


## AN ABSTRACT OF THE THESIS OF

Loraine W. Kiest for the degree of Master of Science in Agricultural and Resource Economics presented on June 6, 1996. Title: The Implicit Value of Water Rights in Rural Residential Properties in Deschutes County, Oregon.

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Abstract Approved: \_\_\_\_\_

 Joe B. Stevens \_\_\_\_\_

During the late summer months water flows in some stretches of the Deschutes River in central Oregon are substantially reduced. Prior appropriation of the river's water to agriculture, municipalities and industry has diminished stream flows, raised water temperatures above levels that are optimal for fish habitat, and consequently reduced water quality. One solution to the problem is the development of incentives for water users to conserve water for sale, lease, or donation. One sector of water users that may be potential benefactors are the rapidly growing numbers of Deschutes County residents who own small parcels of residential property with water rights. The question is how to place a value on these water rights when they are not purchased separately in a water market but are attached as a characteristic of the associated property.

The first step was to identify recent buyers of residential properties ranging from one to forty acres. A private real estate appraisal firm provided addresses, sale price, and some physical characteristics on 173 properties purchased in Deschutes County between January, 1992 and March, 1995. A mail survey was used to collect information on water rights, additional property characteristics, and buyer characteristics for these recent sales. Reported sale prices ranged from \$66,000 to \$430,000. Water rights ranged in size from 0 to 23.7 acres of water and were distributed evenly throughout the range of sale prices.

The second step in developing an implicit value for water was to determine how the presence and size of water rights influence property values. An econometric model based on hedonic price theory was developed to analyze this relationship. Many of the explanatory variables were significant at the 99% level. An  $R^2$  of 0.7702 for the model specifying water as a continuous variable and an  $R^2$  of 0.7663 for the model specifying water as a dummy variable indicate both models were well specified. The estimated coefficients on the water variables indicated the relationship between water rights and property values is not significant contrary to what is suggested by real estate professionals.

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**THE IMPLICIT VALUE OF WATER RIGHTS IN RURAL  
RESIDENTIAL PROPERTIES: DESCHUTES COUNTY, OREGON**

by

Loraine W. Kiest

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Master of Science thesis of Loraine W. Kiest presented on June 6, 1996

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Dean of Graduate School

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Loraine W. Kiest, Author

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# **THE IMPLICIT VALUE OF WATER RIGHTS IN RURAL RESIDENTIAL PROPERTIES: DESCHUTES COUNTY, OREGON**

## **CHAPTER ONE: MOTIVATION AND OBJECTIVES**

### **1.1 INTRODUCTION**

During the warm, summer months in the Deschutes River basin of central Oregon, the river, in some stretches, is substantially reduced in size. The Deschutes River basin has a semi-arid climate that experiences little rainfall during the hot, summer months causing water levels in the river to become too low to support many fish populations. The problem lies in the overappropriation of this watershed to out-of-stream uses. This has traditionally been a region of irrigated farming, but it is now in the process of undergoing a transformation to rural, non-farm residences and small farm tracts (transitional agriculture), which are replacing more intensive agricultural uses of land.

Demand pressures are increasing for municipal, commercial and industrial uses as the result of growing populations and economic development. These pressures are stretching the current water supply to its limit. Unable to meet the growing water demand, the challenge is finding new ways of reallocating water to its highest and best use. If water markets were to improve there may be potential to purchase water from these out-of-stream uses to augment flow during dry periods.

## **1.2 OREGON WATER LAW**

Like many other western states, Oregon's water law is based on the prior appropriations doctrine. The doctrine is based on the principal of "first in time, first in right". A water right is acquired through the act of appropriating water involving diverting water from its source and applying it to a beneficial use.<sup>1</sup> The date in which the water was first put to beneficial use determines the priority of a water right. Priority determines the ranking of the right over other rights with later priority. This ranking permits senior water right holders to use water during times of water shortage; later or junior rights holders may be entirely denied use.

The principal of "first in time, first in right" has given an advantage to the early developers of water resources. Most of Oregon's water is still controlled by these users. For example, as of 1990, 86% of the state's water was controlled by agriculture (USDA 1990). In some sections of the state certain watersheds have been closed to new appropriations out of concern for existing water users and natural resources, leaving very little unappropriated water available for new uses.

In 1987, the Oregon State Legislature passed a bill authorizing a new type of water called an instream flow. Any person, public or private, may purchase, lease, or receive as a gift any water right for instream use (ORS 537.348). Streams were also assigned minimum flow levels, however, these rights are junior to any right with an older priority date.

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<sup>1</sup> ORS 536.300 states that domestic, irrigation, municipal, industrial, power development, mining, recreation, wildlife, fish life, drainage, pollution abatement, flood control, reclamation, and reservoir uses are all beneficial uses.

### **1.3 REAL ESTATE TRANSACTIONS AND WATER RIGHTS**

Irrigator's rights to water are attached to their land, and the amount of the right must be used, in full, every five years to be retained. Because water is attached to land, water rights are transferred to the new land owners when the property is sold. Many irrigators now reside on small hobby farms they have recently purchased. It is the conventional belief among local real estate professional and property owners that buyers of properties pay some premium for the presence of a water right. Determining the premium they have paid for their water may be useful in developing water markets to purchase surplus water from these right holders for instream use.

### **1.4 THESIS OBJECTIVES**

There are two objectives of this thesis. The first objective is to identify how water is used by property owners. These uses are not well documented and may affect the value these right holders' place on their water. This value may influence the relationship between a water right and property selling price.

The second objective is to estimate the monetary value of associated water rights that are incorporated into residential property values in rural Deschutes County. These properties range from one to forty acres in size. Real estate transactions were identified through a private appraisal firm. Additional information was collected through the Deschutes County Assessors office and a mail survey.

### **1.5 THESIS ORGANIZATION**

Chapter Two discusses the economic theory supporting the general framework of a hedonic price model (HPM). The chapter begins by laying out the underlying

assumptions of hedonic pricing methods and then discusses the specific components of these models.

Chapter Three is a review of literature on hedonic pricing models. Different applications for HPM are described along with their empirical results.

Chapter Four outlines the specific hedonic pricing model used to analyze the relationship between water rights and property values.

Chapter Five reviews the questionnaire format, survey methods, and responses from the mail survey used to collect property and owner data. An analysis of nonresponse bias is also performed.

Chapter Six presents a descriptive assessment of market information collected through the mail survey, appraisal firm, and county assessor records. The results include the observed range and distribution of sale prices and water rights and the distribution of water rights over sale prices and irrigation districts. Also presented in this chapter is the econometric analysis of the hedonic price model. The primary objective of this analysis is to understand the relationship between water rights and property sale prices.

Chapter Seven concludes the thesis with an overview of the study, a discussion of the study's findings and weaknesses, and suggestions for policy implications and future research endeavors.



## **CHAPTER TWO: THE ECONOMIC THEORY OF HEDONIC PRICING**

### **2.1 INTRODUCTION**

Markets for buying and selling of water rights are relatively new in the state of Oregon; few recognized transactions have occurred. As a result little explicit data is available to derive an accurate demand for water. Implicit markets can be used to derive water prices using Hedonic Pricing Methods (HPM). These methods use observed product prices and the specific amounts of characteristics associated with each good to define a set of implicit or "hedonic" prices. The goal of this chapter is to explain the economic theory and assumptions underlying HPM.

### **2.2 THE HEDONIC PRICING MODEL**

Hedonic prices are defined as the implicit prices of attributes and are revealed to the economist through observed prices of differentiated products and the specific amounts of characteristics associated with them. These models suggest that because people select goods for their characteristics, the value of the characteristics are reflected in the price of the goods. Goods do not possess final consumption attributes but rather are purchased as inputs into self-production functions for ultimate characteristics (Rosen 1974).

The Hedonic Pricing Method is a method for estimating the implicit prices of the characteristics that differentiate closely related products in a product category. It is a tool that helps to estimate the value of goods not traded in traditional markets, such as

environmental amenities, location factors, and water rights. The tool is based on the assumption that goods are valued for their utility-bearing attributes or characteristics. These attributes cannot be bought or sold separately but are characteristics associated with conventional market commodities. The good being measured in this study, water rights appurtenant to rural residential properties, is realized by the consumer as part of the bundle of goods the land provides (Feather et al. 1992).

Traditionally water rights were sold as a feature of a parcel of land, although there is evidence that explicit markets are developing for water rights independent of associated properties. Transactions are becoming particularly common within irrigation districts. Where water may be sold in explicit water markets, water prices in the implicit market for water must reflect those on the explicit market (Crouter 1987).

### **2.3 UNDERLYING ASSUMPTIONS**

Conventional economic theory dictates in any market transaction that both the buyer and seller are made better off or the sale would not occur. This assumes a buyer places a value premium on all the attributes present in the good. HPM develops two questions: would the seller be willing to trade an attribute for money, and if so, what would the buyer be willing to pay?

For hedonic models to be consistent with economic theory certain assumptions must be made. When gathering data in a particular region the whole region must be treated as a single market for housing. Buyers are considered to have perfect information on all alternatives and enough choices are present in the market so that consumers can adjust bundles of site characteristics to suit their preferences. These assumptions allow

for a reasonable approximation of choice behavior based on the buyer's ability to freely choose a site anywhere in the study market (Freeman 1993). Preferences must be assumed to be weakly separable in housing and its characteristics. This assumptions demands that characteristics be independent of the prices of other goods. The housing market is assumed to be in equilibrium. That is, all individuals make utility maximizing choices given the prices of alternative properties, and these prices just clear the market given the existing stock of housing and its characteristics.

## **2.4 UTILITY MAXIMIZATION**

Hedonic Pricing Methods are based in the theory of rents and utility maximization. The theory of rents states that the equilibrium price for a parcel of land is equal to the present value of the stream of rents produced by that land. Because the productivity (or value received from owning land) differs between sites, any differential in productivity will yield differential rents to land and therefore different land values. In competitive markets with free entry the market is sufficient to guarantee that productivity differences are fully captured in the price of land. This results from potential entrants bidding up land prices where the rent is less than the productivity in order to occupy the site and obtain the profits. At equilibrium, the land price will have been bid up until the rent is just equal to the productivity (Freeman 1993).

In order to maximize utility subject to the income constraint, individuals will buy those quantities of goods that exhaust their income and for which the marginal rate of substitution is equal to the rate at which the goods can be traded one for another in the marketplace. Both buyers and sellers of rural residential properties base their transaction

decisions on utility maximizing behavior; equilibrium prices are determined so that buyers and sellers are perfectly matched. If  $Q$  is the environmental amenity to be valued (in this case, water rights),  $X$  is all other commodities other than housing,  $S$  denotes a vector of a property's physical characteristics, and  $L$  is the vector of location factors, such as distance to a metropolitan area and paved roads, then the price function for the  $i$ 'th site is:

$$P_{zi} = f(Q_i, L_i, S_i) \quad [1]$$

This function relating prices and characteristics is the buyer's and seller's equivalent of a hedonic price regression, obtained from shopping around and comparing prices of properties with different attributes. Implicit prices of non-market attributes are determined by the characteristic coefficient, *ceteris paribus*.

$$P_i = a + b * S_i + c * L_i + d * Q_i \quad [2]$$

Any price differential which exists as a result of an attribute's presence is assumed to be the surrogate value for that good. Because repackaging of attributes is not possible, this makes the demand for characteristics independent of other goods, subject to the budget constraint,  $I$ .

$$I - P_i - X = 0 \quad [3]$$

A utility function is defined for an individual's preferences which are assumed to be represented by a utility function of the form:

$$U = u(X, S_i, L_i, Q_i) \quad [4]$$

where  $X$ ,  $S_i$ ,  $L_i$ , and  $Q_i$  are quantities of each of the goods that might be consumed in a period. Assuming the price of  $X$  is unity, the price of a unit of housing is  $P_i$ , and the number of housing units is  $Z$ , the constrained maximization equation is:

$$\text{Max } V = u(X, S_i, L_i, Q_i) + \lambda (I - X - P_i * Z) \quad [5]$$

The first order conditions are:

$$V_X = u_X - \lambda = 0 \quad [6]$$

$$V_Z = u_Z - \lambda * P_i = 0 \quad [7]$$

$$V_\lambda = I - X - P_i * Z = 0 \quad [8]$$

## **2.5 BID AND OFFER CURVES**

The hedonic pricing function is the result of all the points of tangency between buyers' and sellers' bid and offer functions. The bid and offer curves derived from these functions represent the willingness to pay and willingness to accept positions of participants in a market for a particular characteristic of a particular good.

### **2.5.1 The Bid Function**

The bid function represents the buyer's willingness to pay for a parcel with given quantities of site characteristics given their maximum utility level. In principle, if the product class contains enough models with different combinations of characteristics, it should be possible to estimate an implicit price relationship that gives the price of any model as a function of the quantities of its various characteristics. This relationship is called the hedonic price function. The partial derivative of the hedonic price function

with respect to any characteristic gives its marginal implicit price, that is, the additional expenditures required to purchase a unit of the product with a marginally larger quantity of that characteristic (Freeman 1993).

To illustrate a general model let  $Z$  represent the product class of rural residential properties. Any model of  $Z$  can be completely described by a vector of characteristics. Let  $Q = q_1, \dots, q_j, \dots, q_n$  represent the vector of characteristics of  $Z$ . Then any observation of  $Z$ , say  $z_i$ , can be described by its characteristics, such as  $z_i = z_i(q_{i1}, \dots, q_{ij}, \dots, q_{in})$ , where  $q_{ij}$  is the quantity of the  $j$ th characteristic provided by observation  $i$  of good  $Z$ . The hedonic price function for  $Z$  gives the price of any observation as a function of its characteristics. For  $z_i$ ,

$$p_{zi} = p_z(q_{i1}, \dots, q_{ij}, \dots, q_{in}) \quad [9]$$

An individual's utility is based on the person's consumption of  $X$  and the vector of characteristics provided by  $z_i$ :

$$U = U(X, Z) \quad [10]$$

or the indirect utility function

$$u = u(I - p_{zi}, q_{i1}, \dots, q_{ij}, \dots, q_{in}) \quad [11]$$

if the consumer purchases model  $i$  at  $p_{zi}$ . In order to maximize utility subject to the budget constraint  $I - p_z - X = 0$ , the individual must select quantities of every characteristic to satisfy

$$\frac{\partial u / \partial q_j}{\partial u / \partial X} = \partial p_{zi} / \partial q_j \quad [12]$$

all other attributes held constant. At this point the marginal willingness to pay for  $q_j$  must just equal the marginal cost of purchasing more of  $q_j$ .

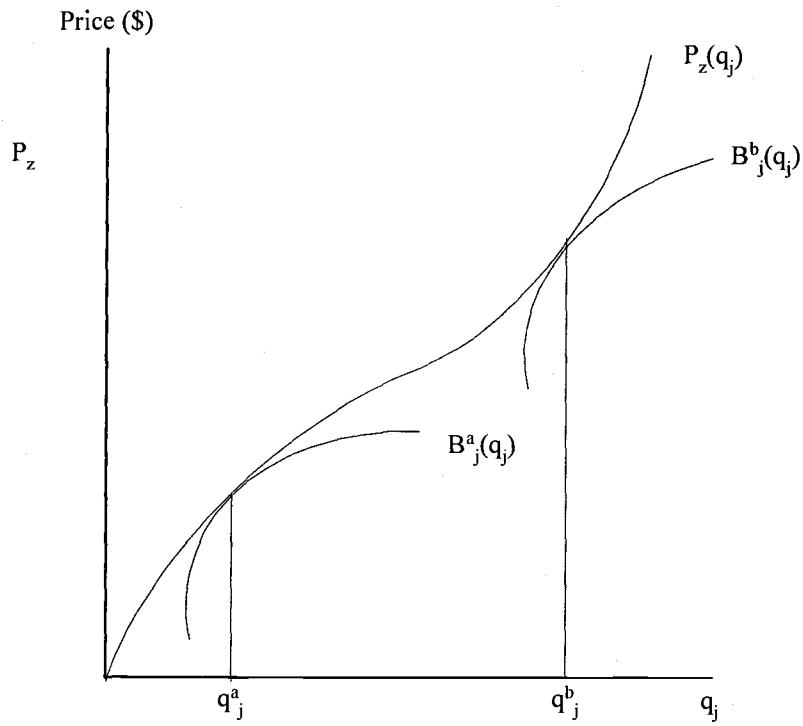
The value of the bid function is derived by inverting the indirect utility function and holding all but characteristic  $j$  constant. This function indicates the amount a buyer is willing to pay for alternative values of  $(q_{i1}, \dots, q_{ij}, \dots, q_{in})$  at a given level of utility and income and is represented by:

$$B_j = B_j(q_j, Q^*, u^*) \quad [13]$$

where  $u^*$  is the maximum level of utility attainable at the constrained level of income and  $Q^*$  represents the optimally chosen quantities of the other property characteristics. This function defines a group of indifference surfaces relating  $q_j$  with “money” in the form of the amount of  $X$  forgone (Freeman 1993).

Individuals have differences in both their preferences and their incomes and therefore two individuals will have two different bid functions. In general, bid functions usually show diminishing willingness to pay for  $q_j$ , that is, a diminishing marginal rate of substitution between  $X$  and  $q_j$ . The levels of  $q_j$  that any two individuals  $a$  and  $b$  will select are determined by the point of tangency between their bid functions and the hedonic price function as shown in Figure 2-1.

**Figure 2-1: Bid Function**



The same theory may also be applied to transactions where the goal is profit, rather than utility maximizing behavior.

### **2.5.2 The Offer Function**

Profit maximizing behavior is assumed when analyzing the supply side, or the offer function. On the supply side are the sellers of the heterogeneous good. The vector of characteristics,  $Q$ , is divided into two sub-vectors,  $q'=(q_j)$  and  $q''=(q_{j+1}, \dots, q_n)$ , where the components of  $q'$  are fixed characteristics and the components of  $q''$  are characteristics that the seller is able to alter. The owner maximizes profits from selling the good by altering characteristics in the sub-vector  $q''$ :



$$\text{Max } \Pi q = f(Q_i, L_i, S_i) - c(q', q'', r, \beta) \quad [14]$$

subject to

$$\Pi q \geq 0 \quad [15]$$

where  $\Pi q$  represents the sale profits of the current owner,  $f(Q_i, L_i, S_i)$  is the price schedule for the observed market price with the vector of  $Q$  characteristics (see equation [1]),  $c(q', q'', r, \beta)$  is the cost function of selling the good where  $r$  is a vector of factor input prices, and  $\beta$  is a vector of owner characteristics which can influence final sale price. The owner's offer function is derived in a manner similar to the bid function.

The offer function,  $O$ , shows the prices at which the owner makes the good available to the market,

$$O_j = O_j(q', q'', \Pi q, r, \beta) \quad [16]$$

given optimal quantities of characteristics and profit while controlling for varying owner characteristics. The owner maximizes profits of the good by equating the marginal offer prices for characteristics that can be altered to the marginal characteristic prices in the market. The offer price is demand-determined for characteristics that can not be altered or changed. The offer price for a fixed characteristic is equated to the market price since at lower offer prices the landowner would forego profits and for offer prices above the market price the offer would be rejected.

The hedonic price function is determined by the interaction of all buyers and sellers of the good; all buyers and sellers set their respective bid and offer functions equal to the hedonic price function (Rosen 1974).

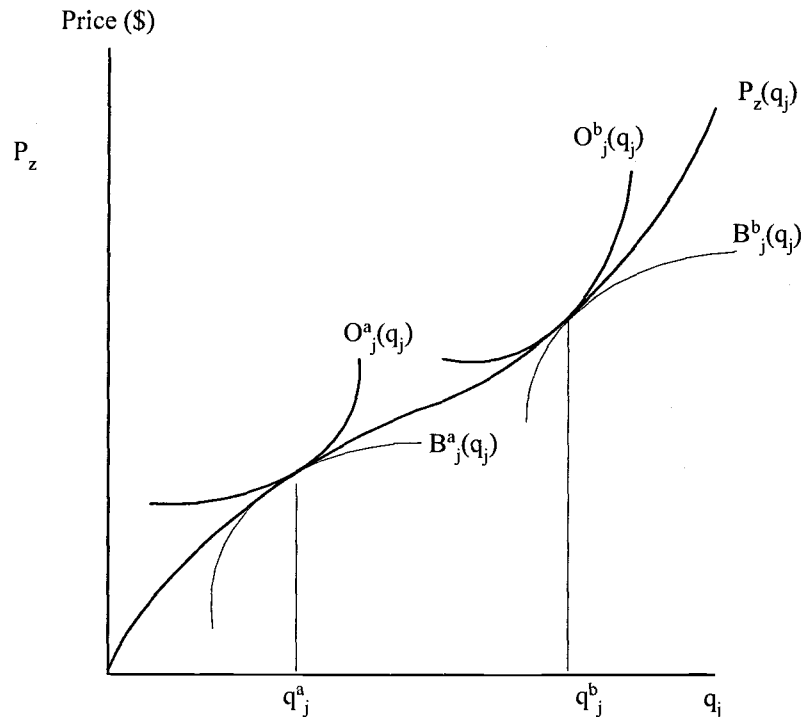
$$P_z(q_j) = f(Q_i, L_i, S_i) = O_j(q', q'', \Pi q, r, \beta) \quad [17]$$

and

$$P_z(q_j) = f(Q_i, L_i, S_i) = B_j = B_j(q_j, Q^*, u^*). \quad [18]$$

For the market to be in equilibrium, all of the bid and offer curves for the characteristics, one for each participant in the market, must be tangent to the hedonic price function (Freeman 1993). Thus the hedonic price function is a double envelope of the two groups of bid curves and offer curves (Rosen 1974). Figure 2-2 shows the equilibrium points between two buyers' bid curves ( $B^a$  and  $B^b$ ) and two sellers' offer curves ( $O^a$  and  $O^b$ ). As a double envelope, the hedonic price function is influenced by determinants on both the supply side and the demand side of the market.

**Figure 2-2: Hedonic Price Function**



### **2.5.3 Supply and Demand Functions**

To estimate the individual demand and supply functions for specific characteristics, a two-stage econometric technique is commonly used. The first stage estimates the hedonic price function using only the relevant characteristics of the good. This stage estimates the double envelope of the bid and offer functions. It also identifies a vector of implicit hedonic prices for the characteristics. The second stage professes to estimate the underlying supply and demand functions by regressing implicit prices estimated in the first stage on socio-economic characteristics of both buyer and seller and parameter restrictions (Goodman 1989).<sup>2</sup>

The second stage estimation is subject to two forms of theoretical and econometric problems (Goodman 1989, Freeman 1993). The first is the result of the fact that the dependent variable in the second stage is not directly observed: rather, the marginal implicit price of the characteristic is estimated from the hedonic price function. Some of the variables used in computing the marginal implicit price also serve as explanatory variables in the second-stage estimation. Since the second stage estimation does not employ any additional information, it may simply reproduce the estimated coefficients from the first stage. Brown and Rosen (1982) and Mendelson (1987) have shown second stage estimations to reproduce identical coefficients to those estimated in the first stage.

The second problem arises from the difficulty of separating out the effects of demand and supply shifters. Buyers and sellers must select both a point on the hedonic

price function and its associated quantity. The selection of that point simultaneously determines the marginal price and the quantity of the characteristic. Marginal prices for other attributes are observed from other individuals with differing socio-economic characteristics. It is difficult to determine if different quantity levels are driven by demand and supply shifts or by the correlation between quantity and the socio-economic factors.

The interest of this study is not to estimate demand and supply functions for the water right characteristic. Rather it is to estimate the first stage coefficients to see how certain determinants, specifically water rights, effect the market price for residential properties.

## **2.6 SUMMARY**

A hedonic pricing model can be developed to determine the implicit value of water rights associated with residential properties. As with most economic models, assumptions are made to simplify the model and make the results easier to interpret. The model is based in economic theory which also requires many of the same assumptions.

When the value of the characteristic being determined is of interest to the buyer, as it is when applying hedonic price functions to the housing market, there is no need to model formally the supply side of the market, since it is assumed that the housing market is in equilibrium (Freeman 1993). Supply sides for hedonic pricing models are generally used when the seller is basing his offer function on profit maximizing behavior. In the

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<sup>2</sup> Generally, the hedonic price function is estimated in a non-linear form allowing the implicit prices of the characteristics to vary (Goodman 1989).

market for rural properties profit maximization is only a consideration when the property is of commercial value and has a production function. Properties targeted in this study produce no significant stream of income and therefore it is assumed that agricultural profitability is not evaluated by either the buyer or seller.

## **CHAPTER THREE: LITERATURE REVIEW**

### **3.1 INTRODUCTION**

Traditionally water rights in the Western United States have not been separable from the physical property to which they are assigned. Although changes from this policy are occurring, this restriction endows water rights with the same traits as other environmental factors that can not be sold separately from residential properties such as proximity to a body of water or local air quality. The following chapter reviews several applications of hedonic pricing models for just these types of amenities.

### **3.2 ENVIRONMENTAL APPLICATIONS OF HEDONIC PRICING MODELS**

Because society places worth on certain features that have no direct monetary value in a market, quantification of certain attributes can elude traditional economic approaches. A Hedonic Pricing Model (HPM) is a well-recognized procedure in economic research, one which uses a statistical model to estimate consumers' marginal willingness to pay for an attribute that is not a traditional market good. Such characteristics as air quality, proximity to wetlands, and water quality as well as the presence of water rights are some of the recent applications of HPM. There is no absolute measure of accuracy by which to compare hedonic pricing analysis, but any price differential that exists as a result of an attribute's presence is assumed to be the surrogate value for that good (Feather and Taff, 1992).

### **3.2.1 Air Quality**

Urban air quality, and particulate matter concentration in particular, has been shown to affect housing prices in Southern California (Graves, Murdoch, Thayer and Waldman, 1988). This study examines how urban air quality impacts residential property values in Los Angeles, Orange, Riverside, and San Bernadino Counties in California. The variables used to represent urban air quality are visibility and total suspended particulate concentrations. These measures are used as proxies for health impacts, aesthetic quality, and physical damage of perceived air quality.

In addition to the air quality variables, the independent variable set includes neighborhood and site characteristics. Neighborhood variables refer to census data that cover income, distance to work, crime data and distance to the beach. Site characteristic data cover lot size, view, and structural attributes. Each county was also assigned a dummy variable to capture any variation in desirability between the counties.

Using a semi-logarithmic functional form, Graves et. al. achieved an  $R^2$  of .776 with significant coefficients on all variables except fireplace, air conditioning, visibility and the dummy variable for San Bernadino County.

### **3.2.2 Proximity to Wetlands**

The existence of a natural resource that can not be traded in traditional markets is the main application of hedonic pricing analysis. Wetlands are just such a resource. One way to extract a value for wetlands is to estimate their relationship to property values. The relationship of property values and wetland proximity was the subject of a study in Ramsey County, Minnesota (Doss and Taff 1993). Using hedonic pricing analysis, the

study investigated whether people pay different amounts to live near four different types of wetlands: forested, emergent, vegetation, scrub shrub, and open water. The attempt was not made to value wetlands but to examine relative values placed on wetlands of different types.

Property characteristics included in this study were structure and location attributes: these were compiled from county tax assessor records. Lot size, number of rooms (not bedrooms), number of bedrooms and bathrooms, square footage, age of structure, and a dummy variable for fireplace were structural variables. Property characteristics such as corner lots, school districts, river view, and hilly topography were included as dummy variables. The wetland variables were measured as distance to the boundary of a wetland within the county. The dependent variable, value, is the 1990 assessed value for the property rather than the sale price. This is considered a reasonably good proxy for the market value and allowed inclusion of properties which may not have been involved in a market transaction during the time period covered by the study. Several models of differing functional form were analyzed, including linear, quadratic, and interaction forms. Each model showed an  $R^2$  of approximately 0.8.

### **3.2.3 Water Rights Market**

The question of separability and competitiveness in a water rights market were analyzed by estimating the hedonic price function for farm real estate in a study conducted in Weld County, Colorado (Crouter 1987). Crouter hypothesized that where laws permitted separate and piecemeal water transfers, the hedonic price function would



be separable and linear in water. Where transactions costs deter the development of separate and competitive water markets, the hedonic price function may be nonlinear.

The study area represented a special case where a water market, separate from the land market, had a competitive price structure. The data collection entailed an audit of all transfer deeds of farm real estate in Weld County for the first six months of 1970. The dependent variable was farm price less the value of any improvements. This value was used based on the theory that a dollar of improvements add a dollar to farm price and that the value of water was connected to the land itself rather than the property as a whole. Independent variables in the model were land characteristics, water characteristics, other water sources, distance to Greeley, distance to a town of population greater than 1,000, and soil quality.

The final model regressed net farm price against land attributes, water, and distance to a town greater than 1,000 population. This model had an  $R^2$  of 0.6526 and used the Box-Cox transformation. The transformation was used to determine if the appropriate functional form for the equation was linear, thus indicating a separate and competitive market for water. Crouter determined that the marginal implicit price for water was dependent on the quantity of the attribute itself rather than being a linear function.

#### **3.2.4 Water Quality**

Another application of hedonic pricing models is valuation of demand for environmental quality such as clean streams. The question of whether and how improvements in water quality affect housing prices was addressed by a study conducted

in Pennsylvania (Epp and Al-Ani 1979). The objectives of this study were to estimate the relationship between water quality and the value of residential properties adjacent to small rivers or streams and to estimate the effects of various components of water quality on these same properties.

The dependent variable in the model was the market value of the property. As in other studies, the independent variables consisted of physical housing characteristics, neighborhood characteristics, accessibility characteristics, and the amenity characteristics such as water quality and topography. Two models were analyzed, one using perceived water quality as the focus variable, the other using actual water pH levels. The model with the perceived variable had an  $R^2$  of 0.69, which was slightly higher than that of the pH model, which had an  $R^2$  of 0.67.

Both models in this study had the same functional form. The logarithms of the dependent variable and the continuous independent variables were used in estimating the parameters. The linear functional form was rejected because of problems with heteroskedasticity. The variables reflecting conditions of the natural environment, flood hazard, and water quality were significant. Water quality was significant whether measured as the owners' perceptions or actual pH levels. Properties along clean streams were also compared to those along polluted streams by running two regressions with the same variables. The results led to the conclusion that where water quality is poor, other characteristics of the housing package such as flood hazard and structural characteristics assume greater importance.

### **3.3 SUMMARY**

Environmental attributes have been shown to affect housing prices but usually cannot be traded independently of the property. Proximity to natural resource amenities are not the only environmental factors that can be evaluated using hedonic pricing models. Air and water quality also have an effect on property values. Whether estimating the value of these non-market goods are well represented by HPM is difficult to determine. For one reason, correct functional form for the HPM may effect results but ascertaining this form is an inexact science (Halverson and Pollokowski 1981). However, a linear model has shown to provide a positive representation when certain attributes are separable from a market good (Cropper, Deck and McConnell 1988).

## **CHAPTER FOUR: SPECIFICATION OF THE MODEL**

### **4.1 INTRODUCTION**

The purpose of this chapter is to determine the potential factors that influence residential land values, and to develop an econometric model that explains how the presence and size of water rights contribute to actual sales prices. Economic theory and previous empirical studies will be used to identify the most influential factors. The general model was adapted from literature using hedonic pricing models to determine how environmental characteristics influence property values. Variable selection was based on reference models as well as consultations with a private appraiser and real estate professionals. An expanded model will also be estimated to determine if additional variables improve explanatory power.

### **4.2 MARKET CHARACTERISTICS**

The market for rural residential properties in Deschutes County, Oregon is currently expanding. The Deschutes Basin of central Oregon has traditionally been a region of irrigated farming. This area is in the process of undergoing a transformation to rural non-farm residences and small farm tracts (transitional agriculture), which are replacing more intensive agricultural uses of land. For this study transitional agriculture is defined as rural non-farm residences and small farm tracts of 40 acres or less in size. The rapid rate of population growth in the Bend-Redmond area has created an increase in

demand for all types of housing and contributed to the urbanization of formerly agricultural lands.

There is a growing popularity of owning small tracts of land that can support small livestock or crop enterprises. Some of these tracts possess irrigation water rights and some do not. By Oregon water law, water is attached to the land and therefore water rights are transferred to new land owners when property is sold. The contribution of these water rights to a parcel's sale price is what is to be determined in this research.

#### **4.3 PRIMARY HEDONIC PRICING MODELS**

This study uses an hedonic pricing model to assess the contribution of water rights to market price of residential properties. Although many factors affect the value of a property, not all characteristics provide significant influence on sale price. In addition to the size of the water right it has been hypothesized that sale price is a function of lot size, square footage of the residence, income, year of the transaction, and distance to an urban center (Brigham 1965; Feather et al. 1992). Variables such as the number of bedrooms and bathrooms have been shown to move in the same direction as square footage and would result in a multicollinearity problem.

Controversy abounds on the correct functional form for a hedonic pricing model. Where attributes can not be broken up and repackaged, the model should not be linear. For example, two two-bedroom homes are not equal to one four-bedroom home (Freeman 1993). To solve this problem it is suggested that the marginal contribution to price of each additional unit of a continuous variable can be measured by converting the variables with a log-log transformation (Epp 1979).

#### **4.4 THE MODEL**

As stated above the primary and alternative pricing models will regress sale price against several explanatory variables.

The primary model is as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{WATER}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i, \text{DIRT}_i, \text{SISTER}_i, \text{DSWAT}_i, \text{DCWAT}_i, \text{DTWAT}_i, \text{DAWAT}_i, \text{DV}_i)$$

The alternative model is as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{DW}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i, \text{DIRT}_i, \text{SISTER}_i, \text{DSDW}_i, \text{DCDW}_i, \text{DTDW}_i, \text{DADW}_i, \text{DV}_i)$$

The following section elaborates on the specification of the dependent and independent variables.

##### **4.4.1 The Dependent Variable**

The dependent variable for the hedonic pricing model will be the dollar value sale price of each observed parcel of land. PRICE will be actual figures obtained from a private appraisal service located in Bend, Oregon. This information was gathered to compile a data base of equivalent properties for the purpose of real estate appraisal comparisons.

##### **4.4.2 Parcel Size**

The data set contains properties ranging from one to forty acres in parcel size. In the model the total size of each individual parcel was separated into acres zoned for exclusive farm use (EFU) and acres not zoned for exclusive farm use (NONEFU). The

distinction between the two types of acreage was made with the assumption that EFU zoned land is less valuable than residentially-zoned land. This assumption is based on the fact that land zoned EFU is restricted to agricultural uses and cannot be subdivided for additional housing. This limits a property owner's ability to sell off portions of property zoned EFU. It is predicted that both these variables will have a positive relationship with sale price.

There are three sources of data for this variable: the Deschutes County Assessor's office, the appraisal service, and the participant survey. The Deschutes County Assessor provided the information on land use zoning. When discrepancies existed among the data sources, the values for EFU and NONEFU were chosen from the county assessors records.

#### **4.4.3 Acres of Water Rights**

Since this is the factor of interest it must be included in the model. WATER is defined as the number of irrigated acres appurtenant to the property. Not all of the subject properties possess a water right. In these cases WATER is given a zero value. It is hypothesized that WATER will have a positive relationship to sale price. A second regression using a dummy variable will also be used. The dummy variable, DW, will take on a value of one if a property possesses a water right and a value of zero if it does not possess a right.

There were two data sources for this variable: the participant survey and the private appraisal service. The county does not appear to keep records on associated water rights because it is not a taxable property attribute. Not all properties reported to have

water by the surveys were identified by the appraisal service. This may be a result of incomplete information available to the appraiser. Therefore, all values for acres of water were taken from the mail survey.

#### **4.4.4 Square Footage**

Square footage is defined as the total living area of the primary residence. The areas in the garage, unfinished basements, and out-buildings are not included. The variable SQFT is included in the model because other studies have shown empirically that this factor has a significant influence on property values. It is hypothesized that SQFT will have a positive relationship to sale price. This variable will also be in logarithmic form. Data for this variable were available from the same sources as parcel size.

Like EFU and NONEFU there were a few discrepancies among sources of data. Different sources had different criteria for reporting square footage. A private appraisal service may be held to stricter guidelines than the county assessor because their results are used by financial institutions for mortgage loan evaluation.. In addition, many of the assessments by the country were conducted as far back as 1989. Many additions and improvements can be made to a residence in three to six years. To reconcile these discrepancies, evaluations were made on the dependability of the source. Where there was not a match between at least two of the sources, a judgment was made based on the criteria of source reliability, age of the appraisal and what, potentially, was the perceived square footage by the participant.



#### **4.4.5 Date of Sale**

Data were gathered from real estate sales spanning the time period of January, 1992 through March, 1995. The date of purchase were defined as the number of years after 1992 in which the transaction occurred. That is, the year 1992 has a value of zero, 1993 has a value of one, etc. Because price trends within a year can vary from month to month, the month of purchase was ignored in the variable DATE (Chicoine 1981). Since most home buyers view their property as an investment and expect it to appreciate over time it is hypothesized that DATE will have a positive relationship to sale price.

DATE was available from both the survey and from the appraiser's data. Discrepancies most likely arise from the perception of when the sale actually occurred, for example, whether on the date the sale closed or the date an offer was made. Since only the year is being considered there is no complication from these discrepancies. The real price of housing has been shown to increase over time due to a slower growth in housing availability than the growth in demand.

#### **4.4.6 Distance to an Urban Center**

The proximity of land to urban centers has been shown to be an important factor in both residential and agricultural land prices (Chicoine 1981; Crouter 1987; Xu et al. 1993). The variable MILES is included in the model to test the hypothesis that properties closer to urban centers sell for higher prices relative to more rural sites because of the availability of jobs as well as the convenience of commuting for employment and retail services. The variable measures the distance, in miles, to the nearest town where

retail and employment opportunities are available. Distance is expected to have a small but negative effect on property values.

Part of the nature of rural living, good or bad, is driving on unpaved roads. According to both professional real estate appraisers and sellers, this is an undesirable characteristic for a property to possess. The number of miles traveled on dirt roads by a property owner to get to their property was asked on the questionnaire. This variable, DIRT, will be included in the model and measured in the actual miles of unpaved roads. This variable is expected to have a negative effect on property values.

#### **4.4.7 Age of House**

The residential structure on the respondent's property is a major portion of a property's value. To eliminate any complication of heterogeneous construction types, only properties with wood-framed, conventionally-constructed homes were considered. Generally, a newer home is worth more than an older home of comparable size. Quality of maintenance and pride in ownership can sustain a home's value but this is difficult to identify in a quantitative measure. Real estate professionals agree that when two houses of similar characteristics are compared, the older house will be worth less. AGE here is measured as the difference between the year of construction and the year of purchase. Age was available from both the questionnaire and the appraisal data. This variable is expected to have a negative effect on selling price.

#### **4.4.8 Agricultural Sales**

Some property owners included in this study produce and sell agricultural products from their land. Although income from these products is only expected to make up a small portion of the owner's income, this productivity is expected to have a positive influence on sale price. The variable SALES represents the gross dollar value of agricultural products sold by the respondent and produced on the property. This data is provided by the respondents on the mail survey.

#### **4.4.9 Distance to the South Sister**

The creation of a neighborhood variable proved difficult in this study. The variable SISTER is included in the model as a way of standardizing a parcel's location. SISTER measures the distance, in aerial miles, from the peak of South Sister to a parcel. This variable was calculated on a Deschutes County map using street number specifications from the parcel address and converting the measured distance from centimeters to miles. The expectation is that SISTER will have a negative influence on property values as the result of a decrease in scenic quality and a flattening of topography.

#### **4.4.10 View**

In an area such as Deschutes County, Oregon, the natural beauty is abundant. Potential home buyers place a premium on any house with a good view of any of the Cascade peaks. Because this variable is difficult to quantify, a dummy variable was used to relate the view from the main living area compared to the view from other houses in the surrounding neighborhood. This information was available from survey responses.

The variable, DV, is given a value of one if the property has a view which is better than most, as perceived by the respondent, and a zero value otherwise. This variable is expected to have a positive effect on property values.

#### **4.4.11 District Interaction Terms**

Each property possessing a water right has their right administered by an irrigation district. The four districts involved in this study included Central Oregon, Swalley, Tumalo, and Arnold Irrigation Districts. A dummy variable was created for each district: DC, DS, DT, and DA. A value of one is given to the dummy representing the irrigation district when a property's water is managed by that district; all the other district dummies are given a zero value. If a property does not possess a water right, then all district dummies are given a value of zero. The dummy variable for each district will be multiplied by the variable WATER or DW to show how the value of water may vary between districts. The name of the irrigation district was provided by each respondent. There is no a priori assumption for how the value of water will compare between the districts.

#### **4.5 EXPANDED MODEL**

Two expanded models will also be estimated by adding other variables such as the number of bedrooms (BED) and bathrooms (BATH) and the presence of a private or shared well (DWELL). One model will use the variable WATER and one will use DW. BED and BATH were not included in the primary models because of the a priori assumption that these variables are redundant to *ln*SQFT and will only produce a problem

of multicollinearity. In addition, previous research has concluded that when both bedrooms and square footage are both use in a model, the number of bedrooms actually has a negative influence on price (Doss and Taff 1993). This results from buyers desiring fewer, larger rooms than more, smaller rooms. DWELL is not predicted to be significant because this is not a limiting factor of a property; many private sources are available for household water.

The expanded models will be tested with an F-significance test to see if they are significantly different from the primary models. This test will indicate if the addition of the other variables improve the explanatory power of the original model. If the calculated F-statistic is not larger than the critical value for F at the 95% level, then the indication will be that the additional variables do not improve the model.

The expanded models will be as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{WATER}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i, \text{DIRT}_i, \text{SISTER}_i, \text{DSWAT}_i, \text{DCWAT}_i, \text{DTWAT}_i, \text{DAWAT}_i, \text{DV}_i, \text{BED}_i, \text{BATH}_i, \text{DWELL}_i)$$

and

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{DW}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i, \text{DIRT}_i, \text{SISTER}_i, \text{DSWAT}_i, \text{DCWAT}_i, \text{DTWAT}_i, \text{DAWAT}_i, \text{DV}_i, \text{BED}_i, \text{BATH}_i, \text{DWELL}_i)$$

#### **4.6 SUMMARY**

A hedonic pricing model is developed to explain how the presence and size of water rights influence rural residential property values. The dollar value of the sales price

is hypothesized to be a function of lot size, square footage, acres of water, date of sale, age of house and distance to an urban center. These characteristics along with their expected relationship with the value of the property are summarized in Table 4-1. The expanded model is developed to see if certain characteristics omitted from the primary model were also significant.

***Table 4-1: Summary of Variables  
and Their Predicted Effects (Primary Model)***

Variable	Effect
EFU	(+)
NONEFU	(+)
<i>ln</i> SQFT	(+)
WATER	(+)
DW	(+)
DATE	(+)
AGE	(-)
MILES	(-)
DIRT	(-)
SALES	(+)
SISTER	(-)
DV	(+)

## **CHAPTER FIVE: SURVEY METHODS AND DATA COLLECTION**

### **5.1 INTRODUCTION**

Activity within a real estate market is well documented, and that knowledge is available to the public. Both private and public sources such as appraisal services and county assessors may be used as sources for data. In this case, a mail survey was also used to obtain additional information that could only be provided by the property owners to complete the data set for the hedonic pricing model. An analysis of nonresponse bias was also conducted. The response rate for the survey and the results of the nonresponse bias tests are presented in this chapter.

### **5.2 DATA COLLECTION AND DATA SOURCES**

Since the purpose of the research endeavor is to examine how water rights affect property values, data on real estate transactions needed to be obtained. There are two methods that have been used by researchers to collect data for hedonic pricing models. The first method is to collect real estate market data through secondary sources. This market information is compiled by private real estate appraisal services; it is also recorded on title transactions and property tax records by county assessors. The second method is to collect parcel information by contacting property owners through survey methods.

Potential study participants were identified through a private appraisal service which provided access to their records on recent home sales. Information was collected

by the service as a means of developing a data base of comparable homes for use in property appraisals for mortgage lenders. This source provided the property address, sale price, and several other property characteristics. The Deschutes County Assessors office provided the names of the property owners for the addresses obtained from the appraiser, along with their mailing address, if different from the property address. Additional information on uses of the property water, location variables, and demographic information could only be obtained from the property owner identified through the county assessor. A total of 212 potential survey respondents were identified through the private appraisal firm.

### **5.3 SURVEY DESIGN**

The mail survey design was patterned after the Total Design Method (TDM) (Dillman 1978). The response rate for surveys that follow this method has been shown to average 74%. To encourage responses, total confidentiality was guaranteed to survey recipients regarding all information provided in their questionnaire. Confidentiality is important to many water rights holders because of the underlying mistrust they may have for state involvement in what they consider to be a private property right.

The survey instrument was developed by the author, drawing upon previous questionnaires (McCloud 1994, Stoff 1994, Landry 1995). The questionnaire form was designed with the assistance of Pamela Bodenroeder, a senior research assistant with the Survey Resource Center, Oregon State University. A random sample of 29 property owners was chosen to receive a pretest mail survey. This sample did not include property owners whose mailing address was different from the parcel address. The pretest



response rate was 62%, and there were no indications that respondents had problems understanding or completing the questionnaire.

#### **5.4 MAILING AND FOLLOW-UP PROCEDURES**

The survey mailing consisted of a questionnaire (Appendix B), a pre-stamped and self-addressed return envelope, and a cover letter signed by the project director Dr. Joe B. Stevens, professor of agricultural and resource economics at Oregon State (Appendix A). The packet was sent to all remaining property owners during the first week of October. Follow-up post cards, served as both a "Thank You" to those who had already responded and a reminder to those who had yet to respond; these were mailed to all respondents one week after the initial mailing. A second complete packet was sent to all nonrespondents three weeks after the initial mailing.

#### **5.5 SURVEY RESPONSE**

Including the pretest, 173 surveys were mailed. Table 5-1 illustrates a summary of the survey response statistics. Two surveys were returned as the result of incorrect addresses, six were returned by respondents who did not wish to participate in this study, and two surveys were returned by respondents who had purchased their homes prior to 1992, the cut off date for eligible responses. A total of 94 respondents returned a completed and usable questionnaire. Of the property owners who resided elsewhere from the address in question, 48.6% responded, compared to 54.6% of those living on the targeted parcel. Some respondents chose not to answer the demographics section of the questionnaire.

***Table 5-1: Survey Response Summary***

Total Surveys Mailed	173
Undeliverable Surveys	2
Did Not Wish to Participate	6
Purchased Prior to 1992	2
Completed Surveys	94
Non-Responses	69
Survey Response Rate	54.9%

## **5.6 NONRESPONSE BIAS**

Information was available from the private appraisal service on sale price, acreage, water rights, and square footage for the properties of the 69 respondents who did not return surveys and the 6 who did not wish to participate in this study. Data gathered for the four properties in which surveys were undeliverable or purchased prior to 1992 was considered to be inaccurate and was not included in determination of nonresponse bias. Means and variances for sale price, acreage, size of water right, and square footage of the 75 non-respondents are compared with those of the usable surveys in Table 5-2.

***Table 5-2: Comparison of Mean and Variance  
for Respondents and Non-Respondents***

	Respondent	Non-Respondent
<b>Sale Price (Dollars)</b>		
Mean	196,910	197,367
Standard Error	79,290	80,187
<b>Acres</b>		
Mean	10.92	11.12
Standard Error	9.79	10.01
<b>Water (Acres of Water)</b>		
Mean	4.85	5.87
Standard Error	5.07	6.10
<b>Square Feet</b>		
Mean	2,164	2,023
Standard Error	721	637

Two tests were performed to determine if differences existed between the non-respondent and respondent samples. First, a t-test was used to determine if there were any differences between the mean values for the two groups. None of the calculated t-values fell into the rejection region at a 0.05 significance level. Therefore, the null hypotheses that the mean values are the same for the two groups could not be rejected.

Second, a variance ratio test was performed to test whether or not the variances were the same across both groups. In this case the calculated F-statistic was less than the critical value of  $F(74,93)$ . Therefore the null hypothesis that the variances are equal between the two samples can not be rejected. Both tests indicated that there was no detectable non-response bias.

Although no detectable difference existed between the mean value for water rights between respondents and nonrespondents, 77.7% of the respondents had a water right while 86.7% of the non-respondents had a water right. There is no cue to suggest what

may be the differences in these percentages other than the belief that the survey was an inconvenience or an intrusion.

## **5.7 SUMMARY**

Information on real estate market transactions and the amenity characteristics of properties in the target group was easily obtained. The 54.9% response rate was disappointing for surveys that followed the TDM . Previous research analyzing implicit values of property characteristics have not used the survey instrument and therefore do not lend any insight as to possible reasons for non-participation. Of the six recipients who indicated they did not wish to participate, no explanation was given for their decision. This may reinforce the perception that water rights holders are leery of any attempts to gather information on the holders themselves and their uses of water.

## **CHAPTER SIX: ECONOMETRIC ANALYSIS OF WATER RIGHT CONTRIBUTION TO PROPERTY VALUES**

### **6.1 INTRODUCTION**

This chapter provides a descriptive summary of the real estate transactions used in this study as well as the analysis of the hedonic pricing model results. The summary statistics will include distribution of sale prices and distribution of water rights in addition to mean values for the primary contributing factors to property values. The econometric analysis of the hedonic pricing model will identify how water rights along with other property characteristics affect sales prices of residential land. The primary hedonic pricing model and the alternative model regression results are presented. The primary and alternative models will be tested for heteroskedasticity and multicollinearity.

### **6.2 EVALUATION OF REAL ESTATE TRANSACTIONS**

There are varying types of residential housing within Deschutes County, Oregon. The potential private homeowner has the option of purchasing property inside or outside a residential development, and within or outside a municipal utility service area: they can also choose the size of lot they wish their home to occupy. Building alternatives include wood frame, manufactured, or mobile homes. Eligible properties for this study were non-commercial, residential properties with wood-framed homes outside of any organized development and without a municipal water supply. These restrictions were imposed to minimize variability when comparing property characteristics.

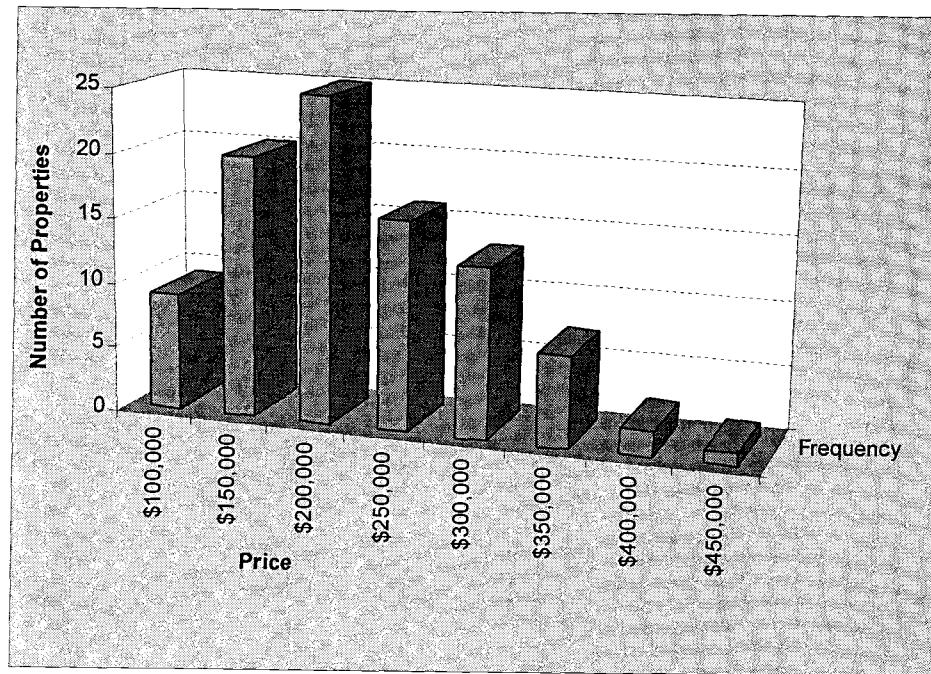
The 94 property transactions reported in the mail survey occurred entirely within Deschutes County but outside the cities of Bend, Redmond, Sisters and La Pine. A wide range in sale price, acreage, square footage, and acres of water was observed among the properties. A summary of the reported properties provides the mean, standard deviation, and minimum and maximum values of the above characteristics. The mean, standard deviation, and minimum and maximum values of all other variables in the primary model are presented in Appendix C.

***Table 6-1: Summary of Major Attributes***

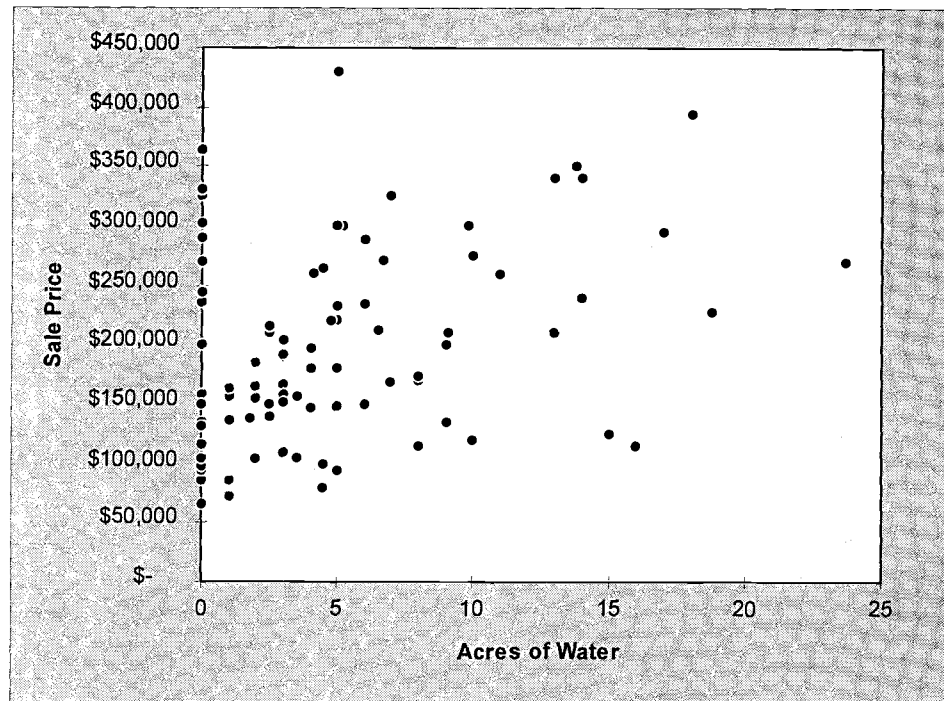
	Price	Acreage	Square Feet	Water (acres)
<b>Mean</b>	\$196,907	10.92	2,164	4.86
<b>Std. Dev.</b>	\$79,293	9.79	721	5.07
<b>Max.</b>	\$430,000	40.00	4,643	23.70
<b>Min.</b>	\$66,000	1.29	800	0.00

Figure 6-1 gives a graphical representation of the distribution of sale prices. Almost 50% of the observed sale prices fell between \$100,000 and \$200,000 with only ten of the properties having a sale price above \$300,000. Figure 6-2 illustrates how water rights are distributed over observed sale prices. Prices are dispersed over a wide range of water right values. There is no clear pattern between the size of a water right and sales price. Reported sale prices from the entire sample ranged from as low as \$66,000 to a high of \$430,000, whereas those properties without water ranged in price from \$66,000 to \$364,000.

***Figure 6-1: Distribution of Sale Prices***



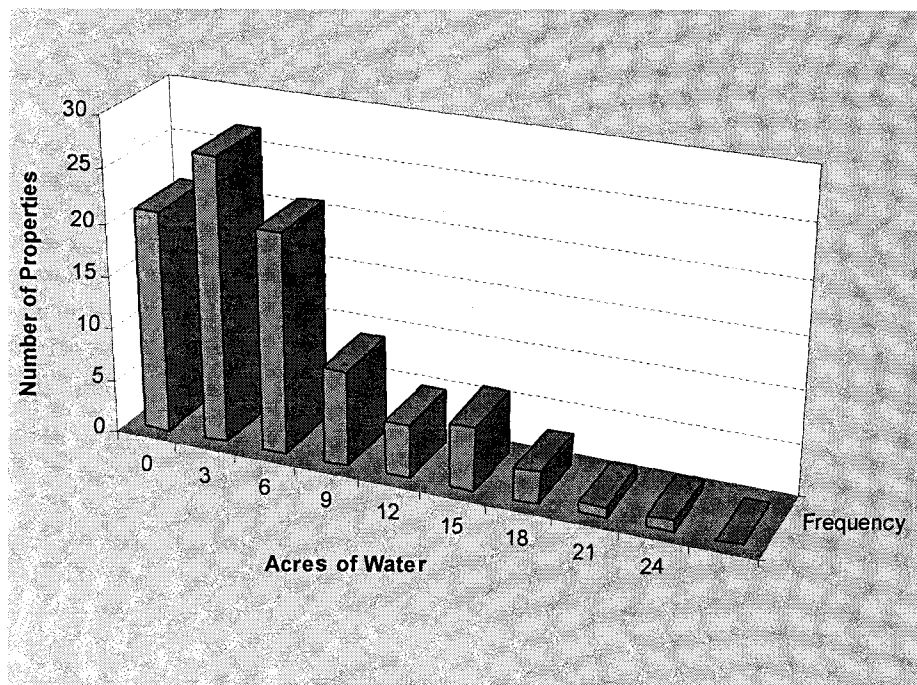
***Figure 6-2: Acres of Water vs. Sale Price***



The size of water rights range from properties with no water to a maximum of 23.7 acres of water. The range of acres of water is not evenly distributed. Of those properties that possess a water right, the majority (65.8%) are under 6 acres as illustrated in Figure 6-3. There are five irrigation districts that administer these water rights in Deschutes County: Swalley, Central Oregon (COI), Tumalo, Arnold, and Squaw Creek. Table 6-2 presents the distribution of water rights among the five districts and those outside any district.



***Figure 6-3: Distribution of Water Rights***



***Table 6-2: Distribution of Water Rights by Irrigation District***

District	Right Holders
Swalley	11
COI	34
Tumalo	17
Arnold	10
Squaw Creek	1

### **6.3 USES OF IRRIGATION WATER**

The questionnaire used to gather data on the properties included a section on how water right holders were using their water. Of the 94 who returned surveys, 73

respondents reported having a water right. A summary of the reported uses and their frequencies are presented in Table 6-3.

***Table 6-3: Summary of Water Applications***

	Lawn & Landscaping	Hay or Pasture	Crop Production	Livestock Water	Fish Pond	Household Use
Number of Users	51	69	18	45	3	8
Percent of Total	70%	95%	25%	62%	4%	11%

The primary uses of water are for landscaping, hay or pasture, and support of livestock. Although more than 60% of water users are involved in some form of farming, only 17 water users reported income from agricultural products produced on their land. This suggests that most users of irrigation water in the category covered by this study are using water for enjoyment of a utilitarian rather than a profit seeking nature.

#### **6.4 ESTIMATION OF THE HEDONIC PRICING MODEL**

The hedonic pricing model presented in Chapter Four includes variables that are primary characteristics of residential housing as well as characteristics of associated water rights if they exist. Data from 94 properties collected through a mail survey, private appraisal service, and county tax assessor records are used for the model estimation. Sale prices are hypothesized to be a function of physical and location characteristics (Crouter 1987, Graves et al. 1988, Xu et al. 1993). Several variations on the primary and alternative models were examined before developing the model used for this study. The model specification is as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{WATER}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i, \text{DIRT}_i, \text{SISTER}_i, \text{DSWAT}_i, \text{DCWAT}_i, \text{DTWAT}_i, \text{DAWAT}_i, \text{DV}_i)$$

where:

- $i$  = the  $i^{\text{th}}$  property
- $f$  = a linear functional form
- $P_i$  = The sale price of the  $i^{\text{th}}$  property
- $\text{EFU}_i$  = Total acres zoned exclusive farm use
- $\text{NONEFU}_i$  = Total acres not zoned exclusive farm use
- $\text{WATER}_i$  = Total acres of water right
- $\ln\text{SQFT}_i$  = Total square footage of residence measured on a logarithmic scale
- $\text{DATE}_i$  = The year the sale of property took place (1992=0, 1993=1, 1994=2, 1995=3)
- $\text{AGE}_i$  = The age of the residence measured as the year purchased minus the year constructed (e.g. 1994-1967=27)
- $\text{SALES}_i$  = Dollar value of any agricultural products produced on parcel
- $\text{MILES}_i$  = Distance, in miles, to nearest town
- $\text{DIRT}_i$  = Miles owner must travel on unpaved roads to access property
- $\text{SISTER}_i$  = Aerial miles from South Sister
- $\text{DSWAT}_i$  = A dummy variable for Swalley multiplied by acres of water
- $\text{DCWAT}_i$  = A dummy variable for COI multiplied by acres of water
- $\text{DTWAT}_i$  = A dummy variable for Tumalo multiplied by acres of water
- $\text{DAWAT}_i$  = A dummy variable for Arnold multiplied by acres of water
- $\text{DV}_i$  = Dummy variable for view from property: "Better than" rather than "About the same" or "Not as good" as others in neighborhood

#### 6.4.1 Primary Model

The econometric model is estimated using Ordinary Least Squares (OLS) procedures. The regression analysis is conducted using SHAZAM (White 1993), a

statistical and econometric analysis software. Results of the initial model estimation are presented in Table 6-4. Coefficients are rounded to the nearest whole number in most cases.

The  $R^2$  of 0.7702 indicates that over three-fourths of the price variation of the properties is explained by this model. A joint significance test of the independent variables indicates overall significance of the regression. Individual t-tests on the independent variables concluded that EFU, NONEFU,  $\ln$ SQFT, AGE, DIRT, SISTER, and DV are significant explanatory variables at the 95% confidence level. DATE, DSWAT, and DAWAT are significant at the 90% confidence level.

Tests for multicollinearity and heteroskedasticity were conducted on the model. The correlation coefficient and auxiliary regressions were used to test for multicollinearity (Griffiths et al. 1993); none was detected (Appendix D) even though there was an expected indication of a correlation between the interaction variables for the districts and WATER.

Because properties observed in the data set were not all from the same real estate market, there was reason to be concerned about the potential for heteroskedasticity. The primary consequence of heteroskedasticity for OLS estimators is that the variance is no longer the smallest among the class of linear estimators, which results in unreliable hypothesis testing of coefficients (Griffiths et. al. 1993). However, the Breusch-Pagan test for heteroskedasticity did not indicate the presence of heteroskedasticity in the model (Appendix E).

*Table 6-4: Primary Regression Results<sup>3</sup>*

Variable	Estimated Coefficient	Standard Error	T-Ratio
EFU	2,436	888	*** 2.743
NONEFU	3,526	885	*** 3.982
WATER	-7,744	5,246	# -1.476
lnSQFT	130,097	15,397	*** 8.507
DATE	10,775	5,951	* 1.810
AGE	-944	300	*** -3.148
SALES	1.1202	1.0172	1.1012
MILES	-1,320	1,570	-0.841
DIRT	12,860	6,341	** 2.028
SISTER	-3,654	1,412	** -2.589
DSWAT	10,147	5,242	* 1.936
DCWAT	8,497	5,260	# 1.615
DTWAT	6,552	5,231	1.253
DAWAT	9,937	5,356	# 1.855
DV	23,878	10,077	** 2.370
CONSTANT	-744,690	127,940	-5.821

$R^2 = 0.7702$     Adj.  $R^2 = 0.7260$      $n = 94$     F-stat = 18.91

#### 6.4.2 Alternative model

An additional analysis was conducted with an alternative model. This was done to evaluate how changing the specification of the variable for water would effect the coefficient estimations of the other explanatory variables. That is, are the estimated coefficients sensitive to the amount of water associated with the property or simply whether or not a water right is associated with the property. The model specification is as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{DW}_i, \text{lnSQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i,$$

<sup>3</sup> \*\*\* Significant at the 0.01 level, \*\* Significant at the 0.05 level, \* Significant at the 0.10 level

# Significant at the 0.20 level

$DIRT_i, SISTER_i, DSDW_i, DCDW_i, DTDW_i, DADW_i, DV_i)$

where:

- $DW_i$  = A dummy variable for the presence of a water right  
(No=0, Yes=1)
- $DSDW_i$  = An interaction term between the dummy for Swalley  
Irrigation District and the dummy variable for water
- $DCDW_i$  = An interaction term between the dummy for Central  
Oregon Irrigation District and the dummy variable for  
water
- $DTDW_i$  = An interaction term between the dummy for Tumalo  
Irrigation District and the dummy variable for water
- $DADW_i$  = An interaction term between the dummy for Arnold  
Irrigation District and the dummy variable for water

The alternative model was also estimated using OLS procedures with the SHAZAM software. Results of the alternative model are presented in Table 6-5.

*Table 6-5: Alternative Regression Results<sup>4</sup>*

Variable	Estimated Coefficient	Standard Error	T-Ratio
EFU	2,959	581	*** 5.097
NONEFU	3,676	754	*** 4.874
DW	-77,213	46,595	* -1.657
<i>ln</i> SQFT	134,300	15,788	*** 8.507
DATE	11,545	6,013	* 1.920
AGE	-881	306	*** -2.883
SALES	0.9587	0.9795	0.9787
MILES	-1,631	1,605	-1.017
DIRT	12,023	6,413	* 1.875
SISTER	-2,681	1,386	* -1.934
DSDW	82,338	47,504	* 1.733
DCDW	65,746	47,331	# 1.389
DTDW	68,261	46,279	# 1.475
DADW	69,097	47,715	# 1.448
DV	26,755	10,136	*** 2.640
CONSTANT	-788,260	133,350	-5.911

$R^2 = 0.7663$     Adj.  $R^2 = 0.7214$      $n = 94$     F-stat = 18.50

The  $R^2$  for the alternative model also indicates a high level of explanatory power with respect to variations in sales price ( $R^2=0.7663$ ). In the alternative model individual t-test's on the independent variables concluded that EFU, NONEFU, *ln*SQFT, AGE, and DV are significant at the 95% confidence level. DW, DATE, DIRT, and DSDW become significant when the confidence level is reduced to 90%.

The alternative model was tested for multicollinearity and heteroskedasticity.

The correlation matrix and auxiliary regressions showed no indication of multicollinearity. As in the initial model this model did not test positive for heteroskedasticity (see Appendices D and E).

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<sup>4</sup> \*\*\* Significant at the 0.01 level, \*\* Significant at the 0.05 level, \* Significant at the 0.10 level, # Significant at the 0.20 level

### 6.4.3 Expanded Model

An expanded model was also analyzed to determine whether inclusion of the variables BED, BATH, and WELL would add significant explanatory power to the model. The expanded model is as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \text{WATER}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i, \text{DIRT}_i, \text{SISTER}_i, \text{DSWAT}_i, \text{DCWAT}_i, \text{DTWAT}_i, \text{DAWAT}_i, \text{DV}_i, \text{BED}_i, \text{BATH}_i, \text{DWELL}_i)$$

Where:

- BED<sub>i</sub>** = The number of bedrooms in the residence  
**BATH<sub>i</sub>** = The number of bathrooms in the residence  
**DWELL<sub>i</sub>** = A dummy variable representing a private or shared well as source of household water (Yes=1, No=2)

The estimated coefficients for the newly added variables were not significant at the 95% level of confidence for either the expanded primary model or the expanded alternative model. The R<sup>2</sup> 's for the two expanded models were 0.7797 and 0.7739, respectively. An F-significance test showed that the additional variables did not add significant explanatory power. Detailed results of the expanded model are presented in Appendix G.

### 6.4.4 The Reduced Model

A reduced model was analyzed to determine whether the inclusion of the water variables added any significant explanatory power to the primary and alternative models. The reduced model is as follows:

$$P_i = f(\text{EFU}_i, \text{NONEFU}_i, \ln\text{SQFT}_i, \text{DATE}_i, \text{AGE}_i, \text{SALES}_i, \text{MILES}_i,$$



$$\text{DIRT}_i, \text{SISTER}_i, \text{DV}_i)$$

An F-significance test showed that the water variables do not add significant explanatory power. Detailed results of the reduced model are also presented in Appendix G.

## **6.5 DISCUSSION OF REGRESSION RESULTS**

The  $R^2$  of 0.7702 for the primary model and the  $R^2$  of 0.7663 for the alternative model indicates that nearly the same extent of price dispersion in the market is explained by the two models. The F-statistics of 18.91 and 18.50 also indicate overall significance for both regressions. With the exception of two variables, all the explanatory variables in both regressions have the expected signs for their coefficients. The following section further discusses the results and compares the two models.

### **6.5.1 Acres of Land (EFU and NONEFU)**

The explanatory variable EFU has a significant coefficient of 2,436 in the primary model and a significant coefficient of 2,959 in the alternative model. The standard error in the primary model is larger than that in the alternative model, this causing a larger t-statistic for the estimated coefficient in the alternative model. These coefficients indicate that the price of a parcel of land increases between \$2,436 and \$2,959 as the size of the parcel increases by one acre zoned for exclusive farm use. This positive result is expected given that a larger parcel of land is considered more valuable than a smaller parcel with a comparable home.

The variable NONEFU had significant coefficients of 3,526 for the primary model and 3,676 for the alternative model. The standard error for the alternative model was slightly smaller, thus providing a larger t-statistic. The positive coefficients were expected for the same reason as that of EFU. It was also predicted that NONEFU would have a larger coefficient than EFU because this land does not carry the same restrictions on use and development as land zoned exclusive farm use. The estimated price differences between EFU and NONEFU are approximately \$1,090 per acre in the primary model and \$717 per acre in the alternative model.

### **6.5.2 Square Footage**

The coefficient on  $\ln\text{SQFT}$  is 130,097; it is significantly different from zero in the primary model. This requires a slightly different interpretation because of the logarithmic specification of the variable  $\ln\text{SQFT}$ . The logarithmic form allows for the change in price per square foot to vary depending on the size of the houses being compared. For example, with all other characteristics being equal, a house of 1,600 square feet would sell for \$8,874 more than a house of 1,500 square feet. The difference in price between a house with 2,000 square feet and one of 2,100 square feet would be \$6,390. This demonstrates a diminishing marginal returns to square footage as the size of the house increases. Intuitively this makes sense because there is quite a difference in adding 100 square feet to a house that is only 800 square feet to begin with and adding the same square footage to a 3,000 square foot house.

The coefficient in the alternative model for  $\ln\text{SQFT}$  is estimated to be 134,300 and is also significantly different from zero. This would produce a change of \$8,667 and

\$6,552 respectively for the example above. The change is slightly different than that of the primary model but the interpretation is the same.

### **6.5.3 Sale Date**

The time trend was modeled as having a linear influence on prices in real estate sales and is measured by the continuous variable DATE, the number of years after 1992 in which the transaction occurred. The coefficient on DATE was positive, as predicted. The coefficient indicates that the price of parcels like those targeted in this research has increased an average of \$10,775 per year since 1992. The variable tested significant at the 90% level. It is still expected that rapid population growth and economic development have placed upward pressures on real estate values so a positive coefficient is expected.

The coefficient on DATE increased slightly in the alternative model to 11,545. An increase in price of \$11,545 per year is an 5.9% increase based on the mean price within the sample. This is a realistic average appreciation over a three year period.

### **6.5.4 Age of the Residence**

Intuitively a newer home is worth more than a comparable older home. The variable AGE measures the age of the residence at the time of the real estate transaction. The coefficient is negative, as predicted, and has a significant t-statistic. Real estate appraisers often use a 100 year life span for single family, wood-frame housing. These guidelines dictate that when comparing similar properties, the value of the older property is reduced by 1% for every year older it is than the comparable property. The variable

AGE has a coefficient of -944, indicating that for every year a house ages it loses \$944 of its value. Based on the mean sample price of \$196,910 this is a reduction of approximately 0.48%, less than half of that suggested by real estate professionals. The alternative model coefficient for AGE is -881, indicating an even lower depreciation rate than did the primary model.

#### **6.5.5 Agricultural Sales**

Only 17 of the 94 observations reported income from the sale of agricultural products produced on the property. The variable SALES, measured as the dollar value of these agricultural sales, has an estimated coefficient of 1.12. If the coefficient were significantly different from zero, which it is not, this would indicate that for every dollar of agricultural products produced on the property the price of that parcel would increase by \$1.12. The result is as expected given that buyers must consider productivity as an income stream to be obtained over the duration of ownership of the property rather than a one-time windfall. Costs of producing the products sold was not included in the agricultural sales figures; this may be influencing the price differentiation.

The alternative model coefficient, 0.9587, is also not significantly different from zero. This would suggest that an additional dollar of agricultural income is only worth an additional \$0.96 to the property buyer. Two possible explanations for this may be production costs, which as previously stated were not considered in the data, and the small contribution these sales make to personal income. The mean value of all sales was \$856, hardly a substantial contribution when the mean income of the sample was \$74,233.

### **6.5.6 Distance to an Urban Center**

The questionnaire asked the respondent the distance, in miles, to the town nearest their property. These towns included Bend, Redmond, Sisters, Tumalo, La Pine, and Alfalfa. As expected, the coefficient for MILES (-1,320) indicated a negative relationship between distance to town and housing prices, but the estimated coefficient did not have a significant t-statistic. The coefficient estimated in the alternative model (-1,631) was also not significant. These results may be influenced by two factors. First, the towns included in responses are heterogeneous in their characteristics; second, some buyers prefer more remote living. The distance to urban centers in other studies was significant and negative (Crouter 1987; Xu et al. 1993). These studies were more specific in homogenizing town characteristics. Crouter (1987) specified the distance to a town with a population of over 1,000. Xu et al. (1993) specified a town as having a service station and a grocery store. The lack of specification and the possibility that some buyers prefer to have some distance between themselves and an urban center may have influenced the results here.

### **6.5.7 Distance Traveled on a Unpaved Road**

The coefficient for the explanatory variable DIRT (12,860) was significantly different from zero in the primary model. This result was unexpected given that the variable measures the distance, in miles, that a resident has to travel on unpaved roads to reach their property. Given that this is considered an undesirable attribute because of the dust and rocks that are present, a negative coefficient was predicted. Hedonic price theory states that undesirable attributes of a composite commodity will be negatively

related to the commodity price (Freeman 1993). The alternative model coefficient estimate (12,023) was significant at the 90% level. There may be other attributes which are associated with unpaved roads, or there may be location preferences that value remoteness over convenience.

#### **6.5.8 Distance to the South Sister**

The explanatory variable SISTER measures the aerial distance, in miles, from the peak of the South Sister to the observed parcel. These distances ranged from 16.5 to 37.8 miles with a mean distance of 25.1 miles. This coefficient was included in an attempt to reflect location factors that may not be explained by MILES, DIRT or DV. The estimated coefficient on SISTER is -3,654 for the primary model and -2,681 for the alternative model. The estimated coefficient was significantly different from zero in the primary model at the 95% level, and tested significant at the 90% level in the alternative model. This indicates that a property loses from \$2,681 to \$3,655 in value for every mile farther away the property is from the peak of South Sister.

#### **6.5.9 View from the Main Living Area**

The explanatory variable DV was measured as a dummy variable, it took on a value of 1 when a view was reported by the respondent to be better than most other residences in a neighborhood and a value of 0 when it was either the same or worse compared to others in the neighborhood. As expected, the significant coefficient estimated for DV (23,878) was positive. This indicates that a property with a relatively good view will sell for \$23,878 more than a property with an average or below average

view. The magnitude of this price increase is 12.1% of the mean sales price for the sample,. This result may be reflecting other unidentified factors that contribute to sale price other than a residence view. The variable is a subjective measure of view but is useful in explaining variances in price. The estimated coefficient in the alternative model is 26,755. This coefficient also has a significant t-statistic.

#### **6.5.10 Water Rights and District Interaction Variables**

In the primary model water rights were represented by the continuous variable WATER, which has an estimated coefficient of -7,744 per acre of water. The coefficient was only significant at  $\alpha = .20$  and therefore, the null hypotheses of the coefficient equaling zero can not be rejected at the standard significance level of  $\alpha = 0.05$ . The negative sign and low significance level is unexpected because of the a priori assumption that water rights add to property values. However, because of the low significance level it is difficult to make assumptions about magnitude or sign. When the partial derivative of price with respect to water is taken the with respect to the interaction terms, however, the value of a water right is positive in all districts except Tumalo. For example, a property with one acre of water in the Tumalo Irrigation District would have a partial derivative:

$$\frac{\partial \text{PRICE}}{\partial \text{WATER}} = -7744 + 6552DT = -1192 \quad [19]$$

Property in the Tumalo Irrigation District loses \$1,192 for each acre of water right. For parcels in Swalley, COI and Arnold Irrigation Districts, sale price increases by \$2,402, \$752, and \$2,192 per acre of water respectively. Differences in the value of

water among the districts may have two possible explanations. First, the irrigation districts are located in different geographic areas of the county. Each area may have varying desirability for housing unrelated to water rights but which is being captured by the district variable. An examination of the mean sale price in each district does not indicate that this is causing the differentiation (Table 6-6). Although some districts have a relatively higher mean selling price, those districts are not necessarily the ones with higher estimated values for water.

***Table 6-6: Mean Parcel Characteristics by Irrigation District***

	Swalley	COI	Tumalo	Arnold	No District
<b>Price</b>	\$214,860	\$176,230	\$211,110	\$227,840	\$193,350
<b>Land (acres)</b>	13.340	11.615	10.916	12.282	6.859
<b>Water</b>	7.091	6.499	5.035	5.665	0

The second possible explanation may be that there are differences in water right attributes among the district. The districts vary in the duty of their water rights, the seniority of the right, the annual district membership fee, and the per acre charge for delivery of the water right to the property. A summary of these attributes for each district is presented in Table 6-7.

***Table 6-7: Characteristics of Irrigation Districts***

	Swalley	COI	Tumalo	Arnold
<b>Duty</b>	5.46	5.45	1.80	4.30
<b>Seniority</b>	1899	1892	1893	1905
<b>Annual Fee</b>	\$242.00	\$200.00	\$250.30	\$303.10
<b>Charge/acre</b>	\$14.13	\$17.00	\$25.00	\$43.00
<b>Ave. Cost *</b>	\$326.78	\$302.00	\$400.30	\$561.10

\* Average cost is based on 6 acres of water right, the approximate mean value of WATER for all properties with water rights.



Again, there does not appear to be a consistent relationship between the relative value for water in each district and the characteristics of water rights in those districts. For example, water in Arnold Irrigation District has relatively high average costs and a junior right. In fact some years district members' water is shut off before the end of the irrigation season, yet the net value of water served by this district is relatively high. However, water rights in Swalley Irrigation District, with about the same estimated value, have relatively low average cost, a larger duty, and a more senior water right.

The alternative model was analyzed using a dummy variable for water, DW. DW took on a value of 1 if the property possessed a water right and a value of 0 otherwise. The variable itself had a non-significant coefficient of -77,213, with  $t = 1.657$  being significant at only the 80% level. Again, the negative sign on the coefficient was unexpected. The value of the partial derivative with respect to DW, which included the district interaction terms, were also negative but the  $t$ -statistics indicated the coefficients on the interaction terms were not significantly different from zero at  $\alpha = 0.05$ . For each district except Swalley, the partial derivative was negative. Properties with water rights in COI were estimated to be worth \$11,467 less than properties without water. Tumalo properties would be worth \$8,952 less and properties supplied by Arnold Irrigation District would be worth \$8,116 less than properties without water. Properties with water supplied by Swalley Irrigation District would be valued \$5,125 more than properties without water. Although these figures seem large, in some cases they are only a small percentage of the mean-valued home in the district (Table 6-8).

Another possible explanation for a negative or zero value coefficient on the water variables is that differences in other non-water characteristics between properties with and without water have not been fully considered. For example, do properties without water have newer, larger homes than those with water? The data was tested for a difference in mean price between the sub-samples of properties with water (n=73) and those without water (n=21). A t-test was performed to determine if the two means for PRICE, SQFT, AGE, and total acreage were significantly different for the two sub-samples. There was no detectable difference between the two means for PRICE; therefore, it is assumed that there is no significant difference in prices between the two sub-samples which may affect the estimated coefficients on the water variables. There was also no detectable difference between the two means for SQFT. A significant difference between the means for AGE and ACRES was detected (Appendix F).

***Table 6-8: Partial Derivative with Respect to WATER & DW  
as a Percent of Mean Property Values***

	Swalley	COI	Tumalo	Arnold
$\delta P / \delta \text{WATER}$	2,402	752	-1,192	2,192
$\delta P / \delta \text{DW}$	5,125	-11,467	-8,952	-8,116
<b>Mean Price (P)</b>	\$214,860	176,230	211,110	227,840
$\delta P / \delta \text{WATER} \% \text{ of } P_i$	1.1%	0.42%	-0.56%	1.0%
$\delta P / \delta \text{DW} \% \text{ of } P_i$	2.4%	-6.5%	-4.2%	-3.6%

## **6.6 SUMMARY**

Two models using different measurements for water were used to estimate the contribution of water rights to sale price. The primary model defined water as a

continuous variable measured in acres of water; the alternative model measured the existence of a water right through a dummy variable. Both models had estimated coefficients for the respective water variables that were significantly different from zero only at the 80% and 90% levels. The models were tested for multicollinearity and heteroskedasticity, but these tests did not indicate the presence of either problem.

An expanded model adding BED, BATH and DWELL was also analyzed in the primary and alternative forms. A model specification test showed no statistical difference between the initial models and the expanded models (Appendix G). The expanded models were tested for heteroskedasticity, which was not indicated. Multicollinearity was also not indicated in the expanded models.

Approximately 77% of the variation in sales prices was explained by both the primary and the alternative models. With the exception of WATER, DW and DIRT, the signs for all estimated coefficients were consistent with the hypothesized signs presented in Chapter Four. Although the  $R^2$  for the primary model was slightly higher than the alternative model, there did not appear to be any pattern in the effects that water variable specification may have had on the estimated coefficients. Some t-ratios were higher in the primary model while some were higher in the alternative model. The magnitude of some coefficients increased while others decreased. There is no conclusive empirical evidence to indicate which definition of the water variable is most appropriate.

## **CHAPTER SEVEN: SUMMARY AND CONCLUSIONS**

### **7.1 A SUMMARY OF FINDINGS**

In the rapidly developing region of Deschutes County, Oregon, there is growing pressure on the local water supply. Competition between agriculture, municipal, industrial and residential uses of water have stretched the capacity of the Deschutes River and its tributaries. Water market transfers have been advocated as a means of reallocating water to higher valued uses. One use of this water is for instream fish habitat improvement. A potential source for water rights is the rural residential property owner whose property has an adjudicated water right. The purpose of this study is to determine what value premium is placed on water rights associated with non-commercial, residential uses.

Conventional wisdom in the Deschutes County real estate market indicates that properties with associated water rights have a higher value than comparable properties without irrigation water. When advertising property, the presence of a water right characteristic is advertised as a desirable attribute. In addition, holders of water rights are protective of their privileges and regard potential reduction of their rights as a threat. To determine the economic value of water to residential property owners, an empirical analysis of the contribution of water rights to market value of rural residential properties was conducted, based on economic theory and current economic literature.

Hedonic price theory provides the structure for examining price variations when goods are heterogeneous. A review of economic literature identified a large number of

studies that have estimated the value of environmental attributes associated with residential property using hedonic pricing models (HPM) (Rosen 1974; Graves et. al. 1988; Crouter 1987). These studies analyzed how improvements in air and water quality, proximity to wetlands, and the presence of water rights have affected property values. Most of these studies used census, county tax assessor, and national survey data to compile their data bases. Some studies used actual sale price of land while others relied on the property tax assessed value. The studies were consistent on the specification of the variables that influence property variables. These factors include location characteristics such as neighborhoods and distance to urban centers, structural characteristics of the home, and some variable of interest that measured air quality, water quality or spatial relationship to the desired environmental attribute.

Data on recent rural real estate transactions involving single-family wood-frame homes on less than forty acres were collected for the purposes of estimating the hedonic price model. Information was obtained from a private appraisal firm and the Deschutes County Assessor. In addition, a mail survey was used to gather water use and owner information. Transactions occurring between January, 1992 and February, 1995 were identified through the appraisal firm. Names and addresses of property owners as well as zoning information was acquired from tax assessment records. The survey response rate was 54.3%, providing 94 observations on real estate transfers usable for the purpose of the analysis.

An econometric analysis was conducted to identify the contribution that water rights and other property characteristics make to property sale prices of rural parcels from 1 to 40 acres in Deschutes County. Two models are analyzed. The first model defines a

water right as a continuous variable equal to the number of acres of water associated with each observation. The alternative model defines water as a dummy variable equal to one if a property has a water right and equal to zero if there is no water right associated with a property. All other variables in the two models were identical. In addition, an expanded model was analyzed to determine if the inclusion of additional variables on housing characteristics improved the explanatory power of the models.

Significant conclusions emerging from the study include the following: 1) The model specification and empirical results were plausible, as compared to other studies, and 2) water rights associated with residential properties did not have a stable and positive effect on property values, based on conventional significance levels and statistical tests.

### **7.1.1 Model Specification**

Although previous hedonic pricing studies have varied in the content and definition of their explanatory variables, it is necessary that any hedonic model be well-specified and produce an  $R^2$  value and t-values for individual variables that are statistically significant. The models analyzed in this study produced  $R^2$ 's of 0.770 and 0.766 and t-values for the primary variables that were significant at the 0.01 level. Also, the strong explanatory power of a certain group of structural variables that are usually included in hedonic price models was replicated in this study. These structural variables included lot size, square footage, and the age of the residence. In this study the estimated coefficients for each of the variables EFU, NONEFU,  $\ln$ SQFT, and AGE indicated significance levels of 99% and had the anticipated sign. Another group of environmental

variables also had highly significant coefficients, particularly DV and SISTER. Other variables including the water variables, however, showed a weaker significance; WATER, DW, and DIRT had coefficients that were not significantly different from zero at conventional levels.

### **7.1.2 Lack of Significance of Water Rights**

When water is used for irrigation of commercial agricultural lands, the dollar value of water is revealed through increased crop yields. For amenity users such as those involved in this study, it was expected that the value of water would be due to improved landscaping, dust reduction, mitigation of fire hazard, and for use by feed crops and livestock. These uses do not necessarily indicate that a specific dollar value is placed on the presence of water rights but rather through an increase in the utility of the property.

The consensus among real estate professionals and property owners with water rights is that a property with a water right, all other factors equal, will have a higher selling price than a property without a water right. However, the results of this study indicate that the effect that water rights have on property values is different from zero only at significance levels that are less than the conventional 0.01 and 0.05 level and are sometimes negative. There are two explanations for this disparity between the expectations and the results. The first is water rights actually do enhance property values in Deschutes County, Oregon despite the results of this study. This may be the result of unmeasured factors that influence coefficient estimation. One of these factors is location. Some aspects of location were measured but others may remain unmeasured. Some properties, by virtue of being located in specific desirable areas, command a higher sale

price than comparable properties in other areas. While consultation with local realtors did not establish that any of the properties involved in this study were located in such areas, the potential for location to influence the observed prices still exists.

To test this possibility, two additional locational variables, SISTER and DIRT, were added to existing locational variables, specifically DV and MILES. Because three of these four variables had highly significant coefficients, it seems unlikely that a major specification error related to location still exists.

The second explanation for the disparity between expectations and results is that water rights today do not add to property values even though water may have had positive value to owners in the past. Water right holders may still be willing to pay the annual assessment for delivery of their water, but they may now be unwilling to pay a premium to have access to that legal right.

## **7.2 STUDY LIMITATIONS**

The most notable limitation of the study was that it was not possible to discern which of the two explanations for the disparity between anticipated results (water is valuable) and actual results (water is not valuable) was valid. Attempts were made to resolve this issue, particularly with respect to locational variables, as noted above. Those attempts included investigation into neighborhood effects, costs to the water right holder, differences among irrigation districts, and differences in mean values between properties with water and those without water.

A second limitation of this study was the small number of observations. A larger data set would have enabled separate regressions to be analyzed for each irrigation



district; this may have improved the estimates of the value of water. Also, a larger data set may have decreased the sensitivity of small changes in model specification. This sensitivity was illustrated by the two alternative definitions of the independent variable for water. Coefficient estimates changed depending on whether water was defined as a continuous or a dummy variable. This volatility makes it difficult to determine which specification is most appropriate for analyzing water rights contribution to property values.

### **7.3 POLICY RECOMMENDATIONS**

Methods for augmenting stream flows along certain stretches of the Deschutes River during the dry summer months are currently being investigated. Several organizations including the Oregon Water Trust and Oregon Waterwatch are searching for opportunities to return water to the river. One potential method for this would be through water markets. Water market activity in Deschutes County and in Oregon has generally been limited. Water user organizations as well as the Oregon Legislature are investigating ways to improve market activity and increase the number of water leases and donations.

Since there is evidence that water in residential markets is not highly valued, there may be a large pool of potential right holders willing to sell or donate their water. Improvement of information-sharing would assist organizations that are seeking donations or to purchase water in identifying potential benefactors. Irrigation districts and regional county watermasters could provide these information services, such as

newsletters or posting boards, through their mailing lists and central office locations.

This would facilitate sales and donations of water.

The threat of revocation of the water right for nonuse, which in most Western states still includes instream uses, should be revised to encourage water donations and leases for in-stream uses. Oregon water right permits are currently issued with the provision that the entire water right must be used at least once every five years to retain the right. Many right holders feel forced to waste a portion of their allotment in order to fulfill this requirement. That portion of a water right that is reallocated by the right holder for instream uses is now considered full use of that right unless the holder chooses to permanently relinquish the right. This is true for Oregon but this is not the case in most other Western states.

#### **7.4 RECOMMENDATIONS FOR FUTURE RESEARCH**

Amenity water users, those who use irrigation water for purposes other than commercial agriculture, are an increasing percentage of water consumers. Many owners purchase their property for the location, size of lot, view, and physical housing factors. It is likely that not all property owners with irrigation rights choose or are able to take full advantage of their total entitlement of water. The potential for these right holders to participate in programs to improve instream flows needs to be studied.

Future research could address rights holders' willingness to lease or donate all or part of their water right for instream use. Possible donors would include commercial irrigators and amenity users. Targeted questions may include topics such as: (1) circumstances under which a right holder would be willing to participate in water right

donations, (2) water rights holders' perceptions of the environmental threat to fisheries and water quality due to periods of low flow levels, and (3) how changes in water rights statutes may affect right holder decisions and public opinion.

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## **APPENDICES**

## APPENDIX A: COVER LETTER

August 31, 1995

«Name»

«Mailing Address»

«City», «State» «Zip»

Dear «Respondent»,

The Deschutes River water is used in many ways including municipal, agricultural, recreational, and fisheries and wildlife habitat. The economic value of this water in various uses has yet to be determined. The goal of our study is to estimate some of these values for people like yourself. The questions in this survey refer to the property at: «Site Address».

Your name was provided by the Deschutes County Assessor as the owner of rural residential property under forty acres. **You may be assured of complete confidentiality in our study.** We have no affiliation with any company or group, and we will keep both your name and reply confidential. The questionnaire has an identification number so that we may check your name off the mailing list when your questionnaire is returned. Your name will not appear on the questionnaire. Only a small sample of property owners will receive this questionnaire, so your participation is critical. Your responses, together with others, will be combined and used for statistical purposes only.

The results of our research will be made available to you through a summary. If you wish to receive a copy of the results, please indicate this by writing "SUMMARY" on the back of the return envelope along with your name and address. Please do not put this information on the questionnaire itself.

I would be happy to answer any question you may have. Please write or call me or call my research assistant, **Loraine Kiest**, at **(503) 737-1451**. Thank you for your time and consideration.

Sincerely,

Dr. Joe B. Stevens  
Professor of Agricultural and Resource Economics  
Phone: **(503) 737-1431**



## APPENDIX B: WATER USE SURVEY

*If you purchased your property in Central Oregon prior to 1992 this survey is not for you. Please return it in the enclosed postage-paid envelope.*

*First we would like to ask you a few questions about the water associated with your property.*

1. Do you have a water right on this property?
  - 1 YES
  - 2 NO (go to question #10)
  
2. How many acres does your water right cover?
 

\_\_\_\_\_ ACRES
  
3. What is the priority date of this right?
 

\_\_\_\_\_ PRIORITY DATE
  
4. Which irrigation district administers your water right?
 

\_\_\_\_\_ IRRIGATION DISTRICT
  
5. What is the maximum rate of diversion that is allowed by the water right?
 

\_\_\_\_\_ OR \_\_\_\_\_  
CUBIC FEET PER SECOND      GALLONS PER MINUTE
  
6. What is the maximum diversion (duty or amount) that is allowed by the water right during the irrigation season?
 

\_\_\_\_\_ ACRE-FEET PER ACRE
  
7. For what months of the year is the use of water permitted by the water right?  
(Circle months of use)
 

JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC

8. Please indicate whether or not you use the water for any of the following purposes. (*Please circle one number for each.*)

<u>YES</u>	<u>NO</u>
------------	-----------

- |   |                              |   |   |
|---|------------------------------|---|---|
| a | Lawn and Landscaping.....    | 1 | 2 |
| b | Hay or Pasture.....          | 1 | 2 |
| c | Crop Production.....         | 1 | 2 |
| d | Livestock Water.....         | 1 | 2 |
| e | Other (please specify) _____ |   |   |

9. What is the primary method that you use to irrigate your pasture or fields? (*Circle one number*)

- 1 SIDE WHEEL
- 2 HANDLINE
- 3 SOLID SET
- 4 FLOOD IRRIGATION
- 5 OTHER (please specify) \_\_\_\_\_

10. What is your source of water for household use?

- 1 PRIVATE OR SHARED WELL
- 2 PRIVATE SUPPLIER
- 3 OTHER (please specify) \_\_\_\_\_

11. Did you sell any agricultural products produced on this land in 1994?

- 1 YES
- 2 NO (*Go to question # 14*)

12. What was the approximate value of your agricultural sales from this property in 1994?

\$ \_\_\_\_\_

13. Were your 1994 sales below average, average or above average for your property compared to previous years?

- 1 BELOW AVERAGE
- 2 AVERAGE
- 3 ABOVE AVERAGE
- 4 NO BASIS FOR COMPARISON

*Now we would like to ask a few general questions about your home and property.*

14. In what year and month did you purchase your home?

\_\_\_\_\_  
MONTH/YEAR

15. In what year was your home built?

\_\_\_\_\_  
YEAR

16. Approximately how many square feet is your home?

\_\_\_\_\_  
SQUARE FEET

17. How many bedrooms are in your home?

\_\_\_\_\_  
BEDROOMS

18. How many acres altogether do you have on this property?

\_\_\_\_\_  
ACRES

19. Please indicate whether or not you have any of these views from your main living area. *(Please circle one number for each.)*

	YES	NO
a River or Stream.....	1	2
b Pasture or Fields.....	1	2
c Other Houses or Outbuildings.....	1	2
d Woods.....	1	2
e Road.....	1	2
{f. Mountains.....	1	2
→ <i>(Please indicate which mountains)</i> _____		
g Other: <i>(Please Specify)</i> _____		

20. Compared to other homes in your area, would you consider the view from your main living area to be better, about the same, or not as good as most?

- 1 BETTER THAN MOST
- 2 ABOUT THE SAME
- 3 NOT AS GOOD AS MOST

21. What is the name of the town nearest to your home?

\_\_\_\_\_ TOWN NAME

22. How many miles is it from your home to that town, one way?

\_\_\_\_\_ MILES ONE WAY

23. How many miles, if any, do you have to drive on unpaved roads to get to this town?

\_\_\_\_\_ MILES

*Next, we have a few general questions about you and your household.*

24. Including yourself, how many people live in your house?

\_\_\_\_\_ NUMBER OF OCCUPANTS

25. Are you employed for pay, self employed or retired?

- 1 NO (*Go to question #27*)
- 2 YES, EMPLOYED FOR PAY
- 3 SELF EMPLOYED
- 4 RETIRED

→ 25a

What type of work do you do and in what industry?

\_\_\_\_\_ TYPE OF EMPLOYMENT

\_\_\_\_\_ INDUSTRY

26. Is your spouse employed for pay, self employed or retired?

- 1 NO (*Go to question #27*)
- 2 YES, EMPLOYED FOR PAY
- 3 SELF EMPLOYED
- 4 RETIRED

→ 26a

What type of work does your spouse do and in what industry?

\_\_\_\_\_ TYPE OF EMPLOYMENT

\_\_\_\_\_ INDUSTRY

27. In which age category are you?

- 1 30 YEARS OR YOUNGER
- 2 31 TO 45 YEARS
- 3 46 TO 60 YEARS
- 4 OVER 60 YEARS

28. What is the highest level of education you have completed? (*Circle one number*)

- 1 8TH GRADE OR LESS
- 2 SOME HIGH SCHOOL
- 3 HIGH SCHOOL OR GED
- 4 TECHNICAL SCHOOL OR TWO YEAR COLLEGE
- 5 SOME FOUR YEAR COLLEGE OR UNIVERSITY
- 6 FOUR YEAR COLLEGE DEGREE (BACHELOR'S)
- 7 SOME GRADUATE SCHOOL
- 8 GRADUATE OR PROFESSIONAL DEGREE
- 9 OTHER:

\_\_\_\_\_

29. What was your total 1994 household income before taxes? (*Circle one number*)

- 1 LESS THAN \$25,000
- 2 \$25,000 - 39,999
- 3 \$40,000 - 59,999
- 4 \$60,000 - 79,999
- 5 \$80,000 - 99,999
- 6 \$100,000 -125,000
- 7 OVER \$125,000

*Finally, we have a few questions about the Deschutes River Basin and your opinion on instream uses of water.*

**In some years trout in the Deschutes River between Bend and Lake Billy Chinook would benefit from increased stream flows and cooler river temperatures in the late summer and early fall.**

30. Assuming that your water rights would not be affected, how likely is it that you would agree to leave one-tenth of your yearly entitlement of irrigation water in the stream during the late summer and early fall in an especially dry year?

1 VERY LIKELY (31)  
 2 SOMEWHAT LIKELY (31)  
 3 NOT TOO LIKELY (15)  
 4 NOT AT ALL LIKELY (5)

31. Is it likely or unlikely that your donation of water would depend on whether other water users also agreed to leave one-tenth of their water in the stream?

1 LIKELY (46)  
 2 UNLIKELY (36)

32. How familiar are you with the Deschutes River in the area below Bend and above Lake Billy Chinook, including Tumalo, Awbrey Falls, Cline Falls, Lower Bridge, and Steelhead Falls?

1 VERY FAMILIAR (21)  
 2 SOMEWHAT FAMILIAR (36)  
 3 NOT TOO FAMILIAR (24)  
 4 NOT AT ALL FAMILIAR (8)

33. Please indicate whether you agree strongly, agree, neither agree nor disagree, disagree, or disagree strongly with the following statement which has been frequently used in national opinion polls: "Economic growth should be given priority over environmental protection"

1 AGREE STRONGLY (2)  
 2 AGREE (8)  
 3 NEITHER AGREE NOR DISAGREE (22)  
 4 DISAGREE (26)  
 5 DISAGREE STRONGLY (30)

**Please indicate below any further comments you would like to make about this survey, water rights or the Deschutes River.**

**(THANK YOU VERY MUCH FOR YOUR COOPERATION WITH THIS SURVEY)**

## APPENDIX C: SUMMARY OF VARIABLE STATISTICS

*Table C-1: Statistics of Primary Variables*

	AGE	EFU	NONEFU	SALES	MILES	DIRT	SISTER
<b>Mean</b>	18.36	4.11	6.8	856.6	5.46	0.273	25.11
<b>Std. Dev.</b>	16.19	9.29	6.54	491.5	3.09	0.740	4.35
<b>Max.</b>	82	39	39.6	4700	15	6	37.8
<b>Min.</b>	0.0	0.0	0.31	0.0	0.0	0.0	16.5



## APPENDIX D: MULTICOLLINEARITY

Multicollinearity occurs when two or more independent variables or combination of variables are systematically correlated. Multicollinearity does not bias the Ordinary Least Squares parameter estimates, but parameter estimates are sensitive to the addition or deletion of observations or to changes in model specification and small changes in data (Griffiths et. al. 1993). Collinearity among variables that is near perfect is a statistical problem that makes it difficult to distinguish the affects of individual variables. Other symptoms of multicollinearity are coefficients with high standard errors and low t-statistics in a model with a high F-statistic and  $R^2$ . Coefficients which have the wrong sign or are of implausible magnitude are other indications of multicollinearity.

A correlation matrix and auxiliary regression are two procedures which are used in the detection of multicollinearity. A correlation matrix illustrates the linear association between two independent variables. A commonly used rule is if the correlation coefficient is 0.8 or greater, multicollinearity may be present (Griffiths et. al. 1993). In the primary model, the correlation coefficient between WATER and DSWAT, DCWAT, DTWAT and DAWAT were -0.9620, -0.93292, -.87874 and -.88105 respectively. In addition, the correlation coefficients between any two district interaction terms were 0.83 or higher. Similar coefficients were present in the alternative model. This level of correlation is expected since the values of the district interaction terms are dependent on the value of WATER. No other variables show a strong relationship with any other

single variable. Table D-1 and Table D-2 show correlation matrices for the primary and alternative models.

*Table D-1: Primary Model Correlation Matrix*

	EFU	NONEFU	WATER	LNSQFT	DATE	AGE	SALES	MILES
EFU	1.000							
NONEFU	0.556	1.000						
WATER	-0.179	-0.336	1.000					
LNSQFT	-0.176	-0.145	0.082	1.000				
DATE	-0.137	-0.120	-0.127	0.208	1.000			
AGE	0.061	0.098	0.098	0.236	-0.159	1.000		
SALES	-0.144	0.060	-0.047	0.235	0.080	0.131	1.000	
MILES	-0.011	0.031	-0.127	0.051	-0.157	0.076	0.185	1.000
DIRT	-0.159	0.009	0.068	-0.116	-0.193	0.108	0.068	-0.036
SISTER	0.174	-0.016	0.086	0.130	0.147	0.064	-0.006	-0.059
DSWAT	-0.054	0.210	-0.936	-0.077	0.116	-0.143	0.062	0.140
DCWAT	-0.079	0.177	-0.933	-0.079	0.119	-0.175	0.047	0.077
DTWAT	0.008	0.128	-0.879	-0.092	0.135	-0.146	-0.121	-0.017
DAWAT	-0.080	0.135	-0.881	-0.128	0.090	-0.126	0.028	0.122
DV	-0.718	0.001	-0.200	-0.068	0.139	-0.126	0.073	-0.004
CONST.	0.114	0.106	-0.084	-0.961	-0.242	-0.270	-0.237	-0.086

	DIRT	SISTER	DSWAT	DCWAT	DTWAT	DAWAT	DV	CONST.
MILES								
DIRT	1.000							
SISTER	-0.048	1.000						
DSWAT	-0.031	-0.131	1.000					
DCWAT	-0.018	-0.265	0.943	1.000				
DTWAT	-0.108	0.030	0.872	0.871	1.000			
DAWAT	-0.026	-0.212	0.901	0.915	0.835	1.000		
DV	0.034	-0.094	0.144	0.213	0.179	0.104	1.000	
CONST.	0.108	-0.384	0.090	0.131	0.070	0.161	0.067	1.000

*Table D-2: Alternative Model Correlation Matrix*

	EFU	NONEFU	DW	lnSQFT	DATE	AGE	SALES	MILES
EFU	1.000							
NONEFU	0.346	1.000						
DW	-0.024	-0.248	1.000					
lnSQFT	-0.304	-0.207	0.101	1.000				
DATE	-0.260	-0.170	-0.113	0.215	1.000			
AGE	-0.098	0.022	0.107	0.240	-0.159	1.000		
SALES	-0.271	-0.033	-0.010	0.245	0.086	0.146	1.000	
MILES	-0.170	-0.080	-0.086	0.059	-0.159	0.016	0.151	1.000
DIRT	-0.092	0.067	0.031	-0.128	-0.200	0.147	0.058	-0.007
SISTER	-0.164	-0.190	0.141	0.228	0.183	0.040	0.104	-0.141
DSDW	-0.053	0.208	-0.934	-0.059	0.123	-0.162	0.025	0.159
DCDW	0.001	0.238	-0.960	-0.118	0.106	-0.176	-0.010	0.106
DTDW	0.013	0.208	-0.943	-0.089	0.137	-0.150	-0.060	0.010
DADW	0.017	0.228	-0.932	-0.145	0.093	-0.138	-0.013	0.122
DV	-0.179	-0.034	-0.202	-0.084	0.126	-0.101	0.071	-0.009
CONST.	0.326	0.208	-0.122	-0.967	-0.252	-0.249	-0.263	-0.074

	DIRT	SISTER	DSDW	DCDW	DTDW	DADW	DV	CONST.
DIRT	1.000							
SISTER	-0.015	1.000						
DSDW	-0.048	-0.103	1.000					
DCDW	-0.038	-0.246	0.939	1.000				
DTDW	-0.101	-0.036	0.921	0.935	1.000			
DADW	-0.041	-0.210	0.915	0.944	0.910	1.000		
DV	0.043	-0.065	0.138	0.193	0.187	0.110	1.000	
CONST.	0.112	-0.447	0.060	0.152	0.079	0.167	0.078	1.000

Auxiliary regressions were used to detect multicollinearity among a combination of independent variables. Each of the explanatory variables is regressed on the remaining explanatory variables. Multicollinearity is considered to be present if the reported  $R^2$  from the auxiliary regression is relatively high or if the sum of the squared errors is relatively minimal (Griffiths et. al. 1993). Table D-3 and Table D-4 report results of the auxiliary regressions for the primary and alternative models respectively.

***Table D-3: Auxiliary Regression Results (Primary Model)***

Dependent Variable		$R^2$
EFU	ON OTHER INDEPENDENT VARIABLES	= 0.7282
NONEFU	ON OTHER INDEPENDENT VARIABLES	= 0.4487
WATER	ON OTHER INDEPENDENT VARIABLES	= 0.9738
LNSQFT	ON OTHER INDEPENDENT VARIABLES	= 0.2551
DATE	ON OTHER INDEPENDENT VARIABLES	= 0.2467
AGE	ON OTHER INDEPENDENT VARIABLES	= 0.2150
SALES	ON OTHER INDEPENDENT VARIABLES	= 0.2590
MILES	ON OTHER INDEPENDENT VARIABLES	= 0.2140
DIRT	ON OTHER INDEPENDENT VARIABLES	= 0.1593
SISTER	ON OTHER INDEPENDENT VARIABLES	= 0.5103
DSWAT	ON OTHER INDEPENDENT VARIABLES	= 0.9388
DCWAT	ON OTHER INDEPENDENT VARIABLES	= 0.9645
DTWAT	ON OTHER INDEPENDENT VARIABLES	= 0.8838
DAWAT	ON OTHER INDEPENDENT VARIABLES	= 0.8741
DV	ON OTHER INDEPENDENT VARIABLES	= 0.2078

*Table D-4: Auxiliary Regression Results (Alternative Model)*

Dependent Variable		R <sup>2</sup>
EFU	ON OTHER INDEPENDENT VARIABLES	= 0.3531
NONEFU	ON OTHER INDEPENDENT VARIABLES	= 0.2268
DW	ON OTHER INDEPENDENT VARIABLES	= 0.9505
LNSQFT	ON OTHER INDEPENDENT VARIABLES	= 0.2795
DATE	ON OTHER INDEPENDENT VARIABLES	= 0.2495
AGE	ON OTHER INDEPENDENT VARIABLES	= 0.2307
SALES	ON OTHER INDEPENDENT VARIABLES	= 0.1873
MILES	ON OTHER INDEPENDENT VARIABLES	= 0.2344
DIRT	ON OTHER INDEPENDENT VARIABLES	= 0.1640
SISTER	ON OTHER INDEPENDENT VARIABLES	= 0.4836
DSDW	ON OTHER INDEPENDENT VARIABLES	= 0.9201
DCDW	ON OTHER INDEPENDENT VARIABLES	= 0.9640
DTDW	ON OTHER INDEPENDENT VARIABLES	= 0.9413
DADW	ON OTHER INDEPENDENT VARIABLES	= 0.9139
DV	ON OTHER INDEPENDENT VARIABLES	= 0.2037

The auxiliary regression results do not support a strong collinear relationship between any of the independent variables, other than the previously mentioned water variables and district interaction variables. The primary model shows a high R<sup>2</sup> value of 0.7282 for the auxiliary regression on EFU; this R<sup>2</sup> is only 0.3531 in the alternative model. Because the correlation matrix does not otherwise indicate a strong correlation between EFU and any other variable, this does not represent a multicollinearity problem.

## APPENDIX E: HETEROSKEDASTICITY

Heteroskedasticity is the result of non-consistency of the error variance (Griffiths et. al. 1993) and is a violation of the assumption of the classical linear regression model that the variance of the error terms is not constant for all observations. The primary consequence of heteroskedasticity that the estimated coefficients are not efficient because the variance is no longer smallest among the class of linear estimators, therefore, hypothesis test on the coefficients may not be valid. The Breusch-Pagan (BP) test was used to test for the presence of heteroskedasticity in the primary, alternative and expanded models. The computed BP statistic for the primary model was 20.549, and for the alternative model it was 12.855. The critical value,  $\chi^2_{15}$ , at the 95% confidence level is 24.9958, thus the hypotheses of heteroskedasticity could not be rejected. For the expanded model the computed BP statistics were 21.764 and 15.525 with the critical value,  $\chi^2_{18}$ , is 25.9894: therefore, there was no evidence of heteroskedasticity.

## APPENDIX F: COMPARISON OF PROPERTIES WITH AND WITHOUT WATER

The estimated coefficients for WATER and DW were negative, as well as four of the partial derivatives with respect to WATER and DW; this created speculation that properties with water may be worth less due to attributes other than the presence of a water right. A summary comparing mean values of major characteristics for parcels with and without water is presented in Table F-1.

A t-test was performed to determine if there were significant differences between the two sub-samples and their mean values of sale price, acres, square feet, and age. The calculated t-statistic for comparing mean sale price was 0.899<sup>5</sup>. The critical statistic,  $t_{.05(92 \text{ d.f.})}$ , is 1.96 which indicates no significant difference between the two sub-sample sale price means. There was also no significant difference in square footage between the two sub-samples (t-stat=-0.561). There was a significant difference between the mean age of a house and the total number of acres: these t-statistics were 2.29 and 2.16 respectively. This would indicate that properties with water tend to have older homes on larger parcels creating similar prices to the newer homes on smaller parcels without water.

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The t value was calculated:  $S^2 = \frac{(72)5.7746 + (20)8.4306}{92} = 6.3520E + 06$

$$s = \sqrt{S^2} = 79699.4$$

$$t = \frac{197930 - 193350}{79699.4 \sqrt{\left(\frac{1}{72}\right) + \left(\frac{1}{20}\right)}}$$

***Table F-1: Comparison of Characteristics for Parcels  
With and Without Water***

Mean Value For:	Properties with Water	Properties w/o Water
Price	\$197,930	\$193,350
Acres	12.091	6.859
Square Feet	2,141	2,243
Age (years)	20.41	11.23
Water	6.26	0

## APPENDIX G: THE EXPANDED AND REDUCED MODELS

An expanded model for both the primary and alternative models was analyzed to determine if the variables BED, BATH and DWELL added any explanatory power to the models. The results of the OLS regression are presented in Table G-1 and Table G-2.

*Table G-1: Expanded Primary Model Results*

Variable	Estimated Coefficient	Standard Error	T-Ratio
EFU	2,323	901	** 2.577
NONEFU	3,067	920	*** 3.331
WATER	-5,465	5,438	-1.005
LNSQFT	125,720	22,282	*** 5.642
DATE	11,197	5,963	* 1.878
AGE	-692	336	** -2.059
SALES	0.988	1.055	0.937
MILES	-861	1,597	-0.539
DIRT	12,711	6,540	* 1.943
SISTER	-3,223	1,433	** -2.248
BED	-9,904	7,003	# -1.414
BATH	17,174	12,669	# 1.356
DWELL	3,452	9,839	0.351
DSWAT	7,583	5,456	# 1.389
DCWAT	6,193	5,468	1.133
DTWAT	4,240	5,388	0.787
DAWAT	8,657	5,510	# 1.571
DV	20,762	10,393	** 1.998
CONSTANT	-725,370	157,630	-4.602

$R^2 = 0.7797$ , Adjusted  $R^2 = 0.7269$ ,  $n = 94$ ,  $F\text{-stat} = 14.943$

The variables DWELL, BED and BATH were added to the expanded model. The estimated coefficients for these variables were not significant at the 95% level of confidence. An F-subset test was performed on the newly included variables to determine if they were significant as a group in adding to the explanation of sale prices.



The F-test indicated that the set of additional variables are not significant in explaining parcel sale prices.<sup>6</sup> A Breusch-Pagan test for heteroskedasticity did not indicate the presence of heteroskedasticity in the expanded model.

The expanded alternative model Table G-2 was also tested for the presence of heteroskedasticity. As in the expanded primary model, there was no indication of the presence of heteroskedasticity

**Table G-2: Expanded Alternative Model Results**

Variable	Estimated Coefficient	Standard Error	T-Ratio
EFU	2,905	592	*** 4.903
NONEFU	3,318	791	*** 4.192
DW	-57,746	48,517	-1.190
LNSQFT	128,890	22,663	*** 5.687
DATE	11,856	6,047	* 1.960
AGE	-677	339	** -1.998
SALES	0.7426	1.0232	0.7258
MILES	-1,288	1,624	-0.793
DIRT	11,964	6,631	* 1.804
SISTER	-2,281	1,430	# -1.595
BED	-9,242	7,023	# -1.316
BATH	15,824	12,798	1.236
DWELL	-182	10,519	-0.017
DSDW	60,578	49,798	1.216
DCDW	46,237	49,623	0.932
DTDW	50,391	47,791	1.054
DADW	53,738	49,924	1.076
DV	24,366	10,516	** 2.317
CONSTANT	-764,010	162,660	-4.697

$R^2 = 0.7739$ , Adjusted  $R^2 = 0.7196$ ,  $n = 94$ ,  $F\text{-stat} = 14.452$

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The calculated F value is:  $\frac{(.7797 - .7702)/3}{(1 - .7797)/(94/18 - 1)} = 1.078$

The Critical F-statistic, with 3 and 75 degrees of freedom at the 95% level, is 2.68.

An F-subset test was performed on the expanded alternative model as in the primary expanded model. The F-test indicated that the set of additional variables was not significant in explaining parcel sale prices.<sup>7</sup>

A reduced model was analyzed to determine if the water variables add any explanatory power to the model. The results of the OLS regression are presented in Table G-3.

***Table G-3: Reduced Model Results***

Variable	Estimated Coefficient	Standard Error	T-Ratio
EFU	3,014	562	*** 5.355
NONEFU	3,404	723	*** 4.708
LNSQFT	133,940	15,235	*** 8.791
DATE	10,204	5,901	* 1.729
AGE	-868	290	*** -2.992
SALES	0.7658	0.9437	0.811
MILES	-2,180	1,465	#-1.488
DIRT	12,128	6,217	* 1.951
SISTER	-2,959	1,057	*** -2.800
DV	24,724	9,483	*** 2.607
CONSTANT	-779,050	124,800	-6.242

$R^2 = 0.7539$     Adjusted  $R^2 = 0.7242$      $n = 94$     F-stat = 28.558

The variables water, DW, as well as the interaction terms for the districts were omitted from the reduced model. An F-subset test was performed on the omitted variables to determine if the water variables were significant in adding to the explanation of sale prices. The F-test indicated that the omitted variables are not significant in

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The calculated F value is:  $\frac{(.7739 - .7663) / 3}{(1 - .7739) / (94 - 18 - 1)} = 0.8403$

The critical F-Statistic, with 3 and 75 degrees of freedom at the 95% level, is 2.68.

explaining parcel sale prices.<sup>8</sup> This result concurs with the results from the primary and alternative models which indicate a relationship between water and sale price which is not significantly different from zero.

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The calculated F values are:  $\frac{(.7702-.7539) / 5}{(1-.7702) / (94 - 15 - 1)} = 1.107$  and  $\frac{(.7663-.7539) / 5}{(1-.7663) / (94 - 15 - 1)} = 0.828$

The critical F-Statistic, with 5 and 78 degrees of freedom at the 95% level, is 2.29