Appendix 5-D Siskiyou County Agricultural Economics Analysis Considering Groundwater Regulation

University of California, Merced

Siskiyou County Agricultural Economics Analysis Considering Groundwater Regulation

Supplementary Information for the Groundwater Sustainability Plan

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1. Introduction

1.1. Background

This economic analysis estimates potential impacts in gross revenues from changing cropping patterns in Siskiyou County's three agricultural valleys namely Butte Valley (Butte), Scott River Valley (Scott), and Shasta Valley (Shasta). This analysis provides insight on economic costs of benefits of land and water use decisions, while identifying areas that may benefit from intervention and stakeholder processes.

Below, we outline the structure and basis for an agricultural production and water use economic model whose purpose is to estimate impacts of land and water use policies on agricultural value in Siskiyou County. Model coverage includes most of the agriculture by irrigated area within the county, with the notable exception of the greater Tulelake area located in the northeast corner of the county (Figure 1) which contains some valuable commodities such potatoes. The Butte, Scott River, and Shasta Valleys were the most distinct agricultural regions within the county and showing significant differences in production factors such as access to groundwater and crop mix. The agricultural model is calibrated using 2018 as a baseline water year because it represents a relatively recent water year with most crop demands fulfilled in comparison to the drier 2014 and 2016 water years (Department of Water Resources, 2021), which are also available at the Department of Water Resources streamflow indices (Department of Water Resources, 2020).

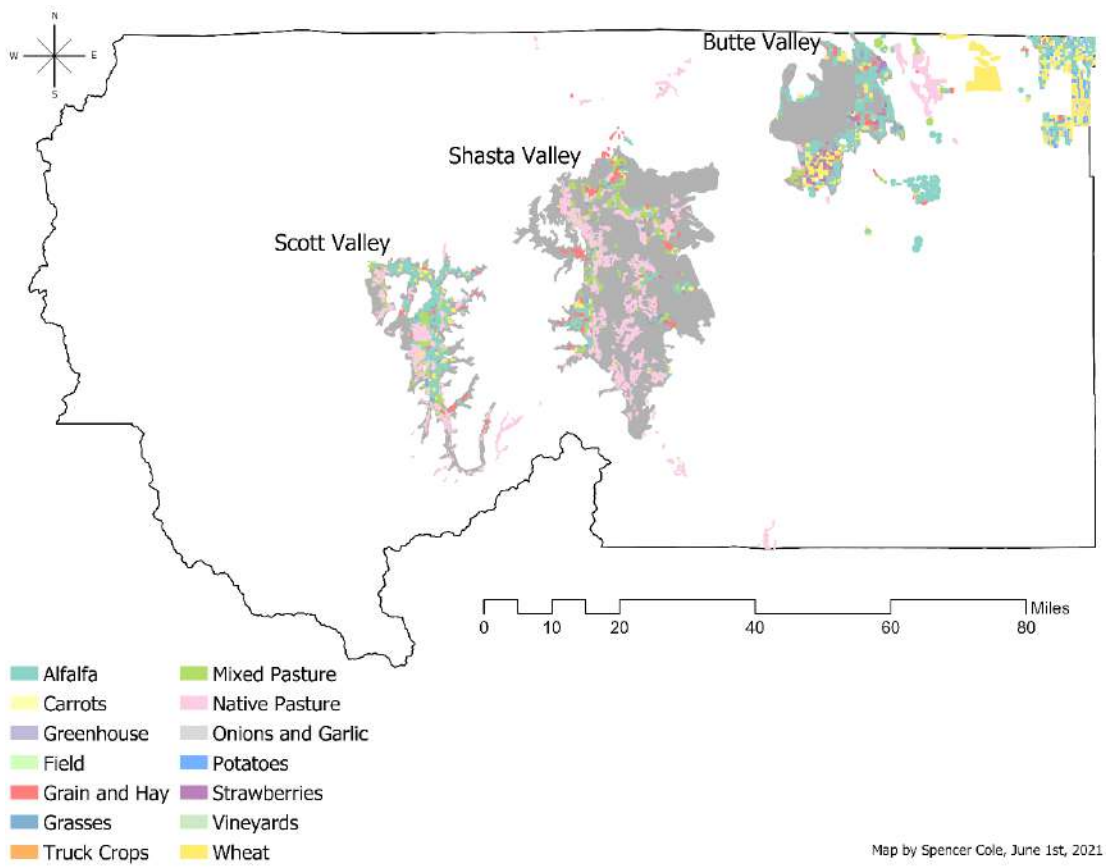

Figure 1: Region delineations and crop coverage represented in the agricultural model. Parcels located outside grey valley boundaries are not included in the model. *Source: 2018 LandIQ land use survey (Department of Water Resources, 2021)*.

1.2. Data sources

Information employed for defining the base case for production in the three valleys is summarized in Table 1. Land use calibration is based on 2018 data for land use and crop production economics where available. Recent cost information for crop commodities is prioritized when available and relevant to the production in Siskiyou County. Applied water requirements for crops are based on specific estimates at the valley scale for use in the integrated valley models. Whereas the model is calibrated using land use information from the LandIQ 2018 land use survey deployed through the California Land Use Viewer (Department of Water Resources, 2021), crop mix across the county and in individual valleys were cross-checked with parcel scale Department of Water Resources surveys for 2000 and 2010, the LandIQ 2016 survey, and the total agricultural footprint represented in the Siskiyou County Agricultural Commissioner's Report to ensure capture of key crops in the region.

Table 1: Summary of data sources for modeling of Siskiyou agricultural production.

Data type	Source	Spatial resolution	Temporal resolution
Valley boundaries	Department of Water Resources[1]	Polygon layer	N/A
Agricultural land use	LandIQ[2]	Parcel	Annual
Crop prices	Siskiyou County Agricultural Commissioner Reports[3]	County	Annual
Crop yields	Siskiyou County Agricultural Commissioner Reports[3]	County	Annual
Crop production costs	UC Davis Cost and Return Studies[4]	Regional	Varies
Applied water	Scott Valley Integrated Hydrologic Model[5], Butte Valley Integrated Hydrologic Model[1], Shasta Valley Integrated Hydrologic Model[6]	Valley	Annual

[1] Provided by Bill Rice.

[2] https://gis.water.ca.gov/app/CADWRLandUseViewer/.

[3] https://www.co.siskiyou.ca.us/agriculture/page/crop-report.

[4] https://coststudies.ucdavis.edu/en/.

[5] Provided by Claire Kouba.

[6] Provided by Cab Esposita.

1.3. Baseline conditions

Tables 2 to 4, below summarize the 2018 base conditions across each of the valleys in the model in terms of land and water use as well as crop revenues. Data is taken directly from the data sources described in section 1.2. above, apart from minor additions and adjustments when necessary to support the model function or to reflect farmer feedback during the workshop stakeholder meetings in June 2021. For example, in Butte Valley, 400 acres of onions and garlic were added to the model because the 2018 land use dataset did not identify any of these crops within the valley boundaries; farmers provided feedback noting that there was cultivation in areas within the valley. Currently, production cost information and crop water demand for nursery berries (raspberries and strawberries) is unavailable and is estimated based on the assumption that returns yield a 15% profit margin over total costs. Cost information available for carrot production is outdated and represents only fresh market cultivation, which does not represent the seed production in Siskiyou County; thus, costs for carrots are scaled to account for these differences. It is assumed that average profit margins for most crops range between zero and five percent of the crop gross revenues, thus some minor adjustments in selected crop prices were implemented in case negative profits from using the cost and return studies data were identified.

Table 2: Butte Valley base conditions. ***Source:*** **Author calculations using data listed in Table 1.**

Crop	Land (ac)	Applied water (AF/ac)	Price ($/ton)	Yield (ton/ac)	Labor cost ($/ac)	Supply cost ($/ac)	Land cost ($/ac)	Gross revenue ($ million)
Alfalfa	14,015	2.22	193	6.4	187	437	482	17.42 (10.6%)
Barley	1,460	1.51	286	2.3	122	285	204	0.97 (0.6%)
Carrots	313	2.09	56	66.7	976	2,278	248	1.16 (0.7%)
Onions and garlic	400	2.09	166	25.0	792	1,849	1,193	1.66 (1.0%)
Other hay	529	2.22	260	4.5	187	437	482	0.62 (0.4%)
Pasture	1,215	2.70	200	3.5	109	254	255	0.85 (0.5%)
Raspberries†	140	3.32	14	4,286	31,945	15,734	1,500	8.10 (4.9%)
Strawberries†	2,537	3.32	0.14	37,0000	28,495	14,035	1,500	131.39 (79.6%)
Wheat	4,502	1.51	203	3.2	122	285	204	2.90 (1.8%)
Total	**25,112**	-	-	-	-	-	-	**165.06 (100%)**

† Units in terms of plants rather than tons.

Table 3: Scott River Valley base conditions. ***Source:*** **Author calculations using data listed in Table 1.**

Crop	Land (ac)	Applied water (AF/ac)	Price ($/ton)	Yield (ton/ac)	Labor cost ($/ac)	Supply cost ($/ac)	Land cost ($/ac)	Gross revenue ($ million)
Alfalfa	12,267	1.97	193	6.4	187	437	482	15.25 (54.9%)
Barley	1,415	1.08	284	2.3	122	285	204	0.92 (3.3%)
Other hay	546	1.97	260	4.5	187	437	482	0.64 (2.3%)
Pasture	13,948	2.30	200	3.5	109	254	255	9.76 (35.1%)
Wheat	1,883	1.08	203	3.2	122	285	204	1.21 (4.4%)
Total	**30,060**	-	-	-	-	-	-	**27.79 (100%)**

Table 4: Shasta Valley base conditions. ***Source:*** **Author calculations using data listed in Table 1.**

Crop	Land (ac)	Applied water (AF/ac)	Price ($/ton)	Yield (ton/ac)	Labor cost ($/ac)	Supply cost ($/ac)	Land cost ($/ac)	Gross revenue ($ million)
Alfalfa	4,584	2.22	193	6.4	187	437	482	5.70 (14.7%)
Barley	3,780	1.51	286	2.3	122	285	204	2.49 (6.4%)
Other hay	1,660	2.22	260	4.5	187	437	482	1.95 (5.0%)
Pasture	30,642	2.70	200	3.5	109	254	255	21.45 (55.2%)
Strawberries†	125	3.32	0.14	370,000	28,495	14,035	1,500	6.49 (16.7%)
Wheat	1,273	1.51	203	3.2	122	285	204	0.83 (2.1%)
Total	**42,063**	-	-	-	-	-	-	**38.89 (100%)**

† Units in terms of plants rather than tons.

Table 5 summarizes overall land use, gross revenue, and water use summed across the three valleys. Following the modifications outlined above. The baseline dataset suggests the gross economic value within the three valleys totals $231.8 million, with $164.8 million, $27.6 million, and $38.4 million allocated to Butte, Scott River, and Shasta Valleys, respectively. Total agricultural land use in the study area is estimated to be about 97,000 acres, with 25,000 acres, 30,000 acres, and 42,000 acres in Butte, Scott River, and Shasta Valleys, respectively. Water use from irrigation is estimated at 220,000 acre-feet per year, of which 55,000 acre-feet, 61,000 acre-feet, and 104,000 acre-feet are used in Butte, Scott River, and Shasta Valleys, respectively on an annual basis. Agricultural value in Butte Valley is dominated by the small but extremely valuable berry plant transplant industry, which contributes $139.5 million of the region's $164.8 million gross revenue on only 11% of land (Siskiyou County Agricultural Commissioner, 2018). Both agricultural land and value in Scott River Valley consist of roughly 85% alfalfa and pasture in combination, with nearly equal area of each crop and small acres of other miscellaneous crops. About 75% of agricultural land and 50% of value in Shasta Valley is composed of pasture, with only about 125 acres of nursery strawberries making up a significant portion of remaining value.

Table 5: Baseline conditions across all three valleys. *Source:* Author calculations using data listed in Table 1.

Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Alfalfa	30,866 (31.7%)	65,511 (29.7%)	38.4 (16.6%)
Barley	6,655 (6.8%)	9,424 (4.3%)	4.4 (1.9%)
Carrots	313 (0.3%)	653 (0.3%)	1.2 (0.5%)
Onions and garlic	400 (0.4%)	834 (0.4%)	1.7 (0.7%)
Other hay	2,734 (2.8%)	5,942 (2.7%)	3.2 (1.4%)
Pasture	45,805 (47.1%)	118,017 (53.5%)	32.0 (13.8%)
Raspberries	139 (0.1%)	465 (0.2%)	8.1 (3.5%)
Strawberries	2,661 (2.7%)	8,837 (4.0%)	137.9 (59.5%)
Wheat	7,657 (7.9%)	10,735 (4.9%)	4.9 (2.1%)
Total	**97,236 (100%)**	**217,121 (100%)**	**231.8 (100%)**

2. Model calibration and assumptions

Calibration of the model is based on the concept of Positive Mathematical Programming (PMP; Howitt, 1995), a self-calibrating technique to economically represent agricultural production and water use based on profit maximization theory and capturing non-linearities in production. PMP modeling avoids overspecialization in land allocation decisions which is common in linear programming. Thus, highly profitable crops which are produced in limited amounts do not expand at the expense of low-value crops in a way that is inconsistent with observations. The PMP calibration method consists of three steps as described in Howitt et al. (2012): (1) constrained linear optimization to derive shadow values of crop land; (2) parametrization of a constant elasticity of substitution (CES) production function and non-linear cost function; and (3) specification of the model objective function and check for calibration quality. Once the model is fully calibrated, constraint and objective function modifications can be used to examine scenarios of interest. Each of the three regions in the model (Butte, Scott River, Shasta) are calibrated and run independently from one another with an annual decision period. The calibrated model employs the equations listed below which include a CES production function and a non-linear exponential cost function (Howitt et al. 2012).

Box 1: Specification of calibrated model.

$$max\ \{x_{i,land}\} \prod = \sum_i \left(p_i \tau_i \left(\sum_j \beta_{i,j}\, x_{i,j}^{\rho_i} \right)^{\frac{1}{\rho_i}} - \delta_i e^{\gamma_i x_{i,land}} - \sum_{labor,supplies,water} \alpha_{i,j} \omega_{i,j} x_{i,land} \right)$$

$$s.t.$$

$$\sum_i x_{i,land} \leq \sum_i \tilde{x}_{i,land}$$

$$\sum_i x_{i,land} \tilde{x}_{i,water} \leq \sum_i \tilde{x}_{i,land} \tilde{x}_{i,water}$$

$$\frac{x_{i,water}}{x_{i,land}} \leq 0.99\tilde{x}_{i,water}$$

$$\forall\ i\ \in \begin{bmatrix} alfalfa, barley, carrots, onions\ and\ garlic, other\ hay, pasture, raspebrries, \\ strawberries, wheat \end{bmatrix}$$

$$\forall\ j\ \in [land, labor, supplies, water]$$

The first equation is the profit maximization objective function, which is followed by the land and water availability constraint sets, and an irrigation stress constraint to avoid deficit irrigation of crops. Parameters in the three constraint sets above can be modified, including the limit of land and/or water available for crops and use of deficit irrigation as a potential adaptation to drought or water rationing policies.

2.4. Model assumptions

Interpretation of model function and output is contingent on several assumptions employed in the model framework. Agriculture is represented in the model as a "snapshot" of cropping patterns and economics observed across one or more years and pertains only to annual decision-making processes. In many cases, agriculture follows rotation cycles which are not captured explicitly in the model; land use data employed in model calibration is assumed to represent an pseudo-equilibrium state for rotating crops which is representative of a typical annual crop mix, with some portion of cropland in each cycle of their rotation. Farm-scale decisions for plantings oftentimes depend on multi-year investments and production conditions which are not captured in the annual structure of the model. As such, the model's purpose is not to suggest planting decisions for individual parcels, but rather to present possible impacts on agriculture at the aggregate scale. To predict annual cropping patterns at the regional scale, the model assumes that some degree of water trading occurs within each region to retain more profitable crops when resource shortages are in place.

3. Scenarios Overview

The calibrated model was applied in seven scenarios which are designed to establish preliminary measure for the effects of land management policies on agricultural value across the three valleys. Table 6 below, summarizes the context and implementation of the scenarios in the model.

Table 6: Summary of model scenarios.

Scenario number / name	Description
Scenario 1a: 15% fallowing of pasture and alfalfa	All alfalfa and pasture are fallowed by 15%, with no ability to re-operationalize land and water use reductions with other crops.
Scenario 1b: 30% fallowing of pasture and alfalfa	All alfalfa and pasture are fallowed by 30%, with no ability to re-operationalize land and water use reductions with other crops.
Scenario 1c: 60% fallowing of pasture and alfalfa	All alfalfa and pasture are fallowed by 60%, with no ability to re-operationalize land and water use reductions with other crops.
Scenario 2: forego third alfalfa cutting	Simulate ceasing half of irrigation for alfalfa by July 1st, represented in the model as 33% deficit irrigation for alfalfa and a corresponding reduction

	in yield of 33%. Water use reductions from deficit irrigating alfalfa are retained.
Scenario 3: 15% fallowing (adaptive)	Total agricultural land undergoes 15% fallowing, and model given flexibility to optimize distribution of cutbacks across individual crops.
Scenario 4: 15% fallowing (“worst case”)	Total agricultural land undergoes 15% fallowing, distributed evenly across all crops (area of all crop reduced by 15%).
Scenario 5: 15% water shortage (adaptive)	Total agricultural water use cutback by 15%, and model given flexibility to optimize distribution of cutbacks across individual crops.
Scenario 6: exploring economic tradeoffs between alfalfa and strawberries in Butte Valley	Comparison of marginal value and unit water use for alfalfa and berry plant transplant strawberries conducted to assess viability of converting between the two crops.
Scenario 7: exploring lower water use alternatives to alfalfa and pasture	Crop portfolio is assessed to locate water saving opportunities through crop conversion, with high retention or expansion of crop value.

4. Scenario Model Outcomes

4.1. Direct agricultural impacts (model results)

4.1.1. Scenario 1a: 15% fallowing of pasture and alfalfa

In this scenario, we simulate prescribed fallowing of pasture and alfalfa by 15% of baseline conditions within each region. Land and water previously devoted to these crops are treated as savings and thus are not allowed to be utilized in the model for the expansion of other crops. Under this land management policy, a total of 11,502 acres are fallowed (11.8%), of which 4,630 acres are alfalfa and 6,871 acres are pasture. Greatest cutbacks in land use occur in Shasta due to the exceptionally high baseline acreage of pasture, resulting in fallowing of 4,596 acres of pasture, nearly half of the total fallowed land. Slack water in lieu of irrigating the fallowed land total 27,530 acre-feet per year across the three valleys (12.5%). Gross revenue losses across all valleys together total $10.56 million (4.6%), concentrated in Scott ($3.75 million; 13.5%) and Shasta ($4.07 million; 10.5%). Economic losses in Butte – 1.7% as a percentage of baseline revenues – are weathered because of the high contribution of other crops such as nursery strawberries to overall agricultural value in the valley. Figure 2 and Table 7 below provide more detailed model outcomes of the cropping patterns, water use reductions, and value associated with this scenario.

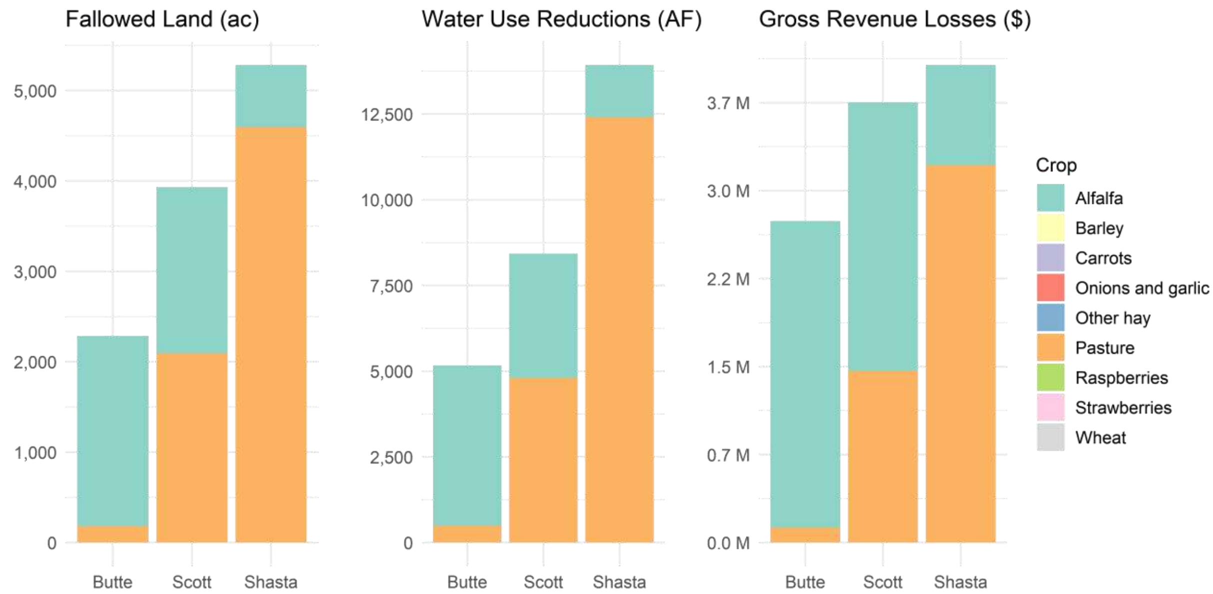

Figure 2: Results of land allocations, water use, and gross revenue differences from base for scenario 1a, 15% fallowing of pasture and alfalfa.

Table 7: Tabulated results of land allocations, water use, and gross revenues for scenario 1a, 15% fallowing of pasture and alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	11,913	26,495	14.81
	Barley	1,460	2,199	0.96
	Carrots	313	654	1.16
	Onions and garlic	400	834	1.66
	Other hay	529	1,177	0.62
	Pasture	1,033	2,789	0.72
	Raspberries	140	465	8.10
	Strawberries	2,537	8,421	131.39
	Wheat	4,502	6,780	2.90
	Subtotal	**22,828 (-9.1%)**	**49,813 (-9.4%)**	**162.32 (-1.7%)**
Scott	Alfalfa	10,427	20,525	12.96
	Barley	1,415	1,532	0.92
	Other hay	546	1,076	0.64
	Pasture	11,856	27,229	8.30
	Wheat	1,883	2,039	1.21
	Subtotal	**26,128 (-13.1%)**	**52,400 (-13.9%)**	**24.04 (-13.5%)**
Shasta	Alfalfa	3,896	8,665	4.84
	Barley	3,780	5,693	2.49
	Other hay	1,660	3,691	1.95
	Pasture	26,046	70,298	18.23
	Strawberries	125	416	6.49
	Wheat	1,273	1,917	0.82
	Subtotal	**36,780 (-12.6%)**	**90,679 (-13.3%)**	**34.82 (-10.5%)**
Three valleys	**Total**	**85,735 (-11.8%)**	**192,892 (-12.5%)**	**221.18 (-4.6%)**

4.1.2. Scenario 1b: 30% fallowing of pasture and alfalfa

Scenario 1b is an upscaled version of scenario 1a, wherein the model prescribes a more severe fallowing of 30% of all pasture and alfalfa. As expected, the results follow the same trends as in scenario 1a but with more significant reductions in all categories. A total of 23,002 acres are fallowed (23.7%), of which 4,569 acres are in Butte, 7,865 acres are in Scott, and the remaining 10,568 acres are in Shasta. Cutbacks in land use represent about one-quarter of all land in Scott and Shasta as individual regions, and about one-fifth of total land in Butte. Water use reductions total 55,060 acre-feet across the three valleys (25.0%). Compared with scenario 1a gross revenue losses are doubled, valuing $21.13 million in total (9.1%) and distributed similarly to each valley (3.3%, 27.7%, and 20.9% loss for Butte, Scott, and Shasta, respectively). Figure 3 and Table 8 below provide more detailed predictions of the cropping patterns, water use reductions, and value associated with this scenario.

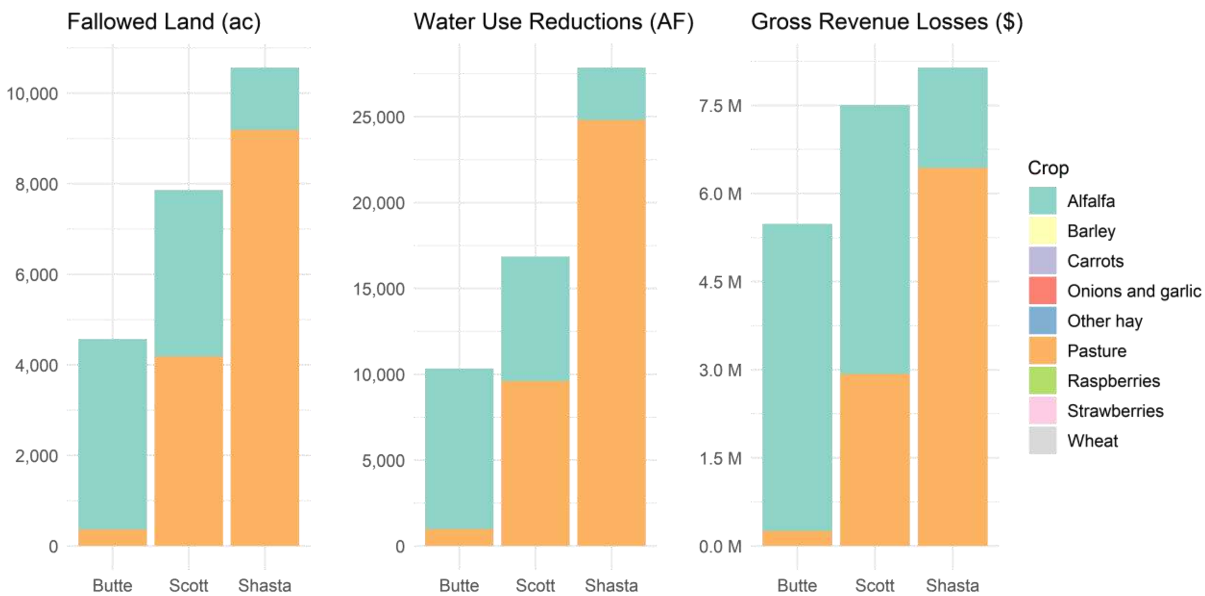

Figure 3: Results of land allocations, water use, and gross revenue differences from base for scenario 1b, 30% fallowing of pasture and alfalfa.

Table 8: Tabulated results of land allocations, water use, and gross revenues for scenario 1b, 30% fallowing of pasture and alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	9,811	21,819	12.20
	Barley	1,460	2,199	0.96
	Carrots	313	654	1.16
	Onions and garlic	400	834	1.66
	Other hay	529	1,177	0.62
	Pasture	851	2,296	0.59
	Raspberries	140	465	8.10
	Strawberries	2,537	8,421	131.39
	Wheat	4,502	6,780	2.90
	Subtotal	**20,543 (-18.2%)**	**43,973 (-18.8%)**	**159.58 (-3.3%)**
Scott	Alfalfa	8,587	16,903	10.68
	Barley	1,415	1,532	0.92

	Other hay	546	1,076	0.64
	Pasture	9,764	22,424	6.83
	Wheat	1,883	2,039	1.21
	Subtotal	**22,196** (-26.2%)	**43,973** (-27.7%)	**20.29** (-27.7%)
Shasta	Alfalfa	3,209	7,136	3.99
	Barley	3,780	5,693	2.49
	Other hay	1,660	3,691	1.95
	Pasture	21,449	57,892	15.01
	Strawberries	125	416	6.49
	Wheat	1,273	1,917	0.82
	Subtotal	**31,496** (-25.1%)	**76,745** (-26.6%)	**30.75** (-20.9%)
Three valleys	**Total**	**74,234** (-23.7%)	**165,363** (-25.0%)	**210.63** (-9.1%)

4.1.3. Scenario 1c: 60% fallowing of pasture and alfalfa

Scenario 1c further extends the fallowing cutbacks from the previous two scenarios and simulates a 60% fallowing of pasture and alfalfa. Total fallowing totals 46,003 acres (47.3%) with 9,139 acres, 15,729, and 21,136 acres occurring in Butte, Scott, and Shasta, respectively. Reductions in land represent over half of the agricultural acreage in Scott and Shasta but roughly one-third of Butte land use. Water use reductions in the three valleys total 110,117 acre-feet or about 50% of total estimated baseline irrigation demands. Gross revenue losses total $42.26 million (18.2%); Butte experiences the least value loss at $10.97 million (6.6%), followed by Scott at $15.01 million (54.0%), and lastly Shasta with $16.29 million (41.9%). Figure 4 and Table 9 below provide more detailed predictions of the cropping patterns changes, water use reductions, and value associated with this scenario.

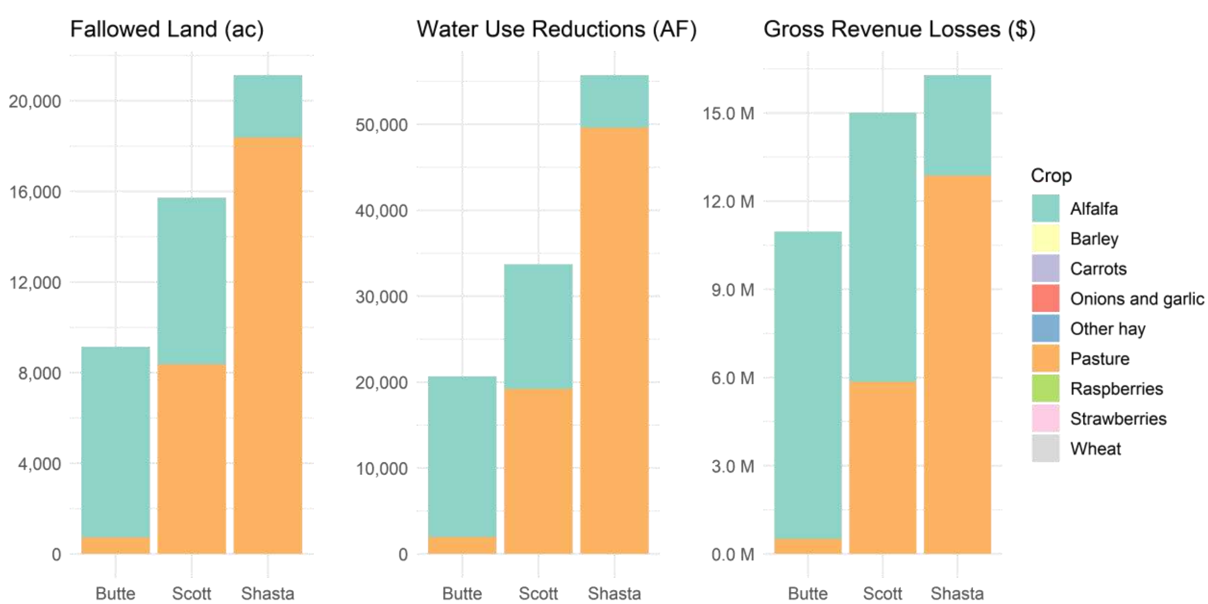

Figure 4: Results of land allocations, water use, and gross revenue differences from base for scenario 1c, 60% fallowing of pasture and alfalfa.

Table 9: Tabulated results of land allocations, water use, and gross revenues for scenario 1c, 60% fallowing of pasture and alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	5,006	12,468	6.97
	Barley	1,460	2,199	0.96
	Carrots	313	654	1.16
	Onions and garlic	400	834	1.66
	Other hay	529	1,177	0.62
	Pasture	486	1,177	0.34
	Raspberries	140	465	8.10
	Strawberries	2,537	8,421	131.39
	Wheat	4,502	6,780	2.90
	Subtotal	**15,974 (-36.4%)**	**34,310 (-37.6%)**	**154.10 (-6.6%)**
Scott	Alfalfa	4,907	9,659	6.10
	Barley	1,415	1,532	0.92
	Other hay	546	1,076	0.64
	Pasture	5,579	12,814	3.91
	Wheat	1,883	2,039	1.21
	Subtotal	**14,331 (-52.3%)**	**27,118 (-55.4%)**	**12.78 (-54.0%)**
Shasta	Alfalfa	1,834	4,078	2.28
	Barley	3,780	5,693	2.49
	Other hay	1,660	3,691	1.95
	Pasture	12,257	33,081	8.58
	Strawberries	125	416	6.49
	Wheat	1,273	1,917	0.82
	Subtotal	**20,928 (-50.2%)**	**48,875 (-53.3%)**	**22.60 (-41.9%)**
Three valleys	**Total**	**51,233 (-47.3%)**	**110,304 (-50.0%)**	**189.49 (-18.2%)**

4.1.4. Scenario 2: forego third alfalfa cutting

Scenario 2 presents results of a less constrained case as compared with scenario 1. The model simulates deficit irrigation of alfalfa during the summer and consequentially a reduction in the number of cuttings harvested from the crop. Total annual irrigation for alfalfa is reduced by one-third (33%) to reflect these conditions, and crop yield is assumed to respond linearly to deficit irrigation. Changes in yield are accounted for in the profitability of alfalfa when land allocations are made by the model and are also applied to the final assessment of gross crop revenues. To reflect changes in harvesting and cultural costs, all costs are also scaled linearly with yield reductions. Reductions in water use connected to deficit irrigation are assumed to be retained in the model, meaning that the water cannot be reallocated to the expansion of other crops beyond what is otherwise used.

This scenario results in minor fallowing of alfalfa land (2.9% of baseline alfalfa) due to the steep decrease in marginal value making it less attractive to grow in comparison with other options, a factor that also lowers the returns of the allocated alfalfa land. Some compensation occurs to account for profitability shifts, leading to minor expansions of some select crops (Figure 5). Fallowing totals 117 acres across the three valleys (0.1%) after considering alfalfa losses and expansion in other crops. Water use reductions total 21,620 acre-feet (9.8%) of which most occur in Butte and Scott where alfalfa is plentiful. Total net gross revenue losses after accounting for combined cropping pattern shifts come to $12.8 million (5.5%), distributed as $5.7 million, $5.1 million, and $1.9 million in Butte, Scott, and Shasta, respectively. As compared with scenario 1a, both gross revenue losses and water use reductions are similar, but total changes in agricultural land use are much lower. Figure 5 and Table 10 below provide more detailed results of the cropping patterns, water use reductions, and value associated with this scenario.

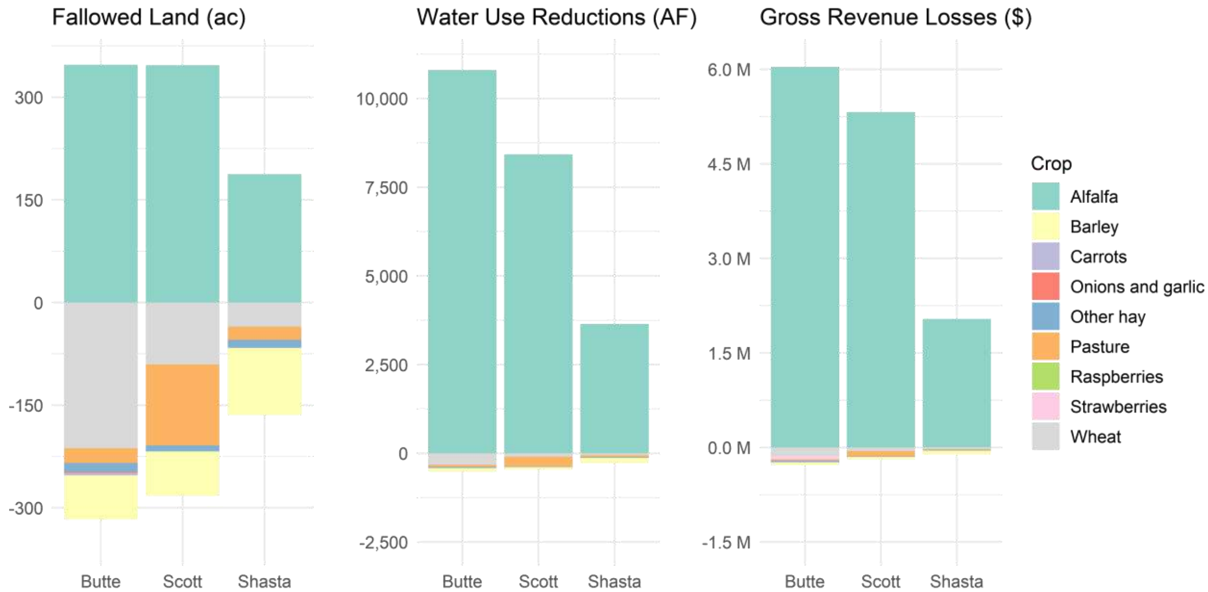

Figure 5: Results of land allocations, water use, and gross revenue differences from base for scenario 2, foregoing third cutting of alfalfa.

Table 10: Tabulated results of land allocations, water use, and gross revenues for scenario 2, foregoing third cutting of alfalfa.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	13,668	20,367	11.39
	Barley	1,525	2,296	1.00
	Carrots	317	662	1.17
	Onions and garlic	401	837	1.67
	Other hay	542	1,206	0.64
	Pasture	1,237	3,339	0.87
	Raspberries	140	465	8.10
	Strawberries	2,537	8,424	131.46
	Wheat	4,714	7,099	3.03
	Subtotal	**25,083 (-0.1%)**	**44,695 (-18.7%)**	**159.32 (-3.5%)**
Scott	Alfalfa	11,921	15,721	9.93
	Barley	1,480	1,602	0.97
	Other hay	555	1,092	0.65
	Pasture	14,067	32,307	9.85
	Wheat	1,974	2,136	1.27
	Subtotal	**29,996 (-0.2%)**	**52,859 (-13.1%)**	**22.66 (-18.5%)**
Shasta	Alfalfa	4,396	6,551	3.66
	Barley	3,879	5,841	2.55
	Other hay	1,671	3,717	1.96
	Pasture	30,661	82,754	21.46
	Strawberries	125	416	6.50

	Wheat	1,308	1,970	0.84
	Subtotal	**42,041** (-0.1%)	**101,250** (-3.2%)	**36.97** (-4.9%)
Three valleys	**Total**	**97,120** (-0.1%)	**198,803** (-9.8%)	**218.94** (-5.5%)

4.1.5. Scenario 3: 15% fallowing (adaptive)

Scenario 3 examines the expected impacts under a 15% land fallowing policy wherein cropping patterns can adapt to reduce the economic impacts. This scenario constrains the total land available to be allocated but does not prescribe fallowing in any given crop, meaning that the model is able to cut back in crops in such a way that minimizes farmer profit losses. Adaptive fallowing in this way assumes that there is some form of water trading which allows valuable crops to resist cutbacks because of some willingness to pay for scarce resources such as water.

Land fallowing totals 14,585 acres (15%) of which a large percentage (6,031 acres, 41.3%) consists of pasture reduction mostly in Shasta or Scott; remaining losses come in the form of alfalfa (4,101 acres, 28.1%), wheat (2,201 acres, 15.1%), barley (1,795 acres, 12.3%), and other crops (457 acres, 3.1%). Reductions in water use are slightly lower than land reductions by percentage, totaling 30,850 acre-feet (14.0%) across the three valleys. Gross revenue losses are in the order of $12.9 million (5.6%), distributed approximately equally across each of the valleys. Alfalfa receives the largest revenue loss of any crop ($5.1 million) followed by pasture ($4.2 million), and other minor crop losses representing the remaining economic impacts. Figure 6 and Table 11 below provide more detailed results of the cropping patterns, water use reductions, and value associated with this scenario.

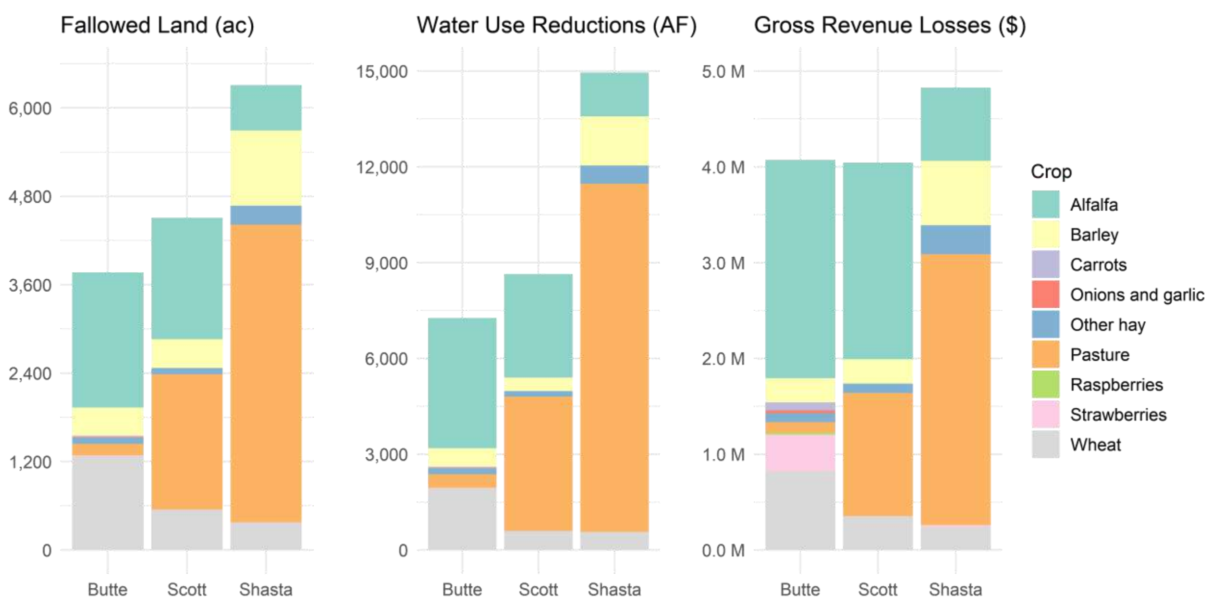

Figure 6: Results of land allocations, water use, and gross revenue differences from base for scenario 3, 15% fallowing of all cropland with adaptive management.

Table 11: Tabulated results of land allocations, water use, and gross revenues for scenario 3, 15% fallowing of all cropland with adaptive management.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	12,181	27,091	15.14

	Barley	1,078	1,623	0.71
	Carrots	291	607	1.08
	Onions and garlic	393	819	1.63
	Other hay	449	1,000	0.53
	Pasture	1,060	2,861	0.74
	Raspberries	140	463	8.08
	Strawberries	2,529	8,421	131.01
	Wheat	3,224	4,856	2.08
	Subtotal	**21,345 (-15.0%)**	**47,717 (-13.2%)**	**160.99 (-2.5%)**
Scott	Alfalfa	10,617	20,899	13.20
	Barley	1,025	1,109	0.67
	Other hay	462	909	0.54
	Pasture	12,114	27,822	8.48
	Wheat	1,333	1,443	0.86
	Subtotal	**25,551 (-15.0%)**	**52,182 (-14.2%)**	**23.75 (-14.5%)**
Shasta	Alfalfa	3,967	8,823	4.93
	Barley	2,758	4,154	1.81
	Other hay	1,403	3,120	1.64
	Pasture	26,601	71,796	18.62
	Strawberries	125	415	6.47
	Wheat	900	1,355	0.58
	Subtotal	**35,754 (-15.0%)**	**89,663 (-14.3%)**	**34.07 (-12.4%)**
Three valleys	**Total**	**82,651 (-15.0%)**	**189,562 (-14.0%)**	**218.81 (-5.6%)**

4.1.6. Scenario 4: 15% fallowing ("worst case")

Scenario 4 examines a similar land policy to that of scenario 3 (15% fallowing of all cropland) but restricts the model's ability to minimize losses. In this case all crop types are equally cut back by 15% without an implicit water trading potential. Removing the potential to shift cutbacks between crops leads to much more drastic economic losses compared to the previous scenario.

As a result of the restrictions imposed on the model, cutbacks across all categories (land, water use, and gross revenues) are all equal to the total fallowing percentage (15%) and do not change based on crop or region. Total fallow land remains at 14,585 acres as in scenario 3, distributed as 3,767 acres, 4,509 acres, and 6,310 acres lost in Butte, Scott, and Shasta, respectively. Water use reductions are slightly higher than the previous scenario, at 33,063 acre-feet. Agricultural revenue losses, however, are nearly three times higher than the adaptive scenario, totaling $34.8 million. Most revenue loss is attributed to reductions in strawberries and raspberries which value $21.9 million (62.9%) in combination; alfalfa and pasture make up most remaining value loss. Figure 7 and Table 12 below provide more detailed results of the cropping patterns, water use reductions, and value associated with this scenario.

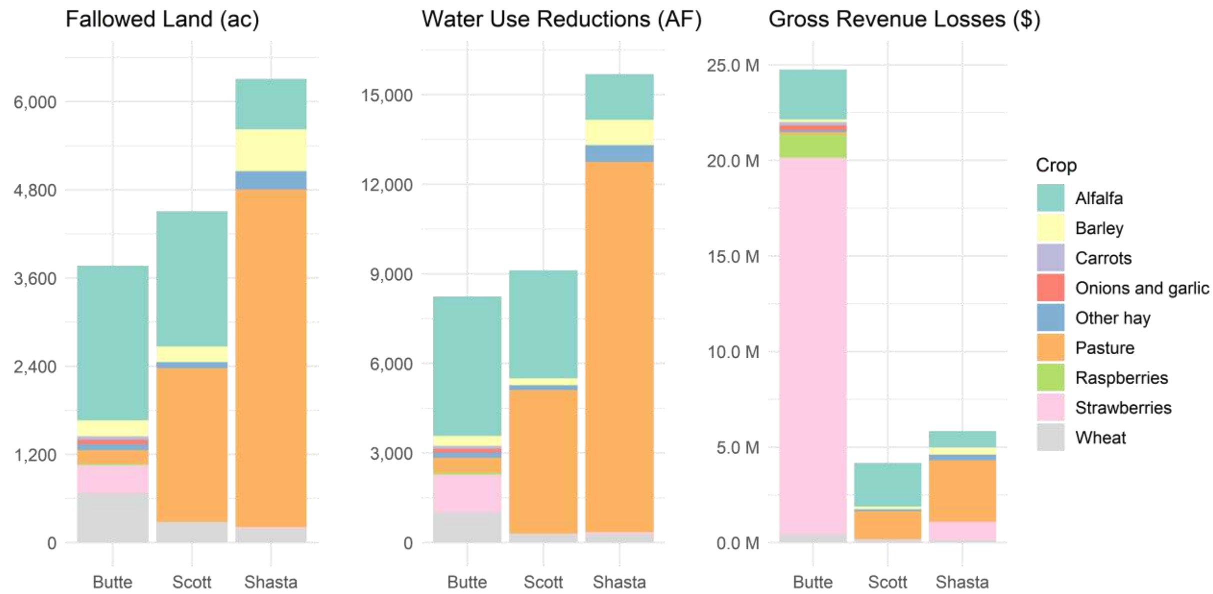

Figure 7: Results of land allocations, water use, and gross revenue differences from base for scenario 4, 15% fallowing of all cropland without adaptive management.

Table 12: Tabulated results of land allocations, water use, and gross revenues for scenario 4, 15% fallowing of all cropland without adaptive management.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	11,913	26,495	14.81
	Barley	1,241	1,869	0.82
	Carrots	266	556	0.99
	Onions and garlic	340	709	1.41
	Other hay	450	1,000	0.53
	Pasture	1,033	2,789	0.72
	Raspberries	119	395	6.88
	Strawberries	2,156	7,158	111.68
	Wheat	3,827	5,763	2.46
	Subtotal	**21,345 (-15.0%)**	**46,734 (-15.0%)**	**140.30 (-15.0%)**
Scott	Alfalfa	10,427	20,525	12.96
	Barley	1,203	1,302	0.79
	Other hay	464	914	0.54
	Pasture	11,856	27,229	8.30
	Wheat	1,601	1,733	1.03
	Subtotal	**25,551 (-15.0%)**	**51,703 (-15.0%)**	**23.62 (-15.0%)**
Shasta	Alfalfa	3,896	8,665	4.84
	Barley	3,213	4,839	2.11
	Other hay	1,411	3,137	1.65
	Pasture	26,046	70,298	18.23
	Strawberries	107	354	5.52
	Wheat	1,082	1,629	0.70
	Subtotal	**35,754 (-15.0%)**	**88,922 (-15.0%)**	**33.06 (-15.0%)**
Three valleys	**Total**	**82,651 (-15.0%)**	**187,358 (-15.0%)**	**196.99 (-15.0%)**

4.1.7. Scenario 5: 15% water shortage (adaptive)

Scenario 5 follows a similar concept and realization to that of scenario 3, however, restrictions are made more broadly to water as opposed to land availability. Under this scenario the model is again allowed flexibility in allocating land to crops and minimizing economic losses. Trends in overall resource use remain roughly the same as they were in the results of scenario 3 with minor differences in land allocation due to variability in unit water demand across crop types.

Fallowed land totals 13,848 acres across the three valleys and is composed primarily of alfalfa and pasture, with less severe cutbacks in barley and wheat owing to the lower unit water demands of these crops. In summary, total land fallowing is reduced compared with scenario 3, but targets towards higher water use crops. Water use reductions total of 32,760 acre-feet (15%). Changes in gross revenue losses are minimal compared with the land-limited scenario, and total $13.0 million. Both scenario 3 and 5 see much more evenly distributed economic impacts as compared to scenario 4, which experiences almost all effects in Butte Valley because of losses in berry plant transplant crops.

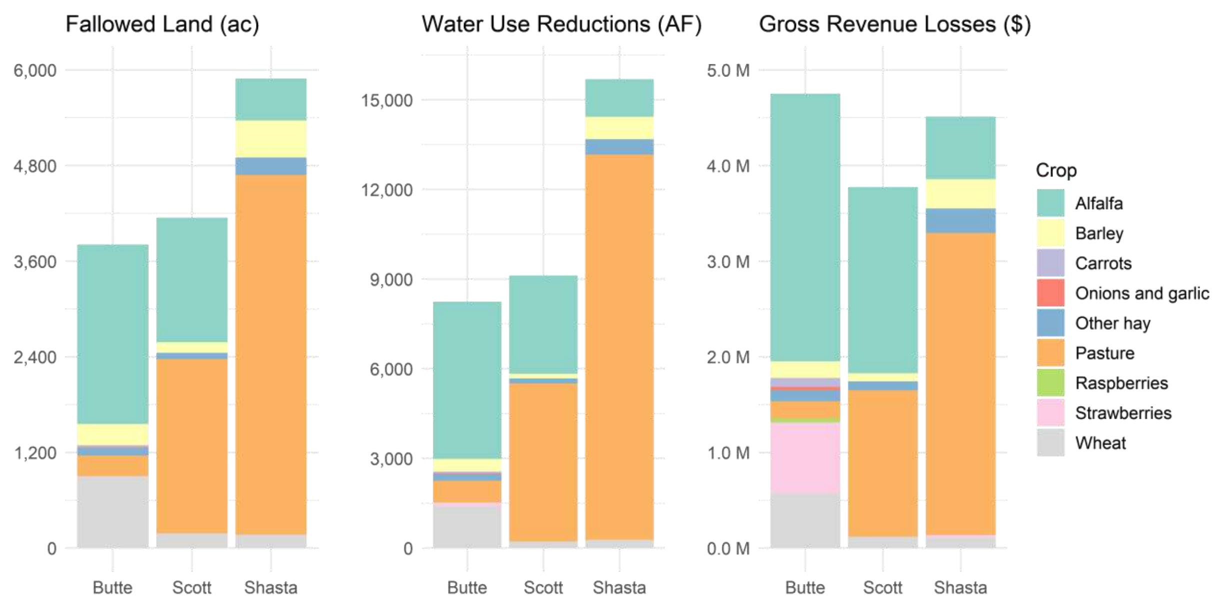

Figure 8: Results of land allocations, water use, and gross revenue differences from base for scenario 5, 15% total water shortage with adaptive management.

Table 13: Tabulated results of land allocations, water use, and gross revenues for scenario 5, 15% total water shortage with adaptive management.

Region	Crop	Land (ac)	Water use (AF)	Gross revenue ($ million)
Butte	Alfalfa	11,765	25,903	14.63
	Barley	1,193	1,779	0.78
	Carrots	288	595	1.07
	Onions and garlic	392	809	1.63
	Other hay	431	949	0.51
	Pasture	959	2,563	0.67
	Raspberries	139	458	8.06
	Strawberries	2,522	8,290	130.65
	Wheat	3,614	5,388	2.33

	Subtotal	**21,303 (-15.2%)**	**46,734 (-15.0%)**	**160.31 (-2.9%)**
Scott	Alfalfa	10,702	20,854	13.31
	Barley	1,284	1,376	0.84
	Other hay	466	909	0.55
	Pasture	11,761	26,742	8.23
	Wheat	1,700	1,822	1.09
	Subtotal	**25,914 (-13.8%)**	**51,703 (-15.0%)**	**24.02 (-13.6%)**
Shasta	Alfalfa	4,057	8,933	5.04
	Barley	3,316	4,943	2.18
	Other hay	1,441	3,172	1.69
	Pasture	26,129	69,817	18.29
	Strawberries	125	410	6.47
	Wheat	1,104	1,647	0.71
	Subtotal	**36,172 (-14.0%)**	**88,922 (-15.0%)**	**34.38 (-11.6%)**
Three valleys	**Total**	**83,389 (-14.2%)**	**187,358 (-15.0%)**	**218.71 (-5.6%)**

4.1.8. Scenario 6: exploring economic tradeoffs between alfalfa and strawberries in Butte Valley

Strawberry plants for transplant are a particularly unique specialty crop grown in Butte Valley due to their high value and importance in supporting downstream berry production on the Central Coast. As such, these crops pose an opportunity for generating great economic value with less land and water resource use – suggesting that conversion of other crops to strawberries may have benefits for managing water use while maintaining agricultural value. Given that alfalfa is the dominant crop by area in the valley (55.8%) and is relatively low value compared to nursery berries, this scenario explores tradeoffs in converting between these two crops.

In this analysis, the marginal revenue of an acre of transplant strawberry plants is estimated to be about $51,800 and the crop is estimated to operate with a 15% profit margin after costs are considered. Irrigation needs for strawberries are estimated at 3.32 AF/ac per year. Alfalfa is estimated to have a marginal revenue of $1,240/ac with a 5% profit margin and irrigation needs of 2.22 AF/ac per year in Butte Valley. Assuming constant returns to scale within both crop groups, about 42 acres of alfalfa produce the same gross revenue as 1 acre of nursery strawberries but use significantly more water in the aggregate.

Tables 14 and 15, below, outline possible options for retiring alfalfa in favor of transplant strawberries. The first strategy focuses on maintaining or expanding value while maximizing resource reductions (1:40 ratio of strawberries to alfalfa). The second strategy replaces alfalfa with strawberries at a higher rate (5:40 ratio of strawberries to alfalfa) in favor of economic expansion. These scenarios recognize the rotations exercised in growing transplant strawberry plants, which are understood to typically operate in 3-year rotations of strawberry-grain-fallow with roughly equivalent acreages of each at any given time. Based on this production model, for each acre of transplant strawberries planted, 1 acre of grain is planted, and 1 acre is set aside as fallow for the rotation with land, water use, and revenue impacts reflecting these conditions.

Table 14: Conservative strategy for converting alfalfa to strawberries (1:40 ratio of strawberries to alfalfa) focused on water use reductions.

Alfalfa fallowed (ac)	Strawberries planted (ac)	Grain planted (ac)	Fallow reserved (ac)	Land reductions (ac)	Water reductions (AF)	Revenue impact ($)
200	5	5	5	185	421	+13,570
400	10	10	10	222	505	+16,284
600	15	15	15	259	589	+18,998
800	20	20	20	296	673	+21,712
1000	25	25	25	333	757	+24,426

Table 15: Progressive strategy for converting alfalfa to strawberries (5:40 ratio of strawberries to alfalfa) focused on economic expansion.

Alfalfa fallowed (ac)	Strawberries planted (ac)	Grain planted (ac)	Fallow reserved (ac)	Land reductions (ac)	Water reductions (AF)	Revenue impact ($)
200	25	25	25	125	324	+1,062,443
400	50	50	50	150	389	+1,274,931
600	75	75	75	175	454	+1,487,420
800	100	100	100	200	519	+1,699,909
1000	125	125	125	225	583	+1,912,397

One consideration to make when examining conversion of alfalfa to higher value crops such as strawberries is the limit on strawberry expansion; consistent with PMP modeling which limits crop specialization, it is typically assumed that valuable crops that are observed to be grown in relatively low amounts are constrained by production conditions and upfront costs aside from profitability. For example, soils used in pasture are often less suitable to grow more sensitive crops such as vegetables because of nutrient deficiencies or soil composition. However, because transplant strawberries in Butte Valley are grown in nursery conditions, this may lend itself to better control of production conditions that might otherwise prevent expansion under natural cultivation practices. Expansion of nursery strawberry production is limited by several additional factors including labor availability and high upfront investment in technical knowledge and infrastructure. Many of the farmers currently involved in this sector have accumulated generational knowledge pertaining to management and business practice which are seen for other crops in the county but require fewer capital investments. These scenarios propose minor expansion of transplant berries by area in recognition of the challenges noted by farmers in this sector that currently prevent significant expansion from occurring.

4.1.9. Scenario 7: exploring lower water use alternatives to alfalfa and pasture

Among the crops cultivated in the three valleys examined for this study of Siskiyou County agriculture, pasture and alfalfa are the largest drivers of water demand, both at the aggregated and unit production scales. There is an interest in exploring the role that these crops play in the context of water use as well as economic value. This scenario examines potential for land use tradeoffs involving these crops with the goal of reducing water use while maintaining gross returns. It is worthwhile noticing alfalfa and pasture support downstream agricultural sectors such as the dairy and beef cattle industry, which may be impacted by higher feed crop costs resulting from a reduction in the local supply of irrigated pasture and alfalfa. Intermountain alfalfa is also known for its higher quality and is used as feed in more specialized animal operations beyond dairies and beef cattle.

Under baseline conditions, alfalfa covers roughly 32% of agricultural land across the three valleys while pasture makes up an additional 47% of crop cover. Alfalfa is mostly concentrated in Butte and Scott and pasture composes a majority of land use in Shasta. Unit water use for alfalfa is estimated at 2.22 acre-feet/acre in Butte and Shasta and 1.97 acre-feet/acre in Scott. Pasture is estimated to require 2.70 acre-feet/acre in Butte and Shasta and 2.30 acre-feet/acre in Scott. In the aggregate, these two crops contribute 83% of total water demand for the three valleys, of which 30% is attributed to alfalfa and 53% to irrigated pasture. Siskiyou does not have as stark of contrasts in unit water use between crops as other regions in California, where it is common to see grains with sub- 2 acre-feet/acre irrigation needs grown alongside alfalfa or almonds requiring over 4.5 acre-feet/acre in annual irrigation. However, there is still significant differences in unit demands which suggest opportunities for improving economic efficiency in applied water.

Table 16 below provides a baseline for comparison between water use and value for crops grown within each of the three valleys. This table serves to highlight opportunities for conversion between crop types in the interest of water management benefits. For example, wheat and barley offer some tradeoff from pasture and alfalfa for lowering total water demand at the expense of reduced agricultural revenue. Alfalfa demands roughly 1.5 times the irrigation of wheat or barley (per acre) but has nearly double the marginal value of these crops. In the Scott River Valley, where irrigation demands tend to be lower, each of these crops has comparable value per unit of applied water ($/acre-feet), however, in Butte and Shasta the economic return of water for grain crops is about 25% lower than that of alfalfa. Pasture, on the other hand, has both the highest unit water demands of any crop in the three valleys as well as the lowest value per unit of applied water. Marginal values for pasture are comparable to grain crops. Crops such as carrots and onions are suitable to be grown in Butte and have higher marginal value both per unit of land and water as compared with alfalfa or pasture. However, these crops are observed to be grown in only small amounts (approximately 400 acres at most), suggesting that other production factors may constrain their expansion despite higher value than alternatives. Likewise, transplant berries have higher water demands than alfalfa, carrots, or onions, but are vastly more valuable than other crops grown within the valley.

Table 16: Unit water use, marginal value, and economic efficiency of applied water for crops in Butte Valley.

Crop	Region	Unit water use (AF/ac)	Marginal value ($/ac)	Marginal value / unit water ($/AF)
Alfalfa	Butte/Shasta	2.22	1,243	559
Alfalfa	Scott	1.97	1,243	632
Barley	Butte/Shasta	1.51	658	437
Barley	Scott	1.08	653	603
Carrots	Butte	2.09	3,699	1,773
Onions and garlic	Butte	2.09	4,150	1,989
Other hay	Butte/Shasta	2.22	1,172	527
Other hay	Scott	1.97	1,172	596
Pasture	Butte/Shasta	2.70	700	259
Pasture	Scott	2.30	700	305
Raspberries	Butte	3.32	57,857	17,427
Strawberries	Butte/Shasta	3.32	51,800	15,602

Wheat	Butte	1.51	644	427
Wheat	Scott	1.08	644	595

4.2. Spillover effects of land and water use decisions

Table 17 lists spillover effects related to changes in the agricultural sector revenues within the County's economy based on the scenarios outlined above. We employed IMPLAN (https://www.implan.com/), an input-output model which allows estimation of broader impacts on employment, gross revenues and after sector-specific economic events, such as land fallowing or crop shifting. IMPLAN estimates direct, indirect, and induced effects. The direct effects correspond to the changes in revenues with respect to baseline (2018) conditions in crop farming. As various crops see reductions or changes in acreage, such changes indirectly affect production inputs including farm labor, agrochemicals, farm services and others. These are known as indirect effects. As agriculture and agriculture-related sectors face some impacts in gross revenues, households and government also face income impacts in what is known as an induced or second round effect. Altogether, direct, indirect, and induced impacts constitute the total or multiplier effect which is reported in this section for gross revenues (or output), value added (close to gross domestic product), and employment (full and part time jobs).

Scenario 1c shows the highest losses in all economic categories, resulting in $56 million in direct, indirect, and induced revenue losses, nearly $43 million in value added losses, and 393 fewer jobs in agriculture and all other sectors. Scenarios such as 3 or 4 are likely more realistic because they do not prescribe responses in specific crop categories, with scenario 3 assuming water trading allows retentions of higher value crops at the cost of deeper cutbacks in low value crops, and scenario 4 assuming all crops receive equal cutbacks. Management practices under water shortages would likely fall somewhere between these cases, representing slightly less aggressive water trading. Scenario 3 suggests total output losses of $17 million, $13 million in value added losses, and 120 fewer jobs. Meanwhile, scenario 4 falls closer to the extreme of scenario 1c with $46 million total revenue losses, $35 million in value added losses, and 323 fewer jobs. Other scenarios tend to fall within a similar range of economic impacts as those suggested by scenario 3.

Table 17: Combined direct and indirect regional economic impacts (IMPLAN results) for all scenarios.

Scenario	**Region**	**Lost output ($ million)**		**Lost value added ($ million)**		**Lost jobs (#)**	
		Direct	**Total**	**Direct**	**Total**	**Direct**	**Total**
Scenario 1a	Three valleys	10.57	14.05	5.82	10.68	71	98
	Butte	2.74	3.65	1.51	2.77	18	25
	Scott	3.75	4.99	2.07	3.79	25	35
	Shasta	4.07	5.42	2.24	4.12	27	38
Scenario 1b	Three valleys	21.13	28.11	11.65	21.36	142	197
	Butte	5.48	7.29	3.02	5.54	37	51
	Scott	7.50	9.98	4.14	7.59	51	70
	Shasta	8.14	10.83	4.49	8.23	55	76
Scenario 1c	Three valleys	42.26	56.21	23.30	42.72	285	393
	Butte	10.97	14.58	6.04	11.08	74	102
	Scott	15.01	19.96	8.27	15.17	101	140
	Shasta	16.29	21.66	8.98	16.46	110	151
Scenario 2	Three valleys	12.79	17.01	7.05	12.93	86	119
	Butte	5.74	7.63	3.16	5.80	39	53

	Scott	5.13	6.82	2.83	5.18	35	48
	Shasta	1.92	2.55	1.06	1.94	13	18
Scenario 3	Three valleys	12.94	17.21	7.13	13.08	87	120
	Butte	4.07	5.42	2.24	4.12	27	38
	Scott	4.04	5.38	2.23	4.09	27	38
	Shasta	4.83	6.42	2.66	4.88	33	45
Scenario 4	Three valleys	34.76	46.23	19.16	35.14	234	323
	Butte	24.76	32.93	13.65	25.03	167	230
	Scott	4.17	5.54	2.30	4.21	28	39
	Shasta	5.83	7.76	3.22	5.90	39	54
Scenario 5	Three valleys	13.04	17.34	7.19	13.18	88	121
	Butte	4.75	6.32	2.62	4.80	32	44
	Scott	3.77	5.02	2.08	3.82	25	35
	Shasta	4.51	6.00	2.49	4.56	30	42

Figure 9 summarizes the economic losses considering spillover effects in the regional economy for each scenario along with the average value lost per unit of water reductions. Scenario 1c, prescribing a large cutback (60%) in alfalfa and pasture cultivation, shows the greatest total economic output reduction at $56 million. Following closely in total output reduction is scenario 4 with $46 million, in which all crops receive an equal cutback of 15%. Scenarios 1a, 2, 3, and 5 are all found to have similar output impacts in the order of about $15-20 million. Average output losses per unit of reduced water is consistent across most scenarios at approximately $500/acre-foot. Scenario 2 has slightly higher value losses per unit of water because of the additional value lost from reduced alfalfa yield. Scenario 4 exhibits almost triple the average value lost per unit of water compared with other scenarios ($1,400/acre-foot) because of the higher marginal value of transplant berries.

Figure 9: IMPLAN combined spillover effects and average value per unit of water reductions by scenario.

4.3. Economic value of instream flows in the Klamath Basin

Various studies and research reports exist for estimating value of water instream flows in the Klamath River Basin. Kruse and Scholz (2006) estimate a range of net costs for the removal of 4 dams in the Klamath Basin and benefits from temporary employment in the removal and non-use water value with many other costs and benefits unknown. The authors provide an estimate of $172 million in benefits from dam deconstructions, and increased tourism and visitors, and a cost of $2 million for the loss of jobs from the hydropower project. In addition, it is estimated a $104 million benefit from non-use value per year. Considering a flow mean annual flow of 13 million acre-feet in the Klamath River, the estimate in use value is in the order of $8 per acre-foot. This figure does not include the benefits of groundwater dependent ecosystems, fisheries, tourism, tribal, water supply increased reliability and other beneficial uses included in the $172 million above that do not have a direct association to the instream flow gains or change in patterns from dam removal. Yet the study demonstrates values exist for environmental flows and should be weighed against costs of water diversions.

4.4. Limitations of analysis

As with most models, the scenario results shown in this report merit recognition of some limitations. First, data availability on crop production represents average production conditions which rarely occur in specific commodities. Size distribution of farms influences activities and productivity and crop attributes that might also have an influence on crop prices and yields in specific market niches. This also influences the profits from farming. Nevertheless, a representation of the aggregate of production at the county level can still provide useful insights for planning and policy analysis. Second, a profit maximizing behavior and costless water exchanges within each of the valleys are assumed to occur. Thus, results may represent a reasonable lower bound for economic costs of water reductions. Lastly, crops in Siskiyou County have an influence that extends beyond the county boundaries as these are exported or serve as inputs to other sectors including animal operations and food processing. Estimates of these impacts is not estimated in this study yet for most of the scenarios modeled decreases in feed crops will result in higher costs to local ranchers in the dairies and beef cattle sectors which may intermittently or permanently reduce herd sizes to cope with higher production costs and maintain profitability. Animal operations represent roughly 20% of both crops and animal agricultural value in Siskiyou County, thus reductions in their total output due to higher costs should not be ignored. Something similar occurs for transplant berries, which provide inputs to other areas that grow specific commodities into end-products for wholesale or retail. Yet due to their value and profit margins, water shortage price increases from traded water or more expensive water could be absorbed easier than in other sectors. With these limitations in mind, this report may provide insights for discussion of paths forward in water management for Siskiyou County.

5. Conclusions

This report provides costs of agricultural land and water use decisions in selected cropping regions within Siskiyou County and contributes to an improved quantitative understanding of tradeoffs associated with such decisions. Some conclusions arise from this work.

1) Agriculture in Siskiyou County within the Butte, Scott River and Shasta Valleys in our baseline year accounts for 97,000 acres, using roughly 220,000 acre-feet of water per year and generating $231 million in direct gross revenues.

2) The agricultural crop mosaic in these three valleys differ substantially both in the selection of crops and access to water resources. Butte Valley holds the smallest agricultural footprint by area with about 25,000 acres but contributes the greatest value of the three regions owing to the production of berry plants for transplant. Scott River Valley contains about 30,000 acres of cropland consisting primarily of alfalfa and pasture. Shasta Valley has about 42,000 acres of cropland and is mostly pasture. Across the three valleys together, alfalfa and pasture account for 32% and 47%, respectively, of total cropland.
3) A range of scenarios for land and water management was analyzed. Scenarios 1a (15% fallowing alfalfa and pasture), 2 (forego third alfalfa cutting), 3 (15% fallowing, adaptive), and 5 (15% water shortage, adaptive) are expected to result in comparable revenues losses in the order of $10-13 million before considering spillover effects or $15-20 million in related sectors. Scenario 4 (15% fallowing, "worst case") results in the most extreme economic impact with an estimated $35 million in losses stemming in large part from transplant berry reductions. Scenarios 1b and 1c form an intermediate between other scenarios but concentrate impacts on alfalfa and pasture.
4) A 15% reduction in water across the board for all crops can potentially result in direct costs of $35 million for Butte, Scott River, and Shasta Valleys, and 234 jobs lost. When the multiplier effects are accounted for, sector output losses total $46 million and 323 jobs. The cost of applied water reductions in this scenario is about $1,400 per acre-foot when considering direct and indirect sectors.
5) Allowing trading within the valleys for up to 15% applied water reductions substantially decreases economic costs of water use reductions down to $13 million in sector output, and when spillover effects are accounted for such impacts can be as high as $17 million for sector output and 120 jobs. This highlights the potential gains from trading water across commodities to lower economic impacts.
6) Scenarios focusing on resource use reductions in alfalfa and pasture tend to concentrate economic impacts on Shasta Valley, followed by Scott River Valley and finally Butte Valley which generates much of its value from berries for transplant. However, when assessing alfalfa centric scenarios such as foregoing a third cutting (scenario 2), this trend reverses and Butte and Scott River Valleys experience much of the losses. Scenarios which prescribe general reductions in land or water use and allow for adaptive fallowing (scenarios 3 and 5) have nearly equal impacts across each of the regions. When water trading is prohibited and crops experience equal reductions (scenario 4), aggregate impacts become highly concentrated in Butte Valley owing to the exceptional value of berry plants for propagation.
7) Effects from crop production changes into downstream sectors such as dairies and beef cattle and the food processing industry can be sizeable for large enough reductions in crop production and depending on the downstream sector's response to local crop commodity shortages these estimates may merit further investigation.

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