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Public open spaces provide many benefits to individuals and society. Many of the services they provide; such as recreation, enjoyment of nature, and improving water quality; are non-exclusive and non-rival in consumption. The "public good" nature of open space services inhibits the formation of a market for open space areas. This may allow the supply of open space areas to be less than socially optimal. Decisions about the supply of open space areas may be improved by using non-market valuation techniques to provide insight into the value of public open space areas

The hedonic property price approach is used in this study to estimate the effect of public open space areas in Corvallis, Oregon on surrounding residential property values. Information about property sales from the period 1990-1995 was gathered to relate the selling price of residential property to the structural, neighborhood, and environmental characteristics of the property by the use of multiple regression analysis. The primary variables of interest were the environmental characteristics, "distance to the nearest open space" and "size of the nearest open space". The regression analysis was then conducted for different sub-samples based on the use and topography of the different types of open space areas included in the study.

The results of the analysis indicate that public open space may have had a positive effect on surrounding residential property, but that the effect may have been dependent on the distance from the open space and the type of open space. Residential properties near municipal parks or located within 200 feet of open spaces were estimated to have had higher values, ceteris paribus. Schools and cemeteries were estimated to have had a negative, but not statistically significant effect on sample residential property values, while upland and wetland open spaces were estimated to have had a positive, but not statistically significant effect.

The estimated implicit marginal value of the amenities produced by the open spaces studied allows a partial estimate of the value of the municipal parks. This partial estimate of value indicates that, under certain conditions, the benefits associated with parks may exceed their cost.

The Value of Public Open Space: An Hedonic Price Approach

By

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THE VALUE OF PUBLIC OPEN SPACE: AN HEDONIC PRICE APPROACH

INTRODUCTION

Municipal parks provide a variety of services. These include providing open space for recreation and cultural events; attract retail consumers, workers and industry to the city; provide a visual amenity; reduce storm drainage and flood damage; improve and maintain air and water quality; and reduce noise and visual pollution (City of Corvallis, 1991).

These benefits may, at least over a given range of use, be non-rival and non-exclusive in consumption. In such cases, there is the potential for the market to fail to provide the quantity of park space for which the residents of a city would be willing to pay (Randall, 1987). Estimating the value of existing city parks may provide some insight in attempting to answer the question of whether or not the benefits of establishing additional city parks would be greater than the costs.

There are many ways to estimate the value of a park. One method is to simply ask people. Another way is to use more indirect methods to infer values. In this study, an hedonic price model is used to estimate the influence of city parks on nearby property values. This will be taken as a partial step to estimating the full social value of city parks.

While the benefits associated with a park may be enjoyed by consumers living some distance from the park, identifying these beneficiaries and estimating the value they receive is problematic. In the area of study, no regular records of park visitors is kept and the author is unaware of any bioengineering model of city park impacts on the airshed, watershed or noise levels. In addition, there exist no established markets for some of the specific benefits of parks such as reduced storm drainage and visual amenity values.

It may be, however, that the benefits associated with parks are mostly enjoyed by nearby residents. Shorter travel distance may mean that nearby residents visit the park more often. Proximity to a park may also mean better utilization of any visual amenity and noise reduction.

There may also be nuisance values associated with being near parks, such as noise, traffic congestion, loss of privacy and crime. To the extent that a park's net utility is enjoyed, or detested, by nearby residents it may be reflected in property values as buyers bid prices up or down in their desire to get closer to or farther from a park.

Justification

The study area chosen is Corvallis, Oregon, a small city of approximately 45,000 people located in the Willamette Valley. It is home to Oregon State University and a Hewlett-Packard computer printer manufacturing facility. Corvallis was the seventh largest city in Oregon in 1989. From 1976 to 1989 voters approved thirty-one annexations to the City of Corvallis (hereafter referred to as the City) totaling 2,515 acres bringing the City's size to 8,217 acres total Kasper,1990). The city's population and new home construction are increasing and additional growth is occurring in rural areas surrounding Corvallis. The city's population in 1970 was 35,153; in 1980 it was 40,960; and by 1990 had grown to 44,757. The City issued building permits for 1,474 new residential units during the 1980's and 2,836 new residential units for the period 1990-1997 (City of Corvallis,1998).

In surveys undertaken by the City the number of residents surveyed who thought that Corvallis was growing too quickly increased from 33.2% in 1993 to 50.5% in 1994. The number who thought that Corvallis was growing at about the right pace declined from 58% in 1993 to 44.2% in 1994 (City of Corvallis, 1994).

Although the State of Oregon has mandated, and the City of Corvallis has implemented, strict comprehensive land use planning, this planning does not ensure that a city will have a certain amount of public open space or parks. Comprehensive planning does not specifically prevent development on a particular parcel, except in a few special cases. Instead, it is an attempt to realize certain statewide goals and keep development ordered by type of use. Comprehensive planning in Oregon relies mainly on zoning to meet plan goals. Zoning private property is not a mechanism the City has used to create any municipal parks.

In a 1994 survey of residents, 54% placed the purchase of land for public open space and riverfront improvement at the top of a parks-related capital improvement list (City of Corvallis, 1994). In a later question, 86.6% of the respondents indicated that they had used city parks in the previous twelve months, the highest use rate of any City service or facility (water and sewer were not listed). In a question asking which services the City should emphasize in the future the number one service requested was land-use planning, with 17% of the respondents requesting "much more" emphasis.

As part of its comprehensive land use-planning effort the City found that its citizens desired a greenbelt around the city and that the community placed a high value on acquiring and maintaining public open space and recreation land (City of Corvallis, 1991b). The City does not require dedication of parks or public open spaces by land developers but instead has acquired title through donation or outright purchase. City staff advised a policy of acquiring land for parks in advance of urban growth and development. City staff also projected land requirements for parks at 111 acres for the period 1990-2010 (City of Corvallis, 1991a).

Some citizens concerned with establishing public open spaces and providing boundaries that preserve the geographic, and possibly cultural, integrity of Corvallis have formed an organization called the Greenbelt Land Trust to acquire conservation easements or outright title to some parcels of land surrounding the city. The group had about 350 members in 1994 (Wulff, 1995, personal communication). The Greenbelt Land Trust has already acquired three parcels of land by open market purchases and donated them as public open space to the City of Corvallis and is attempting to acquire other parcels. Another group, To a Livable Corvallis, has formed in response to a number of growth related issues, acquiring public open space or parks among them.

This proposed action raises a question of interest. Is it worthwhile to remove a parcel of land from private ownership for use as a public park? In economic terms, are the benefits of an additional park greater than the costs?

The costs of preserving parcels as public open space is not inconsequential. The three parcels already acquired by the Greenbelt Land Trust comprised 238 acres purchased at a total cost of $373,000 (McCabe,personal communication,1998). Prices ranged from $1111 to $2777 per acre. The Greenbelt Land Trust prepared an Open Space Report in 1990 at the request of the Benton (County) Government Commission which identified public open space areas that should be protected in the Corvallis area. Four areas on the Report's severely threatened list (Bald Hill addition, Chip Ross Park addition, Neabeck Hill, and Owen's Farm) comprise about 1130 acres. The market value of all the parcels or even the Benton County Assessor's assessed value is not readily available, however sales and assessments of nearby properties show land prices from $3,000 to $11,000 per acre-the latter on small developed lots. Using even the lower $3,000/acre figure would imply removing more than $3 million worth of property from private use for public open space, and these are just four of ten or so areas that have been recommended for preservation.

Although the cost of establishing public open space appears significant the benefits of doing so may be even greater. Residents of Corvallis have invested considerable time and money to provide open space and there is no reason to a priori assume that their behavior is irrational. It may be assumed that for at least some people the benefits of open space are greater than the costs. This study will attempt to provide insight as to whether or not this is true for the community as a whole.

Information about the value of public open space in Corvallis may be of use to private groups dedicated to preserving public open space, City officials and Corvallis residents as they make decisions on public open space acquisition.

Study Objectives

The overall objectives of this research are to estimate the value of certain public open space areas in Corvallis, Oregon and to determine some of the factors that influence value. The ability to estimate total value depends upon the estimation of a demand function for open space. However, the information requirements necessary to estimate this demand function are rarely met in studies of this nature due to the limited number of observations and limited variety of areas to study. It is more likely that some insight may be gained as to the direction of influence that open space's have on welfare and, with the help of simplifying assumptions, possibly some estimates of the magnitude of their effect.

Sub-objectives of this study will be to estimate the implicit marginal effect on residential property prices as distance to public open space varies and to determine if this relationship, if any, changes as public open space characteristics change.

The specific hypotheses that will be tested are:

1). Public open spaces have a significant, positive influence on residential ....property prices.

a. As distance to the nearest public open space increases, the price of property will decrease, ceteris paribus.

b. As the size of the nearest public open space increases, the price of property will increase, ceteris paribus.

....2). Public open spaces have different implicit marginal effects as they vary in use and topography.

Results of this analysis have direct implications for public policy. In addition to providing input to help answer the question of whether or not public open spaces should be provided, some insight may be gained into the questions of what type of public open space is most beneficial.

Organization of the Study

The thesis is divided into six chapters. The next chapter provides a review of existing literature describing the various functions performed by public open spaces, previous research into the value of public open space, and public policy regarding public open space acquisition in Corvallis. The third chapter presents the theory of the hedonic price model used in this study and some issues associated with its application. The fourth chapter focuses on the empirical analysis and includes a description of the study area, the data used in the study, the dynamic nature of the Corvallis property market, and presents the regression results. The fifth chapter discusses the effects of public open spaces on residential property and tests the study hypotheses. The final chapter looks at the value of public open space and discusses implications for market transactions and public policy.

REVIEW OF LITERATURE

Public Open Space Functions

The efficient provisioning of public open spaces arises as matter for public policy mainly due to the nature of public open space amenities. Randall (1987) categorizes goods as rival or non-rival and exclusive or non-exclusive in consumption. The degree to which a good is rival in consumption is determined by the amount that one person's consumption limits another person's consumption. Exclusiveness describes the degree to which people can be denied a particular good. The common term, public good, may be used to describe goods that are non-rival, non-exclusive or both. Public provision of public goods is generally necessary because of the failure of private markets to allocate these goods in a manner that maximizes net social values, including transaction costs.

To the extent that public open spaces provide amenities that are non-rival and non-exclusive in consumption, their supply may be a legitimate public concern. Friedman (1962) allows a legitimate role for government intervention where 'neighborhood effects' are present. He cites two examples of neighborhood effects of a city park: enhanced view and increased value of surrounding property. Enhanced view would be an example of a good non-rival in consumption. Over a certain range of use, one person's enjoyment when looking at a park does not diminish when another person also looks at the park. Increased property value may be an example of a good that is at least somewhat non-exclusive in consumption. Even if a private park owner restricted access to the park a nearby property owner may still enjoy a benefit, such as shorter travel distance to the park or shade from a tree in the park, which could command a premium property price.

The nature of amenities that public open space offers are important in most public policy decisions involving land use planning. As a result there is an established literature which investigates open space functions. An early hedonic investigation into parks (Weicher, 1973) looked at benefits to non-users of parks in Columbus, Ohio and stated that only scenery or attractive landscaping could be enjoyed without entering the park. A review of New York's Open Space Conservation Plan (Bendick, 1993) listed such public open space functions as: recreation, promoting creativity, relaxation, providing a study area, providing a place to interact with the natural world, wildlife habitat, improving water quality, wildlife harvesting, burial grounds, providing scenic, cultural or historic resources, maintaining natural resource based industry, providing a place for education and research, and protecting farmland and forests.
In a discussion of city planning (Smallwood, 1993) the author states that public open space promotes community pride, reduces flooding, recharges groundwater, provides wildlife habitat and wildlife travel corridors, and increases adjacent property values. A benefit/cost analysis of urban parks in Massachusetts (More, 1982) divided benefits into two categories: on-site and off-site. On-site functions

included recreation, freedom, education, increased physical and emotional health, and increased family solidarity. Off-site benefits included visual diversity, preservation of future recreational opportunity, landmarks, traffic control, and increased property values.

A review of a municipal greenbelt effort (Andrews, 1998) concluded that saving a public open space next to the city was a "community character issue". City residents felt that farmland and natural resources formed the historic character of the city. An analysis of urban water parks (Darling, 1973) stated that the primary outputs of the water parks were recreation and aesthetic quality. In a study of a river area in Saskatoon, Saskatchewan (Kulshreshtha, 1993) the authors state that river areas add to the aesthetic beauty and that this may have many impacts on the socio-economic system, such as improving mental health, improving worker efficiency, reducing worker turnover, and making it easier for firm to recruit workers.

In addition to these functions, public open spaces are increasingly being used as areas of temporary residence by homeless people. It is perhaps related to More's (1982) function of freedom mentioned above, but public open spaces provide a legal place for people to exist, usually free of charge and with no expectation of a purchase being made.

It is beyond the scope of this work to establish which, if any, of the public open space functions discussed above are generated by public open spaces in Corvallis, Oregon, with one exception. Further, this research will not attempt to determine the degree to which any functions may be non-rival or non-exclusive in consumption. It is assumed that at least some of the above mentioned functions are present in Corvallis public open spaces.

One particular function, the effect of improving adjacent property values, is the focus of this study. However, in this study it will not be considered a public open space function at all, in the sense that physical processes, such as recreation or improved flood control, are considered a function. A park's influence on nearby property values, if any, is assumed to be the result of people's behavior in markets, not in parks.

A common practice, which this paper will follow, is to divide public open space functions into use and non-use categories. The assignment may be somewhat arbitrary but it is based on the question of whether or not people must be on-site when the amenity benefit is incurred. The following table presents open space functions described in the literature reviewed for this study. Since this study will examine different types of public open space, it is expected that the different types of areas will have different functions and different values associated with them. For example, if physical access to an area is difficult it may provide fewer of the use functions than an area with easier access.

TABLE 2.1 Open Space Functions

USE FUNCTIONS	NON-USE FUNCTIONS
recreation	landscape viewing
creativity	wildlife viewing
relaxation	farm/forest buffer
education	noise buffer
nature experience	flood reduction
wildlife harvesting	wildlife habitat
burial	water provision/storage
cultural/historic resources	water quality
natural resource production	wildlife travel corridor
research	landmarks
freedom mental health	traffic control
temporary residence	future use

Value of Environmental Amenities

Although public open spaces may provide services that are perceived as valuable, discovering the exact value of a particular service is problematic when a traditional market for the service does not exist. In a discussion of inefficiency, Randall notes that "The market derives its effectiveness from nonattenuated property rights and performs its functions through the instrumentality of efficient relative prices" (Randall, 1987). Market failure typically arises in the circumstances of attenuated property rights or peculiarities in the physical nature of the goods involved. The peculiarities of interest are those that allow a good or service to be non-rival or non-exclusive in consumption. Since this is the case for public open space amenities, methods other than examining markets are relied upon.

Three methods used to estimate the value of public open space amenities are the travel cost method (TCM), the contingent valuation method (CVM), and the hedonic price model. The travel cost method was suggested in the late 1940's and popularized in the 1960's as a way to estimate the recreational value of a site. As its name indicates, this method relies on using the cost incurred when traveling to a site to estimate the demand for a site.

There are numerous travel costs studies on sites around the world but most of the sites are of national or regional importance and are used as vacation destinations. For example, a study of Carnarvon Gorge National Park in Queensland, Australia (Beal, 1995) estimated that the 250,000 ha. park had a net present recreation value of $40 million. Since municipal parks and public open spaces are located in or bordering the city from which most of their users live, travel distances are generally very short. One study in Texas utilizing this approach had little success in developing meaningful results (Darling, 1973). However in another study, a survey of visitors to an arboretum and two conservatories in the Chicago, Illinois area led to estimates of a willingness-to-pay ranging from $4.54 to $12.71 per visit (Dwyer, 1983). No figure was presented to estimate the value of the areas. It should be noted that the problem with using this method with municipal parks might only be in measuring the travel costs. A search of literature revealed no other TCM estimates of municipal park benefits.

The contingent valuation method (CVM) is designed especially to deal with goods that are hypothetical, like a proposed park, and goods that possess non-use values. Non-use values arise from amenities that can be enjoyed without actually using the park. These may be off-site functions, as discussed above or more abstract functions such as the potential for future use. CVM became popular in the late 1970's and many studies were done on land values.

Bergstrom, Dillman and Stoll (1985) studied prime agricultural land in South Carolina and estimated a countywide WTP of $13 per acre to protect farmland amenities. Benefits to each household were estimated at $5.70 to $8.94 from parcels that ranged in size from 18,000 to 72,000 acres. Ready et al. (1997) used both CVM and an hedonic price model to estimate the amenity value of Kentucky horse farms. The two methods yielded similar results with the CVM estimating that households would spend $0.49 per year to avoid the loss of the first horse farm and the hedonic model estimating an amount of $0.43 per year.

No CVM studies of the value of urban fringe land around Corvallis were discovered in the literature search.

In addition to formal CVM studies, elections and referendums on public open space acquisition measures can reveal information about the public's willingness-to-pay for areas. However, the City of Corvallis Parks and Recreation Department reported that no such measures had passed since at least 1985 (Jones, 1998). Although one bond levy to acquire a large amount of open space failed in 1995 the City has spent general funds to acquire land for parks and public open space.

Numerous hedonic land price studies have been done to estimate amenity benefits. An exhaustive review of the literature is beyond the scope of this work but a selection will be presented.

The influence of parks on surrounding property prices was noted prior to the use of formal hedonic models. In a discussion of the value of urban public open space, Boerner-Ein (1991) writes that Frederick Law Olmstead, designer of Central Park in New York, noted that tax revenue had increased on lots surrounding Central Park. In a rough benefit/cost analysis Olmstead wrote that New York City had collected $55,880 in property taxes in 1864 from the land that became Central Park and that by 1873 land from the three wards surrounding Central Park were earning the City $4.4 million in taxes. Boerner-Ein also noted that land auctions of the time advertised that lots located near the new park will increase in price "to a point, as high, if not higher, than has been reached in any other part of the city, thus making a good investment." The claims were correct, according to the author. Another early simple price comparison, this time near Rock Creek Park, Maryland, showed that bare lots bordering the park sold for $1000 more than lots in the same subdivision that did not border the park (Knetsch, 1962)

The development of the hedonic price model allowed a better, at least in theory, estimate of the influence of a park's amenities on the price of land. As noted above, a study by Weicher (1973) estimated that the value to a property due to facing an adjacent park ranged from $1130 to $1609. Another early study (Darling, 1973) attempted to estimate the influence of urban lakes, or water parks, on property values by including the distance from the lake to the property as a variable of interest. Although the model may have lacked robustness it was influential in directing subsequent investigations.

The influence of water bodies on land prices continued to be a subject of study. Kulshreshtha (1993) evaluated the influence of a river view on property in Saskatoon and estimated that it contributed $1.2 million annually in value by improving the aesthetic environment. The influence of having a river view on an average house was to add $11.48 per square foot to the selling price. Interestingly, the authors adjusted the "river view" variable by the size of structure, not the size of the lot which may be recommended (Diamond, 1980). They state that the average house in their survey was 1,243 square feet in size, which would imply an average price increase of $14,269 for a house with a river view.

It is important to keep in mind that public areas such as parks and rivers have many functions and they may not all be beneficial. Being close to water may increase the likelihood of flooding, for example. Donnelly (1989) examined the impact on property prices for land located in a floodplain and estimated that it decreased the value by $6,049 for the average property. In a study of vacation property in the northern lower peninsula of Michigan (Gartner, 1996) the authors concluded that, while bordering a lake positively affected property value, the influence of bordering public lands had the unexpected influence of decreasing property value. The authors hypothesized that seclusion and problems with trespass might underlie the relationship.

Hedonic models are well suited to estimating the value of multiple characteristics related to property. An additional study is reviewed to illustrate the variety of amenities and disamenities treated with hedonic price models. In a study of Boston by Li (1980) seventeen neighborhood amenities were included in an hedonic model. They included such variables as distance to schools, recreation sites and transportation corridors; air quality indices; population density; and school quality measures. The coefficient on distance to a recreation area was significant and indicated that land prices decreased as distance increased. Distance to the nearest school was not significant.

Fewer hedonic studies were found which relate specifically to the effect of parks and public open spaces on surrounding land prices. In 1967, Boulder, Colorado adopted a greenbelt acquisition program that had purchased 8000 acres by 1978. An hedonic analysis was performed (Correll, 1978) using data from single family residences which were sold in 1975. The study examined three greenbelt areas ranging in size from 74 acres to 924 acres. The results of the study indicated that for the aggregate sample, housing prices decreased $4.20 for each foot greater distance the lot was from the greenbelt, ceteris paribus. The distance measure used was walking distance to the nearest greenbelt, which is not necessarily the shortest straight-line distance. This may be more appropriate if access to using the greenbelt determined the amenity value instead of a non-use function such as view.

A study was done on four city parks in Worcester, Massachusetts (More, 1982). Properties that were 20 feet from the park were $2,675 higher than those located 2,000 feet from the park, at sample mean values. The four parks together were estimated to add $3,491,940 to surrounding property values.

In a study of the amenity value of forestland in Britain, (Garrod, 1992) estimated that a 1% increase in the size of a forest of broadleaved trees would increase adjacent residential property prices by £42.81 ($75.58, U.S.), at sample means. The influence of public open space area on residential property in Darlington and Reading, UK (Cheshire, 1995) was estimated to be a £50 ($78.92, U.S.) increase in Reading and a £83 ($131.01, U.S.) increase in Darlington, both at sample means, for each 1% increase in public open space area in the surrounding square kilometer of land.

The review of literature revealed no hedonic studies on the value of parks or public open space in Corvallis.

In this study the estimated effect of public open space on residential property will be measured primarily in 1995 dollars per foot. That is, the estimated effect on property value as its distance changes from a public open space. An attempt will be made to convert this to other units of measure to assist in interpreting the results.

As may be noted from the studies above, estimation of the value of public open space lends itself to expressing that value in various units. A selection of values from various studies using four common units is presented. It can be seen that the magnitude of the estimated benefit from open space amenities varied considerably. These previous studies focused on a wide variety of types of open spaces and anticipated amenities and the estimates reflect this diversity. It is expected that the magnitude of any effect of public open space in Corvallis on residential property value will be dependent upon the particular amenities perceived by the local residents and will be unique to this study.

TABLE 2.2 A Survey of Open Space Values

Nominal Amount	Study	1995 U.S. Dollars		Nominal Amount	Study	1995 U.S. Dollars
Per Household				Public Open Space Area		
$76.00/yr	Beasly, 1986	$104/yr		$64.77/ac**	Beal, 1983	$86.86/ac
$0.49/yr	Ready, 1997	$0.46/yr		$13.00/ac	Bergstrom, 1985	$19.97/ac
$0.43/yr	Ready, 1997	$0.40/yr		$97.00/ac	Bowker, 1997	$90.66/ac
$9.00/yr	Champ, 1997	$8.41/yr				
Per Residential Lot				Distance to Public Open Space		
$1,000	Knetch, 1962	$5,010		$0.21/ft	Milon, 1984	$0.31/ft
$1,130	Weicher, 1973	$3986		$4.20/ft	Correll, 1978	$9.24/ft
$1,609	Weicher, 1973	$5676				
$14,269*	Kulreshthra, 1993	$11,657				
$2,675	More, 1982	$4263				

*Canadian

**Australian

Public open spaces perform a wide variety of functions for people. Any particular area may be viewed as a collection of its various functions; they may be use functions that depend on people accessing the area or non-use functions that can be realized more passively. These individual functions may be highly valued, completely ignored, or even disliked by people. The next chapter presents a method for examining how people value the total package of functions a public open space offers.

METHODOLOGY

Theory of the Hedonic Price Model

The hedonic price model is based on the hypothesis that goods exhibit product differentiation and are valued for their utility producing attributes or characteristics (Rosen, 1974). A first stage regression of the product's price on its attributes allows the recovery of the hedonic or implicit prices of the attributes, although the underlying structure of demand and supply of an attribute are not normally revealed (Rosen, 1974)

Economic theory recognizes that parcels of land vary in quality or productivity (Freeman, 1993) The suitability of hedonic pricing to estimate land values is consistent with the classical theory of land rents, which states that parcels of varying productivity will have correspondingly different prices in equilibrium, ceteris paribus, as rents are bid up or down to exhaust all profits from the activity occupying the parcels (Lind, 1973). The hedonic price model works equally well for residential land which is more typically thought of as a consumption good than a factor in production. A residential parcel may be composed of attributes such as size, soil type, availability of sewer and water service, view, and distance to the nearest public open space, which are consumed to improve the owner's utility. It is assumed that buyers implicitly value each of these attributes and combine them to create a total price they would be willing to pay for a parcel.

Of course, no market generally exists for an attribute alone so the price for the attribute is not explicit. In a single market of sufficient size, however, there may be enough variability in the level of the attributes and prices paid for the parcels to disaggregate the effect of each attribute on price and estimate an implicit price for each attribute. If the attribute is one of environmental quality, then this implicit price for the attribute may be taken as some measure of the value of the environmental good.

When analyzing residential property it may be important to distinguish whether an attribute characterizes the structure or the parcel of land when the attribute is expressed properly as a function of other attributes, such as lineal feet of water frontage per acre of land or distance to the nearest school times the number of bedrooms. Many environmental and neighborhood attributes, such as distance to the nearest public open space characterize the parcel of land (Freeman, 1993)

The Hedonic Price Function

The following discussion of the theoretical aspects of the hedonic price model borrows heavily from Freeman (1993).

Assume that each person has a utility function dependent on four types of inputs: **X**, a composite of all commodities besides housing, such as food and transportation, scaled to $1; **Q** a vector of parcel specific environmental amenities, such as residential distance to public open space or noise level; S, a vector of residence structural characteristics, such as size and quality of materials; and **N**, a vector of neighborhood characteristics, such as school quality and size of the nearest public open space. Freeman (1993) describes park accessibility as a neighborhood characteristics but this may vary by parcel within a neighborhood so it is considered as belonging with the parcel specific environmental amenities in this study.

It is assumed that a large, competitive property market exists with sufficient variability for each buyer to find a residence with the mix of attributes necessary to maximize their utility. It is further assumed that this market is in equilibrium, that buyers with full information have purchased the complete stock of housing with the attendant environmental and neighborhood attributes. With these assumptions, it may be stated that the price of the *i*th house, P_{hi}, is a function of the structural, neighborhood and environmental characteristics of the *i*th property. Or that,

$$P_{hi} = P_h (\mathbf{S}_i, \mathbf{N}_i, \mathbf{Q}_i) \qquad \text{(Equation 3.1)}$$

The utility function for the buyer of the *i*th house is given as,

$$u = u(\mathbf{X}, \mathbf{S}_i, \mathbf{N}_i, \mathbf{Q}_i) \qquad \text{(Equation 3.2)}$$

Where

u is the individual's utility,

the other variables as described above.

It is further assumed that this utility function is weakly separable in the attributes for housing. That is, the marginal rates of substitution between any pair of specific attributes within vectors S, N, and Q is independent of the quantities of goods consumed in X. This has the convenient result of simplifying the estimation of the demands for housing characteristics by making them independent of the prices of other goods.

This utility function is maximized subject to the budget constraint,

$M\text{-}P_{hi}\ \text{-}X = 0$ (Equation 3.3)

The first order condition to maximize utility for the choice of environmental attribute q_j is

$$\frac{\partial u / \partial q_j}{\partial u / \partial X} = \partial P_{hi} / \partial q_j \qquad (Equation\ 3.4)$$

This condition equates the ratio of the first partial derivatives of the utility function with respect to the *j*th environmental variable and the composite good to the ratio of the first partial derivatives of the price function to the *i*th house and the *j*th environmental variable. That is, roughly, the change in the price of a residence due to a small change in the level of an attribute is equal to the dollar measured change in the owner's well-being. The importance of this condition is that, in equilibrium, the marginal implicit or hedonic price of an attribute, which can be estimated empirically, is equal to the individual's marginal willingness-to-pay to improve their welfare. Thus, the hedonic price model may allow some insight into changes in welfare due to changes in environmental quality.

The Willingness-to-Pay Function.

As noted above, a first stage regression of the price function reveals hedonic prices but not the complete willingness-to-pay function.

The compensated willingness-to-pay function, or inverse demand curve, for individual ,*i* , is found by solving the choice problem

$b_{ij}= b_{ji}\ (q_j, Q_i^*, S_i, N_i, u^*)$ (Equation 3.5)

Where

b_{ij} is the bid, or willingness-to-pay, of the *i* th individual to obtain the *j*th environmental attribute,q_j.

Q_i^* is a vector of all environmental attributes except for *j*,

u^* is the level of utility found by maximizing Equation 3.2 above, held constant.

The other variables as defined above.

Estimating Equation 3.5 would require a second stage of regression analysis. However the validity of doing this is in question and will be discussed later. The willingness-to-pay function (Equation 3.5) is useful for discussing changes in social welfare due to changes in the quantity of environmental attributes.

If we assume the environmental attribute to be non-exclusive and non-rival in consumption, one person's demand will not be affected by another's use. The simple summation of all individuals' willingness-to-pay for attribute q_j will be society's willingness-to-pay,

$$w_{qj} = \sum_{i=1}^{n} b_{ij} \qquad \text{(Equation3.6)}$$

Where

w_{qj} is the aggregate marginal welfare change.

At market equilibrium this is also equal to the sum of hedonic or implicit prices of the attribute so that

$$w_{qj} = \sum_{i=1}^{n} \partial P_h / \partial q_j \qquad \text{(Equation3.7)}$$

It is possible to specify changes in welfare resulting from non-marginal changes in an environmental attribute by integrating the area under an individual's bid curve (Equation 3.5) over the range of the change then summing over all individuals. It may, however, be difficult or impossible in practice to have sufficient information to achieve a correct measure. The individual bid function in Equation 3.5 is often not known and using the hedonic price may provide only an upper (lower) bound on welfare change for increases (decreases) in supply of the attribute due to income effects.

An exception to this difficulty is pointed out by Freeman (1993) as the case in which only a few households are affected by the environmental change hence the market supply does not shift. The change in welfare is equal to the increase in property values for those residences.

Specification of the Model

Although the hedonic price (Equation 3.1) above, can easily be specified in its general form, several choices must be made prior to its estimation.

Selection of the appropriate dependent variable is one choice that must be made. Residential property value may be reflected by appraised value, assessed value or sales price. Any of these may serve as the dependent variable but the sale price is the result of observable market behavior. One of the strengths of the hedonic model relative to some other non-market valuation techniques, such as contingent valuation, is the ability to use actual, instead of hypothetical, behavior. To utilize this strength sale price must be used.

A potential weakness in using sale price is the possibility of having transactions that are not conducted at arm's length, in which case the buyer may not be revealing their true willingness-to-pay. There is reason to believe this was frequently the case in Corvallis, as will be discussed later. Another potential weakness is that prices may reflect transactions that occurred when the market was not in equilibrium, violating an assumption of the model.

The value of residential property from private appraisers was not available for this study. Assessed values were provided by the Benton County Department of Assessment. They were used informally with one model simply for the sake of comparison. Although the explanatory value of the model was high, assessed values are not determined by local market behavior. They are the result of a deterministic approach based on national engineering standards which are then modified by local cost factors. The use of market behavior based data was desired for this study.

Selecting the correct explanatory variables can be even more difficult. As noted earlier, environmental attributes may influence the price of a parcel of land more than the structure. When samples include parcels with structures present it is important to include variables which account for the value of the structure. It may also be necessary to adjust some variables by the size of the parcel. Diamond (1980) argues that many amenities should be modeled on a per square foot of land basis. For example, if clean air were a valuable amenity, a large parcel would have more clean air than a small parcel. Therefore, it is reasoned, an air quality measure would correctly be divided by the size of the parcel. This need not hold true for every amenity. A family using a park would receive only one family's worth of benefit from a park regardless of the size of parcel on which they live.

Since the factors that influence a person's willingness-to pay may not be known, many explanatory variables may be viewed as proxies with the resultant question being, how well do they function as proxies? The explanatory power of the regression may provide some insight but there is no completely satisfactory answer to the question.

Choosing the correct functional form of the hedonic price equation is a much discussed topic in the literature but it is generally conceded that theory does not dictate one particular form (Milon,1984). Rosen (1974) noted that there is no theoretical reason for the equation to be linear, then proposes that a non-linear function may be more likely due to the underlying assumption of zero repackaging costs inherent in a linear model. A linear model essentially states that a residence with two units of attributes will cost twice as much as a residence with one unit of attributes and, therefore, it must be possible to make the larger residence into two smaller ones at zero cost.

Several authors (Milon,1984; Graves, 1988) argue that the best procedure is to let the data select the form by using a flexible approach such as the Box-Cox transformation of the data and looking for goodness of fit. Criticisms of this approach include the need to estimate more coefficients with the Box-Cox procedure, which reduces the accuracy of any single coefficient and that the non-linear transformations result in complex, difficult to interpret slope coefficients (Cassel, 1984) It has also been shown that the Box-Cox procedure is not robust with respect to heteroskedasticity in the error terms (Lahiri, 1981). Finally, it has been demonstrated that when specification errors are present or when proxy variables are used, a linear function outperforms the Box-Cox procedure in reducing errors (Cropper, 1988).

Estimation Issues

Market equilibrium is one of the assumptions underlying the hedonic price model. This entails that buyers and sellers are fully aware of each other and the properties and that prices adjust freely to clear the market, i.e., sell the entire supply of residences. It is difficult to determine if this assumption is met for this study.

For the time period of this study Corvallis may be characterized as a seller's market regarding residential property. Prices commonly rose 15% per year (Moore, 1998), with some properties remaining on the market for a few hours at most before selling. These conditions don't seem to indicate that buyers or sellers were fully informed; on the other hand rapidly changing prices do indicate a market that adjusts freely. In the case of this study, market equilibrium would also require that both buyer and seller are aware of the nearest public open space and not believe that any vacant, private lots are public. Although it would seem likely that owners of property close to undeveloped private open space would be aware that it is not public, this may not be the case for more distant residents. Data available on site do not clearly distinguish between vacant private land and adjoining vacant public land, especially on the city fringes. This issue may be made more complicated when valuing non-use amenities such as enjoying the view of vacant private land next to public land.

Related to the issue of market equilibrium is the choice of defining the physical size of the market. Freeman (1993) notes that in a large market it is possible for submarkets to exist, each of which may have a separate hedonic price function. Although this would require separate estimation of each function it would allow estimation of the second stage regression if the attribute of interest is present at various levels in the various sub-markets. Freeman (1993) suggests this be done by regressing the implicit prices estimated by the first regression against the quantities of the attribute and the exogenous demand shift variables, such as income, to obtain an uncompensated demand curve.

If sub-markets are not present estimation of the demand curve is not possible, as noted by Brown (1982), since no new information is produced by reformulating the original hedonic price function. A technique suggested by Rosen (1974) was to use the estimated marginal attribute prices as a dependent variable in the individual willingness-to-pay function regressed against same explanatory variables. This approach does not allow identification of the underlying demand curve, as he later noted (Brown, 1982), but instead created a curve that was essentially dependent on the first stage functional form. For example, using a linear first stage equation would always yield a horizontal demand curve.

A potential problem with explanatory variables in hedonic models is the existence of collinearity, that is, when two or more variables tend to increase (or decrease) together. To the degree that variables tend to move together, it increases variance and it is difficult to distinguish the effect of each variable. Omitting the troublesome variables will introduce bias into the estimates.

Heteroskedasticity is another potential problem in residential housing data. Systematic errors in pricing may arise due to size and complexity, age, or completeness of the structure. Typically, in residential housing data the variance in the price increases as the size of the parcels and structures increase. When this increase in variance becomes significant it violates the assumption of constant variance which underlies OLS and must be corrected. Heteroskedasticity is dealt with in more detail in the next chapter.

EMPIRICAL ANALYSIS

Description of the Study Area

The study area for the research is Corvallis, Oregon. The city's population and new home construction were increasing at the time the data were collected. The city's population was 40,960 in 1980 and by 1990 it had grown to 44,757. The 1995 population was 47,487 (Moore, 1998). The City issued building permits for 1,474 new residential units during the1980's and 2,836 new residential units for the period 1990-1997 (City of Corvallis, 1998). The pace of development slowed in 1997 when 207 permits were issued, compared to 580 permits in 1996. The average assessed value of a single-family residence in 1996 was $148,724, while the average value of an owner-occupied home in 1990 was $71,010 (Moore, 1998). Although the values are not directly comparable, the doubling in price is consistent with an informal estimate by the Benton County Assessors office in discussion with the author.

Median family income was $34,816 in 1989, increasing 38% to $48,146 in 1997, in nominal dollars. Corvallis is among the highest of Oregon cities in family income and housing costs. The average household size was 2.31 persons in 1997, below the state average and possibly due in part to the university student population (Moore, 1998).

The city has 14 parks, 10 of which were used in this study. Three parks on the edge of the city and one centrally located park had an insufficient number of nearby residences to be considered useful. Other public open spaces included 7 schools, 3 cemeteries, and 13 other open space areas. This last group included two undeveloped parks, drainage ways, and vacant lots owned by homeowner associations.

Corvallis Property Market

The analysis of the value of residential property in this report relies on cross-sectional data, which provides only a snapshot of a dynamic market. Although this snapshot is of people's values at one particular time, those values will include their expectations about the future. No formal attempt will be made to model the possible shifts in demand and supply, however a brief discussion of some likely factors is presented.

The State of Oregon has instituted statewide land-use planning by requiring local governments to adopt comprehensive land-use plans. The local government plans are tailored to achieved nineteen statewide goals such as protecting farm and forest lands, meeting recreational needs, providing adequate land for housing and conserving public open space and protecting natural and scenic resources (DLCD, 1995).

The City of Corvallis and the surrounding Benton County have implemented comprehensive plans with one result being that most development occurs within the City limits, some development occurs in the urban fringe area and very little occurs in rural areas. The urban fringe is a legally defined area, called the Urban Growth Boundary, where the City and Benton County coordinate planning efforts with the expectation of the land eventually being annexed into the City. In addition to a parcel meeting planning requirements prior to development, voters of the City of Corvallis must approve most annexations to the City.

These two factors, planning requirements and voter approval, may significantly affect the supply of land for development. Comprehensive planning is implemented to reduce urban sprawl and to provide for orderly development. This by its nature reduces the supply of land upon which development is permitted. In addition, the City has infrastructural requirements that must be met prior to development, such as street, water, and sewer service. Access to these services may be limited by the comprehensive plan itself or by the City's budget. The supply of buildable land may also be affected by city voters refusing to annex additions to the City from the Urban Growth Boundary (UGB), as has happened in the past.

The demand for residential property may be influenced by such factors as change in population, demographic change, employment levels and income. The 1990 population for Corvallis was 44,757 (Moore, 1998). This is expected to increase to 58,461 in 2020. Unemployment in Benton County averaged 2.7% in 1996, about one-half the state average of 5.6% (Gazette-Times, 1997).

The City of Corvallis commissioned a study of its land requirements titled "Buildable Land Inventory and Land Need Analyses for Corvallis". It was prepared by Terry Moore and Bob Parker of the economic consulting firm ECONorthwest in 1998 and the following section draws heavily from their report. Moore and Parker (1998) utilized the Real Estate Location Model (RELM) developed by Metro of Portland to analyze Corvallis' need for land for the next 20 years. The analysis focused primarily on the physical requirements for land and was concerned less with the land market and the price of land.

Factored into the demand for land were employment trends for Oregon and Benton County; trends in development density; demographic trends on household and family size, type, income, and age; and trends in type of housing demanded. The authors then forecast a demand for residential land needs. A similar analysis was done for commercial and industrial land and then for public/institutional land. Their summary of land requirements showed that Corvallis would need about 741 acres of residential land, 447 acres of commercial and industrial land, and 657 acres of public/institutional land (which includes park land) for a total of 1845 acres.

Of particular interest to this study is the estimation that 321 acres of additional land for parks will be required based on the City's Comprehensive Plan requirement of 35 acres of park land for every 1,000 people.

The current supply of land was calculated using GIS information supplied by the City and tax lot information from the Benton County Assessor. Moore and Parker (1998) estimate the supply of land within the Urban Growth Boundary (including the City) to be 173.7 acres of agricultural land, 1,787.6 acres of commercial/industrial/mixed use, 94.3 acres of public/institutional, and 4,655.2 acres of residential for a total of 6,710.8 acres. About one-third of this total, 2,311.2 acres, is within the City limits. Although the supply of land is apparently sufficient to meet the demand, with the exception of public/institutional land, the authors make note of the possible restrictions to land supply noted above and of the fact that some parcels may be withheld from development due to topography, legal issues, or speculation.

These restrictions on supply may, in part, explain the significant upward movement of residential property prices in Corvallis that has occurred in the 1990's. The Benton County Assessor (1995) developed a property price deflator schedule that shows prices for vacant residential lots increasing in price by up to 35% per year during the early 1990's.

A more likely explanation for rapid price increases, though, is a shift in demand. Total employment in Benton County increased from 34,330 in 1990 to 41,820 in 1996, (Moore, 1998) an increase of 21.8%.

Residential property prices used in this study of the value of public open space reflect sales over a 5-year period and are adjusted for inflation to reflect constant 1995 prices. The price of land in Corvallis is dependent on many factors, has changed rapidly and significantly in the recent past, and will almost certainly change in the future. The absolute magnitude of any factors of property price estimated in this study should be considered in light of this.

Description of the Data

The dependent variable in this study is the sale price of residential property sold from 1991 through 1995, adjusted to 1995 dollars by a market area specific price index created by the Benton County Department of Assessment. The index is created by interviews with local contractors to determine the construction costs in Corvallis. The use of data collected from several years of property sales is done to increase the number of observations. This has been done in other studies for periods ranging from two years (Diamond, 1980) to nine years (Mooney, 1997).

There are two potentially significant problems with using sale price as the dependent variable. First, as noted earlier, the residential property market may not have been in equilibrium during this time. Secondly, the possibility exists that transactions are not conducted at arm's length.

No clear evidence was found to indicate that the market was not in equilibrium, although prices increased rapidly during this time span. The City annexed about 300 acres between 1990 and 1996 and the population increased by about 4,500 people (Moore, 1998). These may indicate shifts in supply and demand, however, they do not indicate that price is not free to adjust and clear the market. The City does not have any rent control or price control programs for residential property (Weiss, 1998). Thus, it will be assumed that the market was in equilibrium.

The existence of transactions not conducted at arm's length, on the other hand, is almost certain. The Benton County Department of Assessment has created 22 reject codes that identify when transactions may not reflect the fair market value of a property. This may be for such reasons as a trade, donation to a charity, or when a sale includes personal property. When the sample was screened by theses reject codes, approximately two-thirds of the observations were deleted. This proportion was confirmed as normal by Scott Mullen of the Department of Assessment but was greater than the twenty-six percent of observations deleted in a similar study done in Portland, OR (Mahan, 1996).

Given the high proportion of questionable observations, this cast some doubt about the remaining observations. In the remaining sample, the sale price was compared to the assessed value and the observation was rejected if the sale price differed from the assessed value by 50% or more. The 50% difference was chosen because it seemed unlikely that many of the assessed values would differ from fair market value by that much. If the assessed value were high the taxpayer would likely appeal the assessment and; conversely; Benton County would lose revenue if the assessor undervalued a property. This second screening reduced the sample size by another third. The final aggregate sample contained 925 observations. This was taken as evidence that not all tainted sales had been removed by the reject codes. Overall, the assumption that sale prices reflect arm's length transactions may not be valid and this constitutes a fair criticism of the study.

In order to minimize variation not accounted for by the hedonic model the type of residential property examined was limited to three county assessment classes: Class 100-vacant residential land, Class 101-residential improvement and zoned residential, Class 171-single family residence but zoned multi-family.

Selection of the explanatory variables for inclusion in the hedonic price equation was done by reviewing previous literature and in discussions with Scott Mullen, Chief Appraiser, Benton County Department of Assessment.

TABLE 4.1 Variables Used in Previous Studies

Variable	Authors			
Structural Variables				
Dwelling size	Graves, 1988	Cropper, 1988	Mooney, 1997	Correll, 1978
Garage size	Kulshreshtha, 1993	Li, 1980	Donnelly, 1989	Cropper, 1988
Fireplace	Li, 1980	Cropper,1988	Donnelly, 1989	Graves, 1988
Hardwood floors	Department of Assessment			
Sauna	Kulshreshtha, 1993			
Quality index	Mooney, 1997			
Depreciation	Department of Assessment			
Environmental Quality Variables				
Distance to amenity	Graves, 1988	Correll, 1978	Li, 1980	
Landscaping	Department of Assessment			
Traffic/Noise	Department of Assessment	Li, 1980		
Lot size	Li, 1980	Mooney, 1997	Graves, 1988	Cropper, 1988
Neighborhood variables				
Proxy for quantity of amenity	Mooney, 1997	Graves, 1988	Li, 1980	
School quality	Li, 1980	Mooney, 1997		

Although no studies were found which used depreciation as an independent variable, many studies used age, which may function as a proxy for depreciation. The depreciation variable used in this study is the product of three separate measures: physical depreciation, completeness, and functional depreciation. Values for the three measures range from 1 to 100, with 100 being the most desirable condition. Physical depreciation is determined by the percent of a structure's estimated remaining life compared to its total life. For a new structure this value is 100. The completeness measures the degree to which a structure is constructed. A finished house has a value of 100. Functional depreciation measures the usefulness of the design of a structure. An example of poor design would be a basement with a very low ceiling. A house with a useful design would have a value of 100.

Additionally, no studies found used landscaping as a variable but Graves (1988), Li (1980) and Kulshrestha (1993) use view and visual quality as explanatory variables.

TABLE 4.2 Definition of Explanatory Variables

Variable Name	Description	Expected sign
Structural Variables		
LIVE AREA	Square feet of living area	positive
GARAGE	Square feet of garage area	positive
FIREPLACE	Dummy, 1 if fireplace present	positive
HARDWOOD	Dummy, 1 if hardwood floors present	positive
SAUNA	Dummy, 1 if sauna present	positive
CLASS	Values 1-7. Best quality housing is 7	positive
DEPREC	% measure of physical condition	positive
Neighborhood Variables		
OSAREA	Acres of nearest open space area	positive
OSAREA2	Square of OS area variable	negative
CLASS SIZE	Average class size of nearest school	negative
Environmental Quality Variables		
DISTANCE	Distance in feet to nearest open space	negative
DISTANCE2	Square of distance variable	positive
IDISTANCE	Inverse of distance variable	positive
LANDSCAPE	Dummy, 1 if excellent landscaping	positive
TRAFFIC	Dummy, 1 if excess traffic present	negative
LOT SIZE	Square feet of lot size	positive

Information on variables was obtained from the Benton County Department of Assessment with the following exceptions. Class size information was obtained from the Corvallis 509J school district for the 1994-95 school year. Distance to the nearest public open space and the size of all nonrectangular tax lots was calculated using a computer aided drawing program to analyze a digital map supplied by the City of Corvallis Public Works Department. The sample was restricted to observations within the Corvallis City limits. The final aggregate sample contained 925 observations.

The data describing public open space areas were divided into eight sub-samples: (1) the aggregate sample, (2) all property within 200 feet of a public open space, (3) parks, (4) schools, (5) cemeteries, (6) wetland open space, (7) upland open space, and, (8) the wetland and upland samples combined. The use of the generic term open space to mean any relatively vacant parcel accessible to the public may lead to confusion. For the purpose of this study, public open space is used as a generic term for a parcel of relatively vacant land and includes schoolyards, cemeteries, parks, and undeveloped wetlands and uplands. Further, for the purpose of this study, parks are distinguished from upland and wetland areas by the presence of recreational equipment and landscaping. The presence of only trails would not qualify a parcel to be counted as a park.

Each of the public open space areas was inspected to ensure it was placed in the proper category and checked for any unusual conditions, such as restricted access, that would make it an inappropriate study area. Four city parks were dropped from the study due to the lack of surrounding residential property. Two city parks were categorized as upland open spaces because they lacked recreational facilities. On-site inspection also led to reconsideration of the expected sign of the DISTANCE and OSAREA variables for the wetland open space category. The wetland open space areas were typically creeks and drainage ways. Many adjacent property owners had erected privacy fences between the public and private property. This provided some indication that wetland open space was viewed as a nuisance, possibly due to the presence of children playing there as evidenced by the many trails, small dams, and occasional playthings discovered.

The explanatory variables were tested for the degree of collinearity they possessed. Regressors that are nearly linear combinations of other regressors produce estimates that are unstable and have high standard errors (SAS, 1990). The COLLIN option of the SAS computer program uses a collinearity test suggested by Belsey, Kuh, and Welsch (1980) to produce two measures of collinearity, called "condition number" and "variance proportion". A variable has several different variance proportions, one for each of the other independent variables. This option was used on the sample. Belsey, Kuh, and Welsch (1980) suggest that a regressor exhibits strong collinearity when two conditions are met. First, its condition number must be greater than 30, and, second, its variance proportions with at least two other variables must be greater than 0.5. This situation occurred with the variable for CLASS SIZE and the intercept term, suggesting that the regressor "CLASS SIZE" did not vary a great deal. A weak dependency was indicated between the variables HARDWOOD (floors), CLASS (construction quality), and to a lesser extent, LIVE AREA.

A calculation of simple correlation revealed a correlation of 0.69 between CLASS and LIVE AREA and a correlation of 0.48 between CLASS and GARAGE. Although there is some evidence that the CLASS variable is to some degree collinear with other variables its inclusion in the model was recommended by Scott Mullen, the Chief Appraiser for the Department of Assessment.

TABLE 4.3 Descriptive Statistics for the Aggregate Sample

Variable	Sum	Mean	Standard Deviation
LIVE AREA	1493150	1615	703
GARAGE	314278	340	210
FIREPLACE	670	0.72	0.58
HARDWOOD	39	0.04	0.20
SAUNA	72	0.07	0.26
CLASS	3223	3.48	1.02
DEPREC	75623	81.8	13.4
DISTANCE	365351	395	283
LANDSCAPE	7	0.007	0.08
TRAFFIC	64	0.06	0.25
LOT SIZE	8491217	9189	5427
OSAREA	19328	20.9	14.5
CLASS SIZE	24619	26.6	2.0

First Stage Regression Analysis

The first stage regression uses ordinary least squares to estimate the hedonic price function (Equation 3.1). The function relates the sales price of a residential property to its structural, neighborhood, and environmental characteristics. The econometric model estimated is

$P_h = XB + e$ (Equation 4.1)

Where

P_h is a vector of the sale price of residential properties,

X is a matrix of observed values of all the explanatory variables including a constant,

B is a vector of coefficients; one for each variable to be estimated by ordinary least squares,

e is a vector of residuals; one from each observation.

Ordinary Least Squares Regression

A linear form was chosen for this relationship and regression was performed using the REG procedure in the SAS software package.

The sample was tested for the presence of heteroskedastic errors. A normal assumption of ordinary least squares is that the errors have a constant variance. If the error variance is not constant, least squares estimators will be unbiased but inefficient and estimates of their variances will be biased, invalidating tests of significance (Maddala, 1992).

As a part of the regression, the SPEC option was selected which performs a combined test for heteroskedasticity and correct specification suggested by White (1980). The test yielded a chi-square value of 154 with 88 degrees of freedom. The chi-square critical value for a 95% confidence level is approximately 113. The null hypothesis of homoskedastic errors and correct specification was rejected.

Knowledge of the form of the heteroskedasticity is necessary to correct it and reduce the variance of the estimates. Several other tests for heteroskedasticity are suggested in Maddala (1992) and three were selected which revealed more information about the form of the problem. Another test, suggested by White, was used in which the square of the residuals is regressed against all variables and their squares, except for dummy variables. The results supported the conclusion that heteroskedasticity was present and suggested that LIVE AREA, DEPREC, and GARAGE might be the source of the variance in errors.

Personal communication with Professor William Brown, Department of Agricultural and Resource Economics, Oregon State University, combined with the test results led to the conclusion that LIVE AREA and to a lesser degree DEPREC were most strongly influencing the error variance and two additional tests were suggested. A Breusch-Pagan test was performed following Maddala (1992) using DEPREC and LIVE AREA as explanatory variables. The hypothesis of homoskedasticity was rejected and it was noted that LIVE AREA was more significant in explaining the variation in errors than DEPREC. Finally, two Goldfeld and Quandt tests were performed as suggested by Maddala (1992). The F value was 1.32 for the DEPREC test and 3.48 for the LIVE AREA test, both greater than the critical value of 1. The hypothesis of homoskedasticity was rejected in each case, though obviously by a larger margin in the LIVE AREA test.

An assumption about the form of the error variances was made and examined using weighted least squares. The assumption and weight are

Assumption

$$V(e_i) = \sigma^2(a_1(\text{LIVE AREA})^2 + a_2(\text{DEPREC}) + a_3(\text{DEPREC})^2)^2$$

Weight

$$1/\ a_1(\text{LIVE AREA})^2 + a_2(\text{DEPREC}) + a_3(\text{DEPREC})^2$$

Where

$V(e_i)$ is the error variance,

σ^2 is a constant.

The coefficients, a_n, are estimated by regressing the explanatory variables against the squared residuals from the original OLS regression.

The functional form for the OLS regression used to generate the squared residuals was the same as used with the final weighted least squares regression (see below). The weighted observations were then used to develop another first stage regression.

Weighted Least Squares Regression

First stage regression was performed each of the weighted data sub-samples using the following econometric model

$P_h = X_zB + e$ (Equation 4.2)

Where

X_z is a matrix of the observed values of the explanatory variables already discussed, all multiplied by the weight.

The inverse of the DISTANCE variable (IDISTANCE), squared terms for the DISTANCE and OSAREA variables (DISTANCE2 and OSAREA2), and the weight were included in the matrix as a way of allowing a non-linear relationship with heteroskedasticity to be modeled easily. The SAS procedure required data transformations prior to the calculations.

Two different functional forms were specified for the sample. The first form was linear in all variables except that distance to open space was included only as an inverse (IDISTANCE) and open space area was included as a quadratic (OSAREA and OSAREA2). In the second form, IDISTANCE was dropped. Both distance to open space and open space area were entered as quadratic terms (DISTANCE, DISTANCE2, OSAREA, and OSAREA2) and the remainder of the model was linear. In sum, the only difference between the models is that the distance term is an inverse in one model and a quadratic in the second.

Models with non-linear relationships between the dependent variable and the two variables of interest were selected as a compromise between the suggestions by Rosen (1974) and Milon (1984), which tended to support non-linear forms on theoretical grounds, and the comments of Lahiri (1980) and Cassel (1985), which focus on the econometric problems associated with the very flexible Box-Cox procedure. This allows the effect of public open space to diminish as the properties are located farther from the open space but the data are not used to determine the nature of the relationship. In addition to theoretical concerns, a regression with a simple linear form resulted in a low significance level ($t=1.17$) for the coefficient on the distance variable.

The results are presented and discussed in the next chapter.

Second Stage Regression Analysis

The possibility of performing a second stage regression was examined by making the assumption that each public open space formed the nexus of a distinct sub-market. The sample was then disaggregated by each of the 33 public open spaces and regressions were performed using the inverse distance model. As was expected, few coefficients in any of the sub-samples were significant. Statistically, this was likely due to the small sample sizes (the average sample had 28 observations) and weak relationships. As a practical matter, Corvallis is too small and homogeneous of a city to have many residential sub-markets. Results of the attempt at second stage regression are not presented and no further estimations were attempted.

RESULTS

Factors of Residential Property Prices

The weighted first stage regressions were performed to relate the sale price of residential property to its characteristics. The essential idea is that, roughly speaking, the value of a property is equal to the value of its constituent parts. This chapter will examine the estimated value of the parts.

A total of 16 regressions were estimated. These represent two different functional forms for each of eight different sub-samples. The difference between the two functional forms is whether distance is included as an inverse term (IDISTANCE) or as a quadratic term (DISTANCE and DISTANCE2). The data were divided into 8 sub-samples according to the type of nearest public open space. The sub-samples are: the aggregate sample, the aggregate sample but limited to property within 200 feet of a public open space, parks, schools, cemeteries, wetland open spaces, upland open spaces, and wetland and upland open spaces combined.

One measure of a regression model's goodness of fit is the ratio of its explained sum of squares to its total sum of squares, or R^2. The R^2 values for the regressions have been judged acceptable for hedonic models of property price (Diamond, 1980; Graves, 1988; Mooney, 1997). The R^2 values for the regressions ranged from .65 to .91, but were generally about .70. The estimated coefficients and their associated t-value are given in Table 5.1.

When discussing or using the estimated coefficients it is important to remember that, except for dummy variables, they are assumed to represent the effect on price of marginal (small) changes in an attribute for the range of values from which they were estimated. They may not be a valid representation of the effect for changes in the quantity of the attribute outside this range. The estimated coefficients on the dummy variables represent the effect of non-marginal changes in the level of an attribute. Instead, the coefficients estimate the effect of the presence of the attribute.

The only variables significant at the 95 percent confidence level in all regressions were LOT SIZE and LIVE AREA (living area measured in square feet). Other variables failed to be significant at this level anywhere from 2 to 14 times in the 16 regressions. A summary of the frequency of variables failing to be significant is presented in Table 5.2.

Table 5.1 Results of Weighted First Stage Regressions, by Sub-Sample and Model

AGGREGATE-INVERSE N=925 R^2=.72

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	30978	9937.6658503	3.117	0.0019
IDISTANCE	1	1065.844217	2222.5733755	0.480	0.6317
LANDSCAPE	1	5727.300895	9871.5268036	0.580	0.5619
TRAFFIC	1	-9837.155743	2776.4632656	-3.543	0.0004
LOT SIZE	1	1.132328	0.12274602	9.225	0.0001
OSAREA	1	630.478466	123.20232256	5.117	0.0001
OSAREA2	1	-7.271510	2.18166282	-3.333	0.0009
CLASS SIZE	1	-3072.950377	320.79477835	-9.579	0.0001
LIVE AREA	1	54.678636	1.89173646	28.904	0.0001
DEPREC	1	768.622197	66.28754971	11.595	0.0001
CLASS	1	5141.343122	1112.3506556	4.622	0.0001
GARAGE	1	30.746955	4.25647557	7.224	0.0001
FIREPLACE	1	4117.522381	1446.6646439	2.846	0.0045
HARDWOOD	1	4594.345613	4267.3186855	1.077	0.2819
SAUNA	1	26081	4376.0732980	5.960	0.0001

AGGREGATE-QUADRATIC N=925 R^2=.71

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	24396	10613.448844	2.299	0.0218
DISTANCE	1	4.264440	8.29051165	0.514	0.6071
DISTANCE2	1	0.000685	0.00887930	0.077	0.9385
LANDSCAPE	1	4752.399605	9821.2020988	0.484	0.6286
TRAFFIC	1	-10348	2770.7445456	-3.735	0.0002
LOT SIZE	1	1.113135	0.12177090	9.141	0.0001
OSAREA	1	635.451758	123.20449348	5.158	0.0001
OSAREA2	1	-7.510898	2.18476989	-3.438	0.0006
CLASS SIZE	1	-2985.040419	322.98895662	-9.242	0.0001
LIVE AREA	1	54.756487	1.89195414	28.942	0.0001
DEPREC	1	805.201335	67.69427078	11.895	0.0001
CLASS	1	5077.654814	1108.7030151	4.580	0.0001
GARAGE	1	30.456154	4.24690115	7.171	0.0001
FIREPLACE	1	4153.161962	1442.9190105	2.878	0.0041
HARDWOOD	1	4519.287791	4246.0973033	1.064	0.2875
SAUNA	1	25792	4397.7227843	5.865	0.0001

Table 5.1 (Continued)

PARKS-INVERSE N=267 R^2=.71

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	26635	16725.484957	1.592	0.1125
IDISTANCE	1	13335	5828.2606534	2.288	0.0230
LANDSCAPE	1	18638	21566.178515	0.864	0.3883
TRAFFIC	1	-20859	7815.3848862	-2.669	0.0081
LOT SIZE	1	0.934963	0.40651727	2.300	0.0223
OSAREA	1	1999.314961	362.81302743	5.511	0.0001
OSAREA2	1	-40.849425	7.70136647	-5.304	0.0001
CLASS SIZE	1	-2982.272683	557.01407272	-5.354	0.0001
LIVE AREA	1	50.115446	3.19929858	15.665	0.0001
DEPREC	1	619.373513	125.95265455	4.918	0.0001
CLASS	1	9758.241420	2106.2854439	4.633	0.0001
GARAGE	1	29.139914	7.60284019	3.833	0.0002
FIREPLACE	1	2656.750918	2419.1761319	1.098	0.2732
HARDWOOD	1	7980.864335	6679.9954131	1.195	0.2333
SAUNA	1	27302	7118.5524098	3.835	0.0002

PARKS-QUADRATIC N=267 R^2=.70

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	17391	18338.870957	0.948	0.3439
DISTANCE	1	-9.269209	16.27227904	-0.570	0.5694
DISTANCE2	1	0.018371	0.01709248	1.075	0.2835
LANDSCAPE	1	17436	21798.251767	0.800	0.4245
TRAFFIC	1	-21578	7896.6986546	-2.733	0.0067
LOT SIZE	1	0.988426	0.40618341	2.433	0.0157
OSAREA	1	1676.862965	383.97603523	4.367	0.0001
OSAREA2	1	-33.954144	8.10769140	-4.188	0.0001
CLASS SIZE	1	-2748.961824	578.63052281	-4.751	0.0001
LIVE AREA	1	51.112575	3.23156695	15.817	0.0001
DEPREC	1	712.867827	132.83857795	5.366	0.0001
CLASS	1	8576.315202	2111.2102239	4.062	0.0001
GARAGE	1	27.650984	7.60437691	3.636	0.0003
FIREPLACE	1	1908.786816	2444.5063149	0.781	0.4356
HARDWOOD	1	7229.792039	6702.0464741	1.079	0.2817
SAUNA	1	28434	7232.3386926	3.931	0.0001

Table 5.1 (Continued)

COMBINED UPLAND AND WETLAND-INVERSE N=344 R^2=.78

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	23659	15441.055525	1.532	0.1264
IDISTANCE	1	127.131611	2566.6915831	0.050	0.9605
LANDSCAPE	1	8801.333791	12659.075240	0.695	0.4874
TRAFFIC	1	-10563	5063.8762797	-2.086	0.0378
LOT SIZE	1	0.843134	0.13306212	6.336	0.0001
OSAREA	1	117.162984	196.32734619	0.597	0.5511
OSAREA2	1	4.886866	3.34696581	1.460	0.1452
CLASS SIZE	1	-5509.141169	527.53183762	-10.443	0.0001
LIVE AREA	1	62.681372	3.06678637	20.439	0.0001
DEPREC	1	1607.580456	133.19561465	12.069	0.0001
CLASS	1	7172.697923	1880.2359834	3.815	0.0002
GARAGE	1	20.315380	7.08749217	2.866	0.0044
FIREPLACE	1	-719.446452	2283.7876524	-0.315	0.7529
HARDWOOD	1	2892.390915	6623.3979211	0.437	0.6626
SAUNA	1	8714.324791	5627.7982075	1.548	0.1225

COMBINED UPLAND AND WETLAND-QUADRATIC N=433 R^2=.78

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	23365	16110.488454	1.450	0.1479
DISTANCE	1	2.744524	12.55695745	0.219	0.8271
DISTANCE2	1	-0.002823	0.01621350	-0.174	0.8619
LANDSCAPE	1	7996.104193	12649.385570	0.632	0.5277
TRAFFIC	1	-10605	5068.0174577	-2.092	0.0372
LOT SIZE	1	0.836639	0.13179325	6.348	0.0001
OSAREA	1	130.747270	197.68635105	0.661	0.5088
OSAREA2	1	4.565034	3.40639488	1.340	0.1811
CLASS SIZE	1	-5479.014144	529.55114638	-10.347	0.0001
LIVE AREA	1	62.708148	3.07895595	20.367	0.0001
DEPREC	1	1599.656252	133.66123330	11.968	0.0001
CLASS	1	7101.266644	1883.4074327	3.770	0.0002
GARAGE	1	20.623817	7.15546815	2.882	0.0042
FIREPLACE	1	-823.501365	2295.1846619	-0.359	0.7200
HARDWOOD	1	2534.446803	6607.9710624	0.384	0.7016
SAUNA	1	8745.198196	5689.0521798	1.537	0.1252

Table 5.1 (Continued)

UPLAND-INVERSE N=245 R^2=.83

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	11988	72078.583885	0.166	0.8681
IDISTANCE	1	1152.845104	3264.9894000	0.353	0.7243
LANDSCAPE	1	3507.030521	12605.514759	0.278	0.7811
TRAFFIC	1	-1196.696162	5731.4952488	-0.209	0.8348
LOT SIZE	1	0.769914	0.13830577	5.567	0.0001
OSAREA	1	3748.897268	1261.9183345	2.971	0.0033
OSAREA2	1	-96.980772	36.66508652	-2.645	0.0087
CLASS SIZE	1	-7160.454401	2785.8528432	-2.570	0.0108
LIVE AREA	1	55.118219	3.54634344	15.542	0.0001
DEPREC	1	2012.554808	172.89928023	11.640	0.0001
CLASS	1	12023	2295.1107594	5.238	0.0001
GARAGE	1	22.408021	8.96070155	2.501	0.0131
FIREPLACE	1	565.166815	2859.9861033	0.198	0.8435
HARDWOOD	1	34386	10355.614617	3.321	0.0010
SAUNA	1	5089.325353	5792.7462392	0.879	0.3806

UPLAND-QUADRATIC N=245 R^2=.83

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	9624.216938	73115.378068	0.132	0.8954
DISTANCE	1	-1.427693	16.52891940	-0.086	0.9312
DISTANCE2	1	0.001229	0.02259459	0.054	0.9567
LANDSCAPE	1	2970.293928	12602.029019	0.236	0.8139
TRAFFIC	1	-1333.299925	5792.2292489	-0.230	0.8182
LOT SIZE	1	0.763088	0.13662964	5.585	0.0001
OSAREA	1	3809.320397	1270.4466517	2.998	0.0030
OSAREA2	1	-98.609774	36.89486024	-2.673	0.0081
CLASS SIZE	1	-7031.209523	2795.2188682	-2.515	0.0126
LIVE AREA	1	55.123761	3.56014508	15.484	0.0001
DEPREC	1	2006.185367	173.45093059	11.566	0.0001
CLASS	1	11955	2298.2502988	5.202	0.0001
GARAGE	1	22.547861	9.11142404	2.475	0.0141
FIREPLACE	1	572.610842	2875.8850301	0.199	0.8424
HARDWOOD	1	34728	10442.251448	3.326	0.0010
SAUNA	1	5104.682560	5866.0740689	0.870	0.3851

Table 5.1 (Continued)

WETLAND-INVERSE N=99 R^2=.65

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	67399	30372.948238	2.219	0.0291
IDISTANCE	1	3742.552018	4315.4296191	0.867	0.3882
LANDSCAPE	0	0	.	.	.
TRAFFIC	1	-34190	12156.915635	-2.812	0.0061
LOT SIZE	1	1.048451	0.42127391	2.489	0.0148
OSAREA	1	815.895938	905.14595291	0.901	0.3699
OSAREA2	1	-7.194572	13.35163069	-0.539	0.5914
CLASS SIZE	1	-4094.211406	757.39479650	-5.406	0.0001
LIVE AREA	1	72.421122	7.20627700	10.050	0.0001
DEPREC	1	672.973730	411.74119717	1.634	0.1059
CLASS	1	1866.494501	4945.2542701	0.377	0.7068
GARAGE	1	6.691817	10.78979778	0.620	0.5368
FIREPLACE	1	2296.522593	4101.3413065	0.560	0.5770
HARDWOOD	1	-17668	8490.7631949	-2.081	0.0405
SAUNA	1	-23268	27097.118112	-0.859	0.3929

WETLAND-QUADRATIC N=99 R^2=.65

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	69263	33138.319162	2.090	0.0396
DISTANCE	1	-6.253013	20.24462808	-0.309	0.7582
DISTANCE2	1	0.004233	0.02419454	0.175	0.8615
LANDSCAPE	0	0	.	.	.
TRAFFIC	1	-32496	12273.420457	-2.648	0.0097
LOT SIZE	1	1.031784	0.43567487	2.368	0.0202
OSAREA	1	711.336406	906.58881937	0.785	0.4349
OSAREA2	1	-5.691588	13.37862106	-0.425	0.6716
CLASS SIZE	1	-4142.091263	766.24402363	-5.406	0.0001
LIVE AREA	1	72.974757	7.32915434	9.957	0.0001
DEPREC	1	697.277158	416.40508279	1.675	0.0977
CLASS	1	1769.761609	5028.1794472	0.352	0.7257
GARAGE	1	7.182495	10.96327363	0.655	0.5142
FIREPLACE	1	1509.781988	4223.2264487	0.357	0.7216
HARDWOOD	1	-16443	8385.9555234	-1.961	0.0532
SAUNA	1	-22734	27530.450541	-0.826	0.4113

NOTE: Model is not full rank. Least-squares solutions for the parameters are not unique. Some statistics will be misleading. A reported DF of 0 or B means that the estimate is biased. The following parameters have been set to 0, since the variables are a linear combination of other variables as shown.

Table 5.1 (Continued)

CEMETARIES-INVERSE N=50 R^2=.91

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	B	-65472	22983.448916	-2.849	0.0070
IDISTANCE	1	-9067.578757	18020.893528	-0.503	0.6177
LANDSCAPE	0	0	.	.	.
TRAFFIC	1	-3677.620340	6119.2762197	-0.601	0.5514
LOT SIZE	1	2.689596	0.59136947	4.548	0.0001
OSAREA	B	8026.400577	6622.2869217	1.212	0.2330
OSAREA2	B	-223.404828	189.24743788	-1.180	0.2451
CLASS SIZE	0	0	.	.	.
LIVE AREA	1	36.314586	5.92828577	6.126	0.0001
DEPREC	1	744.094155	298.39414850	2.494	0.0171
CLASS	1	10217	3675.4966887	2.780	0.0084
GARAGE	1	14.670385	16.45005441	0.892	0.3781
FIREPLACE	1	11489	5646.8196417	2.035	0.0489
HARDWOOD	1	-2627.943080	12543.779388	-0.210	0.8352
SAUNA	0	0	.	.	.

CEMETARIES-QUADRATIC N=50 R^2=.91

					Parameter
Standard	T for H0:				
Variable	DF	Estimate	Error	Parameter=0	Prob > |T|
INTERCEPT	B	-58364	25941.684224	-2.250	0.0305
DISTANCE	1	6.208925	40.39999059	0.154	0.8787
DISTANCE2	1	-0.017687	0.03804982	-0.465	0.6448
LANDSCAPE	0	0	.	.	.
TRAFFIC	1	-4210.140891	6051.4802348	-0.696	0.4910
LOT SIZE	1	2.642390	0.58782059	4.495	0.0001
OSAREA	B	9876.337465	6616.7408696	1.966	0.0527
OSAREA2	B	-276.224544	189.00666618	-1.930	0.0592
CLASS SIZE	0	0	.	.	.
LIVE AREA	1	36.006205	6.00494501	5.996	0.0001
DEPREC	1	651.843003	289.70875034	2.250	0.0305
CLASS	1	10483	3644.0607166	2.877	0.0066
GARAGE	1	12.554118	16.39042176	0.766	0.4486
FIREPLACE	1	10049	5794.3376187	1.734	0.0912
HARDWOOD	1	1048.751370	12765.342451	0.082	0.9350
SAUNA	0	0	.	.	.

NOTE: Model is not full rank. Least-squares solutions for the parameters are not unique. Some statistics will be misleading. A reported DF of 0 or B means that the estimate is biased. The following parameters have been set to 0, since the variables are a linear combination of other variables as shown.

Table 5.1 (Continued)

SCHOOLS-INVERSE N=263 R^2=.68

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	52535	53257.009104	0.986	0.3249
IDISTANCE	1	-6810.417162	6726.1375630	-1.013	0.3123
LANDSCAPE	1	-8817.423968	19867.015613	-0.444	0.6576
TRAFFIC	1	-10869	4224.8711367	-2.573	0.0107
LOT SIZE	1	1.284640	0.47299109	2.716	0.0071
OSAREA	1	1652.981081	741.36728778	2.230	0.0267
OSAREA2	1	-35.078358	16.80342163	-2.088	0.0379
CLASS SIZE	1	-3509.358529	2134.5080780	-1.644	0.1014
LIVE AREA	1	44.529784	4.06585010	10.952	0.0001
DEPREC	1	455.756034	153.68747616	2.965	0.0033
CLASS	1	9117.588717	2778.5043887	3.281	0.0012
GARAGE	1	29.949535	8.02562572	3.732	0.0002
FIREPLACE	1	11281	2869.9313687	3.931	0.0001
HARDWOOD	1	13456	10349.625572	1.300	0.1947
SAUNA	1	37437	13456.578343	2.782	0.0058

SCHOOLS-QUADRATIC N=263 R^2=.68

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	32594	56902.121410	0.573	0.5673
DISTANCE	1	21.318382	17.24088108	1.237	0.2174
DISTANCE2	1	-0.016325	0.01671223	-0.977	0.3296
LANDSCAPE	1	-9472.394435	19721.549884	-0.480	0.6314
TRAFFIC	1	-10780	4208.8707486	-2.561	0.0110
LOT SIZE	1	1.197159	0.46504040	2.574	0.0106
OSAREA	1	1639.515952	754.20155820	2.174	0.0307
OSAREA2	1	-34.836186	17.08803210	-2.039	0.0426
CLASS SIZE	1	-2943.155185	2251.9078512	-1.307	0.1924
LIVE AREA	1	44.622650	4.08045452	10.936	0.0001
DEPREC	1	465.619016	153.14344410	3.040	0.0026
CLASS	1	9133.334902	2782.1671270	3.283	0.0012
GARAGE	1	29.006529	8.05060003	3.603	0.0004
FIREPLACE	1	11173	2856.9739919	3.911	0.0001
HARDWOOD	1	14213	10433.084369	1.362	0.1743
SAUNA	1	36636	13578.165041	2.698	0.0075

Table 5.1 (Continued)

DISTANCE FROM OPEN SPACE LESS THAN 200'

AGGREGATE-INVERSE N=284 R^2=.65

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	52109	18770.989299	2.776	0.0059
IDISTANCE	1	4189.857744	2786.7621124	1.503	0.1339
LANDSCAPE	1	44348	21631.778192	2.050	0.0413
TRAFFIC	1	-10364	6414.6463887	-1.616	0.1074
LOT SIZE	1	0.901286	0.15236120	5.915	0.0001
OSAREA	1	745.075658	285.89078778	2.606	0.0097
OSAREA2	1	-14.454132	6.14655341	-2.352	0.0194
CLASS SIZE	1	-3729.979481	619.97182085	-6.016	0.0001
LIVE AREA	1	60.473690	3.73873198	16.175	0.0001
DEPREC	1	771.099768	141.19602654	5.461	0.0001
CLASS	1	2126.796651	2194.2441694	0.969	0.3333
GARAGE	1	40.179945	8.77054295	4.581	0.0001
FIREPLACE	1	-1455.167111	2849.4638806	-0.511	0.6100
HARDWOOD	1	5124.714580	7674.9079403	0.668	0.5049
SAUNA	1	29912	7836.7739197	3.817	0.0002

AGGREGATE-QUADRATIC N=284 R^2=.65

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parameter=0	Prob > |T|
INTERCEPT	1	52975	19702.831714	2.689	0.0076
DISTANCE	1	-137.628892	73.08825197	-2.096	0.0394
DISTANCE2	1	0.719083	0.40517354	1.775	0.0771
LANDSCAPE	1	44521	21679.660131	2.054	0.0410
TRAFFIC	1	-10547	6403.6383017	-1.647	0.1007
LOT SIZE	1	0.885251	0.15128091	5.852	0.0001
OSAREA	1	803.606279	289.05181780	2.780	0.0058
OSAREA2	1	-15.839364	6.22515290	-2.544	0.0115
CLASS SIZE	1	-3655.853078	626.28679673	-5.837	0.0001
LIVE AREA	1	60.410503	3.73340484	16.181	0.0001
DEPREC	1	780.415889	141.82562520	5.503	0.0001
CLASS	1	2374.607196	2208.2171516	1.075	0.2832
GARAGE	1	39.231980	8.86788730	4.424	0.0001
FIREPLACE	1	-1531.098951	2849.7896282	-0.537	0.5915
HARDWOOD	1	4456.442107	7681.8266293	0.580	0.5623
SAUNA	1	29868	7867.9691426	3.796	0.0002

In the wetlands and cemeteries sub-samples the models were not full rank. The underlying cause of this is the limited amount of variation in the variables, usually due to small sample size. The result is that variables become linear combinations of each other and their effects can not be distinguished. This is an extreme form of collinearity, as discussed in the Methodology chapter. The coefficients will be either biased or not estimated.

TABLE 5.2 Number of regressions in which a variable has a confidence level less than 95 percent

Variable	Frequency
Structural	
INTERCEPT	8
LIVE AREA	0
GARAGE	4
FIREPLACE	11
HARDWOOD	13
SAUNA	8
CLASS	4
DEPREC	2
Neighborhood	
OSAREA	6
CLASS SIZE	4
Environmental	
DISTANCE, IDISTANCE	14
LANDSCAPE	14
TRAFFIC	6
LOT SIZE	0

In some cases, variables that failed to be significant at the 95 percent confidence level were significant at slightly lower levels. Variables with lower significant levels also will be discussed in order to gain more insight into a relationship that may exist between public open space and residential property values.

Variables Related to Structural Characteristics

Structural variables generally performed as expected. The coefficient on LIVE AREA was always significant, positive and of a reasonable magnitude, usually about $55 per square foot, ceteris paribus. The coefficient on GARAGE (area) was usually significant, always positive and typically about $30 per square foot, ceteris paribus. When coefficients on structural variables failed to be significant it was often in sub-samples with the smaller number of observations, particularly the cemeteries and wetland open space samples. Unexpected negative signs were produced on significant coefficients for three structural variables: FIREPLACE, HARDWOOD, and SAUNA, all dummy variables. This occurred in the combined upland and wetland sub-sample and the wetland sub-sample. Most of the observations in this sub-sample occur in the northern and newer portion of the city and it is possible that the model is not correctly specified for this geographic area. It may be that the SAUNA variable is functioning as a proxy for some unknown factor in higher priced newer homes or it may be viewed as a long-term maintenance liability.

The CLASS variable, an index related to construction quality, was usually significant, always positive (as expected) and typically about $5,000. The variable measuring physical condition, DEPREC, was also usually significant, always positive and typically about $700. This indicates that a 1 percentage point increase is estimated to increase a property's price by about $700, ceteris paribus.

Variables Related to Neighborhood Characteristics

A negative coefficient was expected on the variable for school CLASS SIZE and this was generally the case. No regressions produced a positive, significant coefficient on the variable. The negative coefficient on CLASS SIZE implies that buyers pay less for property near schools with more crowded classrooms. The magnitude of the coefficient was large, a reduction in price of about $3,000 per student increase, ceteris paribus, in average class size. The large magnitude suggests that the CLASS SIZE variable may function as a proxy for other variables. Each elementary school may be associated with other neighborhood amenities, such as commute distance, shade trees, or average income. For example, the school with the largest class size is also located in southeast Corvallis, which has the highest neighborhood crime rate.

The coefficient on the variable of interest, size of the nearest open space (OSAREA), was positive for all 16 sub-samples and was significant at the 90 percent confidence level in 12 of the 16. It was not significant in the wetlands or combined upland and wetlands sub-samples.

The magnitude of the coefficient ranged from about $600 to nearly $10,000. The latter figure was estimated in the cemetery sub-sample and was considerably higher than other areas. The confidence level for OSAREA in the cemetery sub-sample was only 90%, so the magnitude should be regarded with some caution.

For the aggregate sample, the coefficient implied that property prices increased about $600, ceteris paribus, for every acre increase in the size of the nearest public open space. This term was entered as a quadratic form and the squared term had the expected negative coefficient in 14 of 16 sub-samples, 12 of which were significant at the 90 percent confidence level.

Variables Related to Environmental Characteristics

LOT SIZE was the best performing environmental variable. The coefficient was significant at the 95 percent confidence level in all of the samples. The sign of the coefficient was positive and the magnitude of the coefficient was commonly around $1.00, implying that the marginal change in the price of residential land due to change in size was about $1.00 per square foot, ceteris paribus, in the aggregate sample. This does not imply that residential lots sell for about $1.00 per square foot in Corvallis. The total price for a typical lot is often five times this amount. The additional value results from the other amenities included in the model or from amenities not included in the data set

The coefficient on the excess TRAFFIC dummy variable failed to be significant in 6 of 16 samples. The sign of the coefficient was negative as expected. The magnitude in the aggregate sub-sample implied that property prices decreased about $10,000, ceteris paribus, when located on a street with excess traffic.

The coefficient on the LANDSCAPE dummy variable had the expected positive sign except in the schools sub-sample. It was not significant except in the sub-sample of property within 200 feet of open space area. The magnitude of the coefficient in this sub-sample was unexpectedly high, implying that property value increased about $44,000 if it had excellent landscaping. It may be that the excellent landscaping variable is serving as a proxy for a missing variable or variables. It may occur with higher priced luxury homes for which the model might be mis-specified.

The primary variable of interest, distance to the nearest public open space (DISTANCE), had coefficients that failed to be significant with a 95 percent confidence level in 14 out of 16 sub-samples. It was significant at this level in the parks sub-sample and the property within 200 feet of an open space sub-sample.

Unexpected, but not significant, signs were produced in four sub-samples, including schools and cemeteries In the schools and cemeteries sub-sample, both models produced unexpected signs on the DISTANCE variable. Schools may produce disamenities such as noise, litter, vandalism, and traffic congestion, which may outweigh the open space amenities, associated with them and account for the unexpected signs. It would seem that fewer disamenities would be associated with cemeteries although, conversely, there may be fewer benefits. For example, there are limited recreation opportunities in cemeteries. There may be some traffic or superstition associated with cemeteries that is a disamenity and accounts for the unexpected signs.

The DISTANCE variable performed best in the parks and property within 200 feet of an open space sub-samples. In the parks sub-sample, the coefficient on the inverse of distance variable (IDISTANCE) was significant at the 95% confidence level. It implies that the price of property increased $13,335, ceteris paribus, when located adjacent to a park.

In the sub-sample of all property located within 200 feet of an open space, the coefficient for the DISTANCE variable in the quadratic model was significant at the 95% confidence level. The coefficient on the variable of the squared distance term (DISTANCE2) was significant at the 90% confidence level. The coefficients imply that the price of property decreased $137, ceteris paribus, as distance from the park increased 1 foot, but also that the magnitude of this change decreased by $0.72 for each foot of change, a result of the quadratic form. The coefficient for the inverse of the distance variable (IDISTANCE) was significant at the 80% confidence level. It implies that property value increased $4189, ceteris paribus, when adjacent to public open space. The magnitude of the IDISTANCE coefficient should be viewed with caution due to the low confidence level.

Coefficients for DISTANCE or IDISTANCE were not significant for the upland open space sub-samples; t-values did not exceed 1.0. This was unexpected, as most of the upland open space areas were similar to parks, and in fact, two of the upland areas are actually designated by the City as parks, but are undeveloped. The apparent lack of a significant relationship may possibly be due to reduced recreational use value of upland open space or the existence of close substitutes in the form of private, undeveloped land near the city fringe.

As in the upland open space sample, the wetland open space sub-sample did not produce significant coefficients for distance variables in either of the models. On-site inspection of wetland areas had led to a revision of what the expected effect would be of open space on property values. After the inspection it was thought that wetlands would be viewed as a nuisance. This does not appear to be the case. Although neither of the coefficients on IDISTANCE or DISTANCE was significant, the sign on the coefficient for IDISTANCE was positive and the sign on the coefficient for DISTANCE was negative, both indicating that property prices were positively affected by proximity to wetlands.

Testing the Study Hypotheses

As noted in the first chapter, there are two general hypotheses to be tested in this research. First, public open spaces have a significant, positive influence on property prices. Specific hypotheses regarding this relationship are that as distance to the nearest public open space increases, the price of property will decrease, ceteris paribus, and as size of the nearest public open space increases, the price of property will increase, ceteris paribus. Second, public open spaces have different implicit marginal effects as they vary in use and topography.

For public open space in aggregate, the null of the first hypothesis cannot be completely rejected. The coefficients on the distance variables are not significant in the full aggregate sample. They are, however, significant when the analysis is restricted to those properties located within 200 feet of public open space. In the quadratic model, the coefficient on distance was negative and significant with a 95 percent confidence level. With the inverse distance model, the coefficient was positive and significant with an 80 percent confidence level. It is expected that the two models would produce opposite signs on the distance variable. It appears that the effect of public open space on residential property is significant only for property located relatively close to the open space. For this reason, the effect of distance on property price is rejected only for property located within 200 feet of an open space.

The size of the nearest open space area did positively affect property price in the aggregate sub-sample and the property within 200 feet of an open space sub-sample, with a 95 percent confidence level. Each additional acre of an area added about $600, ceteris paribus, to the price of a property. The null of the hypothesis regarding the size of an open space area and property price is rejected.

Examining the sub-samples for parks, schools, cemeteries, and wetland and upland open spaces tests the second hypothesis. For the effect of distance, only parks had a significant, positive influence on property prices. The coefficient on the distance variable for the inverse distance model in the parks sub-sample had a confidence level of 95 percent. Proximity to schools and cemeteries had a negative, but not statistically significant, influence on property prices. Proximity to wetland and upland open spaces had a positive, but not statistically significant, influence on residential property prices. These implicit marginal effects are different, although not in the manner originally expected.

Increasing the size of the nearest public open space is estimated to have a positive effect on the price of residential property. The magnitude of the effect varies with the types of open space. The effect is greatest in the cemetery sub-sample and smallest in the schools sub-sample. The effect of open space area was not statistically significant in the combined upland and wetland sub-sample or the wetland sub-sample. The null of hypothesis 2 is rejected.

The effect of public open space on residential property values in Corvallis is influenced by may factors and this cannot be reduced to a simple rule of thumb. The results presented in this chapter show that the estimated marginal price is dependent upon the type of open space area and the way the open space amenity is measured, i.e., distance or area;. More details on the results and some of their implications will be reviewed in the next chapter.

IMPLICATIONS and CONCLUSIONS

The results presented in the previous chapter suggest that any amenity value of public open space to surrounding property owners should not be generalized to all types of areas, rather it depends on the use, topography, size and location associated with the particular open space in question. Proximity to schools and cemeteries, which may have a nuisance associated with them, may diminish property values, while proximity to parks developed for recreation seemed to increase property values. Proximity to undeveloped upland open spaces, located primarily on the city's edge and commonly viewed as buffers or viewsheds, did not seem to significantly increase residential property values. As noted earlier, this last result was contrary to expectations.

The coefficients on the DISTANCE and OSAREA variables indicate that parks developed for recreation increase property values. The remainder of this chapter will examine some implications of this result.

In the introduction, the fundamental and motivating question for this research was posed, Is it worthwhile to remove a parcel of land from private ownership for use as a public park; i.e., are the benefits of an additional park greater than the costs?

The total economic value of a park includes many benefits not addressed in this study, such as recreation use by people who don't live nearby. The results of this study will be used to estimate a partial value of parks. Limitations to estimating the value of Corvallis parks also include a lack of information necessary to fully apply the results. Since the data sample collected for this study does not include the total number of lots surrounding each park and since the study did not include certain types of property that may have its price influenced by parks, it is not possible to answer that question unequivocally.

The Value of Public Open Space

An approach to estimating the value of parks (and hence to answer the above question) will be presented. A geometric approach is used to estimate the total number of residential lots that will fit around a park of a given size. This number, multiplied by the estimated value added to each lot by the presence of a park, provides an estimate of the value of the park.

A few simplifying assumptions are used for this approach. The first assumption is that parks are surrounded by single family residences such as sampled in this study. Although on-site inspection revealed violations of this assumption, most parks were bordered largely by residential areas. Some newer parks are bordered by large parcels of vacant land that may be developed in the future. Only one park had no adjacent residences.

A more tenuous assumption is that parks are square and that lots face the park with a 75-foot width. This assumption is to allow the estimation of the number of lots around a given size park. Although parks are not square, most are fairly compact in design and the assumption is conservative in nature. The assumption of a 75-foot lot width implies a lot dimension of about 75 by 120 feet for the sample average lot of 9189 square feet. An estimate of the number of lots surrounding a park can be made by using a given park's known area to calculate a perimeter (assuming it is square), then dividing by 75 to find the number of lots facing the park. Possible lots at the park's corners will be ignored.

The coefficients from the inverse distance variable (IDISTANCE), the OSAREA variable, and the OSAREA2 variable from the parks sub-sample will be used to estimate the value of parks. The value of the coefficient on IDISTANCE is $13335, implying that when distance equaled 1 foot (adjacent to a park) a property's price would be $13335 higher, ceteris paribus. The coefficients for the OSAREA and the OSAREA2 variables are about $1999 and $-40, respectively. Two examples of a park's possible value will be provided. Franklin Park, near the city center, is the smallest park at 1.38 acres with an estimated 12 lots facing the park. Inspection revealed it actually has 18 lots and the analysis will proceed using this 18-lot figure. The estimated total effect of the park on adjacent lots would be $288,314 or $208,922 per acre of park. Walnut Park, located on the city fringe, has playing fields, picnic facilities, and a playground. Its 29.8 acres would have an estimated adjacent 60 lots, with a total increase in property values estimated at $2,242,986 or $75,268 per acre of park.[1] Inspection revealed that Walnut Park has no residential lots next to it, but it is surrounded on three sides with land owned by a property developer and it may someday have adjacent housing.

It is possible to relate the size of a park to its estimated partial benefit. This relationship is not a demand function based on individual bid functions. Instead, it merely relates the area of a square to an estimated value. The purpose of such an equation is to assist in planning by estimating the partial benefit of different sized parks. The fact that the perimeter of a square park does not increase proportionally to the area implies, in this approach to estimation, that the total influence of parks on

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[1] In this example, the number of potenial lots adjacent to Walnut Park was rounded down to eliminate fractions of lots. This reduced the benefit to an amount less than that estimated by Equation 6.1

property prices will not be a linear relation. Using the assumptions above, and the estimated marginal price of $13335, the approximate relationship between the size of a park and its estimated partial benefit per acre can be written as

$$B=148434A^{-.5} + 22250A^{.5} - 445A^{1.5} \qquad \text{(Equation 6.1)}$$

Where

A is the size of a single park in acres,

B is the benefit expressed in dollars per acre.

Using the first approach, the total effect of the 10 municipal parks on adjacent property values is estimated to be $9,280,212, assuming that 342 residential lots would fit around the parks used in this study.

It is important to remember that the sample did not include all municipal parks nor did it measure all of the types of values associated with parks. This figure is not an estimate of the value of all the municipal parks in Corvallis. The average value of the 10 parks is an estimated $71,612 per acre for the 129.59 acres of park land in the sample. The estimated value of the individual existing parks ranges from $31,787 to $173,934 per acre.

It may be noted that the effect of parks was calculated only for adjacent lots. This is because the estimated monetary impact diminishes rapidly as distance increases with an inverse model. Since the second tier of lots can be located no closer than 120 feet to the park (by the assumption on lot dimensions), this reduces the effect of the inverse distance variable to $111 per lot, ceteris paribus, or less than 1 percent of the impact on lots adjacent to a park.

The results of the inverse model, combined with discussions with a private appraiser, lead to the assumption that the effect of a park on residential property value diminishes rapidly with distance.

The above estimates will be used to examine some possible implications for decision making.

Implications for Market Transactions

The private owner of vacant residential property wishing to sell the property for housing development may rationally elect to reserve a portion of the property for a park if the increase in value to the remaining lots was greater than the value of the property set aside for the park.

Moore (1998) states that vacant lots in platted subdivisions in Corvallis start in the $50,000 range. For the average size lot in this study, 9189 square feet, this implies a density of 4.7 lots per acre or a cost for platted residential land of $235,000 per acre. By contrast the total value to adjacent lots due to a one acre park may only be about $200,000, using the assumptions above. Thus, even without considering the cost of infrastructure or maintenance for a park, it seems unlikely that private landowners will provide public parks in order to enhance their remaining land value.

In fact, the provision of public parks by landowners seeking to develop their remaining property is not common in Corvallis, although the city has received some parks by donation or through purchase at below market cost.

A market transaction that cannot be explained by the results of this study is the ownership of undeveloped, upland open spaces by homeowner associations. There were 19 such parcels comprising over 22 acres included in this study. The parcels are generally located in the fringe suburbs and are withheld from development then donated to a homeowners association created in the new development. This study failed to show a significant influence on surrounding property prices by these upland areas. While explaining developer behavior is not part of this study, it is possible that the parcels were not suitable for development and they were given away to eliminate future costs for the developer such as taxes and legal liability.

Another possibility for market transactions is for the City or a private group, such as the Greenbelt Land Trust, to make fee simple purchases of land. The stated goal of both organizations is to purchase land in outlying areas, where land has a lower cost per acre. If larger parcels of land outside the city sell for $10,000 per acre, as was the case when the sample data were collected, then it may be possible to purchase land for a price lower than its economic benefit based on its amenity value to future surrounding residential property.

Important to this consideration is the length of time, between the purchase of the rural parcel and the residential development of property surrounding it, and the discount rate. As an example, a 20 year time lapse will be assumed, which is the planning horizon for portions of the City's land use planning, and a 5 percent discount rate is used, which is typical of rates being paid on long term certificates of deposit and is close to the 30 year U.S. Treasury bond rate of 4.98 percent.

The effect of these two factors is to discount the future benefit of a park by about 63 percent. This means that a park would need to generate about $27,000 of benefit per acre 20 years in the future in order to equal its current $10,000 per acre price. This benefit may be realized if the park is about 53 acres or less in size, according to Equation 6.1 and its underlying assumptions.

This size is within the range of two parcels already acquired by the Greenbelt Land Trust but much smaller than the largest parcel (143 acres) the group has acquired. All of the municipal parks used in this study were smaller than 53 acres, although the city does contain three open space areas not used in this study that are larger than 53 acres. This may provide some evidence that acquiring the larger areas was not motivated purely by considerations about the effect on surrounding property, and/or that some assumptions are incorrect, such as the length of time until development occurs.

The results estimated in this study indicate that the benefits of parks may be of sufficient magnitude to encourage market transactions under certain conditions. The cost of acquiring unplatted land outside the urban area may be less than the present value of the land as a developed park.

Implications for Public Policy

Knowledge of the different estimated implicit marginal effects associated with different types of public open space might be of use to public policy makers. The City of Corvallis placed a measure, Measure 02-19, before the voters on the November 1995 ballot to authorize an annual tax levy to acquire public open space. The results of this study indicate that the coefficient on distance to all public open space was not significant in the aggregate sample. It is possible that the general public perceives that there may not be significant amenities associated with generic public open space. In fact, the measure was defeated, 6965 opposed, to 5645 in favor. Yet in 1995, $450,000 was spent by the City to acquire a 125 acre parcel known as Kendall Farms and convert it to a municipal park and soccer complex. This indicates that there may be considerable demand for a specific type of public open space, such as parks, at the same time there is only limited demand for additional open space in general.

One possible reason for the apparent difference in value between parks and cemeteries and wetland and upland open spaces may be a difference in a use value, such as recreation. In a study of discontinuity between citizen demand and willingness to pay for parks, Glaser (1996) found that the portion of his sample that was willing to pay moderate or high increases in taxes for additional parks was composed primarily, (89 percent) of people who were also moderate or high users of parks. To the extent that areas such as cemeteries and wetland and upland open spaces cannot be used like parks, they may not be valued like parks. Public officials may wish to examine the suitability of converting undeveloped open spaces to parks as a means of increasing their value.

The appropriate size of parks is another concern for public policy. To the extent that total social value is increased by an increased number of residential lots adjacent to a park, smaller parks will have a higher value per acre than larger parks, ceteris paribus. It is expected that there would be limitations to this rule of thumb; as parks become very small they may cease to generate some amenities. Also, more linearly configured parks may not generate the values estimated in this study. In a study to model the locational efficiency of urban parks in South Korea, Cho (1992) estimated a negative coefficient on the park size variable, implying that larger, urban fringe parks generated a smaller economic benefit, per user, than smaller, more centrally located parks. An implication of the South Korean study and of this study is that public policy should consider providing relatively small parks surrounded by residential property.

Obtaining the funding necessary to provide additional parks is a concern for public officials. Part of the Corvallis Parks and Recreation Department's park land acquisition strategy is to rely on a variety of traditional mechanisms, such as donations, grants, and taxation, to secure funding for parks (City of Corvallis, 1991a). The results of this study indicate that another strategy, suggested by the City in its Strategic Plan for Parkland Acquisition, should also be considered.

The City may acquire more property than is required for a park, then develop or sell the excess land. The estimates of the value of small parks made in this study indicate that policy makers may buy a large parcel of lower priced rural property well in advance of development with a reasonable expectation that the cost of the land for the park could be recouped in the future by the sale of residential lots. Although this strategy may be economically feasible, Rene Moyer, of the Parks and Recreation Department, stated that it might be politically difficult. He felt that once land had been acquired by the City and withheld from development, citizens would oppose selling a portion of it for development.

The results of this study indicate that the value of open space in Corvallis is dependent on characteristics of the open space. It may be possible to increase the value of an open space parcel by developing it as a municipal park.

Further Study

The quality of the data, especially the dependent variable-sales price, is of concern. Almost three-fourths of the property sales observations were discarded as unusable. This was mainly due to transactions that appeared not to be at arm's length. There were also a small number of errors that appeared to be caused by incorrect data entry. It is unknown if the criteria for rejection of the observations were correlated with any variable in the model. If so, a specific type of property may have been systematically excluded. This could, in turn, bias the regression estimates.

In addition, the existence of a large number of transactions conducted not at arm's length may influence price expectations of buyers and sellers who are operating at arm's length. For example, if an unusually large proportion of low-price sales between relatives characterizes the Corvallis property market, this would reduce the median sale price of property, which is often a publicly reported statistic. This, in turn, may lead buyers and sellers to form expectations of lower prices in general.

A variable representing the assessed value of property is available in the complete data set. Its use as a dependent variable on observations with an invalid sales price would allow the creation of a larger data set. Although the model would no longer reflect only market behavior, the potential reduction in variance may allow a gain in the number of significant coefficients and would remove any possible bias resulting from discarding observations systematically.

Increasing the total number of observations may also increase the precision of the estimated implicit prices and may allow sub-markets to be analyzed. If enough sub-markets exist, it may be possible to estimate a second stage regression.

Examining the influence of public open spaces on surrounding residential property provides only a partial measure of the value of the spaces. The approach in this study could be complimented by the use of the contingent valuation method and the travel cost method to estimate the benefits and costs incurred by other residents of the study area. It may be, for example, that upland open spaces are highly valued for their existence or view amenity by central city residents located a considerable distance away. These other methods could help provide insight into the total economic value of public open spaces.

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