Brief #4: Incentivizing Participation

Determining the Impact of Voluntary Irrigation Withdrawals and Water Conservation Payments on Livestock Producers' Bottom Line

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Overview

- We evaluate the economic feasibility of voluntary irrigation withdrawals in grazing-based livestock systems in the Colorado region of the Upper Colorado River Basin.
- Our framework links reduced irrigation, forage production, and producer profitability, applied to the Western States Ranches irrigation withdrawal trials demonstration site.
- Results show that compensation requirements vary widely by enterprise type, but can be profitable for some enterprise types and irrigation shutoff dates, and increase when recovery effects are considered.

Purpose

This brief assesses whether voluntary irrigation withdrawals can be economically viable for livestock producers

The results and insight gained can help producers and policy makers:

- Quantify compensation needed to incentivize participation in water conservation programs
- Address a gap in understanding impacts on grazing-based livestock systems
- Inform design of agricultural water conservation policies in the Colorado River Basin

Approach

The analysis integrates production outcomes and partial budgeting to assess participation incentives under alternative irrigation withdrawal scenarios. We:

- Develop a partial budgeting framework comparing irrigation withdrawal scenarios to baseline irrigation
- Apply framework to Banner Ranch data from the Western States Ranches trial
- Model three enterprise types: market hay, leased pasture, and livestock grazing
- Evaluate both implementation-year and multi-year recovery impacts on production and profitability

Findings

Breakeven compensation is the minimum payment required to leave a producer no worse off under irrigation withdrawal

- It reflects the value of foregone forage production plus any additional costs associated with implementing the change.

Breakeven values vary widely by enterprise type, and recovery effects increase compensation

- For the implementation year only, breakeven values are about $70/AF (leased pasture), $331/AF (market hay), and $387/AF (livestock grazing)
- When multi-year recovery impacts are included, breakeven values rise roughly 60–70%

Moderate withdrawals can be economically viable, but aggressive reductions are not

- Strategies like a July 1 shutoff tend to yield small positive or near-neutral returns
- More intensive approaches (e.g., shoulder-month or full withdrawal) generate large negative returns at the field scale.

Insights

Feasibility depends on how conservation payments interact with market conditions and operational constraints.

Participation incentives differ across enterprise types

- Leased pasture operations face the lowest breakeven & livestock producers face higher values due to direct impacts

Outcomes are sensitive to prices and program design features

- Profitability depends on livestock prices, water payment levels, and conserved water volumes
- Higher cattle prices raise opportunity costs and increase required compensation

Operational flexibility plays a central role in determining participation feasibility

- Producers with multiple pastures or surplus forage may more easily participate
- Smaller operations may need to adjust herd size, rely on purchase feed, or alter grazing strategies

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Supplemental Information

Background and Motivation

As water scarcity intensifies in the Colorado River Basin, voluntary and compensated agricultural water conservation programs could gain traction as one tool to support regional conservation efforts. These programs would seek to reduce crop water use (i.e., crop evapotranspiration) by intentionally limiting irrigation while managing water stress. While the impacts of irrigation withdrawals on annual cropping systems are relatively well understood, the economic implications for livestock operations, particularly grazing-based operations that are dependent on irrigated pastures, are less well understood. This study contributes to that gap by developing a framework to assess the impact of voluntary irrigation withdrawals and water conservation payments on livestock producers' bottom lines. The framework is applied to data from the Banner Ranch site within the Western States Ranches (WSR) limited irrigation demonstration trial (described in Brief 2 of this report). Impacts are evaluated for the year of withdrawal (2023) and over the subsequent recovery period (2024-2026). Results are summarized as breakeven water conservation payment values ($/acre-foot) and used to identify the optimal within-season irrigation shutoff window at the field scale.

In livestock systems, irrigated pastures serve as an intermediate input, supporting forage that is directly grazed or cut for feed rather than produced primarily for market sale. As a result, the timing and extent of irrigation withdrawals can affect not only forage growth, but also grazing schedules, stocking capacity, haying feasibility, and ranch operations and profitability. By quantifying the impact of irrigation withdrawals on forage availability, we estimate lower-bound compensation levels needed to make participation in water conservation viable for three enterprise types: market hay, leased pasture, and livestock grazing enterprises. This approach helps ensure that conservation incentives targeting these operations reflect the realities of irrigated, grazing-based livestock production. The findings can inform the design of water conservation programs and policies that are feasible and effective for livestock operations.

Voluntary Withdrawal Scenarios

In Figure 1, Panel A, the rows illustrate stylized forage growth, livestock grazing, and haying cutting calendars for a mid-elevation grass pasture in Colorado's Upper Basin under a standard irrigation (SI) or 'no irrigation withdrawal' strategy. In the SI strategy, irrigation events occur regularly throughout the growing season, which extends from early April to

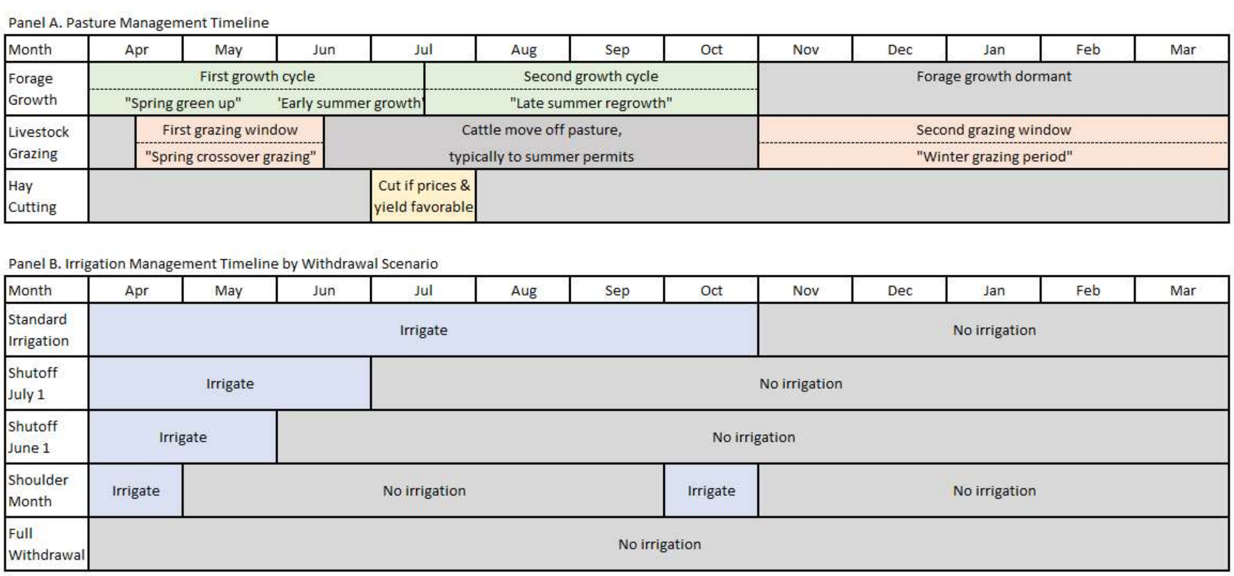

Figure 1. Pasture Management Timeline and Windows of Irrigation Availability by Scenario

late October. In Panel B, the rows represent SI and four alternative irrigation withdrawal treatments (described in Brief 2 of this report): shut off on July 1, shut off on June 1, shoulder month, and full withdrawal. The blue segments represent the time windows during which irrigation is available. Within those windows, irrigation occurs regularly and at levels identical to SI. Earlier shutoff dates represent progressively narrower windows.

An example of a Colorado pilot program that enacted water conservation payments is the System Conservation Pilot Program (SCPP) managed by the Upper Colorado River Commission. These types of irrigation-withdrawal scenarios (e.g., fallowing, split-season deficit irrigation) were allowed under the SCPP provisions.

Impact of Irrigation Withdrawals by Pasture Enterprise Type

As a starting point to investigate the economic feasibility of voluntary withdrawals, we consider three types of pasture-based enterprises: a hay enterprise, a leased pasture enterprise, and a livestock enterprise. In this context, an 'enterprise' refers to a distinct management activity within a farm or ranch business that uses land, labor, and capital to produce a marketable product. Here, the enterprise distinction is primarily used to differentiate among the intended uses of the forage. For this analysis, these enterprises are treated as mutually exclusive within a pasture (although the livestock enterprise may involve both haying and grazing activities, as in Figure 1). At the whole-ranch level, however, a single producer may operate multiple pastures, each with potentially a different intended enterprise objective.

Our focus is on assessing the impact of irrigation withdrawals on the livestock enterprise; however, we include the hay scenario because it represents a realistic management alternative and provides a useful point of comparison. For example, a landowner might manage a pasture primarily for market hay in a particular year or rent the land to a hay producer. In that scenario, irrigation withdrawals will result in lower hay yields (i.e., foregone production). The pasture enterprise represents a case in which a landowner does not own livestock themselves but leases the pasture for grazing. The impact of irrigation withdrawal is reflected here by a reduction in stocking day equivalents. The livestock enterprise could represent either a cow-calf or yearling/backgrounding operation. For ease of presentation, we consider a steer calf stocker operation in which irrigation withdrawals translate into reduced live weight gain. A similar approach could be applied to a cow-calf enterprise by expressing foregone production as a weaning-weight equivalent.

Table 1 summarizes consumptive use (CU) and economic production impacts for different combinations of enterprises and withdrawal scenarios. The CU values are from the WSR Banner site (see Brief 2 of this report). The values reflect outcomes in the year of irrigation withdrawal. We consider the additional impacts of withdrawals on subsequent-year production below.

Table 1. Summary of Consumptive Use (CU, inches/acre) and Estimated Pasture Production by Irrigation Withdrawal and Enterprise Type Scenarios

Withdrawal Scenario	CU (inches/acre)	Pasture Production by Enterprise Scenario		
		Hay Enterprise	Pasture enterprise	Livestock enterprise
		Forage Yield (tons/acre)	Stocking Equivalent (AUM/acre)	Weight Gain Equivalent (lbs/acre)
Standard irrigation	33.8	3.86	9.68	903.6
Shutoff July 1	31.6	3.51	8.80	827.9
Shut off June 1	27.9	2.93	7.35	713.6
Shoulder month	22.3	2.04	5.11	499.0
Full withdrawal	20.5	1.76	4.41	445.4

Estimated forage yield values were obtained by applying the consumptive use (CU) data for each treatment to the crop water production function in Cabot et al. (2026). The production function was applied twice: once for the first forage growth cycle from April to early July, and again for the second growth cycle from early July through October. It requires a minimum evapotranspiration (ET) of approximately 4.7 inches before a functional (non-negative) yield is produced each growth cycle. The estimated annual forage yield if 80% of production is utilizable was 3.86 tons per acre, with 55% and 45% of production occurring in the first and second growth cycles, respectively. This compares to the five-year average alfalfa hay yields of 3.56 tons per acre for 2021–2025 in Colorado (NASS, 2025).

Production for the leased pasture enterprise scenario is expressed as the stocking equivalent of the estimated forage yield. This value was determined by converting estimated forage yields into animal unit months (AUMs), assuming a daily forage requirement of 26.6 pounds per animal unit and a 30-day grazing month. An AUM represents the amount of forage needed to support one animal unit (typically a 1,000-pound cow) for one month and defines the total forage availability over a given area and time. This measure can be converted using coefficients to estimate stocking capacity for other livestock classes (for example, stocker cattle are typically 0.70 AUM per head). Under SI, this translates into a 9.68 AUM per acre equivalent to a 3.86 tons/acre forage yield.

Production for the livestock enterprise scenario is expressed as the live weight gain equivalent of the pasture production. This value is determined by converting forage yield into grazing days using daily dry matter intake requirements of 14.6 and 16.2 pounds per day for a growing steer calf during the spring cross-over and winter grazing periods, respectively (Oklahoma State University, 2025), and then converting grazing days into total pounds of gain using season-specific average daily gain (ADG) assumptions. The estimated total annual forage yield of 3.86 tons per acre is allocated across seasons, with 2.12 tons available during the spring/cross-over grazing period and 1.74 tons during winter grazing. Applying ADG assumptions of 2.0 pounds per day in the spring/cross-over period and 1.5 pounds per day in the winter period, the available forage supports approximately 903 pounds of live weight gain per acre per year.

To summarize, based on this analysis and assuming the SI strategy, a grower could produce and sell 3.86 tons of hay, lease pasture with 9.68 AUMs, or produce 903 pounds of stocker gain from each acre. The impacts of switching from SI to an alternative irrigation strategy are indicated by comparing the difference for each alternative strategy to the SI value.

Partial Budgeting Breakeven Analysis

We first calculate breakeven values for water conservation payments. These values indicate the minimum payment needed to leave a producer no worse off monetarily under an irrigation withdrawal scenario than under the baseline SI scenario, assuming a forage water use efficiency (WUE) of 1.8 tons per AF. This framework is likely to be most appropriate for producers who do not retain the forage for on-ranch use (such as landowners producing market hay or leasing out pasture) or for livestock producers who can implement irrigation withdrawals (e.g., a July 1 shutoff) with only minor operational adjustments. Examples of these smaller adjustments include purchasing supplemental feed or renting an additional pasture to replace the forgone forage production, rather than making larger structural changes to the enterprise, such as reducing herd size.

We obtain the breakeven values using a partial budgeting approach, which is appropriate for evaluating the impacts of proposed changes to an operation by comparing only the costs and revenues directly affected by the change (Kay, Edwards, and Duffy, 2016). In the context of agricultural water conservation, it can help determine whether a producer would be monetarily better off, worse off, or indifferent to participating in a voluntary irrigation withdrawal program as compared to continuing with SI. The impact of implementing the change on a producer's "bottom line" is summarized by *incremental profit*. Incremental profit is the expected change in profit, relative to a baseline or status quo scenario (i.e., the SI strategy). It is calculated as "total positive changes" minus "total negative changes." Positive changes can include increased revenues or decreased costs. Negative changes can include decreased revenues or increased costs. A positive value for incremental profit indicates the proposed change is expected to improve a producer's bottom line, whereas a negative incremental profit indicates the producer is better off without making the change.

Framework

The water conservation payment must be sufficient to offset the value of reduced forage production and added costs associated with the irrigation withdrawal, based on the implied conserved CU (CCU) relative to SI. This may include direct implementation costs, recovery costs, a yield drag in subsequent years, and compensation for added production risk. Breakeven occurs when the conservation incentive payment ($/AF CCU) is high enough that, when multiplied by the volume of conserved consumptive use (AF CCU), it equals or exceeds the combined value of reduced forage production and any additional implementation costs. More formally, the condition is:

$$T \times \Delta CU \geq P \times \Delta Y + \mathrm{C}$$

where T is the water conservation payment ($/AF CCU), ΔCU is CCU (AF/acre), P is forage value by enterprise type

(\$/ton, \$/AUM, or \$/pound of gain), ΔY is reduced forage production or equivalent (tons/acre, AUM/are, or pounds of gain/acre) by enterprise type under the irrigation withdrawal scenario, and C is implementation cost (\$/acre). Here, $P \times \Delta Y$ represents the value of foregone forage, which depends on the intended use (hay, leased grazing ground, live weight gain). The term C captures additional costs required to implement irrigation reductions. In addition to any costs to physically prepare the field or irrigation system, this could also include supplemental feed when appropriate, cost savings from reduced production, and/or monitoring, reporting, and verification costs or other conservation program administrative burdens if those costs fall on the producer. The breakeven payment T* is the water price at which this condition holds. If payments fall below this threshold, the producer incurs a net loss and is unlikely to participate. If payments exceed the threshold, it could incentivize some producers to participate in water conservation programs.

Results

The first set of breakeven values assumes a one-time enrollment decision and year-of-implementation impacts only. Table 2 presents the baseline results for a hay price of \$242/ton, a pasture rental rate of \$20/AUM, and a live-weight price for steer calves of \$1.96/lb. Recent prices for Colorado are shown in Appendix Table A2. For the hay scenario, we include additional cost savings of \$58/ton, representing reduced harvest costs (CSU Extension, 2024). For the pasture scenario, we assume the landowner would simply reduce the grazing lease agreement by the amount of foregone AUM and neither incur nor save on other costs. For the livestock scenario, we assume the producer reduces grazing capacity to match forage availability by grazing fewer stocker calves, resulting in less total live weight gain. The cost savings from reduced stocking are \$0.75/cwt of gain. An equivalent approach for a cow-calf operation (not shown) could be to include the cost of supplementing the herd relative to SI, assuming no reduction in herd size (i.e., supplement feed to maintain the same total weaning weight as the SI scenario).

Table 2. Breakeven Values by Enterprise Scenarios (\$/AF CCU)

	Value	Unit	Enterprise Scenario		
			Market hay	Leased pasture	Livestock grazing
Breakevens, Effects in implementation year only	Breakeven Price /a	\$/AF CCU	\$331	\$70	\$387
	Breakeven Ratio /b	Proportion	1.4	3.5	2.0
	SCPP Ratio /c	Proportion	2.1	25	2.6
Breakevens, Effects with recovery years included	Breakeven Price	\$/AF CCU	\$438	\$114	\$609
	Breakeven Ratio	Proportion	1.8	5.7	3.2
	SCPP Ratio /c	Proportion	2.1	25	2.6

Notes: a/ Breakeven price is the \$/AF CCU value that just compensates producers for the value of foregone forage by enterprise type. b/ Breakeven ratio is the breakeven price divided by the baseline enterprise price (hay price, pasture lease rate, live weight gain price). c/ SCPP ratio is the 2024 SCPP pilot program price (\$509/AF CCU) divided by the breakeven price.

The values in Table 2 can be interpreted in several ways: as a dollar threshold or as relative price ratios. The breakeven price answers, "At what water conservation price am I monetarily better off in a voluntary irrigation withdrawal program than under SI?" The results show substantial variation and clear differences across enterprise types. Leased pastures had the lowest breakeven price at \$70/AF, compared to \$331/AF for market hay and \$387/AF for livestock grazing. This indicates that leased pastures face the lowest hurdle to participation, all else equal, and these fields could be among the first to find participation feasible.

The breakeven ratio, defined as the breakeven price divided by the corresponding baseline forage value price (hay price, grazing lease price, live weight gain price), reinforces this pattern. The relative magnitudes themselves are not comparable due to the different units used, but these ratios provide a simple rule for considering breakeven as market prices change. For example, at a minimum, the hay price (\$/ton) must be 1.4 times the water conservation payment amount offered (\$/AF CCU) to make participation profitable or 'pencil out'. Many, but not all, producers would likely want to receive a rate above that ratio to consider participating, due to the increased administrative, planning, and risk considerations associated with participation.

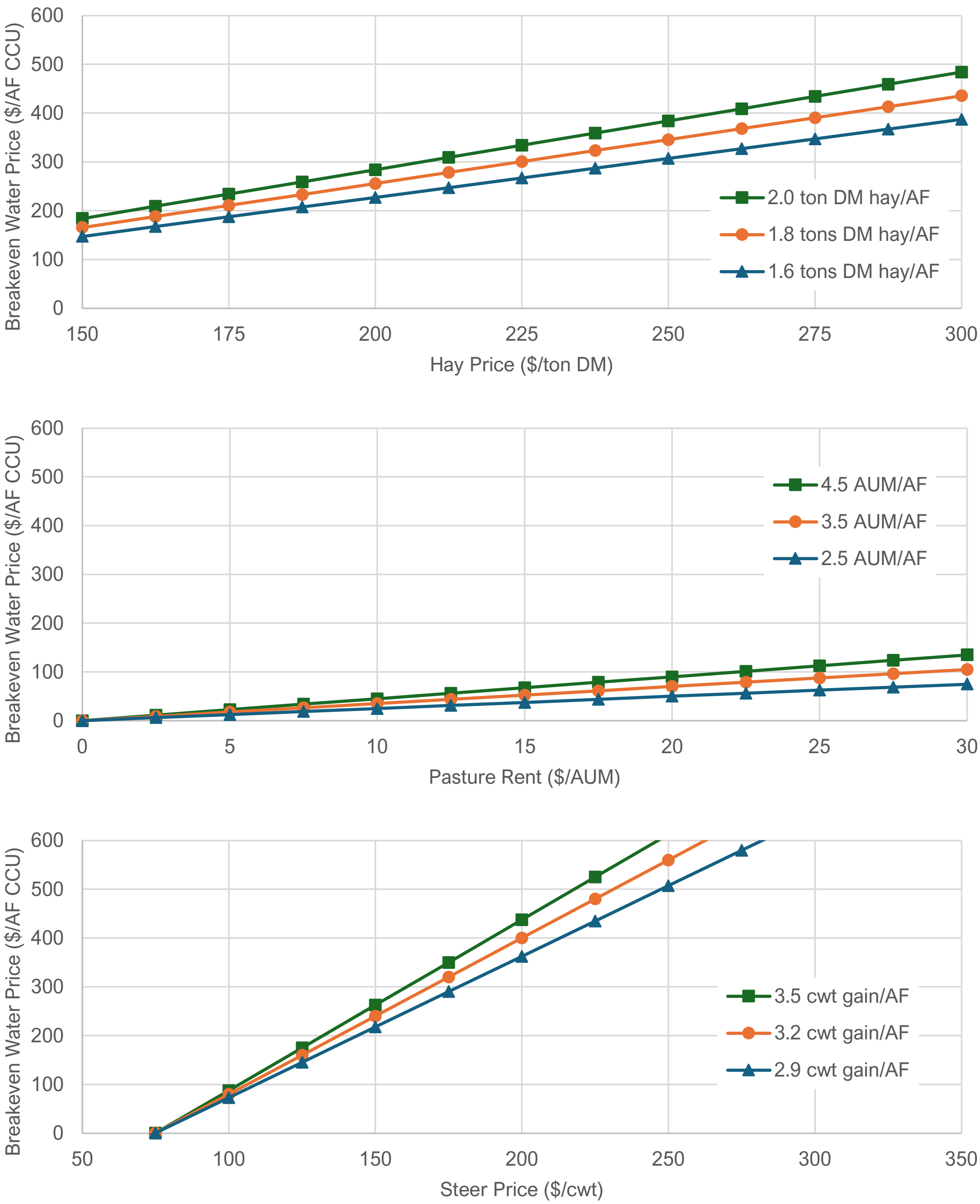

Figure 2. Breakeven values for water conservation payments ($/AF CCU) by enterprise type. Notes: The lines represent breakeven values ($/AF) for alternative water-use efficiency assumptions by enterprise type. The middle line (orange circles) represents the baseline case considered in this analysis. For a given price along the horizontal axis (e.g., hay at $250/ton), the corresponding breakeven water price is read from the vertical axis at the point where the breakeven line intersects the relevant enterprise price (e.g., approximately $346/AF at $250/ton hay in the baseline).

The SCPP ratio further supports this interpretation. Defined at the 2024 SCPP payment level for Colorado ($509/AF CCU) divided by the breakeven price, this metric provides a relative measure of how recent experience compares to the breakeven ratios. At $509/AF CCU, the SCPP ratios are larger than the breakeven ratios but only slightly in the case of the market hay (2.1 compared to 1.4) and livestock grazing (2.6 compared to 2.0) scenarios. The margin is largest for the pasture scenario (25.0 compared to 3.5), again suggesting that the owners of leased pastures will have a strong incentive to enroll in agricultural water conservation payments. Nevertheless, the baseline scenario results show that market hay producers and livestock producers also may face positive incentives to participate. The smaller margins, however, indicate that while participation may be viable, it is more likely to be dependent on operation-specific characteristics and conditions.

Breakeven prices for a wider range of water conservation prices, forage enterprise prices, and water use efficiencies by enterprise type are shown in Figure 2. The middle lines (orange circles) in each panel represent the baseline case considered in this analysis.

The results in Figure 2 show that breakeven payments are most sensitive for livestock grazing enterprises and least sensitive for leased pasture. This pattern is reflected in the slope of the lines. For example, at live gain prices above $225/cwt, enrolling a productive pasture used in a livestock operation would not be feasible at the SCPP payment rate, as the breakeven payment (green square line) exceeds the SCPP price of $509/AF. In contrast, a pasture used for market hay production remains feasible to enroll at that payment level across the full range of hay prices shown, up to $300/ton.

Pasture Recovery Considerations

In practice, irrigation withdrawals may have carryover effects on pasture conditions, forage productivity, and recovery costs in subsequent years, potentially increasing the effective compensation required for participation. The recovery effects that we assume are listed in Appendix Table A1. Those values are determined using a linear interpolation method for forage production and CU recovery over a three-year post curtailment period for July 1 shutoff and June 1 shutoff, and four-year period for the Shoulder Month and no irrigation (full season withdrawal) scenarios. For example, with a July 1 shut-off date, this translates to a present-value equivalent of additional forgone forage production in Years 2 and 3 of 0.44 tons, assuming that the SI yields observed in 2023 approximately represent average yields in the recovery yields.

The bottom half of Table 2 extends the breakeven analysis by incorporating recovery-year effects for the July 1 shutoff scenario, which raises the compensation required across all enterprise types. Breakeven prices increase from $331 to $438/AF for market hay, from $70 to $114/AF for leased pasture, and from $387 to $6097/AF for livestock grazing, reflecting the added cost of reduced productivity beyond the implementation year. These changes are also reflected in higher breakeven ratios, indicating a larger gap between water values and baseline enterprise returns when recovery dynamics are considered. Under these conditions, the SCPP payment of $509/AF continues to exceed the breakeven point for market hay and leased pasture but falls just below it for livestock grazing. This suggests that accounting for recovery effects may materially limit participation among livestock operations, even when program payments are sufficient for other enterprise types.

Field Scale Analysis

In the second set of results, we extend the analysis to the field scale by aggregating outcomes to a 36.2-acre parcel, consistent with the size of the Banner Ranch demonstration site. All results are reported at this field-scale equivalent to provide an operationally relevant perspective on the magnitude of both forgone forage production and CCU at the decision level where management decisions are often made. Grazing-dependent livestock operations in the Upper Basin face the complexity that pastures typically support multiple grazing periods within a season. The breakeven analysis above abstracted from these considerations by focusing on season-average reductions in consumptive use and forage yield. In contrast, the field-scale framework here captures how irrigation withdrawal strategies interact with seasonal forage availability, potential haying decisions, and grazing rotations. In doing so, it enables a more complete picture of irrigation withdrawal and forage tradeoffs that producers face under different scenarios throughout the growing season.

Framework

This analysis incorporates intra-seasonal impacts (documented in Brief 3 of this report), including effects on the grazing calendar, particularly the winter grazing period. For example, producers often leave residual biomass grown during the summer months standing in the field for later consumption by livestock during the winter grazing period. This limits flexibility in how and when forage removal events occur.

The timing of shutoffs plays an important role in both economic outcomes and field conditions. An earlier shut-off (e.g., June 1) typically results in higher CCU levels, increasing potential water payment revenue. However, this approach may also increase weed pressure, shift plant community composition (e.g., toward alfalfa dominance), and reduce overall forage yields, with potentially more difficult recovery in subsequent seasons. While hay cutting can be skipped and forage instead stockpiled for later grazing, total available forage may be lower. A later shutoff (e.g., July 1) generally results in lower CCU and, therefore, smaller water payments, but tends to maintain more stable field conditions. Weed pressure is often reduced, plant communities remain more consistent, and forage recovery may be less severe. Producers may still forgo hay cutting and rely on stockpiled forage, though the pasture will support fewer stocking days.

The scenario we model is described in Table 3, which outlines how forage production is allocated between haying and grazing across irrigation treatments and enterprise types. The table reflects a simplified but representative set of management assumptions about how producers adjust forage use in response to reduced irrigation. Together, these assumptions capture how producers may reallocate forage between haying and grazing in response to irrigation reductions to balance seasonal grazing and pasture health and recovery.

For the hay enterprise, forage in Period 1 (spring through early July) is fully harvested as hay under standard irrigation and moderate withdrawal scenarios. We assume forage yields over 1.0 tons per acre could be feasibly harvested. Under the no-irrigation case, however, only half of Period 1 production is hayed, with the remainder grazed, reflecting reduced yields and a shift toward utilizing available forage in place rather than baled. In Period 2, forage is generally hayed under standard and moderate withdrawal scenarios, but under more severe reductions (shoulder month and no irrigation), production is assumed to be fully grazed rather than harvested, consistent with lower yields (<1.0 tons) which limit the feasibility of a second cutting.

For the pasture enterprise, all forage in both periods is grazed across all irrigation treatments. This reflects a leasing scenario in which forage is not harvested mechanically (baled or other harvest method) but is instead utilized directly by livestock, with irrigation withdrawals resulting in proportional reductions in available AUMs.

For the livestock grazing enterprise, forage use is split between haying and grazing in Period 1 under standard and moderate withdrawal scenarios, with 40% harvested as hay and 60% grazed. As irrigation becomes more limited, a greater share of forage is allocated to grazing (e.g., 75% under the shoulder month and 50% under no irrigation), reflecting increased reliance on in-season forage to support livestock. In Period 2, all forage is grazed under standard and moderate withdrawal scenarios, while more severe irrigation reductions lead to lower overall utilization, with only partial grazing reflecting reduced forage availability and carryover into the winter grazing period.

Results

Figure 3 presents incremental profit (relative to standard irrigation) across enterprise types (shown in separate panels) and irrigation withdrawal scenarios (ordered from left to right along the horizontal axis by increasing CCU). The results for the market hay and livestock gain scenarios illustrate a clear tradeoff: more aggressive withdrawal strategies generate greater water savings but can sharply reduce profitability. Modest reductions (e.g., July 1 shutoff for livestock grazing and July 1 or June 1 shutoff for market hay) tend to produce small positive or near-neutral gains, while more intensive strategies (shoulder month or full withdrawal) lead to large negative returns at the field scale. This indicates that there is likely a narrow range of “middle-ground” strategies where water conservation and profitability can align, but beyond that range, economic losses escalate quickly.

The leased pasture enterprise scenario stands in contrast to the hay and livestock scenarios because returns trend consistently upward as water conservation increases. This is due to the relatively low baseline value of leased forage to the landowner and the absence of direct production costs or complex operational adjustments that they would need to implement as part of enrolling in an agricultural water conservation program. As irrigation is reduced, the loss in AUMs is modest in value relative to the compensation received for conserved water, so higher levels of CCU translate directly into higher net returns.

Table 3. Forage utilization by removal method and irrigation treatment						
	Utilization	Irrigation Treatment				
		SI	Shut off July 1	Shut off June 1	Shoulder month	No irrigation
Hay enterprise						
Period 1	% Hayed	100%	100%	100%	100%	50%
	% Grazed					50%
Period 2	% Hayed	100%	100%	100%		
	% Grazed				100%	100%
Pasture enterprise						
Period 1	% Hayed					
	% Grazed	100%	100%	100%	100%	100%
Period 2	% Hayed					
	% Grazed	100%	100%	100%	100%	100%
Livestock grazing enterprise						
Period 1	% Hayed	40%	40%	40%		
	% Grazed	60%	60%	60%	75%	50%
Period 2	% Hayed					
	% Grazed	100%	100%	75%	50%	50%

Notes: Period 1 is the first forage growth cycle from spring green-up to the end of the first forage growth cycle in early to mid-July. Period 2 is the second forage growth cycle and after, from mid-July to end of winter grazing period.

Sensitivity Analysis

Figure 4 presents a one-way sensitivity (tornado) chart for the July 1 shutoff treatment and the livestock grazing enterprise scenario. The chart provides a visual summary of which model parameters matter most for producers' bottom line and the direction in which they influence outcomes. Each bar shows the change in incremental profit when a single parameter is varied 10% above and below its baseline value, holding all other factors constant. The length of the bar reflects the degree of sensitivity, while the direction (left for negative, right for positive) indicates whether an increase in that parameter reduces or improves profitability. Variables are ordered from top to bottom by their relative sensitivity (±10%), meaning key drivers of economic outcomes are higher up in the figure.

Several parameters stand out, as a 10% change is sufficient to shift the baseline from profitable to unprofitable. Incremental profit is most sensitive to live weight prices, showing the importance of livestock market conditions in participation decisions. As cattle prices rise, the value of forgone gain from irrigation withdrawal also increases, reducing producers' incentive to enroll. Water parameters are also influential: both the CCU payment ($/AF) and the volume of CCU have large effects, highlighting the central role of program design (e.g., setting compensation levels, establishing monitoring and verification protocols). Production factors like forage response to water, grazing efficiency, average daily gain, and cost of gain also affect the outcome, but to a lesser extent. In contrast, hay price and baling costs play a relatively minor role in this grazing scenario.

Implications

The results provide several important implications: First, management implications differ depending on whether producers operate integrated livestock systems. For pasture owners without livestock, irrigation withdrawal may provide an opportunity to skip hay production and instead lease pasture for fall or winter grazing. This can reduce input costs (e.g., baling) and partially offset the loss of hay revenue, while avoiding direct impacts on a livestock enterprise. However, it may also affect existing relationships with hay buyers. For integrated pasture–livestock operations, the decision is more constrained by feed requirements. Producers managing multiple pastures and operating with conservative stocking rates, often generating surplus hay, may be able to enroll a subset of acres without disrupting overall feed

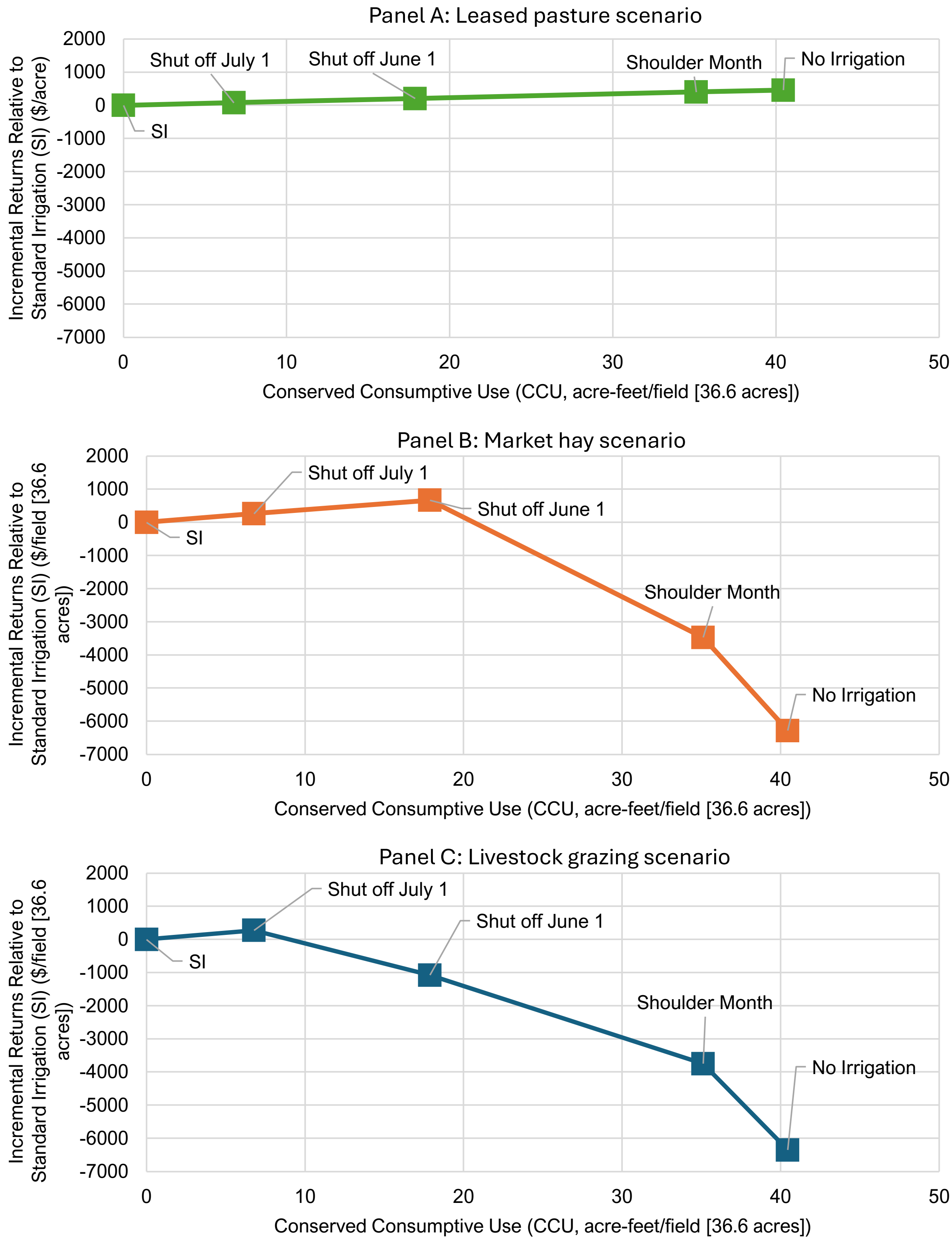

Figure 3. Incremental profit from agricultural water conservation program participation with water conservation payments at the field scale and by enterprise type. Notes: The vertical axis displays the increase or decrease in profit for each withdrawal treatment relative to SI. Treatments are organized left to right along the horizontal axis by the estimated conserved CU per 36.2-acre field.

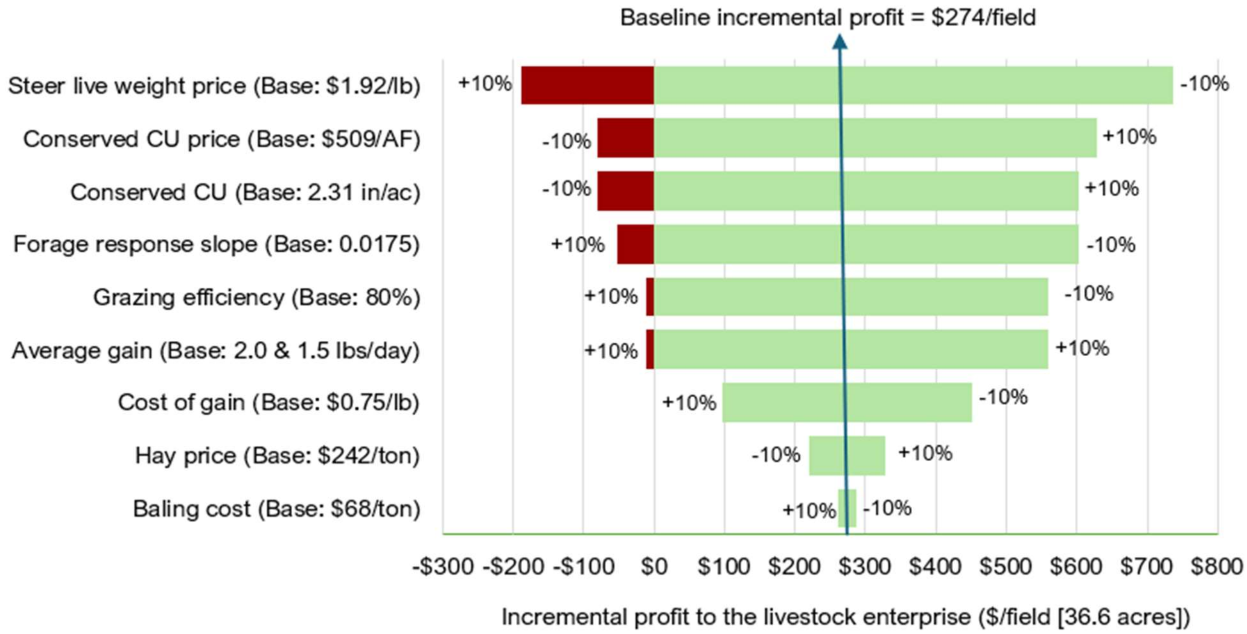

Figure 4. One-way sensitivity of incremental profit to +/- 10% change in baseline parameter value

balance. In contrast, producers relying on a single pasture or routinely harvesting hay for their own use will likely need to secure replacement feed, making participation more sensitive to hay prices and market availability.

Second, there will likely be indirect market effects. Pasture owners who lease land for grazing or produce hay for sale are likely the groups with the greatest incentive and capacity to participate immediately. These operations do not rely on the forage for their own livestock; however, the effects are not eliminated. Rather, they are shifted. Reduced availability of leased pasture and market hay could tighten regional forage supplies and put upward pressure on grazing lease rates and hay prices. As a result, the producers to whom these landowners rent ground or sell hay would be affected, particularly if participation were widespread among such landowners.

Third, from a program design perspective, this highlights the importance of participation guardrails. Limiting the share of acreage that any one producer can enroll each year could help maintain forage availability in local markets. In practice, this may encourage a rotational enrollment strategy among larger operations where producers cycle irrigation withdrawals across fields over time. Such an approach allows previously enrolled fields 3-4 years of recovery, depending on site conditions and withdrawal severity, before re-enrollment, helping to balance water conservation goals with longer-term regional forage productivity.

Lastly, livestock producers, whether participating themselves or responding to potentially tighter forage markets, may adjust herd and forage management strategies. One response might be flexible destocking, in which forage demand is reduced rather than attempting to maintain herd sizes and absorb higher input costs. This may include shrinking their base herds to adjust average stocking rates and/or increasing flexibility in certain production stages, such as weaning and backgrounding, to better match on-farm forage demand with summer forage conditions in the UCRB. In good years, they might regain more yearlings, whereas in dry years, they maintain fewer, or even wean and market calves earlier than normal, to further reduce forage needs.

Takeaways

The results suggest that CCU payments could incentivize participation in voluntary irrigation withdrawal programs under certain conditions. The breakeven condition represents a “no worse off” threshold rather than a guaranteed participation point. Producers may require payments above the breakeven level to compensate for uncertainty in yields, prices, and water availability (Mooney and Hansen, 2024). Particularly for middle- to late-stage adopters, actual participation in water conservation programs will likely require payments exceeding this level to account for risk, transaction costs, and individual producers' preferences. As a result, the estimates presented here should be interpreted as a lower bound on the compensation levels needed to induce participation under voluntary irrigation withdrawal programs. That said, some early-stage adopters are likely to experiment with voluntary irrigation withdrawals and participate in pilot programs and demonstration trials, and the lessons learned from those efforts can provide valuable information for other producers considering participation and for policymakers designing and administering conservation programs.

As final caveats, each component of the breakeven framework is context-specific, implying that estimated thresholds will vary across locations, years, and market conditions. The results presented here should therefore be interpreted as illustrative rather than exact values. For example, CCU will vary with soil characteristics, climate conditions, irrigation method, and water application levels. Reductions in forage will depend on the timing, duration, and intensity of the irrigation withdrawal. Implementation costs will vary depending on the specific adaptation strategy employed, such as purchasing supplemental feed, securing alternative grazing land, or adjusting herd size. In addition, these estimates are based on limited data in terms of years and sample size and could be refined in additional field-based studies. Nor does it consider basin-wide hydrological impacts, though these limitations may be addressed in future work.

Further Reading

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Table A1. Recent Hay Prices, Pasture Rents, and Steer Prices

Year	Hay, All Colorado	Hay, Alfalfa Colorado	Hay, Other Colorado	Pasture rent Colorado	Live gain National
	$/ton	$/ton	$/ton	$/AU Month	$/cwt
2014	206	207	201	17.0	
2015	179	179	173	17.0	
2016	151	151	160	17.5	
2017	172	171	180	19.0	
2018	220	219	220	19.5	
2019	231	231	228	18.5	
2020	212	209	221	19.5	
2021	224	221	234	19.5	177
2022	245	244	248	19.5	188
2023	259	260	252	20.0	223
3-Yr Avg	243	242	245	20	196
10-Yr Avg	210	209	212	19	
Std Dev	32.0	32.0	30.2	1.1	
Min	151	151	160	17	177
Max	259	260	252	20	223

Source: Colorado Agricultural Statistics Service (2024,2016) and USDA NASS (2026).

Table A2. Pasture Recovery Assumptions

Data (treatment)	Curtailment Year		Recovery Years (% of Standard Irrigation)			
	Year 1	% of SI	Year 2	Year 3	Year 4	Year 5+
Estimated CU (inches/acre) a/						
Standard Irrigation	33.77		100%	100%	100%	100%
Shutoff July 1	31.55	0.93	96%	98%	100%	100%
Shutoff June 1	27.91	0.83	88%	94%	100%	100%
Shoulder Month	22.26	0.66	74%	83%	91%	100%
No irrigation	20.51	0.61	71%	80%	90%	100%
Estimated Forage Production (tons/acre) b/						
Standard Irrigation	2.63		100%	100%	100%	100%
Shutoff July 1	2.20	0.84	89%	95%	100%	100%
Shutoff June 1	1.51	0.57	72%	86%	100%	100%
Shoulder Month	0.45	0.17	38%	59%	79%	100%
No irrigation	0.43	0.16	37%	58%	79%	100%
Estimated Water Use Efficiency (Tons/AF CU)						
Standard Irrigation	0.934		100%	100%	100%	100%
Shutoff July 1	0.838	0.897	93%	97%	100%	100%
Shutoff June 1	0.648	0.694	80%	90%	100%	100%
Shoulder Month	0.244	0.261	45%	63%	82%	100%
No irrigation	0.252	0.270	45%	63%	82%	100%

a/ CU estimates are from Brief 2 in this report. Recovery is assumed complete after three years for SI, July 1 shutoff, and June 1 shutoff and after four years for shoulder month and no irrigation scenarios.

b/ Forage estimates are from crop water production for grass pasture in Western Colorado in Cabot (2026)