Impacts of Climate Change Legislation on Agriculture in the Rocky Mountain States: Arizona, Colorado and New Mexico

A White Paper prepared for the American Farmland Trust

Authors:

Brian Hurd
Dept. of Agricultural Economics & Agricultural Business
New Mexico State University
Gerald Thomas Hall, rm 382
Las Cruces, NM 88003-8003
bhurd@nmsu.edu

Christopher Goemans
Department of Agricultural and Resource Economics
Colorado State University
Clark B-312
Fort Collins, CO 80523-1172
Chris.Goemans@ColoState.EDU

George Frisvold
Department of Agriculture and Resource Economics
University of Arizona
319 Cesar Chavez Building
Tucson, AZ 85721
frisvold@ag.arizona.edu

Janine Stone
Department of Agricultural and Resource Economics
Colorado State University
Clark B-312
Fort Collins, CO 80523-1172
jmstone@lamar.colostate.edu

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Executive Summary

The Rocky Mountain region, particularly the Southwestern States of Arizona, Colorado, and New Mexico, has unique agricultural characteristics that are important to consider when assessing economic impacts of climate change legislation, such as the American Clean Energy and Security Act of 2009 (ACES, H.R. 2454, also known as the Waxman-Markey Bill). Based on existing data and studies, this White Paper considers unique aspects of Arizona, Colorado, and New Mexico agriculture in developing some preliminary findings of the economic effects of this legislation on the region's agricultural economy. Agriculture is varied and diverse across this region, from large-scale orchards of citrus and tree nuts, to vegetables, cotton and a variety of row and field crops, and to the widespread importance of cattle grazing and ranching and to large-scale dairy production. The proposed climate change legislation almost surely entails a relative rise in energy and fertilizer costs. Energy costs are expected to rise by as little as 4% or as much as 13% by 2020, and fertilizer costs by a much smaller amount, perhaps ranging between 0.3% and 2% by 2020. The fertilizer increases are much less because of the availability of rebates for energy-intensive, trade exposed (EITE) industries and projected falling natural gas prices. Though the projected increases are modest, such increases will be important for agriculturalists who must operate on relatively thin profit margins. Furthermore, as farmers throughout the nation adjust to these cost increases, increased demand for bio-energy fuels, and increased value of carbon-sequestration, changes in crop management, land use, and market strategies will likely result in higher commodity prices that farmers receive, thus in many cases, largely offsetting projected cost increases. Even in cases where these cost increases are not offset – or if the cost increases are rather perceived by many to be much more certain than revenue increases – the expected rise appears to be well within the range of recent energy-price variability. While new production and revenue opportunities and higher commodity prices will generally benefit farmers, resulting feed prices will adversely affect livestock and dairy producers. In the western states, cattle and dairies are important segments of the agricultural economy. Higher feed and energy costs will pose several threats and challenges. Our preliminary findings suggest that energy, fertilizer, and feed cost increases expected under the proposed legislation could initially shrink the region's agricultural economy until these losses are offset by rising revenues -- primarily from higher commodity prices. On balance, based on expected patterns of cost and price changes, we estimate that compared to baseline levels, state-level net farm income in 2020 rises by 1.2%, 2.9%, and 4.1% for Arizona, Colorado, and New Mexico, respectively. Crop producers will likely experience improved revenues from high crop prices and if they are able to take advantage of new

biofuel crop markets and opportunities to sequester carbon and gain offset revenue they may be able to more than offset their cost increases. Traditional ranchers, which dominate throughout this region have few bright prospects, although dairies and other concentrated feeding operations may be able to generate additional income through methane-saving devices, such as digesters, that will provide not only revenue through carbon-offset markets but also through electricity sales.

Introduction

Growing concern about the possible effects of greenhouse gas concentrations in the atmosphere on global climate has resulted in federal legislation to limit emissions and develop mechanisms and incentives to encourage long-term storage (e.g., sequestration) of carbon. In 2009, the U.S. House of Representatives passed the American Clean Energy and Security Act of 2009 (ACES, H.R. 2454, also known as the Waxman-Markey Bill). This legislation initiates a 'Cap and Trade' (C&T) program for greenhouse gas emissions. Under a C&T program major industrial emissions of greenhouse gases are permitted and the number of permits is limited in total at the level of the CAP. Generators of greenhouse gases then must limit their emissions consistent with the permits they own, or they must purchase additional permits from willing sellers. Thus, the program creates a private property interest in emission permits, and encourages trade and marketing of permits resulting in the desired regulated level of emissions at the least possible industrial cost to consumers.

Agriculture is not included in the proposed legislation as an emissions-capped sector; however, rising energy and fertilizer costs will directly affect agricultural producers. In addition, the legislation highlights the potential for agriculture to benefit from the development and sales of greenhouse gas (aka carbon) offsets and from the increasing production of bioenergy crops that will be in increasingly greater demand as the market value of carbon offsets rise. Among the highest potential for agriculture to supply carbon offsets are through conversion of crop and pasture land to forests (afforestation), production of bioenergy crops (e.g., corn, canola, sunflower, switchgrass, camelina etc.), changing tillage practices on cropland to enhance soil carbon accumulation (sequestration), and through the management of livestock waste (e.g., with methane digesters where livestock are concentrated for example near dairies and feedlots).

Several recent studies investigate and assess the potential costs and benefits of C&T on the agricultural sector of the United States and certain regions and states. This White Paper assesses and compares findings from these studies, focusing on their implications for impacts on agricultural producers of the Rocky Mountain Region (particularly the states of Arizona, Colorado, and New Mexico). The remainder of this report is organized as follows. The next section presents a list and overview of the studies reviewed for this report. This is followed by discussion of land use changes and carbon offset potential in the Rocky Mountain Region. Next, we summarize key agricultural characteristics in Arizona, Colorado, and New Mexico. The methods and scenarios applied to the region are described next followed by a summary of key findings and potential impacts on regional agricultural economies and land use.

Overview of Existing Studies on Climate Change Legislation

Several assessments of the proposed climate change legislation have examined impacts on various aspects of the agricultural economy. We assembled all the currently available, relevant reports and these provide the foundation for our assessment. The eight studies used are given in the box below:

Currently Available Studies Examining the Potential Impacts of Climate Change Legislation on the U.S. Agricultural Economy

(1) Agricultural and Food Policy Center (AFPC) at Texas A&M (2009). "Economic Implications of the EPA Analysis of the CAP and Trade Provisions of H.R. 2454 for U.S. Representative Farms."

(2) Agricultural Policy Analysis Center (APAC) at the University of Tennessee (2009). "Analysis of the Implications of Climate Change and Energy Legislation to the Agriculture Sector."

(3) Doane Advisory Services (2008). "An Analysis of the Relationship Between Energy Prices and Crop Production Costs."

(4) Nicholas Institute for Environmental Policy Solutions (NIEPS) at Duke University (2009). "The Effects of Low-Carbon Policies on Net Farm Income."

(5) USDA, Office of the Chief Economist (2009). "A Preliminary Analysis of the Effects of H.R. 2454 on U.S. Agriculture."

(6) Center for Agricultural and Rural Development (CARD) at Iowa State University by Bruce Babcock (2009). "Costs and Benefits to Agriculture from Climate Change Policy."

(7) Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri (2009). "The Effects of Higher Energy Prices from H.R. 2454 on Missouri Crop Production Costs."

(8) U.S. Senators Hutchison and Bond (2009). "Climate Change Legislation: A $3.6 Trillion Gas Tax."

The first 5 studies in this list represent efforts to model the impacts of H.R. 2454 at the national level. Table 1 presents a summary and comparison of this set of studies, their scope, findings, and key assumptions.[1] None of the studies in this list was specific to the Rocky Mountain Region or any of its states. Most described national-scale impacts to the agricultural sector. The Babcock (2009) and FAPRI (2009) studies represent the exceptions to this; which were state level efforts focused on Iowa and Missouri respectively. The USDA and AFPC were the only two that provided any regionalized estimates. Both studies used similar models and methodologies in their development.

To provide greater relevance and state-level insight for the Rocky Mountain region, we use estimates from the USDA study of changes in agricultural production costs, for example, increases in fuel, electricity, natural gas, and livestock feed and estimates of commodity price changes and carbon offset revenues, as the basis for completing a preliminary analysis of the impacts on farm incomes in Arizona, Colorado, and New Mexico.

[1] A more detailed overview can be found in Golden et al. (2009).

Table 1: Comparison of Select Studies on the Costs and Benefits of Climate Change Legislation on the U.S. Agricultural Economy.

	Doane Advisory Services (May 2008)	**APAC (Nov. 2009)**	**Nicholas Institute of Duke University (Nov. 2009)**	**AFPC at Texas A&M, August 2009**	**USDA, December 2009**
	"An analysis of the relationship between energy prices and crop production costs"	*"Analysis of the Implications of Climate Change and Energy Legislation to the Agricultural Sector"*	*"The Effects of Low-Carbon Policies on Net Farm Income"*	*"Economic Implications of the EPA Analysis of the CAP and Trade Provisions of HR 2454 for U.S. Representative Farms*	*"The Impacts of the American Clean Energy and Security Act of 2009 on U.S. Agriculture"*
Study Assumptions:					
Model Type	Regression-based forecasting model relating farm budgets to energy price forecasts	POLYSYS Agricultural Policy Simulation Model	FASOMGHG economic model; simulates forestry and Ag. Sector response to carbon prices	FLIPSIM Agricultural Policy Simulation Model	FAPISM (Food and Agricultural Policy Simulator Model for production expense impacts); FASOM model for offset projections
Measure of Gains/Losses for Farms	Increase in production costs/acre relative to USDA baseline forecast for 2009, extended by Doane through 2020	Net crop returns relative to baseline	Net producer income or "producer surplus"	Average annual cash costs and ending cash reserves relative to FAPRI 2009 estimated baseline	Changes in production expenses and net farm income (discounted annuity values)
Adaptability of Model: Variables accounted/not accounted for	Does not allow for changes in land use, technology, or inputs; or forecasted commodity prices in response to HR 2454	Accounts for impact of ACES and RFS, changes in land use, & production of bioenergy crops; multiple offset scenarios considered	Simulates impact of changes in CO2 prices on Ag sector; accounts for changes in land use, technology, bioenergy demand, region-specific management decisions, and yield productivity; accounts for impact of RFS requirements	Evaluates cap-and-trade with and without carbon offsets; accounts or estimated energy cost inflation in commodity price forecasts; converts eligible farms to no-till and methane digesters	Farmers may change acreage decisions but not input mix; no changes in technology or production practices in FAPISM modeling. FASOM modeling accounts for changes in management and production practices, land use, and input mix in response to carbon prices/offset opportunities; does not account for EITE rebates

	Doane Advisory Services (May 2008)	APAC (Nov. 2009)	Nicholas Institute of Duke University (Nov. 2009)	AFPC at Texas A&M, August 2009	USDA, December 2009
Time Frame:	2010-2020	2010-2025	2000-2080	2010-2016	2012-2018
Data Sources :					
Source of Energy Estimates	USDA (2008 crude oil) and Energy Information Administration (EIA, natural gas)	EPA (2009)	AEO (2009)	EPA (2009)	EPA (2009) an EIA (2009)
Source of Estimates for Farm Expenses	USDA crop enterprise budgets; crop--not region--specific	NA; model uses national demand, regional supply, and agricultural income modules to find changes in net income	Average cost/acre of "GHG intensive" energy use (not region-specific)	Representative data from 98 representative farms (2 in Colorado)	USDA production cost data (national level)
Carbon Price Estimates	N/A	EPA: $27/ Mt CO2	Simulations for $15, $30, $50/ Mt CO2	$11.17 (2010-2017 average)	$5/ton and $15/ton scenarios, with 5%increase in price/year
Production Cost/Revenue Results for Key Crops In Colorado (No Offsets):	Production Cost Increases in $/acre	Change in Net income, in Millions of Dollars	Commodity Price Changes	Average Annual Cash Costs, no offsets	Per-acre costs of production
Wheat	$16.33/acre	($494)	3.70%	1.27% increase small farm; 2.26% large farms	0.6%, 1.7%
Corn	$40.33/acre	$336	15.94%	N/A	0.4%, 1.5%

	Doane Advisory Services (May 2008)	APAC (Nov. 2009)	Nicholas Institute of Duke University (Nov. 2009)	AFPC at Texas A&M, August 2009	USDA, December 2009
Sorghum	$30.58/acre	($53)	0.57%	N/A	0.9%, 2.2%
Cattle	N/A	0.2% ** (Assuming herd reduction due to pastureland conversion in multiple offset scenario)	(Fed beef) 5.21%	5.99%	0.1%, 0.3% (increased feed costs)
Notes:	**(in low-cost scenario with crude oil prices increasing 27.2%, natural gas 35.2%	** Scenario with CO2 regulation but no offsets	P**Results converted to annuity value using 4% discount rate. Per/acre costs of production increase 1.4, 2.3, and 4.1% across the three carbon price scenarios but are offset by crop price increases above assuming $15/Mt Co2 :		**2012-2018 Averages using EPA and EIA energy estimates.
Offsets:					
Relevant Offset Opportunities for Rocky Mountain Region	None.	Conservation tillage, afforestation, methane capture, grassland sequestration, bioenergy crops	Afforestation; crop soil carbon sequestration	Methane digesters (farms with over 500 head); No till soil management	Afforestation, Forrest management, Carbon sequestration in agricultural soils
Net Gains/Losses with Offsets	N/A	Net income increases of up to $5 M for Ag. In Colorado under multiple offset scenario	Consumer surplus increase (annualized difference from baseline) of between $2 and $6M (2004$)	Net gains in ending cash reserves, relative to baseline, by 2016	Rocky Mountain region estimated to receive 6.7% of total national revenues from carbon offsets

Land Use and Agricultural Offset Implications for Rocky Mountain States

USDA (2009) finds, absent offsets, reductions in acres harvested would be minimal from 2012-18. Reductions are higher using the Energy Information Administration (EIA) base scenario, but still only -0.1% for all field crops nationally (-0.1% for corn and barley, -0.2% for cotton, -0.3% for wheat, and -0.7% for sorghum and oats). With agricultural offsets, there is more scope for shifting cropland and pasture to forest land. Based on Forest and Agricultural Sector Optimization Model (FASOM) simulations, USDA (2009) reports the combined effects of cap and trade and offsets. Cropland falls by 6 million acres (2.3%) in 2020, 14.6 million acres (5.7%) by 2030 and 35 million acres (14.4%) by 2050, as land is converted to forest. Pastureland falls by 8.5 (3.1%), 12 (4.4%) and 24 million acres (8.7%) in 2020, 2030, and 2050. While these changes seem dramatic (35 million acres of cropland is equivalent to all land enrolled in the CRP) they occur over many years. The change in cropland averages less than 0.5% per year.

Lewandrowski et al. (2004) did not consider afforestation in the Rocky Mountain States, reasoning that conditions did not favor forest growth in much of the region. They did, however, estimate 0.249 MT/acre/year of CO_2 equivalent (CO_2E) could be sequestered by switching from continuous annual cropping (CAC) to grassland and another 0.085 MT/acre/year could be sequestered by switching from CAC to conservation tillage. EPA-supported analysis based on FASOM simulations, found greater, if limited scope for afforestation in Rocky Mountain States (EPA, 2005). At low offset prices ($5 / t CO_2 eq.) agricultural soil carbon sequestration, methane (CH_4) reductions and nitrous oxide reductions dominate as offset sources (Table 2). At $15 and $30 per t CO_2 eq., however, afforestation grows in importance.

Table 2: MMT of CO_2E per year net emissions reduction below baseline in Rocky Mountain States, annualized over the time period 2010-2110 for different offset prices

	GHG Price ($ / t CO2 Eq.)		
Activity	**$5**	**$15**	**$30**
Afforestation	0	11.7	11.8
Forest Management	1.9	2	4.7
Agricultural Soil Carbon Sequestration	7.5	9.5	9.6
Fossil Fuel Mitigation from Crop Production	1.2	1.3	1.4
Agricultural CH_4 and N_20 Mitigation	4.7	5.2	5.1
Biofuel Offsets	0	0	0.2
Total MMT of CO_2E per year	15.3	29.8	32.7

Source: EPA (2005)

Based on subsequent simulations using the FASOM model, USDA reports potential for offsets in the Rocky Mountain States for 6.2 MMT CO_2eq / year by 2020, 10 MMT / year by 2030, and 39.2 MMT by 2050. Accompanying offset revenues earned in the Rocky Mountain States would be $100 million by 2020, $300 million by 2030, and $2.8 billion by 2050. For the Rocky Mountain States, USDA (2009b) reports forest acreage increasing by 3.4 million acres in 2020 and by 7.7 million acres by 2050. Up to 2025, reductions in pastureland would be greater than reductions in cropland. Reductions in pastureland peak at 1.7 million acres, while expansion forestland increasingly comes from cropland conversion. There is an increase in crop, pasture and forest land <u>combined</u> over time, however.

Table 3: Potential agricultural offsets, offset revenues, and land cover changes in Rocky Mountain States					
	Agricultural Offsets and Gross Revenue		Change in Land Cover		
Year	Offsets (MMT CO_2eq / year)	Gross revenue ($2004 billion)	Forest (million acres)	Cropland (million acres)	Pasture (million acres)
2015	4.9	0.1	2.3	-0.4	-1.2
2020	6.2	0.1	3.4	-1.0	-1.7
2025	9.6	0.2	4.0	-1.6	-1.7
2030	10.0	0.3	4.7	-2.3	-1.7
2035	13.5	0.5	5.5	-3.1	-1.7
2040	19.6	0.9	6.2	-3.8	-1.7
2045	24.2	1.3	7.0	-4.6	-1.7
2050	39.2	2.8	7.7	-5.3	-1.7

Source: USDA, 2009

Swine and dairy operations may obtain offsets by adopting methane digester technology. EPA (2002a) estimated that New Mexico and Arizona ranked second and third in methane reduction potential on dairy farms. The Global Warming Potential of methane is such that one ton of methane is equivalent to 21 tons of CO_2. Table 4 shows gross annual offset potential for the eight facilities currently operating digesters in Rocky Mountain States from EPA's AgStar database. The 2020 offset price from EPA Scenario 2 is $16.31/MT CO_2E, while it is $29.95/MT CO_2E under the Energy Information Administration (EIA) Basic Scenario.

Table 4: Gross annual offset potential from agricultural operations currently using methane digesters in Rocky Mountain States						
State	**Farm Type**	**Methane Emission Reductions (MT CO_2E / yr) / animal**	**2020 Offset Revenues (EPA)**	**2020 Offset Revenues (EIA)**	**Offset Revenues / Animal (EPA)**	**Offset Revenues / Animal (EIA)**
MT	Dairy	4.3	$24,825	$45,586	$70.93	$130.25
UT	Dairy	2.1	$41,610	$76,409	$34.68	$63.67
ID	Dairy	1.9	$144,313	$265,002	$30.70	$56.38
ID	Dairy	1.9	$307,049	$563,833	$30.70	$56.38
CO	Swine	0.7	$62,404	$114,592	$11.35	$20.83
UT	Swine	0.6	$2,044,957	$3,755,148	$10.54	$19.36
WY	Swine	0.2	$65,219	$119,761	$3.62	$6.65
WY	Swine	0.1	$9,087	$16,687	$1.82	$3.34

Source: EPA AgStar database and authors' calculations

Emission reductions (and offset revenues) per animal are greater on dairy than swine operations. Offset revenues for swine operations range from $2-$11/animal under the EPA scenario and $3-$20/animal under the EIA scenario. Offset revenues for dairy operations range from $30-$80/animal under the EPA scenario and $56-$130/animal under the EIA scenario. Total offsets range from $2.7-$5 million for the eight operations. By 2050, in the EIA scenario, offset prices rise above $61 / MT CO_2E and gross dairy offset revenues reach $110-$260 / cow. While gross offset revenues may be significant, so can capital costs for digester technologies ($1,000 - $1,300 per cow on farms of 1,000 cows (with higher costs per cow on smaller farms) (EPA, 2009b). To help overcome this barrier, USDA Rural Development has provided more than $34 million since 2003 to partially support installation of anaerobic digestion systems (EPA, 2009c).

Agricultural Overview of Arizona, Colorado, and New Mexico

Agriculture varies widely throughout the Rocky Mountain region and Southwest, depending largely on climate and the availability of irrigation. This is a semi-arid region with limited precipitation and some dryland farming (primarily wheat). There is vast rangeland throughout the region where cow-calf ranchers graze cattle on large tracts of private and public lands. Extensive irrigation infrastructure makes production of diverse, high-value crops possible. Agriculture is economically important to the region and is critical to the health and sustainability of rural economies across the region. Figures 1 and 2 describe and compare the composition of the agricultural economies of the three states, highlighting the range and size of agricultural commodities produced. The economic characteristics of the agricultural economies of Arizona, Colorado, and New Mexico are described below.

Figure 1. Key Agricultural Characteristics of Arizona, Colorado, and New Mexico

Arizona

Dairy product and cattle sales accounted for 22% and 18% of total agricultural sales in 2008. Arizona is characterized by highly diversified crop production, including many high-value specialty crops, such as lettuce, melons, broccoli, and cauliflower. Alfalfa production supporting the large dairy industry is important, while the major field crops are cotton, followed by wheat.

Colorado

Colorado has 37,054 farms, comprising 47.6% of the state's total land area. Of this farmland, 36.3% is crop and 56.4% pastureland. The top five agricultural commodities in Colorado are cattle and calves, dairy products, corn, wheat and hay. Principle crops by number of acres harvested are wheat for grain; winter wheat for grain; corn for grain; proso millet; sorghum grain; and sunflower seeds.

New Mexico

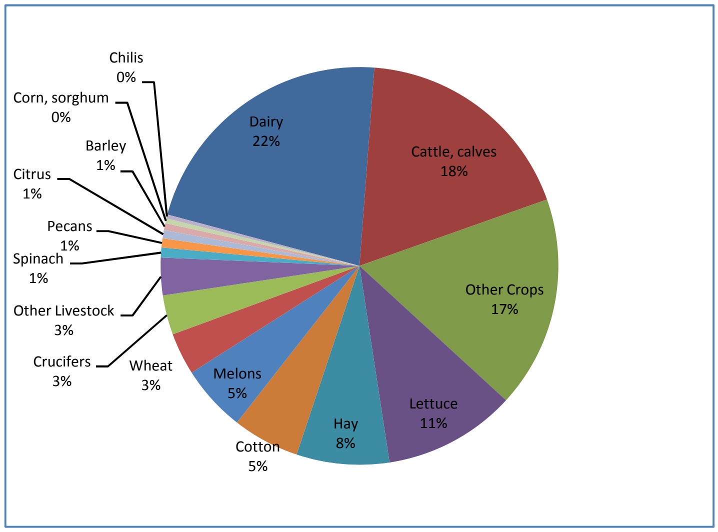
Agriculture contributes an estimated $1.2 billion to the State's gross domestic product (NMBBER, 2010). With a land base comprised of 77.6 million acres, New Mexico is the fifth largest state in total area. Nearly half of this area (about 37 million acres) is used for livestock grazing. Crops are harvested on just over 1 million acres, 83% of which are irrigated (U.S. Census, 2010). Cattle and dairy dominate the agricultural economy of New Mexico, together generating more than 75% of the agricultural income of the state. And if livestock feed crops such as hay and corn silage are included, then livestock-related agriculture generates more than 85% of agricultural revenues in the state. In addition to the dairy and cattle industries, New Mexico is an important producer of pecans (second only to Georgia in overall production. New Mexico also is an important producer of both onions and chile.

Farm Income and Expenses

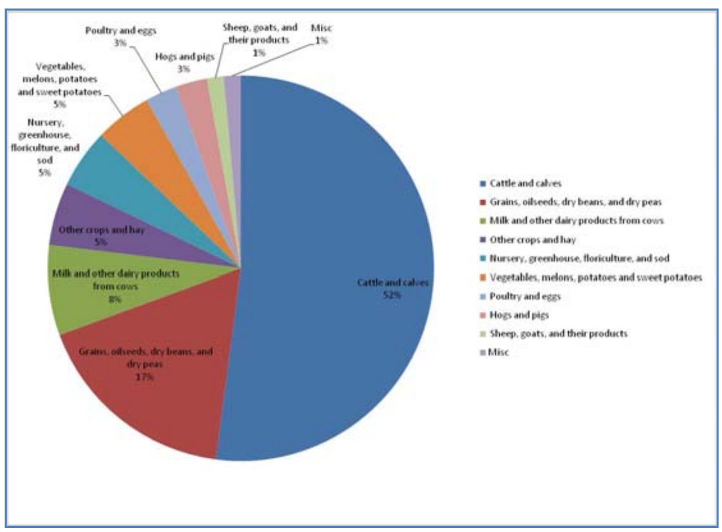
Net farm income is a key indicator of the health and status of the agricultural community and provides an essential starting point for a preliminary assessment of the economic impacts of the proposed climate change legislation. As shown in Tables 5 and 6, the relative size and character of each State's agricultural economy can be expressed as activities that produce commodities and generate revenue balanced by the costs of these activities consisting of purchased inputs including energy, fertilizers, and livestock feed. After some accounting for fixed capital and other assets, net farm income expresses the economic value added to the States economy from agriculture. Livestock production accounts for majority of sales in Colorado and New Mexico. Specialty crops account for relatively more of Arizona's agricultural sales.

Figure 2. Relative Contribution to the Total Value of Agricultural Production by Type of Commodity

A. Arizona



B. Colorado



C. New Mexico

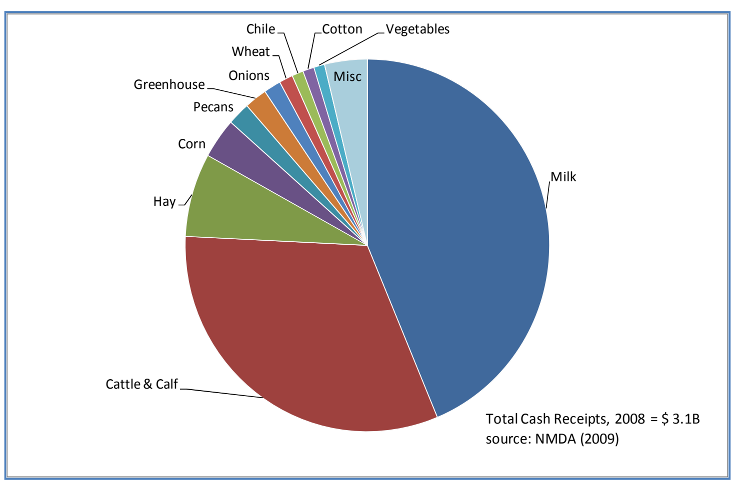


Table 5: Gross Income, Production Expenses and Net Cash Income by State

				Arizona	Colorado	New Mexico
Market Value from Agricultural Sales						
	Value of crop production			$1,913,014	$1,981,399	$698,451
	Value of livestock production			$1,321,538	$4,079,735	$2,420,628
	Revenues from Services and Forestry					$269,555
Other Income						
	Government Payments			$55,947	$155,980	$24,482
	Other Income from Farm-Related Sources			$76,233	$183,091	
	Total			$3,366,732	$6,400,205	$3,413,116
Farm Production Expenses						
	Farm Origin					
		Feed		$617,035	$1,221,367	$680,793
		Livestock		$315,343	$1,778,706	$420,818
		Seed		$199,392	$163,708	$27,114
	Manufactured					
		Fertilizers		$165,318	$201,343	$69,927
		Pesticides		$133,265	$102,032	$33,058
		Petroleum fuel and oils		$146,118	$252,730	$135,396
		Electricity		$104,463	$141,173	$58,521
	Other			$1,101,852	$1,570,221	$1,157,654
	Total			$2,782,786	$5,431,280	$2,583,281
	Net Cash Farm Income			$583,946	$968,925	$829,835

Source: U.S. 2007 Census of Agriculture (2010) and the NMDA (2009)

Table 6: Percent of Total Expenses by Type of Expense

			Arizona	Colorado	New Mexico
Farm Origin					
	Feed		22%	22%	26%
	Livestock		11%	33%	16%
	Seed		7%	3%	1%
Manufactured					
	Fertilizers		6%	4%	3%
	Pesticides		5%	2%	1%
	Petroleum fuel and oils		5%	5%	5%
	Electricity		4%	3%	2%
Other			40%	29%	45%

Source: U.S. 2007 Census of Agriculture (2010) and the NMDA (2009)

Description of Methods and Scenarios Used in the Assessment

The available studies do not provide much information or data on region- or state-specific agricultural impacts. Therefore, some additional assessment is needed in order to develop some preliminary indicators of the plausible direction and magnitude of economic impacts of proposed climate change legislation for the Rocky Mountain and Southwest regions, and in particular the States of Arizona, Colorado, and New Mexico. Given constraints on available time and funding for this assessment, the approach taken was to use the state-specific information on net farm income (described above) and to apply some of the expected changes in costs and revenues to these figures. This approach is consistent with well used methods associated with partial-budgeting and can be used to develop preliminary estimates that give an indication of the order of magnitude of possible impacts. There are, however, several strong and important assumptions with this approach that caution against over-interpretation of the estimated findings. Among these assumptions it is important to note that we are not projecting any changes in farmer behavior or the basic structure of the net farm income accounts. Reality suggests that behavior is dynamic and responsive to changing and evolving conditions. By the year 2020, for example, many changes in management, technology, markets, and policy may alter the essential character of these accounts. *Our simple budget model does not reflect such dynamic responses and as such may overstate the potential costs and understate the potential benefits that may accrue to the assessed policy changes.*

To develop our estimates, we proceeded by defining the following four structural scenarios to apply to the net farm income accounts:

Scenario 1: Energy and fertilizer cost increases considered in isolation

Scenario 2: Feed cost increases considered along with energy and fertilizer cost increases

Scenario 3: Commodity price increases are factored in along with the expected cost increases

Scenario 4: Additional offset revenue from methane digesters is added to Scenario 3

Scenarios 1 and 2: Impact of Cost Increases in Isolation

Under the proposed legislation farmers, ranchers, and dairies will all confront higher energy costs, and farmers will pay more energy-intensive inputs, such as nitrogen fertilizers that rely heavily on natural gas. We utilize USDA estimates of the increases in energy and fertilizer costs, shown in Table 7, for our analysis. These estimates are representative of the estimated price increases across the available studies.

Table 7: Estimated Energy and Fertilizer Price Increase above Projected Baseline Prices Resulting from Proposed Cap and Trade Legislation (H.R. 2454)

	Fuel		Natural Gas		Electricity		Fertilizer (1)	
	2020	2050	2020	2050	2020	2050	2020	2050
EPA (2009)	4.0%	14.6%	8.5%	30.9%	12.7%	35.2%	0.3%	na
EIA (2009)	9.6%	na	12.6%	na	12.2%	na	1.7%	na

(1) Only short-run estimates are reported in Table 4, covering the period of 2012-2018.

Source: USDA (2009), "The Impacts of the American Clean Energy and Security Act of 2009 On U.S. Agriculture." Office of the Chief Economist. Accessed February 2010 at: http://www.usda.gov/documents/PreliminaryAnalysis_HR2454.pdf

Scenarios 3 and 4: Potential for Agriculture to Offset Higher Costs with Increased Revenues

How might revenues change in response to the market changes and opportunities presented by the proposed legislation? Studies with a comprehensive assessment of the impacts of the proposed legislation (e.g., USDA, 2009; Texas A&M, 2009; Nicholas, 2009; and Univ. of Tenn., 2009) indicated that the implementation of a carbon offset program would generally result in diversion of existing agricultural lands into production of bioenergy crops and afforestation resulting in a net decrease in production of current commodity crops and a consequent relative increase in commodity prices, as shown in Table 8. Assuming that crop producers will benefit from the rise in relative commodity prices there is measurable potential to offset some or all of the increased production costs.

Table 8: Estimated Commodity Price Changes from Projected Baseline Prices Resulting from Proposed Cap and Trade Legislation (H.R. 2454)

Corn		Sorghum		Fed Beef		Milk	
2020	2050	2020	2050	2020	2050	2020	2050
11.5%	28.1%	-0.5%	39.8%	4.3%	14.3%	4.8%	33.1%

Source: USDA (2009), Tables 18 and 21, "The Impacts of the American Clean Energy and Security Act of 2009 On U.S. Agriculture." Office of the Chief Economist. Accessed February 2010 at: http://www.usda.gov/documents/PreliminaryAnalysis_HR2454.pdf

Preliminary Estimates of the Range of Impacts of H.R. 2454 on Agriculture in Arizona, Colorado, and New Mexico

The proposed climate change legislation will impact the agricultural economy throughout the Rocky Mountain and Southwest region and States. We summarize the estimated impacts on net farm income across each of the scenarios for our preliminary assessment in Table 9. Three technical appendices are also provided detailing more explicitly the analysis and assessment performed for each of the three States respectively, Appendix A. Arizona; Appendix B. Colorado, and Appendix C. New Mexico.

Energy and fertilizer cost increases, which are almost certain to coincide with the implementation of Cap and Trade legislation are shown in Table 9 to have an immediate effect on regional production costs of between -2.4% and -5%. This range of income effects is largely consistent with those estimated for other regions and cuts across also commodity sectors in response to higher input costs. In Scenario 2, this cost increase is expanded to include livestock feeding costs in a manner consistent with expected changes in corn and hay prices as farmers begin to make adjustments to their crop mix and land uses. This can be expected to have an even greater adverse impact especially for cattle and dairy producers who have significant feeding costs. The estimated change in net farm income for Scenario 2 ranges from -10.3% to -17%. Obviously, crop producers will by this time also be experiencing increased revenues from these commodity price increases. Therefore, Scenario 3 which includes these additional revenues paints a much more realistic and closer picture of the net impacts. In this case, for the states as a whole the net farm income begins to turn positive with increases ranging from 1.1% to 4.1%. Scenario 4 further enhances this potential by including some of the most likely adaptations and responses to carbon-offset markets, primarily methane digesters associated dairies and other concentrated livestock operations adding slightly more to the projected net farm income.

Future Research Needs

- **Impacts on fruit and vegetable prices.** Comprehensive estimates of the impacts of climate change legislation on these prices do not currently exist. USDA (2009) reported analyses of cost, but not revenue effects. The Scenarios 3 and 4 (above) for Arizona conservatively estimated revenue increases of 1%, which may well be an underestimate of how much revenues would increase for these producers.

- **Agricultural offsets and returns to investment in methane digesters.** Revenues from operations adopting digesters include both electricity sales and offset revenues. Studies of the economics of methane digesters usually assume carbon revenues based on recent rates in the Chicago Carbon Exchange. Future offset revenues and electricity prices are projected to be much higher than current rates. Future research could re-evaluate returns to methane digester investment considering higher electricity and offset prices.

- **Biofuel crops provide additional production opportunities.** Research is ongoing and needs to continue to develop biofuel cropping alternatives suitable to semi-arid conditions. Adoption and penetration depends on the technical and economic feasibility, including the development of markets and downstream buyers for this to become a viable practice. Research on technical and economic feasibility would enhance the ability to assess the potential contribution of biofuels.

- **Cropland management and carbon-sequestration.** Tillage practices can affect soil carbon conditions and maintenance. Conservation tillage is practiced to varying degrees throughout the region, primarily as a response to high fuel costs. It is currently difficult to estimate the extent to which a carbon-offset market would stimulate further management changes.

Table 9: Estimated Impacts of Proposed Climate Change Legislation on the Agricultural Economies of Arizona, Colorado, and New Mexico in the Year 2020 Across Four Scenarios

	Arizona	Colorado	New Mexico
Scenario 1: Energy and fertilizer cost increases considered in isolation			
Change in Net Farm Income (millions $2007)	-29.4	-42.7	-20.0
% change	-5.0%	-4.4%	-2.4%
Scenario 2: Feed cost increases considered along with energy and fertilizer cost increases			
Change in Net Farm Income (millions $2007)	-60.4	-164.9	-88.1
% change	-10.3%	-17.0%	-10.6%
Scenario 3: Commodity price increases are factored in along with the expected cost increases			
Change in Net Farm Income (millions $2007)	6.3	27.4	33.7
% change	1.1%	2.8%	4.07%
Scenario 4: Additional offset revenue from methane digesters is added to Scenario 3			
Change in Net Farm Income (millions $2007)	6.7	27.6	34.3
% change	1.2%	2.9%	4.13%

Summary and Conclusion

This preliminary assessment suggests that energy and fertilizer cost increases can be expected to adversely affect the region's agricultural economy in a relatively small but not insignificant amount. The potential for the policy changes to ultimately have a net beneficial impact is largely dependent on the response of commodity markets and resulting output price increases. There is limited potential for participating in carbon-offset programs and markets, though biofuel production is a strong area of current research and may provide significant future opportunities. Cattle and dairy producers will be affected by both energy and feeding cost increases under our scenarios, and though large dairies and livestock feeding operations could benefit from methane management and electricity production, our conclusion is that small ranch operations, primarily cow-calf producers will find the additional costs much more difficult to cope with.

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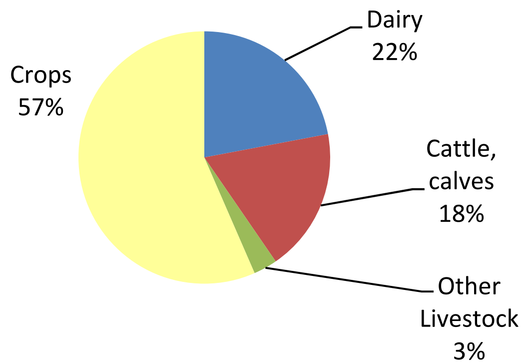
TECHNICAL APPENDIX A: PRELIMINARY ASSESSMENT OF CLIMATE CHANGE LEGISLATION ON ARIZONA AGRICULTURE

This appendix does three things. First, it details data and assumptions used to develop the four scenarios of the potential effects of H.R. 2454 on Arizona agriculture. Second, it provides further discussion of data sources used to assess agricultural offset potential from methane digester technology. Third, it summarizes potential short-term (2020) and medium-term (2030) effects of H.R. 2454 on Arizona representative farms.

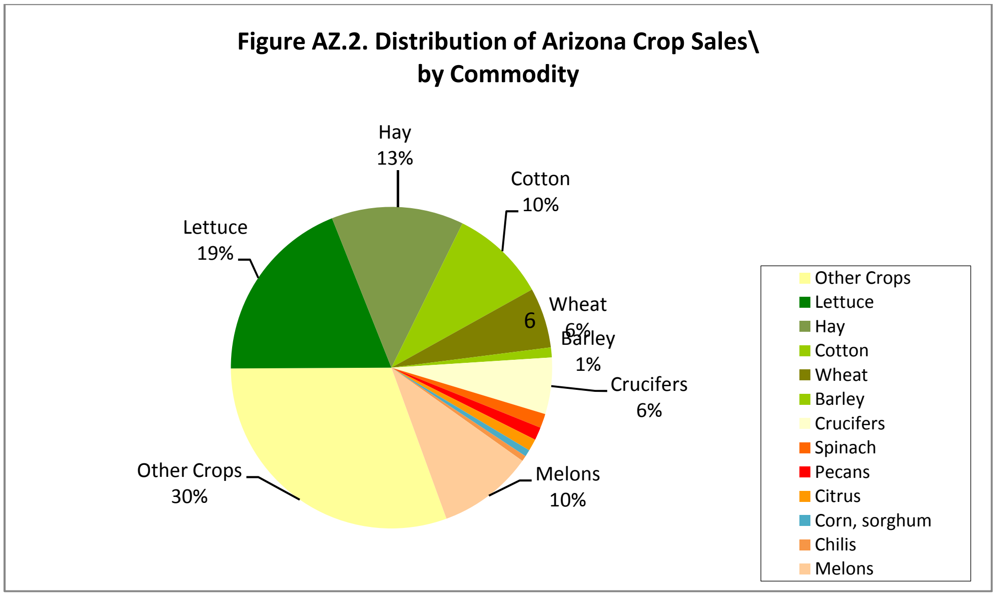
Arizona Statewide Scenario Development

Cattle and dairy sales are relatively large in Arizona, although less dominant than they are in New Mexico. Dairy sales account for 22% of Arizona's total agricultural sales in 2008, while cattle and calf sales accounted for 18% (Figure AZ.1).

Figure AZ.1. Distribution of Arizona Agricultural Sales between Crops and Animal Products



Source: *Arizona Agricultural Statistics Bulletin 2008*



Source: *Arizona Agricultural Statistics Bulletin*

In 2008, lettuce contributed to 19% of state crop sales, hay 13%, cotton 10%, and wheat 6% (Figure AZ.2). Melons and cruciferous crops (broccoli, cauliflower, and cabbage) accounted for another 16% of sales. Arizona's crop production is highly diversified, including many high-value fruit and vegetable crops. To give an indication of this diversity, in Figure AZ.2, "other crops" not reported individually by USDA comprise 30% of crop sales.

Short-run impacts of H.R. 2454 on Arizona agriculture

Table AZ.1. Arizona Gross Income, Production Expenses and Net Cash Income from 2007 Census of Agriculture (figures in $ thousands)

	2007 Values
Gross Farm Income	$ 3,366,732
Crop Sales	$ 1,913,014
Vegetables, melons	$ 865,260
Hay, other crops	$ 266,943
Cotton	$147,761
Nursery, greenhouse	$417,792
Grains	$117,494
Other	$97,764

Animal Products	$ 1,453,718
Dairy products	$634,509
Cattle, calves	$585,479
Other animal products	$101,550
Government Payments	$55,947
Other Farm-Related Income	$76,233
Production Expenses	$2,782,786
Farm Origin	
Feed	$617,035
Livestock	$315,343
Seed	$199,392
Purchased	
Fertilizer	$165,318
Gasoline, fuels, oils	$146,118
Utilities	$104,463
Labor (Hired &Contract)	$457,136
Chemicals	$133,265
All other	$644,716
Net Cash Income	$ 583,946

To approximate short-term (2016-20) impacts of H.R. 2454 on Arizona agriculture, we begin with data from the 2007 Census of Agriculture reporting sources of income and production expenses for the state as a whole (Table AZ.1). Arizona had more than a $3.3 billion in gross farm income in 2007, with production expenditures of nearly $2.8 billion. Net cash returns were more than half a billion dollars. Net cash income was about 21% above production expenses.

Table AZ.2. Contribution of different inputs to total Arizona production expenditures

Input Category	Share of Production Expenditures
Feed	22%
Labor (Hired & Contract)	16%
Livestock	11%
Seed	7%
Fertilizer	6%
Gasoline, fuels, oils	5%
Chemicals	5%
Utilities	4%
All other	23%

Table AZ.2 shows the relative contribution of different inputs to total production expenditures in the state. The particularly energy-related expenses (fertilizer, fuels, and utilities) account for about 15% of total production costs, although this percentage considerable by commodity specialization.

To assess of how H.R. 2454 might affect Arizona agriculture, we assume production expenditures and crop revenues increase by fixed percentages, with percentages derived from estimate from other studies. This approach assumes that farmers and ranchers do not change their input mix, cropping patterns, acreage or output in response to changing prices. It thus assumes a high degree of inflexibility on the part of agricultural producers.

Based on price projections from the Energy Information Administration (EIA) of the Department of Energy, USDA (2009) analysis suggests fertilizer prices would increase by only 1.7% in the short run (2012-18). Fertilizer price increases are modest in the near-term because fertilizer manufacturing is assumed to be designated as an EITE industry. As such, it will receive emission allowances that will allow the industry to avoid most of the effects of rising natural gas prices on fertilizer production costs. USDA also reported petroleum and electricity price increases of 9.6% and 12.2% above baseline. Electricity is the main, though not only, component of utility expenditures. For the scenarios, we assumed that Arizona prices of fertilizer would rise 1.7% above baseline, while gas and fuel prices would rise 9.6% and utility expenditures would rise by 12% (Table AZ.3).

USDA assumes corn prices will rise 11.5% above baseline, while sorghum prices will fall slightly. USDA does not report price effects for alfalfa or other hay. The Texas A&M study, however reports hay price increases about 11.5%. We therefore assumed that feed costs in Arizona would rise 10% above baseline. Both the USDA (2009) and Texas A&M analysis suggest cotton prices increase by about 7% above baseline. USDA analysis suggests milk prices would rise 4.8%. Grain price changes Arizona assumed for the simulations are a weighted average of USDA reported price changes. Percent price changes are weighted by share of sales from different grains in the state. Assumed cattle and calf prices increase are derived by weighting USDA reported increases in fed cattle prices, by the share of fed cattle in total cattle sales.

Table AZ.3. Assumed changes in production expenditures and gross farm revenues by scenario

	Scenario 1	Scenario 2	Scenarios 3 & 4
Fertilizer	1.7%	1.7%	1.7%
Gasoline, fuels, oils	9.6%	9.6%	9.6%
Utilities	12%	12%	12%
Hay, silage & other crops	-	11.5%	11.5%
Feed	-	10%	10%
Cotton	-	-	7%
Grains	-	-	3.2%
Dairy products	-	-	4.8%
Cattle Calves			2.3%

Four different scenarios are considered:

- Scenario 1: Expenditures for fertilizer, gasoline, fuels, oils and utilities all increase by percentages shown in Table AZ.3.

- Scenario 2: Manufactured input expenditures increase as in Scenario 1; in addition, feed costs rise by as do hay and silage revenues
- Scenario 3: Expenditures and revenues change as in Scenario 2; in addition, revenues for cotton, grains and dairy products increase based on assumptions from the USDA December report.
- Scenario 4: Expenditures and revenues change as in Scenario 3; in addition, dairy operations are assumed to obtain offset income by installing methane digesters.

Detailed results from each scenario are presented in Table AZ.4 with values from the 2007 Census of Agriculture used for the baseline. One should interpret these figures as approximate, capturing order-of-magnitude changes. Summary impacts on net cash income are reported in Table AZ.5.

In Scenario 1, production expenses rise by $29.3 million and assuming no change in revenues, net cash income falls by the same amount. This reduces state net farm income 5%. Rising fuel and utility expenses account for most of the cost increase as EITE prevent fertilizer costs from rising substantially in the short run.

In Scenario 2, feed costs and hay and silage revenues both increase. Arizona producers spend more on feed inputs than they earn in hay and silage revenues. Thus, the net effect of higher feed costs is to lower net farm income further. In Scenario 2, net farm income falls by $60 million below baseline (10%).

In Scenario 3, we assume that grower revenues increase based on assumed national price increases. With revenue increases, net cash incomes by 1.1% less than $0.2 million. For scenario 4, we assume that (a) adoption of methane digesters is economically viable for operations with a minimum herd size of 1,000 cows, (b) annualized gains are $4.89 per cow and (c) digesters are installed on one-third of the dairies (or more precisely, on dairies that account for one-third of the total cows (among operations of 1,000 or more cows). At this level of adoption, dairy producers gain an additional $429,000 in offset revenue. Overall, accounting for this offset income, H.R. 2454 raises Arizona net farm income by about 1.2%.

Scenarios 3 and 4 assume that prices for fruit and vegetable crops increase by only 1%. The USDA (2009) report examines impacts of H.R. 2454 on fruit and vegetable production costs, but not on prices, finding costs increase about 1%. Other major studies of the impacts of climate change legislation to date have not included price impacts on specialty crops. In part, this is because large agricultural sector models focus on the primary commodity program crops and do not include fruits and vegetables.[2] Thus, we have no external source of data from existing studies on the potential effects of H.R. 2454 on specialty crops. This is an important gap in data given the relatively high value of specialty crops and their relatively inelastic demand. Output price effects for specialty crops are likely to be quite significant.

[2] One exception is the updated version of the U.S. Agricultural Resources Model (USARM). See Frisvold and Konyar (2009) and Konyar (2001). Along with major field crops, USARM also has extensive regional and national coverage of alfalfa, apples, broccoli, cauliflower, citrus, grapes, lettuce, melons, onions, potatoes, sugar beets and sugar cane.

The results presented here are qualitatively quite similar to findings of other studies. In the near term, prior to 2025 the effects of H.R. 2454 on production costs and net farm are quite modest. This is because most of the impacts of H.R. 2454 on fertilizer and electricity prices are projected to occur after 2025. After 2025, allowances for retail electricity providers and fertilizer manufacturers will be begin to be phased out.

Table AZ.4 Effects of H.R. on Arizona farm costs and income under alternative scenarios for 2016-2020

(figures in $ thousands)

	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Baseline	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Gross Farm Income	$ 3,366,732	$ 3,366,732	$ 3,397,430	$ 3,464,109	$ 3,464,537
Crops	$ 1,913,014	$ 1,913,014	$ 1,943,712	$ 1,966,468	$ 1,966,468
Vegetables, melons	$ 865,260	$ 865,260	$ 865,260	$ 873,913	$ 873,913
Hay, other crops	$ 266,943	$ 266,943	$ 297,641	$ 297,641	$ 297,641
Cotton	$147,761	$147,761	147,761	$ 158,104	$ 158,104
Nursery, greenhouse	$417,792	$417,792	417,792	417,792	$417,792
Grains	$117,494	$117,494	117,494	$ 121,254	$ 121,254
Other	$97,764	$97,764	97,764	97,764	$97,764
Offsets					$429
Animal Products					
Dairy products	$ 1,453,718	$ 1,453,718	$ 1,453,718	$ 1,497,640	$ 1,497,640
Cattle, calves	634,509	634,509	634,509	$ 664,965	$ 664,965
Other animal products	585,479	585,479	585,479	$ 598,945	$ 598,945
Government Payments	101,550	101,550	101,550	101,550	101,550
Other Farm-Related Income	$ 55,947	$ 55,947	$ 55,947	$ 55,947	$ 55,947
	$ 76,233	$ 76,233	$ 76,233	$ 76,233	$ 76,233
Production Expenses	2,782,786	2,812,159	2,873,863	2,873,863	2,873,863
Farm Origin					
Feed	617,035	617,035	678,739	678,739	678,739
Livestock	315,343	315,343	315,343	315,343	315,343
Seed	199,392	199,392	199,392	199,392	199,392

Purchased					
Fertilizer	165,318	168,128	168,128	168,128	168,128
Gasoline, fuels, oils	146,118	160,145	160,145	160,145	160,145
Utilities	104,463	116,999	116,999	116,999	116,999
Labor (Hired &Contract)	457,136	457,136	457,136	457,136	457,136
Chemicals	133,265	133,265	133,265	133,265	133,265
All other	644,716	644,716	644,716	644,716	644,716
Net Cash Income	$ 583,946	$ 554,573	$ 523,568	$ 590,246	$ 590,674
Change from baseline					
($ 000)		$ (29,373)	$ (60,378)	$ 6,300	$ 6,728
Change from baseline (%)		-5.0%	-10.3%	1.1%	1.2%

Methane Digester Offset Potential

Another source of agricultural offsets is through adoption of methane digester technology on swine and dairy operations. AgSTAR, a program jointly sponsored by EPA, USDA and DOE to encourage voluntary adoption of methane digesters on swine and dairy operations, estimates that 6,900 swine and dairy farms could utilize digesters, with New Mexico and Arizona ranked 2nd and 3rd in methane reduction potential on dairy farms. (U.S. EPA 2002). Although methane emissions are small relative to carbon emissions, they have a large Global Warming Potential (GWP). GWP compares the relative ability of a greenhouse gas to trap heat in the atmosphere over a certain time. CO_2, the reference gas has a GWP of 1. Based on a 100-year time frame, the GWP of CH_4 is 21, meaning a ton of methane is equivalent to 21 tons of CO_2.

Table AZ.5 Operations with methane digesters in Rocky Mountain States, current and planned

State	Status	Farm Type	Population Feeding Digester	Biogas End Use(s)	Installed Capacity (kW)	Methane Emission Reductions (metric tons CH_4/yr)	Methane Emission Reductions (metric tons CO_2E/yr)
CO	Operational	Swine	5,500	Flared Full Time		182	3,826
ID	Operational	Dairy	10,000	Cogeneration	2,250	896	18,826
ID	Operational	Dairy	4,700	Cogeneration	1,500	421	8,848
MT	Operational	Dairy	350	Electricity; Boiler / Furnace Fuel	50	72	1,522
UT	Operational	Swine	194,000	Methanol		5,971	125,381
UT	Operational	Dairy	1,200	Cogeneration	150	121	2,551
WY	Operational	Swine	5,000	Electricity	80	27	557
WY	Operational	Swine	18,000	Electricity	160	190	3,999
ID	Construction	Dairy	14,400				
ID	Construction	Dairy		Pipeline Gas			
CO	Planned	Dairy		Pipeline Gas			
ID	Planned	Dairy	3,000	Cogeneration	350		

Source: EPA AgStar data base.

Effects on representative Arizona farms

We use a partial budgeting approach to assess the impacts of H.R. 2454 on Arizona agriculture. This is similar to approaches used previously to assess H.R. 2454 (Babcock; FAPRI; Doanes), although there are important differences, discussed below. The partial budgeting approach takes energy price increases derived from other studies of H.R. 2454 as inputs to analysis. Energy price changes are converted into changes in per acre farm expenditures for energy or energy-embodied farm inputs. Changes in expenditures then are aggregated in crop budgets to evaluate changes in farm costs of production.

The partial budgeting approach overstates negative effects on costs of production for several reasons. First, it implicitly assumes that growers do not substitute between inputs in response to price changes. Second, it assumes that producers do not alter production techniques or adopt more energy efficient technologies in response to energy price changes. Third, because analysis is often on a crop-by crop basis it does not allow farms to change their crop mix (relative acreage devoted to different crops) in response to input price changes. In reality, growers make changes at the extensive margin (crop and acreage choice) and intensive margin (input substitution, change in production techniques) that would reduce overall costs of the cap and trade program.

Our estimates of energy price increases come from analyses of the Environmental Protection Agency (EPA) and Department of Energy, Energy Information Administration (EIA). When data is available from both sources, we use estimates from EIA, which reports larger price increases. Using EIA assumptions, therefore will lead to larger cost-increase estimates for agriculture.

The partial budgeting analysis considers the impacts of H.R. 2454 at two points in time, 2020 and 2030. This is to highlight differences between short-run and medium run impacts on energy and fertilizer prices. Provisions of HR 2454 reduce the short-run effects on fertilizer costs. Energy-intensive, trade-exposed entities (EITEs) will receive emissions allowances. According to EPA analysis, sufficient allowances will be distributed to allow EITE industries to counter increased energy costs. Without these allowances, EITE industries would face energy-related costs, while foreign competitors might not. This would put domestic EITE industries at a competitive disadvantage. The EPA lists nitrogenous fertilizer manufacturing as an eligible EITE sector. USDA analysis has therefore assumed that H.R. 2454 will have minimal effect on the cost of nitrogen fertilizer manufacturing through 2024, despite increases in natural gas prices. We maintain this assumption as well.

H.R. 2454 specifies that allowance rebates be phased out starting in 2026, with a complete phase-out by 2035. The termination of allowances is based on the assumption that, by 2035, other countries will have adopted their own climate change mitigation policies, so that U.S. EITE industries will not be at a competitive disadvantage. The bill includes a provision to extend allowances if the President makes a determination that this is not the case. Following USDA assumptions, we likewise assume that the allowance rebate is sufficient to completely cover the U.S. fertilizer industry and that effects of the legislation on fertilizer costs prior to 2025 are small. We assume, however, that by 2030, fertilizer allowances are completely phased out even though the complete phase-out would not be completed prior to 2035. Again, this assumption will overstate impacts on farm costs.

This analysis differs from some previous partial budgeting analysis in that we explicitly consider the impacts of price increases. Energy price shocks lead to reductions in agricultural output and increases in agricultural prices. While increased costs and reduced output reduce farm income, price increases have a positive effect. Considering production costs alone, therefore, provides an incomplete picture of energy cost shocks on agriculture.

Energy price shocks are derived from EIA analysis that compares the no-legislation, reference scenario with EIA's Basic Case scenario at two points in time, 2020 and 2030. Under the Basic Case, it is assumed there is large-scale deployment of renewable, nuclear, and carbon capture and storage technologies. It also assumed that domestic and international offsets are not constrained and that emission sources are able to bank credits for early emission reductions.

Cap and trade is has a greater impact on energy prices in 2030. These energy price increases are then used to simulate increases in farm-level costs of production. Percentage price increases for on-farm gasoline and diesel fuel are taken directly from the EIA price shocks reported in table ES-1 or the EIA report. The EIA simulations do not directly report impacts on fertilizer prices. Huang (2007) reports that based on cointegration estimation, the long-run ammonia price elasticity with respect to natural gas price is 0.8. This suggests that a 10% increase in natural gas would lead to an 8% increase in ammonia prices. Ammonia is the fundamental ingredient in nitrogen fertilizers. For 2030,

Cotton ginning requires electricity for machinery and fuel for drying. The increases in electricity and natural gas are prorated based on ginning cost shares using data from Valco (2009) to estimate increased ginning costs. Likewise, electricity cost increases for cooling are prorated based on cooling's share of costs in lettuce harvesting to adjust custom harvest costs. USDA analysis did not report impacts on insecticide or herbicide costs. However, analyses by FAPRI and Texas A&M suggest short run cost increases about 0.1%. The FAPRI study assumed cost increases by 2030 about 0.2%. We therefore assume costs for insecticides, herbicides, and other chemicals to rise 0.1% above the no-legislation baseline in 2010 and to rise 0.2% in 2030.

We compare 2020 and 2030 baseline crop budgets with two alternative budgets representing effects of H.R. 2454. Costs are based on budgets for Western Arizona (Yuma and La Paz Counties), which accounts for a third of agricultural sales in Arizona. The first scenario includes only presumed cost increases from climate legislation, while the second includes both price changes along with cost increases. Crop budgets were updated to 2020, from 2006 for Western Arizona to reflect higher baseline energy input cost shares in the future. Western Arizona (Yuma and La Paz Counties) accounts for about a third of agricultural sales in Arizona. If energy inputs comprise a greater share of costs in the future, then subsequent energy price increases will have a larger impact on total production costs.

Upland Cotton

In 2020, H.R. 2454 increases costs by $14.03 / acre above baseline, or by about 1%. Rising diesel fuel costs account for 60% of this cost increase. Although the percentage increase in cost is small, the cotton farm is operating with a very small profit margin, $15.11. So, absent output price increases, legislation would reduce net returns significantly. USDA simulations suggested that cotton prices would increase by 7% above baseline in 2020, while the Texas A & M study reported an 8% increase above baseline by 2016. Assuming a 7% cotton price increase, the net effect of H.R. 2454 is to increase cotton grower returns by $53.16 per acre compared to the 2020 baseline.

In 2030, costs increase $41.92 above baseline, a 3.3% increase. Fertilizers now account for 38% of the cost increase, compared to 11% in 2020. This illustrates the value of the EITE allowance rebates. Diesel fuel accounts for 37% of the cost increase. For 2030, USDA estimated H.R. 2454 would increase cotton price 2.1% above baseline. We assume a 2% price increase in 2030. Including the price increase, legislation reduces net returns by $21.38 / acre.

Wheat

In 2020, H.R. 2454 increase wheat production costs by 1.3% above baseline, $5.03 / acre. Of this, 46% is attributable to rising diesel fuel costs, while 47% is from higher fertilizer prices. Wheat has relatively high fertilizer costs per acre compared to other crops, so even the small short-term fertilizer price increases have an impact. USDA scenarios report a 5% price decrease for wheat in 2020, relative to the baseline, while Texas A&M reports a small increase of 0.5%. With a price decrease, net returns fall $30.02 per acre, while with the price increase they fall by only $2.42 per acre. In 2030, USDA reports a 3% price increase above baseline. Cash expenses rise nearly 7%, however (by $27.11/acre), with 87% of this increase coming from higher fertilizer costs. Net returns fall by $12.71 per acre.

Alfalfa

Alfalfa, in contrast to wheat has relatively low fertilizer costs. In 2020, H.R. 2454 raises alfalfa production costs $7.49 / acre above baseline, or by 1.6%. Assuming no output price change, net returns fall by 1%. USDA does not report price change for alfalfa. The Texas A&M study estimated an 11.5% short-term price increase for hay. Assuming this large price increase, net returns increase by $133.24 / acre. In 2030, costs rise by $15.78 above baseline.

Lettuce

In 2020, lettuce production costs increase 1.5% above baseline, by $52.34, while they increase 3% ($103.15) in 2030. USDA reports a 0.9% increase in aggregate vegetable and melon production costs in the short-run (based on EIA data) and a 2.13% increase in the medium run, based on EPA analysis. So, the estimated cost increases here are comparable. Studies of the impacts of climate change legislation to date have not included price impacts on specialty crops. In part, this is because large agricultural sector models focus on the primary commodity program crops and do not include fruits and vegetables.

Thus, we have no external source of data from existing studies on the potential effects of H.R. 2454 on winter lettuce prices. Hammig and Mittelhammer estimated an imperfect competition model of the winter lettuce market and found an elasticity of supply-price with respect to labor costs of 0.29 and elasticity with respect to other costs of 0.36. Thus, it is reasonable to assume that a 1% rise in production costs will lead to a 0.3% increase in winter lettuce prices. Under this assumption, about half of the cost increases are passed on to first purchasers of lettuce. Including output price impacts, H.R. 2454 reduces net returns 0.7% below baseline ($28.32 / acre) in 2020 and 1% below baseline ($37.25 / acre) in 2030.

The results for representative Arizona farms suggest that there are significant benefits to producers from the EITE fertilizer allowance. This postpones more significant cost effects to beyond 2025, with full effects not taking place until 2035. While cost increases by 2030 are larger, given no change in production practices or technology, fertilizer- and energy-saving technical change could reduce these costs.

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TECHNICAL APPENDIX B: <u>PRELIMINARY ASSESSMENT OF CLIMATE CHANGE LEGISLATION ON COLORADO AGRICULTURE</u>

This appendix provides a brief overview of Colorado's agricultural sector. Also included in this appendix is an overview of previous research on HR 2454 as it relates to Colorado.

<u>Colorado Agriculture</u>

As of the 2007 Census of Agriculture, Colorado had 37,054 farms, comprising 47.6% of the state's total land area. Of this farmland, 36.3% is crop and 56.4% pastureland. The top five agricultural commodities in Colorado are cattle and calves, dairy products, corn, wheat and hay. Principle crops by number of acres harvested are wheat for grain; winter wheat for grain; corn for grain; proso millet; sorghum grain; and sunflower seeds. In terms of production expenses, Colorado is similar to other states in that feed comprises the majority of agricultural production costs (22.5%); followed by gasoline, fuels and oils (4.7%); fertilizer, lime and soil conditioners (3.7%); utilities (2.6%) and chemicals (1.9%).

Tables providing a breakdown of agricultural activities are included in the main section of this report.

Previous Research on HR 2454's and their Relation to Colorado

a. Doane Advisory Services (2008). An *Analysis of the Relationship between Energy Prices and Crop Production Costs.*

Doane Advisory Services developed a model to forecast how HR 2554's effects on energy prices will impact agriculture costs by increasing the price of both direct and indirect production inputs. To accomplish this, Doane develops a statistical model relating energy and production costs for eight crops: corn, soybeans, wheat, cotton, rice, sorghum, oats and barley. The authors then forecast energy prices for crude oil (using USDA data) and natural gas (EIA data), both with and without passage of HR 2454. These results are used in the energy price/production cost model to determine the net impact HR 2454 will have on costs for agricultural producers, relative to a baseline, in 3 scenarios: 1) 35.2% increase in natural gas and 27.2% increase in crude oil prices 2) 49.4% increase in natural gas and 36.6% increase in crude oil prices; and 3) 70.8% increase in natural gas and 52.0% increase in crude oil prices.

<u>Results for: Colorado</u>

Doane Advisory Services forecasts costs for Colorado's major crops to be impacted as follows: costs for producing corn increase $40.33, $55.25, and $78.80 per acre relative to the baseline in scenarios 1, 2 and 3, respectively. For wheat, these cost increases are $16.33, $22.37; and $31.87; and for sorghum, costs are $22.23, $30.53, and $43.56 in each respective scenario. Overall, an increase in the corn costs of $40.33/acre in the lowest-cost scenario would represent a 13.92% over the baseline; for wheat and sorghum, percentage increases would be 13.88% and 14.41%. It should be noted, however, that Doane assumes famers do not change their input use or cropping patterns. Furthermore, the results for this study are not region-specific but are based on a generic farm-budget scenarios, so it cannot be assumed that Colorado's farm costs would mirror those forecasted by in this study.

b. APAC (2009). *Analysis of the Implications of Climate Change and Energy Legislation to the Agricultural Sector.)*

This study by researchers at the University of Tennessee sought "to project how varying specifications for allowable offsets in a cap-and-trade program might impact the agricultural sector" by modeling "how sector changes will impact land use change, feedstock production, feedstock prices, and farm income, as well as carbon costs and payments to producers." The Ugarte model is developed assuming that the Renewable Fuel Standard remains in place; the model then evaluates agricultural costs under three scenarios: regulated GHG emissions but no offsets market; "limited offsets," allowing for methane capture, afforestation, and conservation tillage (harvesting of crop residues must be carbon neutral); "multiple offsets," which also allow for production of bioenergy crops and grassland sequestration in addition to the components of the "limited offsets scenario"(harvesting of crop residues does not need to be carbon neutral); and, lastly, "Multiple offsets/RCN," in which all previously-mentioned offsets are available, but removal of crop residues must be carbon neutral. Net impacts on farm income are estimated in each scenario (as well as a baseline) using the POLYSYS agricultural policy simulation model and EPA forecasts for carbon prices, which the researchers extend from 2015 to 2025.

Results for: Colorado

Results from this study relevant for Colorado are as follows: Average changes in crop returns would decrease for wheat and grain sorghum under the no-offset scenario, though returns for corn are projected to increase. Average change in net crop returns increase for corn, sorghum and wheat under the "Multiple Offsets/RCN" scenario; furthermore, the researchers note that "in addition to changes in net crop returns, net agricultural returns would be supplemented with carbon payments for methane capture." Overall, the researchers find that agricultural producers should benefit from a cap-and-trade system for carbon emissions; however, these findings are crop, not region, specific. Furthermore, the study does not provide detailed information related to whether the Colorado farmers will be able to actively participate in carbon offset markets.

c. *Nichols Institute for Environmental Policy Solutions (2009). The Effects of Low-Carbon Policies on Net Farm Income.*

In this study, researchers use the FASOMGH, the Forest and Agricultural Sector Optimization Model with Greenhouse Gases, to estimate HR 2454's impact on agricultural producers. Unlike the model used in the Doane study, FASOMGH accounts for the fact that managers may change inputs and crop production decisions in response to increased input costs. This model also "incorporates contemporary data on the renewable fuel standard, energy prices (AEI 2009), demand and yield productivity growth, exports, land use, land-use changes, and technological process in bioenergy processing" in determining a baseline scenario. The authors also consider three different carbon pricing scenarios, $15, $30, and $50/ton CO2, all of which coincide with EPA projections. Estimated costs for agriculture "are estimated by pricing the GHG content of nitrogen fertilizer, pesticide, and fossil fuel use and then estimating the behavioral response."

Results for: Colorado

Baker, et. al find that revenues from offset activities—including afforestation, tillage change, nitrogen fertilizer reduction, and manure management—can create net gains in producer surplus in the Rocky Mountain region under all carbon pricing scenarios. Furthermore, the authors conclude "even regions without afforestation opportunities or biofuel production possibilities, or that lack soil carbon or animal offset potential, can still benefit under low-carbon policies due to higher commodity prices." FASOMGH predicts prices for corn to increase 15.94% under the $15/ton carbon scenario; wheat, sorghum, and fed beef prices increase 3.7%, 0.57%, and 5.21%, respectively.

d. Agricultural and Food Policy Center (AFPC) (2009). ***Economic implications of the EPA analyses of the CAP and Trade Provisions of HR 2454 for U.S. representative farms.***

In this study, researchers from the Agricultural and Food Policy Center at Texas A&M University use FLIPSIM, a "risk-based whole farm simulation model," to simulate HR 2454's impact on 98 representative crop farms, dairies, and livestock operations. The researchers use EPA estimates of carbon, energy, and agricultural commodities to estimate impacts for three scenarios: institution of a cap-and-trade system in 2010 without agricultural carbon credits; cap and trade in which farms sell carbon credits gained by converting to no-till methods and installing methane digesters; and a cap and trade scenario with offsets but full carbon saturation of soil by 2014. Each of scenarios is compared to the FAPRI 2009 baseline scenario, and changes in income for representative farms were estimated for years 2010-2016.

Results for: Colorado: The APFC study projects increases in production costs to increase 1.27% and 2.26%, respectively, for small medium representative wheat farms in Colorado. The authors state, however, that "ending cash reserves" in 2016 are the best metric for evaluating the impact of HR454, as this measure accounts for income taxes, loan payment, and living expenses. The model predicts ending cash reserves for wheat farmers increase in all scenarios relative to the baseline, though revenues decline in scenario 4 (relative to scenario 2) when soil becomes carbon-saturated and farms can no longer sell offset credits. Ranchers, however, would see ending cash reserves fall in the model; nevertheless, the model predicts Colorado ranchers would see their net worth increase as a result of land appreciation (FLIPSIM predicts increasing commodity prices will drive land prices up). Lastly, this model uses data from the Chicago Climate Exchange in determining that Colorado could sequester carbon in soil by adopting no-till farming practices; farm budgets were then used to determine changes in costs associated with converting from conventional to no-till farming methods.

e. U.S. Department of Agriculture, Office of the Chief Economist and Economic Research Service (Dec. 2009). ***A Preliminary Analysis of the Effects of H.R. 2454 on U.S. Agriculture*****.**

The USDA uses the Food and Agricultural Policy Simulator Model (FAPISM) to estimate impacts of HR 2454, assuming that farmers can change acreage decisions but not production practices or technology in response to higher energy prices. FAPISM's additional assumptions include the following: energy prices will increase in accordance with EPA and EIA estimates, and farms will not face increased fertilizer costs, as fertilizer and other "trade vulnerable industries" will receive rebates (through year 2024) for increased energy prices. Overall, the model predicts reductions in net farm income of 1-2% without offsets in both the EPA and EIA energy cost scenarios; however, the study also notes, "[W]hile the profitability of management practices varies widely be region, as does the amount of carbon storage attainable, net revenues from agricultural offsets can mitigate the effects of higher carbon costs due to higher energy costs."

Overall, the USDA analysis predicts a 1-2% decline in agricultural revenues in the Rocky Mountain Region. Over the years 2012-2018, average per-acre costs of production for corn are expected to increase 0.4% and 1.5% relative to the baseline in the EPA and EIA price scenarios, respectively. These increases are 0.6% and 1.7% for wheat and 0.9 and 2.2% for sorghum. Regarding livestock, feed costs for beef would increase between 0.1% and 0.3%. At the same time, however, prices for all three major crops are predicted to increase relative to the baseline in these same years, though the authors caution that predicted price effects do not reflect potential land use changes that may result from desire to produce GHG offsets. Lastly, researchers note that offset—predicted using the same FASOM model used by the Nicholson institute-- could total 4.9 MMT CO2eq/year in 2015 in the Rocky Mountain region. This statistic number the region fourth out of ten in rankings of regions with the greatest agricultural offset potential (though overall revenues from offsets are still relatively small, roughly 0.1 billion ($2004 dollars) annually.

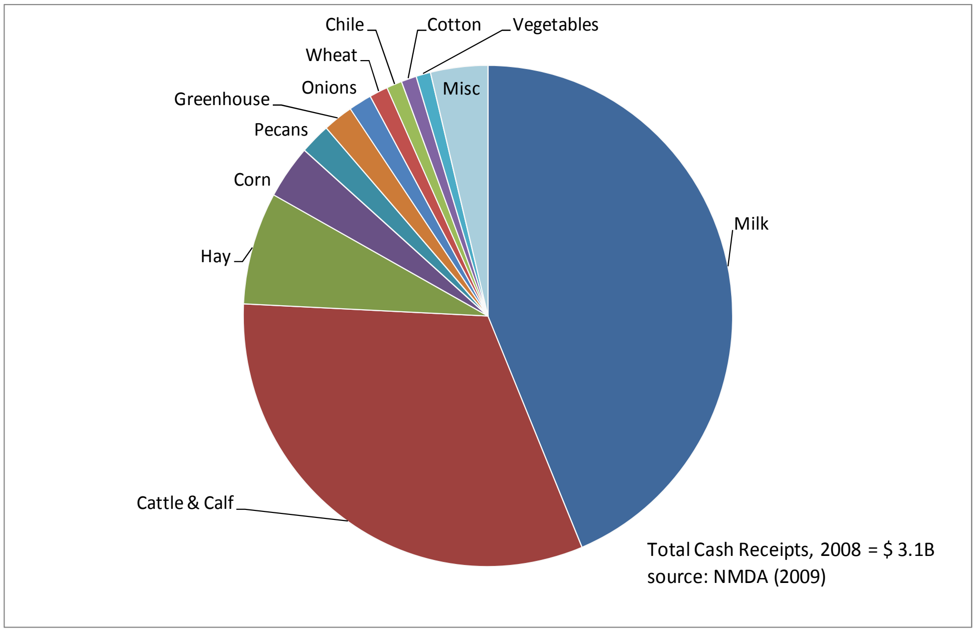
TECHNICAL APPENDIX C: PRELIMINARY ASSESSMENT OF CLIMATE CHANGE LEGISLATION ON NEW MEXICO AGRICULTURE

New Mexico Perspectives

Agriculture is an important industry in New Mexico providing jobs and economic livelihood throughout the State contributing more than $1.2 billion in 2008 to the State's gross domestic product (NMBBER, 2010). With a land base comprised of 77.6 million acres, New Mexico is the fifth largest state in total area. Nearly half of this area (about 37 million acres) is used for livestock grazing. Crops are harvested on just over 1 million acres, 83% of which are irrigated (U.S. Census, 2010).

Cattle and dairy dominate the agricultural economy of New Mexico, together generating more than 75% of the agricultural income of the state. And if livestock feed crops such as hay and corn silage are included, then livestock-related agriculture generates more than 85% of agricultural revenues in the state. In addition to the dairy and cattle industries, New Mexico is an important producer of pecans (second only to Georgia in overall production. New Mexico also is an important producer of both onions and chile. Wheat is important in some areas of the state, as is cotton. Figure C.1 shows the share of gross receipts generated by the various commodities.

Figure C.1 Value of Agricultural Production in New Mexico by Commodity



The aggregate agricultural income of New Mexico is characterized in Table C.1. In particular, the table shows agricultural revenues total about $ 3.4 billion and variable production costs total about $2 billion. Of these variable production costs, energy and fertilizer costs comprise nearly 10% and 3.5%, respectively, of variable production costs averaged over the entire industry and state.

Table C.1 Net Income From Farming in New Mexico

New Mexico, 2008, Agricultural Statistics	Baseline	
Net Income From Farming		
	($1,000s)	
Value of crop production	$ 698,451	
Value of livestock production	$ 2,420,628	
Revenues from Services and forestry	$ 269,555	
Revenues from Carbon Offset Activities	$ -	
Value of Ag Sector Production		$ 3,388,634
Puchased Inputs		
farm origin		
Feed purchased	$ 680,793	
Livestock and poultry purchased	$ 420,818	
Seed purchased	$ 27,114	
Manufactured		
Fertilizers	$ 69,927	
Pesticides	$ 33,058	
Petroleum fuel and oils	$ 135,396	
Electricity	$ 58,521	
Other	$ 590,457	
		$ 2,016,084
Net Gov't Transactions		$ 24,482
Gross Value Added		$ 1,397,032
capital consumption	$ 161,246	
Net Value Added		$ 1,235,786
payments to stakeholders		
employment compensation (total hired labor)	$ 254,210	
Net rent rec'd by nonoperator landlords	$ 34,605	
Real estate and non-real estate interest	$ 117,136	
Net Farm Income		**$ 829,835**

Estimating the Range of Impacts of H.R. 2454 on New Mexico Agriculture

The American Clean Energy and Security Act of 2009 (ACES, aka H.R. 2454) initiates a ‘Cap and Trade’ (C&T) program for greenhouse gas emissions. The proposed legislation does not include agriculture as an emissions-capped sector; however, rising energy and fertilizer costs will directly affect agricultural producers. In addition, the legislation highlights the potential for agriculture to benefit from the development and sales of greenhouse gas (aka carbon) offsets and from the increasing production of bioenergy crops that will be in increasingly greater demand as the market value of carbon offsets rise. Among the highest potential for agriculture to supply carbon offsets are through conversion of crop and pasture land to forests (afforestation), production of bioenergy crops (e.g., corn, canola, sunflower, switchgrass, camelina etc.), changing tillage practices on cropland to enhance soil carbon accumulation (sequestration), and through the management of livestock waste (e.g., with methane digesters where livestock are concentrated for example near dairies and feedlots).

Generating carbon offsets creates a potential new revenue stream for some agricultural producers with the economic capacity and technological opportunity to participate. This capacity and opportunity certainly varies by region and type of operation. Some of the studies that have included this potential in estimating national scale impacts (e.g., USDA, 2009; FAPRI, 2009; Nicholas, 2009; Univ of Tenn, 2009; Texas A&M, 2009) conclude there is significant potential for agriculture to participate in supply carbon offsets and bioenergy crops. These studies conclude that as a result of land use changes into forest and bioenergy acreage (and out of traditional crops) there will be rising commodity prices – which will raise revenues for crop producers, however will also increase feed costs for livestock producers.

Effects of Cost Increases on New Mexico Agriculture

Under ACES New Mexico farmers, ranchers, and dairies will all confront higher energy costs, and farmers will pay more energy-intensive inputs, such as nitrogen fertilizers that rely heavily on natural gas. USDA estimates of higher energy costs are shown in Table C.2, and are representative of the estimated price increases across the available studies.

Table C.2 Estimated Energy and Fertilizer Price Increases above Projected Baseline Prices Resulting from Proposed Cap and Trade Legislation (H.R. 2454)

	Fuel		**Natural Gas**		**Electricity**		**Fertilizer** (1)	
	2020	2050	2020	2050	2020	2050	2020	2050
EPA (2009)	4.0%	14.6%	8.5%	30.9%	12.7%	35.2%	0.3%	na
EIA (2009)	9.6%	na	12.6%	na	12.2%	na	1.7%	na

(1) Only short-run estimates are reported in Table 4, covering the period of 2012-2018.

Source: USDA (2009), "The Impacts of the American Clean Energy and Security Act of 2009 On U.S. Agriculture." Office of the Chief Economist. Accessed February 2010 at: http://www.usda.gov/documents/PreliminaryAnalysis_HR2454.pdf

Using estimated price changes for fuels, electricity, and fertilizer of 8.5%, 12%, and 2%, respectively, and the production costs and cost shares given in Table C.1, the increase in agricultural production costs for New Mexico are estimated at $20 million ($2008) or approximately a 1% in total variable production costs, which results in an estimated loss in net farm income of about 2.4% – not including any changes in livestock feeding costs.

Livestock and dairy producers face substantial animal feeding costs. If corn silage, sorghum, and hay prices rise as a result of acreage diversions and declines from baseline production levels, then feeding costs for dairies and supplemental feeding costs for ranchers can be expected to rise. Table C.3 presents estimated changes in commodity prices for corn, sorghum (used as a proxy for hay), fed beef (used also as a proxy for changes in all cattle prices), and milk estimated by USDA (2009) resulting from the proposed ACES legislation. For example, New Mexico ranchers must budget for significant supplemental feed costs particularly in the event of poor rainfall and vegetation growth on rangelands. In typical cattle and calf operation budgets, the share of variable production costs attributed to feed can range from 20%-40% (pers. comm. Dr. Jerry Hawkes New Mexico State University expert on agricultural production budgets, February 20, 2010). In milk production, feeding costs are a very significant share of total variable costs of production. Dairy production budgets for New Mexico were not readily available; however, for Missouri feeding costs exceeded 60% of total variable production costs (http://agebb.missouri.edu/mgt/budget/dairy.pdf). Therefore, an increase in feeding costs of 10% by 2020 will result in an increase in variable production costs of approximately 0.2%-0.4% for cattle producers and about 0.6% for dairy producers.

Table C.3 Estimated Commodity Price Changes from Projected Baseline Prices Resulting from Proposed Cap and Trade Legislation (H.R. 2454)

Corn		Sorghum		Fed Beef		Milk	
2020	2050	2020	2050	2020	2050	2020	2050
11.5%	28.1%	-0.5%	39.8%	4.3%	14.3%	4.8%	33.1%

Source: USDA (2009), Tables 18 and 21, "The Impacts of the American Clean Energy and Security Act of 2009 On U.S. Agriculture." Office of the Chief Economist. Accessed February 2010 at: http://www.usda.gov/documents/PreliminaryAnalysis_HR2454.pdf

Using the 2008 estimate net farm income figures for New Mexico shown in Table C.1, and applying the fuels, electricity, fertilizer, and feed cost changes, respectively, 8.5%, 12%, 2%, and 10%, the estimated change in variable production costs and net farm income is 4.4% and 10.6% or approximately a loss of $88 million.

Potential for New Mexico Agriculture to Offset Higher Costs with Increased Revenues

How might revenues change in response to the market changes and opportunities presented by the proposed legislation? Studies with a comprehensive assessment of the impacts of the proposed legislation (e.g., USDA, 2009; Texas A&M, 2009; Nicholas, 2009; and Univ of Tenn, 2009) indicated that the implementation of a carbon offset program would generally result in diversion of existing agricultural lands into production of bioenergy crops and afforestation resulting in a net decrease in production of current commodity crops and a consequent relative increase in commodity prices, as shown in Table C.3. Assuming that New Mexico producers will benefit from the rise in relative commodity prices there is measurable potential to offset some or all of the increased production costs. If these commodity price increases are factored in for New Mexico farmers and ranchers, and conservatively assuming no change in the existing shares of crops produced, then gross revenues can be expected to rise, and thus resulting in an increase in net farm income of about $33 million (about 4%) compared to current levels. This assumes that current production levels of both crops and livestock are maintained. Since projected increases in commodity prices are less certain and less immediate than expected increases in energy and energy-intensive input prices, declines in harvested acres and in both dairy and livestock herd sizes can be expected in the short run. *Therefore, projections of a net increase in net farm income resulting from longer-run commodity price increases should be considered optimistic*.

Finally, in addition to the projected increases in commodity prices, there are additional revenue enhancements that could be enjoyed by New Mexico farms and ranchers. The proposed legislation provides opportunities for agricultural producers to enhance revenues and net returns by contributing to renewable energy production, bioenergy crops, and greenhouse gas sequestration. Of these opportunities, the one that appears to have the greatest immediate promise is the installation of methane digesters and the co-production and sale of offsets and electricity on the largest of New Mexico's dairies, as described below. Opportunities for other sectors are somewhat limited by the production environment and currently available mitigation opportunities. For example, cattle and calf producers in New Mexico are primarily grazing pasture and range lands and, therefore, have little or no capacity to either change feedstocks or manage manure in order to reduce methane emissions. Without offsetting increases in beef prices, New Mexico cattle producers will be hard hit by increased costs. There is, however, some potential for New Mexico farms to grow bioenergy crops – research on feedstock crops such as camelina on ongoing, and there may be opportunities from advances in cellulosic ethanol. These are difficult to quantify at present, and are likely to contribute little change in net farm income as close substitutes to existing crop. Another potential but somewhat of a long-shot is the possibility that planting agricultural forests – or afforestation using pecans (maybe even citrus someday if climate changes enough) could someday be counted in the carbon offset markets. Currently in seems that there is little about this on the CCX carbon market – though personal communication with Brian Murray (duke univ) indicates that this is conceptually possible. There maybe a little potential for using orchard prunings for bioenergy sources – some feasibility studies have been done but there seems to be not enough source material to develop the energy producing infrastructure and transportation costs to gather from further afield are high enough (and if they become higher still) would not be optimistic at this point. Finally, there may be some potential to adopt soil-carbon conserving practices on field crops yielding some GHG offset income. Limited tillage is already widely practiced, especially in response to higher fuel costs. In addition, New Mexico farmers are highly dependent on irrigation, much of which is pumped and, therefore, associated with very significant energy costs. It would be difficult to imagine that offset income from tillage practice changes would offset the increased energy costs of pumped groundwater.

Methane digesters, however, could make a significant contribution. Based on economic feasibility assessments on dairies in Pennsylvania, Leuer et al. (2008) indicate that there are likely positive net returns to methane digester installation on dairies with herd sizes in excess of 1,000 head. On these dairies, the net annuitized return is estimated at $4.89 per cow per year.[(1)] If digesters are installed on one-third of the dairies, the result generates an additional $546 thousand per year and, if added to the revenue increases from commodity price increases, results in a net increase in net farm income of approximately 4.1%. Though the potential is there, initial investment costs are high, and increased feeding costs could further constrain consideration and installation of digesters unless and until carbon prices and electricity prices rise sufficiently. Table C.4 summarizes the changes in annual net farm income across each of the four scenarios reported above. (Endnotes: (1) The net annuitized value for returns to the installation of methane digesters on dairies is based on estimates from Leuer et al. (2008)

who estimate the net present value of a digester for a 1,000 head dairy to be $61,000. Assuming a 5% discount rate, and a 20 year facility life, the annuitized value per head is estimate at $4.89 per year.)

Table C.4 Estimated Baseline Changes to New Mexico Net Farm Income in 2020 Resulting from Proposed Cap and Trade Legislation (H.R. 2454)

	Scenario 1 **Cost Changes:** Energy Fertilizer **Revenue Changes:**	**Scenario 2** **Cost Changes:** Energy Fertilizer Livestock Feed **Revenue Changes:**	**Scenario 3** **Cost Changes:** Energy Fertilizer Livestock Feed **Revenue Changes:** Crop Price	**Scenario 4** **Cost Changes:** Energy Fertilizer Livestock Feed **Revenue Changes:** Crop Price GHG Offsets (Manure Mgt)
Change in Net Farm Income (2008$)	- $20.0 million	- $88.1 million	+ $33.7 million	+ $34.3 million
% Chg	- 2.4%	- 10.6%	+ 4.1%	+ 4.1%

Notes:

(1) Est. Baseline Net Farm Income (2008) = $829 million (NMDA, 2009)
(2) Based on estimated cost and price level changes reported in USDA (2009).
(3) GHG offset income based on installation of methane digesters, electricity generators on 33% of the largest dairies in New Mexico, using revenue estimates from Leuer et al. (2008).

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