

**Market-Based Farmland Conservation: Carbon Trading, Nutrient Trading, and Wetland
Mitigation Banking**

A case study with Codorun Farms

By

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Abstract

The burgeoning development of the market-based institutions of wetland mitigation, carbon trading, and nutrient trading provides farmers with economic incentives in the form of payments for credits to change land use practices. Payments are made to the farmer based on the number of credits generated by environmental benefits gained from changing to and continually using best management practices and a market-based determined price of those credits. Using a private client's farm, this project explores the feasibility of participating in these institutions based on associated federal and state policies, eligibility requirements, enrollment processes, and economic costs and benefits.

Codorun Farms (the Farm), a family owned 400-acre farm based in York, Pennsylvania, has asked for a guide to market-based payment programs that promote conservation practices. Codorun Farms is interested in understanding non-governmental economic incentives that can be earned in exchange for switching to and maintaining best management practices. The Farm would like to understand if it's possible to make a profit while at the same time accruing environmental benefits. Questions to be answered include: what are the requirements for participation, is the Farm eligible, and does it make sense for the Farm to enter into contracts with these types of programs? Preliminary conversations with Farm family members have led to an agreement to investigate the following programs: Wetland Mitigation Banking; Carbon Credit Trading and Agricultural Offsets; and Nutrient Trading.

Analysis shows that the Farm would benefit from participating in carbon and nutrient programs but not wetland mitigation banking. Since the Farm is already practicing no-till, it is beneficial to enroll in these two programs as the Farm will receive compensation for operating its business as usual. However, the results of this case study demonstrate that payments from carbon trading alone will probably not be enough incentive to change tilling practices for the small farmer. Participation in nutrient trading alone provides a higher payment and may be enough of an incentive, however the number of pilot programs in the US is very small and thus impedes access to these payments.

| | |
|---|----|
| Introduction..... | 4 |
| Overview of Codorun Farms..... | 6 |
| Methodology..... | 7 |
| Forecasts | 9 |
| Net Present Value | 9 |
| Land Valuation..... | 9 |
| Carbon Credit Trading..... | 10 |
| Program Description | 10 |
| Federal and State Policy..... | 12 |
| Eligibility for Participation in CCX..... | 14 |
| Cost Benefit Analysis | 16 |
| Enrollment Process | 20 |
| Nutrient Trading..... | 22 |
| Program Overview | 22 |
| Federal and State Policy..... | 24 |
| Eligibility | 24 |
| Cost Benefit Analysis | 25 |
| Enrollment Process | 29 |
| Wetland Mitigation Banking..... | 31 |
| Program Description | 31 |
| Federal and State Policy..... | 33 |
| Eligibility | 34 |
| Cost Benefit Analysis | 35 |
| Enrollment Process | 37 |
| Discussion..... | 39 |
| Carbon Trading..... | 39 |
| Nutrient Trading..... | 40 |
| Wetland Mitigation Banking..... | 41 |
| Conclusion and Recommendations | 41 |

Introduction

Codorun Farms (the Farm), a family owned 400-acre farm based in York, Pennsylvania, has asked for a guide to market-based programs that promote conservation practices. Codorun Farms is interested in understanding non-governmental economic incentives that can be earned in exchange for switching to and maintaining best management practices (BMPs). The Farm would like to understand if it's possible to make a profit while at the same time accruing environmental benefits. Questions to be answered include: what are the requirements for participation, is the Farm eligible, and does it make sense for the Farm to enter into contracts with these types of programs? Preliminary conversations with Farm family members have led to an agreement to investigate the following programs: Wetland Mitigation Banking; Carbon Credit Trading and Agricultural Offsets; and Nutrient Trading.

Carbon and nutrient market-based programs are based on credit generation and trading. A credit is generated several different ways including the following: 1) for dischargers when an entity (ie. electricity generator) reduces a ton of CO₂ their federal permit allows them to emit and 2) for offsets when a non-permitted entity (ie a farm) removes a ton of CO₂ that would have been emitted under business as usual. This trading mechanism increases flexibility and reduces costs by allowing dischargers with new or difficult permitting obligations the option of adapting their own facilities or financing comparable reductions by others. Trading makes it profitable for regulated and non-regulated sources to reduce their own pollution beyond legal requirements by generating credits and selling these credits to dischargers with higher treatment costs. This flexibility produces a less expensive outcome while achieving the mandated environmental target.

In carbon trading, agricultural offsets include soil sequestration where farmers generate credits by the amount of carbon their cultivated land stores through a best management practice of no-till (see Carbon Trading section for further explanation of offsets and no-till). In nutrient trading, a credit is generated when a certain amount of nitrogen, phosphorus, or sediment, contained in runoff, is impeded from entering the waterbody of a watershed. No-till farming hampers runoff. Codorun Farms has been practicing no-till for several years, and therefore would not need to invest any money into changing current practices (ie buying no-till tractor attachments). However, Codorun Farms' tilling practice is not the norm with most small farmers. Since profits are a primary driver for most agricultural producers, existing and future market-based programs could help to further establish the economic benefits of switching from conventional tillage to conservation tillage for agricultural operations. In this paper, the reality of the amount of profit actually gained by participating in these programs is explored. Is the profit gained worth the involvement of Codorun Farms and small farms in general?

Wetland mitigation banking is also based on credit generation, however, these credits are not traded but bought and sold in finality. When a wetland mitigation bank is created, the acreage is divided in credits that are sold mainly to developers who destroy wetlands in the process of residential or commercial development. This paper also explores the possibility of Codorun Farms developing a portion of its acreage into a wetland mitigation bank. Does the farm have land that would qualify for a mitigation bank and would it be profitable to engage in this project?

Overview of Codorun Farms

Codorun Farms is 400-acre commodity crop farm based in York, Pennsylvania and located in the Chesapeake watershed. The 400 acres of private farmland is bordered by residential development, a limestone quarry and mining operations, government lands consisting of mainly of woodlands, a government controlled dam (Indian Rock Dam), and Codorus Creek. A small number of private homes exist on the property and additional structures include two working stables and a barn. Land use consists of approximately 70% cropland and 30% woodlands and pasture.

A dairy farm in the early 1900's with cattle, pigs, turkeys, and chickens, the farm switched over to the farming of traditional cash grain crops of wheat, soybeans, and corn in the late 1950's. In 1995, the Campbell family leased the farmland to the Strathmeyer Christmas Tree Company and the majority of cropland was used to produce Christmas trees from 1995 to 2005. The farm has since returned to growing grain crops with some fallow fields.

In 1985, farming techniques were updated in accordance with recommendations from state conservation programs to include contour farming and implementation of no-till techniques. However, leasing the land to Strathmeyer took the land out of the control of the Campbell family for 10 years. When the farm returned to growing crops some of the contour farming was lost. However, the farm continues to practice no-till and has officially been a no-till farm, as defined by NRCS, since 2006. The land is currently leased to Dennis Gimmel, a neighboring farmer, who farms Codorun Farms for his own profit.ⁱ Codorun Farms only income is the rental subsidy generated by the lease with Mr. Gimmel.

The farm is divided into 21 fields of varying acre size. Approximately 298 acres are currently farmed for the commodity crops of corn, wheat and soybeans. Table 1 shows how many acres per crop were planted for the years 2006-2008. Soybeans and wheat are double cropped, meaning that the same plot of land that was planted for wheat and harvested in the first part of the growing season are then planted with soybeans in order to increase total yield for the entire growing season.

**Table 1
Acres of Crops Planted**

| Crop | 2006 | 2007 | 2008 |
|-----------------|------------------------------|----------------------------------|-------------------------------|
| Corn | 173.5 | 190 | 86 |
| Soybeans | 80 and 80 after wheat | 48.5 and 59.5 after wheat | 138 and 12 after wheat |
| Wheat | 80 | 59.5 | 12 |
| Hay | 0 | 0 | 45 |
| Total | 333.5 | 298.1 | 281 |

The knowledge that the farm has been no-till for the past few years influenced the decision to investigate the carbon trading program as it was known that no-till is a requirement for participation. As members of the Farm want to investigate programs outside of federal and state assistance, the market-based programs of nutrient trading and wetland mitigation banking were also chosen to be included in this project.

Methodology

The focus areas for market-based institutions will be wetland mitigation banking, and carbon and nutrient trading. The following points will be investigated: state and federal policy, eligibility, economic factors, and evaluation of participation process. These programs were chosen after preliminary conversations with members of Codorun Farms. Market-based programs were

chosen in order to investigate the earning potential of the Farm outside the boundaries of the government.

Each program analysis will include:

- A program description – This description will define how the program works, major players, an overview of program operations, and any pertinent definitions.
- Federal and State Policy description – This description will include federal and state policies currently in place that support or do not support the program in question. If policies do not support the program, a discussion of what policies are needed or how they need to be changed will be included.
- Eligibility – This section will describe the program’s eligibility requirements and demonstrate whether or not Codorun Farms meets these requirements.
- Cost Benefit Analysis – This Section contains an analysis on the costs of program and how Codorun Farms could or could not profit from participating in the program. This analysis will use an appropriate discount rate (to be discussed later in this section) and show net present values based on 5 year forecasts. Additionally, the program’s process of payments calculation will be discussed.
- Participation Process – This section will define the program’s enrollment process and documentation needed in order to participate.

Forecasts

All forecasts and contract examples are based upon a five-year period beginning in 2010-2014. This period was chosen as five years is a reasonable and comfortable forecasting period for Codorun Farms. It is also a reasonable period due to the nascence of the Nutrient Trading program and the speculative transformation from a voluntary to mandatory cap and trade system.

Net Present Value

Net present values (NPV) were calculated using a standard 7% discount rate. This rate was calculated by taking a three year average of a base rate on corporate loans posted by at least 75% of the nation's 30 largest banks.ⁱⁱ The three year average begins in May 2005 and goes to April 2008. Due to the current economic crisis, the average prime rate has fallen to a low that I do not believe will continue for the next five years. It is more realistic to use a more natural rate for the purposes of this project, thus the rates of May 2008-March 2009 were not averaged in to this rate calculation as a distortion would have occurred.

Land Valuation

Valuation of Codorun Farms was approximated using a 2001 land appraisal and 2008-2009 comparative real estate selling deals of comparable land. The land appraisal was completed by B. Daniel Wagner, MAI, a state certified general real estate appraiser.

Carbon Credit Trading

Program Description

Carbon credit trading is currently a voluntary market-based institution where emitters and reducers of greenhouse gases (GHG) can buy and sell credits in order to meet emission reduction targets. Electric power generators, manufacturing companies and state and local governments are among the purchasers as they emit carbon and other GHGs. Offset credits have been created in order to help emitters meet their emission reduction targets. Polluting industries can either reduce their emissions by making changes in their operations (employing clean technologies or upgrading efficiency) or by investing in offsets. These offset credits are generated by multiple sectors including renewable energy projects, energy efficiency programs, and agricultural land management practices. One carbon credit is equivalent to one metric ton of CO₂.ⁱⁱⁱ

Most emitters are looking for large volume carbon credit or offset credit generating projects.

Third party aggregators purchase credits from small scale projects and pool them in order to sell large volumes to the buying emitters. Codorun Farms falls under a small scale project and will need to engage in an aggregated pool of credits.

Carbon offsets are bought and sold through a number of brokers or third party aggregators and trading platforms, with the current main trading platform being the Chicago Climate Exchange (CCX). The CCX is North America's only voluntary, legally binding greenhouse gas (GHG) reduction and trading system for emission sources and offset projects in North America. One example of a third party aggregator is AgraGate, a spin off of the Iowa Farm Bureau specifically created to buy and sell credits through CCX. AgraGate Climate Credits Corp. was created to

expand the Iowa Farm Bureau Federation Carbon Credit Aggregation Program, which began in 2003. The pools of offsets are verified by a third party, then offered for sale on the Chicago Climate Exchange (CCX).^{iv} These entities – such as local farm associations or cooperatives – would be responsible for bundling the carbon and verifying that the reductions are actually occurring.^v

With regards to Codorun Farms, the focus will be on agricultural offsets, specifically no-till farming as the Farm currently participates in this best management practice (BMP). Under CCX’s current model, Codorun Farms is eligible to create 1 tradable credit per 1.67 acres (see eligibility requirements included later in this section) of continuous no-till cropland. In order to understand how the Farm is able to participate by selling offset credits, it is important to understand the concept behind carbon sinks and how no-till farming applies.

Agricultural Offsets

Agricultural soils and private forests are important to carbon sequestration primarily for their critical role as carbon “sinks” – resources that capture and retain carbon. U.S. agricultural soils have lost, on average, about 40 percent of the carbon they contained before wide-scale cultivation began in the 1800s. Currently, the carbon captured and sequestered by farmland offsets less than 1 percent^{vi} of all U.S. emissions annually. By implementing better management practices, farmland could offset between 8 to 16 percent of total national emissions.^{vii}

Carbon dioxide is stored in virgin soils, un-tilled fields, and thriving plant communities. The potential of different agricultural conservation practices to increase the amount of carbon

sequestration includes: conservation tillage and residue management; improved cropping systems; land restoration; land use change; and irrigation and water management. Tilling, or plowing, disturbs the soil and releases carbon. Conservation tillage such as no-till farming causes as little soil disturbance as possible. Conservation tillage is more cost effective than widespread land use changes, and increases carbon sequestration in two ways: 1) soil-based carbon stocks are protected in the absence of plowing; 2) leaving crop residues on the ground increases the inputs of carbon into the soil.^{viii}

Conservation tillage also generates positive spillover effects, including a slower rate of water movement which serves to increase percolation and reduce runoff, thereby reducing phosphorus loss (see nutrient trading section). Finally, since plowing fields requires energy-intensive equipment, less tillage means fuel-related emissions also are reduced.^{ix}

Federal and State Policy

The Obama administration has signaled its support of a cap and trade policy where certain sectors of GHG emitters (i.e. electricity generation) will be regulated under a mandatory cap of CO₂ equivalent emissions. The offset program is also supported and will be most likely managed by the USDA. For any carbon sequestration program to be systematically addressed, the federal government must provide reliable and rigorous monitoring. Several agencies are working to quantify and predict carbon sequestration by farmland including the U.S.

Departments of Agriculture and Energy and the U.S. Geological Survey. Guidelines for the Voluntary Greenhouse Gas Reporting Program (1505(b)), established in the 1992 Energy Policy Act, enable farmers and land owners to estimate, report and register greenhouse gas reductions and carbon sequestration.^x The U.S. Department of Energy maintains the program's public

database and encourages widespread reporting to foster improved policy formulation and transparency. So far, farmer participation in these programs is limited, in part due to uncertainty about the emerging science and economics of sequestration.

The USDA is committed to a market-based approach to carbon mitigation in the agricultural sector and it is working to build institutional capacity. Three sets of actions have been outlined by the department: (1) develop better tools for estimating credits generated by agriculture, like the newly created Conservation Effects Assessment Program; (2) educate farmers about the benefits of participating in carbon trading; and (3) partner with other agencies to remove programmatic barriers^{xi}. Several bills in the 110th Congress contain pieces of these departmental objectives.^{xii}

Policy is needed within a cap and trade program to support agricultural mitigation measures, but at the moment the ability of soil sequestration permanence is being questioned. While some voluntary market exchanges such as the Chicago Climate Exchange (CCX) sanction soil sequestration as an agricultural offset, other programs do not. It remains to be seen whether or not it will be included as an acceptable offset under a mandatory program. While the agricultural community, which has a huge lobby behind it, supports this type of offset, it must be supported by the appropriate science and applicability. The California Climate Action Registry (CCAR), another voluntary market exchange, is positioned to be a substantial influencer in the creation of mandatory federal policy. CCAR does not currently support soil sequestration as an offset, but are in the process of working through the development of a protocol.

PA state policy

Currently there are no specific Pennsylvania state policies associated with carbon credit trading.

The state branch of the NRCS and conservation districts have been facilitating trades by referring land owners to the Iowa Farm Bureau's AgraGate, a third party credit aggregator. AgraGate operates through the Chicago Climate Exchange (CCX).

The Pennsylvania Farm Bureau is piloting a carbon credit trading program, however, York County is not eligible to participate at this time.

Eligibility for Participation in CCX

The present York County NRCS division refers land owners who want to sell offsets to AgraGate. As AgraGate operates through the CCX trading platform, it must adhere to CCX guidelines. CCX eligibility guidelines follow the NRCS guidelines for conservation tillage:

Continuous No-till or Strip-till -- Must be farmed with no-till or strip till practices based on the 2002 NRCS handbook. Land is treated as no-till if it is classified by FSA as tillable land, capable of being cropped but may be in a grass cover that is hayed or grazed.

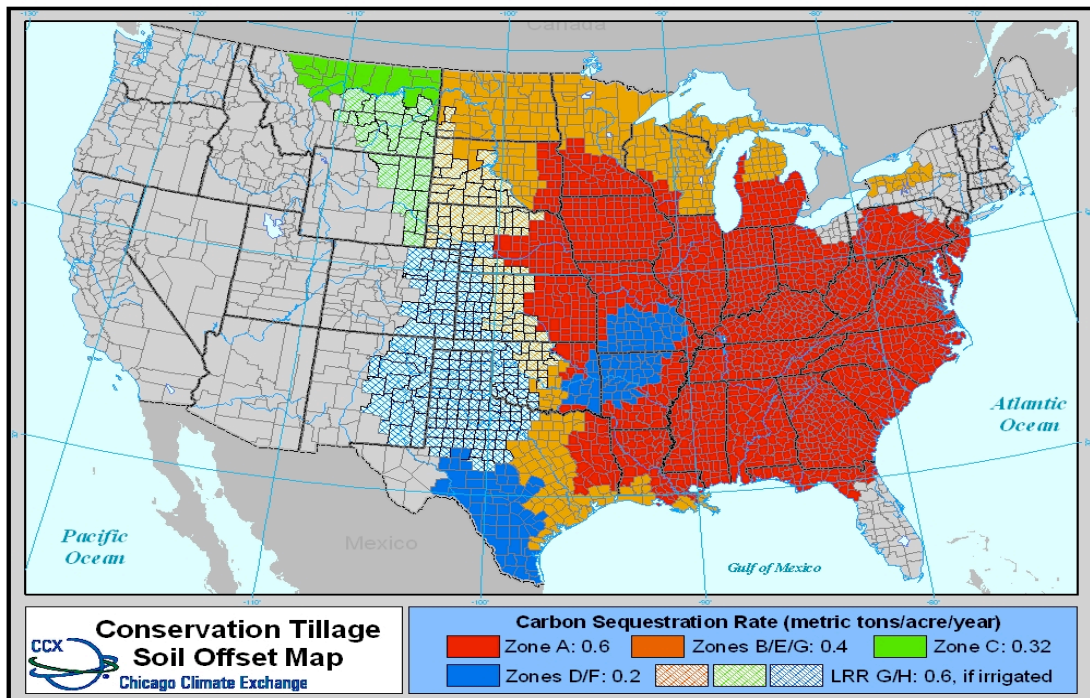
- Alfalfa acres qualify at the no-till rate.
- Continuous cotton or soybeans are eligible only with a cover crop.
- Fallowed acres > twelve months are not eligible in most states.^{xiii}

Codorun Farms is currently eligible to sell carbon credits and may enter into an agreement at any time. In simple terms, the farm has been practicing no-till land management practices since 2006 and therefore satisfies no-till requirements for agricultural offsets. The Farm does not practice continuous soybean plantings but rather practices rotation cropping. Codorun Farms has an up

to date Conservation plan monitored by the NRCS and is therefore eligible to sell offset credits under the no-till agricultural offset requirements. As all crop acreage is no-till, the farm is eligible to sell credits based on 281 acres of farmland.

The amount of credits garnered per acre is dependent upon geographic location. Soil tests for carbon uptake have been incorporated into CCX's Conservation Tillage Soil Offset Map (picture 1) where the carbon storage (or sequestration) rate is defined. Pennsylvania falls into the Zone A where the storage rate is .6 metric tons of carbon are stored per acre/year.

Picture 1
CCX Conservation Tillage Soil Offset Map



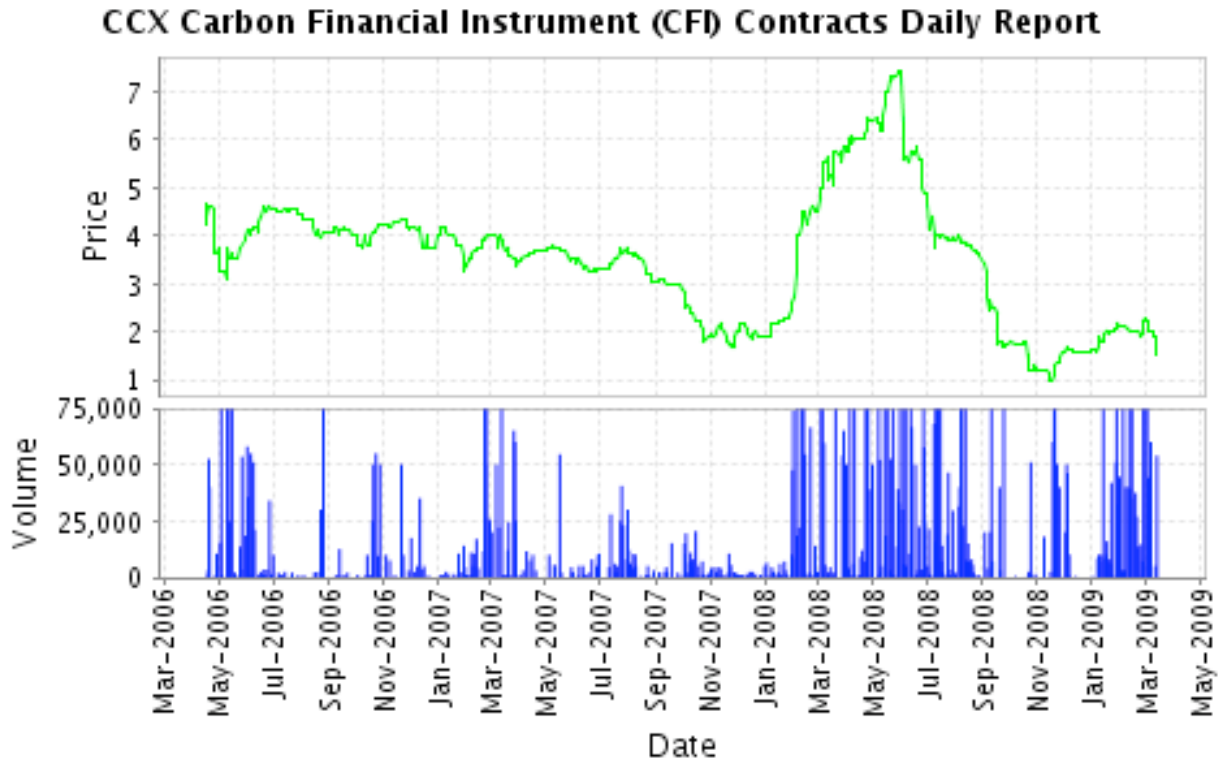
Source: CCX

Cost Benefit Analysis

A 5-6 year contract is required with an annual certification process (usually sending in a certification form). A 10% service fee is charged based upon credit generation. Additionally, a 20 % reserve pool fee is taken out each year for the life of the contract in order to mitigate any unforeseen soil disturbances which may release stored carbon. This fee is given back in the last year of the contract and the credits are able to be sold.

AgraGate will only sell credits on the CCX if prices are \$3 and above. They will sell credits periodically over the year in anticipation of price increases and decreases. Participants get a check from proceeds twice a year usually in January and July. AgraGate and their clients may also choose to bank a customer's credits and not sell them during the year the credits are initiated. These banked credits remain viable and are able to be sold at any time over the course of the contract.^{xiv} Banking may be useful in anticipation of a substantial price increase under a 2012 installment of a mandatory cap and trade regime where the carbon credit prices may jump more than 100 percent.

Graph 1
CCX Carbon Offset Prices, March 2006- March 2008*^{xv}



*Price and volume reported in metric tons CO₂

Source: Chicago Climate Exchange <http://www.chicagoclimatex.com/market/data/summary.jsf>

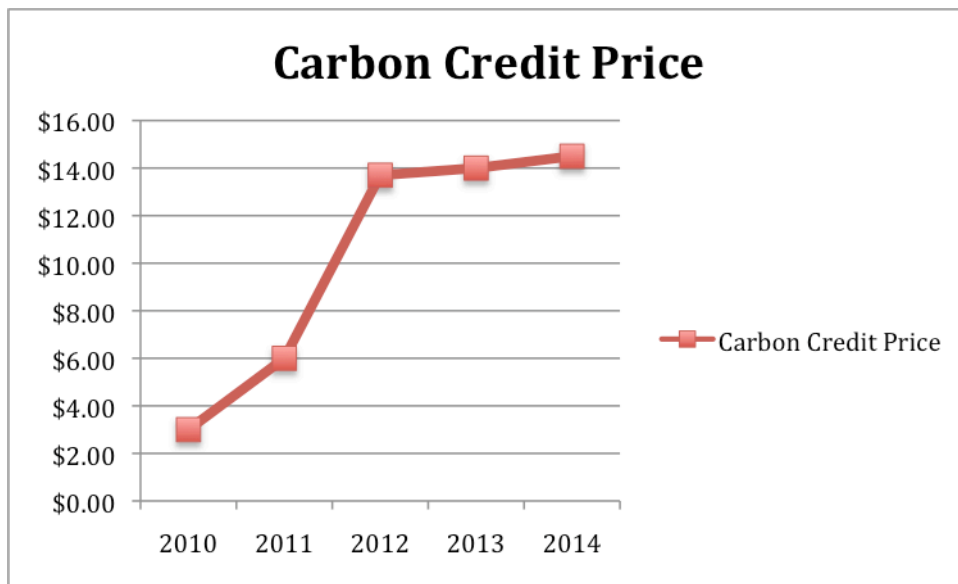
Current CCX carbon prices are at an all time low due to current financial crisis. See graph 1 for recent historical CCX prices.

Carbon Credit Pricing

The price of carbon credits was estimated by looking at current and historical prices on the CCX and a forecast by Point Carbon. According to Point Carbon, the Obama administration's budget

presumes a price for US carbon allowances at \$13.70 in 2012. That number assumes that, starting in 2012, approximately 80 percent of the economy would be placed under a cap on greenhouse gas emissions at 2005 levels, roughly 5.8 billion tons of carbon dioxide equivalent (CO₂e). With the cap declining around 2 percent per year after 2012, Point Carbon estimates the price of carbon in 2020 would go up to \$16.50 per allowance.^{xvi}

Graph 2
Price forecast for US carbon credits



Sources: CCX March 2009; Point Carbon Feb 2009
 Price forecast for 2010-2014 is based on historical CCX values and Point Carbon’s price forecast.

Carbon Credit Calculations

Carbon credits calculations were based on calculation methodology of AgraGate Climate Credits Corp.^{xvii}

1. Calculate how many metric tons of carbon will be sequestered each year – this is the number of gross carbon credits generated
 - a) Number of acres * Carbon storage rate
2. Calculate how many credits will go directly into the reserve pool and subtract from gross –

this gives the total number of tradable credits

b) $\text{Gross credits} - (\text{Gross credits} * 20\%) = \text{tradable credits}$

3. Multiply this number by the future price of carbon credits – this equals gross revenue

c) $\text{tradable credits} * \text{current carbon credit price} = \text{gross revenue}$

4. Calculate AgraGate service charge and CCX transaction fee (10% AgraGate and \$0.20/per credit respectively) and subtract from gross revenue – this equals net revenue

d) $\text{gross revenue} - (\text{gross revenue} * 20\%) - (\text{tradable credits} * .2) = \text{net revenue}$

Calculation

The following table demonstrates the calculation of Codorun Farms carbon credit generation and net revenue for trading the total number of available credits at the price of \$5 for one year. At the end of the contract period the reserve pool credits are given back and able to be sold in the final contract year.

Table 2
Carbon Credit Calculation

| | | |
|----------------------|-----------------------|----------------------|
| Acres | Class rate mT/acre/yr | Gross Carbon Credits |
| 298 | 0.6 | 178.8 |
| Gross Carbon Credits | Reserve Pool(20%) | Total Carbon Credits |
| 178.8 | 0.2 | 143.04 |
| Total Carbon Credits | CCX Transaction Rate | CCX Costs |
| 143.04 | 0.2 | 28.608 |
| Total Carbon Credits | Price | Gross Revenue |
| 143.04 | \$5.00 | \$715.20 |
| Gross Revenue | AgraGate Charge (10%) | Service Charge |
| \$715.20 | 0.1 | \$71.52 |
| Gross Revenue | Costs | Total Revenue |
| \$715.20 | \$100.13 | \$615.07 |

The following are two scenarios of how Codorun Farms could profit from selling carbon credits under a five year contract beginning in 2010. Scenario 1 assumes no banking of credits and a streamlined selling of all credits each year at an average price. Scenario 2 assumes banking 80%

of the credits in the year 2011 and only selling 20% of the 125 available credits. In year 2012 those 100 banked credits are added to the 2012 125 credits and sold for a more substantial profit. This scenario demonstrates how banking can be more profitable if successful. Comparing the NPVs, there is a \$600 difference between the two scenarios.

Table 3
Scenario 1 (No Banking)

| 2010 | 2011 | 2012 | 2013 | 2014 | Total |
|------------|------------|------------|------------|------------|-------------|
| \$615.07 | \$1,001.28 | \$1,735.08 | \$2,031.17 | \$5,185.20 | \$10,567.80 |
| | | | | | |
| NPV | | | | | |
| \$8,112.28 | | | | | |

* 178.8 reserve pool credits added

Table 4
Scenario 2 (With Banking 80% in 2011)

| 2010 | 2011 | 2012 | 2013 | 2014 | Total |
|------------|----------|------------|------------|------------|-------------|
| \$615.07 | \$203.00 | \$3,123.14 | \$2,031.17 | \$5,185.20 | \$11,157.58 |
| | | | | | |
| NPV | | | | | |
| \$8,548.10 | | | | | |

* 178.8 reserve pool credits added

Enrollment Process

In order to enroll in AgraGate’s program, a 5 year contract which includes a 5 year commitment to no-till is needed. A re-certification of no-till BMPs is needed at the beginning of each year. This is completed by filling out and sending in a short recertification form. There is a possibility of the need for onsite verification, but this is usually covered by yearly local NRCS site inspections. The price per credit is determined by the CCX carbon price on the sale date determined by AgraGate.^{xviii}

For participation, the following documents are needed:

Documents Needed for Submission

1. Signed Sales Contract for Exchange Soil Offsets (XSOs)
2. AgraGate Climate Credits Corp/CCX Enrollment Worksheet(s)
3. Copy of FSA maps of enrolled land
4. Copy of FSA 578 reports (report of acreage)

Nutrient Trading

Program Overview

Point source and nonpoint source pollutant discharge of nitrogen and phosphorus are harmful to watersheds in that they add excessive nutrients that spur the growth of algae and other organisms creating dead zones that are devoid of oxygen. Point source pollution stems mainly from industrial discharge and waste water treatment plants. Nonpoint source pollution stems from agricultural and urban runoff. Excessive nutrient loading is the single largest cause of water quality impairment in the US. The discharge is regulated by the Clean Water Act, which requires state regulatory agencies to develop Total Maximum Daily Loads (TMDLs) for impaired waters that serve as targets for meeting the water quality standards. TMDLs contain a maximum pollutant load that an impaired body of water can assimilate without hampering the designated water uses of the waterbody. TMDLs allocate portions of the total load to permitted facilities and other sources contributing to the load.^{xix}

Nutrient trading is based on fixed limits of pollutant discharge to water bodies. If the permitted facilities exceed their permitted discharge allowance, they are in violation of state and federal laws. However, if allowed by state laws, these facilities can meet their regulatory requirements by purchasing credits from other facilities that have generated extra credits from decreased discharge or from farming operations that reduce pollutant runoff through conservation practices.^{xx} As permitted facilities face increased costs to control pollutants, especially pollutants like phosphorus, nitrogen, and sediment, the market demand for pollutant reductions generated by agricultural conservation practices is likely to increase.

The process of trading water quality credits involves a number of players. They include:

1) the seller (farm operators or the waste treatment plants with excess credits), 2) the buyer (municipal waste or other wastewater treatment facilities needing the credits), 3) the regulatory agency (federal, state, or local agency responsible for establishing policies and guidelines for the trading), and 4) trading facilitators (aggregators, consolidators, central exchanges serving as intermediaries between buyers and sellers to facilitate trading transactions, etc.).^{xxi}

Payments are made to the farmer based on the number of credits generated by environmental benefits gained from changing to best management practices and a market-based determined price of those credits.

General Trading Principles:

- Must involve comparable credits (e.g. nitrogen must be traded for nitrogen);
- Must be expressed as mass per unit time (e.g. pounds per year) and can occur only between eligible parties;
- Credits generated by trading cannot be used to comply with existing technology-based effluent limits except as expressly authorized by federal regulations
- May only occur in a Department defined watershed. This can be on any number of different scales, from a stream segment (e.g., in a TMDL) to the entire river basin watershed;
- Is not allowed between sources outside of watershed boundaries;
- May take place between any combinations of eligible point sources, non-point sources and third parties; and
- Each trading entity must meet applicable eligibility criteria established by the Department

for this voluntary program.^{xxii}

Poultry litter or manure will generate more credits as its more readily absorbed by the soil therefore absorbing more nitrogen which is then not transferred into run off.

Federal and State Policy

By 2010, Pennsylvania and other states in the 64,000-square-mile Chesapeake Bay watershed must meet federally established requirements for nutrient and sediment reduction to remove the bay from the U.S. Clean Water Act's list of impaired waters. The state's nutrient reduction goals for 2010 apply to both new or existing facilities and developments in the watershed, and the new discharge limits are designed to reduce phosphorus and nitrogen in the Chesapeake Bay Watershed.^{xxiii} In September 2007, the Pennsylvania Department of Environmental Protection introduced the nutrient and sediment trading policy that offers farmers, dischargers, and developers the ability to trade nutrient credits in order to meet permit standards.^{xxiv}

There is no current Federal policy outlining nutrient trading.

Eligibility

The Farm must meet compliance with the following baseline requirement of Chapter 102 Erosion and Sedimentation Regulations . The Farm must also meet at least one of the following threshold requirements: 100 foot setback or equivalent; 35 foot buffer or equivalent; or the Farm can take a 20% reduction in credits calculated if it cannot meet the threshold requirements. The land enrolled in the nutrient trading program must include annual crop rotation as documented in the operation's conservation or nutrient management plans. Land will be enrolled for three-year

contracts. Land with insufficient winter residue cover such as corn silage is required to have a cover crop planted.^{xxv}

Eligibility can be determined through a site visit or verification of development and implementation of a Nutrient Management Plan, Erosion and Sedimentation Control Plan or an acceptable Conservation Plan and a Manure Management Plan, as applicable. Compliance must be verified by the Department, Conservation District, or other entity approved by PA DEP.

Codorun Farms is eligible for enrollment.

Table 8
Codorun Farms Nutrient Trading Eligibility

| Baseline Requirement | Farm Eligibility | Threshold Requirement | Farm Eligibility |
|--|------------------------------------|-----------------------|------------------|
| Act 38 Nutrient Mangement Regs | Yes | 100 foot setback | Yes |
| Chapt. 102 Erosion & Sedimentation Regs | Yes | 35 foot buffer | Yes |
| Compliance verified by Conservation District | Yes due to Conservation Plan filed | 20% reduction | NA |

Cost Benefit Analysis

Payments are made to the farmer based on the number of credits generated by environmental benefits gained from changing to best management practices and a market-based determined price of those credits. Each credit is generated, certified, and verified during a water year, October 1 – September 31. In the fall the verification process is undertaken by the DEP.

Attenuation and delivery ratios are taken into consideration when calculating credits. While, Nutrient Net states that its trades are on a 1:1 ratio, in reality the ratios are closer to 3:1 or 4:1.

Attenuation is the measurement of nitrogen that is reduced does not equal the actual reduction of runoff to the water. Credits are applicable only in same river basin of the Chesapeake watershed, either the Susquehanna or the Potomac.

Nutrient Trading Pricing

In order to estimate pricing for future nutrient trading contracts, current contract pricing was taken into consideration. Five contracts are in place within the Susquehanna watershed whereby the credits will be used for complying with permit conditions. Three contracts have been with developers for credits to meet the net zero load and two contracts have been with treatment facilities. While these contracts are not good proxies for the amount of credits generated as each project is different in its use of BMPs and changes made to land use, they are useful to establish an expected price for further contracts for any farm as credit valuation is not based on how the credit was calculated, but on that the credit exists.

Table 7
Susquehanna Watershed Nutrient Trading Contracts^{xxvi}

| Buyer | Seller | Region | Date of Agreement (signature date) | Length of Agreement | N Credits* | Price |
|-------------------------------------|-------------------------------------|--------|------------------------------------|---------------------|------------|--|
| Mount Joy Borough Authority | Brubaker Farms | SC | 26-Feb-07 | 3 years | 11,718 | \$3.81 |
| Dunn Lake | Red Barn Trading Company | NE | 17-Oct-06 | 5 years | 223 | \$9 |
| Hamm Equities LLC | Red Barn Trading Company | SC | 2-Feb-07 | 5 years | 1592 | \$9 |
| Fairview Township, York County | Red Barn Trading Company | SC | 10-Apr-08 | 15 years | 20,000 | Starts @ \$5/N in 2010 and escalates up to the highest amount of \$7.56/N in year 2024 |
| Quail Creek Homeowner's Association | Chesapeake Nutrient Management, LLC | SC | 14-Jul-08 | 20 years | 538 | NA |

* Credits are listed as the quantity purchased each year over the length of the contract.

For a five year contract, the price of \$6 is used for all five years.

Nutrient Trading Credits Calculation

Credits for nutrient trading were calculated using the Pennsylvania Department of Environmental Protection's (DEP) NutrientNet online trading calculation tool (<http://pa-demo.nutrientnet.org/>).

All calculations are demonstration only and were carried out by the author. Only PA DEP employees are authorized to make official calculations and no calculations in this document were verified by the PA DEP. The appendix includes a demonstration on how the credits were calculated for the following two scenarios.

There is no banking for nutrient credits, therefore each credit must be certified, verified, and sold within a water year.

Table 8
Scenario 1

| | |
|---|------------------|
| Nitrogen Reductions to Edge of Watershed Segment: | 529.57 lb |
| Delivery Ratio: | 0.961 |
| Nitrogen Reductions to Chesapeake Bay: | 508.92 lb |
| Reduction Retired to Meet Threshold: | 0 lb |
| Credits Generated: | 508 credits/year |
| Credits sent to DEP Reserve: | 50 credits/year |
| Total Credits Available to Trade: | 458 credits/year |

| Price/Credit | # of Credits | Total |
|--------------|--------------|------------|
| 6 | 458 | \$2,748.00 |
| | | |

Table 9
Scenario 2

| | |
|---|------------------|
| Nitrogen Reductions to Edge of Watershed Segment: | 961.78 lb |
| Delivery Ratio: | 0.961 |
| Nitrogen Reductions to Chesapeake Bay: | 924.27 lb |
| Reduction Retired to Meet Threshold: | 0 lb |
| Credits Generated: | 924 credits/year |

Credits sent to DEP Reserve: 92 credits/year
Total Credits Available to Trade: 832 credits/year

| Price/Credit | # of Credits | Total |
|--------------|--------------|------------|
| 6 | 832 | \$4,992.00 |
| | | |

While the total amount of credits would need to be verified by a NRCS employee and the price would have to be negotiated, it is reasonable to assume that the Farm could make between \$2700 and \$5000/yr just by continuing business as usual. However, there must be buyer who is willing to purchase the credits and current demand is low. Most trades have been through relationships made between local municipalities and developers and farmers.

The York City wastewater treatment plant has no current plans to either participate in or investigate cost benefits of nutrient trading. The new limits will not take effect until 2011 water year (Oct 1). The plant is looking into biological nutrient removal. There are few plans in the surrounding counties of Dauphin, Adams, and Lancaster counties to participate in the program. York WWTP is concerned about TMDLs and while the plant is not ruling the program out all together, many other options of technological improvements would have to be exhausted.^{xxvii} In addition, while it is possible to have a third party aggregator sell credits piecemeal by smaller projects, most WWTP are looking for large scale projects where large amounts of credits are produced so that they have a relationship with whom they are trading credits. While this preference for relationship establishment will most likely change as an established business model is instituted, the small community mindset will remain for the next few years.

The demand for nutrient credits in the Susquehanna watershed is low at the present time (2009). However, the demand is expected to increase substantially in 2010 due to the reissuance of NPDES permits. Waste water treatment plants (WWTP) will have their discharge caps decreased in 2010 creating the need for WWTPs to either increase capital investment to upgrade treatment technologies or buy offsets in order to meet permit requirements. Most likely there will be a combination of both being done, but it is widely accepted that WWTPs (those that have done a cost benefit analysis have found this to be true) will need to purchase more credits in the coming years in order to offset costs. Additionally demand is and will continue to be driven by development.

Enrollment Process

Baseline requirements – these documents are needed in order to establish the farm’s baseline in order to calculate nutrient reduction. For agricultural farmers, a conservation plan is needed which is a requirement of the Food Security Act (FSA) that is completed by the PADEP, the Conservation District, or any other agent approved by the PADEP.

Threshold requirements – these requirements are ecological minimums the farm must have.

There are three ways to meet these requirements:

- 1) 100 foot setback or equivalent – manure is not mechanically applied within 100 feet of surface water, or there are no surface waters within 100 feet of the farm, or the farm uses no manure application and applies commercial fertilizer at or below the Penn State recommended agronomic rate

- 2) 35 foot buffer or equivalent – a minimum of 35 feet of permanent vegetation is established and maintained between the field and surface water, or the area can be grazed or cropped under a specific management plan, and permanent vegetation must be maintained at all times
- 3) Allowance of 20% reduction of credits^{xxviii}

It is necessary to contact your conservation district representative in order to begin the enrollment process. They have all of the necessary information on file to complete the nutrient trading credit calculations and will do so for you. The finalized credits will be posted on a password protected file path on nutrientnet.org.

Wetland Mitigation Banking

Program Description

Federal Law under the Clean Water Act requires that wetlands be created, restored, or enhanced to replace wetlands lost in developments such as highway construction, coastal drainage and filling, or commercial development. Replacement wetlands are designed using a mitigation ratio of 2:1, where two acres of wetlands are restored for every one acre destroyed, so that more wetlands are created and/or restored than are lost. The wetlands acreage is then divided into credits that can be bought in order to fulfill federal law requirements. Buyers are most commonly developers who destroy wetlands through the process of a development project. By buying mitigation credits, developers address their wetland mitigation responsibility and save time and money by not having to do the actual wetlands creation at a separate site.

“A mitigation bank is defined as “a site where wetlands and/or other aquatic resources are restored, created, enhanced, or in exceptional circumstances, preserved expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources.” (Federal Register, Nov 28, 1995, “Federal Guidance for the Establishment, Use, and Operation of Mitigation Banks”). Banks are seen as a way of streamlining the process of mitigating wetland loss and, in many cases, providing a large fully functional wetland rather than small questionable wetlands near the site of wetland loss. The mitigation bank can be set up with bonds ensuring compliance. Arrangements are easier for wetland mitigation banks to be managed in perpetuity through conservation easements or transfer of titles to resource agencies. Financial resources can be arranged ahead of time for proper monitoring of the bank. Mitigation banks can be publicly or privately owned, although there is a potential conflict of interest if

public agencies run mitigation banks. Public agencies could be involved in enforcing regulations on mitigating wetland loss and then steer permittees toward their own banks rather than to private banks.^{»xxix}

In most states, a binding legal agreement between the bank sponsor and a regulatory agency must be signed. This agreement stipulates that the bank sponsor must monitor and maintain the mitigation credits at specific standards. These standards are set to guarantee that the mitigation wetlands have achieved a jurisdictional, functional, and self-sustaining status. The bank sponsor is solely responsible for meeting these standards, meaning the buyer is not subject to mitigation liabilities should the bank become compromised. Upon meeting these standards, a permanent conservation easement on the property is assigned to a non-profit entity that will ensure that the wetlands remain in perpetuity.^{xxx}

In-Lieu Fee Programs. This method takes monetary contributions from permit holders, accrues funds in reserve, and eventually uses the money to create, restore or enhance wetland ecosystems. Instead of undertaking a mitigation project to replace impacted wetlands, the permit holder would make a contribution to the fund in an amount determined by the regulatory agency, generally equal to the cost of implementing the individual mitigation requirement. This alternative results in mitigation occurring after the fact, a practice that is generally discouraged by the regulators.

Mitigation Banking: A wetlands mitigation bank is a wetland area that has been restored, established, enhanced or preserved, which is then set aside to compensate for future conversions of wetlands for development activities. Permittees, upon approval of regulatory agencies, can

purchase credits from a mitigation bank to meet their requirements for compensatory mitigation. The value of these “credits” is determined by quantifying the wetland functions or acres restored or created. The bank sponsor is ultimately responsible for the success of the project. Mitigation banking is performed "off-site," meaning it is at a location not on or immediately adjacent to the site of impacts, but within the same watershed. Federal regulations establish a flexible preference for using credits from a mitigation bank over the other compensation mechanisms.^{xxxii}

Federal and State Policy

Federal

Pursuant to Section 404 of the Clean Water Act, any development activity that adversely affects wetlands must be authorized in advance through a Section 404 permit. In order to obtain a 404 permit, the applicant must demonstrate compliance with the Section 404 (b)(1) sequencing guidelines. Permit applicants must establish, in sequence, that: 1) impacts to aquatic resources cannot be avoided, 2) efforts to minimize aquatic resource impacts through modification of construction plans and designs have been taken, and 3) compensation. As part of a sales transaction, the number of credits necessary to satisfy the requirements of a permit holder’s Section 404 permit are debited against the mitigation bank’s assets.^{xxxii}

PA state law

The Commonwealth of Pennsylvania supports in lieu fees over entrepreneurial mitigation banking and currently has a banking agreement with the Pennsylvania Department of Transportation (PennDOT) to compensate for impacts that occur as a result of the highway construction. Because of the small acreage of wetland impacts that are permitted in the

Commonwealth, entrepreneurial banking does not appear to be financially viable.^{xxxiii}

With mitigation banks and projects needing to be located in the same district as close to the disturbed wetland as possible, it is important to understand the rate of development in York Country and if wetlands are actually being destroyed in this development.

PA Wetland Mitigation Programs

Project-specific wetland mitigation as opposed to wetland banking dominates in PennDOT's overall program. To facilitate cost-effective land acquisition, PennDOT attempts to build mitigation on land owned by other Pennsylvania government entities. Right-of-way costs and costs for maintenance are reduced by partnering with State land management agencies to locate mitigation sites on those agencies' lands. The land management agencies retain ownership of the land and long-term maintenance responsibilities. To date, PennDOT has implemented a total of 19 wetland mitigation bank projects in 7 of its 11 districts. These projects represent a combined total of 229 wetland acres with 161 approved credits, of which 55 have been debited against the bank.^{xxxiv}

Eligibility

Approximately 23.6 acres of field 26 (See map in Appendix) of Codorun Farms is most likely eligible for wetland restoration. While Codorun Farms possesses a significant amount of acreage that could be re-established as a wetland, PA policies inhibit the possibility of participating in a wetland mitigation bank program at this time. However, in the interest of fully understanding how Codorun Farms could potentially participate in a wetland mitigation program, a brief discussion of Farm wetland eligibility follows.

Codorun Farms has approximately 90 contiguous acres of wetlands and drained wetlands. The drained wetlands could potentially be restored to be used as a wetlands mitigation bank. Field 26 is most likely a drained wetland for agricultural use. This field currently has two drainage tiles in place and is made up of the following hydric soils all of which are the national hydric soils list: Codorus Silt Loam, Glenville Silt Loam 0-3% slopes, and Glenville Silt Loam 3-8% slopes. (see table and map). While a scientific study of the land would have to be conducted to be eligible for a conducting a reconstructed wetland, based on the above evidence, the likelihood that a partial amount of land would be eligible is strong. The acreage that lies in the flood plain which includes the soils Cm and GdA are most likely current wetlands and would not be eligible for a reconstructed wetland project. Therefore, it is likely that only 23.6 acres are eligible for wetland mitigation banking.

Table 5
Codorun Farms Field 26 Soil Makeup

| Map Unit Symbol | Map Unit Name | Acres | Eligible |
|-----------------|----------------------------------|-------|----------------------|
| Cm | Codorus Silt Loam | 27.6 | No – current wetland |
| GdA | Glenville Silt Loam, 0-3% slopes | 56 | No - current wetland |
| GdB | Glenville Silt Loam 3-8% slopes | 23.6 | Yes |

Cost Benefit Analysis

The current value of the 24 acres is approximately \$160,000 - \$200,000 or \$6700 - \$8300 per acre.^{xxxv}

Under the current PennDOT program, the acreage of the farm to be restored would be purchased

through a 15yr conservation easement for a lower price than current land valuation. This is due to how the program values this land. Codorun farms would most likely receive 75% of it valued price. In general, payments for WMBs are calculated by in lieu of mitigation fee program and are stringent in regard to a hierarchical system for locating mitigation with a preference for on-site, in-kind replacement. In this case the state would most likely pay \$50 per acre/yr for a 15 year contract.^{xxxvi}

This would generate \$1200 per year for the farm with a NPV of about \$11,000 for a 15 year contract

The Farm leases the land at approximately \$140 an acre which generates \$3360 per year. This is 280% more revenue per year over the mitigation bank rate.

Private WMBs in surrounding areas are paying \$2,000-\$5000 per acre for easements which is still undervaluing the land.^{xxxvii}

Table 6
Revenue Comparison: Wetland Mitigation Bank vs. Codorun Farms

| | Bank | Farm |
|------------|-----------|-----------|
| Land Value | \$135,000 | \$180,000 |
| Rent | \$1200/yr | \$3360/yr |
| 5 yr NPV | \$4920 | \$13777 |

It is clear that in the unlikely event that PENNDot would offer the Farm an agreement for the creation of a WMB, the revenues would not be even close to what the Farm is currently earning.

Enrollment Process

In the future, if the Farm decides to participate as a Bank, the following must take place:

- “The wetland replacement areas must be monitored for a period of not less than five years. The monitoring shall include periodic inspections by a qualified wetland specialist as many times as would be necessary, but at a minimum of twice a year for the first three years and once a year for the remaining two years. The inspections must occur during the growing season. The wetland specialist shall submit reports after each visit assessing the success of the wetland replacement activity.
- The report must include: a discussion of success to date, an analysis of the functions being provided, and discussions of any problems which have been or are being encountered. The report must also include photographs of the replacement site with a plan correlated to the location of each of the photos.
- At the end of two growing seasons, the wetland specialist shall conduct a detailed survey of the vegetative composition of the site. This survey must provide results of 100% coverage of revegetated areas, with at least 85% coverage by the hydrophytic species proposed in the replacement plan. If the 85% success has not been met, then additional planting must be undertaken to achieve that rate. The vegetational analysis must continue on a yearly basis until the 85% success rate is achieved.”^{xxxviii}

This process is too involved for the Farm to undertake on its own as it does not employ wetland specialists and would have to enter into a contract with a private firm in order to participate in this type of program.

Discussion

Carbon Trading

Carbon trading is currently a voluntary market but is expected to become mandatory around 2012. The transition from voluntary to mandatory will affect current policy and credit pricing. Signals from the current administration are supporting a cap and trade policy where the government would administer its own trading platform and appoint an entity (public or private) to run the platform. The policy will have its own eligibility requirements that could be different from CCX's current requirements. However, any changes will most likely NOT affect the no-till portion of agricultural offsets and therefore will NOT affect Codorun Farm's participation in a carbon trading program. Both the Bush and Obama administrations have signaled support for agricultural offsets to be a part of a cap and trade program and the 2008 Farm Bill has specific language requiring the USDA to define and support agricultural offsets.

Pricing will be affected and may be volatile in the first few years of the mandatory program. However, most analytical reports from the International Panel on Climate Change (IPCC) and carbon analysts such as Point Carbon suggest a substantial price raise, up to as much as \$30 in the first few years. While price forecasting is speculation, it is fair to say that most likely the price will rise and therefore it is wise to participate in credit banking measures leading up to the installment of a mandatory program. It is also recommended to watch for policy defining for agricultural offsets to ensure continued compliance for the Farm.

Nutrient Trading

There are concerns about the validity of nutrient trading programs and the PA program should be monitored to ensure that the pilot program evolves into a state and federally supported program. It is possible that the program will need to be altered and that these alterations could compromise both the eligibility of the Farm with its current BMPs and the amount of credits the current program grants the Farm. As the Farm would be working directly with representatives from PADEP and most likely the local conservation district representatives, monitoring changes to the program should be relatively easy.

One of the concerns about a nutrient trading program is leakage. In the case of manure removal programs, instead of true reductions, the manure could be merely trucked from one watershed to another. While this would provide the Susquehanna and Chesapeake watersheds with the proper nutrient loads, it would compromise neighboring watersheds.

With the onset of permit renewals in 2010, there is the potential for demand for credits to rise. More WWTPs, including York's WWTP, may become interested in doing cost benefit analysis concerning new equipment installation to meet stricter requirements or buying credits instead. 2010 and 2011 will be crucial years in the adoption of this trading program and the nutrient trading program should be monitored. A relationship with Red Barn Trading Company would be beneficial in helping to monitor this market, in addition to contact with local conservation district representatives.

Wetland Mitigation Banking

It is not recommended that Codorun Farms participate in a wetland mitigation banking program as the conservation easement bought by PennDOT would severely undervalue the present value of the land. The State of Pennsylvania would need to change its emphasis from in lieu fees to mitigation banking on order for both developers in Pennsylvania to participate in purchasing credits from a bank as well as for private wetland banking to become profitable. Currently, the state encourages payments for wetlands destruction after the fact and these payments go towards PennDOT's wetland restoration program. Private banking encourages restoration of wetlands prior to developer site destruction and as with the in lieu fee program must be in the same local watershed and county.

As there is no current signaling from the State for change in the current laws, it is not likely that the State will enact legislation encouraging private banking in the near future.

Conclusion and Recommendations

- It is not recommended that Codorun Farms participate in a wetland mitigation banking program as the conservation easement bought by PennDOT would severely undervalue the present value of the land.
- The restoration and maintenance of a wetland bank would most likely be too difficult a task for Codorun Farms to complete on its own. A specialist and contractor would need to be brought in and would be too costly for the Farm. In the event that the PA laws do change and mitigation banking is encouraged, it is recommended that the Farm investigate working with a private wetland mitigation banking firm. A cost benefit

analysis would need to be done in order to assess whether or not participation in a bank would be more profitable than continuing with business as usual.

- It is recommended that Codorun Farms participate in the current voluntary carbon market. While revenues with current pricing are not substantial, participation in the current program through AgraGate is easy and allows for knowledge transfer in anticipation of participating in a regulated market.
- It is recommended that Codorun Farms begin to work with its conservation district and PADEP representatives in order to facilitate participation into the nutrient trading program. While there are no guarantees that generated credits would be bought, changes to current farm practices to generate credits are not substantial and may not be needed at all.
- One member of Codorun Farms should be appointed as an official liaison to all nutrient trading program representatives.
- Shorter contracts of 5 years or less are recommended as this program will most likely change as it evolves. With the onset of new permitting in 2010, there is the possibility of credit price increases and shorter contracts will allow the Farm to take advantage of these increases.
- A relationship with Red Barn Trading company should be cultivated in order to monitor the development of this market.
- Relationships should be developed with the local WWTPs and developers in order to take advantage of any potential demand for credits.

Appendix

Nutrient Trading Calculations using NutrientNet

| | |
|---|------------------|
| Nitrogen Reductions to Edge of Watershed Segment: | 529.57 lb |
| Delivery Ratio: | 0.961 |
| Nitrogen Reductions to Chesapeake Bay: | 508.92 lb |
| Reduction Retired to Meet Threshold: | 0 lb |
| Credits Generated: | 508 credits/year |
| Credits sent to DEP Reserve: | 50 credits/year |
| Total Credits Available to Trade: | 458 credits/year |

Credit Calculations

Nitrogen Applications and Reduction

Nitrogen Applications

| | |
|--|---------------|
| Total Nitrogen Applied, Current: | 175.50 lbs/ac |
| Total Nitrogen Available for Crop Uptake, Current: | 128.33 lbs/ac |
| Total Nitrogen Applied, Planned: | 175.50 lbs/ac |
| Total Nitrogen Available for Crop Uptake, Planned: | 175.50 lbs/ac |

Nitrogen Reduction from Change in Application Rate

| | |
|--|----------------|
| Edge-of-Field Nitrogen Reduction, per acre: ¹ | 0.00 lbs/ac/yr |
| Edge-of-Field Nitrogen Reduction, total: | 0.00 lbs/yr |
| Edge-of-Segment Delivery Ratio: | 0.31 |
| Edge-of-Segment Nitrogen Reduction: ² | 0.00 lbs/yr |

Nitrogen Loading

| | |
|--|------------------|
| PSU Recommended Nitrogen Application Rate: ³ | 160.00 lbs/ac/yr |
| Nitrogen Available - Current: | 178.33 lbs/ac |
| Nitrogen Available - Planned: | 178.33 lbs/ac |
| Nitrogen Uptake from Crop: ⁴ | 126.86 lbs/ac |
| Edge-of-Field Nitrogen Load (after application reduction): | 51.46 lbs/ac |
| Edge-of-Segment Nitrogen Load (after application reduction): | 15.95 lbs/ac |
| Nitrogen reduction for conservation till or no-till: | 4.79 lbs/ac |
| Nitrogen Reduction for Current Buffers: | 0.00 lbs/ac |
| Edge-of-Segment Nitrogen load, per acre: | 11.16 lbs/ac/yr |
| Edge-of-Segment Nitrogen Load: | 959.89 lbs/yr |

Nitrogen Reduction from BMP Implementation

Edge-of-Segment Nitrogen Reduction, all BMPs 529.57 lbs/yr

Reduction Summary and Credit Calculation

Edge-of-Segment Nitrogen Reductions: 529.57 lbs/yr

Delivery Ratio: 0.96

Nitrogen Reductions to Chesapeake Bay: 508.92 lbs/yr

Total credits generated: 508.92 credits/year

Total Credits Available to Trade: 458 credits/year

Nitrogen Reductions to Edge of Watershed Segment: 961.78 lb

Delivery Ratio: 0.961

Nitrogen Reductions to Chesapeake Bay: 924.27 lb

Reduction Retired to Meet Threshold: 0 lb

Credits Generated: 924 credits/year

Credits sent to DEP Reserve: 92 credits/year

Total Credits Available to Trade: 832 credits/year

Credit Calculations

Nitrogen Applications and Reduction

Nitrogen Applications

Total Nitrogen Applied, Current: 175.50 lbs/ac

Total Nitrogen Available for Crop Uptake, Current: 128.33 lbs/ac

Total Nitrogen Applied, Planned: 175.50 lbs/ac

Total Nitrogen Available for Crop Uptake, Planned: 175.50 lbs/ac

Nitrogen Reduction from Change in Application Rate

Edge-of-Field Nitrogen Reduction, per acre:¹ 0.00 lbs/ac/yr

Edge-of-Field Nitrogen Reduction, total: 0.00 lbs/yr

Edge-of-Segment Delivery Ratio: 0.31

Edge-of-Segment Nitrogen Reduction:² 0.00 lbs/yr

Nitrogen Loading

PSU Recommended Nitrogen Application Rate:³ 160.00 lbs/ac/yr

Nitrogen Available - Current: 220.33 lbs/ac

Nitrogen Available - Planned: 220.33 lbs/ac

Nitrogen Uptake from Crop:⁴ 126.86 lbs/ac

Edge-of-Field Nitrogen Load (after application reduction): 93.46 lbs/ac
 Edge-of-Segment Nitrogen Load (after application reduction): 28.97 lbs/ac
 Nitrogen reduction for conservation till or no-till: 8.70 lbs/ac
 Nitrogen Reduction for Current Buffers: 0.00 lbs/ac
 Edge-of-Segment Nitrogen load, per acre: 20.27 lbs/ac/yr
 Edge-of-Segment Nitrogen Load: 1,743.30 lbs/yr

Nitrogen Reduction from BMP Implementation

Edge-of-Segment Nitrogen Reduction, all BMPs 961.78 lbs/yr

Reduction Summary and Credit Calculation

Edge-of-Segment Nitrogen Reductions: 961.78 lbs/yr
 Delivery Ratio: 0.96
 Nitrogen Reductions to Chesapeake Bay: 924.27 lbs/yr
 Total credits generated: 924.27 credits/year
 Total Credits Available to Trade: 832 credits/year

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