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Income Earning Potential versus Consumptive Amenities in Determining Ranchland Values

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The relative importance of income earning potential versus consumptive values in setting ranchland prices is examined using a truncated hedonic model. The market value of New Mexico ranches is related to annual income earning potential and other ranch characteristics including ranch size, location, elevation, terrain, and the amount of deeded, public, and state trust land on the ranch. We found ranch income to be a statistically important determinant of land value, but yet a relatively small percentage of ranch value was explained by income earnings. Ranch location, scenic view, and the desirable lifestyle influenced ranch value more than ranch income.

Key words: consumptive value, grazing fees, grazing permit value, hedonic model, land value, lifestyle agriculture, public land grazing, voluntary grazing permit buyout

Introduction

The influence of desirable quality-of-life (QOL) attributes on the market value of ranches was studied by William Martin and various co-authors nearly 40 years ago (Martin, 1966; Martin and Jeffries, 1966; Smith and Martin, 1972). Martin studied Arizona ranches and noted that non-livestock ranch outputs, including tax shelters, land appreciation, and especially the ranching lifestyle, were the most important reasons for ranch purchase and investment. It is now widely recognized that the desirable rural lifestyle and agrarian values significantly inflate the market value of farms and ranches (Gosnell and Travis, 2005; Blank, 2002). People want an investment they can touch, feel, and experience (Pope, 1987).

Consumptive and quality-of-life influences on land value appear to have grown in economic importance. Recent surveys suggest that livestock production and profits are now only secondary in importance in the ranch purchase decision. In addition to expectations of long-term capital gains, the lifestyle and social fulfillment experienced by ranch buyers from owning ranchland properties is what matters most (Liffman, Huntsinger,

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and Forero, 2000; Gentner and Tanaka, 2002; Rowe, Bartlett, and Swanson, 2001). Owners of large ranches, those with a long legacy on the land, and those most dependent on the ranch for income are concerned about profit (Rowe, Bartlett, and Swanson, 2001). However, these large, traditional ranches are declining in number [U.S. Department of Agriculture/Economic Research Service (USDA/ERS), 2002]. Gentner and Tanaka (2002) found that over half of western public land ranchers depend on the ranch for no more than 20% of annual disposable income.

Previous studies have developed hedonic price models and identified numerous ranch-price influencing factors (see, for example, Bastian et al., 2002; Rowan and Workman, 1992; Sengupta and Osgood, 2003; Sunderman et al., 2000; Torell and Doll, 1991). But only one previous study (Pope, 1985) directly incorporated agricultural income as an explanatory variable and provided direct estimates of the relative contributions of income earning versus consumptive values in setting ranch prices. Pope estimated that in 1981, a dollar of ranch income was capitalized into \$12 of land value, implying an 8.3% capitalization rate using the standard capitalization formula, $V = A/r$. The average agricultural use value of the Texas ranches studied was less than one-fourth the market value of the land.

In this study, we use ranch sales data compiled by Farm Credit Services (FCS) appraisers, and income appraisal data included with each sale, to evaluate which factors have influenced New Mexico ranch values. Income from crops, livestock, and wildlife are considered in the analysis. Further, because grazing capacity leased from the New Mexico State Land Office, Bureau of Land Management (BLM), and U.S. Forest Service (FS) is integrated into New Mexico ranches, and transferred at the time of sale, the market value of these grazing permits is also evaluated. Adapting the truncated nonlinear hedonic model proposed by Xu, Mittelhammer, and Torell (1994) for modeling non-negative dependent variables proved to be important, revealing significant implications about how ranch prices vary between relatively low-priced public land ranches and high-priced deeded land ranches.

The Hedonic Model and Estimation Issues

Let $\mathbf{E}$ be a vector of production and economic variables that affect annual ranch earning potential (i.e., $A = A(\mathbf{E})$), and let $\mathbf{Q}$ be a vector of site-specific factors influencing quality-of-life (QOL) values. A is assumed to be capitalized into land value at some interest rate r. Certain price-influencing characteristics can be elements of both $\mathbf{E}$ and $\mathbf{Q}$, and their effect on ranch price may be opposite. The observed market price of a ranch (P) will be the sum of productive value (V) and QOL value:

$$(1) \qquad P(\mathbf{E}, \mathbf{Q}, \mathbf{B}) = V\big(A(\mathbf{E}), r, \mathbf{B}_A\big) + QOL(\mathbf{Q}, \mathbf{B}_Q),$$

where $\mathbf{B}_A$, $\mathbf{B}_Q$, and $\mathbf{B} = [\mathbf{B}_A\ \mathbf{B}_Q]$ are parameter vectors.

An important decision is how to define the dependent variable in the model. This is not trivial when ranches include public land grazing permits (BLM, FS, and state trust land permits) and the ranch purchaser can graze all lands transferred with the sale, but purchasers do not acquire title to the public lands.[1]

[1] We recognize that state trust lands are not public land. We refer to FS, BLM, and New Mexico state trust land as public land for convenience.

Pope (1985), Sunderman et al. (2000), Bastian et al. (2002), and Sengupta and Osgood (2003) all used dollars per deeded acre as the dependent variable in their hedonic models. This is adequate, if not preferred, for areas with primarily deeded lands. However, in public land ranching areas, the price per deeded acre is misleading because a ranch with few deeded acres and large public and state land permits attached will have high prices per deeded acre when total ranch value comes from both deeded and public land acreages. Alternatively, the total value of the ranch has been used as the dependent variable in some hedonic land value models (Martin and Jeffries, 1966; Rowan and Workman, 1992; Spahr and Sunderman, 1995; Sunderman and Spahr, 1994). This is also problematic because the model coefficients now measure average responses across all ranch sizes, but responses are expected to be quite different with ranch size.

Other ranch value models have defined the dependent variable to be $/brood cow, $/AUM, or $/AUY[2] (Workman and King, 1982; Torell and Doll, 1991). Dividing the ranch selling price by the number of cows, AUMs, or AUYs to estimate a $/livestock-unit price tacitly assumes that all ranch value arises from livestock production. This is not consistent with the observation that western ranches have value far in excess of expected discounted income.

A previously unexplored approach, which is used in this study, defines the dependent variable as $/total acre ($\$/TAC$), including in the denominator both deeded and public land acreages. An obvious criticism of this approach is that clear title to public and state trust lands is not acquired with ranch purchase.

The market value of deeded land is observed to be much higher than public land. This is addressed by including the percentages of the ranch composed of BLM, FS, and state grazing lease acres (*STATE*) as explanatory variables in the model. Specifically, let P_D, P_{BLM}, P_{FS}, and P_{STATE} be the per acre prices of deeded land and the three previously discussed types of public lands, and:

$$(2)\qquad P_D = P(\mathbf{E}, \mathbf{Q}, \mathbf{B}), \qquad P_{BLM} = P(\mathbf{E}, \mathbf{Q}, \mathbf{B}) + B_{BLM},$$
$$P_{FS} = P(\mathbf{E}, \mathbf{Q}, \mathbf{B}) + B_{FS}, \qquad P_{STATE} = P(\mathbf{E}, \mathbf{Q}, \mathbf{B}) + B_{STATE},$$

where $P(\mathbf{E}, \mathbf{Q}, \mathbf{B})$ is as defined in equation (1), and B_{BLM}, B_{FS}, and B_{STATE} are fixed per acre price-difference parameters. Then, by definition, the dependent variable is specified as:

$$(3)\qquad \$/TAC = \left(P_D\#A_D + P_{BLM}\#A_{BLM} + P_{FS}\#A_{FS} + P_{STATE}\#A_{STATE}\right)/\left(\#A_D + \#A_{BLM} + \#A_{FS} + \#A_{STATE}\right)$$
$$= \left(P_D\%A_D + P_{BLM}\%A_{BLM} + P_{FS}\%A_{FS} + P_{STATE}\%A_{STATE}\right),$$

where $\#A$ and $\%A$ refer to the number and percentage of acres in each land type, respectively. Substituting (2) into (3), gathering the common term $[P(\mathbf{E}, \mathbf{Q}, \mathbf{B})]$, and recognizing that $\%A_D + \%A_{BLM} + \%A_{FS} + \%A_{STATE} = 1$, leads to the following conceptual model:

$$(4)\qquad \$/TAC = P(\mathbf{E}, \mathbf{Q}, \mathbf{B}) + B_{BLM}\%A_{BLM} + B_{FS}\%A_{FS} + B_{STATE}\%A_{STATE} + \nu,$$

[2] An animal unit (AU) is considered to be one mature cow with calf or its equivalent. An animal unit month (AUM) is the amount of forage required by an AU for one month. An animal unit yearlong (AUY) is the forage requirement for an AU for the year. A cow unit represents one mature brood cow.

where ν is the error term. The defined hedonic model is consistent with a situation in which ranch buyers formulate per acre bid prices depending on ranch characteristics and with public land acres discounted in price by B_{BLM}, B_{FS}, and B_{STATE}. It may also be appropriate to include discounts based on the percentage of livestock carrying capacity located on public lands, especially when rangeland productivity between land ownership types is greatly different.

The Nonnegativity Restriction

Because land values cannot theoretically be negative, the distribution of the error term in equation (4) should not allow for negative dependent variable values. Xu, Mittelhammer, and Torell (1994) demonstrated a procedure to truncate the dependent variable predictions at zero. This proved to be most appropriate for our application. Many of the public land ranch prices in New Mexico are clustered within a low \$10–\$50/acre, but none are negative. The empirical model produced a truncation in the dependent variable predictions at about \$14/acre, consistent with the observed minimum prices in the data set.

The truncated model of Xu, Mittelhammer, and Torell (1994) is given by:

$$(5)\qquad \begin{aligned} Y &= E(Y \mid Y \geq 0) + \varepsilon \\ &= g(\mathbf{X};\beta) + \tau \frac{\phi(-g(\mathbf{X};\beta)/\tau)}{\Phi(g(\mathbf{X};\beta)/\tau)} + \varepsilon = H(\mathbf{X};\beta,\tau) + \varepsilon, \end{aligned}$$

where $g(\cdot)$ represents the empirical specification of the conceptual model [equation (4)], $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability and the cumulative density functions for a standard normal variable, and τ is a truncation parameter to be estimated. The only requirement on $g(\cdot)$ is to be a differentiable function of the explanatory variables,

$$\mathbf{X} = \left[\mathbf{E}\,\mathbf{Q}\;\%A_{BLM}\;\%A_{FS}\;\%A_{STATE}\right],$$

and the vector of unknown parameters,

$$\beta = \left[\mathbf{B}\,B_{BLM}\,B_{FS}\,B_{STATE}\right].$$

Because of the inclusion of the nonnegativity restriction, this model must be estimated using nonlinear least squares or maximum likelihood procedures. Assuming that the error term is independently and normally distributed, the concentrated log-likelihood function to be maximized for parameter estimation is:

$$(6)\qquad \text{LF} = -\sum \ln(\sigma_i) - 0.5\sum(\varepsilon_i/\sigma_i)^2,$$

where $\varepsilon_i = Y_i - H(X_i;\beta,\tau)$ from equation (5), and the summation is over n ranch sale observations. The assumption of a constant variance will have to be released in this study, as described below.

Characterization of the marginal effects of the explanatory variables is complicated by the inclusion of the nonnegativity restriction, as described in detail by Xu, Mittelhammer, and Torell (1994). There is a functional relationship between $\partial H(\mathbf{X};\beta,\tau)/\partial X_i$ and $\partial g(\mathbf{X};\beta)/\partial X_i$, with the marginal impact of a change in X_i on Y_i given by:

(7) $$\frac{\partial H(\mathbf{X};\beta,\tau)}{\partial X_i} = D\left(\frac{g(\mathbf{X};\beta)}{\tau}\right)\frac{\partial g(\mathbf{X};\beta)}{\partial X_i},$$

where

(8) $$D\left(\frac{g(\mathbf{X};\beta)}{\tau}\right) = 1 - (g(\cdot)/\tau)\frac{\phi(g(\cdot)/\tau)}{\Phi(g(\cdot)/\tau)} - \left(\frac{\phi(g(\cdot)/\tau)}{\Phi(g(\cdot)/\tau)}\right)^2.$$

Note that the D-function [equation (8)] is a proportionality factor rescaling the marginal effects of the explanatory variables on Y. The scaling factor is applied equally to all explanatory variables in the model. The closer $g(\mathbf{X};\beta)/\tau$ is to zero, the larger $\partial g(\mathbf{X};\beta)/\partial X_i$ is relative to $\partial H(\mathbf{X};\beta)/\partial X_i$.

As noted by Xu, Mittelhammer, and Torell (1994), for positive values of $g(\cdot)$, the D-function will range from 0.3634 to 1. With the nonnegativity restriction in place, $H(\cdot)$ is always positive, but it is possible for $g(\cdot)$ to be negative, an alternative not considered by Xu, Mittelhammer, and Torell. This was the case for many of the ranch sale observations in this study. The D-function will approach zero for relatively large negative values of $g(\cdot)$, implying the marginal impact of X_i on ranch value also approaches zero. This has important implications in the current application where ranches with increasing amounts of public land have decreasing sale prices. The marginal effect of improving range condition, adding ranch income, or adding additional acreage will have less effect on a public land ranch than it will on a deeded land ranch. The diminishing marginal value of altering X_i for lower-priced versus higher-priced ranches is a characteristic of the truncated model that may or may not be valid, and a more flexible function that does not equally scale all explanatory variables may be most appropriate. To assess the validity of the truncated model, we considered the statistical significance of τ, residual plots, and comparisons of R^2 values from this model and alternative nontruncated functional forms.

Heteroskedasticity

Following standard procedures, the null hypothesis of homoskedasticity was tested by regressing the squared residuals from a constant-variance model on all explanatory variables, their squares, and cross-products. The standard "White" test strongly rejected the homoskedasticity hypothesis ($P < 0.001$). After all of the statistically insignificant variables had been excluded and their joint insignificance was confirmed through an F-test, the ε_i^2 predictions from this "White regression" were used as estimates for the σ_i^2's in equation (6) to reestimate model parameters. The White test was reapplied to the standardized residuals from the latter model to confirm the effectiveness of the heteroskedasticity correction. Estimation was carried out using GAUSS™ 5.0 constrained maximum likelihood subroutines.

Data

New Mexico ranch sales information was collected from a sales database maintained by Farm Credit Services (FCS), and included 492 sales negotiated between January 1996 and December 2002. FCS appraisal data sheets include extensive information about the documented sale, including financial terms of the sale; ranch location; acreage and

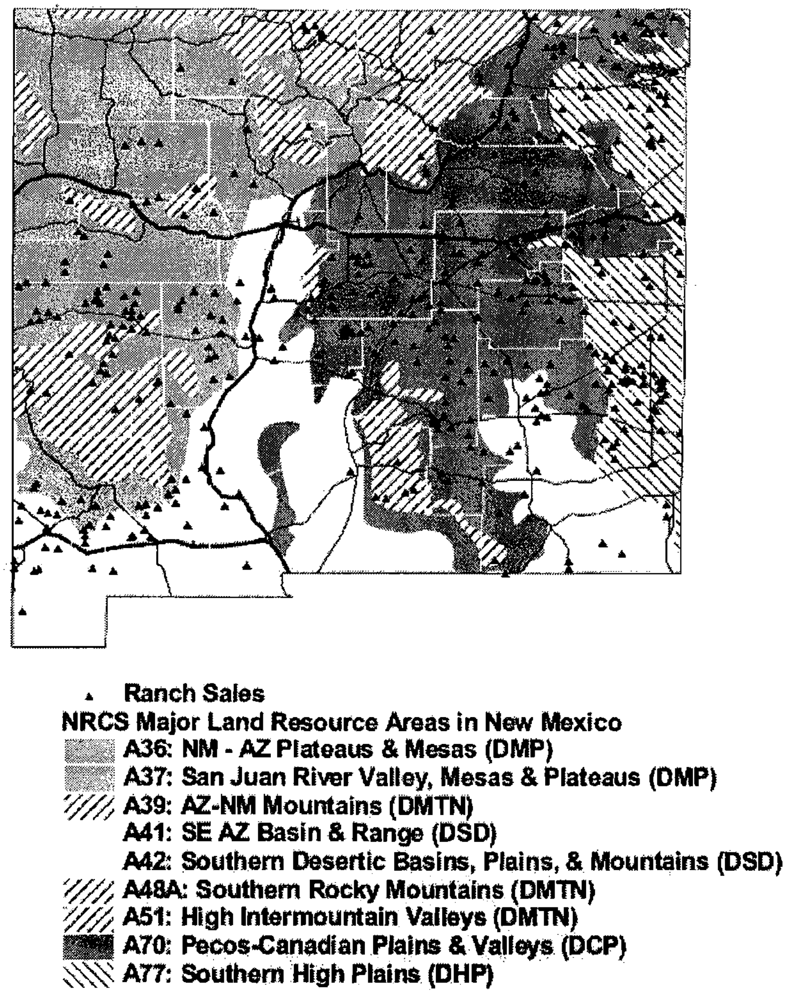


Figure 1. NRCS major land resource areas and location of study ranches

livestock carrying capacity by land type; the value of real property such as houses, buildings, and major structural improvements; and FCS appraiser estimates of income earning potential. The income appraisal sheet includes estimates of annual crop and livestock income, wildlife income, potential rental income of facilities and housing, and occasionally income from surface minerals like sand, gravel, and caliche. All comparable sales located and documented by FCS appraisers were included regardless of FCS loan involvement with the sale.

Major land resource area (MLRA) designations by the Natural Resources Conservation Service (NRCS) were used to evaluate differences in ranch value by area (figure 1). These areas vary in soils, rangeland productivity, topography, vegetation, and land ownership, and are used to differentiate between NRCS range sites (USDA/Soil Conservation Service, 1981). Some MLRA areas were combined because of limited ranch sales data. Also shown in figure 1 is the location of the 492 ranch sales used in the analysis. Other characteristics, such as elevation of the ranch at the headquarters, distance to a trade center, and steepness of terrain, were estimated from the ranch location defined on the FCS appraisal sheets.

Table 1 provides a detailed listing of how income and expense variables were defined and computed, along with other variables used in the hedonic regression model and analysis. It can be seen that estimated net annual livestock returns ultimately depend on the assigned forage leasehold value, land mix, and the total AUY on the ranch. Total AUY further depends on ranch size and rangeland productivity (*PROD*). Historical grazing use of the ranch and allowed grazing capacities from federal and state land agencies were considered by FCS appraisers when defining average grazing capacity of each ranch. For any particular ranch, FCS appraisers generally used a constant AUY/section productivity across all land ownership types (i.e., deeded, BLM, FS, and State). Correspondingly, the average percentage of land area by land type was nearly identical to the average percentage of livestock carrying capacity by land type (<1% difference).

Including wildlife income in the analysis was possible because New Mexico has a unique program whereby wildlife permits are issued to landowners as compensation for providing wildlife habitat on private lands. After the wildlife permits are issued, landowners have the option of using the wildlife permits themselves or they may sell them. Estimates of allowed wildlife harvest on each ranch were determined using a database of New Mexico landowners with elk and antelope hunting authorizations, as maintained by the New Mexico Department of Game and Fish (2005). Estimates of wildlife income from fishing and for game species not in the Game and Fish database were also made by FCS appraisers.

Of the 492 study ranches, 125 (25%) were identified to have wildlife income-earning opportunities. Those ranches with annual wildlife income over \$2.50 per total acre (25 sales) were located in or near the mountainous areas of the state and had income from elk. Many ranches in the northern part of the High Plains (HP) MLRA and in the northern and central part of the Canadian Plains (CP) MLRA (figure 1) had wildlife income ranging from \$0.25 to over \$2 per total acre. Antelope are common in these areas.

Once the average livestock carrying capacity of the ranch was estimated by FCS appraisers and multiplied by estimated forage value, and wildlife income and other miscellaneous annual income had been defined, ranch expenses were subtracted to estimate net annual earning potential for the ranch. Grazing fees were computed using the fee for the year of the ranch sale. Ranch maintenance and management charges were calculated as 5% of gross returns for each category. Taxes, insurance, and other miscellaneous expense items were included by FCS appraisers for some of the sales, but expenses primarily included grazing fees and management and maintenance charges. The hedonic model was estimated on both a nominal- and real-price basis (CPI inflation adjusted to 2002 price levels).

Empirical Model Specification and Hypothesis Testing

The Empirical \$TAC Model

The empirical \$TAC model was obtained by specifying the functional form and specific variables to be included in $g(\mathbf{X}; \beta)$ [equation (5)]:

Table 1. Variable Description and Summary Statistics (sample size = 492 ranch sales between 1996–2002)

Variable	Description	Units of Meas.	Mean[a]	Std. Dev.	Min.	Max.
Ranch Selling Price:						
$TOTAL	Cash equivalent total ranch selling price ($) excluding cattle and machinery	$000s	1,090	1,746	25	24,000
$AUY	$ per AUY ranch selling price, *$TOTAL / TOTAUY*	$	6,603	8,417	632	82,500
$TAC	$ per total acre ranch selling price including deeded land, and federal and state grazing permits, *$TOTAL / TOTAC*	$	128	133	5	887
$DAC	$ per deeded acre ranch selling price, *$TOTAL / DEEDAC*	$	563	6,119	44	135,000
Acreages and Grazing Capacity:						
TOTAC, *TOTSECT*	Total acres (sections) on the ranch	acres	13,968	20,006	280	183,641
DEEDAC, Ln(*DEEDSECT*)	Acres (sections) of deeded land; Ln(*DEEDSECT*) is the natural log of deeded sections	acres	7,269	12,019	0	106,065
BLMAC	Acres of Bureau of Land Management land	no.	2,868	8,530	0	136,195
FSAC	Acres of Forest Service land	no.	1,390	8,003	0	81,600
STATEAC	Acres of State trust land	no.	2,449	5,513	0	53,273
%BLM	*BLMAC / TOTAC* * 100	no.	13.5	26.1	0	100
%FS	*FSAC / TOTAC* * 100	no.	4.1	18.4	0	100
%STATE	*STATEAC / TOTAC* * 100	no.	14.8	21.9	0	100
$IRR	Irrigated acres/*TOTAC* * 100	no.	0.8	6.1	0	92
TOTAUY	Total AUY on the ranch	no.	248	323	7	2,600
PROD	Rangeland productivity, *TOTAUY / TOTSECT*	no.	13.0	4.6	2.0	49.6
Annual Ranch Income and Expenses:						
ERSAUM	Average USDA/NASS 11-state AUM lease rate for cattle grazing non-irrigated rangeland during the year of the ranch sale (USDA, *Monthly Agricultural Prices*, various issues)	$	11.29	0.64	10.40	12.50
LIVETOT	Gross income from forage lease, (*ERSAUM* * 0.70) * *TOTAUY* * 12; assumes forage value is 70% of ERS lease rate (Bartlett et al., 2002)	$	23,445	30,474	629	248,976
OTHERTOT	Gross income from facility and house rental, surface minerals, crop sales, and CRP payments as defined by FCS appraisers	$	2,148	13,844	0	264,000
AGTOT	Gross income from agricultural enterprises, *LIVETOT* + *OTHERTOT*	$	25,592	33,119	629	276,028
WILDTOT	Gross income from hunting and wildlife-related activities	$	3,739	13,303	0	119,500
GROSSINC	Total gross ranch income, *AGTOT* + *WILDTOT*	$	36,426	51,362	600	593,200
TOTALEXP	Total ranch expenses including maintenance, management, grazing fees, taxes, insurance, and other miscellaneous expenses recorded by FCS appraisers	$	8,985	13,519	85	107,603
NETINCOME	Net ranch returns, *GROSSINC* – *TOTALEXP*	$	27,440	40,505	515	488,313
AGEXP	Agricultural production expenses, *AGTOT* / *GROSSINC* * (*TOTALEXP* – grazing fees) + grazing fees	$	8,430	12,430	85	104,515

(continued . . .)

Table 1. Continued

Variable	Description	Units of Meas.	Mean [a]	Std. Dev.	Min.	Max.
Annual Ranch Income and Expenses (cont'd.):						
WILDEXP	Wildlife production expenses, *WILDTOT / GROSSINC* ∗ (*TOTALEXP* – grazing fees)	$	743	2,933	0	30,871
NETAGTAC, *NETAG*	Net agricultural income (*$ / TOTAC*, $ total) from livestock, facility rental, and crop sales, (*AGTOT – AGEXP*)	$	2.26	4.82	0.10	62.19
NETWILDTAC, *NETWILD*	Net income from wildlife (*$ / TOTAC*), (*WILDTOT – WILDEXP*) / *TOTAC*; *NETWILD* is the total for the ranch	$	0.36	1.22	0	12.66
NETTAC	Net total income (*$ / TOTAC*), *NETAGTAC* + *NETWILDTAC*	$	2.62	4.94	0.10	62.19
Miscellaneous Variables:						
HBVALUE	Appraised real property value (houses, buildings, and improvements) ($ Total)	$000s	50.59	108.78	0	1,122
HBVALTAC	Appraised real property value per total acre, *HBVALUE / TOTAC*	$	5.90	18.08	0	183.83
ELVFT, Ln(*ELVFT*)	Elevation of ranch headquarters in feet as defined at http://www.esg.montana.edu/gl/; Ln(*ELVFT*) is natural log	no.	5,540	1,331	2,900	10,626
ROUGH	Roughness coefficient, the standard deviation of surrounding elevation values as defined at http://www.esg.montana.edu/gl/; flat is equal to zero	no.	3.39	5.31	0	40.60
DISTANCE	Road miles to a trade center, defined approximately following the rule: "Does the town have a Wal-Mart?"	no.	53	29	1	153
POPDEN	Population density (# people/square mile) of the county where the ranch is located, as defined from the *2000 Census*	no.	6.13	8.07	0.38	67.19
Dummy Variables (1 = true, 0 = false):						
DMP, *DMTN*, *DSD*, *DCP*, *DHP*	Dummy variables for ranch location in a particular MLRA (see figure 1). *DCP* was excluded from the model so all comparisons were made relative to this ranching area. (See table 3 for price statistics by area.)					
D96 to *D03*	Weighted time-of-sale variables; data are for the period 1996–2002. (See text for additional discussion.)					
DPAG	Dummy variable when percent assured grazing (*%BLM* + *%FS* + *%STATE*) was greater than 90%	0/1	0.13			

Time-of-sale variables (*D96* to *D03*):

	Number	Percent
1996	70	14%
1997	85	17%
1998	95	19%
1999	77	16%
2000	77	16%
2001	53	11%
2002	35	7%
All Years	492	100%

[a] Mean values for economic variables are reported on a nominal-price basis.

$$(9)\qquad g(\mathbf{X};\beta) = \beta_1 + \beta_2 NETAGTAC + \beta_3 NETWILDTAC + \beta_4 HBVALTAC + \beta_5 \text{Ln}(DEEDSECT) + \beta_6 \text{Ln}(ELVFT) + \beta_7 ROUGH + \beta_8 DISTANCE + \beta_9 POPDEN + \beta_{10} PROD + \beta_{11} DPAG + \beta_{12} DMP + \beta_{13} DMTN + \beta_{14} DSD + \beta_{15} DHP + \beta_{16} D96 + \beta_{17} D97 + \beta_{18} D98 + \beta_{19} D99 + \beta_{20} D00 + \beta_{21} D01 + \beta_{22} D02 + \beta_{BLM}\%BLM + \beta_{FS}\%FS + \beta_{STATE}\%STATE.$$

Definitions of variables in the model, along with other variables defining the elements of $\mathbf{E}$ and $\mathbf{Q}$, are presented in table 1. Hypothesis testing about the statistical significance of individual parameters and joint parameter restrictions was conducted using likelihood ratio tests.

In the empirical model, the combined variables *NETAGTAC* and *NETWILDTAC*, which depend on elements of $\mathbf{E}$ described in the income and expense section of table 1, measure dollar per total acre of expected annual ranch income earning potential (A). The expected sign of the corresponding parameters, β_2 and β_3, is positive. If ranches have value only because of the income they earn, these would be the only significant parameters in $g(\mathbf{X};\beta)$, and the resulting model would be the one implied by the traditional income capitalization formula. It was anticipated that β_3 would either be the same or larger than β_2, implying ranch buyers obtain additional utility from wildlife and hunting opportunities on the ranch, and thus capitalize wildlife income into land value at a higher rate (i.e., at a lower capitalization rate).

Initial analyses identified several data limitations and pointed to the need for modification. First, alternative specifications of ranch size were included to recognize that per acre ranch value is expected to decrease with increasing ranch size. Larger ranches sell for less on a per acre basis than smaller ranches. *DEEDSECT* and *LEASESECT* were initially included as separate variables to evaluate whether ranches are discounted based only on increasing size of the deeded land acreage or if additional discounts are warranted for public land acreages. *LEASESECT* was not statistically significant, suggesting ranch buyers discount ranch prices based on the percentage of the land area on public lands [equation (4)] but are not concerned with the overall size of grazing leases. The discount for deeded sections fit best as the natural log of *DEEDSECT*, suggesting the size discount decreases at a diminishing rate.

Residual plots indicated the model tended to over-predict the market value of ranches that were almost entirely public land. A dummy variable (*DPAG*) was added to shift the intercept when more than 90% of the ranch acres were public lands. This cutoff point was visually determined from residual plots. Alternative functional forms for the public land price discounts were explored, but the linear definition with the added *DPAG* dummy variable provided the best fit.

The average number of animal units per section that a ranch can maintain yearlong is a measure of productivity affecting annual ranch returns and land value. Additionally, a more productive ranch may have value beyond added annual earnings if ranch buyers desire vegetative cover, plant diversity, and greenness on the ranch. Higher rangeland productivity may also be an indication of past good management and stewardship. The *PROD* variable measures this additional source of value with β_{10}

expected to be positive, or zero if enhanced rangeland productivity is valued only for added ranch income.

Only 28 of the ranches included irrigated cropland, and another 16 produced crops on dryland acreages. The percentage of the land area in crops and pasture was explored as a potential explanatory variable. It was determined that having relatively productive tillable acreages did increase the value of the ranch because of the additional livestock carrying capacity and crop sales, but there were no additional price influences because some of the land was tillable.

Dummy variables were included to evaluate whether ranch selling prices differed by major land resource area (MLRA) classification. The dummy variable for the Canadian Plains (*DCP*) was excluded, and thus MLRA variables measure value relative to this area (figure 1).

Time of sale was incorporated into the model using dummy variables and the procedure of Sunderman et al. (2000) in which the value of the dummy variable for the year of sale is computed as the proportion of the year that remains after the sale date, while the dummy variable for the following year is one minus that proportion. The dummy variables for all other years were set to zero. As noted by Sunderman et al., while this approach allows the rate of change in ranch values to be different through time, it provides for a sale price continuum rather than a step function. All sales occurred between January 1, 1996 and December 31, 2002. *D03* was excluded so that the dummy variable coefficients shift the intercept relative to the January 2003 endpoint.

Empirical Results

Parameter Estimates

Parameter estimates for the ranch value models estimated on both a real- and nominal-price basis are presented in table 2. With the exception of some date-of-sale and location dummy variables, all parameters were significant at the 90% confidence level or higher. The nonnegativity parameter (τ) was highly significant in both the nominal- and real-price models ($P < 0.0001$), and the predictive power of the model was greatly improved with inclusion of the nonnegativity truncation.

The R^2 for both the real- and nominal-price models was above 93%. The R^2 of a similar real-price model but without the nonnegativity truncation (i.e., $\tau = 0$, not shown) was 79%, and the root mean squared error of the model was reduced from \$68/TAC without the truncation to \$53/TAC with the truncation. Similarly, the R^2 for alternative models formulated as traditional linear and log-log models (not shown) dropped by over 14%, to 79% and 75%, respectively. The nontruncated models also inappropriately predicted negative land values in some cases, especially for relatively low-priced public land ranches.

As noted by Xu, Mittelhammer, and Torell (1994), the importance of the truncation increases for lower-priced ranches. Measuring the dependent variable on a dollar per total acre basis likely increased the importance of the truncation relative to other models estimated on a \$/deeded acre or \$/livestock unit basis. Others have not found the truncation parameter to be statistically significant (Faux and Perry, 1999), or they were not able to obtain solutions to the complex nonlinear model (Perry and Robison, 2001).

Table 2. Ranch Value Model Parameter Estimates (dependent variable = *$/TAC Ranch Selling Price*)

		Real-Price Model		Nominal-Price Model	
Parameter	Variable	Parameter Estimate	Likelihood-Ratio Statistic	Parameter Estimate	Likelihood-Ratio Statistic
β_1	Intercept	-12,318.48	33.94***	-11,630.37	50.25***
β_2	*NETAGTAC*	25.10	10.79**	17.02	9.11**
β_3	*NETWILDTAC*	62.32	14.68***	36.70	8.99**
β_4	*HBVALTAC*	6.01	31.82***	4.77	30.47***
β_5	Ln(*DEEDSECT*)	-58.65	6.06*	-59.30	10.13**
β_6	Ln(*ELVFT*)	1,245.19	343.96***	1,271.96	41.29***
β_7	*ROUGH*	24.30	14.19***	13.27	9.61**
β_8	*DISTANCE*	-4.89	22.44***	-4.07	30.45***
β_9	*POPDEN*	15.57	12.83***	8.98	11.22***
β_{10}	*PROD*	43.31	60.12***	28.81	48.75***
β_{11}	*DPAG*	-3,053.16	3.07	-2,467.05	4.88*
β_{12}	*DMP*	54.27	0.22	29.16	0.12
β_{13}	*DMTN*	467.81	13.77***	247.85	8.58**
β_{14}	*DSD*	301.40	1.68	350.90	3.65
β_{15}	*DHP*	-347.94	9.88**	-67.87	0.85
β_{16}	*D96*	-206.09	1.63	-287.86	1.58
β_{17}	*D97*	-725.74	1.47	-610.70	4.08*
β_{18}	*D98*	277.32	0.30	-4.77	0.04
β_{19}	*D99*	-65.40	0.53	-140.16	0.30
β_{20}	*D00*	5.56	0.16	-87.15	0.14
β_{21}	*D01*	311.61	1.63	142.81	0.31
β_{22}	*D02*	170.48	0.77	183.77	0.31
β_{BLM}	*%BLM*	-69.76	108.55***	-30.94	65.42***
β_{STATE}	*%STATE*	-32.82	109.84***	-16.61	82.86***
β_{FS}	*%FS*	-74.22	21.41***	-30.55	18.04***
τ	Nonnegativity	514.69	225.53***	348.36	185.24***
R^2		= 0.93		= 0.94	
n		= 492		= 492	
Mean of Dependent Variable		= 138		= 128	
Root Mean Squared Error		= 52.65		= 47.20	
Log Likelihood		= -2,206		= -2,142	

Notes: Single, double, and triple asterisks (*) denote coefficients are statistically different from zero at the 5%, 1%, and 0.1% levels, respectively. The R^2 was computed as the squared coefficient of correlation between the actual Y_i and the predicted Y_i.

The White tests applied to the final models did not reject the null hypothesis of homoskedasticity ($P = 0.50$ for the real-price model and $P = 0.99$ for the nominal-price model). All estimated parameters bear the expected signs, though the sign for ranch elevation, roughness, and population density were uncertain a priori. The positive parameter estimates for Ln(*ELVFT*) and *ROUGH* are contrary to what would be expected if livestock production were the primary reason for ranch ownership, but consistent with the hypothesis that ranch buyers assign a high value to recreation and scenic amenities.

Spatial correlation has been noted as a potential problem with hedonic land value models (Irwin, 2002), with the effect being a loss of efficiency and a bias in the standard errors. Because of the complexity of the hedonic model, we did not formally test for spatial correlation of the errors. Residual plots indicated that the regression models predicted equally well for all ranch sizes, leased land percentages, and for all years and NRCS major land resource areas (MLRAs). Standard errors could increase substantially and one would still reach the same statistical conclusions for important variables in the model.

The public land discount parameters β_{BLM}, β_{FS}, and β_{STATE} were statistically different from one another ($P = 0.01$) based on the likelihood-ratio test. Further analysis indicated the acreage discount for *BLM* and *FS* was not different ($P = 0.79$), while the discount for *STATE* trust lands was statistically less than *BLM* ($P = 0.007$), but not *FS* ($P = 0.13$). Average livestock carrying capacity is less on Forest Service land in New Mexico when compared to all other land types (Stuckey and Henderson, 1969). Grazing fees on New Mexico state trust lands are currently about 2.7 times greater than the federal grazing fee. These productivity and cost differences affect ranch value and further differentiate grazing permit values through differentials in income earning potential, though these value differences are minimal with the relatively small parameter estimate for ranch income (table 2).

Marginal Price Effects

As noted above, the changing value of the *D*-function means the marginal impact of changes in explanatory variables will be different depending on ranch-specific characteristics. Consider the relative frequency of the values taken by the *D*-function in the sample and what this implies about marginal changes in land value. Figure 2, panel A shows the strong correlation between *D*-function values and the $/TAC selling price of the ranch. Panel B shows a similarly strong but inverse correlation between *D*-function values and the percentage of the ranch acreage on public and state trust lands. The cumulative distribution of *D*-function values is presented in panel C.

Several parameter estimates seem illogical until the changing value of the *D*-function is recognized. The estimated parameter for house and building value ($\hat{\beta}_4 = 6.01$) seems exceptionally high. Rather, this coefficient would be anticipated to be near 1, implying that a dollar of structures and improvements adds about a dollar to the value of the ranch. The marginal effect of increasing *HBVAL* will be $1 or less when the *D*-function is 0.16 or less [equation (7)]. As shown in figure 2, this was the case for 90% of the ranches studied.

The coefficient associated with *DPAG* (−3,053) also appears exceptionally large until it is recognized that the public land ranches where this adjustment applies are relatively low valued and have *D*-function values ranging from 0.002 to 0.004. The marginal effect of moving a ranch to over 90% public or state land, all other things equal, is to decrease its selling price by $6 to $12 per total acre.

Ranch Location

Topography, elevation, and vegetative characteristics vary greatly across New Mexico, and the MLRA classification of the NRCS (figure 1) attempts to capture these differences.

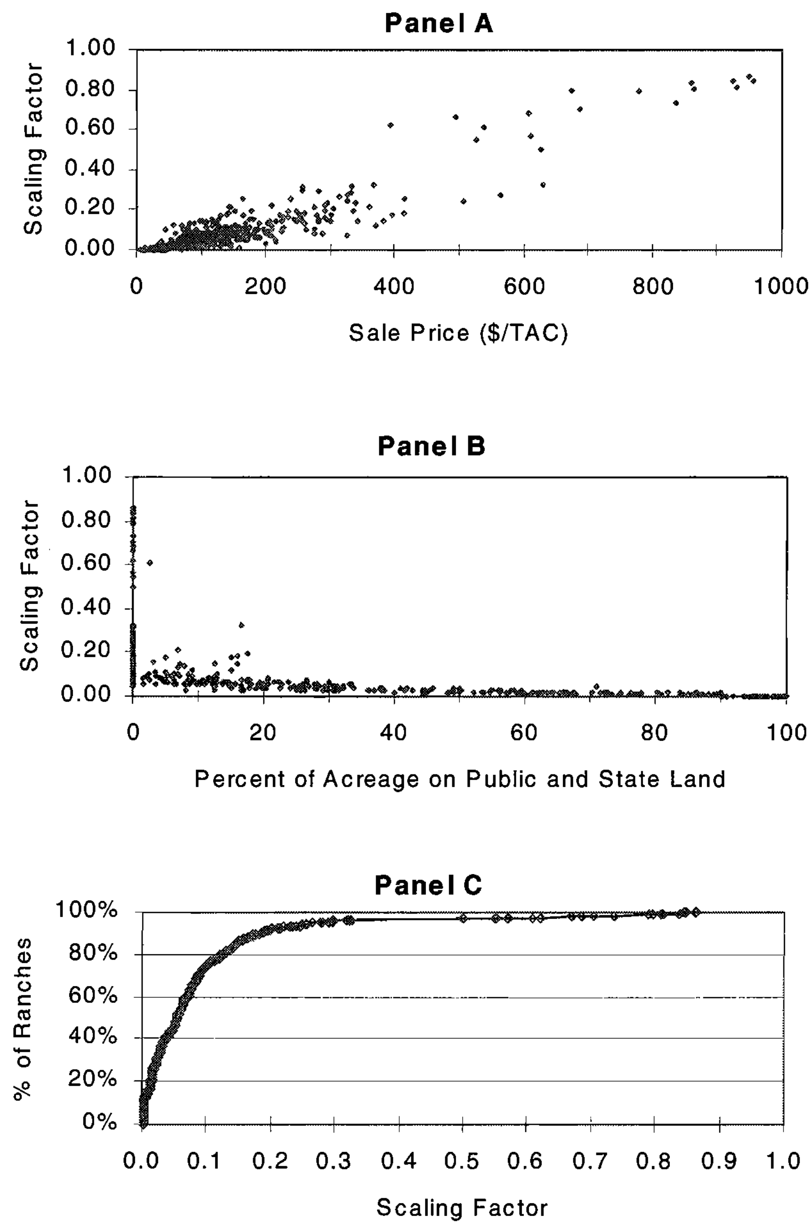


Figure 2. Distribution of scaling factor values

Table 3. Average *D*-Function Value and Average *$/TAC* Real 2002 Ranch Selling Prices by Ranching Area

Ranching Area	*D*-Function Value	*n*	Mean ($)	Std. Dev. ($)	Minimum ($)	Maximum ($)
Canadian Plains (*DCP*)	0.090	210	128	102	12	852
High Plains (*DHP*)	0.072	97	128	62	31	300
Mountains (*DMTN*)	0.258	39	268	282	5	850
Southern Deserts (*DSD*)	0.027	64	50	74	9	565
Mesas & Plateaus (*DMP*)	0.082	82	119	139	9	887
All Areas	0.090	492	128	133	5	887

Elevation and roughness are obviously higher in the mountains. The most productive rangelands are on the plains of northeastern New Mexico (Stuckey and Henderson, 1969), and the highest percentage of leased public lands is for BLM ranches in the southern deserts and FS ranches in the mountainous areas. These differences explained much of the regional variation in ranch sale price (table 3). Consistent with desired amenity values of greenness and scenic views, the dummy variable for location in the mountains was statically significant ($P = 0.0002$). The average *D*-function value when ranches were located in the mountains was 0.258, which by equation (7) reduces the average marginal impact of the mountain location to $122/acre ($468 × 0.258). Ranch location on the flat windswept High Plains reduced average real ranch selling price by about $25/acre (−$348 × 0.072) relative to ranches located in the adjacent Canadian Plains area.

Ranch Income

Total ranch value is estimated by multiplying the predicted acre price by the total acres on the ranch. The marginal change in total ranch price from adding agricultural income is then estimated as $D(\cdot)\hat{\beta}_2 \Delta NETAG$, so $1/(D(\cdot)\hat{\beta}_2)$ provides an estimate of the implied capitalization rate. The parameter estimate for β_2 in the real-price model ($25) suggests a minimum capitalization rate of about 4% for high-valued ranches where $D(\cdot)$ is close to one. The implied capitalization rate increases as the *D*-function value decreases.

To explore how livestock income influenced ranchland value, and to estimate the market value of public land grazing permits, we consider a 20-section desert ranch in southern New Mexico and a mountain ranch of similar size in western New Mexico. Average rangeland productivity was defined differently depending on ranch location and land type (table 4). Assumed differences in rangeland productivity between land types were defined from regional averages reported in the ranch sales database and by Stuckey and Henderson (1969). January 2003 market values are reported.

Ranch value estimates were obtained by changing the relative amounts of public versus deeded land in the real-price model while holding rangeland productivity for each land type constant at the levels shown in table 4. Average rangeland productivity was held constant by changing the total number of AUY on the ranch, and because deeded land acreages were defined to have higher average rangeland productivity, the total number of AUY increased with increasing amounts of deeded land. The part of ranch value attributed to livestock production was estimated by noting how ranch value was

Table 4. Baseline Conditions for Representative BLM and FS Ranches (January 2003 market values)

Model Parameter	Units	Southern Desert Ranch	High Mountain Ranch
Ranch Size	sections	20	20
Deeded Land Productivity	AUY/section	11.0	16.3
State Trust Land	AUY/section	10.0	15.0
BLM Land	AUY/section	9.8	—
FS Land	AUY/section	—	5.8
Acres of State Trust Land[a]	acres	2,560	2,560
House and Building Value	$ total	$43,500	$43,500
Roughness Coefficient	index	3.3	15.0
Ranch Headquarters Elevation	feet	4,400	7,500
Approximate Location	—	Animas	Reserve
Distance to Trade Center	miles	30	110
County	—	Hidalgo	Catron
Population Density	people/square mile	1.71	0.51
MLRA	—	SD	MTN

[a] Acreage on state land remained constant. Acreage allocation among deeded, BLM, and FS varied.

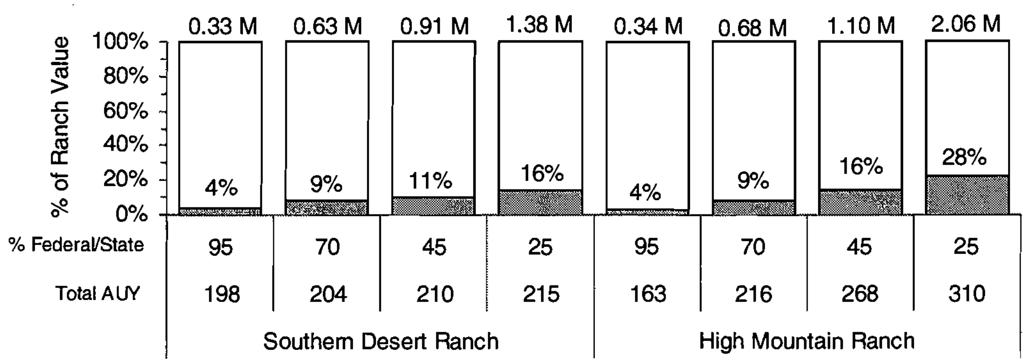
reduced when all AUY on the ranch were removed from the model. The analysis was performed using a spreadsheet, and the interested reader is referred to the RANVAL website for program access (Torell, Rimbey, and Ramírez, 2005). The data and statistical programs used in the analysis are also available at the site.

As shown in figure 3, when the model ranches were defined to have 95% of acreage on public lands (20% state, 75% federal), the estimated January 2003 market value was similar at $0.33 million ($26/TAC) for the desert ranch and $0.34 million ($27/TAC) for the mountain ranch. Of this amount only about 4% of ranch value was explained by livestock income earning potential. The estimated January 2003 ranch value increased to $1.38 million ($108/TAC) for the desert ranch and to $2.06 million ($161/TAC) for the mountain ranch when leased state and federal land was reduced to only 25% of the land base. Agricultural earnings explained 28% of the ranch market value for the high-mountain deeded land ranch.

Wildlife Income

A dollar of wildlife income added significantly more to ranchland value then did a dollar of agricultural income ($P = 0.008$). The hunting and recreation experience is the apparent reason for this finding.

A ranch authorized with a landowner bull elk permit that is marketable at $5,000 annually could expect the total value of the ranch to increase by $D(\cdot)\hat{\beta}_3 \Delta NETWILD$, or $D(\cdot) \times 62 \times 5{,}000$. Consider the 39 study ranches located in the mountainous areas of the state. Fifteen of these ranches did not have wildlife income, and the estimated average D-function value for these ranches was 0.050. In contrast, 24 of the mountain ranches had wildlife income averaging $3.87/TAC, and the estimated average D-function value for these ranches was 0.388. Evaluated at this average, the marginal land value



Notes: Ranch characteristics are defined in table 4. State land was held constant at four sections, or 20% of acreage. Total AUY was adjusted to maintain the defined rangeland productivity by land type.

Figure 3. Predicted January 2003 ranch value and percentage of value attributed to livestock production with varying amounts of public land

contribution of a $5,000 bull elk permit is estimated to be $120,280. This suggests an approximate 4% capitalization rate. But, when the elk permit is added to a lower-priced ranch with a lower D-function value, the implied capitalization rate is greatly increased and the land-value impact is reduced.

Grazing Permit Value

The contribution of federal and state land grazing permits to ranch value is of continued interest with the ongoing debate about the management of public lands. Recent proposals by environmental groups are to use public funds to pay ranchers $175/AUM for grazing permits as a way to eliminate grazing on public lands. The contention is that this is a lucrative offer given that the average market value of these permits is only $35 to $75/AUM (National Public Lands Grazing Campaign, 2005).

The marginal value of grazing permits can be computed by recognizing that the total value of the ranch is the estimated per acre value times total acreage. It matters whether public land grazing capacity or grazing capacity plus leased acreage is altered. Consider first the situation where ranch acreage is not changed, but the allowed grazing capacity of the federal allotment is reduced by 1 AUY (or 12 AUMs). Starting with equation (7) and following the variable definitions in table 1, the marginal impact on per acre ranchland value is given by:

$$\frac{\partial H(\mathbf{X};\beta)}{\partial FEDAUY} = D(\cdot)\left(\beta_2 \frac{\partial NETAGTAC}{\partial FEDAUY} + \beta_{10} \frac{\partial PROD}{\partial FEDAUY}\right). \tag{10a}$$

When multiplied by total acres, the marginal change in total ranch value is:

$$\frac{\partial H(\mathbf{X};\beta)}{\partial FEDAUY} TOTAC = D(\cdot)\left(\beta_2 \frac{\partial NETAG}{\partial FEDAUY} + \beta_{10} 640\right), \tag{10b}$$

where it is noted that $\partial PROD/\partial FEDAUY = \partial[640 \times TOTAUY/TOTAC]/\partial FEDAUY = 640/TOTAC$. Altering grazing capacity on other land types is similarly computed.

Estimates of $D(\cdot)$, β_2, and β_{10} in equation (10) are positive, such that decreasing the number of AUY on federal allotments will decrease the market value of the ranch. As shown in panel A of figure 4, adding the grazing capacity from a section of rangeland increased the market value of the desert ranch by as much as $30,308 ($47/added acre) if the initial ranch was defined to be 100% deeded land. If the ranch was at the other extreme with no deeded land, the grazing value of an added section was approximately $728 ($1.14/added acre). The *DPAG* dummy variable shifts ranch value down for ranches exceeding 90% public land, and there is a discontinuous break at this point. Because grazing capacity was defined to be similar between land classes for the desert ranch (table 4), the grazing contribution was similar between land types.

A similar pattern of value arises for the mountain ranch, but because AUY/section carrying capacity was defined to be substantially less for FS land (table 4), the change in land value per section from reduced grazing was less for FS land versus state and deeded land. On a $/AUM basis, the capitalized grazing value of public lands (figure 4, panel A) on high percentage public land ranches was considerably less than the $175/AUM proposed buyout payment for removing grazing on these lands.

Reduced grazing capacity is estimated to reduce land values. It does not necessarily follow, however, that removing grazing capacity plus public land acreages will decrease the total value of the ranch. The marginal change in total ranch value from altering leased land acreages (we consider BLM here) is given by:

$$\text{(11a)} \qquad \frac{\partial \$TOTAL}{\partial BLMAC} = H(\mathbf{X}; \beta, \tau) + \frac{\partial H(\mathbf{X}; \beta, \tau)}{\partial BLMAC} TOTAC,$$

where

$$\text{(11b)} \qquad \frac{\partial H(\mathbf{X}; \beta, \tau)}{\partial BLMAC} = D(\cdot)\left(\beta_2 \frac{\partial NETAGTAC}{\partial BLMAC} + \beta_3 \frac{\partial NETWILDTAC}{\partial BLMAC} + \beta_4 \frac{\partial HBVALTAC}{\partial BLMAC} + \beta_{10} \frac{\partial PROD}{\partial BLMAC} + \beta_{11} \frac{\partial DPAG}{\partial BLMAC} + \beta_{BLM} \frac{\partial \% BLM}{\partial BLMAC} + \beta_{STATE} \frac{\partial \% STATE}{\partial BLMAC} + \beta_{FS} \frac{\partial \% FS}{\partial BLMAC} \right).$$

As indicated by the derivative, the marginal value of the grazing permit depends on all factors that determine ranchland value plus how the land mix and net ranch income is altered as permit acreage changes.

Consider first the marginal value of deeded rangeland. As shown in figure 4 (panel B), with the desert ranch, removing a section of deeded rangeland from a 20-section ranch that is 100% deeded decreased ranch value by an estimated $163/acre removed. Of the total value contribution, $47/acre (29% of total value) was from the livestock supported on the acreage (panel A). For the similar 100% deeded mountain ranch, deeded lands contributed $501/acre, with income earning potential from the land contributing $191/acre of that value (38%). Because deeded lands are not discounted in the model, adding deeded land acres necessarily increases ranch value, but the marginal contributory value decreases as the initial land base of the ranch includes more and more public land. Two contrary effects are important. In equation (11), added agricultural and wildlife income, and added rangeland productivity, necessarily increases ranch

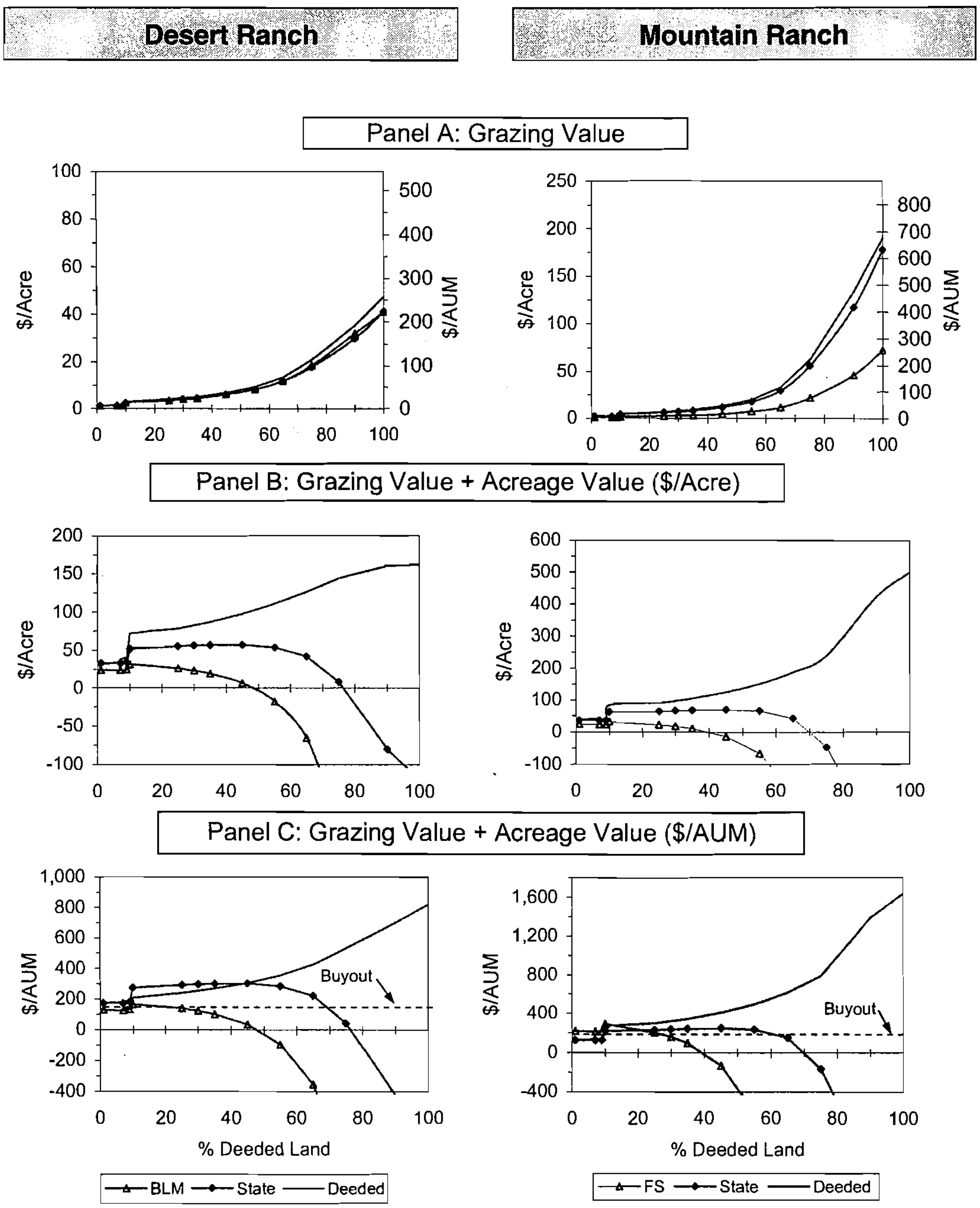


Figure 4. Marginal change in ranch value from altering grazing capacity and grazing capacity plus land acreage on desert and mountain ranches with different initial amounts of deeded and leased public land

value.[3] However, because public lands are discounted, the negative discount for public land acreages may more than offset the positive income value. This is especially true for high-priced deeded land ranches where the *D*-function value is relatively high.

Consider now the case where the desert ranch was defined to have 25% BLM land, 20% state trust land, and 55% deeded land. The estimated January 2003 market value of this ranch was $0.90 million (figure 3). Removing grazing from a BLM section on the ranch decreased capitalized grazing value by $5,240 ($8.19/acre), but estimated total ranch value increased by $11,426 ($17.85/acre removed) when the public land acreage was also removed. As observed from figure 4 (panel B), grazing capacity plus acreage on BLM or FS land added about $20–$25/acre to ranch value when ranches were defined to initially have no more than 30% deeded land. The grazing income portion of value was less than $3/acre (panel A). It is the public land acreage that contributes the majority of land value.

On an AUM basis (figure 4, panel C), the BLM acreage and grazing capacity contributed about $130/AUM to ranchland value for high percentage public land ranches. The similar value was over $200/AUM for the FS permit. With similar per acre contributions for BLM and FS lands (panel B), the higher AUM value for FS is because of the assumed lower grazing capacity (i.e., dividing by less AUMs) on the FS allotment. The total contributory value of the grazing permits (acreage + grazing capacity) is at or below the $175/AUM buyout offer (panel C), depending on the amount of deeded land initially included.

For the most part, New Mexico ranches are contiguous with yearlong grazing of different types of land scattered throughout the ranch. The conclusion that both public and deeded lands add land area, making the ranch bigger, and that this adds the majority of ranchland value, is logical with this land use pattern. Consistent with this finding of "bigger is better," Sunderman and Spahr (1994) found deeded acres add value to Wyoming ranches even when they do not result in an increase in the forage productivity of the ranch. They did not consider the contributory value of public land acres, only public land AUMs.

Estimated ranch value decreased with the addition of BLM land when the initial ranch was greater than 50% deeded land (figure 4, panel B). This point of negative value occurred with an approximate 40% deeded base for the FS ranch and 75% deeded base for state permits. Sunderman and Spahr (1994) similarly concluded that BLM and FS permits in Wyoming diminish ranch price when a small amount of public land is included on the ranch. There are a number of reasons why adding public land to a high percentage deeded land ranch might decrease value. The bureaucratic red tape and hassle of dealing with land agencies, environmental rules and regulations, and anti-grazing activists is a growing concern and expense for public land ranchers. The lack of control and the inability to stop outsiders from entering the ranch is another obvious reason.

Grazing Fees

Grazing fees affect net ranch income, and the change in land value as grazing fees increase depends on the degree to which annual livestock income influences land values.

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[3] If ranch income has a minimal effect on ranchland value, as we estimate it does, land values could go down as grazing capacity on public land increases. This could occur if the model has additional price discounts related to the percentage of grazing capacity on public lands. Our model included a discount only for the percentage of acreage on public lands because these percentages were nearly identically defined in the data set.

This change can be estimated as $\beta_2 D(\cdot)\Delta FEE$. In the sample, D-function values ranged from about 0.002 to 0.2 for ranches with federal and state land (figure 2). The realized range of land value reduction from a $1/AUM grazing fee increase would be a minimal amount—from about $5/AUM to zero. Whenever significant increases in grazing fees are proposed, one of the arguments against the fee increase is that ranchland values will greatly diminish [see, for example, comments to land use reforms proposed under Rangeland Reform '94 (U.S. Department of the Interior/USDA, 1995, p. 128)]. Yet, when variation in ranch income explains very little of the variation in ranchland value, how can this be the case?

We estimated a net average 2002 forage value of $7.83/AUM based on average ERS reported lease rates (USDA/National Agricultural Statistics Service). Total fee and non-fee grazing costs above this amount would mean a negative net income from the public land acreage. However, because such a small percentage of ranch value depends on ranch earning potential, it does not imply a negative market value for the grazing permit. Following the procedure of Torell and Doll (1991) and Sunderman and Spahr (1994) for computing the grazing fee that forces permit value to zero is a fruitless exercise when ranchland value does not depend on ranch earnings. Grazing permit value is not determined exclusively by livestock production value as traditionally stated (Roberts, 1963). While it is certainly possible that a major increase in grazing fees will alter the mindset of ranch buyers and diminish their willingness to pay for public land grazing permits, under the current fee structure the linkage among ranch income, grazing fees, and land value is minimal.

Land Appreciation

Using the RANVAL spreadsheet for calculation (Torell, Rimbey, and Ramírez, 2005), the estimated real-price value of the 95% public land desert ranch increased from about $0.328 million in January 1996 to $0.339 million by April 2002. This suggests a nearly constant real value with an estimated appreciation rate of about 0.5% per year. Torell et al. (2001) reported a declining real value for grazing permits over the earlier 1966 to 1996 period.

Martin and Jeffries (1966) concluded that the major reason for inflated ranch prices must be consumptive-related outputs, and we agree for public land leases, given their minimal value appreciation and the minimal contribution of ranch income to ranchland value. Public land leases allow the purchase of a bigger ranch, and because the price is less, some individuals who can only afford a relatively low-priced ranch can enter the ranching business and live the desired lifestyle.

The estimated rate of land appreciation increased with successive increases in the percentage of deeded land on the ranch. Over the January 1996–December 2002 study period, most of the value increase occurred during 1997 and 2000. Peak values were estimated during January 2001. The desert ranch with 75% deeded land was estimated to increase in real value by about 2% per year from January 1996 through April 2002. Scenic deeded mountain ranches with wildlife income appreciated in value by 8% to 9% per annum on a nominal-price basis and by 4% to 5% on a real-price basis. An obvious implication is that high-priced deeded ranches are a better buy. Land speculation may be the most important reason for purchase of these ranches.

Conclusions and Policy Implications

Numerous policy and rural development implications arise when consumptive values are associated with rural land ownership. Over 30 years ago, Smith and Martin (1972) noted that, based on livestock production value, most range improvements show a negative benefit/cost ratio, and that rates of return from livestock operations are low by any standard investment criteria. Rates of return on nonfarm assets now dominate investment returns from agricultural assets (excluding land appreciation), producing both a higher rate of return and lower risk (Erickson, Moss, and Mishra, 2004).

Our results indicate that the capital gains component of ranch returns and the marginal benefit from range improvement vary with ranch characteristics. High-valued ranches are more responsive to altered ranch income and improvement. This conclusion about differentials in appreciation rates and marginal changes for high-priced versus low-priced ranches is an area of potential concern and need for further research. The truncated model suggests that marginal impacts are rescaled based on the market value of the ranch and that the scaling is applied equally to all X_i. While the truncated model fit the data substantially better than other traditional formulations of the hedonic model, a more flexible functional form that allows variation in the scaling factor may be more appropriate. It is also uncertain how broadly the results of this study would appropriately apply. The marginal contribution of agricultural income may be considerably different for seasonal leases in northern states, though research in Wyoming by Sunderman and Spahr (1994) supports the "bigger is better" finding of this investigation. Deeded Wyoming rangeland added ranchland value even without added livestock grazing capacity.

Smith and Martin (1972) concluded that economic models attempting to explain rancher behavior based only on the profit motive are inadequate and will lead to ill-conceived land-use policies and policy assessments. This statement is likely even more relevant today. We found ranch values vary significantly and consistently, with high value placed on ranch location in the mountains and with recreational opportunities. A statistically significant but yet relatively small amount of variation in ranchland value was explained by variation in ranch income-earning potential. Ranch buyers maximize utility, not profit. Land-use policy development and implementation requires a great deal more than is offered by traditional cost-and-return studies related only to the most obvious livestock product.

When consumptive outputs from ranches are considered, the answers to some policy questions are obvious, at least in hindsight. Consider as an example the 1992 Incentive-Based Grazing Fee Study (U.S. Department of the Interior/USDA, 1993). In this study, it was anticipated that the willingness to pay for public land forage would be consistent with the traditional profit-maximization model. Fee and non-fee grazing cost data were gathered from western ranchers leasing both public and private forage. It was assumed the estimated difference in grazing costs (implied forage value) would be high enough that BLM and FS could devise incentives to compensate ranchers who were managing and improving public lands to the agencies' satisfaction. Contrary to expectations, considering the existing grazing fee and other non-fee grazing costs, BLM and FS permit holders were found to pay more on average than those leasing private forage. Public land ranchers could justifiably argue that they could not afford to pay higher grazing fees, largely because they had paid too much for the public land ranch. Lifestyle amenities explain the apparent inconsistency in the study results. Consistent with the findings of Blank (2002), western ranching has been both a way of life and a business, but it is now a business only to some.

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