Evaluating Conserved Consumptive Use in the Upper Colorado:

2020 Economics and Enterprise Budgeting Report

Jenny Beiermann[1] and John Ritten[2]

[1] Colorado State University Extension, Grand Junction, CO; Jenny.Beiermann@colostate.edu
[2] Department of Agriculture and Resource Economics, Fort Collins, CO; John.Ritten@colostate.edu

Abstract

The economic contributions of the agriculture industry to the state of Colorado are vital for a thriving economy. Grand county agriculture alone contributes $14,400,000 dollars to the economy annually (Census of Agriculture, 2017). Increased threats of severe water shortages pose the question of how to conserve irrigation water used on hay meadows while supporting productive agriculture. In a study to evaluate the impacts of temporary fallowing on agricultural operations, producers accepted per acre payments to curtail their water use for all or part of the irrigation season in 2020. As part of the study, financial data were collected from six participating producers and entered into enterprise budgets to determine if the payment rates were adequate to offset the yield and production losses due to water curtailment. Producers with livestock enterprises were also entered into a partial budget analysis to evaluate considerations for their herds. Results indicate that payments were beneficial to hay enterprises, especially those who participated in full season curtailment. However, producers with livestock herds experienced an overall loss due to lack of late season and fall pasture for grazing. Other factors beyond direct financial impacts that are anecdotally considered in this analysis are drought, coordination among operations, long-term implications to production and profitability, and production system dynamics.

1. Introduction

Agriculture is one of the top driving industries in the state of Colorado. Colorado boasts a large amount of public land, 8.3 million acres total (Bureau of Land Management, 2022), but also has nearly 32 million privately owned acres in agricultural production across the state. Grand County, located just west of the Front Range and the Continental Divide, mainly produces hay and cattle. According to the 2017 Census of Agriculture, the annual total market value of cattle and calves sold was $11,052,000; total annual crop sales were $3,388,000 (Census of Agriculture, 2017).

One of the most important decisions farmers and ranchers make in their daily operations is choosing an enterprise mix. Put differently, they must choose the best mix of crops and livestock to produce to be the most profitable. These decisions should be made on at least an annual basis, and farmers and ranchers should also be constantly monitoring their enterprise mix for potential management changes that may help them remain profitable.

A better understanding of economic factors is needed to help farmers, ranchers, water managers, and other stakeholders evaluate how compensation for temporary reductions in water use fits into agricultural operational planning. The economic impact of participating in water sharing arrangements can be considerable and must be offset by proper compensation for a market-based approach to be successful. For purposes of this economic and enterprise budgeting analysis, compensation levels for the study are examined to determine if the payments were adequate to offset the losses incurred from reduced irrigation

in 2020 compared to a reference field under normal conditions. It is expected that reduced irrigation not only affects hay and forage enterprise profitability, but will also impact cattle and livestock enterprises dependent on the forage grown in these fields.

The purpose of this economic analysis is to evaluate the operational and financial impacts of participation in a water conservation program in Grand County Colorado. To do this, interviews with a small set of agricultural producers participating in the study were conducted to determine costs and revenues associated with their hay production on both reference (control) and treatment (variable) fields. Data related to operations were collected from producers and used to build enterprise budgets for each of their study fields to determine their overall profit/loss on a per acre and per field basis. While enterprise budgets are a listing of all income and expenses associated with a specific enterprise, partial budgets are used to evaluate the economic effect of adjustments or changes in a portion of the business. Therefore, producers with livestock enterprises were interviewed further to determine the costs and revenues associated with their livestock herds who graze and consume hay grown on the study fields. These additional data collected were entered into a separate partial budget to determine impacts to their livestock enterprises that are dependent on the forage supplied by these hay meadows.

2. Materials and Methods

Six agricultural producers provided data for this enterprise analysis (Table 1). Each producer was instructed to provide budget data including a listing of all incomes and expenses associated with growing native grass hay for 2020 for each of their treatment (variable) and reference (control) fields. Producers with livestock were also instructed to provide budget data regarding their animals' typical consumption of the native grass hay harvested or grown on the fields. Data were then analyzed and entered into formal enterprise budgets and partial budgets (livestock producers only) to indicate a profit or loss incurred by the producer for each field (enterprise analysis) and operation (partial budget). Reference and treatment fields profit/losses were directly compared for each producer on a per/acre basis to determine effectiveness of the payment rates. Only aggregate or averaged data is reported for study results to allow financial anonymity for producers participating in this study.

Table 1. Operations, water conservation practices, and acres for fields who provided financial and production data for analysis in this study.

Operation Name	Reduced Irrigation Practice	Reference Acres	Treatment Acres
GPR*	Full Season	93.5	548.8
JLM	Full Season	15.8	15.8
SBR*	Full Season	28.7	70.3
SPR*	Full Season	28.7	220.7
RCR*	Split Season	233.7	37.6
RSR	Split Season	21.1	123.3
***Operations with livestock that were entered into a partial budget**			

2.1 Payment Types

Producers either entered into a split season or full season reduced irrigation agreement. Under the split season agreements, they agreed to turn off irrigation water on June 15th. For the full season, they agreed to turn off water for their fields for the entire irrigation season – allowing their field to be 'fallowed'. RCR and RSR, participated in split season curtailment; JLM, GPR, SBR, and SPR participated in a full season curtailment (Table 1). Split season payments were set at $281 per acre and full season payments were $621 per acre for the one year of reduced irrigation. These payments were added to each treatment enterprise budget as additional cash receipts for each respective operation and listed as additional revenues for the partial budget for the operations with a livestock component.

2.2 Developing an Enterprise Budget

Enterprise budget templates developed by the CSU Extension Agriculture and Business Management (ABM) Team were used (Figure 1). Enterprise budgets account for income and expenses for a specific enterprise, ignoring the rest of the operation. The first step is to determine total production (output or yield) and expected or received output price. The second step is to determine variable costs. Variable costs are those that vary with the amount of product produced. These are the out-of-pocket costs that must be incurred if the enterprise is produced or grown. Some examples of variable costs for this example include: hired labor; repairs; feed; supplies; veterinary medicine; fuel; seed; etc. The third step is to assess fixed costs. Fixed costs will occur no matter how much is produced, or, in most cases whether or not production occurs at all. Some examples of fixed costs are: depreciation of assets; taxes; insurance; etc. At times the proration of such charges is quite difficult, particularly when more than one crop enterprise is involved. Land charges are generally based on one of three acceptable methods: 1) interest opportunity based on current value of land; 2) owner rental income; or 3) typical cash rent charge (market rent). The last step is calculating net receipts. Net receipts represent that income which is left for the farmer/rancher and family to live on, pay debt, invest, or save (Sharp, Tranel, and Dalsted, 2008).

Figure 1. All participating producer data was entered into this template to analyze profitability. This figure contains sample data only.

Western - Grass Hay **2020**

Estimated Production Costs & Returns

GROSS RECIPTS FROM PRODUCTION						
GROSS RECIPTS	UNIT	PRICE	YIELD	PER ACRE	PER TON	YOUR FARM
Grass Hay	ton	$0.00	0	$0	$0.00	
Other						
Total Receipts				**$0**		**$0**
DIRECT COSTS						
	UNIT	COST PER UNIT	QUANTITY	PER ACRE	PER TON	YOUR FARM
OPERATING PREHARVEST						
Fertilizer	lbs	0.00	0	0.00	0.00	
Custom Application	acre	0.00	0	0.00	0.00	
Herbicide	dollars	0.00	0	0.00	0.00	
Custom Application	acre	0.00	0	0.00	0.00	
Interest Expense (6 months @ 5.5%)	dollars	0.00	0	0.00	0.00	
Total Pre-Harvest Expenses				$0.00	$0.00	$0.00
HARVEST COSTS						
Swath	acre	0.00	0	0.00	0.00	
Rake	acre	0.00	0	0.00	0.00	
Bale (rounds)	bale	0.00	0.00	0.00	0.00	
Hauling	bale	0.00	0	0.00	0.00	
Total Harvest Costs					$0.00	$0.00
Total Operating Costs				**$0.00**	**$0.00**	**$0.00**
PROPERTY & OWNERSHIP COSTS						
General Farm Overhead	dollars	0.00	0	0.00	0.00	
Machinery Ownership Costs	dollars	0.00	0	0.00	0.00	
Real Estate Taxes	dollars	0.00	0	0.00	0.00	
Total Property & Ownership Costs				$0.00	$0.00	$0.00
TOTAL DIRECT COSTS				**$0.00**	**$0.00**	**$0.00**
NET RECEIPTS BEFORE FACTOR PAYMENTS				**$0.00**	**$0.00**	**$0.00**
FACTOR PAYMENTS						
Land ($4,760 @ 3.7%)				0.00	0.00	
RETURN TO MANAGEMENT & RISK				**$0.00**	**$0.00**	**$0.00**

2.3 Partial Budget Analysis

In cases where producers also have a livestock enterprise for their operation, a separate partial budget analysis was used in addition to the enterprise budget analysis to account for the financial impacts of lack of hay and/or grazing for the livestock enterprise on a given operation. Business owners must often make decisions about changes they are either contemplating making or that must be made. Many of the decisions are incremental, such as adding land, expanding or reducing an enterprise, or changing how an enterprise is managed. The partial budget is a useful tool for farm managers when these situations arise. A partial budget helps farm owners/managers evaluate the financial effect of implementing a change in management to an operation.

For this study, the partial budget helps to determine the break-even point for the livestock enterprise relative to the reference fields and helps determine the financial viability of participating in the water program when producers have livestock who are dependent on the harvested hay and additional grazing of treatment fields. The partial budget analysis conducted takes into account specific impacts to the livestock portion of their operation due to reduced irrigation on the treatment fields only.

Unlike an enterprise budget, which includes a listing of all incomes and expenses associated with a specific enterprise, a partial budget only accounts for incomes and expenses that are varied due to a change in current management practices. This allows for the ability to show increased or decreased income in the farm business due to a change in management, i.e. feeding your own hay/grazing your own ground vs. purchasing additional hay/renting additional pasture. Partial budgets are based on the principle that small business changes have effects in one or more of the following areas:

1. Increases to income
2. Reduced or eliminated costs
3. Increases to costs
4. Reduced or eliminated income

The net impact of the above effects is the positive financial changes minus the negative financial changes. A positive net indicates that farm income will increase due to the change, while a negative net indicates the change will reduce farm income.

3. Results

3.1. Enterprise Analysis

Data collected for the 2020 production season from interviews for six operations participating in the study were entered into enterprise budgets to analyze profitability of their grass hay enterprises. Six of the nine total participating operations were selected to be interviewed due to their interest in the study and their operations being more representative of commercial operation size. Treatment fields were compared to reference fields for each respective enterprise to determine relative profitability of the grass hay enterprise for this study. Rather than use a true breakeven analysis (where revenues are equal to costs), we use the profitability of the reference field as the comparison (rather than zero profit). Therefore, a treatment field may be more profitable than the reference field, yet still be unprofitable.

The following variables are reported for the reference and treatment fields: Gross Receipts, Total Operating and Fixed Costs, Net Receipts Before Factor Payments, and Total Return to Management and Risk. Gross Receipts are the revenues realized before expenses from selling the hay grown. Total operating costs include all pre-harvest, harvest, property, and ownership costs for each of the producers associated with growing their hay. Net Receipts Before Factor Payments is profit realized from the grass hay enterprise before factor payments are included. In economics, factor payments are those costs associated with supplying factors of production, including land, labor, capital, or entrepreneurship. It is good farm/ranch business principle to consider factor payments as an expense, even if you own the land, to account for payments made to scare resources in return for productive services. Including factor payments helps producers to determine whether they are more profitable farming the land themselves, or if they would be better off renting or selling the land. Further, factor payments are included in our analysis to allow direct comparison of producers that rent and own the fields used in the study. Factor payments for this study were valued at $203.50 per acre. This is calculated by taking the value of agricultural land at $5,500 per acre and applying a 3.7% rate of return to represent the percentage of change of an investment's initial cost over a period of time. Total Return to Management and Risk is the profit realized by the operator including factor

payments for land. It is calculated by taking gross receipts, subtracting fixed and variable costs, and then subtracting factor payments. Total Return to Management and Risk is the value used in this analysis to compare the returns between the treatment and reference fields. Individual results from both reference and treatment fields are reported for the grass hay enterprise first, and then treatment fields are directly compared to respective reference fields in following sections. This allows producers/managers using this study to evaluate adoption of water conservation practices to better determine their willingness to participate based on their own reference and conservation conditions and practices.

3.1.1 Reference Fields

Participants' reference fields served as a baseline for production in a 'normal' year. These fields were used to compare to the treatment fields to determine the viability of payment rates. Again, total return to management and risk is calculated by taking gross receipts, subtracting operating and fixed expenses, and then subtracting factor payments. On average, gross receipts for producer's reference field crop were $319.61 per acre. Producers total operating and fixed costs for reference fields were $313.14 per acre. Average net receipts before factor payments (land payments) were $7.47 per acre. Total return to management and risk, on average for the operations in this study, was a loss of $(196.03) per acre (Table 2). Table 2 shows average, maximum, and minimum results from the reference field enterprise analysis to outline how the average baseline return of $(196.03) per acre was determined. Maximum numbers reported indicate the operation that had the highest return to management and risk and minimum numbers indicate the operation that had the lowest return to management and risk. Due to volatility in weather and markets, it is not uncommon for producers to have certain years where they are operating at a loss, as is the case for reference fields in this analysis. During interviews with producers, the word 'brutal' was used often to describe the nature of the 2020 production season due to extreme drought conditions and reduced water availability, causing decreased yields directly impacting the hay enterprise budget. Even with elevated hay prices for those non-livestock producers that sell their crop, yield reductions were so high that they were not able to cover input costs. The value of $(196.03) return to management and risk per acre is used as the baseline for comparison of all treatment fields and for further partial budget analysis conducted for livestock enterprises.

Table 2. Results from reference field enterprise analysis for the six operators participating in the study. Results reported are gross receipts, total operating and fixed costs, net receipts before factor payments, and return to management and risk.

REFERENCE FIELDS	Average	Max	Min
Gross Receipts	$ 319.61	$ 455.28	$ 66.00
Total Operating + Fixed Costs	$ 313.14	$ 426.74	$ 211.21
Net Receipts Before Factor Payments	$ 7.47	$ 192.82	$ (282.88)
Factor Payments	$203.50	$203.50	$203.50
Return To Management and Risk	$ (196.03)	$ (4.68)	$ (486.38)

3.1.2 Treatment Fields

Once the analysis for reference fields was completed, the data for treatment fields were then entered into enterprise budgets for comparison. Producers in full season agreements received $621 per acre to stop irrigation water for the entire season. When irrigation water was not applied to these fields, no vegetation was harvested due to lack of growth. Their average total operating and fixed costs were $220.30. Net receipts before factor payments averaged $400.69 per acre. Including factor payments, total return to management and risk, on average, was $197.19 per acre for producers participating in full season agreements (Table 3). This indicates that on average, these producers had a net profit of $197.19 per acre. Similar to the reference fields, Table 3 shows average, maximum, and minimum results from the full season treatment fields. Maximum numbers reported indicate the operation that had the highest return to management and risk and minimum numbers indicate the operation that had the lowest return to management and risk.

Producers in split season agreements received $281 per acre to stop irrigation water on June 15th. When irrigation water is stopped mid-season, ranchers are still able to harvest an initial crop, meaning additional revenue is generated, but variable expenses are still incurred as well. Producers participating in split season treatment, on average, had gross receipts of $467.50. They incurred operating and fixed costs averaging $310.00 per acre. Net receipts before factor payments averaged $157.51 per acre and total return to management and risk was a loss of $(46.00) per acre (Table 4). Again, operating at a loss is not uncommon for producers in certain years given multiple circumstances out of their control. Table 4 shows the average, maximum, and minimum results from the split season treatment fields. Maximum numbers reported indicate the operation that had the highest return to management and risk and minimum numbers indicate the operation that had the lowest return to management and risk.

Table 3. Results from treatment field enterprise analysis for the four operators participating in full season curtailment. Results reported are total operating costs, net receipts before factor payments, and return to management and risk.

TREATMENT FIELDS – Full Season	Average	Max	Min
Gross Receipts	$ 621.00	$ 621.00	$ 621.00
Total Operating + Fixed Costs	$ 220.30	$ 266.18	$ 152.74
Net Receipts Before Factor Payments	$ 400.69	$ 468.26	$ 354.77
Factor Payments	$203.50	$203.50	$203.50
Return To Management And Risk	$ 197.19	$ 264.76	$ 151.27

Table 4. Results from treatment field enterprise analysis for the two operators participating in split season curtailment. Results reported are gross receipts, total operating and fixed costs, net receipts before factor payments, and return to management and risk.

TREATMENT FIELDS – Split Season	Average	Max	Min
Gross Receipts	$ 467.50	$ 566.00	$ 369.00
Total Operating + Fixed Costs	$ 310.00	$ 325.40	$ 294.59
Net Receipts Before Factor Payments	$ 157.51	$ 240.60	$ 74.41
Factor Payments	$203.50	$203.50	$203.50
Return To Management And Risk	$ (46.00)	$ 37.10	$ (129.09)

3.2 Comparison of Reference vs. Treatment Fields

Treatment fields were compared to reference fields for each respective enterprise to determine profitability relative to the reference condition. Rather than use a true breakeven analysis as was used in the above sections (where revenues are equal to costs), we now use the profitability of the reference field as the comparison (rather than zero profit). As evidenced from results in Table 3, enterprise analysis indicated that the most profitable option for the participating hay enterprises was the full season agreement. Accepting full season payments was more viable because of the higher compensation payment and because of reduced variable expenses since the field was never mechanically harvested. When comparing full season treatment fields to the reference fields at $(196.03), producers in full-season agreements experienced a positive net profit on treatment fields of $393.22 per acre. Producers who accepted split season payments of $281 per acre also experienced an increase in income relative to the reference fields of $150.03 per acre.

These results indicate that treatment fields in full season agreements were $393.22 per acre more profitable than reference fields. Treatment fields under split season curtailment agreements at $281 per acre were still operating at a loss of $(46.00) per acre, however, the loss is less than reported under reference conditions – meaning these fields were $150.03 per acre more profitable than reference fields.

3.3 Partial Budget Analysis

Further analysis for the livestock producers participating in the study was conducted to determine and show changes/impacts to other enterprises in the operation. Producers who also have livestock (e.g. cow-calf operations) in their current ranch enterprise mix are very dependent on fall grazing pasture provided by their hay meadows. After harvest occurs, they normally turn their water back on their fields and irrigate for a few more weeks. This can provide them with up to 2 – 3 months of additional pasture to feed their cattle. This additional period where they do not have to rent pasture or feed hay is crucial for their profitability. With reduced irrigation impacting forage yields, they are responsible for procuring additional feed and/or pasture to sustain their livestock. This is due to the loss of regrowth that would occur post-harvest on irrigated hay production. By using a partial budget, we can show how changes in one enterprise (the hay enterprise) will affect the other enterprises in the operation. These additional costs are simply new costs imposed on the cow/calf enterprise due to changes in management of the hay enterprise.

The four operations, three full season and one split season, who also support livestock enterprises were entered into a partial budget analysis to determine if the loss of available grazing pasture and additional

expenses incurred for purchasing feed and/or pasture outweighed the benefits realized from the reduced irrigation payments. An average of the four operations is reported due to confidentiality for the single split season operation. Reporting an average rate in this instance is allowable, as the additional feed costs and irrigation payment rates are proportional for each of the treatments (full and split season). In each case, increases to income from water conservation payments, reduced net operating costs from treatment fields, and increased costs for rented pasture, purchased hay, and freight to haul livestock were considered. The changes in income and expenses were determined for the acres in full and split season treatment fields on a weighted basis to further validate the average rates reported for the four operations with livestock. Net Increase/Decrease to Income is calculated by using the following formula:

Net Increase/Decrease to Income = (Increase to Income + Reduced Costs) – (Added Costs + Reduced Costs)

To begin the analysis, the return to management and risk determined for these fields from the hay enterprise budgets, i.e. without the livestock component, were first entered into a partial budget in order to create a reference (control) scenario to accurately compare the addition of the livestock component to the four operations. Once the control scenario was created, the impacts to the treatment fields for the livestock operation were then determined and weighted based on the total acres in treatment fields for full season and split season irrigation practices. When considering just the direct impacts to fields (three fields under full season agreements and one under split season), the payments resulted in returns to management and risk being $221.18 greater for the four fields with reduced irrigation (see Table 5). This is due to both increases in revenue per acre from supplemental payments (average increase of $188 per acre across all four fields) and decreased costs due to reduced management (average decreased costs of $32.90 per acre). The difference was slightly greater for fields under a full season agreement (average difference of $271 per acre across those three fields) due mainly to the fact no harvesting operations (or costs) occurred in those fields and the per acre payment was able to more than offset foregone revenues.

However, when considering the impacts to the livestock portion of the operation, including costs of managing livestock to make up for lost hay/grazing from curtailed fields, participating in the water conservation program resulted in a relative loss of $(349.66) per acre across all four fields (see Table 6) relative to the reference field. While there was still a $188 per acre increase in revenues across all four fields, the additional costs required to manage and feed livestock resulted in an increase in costs of $537.94 per acre as compared to the refence fields. This leads us to conclude that payment rates would have needed to be $349.66 higher to return livestock producers participating in this study to normal (reference) conditions. Hay production provides both hay and regrowth late season grazing for livestock production, therefore reduced irrigation could negatively impact the profitability of any associated livestock enterprise, depending on the price and availability of supplemental hay and pasture. When looking at the partial budget analysis to determine added costs to livestock producers, they experienced a loss for both split season and full season agreements. Payments for livestock producers participating in this study would have needed to be increased by $349.66 to return their operation to reference conditions of $(196.03). Again, drought conditions for the 2020 season caused reduced yields and reduced availability of grazing pasture. As evidenced by the enterprise analysis, harvested hay yields were so low that they did not have enough on hand to last through the lengthy winters in Grand County and there was little water available for pasture regrowth which provides fall grazing for those producers who also have livestock. This caused direct impacts to the partial budget, which increased the payment rate needed to return operations to the reference condition.

Table 5. Results from partial budget analysis for four treatment fields (three full season, one split season) combined without additional purchase of livestock feed component.

Average Per-Acre across Full and Split Season Curtailment Fields without Livestock					
Additional Income	$550.63			**Additional Costs**	$230.07
Reduced Costs	$262.97			**Reduced Income**	$362.35
Total	**$813.60**			**Total**	**$592.42**
		Net Increase/Decrease to Income			**$221.18**

Table 6. Results from partial budget analysis for four treatment fields (three full season, one split season) combined with additional purchase of livestock feed component.

Average Per-Acre across Full and Split Season Curtailment Fields with Livestock					
Additional Income	$550.63			**Additional Costs**	$800.91
Reduced Costs	$262.97			**Reduced Income**	$362.35
Total	**$813.60**			**Total**	**$1,163.26**
		Net Increase/Decrease to Income			**-$349.66**

4. Discussion

To fully evaluate the effects/productivity of reduced irrigation beyond direct financial impacts, it is important to consider all impacts to profitability, efficiency, and production. Those impacts can be controllable (e.g., management practices) or uncontrollable impacts (e.g., weather conditions). The results of the budget analyses performed indicate the direct financial implications of payment rates for reducing irrigation; however, it is important to report any external factors outside of our control that had the potential to affect the results of our study. Farming and ranching in Grand County is known to be more challenging than other areas, given their high elevation, shortened growing season, and inclement weather (especially their long winters), similar to other high elevation areas in Colorado and other upper basin states, such as Wyoming. Lower areas of Colorado and the lower basin states do not have as many management considerations and less risk of weather events. Hay producers in these other areas are generally able to harvest more than one cutting of hay, and do not usually have weather events that require the responsibility of prolonged feeding for cattle herds. In addition, as mentioned above, 2020 was a very tough year for drought, causing further problems for operations participating in this study. Therefore, it is possible that under different circumstances and in different years, returns or losses can be affected (positively and negatively) due to the volatile nature of farming and ranching. Also, due to the smaller size of this study, having a larger group of participating producers could similarly affect determined returns and losses. However, this program also identifies how to evaluate and what water conservation programs look like during drought years, which happen often in agriculture, serving as a good baseline for future conservation programs in more productive years and with larger group participation. It is important to discuss conclusions drawn from the reported results that identify key factors that make temporary water conservation the most viable and successful, while also mitigating the potential damage to ranchers' livelihoods, as they bear the most risk of water conservation programs.

4.1 Drought Conditions

The severe drought in 2020 harshly impacted hay production yields of the study fields. According to Colorado averages for yield production determined by the National Agricultural Statistics Service, some producers in Colorado experienced up to one ton loss of yield. Participants in the study reported between 15% and 20% losses on reference fields from historical production yields. Some producers expressed during interviews that they were forced to employ abnormal management practices due to drought and the water conservation program, such as selling hay on the stem for a discounted rate, to make it through the year due to drought. These changes in normal management practices caused producers to incur higher variable costs. This implies that the reported results from enterprise budgets for reference fields return to management and risk were likely lower than normal due to 2020 being an outlier year. Increased return to management and risk could potentially reduce the determined profit benefits from water conservation payments ($393.22 and $150.03 for full and split season, respectively) relative to the reference fields.

The drought also caused a spike in hay prices and grazing pasture leases across the United States. Many ranchers needing to purchase additional hay to feed their cows paid much more, or in some instances, were unable to find available resources to compensate for yield reduction due to water conservation. Due to the increased prices of hay and grazing, producers seeking additional forage for livestock because of reduced production on treatment fields incurred significant additional costs to support their herds. This would cause a net decrease in income for the partial budget, meaning the determined increase to the payment rate necessary ($349.66) could be less in some years.

4.2 Coordination Across Operations

One key factor identified that is necessary for water conservation programs to be a viable, long-term option for agricultural operations is coordination across operations in a geographic area. Irrigation management can be complex in regular years and dependent on other property in proximity, given the changing nature of water levels, flow patterns, water rights and access, and tail waters. For example, one specific producer in the study spent more time and money making sure that the treatment field remained unirrigated for the study than would have normally been spent irrigating due to the tail waters from neighboring operations.

4.3 A Dynamic System

Hay production and livestock production in Grand County is a very dynamic system, characterized by many diverse operations. Some owners grow hay on large operations to subsidize their cattle production, others have small parcels that they grow and cut hay to sell, while others rent out or contract their ground to others to operate and manage. This makes it difficult to create a one size fits all water conservation program that will work for each operation. Given the results of this particular study, there is strong indication a program may be better suited for those that do not own livestock who can enter into full season agreements because they do not rely on late season pasture for livestock operations. In this analysis, the full season reduction was the most profitable option because it kept variable and operating costs low and the payment rate was also higher. This is an important consideration for potential future water conservation programs.

5. Conclusions

Remaining profitable in agriculture is tough. Resiliency to risk is key for farmers and ranchers to continue operating and weather the impending financial downturn and the low cycles of agriculture, while still appropriately managing available resources and ensuring the availability of water for future years. This small study of Grand County producers shows that there is an economic value associated with allowing operators that do not own livestock to earn additional revenue by voluntarily conserving irrigation water. Livestock operators who rely on the fall pasture after harvest will likely need substantially increased payment rates in order to participate. Other factors in addition to payments such as drought conditions, coordination across operations, and system dynamics also affect producers' overall profitability relative to water conservation.

Acknowledgements

The authors would like to acknowledge all the producers in Grand County who participated in interviews and shared their economic and production data for analysis. A special thanks to the Bruchez family at Reeder Creek Ranch for leading the project and data collection.

References

Sharp, R., Tranel, JE., and Dalsted, N. (2008). Agriculture and Business Management Note: Enterprise Budgeting. Retrieved from https://extension.colostate.edu/docs/abm/abmenterprisebudget.pdf. Accessed September 12, 2022.

US DOI Bureau of Land Management. (2022). U.S. Department of the Interior: BLM Colorado – What We Manage. Retrieved from https://www.blm.gov/about/what-we-manage/colorado. Accessed September 12, 2022.

USDA Economic Research Service. (2022). Agricultural Trade Multipliers Calculator. Retrieved from https://data.ers.usda.gov/ATM.aspx. Accessed September 12, 2022.

USDA National Agricultural Statistics Service, Census of Agriculture. (2017). Complete data available at https://nass.usda.gov/AgCensus. Accessed September 12, 2022.

USDA National Agricultural Statistics Service, Colorado Agricultural Statistics. (2021). Retrieved from https://www.nass.usda.gov/Statistics_by_State/Colorado/Publications/Annual_Statistical_Bulletin/index.php. Accessed September 12, 2022.