Why Grazing Permits Have Economic Value

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Grazing permit value supposedly arises as a cost advantage for permit holders. Yet, ranches are overpriced relative to income earning potential. Hedonic models for New Mexico and the Great Basin were used to evaluate permit value. We found less than 16% of the marginal value of grazing permits in New Mexico can be attributed to livestock production, and for Great Basin ranches, estimates indicate none of the value can be assigned to livestock production. Deeded and public land acreages make the ranch bigger and it is the acreage, not the cattle grazing it, that adds the most to ranchland value.

Key words: amenity owners, grazing fees, hedonic model, land value, public land grazing, ranch sales, ranch value

Introduction

The reason public land grazing permits have economic value is obvious to economists. Gardner (1997, p. 11) offers the traditional reason:

> For the past few decades the grazing fee has been set by a formula which has priced the forage below its value to permittees. The fact that permits have market value proves that the fee is less than the value of the forage. The permit's value represents the capitalized value of expected future differences between the fee and the value of the forage.

With a strong tie to production economic theory, few economists have questioned what appears to be the logical explanation for the existence of permit value. Yet, it has long been recognized that western ranches are overpriced relative to their income earning potential and that the lifestyle and social fulfillment experienced by ranch families are major reasons for ranch purchase. Ranchers maximize utility, and the desirable lifestyle is an additional important reason ranch prices are inflated relative to price levels justified from livestock income earnings. This is also true for public land grazing permits.

Perhaps the first person to recognize and write about this subject was William Martin in studies examining the market value of Arizona ranches in the 1960s. Referring to

earlier research by Roberts (1963) that conceptualized the capitalized value as the reason for permit value, Martin and Jeffries (1966, p. 236) noted:

> The total marginal value product (MVP) of a section of rangeland is higher than the MVP for grazing only. Roberts' analysis is correct as far as it goes. It shows that under current grazing-fee policy there will be a positive value to be capitalized into a sale price for the lease. But sale prices for leases are very much higher than the difference due to beef productivity alone would warrant.

In Martin's (1966) work, economic satisficing ranchers were said to receive "other outputs" from ranch ownership including utility, prestige, and potential capital gains from owning both private and public lands.

This paper briefly revisits the historical progression of economists' beliefs about why grazing permits have economic value, including the pioneering work of William Martin, Delworth Gardner, Keith Roberts, and Darwin Nielsen. Hedonic ranch value models developed for New Mexico and the Great Basin (southern Idaho, northern Nevada, and eastern Oregon) are used to explore the relative importance of beef production versus Martin's other outputs. We present recent estimates of permit value for the two ranching areas and estimate how permit value changes as public land acreages, grazing use, and grazing fees change. We highlight the historical evidence that various factors including livestock production and land use policy have played an important role in determining permit value. The objective of the research is to test the validity of the traditional permit value model.

Historical Evidence For and Against the Grazing Cost Advantage Model

Foundation grazing fee studies were conducted in Utah in the 1960s that formed the basis for current beliefs about why grazing permits have economic value. Using ranchers' opinions of value for 30 grazing permit sales and with comparison to capitalized rental fees for private forage, Gardner (1962) concluded that eligibility requirements imposed on the transfer of grazing permits which tied the permit to specific ranches had produced an inefficient allocation of grazing permits. The price of actual permit transfers was found to be less than expected based on livestock production rental value. In a following study, Gardner (1963) proposed reforms to the permit system that would more efficiently allocate grazing permits.

Nielsen and Wennergren (1970) found there to be a reasonable amount of competition for grazing permits, even with the transfer restrictions identified by Gardner. They reported on an empirical test of the validity of the Utah grazing fee model using data from seven forests in Utah and concluded that the cost differential between total fee and non-fee federal and private grazing costs, when capitalized at about a 4% rate of interest, approximated the average observed permit value.

While on average a capitalized cost advantage appeared to explain the value of Utah Forest Service grazing permits in 1964, a great deal of variability was found. Jensen and Thomas (1967) reported that factors associated with grazing cattle on federal ranges explained only 55% of the variation in permit value. Non-fee grazing costs were highly variable throughout the West, and corresponding permit values were also variable and inconsistent in many cases [U.S. Department of the Interior/U.S. Department of

Agriculture (USDI/USDA), 1977]. It is also important to remember that at nearly the same time, Martin and various coauthors (Martin, 1966; Martin and Jeffries, 1966; Smith and Martin, 1972) were questioning the profit motive as a reason for ranch purchase. Private lands were estimated to be overpriced by nearly three times relative to the value justified for livestock production, and while not specific about the level of overpricing for federal lands, Martin and Jeffries (1966) characterized federal land permits as overpriced as well. It is now widely recognized that the desirable rural lifestyle and agrarian values described by Martin have significantly inflated the market value of farms and ranches (Blank, 2002; Gosnell and Travis, 2005; Gosnell, Haggerty, and Travis, 2006; Torell et al., 2005).

There is a great deal of evidence showing that the market value of grazing permits has responded to alterations in the rules and regulations governing livestock grazing on public lands, to negative news about potentially restrictive land use regulations, and to the potential of higher grazing fees. As noted by Egan and Watts (1998), as other public land uses have gained greater importance, and political pressure has been applied to emphasize these other uses, the market value of grazing permits has decreased. They estimated the 1992 real-price of a public land AUM[1] in Nevada decreased from $72/AUM in 1978 to $22/AUM in 1994, a 70% decrease.

Trends in New Mexico permit values are consistent with these findings. Figure 1 shows historical permit and deeded land value estimates from 1966 through January 2003. The estimates come from various sources, including a survey of ranch appraisers conducted by Fowler and Gray (1980, covering the period from 1966–1979) and hedonic models estimated by Martin and Jeffries (1966), Torell and Kincaid (1996, for the period 1979–1989), Torell and Bailey (2000, for the period 1987–2000), and Torell et al. (2005, for the period 1996 through January 2003). The discontinuities in the graph reflect different permit value estimates from the various hedonic models. Further, with the exception of the appraiser estimates of permit value in the 1960s and 1970s, permit value estimates shown are real-priced marginal values. Value estimates are for a 20-section ranch with characteristics similar to the representative desert and mountain ranches described in table 1.

With CPI adjustment for inflation, Bureau of Land Management (BLM) permits appreciated in real value from $73/AUM in 1966 to about $123/AUM by the end of 2002, a 1.44% annual rate of appreciation over the 37-year period. This is far less than average appreciation rates for deeded lands [USDA/National Agricultural Statistics Service (NASS), 2005]. Real Forest Service (FS) values depreciated at an annual rate of -0.76%.

The latest New Mexico hedonic model (Torell et al., 2005) estimates state land permit value to be substantially more than estimates from the earlier model ($300/AUM versus $150/AUM, figure 1). With an expanded and updated sample of ranch sales and with redefinition of the dependent variable in the model to be on a dollar per total acre ($/TAC) basis, we believe the recent estimates of state land permit value accurately reflect the current situation. Given this assumption, the peak inflation-adjusted value of New Mexico state land permits was estimated to be $364/AUM in 1982, decreasing to about $100/AUM by 1989, and returning to about $300/AUM by 2001.

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[1] 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.
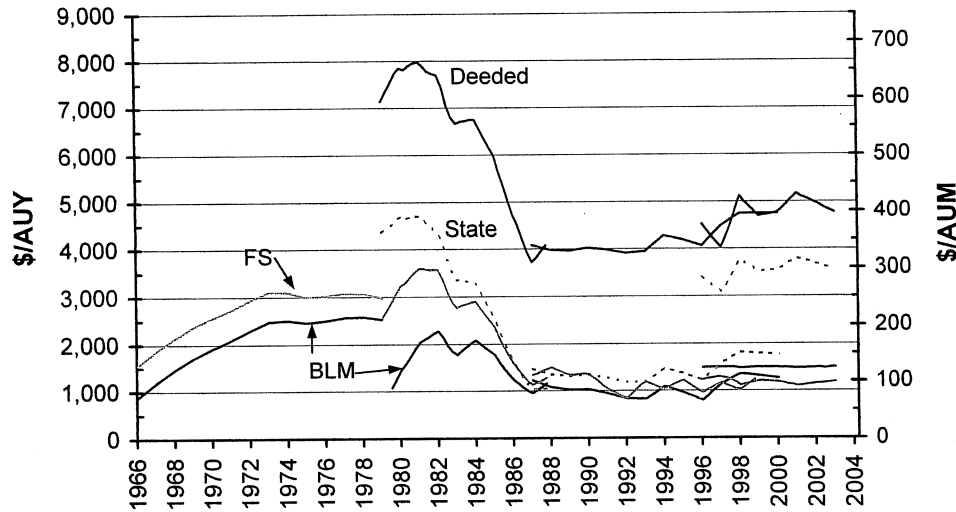
Sources: Martin and Jeffries (1966); Fowler and Gray (1980); Torell and Kincaid (1996); Torell and Bailey (2000); and Torell et al. (2005). Earlier hedonic models were reestimated with the characteristics of the 20-section desert and mountain ranches described in table 1.

Figure 1. Marginal 2002 real-price deeded land values and grazing permit values in New Mexico, 1966–January 2003

The trends in New Mexico ranchland and permit values shown in figure 1, and the periodic estimates of value available for other states, do not follow any logical progression of livestock returns, grazing fee levels, or conceivable cost advantages that could have possibly existed. The trend does follow the broader movement of farm and ranch land values at the national scale (USDA/NASS, 2005), suggesting grazing permits are treated similar to deeded land but with a discounted price. This point was reinforced in 1992, when an updated grazing cost survey was completed. The 1992 Incentive-Based Grazing Fee Study (Bartlett et al., 1993) used what has been called the total cost approach to value forage with the total fee and non-fee costs of grazing federal and private land leases compared. Using grazing cost data from Idaho, Wyoming, and New Mexico, it was determined that permit values occurred in 1992 without a cost advantage for grazing public lands. The average grazing cost difference between federal and private land, excluding interest on the grazing permit, was $0.13/AUM. On average, there was nothing left to capitalize. This finding was markedly different from the earlier observations and calculations of Nielsen and Wennergren (1970).

Public land ranchers now face many contentious issues about the terms of their leases, including de-stocking and altered grazing use to protect endangered species and riparian areas, and the need to accommodate other non-grazing uses. In recent years some ranchers have been forced to temporarily de-stock. Forest Service policies in New Mexico are now generally more contentious than BLM, and federal policies are now considerably more controversial than state land policies. This has not always been the case, as noted by Torell and Doll (1991). Until 1982, New Mexico ranchers generally favored holding a state land lease because of the hands-off management style of the land agency. This all changed with the 1982–86 New Mexico State Land Office administration when higher grazing fees were proposed in combination with other more restrictive

Table 1. Base Ranch Conditions for Permit Value Estimation

PANEL A. New Mexico–Southern Desert Ranch

Description	Acres	AUMS	% of Acres	% of AUMs	Acres/ AUM
Deeded Land	3,840	792	30.0%	32.4%	4.8
BLM Land	6,400	1,176	50.0%	48.0%	5.4
State Trust Land	2,560	480	20.0%	19.6%	5.3
Total Ranch Size	12,800	2,448	100.0%	100.0%	5.2
Total Livestock Carrying Capacity (AUY)		204			
Roughness Index		3.3			
Elevation (feet)		4,400			
Distance to Trade Center (miles)		30			
Population Density (people/square mile)		1.71			
Major Land Resource Area (MLRA)	**Southern Desert:**				
Net Livestock Income ($Total)	$15,756 ($77/AUY) ($1.23/TAC)				
Value of Houses, Buildings & Facilities ($Total)	$43,500 ($213/AUY) ($3.40/TAC)				

PANEL B. New Mexico–High Mountain Ranch

Description	Acres	AUMS	% of Acres	% of AUMs	Acres/ AUM
Deeded Land	3,840	1,174	30.0%	47.9%	3.3
USFS Land	6,400	1,176	50.0%	48.0%	5.4
State Trust Land	2,560	720	20.0%	29.4%	3.6
Total Ranch Size	12,800	3,070	100.0%	100.0%	4.2
Total Livestock Carrying Capacity (AUY)		256			
Roughness Index		15			
Elevation (feet)		7,500			
Distance to Trade Center (miles)		110			
Population Density (people/square mile)		0.51			
Major Land Resource Area (MLRA)	**Mountains:**				
Net Livestock Income ($Total)	$19,711 ($77/AUY) ($1.54/TAC)				
Value of Houses, Buildings & Facilities ($Total)	$43,500 ($170/AUY) ($3.40/TAC)				

PANEL C. Great Basin Ranches

Description	Acres	AUMS	% of Acres	% of AUMs	Acres/ AUM
Deeded Land	1,920	960	15.0%	60.0%	2.0
BLM or USFS Land	10,880	640	85.0%	40.0%	17.0
State Trust Land	0	0	0.0%	0.0%	
Total Ranch Size	12,800	1,600	100.0%	100.0%	8.0
Total Livestock Carrying Capacity (AUY)		133			
Roughness Index		6.1			
Major Land Resource Area (MLRA)	**Variable:**				
Net Livestock Income ($Total)	$11,664 ($87/AUY) ($0.91/TAC)				
Value of Houses, Buildings & Facilities ($Total)	$104,700 ($785/AUY) ($8.18/TAC)				

land use policies (Torell and Doll, 1991). With a new grazing fee formula that includes an annual adjustment, state land grazing fees moved from $1.60/AUM in 1986 to $3.46/AUM in 1990, and continued to increase to a peak level of $4.63/AUM in 2004. By comparison, the federal grazing fee has remained near the $1.35/AUM floor established by Executive Order in 1986.

State land policies, viewed by many as detrimental to ranchers, contributed to the declining trend in state land permit values in New Mexico through the late 1980s. The dampening effect of these policies on permit value is consistent with expectations in some cases and not in others. As public land rancher opinion about Forest Service management declined, the relative ranking of BLM and FS permit values switched places (figure 1). However, BLM and FS permits by the most recent estimates are not statistically different in value (Torell et al., 2005).

As would be expected with higher state land grazing fees and with the first real controversy about state lands in decades, state land permits moved from being the most valuable permit to the least valuable permit over the 1982–1987 period (Torell and Doll, 1991). Yet, with the doubling of state grazing fees between 1986 and 1990, to levels nearly three times the federal fee, it would be expected that state land permit values would have fallen relative to BLM and FS. In fact, because estimates of forage value in New Mexico were near the $3.50 to $4.50/AUM state fee paid after 1990 (Bartlett et al., 1993, p. 53), state land permits would be expected to have continued a downward trend in value, going to zero if forage value estimates were correct and the traditional cost advantage reason for permit value holds. Clearly, that did not happen. As shown in figure 1, current estimates of state land permit value are statistically higher than BLM and FS permits (Torell et al., 2005), and the value has rebounded to be about 75% of deeded land.

Several factors have likely contributed to the apparent inconsistent response to higher state land grazing fees. First, it provides support for our belief that the traditional cost capitalization reason for the existence of grazing permit value is not correct. Second, it supports the findings of Egan and Watts (1998) that permit values are influenced by land use controversies and expectations about future tenure and use. State land ranchers in New Mexico have complained about the higher fee, but they have paid the fee with no significant decrease in the number of acres leased.[2] The state land grazing fee is now set by a formula with annual adjustments tied to the same Public Rangeland Improvement Act (PRIA) indices used to set the federal fee. Prior to this, periodic political fights were required to increase the fee. The New Mexico State Land Office has not been in the news of late. Ranchers' opinions about the management of state lands are now generally favorable.

A second important factor likely contributing to the rebound of state land permit values is the relatively small percentage comprised by state lands on most New Mexico ranches (Torell, Ghosh, and Fowler, 1988). This is also true for other states, including Idaho and Oregon (Oregon Department of State Lands, 2006). It is likely not worth a great deal of sustained consternation when total state land grazing fee payments are a relatively small amount, even at relatively high fee levels.

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[2] This information was provided to the authors through personal communication with Dennis Garcia, New Mexico State Land Office, June 12, 2006.

A Generalized Hedonic Ranch Value Model

Sorting out the factors which contribute to the market value of grazing permits, and specifically evaluating the relative contribution of capitalized income earnings, requires that an estimate of expected annual ranch income be directly considered. Consider a simplified hedonic model:

(1) $PRICE = \beta_0 + \beta_1 CHARACTERISTIC + \beta_2 DISCOUNT + \beta_3 INCOME + u.$

Let the dollar per acre price of a ranch (*PRICE*) be measured as the total ranch price divided by total acreage including both deeded and public lands. Consider *CHARACTERISTIC* to be some desirable factor that adds to the value of the ranch. There may be several *CHARACTERISTIC* variables in the model and the desirability of these attributes is not limited to the deeded land portion of the ranch; it can also apply to public and state lands.

Now consider *INCOME* to be a measure of expected net annual income earning potential from the ranch and let *DISCOUNT* be a deduction from ranch price when the amount of public land on the ranch increases. Public lands are expected to be discounted in price because ranch buyers do not receive clear title to these lands. There can also be a lack of control on the ranch with the addition of public land, as other users must now be allowed on the ranch and there is an added bureaucracy when dealing with land agencies and other interested parties. The β_2 parameter would be negative and would measure the monetary value assigned in the ranch real estate market for these negative permit attributes.

Consider first the situation where ranch value depends only on income earning potential. This suggests β_0 and β_1 are zero, and β_3 is a measure of the rate at which annual ranch income is capitalized into land value. The inverse, $1/\beta_3$, gives an indication of the average discount rate used to capitalize expected annual income. Public lands contribute to ranch income, and the capitalized value of the grazing permit is influenced by expectations about grazing fees, non-fee grazing costs, future permit access and grazing capacity, and how the public forage contributes to the seasonal supply of forage as compared to other forage alternatives. In this first scenario, computing marginal or average permit value on a dollar per AUM basis is an appropriate calculation because the net change in ranch value results only from the annual income the permit adds.

Consider now the other extreme. Suppose ranch income does not affect ranchland value, and the land is valued as a place to live and for the other outputs described by Martin and Jeffries (1966). In this case, β_1 will be greater then zero and β_3 will be zero. There are still discounts associated with incorporating the permit into the ranch (β_2 less than zero) and, with non-use clauses included with the permit agreement, the ranch buyer must continue to produce livestock regardless of profitability. It is the bigger ranch, the ranching lifestyle, the livestock-raising activity, the added recreational experiences, access to public lands, and whatever else it is that motivates ranch buyers which combine to give the grazing permit economic value under this second scenario. Permit value comes from the added public land acreage, not the added livestock income. With this scenario it now makes no sense to compute permit value or ranch value on a $/AUM or $/AUY basis. Ranchers, appraisers, and ranch brokers have come to realize this as they observed what they consider to be exorbitant ranchland values when the value is expressed on a $/livestock-unit basis (Thompson, 2003).

The intermediate scenario as suggested by Martin and Jeffries (1966) is the most likely situation. In this case ranch buyers consider income earning potential from the permit, but they also value many additional attributes associated with the ranch, and in particular the bigger ranch and enhanced access to public lands which results from purchasing the grazing permit.

Testing whether permit value arises because of a capitalized cost advantage is equivalent to testing whether β_1 is equal to zero. If it is not zero, the relative share of land value attributed to β_1 versus β_3 can be computed, though perhaps not exactly because the livestock-raising activity adds income and it may also be valued as a lifestyle or recreational activity.

Computing a \$/AUM or \$/AUY permit value is the procedure adopted by every researcher who has estimated grazing permit value, because it has always been assumed it is the added livestock income generated from public lands that gives the permit value. The general procedure has been to specify the dependent variable as total ranch value in a hedonic model. The parameter estimate on the leased or deeded AUM variable now provides a direct estimate of the contributory value of the AUM, expressed as an average over all ranch sizes (Martin and Jeffries, 1966; Spahr and Sunderman, 1998; Egan and Watts, 1998).

Three previous studies have considered annual ranch income and its effect on grazing permit value. Using the private land lease rate times 70% as an estimate of annual forage value, Torell and Doll (1991) (with conceptual model modification by Xu, Mittelhammer, and Torell, 1994) and Egan and Watts (1998) concluded annual ranch income was capitalized into land value using a real discount rate ranging from 2.5% (Xu, Mittelhammer, and Torell) to 4.3% (Egan and Watts). The AUM, and not the acre, was considered to add to ranchland value.

Torell and Doll (1991) included several *CHARACTERISTIC* variables in their hedonic model and noted that factors other than ranch income have contributed to the market value of grazing permits. Egan and Watts (1998) considered only one *CHARACTERISTIC* variable in their model, the dollar value of buildings and improvements; thus, all non-income-related variation in ranchland value was captured through this variable or the model residual. They estimated that each dollar of house and building value contributed over \$3 to ranch value, and with this value far exceeding \$1, it is certainly possible that it captured other non-income price influences correlated with structural ranch improvements.

Model Estimation and Data Description

New Mexico

A hedonic ranch value model was estimated using 492 ranch sales in New Mexico. This model was published earlier and is described in detail by Torell et al. (2005). We used this model to estimate New Mexico permit values. A similar hedonic model was developed and described below for Great Basin ranches. Both models are adaptations of the generalized hedonic model described above. Agricultural income is included as an explanatory variable. Variables that measure desired characteristics giving ranches market value are included along with discounts for dependency on public land.

For a basic understanding and interpretation of model results, we briefly review several key points about the truncated model. A detailed presentation of models with truncated dependent variables is provided by Xu, Mittlehammer, and Torell (1994) and the interested reader is referred to their work for a complete description. The truncation recognizes that land values cannot be negative.

The dependent variable in the model is given by:

$$(2) \qquad Y = E(Y \mid Y \ge 0) + \varepsilon = g(\mathbf{X}; \boldsymbol{\beta}) + \tau \frac{\phi\left(-g(\mathbf{X}; \boldsymbol{\beta})/\tau\right)}{\Phi\left(g(\mathbf{X}; \boldsymbol{\beta})/\tau\right)} + \varepsilon = H(\mathbf{X}; \boldsymbol{\beta}, \tau) + \varepsilon.$$

The selling price of the ranch is related to explanatory variables in the model via the function $g(\cdot)$; $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability and the cumulative distribution functions for a standard normal variable, and τ is a truncation parameter to be estimated.

The dependent variable in the model is considered to be the dollar/total acre ($/*TAC*) selling price of the ranch which includes all acreages—deeded, state, and public. Total ranch value is estimated by multiplying the per acre value estimate times total acres. Others have used dollar per deeded acre ($/*DAC*) as the dependent variable (Winter and Whittaker, 1981; Pope, 1985), but in public land ranching areas this is misleading because a ranch with few deeded acres and large permit acreages will have a high price per deeded acre with additional value coming from public lands. As described in greater detail in our earlier paper (Torell et al., 2005), the $/*TAC* specification avoids statistical and interpretative problems encountered when specifying ranch value on either a total, $/*DAC*, or $/livestock-unit basis.

Marginal impacts in the nonlinear truncated model are estimated with inclusion of a scaling factor that rescales the effects of the explanatory variables. The marginal impact of a change in X_i on ranch price is given by:

$$(3) \qquad \frac{\partial H(\mathbf{X}; \boldsymbol{\beta}, \tau)}{\partial X_i} = D\left(\frac{g(\mathbf{X}; \boldsymbol{\beta})}{\tau}\right) \frac{\partial g(\mathbf{X}; \boldsymbol{\beta})}{\partial X_i}.$$

The calculated scaling factor, or D-function, ranges from 0 to 1 depending on ranch-specific characteristics. It is a proportionality factor rescaling marginal effects of the explanatory variables on Y. Marginal changes in value will be ranch-specific, depending on site-specific estimates of $g(\cdot)$ and the scaling factor (Xu, Mittelhammer, and Torell, 1994). Further, marginal changes will be less for lower-valued ranches, including those more dependent on public lands.

Great Basin

To estimate permit value for Great Basin ranches, a hedonic ranch value model was estimated using data from ranch sales negotiated between December 1997 and October 2004. Ranch sales data were supplied by Farm Credit Services (FCS) and independent ranch appraisers in Caldwell and Idaho Falls, Idaho, and Ontario, Oregon.

Upon further examination, 26 of the ranch sales were clearly not range cattle operations as we intended to study, or there were incomplete data. Attempts to explain price variation for the high-priced properties were not successful. As shown in figure 2 where the location of each sale is plotted by sale price category, and overlaid over major land resource area (MLRA) designations of the Natural Resources Conservation Service
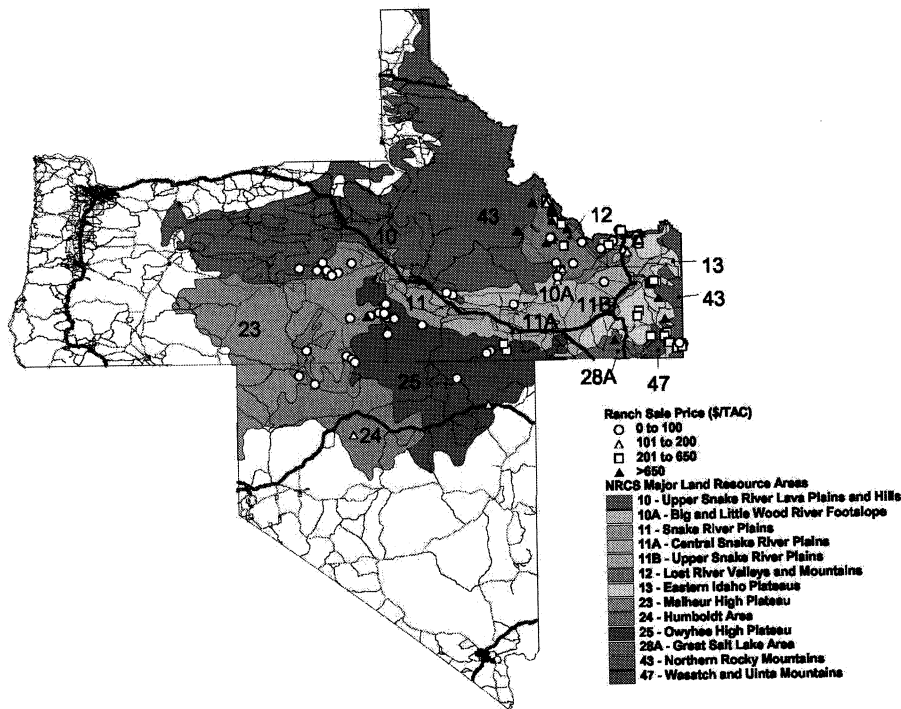
Figure 2. NRCS major land resource areas, ranch locations, and price categories of Great Basin study ranches (December 1997–October 2004)

(NRCS), 23 of the negotiated sales that sold for >$650 were located at or near recreation areas at Challis and Salmon, Idaho, or near Bear Lake, Idaho. These high-priced sales were deeded land parcels less than 2½ sections in size, where the purchase motivation was identified to be recreation and home site development. Thus, all sales with $/TAC price greater than $650/TAC were deleted. Additionally, three ranches were excluded in other areas because they were not range livestock operations or the data were incomplete. With these exclusions, a total of 84 ranch sales were used in the Great Basin analysis.

Ranch sale sheets included very little detail about grazing permit acreages and land productivity. Therefore, much of this detail was obtained from land agencies. Three of the study ranches grazed public lands in common as a member of a grazing association or a common-use grazing allotment. The acreage of these common-use allotments was split based on the share of total AUMs allocated to the ranch sold.

We assumed that federal and state trust lands, plus deeded rangeland, crop aftermath, and hay produced on the ranches, were adequate to carry the herd for the year. Grazing capacity for deeded lands was calculated as the total AUM requirement for the herd size specified on the appraisal sheet minus the forage supplied on federal and state trust land. Deeded land forage was thus computed as the residual amount. For the 84 Great Basin study ranches, it took an average of 17 acres [standard deviation (SD) = 13.9, $n = 62$] to support an AUM on BLM land, 11 acres (SD = 1.5, $n = 8$) on FS land, 8 acres

(SD = 5.9, n = 23) on state trust land, and 2 acres (SD = 4.9, n = 84) on deeded land. By comparison, the same statewide productivity rating for the 492 New Mexico sales was nearly a constant 5 acres/AUM (SD = 2.6, n = 491) across all land types except Forest Service (11 acres/AUM, SD = 7.6, n = 27).

Expected annual net ranch income was calculated as gross ranch income from live-stock and crops less total ranch expenses including maintenance, management, grazing fees, taxes, insurance, and other miscellaneous expenses recorded by the appraisers (see Torell et al., 2005, table 1, for additional detail). Annual livestock income was calculated as the lease value of the forage using USDA/NASS's *Monthly Agricultural Prices* lease rates for the year of the sale. Lease rates and grazing fees varied slightly by year, and state land fees were different by state and by year. Higher public and state land grazing fees and a higher dependency on these lands decreases the estimate of expected ranch income. Because forage lease rates and grazing fees changed little between years, using the reported annual lease rate versus some longer-term average to formulate an expec-tation of net ranch income would be nearly equivalent.

Crop income and cropping expenses were recorded by appraisers on the sale sheets. Hay that was produced and fed to the cow herd was valued at the AUM lease value and was not recorded as a separate crop income. Crop income averaged $1.78/TAC, with 19 of the 84 study ranches producing and selling crops in addition to livestock.

Once the hedonic models were estimated, for application to grazing permit valuation, specific assumptions were made about acreages, rangeland productivity, lease rates, and grazing fees for the model ranches described in table 1. With the assumed forage lease rate and other assumptions used to define annual ranch income, the calculation proce-dure was equivalent to valuing deeded forage at $7.83/AUM. A $1.35/AUM grazing fee was subtracted so that Bureau of Land Management and Forest Service forage was valued at $6.48/AUM. State land grazing fees ranged from $3.50/AUM to over $5.00/AUM such that when an average fee was subtracted, net forage value was assumed to be $4.03/AUM in New Mexico, $3.02/AUM in Idaho, and $3.89/AUM in Oregon. Studies have shown non-fee grazing costs to be higher on public lands as compared to deeded land (Bartlett et al., 1993), but we did not include a non-fee grazing cost differential because current estimates of non-fee grazing cost differences are not available. Including higher grazing costs for public lands would reduce income earned from these lands and reduce the income contribution of the grazing permit.

Similar to the earlier New Mexico study, ranch elevation and roughness (steepness of terrain) were estimated based on the township and range location of the ranch head-quarters recorded on the appraisal sheet. Distances to a major trade center and popula-tion density of the county were estimated using the procedures described by Torell et al. (2005). Only roughness was statistically significant (P = 0.06) and included in the final Great Basin model. Sample size and data variability may not have been adequate to measure value differences attributed to the other factors.

Alternative functional forms and explanatory variables were explored in defining the hedonic model, with the final definition of $g(\mathbf{X}; \boldsymbol{\beta})$ in equation (2) given by:

$$
(4) \quad g(\mathbf{X}; \boldsymbol{\beta}) = \beta_1 + \beta_2 NETAGTAC + \beta_3 HBVALTAC + \beta_4 \mathrm{Ln}(DEEDSECT)
$$
$$
+ \beta_5 D12 + \beta_6 D23\text{-}24\text{-}25 + \beta_7 ROUGH + \beta_8 \%FEDAC
$$
$$
+ \beta_9 \%FEDAUM + \beta_{10} \%STATEAUM.
$$

Table 2. Great Basin Ranch Value Model Results (dependent variable = $/*TAC* ranch selling price)

Parameter	Variable	Variable Description	Truncated Model	
			Parameter Estimate	Standard Error
β_1	Intercept	Model Intercept	332.12***	23.83
β_2	*NETAGTAC* *NETAG*	Net agricultural income per acre ($/*TOTAC*) Total agricultural income for the whole ranch ($)	5.98***	0.90
β_3	*HBVALTAC*	Appraised real house and improvement value ($/*TAC*)	1.52***	0.25
β_4	Ln(*DEEDSECT*)	Natural log of sections of deeded land	-25.63***	7.81
β_5	*D12*	Dummy variable for location in Lost Rivers valleys and mountains (see figure 1)	50.43**	21.46
β_6	*D23-24-25*	Dummy variable for location in the desert areas of Malheur, Humboldt, and Owyhee High Plateau	-79.97**	28.66
β_7	*ROUGH*	Roughness coefficient, the standard deviation of surrounding elevation values (as defined at http://www.esg.Montana.edu/gl/trs-data.html).	2.48*	1.31
β_8	*%FEDAC*	Percent of acreage on federal land (BLM or FS)	-2.89***	0.37
β_9	*%FEDAUM*	Percent of AUMs on federal land	-1.98**	0.99
β_{10}	*%STATEAUM*	Percent of AUMs on state trust land	-4.01**	2.05
τ	Nonnegativity	Nonnegativity truncation parameter	61.16***	1.55

R^2 = 0.93
N = 84
Mean of dependent variable = $169
Root mean squared error = $54

Notes: Single, double, and triple asterisks (*) denote coefficients are statistically significant at the 10%, 5%, and 0.1% levels, respectively. Refer to Torell et al. (2005) for a more complete description of variables and detail about how the variables were computed.

Variable descriptions and parameter estimates are given in table 2. Parameters were estimated using nonlinear least squares in SAS™ after adjusting all economic variables to a real 2002 price basis using the CPI. The standard White's test did not indicate a problem with heteroskedasticity ($P = 0.20$). All parameters were significant at the 10% level or higher for the truncated model. The model explained 93% of the variation in per acre prices in the sample.

The Great Basin model did not include a significant time trend variable because inflation-adjusted ranch prices were estimated to be similar over the 1997–2004 study period. A linear time trend variable was not significant in the model ($P = 0.55$). Similar to the New Mexico model, statistically significant variables included ranch location within selected MLRAs, net annual ranch income, number of deeded acres, the value of houses and buildings, and the discounts for percentage of acreage and carrying capacity coming from public and state lands. Ranch values were estimated to be higher in mountainous, scenic areas and with an increase in value when the terrain was steeper.

A strong inverse linear relationship between ranch selling price and dependency on public land was evident in plots between ranch selling price and level of public land dependency (figure 3). With only eight of the study ranches grazing FS lands, it was not possible to estimate permit values separately for BLM and FS; therefore, federal leases were combined in the analysis. Both increasing land acreage and increasing herd size on federal lands were discounted in the Great Basin model (table 2), in contrast to the
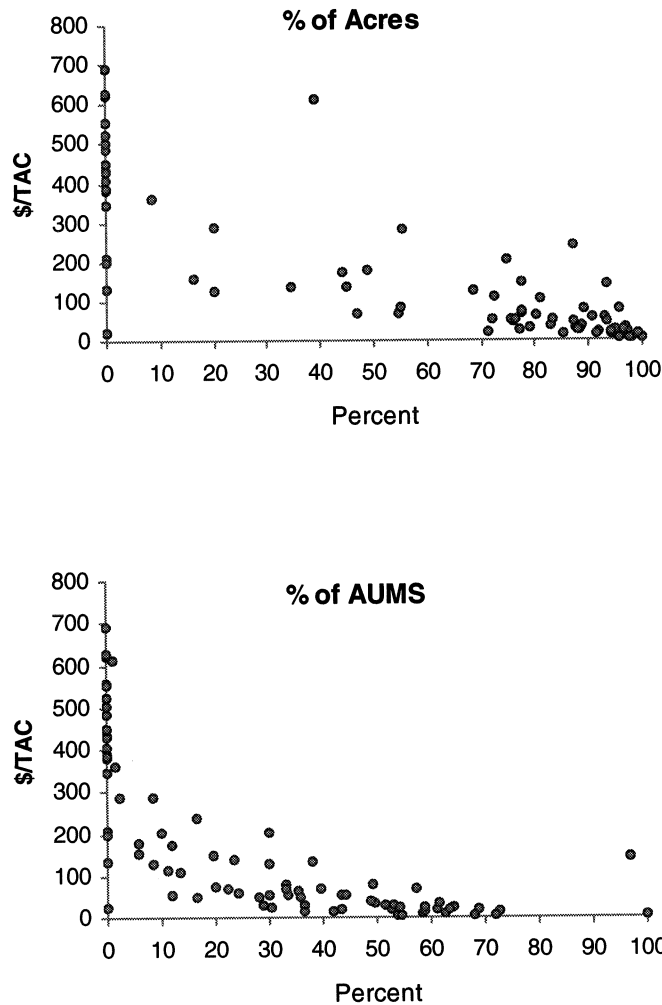
Figure 3. Real 2002 ranch selling price ($/*TAC*) versus dependency on public (BLM and FS) lands (*N* = 84)

New Mexico model where federal and state land acres were discounted but not AUMs of grazing capacity. This is because in the New Mexico data set the percentage of acreage on leased lands and the percentage of AUMs were nearly identical. For a particular New Mexico ranch, grazing capacity was not greatly different across different land ownership types.

Only 23 of the study ranches in the Great Basin had state trust land, and the percentage of acres and AUMs coming from state trust lands was consistently less than 20%. The discount for state trust land acres was not statistically significant in initial models ($P = 0.74$), and thus excluded. The discount for state land AUMs was statistically significant ($P = 0.01$).

The null hypothesis that the truncation effect is insignificant ($\tau = 0$) was rejected at the 0.001 level for both the New Mexico and Great Basin models; consequently, specification of the model without accounting for the truncation is inappropriate. The R^2 of the

Great Basin truncated model (93%) increased 2% over a similar model estimated by ordinary least squares which excluded the truncation. Perhaps more importantly, of the 24 sales having over 90% of acreage on public lands, by ignoring the truncation the predicted value of the ranches was inappropriately estimated to be negative in 11 cases. Truncating the model at zero appears to be very important when specifying the dependent variable on a $/TAC basis because observed per acre sale values will approach zero for high-dependency public land ranches.

Land Values

New Mexico

Permit value estimates shown in figure 1 are for a ranch with 70% of acreage on state and federal land and with additional characteristics described in table 1. Marginal land value estimates are substantially different when the land base on the ranch is altered. Figure 4 shows January 2003 marginal New Mexico permit value estimates when the 20-section ranch has different initial amounts of deeded and leased land. Consider first the ranch described in table 1 with 70% of the acreage on state and public land and note that at this point the 2003 marginal permit value estimates are equivalent in figure 1 and figure 4, about $100/AUM for FS ($20/acre), $128/AUM for BLM ($24/acre), and $300/AUM for state ($56/acre).

As the initial amount of leased land on the ranch decreases, the contributory value of federal and state land grazing permits diminishes. Torell et al. (2005) computed marginal permit values for the New Mexico model and demonstrated that permit value depends on all the factors that determine ranchland value plus how the land mix and net ranch income are altered as permit acreage changes. BLM permits are estimated to contribute positive amounts to ranchland value only when the initial permit acreage is over 50% of the total (figure 4). Similarly, positive FS permit values arise only when permit lands comprise over 58% of the land base. The cutoff point is 23% for state trust land. Sunderman and Spahr (1994) similarly concluded that grazing permits diminish ranch value when a small amount of public land is included on the ranch.

Added deeded lands contribute less value to ranches with higher levels of initial leased land. Notice the sharp drop in value when the initial land base was over 90% public and state land. This is because high-percentage public land ranches in New Mexico were determined to be more heavily discounted in price, and the hedonic model included a dummy variable to account for this (Torell et al., 2005).

Great Basin

We estimated the market value of a 20-section Great Basin ranch with the initial conditions specified in table 1 using a spreadsheet version of the hedonic model available at http://ranval.nmsu.edu. The market value of the model ranch with 40% of the forage base supplied from federal land was estimated to be $0.685 million ($5,142/AUY) if located in eastern Idaho, $1.02 million ($7,658/AUY) for the scenic Lost Rivers area of central Idaho, and $0.395 million ($2,963/AUY) for the desert areas of southern Idaho, northern Nevada, and eastern Oregon.
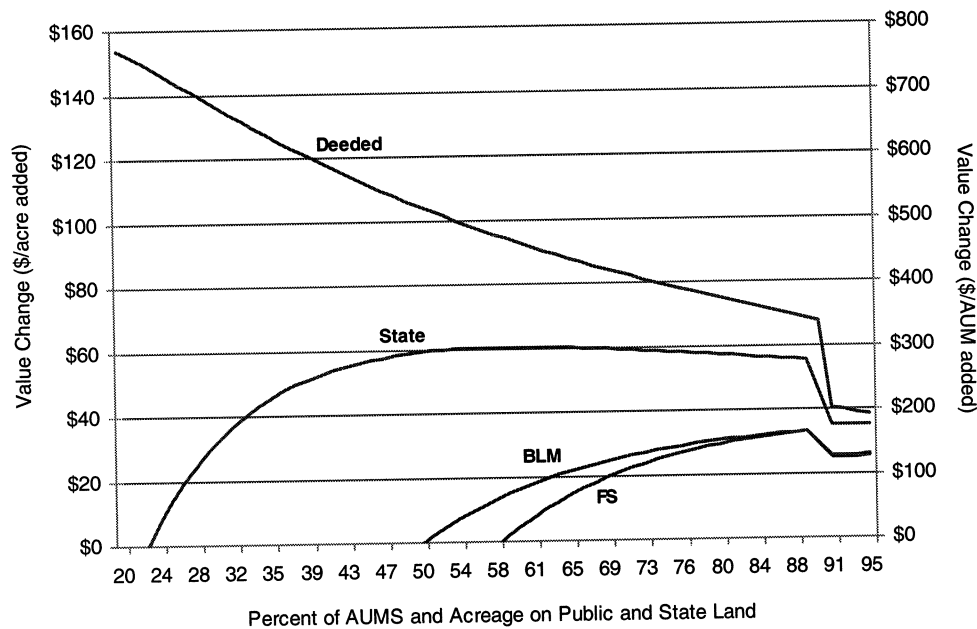
**Figure 4. Marginal change in ranch value from altering acreage
and grazing capacity on a 20-section New Mexico ranch in either
the southern deserts (BLM ranch) or mountains (FS ranch),
January 2003**

Adding 17 acres of federal land plus one additional federal AUM to the model ranch suggests a marginal value for a BLM or FS permit of about $112/AUM ($6.60/acre) in eastern Idaho and the Lost Rivers areas. In this particular case, the value estimate is higher if the ranch is located in the desert areas of Malheur, Humboldt, and the Owyhee Plateau, $160/AUM ($9.40/acre). These estimates would be for the 1997–2004 study period for which Great Basin ranch sales data were gathered and without distinction between BLM and FS permits.

Marginal state land permit values were estimated by adding eight state land acres and one state land AUM to the base model. The resulting permit value estimates were $127/AUM ($16/acre), $169/AUM ($21/acre), and $109/AUM ($14/acre), respectively, for the eastern Idaho, Lost Rivers, and Malheur, Humboldt, and Owyhee desert areas. By adding an additional AUM of grazing on deeded land and the two deeded acres required to obtain the AUM, estimated ranch value was increased by $432/AUM ($216/acre) in eastern Idaho; by $665/AUM ($333/acre) in the scenic Lost River area; and by $210/AUM ($105/acre) in the desert areas of Malheur, Humboldt, and the Owyhee Plateau.

Figure 5 shows marginal land value estimates when the Great Basin ranch has different initial amounts of deeded and leased land. As was true in New Mexico, Great Basin land value estimates are substantially different when the initial land base is altered. Notice at the bottom of the figure that with differences in assumed productivity between deeded (2 acres/AUM) and federal land (17 acres/AUM), the total number of animal units yearlong (AUY) on the 20-section model ranch varies from 486 head when the ranch is considered to have 1% of its grazing capacity (10% of acres) on federal land
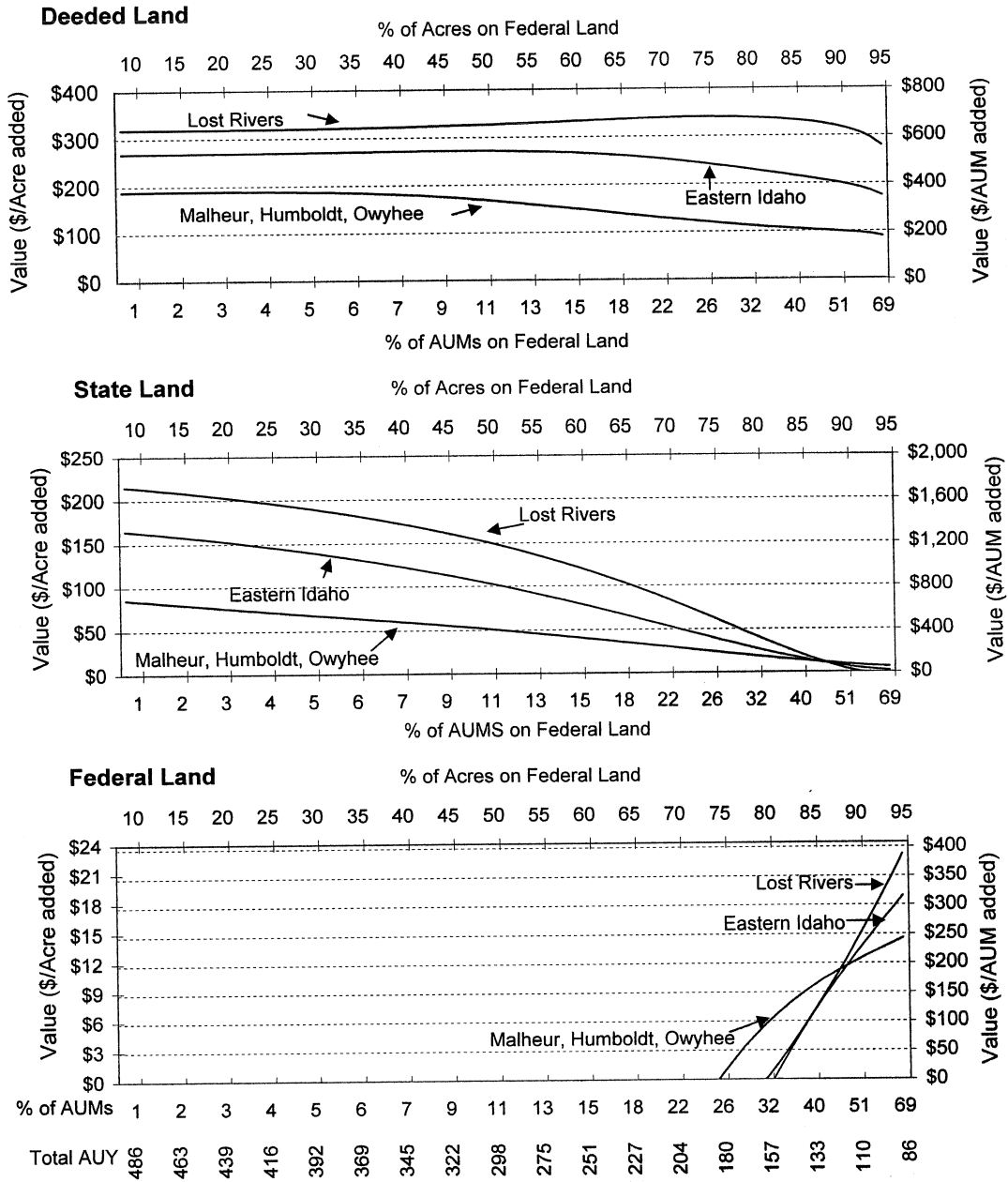
Deeded Land

State Land

Federal Land

**Figure 5. Marginal change in Great Basin ranch value
from altering acreage and grazing capacity**

to only 86 head when 95% of acres are on federal land.[3] Also note the vertical scale is not the same for the different land types.

Similar to the yearlong grazing permits in New Mexico, seasonal federal grazing permits in the Great Basin were estimated to contribute to ranchland value, but only for ranches with a relatively high percentage of federal land (> 75% of acres and 25% of grazing capacity on public lands, figure 5). Many ranches in the Great Basin fit this situation. Of the 84 study ranches, 63 had federal land. For the study ranches with federal land, 87% had over 25% of grazing capacity on federal land. Marginal permit values were estimated to be from $0 to $24/acre ($0 to $400/AUM) for these high-percentage public land ranches (figure 5).

Marginal deeded land values ranged from about $320/acre in the Lost Rivers area down to about $100/acre for a high percentage public land ranch in the Malheur, Humboldt, and Owyhee region. This value was increasingly reduced as the amount of public land on the ranch increased (figure 5), though the value estimate was relatively flat for ranches with mostly deeded lands. State trust lands are similarly discounted as the land base includes a higher amount of federal and state trust land. State land grazing permits contribute an amount similar to federal lands for high percentage public land ranches, but the contribution is estimated to be much higher as the amount of deeded land on the ranch increases.

What Gives Grazing Permits Value?

Both the New Mexico and the Great Basin models include agricultural income (*NETAGTAC*) as a statistically significant variable. The real-price agricultural income coefficient for New Mexico was estimated to be $25 (see Torell et al., 2005, table 2) as compared to $6 for the Great Basin ranches (table 2). While the coefficients appear greatly different, it must be recognized from equation (3) that the marginal change in ranchland value also depends on the *D*-function scaling factor with the derivative estimated as $\partial H(\mathbf{X})/\partial NETAGTAC = D(\cdot)\beta_k$, where β_k is the beta coefficient associated with agricultural income.

The *D*-function scaling between the Great Basin and New Mexico models was much different. As noted by Torell et al. (2005, table 3), the average *D*-function value for the 492 study ranches in New Mexico was 0.09. The average value was 0.26 in the mountainous areas and less than 0.09 in other areas. The *D*-function ranged from 0.002 to 0.2 for ranches with federal and state land, averaging 0.04. By comparison, the average *D*-function for the 84 Great Basin ranches was 0.58. The value ranged from 0.05 to 1 for the 67 Great Basin ranches that had federal and/or state land. The average was 0.48 in this case.

Evaluated at the mean *D*-function value for each area, and considering only ranches with state and/or public lands, the average marginal impact of adding a dollar of agricultural income is estimated to be $1.04/TAC for New Mexico and $2.88/TAC for the Great Basin. Given the range in *D*-function values for public land ranches in New Mexico

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[3] The bottom scale in figure 5 (% of AUMs) would change with different assumptions about the relative productivity of public versus private lands. Further, the bottom axis does not increase at a constant rate because of the assumed differences in productivity between federal versus private land. The state land panel is drawn assuming eight acres of state land, and one AUM of state grazing is added to a ranch that does not initially have state land (table 1).

(0.002 to 0.2), the marginal impact of adding livestock income varied from $0.01/TAC to $5/TAC. The *D*-function range for public land ranches in the Great Basin (0.05 to 1.0) suggests marginal values from adding income ranging from $0.30/TAC to $6/TAC. The implied capitalization rate for public land ranches is then very high, starting with minimum values of 20% (1/5) for the New Mexico model and 17% (1/6) for the Great Basin model, and proceeding upward from there.

Higher grazing fees would decrease net ranch income and the expected change in ranchland value as fees increase can be estimated as $D(\cdot)\beta_k\Delta FEE$. A $1/AUM fee increase would decrease land values within the ranges stated in the paragraph above. One of the arguments against an increase in grazing fees is that land values will greatly diminish, following the logic of the cost capitalization model for the existence of permit value. Yet, without a strong correlation between livestock income and land value this will not be the case.

The marginal impact of changing the number of federal and state AUMs on a ranch is different for each of the regional models. For the New Mexico model, it was determined that rangeland productivity was valued in addition to what it contributes to ranch earnings. The average rangeland productivity rating of the ranch, measured in AUY/section, was used as one of the explanatory variables in the hedonic model. As reported by Torell et al. (2005), agricultural income and productivity factors related to livestock grazing contributed less than $3/acre to ranchland value for ranches with over 70% of acreage on federal and state trust land. The total marginal value of federal lands for these ranches was $25–$30/acre (figure 4). Thus, grazing contributed only 4% to about 16% of the total value of the grazing permit for New Mexico ranches.

For the Great Basin model, adding an AUM of grazing from federal land affects total ranch value in two contrary ways, as shown by the derivative for computing the marginal change in total ranch value:

$$(5) \quad \frac{\partial H(\mathbf{X};\boldsymbol{\beta},\tau)}{\partial FEDAUM} \times Total\ Acres = D(\cdot)\left(\beta_2 \frac{\Delta NETAG}{\Delta FEDAUM} + \beta_9 \frac{\Delta\%FEDAUM}{\Delta FEDAUM} TOTAC \right).$$

With the added AUM, net ranch income is increased and β_2 measures the rate at which this additional income is capitalized into land value. The percentage of AUMs coming from federal lands increases, and this increased dependency on federal lands is discounted in the model. With the parameter estimates for the Great Basin model (table 2), the net change in land value from adding an AUM of federal grazing is negative because the added income from the AUM is not enough to offset the discount for a higher dependency on federal land. Consider the 20-section Great Basin ranch described in table 1 with location in eastern Idaho. As discussed above, if 17 acres of public land are added with the accompanying AUM of grazing capacity, the value of the ranch is estimated to increase by $112. If only the acreage had been added, the value change would be $485. The value of the permit comes totally from the acreage and not the livestock grazing it.

Discussion and Policy Implications

If Nielsen and Wennergren (1970) were correct, capitalized livestock income explained permit value during the 1960s. If Martin and Jeffries (1966) were correct, the market value of grazing permits was inflated above the value justified from livestock production.

This latter case is certainly the case now. We found less than 16% of the marginal value of grazing permits in New Mexico can be attributed to livestock production, and estimates for Great Basin ranches indicate none of the value can be assigned to livestock production.

Thompson (2003) noted that many Rocky Mountain ranches were purchased for recreation use, and income from livestock explained very little of ranchland value. Few appraisers bother with an income appraisal for ranches judged to be recreation-based. Thompson further suggested that grazing permits may contribute a spin-off value. Public lands are desired for recreation activities such as fishing, hunting, and observing the flora and fauna of the timber and range country. Prices escalate as the perceived quality of the surroundings increases and public lands can effectively create a semi-private use area. Our research shows that the recreation and lifestyle reasons for ranch ownership may be much broader than just the trophy ranches to which Thompson referred. Expected investment appreciation, recreation and lifestyle opportunities, and prestige now motivate the ranch buyers who have the financial resources to afford ranch purchases. Martin (1966) concluded this was true 40 years ago. It applies to grazing permits as well. In this study, non-livestock factors explained the majority of land value for all types of ranches studied, including those ranches dominated by public lands.

It has been proposed that public land ranchers be paid $175/AUM to permanently remove their livestock from public lands (National Public Lands Grazing Campaign, 2006). By the traditional income capitalization model, this would eliminate the market value of the grazing permit. Contrary to this notion, our research indicates public lands will continue to add value to those ranches composed mostly of public lands, which are those ranches we estimate currently have a positive permit value.

Significant policy implications arise when the primary reason for ranch ownership and livestock production is not profit. Whittlesey, Huffaker, and Butcher (1993, p. 16) expounded on some of these implications after highlighting some of the same inconsistencies we describe above:

> Extensive cost-of-grazing studies have shown that ranchers, on average, are currently spending as much per unit of forage on public lands (current fees plus costs of use— travel, herding, salting, and so on) as is paid for forage on private lands. Economic theory suggests, therefore, that the value of permits for grazing public lands should be zero, but that is not the case. This leaves some troubling possibilities: our economic models are wrong, ranchers are not profit maximizers, or ranchers benefit from more than forage through the use of the grazing permit.

Ranchers do benefit from more than just the forage provided from public lands. Further, because they are not strictly profit maximizers, the income capitalization model explains only a small amount of ranchland value. Traditional profit-maximizing models are not appropriate for assessing how ranchers will respond to policy changes like higher grazing fees and tightened grazing standards. We cannot accurately assess how land values might change as policies change without a better understanding of the many motivations for ranch ownership.

A different model structure must also be used to estimate permit value. The hedonic model must be structured to allow sale price to vary as both income (grazing capacity) and public land acreage varies. Because acreage and total livestock numbers allowed on the permit are closely tied, past studies that have used only AUMs as an explanatory variable have consistently shown public land AUMs to add to ranchland value. But, by

our estimates, past studies have unjustifiably assigned a great deal of value to the AUM which should have been assigned to the acreage. Only by separately considering variation in the income component and acreage component can the relative contribution of the two factors be assessed.

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