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

Richard D. Taylor and Won W. Koo
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Climate Change Legislation: Positive or Negative For North Dakota Agriculture?
Richard D. Taylor and Won W. Koo

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 woodland establishment. The North Dakota Representative Farm Model operational at 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
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.
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 widespread 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,
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

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

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

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

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>
<thead>
<tr>
<th>Year</th>
<th>Optimistic</th>
<th>High Cost</th>
<th>Pessimistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>9.33</td>
<td>16.59</td>
<td>42.62</td>
</tr>
<tr>
<td>2013</td>
<td>10.20</td>
<td>18.17</td>
<td>46.81</td>
</tr>
<tr>
<td>2014</td>
<td>11.20</td>
<td>19.97</td>
<td>51.61</td>
</tr>
<tr>
<td>2015</td>
<td>12.31</td>
<td>21.94</td>
<td>56.91</td>
</tr>
<tr>
<td>2016</td>
<td>13.53</td>
<td>24.13</td>
<td>62.79</td>
</tr>
<tr>
<td>2017</td>
<td>14.89</td>
<td>26.55</td>
<td>69.28</td>
</tr>
<tr>
<td>2018</td>
<td>16.39</td>
<td>29.21</td>
<td>76.48</td>
</tr>
<tr>
<td>2019</td>
<td>18.05</td>
<td>32.16</td>
<td>84.43</td>
</tr>
<tr>
<td>2020</td>
<td>19.89</td>
<td>35.43</td>
<td>93.27</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Base</th>
<th>Optimistic</th>
<th>High Cost</th>
<th>Pessimistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dollars</td>
<td>% change from base</td>
<td>dollars</td>
<td>% change from base</td>
</tr>
<tr>
<td>2012</td>
<td>91,548</td>
<td>2.19</td>
<td>87,985</td>
<td>3.89</td>
</tr>
<tr>
<td>2013</td>
<td>88,681</td>
<td>2.53</td>
<td>84,678</td>
<td>4.51</td>
</tr>
<tr>
<td>2014</td>
<td>89,493</td>
<td>2.83</td>
<td>84,979</td>
<td>5.04</td>
</tr>
<tr>
<td>2015</td>
<td>90,909</td>
<td>3.14</td>
<td>85,817</td>
<td>5.60</td>
</tr>
<tr>
<td>2016</td>
<td>92,641</td>
<td>3.48</td>
<td>86,896</td>
<td>6.20</td>
</tr>
<tr>
<td>2017</td>
<td>95,597</td>
<td>3.81</td>
<td>89,110</td>
<td>6.79</td>
</tr>
<tr>
<td>2018</td>
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<td>94,913</td>
<td>5.53</td>
<td>85,563</td>
<td>9.85</td>
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</table>

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.
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](image)

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.
Carbon Sequestration Impacts on Cropland: No-till Farming

Agriculture may have the ability to mitigate some of 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

<table>
<thead>
<tr>
<th>Year</th>
<th>Base Without</th>
<th>Base With</th>
<th>Optimistic Without</th>
<th>Optimistic With</th>
<th>High Cost Without</th>
<th>High Cost With</th>
<th>Pessimistic Without</th>
<th>Pessimistic With</th>
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</thead>
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<td>87,278</td>
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<td>94,347</td>
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</table>

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Base Sequestration</th>
<th>Optimistic Sequestration</th>
<th>High Cost Sequestration</th>
<th>Pessimistic Sequestration</th>
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<td>89,893</td>
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<td>90,893</td>
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<td>89,664</td>
<td>93,120</td>
<td>85,563</td>
</tr>
</tbody>
</table>

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>
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<td>93,573</td>
<td>85,563</td>
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</table>

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.
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>
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<th>Year</th>
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<th>Base NC</th>
<th>Base SC</th>
<th>Base West</th>
<th>Optimistic RRV</th>
<th>Optimistic NC</th>
<th>Optimistic SC</th>
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<th>Percent Decrease From Base in Parenthesis</th>
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Percent Decrease From Base in Parenthesis
Table 9. Net Farm Income and Percentage Decrease From Base Under Alternative Scenarios With No-till Practices

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<td>81,184</td>
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<tr>
<td></td>
<td>(5.74)</td>
<td>(-1.40)</td>
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</table>

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Base</th>
<th>Optimistic</th>
<th>Base</th>
<th>Optimistic</th>
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<td>RRV</td>
<td>NC</td>
<td>SC</td>
<td>West</td>
</tr>
<tr>
<td></td>
<td>dollars</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>74,988</td>
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<td>(0.71)</td>
</tr>
<tr>
<td>2013</td>
<td>122,309</td>
<td>75,695</td>
<td>84,286</td>
<td>72,434</td>
</tr>
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<td>(2.36)</td>
<td>(1.64)</td>
<td>(1.64)</td>
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</tr>
<tr>
<td>2014</td>
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<td>86,526</td>
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<tr>
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<td>75,167</td>
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</tr>
<tr>
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<td>79,397</td>
<td>94,067</td>
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<td>(1.54)</td>
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<td>80,065</td>
<td>93,083</td>
<td>87,643</td>
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<tr>
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<td>(4.13)</td>
<td>(1.38)</td>
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<td>93,232</td>
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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

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<th>Base RRV</th>
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<th>West</th>
<th>RRV</th>
<th>NC</th>
<th>SC</th>
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</tr>
</tbody>
</table>

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 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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North Dakota Farmers Union, personal conversation


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