Ranch-Level Economic Impacts of Altering GRAZING POLICIES on Federal Land to Protect the GREATER SAGE-GROUSE

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B-1258A
June 2014

ABSTRACT

The greater sage-grouse (*Centrocercus urophasianus*) is a candidate for listing as an endangered species. Proposed proactive policies and conservation measures to protect the species could potentially alter grazing policies on federal lands to include reductions in allowed grazing levels and with adjustments in seasonal grazing use of federal permits - particularly during spring and fall. We use profit-maximizing models developed for Idaho, Nevada, Oregon, and Wyoming to estimate the economic value of public land forage to ranches that are highly dependent on public lands for seasonal grazing capacity. Optimal (profit maximizing) adjustments to reductions in allowed grazing uses of Bureau of Land Management (BLM) permits were to substitute alternative sources of forage when possible and to reduce herd sizes. As expected, the less substitute forages available in the models and the higher the dependency on public land grazing in the current situation, the higher the estimated economic impact of changing BLM grazing capacities and seasonal forage uses. Spring BLM forage was found to have the highest annual economic value, from about $15/AUM in the Wyoming ranch model to $50/AUM in the Oregon ranch model. Capitalized into a grazing permit value that reflects the capitalized contributions of the grazing permit to profit over a 40-year production period, the economic value of the BLM grazing permit ranged from about $140/AUM to over $600/AUM. Cash flow restrictions could not be met if all grazing on the BLM permit were eliminated. The highly dependent public land ranches considered in the analysis would then be forced to reduce herd sizes to levels that would no longer be economically viable.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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INTRODUCTION

On January 11, 2013, the U.S. Fish and Wildlife Service (USFWS) published a Proposed Rule listing the Gunnison sage-grouse (*Centrocercus minimus)* as endangered under the Endangered Species Act (ESA) with designation of critical habitat for the species in Colorado and Utah (U.S. Fish and Wildlife Service 2013a). The greater sage-grouse (*Centrocercus urophasianus*) is also a candidate species under the ESA, which means it has been determined to warrant protection afforded by the ESA (U.S. Fish & Wildlife Service 2013b) but was precluded from listing due to more pressing species considerations by the agency. The USFWS has until 2015 to make a final determination on listing the species. This has resulted in major efforts by the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) to update Forest and Resource Management Plans to reflect the national concern for sage-grouse and their habitats (USDI-BLM 2013).

Improper livestock grazing has been identified as a factor associated with the widespread degradation of sage-grouse habitat and decline in numbers (Beck and Mitchell 2000; Gunnison sage-grouse rangewide steering committee 2005). Livestock management proposals suggest grazing operations can minimize impacts to sage-grouse by 1) maintaining vegetation structure suitable for sage-grouse; 2) implementing pasture rotations and similar techniques to improve livestock distribution and minimize impacts to vegetation; 3) providing seasonal rest from livestock grazing in sage-grouse habitat areas; and 4) by reducing livestock stocking rates (Gunnison sage-grouse rangewide steering committee 2005; Industrial Economics Inc. 2013). Implementing these management changes will economically impact ranching operations.

One major effect of changing season-of-use or stocking rates may be reduced grazing levels on federal grazing allotments because sage-grouse habitat needed for breeding, nesting, and brooding coincide when livestock are on public lands (Connelly et al. 2000). An economic impact study prepared for the Gunnison sage-grouse estimated 107 federal grazing allotments in Utah and Colorado could realize Animal Unit Month (AUM) reductions of about 64 percent (9, 915 AUMs) due to proposed conservation efforts (Industrial Economics Inc. 2013). Other studies where the greater sage-grouse are present have updated land use plans that indicate a potential for minimal (1 percent) to substantial (100 percent) reductions in grazing use. A draft Environmental Impact Statement (EIS) recently submitted for public comment for Idaho and southwestern Montana (USDI-BLM and USDA-FS 2013) indicated grazing reductions between 17 percent and 100 percent for areas within the sage-grouse habitat areas of concern. This amounted to a minimum of 200,000 AUMs of forage potentially lost due. Similar levels of reduction are considered in EIS releases for Oregon, Nevada, and Nevada/California (USDI-BLM 2013).


Photo by Neil Rimbey, University of Idaho

On many western ranches within the sage-grouse range, the typical pattern of harvest for forages and raised feeds and the level of dependence on federal, state, and private rangelands varies by season. A typical seasonal grazing use pattern may start feeding hay in November or December and continue until March, April, or early May when livestock are moved to BLM and state rangelands. During summer, livestock may move to USFS permits or remain on BLM and state rangelands. As hay harvest is completed and temperatures cool in the fall, cattle are moved back to the ranch headquarters to graze deeded lands and hay aftermath until the cycle starts again. Providing seasonal rest and changing this seasonal grazing pattern has the potential for significant economic impacts for public-land dependent ranches. While the condition of spring habitat is critical to survival of sage-grouse chicks and forb production for sage-grouse diets (Connelly et al. 2000), spring grazing is also critical for the economic viability of western ranches. Extending the period of hay feeding is expensive and other forage sources are extremely limited and/or expensive. Crawford et al. (2004) noted that meadow and riparian sites are particularly vulnerable during the late summer and fall when excessive grazing and browsing may damage riparian shrubs, reduce the availability of succulent herbs, and deteriorate riparian function. Limiting livestock access and grazing use during this late summer period to improve degraded meadows and riparian areas has implications for ranch economics as well.

This paper provides an economic analysis of potential ranch-level impacts from altered livestock grazing uses on BLM lands aimed at improving greater sage-grouse habitat. This study provides an estimate of the economic value of public land forage potentially lost to representative ranches in each of four study states - Idaho, Nevada, Oregon, and Wyoming. Seasonal forage values are provided using a linear programming (LP) analysis of proposed changes to allowed stocking levels and altered seasonal availability of forage on federal grazing allotments. The projected economic consequences of federal land use policy changes are applicable for numerous other endangered species and land-use issues where similar policy changes have been suggested. The economic analysis is generic in its application.

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METHODS AND PROCEDURES

Representative Ranches

We define the economic situation, typical resource base, production rates, and production practices for western ranches in four ranching areas in the west: Owyhee County, Idaho; Northeastern Nevada; Lake County, Oregon; and Fremont County, Wyoming. Ranches in these areas were selected because livestock cost and return estimates and policy impact models had been developed for these areas. Additionally, rangelands in these areas provide greater sage-grouse habitat and are dominated by sagebrush ecosystems.

Representative ranches and policy impact models were originally developed using 1997 cost and return data for Idaho, Nevada, and Oregon. These models and data were used to conduct a ranch-level assessment of the potential economic impacts of possible grazing policy changes to protect and improve habitat for the greater sage-grouse (Torell et al. 2002). As noted in the earlier study, ranch-level cost and return data were gathered from group interviews with ranchers in the study areas. Multi-period linear programming models were developed to depict the production processes of each representative ranch. Similar models were developed for Wyoming in research by Taylor et al. (2004).

Only the Idaho cost and return study was updated from the earlier 1997 representative ranch definition period (Painter et al. 2012). Production cost indices were used to update the earlier cost estimates of other models to 2012 levels based largely on the percentage change in production costs from the updated Idaho ranch budget. The resource base, production rates, and methods of production defined for the representative ranches were assumed to have remained relatively unchanged from the earlier study period.

Table 1 summarizes forage resources, typical production rates and costs, and forage harvesting alternatives defined for each of the updated ranch models. The grazing seasons and the seasons when alternative forages were considered to be available for grazing are defined differently for each model ranch (Table 2). Seven seasons were defined for each model based on typical turn-out dates, potentially adjusted turn-out dates, and livestock marketing dates. Differences in each state model are based on the information derived from the published cow-calf enterprise budgets.

Table 1. Characteristics and resources of the representative ranches.

	Units	Number of Units ID	NV	OR	WY	Objective Function Cost ($/unit) ID	NV	OR	WY
Land resources owned									
Alfalfa hayland	Acres			90				400.00	
Native meadow hayland	Acres[a]	325	800	290	793	73.00	107.00	208.00	197.00
Convert meadowland to pasture	Acres[a]	325	800	290	793	93.50	85.00	93.50	93.50
Deeded rangeland	AUMs	240	115	113	1,076	4.36	4.36	4.36	4.36
Land resources leased or purchased[b]									
State rangeland	AUMs	144			538	14.26			14.46
BLM	AUMs	2,098	3,675	2,400	3,765	9.18	9.18	9.18	9.18
USFS	AUMs			2,560				12.22	
Purchase alfalfa hay	Tons		Unlimited			185.00	185.00	210.00	185.00
Purchase meadow hay	Tons		Unlimited			150.00	150.00	165.00	150.00
Sell alfalfa hay	Tons		All available					185.00	
Sell meadow hay	Tons		All available			110.00	110.00	140.00	110.00
Livestock resources[c]									
Animal units yearlong	AUY	333	700	607	775				
Brood cows	Head	286	602	511	590	81.57	74.00	19.50	42.24
Replacement heifers	Head	65	120	86	100	81.57	74.00	19.50	42.24
Bulls	Head	19	36	29	38				
Horses	Head	6	12	10	6				
Miscellaneous income/expenses									
Fixed ranch expenses	$					28,467	38,874	27,532	40,434
Family living allowance	$					35,000	35,000	35,000	35,000
Off-ranch annual income	$					35,000	35,000	35,000	35,000
Required minimum cash reserve	$					10,000	10,000	10,000	10,000
Efficiency measures[d]									
Calf crop (Calves born as % of Jan. 1 cow inventory)	%	88	85	90	95				
Minimum cow replacement rate	%	15	18	15	15				
Maximum % of heifer calves retained as replacements	%	80	80	80	80				
Minimum % of heifer calves retained for sale as yearlings	%	12	11	10	12				
Bull replacement rate	%	25	20	25	25				
Cow-to-bull ratio		18	20	20	18				
Calf death loss	%	4	3	4	4				
Cow death loss	%	2	2	2	2				
Bull death loss	%	1	1/2	1	1				
Steer calf sale weight	lb	560	475	525	440				
Heifer calf sale weight	lb	520	435	450	390				
Heifer yearling sale weight	lb	800	750	850	800				
Cull cow sale weight	lb	950	950	1,100	950				
Cull bull sale weight	lb	1,800	1,160	2,000	1,800				

[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.

[b]/Grazing costs shown in the table include estimates of the grazing fee paid and additional non-fee grazing costs for herding, checking, moving, and tending cattle while on the allotment.

[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 2. Seasonal availability (*) of hay and forage for representative ranches.

	Season						
Idaho	1-Mar 15-Apr	15-Apr 15-May	15-May 15-Sep	15-Sep 15-Oct	15-Oct 15-Nov	15-Nov 15-Dec	15-Dec 1-Mar
State trust land		*	*	*	*		
BLM		*	*	*	*		
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-Sep	1-Sep 1-Oct	1-Oct 23-Nov	23-Nov 15-Dec	15-Dec 8-Apr
BLM	*	*	*	*			
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-Sep	1-Sep 1-Oct	1-Oct 1-Nov	1-Nov 1-Dec	1-Dec 1-Mar
BLM	*	*	*	*	*		
USFS			*	*			
Deeded range	*			*	*	*	
Aftermath grazing					*	*	
Convert meadow to pasture		*	*	*	*	*	
Feed raised/purchased hay	*	*				*	*
	Season						
Wyoming	1-Mar 15-Apr	15-Apr 15-May	15-May 15-Sep	15-Sep 15-Oct	15-Oct 15-Nov	15-Nov 15-Dec	15-Dec 1-Mar
State trust land		*	*	*	*		
BLM		*	*	*	*		
Deeded range		*	*	*	*	*	
Aftermath grazing				*	*	*	
Convert meadow to pasture		*	*	*	*	*	
Feed raised/purchased hay	*					*	*

Photo by Neil Rimbey, University of Idaho

Idaho Ranch Model

The Idaho model ranch is typical of range cattle production in southwestern Idaho that uses a mixture of public and private rangelands during the spring-to-fall period. Native meadows are used for hay production necessary to feed cattle during winter. These meadows are also used for a critical forage source as aftermath (post-harvest) grazing of residues in the fall when cattle return to the base ranch. The ranch purchases alfalfa hay to feed calves and yearling replacement heifers. The ranch runs 333 Animal Units Yearlong (AUY). Cows are bred late spring, and calves are born late winter. Cows are kept until 8 or 9 years old with a 15 percent replacement rate from retained heifer calves. Cows and calves are turned out on rangelands in April and graze through October. Upon return to the base operation, calves are weaned and sold in November. Steers average 560 pounds and heifers average 520 pounds when sold.

Typical of ranches in the area, the representative ranch is dependent upon public rangelands, both on an annual basis and particularly during the spring, summer, and fall seasons. On a year-round basis, about half (51 percent) of the forage used by the cowherd comes from BLM and state rangelands. During the critical spring-summer period, the model ranch is very dependent upon public rangelands, with over 95 percent of the forage coming from BLM and state rangelands.

Nevada Ranch Model

The northeastern Nevada ranch model is a larger operation than the Idaho ranch. This ranch was modeled after a typical range cattle operation in the Elko-Eureka area of Nevada. The ranch runs 700 AUY utilizing a mixture of private and public rangelands during the grazing season and private hay meadows for the production of winter feed and aftermath grazing in fall. Cattle are turned out on public rangelands in early April and return to private lands in early October. Calving takes place late winter with breeding of the cowherd occuring in late spring/early summer. Calves are weaned upon return to the base property in October and sold in November with steer calves averaging 475 pounds and heifers averaging 435 pounds when marketed.

Similar to the Idaho model ranch, dependency upon public land forage is significant with nearly half (45 percent) of the year-round forage derived from public lands. During the growing season (April – October), BLM lands provide nearly all (99 percent) of the forage as hay is produced at the ranch headquarters on irrigated meadows.

Oregon Ranch Model

The Oregon model ranch is another larger sized cow-calf operation developed in the Lake County area of southern Oregon. The ranch has the forage base to run about 600 AUY and utilizes public and private rangelands during the grazing season and aftermath grazing of hay fields (alfalfa and meadow hay are produced) in the fall. Winter feeding is during the December-March timeframe. Calving takes place in late winter/early spring with turnout on BLM rangelands in early March and moving onto higher elevation USFS rangelands early May through October. Cattle are moved back to BLM rangelands in fall (October-November) prior to returning to the base ranch in November. Average sale weights are 525 pounds for steer calves and 450 pounds for heifer calves.

Dependency on public forage is somewhat higher in the Oregon model ranch with about 65 percent of the year-round forage derived from public sources. During the grazing period, over 95 percent of the forage comes from public sources. Public land forage is about evenly split between BLM and USFS.

Wyoming Ranch Model

The Wyoming model ranch depicts production practices of a large operation in the Fremont County area of west-central Wyoming. The ranch runs about 600 AUY on a mixture of public and private lands. The grazing season is mid-April through mid-November. Winter feeding of produced and purchased hay occurs during the December-April timeframe with calving in late winter/early spring. Cattle are turned out on BLM and state grazing lands in mid-April and return to the base operation in mid-November where deeded rangelands and hay aftermath are grazed until winter feeding commences in mid-December. Steer calves average 440 pounds and heifers average 390 pounds when sold in the fall.

On a year-round basis, the model ranch derives about 45 percent of forage from BLM and state rangelands. During the grazing season, nearly 90 percent of the forage needed by the herd comes from public lands.

Linear Programming Model

The multi-period LP model was developed by the authors and others as part of regional research efforts and has been widely used and adapted for federal land policy impact analysis (Torell et al. 2002; Rimbey et al. 2003; Taylor et al. 2004, 2005), evaluations of drought management strategies (Torell et al. 2010; Bastian et al. 2009; Ritten et al. 2010), grazing management assessments (Stillings et al. 2003; Tanaka et al. 2007), juniper control (Aldrich et al. 2005), and wildfire impacts (Maher et al. 2013). The net present value (NPV) of discounted net annual returns (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. In this application, a 40-year planning horizon was considered. The general structure of the multi-period LP model is shown in Figure 1. The model is ultimately constrained by available land (i.e., forage) and cash with numerous equations to transfer animals, land, and cash between years and seasons.

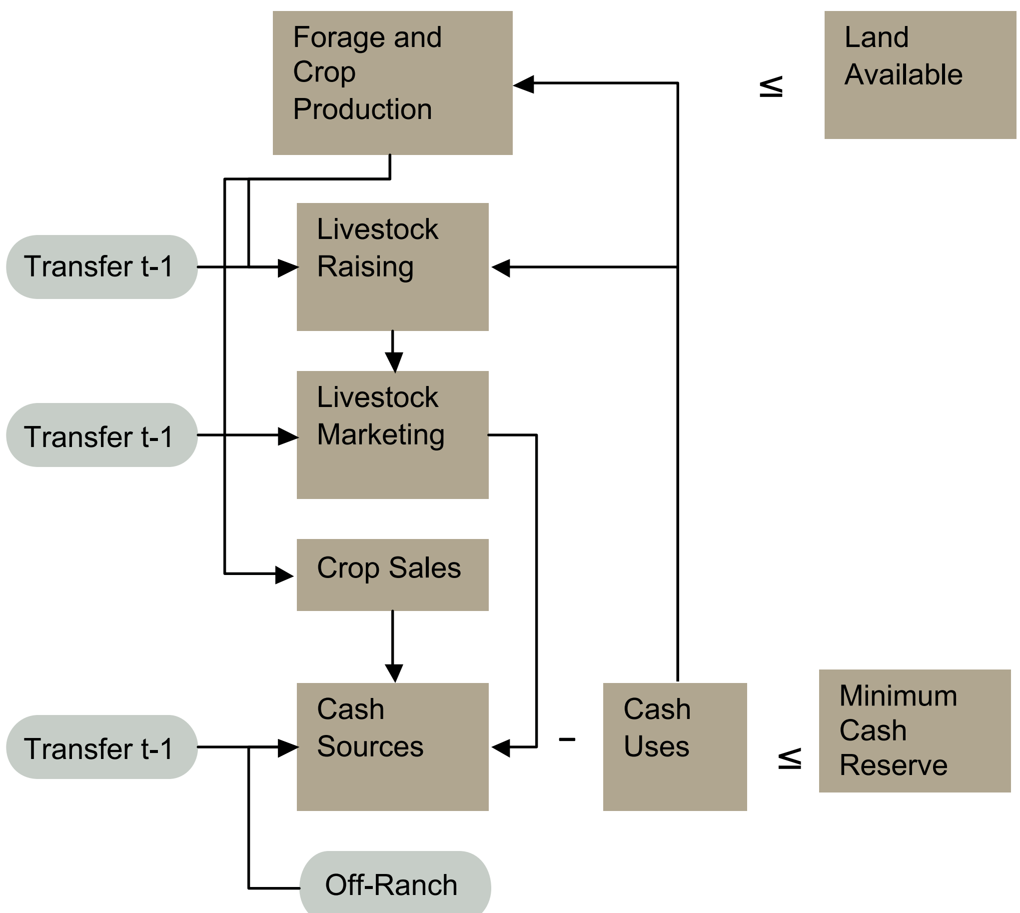

Figure 1. LP model constraint structure.

Forage and Crop Activities

Each model ranch has a given set of cropland and rangeland resources available for harvest and grazing. Each type of land is restricted at a level at or below some available upper limit (Table 1) - the first block of equations in the model. Forages are restricted to be used in only selected seasons (Table 2) because of regulation, physical availability, and production limitations. Additional restrictions require cattle remain on the federal grazing allotment for the duration of the allowed grazing season. Conforming to long-run land-use policies, non-use of federal and state grazing permits was not allowed. Flexibility of use for deeded range and meadows was assumed except for the seasonal use restrictions detailed in Table 2. Land-use restrictions are defined in the model with an AUM limit for grazing resources and an acreage limit for hayland (Table 1). The optimizing model balances forage demand and supply by season on an AUM basis. Table 3 shows the assumed AUM conversion rates for various harvested and grazed forages. Federal, state, and deeded rangeland forages are specified in the model on an AUM basis, so no AUM conversion is necessary.

Converting hayland to grazable pasture was included as an option in each of the four models. This conversion is not common, but it is one of the few sources of forage in the study areas if public land AUMs are removed. This conversion would reduce the amount of land available for hay production but would provide five or more AUMs/acre of grazing capacity (Table 3) and with a more flexible grazing season than the traditional fall grazing of hay crop residue and regrowth. We priced meadow conversion based on the average 2012 lease rate for private forage in the 11 western states (USDA-NASS 2012) with an assumed cost of $17/AUM.

Leasing is another potential source of forage if federal forage availability decreased available private lands from area ranches. This option was not included in the models because a surplus of private leases does not exist in the study areas. Further, since this is a representative ranch for the region, if the modeled ranch were to lease land the implication is that every ranch in the region would do the same. In fact, little summer grazing is available on private land in the study areas since much of the deeded land base is dedicated to raising hay for winter feed.

Native grass hay and alfalfa hay could be sold in the models if that option was most profitable. Grass or alfalfa hay could also be purchased as needed. Oregon was the only ranch model defined to have alfalfa hay land available.

Livestock Raising and Marketing Activities

Cow/calf production requires replacement of the herd, bull-to-cow ratios, and other typical ratios that define calving success, death losses, and carryover of animals between years. Three animal age classes are on the ranches during various times of the year: calves (< 1 year old), yearling animals including replacement heifers and yearlings carried over for sale, and mature cows and bulls of various ages.

Typical production strategies in the study areas were to sell all steer calves in the fall (Table 1). The option of retaining steers for sale as yearlings was not considered in any of the ranch models. Replacement heifers were assumed to be retained from the calf crop, but additional replacements could be purchased or raised if herd expansion were economically justified. Each model includes equations that define the minimum replacement rate

Table 3. Productivity measures for harvested and grazed forages.

Description	Unit	Idaho	Nevada	Oregon	Wyoming
Hay conversion to AUMs	AUMs/ton	2.42	2.42	2.42	2.42
Raised native hay	tons/acre	1.5	1.5	1.5	1.5
aftermath	AUM/acre	2.3	2.5	2.3	1.4
Raised alfalfa hay	tons/acre			4.5	
Pasture native hayland	AUMs/acre	5.5	5.0	5.5	5.5

(ranging from between 15 percent to 18 percent of the cowherd depending on the model (Table 1). A maximum of 80 percent of heifer calves could be retained as replacements, recognizing that not all animals would be satisfactory as breeding animals. Additionally, between 10 percent and 12 percent of heifer calves were required to be sold as yearling heifers instead of weaned calves (Table 1) because some replacement animals originally selected will not turn out to be satisfactory and will be sold at a heavier weight. All heifer calves in excess of the replacement requirement could be sold as yearlings if that was more economical.

Seasonal forage requirements for each animal class are calculated based on defined animal unit equivalencies[1] (Table 4) and the length of each grazing season (Table 2). 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 and have forage requirements in both years. Livestock sales include calves, yearlings, cull cows, and cull bulls. Brood cows, beyond those normally culled, can be sold at cull prices if herd reductions are necessary and optimal.

Table 4. Animal unit equivalences used to calculate seasonal forage requirements.

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

Source: Vallentine (1990)

Photo by Tim Torell, Digital Wildlife Images

Cash Flow Constraint

Crop and livestock sales generate income and are a source of cash for use in the operation of the ranches. Livestock, crop, and forage raising activities use cash. The cash constraint requires a cash reserve be maintained to cover variable production expenses, fixed ranch expenses, family living expenses, loan obligations, and an annual $10,000 cash residual (Table 1). A family living allowance of $35,000 was assumed for all models. This was offset in the cash flow constraint by an equivalent amount of off-ranch income (e.g., off-ranch employment, investment income, mineral income, recreation income). Gentner and Tanaka (2002) surveyed public land ranchers westwide and found all types of public land ranchers, both part-time and full-time, have alternative sources of income. In the Gentner and Tanaka (2002) research, large, full-time ranchers, as all but the Idaho model are defined to be, depended on the ranch for 75 percent to 85 percent of disposable income.

Excess cash at year t-1 can be transferred to year t, and it was assumed half of any excess cash from a "good" year will be transferred to cover variable and fixed expenses and cash shortfalls in future years. Other sources of cash include off-ranch income and annual borrowing. Any funds borrowed must be repaid the next year, but continuous annual borrowing can occur. Borrowing is not allowed the last year, and all debt obligations must be paid in full by the end of the year planning horizon. While numerous equations are included to define the production and economic structure of the representative ranch, forage resources and available cash ultimately determine the level of production possibilities.

[1] An animal unit is defined as a 1,000-pound cow and her calf. Animal unit equivalencies seek to define other animal species and classes on an equivalent basis.

Objective Function

The objective function of the LP models is to

$$MAX\ Z = \sum_{t=1}^{T} DF_t \times (Income_t - Variable\ costs_t)$$

A discount rate of 7 percent was used in present value calculations (DF_t = discount factor). Gross margin is defined to be the difference between income and variable production costs. Annual income includes livestock revenue from all animal classes including cull animals plus hay sales. Livestock revenue is a function of the number of cattle sold, weight of the cattle, and the market price received. While the model seeks to maximize the present value of the gross margins, final results also account for off-ranch income and fixed costs (e.g., mortgage payments) that do not change year to year.

Variable production expenses include animal production expenses plus feed expenses. Variable expenses vary with the level of production included in the models and include items such as labor, veterinary/medical costs, marketing, and other costs that vary with the number of cows in the operation. Expenses for other animal classes are included in per-cow expense estimates (Table 1) because their numbers are a ratio to the number of cows. The cost of feed, grazing fees, and non-fee grazing costs vary with optimal decisions about forage use levels. Per unit grazing and forage costs shown in Table 1 include estimates of the grazing fee paid and additional non-fee grazing costs for herding, checking, moving, and tending cattle while on grazing allotments and private lands.

Output Prices

Annual ranch income and optimal production strategies are greatly influenced by livestock prices. To consider the effect of beef cattle price variation on ranch returns and optimal production strategies, a Monte Carlo analysis[2] was used. Different beef cattle prices were generated for each of 100 model iterations over a 40-year planning horizon using the beef cattle price cycle, trends, and inter-relationships defined in a beef cattle price forecasting model developed for the earlier sage-grouse economic study (Torell et al. 2002). The price series from the earlier ranch models were used to capture observed stochastic and cyclic fluctuations in beef cattle prices while also capturing the linkage in prices between years and the relationship in prices between livestock classes and sexes. Prices were updated to 2012 levels by normalizing the price series so the average real 2012 price (adjusted using the Producer Price Index, PPI) during the month of sale for a particular weight and sex of animal was equal to the 1980 – 2012 average real price recorded for state livestock markets by CattleFax™ (CattleFax 2013).

Real 2012 livestock prices were stochastic exogenous variables[3] in the LP model objective function, and the model maximizes profit with knowledge about the 40-year price history. The starting point of the beef cattle price cycle was randomly assigned at the beginning of each iteration. The peaks and valleys of the price series were different for each 40-year price scenario with an approximate 12-year cycle from peak to peak. Brood cows were sold at cull prices whereas cow purchases were at the considerably higher bred cow price. Table 5 summarizes average prices and variation in prices for various livestock classes used in the LP models. Prices varied by state because animal sale weights and sale months were different and because of market differences.

Hay prices and forage grazing costs were not varied by iteration or year because long-term data series were not available to estimate annual price variability and relationships for crop and forage inputs and outputs. Bastian et al. (2009) also did not find any relationship between hay prices and drought in Wyoming mainly due to the fact most hay in this region came from irrigated land. The assumed real purchase and sale price of hay and forage was considered to be the same during each year of the analysis (Table 1).

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[2] Monte Carlo analysis is a method where random sets of input values are selected and the model run with each set. The results are then analyzed to find the relationships.

[3] Stochastic exogenous variables is a term used to identify random data that is generated outside of the model. It is "given" to the model to be used in the analysis.

Table 5. Average and variation in simulated 2012 real beef cattle prices used in the economic analysis.

		Simulated beef prices			
Description	Units	Average	Min	Max	Standard deviation
Idaho					
Steer Calf (560 lb)	$/lb	1.40	0.74	2.08	0.24
Heifer Calf (520 lb)	$/lb	1.26	0.56	1.92	0.25
Cull Cow (950 lb)	$/lb	0.67	0.32	1.06	0.15
Cull Bull (1,800 lb)	$/lb	0.90	0.50	1.32	0.17
Buy Brood Cow	$/head	1,198	414	1,567	253
Buy Bull	$/head	2,609	1,002	3,365	518
Nevada					
Steer Calf (475 lb)	$/lb	1.52	0.85	2.17	0.26
Heifer Calf (435 lb)	$/lb	1.34	0.71	1.99	0.25
Cull Cow (950 lb)	$/lb	0.66	0.33	0.97	0.13
Cull Bull (1,160 lb)	$/lb	0.90	0.48	1.30	0.17
Buy Brood Cow	$/head	1,198	476	1,891	244
Buy Bull	$/head	2,609	1,129	4,028	500
Oregon					
Steer Calf (525 lb)	$/lb	1.39	0.79	2.06	0.23
Heifer Calf (450 lb)	$/lb	1.33	0.66	2.10	0.26
Cull Cow (1,100 lb)	$/lb	0.61	0.29	0.93	0.12
Cull Bull (2,000 lb)	$/lb	0.83	0.45	1.22	0.16
Buy Brood Cow	$/head	1,198	332	1,945	261
Buy Bull	$/head	2,609	835	4,139	534
Wyoming					
Steer Calf (440 lb)	$/lb	1.57	0.83	2.34	0.27
Heifer Calf (390 lb)	$/lb	1.50	0.67	2.29	0.30
Cull Cow (950 lb)	$/lb	0.62	0.29	0.98	0.14
Cull Bull (1,800 lb)	$/lb	0.85	0.47	1.24	0.16
Buy Brood Cow	$/head	1,198	536	2,030	253
Buy Bull	$/head	2,609	1,252	4,313	518

Photo by Steve Stuebner, Idaho Rangeland Resource Commission

Photo by Tihomas Foulke, University of Wyoming

Policy Alternatives Considered

An initial baseline optimization was estimated for each model ranch, and production strategies found to be optimal under current grazing policies were estimated. 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 was estimated as the difference in optimal herd size, forage use, and economic returns as compared to the baseline.

During year one, the ranch models start with an initial number of breeding animals (cows, replacements, and bulls) that was about 85 percent of the herd size for each representative ranch (Table 1). Herd size adjustments are made in the optimization during the first five or six years as the model balances forage use to profit maximizing levels. Because the initial endowment of breeding animals is an arbitrary starting point, results are reported as average values tabulated for years 6 to 40 over the 100 model iterations.

Given the actions proposed to protect both the Gunnison and greater sage-grouse (Connelly et al. 2000; U.S. Fish and Wildlife Service 2013a; U.S. Fish & Wildlife Service 2013b) several alternative management strategies were considered appropriate for analysis. The seasonal adjustments considered were: 1) delay spring turnout by one month; 2) end fall grazing one month early; and 3) delay spring turnout one month AND end fall grazing one month earlier (Table 2). BLM AUMs grazed in the baseline run during the removed season were subtracted from the total BLM AUMs available in the seasonal adjustment analysis in addition to excluding BLM grazing during that period. BLM allotment reductions during all seasons of 25, 50, 75, and 100 percent were also considered.

Tables in Appendix A summarize economic impact assessment, optimal resource use, and production levels under the various policy assumptions. Because impacts are measured relative to baseline optimization runs of the LP models, optimal production strategies for current policies are also presented in the various Appendix tables. The results section compares the impact estimates on a $/BLM AUM removed basis for all of the impact scenarios.

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RESULTS

Current Optimal Production and Economics

Idaho Ranch Model

With current grazing policy, 2,098 AUMs of BLM forage were defined to be available in the Idaho Ranch Model, and this was the primary source of forage from mid-April to mid-October. BLM lands provided 45 percent of the annual AUM requirement (Appendix Table A-5).

The average optimal herd size was estimated to be 260 brood cows or 385 AUY (Appendix Table A-1). All available rangeland forage would be fully used 59 percent of the time with some AUMs from deeded range going unused in some years. As an average, 185 AUMs of the available 240 deeded AUMs would optimally be used. All available meadow hayland (325 acres) would produce hay and aftermath grazing, and an average of 50 tons of meadow hay would optimally be sold each year. On average, 438 tons (1.7 tons/cow) of meadow hay would be fed during the winter along with an additional 161 tons of purchased alfalfa hay for yearlings and weaned calves (Appendix Table A-1).

Gross annual returns were estimated to average $189,081 ($491/AUY) with a standard deviation of $46,593. Variable production expenses averaged $113,143 ($294/AUY), leaving a net return of $75,938 ($197/AUY) to pay fixed expenses (assumed to be $28,467 each year), loan expenses, and family living expenses (Appendix Table A-1). With variability in beef cattle prices, negative returns over fixed expenses occurred 17 percent of the time, but these shortfalls were covered with carryover savings with no borrowing required. The objective function value (present value of the net income stream over the 40-year planning horizon in 2012 dollars) averaged $1.048 million for the base situation.

Nevada Ranch Model

The current situation for the Nevada Ranch Model finds the unit utilizing 3,675 AUMs of BLM forage from early April through September - 99 percent of the AUM use for the period. Cattle are on deeded lands or fed hay other times of the year, and the overall annual dependency on BLM forage is 45 percent (Appendix Table A-6).

The average optimal herd size was estimated to be 464 brood cows or 683 AUYs (Appendix Table A-2). The model ranch includes 800 acres of meadow hay land that produces about 1,200 tons of meadow hay each year and contributes 2,000 AUMs of aftermath grazing during the fall. The ranch feeds an average of 866 tons (1.87 tons/cow) of meadow hay during winter (mid-December to early April turnout) with an average of 333 tons being sold. The ranch also purchases 162 tons of alfalfa to supplement winter feeding requirements (Appendix Table A-2).

The ranch generates an average of $321,813 in gross returns per year ($471/AUY), with a standard deviation of $63,672. Variable production costs average $212,838 ($312/AUY) and net returns averaged $108,975 ($160/AUY). Annual fixed expenses were estimated to be $38,874 (Table 1). Variability in cattle prices results in negative returns over fixed costs 14 percent of the time. No borrowing was required in the base situation. The objective function value was estimated to be $1.525 million.

Oregon Ranch Model

The Oregon Ranch Model utilizes 2,400 AUMs of BLM forage March 1 to November 1 with additional federal forage (2,560 AUMs) obtained from a USFS allotment grazed from May through September. The majority of animals are moved from BLM to USFS on May 1. The ranch depends on BLM and USFS land for 98 percent of spring and summer grazing demand and for 65 percent of annual forage demand (Appendix Table A-7).

The optimal herd size was estimated to be 479 brood cows (629 AUYs). The ranch raises meadow and alfalfa hay for winter feeding and sale and utilizes meadow hay fields for aftermath grazing when cattle return to the ranch in the fall. Winter feeding of hay occurs December through March with 560 tons of raised and purchased meadow hay fed to the cows (1.2 tons/cow) and raised alfalfa hay fed to calves and yearling replacement heifers (Appendix Table A-3).

Gross annual returns were estimated to average $325,412 ($517/AUY) with a standard deviation of $61,537. Variable expenses averaged $203,141 ($323/AUY) resulting in a net return of $122,270 ($194/AUY). Fixed expenses were estimated to be $27,532 (Table 1). Negative net annual income occurred 7 percent of the time. The objective function value was estimated to be $1.646 million.

Wyoming Ranch Model

The Wyoming Ranch Model relies upon 3,765 AUMs of BLM forage during mid-April through mid-November. This is 79 percent of the forage demand over the grazing period and 40 percent of annual forage use. The model ranch also utilizes deeded rangelands (1,068 AUMs) and state rangelands (538 AUMs) over the grazing period. An average of 71 acres of hayland would optimally be converted to pasture producing 393 AUMs of forage also used during the spring, summer, and fall grazing period (Appendix Table A-8).

The ranch uses 650 acres of meadows to produce grass hay is fed to cattle during the winter along with aftermath grazing in the fall. The ranch feeds 975 tons of raised meadow hay and purchases 82 tons of alfalfa and 29 tons of meadow hay to round out winter feed needs. Meadow hay fed amounts to 1.7 tons/cow.

The optimal herd size was estimated to be 590 head of cows (775 AUYs) (Appendix Table A-4). Gross annual returns are estimated to average $369,639 ($477/AUY) with a standard deviation of $91,850. Variable expenses are estimated at $256,744 ($331/AUY) resulting in average net cash income of $112,895 ($146/cow). Fixed costs are estimated to be $40,434. Negative net annual income was estimated to occur 22 percent of the time in the base situation. The objective function value was estimated to be $1.471 million.

BLM Grazing Reductions

Idaho Ranch Model

Reductions in the overall BLM AUM allocation reduced the optimal herd size of the Idaho Ranch Model but by less than the percentage reduction in permitted BLM AUM use. For example, a 25 percent cut in permitted use resulted in a 17 percent herd size reduction from 385 AUY to 321 AUY (Appendix Table A-1). Very little alternative grazing capacity was assumed to be available on the ranch. Unused deeded forage was more fully utilized in the optimization but with minimal conversion of meadow hayland to grazable pasture (< 6 acres). Hay feeding decreased as optimal herd sizes were reduced and the Idaho ranch would move to selling hay as the primary source of income as the grazing permit was eliminated.

With decreasing herd sizes and increasing hay sales, gross income expressed on a $/AUY basis increased with successive decreases in BLM forage availability. However, as expected, net ranch income decreased with BLM allotment reductions. The average net annual revenue reduction was -$13.21/ BLM AUM removed with a 25 percent cut, -$16.51/BLM AUM removed with a 50 percent cut, and moved to nearly -$30/AUM when the total grazing capacity of the allotment was removed (Table 6).

The 100 percent allotment reduction would not be sustainable. Without the BLM permit and with few alternative sources of forage, herd size would optimally be reduced from 385 AUY to only 67 AUY. Net income over variable and fixed costs was estimated to be negative 88 percent of the time with a 100 percent BLM cut. Annual borrowing would average about $21,000/year and borrowing amounts greater than $20,000/year would occur in 87 percent of the years. The ranch would be forced out of business without the BLM grazing allotment given the assumed level of off-ranch income, family living expenses, and carry-over of net ranch income (50 percent) between years.

Measured over the 40-year planning horizon assumed in the model, the average loss in objective function value (net returns discounted at a 7 percent rate) was estimated to range from $160/BLM AUM with a 25 percent cut to $324/BLM AUM with total elimination

Table 6. Policy Impacts summarized on a $/BLM AUM removed during various seasons and at different levels.[a]

State	Spring	Fall	Spring and Fall	Season Long BLM Permit Reduction			
Average reduction in net annual income ($/BLM AUM removed)							
Idaho	16%[b]	4%	20%	25%	50%	75%	100%
	-$17.04	-$12.54	-$17.15	-$13.21	-$16.51	-$21.99	-$29.76
Nevada	17%	17%	34%	25%	50%	75%	100%
	-$29.40	-$31.10	-$30.28	-$14.73	-$16.25	-$19.99	-$26.50
Oregon	22%	35%	56%	25%	50%	75%	100%
	-$50.50	-$30.91	-$40.76	-$13.19	-$16.98	-$22.82	-$28.71
Wyoming	17%	17%	34%	25%	50%	75%	100%
	-$14.82	-$14.82	-$14.78	-$14.91	-$14.97	-$17.04	-$21.49
Average	-$27.94	-$22.34	-$25.74	-$14.01	-$16.18	-$20.46	-$26.62
Reduction in discounted net income ($/BLM AUM removed)							
Idaho	16%	4%	20%	25%	50%	75%	100%
	-$190	-$133	-$197	-$160	-$207	-$251	-$324
Nevada	17%	17%	34%	25%	50%	75%	100%
	-$364	-$388	-$385	-$186	-$200	-$226	-$278
Oregon	22%	35%	56%	25%	50%	75%	100%
	-$665	-$390	-$513	-$148	-$211	-$283	-$358
Wyoming	17%	17%	34%	25%	50%	75%	100%
	-$138	-$138	-$152	-$145	-$161	-$187	-$225
Average	-$271	-$262	-$312	-$160	-$195	-$237	-$296

[a]/More detail about optimal resource use, optimal herd sizes and economic impacts are presented in Appendix A.

[b]/The percentage shown is the percent reduction in the BLM grazing allotment when grazing was removed during this season. The percentage of AUMS optimallly used during the various seasons varied for each model depending on the forage alternatives considered to be available.

of the BLM grazing permit. These changes in discounted returns are similar to grazing permit values reflected in the Great Basin ranch real estate market. Rimbey et al. (2007, Fig. 5) used 84 Great Basin ranch sales to estimate that a ranch in the desert areas of Malheur County, Oregon, Humboldt County, Nevada, and Owyhee County, Idaho, that depended heavily on BLM grazing had a 2003 grazing permit value ranging from about $100 to $250/AUM.

Nevada Ranch Model

Similar to the Idaho model, the optimal adjustment for the Nevada Ranch Model to reduced BLM forage availability was a reduction in herd size and increased hay sales. A 25 percent reduction in BLM AUMs resulted in a 22 percent reduction in optimal herd size. Similarly, a 75 percent reduction meant a 71 percent reduction in optimal herd size (Appendix Table A-2). Very little adjustment in deeded land use occurred as the BLM allotment was reduced because few alternatives were assumed to be available. Hayland provided more value in producing hay rather than converting to grazable pasture (with < 12 acres optimally converted).

The average net annual revenue reduction was -$14.73/BLM AUM removed with a 25 percent cut, -$16.25/AUM with a 50 percent cut, -$20/AUM with a 75 percent cut and -$26.50/AUM when the total grazing capacity of the BLM allotment was removed (Table 6). The loss in discounted net income was estimated to be $186/BLM AUM removed with a 25 percent allotment reduction and nearly $280/BLM AUM with elimination of the BLM permit.

Similar to the Idaho model, the Nevada Ranch Model could not financially survive total elimination of the BLM grazing permit. Herd size would be reduced from 683 AUY to 31 AUY and the ranch would move to producing and selling hay - more than tripling the amount of meadow hay sold. While nearly the same amount of aftermath grazing on the meadows would be produced (1,969 AUMs), nearly all of this would go unused with a 95 percent reduction in optimal herd size. Spring and summer grazing now limits cow/calf production on the ranch. An average of nearly $31,000 would be borrowed each year, and fixed ranch expenses could not be covered 83 percent of the time.

Oregon Ranch Model

The Oregon Ranch Model was the only model defined to have both BLM and USFS grazing available. Policy alternatives were only applied to BLM permits in the analysis. The USFS permit provided a major source of summer forage in the model (2,560 AUMs, Appendix Table A-7). A 25 percent BLM reduction represents a 12 percent reduction in the federal grazing capacity of the Oregon model ranch. When evaluated from this overall perspective, the results are similar to the Idaho and Nevada models. A 25 percent reduction in BLM grazing resulted in a 10 percent reduction in herd size, which is slightly less than the 12 percent reduction in available federal AUMs (Appendix Table A-3). Eliminating BLM grazing reduced the optimal herd size by 55 percent, far less than for Idaho and Nevada that did not have BLM and FS permits.

With the full allocation of USFS grazing remaining available during the May through September period, filling seasonal grazing needs from deeded forage sources and rearranging seasonal use of the BLM permit was most profitable. Conversion of meadow to pasture increased from 15 acres in the base situation to 105 acres with a 75 percent BLM allotment reduction.

The average net annual revenue reduction ranged from about -$13/BLM AUM removed with a 25 percent cut to -$29/AUM when the total grazing capacity of the BLM allotment was removed (Table 6). The objective function was reduced by $148/BLM AUM removed with a 25 percent BLM allotment reduction to nearly $360/AUM with elimination of the BLM permit.

Wyoming Ranch Model

With only a 68 percent level of dependency on BLM land during the April to November grazing season, the Wyoming Ranch Model had more grazing flexibility than the other state models where grazing season dependencies were defined to be much higher. Herd size reductions were minimized by adjusting the seasonal use of available deeded and state land AUMs and by converting an increasing acreage of hayland to grazable pasture. A 25 percent reduction in the permitted use of the BLM permit resulted in a 10 percent herd size reduction, a 75 percent BLM cut resulted in a 31 percent reduction in optimal herd size. Hay feeding decreased as optimal herd sizes were reduced with increased acreages of hayland converted to grazable pasture (Appendix Table A-4).

The average net annual revenue reduction ranged from about -$15/BLM AUM removed with a 25 percent cut to -$21/AUM when the total grazing capacity of the BLM allotment was removed (Table 6). The objective function value was reduced by $145/BLM AUM removed with a 25 percent BLM allotment reduction to $225/AUM with elimination of the BLM permit. Similar to the Idaho and Nevada models, the Wyoming model could not financially withstand complete elimination of the BLM grazing permit. Without the permit, net returns over fixed and variable expenses would be negative 53 percent of the time and force the model ranch to borrow an average of nearly $22,000/year to cover the annual shortfall (Appendix Table A-4).

Seasonal Forage Adjustments

Appendix Tables A-5 to A-16 detail the optimal adjustments and economic impacts of eliminating spring grazing, fall grazing, and spring and fall grazing on BLM land. Table 6 further summarizes the economic impact on a $/BLM AUM removed basis.

Eliminating Spring Grazing

Eliminating one month of spring grazing meant an average BLM allotment reduction of between 16 percent and 22 percent for the various study states (Table 6). The additional restriction that use of remaining BLM AUMs could not occur during the defined spring period (Table 2) was also imposed.

Optimal production adjustments were similar for the various models. First, forage from other grazing resources were substituted when available and allowed. All available deeded and state rangeland forage would now be grazed during the spring period. This may be unrealistic given seasonal forage growth patterns. Herd sizes would be reduced (ranging from 11 percent for the Nevada model to 3 percent for the Oregon model). With reduced herd size, hay feeding would generally decrease. This was not true for the Oregon Ranch Model, however. The Oregon model had a substantial block of forage available from the FS permit that could be grazed May 1 to October 1. Non-use restrictions forced use of the FS permit in the model. Few alternatives except hay feeding could replace the spring BLM forage (Appendix Table A-7). Hay purchases as the least cost adjustment strategy nearly doubled the average annual economic value of the spring BLM forage in the Oregon model ($51/AUM) as compared to other state models where available grazing resources could fill most of the forage demand void (Table 6). Spring forage was the most expensive to replace and generally had the highest economic value.

Eliminating Fall Grazing

The fall grazing period eliminated in the models varied between states, but in most cases hay meadow aftermath grazing would be available at this time (Table 2), though already fully used in the baseline situation. As shown in the appendix tables, deeded grazing resource use would switch to the fall period. Herd sizes would be reduced and vary depending on the number of AUMs eliminated in the fall period. The Idaho model, for example, had only 80 AUMs (4 percent of BLM AUMs) eliminated during the fall period (Appendix Table A-9) and would adjust with a herd reduction of 10 AUY and a 10-ton increase in hay sales. Other state models grazed 17 percent to 35 percent of BLM AUMs during the fall period (Table 6) and the primary adjustment for these models was to convert available hayland to pasture for use during the fall period. The economic value of the BLM AUMs for fall grazing ranged from $13/AUM for the Idaho model to $31/AUM for the Nevada and Oregon models (Table 6).

Eliminating Spring and Fall Grazing

Eliminating spring and fall BLM grazing in the optimization models meant a 20 percent (Idaho) to 56 percent (Oregon) reduction in the BLM allotment allocation (Table 6). In response, optimal average herd size reductions ranged from about 12 percent in Idaho and Wyoming to about 24 percent in Nevada and Oregon. Full use of federal forage in the adjusted seasons would be the primary factor setting optimal herd sizes. Deeded and state lands along with converted pasture land would meet rangeland forage demands during the eliminated seasons and with hay feeding during the winter.

The change in net annual income when spring and fall forage was eliminated ranged from $15/BLM AUM in Wyoming to $41/BLM AUM in Oregon (Table 6). Having the summer FS permit increased the economic value of the spring and fall BLM forage for the Oregon model, as noted earlier.

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DISCUSSION

Public land ranches are very heterogeneous in their characteristics, including ranch size, level of annual and seasonal dependency on public lands for grazing capacity, and in the alternative forage sources available to them (Gentner and Tanaka 2002). For each state we developed one optimization model which can be misleading given the heterogeneity in characteristics. The Oregon Ranch Model, for example, was the only model that had both BLM and USFS grazing included. This same situation is common for many ranches in the western states. Consistency of model results for the state models with similar characteristics suggest results will be similar between areas if key characteristics like seasonal forage use patterns and level of federal land dependency are similar.

One common factor for most northern-climate western ranches is the significance of spring forage for rangeland-based operations. As cattle come out of winter and begin calving (with high nutritional demands) and the grasses begin to green up, there is lower preference for hay. From a rangeland health perspective, proper management would indicate cattle should be held off the spring green-up until plants have grown enough to withstand grazing pressure (what is termed range-readiness). Ranchers want to be able to turn their cattle out as soon as possible to avoid feeding the high-cost winter feeds. This dilemma has historically led to the search for pasture that greens up earlier and explains the many acres of crested wheatgrass seeded throughout the west. Loss of additional spring forage (after range-readiness) will create additional hardships on these ranches.

The model ranches were defined to depend on public lands for about 90 percent of spring and summer grazing capacity. As would be expected, the fewer substitute forages available in the models, the higher the estimated economic impact of changing BLM grazing capacities. Many ranches are not nearly this dependent on public lands for seasonal grazing capacity, and economic impacts would be much less in these cases.

The optimization results generally show that as public land forage is removed during a particular season, the optimal adjustment will be to graze other forage resources during that season to the degree possible and to convert and improve alternative forage sources if possible (like the hayland conversion to pasture as allowed in the LP analysis or private forage leasing when available). Herd reductions were made after seasonal forage use adjustments and the size of the public land permit set optimal herd size after the policy changes. Hay feeding generally decreased with herd reductions and was not a viable adjustment to the loss of spring or fall forage. Replacing lost BLM grazing during the grazing season was not allowed.

With the exception of the Oregon Ranch Model that was defined to have substantial unaltered summer grazing resources with a FS permit, and thus the need to fill any spring and fall grazing void by converting hayland to pasture, the optimization models suggested the profit maximizing strategy would be to sell more and more hay as the BLM permit was reduced at increasing rates. Distance to hay markets and the suggested lifestyle change may preclude this alternative for many.

We assumed a very frugal and dedicated ranch family in the analysis. One-half of any positive annual ranch profit was moved forward to meet future cash shortfalls. Alternative off- ranch investment opportunities of funds were not considered. Consistent with the strong lifestyle motives of public land ranchers documented by Gentner and Tanaka (2002) and widely observed, we assumed the ranch family would stay in business until forced to do otherwise by cash flow restrictions. With off-ranch income sufficient to cover an assumed $35,000/year family living allowance and without substantial initial wealth, the cash flow restrictions imposed in the model could be met in all situations except for when the BLM permit was totally eliminated (100 percent reduction). The model ranches would then be forced into a continued borrowing situation with negative returns realized over half of the time depending on the beef cattle price situation. This result will actually be highly variable. It will not be true if the public land permit meets but a small part of forage demands. Ranchers have a strong desire to remain in the ranching business but with highly variable economic and wealth situations and different degrees of commitment to the business. Projecting how many ranchers would actually be put out of business is nearly impossible short of evaluating every ranch.

Grazing Permit Values

Federal and state land grazing permits supposedly have economic value because of the discounted future stream of economic contributions the grazing permits make to ranch returns. As noted by Gardner (1997, p. 11) "The permit's value represents the capitalized value of expected future differences between the fee (and non-fee grazing costs) and the value of the forage." In this study, the change in the LP model objective function value as grazing permits were reduced or eliminated, with 40 years of discounted returns, provides an estimate of income-based grazing permit value. The range of estimated values, from about $150/AUM to over $350/AUM for elimination of the season long permit (Table 6), are similar to recent BLM permit value estimates made for Great Basin ranches and for New Mexico ranches when the ranch was highly dependent on federal lands for grazing capacity. But in our earlier ranch value studies (Rimbey et al. 2007; Torell et al. 2012), federal grazing permits were found to add no value or even diminish ranch value when less than 30 percent of grazing capacity came from federal lands. High federal land dependent ranches had permit value estimates ranging from about $100 to $350/AUM (Rimbey et al. 2007, Fig, 5; Torell et al. 2012, Fig. 11) - a range not unlike the capitalized return reductions estimated here (Table 6).

Earlier ranch value studies (Rimbey et al. 2007; Torell et al. 2012) used hedonic regression models to evaluate what factors contribute to the market value of ranches. Ranches were found to be overpriced relative to income earning potential and concluded the acreage of the permit and not the cattle grazing added the most to ranchland value. Those studies did not find a strong relationship between ranch earnings, ranch values, and grazing permit values. This is different from the traditional and widely held income-based reason given for why grazing permits have economic value (Roberts 1963; Gardner 1997).

If the capitalized returns reasoning for grazing permit value holds, the implication is that as ranch earnings are reduced from altered land-use policies, public land ranchers will incur economic losses and reduced ranchland values. Recognizing this income-based linkage, Industrial Economics Inc. (2013, Exhibit 3-2) used inflation indexing of permit values estimated from eight 1980 to 2002 studies conducted primarily in Utah and

New Mexico to estimate that the average 2012 capitalized value of a BLM AUM was $105/AUM and a FS AUM was $96/AUM. They used these economic values to estimate grazing impacts of policy proposals to protect the Gunnison sage-grouse considering an average allotment reduction of 64 percent on 107 allotments in Colorado and Utah. Their capitalized value estimate is about half as much as we estimated the discounted annual returns would be for this level of allotment reduction in our four-state study area (Table 6). Their value estimate and extrapolation of permit values are also considerably less than estimates from ranch value studies when highly dependent public land ranches are considered (Rimbey et al. 2007; Torell et al. 2012). The approximate $100/AUM 2012 permit value estimate used in the Gunnison sage-grouse economic study would be in-line with our estimates for ranches depending on federal lands for about 35 percent of annual grazing capacity, whereas the 40-45 percent level of annual dependency defined for the Idaho, Nevada, and Wyoming LP models used in this study would give a permit value estimate of about $175/AUM (Rimbey et al. 2007, Fig. 5). The Oregon model with 65 percent dependency on federal land would have a permit value estimate of approximately $225/AUM.

Given the seasonal importance of federal AUMs to western ranches, the ranch-level economic impacts of reducing and altering grazing uses on federal lands can be substantial. High-dependency public land ranches, like those considered in this analysis, are dependent on federal grazing permits for their economic viability. Whether our model results are indicative of total ranch populations in each of the states is debatable and hinges on numerous assumptions about seasonal sources of alternative forage available and economic position of ranch families. Beyond the individual ranch impacts, regional economic impacts are likely to be greater when considering direct, indirect, and induced economic impacts; however, our estimates of economic losses expressed on a $/AUM basis help inform the debate about potential land-use and grazing policy changes. Land managers and policy makers should be aware of the magnitude of the economic impacts of their decisions as required by the National Environmental Policy Act (NEPA, PL 91-190).

Photo by Neil Rimbey, University of Idaho

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APPENDIX A: IMPACT SUMMARY TABLES

Appendix Table A-1. Optimal adjustments to reductions in BLM AUMs, Idaho Ranch Model.

	Percent reduction in BLM AUMs				
Adjustments in optimal use levels	0%	25%	50%	75%	100%
BLM available (AUMs)	2,098	1,574	1,049	525	0
Percent of AUMs from BLM land	45%	41%	36%	28%	0%
Average number of brood cows (head)	260 (11)[a]	218 (10)	163 (10)	104 (10)	42 (10)
Average number of AUY	385 (13)	321 (11)	240 (12)	154 (13)	67 (14)
Percent reduction in AUY (%)	--	-17%	-38%	-60%	-83%
Average annual gross returns ($)	189,081 (46,593)	165,614 (37,579)	135,709 (28,096)	104,692 (17,701)	73,507 (8,865)
Average annual gross returns ($/AUY)	491	516	565	680	1,097
Average annual variable production costs ($)	113,143 (6,442)	96,606 (4,838)	77,095 (4,159)	63,349 (10,241)	60,005 (11,319)
Average annual variable production costs ($/AUY)	294	301	321	411	896
Average annual net income ($)	75,938 (46,977)	69,008 (36,995)	58,614 (28,874)	41,343 (20,351)	13,503 (14,457)
Average annual net income ($/AUY)	197	215	244	268	202
Average change in net income ($/BLM AUM removed)	--	-13.21	-16.51	-21.99	-29.76
Objective function value ($ 000's)	1,048.2 (59.3)	964.4 (51.2)	831.2 (43.9)	652.9 (65.3)	369.5 (71.4)
Average change in objective function ($/BLM AUM removed)	--	-160	-207	-251	-324
Deeded range (AUMs)	185 (82)	217 (58)	227 (42)	232 (26)	237 (10)
State trust land (AUMs)	144 (0)	144 (0)	144 (0)	144 (0)	144 (0)
Meadow hayland acres hayed/grazed (acres)	325 (0)	323 (5)	320 (11)	319 (14)	320 (16)
Meadow hayland acres hayed/grazed (AUMs Aftermath grazing)	748 (0)	742 (11)	735 (26)	735 (31)	737 (37)
Meadow acres converted to pasture (acres)	0 (0)	2 (5)	5 (11)	6 (14)	3 (16)
Meadow acres converted to pasture (AUMs)	0 (0)	12 (27)	29 (62)	30 (75)	18 (87)
Raised meadow hay fed (tons)	438 (21)	368 (19)	279 (17)	181 (17)	68 (22)
Raised meadow hay sold (tons)	50 (21)	116 (20)	201 (28)	298 (34)	414 (44)
Purchased meadow hay fed (tons)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Purchased alfalfa hay fed (tons)	161 (21)	133 (17)	95 (15)	59 (11)	24 (7)
Average amount borrowed annually ($)	0 (0)	0 (0)	≈ 0 (26)	5,632 (9,457)	20,667 (10,905)
Probability of negative net annual returns over fixed costs (%)	17%	15%	14%	25%	88%

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

Appendix Table A-2. Optimal adjustments to reductions in BLM AUMs, Nevada Ranch Model.

	Percent reduction in BLM AUMs				
Adjustments in optimal use levels	0%	25%	50%	75%	100%
BLM available (AUMs)	3,675	2,756	1,838	919	0
Optimal average BLM used (AUMs)	3,675 (0)	2,756 (0)	1,838 (0)	919 (0)	0 (0)
Percent of AUMs from BLM land	45%	43%	42%	38%	0%
Average number of brood cows (head)	464 (20)	367 (21)	249 (22)	132 (20)	12 (36)
Average number of AUY	683 (20)	536 (23)	368 (26)	200 (35)	31 (49)
Percent reduction in AUY (%)	--	-22%	-46%	-71%	-95%
Average annual gross returns ($)	321,813 (63,672)	278,230 (49,207)	230,034 (33,867)	181,829 (19,666)	133,604 (13,264)
Average annual gross returns ($/AUY)	471	519	625	909	4310
Average annual variable production costs ($)	212,838 (12,114)	182,784 (9,413)	150,916 (6,577)	127,949 (13,220)	122,028 (20,897)
Average annual variable production costs ($/AUY)	312	341	410	640	3,936
Average annual net income ($)	108,975 (66,119)	95,446 (49,973)	79,118 (33,694)	53,880 (23,545)	11,576 (24,942)
Average annual net income ($/AUY)	160	178	215	269	373
Average change in net income ($/BLM AUM removed)	--	-14.73	-16.25	-19.99	-26.50
Objective function value ($ 000's)	1,525.1 (102.3)	1,354.3 (89.6)	1,157.0 (81.0)	903.1 (116.5)	503.1 (131.7)
Average change in objective function ($/BLM AUM removed)	--	-186	-200	-226	-278
Deeded range (AUMs)	83 (49)	98 (38)	101 (34)	106 (25)	115 (1)
Meadow hayland acres hayed/grazed (acres)	800 (1)	791 (21)	790 (27)	788 (38)	788 (54)
Meadow hayland acres hayed/grazed (AUMs Aftermath grazing)	2,000 (3)	1,977 (52)	1,974 (67)	1,969 (95)	1,969 (136)
Meadow acres converted to pasture (acres)	0 (1)	9 (21)	10 (27)	12 (38)	12 (54)
Meadow acres converted to pasture (AUMs)	0 (0)	5 (46)	52 (134)	62 (189)	61 (272)
Raised meadow hay fed (tons)	866 (37)	684 (36)	471 (36)	259 (45)	43 (61)
Raised meadow hay sold (tons)	333 (37)	502 (56)	713 (71)	923 (100)	1,138 (143)
Purchased meadow hay fed (tons)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Purchased alfalfa hay fed (tons)	162 (22)	125 (18)	84 (13)	44 (9)	3 (9)
Average amount borrowed annually ($)	0 (0)	0 (0)	33 (845)	7,989 (12,030)	30,951 (19,574)
Probability of negative net annual returns over fixed costs (%)	14%	12%	11%	23%	83%

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

Appendix Table A-3. Optimal adjustments to reductions in BLM AUMs, Oregon Ranch Model.

	Percent reduction in BLM AUMs				
Adjustments in optimal use levels	0%	25%	50%	75%	100%
BLM available (AUMs)	2,400	1,800	1,200	600	0
Optimal average BLM used (AUMs)	2,400 (0)	1,800 (0)	1,200 (0)	600 (0)	0 (0)
Percent of AUMs from BLM land	32%	27%	20%	12%	0%
Average number of brood cows (head)	479 (9)	429 (8)	371 (16)	307 (32)	210 (28)
Average number of AUY	629 (19)	564 (17)	489 (27)	404 (43)	281 (36)
Percent reduction in AUY (%)	--	-10%	-22%	-36%	-55%
Average annual gross returns ($)	325,412 (61,537)	298,914 (54,863)	271,212 (52,558)	238,530 (44,064)	189,971 (33,502)
Average annual gross returns ($/AUY)	517	530	555	590	676
Average annual variable production costs ($)	203,141 (16,332)	184,555 (14,166)	169,313 (13,385)	157,336 (16,136)	136,607 (12,426)
Average annual variable production costs ($/AUY)	323	327	346	389	486
Average annual net income ($)	122,270 (64,898)	114,359 (57,079)	101,899 (52,239)	81,194 (41,164)	53,363 (28,767)
Average annual net income ($/AUY)	194	203	208	201	190
Average change in net income ($/BLM AUM removed)	--	-13.19	-16.98	-22.82	-28.71
Objective function value ($ 000's)	1,646.1 (90.4)	1,557.2 (87.1)	1,392.6 (81.8)	1,137.0 (77.1)	787.7 (86.2)
Average change in objective function ($/BLM AUM removed)	--	-148	-211	-283	-358
Deeded range (AUMs)	73 (52)	30 (49)	107 (22)	113 (2)	113 (0)
Forest Service (AUMs)	2,560 (0)	2,560 (0)	2,560 (0)	2,560 (0)	2,560 (0)
Meadow hayland acres hayed/grazed (acres)	287 (17)	288 (13)	257 (31)	185 (56)	201 (38)
Meadow hayland acres hayed/grazed (AUMs Aftermath grazing)	661 (39)	662 (30)	591 (70)	425 (130)	463 (87)
Meadow acres converted to pasture (acres)	3 (17)	3 (15)	33 (31)	105 (56)	89 (38)
Meadow acres converted to pasture (AUMs)	15 (93)	15 (84)	181 (168)	578 (310)	488 (208)
Raised alfalfa hay sold (tons)	185 (42)	208 (37)	236 (38)	270 (32)	311 (22)
Raised meadow hay sold (tons)	0 (0)	0 (0)	5 (10)	11 (26)	26 (34)
Raised meadow hay fed (tons)	431 (25)	431 (23)	381 (41)	267 (73)	276 (46)
Purchased meadow hay fed (tons)	129 (35)	71 (32)	57 (58)	96 (109)	32 (84)
Purchased alfalfa hay fed (tons)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Average amount borrowed annually ($)	0 (0)	0 (0)	0 (0)	0 (0)	70 (1,148)
Probability of negative net annual returns over fixed costs (%)	7%	6%	8%	9%	19%

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

Appendix Table A-4. Optimal adjustments to reductions in BLM AUMs, Wyoming Ranch Model.

	Percent reduction in BLM AUMs				
Adjustments in optimal use levels	0%	25%	50%	75%	100%
BLM available (AUMs)	3,765	2,824	1,883	941	0
Optimal average BLM used (AUMs)	3,765 (0)	2,824 (0)	1,883 (0)	941 (0)	0 (0)
Percent of AUMs from BLM land	40%	34%	25%	15%	0%
Average number of brood cows (head)	590 (26)	530 (25)	472 (26)	407 (38)	352 (36)
Average number of AUY	775 (45)	696 (43)	620 (41)	534 (55)	463 (52)
Percent reduction in AUY (%)	--	-10%	-20%	-31%	-40%
Average annual gross returns ($)	369,639 (91,850)	331,640 (81,632)	295,402 (72,472)	254,433 (64,112)	220,323 (56,685)
Average annual gross returns ($/AUY)	477	476	476	476	476
Average annual variable production costs ($)	256,744 (22,389)	232,776 (20,921)	210,695 (19,973)	189,664 (28,947)	188,341 (37,707)
Average annual variable production costs ($/AUY)	331	334	340	355	407
Average annual net income ($)	112,895 (78,370)	98,863 (69,683)	84,707 (61,589)	64,768 (53,726)	31,981 (60,073)
Average annual net income ($/AUY)	146	142	137	121	69
Average change in net income ($/BLM AUM removed)	--	-14.91	-14.97	-17.04	-21.49
Objective function value ($ 000's)	1,471.0 (121.7)	1,334.7 (120.7)	1,167.5 (122.7)	943.6 (162.2)	623.9 (189.8)
Average change in objective function ($/BLM AUM removed)	--	-145	-161	-187	-225
Deeded range (AUMs)	1,069 (38)	1,076 (8)	1,076 (3)	1,075 (9)	1,076 (1)
State trust land (AUMs)	538 (0)	538 (0)	538 (0)	538 (0)	538 (0)
Meadow hayland acres hayed/grazed (acres)	650 (48)	586 (43)	523 (39)	451 (47)	389 (45)
Meadow hayland acres hayed/grazed (AUMs Aftermath grazing)	910 (68)	820 (60)	733 (55)	631 (66)	545 (64)
Meadow acres converted to pasture (acres)	71 (73)	133 (68)	202 (63)	256 (79)	332 (75)
Meadow acres converted to pasture (AUMs)	393 (402)	733 (373)	1,109 (348)	1,411 (432)	1,825 (407)
Raised meadow hay fed (tons)	975 (73)	879 (65)	785 (59)	676 (71)	584 (68)
Raised meadow hay sold (tons)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Purchased meadow hay fed (tons)	29 (99)	23 (83)	19 (70)	16 (59)	16 (59)
Purchased alfalfa hay fed (tons)	82 (15)	73 (13)	65 (12)	55 (11)	48 (10)
Average amount borrowed annually ($)	22 (737)	19 (695)	79 (1,367)	4,874 (13,224)	21,896 (28,777)
Probability of negative net annual returns over fixed costs (%)	22%	24%	28%	37%	53%

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

Appendix Table A-5. Optimal adjustments to elimination of spring grazing on BLM land, Idaho Ranch Model.

Season	BLM	State	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Purchased alfalfa hay	Total
Base run with BLM spring grazing (AUMs)									
1-Mar to 15-Apr						430		110	540
15-Apr to 15-May	331	18	13						362
15-May to 15-Sep	1,356	17	109						1,482
15-Sep to 15-Oct	331	108	56						495
15-Oct to 15-Nov	80	1	6	391					478
15-Nov to 15-Dec			2	357					359
15-Dec to 1-Mar						629		279	908
TOTAL USED (AUM)	2,098	144	186	748		1,059		389	4,624
Annual Dependency on Federal Land (%)									45%
No BLM spring grazing (Change in AUMs)									
1-Mar to 15-Apr						-44		-10	-54
15-Apr to 15-May	-331	96	185		6	7			-37
15-May to 15-Sep	38	-17	-108						-87
15-Sep to 15-Oct	9	-78	-16		34				-50
15-Oct to 15-Nov	-48	-1	-6	17					-38
15-Nov to 15-Dec			-2	-34					-36
15-Dec to 1-Mar						-64		-27	-91
TOTAL USED (AUM)	-331	1	52	-17	40	-101		-37	-392

Adjustments in:	Base run with BLM spring grazing	Without BLM spring grazing	Change
Average number of AUY	385	346	-39
	(11)	(14)	
Average number of brood cows	260	233	-27
	(11)	(10)	
Average annual net income ($)	75,938	70,298	-5,640
	(46,977)	(41,680)	
Average annual net income ($/AUY)	197	203	5.93
during the spring period)			-17.04
Objective function value ($ 000's)	1,048.2	985.1	-63.1
during the spring period)			-190.54
Raised meadow hay sold (tons)	50	80	30
Average amount borrowed annually ($)	0	0	0
Probability of negative returns over fixed costs (%)	17%	18%	

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

Appendix Table A-6. Optimal adjustments to elimination of spring grazing on BLM land, Nevada Ranch 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 spring grazing (AUMs)								
8-Apr to 8-May	626	9						635
8-May to 8-Jun	647	9						656
8-Jun to 1-Sep	1,775	25						1,800
1-Sep to 1-Oct	626	9						635
1-Oct to 23-Nov		31		1,595				1,626
23-Nov to 15-Dec				405			63	468
15-Dec to 8-Apr					2,097		329	2,426
TOTAL USED (AUM)	3,675	83	0	2,000	2,097	0	392	8,247
Annual Dependency on Federal Land (%)								45%
No BLM spring grazing (Change in AUMs)								
8-Apr to 8-May	-626	106	365		82			-73
8-May to 8-Jun		-9						-9
8-Jun to 1-Sep		-25						-25
1-Sep to 1-Oct		-9						
1-Oct to 23-Nov		-31		-138				-169
23-Nov to 15-Dec				-44			-8	-52
15-Dec to 8-Apr					-227		-40	-267
TOTAL USED (AUM)	-626	32	365	-182	-145	0	-48	-595

Adjustments in:	Base run with BLM spring grazing	Without BLM spring grazing	Change
Average number of AUY	683	608	-75
	(20)	(29)	
Average number of brood cows	464	414	-50
	(20)	(22)	
Average annual net income ($)	108,975	90,561	-18,414
	(66,119)	(59,765)	
Average annual net income ($/AUY)	160	149	-10.60
removed during the spring period)			-29.40
Objective function value ($ 000's)	1,525.1	1,296.8	-228.2
removed during the spring period)			-364.33
Raised meadow hay sold (tons)	333	284	-49
Average amount borrowed annually ($)	0	2	2
Probability of negative returns over fixed costs (%)		17%	

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

Appendix Table A-7. Optimal adjustments to elimination of spring grazing on BLM land, Oregon Ranch Model.

Season			BLM	Forest Service	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Raised alfalfa hay	Total
Adjustments in seasonal forage use											
Base run with BLM spring grazing (AUMs)											
1-Mar	to	1-Apr	521		19					66	606
1-Apr	to	1-May	586								586
1-May	to	1-Sep	378	2,058			10				2,446
1-Sep	to	1-Oct	85	502							587
1-Oct	to	1-Nov	830		32	5					867
1-Nov	to	1-Dec			22	656	5				683
1-Dec		1-Mar						1,043	312	468	1,823
TOTAL USED (AUM)			2,400	2,560	73	661	15	1,043	312	534	7,598
Annual Dependency on Federal Land (%)											65%
No BLM spring grazing (Change in AUMs)											
1-Mar	to	1-Apr	-521		94			105	302	-1	-21
1-Apr	to	1-May	-19								-19
1-May	to	1-Sep	34				-8				26
1-Sep	to	1-Oct	-20								-20
1-Oct	to	1-Nov	5		-32	-1					-28
1-Nov	to	1-Dec			-22	-1	12				-11
1-Dec	to	1-Mar						-108	57	-5	-56
TOTAL USED (AUM)			-521	0	40	-2	4	-3	359	-6	-129

Adjustments in:	Base run with BLM spring grazing	Without BLM Spring Grazing	Change
Average number of AUY	629	609	-20
	(19)	(25)	
Average number of brood cows	479	463	-16
	(9)	(14)	
Average annual net income ($)	122,270	95,962	-26,308
	(64,898)	(60,344)	
Average annual net income ($/AUY)	194	158	-36.81
during the spring period)			-50.50
Objective function value ($ 000's)	1,661.6	1,315.3	-346.3
during the spring period)			-664.74
Raised meadow hay sold (tons)	0	0	0
Average amount borrowed annually ($)	0	0	0
Probability of negative returns over fixed costs (%)	7%	14%	

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

Appendix Table A-8. Optimal adjustments to elimination of spring grazing on BLM land, Wyoming Ranch Model.

Season	BLM	Deeded	State	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 spring grazing (AUMs)									
1-Mar to 15-Apr						658	36	28	722
15-Apr to 15-May	634	21	59	31					745
15-May to 15-Sep	1,883	129	100	100					2,212
15-Sep to 15-Oct	614	34	73						721
15-Oct to 15-Nov	634	153	306	21					1,114
15-Nov to 15-Dec		731		241	910				1,882
15-Dec to 1-Mar						1,702	35	171	1,908
TOTAL USED (AUM)	3,765	1,068	538	393	910	2,360	71	199	9,304
Annual Dependency on Federal Land (%)									40%
No BLM spring grazing (Change in AUMs)									
1-Mar to 15-Apr						-42	-6	-2	-50
15-Apr to 15-May	-634	357	118	107					-52
15-May to 15-Sep		-55	-36	-61					-152
15-Sep to 15-Oct		-23	-32	5					-50
15-Oct to 15-Nov		-14	-50	-13					-77
15-Nov to 15-Dec		-260		188	-60				-132
15-Dec to 1-Mar						-115	-6	-13	-134
TOTAL USED (AUM)	-634	5	0	226	-60	-157	-12	-15	-647

Adjustments in:	Base run with BLM spring grazing	Without BLM Spring Grazing	Change
Average number of AUY	775	721	-54
	(45)	(43)	
Average number of brood cows	590	550	-40
	(26)	(25)	
Average annual net income ($)	112,895	103,496	-9,399
	(78,370)	(72,413)	
Average annual net income ($/AUY)	146	144	-2.13
removed during the spring period)			-14.82
Objective function value ($ 000's)	1,471.0	1,383.6	-87.4
during the spring period)			-137.86
Raised meadow hay sold (tons)	0	0	0
Average amount borrowed annually ($)	22	18	-4
Probability of negative returns over fixed costs (%)	22%	23%	

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

Appendix Table A-9. Optimal adjustments to elimination of fall grazing on BLM land, Idaho Ranch Model.

Season	BLM	State	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Purchased alfalfa hay	Total
Adjustments in seasonal forage use									
Base run with BLM fall grazing (AUMs)									
1-Mar to 15-Apr						430		110	540
15-Apr to 15-May	331	18	13						362
15-May to 15-Sep	1,356	17	109						1482
15-Sep to 15-Oct	331	108	56						495
15-Oct to 15-Nov	80	1	6	391					478
15-Nov to 15-Dec			2	357					359
15-Dec 1-Mar						629		279	908
TOTAL USED (AUM)	2,098	144	186	748		1,059		389	4,624
No BLM fall grazing (Change in AUMs)									
1-Mar to 15-Apr						-10		-3	-13
15-Apr to 15-May		-8							-8
15-May to 15-Sep			-36						-36
15-Sep to 15-Oct		-19	7						-12
15-Oct to 15-Nov	-80	28	33	8					-11
15-Nov to 15-Dec			-1	-8					-9
15-Dec to 1-Mar						-15		-7	-22
TOTAL USED (AUM)	-80	1	3	0	0	-25	0	-10	-111

Adjustments in:	Base run with BLM fall grazing	Without BLM fall grazing	Change
Average number of AUY	385	375	-10
	(11)	(12)	
Average number of brood cows	260	254	-6
	(11)	(11)	
Average annual net income ($)	75,938	74,935	-1,003
	(46,977)	(45,815)	
Average annual net income ($/AUY)	197	200	2.59
during the fall period)			-12.54
Objective function value ($ 000's)	1,048.2	1,037.5	-10.7
during the fall period)			-133.33
Raised meadow hay sold (tons)	50	60	10
Average amount borrowed annually ($)	0	0	0
Probability of negative returns over fixed costs (%)	17%	17%	

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

Appendix Table A-10. Optimal adjustments to elimination of fall grazing on BLM land, Nevada Ranch Model.

Season	BLM	State	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Purchased alfalfa hay	Total
Adjustments in seasonal forage use									
Base run with BLM fall grazing (AUMs)									
8-Apr to 8-May	626		9						635
8-May to 8-Jun	647		9						656
8-Jun to 1-Sep	1,775		25						1,800
1-Sep to 1-Oct	626		9						635
1-Oct to 23-Nov			31	1,595					1,626
23-Nov to 15-Dec				405				63	468
15-Dec 8-Apr						2,097		329	2,426
TOTAL USED (AUM)	3,674		83	2,000	-	2,097		392	8,246
No BLM fall grazing (Change in AUMs)									
8-Apr to 8-May			-9						-9
8-May to 8-Jun			-9						-9
8-Jun to 1-Sep			-25						-25
1-Sep to 1-Oct	-626		106		437				-83
1-Oct to 23-Nov			-31	-154					-185
23-Nov to 15-Dec				-64		14		-9	-59
15-Dec to 8-Apr						-261		-45	-306
TOTAL USED (AUM)	-626	0	32	-218	437	-247	0	-54	-676

Adjustments in:	Base run with BLM fall grazing	Without BLM fall grazing	Change
Average number of AUY	683	597	-86
	(20)	(20)	
Average number of brood cows	464	406	-58
	(20)	(20)	
Average annual net income ($)	108,975	89,504	-19,471
	(66,119)	(59,475)	
Average annual net income ($/AUY)	160	150	-9.63
fall period)			-31.10
Objective function value ($ 000's)	1,525.1	1,282.4	-242.7
during the fall period)			-387.68
Raised meadow hay sold (tons)	333	305	-28
Average amount borrowed annually ($)	0	2	2
Probability of negative returns over fixed costs (%)	14%	18%	

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

Appendix Table A-11. Optimal adjustments to elimination of fall grazing on BLM land, Oregon Ranch Model.

Season	BLM	Forest service	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Raised alfalfa hay	Total
Adjustments in seasonal forage use									
Base run with BLM fall grazing (AUMs)									
1-Mar to 1-Apr	521		19					66	606
1-Apr to 1-May	586				-				586
1-May to 1-Sep	378	2,058			10				2,446
1-Sep to 1-Oct	85	502	-						587
1-Oct to 1-Nov	830		32	5	-				867
1-Nov to 1-Dec			22	656	5				683
1-Dec to 1-Mar						1,043	312	468	1,823
TOTAL USED (AUM)	2,400	2,560	73	661	15	1,043	312	534	7,598
No BLM fall grazing (Change in AUMs)									
1-Mar to 1-Apr	15		-19					-6	-10
1-Apr to 1-May	-28								-28
1-May to 1-Sep	41				-10				31
1-Sep to 1-Oct	-28								-28
1-Oct to 1-Nov	-830		18	123	645				-45
1-Nov to 1-Dec			40	-610	529				-41
1-Dec to 1-Mar						-768	711	-41	-98
TOTAL USED (AUM)	-830	0	39	-487	1164	-768	711	-47	-217

Adjustments in:	Base run with BLM fall grazing	Without BLM fall grazing	Change
Average number of AUY	629	598	-31
	(19)	(34)	
Average number of brood cows	479	456	-23
	(9)	(20)	
Average annual net income ($)	122,270	96,611	-25,659
	(64,898)	(68,281)	
Average annual net income ($/AUY)	194	162	-32.83
fall period)			-30.91
Objective function value ($ 000's)	1,661.6	1,337.9	-323.7
during the fall period)			-390.05
Raised meadow hay sold (tons)	0	0	0
Average amount borrowed annually ($)	0	0	0
Probability of negative returns over fixed costs (%)	7%	17%	

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

Appendix Table A-12. Optimal adjustments to elimination of fall grazing on BLM land, Wyoming Ranch Model.

Season	BLM	Deeded	State	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 fall grazing (AUMs)									
1-Mar to 15-Apr						658	36	28	722
15-Apr to 15-May	634	21	59	31					745
15-May to 15-Sep	1,883	129	100	100					2,212
15-Sep to 15-Oct	614	34	73						721
15-Oct to 15-Nov	634	153	306	21					1,114
15-Nov to 15-Dec		731		241	910				1,882
15-Dec to 1-Mar						1,702	35	171	1,908
TOTAL USED (AUM)	3,765	1,068	538	393	910	2,360	71	199	9,304
No BLM fall grazing (Change in AUMs)									
1-Mar to 15-Apr						-41	-6	-2	-49
15-Apr to 15-May		-5	-30	-16					-51
15-May to 15-Sep		-64	-27	-62					-153
15-Sep to 15-Oct		2	-52	1					-49
15-Oct to 15-Nov	-634	400	109	48					-77
15-Nov to 15-Dec		-327		256	-60				-131
15-Dec to 1-Mar						-115	-5	-13	-133
TOTAL USED (AUM)	-634	6	0	227	-60	-156	-11	-15	-643

Adjustments in:	Base run with BLM fall grazing	Without BLM fall grazing	Change
Average number of AUY	775	722	-53
	(45)	(43)	
Average number of brood cows	590	550	-40
	(26)	(25)	
Average annual net income ($)	112,895	103,499	-9,396
	(78,370)	(72,420)	
Average annual net income ($/AUY)	146	143	-2.32
during the fall period)			-14.82
Objective function value ($ 000's)	1,471.0	1,383.6	-87.4
during the fall period)			-137.88
Raised meadow hay sold (tons)	0	0	0
Average amount borrowed annually ($)	22	18	-4
Probability of negative returns over fixed costs (%)	22%	23%	

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

Appendix Table A-13. Optimal adjustments to elimination of spring and fall grazing on BLM land, Idaho Ranch Model.

Season	BLM	State	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Purchased alfalfa hay	Total
Adjustments in seasonal forage use									
Base run with BLM spring and fall grazing (AUMs)									
1-Mar to 15-Apr	-	-	-	-	-	430		110	540
15-Apr to 15-May	331	18	13	-		-	-	-	362
15-May to 15-Sep	1,356	17	109	-		-	-	-	1,482
15-Sep to 15-Oct	331	108	56	-		-	-	-	495
15-Oct to 15-Nov	80	1	6	391	-	-	-	-	478
15-Nov to 15-Dec	-		2	357	-	-	-	-	359
15-Dec 1-Mar	-	-	-	-	-	629		279	908
TOTAL USED (AUM)	2,098	144	186	748	-	1,059	-	389	4,624
No BLM spring or fall grazing (Change in AUMs)									
1-Mar to 15-Apr						-59		-11	-70
15-Apr to 15-May	-331	71	192		2	18			-48
15-May to 15-Sep		-17	-109						-126
15-Sep to 15-Oct		-54	-24		13				-65
15-Oct to 15-Nov	-80		-6	44					-42
15-Nov to 15-Dec			-2	-50					-52
15-Dec to 1-Mar						-86		-34	-120
TOTAL USED (AUM)	-411	0	51	-6	15	-127	0	-45	-523

Adjustments in:	Base run with BLM spring and fall grazing	Without BLM spring and fall grazing	Change
Average number of AUY	385	334	-51
	(11)	(14)	
Average number of brood cows	260	224	-36
	(11)	(9)	
Average annual net income ($)	75,938	68,888	-7,050
	(46,977)	(39,407)	
Average annual net income ($/AUY)	197	206	9.01
spring and fall period)			-17.15
Objective function value ($ 000's)	1,048.2	967.3	-81.0
during the spring and fall period)			-196.96
Raised meadow hay sold (tons)	50	96	46
Average amount borrowed annually ($)	0	0	0
Probability of negative returns over fixed costs (%)	17%	17%	

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

Appendix Table A-14. Optimal adjustments to elimination of spring and fall grazing on BLM land, Nevada Ranch Model.

Season	BLM	State	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Purchased alfalfa hay	Total
Adjustments in seasonal forage use									
Base run with BLM spring and fall grazing (AUMs)									
8-Apr to 8-May	626	-	9	-	-				635
8-May to 8-Jun	647		9	-		-	-	-	656
8-Jun to 1-Sep	1,775		25	-		-	-	-	1,800
1-Sep to 1-Oct	626		9	-		-	-	-	635
1-Oct to 23-Nov		-	31	1,595	-	-	-	-	1,626
23-Nov to 15-Dec	-	-	-	405	-	-	-	63	468
15-Dec 8-Apr	-	-	-	-	-	2,097		329	2,426
TOTAL USED (AUM)	3,674	-	83	2,000	-	2,097	-	392	8,246
No BLM spring or fall grazing (Change in AUMs)									
8-Apr to 8-May	-626		10		434	19			-163
8-May to 8-Jun			-9						-9
8-Jun to 1-Sep			-25						-25
1-Sep to 1-Oct	-626		87		376				-163
1-Oct to 23-Nov			-31	-304					-335
23-Nov to 15-Dec				-101				-17	-118
15-Dec to 8-Apr						-521		-87	-608
TOTAL USED (AUM)	-1252	0	32	-405	810	-502	0	-104	-1421

Adjustments in:	Base run with BLM spring and fall grazing	Without BLM fall and spring grazing	Change
Average number of AUY	683	511	-172
	(20)	(39)	
Average number of brood cows	464	348	-116
	(20)	(29)	
Average annual net income ($)	108,975	71,063	-37,912
	(66,119)	(48,651)	
Average annual net income ($/AUY)	160	139	-20.49
fall and spring period)			-30.28
Objective function value ($ 000's)	1,525.1	1,042.5	-482.6
during the fall and spring period)			-385.46
Raised meadow hay sold (tons)	333	298	-35
Average amount borrowed annually ($)	0	1,296	1,296
Probability of negative returns over fixed costs (%)	14%	24%	

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

Appendix Table A-15. Optimal adjustments to elimination of spring and fall grazing on BLM land, Oregon Ranch Model.

Season			BLM	Forest Service	Deeded	Meadow hayland grazed/ hayed	Meadow grazed	Raised meadow hay	Purchased meadow hay	Raised alfalfa hay	Total
Adjustments in seasonal forage use											
Base run with BLM spring and fall grazing (AUMs)											
1-Mar	to	1-Apr	521		19					66	606
1-Apr	to	1-May	586				-				586
1-May	to	1-Sep	378	2,058			10				2,446
1-Sep	to	1-Oct	85	502	-						587
1-Oct	to	1-Nov	830		32	5	-				867
1-Nov	to	1-Dec			22	656	5				683
1-Dec	to	1-Mar						1,043	312	468	1,823
TOTAL USED (AUM)			2,400	2,560	73	661	15	1,043	312	534	7,598
No BLM spring or fall grazing (Change in AUMs)											
1-Mar	to	1-Apr	-521		94			46	260	-17	-139
1-Apr	to	1-May	-61								-61
1-May	to	1-Sep	133				-10				124
1-Sep	to	1-Oct	-73		-0						-73
1-Oct	to	1-Nov	-830		-32	175	487				-201
1-Nov	to	1-Dec			-22	-542	402				-162
1-Dec	to	1-Mar						-629	325	-122	-426
TOTAL USED (AUM)			-1352	0	40	-367	879	-583	585	-139	-938

Adjustments in:	Base fun with BLM spring and fall grazing	Without BLM spring or fall grazing	Change
Average number of AUY	629	484	-145
	(19)	(87)	
Average number of brood cows	479	370	-109
	(9)	(66)	
Average annual net income ($)	122,270	67,209	-55,061
	(64,898)	(48,655)	
Average annual net income ($/AUY)	194	139	-55.53
fall and spring period)			-40.76
Objective function value ($ 000's)	1,661.6	968.4	-693.2
during the fall and spring period)			-513.12
Raised meadow hay sold (tons)	0	5	5
Average amount borrowed annually ($)	0	208	208
Probability of negative returns over fixed costs (%)	7%	20%	

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

Appendix Table A-16. Optimal adjustments to elimination of spring and fall grazing on BLM land, Wyoming Ranch Model.

Season	BLM	Deeded	State	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 spring and fall grazing (AUMs)									
1-Mar to 15-Apr						658	36	28 \\	
15-Apr to 15-May	634	21	59	31					745
15-May to 15-Sep	1,883	129	100	100					2,212
15-Sep to 15-Oct	614	34	73						721
15-Oct to 15-Nov	634	153	306	21					1,114
15-Nov to 15-Dec		731		241	910				1,882
15-Dec to 1-Mar						1,702	35	171	1,908
TOTAL USED (AUM)	3,765	1,068	538	393	910	2,360	71	199	8,582
No BLM spring or fall grazing (Change in AUMs)									
1-Mar to 15-Apr						-83	-6	-4	-93
15-Apr to 15-May	-634	260	105	181					-88
15-May to 15-Sep		-110	-67	-76					-253
15-Sep to 15-Oct		-22	-65	5					-82
15-Oct to 15-Nov	-634	236	28	237					-133
15-Nov to 15-Dec		-358		246	-114				-226
15-Dec to 1-Mar						-211	-5	-13	-229
TOTAL USED (AUM)	-1,268	6	1	593	-114	-294	-11	-17	-1,104

Adjustments in:	Base run with BLM spring and fall grazing	Without BLM spring or fall grazing	Change
Average number of AUY	775	683	-92
	(45)	(37)	
Average number of brood cows	590	520	-70
	(26)	(21)	
Average annual net income ($)	112,895	94,159	-18,736
	(78,370)	(67,906)	
Average annual net income ($/AUY)	146	138	-7.81
during the fall and spring period)			-14.78
Objective function value ($ 000's)	1,471.0	1,278.0	-193.0
during the fall and spring period)			-152.20
Raised meadow hay sold (tons)	0	0	0
Average amount borrowed annually ($)	22	31	9
Probability of negative returns over fixed costs (%)	22%	26%	

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