i.

For nonmarginal changes in z_i, the implicit price function provides an exact measure of the benefit or cost to the household only if the change affects only a small number of houses, and moving costs to relocate are minimal. If moving costs are substantial, the implicit price function can still provide either an upper or a lower bound on the willingness to pay of the household for an exogenous change in z_i. If a nonmarginal change from $\mathbf{z}^0$ to $\mathbf{z}^1$ is seen as an improvement, then $\Delta P = P(\mathbf{z}^1) - P(\mathbf{z}^0)$ is an upper bound on the willingness to pay of the household for that exogenous change. If the change from $\mathbf{z}^0$ to $\mathbf{z}^1$ is seen as a worsening, then $\Delta P = P(\mathbf{z}^0) - P(\mathbf{z}^1)$ is a lower bound on the amount the household would need to be compensated to accept the exogenous change. If the change affects many or all houses in the market, then the problem is much more complex, because the hedonic price function itself shifts as a result of the nonmarginal change.

Nonetheless, the marginal implicit price for an attribute is a reliable signal of the household's marginal willingness to pay for a change in that attribute, and provides information about the benefits and costs from changes in those attributes. In our context, **z** includes both measures of land use near the house and measures of proximity to intensive agricultural production. The marginal implicit prices derived from the hedonic price function therefore estimate the amenity and disamenity impacts from these measures of agricultural activity.

Previous Hedonic Pricing Studies of Land Use

Two distinct approaches have been used to estimate the value that nonfarmers place on the existence of farms in their community. Several studies have used stated preference techniques to estimate the amenity values generated by agriculture (Halstead 1984, Bergstrom 1985, Beasely et al. 1986, Willis et al. 1993, Willis and Garrod 1993, Drake 1992, Ready et al 1997, Santos

1999). These studies find that nonfarmers do indeed state positive willingness to pay to preserve agricultural land. The most commonly-expressed motivations are aesthetics, wildlife habitat, outdoor recreation, preserving a traditional way of life, and protection from all of the external costs associated with urbanization, including traffic congestion, air, water, and noise pollution, and crime.

A second set of studies have used hedonic pricing models to analyze the effects of open space on nearby residential property values. Garrod and Willis (1992) found that the effects of open space, specifically forests, on residential property values depend on the species of forests. They conclude that deciduous trees within one-km significantly increase house prices, but spruce conifers significantly decrease house price. Geoghegan et al (1997) examine the effects of agricultural and forest land on the surrounding residential housing values in a central Maryland region. However, their results vary with the size of the neighborhood considered. Cheshire and Sheppard (1995) estimate the effects of open space on residential property values in England. They found that the effects of open space depend on the relative scarcity of open space surrounding the study area. Specifically, open space has a positive and significant effect on residential property values only if the amount of open space is sufficiently scarce. Tyrvainen and Miettinen (2000) found that the distance to the nearest small area of forest has a negative effect on residential house price in Finland, while the presence of a forest view from the housing unit has a positive influence. However, the relative amount of forest land surrounding the housing unit and distance to the nearest large forest area are found insignificant.

The study closest to this one in purpose and method is that done by Irwin (2002). In a hedonic pricing analysis of residential properties in Maryland, Irwin measures the proportion of area within 400m of each house in different land uses. Within the broad category of open space uses, Irwin distinguishes among cropland, pasture, forest, permanently-conserved privately-owned open space, and publicly-owned open space. Irwin found that compared to residential, commercial or industrial uses, open space located within 400m of a residential property has a positive impact on that property's price. Further, pasture and cropland generate higher amenity benefits to nearby residences than forested open space. Finally, both permanent conservation through easements and public ownership increase the positive impact that open space has on neighboring residential prices.

Endogeneity and Spatial Correlation in Land Use and Property Values

A unique issue arises when trying to estimate, with a hedonic price function, the impact of surrounding land use on residential property values. That issue is the potential endogeneity of open space in the hedonic price function. This can arise if there is a housing attribute that varies spatially that is not observable to the researcher, but that influences house prices. Areas with higher levels of this attribute will tend to have higher house prices. Because of high residential property values, any open space in such an area will be under development pressure and, over time, the amount of open space will decline. In equilibrium, areas with higher levels of the unobservable attribute will tend to have higher property values and less open space than other areas with lower levels of the attribute. Because open space is endogenous to house price, ordinary least squares regression will generate biased parameter estimates. In this case, the marginal implicit price of open space will be biased downward.

Irwin used IV estimation in her study on open space in Maryland (Irwin 2002, also Irwin and Bockstael 2001). She instrumented five endogenous variables: land in low density residential use, land in medium and high density residential use, land in commercial and industrial use, land in crops, and land in forested open space. Her instruments included physical features of the land, such as slope, drainage potential of the soil, and soil quality for agricultural use. This project takes a similar approach, with a slightly broader set of instrumental variables.

In addition to potential endogeneity in land use, unobservable attributes that vary spatially and that influence house prices can lead to spatial correlation in the house prices. Spatial correlation exists if the error term in the hedonic price regression is positively correlated for observations that are located near each other. If spatial correlation exists, OLS and IV regression will be inefficient, and estimated standard errors on the parameters will be biased upwards. Statistical inference in hypothesis tests is weakened, because standard errors are overstated.

Unfortunately, it is not clear how one would estimate a regression model that accounts both for spatial correlation and endogeneity. Irwin (2002) uses an approach where observations are deleted from the dataset until there are no two that are "close" to each other. However, she finds that expanding the minimum separation among observations from 100m to 600m has little effect on the IV regression results. This approach also weakens statistical inference, however, because information in the excluded observations is lost. In this project, all observations will be retained. It should be remembered, then, that reported standard errors may be biased upward.

Previous Hedonic Studies of the Disamenty Impacts from Agriculture

Few hedonic studies have been conducted that specifically address the disamenity impact of animal production on residential property values. Abeles-Allison and Connor (1990), in a study of property values near large hog operations in Michigan, found that house values decreased by $1.74 for each additional hog within a 2 kilometer radius of the house. They did not find significant impacts outside of 2 kilometers. When comparing the impact per hog of large farms versus small farms, no clear difference was found, though the dataset included very few residential properties located near small farms, making statistical inference difficult. They did not find any difference between residences located upwind of hog farms versus downwind. One limitation of this study is that it only included eight hog operations that had received multiple odor complaints. Property price impacts from these eight operations might well be greater than those from other operations that did not receive complaints.

Palmquist et al (1997) measured the impact on residential property values of hog production in the coastal plain of North Carolina, where some of the largest animal production facilities in the nation are located. For each residential property, the total amount of hog manure produced within ½ mile, within 1 mile, and within 2 miles was determined. Due to confidentiality constraints, the authors were not able to determine how many individual operations combined to give these totals, or where, exactly, those operations were located. Palmquist et al found that house price was negatively affected by the concentration of hogs near the house, and that the impact on house price from a single hog operation could be as large as 8.4%. Further, the impact

of an additional hog located within ½ mile of the house was found to be about 200 times greater than that from an additional hog located more than ½ mile from the house, though the more-distant hogs still did have a statistically significant negative impact on house price.

The Michigan study took as a maintained assumption that the negative impact from a livestock operation on house prices increased linearly with the number of livestock increased. The North Carolina study assumed that the impact from hog production was tied to the total tons of manure generated within each ring around the house. One issue that is addressed in this project is the relationship between the impact of animal production on house price and the scale of animal production near the house. Second, both the Michigan and the North Carolina studies are restricted to hog operations. This project includes poultry, swine, and beef and dairy operations. Finally, the Michigan and North Carolina studies investigated the impact of animal production on house price in isolation. This study estimates the impacts from several potential local disamenities simultaneously, as well as from open space versus developed land use.

A contrary result was found by Taff et al (1996). In a study 292 residential sales in Minnesota, they found that houses with a higher number of large feedlots within 3 miles sold for higher prices than houses with fewer large feedlots nearby. Their dataset included a cluster of sales, all in a single community, with an unusually high number of feedlots. Their hedonic price regression also included few explanatory variables tied to location other than proximity to feedlot. Their result could be driven by unmeasured differences between that one community and other communities that happen to have fewer feedlots.

III. Methods

Description of the Study Area and Regulatory Landscape

Berks County occupies an area (864 square miles) between Philadelphia and Harrisburg in southeastern Pennsylvania. Farming remains a very important sector for the county amidst a suburbanizing country-side and a diversifying economy. Currently, about 40% of the county's land is devoted to agriculture. As of 1997, Berks County ranked third in Pennsylvania in number of farms and in cash receipts from agricultural products. Animal agriculture is significant to Berks County's agriculture. 52% of the market value of agricultural products sold is livestock. In addition 35% of the market value is nursery and greenhouse, including mushrooms. Mushrooms are the largest market value crop grown (US Census of Agriculture 1997).

Recent population growth patterns in the county reflect suburban sprawl outward from Reading as well as development in rural land beyond suburban areas. Suburban growth is related to economic activities in Philadelphia, Allentown and Lancaster (Myers and Auchenbach, 2002). This population shift and suburbanization are affecting the viability of farming as well as the rural landscape in Berks County. To reduce rural-urban conflict and increase the viability of the county's agricultural industry, Berks County has developed a suite of land use management tools to encourage landowners and municipalities to use the laws available in Pennsylvania for protection of the farming and related industries (Myers and Auchenbach 2002). These include:

1. Pennsylvania's Right to Farm Law, which offers protection from nuisance action;
2. Clean and Green which assesses land according to its use—not according to developmental value. The county has 244,727 acres in this program.
3. Agriculture Security Area (ASA) Program—a local municipality established area providing benefits of protection from ordinances restricting normal farm structures and practices; land condemnations. Thirty-four townships with 139,254 acres are enrolled in this program.
4. Purchase of Agriculture Conservation Easements (PACE). Landowners are paid for their land's development rights permanently preserving it for agriculture production. Land must be located in an ASA to qualify. In Berks County, 31,372 acres on 256 farms are covered by such easements
5. Effective Agricultural Zoning – A local land use planning tool that is authorized for municipalities by state law. Local governments can provide for or allow land uses including agriculture. Twenty townships in Berks County have Effective Agricultural Zoning, covering 118,000 acres.

In its 1991 county comprehensive plan, the county set the goal of preserving 200,000 acres of farmland through PACE and effective agricultural zoning. Specifically, the county desired to preserve large contiguous areas (minimum of 500 acres) with existing agricultural productivity. (Factors for inclusion in this area were prime/unique soils, existing farms, land in programs administered by the Farm Service Agency, agricultural security areas, agricultural eased parcels, effective agricultural zoning.) In addition, the Planning Commission initiated an Agricultural Zoning Incentive Program in 1997 to encourage municipal adoption of effective agricultural zoning by paying costs associated with amending or revising the zoning ordinances (Myers and Auchenbach 2002).

Data on House Prices and Land Use

The implicit house price function was estimated using 8,090 residential properties that were sold between 1996 and 2002. To focus on the rural/urban fringe, houses located in the City of Reading were excluded from the analysis. Data on house sales and characteristics were obtained from a county-wide parcel map maintained by the Berks County Office of Assessment. For each house in the analysis, information was collected on the sale price of the house, the size of the house, the lot size, the number of bedrooms, the number of bathrooms, whether the house has a basement, whether some of the finished area in the house is located in an attic, the exterior façade of the house, whether the house has central air conditioning, the physical condition of the house (an index from 1 to 5, with lower values indicating better condition), the year of construction, the year sold, and whether the house had public water and/or public sewer. Nominal sale prices were inflated to 2002 dollars.

A county-wide land use map was constructed based on the parcel map. Details of the construction of the land use map are available in Ready et al 2003. Categories of land use were open space, residential, commercial, and industrial. Within the category of residential use five subcategories were defined, small-lot single family (less than 0.2 acres), medium-lot single family (0.2 to 0.5 acres), large-lot single family (0.5 to 1.5 acres) and very large-lot single family (over 1.5 acres). Within the category of open space, the amount of open space that is in crop, pasture or grass cover (as opposed to forested or open water), open space owned by government

entities, open space that is currently vacant but zoned for developed use, and open space covered by conservation easements were mapped.

For each house included in the analysis, the amounts of land in each land use within 400 meters of the house and within 1600 meters of the house were measured. These two radii represent two different definitions of the "neighborhood" that surrounds the house. A resident might travel up to four hundred meters from the house while taking a dog for a walk, while schoolchildren would typically walk up to one mile to get to school. Irwin (2002) considered only land use within 400 meters of the house.

Measuring Proximity to Disamenities

The locations of six different types of potential local disamenities were determined and mapped. These included high traffic roads (roads with more than 10,000 vehicles per day), four landfills, one regional airport, twenty-seven sewage treatment plants (not including plants located in the City of Reading), seventy-four properties that have been used for mushroom production, and seventy-one large-scale animal production operations, defined here as a cluster of buildings housing more than 200 animal equivalent units (aeu's), as defined for each species by the Pennsylvania Nutrient Management Act (Act 6 of 1993) (Beegle 1997).

For each house, the proximity of the house to potential local disamenities was measured. For landfills, mushroom production facilities, and high-traffic roads, the distance to the closest landfill, facility, or road was measured. For the regional airport, the distance to a line extending two miles from either end of the main runway was measured. For sewage treatment plants and animal production facilities, the location to each plant or facility was measured.

For each potential local disamenity, an index of proximity was constructed. The form of these indices was chosen so that they had the property that the impact on house price from a local disamenity decreases as the distance from the house to the disamenity increases, reaching 0 at a specified distance. For high traffic roads, landfills, the airport, and mushroom production facilities, these indices took the form

$$\text{Index of Proximity} = \begin{cases} 1/\text{Distance} - 1/K & \text{if Distance} < K \\ 0 & \text{if Distance} \geq K \end{cases}$$

where K is the outer limit of the impact. These four indices are given variable names HTIND_K, LFIND_K, AIRIND_K; and MRIND_K, respectively.

To explore the appropriate value of K for each disamenity, a second index was constructed for properties located more than K meters from the disamenity. This index took the form

$$\text{More-Distant Index of Proximity} = \begin{cases} 1/K & \text{if Distance} < K \\ 1/\text{Distance} - 1/J & \text{if } K \leq \text{Distance} < J \\ 0 & \text{if Distance} \geq J \end{cases}$$

with J>K. Inclusion of both of these indices in the hedonic price regression allows a test of whether the house price impact of a disamenity extends more than K meters from the disamenity. If the estimated coefficient on the first index is negative and the estimated coefficient on the second is zero, then we conclude that the disamenity impact does not extend past K meters. If both estimated coefficients are negative, then we conclude that the disamenity impact does extend past K meters.

For sewage treatment plants and animal production facilities, the indices have the additional property that each plant or facility can impact house price independently of other plants or facilities. This was accomplished by calculating an index value for each house for each facility, and then summing over all facilities, so that the index of proximity becomes

$$\text{Index of Proximity} = \sum_i 1/\text{Distance}_i - 1/K \,.$$

where the summation is over all sewage treatment plants or all animal production facilities. These indices were given variable names SPIND_K and ANBCIND_K respectively (with AN referring to animals, and BC referring to the building cluster that constitutes the production facility).

The ANBCIND_K index implicitly assume that the house price impact from an animal production facility is the same for each facility, regardless of how many animals are housed in each. A second index was calculated that implicitly assumed that the house price impact from an animal production facility was proportional to the number of animal equivalent units housed at the facility. This was

$$\text{ANAEUIND_K} = \sum_i \text{aeu}_i * \left[1/\text{Distance}_i - 1/K \right].$$

where aeu_i is the number of animal equivalent units housed at facility i. A regression model including both the building-cluster based index and the aeu-based index allows exploration of the issue of whether it is the number of facilities that matters, or the number of animals.

The aeu-based index was further broken down by species, where aeu_i was the number of animal equivalent units of poultry, swine, or dairy or beef cattle, generating three indices, POULTRYAEUIND_K, SWINEAEUIND_K, and COWAEUIND_K, which sum to equal ANAEUIND_K. An analogous set of building cluster-based index were constructed as

POULTRYBCIND_K= ANBCIND_K * POULTRYAEUIND_K/ANAEUIND_K

SWINEBCIND_K = ANBCIND_K * SWINEAEUIND_K/ANAEUIND_K

COWBCIND_K = ANBCIND_K * COWAEUIND_K/ANAEUIND_K

which sum to equal ANBCIND_K.

Finally, because this study focuses on the disamenity impact of animal production facilities, their impact on house prices was modeled more flexibly than other dismenities by including a second index of proximity, given by

$$\text{ANBCIND2_K} = \sum_i 1 \big/ \text{Distance}_i^{\,2} - 1 \big/ K^2 \,.$$

Inclusions of both ANBCIND_K and ANBCIND2_K allows the house price index of animal production facilities to vary with distance in a more flexible way.

The ANIND_K and ANIND2_K indices implicitly assume that the house price impact from an animal production facility is the same for all facilities. Additional indices were constructed to test whether the house price impact varied by scale of operation (number of aeu's housed in the facility), species housed in the facility, and whether farm has a detailed conservation management plan on file with the conservation district (an imperfect indicator of the operators level of managerial care related to minimizing off-site impacts.

Other databases used in the analysis included information on elevation and slope, soils, location of streams, zoning, school district, and commuting distance to regional employment centers, Reading, Allentown and Philadelphia.

Model Estimation

The implicit house price function was estimated using both an instrumental variables (IV) approach, similar to that used by Irwin (2002), and ordinary least squares. In the IV regression, the following variables were treated as endogenous: acres of land in open space uses, acres in residential uses, acres in commercial use, and the proportion of open space that is vacant land. The omitted land use category in all estimations is Industrial, so all coefficient values should be viewed as the marginal difference between the land use in question and industrial use.

In addition to the variables listed above, the sewage treatment plant index, SPIND_K, is also treated as endogenous. This modeling choice was motivated by the observation that in an OLS estimation of the hedonic price model, SPIND_K entered the function with a significantly positive coefficient, suggesting that sewage treatment plants are a positive amenity for home owners. This even though service by public sewers is already accounted for in the model. This result may be due to endogeneity in the decision of where to build sewage treatment plants. If sewage treatment plants tend to be built in areas where demand for housing is strong, then their location could be, at least in part, endogenous to house price.

Within the broad land use categories of Open Space and Residential Use, there are subcategories. With the exception of Vacant Land, which is treated as endogenous, the proportions of open space land and residential land that fall into each subcategory are treated as exogenous. These include the proportion of open space that is government owned, the proportion that is in an ASA, the proportion that has a conservation easement, the proportion that is in grass, pasture or crops, the proportion of residential land that is in small, medium, large or very large lot single family use, and the proportion of residential land that is in multi-family or other non-single family use.

Thus, we assume that how much land remains in open space use in a given location is endogenous to house price in that area, but that the type of open space (forested vs grassy, eased vs. noneased, ASA vs nonASA) is exogenously determined. Similarly, the amount of land in residential use is endogenous to house price, but the mix of types of residential use is taken as exogenous. The exception is for vacant land. Most vacant open space land is zoned for residential use. The speed with which that land is developed is likely determined in part by the demand for house (and the price of houses) in that area. It is reasonable to think, therefore, that the proportion of open space in vacant use will be endogenous to house price.

Other exogenous variables included in the hedonic price regression are structural characteristics of the house, distance of the house from downtown Reading, distance from commuting waypoints to Philadelphia, and distance to commuting waypoints to Allentown, soil slope at the house site, elevation, a measure of elevation relative to the surrounding terrain, zoning (with dummies for zoning type, with Residential as the excluded type), and the disamenity indices (other than SPIND, which as treated as endogenous).

Instrumental variables used in the IV regression were average slope, average elevation, a measure of suitability for septic tanks, a measure of soil suitability for construction, an agricultural productivity index, and the proportion of open space surrounding the house that is in an ASA. Each of these instruments affect either the return from agricultural production (and thus the opportunity cost of residential development) or the cost of residential construction. They should therefore help explain variation in the amount of land in open space uses. In addition, distance to the nearest stream was included as an instrumental variable, to help explain location of sewage treatment plants. Because the list of exogenous and endogenous variables is a mix of measures of acreage and proportion, and nonlinear IV approach was used (SAS PROC MODEL with N2SLS option).

IV. Estimation Results

Regression Results - House Characteristics

Results of the IV and OLS regressions are presented in Tables 1a through 1c. The R-square for the IV estimation was 0.8645. The R-square for the OLS regression was 0.8739.

Because it is theoretically more valid, we focus on the results of the IV estimation. All of the coefficients for the structural characteristics of the house were significantly different from zero, and of the expected sign. With the log-linear model used here, the coefficient values can be interpreted as the percent increase or decrease in house price associated with a one-unit change in the explanatory variable. So, for example, an increase in house size of 1 square foot increases the value of the house by 0.023%. Likewise, one extra bathroom increases the value of the house by 6.67%. The following characteristics are associated with higher house price: more bedrooms, existence of a basement, a brick, stone or masonry exterior, central air conditioning, better physical condition, newer construction, and location in a school district with higher 12th grade PSSA average test scores. For a given size, a house is worth less if some of its finished area is in an attic.

The influence of lot size is modeled nonlinearly, by including both a linear term and a log-transformed term. Both terms are significantly different from zero. The net effect of the two terms is that house price increases with lot size, but at a decreasing rate.

Houses on more sloped lots are worth less. Elevation in and of itself does not influence house price, but elevation relative to the surrounding terrain does. Houses that sit above the surrounding terrain are worth more than those that sit below the surrounding terrain. Public water service increases house value, but public sewer service does not. There is high correlation between these two features, however, decreasing our ability to distinguish their individual effects. House prices did not increase as fast as inflation during the study period (real prices declined over time).

Shorter commuting distance to Allentown and Philadelphia are associated with higher house prices, but lower distance to Reading was not seen as a positive amenity.

Regression Results - Surrounding Land Use

The coefficient estimates in Table 1b represent the marginal impact on house price of one more acre of each type of land. The total impact of a land use that combines more than one feature (for example eased open space) is given by the sum of the relevant coefficients. For each land use type, these summed implicit prices are given in Table 2a and 2b, for both the IV and OLS regressions. In each case, the marginal implicit price represents the percent impact on house price from a one-acre change in land use, with industrial use as the baseline.

Within 400 meters of the house, the land use with the largest positive amenity impact is forested, government-owned open space. However, forested, privately-owned open space has a similarly-high amenity value, and the difference between the two is not statistically significant. Open space in grass, pasture, and crops is less valued than forested open space, but again the difference is not statistically significant. Eased open space is less valued than noneased open space, and here the difference is statistically significant. Vacant open space is the least valued, and has in fact a more negative impact on land values than does industrial land. A second regression showed that whether surrounding open space was in an ASA had no impact on its amenity value.

Medium, Large, and Xlarge lot residential development has a positive impact on house price, relative to industrial use. Differences among these three groups are not statistically significant. Small-lot residential use and non-single family residential use have lower amenity value, and are not statistically distinguishable from industrial use.

Commercial land use within 400 meters of the house has a more positive impact than small-lot and non-single family residential, but the difference between commercial use and industrial use is not statistically significant.

When comparing among these results, the marginal implicit price of privately-owned, forested open space is significantly higher than for industrial use, commercial use, small and medium lot single family residential use, and non-single family residential use. Conversion of privately-

owned forested open space located within 400 meters of a house to any of these uses would reduce the price of a house. The marginal implicit price for privately-owned grass, pasture and cropland is significantly larger than that for small lot single family residential, for non-single family residential, for commercial, and for industrial. The marginal implicit price for eased, privately-owned grass, pasture and cropland is significantly larger than that for small lot single family residential, for non-single family residential, and for industrial.

To summarize, within 400 meters of a house, the surrounding land use that has the highest amenity impact is open space. Whether that open space is forested or in grass, pasture or crops does not matter much. Whether that open space is owned by the government does not matter much. If the open space is eased, it has a smaller positive impact on house price. Among developed land uses, the neighboring land use with the most positive amenity impact is medium or larger lot single family residential. The land uses with the least positive impact on house price are small lot residential, non-single family residential, commercial, industrial, and vacant land.

A comparison of the IV estimation results to the OLS regression results demonstrates the impact of endogeneity on the estimated marginal implicit prices of open space uses. The differences between the amenity value of open space and the amenity value of residential or commercial are larger for the IV estimation than for the OLS regression. This difference is due to the endogeneity of the open space.

One curious result is the difference in the value of vacant open space between the two regressions. The IV estimation shows vacant open space within 400 meters to be a disamenty relative to industrial use, a somewhat surprising finding. However, the OLS regression shows the opposite result. An IV estimation that treats the proportion of open space that is vacant as an exogenous variable also shows vacant open space to be an amenity relative to industrial use (with the difference statistically significant at the 5% level). If the proportion of open space that is vacant is endogenous to house price, this pattern suggests that higher house prices increase that proportion. This could be the case if development is occurring at a higher rate in areas with higher house prices, so that at any given time there is more land that has already been subdivided but that has not yet been built upon. Why this land (which is almost all zoned residential) would have lower amenity value than residential land that has already been built out is unclear. The disamenity may stem from aversion to uncertainty over exactly how the neighboring residential land will be developed, or aversion to the noise, dirt, and congestion associated with construction.

Moving farther from the house (Table 2b) the picture changes somewhat. Marginal implicit prices for land uses between 400 meters and 1600 meters from the house are generally an order of magnitude smaller than those for land use within 400 meters. This makes sense not only because the land use is located more distant from the house, and is therefore less noticeable to the occupants, but also because one acre of land represents a smaller proportion of the total located at that distance.

Still, land use between 400 meters and 1600 meters from the house does significantly impact house price. At that distance, the land use with the most positive impact on house price is commercial, closely followed by large and xlarge lot residential. Of open space uses, only eased

or government-owned open space has a significantly positive impact on price, relative to industrial use. In fact, privately-owned, forested open space has a negative impact on house price. Grass, pasture and crops have a significantly more positive impact than forested open space, but the difference is small.

Comparing among land uses between 400 meters and 1600 meters from the house, even the more-highly valued open space uses are significantly less attractive than large or xlarge lot single family residential use or than commercial use. The only developed use significantly worse than these two open space uses is industrial.

Marginal implicit prices for land uses located farther from 400 meters from the house should be interpreted with caution. Land use measures within 400 meters are highly correlated with land use measures between 400 meters and 1600 meters from the house, making identification of the marginal implicit prices difficult. One consequence of this collinearity is that the marginal implicit prices for the outer ring are less robust to changes in modeling decisions than those for measures of land use closer to the house.

To summarize, open space is an amenity to residential home owners, but the amenity value generates only within 400 meters of the house. Outside of 400 meters, the preferred surrounding land use is commercial. If open space does exist outside of 400 meters, then eased or government-owned open space is preferred to privately-owned, uneased open space. The ideal house, then, is located in the middle of forested open space, with commercial land located 400-1600 meters away.

Regression Results - Potential Local Disamenities

<u>Roads, Sewage Treatment Plants, Mushrooms, Airports and Landfills</u>

Proximity to high-traffic roads is measured using both the index, HTIND_100 (with an outer limit of 100 meters), and a straight-line distance from the house to the nearest high-traffic road, HTDIST. The coefficient on HTIND_100 is negative, and nearly significant, giving weak evidence that proximity to high traffic roads is a local disamenity. When two indices are included in the model, HTIND_100 and HTIND_100to200, the coefficient on HTIND_100 is negative and significant at the 1% level, while the coefficient on HTIND_100to200 is positive. We conclude from this that the disamenity impact from high traffic roads does not extend past 100 meters.

Using the coefficient estimate for HTIND_100 from table 1b, we can calculate the disamenity impact on house price at a specific distance. At 20 meters from the road, this disamenity impact decreases house price by 0.63%. At the same time, the coefficient on straight-line distance to a high-traffic road, HTDIST, is negative and significant, indicating that close access to major road arteries is an amenity. Past 100 meters from the road, each additional km of distance from high traffic roads decreases house price by 0.47%.

Proximity to the airport is also a local disamenity. When APIND_1600 and APIND_3200 are included in the model, the former is negative and significant, while the latter is negative but

insignificant (t=-0.93). We conclude that the disamenity impact of the airport and flight path extends to 1600 meters, but does not extend past 1600 meters.

When proximity to sewage treatment plants is modeled as an endogenous variable, SPIND is not significantly related to house price. It remains to be determine why SPIND is positively related to house price when it is treated as an exogenous variable.

Proximity to a landfill is also a local disamenity. When LFIND_1600 and LFIND_3200 are included in the model, both coefficients are significantly negative at the 5% level, and they are not significantly different from each other. We conclude that the disamenity impact from landfills extends to 3200 meters. Rerunning the analysis with LFIND_3200 and LFIND_4800, the coefficient on LFIND_4800 is no longer negative, and the two coefficients LFIND_3200 and LFIND_4800 are significantly different. We conclude that the disamenity impact from landfills does not extend beyond 3200 meters.

Proximity to mushroom production is also a local disamenity. It was not possible to conclusively establish an outer boundary of the impact of mushroom production on house prices. Inclusion of two mushroom indices gave unstable results. However, estimation using only one index gave very similar results, regardless of the outer limit chosen. Estimations were run with MRIND with an outer limit of 400 meters, 800 meters, 1600 meters, and 3200 meters. The coefficient on MRIND is negative and significant for all outer limits, and ranges in size from -5.05 to -6.70. We conclude that mushroom production does represent a disamenity to nearby homeowners, but we are not able to make any statements about how far the disamenity impact extends. We set the outer limit at 1600 meters to be consistent with the treatment of large-scale animal production facilities and the regional airport.

Large-Scale Animal Production

Three issues are relevant for accurately estimating the potential local disamenity from animal production. First, is the disamenity impact, if it exists, proportional to the number of animals near the house, or proportional to the number of building clusters near the house. Second, does the disamenity impact depend only on the closest building cluster, or does it depend on farther clusters as well? Finally, how far from a building cluster does the disamenity impact extend?

To address the first issue, the performance of the building cluster index, ANBCIND_1600, was compared to that of the aeu-based index, ANAEUIND_1600. Because these two indices measure similar things, they tend to be highly correlated, and it is difficult to distinguish which does a better job explaining variation in house prices. However, in a model that includes both indices, the estimated coefficient on ANBCIND_1600 is negative and nearly significant (t=-1.90), while the coefficient on ANAEUIND_1600 is positive but insignificant. In a model that includes only ANBCIND_1600, the estimated coefficient on the index is negative and significant (t=-2.08). In a model that includes only ANAEUIND_1600, the estimated coefficient on the index is negative but not significant (t=-1.42). Based on this set of results, we conclude that the building-cluster based index does a better job explaining house price variation than the aeu-based index.

Next, we investigate whether only the closest building cluster generates a disamenity impact. The ANBCIND_1600 index is divided into two parts, one containing information only on the closest building cluster, the other containing information on all other building clusters located within 1600 meters of the house. In a regression that includes both of these indices, both estimated coefficients are negative, and are not significantly different from each other. In fact, the estimated coefficient on the closest building cluster is smaller in absolute size than the coefficient on the index for more-distant building clusters. We conclude that all building clusters within 1600 meters can have an impact on house price.

Next, we investigate the spatial extent of the disamenity impact from large-scale animal production. A model was estimated that included two indices, ANBCIND_1600 and ANBCIND_3200. The estimated coefficient on ANBCIND_3200 is positive, indicating that the disamenity impact from animal production does not extend past 1600 meters. Similarly, Palmquist et al. (1997) found that hog operations located between ½ and 1 miles from the house had a statistically significant impact on house price (t=2.08), but that operations between 1 and 2 miles from the house did not (t=0.26).

We conclude that the best index for measuring the disamenity impact of large-scale animal operations is a building-cluster-based index and includes all building clusters within 1600 meters of the house.

To investigate whether the disamenity impact varies due to the species housed in the building clusters, a model was estimated with the three species-weighted building cluster indices, POULTRYBCIND_1600, SWINEBCIND_1600, and COWBCIND_1600. The coefficients on each of these three indices are presented in Table 3. While the results suggest that poultry generate the largest disamenity impact, and cows generate the least disamenity impact, the pairwise tests show that estimated coefficients are not significantly different, though the cow vs. poultry comparison is close to being statistically significant (t=1.84). These results are suggestive, but are not strong enough to allow us to conclude that the disamenity impact varies by species.

Table 3. Disamenity impacts by species

Species Index	Coefficient Estimate	Standard Error	T-Stat
COWBCIND	-8.071	16.442	-0.49
POULTRYBCIND	-92.598	40.306	-2.30
SWINEBCIND	-48.555	33.978	-1.43

To investigate whether managerial care affects the disamenity impact from animal production, the ANBCIND index was split into two pieces, one including building clusters on farms that have a detailed conservation plan on file with the conservation district, the other including building clusters on farms without a conservation plan. Whether a farm has a conservation plan is an admittedly imperfect indicator of the amount of care the operator takes in managing the operation to minimize off-farm impacts. Fifty-three of the 71 building clusters are on farms with conservation plans. The estimated coefficients on each sub-index are shown in Table 4. While its appears that the disamenity impact from building clusters on farms that do not have a

conservation plan is larger than that from building clusters on farms that do have a conservation plan, the difference between the estimated coefficients is not statistically significant (t=1.42). Again, the results are suggestive, but not strong enough to warrant a definitive conclusion.

Table 4. Disamenity impact by conservation plan

Facility Type	Coefficient Estimate	Standard Error	T-Stat
No Cons Plan	-67.198	30.999	-2.17
Has Cons Plan	-18.283	14.446	-1.27

In order to model the disamenity impact from animal production more flexibly, a second index is added, ANBCIND2_1600. The combination of ANBCIND_1600 and ANBCIND2_1600 allows the marginal implicit price to vary with distance in a more flexible way, though it still is constrained to equal 0 for houses that have no building clusters within 1600 meters. This is the regression model shown in Table 4c.

It is possible, using the coefficient estimates in Table 4c, to calculate the impact on a house's price from a single building cluster located at different distances from the house. This impact is shown in Figure 1, along with 95% confidence intervals. A building cluster located 500 meters from the house decreases its price by 6.4%. At 800 meters, the impact on house price is 4.1%. At 1200 meters, the impact is 1.6%. An outer limit to the impact of 1600 meters is imposed, so the impact is assumed to be zero past that point. Because very few houses are located within 500 meters of a building cluster, we have little confidence in using the model to predict impacts for such distances. We would presume that the impact would be no less than 6.4%, but cannot, based on our data, state how much greater it might be.

By way of comparison, Palmquist et al. (1997) found that the impact on house price of hog operations located ½ mile to 1 mile from the house was less than 1% of the impact of operations located within ½ mile of the house. While exact distances between the hog operations and the houses is not known for their dataset, it may include more sales of houses located very close to hog operations than we observed in Berks County.

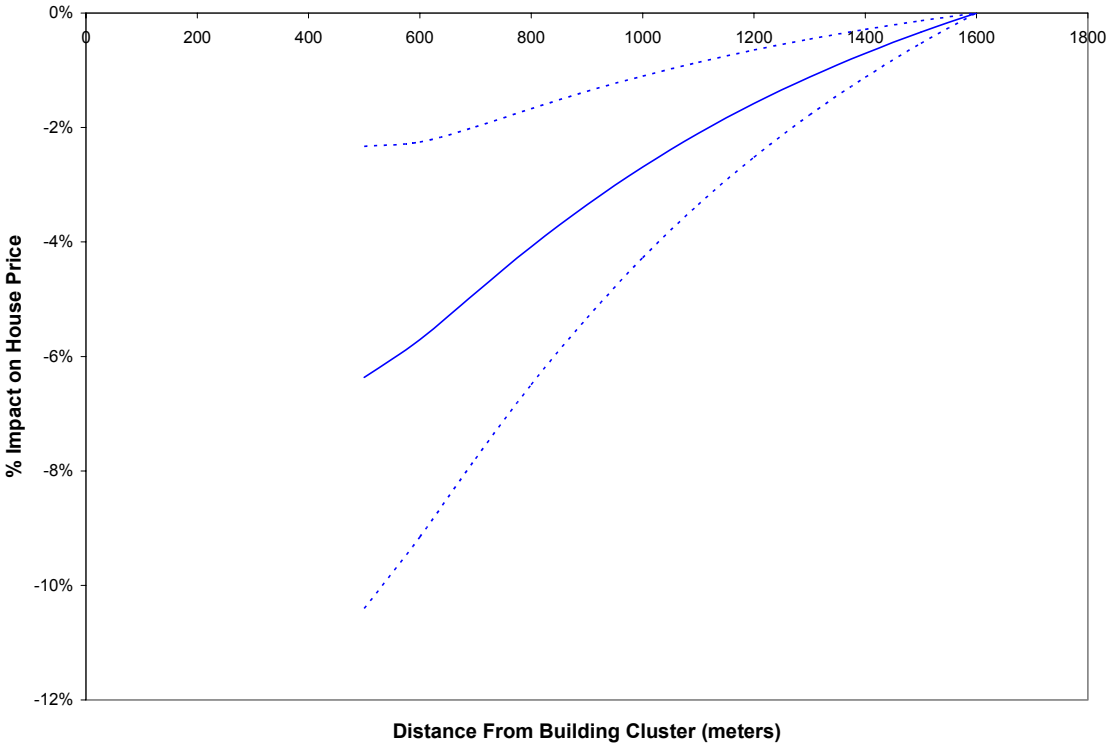

Figure 1. Impact on house prices from a single building cluster

Finally, to investigate whether the scale of the operation at a building cluster influences its disamenity impact, building clusters were divided into three groups: Medium (≥ 200 but <300 aeu's), large (≥ 300 but less than 600 aeu's) and very large (≥ 600 aeu's). No information is available on the location of small operations (<200 aeu's). The ANBCIND_1600 and ANBCIND2_1600 indices were each divided into three parts accordingly, and a hedonic price equation was estimated that included the three pairs of sub-indices. From this estimation, the percent impact on house price from a facility of each size, located at 800 meters from the house, was calculated, and shown in Table 5.

Table 5. Percent impact on house price from a facility located 800 meters from house (with 95% confidence intervals)

Facility Size	% Decrease in House Price
Medium	-7.5% (-13.0, -1.9)
Large	-0.9 (-4.5,2.7)
Very Large	-15.0 (-31.0,0.9)

The estimated impact of a facility is largest for very large facilites, as might be expected. However, this estimate is not significantly different from zero (t=1.84), probably due to the fact

that there are few very large production facilities in Berks County, limiting the statistical power of the regression. There are more medium-sized facilities in Berks County, and the estimated disamenity impact of these operations is negative and significantly different from zero. Interestingly, the estimated disamenity impact from large facilities is less than that from medium facilities. However, the difference between the two estimates (medium vs. large) is not statistically significant (t=1.88). Based on pairwise comparisons among the three size classes, we cannot conclude with statistical confidence that different-sized operations have different impact on house prices. We can state with 95% confidence, however, that operations between 200 and 300 aeu's do have a negative impact on house prices.

Because differences among facilities related to size, species, or presence of a conservation plan were not statistically significant, we favor a model that does not distinguish among facilities. The amenity impacts listed below therefore apply to all facilities larger than 200 aeu's.

Summary of Disamenity Impacts

Table 6 summarizes the disamenity impacts from landfills, the regional airport, mushroom production and large-scale animal production facilities.

Table 6. House price impacts by distance from the house.

	Distance from the House			
	500m	800m	1200m	2400m
Landfill	-12.4%	-6.9%	-3.8%	-0.8%
Airport Runway	-0.3%	-0.2%	-0.1%	
Mushroom Production Facility	-0.8%	-0.4%	-0.1%	
Large-scale Animal Production	-6.4%	-4.1%	-1.6%	

V. Discussion

To summarize our empirical results:

1) Spatial interactions among parcels do impact residential property values. In Berks County, we found both nearby land uses and proximity to potential local disamenities impact the sale prices of single family houses.

2) Endogeneity is important when modeling amenity impacts from surrounding land use. This is demonstrated by the difference in parameter estimates between the hedonic price model estimated using instrumental regression and the parameter estimates from ordinary least squares regression.

3) Within 400 meters of a house, open space is the most desirable surrounding land use, followed by large-lot residential use. Commercial and small and multifamily residential use are less desirable. One implication is that conversion of open space to commercial, industrial, small-lot residential, or multi-family residential will have a negative impact on house prices within 400 meters.

4) Within 400 meters, privately-owned open space with conservation easements have a less positive impact on house price than privately-owned open space without easements. The act of purchasing a conservation easement may not in itself drive neighboring house prices down. Rather, it may be that conservation easements tend to be associated with a certain type of open space (actively-farmed, productive farmland) that is less desirable as a near neighbor. Consistent with this explanation is the finding that open space within 400 meters that is covered in grass, pasture or crops has a lower amenity value than forested open space, though the difference in estimated amenity values is not quite significant. These finding suggest that agricultural open space is not as attractive to neighboring homeowners as other types of open space.

5) Between 400 and 1600 meters from a house, commercial is the most attractive land use, followed by large-lot residential, and then open space. Of open space uses, grass, crops and pasture are preferred to forested open space and eased open space is preferred to uneased open space, both results opposite to the results for open space within 400 meters of the house. Outside 400 meters, government-owned open space is preferred to privately-owned, uneased open space. We can therefore characterize the ideal house as being immediately surrounded by forested open space, but with commercial uses (offices and shopping) located within one mile of the house. At all distances, small-lot and multifamily residential use is less attractive than large-lot residential development.

6) The hedonic price regression was able to measure impacts on house prices from potential local disamenities. Among the potential local disamenities investigated, landfills and large-scale animal production facilities had the largest negative impact on house prices. Mushroom production and the airport had smaller negative impacts. High-traffic roads had a small negative effect that extended only a short distance from the road. No impact could be identified from sewage treatment plants.

7) Specific to large-scale animal production facilities, we find a significant impact within 1600 meters from such facilities, but not farther than 1600 meters. We find that facilities with between 200 and 300 aeu's are large enough to have a negative impact on neighboring house prices. However, we were not able to draw firm conclusions about whether the negative impact varies by species of animal, size of operation, or whether the operator has developed a detailed conservation plan.

8) Single family residences tend not to be located near large-scale animal production facilities. It is not known whether this is the result of decisions made by animal producers to locate in areas with fewer houses, by decisions made by developers not to build homes near animal facilities, or whether each group is locating on land with different attributes, resulting in a natural separation. Nor can we determine whether this separation is a result of policy measures such as Agricultural Security Areas or Effective Agricultural Zoning. However it has occurred, this separation tends to mitigate the impact that animal production facilities have on property values.

This project has demonstrated the utility of using GIS analysis to investigate issues of spatial interaction in land use and value. The study area chosen, Berks County, was well suited for this pilot study. First, Berks County has well-developed GIS data resources, and local officials and

their staff were very helpful to the project. Second, Berks County has a high proportion of open space that is in ASA's and a high proportion enrolled in ACE's, and these lands are spread broadly throughout the county. This is important because it allows us to identify the impact of these lands on house prices independent of other factors that vary spatially. Third, it was possible to map all animal production facilities in Berks County - a task that might be somewhat more difficult in another county.

At the same time, performing the analysis in only one county has its limitations. Berks County is still fairly well endowed with open space. It may be that the amenity value of open space near a house will be larger in a county where open space is more scarce. Restricting the analysis to only one county limited the number of animal operations included in the hedonic price analysis, and limited the number of residential conversions in the probit probability-of-development analysis. Extending this research approach to other counties will increase the amount of data, allowing more-precise estimation of the hedonic price regression and will allow us to determine to what extent the findings apply to other regions.

For these reasons, we recommend that the approach used in this study be expanded to a larger region. Specifically, the hedonic price analysis should be broadened to include counties where open space is more scarce, and where animal production is located closer to residential areas. It is quite possible that the amenity value of open space will be higher in areas where open space is more scarce, and that the marginal impact of eased open space will be positive, as it was found to be in Maryland by Irwin (2002).

With more observations on house/animal interactions, we will be better able to distinguish the relative impacts of different scales of animal operation, and different species. To the extent that operation-specific information can be collected without violating the privacy rights of the operators, that information could be used to help explain variation in the disamenity impact from animal production. Similarly, more-detailed information on mushroom production facilities would allow a more refined analysis of their impact on house prices.

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Table 1a. Hedonic Price Regression Results - House Characteristics

	IV Model			OLS Model		
Variable	Coefficient	Standard Error	T stat	Coefficient	Standard Error	T stat
House and Location Characteristics						
Intercept	-1.7308	0.3237	-5.35	-1.08355	0.2526	-4.29
Living Area (sq feet)	0.00023	3.39 E-06	67.95	0.000227	3.11E-06	73.12
Lot Size (acres)	-0.01799	0.00542	-3.32	-0.02087	0.00508	-4.11
ln(Lot Size)	0.1276	0.00579	22.03	0.140651	0.00517	27.22
# Bedrooms	0.03326	0.00314	10.58	0.035191	0.00298	11.79
# Baths	0.06666	0.00403	16.56	0.067237	0.00381	17.64
Basement (1=yes)	0.04959	0.00722	6.87	0.059085	0.00673	8.77
Finished Attic (1=yes)	-0.01752	0.00669	-2.62	-0.02574	0.00621	-4.14
Brick Exterior (1=yes)	0.07353	0.00516	14.24	0.074897	0.00482	15.52
Stone Exterior (1=yes)	0.1132	0.0142	7.95	0.116432	0.0135	8.60
Masonry Exterior (1=yes)	0.04966	0.00571	8.69	0.050638	0.00534	9.48
Central AC (1=yes)	0.05050	0.00442	11.42	0.050064	0.00416	12.04
Phys. Cond. (1-5, 5 worst)	-0.05849	0.00686	-8.53	-0.05844	0.00615	-9.50
Year Built	0.003422	0.000133	25.78	0.00311	0.000107	29.07
Year Sold	-0.01216	0.00139	-8.75	-0.01368	0.00128	-10.71
Distance to Reading (km)	0.00104	0.000523	1.99	-0.00051	0.000394	-1.30
Distance to Allentown (km)	-0.00161	0.000263	-6.14	-0.00158	0.000228	-6.94
Distance to Phil. (km)	-0.00271	0.000396	-6.83	-0.00375	0.000305	-12.30
Slope (%)	-0.00258	0.00103	-2.51	-0.00288	0.000799	-3.61
Elevation (m)	-0.00002	0.000087	-0.20	0.000137	0.000066	2.07
Elevation Difference (m)	0.001152	0.000192	5.99	0.001203	0.000166	7.24
PSSA Score	0.000749	0.000101	7.41	0.000788	0.000088	8.94
Public Sewer (1=yes)	0.004988	0.00911	0.55	-0.00214	0.00777	-0.28
Public Water (1=yes)	0.02327	0.00867	2.68	0.02247	0.00765	2.94

Table 1b. Hedonic Price Regression Results - Surrounding Land Use

	IV Model			OLS Model		
Variable	Coefficient	Standard Error	T stat	Coefficient	Standard Error	T stat
Surrounding Land Use						
Open Space w/in 400m	0.00276	0.000431	6.41	0.002129	0.000278	7.65
Open Space 400-1600m	-0.00008	0.000036	-2.12	1.53 E-06	0.00002	0.08
Gov Owned OS w/in 400m	0.00005	0.000374	0.13	0.000561	0.000222	2.52
Gov Owned OS 400-1600m	0.000199	0.000035	5.75	0.000064	0.000015	4.26
Eased OS w/in 400m	-0.00075	0.000321	-2.34	-0.00045	0.000259	-1.73
Eased OS 400-1600m	0.000104	0.000023	4.49	0.00004	0.000018	2.25
Vacant Land w/in 400m	-0.00367	0.000912	-4.02	-0.00066	0.000153	-4.33
Vacant Land 400-1600m	0.000058	0.00013	0.45	-0.00005	0.00003	-1.64
Pasture/Crops w/in 400m	-0.00039	0.000222	-1.75	-0.00018	0.000144	-1.23
Pasture/Crops 400-1600m	0.000081	0.00002	4.00	0.000035	0.000013	2.63
Residential w/in 400m	0.002143	0.000351	6.11	0.00168	0.000291	5.77
Residential 400-1600m	0.000305	0.000053	5.75	0.000055	0.00003	1.84
Small-lot Res w/in 400m	-0.00186	0.000306	-6.07	-0.0007	0.00021	-3.36
Small-lot Res 400-1600m	-0.00022	0.000062	-3.50	0.00001	0.000035	0.29
Med-lot Res w/in 400m	-0.00022	0.00022	-0.98	0.000193	0.000163	1.19
Med-lot Res 400-1600m	-0.00027	0.000051	-5.31	-4.3 E-06	0.000027	-0.16
Large-lot Res w/in 400m	0.000262	0.000293	0.89	0.001104	0.000231	4.77
Large-lot Res 400-1600m	-0.00001	0.000077	-0.16	0.000213	0.000058	3.67
Other Res w/in 400m	-0.00176	0.000403	-4.36	-0.00208	0.00032	-6.48
Other Res w/in 400m	-0.00017	0.000077	-2.27	0.000069	0.000057	1.20
Commercial w/in 400m	0.001089	0.00069	1.58	0.001909	0.000288	6.64
Commercial 400-1600m	0.000328	0.000056	5.90	0.000152	0.000023	6.65

Table 1c. Hedonic Price Regression Results - Potential Local Disamenities and Zoning

	IV Model			OLS Model		
Variable	Coefficient	Standard Error	T stat	Coefficient	Standard Error	T stat
Potential Local Disamenities						
HTIND	-0.1575	0.0854	-1.84	-0.17366	0.0806	-2.15
HTDIST (km)	-0.0047	0.00203	-2.32	-0.00687	0.001621	-4.24
MRIND_1600	-6.0360	1.8368	-3.29	-7.2706	1.6926	-4.30
LFIND_3200	-73.2097	19.328	-3.79	-99.8715	15.9685	-6.25
APIND_1600	-2.5287	1.2783	-1.98	-1.7303	1.2089	-1.43
ANBCIND_1600	-112.968	35.633	-3.17	-94.8982	33.9607	-2.79
ANBCIND2_1600	25391.44	9798.5	2.59	20280.35	9353.8	2.17
SPIND_1600	7.1859	12.029	0.60	18.3067	3.2129	5.70
Zoning						
Zoning Agricultural	-0.01116	0.013	-0.86	-0.01269	0.0124	-1.02
Zonging Effective Ag	-0.01834	0.0132	-1.39	-0.00323	0.0114	-0.28
Zoning Comm/Indust	-0.00793	0.00949	-0.84	-0.00821	0.00824	-1.00
Zoning Multiple	0.025325	0.00569	4.45	0.02686	0.00428	6.27
Zoning Conservation	-0.01497	0.0118	-1.27	0.003911	0.0107	0.37

Table 2a. Marginal Implicit Prices for Land Use Within 400m of House

	IV Model			OLS Model		
Land Use Type	Total Impact	Standard Error	T stat	Total Impact	Standard Error	T stat
Within 400m of House						
Privately-owned Forested Open Space	0.00276	0.000431	6.41	0.002129	0.000278	7.65
Govt-owned Forested Open Space	0.00281	0.000433	6.48	0.00269	0.00032	8.41
Privately-owned Grass, Pasture, and Crops	0.002373	0.000396	6.00	0.001953	0.000267	7.31
Eased, privately-owned grass, pasture, crops	0.00162	0.000438	3.70	0.001504	0.000367	4.10
Vacant privately-owned Open Space	-0.00091	0.000789	-1.15	0.001465	0.000301	4.87
SF residential small lot	0.000284	0.000335	0.85	0.000975	0.000281	3.46
SF residential medium lot	0.001927	0.000306	6.29	0.001873	0.000258	7.26
SF residential large lot	0.002405	0.000378	6.37	0.002784	0.000302	9.21
SF residential xlarge lot	0.002143	0.000351	6.11	0.00168	0.000291	5.77
Other residential	0.000383	0.000477	0.80	-0.0004	0.000386	-1.02
Commercial	0.001089	0.00069	1.58	0.001909	0.000288	6.64

Table 2b. Marginal Implicit Prices for Land Use Between 400m and 1600m from House

	IV Model			OLS Model		
Land Use Type	Total Impact	Standard Error	T stat	Total Impact	Standard Error	T stat
Between 400m and 1600m						
Privately-owned Forested Open Space	-0.00008	0.000036	-2.12	1.53 E-06	0.00002	0.08
Govt-owned Forested Open Space	0.000123	0.000029	4.28	0.000066	0.000021	3.08
Privately-owned Grass, Pasture, and Crops	5.62E-06	0.000028	0.20	0.000037	0.000017	2.15
Eased, privately-owned grass, pasture, crops	0.00011	0.000031	3.49	0.000076	0.000022	3.41
Vacant privately-owned Open Space	-0.00002	0.000121	-0.14	-0.00005	0.000034	-1.42
SF residential small lot	0.000087	0.000043	2.04	0.000065	0.000029	2.28
SF residential medium lot	0.000032	0.000033	0.96	0.000051	0.000023	2.20
SF residential large lot	0.000293	0.000062	4.70	0.000268	0.000046	5.79
SF residential xlarge lot	0.000305	0.000053	5.75	0.000055	0.00003	1.84
Other residential	0.00013	0.000075	1.72	0.000124	0.000055	2.23
Commercial	0.000328	0.000056	5.90	0.000152	0.000023	6.65