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Net Returns to Carbon Farming

File A1-78

Carbon Farming

There is a growing concern among investors, consumers, producers, and the public sector about the environmental effects of modern life on global warming and the frequency of extreme weather events. More than 20% of all greenhouse gas (GHG) emissions in the world are currently under some kind of pricing scheme, increasing costs for high emitters and incentivizing the development and adoption of less contaminating technologies.

Different GHGs affect the environment in different ways, but scientists have developed conversion factors to express the global warming potential of all GHGs in carbon dioxide equivalent (CO_2e) units. For example, the global warming potentials of nitrous oxide (N_2O) and methane (CH_4) over a 100 year period are 298 and 28 times the global warming potential of carbon dioxide (CO_2), respectively. For GHG accounting:

1 ton of N_2O = 298 tons of CO_2e, and
1 ton of CH_4 = 28 tons of CO_2e.

In the United States, the agricultural sector accounts for 11% of all GHG emissions (mostly N_2O from crop fertilization and CH_4 from livestock production). However, it is one of the few sectors of the economy that can also remove GHGs from the atmosphere and store carbon in the soil with existing technologies, through regenerative practices.

A growing number of private companies are trying to capitalize on the seemingly growing demand for lower-GHG-emission goods and services by producing and certifying environmental services, and selling the certificates for a profit. In the agricultural sector, multiple "carbon programs" are entering into contracts with farmers to have them implement regenerative practices and certify the provision of environmental services in exchange for compensation. The most common regenerative practices in crop production are adding cover crops and reducing the tillage intensity, but the list of practices varies by carbon program (see File A1-76, How to Grow and Sell Carbon Credits in US Agriculture, https://go.iastate.edu/VPHJ0J).

Carbon farming represents an opportunity to farmers interested in implementing regenerative practices at a lower net cost (and maybe even a profit) than in the absence of the carbon programs. Some carbon programs compensate farmers by type of regenerative practice (payment per practice), but most compensate farmers for the magnitude of the environmental service provided (payment per outcome). Carbon programs that pay per practice stipulate a price for each practice in dollars per acre that is not dependent on the amount of carbon removal. Carbon programs that pay per outcome offer a carbon price in dollars per ton of CO_2e reduction, and the final payment to the farmer depends on the amount of CO_2e removed.

The specific methodologies to measure CO_2e removal vary across carbon programs (see File A1-76, https://go.iastate.edu/VPHJ0J and File A1-77, How do Data and Payments Flow through Ag Carbon Programs?, https://go.iastate.edu/QGA627), but they always involve the comparison of GHG emissions from the current production system (baseline) against the emissions from a modified production system with additional regenerative practices. The decline in emissions from the baseline to the modified production system is the carbon farming output, conceptually equivalent to a "yield" in crop production.

Farmers rely on scales to determine the volume of No. 2 yellow corn they sell at the elevator, but there are no "scales" (yet) for the output of carbon farming. The lack of well-known and reliable "scales" for carbon farming poses a major challenge for farmers considering carbon contracts with payments per outcome, since they have no way to validate whether the measurement of CO_2e made by the carbon program (through statistical and

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biophysical models) is fair to them. In theory, soil tests and Eddy Covariance towers could become the trusted "scales" for CO_2e measurement in the future, but they are still cost-prohibitive at field level.

Similar to corn and soybean production, CO_2e reduction is not only affected by a specific agronomic practice implemented by a farmer, but also by its timing, previous practices, their interaction with weather events, and the physical characteristics of the soil. For example, how much CO_2e can a cover crop that fails to germinate remove from the atmosphere?

Net Returns to Carbon Farming

The accompanying spreadsheet (AgDM Decision Tool A1-78, [Net Returns to Carbon Farming in Iowa](https://go.iastate.edu/SGTIZB), https://go.iastate.edu/SGTIZB) is a decision tool to evaluate the net returns to a carbon farming contract, based on the following attributes:

a. Farm location, by county,
b. Current farming practices: tillage management, cover crop use, irrigation, compost and manure use,
c. Contract type: per outcome or per practice,
d. Contract length,
e. Additional regenerative practice, from a list of 66 practices for working croplands,
f. Frequency of additional practice implementation,
g. Contracted price: price per ton of CO_2e or price per practice,
h. Expected change in contract price,
i. Farm area enrolled in carbon contract,
j. Participation in cost-share programs: area, contract length, annual payments,
k. Expected changes in cash and non-cash cost,
l. Discount rate.

A major contribution of this decision tool is to illustrate the effects of uncertainty in CO_2e reduction on the economic evaluation of the carbon contract. If one practice A is more consistent than another practice B in CO_2e reduction, and they both remove, on average, the same amount of CO_2e from the atmosphere, then there is less uncertainty with practice A than with practice B, and net returns should be less variable under practice A than under practice B.

Uncertainty in the amount of CO_2e reduction is represented via a triangular distribution parametrized with data from Swan et al. (2022). The underlying CO_2e reduction data by regenerative practice and county stems from one of the multiple GHG emission models used by carbon programs: COMET-Planner. The COMET-Planner model was developed by the US Department of Agriculture (USDA) and Colorado State University, and is the carbon and GHG evaluation tool for the USDA's Natural Resources Conservation Service (NRCS) conservation practice planning.

Our assumptions to parametrize the county- and practice-specific model include using the reported mean, minimum, and maximum CO_2e reduction values from Swan et al. (2022) as the mode (peak value), minimum, and maximum values of a triangular distribution. The triangular distribution was chosen as a simple way to introduce variability after deeming other parametric distributions (normal, truncated normal, Beta, logarithmic) unsatisfactory.

The calculations assume a contract with annual payments, for the entire value of the corresponding payment. This is a simplistic assumption to maintain tractability, but payments tend to be front-loaded in many contacts (with over half of the expected payments distributed over the first half of the contract length).

The calculations for programs with per outcome payments assume that the only penalty for producing less carbon than expected is a decline in the annual payment. Some practices are associated with a wide range of possible CO_2e reduction outcomes, including CO_2e increases (negative reductions). When the expected annual amount of CO_2e reduction is negative, the decision tool calculates a negative carbon payment as if the farmer had to write a check to the carbon program to reimburse it for adding carbon into the atmosphere. For example, the expected amount of CO_2e removal associated with a 15% reduction in fertilizer application under conventional tillage and no-irrigation in Adair County, Iowa, is -0.01718. When the expected carbon payment is negative, the Decision Tool reports that no breakeven price or quantity can be calculated (even if there are cost savings from implementing the practice change, the net returns to implementing the practice change outside of the carbon program should be higher than under the carbon program).

When the expected amount of CO_2e reduction associated with a practice in a specific county is positive, but the lower bound of the CO_2e reduction distribution is negative, it means that in any year there could be weather events or other conditions that render the regenerative practice ineffective. The decision tool reflects this possible ineffectiveness in the two tables reporting probabilities of incurring economic losses in Section 4.

The accompanying Decision Tool does not account for CO_2e releases into the atmosphere from the intended or unintended discontinuation of a contracted practice (carbon reversals), such as doing a vertical tillage pass in year 5 of a 10-year, no-till contract and releasing 40% of the amount of the CO_2e accumulated in years 1-4.

Instructions

The Decision Tool is organized into four sections: location, current farming practices, carbon farming plan, and expected annual returns. Users are required to enter information in the yellow shaded, unprotrected cells. Information must be entered sequentially, from the top to the bottom of the worksheet, for all yellow shaded cells.

If, at any point, a user decides to modify the information entered in a previous step, they must review that all yellow shaded cells provide consistent information with the new information. Warning messages in red will appear when inconsistencies are detected, but results might still be reported in Section 4. The user must resolve all inconsistencies before attempting to interpret the final results.

Most attributes must be selected from a limited set of possible options using drop-down menus. Since most carbon programs will only enroll farms whose operators agree to add regenerative practices not previously implemented in those farms ("additionality" requirement), the menu of possible additional regenerative practices adjusts based on the choices for current farming practices. For example, if a farm is already in a no-till system, then the list of possible practices will exclude all residue and tillage management practices due to non-additionality of those practices. See File A1-76, https://go.iastate.edu/VPHJ0J to compare participation requirements across carbon programs.

The only attributes that require typing by the user are the contracted price, the farm area in carbon contract and the farm area receiving cost-share, the cost-share payment, and the expected changes in costs in the first year of the contract.

The outputs of the Decision Tool depend on the selected contract type. For contracts with payments per outcome, the information is organized into:

- Expected annual net cash flows and net returns,
- Minimum carbon price in dollars per ton of CO_2e needed to breakeven based on chosen practices, changes in costs, and cost-share payments,
- Minimum amount of CO_2e reduction in tons per acre to breakeven based on the carbon price, expected changes in costs, and cost-share payments,
- Annual probabilities of incurring losses,
- Annual probabilities of generating profits,
- Annual probabilities of obtaining different net returns per acre:
  - Losses larger than -$20 per acre
  - Losses between -$20 per acre and -$10 per acre
  - Losses smaller than -$10 per acre
  - Profits smaller than $10 per acre
  - Profits between $10 per acre and $20 per acre
  - Profits larger than $20 per acre
- Discounted annual net returns,
- Net present value of the carbon contract.

For contracts with payments per practice, where the amount of CO_2e removal does not affect the contract payment, the information is limited to:

- Expected annual net cash flows and net returns,
- Discounted annual net returns,
- Net present value of the carbon contract.

The Decision Tool, Net Returns to Carbon Farming in Iowa, https://go.iastate.edu/SGTIZB is designed to evaluate only one carbon contract at a time. To evaluate multiple carbon contracts, the user is advised to save each alternative as a separate spreadsheet file. Decision Tools for all additional states are available on the Ag Decision Maker Carbon Market Information webpage, https://go.iastate.edu/9HIN8G.

Disclaimer

This fact sheet and accompanying decision tool are only for educational purposes and no implicit or explicit guarantees or warrantees are made for the economic viability or suitability of carbon farming.

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Prepared by Alejandro Plastina, extension economist, plastina@iastate.edu
Haeun Jo, graduate research assistant
Department of Economics