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# Ranch economics of prescribed grazing on rangelands: the case of representative ranches in Northern Montana

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**Abstract**

Rangeland management practitioners typically agree that prescribed grazing practices have a positive impact on rangeland health with positive implications for ranching productivity. The economic impact of implementing these practices, however, is insufficiently explored. This article assesses the impact of two variants of NRCS-promoted prescribed grazing programs on the profitability of four ranch types in Northern Montana. Preliminary results suggest that outcomes are highly dependent on initial ranch conditions and the level and type of financial incentives. Ranches with large tracts of deeded land and insufficient water developments stand to gain the most from adopting prescribed grazing practices.

## Introduction

Prescribed grazing consists of managing the timing, intensity and frequency of grazing and stocking animal species based on dietary preferences (Rinella and Hileman, 2009). These types of practices are of public interest because they should support ecosystem sustainability and restoration of degraded ecosystems that can result in improved plant productivity and health (Briske et al., 2001).

The Natural Resources Conservation Service (NRCS) offers a number of programs designed to assist ranchers in managing their grazing land resources (Gordon, 2018). Prescribed grazing is one of these programs for ranchers, and the NRCS offers both technical assistance and financial incentives to adopt this practice and

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related conservation practices such as fencing and water development. This article assesses the impact of adopting prescribed grazing programs on ranch profits. We simulate and evaluate two specific prescribed grazing programs in Major Land Resource Area (MLRA) 52 in Northern Montana, and consider four types of cow-calf ranches under alternative cattle price and conservation scenarios.

The first treatment, rotational grazing (rotation), involves dividing the operation into smaller pastures through which the herd moves during the production cycle. Water infrastructure is also implemented to ensure that all areas of the pasture are within a mile of a water source. The smaller area of the pastures and additional water locations encourage a more uniform distribution of the herd over shorter periods. The practice increases the percentage of available forage ingested (harvest efficiency[2]) by cattle, as opposed to forage that is unused or trampled when the herd moves over larger distances. The second treatment (rest-rotation) adds a requirement to rest 20% or more of the pastures for 12 months or more between grazing events.

**Area of study**

MLRA 52, called the Brown Glaciated Plain, is located in Northern Montana (see figure 1) and spans approximately 23,040 square miles. Several tribal reservations and wildlife refuges are located in this area. Elevation ranges from 1,970 to 4,600 feet. This MLRA is almost completely covered by glacial till plains. Average annual precipitation ranges from 10 to 17 inches and occurs mostly as high-intensity, convective thunderstorms during the growing season. Average annual temperature ranges from 38 to 45 degrees Fahrenheit with freeze-free periods ranging from 120 to 165 days per year (NRCS, 2006). This area encompasses a rich ecosystem that includes grassland vegetation and major wildlife and fish species (NRCS, 2006).

The soils in the area are generally very deep, well drained, and loamy or clayey. To estimate forage production in the MLRA, we followed NRCS' Ecological Site Description (ESD) representative area guideline (Chambers, 2016) and obtained the annual vegetative production by averaging data found in ESDs for clayey, dense clay, and silty solid soil types that receive between 10 and 14 inches of precipitation per year. The average annual forage production across the representative sites is approximately 1,167 lbs./acre.

Land use is approximately 45% private cropland, 36% private grassland and 16% federal and state grassland (NRCS, 2006). Hence, although we only consider deeded rangelands for the prescribed grazing programs, grazing crop residue and public lands are important sources of forage for many ranches in this area.

[2] Harvest efficiency is "[t]he total percent of vegetation harvested by a machine or ingested by a grazing animal compared to the total amount of vegetation grown in the area in a given year…. Harvest efficiency is the percentage of forage actually ingested by the animals from the total amount of forage produced."

**Representative cow-calf ranching operations**

Modelling representative ranching operations in study areas is key to assessing the economic impact of prescribed grazing practices. To adequately represent ranching operations, researchers at the University of Wyoming (Dyer et al., 2018a, b, c, d) developed cow-calf ranch enterprise budgets (EBs) that document typical management practices, resource availability, and technology employed in these operations. Dyer et al. (2018a, b, c, d) validated the EBs with ranchers' input to ensure that they are representative of ranches in the area. Given the heterogeneity of operations in the study area, there are four basic types of ranches modeled for MLRA 52. The four types of ranches modeled are differentiated by grazing availability (only private land or a combination of private and public land), and by size (as measured by small or large herds). Table 1 summarizes the salient characteristics of each ranch type.

The ranches with access to public grazing lands hold permits for either state land or Bureau of Land Management (BLM) land[3]. The fees to use these public lands are published on a per animal unit month (AUM) basis. An AUM is the monthly amount of forage necessary for the sustenance of a 1,000 lb. cow and its unweaned calf[4]. While grazing fees on public lands are significantly lower than rental rates of private pastures, there are significant non-fee costs related to grazing in public lands such that they are approximately equal to public and private lands (Torell et al., 1993).

Off-ranch income is a crucial aspect of ranching in the rangelands. Many ranches would not be viable without the influx of funds from this source and we incorporate this aspect in our model. The 2012 Census of Agriculture (USDA NASS, 2014) indicated an average of $87,110 in annual off-ranch income in ranch-operating households[5]. Although our model uses a profit-maximizing framework, we recognize that profit seeking may not be the principal motivation in the representative ranching operation. In fact, ranchers have consistently mentioned the associated lifestyle as one of the main drivers for being a rancher (Lind, 2015). The willingness to work off ranch to sustain the lifestyle (of which preserving the landscape is presumably a major component) suggests a sense of stewardship of the rangeland among ranchers. These features have been previously identified in the literature (e.g., Gentner and Tanaka, 2002; Tanaka et al., 2011; and Torell et al., 2014). The ranchers' sense of stewardship and dependence on external income suggests that they should be receptive to the technical assistance and financial incentives associated with participating in NRCS prescribed grazing programs.

[3] There may be some ranchers grazing U.S. Forest Service (USFS) land but this type of land was not considered as a representative source of forage in this MLRA.

[4] Other animal classes are typically assigned Animal Unit Equivalents (AUE).

[5] Includes farm operator households classified as beginning farmers and ranchers, socially disadvantaged farmers, or limited resource farmers, https://www.ers.usda.gov/webdocs/DataFiles/48870/table10.xls?v=2261.3.

In determining how many AUMs are available on each acre of deeded rangeland, we model a number of representative management practices. One such practice follows a common rule of thumb in determining stocking rates: take half, leave half. Virtually all ranchers interviewed apply a version of this rule of thumb. An average harvest efficiency across ranch types of 25% is assumed in the baseline model (Green and Brazee, 2012).

The distance that cattle need to travel to a water source has a significant impact on the amount of accessible forage on a pasture (i.e., AUM/acre). Valentine (1947) was first to document an adjustment factor for distance from water. We calculate the water distance adjustment factors following guidance in NRCS (2012) so that stocking rates for a given pasture are adjusted based on its distance from water at 100% for zones within 0.5 miles, 90% for zones within 1 mile, 70% for zones within 1.5 miles, and 50% for zones within 2 miles. Presumably, no grazing occurs in areas where cattle need to travel more than 2 miles from water. Furthermore, across ranch types, we assume that each baseline operation has a perimeter fence on their [single, square] private pasture and enough water developments to achieve a minimal water distance factor adjustment of 70 percent.

Each of the representative ranches is modeled using a linear, dynamic, profit-maximizing General Algebraic Modeling System (GAMS, 2017) model that is capable of replicating the key ranch characteristics. The choice variables are the annual number of animals in each class (brood cows, cull cows, replacement heifers, etc.) and the amount of forage used from each source each season. The choice variables are dynamically related to establish the dependence of herd size across years. The procedure is then to calibrate the model to ensure that forage demand is no greater than forage availability in every season of every year, and to produce a baseline simulation for 40 years of operation under 100 different price scenarios[6] (see table 2 for summary).

Table 3 illustrates the sources of forage that are available to ranchers in MLRA 52 during a typical year. The actual grazing schedule depends largely on whether ranchers have access to public grazing land or to crop residue and hay aftermath grazing. However, grazing on deeded rangelands is under the control of the rancher year round and can be used to adapt to changes in the availability of public land and aftermath grazing.

**Impact models**

The adoption of the two prescribed grazing scenarios (rotational grazing and rotational grazing with extended resting periods for a subset of the grazed pastures) involves a

[6] The price scenarios were developed from CattleFax price data that are indexed and from which a dynamic regression analysis is used to estimate parameters that capture seasonal and cyclical variation and long-term trends. The estimated parameters are used to simulate 100 different 40-year-long price scenarios that capture the volatility and trends in the original data.

number of infrastructure developments and changes in herd management. Although NRCS does not prescribe a specific number of divisions of the existing pasture or require a specific pasture size, we assume that the treatment on the existing private grazing lands consists of subdividing them into five smaller pastures of equal size.

For both prescribed grazing scenarios being evaluated, this implies an investment in cross fencing the length of the main field four times (i.e., five pastures). Fence markers are added to the existing perimeter fences and the new cross fences. These markers are designed to avoid wildlife collisions with the fence, which are usually lethal to species such as the greater sage-grouse.

The new fencing also requires an investment in new water developments to allow cattle access to water at all times. The number and location of the new water developments ensure access to water at all times and to achieve a water distance efficiency of 90% or more on average. Each new water development requires troughs, pipelines, and pumps sufficient to distribute water from the existing sources on the land.

The impact models assume the cost of installing the required infrastructure is based on the Environmental Quality Incentive Program (EQIP) reimbursement rates (see Table 4). These rates cover up to 75% of the costs of each listed item with the rancher paying 25%. The assumed annual cost of operating and maintaining the new infrastructure is 10% of the installation costs. The replacement of these components occurs based on their estimated useful life.

The changes in management include the need to move the cattle from each sub-pasture to the next at prescribed intervals. To this added managerial load, the NRCS programs also require the measuring and monitoring of certain rangeland health aspects. As an incentive to adopt these practices, NRCS establishes a per-acre payment rate that occurs annually for the first three years for each of the prescribed scenarios evaluated. However, ranchers do not qualify for these incentive payments after the initial three-year period. The management and labor costs for the ranch are included as a component of the variable cost of production (per cow[7]). A differential increase in herd size across ranch types and grazing programs will incorporate the differential in managerial and labor costs of running the prescription.

There are many rangeland health related qualitative benefits to adopting prescribed grazing practices. Plant communities' health and vigor is expected to improve, which prevents the negative effects of soil erosion and soil quality degradation. Similarly, improved vegetative cover should reduce water runoff and improves infiltration while reducing soil surface evaporation. The management systems also enhance the plant and wildlife diversity (Briske et al., 2011). This project

[7] This approach is consistent with the American Agriculture Economics Association's "Commodity costs and returns estimation handbook."

seeks to answer the question of whether participation in NRCS prescribed grazing programs is profitable for a representative ranch. Hence, we focus on quantitative variables that affect payments, costs, and amount of forage available for livestock.

Each of the two impact scenarios are evaluated at two alternative levels of harvest efficiency. The first case assumes the same baseline harvest efficiency of 25 percent. The second case assumes a harvest efficiency of 30 percent. The rationale for the alternative case is because the smaller pasture sizes and added water developments imply, among other things, a reduction in the proportion of forage that is trampled by livestock movement or otherwise not grazed (Martin and Ward, 1973).

The baseline cow-calf ranching model is modified to incorporate the features associated with the impact scenarios to be evaluated. Figure 2 illustrates the conceptual diagram that underlies the optimization model. As in the baseline simulation, we solve the optimization over 40 years under the same price scenarios as in the baseline cases. By comparing the results of the different impact scenarios to the baseline we can assess the impact of the prescribed practices on ranch operations and profitability.

**Results and discussion**

The simulation of the results for the baseline and impact models involves maximizing the net present value (NPV) of the stream of ranch profits over a 40-year period. A total of 100 different price scenarios are considered. The prices are obtained from a harmonic price model that was estimated from actual market price data from CattleFax (see table 2 for summary). The harmonic model incorporates seasonal and cyclical variation, and long-term trends; i.e., each scenario produces 40 years of price data that replicates the volatility and trends of the original data.

The four representative baseline cow-calf ranches partially capture the heterogeneity of ranching operations in the area. The different initial conditions associated with each type and the asymmetry of the results to equal treatments highlight the importance of evaluating the idiosyncrasies of each prescribed grazing contract separately. While it is clear that both prescribed grazing scenarios enhance the productive capacity of the treated rangelands, their effect on ranch profitability across ranch types is not uniform.

Table 5 summarizes the average impact of adopting prescribed grazing practices on ranch operation indicators. The size of the initial deeded rangeland and its initial water distance factor are estimated to yield at least 70% initial water distance factor. The small ranches have a large initial water distance factor and so the addition of the new water infrastructure result in smaller gains in that regard.

The profitability of the practices depends greatly on the initial conditions of the ranch. The model revealed that two factors increase the chance of the adopted practices being profitable: larger achievable improvements in water-distance efficiency, and larger portions of deeded rangeland included in the treatment. Small operations with relatively good water distance efficiency would be (negatively) impacted to a larger degree by the additional burden of the conservation practices and the operations and maintenance costs of the added infrastructure.

Ranches with large tracts of deeded land and relatively poor initial water distance efficiency stand to gain the most from adopting prescribed grazing practices. The installation, operation, and maintenance costs increase linearly with the perimeter of the pasture while the incentive payments increase exponentially with the perimeter of the field—i.e., the incentive payments increase faster than the installation, operation, and maintenance costs.

In summary, this study shows that there are strong quantitative (production, profits) reasons to adopt prescribed grazing practices as promoted by NRCS. The literature suggests there also are rangeland health benefits associated with prescribed grazing. However, they are not a silver bullet in terms of improving the profitability of ranch operations but rather depend on the ranch's initial characteristics. The current NRCS approach of evaluating site-specific conditions as a precursor to entering into these contracts seems to be the best course of action to promote appropriate implementation of these practices. This is particularly important when evaluating similar programs in markedly different ecological sites across the western rangelands.

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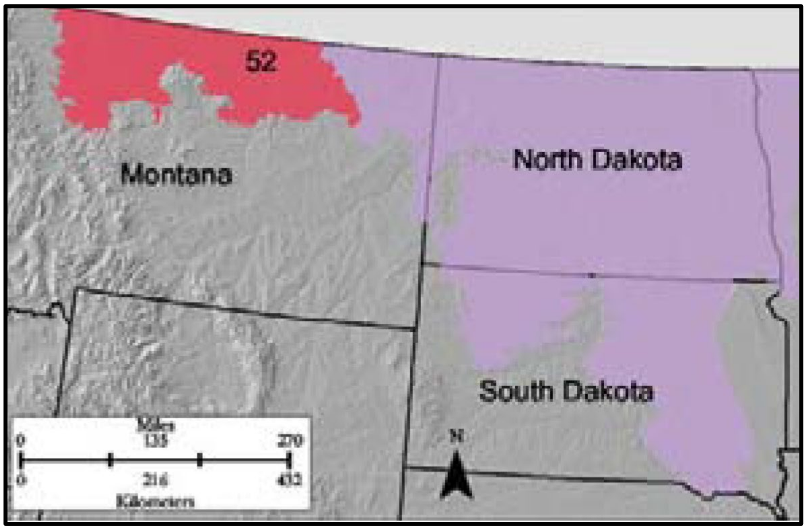


*Figure 1. Location of MLRA 52. Source: NRCS, 2006.*

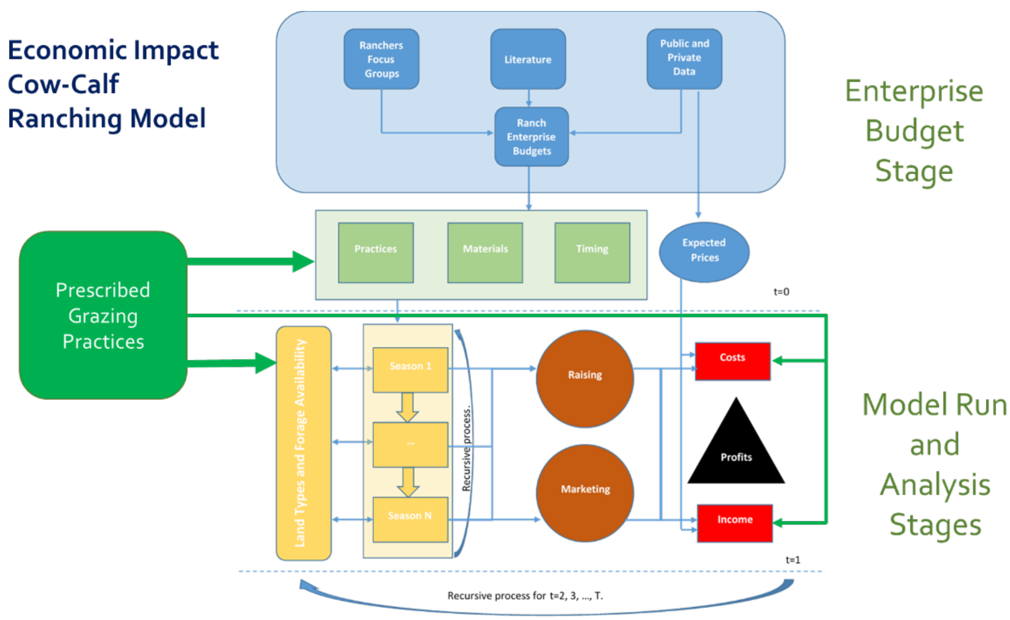


*Figure 2. Conceptual diagram of cow-calf ranching model.*

*Table 1. Select representative ranch operational indicators. Source: Dyer et al., 2018a, b, c, d.*

| | Small Private | Small Public[8] | Large Private | Large Public[2] |
|---|---|---|---|---|
| Beef cows | 75 | 100 | 250 | 300 |
| Avg. annual revenues from animal sales | $75,769 | $98,663 | $273,081 | $312,211 |
| AUMS from rangelands | 614 private | 369 private<br>598 public | 2,244 private | 1,215 private<br>1,984 public |
| Forage from deeded land | 46.08% | 20.66% | 45.66% | 20.45% |
| Est. acres of deeded land | 2,981 | 1,226 | 13,841 | 7,123 |
| AUMS from aftermath[9] | 278 | 224 | 1,015 | 743 |
| Tons of winter feed | 182 | 246 | 684 | 826 |

*Table 2. Summary statistics of simulated 2016 Real beef cattle prices used in simulation.*

| | Units | Average | Min | Max | Std. Dev. |
|---|---|---|---|---|---|
| Steer Calf (560 lb) | $/cwt | 171.29 | 90.91 | 254.57 | 29.32 |
| Heifer Calf (520 lb) | $/cwt | 163.51 | 73.08 | 249.36 | 32.33 |
| Cull Cow (950 lb) | $/cwt | 67.22 | 31.89 | 107.21 | 14.76 |
| Cull Bull (1,800 lb) | $/cwt | 92.22 | 50.90 | 134.57 | 17.81 |
| Purchased Brood Cow | $/head | 1304.58 | 583.66 | 2210.96 | 275.14 |

[8] Refers to operations that includes public lands in addition to other types.
[9] Aftermath includes the grazing of crop residue and hay fields after the final cut of the season.

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

| | | *Grazing season* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | May 1<br>May 15 | May 16<br>May 31 | June 1<br>June 15 | June 16<br>Sep. 15 | Sep. 16<br>Oct. 31 | Nov. 1<br>Dec. 31 | Jan. 1<br>Apr. 30 |
| *Small private* | Deeded range | ● | ● | ● | ● | ● | ● | |
| | Aftermath | | | | | ● | ● | |
| | Winter feed | | | | | | | ● |
| *Small public* | BLM/State | | | ● | ● | | | |
| | Deeded range | ● | ● | ● | ● | ● | ● | |
| | Aftermath | | | | | ● | ● | |
| | Winter feed | ● | | | | | | ● |
| *Large private* | Deeded range | ● | ● | ● | ● | ● | ● | |
| | Aftermath | | | | | ● | ● | |
| | Winter feed | | | | | | | ● |
| *Large public* | BLM/State | | ● | ● | ● | | | |
| | Deeded range | ● | ● | ● | ● | ● | ● | |
| | Aftermath | | | | | ● | ● | |
| | Winter feed | | | | | | | ● |

*Table 4. Program participation costs and incentives.*

| *EQIP Code* | *Description* | *EQIP Share* | *Rancher Share* | *Operation & Maintenance* | *Useful life* |
|---|---|---|---|---|---|
| *382* | Fence, Barbed/Smooth Wire | $1.19/ft | $0.40/ft | $0.159/ft/yr | 20 yrs |
| *649* | Fence Markers, Vinyl Undersill | $0.11/ft | $0.015/ft | $0.015/ft/yr | 20 yrs |
| *614* | Watering Facility, Automatic or Winter, < 450 Gallons | $634.68/ea | $211.56/ea | $84.62/ea/yr | 20 yrs |
| *516* | Livestock Pipeline, Buried PVC, IPS, HDPE, PE | $1.10/ft | $0.37/ft | $0.147/ft/yr | 20 yrs |
| *533* | Photovoltaic-Powered Pump, submersible | $3,042.37/ea | $1,014.12/ea | $405.65/ea/yr | 15 yrs |
| *528* | Prescribed Grazing, Range, Standard (scenario 5) | $3.08/acre/yr | - | - | |
| *528* | Presc. Grazing., Rest-Rotation (scenario 6) | $7.56/acre/yr | - | - | |

*Table 5. Select ranch operational indicators for the impact of program participation.*

| | Scenario | Baseline NPV | Change in Water Dist. Factor. | Change in herd size | Change in deeded AUMs avail. | Change in NPV | Change in NPV/cow |
|---|---|---|---|---|---|---|---|
| *Small Private* | Rotation, 25% HE[10] | $231,064 | +11% | +8.0% | +12.94% | -5.1% | -12.1% |
| | Rotation, 30% HE | | | +24.0% | +35.53% | +4.5% | -15.7% |
| | Rest-Rot., 25% HE | | | +9.3% | +12.94% | +10.2% | +0.8% |
| | Rest-Rot., 30% HE | | | +24.0% | +35.53% | +19.8% | -3.4% |
| *Small Public* | Rotation, 25% HE | $338,197 | +2.8% | +1.0% | +2.96% | -5.8% | -6.8% |
| | Rotation, 30% HE | | | +6.0% | +19.62% | -1.5% | -7.1% |
| | Rest-Rot., 25% HE | | | +1.0% | +2.96% | -1.5% | -2.4% |
| | Rest-Rot., 30% HE | | | +6.0% | +19.62% | +2.9% | -3.0% |
| *Large Private* | Rotation, 25% HE | $928,326 | +20.3% | +30.4% | +29.06% | +28.3% | -1.6% |
| | Rotation, 30% HE | | | +49.6% | +54.87% | +44.0% | -3.8% |
| | Rest-Rot., 25% HE | | | +31.2% | +29.06% | +51.0% | +15.1% |
| | Rest-Rot., 30% HE | | | +50.4% | +54.87% | +65.3% | +9.9% |
| *Large Public* | Rotation, 25% HE | $434,657 | +23.5% | +7.0% | +28.49% | +130.4% | 115.4% |
| | Rotation, 30% HE | | | +15.0% | +54.19% | +146.5% | 114.3% |
| | Rest-Rot., 25% HE | | | +7.3% | +28.49% | +154.0% | 136.7% |
| | Rest-Rot., 30% HE | | | +15.3% | +54.19% | +169.3% | 133.5% |

[10] Harvest efficiency.