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Solving the Cheatgrass Problem in the Range and Basin Region

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1. Introduction

Ranchers, rural communities, and those interested in agricultural production and the incidence of wildfires and other threats in the Basin and Range Region have little analysis to support issues with the Bureau of Land Management (BLM) or other federal and state agencies that fashion regulations and policies. These citizens and groups simply lack significant input into such regulations and policies. The result is that the many constituents that have a stake in the policies and regulations of federal and state lands are left-out of important decisions about grazing, wildfires, wildlife habit and other major decisions about management of resources that affect their livelihoods.

This report is will provide those constituents without systematic information about these rangeland issues mentioned above with information that can give them a substantive role as stakeholders. Examples of the issues that could benefit from the valuable input of citizens and communities that are left out of policy and regulatory decisions include, differences between grazing of perennials and invasive species, wildfire management and control, grazing after wildfires, active ranching versus allocations to wilderness, and other timely regulatory and policy matters.

One of the cardinal features of public policy and regulatory decisions is full inclusion of stakeholders. Where the federal and state governments control large areas of public lands there is reason to provide stakeholders analysis so they can have an informed voice in decisions.

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This report provides steps that can provide a stronger basis for input of citizens, groups and private and public agencies into the decisions on range management. We wish to stress that the analysis is preliminary, and much of it depends on previously available but uncollated scientific reports. For example, the costs, returns and net revenue budgets from the land grant universities, cattle numbers that can make the budgets provide estimates for whole counties, community economic models, and cheatgrass coverage estimates that are not complete. As well, the scoring analysis and climate models that are not complete.

The focus of this analysis is two-fold: cattle number decreases in the Range and Basin Region in recent years and what is the current concern about cheatgrass grazing and potential for fall term use by cattle? Of course, other regulatory issues that deserve input by the broad set of stakeholders like spaying and management of cheatgrass that is not the subject of our current focus. Still, in this analysis we will concentrate on only two questions, although the background prepared for this analysis can be used for a number of related rang land concerns.

2. Objectives

It is high time that all of the participants in decisions about the range and the landscape in the Basin and Range Region have a an opportunity to provide input into the decisions that are now handed down from the federal agencies and in fact, selected state agencies as well. The specific objectives of this research for the range and basin Region are:

-- to generation of complete costs, returns and net revenue information (budgets) for all counties,

--to obtain cattle numbers (beef cows) can be included with the costs, returns and net revenue estimates for counties,

--to investigate the Forest Service on animal unit months (AUMs) for consistency with cattle numbers,

--to estimate economic impacts of grazing for communities and states

--to estimate wildfires, and

-- to apply scoring analysis for making decisions about cattle grazing in the Basin and Range Region.

We emphasize that these sets of calculations will be necessary for most other and landscape investigations of conditions in the Range ad Basin Region.

3. Budgets for Cattle Grazing, in the Basin and Range Region

Two sets of budgets were prepared that include all counties in the Basin and Range Region (with California and Colorado omitted). These budgets were for 2016; and for the years 2014, 2015 and 2016. The corresponding cattle numbers were averaged for each of the years in the three-year period as well reflecting the cattle numbers in the 2014 - 2016 years. In the Basin and Range Region, there were 169 counties required for inclusion in the budgets or costs, returns and net returns. Some of the budgets are for specific counties and some collections of counties. Again, we used the budgets prepared by land grant institutions in each state to define the specific counties or collections of counties for application of the estimates. We used the three-year averages as per agreement from our Budget Committee indicating that 2016 was an off year for cattle production and sales due to both low prices and low cattle numbers

The counties within the Basin and Rage Region for each state are in Appendix B (in graphic and listed form). Note that there are Tables and/or Figures for each state; Washington, Idaho, Montana, Wyoming, Utah, Oregon, Nevada, New Mexico and Arizona. California and Colorado have some counties in the Basin and Range Region but did not have available budgets. Colorado had only a stocker budget and California did not have available budgets for counties or portions of counties in the Basin and Range Region. Thus, in this analysis we omitted these states and counties from the calculations of variable costs, returns and net returns. The counties in the omitted states could be included, if budgets were available or we could use the budgets from bordering states for this calculation.

A major problem in developing the budgets was the fact that the land grants in the Region had not kept up with the changing times. Because most of the budgets were not for 2014, 2015, and 2016, they needed updating to reflect the years for analysis. The process that we used for updating involved several sets of available numbers, including State Agricultural Statistics, the UDSA National Agricultural Statistics and Prices Paid by Ranchers (state data), and Bureau of Labor price indices. We in fact, used a combination of these data series to update the budgets. For the prices of cattle we used the USDA reported Commodity returns from Cow-Calf Operations in the Basin and Range Region, and for hay and other cost requirements--we used the Prices Paid from each state and other price indices that were available from the Bureau of Labor Statistics.

The budgets for 2014–2016 are in Appendix C and the budgets for 2016 alone are in Appendix D. Note that the numbers at the top of the budget pages provide information on the year (or years) when the budgets were actually prepared by the state land grant institutions. Again, some these budgets are for at least 10 years older than for the years of the analysis. Also, note again that the updated budgets were prepared only for variable costs and returns. We decided to leave the long term "fixed" costs out of the budget analysis because they do not reflect the short-term annual decisions made by ranchers for production.

Reviewing the budgets across states, we found that the basic technologies were more or less the same for cow-calf or cattle production. The primary differences in bred cow costs and returns were due to efficiencies gained from scale of operation, growth conditions for forage and climate, and the proportion of feed supplied when grazing occurred on public lands. Revenues per bred cows and calves for 2014-2016 range between $540 and $1,253 across the region and variable costs ranged from $147 to $1,106. The variable cost estimates that stick out are for the counties and collections of counties in the states of Arizona on the low side and Oregon on the high side. The lowest overall revenues were for Arizona, with the highest in the Washington area, but Idaho and Montana also yielded higher than average revenues per cow.

4. NASS Cattle Numbers

The USDA National Agricultural Statistics Service (NASS) "beef cow" inventories are available for each county within the Basin and Range Region. These numbers or "estimates" however require some qualification. The actual numbers are available for each county during the Census years and were extrapolated for non-Census years, except for counties with large beef cow numbers were directly available from NASS (but not on an interpolated basis). With this qualification, the numbers were used and available for all of the counties in the Range and Basis Region. For the three-year budgets presented, the beef cow numbers for counties had to be averaged. These county averages are presented in Appendix E. Again, we felt that the numbers or estimates for a three-year period would be better for use than 2016 numbers alone in the development of beef cow costs and returns for the Basin and Range Region.

The beef cow numbers however require added explanations. Beef cows for the year and lead to cow calf production. These calf numbers are adjusted for by NASS, and the NASS numbers account for replacements and or culling of beef cows. See the NASS explanation for the reference (need reference).

The beef cows are grazed on range land mostly after calving, and the calves are sold at 400+ pounds live weight. This is the major source of revenue for the beef cow growers, even when culling of cows is included. These beef cow numbers are the ones for use for evaluating costs, returns and net returns for the cattle operations in counties.

With the three- year average beef cow inventory numbers and the three-year averages for the budgets, we can compute total variable costs, returns and net returns for each county and state in the Basin and Range Region. The results for the budgeted counties or regions are provided in Appendix F. The state estimates for sets of counties (or single counties) in the Basin and Range Region are summarized in Table 1.

First, the total net variable returns (variable returns less variable costs) for the Basin and Range Region for the average period 2014-2016 were 1,202,220,000 or about 1.20 billion dollars. This totals distributed by state for BLM lands (which are often only a part of the stats) are shown in Table 1. Montana had the highest beef cow inventories (767,245) followed by Utah and Oregon at approximately 329,117 and 329,667, respectively. In county or collections of counties, numbers the largest beef cow numbers were in Elk County, Nevada, Klamath/lake Counties Oregon and Southwest New Mexico, all in the neighbor of 72,000 plus. Smaller numbers of beef cows on range land were mostly in the Nevada counties. More refined numbers are available in the county estimates in Appendix Table F and on the regional levels on Table 1.

Table 1. Total Revenues, Variable Costs, and Returns

		Thousand dollars		
	Beef Cow Inventory	Total Revenue	Total Costs	Returns
Arizona				
Plateau Region	35,106	$21,987	$9,828	$12,158
SW Desert Region	40,710	$21,998	$5,983	$16,014
Strip Region	13,498	$8,302	$6,654	$1,648
Western Desert Region	50,542	$27,436	$10,671	$16,765
Arizona Basin & Range	139,856	$79,722	$33,136	$46,586
Idaho				
Northern Idaho	42,294	$49,414	$29,848	$19,566
Magic Valley	94,333	$97,512	$47,749	$49,762
Eastern Idaho	142,784	$166,774	$89,139	$77,634
Idaho Basin & Range	279,411	$313,699	$166,737	$146,963
Montana				
Montana Basin & Range	767,245	$868,834	$362,476	$506,359
New Mexico				
Northwest New Mexico	37,833	$30,396	$12,930	$17,466
Central New Mexico	44,633	$35,064	$13,852	$21,212
Southwest New Mexico	79,491	$59,336	$23,268	$36,068
New Mexico Basin & Range	161,957	$124,797	$50,061	$74,736
Nevada				
Douglas County	5,653	$5,168	$3,376	$1,792
Elko County	72,214	$67,710	$37,187	$30,523
Eureka County	11,907	$11,945	$6,892	$5,053
Humboldt Couunty	36,597	$35,901	$22,763	$13,137
Lyon County	11,453	$10,695	$7,224	$3,471
Pershing County	11,887	$11,621	$6,841	$4,780
White Pine County	15,561	$17,382	$10,768	$6,614
Other Nevada Basin & Rang	57,763	$56,068	$33,221	$22,847
Nevada Basin & Range	223,035	$216,488	$128,272	$88,216
Oregon				
Klamath/Lake Counties	73,833	$79,915	$69,810	$10,105
North Central Plateau	48,652	$44,319	$30,889	$13,431
High Desert Area	197,532	$174,004	$156,164	$17,840
Oregon Basin & Range	320,017	$298,238	$256,862	$41,376
Utah				
Box Elder County	33,500	$32,409	$18,950	$13,458
Duchesne County	25,000	$26,371	$10,966	$15,405
Tooele County	13,767	$13,711	$4,996	$8,715
Rich County	29,500	$28,622	$11,781	$16,841
Utah Other Basin & Range C	227,900	$226,805	$104,566	$122,239
Utah Basin & Range	329,667	$327,917	$151,259	$176,658
Washington				
Washington Basin & Range	49,579	$62,113	$24,611	$37,502
Wyoming				
Wyoming Basin & Range	49,579	$299,424	$215,599	$83,824
Total Basin & Range	2,320,346	$2,591,233	$1,389,012	$1,202,220

Clearly, the numbers of beef cows available for grazing on the public lands could be increased, if cheatgrass and other invasives were included in the basic calculations for authorized grazing numbers approved for the respective counties. Cheatgrass grazing is not a part of the calculations for BLM lands for the Basin and Range Region. If authorized by the BLM, the numbers of beef cows grazed could increase by roughly the amount of available land estimated to reflect cheatgrass cover. The increase in beef cow numbers and the grazing of cheatgrass, in association with appropriate post-grazing vegetation restoration prescriptions could lead to reductions in wildfire incidence in the Basin and Range Region. How much of the cheatgrass that is potentially available will be estimated in the application of the wildfire model in the section below. This is a real question for the "BLM and management"— ishow much could the wildfire incidence be reduced, if additional beef cow numbers were authorized and cheatgrass grazing allowed. Again, this calculation has important implications for the Basin and Range Region as indicated in Equations 1. The improvement in habit is also important for sage grouse restoration, for example.

5. BLM Cow Calf AUMs and Beef Cow Comparisons

The AUM numbers in this analysis were from three sources: 1. the BLM data is from the Rangeland Administration System (RAS) for all states in the Basin and Range Region (Appendix G), 2. the Forest Service AUM and grazed cattle data is from the U.S. Forest Service, *Grazing Statistical Summary* for all states in the Region (Appendix H), and 3. the total Federal AUMs are aggregated from the data in these two reports (Appendix I) . This section will take each of these appendices in order and attempt to explain their implications for this study. As a first observation, we note that the explanations in Appendix G and H are in animal unit months (AUMs) and not identical in definition to the beef cow numbers from NASS. Thus, the first approach is to attempt to reconcile these AUMs with beef cow numbers. It is very confusing to have several agencies reporting numbers that cannot be completely reconciled with other data sources. This issue needs careful attention when using and interpreting this information. With this qualification we will begin to provide an explanation of the AUMs reported by the BLM and Forest Service.

BLM Reports on AUMs in the Selected States (Appendix G)

In Appendix G we find several measures of AUMs and beef cattle numbers. For the BLM numbers we have plotted in the charts "Active", "Authorized" and "Active Less Suspended" AUMs for the historical record for the included states. Active AUMs are those that could be authorized for use on public lands. Authorized AUMs are our best information about the available AUMs for grazing consumption as they are those AUMs that are actually allowed for public use. There is some controversy about the suspended category since it includes several reasons for reducing the active category, and does not actually reflect the AUMS that are not in use. In other words, it falls far short of measuring the difference between active and authorized AUMs. We will use the authorized category for this analysis but there is much to learn about the active less suspended category. This category needs better explanation from the BLM than is now available.

If we take the BLM authorized AUMs and compare them to beef cow numbers available for each state we get varying results. For example, for Nevada where the Forest Service and other alternative sources of grazing land have relatively little land allocated to grazing, the ratio of cattle numbers from NASS equates to about five animal units per cow on average, or about five months of grazing per cow for the state. This compares to a roughly six-month grazing season for many of the operations in the state. That is if we use about six AUMs for cattle we get beef cow numbers that are roughly consistent. On the other hand, for Arizona and Utah, where the Forest Service has a substantial presence on potential grazing lands, we get very different numbers for beef cattle numbers compared to the BLM AUMs. The reason for this is that the Forest Service controls significant tracts of land in Arizona and Utah. Thus we need to capture the Forest Service AUMs before making such comparisons.

This set of comparisons is suggestive of still another possibility for land available for grazing, private lands. Many private lands are used for haying to prepare for the winter season. But beef cows can graze these lands as well and this makes up another area for comparison which may be more important in other Basin and Range states than in Utah and Nevada. In addition, there are private pasture lands that are used specifically for grazing. We will take up this in connection with Appendix I.

Forest Service Reports on AUMs for Selected States (Appendix H)

The Forest Service AUMs are reported in Annual Reports similar to the BLM reports. For Appendix H we accessed these reports. As for the BLM numbers by state, these numbers are reported in a list and then graphed for ease of comparison to the BLM numbers. In one of the charts we have plotted the “Permitted” and “Paid” AUMs and in a second chart we have plotted beef cattle numbers from NASS against the AUMs for each state. Again, there is room for confusion. In some states there is a rather close coherence between cattle numbers and AUMs divided by months, while in others there is not a complete coherence in the two numbers. The reason may be due to private grazing in some of the included states.

The obvious change in counting of AUMs is to reduce them to comparisons to beef cattle numbers. These comparisons would be easier if, like the Forest Service, the BLM consistently reported numbers of animals grazed per state. The combination of the two agencies’ cattle numbers grazed could then be compared to NASS beef cow numbers and a clearer picture of the grazing patterns would emerge. Obviously we need additional data on the states to fully make the AUM and beef cattle numbers more consistent. This would give ranchers and others interested in agriculture a sounder basis for participating in discussions relating to grazing allocations.

Attempts at Reconciliation are in Appendix I.

6. Results of Input Output Analysis

The Input output analysis was carried-out only a selected county in Nevada and the State of Nevada. This was because the input output models were not available for other states in the Region. We calculated economic benefits in the input output models to find the value of cattle grazing for two reasons; the calculation of economic impacts of cattle grazing at State and county level. For the State, the economic benefits are much smaller than for the agricultural county, Elko. The calculation of implications of increased cattle grazing used 1982 Census estimates for Elko County. Of course, this estimate has major implications for the wildfire model and related concerns about the economics of increased cattle numbers, causes and costs of wildfire damage.

A review of the IMPLAN model

To calculate economic impacts, an input-output framework was used. Input-output analysis uses a transaction matrix to show how outputs from one industry become inputs for another. The columns of the matrix represent purchases made by each industry and the rows represent sales made by each industry. This framework facilitates tracing of supply chains between industries by calculating proportions of industry sales and purchases to every industry represented in the input-output matrix.

For example, consider a specific element (x_{ij}) of the transaction matrix, where *i* is the output (selling) industry and *j* is the input (purchasing) industry. This element in the matrix indicates the quantity of output of industry *i* sold to industry *j*; or conversely, the quantity of input purchased by industry *j* from industry *i*. From this “base” transaction matrix, a second matrix of direct requirements can be derived by dividing each element of the transaction matrix by the sum of its column:

$$a_{ij} = \frac{x_{ij}}{\sum_{i=1}^{i} x_{ij}}$$

This yields a matrix of backward linkages, direct requirements that indicate the proportion of inputs from each industry *i* needed to produce one unit of output by industry *j*. Subtracting this matrix from an identity matrix and inverting the resulting matrix $[(I - A)^{-1}]$ yields a matrix of final demand coefficients. The sum of the columns of the final demand matrix yields the output multiplier.

The analysis was conducted using the software, IMPLAN, which automates the input-output method. IMPLAN defines industries using a ”proprietary classification system” that separates industries into 536 categories and assigns each an industry code numbered, 1 through 536. In general, IMPLAN industry codes correspond to those defined by the North American Industry Classification System (NAICS) at varying levels of specificity. Beef cattle ranches fit under the IMPLAN industry code 11, "Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming", which was used to calculate the economic impact for the region.

An “analysis-by-parts” method is used to calculate impacts for Elko County individually, and Nevada as a whole. With this method, ranch level budget data is used to derive percentages of expenditures of beef cattle ranches on commodities produced by other industries and on employee compensation and proprietor income. Impacts are determined by inputting the spending percentages with an accompanying spending level, and the level of employee compensation and proprietor income. IMPLAN uses these values to calculate Direct, Indirect, Induced, and Total economic impacts.

Direct effects are the initial changes in demand in the economy caused by the activity of green jobs. Indirect effects are changes in the same and other industries caused by the changes in inter-industry purchases through the supply chain of the green sectors. Induced effects are changes in consumption caused by changes in employee compensation from both direct and indirect effects. The total contribution effect is the sum of direct, indirect, and induced effects.

Results

Nevada has seen a decline in the number of cattle over the last few decades. In 1982, there were 359,000 beef cattle in the state, whereas today and averaging over the years of 2014 to 2016; the number of cattle in Nevada has decreased 223,035. Elko County has by far the greatest portion of cattle ranches in the state and has seen a decline from 101,578 head in 1982 to 72,214 head that is and average of 2014 to 2016 numbers.

Impacts for Elko County are presented in Tables 2 and 3. Table 2 shows the current impacts of beef cattle in Nevada, given the current number of cattle in the County. Table 3 shows the hypothetical impacts of beef cattle ranch operations, if the number of cattle in the County were returned to the numbers of 1982. The difference in impacts in Tables 2 and 3 represent an increase of 29,364 cattle in the county.

Table 2: Elko County 2016 with 2014-2016 Average Number of Cattle

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	188.9	5,990,868	8,802,269	67,709,764
Indirect Effect	259.6	14,673,361	11,063,141	20,883,959
Induced Effect	55.6	2,101,932	3,789,814	6,187,388
Total Effect	504.1	22,766,161	23,655,225	94,781,110

Table 3. Elko County with 1982 Number of Cattle

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	265.7	8,426,904	12,381,490	95,242,230
Indirect Effect	365.1	20,639,910	15,561,687	29,375,890
Induced Effect	78.2	2,956,630	5,330,846	8,703,332
Total Effect	709.1	32,023,444	33,274,023	133,321,452

According to the analysis, the current lower number of cattle is associated with approximately 200 fewer jobs in Elko County; $10 million less labor income, $10 million less GDP, and $40 million lower value of output.

Impacts for the entire state of Nevada are presented in Tables 4 and 5 and are analogous to Tables 2 and 3. The direct and related effects are reported in Table 4. The differences in the impacts are presented in Tables and 5 represent an increase of 135,965 cattle in the state.

Table 4: Nevada 2016 with 2014-2016 Average Number of Cattle

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	683.4	20,919,990	28,143,504	216,488,489
Indirect Effect	2,140.7	49,867,855	113,240,047	198,604,918
Induced Effect	305.7	12,055,132	23,464,118	37,509,411
Total Effect	3,129.9	82,842,977	164,847,668	452,602,818

Table 5: Nevada 2016 with 1982 Number of Cattle

Impact Type	Employment	Labor Income	Total Value Added	Output
Direct Effect	1,100.1	33,673,085	45,300,145	348,462,652
Indirect Effect	3,445.8	80,267,937	182,272,628	319,677,015
Induced Effect	492.1	19,404,095	37,768,144	60,375,628
Total Effect	5,038.0	133,345,117	265,340,917	728,515,295

The analysis shows that the current lower number of cattle is associated with approximately 1,900 fewer jobs in Nevada, $51 million less labor income, $100 million less GDP, and numbers for comparison, $276 less value of output.

Taken together, the rest of the counties in addition to Elko would have approximately 1,700 fewer jobs, $41 million less labor income, $90 million less GDP, and $236 million lower value of output due to the smaller number of cattle between 1982 and the average of 2014 – 2016.

These results show two things: First, the difference between county and state level evaluations. Rural counties have much greater impact of cattle grazing. Secondly, the results show bias that is implied by taking only state level information for evaluating the impacts of grazing cattle.

7. The Benefits of Reduced Wildfire Return Intervals from Novel Grazing Management

The potential for the novel grazing management techniques (henceforth *novel grazing management*) s to reduce wildfire activity and suppression costs in two ecological states in the Wyoming Sagebrush Steppe ecosystem in the Great Basin. The analysis assumes that novel grazing management will reduce the size and frequency of rangeland wildfires, thereby reducing the wildfire return interval on the landscape. Given that we do not yet have empirical estimates of the impacts of novel grazing management on wildfire return intervals, this section reports from the results from a sensitivity analysis that explores what the impact of these novel grazing techniques would be if they resulted in a 10%, 25%, etc. increase in wildfire return intervals.

Materials and Methods

The analysis in this section uses the simulation presented in Taylor et al. (2013). The WSS ecosystem is generally between 4,700 and 6,500 feet and comprises roughly 37.8 million acres in the Great Basin (26% of the 145-million-acres are in Great Basin). Figure 3 depicts the geographic extent of the WSS ecosystem . The spread of exotic annual grasses such as cheatgrass (Bromus tectorum) is most prominent resource management concern relative to wildfire in the WSS ecosystem (Pellant, 1994; Miller and Tausch, 2001).

The simulation model captures rangeland ecosystem dynamics using the state-and-transition model (STM) framework from rangeland ecology (Stringham et al., 2003). Figure 4 shows the stylized STM of the WSS ecosystem used in the simulations is provided. The STM consists of three ecological states:

1. Perennial grasses and sagebrush with a small presence of invasive annual grasses characterize the "healthiest" state (WSS-1);

2. Overgrown "decadent" sagebrush with reduced perennial grasses and increased annual grasses (WSS-2); and

3. Invasive grass dominated state (WSS-3). Novel grazing management is assumed to be applied in WSS-2 and WSS-3, i.e., in the two ecological states where invasive annual grasses are present.

The wildfire suppression costs information comes from a data set of 400 wildfires occurring from 1995 through 2007 in USFS Region 4, the Intermountain Region (which includes Wyoming, Utah, Idaho, Nevada, and portions of Colorado and California). Table 6 shows the wWildfire suppression costs (see Taylor et al. 2013) for details.

Table 6. Wildfire Suppression Costs ($000 in 2010 dollars; 000's of acres)

Ecological State	NFDRS Fuel Model [a]	No. Obs	Avg. $/fire	Total expenditure	Avg. Acres/ fire	Total Acres burned	Avg. $/acre [c]
WSS-1	T and L	43	$441.9	$19,003.7	2.3	100.0	$190.1
WSS-2	B	14	$844.1	$11,817.6	1.1	15.0	$788.7
WSS-3	A	12	$1,314.8	$15,777.5	12.9	154.2	$102.3

[a] See Taylor et al. (2013) for discussion of National Fire Danger Rating System (NFDRS) fuel models.

Wildfire is expressed as a stochastic event that may or may not occur in a given year. Wildfire return intervals for each state in the WSS ecosystem are from the "Wyoming Sagebrush Steppe" LANDFIRE Rapid Assessment Vegetation Model. Wildfire return intervals are reported in Table 7. See Taylor et al. (2013) for details.

Table 7. Wildfire Frequency

	Ecological State		
	WSS-1	WSS-2	WSS-3
Wildfire-return interval (years)	107	75	9
Annual large fire probability	0.009	0.013	0.111

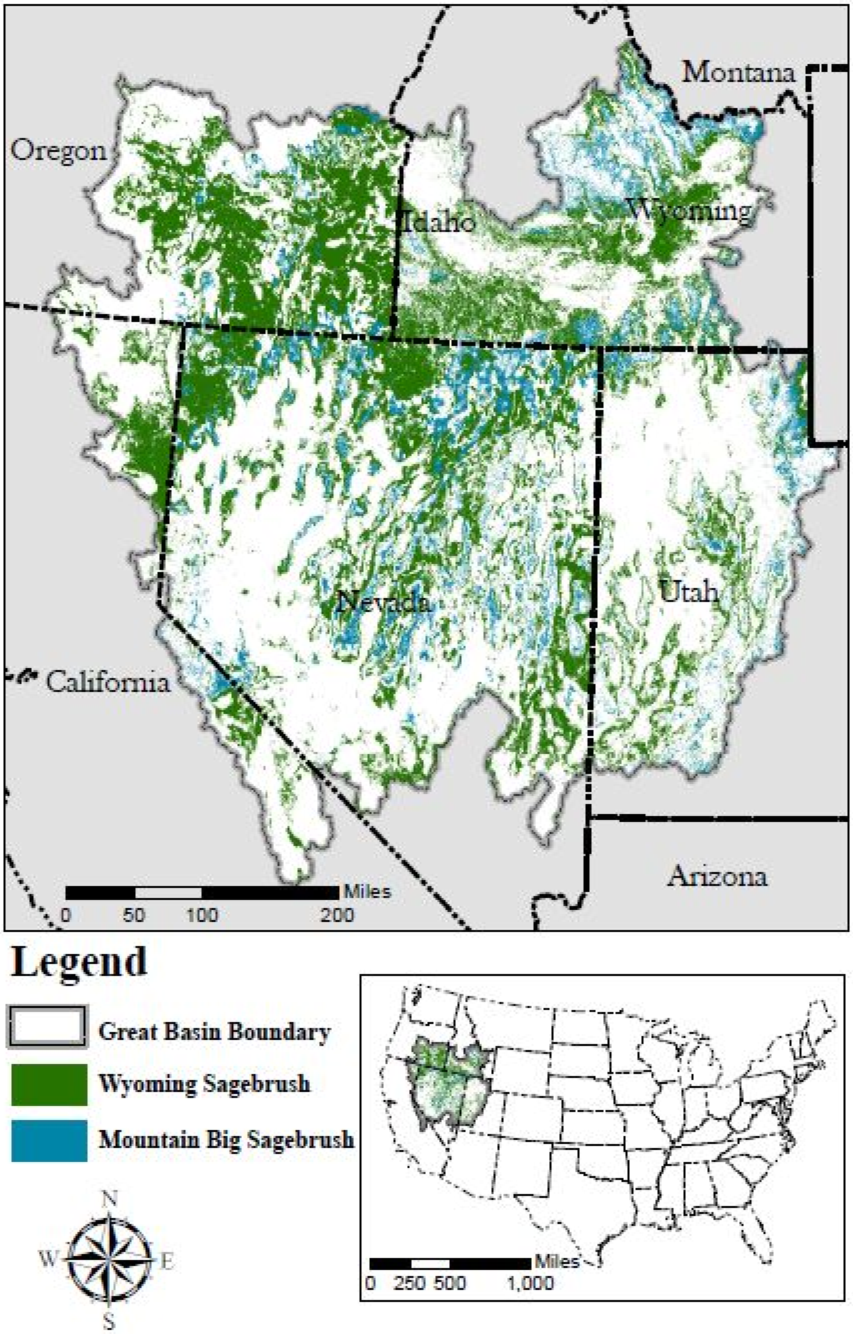

Figure 3. Geographic Distribution of Wyoming Sagebrush Steppe (WSS) Plant Communities in the Great Basin. (Reproduced from Taylor et al. (2013).)

The number of years to transition from an ecological state to another through ecological succession absent disturbance (i.e., wildfire) were taken from the "Wyoming Sagebrush Steppe" LANDFIRE Rapid Assessment Vegetation Model. The transition between ecological states after wildfire depend on the presence of annual grasses in the understory. Wildfire in WSS-1 is ecologically beneficial and restores the system to an earlier successional stage in WSS-1. Wildfire in WSS-2, however, causes the system to transition to WSS-3. See Taylor et al. (2013) for details. Transitions with and without wildfire for the WSS ecosystem are summarized in Table 8.

Table 8. Transitions between States

	Ecological State		
	WSS-1	WSS-2	WSS-3
Time to Transition w/o Wildfire	60 years □ WSS-2	NA	NA
Transition with Fire	□ Year 1 in WSS-1	□ WSS-3	Stay in WSS-3

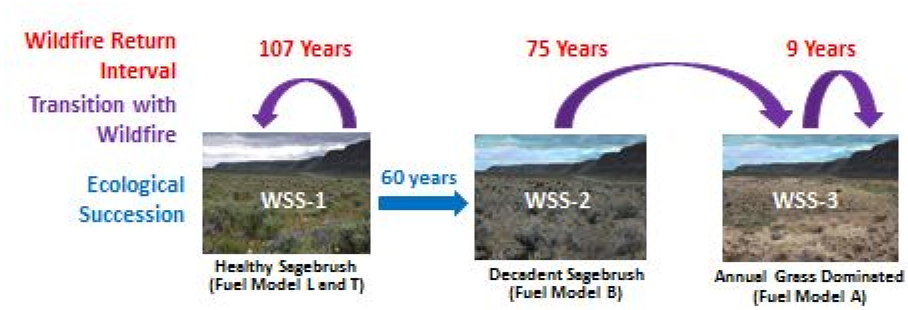

Figure 4. Wyoming Sagebrush Steppe Stylized State-and-Transition Model (Reproduced from Taylor et al. (2013).)

Results

Tables 9, 10, and 11. the reported results on the potential benefits of the novel grazing management if it is successful at increasing the wildfire return interval on the landscape, thereby making wildfires less frequent. Tables 4, 5, and 6 report results for five hypothetical increases in the wildfire return interval: 25%, 50%, 100%, 150%, and 200%. The results assume that the novel grazing treatment is applied in both WSS-2 and WSS-3.

Table 9 reports results when the initial state is WSS-2 and WSS-3. The results indicate that if novel grazing management is successful at increasing the wildfire return internals, it can result in substantial reductions in public wildfire suppression costs. For example, if novel grazing management was to double the wildfire return interval, it would lead to 1.13 fewer fires over a 50-year time horizon, on average, when the initial state is WSS-2. The expected net present value of the suppression cost saving from this reduction in wildfire activity is $112 per acre. When the initial state is WSS-3, novel grazing management is predicted to lead to 2.69 fewer wildfires and $142 in per acre suppression costs savings over 50 years. Per acre suppression costs do not increase linearly with wildfire occurrence when the initial state is changed from WSS-2 to WSS-3 because wildfires in WSS-3 (i.e., on annual grass dominated rangelands) are more likely to be allowed to burn without active suppression efforts, so that the pre-acre suppression expenditures are lower in WSS-3 compared to WSS-1 or WSS-2.

Table 9. Grazing Treatment ($ per acre; 2010 dollars)

	Fire Return Interval Increase from Treatment					
Initial State = WSS-2	**Baseline**	**25%**	**50%**	**100%**	**150%**	**200%**
Mean Number of Wildfires [a]	1.92	1.40	1.09	0.79	0.48	0.34
Reduction in Number of Wildfires	-	0.52	0.83	1.13	1.44	1.58
Mean Total Suppression Costs [b] (NPV)	$277.0	$225.4	$221.2	$165.3	$101.5	$77.0
Total Cost Savings	-	$51.6	$55.8	$111.7	$175.5	$200.0
Mean Annual Suppression Costs	$10.4	$8.6	$7.7	$6.1	$4.0	$3.0
Annual Cost Savings	-	$1.9	$2.8	$4.3	$6.4	$7.4
Final State [c] (WSS-1, WSS-2, WSS-3)	(0,527,473)	(0,594,406)	(0,634,366)	(0,688,312)	(0,777,223)	(0,822,178)
Initial State = WSS-3	**Baseline**	**25%**	**50%**	**100%**	**150%**	**200%**
Mean Number of Wildfires	5.54	4.44	3.76	2.85	2.16	1.87
Reduction in Number of Wildfires	-	1.10	1.78	2.69	3.38	3.67
Mean Total Suppression Costs (NPV)	$299.2	$242.9	$207.1	$156.7	$115.4	$104.9
Total Cost Savings	-	$56.3	$92.1	$142.4	$183.8	$194.2
Mean Annual Suppression Costs	$11.2	$9.1	$7.7	$5.8	$4.4	$4.0
Annual Cost Savings	-	$2.1	$3.4	$5.3	$6.8	$7.2

[a] The simulation model considers the progression of the WSS ecosystem over 50 years
[b] All dollar values are discounted at a constant rate of 3%.
[c] Final State' is the final state of the system (WSS-1, WSS-2, or WSS-3) after 50 years. Final state results not reported when the initial state is WSS-3 (the annual grass dominated state) because the system never exits WWS-3 in this state.

An additional benefit of novel grazing management in WSS-2 is that by reducing wildfire, the system is less likely to transition to WSS-3 as a result of wildfire. For example, when the initial state is WSS-2, the system ends up in WSS-3 after 50 years in 47% of simulation runs under our baseline assumptions. In contrast, if the grazing treatment successfully double the fire return interval, the system ends up in WSS-3 in only 37% of simulation runs.

Novel grazing management increases the costs of herd management. In economic terms, these are variable (as opposed to fixed) costs. Tables 9, 10, and 11 report results for the predicted annual per-acre suppression cost savings. These cost savings, scaled up to the size of the ranch, can be compared to the increased cost herd management over a grazing season and, as such, can be used to evaluate whether a public program subsidizing ranchers to pursue this novel grazing strategy can be justified on the basis of wildfire suppression cost savings alone. Such a program could potentially be implemented through a Farm Bill program such as Natural Resources Conservation Service's *Environmental Quality Incentives Program*. The results in Table 4 indicate that the expected annual per-acre suppression costs savings range from $1.9-$7.4 when the initial state is WWS-2 and $2.1 to $7.2 when the initial state is WSS-3 depending on the anticipated increase in wildfire return intervals in WSS-2 and WSS-3.

Table 10 reports the results when in addition to reducing wildfire frequency, novel grazing management alters plant community composition in a way that enhances ecosystem resilience and encourages post-fire recovery. Specifically, the results reported in Table 10 assumes that wildfires in WSS-2 are ecological beneficial and cause the system to transition to WSS-1. In contrast, the results reported in Table 4 assume that wildfires in WSS-2 cause the system to transition to WSS-3. Table 5 shows that if novel grazing management enhances ecological resilience it will lead to a further reduction in wildfire activity and suppression costs. For example, comparing the Table 4 and 5 results for a 100% increase in wildfire return interval, including ecological resilience leads to 1.55 fewer fires over 50 years versus 1.13 with a $141 in per acre suppression cost savings versus $112. These results indicate that the economic benefits of novel grazing management will depend critically on whether it increases the ecological resilience treated plant communities.

Table 10. Grazing Treatment: Ecological Resilience ($ per acre; 2010 dollars)

	Fire Return Interval Increase from Treatment					
Initial State = WSS-2	**Baseline**	**25%**	**50%**	**100%**	**150%**	**200%**
Mean Number of Wildfires [a]	1.92	0.54	0.45	0.37	0.27	0.22
Reduction in Number of Wildfires	-	1.38	1.48	1.55	1.65	1.70
Mean Total Suppression Costs [b] (NPV)	$277.0	$207.5	$171.1	$136.1	$98.4	$77.1
Total Cost Savings	-	$69.5	$105.9	$140.9	$178.6	$199.9
Mean Annual Suppression Costs	$10.4	$7.6	$6.4	$5.0	$3.7	$2.9
Annual Cost Savings	-	$2.8	$4.0	$5.5	$6.7	$7.5
Final State [c] (WSS-1, WSS-2, WSS-3)	(444,556,0)	(424,576,0)	(358,642,0)	(291,709,0)	(216,784,0)	(178,822,0)

[a] The simulation model considers the progression of the WSS ecosystem over 50 years
[b] All dollar values are discounted at a constant rate of 3%.
[c] Final State' is the final state of the system (WSS-1, WSS-2, or WSS-3) after 50 years.

Table 10 also indicates that the primary benefit of enhanced ecological resilience may not be from reductions in wildfire activity or suppression costs, but rather from preventing the system from moving to WSS-3, which entails permanent degraded resource values. In our simulations, when the initial state is WSS-2, allowing novel grazing management to enhance ecological resilience causes the system to be restored to WSS-1 in the majority of simulations, and prevents the system from transitioning to WSS-3. Note that Table 5 only considers when the initial state is WSS-2. The analysis assumes that, on its own, novel grazing management is not sufficient to rehabilitate the system from WSS-3.

Table 11 reports results from an alternative baseline where future fire return intervals are lower than historic averages as a result of invasive plants, changes in disturbance regimes, climate change, and other factors. These reductions in wildfire return intervals are anticipated in the WSS ecosystem and in other ecosystems throughout the Great Basin (Baker, 2009; Romme et al., 2009). Table 6 indicates that the benefits of novel grazing management are likely to increase significantly if wildfires are more frequent in the future. This result suggests that evaluating novel grazing management using current estimates of wildfire return intervals may significantly understate its potential benefits.

Table 11. Grazing Treatment: Shortened Fire Return Intervals ($ per acre; 2010 dollars)

	Fire Return Interval Increase from Treatment					
Initial State = WSS-2	**Baseline**	**25%**	**50%**	**100%**	**150%**	**200%**
Mean Number of Wildfires [a]	5.74	3.99	3.10	2.03	1.48	1.07
Reduction in Number of Wildfires	-	1.75	2.64	3.71	4.26	4.66
Mean Total Suppression Costs [b] (NPV)	$568.8	$464.4	$390.1	$281.8	$236.3	$185.1
Total Cost Savings	-	$104.4	$178.7	$287.0	$332.5	$383.8
Mean Annual Suppression Costs	$21.6	$17.5	$15.1	$10.4	$8.6	$7.1
Annual Cost Savings	-	$4.1	$6.5	$11.2	$12.9	$14.5
Final State [c] (WSS-1, WSS-2, WSS-3)	(0,255,745)	(0,353,647)	(0,398,602)	(0,534,466)	(0,580,420)	(0,647,353)
Initial State = WSS-3	**Baseline**	**25%**	**50%**	**100%**	**150%**	**200%**
Mean Number of Wildfires	11.0	8.8	7.3	5.5	4.5	3.7
Reduction in Number of Wildfires	-	2.2	3.7	5.5	6.5	7.3
Mean Total Suppression Costs (NPV)	$588.8	$475.0	$386.6	$303.1	$248.3	$201.7
Total Cost Savings	-	$113.8	$202.2	$285.8	$340.5	$387.1
Mean Annual Suppression Costs	$22.3	$17.9	$14.8	$11.4	$9.3	$7.6
Annual Cost Savings	-	$4.4	$7.5	$10.8	$13.0	$14.7

[a] The simulation model considers the progression of the WSS ecosystem over 50 years
[b] All dollar values are discounted at a constant rate of 3%.
[c] Final State' is the final state of the system (WSS-1, WSS-2, or WSS-3) after 50 years. Final state results not reported when the initial state is WSS-3 (the annual grass dominated state) because the system never exits WWS-3 in this state.

Conclusions

- If novel grazing management is successful at increasing the wildfire return internals (i.e., reducing wildfire frequency), it can result is substantial reductions in wildfire suppression costs, with the net present value of suppression cost savings over a 50-year horizon ranging from a low of around $50 per acre to over $300 per acre depending on model assumptions.
- The economic benefits of novel grazing management will depend critically on whether it increases the ecological resilience treated plant communities.
- Novel grazing management will make WSS ecosystems less likely to transition to an annual grass dominated state, thereby avoiding permanently degraded resource values.
- The benefits of novel grazing management are significantly greater if future wildfire return intervals are reduced due climate change and other factors identified in the literature. This

suggests that evaluating novel grazing management using current estimates of wildfire return intervals may significantly understate its potential benefit.

Limitations

- The results reported here provide conservative estimates of the benefits of novel grazing management. Most significantly, the analysis only considers wildfire suppression costs savings. Other potential benefits not considered in the analysis include improved forage for livestock and economic outcomes for ranchers, reductions in wildfire damages to private property and public infrastructure, and improvements in wildlife habitat, recreation opportunities, erosion control, and other ecosystem goods and services.
- The analysis does do not consider the cost of novel grazing management. As such, the analysis can only answer the more limited question of at what per acre costs will novel grazing management be justified on the basis of wildfire suppression cost savings alone. The results reported here that a public subsidy for ranchers implementing novel grazing management exceeding 10$ per acre per year could be justified. This would imply a negative grazing fee for ranchers implementing novel grazing management on public rangelands.

Impact of Extended Grazing of Cheatgrass on a Cow-calf Budget: An Example

Using grazing prescriptions that include an estimated two months of fall cheatgrass not only has environmental benefits, but also directly impacts the costs and profitability of cattle ranches. Substituting two months of grazing for two months of much more costly winter feeding of hay and grain can add a significant amount to ranchers' bottom lines. We used the Elko County 700 cow-calf operation 2014-2016 average budget to estimate such impacts. A number of simplifying assumptions were made for this exercise, and the results should be viewed as a general example. Assumptions include:

1. The original grazing season is six months and would be expanded to eight months.
2. The original winter feeding period is six months and would be reduced to four months.
3. There is adequate cheatgrass area for all cattle on the ranch during the expanded grazing season.
4. We did not adjust other variable costs such as changing protein and other supplements, transportation costs or labor costs. We realize that these might be different but would require meeting with a rancher panel to discuss.
5. Adequate nutrition was obtained during the extended grazing system and animal weights are not affected.

Figure 5 illustrates the estimated difference between the traditional grazing schedule and one that included an extended period of cheatgrass grazing. Grazing fees per cow would increase approximately $4, more than twice the $1.35 per AUM, as again, our assumption is that all cattle utilize extended grazing, and are included in per cow averages.

In addition, the extended grazing on cheatgrass would require protein supplements for proper nutrition. Assuming one pound per head per day, a total of 60 pounds per head would be required for the two months additional grazing. Again, we assume that all cattle would require the supplement, so we approximate the total used to be somewhere in the neighborhood of 60,000 pounds. Recent prices for 24% protein beef cattle supplements for pasture and forage fed cattle run around $0.33 per pound, or a total expense of around $18,000. Allocating that to a 700 cow herd gives a price per cow of around $26. Although grazing fees show a modest increase, and protein supplement costs are substantial, hay and grain costs, the largest cost category, decline by one-third, or $91 per cow. With the added protein supplement costs, and the small increase in grazing costs, the overall variable costs will be reduced by $63 per cow. With cattle prices being the same with both treatments, this translates directly into increased profits of the same magnitude. Again, it must be emphasized that this is a simplified view and shows the maximum of savings and increased net returns.

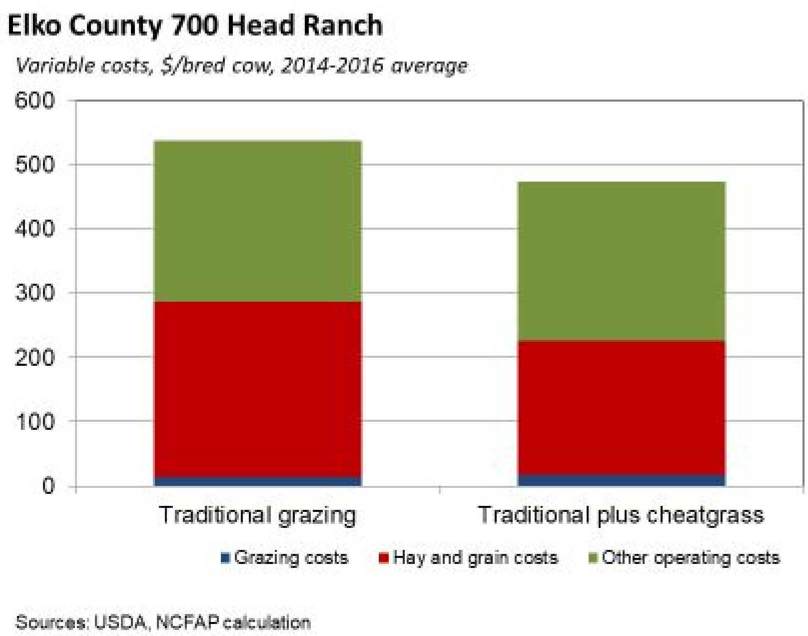

Figure 5. Comparison of Costs and Net Returns from Traditional and Extended Grazing

For the 700 cow ranch, this translates into approximately $44,000 higher net returns for the 2014-2016 average period. If adequate cheatgrass existed in the appropriate locations that all ranchers in Elko County could utilize the extended grazing period, the county-wide impacts could be as much as $4.4 million. However, we must not assume that this would be a persistent possibility. Reducing the cheatgrass load in areas that could subsequently move to improved vegetation stages would eventually eliminate much of the cheatgrass. On the other hand, there could also be an increase in native species and expanded grazing areas that could accommodate higher numbers of cattle during traditional grazing seasons. Such decisions on grazing allotments and permits would ultimately be the purview of the BLM and Forest Service.

In addition, the removal of cheatgrass has implications for fuel reduction. Cattle grazing cheatgrass will consume from 20 to 25 pounds per day for the two fall months. We select 25 pounds as the figure because the cattle are rather mature during the fall season. At the upper limit of 25 pounds times 60 days this cheatgrass consumption level equals 1,500 pounds per head for the fall season. Multiplying this number times the approximate number of cattle available for fall grazing which is approximately 70,000 in Elko County equals an estimated 1.05 million pounds of cheatgrass consumed during the fall two month season. A natural comparison would be to relate this number to the annual growth of cheatgrass in Elko County, which would give a number that would help the BLM evaluate the impact of cattle fall grazing.

Cheatgrass" thatch" left from earlier years is a good medium for the germination of cheatgrass. When the thatch is consumed by cattle in the fall, the rate of germination will decrease and there will be fewer plants that germinate the following year due to greater exposure to weather conditions. Depending on conclusive evidence of germination of cheatgrass in thatch, this factor may be a major contribution to cheatgrass control due to lower germination in the spring when the growing season for cheatgrass commences.

There are of course limitations to this fall grazing strategy—water must be available for cattle which is problematic in some cheatgrass infested areas. There must be adequate water in the proximity of the protein supplement to make both readily accessible to the herd. As well, there is the commitment of ranch hands to the change locations of cattle for full implementations of fall grazing. One of the reasons for the avocation of fall grazing is that the cattle do not stray far from the protein feeder that dispenses the nutrients that supplement the carbohydrates in the cheatgrass. Cattle will not go much more than 300 yards from the protein feeder, making it possible to graze the cattle with limited ranch hand supervision. All that is needed is to pull the feeder along as the cheatgrass is consumed.

Finally, there is some amount of grazing of perennials during the fall grazing season. If the grazing of cheatgrass is in areas that have near 100 percent infestation, there is not much grazing of perennials. However, if the cheatgrass is mixed with perennials in cheatgrass infested areas there will be some grazing of perennials. Some estimates of the grazing of perennials put the level at about 20 percent. This is not problematic for the perennials since they are in a dormant state during the fall season after a hard frost.

8. Alternative Approaches to Scoring Rules

The "scoring' literature is extensive, often provided under the title "environmental scoring". This reflects a theme from the beginning of the approach featuring an environmental dimension. Scoring can be applied to firms or organizations with profit incentives, communities (the approach we will select) and regions or nations. The best example of scoring applied to communities is from Wikipedia (Wikipedia, 2018). This lays out the approach in simple terms and it is in four areas; environmental concerns, social concerns, corporate governance concerns and responsible investment. These will be demonstrated to provide a scope that is sufficient to cover the communities in the Basin and Range Region. Again, the motivation for the communities approach is to eventually test the mechanism in several communities in the Basin and Range Region.

The procedure is discussed in several documents and relates to first going to the communities and discussing the approach with citizens groups reflecting a cross section of interests in the communities- usually 15 to 20 members. The idea is to go through the scoring system and solicit community members' input on the issues that they will be asked to score. There will likely be broad discussion of the questions or assertions that they are asked to score, and the system that will be applied for summarizing the scores. This process should take about 2 – 3 hours.

After several weeks the organizers of the scoring exercise should return to the communities for an application of the scoring method. This will likely be preceded by a number of questions based on the earlier visit. After answering about process and responding to these questions, the community leaders will proceed to answer the questions on issues designated in the scoring sheet. The scoring sheet must be rather brief since the community participants will be interested in returning to their occupations.

With this preliminary review of the process we will turn to the concerns raised in the Wikipedia review of the approach. Here we will suggest some of the questions or issues that the community participants may be asked to respond too.

History

The history of community involvement in scoring and other involvements in the future of the establishments is rather recent. Initially, Milton Friedman was an advocate of not tying the hands of communities to eliminate "soft" concerns about the future of the communities focusing only on profitability. This was a central theme of early approaches to scoring. The approach emphasized that concerns about the community were drags on the profitability of firms and should not be considered if the objective was to grow and develop.

This began to lose ground as other leaders were more interested in the community at large than in single firms. A major departure from the older philosophy came with a writing of Coleman on "Social Capital in the Creation of Human Capital" (Coleman, 1988). His assertion was that for the long run good of society other factors should be included in scoring than simply profitability. This article led to a proliferation of other writings on the subject and to a new concept of community leaders as participants in the management of community activities.

The evolution of scoring was a later extension of more involvement in national and international scoring and in the future of communities. Currently there are many focuses on aspects of communities ranging from those with an environmental bent to those with particular emphasis on problem areas for communities. In this summary we are contemplating using the scoring approach to deal with agricultural communities that are threatened by wildfire and dealing with fuel loads that are a byproduct of cheatgrass domination in the local area.

A Design for wildfiress

The design of this research for objective one on cattle grazing, cheatgrass, wildfires, communities, and wildlife habit is shown in Figure 1. In Figure2, show how the scoring approach is applied. Reviewing Figure 1, notice that the trade-off involves net returns, cattle numbers, communities and wildfires.

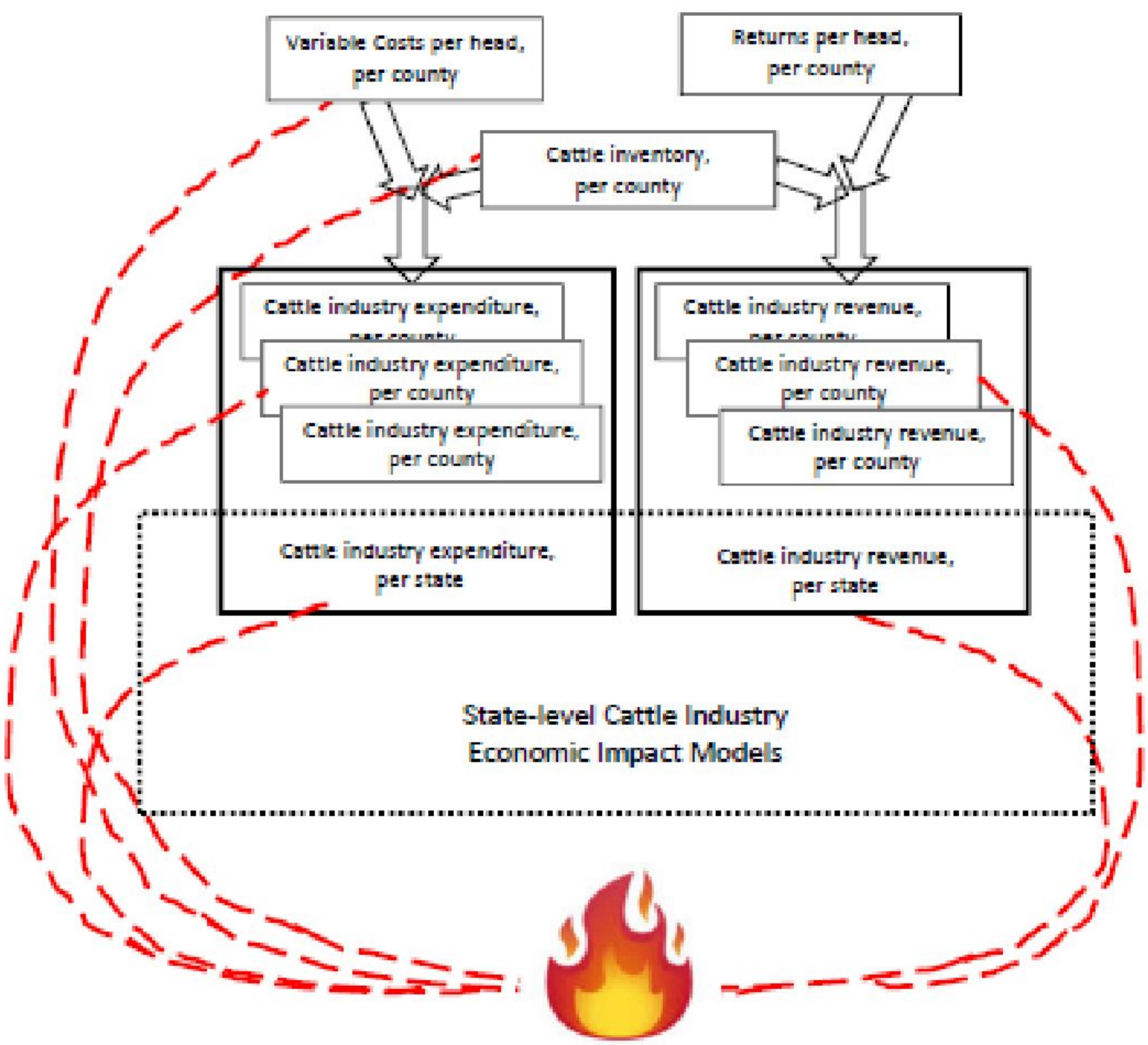

Figure 1. Representation of the Economic Analysis of the Research Proposal

Note from Figure 1, we have a separation between the costs and returns. Costs are indicated at a number of stages in the chart for Figure 1. These cost factors feed into cattle numbers and community analysis. These elements of Figure 1 are prepared at the county levels, but the analysis can be directly applied for state and Basin and Range Region levels.

In Figure 1 the cost side is more impacted the returns side in terms of net revenues.. This is because the cost is where the wildfire impacts are more important.   The revenue side is from the sales to the markets in the states and Basin and Range Region. The costs and revenues relate also to state and community impacts on residents. These distinctions will be important as we proceed through the substance of the research report.

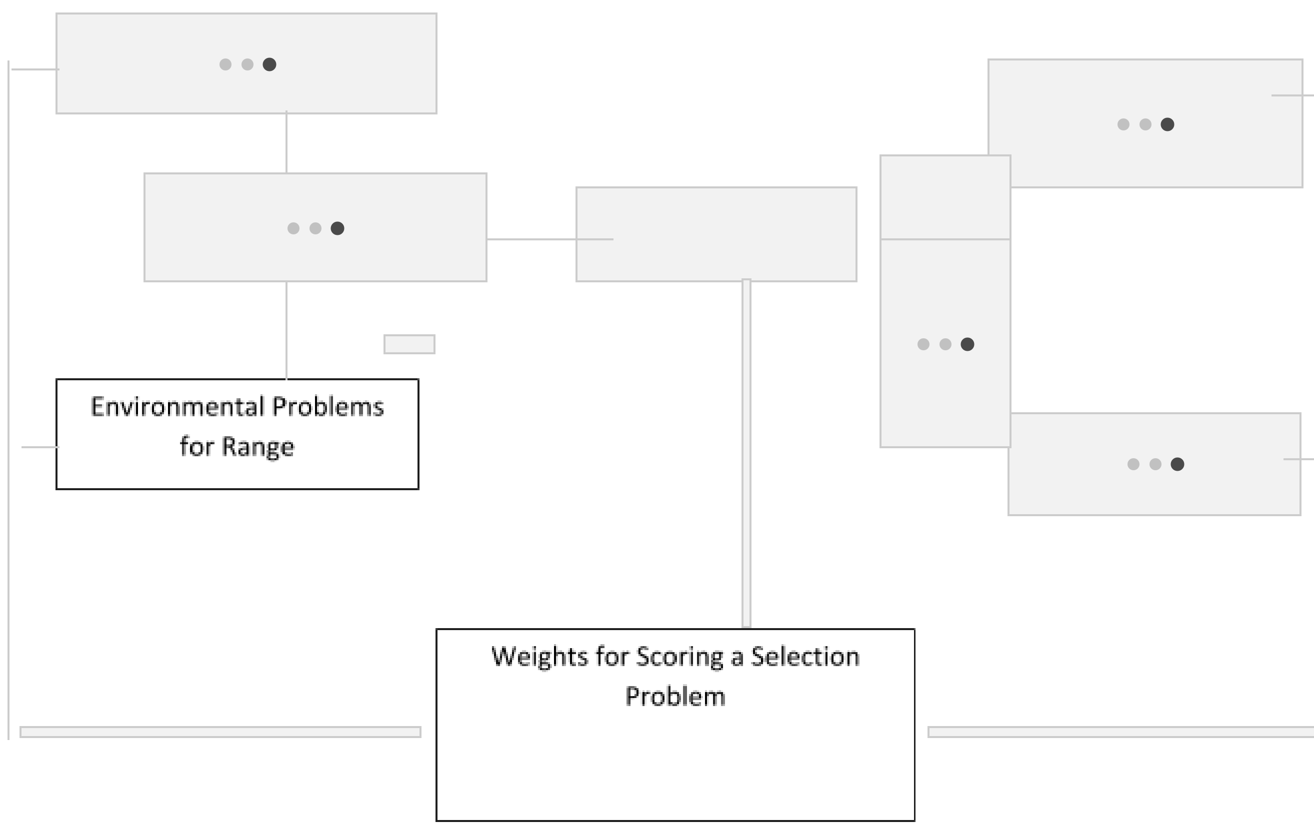

Figure 2. Possibilities for Scoring in the context of BLM Lands

Figure 2 supports scoring to better understand the motives for cattle numbers, communities, wildlife, and cheatgrass grazing. It is structured is to include consideration for objective two since it reflects adding to the cattle numbers by opening and authorizing cheatgrass grazing in the fall when cheatgrass, can be used by cattle. For the two fall months there are distinct advantages of including this condition in the allotments cheatgrass grazing. First, the grazing of cheatgrass does not require hay which is fed to cattle during the during the fall season. This is a benefit to ranchers since they do not have to supply feed for their cattle taken-off of the traditional grazing range (see later analysis). Second, the grazing of cheatgrass is beneficial since it cleans-up the current year's growth and the available thatch from last year or previous years. This reduces the fuel load and thus wildfire risk. Third, these benefits go to states and rural communities that are subject to recurring wildfires and to wildlife. Of course, there are other benefits but these will be the ones selected for the scoring experiment.

A simple scoring equation will suggest this scoring approach. That is,

1) Increased Cattle umbers (+) Degrading of range land (-) Fuel load reduction (+) Increased wildfire retardation (+) Community wildfire protection (+) and Improved wildlife habitat (+-).

The idea is to put weights on the plus and minus terms in this equation and add them up for supporting decisions about the public lands grazing allocations--applied to groups in selected communities. Then we would add it up to indicate what the community preference would be. Of course, this scoring mechanism must be for a particular area of land—presumably including rural communities. The other features of the scoring can be included for consideration, since available cheatgrass can increase the duration of cattle grazing. As is clear from the equation, there are a number of additional terms to be introduced making the equation work better.

For example, there should be scouting for the cheatgrass in spring and summer for growth that could be available for fall grazing. In some summers will be low growth and some summers will be high growth. We suggest types of compromise for these considerations--decreasing the cattle grazing numbers somewhat during higher growth years (good years) to manage appropriately low years of the cheatgrass growth. In short, it takes active management to handle cheatgrass grazing levels in publicly managed lands. Still another possibility for low growth years would be to take the cattle off the cheatgrass earlier making them demand more hay, but at the same time effectively managing the cheatgrass available on the land.