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Soil Health and Climate Resilient Farming: Quantifying a Farm's Capacity to Achieve More Resilient Agricultural Production Systems

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American Farmland Trust

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The authors welcome comments, questions and, or suggestions to improve the value of this work. Please contact the corresponding author, John Hanchar, jjh6@cornell.edu

Summary

- Successful adopters of soil health systems observe greater stability with respect to crop production when compared with previous, more conventional cropping programs – relatively fewer occurrences of unfavorably low crop production; greater evenness regarding crops produced, harvested acres, yields, etc. over time.
- Reservation price for insurance concepts may provide a measure for quantifying the value to the farm of an enhanced ability to achieve more stable, less variable, more resilient agricultural production systems.
- For illustration and discussion purposes only, results for a case study example farm yielded a value of achieving greater stability -- calculated here as the difference between before and after time periods' reservation prices for insurance, and equal to $5 per tillable acre per year.

Background

NYS Department of Agriculture and Markets, NYSDAM, describes the objectives of climate resilient farming efforts as follows (NYSDAM, 2022).

- to reduce the impact of agriculture on climate change (mitigation)
- to increase the resiliency of New York State farms in the face of a changing climate (adaptation)

Regarding adaptation, climate resilient farming seeks optimal management of resources given a less favorable risk and uncertainty environment attributed to climate change and extreme weather conditions – an environment characterized by greater chance of negative impacts on the farm business. Optimal management should seek to maintain or improve farm viability and achieve other farm and family environmental and other objectives and goals. Decisions should reflect resource constraints and changing, less favorable risk and uncertainty circumstances

Soil health system adoption by farm business owners plays a key role in optimal management of farm resources. Work to achieve climate sustainability objectives, for example, the dairy industry's "Net Zero Initiative," will draw upon decades of work in the soil health systems area (Quaassdorff, M., 2021).

To plan and successfully implement soil health systems, farm business owners seek comprehensive information regarding expected differences in benefits and costs, and strategies for planning and successfully implementing soil health systems. American Farmland Trust's Soil Health Case Study methods and reporting of results are examples of information (American Farmland Trust). Information resources improve understanding of important topics, stimulate readers' interests in the topic, quantify economic and environmental benefits and costs, and provide strategies for planning and successfully implementing soil health systems. Farm business owners will seek, and benefit from similar information when making decisions about climate resilient farming systems, systems that are better able to endure climate and weather related setbacks.

A prominent, frequently mentioned topic from recent American Farmland Trust, AFT, Case Study work, including demonstration farm network efforts in New York, is the observation by farmers that successful adoption of a soil health system contributes to increased stability in outcomes – increased crop resiliency, reduced variability (American Farmland Trust). AFT soil health case study methods and results effectively quantity numerous farm level economic benefits and costs using before-after analyses -- value of harvested crops over time, cropping program expenses (fertilizer & lime, seeds & plants, spray and other crop expenses, machinery costs, labor), and profit changes.

To date, analyses do not reflect the economic value at the farm level of achieving greater crop stability, crop resiliency, more hardy cropping systems associated with soil health systems adoption. The purpose of the work reported here is to estimate the value of a farm's capacity to achieve increased stability, less variability. If the approach described has value, then it might also have application for evaluating climate resilient farming systems. The remainder of this paper describes selected features of the approach, data, and results with discussion.

Approach, Methods and Data

Selected features of the approach, methods follow.

- Apply "reservation price for insurance" concepts to answer, "What is the most a consumer would pay for insurance against a loss?" (Frank, R., 1991) (Hanchar, J. and A. Ristow, 2022)
- Analysts used historical financial and production data for a case study example farm.
- Analysis a) is for illustration and discussion purposes only; b) reflects before and after periods of different lengths; c) acknowledges the roles assumed by markets for insurance products and services, and the availability of crop and revenue insurance products and services from the United States Department of Agriculture/Risk Management Agency, USDA/RMA (USDA/RMA, 2022).

Historical records from the example farm's annual farm business summary and analysis efforts for the period 1993 through 2020 provide data for the analysis.

Results and Discussion

Analysts noted the following (Table 1).

- For the 1993 to 2000 period -- the before, former cropping program period chosen by the farm business owners -- value of harvested crops in real terms (2011 = 100) averaged $784 per acre annually, ranging from a low of $630 per acre to a high of $932 per acre.
- For the 2001 through 2020 period -- the after, soil health system period chosen by the farm business owners -- the measure averaged about $895 per acre annually, about 14 percent greater than the average for the 1993 to 2000 period, ranging from a low of $636 per acre to a high of $1,148 per acre.
- Minimum, maximum and range measures differed considerably by period.
- In real terms,
    - o the annual value of harvested crops for the before period was less than or equal to $800 per acre 4 times during the 8 years of the period, 50 percent of the period's years, while

- o in comparison, the annual value of harvested crops for the soil health period was less than or equal to $800 per acre, roughly the average value for the before period, 4 times during the period's 20 years, 20 percent of the period's years

Suppose the case study example farm's owners/operators
- wish to manage risks and uncertainties associated with value of crop production variability by shifting risk to an insurer
- define a loss equal to the actual value of production in real terms minus a coverage target value for all values of production less than the coverage target
- feel that when outcomes fall below a coverage target of $660 per tillable acre per year, approximately one standard deviation below the average for the before period, the business' abilities to achieve financial and other objectives decline -- for example, meeting cash obligations in a timely manner, meeting the farm's quantity and quality objectives for feed, and others

For the 1993 through 2000 period, losses (as defined above) occurred 2 times during the 8 year period, totaled about negative $49 per acre for the period, and averaged about negative $6 per acre per year. For the 2001 through 2020 period, losses (as defined above) occurred 1 time during the 20 year period, totaled negative $24 per acre for the period and averaged about negative $1 per acre per year. Please note the comment above regarding the number of years for the before period relative to the after period, and the case study nature of this illustration.

A "for illustration and discussion purposes only" analysis of the before and after periods applies reservation price for insurance concepts. Results for the before period suggest that the farm business owner would pay at most $6 per acre per year for fair gamble coverage (actuarially fair) insurance against a loss, excluding administrative and other risk shifting charges. In exchange for premium payments the insured mitigates, reduces the negative, undesirable effects of unfavorable outcomes, risks and uncertainties. Given the risk and uncertainty environment of the soil health systems period 2001 through 2020, analysis suggests that the farm managers from a case study example farm would pay at most $1 per acre per year for fair gamble insurance excluding administrative and other risk shifting charges against a loss (value of crop production less than a target coverage level).

When compared with the before period's reservation price ($6 per acre per year), the after period's lower reservation price for insurance ($1 per acre per year) suggests that a more favorable risk management environment – reduced variability, increased stability with respect to value of crop production outcomes, resiliency – is characteristic of the soil health system when compared with the former cropping program. Please note the comment above regarding managing agricultural risks using risk shifting, insurance type products. Applications of the concepts as part of future soil health case study work will help to determine usefulness for quantifying similar attributes of climate resilient farming practices and systems.

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Table 1. Value of Crop Production (Real Terms, 2011 = 100) (dollars per acre) and Loss (dollars per acre) by Year, Example Case Study Farm, Genesee River Watershed, NY

Year	Value of Crop Production[1]	Loss[2]
	($/acre)	($/acre)
1993	629.54	-30.455
1994	665.29	0
1995	790.88	0
1996	641.86	-18.135
1997	850.63	0
1998	932.06	0
1999	915.65	0
2000	849.63	0
2001	787.25	0
2002	875.35	0
2003	885.57	0
2004	635.86	-24.139
2005	789.16	0
2006	1024.22	0
2007	698.97	0
2008	1025.4	0
2009	900.11	0
2010	892.23	0
2011	847.07	0
2012	1147.65	0
2013	1088.51	0
2014	880.58	0
2015	914.03	0
2016	950.23	0
2017	906.19	0
2018	942.07	0
2019	893.76	0
2020	854.63	0

[1]*annual crop production valued in real terms, 2011 = 100*

[2]*Loss in real terms equals the value of crop production minus the coverage target when the result is less than 0, else loss equals 0. For discussion, illustration purposes, suppose the coverage target equals the mean value of crop production for the 1993 through 2000 minus 1 standard deviation, or $784 per acre minus $124 per acre, or $660 per acre. For example, consider the year 1993 -- $629.54 minus $660 equals negative $30.46 per acre, a loss. In contrast, for 2020, $854.63 is greater than the target and the loss is 0.*