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A GENERAL PROCEDURE FOR INCORPORATING BLM AND FS GRAZING ACTIVITIES IN LINEAR PROGRAMMING MODELS

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Summary

This paper proposes use of the Multiple Grazing Activities (MGA) Approach to include federal grazing in linear programming models. The MGA method accurately represents the pricing and stocking strategies of federal agencies. The realistic representation of federal grazing activities results in a more efficient allocation of federal grazing by LP models. Furthermore, the MGA approach can be modified to account for transportation costs for moving cattle from one forage source to another. It is also possible to account for range forage growth with the MGA approach. Numerical examples are given and the results illustrate that the previously used methods utilize federal ranges ineffectively. This inefficient use results in substantially lower objective function values.

Introduction

The federal government presently controls about 87 percent of the land in Nevada. Nevada's range livestock industry has long been a major user of federal land. Public lands are an important source of forage for the industry. Linear programming (LP) has been widely used in ranch management studies. The importance of federal grazing makes it desirable to have a generally accepted procedure to account for grazing on federal land in linear programming models.

A difficulty that has been encountered when federal grazing activities are included in LP models is accounting for the actual number of AUM's[1] supplied to the ranch. The BLM requires that a full grazing fee be paid [4]:

> "...for each paying animal unit, which is defined as each animal six (6) months of age or over at the time of entering public lands, for all weaned animals regardless of age, and such animals as will become twelve (12) months of age during the authorized period of use..."

Each class of cattle, other than suckling calves, is charged a full fee to graze on federal land.

Table 1 shows the livestock classes a typical spring cow-calf operation might have on BLM land during the summer. Each of these livestock classes would be assessed a full fee under Department of Interior regulations. In this Table the animal unit coversion factor (AUCF)[2] of each livestock class is also shown.

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[1] An AUM (Animal Unit Month) is the amount of forage required to maintain a cow or its equivalent for one month.

[2] AUCF is a numerical figure which allows conversion of one class of animal to another. An AUCF is synonymous with AUM. Also, the authors are aware of the controversy over what the proper AUCF is for Nevada and that AUCF's may vary from region to region. Valentine's AUCF's are used in this study.

Table 1. AUCF and the Grazing Fee that would be Paid to Graze Each Livestock Class on BLM Land for One Month

LIVESTOCK	AUCF	GRAZING FEE (1980)
Mature cow, maintenance or gestation	1	$2.36
Mature cow, with calf 0 to 3 months old	1.25	$2.36
Mature cow, with calf 4 to weaning	1.4	$2.36
Yearling 13 to 17 months	.65	$2.36
Yearling 18 to 24 months	.8	$2.36
Bull	1.25	$2.36
Horse	1.25	$2.36

Source: Valentine (1965)

Forage consumption of different livestock classes vary, while the grazing fee for federal land usage is the same for each livestock class. This disparity between livestock forage consumption and federal lands pricing and stocking strategies causes a difficulty in accounting for the number of AUM's obtained from federal sources in linear programming models. As an example, if 10 young yearlings are raised on BLM land for a month they will consume 6.5 AUM's and be charged for 10 AUM's. Raising 10 bulls on BLM land will result in 12.5 AUM's being consumed while being charged for only 10 AUM's. The problem is that techniques that have been used to incorporate federal grazing in linear programming models have not been able to specify properly the number of AUM's obtained from the payment of grazing fees.

This problem has been recognized by many authors and a variety of methods have been developed to account for it in LP models. The BLM uses a weighted average (WA) BLM grazing and consumption figure for a "unit cow" [3]. A unit cow is a brood cow and all the complementary livestock. An example of a unit cow is 1.0 brood cow, 0.16 replacements, 0.05 bulls and 0.0125 horses.

These are the weights that are used with the AUCF of each livestock class to determine the estimated forage consumption of the 'unit cow".

The estimated forage consumption of the "unit cow" is then divided by the sum of the weights to determine the number of AUM's obtained from paying a grazing fee (one BLM grazing activity). These calculations, consumption of the "unit cow" and the number of AUM's obtained from BLM grazing activities are then incorporated into the forage transfers of the model.

However, there are a number of problems associated with this method. First, it is cumbersome since new weighted averages must be calculated if the livestock ratios change. For instance, a change in calving percentages would require that a new average be obtained because the ratio of cows with calves to cows without calves would change. Secondly, it requires that livestock classes graze land in a fixed proportion. For example, when a brood cow is on deeded range, there must also be 0.16 replacements, 0.05 bulls and 0.0125 horses on deeded range. This does not allow the model to determine the most profitable grazing system for each livestock class. Thirdly, this technique is not suitable methodology for all studies. More specifically, this procedure cannot be used in studies where the objective is to determine the most profitable livestock class ratios. For example, it could not be used to determine whether cow-yearling operations are more profitable than cow-calf operations, since the solution to the problem would involve determining profit maximizing livestock class ratios.

Torell et al. (1981) used an adjusted grazing fee (AGF) approach. The consumption levels of certain livestock classes increase during the BLM grazing season. During these seasons of increased forage consumption, the grazing fees remain constant. This results in a decrease in the average cost of forage obtained from the BLM. The AGF method accounts for this by reducing the cost of grazing on BLM land in each successive season. The discounted grazing fee is calculated by determining a weighted average livestock consumption figure for each season that BLM land is available. This is used to determine the percentage increase in forage consumption from season to season. The grazing fee is then discounted by the percentage increase in forage consumption.

This method properly reflects the seasonal variation in the amount of forage consumed by livestock on BLM land. The adjusted grazing fee compensates for the increase in grazing activity levels that are needed to supply the increased forage consumption. The grazing activity levels increase because the model is constructed so that seasonal BLM activities supply one AUM. As forage consumption increases so must the BLM grazing activity level.

There are two major problems associated with this procedure. The first is that the adjusted grazing fees will not be accurate if LP activities for raising each livestock class are included in the model. In this case the model has the flexibility to determine forage use by livestock class. This will result in livestock classes grazing BLM land in a different ratio than that used to determine the adjustment. If livestock are raised in a "unit cow" activity then the model lacks flexibility as in the WA method.

The other problem is that this approach does not resolve the disparity between the amount of forage actually consumed by livestock and the grazing fees paid. This disparity remains because each BLM grazing activity is constructed to supply 1 AUM, while the actual AUM consumption level of each livestock class is used in the model. This results in fraction BLM grazing activity levels being used to supply actual consumption. In actuality the AUM consumption of each livestock class is supplied by the payment of one grazing fee.

The objective of this paper is to develop a precise and flexible methodology for including federal grazing in LP models concerned with the range cattle industry. The new methodology will be incorporated into an LP model to demonstrate that this specification of federal grazing will have a notable impact on the objective function value. This will be accomplished by comparing the solution of this model with two other LP models which use current methods of incorporating federal grazing.

Multiple Grazing Activities Approach

The most distinctive feature of the proposed method is that several BLM grazing activities are included in each season that BLM grazing is available. Each seasonal BLM grazing activity supplies a different amount of forage. This makes it possible for the forage requirements of each livestock class to be obtained from a single BLM grazing activity.

The first concern when incorporating the new method in LP models is to include the proper BLM grazing activities. Since the number of AUM's obtained from BLM land depends on the livestock classes that are grazing, a distinction between BLM grazing activities must be made. This is accomplished by including separate BLM and/or FS grazing activities for livestock classes with different forage requirements for each season that BLM grazing is available. The grazing and feeding activities are separated by season to allow the model the flexibility to determine forage use by season and livestock class. These grazing activities are included in the partial matrix of Table 2.

The construction of the forage transfers allows the seasonal forage consumption of each livestock class to be supplied from the appropriate BLM grazing activity. The appropriate BLM grazing activity is the one that supplies the amount of forage that will be consumed by that livestock class. The positive input-output matrix coefficients of these transfers are the seasonal AUM consumption of each livestock class. The negative coefficients of these inequalities are the number of AUM's supplied by the grazing activities. Each inequality states that the number of AUM's supplied by the grazing activities is greater than or equal to the season AUM consumption of each livestock class.[3]

The second concern is to include a constraint that will limit the total number of BLM grazing activities that can enter the solution. The limit that can be obtained is the grazing preference, which is determined by the BLM. The grazing preference is defined as the total number of AUM's that the rancher can obtain from the allotment. In actuality, the grazing preference is the product of the number of livestock[4] and the length of time in months that livestock can be on BLM land. As such, the grazing preference does not directly limit the number of AUM's that can be used. For instance, a rancher with a grazing preference of 3300 could obtain 4125 AUM's if 3300 livestock that consumed 1.25 AUM's were on the range. Placing livestock that consumed .65 AUM's would limit the number of AUM's obtained from the

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[3]In this case BLM and deeded range are the only forage sources available during the spring and summer seasons. Additional sources can be incorporated into the model using the same procedure.

[4]Except in the case of a cow with calf which counts as 1.

Table 2 Partial LP Matrix of NGA-LP Model For Incorporating BLM Grazing

		UNIT	Raise Cow With Calf	Raise Cow W/O Calf	Raise Yearling	Raise Replacement	Raise Bull	Graze BLM 1-.65	Graze BLM 2-.65	Graze BLM 3-.65	Graze BLM 3-.8	Graze BLM 1-1	Graze BLM 2-1	Graze BLM 3-1	Graze BLM 1-1.25	Graze BLM 2-1.25	Graze BLM 3-1.25	Graze BLM 2-1.3	Graze BLM 3-1.4	Total Deeded Land	Graze Deeded Land 1-.65	Graze Deeded Land 2-.65	Graze Deeded Land 3-.65	Graze Deeded Land 3-.8	Graze Deeded Land 1-1	Graze Deeded Land 2-1	Graze Deeded Land 3-1	Graze Deeded Land 1-1.25	Graze Deeded Land 2-1.25	Graze Deeded Land 3-1.25	Graze Deeded Land 2-1.3	Graze Deeded Land 3-1.4		RHS
Objective Function		AUM	-82.78	-82.78[a]				-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36	-2.36															
	1- .65[b]	AUM			.65			-.65													-.65												≤	0
	2- .65	AUM			.975				-.65													-.65											≤	0
Forage	3- .65	AUM			.975					-.65													-.65										≤	0
Transfer	3- .8	AUM				.8					.8													-.8									≤	0
	1- 1	AUM		1								-1													-1								≤	0
	2- 1	AUM		1.5									-1													-1							≤	0
	3- 1	AUM		2.5										-1													-1						≤	0
	1- 1.25	AUM	1.25				1.25								-1.25													-1.25					≤	0
	2- 1.25	AUM					1.875									-1.25													-1.25				≤	0
	3- 1.25	AUM					3.125										-1.25													-1.25			≤	0
	2- 1.3	AUM	1.95															-1.3													-1.3		≤	0
	3- 1.4	AUM	3.5																-1.4													-1.4	≤	0
Total Deeded Rangeland		ACRE																		1													≤	17632
Native Grass Transfer		AUM																		-.0625	.65	.65	.65	.8	1	1	1	1.25	1.25	1.25	1.3	1.4	≤	0
BLM AUM Preference		AUM						1	1	1	1	1	1	1	1	1	1	1	1														≤	3300
Bull Graze Constraint (1)		HEAD							1				1			-18		1															≤	0
Bull Graze Constraint (2)		HEAD																				1				1			-18		1		≤	0

[a]The cost of raising a cow without calf would probably be lower than raising a cow with calf, but it was assumed equal.

[b]The first number refers to the season and the second number refers to the numbers of AUM's supplied by the grazing activities. Season 1 refers to a period between April 1st and April 30, Season 2 refers to a period between May 1st and June 14, and Season 3 refers to a period between June 15 and August 31.

preference to 2145. Consequently, the number of AUM's obtained from the grazing preference will vary depending on the livestock class that is grazing the range.

The grazing preference constraint is shown in the partial LP matrix of Table 2. The BLM grazing preference constraint serves as a BLM grazing activity counter. Each head of livestock that uses BLM land, regardless of its AUM consumption, counts as one BLM grazing activity. This is the same counting procedure used by the BLM.

The final concern is to include constraints that will ensure that bulls are raised with brood cows and yearling replacements during the breeding season. These constraints are included in Table 2. The first constraint states that the BLM grazing activities must be used in the same proportion as the sum of the raise breeding stock activities to the raise bull activity, during the breeding season. In this model, one bull must be raised for every 18 brood cows and yearling replacements raised. During the breeding season, for every 18 brood cows or yearling replacements grazing on BLM land, there must also be one bull grazing on BLM land. This constraint is necessary because the model will choose to raise bulls on BLM land before it would raise brood cows without calves and yearling replacements. The situation would develop where some of the brood stock is being raised separately from the bulls during the breeding season. A second constraint is included to ensure that the necessary livestock ratio is also maintained on deeded range during the breeding season.

Comparisons

Linear programming models were constructed using the three procedures discussed in this paper. These models relied on the spring cow-calf option in the study "Economic Impacts of BLM Grazing Allotment Reductions on Humboldt county, Nevada" [1] for the input-output, objective function and resource levels. The only difference among these models is the modification necessary to incorporate the three methods that account for BLM grazing. Resulting objective function values, allocation of the grazing preference, AUM's obtained and number of brood cows raised in each model are shown in Table 3.

Table 3. Summary of LP Models Utilizing a Grazing Preference of 3300.

	Objective Function Value	Allocation of the Grazing Preference by Season[5]				AUM's Actually Consumed	Brood Cows Raised
		Season 1	Season 2	Season 3	Total		
AGF Method	$66,364.40	481	1038	1781	3300	3300	597
WA Method	$72,125.62	643	968	1689	3300	3901	635
MGA Method	$74,970.01	550	1082	1668	3300	4212	680

The objective of each model is maximization of net returns to variable cost. The net return obtained from using the MGA method is greater than that of the other two models. The difference between the MGA model and the AGF model is $8,605.61. This large difference occurs because the AGF method underestimates the amount of forage obtained from BLM land. This is evident since the BLM grazing activity level is the same as the other two models, while the number of AUM's consumed is lower. This results in the smallest herd size of the three models. The adjusted grazing fees are not able to fully compensate for the underestimation of BLM forage.

The difference in net returns between the MGA model and the WA model is $2,844.39. The objective function value of the MGA model is higher because this method places less restrictions on the use of grazing resources. The MGA method has the flexibility to allow seasonal forage use by livestock class.

[5]The seasons are the same as in Table 2.

This enables the MGA model to sequentially select livestock classes with higher forage consumption levels to graze on BLM land.[6] Thus, the model avoids the higher cost per AUM associated with livestock classes with lower forage consumption levels.

The flexibility of each method can more readily be observed by analyzing the adjustments made in each model due to a grazing preference reduction. The results of a 50 percent grazing preference reduction are summarized in Table 4.

Table 4. Summary of LP Models Utilizing a Grazing Preference of 1650

	Objective Function Value	Allocation of the Grazing Preference by Season				AUM's Consumed	Brood Cows Raised
		Season 1	Season 2	Season 3	Total		
AGF Method	$47,460.46		615	1035	1650	1650	397
WA Method	$51,764.87		635	1015	1650	1972	452
MGA Method	$55,099.56		644	1006	1650	2209	493

The objective function value of the AGF and WA methods have been reduced 28.5 and 28.2 percent, respectively. The objective function value of the MGA method has been reduced 26.5 percent due to the grazing preference reduction. The smaller percentage decrease of the objective function is due to the greater flexibility incorporated in the MGA method.

The more flexibility built into the model the more efficiently BLM grazing can be allocated. In this case efficiency is defined as AUM's obtained per grazing activity. Table 5 shows the efficiency of each method for the original and reduced grazing preference situations.

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[6] This occurs if the model is not specifically constrained to reflect some management practice.

Table 5. The Efficiency (AUM's Obtained per Grazing Activity) for Each Method with the Original and Reduced Grazing Preference

	Original Grazing Preference of 3300	Reduced Grazing Preference of 1650
AGF Method	1	1
WA Method	1.18	1.20
MGA Method	1.28	1.34

The AGF method has no flexibility with regard to the number of AUM's that can be obtained from a grazing activity. The AGF method allows only 1 AUM to be obtained from a grazing activity. The WA method characteristically recognizes that more than 1 AUM can be obtained from BLM grazing activities. This results in an efficiency of 1.18 for the original grazing preference. The only flexibility in the WA method is seasonal, which results in a slightly higher efficiency for the reduced grazing preference. The MGA method has flexibility regarding forage use by season and livestock class. The scarcity of the grazing resource causes the MGA method to allocate BLM grazing to livestock classes with higher forage consumption levels. This results in higher efficiencies for both the original and reduced grazing preference.

Conclusion

Linear programming has commonly been used to determine the economic allocation of resources in range cattle studies. Federal grazing is usually an important resource to consider in these studies. The BLM and FS pricing and stocking strategies make it difficult to incorporate federal grazing in linear programming models. This difficulty has generated a number of different methods for including federal grazing activities. The currently used methods do not adequately represent the pricing and stocking strategies of federal agencies. Also, the inflexibility of these methods restricts efficient utilization of federal grazing.

The realistic representation of federal policies by the MGA method results in more efficient utilization of federal ranges. This efficiency is reflected in higher objective function values.

In addition, the MGA approach provides a suitable approach for including transportation cost from one forage source to another. It is also possible to account for forage growth with this procedure.

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