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Climate Change Legislation: Positive or Negative For North Dakota Agriculture?

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ABSTRACT

The United States House of Representatives passed a climate change bill entitled "The American Clean Energy and Security Act" in June 2009. The bill establishes a combined efficiency and renewable electricity standard which requires retail electricity suppliers to utilize 20% renewable energy by 2020. The objective of this study is to estimate the costs of the American Clean Energy and Security Act in crop production and the benefits of carbon sequestration under the legislation. This study especially evaluates the impact of the legislation on the North Dakota farm income under a Cap and Trade system with and without carbon sequestration. Three different carbon sequestration programs are evaluated to estimate the impact of each program on the net farm income in North Dakota: no-till farming, wetlands restoration and wood land establishment. The North Dakota Representative Farm Model operational a North Dakota State University was used to estimate the impact of the Cap and Trade legislation and evaluate the impact of the various carbon sequestration programs.

Keywords: Carbon sequestration, American Clean Energy and Security Act, North Dakota Representative Farm model, no-till, wetlands, woodlands, net farm income

HIGHLIGHTS

A base scenario and three alternative scenarios were developed to estimate the impact of the carbon legislation on the net farm income in North Dakota. The optimistic scenario assumes that low-emission technologies, including nuclear, fossil with carbon capture and storage (CCS), and other various renewable energy sources, are developed and used on a large scale without any obstacles; and international agreements covering international offsets proceed with no difficulties. The second scenario makes similar assumptions of the optimistic scenario except that the costs of low-emission technologies are 50% higher cost than the optimistic scenario. The pessimistic scenario assumes that low-emission technologies cannot be developed beyond the levels in the base scenario and that international offsets are limited by cost, regulation, and slow progress in negotiations of international agreements.

If there is no carbon sequestration program under the legislation, North Dakota agriculture would suffer from increases in production costs. Under the optimistic scenario, the net farm income averages $5,249 lower in 2020 than the base scenario without carbon sequestration under the carbon emission legislation. The net farm income would decrease by $9,350 under the high cost scenario. Under the pessimistic scenario, the net farm income would decrease by $24,615 in 2020 or about $12 per acre.

The impact on the net from income of no-till farming is an increase of $3,424 due to carbon sequestration in 2020. Under the pessimistic scenario the increase in the net farm income due to carbon sequestration is $25,957 in 2020. That payment combined with increased no-till acres increase the net farm income by 1.4% above the base scenario.

In 2020, carbon payments for wetland restoration and no-till farming would amount to $3,456 under the optimistic scenario, $8,840 for the high cost scenario, and $37,784 for the pessimistic scenario. The decrease in the net farm income under the carbon legislation would be 1.9% under the optimistic scenario compared to the base scenario and less than 1% for the high cost scenario. Under the pessimistic scenario the net farm income would be 13.9% higher than the base scenario.

With woodland establishment, wetland restoration and no-till farming, the net farm income is 1.4% lower under the optimistic scenario and 1.2% higher under the high cost scenario than the base scenario in 2020. The net farm income under the pessimistic scenario is higher than the base scenario with carbon sequestration in 2020.

There are substantial differences in the regional impacts of carbon sequestration. The benefits to the west region would be the largest while the benefits in the Red River Valley (RRV) would be the least. The RRV has limited marginal land to be converted to either wetland or woodland.

Much of the impact on agriculture could be mitigated if the legislation allows international transfers of carbon offsets and the development of clean energy sources to reduce the negative impact of the legislation and encourage U.S. agriculture to sequester carbon. The benefits from carbon sequestration under the legislation could be larger than the cost of the legislation. The U.S. agricultural sector could sequester much more carbon in the soil if the price of carbon is high enough or if the government provides incentives to offset the cost of establishing wetlands and woodlands.

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INTRODUCTION

In the recent political discussions, two different avenues of limiting carbon emission to the atmosphere have been proposed. First is the Cap and Trade proposal and the second is a tax on carbon emissions. The Cap and Trade policy would use a market system to price the emissions after the government determined an acceptable level, while the tax on carbon emissions would be determined by Washington. The Cap and Trade proposal, under economic theory, would be more efficient; however, it would not supply any tax revenues to the government.

In 1997, the Kyoto Protocol was adopted in Kyoto, Japan under the direction of the United Nations and entered into force on February 16, 2005. By early 2009, 183 nations have signed and ratified the protocol. The United States is one of six countries which have not ratified the protocol. The protocol directed developed (industrialized) countries to lower greenhouse gases (GHG) an average of 5.2% from the 1992 level. It also setup a mechanism to allow carbon trading between countries to allow developed countries to purchase carbon credits from developing nations.

The United States House of Representatives passed a carbon limiting bill entitled "The American Clean Energy and Security Act (ACESA)" in June 2009. The bill establishes a combined efficiency and renewable electricity standard (CERES) which requires retail electricity suppliers to utilize 20% renewable energy by 2020. It also focuses on improving energy efficiency of generation and distribution of energy. The bill is now being considered by the Senate.

The bill requires that GHG emissions, less offsets, are reduced from 2005 levels by 3% in 2012, 17% in 2020, 58% by 2030 and 83% by 2050. The bill also includes offsets in which both domestic and foreign countries may purchase or trade carbon offsets to allow companies to meet the goals established by the legislation.

The agricultural impact of the proposal has been discussed and currently no clear opinion has surfaced. In the current legislation, agriculture is exempted from emission restrictions although the costs due to the current legislation would be passed on to the final users of manufactured goods. Agriculture is a large consumer of fuels and lubricants along with fertilizers and chemicals. The additional costs would increase input costs, thereby lowering net farm returns as agriculture cannot pass higher production costs on to consumers.

The objective of this study is to estimate the costs of the ACESA in crop production and the benefits of carbon sequestration under the legislation. This study especially evaluates the impact of the legislation on the North Dakota farm income under a Cap and Trade system with and without carbon sequestration.

Agriculture could be able to benefit from the legislation if producers sequester carbon in the soil with a change in farming technology. Producers practicing no-till farming are able to store carbon in the root structure of agricultural crops. They can be paid for the stored carbon, based on the current carbon price from one of the carbon exchanges. The carbon program,

managed by the North Dakota Farmers Union, requires producers to no-till their land for five years to be eligible for the program. The current carbon price is low, however, that would increase if an emission policy mandates GHG emissions. The location, moisture level, crop mix, and soil types determine if and to what extent producers can practice no-till farming. For this study, it is assumed that the costs of no-till farming are the same as conventional tillage and does not affect crop yield.

A second method of carbon sequestration is in reclaimed wetlands. North Dakota had 4.9 million acres of wetland, 11% of total area, before wide-spread drainage. By the 1980s, that had decreased to 2.7 million acres due to drainage for increased agricultural production (North Dakota Water Service Center). Some of those areas may be returned to wetland as a means of carbon sequestration. Another method of carbon sequestration is with the establishment of woodlands. Fast growing trees can be used to store carbon if it is economically feasible to convert farmland into forest.

Agriculture is unique among industries in that it is possible for it to benefit under the federal carbon emission legislation. Producers are able to sequester carbon in the soil profile with proper farming techniques. For this study, it is assumed that 0.4 tons of carbon per acre can be stored per year in the soil under no-till conditions. Some crops in the state cannot be no-tilled, for example, sugar beets and potatoes due to harvesting methods.

The impact of wetlands is uncertain since carbon and methane gas can be released through decomposition of plant material and well as being sequestered by the root structure. Euliss et al. (2006) estimated that wetlands in the northern plains region sequestered 5.72 metric tons per acre per year for the first five years and then sequestered 1.25 metric ton per acre thereafter. They also estimated that forested woodlands sequestered 5.17 metric tons per acre per year with no reduction in the future.

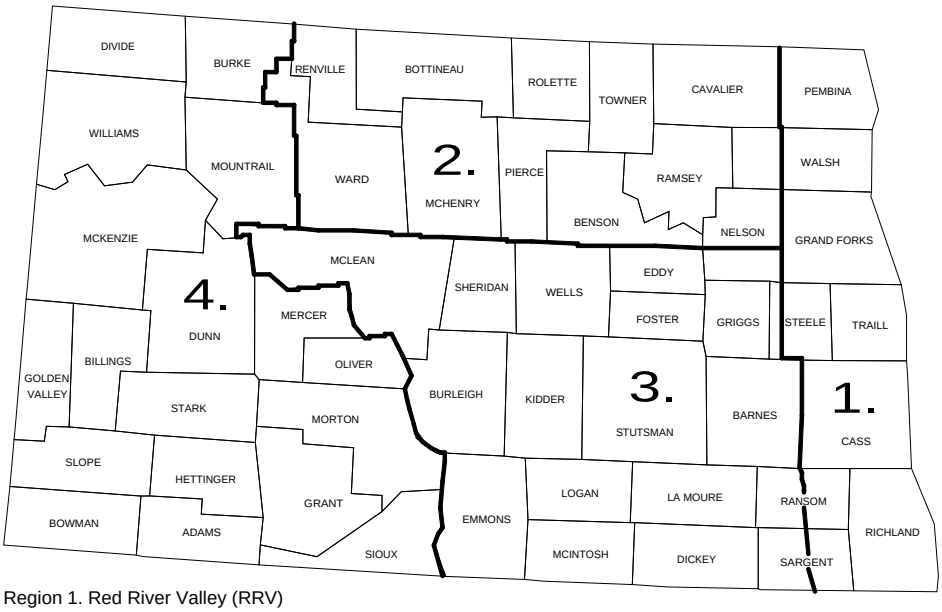
The level of conversion from farmland into wetland or woodland is unknown. The level depends on the price of carbon. High carbon prices would increase the likelihood of producer willingness to participate in a carbon sequestration program. For example with a carbon price of $20 per ton, wetland could generate $114 per acre for 5 years and then $25 per acre thereafter. Restored woodland could annually generate $103 per acre forever. With a carbon price of $50 per ton, wetland would generate $285 per acre and woodland would return $257 per acre.

THE NORTH DAKOTA REPRESENTATIVE FARM

The North Dakota Representative Farm Model is a stochastic simulation model designed to analyze the impact of policy changes on farm income. The model projects average net farm incomes, debt-to-asset ratios, cash rents, and cropland prices for representative farms producing five major crops: wheat, barley, corn, soybeans, and sunflowers. The model is linked to the FAPRI and North Dakota econometric simulation models, and it uses the prices of the crops generated from these models.

The model has 24 representative farms: six farms in each of the four regions of North Dakota. These regions are the Red River Valley (RRV), North Central (NC), South Central (SC), and Western (West) (Figure 1). The farms in each region are representative of the average,

high, and low-profit farms and small, medium, and large-size farms enrolled in the North Dakota Farm and Ranch Business Management Education Program. For this study, only the average profit representative farm is used in the four regions.



Region 1. Red River Valley (RRV)
Region 2. North Central (NC)
Region 3. South Central (SC)
Region 4. Western (West)

Figure 1. North Dakota Farm and Ranch Business Management Regions

The Representative Farm model will determine the costs of carbon emission controls in the four different regions of the state, RRV, NC, SC, and West and the benefits of carbon sequestration in each region under various carbon price assumptions. Each region has different cropping patterns, different soil conditions and different moisture conditions. Therefore, each would have a different ability to capture carbon.

The representative farms average 1,894 acres of cropland and 642 acres of pasture. The farms are about 84% larger than the state average reported by the North Dakota Agricultural Statistics Service. A reason for this difference is that the state average includes all farms with $1,000 or more in sales; therefore, hobby farms, farms operated as part of combined larger farms, semi-retired farms, and commercial farms are all included, while the farms used in this study mainly represent commercial farms.

The average representative farm is an average of all farms in the Farm and Ranch Business Management Records System in each production region. Average farm sizes are 1,882 cropland acres for the RRV, 2,070 cropland acres for the NC, 1,955 cropland acres for the SC, and 1,668 on cropland acres for the West region (Table 1). The farms in RRV includes some farms located the east side of the North Dakota and Minnesota border.

Table 1. Characteristics of North Dakota Representative Farms (Profit), 2008

	RRV	NC	SC	West
Number of Farms	206	170	134	91
Total Cropland (ac)	1,882	2,070	1,955	1,668
Spring Wheat (ac)	375	462	428	531
Durum Wheat (ac)		55	17	80
Barley (ac)	7	170	94	74
Corn (ac)	248	55	228	40
Sunflower (ac)	43	110	88	70
Soybeans (ac)	676	122	475	

Assumptions and Data

The base model assumes an average trend yield based on historical data and average predicted prices received by farmers based on the historical relationships between FAPRI prices and North Dakota prices. In addition, macro policies and assumptions, trade policies, and agricultural policies are incorporated into the model directly or indirectly.

Production cost increases due to the carbon legislation will be determined by the use of inputs which are energy intensive in their manufacture. Table 2 shows the amounts and percentage of energy intensive or energy related inputs. These inputs would react to higher energy costs due to federal regulations. The fertilizer industry will be unaffected until 2025 due to a provision in the ACESA that would distribute specific quantities of emission allowances to energy-intensive trade exposed entities (USDA, 2009).

Table 2. Energy Intensive Input Costs and Percentage of Total Expenses for Average Profit Representative Farms

	RRV	NC	SC	West
	----------dollars----------			
Fuel	55,414	37,214	41,655	27,318
	(0.08)	(0.09)	(0.08)	(0.08)
Fertilizer*	127,549	82,174	94,276	53,864
	(0.18)	(0.19)	(0.17)	(0.15)
Chemicals	70,624	57,592	53,349	31,070
	(0.10)	(0.13)	(0.10)	(0.09)
Drying	8,055	869	2,523	46
	(0.01)	(0.00)	(0.00)	(0.00)
Utilities	6,867	4,103	6,521	4,621
	(0.01)	(0.01)	(0.01)	(0.01)
Energy intensive	140,960	99,778	104,048	63,055
Expenses less fertilizer	(0.20)	(0.23)	(0.19)	(0.18)
Total Expenses	*718,942*	*427,880*	*540,226*	*348,463*

Percent of Total Expenses in Parenthesis
*Fertilizer is exempt until 2025

A gallon of diesel fuel emits 10.1 kilogram of carbon dioxide (CO_2) when burned. The RRV representative farm uses about 9.8 gallons of diesel fuel per acre. NC, SC, and West regions use 6.2 gallons, 6.9 gallons and 4.6 gallons per acre, respectfully. That includes all farm related fuels and lubricants used by a producer. It is assumed that the price of diesel fuel is $3.00 per gallon. The price of carbon will be determined by the market in a cap and trade system. The additional fuel cost to the producer would be about $1.00 per acre with a carbon price of $10 per ton, $2.00 per acre with a carbon price of $20 per ton and $3.00 per acre with a carbon price of $30 per ton. The increased cost to representative farms with a carbon price of $20 per ton are $1.20 per acre RRV and NC, $1.40 per acre in SC, and $1.08 per acre in West regions.

It is assumed that chemical, drying and utility costs would increase by 2.5% due to carbon emission restrictions with a carbon price of $10 per metric ton, 5% with a carbon price of $20 per metric ton and 7.5% with a carbon price of $30 per metric ton.

It is also assumed that producers would return, on average across the state, about 3.5% of the farmland into wetland and 1.75% into woodland, but the restoration ratios could differ, depending on the region of the state (USGS). The conversion in RRV would be lower because of higher value land and fewer areas which could be established. At a carbon price of $30 per ton, an average profit farm (2,100 acres) in the north central region of the state would reclaim 75 acres into wetlands and 37 acres into woodland. That would generate a return of $15,149 per year or $135 per acre with little or no input cost beyond establishment. An opportunity cost of $30 per acre per year is subtracted from carbon payments for wetland restoration and woodland establishment.

No-till acres for carbon sequestration are assumed to increase as the price of carbon credits in a carbon market increases. For example, it is assumed that no-till acres will be about one million acres if the price of carbon is $5.00 per ton and would increase to about 4 million acres if the price of carbon is $20 per ton (ND Farmers Union).

The Base and Alternative Scenarios

A base scenario and three alternative scenarios were developed to estimate the impact of carbon legislation. The base scenario assumes no restrictions on greenhouse gas emissions. Therefore, the net farm income under the base scenario is not influenced by the ACESA. The Energy Information Administration of the Department of Energy estimated the carbon price under six different assumptions dealing with the cost of alternative energy sources, the availability of future technology, and the use of international offsets. The optimistic scenario assumes that low-emission technologies, including nuclear, fossil with carbon capture and storage (CCS), and other various renewable energy sources, are developed and used on a large scale without any obstacles; international agreements covering international offsets proceed with no difficulties; and the availability and quantity of carbon capture, clean energy, and international offsets match the reduction in CO_2 emission required by law. The second scenario (High cost) makes similar assumptions of the optimistic scenario except that the costs of low-emission technologies including nuclear, fossil with carbon capture and storage (CCS), and various renewable are 50% higher cost than the optimistic scenario.

The pessimistic scenario assumes that low-emission technologies including nuclear, fossil with carbon capture and storage (CCS), and various renewable cannot be developed beyond the levels in the base scenario and that international offsets are limited by cost, regulation, and slow progress in negotiations of international agreements.

Table 3 shows the estimated carbon price under the three alternative scenarios (EIA). The carbon price under the optimistic scenario increases to $19.89 per ton in 2020 while the carbon price is $35.43 per ton under the high cost scenario and $93.27 under the pessimistic scenario. The table shows that the availability of international offsets are extremely important. Without international offsets, the carbon price in 2020 could be 368% higher than under the optimistic scenario.

Table 3. Energy Information Administration Estimated Carbon Price Under Various Assumptions

	Optimistic	High Cost	Pessimistic
	---------- Dollar/ton----------		
2012	9.33	16.59	42.62
2013	10.20	18.17	46.81
2014	11.20	19.97	51.61
2015	12.31	21.94	56.91
2016	13.53	24.13	62.79
2017	14.89	26.55	69.28
2018	16.39	29.21	76.48
2019	18.05	32.16	84.43
2020	19.89	35.43	93.27

Source:EIA

RESULTS

Net farm income for average profit representative farm in North Dakota under the base and three alternative scenarios are estimated for four different systems regarding carbon sequestration practices. They are a system that does not allow carbon sequestration, one that allows carbon sequestration on only cropland (no-till), one that allows carbon sequestration on both cropland and wetland, and one that allows carbon sequestration on cropland, wetland, and woodland. It is assumed that land used for carbon sequestration increases as the price of carbon increases.

No Carbon Sequestration

Table 4 shows the state average net farm income under the base and alternative scenarios. The carbon legislation passed by the House of Representatives begins to limit carbon emission in 2012. Under the optimistic scenario, net farm income averages $5,249 lower in 2020 than the base scenario without carbon sequestration. The net farm income would decrease by $9,350 under the high cost scenario or about $4.45 per acre. Carbon prices increases to over $90 per metric tons in the pessimistic scenario. Under this scenario, net farm income would decrease by $24,615 in 2020 or about $12 per acre.

Table 4 Forecasted State Net Farm Income and Percent Decrease From Base, Representative Farms, Various Scenarios

	Base	Optimistic		High Cost		Pessimistic	
	-------dollars-----		% change from base	dollars	% change from base	dollars	% change from base
2012	91,548	89,544	2.19	87,985	3.89	82,396	10.00
2013	88,681	86,433	2.53	84,678	4.51	78,367	11.63
2014	89,493	86,960	2.83	84,979	5.04	77,824	13.04
2015	90,909	88,053	3.14	85,817	5.60	77,705	14.52
2016	92,641	89,419	3.48	86,896	6.20	77,691	16.14
2017	95,597	91,959	3.81	89,110	6.79	78,670	17.71
2018	95,884	91,775	4.29	88,559	7.64	76,707	20.00
2019	95,553	90,909	4.86	87,278	8.66	73,827	22.74
2020	94,913	89,664	5.53	85,563	9.85	70,298	25.93

Figure 2 shows the 85% confidence interval for the base scenario and the optimistic scenarios. In 2012, the first year of the carbon legislation, net farm income is expected to fall an average of $2,004 due mainly to higher costs under the legislation. The net farm income would decrease by $5,249 in 2020 as carbon price increases from $9.33 per metric ton in 2012 to $19.89 per metric ton in 2020. With the 85% confidence interval, the net farm income under the base scenario ranges between $102,827 and $80,716 with a mean of $91,548 in 2012. Because of uncertainty in crop prices and yields, net farm income is expected to vary 12% from the mean both positively and negatively. Net farm income under the optimistic scenario is between $100,577 and $78,950 with the 85% confidence interval in 2012. By 2020, the confidence interval increases to 23% of the mean value.

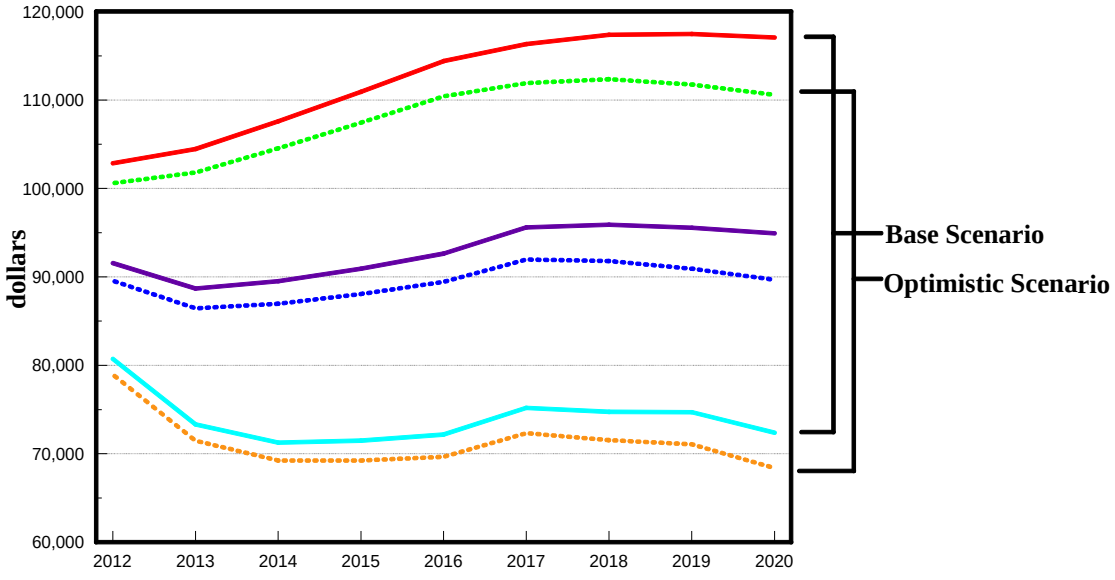


Figure 2. Net Farm Income for Average Profit Representative Farm with 85% Confidence Interval for the Base and Optimistic Scenarios

The reduction in the net farm income under the high cost scenario is greater than the optimistic scenario (Figure 3). The estimated carbon price is $16.59 per metric ton under the high cost scenario compared to $9.33 per metric ton for the optimistic scenario in 2012. The carbon price increases in 2020 to $19.89 per metric ton for the optimistic scenario compared to $35.43 per metric ton under the high cost scenario. Mean net farm income decreases by $9,350 or 10% in 2020.

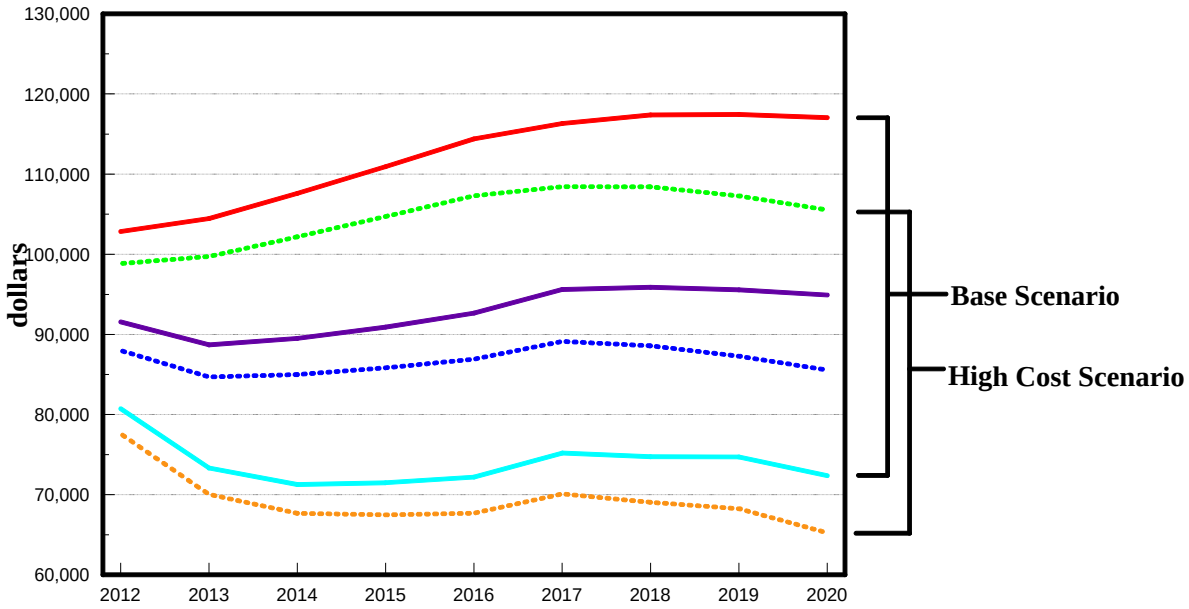


Figure 3. Net Farm Income for Average Profit Representative Farm with 85% Confidence Interval for the Base and High Cost Scenarios

Net farm income under the pessimistic scenario is 10% lower in 2012 than the base scenario and 26% lower in 2020 (Figure 4). The carbon price under the pessimistic scenario increases from $42.62 per metric ton in 2012 to $93.27 per ton in 2020. The main difference between the pessimistic scenario and the others is that foreign carbon offsets are not allowed; that is, U.S. firms are not allowed to purchase carbon offsets from international sources. Average production costs would increase by $9,152 in 2012 for the average profit farm and by $24,615 in 2020 for the same farm. That increase amounts to about $4.36 per acre in 2012 and $11.51 per acre in 2020.

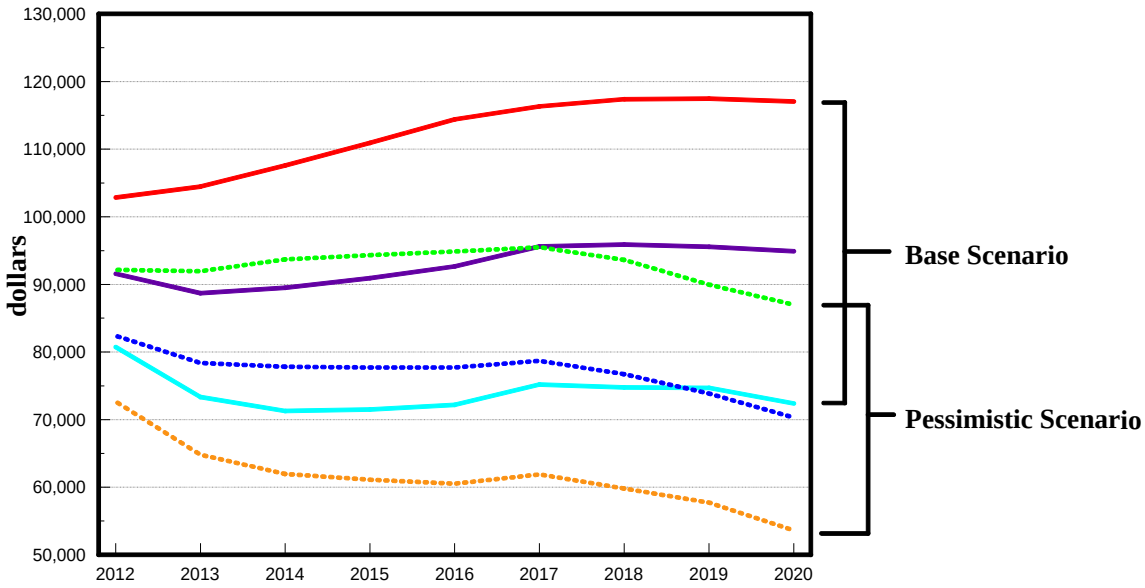


Figure 4. Net Farm Income for Average Profit Representative Farm with 85% Confidence Interval for the Base and Pessimistic Scenarios

Carbon Sequestration Impacts on Cropland: No-till Farming

Agriculture may have the ability to mitigate some to the impacts of the carbon legislation if programs are developed to allow producers to store carbon in the soil profile. Currently there is a program which pays producers to store carbon under no-till farming practices. Other programs may be developed for wetlands and woodlands. The model was run first with no-till practices, then wetland restoration, and finally woodlands.

Table 5 shows the net farm income under the alternative scenarios and the impacts of sequestration of carbon with a change in farming practices towards no-till production under a cap and trade system. The impact of no-till is limited because of the low sequestration rate for crop land. With the optimistic scenario, the carbon price increases to $19.89 per metric ton in 2020. The impact on the net farm income is an increase of $3,424 due to carbon sequestration in 2020. Under the pessimistic scenario, the increase in net farm income due to carbon sequestration is $25,957 compared to that without carbon sequestration in 2020. The carbon price in 2020 under this scenario is $93.27 per metric ton which would provide a payment of $37 per acre to the producer. That payment under a no-till program increases the net farm income by $1,342, or 1.4% above the base scenario.

Table 5. Net Farm Income Under Base and Alternative Scenarios With and Without Carbon Sequestration With No-till Farming

	Base	-----Optimistic-----		----- High Cost----		--- Pessimistic---	
		Without	With	Without	With	Without	With
	----------dollars----------						
2012	91,548	89,544	90,101	87,985	89,851	82,396	91,294
2013	88,681	86,433	87,140	84,678	86,975	78,367	88,666
2014	89,493	86,960	87,860	84,979	87,808	77,824	89,689
2015	90,909	88,053	89,191	85,817	89,283	77,705	91,249
2016	92,641	89,419	90,852	86,896	91,120	77,691	93,031
2017	95,597	91,959	93,753	89,110	94,230	78,670	95,944
2018	95,884	91,775	94,010	88,559	94,726	76,707	96,167
2019	95,553	90,909	93,682	87,278	94,661	73,827	95,983
2020	94,913	89,664	93,088	85,563	94,347	70,298	96,255

Under the high cost scenario, payments under a no-till program would be $2,297 in 2013 and $8,784 in 2020. The net farm income would be about the same under the high cost scenario compared to the base scenario in 2020.

Carbon Sequestration with No-till and Wetland Restoration

Wetlands restoration would allow producers to mitigate most of the impacts of carbon legislation. Table 6 shows the net farm income under the base and alternative scenarios with wetland restoration under a carbon sequestration system. It is assumed that the producers use limited no-till practice to sequester carbon before the restoration of wetlands. For the average profit representative farm, it was assumed that producers would restore a maximum 57 acres of wetlands. That assumption is based on the 2.2 million acres of wetlands lost in North Dakota due to drainage and producers could restore 25% of them for carbon sequestration.

Table 6. Net Farm Income Under Base and Alternative Scenarios With and Without Carbon Sequestration From No-till Farming and Wetland Restoration

	Base	----Optimistic----		----High Cost-----		----Pessimistic---	
			Sequestration		Sequestration		Sequestration
2012	91,548	89,544	90,127	87,985	89,897	82,396	95,514
2013	88,681	86,433	87,170	84,678	87,025	78,367	93,957
2014	89,493	86,960	87,893	84,979	87,865	77,824	96,372
2015	90,909	88,053	89,228	85,817	89,348	77,705	99,682
2016	92,641	89,419	90,893	86,896	91,193	77,691	103,677
2017	95,597	91,959	93,780	89,110	94,277	78,670	103,173
2018	95,884	91,775	94,039	88,559	94,776	76,707	104,808
2019	95,553	90,909	93,712	87,278	94,714	73,827	106,155
2020	94,913	89,664	93,120	85,563	94,403	70,298	108,082

Under the optimistic scenario, producers would restore 13 acres or 22% of the maximum acres. Under the pessimistic scenario, producers would restore 57 acres and they would restore 22 acres under the high cost scenario. In 2020, carbon payments would amount to $3,456 under the optimistic scenario, $8,840 for the high cost scenario, and $37,784 for the pessimistic scenario.

The decrease in net farm income for carbon legislation would be 1.9% under the optimistic scenario compared to the base scenario and less than 1% for the high cost scenario. Under the pessimistic scenario, net farm income would be 13.9% higher than the base scenario. Carbon sequestration in wetlands may be a viable solution for reducing the additional costs of the carbon legislation.

Carbon Sequestration with No-till, Wetland Restoration, and Woodland Establishment

Table 7 shows the results of the three alternative scenarios when woodland restoration is included. It is estimated that in 2020 five acres of trees are planted to sequester carbon under the optimistic scenario, nine acres under the high cost scenario and 23 acres under the pessimistic scenario. The acres planted are directly related to the estimated carbon price. Under the optimistic and high cost scenarios, net farm income is 1.4% lower and 1.2% higher than the base scenario, respectively, in 2020. The net farm income under the pessimistic scenario is higher than the base scenario with carbon sequestration in 2020 because 23 acres are planted to trees which will generate $452 per acre carbon sequestration payment.

Table 7. Net Farm income Under Base and Alternative Scenarios With and Without Carbon Sequestration From No-till Farming, Wetland and Woodland Restoration

	Base	-----Optimistic-----		------High cost------		----Pessimistic-----	
		sequestration		sequestration		sequestration	
	----------dollars----------						
2012	91,548	89,544	90,172	87,985	90,130	82,396	97,500
2013	88,681	86,433	87,231	84,678	87,325	78,367	96,452
2014	89,493	86,960	87,978	84,979	88,252	77,824	99,528
2015	90,909	88,053	89,343	85,817	89,844	77,705	103,670
2016	92,641	89,419	91,047	86,896	91,828	77,691	108,716
2017	95,597	91,959	93,983	89,110	95,088	78,670	109,535
2018	95,884	91,775	94,306	88,559	95,809	76,707	112,844
2019	95,553	90,909	94,061	87,278	96,028	73,827	116,295
2020	94,913	89,664	93,573	85,563	96,071	70,298	120,878

Figure 5 shows the average net farm income with carbon sequestration under the base and alternative scenarios. The net farm income for the optimistic scenario is about $87 thousand for the optimistic scenario in 2013 compared to about $89 thousand for the base scenario. Between 2013 and 2020, net farm income under the optimistic scenario remains below the net farm income from the base scenario. Net farm income increases from $87 thousand in 2013 to $96 thousand in 2020 under the high cost scenario. The net farm income is slightly higher than that in the base scenario in 2020. Net farm income for the pessimistic scenario is about $96 thousand in 2013 and increases to 121 thousand because of high carbon prices. Between 2013 and 2020, carbon price is estimated to increase from about $43 per metric ton to over $93 per metric ton.

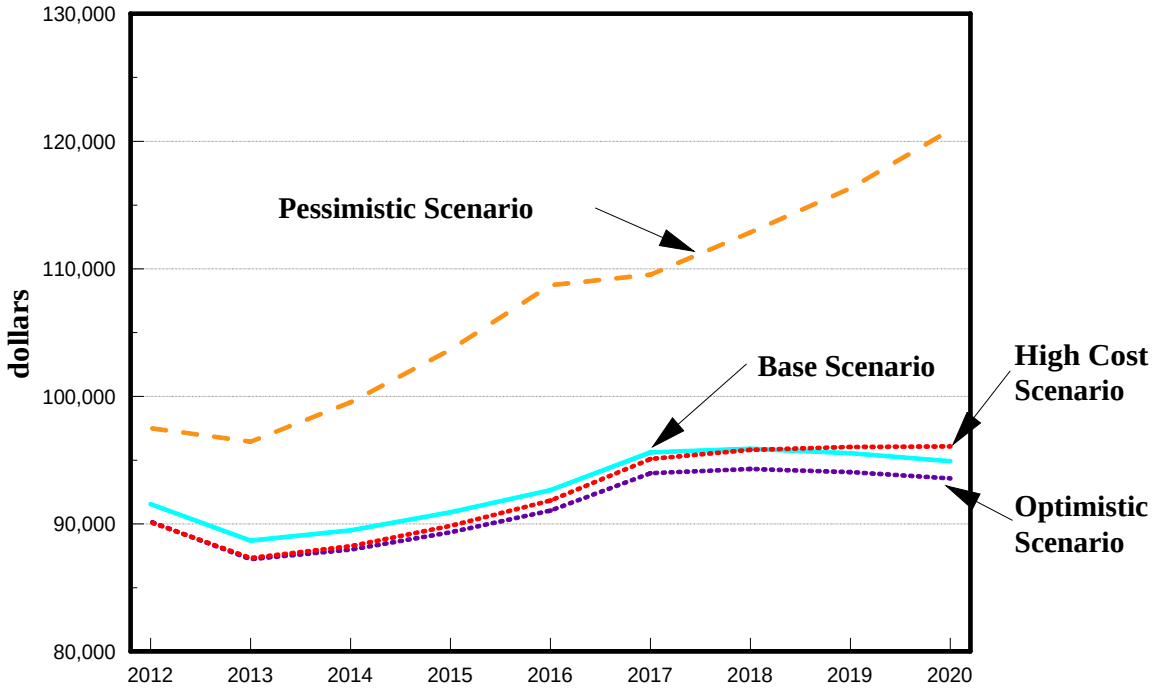


Figure 5. Net Farm Income for Average Profit Representative Farm With Notill, Wetlands and Woodlands Restoration

Carbon Sequestration Impacts on Regional Net Farm Income

Table 8 shows the regional net farm income and percentage change under the base and alternative scenarios. Under the legislation without carbon sequestration, the net farm income under the optimistic scenario is between 4% and 7% less than under the base scenario in 2020. In the RRV, net farm income is expected to be $6,833 less under the optimistic scenario due to increased expenses under carbon legislation in 2020. The net farm income decreases in the NC, SC, and West region is $5,336, $5,299, and $3,539, respectively, in 2020. The decrease in net farm income under the high cost scenario is about $12 thousand in the RRV, $9 thousand in the NC and SC regions, and $6 thousand in the West in 2020. The percentage change is between 7% and 12%. Net farm income is reduced by more than 25% for the RRV, NC and SC regions under the pessimistic scenario. Net farm income in the West decreases by 19% under the pessimistic scenario.

No-till practices provide increases in net farm income under the optimistic and high cost scenarios compared to the scenarios without carbon sequestration (Table 9). Net farm income with sequestration under the optimistic scenario is slightly lower than the base scenario. Under the high cost scenario, net farm income is slightly higher due to carbon payments. Net farm income under the pessimistic scenario with carbon payments is between $3,400 and $12,100 higher in the NC, SC, and West regions due to no-till practices.

Table 8. Net Farm Income and Percentage Decrease From Base Under Alternative Scenarios Without Carbon Sequestration

	Base				Optimistic			
	RRV	NC	SC	West	RRV	NC	SC	West
	----------dollars----------							
2012	120,234	83,133	87,835	74,988	117,498	81,159	85,794	73,726
					(2.28)	(2.37)	(2.32)	(1.68)
2013	122,309	75,695	84,286	72,434	119,257	73,472	81,998	71,006
					(2.50)	(2.94)	(2.71)	(1.97)
2014	122,669	76,163	86,526	72,613	119,251	73,649	83,951	70,990
					(2.79)	(3.30)	(2.98)	(2.24)
2015	122,693	77,349	88,426	75,167	118,862	74,504	85,526	73,321
					(3.12)	(3.68)	(3.28)	(2.46)
2016	122,975	77,930	90,842	78,818	118,678	74,708	87,574	76,717
					(3.49)	(4.14)	(3.60)	(2.67)
2017	123,695	79,397	94,067	85,228	118,873	75,745	90,381	82,836
					(3.90)	(4.60)	(3.92)	(2.81)
2018	120,100	81,458	94,351	87,625	114,687	77,318	90,193	84,900
					(4.51)	(5.08)	(4.41)	(3.11)
2019	119,267	80,942	93,920	88,083	113,186	76,246	89,226	84,977
					(5.10)	(5.80)	(5.00)	(3.53)
2020	118,862	80,065	93,083	87,643	112,029	74,739	87,784	84,104
					(5.75)	(6.65)	(5.69)	(4.04)
	High Cost				Pessimistic			
2012	115,367	79,623	84,205	72,744	107,733	74,116	78,511	69,223
	(4.05)	(4.22)	(4.13)	(2.99)	(10.40)	(10.85)	(10.62)	(7.69)
2013	116,874	71,736	80,212	69,891	108,304	65,495	73,789	65,880
	(4.44)	(5.23)	(4.83)	(3.51)	(11.45)	(13.48)	(12.45)	(9.05)
2014	116,576	71,682	81,937	69,720	106,919	64,579	74,663	65,134
	(4.97)	(5.88)	(5.30)	(3.98)	(12.84)	(15.21)	(13.71)	(10.30)
2015	115,862	72,276	83,256	71,876	104,978	64,192	75,017	66,632
	(5.57)	(6.56)	(5.85)	(4.38)	(14.44)	(17.01)	(15.16)	(11.36)
2016	115,313	72,183	85,014	75,072	103,038	62,978	75,678	69,071
	(6.23)	(7.37)	(6.42)	(4.75)	(16.21)	(19.19)	(16.69)	(12.37)
2017	115,097	72,886	87,496	80,963	101,259	62,406	76,919	74,098
	(6.95)	(8.20)	(6.99)	(5.00)	(18.14)	(21.40)	(18.23)	(13.06)
2018	110,450	74,078	86,939	82,768	94,836	62,137	74,946	74,908
	(8.03)	(9.06)	(7.86)	(5.54)	(21.04)	(23.72)	(20.57)	(14.51)
2019	108,432	72,575	85,557	82,549	90,819	58,973	71,963	73,552
	(9.08)	(10.34)	(8.90)	(6.28)	(23.85)	(27.14)	(23.38)	(16.50)
2020	106,691	70,578	83,645	81,340	86,819	55,089	68,235	71,048
	(10.24)	(11.85)	(10.14)	(7.19)	(26.96)	(31.19)	(26.69)	(18.93)

Percent Decrease From Base in Parenthesis

Table 9. Net Farm Income and Percentage Decrease From Base Under Alternative Scenarios With No-till Practices

	Base				Optimistic			
	RRV	NC	SC	West	RRV	NC	SC	West
	dollars							
2012	120,234	83,133	87,835	74,988	117,565	81,911	86,494	74,434
					(2.22)	(1.47)	(1.53)	(0.74)
2013	122,309	75,695	84,286	72,434	119,409	74,407	82,864	71,882
					(2.37)	(1.70)	(1.69)	(0.76)
2014	122,669	76,163	86,526	72,613	119,517	74,816	85,027	72,079
					(2.57)	(1.77)	(1.73)	(0.74)
2015	122,693	77,349	88,426	75,167	119,274	75,957	86,860	74,674
					(2.79)	(1.80)	(1.77)	(0.66)
2016	122,975	77,930	90,842	78,818	119,276	76,514	89,222	78,395
					(3.01)	(1.82)	(1.78)	(0.54)
2017	123,695	79,397	94,067	85,228	119,704	77,983	92,414	84,911
					(3.23)	(1.78)	(1.76)	(0.37)
2018	120,100	81,458	94,351	87,625	115,808	80,081	92,690	87,461
					(3.57)	(1.69)	(1.76)	(0.19)
2019	119,267	80,942	93,920	88,083	114,665	79,646	92,285	88,130
					(3.86)	(1.60)	(1.74)	(-0.05)
2020	118,862	80,065	93,083	87,643	113,947	78,911	91,520	87,976
					(4.13)	(1.44)	(1.68)	(-0.38)
	High Cost				Pessimistic			
2012	116,132	81,990	86,409	74,874	113,141	84,869	88,519	78,649
	(3.41)	(1.37)	(1.62)	(0.15)	(5.90)	(-2.09)	(-0.78)	(-4.88)
2013	117,913	74,618	82,882	72,486	114,600	77,929	85,307	76,827
	(3.59)	(1.42)	(1.67)	(-0.07)	(6.30)	(-2.95)	(-1.21)	(-6.06)
2014	117,963	75,200	85,180	72,890	114,178	78,907	87,870	77,802
	(3.84)	(1.26)	(1.56)	(-0.38)	(6.92)	(-3.60)	(-1.55)	(-7.15)
2015	117,669	76,552	87,178	75,734	113,226	80,563	90,034	81,173
	(4.09)	(1.03)	(1.41)	(-0.75)	(7.72)	(-4.16)	(-1.82)	(-7.99)
2016	117,624	77,362	89,741	79,753	112,294	81,551	92,632	85,649
	(4.35)	(0.73)	(1.21)	(-1.19)	(8.69)	(-4.65)	(-1.97)	(-8.67)
2017	118,006	79,129	93,167	86,618	111,551	83,365	95,957	92,901
	(4.60)	(0.34)	(0.96)	(-1.63)	(9.82)	(-5.00)	(-2.01)	(-9.00)
2018	114,059	81,568	93,709	89,568	106,285	85,801	96,337	96,245
	(5.03)	(-0.13)	(0.68)	(-2.22)	(11.50)	(-5.33)	(-2.11)	(-9.84)
2019	112,851	81,511	93,596	90,686	103,766	85,946	96,227	97,991
	(5.38)	(-0.70)	(0.35)	(-2.95)	(13.00)	(-6.18)	(-2.46)	(-11.25)
2020	112,036	81,184	93,140	91,028	102,120	86,653	96,491	99,758
	(5.74)	(-1.40)	(-0.06)	(-3.86)	(14.09)	(-8.23)	(-3.66)	(-13.82)

Percentage Decrease From Base in Parenthesis

Wetland restoration provides additional income support for agriculture. Net farm income under the optimistic scenario with wetland restoration is lower than the base scenario, but higher in the RRV, NC and SC regions than the optimistic scenario without wetland restoration (Table 9). Additional payments for wetland restoration are $9 per acre in the RRV, $49 in the NC region, $43 in the SC region and $25 in the West region under the optimistic scenario. Under the high cost scenario, payments for wetland sequestration are $16, $85, $76, and $40 per acre in the RRV, NC, SC, and West regions, respectively, in 2020. Wetland restoration under the pessimistic scenario provides for substantial additional income for producers. Payments are $3,485 in the RRV, $18,134 for the NC region, $16,234 for the SC region, and $9,454 for the West region in 2020. The net farm income in the NC, SC, and West region are higher under the pessimistic scenario with wetland restoration than the base scenario.

When woodland restoration is added to wetland restoration, the impact of carbon legislation is largely mitigated except for the RRV (Table 10). Most regions would experience an increase in net farm income. Under the pessimistic scenario, net incomes are higher than the base scenario. With carbon prices over $90 per ton, payments for wetland and woodland restoration is over $430 per acre. That is higher than most crop returns. The woodlands and wetlands would require little yearly upkeep or expenses.

Table 10. Net Farm Income and Percentage Decrease From Base Under Alternative Scenarios With No-till Practices and Wetland Restoration

	Base				Optimistic			
	RRV	NC	SC	West	RRV	NC	SC	West
	----------dollars----------							
2012	120,234	83,133	87,835	74,988	117,574	81,951	86,531	74,454
					(2.21)	(1.42)	(1.48)	(0.71)
2013	122,309	75,695	84,286	72,434	119,418	74,451	82,905	71,904
					(2.36)	(1.64)	(1.64)	(0.73)
2014	122,669	76,163	86,526	72,613	119,527	74,866	85,073	72,105
					(2.56)	(1.70)	(1.68)	(0.70)
2015	122,693	77,349	88,426	75,167	119,285	76,014	86,911	74,703
					(2.78)	(1.73)	(1.71)	(0.62)
2016	122,975	77,930	90,842	78,818	119,288	76,577	89,280	78,427
					(3.00)	(1.74)	(1.72)	(0.50)
2017	123,695	79,397	94,067	85,228	119,712	78,024	92,451	84,932
					(3.22)	(1.73)	(1.72)	(0.35)
2018	120,100	81,458	94,351	87,625	115,816	80,124	92,730	87,484
					(3.57)	(1.64)	(1.72)	(0.16)
2019	119,267	80,942	93,920	88,083	114,674	79,693	92,327	88,154
					(3.85)	(1.54)	(1.70)	(-0.08)
2020	118,862	80,065	93,083	87,643	113,957	78,960	91,563	88,001
					(4.13)	(1.38)	(1.63)	(-0.41)
	High cost				Pessimistic			
2012	116,146	82,059	86,472	74,909	114,469	91,261	94,468	81,856
	(3.40)	(1.29)	(1.55)	(0.11)	(4.79)	(-9.78)	(-7.55)	(-9.16)
2013	117,929	74,695	82,953	72,524	116,252	85,959	92,744	80,873
	(3.58)	(1.32)	(1.58)	(-0.12)	(4.95)	(-13.56)	(-10.03)	(-11.65)
2014	117,981	75,287	85,259	72,934	116,247	89,064	97,231	82,946
	(3.82)	(1.15)	(1.46)	(-0.44)	(5.24)	(-16.94)	(-12.37)	(-14.23)
2015	117,689	76,650	87,268	75,784	115,816	93,400	101,809	87,705
	(4.08)	(0.90)	(1.31)	(-0.82)	(5.61)	(-20.75)	(-15.13)	(-16.68)
2016	117,646	77,473	89,842	79,809	115,536	97,779	107,445	93,947
	(4.33)	(0.59)	(1.10)	(-1.26)	(6.05)	(-25.47)	(-8.28)	(-19.20)
2017	118,020	79,201	93,232	86,655	113,735	94,402	105,983	98,572
	(4.59)	(0.25)	(0.89)	(-1.67)	(8.05)	(-18.90)	(-12.67)	(-15.66)
2018	114,074	81,645	93,779	89,608	108,874	99,013	108,281	103,067
	(5.02)	(-0.23)	(0.61)	(-2.26)	(9.35)	(-21.55)	(-14.76)	(-17.62)
2019	112,866	81,592	93,669	90,728	106,788	101,521	110,238	106,071
	(5.37)	(-0.80)	(0.27)	(-3.00)	(10.46)	(-25.42)	(-17.37)	(-20.42)
2020	112,053	81,269	93,216	91,072	105,604	104,787	112,725	109,212
	(5.73)	(-1.50)	(-0.14)	(-3.91)	(11.15)	(-30.88)	(-21.10)	(-24.61)

Percentage Decrease From Base in Parenthesis

Table 11. Net Farm Income and Percentage Decrease From Base Under Alternative Scenarios With No-till Practices, Wetland and Woodland Restoration

	Base				Optimistic			
	RRV	NC	SC	West	RRV	NC	SC	West
	dollars							
2012	120,234	83,133	87,835	74,988	117,587	82,018	86,593	74,488
					(2.20)	(1.34)	(1.41)	(0.67)
2013	122,309	75,695	84,286	72,434	119,437	74,545	82,992	71,952
					(2.35)	(1.52)	(1.54)	(0.67)
2014	122,669	76,163	86,526	72,613	119,553	74,996	85,192	72,171
					(2.54)	(1.53)	(1.54)	(0.61)
2015	122,693	77,349	88,426	75,167	119,320	76,190	87,071	74,793
					(2.75)	(1.50)	(1.53)	(0.50)
2016	122,975	77,930	90,842	78,818	119,334	76,812	89,493	78,549
					(2.96)	(1.43)	(1.48)	(0.34)
2017	123,695	79,397	94,067	85,228	119,772	78,336	92,732	85,094
					(3.17)	(1.34)	(1.42)	(0.16)
2018	120,100	81,458	94,351	87,625	115,895	80,534	93,097	87,698
					(3.50)	(1.13)	(1.33)	(-0.08)
2019	119,267	80,942	93,920	88,083	114,776	80,229	92,805	88,435
					(3.77)	(0.88)	(1.19)	(-0.40)
2020	118,862	80,065	93,083	87,643	114,088	79,656	92,180	88,367
					(4.02)	(0.51)	(0.97)	(-0.83)
	High cost				Pessimistic			
2012	116,218	82,413	86,799	75,088	115,084	94,280	97,251	83,384
	(3.34)	(0.87)	(1.18)	(-0.13)	(4.28)	(-13.41)	(-10.72)	(-11.20)
2013	118,021	75,151	83,371	72,756	117,018	89,757	96,228	82,806
	(3.51)	(0.72)	(1.09)	(-0.44)	(4.33)	(-18.58)	(-14.17)	(-14.32)
2014	118,098	75,876	85,797	73,235	117,208	93,875	101,623	85,406
	(3.73)	(0.38)	(0.84)	(-0.86)	(4.45)	(-23.26)	(-17.45)	(-17.62)
2015	117,838	77,407	87,956	76,173	117,021	99,488	107,339	90,834
	(3.96)	0.08	(0.53)	(-1.34)	(4.62)	(-28.62)	(-21.39)	(-20.84)
2016	117,836	78,444	90,720	80,311	117,046	105,484	114,410	97,926
	(4.18)	0.66	(0.13)	(-1.89)	(4.82)	(-35.36)	(-25.94)	(-24.24)
2017	118,261	80,443	94,349	87,299	115,625	104,143	114,746	103,626
	(4.39)	1.32	0.30	(-2.43)	(6.52)	(-31.17)	(-21.98)	(-21.59)
2018	114,378	83,229	95,197	90,433	111,241	111,333	119,310	109,490
	(4.76)	2.17	0.90	(-3.21)	(7.38)	(-36.68)	(-26.45)	(-24.95)
2019	113,250	83,609	95,466	91,785	109,751	117,091	124,109	114,228
	(5.04)	3.30	1.65	(-4.20)	(7.98)	(-44.66)	(-32.14)	(-29.68)
2020	112,536	83,835	95,491	92,422	109,314	124,462	130,172	119,566
	(5.32)	4.71	2.59	(-5.45)	(8.03)	(-55.45)	(-39.85)	(-36.42)

Percent Decrease From Base in Parenthesis

CONCLUSIONS AND IMPLICATIONS

The American Clean Energy and Security Act of 2009 was passed by the House of Representatives. The U.S. Senate could start to debate the legislation mandating GHG emission in the near future. The EIA of the U.S. Department of Energy estimated the impacts of that bill and estimated the carbon price under various assumptions. Based on their respective assumptions, three scenarios were chosen to estimate the impact of carbon legislation on North Dakota agriculture. They are optimistic, high cost and pessimistic scenarios. Two of the scenarios (optimistic and high cost) allow for international transfers of carbon offsets while the third one (pessimistic) does not allow for international transfers. Throughout the forecast period, carbon price ranges from $9.33 per metric ton for the optimistic scenario in 2012 to $93.27 per metric tons for the pessimistic scenario in 2020. The optimistic scenario allows for international carbon transfers and for growth in clean and renewable energy. The high cost scenario also allows for international carbon transfer but clean and renewable energy sources costs 50% more than under the optimistic scenario. Under the pessimistic scenario, no international carbon offsets are allowed and clean and renewable energy sources do not expand.

Agriculture is not capped by this legislation; however, the higher energy costs due to the legislation will be transferred to producers in the form of higher fuel, fertilizer, chemical, utility and shipping costs. Those costs will reduce net farm income in the state.

Agriculture has the ability to sequester carbon in the soil profile with certain practices. Currently a carbon sequestration program is available to store carbon in the soil under no-till cultivation. Other programs may be developed if the need arises. Two of those are wetland restoration and woodland establishment; both of these are able to store substantially more carbon than no-till farming.

The Representative Farm Model was used to estimate the impact of the carbon legislation on North Dakota farms. There would be significant reductions in the net farm income under the legislation without the carbon sequestration programs. The net farm income under the optimistic scenario would be 6% lower in 2020 than under the base scenario due to higher input costs under the legislation without carbon sequestration. The high cost scenario would lower net farm income by 10% in 2020 because higher carbon prices increase expenses more than the optimistic scenario. Under the pessimistic scenario, net farm income would be 26% lower than the base scenario in 2020 with the carbon price of $93 per metric ton. There are substantial differences between the four regions of the state but the impacts for three regions (RRV, NC and SC) are similar. The impacts on the West region are less than the others.

Three different carbon sequestration programs were evaluated to determine if they could mitigate the negative impact of the carbon legislation. The no-till farming program could have a major impact as it is estimated that up to 6 million acres would be brought into the program with higher carbon prices. Under the wetland restoration and woodland establishment, additional carbon could be stored. Both programs store over five metric tons per acre per year. Under the optimistic scenario, carbon storage with the wetlands and woodlands program is small because of low carbon prices. A carbon price of $20 per metric ton does not encourage producers to establish either of the programs. However under pessimistic scenario with carbon prices over $90 per metric ton, land would be converted to wetlands and woodlands. Carbon sequestration in both wetlands and woodlands increase the net farm income above the base scenario as producers

receive additional carbon payments of over $400 per acre per year. The RRV does not benefit as much as the other three regions because there is little marginal land available for conversion.

It is highly unlikely that the carbon price would increase to the $90 per metric ton. At carbon price near that, agricultural land would be converted to wetlands and woodlands to sequester carbon. The removal of agricultural land from crop production would increase crop prices as supplies of crops decrease. The equilibrium price of carbon would be found when the return from crop production equals the return from carbon sequestration.

Major findings of this research are as follows:

1. As the prices of carbon increases, net farm income increases with the carbon sequestration program under the climate change legislation, and decreases without the program. With carbon prices ranging between $20 and $35, the benefits from the carbon sequestration could be large enough to offset the cost of the legislation.

2. If the legislation allows international transfer of carbon offsets and development of clean energy sources, the negative impact of the legislation on the net farm income would be reduced. It is also important to develop new technologies to reduce carbon emissions in the major carbon emitting industries to maintain the price of carbon at the acceptable level.

3. The U.S. agricultural sector could benefit from participating in carbon sequestration through no-till farming. Restoration of wetlands and woodlands would be an efficient way to sequester carbon. However, the acceptable price of carbon may not be high enough to establish the program. The price of carbon needs to be above $35 per ton for producers to restore wetlands and woodlands for carbon sequestration. The government, therefore, may provide incentives to help the establishment of wetlands and woodlands to maximize carbon sequestration.

4. Benefits from the carbon sequestration differ from one region to another, depending upon soil types and weather conditions. In North Dakota, the western part of the state would gain more benefits from the carbon sequestration than the eastern part of the state.

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