AN ABSTRACT OF THE THESIS OF

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Richard M. Adams

Wetlands play an important role in our social and economic well being. Many services wetlands provide, such as wildlife habitat, recreation, and aesthetics, are collective goods. Because these services are not represented in a market, an over supply of wetlands converted to other uses and an under supply of protected wetlands may result. In order to improve wetland resource allocation decisions, nonmarket valuation techniques can be used to estimate the economic value of wetland attributes that represent collective goods.

Using the hedonic property pricing approach, this study estimates the value of wetland environmental amenities in the Portland, Oregon metropolitan area. Detailed residential housing and wetland data are used to relate the sales price of a residential property to the structural characteristics of the property, neighborhood attributes in which the property is located, and amenity values of wetlands and other environmental characteristics. The measures of primary interest are distance to four different wetland types (open water, emergent vegetation, scrub shrub, and forested). Other environmental variables evaluated include size of nearest wetland and proximity to parks, lakes, streams, and rivers.

The results of the hedonic price function analysis indicate that wetlands influence the value of residential property and that the degree of influence varies by wetland type. The results also show that wetlands influence property values differently than other amenity generating features such as parks, lakes, rivers, and streams. The results concerning the influence on price of proximity to specific wetland types were mixed. For some wetlands, proximity had a positive effect on sales price, while for others, proximity had either a negative relationship or no effect. The estimated marginal implicit prices on wetland proximity were sensitive to the function form used.

In addition to estimating the hedonic price functions, second-stage regression analysis was used to estimate the willingness-to-pay function for wetland size. Example welfare effects are computed using the estimated willingness-to-pay function. The estimated willingness-to-pay function appears reasonable based on the expectation that residents have a small, but significant, positive willingness to pay larger wetlands.

Valuing Urban Wetlands: A Property Pricing Approach

by

Brent L. Mahan

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Brent L. Mahan, Author

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INTRODUCTION

The nation's wetlands play a vital role in our social and economic well being. They provide services such as improved water quality, groundwater recharging, shoreline anchoring, natural flood control, and support a diverse variety of fish, wildlife, and plants (White House Office on Environmental Policy, 1993; Council for Agricultural Science and Technology, 1994, National Research Council, 1995). Wetlands, like other natural resources such as mountains, rivers, and oceans, provide positive amenity values for nearby residents. On the other hand, wetlands can produce disamenities like odor problems and insect and mammal nuisances (Lupi et al.,1991).

Despite the importance of wetlands, by the 1970's, the U.S. has lost over 50 percent of the wetland acreage that existed at the time of European settlement in the area now comprising the 48 contiguous states. Between the 1950's and 1970's, there was a net loss of nine million acres of wetlands, an annual average loss approximating 450 thousand acres. In the 1970's, there were an estimated 106.3 million acres of wetlands in the U.S. By the 1980's wetland acreage had been reduced to 103.3 million. The average annual net loss was 290.2 thousand acres for a total loss of 2.6 million acres over the 20-year period beginning in 1970. Most of the losses occurred as wetlands were converted to agriculture (Frayer, 1991).

Historically, federal wetland policy encouraged "reclamation" of wetlands for commercial uses, such as agriculture. More recently, as views on the importance of wetlands have changed, federal policy has become more restrictive and has even promoted the protection and restoration of wetlands (Water Bank Act, 1970; Section 404 of the Federal Pollution Control Act, 1972; Section 404 of the Clean water Act, 1977; Executive Order 11990 - established wetland protection as official U.S. government policy and ended direct Federal assistance for conservation of wetlands, 1979; Emergency Wetlands Act, 1986, North American Wetlands Conservation Act and Coastal Wetlands Conservation and Restoration Act, 1989).

Federal wetland policy changes began in the late 1960's, but the key legislation forming the basis of current wetland policy began with Section 404 of the amendments to the Federal Water Pollution Control Act of 1972 (Shabman and Batie, 1987) and later in Section 404 of the Clean Water Act of 1977. Section 404 requires that impacts to wetlands must be avoided if reasonable alternatives exist. If impacts are unavoidable, developers must first minimize the impacts and then compensate for any remaining wetland impacts. Compensation includes functional wetland enhancement, degraded wetland restoration, or wetland creation from uplands. In 1990, the Environmental Protection Agency and U.S. Army Corps of Engineers clarified compensatory mitigation to include, at a minimum, a one-to-one replacement ratio for wetland functions. This is the "no-net-loss" policy (Shabman et al., 1993). The Clinton Administration considers the no overall net loss of the Nation's wetlands to be an interim measure. The long-term goal is to increase the quality and quantity of the wetland resource base (White House Office on Environmental Policy, 1993).

This leads to important wetland resource management questions. What kind of characteristics should enhanced, restored, or created wetlands exhibit? Are urban home buyers willing to pay to have wetlands near their residences? What are the economic benefits of creating a new wetland or preventing the loss of an existing wetland? Economic analysis provides a means of addressing these questions. Economic information has long been applied to analyze water resources development projects, starting with the Rivers and Harbors Act of 1902 which required an accounting of project benefits and costs. The Flood Control Act of 1936 additionally mandated that for project approval, benefits must exceed the costs. The most recent guide for economic evaluation of water resources development is the U.S. Water Resources Council "Principles and Guidelines" (1983). This document emphasizes that only economically feasible projects be undertaken. For example, environmental projects, such as wetland mitigation, should have positive net benefits.

Estimating the benefits of environmental resources, including wetlands, is difficult because many of the services provided are not traded in a market. In other words, there is limited information on the economic value of such resources. In an attempt to overcome this problem, non-market valuation techniques have been developed which provide dollar estimates for such unpriced goods (Cropper and Oates, 1992). Table 1 presents a list of economic techniques that have been used to value various wetland services. The hedonic property price model, used in this study, is an indirect observed valuation technique where estimates are obtained from observed behavior, but values must be derived from an inferred relationship between the observed activity and the environmental service. The hedonic pricing method has the distinct advantage of measuring the actual price paid for a wetland resource.

Table 1. Valuation Techniques and Wetland Services

Benefit Type	Valuation Method
Habitat for commercial species	Market prices for commercial species and productivity per acre
Habitat for wildlife and visual/cultural benefits	Prices paid by government agencies to protect wetlands
Amenity or aesthetic value	Hedonic property price model
Recreation value	Travel cost method; Participation model using unit-day values; Contingent valuation
Flood control and shoreline anchoring	Damages avoided

Table 1 Continued. Valuation Techniques and Wetland Services

Benefit Type	Valuation Method
Water purification	Reduced treatment costs by alternative methods
Wetland conservation	Opportunity costs; i.e., benefits of wetland conversion
Non-use and option value	Contingent valuation

Source: Adapted from David W. Pearce and R. Kerry Turner. 1990. Economics of Natural Resources and the Environment. Baltimore: Johns Hopkins University Press. Pp. 226-235.

Study Objectives and Hypotheses

The overall objective of this study is to value wetland environmental amenities in the Portland, Oregon metropolitan area using the hedonic property pricing method. The principal measure of interest is proximity value; i.e., the willingness to pay to live closer to a wetland of a given type. Econometric techniques are used to estimate the marginal implicit price and willingness-to-pay function for wetland characteristics. Specific study objectives include:

1) Estimate the implicit marginal effect of different wetland types on residential property values in Portland, Oregon.

2) Estimate the demand for wetlands; i.e., the willingness-to-pay function for wetlands.

In the process of meeting the thesis objectives, three hypotheses are tested regarding the role and significance of wetland characteristics in determining the sales price of a residential property. The hypotheses are:

1) Wetlands have a significant influence on nearby residential property values.

2) Different types of wetlands have significantly different marginal implicit prices.

3) Wetlands and non-wetland greenspaces (public parks, lakes, and rivers) have significantly different marginal implicit prices.

Study Area Description

The study area is Portland, Oregon. Specifically, it is the portion of Multnomah County that lies within the Portland urban growth boundary. Multnomah County is Oregon's smallest county in size and largest in population. Portland's population in 1990 was 437,300 while the county's population was 583,900. The greater Portland area, which includes the urban portions of Multnomah, Washington, and Clackamas Counties had a population of about 1.5 million in 1990. Between 1980 and 1990, this urban area's population increased by 19 percent and the area's population is expected to continue to grow into the next century. The median age in Portland in 1990 was 35, an increase of 4 years compared to the median age in 1980. There were 187,300 occupied houses in Portland in 1990; about 53 percent of these were owner occupied.

Per capita income in Portland was $14,500, an increase of 79 percent compared to per capita income in 1980. Employment in Portland in 1990 was 219,000. The unemployment rate was 6.2 percent. Private industry comprised 79 percent of the employment. Retail trade, manufacturing of durable goods, and health services are the three largest employment sectors, respectively. The largest change in employment between 1980 and 1990 occurred in the other professional and related services sector with an increase of 768 percent (U.S. Department of Commerce, 1990).

Historically, Portland's economy has centered around its deep water port which lies 110 miles from the Pacific Coast. Oregon's largest and most diversified port, Portland ranks third in total West Coast waterborne commerce behind Long Beach and Los Angeles. In more recent years, Portland's growth has been influenced by high-tech industries.

Being located in the maritime Pacific Northwest, the area enjoys significant water resources including two major rivers, several lakes, numerous streams and many wetlands. Figure 1 illustrates open water wetlands in the Portland area where the gray shading illustrates the distance gradient; lighter gray means more distant. The greater Portland area has over 4,500 wetlands and deepwater habitats representing over 200 different classifications.

Organization of Thesis

The second chapter, Literature Review, discusses the literature covering the services wetlands provide, economic methods used to value wetland services, hedonic property price analysis of water resources including wetlands, and estimating willingness-to-pay functions using hedonic property price analysis. The subsequent chapter, Methodology, discusses the theoretical model for the hedonic price and willingness-to-pay functions and estimation issues in hedonic price modeling. The chapter, Procedures, discusses how the methods are implemented to achieve the objectives of this thesis. It includes a description of the data used in the analysis. The study results are presented and discussed in the chapter, Results and Implications. The final chapter, Conclusions and Recommendations, summarizes the study, discusses its applications, and presents opportunities for further research.

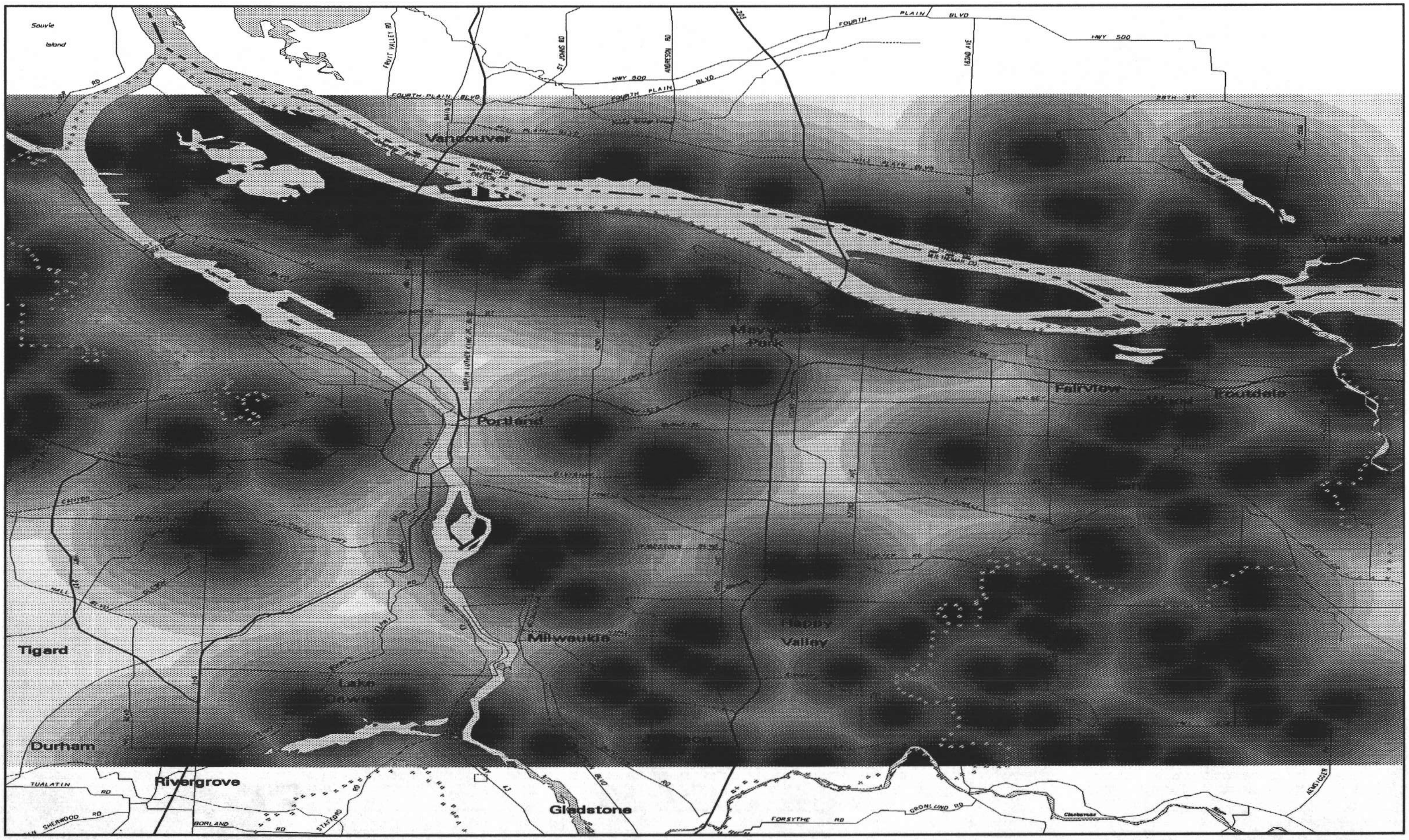

Figure 1. Open Water Wetlands in the Greater Portland Area. Lighter Shading Represents Greater Distance from a Wetland Site. Source: Metro, 1996

LITERATURE REVIEW

This chapter begins by introducing the services wetlands provide to society. It then discusses nonmarket valuation techniques for wetland resources. The literature review focuses specifically on studies that have used the hedonic property-price method to value water resources including wetlands. None of the existing wetland studies attempt to estimate willingness-to-pay functions. Because of the importance of these functions to this thesis, the chapter concludes by addressing non-water resource hedonic property-price studies that have estimated willingness-to-pay functions for implicit characteristics.

Wetland Functions and Services to Society

Wetland ecosystems, like all ecosystems, include biotic (living) and abiotic (nonliving) components that interact dynamically over space and time. Wetland functions are the natural processes that occur in the ecosystem (Miller, 1975). When humans benefit from these functions, an economic measurement system can be devised that values the goods and services derived from the ecosystem processes. Wetlands provide a wide range of services, from the production of valuable resources such as marine shellfish to aesthetics.

The Council for Agricultural Science and Technology (1994) has identified and grouped wetland ecosystem functions with human services from works by Gosslink and Maltby (1990), Mitsch and Gosslink (1986), Niering (1988), Sather and Smith (1984), and Tiner (1984). These functions and services are shown in Table 2.

Table 2. Functions and Services of Wetland Ecosystems

- Planetary ecosystem functions
  - Biogeochemical cycling
    - Carbon, nitrogen, phosphorous, sulfur, methane
  - Biospheric stability
  - Primary production (energy flow)
  - Biodiversity

- Hydrological properties
  - Ground water recharge
  - Ground water discharge
  - Flood flow alteration
    - Storage
    - Conveyance
  - Salt water gradient potentiation

- Water quality provision
  - Sediment stabilization/entrapment
  - Sediment/toxicant retention
  - Nutrient removal/transformation/enrichment

- Habitat provision
  - Plants
  - Animals
    - Aquatic
    - Terrestrial

- Direct human utilization of ecosystem services
  - Production/export
    - Timber, forage, peat, wild rice, phosphate, rock, fish, shellfish, game, fur, aquaculture
  - Recreation
  - Aesthetics
  - Education
  - Uniqueness/heritage
  - Bank Stabilization

Source: Council for Agricultural Science and Technology. 1994. Wetland Policy Issues.

Valuing Wetland Services

Value is the monetary measure of the change in human well-being brought about by a function or service, whether from a wetland or golf course (Taff, 1992). For wetland services that are traded in a market, such as crop production and harvesting of commercial fish species, the economic value is the sum of the payments made for the commodities plus an appropriate estimate for consumer surplus. Markets disclose price and quantity information from which payments and consumer surplus can be derived.

Market transactions involve the trading of property or ownership rights. For wetland services that represent collective goods, like recreation, waterfowl habitat, and amenities services, market exchanges do not capture consumers' preferences because property rights are not well defined. This occurs when consumers can not be excluded from enjoying the resources' benefits and when one person's consumption does not reduce another's ability to consume the same commodity. These circumstances lead to an under valuation of the benefits of wetland services and an inefficient use of environmental commodities (Randall, 1987).

Wetland development (such as, draining and filling for building construction) usually has market attributes. Price signals regarding the benefits of such wetland utilization provide incentives to economic agents for conversion of wetlands to alternative uses. The result is an under supply of protected wetlands. In an effort to stop wetland losses, the Federal government enacted the policy of "no-net-loss."

Barbier (1994) categorizes and defines different types of wetlands values in the context of total economic value and assigns appropriate valuation techniques to each category. The categories include:

(1) Direct use values - benefits resulting from the direct use or interaction with a wetland or its services. Examples include seafood and recreation. Direct use valuation techniques include both market and nonmarket approaches such as market pricing, the

travel cost method (TCM), contingent value method (CVM), hedonic price method (HPM), public prices, opportunity cost approach, and alternative or substitute cost approach,

(2) Indirect use values - benefits resulting from the indirect support and protection provided by the wetland functions to economic activities and property. Examples of indirect use values include flood control and storm protection. Valuation methods include damage costs avoided, avoidance expenditures, value of changes in productivity, and relocation and replacement costs.

(3) Nonuse values - benefits that are derived from neither direct nor indirect use. Existence and bequest values are examples. Revealed preference approaches, such as the contingent valuation method, are the only approaches that allow for the measurement of these nonuse benefits.

A significant body of literature addresses the economic valuation of wetland services (e.g., Leitch and Ekstrom, 1989; Douglas,1989; Pearce and Turner, 1990). A brief summary of studies that attempt valuation are summarized below. Hedonic studies in water resources valuation are discussed in the subsequent section.

Studies using direct observed approaches have valued wetlands as habitat for commercially harvested products (Lynne et al., 1981; Batie and Wilson, 1979). Direct observed techniques use both competitive market prices and simulated markets to estimate individual values. Monetary values are derived from observing actual choices made by individuals in response to prices. These individuals are assumed to maximize their utility subject to relevant constraints (Freeman, 1993). The analytical challenge for wetland studies is determining the marginal productivity of a wetland acre. The studies evaluated the contribution made by coastal wetlands on the production of shrimp, blue crab, oyster, menhaden, and commercial trapping (mainly nutria and muskrat). Marginal product values of coastal wetlands ranged from $.30 per acre (1981 price level) to $37.46 per acre (1983 price level) for shellfish and fish. Gupta and Foster (1975) used land prices to estimate wildlife and visual-cultural benefits of wetlands. The economic benefits were implicitly estimated by the prices paid by public agencies to purchase wetlands for preservation purposes. The capitalized value of wildlife benefits was $1,200 per acre for the highest quality land. For highest quality open space, the capitalized value was estimated to be $5,000 per acre. An expert opinion scoring index was used for estimating the value of lower graded lands. There was no attempt to measure consumer surplus.

Batie and Mabbs-Zeno (1985) used a direct observed approach by estimating the opportunity costs of preserving coastal wetlands through foregone recreational development benefits. The research found that the total development benefits for 58 acres of wetlands on Virginia's Eastern Shore was $31,890,000. This represents the total return for the subdivision development including 58 acres of wetlands. Marginal returns peaked between the 14th and 20th converted wetland acre at a per acre return of $120,000. This occurred because all possible shorefront lots had been included. Stable returns occur at about $43,000 per acre when all possible canal-front lots are included.

Heimlich (1994) conducted an incremental least cost analysis of a wetland reserve program included in the Food, Agricultural, Conservation, and Trade Act of 1990. The study identified 55 million acres of cropland converted from wetlands eligible for the wetland reserve program. Average easement costs based on capitalized net returns to crop production for the least expensive reserves ranged from $105 to $639 per acre. Marginal costs ranged from $310 to $1,184 per acre. Restoration costs varied from $89 to $139 per acre.

Contingent valuation is a direct hypothetical method which creates a simulated market by asking people directly how they value particular environmental resources (Freeman, 1993). Using this approach, Bergstrom et al. (1990) measured expenditures and consumer surplus associated with current on-site recreational use of a coastal wetlands area in Louisiana. Total user consumer surplus per year was estimated to be

$360, plus $1,511 per user/year in expenditures, for a total willingness-to-pay of $1,911 per year. The aggregate gross economic value totaled $145.2 million. Whitehead (1990) used CVM to measure both the use and nonuse value of preserving the Clear Creek wetland area in Kentucky. Mean willingness-to-pay results ranged from $6.31 to $12.67 per household, depending on the functional form used. Aggregate benefits of preservation of Clear Creek wetland ranged from $9.48- to $19.05 million. Hammack and Brown (1974) used the contingent valuation method to estimate the net willingness-to-pay for bagged waterfowl by Pacific flyway hunters. The value was $3.29 per bird (in 1974 dollars). Using the $3.29 value, along with the estimated marginal physical product of a pond of 2.2 birds, the study calculated the marginal value product of a Canadian prairie pothole to be $8.88. Faber and Costanza (1987) measured the value of various recreational activities (hunting, fishing, boating, and shoreline activities) pursued in wetlands in Terrebonne Parish, Louisiana. The contingent valuation approach yielded a total annual individual consumer surplus of $4.86.

One method of measuring wetland recreation is the travel-cost approach (Pearce and Turner, 1990). Travel cost is an example of the indirect observed method which is similar to direct observed techniques described above. As with the direct observed techniques, estimates are obtained from observed behavior, but values must be derived from an inferred relationship between the observed activity and the environmental service (Freeman, 1993). In the travel cost approach, the costs of traveling to a site are considered surrogates for visitation market prices. Faber and Costanza (1987) applied this approach on recreation in wetlands in Terrebonne Parish, Louisiana. Total annual individual consumer surplus was estimated to be $6.00 which compares well with the contingent value estimated consumer surplus value of $4.86 estimated in the same study.

Thibodeau and Ostro (1981) evaluated recreation benefits provided by the wetlands of the Charles River basin in Massachusetts using a participation model based on national unit-day values. Activities included small game hunting, waterfowl hunting, trout fishing, warmwater fishing, and nature study. Total annual individual willingness-to-pay per acre was $102.02. The annual individual consumer surplus was estimated at $56.23. The results of such an approach are questionable because the unit-day values are not linked to site specific qualities and activities (Pearce and Turner, 1990).

Several points can be drawn from the valuation studies presented in this section. The first is that a variety of techniques have been used to value wetland service flows. This includes techniques that do not measure benefits, but rather opportunity costs, as well as, some approaches that do not withstand economic scrutiny, such as wetland values based on prices paid by agencies. The second point is that different techniques tend to capture benefits from different services or sets of services and the value of services being measured tends to overlap with different techniques. It is not clear exactly what values are actually being measured. For example, while the hedonic price method primarily measures amenities values, it is likely capturing values for recreational use and other perceived services. It is difficult to get a clear estimate of the total economic value of wetland resources. Measuring wetland services is, thus, imperfect, although meaningful economic information has been obtained in some settings.

The contingent valuation method and hedonic pricing are the two most commonly used techniques for measuring willingness to pay for the aesthetic amenities associated with wetlands (Graves, 1991). This thesis focuses on the latter. The hedonic method appears to be reemerging in the environmental economics literature and has the distinct advantage of measuring the actual price paid for a wetland resource.

Property Price Methods In Water Resources Valuation

This section reviews key aspects of studies that have used property models to value water resources. A limited number of water resource valuation studies have used hedonic property methods. Most have involved estimating amenity values for lakes. Two studies focused specifically on wetlands valuation (Doss and Taft, 1993, 1996; Lupi et al., 1996). Table 3 summarizes 16 hedonic water resource studies that have been undertaken. The studies are listed in alphabetical order by the authors' last name.

The water resource valuation studies can be categorized into four groups, floodplain, lakes and reservoirs, rivers and streams, and wetlands. Antle (1977) and Donnelly (1989) examined the influence of potential flooding on property values. Antle found that parcels located in the Chester Creek basin, Pennsylvania, floodplain had values that were $5,100 less than parcels outside the floodplain. In a similar study in LaCrosse, Wisconsin, Donnelly found a floodplain parcel to be valued $6,000 less than parcels not subject to flooding.

Brown and Pollakowski (1976), d'Arge and Shogren (1989), Daring (1973), David (1968), Feather et al. (1992), Knetsch (1964), Lansford and Jones (1995), Reynolds et al. (1973), Young and Teti (1984) studied the influence of lakes and reservoirs on nearby property values. The studies consistently found that lake frontage and lake proximity increased property values. Some studies evaluated the influence of water quality on value in addition to shorefront and proximity (d'Arge and Shogren,1989; David, 1968; Feather et al., 1992; Young and Teti, 1984). Improved water quality consistently increased property values. Khairi-Chetri and Hite (1990) considered how hydropower regulated reservoir levels affected property values near Lake Keowee, South Carolina. They found that a one foot decrease in stage from normal pool elevation leads to a $5,400 decrease in sales price.

Two water resource property studies focused on rivers and streams. Kulshreshtha and Gillies (1993) estimated the marginal implicit price of a river view in neighborhoods located adjacent to the South Saskatchewan River in Saskatoon, Canada. The researchers found that home buyers are willing to pay from $.84 to $26.76 per square foot of house size for a view of the river. Streiner and Loomis (1995) estimated residents' marginal

Table 3. Summary of Hedonic Models Used in Water Resources Valuation

Study	Final Model					Comments
Author/ Location	Functional Form	Dependent Variable	Relevant Environmental Variables	Neighbor-hood Variables	Statistics	
Antle (1977)*/ Chester Creek Basin, PA	Linear	Property value from various sources	Location in floodplain	Yes	N = 1,625 $R^2 = .31$	Flooding reduced floodplain parcel values by $5,100
Brown & Pollakowski (1976)*/ Seattle, WA	Linear	Sales price	-Lake view -Distance to water front	No	N = 89 $R^2 = .78$	Property values increase with closer proximity to lake
d'Arge & Shogren (1989)*/ Okoboji Lakes, IA	Linear	Assessed value	Lakefront footage	No	N = 66 $R^2 = .87$	Property values greater with increased water quality. Results consistent with parallel CVM study
Darling (1973)*/ Lakes Merritt, Murray & Santee, CA	Linear	Assessed value	Distance to lake	Yes	Not reported (NR) $R^2 = .85$	Property values increase with closer proximity to urban water parks. Results inconsistent with parallel CVM study
David (1968)*/ Wisconsin	Linear	Weighted sum of land values per tract	-Existence of swamp -Lake access -Surface water index -Water quality	No	N = 2,131 R^2 = NR	Related property values to several lake characteristics. Study lacked good environmental data requiring numerical aggregations and simplifying assumptions
Donnelly(1989)*/ LaCrosse, WI	Linear	Sales Price	Location in floodplain	Yes	N = 224 $R^2 = .84$	Flooding reduced floodplain parcel values by $6,000

Table 3 Continued. Summary of Hedonic Models Used in Water Resources Valuation

Study	Final Model					Comments
Author/ Location	Functional Form	Dependent Variable	Relevant Environmental Variables	Neighbor- hood Variables	Statistics	
Doss & Taff (1993, 1996)/ Ramsey County, MN	-Linear -Quadratic -Closest linear -Linear interaction -Closer quad. -Closer inverse	Assessed value	-Wetland type -Distance to wetland	Yes	N = 105,568 R^2 = all > .8	In general, property values increase/decrease depending on proximity to type of urban wetlands.
Feather et al. (1992)/Orange County, FL	-Linear -Semilog	Sales price of vacant land	-Lake size -Water quality (TSI index) -Distance to lake	No	N = 3,214 R^2 for lake quality = .46 R^2 for distance = .76	Property values are influenced by lakefront location, lake size, water quality, and proximity.
Khairi-Chetri & Hite (1990)[*]/Lake Keowee, SC	Linear	Sales price per acre of vacant lakefront property	Lake level	No	N = 170 R^2 = .29	Property values are decreased by lowering reservoir levels for hydropower generation.
Knetsch (1964)[*]/ Tennessee Valley	Linear in all variables except distance which was squared	Property value in $ per acre	-Reservoir-front property -Distance to reservoir	Yes	N = 519 R^2 = .76	Reservoir-front property has greater value than non-reservoir-front property
Kulshreshtha & Gillies (1993)/ Saskatoon, Saskatchewan, Canada	Linear	Sales price	-River view	Yes	N = 393 R^2 = .93	Property values increased by view of river.

Table 3 Continued. Summary of Hedonic Models Used in Water Resources Valuation

Study	Final Model					Comments
Author/ Location	Functional Form	Dependent Variable	Relevant Environmental Variables	Neighbor-hood Variables	Statistics	
Lansford and Jones (1995)/Travis County, TX	Box-Cox	Sales price	-Waterfront -Lake distance -Lake-level deviation	Yes	N = 593 $R^2 = .79$	Proximity to lake is most important component of recreational and aesthetic value.
Lupi et al. (1991)/Ramsey County, MN	Linear in all variables except wetland var. which was squared	Sales price	-Wetlands acres per section -Lake acres per section -Mississippi R. in section -Lakeside property	Yes	N = 18,985 $R^2 = .72$	Property values are increased by a larger number of wetland acres in the section.
Reynolds et al.(1973)*/ Kissimmee R., FL	Linear	Vacant lot sales price	-Lakefront -Canal-front	No	N = 316 $R^2 = .63$	Property value increased by lake/canal-front location. Results inconsistent with parallel CVM study
Streiner & Loomis (1995)/ Contra Costa, Santa Cruz, Solano Counties, CA	Box Cox	Sales price and assessed values	-Restoration project -Stream and bank characteristics	Yes	N ≈ 1050 $R^2 \approx .54$	Restored streams increased property values by $4,500 to $19,000.
Young & Teti (1984)*/St. Albons Bay, VT	Linear	Sales price	-Lakefront -Water quality	No	N = 93 $R^2 = .68$	Reduced water quality lowered property values.

*/ Source: Feather, Timothy D. in collaboration with Edward M. Pettit and Panagiotis Ventikos. 1992. "Valuation of Lake Resources Through Hedonic Pricing." IWR Report 92-R-8. U.S. Army Corps of Engineers Institute for Water Resources, Fort Belvoir, VA.

willingness to pay for restored urban streams in California. Areas with improved streams were shown to have property value increases from $4,500 to $19,000 due to the restoration measures.

Two hedonic property price studies examined the relationship between urban wetlands and property values. Lupi et al. (1991) estimated the relationship of the number of wetland acres in a survey section on the price of a house located in the section. The study used 1987 - 1989 sales and property characteristics data and wetland data from the Minnesota Protected Waters Inventory (PWI) for Ramsey County, Minnesota. With a data set of 18,985 properties, the study estimated a linear model in all variables except a wetland term which was squared. The final estimated equation had an R^2 of .72 and an F statistic of 1230. All of the variables were significant at a 95 percent level of confidence except for a few house characteristics and a local school district.

PWI wetland acres per section and property values were found to have a statistically significant positive relationship. If the number of houses per section are held constant, the study showed that changes in wetland acreage are relatively more valuable in sections where wetland acreage is low than in sections where wetland acreage is higher. The study did not describe what wetland values were being measured (i.e., open space, view, habitat, etc.) The key study findings are that preserving wetlands may be a preferred social choice to converting wetlands to other uses and that preserving or restoring wetlands will have a greater value if they occur in locations where wetlands are relatively scarce.

Doss and Taff (1993, 1996) conducted a similar study also in Ramsey County, Minnesota. This research had two objectives: Do people value different types of wetlands differently and are people willing to pay more to live closer to a wetland rather than farther away from a wetland. Using assessed value and property characteristics data on 105,568 residences, a marginal implicit price was estimated for living closer to a given type of wetland. Four wetland types were identified, forested, scrub-shrub, emergent vegetation, and open water. Property proximity to wetlands was measured using wetland locations and classifications from the digitized National Wetlands Inventory for those wetlands and properties located within Ramsey County.

Six different models were estimated; linear, quadratic, closest linear (considers only those properties that are closest to a given wetland type), closest interaction, closer quadratic (properties within 1,000 m. of all four wetland types), and inverse on closer properties. The R^2 was greater than .8 for all models and all variables were shown to be statistically different from zero at a 99 percent confidence level except for a few non-distance coefficients.

In general, the results point to a positive willingness to pay to live closer to scrub-shrub and open-water wetlands. A negative relationship exists for forested and emergent-vegetation wetlands. The most definitive conclusion is a preference ranking where scrub-shrub and open water wetlands are clearly preferred to forested and emergent vegetation wetlands. The two key results are that preferences vary for wetlands with different characteristics and wetland investment and preservation decisions should consider these preferences or at least consider the social tradeoffs in choosing alternative strategies.

Estimating Willingness-To-Pay Parameters in Hedonic Property Price Models

Under certain conditions the hedonic price function can be used to estimate the willingness-to-pay function which, in turn, can be used to estimate nonmarginal welfare effects. None of the water resource studies attempted to estimate willingness-to-pay functions. Rosen (1974) suggested the benefits of nonmarginal amenity changes can be estimated by regressing the marginal attribute price, computed from the hedonic price function, on the arguments from the marginal bid function. The bid curve gives the maximum amount an individual would pay for a property as a function of one of its attributes. The problem with Rosen's concept is that this second-stage estimation encounters an identification problem which is discussed in detail in the next chapter.

Different approaches have been used to overcome the identification problem. Mendelsohn (1984, 1985) and Bartik (1987) used exogenous variables as instruments. However, finding truly exogenous variables that shift the hedonic price function appears to be difficult (Freeman, 1993). As an alternative to instrumental variables, assumptions can be used to restrict the model's structure. Such assumptions can meet the conditions for identification of the marginal willingness to pay curve. An example is to assume the functional form for preferences is homothetic. Designating the relationship between income and demand allows the separation of the effects of income and changes in quantity on the marginal willingness to pay for characteristics (Quigley, 1982). Another approach is to assume a characteristic exists in the marginal hedonic price function that is not an argument in the marginal willingness to pay curve for some other characteristic. The omitted characteristic can then be used as an instrumental variable. Many authors have been critical of such assumptions because the results are dependent on assumptions that cannot be tested (Freeman, 1993). Freeman (1993) suggests that the most reliable method for dealing with the identification issues is the use of segmented markets, either from within a city or from different cities.

METHODOLOGY

This chapter presents the methods used in this thesis. It includes a description of the theoretical model for the hedonic price and the willingness-to-pay functions. The chapter also discusses estimation issues in hedonic price modeling including variable selection, functional form, market equilibrium, market segmentation, and econometric identification.

The Theoretical Model

The hedonic price method is a technique which estimates the marginal embedded prices of characteristics which make up a composite good, where the good consists of closely related products or models in a product class (Freeman, 1993). In principle, if there are a sufficient number of models with different combinations of characteristics, then it should be possible to estimate the relationship between a particular model's price and the quantities of its respective characteristics (Freeman, 1993). This is the hedonic price function.

The economic foundation of using hedonic pricing to value environmental resources comes from the long recognized concept that land productivity varies from site to site. The value of land, as a productive commodity, is reflected by the differences in the attributes which lead to the different levels of productivity, *ceteris paribus* (Kulshreshtha and Gillies, 1993). Similar logic applies to property as a consumer good. The market value of the property can be used to identify attributes which consumers differentiate in making purchase decisions. That is, consumers implicitly price the attributes or characteristics embodied in the property and these implicit prices can be disaggregated by evaluating variability in value among properties. Some characteristics may relate to environmental quality provided by a nearby wetland resource. Hedonic pricing methods use econometric techniques to estimate the marginal price effect due to the presence of the environmental good. This price differential is assumed to be the proxy value of the environmental commodity.

Most recent research using hedonic pricing to value environmental goods has been based on a theoretical model presented in Sherwin Rosen's 1974 seminal article (Palmquist, 1991). Rosen provided the theoretical underpinnings of the hedonic regressions that were in common use at the time. Freeman (1993) addresses the theoretical aspects of the property value model, which are discussed below.

The Hedonic Price Function

Assume that each individual's utility function has arguments for X, a composite commodity representing all goods other than a house, Q, a vector of environmental amenities associated with a specific location, S, a vector of structural characteristics (e.g. square footage, number of rooms, lot size) of the individual's residence, and N, a vector of neighborhood characteristics like access to transportation, shopping, and work.

Freeman (1993) uses the analogy that a large urban housing market is like a huge supermarket offering a wide variety of selections. Rather than individuals being able to fill their shopping carts by moving around the store, they must choose from an assortment of already filled carts. The quantity of any one characteristic can be increased by selecting another location which has more of the preferred characteristic, but is otherwise the same.

The housing market is assumed to be in equilibrium, which requires that individuals have optimized their residential choice based on the prices of alternative locations. The prices are assumed to be market-clearing prices given the existing inventory of housing choices and their characteristics. With these assumptions, the price of any residence can be described as a function of the environmental, structural, and neighborhood characteristics of the residence location:

$$P_{hi} = P_h(S_i, N_i, Q_i)$$

Where:

P_{hi} is the price of the *i*th residential location.

S_i is a vector of the *ith* property's structural characteristics.

N_i is a vector of characteristics of the neighborhood in which the *ith* house is located.

Q_i is a vector of environmental amenities at the *ith* location.

Now consider the individual who occupies house *i*. Assume that preferences are weakly separable in housing and its characteristics, which allows the demand for characteristics to be independent from the prices of other goods. The person's utility, $u = u(\mathrm{X, Q, S, N})$, is maximized subject to their income constraint given by M - $\mathrm{P_h}$ - X = 0 (Where: M is income and X is a composite commodity representing all goods except housing. The price of X is implicitly scaled to \$1). The first order conditions for choosing the constrained optimum level of the *j*th environmental amenity, q_j, is the ratio of the first partial derivatives. That is, the change in utility with respect to a change in the environmental amenity q_j divided by the change in utility with respect to a change in X. This expression is equal to the first partial derivative: the change in residence price with respect to a change in the *j*th environmental amenity as shown below.

$$\frac{\partial u / q_j}{\partial u / \partial X} = \frac{\partial P_{hi}}{\partial q_j}$$

One result of these optimizing conditions is that the implicit marginal price of a characteristic can be derived from the estimated hedonic price function. The partial derivative of the hedonic price function with respect to any characteristic yields its marginal implicit price. For example, if q_j is the distance to an open-water wetland, then the first partial derivative represents the additional amount that must be paid (received) to be located an additional unit closer to the wetlands. For a linear specification, the first partial derivative is the coefficient on the variable of interest.

Another result, assuming the individual is a price taker and is in equilibrium, is that the marginal implicit price corresponds to the marginal willingness to pay for q_j. While price and willingness-to-pay information is provided by this analysis, the marginal willingness to pay function for the individual is not directly revealed.

Willingness-to-Pay Function

The hedonic technique's second stage is an effort to identify the marginal willingness-to-pay function by combining the quantity and price information obtained from the first stage[1]. Whether or not the marginal willingness-to-pay function can be identified depends on the conditions under which it was estimated. This topic is addressed in the section on estimation issues later in this chapter. Individual *i*'s marginal willingness-to-pay function or uncompensated inverse demand function for q_j can be obtained by solving the choice problem:

$$b_{ij} = b_{ij}(q_j, \boldsymbol{S_i}, \boldsymbol{N_i}, \boldsymbol{Q^*_i}, \boldsymbol{u^*})$$

Where:
b_{ij} is individual *i's* willingness to pay for q_j.
$\boldsymbol{Q^*}_i$ represents all amenities except q_j.
And, other variables are as previously defined.

[1] *Hedonic empirical applications have typically focused on uncompensated inverse demand functions, which represents a short run evaluation (Cropper and Oates, 1992).*

The intersection of the individual's inverse demand function and the marginal implicit price function for q_j, p^q_j (opportunity locus to purchase q_j, where p^q_j is the price of q_j) is the utility maximizing equilibrium for individual *i*. Thus, it measures the individual's equilibrium marginal willingness to pay for q_j.

As long as the willingness to pay (as defined by individuals' inverse demand curves) exceeds the marginal implicit price, individuals will move out along p^q_j. Therefore, p^q_j, represents a locus of individuals' equilibrium willingness to pay.

Measuring Changes in Welfare

An important application of both the hedonic price function and the willingness-to-pay function is the ability to measure welfare effects. The value of a marginal change in an amenity is the sum of the marginal willingnesses to pay for each of the individuals affected by the change evaluated at the existing housing market equilibrium. That is, for the characteristic, q_j:

$$w_q = \sum_{i=1}^{n} b_{ij} = \sum_{i=1}^{n} \partial p_{hi} / \partial q_j$$

where w_q is the aggregate marginal welfare change.

For nonmarginal changes, in the partial equilibrium or short run case where other prices and characteristics are held constant, the welfare change is the area under the willingness-to-pay function.

$$W_q = \sum_{i=1}^{n} \int_{q0j}^{q1j} b_{ij}(q_{ij}, P, u^*_j)\, dq_j$$

where W_q is the aggregate benefit. This measure also represents the lower bound of the long-run welfare change (Bartik, 1988).

The upper bound of the long run welfare change can be directly estimated by the hedonic price function (Kanemoto, 1988). It is the predicted incremental change in the price of properties in the improved area.

In a related approach, Freeman (1993) points out a special case where exact welfare measurement is relatively easy. This occurs when the hedonic price function does not shift as a result of the environmental amenity change. Such a situation exists when the amenity level change affects only a few households relative to the total urban market. This would likely be the case for a specific project within a greater urban area. Assuming zero moving costs, the benefits of the change are calculated by predicting the incremental increase in value of the affected properties. To obtain net benefits, moving costs must be subtracted from the total increase in welfare.

Estimation Issues

While defining the hedonic price function and the willingness-to-pay function is relatively straight forward theoretically, practical application has numerous challenges. This section examines these challenges. How the issues were resolved in the context of this study is addressed in the Procedures chapter.

The Dependent Variable

There are two primary issues related to the dependent variable in specifying the hedonic price function. The first is whether the value of the environmental amenity of interest is reflected in the land value only or if it is reflected in both the land and house value. Because wetland amenities are location specific, rather than being associated with the structure, the value should be linked only to the land. However, since the land and house are normally purchased together, the full land and structure transaction prices can be used as long as the house characteristics are controlled for in the hedonic price equation.

The other issue relates to the source of the property values. Property values can come from aggregated census data, expert opinion such as professional appraisers, tax assessor values, and actual individual market transactions. The latter has been the primary source in recent published studies (Freeman, 1993). The preference for actual sales data over other sources is based on the presumption that such transactions come closest to reflecting true market values. "True" market values result when all buyers and sellers have perfect information and have exhausted all opportunities for further gains from additional trades. While both market and nonmarket data may be biased and will tend to cloud the relationship between true property values and the environmental amenities, they will not result in biased parameter estimates unless the error terms are correlated with other regressors in the model (Freeman, 1993).

The Explanatory Variables

There are a number of practical and conceptual issues in selecting variables which make up the hedonic price function and explain the transaction price of a residential property (Freeman, 1993). For environmental valuations, primary issues relate to the environmental amenities of interest; in this case, wetlands amenities. Wetlands provide environmental amenities that are fixed by location. The key is finding objective variables that capture the environmental amenities provided. In selecting the objective variables, there are several questions the analyst must address: Is there a close mapping between the objective measure, for example distance to nearest wetland, and the amenity levels perceived by nearby residents? Can the effects of different amenities on property values be identified when the amenities' measures are correlated? Since wetland amenities tend to be spatially oriented, correctly specified neighborhood variables become important. One key to obtaining robust results is controlling for variables that are correlated with the environmental characteristics being measured (Mendelsohn and Markstrom, 1988). If appropriate neighborhood variables are omitted the results will be biased. Similar to the requirements for objective measures of environmental amenities, neighborhood characteristics need objective measures which capture residents' perceptions of their neighborhood.

To delineate clearly the effects of an environmental characteristic on property price, the analysis must control for the effects of other characteristics, including other environmental, neighborhood, and structural variables. This challenge is made more troublesome by the introduction of multicollinearity. If some of the variables in the hedonic price function are correlated, the variance or imprecision of the coefficient estimates are increased. On the other hand, if relevant variables are left out of the regression to reduce collinearity problems, the coefficient estimates will be biased. Unfortunately, theory provides little help in addressing the bias/variance tradeoff and its resolution is left to the art of econometrics.

Functional Form

Many functional forms have been proposed and used for hedonic property models including linear, quadratic, log-log, semi-log, inverse semi-log, exponential, and Box-Cox transformation. Theory only suggests that the first derivative of the hedonic price function with respect to the characteristic in question be positive (negative) if the characteristic is desirable(undesirable). Properties of the second derivative cannot be deduced from the general features of the model (Freeman, 1993). Popular methods to select the functional form include using a linear relationship and altering any variables which are believed *a priori* to be nonlinear and using flexible forms (e.g. Box-Cox Transformations) to determine the best fit (Kulshreshtha and Gillies, 1993).

Goodness of fit has traditionally been the basis for selecting functional form. Cropper, Deck, and McConnell (1988) examined the question of functional form selection in a housing market study using real data on buyers and housing characteristics for Baltimore, MD. Functional form and parameters of individual's utility functions were specified and taste characteristics across individuals were distributed. The authors then solved an assignment problem that reflected a housing market equilibrium based on each house being assigned to the individual with the greatest willingness to pay for the house's bundle of characteristics. The true mean marginal implicit prices were then computed and compared to the estimated bid prices from six different hedonic price functions (linear, semi-log, log-log, Box-Cox linear, quadratic, Box-Cox quadratic).

They found that in models with omitted or proxy variables (a likely phenomenon in applied econometrics) the simpler forms (linear, semi-log, double-log) and the more complex, linear Box-Cox, functions perform best (most accurate marginal price estimates) as compared to the quadratic and Box-Cox quadratic forms. In the linear Box-Cox form, the independent variables were constrained to have the same transformation, which were allowed to differ from the transformation of the dependent variable. Dummy variables were not transformed. This form performed well for correctly specified models (perfect information) and performed best (least average bias) for models with unobserved attributes or proxy variables. The simple linear function also performed well by producing the smallest maximum bias in the case of unobserved attributes or proxy variables.

Market Equilibrium

Correct interpretation of the marginal implicit prices requires the assumption that the housing market is in equilibrium. This further requires that individuals have perfect information, that moving costs are zero, and that prices adjust immediately to changes in demand and supply. Freeman (1993) concludes that deviations from full equilibrium frequently will only introduce random errors into the parameter estimates. However, when markets or market expectations are continuously changing in one direction, incomplete market adjustments can introduce biases in marginal willingness-to-pay estimates and caution should be used with cross-sectional data. When this occurs, however, the direction of the bias can be determined and the marginal willingness-to-pay estimates can be classified as an upper or lower bound based on the analysis.

Market Segmentation

Several authors have raised the issue that urban housing markets are really made up of separate submarkets which require different hedonic price functions for each (Straszheim, 1974; Schnare and Struyk, 1976; Harrison and Rubinfeld, 1978; Goodman, 1978; and Michaels and Smith, 1990). If housing market segmentation exists and the hedonic price function is estimated for the urban market as a whole, the implicit price estimates will be incorrect for the residents located in the submarkets. The practical severity of the market segmentation issue is not clear, but if submarkets do exist they provide a means to estimate the willingness-to-pay function (Freeman, 1993).

Identification Problems in Estimating the Willingness-to-Pay Function

The second-stage regression (to estimate the willingness-to-pay function) poses an econometric identification problem which comes from two sources. First, the second-stage estimation provides no new information beyond what is already provided in the hedonic price function. This occurs because the dependent variable (marginal implict price of the attribute of interest) is not directly observed, but is calculated from the estimated hedonic price function. The dependent variable and the explanatory variables for the willingness-to-pay function have the same source data (Freeman, 1993). Brown and Rosen (1982) and Mendelson (1987) have shown that this procedure can, in some instances, lead to second-stage estimated parameters that are the same as those in the hedonic price function. The other problem occurs because individuals are choosing both price and quantity simultaneously. That is, the quantity of the wetland characteristic, for example, and its marginal implicit price are endogenous in the hedonic price model. This means that points along an individual's willingness-to-pay function are only observed for other individuals and provide no information on the original consumers bid for different quantities of the characteristic (Palmquist, 1991) Endogeneity in both price and quantity make it very difficult to isolate the effects of demand shift variables from the price-quantity interaction (Freeman, 1993).

Using exogenous variables as instruments has been one approach to overcome the identification problem (Mendelsohn (1984, 1985), Bartik (1987). However, finding truly exogenous variables that shift the hedonic price function appears to be difficult (Freeman, 1993). As an alternative to instrumental variables, assumptions can be used to restrict the model's structure. Such assumptions can meet the conditions for identification of the marginal willingness to pay curve. An example is to assume that the functional form for preferences is homothetic. Designating the relationship between income and demand allows one to separate the effects of income and changes in quantity on the marginal willingness to pay for characteristics (Quigley, 1982). Another approach is to assume a characteristic exists in the marginal hedonic price function that is not an argument in the marginal willingness to pay curve for some other characteristic. The omitted characteristic can then be used as an instrumental variable. Many authors have been critical of such assumptions because the results are dependent on assumptions that cannot be tested (Freeman, 1993).

Freeman (1993) suggests that the most reliable method for addressing the identification issue is the use of segmented markets, either from within a city or from different cities. With segmented markets, the marginal implicit prices of characteristics vary independently from the demand shifters. In other words, households with the same preferences, incomes, etc. face different marginal implicit prices for characteristics.

To implement this approach, the first step is to estimate separate hedonic price functions for each housing market while keeping the same specification for each segment. Then each individual's marginal implicit price for the variable of interest is computed for each housing market segment from the hedonic price function. Finally, the computed marginal implicit prices become the dependent variable and are regressed on the characteristic's observed quantities and socioeconomic data (exogenous demand-shift variables). The resulting estimation represents the uncompensated willingness-to-pay function. Assuming adequate independent variation across markets and no unobserved differences in preferences across individuals, the proposed technique can lead to reliable and properly identified bid functions (Freeman, 1993).

PROCEDURES

This chapter discusses how the methods addressed in the last chapter are implemented to achieve the objectives of this thesis. Topics addressed include descriptions of the study area and data. Also covered are the procedures used to estimate the hedonic price function and the willingness-to-pay functions for wetland variables.

Data

The successful application of a hedonic study requires large, well-ordered data sets. This study uses a data set of approximately 14,200 observations, with each observation representing a residential home sale within the urban portion of Multnomah County, Oregon between June 1992 and May 1994. Information on each sale consists of the sales price and a variety of structural, neighborhood, environmental, and other characteristics associated with the property. This section describes the data used in the study. It includes discussions on the study area, data sources, and data characteristics, as well as a description of assumptions and procedures to ensure consistency and conformability in the data.

Study Area Description

The study area is that portion Multnomah County that lies within the Portland urban growth boundary.[2] The study area is generally referred to Portland throughout this thesis. Only home sales that occurred within the urban growth boundary are included in

[2] *An original objective of the study was to encompass the multicounty urban area of Portland, Oregon which includes Washington, Clackamas, and Multnomah Counties. Data quality and compatibility concerns required narrowing the study area to urban Multnomah County. A significant portion of Multnomah County's land area is rural. Only the urban area (within Portland's urban growth boundary) has been included in this research since the urban wetlands valuation is the study's focus.*

the study area. Some of the characteristics that could affect property sales within the study area may be located outside Portland, but are included in this research. Examples include wetlands, parks, and industrial areas.

Multnomah County encompasses the City of Portland, Oregon's largest city. Located in the northwestern portion of the state, the county straddles the Willamette River and borders the Columbia River. Multnomah is the smallest Oregon county and has the largest population. Portland's population in 1990 was 437,300 while the county's population was 583,900. The greater Portland area, which includes the urban portions of Multnomah, Washington, and Clackamas Counties had a population of about 1.5 million in 1990. Between 1980 and 1990, this urban area's population increased by 19 percent and the areas population is expected to continue to grow into the next century. The median age in Portland in 1990 was 35, an increase of 4 years compared to the median age in 1980. There were 187,300 occupied houses in Portland in 1990; about 53 percent of these were owner occupied.

Per capita income in Portland was $14,500, an increase of 79 percent compared to per capita income in 1980. Employment in Portland in 1990 was 219,000. The unemployment rate was 6.2 percent. Private industry comprised 79 percent of the employment. Retail trade, manufacturing of durable goods, and health services are the three largest employment sectors, respectively. The largest change in employment between 1980 and 1990 occurred in the other professional and related services sector with an increase of 768 percent (U.S. Department of Commerce, 1990).

Historically, Portland's economy has centered around its deep water port which lies 110 miles from the Pacific Coast. Oregon's largest and most diversified port, Portland ranks third in total West Coast waterborne commerce behind Long Beach and Los Angeles. In more recent years, Portland's growth has been influenced by high-tech industries.

Being located in the maritime Pacific Northwest, the area enjoys significant water resources including two major rivers, several lakes, numerous streams and many wetlands. Figure 1 illustrates open water wetlands in the Portland area. The gray shading represents the distance gradient; lighter gray means more distant. The greater Portland area has over 4,500 wetlands and deepwater habitats representing over 200 different classifications. See the appendix for a listing of Portland area wetlands and deepwater habits.

Data Sources

Two principal data sources were used in this study. MetroScan, located in Sacramento, California, collects real estate data from assessor's records for numerous cities throughout the U.S. MetroScan provided a CD-ROM containing real estate data from the Multnomah County assessor's office. Table 4 shows the available fields for Multnomah County in the MetroScan data set. While Metroscan's data contain a large number of entries, many of the fields contained missing information or information of questionable quality.

The Portland regional agency, Metro, provided digital neighborhood and environmental characteristics for each residential property that sold during the study period. Metro is a directly elected regional government that serves the greater Portland area, including Multnomah, Clackamas, and Washington Counties. Growth management, transportation, and land-use planning, as well as other services are Metro's responsibility. The characteristics provided by Metro are shown in Table 5. Metro's Arc/Info geographic information system (GIS) was employed to generate the data. Distance calculations were made using a raster system where all data are arranged in a grid of cells. Each cell is 52-feet square. Distances were measured from cell center to cell center.

Table 4. Available fields for Multnomah County Assessor's Data

Absentee Owner by Zip	Owner Status	Class Code
Assessed Land	Parcel Number	Construction Type
Assessed Structure	Parcel Splits	Deck
Assessed Total	Phone Number	Fireplace
Census Tract And Block	Reference Parcel Number	Garage (Spaces)
Deed Type	Rng/Twn/Sec/Qtr	Garage Sq Ft
Improved %	Sale Price	Garage Type
Improvement	Site City & Zip Code	Heat Source
Improvement Code	Street Address	Heat Type
Interest Rate Type	Street Name	Lot Acreage
Land Use	Street Number	Lot Sq Ft
Legal Description	Subdivision/Plat	Patio
Lender Name	Transfer Date	Pool
Levy Code	Use Code	Roof Type
Loan Amount	Zoning Code	Sewer
Loan Type	Air Conditioning	Stories
Mail Address	Appliances	Street Surface
Map Number	Basement Sq Ft	Units
Map Page & Grid	Bathrooms	View Quality
Millage Rate	Bedrooms	Wall Material
Neighborhood Code	Building Sq Ft	Water Source
Owner Name	Building Style	Year Built

Source: MetroScan, 1994

Table 5. Metro GIS Neighborhood And Environmental Characteristics Data

Distance from residence to major transportation corridor; e.g. freeway, lightrail, through street
Distance from residence to nearest wetland by classification
Size of wetland nearest to residence
Distance from residence to nearest public park
Distance from residence to Portland's central business district
Distance from residence to nearest industrial area
Distance from residence to nearest commercial area
Property elevation, slope and aspect
Median age of residents in census block group
Median income of residents in census block group
Percent of population nonwhite in census block group
Percent of households in census group with < 1 person per room

Source: Metro, 1995

Data Characteristics

There were 23,039 recorded deeds for residential single-family owner-occupied homes in urban Multnomah County between June 1992 and May 1994. This set of observations represents the potential sample for use in testing the model described in the Methodology Chapter. Not all of the observations represent home sales. Also, many of the observations are unusable due to data quality problems and non-market transactions. For example, recording errors, missing information, sales between related parties, deed corrections caused sample observations to be rejected. This section describes the characteristics of the data used in the study including processes used to check and clean the data for relevant observations.

Sales Price -- The Dependent Variable

The dependent variable of the hedonic price function is the sales price of a residence. Actual sales prices of individual properties are preferred to other forms of valuation such as assessed, appraised or census tract estimates (Freeman, 1993). The preference for sales data is based on the presumption that the sales come closest to reflecting true market trades.

To reduce the risk of a biased dependent variable, urban Multnomah County deed recordings were screened for home sales representing arms-length or market transactions. The first filter was to include only recordings for warranty deeds (about 74 percent of the recordings during the study period)[3]. Deed types that indicated a doubtful market transaction include bargain and sale, conservators, correction, executors, grant, miscellaneous, personal representative, quit claim, re-contract, re-record, and special

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[3] *A deed is a legal instrument that conveys ownership from the grantor to the grantee of an interest in real property. Deeds can be differentiated by the guarantee that the grantor has legal title to the property; i.e., the right to sell. For example, a warranty deed conveys the usual covenants of title which protects the grantee for all future claims on the title while a quit claim deed gives no protection or title guaranty. Warranty deeds are the most preferred from a buyer's perspective (Dasso, 1989).*

warranty. Warranty deeds provide the strongest evidence that an arms-length sale occurred, yet many of the warranty-deed sales have prices that are reported with questionable values. For example, about 6 percent of the warranty-deed sales have a blank price field or the recorded sales price is $5,000 or less. To reduce these potential problems, a second filter was applied which included homes with sales prices greater than 60 percent of the total assessed value. About 90 percent or 14,485 of the warranty-deed transactions fall into this category. The Multnomah County assessor's office uses the greater than 60 percent of assessed value criteria for conducting market- and assessed-value ratio analysis. The ratio analysis is used to keep annual assessed values current with market values between the six-year appraisal cycles. As a result of these filters, a total of 14,485 market-based residential sales for Multnomah County between June 1992 and May 1994 were obtained.

Since the sales occurred over a two year period, the sales prices were adjusted by a price index for the Multnomah County residential housing market. The index is shown in table 6. All home sales are expressed in May 1994 dollars.

The average sales price for a residence using the May 1994 price level was $123,109; the median price was $104,240. The most expensive home sold for $1,913,814, while the least expensive sold for $9,656. Ninety percent of the residences had market values between $55,000 and $250,000. Figure 2 displays a histogram of the sales prices.

Table 6. Residential Housing Price Index, Multnomah County, Oregon

Month	Index
Jun-92	83.987
Jul-92	84.203
Aug-92	84.501
Sep-92	85.407

Table 6 Continued. Residential Housing Price Index, Multnomah County, OR

Month	Index
Oct-92	84.424
Nov-92	85.018
Dec-92	85.131
Jan-93	85.176
Feb-93	85.637
Mar-93	84.982
Apr-93	85.793
May-93	89.762
Jun-93	91.070
Jul-93	92.043
Aug-93	91.403
Sep-93	92.337
Oct-93	92.919
Nov-93	93.358
Dec-93	94.513
Jan-94	95.568
Feb-94	95.309
Mar-94	97.776
Apr-94	98.055
May-94	100.000

Source: Multnomah County Assessor's Office, 1995

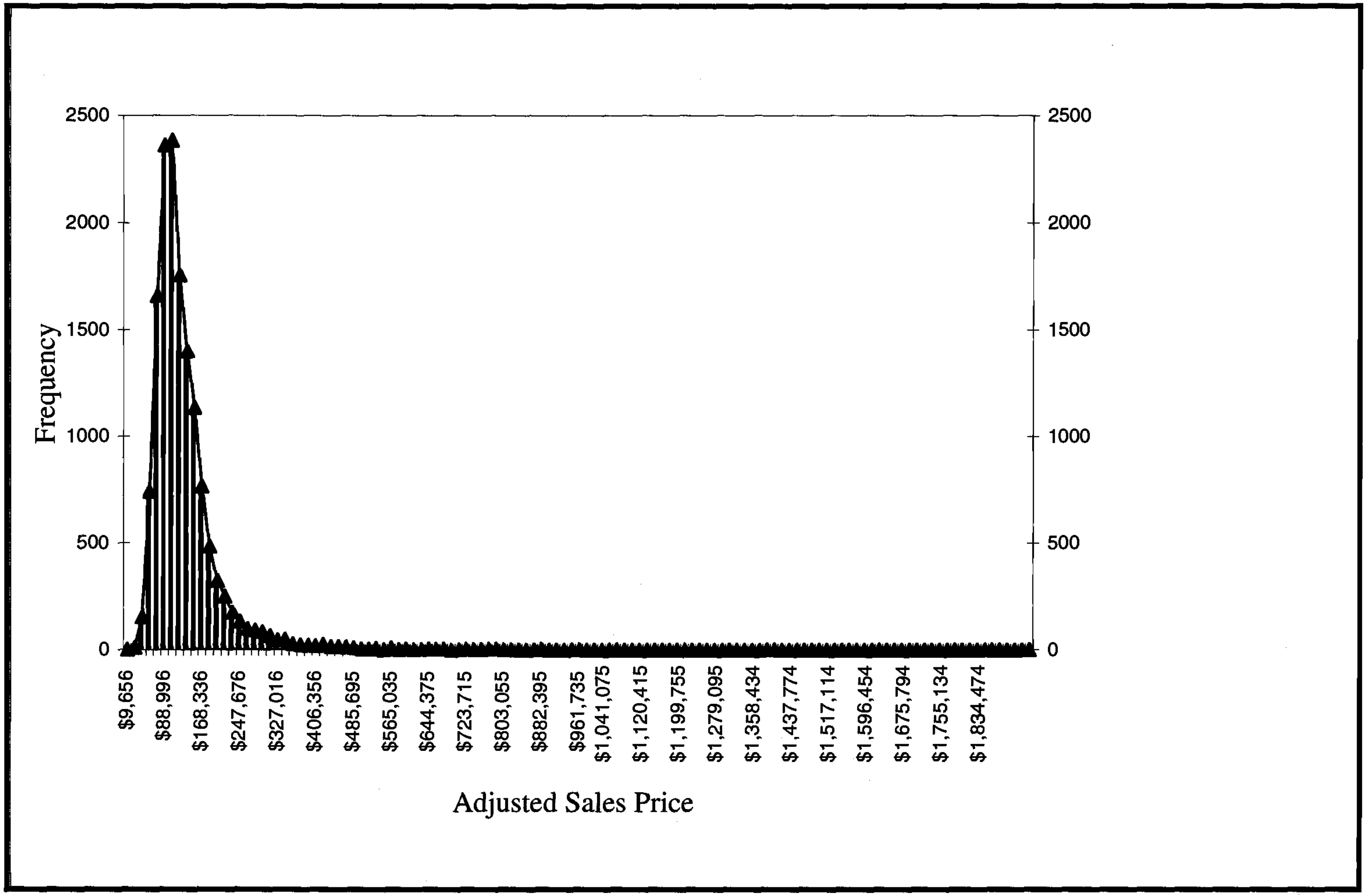

Figure 2. Histogram of Sales Prices for Single Family Residences from June 1992 to May 1994.

Structural, Neighborhood, and Environmental Characteristics -- The Explanatory Variables

For each home sale there is a set of associated explanatory variables that can be used to explain statistically the sales price of the home. These variables consist of structural, neighborhood, and environmental characteristics linked to each property in the data set. The explanatory variables, their definitions, and their expected relationship to the dependent variable, sales price, are shown in Table 7.

Table 7. Explanatory Variable Definitions

Name	Description	Expected Relationship to Dependent Variable
	Structural Variables	
BATHTOT	Number of bathrooms. Partial bathrooms were not specified in the data	Positive
FIREPLCE	Number of fireplaces	Positive
DGAS	Intercept dummy variable for gas heating source	Positive
DHARDWD	Intercept dummy variable for hardwood flooring	Positive
POOL	Intercept dummy variable for swimming pool	Positive
SIDEWALK	Intercept dummy variable for sidewalk	Positive
TOTALSF	Total structure square footage	Positive
GARAGESF	Garage square footage	Positive
LOTSQFT	Lot square footage	Positive
AGE	Year house was built subtracted from 1994	Negative
	Neighborhood Variables	
MILLRTE	Mill rate which indicates the tax rate	Negative
CBD	Distance to central business district	Negative*
DLTTRAF	Intercept Dummy variable for light traffic	Positive
ELEV	Elevation of property above sea level	Positive
SLOPE	Slope of property as a percent	Positive
INDUS	Distance in feet to nearest industrial zone	Positive*
COMM	Distance in feet to nearest commercial zone	Negative*
VIEWQLTY	Quality of view as indicated by county assessor	Positive
	Wetland Variables	
OPWTR_L	Distance in feet to nearest linear open water wetland	Unknown
OPWTR_A	Distance in feet to nearest areal open water wetland	Unknown
EMRVEG_L	Distance in feet to nearest linear emergent vegetation wetland	Unknown
EMRVEG_A	Distance in feet to nearest areal emergent vegetation wetland	Unknown
FOREST_L	Distance in feet to nearest linear forested wetland	Unknown
FOREST_A	Distance in feet to nearest areal forested wetland	Unknown
SCRSCB_L	Distance in feet to nearest linear scrub shrub wetland	Unknown

Table 7 Continued. Explanatory Variable Definitions

Name	Description	Expected Relationship to Dependent Variable
SCRSCB_A	Distance in feet to nearest areal scrub shrub wetland	Unknown
WTLDSIZE	Size of nearest wetland of any type in acres	Unknown
NEARDIST	Distance to nearest wetland of any type in feet	Unknown
Other Environmental Variables		
RIVER_L	Distance in feet to nearest stream	Unknown
RIVER_A	Distance in feet to nearest river	Negative*
LAKE_A	Distance in feet to nearest lake	Negative*
PARKS	Distance in feet to nearest improved public park	Negative*

*/ For distance variables such as distance to central business district (CBD) and distance to nearest lake (LAKE_A), a negative (positive) relationship to the dependent variable means residents are willing to pay more (less) to live closer to the characteristic. That is, the smaller (greater) the distance value, the more (less) the residence is worth.

Wetland characteristics used in this research are based on the U.S. Fish and Wildlife Service's National Wetlands Inventory in Oregon (Oregon Division of State Lands, 1990). The inventory uses the Cowardin classification system (Cowardin et al, 1979). The system is hierarchical allowing for various levels of detail and consists of system, subsystem, class, subclass, and modifier designators.

Doss and Taft (1993, 1996) aggregated the Cowardin system, subsystem and class designators into six major types related to visual aesthetics which are expected to influence home purchasers willingness to pay to live nearby. The major categories include forested, scrub-shrub, emergent-vegetation, and open-water wetlands, and lakes and rivers.

Forested wetlands are characterized by woody vegetation that is 20-feet tall or taller and includes wooded swamps and bogs. They tend to be the least visually open. Scrub-shrub wetlands are typically dominated by woody vegetation less than 20-feet tall. True shrubs, young trees, and stunted trees and shrubs predominate; alders, willows, and dogwoods are examples. Emergent-vegetation wetlands include marshes, meadows, fens and sloughs. Perennial plants usually dominate. Open-water wetlands are the most visually open and provide high quality habitat for waterfowl. They are usually less than 10-feet deep and include shallow ponds and reservoirs. Riverine habitats include rivers, streams, and creeks contained within a channel. They are usually, but not always, flowing. Lakes, including deep reservoirs and ponds, typically have a large area of deep, open water with wave action.

The Doss and Taft (1993, 1996) wetland types are used in this study. Metro's GIS database allowed an additional designation for each type based on its geographical distribution. Wetlands that are less than 52 feet in one dimension, but relatively long in the other dimension are considered linear features. A riverine designation of this kind would be considered a stream or creek. Alternatively, a polygonal shaped wetland that is greater than 52 feet on its shortest side is consider an areal feature. The wetland variables are measured as distance in feet from a residence to the nearest wetland of a given type.

The explanatory variables for the 14,485 home sales were checked for questionable observations using histograms, maximums, minimums, and means for quantitative variables and occurrence counts for qualitative variables. Examples of variables with unrealistic values include: blank values for bedrooms, bathrooms, lot square footage, zero values for house square footage, $80,000 residence with 74 bathrooms. There were 252 observations deleted from the data set, leaving a final sample size of 14,233.

Segmenting the Portland Housing Market

This study uses a segmented market approach for the Portland residential housing market. The Portland housing market was divided into five segments, north (reference segment), northeast, northwest, southeast, and southwest. Area addresses generally reflect these segment identifiers and many residents perceive the segments as being distinctly different in character. For example, several home buyers were informally interviewed regarding their perceptions of Portland area submarkets. They stated that they limited their search to certain parts of the city that correspond to the segments used in this study. Contacts were made with Metro and the Multnomah County assessors office. Both sources agreed that the geographical groupings identified in this study, in general, reflect different Portland area housing markets. Based on the conversations with area residents and with the local agency contacts, the highest to lowest ranking of average property values for Portland submarkets is northwest or southwest, southeast, northeast, and north. Table 8 describes the variables used in defining the market segments.

Table 8. Market Segment Variables. The Reference Location Represents Property Located In North Portland.

Name	Description
DSTHWST	Intercept dummy variable for property located in southwest portion of Multnomah County
DNTHWST	Intercept dummy variable for property located in northwest portion of Multnomah County
DSTHEST	Intercept dummy variable for property located in southeast portion of Multnomah County
DNTHEST	Intercept dummy variables for property located in northeast portion of Multnomah County

<u>Socio-Economic Demand-Shift Variables.</u>

Estimating the willingness-to-pay function in the second-stage hedonic analysis requires variables (income, race, age, etc.) that control for differences among home purchasers. These variables are shown and defined in table 9.

Table 9. Socio-Economic Demand-Shift Variables

Name	Description
D1519 D2024 D2529 D3034 D3544 D4554	Intercept dummy variables representing median age of residents in census block group
MEDINC	Median income of residents in census block group
PERROOM	Percent of homes in census block group with ≤ 1 persons per room
NONWH	Percent of population nonwhite in census block group

First-Stage Analysis -- Estimating the Hedonic Price Functions

The first stage analysis used ordinary least squares regression to estimate the hedonic price function. This function relates property sales price to the structural characteristics of the property, neighborhood attributes in which the property is located, and amenity values of nearby wetlands and other environmental characteristics. The formal econometric model is stated as:

$$P_h = XB + e$$

where P_h is a vector containing all the observations on the dependent variable (sales price of a residence), X is a matrix containing all the observations on all the explanatory variables including the constant term, B is a vector of the coefficients to be estimated, and e is a vector containing the error terms for all observations. See tables 7, 8, and 9 for a description of the explanatory variables and table 10 for the descriptive statistics of the dependent and explanatory variables (note that the demand-shift variables are not used until the second stage where the willingness-to-pay functions are estimated).

Table 10. Descriptive Statistics of the Variables

Name	n	Mean	Stnd Dev	Variance	Minimum	Maximum
			Structural Variables			
ADJPRICE	14233	0.12257E+06	79158.	0.62660E+10	9656.0	0.19138E+07
BATHTOT	14233	1.3998	0.58901	0.34693	0.00000	6.0000
FIREPLCE	14233	0.94871	0.70125	0.49175	0.00000	15.000
DGAS	14233	0.48872	0.49989	0.24989	0.00000	1.0000
DHARDWD	14233	0.21668	0.41200	0.16974	0.00000	1.0000
POOL	14233	0.11312E-01	0.10576	0.11185E-01	0.00000	1.0000
SIDEWALK	14233	0.65973	0.47382	0.22450	0.00000	1.0000
TOTALSF	14233	1426.1	573.89	0.32935E+06	364.00	8099.0
GARAGESF	14233	301.70	213.72	45678.	0.00000	7757.0
LOTSQFT	14233	7612.6	6546.4	0.42856E+08	963.00	0.43952E+06
			Neighborhood Variables			
AGE	14233	44.520	26.943	725.90	0.00000	114.00
MILLRTE	14233	18.035	0.54448	0.29646	13.734	19.314
CBD	14233	31658.	17968.	0.32284E+09	4060.0	79206.
DLTTRAF	14233	0.91351	0.28109	0.79014E-01	0.00000	1.0000
ELEV	14233	265.33	142.45	20291.	9.0000	1200.0
SLOPE	14233	4.2609	6.7833	46.014	0.00000	171.00
INDUS	14233	3691.6	2986.3	0.89178E+07	0.00000	15321.
COMM	14233	1228.5	1009.5	0.10191E+07	0.00000	7636.0
VIEWQLTY	14233	0.14642	0.78207	0.61164	0.00000	9.0000
			Wetland Variables			
OPWTR_L	14233	21032.	13417.	0.18000E+09	773.00	59312.
OPWTR_A	14233	4921.8	2580.2	0.66572E+07	104.00	12843.
EMRVEG_L	14233	9292.9	4485.9	0.20124E+08	104.00	23913.
EMRVEG_A	14233	10350.	5426.0	0.29441E+08	0.00000	28525.
FOREST_L	14233	9087.2	6348.0	0.40297E+08	0.00000	23423.
FOREST_A	14233	7780.2	3916.3	0.15338E+08	0.00000	17952.
SCRSCB_L	14233	12149.	5887.3	0.34660E+08	0.00000	27253.
SCRSCB_A	14233	8392.2	4220.7	0.17814E+08	73.000	19697.
WTLDSIZE	14233	40.799	52.554	2762.0	1.0000	358.00
NEARDIST	14233	3580.5	2485.1	0.61759E+07	0.10000	11930.
			Other Environmental Variables			
RIVER_L	14233	7608.7	4327.5	0.18728E+08	0.00000	18484.
RIVER_A	14233	11738.	6618.1	0.43800E+08	0.00000	28838.
LAKE_A	14233	17695.	6790.1	0.46105E+08	0.00000	35535.
PARKS	14233	1347.9	870.56	0.75787E+06	0.00000	5553.0
			Market Segment Variables			
DSTHWST	14233	0.13349	0.34012	0.11568	0.00000	1.0000
DNTHWST	14233	0.13279E-01	0.11447	0.13104E-01	0.00000	1.0000
DSTHEST	14233	0.36029	0.48010	0.23050	0.00000	1.0000
DNTHEST	14233	0.40582	0.49107	0.24115	0.00000	1.0000
			Demand-Shift Variables			
D1519	14233	0.77285E-02	0.87575E-01	0.76693E-02	0.00000	1.0000
D2024	14233	0.99206E-01	0.29895	0.89371E-01	0.00000	1.0000
D2529	14233	0.45795	0.49825	0.24825	0.00000	1.0000
D3034	14233	0.41720	0.49311	0.24316	0.00000	1.0000
D3544	14233	0.17354E-01	0.13059	0.17054E-01	0.00000	1.0000
D4554	14233	0.49181E-03	0.22172E-01	0.49161E-03	0.00000	1.0000
MEDINC	14233	32970.	12338.	0.15222E+09	6193.0	0.10599E+06
PERROOM	14233	96.670	2.9958	8.9748	82.000	100.00
NONWH	14233	10.610	11.878	141.08	1.0000	83.000

The functional forms used in the first stage analysis were chosen based on the results of the Cropper, Deck, and McConnell (1988) study. They showed that in models with omitted or proxy variables, the simpler forms, such as linear, semi-log, double-log, and the more complex flexible forms such as linear Box-Cox, estimated the most accurate marginal implicit prices. Palmquist (1991) encountered identification problems when flexible functional forms were introduced in the second stage. For these reasons, two simpler forms were chosen. The linear form, representing a linear relationship between the dependent and independent variables and the log-log form representing a non-linear relationship[4]. With the linear form, the coefficient on a characteristic variable represents the estimated marginal implicit price of the characteristic. The implicit price is constant for all levels of the characteristic. With the log-log form, the coefficient on a characteristic variable is the estimated elasticity (the percentage rate of response or change in the dependent variable for a given percentage change in one of the explanatory variables). While the elasticity is constant for all levels of the characteristic, the marginal implicit price changes, depending on the characteristic's quantity.

Dummy variables, which only take on the value of 1 or 0, were used to estimate the effects of qualitative characteristics, such as whether a residence has hardwood floors, and to include the effects of a residence being located in different Portland housing submarkets. Intercept dummy variables were used to capture structural shifts, which affects the intercept of the regression equation; i.e., parallel shifts up or down of the regression equation. The use of intercept dummy variables for housing market segments generated different regression equations for each submarket. As noted earlier, this market segment approach may produce the additional information needed to overcome the econometric identification problem, thus allowing estimation of the willingness-to-pay functions in the second-stage analysis.

Hypothesis testing conducted in the first-stage regressions is detailed in the Results chapter.

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[4] *A quadratic functional relationship was also explored, but dropped due severe multicolinearity.*

Second-Stage Analysis -- Estimating the Willingness-to-Pay Functions

The second stage analysis consisted of estimating willingness-to-pay function for size of nearest wetland to a residence (WTLDSIZE). This function could be used to estimate the benefits of a wetland project by integrating under the willingness-to-pay curve over the range established by the quantity means, with and without the project.

To estimate the willingness-to-pay function, Freeman's (1993) recommended approach was used. The first partial derivative with respect to wetland size (WTLDSIZE) was calculated from the estimated hedonic price function (first-stage regression) to compute the wetland size marginal implicit price for each property sale. Next, the computed marginal implicit prices were regressed on the observed quantities of wetland size and the exogenous demand shifters (socio-economic variables) to produce the uncompensated inverse demand function or willingness-to-pay function. The log-log functional form was used in the second stage regression. The willingness-to-pay function cannot be estimated for the linear model because the marginal implicit price is constant.

The essence of this process is to explain the price of an attribute (marginal implicit price per wetland acre) as a function of the quantity of the attribute (size of nearest wetland); all other things being held constant. The determinants of an individual's willingness to pay for an attribute includes the attribute's quantity and other demand-shift variables. Exogenous demand-shift variables include income of the home purchaser, which is indirectly described by the median income of residents of the census block group where the property is located, and preferences of the purchaser, which are indirectly described by age (dummy variables for median age of residents in the residence's census block group), race (percent of population nonwhite in the census block group) and number of occupants per residence (percent of homes in census block group with 1 or less persons per room).

In order to overcome the econometric identification problem, separate hedonic price functions were estimated for each submarket by including intercept dummy variables for the different market segments in the second-stage formulation. Assuming that the underlying demand structure is the same across all the submarkets; i.e., the differences in the determinants of the willingness to pay are controlled, this approach increases the quantity of information obtained from the marginal implicit prices. This additional information may allow the willingness-to-pay functions to be properly identified.

RESULTS AND IMPLICATIONS

This chapter presents the results of both the first- and second-stage hedonic analysis. It includes discussions on the interpretation of the results, as well as hypothesis tests and their implications. The first section covers the estimated hedonic price function for both linear and log-log models. The second section focuses on the estimated willingness-to-pay function. One willingness-to-pay function was estimated for size of nearest wetland (WTLDSIZE) using the log-log functional form.

First-Stage Results -- The Estimated Hedonic Price Function

In the first stage analysis, ordinary least squares regressions were estimated on the relationship between the property transaction price and the structural characteristics of the property, neighborhood attributes in which the property is located, and nearby wetlands and other environmental features. The results of the first stage regressions for linear and log-log functional forms are presented in table 11.

A frequent concern when using cross-sectional data in regression analysis is heteroskedasticity. Heteroskedasticity occurs when the error terms are not constant across observations. Diagnostic tests indicated that heteroskedasticity was present (see test results in table 12), so the standard errors have been corrected (White, 1980). White's approach corrects for hetroskedasticity where the form is unknown. While this approach yields consistent estimates, it is not asymptotically efficient.

Another modeling concern is multicollinearity (the presence of high correlations between two or more explanatory variables). When multicollinearity exists the parameter estimates are unbiased, but they have a high degree of variability. Basically, the coefficients on the collinear variables may become unreliable. An obvious indicator of multicolinearity, a high R^2 combined with low t-ratios, is not evident. Simple correlations among the variables of concern, specifically wetlands and other environmental variables, were checked. Generally, if simple correlations exceed .80 collinearity may be a concern. Only two correlations greater than .70 were encountered. Forested areal (FOREST_A) and emergent vegetation linear (EMRVEG_L) wetlands had a simple correlation of .78. Emergent vegetation areal (EMRVEG_A) and scrub-shrub linear (SCRSCB_L) had a simple correlation of .76. It is possible that more complex forms of multicolinearity exist; however, they do not raise concerns as long as the t-statistics are significant. It was concluded that multicolinearity is not a significant concern with the models estimated here.

Table 11. First-Stage Regression Results

Linear Model				Log-Log Model			
VARIABLE NAME	ESTIMATED COEFFICIENT	T-RATIO 14184 DF	P-VALUE	VARIABLE NAME	ESTIMATED COEFFICIENT	T-RATIO 14184 DF	P-VALUE
Structural Variables							
BATHTOT	7542.4	6.290	0.000	BATHTOT	0.53788E-01	4.739	0.000
FIREPLCE	6443.3	7.771	0.000	FIREPLCE	0.87404E-01	17.17	0.000
DGAS	1331.8	1.747	0.081	DGAS	0.28842E-01	6.727	0.000
DHARDWD	6743.6	7.427	0.000	DHARDWD	0.31411E-01	6.429	0.000
POOL	15314.	1.774	0.076	POOL	0.64919E-01	2.753	0.006
SIDEWALK	6953.9	5.872	0.000	SIDEWALK	0.54541E-01	11.68	0.000
TOTALSF	69.569	27.52	0.000	TOTALSF	0.62806	68.16	0.000
GARAGESF	21.152	4.697	0.000	GARAGESF	0.51670E-02	17.73	0.000
LOTSQFT	1.2144	3.366	0.001	LOTSQFT	0.11768	16.92	0.000
AGE	-99.036	-3.636	0.000	AGE	-0.14810E-01	-17.05	0.000
Neighborhood Variables							
MILLRTE	-15203.	-6.917	0.000	MILLRTE	-0.51820	-5.091	0.000
CBD	-0.51333	-4.737	0.000	CBD	-0.13180	-13.18	0.000
DLTTRAF	5523.9	3.910	0.000	DLTTRAF	0.56054E-01	7.859	0.000
ELEV	36.358	3.352	0.001	ELEV	0.39788E-01	3.842	0.000
SLOPE	-21.806	-0.1353	0.892	SLOPE	0.19786E-02	5.433	0.000
INDUS	-2.5121	-8.450	0.000	INDUS	0.23638E-01	9.289	0.000
COMM	5.5584	7.391	0.000	COMM	0.10498E-01	8.326	0.000
VIEWQLTY	12959.	8.213	0.000	VIEWQLTY	0.14868E-01	15.13	0.000
Wetland Variables							
OPWTR_L	0.17533	1.579	0.114	OPWTR_L	0.41743E-01	5.984	0.000
OPWTR_A	-3.1954	-9.871	0.000	OPWTR_A	-0.40482E-01	-9.432	0.000
EMRVEG_A	-0.34006	-1.415	0.157	EMRVEG_A	-0.31253E-02	-0.4874	0.626
EMRVEG_L	2.8583	12.82	0.000	EMRVEG_L	0.38292E-01	7.637	0.000
FOREST_L	0.62296	4.193	0.000	FOREST_L	0.66496E-02	1.914	0.056
FOREST_A	-1.2286	-5.949	0.000	FOREST_A	-0.32378E-02	-0.7546	0.450
SCRSCB_L	-0.37854	-2.025	0.043	SCRSCB_L	-0.16862E-03	-0.3367E-01	0.973
SCRSCB_A	2.3125	8.838	0.000	SCRSCB_A	0.20441E-01	3.527	0.000
WTLDSIZE	34.554	5.863	0.000	WTLDSIZE	0.44243E-02	2.675	0.007
NEARDIST	2.5466	6.193	0.000	NEARDIST	-0.76427E-02	-2.097	0.036
Other Environmental Variables							
RIVER_L	-3.4608	-13.81	0.000	RIVER_L	-0.35354E-01	-6.587	0.000
RIVER_A	0.40243	2.785	0.005	RIVER_A	0.17835E-01	1.878	0.060
LAKE_A	-0.69712	-7.511	0.000	LAKE_A	-0.81017E-01	-5.254	0.000
PARKS	0.90624	2.340	0.019	PARKS	0.31782E-02	1.552	0.121

Table 11Continued. First-Stage Regression Results

Linear Model				Log-Log Model			
VARIABLE NAME	ESTIMATED COEFFICIENT	T-RATIO 14184 DF	P-VALUE	VARIABLE NAME	ESTIMATED COEFFICIENT	T-RATIO 14184 DF	P-VALUE
Market Segment Dummy Variables							
DSTHWST	73150.	10.86	0.000	DSTHWST	0.38322	23.17	0.000
DNTHWST	42278.	5.996	0.000	DNTHWST	0.46002	17.66	0.000
DSTHEST	19392.	9.211	0.000	DSTHEST	0.21203	20.25	0.000
DNTHEST	10219.	5.849	0.000	DNTHEST	0.24182	21.79	0.000
CONSTANT	0.24379E+06	6.361	0.000	CONSTANT	8.5291	31.99	0.000
Model Tests							
R-SQUARED = 0.7611				R-SQUARED = 0.7674			
R-SQUARED ADJUSTED = 0.7605				R-SQUARED ADJUSTED = 0.7668			
F 3,073.372 P-VALUE 0.000				F 1,017,104.128 P-VALUE 0.000			

Table 12. Tests for Heteroskedasticity

Linear Model
E**2 ON YHAT CHI-SQUARE=1523 W/ 1 DF; for α=.05 critical value = 3.8
E**2 ON YHAT**2 CHI-SQUARE=3307 W/ 1 DF; for α=.05 critical value = 3.8
E**2 ON LOG(YHAT**2) CHI-SQUARE=521 W/ 1 DF; for α=.05 critical value = 3.8
E**2 ON X B-P-G TEST CHI-SQUARE=2136 W/ 36 DF; for α=.05 critical value=56
LOG(E**2) ON X HARVEY TEST CHI-SQUARE=2292 W/ 36 DF; for α=.05 critical value=56
ABS(E) ON X GLEJSER TEST CHI-SQUARE=8614 W/ 36 DF; for α=.05 critical value=56
Log-Log Model
E**2 ON YHAT CHI-SQ=47 W/ 1 DF; for α=.05 crit value=3.8
E**2 ON YHAT**2 CHI-SQ=51 W/ 1 DF; for α=.05 crit value=3.8
E**2 ON LOG(YHAT**2) CHI-SQ=44 W/ 1 DF; for α=.05 crit value=3.8
E**2 ON X B-P-G TEST CHI-SQ=954 W/ 36 DF; for α=.05 crit value=56
LOG(E**2) ON X HARVEY TEST CHI-SQ=876 W/ 36 DF; for α=.05 crit val=56
ABS(E) ON X GLEJSER TEST CHI-SQ=1716 W/ 36 DF; for α=.05 crit val=56

Structural and Neighborhood Variables

For the linear model, most of the structural and neighborhood variables are statistically significant at the .05 level and their coefficients' signs and magnitudes appear reasonable (see table 7 for the expected relationship between the dependent and explanatory variables)[5]. Exceptions to the significance tests are two intercept dummy

[5] *A negative sign on a distance variable; e.g., distance to the central business district (CBD), is interpreted as a positive marginal willingness to pay for that characteristic. Property value increases as distance becomes less.*

variables representing gas heat (DGAS), and whether the property has a swimming pool (POOL) and one variable representing the slope of the property (SLOPE). It was anticipated that gas heating and a swimming pool would add value to a house. Similarly, it was expected that sloping lots would increase a property's value since the construction costs would likely be greater. The relatively low t-statistics indicate that these variables have little influence on the selling price of a residence.

Two significant variables, distance to nearest industrial area (INDUS) and distance to nearest commercial area (COMM) had unexpected signs. It was anticipated that living near an industrial area would reduce a property's value because of possible congestion and air and noise pollution. Rather, it may be that living near an industrial area reduces commuting time and is, therefore, a positive attribute. On the other hand, because living near a commercial area might mean easier access to shopping, it was expected that residents would prefer to live closer to a commercial zone. The positive sign on the coefficient, however, did not support this conclusion, perhaps because of the added congestion surrounding commercial zones.

For the log-log model, all of the structural and neighborhood variables are statistically significant at the .05 percent level. Coefficient signs are as expected (see table 7) except for distance to commercial zone (COMM). It is difficult to explain the difference in the structural and neighborhood variable results between the two models.

Wetland Variables

The primary focus of this hedonic analysis is on the role and significance of the wetland variables. Interpreting the results of the linear model, nearly all four wetland types, open water (OPWTR), emergent vegetation (EMRVEG), forested (FOREST), and scrub-shrub (SCRSCB) for each of the two geographic measures, linear and areal, are statistically significant at the .05 level. The two exceptions are open water linear

(OPWTR_L) and emergent vegetation areal (EMRVEG_A) which are not significant and indicate that residents are indifferent about living closer to wetlands of these types. For the remaining types, the signs on the wetland variables were mixed. In general, open water areal (OPWTR_A), forested areal (FOREST_A), and scrub-shrub linear (SCRSCB_L) had a positive effect on property sales price, while for emergent vegetation linear (EMRVEG_L), forested linear (FOREST_L), and scrub-shrub areal (SCRSCB_A) there was a negative effect. The wetland type with the greatest affect on price is open water areal (OPWTR_A). There is a marginal willingness to pay of $3.20 for each foot closer a property is to wetlands of this type. The wetland type with the greatest negative effect is emergent vegetation linear (EMRVEG_L) ; residents have a marginal willingness to pay of $2.86 per foot to live further away from such wetlands.

Size of nearest wetland (WTLDSIZE) and distance to nearest wetland (NEARDIST) provide information on how wetlands affect property prices in general, without regard to specific types and geographical measures. Results for these variables indicate that "larger" is more valuable, a one acre increase in size is worth $35. An apparent contradiction, however, is that properties that are further away from wetlands, in general, are more valuable.

The log-log model results are somewhat different. Four of the variables are significant at the .05 level. They are open water linear and areal (OPWTR_L, OPWTR_A), emergent vegetation linear (EMRVEG_L), and scrub-shrub areal (SCRSCB_A). Of the eight specific wetland categories evaluated, only three, open water areal (OPWTR_A), emergent vegetation linear (EMRVEG_L), and scrub-shrub areal (SCRSCB_A), had the same signs and were consistently significant between the two models. For the log-log model and for both the log-log and linear models, open water areal (OPWTR_A) was the only type that shared a consistent positive value for proximity. The interpretation of the coefficient on open water areal wetlands (OPWTR_A) in the log-log model, for example, would be: A house that is one percent closer to a open water areal wetland would have a .04 percent greater value, all other things being equal. Using mean distance and home value, moving 49 feet closer to a open water areal wetland results in a $50 increase in home value.

For the nonspecific wetland variable, wetland size (WTLDSIZE), an increase in the size of the closest wetland was again positive. With the log-log model, however, properties closer to wetlands had greater value as indicated by the negative coefficient on the variable distance to nearest wetland (NEARDIST).

Other Environmental Variables

The other environmental variables, distance to nearest stream (RIVER_L), distance to nearest river (RIVER_A), and distance to nearest lake (LAKE_A) and distance to nearest public developed park (PARKS) are significant and consistent between the two models except for rivers and parks in the log-log model which are insignificant at the .05 level. Properties closer to streams and lakes are more valuable. Proximity to streams has a greater influence on price ($13.81 per foot) than does proximity to lakes ($7.51 per foot). Somewhat surprisingly, proximity to rivers and parks had the opposite effect on market price. Concern over flooding and heavy commercial and industrial development along much of Portland's river front may explain why being closer reduces property value. Similarly, neighborhood congestion and concern over crime in urban parks may explain why park proximity diminishes value.

Market Segments

The coefficients on the market segment variables show how each submarket compares to the reference location, north Portland. For example, homes in the southwest segment are, on average, $73,000 more valuable than homes in the north segment. For the linear model, the regression results ranking average property values by segment match the expected ranking. Southwest Portland has the greatest value, followed by northwest, southeast, northeast and north.

Testing the Study Hypotheses and other First-stage Hypotheses

Three informal hypotheses or expectations were identified regarding the significance of wetland characteristics in determining the sales price of residential property. The hypotheses are:

1) Wetlands have a significant influence on nearby residential property values.

2) Different types of wetlands have significantly different marginal implicit prices.

3) Wetlands and non-wetland greenspaces; i.e., public parks, lakes, and rivers have significantly different marginal implicit prices.

Tests for the first hypothesis are performed by using the t-statistic for each wetland variable in table 13. The null hypothesis is that a given coefficient is equal to zero. As discussed in the previous section on the first-stage analysis of wetland variables, some of the wetlands variables are significant (null hypothesis rejected) at the .05 level, while others are not (null hypothesis not rejected). From the results it can be inferred that wetlands proximity clearly influences property values in Portland.

For the second hypothesis, individual paired F-tests were conducted for each of the wetland coefficients. The null hypothesis is that each pair of wetland coefficients would be equal. The test results for the linear model are shown in table 13. Twenty six of the 28 coefficient pairs for wetlands are significantly different from each other at the .05 level. The exceptions include emergent vegetation areal (EMRVEG_A) and scrub-shrub linear (SCRSCB_L) and emergent vegetation linear (EMRVEG_L) and scrub-shrub areal (SCRSCB_A). Twenty two of the 28 wetland coefficient pairs are significantly different at the .05 level for the log-log specification (results not shown). The inference is clear that most different types of wetlands have significantly different marginal implicit prices.

Table 13. Null Hypothesis Tests that Wetland Coefficients Are Equal (F-Statistics, Linear Model)

Wetland Type	FOREST_L	OPWTR_A	SCRSCB_L	EMRVEG_A	FOREST_A	SCRSCB_A	EMRVEG_L
OPWTR_L	7.32	97.20	7.04	4.62	30.30	48.23	110.60
FOREST_L		160.04	12.02	13.02	70.89	24.03	48.47
OPWTR_A			46.83	51.81	47.91	152.14	164.24
SCRSCB_L				.011	8.12	123.59	134.31
EMRVEG_A					6.73	34.50	94.28
FOREST_A						107.43	118.76
SCRSCB_A							3.25

Note: If the F-Statistic exceeds 3.85, the null hypothesis of coefficient equality is rejected at the .05 level of significance.

Table 14. Null Hypothesis Tests that Wetland Coefficients Are Equal to Other Types of Open Spaces (F-Statistics, Linear and Log-Log Models)

Open Space	**Linear Model** Dist. to Nearest Wetland (NEARDIST)	**Log-Log Model** Dist. to Nearest Wetland (NEARDIST)
Dist. to Streams (RIVER_L)	141.27	25.79
Dist. to Rivers (RIVER_A)	24.71	6.08
Dist to Lakes (LAKE_A)	59.94	25.12
Dist to Parks (PARKS)	9.03	6.44

Note: If the F-Statistic exceeds 3.85, the null hypothesis of coefficient equality is rejected at the .05 level of significance.

The last hypothesis examines whether the marginal implicit prices for wetlands are different than other types of open spaces. Separate paired F-tests were conducted to check for equality between coefficients on distance to the nearest wetlands (NEARDIST) and distance to nearest parks (PARKS), rivers (RIVER_A), streams (RIVER_L), and lakes (LAKE_A). At the .05 level of significance, for both the linear and log-log specifications, the marginal implicit price for wetlands is significantly different than the marginal implicit prices for the other open spaces. The test results are shown in table 14.

In addition to testing these three basic relationships between wetland characteristics and prices, two other groups of tests were conducted. The first tested the null hypothesis that the coefficients for linear wetlands equal the coefficients on areal wetlands to see if wetland geographical measures are valued differently. An F-test was used to compare the sum of the areal coefficients against the sum of the linear coefficients. The computed F-statistic for the linear model is 74.01 and for the log-log model is 58.81. The critical value at the .05 level is 3.85. The test results lead to the inference that linear wetland features are valued differently than areal wetland features.

The second group of tests examined the statistical evidence of market segmentation. The first null hypothesis was that all market segment coefficients were equal to the reference segment (north Portland), against the alternative that at least one coefficient was not equal to the reference segment. Using a joint F-test the computed F-statistic is 46.40 for the linear model and 228.13 for the log-log specification. The null hypothesis is rejected.

Next, separate paired F-tests were undertaken for each segment variable. The null hypothesis was that the coefficients on each pair were equal which would indicate market segmentation did not exist for those two segments. The minimum F-statistic for all the tests in both models was 8.68 which supports the conclusion for market segmentation.

It is important to note that while the test results may indicate market segmentation, the dummy variables for market segments could be explaining variation in sales price that is not otherwise explained in the model. Thus, the test results are not an absolute indication of market segmentation. Market segmentation is critical to robust results because, along with socio-economic variables such as median income, it provides the exogenous information to overcome the econometric identification problem in estimating the second stage of the hedonic analysis, the willingness-to-pay function.

Second-Stage Results -- The Willingness-to-Pay Function

In the second stage analysis, the willingness-to-pay function was estimated for size of nearest wetland to a residence (WTLDSIZE). The second stage analysis consisted of two steps. First, the wetland size marginal implicit price for each property sale was computed by calculating the first partial derivative with respect to wetland size from the hedonic price function (first-stage regression). Next the computed marginal implicit prices were regressed on the observed quantities of wetland size, and the exogenous demand shifters (socio-economic variables) to produce the uncompensated willingness-to-pay function. Only the log-log functional form was used in the second stage. It was not possible to estimate the willingness-to-pay function for the linear model because the marginal implicit price is a constant.

The second-stage regression results for WTLDSIZE are shown in table 15. As expected, size of nearest wetland (WTLDSIZE) is highly significant (.05 level) in explaining the variation in the implicit price of WTLDSIZE. Income (MEDINC) and persons per room (PERROOM) are also significant. An alternative second-stage specification was explored by including in the second-stage regression all of the structural and neighborhood explanatory variables from the hedonic-price function in addition to the second-stage explanatory variables shown in table 15. Thirteen of the 18 additional variables were significant (.05 level) in the expanded specification (results not shown). The estimated coefficient on the variable of interest, wetland size, is -0.0447 (t-statistic: -74.79) using the simpler specification and -0.0448 (t-statistic: .74.72) using the expanded specification. This small difference is an indication of estimated parameter stability for WTLDSIZE.

Table 15. Second-Stage Regression -- Dependent Variable: Computed Implicit Price of WTLDSIZE, Variable of Interest: WTLDSIZE (Size of Nearest Wetland in Acres)

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 14222 DF	P-VALUE
WTLDSIZE	-0.44727	0.5981E-02	-74.79	0.000
D1519	-0.27619E-01	0.9316	-0.2965E-01	0.976
D2024	-0.19506	0.9277	-0.2102	0.833
D2529	0.91868E-01	0.9274	0.9906E-01	0.921
D3034	0.51454E-01	0.9274	0.5548E-01	0.956
D3544	-0.52024	0.9292	-0.5599	0.576
D4554	-0.17133	0.9913	-0.1728	0.863
MEDINC	0.19576	0.3167E-01	6.181	0.000
PERROOM	-0.67061	0.2987	-2.245	0.025
NONWH	0.15432E-01	0.1366E-01	1.129	0.259
CONSTANT	2.5940	1.628	1.593	0.111
R-SQUARE=0.2879 R-SQUARE ADJUSTED=0.2874				
F 632.155	P-VALUE 0.000			

The simpler specification was used to produce the uncompensated willingness-to-pay function for nearest wetland size (WTLDSIZE). This was done by evaluating all of the explanatory variables except WTLDSIZE at their means. The uncompensated inverse willingness-to-pay function for WTLDSIZE is as follows:

$$\ln(p) = 1.62 - .45\ln(q)$$

$$= 5.05q^{-.45}$$

Where:

p is the implicit price per acre of the nearest wetland.

q is the size of nearest wetland in acres.

A graphical representation of the function is shown in figure 3. The inverse form shown above is commonly used with environmental goods where quantity is given and purchasers are choosing an implicit price. If the nearest wetland is 30 acres in size, then, on average, residents would be willing to pay \$1.09 per acre. If the nearest wetland size is 40 acres, then the willingness to pay drops to \$.96 per acre. The price elasticity of demand is elastic and constant at -2.22 (1/-.45). Constant elasticity is a constraint of the log-log functional form. The downward sloping willingness-to-pay function is consistent with the expectation that residents prefer the closest wetlands to be larger, but that they are willing to pay less per acre as wetland acreage increases. The benefits of a project that increases the mean size of the nearest wetland to all residences from, say, 40.8 acres to 41.8 acres would be the area under the willingness-to-pay function (consumer surplus)

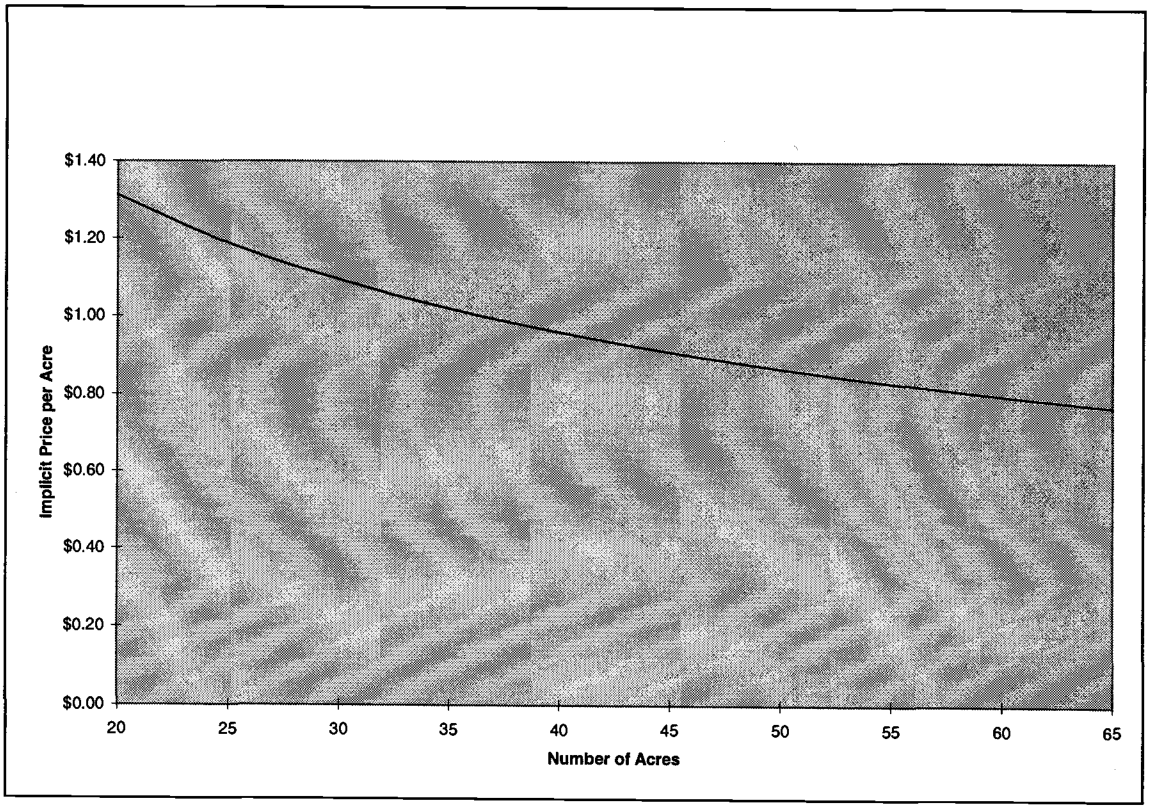

Figure 3. Willingness-to-Pay Function for Size of Nearest Wetland (WTLDSIZE) -- Log-Log Model

per residence multiplied by the number of residences in Portland. Assuming there are 100,000 single family owner occupied residents in Portland, the present value of project benefits would be $116,000 ($1.16 per residence x 100,000). Note that a wetland project that changes the mean size of the nearest wetland by one acre would be quite large.

The estimated willingness-to-pay function appears reasonable based on the expectation that residents would prefer larger wetlands to smaller ones, but that they would have a relatively small willingness to pay for additional wetland acreages.

CONCLUSIONS AND RECOMMENDATIONS

Wetlands play an important role in our social and economic well being. Many services wetlands provide, such as wildlife habitat, recreation, and aesthetics, exhibit collective-good characteristics. Because these services are not represented in a market, an over supply of wetlands converted to other uses and an under supply of protected wetlands may result. In order to improve wetland resource allocation decisions, nonmarket valuation techniques can be used to estimate the economic value of wetland attributes that represent collective goods. Using the hedonic property pricing approach, this study estimated the value of wetland environmental amenities in the Portland, Oregon metropolitan area. The principal measure is proximity to wetlands of different types. The analysis used ordinary least squares regression for two functional forms (linear and log-log). The analysis was carried out in two stages.

The first stage estimated the hedonic price function which relates the sales price of a residential property to the structural characteristics of the property, neighborhood attributes in which the property is located, and amenity values of wetlands and other environmental characteristics. The variables of primary interest were distance to four different wetland types, open water, emergent vegetation, scrub shrub, and forested. Each wetland variable was subdivided into two groups that defined the wetlands' geographic extent (linear or areal). Thus, there were a total of eight specific wetland categories. Other environmental variables evaluated included two general wetland variables (distance to nearest wetland of any type and size of nearest wetland) and other open spaces (parks, lakes, streams, and rivers).

The results of the first-stage analysis were mixed concerning the effect of wetlands on sales price. For some wetlands, proximity had a positive effect on sales price, while for others, proximity had either a negative relationship or no effect. For example, home buyers preferred to live closer to open water areal (OPWTR_A) and further away from emergent vegetation linear (EMRVEG_L) and scrub-shrub areal

(SCRSCB_A). There was a positive willingness to pay on the part of home buyers for the nearest wetlands to be larger rather than smaller. These findings held across both functional forms.

The study results indicate that wetlands influence the value of residential property and that the degree of influence varies by wetland type. The results also clearly show that wetlands influence property values differently than other amenity generating features such as parks, lakes, rivers, and streams. These conclusions are broadly consistent with those of Doss and Taft (1993, 1996). In their study, which used the hedonic property pricing approach and similar wetland classifications and proximity measures for Ramsey County, Minnesota, the authors found that wetlands proximity influences property prices. The specific results, however, are different. Doss and Taft concluded that scrub-shrub wetlands are the most preferred, followed by open water, then forested. It is important to note that it is difficult to compare the two studies directly, since two distinctly different geographic locations are involved and the wetland types are not defined in exactly the same way.

The willingness-to-pay function for size of nearest wetland (WTLDSIZE) was estimated in the second-stage analysis. The first stage results were used to estimate uncompensated willingness-to-pay function by regressing the calculated implicit price of the size of nearest wetland on the observed sizes and the exogenous demand shift variables, income, age, race, and persons per room. To overcome the identification problem common to such econometric exercises, separate equations were estimated in the first stage analysis through the use of intercept dummy variables for each Portland area submarket. This allows individuals with the same socio-economic characteristics to face different marginal implicit prices in each of the different submarkets, thereby providing the necessary additional information needed to estimate the willingness-to-pay function. Only the log-log model were used in the second stage.

The estimated willingness-to-pay function appears reasonable. That is, the predicted marginal implicit price given a wetland size does not seem out of line. This conclusion is based on the expectation of a positive, but small, willingness to pay for larger wetlands.

Application of the Estimated Models

The results of this study are significant. They show that wetlands proximity and size significantly influence residential property values, and that proximity to different kinds of wetlands are valued differently from each other and from other urban open spaces. In addition, this is the first study which estimates a willingness-to-pay function for wetlands amenity values as measured by size. However, differences in the magnitudes and signs of the parameter estimates between functional forms in the first stage leads to questions concerning the reliability of the results in evaluating real world wetland projects.

The inconsistent results reflect the problematic influence functional form has on estimating marginal implicit prices. Since economic theory provides little guidance in the selection of functional form, most researchers use the "goodness-of-fit" criterion. The problem is that this, or any other, criterion does not necessarily yield accurate estimated marginal implicit prices which is normally the goal of the hedonic price approach (Cropper, Deck and McConnell, 1988). Because marginal implicit prices make up the dependent variable when estimating willingness-to-pay functions, errors in implicit price measurement may bias estimated welfare effects. Measuring errors in the estimated marginal implicit prices is not possible since the true implicit prices are not known. Most researchers seem to avoid this "catch-22" by only reporting the results of one functional form.

Doss and Taft (1993) reported the results of six different specifications (four functional forms and two data sets defined by proximity) used in estimating the influence of wetland type and proximity on residential property values. To compare their results across specifications, the authors estimated the marginal willingness to pay to be 10 meters farther from a wetland type evaluated at mean distance. The willingness-to-pay estimates were highly sensitive to specification. The authors did conclude that the ranking of wetland types among the specifications were reasonably similar.

Cropper, Deck, and McConnell (1988) also found that estimated marginal implicit prices are sensitive to the functional form used. Their research examined how functional form affects the measurement of marginal attribute prices. Errors in measuring marginal prices were calculated using simulated "true" implicit prices. Functional form sensitivity remains a problematic issue.

Among non-market valuation techniques, the hedonic property pricing approach has the important advantage of measuring the actual price paid for an amenity. However, its application manifests numerous challenges. Extensive and high quality data are essential to robust results. Gathering data of adequate quality is expensive and time consuming. Computerized structural and neighborhood data are becoming more readily available for major metropolitan areas, but this limits the locations where the hedonic method can be applied. Finding good quality environmental data present additional problems. As GIS systems become more common and accessible , environmental data may be more readily available, but the data may not be in a form that lends itself to valuation. The hedonic approach only captures those attributes that are apparent to home buyers. That is, the method only measures the attributes of which people are aware. Wetlands provide important amenities to society, but it is difficult to know whether the proximity defined wetland variables employed here reflect the perceptions that home buyers use in making purchase decisions. For example, if many of the open water wetlands contain disamenities, such as trash and industrial wastes, residents may be valuing those attributes, rather than the NWI classification. Further, even the most careful data collection process will leave out attributes that affect purchase decisions. If the variables left out are correlated with the environmental variables, the coefficients on the environmental variables will be biased.

Assuming the estimated hedonic model provides good measures of marginal implicit values, useful benefit information can be gleaned from the hedonic price function or first-stage analysis. The estimated marginal implicit attribute price provides the lower bound on the individual's short run willingness-to-pay for the attribute. In the special case where the hedonic price function does not shift, as when only a relatively small number of homes are affected by the environmental change, the predicted change in property value is the exact welfare measure. To measure the short-run benefits of nonmarginal changes, the second-stage is required to estimate the willingness-to-pay function. Overcoming the identification issues in doing this are problematic.

It is important to recognize that even with properly identified willingness-to-pay measures for proximity to wetlands, the hedonic approach applied in this study only provides a limited measure of total benefits. First, the approach can only capture the short-run benefits before households and prices adjust to a change. The area under the willingness-to-pay function is, however, the lower bound on the long-run benefits (Bartik, 1988) and the upper bound is the predicted incremental change in property values (Kanemoto, 1988). Next the hedonic approach measures only the amenity value of proximity to wetlands perceived by owner occupied single family residence purchasers. While urban wetlands provides many other services to society, such as water quality improvements, biodiversity, ground water recharge and discharge, and recreation, these are not valued unless perceived by residents and reflected in the wetland variables. Nor does the approach measure the benefits received by other people in the area such as renters and visitors. Further, because the benefits are partial and site specific, the approach does not readily address the issue of how a wetland project in Portland benefits society relative to a wetland project in some other location. The method only provides a limited opportunity to provide a comparison of amenities provided by wetlands to those provided by other natural and human resources. For these reasons, the results do not fit cleanly into a measure of the total economic value of wetlands.

Further Research

Opportunities for further research related to this study come from four general areas; additional valuation studies on the data used in this research, conducting similar studies in other locations, research into estimating the willingness-to-pay functions, and wetlands data research. The data set used in this study is quite rich and opportunities exist to glean additional information. One important area would be to estimate willingness-to-pay measures for wetlands that are relatively close to residences. This study used all distances within the study area. For all proximity-related wetland variables, mean distances exceeded one-half mile. A similar evaluation should be conducted that limits the maximum distance to a nearest wetlands and compared to the results presented here. This approach may resolve some of the inconsistencies found here. Another research area would be to examine further the price effects of other functional relations. Perhaps a flexible functional form could be used to determine which form best fits the data.

The results of this study in Portland, Oregon are broadly consistent with those of Doss and Taft (1993, 1996) in Ramsey County, Minnesota. However, a number of inconsistencies occur when specific variables are compared. Similar studies could be conducted in other cities and the results compared to identify possible differences in geographic preferences and valuation patterns.

Developing and specifying a theoretically consistent hedonic willingness-to-pay function is well understood. Applying the theoretical model using the hedonic price approach has major challenges. The methods for estimating the willingness-to-pay function and for making statistical inferences about the robustness of the estimation are not well developed. As a result, there are few empirical studies that develop these second-stage estimates. Additional research is needed in the area of econometric estimation of the willingness-to-pay function using the hedonic property price method.

Wetlands are complex ecosystems that provide important services to society. The goal of wetlands economic valuation is to assign value to these services. There has been little research conducted on linking indicators of wetland ecosystem functions and specific ecological outputs to socio-economic outcomes (Cole et al., 1996; Costanza et al., 1989). As a result, most wetlands valuation research has used indirect measures such as proximity to different wetlands types. Considerable work is required to bridge the gap between ecology and economics.

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APPENDIX

APPENDIX

WETLANDS AND DEEPWATER HABITATS FOR THE GREATER PORTLAND, OREGON AREA

Frequency	Cowardin Classification	Type
2	PEM/ABF	Emergent Vegetation
1	PEM/ABH	Emergent Vegetation
8	PEM/SSA	Emergent Vegetation
2	PEM/SSAD	Emergent Vegetation
33	PEM/SSC	Emergent Vegetation
7	PEM/SSR	Emergent Vegetation
1	PEM1/FLR	Emergent Vegetation
27	PEM1/OWY	Emergent Vegetation
1	PEM1F	Emergent Vegetation
1	PEM1Fx	Emergent Vegetation
16	PEM1Kyh	Emergent Vegetation
37	PEM1Kyx	Emergent Vegetation
54	PEM1W	Emergent Vegetation
2	PEM1Wd	Emergent Vegetation
196	PEM1Y	Emergent Vegetation
64	PEM1Yd	Emergent Vegetation
4	PEM1Yh	Emergent Vegetation
5	PEM1Yx	Emergent Vegetation
242	PEMA	Emergent Vegetation
7	PEMAD	Emergent Vegetation
1	PEMAH	Emergent Vegetation
1	PEMAS	Emergent Vegetation
1	PEMAd	Emergent Vegetation
4	PEMB	Emergent Vegetation
757	PEMC	Emergent Vegetation
3	PEMCD	Emergent Vegetation
1	PEMCH	Emergent Vegetation
1	PEMCS	Emergent Vegetation
4	PEMCX	Emergent Vegetation
2	PEMCd	Emergent Vegetation
4	PEMCd	Emergent Vegetation

Frequency	Cowardin Classification	Type
33	PEMCh	Emergent Vegetation
7	PEMCx	Emergent Vegetation
54	PEMF	Emergent Vegetation
1	PEMFH	Emergent Vegetation
4	PEMFX	Emergent Vegetation
2	PEMFb	Emergent Vegetation
8	PEMFh	Emergent Vegetation
2	PEMFx	Emergent Vegetation
1	PEMKC	Emergent Vegetation
3	PEMKCX	Emergent Vegetation
6	PEMN	Emergent Vegetation
47	PEMR	Emergent Vegetation
3	PEMS	Emergent Vegetation
20	PEMT	Emergent Vegetation
23	PEMW	Emergent Vegetation
12	PEMY	Emergent Vegetation
1	PFL/SS1Y	Forested
1	PFLKYh	Forested
1	PFLKYx	Forested
1	PFO/AB5Y	Forested
9	PFO/EM1W	Forested
31	PFO/EM1Y	Forested
1	PFO/EMC	Forested
1	PFO/EMY	Forested
4	PFO/SS1W	Forested
17	PFO/SS1Y	Forested
4	PFO/SSA	Forested
15	PFO/SSC	Forested
4	PFO/SSR	Forested
1	PFO1C	Forested
3	PFO1Kyh	Forested
3	PFO1S	Forested
231	PFO1W	Forested
1	PFO1Wd	Forested
56	PFO1Y	Forested
1	PFO1Yh	Forested
175	PFOA	Forested
215	PFOC	Forested
6	PFOCh	Forested
8	PFOR	Forested
3	PFOS	Forested

Frequency	Cowardin Classification	Type
35	PFOW	Forested
15	PFOY	Forested
5	L1OWKZh	Lake
4	L1OWKZx	Lake
1	L1OWV	Lake
2	L1OWZ	Lake
3	L1UBH	Lake
1	L1UBHh	Lake
1	L1UBHx	Lake
2	L1UBKx	Lake
5	L1UBV	Lake
1	L2ABF	Lake
4	L2ABV	Lake
1	L2ABZ	Lake
2	L2FLKYx	Lake
2	L2UBT	Lake
1	L2USC	Lake
3	L2USN	Lake
29	L2USR	Lake
1	L2USS	Lake
26	PAB4Z	Lake
26	PAB5/OWY	Open Water
7	PAB5/OWZ	Open Water
7	PAB5KZh	Open Water
18	PAB5Z	Open Water
13	PABF	Open Water
15	PABFh	Open Water
11	PABFx	Open Water
22	PABH	Open Water
1	PABHH	Open Water
5	PABHX	Open Water
17	PABHh	Open Water
4	PABHx	Open Water
1	PABT	Open Water
1	PABZ	Open Water
2	POWKYh	Open Water
2	POWKYx	Open Water
7	POWKZ	Open Water
424	POWKZh	Open Water
386	POWKZx	Open Water
1	POWKZxr	Open Water

Frequency	Cowardin Classification	Type
10	POWY	Open Water
38	POWZ	Open Water
7	POWZh	Open Water
21	PBUF	Open Water
2	PUBFH	Open Water
12	PUBFX	Open Water
67	PUBFh	Open Water
58	PUBFx	Open Water
83	PUBH	Open Water
32	PUBHH	Open Water
1	PUBHR	Open Water
72	PUBHX	Open Water
84	PUBHh	Open Water
36	PUBHx	Open Water
3	PUBKHR	Open Water
9	PUBKHX	Open Water
10	PUBKR	Open Water
2	PUBKX	Open Water
5	PUBKX	Open Water
5	PUBV	Open Water
4	PUSA	Open Water
3	PUSC	Open Water
2	PUSCS	Open Water
5	PUSCX	Open Water
1	PUSCh	Open Water
6	PUSCx	Open Water
1	PUSH	Open Water
2	PUSKR	Open Water
2	PUSKx	Open Water
1	PUSR	Open Water
1	R1ABV	Riverine
11	R1FLR	Riverine
2	R1OWT	Riverine
4	R10WV	Riverine
4	R1UBT	Riverine
16	R1UBV	Riverine
66	R1USN	Riverine
62	R1USR	Riverine
2	R1USS	Riverine
1	R2ABH	Riverine
1	R2ABHX	Riverine

Frequency	Cowardin Classification	Type
2	R2FLY	Riverine
1	R2OWKZ	Riverine
34	R2OWZ	Riverine
6	R2UBH	Riverine
8	R2UBHX	Riverine
1	R2USA	Riverine
3	R2USC	Riverine
1	R3FL/OWY	Riverine
1	R3FLC	Riverine
123	R3FLY	Riverine
1	R3OWH	Riverine
25	R3OWZ	Riverine
5	R3UBH	Riverine
2	R3USA	Riverine
53	R3USC	Riverine
2	R4SBY	Riverine
2	PSS1C	Scrub/Shrub
1	PSS1Kyh	Scrub/Shrub
1	PSS1R	Scrub/Shrub
1	PSSIS	Scrub/Shrub
19	PSS1W	Scrub/Shrub
52	PSS1Y	Scrub/Shrub
2	PSS1Yh	Scrub/Shrub
61	PSSA	Scrub/Shrub
1	PSSAh	Scrub/Shrub
6	PSSB	Scrub/Shrub
317	PSSC	Scrub/Shrub
2	PSSCH	Scrub/Shrub
8	PSSCh	Scrub/Shrub
2	PSSN	Scrub/Shrub
67	PSSR	Scrub/Shrub
3	PSSS	Scrub/Shrub
12	PSST	Scrub/Shrub
4	PSSW	Scrub/Shrub
2	PSSY	Scrub/Shrub
50	PSS/EM1Y	Scrub/Shrub
12	PSS/EMC	Scrub/Shrub
2	PSS/EMN	Scrub/Shrub
4	PSS/EMR	Scrub/Shrub
2	PSS/EMW	Scrub/Shrub
1	PSS/EMY	Scrub/Shrub

Frequency	Cowardin Classification	Type
1	PSS/FL1Y	Scrub/Shrub
1	PSS/FOA	Scrub/Shrub
7	PSS/FOC	Scrub/Shrub
7	PSS1/FLW	Scrub/Shrub
32	PSS1/FLY	Scrub/Shrub
2	PSS1/OWY	Scrub/Shrub

Source: Metro, 1994