Opportunity Costs of Wild Horses: An Allotment Case Study in Wyoming

Chris T. Bastian
Larry W. VanTassell
Ann C. Cotton
Michael A. Smith

Presented at Western Agricultural Economics Association 1997 Annual Meeting
July 13-16, 1997
Reno/Sparks, Nevada

Opportunity Costs Of Wild Horses: An Allotment Case Study In Wyoming

Chris T. Bastian, Larry W. VanTassell, Ann C. Cotton and Michael A. Smith

Authors are extension specialist, professor, and graduate assistant, Agricultural Economics Department and professor, Rangeland Ecology and Watershed Management Department, respectively, University of Wyoming, Laramie, Wyoming, 82071.

Opportunity Costs Of Wild Horses: An Allotment Case Study In Wyoming

This study estimates opportunity costs of foregone wildlife and domestic livestock due to wild horses using a Bureau of Land Management allotment in Wyoming. Results indicate the marginal opportunity costs associated with horse numbers beyond the median target level specified in the allotment management plan are well over $1,900/ horse.

Introduction

Concern over the humane treatment and diminishing numbers of wild horses and burros led to the Wild Free-Roaming Horse and Burro Act of 1971 (Cook 1975, Fisher 1983). The original act authorizes the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS) to remove feral horses in excess of the ecological balance from public rangelands in eleven western states (Fisher 1983).

Since the passage of the Public Range Improvement Act in 1978, research has largely focused on the biological and behavioral aspects of wild horses. Much research indicates similarities in habitat selection and diet composition between feral horses, big game species and domestic livestock (Krysl et al. 1984, Denniston et al. 1982, Smith et al. 1982, Rittenhouse et al. 1982, Miller 1983, Salter and Hudson 1980, Olsen and Hansen 1977). This research, however, does not provide any information concerning benefits or costs associated with wild horses. Public land managers are aware of the expense of the current program, but little applied economic research concerning wild horses has been undertaken to aid in allocating the public range in a multiple use context.

Hyde (1978) suggests the wild horse issue be expressed in an economic framework to determine the efficient allocation of public resources used by wild horses in competition with domestic livestock and wild game. The general framework would compare wild horse management costs with wild horse benefits. Qualitatively, Hyde (1978) describes these benefits and costs as follows: benefits include 1) value of recreational viewing of the horses, 2) vicarious values such as existence value and 3) value of wild horses to their foster homes; costs include 1) opportunity value for domestic livestock and wildlife foregone, 2) separable cost of managing wild horses, 3) cost of public scrutiny of foster homes, and 4) cost of negative externalities created by horses. Hyde (1978) goes on to state that a demonstrative case study could help guide land managers.

The focus of this study addresses the issue of opportunity costs associated with foregone wildlife and domestic livestock due to wild horses as proposed by Hyde (1978). The economic analysis takes a case study approach and is based on a BLM allotment complex in Wyoming.

Study Area

The case study area is based on the Whiskey Peak allotment complex (36,479 ha) administered by the BLM. Elevations on the complex range from 1,976 meters to 2,812 meters. The majority (80%) of the Whiskey Peak Allotment Complex contains sagebrush-mixed grass vegetation type (BLM 1990). The remaining vegetative types comprise about 20% of the area, and include riparian zones, aspen woodland, conifer woodland and mountain shrubland.

Allotment Management Plan

The Whiskey Peak Complex Allotment Management Plan (AMP) describes vegetation, soils, issues, management objectives, management actions, monitoring plan and evaluation of plan (BLM 1990). This case analysis uses the AMP management goals concerning horses to illustrate tradeoffs that might occur at different horse population levels. To better understand the horse population levels studied in the analysis, it is important to note that the Whiskey Peak Allotment lays within the Green Mountain Wild Horse Herd Area. The Whiskey Peak AMP states that approximately 75% of the horses in the Green Mountain Wild Horse Herd Area reside in the Whiskey Peak complex. This provides a targeted minimum of 128, median of 184 and a maximum of 225 horses in the Whiskey Peak Allotment. In 1992, over 500 horses occupied this Wild Horse Herd Management Area (WHHMA), and consequently, the BLM conducted a round-up to remove horses in excess of specified management levels (Crane 1994). If we view the 1992 population of 500 horses as a recent historical maximum for the Green Mountain Herd

Management Area, a resulting historical maximum of 375 (75% of Green Mountain total) can be inferred for the Whiskey Peak Allotment. Thus, population levels of 128, 184, 225 and 375 provide target levels which can be used to depict possible tradeoffs at different numbers of wild horses.

The primary recreational use on the allotment is elk, mule deer and antelope hunting (BLM, 1990). Antelope numbers using the Whiskey Peak complex range between 700 and 900 head from two different herd units, and the target objective is to provide around 9,415 antelope months. Mule deer numbers using the complex range between 300 and 830 on a seasonal basis with a target objective of providing 7,331 deer months of forage. The Whiskey Peak Complex is targeted to provide forage for 300 elk in the allotment year round according to the AMP. Given these objectives in the AMP, it was assumed for the analysis that desirable levels of wildlife on the complex were as follows: antelope- a minimum of 700 and a maximum of 900; mule deer- a minimum of 300 and a maximum of 830; and elk- a steady population of at least 300.

The target objective for cattle grazing is 8,427 animal unit months (AUMs) according to the AMP. Cattle numbers on the allotment complex have also varied, with a minimum of 4,000 AUMs being used. It was assumed in the analysis that the maximum and minimum AUMs of cattle grazing for the allotment were 8,427 and 4,000, respectively.

Another major allotment management goal used in this analysis was the specified objective of maintaining utilization of key species by all grazing animals at 50% or less. The forage goal of take half-leave half coupled with the above mentioned minimums and maximums for wildlife and cattle provided limits on constraints in the model used to estimate the tradeoffs between wild horses, elk, deer, antelope and cattle.

Economic Analysis

The general framework for the economic analysis is as follows. First, a linear programming model was used to estimate different levels of wildlife and cattle production for five different population scenarios of wild horses, including a scenario of no horses. Diet composition data was used to develop grazing activity constraints in the LP model. The right hand side constraints were based on the assumption of 50% forage utilization and minimum and maximum target levels of wildlife as described previously. The LP model was solved subject to an objective function that maximized the number of animals at various levels of wild horses. This objective function is consistent with BLM objectives. The total number of animals for each species estimated in the five scenarios provided the basis for estimating opportunity costs. Economic values for the different wildlife species and cattle were used to calculate the opportunity cost of foregone wildlife and cattle production at different levels of wild horses as compared to estimated production with no wild horses. This was consistent with procedures used by Bastian et al. (1991).

$$\text{Max } Z = \sum_{j=1}^{n} C_j \, XSUBj$$

The general LP model used to estimate animal numbers is as follows:

$$\sum_{i=1}^{m} \sum_{j=1}^{n} aSUBij \, X_j \; \_,=,\_ \; b_i \text{, given } X_j \,\_\, 0$$

subject to:

where:

Z = the number of animals

C_j = the change in Z for a unit change in X_j, in this case C_j=1

X_j = the unknown number of animal j to be estimated (wild horses, cattle, elk, mule deer and antelope)

b_i = the amount of the i^{th} resource available (the right hand limits for animals e.g. 300 elk, and forage class by season, e.g. spring grass)

a_{ij} = the amount of resource i required per unit of activity X_j (i.e., amount of forage by class and season for each species).

Production of forage is based on the productivity and target requirements as outlined in the AMP given a take half -leave half rule, standing crop estimates from Crane (1994) and Soil Conservation Service Technical Guide to range sites relevant for the area. Table 1 specifies percent composition of diet for each animal species by season. Grasses and forbs were combined in terms of intake and right hand side constraints (b_i). This is consistent with recommendations by Sundstrom et al. (1973) which suggests forbs may substitute for grasses and is consistent with Bastian et al. (1991). The percentages of each forage class by season (Table 1) were multiplied by intake requirements for each animal to estimate grazing activity by forage class and season for each species. Dry matter intake for wild horses, elk, mule deer, and antelope were based on estimates in Holecheck (1988). Diets of animals are assumed to remain constant in the analysis. The objective function maximized the number of cattle, elk, deer and antelope for each specified level of wild horses given the forage constraints.

Table 1. Percent composition of diet by forage class and season for each species.

	Wild Horses[a]	Cattle[b]	Elk[a]	Mule Deer[a]	Antelope[c]
Forage Category			% Diet		
Spring grass*	99	98	24	30	7
Spring shrubs	1	2	76	70	93
Summer grass	98	98	28	12	6
Summer shrubs	2	2	72	88	94
Fall grass	87	84	22	11	16
Fall shrubs	13	16	78	89	84
Winter grass	76	86	15	10	14
Winter shrubs	24	14	85	90	86

[a] Based on Crane (1994).
[b] Based on percentages used and reported in Bastian et al. (1991).
[c] Based on Medcraft and Clark (1986).
* Percentages are based on combined percentage of grasses and forbs.

Cattle grazing activities for the analysis was based on stocker steers. Steers were assumed to graze three months in the summer and one month in the fall at an average daily gain of 0.68 kg, with beginning and ending weights of 270 kg and 352 kg. Forage consumption was calculated by multiplying percent of diet by each plant class and by kg of dry matter required by the steers each month based on Ensminger and Olentine (1978).

Economic values for wildlife representative of the region were needed. Given hunting is the primary recreational use of the allotment, value estimates from hunters were reviewed as published in Sorg and Loomis (1984). Hansen (1977) was the only study reported that estimated values for deer, antelope and elk hunting in the Intermountain region. Hansen (1977) utilized CVM to derive values for antelope, deer and elk based on a mail survey sent to a sample taken from respondents to the 1975 U.S. Fish and Wildlife Service Hunting and Fishing Survey. The following user day values, as adjusted by Sorg and Loomis (1984) to 1982 dollars, were used, deer hunting: \$33.03 per hunter day, elk hunting: \$36.37 per hunter day, and antelope hunting: \$18.81 per hunter day. Each of these values were multiplied by average number of days per hunt for each species in Wyoming during 1994 (deer: 8.6 days, elk: 13.5 days, antelope: 2.2 days, Wyoming Game and Fish Department (1995)), and an estimated permit factor. The permit factor is licenses sold divided by population of the species. The consumer surplus for the hunt is only realized if the hunter draws a permit. Thus, a particular herd size will not provide as many permits as there are animals. The resulting consumer surplus is likely a conservative estimate of wildlife value as it doesn't take into account any non-consumptive values. The resulting economic values used in the analysis were \$60.50 per deer, \$285.76 per elk and \$18.83 per antelope.

The value of the benefits from cattle grazing was based on value of weight gain minus costs of gain for the four month period assumed in the analysis. The value of gain was equal to the ending weight (352 kg) multiplied by average market price for that weight class during October for 1985-1994 (Kearl 1990, Bastian 1995) minus beginning weight (270 kg) multiplied by average market price for the same time period during June all deflated to 1982 dollars using the GNP Implicit Price Deflator. Total costs of grazing were equal to costs of production associated with federal grazing in Wyoming plus an opportunity cost associated with the investment in cattle. Costs of federal grazing as reported by Torell et al. (1995) for Wyoming BLM permittees in 1992 were $13.76/AUM. Production costs used for this analysis were equal to $28.98 per steer ($13.76/AUM (adjusted to 1982 $) * .75 AUM coefficient * 4 months). The net value of grazing per steer was estimated to be $12.75 per head for this analysis.

Results

Five different scenarios of animal production were estimated. The first scenario estimated was the zero horse scenario. This baseline scenario, reported in Table 2, estimated the number of cattle, elk, deer and antelope that could be produced on the allotment if there were no horses, given the 50% forage utilization assumption and having wildlife constrained at greater than or equal to the minimum numbers specified earlier (minimums- elk = 300, deer = 300 and Antelope = 700). The number of wildlife all came in at or near the maximum target levels specified in the AMP except for antelope, indicating the LP model does reasonably well in estimating wildlife capacity. Antelope came in well above the maximum target level (900 head) at 1200 head. This is due to the high content of shrubs in their diet and allowing them to use up to 50% of the production. The number of steers estimated were 2,809 head which is at the maximum of 8,427 AUMs. This scenario provides the base for all the opportunity cost estimates.

The second scenario estimated was the minimum horse scenario (i.e., horses were forced into the solution at the minimum target level of 128). At a level of 128 horses, the constraints for wildlife were again set at greater than or equal to the minimum levels and steers were set at greater than or equal to zero. These constraints were used to represent target goals for wildlife in the AMP, realizing that BLM managers would have a greater opportunity to change grazing permits than wildlife levels. Results in Table 2 indicate that the minimum horse scenario (i.e., 128 horses) requires a reduction in steers of 449 head, a reduction in deer of 90 head and a reduction in antelope of 1 head given elk are held at the minimum level of 300 head. Table 3 provides an estimated opportunity cost of $11,189.

Table 2. Number of animals* estimated for different levels of wild horses.

Animal Species	-----------------------------Number of head---------------------------				
Wild Horses	0	128	184	196	241
Steers	2,809	2,360	2,173	2,162	2,159
Elk	300	300	300	300	0
Mule deer	830	740	586	300	0
Antelope	1,200	1,199	1,199	856	133

* Constrained by assumption of limiting forage consumption to 50% of current annual growth.

The third scenario estimated is the median horse scenario. Horses were forced into the solution at the median population target level of 184 head. Wildlife constraints were placed at less than or equal to the maximum target levels for deer and elk, and 1199 head for antelope. At this number of horses, steers were reduced 636 head compared to the solution with no horses, deer were reduced 244 head and antelope stayed at 1199 head. Solutions for both the minimum and median wild horse scenarios had estimates that came reasonably close to meeting the target levels of animal months specified in the AMP for cattle and wildlife. The opportunity cost in this scenario is $22,890.

An infeasible solution was obtained for the upper population levels of 225 and 375 horses given the forage utilization was constrained at 50% in the model. This suggests the upper levels of wild horses may place pressure on the range resource to the extent that the goal of 50% utilization of key species may not be met at higher levels of wild horses. Thus, the next scenario estimated was the maximum horse scenario given minimum wildlife and 50% forage utilization. This scenario was estimated given wildlife were constrained at greater than or equal to the minimum levels (elk - 300, deer - 300, antelope - 700), and cattle were constrained at greater than or equal to zero. This scenario then estimates the potential maximum horse population on the allotment given the goals of maintaining minimum target levels of wildlife and utilizing 50% of the forage. The horse constraint was increased from 184 head until adding one more horse created an infeasible solution. Only 196 horses were allowed into the solution given the minimum wildlife constraints (Table 2). At this level of horses, elk were 300 head, deer were 300 head and antelope were in between the minimum and maximum target levels at 856 head. Steers numbered 2,162 head in this scenario, and the estimated opportunity cost was $46,792 (Table 3).

The next scenario estimated the maximum number of potential horses on the allotment given a 50% forage utilization, and wildlife populations that were allowed to fall below minimum target levels. All wildlife constraints were relaxed to greater than or equal to zero. Again, horses were added until one more horse created an infeasible solution. The maximum level of horses allowed into the solution was 241 head. Thus, this scenario estimated the opportunity cost of foregone production of other animals if managers managed for maximum horses given a 50% utilization of the forage base. The maximum wild horse population in this scenario was below the upper bound of 375 horses. Elk and deer were reduced to 0, and antelope were reduced to 133 head when the horse level was at 241 head. The opportunity cost in this scenario was $164,323 (Table 3).

Table 3. Opportunity cost estimated for different levels of wild horses.

Wild Horse Level	0	128	184	196	241
Animal Species			$		
Steers	$0	$5,725	$8,109	$8,249	$8,288
Elk	0	0	0	0	85,728
Mule deer	0	5,445	14,762	32,065	50,215
Antelope	0	19	19	6,478	20,092
Total Cost	$0	$11,189	$22,890	$46,792	$164,323

The biological tradeoffs in Table 2 are realistic at the lower levels of horses. The upper level of horses, 196 and 241, represent required tradeoffs to meet the 50% forage utilization goal. Competitive pressures associated with the upper levels of horses could force some animals to forage elsewhere, but it is impossible for this model to predict how many would stay on the allotment. Animals may also have changes in diet composition and habitat selection given higher numbers of horses. The literature suggests high levels of horses can cause reductions in stocking rates for cattle, smaller wildlife numbers and decrease range condition, and the model supports these conclusions given the imposed constraints.

It is important to remember solutions at those higher levels estimate required tradeoffs to meet the 50% utilization goal for the range. Actual wildlife and steer numbers would most likely be higher than estimated, but it is likely the range resource would be in danger of deterioration.

Discussion and Conclusions

This analysis illustrated biological tradeoffs and opportunity costs of foregone wildlife and cattle production associated with the current wild horse program. Given the case study area, and the assumptions used, results indicate costs associated with foregone wildlife and cattle production are much lower at the minimum and median target population levels outlined in the allotment management plan. Marginal opportunity costs associated with horse numbers beyond those levels are well over $1,900 per horse.

The BLM is faced with managing these public rangelands given legislative mandates requiring maintained existence of wild horses, multiple use and sustained yield of the forage resource. Results of this analysis suggest viable wild horse populations could be maintained and much lower opportunity costs of foregone wildlife and cattle production would be realized if the BLM were able to remove wild horses in a more timely fashion. The BLM, however, has been constrained in conducting timely roundups to reduce population levels of wild horses under the current adopt-a-horse program (Huffaker et al. 1990). The results and conclusions of this analysis are consistent with the institutional framework faced by BLM managers concerning public range allocation. Estimates of opportunity costs at the higher levels of wild horses should be viewed cautiously since they are based on the hypothetical case of what tradeoffs would have to occur to achieve 50% forage utilization. Realistically wildlife numbers would most likely be higher than those estimated since wildlife would not tend to change forage consumption patterns or habitat selection unless grazing conditions deteriorated significantly. It is impossible to say that lower levels of horses would represent a more economically efficient allocation of the range. Only when all the costs and benefits of wild horses as presented by Hyde (1987) are estimated can the issue of economic efficiency concerning wild horses and public resource allocation be addressed.

Literature Cited

Bastian, C.T. 1995. Average prices of cattle and calves: eastern Wyoming and western Nebraska, 1990-1994. Bull. AE95-2. Dep. Agricultural Economics. Univ. of Wyoming. Laramie, Wyoming.

Bastian, C.T., J.J. Jacobs, L.J. Held and M.A. Smith. 1991. Multiple use of public rangeland: antelope and stocker cattle in Wyoming. J. Range Manage. 44:390-394.

Bureau of Land Management. 1990. Draft outline for Whiskey Peak complex allotment management plan. USDI, BLM Rock Springs District, Wyoming.

Cook, C.W. 1975. Wild horses & burros: a new management problem. Rangeman's J. 2:19-21.

Crane, K. K. 1994. Habitat selection patterns of feral horses in southcentral Wyoming. M.S. Thesis. University of Wyoming. Laramie.

Denniston, R.H., M. Boyce, W.D. McCort, J. Timmerman, B. Holz and L. Wollrab. 1982. Feral horse study: habitat preference and use. University of Wyoming Dep. of Zool. and Physio. Report to USDI-BLM Contract AA85-CTO-31.

Ensminger, M.E., and C.G. Olentine, Jr. 1978. Feeds and nutrition- abridged. Ensminger Publ. Co., Clovis, California.

Fisher, C. 1983. The wild horse dilemma: background, prospective, and action. Rangelands. 5:164-166.

Hansen, C. 1977. A report on the value of wildlife. USDA Forest Serv., Intermountain Region. Ogden, Utah.

Holecheck, J.L. 1988. An approach for setting the stocking rate. Rangelands. 10:10-14.

Huffaker, R.G., J.E. Wilen and B.D. Gardner. 1990. A bioeconomic livestock/wild horse trade-off mechanism for conserving public rangeland vegetation. Western J. Agr. Econ. 15:73-82.

Hyde, W.F. 1978. Wild horses and allocation of public resources. Rangeman's J. 5:75-77.

Kearl, W.G. 1990. Average prices of cattle and calves: eastern Wyoming and western Nebraska, 1985-1989. Bull. AE90-2. Dep. Agricultural Economics. Univ. of

Wyoming. Laramie, Wyoming.

Krysl, L.J., M.E. Hubbert, B.F. Sowell, G.E. Plumb, T.K. Jewett, M.A. Smith, and J.W. Waggoner. 1984. Horses and cattle grazing in the Wyoming Red Desert I, food habits, and dietary overlap. J. Range Manage. 37:72-76.

Miller, R. 1983. Habitat use of feral horses and cattle in Wyoming's Red Desert. J. Range Manage. 36:195-199.

Medcraft, J.R., and W.R. Clark. 1986. Big game habitat use and diets on a surface mine in Northeastern Wyoming. J. Wildl. Manage. 50:135-142.

Olsen, F.W., and R.M. Hansen. 1977. Food relations of wild free-roaming horses to livestock and big game, Red Desert, Wyoming. J. Range Manage. 30:17-20.

Rittenhouse, L.R., D.E. Johnson, and M.M. Borman. 1982. A study of food consumption rates and nutrition of horses and cattle. Final report of the BLM. U.S. Dep. of the Interior. Washington, D.C.

Salter, R.E., and R.J. Hudson. 1980. Range relations of feral horses with wild ungulates and cattle in western Alberta. J. Range Manage. 33:266-271.

Smith, M.A., B.F. Sowell, L.J. Krysl, G.E. Plumb, M.E. Hubbert, J.W. Waggoner and T.K. Jewett. 1982. Vegetation utilization, diets, and estimated dietary quality of horses and cattle grazing in the Red Desert of westcentral Wyoming. Univ. of Wyoming Dep. of Range Manage. Bureau of Land Management contract No. AA851-CTO-31. U.S. Dep. of Interior. Washington, D.C.

Sorg, C.F., and J.P. Loomis. 1984. Empirical estimates of amenity forest values: a comparative review. Gen. Tech. Rep. RM-107, USDA, Forest Serv., Rocky Mountain Forest and Range Exp. Sta., Ft. Collins, CO.

Sundstrom, C., W.G. Hepworth and K.L. Diem. 1973. Abundance, distribution and food habits of the pronghorn (a partial characterization of the optimum pronghorn habitat). Bull. 12 Wyoming Game and Fish Commission, Cheyenne.

Torell, L.A., L.W. VanTassell, N.R. Rimbey, E.T. Bartlett, T. Bagwell, P. Burgener and J. Coen. 1995. The value of public land forage and the implications for grazing fee policy. Agr. Exp. Sta. Bull. 767. New Mexico State University.

Wyoming Game and Fish Department. 1995. Annual report. Cheyenne, WY.