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Ranch-Level Impacts of Changing Grazing Policies on BLM Land to Protect the Greater Sage-Grouse: Evidence from Idaho, Nevada and Oregon

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1. Introduction

The greater sage-grouse (*Centrocercus urophasianus*) is widely discussed as a candidate for listing under the Endangered Species Act (ESA). Biologists, conservation groups and government organizations have documented sage-grouse population declines and the apparent reasons for these declines, and have made recommendations for how to recover the species (see, for example, American Lands Alliance 2002, Connelly et al. 2000, USDI-BLM 2000 and 2001). Most states have convened local sage-grouse working groups to develop sage-grouse recovery plans built on collaboration across agencies and communities (see Nevada Sage-Grouse Project 2001, USDI-BLM 2001). Suggested conservation actions include educational programs about the species, mapping of sage-grouse habitat and distributions, research to evaluate how to manage and improve sage-grouse habitat, and habitat-restoration programs to recover the species and maintain habitat quality (Connelly et al. 2000, USDI-BLM 2001). Some proposed actions include significant changes to livestock grazing, and many biologists and environmentalists believe livestock grazing is the single greatest threat to sage-grouse (Clifford 2002).

A Memorandum of Understanding (MOU) between the Western Association of Fish and Wildlife Agencies (WAFWA), the U.S. Department of Agriculture, Forest Service (USFS), the U.S. Department of the Interior, Bureau of Land Management (BLM), and the USDI Fish and Wildlife Service (FWS) was signed in 2000. This MOU provided for the establishment of a team of representatives from the federal agencies and four states (Nevada, Idaho, Montana and Wyoming) to coordinate state and federal efforts to conserve sagebrush and sage-grouse. Specifically, the states and agencies agreed to consider, among other things, the WAFWA Guidelines to Manage Sage-Grouse Populations (Connelly et. al. 2000) in designing recovery plans for sage-grouse. These guidelines call for recovery plans that use local working groups to identify and solve regional problems related to the grouse. Local differences in conditions that affect sage-grouse populations may occur and Connelly et al. (2000) suggests these local differences should be considered in conservation plans.

Most management actions in completed state and regional sage-grouse plans are general and could apply in varying degrees to almost any area of the sagebrush ecosystem. This generality makes an assessment of potential impacts stemming from management changes impossible until local and specific courses of action are defined. One possible exception is livestock grazing.

Relatively healthy populations of sage-grouse occur in habitats grazed by domestic livestock, and grazing management in these areas results in habitat characteristics that support sage-grouse populations. However, low density or declining sage-grouse populations also occur in some areas characterized by a depleted herbaceous understory that may be the result of past or present grazing practices. Changes in grazing management may be necessary to increase sage-grouse populations, but experimental data are lacking to guide management decisions.

The political discussion surrounding livestock grazing and sage-grouse recovery is intense (see Clifford 2002). In many western states, the BLM lists the sage-grouse as a "sensitive species," and USFS defines it as a "management indicator species." This obligates these agencies to account for the needs of sage-grouse populations in their planning and management decisions. Management of public lands for the needs of livestock and sage-grouse will, at a minimum, require changes in land-use policies and goals. These changes are likely to occur even if an Endangered Species Act listing is postponed.

An example of these changes is a recent appeal by the National Wildlife Federation of a USFS environmental assessment (EA) on the Big Sheep grazing allotments in the Beaverhead-Deerlodge National Forest in Montana (National Wildlife Federation 2001). The appeal was based on two essential points. First, the appellants asserted that the USFS had failed to monitor sage-grouse populations over time on the grazing allotments in question. Second, the agency concluded that continuation of current grazing programs and maintenance of upland range improvements would have no significant impact on sage-grouse, even though the agency had virtually no population information for sage-grouse. The appellants argued that, because sage-grouse population data was lacking, this decision violated federal law. They requested that a "sage-grouse" alternative be added and the EA process be repeated with this alternative considered. The proposed alternative did not include elimination of grazing. It contained two main objectives (National Wildlife Federation 2001, p. 16):

> 1."...fully implement the *Guidelines to Manage Sage-Grouse Populations* (Connelly et al. 2000) by adopting range utilization standards that provide optimal breeding habitat and protect summer and winter habitats. Such an alternative would have forage utilization standards of around 25% (well

below current levels), would avoid the construction of new water developments, and would assess whether elk winter range utilization was negating the effects of livestock utilization standards."

2. "...reduce or eliminate the existing upland water developments and fences."

Sage-grouse is a management indicator species for the USFS and this appeal constitutes an example of how that management status will confront land agencies with demands to modify grazing use to meet the habitat needs of sage-grouse. Modifications to forage utilization, existing and potential range improvements and changes in grazing seasons in the name of sage-grouse are within the realm of likely policy changes.

Sage-grouse habitat needs for breeding, nesting and brooding coincide with the periods when cattle are grazing on public lands (Connelly et al. 2000). Thus, the habitat needs of the grouse will likely constitute a benchmark against which management policies will be judged under both the threat of and the event of an ESA listing. If sage-grouse habitat does not meet this benchmark, it is our conclusion that reductions in grazing on public lands (such as the 25% forage utilization limit mentioned in the USFS appeal discussed above) is as likely to occur as any other management change.

Given the continuing controversy and efforts to list the sage-grouse under the ESA, the Policy Analysis Center for Western Public Lands (PACWPL) was asked to evaluate policy alternatives and the implications of an ESA listing for both the sage-grouse and for affected human communities. This paper provides an analysis of potential ranch-level impacts from altered livestock grazing uses on public lands.

1.1. Impact Alternatives Considered

During the spring, sage-grouse chicks need herbaceous cover for protection. Forbs are particularly critical to their diet during this period (Connelly et al. 2000). While the condition of spring habitat is critical for the survival of sage-grouse chicks, this spring period is also critical for forage and livestock production. In this paper, we estimate the value of BLM spring forage for livestock production. We also estimate the economic consequences of eliminating spring grazing and reducing grazing capacity on BLM lands so as to improve and maintain habitat for sage-grouse. The projected economic consequences of two policy changes (i.e. eliminating spring grazing and reducing federal land allotments) would be applicable for numerous other endangered species and land-use issues where similar policy changes have been suggested. The answer is generic in its application.

Economic options available to many ranchers are to use deeded lands and meadows more intensively as grazing alternatives to public lands. Unfortunately, these same acreages are often prime habitat for sage-grouse, and adjusting seasons of use and stocking levels on deeded rangelands and meadows could be counterproductive. We make no judgment about whether the adjusted grazing strategies determined to be economically optimal with altered public land grazing policies would actually benefit sage-grouse. Our purpose is to provide an estimate of the economic value of public land forage potentially lost to representative ranches in each of three study states: Idaho, Nevada and Oregon.

2. Literature Review

2.1. Removal of Spring Grazing

On western ranches, the typical harvest pattern for forages and raised feeds, and level of dependence on western rangelands, varies by season. In northern climates where rangelands are grazed seasonally during the spring, summer and fall, a typical seasonal grazing use pattern may include feeding hay in November or December and continuing until March, April or early May when livestock are moved to BLM and state trust lands. During the summer, livestock may be moved to USFS permits or remain on BLM and state trust lands. As hay harvest is completed and temperatures cool in the fall, cattle are moved back to the ranch headquarters, grazing deeded lands and hay aftermath until the cycle starts again.

Rangelands traditionally provide a substantial amount of forage during selected seasons for many western ranches. If a ranching operation is permitted for yearlong grazing on public lands, as is typical in New Mexico and Arizona, a decrease in allowed federal grazing would likely reduce production in the same proportion as the decrease in available public AUMs. If the ranch is dependent seasonally on federal forage, a reduction in federal AUMs may create forage imbalances and produce a greater reduction in grazing capacity than just the loss of the federal AUMs.

The federal government has recognized the varying seasonal importance of federal grazing in many parts of the West. The 1986 Grazing Fee Review and Evaluation report (USDA/USDI 1986, p. 3) states:

> In numerous local areas in the West, the operating size of many livestock operations often is affected by the amount of federal range available during seasons of feed shortage on privately owned lands. Such critical periods may occur in the fall prior to hay feeding, in the summer when forage on private lands is low in nutritive value compared to forage on public ranges at higher elevations, and in the spring when private lands are needed to produce next winter's feed.

The impacts of eliminating or reducing spring grazing will depend on ranch resources and the substitute forage alternatives that are economically available. Obviously, the winter feeding period could be extended if spring grazing was eliminated, but this would increase feed costs. In many cases it would mean spring hay feeding would have to move from meadows to other areas so irrigation water could be applied.

Leased private lands might be available in the spring if public land grazing capacity were reduced, but in many cases additional grazing forage could only be leased by shipping livestock a substantial distance and with a substantial increase in feed costs. Marginal hay land could be converted to pasture and grazed, and grazing use of deeded rangelands and existing improved pastures could be adjusted by season where possible. However, in most cases there is little flexibility to implement seasonal changes in grazing use, and herd size reductions may be the only alternative, at least in the short run.

Some research on the economics of reduced or eliminated federal land grazing is available. Greer (1994) found that the reliance of southeastern Oregon ranchers on public lands can appear insignificant when calculated on an acreage or AUM basis, but, when calculated on a seasonal dependency basis, federal grazing is quite important. Taylor et al. (1992) found that, in Colorado, federal forage meets only 25% of annual forage requirements; yet, over 50% of summer season forage is obtained from federal lands.

Cook et al. (1980) found that changes in spring use had a greater impact on livestock sales per AUM for Colorado ranchers than did AUM changes in any other season. Van Tassell and Richardson (1998) also found that spring and summer forage obtained from public lands was critical to the operation of federally based ranches in Wyoming. Similarly, Torell et al. (1981) found the same situation for public land ranches in northern Nevada. Optimal production strategies and ranch income were not exceptionally sensitive to increases in the grazing fee, but production and net returns changed substantially when federal AUMs were removed from any season, particularly the spring season.

If an altered land-use policy means that grazing will not be allowed during the spring period, but the number of public land AUMs allowed for grazing is not correspondingly reduced, it is possible that eliminating spring grazing and shortening the allowed grazing period on public lands would increase optimal herd sizes. Torell et al. (1981) estimated this would be the situation for northeastern Nevada ranchers when spring grazing was eliminated. Given the cost/price definition of the analysis, the profit-maximizing strategy was to make up lost public land AUMs during the spring period by feeding more hay and to substitute other forages where possible. Net returns were reduced, but it was most profitable to use BLM AUMs previously grazed during the spring in other seasons and to expand herd size. For other ranches with few low-cost alternative sources of forage, optimal herd size could decrease with the elimination of spring grazing.

2.2. Allotment Reductions

Linear programming (LP) and ranch budgeting procedures have been used to estimate the seasonal value of public land forage (Bartlett 1983, Gee 1983, Hahn et al. 1989) and to estimate economic impacts from changes in federal land policies (Bartlett et al. 1979, Gee 1981, Perryman and Olson 1975, Rowe and Bartlett 2001, Torell et al. 1981, Van Tassell and Richardson 1998). All of these earlier LP models were single-year models that considered production under some defined average cost/price situation. Typical or representative ranches were defined from available cost-and-return studies in the various study areas. These studies found reductions in income and net ranch returns were not proportional to reductions in federal forage. The rigidity of seasonal forage availability meant the optimal use of other forages and resources were impacted when federal AUMs were removed. Other forages were reallocated to offset part of lost federal forage (Gee 1981, Van Tassell and Richardson 1998).

Gee (1981) and Hahn et al. (1989) used LP to estimate forage value on BLM and USFS lands. Forage values in 1981 were estimated to be \$10.86/AUM for BLM and \$11.58/AUM for USFS (Gee 1981). Hahn et al. (1989) updated Gee's work and reported forage values for each of nine USFS regions and as a national average. Values ranged from \$9.22/AUM in Region 3 (New Mexico and

Arizona) to $15.11/AUM in Region 5 (California). Van Tassell and Richardson (1998) reported much higher values for BLM and USFS AUMs. For the Wyoming ranches studies, complete elimination of the BLM permit was estimated to decrease annual net cash income by an average of $55/BLM AUM removed. Eliminating the USFS permit decreased annual net returns by a similar amount, $52/AUM. At the other extreme, because some western ranchers are not necessarily in the business to make a profit and spend more than they justifiably should to produce livestock, Rowe and Bartlett (2001) found that eliminating federal grazing permits in Colorado would actually benefit some ranchers by forcing them to reduce the size of their money-losing livestock enterprise. Economic changes from allotment adjustments varied widely, ranging from a loss of $40/AUM to a gain of $27/AUM when herd reductions were the assumed adjustment strategy.

3. Methods and Procedures

We define the economic situation, typical resource base, production rates and practices for western ranches in three areas in the West: Owyhee County, Idaho; Northeastern Nevada; and Lake County, Oregon. Representative ranches in these areas were selected because livestock cost-and-return estimates and policy impact models had been developed for these areas. Additionally, ranches in these areas provide sage-grouse habitat and are dominated by the sagebrush rangeland type.

Data from cost-and-return studies were used to build multi-period linear programming (LP) models to evaluate how optimal (profit-maximizing) production strategies would change as permitted grazing use on public land changes. The specific ranches considered included medium-sized (300 cows) ranches in the Jordan Valley area of Owyhee County, Idaho; large ranches (720 cows) in northeastern Nevada; and large ranches (500 cows) in Lake County, Oregon.

The economic analysis was completed in four steps. First, ranch-level data defining typical production practices, production rates and production costs were gathered from group interviews with area ranchers (Darden et al. 2001, Rimbey et al. 1998, Oregon cost-and-return studies have not yet been published). Second, a multi-period linear programming model was developed to depict the production processes of each representative ranch. Published cost-and-return studies that provided baseline cost data were for either the 1997 or 1998 production years. All prices were adjusted to real 1997 levels.

An initial baseline optimization was estimated for each model ranch. This was followed by additional optimizations that evaluated profit-maximizing production strategies under different policy scenarios. The estimated impact of changes in land-use policies is then the difference in optimal herd size, forage use and economic returns as compared to the baseline.

The projected economic consequences of two policy changes, elimination of spring grazing on BLM land and BLM allotment reductions, are evaluated. For eliminating spring grazing, we considered the removal of the first month of grazing. Spring grazing dates considered varied between the representative ranches because typical turn-out dates are different for each ranching area and ranch model, but in all cases the defined spring period would correspond to a period of critical concern for sage-grouse. During these spring months, sage-grouse use sagebrush habitats for breeding, feeding, roosting, nesting and rearing young. Available sagebrush, herbaceous cover and insects are considered to be critical for sage-grouse chick survival during the spring period (Connelly et al. 2000).

Allotment reductions considered included a 50% reduction, 75% reduction and total elimination of available BLM AUMs. The actual reduction level that might be necessary to improve sage-grouse habitat on a particular allotment, and alternative management options that could be used to minimize the disruption of grazing uses, will be site specific and variable. Further, reduction levels considered in the analysis may not be adequate because of the inter-dispersed nature of land tenure on many western ranches. State trust lands are often small, scattered parcels located with the BLM allotment, and private lands are also scattered within allotment boundaries. The Jordan Valley, Idaho model, for example, was defined to have state trust lands in addition to BLM lands, but the exact location of these lands was not defined. Elimination of spring grazing or reductions in federal land grazing may mean elimination or reductions on these other lands as well.

Each representative ranch has different amounts and types of resources defined to be available for grazing, and different options for replacing public land forage. Substitute forages and strategies considered to be available as BLM allotment grazing capacity was reduced included leasing outside private forage, converting native meadow hay land to irrigated pasture, extending the hay feeding period, and reducing the size of the cow herd. These alternative forage sources were considered to be available during selected seasons for both the base run and for additional policy impact runs. Converting hay land to pasture was not considered an option in the Oregon model because of the improved meadow and meadow hay produced.

We considered two alternative analyses for the elimination of spring grazing on BLM land. The first scenario was restrictive but may be most realistic in many cases because of limited opportunities to develop forage substitutes. This scenario considers only the options of feeding hay or reducing herd size. The second scenario allowed leasing outside private AUMs, converting hay land to pasture, moving the season of use of all deeded land to the spring, extending the winter feeding period, and reducing herd size.

We considered reductions to the BLM allotment to be phased in over five years in equal increments. The first 1/5 of the reduction was considered to occur during the second year. Results reported for optimal number of BLM AUMs used started with the sixth year when the full reduction had been implemented.

3.1. Linear Programming Model Description

The policy impact models used in this analysis were developed in five states and are structured for western livestock ranches that rely on both deeded and public lands for grazing capacity. A limited number of crop-raising alternatives are included in the models, but only as these crops provide forage, crop residue and feed for livestock production.

The net present value (NPV) of discounted net annual returns (profits or gross margin) is maximized over a T-year planning horizon subject to linear constraints that define resource limitations and resource transfers between years. Seasonal forage supply and demand is explicitly considered.

Figure 1 illustrates the general structure of the constraint set for the LP models during a given year t. Equations are discussed from top to bottom in the figure. A ranch has available a given set of cropland and rangeland for harvest and grazing. Each type of land is restricted at a level at or below some available upper limit, and that is the first block of equations in the model. Also considered in this block is recognition that certain forages will be restricted in use to only selected seasons, because of regulation, physical availability or production limitations.

The next block of equations is included to

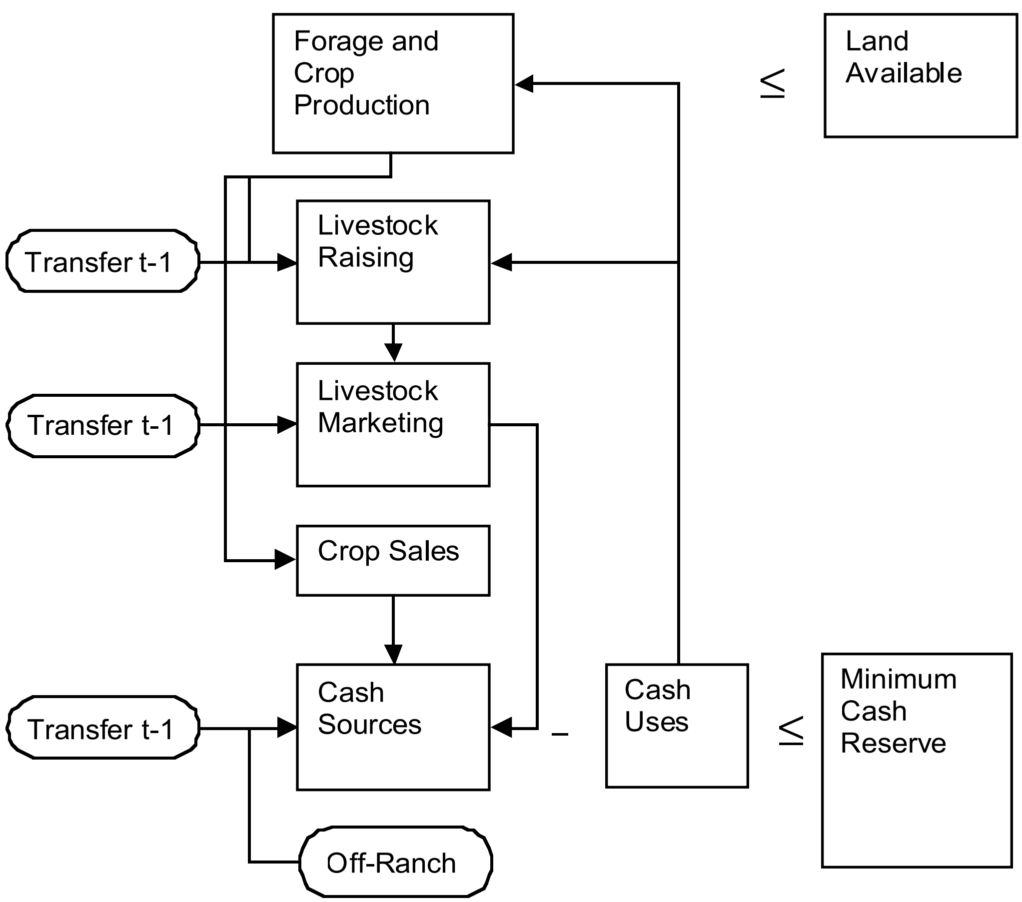

Figure 1. LP model constraint structure.

transfer forage and crop production to livestock-raising activities and crop-selling activities. Within the livestock-raising block are equations that define the required ratio between different animal classes. Some examples: bulls must be included based on a specified bull-to-cow ratio and the specified calf crop defines the number of young animals available for sale and herd replacement.

Seasonal forage requirements for each animal class are calculated based on defined animal unit equivalencies (Table 1) and the length of each grazing season. Equations are also included that transfer brood animals from the previous year. Typical animal death loss and the relative number of different animal classes are considered at the time of the transfer. The livestock-marketing block includes equations that transfer between livestock-raising and livestock-selling activities. Yearling animals are carried over from year t-1 to year t; this is another inter-year linkage in the model.

Table 1. Animal unit equivalencies used to calculate seasonal forage requirements [from Vallentine (1990)].

Animal Class	Animal Unit Equivalency (AUE)
Brood cows	1.00
Bulls	1.25
Horses	1.25
Weaned calves	0.50
Yearlings	0.75

The next equations define the cash flow constraint. Crop and livestock sales generate income and are a source of cash. Livestock-, crop- and forage-raising activities use cash. The cash constraint requires that a cash reserve be maintained so as to cover variable production expenses, fixed ranch expenses, family living expenses, loan obligations and an annual cash residual. Excess cash at year t-1 can be transferred to year t, and in fact it is implicitly assumed that any excess cash from a "good" year will be transferred to cover expenses and cash shortfalls in future years. Other sources of cash include off-ranch income and annual borrowing. Any funds borrowed must be repaid during the next year. Borrowing is not allowed during the last year and all debt obligations must be paid in full by the end of the T-year planning horizon. While numerous equations are included to define the production and economic processes of the representative ranch, forage resources and available cash ultimately determined the level of production possibilities.

Torell et al. (2001) and numerous other studies reviewed in that paper highlight that western ranchers do not have profit maximization as the primary goal; rather, they ranch for the way of life and the desirable attributes of rural living. As noted by Van Tassell and Richardson (1998), western public land ranchers will, for the most part, continue to ranch until forced to do something else. How, then, do we justify using profit maximization as our model objective? First, the utility-maximization model that ranchers subscribe to is impossible to measure and quantify. Individual ranchers and ranch families have differing levels of commitment to the ranching lifestyle and decreasing annual ranch income through altered land-use policies can be expected to dampen enthusiasm for ranching to varying degrees. It will not be possible to predict how many ranchers a particular land-use policy will force out of business (Torell et al. 2001).

The profit-maximizing objective provides a measurable criterion against which to judge policy changes. It is tempered by considering only investment alternatives related to ranching and livestock production, and by including cash flow restrictions. The LP model determines the optimal production strategy with the current policy prescription and how optimal production changes with a new policy. The implicit assumption is that ranch families will continue to consider only the limited investment opportunities associated with the ranch property; they prefer more money to less; and will continue to ranch until cash flow restrictions can no longer be met and they are forced from the business.

3.2. Representative Ranches

Table 2 summarizes forage resources, typical production rates and costs, and forage harvesting alternatives defined for each of the representative ranches. The grazing seasons and the seasons when alternative forages were considered to be available for grazing are defined in Table 3. Grazing seasons were defined based on typical turn-out dates, potentially adjusted turn-out dates and livestock marketing dates. Notice that the cost per unit of harvesting both federal and private forage (Table 2) includes both fee and non-fee grazing costs (e.g. herding cattle, checking cattle, improvement maintenance) as estimated by Van Tassell et al. (1997) and Van Tassell and Richardson (1998). The cost of leasing private rangeland in Nevada was considered to be exceptionally high ($30/AUM) because little private forage is available for lease in the state and this activity would require high non-fee costs because of the distance to available private leases.

Table 4 presents the assumed productivity of rangeland and pasture resources for each of the

Table 2. Characteristics and resources of the representative ranches.

		Number of Units			Objective Function Cost ($/unit)		
	Units	Idaho	Nevada	Oregon	Idaho	Nevada	Oregon
Land resources owned							
Alfalfa hayland	Acres			90			400.00
Native meadow hayland	Acres[a]	325	800	290	50.00	50.00	97.00
Convert meadowland to pasture	Acres[a]	325	800		13.75	12.50	
Deeded rangeland	AUMs	240	115	600	3.25	3.25	3.25
Land resources leased or purchased[b]							
State trust land	AUMs	144			10.64		
BLM	AUMs	2,098	4,148	2,400	7.19	7.19	7.19
USFS	AUMs			2,560			9.46
Private leased land	AUMs	500	500	500	13.25	30.00	13.25
Purchase alfalfa hay	Tons		Unlimited		100.00	85.00	120.00
Purchase meadow hay	Tons		Unlimited		NA	70.00	85.00
Sell alfalfa hay	Tons		All available				100.00
Sell meadow hay	Tons		All available		55.00	55.00	65.00
Livestock resources[c]							
Animal units yearlong	AUY	333	700	607			
Brood cows	Head	286	602	511	68.75	62.40	9.88
Replacement heifers	Head	65	120	86	68.75	62.40	9.88
Bulls	Head	19	36	29			
Horses	Head	6	12	10			
Miscellaneous income/expenses							
Fixed ranch expenses	$				24,430	33,361	25,432
Family living allowance	$				24,000	24,000	24,000
Off-ranch annual income	$				30,000	10,000	10,000
Required minimum cash reserve	$				500	500	500
Efficiency measures[d]							
Calf Crop (Calves born as % of Jan. 1 cow inventory)	%	88	85	90			
Calf death loss	%	4	3	4			
Cow death loss	%	2	2	2			
Bull death loss	%	1	1/2	1			
Steer calf sale weight	lb	440	475	525			
Heifer calf sale weight	lb	390	435	450			
Heifer yearling sale weight	lb	800	750	850			
Cull cow sale weight	lb	950	950	1,100			
Cull bull sale weight	lb	1,800	1,450	2,000			

[a]/Converting hayland to grazable pasture is not generally practiced but is a possible source of forage if public land AUMs are removed. This conversion would use some of the available hayland and thus would reduce the land available for crop production. The cost of the conversion was estimated by Van Tassel and Richardson (1998).

[b]/In addition to the $1.35/AUM grazing fee that has been paid for public land grazing in recent years, grazing costs shown above include estimates of non-fee grazing costs (e.g. herding, checking, moving). These estimates were made by Van Tassell and Richardson (1998) using rancher producer panel data and grazing cost data reported by Van Tassell et al. (1997).

[c]/Animal numbers reported are from the published cost-and-return publications for each state. Optimal animal numbers in the LP model will vary by year as beef prices vary. Animal costs exclude the cost of feed stuffs and non-fee grazing costs which are separate activities in the LP model. Animal costs include expenses for other classes of animals like bulls and horses as well.

[d]/Other production parameters used to develop the LP models are defined in the cost-and-return series publications.

Table 3. Seasonal availability (*) of hay and forage for representative ranches.

	Season					
Idaho	1-Mar 15-Apr	15-Apr 15-May	15-May 15-Oct	15-Oct 15-Nov	15-Nov 15-Dec	15-Dec 1-Mar
State trust land		*	*			
BLM		*	*			
Private lease	*	*	*	*	*	
Deeded range	*	*	*	*	*	
Aftermath grazing				*	*	
Convert meadow to pasture	*	*	*	*	*	
Feed raised/purchased hay	*	*				*

	Season					
Nevada	8-Apr 8-May	8-May 8-Jun	8-Jun 1-Oct	1-Oct 23-Nov	23-Nov 15-Dec	15-Dec 8-Apr
BLM	*	*	*			
Private lease	*	*	*	*	*	*
Deeded range	*	*	*	*		
Aftermath grazing				*	*	
Convert meadow to pasture	*	*	*	*	*	
Feed raised/purchased hay	*	*			*	*

	Season					
Oregon	1-Mar 1-Apr	1-Apr 1-May	1-May 1-Oct	1-Oct 1-Nov	1-Nov 1-Dec	1-Dec 1-Mar
BLM	*	*	*	*		
USFS			*			
Private lease	*	*	*	*	*	
Deeded range	*				*	
Aftermath grazing					*	
Convert meadow to pasture		*	*	*	*	
Feed raised/purchased hay	*	*			*	*

Table 4. Productivity measures for harvested and grazed forages.

	Unit	Idaho	Nevada	Oregon
Hay conversion to AUMs	AUMs/ton	2.42	2.42	2.42
Raised native hay	tons/acre	1.5	1.5	1.5
aftermath	AUM/acre	2.3	2.5	2.3
Raised alfalfa hay	tons/acre			4.5
aftermath	AUM/acre			0.3
Pasture native hayland	AUMs/acre	5.5	5.0	

representative ranches. These rates were defined in the cost-and-return publications for each state.

3.3. Linear Programming Analysis

Optimal production and economic returns for the representative ranches was simulated over a 40-year planning horizon with 100 different iterations (beef price situations). The ranch starts the process in year 1 with an inventory of breeding animals (Table 2). From this point, during years 2 through 40, the model is free to adjust herd size (purchase or sell) to profit-maximizing levels subject to forage and cash limitations. Forage and pasture resources can be grazed or not grazed depending on its potential contribution to profit. An exception to this was state trust land in Idaho. Because the Idaho Department of Lands requires fees be paid whether the land is grazed or not, the restriction was included that state land AUMs had to be used.

3.3.1. Output Prices

Annual ranch income and optimal production strategies are greatly influenced by crop and livestock prices. To minimize the effect of beef prices on the results of the policy assessment, a Monte Carlo analysis was used (Hillier and Leiberman 1986). Real (constant 1997) livestock prices were stochastic exogenous variables in the LP analysis. Monthly average livestock prices were used from markets in each of the three study states for the period January 1, 1980 to August 24, 2000 (Unpublished data supplied by David Weaber, Cattle-Fax, Inc., Centennial, Colo., Sept. 8, 2000) to estimate a time series price-forecasting model. The beef price model considers and estimates an approximate 12-year cycle of beef prices. It considers the relative price spread between different classes of livestock and the interdependence of beef prices for different animal classes at any point in time.

The starting point of the beef price cycle was randomly assigned for each iteration. Running the model with numerous alternative beef price scenarios and reporting averages and standard deviations across all iterations minimizes the effect of beef prices in the policy impact assessment.

The cost of purchasing bulls was not reported in the Cattle-Fax data. Data from the Tucumcari, N.M. bull sale was used to estimate that the sale price of bulls (constant 1997) is about twice that of bred cow prices.[1]

Hay prices were not varied by iteration because a long-term data series was not available to estimate annual price variability and relationships. The assumed real purchase and sale price of hay (Table 2) was considered to be the same during each year of the analysis. Another limitation was that annual fluctuations in forage production were not considered. While the importance of variability in annual forage production and the need to adjust stocking rates downward when production is low is widely recognized (Vallentine 1990), it is rarely considered in economic studies because of data limitations. We followed the standard analysis procedure of assuming an average annual level of forage production from each alternative forage source.

Initial debt obligations were not considered as an expense category in the analysis. This is because cost-and-return data used to define typical production practices, production rates, and costs and returns of the representative ranches do not include information about "typical" debt obligations of area ranchers. This personal data is generally not available and is known to vary widely from ranch to ranch. Gentner and Tanaka (2002) reported relatively low average debt loads for different classifications of public land ranchers responding to a West-wide survey.

The amount of off-ranch income and wealth available to ranch families is also variable. Recent studies have found new ranch buyers are not the traditional ranch family that depends exclusively on the ranch for disposable income (Gentner and Tanaka 2002, Torell et al. 2001). People with wealth or great outside income are purchasing many western ranches. As an overall weighted average, Gentner and Tanaka (2002) found large, full-time ranchers to have about $10,000 in annual off-ranch, retirement, and/or investment income. Small, part-time ranchers had $47,000 in off-ranch and other income, and depended on the ranch for less than 20% of annual disposable income. By comparison, full-time ranchers depended on the ranch for about 80% of disposable income (Gentner and Tanaka 2002).

While debt loads, wealth and off-ranch income are highly variable between ranches, the commitment of western ranchers to remain on the ranch remains constant (Gentner and Tanaka 2002, Torell et al. 2001). Given this commitment and the variability in financial resources across ranches, we followed two modeling procedures. First, we did not include investment opportunities like land development or the stock market. The LP model maximizes net discounted returns given the economic opportunity of raising cows or selling hay. Second, we assumed that the representative ranch would have at their disposal average levels of off-ranch income near that found by Gentner and Tanaka (2002). We assumed the 333 AUY ranch in Jordan Valley, had $30,000 in off-ranch income and the larger Nevada and Oregon models had $10,000 in off-ranch income. We assumed no initial wealth other than the initial inventory value of breeding animals and the ranch capital investment. For the base run and impact assessment, there were no debt obligations against the cow herd or the land. Given the known variability in debt across ranches, we then conducted a sensitivity analysis to investigate how the base run and policy impacts would change with increasing debt obligations and/or reduced levels of off-ranch income. We computed the average annual debt payment that could be sustained before and after the land-use policy change. The cash flow constraints of the LP model are of key importance for this assessment in that they require all variable, fixed and family living expenses to be covered each year, given calculated

[1] The regression equation estimated was Bull Price = 154 + 2.0549_Bred Cow Price, R^2 = 73%. [Annual average prices 1975 – 2001].

annual ranch returns and alternative assumptions about off-ranch income.

Annual borrowing was allowed (10% annual interest rate) with the full amount repaid the following year. The model allows repeated borrowing from year to year across a 40-year planning horizon, but debt must be repaid at the end of that period. Incurring an annual land payment or intermediate loan payment is equivalent to having an additional fixed expense obligation. If fixed expense obligations are too high, the cash flow constraint cannot be met and an "infeasible solution" is obtained. This is how the sensitivity analysis was conducted. The assumed level of off-ranch income was repeatedly reduced and even made negative (implying a borrowing situation) to investigate how decreasing levels of off-ranch income and increasing levels of debt added to the frequency by which annual cash flow requirements would become limiting. This was done for both the base run and the policy impact runs.

The sensitivity analysis presents a best-case situation because the model assumes that all excess funds in good years are saved to meet future cash shortfalls. With this definition the ranch family does not squander money during the good years; they live within the $24,000 family living allowance. Other fixed obligations of the ranch including depreciation and replacement of vehicles, equipment and improvements; electricity; telephone; and insurance are also subtracted as an annual fixed expense (Table 2).

4. Results

4.1. BLM Grazing Reductions

4.1.1. Jordan Valley, Idaho Model

Table 5 presents the average and standard deviation [computed over 100 beef price situations (iterations) and 40 years] of key production, and economic and resource variables estimated to be optimal (profit-maximizing) for the Jordan Valley, Idaho model under different levels of BLM AUM availability. For the current situation, given the defined seasonal forage resources of the representative ranch, approximately 22% of BLM AUMs would optimally go unused each year because cash and forage resources in other seasons are more limiting. An average 345 AUY would be maintained on the ranch. Annual net cash income[1] was estimated to be $8,856 with a great deal of variability (standard deviation of $21,820). Given an assumed annual input of $30,000 from off-ranch sources, this means the ranch was subsidized by off-ranch employment by about $21,000/year. Approximately 35% of the time net annual income (including ranch and off-ranch sources) would be negative, requiring transfer of savings from previous years or borrowing to meet cash flow requirements. These periods of negative income occurred in low beef price years or when herd expansion was economically optimal.

With off-ranch income and assumed frugal behavior and saving, the Jordan Valley model was always able to find a feasible solution, i.e., cash flow requirements could always be met. Only a minimal amount of annual borrowing was required with current allowed uses of federal forage.

As BLM grazing was sequentially reduced, net annual ranch returns decreased. The reduction in net ranch income per BLM AUM removed ranged from $2.41/AUM with a 50% BLM reduction to $3.44/AUM when BLM grazing was precluded. Average annual net cash income decreased from $8,856/year under the current situation to $1,631/year with a 100% BLM grazing reduction. This is the average residual amount that remains as a return on total ranch investment once all variable costs, loan costs, fixed costs and family living expenses have been paid.

Because the representative ranch did not depend on BLM land for 100% of annual grazing capacity, the optimal reduction in herd size was far less in percentage terms than the percent reduction in BLM forage. A 50% BLM reduction, for example, reduced optimal average herd size by 19% and a 100% BLM reduction reduced optimal average herd size by 42% (Table 5). This reduction is very near the average 39% that the representative ranch depended on BLM for annual grazing capacity under the current allotment allocation.

In addition to herd size reductions, other optimal adjustments to reduced BLM AUMs included conversion of hay land to pasture. Over 100 acres of hay land would optimally be used as pasture if the total BLM allotment were removed (Table 5). At an assumed cost of $13.25/AUM, private leased forage would only be the least-cost forage substitute when beef prices were relatively high and minimum number of private leased AUMs would optimally be used.

4.1.1.1. Sensitivity Analysis

It was assumed that the representative Jordan Valley model ranch had at its disposal an annual $30,000 in off-ranch income. The utmost level of

[1]/Net cash income was defined to be gross crop and livestock sales + off-ranch income – variable production expenses – annual loan costs – fixed ranch expenses - family living expenses. It is the residual return to the investment in land and cattle, and to risk.

frugality was assumed with all excess funds in the good years saved to meet shortfalls in future years. With this frugal savings plan, a minimal level of annual borrowing was required.

Figure 2 shows how the likelihood of going broke (i.e. incurring an infeasible solution) increased with decreasing amounts of off-ranch income and for alternative reductions in available BLM AUMs. As shown, access to about $25,000 in outside annual income is crucial. With the current allocation of BLM AUMs, the Jordan Valley ranch would be unable to meet cash flow requirements in 5 out of 100 iterations (beef price situations) when off-ranch income was reduced to the $25,000 level. These infeasible solutions occurred when relatively low beef prices were realized in the early years of the analysis.

As off-ranch income was reduced to $20,000/ year and below, cash flow restrictions became limiting in all cases. The $15,000 range in off-ranch income (from $30,000 to $15,000) between being able to always meet annual ranch and family expenses and the 100% probability of going broke is extremely narrow. There is no ability to service

Table 5. Optimal adjustments to reductions in BLM AUMs, Jordan Valley, Idaho model.

	Percent reduction in BLM AUMs			
Adjustments in optimal use levels	0%	50%	75%	100%
BLM available (AUMs)	2,098	1,049	525	0
Optimal average BLM used (AUMs)	1,632 (223)	1,040 (35)	523 (14)	0 (0)
Percent of AUMs from BLM land	39%	31%	18%	0%
Average number of brood cows (head)	223 (18)	180 (22)	154 (28)	127 (34)
Average number of AUY	345 (31)	280 (33)	239 (41)	199 (50)
Percent reduction in AUY (%)	–	-19%	-31%	-42%
Average annual variable production costs ($)	71,231 (7,569)	59,246 (6,718)	49,268 (8,156)	39,646 (11,083)
Average annual variable production costs ($/AUY)	206	212	206	199
Average annual net cash income ($)	8,856 (21,820)	6,331 (17,624)	4,223 (15,472)	1,631 (14,814)
Average annual net cash income ($/AUY)	25.67	22.61	17.67	8.20
Average change in net cash income ($/BLM AUM removed)	–	-2.41	-2.94	-3.44
Deeded Range (AUMs)	240 (0)	240 (0)	240 (0)	240 (47)
State trust land (AUMs)	144 (0)	144 (0)	144 (0)	144 (0)
Private Lease (AUMs)	1 (9)	35 (91)	38 (100)	38 (100)
Meadow hayland acres hayed/grazed (acres)	325 (0)	313 (10)	265 (14)	214 (14)
Meadow acres converted to pasture (acres)	0 (0)	12 (10)	60 (14)	111 (14)
Raised meadow hay fed (tons)	440 (35)	359 (42)	307 (54)	256 (65)
Raised meadow hay sold (tons)	47 (35)	113 (44)	100 (46)	82 (44)
Purchased alfalfa hay fed (tons)	123 (34)	98 (26)	83 (24)	68 (22)
Average amount borrowed annually ($)	83 (1,234)	66 (1,118)	57 (1,012)	457 (5,222)
Probability of being forced out of business (%)	0%	0%	0%	0%
Probability of negative net annual cash income (%)	35%	37%	40%	45%

[a]/Number in parenthesis is the standard deviation measured over the 100 iterations and 40 years.

[b]/The assumption was made that the reduction in allowed grazing capacity would be incrementally phased in over 5 years. Thus, the computed average is for years 6 through 40 after the reduction is fully implemented.

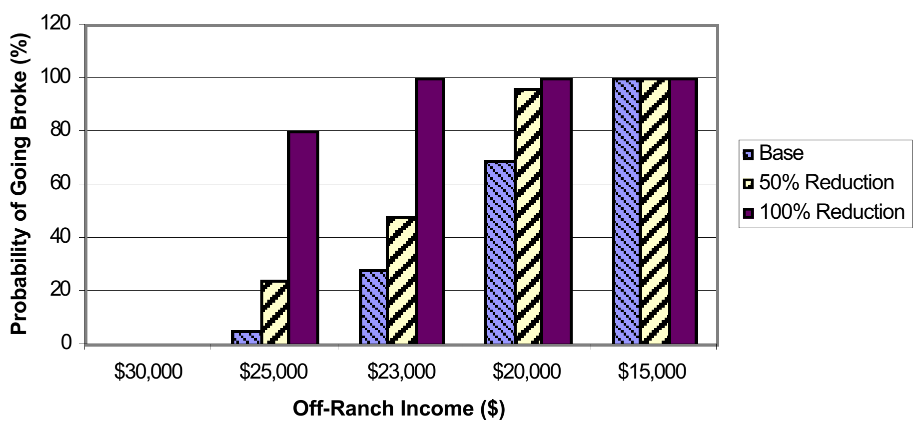

Figure 2. Probability of not being able to meet cash flow requirements with alternative levels of off-ranch income and with BLM allotment reductions, Jordan Valley, Idaho model.

long-term or intermediate debt from net ranch income for this 300-AUY ranch. This representative ranch must be subsidized by off-ranch income or accumulated wealth if the assumed fixed costs and family living allowance is to be paid each year.

The percentage of time that the representative ranch went broke increased as increasing levels of BLM forage was removed. Removal of the BLM permit would cause an 80% probability of going broke when off-ranch income was reduced from $30,000, to $25,000 (Fig. 2).

As shown by Gentner and Tanaka (2002), many public land ranchers have annual off-ranch income and wealth far in excess of what was assumed here. Others have less. Whether ranchers will remain in business as federal AUMs are removed will depend on their willingness to incur reduced ranch income, and their commitment to the ranching lifestyle. The cash flow restriction does not limit production opportunities for ranchers subsidizing the ranch enterprise with large amounts of off-ranch income and wealth, but it was a limiting factor for the defined representative ranch.

4.1.2. Northeastern Nevada Model

Table 6 presents results for the Northeastern Nevada model under different levels of BLM AUM availability. About 7% of available BLM AUMs would optimally go unused with the current AUM allocation. An average 728 AUY would be produced on the ranch. Annual net cash income was estimated to be $30,794 ($42.30/AUY) with the current BLM allotment. Given an assumed annual input of $10,000 from off-ranch sources, this means the representative northeastern Nevada ranch returned an average net annual profit from livestock and crop production of about $20,800/year (i.e., return to investment and risk). Approximately 25% of the time, net annual income would be negative.

As BLM AUMs were reduced by 50%, 75% and 100%, a nearly constant reduction in net returns per AUM was estimated, $5.77/AUM, $6.03/AUM and $6.16/AUM, respectively (Table 6). Annual net cash income decreased from $30,794/year under the current situation to $5,259/year (83% reduction) with a 100% BLM grazing reduction. This means the ranch would move from a positive average profit of $20,800/year to an average loss of $4,741/year with removal of the BLM permit. Annual net cash income was estimated to be positive because of the assumed off-ranch income. With a 100% BLM reduction, 44% of the time, annual net cash income would be negative. In addition to herd size reductions, other optimal adjustments to reduced BLM AUMs included conversion of hay land to pasture (Table 6). Private leased land was not profitable to graze at the assumed $30/AUM cost for the Nevada model (Table 2).

4.1.2.1. Sensitivity Analysis

A negative level of off-ranch income is equivalent to including an annual loan payment or cash outlay. Sensitivity analysis indicates the representative Northeastern Nevada model, given the current allocation of BLM grazing capacity, could incur an additional $10,000 fixed annual

Table 6. Optimal adjustments to reductions in BLM AUMs, Northeastern Nevada model.

Adjustments in optimal use levels	Percent reduction in BLM AUMs 0%	50%	75%	100%
BLM available (AUMs)	4,148	2,074	1,037	0
Optimal average BLM used (AUMs)	3,847 (276)[a]	2,074 (0)	1,037 (0)	0 (0)
Percent of AUMs from BLM land	44%	31%	18%	0%
Average number of brood cows (head)	419 (27)	321 (41)	272 (51)	223 (62)
Average number of AUY	728 (39)	556 (52)	472 (68)	389 (87)
Percent reduction in AUY (%)	–	-24%	-35%	-47%
Average annual variable production costs ($)	127,341 (6,705)	96,010 (6,804)	78,045 (9,995)	60,076 (13,567)
Average annual variable production costs ($/AUY)	175	173	165	154
Average annual net cash income ($)	30,794 (40,254)	18,836 (31,620)	12,028 (28,477)	5,259 (26,140)
Average annual net cash income ($/AUY)	42.30	33.88	25.48	13.52
Average change in net cash income ($/BLM AUM removed)	–	-5.77	-6.03	-6.16
Deeded Range (AUMs)	115 (0)	115 (0)	115 (0)	115 (0)
Private Lease (AUMs)	0 (0)	0 (0)	0 (0)	0 (0)
Meadow hayland acres hayed/grazed (acres)	778 (31)	651 (45)	542 (38)	432 (31)
Meadow acres converted to pasture (acres)	22 (31)	149 (45)	258 (38)	368 (30)
Raised meadow hay fed (tons)	934 (50)	610 (91)	610 (91)	503 (114)
Raised meadow hay sold (tons)	221 (98)	271 (98)	226 (85)	181 (71)
Purchased alfalfa hay fed (tons)	170 (25)	106 (16)	106 (16)	79 (19)
Purchased meadow hay fed (tons)	2 (18)	1 (17)	1 (16)	0 (14)
Average amount borrowed annually ($)	6 (382)	7 (323)	5 (269)	4 (248)
Probability of being forced out of business (%)	0	0	0	0
Probability of negative net annual cash income (%)	25%	30%	36%	44%

[a]/Number in parenthesis is the standard deviation measured over the 100 iterations and 40 years..

[b]/The assumption was made that the reduction in allowed grazing capacity would be incrementally phased in over 5 years. Thus, the computed average is for years 6 through 40 after the reduction is fully implemented.

payment and still cover production expenses, fixed costs and the family living allowance. With this $10,000 annual payment, the model would fail to meet cash flow requirements only 2% of the time (Fig. 3). This payment could service an approximate $100,000, 30-year loan to purchase the ranch, or a revolving $35,000 5-year loan (assuming a 9% interest rate). The likelihood of going broke quickly increases as additional $5,000 increments of annual loan obligation are added. Further, the ability of the representative Northeastern Nevada ranch to incur added debt is quickly removed as BLM AUMs are removed (Fig. 3). The average optimal size of the ranch moves from 728 AUY with the current BLM allotment allocation to 389 AUY when the permit was removed (Table 6), and this reduced ranch size is no longer able to generate the income needed to cover loan payments.

4.1.3. Lake County, Oregon Model

Table 7 presents results for the Lake County, Oregon model under different levels of BLM AUM availability. All available BLM AUMs would be used each year with the current allotment allocation and resource combination. About 2% of available USFS AUMs would optimally go unused in the baseline situation. An average of 723 AUY would optimally be produced on the ranch. Over half (57%) of the grazing capacity of the ranch would come from BLM and USFS grazing allotments.

Annual average net cash income was estimated to be $50,059/year ($69.24/AUY) with current BLM and USFS allotments. Approximately 16% of the time, net annual income would be negative.

The economic impact of sequentially reducing the availability of BLM AUMs ranged from about $10/BLM AUM removed for 50% and 75% BLM allotment reductions to $11.77/AUM with total elimination of BLM grazing. Annual net cash income was reduced to $21,808/year (56% reduction) with a 100% BLM reduction (Table 7).

With a 100% reduction in BLM grazing, the optimal use of USFS AUMs would be reduced by about 11%. Some of the BLM AUMs were replaced by leasing increasing amounts of private forage (Table 7), but the primary way the profit-maximizing model adjusted to AUM reductions was to reduce herd size. The average number of livestock produced was reduced from 723 AUY with the current allotment allocation to 485 AUY (33% reduction) with elimination of the BLM permit (Table 7). The representative Lake County, Oregon model is defined to have substantial hay land resources and optimally switches to hay selling when the size of the BLM allotment is reduced.

4.1.3.1. Sensitivity Analysis

With the current BLM and USFS allotment allocation, the representative Lake County, Oregon model could sustain a $40,000 annual debt payment (Fig. 4). Similar to the other two ranch models, removing BLM AUMs reduced the optimal scale (herd size) and profitability of the ranch. The ability to service debt was increasingly reduced with increasing reductions in BLM grazing capacity.

4.2. Eliminating Spring Grazing

4.2.1. Jordan Valley, Idaho Model

The representative Jordan Valley Ranch under current policy turns out on BLM and state lands on April 15. Table 8 presents the optimal seasonal grazing use when the turn-out date is moved to May 15. In this analysis, the only possible or allowed grazing alternative was to extend winter feeding through the April 15 – May 15 period. Herd size

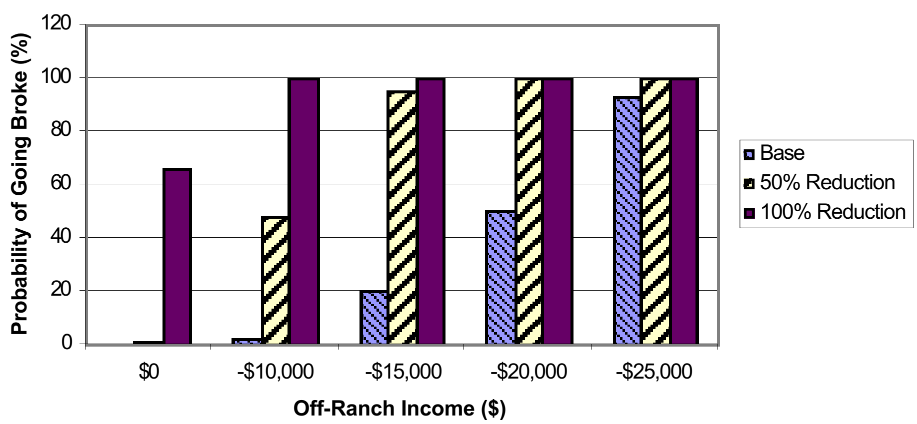

Figure 3. Probability of not being able to meet cash flow requirements with alternative levels of annual debt payment and with BLM allotment reductions, Northeastern Nevada model.

Table 7. Optimal adjustments to reductions in BLM AUMs, Lake County, Oregon model.

Adjustments in optimal use levels	Percent reduction in BLM AUMs 0%	50%	75%	100%
BLM available (AUMs)	2,400	1,200	600	0
Optimal average BLM used (AUMs)	2,400 (0)[a]	1,200 (0)	1,200 (0)	0 (0)
Optimal average USFS used (AUMs)	2,513 (132)	2,540 (78)	2,533 (76)	2,269 (150)
Percent of AUMs from BLM and USFS lands	57%	51%	56%	39%
Average number of brood cows (head)	416 (17)	350 (26)	318 (31)	278 (41)
Average number of AUY	723 (37)	607 (37)	552 (42)	485 (58)
Percent reduction in AUY (%)	–	-16.0%	-23.7%	-32.9%
Average annual variable production costs ($)	140,703 (10,999)	122,757 (9,298)	115,635 (8,027)	109,411 (8,529)
Average annual variable production costs ($/AUY)	195	202	209	226
Average annual net cash income ($)	50,059 (49,542)	37,972 (40,818)	31,456 (38,066)	21,808 (35,256)
Average annual net cash income ($/AUY)	69.24	62.56	56.99	44.96
Average change in net cash income ($/BLM AUM removed)	–	-10.07	-10.34	-11.77
Deeded Range (AUMs)	113 (0)	113 (0)	113 (0)	113 (0)
Private Lease (AUMs)	249 (208)	296 (198)	376 (139)	492 (24)
Meadow hayland acres hayed/grazed (acres)	290 (0)	290 (0)	290 (0)	290 (1)
Raised Alfalfa hay fed (tons)	341 (45)	182 (44)	253 (35)	221 (39)
Raised meadow hay fed (tons)	435 (0)	543 (75)	425 (13)	402 (37)
Raised meadow hay sold (tons)	0 (0)	0 (1)	10 (13)	33 (36)
Raised alfalfa hay sold (tons)	64 (45)	123 (38)	152 (35)	184 (39)
Purchased alfalfa hay fed (tons)	0 (0)	0 (0)	0 (0)	0 (0)
Purchased meadow hay fed (tons)	135 (26)	1 (10)	16 (35)	21 (40)
Average amount borrowed annually ($)	0 (0)	0 (0)	0 (0)	2 (117)
Probability of being forced out of business (%)	0	0	0	0
Probability of negative net annual cash income (%)	16%	18%	21%	27%

[a]/Number in parenthesis is the standard deviation measured over the 100 iterations and 40 years..

[b]/The assumption was made that the reduction in allowed grazing capacity would be incrementally phased in over 5 years. Thus, the computed average is for years 6 through 40 after the reduction is fully implemented.

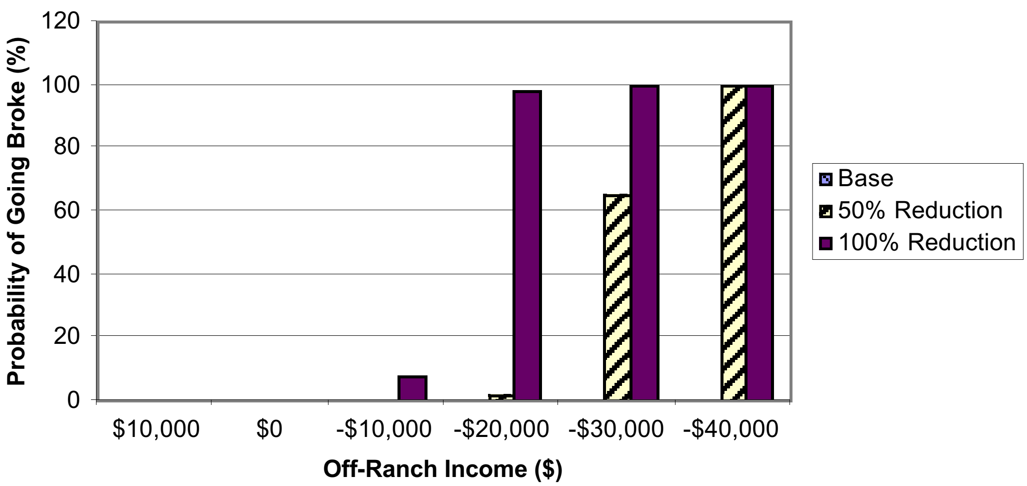

Figure 4. Probability of not being able to meet cash flow requirements with alternative levels of annual debt payment and with BLM allotment reductions, Lake County, Oregon model.

could also be altered if that was most profitable.

With these two available options, the profit-maximizing adjustment would be to reduce average herd size from 345 AUY to 274 AUY. An estimated 75 tons (182 AUMs) of hay would be required to replace the loss of AUMs of grazing capacity previously harvested from BLM land (Table 8). With the reduced herd size, 18 tons of additional hay would be sold.

The average 248 AUMs previously grazed during the April 15 – May 15 on BLM land was not removed from potential grazing; only the season of use was restricted in the analysis, but, eliminating spring grazing reduced optimal average BLM AUM use to 972 AUMs. This was a 683 AUM reduction relative to the base run. Spring grazing now limits annual production, and AUMs supplied in other seasons are not economically useful; thus, elimination of spring grazing became economically equivalent to an allotment reduction.

Average net economic returns decreased by $5,994 with the elimination of spring grazing (Table 8). When divided by the 248 AUMs previously grazed on BLM land during the spring period (Table

Table 8. Optimal adjustments to elimination of spring grazing on BLM land, Jordan Valley, Idaho model.

Season	BLM	State	Deeded	Meadow hayland grazed/ hayed	Raised meadow hay fed	Purchased alfalfa hay	Total
Adjustments in seasonal forage use							
Base run with BLM spring grazing (AUMs)							
2-Mar to 16-Apr	0	0	0	0	433	51	485
16-Apr to 16-May	248	0	40	0	0	34	322
16-May to 16-Oct	1,407	144	97	0	0	0	1,648
16-Oct to 16-Nov	0	0	100	377	0	0	477
16-Nov to 16-Dec	0	0	3	369	0	0	373
16-Dec to 2-Mar	0	0	0	0	632	213	845
TOTAL USED (AUM)	1,655	144	240	747	1,066	298	4,150
No BLM spring grazing (AUMs)							
2-Mar to 16-Apr	0	0	0	0	343	41	384
16-Apr to 16-May	0	0	40	0	189	27	256
16-May to 16-Oct	972	144	188	0	0	0	1,304
16-Oct to 16-Nov	0	0	12	453	0	0	464
16-Nov to 16-Dec	0	0	0	294	0	0	295
16-Dec to 2-Mar	0	0	0	0	490	179	669
TOTAL USED (AUM)	972	144	240	747	1,022	247	3,372

Adjustments in:	Base Run with BLM spring grazing	Without BLM Spring Grazing	Change
Average number of AUY	345 (31)	274 (53)	-71
Average number of brood cows	223 (18)	175 (34)	-48
Average annual net cash income ($)	8,856 (21,820)	2,862 (17,235)	-5,994
Average annual net cash income ($/AUY)	25.67	10.44	-15.22
Average change in net cash income ($/BLM AUM removed during the spring period)			-24.17
Raised meadow hay sold (tons)	47	65	18
Average amount borrowed annually ($)	83	493	410
Probability of being forced out of business (%)	0%	2%	
Probability of negative net annual cash income (%)	35%	45%	

8), the loss in net returns is $24.17/AUM removed.

The economic impact of removing spring grazing will depend on what alternative forages are considered to be available. Thus, as a second analysis, spring grazing on BLM land was removed, but in this case it was assumed the ranch could freely adjust the seasonal use of all deeded AUMs. Hay land could be converted to pasture and grazed in the spring, and private leased land could be leased during the spring. With these forage alternatives (table not shown), the economic impact of removing spring grazing on BLM land was much less ($5.34/AUM removed from spring grazing). The optimal adjustment would be to graze nearly all deeded AUMs in the spring and lease a small amount of private AUMs. Optimal herd size would be reduced to 311 AUY. Optimal BLM AUM use would decrease to 1,342 AUMs.

The flexibility to have alternative forage sources is likely not possible for many of the Jordan Valley ranches, but the analysis clearly shows the potential to minimize the economic impact of removing spring grazing if other grazing resources can be substituted.

4.2.2. Northeastern Nevada Model

The representative Northeastern Nevada ranch under current policy turns out on BLM land on April 8. Table 9 presents the optimal seasonal grazing adjustments when the turn-out date is moved to May 8. In this analysis, the only possible or allowed grazing alternative was to extend winter feeding through the April 8 – May 8 period. Herd size could also be altered.

With elimination of BLM spring grazing, hay sales would be reduced from 221 tons to 120 tons.

An estimated 222 tons (538 AUMs) of hay would be required to replace the loss of AUMs of grazing capacity previously harvested from BLM land during the spring (Table 9). Average herd size would also be reduced from 728 AUY to 589 AUY.

Eliminating spring grazing reduced optimal average BLM AUM use to 2,187 AUMs. This was a 1,684 AUM reduction (44% reduction) from the base run. A major shift in the seasonal use of forage would optimally occur. BLM AUMs supplied in other seasons could not economically be used because of the forage shortages in the spring.

Net economic returns decreased by $17,171 with elimination of spring grazing (Table 9). When divided by the 665 AUMs previously grazed on BLM land during the spring period, the loss in net returns was $25.82/AUM removed from spring grazing. If more seasonal flexibility of other forages was assumed, the estimated loss would still be relatively high, $18.76/BLM AUM removed in the spring. In this second analysis, additional hay land would optimally be converted to pasture and deeded AUMs would be allocated for spring grazing (table not shown). Hay feeding would not increase. Similar to the Jordan Valley, Idaho model, grazing alternatives are cheaper then hay feeding if those alternatives exist.

4.2.3. Lake County, Oregon

The representative Lake County, Oregon ranch under current policy turns out relatively early on BLM land (March 1). Table 10 presents the optimal adjustments when this turn-out date is moved to April 1. Alternative sources of spring forage considered only the feeding of hay. Herd size could be altered if that would be more profitable. With these two allowed adjustments, the optimal strategy would be to extend the winter hay feeding period by a month. The 285 BLM AUMS removed during March would optimally be used later in the grazing

Table 9. Optimal adjustments to elimination of spring grazing on BLM land, Northeast Nevada model.

Season	BLM	Deeded	Hayland converted to pasture	Meadow hayland grazed/ hayed	Raised meadow hay fed	Purchased meadow hay	Purchased alfalfa hay	Total
Adjustments in seasonal forage use								
Base run with BLM land spring grazing (AUMs)								
9-Apr to 9-May	665	0	0	0	0	0	0	665
9-May to 9-Jun	688	0	0	0	0	0	0	688
9-Jun to 2-Oct	2,518	29	4	0	0	0	0	2,551
2-Oct to 24-Nov	0	86	125	1,435	0	0	0	1,646
24-Nov to 16-Dec	0	0	15	490	0	0	67	572
16-Dec to 9-Apr	0	0	0	0	2,260	5	346	2,612
TOTAL USED (AUM)	3,871	115	144	1,925	2,260	5	413	8,734
No BLM land spring grazing (AUMs)								
9-Apr to 9-May	0	0	0	0	525	13	0	538
9-May to 9-Jun	536	3	17	0	0	0	0	556
9-Jun to 2-Oct	1,651	100	312	0	0	0	0	2,063
2-Oct to 24-Nov	0	12	19	1,371	0	0	0	1,401
24-Nov to 16-Dec	0	0	2	394	0	0	53	449
16-Dec to 9-Apr	0	0	0	0	1,834	8	273	2,116
TOTAL USED (AUM)	2,187	115	349	1,765	2,360	21	326	7,123

Adjustments in:	Base Run with BLM spring grazing	Without BLM Spring Grazing	Change
Average number of AUY	728	589	-139
	(39)	(55)	
Average number of brood cows	419	341	-78
	(27)	(41)	
Average annual net cash income ($)	30,795	13,624	-17,171
Average annual net cash income ($/AUY)	42.30	23.13	-19.17
Average change in net cash income ($/BLM AUM removed during the spring period)			-25.82
Raised meadow hay sold (tons)	221	120	-101
Average amount borrowed annually ($)	7	92	85
Probability of negative net annual cash income (%)	25%	37%	

[1]/Number in parenthesis is the standard deviation computed over the 100 iterations and 40 years.

season, allowing herd size to increase by 19 head.

This result of using the BLM forage during a later season and increasing herd size is different from the results for the Nevada and Idaho models, but similar to the findings of Torell et al. (1981). The Oregon model is defined to have substantial hay resources, yet the assumed production cost of the hay ($/ton) is nearly equivalent to the sale price (Table 2). By comparison, the profit margin is defined to be $22/ton for the Idaho and Nevada models. Further, developing marginal hay meadows for grazing was not considered to be a viable option for the Oregon model whereas these activities were included for the Idaho and Nevada models. For the Oregon model, limited alternatives for hay land were included and the opportunity cost of feeding the hay to cows was relatively low. This likely explains the difference in the optimal adjustment strategy when spring BLM AUMs were removed.

The economic consequences of eliminating spring BLM grazing was to reduce net income by $8.17/BLM AUM removed from grazing during March. The total loss of net income for the ranch was $5,607.

If an expanded number of leased private AUMs are allowed to be grazed during the March period (table not shown), the economic consequences of removing spring grazing on BLM is minimal. Under the current situation, the ranch optimally leases an average of 250 AUMs of private leased forage. Most of that is leased May 1 to October 1 (Table 10). If the ranch has the flexibility to alter when those private AUMs are leased, the cost-minimizing adjustment would obviously be to move them to March and graze BLM later in the summer. By doing this, the model suffered no economic losses from the season-of-use adjustment. Economic returns and herd size remained unchanged; just the seasonal use pattern of forage was changed.

5. Summary and Conclusions

Public land is an important seasonal source of forage for western ranches. Thus, eliminating BLM grazing to improve habitat for sage-grouse would

Table 10. Optimal adjustments to elimination of spring grazing on BLM land, Lake County, Oregon model.

Season	BLM	USFS	Deeded	Leased private forage	Meadow hayland grazed/ hayed	Raised meadow hay fed	Purchased meadow hay	Purchased alfalfalfa hay	Raised alfalfalfa hay	Total
Adjustments in seasonal forage use										
Base run with BLM land spring grazing (AUMs)										
2-Mar to 2-Apr	285	0	266	0	0	0	0	0	160	711
2-Apr to 2-May	686	0	0	0	0	0	0	0	0	686
2-May to 2-Oct	763	2,496	0	243	0	0	0	0	0	3,502
2-Oct to 2-Nov	666	0	0	2	284	0	0	0	0	952
2-Nov to 2-Dec	0	0	334	5	383	0	0	0	0	722
2-Dec to 2-Mar	0	0	0	0	0	1,053	327	1	666	2,046
TOTAL USED (AUM)	2,400	2,496	600	250	667	1,053	327	1	825	8,619
No BLM land spring grazing (AUMs)										
2-Mar to 2-Apr	0	0	266	0	0	155	140	2	165	728
2-Apr to 2-May	705	0	0	0	0	0	0	0	0	705
2-May to 2-Oct	977	2,445	0	173	0	0	0	0	0	3,595
2-Oct to 2-Nov	718	0	0	0	0	0	0	0	0	718
2-Nov to 2-Dec	0	0	334	2	892	0	0	0	0	1,228
2-Dec to 2-Mar	0	0	0	0	0	922	513	5	687	2,127
TOTAL USED (AUM)	2,400	2,445	600	175	892	1,077	653	7	852	9,101

Adjustments in:	Base Run With BLM Spring Grazing	Without BLM Spring Grazing	Change
Average number of AUY	723	742	19
	(37)	(44)	
Average number of brood cows	416	425	9
	(17)	(19)	
Average annual net cash income ($)	50,059	44,452	-5,607
Average annual net cash income ($/AUY)	69.24	59.91	-9.33
Average change in net cash income ($/BLM AUM removed during the spring period)			-8.17
Raised alfalfa hay sold (tons)	64	53	-11
Raised meadow hay sold (tons)	0	0	0
Average amount borrowed annually ($)	0	0	0
Probability of negative net annual cash income (%)	16%	19%	

have a significant impact on the economic viability of affected ranches. This is especially true during the spring period. Early spring grazing is valuable because few alternative forage sources are available at that time. In most cases, the only feasible forage alternative would be to feed hay.

Rowe and Bartlett (2001, p. 64) concluded that once hay was needed to compensate for public forage losses, reducing herd size would be the most cost-effective adjustment. Our results generally support this conclusion. Making alterative grazing resources available during the spring always minimized losses relative to feeding hay or reducing herd size. If complete flexibility of other deeded forages were assumed, the economic loss of restricting the early use of BLM lands was minimal; seasonal use of alternative forages would be rearranged with little if any economic consequence.

The economic value of the BLM forage during the spring period was found to be 5 to 10 times the value in other seasons later in the year for both the Idaho and Nevada models. In this case, the elimination of spring grazing was equivalent to a grazing reduction because the BLM forage would not be used at a later date for profit maximization. This was not the case for the Oregon model with the major difference being the assumed hay resources. The Lake County, Oregon model was defined to have substantial hay land resources that made feeding hay a feasible alternative for the spring period. BLM AUMs would optimally be used in a later season allowing an increase in the average optimal herd size.

The economic impacts from reducing BLM grazing in any season were found to vary widely depending on several key factors. First, individual ranches will be able to substitute alternative forages to varying degrees as federal AUMs are eliminated. Substituting forages minimizes economic losses relative to the option of feeding hay and reducing cow herd size. Those ranches with restricted seasons of forage availability will have less ability to substitute alternative forages if BLM grazing is removed.

Annual average economic losses from removing AUMs ranged from about \$3/AUM for the Jordan Valley, Idaho model, \$6/AUM for the Northeastern Nevada model, to about \$10/AUM for the Lake County, Oregon model. This is a wide range in annual value, but other similar studies in the literature report even a wider value range (Hahn et al. 1989). The contributory value of the federal grazing permits for livestock production varies widely depending on the seasonal complement of forage and pasture resources ranches have, and the level of dependency on federal lands.

Seasonal forage limitations, the degree to which public land forages meet seasonal forage demands, and the availability of substitute forages largely determined the economic value of the federal grazing permit. It is widely believed that the complement between public and private lands contributes greatly to the economics of western ranching and our analysis clearly shows that to be the case. Economic losses estimated here from reducing or changing seasons of grazing use on public lands are annual values. Capitalizing these annual values at any reasonable rate suggests a significant "permit value" and contribution from holding the federal grazing permit.

Western ranches vary greatly in financial resources (Gentner and Tanaka 2002). For those ranches with limited off-ranch wealth and income, reducing public land grazing capacity by even marginal amounts was found to greatly impact the ability of ranchers to meet annual financial obligations and to repay debt. We provided an estimate of what percentage of the time the representative ranches would be unable to meet the cash flow requirements assumed in the model when grazing policies were changed. Yet, in reality, how many ranchers will potentially be forced from the business as policies change cannot be determined because debt loads and off-ranch income are highly variable and unknown. The level of commitment to remain on the ranch is also variable and unknown.

Ranch-level impact estimates of how ranch returns would change if public land grazing levels and allowed seasons of use change are generic. The assessment and impact estimates apply to any situation where public land grazing are reduced or spring grazing is eliminated. As related specifically to sage-grouse, eliminating public land AUMs or removing grazing during the spring are options that have been discussed (Clifford 2002). Hopefully less drastic management options can be adopted. "The Gunnison Sage-Grouse Working Group recognizes the need to be opportunistic and carry out specific conservation actions as situations present themselves", as an example (USDI-BLM 2001, p. 7). What this analysis shows is that, if less drastic management options cannot be found and grazing use on public lands is curtailed or allowed seasons of use altered in the name of protecting the sage-grouse, the economic impact to western public land ranchers will be significant.

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