Carbon and Nutrient Co-benefits of Large Conservation Programs: An Illustration with EQIP in Iowa

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THE FEDERAL government and many communities and private companies have set net zero greenhouse gas emission (GHG) goals, mostly by 2050. The federal government is investing up to $1 billion to support climate-smart agriculture and forestry through voluntary conservation programs (USDA 2021). Various companies (e.g., Indigo, Truterra, Bayer, and Corteva) have also injected much private investment into the agricultural sector and various companies have set up mechanisms to provide incentives for farmers to adopt carbon sequestering conservation practices. Many agricultural conservation practices that sequester carbon can also improve soil health and reduce nutrient runoff and there have been decades of efforts and investment to promote conservation practice adoption. The two largest federal conservation programs in the United States, the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP), had more than $437 million and $345 million in obligations in Iowa over the ten years from 2011 to 2020 to promote conservation practice adoption (NRCS 2021).

Traditional conservation programs like EQIP and CSP have substantial carbon sequestration co-benefits; similarly, innovative carbon-sequestration focused programs targeting the agricultural sector will likely generate substantial co-benefits in soil health and water quality. Carbon markets and related programs are at the developmental stage and thus little systematic data are available. On the other hand, conservation programs have been around for decades, which allows for some assessment of co-benefits of conservation practices enrolled in the programs.

With a simple analysis based on data of program participation and existing literature, this article aims to illustrate the co-benefits of improved water quality and sequestered carbon by practices enrolled in EQIP. We focus on the payment and impacts of the EQIP program since a specific CSP contract may include multiple conservation practices as a bundle, making it difficult to conduct benefit-cost analysis for individual conservation practices. Table 1 lists the top-10 most used EQIP

Table 1. Top 10 Ranking of EQIP Practices by Payment/Acreage

Ranking (Top 10)	EQIP Practices (ranked by payment)	Payment (million dollars)	EQIP Practices (ranked by acreage)	Acreage (thousand acres)
1	Cover crops	38.9	Cover crops	1219.6
2	Waste storage facility	27.8	Residue management-No till	362.2
3	Underground outlet	12.8	Nutrient management	209.8
4	Terrace	12.0	Prescribed grazing	73.6
5	Grade stabilization structure	11.4	Pasture & hay planting	61.6
6	Roofs and covers	9.4	Subsurface drain	36.4
7	Farmstead energy Improvement	7.3	Fence	27.8
8	Fence	7.1	Underground outlet	24.6
9	Pasture & hay planting	6.8	Conservation crop rotation	21.7
10	Streambank & shoreline protection	6.4	Terrace	20.6

Table 2. Grouping of Top 40 EQIP Practices based on Water and Carbon Benefits

Benefits	Number of practices	Practices
Primarily water	10	Underground outlet, Subsurface drain, Water & sediment control basin, Grade stabilization structure, Waste storage facility, Streambank & shoreline protection, Pond, Pumping plant for water control, Roofs and covers, Stream crossing
Primarily carbon sequestration	5	Forest stand improvement, Energy efficient lighting system, Forest site preparation, Farmstead energy improvement, Agricultural energy management plan
Both water quality and carbon sequestration	12	Cover crop, Residue management: no-till, Nutrient management, Critical area planning, Heavy use area protection, Terrace, Pasture & hay planting, Prescribed grazing, Grassed waterway, Conservation cover, Conservation crop rotation, Tree shrub establishment
Neither water nor carbon sequestration	13	Fence, Watering facility, Livestock pipeline, Brush management, Prescribed burning, Access control, Mulching, Wetland wildlife habitat management, Herbaceous weed treatment, Structures for wildlife, Seasonal high tunnel system for crops, High tunnel system, Pest management

practices in Iowa by payment and by acreage from 2012 to 2021. There are five practices that appear in both the top ten by payment and the top ten by acreage, with cover crops being the most used practice by both payment and by acreage. In addition to cover crops, no-till and nutrient management were also used in large areas.

There are 125 conservation practices listed in Iowa's EQIP payment schedule. For analysis of co-benefits, we examine the top-40 most frequently used EQIP practices in Iowa, which account for 96.3% of total EQIP spending (i.e., $181.6 million of $188.5 million from 2012 to 2021). We categorize the top 40 practices into four groups: primarily water benefit practices (10); primarily carbon benefit practices (5); both water and carbon benefit practices (12); and, neither water nor carbon benefit practices (13). Table 2 lists the practices in each group. The main purpose of the grouping here, which is admittedly crude, is to conceptually and quantitively illustrate the co-benefit nature of commonly used conservation practices.

Figure 1 presents the geographical distribution of payments for the four groups in the past ten years. To facilitate comparison, all four maps use the same numerical scale. Figure 1 indicates that, by far, the most payments were made for practices that generated both water and carbon benefits, including cover crops, residue management: no-till/reduced till, and nutrient management, etc. Payments for practices that primarily have carbon benefits were the smallest among the four groups. Practices that had both water and carbon benefits tended to be evenly distributed around the state, whereas primarily carbon and primarily water benefit practices that were enrolled in EQIP during 2012–2021 tended to be located in different regions of the state.

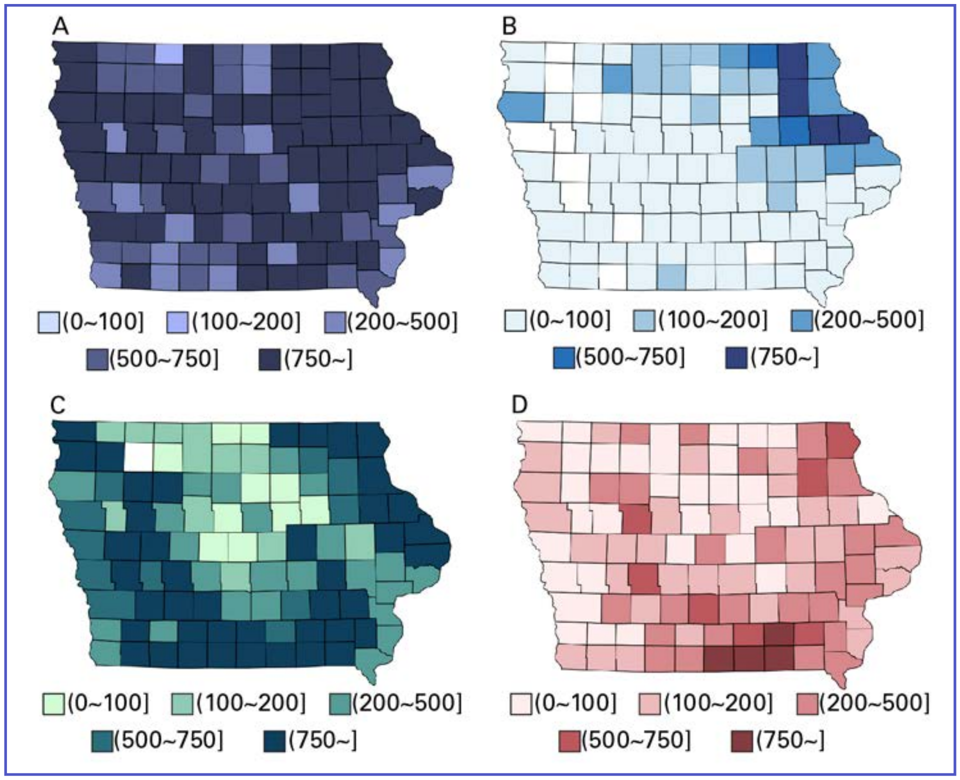

Figure 1. Total 2012–2022 EQIP payments (thousand dollars) by county for: (a) both water- and carbon-focused practices, (b) carbon-focused practices, (c) water-focused practices, (d) neither water- nor carbon-focused practices.

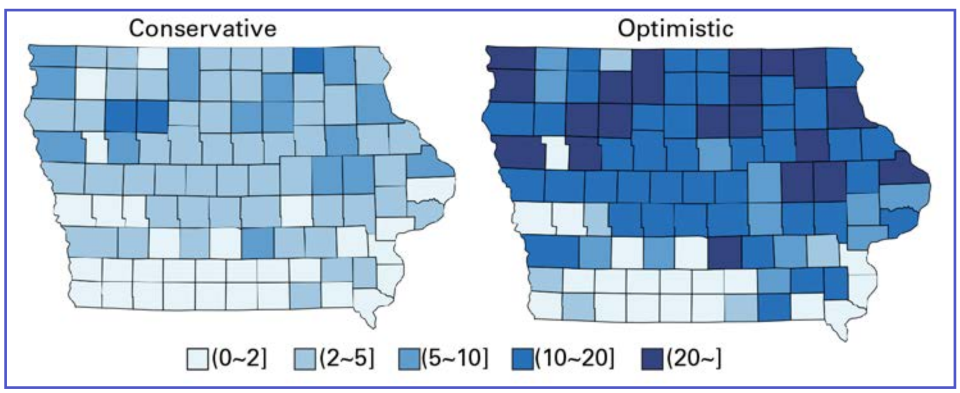

Figure 2. Conservative and optimistic estimates of carbon sequestration (thousand tons of CO_2) from CC, NT, and RT in Iowa, 2012–2022.

To illustrate the magnitude of the carbon and water co-benefit relationship, we select three widely adopted and extensively studied practices: cover crops (CC), no-tillage (NT), and reduced tillage (RT). The 2021 Iowa Farm and Rural Life Poll (IFRLP) Survey shows that 48% respondents used NT, 33% used CC, and 25% used strip-till or similar "minimum disturbance" tillage in 2020 (IFRLP 2020). Many studies estimate the net CO_2 avoidance under CC, NT, and conservation tillage-reduce till (RT) and the results vary widely. Most results show the practices have positive carbon sequestration and, for illustration purposes, we use a range of 0.20~0.92 tons of CO_2 per acre per year for CC, 0.14~1.21 tons of CO_2 per acre per year for NT, and 0.13~0.31 tons of CO_2 per acre per year for RT. Nutrient management is also a frequently adopted practice; however, there is not enough information for net CO_2 emission avoidance by nutrient management practices and so we do not study it here. We select the second-lowest and the second-highest carbon sequestration rates from the above studies to obtain conservative and optimistic estimates of carbon sequestration, respectively. We estimate the carbon impacts of CC, NT, and RT form 2012 to 2021 ranges from about 346,000 tons (conservative rate) to about 1.371 million tons (optimistic rate) in total for Iowa. Figure 2 shows that we estimate counties in north and northeastern Iowa generated the most carbon sequestration benefits under EQIP through CC, RT, and NT.

Similarly, we estimate the ballpark water quality improvement of CC, NT, and RT, as measured by NO_3-N (nitrate-nitrogen) mass reduction. The range of parameters from the existing literature also vary widely and, again for illustration purposes, we use a range of 16~49 pounds per acre per year for CC; 36.5~41.0 pounds per acre per year for NT; and, 21~23 pounds per acre per year for RT. Similar to our carbon sequestration estimation, we choose a low and high benefit rate to represent conservative and optimistic benefit estimates, which are about 4.495 million pounds and 7.463 million pounds in total, respectively, for nitrate-nitrogen reduction in Iowa from 2012 to 2021. Figure 3 shows the geographical distribution of the program benefits in nitrate-nitrogen reduction for CC, NT, and RT enrolled in EQIP, which indicates that most of the program benefits occurred in the northern part of the state.

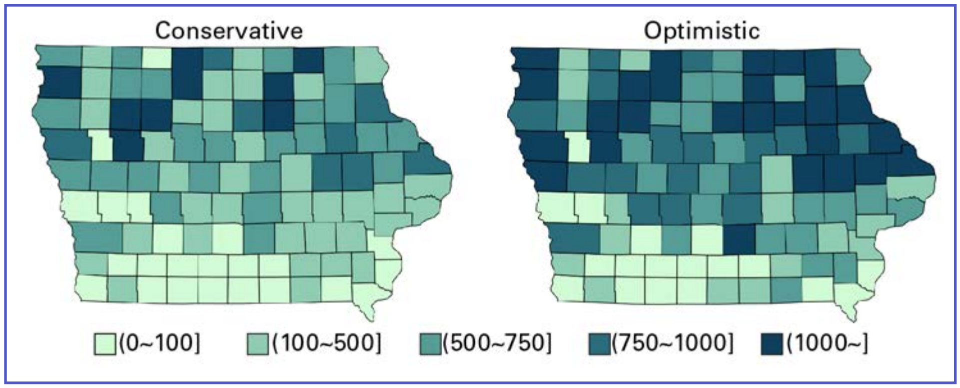

Figure 3. Conservative and optimistic estimates of nitrate-nitrogen reduction (thousand tons of NO_3-N) from CC, NT, and RT in Iowa, 2012–2022.

To gain further perspective, we derive back-of-the-envelope estimates of the monetary value of carbon and water quality benefits. Many studies examine the price of carbon and we will not enumerate them here. We use the range in Nordhaus (2017), which estimates the social cost of carbon as $37.30 per ton of CO_2 (in 2010 US $), with a range from $22.60 to $140 depending on discount rate used. Our rough calculation of carbon benefits generated by CC, RT, and NT from 2012 to 2021 is $12.9~$51.1 million. By contrast, few studies estimate the monetary benefits of nitrate-nitrogen reduction, which depends on nitrogen movements, and the location, vulnerability, and preferences of populations affected by nitrogen. In this analysis, we follow the recent "Carbon Science for Carbon Markets" report (Schulte Moore and Jordahl 2022) and use the range of $8.60–$10.30 per pound for NO_3-(nitriate). After conversion between NO_3-(nitriate) and NO_3-N (nitrate-nitrogen), a rough calculation of the water quality benefits induced by CC, RT, and NT enrolled in EQIP in Iowa is $1.7~$3.4 million dollars from 2012 to 2021. Thus, based on our simple calculation, the three conservation practices—CC, RT, and NT—seem to have generated much more carbon benefits than water quality benefits while the overall EQIP investment on the three practices seems to be comparable to the total carbon and water quality benefits ($14.6~$54.5 million).

We note several important caveats associated with these estimates including simplicity of calculation, not accounting for the dynamic and non-permanence nature of carbon sequestration, and the omission of other co-benefits such as improved soil health. Our study is meant as an illustration of the interconnected nature of carbon sequestration, water quality, and likely other co-benefits associated with conservation practice adoption in the agricultural sector. More formal and systematical investigation of these interconnected relationships are needed for sound policy design and assessment.

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