The Economic Value of Protecting Inventoried Roadless Areas: A Spatial Hedonic Price Study in New Mexico

Germán M. Izón, Michael S. Hand, Matías Fontenla, and Robert P. Berrens

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Izón: Doctoral Candidate, Department of Economics, University of New Mexico, Albuquerque, NM 87131. Phone 505-277-1951, Fax 505-277-9445, E-mail: german@unm.edu.

Hand: Economist, USDA Economic Research Service, 1800 M St. NW, S-4014, Washington, DC 2003. Phone 202-694-5485, Fax 202-694-5776, E-mail: mhand@ers.usda.gov.

Fontenla: Assistant Professor, Department of Economics, University of New Mexico, Albuquerque, NM 87131, Phone 505-277-5304, Fax: 505-277-9445, E-mail: fontenla@unm.edu .

Berrens: Professor, Department of Economics, University of New Mexico, Albuquerque, NM 87131. Phone 505-277-9004, Fax 505-277 9445, E-mail: rberrens@unm.edu.

Abstract:

The objective of this paper is to examine the off-site benefits, as capitalized into housing values, of protecting 1.6 million acres of Inventoried Roadless Areas (IRAs) in the state of New Mexico, U.S.A. In light of petitions filed by various U.S. states to maintain the status of IRAs as roadless lands, spatial hedonic price models are estimated and used to calculate the implicit value of IRAs in New Mexico. Findings show that a two-stage least squares (2-SLS), robust spatial-lag model is the most appropriate econometric representation of the hedonic price function, and that IRA lands are a significant and positive determinant of house value. After controlling for the presence of Wilderness Areas (WAs) and other characteristics, results indicate that, on average, there is a 5.6% gain in the property value of a house from being located in, or adjacent to, a Census tract with IRAs. In the aggregate, this gain represents 3.5 percent of the value of all owner-occupied units in New Mexico ($1.9 billion in capitalized value, or an annualized value in perpetuity of $95 million, assuming a 5 percent interest rate).

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I. Introduction

Undeveloped, open-space lands, such as Inventoried Roadless Areas (IRAs) and Congressionally-designated Wilderness Areas (WAs) provide a number of non-market benefits to society, which may not be fully accounted for in land management decisions. While the status of WAs is relatively certain,[1] the status of IRA lands is tied to Federal agency rulemaking and a protracted political and legal debate, which makes their condition highly uncertain. The 58.5 million acres of IRA lands represent about 7 percent of all forested lands (Berrens et al. 2006), and 30 percent of all National Forest lands in the U.S.; they are often located on the fringe or buffer of many WAs lands (USDA 2001a).[2] The policy debate over the fate of IRAs centers on whether to manage them consistent with Wilderness designation. Given the difficulties of measuring the benefits of protecting IRA lands, and the changes that the federal regulations governing IRAs have experienced in the last 15 years, this debate is far from over.

As of this writing, a State Petition Rule allows each state to petition the protection of these areas to the United States Department of Agriculture (USDA 2005).[3] In New Mexico (NM), Governor Bill Richardson filed a petition in May, 2006, to protect all 1.6 million acres of IRAs in NM (and an additional 100,000 acres in the Valle Vidal unit of the Carson

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[1] By comparison, Wilderness Areas (WAs) total 35 million acres, representing 18 percent all National Forest land in the U.S. (USDA 2001a)

[2] IRAs are defined as Public Forest or Grasslands exceeding 5,000 acres that meet the minimum criteria for wilderness consideration under the Wilderness Act of 1964 (USDA 2001a).

[3] These petitions are reviewed by a National Roadless Area Conservation Advisory Committee (RACAC) that makes recommendations to the USDA as to whether or not the petitions should be accepted (36 C.F.R. § 294.12).

National Forest). This petition and other similar protection-oriented petitions from other states with IRAs rest on the arguments that these lands provide various ecosystem and amenity services, recreation values, and cultural significance, both on-site and off-site on proximal lands, and further that these values would be lost or significantly degraded if commercial activities were allowed on these lands.

Nationwide, the IRA policy debate involves questions about the relative values of protection versus development. The state of New Mexico has submitted a petition based largely on the non-market environmental benefits that IRAs provide in the state. The purpose of this paper is to investigate whether one type of benefit – off-site benefits accruing to homeowners in proximity to IRAs – is observable as a hedonic premium paid for in housing prices in New Mexico. Since there are other potential benefits (e.g., on-site recreation values, and non-use values) derived from protecting IRAs and WAs (Morton 1999), the estimated off-site benefits to homeowners may only represent a small portion of the total economic value of these lands (e.g., see Loomis 1996). As a state that is becoming relatively more dependent on role of natural landscapes and amenities, including protected forests and grasslands, within the regional economy (e.g., Berrens et al. 2006; Hand et al. 2008a and b; Rasker et al. 2008), the importance of the 1.6 million acres of IRAs may plausibly lie in their role as protected open spaces. If IRAs provide non-market benefits, as argued nationally (Loomis and Richardson 2000), then NM is a place where they should be observable.

Since the benefits provided by IRAs do not have explicit market prices associated with them, testing the validity of this argument requires the application of non-market methods (Champ et al. 2003). This study applies a hedonic pricing framework to NM residential housing values by combining the 2000 Decennial Census data with available Geographic Information Systems (GIS) data. Spatial hedonic models are estimated to determine if the density of IRAs has a positive and statistically significant effect on the median price of a home in NM. Results indicate that there is a 5.6% gain in the price of a house from being located in or adjacent to a Census tract with IRAs. In the aggregate, this gain represents 3.5 percent of the value of owner-occupied units in New Mexico ($1.9 billion in capitalized value or an annualized value in perpetuity of $95 million, assuming a 5 percent interest rate).

II. Current Policy Debate

The final Roadless Area Conservation Rule, which was designed to protect 58.5 million acres of National Forest land from further road construction and development, was published in the Federal Register before the Clinton administration left office in January, 2001 (USDA 2001a). Shortly thereafter, the Bush administration set aside the rule for further study as part of a White House moratorium on all Federal rules not yet in effect (USDA 2001b). In 2005, the Bush administration published a rule to replace the original Roadless Rule of 2001 (USDA 2005). This replacement rule used existing individual forest plans as the baseline for managing IRAs, with a mechanism for states to petition the U.S. Department of Agriculture (USDA) for state-specific IRA management. Several states submitted or prepared petitions for state-specific IRA rule making.[4] During the petitioning period a Federal district judge, in a 2006 lawsuit brought by the states of California, New Mexico, and Oregon, found that the 2005 rule was invalid, thus reinstating the original 2001 Roadless rule (U.S. District Court Northern District of California 2006).

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[4] Virginia, South Carolina, and North Carolina submitted petitions that were accepted by the Secretary of Agriculture (Warner 2005; Sanford 2006; Easley 2006). New Mexico, California, and Colorado prepared petitions, but they have been either not submitted or not considered due to legal uncertainty about the original 2001 rule. Idaho prepared a petition that it planned to submit under the Administrative Procedures Act (Risch 2006).

On August 12, 2008, Judge Brimmer invalidated the 2001 Roadless Area Conservation Rule for the second time, without making any reference to the State Petition rule (U.S. District Court for the District of Wyoming 2008). As a result, the Forest Service has now been directed by Federal courts in different districts to both follow and also not follow the original 2001 Roadless Area Conservation Rule. A new appeal of this decision is pending in the U.S. District Court for the Northern District of California (U.S. District Court Northern District of California 2008). Clearly, the legal debate over the status of IRAs is far from over.

Aside from the legal debates relating to the Roadless Rule of 2001, there is evidence of an economic debate about the role of IRAs in local, state, and regional economies. In a 2001 report to Congress, the Office of Management and Budget (OMB) concluded that prohibiting timber harvest and mining on all IRA lands nationally would cost about $184 million compared to just $219,000 in annual benefits, attributed only to the avoided costs of road building (OMB 2002). Similarly, a study from the U.S. Forest Service reported that costs from the IRA rule would total about $262 million annually and 4,559 lost jobs, but no economic benefits were quantified (USFS 1996). As stated in a recent law review article (and see discussion in Berrens et al. 2006), Heinzerling and Ackerman (2004, p. 7) note:

> "How did a rule protecting 60 million acres of publicly owned lands, containing fragile and precious sources of water, wildlife, and plant species, come to look so bad in economic terms? The answer is simple: just ignore most of the good things one wants to protect forests for – both the good things that could comfortably be stated in dollar terms (such as the economic value of a forest for tourism) and the good things that money cannot buy (such as the knowledge that pristine forests are being protected in perpetuity)."

The often-contentious debates over public land management in the West are clearly visible in the history of the Roadless rule. For example, the states' petitions to the USDA for state-specific IRA management indicate the differing role that IRAs are perceived to play in the economies of each state. Idaho, which petitioned to exempt millions of acres from a prohibition on road building, seeks to strike a "careful balance between all of the needs of those who depend on and enjoy IRAs," (Risch 2006, p. 59). This balance includes classifying a portion of IRAs under a "General Forest" management theme, which allows road building, timber harvesting, and minerals extraction as appropriate activities. Under this management theme, "fish, wildlife, and ecosystem restoration are not necessarily the driving force behind management activities" (Risch 2006, p. 67).

Other states, including New Mexico, make an appeal to the importance of tourism and recreation in their states' economies, the importance of unique natural features that people value, and of the role of IRAs in generating certain ecosystem services. The New Mexico IRA petition, which seeks to manage the state's IRA lands consistent with the 2001 rule, notes that IRAs "protect watershed health, increase and conserve biodiversity, [and] provide opportunities for outdoor recreation and personal renewal," (Richardson 2006, p. 6). According to New Mexico's petition, *inter alia*, the cost of protecting the $1 billion of wildlife-related spending in the economy outweighs the small (if any) negative impact on the forestry sector (Richardson 2006).

New Mexico's and other states' petitions suggest that the states have to some degree engaged in a kind of rough benefit-cost analysis of IRA protection in their state, and have taken regulatory and legal action based in part on that analysis. For example, California's petition claims that preservation "protects both economic and intrinsic values for current and future generations," (Schwartzenegger 2006, p. 1). Virginia's petition came down on the side of IRA preservation with a clear appeal to notions of benefit-cost analysis: "economic reasons for prohibiting development activities in roadless areas far outweigh arguments against such a ban," (Warner 2006, sec. 3.f). Colorado's petition seeks to exempt ski areas from IRA protection, indicative of the relatively important role of ski areas in Colorado's tourism economy (Owens 2006). And Idaho's proposed exemption of 6 million acres (of Idaho's total 9.3 million acres of IRAs) from road-building prohibitions may reflect a greater dependence on the wood products industry in that state (Risch 2006). This poses the question of whether these apparent benefit-cost analyses or trade-off considerations, and thus the conclusions based on them, are accurate representations of the states' public preferences.

While a number of studies applying hedonic price models have shown that proximity to open-space amenities is capitalized in the real estate market (e.g., Hand et al. 2008a; Schmidt and Courant 2006; Kim and Wells 2005; Phillips 2004; Kim and Johnson 2002; Shultz and King 2001; Phillips 1999; Doss and Taff 1996), little is known about the economic benefits of protecting IRA lands, aside from some "back of the envelope" estimates of the non-market values of IRAs (Loomis and Richardson 2000; and Berrens et al. 2006). Both of these studies apply a benefit transfer technique based on Phillips' (1999) findings to estimate the impact of IRAs on housing values at a national level (Loomis and Richardson 2000) and in NM (Berrens et al. 2006) [5]. Loomis and Richardson (2000)

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[5] In Phillips (1999), a hedonic price analysis was applied to over 6,148 land sales to isolate the value of parcels near designated Wilderness areas in Vermont. Results indicate that proximal parcels sold at prices 13 percent higher than otherwise, with a price decrease of 0.8 percent per acre for each kilometer of distance from the wilderness area (Phillips 1999; Loomis and Richardson 2000; and Berrens et al. 2006). To estimate the off-site benefits of IRAs on a national level, Loomis and Richardson (2000) used the Phillips (1999) findings by assuming that the 13 percent estimated for designated Wilderness areas can be applied to other natural areas, such as IRA lands. Berrens et al. (2006) adjust this estimate to a 6 percent gain in local ranch properties for NM based on the relative scarcity of protected areas in the Eastern U.S. compared to the Western region. More recently, Phillips (2004) updated his original study to cover all property sales in the area from 1987-2002, covering more than 12,000 transactions and 82 towns across southern and central Vermont within 14 kilometers

estimated that the gain in real local property values is 13 percent compared to 6 percent for NM (Berrens et al. 2006).

To provide background for the case of New Mexico, Table 1 presents selected measures of economic performance for New Mexico counties with significant IRAs, and counties with little or no IRAs. High-IRA counties appear to be doing well economically, keeping up with and in some cases surpassing non-IRA counties. Growth in real income per capita, non-farm employment, and real earnings per job was faster in IRA counties as compared to non-IRA counties. And while natural resource extraction is relatively more important in IRA counties, growth in employment in service industries was faster in IRA counties.

Roadless areas may also play a role in the larger regional economy if the economic performance of one county influences nearby counties (see Khan et al. 2001; Wheeler 2001). In New Mexico, counties with large tracts of roadless land, which are predominately rural and sparsely populated, appear to be increasingly tied to the economy and labor markets of nearby urban areas (Hand et al. 2008a). Earnings flows measure the amount of wages and salaries that are earned in a county that is different from where a worker resides. As shown in Table 1, net earnings flows in IRA counties are positive, about $511 million in 2005, and have increased by about 27 percent since 2001. This suggests that New Mexicans increasingly live in more rural, IRA-dominated counties and commute to proximal urban areas for access to employment opportunities.

These descriptive data support a *prima facie* case that New Mexico's petition is based on a plausible accounting of the benefits and costs of developing IRAs. However, it remains unclear whether people value IRA-derived benefits to the degree that some Western

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of the NF boundary. A key finding is that towns with adjacency -- designated Wilderness Area acreage within their borders – had a 19 percent higher per acre price than those without.

governors suggest, or whether we can observe any empirical signals of those values.[6] The remainder of this paper focuses on a piece of this larger benefit-cost analysis question and a particular category of benefit, by investigating whether off-site benefits accruing to homeowners in proximity of IRAs are being capitalized in the New Mexico housing market.

III. Hedonic Empirical Framework

In this section, the hedonic framework and a theoretical discussion on spatial-dependence relationships are presented to inform the empirical approach. In hedonic price studies, the hypothesis is that visual or proximal access to some set of environmental amenity and disamenity characteristics gets capitalized into the sales price of the property. The hedonic pricing method decomposes the statistical variation in prices for a heterogeneous good (e.g., residential real estate) to isolate the contribution of individual attributes or characteristics of the good (Taylor 2003).

An important feature of the empirical framework pursued here is that the hedonic analysis is carried out on observations of representative households. Due to housing price disclosure limitations in New Mexico (see Berrens and McKee 2004), the median characteristics of each Census tract are assumed to be representative of the housing stock in

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[6] Rather than reflecting solely an accounting of public preferences, it is possible that the petitions represent some other kind of safety perspective, such as a Safe Minimum Standard (SMS) approach to conservation. Randall and Farmer's (1995, pp 3) "circumstantial" case for conservation suggests that conservation policy be made "on the basis of benefits and costs, but subject always to the constraint that actions we fear we (or future generations of people we care about) will regret are forbidden,". In this policy framework, benefit-cost analysis plays a role, but not necessarily a decisive role.

that location.[7] We also adopt conventional assumptions for hedonic models: that the participants in the real estate market have full information about the relevant natural resource characteristics (Freeman 2003), that the housing market is in equilibrium, and that the state of New Mexico represents a single composite housing market.

Following Freeman's (2003) theoretical hedonic price framework and using a vector notation, a household's utility function depends on goods consumed **C**, housing characteristics **S**, neighborhood characteristics **N** and location-specific environmental amenities **Q**. In particular, the purpose of this paper is to econometrically estimate the housing price function, which is derived from the utility maximization problem (Freeman 2003):

(1) $$P_{hj} = p(S_{hj}, N_j, Q_j),$$

where *h* represents an individual house with location *j*.

In the context of this study, the environmental amenity vector **Q** includes the percentage of IRAs and Wilderness Areas within a Census tract. In this setting, it is assumed that a household in location *j* faces tradeoffs when choosing the level of, for instance, IRA lands as given by the first order condition:

(2) $$\frac{\partial u / \partial Q_{IRAs}}{\partial u / \partial C} = \frac{\partial p_j}{\partial Q_{IRAs,j}}$$

[7] See Chay and Greenstone (2004) and Greenstone and Gallagher (2008) for examples using median housing values at the census tract level and relying on a "natural experiment" framework to estimate the benefits of environmental regulations and policies.

In this study, location *j* corresponds to a Census tract *j* and since each observation corresponds to a Census tract with a representative house, the *h* subscript is dropped. The econometric equivalent of equation (1), assuming a log-linear specification,[8] is:

(3) $$\ln P = \alpha_0 + \beta S_j + \phi N_j + \eta Q_j + \varepsilon,$$

where $\varepsilon \sim N(0,\Omega)$, and β, φ, and η are the coefficients to be estimated.

A. Spatial Econometrics

The model specification in equation (3) is perhaps still the most common in applied hedonic studies. However, equation (3) does not address spatially-dependent relationships that emerge when using geographic data (Anselin 1988). In the context of this paper, spatial dependence arises when the value of a house located in Census tract *j* is determined by both its own housing and environmental characteristics and the values and characteristics of homes located in neighboring Census tracts.

At present, a small but growing number of empirical papers applying the hedonic pricing framework have tested for the presence of spatial-autocorrelation (Kim et al. 2003; Pace and Gilley 1997; Anselin and Lozano-Garcia 2008; Huang et al. 2006; and Brasington and Hite 2005). As one example, Kim et al. (2003) apply spatial hedonic models (e.g. equations 4 and 6, presented below) to estimate the benefits of air quality improvement in Seoul, South Korea and to test for the presence of spatial-autocorrelation. The authors find that the OLS coefficient on nitrogen oxides overestimated the effect of this pollutant on the housing value

[8] Other model specifications were tested but due to high degree of multicollinearity (e.g., a condition number > 30), they are not reported in this paper.

in the presence of spatial dependence. Moreover, Kim et al. (2003) show that the model that accounts for spatial autocorrelation is preferred to the OLS specification.[9]

As a second example, Pace and Gilley (1997) draw upon Harrison and Rubinfeld's (1978) applied-hedonic study for the housing market in Boston to empirically demonstrate the implications of ignoring spatial autocorrelation. Based on a spatial autorregresive model, Pace and Gilley (1997) find that the estimated sum-of-squares errors fall by 44 percent compared to the OLS results estimated in Harrison and Rubinfeld (1978). Moreover, the effect of nitrogen oxides (NO_x) levels on housing prices, the variable of interest in the paper, decreases by 38 percent when using a spatial autorregresive model as opposed to a log-linear model. These two papers empirically show that accounting for spatial autocorrelation improves the estimated coefficients and overall results of the respective study.

In this paper, spatial dependence is addressed by estimating two different models: a spatial lag model, and a mixed spatial lag model. The first model is estimated using both a Maximum Likelihood (ML) and a 2-SLS robust approach. The mixed spatial lag model is estimated using the ML technique. In the first spatial model, a vector of house prices observed at other locations is included on the right hand side of the hedonic model, according to (Anselin 1988)[10]

(4) $$\ln P = \alpha_0 + \rho_{price} W \ln P + S\beta + N\phi + Q\eta + \varepsilon,$$

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[9] Kim et al. (2003) estimate that the marginal willingness to pay (MWTP) for a 4 percent reduction in SO_2 concentration is \$2,333 or 1.4 percent of the mean housing price, using a 2-SLS Robust approach to estimate the spatial hedonic model.

[10] While use of a more flexible functional form such as a Box-Cox transformation may be more appropriate, estimation in the presence of spatial dependence raises a number of methodological issues, which we leave to future research and investigation.

where and **W** is an *nxn* matrix that describes the contiguity relationship between spatial units and has non-zero elements w_{ji} in each row *j* for those columns *i* that are neighbors of location *j*. For a particular location, this model is represented by the following expression: $\ln p_1 = \rho (w_{11} p_1+w_{12} p_2+w_{13} p_3...+w_{1n} p_n)+X_1\beta+\varepsilon_1$, where $w_{11} = 0$ and $\rho_{price} \in[-1,1]$ is the spatial autoreggresive coefficient to be estimated and represents the effect of housing prices in neighboring Census tracts on the median price in location *j*. In other words, equation (4) is the analogue of equation (3) but ρ_{price} is not assumed to be equal to zero. In equation (4), the direct effects that structural, neighborhood and environmental characteristics in neighboring Census tract *i* may have on the price of a house in Census tract *j* are assumed to be zero. A more general model that introduces these types of spatial correlations is (Anselin 1988):

$$(5) \qquad \ln P = \alpha_0 + \rho_{price} W \ln P + S\beta + N\phi + Q\eta + \rho_S WS + \rho_N WN + \rho_Q WQ + \varepsilon,$$

where ρ_i (for i = S, N, and Q) is the autoregressive coefficient that corresponds to each explanatory variable and represents the effect of, for instance, housing characteristics (**S**) in neighboring Census tracts on the median price in location *j*. The presence of significant spatial lagged coefficients (e.g., ρ_{price}) means that the estimated OLS coefficients in equation (3) would be biased and inefficient due to correlation or endogeneity problems between the lagged dependent variable (WP) and the error term (Anselin 1988), which underlines the importance of testing spatial lag dependence.

To correct for this problem, a common solution is to implement an ML or a 2-SLS approach. An important assumption made when using the ML method to estimate equations (4) and (5) is that the error term is normally distributed. A plausible alternative that addresses this potential issue is a 2-SLS method. Since a 2-SLS approach uses an OLS estimation technique, the probability distribution function of the error term is not required, which suggests that the distribution of the error term is not an issue. Moreover, the existence of endogeneity is solved by finding the instruments for the vector of prices on the right hand side of equations (4) and (5). In the empirical literature, it is common practice to use the spatially lagged explanatory variables (e.g., **WX**), as instruments (Anselin 1988). Given the specific empirical application of this paper, equation (4) can be written in the following way:

(6) $$\ln P = \alpha_0 + \rho_{price} W \hat{\ln} P + S\beta + N\phi + Q\eta + v,$$

In this equation, $W \hat{\ln} P$ is obtained by using **WX** as instruments for **W lnP**, where **WX** = [**WS WN WQ**] (Anselin 1988). As a result, including the spatial lags of the explanatory variables on the right hand side of equation (6) would result in a misspecification of the 2-SLS model.[11] Based on these models, two marginal effects of interest are estimated: the

[11] In the 2-SLS approach, the instruments used to correct the endogeneity problem are the spatially lagged explanatory variables. In this case, the econometric estimation is divided into two stages. In the first stage, **WP** is regressed using the instruments mentioned above to obtain $\hat{WP}$. In this second stage, equation (4) is estimated after substituting $\hat{WP}$ for **WP** to solve the endogeneity problem arising from housing price effects. Mathematically this can be represented as follow:

1st Stage: $\mathbf{WP} = \rho_s \mathbf{WS} + \rho_N \mathbf{WN} + \rho_Q \mathbf{WQ} + \varepsilon$.

2nd Stage: $\mathbf{P} = \alpha_0 + \rho_{price} \hat{WP} + \beta S + \phi N + \eta Q + v$.

From the 1st stage estimation, WP = $\hat{WP} + \varepsilon$. After substituting this right hand side expression for WP in equation (4) and simplifying notation, the equation estimated in the 2nd stage is equivalent to equation (6). As a result, including spatially lagged independent variables on the right hand side of the 2nd stage equation would result in a model misspecification since the instruments would be used twice, first in the estimation of **WP** (1st stage) and then in the 2nd stage (Anselin 1988).

marginal effect of a 1 percent change in IRAs and a 1 percent change in WAs on housing prices. These effects can be mathematically expressed as:

(7) Log-linear: $\frac{\partial P}{\partial Q_{IRAs,j}} = Q_{IRAs,j} P$,

(8) Spatial lag: $\frac{\partial P}{\partial Q_{IRAs,j}} = Q_{IRAs,j} [\frac{1}{1-\rho_{PRICE}}]^{-1} P,$

(9) Mixed Spatial lag: $\frac{\partial P}{\partial Q_{IRAs,j}} = Q_{IRAs,j} [\frac{1}{1-\rho_{price}}]^{-1} P + [\frac{1}{1-\rho_{price}}]^{-1} \rho_{Q\,IRAS,j}.$

Equation (7) estimates the direct-contemporaneous effect ($Q_{IRAs,j}$) of a 1 percent change in IRAs located in Census tract j on house prices located in census tract j. In equation (8) two types of effects are estimated: the direct-contemporaneous effect and indirect effects. The latter represents the effect on home prices in Census tract j of a 1 percent change IRAs in neighboring Census tracts through an intermediate channel such as neighboring Census tract home prices (represented by ρ_{price}). In equation (9) three effects are estimated: the direct-contemporaneous, the indirect, and direct spatial-spillover effects ($\rho_{QIRAS,j}$). A direct spatial-spillover represents the effect on home prices in Census tract j of a 1 percent change in IRAs in neighboring Census tracts on own-tract home prices; the effect is direct in the sense that the nearby IRAs are directly affecting home prices, but it is a spatial spillover (i.e., it is not spatially contemporaneous). A positive and statistically significant $Q_{IRAs,j}$ would mean that houses in Census tracts with a higher density of undeveloped IRAs would have a higher market value as compared to houses with lower or no IRAs, ceteris paribus. The ρ_{price} coefficient is estimated in equations (4)-(6), and signifies spatial autocorrelation.

The results obtained in the log-linear model (equation 3) that ignores any type of spatial autocorrelation are compared to those of the three spatial-lag model specifications presented above. The spatial weight matrix, **W**, is constructed using a five-closest neighbors criterion.

The five Census tracts nearest to location *j* are defined as neighbors, for which the average distance is 2.64 miles.[12]

IV. Data and Hypotheses

In order to estimate equations (3), (4), (5), and (6) we use the 2000 U.S. Census of Population and Housing Information for the state of New Mexico at the Census tract level for the structural and neighborhood variables. A Census tract is a relatively permanent statistical subdivision of a county delineated by a local committee of Census data users. Census tracts average about 4,000 inhabitants and are designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions at the time of establishment (U.S. Department of Commerce 2000).

The data provides median values for various variables for each Census tract, based on responses that individuals gave to the 2000 Decennial Census. For each Census tract the median value for income, number of rooms, house age, number of houses, and house value is reported. In the 2000 Decennial Census a house value is obtained by asking the house owner to state his perceived price at which the house would be sold if it were in the market

[12] The weight matrix was constructed using the X-Y coordinates of each Census tract. The distance between the different Census tracts was calculated using GeoDa software. Other specifications of the weight matrix were computed (i.e. 3, 4, and 6-nearest neighbors) but the estimated coefficients were not significantly different from the spatial lag model based on the 5-nearest neighbors criterion. Other alternatives for constructing a weight matrix includes rook criterion (locations sharing a boundary), queen criterion (locations sharing a vertex), and threshold distance. A k-nearest neighbor's criterion has the advantage of ensuring that each Census tract has an equal number of neighbors.

(Freeman 2003).[13] In all, there are 456 Census tracts in New Mexico, which is our number of observations since each location *j* corresponds to a representative house and a Census tract.

The reason for using U.S. Census data relates to New Mexico's housing sales disclosure laws. New Mexico is one of the few states that do not publicly disclose actual housing market price transactions. Despite a 2004 a law requiring real estate transactions to be filed with the county assessor's office, this information has yet to be publicly accessible (Berrens and McKee 2004, p. 510). Given this restriction, the U.S. Census is the best publicly available source to estimate the effects of open-space amenities on NM housing values. A possible shortcoming of using data aggregated at the Census tract level is that the variables represent a broad description of the stock of housing in the Census tract, rather than individual homes and market transactions.

The dependent variable is LNHVALUE, which is the natural logarithm of the median price of owner-occupied homes in each Census tract .The open-space variables, IRAs and WAs, were constructed using GIS and represent the percentage of such lands in a Census tract. For each Census tract, the number of acres of IRAs and WAs are separately divided by the total size of the Census tract to obtain the percentage of inventoried roadless areas (IRAs) and wilderness areas (WAs) within a Census tract. The size of IRA lands in a Census tract ranges from 2 to 423,100 acres and that of WAs ranges from 2 to 498,600 acres. In percentage terms, IRA values ranges from 58 percent to 0.0033 percent, and WA values from 68 percent to 0.003 percent for a given Census tract.[14]

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[13] Kiel and Zabel (1999) tested the accuracy of this methodology by comparing the actual market sale price of a house with the price estimated by the owner of that house. The study shows that using Census data to estimate hedonic price functions yield unbiased coefficients.

[14] For both IRAs and WAs, the lands in question were identified several years before the Census data was collected in 2000. In the case of IRAs, the land identified in the GIS data is

The distribution of IRAs and WAs values in the data indicate a high degree of heterogeneity across Census tracts (Figure 1). However, there are also underlying differences in Census tract size and area of IRAs and WAs. For example, the largest percentage value of IRAs is located in a Census tract in Santa Fe county (58 percent), but contains only 4,727 acres of IRA land. In contrast, a Census tract located in Eddy county has an IRAs percentage value of 2, but its total IRA area is 32,232 acres. To address this issue, an independent variable representing census size in acres (DCENSIZE) is included in the models.

In terms of the geographical distribution of IRAs and WAs in New Mexico, fourty-three of the 456 Census tracts have IRAs[15], representing 2 percent of the total land and 17 percent of the national forest land in the state (USDA 2000).[16] The largest portion of both IRAs and WAs lands is located in the southwest of NW and is part of the Gila National Forest (north of Silver city). This National Forest accounts for almost 50 percent of IRAs and WAs in New Mexico. Census tracts that contain IRAs tend to be more rural and larger than other Census tracts; the average size of census tracts with IRAs is 778,143 acres compared to 110,653 acres for those without IRAs.

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based on an evaluation dating from 1979 (RARE II, see below). Almost all WAs in NM were designated prior to 1987. The use of RARE II as the basis of the current IRAs is mentioned in the 2001 Roadles Rule: Federal Register, January 12, 2001, Vol. 66, No. 9, pg. 3246 (http://roadless.fs.fed.us/documents/rule/index.shtml). A listing of all WAs designations through 1999 is published at: http://www.fs.fed.us/rm/pubs/rmrs_gtr018.html.

[15] A GIS map of the IRAs and Wilderness areas in NM can be found at: http://roadless.fs.fed.us/states/nm/state3.shtml, accessed July 8, 2008.

[16] New Mexico counties with IRA lands are Catron, Cibola, Eddy, Grant, Harding, Hidalgo, Lincoln, Los Alamos, McKinley, Mora, Otero, Rio Arriba, Sandoval, San Miguel, Santa Fe, Sierra, Socorro, and Taos (USDA 2000).

An advantage of measuring IRAs and WAs as a percentage of a Census tract's total size is that it can be interpreted as a relative measure of open-space access. For instance, while the size of IRA lands in acres in Census tract *j* is much smaller than that of Census tract *i*, its size as a percentage of the Census tract's total size may be larger which implies that the access to such lands would require, on average, lower traveled distance compared to Census tract *i*. A disadvantage of these measures is that a small tract may have the same percentage value as a large tract, even though the accessible amount of IRAs may be different in absolute terms.

Table 2 lists the summary statistics and descriptions of the dependent and independent variables used to estimate the models presented above. The open-space variables included in the models are IRA lands and Wilderness Areas (WAs). The structural variable **S** is a vector that includes number of rooms coded as a dummy variable (coded 1 for houses that have number of rooms greater than the average number of rooms in the sample; and 0 otherwise), and age of a house (2000-year a house was built); **N** is a vector that represents median income level coded as a dummy variable (coded 1 for houses that are located in Census tracts that have income levels higher than the average income level in the sample; and 0 otherwise), number of houses per acre, and size of a Census tract in acres also coded as a dummy variable (coded 1 for Census tracts whose sizes in acres are higher than the average Census size in the sample; and 0 otherwise); and **Q** is a vector that includes percentage of IRAs and percentage of WAs within a Census tract.

We use the empirical models to test several hypotheses about the impact of open space and spatial relationships on housing prices. These hypotheses can formally be expressed as:

H_1: H_0: $\eta_{IRAs} = 0$ and H_A: $\eta_{IRAs} > 0$.

H_2: H_0: $\eta_{WAs} = 0$ and H_A: $\eta_{WAs} > 0$.

H_3: H_0: $\eta_{WAs} \geq \eta_{IRA}$ and H_A: $\eta_{WAs} \leq \eta_{IRA}$

H_4: H_0: $\rho_{PRICE} = 0$ and H_A: $\rho_{PRICE} \neq 0$.

H_5: H_0: $\rho_{IRA} = 0$ and H_A: $\rho_{IRA} \neq 0$.

H_6: H_0: $\rho_{WAs} = 0$ and H_A: $\rho_{WAs} \neq 0$.

The hypotheses in H_1 and H_2 pertain to the effect that IRAs and WAs in Census tract *j* have on the price of houses located in the same Census tract. In particular, the alternative hypotheses in H_1 and H_2 suggest that IRAs and WAs in Census tract *j* have a positive and statistically significant effect on the median price of a home located within the same Census tract. Failing to reject these alternative hypotheses would mean that benefits from IRAs and WAs are being capitalized in the price of houses in NM. This finding would provide a measure of support for efforts in New Mexico to manage these lands consistent with wilderness designation and counter arguments that the value of such benefits are near zero (e.g. OMB 2002 report and USFS 1996 report). Hypothesis H_3 relates to the geographic location of IRAs relative to WAs. IRA lands are often located on the periphery of WAs (e.g., a prominent example of this is in the Gila National Forest located in the Southwest of NM). This suggests that IRA lands are commonly the more immediate open-space that a house faces. As a consequence, the ex-ante expectation is for the magnitude of the coefficient on the IRA variable to be larger than that of the wilderness variable. This means that the effect that IRAs have on the housing value is expected to be higher than that of WAs.

Hypotheses H_4-H_6 relate to the effect that changes in housing prices, IRAs, and WAs lands in neighboring Census tracts have on the price of houses located in Census tract *j*. For instance, failing to reject the alternative hypothesis in H_4 would mean that the price of a house located in a Census tract *j* is affected by changes in prices of houses located in neighboring Census tracts.

Since in these models IRAs and WAs areas are two different explanatory variables, the impact of IRAs on the housing market can be isolated. Furthermore, since these coefficients allow us to monetarily quantify the additional price that the representative homeowner pays for being close to IRAs and WAs, this study estimates the value that these areas provide to the local communities, separately.

V. Empirical Results

The estimates of equations (3) – (6) tend to support the general hypothesis that open space measures (IRA and WAs) represent amenities that have a positive impact on median housing prices. Table 3 reports the results for the log-linear and the spatial lag models estimated to test the hypotheses H_1 through H_5.

The coefficients for IRA and WAs are positive and significant at the 1 percent level in all models, suggesting that the null hypotheses in H_1 and H_2 can be rejected. While the estimated coefficient for IRAs is larger than that for WAs in all the models, a two-tailed t-test indicates that they are not statistically different.[17] Based on this test, we cannot reject the hypothesis that the impact of IRAs on housing prices is not statistically different from that of WAs (H_3). The ρ_{price} coefficient, which measures the effect of neighboring house prices on the median house price in a given Census tract, is positive and significant (models 2 – 4). This indicates that spatial dependence is an important characteristic of the housing market in New Mexico, thus rejecting the null hypothesis; the evidence supports H_4.

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[17] The estimated IRAs and WAs coefficients from the spatial-lag (2-SLS) robust model were used to determine if these coefficients are statistically different from each other (β_{IRAs} = 1.58 and β_{WAs} = 0.72). Neither a likelihood ratio test nor a Wald test is feasible with a least squares approach. The formula used to calculate the t-value is: $t = \frac{(\beta_{IRAs} - \beta_{WAs})}{(SE_{IRAs} - SE_{WAs})}$. The t-value in this case (1.67) is smaller than the critical t-value (1.96) at the 95 percent confidence level, indicating that these two coefficients are not statistically different.

For the log-linear model, the benchmark case, the estimated coefficients for the IRAs and WAs variables are 2.27 and 1.19, respectively. In the spatial-lag models, these estimated coefficients are also positive but their effect on median house price is much smaller compared to the log-linear results. This is due to the inclusion of lag variables, such as ρ_{price}, ρ_{IRA} and ρ_{WAs}, which represent the effect of changes in prices, IRAs, and WAs in neighboring Census tracts on the value of houses in a given Census tract.

Calculating marginal effects of changes in IRA and WAs sheds some light on the magnitude of the coefficients estimated in the models. Table 4 displays the marginal WTP for a 1 percent change in the value of IRA and WAs in the log-linear model and the spatial-lag models. The marginal WTP for a 1 percent change in the value of IRAs ranges between $2,194 and $2,943, evaluated at the mean house value, which is equivalent to an annualized WTP of $109.7 and $147.15, respectively (assuming a 5 percent interest rate).

Another important result that relates to the difference between the log-linear model and the spatial models is the overall effect that changes in IRAs and WAs lands have on housing values. In model 2, housing values in a given Census tract can be affected by a change in its own IRAs and by housing values in neighboring Census tracts (via the ρ_{price} coefficient). In model 3, a given Census tract is affected by the value of IRAs in neighboring Census tracts (via the ρ_{IRA} coefficient) and the median housing price in neighboring Census tracts (via the ρ_{price} coefficient). The estimated coefficients in the log-linear model may be upwardly biased because own-tract IRAs and WAs are probably correlated with nearby-tract IRAs and WAs, but may still ignore some of the impact of IRAs and WAs in nearby tracts. In the case of hypotheses H_5 and H_6, estimates of ρ_{IRA} and ρ_{WAs} are not significantly different from zero, which suggests that we cannot reject the null hypotheses; the evidence does not support H_5 and H_6. Results indicate that while marginal changes in neighboring house prices affect the price of the median house in a given Census tract (i.e., null hypothesis is rejected in H_4), marginal changes in IRA and WAs in neighboring Census tracts have no direct-spillover effects on house prices.

In terms of model specification, four statistical tests suggest that the spatial-lag models (models 2 and 3) are preferred to the log-linear model. The presence of spatial dependency is statistically significant as evidenced by the Lagrange Multiplier (LM) tests (LM-lag, and LM-error values) and the z-score of the ρ_{price} coefficient (i.e. null hypothesis in H_3 is rejected). The LM-lag test has a χ^2 distribution and tests for the presence of spatial lag dependence in the hedonic OLS model in which the null hypothesis is that $\rho_{price} = 0$ (i.e. there is no spatial lag dependence) and the alternative hypothesis is $\rho_{price} \neq 0$ (Anselin 1988). Another type of spatial autocorrelation is spatial error dependence. In this case the model is: $P = X\beta + \varepsilon$, where $\varepsilon = \lambda W + \mu$. However, based on the spatial diagnostics tests reported in Table 3, the estimation of the spatial error model is not necessary. While the LM-error test is significant in the hedonic OLS model, the spatial error dependence is no longer statistically significant after introducing the spatial effect (e.g., ρ_{price}). A spatial-error model would suggest that there are other unobserved variables that are related in space (across Census tracts) and captured in the error structure. But the LM-error test result, after estimating the spatial-lag model (e.g., LM-error = 0.54), suggests that this is not the case, or at least that the spatially lagged independent variables adequately capture the spatial relationship between Census tracts. [18]

[18] There may be theoretical arguments for estimating a spatial-lag model instead of a spatial-error model. The error dependence between housing transactions is likely to occur on a small scale, e.g., within neighborhood or at least within Census tracts (Anselin 2002). In the representative household framework, any within-tract error dependence is likely hidden behind the median values obtained for each Census tract.

The Akaike's information criterion (AIC)[19] values reported for each model also suggest that models 2 and 3 are superior specifications to the log-linear model. However, while these models are better specifications of the hedonic price equation than the log-linear model, there still may be endogeneity problems as a result of including a price vector as an explanatory variable (Anselin 1988) as well as heteroskedasticity problems (e.g., the Breusch-Pagan (BP) test in the first three models indicate the presence of heteroskedasticity). To address these issues, a robust 2-SLS approach is used to estimate the spatial-lag model as opposed to a ML approach. Based on the z-values reported for the 2-SLS coefficients, the evidence supports hypotheses H_1-H_4.

A. Aggregate Benefits of IRA Lands in New Mexico

In order to understand the policy implications of the results found in this paper, it is necessary to estimate the total capitalized benefits of IRA lands in the New Mexico housing market. Using the results reported in the 2-SLS robust model (equation 6), a thought experiment is proposed where the effect on total housing value of eliminating all IRA lands in NM is estimated. Estimating the impact of such a change allows calculation of the total value of IRAs in their current status of roadless lands.[20] Following the framework in Kim et

[19] AIC = -2*(log-likelihood)+2*K, where K is the number of parameters to be estimated including the constant term. The interpretation is that the lower the AIC value the better the model specification. In this case, R^2 would not be a valid goodness of fit measure to compare the models, given that for the spatial-lag models a pseudo R^2 measure is reported.

[20] A back-of-the-envelope calculation would be to use the average level of IRAs (0.008 percent), the implicit price in the 2-SLS model ($2,654) and the average housing value ($111,461) to calculate the aggregate value that IRA lands have in the housing market in NM. However, this approach would not take account of differences in the percentage of IRAs, Census tract size, density of housing units, and differences in median home values.

al. (2000), an aggregate value of IRAs is estimated. The first step is to write equation (4) in its reduced form as follows:

(4') $$P = [I - \rho_{price} W]^{-1} X\beta + [I - \rho_{price} W]^{-1} \varepsilon ,$$

where, for ease of presentation, the logged price is dropped and the different explanatory variables included in this model are represented by the vector **X**. Letting $v = [I - \rho_{price} W]^{-1} \varepsilon$ and $A = [I - \rho_{price} W]^{-1}$, equation (4') becomes:

(4'') $$P = AX\beta + v$$

In matrix form, equation (4'') can be written as follows:

(11) $$\begin{pmatrix} P_1 \\ P_2 \\ \vdots \\ P_n \end{pmatrix} = \begin{pmatrix} a_{11}, a_{12}, & \cdots & , a_{1n} \\ a_{21}, a_{22}, & \cdots & , a_{2n} \\ \vdots \quad \vdots & \ddots & \vdots \\ a_{n1}, & \cdots & , a_{nn} \end{pmatrix} * \begin{pmatrix} x_{11}, x_{12}, & \cdots & , x_{1k} \\ x_{21}, x_{22}, & \cdots & , x_{2k} \\ \vdots \quad \vdots & \ddots & \vdots \\ x_{n1}, & \cdots & , x_{nk} \end{pmatrix} * \begin{pmatrix} ß_1 \\ ß_2 \\ \vdots \\ ß_k \end{pmatrix} + \begin{pmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{pmatrix}$$

Letting X'_{IRAs} be a column vector (n *x* 1) that represents the density of IRAs in the different Census tracts, the derivate of **P** with respect to X'_{IRAs} is defined as follows:

(12) $$\frac{\partial P}{\partial X'_{IRAs}} = \begin{pmatrix} \partial P_1 / \partial x_{1,IRAs}, \partial P_1 / \partial x_{2,IRAs}, & \cdots & , \partial P_1 / \partial x_{456,IRAs} \\ \partial P_2 / \partial x_{1,IRAs}, \partial P_2 / \partial x_{2,IRAs}, & \cdots & , \partial P_2 / \partial x_{456,IRAs} \\ \vdots \quad \vdots & \ddots & \vdots \\ \partial P_{456} / \partial x_{1,IRAs}, \partial P_{456} / \partial x_{2,IRAs}, & \cdots & , \partial P_{456} / \partial x_{456,IRAs} \end{pmatrix}$$

In this matrix, row *j* shows the impact that a marginal change in IRAs density in Census tract *j* (direct-contemporaneous effect) and neighboring Census tracts (indirect effect) has on the housing price with location *j*. This means that the price of a house in Census tract *j* is not only affected by changes of IRAs density in Census *j* but also affected by changes of IRAs density in neighboring Census tracts (due to spatial autocorrelation). For instance, the first row shows the direct-contemporaneous effect on housing prices located in Census tract 1 ($\partial P_1/\partial x_{1,IRAs}$) and the indirect effects on housing prices located in Census tract 1 ($\partial P_1/\partial x_{2,IRAs}$, …, $\partial P_1/\partial x_{456,IRAs}$). Based on equation (11), the marginal effect of a change in IRAs density can be expressed as:

$$(12')\ \frac{\partial P}{\partial X'_{IRAs}} = \begin{pmatrix} \beta_{IRAs}a_{11}, & \beta_{IRAs}a_{12}, & \cdots & , \beta_{IRAs}a_{1n} \\ \beta_{IRAs}a_{21}, & \beta_{IRAs}a_{22}, & \cdots & , \beta_{IRAs}a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \beta_{IRAs}a_{n1}, & \cdots & \cdots & , \beta_{IRAs}a_{nn} \end{pmatrix} = \beta_{IRAs}[I - \rho\, W]^{-1}$$

where **W** is a row-standardized weight matrix, $[I - \rho_{price}W]^{-1} = \frac{1}{1-\rho_{price}}$ (Kim et al. 2003), β_{IRA} = 1.58, and ρ_{price}= 0.429 (from the 2-SLS model). In the context of this thought experiment, the direct contemporaneous effect of eliminating IRAs on the value of houses located in Census tract 1 is given by $\beta_{IRAs}a_{11}$, and the aggregate indirect effect is $\sum_{i=2}^{456}\beta_{IRAs}a_{i,IRAs}$.

Note that Census tracts that do not currently have IRAs will have no direct effect on house prices because IRAs are already zero in these locations.

As an example meant to illustrate how we calculate aggregate benefits for the entire state, Table 5 shows the effect of eliminating IRAs on houses located in Census tract 360. This Census tract is located in Sierra County in the southwest of NM. Its size is 2.7 million acres, which represents 98 percent of Sierra County's total size. The total number of owner-occupied housing units is 2,014 with a median house value of $108,400. The total number of IRA lands is 128,654 acres, which represents almost 5 percent of the total size of the tract, and they are part of the Gila National Forest.

Each row in Table 5 represents the marginal effect of eliminating all IRAs in Census tract 360 and in its neighboring Census tracts on the value of houses located in Census tract 360. As described above, there are three ways IRAs can affect home prices in a Census tract: direct-contemporaneous (i.e., IRAs = 1.58); direct-spillover (the ρ_{IRAs} coefficient, which is not significantly different from zero in the mixed-spatial model); and indirect effects (i.e., $\rho_{price} = 0.429$).

Since only decreases in IRAs are evaluated in this example, the dollar amounts that appear in Table 5 can be interpreted as the marginal willingness to accept (MWTA) to eliminate IRAs in Census tracts 360 and in its neighboring Census tracts. Based on the fifth column, the aggregated direct-contemporaneous effect is $16.9 million compared to $18.9 million for aggregated indirect effects.[21] In the aggregate, such a change would translate into a 16 percent loss in the value of housing in Census tract 360 given that their current total housing value is $218.3 million (($16.9+$18.9)/$218.3 = 16.3 percent). The importance of estimating models that account for spatial autocorrelation is supported by these results since

[21] These numbers are calculated by multiplying the marginal effects in the fourth column by the number of owner-occupied units in Census tract 360.

indirect effects represent 53 percent of the total effect on house values in Census tract 360, which would have been otherwise ignored.

Table 6 shows the aggregate MWTA of eliminating all IRAs in NM. Based on the numbers reported in the table, the aggregate loss in housing value in NM of such a change would represent 3.5 percent of the aggregate value of owner-occupied units. Thirty-four percent of this loss is explained by indirect effects, which highlights the importance of estimating spatial-lag models as opposed to the traditional non-spatial models.[22] This estimated effect of IRAs on the housing market in NM is about one-fourth (27 percent) of the impact that wilderness proximity has on housing values in Vermont in Phillip (1999).[23]

VI. Conclusions

This paper represents the first attempt to econometrically estimate the value of IRA lands in NM using a spatial hedonic pricing approach. In light of the ongoing national debate about the future of nearly 60 million acres of IRA lands, this paper provides evidence of the importance of better understanding the monetary benefits of IRAs as they currently exist.

After controlling for median housing and neighborhood characteristics, and the separate effect of Wilderness Areas, the percent of IRA lands in a Census tract has a positive and

[22] The estimated models indicate that both direct-contemporaneous and indirect effects are statistically significant, but the direct-spillover effect is insignificant.

[23] This is also roughly consistent with the Loomis and Richardson's (2000) summary findings that various estimates of recreation use values per acre in the Western U.S are typically only about one-fourth of comparable Eastern U.S. value estimates, and that estimated passive use values per acre in the West are only about two-thirds the magnitude of comparable Eastern values.

statistically significant effect on median home values in all estimated models. These 1.6 million acres of protected IRA lands provide about 3.5 percent of the total housing value in NM. This result is consistent with recent evidence in the Southwestern U.S of strong amenity effects in the regional economy including in-migration, property value, and labor market outcomes (e.g., Hand et al. 2008a and 2008b).

Non-market benefit estimates, as part of a more comprehensive benefit-cost analysis, can be an important informational input in any major regulatory action (e.g., Arrow et al. 1996), including public lands management (Loomis 2002). As such, these results suggest that not accounting for such benefits (e.g., off-site benefits) would significantly underestimate the value society places on these lands. Off-site benefits are components of the larger bundle of ecosystem services and non-market benefits that protected lands may offer (Loomis and Richardson 2000; Berrens et al. 2006). Thus, this paper reports estimates for a portion of the total economic value (TEV) of these protected areas. For instance, there may also be on-site recreation values, and passive use values that are not captured in house prices. Loomis (1996) reviews evidence from various contingent valuation studies that passive use values may represent a significant percentage, and sometimes a majority proportion, of the TEV associated with protected forest areas in the U.S. This suggests that off-site amenity values to residents, as measured here, might represent just one of several significant components of the TEV.

From an econometric perspective, the results of this paper provide further evidence on the importance of spatial considerations in non-market valuation techniques such as hedonic price functions. Based on the empirical framework of Anselin (1988), this paper finds that spillover effects represent 34 percent of the total impact, which in the traditional log-linear regression are assumed to be zero.

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Table 1: Selected Economic Performance Measures for IRA and non-IRA counties in New Mexico

	NM IRA counties[1]	NM Non-IRA counties	New Mexico, all counties	U.S.
Percent growth, 1990-2005				
Real income per capita[2]	29.7	23.3	25.1	18.4
Non-farm employment	29.8	26.3	27.3	20.1
Real earnings per job[2,3]	21.4	13.2	17.5	20.4
Service industry employment				
Percent of non-farm employment in services, 2000[4]	29.9	31.5	31	32.8
Growth in service employment, 1990-2004	44.1	41.4	42.1	37
Earnings flows				
Net earnings flows, 2005 (thousands of $)[5]	511,793	-240,785	–	–
Change in real net earnings flows, 2001-2005 (thousands of $)[2,5]	110,229	-115,693	–	–

Source: Calculations from Bureau of Economic Analysis, Local Area Personal Income data. Available at http://www.bea.gov/bea/regional/reis/, accessed March 21, 2008.

[1]IRA counties are those with at least 1% of land and 10,000 acres in IRA. Includes Catron, Eddy, Grant, Hidalgo, Lincoln, Otero, Rio Arriba, San Juan, San Miguel, Santa Fe, Sierra, Socorro, and Taos counties.

[2]Real figures are calculated as 2005 constant dollars using the annual CPI for all urban consumers (all items). Source: U.S. Bureau of Labor Statistics.

[3]Real earnings per job calculated as real earnings divided by total wage and salary employment.

[4]Most industry-level data is undisclosed for each county due to the change from SIC to NAICS industry classifications. The old SIC industries used a higher level of aggregation and are reportable by county for the last year data are available, 2000.

[5]Net earnings flows are calculated as the earnings of out-commuters minus the earnings of in-commuters for each county. See notes for BEA table CA91 for a detailed description.

Table 2: Descriptive statistics

Variable	Description	Mean	Std. Dev.
LNHVALUE	Owner-occupied median property value in LN, $	11.47	0.59
DROOMS	Binary variable (coded 1 if number of rooms $\geq$ mean number of rooms; 0 otherwise)	0.46	0.50
DINCOME	Binary variable (coded 1 if income level $\geq$ mean income level; 0 otherwise)	0.37	0.48
HAGE	Structure age	25.88	12.94
HPERACRE	Number of houses per acre in a census tract	1.19	1.55
DCENSIZE	Binary variable (coded 1 if census size in acres $\geq$ mean census size; 0 otherwise)	0.18	0.40
IRAs	Percentage of Inventoried Roadless Areas in a census tract	0.0079	0.0446
WAs	Percentage of Wilderness Areas in a census tract	0.0133	0.0637

Table 3: Estimation Results

Variables	Log-linear model	Spatial-lag (ML)	Mixed Spatial-lag (ML)	Spatial-lag (2-SLS) robust
DROOMS	0.185***	0.155***	0.158***	0.131***
	(3.43)[a]	(3.43)[b]	(3.53)[b]	(3.55)[b]
DINCOME	0.409***	0.300***	0.289***	0.324***
	(6.96)	(6.05)	(5.74)	(7.93)
HPERACRE	0.049	0.008	-0.007	0.011
	(2.99)	(0.58)	(0.37)	(1.00)
DCENSIZE	-0.345***	-0.253***	-0.252***	-0.298***
	(5.90)	(5.15)	(4.99)	(4.99)
HAGE	-0.007***	-0.004***	-0.008***	-0.004***
	(3.45)	(2.66)	(4.18)	(2.81)
IRAs	2.270***	1.420***	1.040***	1.580***
	(4.87)	(3.64)	(2.59)	(5.10)
WAs	1.190***	0.641**	0.640**	0.720***
	(3.64)	(2.32)	(2.29)	(3.39)
ρ_{PRICE}		0.513***	0.545***	0.429***
		(12.14)	(10.77)	(7.14)
ρ_{DROOMS}			-0.017	
			(0.18)	
$\rho_{DINCOME}$			-0.051	
			(0.49)	
$\rho_{HPERACRE}$			0.008	
			(0.29)	
$\rho_{DCENSIZE}$			-0.073	
			(0.70)	
ρ_{HAGE}			0.009***	
			(2.77)	
ρ_{IRAs}			0.355	
			(0.49)	
ρ_{WAs}			0.071	
			(0.13)	
INTERCEPT	11.38	5.52	5.04	6.49
R^2	0.456			

Table 3: Estimation Results (continued)

Variables	Log-linear model	Spatial-lag (ML)	Mixed Spatial-lag (ML)	Spatial-lag (2-SLS) robust
LK	-263.4	-194.4	-185.8	
AIC	544.7	404.8	405.7	
BP-test	49.4 ***	86.2 ***	146.0 ***	
LM-lag	197.1***			
LM-error	175.5***	0.54	0.16	
N = 456				

*, **, and *** denote 90%, 95%, and 99% confidence levels, respectively.
( )^a: t-value
( )^b: z-value

Table 4: Implicit Prices ($), WTP for a 1% Change in IRAs or WAs

	WTP (for a 1% change)		% of median housing price	
	IRAs	WAs	IRAs	WAs
Log-linear	$2,173	$1,147	2.3%	1.2%
Spatial-lag (ML)	$2,787	$1,260	2.9%	1.3%
Mixed spatial-lag (ML)	$2,943	$1,495	3.1%	1.6%
2-SLS robust	$2,654	$1,194	2.8%	1.2%

Notes: Implicit prices are calculated for each model using equations (7) through (9). Given that a one unit change in IRAs is equal to 100% of the average census tracts land area for the sample (the average IRA value is about 0.008) this change would bring the value of IRA in the average census tract to 1.008, which is not realistic. To make this analysis reasonable in the context of this paper, the calcualted marginal WTP is divided by 100. As a result, the marginal effect of a 1 percentage point increase in IRAs in the average census tract (which means that average IRAs would increase to 0.018) would be, for instance, $2,654 for the 2-SLS robust approach. The same methodology is applied to the marginal effect for wilderness lands.

Table 5: The Impact of Eliminating IRAs in Houses Located in Census Tract 360 ($)

		Census 360	Direct Contemporaneous Effect	Indirect Effect	Total Effect, per housing unit	Direct Effect, Aggregated	Indirect Effect, Aggregated
	360	8,237	8,237	0	8,237	16,950,089	0
Census	376	5,919	0	5,919	5,919	0	11,920,082
Tract	391	2,620	0	2,620	2,620	0	5,275,958
	375	895	0	895	895	0	1,802,543
						16,950,089	18,998,583

Notes: The aggregate monetary effects of this empirical exercise are calculated using equations (8) and (12') as follows: $(\frac{\partial \mathbf{P_{360}}}{\partial \mathbf{IRAs'}})' * IRAs' * HVALUE_{360} * units_{360}$, where $(\frac{\partial \mathbf{P_{360}}}{\partial \mathbf{IRAs'}})'$ is a $5x456$ matrix and $\mathbf{IRA}\mathrm{s}'$ is a $456x1$ matrix and units_{369} is the total number of owner-occupied units in census tract 360.

Table 6: Aggregate Benefits of IRAs for the Real Estate Market in the State of New Mexico (thousands of $)

	Direct-contemporaneous Effect, Aggregated	Indirect Effect, Aggregated	Total Effect, Aggregated	Agg. Effect as % of Total Housing Value
Bernalillo	-	255	255	0.00%
Catron	15,785	1,929	17,714	16.93%
Chaves	-	3	3	0.00%
Cibola	650	555	1,206	0.31%
Colfax	-	10,337	10,337	3.12%
Curry	-	-	-	-
De Baca	-	-	-	-
Dona Ana	-	852	852	0.02%
Eddy	6,290	2,616	8,906	0.88%
Grant	50,990	60,660	111,650	12.86%
Guadalupe	-	814	814	1.28%
Harding	37	436	473	6.21%
Hidalgo	2,152	423	2,575	2.18%
Lea	-	41	41	0.01%
Lincoln	5,848	3,456	9,305	1.30%
Los Alamos	182,893	84,597	267,490	20.05%
Los Lunas	-	-	-	-
McKinley	13	270	282	0.04%
Mora	1,776	7,931	9,707	7.69%
Otero	30,214	14,878	45,092	3.54%
Quay	-	-	-	-
Rio Arriba	79,903	58,649	138,551	10.20%
Roosevelt	-	-	-	-
San Juan	-	112	112	0.00%
San Miguel	22,164	58,914	81,078	10.49%
Sandoval	6,904	23,229	30,133	0.89%
Santa Fe	710,016	209,982	919,998	11.95%
Sierra	16,590	22,670	39,260	10.14%
Socorro	6,202	6,497	12,699	3.27%
Taos	102,636	75,266	177,902	12.65%
Torrance	-	2,006	2,006	0.46%
Union	-	985	985	1.56%
Valencia	-	-	-	-
Total Effect	1,241,063	648,362	1,889,425	3.51%

Figure 1: Percentage of Land in Census Tracts Covered by IRAs and WAs