Comparison of Regional and Statewide Impacts on Salinity Mitigation in the Arkansas River Valley

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INTRODUCTION

The Arkansas River in Colorado has a major salinity problem, a problem so severe that most of the river is on the Environmental Protection Agency's 303d list for violating the Clean Water Act. The high salinization in the Arkansas River Basin poses a threat to farmers that use the Arkansas River as a water source. The majority of this salinity problem is a combined problem of naturally saline soils being made progressively worse by salts caused by irrigation. There are various on-farm management practices that could be implemented to control for salinity in the Arkansas River Valley. The management practices evaluated are: reducing aquifer recharge and modification of cropping patterns through changes in crop mix and fallowing of crops. It is necessary to see how on-farm net sales are affected by each of the management alternatives in order to determine the most effective and efficient management practice for controlling salinity. However, it is also necessary to evaluate how each alternative may affect the region and the state of Colorado as far as employment and income impacts.

In order to improve water quality, runoff from crops needs to be reduced. This can be achieved by choosing the best management practice that simultaneously optimizes on-farm net sales and provides the greatest positive economic impact. It is important to see if the best management practice for the Arkansas River Valley region is also beneficial to the state of Colorado. Since each crop has different thresholds of soil salinity levels and water table depth levels, optimization over crops and irrigation technology must account for these constraints. The goal of this research is to find the management alternative that increases in-stream flows, reduces salinity, optimizes on-farm net sales and provides positive economic impact to the region and the state, while controlling for the soil salinity threshold and water table depth limits of the crops.

By determining which management alternative maximizes the farmers' net sales and generates the greatest economic benefit in terms of employment and income to the region, it provides a better understanding of the regional farm impact in Southeastern Colorado. Further, the results of the regional impact study will assist in future policy analysis pertaining to the severity of the environmental degradation of the Lower Arkansas River Basin.

DATA AND METHODOLOGY

This study is on a field level and it is examines 3,482 farms along the Arkansas River, specifically located in the Lower Arkansas River Valley in Southeastern Colorado. The original data used to calculate the on-farm net sales was collected along the Arkansas River where the area of environmental degradation occurs. Therefore, the county level regional impacts will focus on Bent and Otero counties where the farms are located.

Specifically, the data for the optimization analysis was generated from an engineering model and translated into an economic model. MODSIM is an engineering model obtained from the Colorado State University Engineering Office that provided the following information: in-stream flows, salinity levels and acreage coverage. The crop mix for the area of study consisted of eight different types of crops: alfalfa, beans, corn, grass, melons, onions, sorghum and wheat. The canal companies included in the Lower Arkansas River Valley were Holbrook, Rocky Ford, Caitlin, Otero, Rocky Ford Highline and Fort Lyon. The crop price and cost data was obtained from the Colorado Agricultural Statistics in order to calculate the on-farm net sales (Houk, 2003). The acreage coverage will reveal each farm's level of water use and their income received via their crop production.

This research builds on a positive mathematical programming model that simulates crop production in the Arkansas River basin across alternative salinity and hydrologic states. The change in on-farm net sales for each alternative is generated within GAMS. A base model for on-farm yields and net sales were developed using positive mathematical programming based on work previously conducted by Howitt (1995). Aillery *et al.* (2001), Cox and Chavas (2001), Lee *et al.* (1987) and Ulibarri *et al.* (1998) also use an extension of linear programming to model crop yield and farm profitability.

Positive mathematical programming was used to replicate baseline cropping patterns. Positive mathematical programming involves three stages in its calculations. The first stage is the calibration run in which the acreage levels are calibrated and profit is calculated linearly. The second stage is an estimation of the parameters based on the calibration mathematical run. The second stage accurately models the baseline acreage that results in a nonlinear profit function. From the second stage, the data can easily be manipulated in order to evaluate certain policy changes. During the third stage the policy changes are implemented (Howitt, 1995). The effect of acreage and profit levels for each canal area based on varying irrigation technologies was examined. The irrigation technologies were based on the recharge rate back into the ground. The recharge rate is the percent of applied water that is not consumed and is returned to the system. Therefore, an increase in the recharge rate implies a decrease in efficiency of irrigation technology.

The percentage change in net sales levels generated from this integrated model are implemented into IMPLAN for each policy option. The percentage change in net sales will then generate the regional economic impacts in terms of employment and income impacts. The on-farm net sales are already calculated; therefore, the focus of this study is on the economic impact

results generated in IMPLAN. IMPLAN uses input/output analysis to calculate economic impacts for a specified region. The region of analysis specific to this study consists of Bent and Otero counties located in Southeastern Colorado and the entire state of Colorado. Broomhall and Johnson (1990), Mattas, *et al.* (1999) and Lee *et al.* (1987) used input/output analysis, as does this study to evaluate regional impacts as a result of policy changes in agriculture.

The economic impacts generated in IMPLAN will be examined on two levels: an employment base level and an income base level. Further, these effects will be evaluated at the county level and extrapolated to the state level. There is not a specific statistical test that can be applied to the IMPLAN results. However, the results can reveal whether the employment and income generated for each management option may or may not be at the expense of employment or income from within the region. If a change in the objective function generates a positive impact on regional employment and income while not hindering employment or income in other industries within the region, then the alternative resulting in increased regional economic activity will be preferred.

In addition, the regional economic analysis will be extended to the state level. Initially, the regional model will consist of only Bent and Otero counties, which is where the sample of farms was collected. The regional impacts of the state will be evaluated based on the management practices along the Lower Arkansas River. From this extrapolation of the results, it can be determined which policy alternative has the greatest impact locally, regionally and throughout the state of Colorado.

The policy options that are compared in this study are the different possible recharge rates. Ten different scenarios of recharge rates ranging from 10% to 90% were evaluated. The sprinkler system, which is most commonly used in the Arkansas River Valley, recharges water at

rates from 30% to 50%; therefore, its technology efficiency ranges from 50% to 70%. The other irrigation technology used along the Arkansas River Valley is the drip system, which recharges 10% to 20% of the applied water so it is 80% to 90% efficient (Texas, 2004).

For the IMPLAN analysis, the employment and income impacts were evaluated for Bent and Otero counties and then for the entire state of Colorado at the current state (i.e. base) and for each recharge rate. The sectors in IMPLAN were broken down by the two-digit Standard Industry Classification (SIC) code. The farming sector was broken into two different sectors, the farm feeds sector and the farm others sector. The farm feeds sector includes feed grains, hay and pasture, and grass seeds. This sector encompasses the majority of the crops found within the sample farms in Bent and Otero counties. The farm others sector includes everything else that is under the farm industry sector such as livestock and other crops in Colorado.

In order to extrapolate the change in farm net sales to the regional and state level, the percent change in net sales calculated from the GAMS output was multiplied by the total output level for the farms feed sector in the baseline scenario for Bent and Otero counties to determine the dollar value to shock the farm feeds sector in IMPLAN. The same monetary output shock was applied at the regional and state level. From this the employment and income impacts for regional and state level were analyzed.

The null hypothesis is that the profitability effects of changes in management options will have the same regional impacts on the Arkansas River Valley and the state of Colorado. The alternative hypothesis is that these effects will vary spatially and possess differing regional impacts at the county and state level. It is hypothesized that larger increases in on-farm net sales will have greater regional impacts, particularly in employment. However, it is important to realize that net sales and employment may not be complementary. Specifically, policy options

that require additional labor may expand regional employment at the expense of regional employment in other areas of the state. For this reason, the regional analysis must account both for how decisions affect on-farm profitability and how these options influence regional employment relative to state employment.

Since the IMPLAN model is derived from an optimization model, changes in the objective function (maximizing on-farm net sales) across each management alternative will be analyzed. In so much, the net sales levels, employment and income impacts will be compared across each management policy option. The management alternative with the greatest net sales and regional income will be deemed the optimal alternative. Further, the preferred policy options will improve water quality, in stream flows, on-farm net sales, and employment at the regional level.

RESULTS

Table 1 displays the farms' net sales and the percent change in net sales for each recharge rate. The percent change in net sales for each scenario was used to determine the shock to the farm feeds sector in IMPLAN. As can be seen in Table 1, the optimal recharge rate for the sample of farms in the Arkansas River Valley is 40% followed by 50% and 60% recharge rates. These recharge rate levels imply a sprinkler irrigation system. The percent change in net sales was then multiplied by the total output value for the baseline model, which was $32,368,000. The monetary output shocks implemented into IMPLAN for each scenario are displayed in Table 2. The baseline value is the total output in the farm feeds sector for the current state. The values for each recharge rate are the output shock associated with the percent change in net sales that was generated in GAMS. For example, if the farms in Bent and Otero counties were to use an

irrigation technology that corresponded with a 30% recharge rate, then the counties' output for the farm feeds sector would increase by $2,553,896. The greatest output shock coincides with the optimal recharge rate of 40%, followed by 50% and 60% with the smallest impact being the 10% recharge rate.

Tables 3 and 4 show the regional employment and output impacts while Tables 5 and 6 display the state level employment and output impacts, respectively. For the employment impact tables (Tables 3 and 5), the first column is the name of each sector; the second column is the total number of jobs within each sector without any shocks to the system. The rest of the columns display the change in jobs for each corresponding recharge rate. The income impact tables (Tables 4 and 6) are formatted in a similar fashion where the second column is the total output in millions of dollars without any shocks. The proceeding columns are the change in output for each respective recharge rate. It is important to note that these dollar values are not in millions of dollars as is the baseline scenario.

The farm feeds sector is the sector that was shocked in result to the changes in recharge rates because the dominant crop in the region is alfalfa, which falls under this sector. The main industries that are impacted by this shock to the farm feeds sector are as follows: retail trade, real estate, health services, agricultural, forestry and fishery services and the "other" sector. The employment impacts at the regional and state levels show the greatest change in the "other" sector and the agricultural, forestry and fishery services. It is important to note that the "other" sector includes such industries as forestry products, commercial fishery, banking and insurance services. The "other" sector and real estate result in the largest output impacts at the state and regional levels as a result in the monetary shock to the farm feeds sector.

The farm feeds sector monetary shock as a result to changes in recharge rates provided, on average, ten more jobs for that sector at the state level versus the regional level. The difference in employment levels at the state and regional in the farm feeds sector resulted in the same difference in the total employment impact. Therefore, the change in recharge rates produces ten additional jobs outside of Bent and Otero counties. The optimal recharge rate that produces the most number of jobs at both the regional and state level is the recharge rate of 40%, which can be translated into a 60% technically efficient irrigation system.

The monetary shock to the farm feeds sector is equivalent at the regional and state level. However, the resulting total output impacts are on average $400,000 greater at the state level than the regional level. As with the employment impacts, the 40% recharge rate produces the greatest output impact. In addition, the differences between regional and state output impacts with the 40% recharge rate are also the greatest. The total output impact is 14.4 million dollars regionally and 15.6 million dollars at the state level with a recharge rate of 40%. In general, the scale of the shocks with respect to each recharge rate is the same at the state and regional levels. The state level analysis results in greater levels of both employment and income impacts. However, both regional and state employment and income impact analyses conclude that the 40% recharge rate is the optimal policy option for the Lower Arkansas River Valley.

CONCLUSION

The high salinization in the Arkansas River Basin poses a threat to farmers that use the Arkansas River as a water source. In order to improve water quality in the basin, runoff from crops needs to be reduced. A farmer's goal is to maximize profits, however, acreage and water constraints need to be taken into account when producing crops. Positive mathematical

programming was used in order to model the acreage levels and cropping patterns for farms along the Arkansas River. To further this analysis, the percent change in net sales from the baseline scenario for each recharge rate was implemented into IMPLAN so that regional impacts could be analyzed. Regional and state level employment and income impacts were evaluated for each policy option.

The recharge rate of 40%, which can be translated into a 60% technically efficient irrigation system, was deemed the optimal policy choice at both the regional and state levels. Under this policy option, the employment and income impacts were greatest for Bent and Otero counties and for the state of Colorado. The results of this regional and state impact study will assist in future policy analysis pertaining to the severity of the environmental degradation of the Lower Arkansas River Basin. Further, these results can be applied to other basins facing similar water quality issues.

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APPENDIX OF TABLES

Table 1: Net Sales Under each Management Scenario for the Sample Farms in GAMS

Management Scenario	Net Sales	% Change from Baseline
Baseline Model	$ 9,206,370	
10% Recharge Rate	$ 9,519,226	3.40%
20% Recharge Rate	$ 9,791,222	6.35%
30% Recharge Rate	$ 9,932,770	7.89%
40% Recharge Rate	$11,815,053	28.34%
50% Recharge Rate	$10,144,247	10.19%
60% Recharge Rate	$10,146,418	10.21%
70% Recharge Rate	$10,082,431	9.52%
80% Recharge Rate	$ 9,955,865	8.14%
90% Recharge Rate	$ 9,687,630	5.23%

Table 2: Farm Feed Sector Output Shocks for each Management Scenario

Farm Feeds Sector IMPLAN Shocks	
Management Scenario	Output Shock
Baseline Model	$ 32,368,000
10% Recharge Rate	$ 1,099,948
20% Recharge Rate	$ 2,056,240
30% Recharge Rate	$ 2,553,896
40% Recharge Rate	$ 9,171,676
50% Recharge Rate	$ 3,297,411
60% Recharge Rate	$ 3,305,045
70% Recharge Rate	$ 3,080,080
80% Recharge Rate	$ 2,635,096
90% Recharge Rate	$ 1,692,026

Table 3: Employment Impacts (in number of jobs) of Each Scenario for Bent and Otero Counties

Industry	Base	Rech10	Rech20	Rech30	Rech40	Rech50	Rech60	Rech70	Rech80	Rech90
Farms Other	615	0.09	0.18	0.22	0.78	0.28	0.28	0.26	0.23	0.14
Farms Feed	**570**	**19.47**	**36.39**	**45.20**	**162.31**	**58.35**	**58.49**	**54.51**	**46.63**	**29.94**
Other sectors	1,924	2.40	4.49	5.58	20.03	7.20	7.22	6.73	5.75	3.70
Agricultural, Forestry, Fishery Svcs	245	1.92	3.59	4.46	16.02	5.76	5.77	5.38	4.60	2.96
Landscape and Horticultural Svcs	4	0.00	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01
Metal mining	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oil mining	64	0.02	0.03	0.04	0.13	0.05	0.05	0.04	0.04	0.02
Non-metal mining	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Construction	551	0.22	0.42	0.52	1.87	0.67	0.67	0.63	0.54	0.35
Food processing	273	0.00	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01
Tobacco mfg	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apparel	94	0.02	0.03	0.04	0.13	0.05	0.05	0.04	0.04	0.02
Wood products	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Furniture	62	0.01	0.01	0.02	0.06	0.02	0.02	0.02	0.02	0.01
Pulp and paper	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Printing and publishing	76	0.03	0.06	0.07	0.25	0.09	0.09	0.08	0.07	0.05
Chemicals and allied	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum products	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rubber products	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leather products	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stone, glass and clay	16	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Primary metals	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fabricated metal	84	0.03	0.05	0.07	0.24	0.09	0.09	0.08	0.07	0.04
Industrial machinery	67	0.00	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01
Electrical equipment	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation equipment	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Scientific instruments	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Miscellaneous mfg	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Services	64	0.05	0.09	0.11	0.41	0.15	0.15	0.14	0.12	0.08
Communications	97	0.05	0.10	0.13	0.45	0.16	0.16	0.15	0.13	0.08
Utilities	60	0.06	0.12	0.15	0.52	0.19	0.19	0.18	0.15	0.10
Retail Trade	1,983	0.86	1.61	1.99	7.16	2.58	2.58	2.41	2.06	1.32
Real estate	268	0.34	0.64	0.79	2.85	1.02	1.03	0.96	0.82	0.53
Personal services	209	0.10	0.19	0.24	0.85	0.31	0.31	0.29	0.24	0.16
Business services	126	0.10	0.18	0.23	0.81	0.29	0.29	0.27	0.23	0.15
Automotive services	121	0.17	0.32	0.40	1.42	0.51	0.51	0.48	0.41	0.26
Repair services	108	0.17	0.32	0.40	1.45	0.52	0.52	0.49	0.42	0.27
Recreation services	62	0.03	0.06	0.07	0.25	0.09	0.09	0.08	0.07	0.05
Health services	1,219	0.50	0.94	1.16	4.18	1.50	1.51	1.40	1.20	0.77
Education services	20	0.01	0.02	0.02	0.07	0.03	0.03	0.02	0.02	0.01
Social services	504	0.13	0.23	0.29	1.05	0.38	0.38	0.35	0.30	0.19
Non-profit organizations	209	0.11	0.21	0.27	0.96	0.34	0.34	0.32	0.27	0.18
Professional services	363	0.25	0.47	0.58	2.10	0.75	0.76	0.71	0.60	0.39
State & local non-ed government	2,240	0.34	0.64	0.79	2.84	1.02	1.02	0.95	0.82	0.52
Federal non-military	843	0.10	0.19	0.23	0.84	0.30	0.30	0.28	0.24	0.15
Special sectors	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	**13,142**	**27.60**	**51.60**	**64.09**	**230.16**	**82.75**	**82.94**	**77.29**	**66.13**	**42.46**

Table 4: Output Income Impacts of Each Scenario for Bent and Otero Counties

Industry	Base*	Rech10	Rech20	Rech30	Rech40	Rech50	Rech60	Rech70	Rech80	Rech90
Farms Other	137.78	21,051	39,353	48,877	175,529	63,106	63,253	58,947	50,431	32,382
Farms Feed	**32.37**	**1,105,777**	**2,067,138**	**2,567,431**	**9,220,283**	**3,314,886**	**3,322,561**	**3,096,404**	**2,649,061**	**1,700,996**
Other sectors	183.70	229,334	428,717	532,476	1,912,253	687,495	689,087	642,183	549,406	352,780
Agricultural, Forestry, Fishery Svcs	3.90	30,607	57,217	71,065	255,212	91,754	91,967	85,707	73,324	47,083
Landscape and Horticultural Svcs	0.10	88	164	204	733	263	264	246	210	135
Metal mining	0.00	0	0	0	0	0	0	0	0	0
Oil mining	22.36	5,363	10,026	12,453	44,721	16,078	16,115	15,018	12,849	8,250
Non-metal mining	0.00	0	0	0	0	0	0	0	0	0
Construction	63.36	25,840	48,306	59,997	215,465	77,464	77,644	72,359	61,905	39,750
Food processing	75.77	1,328	2,482	3,083	11,070	3,980	3,989	3,718	3,181	2,042
Tobacco mfg	0.00	0	0	0	0	0	0	0	0	0
Textiles	0.00	0	0	0	0	0	0	0	0	0
Apparel	10.24	1,675	3,132	3,889	13,968	5,022	5,033	4,691	4,013	2,577
Wood products	0.00	0	0	0	0	0	0	0	0	0
Furniture	7.82	958	1,792	2,225	7,992	2,873	2,880	2,684	2,296	1,474
Pulp and paper	0.00	0	0	0	0	0	0	0	0	0
Printing and publishing	5.65	2,224	4,157	5,163	18,541	6,666	6,681	6,227	5,327	3,421
Chemicals and allied	0.00	2	4	5	18	6	6	6	5	3
Petroleum products	0.00	0	0	0	0	0	0	0	0	0
Rubber products	0.00	0	0	0	0	0	0	0	0	0
Leather products	0.00	0	0	0	0	0	0	0	0	0
Stone, glass and clay	2.71	222	414	514	1,847	664	666	620	531	341
Primary metals	0.00	0	0	0	0	0	0	0	0	0
Fabricated metal	9.50	3,246	6,068	7,537	27,067	9,731	9,754	9,090	7,777	4,993
Industrial machinery	7.92	415	776	964	3,463	1,245	1,248	1,163	995	639
Electrical equipment	0.00	0	0	0	0	0	0	0	0	0
Transportation equipment	0.19	139	259	322	1,156	416	417	388	332	213
Scientific instruments	0.00	0	0	0	0	0	0	0	0	0
Miscellaneous mfg	0.00	0	0	0	0	0	0	0	0	0
Transportation Services	2.72	2,092	3,911	4,857	17,443	6,271	6,286	5,858	5,012	3,218
Communications	26.67	14,843	27,748	34,464	123,768	44,497	44,600	41,565	35,560	22,833
Utilities	26.08	27,175	50,800	63,095	226,590	81,464	81,652	76,095	65,101	41,802
Retail Trade	72.64	31,471	58,832	73,071	262,415	94,344	94,562	88,125	75,394	48,411
Real estate	98.80	126,020	235,581	292,597	1,050,789	377,781	378,655	352,881	301,900	193,854
Personal services	5.51	2,687	5,024	6,239	22,407	8,056	8,075	7,525	6,438	4,134
Business services	7.73	5,979	11,178	13,883	49,857	17,925	17,966	16,743	14,324	9,198
Automotive services	8.57	12,043	22,513	27,962	100,417	36,102	36,186	33,723	28,851	18,525
Repair services	6.61	10,618	19,849	24,652	88,533	31,829	31,903	29,732	25,436	16,333
Recreation services	1.47	717	1,340	1,664	5,976	2,148	2,153	2,007	1,717	1,102
Health services	62.47	25,681	48,008	59,626	214,133	76,985	77,164	71,911	61,522	39,504
Education services	0.83	363	678	842	3,024	1,087	1,090	1,016	869	558
Social services	16.14	4,024	7,522	9,342	33,549	12,062	12,090	11,267	9,639	6,189
Non-profit organizations	6.64	3,644	6,813	8,462	30,388	10,925	10,950	10,205	8,731	5,606
Professional services	14.00	9,722	18,173	22,572	81,061	29,143	29,211	27,222	23,289	14,954
State & local non-ed government	86.10	13,098	24,486	30,412	109,216	39,265	39,356	36,677	31,379	20,149
Federal non-military	49.57	5,911	11,051	13,725	49,291	17,721	17,762	16,553	14,162	9,093
Special sectors	-0.29	0	0	0	0	0	0	0	0	0
Totals	**1,055.61**	**1,724,357**	**3,223,510**	**4,003,671**	**14,378,178**	**5,169,258**	**5,181,226**	**4,828,555**	**4,130,966**	**2,652,546**

*Baseline scenario is in millions of dollars

Table 5: Employment Impacts (in number of jobs) of Each Scenario for the State of Colorado

Industry	Base	Rech10	Rech20	Rech30	Rech40	Rech50	Rech60	Rech70	Rech80	Rech90
Farms Other	27,352	0.10	0.19	0.24	0.86	0.31	0.31	0.29	0.25	0.16
Farms Feed	**17,076**	**23.33**	**43.62**	**54.18**	**194.56**	**69.95**	**70.11**	**65.34**	**55.90**	**35.89**
Other Sectors	524,462	2.13	3.99	4.95	17.79	6.39	6.41	5.97	5.11	3.28
Agricultural, Forestry, Fishery Svcs	6,732	1.55	2.89	3.59	12.91	4.64	4.65	4.33	3.71	2.38
Landscape and Horticultural Svcs	23,075	0.04	0.07	0.09	0.33	0.12	0.12	0.11	0.10	0.06
Metal mining	1,856	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Oil mining	18,819	0.02	0.04	0.05	0.19	0.07	0.07	0.06	0.06	0.04
Non-metal mining	2,252	0.01	0.01	0.01	0.05	0.02	0.02	0.02	0.01	0.01
Construction	260,398	0.23	0.43	0.54	1.93	0.69	0.69	0.65	0.55	0.36
Food processing	25,741	0.04	0.07	0.09	0.33	0.12	0.12	0.11	0.09	0.06
Tobacco mfg	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Textiles	487	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Apparel	4,266	0.01	0.02	0.02	0.09	0.03	0.03	0.03	0.03	0.02
Wood products	7,399	0.01	0.01	0.02	0.06	0.02	0.02	0.02	0.02	0.01
Furniture	6,868	0.01	0.02	0.02	0.07	0.03	0.03	0.02	0.02	0.01
Pulp and paper	3,329	0.01	0.02	0.02	0.08	0.03	0.03	0.03	0.02	0.02
Printing and publishing	31,479	0.03	0.05	0.06	0.23	0.08	0.08	0.08	0.07	0.04
Chemicals and allied	5,399	0.14	0.26	0.32	1.14	0.41	0.41	0.38	0.33	0.21
Petroleum products	673	0.01	0.02	0.03	0.09	0.03	0.03	0.03	0.03	0.02
Rubber products	6,941	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Leather products	1,072	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.00	0.00
Stone, glass and clay	11,995	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Primary metals	2,407	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fabricated metal	14,965	0.00	0.01	0.01	0.04	0.01	0.01	0.01	0.01	0.01
Industrial machinery	31,830	0.06	0.11	0.13	0.48	0.17	0.17	0.16	0.14	0.09
Electrical equipment	22,321	0.04	0.07	0.08	0.30	0.11	0.11	0.10	0.09	0.05
Transportation equipment	11,633	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scientific instruments	21,347	0.01	0.02	0.02	0.08	0.03	0.03	0.03	0.02	0.01
Miscellaneous mfg	6,734	0.00	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01
Transportation Services	10,941	0.03	0.05	0.07	0.24	0.08	0.08	0.08	0.07	0.04
Communications	54,540	0.04	0.07	0.09	0.31	0.11	0.11	0.10	0.09	0.06
Utilities	11,742	0.06	0.12	0.15	0.52	0.19	0.19	0.18	0.15	0.10
Retail Trade	492,662	1.06	1.99	2.47	8.87	3.19	3.20	2.98	2.55	1.64
Real estate	93,678	0.35	0.65	0.81	2.92	1.05	1.05	0.98	0.84	0.54
Personal services	52,755	0.12	0.23	0.28	1.01	0.36	0.36	0.34	0.29	0.19
Business services	255,788	0.35	0.66	0.82	2.93	1.05	1.06	0.98	0.84	0.54
Automotive services	32,519	0.15	0.27	0.34	1.22	0.44	0.44	0.41	0.35	0.22
Repair services	13,436	0.14	0.26	0.32	1.15	0.41	0.42	0.39	0.33	0.21
Recreation services	74,558	0.12	0.22	0.27	0.97	0.35	0.35	0.32	0.28	0.18
Health services	164,438	0.44	0.83	1.03	3.70	1.33	1.33	1.24	1.06	0.68
Education services	39,786	0.10	0.19	0.23	0.84	0.30	0.30	0.28	0.24	0.15
Social services	42,311	0.11	0.20	0.25	0.91	0.33	0.33	0.31	0.26	0.17
Non-profit organizations	48,527	0.09	0.17	0.22	0.78	0.28	0.28	0.26	0.22	0.14
Professional services	136,455	0.19	0.35	0.43	1.55	0.56	0.56	0.52	0.45	0.29
State & local non-ed government	282,661	0.21	0.39	0.49	1.75	0.63	0.63	0.59	0.50	0.32
Federal non-military	72,686	0.07	0.13	0.16	0.58	0.21	0.21	0.19	0.17	0.11
Special sectors	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	**2,978,389**	**31.41**	**58.72**	**72.94**	**261.93**	**94.17**	**94.39**	**87.96**	**75.25**	**48.32**

Table 6: Output Income Impacts of Each Scenario for the State of Colorado

Industry	Base*	Rech10	Rech20	Rech30	Rech40	Rech50	Rech60	Rech70	Rech80	Rech90
Farms Other	4,132.45	15,671	29,296	36,386	130,673	46,980	47,088	43,883	37,543	24,107
Farms Feed	**808.64**	**1,104,957**	**2,065,603**	**2,565,525**	**9,213,440**	**3,312,426**	**3,320,095**	**3,094,106**	**2,647,095**	**1,699,734**
Other Sectors	54,973.44	223,590	417,978	519,138	1,864,355	670,275	671,827	626,097	535,644	343,944
Agricultural, Forestry, Fishery Svcs	125.04	28,749	53,743	66,750	239,716	86,183	86,382	80,503	68,872	44,224
Landscape and Horticultural Svcs	843.80	1,464	2,736	3,398	12,204	4,388	4,398	4,098	3,506	2,251
Metal mining	452.60	152	283	352	1,264	454	455	424	363	233
Oil mining	6,557.12	8,080	15,105	18,761	67,376	24,223	24,279	22,627	19,358	12,430
Non-metal mining	326.63	819	1,530	1,901	6,826	2,454	2,460	2,292	1,961	1,259
Construction	32,661.28	28,958	54,133	67,235	241,457	86,809	87,010	81,087	69,372	44,545
Food processing	9,064.52	13,877	25,941	32,220	115,709	41,600	41,696	38,858	33,244	21,346
Tobacco mfg	0.00	0	0	0	0	0	0	0	0	0
Textiles	57.78	76	141	176	631	227	227	212	181	116
Apparel	448.78	1,115	2,084	2,588	9,293	3,341	3,349	3,121	2,670	1,714
Wood products	865.06	828	1,547	1,922	6,902	2,481	2,487	2,318	1,983	1,273
Furniture	859.44	1,049	1,961	2,436	8,747	3,145	3,152	2,937	2,513	1,614
Pulp and paper	738.93	2,246	4,199	5,216	18,731	6,734	6,750	6,290	5,382	3,456
Printing and publishing	4,413.60	3,810	7,122	8,846	31,768	11,421	11,448	10,668	9,127	5,861
Chemicals and allied	1,354.07	34,354	64,222	79,765	286,456	102,987	103,226	96,199	82,301	52,847
Petroleum products	1,290.64	21,370	39,948	49,617	178,186	64,062	64,210	59,839	51,194	32,872
Rubber products	1,271.57	250	467	580	2,082	748	750	699	598	384
Leather products	198.19	367	686	852	3,061	1,100	1,103	1,028	879	565
Stone, glass and clay	1,992.06	236	441	548	1,967	707	709	661	565	363
Primary metals	656.24	86	161	199	716	257	258	240	206	132
Fabricated metal	2,674.73	851	1,591	1,976	7,097	2,551	2,557	2,383	2,039	1,309
Industrial machinery	8,160.64	14,637	27,363	33,986	122,051	43,880	43,982	40,988	35,066	22,517
Electrical equipment	5,947.13	9,490	17,740	22,034	79,130	28,449	28,515	26,574	22,735	14,598
Transportation equipment	2,700.46	54	101	126	452	162	163	152	130	83
Scientific instruments	4,494.36	2,038	3,811	4,733	16,997	6,111	6,125	5,708	4,883	3,136
Miscellaneous mfg	589.52	305	569	707	2,540	913	915	853	730	469
Transportation Services	686.12	1,768	3,305	4,104	14,739	5,299	5,311	4,950	4,235	2,719
Communications	24,500.46	16,582	30,998	38,500	138,264	49,709	49,824	46,433	39,724	25,508
Utilities	5,465.99	29,195	54,578	67,787	243,439	87,522	87,724	81,753	69,942	44,911
Retail Trade	21,943.40	47,378	88,569	110,005	395,054	142,030	142,359	132,669	113,502	72,881
Real estate	32,201.37	120,395	225,066	279,537	1,003,888	360,919	361,754	337,131	288,425	185,201
Personal services	1,876.55	4,313	8,062	10,014	35,962	12,929	12,959	12,077	10,332	6,634
Business services	19,907.03	27,336	51,102	63,469	227,934	81,947	82,137	76,546	65,487	42,050
Automotive services	2,912.64	13,071	24,435	30,349	108,992	39,185	39,276	36,602	31,314	20,107
Repair services	961.17	9,889	18,487	22,962	82,461	29,646	29,715	27,692	23,692	15,213
Recreation services	3,376.29	5,249	9,812	12,186	43,764	15,734	15,771	14,697	12,574	8,074
Health services	11,635.70	31,430	58,755	72,975	262,073	94,221	94,439	88,011	75,296	48,348
Education services	1,606.32	4,064	7,597	9,436	33,887	12,183	12,211	11,380	9,736	6,252
Social services	1,970.02	5,101	9,536	11,844	42,536	15,292	15,328	14,285	12,221	7,847
Non-profit organizations	2,446.41	4,690	8,768	10,890	39,108	14,060	14,093	13,134	11,236	7,215
Professional services	11,072.24	15,125	28,275	35,119	126,119	45,343	45,448	42,354	36,235	23,267
State & local non-ed gov't	13,926.06	10,340	19,330	24,009	86,221	30,998	31,070	28,955	24,772	15,906
Federal non-military	4,660.45	4,436	8,292	10,299	36,986	13,297	13,328	12,421	10,626	6,823
Special sectors	-101.25	0	0	0	0	0	0	0	0	0
Totals	**309,705.68**	**1,869,840**	**3,495,474**	**4,341,456**	**15,591,251**	**5,605,384**	**5,618,361**	**5,235,935**	**4,479,491**	**2,876,339**

*Baseline scenario is in millions of dollars