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Property Rights, Grazing Permits, and Rancher Welfare

David K. Lambert and J. S. Shonkwiler

This study attempts to link factors affecting the demand for Bureau of Land Management grazing to perceived changes in permittee welfare over the 1962–92 period. Annual demand for federal forage is found to be sensitive to active preference, beef cow and breeding ewe inventories, and grazing fees and nonfee allotment utilization costs. No evidence is found to support the notion that the demand for grazing has been affected by changes in property rights associated with the federal grazing permit that are not reflected in higher user costs. The total decrease in welfare generated from the permit to graze public lands has been about 9% per authorized cattle animal unit month and 65% per authorized sheep animal unit month over the study period.

Key words: confirmatory factor analysis, grazing fees, latent variables, property rights, public lands

Introduction

The Bureau of Land Management (BLM) of the Department of the Interior manages over 150 million acres of rangeland in the western United States. These lands have traditionally been managed for commercial uses, such as livestock grazing, timber harvest, and mining. Noncommercial use of public land resources has always been present (Clawson and Held), but high costs of access and remoteness from population centers prevented serious conflicts among users until recently.

Within the last thirty years, increasing demand for nonconsumptive use of natural resources has resulted in increasing conflicts among claimants to the public lands. The objective of this article is to analyze the conflict, especially as changes in resource values have altered the sets of property rights agricultural users of the public lands enjoy. Ranching interests maintain that the transaction costs associated with utilizing BLM permits have greatly increased due to expanded permittee responsibility for maintaining the natural and man-made attributes of an allotment, as well as the livestock industry's declining influence in resource use decisions. Although some evidence exists that rents accruing to holders of the permits have decreased over time (Torell and Doll), there has been little empirical analysis to identify the factors affecting aggregate demand for public land grazing (exceptions include Johnson and Watts; Narayanan et al.). This study investigates changes in the market for BLM forage resulting from changes both internal and external to the system. The conceptual foundation for the demand analysis rests upon the newly evolving school of economic property rights analysis (Barzel). Any changes in demand unaccounted for by fee

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and nonfee grazing costs and livestock industry trends will be interpreted to arise from changes in the set of property rights held by permittees.

The Nature of Property Rights in Natural Resources

The assignment of property rights is integral to the operation of an economic system. Property rights allocate actors' abilities to consume, to derive income from, and/or to alienate certain attributes of an asset (Barzel). It is important to note the distinction between the economic and the legal definitions of property rights. Legal rights generally enhance economic rights, but are neither sufficient nor necessary for economic rights to exist (Barzel). One role of legal rights is to reduce the transaction costs associated with protecting an economic property right. As Coase points out, what are exchanged in market transactions are not physical entities but the rights to perform certain actions. Holders of a federal grazing permit, thus, have purchased the right to graze a certain number of animals for a certain period of time. Certain use restrictions may apply. Uses that are not stipulated may be left to the discretion of the permittee. As social values change, the set of property rights available to the permittee may be reduced when the opportunity costs of grazing increase. Consequently, the set of property rights enjoyed by permittees may change over time.

Several authors have provided historical analyses of the evolution of property rights in the lands of the American West (e.g., Voight; Libecap). Constraints included in the laws governing land disposal prevented the establishment of legal rights in the large tracts of land necessary for commercial livestock production in the region. Ownership and, consequently, legal control were centered on sources of water or productive meadowlands. The problem facing ranchers was to develop methods to establish control over the remainder of the unowned, or open, range deemed necessary for their operations, yet beyond the ranchers' purview to own in fee simple.

Open range meant open access, so that overgrazing was often practiced to dissipate any benefits competing range users might attain (Libecap). As the West became more populated, competition from other settlers, both graziers and farmers, resulted in the creation of exclusive livestock associations and fencing, in many cases illegal, to prevent access to unclaimed public lands (Libecap). Finally, with the passage of the Taylor Grazing Act in 1934 (PL 73-482), grazing districts were established under the joint administration of the Grazing Service and the General Land Office. Legislative intent with respect to the Taylor Grazing Act included the establishment of property rights in the use of the public range, thus reducing the transaction costs incurred by ranchers in protecting their access to the public domain. The issuance of permits established a vehicle by which wealth could reasonably be expected to arise from more secure access to the public range.

The original act identified 142 million acres for inclusion in grazing districts. Six regional offices provided administrative and enforcement duties but also were mandated to "interpret the desires and needs of the local stockmen" (Buckman). The "desires and needs of the local stockmen" were expressed through district advisory boards composed of local stockmen having historical access to the public range. Little concern was expressed for other users of the range, excepting that the carrying capacity of the range should not be exceeded (Buckman). If the role of property rights is to define actors' roles in decisions affecting scarce resources (Furubotn and Pejovich), the livestock industry clearly enjoyed vast rights in the management of the range in the early days of grazing district management.

For the year 1936, 15,067 permits were issued allowing 7,434,416 head of livestock to use the lands of the grazing districts (Buckman). Livestock numbers remained relatively unchanged through the beginning of the 1960s. Although incitements against cattle grazing appeared in special interest group press (e.g., Stegner), it was in the 1960s[1] that effective environmental legislation began to appear that would constrain permittees' property rights in the public range.

Beginning in 1959, the Bureau of Land Management itself began presenting findings of range deterioration resulting from overstocking (USDI/BLM 1959). Successive reports called for further grazing controls to be established to promote scientific management of the public rangelands. In a 1975 study, significant deterioration of public range in Nevada was accredited to the wide management discretion granted to permittees (USDI/BLM 1975).

Means for the attenuation of permittee property rights were provided by a wave of legislation. Among the acts affecting decision making on the public lands was the Classification and Multiple Use Act of 1964 (PL 88-607). This act expanded the set of legitimate claimants to the resources associated with the public lands. No longer was the goal of land management to be the promotion of the maximum livestock production attainable from the land. Instead, land managers were mandated to consider the relative values derived from all resources.

The National Environmental Policy Act (NEPA) of 1969 (PL 91-190) required all federal agencies to consider the impacts of policy decisions on environmental quality. The NEPA was an important basis for *Natural Resources Defense Council* (NRDC) v. *Morton* (388 Fed. Supp. 829), in which it was determined that grazing constituted a significant alteration of the environment. Consequently, local BLM grazing plans were required to be analyzed by environmental impact statements (EIS). These EISs were required to include alternative management plans that did not emphasize livestock grazing as a major use of the land.

The *NRDC* v. *Morton* case eventually gave rise to the bureau's first organic act, the Federal Land Policy and Management Act of 1976 (PL 94-579). This act ended the policy of disposal of the public lands and established goals of long-run management of the lands for sustained yield and multiple use. The act also ended the domination of grazing advisory boards by local livestock interests. The act mandated the establishment of advisory boards having representation from a variety of groups interested in the management of the lands.

A final piece of legislation affecting management of the public lands was the Public Rangeland Improvement Act (PRIA) of 1978 (PL 95-514). PRIA codified range management practices through the requirement of allotment management plans (AMPs) being developed for all grazing areas. The AMPs resulted from consultation among ranchers, bureau staff, and other interested parties in determining grazing practices within an allotment. Additional powers were granted to the secretary of the interior to reduce livestock stocking levels and shorten the term of grazing permits if required to comply with range improvement guidelines.

At the time of this writing, additional proposals are being debated that will further limit permittees' influence in the decision-making process by expanding the range of interests represented on citizens' advisory boards (USDI/BLM 1994). Additional proposals would affect both grazing fees and other transaction costs incurred by ranchers wishing to graze stock on the public lands, as well as reduce the security of tenure associated with a grazing permit (Davis).

In spite of the increasingly stipulated requirements placed on the permittee in using the grazing allotment, there has been little change in the number of cattle permitted to graze or

[1]Comparable measures for 1960 calendar year were 19,371 permits issued to 18,337 operators, who were allowed to graze 7,216,490 animals (USDI/BLM 1961).

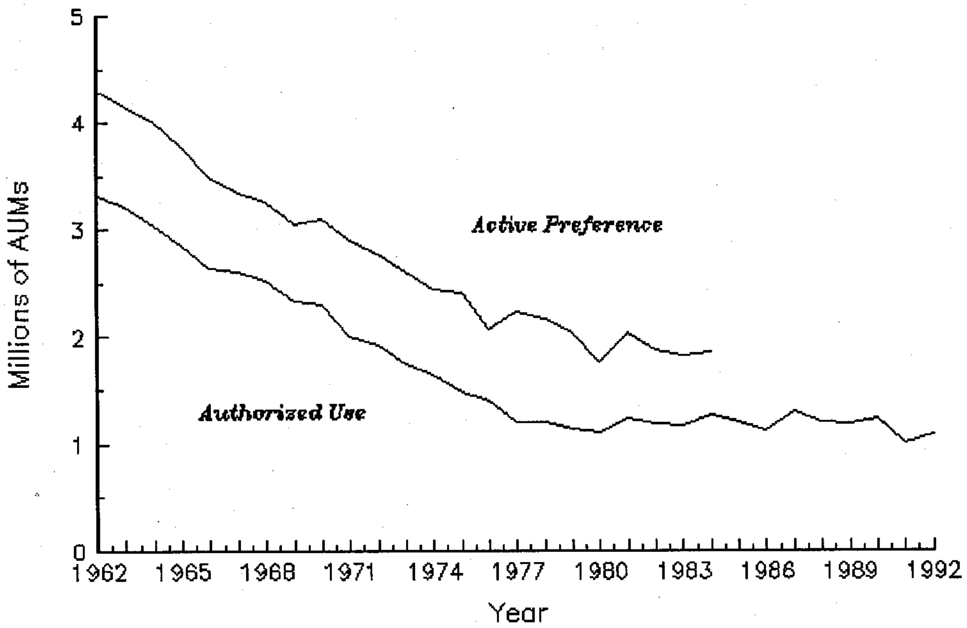

Figure 1. Active preference and authorized use on BLM section 3 lands, sheep.

Note: Active preference figures were aggregated with cattle and horse preference following 1984.

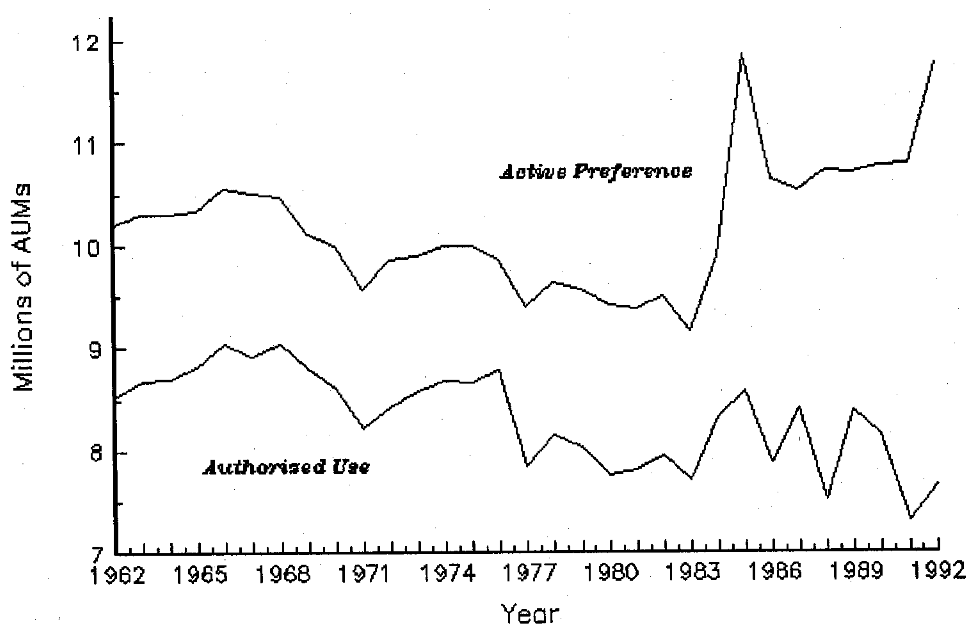

Figure 2. Active preference and authorized use on BLM section 3 lands, cattle

Note: Active preference values for 1985–92 are combined cattle and sheep preference.

in the grazing fee. Sheep numbers have fallen dramatically on the public range. The number of authorized animal unit months (AUMs) of grazing available to sheep producers fell about 65% between 1962 and 1992 (fig. 1). However, there has only been a 10% reduction in authorized cattle AUMs on section 3 lands (fig. 2). Fees paid by ranchers have not increased relative to other production costs. Figure 3 indicates some increase in the real grazing fee up to 1980. However, the institution of the PRIA formula in 1980 for calculating grazing fees has provided ranchers with a fairly stable grazing fee. It thus appears that we must look at other factors affecting the market for federal forage to determine the source of any changes in permittee welfare.

The Market for Public Forage

The attractiveness of a grazing permit depends upon the property rights associated with the permit and on exogenous factors affecting the derived demand for forage. The demand for forage derives from the expected net revenues generated from the sale of animals consuming the forage. Demand can be met from several sources, including public rangelands, lands leased from private sources, and from the ranchers' privately owned lands. The marginal value of a unit of rangeland may differ among the various sources depending upon the seasonal availability of alternative forage and feed supplies, the nutritional quality of the forage, energy expended by the grazing animal in consuming the forage, and the provision of feed supplements to enhance the efficacy of forage metabolism. The property rights enjoyed by the rancher with respect to harvesting the forage may differ among the alternative sources of forage.

Administrative decree places upper bounds on forage supplies from public rangelands. This quantity, termed active preference, is available to the qualifying rancher if he agrees to pay the current grazing fee and to incur the nonfee costs and management restrictions required for the utilization of the public land. However, as Johnson and Watts note, differing amounts of nonuse are voluntarily taken by ranchers from year to year. The proportion of active preference actually paid for each year, termed authorized use, averages about 85%. Although constrained by agency limits, especially in the long run, actual animal unit months consumed appear to be affected by factors other than active preference.

Figure 4 illustrates the market for federal forage for a typical year. Active preference, or the upper limit available, is Q^{max}. It is well established that total grazing costs exceed the federal grazing fee (Torell et al.). Quantity actually used by the permittees is Q_0, determined by the intersection of the demand curve and the total fee and nonfee costs associated with using the public range.

Changes in the derived demand for forage may influence nonuse requested by ranchers. In figure 5, demand for forage has shifted to the left, perhaps due to depressed beef cattle prices or falling prices for substitute forage. This inward shift increases nonuse of the federal forage, from Q_0 to Q_1. Welfare changes resulting from the shift equal area a. Declining demand, ceteris paribus, will reduce surplus associated with the permit. The change in average permit value will depend on whether b/Q_1 is greater or less than $(a + b)/Q_0$.

Changes in either the grazing fee or in transaction costs associated with using the permit will also affect permittee surplus. An increase in fee and/or nonfee costs will shift the cost of using the range upwards (fig. 6). Fewer animal unit months will be harvested, and total rancher surplus will fall by area $b + c$. Finally, reductions in active preference may affect

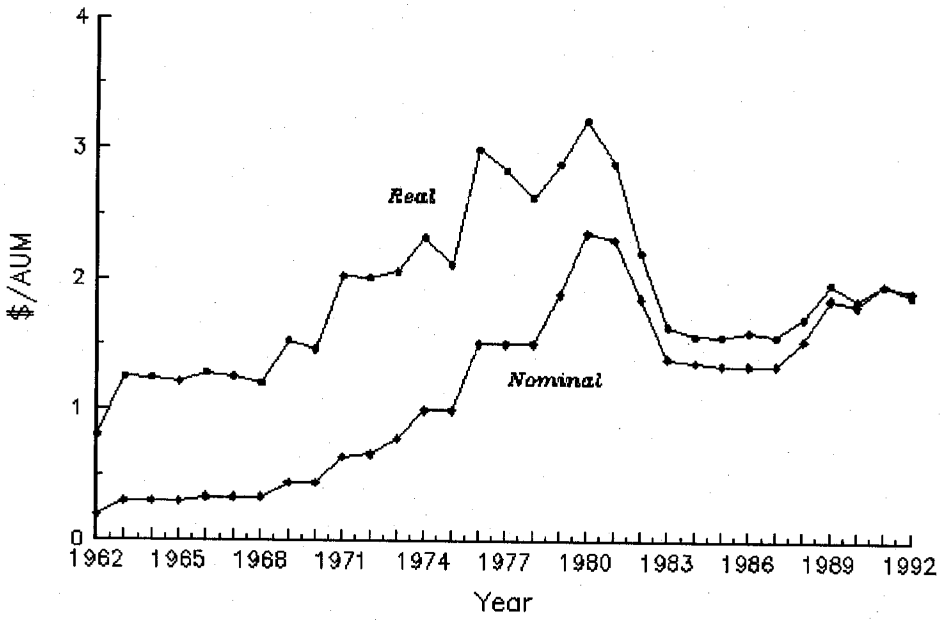

Figure 3. Real (1991 dollars) and nominal BLM grazing fee

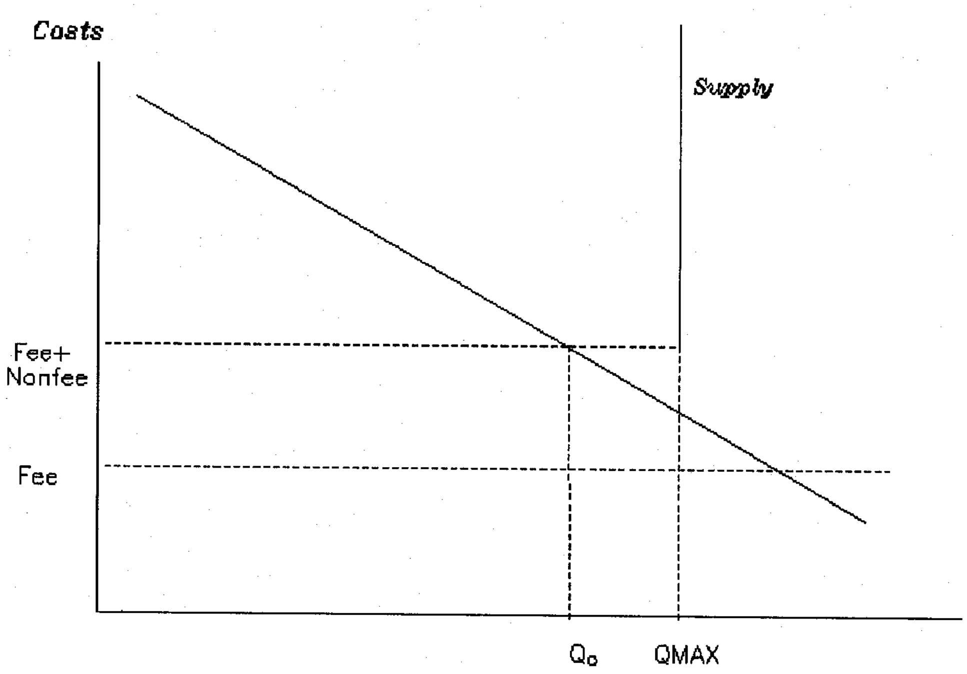

Figure 4. Demand (*D*) and supply (*S*) in the market for federal forage

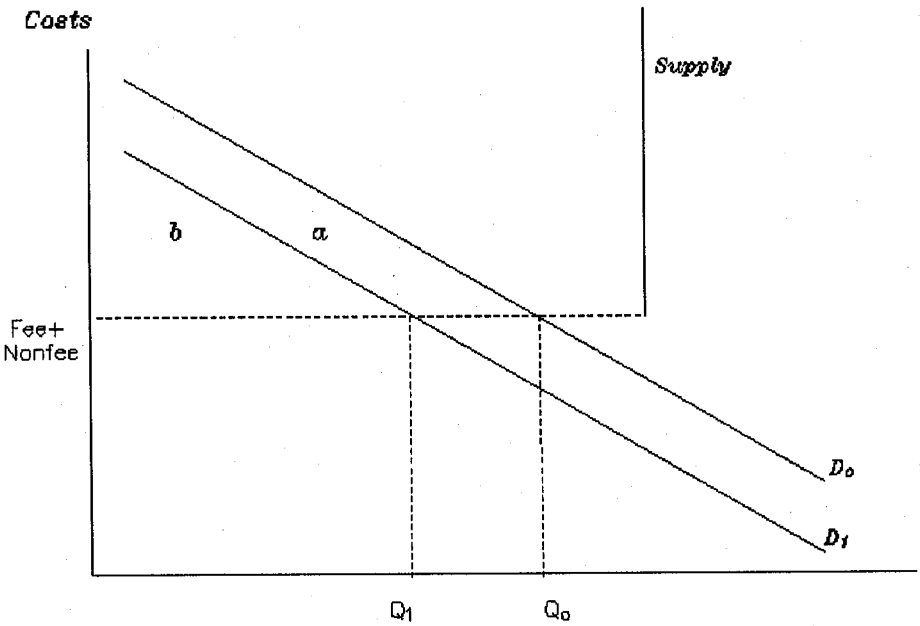

Figure 5. Changing demand and the market for federal grazing

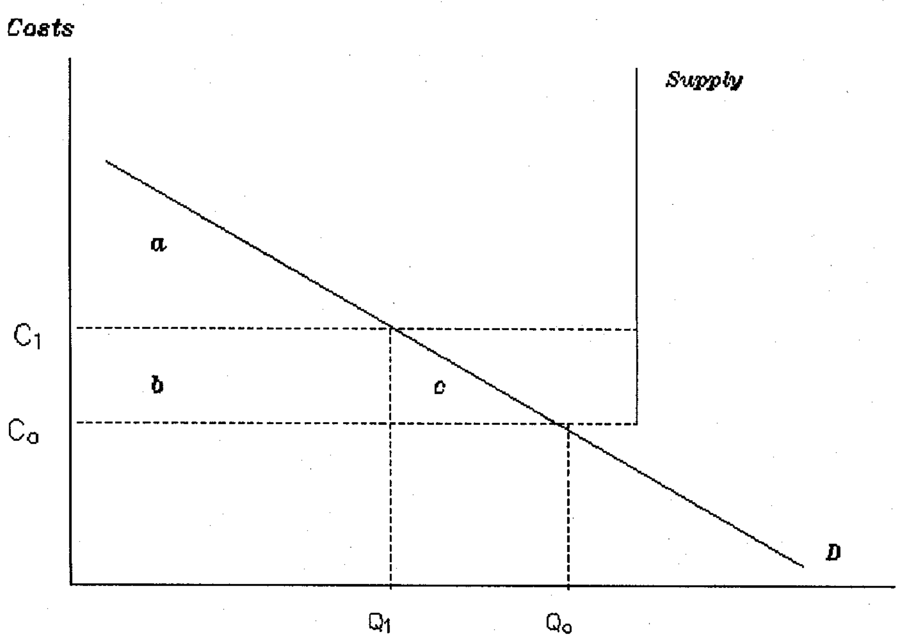

Figure 6. Changing use costs and the market for federal grazing

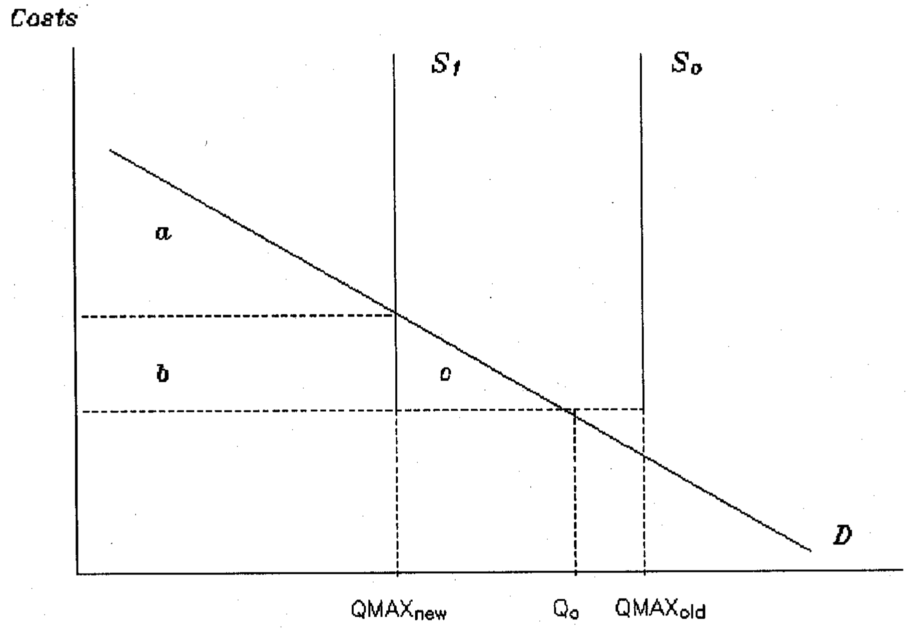

Figure 7. Change in active preference and the market for federal grazing

actual use. If, for example, $Q^{\max}$ is reduced $Q^{\max}_{\text{new}}$, the upper bound becomes binding. In this example (fig. 7), producer surplus will decrease by area $b + c$.

Measurement of the Derived Demand for Federal Grazing

Supply in time S_t is constrained by the upper bound decreed by the BLM ($S^{\max}$). Demand (D_t) for forage is influenced by both fee and nonfee allotment costs, *Fee* and *Nonfee*, and a set of demand shifters, X_t, such as the size of the beef cow herd or flock of breeding ewes and prices of substitutes. The "market" for forage can be expressed as folllows:

$$(1)\quad \begin{aligned} &S_t = S_t^{\max}, \\ &D_t = D_t\,(Fee_t, Nonfee_t, X_t), \\ &D_t \le S_t, \text{ or} \\ &D_t = S_t - Nonuse_t. \end{aligned}$$

The inclusion of $Nonuse_t$ allows writing of the market clearing condition in (1) and derivation of a reduced-form representation of the BLM forage market.[2] Factors affecting $Nonuse_t$ are

[2]Technically, permittees may request nonuse for a maximum of three years before BLM administrators adjust the ranchers' active preference to reflect the lower demands for forage made by the rancher. However, persistent nonuse of about 15% of active preference and apparent laxity by the BLM in enforcing the legal requirement (Johnson and Watts) allows treating nonuse as a choice variable more or less freely available to the rancher.

the same, though opposite in sign, to factors affecting use. As grazing fees go up, for example, one would expect use to decline and, ergo, $Nonuse_t$ to go up. The resulting model for authorized use can be expressed as:

(2) $$D_t = \beta S_t^{\max} - (\gamma\,(Fee_t + Nonfee_t) + \delta' X_t) + \eta_t,$$

where β, γ, and δ are parameters to be estimated. The error terms, η_t, are assumed to be normally distributed with mean zero.

The problem with standard estimation procedures applied to equation (2) is that *Nonfee* is unknown. However, scattered evidence has been collected to estimate BLM grazing costs at selected points in time. Although not perfect, these observations might provide some indication of the unobservable latent variable, $Nonfee_t$. Other sets of information, such as price series for selected production items, might also be imperfect indicators of $Nonfee_t$.

Confirmatory factor analysis (CFA) (Bollen) can be used to specify a relationship among a set of indicators and the unobserved latent variable ξ_t. We can infer the influence of the different observed indicators on ξ. Following Ford and Shonkwiler, CFA can represent these relationships:

(3) $$\begin{bmatrix} m_{1t} \\ m_{2t} \\ \vdots \\ m_{kt} \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \vdots \\ \lambda_k \end{bmatrix} \xi_t + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{kt} \end{bmatrix}.$$

The k variables, $m_{1t}, \ldots, m_{kt}$, serve as indicators of the latent variable ξ_t. The elements of $\lambda = (\lambda_1, \ldots, \lambda_k)$ are the factor loadings, or the factor proportionalities between the different indicators and the unobserved variable $Nonfee_t$. None of the indicators are perfect but are rather observed as influencing ξ_t with errors $\varepsilon_{1t}, \ldots, \varepsilon_{kt}$. The closeness of the relationship between any indicator m_{it} and ξ_t is proportional to λ_i and the variance of ε_{it}.

This relationship is seen by forming the second moment of (3):

(4) $$\mathrm{cov}(m) = \lambda\phi\lambda' + V_\varepsilon = \textstyle\sum_{MM}(\theta),$$

where ϕ is the variance of ξ and

$$V_\varepsilon = \begin{bmatrix} \sigma_{11} & \ddots & 0 \\ 0 & & \sigma_{kk} \end{bmatrix}.$$

Note that each m_{it} is an imperfect indicator as long as $\sigma_{ii} > 0$. Also, since scale of the relationships is more important than location, the indicators are usually centered around zero, and one of the λ_is is normalized to one (Ford and Shonkwiler).

Inclusion of the latent variable ξ_t in the demand equation (2) results in

(5) $$D_t = \beta S_t^{\max} - (\gamma\,(Fee_t + \xi_t) + \delta' X_t) + \eta_t.$$

Letting $\Gamma = [\gamma, \beta, \delta, \gamma]$ and $Z = [\xi\ S^{max}\ X\ Fee]$, where ξ, S^{max}, X, and *Fee* are the vector or matrix which contains the observations for all time periods, then (5) can be written more compactly as:

(6) $$D = Z\Gamma + \eta,$$

where $D = (D_1, \ldots, D_t)$.

The second moment of (6) is

(7) $$\text{var}(D) = \Gamma'\Phi\Gamma + \Psi = \sum\nolimits_{DD}(\theta),$$

where Ψ is the variance of η_t and Φ is the variance-covariance matrix of both the latent variable ξ and the observed variables, *Fee*, S^{max}, and X.[3] Estimation of the parameters, factor loadings, and variances is accomplished using the second moments of (3) and (6). Let W represent all observed predetermined variables then the observed second moments are

(8) $$V = \begin{bmatrix} V_{DD} & V_{DW} \\ V_{WD} & V_{WW} \end{bmatrix},$$

and the structural second moments are

(9) $$\sum(\theta) = \begin{bmatrix} \sum_{DD}(\theta) & \sum_{DW}(\theta) \\ \sum_{WD}(\theta) & \sum_{WW}(\theta) \end{bmatrix},$$

and recognizing that

(10) $$\sum\nolimits_{DW}(\theta) = \lambda\Phi\Gamma',$$

results in the likelihood function used for estimation:

(11) $$-0.5N\ln[\det(\sum(\theta))] - 0.5N\text{tr}(\sum(\theta)^{-1}V).$$

[3]Modifications are necessary to equation (3) and to the variance-covariance matrix Φ. Letting X represent the observed independent variables, (3) becomes

$$W = \begin{bmatrix} m \\ \cdots \\ X \end{bmatrix} = \begin{bmatrix} \lambda & 0 \\ 0 & I \end{bmatrix} \begin{bmatrix} \xi \\ \cdots \\ X \end{bmatrix} + \begin{bmatrix} \varepsilon \\ \cdots \\ 0 \end{bmatrix}, \quad \text{and} \quad \Phi = \begin{bmatrix} \sigma_{\xi\xi} & \sigma_{\xi X} \\ \sigma_{X\xi} & \sigma_{XX} \end{bmatrix}.$$

Data

Data are available for the years 1962 through 1992 for ten western states having significant BLM grazing district lands. Annual data on grazing permits, including number of permits, active preference, and authorized use, are published by the BLM in *Public Land Statistics* (USDI/BLM). Active preference is the difference between grazing preference, or the total amount of grazing tied to a permit, and suspended nonuse. Suspended nonuse includes grazing privileges removed from the permit more or less permanently, based on continuing monitoring of range carrying capacity. Active preference is the amount of grazing the rancher could theoretically use (Hines). Authorized use is the amount of forage for which the permittee has actually paid over the bureau's fiscal year.

Active preference data are available for cattle and for sheep separately up to 1984.[4] From 1985 onwards, active preference is only available on an aggregated basis (Pack). Consequently, separate coefficients are estimated for S^{max} for the years before 1985 and for the later years. January first beef cow and breeding ewe numbers were collected for each state (USDA). The aggregate inventory series were constructed by weighting each state's inventory by the proportion of the ten-state total AUMs for that state. The price of substitute forages was represented by the private land lease rate compiled each year by the National Agricultural Statistical Service. The lease rate was deflated by the producer price index for all commodities and services, interest, taxes, and wage rates. BLM grazing fees were deflated by the producer prices paid index.

Indicators for the $Nonfee_t$ latent variable included deflated price series for wages, to reflect both paid and unpaid labor employed in allotment management, and a combined index of auto and truck expenses and fuel costs. Estimates of the actual costs arising from operating a BLM grazing allotment were derived from studies reporting utilization costs for running cattle (sheep) on public lands (table 1)—six for cattle and two for sheep. A smoothing procedure was employed for extrapolating these point estimates over the 31 years. The six (2) observed values were deflated by the general producer price index, and these observations were then regressed on the input cost index (USDA/USDI 1986, 1993) compiled to reflect cow-calf costs, similarly deflated. The rationale for this procedure was to reflect cost differences more likely to reflect production expenditure shares faced by western livestock producers. The latent variable $Nonfee_t$ was estimated using this extrapolated series of nonfee utilization costs, as well as the observed price series on wages and the fuel/vehicle cost index.[5]

[4]Use and preference values for cattle include horses. Unfortunately, separate cattle and horse values are not available for all years. However, for most of the years from 1973 onwards for which authorized use is available for both, horse use is less than 1% of the total. Sheep and goat use is also combined in the BLM data. However, for 1959, the last year in which the separate livestock classes are listed, goats represented less than 0.5% of the authorized use.

[5]The rationale behind this application of confirmatory factor analysis is that nonfee costs are a significant expense in using a grazing allotment, but no annual series are collected to quantify this expense. A few isolated cost studies exist to provide some estimate of the magnitude of these costs. Intrayear extrapolations provide a rough estimate of how these costs might have changed in the years for which no cost studies were conducted. This smoothed series, adjusted by a price index reflective of the composition of the actual tasks associated with managing livestock in an allotment, provides one of the three imperfect indicators of the desired unobservable $Nonfee_t$. This unobserved variable is measured with error, but that is explicit in the nature of the analysis.

Table 1. Survey Estimates of Nominal Nonfee Costs Associated with BLM Cattle and Sheep Allotments

Year	Survey Area	Cattle cost ($)	Sheep cost ($)
1966	Western U.S.[a]	2.83	4.53
1982	Oregon[b]	10.13	—
1983	Idaho[b]	15.46	—
1983	Nevada[b]	8.99	—
1990	Updated Western U.S.[c]	12.48	—
1992	Idaho, New Mexico, and Wyoming[d]	15.41	23.23

[a]Reported in USDA/USDI 1986.
[b]Obermiller and Lambert 1984.
[c]Nielson, D. B.
[d]Torell et al.

Data Analysis and Results

Cattle

Confirmatory factor analysis parameter estimates from the maximization of the log-likelihood function (11) for both cattle and sheep are presented in table 2. Results of the cattle CFA indicate that the factor loadings for wages and on the transportation cost index are significant. Estimates of the standard deviations of the measurement errors associated with these indicators, as well as the cost series $Nonfee_t$ constructed from the six surveys considered, are also highly significant. The results suggest that the indicators used are significant, though imperfect, indicators of the utilization costs latent variable $Nonfee_t$.

Given factor loadings and the estimated variances, unbiased estimates of the latent variable series can be constructed (from Bartlett, as discussed in Lawley and Maxwell):

$$\hat{\xi}_t = \left[\hat{\lambda}'\hat{\Sigma}^{-1}\hat{\lambda}\right]^{-1}\hat{\lambda}'\hat{\Sigma}^{-1}m_t, \tag{12}$$

where $\hat{\Sigma}$ is the diagonal variance-covariance matrix of the errors from equation (3), $\hat{\lambda}$ is the vector of factor loadings, and m_t are the indicators. Both real and nominal estimates of the costs $Nonfee_t$ are presented in figure 8.

Nominal estimates appear to track well the few survey results available for the period. In real terms, the estimate of the nonfee costs have risen approximately 12% over the 31 years, or an annual increase of about 0.4% over the general index of producer prices.

Maximum likelihood coefficient estimates for predicting cattle and sheep authorized use are reported in table 3. The overall influence on cattle AUMs demanded of both grazing fees and nonfee costs has been negative and mildly significant ($t = -1.591$). Scaling of the data prevents easy interpretation of the parameter estimates. However, the elasticity of demand calculated at the means of the data (table 4) is – 0.249. This value is similar to the estimates of Johnson and Watts (– 0.2) and Narayanan et al. (– 0.178), though input price in both of these studies was limited to the observed grazing fee. Our results support the conclusions of

Table 2. Confirmatory Factor Analysis Results for Cattle and Sheep

Variables		Factor Loadings λ	Standard Deviation
Cattle:			
	Wages	0.59748	6.60792
		(0.13509)	(0.83729)
	Buildings, fences, autos and trucks	0.20364	2.21009
		(0.04158)	(0.26669)
	Nonfee cost studies	1	0.16470
		(NA)	(0.06025)
	ξ_t (latent variable for $Nonfee_t$)		6.11921
			(0.83098)
Sheep:			
	Wages	2.74813	5.80475
		(0.59022)	(0.65992)
	Buildings, fences, autos and trucks	4.61623	6.09524
		(0.45111)	(0.91056)
	Nonfee cost studies	1	0.54913
		(NA)	(0.12350)
	ξ_t (latent variable for $Nonfee_t$)		1.75784
			(0.07831)

Notes: Standard errors are in parentheses.

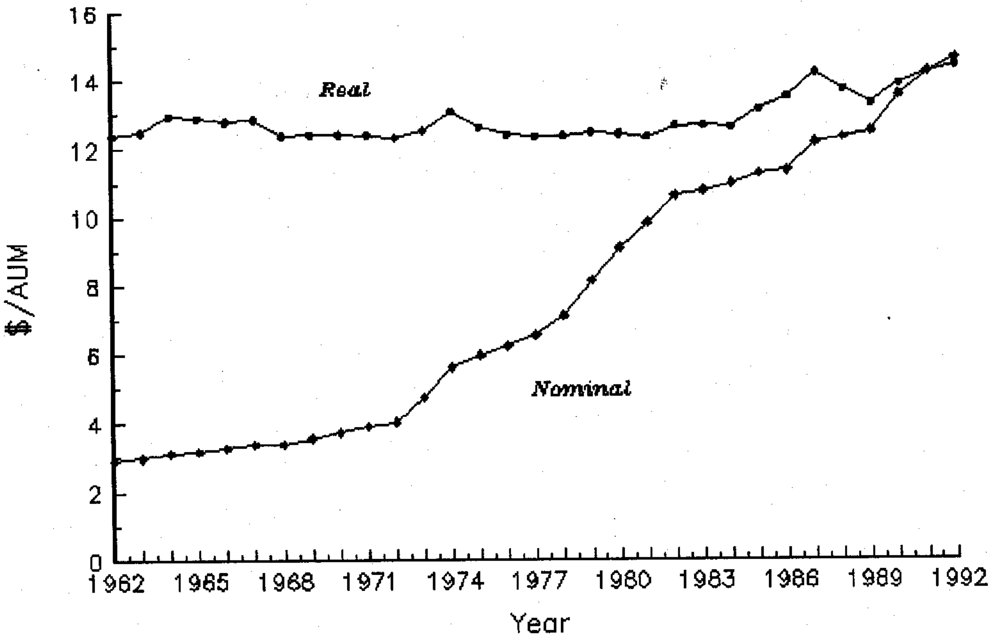

Figure 8. Nominal and real (1991 dollars) unbiased estimates of the latent variable nonfee grazing costs for cattle

Table 3. Maximum Likelihood Parameter Estimates for Predicted Cattle and Sheep AUMs

Variables	Estimated Coefficient	Covariance with ξ
Cattle:		
Fee and Nonfee Costs	– 1.39749 (0.87863)	
$AUMS_{1962–84}$	0.29240 (0.11003)	
$AUMS_{1985–92}$	0.27012 (0.08284)	
Cows	0.27270 (0.07070)	
PLLR	1.63391 (0.35106)	
$\Psi^{1/2}$ (standard deviation)	2.42680 (0.31043)	
Sheep:		
Fee and Nonfee Costs	– 0.97806 (0.40634)	0.21242 (0.03768) *(fees only)*
$AUMS_{1962–84}$	0.57389 (0.20528)	– 23.0315 (1.01725)
$AUMS_{1985–92}$	0.10132 (0.02779)	76.3055 (4.21212)
Sheep	0.13760 (0.09150)	– 29.1862 (1.20505)
PLLR	– 0.96630 (0.39105)	– 3.00622 (0.12857)
$\Psi^{1/2}$ (standard deviation)	0.70474 (0.08341)	

Note: Standard errors are in parentheses.

Table 4. Elasticity Estimates Calculated at the Means of the Data

	Grazing Fee and Nonfee Costs	PLLR	Inventory	Active Pref. 1962–84	Active Pref. 1985–92
Cattle	– 0.248	0.234	0.223	0.344	0.407
Sheep	–1.224	– 0.663	0.426	0.817	1.037

these earlier studies: the demand for authorized use by cattle ranchers is inelastic, even when nonfee costs are included in the price of the input. Small increases in these costs will have a negative effect on AUMs demanded, but public land grazing costs will increase as a share of ranchers' total costs due to the inelastic nature of the demand. Whether these increased expenditures go to the federal treasury, to local agricultural input suppliers, or require additional inputs of permittees' owned resources, including time, will depend upon whether the source of the cost increases is from increased grazing fees or increased nonfee costs due to higher transaction costs arising from changes in the set of property rights associated with the grazing permits.

The other factors affecting demand for BLM forage by cattle ranchers are all highly significant and of the expected sign. The influence of active preference (i.e., S^{max}) is similar between the two periods representing changes in BLM's reporting procedures. A 1% change in active preference results in a less than unitary percentage change in authorized use (0.34% for 1962–84 and 0.41% for 1985–92). Two possible explanations might apply to the elasticity estimates. One, reductions (there were very few years in which active preference increased) might only affect those permits which were not being used anyway. For example, permits for use in allotments that had not been used for many years might not be reissued at the time of a ranch sale. Consequently, such a reduction in active preference would have no effect on authorized use. In other cases, reductions in active preference might lead to the nonuse of allotments having low marginal value product relative to utilization costs. Referring to figure 7, restrictions in S^{max} might lead to the abandonment of $(Q_0 - Q_{new}^{max})$ AUMs. However, changes in demand and in allotment utilization costs over the study period did not result in S^{max} ever being a binding constraint.

The demand shifters, state beef cow inventory and private land lease rate, both have positive and significant influences on AUMs of authorized use, as expected from the discussion of figure 5. As cattle inventories change 1%, authorized AUMs demanded change 0.224%. Similar responses are noted for changes in the lease price of private land grazing. These inelastic responses may be attributed to rigidities in the contractual arrangements of the grazing permit. Although never binding in the years studied, active preference does impose a limit on any increases in forage demand resulting from increased inventories or increases in substitute forage costs. Factors resulting in an outward shift in the demand for federal grazing may limit individual ranchers to limits imposed by their active preference. Transaction costs associated with initiating use of previously unused allotments may mask eventual increases in their use that would not be captured in this short-run model. Conversely, leftward shifts in demand may see abandonment of higher priced nonfederal forage and feed sources, with ranchers continuing use of what may be their lowest priced forage resource.

Sheep

Parameter estimates resulting from the sheep log-likelihood function are in tables 2 and 3. Many of the results are analogous to those previously discussed with respect to cattle use of BLM section 3 lands. Estimated factor loadings for the first two indicator series are both positive and significant. Variance estimates in the CFA are all highly significant, again indicating that the series are imperfect indicators of the latent variable sheep nonfee costs. Real and nominal nonfee cost variable estimates are seen in figure 9. Real nonfee costs are estimated to have increased 26% over the period, or 0.9% a year. These real cost increases are over twice as large as those estimated for cattle nonfee costs.

The effects of changes in fee and nonfee costs are greater for sheep than for cattle. The negative parameter estimate is significant ($t = -2.407$). In addition, demand is elastic (elasticity = −1.224) for changes in fee and nonfee costs. Further increases in the costs of utilizing BLM grazing lands would likely precipitate a greater than proportional decrease in sheep use of the public lands. These elasticity estimates may reflect the sensitivity of the

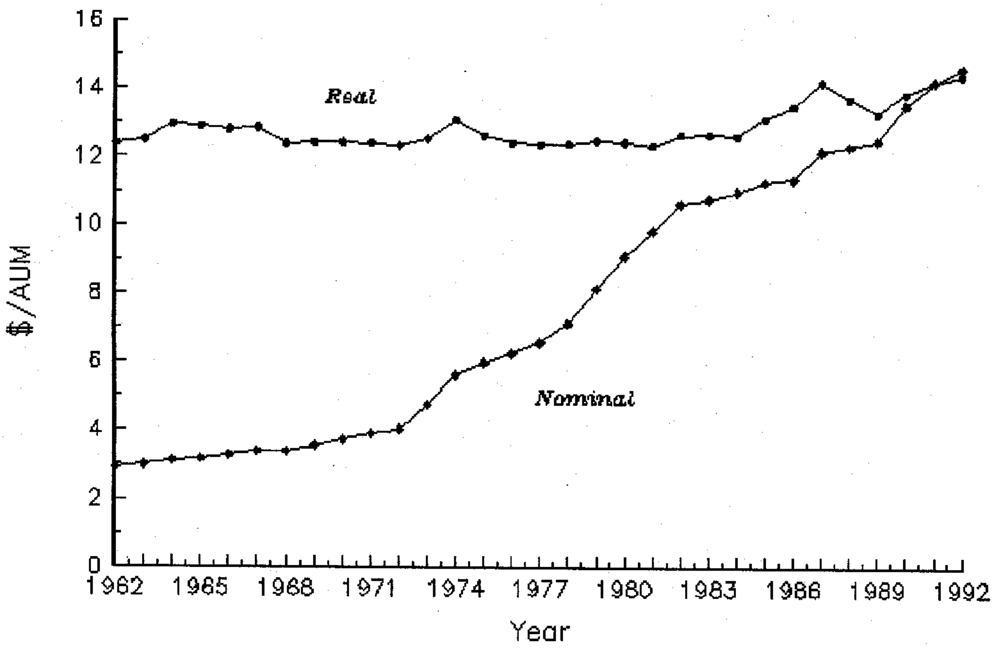

Figure 9. Nominal and real (1991 dollars) unbiased estimates of the latent variable *Nonfee* grazing costs for sheep

U.S. sheep industry to any additional exogenous factors having a detrimental effect on industry profits (Whipple and Menkhaus).

Sheep authorized use is more sensitive to the other independent variables considered. Changes in active preference have a nearly unitary impact on authorized use (elasticities of 0.818 for the 1962–84 period and 1.038 for the 1985–92 period). One percent changes in the breeding ewe inventory results in a 0.427% change in demand.[6]

The sign and significance of the coefficient estimate on the private land lease rate (PLLR) is surprising. The negative influence of the PLLR on sheep authorized use might be explained by the limited potential to substitute privately leased rangelands for federal grazing allotments because of the land extensive nature of western sheep production. Changes in the PLLR might also affect sheep use indirectly. For example, increases in the private lease rate may reflect higher opportunity costs of resources devoted to sheep production. Higher opportunity costs may in turn drive additional sheep producers out of business, thus decreasing the demands sheep producers make on the public rangelands. Tests of alternative hypotheses might be the subject of future research.

Welfare Analysis and Imputed Value of the Federal Grazing Permit

Earlier discussion addressed the welfare effects of changes in the market for public land grazing permits. Total surplus can be measured by integrating under the demand curve and

[6]One reviewer suggested that many sheep allotments are converted to cattle use. Consequently, some of the decreases in sheep active preference may appear as increases in cattle active preference. The aggregate level of the data and the change in bureau reporting procedures in 1985 preclude testing the significance of this phenomenon.

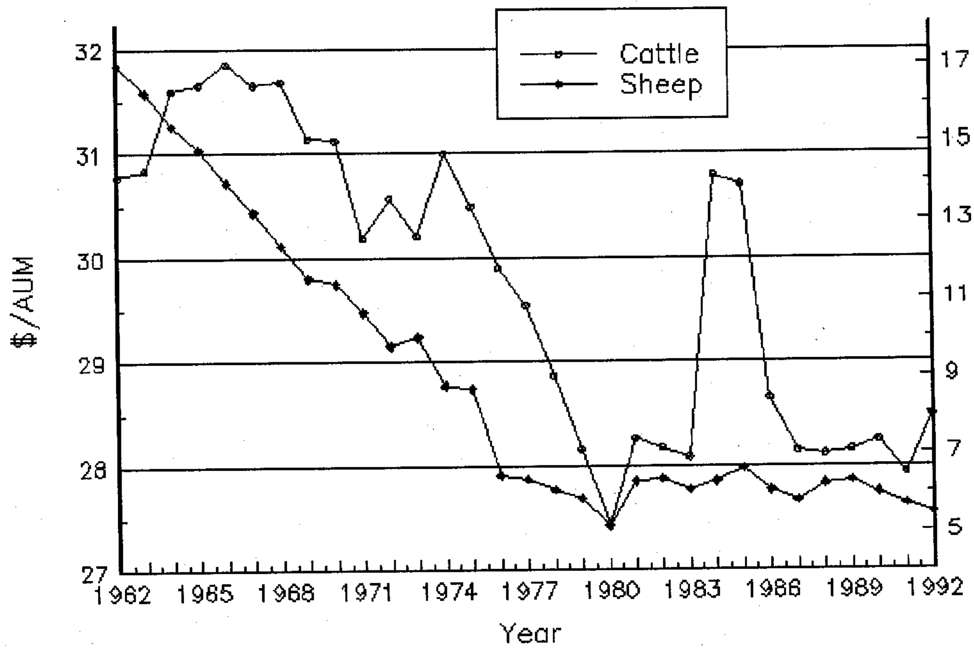

Figure 10. Real (1991 dollars) estimates of the Marshallian surplus per AUM arising from cattle (lefthand scale) and sheep (righthand scale) BLM grazing permits

above the fee and nonfee costs estimated for each year. These surplus measures are illustrated in figure 10 for cattle and sheep. There has been a gradual decline in the average surplus per cattle AUM over the last 30 years of about 10%, from about $31 to $28. However, surplus estimates have been stable since 1980 (except for the jumps in 1984 and 1985), fluctuating around $28 per AUM. It would appear that the adoption of the PRIA formula grazing fee in the 1980 grazing year may have stabilized the estimated surplus associated with cattle grazing on BLM lands. Other factors affecting the demand for federal forage, such as active preference, cow inventory, and private lease rates, will shift either the demand or supply schedules in figures 4–7, leading to the changes in welfare discussed earlier. With little change in the estimates of surplus since 1980, it may be possible that the fee is mitigating demand shifts resulting from factors affecting cow inventories (i.e., the beef price index) or the price of substitute forage sources (PLLR) to stabilize rancher welfare. Most of the change in active preference (figs. 1 and 2) also occured before 1980, thus reducing the possibility of surplus change resulting from this supply-side source.

There has been a much greater fall in both relative and absolute terms in the surplus associated with the sheep permits. Surplus per sheep AUM has fallen from about $16 to $6, or a fall of about 63%. As discussed previously, nonfee costs have increased more for sheep producers than for cattle producers, explaining part of the decline in surplus (see the discussion of fig. 6). In addition, there has been significant downsizing in the U.S. sheep industry due to increasing labor costs, low lamb prices, and reductions in predator control (Whipple and Menkhaus). These changes would probably appear as leftward shifts in the demand for federal grazing by sheep producers. The combination of these two forces has apparently had significant effects on the surplus accruing to sheep permittees. Similar to estimates of surplus for grazing by cattle, however, surplus in the sheep market has been stable since 1980. Most of the changes in active preference appear to have occured prior to 1980, though the aggregation of cattle and sheep preference numbers in 1985 hide changes in sheep preference the last few years of the study. It appears again that the PRIA grazing fee may be contributing to stability in sheep permittee welfare since its adoption in 1980.

Conclusions

Property rights enjoyed by BLM permitees have changed over the last 30 years. Permittees contend that these changes have increased transaction costs, including nonfee utilization costs, and reduced permittee welfare. The results presented in this study confirm these claims to a certain extent. Combined real fee and nonfee costs have increased about 17% and 29% for cattle and sheep permittees, respectively, over the last 31 years. Concurrent with these cost increases have been reductions in active preference for sheep and, to a lesser extent, for cattle permits. Surplus associated with BLM grazing permits has fallen slightly for cattle ranchers. Surplus accruing to sheep producers has fallen substantially, resulting from both changes in active preference for sheep grazing and increases in utilization costs, as well as exogenous forces that have shifted the sheep industry's demand for federal forage leftwards.

The analysis found no evidence of trends in demand that could not be accounted for by the variables included in the models. Residuals from both the cattle and sheep models were stationary, with the probability of incorrectly rejecting unit roots exceeding 99% for each series. Although there have been changes in the economic property rights associated with the federal grazing permit, the effects were adequately captured by both the observed data series and the latent variable constructed to reflect nonfee costs. Nonstationary residuals might have indicated changes in demand resulting from expectations of further attentuations of the property rights associated with the grazing permits.

A final comment applies about the sensitivity of demand to changes in utilization costs. Since the PRIA formula was instituted in 1980, grazing fees have been procyclical. When ranch profitability improves, the grazing fee generally increases. Our results indicate that the PRIA fee stabilized permittee surplus associated with the grazing permit. Perhaps because of this success, fee alternatives proposed by various western livestock producer associations retain some or all of the PRIA components.[7] The stabilizing influence may also be responsible for the observed resistence to changing the basis for the grazing fee. Perhaps the proposed levels are not such a concern as are the uncertainties associated with subsequent annual changes.

Because of the procyclical nature of the present formula fee, future changes in the grazing fee that ignore the timing of introduction may have a greater impact on the demand for AUMs than indicated by the elasticities estimated here. Although there currently is no legislative mandate to consider ability to pay, the financial impacts of any future changes in either the grazing fee or nonfee utilization costs will depend upon conditions in the two industries at the time any change is adopted.

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[7]See, for example, the fee alternatives proposed by the Western Livestock Producers Alliance and the High Country Citizen's Alliance contained in *Rangeland Reform '94* (USDI/BLM 1993).

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