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# Estimating the Value of Water Use Permits: A hedonic approach applied to farmland in the southeastern US

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ABSTRACT

In the State of Georgia, agricultural irrigation permits in the Flint River Basin had been routinely granted until a moratorium was placed on permit issuance in 1999. This research exploits this policy change within a hedonic pricing framework to estimate the value of irrigation rights in the Southeast US. While the value of irrigation rights has been studied extensively in the western US, differences in property rights and legal regimes, as well as a lack of established water-rights markets in the East, leave us with little information regarding the value of irrigation rights in this setting.

## I. INTRODUCTION

In 1999, during the first year of what became a four-year drought, and amid growing demands for water from Atlanta and the agricultural sector in Southeast Georgia, as well as litigation with Florida and Alabama over waters in the Flint River (as well as other rivers), the State of Georgia initiated a moratorium on the issuance of agricultural water permits in the Flint River Basin. Any land owner with an existing water permit at the time of the moratorium still has the legal right to irrigate. The permit, required for any water use in excess of 100,000 gallons of water a day, is attached to the land, and in the event of a sale of the land, the permit is transferred to the new owner. Land owners without permits can dryland crop or pump-irrigate less than 100,000 gallons a day (approximately one-third of an acre-foot of water a day).[1]

Although the purpose of the moratorium was to contain the amount of water pumped from the Flint River, it is likely to have consequences for agricultural property markets. Permits and the irrigation they allow, while essentially a free resource prior the moratorium, are now restricted to specific parcels.[2] This constraint on a vital input into agricultural production would most likely raise the value of existing permits and, by extension, affect property values.

While there is much evidence of the value of water rights in the Western U.S., very little is known about the value of water use permits in the East.[3] Important differences exist between the western half of the US and the east such that applying derived values from the west to the east may not be appropriate. Under western water-law, a right to use water is established by putting water to beneficial use. This water right is a property right which can be sold or leased; such rights are not tied to the land, nor is a state permit involved. The value of water rights in these situations will reflect local supply and demand conditions for water use for agriculture, industry, and municipal use.[4] However, in Georgia, and many other states in the eastern U.S., permits for water use must be obtained from the state, and these permits can only be used for irrigation of the land for which the permit was given and may not be traded or leased. Thus, the estimated value will only reflect the value of irrigation on-site, and it is not clear how markets for agricultural land will react to a constraint on permit issuances.

In this research, hedonic analysis is applied to agricultural property sales data from 1993 to 2003 for Dooly County, Georgia, to estimate the impacts of the water-use permit moratorium on property values. While there have been hedonic applications to farmland for the purposes of valuing water rights in the west (e.g., Hartmand and Anderson, 1962, and Faux and Perry, 2000), no analyses have been conducted that estimate the value of water-use permits in agriculture in the Southeast. Dooly County is an ideal setting to conduct the analysis as roughly half of the county is in the Flint River Basin and the other half is in basins that are unaffected by the moratorium. This environment allows us to separate the effects of the moratorium on property values and control for any spurious correlation by observing how property values changed in the unaffected basins during the same time period.

With increasing population in metropolitan areas and associated urban sprawl, the conflict between urban and rural economies grows. Water allocation among these competing demands continues to play a more central role. Currently, there are conflicts between each southeastern state and at least one neighbor over interstate streams. For example, rivers such as the Potomac (Maryland/Virginia)[5], Roanoke (Virginia/North Carolina)[6], Pee Dee (North Carolina/South Carolina)[7], Savannah (South Carolina/Georgia)[8], and the Chattahoochee and Flint (Georgia/Alabama/Florida)[9] have been the source of inter-state allocation conflicts and/or lawsuits. Intrastate disputes among localities mirror this relatively new, contentious, climate in the southeast. For example, an ongoing, sometimes heated, debate has developed regarding the potential development of water permit trading markets in Georgia as a method to meet growing water-demands in urban areas (primarily Atlanta). An ex-ante estimate of the value of irrigation rights for agricultural purposes in the Southeast is an important input into these debates.

## II. MODEL

The hedonic model recognizes that the sale price of an agricultural parcel reflects the net-present value of the future rents expected from the parcel (Palmquist, 1989). The land is a considered a differentiated factor of production, with the n characteristics of the land, $\{z_1, \ldots z_n\}$, affecting productivity and thus affecting sales price, P, or $P = P(z_1, \ldots z_n)$. While it is convenient to consider sales prices from an empirical standpoint, a time-consistent theoretical model of profit-maximization for the farmer is more conveniently represented in a per-period context. Thus, let us assume that rental rates, are a simple transformation of the sales price $R = R(P(z_1, \ldots z_n))$.[10] In other words, rental rates are equivalent to the annuitized sales price with all farmers having access to the same market-clearing interest rate.

Let a farmer seeking to purchase a property produce a single output, q, sold in a competitive market. His production function, $q = q(X, Z, \alpha)$, depends on a vector of non-land inputs, X, such as irrigation equipment, and a vector of property inputs (characteristics), Z, and a set of farmer-specific skills, $\alpha$.

Initially, consider the farmer's maximization of "variable profits", $\Pi^V$, which is defined here as the difference between the value of output and the value of non-land inputs.[11] The farmer's maximization problem is given by:

$$\max_x \Pi^V = mq - \sum_j c_j x_j$$
$$s.t.\ q = q(X, Z, \alpha) \qquad [1]$$

where m is the market price of output, c is the cost of variable input x, and all other variables are as defined above.[12] First order conditions imply the following input demand for the $j^{th}$ non-property input:

$$x^j = x_j(r, \boldsymbol{Z}, C, \alpha)\,. \qquad [2]$$

Substituting $x^j$ back into $\Pi^V$ to obtain $\Pi^{V*}$, we can compute total profit, $\Pi$, as the difference between variable profit and property costs (assuming all non-property inputs are variable):

$$\Pi = \Pi^{V*} - R(\boldsymbol{Z}) = m \cdot q(X, \boldsymbol{Z}, \alpha) - \sum_j c_j x^j(r, \boldsymbol{Z}, C, \alpha) - R(\boldsymbol{Z})\,. \qquad [3]$$

Profit maximization thus requires that the choice of land characteristics be such that the marginal rent paid for the characteristic equals its incremental contribution to variable profits, evaluated at the optimum level of non-property inputs, or:

$$\partial \boldsymbol{R}(z_i)/\partial z_i = \partial \Pi^{V*}/\partial z_i = \boldsymbol{m} \cdot \partial \boldsymbol{q}/\partial z\boldsymbol{i} - \sum_j c_j\, \partial x^j/\partial z_i\,. \qquad [4]$$

The alternative formulation of the farmer's problem is to determine the optimal amount the farmer will bid on a property with characteristics Z. The optimal bid, $\theta$, is defined by $\Pi = \Pi^{V*} - \theta$. It is the difference between variable profits and the price paid for land, such that a desired level of profit is achieved. Thus, we have:

$$\theta(\boldsymbol{Z}, m, C, \Pi, \alpha) = m \cdot q(X, \boldsymbol{Z}, \alpha) - \sum_j c_j x^j(r, \boldsymbol{Z}, C, \alpha) - \Pi . \quad \textbf{[5]}$$

From equation (5), the marginal bid for any specific characteristic of land is:

$$\theta_{z_i} = \partial\theta/\partial z_i = m \cdot \partial q/\partial zi - \sum_j c_j \partial x^j/\partial z_i . \quad \textbf{[6]}$$

Consider a land characteristic that increases agricultural productivity, such as improved soil quality. These characteristics will have positive marginal bids ($d\theta/dz_i \geq 0$) since $\partial x^j/\partial z_i \leq 0$ and/or $\partial q/\partial z_i \geq 0$. For instance, the demand for fertilizer might decrease if land has better quality soils, and/or plant yields (i.e., output) might increase with increased soil quality.

The above defines the optimal rental bid. For farmers who own their land, they can be considered renting the land from themselves, and in general the optimal rental bid will have a direct corresponding optimal bid for land purchases. However, there are deviations possible. For farmers who are not landowners, the optimal rental bid will only consider factors which influence cropland productivity during the course of the rental contract. Future productivity, or alternative future uses of the land (such as conversion to residential property) will not be considered in a rental bid. However, these factors would be considered in an optimal bid to purchase the land. As discussed below, one of our empirical models directly considers the possibility that sales prices, and the influence irrigation rights have on sales prices, may be affected by expectations about future productivity of the land (i.e., expected productivity of land that is not currently cropland, but could be converted to cropland).

The model makes clear how to incorporate irrigation rights in the empirical specification of the hedonic price function. In the case of irrigation permits in Georgia, we can consider the presence of a permit as a site-specific characteristic of the land. Unlike western states where rights can be traded and thus have value which is separable from the land, an irrigation permit in Georgia cannot be traded separately from the parcel to which it was issued, and thus has no value other than the increased productivity it allows through crop-land irrigation. Thus, the value of a permit in Georgia will be either through $\partial q/\partial z_i$ (i.e., increased output associated with the ability to irrigate sufficiently) or due to reductions in demand for other inputs, such as fertilizer, when sufficient irrigation is possible (i.e., through $\partial x^j/\partial z_i$ in equation (6)). An empirical specification must thus be chosen which is consistent with the value of a permit being expressed only through the acreage to which irrigation would be applied — i.e., to cropland. For example, woodlands would not benefit from having an irrigation right (assuming no future conversion of the land to cropland is possible), and thus irrigation rights would have no value to acreage in this landuse.[13]

## III. STUDY AREA

Agricultural property sales in Dooly County, Georgia will be the subject of our analysis. Dooly County is an ideal geographical location to study the effects of the agricultural water permit moratorium on property values for two important reasons. First, we can exploit its unique geographic location straddling several river basins, including the Flint River basin, the Suwannee, and the Ocmulgee. The moratorium applied only to the issuance of water permits in the Flint River Basin. Thus, by examining land sales not subject to the moratorium, but in agricultural areas with similar productivity, we can isolate the effects of the policy change on property values. Prior to the moratorium on the issuance of water permits, we would expect sales prices to be unaffected by the possession of a water permit, for land both within and outside of the Flint River Basin. The cost of applying for a permit was small, and all permit applications were approved. After the moratorium was implemented, however, we would expect the value of irrigation rights to be capitalized into the value of the land. We would expect this to be the case for parcels in the Flint River Basin but not necessarily for parcels outside of the basin. Our analysis will investigate these hypotheses.

Second, the county tax assessors office in Dooly County, from which sales information is collected, has developed electronic databases describing properties and sales information. This makes study of Dooly County possible. Many other rural counties in Georgia still keep property and sales records on paper only, making the collection of transactions data for all sales in the county so labor intensive as to be prohibitive.

Dooly County is located on the Eastern most edge of the Flint River Basin in Southwestern Georgia. The population of the county is 11,552 (2000 Census) and covers 393 square miles. The county is the largest single producer of cotton in the state (140,000 bales valued at approximately $41 million in 2003[14]) and is also a leading producer of wheat. Dooly also has a substantial production of peanuts and soybeans.

Before describing the data we use to estimate the value of irrigation rights, we first describe a few key aspects of Dooly County agricultural production that must be considered in our analysis as well. While much of the non-residential land in Dooly County is used for some type of agricultural production, leasing land for recreational hunting is a common and profitable activity. Since 1993, Dooly County has implemented regulations protecting young antlered whitetail bucks from being hunted, and as a result, the number of mature bucks available to the hunting public has increased by 300%.[15] As a result, since 1995, the county has experienced a surge in the purchase and subsequent rental of land for recreational hunting. Land suited for this purpose typically has forest cover and a water source located on the land and is not necessarily in competition with agricultural production. Crop and recreational land are geographically distinct, and we will control for the type of land in each sale in order to isolate the effects of irrigation rights on cropland values.

Another factor to be considered is whether or not peanut poundage quotas were transferred in an agricultural sale. Up until the enactment of the 2002 Farm Bill, peanut farmers holding a peanut poundage quota received a subsidized per pound payment from the government for the allowable pounds of peanuts on the quota. With the 2002 Farm Bill, those subsidized payments were eliminated, and peanut farmers only received the prevailing market price. Prior to 2002, peanut poundage quotas could be transferred, and they were sometimes sold as part of a real estate transaction. We have gathered information from Dooly County on whether or not a peanut poundage quota was transferred with the land at the time of sale. In addition, whether there is saleable timber on a parcel was recorded by the Dooly County assessors. We also include this feature in our analysis of property sales in the county.

Lastly, the state of Georgia has two programs that provide tax savings to agricultural property owners. In 1992, the state implemented the Conservation Use Valuation (CUV) program. If enrolled in this program, agricultural land owners are taxed at the current use value of the land rather than the fair market value. In exchange, the land owner agrees to keep the land in agricultural or forest use for a period of ten years. The second program, Agricultural Preferential Assessment (Ag. Pref.) is for agricultural and forest land. Owners receive an average tax savings of 25%. Enrollment in these programs could have important effects on sales prices, and thus we also include information on whether or not the land is enrolled in these programs at the time of sale.

## IV. DATA

Three databases are combined for the hedonic analysis: (1) data on land sales, characteristics and improvements, (2) data on additional assets included in the sale including timber or peanut poundage quotas, and (3) data on water permit locations. Each of these data are described in turn below.

*Sales Prices, Land Characteristics and Improvements*

Data on sales prices and characteristics of the land were collected from the Dooly County tax assessors office. The data include information on all digitally recorded property sales in Dooly County (some 16,000 individual sales from 1930 to the present). Each observation is a legally-defined parcel of land. Because we are only interested in sales of agricultural land, we will limit the data to only those sales of agricultural land, including sales of land in the Conservation Use Value or Agricultural Preferential programs, from 1993 to 2003. If a property was sold multiple times over the 10-year period, the most recent sale was chosen. The database thus contains information describing 341 sales of agricultural land in Dooly County for the period 1993 to 2003.[16] The 341 sales represent a total of over 50,000 acres of agricultural land in Dooly County, which is a substantial portion of the total land area of Dooly County, and are widely dispersed throughout the county. There were fourteen observations missing key data and three sales which were not considered reliable, thus leaving 324 observations available for analysis.[17]

Table 1 summarizes variables that have been developed to describe the agricultural sales. The mean sales price (unadjusted for inflation) in our data was $175,800.[18] There were generally between 25 and 40 sales in each year and sales prices varied substantially, from under $20,000 to well over $1 million. Sixteen properties were enrolled in a conservation use program at the time of sale. Total acreage included in each sale also varied substantially. The mean parcel size was 142 acres, and acreage included in the sale varied from less than 10 acres to just over 1,100 acres.[19] Dooly County tax assessors record the land-use of each parcel (parcels may have acreage in more than one land-use). We developed three major land-use categories to describe each parcel: cropland, recreation/residential, and a general category that combines woodland, ponds and orchards (see Table 1). There are approximately 14,000 acres of land that sold in Dooly County during our study period that are recorded as cropland. The largest category of land is recreation/residential with over 24,000 acres, and the smallest category includes land that is recorded as woodland, orchards or ponds with approximately 8,000 acres. Of the acres in this latter category, over 7,000 are categorized as woodland. As such, for ease of exposition, we refer to this aggregate category as just "woodlands."

Dooly County also records the quality of the soil of each acre of land. We aggregate the tax-assessor's six-category index of soil quality into three categories: above-average, average, and below-average soils.[20] Table 1 also reports the total number of acres recorded in each of our three soil quality categories. As indicated in Table 1, most of the acreage in Dooly County (62%) is categorized as having above-average soil, and only a small proportion (14%) is categorized as having average soil. The remaining 24% of land is categorized as having below-average soil.

In addition to information on the land-use and soil quality, other characteristics of the land which we include in our analysis are whether or not the lot is considered level, whether or not there is access to municipal or well-water, and whether or not the land is generally considered to be of average or above-average "desirability" by the Dooly County tax assessor (see Table 1 for summary statistics of each of these property descriptors).[21]

Dooly County is active in peanut production. Because the peanut poundage quotas were quite valuable and could be transferred in a land sale prior to 2002, it is important to include in the analysis whether or not a property sale included the transfer of quotas in the sales price. Dooly County tax assessor maintains a list of agricultural properties sold every year and if the sale included other assets not captured in the existing data on land improvements. The list includes information on whether or not a peanut poundage quota was transferred with the sale (and thus included in the sale price). Because the exact number of pounds of peanut quota sold with the land is not recorded for each sale (i.e., some sales simply record that a peanut quota was transferred, but do not indicate the poundage of the quota), we can only include in our analysis a categorical variable equal to one if the sale included a peanut poundage quota, and equal to zero otherwise (see Table 1).

Also included in the Dooly County records are whether or not marketable timber was present on the land at the time of sale. Again, the records only indicate the number of acres of timber for a few properties, and most properties are simply recorded as having some (unknown) amount of timber. Thus, included in our analysis a categorical variable equal to one if the land had marketable timber on it at the time of sale, and equal to zero otherwise (see Table 1).

Information about improvements associated with the land (housing) is also recorded by the assessor. As reported in Table 1, 114 or 35 percent of the properties had some improvement on them at the time of sale. Dooly County records a number of characteristics of these improvements including whether it is a mobile-home, house, or multi-family dwelling, the square footage of each improvement that is heated, whether or not the improvement has central heat or air-conditioning, and the observed condition of the improvement (as determined by looking at the improvement from the outside only). We include total heated area of improvements in our models, and interact total heated area with a variable which captures the quality of the improvements on site (see "Above Average Quality" in Table 1). Because twenty percent of sales included more than one improvement (i.e., a single parcel might have both a single-family home and a mobile home), we also include in our models a variable which weights the total heated area by the number of improvements on the property. Table 1 reports that the mean heated area of improvements included in a sale is 1,838 square feet. Note, the average square feet of heated area pertains to all improvements included in a sale. Thus, the average square feet of heated area for any single improvement will be less than 1,838 square feet.

Lastly, we compute the value of accessories included in each sale. Irrigation equipment such as a center-pivot or subsurface drip irrigation system is expensive, and likely to remain with the land in the event of a property transfer. While we do not have information on the type of irrigation systems included in a sale explicitly, we can compute a proxy measure for the value of all accessories included in a sale. The Dooly County assessors data include a field for the current assessed value of the property. This value includes the estimated value of land, improvements and all accessories associated with the sale. The assessor data also includes separate fields for the assessed value of land only, and the assessed value of improvements only. To compute the value of accessories, we simply subtract the assessed value of land and improvements from the total assessed value of the property (see "Accessory Value" in Table 1). In addition to irrigation equipment, this value would include additional features such as tractors or other heavy equipment included in the sale. In many cases, however, the value of irrigation equipment would be the primary component of accessories sold in a transaction.

*Irrigation Permits*

The Environmental Protection Division (EPD) of the Georgia Department of Natural Resources provided data on whether or not each property had been issued an irrigation permit (surface or groundwater) at the time of sale. The data are contained in a Geographic Information System (GIS) map of the location of surface and groundwater permits in Dooly County. Included in the GIS map is the exact location of the permitted pump, the basin in which the pump is located, the year the permit was issued, and the unique permit identification number. To match permits with parcels, it was necessary to accurately geo-locate each parcel in the sales database on a GIS map consistent with the permit map. Dooly County tax assessors office maintains paper copies of parcel boundaries for properties that transfer ownership. These boundaries are hand-drawn onto a satellite image of the county. The satellite image used by Dooly County is identical to that available for permits. Thus, we could digitize the boundaries of each parcel on an electronic map and overlay the EPD permit data.[22] A spatial join was then performed using ArcView GIS to determine which parcels had an irrigation permit located within its border.

Overall, in Dooly County there are 151 surface-water permits. Of those, 101 are in the Flint River Basin, 22 are in the Ocmulgee Basin and 28 are in the Suwannee Basin. There were 351 ground-water permits issued in Dooly County, of which 245 are in the Flint River Basin, and 102 are in the Ocmulgee and 4 are in the Suwannee Basins. In addition to determining which properties have a permit, it was necessary to determine if the permit was issued prior to the sale of the parcel. The EPD permit data contains information on the date of issuance of a permit, so we could incorporate this aspect into our analysis. In our sales data, there are 46 sales which included parcels with a permit located within their boundaries at the time of sale. Of these, 31 sales included permits that lie in the Flint river basin, and 15 sales included permits that lie in either the Suwannee or Ocmulgee basin. As indicated in Table 1, of the 46 properties that sold with a permit, 33 sales occurred prior to the moratorium, and 13 sales occurred post-moratorium.

Table 2 reports summary statistics regarding parcels that had a permit issued to them at the time of sale. Of note in Table 2 is the difference in the average number of acres included in a sale. As Table 2 indicates, for all three land-use types, the mean number of acres included in a sale was larger if a permit was attached to the land at the time of sale. This is true for each of the major land-use categories as well (cropland, recreation/residential, and woodlands). While the mean number of acres is larger for permitted properties, the range is similar across categories (i.e., there are very large parcels that do not have a permit).

Lastly, the digitized parcel-boundary map was used to determine in which basin all parcels lie, not just those with a permit. In the sales data, 230 sales (71%) had parcels lying within the Flint River Basin, and 94 sales (29%) had parcels lying within either the Ocmulgee (91 sales) or the Suwannee (3 sales) basin.

## V. EMPIRICAL MODEL AND RESULTS

We estimate two types of hedonic price functions. The first is naive and assumes that the value of irrigation rights are priced into all acres of a parcel equally. This assumption implies that all acres can be used or converted to productive agricultural land (at a small cost) within each parcel. Under this assumption, the hedonic price function that we estimate is given in equation (7):

$$\ln(P_{it}) = \alpha_0 + \sum_{t=1}^{T} \alpha_t D_t + \sum_{j=1}^{J} \alpha_j L_{jit} + \qquad [7]$$

$$\beta_1 \, Totalacres + \beta_2 \, Totalacres * permit^{pre} + \beta_3 \, Totalacres * permit^{post} + e_{it},$$

where $\ln(P_{it})$ is the natural log of sales price of property i in time t; $\alpha$ and $\beta$ are coefficients to be estimated; $D_t$ are dummy variables indicating the year of the sale; $L_{jit}$ are J characteristics other than acreage of the land which are hypothesized to influence sales price, and $e_{it}$ is the error term. The variables included in $L_{jit}$ are Conservation Use, Level Lot, No Water, Overall Desirability, Peanut1, Timber1, Totalheat, Totalheat interacted with Above Average Quality, Totalheat divided by the Number of Improvements, and Accessory Value (see Table 1 for a description of each variable). Also included in Equation (7) are the total acres included in the sale and the total acres interacted with two dummy variables, $permit^{pre}$ and $permit^{post}$. The variable $permit^{pre}$ is equal to one if a the property had a permit at the time of sale and the sale occurred either pre-moratorium if the property was located in the Flint basin or in any year if the property was located outside of the Flint basin. Thus, in this category, we are capturing all sales which occurred when permits were essentially freely obtainable. The moratorium took effect on December 1, 1999, which is the cut-off date for determining whether a sale was pre-moratorium or post-moratorium. Because there was some prior warning of the moratorium, we examine how prior information may have been incorporated into the land market. The Georgia Environmental Protection Division (EPD) officially announced the moratorium only one month prior to its effective date. However, in the spring of 1999, the Director of the Environmental Protection Division had informally mentioned that permits could not be granted in the basin “indefinitely”. So, while no direct discussion of a moratorium had taken place, the mention had been made.

Uncertainty regarding the future availability of permits may have been capitalized into the land prices prior to the moratorium effective date of December 1, 1999. We test the robustness of our models to the date chosen to represent the beginning of the moratorium.

There has been no discussion among policy makers in Georgia to date about restricting permits in the Ocumulgee or Swannee basins. Thus, it is reasonable to assume that these permits continue to be viewed as freely attainable both pre- and post-moratorium.

The empirical model given in equation (7) indicates that the value of irrigation rights, per acre, post-moratorium can be simply computed as:

$$Permit\ Value\ per\ Acre\ =\ \beta_3^e \times Saleprice, \qquad \textbf{[8]}$$

where $\beta_3^e$ is the estimate of $\beta_3$.[23] An analogous computation would be made to compute the value of irrigation rights pre-moratorium, should they be found to significantly affect sales price.

As stated earlier, equation (7) presents a model in which it was assumed that the value of permits are captured equally in all acreage associated with a property. This may not be true if parcels are not uniform in terms of potential land-use. For instance, if acreage classified as recreation/residential cannot be converted to crop land, or if it is costly to convert, the value of irrigation rights should be capitalized into the land-prices differentially, depending on the land-use of the acreage. To test this hypothesis, we also estimate models which follow the basic structure given in equation (7), but disaggregates land use as follows:

$$\ln(P_{it}) = \alpha_0 + \sum_{t=1}^{10} \alpha_t D_t + \sum_{j=11}^{17} \alpha_j L_{jit} + \beta_1 \, crop + \quad \textbf{[9]}$$

$$\beta_2 \, crop * permit^{pre} + \beta_3 \, crop * permit^{post} + \beta_4 \, recres + \beta_5 \, recres * permit^{pre} +$$

$$\beta_6 \, recres * permit^{post} + \beta_7 \, woods + \beta_8 \, woods * permit^{pre} + \beta_9 \, woods * permit^{post} + e_{it},$$

where crop, recres, and woods indicate the number of acres under each land-use (see Table 1 for a description), and all variables other than land-use are as described for equation (7). This model allows us to test for differences in the capitalization of irrigation rights across land-use types.

*Results*

Equations (7) and (9) are estimated using a linear regression model with robust standard errors.[24] Tests for spatial autocorrelation were conducted, and we could not reject the null hypothesis of no spatial dependence in the error term.[25] This is not surprising as the study area is relatively small and homogenous. The county is roughly rectangular in shape and approximately 20x20 miles in dimension. There are no major urban areas, or particularly important agricultural marketplaces, in or near the county (the county seat has a population of less than 3,000). Thus, we expect the primary factors that influence agricultural land prices would be the suitability of the acreage contained in the parcel for agricultural purposes. While soil quality and topography may be spatially related across parcels, we control for these factors directly in our hedonic regression.

The dependent variable is the natural log of sales price. Changes in prices due to inflation are controlled for by including a series of dummy variables indicating the year in which the sale occurred (given by $\Sigma D_t$ in equations 7 and 9). Before discussing the results of the variables directly related to permits, a brief description of the results for variables describing the parcels given by $L_{jit}$ in equations (7) and (9) is warranted. The results for these variables are stable across all models in Table 3 and, although not reported, also in Table 4. Across all models, the presence of marketable timber or a peanut quota has a large and statistically significant effect on sales price. In addition, sales prices are significantly higher if a parcel is enrolled in a conservation use program. Parcels that are characterized by the tax assessors office as having average or above average desirability have significantly higher sales prices as well (see "Overall Desirability" in Table 3). Whether or not the parcel has some segments that are considered "level lots" or a potable water supply installed are generally not statistically significant.[26]

The variables describing the total heated size of housing improvements on the property and their quality are significant in all models. Accessory value is also an important determinant of sales price. The models generally indicate that a $1 increase in the value of accessories increases sales price by approximately the same amount.

Of primary interest are the results regarding our hypothesis that the value of an irrigation permit will be capitalized into the sales price of the land post-moratorium. Both models in Table 3 are naive models in the sense that they assume the value of irrigation rights are capitalized into all acres equally. Model 1 is a parsimonious model, and Model 2 includes variables which control for the quality of the soils present in the parcel (percent of total acres included in the sale that are characterized as above average or percent that are characterized as average), and interaction terms that test for general basin-wide effects. The basin-wide effects are captured by four interaction terms: *flintbasin*pre*, *flintbasin*post*, *otherbasin*pre*, *otherbasin*post*. The variables *flintbasin* and *otherbasin* are dummy variables indicating the basin in which the parcel is located (see Table 1 for a description) and the variables *pre* and *post* are dummy variables equal to 1 if the property sold pre-moratorium or post-moratorium, respectively. The category left out of the model is *flintbasin*pre*.

As indicated by the coefficient estimate for *totalacres* in both models presented in Table 3, the value of an acre of land without a permit is approximately $630, when the model is evaluated at the mean sales price. The models also indicate that having a permit present on the land, pre- or post-moratorium is not associated with an increase in the value of the land. The coefficients for $totalacres*permit^{pre}$ and $totalacres*permit^{post}$ are not statistically significant at any standard level of confidence in model 1 or 2. In addition, model 2 indicates that there are no basin-wide fixed effects associated with the moratorium (coefficient estimates for *flintbasin*post*, *otherbasin*pre*, and *otherbasin*post* are not statistically significant). Lastly, model 2 also indicates that measures of the soil quality associated with a parcel (*percent above average*, and *percent average*) are not statistically significant.

The above discussion is based on models that assume all acreage benefits equally from irrigation. This may not be the case. Some portions of a parcel may not be suitable for agricultural production (either current or future). While measures of the potential productivity of each acre of land contained in a parcel do not exist, we do have crude measures that might be related. The tax assessor categorizes the land use of each acre in a parcel as either crop, recreation/residential or woodlands. The first two models presented in Table 4 allow that the value of a permit might be capitalized differently into each of these three land-uses. The acreage of each land use type is interacted with a dummy variable indicating the sale occurred pre-moratorium (or outside the Flint River basin) or post-moratorium. Model 1 is a parsimonious model, and model 2 includes the measures of soil quality and basin-wide fixed-effects as described in Table 3.

As indicated in model 1, there is no significant difference between the value of land with a permit or without a permit pre-moratorium (or outside the Flint basin), regardless of its land-use classification. However, post-moratorium, there are significant differences in the value of land with and without a permit. Land characterized as cropland or recreation/residential have significantly higher prices per-acre post-moratorium if a permit is attached to the land at the time of sale. Land classified as either cropland or recreation/residential is estimated to sell for approximately $500 more per acre post-moratorium if a permit is associated with the sale. Model 2, which includes controls for soil quality and basin-wide fixed-effects indicates a somewhat larger value of a permit post-moratorium for crop and recreation/residential land (approximately $550 to $600), although these estimates are not significantly different than those from model 1.

Similar to the results presented in Table 3, there are no statistically significant basin-wide effects associated with the moratorium, however, in contrast to the results in Table 3, the measures of soil quality for each type of land is statistically significant.[27] For all three land-use types (crop, recreation/residential, and woods), the percent of a tract that has above average soils is associated with a higher sales price. These results are particularly strong for cropland. Indeed, when the soil quality associated with cropland is included in the model, the coefficient estimate for the number of acres of cropland is not significantly different from zero. This is not surprising given the correlation coefficient between *crop* and *percent crop above average* is over 0.7 and soil quality would be expected to be a particularly important determinant of the value of crop land.

The results for woodlands are somewhat puzzling. The coefficient estimate for *woods* indicates land classified as woodlands (without a permit) sells for approximately the same amount, per acre, as land classified as recreation/residential. This perhaps reflects the value of this type of land for hunting purposes as discussed earlier. However, the models in Table 4 also indicate that parcels with more acreage classified as woodland and have a permit sell for less post-moratorium as compared to parcels with woodlands, without a permit. The negative, significant coefficient for $woods*permit^{post}$ could indicate that properties with significant woods are less agriculturally productive than parcels without woodlands if the woods reflect natural barriers to large-plot farming (i.e., reflect something about topography that precludes the development of optimally sized fields).

Two additional models are reported in the last two columns of Table 4. Model 3 is identical to model 2, but aggregates crop and recreation/residential acres. F-tests indicate that the coefficient estimates for $crop*permit^{post}$ is not statistically different than the coefficient estimate for $recres*permit^{post}$ in either model 1 or 2 (p-values are greater than 0.8 in each test). This may indicate that the recreation/residential land, which the tax assessors office indicated was "desirable" land with broad potential, might be suitable for converting to agricultural production at minimum cost. Thus, we aggregate these two land uses (call them "productive acres" for ease of exposition) and interact the number of productive acres with the pre- and post-moratorium dummy variables. The estimated value of a permit from this model is somewhat lower than the first two models ($420), but again, is not significantly different than the estimates from model 1 or 2.

Model 4 considers the possibility that agricultural producers in the area may have had some prior warning of the moratorium. Recall, the moratorium was officially announced one month prior to its effective date. However, an informal statement suggesting that permits may not be granted indefinitely in the basin had been made by the Director of the agency earlier in the year, which may have suggested that a moratorium was coming at some point. Thus, uncertainty regarding the future availability of permits may have been capitalized into land prices prior to December 1999. Model 4 is identical to model 2, except it uses a cut-off date for post-moratorium sales of May 1, 1999. Results are qualitatively unchanged, although the coefficient estimates indicating the value of a permit post-moratorium are smaller and have increased standard errors. This result is consistent with our original presumption that there was no effective prior warning of a moratorium. If we erroneously attribute sales prior to the moratorium as being part of post-moratorium sales, then we would expect the coefficient estimates indicating the value of permits post-moratorium to be biased towards zero.[28]

## V. CONCLUSIONS

While water *rights* have been extensively studied in the west, we know very little regarding the value of water *permits* for agricultural purposes in the eastern U.S. Permits for water use in the eastern half of the U.S. may not be traded or leased, and thus market values for water use in agricultural production are not directly observable. We exploit a policy change by the state of Georgia, which placed a moratorium on the issuance of new water-use permits in 1999, to estimate the value of water use permits as capitalized into agricultural land values post-moratorium.

Overall, our results indicate that permits confer substantial value to agricultural land once access to permits is restricted. For productive agricultural acreage, we find that post-moratorium, land with a permit sells for approximately $500/acre more than land without a permit.[29] The median sales price of an acre of land during our study period is $1,500 (2003 dollars), indicating approximately a 30% increase in property values if a permit for irrigation has been granted to the parcel.

We have no evidence from the eastern US to which we can compare these values, and so we compare our estimates to those found from western water markets. Of course, the observed market values for water rights in the west are not strictly comparable to those we estimate. Our estimate is based on revealed preference techniques and indicate the value of a permit that is tied to the land. The market forces at play are very different than those observed in the west where water rights are separable from the land and may be traded for use in agriculture, industry or municipal purposes. Further complicating our comparison is that water prices in the western-half of the U.S. are denominated in dollars per acre-foot of water per year.[30] Our estimate of the value of a permit is denominated in dollars per acre of land to which the permit is attached. Because agricultural water permits in Georgia allow the permit holder to irrigate as much as desired, we must estimate the expected average irrigation needs in Dooly County to convert our estimate of dollars per acre of land to dollars per acre-foot of water.

During the years 1989 to 2004, drought conditions existed 25% of the time, very wet conditions were experienced 20% of the time, and "normal" rainfall was experienced the remaining 55% of the years. A rough estimate of water use during normal and wet years is 7 and 4 inches of water applied per acre during the growing season, respectively. Estimates of water use during dry years are approximately 1 to 1.5 feet of water applied per acre during the growing season. Given these estimates, and assuming farmers consider the past 16 years representative of the future, an expected average annual irrigation need would be approximately eight and a half inches, or 0.7 acre-feet per acre. Thus, assuming a 3% interest rate and a 30 year time horizon, our estimated value per acre of land of $500, translates to an implied annuity value $24.77 for 0.7

acre-feet of water, or $35.38 per acre-foot of water per year.

Brown (2004) collected data on water market transactions in fourteen western states from 1990-2003, and reports a median price of an acre-foot of water for the purposes of irrigation to be $28 (2003 dollars) — somewhat smaller than our estimate for Georgia.[31] However, median prices for the purpose of irrigation varied substantially across western states, from $72/acre-foot in Colorado to $4/acre-foot in Idaho (Brown, 2004). If one excludes transactions in the state of Colorado, the median annualized price for water transfers was $16/acre-foot. Our estimate of the value of a permit to irrigate is in the upper range of these western values (e.g., annualized median prices are $24/acre-foot in Texas and $45/acre-foot in Arizona and California).

As conflict over water allocation between urban and rural economies becomes more common in the eastern U.S., it is important to understand the value of water-use to each of the stakeholders. An *ex-ante* estimate of the value of water use in agricultural production is one important input into debates about water allocation among competing demands. This research provides the first estimate of the value of water in agricultural irrigation in the South Eastern United States.

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ENDNOTES

1. Roughly, 100,000 gallons/day could be sufficient to irrigate 10-20 acres of most crops grown in Georgia (e.g., cotton, corn, wheat, peanuts, soybeans) in a dry season if applied judiciously.

2. Permits were routinely granted and the cost to apply for a permit was negligible prior to the moratorium. The land owner merely had to fill out an application.

3. Water use permits in Georgia, or any Eastern state, confer a usufructuary right (the right to use) to water use. In Georgia there is no time limit or expiration to this usufructuary right for agricultural permits, and the right stays with the land. We will use the term "irrigation rights" interchangeably with "irrigation permits" for ease of exposition, although we note here that the correct terminology would be to qualify "rights" as "usufructuary rights."

4. Brown (2004), in his review of water valuation studies in the West, states that roughly half of water transactions are for municipal purposes. Only 23% of transactions are for irrigation. For another review of valuation studies, see Frederick, VandenBerg, and Hanson (1996).

5. *Virginia* v. *Maryland*, 540 U.S. 56 (2003).

6. For a chronology of events, see Virginia Beach Public Utilities, "Department of Public Utilities — Lake Gaston Pipeline Project Information," http://www.vbgov.com/common/printable/0,1359,11728,00.html.

7. See Franck and Pompe, 2005

8. Georgia Water Planning and Policy Center, "Water Scarcity Battles Heat up in Fast-Growing Coastal Georgia," *Water Talk*, June 2004. http://www.h2opolicycenter.org/pdf_documents/June%202004.pdf

9. See Moore (1999).

10. Either the owner rents land to a farmer, or can be considered renting the land to him/herself for the purposes of agricultural production.

11. We are not using the term "variable profits" in the usual way, unless all property characteristics are considered fixed and all other inputs are variable.

12. This specification does not explicitly model the presence of housing on an agricultural parcel. Housing can be an important component of total parcel value, and approximately 35% of the parcels used in our analysis have some form of improvement located on the property. To reflect this, the model may be extended by allowing the cost function to be separable in non-land inputs — specifically to allow the value of housing stock to be separable from other non-land inputs. This formulation would recognize that the farmer may either rent the housing or be thought of as renting the housing from him/herself. In this formulation, the variable profit function would become $\Pi^V = mq - \sum_j c_j x_j - a(H)$, where $a(H)$ is the time-consistent rental value of the housing on-site.

13. Note, woodlands are distinct from orchards.

14. Value estimate derived from *Georgia Agricultural Facts* (2004).

15. Dooly County Chamber of Commerce, http://www.doolychamber.com/outdoor.html, provided this information.

16. Note, there were 399 parcels involved in 341 sales. Some parcels were sold as a group, and one sale price was recorded. In these instances, we aggregated the information for each parcel to represent the characteristics associated with the sale. For instance, the number of acres of cropland for each parcel was added together to represent the total number of acres of cropland purchased in a particular sale.

17. By reliable, we mean that the recorded sales price does not reflect an arms-length

transaction generated by local supply and demand conditions. For instance, one removed sale was for the largest tract that sold in Dooly during our study period (2,538 acres, more than twice the size of the next largest parcel), all in the recreation/residential category. The property sold for more than 50% more than the next highest sale (its sale price was over $3 million), however, the sale was from a private landowner to the State of Georgia. This property had a permit associated with it, and the sale occurred pre-moratorium. Coefficients estimates for pre-moratorium variables are affected by the inclusion of this sale. A second sale included 692 acres of cropland (95th percentile in size), and sold for a price of approximately $400/acre, which is the bottom 5th percentile for sales prices in our study. The grantee and grantor in this sale had the same first and last name, thus indicating that this was likely not an arms-length transaction. This sale occurred post-moratorium, and coefficient estimates for post-moratorium variables are affected by the inclusion of this sale. A last sale also occurred at a low acre-price given the land characteristics. Results are qualitatively unchanged whether or not this sale is included in the models. Note, the tax assessor data did include a field indicating if the sale was arms-length. This field was not used to determine whether a sale price was reliable. The coding of this field was erratic and missing for a number of parcels. Nonetheless, we have tested the robustness of our results to inclusion of 16 sales that the tax assessor data originally coded as not arms-length. Coefficient estimates (and significance) remain remarkably stable, especially for those related to the value of an irrigation permit.

18. If one adjusts for inflation in agricultural land prices over the study period, the mean price is $249,300 (2003 dollars, using a price index created from average agricultural land prices in Georgia as reported by *Georgia Agricultural Facts* (various years)).

19. Results remain unchanged if transactions of less than 20 acres are excluded from the

analysis.

20. Dooly County's classification system aggregates a 1-9 quality index developed by the state of Georgia for parcels in conservation-use programs. The state's quality index is based on the 107 soil types found in the state.

21. Other characteristics of the land which we had available for analysis were whether or not the road leading to the property was paved, the drainage quality of the land (above-average, average or below-average drainage), and whether or not there is sewage treatment available. These factors were not included in our analysis because of correlation with factors already included (for example, almost all properties that are coded as having no water on site also have no sewage removal capabilities) or little variation in the data (for example, only 3 properties were coded as having below average drainage).

22. The property boundary match with the EPD map is quite good. The EPD map includes outlines of the irrigated acreage associated with each of the permits. The outlines of the irrigated acreage matched the parcel boundaries consistently for the entire county.

23. More correctly, the value of the permit post-moratorium should be computed using the Halvorsen-Palmquist adjustment to our coefficient estimate (Halvorsen and Palmquist, 1980). However, our coefficient estimates are so small that the adjustments only affect our coefficients at the fifth decimal place, and indicate no practical change in our permit value estimates. Furthermore, Kennedy's (1981) extension of the Halvorsen-Palmquist adjustment indicates the Halvorsen-Palmquist adjustment would be an over-adjustment in our case.

24. We can reject the null hypothesis of homoskedastic errors at the 1% level using a Cook-Weisberg (1983) test. Thus, we correct for an unknown form of heteroskedasticity using a Huber/White/sandwich estimator for the variance/covariance matrix.

25. Tests for spatial correlation are based on Moran's I test statistic. Moran I test statistics are estimated under the assumption of homoskedastic innovations in the error term, as well as under the assumption of heteroskedastic innovations in the error term (see Kelejian and Prucha, 2001). Moran I statistics are not greater than 0.92 (in absolute value) for any of our models, regardless of whether homoskedastic or heteroskedastic errors are assumed. The test statistics are not significant at any conventional level, indicating that we cannot reject the null of no spatial correlation of the error terms.

26. The variable for "level lot" is statistically significant in two of the four models reported in Table 4.

27. Note, there were no acres of woodlands categorized as having average soils, only above average and below average.

28. We do not know the exact date at which the Director made an informal comment about the potential restriction on permits, only that it occurred in the spring of 1999. Thus, we estimated models which assume a variety of cut-off dates for what is considered to be a post-moratorium sale. The earlier the assumed cut-off date, the lower the estimated coefficient for the value of a permit post-moratorium.

29. We recognize that our estimates are generated from a relatively small number of parcels that sold post-moratorium with a permit. However, they do represent all parcels that sold within our study area post-moratorium. While caution should be used to extrapolate our results to other counties and settings, we do note that our estimates are within the range of "conventional wisdom" regarding the value of permits in the agricultural region we study. Real estate agents in the area loosely estimate the value per acre of a permit to be between $500 and $700.

30. One acre-foot of water is enough water to cover one acre of land one foot deep in water,

which is 325,851 gallons.

31. Brown emphasizes the use of median prices, rather than mean prices in his analysis because he finds that the price distributions are heavily skewed, and so median prices better reflect the price of a typical water sale.

Table 1. Property Sales Description[a]

| Variable Name | Variable Description | Summary Statistics |
|---|---|---|
| Sales Price | Sales price of property | \$175,800[a] (238,000) |
| Total Acres | Total acres included in the sale. | 141.7[b] (169.1) |
| Crop | Number of acres included in the sale that are designated as open and/or crop-land by Dooly County tax assessors office. | 13,805 acres total (30% of total acreage); mean=43 acres per sale |
| Recres | Number of acres included in the sale that are designated as recreation/residential by Dooly County tax assessors office. This land is characterized as having some water available on the land, some wooded coverage, and is considered suitable for wildlife habitat and hunting. | 24,115 acres total (52% of total acreage); mean=74 acres per sale |
| Woods | Number of acres included in the sale that are designated as woodland, orchards, or ponds by Dooly County tax assessors office. Woodlands are the dominate land-use in this category, with over 7,000 acres recorded as woodland. | 7,993 acres (17% of total acreage); mean=17 acres per sale |
| Bestsoil | Categorical variable equal to one if the acreage is considered to have above average soil quality (a code of 1 or 2 in the Dooly County soil classification).[c] | 28,294 acres (62% of total) |
| Avgsoil | Categorical variable equal to one if the acreage is considered to have above average soil quality (a code of 3 in the Dooly County soil classification).[c] | 6,365 acres (14% of total) |
| Worstsoil | Categorical variable equal to one if the acreage is considered to have above average soil quality (a code of 4, 5, or 6 in the Dooly County soil classification).[c] | 11,254 acres (24% of total) |
| Conservation Use | =1 if the property was in a conservation use program at the time of sale, =0 otherwise. | 16 properties[d] (5%) |

| Variable Name | Variable Description | Summary Statistics |
|---|---|---|
| Level Lot | =1 if lot is considered level by the tax assessors office, =0 otherwise | 53 properties[d] (16%) |
| No Water | =1 if the parcel does not have municipal or well water, =0 otherwise | 25 properties[d] (8%) |
| Overall Desirability | =1 if property is designated as being of average, or above-average desirability, =0 otherwise. This variable is coded from the tax assessor's categorization of desirability, on a 5 point scale (with 3 being average). | 315 properties[d] (97%) |
| Peanut | =1 if the sale included a transfer of a peanut quota, =0 otherwise. | 33 properties[d] (10%) |
| Timber | =1 if the land included marketable timber, =0 otherwise. | 40 properties[d] (12%) |
| Improvement | =1 if property has an improvement on site (e.g., home or mobile home), =0 otherwise. | 114 properties[d] (35%) |
| Totalheat | Total heated area of all housing improvements included in the sale. | 1,838[e] (1,747) |
| Above Average Quality | = 1 if the weighted average construction quality of all improvements on-site is one standard deviation above the mean construction quality in the sample, =0 otherwise. | 33 properties (of 114 with improvements) |
| Accessory Value | = value of all accessories included in the sale. Computed by subtracting the assessed value of land and improvements from the total assessed value. | 11,569 (49,041)[b] |
| flintbasin | =1 if a property is located in the Flint basin, =0 otherwise. | 230 properties (71%) |
| otherbasin | =1 if a property is located in the Ocmulgee (98 properties) or Suwannee (3 properties) basin, =0 otherwise. | 94 properties (29%) |
| $Permit^{Pre}$ | =1 if property had an irrigation permit at time of sale and the sale occurred either pre-moratorium (for properties located in the Flint River basin) or during any year if the property is located outside the Flint River basin (i.e., in either the Swannee or Ocumulgee basins). | 33 properties (10%) |
| $Permit^{Post}$ | =1 if property had an irrigation permit at time of sale and the sale occurred in the Flint basin post-moratorium | 13 properties (4%) |

[a] Source: Dooly County tax assessors office.

[b] Mean (standard deviation).

[c] Dooly County tax assessors aggregate a 1-9 quality index assigned by the state of Georgia (originally developed for parcels in conservation-use programs, but every property in Dooly County is given soil quality codes). The state's quality index is based on the 107 soil types found in the state. The codes that Dooly County developed are =1 if best soil, =2 if second-best soil, =3 if average soil, =4 if fourth-best soil, =5 if fifth-best soil, and =6 if wetland/swamp.

[d] The number of properties with specific characteristic present (in parentheses is the percentage of properties with the specific characteristic present).

[e] Mean (standard deviation) is reported for just the properties which have a value of this variable that is greater than zero.

Table 2. Summary of major land-use types and permit holdings in Dooly County sales data.

| | Land-Use Category | | | |
| --- | --- | --- | --- | --- |
| | Cropland | Recreation/ Residential | Woods, etc. | Total |
| *Mean acres [range] for all parcels.* | | | | |
| Land having a Flint permit at time of sale. | 122 [0 - 543] | 77 [0 - 482] | 37 [0 - 120] | 236 [3 - 657] |
| Land having a Suwannee or Ocmulgee permit at time of sale. | 176 [0 - 814] | 25 [0 - 176] | 52 [0 - 183] | 253 [24 - 91400] |
| Land having no permit at time of sale. | 26 [0 - 765] | 77 [0 - 1,118] | 22 [0 - 780] | 1267 [2 - 1,118] |
| *Mean acres [range], not including parcels with 0-acres in a specific land-use.* | | | | |
| Land having a Flint permit at time of sale. | 223 [51 - 543] | 150 [42 - 482] | 44 [1 - 120] | — |
| Land having a Suwannee or Ocmulgee permit at time of sale. | 241 [12 - 814] | 93 [33 - 176] | 64 [3 - 183] | — |
| Land having no permit at time of sale. | 128 [1 - 765] | 115 [9 - 1,118] | 48 [1 - 779] | — |

Table 3. Model results with aggregated land use.[a]

| | Model 1 | Model 2 |
|---|---|---|
| Conservation Use | 0.3990[c] (0.1943) | 0.4055[c] (0.1898) |
| Level Lot | -0.2759 (0.1796) | -0.2779 (0.1800) |
| No Water | 0.1985 (0.1991) | 0.2072 (0.1989) |
| Overall Desirability | 1.319[b] (0.2347) | 1.214[b] (0.2435) |
| Peanut 1 | 0.4210[b] (0.1186) | 0.4657[b] (0.1252) |
| Timber1 | 0.3416[c] (0.1383) | 0.3171[c] (0.1436) |
| Total Heat | 0.00005[c] (0.00002) | 0.00005[c] (0.00002) |
| Total Heat * Above Average Quality | 0.00026[b] (0.00008) | 0.00026[b] (0.00009) |
| Total Heat/Number of Improvements on Site | -0.0002[c] (0.00009) | -0.0002[c] (0.0000) |
| Accessory Value[d] | 0.00006[b] (0.000007) | 0.000006[b] (0.00001) |
| totalacres | 0.0036[b] (0.0005) | 0.0035[b] (0.0005) |
| totalacres* $permit^{pre}$ | 0.0003 (0.0006) | 0.0005 (0.0006) |
| totalacres* $permit^{post}$ | -0.00002 (0.0006) | -0.00002 (0.0006) |
| percent above average | | -0.2346 (0.1844) |
| percent average | | 0.0189 (0.3193) |
| flintbasin*post | | 0.1023 (0.1877) |
| otherbasin*pre | | 0.0566 (0.1225) |
| otherbasin*post | | 0.0930 (0.2705) |
| Number Obs. | 324 | 324 |
| F (p-value) | 15.3 (0.000) | 13.3 (0.000) |

[a] Dependent variables is ln(salesprice) for all models. Robust standard errors are reported in

parentheses. A series of year-specific dummy variables are also included in the models, but not reported here for succinctness.

[b] Indicates significance at the 1% level.

[c] Indicates significance at the 5% level.

[d] Accessory Value is in thousands of dollars.

Table 4. Model results with dis-aggregated land use.[a]

| | Model 1 | Model 2 | Model 3 | Model 4[b] |
|---|---|---|---|---|
| crop | 0.0026[d]<br>(0.0011) | -0.00008<br>(0.0009) | | -0.0001<br>(0.0009) |
| recres | 0.0041[c]<br>(0.0005) | 0.0044[c]<br>(0.0006) | | 0.0044[a]<br>(0.0006) |
| woods | 0.0041[c]<br>(0.0009) | 0.0049[c]<br>(0.0012) | 0.0041[c]<br>(0.0008) | 0.0049[c]<br>(0.0010) |
| crop/recres | | | -0.0034[c]<br>(0.0005) | |
| crop*permit$^{pre}$ | 0.0007<br>(0.0015) | 0.0014<br>(0.0011) | | 0.0016<br>(0.0010) |
| crop*permit$^{post}$ | 0.0026[d]<br>(0.0013) | 0.0029[c]<br>(0.0011) | | 0.0022[e]<br>(0.0013) |
| recres*permit$^{pre}$ | 0.0003<br>(0.0007) | -0.00006<br>(0.0007) | | -0.0002<br>(0.0008) |
| recres*permit$^{post}$ | 0.0029[c]<br>(0.0010) | 0.0034[c]<br>(0.0011) | | 0.0026[c]<br>(0.0008) |
| woods*permit$^{pre}$ | 0.0022<br>(0.0030) | -0.0006<br>(0.0022) | -0.0011<br>(0.0021) | -0.0016<br>(0.0023) |
| woods*permit$^{post}$ | -0.0098[c]<br>(0.0027) | -0.0125[c]<br>(0.0028) | -0.0131[c]<br>(0.0032) | -0.0074[e]<br>(0.0043) |
| crop/recres*permit$^{pre}$ | | | -0.00001<br>(0.0008) | |
| crop/recres*permit$^{post}$ | | | 0.0024[c]<br>(0.0007) | |
| percent crop above average | | 1.666[c]<br>(0.2899) | | 1.7165[c]<br>(0.2909) |
| percent crop average | | 2.412[c]<br>(0.6636) | | 2.0317[c]<br>(0.6588) |
| percent recres above average | | 0.3646[e]<br>(0.1973) | | 0.3531[e]<br>(0.1964) |
| percent recres average | | 0.4163<br>(0.3315) | | 0.3970<br>(0.3349) |
| percent woods above average | | 1.152[c]<br>(0.3195) | 1.1858[c]<br>(0.3992) | 1.1543[c]<br>(0.3281) |

| | Model 1 | Model 2 | Model 3 | Model 4[b] |
|---|---|---|---|---|
| percent crop/recres above average | | | 0.4869[d] (0.1959) | |
| percent crop/recres average | | | 0.3845 (0.3204) | |
| flintbasin*post | | 0.0818 (0.1796) | 0.0895 (0.1827) | -0.1227 (0.2581) |
| otherbasin*pre | | -0.0025 (0.1244) | 0.0024 (0.1294) | 0.0495 (0.1331) |
| otherbasin*post | | 0.1649 (0.2680) | 0.1216 (0.2622) | -0.2611 (0.2710) |
| Number Obs. | 324 | 324 | 324 | 324 |
| F (p-value) | 19.6 (0.000) | 17.5 (0.000) | 15.4 (0.000) | 17.0 (0.000) |
| Permit Value post-moratorium for Crop Land[f] | 453 [10 - 897] | 513 [117 - 910] | | 387 [-54 - 828] |
| Permit Value post-moratorium for Rec./Res. Land[f] | 522 [175 - 869] | 603 [229 - 978] | | 463 [180 - 745] |
| Permit Value post-moratorium for Crop/Rec./Res. Land[f] | | | 413 [14 - 686] | |

[a] Dependent variables is ln(salesprice) for all models. Robust standard errors are reported in parentheses. Each model reported also contains the first ten variables reported in Table 3, as well as a series of year-specific dummy variables. Results for these variables are not reported here for succinctness, but are available from the authors upon request.

[b] Model 4 is identical to Model 2, but uses a beginning date of May 1, 1999 to signify the beginning of the moratorium.

[c] Indicates significance at the 1% level.

[d] Indicates significance at the 5% level.

[e] Indicates significance at the 10% level.

[f] Values are $/acre, evaluated at the mean sale price for all sales. The 95% confidence interval is in brackets.