GIS Analysis of Land Use on the Rural-Urban Fringe: The Impact of Land Use and Potential Local Disamenities on Residential Property Values and on the Location of Residential Development in Berks County, Pennsylvania

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Final Report

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Executive Summary

This research project examined two issues related to spatial interactions between residential properties and nearby land use, using data from Berks County, Pennsylvania. First, the project modeled the impact that surrounding land use and potential local disamenities have on residential property values. If a land use is seen as an amenity by nearby residents, then the value of that amenity will be capitalized into the market price of nearby homes. Similarly, a nearby land use that is seen as a local disamenity will decrease house prices. A hedonic (or implicit) price regression was used to estimate the marginal impact of surrounding land use on house prices and measure the relative amenity values of different types of land use. Second, the project investigated whether surrounding land use has on effect on the location of new residential development. This was done by modeling the impact of surrounding land use on the probability that a parcel that was undeveloped in 1996 would subdivide for residential development during the period 1996-2002.

For the hedonic house price analysis, land use for each parcel in Berks County was categorized as either open space, residential, commercial or industrial. For 8,090 single family houses sold between 1998 and 2002, land use within 400 meters and within 1600 meters of the house was measured, using a geographic information system (GIS). In addition, distances were measured to potential local disamenities, including landfills, sewage treatment plants, the regional airport, high-traffic roads, mushroom production facilities, and large-scale animal production operations. A regression analysis modeled variation in house prices, with explanatory variables including structural characteristics of the house, measures of proximity to employment centers, and measures of surrounding land use. An instrumental variables regression approach was used to reduce possible bias due to endogeneity between land use and house prices.

The hedonic house price regression showed that, within 400 meters of the house, the land use that has the most positive impact on house price was open space, followed by large-lot single family residential land. Commercial, small-lot single family residential, and multi-unit residential were less desirable. The least desirable land use within 400 meters of the house was industrial. Of open space uses, land that is currently vacant but that has been zoned for residential, industrial or commercial development was found to have a much lower amenity benefit than other land in open space, possibly reflecting the negative impact of uncertainty over the future use of that land and the potential for noise, dust and traffic during the building process. Also, open space on parcels that are covered by conservation easements, including agricultural conservation easements, has a less-positive amenity impact than open space not covered by such easements. This does not necessarily mean that easements cause nearby property values to decrease. It may be that farms with agricultural conservation easements tend to be managed more intensively, which may be seen as less attractive by nearby homeowners.

Between 400 and 1600 meters away from the house, the land use with the most positive amenity impact on house price was commercial, followed closely by large-lot single family residential.

Of open space uses, only land that is owned by Local, State or Federal Government and land that is covered by conservation easements have a statistically significant positive amenity value. To summarize, the ideally-situated house would be immediately surrounded by open space, with commercial properties (stores and offices) located 400 to 1600 meters away.

Several potential local disamenities were found to have a negative impact on nearby house prices. Of the potential local disamenities investigated, the impact of landfills on house price was largest, and extended the farthest (up to 3200 meters). A landfill located 800 meters from a house decreases that house's sale price by an estimated 6.9%. The impact of a large-scale animal production facility (over 200 animal equivalent units or aeu's) on house price was about one half to two thirds as large as that from a landfill (4.1% at 800 meters), and did not extend as far (up to 1600 meters). The impacts on house price from mushroom production and from the regional airport were much less (0.4% and 0.2%, respectively, at 800 meters). The impact from high-traffic roads was small, and extended only a short distance. No significant impact was found for sewage treatment plants.

Additional analysis attempted to investigate whether different types of animal production facilities had different impact on nearby house prices. Differences in the impact due to differences in the size of the operation (number of aeu's) were not statistically significant. Further, medium-sized production facilities (200 to 300 aeu's) were found to have a statistically significant negative effect on house prices when considered apart from larger facilities. Similarly, the impact did not vary significantly by species (poultry, swine, and beef/dairy). An analysis of proximity of animal production facilities and residential properties showed that the density of single family homes around animal production facilities was lower than the average for rural parts of the county. An implication is that some potential for conflicts is avoided due to the way in which these land uses are located on the land.

The total impact on surrounding house prices was calculated for a landfill, the regional airport, and an animal production facility. The average impact on the value of 3342 houses located within 3200 meters was $2442 (all values are in 2002 dollars). The total impact on all houses was $8,162,000, which is 2.6% of the assessed value of the affected properties. The average impact of the regional airport on 2256 houses located within 1600 meters of the airport runway and its flight paths was $104, and the total impact on the value of these properties was $235,000, or 0.1% of the assessed value of the affected properties. This calculation does not include 2391 properties located near the airport within the City of Reading. The average impact of a single animal production facility on 119 single family residences located within 1600 meters of the facility $1,803. The total impact on all 119 houses is $215,000, or 1.7% of the assessed value of the affected houses. These figures are intended as illustrations, and should not be considered averages for similar facilities. The impact from any given landfill, airport, or animal production facility will depend on the number of houses located near the site, and on the market value of those houses absent the facility.

An analysis of the location of new residential development was limited by the small number of subdivisions that occurred during the study period. Still, the analysis showed that larger lots are more likely to be developed, that lots located near existing residential areas are more likely to be developed, and that proximity to government-owned open space has a small positive impact on probability of development. Potential house price, as predicted by the hedonic price function, did not help explain the pattern of development. There was a tendency for new development to locate near government-owned open space. However, for privately-owned open space, there was not found a significant tendency toward leapfrogging, where new development locates in areas with more open space.

The project demonstrated the utility and feasibility of using GIS and hedonic pricing analysis to investigate spatial interactions between residential and other land uses. The study area chosen, Berks County, was well suited to this type of analysis, in terms of data availability and the diversity and dispersed spatial pattern of land uses and agricultural production. The research method should be extended to more study areas, to see if differences in population density, demographics, or type and amount of open space and agricultural production influence the results. Until more research is conducted in more counties, care should be taken in extrapolating the results from this research to other regions.

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I. Introduction and Project Objectives

Increased attention is being focused throughout the Northeast on how land use is changing over time. Concerns over urban "sprawl," with its patchy, diffuse pattern of development, include the loads placed on the transportation infrastructure, the costs of delivering local services, the impacts on natural systems, and the effects on the aesthetic and cultural value of the landscape. Local authorities who manage and regulate growth and development need information on both the relative desirability of alternative land use patterns, and on the forces generating those patterns.

One means of assessing the relative desirability of alternative land use patterns in a region is to measure the benefits and costs that the region's citizens enjoy or suffer from those patterns. Benefits and costs associated with land use changes can be measured using survey techniques (for example Halstead 1984; Bergstrom, Dillman and Stoll 1985; Beasley, Workman and Williams 1986; Ready, Berger and Blomquist 1997), hedonic pricing techniques that measure differences in property values across different land use patterns (for example Garrod and Willis 1992a, 1992b; Ready, Berger and Blomquist 1997), or fiscal impact techniques (Burchell, Listokin and Dolphin 1985). Survey and hedonic pricing studies have consistently found that citizens place positive value on open space near their residence.

Because of data limitations, these studies have until recently tended to treat open space in a fairly aggregated way, measured as percent of total area in the region, or total number of acres, in forest or farmland uses. This simplification masks an important characteristic of the land use pattern - its patchiness. The value to residents of open space in a region depends on how that open space is distributed relative to residences and shopping and work centers. Fortunately, with the development of detailed, more-or-less uniform, GIS-formatted land use data, it is now possible to specify and estimate hedonic property price models that model spatial interactions among land parcels in a much more detailed way.

Within the last few years, researchers have started using detailed GIS data to estimate hedonic pricing models valuing open space and water quality (for example Bockstael 1996, Leggett and Bockstael 2000). These studies represent an important advance in hedonic modeling because they are based on much finer resolution data on land use, and therefore give a much more detailed picture of the spatial interactions that occur among parcels. Using detail GIS-based data, it is possible to differentiate, at a much finer level of detail, between open space located close to a parcel and open space located farther away, and to estimate the marginal impact of each on land prices.

Spatial interaction among parcels is important not only because it influences land values, but also because it influences land use change. If residents value proximity to open space, then newly constructed homes located farther away from high density development will have higher value than new homes located in more-densely developed areas. This price differential may favor new home construction in areas with more open space, leading to a tendency for patchy and/or leapfrog development patterns (Irwin and Bockstael 2001a, Irwin 2000).

This project had three main objectives. The first objective was to develop a GIS database on land use and residential property values for a county in Southeastern Pennsylvania, a region characterized by highly productive agricultural land but also by continuing development pressure and a rapid rate of farmland loss. This database included factors that would influence residential property values, including both land use and location of several different types of potential local disamenities.

The second objective was to estimate a hedonic pricing function that explains variation in single-family residential properties. Explanatory variables include structural characteristics of the properties (square feet of living space, lot size, etc.), factors that vary spatially related to local government (school district quality, zoning, etc.), measures of surrounding land use, and proximity to potential local disamenities.

The third objective was to characterize the pattern of recent residential development, to determine whether spatial interactions among parcels were an important determinant of the location of new home construction.

II. A Review of Theory and Previous Research

IIa. 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 goods will exist with slightly different levels of these attributes. The market price of a particular good will depend on its levels of those attributes, which can be characterized as a vector, $\mathbf{z}$. Goods 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), $P(\mathbf{z})$, is an empirical relationship that predicts the market price of a given good as a function of the levels of its attributes. For single family homes, this function is 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 $V(W-P(\mathbf{z}),\mathbf{z})$, where W is the wealth of the household. If houses with sufficient variability in $\mathbf{z}$ 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 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 ?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 ?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. However, as Palmquist and others make clear, this is not the final benefit or cost to the household operating in the housing market because households can relocate and market prices can adjust. If the change affects only a small number of houses, then ?P will exactly equal the windfall gain or loss to the house owner and no further welfare effects accrue as long as transactions costs of moving to new equilibrium locations are minimal. For more widely dispersed effects 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. These benefits and costs can be of particular policy relevance when the attributes are influenced either by government policy or by actions taken by neighbors located near the parcel. In our context, **z** includes measures of land use near the house, which is determined by the owners of nearby parcels who make decisions within the context of local planning and zoning regulations. If surrounding land use is an attribute that households care about, then a change in land use near a particular house will change the price of that house, and will impose costs or benefits to the affected household that can be measured using the estimated marginal implicit price for that attribute.

IIb. Previous Hedonic Pricing Studies of Land Use

Many papers have used hedonic pricing models to analyze the effects of open space on residential property values (Cheshire and Sheppard 1995, Garrod and Willis 1992, Greghegan etal 1997, Tyrvainen and Miettinen 2000, Irwin, 2002, etc.). However, results from these papers are mixed due to different kinds of open space considered, specification of the open space variables, and differences across study regions (Irwin 2002).

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 400 meters 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 400 meters 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.

IIc. 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.

For example, consider two neighborhoods that are otherwise similar. The first suffers from a localized odor problem from a facility that is unknown to the researcher. The second is desirable because of its proximity to unique shopping or dining opportunities. Residential property values will tend to be higher in the second neighborhood than in the first. Because of high residential property values, any open space in the second neighborhood will be under development pressure, and, over time, the amount of open space in the second neighborhood will decline. Conversely, because residential property values are low, open space in the first neighborhood will be under less development pressure, and will decline less over time. The amount of open space is said to be endogenous to house price. That means that the amount of open space in the neighborhood influences house price, but house prices in the neighborhood influence how much open space remains.

The end result will be that the researcher will observe low property values and more open space in the first neighborhood, and high property values and less open space in the second neighborhood. If the researcher naively estimates a hedonic price function using ordinary least squares (OLS) regression, he will conclude that open space is associated with lower house prices. The danger is in concluding that open space is depressing house prices, when in fact it is the low house prices that are allowing open space to survive.

One approach to estimating the structural relationship between open space and house prices in the presence of this kind of endogeneity is to estimate a two-stage regression model using instrumental variables (IV). In IV estimation, the right-hand-side variables in the hedonic price function are divided into two groups, endogenous variables and exogenous variables. A third set of variables, called instruments, is identified with the following characteristics: instrumental variables are correlated with the endogenous right hand side variables, but are not correlated with the error term in the hedonic price regression. In other words, the instrumental variables help explain variability in the endogenous right-hand-side variables, but do not help explain variability in house price.

IV estimation proceeds in two stages. In the first stage, the endogenous right-hand-side variables are regressed, using OLS, on the instrumental variables and on some or all of the exogenous right-hand-side variables. In the second stage, the hedonic price function is estimated using OLS, but with the endogenous variables replaced by their predicted values from the first-stage regressions. OLS standard errors from the second stage regression are biased, and must be adjusted.

Irwin used IV estimation in her study on open space in Maryland (Irwin 2002, also Irwin and Bockstael 2001b). 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. These instruments are appropriate because they help explain variation in the endogenous variables, but would not directly influence house prices. This project takes a similar approach, with a slightly broader set of instrumental variables.

A second issue is that of spatial correlation among house prices. 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, affecting statistical inference in hypothesis tests.

To date, no hedonic pricing study has estimated an implicit price function that accounts for both endogeneity spatial correlation. 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 100 meters to 600 meters has little effect on the IV regression results. This approach weakens statistical inference, however, because information in the excluded observations is lost. In this project, all observations will be retained. The model assumes, therefore, that spatial correlation in the errors does not exist. To the extent that such correlation is present in the data, the estimated standard errors, and possibly the parameters, may be biased.

IId. Previous Hedonic Studies of Local Disamenties

In this project, we investigate the impact on nearby residential property values of several different types of potential undesirable facilities and land uses. These include sewage treatment plants, landfills, high-traffic roads, airport runways, mushroom production facilities and large-scale animal production facilities. Particular attention is paid to the potential disamenity associated with animal production, as this is an activity that would be allowed on land that is covered by an agricultural conservation easement.

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.

Several studies have investigated the impact of other types of local disamenities on residential property values. Boyle and Kiel (2001) review several of these that show negative impacts on property values from landfills, airports, and high-traffic roadways. Brisson and Pearce (1995) review several studies that estimate the impact from hazardous and municipal waste facilities. These studies show that municipal waste landfills, airports, and high-traffic roadways can have localized negative effects on house prices.

IIe. Previous Studies of Location of Open Space Development

Many researchers have modeled the conversion of suburban and exurban land parcels from agricultural or forest uses to residential use in different areas and different context. For the purposes of this study, we are particularly interested in studies that have focused on the role played by spatial interactions among parcels in the conversion process.

Irwin and Bockstael (2001a) model land development (conversion from open space uses to residential uses) in Maryland, using parcel-level data. They track what happened to developable parcels over a six year period in four Maryland counties, and model the probability of survival (non-development) over the period, using a proportional hazards survival model. They find that developable parcels located in areas with more surrounding open space are more likely to develop. They conjecture that this is because of inter-parcel externalities. Parcels surrounded by open space will be more highly valued in residential use, and will therefore experience higher development pressure, *ceteris paribus*, than parcels surrounded by developed uses. This tendency to develop in areas with more open space could lead to classical "sprawl" features such as patchy patterns of development and leapfrogging.

One key assumption underlying their explanation remains untested, however. Irwin and Bockstael argue that parcels with higher potential residential value (after development) will tend to be developed before parcels with lower potential residential value, holding constant construction costs and opportunity cost of land. They then argue that inter-parcel externalities generate higher potential residential values for parcels located in areas with more open space. But do parcels with higher potential residential value develop first? In this project, we test this assumption, by estimating a discrete choice model of development, but with potential residential value as the key explanatory variable, rather than surrounding land use. In this way, we can test whether spatial interactions influence development directly, or through their role in determining potential residential value.

III. Selection of the Study Area

IIIa. Criteria for Selection of the Study Area

The focus of this project was on Southeastern Pennsylvania. Seven counties in Southeastern Pennsyvlvania (Berks, Bucks, Chester, Delaware, Lancaster, Lebanon, and Montgomery) account for 47% (by value) of the state's crop production and 39% of the state's livestock and livestock products production (PASS 2003), even though they are located in close proximity to the state's largest city (Philadelphia). Several of these counties are experiencing rapid loss of farmland at the same time as they are seeing increases in population (see Table 1).

Table 1. Characteristics of selected Southeastern and Southcentral PA counties

County	% change in population 1990-2000	population density (persons/mi^2)	% of area in farmland (1997)	farmland loss 1987-1997 (percent)
Bucks	10.4%	984.6	21.5%	-1.9%
Montgomery	10.6%	1553.0	13.4%	-26.8%
Chester	15.2%	573.4	36.2%	-7.7%
Berks	11.0%	435.0	40.3%	-8.9%
Lehigh	7.2%	899.4	41.2%	-5.5%
Northampton	8.1%	714.1	32.7%	-9.7%
Lancaster	11.3%	496.0	64.5%	-3.0%
York	12.4%	422.3	45.1%	-6.1%
Adams	16.6%	175.6	53.7%	-4.4%
Lebanon	5.8%	332.4	47.7%	-5.8%

Sources: U.S. Bureau of the Census and U.S. Census of Agriculture

In contrast to some other states (notably Maryland and Wyoming), where parcel-level GIS data is available for the entire state in a consistent format, parcel-level GIS data is developed and maintained at the county level in Pennsylvania, and is not even available for some counties. Given the resources available for this project, it was feasible to develop a parcel-level database for only one county.

Several criteria were identified for selecting a suitable county for study. These are

- Policy Relevance - The study area should be currently experiencing land use change, but should have a fair amount of less-developed land remaining.

- Representativeness - This study is a demonstration project. In order for it to serve as a useful model for application to other areas, the study area should not be unique in any important way.

- Variability in land use patterns - The study area should have diversity not only in land use, but in the spatial pattern of land use.

- Simplicity in growth patterns - It will be easier to discern the influence of land use pattern on growth if there are fewer urban centers in or surrounding the study area.

- Data Availability - Geocoded data on land use should already be available, as well as good data on property sales and characteristics.

- Willingness of local authorities to work with the project.

Berks County scored well in all criteria. Of particular importance were the following considerations:

- Berks County has been active in protecting farmland from development through agricultural conservation easements and the use of zoning. Further, existing easements are geographically dispersed, allowing statistical identification of their impact on residential property values.

- Berks County has been experiencing a moderate level of land use change during the past decade, but still has a fair amount of open space remaining.

- Parcel-level GIS maps of the county exist, with complete data on parcel characteristics (from the county assessor's office)

- Penn State's Land Analysis Laboratory already had good working relationships with several important county offices in Berks County.

IIIb. Characteristics of Berks County

IIIb1. Overview of Berks County Agriculture and Land Use

Berks County occupies an area (864 square miles) between Philadelphia and Harrisburg in southeastern Pennsylvania. Between the Blue Mountain in the north and the South Mountain Ridge, lies a valley with rich agricultural resources. In the early 18th century, the mild climate, fertile soil and the Schuylkill River combined to attract immigrant groups, including the Amish and Mennonites, to farming. The area became known as the "bread basket" for Philadelphia and southeast Pennsylvania (Myers and Auchenbach 2002).

Today in Berks County, farming remains a very important sector 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 had total farm sales of almost $248 million. It ranked third in Pennsylvania in number of farms, cash receipts from agriculture products, layers, swine, corn grain, soybeans, and apples. It ranked fourth statewide in dairy, broilers, cattle and calves, peaches, nursery and greenhouse crops (includes mushrooms), and barley. Other selected agricultural statistics for the county included: 221,511 acres in farmland, 187,645 acres in crop production, and 1,586 farms. 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).

Parallel to the agricultural growth in the 18th and 19th centuries was industrial development and population increases in Berks County. The 1900's found the county's population doubling with it concentrated in Reading and several larger towns. Recent growth patterns reflect suburban sprawl outward from Reading as well as development in rural land beyond suburban areas. Surbuban growth is related to economic activities in Philadelphia, Allentown and Lancaster (Myers and Auchenbach 2002).

IIIb2. Berks Land Use and Farmland Protection Programs

Population shifts and suburbanization are affecting the viability of farming as well as the rural landscape in Berks County. Recently, suburban sprawl and the changing agricultural industry have been factors leading to increasing conflicts between rural residents and agriculture production over issues such as odor, flies, chemical use, and farm traffic. 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; and the requirement of being located in ASA's to be considered for the purchase of conservation easements. (Thirty-four townships with 139,254 acres are enrolled in this program.)
4. Purchase of Agriculture Conservation Easements. Landowners are paid for their land's development rights permanently preserving it for agriculture production. In Berks County, 31,372 acres on 256 farms are covered by such easements
5. Effective Agriculture 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.

Though all of these acts play an important role for the preservation of farms and/or farmers and the agriculture industry, only the "Purchase of Agriculture Conservation Easements" and development of "Effective Agriculture Preservation Zoning" are viewed as providing the agriculture resource base needed for future production. In its 1991 county comprehensive plan, the county set the goal of preserving 200,000 acres of farmland through these two programs. 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).

IIIc. Project Local Advisory Group

The Project Local Advisory Group was formed to fulfill two functions. Early in the project, the advisory panel provided input to the research team, including local knowledge of factors influencing land use and values. The advisory panel also helped to identify the policy analysis needs of the community. In addition to telephone and email exchanges between the researchers and the advisory group, members of the research team met with the advisory group, both individually and with the group as a whole.

Toward the end of the project, the research team presented preliminary research results to the advisory panel. This meeting helped the research team refine its analysis to better meet local policy analysis needs, and to refine the presentation of the research results to make them more accessible and useful to local stakeholders.

After completion of the project, research team members will present final results to the advisory group, and other interested parties in Berks County, both through presentations and through extension materials developed from this final report.

The members of the Project Local Advisory Group are listed in Appendix 1 of this report.

IV. Data Sources and Manipulation

IVa. Data Based on Parcel Maps

The most important database for this analysis was the 2002 parcel map of Berks County. This database, maintained by the Berks County Office of Assessment, includes a map showing the boundaries of 152,809 parcels in the county, as well as of roads and streams. A second database, contained in the Office Of Assessment's CAMA file, includes information collected for each parcel for assessment purposes, such as characteristics of built structures on each parcel, the current use of the parcel, and the parcel's owner.

<u>IVa1. Single-Family Residential Properties</u>

Special attention was paid to parcels that were identified as single family residences, as it is these parcels for which the hedonic price function was estimated. For each of the 88,798 single-family residential parcels, a parcel centroid was located. This point dataset was for calculating distances to features in the County, and as centerpoints of circular buffers for measuring surrounding land use.

From this set of parcels, a subset was chosen for use in the hedonic price model estimation. First, because the analysis focused on property values on the urban/rural fringe, residences located within the City of Reading were excluded. Second, in order that surrounding land use could be completely characterized for each residence in the analysis, residences within one mile of the county border were excluded. Third, because land use in New Morgan Borough is somewhat unique (about ¾ of the Borough is zoned Industrial), properties located within one mile of the Borough were excluded. Fourth, several restrictions were used to exclude "unusual" properties that a hedonic price model would have difficulty valuing. To be included in the hedonic price analysis, the property must meet the following criteria:

- lot size at least 0.1 acres - to avoid cases where the lawn surrounding a house is covered by a separate deed

- lot size no larger than 5 acres - to avoid cases where the land has multiple uses
- living area at least 600 square feet - to avoid structures misclassified as detached houses
- physical condition “poor” or better - to avoid condemned or damaged properties

Fifth, the analysis was limited to sales that occurred in 1998 or later. Finally, to assure that the listed sale price included the house and not just the land, the analysis included only houses where the assessed value was within 20% of the sale price. Also, only sales that were judged as “arms length” by the assessor were included in the hedonic price analysis. This set of restrictions resulted in 8,090 residential sales that were included in the hedonic price analysis.

For each of the 8,090 residential properties used in the hedonic price analysis, information was extracted on the size of the house, the lot size, the number of bedrooms, the number of bathrooms (including half baths), 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 1 being the best, and 5 being the worst), the year of construction, the year sold, and whether the house had public water and/or public sewer. The nominal sale price of the house was inflated to 2002 dollars.

<u>IVa2. Land Use</u>

Several features of parcel database were useful for our purposes. First, the assessor’s land use codes served as a starting point for constructing a land use map of Berks County. For most parcels, the land use code was sufficient for classifying each parcel into one of the following 12 land use categories:

Agricultural and other open space uses, including parks, golf courses and water bodies
Vacant land zoned for residential use
Vacant land zoned for commercial use
Vacant land zoned for industrial use
Single Family Residential with lot size $\leq$ 0.2 acres
Single Family Residential with lot size > 0.2 and $\leq$ 0.5 acres
Single Family Residential with lot size > 0.5 and $\leq$ 1.5 acres
Single Family Residential with lot size > 1.5 acres
Other Residential (multi-family and various other types including mobile homes)
Commercial
Industrial
Transportation (Roads and Railroads)

Landfills were classified as an industrial use. Mushroom production facilities were classified as an agricultural use. Parks, golf courses, and water bodies were classified as open space uses.

In some cases, the land use code was not specific enough for categorization. This occurred, for example, for tax exempt properties, where the assessor did not need to keep track of land use. For these parcels, other information was used to categorize the parcels use. For example, if the parcel was owned by a school district, its use was assumed to be similar to a commercial use. Likewise, parcels owned by religious organizations were categorized as commercial use. If the parcel was owned by a private hunting and fishing club, it was assumed to be in an open space use.

Where land use could not be classified based on the assessor's land use code or other clues from its ownership, its use was determined based on its land cover. The 1992 National Land Cover Database categorizes land into 21 land use classes, of which 14 occur in Berks County, based on satellite images collected during the early 1990's. These 14 classes were divided into two groups, developed-use land covers and undeveloped-use land covers (NLCD codes 21, 22, and 23). For each uncategorized parcel in the Berks County parcel database, the proportion of land area in developed use was calculated. If more than 10% of the parcel was classified as developed by the NLCD, then the parcel was considered to be a commercial parcel. It less than 10% of the parcel was classified as developed by the NLCD, the parcel was considered to be in an open space use. This approach was applied to 1807 parcels (1.2% of the total), affecting 21,514 acres (3.9% of the total land in the parcel database). An additional 217 parcels totaling 39 acres could not be assigned using this approach. No land use code was assigned for these parcels.

After each parcel was categorized into one of the 12 land use groups, transportation parcels were dissolved into neighboring parcels. This approach was taken to better represent the amenity impacts of different types of neighborhoods. A small-lot residential neighborhood may have as much as 20-25% of its land in transportation uses. When considering amenity impacts, such a neighborhood is not typically viewed as 75% residential and 25% transportation. A "residential neighborhood" is viewed as a mix of houses, lawns, and streets. Similarly, from an amenity viewpoint, a commercial area is viewed as a mix of shops, offices, parking lots, and streets. In order to better match how these neighborhoods are perceived, land used in transportation was assigned to the same category as the nearest non-transportation parcel. Thus, a street with residential properties on both sides was categorized as residential land use. A street with residential properties on one side and commercial properties on the other was split down the middle.

The amount of land in Berks County categorized into each land use category using this method is given in Table 2.

Table 2. Land Use in Berks County, 2002

Land Use Category	Number of Parcels	Acres	Percent Area
Ag and Open Space	13,032	383,159	69.1%
Vacant Commercial	531	3,156	0.6%
Vacant Industrial	108	1,444	0.3%
Vacant Residential	13,097	23,619	4.3%
Single Family Xlarge Lot	14,715	55,698	10.0%
Single Family Large Lot	15,747	16,745	3.0%
Single Family Medium Lot	28,999	11,394	2.1%
Single Family Small Lot	30,175	4,961	0.9%
Other Residential	25,278	9,170	1.7%
Commercial	8,733	24,362	4.4%
Industrial	2,177	20,933	3.8%
No Data	217	39	0.0%
Total	152,809	554,680	100.0%

Notice that open space uses (the first four categories) account for 74.3% of land in Berks County. Of the "vacant" land, the majority is vacant residential parcels. These are typically parcels that have been subdivided and zoned for residential use, but that have not yet had houses built on them. The location of residential, commercial and industrial land is shown in Plate 1. Clear areas in Plate 1 represent open space.

For each house in the hedonic price analysis, circular buffers were constructed at 400 meters and 1600 meters, and the total number of acres in each land use category was measured for each buffer. These distances were chosen to represent two different conceptions of the "neighborhood" the house is located in. A resident might easily travel 400 meters from his or her house while taking a walk, while his or her child might walk up to 1600 meters to get to school. Several previous studies used 400 meters as the definition of the neighborhood. We investigate whether more distant land use also impacts house prices.

IVa3. Agricultural Security Areas and Eased Parcels

Two map databases were obtained from the Berks County Agricultural Land Preservation Board. The first identifies all parcels in the County that were included in Agricultural Security Areas (ASA). A total 131,647 acres in Berks County are in ASA's. The second identifies all lands that with Agricultural Conservation Easements (ACE). The ACE database included 29,543 acres of land. All parcels with ACE's must also be in an ASA. The ACE database was combined with another map database that identified conservation easements held by other bodies, such as the Berks County Conservancy (3,476 acres). The location of land in ASA's and land with conservation easements is shown in Plate 2.

For each residential property in the hedonic price analysis, the number of acres of eased open space and the number of acres of open space contained within ASA's within 400 meters and between 400 meters and 1600 meters from the house were calculated.

IVa4. Government-Owned Open Space

It is important to identify open space land that is owned by the government because the use of such land is less likely to change over time. Government-owned open space was identified using both the Managed Lands Database developed in 1998 by the Penn State Environmental Resource Research Institute (ERRI) and information contained in the County Assessement Office's parcel database. 1,623 parcels totaling 53,986 acres were identified as parcels that were owned by Federal, State, or local government, and that were in open space use. The location of government-owned open space is shown in Plate 3. Several large tracts accounted for the majority of this land. An Army Corps of Engineers reservoir, Blue Marsh Lake, is located west of Reading. A large water supply reservoir, Lake Ontelaunee, is located north of Reading. French Creek State Park is located in the southeastern part of the county, and a large portion of the ridge that defines the northwestern border of the county (Blue Mountain) is owned by the Pennsylvania Game Commission.

For each residential property in the hedonic price analysis, the number of acres of government-owned open space within 400 meters and between 400 meters and 1600 meters from the house was calculated.

IVa5. Developable and Developed Parcels

The probability-of-development analysis to model residential land conversion started with the County Assessment Office's 1996 parcel map. A similar approach to that outlined above was used to identify 7,399 parcels that existed in 1996 that could be developed. These were parcels that were

- in open space land uses
- were not owned by a government body
- did not have a conservation easement on them
- were at least 5 acres in size
- were not located within 1 mile of the county boundary, or within one mile of New Morgan Borough

To simplify the analysis, parcels that were eased after 1996 were also considered as "not developable" in 1996. A more complete analysis that models the decision to develop versus the decision to sell an easement would have to model competition for land between residential developers and the Berks County Agricultural Land Preservation Board, a task that was beyond the scope of this project.

A developable parcel was defined to have "developed into residential use" if its owner requested subdivision, with at least three of the subdivided parcels rezoned for residential use. From a list of maintained by the Planning Commission, 92 parcels were identified that met this criterion. All of these parcels were considered to have developed, even though not all of them parcels had completed the process by 2002. In this way, the analysis focuses on the factors that trigger the subdivision request, rather than on the factors that result in successful subdivision.

The location of all developable parcels used in the analysis is shown in Plate 4. Parcels that subdivided are shown in red.

IVb. Physical and Political Features

Supplementing the parcel-based databases were several GIS databases that included information on physical features of the landscape and on boundaries of political jurisdictions.

The 1992 NLCD database was discussed briefly above. In addition to its use in categorizing land use for parcels, this database provided information on type of open space. Land categorized as open space was subdivided into three types based on the NLCD database, forests; grass, pasture, and crops; and open water. For each residential property in the hedonic price analysis, the number of acres of open space within 400 meters and between 400 meters and 1600 meters that is in grass, pasture and crops was calculated.

Several databases were obtained from the Pennsylvania Geospatial Data Clearinghouse. These included the USGS Digital Elevation Model for Berks County, from which were calculated elevation and slope, a digital map of streams in Berks County developed by ERRI, and school districts and municipal boundaries. Slope and elevation at the house site were included in the hedonic price function, as was a measure of elevation relative to the surrounding terrain. This measure was the difference between the elevation at the house site, and the average elevation within 800 meters of the house site. Positive values of this difference indicate that the house sits above the surrounding terrain.

A zoning map of the county was provided by staff from the Berks County Planning Commission. Zoning regulations were grouped into six categories, Agricultural, Effective Agricultural (with more stringent restrictions on the ability to subdivide parcels), Commercial and Industrial, Multiuse/Village, Conservation (for erodible and other naturally sensitive areas), and Residential.

Information on soils was obtained from a digitized soil map of Berks County, created by the USDA Natural Resources Conservation Service. For each soil type, three relevant measures were obtained, an index of the soil's suitability for construction (ranging from 0 to 10, with 10 being soils least suitable for construction), an index of the soil's suitability for septic systems (ranging from 0 to 10, with 10 being soils least suitable for septic systems), and index of the soil's potential for agricultural production (ranging from 0 to 100, with 100 being soils best suited for agricultural production). The septic suitability and construction suitability indices are published with the county soil survey. The agricultural productivity index is developed by the Pennsylvania State Office of the Natural Resources Conservation Service. For soil map polygons with complexes of multiple soil types, area-weighted averages were used for the three indices.

Three employment centers were identified based on conversations with the Local Project Advisory Group. These are Reading, Allentown, and Philadelphia. For purposes of calculating distance to downtown Reading, the city center was taken to be located at the corner of Penn Street and Third Street. For Philadelphia, it was assumed that most commuters from the County would travel through one of two points, where Route 422 crosses the County boundary heading toward Philadelphia or where I-76 (The Pennsylvania Tollway) crosses the County boundary heading toward Philadelphia. As these two points are about the same distance from Philadelphia, for points within Berks County, commuting distance to Philadelphia was taken to be the linear distance to the closer of these two points. A similar approach was taken for measuring the distance to Allentown, with two waypoints, one located where Route 737 crosses I-78, the other located where Route 222 crosses the northeastern border of the County.

IVc. Potential Local Disamenities

The project advisory group recommended that the analysis allow for measurement of the impact of potential local disamenities, including landfills, mushroom production, and large-scale animal production facilities. Additional financial support from Citizens for Pennsylvania's Future allowed collection of information on the location of several different types of potential local disamenities.

IVc1. Landfills

Landfills can be a source of disamenities to nearby neighbors. These can include concerns over groundwater contamination, noise from trucks and machinery, dust, blowing trash, birds, and odor. There are four landfills located within Berks County (BFI Conestoga Landfill in New Morgan Borough, Western Berks Refuse Authority Landfill in Cumru Township, Rolling Hills Landfill in Earl Township, and Pioneer Crossing Landfill in Exeter Township). A fifth landfill located just outside Berks County in Pottstown was not included in the database. The four landfills were mapped from the parcel database. For each residential property in the hedonic price analysis, linear distance was calculated to the boundary of the closest landfill (LFDIST). The locations of the landfills are shown in Plate 5.

The amenity impact of landfills on residential properties is expected to be larger for properties located nearer to a landfill. We assume that past some distance, K, the landfill has no amenity impact on the residential property. An index of the landfill amenity impact (LFIND) was constructed of the form

$$\text{LFIND} = \begin{cases} 1/(\text{LFDIST}) - 1/K & \text{if LFDIST} \leq K \\ 0 & \text{if LFDIST} > K \end{cases}$$

This index decreases as distance to the landfill increases, and reaches value 0 at distance K from the landfill.

To test the spatial limit of the amenity impact from landfills, the Landfill Index is further divided into two pieces, one measuring impacts up to a distance K_1 from the landfill, the second measuring impacts between distance K_1 from the landfill and distance $K_2 > K_1$. These indices take the form

$$\text{LFIND1} = \begin{cases} 1/(\text{LFDIST}) - 1/K_1 & \text{if LFDIST} \leq K_1 \\ 0 & \text{if LFDIST} > K_1 \end{cases}$$

$$\text{LFIND2} = \begin{cases} 1/K_1 & \text{if LFDIST} \leq K_1 \\ 1/(\text{LFDIST}) - 1/K_2 & \text{if } K_1 < \text{LFDIST} \leq K_2 \\ 0 & \text{if LFDIST} > K_2 \end{cases}$$

LFIND1 is the same as LFIND, with $K=K_1$. LFIND2 is constructed so that LFIND1+LFIND2=LFIND with $K=K_2$. In the hedonic price model, if the coefficient on LFIND1 is negative and the coefficient on LFIND2 is zero, then the disamenity impact extends only to distance K_1. If the coefficient on LFIND2 is equal to the coefficient on LFIND1, then the amenity impact extends to distance K_2.

The choice of which values of K_1 and K_2 to investigate depends on *a priori* expectations about the spatial extent of any amenity impacts. Nelson, Genereux and Genereux (1992) found negative impacts on house prices from a landfill that extended to two miles from the landfill. We use as starting points K_1=1600 meters and K_2=3200 meters, to test whether any impact of landfills on house prices extends as far as two miles.

IVc2. Airports

Airports can be a source of noise problems to nearby neighbors. However, close proximity to the airport may be an amenity for households who travel frequently. There is one commercial airport in Berks County, located in Bern Township (see Plate 5). This airport is served by propeller-driven commuter aircraft. The local disamenity impact from airport operation is best measured by looking at the noise level at the residential property. Unfortunately, information was not available on the distribution of aircraft noise surrounding the airport. Instead, the take-off and landing flightpaths were approximated with a straight line extending two miles from either end of the main runway. For each residential property in the hedonic price analysis, the linear distance to this line was calculated. A set of airport indices, APIND, APINDK1, and APINDK2 were constructed in the same way as for the landfill indices. As with landfills, we use as starting points K_1=1600 meters and K_2=3200 meters.

IVc3. Mushroom Production

Mushroom production can also be associated with odor problems. From the County Assessment Office's parcel map, 74 parcels were identified where mushroom production occurred. The total acreage of these parcels is shown, by township, in Plate 6. The mushroom production industry in Berks County has been shrinking, and many of these parcels are no longer in active production. Working with Mena Hautau, the county horticulture extension agent, and David Beyer, Associate Professor of Plant Pathology at Penn State, an attempt was made to determine which of the 74 operations were still active during the period of study, 1998-2002. For each residential parcel in the hedonic price analysis, the distance to the closest parcel that was actively producing mushrooms at the time of the residential property's sale was calculated. A set of mushroom production indices MRIND, MRINDK1, and MRINDK2 were constructed in the same way as for the landfill indices. As a starting point for investigating the spatial extent of any potential local disamenity, we use K_1=400 meters and K_2=1600 meters.

IVc4. Large-scale Animal Production

Large-scale animal production facilities can be a source of problems with odors, flies, and concerns over ground- and surface-water contamination. Working with aerial photos, and assisted by County Extension Agent Clyde Meyers and Donald Reinert, Nutrient Management Specialist with the Berks County Conservation District, 71 large-scale animal production operations (200 animal equivalent units or more) were identified. An operation was defined as a cluster of buildings located within 400 meters of each other. A single operator could control more than one building cluster. For each building cluster, the number of animal equivalent units (aeu's) was determined for three groups of livestock, poultry, swine, and cows (beef and dairy).

Animal equivalent units are as defined for each species by the Pennsylvania Nutrient Management Act (Act 6 of 1993), and represent 1,000 pounds of live weight (Beegle, 1997). Important changes in the scale of operation during the study period (1998 to 2002) were noted, so that data on scale of operation (number of aeu's) was recorded for each year. The number of facilities located in each township is shown in Plate 7.

When modeling the amenity impact of animal production, it is not clear whether that impact should be proportional to the scale of nearby operations. It is an empirical question whether a building cluster with more aeu's has a larger disamenity impact on nearby properties than a building cluster with fewer aeu's. Second, it is an empirical question whether having two building clusters near the home is worse than having one. Finally, different species of animals may have different disamenity impacts (e.g. air quality or odor emissions), as a result of animal production methods or manure characteristics (e.g. wet versus dry). We construct several animal production indices to investigate these issues. In the following definitions, ANDIST1 measures the distance from the house to the nearest building cluster, ANDIST2 measures the distance to the second nearest building cluster, etc.

IVc4i. Animal Indices Based on Building Clusters. The first animal production index is based on the distance from the homes to each of the building clusters

$$\text{ANBCIND} = ?_i \; 1/(\text{ANDIST}_i) - 1/K$$

where the summation is over all building clusters located within K meters of the house. Again, this index can be further divided by distance, into ANBCINDK1 and ANBCINDK2. As with landfills, we use as starting points K_1=1600 meters and K_2=3200 meters. Under certain conditions, odor problems from large-scale animal production can occur up to a mile from the source (VanDevender 1998, Mikesell 2002), but it is not clear that property value impacts would be detected at that distance.

To investigate whether the disamenity impact depends on only the closest building cluster, or whether it depends on all building clusters within K meters from the house, the ANBCIND index was divided into two pieces

$$\text{ANBCINDC} = 1/(\text{ANDIST1}) - 1/K \qquad \text{if ANDIST1} \leq K$$
$$= 0 \qquad \text{if ANDIST1} > K$$

and

$$\text{ANBCINDO} = \text{ANBCIND} - \text{ANBCINDC}$$

where the last letter signifies C=closest building cluster, and O=all other building clusters within K meters of the house. In the hedonic price estimation, if the coefficient on ABCINDO is zero, then it is only the closest building cluster that generates disamenity impacts. If the coefficient on ABCINDO is equal to the coefficient on ABCINDC, then all building clusters contribute equally to the disamenity impact (given their distance from the house), and it is appropriate to use ABCIND as the single index of that disamenity.

Finally, because animal production is of particular interest in this study, the functional form of the index is investigated in more detail than for other potential local disamenities. A second index is constructed that uses squared distances

$$ANBCIND2 \quad = ?_{i} \ 1/(ANDIST_{i})^{2} - 1/K^{2}$$

The two indices together provide a more flexible functional form for the relationship between the disamenity impact and distance to the building clusters.

Additional analyses were performed using building clusters as the unit of observation. To investigate size of operation, the ANBCIND index was further split into two size classes, medium sized operations ($\geq$ 200 aeu but < 300 aeu) and large operations ($\geq$ 300 aeu). To investigate managerial care related to conservation, ANBCIND was split into two groups based on whether the farm had on file with the NRCS a detailed conservation plan. This is an imperfect indicator of managerial care, but was the only objective measure available.

<u>IVc4ii Animal Inidices Based on AEU's</u>. A second set of indices was developed based on the number of aeu's in each building cluster. The main aeu-based index was

$$ANAEUIND \quad = ?_{i} \ AEUi/(ANDISTi) - 1/K$$

where AEUi is the number of aeu's in the i^{th} closest building cluster in the year the house was sold, and the summation is done over all building clusters located within K meters of the house. This index retains the distance decay feature of the building cluster index, but assumes that the disamenity impact is directly proportional to the number of aeu's in each building cluster.

This index was further divided into three pieces by species of animal, POULTRYAEUIND, SWINEAEUIND, and COWAEUIND, where each index includes only the number of aeu's for that species.

Finally, a hybrid index was constructed that used building clusters as the unit of interest, but that weighted those building clusters by animal species. These took the form

POULTRYBCIND = ANBCIND * POULTRYAEUIND/ANAEUIND

SWINEBCIND = ANBCIND * SWINEAEUIND/ANAEUIND

COWBCIND = ANBCIND * COWAEUIND/ANAEUIND

These hybrid indices assume that the disamenity impact is proportional to the number of building clusters, rather than to the number of aeu's in those clusters, but allows consideration of whether the impact is sensitive to the species housed in the clusters.

IVc5. Sewage Treatment Plants

Sewage treatment plants can also be associated with odor problems. From EPA and other sources, 27 sewage treatment plants were identified in Berks County. These were located using aerial photos, the parcel map, and information contained in the EPA NPDES database. For each residential property in the hedonic price analysis, the distance to each sewage treatment plant was calculated. A sewage treatment plant index, SPIND, was calculated using the same approach as for ANBCIND. Only one distance limit, K=1600 meters, was investigated.

IVc6. High-Traffic Roads

High-traffic roads can be a source of problems with noise and air quality. At the same time, access to main roads is an important amenity, because it reduces travel times to shopping, recreation, and work sites. A database of Federal, State and County Roads was obtained from the PennDOT. Roads in Berks County with more than 10,000 vehicles per day were identified, and the distance to the nearest high traffic road was calculated for each residence in the hedonic price analysis.

The potential noise and pollution disamenities from living in close proximity to a main road is conjectured to extend only a short distance, likely less than 100 meters. Access and convenience issues are likely to be relevant at all distances from main roads. To capture both effects, the distance to the nearest high-traffic road (HTDIST) entered the hedonic price analysis in two ways. First, the disamenity impact was modeled using a index similar to that used for the other potential local disamenities in the study

$$\text{HTIND} = 1/(\text{HTDIST}) - 1/K \qquad \text{if HTDIST} \leq K$$

$$= 0 \qquad \text{if HTDIST} > K$$

where K was set equal to 100 meters. Second, distance to the nearest main road was entered linearly. If the coefficient on both terms is negative, then we confirm that proximity to main roads is a disamenity for distances less than 100 meters, but an amenity for distances greater than 100 meters.

V. Hedonic Analysis of Residential Property Values

Va. Details of the IV estimation

The hedonic price function was estimated using both IV estimation and OLS regression. The dependent variable in both cases was ln(real house price). In the IV estimation, the following variables were treated as endogenous. Each entry in the list represents two variables, one for land use within 400 meters of the house, the other for land use between 400 meters and 1600 meters from the house.

- acres of land in open space uses
- acres of land in residential uses

- acres of land in commercial use
- 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, SPIND is also treated as endogenous. This modeling choice was motivated by the observation that in an OLS estimation of the hedonic price model, the sewage treatment plant index, SPIND, 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. The choice of where to build a new sewage treatment plant involves several considerations, one being proximity to housing. 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 following variables are treated as exogenous

the proportion of open space that is government owned
the proportion of open space that is in an ASA
the proportion of open space that has a conservation easement
the proportion of open space that is in grass, pasture, or crops
the proportion of residential land in small-lot single family use ($\leq$ 0.2 acres)
the proportion of residential land in medium-lot single family use
(> 0.2 acres and $\leq$ 0.5 acres)
the proportion of residential land in large-lot single family use
(> 0.5 acres and $\leq$ 1.5 acres)
the proportion of residential land in xlarge-lot single family use (> 1.5 acres)
the proportion of residential land in uses other than single family housing

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 houses (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 are exogenous variables that are not included as explanatory variables in the hedonic price function. These are variables that help explain the endogenous variables, but do not help directly explain house price. Each of the following instrumental variables was calculated both for land within 400 meters of the house and for land between 400 meters and 1600 meters from the house,

- average slope
- average elevation
- average septic suitability index
- average building suitability index
- average agricultural productivity index
- 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.

A nonlinear IV approach was used (SAS PROC MODEL with N2SLS option). In this procedure, the endogenous variables are first regressed, using OLS on all of the exogenous and instrumental variables. The resulting OLS predicted values of the endogenous variables are then used to calculate the acres of each different type of Open Space and Residential use in the buffers surrounding each house. The second stage regression uses these calculated measures of surrounding land use as explanatory variables.

While the estimation does account for endogeneity in land use, it does not model spatial error correlation. The model results presented in this section assume that prediction errors are not spatially correlated.

Vb. Regression Results - House Characteristics

Results of the IV and OLS regressions are presented in Tables 3a through 3c. 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.

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 the 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.

Of particular interest are the results related to lot size. To provide for a flexible relationship between lot size and house price, lot size entered the hedonic price function both linearly and as a natural log. The combined effect of these two terms is shown in Figure 1. In Figure 1, the price of a house built on a 0.1 acre lot is normalized to equal 1.0. Figure 1 shows how the house price will increase as the lot size increases. So, for example, a house built on a 1 acre lot will cost 32% more than the same house built on a 0.1 acre lot. The marginal impact of additional lot size decreases, however, so that a house built on a 5 acre lot is worth only a little bit more than a house built on a 3 acre lot. This relationship can help inform developers and planners when considering density of a new residential development.

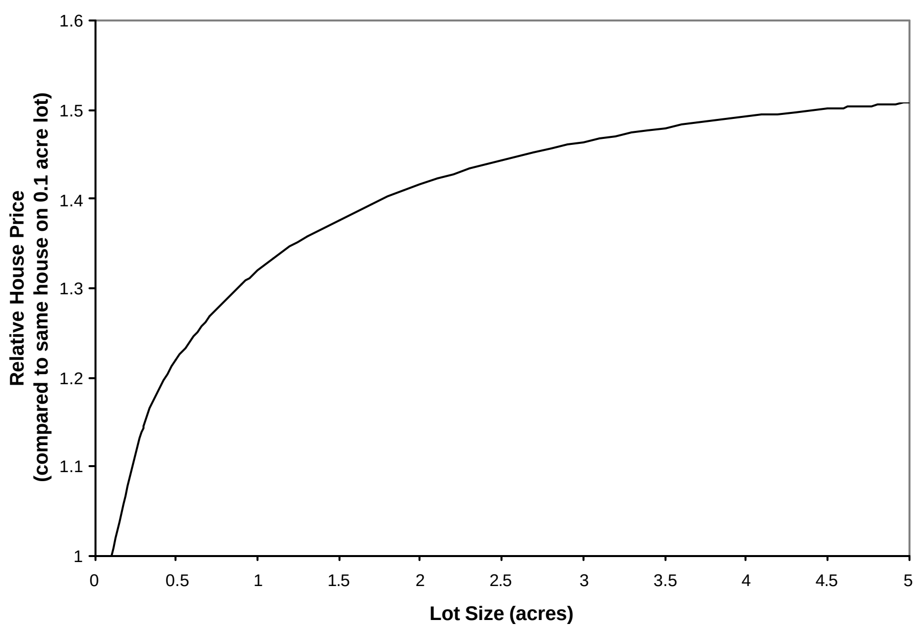

Figure 1. Relative house price as a function of lot size.

Vc. Regression Results - Surrounding Land Use

The coefficient estimates in Table 3b 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 4a and 4b, 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 4b) 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 eased or government-owned open space is industrial.

Marginal implicit prices for land uses located farther than 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.

Vd. Regression Results - Potential Local Disamenities

Vd1. Roads, Sewage Treatment Plants, Mushrooms, Airports and Landfills

The coefficient on HTIND_100 is negative, and nearly significant, giving weak evidence that proximity to high traffic roads is a local disamenity. At 20 meters from the road, this disamenity impact decreases house price by 0.63%. The coefficient on 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 a local disamenity. When APINDK1 and APINDK2 are included in the model, with K1=1600 and K2=3200, 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 a local disamenity. When LFINDK1 and LFINDK2 are included in the model, with K1=1600 and K2=3200, 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 K1=3200 and K2=4800, the coefficient on LFINDK2 is no longer negative, and the two coefficients LFINDK1 and LFINDk2 are significantly different. We conclude that the disamenity impact from landfills does not extend beyond 3200 meters.

Proximity to mushroom production is a local disamenity. It was not possible to conclusively establish an outer boundary of the impact of mushroom production on house prices. Inclusions 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 use an outer limit of 1600 meters, and 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.

Vd2. 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, was compared to that of the aeu-based index, ANAEUIND. 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 is negative and nearly significant (t=-1.90), while the coefficient on ANAEUIND is positive but insignificant. In a model that includes only ANBCIND, the estimated coefficient on the index is negative and significant (t=-2.08). In a model that includes only ANAEUIND, 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 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, ANBCINDK1 and ANBCINDK2, with K1=1600 meters and K2=3200 meters. The estimated coefficient on ANBCINDK2 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, SWINEBCIND, and COWBCIND. The coefficients on each of these three indices are presented in Table 5. 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 5. 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 6. While it 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 6. 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. The combination of ANBCIND and ANBCIND2 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 3c.

It is possible, using the coefficient estimates in Table 3c, 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 2, 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.

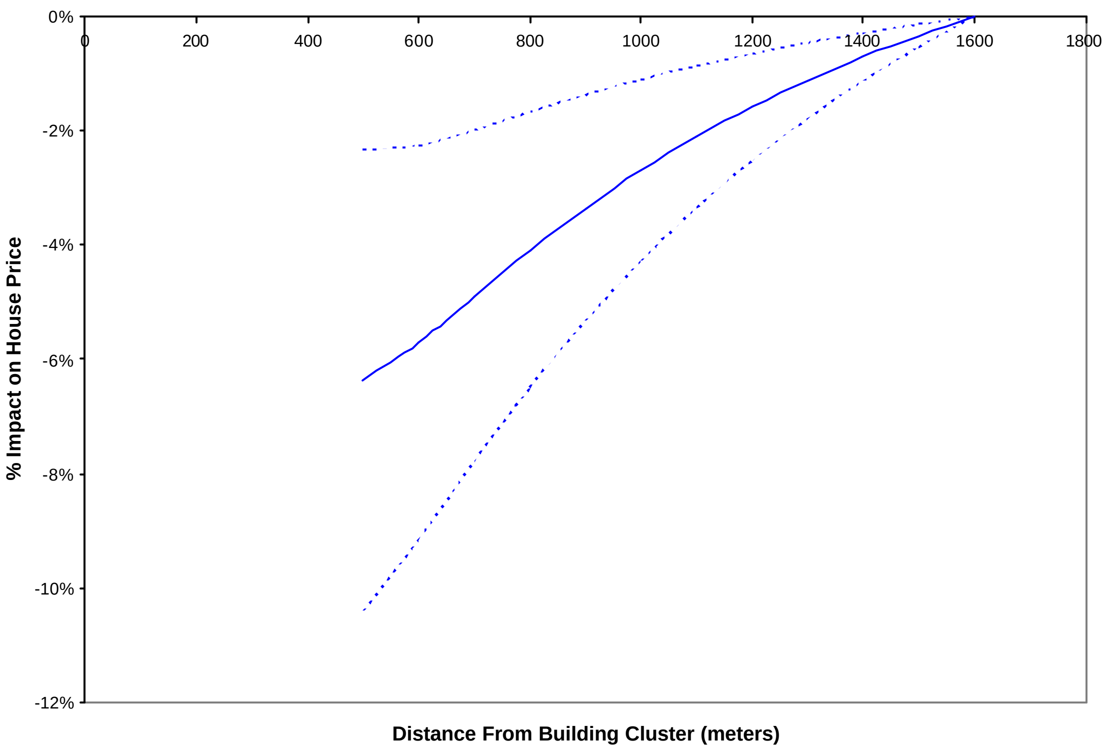

Figure 2. Impact on house prices from a single building cluster

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). Of the 71 facilities identified in Berks County, 32 fall into the medium size category, 30 fall into the large category, and 9 fall into the very large category. No information is available on the location of small operations (<200 aeu's). The ANBCIND and ANBCIND2 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 7.

Table 7. 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 in Table 2 apply to all facilities larger than 200 aeu's.

Ve. The Spatial Distribution of Housing and Potential Local Disamenities

The total impact that a potential local disamenity has on residential property values depends on the location of the residences relative to the potential local disamenity, and on the value that the residences would have absent the disamenity impact. In this section, we calculate the total impact of a landfill, the regional airport, and an animal production facility on neighboring residential property values. The numbers presented here are illustrations, and should not be interpreted as averages. The information on the location of mushroom production facilities is not specific enough to allow a similar calculation for mushroom production.

Ve1. Housing and Landfills

Three of the four landfills located within Berks County are considered here. The Conestoga landfill in New Morgan Borough is atypical, in that it is located in a borough that is almost exclusively industrial. The other three landfills vary substantially in the number of single family residences located within 3200 meters of the landfill. The landfill located in Earl Township is located in a relatively less-populated area of the county. There are 341 residences located within 1600 meters of the landfill, and a total of 918 located within 3200 meters. In contrast, the landfill located in Cumru Township is located in an industrial area, but near Reading. Consequently, it has fewer residences located within 1600 meters (79) but more total located within 3200 meters (4549). The landfill located in Exeter Township has 1561 residences located within 1600 meters, and a total of 3342 located within 3200 meters.

The landfill in Exeter Township is chosen to serve as an illustrative example. For each house located within 3200 meters of the landfill, the percent decrease in house price due to the landfill's presence was calculated. This was then multiplied by the total assessed value of the house, to give the dollar impact on house price due to the landfill. This approach assumes that the assessed value does not already include a discount due to the proximity of the landfill. If a discount in the assessed values does exist, then the estimates presented here will underestimate the true impact of the landfill on house prices. Because there were few house sales observations included in the regression analysis where the house was located less than 500 meters from a landfill, the predicted house price impacts are less reliable for such houses. To be conservative for residences located very close to the landfill, the percent impact on house price is set equal to the impact on a house located 500 meters from the landfill.

For the 1561 residences located within 1600 meters of the landfill, the average house price impact from the landfill is $3,937 (all values are in 2002 dollars). For the 1781 houses located between 1600 and 3200 meters away from the landfill, the average house price impact is $1,132. The average impact on all 3342 houses is $2442, for a total impact on all houses within 3200 meters of $8,162,000, which represents 2.6% of the assessed value of those properties.

Ve2. Housing and the Airport

The disamenity impact from the regional airport was determined to extend 1600 meters from a line extending two miles from either end of the main runway. This approach is a crude approximation to the noise disturbance associated with take-offs and landings. There are 1246 single family houses located within 800 meters of the flightpath, and a total of 4647 single family houses located within 1600 meters. Of these, however, 2391 are located with the City of Reading. Because the hedonic price function was estimated only for residences outside the City of Reading, it should not be used to calculate property value impacts within the City.

For each of the remaining 2256 single family residences located outside of the City of Reading and within 1600 meters of the runway or flight path, the impact on property value was calculated. For consistency with the analysis on landfills and animal production facilities, houses located within 500 meters of the runway and flightpath are treated as if they were located exactly 500 meters away. The average house price impact from the airport was $104, and the total impact on the 2256 residences was $235,000, which is 0.1% of the assessed value of those 2256 houses. This estimate only counts the impacts on houses located outside of the City of Reading, however.

Ve3. Housing and Animal Production

There are no setback requirements when constructing animal barns, though manure handling facilities must be located at least 100-300 feet from property boundaries, depending on slope. In this section, we measure how many houses are located close to animal facilities, and compare this spatial distribution to what would be expected if animal facilities were randomly located.

The following analysis is done for the 60 animal building clusters that are located at least 1600 meters from the county border. For each building cluster, the number of single-family houses located within 400 meters, within 800 meters and within 1600 meters was determined. The average numbers of houses are given in Table 8.

Table 8. Number of houses located near animal facilities

Distance	Animal Facilities	Randomly-Chosen Points
400 meters	2.64	16.79
800 meters	16.70	60.32
1600 meters	105.86	238.24

For comparison purposes, 60 random points were selected in the county. These were the parcel centroids of parcels that were in privately-owned open space use and that were at least 5 acres in size. These are the types of parcels where animal operations are likely to located. Table 8 shows that the actual animal facilities tend to be located in areas that have few houses. The number of houses located within 400 meters and within 800 meters of actual animal facilities is about ¼ of that which would be expected if these facilities were locating themselves randomly in the landscape. The number of houses in the two columns is significantly different at all three distances. We conclude that some process is working to minimize conflicts between residential use and animal production by separating the uses spatially.

Part of the reason why there are fewer houses near animal facilities than would otherwise be expected may be due to the effect of agricultural zoning and ASA's. Fifty-nine of the 71 animal production facilities (83.1%) are located in ASA's. In contrast, of the privately-owned open space parcels of at least 5 acres in size, only 37.6% of the land (by area) is located within ASA's. This difference is statistically significant, and we conclude that animal production facilities have a tendency to be located in ASA's. However, we do not know whether this is because animal production facilities tend to locate in ASA's, or if ASA's tend to be created in areas that have more animal production.

It is also interesting to look at the relationship between agricultural conservation easements and location of animal production. Twenty-two of the 71 animal production facilities are located on farms with ACE's. In contrast, of the privately-owned open space parcels of 5 acres or more, only 8.8% (by area) are under ACE's. This difference is also significant, and we conclude that animal production facilities have a tendency to locate on farms with ACE's (or conversely, that farms with ACE's are more likely to have animal production facilities).

Finally, we calculate the total impact of one animal production facility on house prices. We choose a production facility that is close to the average in terms of its location relative to houses, with 119 houses located within 1600 meters and 17 houses located within 800 meters. For each house, the percent decrease in price due to the animal production facility is calculated, and this is multiplied by the house's assessed value. No houses were located within 500 meters of this animal production facility.

For this illustrative case, the average house price impact due to the animal production facility is a decrease in value of $1,803. The total impact on all 119 houses is $215,000, which is 1.7% of the total assessed value of the 119 houses. This total is intended as an illustration, and should not be viewed as an average value for all animal facilities. The impact from any given facility will depend on the number of houses near the facility, the location of those houses relative to the facility, and the value of those houses.

It should be noted that this estimate of the impact on property values does not include amenity or disamenity impacts that are not tied to house location. Price differentials for houses located near a large-scale animal production facility would not capture benefits or costs experienced by commuters or tourists who travel past such facilities, or any negative impact on water quality that is experienced downstream from the facility.

Vf. Summary of Disamenity Impacts

Table 9 summarizes the disamenity impacts from landfills, the regional airport, mushroom production and large-scale animal production facilities.

Table 9. 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	-0.8%	-0.4%	-0.1%	
Animal Production	-6.4%	-4.1%	-1.6%	

VI. Location of New Residential Development

If house price depends on location and on surrounding land use, and if residential development tends to occur in places where houses are valued highest, then information on land use might help explain the pattern of residential development. A probit analysis was used to model factors that influence the probability that any given lot converts from open space to residential use.

The analysis treats as the unit of observation parcels of land that can be subdivided. The population of such parcels was defined as every parcel that satisfied the following requirements

- was privately owned and in open space use in 1996
- is over 5 acres in size
- does not have an ACE at any time
- is not located within 1 mile of the county boundary, or within one mile of New Morgan Borough

7,399 parcels were identified as potentially developable. From Planning Commission records, 92 of these parcels were identified where the owner sought to subdivide, with at least 3 of the daughter parcels to be designated as residential. Our analysis then models factors that influence the decision to subdivide for residential construction. It does not model commercial or industrial development, and does not model home construction on parcels that are not subdivided.

A probit regression was used to model the probability of subdivision, conditional on measured characteristics of the parcel. The measured characteristics are the same measures used in the hedonic regression (with the exception of the house's structural characteristics, which is endogenously determined by the builder, and not a characteristic of the parcel prior to development). So, for example, the land use observed in 2002 was used to measure prospective land use surrounding the new residential parcel. An additional factor that might influence development location is access to utilities. Unfortunately, digitized maps showing the location of public utility service were not available. Based on the Assessment Office's parcel database, the distance from the developable parcel to a parcel that has public water and/or public sewer was calculated. A variable measuring the number of utilities located within 200 meters of the developable parcel was used as an index of public utility availability.

Two probility-of-development models were estimated. The first model examined whether prospective house price influenced the location of development. For each potentially-developable parcel, a Prospective House Price Factor was calculated, equal to X'ß, where X is the vector of location-specific attributes from the hedonic price analysis, and ß are the hedonic price model coefficients for those attributes. X included all explanatory variables other than structural characteristics of the house. While not a house price, X'ß will capture differences in location that will generate differences in house prices.

Prospective house price is not the only factor influencing location of development. Cost of development also matters. Here, the three soil indices (suitability for septic systems, suitability for construction, and agricultural productivity) are used to reflect the costs of construction, and the opportunity costs of taking the land out of agricultural production. Slope and elevation may also influence construction costs, as will access to public utilities. Parcel size may matter if there are economies of scale in subdivision. Finally, zoning should influence probability of residential development, as should whether the parcel is in an ASA, if these policy tools are at all effective. The individual effects of Effective Ag Zoning and ASA may not be additive, so an interaction term between these two is included.

The results of the probit regression using these explanatory variables are shown in Table 9, Model 1. The most striking result is that prospective house price has no impact on the probability of subdivision. We have no evidence that location-specific differentials in house prices are driving the pattern of development. The second most striking result is that large parcels are much more likely to subdivide than small parcels. This makes sense, particularly if small parcels tend to convert to residential use without first subdividing. Both Effective Ag Zoning and ASA's are associated with lower probability of subdivision, indicating that these policy tools are effective in directing development to other areas. The only remaining explanatory variable that had a significant effect on probability of development was elevation. Here, higher-elevation parcels were less likely to subdivide. The coefficient on access to public utilities was positive, consistent with expectations, but the significance level was marginal.

Model 1 does not show that lots with higher potential house price are more likely to be developed. However, some caveats should accompany that result. First, Model 1 relies on a two-stage modeling process, where the hedonic price regression is estimated in the first stage, and the probability-of-development model estimated in the second stage, using the first stage hedonic pricing model. It is not unreasonable to suppose that errors in the first stage model would be spatially correlated with errors in the second stage model, but no attempt is made to account for this possibility. Second, the hedonic price model is estimated for house prices, whereas probability of development is more likely to depend on the value of a developable lot.

If we cannot show that location-specific house price differentials are driving development patterns, can we show any spatial interactions in land use change? A second probit regression model was estimated (Model 2) that included measures of surrounding land use out to 400 meters from the prospective house site. In contrast to Model 1, surrounding land use for Model 2 is measured prior to conversion, i.e. as it existed in 1996. Here, it was found that parcels that have more residential land near them are more likely to subdivide. The estimated coefficient on surrounding open space is positive, but is not significant (?^{2} = 2.30). However, parcels located near government-owned open space are slightly but significantly more likely to subdivide. These result are somewhat at odds with that found by Irwin and Bockstael (2001a) who found that new residential development was more likely in areas with less development. We find that new development tends to locate near existing residential land, with the exception that proximity to government-owned open space tends to attract residential development.

We also examine what impact animal production has on the location of residential development. We calculated our animal facility index, ANBCIND, for every potentially-developable parcel. The estimated coefficient is negative, as would be expected if animal production is a local disamenity, but is not significant (?^{2} = 1.99).

It should be remembered that while the regressions shown in Table 9 are based on several thousand potentially-developable parcels, the observed number of subdivisions is small (only 92). Our ability to detect patterns having observed only 92 conversions is limited. Further, the errors in the probit models may be spatially correlated, which would give biased parameter estimates. However, Plate 4 shows no tendency toward clustering in the spatial pattern of parcels that developed. If any spatial pattern exists, it is that parcels that develop may tend to be isolated form one another. This is an issue that warrants further research.

To summarize, surrounding land use does appear to have some impact on the probability of development, but the "leapfrog" model, where development occurs away from previously-developed areas because new home buyers want to be located in areas with lots of open space, was not supported by our results. In Berks County, it appears that new development is most likely to occur near existing residential development, though proximity to government-owned open space appears to have some effect.

VII. Conclusions and Future Research Directions

VIIa. Key Findings of This Research

We highlight several important conclusions from this research:

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.

5) The impact of open space that is zoned for residential use, but that has not yet been built is statistically indistinguishable from the impact of industrial use, and is significantly worse than medium or large-lot residential use. This may be a short-term decrease in house price, reflecting the uncertainty and disruption that accompany new residential construction.

6) 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.

7) 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.

8) 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.

9) 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.

10) The total impacts of one landfill, the airport, and one animal production facility on nearby house prices were calculated, as illustrations. The total impact of a landfill on the value of 3342 properties located within 3200 meters was calculated to be $8,161,771, or 2.6% of the assessed value of the affected properties (in 2002 dollars). The impact of the regional airport on 2256 properties located within 1600 meters of the runway and flight path was calculated to be $235,111, or 0.1% of the assessed value of the affected properties. The total impact of an animal production facility on 119 properties located with 1600 meters was calculated to be $214,589, or 1.7% of the assessed value of those properties. These estimates capture only those impacts that fall on residents who live near the facilities. They do not include costs of impacts that occur farther from such facilities, such as impacts on downstream water quality, or positive or negative amenity impacts on tourists or commuters who travel past such facilities. These calculations are illustrative, but should not be viewed as averages for similar facilities. The total impact from a given facility like these will depend on the number of houses located near the facility, the distance between the facility and the houses, and the market value the houses would otherwise have.

11) An analysis of the spatial pattern of development showed that larger lots are more likely to be developed, that lots located near existing residential areas are more likely to be developed, and that proximity to government-owned open space has a small positive impact on probability of development. Of interest here is that potential house price, as predicted by the hedonic price function, did not help explain the pattern of development. Also, other than for government-owned open space, we did not find a significant tendency for new development to locate in areas with more open space.

VIIb. Future Research Needs

This project has demonstrated the utility of using GIS analysis to investigate issues of spatial interaction in land use, both interactions that affect house prices and interactions that affect the pattern of development that occurs over time. 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 land coversion probit 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. Finally, the land conversion analysis requires observation of more conversions in order to be able to identify the more subtle factors that influence the pattern of development.

A second extension to the research is to apply new estimation techniques that can simultaneously account for endogeneity in land use and spatial correlation in house prices. This has not previously been done for a hedonic pricing model.

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Appendix 1. Project Local Advisory Group

The research team is grateful to the Project Local Advisory Group for their contributions and for the time and energy they donated to this effort. However, the research team takes sole responsibility for the project's results, for the contents of this report, and for any and all errors contained within.

The members of the Project Local Advisory Group are:

Clyde Myers, Extension Agent, Berks County Cooperative Extension, Pennsylvania State University

Judith Schwank, County Commissioner, Berks County

Glenn Knoblauch, Executive Director, Berks County Planning Commission

Duane Rashlich, Director or Real Estate, Berks County Assessment Office

Tami Hildebrand, Executive Director, Berks County Agricultural Land Preservation Board

Kenneth Grimes, Chairman, Upper Tulpehocken Township Supervisors

Robert Behling, Chairman, South Heidelberg Township Planning Commission

Table 3a. 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 3b. Hedonic Price Regression Results - Surrounding Land Use

Variable	IV Model Coefficient	IV Model Standard Error	IV Model T stat	OLS Model Coefficient	OLS Model Standard Error	OLS Model 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 3c. 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 4a. Marginal Implicit Prices for Land Use Within 400m of House

Land Use Type	IV Model Total Impact	IV Model Standard Error	IV Model T stat	OLS Model Total Impact	OLS Model Standard Error	OLS Model 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 4b. Marginal Implicit Prices for Land Use Between 400m and 1600m from House

Land Use Type	IV Model Total Impact	IV Model Standard Error	IV Model T stat	OLS Model Total Impact	OLS Model Standard Error	OLS Model 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

Table 9. Probit Regressions of Probability of Subdivision

	Model 1				Model 2			
Variable	Coefficient	Standard Error	Chi Square	Signif. Level	Coefficient	Standard Error	Chi Square	Signif. Level
Intercept	-1.9967	0.9295	4.61	0.032	-4.7768	1.6112	8.03	0.003
Prospective House Price	-0.0019	0.608	0	0.997				
Parcel Size (acres)	0.0051	0.0008	42.78	0.001	0.006	0.0009	47.66	0.001
Utilities w/in 200m	0.0861	0.053	2.64	0.104	0.0836	0.0574	2.12	0.146
Elevation (meters)	-0.0018	0.0009	3.95	0.047	-0.0027	0.001	7.22	0.007
Slope	-0.0239	0.0175	1.86	0.173	-0.0163	0.0183	0.80	0.371
Ag Productivity Index	0.0016	0.0019	0.69	0.405	0.0026	0.002	1.60	0.206
Septic Suitability Index	0.0525	0.0423	1.54	0.214	0.0682	0.0443	2.37	0.124
Building Suitability Index	-0.0057	0.0215	0.07	0.791	-0.008	0.0225	0.12	0.724
Dist to Philadelphia					0.0052	0.0047	1.20	0.273
Distance to Reading					0.0089	0.0077	1.32	0.251
Distance to Main Roads					-0.0089	0.0273	0.11	0.746
Open Space w/in 400m					0.0197	0.0130	2.30	0.129
Commercial w/in 400m					0.0105	0.0156	0.45	0.503
Residential w/in 400m					0.0275	0.0131	4.39	0.036
Eased Open Space					-0.0046	0.0066	0.48	0.491
Govt -Owned O.S.					0.0086	0.0038	4.98	0.026
ANBCIND					-331.9	235.1	1.99	0.158
ASA	-0.4419	0.1648	7.19	0.007	-0.4162	0.1696	6.02	0.014
Zoning Effective Ag	-0.3232	0.1481	4.76	0.029	-0.2949	0.1582	3.47	0.062
Zoning Agricultural	-0.2069	0.1673	1.53	0.216	-0.2061	0.1741	1.40	0.236
Zoning Comm/Indust	-0.2047	0.1833	1.25	0.264	-0.0724	0.1975	0.13	0.714
Zoning Multiple	-0.3619	0.3751	0.93	0.334	-0.3813	0.3960	0.93	0.336
Zoning Conservation	0.0204	0.1259	0.03	0.871	0.0298	0.1314	0.05	0.821
ASAxEff Ag Zoning	0.2726	0.265	1.06	0.304	0.3134	0.2698	1.35	0.245

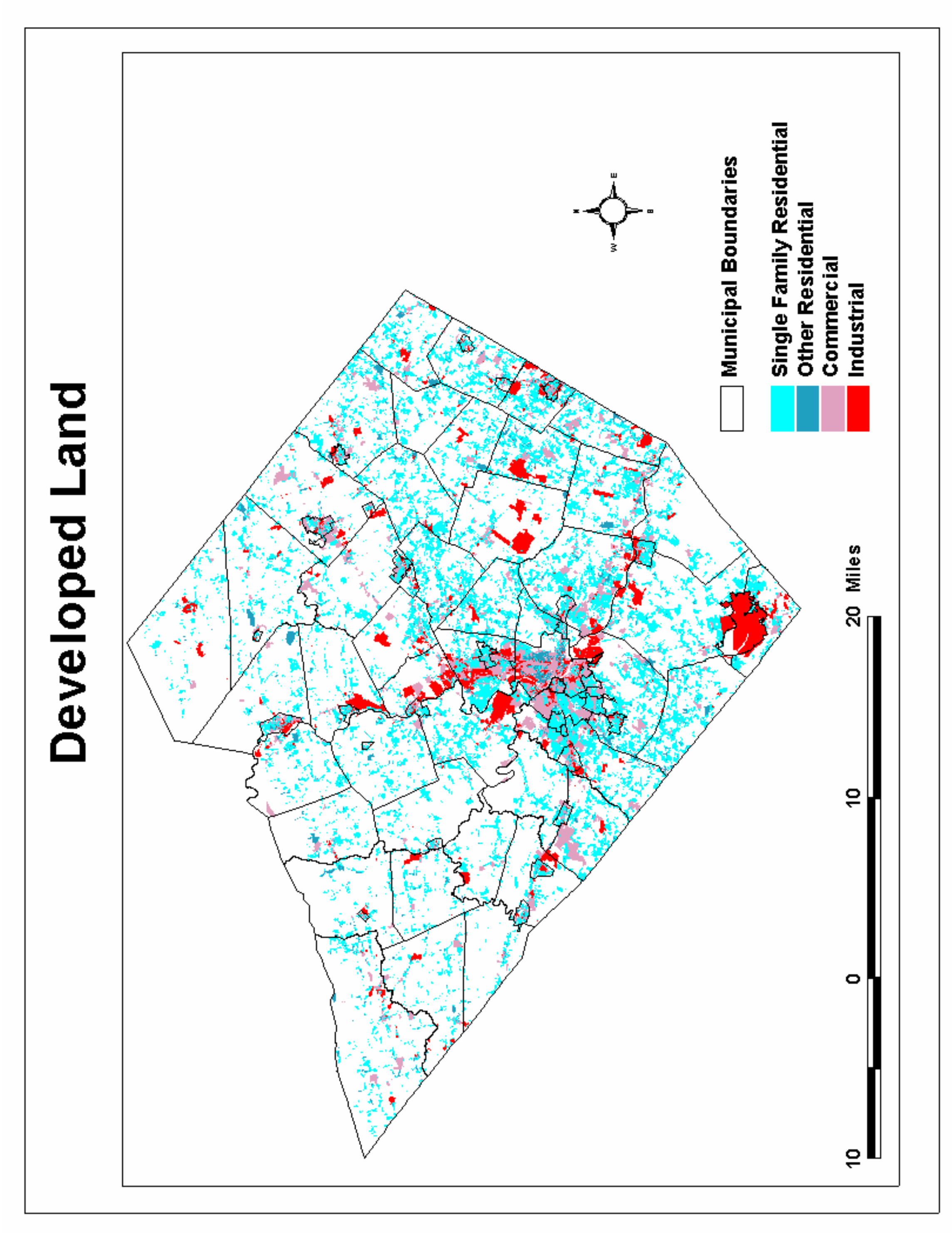

Plate 1 - Developed land - Residential, commercial and Industrial

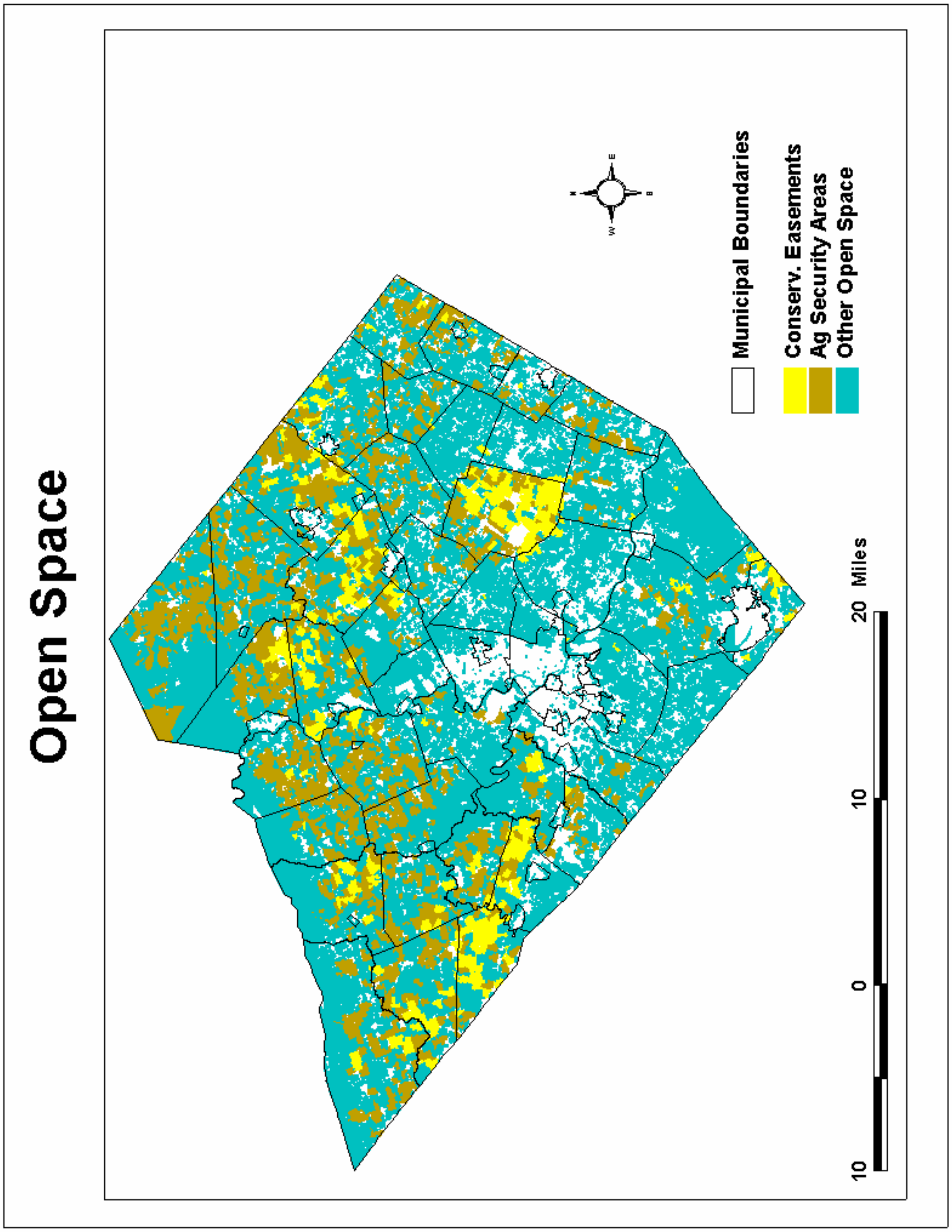

Plate 2. Open Space - Agricultural security areas and conservation easements.

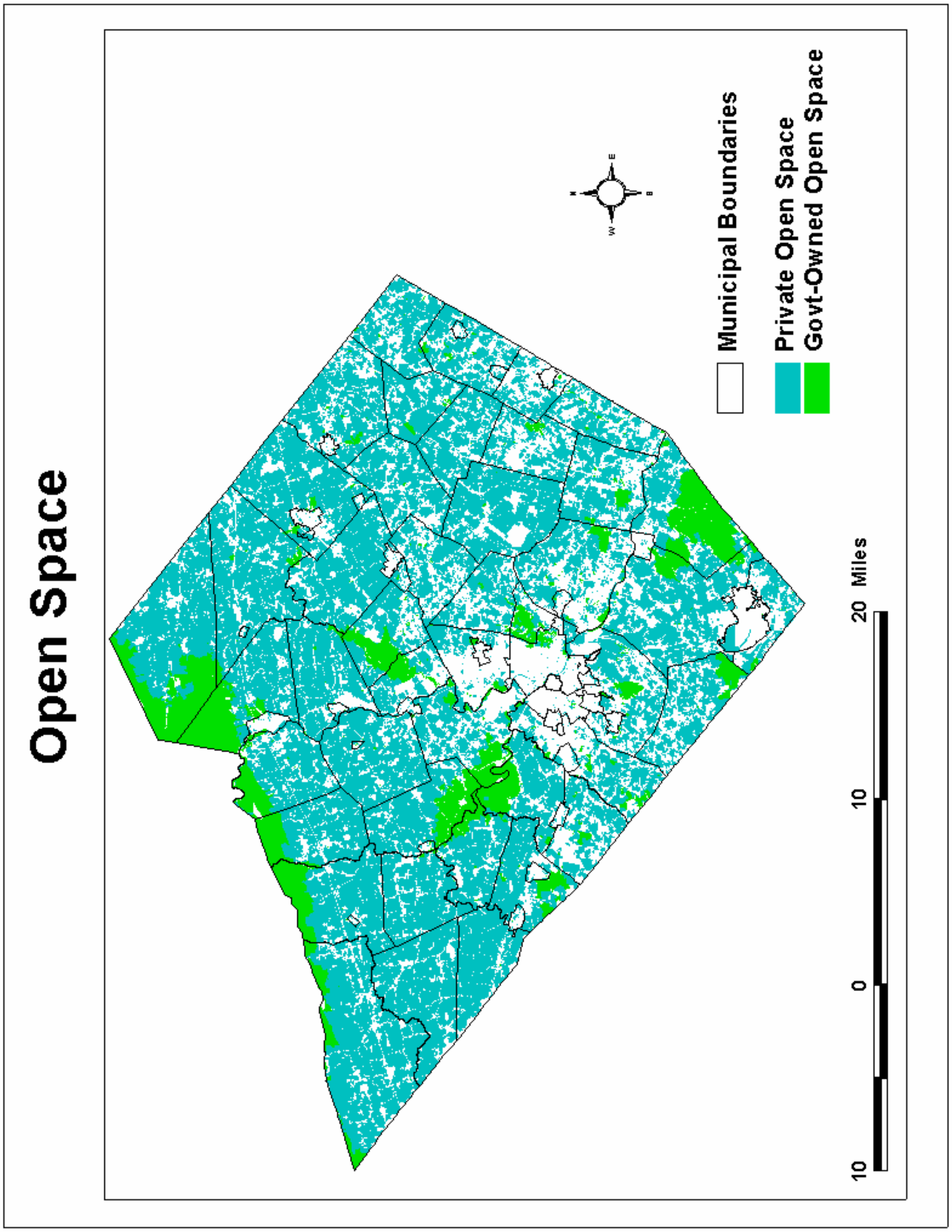

Plate 3. Open space - Government-owned vs. privately-owned.

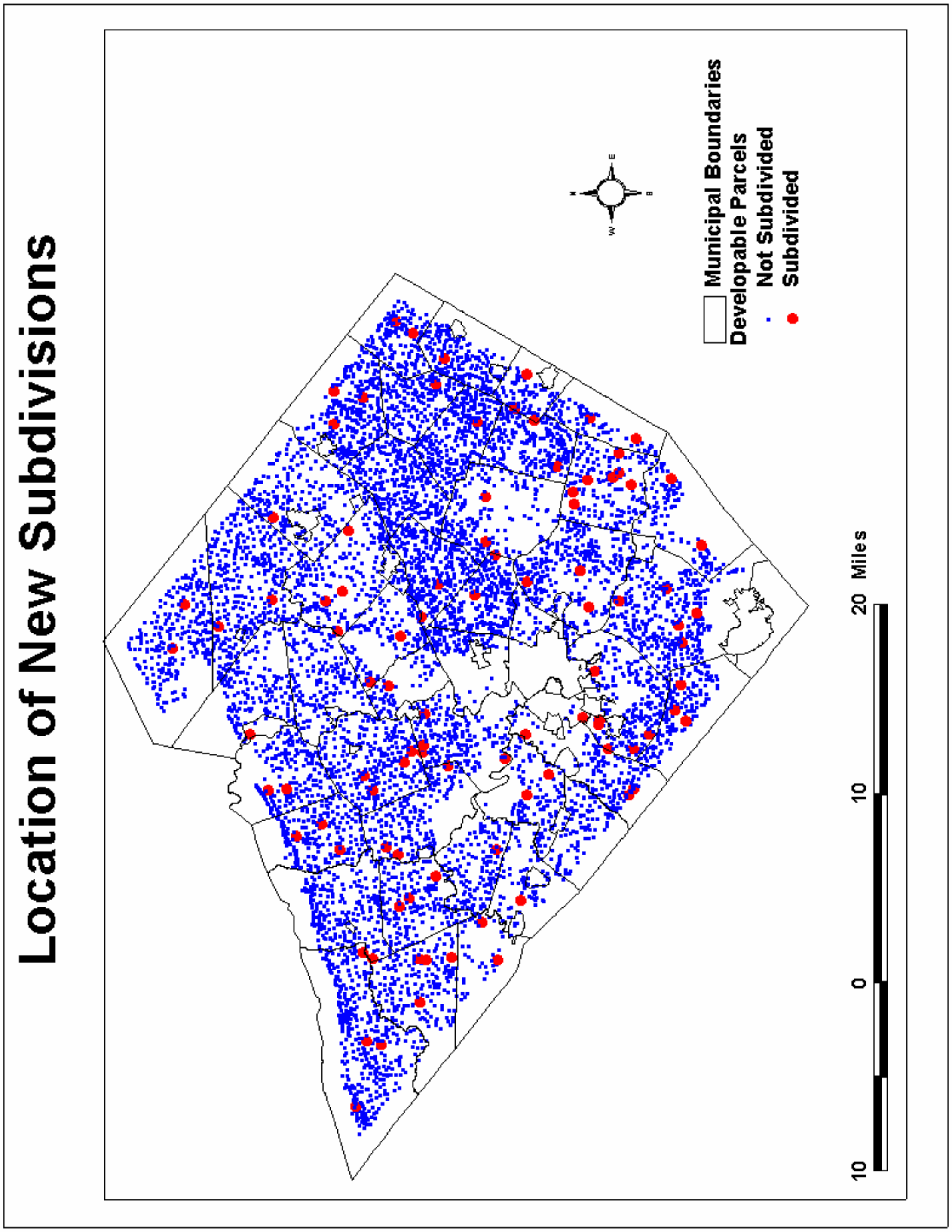

Plate 4 - Location of newly subdivided parcels.

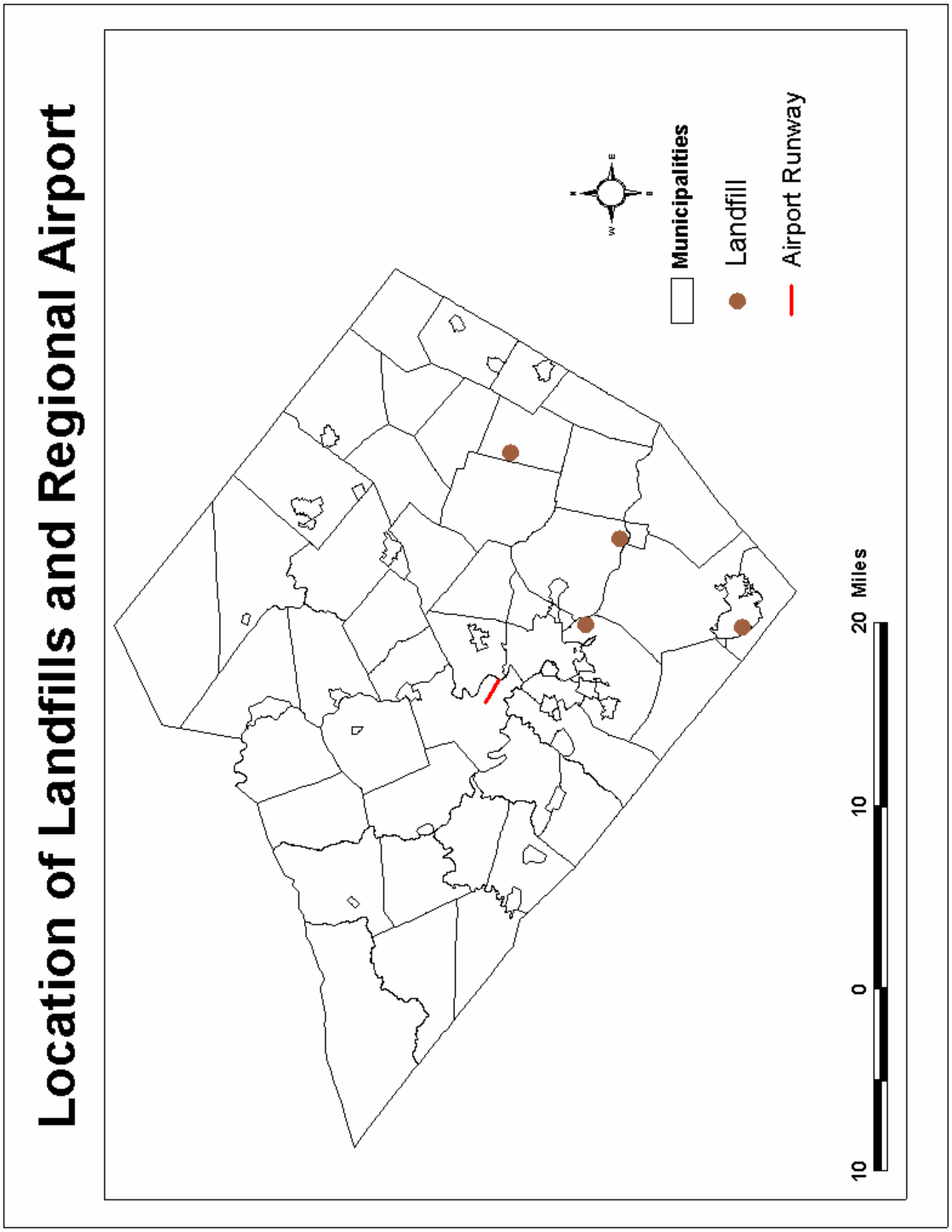

Plate 5 - Location of landfills and regional airport.

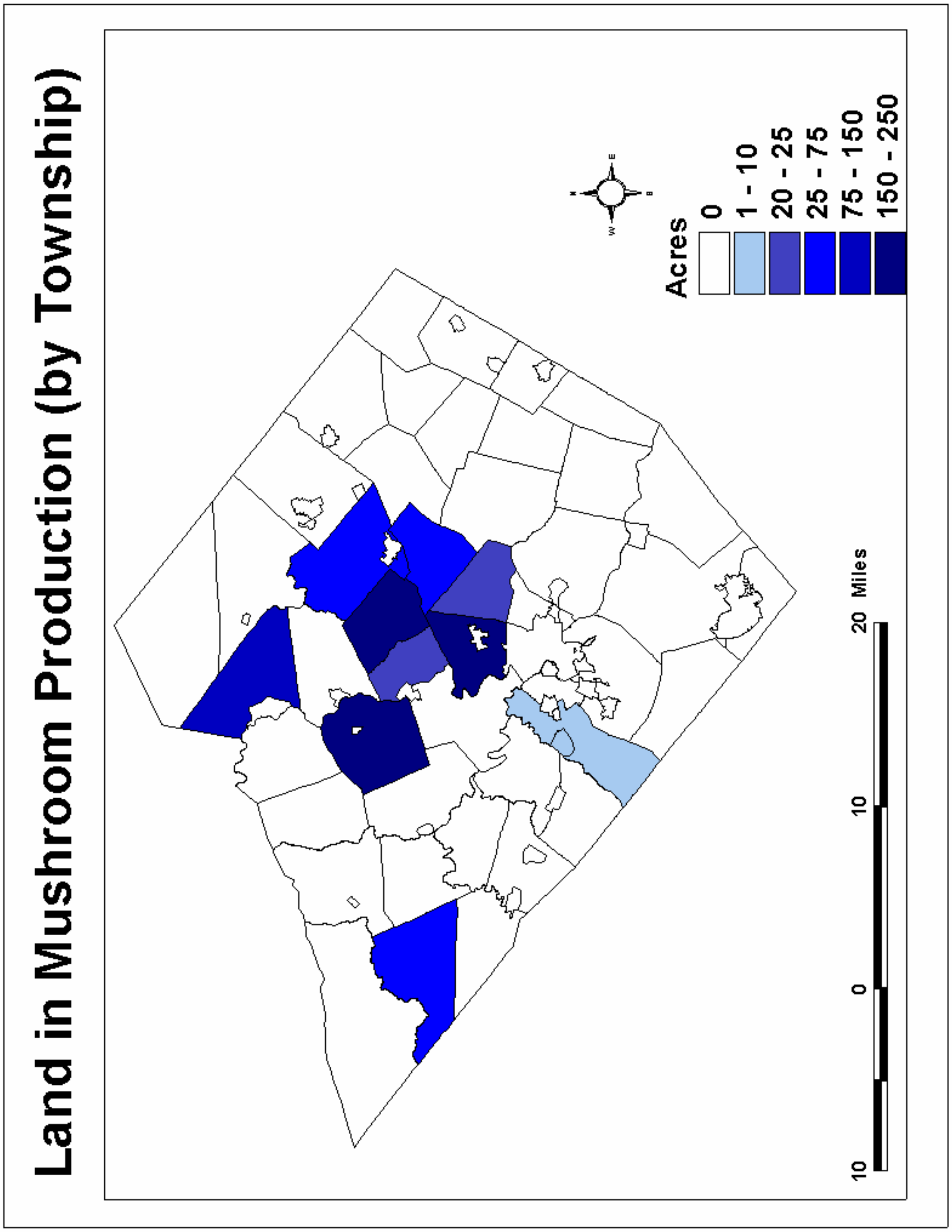

Plate 6 - Location of mushroom production, by township.

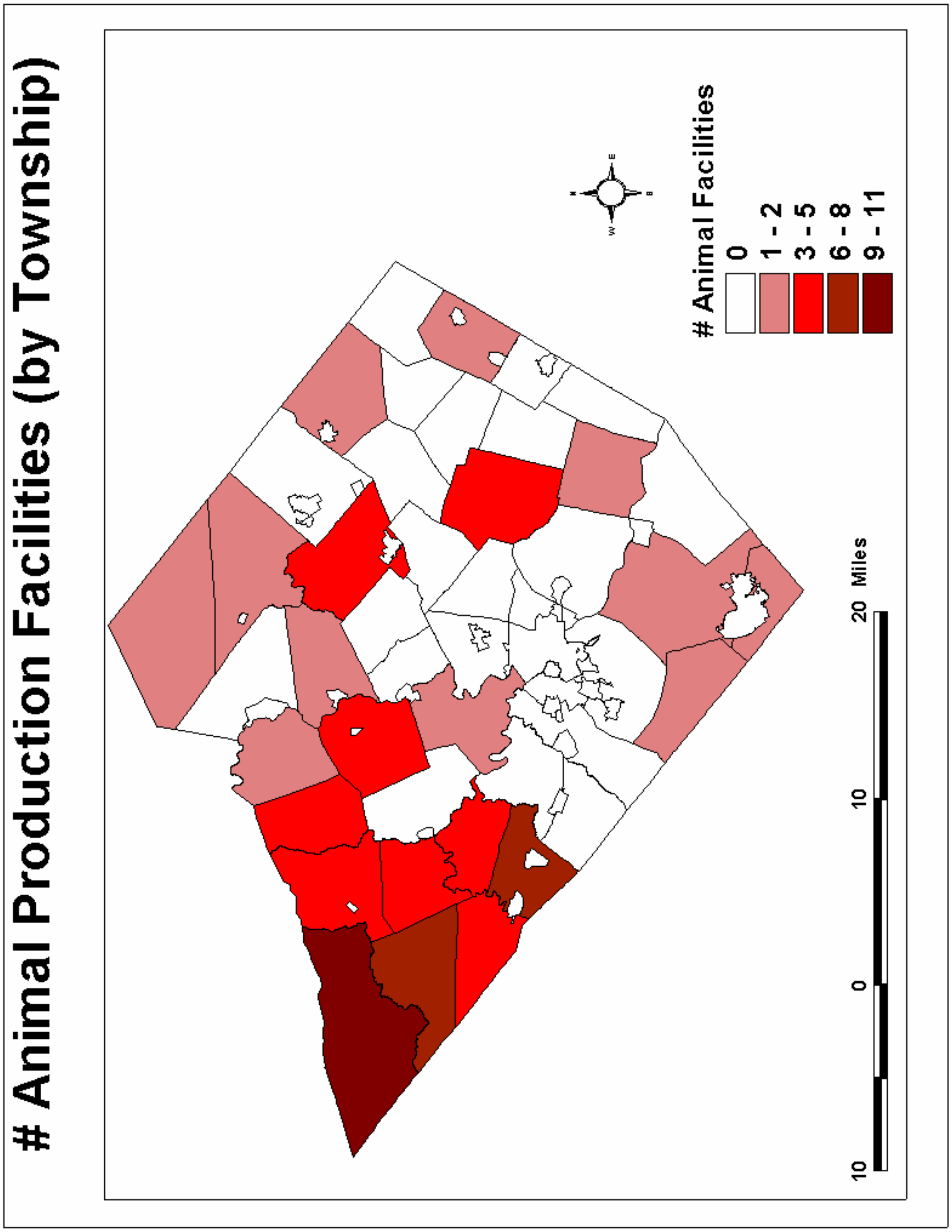

Plate 7. Location of animal production facilities, by township.