Economic Assessment of a Water Demand Management Program in Wyoming's Portion of the Colorado River Basin

by

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Prepared for the Wyoming Chapter of The Nature Conservancy

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Table of Contents

The Colorado River Basin has been experiencing persistently dry hydrology since the turn of the 21st Century. The compacts that govern Colorado River water allocation for the states in the basin were developed based on data from a period with much more moisture than we have experienced in the last 20 years. Given this, the Upper Division States of Colorado, New Mexico, Utah and Wyoming have coordinated with the Department of the Interior and stakeholders throughout the Basin to evaluate proactive options for protecting critical elevations at Lake Powell, the Upper Basin's primary storage facility, to help assure compliance with the Colorado River and Upper Colorado River Basin Compacts.

The State of Wyoming, along with the other three upper basin states, is currently assessing whether or not demand management – voluntary, temporary and compensated reductions in consumptive use of water – will be helpful in protecting Wyoming water users by preventing shortage and subsequent regulation in the Basin. When this assessment began, the State of Wyoming, with the help of the University, began a public process to collect input on whether demand management could or should be part of a solution to protect Wyoming water users. At public meetings, attendees asked how a demand management program might impact local economies. In other words, if some producers in the Upper Green or Little Snake basins choose to irrigate less ground under a demand management program, how might that affect the economy locally and at a regional scale? This study attempts to answer this question.

This report presents the results of an assessment performed by the University of Wyoming's Agricultural and Applied Economics Department to estimate the local and regional economic impact of a demand management program, should such a program be implemented in Wyoming's portion of the Colorado River Basin. The study was designed by the University, in partnership with The Nature Conservancy, the Wyoming Stock Growers' Association and University of Wyoming Extension. It includes a survey of agricultural operators in the Upper Green and Little Snake river basins. The model built to estimate economic impact is based on key assumptions about agricultural operations which are spelled out in the study and have strong influence on the results. The model addresses three water delivery scenarios, each designed to generate different amounts of water to replicate potential demands on Wyoming in the face of shortage in the basin. A six-page summary of the study is available, as well as the full study for those who want to review the details of all three scenarios.

We appreciate this work that will help shed light on this important topic.

Sincerely,

Jennifer Lamb
The Nature Conservancy

Jim Magagna
Executive VP, Wyoming Stock Growers Association

Kelly Crane
Director, University of Wyoming Extension

Economic Assessment of a Water Demand Management Program in Wyoming's Portion of the Colorado River Basin: Abstract

Given the persistently dry hydrology that the Colorado River Basin has experienced over the past 20 years, four states in the Upper Colorado River Basin (Colorado, New Mexico, Utah, and Wyoming) are considering proactive options to ensure they meet their obligations under the Colorado River Compact of 1922. One option under consideration is a Demand Management (DM) program, in which water users in these four states would be compensated for voluntarily reducing their consumptive use of water. These consumptive use reductions would be stored and then released, if needed, to meet downstream Compact obligations.

This study assesses the impacts of a potential DM program in the Wyoming portion of the Colorado River Basin on agricultural operations, households, and communities in the region, if consumptive use reductions came from the agricultural sector, through decreased production of irrigated grass hay. A DM program would be voluntary, so the payment participants receive for enrolling acres in such a program would need to be sufficiently high to compensate them for the costs of participating. Based on assumptions regarding producer participation, regional economic impacts are estimated using a modified IMPLAN regional impact model constructed for the regional functional economy of the Wyoming portion of the Colorado River Basin.

Net regional economic impacts of a one-year DM program with a target volume level of 25 thousand acre-feet are estimated to range from $2.17 to $4.77 million in lost income and 95 to 146 in lost jobs, depending on how producers change their hay and livestock operations in response to the program. This range represents 3.12% to 6.85% of income in the regional agricultural economy and 0.04% to 0.10% of income in the overall regional economy. Because a realistic baseline for an uncertain future has not yet been established, by default, this study evaluates the economic impacts of a DM program relative to "business as usual" baseline rather than to a baseline of heightened risk of curtailment (involuntary and uncompensated reductions in water use to ensure downstream Compact obligations are met). Results are sensitive to assumptions about how irrigation reductions would affect hay yields in both the enrollment year and the following year.

Economic Assessment of a Water Demand Management Program in the Wyoming Colorado River Basin: Executive Summary

Background

Given the persistently dry hydrology that the Colorado River Basin has experienced over the past 20 years, four states in the Upper Colorado River Basin (Colorado, New Mexico, Utah, and Wyoming) are considering proactive options to ensure they meet their obligations under the Colorado River Compact of 1922. One of these options is a Demand Management (DM) program, in which water users in these four states would be compensated for voluntarily reducing their consumptive use of water. These consumptive use reductions would be stored and then released, if needed, to meet downstream Compact obligations.

Study Objective

To assess the regional economic impacts of a potential DM program in the Wyoming portion of the Colorado River Basin on agricultural operations, households, and communities in the region, if consumptive use reductions came from the agricultural sector. Because a realistic baseline for an uncertain future has not yet been established, by default, this study evaluates the economic impacts of a DM program relative to a *baseline of no curtailment risk*.

Strategies for accomplishing this objective:

- Conducted interviews, focus groups, and a **survey of agricultural water rights holders** in the Wyoming CRB to understand motivations for participating (or not) in a DM program.
- Developed **hypothetical DM program scenarios** and a **producer participation profile**.
- Estimated **regional economic impacts** using an IMPLAN model to determine how the participation payment, reduction in hay production, and replacement hay purchases resulting from a DM program would ripple through the regional and local economy.

Survey of Agricultural Water Rights Holders: Key Results

<u>System Conservation Pilot Program (SCPP) Participant Experiences</u>. Wyoming and other CRB states implemented the SCPP—a temporary, voluntary, and compensated water conservation pilot program—from 2015 to 2018. The survey conducted as part of this project asked SCPP participants about their experience in the program.

- Overall, survey respondents reported being satisfied with the program.
- Respondents generally reported that their household and county was about the same or better off as a result of the program and that the county would be about the same or better off with an expanded version of the program in the future.
- Positive effects reported: financial benefits of participation; brought the community together; helped people to realize the value of the region's natural resource base.
- Negative impacts reported: early drying up of hay fields with negative yield impacts in the following year; concern about long-term impacts of participation on water rights.

<u>Producer Interest in Various Demand Management Practices</u>. Agricultural water rights holders in the Wyoming CRB were asked what practices they might be interested in, if there was a voluntary program available to compensate producers.

- 58% of respondents (85 producers) indicated they would be interested in investments that reduce water use by enhancing delivery systems.
- 39% (57) indicated they would be interested in partial-season (irrigate early in season then shut off water), a version of which was implemented in the SCPP.
- 10% (15) indicated interest in no irrigation on some fields for an entire season.
- "No irrigation for an entire season" is the practice included in this study because consumptive use reductions for no irrigation are much easier to track and quantify in a DM program framework than partial-season reductions or irrigation investments.

Hypothetical DM Program Scenarios

The WY State Engineer's Office estimates, very roughly, that Wyoming's maximum exposure to curtailment would be 70-80 thousand acre-feet (KAF); and that more realistically, Wyoming's exposure would be 30-50 KAF, depending on water year conditions and historical consumptive use. This study models a ten-year DM program of three different sizes, each with an initial target volume level for the first few years of a ten-year program, with some possible replacement of water used or evaporated in later years (Table 1).

Table 1. Demand Management Scenarios

Scenario	Initial Target Volume	Replacement in Years 5, 7, and 9	Total CU Reductions in Ten Years
1	25 KAF	0	25 KAF
2	50 KAF	10 KAF	80 KAF
3	75 KAF	20 KAF	135 KAF

Producer Participation

The following assumptions are made regarding producer participation.

- **Flooded grass hay** acres are enrolled (not alfalfa or pivot grass).
- Management practice: No irrigation for the **full season.**
- Assume 70% **yield reduction in enrollment year** and **50% yield reduction** in next year.
- **Temporary and rotational**: No acre is enrolled two seasons in a row. (Thus abandonment of water rights is not an issue.)
- A DM program would be voluntary, so the payment participants receive for enrolling acres would need to be sufficiently high to compensate them for the costs of participating. Participation payment is assumed to be **$230/AF.**

Table 2 presents acreage and consumptive use reductions for a one-year 25 KAF program (Scenario 1) under these assumptions. However, if a DM program were large, more practices and different payment levels might need to be implemented to achieve the target reductions.

Table 2. Scenario 1 (25 KAF Reduction in One Year)

	Grass Flood (Acres)	% of County's Irrigated Acres	Consumptive Use Reductions (AF)	% of the Region's CU Reduction
Carbon	712	0.44%	1,275	5%
Lincoln	1,132	0.47%	1,884	8%
Sublette	8,788	0.53%	13,200	53%
Sweetwater	1,256	0.45%	2,213	9%
Uinta	3,143	0.39%	6,429	26%
Wyoming CRB	15,031	0.47%	25,000	100%

Regional Economic Impacts

Based on the hypothetical DM program scenarios and producer participation profile, regional economic impacts are estimated using a modified IMPLAN regional impact model constructed for Carbon, Lincoln, Sublette, Sweetwater, and Uinta counties and for the broader regional functional economy of the Wyoming portion of the Colorado River Basin.

Four types of economic impacts are measured in this study:
Private Enrollee Impacts: Net benefit to ranchers of enrolling acres. This is the participation payment of $230/AF less any replacement hay purchases. The program is voluntary, so producers would only participate if these impacts are **positive** and sufficiently cover income losses and risk.
Direct Impacts: Transactions between DM program participants and others in the local economy. Examples: DM program participant buys a new truck, hires less help for harvest.
Indirect Impacts: Firm-to-firm transactions in the economy. Examples: truck dealership pays its accountant; custom harvest company has less business.
Induced Impacts: Changes in household spending by enrollees and other households affected by the program. Examples: the accountant's household buys more groceries; custom harvest company employees reduce household expenditures.

Results are measured in two ways:
Value-Added Income: The income or wealth portion of industry output (includes employee compensation, proprietary income, other depreciation payments, property income, and indirect business taxes).
Employment: The number of jobs (both full-time and part-time) throughout the economy that derive, directly and indirectly, from the change in activity.

Table 3. Net Regional Economic Impact Estimates of a 25 KAF DM Program

	Option 1: Reduce Hay Exports		**Option 2: Purchase Replacement Hay**		**Option 3: Reduce Herd Size**	
Scenario 1. 25 KAF Initial Reduction with No Replacement in Later Years						
Participant Benefits ($)	5,750,000		1,181,988		5,750,000	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-1,671,954	-81	-2,599,785	-95	-3,847,142	-129
Indirect	-272,785	-9	-424,164	-11	-573,066	-12
Induced	-227,898	-4	-354,367	-5	-347,834	-5
Total	-2,172,638	-95	-3,378,316	-111	-4,768,043	-146

Hay Sector Results. Table 3 presents results for Scenario 1, in which 25 KAF in consumptive use reductions are achieved. In option 1, all DM participants are assumed to respond to the reduced hay production that results from enrolling acres in the DM program by reducing hay exports out of the region. In option 2, all DM participants are assumed to respond by purchasing hay to replace their lost production. No changes are made to livestock operations in the region under either of these options.

The top row of Table 3 indicates the participation benefits experienced directly by DM program participants. For option 1 of Scenario 1, this is the full $5.75 million in gross participation payment ($230/AF multiplied by the consumptive water use reduction associated with Scenario 1, which is 25 KAF). For option 2 of Scenario 1, this is the gross participation payment less replacement hay purchases, for a total of $1.82 million.

The net regional economic impacts for options 1 and 2 are all negative at a participation payment level of $230/AF. They range from a decrease of $2.17 million to $3.38 million in lost income and 95 to 111 lost jobs for Scenario 1. Net impacts are more negative for option 2 than for option 1 because program participants in option 2 spend a large portion of their participation payment on replacement hay instead of re-spending it locally.

Livestock operation impacts. This study also includes analysis of potential impacts to the livestock sector that might result from a DM program. A DM program could affect livestock production if DM participants reduce herd size in response to their decreased hay production. Net regional economic impacts on the Wyoming CRB economy when livestock operations are affected are estimated to be $4.77 million in lost income and 146 in lost jobs for Scenario 1.

Impacts in Context. It is useful to place these impacts into the context of the regional economy. The impact to the agricultural economy of a 25 KAF DM program (Scenario 1) would be -3.12% if all DM participants under option 1) (all participants reduce hay exports), -4.86% under option 2 (all participants purchase replacement hay, and -6.85% under option 3 (all participants reduce herd size) in response to reduced hay production. The impact to the overall regional economy would consequently be -0.04% for option 1, -0.07% for option 2, and -0.10% for option 3. This analysis has assumed that enrolled acres would be distributed evenly across the Wyoming CRB. These impacts could fall more heavily on some communities than others, depending on the location of enrolled acres.

Data Needs and Study Limitations

The analysis points to several scientific data needs:

- Results are sensitive to assumptions made about yield impacts. Decreasing the yield impact assumption by 10% reduces the size of the negative net impacts by 17% (for option 1, from -$2.17 million to -$1.80 million). Better yield impact data would improve accuracy of impacts.
- Partial-season irrigation reductions (much preferred by survey respondents to full-season irrigation reductions) could not be modeled for lack of reliable mid-season consumptive use estimates. Such estimates would be useful to have.
- This study does not consider the ecological impacts of changes in quantity and timing of flows that would result from implementation of a DM program. A significantly sized DM

program could result in significant changes on the landscape, though it is impossible to quantify the full impact of the changes with currently available data.

The IMPLAN modeling framework has limitations that should be noted:

- This analysis framework assumes well-functioning, large regional economies (that span multiple states) so that imported labor and inputs are replaced without short-run price or wage changes. For small economies that are integrated into larger well-functioning markets, this is a reasonable assumption.
- This analysis framework tends to overstate impacts, negative or positive, to the extent that producers and community members are able to adjust to reduced hay production in ways that are not directly captured in the IMPLAN modeling framework.

Table 4 contains a full list of assumptions made in this study. The following points in particular should be noted:

- Livestock estimates would be improved with a better understanding of ranch-level management of year-to-year variability in hay yields and livestock prices and multi-year decision-making on herd culling and management.
- Evaporation and conveyance losses that might reduce credited consumptive use savings are NOT included.
- All modeling done in this study assumes **temporary** participation, so **abandonment of water rights** is not at issue.

Key Points

- Net regional economic impacts of a 25 KAF program (with reductions occurring in a single year) range from $2.17 to $4.77 million in lost income and 95 to 146 in lost jobs, depending on how producers change their hay and livestock operations in response to the program. This range represents 3.12% to 6.85% of income in the regional agricultural economy and 0.04% to 0.10% of income in the overall regional economy. Where in this range the impacts of a DM program of this size would fall depends on how many DM participants would actually implement each of these three strategies in response to decreased hay production.
- Results are presented against a base case of normal water years with no curtailment. A future with higher curtailment risk may be a more realistic base case moving forward.
- Results are sensitive to assumptions about how irrigation reductions would affect hay yields in both the enrollment year and the following year. Better scientific data on the relationship between yields and irrigation reductions would increase the certainty around these results.
- Results are sensitive to water availability. Relative to economic conditions in the agricultural sector during an average water year, dry conditions have a larger impact on the agricultural economy than implementing a DM program in an average year. In other words, drought is harder on agriculture than a DM program of the size modeled here would be.

- A mitigation account could help alleviate some of the negative regional economic impacts associated with a DM program.
- A desire for model transparency and relevance to regional decision-making drives this study. The results of this study are highly dependent on the inputs. Help ground-truthing the model is **very welcome**.

Table 4. Summary Table of Study Assumptions

Demand Management Scenario Construction	
Program Length	Ten years
Program Size	Ranges from 25 to 135 KAF, never more than 25 KAF in one year
Evaporation	Evaporation losses for water stored through the program not considered
Producer Participation	
Crop Choice	Flood-irrigated grass hay
Management Practice	No irrigation for full season
Yield Impacts	100% yield reduction in enrollment year; 10% reduction in following year
Participation Payment	$230/AF
Acres Enrolled for 25 KAF	5% (1-in-20) of irrigated acres (5,000 acres)
Enrollment Frequency	Program is temporary and rotational, so no acre is enrolled two seasons in a row. (Abandonment of water rights is not an issue.)
Water Year Conditions	Precipitation, irrigated acreage, output prices, consumptive use estimates based on 2011-2019 averages
Pattern of Enrollment	Enrolled acres proportionally distributed across the five counties in the Wyoming CRB
IMPLAN	
Regional Hay Prices	Do not change as a result of program
Hay Trade Balance	Wyoming is net exporter of hay
Replacement Hay Origin	Any replacement hay purchased as a result of program is imported
Household Re-Spending %	26% of payments received (net of savings, capital flows, and imports) are spent within the region.
Regional Economic Impact Analysis	
Possible Producer Responses to Program Participation	Three possibilities (export less hay, purchase replacement hay, or reduce livestock herd size) are explored; actual response is likely a combination of all three)
DM Participant Decision-Making	Whether to purchase replacement hay or reduce livestock operations is a household (rather than business) decision
Analysis Baseline	DM Program regional economic impacts compared to a curtailment-free baseline rather than a possible future with heightened curtailment risk
Inflation	Not taken into account

1 Background and Study Objective

The Colorado River Basin (CRB) has been experiencing persistently dry hydrology since the turn of the 21st Century. Given these conditions, the states of Colorado, New Mexico, Utah and Wyoming have coordinated with the United States (U.S.) Department of the Interior and stakeholders throughout the Upper Basin to evaluate proactive options for protecting critical elevations at Lake Powell and to ensure compliance with the 1922 Colorado River Compact (1922 Compact).[1] These efforts are collectively called the Upper Basin Drought Contingency Plan (DCP). The DCP has three components: supply augmentation (for example weather modification practices such as cloud seeding), drought response reservoir operations, and demand management as described by the Demand Management Storage Agreement (DMSA).[2]

This study focuses on the demand management (DM) component of the DCP. Under a DM program, the Upper Basin states would conserve water that has historically been put to beneficial use to help them assure continued compliance with the 1922 Compact. Water user participation in a DM program would be voluntary, temporary and compensated. The states of Colorado, New Mexico, Utah, and Wyoming must decide whether to establish a DM program. In addition, no DM program can be established and implemented unless the four states and the Upper Colorado River Commission determine it is feasible and consistent with the terms of the DCP. If, after study, the four states collectively agree that a DM program is feasible consistent with the terms of the DMSA, they may then finalize and implement a program. A DM program can only be implemented if approved independently by each state's Commissioner to the Upper Colorado River Commission and the Commission as a whole.

No state would likely be able to conserve enough water in a single year to be helpful toward this goal of continued Compact compliance if the region experienced extended drought conditions. For this reason, one element of the DMSA authorizes the Bureau of Reclamation to allow the Upper Basin states to store water in certain federal reservoirs (the initial units of the Colorado River Storage Project Act [CRSPA]: Powell, Navajo, the Aspinall Unit, and Flaming Gorge) before the water is needed. The DMSA would allow for storage of up to 500 thousand acre-feet (KAF) conserved water in the initial CRSPA units.

Each state is likely to consider a number of issues as it explores the feasibility of a DM program. One such issue is the economic impacts of a DM program. Participation in a DM program would be voluntary, and participants would be compensated for any savings in consumptive water use

[1] Article III of the 1922 Compact requires that the Upper Division states of Colorado, New Mexico, Utah, and Wyoming do not deplete flows in the Colorado River at Lee Ferry, the dividing point between the Upper and Lower Basins of the CRB, below 75 million acre-feet of water for any period of 10 consecutive years exclusive of present perfected (pre-compact) water rights. Lake Powell, 15 miles upstream from this point, is the Upper Basin's primary storage facility to help assure continued compliance with the 1922 Compact as well as the Upper Colorado River Basin Compact of 1948.

[2] Agreement Regarding Storage at Colorado River Storage Project Act Reservoirs Under an Upper Basin Demand Management Program. U.S. Bureau of Reclamation, 2019. https://www.usbr.gov/dcp/docs/final/Attachment-A2-Drought-Managment-Storage-Agreement-Final.pdf.

they generated. However, there could be other impacts to the region, in addition to the direct positive benefits experienced by program participants. A DM program could have economic impacts that ripple through the regional agricultural economy. For example, a reduction in hay production could result in fewer harvesting jobs on ranch operations throughout the region. There might also be less activity at local businesses off the ranch as a result of reduced hay production. On the other hand, a DM program might also induce additional spending in the local economy, if participants spend the payments they receive locally.

Another issue states will explore as they evaluate the feasibility of a DM program is the economic impacts of *not* implementing a DM program. If the dry hydrology that the Colorado River Basin has experienced for the past 20 years persists, Upper Basin states may face a higher risk of "curtailment," under which Upper Basin states would be required to regulate post-compact rights to reduce consumptive water use in proportion to their historical consumptive use.[3] The negative economic impacts of curtailment could potentially be larger than the negative economic impacts associated with a DM program. The purpose of a DM program would be to reduce or remove entirely the risk of curtailment. Thus weighing the costs and benefits of a DM program involves an estimate of the benefits to the region associated with reducing or removing entirely the risk of curtailment.

<u>Study Objective.</u> The purpose of this study is to assess the impacts—both to program participants and to the agricultural sector as a whole—of a potential DM program in the Wyoming portion of the Colorado River Basin on agricultural operations, households, and communities in the region. This study assesses impacts assuming that the reductions in consumptive use occur through reductions in irrigated hay production. Reductions in consumptive use could also come from other sectors of the economy, for example municipal and industrial water users. However, this study is focused on a hypothetical case where all reductions in consumptive use come from the agricultural sector. This hypothetical case explores what the impacts of a DM program—both positive and negative—could be to agricultural communities in the Wyoming portion of the CRB.

This study is limited to evaluating the economic impacts of a DM program relative to a *baseline of no curtailment risk*. This allows for a clearer and more transparent statement of assumptions made in this study regarding how large a DM program in Wyoming might be, what producer participation might look like (for example number of acres enrolled, management practices adopted, and likely participation price), and what the assumptions and parameters should be for assessing economic impacts. The next step of comparing the economic impacts of a DM program to a future with a risk (or even heightened risk) of curtailment will involve additional sets of assumptions regarding long-term precipitation patterns, probability of curtailment, and impacts not just to agriculture but also to the municipal and industrial sectors. This broader

[3] Wyoming would meet this obligation by regulating off water rights in the Wyoming portion of the CRB in reverse priority (starting with the most junior and working backwards by priority date) until its obligation was met.

comparison will be an important next step to evaluating the feasibility and desirability of a DM program.

This study uses information from producer interviews and secondary data sources, such as the U.S. Department of Agriculture National Agricultural Statistics Service (USDA NASS), to create crop budget information for the Wyoming portion of the CRB. This budget information on costs and revenues of crops commonly grown in the region indicates the financial costs and benefits to ranchers of enrolling acres in a DM program. A DM program would be voluntary, so the payment participants receive for enrolling acres would need to be sufficiently high to compensate them for the costs of participating.

These firm-level decisions regarding participation are aggregated to the regional level and used as inputs into the estimation of regional economic impacts using a regional impact model (IMPLAN 2020), with modified estimates for production of flood-irrigated grass hay and pivot-irrigated alfalfa hay. Separate models are constructed for Carbon, Lincoln, Sublette, Sweetwater, and Uinta Counties and for the broader regional functional economy of the Wyoming portion of the Colorado River Basin. Finally, because changes in hay production may impact cattle operations, a separate broad regional model of the livestock sector is also constructed. The models are parameterized based on Yeatman (2020), Eisele et al. (2010), and Eborn et al. (2019).

The study also relies on Wyoming's experience with a recent pilot program. From 2015 through 2018, water users in Wyoming and other states in the Upper Basin were compensated for temporarily and voluntarily reducing their consumptive water use through a program called the System Conservation Pilot Program (SCPP). The purpose of the SCPP was to assess the likelihood of water users participating in a program designed to voluntarily and temporarily reduce their consumptive water use (UCRC 2018). Consumptive use (CU) is defined as the water used in plant growth and lost to evaporation. This is the metric by which saved water was measured in the SCPP and would need to be measured in any future DM program. Selected projects were compensated per estimated acre-foot (AF) of consumptive use savings. All but two SCPP projects in the Upper Basin were undertaken by agricultural water users, primarily ranchers growing grass or alfalfa hay. An estimated 47,213 AF of CU savings were produced for approximately $8.5 million from 64 projects over the four years of the SCPP. In the final year of the program, average price across the Upper Basin was $158/AF (UCRC 2018; 2019).[4]

A survey of agricultural water users in the Wyoming portion of the CRB was also conducted as part of this study. All agricultural water users in this region were asked questions about their ranch operations, irrigation water management, and demographic questions, to give a sense of how ranch operations, crop mix, and yields vary. Wyoming producers who participated in the

[4] This price is a volume-weighted average for estimated consumptive use reductions (reported in 2018 dollars). In Wyoming alone, an estimated 24,181 AF of CU savings were produced for approximately $2.2 million from 23 projects over the four years of the SCPP. In the final year of the program, volume-weighted average price in Wyoming was $150/AF.

SCPP were asked additional questions about household expenditures they made as a result of SCPP participation. Results were used to supplement the above-listed data sources for the firm-level and regional economic impact analyses. Survey results also provide insight into producer preferences for a DM program as well as some differences between producers in different regions of the WY CRB. After a brief overview of the general economy and agricultural sector of the Wyoming portion of the CRB (Section 2), Section 3 details responses to key survey questions and results, particularly as they relate to the assumptions made about firm-level participation in a DM program and the regional economic impact analysis.

Many of the details about what a DM program would look like have not yet been determined. Any DM program the Upper Basin states decide to implement might be structured similarly to the hypothetical program examined in this study or it might look quite different. This study must make a number of decisions about what the program might look like to determine participant benefits and regional economic impacts. These decisions are about program size (how much consumptive use reduction overall will occur through the program), rancher participation (practices undertaken, crops enrolled, range of feasible participation payments), and considerations about how location of acres enrolled are likely to affect results. These details are outlined in Section 4.

Section 5 describes the IMPLAN models used to determine how a DM program could potentially affect the agricultural economy and in turn the broader regional economy. It also details data, methods, and assumptions used to conduct the analysis. Section 6 presents results of the impact analysis.

Section 7 discusses the results and suggests areas where further data or research would be required to improve estimates of direct participant benefits and regional economic impacts of a DM program in the Wyoming portion of the CRB.

2 Colorado River Basin in Wyoming

2.1 Geography and Economy

The Colorado River Basin spans seven U.S. states before crossing into Mexico and reaching its terminus in the Gulf of California. As a whole, the Basin provides water to over 40 million people and supports economic activity valued at approximately $1.4 trillion annually (Wyoming State Engineer's Office [WSEO] 2016).

Wyoming's portion of the Colorado Basin covers over 17,000 square miles across the Green River and Little Snake River Basins (see Figure 2-1). The Green River originates in the northern Wind River Range flowing downstream and joining with the Big Sandy and Blacks Fork tributaries and entering the Flaming Gorge River and crossing the Utah state line. To the southeast of the Green River Basin, the Little Snake River is a tributary to the Yampa River in Colorado and incorporates the Muddy, Savery, Battle, and Slater Creeks before crossing into Colorado near Baggs, Wyoming. This report refers to the Green River and Little Snake Basins collectively as the Wyoming portion of the Colorado River Basin (Wyoming CRB).

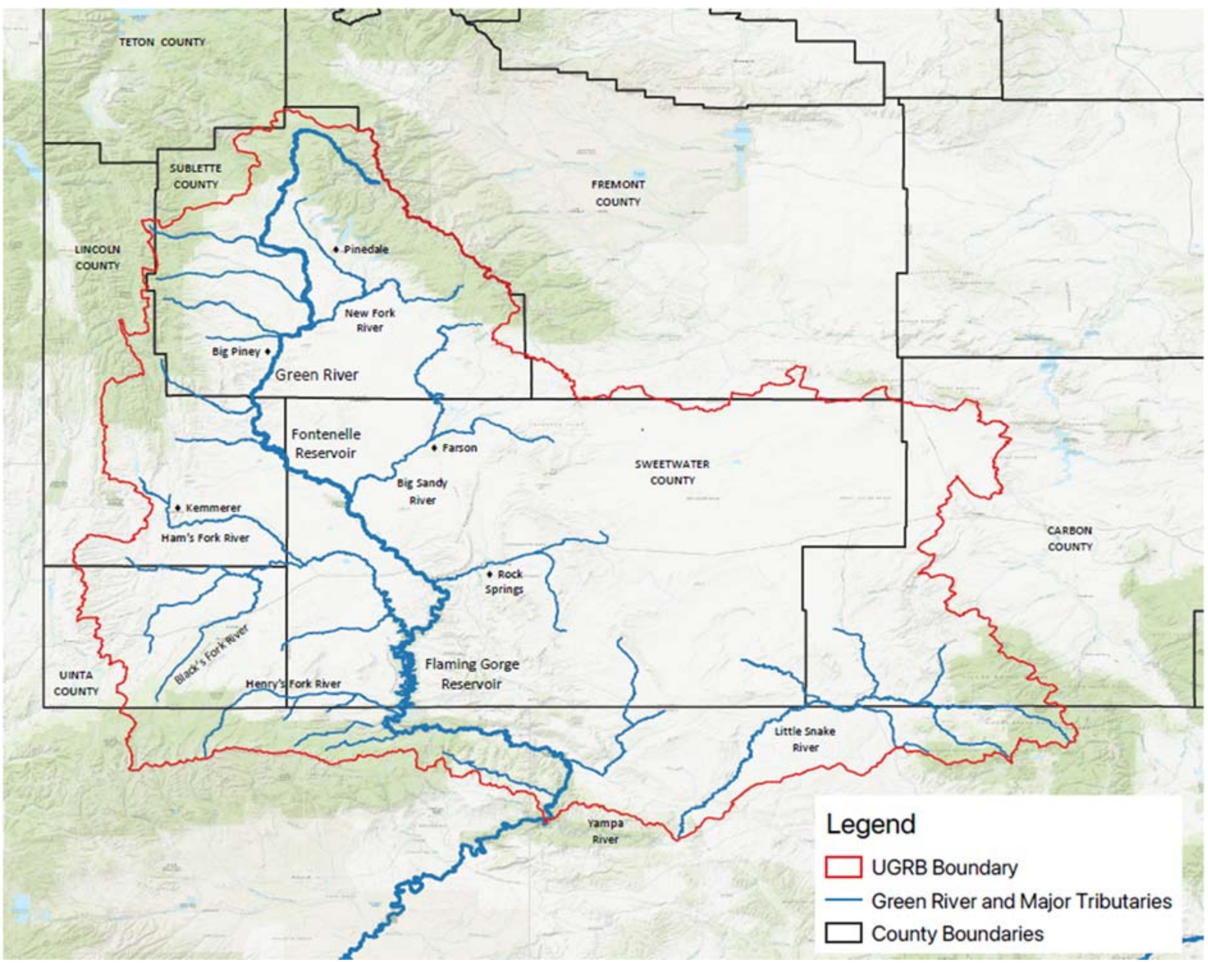

Figure 2-1. Wyoming's Portion of the Colorado River Basin

The Wyoming CRB is located in the Wyoming counties of Carbon, Lincoln, Sublette, Sweetwater, and Uinta (see Figure 2-1). Although the footprint of the Wyoming CRB is fully contained within these five counties, some parts of these five counties are not located within the Wyoming CRB. Table 2-1 (middle columns) indicates the area of each county (in square miles) and the percentage of each county that is in the Wyoming CRB. The economic data presented below is collected and reported at the county level. It consequently overstates the size of the economy located within the Wyoming CRB footprint. However, county-level data more accurately captures the functional economy of the study area than strict, watershed-based dataset would, given that economic activity follows county boundaries more closely than it does watershed boundaries. The final column of Table 2-1 indicates the percentage of the Wyoming CRB represented by each county.

Table 2-1. Wyoming Counties Located in the Wyoming CRB

County	County Area (square miles)	Portion of County in the WY-CRB (square miles)	Portion of County in the WY-CRB %	% of the WY-CRB in each county
Sublette	4,883	4,433	91%	21%
Lincoln	4,069	1,935	48%	9%
Carbon	7,896	2,414	31%	12%
Sweetwater	10,425	10,463	100%	50%
Uinta	2,082	1,592	76%	8%
WY-CRB	29,355	20,837	71%	100%

The population of the five counties in which the Wyoming CRB is located is reported in Table 2-2. Overall population was 108,870 in 2018, which is a slight decrease from the 2010 level. This is a slight overstatement of population within the Wyoming CRB, to the extent that portions of these counties are located in other basins (see Table 2-1). These data nonetheless provides an indication of the size of the Wyoming CRB economy and how it has changed over time. Over this same time period that the Wyoming CRB counties were shrinking slightly, Wyoming population grew just over 2% and U.S. population grew over 5%.

Table 2-2. Wyoming Population by County: 2010 vs. 2018

	Carbon	Lincoln	Sublette	Sweetwater	Uinta	Wyoming CRB	Wyoming	United States
2010 Population	15,848	18,098	10,261	43,574	21,089	108,870	564,483	309,326,085
2018 Population	14,971	19,434	9,813	43,051	20,299	107,568	577,737	327,167,434
2010-2018 Net Change	-877	1,336	-448	-523	-790	-1,302	13,254	17,841,349
2010-2018 Net % Change	-6%	7%	-4%	-1%	-4%	-1%	2%	6%

Source: Calculations by the Wyoming Regional Economic Analysis Project (WY-REAP) (November 2019) with data provided by the U.S. Department of Commerce, Bureau of Economic Analysis (BEA).

Table 2-3. Wyoming CRB Employment (Measured in Jobs) by County: 2010 vs. 2018

	Carbon	Lincoln	Sublette	Sweetwater	Uinta	Wyoming CRB	Wyoming	United States
2010 Jobs	9,599	9,833	8,157	29,291	12,791	69,671	385,059	172,901,700
2018 Jobs	9,815	10,891	6,698	28,100	11,857	67,361	405,010	200,746,000
2010-2018 Net Change	216	1,058	-1,459	-1,191	-934	-2,310	19,951	27,844,300
2010-2018 Net % Change	2%	11%	-18%	-4%	-7%	-3%	5%	16%

Source: Calculations by WY-REAP (November 2019) with data provided by the U.S. Department of Commerce, BEA.

Table 2-4. Real* Gross Domestic Product (in $millions) by County: 2010 vs. 2018

	Carbon	Lincoln	Sublette	Sweetwater	Uinta	Wyoming CRB	Wyoming	United States
2010	1,428	771	2,712	4,378	1,161	10,449	39,801	15,598,753
2018	1,324	793	1,684	3,837	907	8,545	38,040	18,638,164
2010-2018 Net Change	-103	22	-1,028	-541	-255	-1,904	-1,761	3,039,411
2010-2018 Net % Change	-7%	3%	-38%	-12%	-22%	-18%	-4%	19%

Source: Calculations by WY-REAP (November 2019) with data provided by the U.S. Department of Commerce, BEA.

*Real gross domestic product growth estimates are measured in chained (2012) dollars.

The regional economy of the Wyoming CRB counties supports approximately 60,000 jobs in total. Table 2-3 indicates county-specific employment and a snapshot of how employment levels changed between 2010 and 2018. The number of jobs in the Wyoming CRB region declined slightly over this time period, by just over 3%. Over this same period, the number of jobs in Wyoming and the U.S. increased over 5% and 16%, respectively. Gross Domestic Product (GDP) in Wyoming CRB counties decreased over 18% between 2010 and 2018 (Table 2-4). Wyoming GDP decreased by 4% over the same time period, while U.S. GDP increased by over 19%.

Although county-level data indicates some variability in population, job, and GDP changes, these three tables paint an overall picture of slight declines in these key economic indicators at a time when the Wyoming economy is holding relatively steady and the U.S. economy overall is growing. This is no doubt due to decreasing energy prices that have such a significant impact on Wyoming's energy-based economy. On the other hand, per capita income in Wyoming CRB counties has increased by nearly 10% between 2010 and 2018 (Table 2-5). This may reflect in-migration of retirees and others with significant wealth who have moved to southwestern Wyoming for the natural resource amenities rather than for job prospects.

Table 2-5. Real* Per Capita Income by County: 2010 vs. 2018

	Carbon	Lincoln	Sublette	Sweetwater	Uinta	Wyoming CRB	Wyoming	United States
2010	40,685	34,483	47,209	45,057	40,259	41,936	47,766	42,366
2018	53,976	39,807	47,493	49,144	37,247	45,734	55,816	50,347
2010-2018 Net Change	13,291	5,325	284	4,087	-3,012	3,798	8,050	7,981
2010-2018 Net % Change	33%	15%	1%	9%	-7%	9%	17%	19%

Source: Calculations by WY-REAP (November 2019) with data provided by the U.S. Department of Commerce, BEA.

* Real per capita personal income determined using the Implicit Price Deflator forPersonal Consumption (2012=1.00).

The economy in the Wyoming CRB counties is driven largely by mining, quarrying, oil and gas extraction, and associated support industries. The extractive industries sector is the primary employment sector for the region. Agriculture accounts for between 3% and 6% of jobs in the region, depending on the estimation method (U.S. Dept. of Commerce, Bureau of Economic Analysis).[5] Both the government and tourism sectors have been increasing in relative contribution and importance recently.

2.2 Water Use

Consumptive water use is water removed from a water resource system (for example through use by plants or evaporation) that is not returned to a stream or river. Agriculture accounts for the majority of consumptive use in the Wyoming CRB (see Table 2-6). In 2019, agriculture accounted for an estimated 453,125 of the total 566,975 acre-feet of consumptive use in the Wyoming CRB, or 80%. Municipal and industrial uses accounted for roughly 11% and reservoir evaporation for 5% of 2019 consumptive use.

Table 2-6. 2019 Consumptive Water Use by Sector

	Green River Basin		Little Snake River Basin		Wyoming CRB		LSRB as % of
Use Sector	**AF**	**% of GRB**	**AF**	**% of LSRB**	**AF**	**% of WY-CRB**	**WY-CRB:**
Agriculture	422,532	81%	30,593	65%	453,125	80%	7%
Municipal and Industrial	62,372	12%	282	1%	62,654	11%	<1%
Reservoir Evaporation	25,148	5%	1852	4%	27,000	5%	7%
Trans-Basin Diversions	1,515	0%	14,500	31%	16,015	3%	91%
Total	519,748		47,227		566,975	100%	8%

Source: WY-SEO.

Table 2-6 also breaks down Wyoming CRB consumptive use between the Green River Basin (GRB) and Little Snake River Basin (LSRB). Overall, the Little Snake River Basin accounts for 8% of consumptive water use in the Wyoming CRB and 7% of its agricultural water use. The trans-basin diversion from the Green River Basin is to the Bear River Basin and the trans-basin diversion from the Little Snake River Basin is to the City of Cheyenne.

The agricultural sector has the most variable consumptive use, ranging over the 2011-2019 period from a high of over 530,000 acre-feet in 2011 to below 370,000 acre-feet in 2013. During this same period, the other major consumptive use sectors had little annual variability. Annual variability in the agricultural sector is largely driven by water supply during the irrigation season linked to snowpack and water storage conditions.

[5] Accurate output and jobs data are difficult to obtain in rural counties with low population levels, because observations are often omitted to protect anonymity. IMPLAN has imputed values for output and jobs. Table 5-1 later in the report provides a sector-level breakdown of output and employment for the Wyoming CRB economy, using values imputed by IMPLAN.

2.3 Agricultural Sector in the Wyoming Portion of the CRB

Livestock production is the largest part of Wyoming's agricultural economy, generating over 60% of the value of production (USDA 2019). In the Upper CRB, the estimate jumps to over 78% of the region's agricultural economy (BEA 2020). Approximately 30% of the land in the region is private, of which over 88% is assessed as agricultural land (Wyoming EAD, 2010). This land provides important attributes to the region's larger industries in the form of water resources and ecosystem services.

Table 2-7 Average Irrigated Acreage and Consumptive Use by Crop and County (2011-2019)

	Irrigated Land				Crop Consumptive Use		
	Alfalfa Pivot	**Grass Pivot**	**Grass**	**Total**	**Alfalfa**	**Grass**	**Total**
County	acres	acres	acres	acres	AF/acre	AF/acre	AF
Carbon	401	3,498	12,242	16,140	1.98	1.79	28,960
Lincoln	919	2,703	20,228	23,850	1.81	1.66	39,835
Sublette	6,327	16,859	143,922	167,108	1.52	1.50	251,141
Sweetwater	11,996	3,087	12,927	28,010	1.94	1.76	51,438
Uinta	8,733	21,002	51,650	81,385	2.18	2.05	167,615
WY CRB	28,376	47,149	240,969	316,494	1.91	1.68	538,989

Source: WSEO WY 2019 Consumptive Use Report. Irrigated acres assigned to crop and county in Appendix C.

While this study is not directly focused on livestock, it is clear that much of the agricultural land in the Wyoming CRB is tied to livestock production. Alfalfa hay and grass hay represent virtually all irrigated acres in the Wyoming CRB (USDA-NASS).[6] Both crops are primarily used as feed for livestock production. Table 2-7 indicates acreage levels for these two crops and also distinguishes between flood-irrigated and pivot-irrigated grass hay. Averages are based on irrigated acreage during the years 2011 through 2019.

[6] A few acres of barley, oats, and peas are also grown in the region. Barley acres are numerous enough to be reported in the county-level USDA NASS data in a few of the years between 2011 and 2019. Oat and pea crop acres are not.

3 Survey of Agricultural Water Rights Holders

3.1 Survey Design

A survey of agricultural water rights holders (called producers below) in the Wyoming CRB was designed and implemented as part of this study. Producers were asked questions about their ranch operations, irrigation water management, and demographics, to give a sense of how ranch operations, crop mix, and yields vary across the Wyoming CRB. The survey instrument is in Appendix A. Survey design, implementation procedures, and comprehensive survey questions and responses are reported in Appendix B.

The survey was received by 474 agricultural producers with agricultural water rights in the Wyoming CRB in December 2019. A total of 147 producers responded to the survey, for an overall response rate of 31%.

Two versions of the survey were distributed. Most producers received a general version of the survey that contained questions about their operations, irrigation water management practices, and demographics. General version survey results are reported in Section 3-2. A different version of the survey was mailed to 22 of the 23 producers who had participated for at least one year in the SCPP.[7] In addition to the questions in the general version, this SCPP version also asked these 22 producers about their experiences with and reflections on the SCPP. Survey results from SCPP participants are reported in Section 3-3. The SCPP version of the survey instrument is located in Appendix A.

3.2 Survey Results Related to Ranch Participation in a DM Program

Comprehensive survey questions and responses are reported in Appendix B. This section contains a few key survey results related to ranch participation in a DM program. Most of the 147 respondents indicated that their operation was either cow-calf only (81) or cow-calf combined with yearling or sheep (33), or cow-calf combined with "Other," which was primarily hay production and/or leased pasture (Table 3-1). Respondents who indicated "Other" primarily produced hay or leased pasture to their neighbors.

[7] SCPP participant contact information was obtained from Trout Unlimited. The 23rd producer did not receive a survey because Trout Unlimited did not facilitate their SCPP participation.

Table 3-1. Type of Operation

Question: *What kind of operation do you have? (Mark all that apply.)*

Response	#	%
Cow-calf only	81	55%
Yearling only	4	3%
Cow-calf/yearling	26	18%
Cow-calf/sheep	7	5%
Cow-calf/other	8	5%
Combinations of yearling/sheep/other	8	5%
Other (primarily hay production/pasture lease)	13	9%
Total responses	147	

Survey respondents were asked to indicate in which regions of the Wyoming CRB they have irrigated acreage (Figure 3-1). Region boundaries were drawn based on differences in climate, soils, water availability, crop mix, and yields. Regional differences in survey responses were used to inform assumptions about crops grown, yields, irrigation water management practices producers might undertake, and potential cattle operation impacts of participation in a DM program.

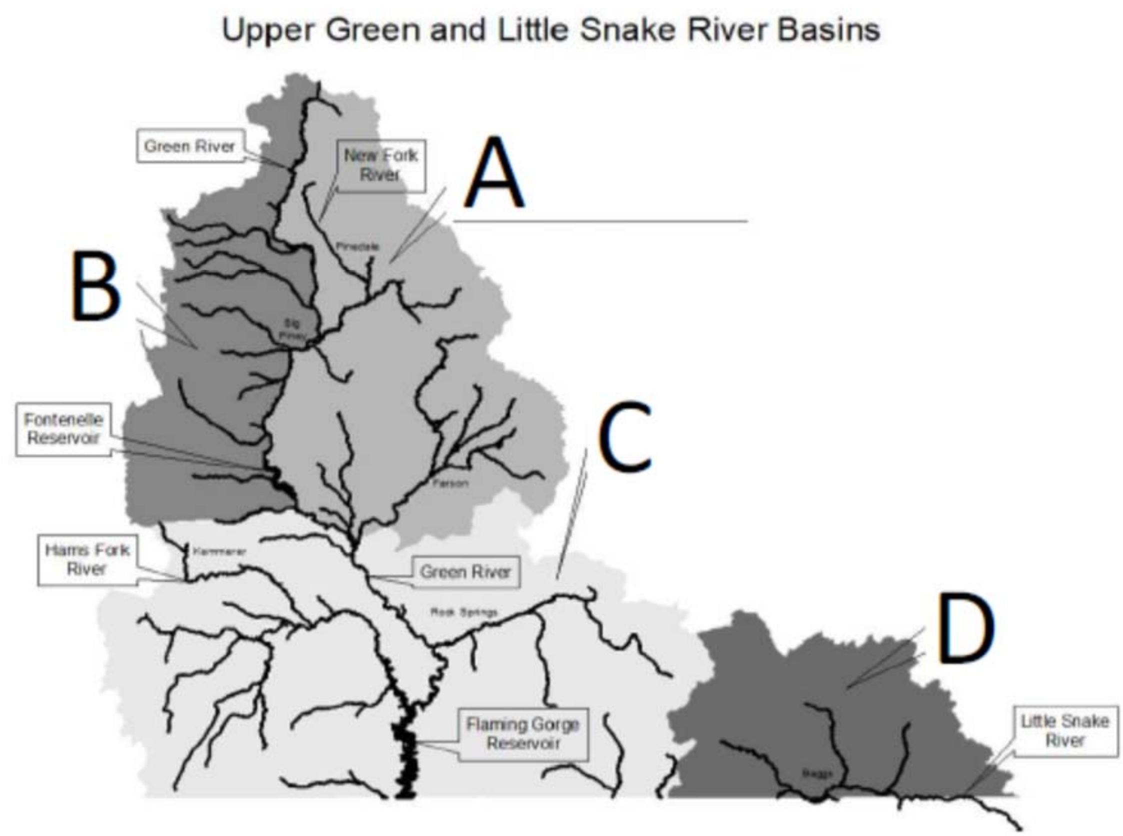

Figure 3-1 Survey Regions of the Wyoming CRB

Table 3-2 shows the irrigated lands reported by survey respondents in each of the four regions. Survey respondents on the upper west side (Region B) tend to have more irrigated lands than operations in the other areas.

Table 3-2 Responses and Irrigated Lands in Each Survey Region
Question: *In which location(s) do you have irrigated lands, and approximately how many irrigated acres in those location(s)?*

		Responses		Acres Reported by Respondents	
Region	**Location**	**#**	**%**	**Average Response**	**Region Total**
A	Upper East side	58	39%	540	31,293
B	Upper West side	43	29%	1,383	59,464
C	South Central	35	24%	526	18,405
D	Little Snake	11	7%	479	5,269
	Wyoming CRB	147		778	114,431

The three main crops grown in the region are irrigated pasture, grass hay, and alfalfa hay. Yields for the primary crops grown tend to vary by region. They also tend to vary markedly by water year. Table 3-3 presents average yields and number of cuttings by crop and water year type. Region-specific yields are reported in Appendix C.

Table 3-3 Survey Respondent Yields by Water Year Type, Crop, and Irrigation Method
Question: *For this question, please think about years in which there are enough frost-free days that yields are NOT negatively affected by cold temperatures. Please tell us your average per-acreage yields over the last 10 years for dry, average, and wet years for the following crops and irrigation methods.*

		Grass Hay Flood	**Grass Hay Sprinkler**	**Alfalfa Sprinkler**
Dry	Tons/acre	1.12	1.39	1.82
	Number of Cuttings	0.99	1.00	1.46
Average	Tons/acre	1.64	1.83	2.56
	Number of Cuttings	1.02	1.19	1.81
Wet	Tons/acre	1.96	2.00	2.83
	Number of Cuttings	1.03	1.25	1.77

The average yield values provided here are comparable to values reported by USDA-NASS from 2011 to 2019.

Table 3-4 asked survey respondents to indicate which management practices they might be interested in undertaking in exchange for compensation. By far the most popular practice was Practice 6 (Investments that reduce water use by enhancing delivery systems). Less popular were practices that would reduce applied water and hay production (Practices 2, 3, and 4). Producers were not asked in this question or anywhere else in the survey what compensation they might need to be enticed to enroll acres. If the payment level were high enough to include a premium in addition to compensation for participation costs, there could be more producers willing to enroll acres for full-season irrigation reduction.

Table 3-4 Producer Interest in Various Demand Management Practices

Question: *If there was a voluntary program available to compensate producers for a reduction in irrigation would you be interested in any of the following demand management practices?*

	Practice	**Yes**	**No**	**No Response**	**% Yes**
1	Split season (do not turn water back on after last cutting)	57	56	34	39%
2	Earlier harvest than normal (and then turn off water)	15	87	45	10%
3	No irrigation on some fields for the whole year	15	90	42	10%
4	No irrigation on the same fields for multiple years	7	95	45	5%
5	Forego the use of any stored water	17	79	51	12%
6	Investments that reduce water use by enhancing delivery systems	85	22	40	58%
7	Everyone on a tributary (or irrigation district) agrees to implement specified management practices (e.g., above programs)	47	58	42	32%
8	Everyone on a tributary (or irrigation district) agrees to save a certain amount of water (no specification of management practices)	37	62	48	25%
9	Other (specify)	8	9	130	5%
10	None of the above (mark yes and explain)	25	4	118	17%
	Number of respondents				147

Respondents could indicate interest in more than one practice. Respondents who indicated just one practice overwhelmingly chose Practice 6 (Investments that reduce water use by enhancing delivery systems). Respondents who indicated interest in more than one practice tended to select some combination of Practices 1, 6, 7, and 8. Substantial interest in joint management of water on a creek is logical, given that over half of survey respondents indicated that their water management decisions affect their neighbors and that their neighbors' water management decisions affect them.

3.3 Survey Results Related to SCPP Participants

Additional survey questions were sent to 22 ranch operations that participated in the SCPP for at least one year of the four years it was active (2015-2018). Of these 22 ranch operations, 14 responded (response rate of 64%). Respondents represent 60% of total acreage that was enrolled over the four years of the program. The small sample size increases the possibility of response bias. Results may not be representative because producers who are more enthusiastic about the SCPP may be more likely to respond. Responses may also be biased in some other way. However, only a 64% response rate is high for surveys of this type. This summary of SCPP participant results focuses on grass hay because only a very low number of participants indicated enrolling alfalfa hay acres.

Table 3-5. Impact of SCPP on Ranch Operation

Question: *Overall, what type of impact has program participation had on your operation?*

	Response	#	%
1	Positive impact	8	57%
2	Negative impact		0%
3	Both positive and negative	2	14%
4	No impact	2	14%
5	Missing response	2	14%
	Total responses	14	

The majority of respondents indicated that the program had a positive impact on their ranch operation (Table 3-5). (Two respondents indicated positive and negative impacts; two others indicated no impact.)[8] Major positive effects on operation related to the financial benefits of participation, though several respondents did also note that the program had brought the community together and helped people to realize the value of the natural resource base in the region. Negative impacts were related to the early drying up of hay fields and negative yield impacts in the following year. Concern about the impacts of participating on long-term water rights was also expressed.

The survey asked participants to comment on whether they observed changes or made changes to their operations as a result of SCPP participation. Six respondents indicated that grass hay yields decreased in the year following program participation; three indicated that they stayed the same. (Five did not respond to the question.) In interviews, participants reported just "making do" or having to purchase some hay to replace lost hay production. In terms of changes to operations, several reported turning off their water earlier than usual and a number indicated less aftermath grazing was available. One respondent indicated spreading cattle further, and another indicated running fewer cattle. Another indicated no changes to their operation because participation was just for one year.

The survey also asked participants whether they had observed any ecological impacts (related to grass composition, invasive species, wildlife presence, return flows) resulting from SCPP participation. Most participants indicated no change to these indicators or that it was too early to tell. A few respondents did indicate reductions in return flows and bird presence, and changes in grass composition; a few also indicated gains in return flows, invasive species coverage, stream bank erosion, and water turbidity.

All survey respondents reported using at least some of their compensation through the SCPP to make purchases for the ranch. Nearly half reported also spending money on debt reduction or savings. Most participants report not consulting with anyone outside their family when changing management practices to participate in the program, though a few reported

[8] Approximately two to three respondents did not provide responses to questions about their impressions of the SCPP. The same two or three individuals tended not to respond.

consulting with a financial manager, conservation district, or conservation non-governmental organization. (It should be noted that Trout Unlimited was heavily involved in facilitating participation in the SCPP.)

Overall, survey respondents reported being satisfied with the program. The one respondent who said they wished they had done something differently reported wanting to participate for longer. Respondents generally reported that their household and county was about the same or better off as a result of the program and that the county would be about the same or better off with an expanded version of the program in the future.

There could be systematic differences in responses between SCPP participants and non-participants, regarding farm/ranch characteristics, irrigation management practices, or demographic questions. Appendix B.3 explores this possibility in more detail. In summary, SCPP participants had larger operations on average than non-participants but were otherwise quite similar to non-participants, especially to non-participants located in the same regions as themselves. There are two notable exceptions to this. First, SCPP participants expressed more interest in several management practices than non-participants (split-season, early harvest, and the two cooperative, drainage-wide practices). Second, SCPP participants observed fewer negative agronomic and ecological impacts than non-participants expected to observe (grass composition and species diversity, wetland presence, and to some extent bird presence). This may suggest that SCPP participants chose to participate because the management practices suited them and the agronomic and ecological impacts were not anticipated to be too severe, given their particular operations' characteristics.

4 Firm-Level Considerations and Participation Benefits

As mentioned above, many of the details about what a DM program would look like have not yet been determined. Any DM program the Upper Basin states decide to implement might be structured similarly to the hypothetical program examined in this report or it might look quite different. This section outlines the structure of the hypothetical program used in this study to consider economic impacts.

4.1 Size of a Demand Management Program

Wyoming and the other Upper Basin states have not determined how the 500 KAF in storage capacity available through the Demand Management Storage Act might be allocated between them if they implemented a DM program. If this storage capacity were divided between the four states in proportion to each state's share of Upper Colorado River Basin water under the 1948 Compact, Wyoming would receive 14% of the 500 KAF of storage capacity, which is 70 KAF. Although the Upper Basin states have not publicly discussed if or how the 500 KAF of storage capacity might be divided among the four states, this 70 KAF could represent a potential quantity of water that a DM program in Wyoming might reasonably be able to store at the start of a program.

The largest initial target volume in this study is consequently 75 KAF, to mimic (approximately) 14 percent of 500 KAF. Two smaller initial target volumes of 50 and 25 KAF represent more moderately sized potential DM programs. No Wyoming state agencies or policymakers have suggested any specific target volume levels, initial or otherwise, for a potential DM program. These three initial target volumes were chosen to give an indication of potential regional economic impacts across a broad range of possible DM program sizes.

Several other reference points provide additional context for the range of initial target volumes selected for this study. First, during the 2018 irrigation season, the SCPP's final year, Wyoming participants enrolled 14,298 acres in split-season irrigation reduction (they did not turn their water back on after harvesting grass hay), which generated over 14.5 KAF in estimated consumptive use savings. There were 23 participants in 2018, with an average of 622 acres participating.

Second, WSEO estimates, very roughly, that Wyoming's maximum exposure to curtailment would be 70-80 KAF. More realistically, Wyoming's exposure would be 30-50 KAF, depending on water year conditions and historical consumptive use. This exposure could very likely be smaller, as well. For example, if a curtailment came at the tail end of a series of dry years, Wyoming's historical consumptive use would be small, which would reduce its obligation under curtailment. Estimates regarding the size of Wyoming's potential obligation under curtailment can only be approximate given the various climate, hydrology, and historical use considerations that factor into the calculation as well as uncertainties and unresolved issues in how a curtailment would be implemented. Reducing or avoiding this uncertainty regarding obligation size (along with the resulting disruptions to water use patterns and the associated negative economic impacts of curtailment) would be the purpose of a potential DM program. A potential DM program with negative economic impacts larger than those anticipated under curtailment would not be politically feasible, which places an effective cap on the size of a potential DM program.

This study examines potential economic impacts of a hypothetical DM program that operates for a ten-year period. If a DM program set an initial target volume of 25, 50, or 75 KAF, it might use the first few years of the program to meet this initial target volume. In later years, the DM program might decide to seek additional consumptive use reductions, to replace water that is either released to meet 1922 Compact obligations to the Lower Basin states or lost to evaporation. The size and frequency of replacement would depend on the size and frequency of Upper Basin releases.

Table 4-1 Demand Management Scenarios

Scenario	Initial Target Volume	Replacement in Years 5, 7, and 9	Total CU Reductions in Ten Years
1	25 KAF	0	25 KAF
2	50 KAF	10 KAF	80 KAF
3	75 KAF	20 KAF	135 KAF

Table 4-2 Consumptive Use Reduction Patterns by Scenario

	Scenario 1 Ten-Year DM Program (25 KAF Reduction in Year 1)	**Scenario 2** 50 KAF Initial Reduction with Occasional Replacement in Later Years	**Scenario 3** 75 KAF Initial Reduction with Occasional Replacement in Later Years
Year 1	25	25	25
Year 2		25	25
Year 3			25
Year 4			
Year 5		10	20
Year 6			
Year 7		10	20
Year 8			
Year 9		10	20
Year 10			
Total Reduction (KAF)	25	80	135

Table 4-1 lists the scenarios modeled in this study and Table 4-2 indicates the pattern of consumptive use reductions over time in each of the three scenarios:

- Scenario 1 has consumptive use reductions of 25 KAF in the first year of a DM program's operation but no replacement in later years. Results for Scenario 1 are presented in two different ways: Scenario 1a will present overall program results as one-year impacts and Scenario 1b (like Scenarios 2 and 3) will present results in terms of annual averages calculated over the ten years of the study period.

- Scenario 2 models a moderately sized program with an initial target volume level of 50 KAF (achieved through 25 KAF in consumptive use reductions in years 1 and 2) and also includes replacement of 10 KAF of stored water in years 5, 7, and 9 that is either released to meet downstream obligations or lost due to evaporation.
- Scenario 3 models a larger program with an initial target volume level of 75 KAF (achieved through 25 KAF in consumptive use reductions in years 1, 2, and 3) and assumes replacement in some later years of 20 KAF.

4.2 Firm-Level Decision-Making

The first step to estimating potential regional economic impacts of a hypothetical DM program is to understand an agricultural producer's decision of whether to participate. Such firm-level decisions aggregated to the regional level and serve as inputs into the impact model described in Section 5.

This study envisions that a typical DM program participant is an agricultural producer with a moderately-sized cattle herd who would enroll grass hay acres for one year by not irrigating for the full season. The producer might decide to do one of three things in response to the resulting loss in hay production. First, they might simply reduce hay production without making any other changes to their operations. This could mean that they absorb the loss of hay production into their operation by stretching their other hay resources a bit further or that they reduce hay exports from the region. Second, they might use a portion of the compensation they receive from the DM program to purchase replacement hay. Third, they might reduce their cattle herd size in proportion to the lost hay production.

This hypothetical producer would potentially participate for one year, or maybe three out of five years, so that their participation in the program is clearly temporary and not putting the producer in danger of abandonment of their water right.[9] The requirement that participation be temporary makes it less likely that a producer would reduce herd size in response to the DM program, but the program may be attractive to a producer who was already considering a change in their cattle operations.

4.3 Program Participation Considerations

The decision to participate in a DM program would depend on a number of operation-specific factors, including the role that hay production (or fall pasture) plays in the ranch operation or an interest in maintaining existing return flow patterns for wildlife habitat. Regardless of whether these or other factors play a role in decision-making, a good place to start in thinking about the decision to participate is the producer decision about what crops to enroll and what

[9] Under Wyoming water law, any water right not put to its permitted beneficial use within the previous five years could be forfeited through an abandonment procedure. Thus any failure to use available water under a water right, including voluntary participation in a potential DM program, for fewer than five successive years should not result in a forfeiture of the right.

management practices to adopt. Also key is the financial implications of enrolling acres and the determination of a participation payment.

Crop Choice. The three crops considered for enrollment in a DM program are flood-irrigated grass hay, grass hay under pivot, and alfalfa hay under pivot. These are the crops most commonly grown in the Wyoming CRB. Appendix C reports estimated per-acre consumptive use, crop yields, hay prices, and production costs for these crops at various locations across the region. From a purely financial perspective and based on the crop budget information in Appendix C, the most profitable way to generate consumptive use reductions is to enroll flood-irrigated grass hay acres. Focus group conversations and individual interviews affirm that producers would be more likely to enroll flood-irrigated grass hay acres than grass or alfalfa hay under pivot, primarily due to the higher yields they receive under pivot.

This study assumes that producers will enroll flood-irrigated grass hay acres rather than alfalfa or grass hay acres under pivot. This determination is based on averages that do not take into consideration individual differences between operations. A producer could determine that it would be more profitable for their operation to enroll acres of other crops besides flood-irrigated grass hay (for example alfalfa or grass hay under pivot), based on firm-specific circumstances.

Management Practice. The survey described in Section 3 asked producers about their interest in management practices to reduce consumptive use through a DM program. Practices 1 through 5 involve reducing the amount of water applied to fields. Reductions in consumptive use from these methods are relatively straightforward to measure in a DM program.

Consumptive use reductions from increases in efficiency (Practice 6) was by far the most popular practice listed in the survey. However, this practice would not necessarily produce consumptive use reductions, and any reductions that were achieved through this practice would be difficult to measure in a DM framework. Yield improvements that result from increased efficiencies, while desirable from an agricultural operations perspective, do not result in decreased crop consumptive use of water. There may be some ways that efficiency increases can be made to work within a DM framework that are worth exploring in the future, but they are not modeled in this study.

The idea of having all irrigators on a tributary or within an irrigation district work together to achieve consumptive use reductions (Practices 7 and 8) was also popular. This is probably because collective action at the tributary or irrigation district level would likely reduce conflict with downstream neighbors that might result from changes in water use patterns.

The practice modeled in this study is no irrigation for the full season. The survey results indicate that this was not a popular practice with survey respondents; only 10% said they would participate. This may be an indication that the larger scenarios modeled in this study would not be popular enough with agricultural producers to generate the target volume levels from entirely within the agricultural sector, or that they may require higher levels of compensation.

This study models the full-season reduction in spite of this lack of popularity because consumptive use reductions from full-season irrigation reduction are substantially easier than partial-season irrigation reductions to track and quantify. Even after water is shut off, a crop is still consumptively using water that is being stored in the soil. In a DM program, a producer would not get "credit" for consumptive use reductions until the point at which all the water applied before the shut-off date had been used by the crop or evaporated.[10] Two hydrologic studies are currently underway in the Upper Green River Basin and Colorado to help determine how crop, soil type, and land location (bench or bottomland) affect the soil moisture profile after water has been shut off in high-elevation mountain valleys. When these issues have been resolved, it may be easier to make reasonable assumptions about consumptive use savings associated with partial-season irrigation reductions.

There is little information available on the yield impacts associated with foregoing irrigation on alfalfa and grass hay for an entire season. A 2020 study similar to this one and prepared for the Water Bank Work Group (WBWG) in Colorado analyzed regional economic impacts of a potential DM program in Colorado (BBC Consulting 2020). This WBWG study relied on field trials conducted by Dr. Joe Brummer in Colorado for its estimates of yield impacts. Based on the results of Dr. Brummer's field trials, the WBWG study assumed a decrease in yields of 70% in the year that acres are enrolled and a decrease of 50% in the following year (during which full irrigation occurs as usual).[11] This study is from the west slope of Colorado rather than Wyoming, but some trials occurred at high elevation on grass hay, suggesting that results might be comparable in the Wyoming CRB.

For simplicity and lack of better information, this study also assumes a 70% yield reduction in the enrollment year and a 50% yield reduction in the following year. Negative yield impacts in the enrollment year and the following year may quite likely be higher or lower than these levels in any given year, depending on specific field characteristics and water available to enrolled fields through sub-irrigation and precipitation. Section 6 includes sensitivity analysis to indicate how regional economic impact estimates vary in response to this yield impact assumption.

We model the full-season irrigation reduction practice because it is transparent and relatively straightforward to model and because it fits well within the framework of a DM program. However, survey responses suggest that if a DM program were large, and if the consumptive use reductions came from agriculture, a variety of practices might need to be implemented to achieve the target reductions.

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[10] Under the SCPP, participants were credited with estimated consumptive use reductions that were calculated before the start of the season. Actual consumptive use reductions were likely smaller. Regional policymakers have indicated that in any future DM program, the accounting would need to be improved so that funders and regional policymakers can be assured that consumptive use reductions paid for are actually realized.

[11] Agronomic Responses to Partial and Full Season Fallowing of Alfalfa and Grass Hayfields. Update 2015 & 2016. Power Point presentations. Dr. Joe Brummer. Colorado State University.

Participation Payment. Participation in a DM program would be voluntary and compensated. Payments provide direct financial benefits to participants to compensate them for the extra costs they would face by participating. The payments also potentially have positive impacts on the community, to the extent that participants spend their payments in the local economy.

One way to calculate a participation payment level is to determine the "break-even" cost of participation. The break-even cost covers the cost of participating in a DM program. Since a DM program would be voluntary, no producer would participate unless their net operating income were covered at a minimum. Net operating income (NOI) is revenue minus agricultural operating expenses associated with producing a crop. (In the context of the crops and irrigation methods used in the Wyoming CRB, agricultural operating expenses are primarily irrigation and harvest costs). NOI is the income available to producers under normal operating conditions to cover reasonable and necessary operating expenses such as salaries, wages, and property taxes. Following are two ways that the break-even cost of participation might be calculated.

Include replacement hay purchases. If a participant is also going to purchase hay to replace lost hay production, replacement hay costs must also be covered. Table 4-3 estimates break-even costs for alfalfa pivot, grass hay pivot, and grass hay flood acres, calculated assuming that net operating income and replacement hay costs are covered. Replacement hay costs are calculated as hay price ($/ton) multiplied by the quantity of hay anticipated to have been produced on an enrolled acre (anticipated yields), in the absence of a DM program.[12] Appendix C contains more information on the data used for these calculations. In particular, Table C-5 indicates NOI and per-acre break-even costs for each crop and county. For example, the estimated per-acre break-even cost for grass flood in Sweetwater County is $457/acre. This is net operating income (hay price multiplied by yield minus agricultural operating expenses) plus the cost of purchasing replacement hay (hay price multiplied by yields):

Break-Even Cost #1 = NOI + Replacement Hay Purchase Costs.

Table 4-3 Break-Even Costs by Crop in an Average Year

Break-Even Costs by Crop in an Average Year						
County	Alfalfa Pivot		Grass Pivot		Grass Flood	
	Per Acre $/acre	Per Acre-Foot $/AF	Per Acre $/acre	Per Acre-Foot $/AF	Per Acre $/acre	Per Acre-Foot $/AF
Carbon	761	384	531	297	456	255
Lincoln	813	450	717	430	463	278
Sublette	726	477	644	428	399	266
Sweetwater	769	397	522	296	457	259
Uinta	899	413	686	336	543	265
WY CRB	801	418	651	363	441	266

Note: Calculations are based on yield, price, and cost data for 2011-2019 reported in Appendix C. WY CRB prices (by both $/acre and $/AF) are volume-weighted, so that counties with more irrigated acreage are weighted more heavily in the average than counties with less irrigated acreage.

[12] For simplicity, aftermath grazing forage has been incorporated into anticipated yields, under the assumption that any hay on enrolled acres not available for forage would also have to be replaced.

Include a premium. The Colorado WBWG study set the break-even cost equal to net operating income plus fallow costs plus a 50% premium on net operating income, something the authors of that study observed was necessary to induce participation in similar programs (BBC Consulting 2020). For purposes of comparison, Table 4-4 presents break-even costs for flood-irrigated grass hay using this alternative method and Wyoming-specific numbers. The break-even costs are lower with this alternative method, but they are relatively close given the range of considerations and differences between operations:

Break-Even Cost #2 = NOI + Fallow Cost + 50% premium on NOI.

Table 4-4 Alternative Calculation of Break-Even Costs for Grass Flood Acres

County	Alfalfa Pivot		Grass Pivot		Grass Flood	
	Per Acre	Per Acre-Foot	Per Acre	Per Acre-Foot	Per Acre	Per Acre-Foot
	$/acre	$/AF	$/acre	$/AF	$/acre	$/AF
Carbon	469	237	297	166	346	193
Lincoln	509	281	436	262	351	211
Sublette	444	291	381	254	303	202
Sweetwater	475	245	290	165	346	196
Uinta	573	263	414	202	411	201
WY CRB	499	261	387	216	335	202

Note: Calculations are based on yield, price, and cost data for 2011-2019 reported in Appendix C. WY CRB prices (by both $/acre and $/AF) are volume-weighted, so that counties with more irrigated acreage are weighted more heavily in the average than counties with less irrigated acreage.

Tables 4-3 and 4-4 indicate a range of break-even costs for flood-irrigated grass hay of $193 to $278/AF based on the county-level average prices calculated under each method. These county-level figures are based on average values of yields, hay prices, and costs (see Appendix C). The two methods for calculating break-even costs indicate just two possible decision-making frameworks for participation; there are as many other possibilities are there are different types of hay and livestock operations. Some producers in the region would likely find it beneficial to participate at prices lower than even the lowest prices suggested in Tables 4-3 and 4-4.[13] Other producers in the region might only be able to participate if the payment were significantly higher, and yet other producers would not participate at any price. This study considers a participation payment level at the approximate midpoint of the range, at $230/AF. Section 6.4 performs sensitivity analysis on participation payment level to see how regional economic impacts respond to different payment levels.

4.4 Rancher Participation

Table 4-5 indicates total acreage quantities that would be enrolled in a DM program from each county over the course of the ten-year study period to meet the target volume levels of each scenario. The numbers in Table 4-5 assume flood-irrigated grass hay acres are enrolled in a DM

[13] Recall that payments to producers for partial-season fallow were $150/AF in the final year of the program. There are significant differences, however, between that program and the hypothetical DM program of this study: the SCPP compensated participants based on estimated (rather than actual) consumptive use reductions, and the practice implemented in the SCPP was partial-season (rather than full-season) irrigation reduction.

program implementing full-season irrigation reduction and that the participation payment is high enough to encourage producers to participate, as discussed in Section 4.3 above.

Table 4-5 Total Acreage Enrollment by Scenario and County

	Scenario 1. (25 Total KAF Reduction)		Scenario 2. (80 Total KAF Reduction)		Scenario 3. (135 Total KAF Reduction)	
Basin	Grass Flood (Acres)	% of County's Irrigated Acres	Grass Flood (Acres)	% of County's Irrigated Acres	Grass Flood (Acres)	% of County's Irrigated Acres
Carbon	712	0.44%	2,280	1.41%	3,847	2.38%
Lincoln	1,132	0.47%	3,621	1.52%	6,111	2.56%
Sublette	8,788	0.53%	28,120	1.68%	47,453	2.84%
Sweetwater	1,256	0.45%	4,018	1.43%	6,780	2.42%
Uinta	3,143	0.39%	10,059	1.24%	16,974	2.09%
WY CRB	15,031	0.47%	48,098	1.52%	81,166	2.56%

Acreage numbers are ten-year totals. For example, in Scenario 2, 2,280 acres are enrolled over the course of the ten-year study period: 712 acres in each of Years 1 and 2, and 285 acres in each of years 5, 7, and 9. Also shown is the percentage of each crop's acreage removed from production over the course of the ten-year study period.

One additional feature about Table 4-5 should be mentioned. Participant benefits and estimated regional economic impacts are reported based on an average of 2011-2019 water year conditions. Economic conditions vary markedly between normal, wet, and dry water year types. Regional economic impacts may differ depending on water year type. Section 6.4 performs sensitivity analysis on water year type to see how regional economic impacts vary depending on water availability.

Table 4-6 Consumptive Use Reductions by Scenario and County (in AF)

Basin	Scenario 1. (25 Total KAF Reduction)	Scenario 2. (80 Total KAF Reduction)	Scenario 3. (135 Total KAF Reduction)	% of the Region's CU Reduction
Carbon	1,275	4,079.78	6,884.62	5%
Lincoln	1,884	6,028.56	10,173.20	8%
Sublette	13,200	42,239.95	71,279.91	53%
Sweetwater	2,213	7,080.15	11,947.75	9%
Uinta	6,429	20,571.57	34,714.52	26%
WY CRB	25,000	80,000	135,000	100%

Table 4-6 indicates the consumptive use reductions contributed by each county under the different scenarios. The information in Tables 4-5 and 4-6 and the budget information from Section 4-3 are used to calculate the potential regional economic impacts associated with a DM program of difference sizes.

Section 5. Impact Analysis Methods

The modeling framework used to estimate regional economic impacts of a potential DM program is IMPLAN (IMPLAN 2020), a standard model used for regional economic impact analysis at the local and other subnational economic levels. There are two basic components to an IMPLAN model. The first component is activity levels associated with the economy sector of interest, including their economic dollar values. In this study, the economy sector of interest is hay production, and the associated economic values are the output value of hay and the cost of producing it. The purpose of Section 4 was to characterize the likely nature of producer participation in a potential DM program, in order to generate these inputs to the impact analysis.

The second component to an IMPLAN model is the general structure of the economy, including "multipliers" that define how large the impact of a change in one sector is on other sectors. For example, if the hay sector output multiplier in a particular location is 1.6, increasing hay production by one unit will increase the regional economy beyond the hay sector by 0.6. If that increased hay production is exported outside the region, it represents a gain in economic activity.

Impact models such as IMPLAN typically contain multipliers for different metrics: value of output, value-added income, labor income, and jobs. They all indicate how a change in one sector affects value of output (or one of the other metrics) in other sectors of the economy. Multipliers cannot be compared across metrics. See Beattie and Leones (1993) for other rules and limitations of using multipliers. Default values for these inputs are calculated by IMPLAN, though it is possible for the modeler to make changes to these multipliers to better reflect local conditions, if circumstances warrant. These modifications are described in Appendix D.

5.1 Wyoming Colorado River Basin Regional Economy

The regional economy of the Wyoming CRB is for the most part highly diversified though still primarily natural resource-based. Table 5-1 summarizes the structure of the region's economy, in terms of output (measured in dollars) and employment (measured in jobs). Note that although the hay economy, the focus of this study, comprises a large component of the land use in the region, it has a relatively small output compared both to the rest of the agricultural sector and especially to the broader regional economy. (Hay subsector output is only 13% of agricultural sector output and less than 1% of the broader regional economy output.) However, the hay subsector represents a higher percentage of regional employment (54% of agricultural sector employment and nearly 4% of employment in the broader regional economy). The relatively higher employment percentage comes from IMPLAN's use of US Department of Commerce Bureau of Economic Analysis job counts rather than full-time equivalency estimates. As such, an individual who works part-time in the hay subsector and part-time in another industry (e.g., construction) is counted as having one job in the hay sector and one job in the construction sector. The relatively higher employment percentage for the hay subsector thus indicates shared employment with the livestock subsector and other sectors of the economy ranging from mining to real estate.

Table 5-1. Regional Economy of the Wyoming CRB

	Output		Employment	
Sector	**$**	**% of Total $**	**Jobs**	**% of Total**
Agriculture: Sector Totals	**254,239,751**	**1.42%**	**4,370**	**6.14%**
Livestock	191,503,211	1.08%	1,542	2.31%
Hay (Alfalfa and Grass)	32,163,906	0.18%	2,377	3.56%
Other Ag Sectors	24,099,626	0.14%	161	0.24%
Ag Support services	6,473,008	0.04%	290	0.43%
Mining	**4,893,797,637**	**27.72%**	**8,494**	**12.72%**
Construction	**1,023,100,115**	**5.80%**	**5,645**	**8.45%**
Manufacturing	**5,808,695,230**	**32.90%**	**2,904**	**4.35%**
Services	**4,782,945,611**	**27.09%**	**34,049**	**50.99%**
Government	**891,692,867**	**5.05%**	**11,314**	**16.94%**
Total	**17,908,710,962**	**100%**	**71,146**	**100%**

Source: IMPLAN 2020

Six distinct economic impact models are created for the analysis (Table 5-2). The first five models represent each of the counties in the study area. The sixth model is of the entire Wyoming CRB. It is a representation of the entire regional functional economy, to more precisely characterize trade between firms and households across counties. The Wyoming CRB aggregate model and the five county models capture different dynamics within the regional economy. The aggregate model will indicate a smaller impact than the sum of county impacts for any one type of impact, because the aggregate model nets out trade between counties. For example, if hay is produced in Carbon County and sold to a rancher in Sweetwater County, the economy activity is double-counted—once in the Carbon model and once in the Sweetwater model. The aggregate model presents a picture of the impacts of the broader functional economy across the southwestern Wyoming region. The county-level models would be useful to, for example, somebody interested in economic development specifically in Carbon County.

Table 5-2 indicates the size of each county's economy (and the economy of the Wyoming CRB overall), in terms of gross regional product (which is the regional version of gross domestic product at the national economy level), employment, number of industries, and number of households.

Table 5-2. Model Descriptions

County	Gross Regional Product/ Value-Added (in $1,000s)	Employment (2017)	Number of industries	Number of Households
Carbon	$756,802	9,495	154	6,153
Lincoln	$764,067	10,569	172	6,951
Sublette	$488,751	6,526	144	3,750
Sweetwater	$2,168,785	27,534	173	15,768
Uinta	$815,117	11,161	161	7,150
Wyoming CRB	$4,993,524	65,118	215	39,773

Source: IMPLAN 2020

IMPLAN analyses usually take place at the county level (or regions comprised of whole counties), because economic data is generally reported at the county level. The footprint of the Wyoming CRB is fully contained within the five counties listed in Table 5-2, but some parts of these five counties are not located within the Wyoming CRB (see Figure 2-1 and Table 2-1). For example, roughly 25% of Uinta County, including Evanston, is located in the Bear River Basin. Table 5-2 numbers consequently include parts of the functional economy that are not geographically within the Wyoming CRB region, to the extent that portions of these counties are located in other basins. However, Evanston is an important component of the functional regional economy, even if it happens to be located outside of the Wyoming CRB, and as such should be included in the analysis.

5.2 Measurement of Economic Impacts

Economic Impact Metrics. This study uses two metrics to measure economic impacts: value-added income and jobs. Value-added income is defined as the value of gross output less intermediate expenditures, payments to debt, savings, and leakages (i.e., commodities, services, and labor provided from outside the region). Value-added income includes wage and salary income, proprietary income, business taxes, and other property type income. This value-added income is the portion of gross output that recirculates in the local regional economy and which generates, in dollar terms, regional economic impacts. Jobs is the number of people employed in full-time, part-time, and proprietor positions. Job counts in IMPLAN are an over-count in the sense that people with multiple jobs are counted multiple times.

Impact Components. The regional economic impacts of a potential DM program can be separated into three components: participation payment, reduction in hay production, and replacement hay purchases. Table 5-3 lists the three components and whether each component's impact is (by its nature) positive or negative. Each component can also be separated into the three economic impact types described below. An example of each type of economic impact is provided for each component in the final column of Table 5-3. The final row of Table 5-3 sums the positive participation payment with the negative reductions in hay production and negative cost of purchasing replacement hay, to indicate the net regional economic impacts of a potential DM program.

Table 5-3. Economic Impact Components

	Component	Expected Sign	Decision Type	Economic Impact Type	Example
1	Participation payment	(+)	Household spending	Direct Indirect Induced	- Participant buys a new truck - The truck dealership pays its accountant - The accountant's household buys more groceries
2	Replacement hay purchase	(-)	Household spending	Direct Indirect Induced	Same as above except that fewer such expenditures are made by program participants because they spend a portion of their payment on replacement hay purchases
3	Hay production reduction	(-)	Hay industry	Direct Indirect Induced	- Participant hires fewer custom harvest services - Custom harvest company has less business - Custom harvest company reduces household expenditures
4	Net impact (= 1 - 2 - 3)	(+/-)	Household and industry	Direct Indirect Induced	

Types of Economic Impacts. Three types of potential economic impacts are measured in this study.

Direct Impacts: This captures impacts (measured in value-added income and jobs) from transactions made directly by the industry of focus as a result of the DM program. In this study, the industry of focus is hay producers, so direct impacts cover transactions between hay producers who participate in the DM program and others in the local economy. Some direct impacts occur when DM program participants use their participation payments to make purchases in the local economy. These are positive (row 1 of Table 5-3). Other direct impacts occur because DM participants reduce hay production and make fewer business-related purchases and hire less labor as a result. These are negative (row 2 of Table 5-3).

Additional direct impacts may occur if DM participants choose to replace some or all of their lost production by purchasing hay. This reduces the amount of participation payment that DM participants are able to spend on local goods and services. These impacts would consequently be negative (row 3 Table 5-3). Direct impacts also include potential changes in the livestock sector itself that could result if DM participants respond to reduced hay production by adjusting livestock operations (i.e., reducing herd size). These impacts would also be negative. This possibility is not included in Table 5-3 but is discussed separately in Section 6.3.[14]

Indirect Impacts: These impacts are firm-to-firm transactions that occur as a result of direct impacts. This includes, for example, transactions between firms that sell goods and services to participants in a DM program and the firms that supply these firms. Indirect impacts resulting from participation payments are positive (row 1 of Table 5-3), while indirect impacts of reduced hay production are negative (row 2 of Table 5-3). If DM participants choose to purchase

[14] Indirect and induced impacts also occur to the extent that livestock operations reduce herd size in response to the hay production reductions that would come with DM program participation. These are also negative, as firms in industries linked to livestock operations have less business (indirect) and as employees of these firms reduce household expenditures (induced). These impacts are also discussed further in Section 6.3.

replacement hay, they would have less of their participation payment to spend on local goods and services. This impact is consequently negative (row 3 of Table 5-3).

Induced Impacts: Induced impacts are created through household spending. Program participants that receive a payment generate a positive induced impact when they spend program payments locally on household items (row 1 of Table 5-3). Employees of agricultural operations, firms that sell to agricultural operations, or firms that sell to other supplier firms also create an induced impact through changes in their own household spending. Expenditures of these other households in the region decrease due to reduced hay production and any replacement hay purchases that occur, generating negative induced impacts (rows 2 and 3 of Table 5-3). Whether component impacts are positive or negative is the same for induced impacts as it was for direct and indirect: induced impacts from the participation payment are positive (row 1 of Table 5-3), from hay production reductions are negative (row 2 of Table 5-3), and from any possible replacement hay purchases (row 3 of table 5-3) or adjustments to livestock operations (Section 6.3) are negative.

Each type of impact (direct, indirect, induced) can be summed across components (participation payment, hay production reduction, and replacement hay purchase) to indicate a net impact for that type. For example, the sum of indirect impacts for participation payment, reduced hay production, and replacement hay purchase gives a net indirect impact for the DM program. Regional economic impacts are broken out by type of regional economic impact and impact component in Section 6. Breaking out impacts by component in this fashion allows for easy assessment of how impact estimates change in response to different assumptions about whether and how much producers purchase replacement hay and adjust livestock operations in response to DM program participation.

Impact Analysis versus Benefit-Cost Analysis. An important distinction must be made between impact analysis and benefit-cost analysis. Impact models (such as the one used in this study) measure only formal, transaction-based impacts. Another approach would be a benefit-cost analysis, which could include opportunity costs (the cost of not choosing an alternative decision) and non-market or cultural costs along with transaction-based impacts. For example, the negative (or positive) *social* impacts of a firm's decision on neighbors would change the results of a benefits approach but would not affect the results of an impact analysis, which only considers formal transactions.

Section 6 presents the regional economic impacts estimated in this report. Component impacts are first identified for each scenario. Then, net impacts for each scenario are estimated and discussed.

Section 6. Impact Analysis Results

The final step in the analysis is to use the assumptions regarding scenarios and firm-level participation developed in Section 4 to estimate the regional economic impacts of a potential DM program of various sizes and target volume patterns. Section 6.1 reviews the basic assumptions regarding scenarios and firm-level participation developed in Section 4 and then describes key assumptions about how impact models like IMPLAN work.

Sections 6.2 and 6.3 present estimated regional economic impacts under different assumptions regarding how agricultural producers would adjust to the reduced hay production that results from DM program participation. In Section 6.2, producers are assumed to make no changes to their livestock operations; they either reduce hay exports or purchase hay from outside the region to replace lost production. In Section 6.3, producers are assumed to reduce herd size in response to lost hay production. Section 6.2 results may underestimate regional economic impacts, to the extent that producers reduce herd size in response to a DM program. Section 6.3 may overestimate regional economic impacts, to the extent that producers were already planning to reduce herd size for other reasons (e.g., low beef prices) besides DM program participation. The results of Section 6.2 and 6.3 together provide a range of possible regional economic impacts associated with a DM program in which consumptive use reductions come from the agricultural sector.

Section 6.4 provides results of a sensitivity analysis on several key assumptions: participation payment, yield impacts of reduced irrigation, location of enrolled acres, consumptive use estimates of enrolled acres, water year type (normal, dry, wet), and replacement hay purchase level.

Section 6.1 IMPLAN Assumptions and Modeling Framework

Recall the basic assumptions regarding scenarios and firm-level participation from Section 4. The impact of a DM program is evaluated over a period of 10 years. DM program size varies from a relatively small program taking place in just one year (Scenario 1) to larger programs taking place in multiple years (Scenarios 2 and 3). (Scenario descriptions and the pattern of consumptive use reductions over the ten-year period were presented in Tables 4-1 and 4-2.) Agricultural producers enroll acres of flood-irrigated grass hay for the full irrigation season in exchange for a participation payment of $230/AF. Hay yields on enrolled acres are assumed to be zero during the enrollment year and reduced by 10% in the following production year. Consumptive use reduction estimates are based on average water year conditions (2011-2019 average).

The scenarios and firm-level assumptions developed in Section 4 are parameterized and evaluated with the set of six models described in Section 5. Baseline value of production for grass hay presented in Table 6-1 is the starting point for the IMPLAN analysis. Baseline value of production for grass hay is calculated as the quantity of hay acres multiplied by typical yields in a normal water year (2018) multiplied by prevailing market prices. This baseline assumes no program participation and no enrolled acres in any year. Thus the estimated hay production and value of hay production are the same each year of the ten-year study period in Table 6-1.

Table 6-1. Baseline Value of Production for Grass Hay, by County

County	Value of Production ($1000s)
Carbon	2,426
Lincoln	5,581
Sublette	35,586
Sweetwater	3,230
Uinta	14,571
Wyoming CRB	61,393

Note: Calculations made based on acreage, yield, and price data presented in Section 4.

Value of production changes relative to the baseline are then used to calculate impacts of a potential DM program for each county and the overall Wyoming CRB region. Reductions in hay production that result from program participation are then carried through to other sectors of the economy due to the regional interdependencies modeled within IMPLAN.

A few assumptions about the overall analysis should be noted. First, the analysis assumes that regional hay prices do not change as a result of the DM program. The underlying rationale for this assumption is that the hay market in Southwest Wyoming is embedded in a well-functioning hay market that encompasses Wyoming, eastern Idaho, Colorado, Utah, and beyond. The consumptive use reductions contemplated in a Wyoming DM program are likely sufficiently small that the associated reduction in hay production would not be large enough to cause an increase in hay prices. On the other hand, if Wyoming implements a DM program, Colorado is likely to implement one at the same time. The resulting hay production decreases could be sufficiently large to cause changes in local hay prices as the market responds to the DM program. If this were to occur, additional quantities of hay might be imported, which might move regional hay prices back toward pre-DM program levels. Alternatively, participation payment might need to increase to induce more participation.

Second, the IMPLAN model treats southwestern Wyoming as a net exporter of hay within a well-functioning market that extends beyond the modeled region. Hay imports and exports into and out of the modeled region are happening simultaneously; the local livestock sector purchases its hay both from within and outside the modeled region but more exports than imports occur on net. Thus *on net*, the livestock sector can be considered to use local hay production first (which generates positive regional economic impacts), and any local hay production in excess of these needs can be considered to be exported. If Wyoming were a net importer of hay, then the positive regional economic impacts associated with hay production would accrue to outside the region, and the negative net regional economic impacts associated with a DM program would be larger. Imported purchases are referred to as "leakage," where commodities and services are imported and the dollar value of purchases is exported, so that the positive regional economic impacts of production accrue outside the region.

Third, IMPLAN compensates for any changes in hay production by increasing imports into the region. This is akin to assuming that hay markets are at equilibrium; if a producer tends to find it profitable to sell hay to eastern Idaho (or already perhaps has existing contractual and business relationships there), the implementation of a DM program alone is not going to cause them to change their mind. This means that any replacement hay purchased by DM participants (as described below in Section 6.2) is assumed to come from outside the region. If replacement hay purchases came from inside the region, it could only be because producers within the region (DM participants and non-participants) implemented efficiencies on non-enrolled acres to increase hay production. For example, producers might increase use of fertilizer or other inputs on non-enrolled acres.[15] However, producers in the region report that the potential for increasing productivity on existing acres is limited in the Wyoming CRB.

Section 6.2 Basic Regional Economic Impact Results

Producers might adjust operations in one of three ways when they choose to participate in a DM program.

- Option 1. Export less hay as a result of DM program participation. The same quantity of hay would be used within the region for livestock operations, so herd size would remain unchanged.[16]
- Option 2. Use a portion of their DM program payment to purchase replacement hay from outside the region. DM participants who produce livestock but do not wish to reduce herd size might choose to do this. As in option 1, the same quantity of hay would be used within the region for livestock operations, so herd size would remain unchanged.
- Option 3. Reduce herd size. This third option would have additional regional economic impacts related to changes in the livestock sector. These additional livestock impacts are addressed in Section 6.3.

This section presents regional economic impacts for the first and second options, both of which assume that livestock operations within the region are not affected by a DM program. (Whether producers who participate in a DM program reduce exports (option 1) or purchase hay from outside the region to replace lost hay production (option 2), they do so in ways that do not affect livestock operations in the region.) Several assumptions regarding the results presented in this section are related to this premise.

First, producers who choose not to reduce herd size in response to DM program participation (and so who are contemplating options 1 and 2) may choose to do some combination of

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[15] Producers could not increase hay production by increasing consumptive water use on non-enrolled acres within the Wyoming CRB, as this would defeat the purpose of a DM program.

[16] Another way that DM participants might forego replacement hay purchases without changing livestock operations is by finding efficiencies and increasing hay production on non-enrolled acres within the region. This is not modeled in this study for the same reason that replacement hay purchases are assumed to come from outside the region: there is little capacity for increased hay production in the region.

reducing exports and purchasing replacement hay. Reducing exports may involve disrupting business relationships with regular customers. Interviews with producers and Extension specialists also suggest that livestock producers plan a 10% cushion on hay to manage for variability in hay yields, which could also provide producers with additional strategies for dealing with reduced hay production associated with DM program participation.

Second, the decisions of whether to purchase replacement hay and whether to alter livestock operations are more likely household decisions rather than agricultural operation decisions for the family-run livestock operations that tend to exist in the Wyoming CRB. The regional economic impacts associated with replacement hay (row 2 of Table 5-3) and with livestock operations (Section 6.3 below) are thus modeled in IMPLAN as a household decision rather than an agricultural operation decision. This changes the multipliers within IMPLAN used to indicate the size of the regional economic impacts, since one multiplier captures the re-spending effect in household spending and the other captures the re-spending effect in hay production.

The following five tables present impacts for the case where DM program participants make no change to livestock operations.

Scenario 1. Table 6-2 presents results for Scenario 1 for each county in the Wyoming CRB as well as for the entire Wyoming CRB. Row 1 of Table 6-2 indicates payments of $5.75 million made to participants for participation in this hypothetical DM program. (The number of enrolled acres in each county or region multiplied by per-acre consumptive use reductions multiplied by the payment of $230/AF results in $5.75 million.)

Program Payment Impacts. The next eight rows of Table 6-2 indicate the positive impacts to the regional economy (in terms of value-added income and jobs) associated with the gross payment in row 1. Of the gross payments of $5.75 million for the overall Wyoming CRB (row 1 final column), $1.52 million is "value-added" income that remains in the local economy (row 5). Value-added was defined in Section 5.2. This is the portion of the gross payment that includes wage and salary income, proprietary income, business taxes, and other property type income and which recirculates in the local regional economy to generate, in dollar terms, regional economic impacts.[17] Of the $1.52 million in value-added income for the overall Wyoming CRB, $1.67 million is direct, $0.19 million is indirect, and $0.16 million is induced. The gross payment of $5.75 million in row 1 creates 21 new jobs during the one year of Scenario 1a (row 9). Of these jobs, 18 are direct, 2 are indirect, and 1 is induced.

Table 6-2. Scenario 1. 25 KAF Initial Reduction, No Replacement in Later Years (by County)

[17] According to IMPLAN, 26% of the gross payment is value-added income for the Wyoming CRB. Multipliers such as this 26% vary by county/region and depend on, for example, how dependent the local economy is on goods and services provided from outside the region. Multipliers for all counties and the overall Wyoming CRB are included in Appendix D.

	Carbon	Lincoln	Sublette	Sweetwater	Uinta	Wyoming CRB
1 **Gross Participation Payment ($)**	**293,234**	**433,303**	**3,035,996**	**508,886**	**1,478,582**	**5,750,000**
Program Payment Impacts - Value Added ($)						
2 Direct	43,013	86,694	699,267	114,678	350,624	1,167,910
3 Indirect	5,009	12,524	53,456	12,736	38,939	190,548
4 Induced	7,821	13,543	9,414	9,750	29,811	159,194
5 Total Value-Added	55,843	112,761	762,137	137,164	419,374	1,517,652
Program Payment Impacts - Jobs						
6 Direct	1	2	9	2	5	18
7 Indirect	0	0	1	0	0	2
8 Induced	0	0	1	0	0	1
9 Total Jobs	1	2	10	2	6	21
10 **Gross Hay Production Reduction ($)**	**-222,733**	**-358,236**	**-2,447,855**	**-392,917**	**-1,146,271**	**-4,568,012**
Hay Production Reduction Impacts - Value-Added ($)						
11 Direct	-88,047	-222,710	-1,521,794	-244,271	-712,619	-2,839,864
12 Indirect	-10,254	-24,499	-219,845	-18,674	-79,140	-463,334
13 Induced	-16,010	-17,634	-237,722	-3,289	-60,589	-387,092
14 Total Value-Added	-114,311	-264,843	-1,979,362	-266,233	-852,348	-3,690,289
Hay Production Reduction Impacts - Jobs						
15 Direct	-3	-11	-41	-7	-24	-99
16 Indirect	0	-1	-3	0	-2	-11
17 Induced	0	0	-3	0	-1	-5
18 Total Jobs	-4	-12	-47	-7	-26	-116
Net Regional Economic Impacts for Option 1 (Reduce Hay Exports)						
Value-Added ($) (lines 5 and 14)	-58,467	-152,082	-1,217,225	-129,069	-432,975	-2,172,638
Jobs (lines 9 and 18)	-3	-10	-37	-6	-21	-95
19 **Gross Replacement Hay Purchases ($)**	**-222,733**	**-358,236**	**-2,447,855**	**-392,917**	**-1,146,271**	**-4,568,012**
Program Payment Impacts - Value Added ($)						
20 Direct	-32,671	-78,395	-472,442	-97,169	-271,821	-927,830
21 Indirect	-3,805	-8,624	-68,251	-7,428	-30,187	-151,379
22 Induced	-5,941	-6,207	-73,801	-1,308	-23,111	-126,469
23 Total Value-Added	-42,417	-93,226	-614,494	-105,906	-325,120	-1,205,678
Replacement Hay Purchases - Jobs						
24 Direct	-1	-1	-7	-4	-4	-14
25 Indirect	0	0	-1	0	0	-2
26 Induced	0	0	-1	0	0	-1
27 Total Jobs	-1	-2	-8	-4	-4	-16
Net Regional Economic Impacts for Option 2 (Purchase Replacement Hay)						
Value-Added ($) (lines 5, 14, and 23)	-100,884	-245,307	-1,831,719	-234,975	-758,094	-3,378,316
Jobs (lines 9, 18, and 27)	-4	-12	-45	-10	-25	-111

Source: IMPLAN 2020

Note: Gross participation payments and resulting program payment impacts (lines 2-9) are based on a payment level of $230/AF. Numbers may not add up to the totals due to rounding error.

The modeling framework nets out "leakages" that occur when firms make purchases from outside the region, so that only within-region impacts remain. This means that purchases of goods and services from outside the region or that occur locally through a local intermediary (e.g., wholesale, retail, transportation services) do not benefit from the re-spending effects by firms and households. For example, program participants in Sublette County are estimated to re-spend $0.76 million (row 5) of their $3.04 million (row 1) in average annual gross participation payment within Sublette County. The remaining $2.27 million is either saved or spent outside Sublette County. Some of this remainder is actually spent in Sweetwater and other Wyoming CRB counties. This leakage is excluded from the Sublette County model, but the positive impacts of these expenditures are still included in the Wyoming CRB model (rows 2 through 5, final column).

Hay Production Reduction Impacts. The reduced hay production that would result from a DM program generates negative regional economic impacts. The following nine rows (i.e., rows 10 through 18) of Table 6-2 indicate the negative impacts to the regional economy associated with reductions in hay production that occur as a result of the DM program. Row 10 indicates the gross reduction in hay sector value that results from the reduction in hay production. For the Wyoming CRB region overall, this is a reduction of $4.57 million. Of this amount, -$3.69 million is total regional impacts that ripple through the economy. Of this amount, -$2.84 million is direct, -$0.46 million is indirect, and -$0.39 million is induced. The gross reduction in hay production of $4.57 million in row 10 results in a reduction of 116 jobs during the one year of Scenario 1 (row 18). Of these jobs, 99 are direct, 11 are indirect, and 5 are induced.

The summary directly after row 18 indicates the estimated regional economic impacts associated with Option 1, in which all DM participants are assumed to respond to their reduced hay production by reducing exports or making due with existing hay supplies (rather than purchasing replacement hay or making changes to their livestock operations). Value-added income and jobs for the overall Wyoming CRB region are reduced by $2.17 million and 95 jobs, respectively. Estimated impacts for individual counties are also reported here.

Replacement Hay Purchase Impacts. Row 19 indicates the gross cost of purchasing replacement hay, $4.57 million. This is the amount by which the gross participation payment received by DM participants would be reduced if all DM participants purchased hay to replace 100% of their lost production. Similarly, rows 20 through 27 of Table 6-2 indicates the *additional* negative regional economic impacts that would occur (over and above the net impacts listed directly below row 19) if all DM participants purchased hay to replace their lost production, rather than reducing exports. These additional negative regional economic impacts occur because DM participants who purchase replacement hay are consequently re-spending less of their participation payments locally.

$1.21 million is the “value-added” income that is not re-circulated through the local economy if replacement hay is purchased (row 23). Of this amount, $0.93 million is direct, $0.15 million is indirect, and $0.13 million is induced. Row 27 indicates a total reduction of 16 jobs that are not added if replacement hay is purchased in Scenario 1. Of these 16 jobs, 14 are direct, 2 is indirect, and 1 is induced.

In summary, if all DM participants reduce exports rather than purchase replacement hay (option 1), then the positive payment impacts in rows 2 through 9 indicate the full magnitude of the positive impacts resulting from a DM program. If on the other hand DM participants spend a portion of their program payments on replacement hay imports (option 2), then they are

Table 6-3. Scenario 1. 25 KAF Initial Reduction, No Replacement in Later Years (Wyoming CRB by Year)

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
1	**Gross Participation Payment ($)**	**5,750,000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**5,750,000**
	Program Payment Impacts - Value Added ($)											
2	Direct	1,167,910	-	-	-	-	-	-	-	-	-	1,167,910
3	Indirect	190,548	-	-	-	-	-	-	-	-	-	190,548
4	Induced	159,194	-	-	-	-	-	-	-	-	-	159,194
5	Total Value-Added	1,517,652	-	-	-	-	-	-	-	-	-	1,517,652
	Program Payment Impacts - Jobs											
6	Direct	18	-	-	-	-	-	-	-	-	-	18
7	Indirect	2	-	-	-	-	-	-	-	-	-	2
8	Induced	1	-	-	-	-	-	-	-	-	-	1
9	Total Jobs	21	-	-	-	-	-	-	-	-	-	21
10	**Gross Hay Production Reduction ($)**	**-2,664,674**	**-1,903,338**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-4,568,012**
	Hay Production Reduction Impacts - Value-Added ($)											
11	Direct	-1,656,587	-1,183,277	-	-	-	-	-	-	-	-	-2,839,864
12	Indirect	-270,278	-193,056	-	-	-	-	-	-	-	-	-463,334
13	Induced	-225,803	-161,288	-	-	-	-	-	-	-	-	-387,092
14	Total Value-Added	-2,152,669	-1,537,621	-	-	-	-	-	-	-	-	-3,690,289
	Hay Production Reduction Impacts - Jobs											
15	Direct	-58	-41	-	-	-	-	-	-	-	-	-99
16	Indirect	-7	-5	-	-	-	-	-	-	-	-	-11
17	Induced	-3	-2	-	-	-	-	-	-	-	-	-5
18	Total Jobs	-68	-48	-	-	-	-	-	-	-	-	-116
	Net Regional Economic Impacts for Option 1 (Reduce Hay Exports)											
	Value-Added ($) (lines 5 and 14)	-635,017	-1,537,621	-	-	-	-	-	-	-	-	-2,172,638
	Jobs (lines 9 and 18)	-47	-48	-	-	-	-	-	-	-	-	-95
19	**Gross Replacement Hay Purchases ($)**	**-2,664,674**	**-1,903,338**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-4,568,012**
	Replacement Hay Purchases - Value Added ($)											
20	Direct	-541,234	-386,596	-	-	-	-	-	-	-	-	-927,830
21	Indirect	-88,304	-63,074	-	-	-	-	-	-	-	-	-151,379
22	Induced	-73,774	-52,696	-	-	-	-	-	-	-	-	-126,469
23	Total Value-Added	-703,312	-502,366	-	-	-	-	-	-	-	-	-1,205,678
	Replacement Hay Purchases - Jobs											
24	Direct	-8	-6	-	-	-	-	-	-	-	-	-14
25	Indirect	-1	-1	-	-	-	-	-	-	-	-	-2
26	Induced	0	0	-	-	-	-	-	-	-	-	-1
27	Total Jobs	-10	-7	-	-	-	-	-	-	-	-	-16
	Net Regional Economic Impacts for Option 2 (Purchase Replacement Hay)											
	Value-Added ($) (lines 5, 14, and 23)	-1,338,329	-2,039,987	-	-	-	-	-	-	-	-	-3,378,316
	Jobs (lines 9, 18, and 27)	-56	-55	-	-	-	-	-	-	-	-	-111

Source: IMPLAN 2020

Note: Gross participation payments and resulting program payment impacts (lines 2-9) are based on a payment level of $230/AF. Numbers may not add up to the totals due to rounding error.

spending less money locally, and the positive regional economic impacts of a DM program will be smaller, by the amounts listed in rows 20 through 27.

Table 6-3 presents the same component impacts results as were presented in Table 6-2 by year, for the entire Wyoming CRB region.[18] Because all consumptive use reductions occur in the first year of the program in Scenario 1, gross participant payments (row 1) and associated regional economic impacts (rows 2-9) in Table 6-3 occur only in Year 1. Some reductions in hay production (row 10) and associated regional economic impacts (rows 11-18) do occur in Year 2 because residual yield impacts of 50% are assumed to occur in the year following program participation. Similarly, to the extent that program participants spend some of their payment on replacement hay purchases (row 19), some of the regional economic impacts (rows 20-27) associated with these replacement hay purchases take place in Year 2, when residual yield impacts occur.

Total positive regional impacts for the overall Wyoming CRB functional economy associated with the total $5.75 million gross participation payments are $1.52 million in value-added income and an additional 21 jobs for Scenario 1 with no replacement hay purchases (option 1). If all DM participants purchased replacement hay, positive impacts would be reduced, to $0.41 million in value-added income (row 5 minus 23) and an additional 6 jobs (row 9 minus 27). Positive impacts lie somewhere between these two bookends if only some fraction of DM participants purchase replacement hay, or for just a fraction of their lost production.

Negative regional impacts for the overall Wyoming CRB functional economy associated with reduced hay production are $3.69 million in value-added income (row 14) and 116 in lost jobs (row 18), regardless of whether all DM participants reduce exports, purchase replacement hay, or some combination of the two.

Overall, the net regional economic impacts range from -$2.17 million to -$3.38 million in lost income and between 95 and 111 lost jobs. The positive regional impacts from the DM program are not enough to offset the negative regional impacts under Scenario 1, especially to the extent that replacement hay purchases are made.

Scenario 2. Scenario 2 models 25 KAF of consumptive use reductions in each of the first two years of a ten-year DM program, with replacement of 10 KAF in years 5, 7, and 9. This results in a total of 80 KAF in consumptive use reductions over the ten-year study period. There is no inflation or discount rate incorporated into the study, which is appropriate given that this is a hypothetical exercise rather than an explicit planning tool. Annual impacts are reported in Table 6-4. The same pattern of overall negative regional economic impacts as was observed in Scenario 1 persists in Scenario 2, because Scenario 2 is simply a “scaling up” of Scenario 1 impacts, from the 25 KAF program modeled in Scenario 1 to the 80 KAF program modeled in Scenario 2.

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[18] Similar tables presenting component impacts estimates for each county are available from the authors on request.

Table 6-4. Scenario 2. 50 KAF Initial Reduction, 10 KAF Replacement in Years 5, 7, and 9 (Wyoming CRB Region)

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
1	**Gross Participation Payment ($)**	**5,750,000**	**5,750,000**	**-**	**-**	**2,300,000**	**-**	**2,300,000**	**-**	**2,300,000**	**-**	**18,400,000**
	Program Payment Impacts - Value Added ($)											
2	Direct	1,167,910	1,167,910	-	-	467,164	-	467,164	-	467,164	-	3,737,311
3	Indirect	190,548	190,548	-	-	76,219	-	76,219	-	76,219	-	609,755
4	Induced	159,194	159,194	-	-	63,677	-	63,677	-	63,677	-	509,419
5	Total Value-Added	1,517,652	1,517,652	-	-	607,061	-	607,061	-	607,061	-	4,856,485
	Program Payment Impacts - Jobs											
6	Direct	18	18	-	-	7	-	7	-	7	-	56
7	Indirect	2	2	-	-	1	-	1	-	1	-	7
8	Induced	1	1	-	-	0	-	0	-	0	-	3
9	Total Jobs	21	21	-	-	8	-	8	-	8	-	66
10	**Gross Hay Production Reduction ($)**	**-2,664,674**	**-4,568,012**	**-1,903,338**	**-**	**-1,065,869**	**-761,335**	**-1,065,869**	**-761,335**	**-1,065,869**	**-761,335**	**-14,617,639**
	Hay Production Reduction Impacts - Value-Added ($)											
11	Direct	-1,656,587	-2,839,864	-1,183,277	-	-662,635	-473,311	-662,635	-473,311	-662,635	-473,311	-9,087,565
12	Indirect	-270,278	-463,334	-193,056	-	-108,111	-77,222	-108,111	-77,222	-108,111	-77,222	-1,482,668
13	Induced	-225,803	-387,092	-161,288	-	-90,321	-64,515	-90,321	-64,515	-90,321	-64,515	-1,238,693
14	Total Value-Added	-2,152,669	-3,690,289	-1,537,621	-	-861,067	-615,048	-861,067	-615,048	-861,067	-615,048	-11,808,925
	Hay Production Reduction Impacts - Jobs											
15	Direct	-58	-99	-41	-	-23	-17	-23	-17	-23	-17	-317
16	Indirect	-7	-11	-5	-	-3	-2	-3	-2	-3	-2	-37
17	Induced	-3	-5	-2	-	-1	-1	-1	-1	-1	-1	-17
18	Total Jobs	-68	-116	-48	-	-27	-19	-27	-19	-27	-19	-370
	Net Regional Economic Impacts for Option 1 (Reduce Hay Exports)											
	Value-Added ($) (lines 5 and 14)	-635,017	-2,172,638	-1,537,621	-	-254,007	-615,048	-254,007	-615,048	-254,007	-615,048	-6,952,440
	Jobs (lines 9 and 18)	-47	-95	-48	-	-19	-19	-19	-19	-19	-19	-304
19	**Gross Replacement Hay Purchases ($)**	**-2,664,674**	**-4,568,012**	**-1,903,338**	**-**	**-1,065,869**	**-761,335**	**-1,065,869**	**-761,335**	**-1,065,869**	**-761,335**	**-14,617,639**
	Replacement Hay Purchases - Value Added ($)											
20	Direct	-541,234	-927,830	-386,596	-	-216,494	-154,638	-216,494	-154,638	-216,494	-154,638	-2,969,058
21	Indirect	-88,304	-151,379	-63,074	-	-35,322	-25,230	-35,322	-25,230	-35,322	-25,230	-484,412
22	Induced	-73,774	-126,469	-52,696	-	-29,509	-21,078	-29,509	-21,078	-29,509	-21,078	-404,702
23	Total Value-Added	-703,312	-1,205,678	-502,366	-	-281,325	-200,946	-281,325	-200,946	-281,325	-200,946	-3,858,171
	Replacement Hay Purchases - Jobs											
24	Direct	-8	-14	-6	-	-3	-2	-3	-2	-3	-2	-45
25	Indirect	-1	-2	-1	-	0	0	0	0	0	0	-5
26	Induced	0	-1	0	-	0	0	0	0	0	0	-2
27	Total Jobs	-10	-16	-7	-	-4	-3	-4	-3	-4	-3	-52
	Net Regional Economic Impacts for Option 2 (Purchase Replacement Hay)											
	Value-Added ($) (lines 5, 14, and 23)	-1,338,329	-3,378,316	-2,039,987	-	-535,332	-815,995	-535,332	-815,995	-535,332	-815,995	-10,810,611
	Jobs (lines 9, 18, and 27)	-56	-111	-55	-	-23	-22	-23	-22	-23	-22	-357

Source: IMPLAN 2020

Note: Gross participation payments and resulting program payment impacts (lines 2-9) are based on a payment level of $230/AF. Numbers may not add up to the totals due to rounding error.

Table 6-5. Scenario 3. 75 KAF Initial Reduction, 20 KAF Replacement in Years 5, 7, and 9 (Wyoming CRB Region)

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
1	**Gross Participation Payment ($)**	**5,750,000**	**5,750,000**	**5,750,000**	**-**	**4,600,000**	**-**	**4,600,000**	**-**	**4,600,000**	**-**	**31,050,000**
	Program Payment Impacts - Value Added ($)											
2	Direct	1,167,910	1,167,910	1,167,910	-	934,328	-	934,328	-	934,328	-	6,306,712
3	Indirect	190,548	190,548	190,548	-	152,439	-	152,439	-	152,439	-	1,028,962
4	Induced	159,194	159,194	159,194	-	127,355	-	127,355	-	127,355	-	859,645
5	Total Value-Added	1,517,652	1,517,652	1,517,652	-	1,214,121	-	1,214,121	-	1,214,121	-	8,195,319
	Program Payment Impacts - Jobs											
6	Direct	18	18	18	-	14	-	14	-	14	-	95
7	Indirect	2	2	2	-	2	-	2	-	2	-	11
8	Induced	1	1	1	-	1	-	1	-	1	-	5
9	Total Jobs	21	21	21	-	16	-	16	-	16	-	111
10	**Gross Hay Production Reduction ($)**	**-2,664,674**	**-4,568,012**	**-4,568,012**	**-1,903,338**	**-2,131,739**	**-1,522,671**	**-2,131,739**	**-1,522,671**	**-2,131,739**	**-1,522,671**	**-24,667,265**
	Hay Production Reduction Impacts - Value-Added ($)											
11	Direct	-1,656,587	-2,839,864	-2,839,864	-1,183,277	-1,325,270	-946,621	-1,325,270	-946,621	-1,325,270	-946,621	-15,335,266
12	Indirect	-270,278	-463,334	-463,334	-193,056	-216,222	-154,445	-216,222	-154,445	-216,222	-154,445	-2,502,001
13	Induced	-225,803	-387,092	-387,092	-161,288	-180,643	-129,031	-180,643	-129,031	-180,643	-129,031	-2,090,295
14	Total Value-Added	-2,152,669	-3,690,289	-3,690,289	-1,537,621	-1,722,135	-1,230,096	-1,722,135	-1,230,096	-1,722,135	-1,230,096	-19,927,562
	Hay Production Reduction Impacts - Jobs											
15	Direct	-58	-99	-99	-41	-46	-33	-46	-33	-46	-33	-535
16	Indirect	-7	-11	-11	-5	-5	-4	-5	-4	-5	-4	-62
17	Induced	-3	-5	-5	-2	-2	-2	-2	-2	-2	-2	-28
18	Total Jobs	-68	-116	-116	-48	-54	-39	-54	-39	-54	-39	-625
	Net Regional Economic Impacts for Option 1 (Reduce Hay Exports)											
	Value-Added ($) (lines 5 and 14)	-635,017	-2,172,638	-2,172,638	-1,537,621	-508,014	-1,230,096	-508,014	-1,230,096	-508,014	-1,230,096	-11,732,243
	Jobs (lines 9 and 18)	-47	-95	-95	-48	-38	-39	-38	-39	-38	-39	-514
19	**Gross Replacement Hay Purchases ($)**	**-2,664,674**	**-4,568,012**	**-4,568,012**	**-1,903,338**	**-2,131,739**	**-1,522,671**	**-2,131,739**	**-1,522,671**	**-2,131,739**	**-1,522,671**	**-24,667,265**
	Replacement Hay Purchases - Value Added ($)											
20	Direct	-541,234	-927,830	-927,830	-386,596	-432,988	-309,277	-432,988	-309,277	-432,988	-309,277	-5,010,285
21	Indirect	-88,304	-151,379	-151,379	-63,074	-70,643	-50,460	-70,643	-50,460	-70,643	-50,460	-817,445
22	Induced	-73,774	-126,469	-126,469	-52,696	-59,019	-42,156	-59,019	-42,156	-59,019	-42,156	-682,934
23	Total Value-Added	-703,312	-1,205,678	-1,205,678	-502,366	-562,650	-401,893	-562,650	-401,893	-562,650	-401,893	-6,510,664
	Replacement Hay Purchases - Jobs											
24	Direct	-8	-14	-14	-6	-7	-5	-7	-5	-7	-5	-76
25	Indirect	-1	-2	-2	-1	-1	-1	-1	-1	-1	-1	-9
26	Induced	0	-1	-1	0	0	0	0	0	0	0	-4
27	Total Jobs	-10	-16	-16	-7	-8	-5	-8	-5	-8	-5	-88
	Net Regional Economic Impacts for Option 2 (Purchase Replacement Hay)											
	Value-Added ($) (lines 5, 14, and 23)	-1,338,329	-3,378,316	-3,378,316	-2,039,987	-1,070,664	-1,631,989	-1,070,664	-1,631,989	-1,070,664	-1,631,989	-18,242,906
	Jobs (lines 9, 18, and 27)	-56	-111	-111	-55	-45	-44	-45	-44	-45	-44	-602

Source: IMPLAN 2020

Note: Gross participation payments and resulting program payment impacts (lines 2-9) are based on a payment level of $230/AF. Numbers may not add up to the totals due to rounding error.

Scenario 3. Scenario 3 models 25 KAF of consumptive use reductions in each of the first three years of a ten-year DM program, with replacement of 20 KAF in years 5, 7, and 9. This results in a total of 135 KAF in consumptive use reductions over the ten-year study period. Annual impacts are reported in Table 6-5. The same pattern of overall negative regional economic impacts as was observed in Scenario 1 also persists in Scenario 3.

Net Impact Estimates. Table 6-6 presents estimated net regional economic impacts for the overall Wyoming CRB for Scenarios 1, 2, and 3. The net regional economic impacts are all negative at a participation payment level of $230/AF. They range from a decrease of $2.17 to 3.38 million in value-added income and 95 to 111 lost jobs for Scenario 1, to a decrease of $11.73 to 18.24 million in value-added income and 514 to 602 lost jobs for Scenario 3.

The table also indicates the participation benefits experienced directly by DM program participants, for reference. For option 1 of Scenario 1, this is the full $5.75 million in gross participation payment. For option 2 of Scenario 1, this is the gross participation payment less replacement hay purchases, for a total of $1.18 million. In all scenarios, the regional economic net impacts are larger than the participation benefits experienced directly by DM participants. Note that it would not be correct to sum the gross participation payment and the net regional economic impacts because the two are measuring different types of things. The participation payment is the primary benefit received by DM program participants. The net regional economic impacts are experienced by the overall economy and calculated based on IMPLAN estimates of how much of the participation payment remains local.

The net impacts presented in Table 6-6 are instructive and frame the issues confronting both the region and a potential program. However, decision-makers do not generally use these net impacts directly in a benefit-cost framework. For example, they would not necessarily reject a DM program because the regional economic net impacts are larger in magnitude than the participant benefits. These net impacts are more often used to help decision-makers consider how to design programs in a broader regional economic development framework. If the net impacts of a potential DM program are negative, how can the program be designed to mitigate these negative impacts for agricultural operations and communities?

Further, although these net impact estimates are negative, it is possible that they could be preferred, from a regional economy perspective, to no DM program. Recall that because a realistic baseline for an uncertain future has not yet been established, by default, this study evaluates the economic impacts of a DM program relative to a *baseline of no curtailment risk*. If the dry hydrology that the Colorado River Basin has experienced for the past 20 years persists, Upper Basin states may face a higher risk of "curtailment" in the future. The economic impacts of curtailment could potentially be even larger than the ones presented here, and they could potentially spread beyond the agricultural economy to the municipal and industrial sectors within the region. More work is needed to quantify the regional economic impacts of curtailment before a true comparison could be made between the regional economic impacts of a DM program relative to no DM program.

Table 6-6. Net Regional Economic Impact Estimates to the Hay Sector

	Option 1: Reduce Hay Exports		Option 2: Purchase Replacement Hay	
Scenario 1. 25 KAF Initial Reduction with No Replacement in Later Years				
Participant Benefits ($)	5,750,000		1,181,988	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-1,671,954	-81	-2,599,785	-95
Indirect	-272,785	-9	-424,164	-11
Induced	-227,898	-4	-354,367	-5
Total	-2,172,638	-95	-3,378,316	-111
Scenario 2: 25 KAF in years 1 and 2; 10 KAF in years 5, 7, and 9				
Participant Benefits ($)	0		0	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-5,350,254	-261	-8,319,312	-305
Indirect	-872,912	-30	-1,357,324	-35
Induced	-729,274	-14	-1,133,975	-16
Total	-6,952,440	-304	-10,810,611	-357
Scenario 3: 25 KAF in years 1, 2, and 3; 20 KAF in years 5, 7, and 9				
Participant Benefits ($)	0		-1,205,678	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-9,028,554	-440	-14,038,838	-515
Indirect	-1,473,040	-51	-2,290,485	-60
Induced	-1,230,650	-23	-1,913,583	-27
Total	-11,732,243	-514	-18,242,906	-602

Source: IMPLAN 2020

Note: Gross participation payments and resulting program payment impacts (lines 2-9) are based on a payment level of $230/AF. Numbers may not add up to the totals due to rounding error.

6.3 Livestock Operation Impacts

The impact analysis results in the previous section assumed that DM program participants would either reduce exports or purchase replacement hay in response to lost hay production. However, some DM program participants might decide to reduce their herd size rather than purchase replacement hay. This would create regional economic impacts in the livestock sector. The extent to which DM program participants would purchase replacement hay versus cull herds is a complicated question and would require a more detailed modeling of on-ranch bioeconomic relationships and management to answer fully. However, this section begins to answer the question by making some assumptions about the extent to which DM program participants reduce their herd size rather than purchase replacement hay.

This section assumes that all DM participants reduce their herd size in response to DM program participation. However, it is unlikely that all DM participants would respond in this way, for several reasons. First, 9% of survey respondents do not report having any livestock, so their participation could not affect livestock production directly. Second, some DM program participants may be planning to reduce their livestock holdings anyway, for reasons related to cattle markets rather than reasons directly related to DM program participation. Third, the DM program is intended to be temporary and rotational, so a producer might participate only one or two years out of four. The dynamics of herd size adjustments are multi-year (it can take up to three years to replace the productive capacity of a culled cow), so producers would not necessarily reduce herd size in response to temporary participation in a DM program.

There are some challenges, however, with determining how many and what type of livestock/hay operations would be likely to participate in a DM program and reduce herd size as a result. First, to what degree is the lost hay production absorbed by year-to-year variability in producers' risk management practices rather than replaced with purchases from the market? Second, what part of a herd do producers cull? If they cull relatively less productive animals, impacts on livestock operations may be less than proportional.) Third, what other risks are producers considering (for example cattle prices) when they make a decision to reduce herd size? Finally, what other ways might producers increase hay production temporarily without increasing consumptive use, while they participate in a DM program? For example, producers (both DM participants and non-participants) might rely more heavily on fertilizer, to increase yields on alfalfa and hay fields still in production. In summary, the results presented in this section (which assume that all DM participants reduce their herd size) can be considered an upper bound on how large regional economic impacts for a given DM program size could be.

The cost of hay purchases and the returns to livestock production can be used to estimate the extent to which livestock producers might reduce herd size if given the opportunity to do so. In Section 6.2, DM program participants were assumed to keep livestock operations intact. The participant readjusted expenditures between hay and household finances in response to the lost hay production. In this section, the participant readjusts expenditures between hay, livestock, and household finances. Higher hay purchase costs result in lower returns to livestock production. Given the expenditures and multipliers contained within IMPLAN, the participant will maintain their herd (by purchasing replacement hay) until the point where it makes more sense for them to reduce herd size than to purchase more replacement hay.

Table 6-7. Net Regional Economic Impact Estimates to the Hay and Livestock Sectors

	Option 1: Reduce Hay Exports		Option 2: Purchase Replacement Hay		Option 3: Reduce Herd Size	
Scenario 1. 25 KAF Initial Reduction with No Replacement in Later Years						
Participant Benefits ($)	5,750,000		1,181,988		5,750,000	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-1,671,954	-81	-2,599,785	-95	-3,847,142	-129
Indirect	-272,785	-9	-424,164	-11	-573,066	-12
Induced	-227,898	-4	-354,367	-5	-347,834	-5
Total	-2,172,638	-95	-3,378,316	-111	-4,768,043	-146
Scenario 2: 25 KAF in years 1 and 2; 10 KAF in years 5, 7, and 9						
Participant Benefits ($)	18,400,000		3,782,361		18,400,000	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-5,350,254	-261	-8,319,312	-305	-12,310,855	-413
Indirect	-872,912	-30	-1,357,324	-35	-1,833,812	-40
Induced	-729,274	-14	-1,133,975	-16	-1,113,070	-16
Total	-6,952,440	-304	-10,810,611	-357	-15,257,737	-468
Scenario 3: 25 KAF in years 1, 2, and 3; 20 KAF in years 5, 7, and 9						
Participant Benefits ($)	31,050,000		6,382,735		31,050,000	
	Value-Added ($)	Jobs	Value-Added ($)	Jobs	Value-Added ($)	Jobs
Direct	-9,028,554	-440	-14,038,838	-515	-20,774,569	-697
Indirect	-1,473,040	-51	-2,290,485	-60	-3,094,557	-67
Induced	-1,230,650	-23	-1,913,583	-27	-1,878,306	-27
Total	-11,732,243	-514	-18,242,906	-602	-25,747,432	-790

Source: IMPLAN 2020

Note: Gross participation payments and resulting program payment impacts (lines 2-9) are based on a payment level of $230/AF. Numbers may not add up to the totals due to rounding error.

The first two columns of Table 6-7 report the same net regional economic impacts already reported in Table 6-6. The final column in Table 6-7 reports net regional economic impacts assuming that all DM participants reduce their herd size in response to DM program participation. If all producers who participate in a 25 KAF DM program (Scenario 1) reduce their herd size, total regional economic impacts would be a decrease of $4.77 million in value-added income and 146 lost jobs. The net impacts to the regional economy are significantly larger when DM participants respond by reducing herd size. The impacts of herd size reduction are 55% higher in value-added income terms and result in an approximately 17% increase in the number of the jobs lost relative to option 1. The impacts of herd size reduction are 41% greater in value-added income terms and result in 31% more jobs being lost relative to option 2.

The positive impacts of program payments are clearly important to the region. However, the regional economic impacts suggest a negative impact on the overall economy in all scenarios. There may be important differences between the three adjustment strategies, as noted at the start of this section. More research is needed to more fully answer the questions of what types of producers would be likely to participate in a DM program and how participants would adjust the rest of their operations in response. It is also important to keep in mind that there are likely efficiencies that could be implemented on both the hay and livestock sides of the operation that would lessen the size of these net regional economic impacts.

6.4 Sensitivity Analysis

The assumptions (listed at the start of section 6.1) that underlie the regional economic impact estimates reported in this section are representative of average conditions that exist throughout the basin, based on data reported from the WSEO and NASS. However, conditions for each operation will vary. Each operation also has different restrictions and considerations that may influence their decision to participate and at what payment level. Further, although the averages reflect the best information available right now, these numbers may be updated or change over time in response to changes in agricultural markets, climate conditions, or producer preferences.

This section performs a sensitivity analysis on several key assumptions in the model, to better understand how sensitive the regional economic impact estimates are to changes in the underlying model assumptions. The results presented in this section are based on Scenario 1, in which the impacts of 25 KAF in consumptive use reductions are reported for a single year.

Participation Payment. Section 4.3 calculated participation payment level in two different ways. The first method set a break-even cost that covers net operating income and the cost of acquiring replacement hay. This generated payment levels for flood-irrigated grass hay ranging from \$255 to \$278 depending on county, with a volume-weighted average break-even cost of \$266 (Table 4-3, last column). The second method follows the method used by the Colorado WBWG Study (though using Wyoming-specific crop and consumptive use information) sets a break-even cost that covers net operating income, fallow costs, and a 50% premium on net operating income. This provided payment levels for flood-irrigated grass hay ranging from \$193 to \$211, with a volume-weighted average break-even cost of \$202 (Table 4-4, last column). We chose the approximate midpoint of the range generated by these two different methods, \$230/AF, to produce the results presented in Sections 6.2 and 6.3.

Block 1 of Table 6-8 indicates how net regional economic impact estimates change in response to an increase and decrease of 10% in participation payment. The boldface row indicates the net impact estimates for Scenario 1, option 1, that were presented in Tables 6-6 and 6-7. (The net impact estimate of -\$2.17 million for the Wyoming CRB in Scenario 1, option 1 of Table 6-8

Table 6-8. Net Regional Economic Impacts Sensitivity Analysis by County and Wyoming CRB

	Level	Carbon		Lincoln		Sublette		Sweetwater		Uinta		Wyoming CRB	
		$	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**
Participation Payment	$207	-64,052	-10%	-163,358	-7%	-1,293,438	-6%	-142,786	-11%	-474,912	-10%	-2,324,403	-7%
	$230	**-58,467**	**-**	**-152,082**	**-**	**-1,217,225**	**-**	**-129,069**	**-**	**-432,975**	**-**	**-2,172,638**	**-**
	$253	-52,883	10%	-140,806	7%	-1,141,011	6%	-115,353	11%	-391,037	10%	-2,020,872	7%
Yield Impacts	108%	-47,036	20%	-125,598	17%	-1,019,289	16%	-102,446	21%	-347,740	20%	-1,803,609	17%
	120%	**-58,467**	**-**	**-152,082**	**-**	**-1,217,225**	**-**	**-129,069**	**-**	**-432,975**	**-**	**-2,172,638**	**-**
	132%	-69,898	-20%	-178,566	-17%	-1,415,161	-16%	-155,693	-21%	-518,210	-20%	-2,541,666	-17%
Distribution of Enrolled Acres	**Proportional**	**-58,467**	**-**	**-152,082**	**-**	**-1,217,225**	**-**	**-129,069**	**-**	**-432,975**	**-**	**-2,172,638**	**-**
	Concentrated	-77,509	-33%	-127,551	16%	-1,035,121	15%	-142,647	-11%	-566,490	-31%	-2,159,180	1%
Household Re-Spending	**26%**	**-58,467**	**-**	**-152,082**	**-**	**-1,217,225**	**-**	**-129,069**	**-**	**-432,975**	**-**	**-2,172,638**	**-**
	29%	-52,883	10%	-140,806	7%	-1,141,011	6%	-115,353	11%	-391,037	10%	-2,020,872	7%
Water Year	Dry (2013)	-57,661	1%	-70,823	53%	-514,173	58%	-33,505	74%	-148,303	66%	-906,832	58%
	Average	**-58,467**	**-**	**-152,082**	**-**	**-1,217,225**	**-**	**-129,069**	**-**	**-432,975**	**-**	**-2,172,638**	**-**
	Wet (2017)	-97,674	-67%	-177,072	-16%	-1,539,094	-26%	-173,447	-34%	-588,073	-36%	-2,738,740	-26%

Note: Sensitivity analysis is based on total regional economic impact estimates for Option 1 (all participants reduce exports rather than purchase replacement hay or reduce herd size) and Scenario 1 (25 KAF consumptive use reduction).

Table 6-9. Net Regional Economic Impacts Sensitivity Analysis to Yield Impact Assumption, by County and Wyoming CRB

Level	Carbon		Lincoln		Sublette		Sweetwater		Uinta		Wyoming CRB	
	$	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**	**$**	**% Diff.**
90%	-29,890	49%	-85,871	44%	-722,384	41%	-62,511	52%	-219,888	49%	-1,250,065	42%
100%	-39,416	33%	-107,941	29%	-887,331	27%	-84,697	34%	-290,917	33%	-1,557,589	28%
110%	-48,941	16%	-130,012	15%	-1,052,278	14%	-106,883	17%	-361,946	16%	-1,865,113	14%
120% (Current Assumption)	**-58,467**	-	**-152,082**	-	**-1,217,225**	-	**-129,069**	-	**-432,975**	-	**-2,172,638**	**-**
130%	-67,993	-16%	-174,152	-15%	-1,382,172	-14%	-151,255	-17%	-504,004	-16%	-2,480,162	-14%
140%	-77,519	-33%	-196,222	-29%	-1,547,118	-27%	-173,441	-34%	-575,033	-33%	-2,787,686	-28%
150%	-87,045	-49%	-218,292	-44%	-1,712,065	-41%	-195,628	-52%	-646,062	-49%	-3,095,210	-42%

Note: Sensitivity analysis is based on total regional economic impact estimates for Option 1 (all participants reduce exports rather than purchase replacement hay or reduce herd size) and Scenario 1 (25 KAF consumptive use reduction). The assumption of 120% yield reduction currently used throughout the study comes from assuming 70% yield reduction in the enrollment year and 50% reduction in the following year. Yield impacts are added between the two years to get to 120%; so assuing 80% yield reduction in the enrollment year and 40% in the following year would also amount to assuming 120% yield impact.

is also located in the final column of Tables 6-6 and 6-7.) This boldface row assumes a payment level of $230/AF, 70% yields on enrolled acres in the enrollment year, 50% residual yield impacts in the year following enrollment, and an average water year.

Decreasing the participation payment by 10% from $230/AF to $207/AF increases the magnitude of the net regional economic impacts of a one-year 25 KAF DM program even further (from -$2.17 million to -$2.32 million) by 7%. Increasing the payment by 10% from $230/AF to $253/AF decreases the magnitude of the net regional economic impacts (from -$2.17 million to -$2.02 million) by 7%. County-specific changes in net impacts vary from 6% to 11%. Differences between counties are due to differences in crop yields, per-acre consumptive use, and the degree to which DM program participants re-spend participation payments locally versus elsewhere.

Although Table 6-8 increases and decreases price by just 10% to indicate the model's sensitivity to participation payment level, it is also possible to see what net regional economic impacts would be if the price were significantly higher or lower than $230/AF. If the participation payment were $150/AF (as it was in the final year of the SCPP), net regional economic impacts for option 1 would be -$2.70 million for the overall Wyoming CRB, which is 24% more negative than at the price of $230/AF. If on the other hand the price were $278/AF, which is the highest county-level break-even price calculated in Tale 4-3, net regional economic impacts would be -$1.85 million, which is 15% less negative than at the price of $230/AF.

Yield Impact Assumption. DM participants are assumed to experience a 70% yield reduction in the enrollment year and also to experience a 50% yield reduction in the following year, for a total yield impact of 120%.[19] Block 2 of Table 6-8 indicates how net regional economic impacts change if these residual yield impacts are decreased and increased by 10%, to 108% and 132%, respectively. Decreasing the total yield impact from 120% to 108% reduces the size of the negative net regional economic impacts of a one-year 25 KAF DM program (from -$2.17 million to -$1.80 million) by 17%. This reflects the fact that higher levels of hay production reduce the negative net regional economic impacts associated with lost hay production. Increasing the residual yield impact from 120% to 132% increases the size of the negative net regional economic impacts (from -$2.17 million to -$2.54 million) by 17%, for the opposite reasons. Section 4.3 emphasized the need for additional agronomic research to better understand the yield impacts of DM program participation in the enrollment year and subsequent years. The large impact of the yield assumption on net regional economic impacts emphasizes this point. To further illustrate the impact of yield assumptions, Table 6-9 expands the yield impact sensitivity analysis beyond a 10% decrease/increase.

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[19] The basic assumption used in previous sections that cut hay yields are reduced by 70% in the enrollment year and by 50% in the following year can be thought of as a yield decrease of 120% over the course of the two years. For example, the 70%/50% baseline assumption is equivalent to the case where cut hay yields are 80% in the enrollment year and 40% in the following year, also for a total yield impact of 120%.

Consumptive Use Estimates. Another way that using averages to represent operations might not capture likely participation decisions for a DM program is this study's use of WSEO district-level consumptive use estimates. This study relies on annual consumptive use estimates made by the WSEO for each WSEO district (see Appendix C of this report for more details). A potential DM program may calculate consumptive use at the field level using satellite data. This more accurate method would capture variation in consumptive use (due to local differences in climate, soil type, etc.) between fields within the same WSEO district that the averages used in this study cannot. Yields are, generally speaking, positively correlated with consumptive use.[20] Because producers are more likely to enroll their less productive fields in a DM program, fields with lower consumptive use might tend to be the ones enrolled in a DM program.

The positive correlation between yields and consumptive use combined with the likelihood that low-productivity fields might tend to be enrolled in a DM program suggest that more acres may need to be enrolled than indicated in Table 4-5. Table 6-10 indicates a range of acres that would need to be enrolled in Scenario 1 (a target volume level of 25 KAF), assuming increasingly lower rates of crop consumptive use. The starting point for Table 6-10 is the county-level crop consumptive use estimates for native grass hay in Table 2-7 and the acreage levels reported for Scenario 1 in Table 4-5. If producers did tend to enroll their less productive fields, it could be that the net regional economic impacts would be lower than those reported in this study.

Table 6-10. Grass Hay Acreage Enrollment Required under Different Consumptive Use Estimates

		Carbon		**Lincoln**		**Sublette**		**Sweetwater**		**Uinta**		**Wyoming CRB**	
WY-CRB Irrigated Acres in Each County		16,140		23,850		167,108		28,010		81,385		316,494	
% of Basin's Irrigated Acres in this County		5%		8%		53%		9%		26%		100%	
CU from Each County to Achieve 25KAF (acre-feet)		1,275		1,884		13,200		2,213		6,429		25,000	
Number of Acres Implied by this CU Quantity		CU	Acres	CU	Acres	CU	Acres	CU	Acres	CU	Acres	CU	Acres
	Study CU	**1.79**	**712**	**1.66**	**1,132**	**1.50**	**8,788**	**1.76**	**1,256**	**2.05**	**3,143**	**1.68**	**15,031**
	-10%	1.61	792	1.50	1,257	1.35	9,764	1.59	1,395	1.84	3,493	1.51	16,701
	-20%	1.43	891	1.33	1,415	1.20	10,984	1.41	1,570	1.64	3,929	1.35	18,788
	-30%	1.25	1018	1.17	1,617	1.05	12,554	1.23	1,794	1.43	4,491	1.18	21,472

Notes. Table is for a target volume level of 25 KAF (Scenario 1). CU is consumptive use measured in AF/acre. WY CRB CU is volume-weighted, so that counties with more irrigated acreage are weighted more heavily in the average than counties with less irrigated acreage. Study CU (bold row towards the bottom) calculates enrolled county acreage using the crop CU values used throughout the study. (For example, for Carbon County, 712 acres * 1.79 AF/acre = 1,275 AF.) The rows below the bold row calculate irrigated acreage assuming increasingly lower CU values.

Household Re-spending. Another key assumption in the model is the percentage of payments received by participants that is assumed to be spent locally within the region on goods and services. This is spending that occurs net of savings, capital flows, and imports. Increasing the household re-spending percentage by 10% from 26% to 29% decreases the magnitude of the net regional economic impacts (from -$2.17 million to -$2.02 million) by 7% (block 3 of Table 6-8).

[20] How responsive yields are to increases in water will vary with differences in climate, soil type, etc. The two hydrologic studies currently underway in the Upper Green River Basin and Colorado will shed some more light on the yield-consumptive use relationship.

Water Year Type. Results to this point have been presented for an average year. However, net regional economic impacts can be quite different for dry, normal, and wet water years, because consumptive use estimates, crop yields, and hay prices can differ substantially. To get a sense of how much the net regional economic impacts can change from year to year based on water year conditions, the final block of Table 6-10 compares net regional economic impacts under average conditions to net regional economic impacts for representative dry and wet years (2013 and 2017, respectively).

For the overall Wyoming CRB, net regional economic impacts are still negative in the dry year but they are substantially smaller in magnitude than they are in the normal year (-$0.91 million instead of -$2.17 million) for a one-year 25 KAF DM program, which is an increase of 58%. Net regional economic impacts are slightly more negative in the wet year than they are in the normal year (-$2.74 million instead of -$2.17 million) for a one-year 25 KAF DM program, by 26%. Dry year conditions have a much more substantial positive effect on net regional economic impacts than wet year conditions have a negative effect because economic conditions in the dry year are already reduced from what they are in an average year.

This sensitivity analysis is a bit different than the others in Table 6-8 in two ways. First, the modeled change is large rather than incremental. Second, the other blocks in Table 6-8 indicate how results might be different if the study assumptions are updated or change over time in response to changes in agricultural markets, climate conditions, or producer preferences. By contrast, this block reflects year-to-year variability in water conditions that exist regardless of whether Wyoming implements a DM program and regardless of how a DM program is structured.

Other Considerations.
Crop Type. The percentage of the total impact allocated to direct, indirect, and induced depends on the cost components of the crop not grown on the enrolled acres. For example, if any pivot-irrigation acres were enrolled, electricity would be a higher percentage of costs for those acres than for the flood-irrigated acres actually enrolled. Pivot-irrigated enrolled acres would consequently have smaller indirect impacts than flood-irrigated enrolled acres, because the electricity-related impacts would leave the region (for example because the electric company is based outside the region).

Payment Levels and Community Mitigation Account. It is possible to increase the payment level until the point where the participant benefits equal the net regional economic impacts. In an average year and assuming a 25 KAF DM program, this occurs for option 1 (reduce exports) when the participation payment is approximately $115/AF. For options 2 (purchase replacement hay) and 3 (reduce herd size), this occurs when the participation payment is approximately $300/AF and $200/AF, respectively. It is also possible to increase the payment level until the point where participant benefits (and the associated re-spending that occurs by participants through the economy) are sufficiently high that the net regional economic impacts of the program are approximately zero. In an average year and assuming a 25 KAF DM program, this occurs for option 1 (reduce exports) when the participation payment is $560/AF. For options 2 and 3, this occurs when the participation payment is $740/AF and $955/AF, respectively. These are unrealistically high payment levels, but they do illustrate the tradeoff between payment level and regional economic impacts. One logical approach could be to maintain a participant payment sufficient to induce voluntary participation by producers (the range discussed in this study is $193/AF to $278/AF) and to place any remaining available funds into a regional economic mitigation account, to help industries and other parts of communities negatively affected by the DM program to adjust. As discussed earlier, the estimates in this report are compared to a baseline of no curtailment risk. If the baseline contained a greater than zero risk of curtailment, these calculations might be different.

Section 6.5 Discussion of Job Impact Results

There are some important qualifications to this analysis. One qualification is that job changes are smaller than one might expect. There are at least three reasons for this. First, impact models such as IMPLAN measure jobs in both a proprietor category and a wage and salary category. Job changes that affect the wage and salary employees will be heavier than job changes to proprietors. Farm proprietors would be more likely than wage and salary employees to stay with a lower return to ownership and management in the hopes of recovering another year. Proprietor jobs are more heavily emphasized in an agricultural economy where small business is the primary firm type and the land resource ownership is part of the proprietor's management decisions.

Second, jobs are measured in terms of 'a job' rather than a portion of a job, so changes are constrained to a single job change. The lack of major changes in employment is thus a function of the proprietor operational decision and the transaction costs associated with changing land ownership. The lower employment also falls in line with another reason that could be driving this, which is the transaction costs associated with shifting out of ranching. The proprietor has a stronger hold and self-identity to the land they work so moving out of agriculture in the region not only involves finding another area but also either selling the land or using it in another industry (e.g., real estate.)

Third, this type of impact analysis generally overstates job impacts because it does not take into account secondary adjustments that may occur in the economy in response to implementation of a DM program. For example, if a producer stops irrigating as a result of a DM program, IMPLAN will move them to another sector of the existing economy where their labor can be effectively utilized. However, in reality, they may very well find a new and different job in a sector of the economy that IMPLAN does not envision.

7. Discussion of Results and Conclusions

This study has examined the potential economic impacts to the agricultural sector associated with implementing a DM program in the Wyoming CRB, if the consumptive use reductions came from the agricultural sector. Benefits to participants who enroll acres are calculated assuming full-season irrigation reductions on flood-irrigated grass hay acres. Acres enrolled in a DM program are assumed to be spread evenly over the entire basin. The participation payment used to estimate impacts in the study is set to $230/AF, which is the midpoint of the range of payments (from $193 to $278/AF) estimated to cover the costs of participation for different types of operations and at different locations across the Wyoming CRB.

These firm-level assumptions are based on available data on hay prices, yields, per-acre consumptive use savings, and production costs at various locations across the region, as well as interviews and focus groups with producers and a survey. These are, however, averages that do not take into consideration individual differences among operations. A producer could determine that it would be profitable for their operation to enroll acres of other crops besides flood-irrigated grass hay based on firm-specific circumstances. A producer could also find it profitable to enroll acres at prices lower than the range calculated here.

If a DM program were established, enrollment of any one field would be temporary. This study does not consider the possibility that a producer would include a field in the program for more than one year in a row. This means that no field would be put at risk of abandonment as a result of being enrolled in this program. Further, yield impacts in subsequent years would not be as severe after a single year of no irrigation as they would be during multiple years of no irrigation.

Regional Economic Impacts. The overall approach for estimating impacts of a payment program involves estimating participant payments for reducing consumptive use of water and changes in the agricultural economy that result from lower levels of hay production. The hay market in the region is well developed and spans parts of three states outside of the Wyoming CRB region. Impacts of a DM program would be positive to participants but potentially negative to others in the agricultural economy.

The participant payments generate positive regional economic impacts, even when DM participants purchase replacement hay from outside the region. However, the negative regional economic impacts associated with reductions in hay production more than outweigh these positive impacts in all scenarios. If DM participants make no change to their livestock operations, net regional economic impacts on the Wyoming CRB functional economy range from $2.17 million to $3.38 million in lost income and 95 to 111 lost jobs for a relatively small program (Scenario 1). (The larger negative end assumes that all DM participants purchased replacement hay.) The range of potential impacts is larger for a more significant program (Scenario 3), ranging from $11.73 million to $18.24 million in lost income and 514 to 602 in lost jobs. In all scenarios, participants are compensated above their break-even costs, but the ripple effects through the economy of both the positive and negative impacts are net negative at the payment level used.

This study also includes analysis of potential impacts to the livestock sector that might result from a DM program. A DM program could affect livestock production if DM participants reduce herd size in response to their decreased hay production. Net regional economic impacts on the Wyoming CRB functional economy when livestock operations are affected are estimated to be $4.77 million in lost income and 146 in lost jobs for a relatively small program (Scenario 1) and $25.75 million in lost income and 790 in lost jobs for a relatively larger program (Scenario 3).

It is useful to place these impacts into the context of the regional economy. The impact to the agricultural economy of a 25 KAF DM program (Scenario 1) would be -3.12% if all DM participants under option 1) (all participants reduce hay exports), -4.86% under option 2 (all participants purchase replacement hay, and -6.85% under option 3 (all participants reduce herd size) in response to reduced hay production. The agricultural economy is estimated to be approximately 1.42% of the overall economy in the Wyoming CRB (see Table 5-1). The impact to the overall regional economy would consequently be -0.04% for option 1, -0.07% for option 2, and -0.10% for option 3. This analysis has assumed that enrolled acres would be distributed evenly across the Wyoming CRB. These impacts could fall more heavily on some communities than others, depending on the location of enrolled acres.

One question that water users and other stakeholders in the Wyoming CRB could consider is how a DM program could be structured to reduce negative regional economic impacts. It could be possible to include a corollary payment as part of the program, designed to mitigate some of these negative impacts. In similar programs that have been implemented elsewhere, policymakers have made program approval contingent on the establishment of a fund to mitigate for negative regional economic impacts. Some type of a similar community mitigation fund could be established to offset regional economic impacts of a DM program in Wyoming.

Although benefits are positive for participants, the net regional economic impacts are negative in all scenarios modeled in this study. However, the baseline to which these net impacts are compared is a "business as usual" scenario that might not continue to exist in the Colorado River Basin. If the dry hydrology that the Colorado River Basin has experienced for the past 20 years persists, the Upper Basin states could face a higher risk of curtailment in the future than it does now. The net regional economic impacts of curtailment could potentially be even larger than the ones presented here, and they could potentially spread beyond the agricultural economy to the municipal and industrial sectors within the region.

Limitations and Assumptions. If a DM program were established similar to the hypothetical program discussed in this study, if a funder could be found to fund it, and if the available prices were high enough that agricultural producers were interested in participating, the results presented in this study are an indication of what the regional economic impacts associated with the program might be. However, the assumptions that contributed to these results and the limitations of the modeling framework used must be acknowledged.

IMPLAN Limitations and Assumptions. Three key IMPLAN modeling assumptions are worth noting. (The first two were raised in Section 6.1 and the last one in Section 6.5.) First, this analysis assumes that hay prices do not change in response to hay production reductions that would occur with a DM program. The underlying rationale is that the hay market in Southwest Wyoming is embedded in a well-functioning regional hay market that is much larger than the Wyoming CRB. Second, IMPLAN assumes that Wyoming is a net exporter of hay, so that the Wyoming CRB livestock sector uses local hay production (which generates positive regional economic impacts) and whatever it does not consume itself is exported. If Wyoming were a net importer of hay, then the positive regional economic impacts associated with hay production would accrue to outside the region, and the negative net regional economic impacts associated with a DM program would be larger. Finally, impact analysis generally overstates impacts because it does not take into account secondary adjustments that may occur in the economy in response to implementation of a DM program.

DM Program Design. Many important design features of a potential DM program are not addressed in this study because, although they are important to the ultimate feasibility of a potential DM program, they would not affect the study's results. First, the study makes no assumptions about how the size of the participation payment would be determined. Price might be determined through private negotiation, group negotiation, or a price set by the funder. These details could alter the participation payment level, which would affect distribution of impacts throughout the economy, but the effect on regional economic impact calculations would not be large. Second, the study makes no assumption regarding how many acres each operation in the Wyoming CRB would enroll. This is because IMPLAN results would not change depending on the distribution of acres among operations, given the structure of this type of impact analysis. However, in reality, larger acreage enrollment from a few operations would likely cut deeper into their livestock operations, thereby increasing regional economic impacts. Yet larger acreage enrollment from a few operations would likely decrease transaction costs associated with administering a DM program. Third, this study makes no assumptions about evaporation losses of water stored in Lake Powell or the other CRSPA units through a DM program. Incorporating evaporation losses would not affect regional economic impact calculations but could have an impact on the quantity of achieved consumptive use reductions at a given payment level.

Full- versus Partial-Season Management Practice. The management practice modeled in the study was full-season no-irrigation, which producers surveyed expressed relatively little interest in implementing (see survey results in section 3). Survey respondents were much more interested in implementing the partial-season practice. However, as discussed in section 4, we did not model the partial-season practice in this study because reliable consumptive use estimates for it are not currently available. A DM program could not compensate producers for implementing the partial-season practice without a more robust understanding of how much water would be saved. This study brings to light the disconnect between what agricultural water users would be willing to do under a DM program and what is technically feasible to implement at this time. Two hydrologic studies are currently underway in the Upper Green River Basin and Colorado to help determine how crop, soil type, and land location (bench or bottomland) affect the soil moisture profile after water has been shut off in high-elevation mountain valleys. When these issues have been resolved, it may be easier to make reasonable assumptions about consumptive use savings associated with partial-season irrigation reductions.

Ecological Impacts. This study does not consider the ecological impacts of changes in quantity and timing of flows that would result from implementation of a DM program. Enrollment in a DM program would reduce diversions to flood-irrigated fields, many of which serve as irrigation-dependent wetlands that provide habitat for birds and other wildlife, both migratory and resident. Water diverted for irrigation also often provides water to rough, non-hayed areas that provide additional forage and habitat opportunities for wildlife as well as for livestock on many operations. Further, producers who rely on longstanding return flow patterns to irrigate their fields could find their own fields affected by their neighbors' enrollment of acres in a DM program. On the other hand, reducing diversions can increase stream flows in ways that may improve fisheries. For example, many SCPP participants worked with TU to upgrade their diversion structures, which improved fish passage and gave water users greater control over water diversions moving forward.

In short, a significantly sized DM program could result in significant changes on the landscape, though it is impossible to quantify the full impact of the changes—how wetlands, bird and wildlife habitat, stream flows, and water management would all be affected—with currently available data. Given the challenges of quantifying the impacts that could result from changes to quantity and timing of return flows, these impacts have not been incorporated into the regional economic impacts estimated in this study.

The magnitude of these impacts would likely be more significant in some parts of the Wyoming CRB than others, depending on the degree of hydrologic interconnectivity between fields and neighbors' fields and the relative reliance of wildlife habitat on rough forage in different areas. Landowners from parts of the Wyoming CRB where these interconnectivities are less intense may be more likely to enroll acres, either because their operations rely less on incidental irrigation of rough forage or because it would cause less tension with their downstream neighbors. Enrollment from parts of the Wyoming CRB where these interconnectivities are less intense would tend to lessen the magnitude of these difficult-to-quantify impacts. It is certainly the case that SCPP participants reported fewer negative impacts than non-participants *anticipated* they would experience (see section 3). It could be that producers in parts of the Wyoming CRB where these interconnectivities are less intense would continue to be more active in DM-type activities moving forward.

Treatment of Bottomland versus Bench Fields. A related limitation of this study is its treatment of all irrigated acres within a single SEO district as identical rather than distinguishing between bottomland (irrigable land in the floodplain) and bench (irrigable land above the floodplain). Ranchers may tend to enroll bench acres rather than bottomland, to the extent that these acres are less productive. This would tend to reduce the ecological impacts describe above. However, available estimates of consumptive use do not distinguish between bottomland and bench, and other factors besides land type will influence producer decisions regarding whether and which fields to enroll in a DM program. Thus, a lack of reliable data also prevents this study from explicitly incorporating land type.[21] The two hydrologic studies currently underway in the Wyoming CRB and Colorado will shed some light on this issue.

In summary, the results of this study depend on many assumptions that likely influence the results. Sensitivity analysis on key parameters indicated in particular the need for a more thorough understanding of what the yield impacts would be from enrolling acres in a DM program. Better understanding of hydrology related to calculation of consumptive use, especially with respect to soil moisture, would improve estimates of regional economic impacts in the future. A better understanding of how and to what extent agricultural producers who participate in a DM program would reduce herd size would also be of value. A better understanding of producer interest in participating in a DM program and under what circumstances and at what price, would also be necessary to evaluating the ultimate success of any DM program that might be implemented.

[21] Yeatman (2020), an M.S. agricultural economics thesis on the economic and ecological tradeoffs of a DM program, explicitly addressed land type in participation decisions for three drainages in the Upper Green River Basin.

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Appendix A

Water Conservation Survey

Water Conservation Survey

Thank you for taking the time to complete this survey. Under Title 7 of the U.S. Code and CIPSEA (Public Law 107-347), facts about your operation are kept confidential and used only for statistical purposes. Your participation in this survey is voluntary. Refusal to participate will have no effect on any benefits to which you are otherwise entitled. Fill in bubbles completely using either pencil or pen (blue or black ink), but please do NOT use a felt-tip marker.

Mark Answers Like This ⇨ ● ▮
NOT Like This ⇨ ✗ ✓

Section 1. General Farm/Ranch Characteristics

1. Do you have water rights in the Colorado River Basin (Green River Basin or Little Snake Valley) and use them to irrigate for agricultural production?

- O Yes — please continue to fill out the survey.
- O No — return the survey in the enclosed postage-paid envelope, so we know that this survey does not apply to you.

2. What is the location of your primary residence?

- O Carbon County
- O Lincoln County
- O Sublette County
- O Sweetwater County
- O Uinta County
- O Elsewhere in Wyoming
- O Outside Wyoming

3. What kind of operation do you have? (Mark all that apply.)

- ☐ Cow-calf
- ☐ Yearling
- ☐ Sheep
- ☐ Other (specify): ______________________

4. Approximately how many head of livestock do you have?

Cattle (cow-calf pairs)	Sheep	Goats	Other (please specify): ____________
O < 200	O < 200	O < 200	O < 200
O 200-500	O 200-500	O 200-500	O 200-500
O 500-800	O 500-800	O 500-800	O 500-800
O >800	O >800	O >800	O >800

5. How many months of the year do you have livestock primarily on:

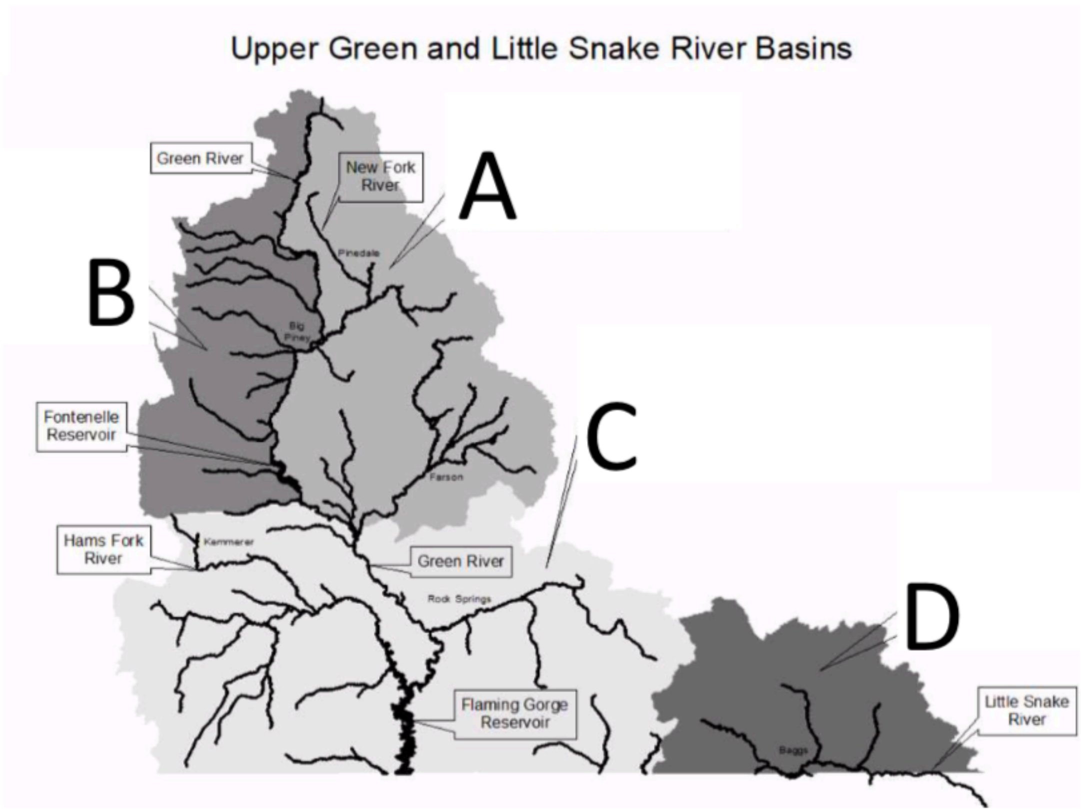
a. Private land: ☐☐ months

b. BLM land: ☐☐ months

c. USFS land: ☐☐ months

d. State land: ☐☐ months

46138



6. Please consult the areas on the map above labeled A, B, C, and D. In which location(s) do you have irrigated lands, and approximately how many irrigated acres in those location(s)?

A ☐ irrigated acres. **C** ☐ irrigated acres.

B ☐ irrigated acres. **D** ☐ irrigated acres.

7. Please write the name of the creek(s) and/or river(s) from which you irrigate:

____

____

8. Please answer both 8a and 8b:

8a. Approximately how many irrigated acres do you have of each of these crops?

8b. For each crop you grow, please indicate approximate acreage irrigated by each method:

	Acres	Exclusively sub-irrigation	Flood irrigation	Sprinkler (e.g., center pivot, handroll)
Irrigated pasture				
Grass hay				
Alfalfa hay				
Legume-grass mix				
Other (please describe): ________ ________				

9. **For this question, please think about years in which there are enough frost-free days that yields are NOT negatively affected by cold temperatures. Please tell us your average per-acre yields over the last 10 years for dry, average, and wet years for the following crops and irrigation methods:**

Grass hay

Flood irrigation

Year type	Ton(s)/acre	# cuttings	Fertilizer applied?
Dry	☐	☐	O Yes O No
Average	☐	☐	
Wet	☐	☐	

Sprinkler (e.g., center pivot, handroll)

Year type	Ton(s)/acre	# cuttings	Fertilizer applied?
Dry	☐	☐	O Yes O No
Average	☐	☐	
Wet	☐	☐	

Alfalfa hay

Flood irrigation

Year type	Ton(s)/acre	# cuttings	Fertilizer applied?
Dry	☐	☐	O Yes O No
Average	☐	☐	
Wet	☐	☐	

Sprinkler (e.g., center pivot, handroll)

Year type	Ton(s)/acre	# cuttings	Fertilizer applied?
Dry	☐	☐	O Yes O No
Average	☐	☐	
Wet	☐	☐	

Legume-grass mix hay

Flood irrigation

Year type	Ton(s)/acre	# cuttings	Fertilizer applied?
Dry	☐	☐	O Yes O No
Average	☐	☐	
Wet	☐	☐	

Sprinkler (e.g., center pivot, handroll)

Year type	Ton(s)/acre	# cuttings	Fertilizer applied?
Dry	☐	☐	O Yes O No
Average	☐	☐	
Wet	☐	☐	

10. **In an average hay production year, how many tons of hay do you purchase/sell?**

	Purchase	Sell	Neither
Grass Hay	☐ tons	☐ tons	☐
Alfalfa Hay	☐ tons	☐ tons	☐

46138

Section 2. Irrigation and Water Management

11. When you make decisions about how, when, and how much you irrigate, do you consider how these decisions affect your neighbors (e.g., return flows, their ability to irrigate)?

O Not at all O Not very likely O Likely O Very likely O Always

Explain:

____

____

12. Do your neighbors' decisions about how, when, and how much they irrigate affect your water availability (e.g., return flows, your ability to irrigate)?

O Not at all O Not very likely O Likely O Very likely O Always

Explain:

____

____

13. What percentage of your acres do you usually irrigate late in the season (e.g., turn water back on after your last cutting)?

O 0-25% O 26-50% O 51-75% O 76-100%

14. If you do not irrigate some/all of your acres late in the season, what are the reasons?
(Mark all that apply.)

☐ I have hay stacked in the meadow.

☐ I don't want to overflow the field.

☐ I can't turn back on because my neighbors do not.

☐ I have other employment in the fall and so do not have the time.

☐ Water is not available.

☐ Other (Specify): ____________________

Water Conservation Program Description

The Colorado River Basin is currently experiencing record drought conditions. Both Lake Powell and Lake Mead have regularly reached historic lows since the year 2000. Should such patterns continue over time, both Lake Powell and Lake Mead could reach critical reservoir water elevations below the levels required to protect the 1922 Colorado River compact legal apportionments and to maintain hydroelectric power production.

From 2015-2018, the Upper Colorado River Commission with cooperation from the Wyoming State Engineer's Office operated the System Conservation Pilot Program (SCPP) to help inform the Upper Colorado River Basin's drought contingency plan. The purpose of the pilot program was to explore and learn if temporary, voluntary, and compensated measures might be used, if necessary, to help maintain critical water levels in Lake Powell. In Wyoming, 52 projects were implemented in which landowners were compensated to reduce water use during the season. These payments were separate from and additional to other income sources that landowners may have from livestock grazing, crops, or other production on their land.

15. **If there was a voluntary program available to compensate producers for a reduction in irrigation would you be interested in any of the following demand management practices?**

Irrigation reduction alternative	Yes	No
Split season (do not turn water back on after last cutting)	O	O
Earlier harvest than normal (and then turn off water)	O	O
No irrigation on some fields for the whole year	O	O
No irrigation on the same fields for multiple years	O	O
Forego the use of any stored water	O	O
Investments that reduce water use by enhancing delivery systems	O	O
Everyone on a tributary (or irrigation district) agrees to implement specified management practices (e.g., above practices)	O	O
Everyone on a tributary (or irrigation district) agrees to save a certain amount of water (no specification of management practices)	O	O
Other (specify):____________________	O	O
None of the above (mark yes and please explain): ____________________	O	

Section 3. System Conservation Pilot Program Participation Experience

You are receiving this section of the survey because you participated in the System Conservation Pilot Program (SCPP) at least one year of the program's lifetime (2015-2018 irrigation seasons). If you did not, please leave this section of the survey blank and skip to the final section of the survey.

16. Approximately how many acres did you enroll over the lifetime of the SCPP?

	Participating Acreage			
Crop	2015	2016	2017	2018
Grass hay				
Alfalfa hay				

17. The relationship between late-season water application and yields is not well understood. This is an area that requires more scientific research. This question will not be used to make a determination of whether there are yield impacts from late-season water reductions, or what they are. We are interested in your experience.

If you participated more than one year, has participation affected your yields?

Grass Hay

- O Grass hay yields decrease
- O Grass hay yields increase
- O Grass hay yields stayed the same
- O Too early to tell for grass hay

Alfalfa Hay

- O Alfalfa hay yields decrease
- O Alfalfa hay yields increase
- O Alfalfa hay yields stayed the same
- O Too early to tell for alfalfa hay

46138

18. **We want to understand the potential agronomic and ecological tradeoffs of a program like the SCPP, along with the local economic impacts. For the split-season irrigation reductions implemented through the SCPP, have you or your neighbors observed agronomic impacts (e.g., changes in grass composition and yields), ecological impacts (e.g., changes in fish and bird presence), or hydrologic impacts (e.g., changes in return flow)?**

Mark one for each potential impact.	Losses or reductions	No change	Gains	Too soon to tell
Grass composition or species diversity	O	O	O	O
Invasive species coverage (e.g. cheat grass)	O	O	O	O
Fish presence	O	O	O	O
Bird presence	O	O	O	O
Big Game presence	O	O	O	O
Wetland presence	O	O	O	O
Return flows	O	O	O	O
Stream bank erosion	O	O	O	O
Water turbidity	O	O	O	O
Others (explain below)	O	O	O	O

Explain:

19. **Overall, what type of impact has program participation had on your operation?**

O Positive impact O Negative impact O Both positive and negative O No impact

20. **Please describe any major positive effects of program participation on your operation.**

21. **Please describe any major negative effects of program participation on your operation.**

22. **What changes did you make to your ranch or land management practices as a result of program participation? Please describe the changes you've made, and why:**

23. Who did you work with or receive feedback from when changing your management practices to participate in the program? (Mark all that apply.)

☐ No one - did it myself
☐ Family members
☐ For-profit farm consultant
☐ Feed dealer
☐ Business consultant
☐ Financial manager
☐ Local business association
☐ Lawyer
☐ Extension educator or specialist
☐ Conservation District
☐ Local government
☐ Conservation NGO
☐ Other (specify): ______________________________

24. In retrospect, do you wish your agricultural operation had done anything differently regarding challenges and opportunities arising from participating in the SCPP?

○ Yes ○ No

Why:

____

____

____

25. On which of the following items have you or someone in your household spent money you received from participating in the SCPP? (Mark all that apply.)

☐ Purchased a new car or truck
☐ Home repairs/improvements
☐ Vacation, travel, or entertainment
☐ College or other educational expenses
☐ Donated to charity
☐ Saved or invested for other future needs
☐ Repairs to or new construction of ranch-related buildings
☐ Debt reduction
☐ Purchased new machinery or equipment
☐ Started a new ranch enterprise
☐ Otherwise invested in the ranch
☐ Purchased more land for operation
☐ Started a non-ranch business
☐ Expanded or improved an existing non-ranch business
☐ Estate planning
☐ Other (specify): ______________________________

26. What other benefits (besides money) or downsides have you or someone in your household experienced as a result of participating in the SCPP?
(Mark one for each row.)

	Worse off	A little worse off	About the same	A little better off	Better off
Overall, do you feel you and members of your household are better off or worse off as a result of program participation?	○	○	○	○	○
Overall, do you feel your county is better off or worse off as a result of the program?	○	○	○	○	○
Do you feel that the county would be better off or worse off if the program were to be expanded?	○	○	○	○	○

27. **Please describe any major positive effects of program participation in your community.**

____

____

____

Section 4. Demographics

28. **Which one of the following best describes you?**
    - O Landowner who operates the ranch
    - O Landowner who leases out the ranch
    - O Manager
    - O Lessee
    - O Accountant
    - O Other (specify): ______________

29. **How long has the current landowner and their family owned the ranch?**
    - O 5 years or less
    - O Between 5 and 30 years
    - O This is a generational ranch

30. **Does the ranch have a succession plan?** (Mark one.)
    - O Yes: Transfer to family member or others to maintain as a working ranch
    - O Yes: Sell the property
    - O Yes: Other (specify): ______________
    - O No

31. **What is your age?**
    - O Less than 30 years old
    - O 30-50 years old
    - O 51-70 years old
    - O Over 70 years old

32. **What was the landowner's approximate total household adjusted gross income in 2018, from the ranch operation and all sources, before taxes?**
    - O Less than $24,999
    - O $25,000-$74,999
    - O $75,000-$149,999
    - O $150,000 or more

33. **In 2018, what percentage of the landowner's total household adjusted gross income was generated from ranching?**
    - O 0-25%
    - O 50-75%
    - O 25-50%
    - O 75-100%

34. **In 2018, was the ranch operation profitable? (For this question, please think just about the ranch operation rather than all sources of income.)**
    - O The ranch was profitable
    - O The ranch lost money
    - O The ranch roughly broke even

35. **Please share any final comments you may have related to water management in your community.**

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Appendix B

Survey Design and Results

Appendix B. Survey Design and Results

A survey of agricultural water users in the Wyoming CRB was designed and implemented as part of this study. Survey design and implementation procedures and comprehensive survey responses are reported below. The final section of this appendix is a comparison of survey responses from SCPP participants and non-participants.

B.1 Survey Design and Implementation

Survey development. The purpose of the survey was to characterize agricultural operations in the Wyoming CRB. This information was used to help better identify locations and ranch types that could potentially be interested in participating in a Demand Management program. This information was also used to inform the analysis of secondary impacts that could result from implementation of a DM program in Wyoming.

The starting point for this survey was research undertaken by Ellen Yeatman as part of her M.S. thesis in agricultural economics at the University of Wyoming. Her thesis examined the economic and ecological tradeoffs of participating in a hypothetical DM program at three locations in the Upper Green River Basin (Yeatman 2020). The initial draft of the survey was informed by data obtained through producer interviews for that project. The draft survey instrument was shared with groups of producers in three locations throughout the Wyoming portion of the Colorado River Basin: Baggs, Big Piney, and Pinedale. These producer focus groups provided feedback on the survey instrument, which was incorporated into the final version of the survey.

The survey has two versions. Most producers received a general version of the survey that contained questions about their ranch operations, irrigation water management practices, and rancher demographics. A different version of the survey was mailed to 22 of the 23 producers who had participated for at least one year in the SCPP. SCPP participant contact information was obtained from Trout Unlimited. The 23rd producer did not receive a survey because Trout Unlimited did not facilitate their SCPP participation. In addition to the questions in the general version, this SCPP version also asked these 22 producers about their experiences with and reflections on the SCPP. The SCPP version of the survey instrument is located in Appendix A. Survey results from SCPP participants are reported in Section 3-3.

Survey sample construction. The survey was sent to the population of agricultural producers with irrigated lands located in the Wyoming portion of the Colorado River Basin. The sample frame was county tax rolls. All producers possessing land classified as irrigated agricultural land for taxation purposes in four of the five counties partially located within the Colorado River Basin were sent the survey: Carbon, Lincoln, Sublette, and Sweetwater. Associated location information for irrigated parcels was available. Thus the sample frame could be restricted to the boundaries of the Colorado River Basin, to ensure that only agricultural producers within the Colorado River Basin were sent the survey. Observations where county data indicated less than 100 acres of irrigated land were owned by the producer were also removed from the dataset.

County-level irrigated land data was not available for Uinta County, so a list of BLM grazing lease recipients whose home address was located in Uinta County was used instead as a starting point for Uinta County. Uinta County agricultural producers without irrigated land in the CRB may have received the survey, and Uinta County producers with less than 100 acres of irrigated land may have also received the survey. Conversely, if there are any Uinta County producers without grazing leases, they will not have received the survey. Further, any producers who do have a grazing lease that is associated with an address located outside Uinta County will not have received the survey, either. This process resulted in a sample of 512.

The Wyoming Statistical Analysis Center (WYSAC) printed and mailed the survey to the survey sample. They initially sent out a cover letter to everybody on the list to invite them to fill out the survey electronically. Producers that did not fill out the survey electronically were sent a follow-up letter along with a paper copy of the survey. Producers who did not fill out this paper copy received a second copy of the survey.

Of the 512 surveys mailed to producers, 38 were returned to sender due to bad addresses, resulting in a total sample of 474. Although as many duplicate observations as possible were manually removed from the survey, it is likely that some producers received more than one copy of the survey in the mail, to the extent that they own irrigated agricultural land in more than one county or have two addresses on file with one or more counties for the same operation.

The survey was open for approximately two months, from mid-December 2019 to mid-February 2020. At the conclusion of the survey period, 106 paper surveys and 47 web-based surveys had been received by WYSAC, for a total of 155 surveys. Two households submitted two surveys each; one duplicate was removed for each household. Five surveys answered “No” to the first question and so were removed from the survey. This left 147 observations in the survey for an overall response rate of 33% (see table below). The actual response rate is likely higher, given that some additional households probably received multiple surveys, in spite of the sample-cleaning efforts described above.

Sample Response Rate

	Total Sample	Completed Surveys			
		Paper	Web	Total	% Returned
General Version	452	98	35	133	29%
SCPP Version	22	7	7	14	64%
Total	474	105	42	147	31%

B.2 Raw Survey Results
Following are raw survey responses, with some additional analysis when merited.

Section 1. General Farm/Ranch Characteristics

Question 1: Do you have water rights in the CRB and use them to irrigate for ag production?
147 of the 153 respondents indicated yes. The remaining 7 were removed from the sample.

Question 2: What is the location of your primary residence?

Location of Primary Residence	
Carbon	11
Lincoln	13
Sublette	69
Sweetwater	33
Uinta	16
Elsewhere in WY	1
Outside WY	4
Total	147

Question 3: What kind of operation do you have? (Mark all that apply.)
116 respondents indicated that their operation was Cow-calf, 30 indicated Yearling, 8 indicated Sheep, and 28 indicated Other. There are more responses than there are respondents because respondents were invited to mark all that apply.

Type of Operation, Version 1	
Cow-calf	116
Yearling	30
Sheep	8
Other (specify):	28
Total responses	182

Of the 116 Cow-calf responses, 26 also indicated Yearling, 7 also indicated Sheep, and 8 indicated Other. Of the 31 respondents that did not indicate Cow-calf, 4 indicated just Yearling and 1 indicated just Sheep, and 20 indicated just Other. The Other responses are overwhelmingly grass hay, lease ground to neighbor, and similar responses. Of the Other responses, 13 did not indicate any other kind of operation and so can be considered primarily hay operations. Most respondents indicated that their operation was either cow-calf only (81) or cow-calf combined with yearling or sheep (33), or cow-calf combined with “other,” which was primarily hay production and/or lease pasture (see below).

Type of Operation, Version 2	
Cow-calf only	81
Yearling only	4
Cow-calf/yearling	26
Cow-calf/sheep	7
Cow-calf/other	8
Combinations of yearling/sheep/other	8
Other (primarily hay production/pasture lease)	13
Total	147

Question 4: Approximately how many head of livestock do you have?

Number of Livestock				
	Cattle (cow-calf pairs)	Sheep	Goats	Other
0<200	41	7	5	19
200-500	53	1	1	23
500-800	13	2		
>800	15	5		
No response	9	43	47	
Total Responses	131	58	53	42

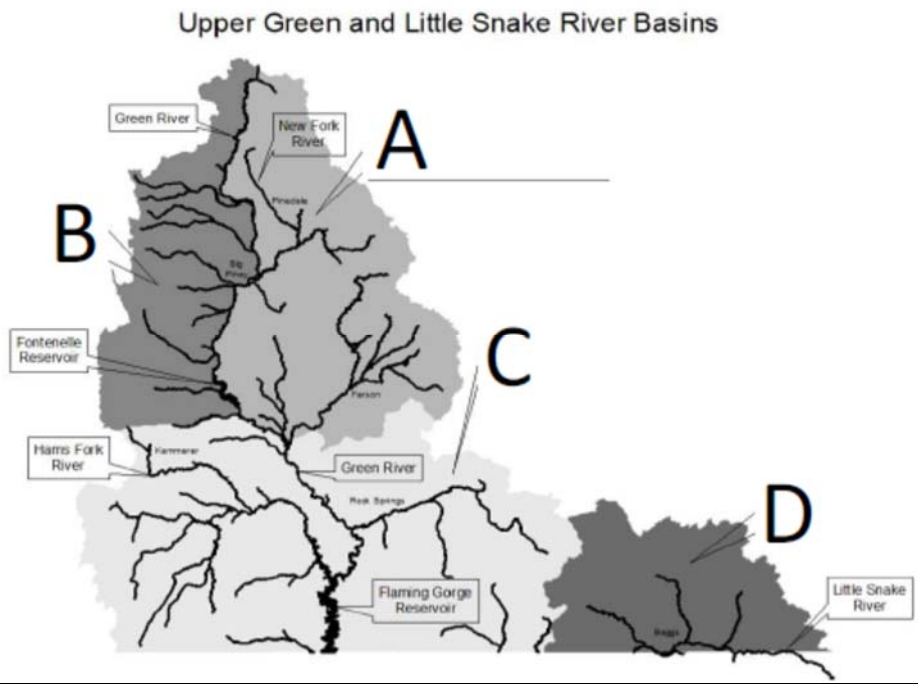
The Other category is predominantly horses, though some respondents indicated yearlings in the Other category, since that was not presented as a stand-alone option.

Question 5: How many months of the year do you have livestock primarily on:

# of Months	Private	BLM	USFS	State
0	5	19	48	41
1		14	2	12
2	5	14	5	6
3	4	13	23	6
4	6	17	6	5
5	5	17		3
6	16	7		8
7	16	2		2
8	15	1		1
9	10	1		
10	4	1		
11	4			
12	52	5		2

Question 6: Please consult the areas on the map above labeled A, B, C, and D. In which location(s) do you have irrigated lands, and approximately how many irrigated acres in those location(s)?

Survey respondents were asked to indicate what part of the Wyoming CRB they are located in. Region boundaries were drawn based on differences in climate, crop mix, and yields. Survey question results indicate regional differences in responses when there are any.



Irrigated Lands in Each Survey Region					
Region	Location	# of Responses	% of Responses	Average Acres	Total Acres
A	Upper East side	58	39%	540	31,293
B	Upper West side	43	29%	1,383	59,464
C	South Central	35	24%	526	18,405
D	Little Snake	11	7%	479	5,269
	SW-WY Region	147			

Ranch operations on the upper east side appear to have more irrigated lands than operations in the other areas. All but 8 of the 147 respondents indicated the location of their acres. In addition, seven respondents indicated that they had irrigated land in Regions A and B; one indicated having irrigated land in Regions A and D.

Question 7: Please write the name of the creek(s) and/or river(s) from which you irrigated: 135 respondents indicated names of creeks. 12 did not.

Question 8a: Approximately how many irrigated acres do you have of each of these crops?

Irrigated Acres, by Crop						
	mean	sd	min	max	N	sum
Irrigated pasture	550	1071.28	0	7000	97	53,379
Grass hay	505	536.77	0	2674	96	48,480
Alfalfa hay	138	163.13	0	880	44	6,081
Legume-grass mix	187	224.61	0	1000	33	6,160
Other	86	124.02	0	366	10	859

Ten respondents also indicated "Other." Text responses given were, Fallow rotation, Grain (2 responses), "Pea, Oat, Barley", Barley (2 responses), and Sanfoin.

Question 8b: For each crop you grow, please indicate approximate acreage irrigated by each method:

The table below indicating acreage of commonly grown crops by irrigation method indicates that most irrigated pasture and grass hay is flood-irrigated. Most alfalfa hay is on a pivot. Looks like ranches that have pivot alfalfa mostly have one pivot (mean is 173). Legume-grass mix is split 30/60 between flood and pivot. Other (primarily barley, pea, oats) is 75% pivot.

Irrigated Acreage by Crop and Method						
	Irrigated pasture			**Grass hay**		
	Mean	**N**	**Sum**	**Mean**	**N**	**Sum**
Acres	550	97	53,379	505	96	48,480
Exclusively sub-irrigation	368	29	10,681	12	7	81
Flood irrigation	542	85	46,099	570	76	43,342
Sprinkler	98	11	1,075	67	9	605
Totals			111,234			92,508

	Alfalfa hay			**Legume grass**		
	Mean	**N**	**Sum**	**Mean**	**N**	**Sum**
Acres	138	44	6,081	187	33	6,160
Exclusively sub-irrigation	0	5	-	0	5	-
Flood irrigation	31	11	345	91	13	1,187
Sprinkler	168	28	4,696	164	21	3,447
Totals			11,122			10,794

Question 9: For this question, please think about years in which there are enough frost-free days that yields are NOT negatively affected by cold temperatures. Please tell us your average per-acreage yields over the last 10 years for dry, average, and wet years for the following crops and irrigation methods.

Yields and Number of Cuttings in Dry, Normal, and Average Years, by Crop and Irrigation Method

Grass Hay Flood

	mean	sd	N
Tons per acre in dry year	1.12	0.58	65
Number of cuttings in dry year	0.99	0.27	71
Tons per acre in average year	1.64	0.74	85
Number of cuttings in average year	1.02	0.27	85
Tons per acre in wet year	1.96	0.89	65
Number of cuttings in wet year	1.03	0.30	66
=1 if fertilizer applied, 0 if not	0.46	0.50	114

Grass Hay Sprinkler

	mean	sd	N
Tons per acre in dry year	1.39	1.46	14
Number of cuttings in dry year	1.00	0.71	13
Tons per acre in average year	1.83	1.52	19
Number of cuttings in average year	1.19	0.83	16
Tons per acre in wet year	2.00	1.74	14
Number of cuttings in wet year	1.25	0.87	12
=1 if fertilizer applied, 0 if not	0.37	0.49	38

Alfalfa Flood

	mean	sd	N
Tons per acre in dry year	1.11	0.98	13
Number of cuttings in dry year	1.32	0.72	14
Tons per acre in average year	1.85	1.30	17
Number of cuttings in average year	1.56	0.70	18
Tons per acre in wet year	2.34	1.71	14
Number of cuttings in wet year	1.75	0.75	14
=1 if fertilizer applied, 0 if not	0.19	0.40	36

Alfalfa Sprinkler

	mean	sd	N
Tons per acre in dry year	1.82	1.24	29
Number of cuttings in dry year	1.46	0.71	26
Tons per acre in average year	2.56	1.28	33
Number of cuttings in average year	1.81	0.54	31
Tons per acre in wet year	2.83	1.45	28
Number of cuttings in wet year	1.77	0.59	26
=1 if fertilizer applied, 0 if not	0.45	0.50	40

Legume-Grass Flood

	mean	sd	N
Tons per acre in dry year	1.32	0.93	18
Number of cuttings in dry year	1.11	0.58	18
Tons per acre in average year	1.82	1.19	19
Number of cuttings in average year	1.16	0.60	19
Tons per acre in wet year	2.33	1.40	19
Number of cuttings in wet year	1.22	0.65	18
=1 if fertilizer applied, 0 if not	0.23	0.43	31

Legume-Grass Sprinkler

	mean	sd	N
Tons per acre in dry year	2.05	1.36	17
Number of cuttings in dry year	1.25	0.68	16
Tons per acre in average year	2.41	1.44	20
Number of cuttings in average year	1.50	0.69	20
Tons per acre in wet year	2.49	1.57	16
Number of cuttings in wet year	1.41	0.71	17
=1 if fertilizer applied, 0 if not	0.42	0.50	26

Question 10: In an average hay production year, do you sell and/or buy hay?

Hay Market Activity in an Average Hay Production Year						
	mean	sd	min	max	N	sum
Purchase grass hay (tons)	148	210.2565	0	1000	43	6385
Sell grass hay (tons)	153	257.3097	0	1000	41	6272
1=neither sell nor purchase grass hay	1	0	1	1	43	43
Purchase alfalfa hay (tons)	110	117.3725	0	500	37	4080
Sell alfalfa hay (tons)	263	546.1466	0	3000	33	8694
1=neither sell nor purchase alfalfa hay	1	0	1	1	24	24

Section 2. Irrigation Water Management

Question 11: When you make decisions about how, when, and how much you irrigate, do you consider how these decisions affect your neighbors (e.g., return flows, their ability to irrigate)?

Own Irrigation Decisions Affect Neighbors			
	Response	#	%
1	Not at all	28	19%
2	Not very likely	20	14%
3	Likely	33	22%
4	Very likely	26	18%
5	Always	31	21%
	No response	9	6%
		147	

Responses seem fairly uniform across possible responses; approximately as many respondents indicated “Not at all” as “Always,” “Not very likely” as “Very likely,” and the median response is “Likely.”

Responses are assigned to region below. The Mean column indicates the average response for each region, using the numeric values 1-5 (with 1 being “Not at all” and 5 being “Always”). Region B has the highest ranking, with average response being between “Likely” and “Very Likely.” Region D has the lowest, with the average response being between “Not very likely” and “Likely.” Using a Wilcoxon non-parametric test at an α =0.05 level, Region B respondents are more likely than respondents from any of the other three regions to consider how their decisions about irrigation affect their neighbors. There is no statistically significant difference between responses from regions A, B, and D.[1]

[1] A Wilcoxon non-parametric rank- sum tests the hypothesis that two samples (for example, responses to this question from region A versus region B) are from populations with the same distribution. All pairwise comparisons between regions below also use this test, at a significance level of α=0.05.

Regional Differences in Own Irrigation Decisions			
Region	Mean	SD	Sum
A	2.90	1.46	148
B	3.68	1.23	136
C	2.85	1.50	94
D	2.73	1.42	30
Total	3.09	1.44	408

Question 12: Do your neighbors' decisions about how, when, and how much they irrigate affect your water availability (e.g., return flows, your ability to irrigate)?

Neighbor Decisions Affect Own Water Availability			
	Response	#	%
1	Not at all	31	21%
2	Not very likely	18	12%
3	Likely	25	17%
4	Very likely	27	18%
5	Always	38	26%
		8	
		147	

Responses to this question are also fairly uniform. A comparison of these responses to the responses from question 11 suggests that people are approximately just as likely to think their neighbors' management affects them than they are to think that their management affects their neighbors. Once again, Region B has the highest ranking among the four regions, and Region D once again has the lowest. B respondents are more likely than respondents from regions A and C to consider how their decisions about irrigation affect their neighbors. There are no differences between the other regions.

Regional Differences in Neighbor Decisions			
Region	Mean	SD	Sum
A	2.98	1.59	152
B	3.78	1.34	140
C	2.88	1.49	98
D	2.82	1.54	31
Total	3.17	1.53	421

Question 13: What percentage of your acres do you usually irrigate late in the season (e.g., turn water back on after your last cutting)?

% of Acres Irrigated Late in the Season			
	% of Acres	#	%
1	0-25	53	36%
2	26-50	23	16%
3	51-75	28	19%
4	76-100	33	22%
	No response	10	7%
		147	

Overall, 53 respondents (39%) who answered this question indicated that they usually irrigate between 0 and 25% of their acres late in the season. The other responses were roughly evenly distributed in the other three quartiles.

Regional Differences in Late-Season Irrigation			
Region	Mean	SD	Sum
A	2.24	1.22	110
B	2.17	1.13	78
C	2.20	1.26	77
D	3.73	0.47	41
Total	2.34	1.23	306

Region D irrigates a larger percentage of their acres late in the season. There are no differences in late-season irrigation between the other regions.

Question 14: If you do not irrigate some/all of your acres late in the season, what are the reasons? (Mark all that apply.)

Reason	#	%
I have hay stacked in the meadow.	22	15%
I don't want to overflow the field.	11	7%
I can't turn back on because my neighbors do not.	12	8%
I have other employment in the fall and so do not have the time.	5	3%
Water is not available.	91	62%
Other	25	17%
Response Total	166	
Respondent Total		147

"Water is not available" is the reason most often given for not turning water back on. The 28 Other responses indicated water was not turned back on because the respondent grazed cows, wanted to dry the land out for various reasons, vacation, or it did not make economic sense.

Regional differences to this question's responses are below. (The percentage of responses, standard error, and number of responses are reported for each reason and region.) There are no statistically significant differences between region A, B, and C. Only four of the 11 respondents from Region D indicated any response to this question, and all four indicated that they do not turn water back on because water is not available.[2] This is a statistically significantly lower proportion of respondents than from the other regions.

Regional Differences in Reasons Given for Not Irrigating Late in the Season						
Reason		A	B	C	D	Total
1	I have hay stacked in the meadow.	15% 0.36 8	23% 0.43 9	11% 0.32 4	0% 0.00 0	15% 0.36 21
2	I don't want to overflow the field.	6% 0.23 3	13% 0.34 5	6% 0.24 2	0% 0.00 0	7% 0.26 10
3	I can't turn back on because my neighbors do not.	13% 0.34 7	8% 0.27 3	6% 0.24 2	0% 0.00 0	9% 0.28 12
4	I have other employment in the fall and so do not have the time.	2% 0.14 1	3% 0.16 1	6% 0.24 2	0% 0.00 0	3% 0.17 4
5	Water is not available.	65% 0.48 35	64% 0.49 25	71% 0.46 25	36% 0.50 4	64% 0.48 89

[2] Two of these four Region D respondents indicated reasons under Other: water too low in the creek and cost of running the pump not worth it.

Question 15: If there was a voluntary program available to compensate producers for a reduction in irrigation would you be interested in any of the following demand management practices?

	Producer Interest in Various Demand Management Practices				
	Practice	**Yes**	**No**	**No Response**	**% Yes**
1	Split season (do not turn water back on after last cutting)	57	56	34	39%
2	Earlier harvest than normal (and then turn off water)	15	87	45	10%
3	No irrigation on some fields for the whole year	15	90	42	10%
4	No irrigation on the same fields for multiple years	7	95	45	5%
5	Forego the use of any stored water	17	79	51	12%
6	Investments that reduce water use by enhancing delivery systems	85	22	40	58%
7	Everyone on a tributary (or irrigation district) agrees to implement specified management practices (e.g., above programs)	47	58	42	32%
8	Everyone on a tributary (or irrigation district) agrees to save a certain amount of water (no specification of management practices)	37	62	48	25%
9	Other (specify)	8	9	130	5%
10	None of the above (mark yes and explain)	25	4	118	17%
	Number of respondents				147

Practice 1 (Split-season) was one of the more popular practices with survey respondents, as 57 (39%) indicated they would be interested in undertaking this practice. This is the practice that SCPP participants implemented. Practices 2 (Earlier harvest than normal) and 3 (No irrigation on some fields for the whole year) were among the least popular with respondents. Practice 4 (No irrigation on the same fields for multiple years) was the least popular practice of all. The decreased interest in practices that would reduce hay production by more is logical, as these practices would have a larger financial impact on the ranch and potentially generate additional costs that would be harder to quantify, such as larger impacts to yields in subsequent years, and impacts on the overall cattle operation.

Practice 6 (Investments that reduce water use by enhancing delivery systems) is the most popular with survey respondents, with 85 respondents (58%) indicating interest. This echoes comments by focus group participants indicating a strong interest in improving efficiency. However, it would be difficult to fit this practice within the consumptive use framework of a DM program.

Practices 7 and 8 (Everyone on a tributary (or irrigation district) agrees to implement specified management practices (e.g., above programs) or to save a certain amount of water) are also popular with respondents.

Other. 8 respondents (5%) indicated “Other,” though 17 respondents provided open-ended responses for this option. (7 of the 8 respondents who said “Yes” to this option provided an explanation.)

None of the above. 25 respondents (17%) indicated “None of the above.” 24 respondents provided open-ended responses for this option. (24 of the 25 respondents who said “Yes” to this option provided an explanation.)

Patterns in Multiple Responses. The table below indicates the frequency with which survey respondents expressed interest in the various management practices. For example, 19 respondents indicated interest in just one practice and 15 respondents indicated interest in two. Of the 82 respondents who did not indicate they would undertake any practices, 16 actively indicated “No” and 66 left the question blank.

Multiple answers tend to cluster around practices 1, 6, 7, and 8. Of the 19 respondents who indicated interest in one practice, 17 indicated interest in Practice 6, 1 indicated interest in Practice 1, and 1 indicated interest in Practice 10. Of the 15 respondents who indicated interest in two practices, 14 indicated interest in Practice 6 and 8 indicated interest in Practice 7. Of the 9 respondents who indicated interest in three practices, all indicated interest in Practice 6 and 6 indicated interest in Practice 1. Of the 10 respondents who indicated interest in four practices, 9 indicated interest in Practice 1, 6, 7, and 8.

Number of Practices Indicated by Respondents			
Practice Count	**# of Respondents**	**% of Positive Responses**	**% of All Respondents**
1	19	23%	13%
2	15	19%	10%
3	9	11%	6%
4	10	12%	7%
5	6	7%	4%
6	3	4%	2%
7	3	4%	2%
0	82	n/a	56%
Respondents who indicated at least one practice		81	
Total Survey Respondents			147

Regional differences. The table below indicates regional differences in producer interest in various DM practices. Yes=1 and No=0. Average responses have been converted to percentage values (first row of each practice), so higher percentages indicate greater interest, on average, in the management practice. Second row indicates standard errors; third row indicates number of respondents.

Regional Differences in Producer Interest						
	Practice	**A**	**B**	**C**	**D**	**Total**
1	Split season (do not turn water back on after last cutting)	53%	70%	35%	22%	51%
		0.50	0.47	0.49	0.44	0.50
		23	21	9	2	55
2	Earlier harvest than normal (and then turn off water)	10%	27%	12%	11%	15%
		0.31	0.45	0.33	0.33	0.36
		4	7	3	1	15
3	No irrigation on some fields for the whole year	17%	12%	7%	22%	14%
		0.38	0.33	0.27	0.44	0.35
		7	3	2	2	14
4	No irrigation on the same fields for multiple years	8%	4%	4%	11%	6%
		0.27	0.20	0.19	0.33	0.24
		3	1	1	1	6
5	Forego the use of any stored water	8%	38%	4%	30%	17%
		0.28	0.49	0.21	0.48	0.38
		3	9	1	3	16
6	Investments that reduce water use by enhancing delivery systems	83%	76%	74%	80%	79%
		0.38	0.44	0.45	0.42	0.41
		35	19	20	8	82
7	Everyone on a tributary (or irrigation district) agrees to implement specified management practices (e.g., above programs)	38%	67%	41%	22%	45%
		0.49	0.48	0.50	0.44	0.50
		15	18	11	2	46
8	Everyone on a tributary (or irrigation district) agrees to save a certain amount of water (no specification of management practices)	29%	65%	25%	13%	36%
		0.46	0.49	0.44	0.35	0.48
		11	17	6	1	35

There are some statistically significant regional differences in responses to this question. Unlike elsewhere in this report, statistical significance is given at alpha=0.1 on this question, at least for now, to help identify trends.

Practice 1: Region A and B respondents are more interested than Region D respondents. Region B respondents are more interested in Region C respondents.

Practice 2: Region B respondents are more interested than Region A respondents.

Practices 3, 4, and 6: No differences between regions.

Practice 5: Region B and D respondents are more likely than Region A and C respondents.

Practices 7 and 8: Region B respondents are more likely than Region A, C, and D respondents.

Question 16: There are potential agronomic and ecological tradeoffs associated with implementing these practices. Do you think there would be agronomic impacts, ecological impacts, or hydrologic impacts from implementing these practices on your ranch?

The table below reports results for the General Version only. Percentage responses are therefore based on the General Version sample of 133 rather than the total sample of 147.) This question was worded slightly differently on the SCPP version of the survey, because the SCPP version asked SCPP participants what their actual experience was with the SCPP rather than asking them to consider hypothetical adoption of these practices, as was the case for this question. The SCPP Version also includes an option (in addition to "Losses or reductions," "No change," and "Gains") of, "Too early to tell."

Potential Impacts on Ranch from DM Participation									
	Impact	Losses or reductions		No change		Gains		Missing	
		#	%	#	%	#	%	#	%
1	Grass composition or species diversity	68	51%	31	23%	6	5%	28	21%
2	Invasive species coverage (e.g., cheat grass)	32	24%	33	25%	40	30%	28	21%
3	Fish presence	23	17%	70	53%	12	9%	28	21%
4	Bird presence	49	37%	50	38%	7	5%	27	20%
5	Big Game presence	42	32%	54	41%	9	7%	28	21%
6	Wetland presence	65	49%	32	24%	9	7%	27	20%
7	Return flows	53	40%	34	26%	16	12%	30	23%
8	Stream bank erosion	13	10%	71	53%	15	11%	34	26%
9	Water turbidity	13	10%	66	50%	12	9%	42	32%
10	Other (specify):	5	4%	5	4%	2	2%	121	91%
	Total Respondents		133		133		133		133

Section 3. Survey Results for SCPP Participants

Question 16. Approximately how many acres did you enroll over the lifetime of the SCPP?

Number of Grass Hay Acres Enrolled in SCPP				
Year	Mean	SD	Sum	N
2015	467	489	1400	3
2016	200	131	800	4
2017	715	681	4292	6
2018	719	341	7913	11

Two respondents indicated enrollment of alfalfa hay but they did not provide acreage information.

Question 17 The relationship between late-season water application and yields is not well understood. This is an area that requires more scientific research. This question will not be used to make a determination of whether there are yield impacts from late-season water reductions, or what they are. We are interested in your experience. If you participated more than one year, has participation affected your yields?

Yield Impacts of SCPP Participation		
	Grass Hay	Alfalfa Hay
Yields decrease	6	
Yields increase		1
Yields stay the same	3	
Too early to tell		
No response	5	13
Total responses	14	14

Question 18 We want to understand the potential agronomic and ecological tradeoffs of a program like the SCPP, along with the local economic impacts.

Ecological and Hydrologic Impacts of SCPP Participation											
		Losses or reductions		No change		Gains		Too early to tell		No response	
		0	%	#	%	#	%	#	%	#	%
1	Grass composition or species diversity	1	7%	6	43%	0		3	21%	4	29%
2	Invasive species coverage (e.g. cheat grass)	1	7%	3	21%	1	7%	5	36%	4	29%
3	Fish presence			6	43%			4	29%	4	29%
4	Bird presence	1	7%	5	36%	0		5	36%	3	21%
5	Big Game presence	0		5	36%	0		5	36%	4	29%
6	Wetland presence	1	7%	6	43%	0		4	29%	3	21%
7	Return flows	3	21%	4	29%	1	7%	2	14%	4	29%
8	Stream bank erosion			7	50%	2	14%			5	36%
9	Water turbidity			6	43%	1	7%	2	14%	5	36%
10	Others (explain below)							1		13	
	Total Respondents		14		14		14		14		14

Question 19. Overall, what type of impact has program participation had on your operation?

Impact of SCPP on Ranch Operation			
	Response	**#**	**%**
1	Positive impact	8	57%
2	Negative impact		0%
3	Both positive and negative	2	14%
4	No impact	2	14%
5	Missing response	2	14%
	Total responses	14	

Question 20 Please describe any major positive effects of program participation on your operation.
Text responses.

Question 21 Please describe any major negative effects of program participation on your operation.
Text responses.

Question 22 What changes did you make to your ranch or land management practices as a result of program participation? Please describe the changes you've made, and why:
Text responses.

Question 23. Who did you work with or receive feedback from when changing your management practices to participate in the program? (Mark all that apply.)

Who Did You Work With?				
		Yes	No	No response
1	No one - did it myself	7	4	3
2	Family members	2	9	3
3	For-profit farm consultant	0	11	3
4	Feed dealer	0	11	3
5	Business consultant	0	11	3
6	Financial manager	1	10	3
7	Local business association	0	11	3
8	Lawyer	0	11	3
9	Extension educator or specialist	0	11	3
10	Conservation District	1	10	3
11	Local government	0	11	3
12	Conservation NGO	1	10	3
13	Other (specify):	0	11	3

Question 24 In retrospect, do you wish your agricultural operation had done anything differently regarding challenges and opportunities arising from participating in the SCPP?

Would Have Done Something Differently?		
	#	%
Yes	1	7%
No	11	79%
Response not provided	2	14%
Total responses	14	

Question 25 On which of the following items have you or someone in your household spent money you received from participating in the SCPP? (Mark all that apply.)

Household Expenditures Due to SCPP			
		#	%
1	Purchased a new car or truck	0	
2	Home repairs/improvements	0	
3	Vacation, travel, or entertainment	0	
4	College or other educational expenses	0	
5	Donated to charity	1	7%
6	Saved or invested for other future needs	1	7%
7	Repairs to or new construction of ranch-related buildings	5	36%
8	Debt reduction	4	29%
9	Purchased new machinery or equipment	1	7%
10	Started a new ranch enterprise	0	
11	Otherwise invested in the ranch	7	50%
12	Purchased more land for operation	1	7%
13	Started a non-ranch business	0	
14	Expanded or improved an existing non-ranch business	0	
15	Estate planning	0	
16	Other (specify): "paid off debt"	1	7%

Question 26 What other benefits (besides money) or downsides have you or someone in your household experienced as a result of participating in the SCPP?

Other Non-Monetary Benefits to SCPP Participation							
		Other benefits to the household?		Other Benefits to the County?		Would the County be Better or Worse off with an Expanded Program?	
		#	%	#	%	#	%
1	Worse off	0	0%	0	0%	0	0%
2	A little worse off	1	7%	0	0%	0	0%
3	About the same	3	21%	3	21%	2	14%
4	A little better off	3	21%	5	36%	3	21%
5	Better off	4	29%	3	21%	6	43%
	Missing response	3		3		3	
	Total responses	14		14		14	

Question 27. Please describe any major positive effects of program participation in your community.
Text responses.

Section 4. Demographic Questions

Question 28 (was 17 in the General Version): Which one of the following best describes you?

Respondent Self-Description	
Landowner who operates the ranch	106
Landowner who leases out the ranch	28
Manager	5
Lessee	2
Accountant	2
Other (specify):	4
Total Responses	147

Question 29 (was 18 in the General Version): How long has the current landowner and their family owned the ranch?

Ownership Tenure		
	#	%
5 years or less	4	3%
Between 5 and 30 years	45	31%
This is a generational ranch	91	62%
No response	7	5%
	147	

Question 30 (was 19 in the General Version): Does the ranch have a succession plan?

Succession Plan?		
	#	%
Yes: Transfer to family member or others to maintain as a working ranch	109	74%
Yes: Sell the property	12	8%
Yes: Other (specify):	5	3%
No	12	8%
No response	9	6%
Total responses	147	

Question 31 (was 20 in the General Version): What is your age?

Respondent Age		
	#	%
Less than 30 years old	1	1%
30-50 years old	21	14%
51-70 years old	70	48%
Over 70 years old	51	35%
No response	4	3%
Total responses	147	

Question 32 (was 21 in the General Version): What was the landowner's approximately total household adjusted gross income in 2018, from the ranch operation and all sources, before taxes?

Percentage of Total Household Adjusted Gross Income from All Sources

	#	%
Less than $24k	26	18%
$25k-$74k	41	28%
$75k-$149k	25	17%
$150k or more	36	24%
No response	19	13%
Total responses	147	

Question 33 (was 22 in the General Version): In 2018, what percentage of the landowner's total household adjusted gross income was generated from ranching?

Percentage of Total Household Adjusted Gross Income from Ranching

	#	%
0-25%	45	31%
25-50%	17	12%
50-75%	20	14%
75-100%	47	32%
No response	18	12%
Total responses	147	

Question 34 (23): In 2018, was the ranch operation profitable? (For this question, please think just about the ranch operation rather than all sources of income.)

Profitability of Ranch Operation		
	#	%
The ranch was profitable	51	35%
The ranch lost money	32	22%
The ranch roughly broke even	51	35%
No response	13	9%
Total responses	147	

Question 35 (was 24 in the General Version): Please share any final comments you may have related to water management in your community.
Text responses.

B.3 Comparison of SCPP Participant and Non-Participant Responses

Section B2 above reported the responses of SCPP participants to questions about the SCPP program (Section 3 of the survey). This section reports on systematic differences in responses between SCPP participants and non-participants, regarding farm/ranch characteristics, irrigation management practices, or demographic questions.[3]

In sum, SCPP participants had larger operations on average than non-participants but were otherwise quite similar to non-participants, especially non-participants located in the same regions as themselves. There are two notable exceptions to this. First, SCPP participants

[3] The comparisons made in this section between SCPP participants and non-participants refers only to SCPP participants and non-participants who responded to the survey.

expressed more interest in several management practices than non-participants (split-season, early harvest, and the two cooperative, drainage-wide practices). Second, SCPP participants observed fewer negative agronomic and ecological impacts than non-participants expected to observe (grass composition and species diversity, wetland presence, and to some extent bird presence). This may suggest that SCPP participants chose to participate because the management practices suited them and the agronomic and ecological impacts were not anticipated to be too severe, given their particular operations' characteristics. Details below.

Farm/Ranch Characteristics. SCPP participants reported having more cow-calf pairs on average than non-participants (500-800 versus 200-500).[4] They also reported having more irrigated acres on average than non-participants (2,266 acres versus 667 acres). They had more sub-irrigated and flood-irrigated acres of irrigated pasture than non-participants, as well as more sub-irrigated and flood-irrigated acres of grass hay. Survey responses do not indicate any other difference in farm/ranch characteristics between SCPP participants and non-participants also located in Regions A and B (the two regions in which SCPP participants were located).[5]

Irrigation Management Practices. On average, SCPP participants reported the same levels of neighbor impacts as non-participants. They also reported the same percentage of acres irrigated late in the season as non-participants. SCPP participants reported more often than non-participants that having hay stacked in the meadow was a reason for not irrigating some/all of their acres late in the season (28% of SCPP participants versus 16% of non-participants). There were no differences in reporting rates between SCPP participants and non-participants for the other reasons.

The most significant difference between SCPP participants and non-participants was in their interest in different types of management practices and their perceptions of ecological impacts. SCPP participants were more likely to indicate willingness to implement practices 1 and 2 (split season and early harvest) than non-participants. (Table B3-1 indicates average differences between SCPP participants and non-participants for practices where the average responses for the two groups were statistically significantly different from one another.) This is logical, as SCPP participants had already implemented the split-season practice through the SCPP. These types of practices may tend to work better within SCPP participant operations than non-participant operations, or SCPP participants could tend to be more willing to try new practices than their non-participant neighbors, for any number of reasons not explored in this study.

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[4] The null hypothesis for all comparisons in this section is that the average response of the SCPP participants is the same as the average response of non-SCPP participants. Differences are reported using a t-test at an $\alpha = 0.05$ level of statistical significance.

[5] Comparisons between SCPP participants and non-participants were calculated in two different ways: SCPP participants versus ALL non-participants, and SCPP participants versus non-participants located in Regions A and B. The two comparisons gave the same results in all instances except for the following: SCPP participants tended to use more fertilizer, sell more tons of grass hay in an average year, be more interested in foregoing stored water as a management practice, and be less concerned that bird presence would be affected by the split-season management practice than non-participants in all regions. Non-participant averages presented in the text are for non-participants in Regions A and B.

SCPP participants were also more interested than non-participants in practices 7 and 8 (both involving cooperation on a tributary).

Table B3-1. Interest in Demand Management Practices Reported by SCPP Participants and Non-Participants.

	Practice	SCPP respondents		Non-participants in Regions A and B		Non-participants in entire region	
		Number	Average	Number	Average	Number	Average
1	Split season (do not turn water back on after last cutting)	11	0.91	67	0.54	102	0.46
2	Earlier harvest than normal (and then turn off water)	10	0.40	57	0.12	92	0.12
3	No irrigation on some fields for the whole year						
4	No irrigation on the same fields for multiple years						
5	Forego the use of any stored water	10	0.40			86	0.15
6	Investments that reduce water use by enhancing delivery systems						
7	Everyone on a tributary (or irrigation district) agrees to implement specified management practices (e.g., above programs)	11	0.73	58	0.45	94	0.41
8	Everyone on a tributary (or irrigation district) agrees to save a certain amount of water (no specification of management practices)	11	0.82	56	0.38	88	0.32
9	Other (specify)						
10	None of the above (mark yes and explain)						

Notes. For row 1, 11 SCPP participants responded to the question, would you be interested in undertaking practice 1, with a yes or no answer. Of these 11 respondents, 10 indicated yes (91%). 67 non-participants in regions A and B responded to the question regarding their interest in practice 1. Of these 67 respondents, 54% indicated interest in practice 1. Given the number of respondents and the dispersal of responses around the average in each group, 91% is statistically significantly different than 54%, indicating a difference in means between the two groups, and a larger interest in practice 1 among SCPP participants than other producers in Regions A and B.Respondent averages are only reported for potential impacts and groups for which there were statistically significant differences between groups.

Compared to all non-SCPP participants, SCPP participants were more likely to be interested in implementing practice 5 (forego storage water), though when they were compared just to their neighbors in Regions A and B, they were no more or less interested than their neighbors in implementing practice 5.[6] SCPP participants were no more or less interested in practices 3 or 4 (no irrigation for one or more full seasons) or 6 (investments to reduce water use) than non-participants.

SCPP participants and non-participants were both asked about potential agronomic and ecological tradeoffs associated with implementing the practices listed Question 15. However, because SCPP participants had actual experience with these impacts during the SCPP and non-participants did not, the questions in the two survey versions were worded differently. SCPP participants were asked, *For the split-season irrigation reductions implemented through the SCPP, have you or your neighbors observed agronomic impacts (e.g., changes in grass composition and yields), ecological impacts (e.g., changes in fish and bird presence), or hydrologic impacts (e.g., changes in return flow)?* Non-participants were asked, *If you marked YES for any of the practices [in question 15], do you think there would be agronomic impacts (e.g., changes in grass composition and yields), ecological impacts (e.g., changes in fish and bird presence), or hydrologic impacts (e.g., changes in return flow) from implementing these practices on your ranch?*

[6] Survey respondents from the Little Snake River (Region D) are included in the first comparison but not the second. Region D respondents were less interested than respondents from other regions in foregoing late-season storage, presumably due to the importance of late-season storage from High Savery Reservoir (see discussion of Question 15 in Section B2).

Table B3-2. Ecological Impacts Reported by SCPP Participants and Non-Participants

		SCPP respondents		Non-participants in Regions A and B		Non-participants in entire region	
		Number	Average	Number	Average	Number	Average
1	Grass composition or species diversity	10	1.90	29		39	1.28
2	Invasive species coverage (e.g. cheat grass)						
3	Fish presence						
4	Bird presence	11	1.91	29	1.55		
5	Big Game presence						
6	Wetland presence	11	1.91	31	1.32	41	0.10
7	Return flows						
8	Stream bank erosion						
9	Water turbidity						
10	Others (explain below)						

Notes. SCPP participants were asked about actual impacts, whereas non-participants were asked about what they thought the impacts might be. Only non-participants who indicated they would be interested in the split-season management practice are included in the second and third column blocks, since split-season is the management practice for which SCPP participants are reporting impacts. For a given potential impact, "Losses or reductions" is given a value of 1, "No change" is 2, and "Gains" is 3. SCPP participants had the option to indicate, "Too early to tell." For the purpose of this comparison, "Too early to tell" responses are treated as "No change" and given a value of 2. Respondent averages are only reported for potential impacts and groups for which there were statistically significant differences between groups.

50 non-participants indicated interest in implementing the split-season practice; these non-participants' responses are used for this comparison. SCPP participants were less likely to report reductions or losses in grass composition or species diversity, bird presence, and wetland presence. Averages for these three potential impacts are reported in Table B3-2.

Demographic Questions. SCPP participants were younger than non-participants. Other than age, SCPP participants did not give different answers to demographic questions, on average, than non-participants.

Appendix C

Firm-Level Data and Budget Information

Appendix C Firm-Level Data and Budget Information

3.1. Data Sources and Organization

Data underlying firm-level decision-making comes from the Green River Basin Annual Consumptive Use Report (CU Report) wherever possible. The CU Report is a document prepared annually by the WSEO that reports the data and methods underlying the WSEO's calculation of crop consumptive use in the Wyoming CRB. The most recent version was released in 2018. Underlying tables from the 2019 version are already available, however, and have been used for this report.

The CU Report provides data by WSEO Hydrographer District (Figure C-1). The Little Snake River is included in the CU Report even though it is not located in the Green River Basin. The Little Snake River is located in Division I in southeast Wyoming rather than Division III in southwest Wyoming, the location of all the other Districts in the Wyoming CRB. Its Hydrographer District is denoted I-8 below to reflect this difference.

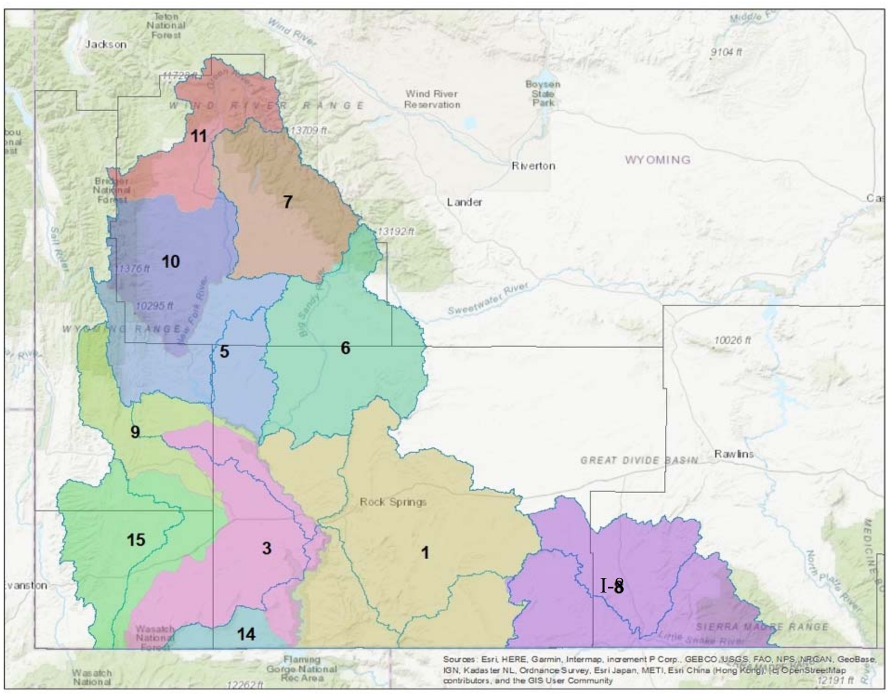

Figure C-1. WSEO Hydrographer Districts in the Wyoming CRB

Precipitation, Irrigated Lands, and Crop Consumptive Use. The WSEO reports effective precipitation, annual irrigated acreage estimates, and per-acre crop consumptive use estimates by year for each WSEO Hydrographer District. Most analysis in this report is conducted using average annual values for these parameters, taken over the 2011-2019 time period. Some additional sensitivity analysis is conducted using values of these parameters from 2013 as a representative dry year and 2017 as a representative wet year. The dry and wet year analyses in this study are consequently representative of dry and wet years but are not constructed based on averages. Tables C-1 and C-2 present these parameter values.

Table C-1 Irrigated Lands Under Different Water Year Types (acres)

Drainage	WSEO District	Dry (2013)	Average (2011-2019)	Wet (2017)	% Acres Grass Flood
Bitter Cr.	1	985	1,437	1,544	80%
Smith's Fk	3	37,128	40,892	42,903	64%
LaBarge/Fontenelle	5	15,096	15,947	16,951	82%
Eden Val/Big Sandy	6	16,539	19,143	20,887	17%
New/East Fk	7	47,160	50,494	54,455	76%
Ham's Fk	9	10,266	12,183	14,339	88%
Piney/Cottonwood Cr	10	60,365	67,987	74,571	87%
Green R/Horse Cr	11	38,747	43,701	47,139	99%
Henry's Fk	14	15,987	17,797	18,994	98%
Black's Fk	15	26,446	30,771	32,529	52%
Little Snake	I-8	14,435	16,140	16,582	76%
Total		283,153	316,494	340,894	

Source: WSEO WY 2019 Consumptive Use Report.

Table C-2 Crop Consumptive Use (AF/yr)

		Alfalfa Hay			Grass Hay		
Drainage	WSEO District	Dry (2013)	Average (2011-2019)	Wet (2017)	Dry (2013)	Average (2011-2019)	Wet (2017)
Bitter Cr.	1	2.06	1.91	1.80	1.78	1.70	1.59
Smith's Fk	3	2.39	2.20	2.17	2.21	2.06	2.02
LaBarge/Fontenelle	5	2.06	1.86	1.74	1.78	1.66	1.55
Eden Val/Big Sandy	6	2.06	1.91	1.80	1.78	1.70	1.59
New/East Fk	7	1.49	1.38	1.23	1.61	1.48	1.36
Ham's Fk	9	1.87	1.75	2.07	1.66	1.67	1.94
Piney/Cottonwood Cr	10	1.87	1.62	1.61	1.66	1.54	1.43
Green R/Horse Cr	11	1.82	1.49	1.07	1.61	1.44	1.22
Henry's Fk	14	2.39	2.02	1.48	2.21	1.93	1.73
Black's Fk	15	2.39	2.20	2.17	2.21	2.06	2.02
Little Snake	I-8	2.06	1.98	2.07	1.78	1.79	1.96

Source: WSEO WY 2019 Consumptive Use Report.

The final column in Table C-2 indicates percentage of irrigated acres in each WSEO District assigned to grass flood. The Grass Hay columns in Table C-2 include irrigated pasture acreage because of the difficulty of distinguishing between grass flood and irrigated pasture acreage in the satellite data used by the WSEO to generate these numbers.

Yields. Crop yield data by region is from the survey conducted as a part of this study. Crop yields were reported by respondents for average, wet, and dry years (Table C-3). Region D yield data for alfalfa and grass hay pivot are withheld due to low response. Averages for the entire Wyoming CRB were used for Region D, for these two crops.

Table C-3 Crop Yields by Water Year Type and Region (tons/acre)

	Grass Hay Pivot			Grass Hay Pivot			Grass Hay Flood		
Region	**Dry**	**Average**	**Wet**	**Dry**	**Average**	**Wet**	**Dry**	**Average**	**Wet**
A	1.52	2.34	2.35	0.64	1.50	1.36	0.94	1.46	1.61
B	1.86	2.50	2.81	2.33	2.50	2.67	0.98	1.42	1.62
C	2.17	3.00	3.56	2.00	2.33	2.63	1.30	1.95	2.47
D	.	.	.	.	.	.	1.70	2.43	2.60
Total	1.82	2.56	2.83	1.39	1.83	2.00	1.11	1.64	1.95

Source: Survey results.

Hay Prices. Wyoming hay prices are reported in Table C-4. Wyoming hay prices averaged over 2011-2019 were used for the "average year" analysis. Wyoming hay prices from 2013 and 2017 were used for the dry and wet year analyses, respectively.

Table C-4 Wyoming Hay Prices ($/ton))

Year	Alfalfa Hay	Grass Hay
2011	142	122
2012	210	193
2013	187	168
2014	145	128
2015	118	101
2016	122	106
2017	143	130
2018	172	142
2019	181	151
3-yr average (2017-2019)	165	141
5-yr average (2015-2019)	147	126
9-yr average (2011-2019)	158	138

Source: USDA NASS.

Operating Expenses. The starting point for production cost information is partial enterprise budgets for pivot-irrigated alfalfa and flood-irrigated grass hay reported in Yeatman (2020). These budgets did not include fixed costs (depreciation, etc.) and so were supplemented for the regional economic analysis in Sections 5 and 6 with hay budgets from eastern Washington and Idaho. Operations data needed for the break-even analysis, along with crop consumptive use estimates, yields, and prices reported above, are reported in Table C-5 by crop and county.

Table C-5 Crop-Level Financial Data for the Average Year Analysis (2011-2019)

County	Irrigated Land	Crop	Crop Acres	Cut Hay Yields	Aftermath Grazing Yields	Crop Consumptive Use	Gross Revenue	Operating Expenses	Net Operating Income	Per-Acre Break-Even Cost	Per-AF Break-Even Cost
	acres		acres	tons/acre	tons/acre	AF/acre	$/acre	$/acre	$/acre	$/acre	$/AF
Carbon	16,140	Alfalfa Pivot	401	2.56	0.50	1.98	483	205	278	761	384
		Grass Pivot	3,498	1.83	0.50	1.79	368	205	163	531	297
		Grass Flood	12,242	1.64	0.25	1.79	261	65	196	456	255
Lincoln	23,850	Alfalfa Pivot	919	2.73	0.50	1.81	509	205	304	813	450
		Grass Pivot	2,703	2.42	0.50	1.66	461	205	256	717	430
		Grass Flood	20,228	1.66	0.25	1.66	264	65	199	463	278
Sublette	167,108	Alfalfa Pivot	6,327	2.45	0.50	1.52	466	205	261	726	477
		Grass Pivot	16,859	2.19	0.50	1.50	424	205	219	644	428
		Grass Flood	143,922	1.43	0.25	1.50	232	65	167	399	266
Sweetwater	28,010	Alfalfa Pivot	11,996	2.59	0.50	1.94	487	205	282	769	397
		Grass Pivot	3,087	1.80	0.50	1.76	363	205	158	522	296
		Grass Flood	12,927	1.64	0.25	1.76	261	65	196	457	259
Uinta	81,385	Alfalfa Pivot	8,733	3.00	0.50	2.18	552	205	347	899	413
		Grass Pivot	21,002	2.33	0.50	2.05	446	205	241	686	336
		Grass Flood	51,650	1.95	0.25	2.05	304	65	239	543	265

Table C-6 Crop-Level Financial Data for the Dry Year Analysis (2013)

County	Irrigated Land	Crop	Crop Acres	Cut Hay Yields	Aftermath Grazing Yields	Crop Consumptive Use	Gross Revenue	Operating Expenses	Net Operating Income	Per-Acre Break-Even Cost	Per-AF Break-Even Cost
	acres		acres	tons/acre	tons/acre	AF/acre	$/acre	$/acre	$/acre	$/acre	$/AF
Carbon	14,435	Alfalfa Pivot	359	1.82	0	2.06	$ 339	$ 205	$ 134	$ 474	$ 230
		Grass Pivot	3,128	1.39	0	1.78	$ 234	$ 205	$ 29	$ 263	$ 148
		Grass Flood	10,948	1.12	0	1.78	$ 188	$ 65	$ 123	$ 310	$ 174
Lincoln	21,404	Alfalfa Pivot	862	2.00	0	1.97	$ 374	$ 205	$ 169	$ 543	$ 276
		Grass Pivot	2,430	2.18	0	1.72	$ 367	$ 205	$ 162	$ 528	$ 307
		Grass Flood	18,112	1.12	0	1.72	$ 189	$ 65	$ 124	$ 313	$ 182
Sublette	150,812	Alfalfa Pivot	5,718	1.76	0	1.75	$ 328	$ 205	$ 123	$ 452	$ 258
		Grass Pivot	15,428	1.81	0	1.63	$ 304	$ 205	$ 99	$ 403	$ 246
		Grass Flood	129,666	0.97	0	1.63	$ 162	$ 65	$ 97	$ 260	$ 159
weetwate	24,196	Alfalfa Pivot	10,320	1.76	0	2.14	$ 329	$ 205	$ 124	$ 453	$ 212
		Grass Pivot	2,667	1.14	0	1.89	$ 192	$ 205	$ (13)	$ 179	$ 95
		Grass Flood	11,209	1.07	0	1.89	$ 181	$ 65	$ 116	$ 296	$ 157
Uinta	72,305	Alfalfa Pivot	7,600	2.17	0	2.39	$ 405	$ 205	$ 200	$ 605	$ 253
		Grass Pivot	18,680	2.00	0	2.21	$ 336	$ 205	$ 131	$ 467	$ 212
		Grass Flood	46,025	1.30	0	2.21	$ 219	$ 65	$ 154	$ 372	$ 169

Table C-7 Crop-Level Financial Data for the Wet-Year Analysis (2017)

County	Irrigated Land	Crop	Crop Acres	Cut Hay Yields	Aftermath Grazing Yields	Crop Consumptive Use	Gross Revenue	Operating Expenses	Net Operating Income	Per-Acre Break-Even Cost	Per-AF Break-Even Cost
	acres		acres	tons/acre	tons/acre	AF/acre	$/acre	$/acre	$/acre	$/acre	$/AF
Carbon	16,582	Alfalfa Pivot	412	2.83	0.50	2.07	$ 476	$ 205	$ 271	$ 747	$ 360
		Grass Pivot	3,593	2.00	0.50	1.96	$ 325	$ 205	$ 120	$ 445	$ 228
		Grass Flood	12,576	1.96	0.25	1.96	$ 288	$ 65	$ 223	$ 510	$ 261
Lincoln	26,622	Alfalfa Pivot	984	3.15	0.50	1.89	$ 522	$ 205	$ 317	$ 839	$ 445
		Grass Pivot	3,014	2.65	0.50	1.73	$ 409	$ 205	$ 204	$ 613	$ 355
		Grass Flood	22,624	2.01	0.25	1.73	$ 293	$ 65	$ 228	$ 521	$ 302
Sublette	181,438	Alfalfa Pivot	6,874	2.67	0.50	1.36	$ 453	$ 205	$ 248	$ 700	$ 514
		Grass Pivot	18,299	2.26	0.50	1.36	$ 359	$ 205	$ 154	$ 513	$ 377
		Grass Flood	156,264	1.62	0.25	1.36	$ 243	$ 65	$ 178	$ 421	$ 310
Sweetwate	30,443	Alfalfa Pivot	13,080	2.80	0.50	1.73	$ 471	$ 205	$ 266	$ 738	$ 427
		Grass Pivot	3,378	1.82	0.50	1.65	$ 302	$ 205	$ 97	$ 399	$ 242
		Grass Flood	13,985	1.93	0.25	1.65	$ 283	$ 65	$ 218	$ 501	$ 304
Uinta	85,810	Alfalfa Pivot	9,221	3.56	0.50	2.09	$ 581	$ 205	$ 376	$ 957	$ 459
		Grass Pivot	22,098	2.63	0.50	1.99	$ 406	$ 205	$ 201	$ 608	$ 306
		Grass Flood	54,491	2.47	0.25	1.99	$ 353	$ 65	$ 288	$ 642	$ 323

Data for creating partial crop enterprise budget information is at three different resolutions: WSEO Hydrographer District (precipitation, irrigated acreage, and consumptive use), survey region (yields, supplemental information from rancher interviews), and the Wyoming CRB (hay prices, costs). The IMPLAN model used in this analysis to calculate secondary impacts requires data to be organized at the county level. Acreage and crop consumptive use data were assigned to the five counties in the study region based on the proportion of each WSEO's district's Wyoming CRB irrigated acreage located in each county. Percentages were determined using 2018 GIS data on irrigated acreage in the Wyoming CRB, WSEO District boundaries, and county boundaries (Table C-8). Yield data and supplemental information from rancher interviews were assigned to the five counties by survey region (Table C-9).

Table C-8 District-to-County Conversion (% WSEO District Acreage Attributed to Each County)

SEO District	Carbon	Lincoln	Sublette	Sweetwater	Uinta
1				1.00	
3					1.00
5		0.78	0.22		
6			0.09	0.91	
7			1.00		
9		0.90		0.10	
10		0.01	0.99		
11			1.00		
14				0.44	0.56
15					1.00
I-8	1.00				

Table C-9 Region-to-County Conversions

Region	Counties
A	Sublette, Sweetwater
B	Lincoln, Sublette
C	Lincoln, Sweetwater, Uinta
D	Carbon

Appendix D

Regional Model Development

Appendix D. Regional Impact Model Development

The following section describes the construction of the impact analysis used in this study. The analytical framework is a set of models developed in IMPLAN and adjusted to fit the regional economic structure and the scenario developed in the study. The models allow one to compare across scenarios income and job impacts generated directly and secondary impacts from the re-spending that occurs in the functional economy of concern (county or multi-county region). Impact models of this type have a number of restrictive assumptions, some of which are detailed in the main section of the study. (For more a more complete discussion of those limitations see Hamilton, et al 1991; Beattie and Leones, 1993) This approach assumes that change in prices for goods or services do not occur, t herefore, opportunity costs are not part of the calculation.

The geographic scope of the region, as detailed in the main report consists of five counties, Carbon, Lincoln, Sweetwater, Sublette, and Uinta Counties. Together they comprise the Southwest Wyoming functional economic region encompassing the Wyoming portion of the Colorado River Basin. The region in turn is highly integrated with larger economic regions Western Colorado, the Wasatch Front, and Eastern Idaho- Pocatello region. All commodities and services in this small open functional economic region have the capacity to trade with each other. SWW functional economic region has 215 separate sectors that are detailed descriptions of industries but with national level input output data and adjusted to local conditions through primarily employment levels. The agricultural sectors that occur in IMPLAN's economic accounts for this region are listed below:

Table D1. Agricultural Sector description in IMPLAN

Industry Sector No.	**Description**	**NAICS 2012**
2	Grain farming	11113-6, 11119
3	Vegetable and melon farming	1112
4	Fruit farming	111331-2, 111331-4, 111336*, 111339
6	Greenhouse, nursery, and floriculture production	1114, 1125*
10	***All other crop farming***	***11194, 111992, 111998***
11	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	11211, 11213
12	Dairy cattle and milk production	11212
13	Poultry and egg production	1123
14	Animal production, except cattle and poultry and eggs	1122, 1124, 1125*, 1129
16	Commercial logging	1133
18	Commercial fishing	1141

Source: IMPLAN

Hay and alfalfa are not a separate identified commodity in IMPLAN. Rather they are aggregated into one sector of the database: Sector 10 "All Other crop farming", which is in bold italics in Table D1. The sector is more of a balancing and residual sector to estimate outputs that do not fit other agricultural categories. As such this industry sector had to be modified to approach expenditures pattern in Hay and alfalfa. While a detailed expenditure profile is not possible some major changes could be made. Gross absorption coefficients (GAC) are a standard ratio otherwise known as technical coefficients and calculated as the ratio of value of output to value of an input. The first step was to adjust gross absorption coefficients (GAC) based upon enterprise budgets and cost of production estimates to account for cost differences between pivot and flood. The replacements are in Table D2 and are based upon cost of production studies and enterprise budgets. More changes could be made if detailed data were available but these are most obvious and notable, as well as the largest.

Table D2. Changes in IMPLAN SAM Gross Absorption Coefficients(13 out of 537 sector purchases)

IMPLAN	Commodity	GAC	Pivot	Flood	Notes
3002	Grains	0.006	0.000	0.000	
3011	Beef cattle	0.000	0.000	0.000	
3013	Poultry and egg products	0.000	0.000	0.000	
3030	Stone	0.001	0.000	0.000	
3049	Electricity transmission and distribution	0.008	0.008	0.007	Cost of production and enterprise budgets for Wyoming and Idaho
3169	Nitrogenous fertilizer	0.007	0.073	0.073	Cost of production and enterprise budgets for Wyoming and Idaho
3170	Phosphatic fertilizer	0.010	0.010	0.010	Cost of production and enterprise budgets for Wyoming and Idaho
3172	Pesticides and other agricultural chemicals	0.041	0.004	0.004	Cost of production and enterprise budgets for Wyoming and Idaho
3208	Concrete pipes	0.001	0.000	0.000	
3336	Storage batteries	0.001	0.000	0.000	
3411	Truck transportation services	0.006	0.048	0.048	Hay transport costs
3433	Monetary authorities and depository credit intermediation	0.010	0.020	0.020	interest costs
3460	Marketing research and all other miscellaneous professional, scientific, and technical services	0.002	0.001	0.000	Assumed 50 pct of IMPLAN

Source: IMPLAN

Each county and the large functional SWW region were modeled. Also, since input costs for flood and pivot are quite different but contained in one economic sector (10) two versions of each model were constructed with different GAC's, one with pivot and one with flood.

The SWW economy is part of a larger economy that includes Western Colorado, Eastern Utah and the Wasatch Front, and Eastern Idaho. We make the assumption that SWW is a smaller part of that broader region and that exports, imports, and local consumption in all goods and services can span the broader region. The regional modeling framework assumes a small open economy that will not necessarily affect individual market prices for most commodities and services (with some exceptions). Changes in hay and alfalfa production, livestock production, and others will not affect the larger regional price level noticeably. Changes in price levels do not necessarily mean changes in production levels, and therefore no real secondary effects (Hamilton, et al 1991; Beattie and Leones 1993). IMPLAN recommends a trade flow approach, balancing within-region transactions with outside-of-region transaction flows. The balance of payments for each sector and institution then starts with a fixed amount of international exports and imports, then estimates within-region consumption based upon national ratios, in this case using USDA/NASS data to model industry expenditures, leaving the residual being part of net domestic exports and imports. The approach assumes a substantial level of exports and imports, which is partially validated by interviews. However, USDC Bureau of Economic analysis of reported crop marketing data suggest the opposite, that most is consumed locally. The limitation of the location quotient analysis of BEA data is that price of grass hay could still be driven by the broader regional market. So within-region transaction could still be at the broad-region price. A well-functioning market would make sure of that. As such the regional purchase coefficient for sector 10 uses the IMPLAN assumption and the gravity model results. However, this question of exports is nonetheless relevant, but the survey and public data are not sufficient to conclusively address it at this point in time. So any future policy needs to consider a broader study of the agricultural market region for those outputs like hay, that could be impacted by a curtailment of water and connected to sales inside the region as well as outside the region. Table D3 provides summary descriptions of each model.

Generally, the larger the economies the larger the multipliers because there are more industries in the region, though there are notable exceptions highly concentrated small areas. Large local multipliers can occur when hay production is primarily done by livestock producers. Less hay is exported to producers outside the region. However, there could also be transportation and quality issues that can limit or encourage exportation. That assumes the livestock producers in other area are not finding enough feed in their own areas.

Finally, we did not investigate equine industry use of hay in this study. Discussion with Farm and Ranch Specialists suggest the use of hay as feed for horses in the broader region may be a significant amount. Currently there are 99,000 horses in Wyoming (Horse Properties.net). That part of the demand could keep hay exports high, and associated prices for hay higher in rural areas surrounding larger urban areas in the broader region.

Table D3. Overall IMPLAN results of of the frameworks and models.

REGIONAL INFORMATION	Carbon	Lincoln	Sublette	Sweet-water	Uinta	So. West Wyoming
GROSS REGIONAL PRODUCT ($1,000)	$1,274,293	$1,067,135	$791,802	$4,549,334	$1,041,728	$8,619,545
TOTAL PERSONAL INCOME ($1,000)'	$756,803	$764,067	$488,751	$2,168,785	$815,118	$4,993,524
TOTAL EMPLOYMENT	9,495	10,569	6,526	27,534	11,161	65,118
NUMBER OF INDUSTRIES	154	172	144	173	161	215
LAND AREA (SQ. MILES)	7,897	4,069	4,882	10,426	2,082	29,355
AREA COUNT	1	1	1	1	1	5
POPULATION	15,303	19,265	9,799	43,534	20,495	108,396
TOTAL HOUSEHOLDS	6,153	6,951	3,750	15,768	7,150	39,773
AVERAGE HOUSEHOLD INCOME	$122,990	$109,918	$130,349	$137,544	$113,997	$125,552
TRADE FLOWS METHOD	Trade Flows	Trade Flows	Trade Flows	Trade Flows	Trade Flows	Trade Flows
SHANNON-WEAVER INDEX	.66262	.68862	.65094	.66613	.68409	.70599

Source: IMPLAN 2020

In impact modeling development there are two components: the underlying data structure and framework that drives the creation of the impact model itself. So each county /region category is a summary of a functional impact model with an underlying multiplier matrix.

The models are summarized in Table D4. They include all six regions for flood alfalfa, pivot alfalfa, flood hay, and participant payments. An extra model on livestock is also presented but is separate from the hay economy impacts for the reasons given in the study. The livestock model was generated assuming flood grass hay market GAC's rather than pivot GAC's. So the underlying data structure for livestock is the same as the underlying structure for the grass flood model is the same underlying structure of the livestock model.

Table D4. Impact models used in the study geographic area and type of multiplier analysis.

	Alfalfa Pivot		Alfalfa flood		Grass Flood		Participant Payments/Dollar*	
	Employ-ment	Value-Added	Employ-ment	Value-Added	Employ-ment	Value-Added	Employ-ment	Value-Added
Carbon								
Direct	1.000	1.000	1.000	1.000	1.000	1.000	1.0000000	1.000
indirect	0.063	0.053	0.104	0.141	0.096	0.116	0.0000000	0.000
Induced	0.106	0.180	0.069	0.183	0.068	0.182	1.0000027	0.079
Total	1.169	1.234	1.173	1.324	1.164	1.298	1.0000027	0.079
Lincoln								
Direct	1.000	1.000	1.000	1.000	1.000	1.000	1.0000000	1.000
indirect	0.046	0.157	0.056	0.091	0.068	0.110	0.0000000	0.000
Induced	0.027	0.080	0.025	0.077	0.026	0.079	1.0000045	0.106
Total	1.072	1.237	1.082	1.167	1.095	1.189	1.0000045	0.106
Sweetwater								
Direct	1.000	1.000	1.000	1.000	1.000	1.000	1.0000000	1.000
indirect	0.012	0.078	0.009	0.076	0.009	0.076	0.0000000	0.000
Induced	0.006	0.014	0.006	0.013	0.006	0.013	1.0000045	0.106
Total	1.018	1.092	1.015	1.090	1.014	1.090	1.0000045	0.106
Sublette								
Direct	1.000	1.000	1.000	1.000	1.000	1.000	1.0000000	1.000
indirect	0.057	0.124	0.110	0.153	0.079	0.144	0.0000000	0.000
Induced	0.071	0.151	0.075	0.159	0.073	0.156	1.0000033	0.095
Total	1.128	1.275	1.185	1.312	1.152	1.301	1.0000033	0.095
Uinta								
Direct	1.000	1.000	1.000	1.000	1.000	1.000	1.0000000	1.000
indirect	0.102	0.145	0.106	0.130	0.092	0.111	0.0000000	0.000
Induced	0.033	0.088	0.033	0.087	0.032	0.085	1.0000039	0.129
Total	1.135	1.234	1.138	1.218	1.124	1.196	1.0000039	0.129
Southwest Wyoming								
Direct	1.000	1.000	1.000	1.000	1.000	1.000	1.0000000	1.000
indirect	0.105	0.160	0.094	0.132	0.116	0.163	0.0000000	0.000
Induced	0.052	0.135	0.051	0.132	0.052	0.136	1.0000036	0.115
Total	1.157	1.295	1.145	1.263	1.168	1.299	1.0000036	0.115
Southwest Wyoming Livestock								
Direct							1.000	1.000
indirect							0.548	0.639
Induced							-0.004	-0.007
Total							1.544	1.632

Source: IMPLAN,

* The employment direct impact is in dollars not jobs because of the nature of a household impact in IMPLAN. The rest of the multiplier numbers in the column are in dollars.

Each employment and value-added blocks represent a separate model