Water Quality Benefits Estimator: A Tool for Estimating Edge-of-Field Outcomes/Benefits Provided by Conservation Practices on Cultivated Cropland

Introduction

The Water Quality Benefits Estimator (WQBE) tool provides an estimation of the reductions in wind erosion losses, edge-of-field sediment losses, and edge-of-field nutrient losses associated with conservation practice adoption on cropland through USDA programs. The amount of sediment and nutrients prevented from leaving the edge of the field can be estimated using the WQBE based on the known acres treated by each conservation practice implemented through the assistance of NRCS Conservation Planners.

Though the NRCS National Planning and Agreements Database (NPAD) provides data on conservation practices adopted by producers with NRCS assistance each year through programs such as the Environmental Quality Incentive Program (EQIP) and the Conservation Stewardship Program (CSP), the database does not include information on existing practices or practices implemented through the assistance of other state and local partners or through the producer's own means. The impacts of any single conservation practice depend on site-specific conditions, including soils, topography, weather, management and cropping practices, and existing conservation practices. Estimating practice impacts under the assumption that no other conservation practices are in place would generally overestimate the impacts of any single practice. In order to characterize existing practice levels, and more realistically quantify the effects of new conservation practice adoption, the WQBE leverages data collected by the Conservation Effects Assessment Project (CEAP) Cropland Assessment. Uniquely, the CEAP survey captures all avenues of practice implementation on the surveyed points and can be used to provide a clearer picture of the likelihood of practices being applied together.

The CEAP Cropland Assessment draws from the CEAP I (2003–2006) and CEAP II (2013–2016) farmer surveys conducted jointly by NRCS and the National Agricultural Statistics Service (NASS), and from Agricultural Policy Environmental Extender (APEX) model results estimating conservation effects at the field scale. The CEAP Farmer Survey includes three years of crop and conservation history, regardless of whether NRCS was involved with implementing the practices. These data represent the most complete dataset available on what practices are in place on a statistically representative sample of cropland covering the contiguous United States. The data sample for this survey is derived from the National Resources Inventory (NRI), and data points collected in the survey are statistically weighted based on the sample's representation of cultivated cropland in the contiguous U.S. From this rich dataset we can observe and characterize the prevalence of specific practice types and the combinations in which they occur.

The estimation of erosion, sediment, and nutrient loss reductions resulting from conservation practices relies on modeled results of survey data obtained during the CEAP I and CEAP II Farmer Surveys. Cropping practices, including planting, harvesting, tillage, nutrient applications, pesticide applications, and irrigation, as well as implemented conservation practices and planned cropping rotations provided by producers in the surveys are used as inputs to the APEX model. The CEAP modeling framework enables calculation of site-specific average annual per-acre reduction estimates of erosion, sediment, nitrogen (N), and phosphorus (P) losses. Four resource concerns with direct or indirect water quality benefit outcomes are incorporated into the WQBE:

- Sediment, tons/acre
- Total N loss, lbs/acre

- Total P loss, lbs/acre
- Wind erosion, tons/acre

These average per-acre loss reduction estimates, in combination with NRCS NPAD data on conservation practice adoption in a given fiscal year can provide a more informed and accurate estimate than could be done in the absence of existing conservation practice data. Methodology for the calculations underlying the tool is explained in greater detail below.

Methods

The benefits from a specific practice or combination of practices applied to a land unit through USDA programs between 2019 and 2024 are calculated by multiplying the total acres treated each year by specific conservation practices or sets of practices (using NRCS NPAD data) by the per-acre average annual loss reductions for the four outcomes estimated through the use of the APEX modeling results. The results show the estimated reductions in erosion via wind, edge-of-field sediment losses, and edge-of-field nutrient losses from the application of conservation practices with NRCS assistance.

Geographical Considerations

Outcomes from conservation practices applied on cropland vary by cropping system and geographical location. The USDA Economic Research Service (USDA-ERS) has developed Crop Production Regions to group together regions that are climatically and agriculturally similar (Appendix A: Map 1). Various USDA agencies use the Crop Production Regions to analyze and report results, and unique WQBE loss reduction estimates are calculated for each Crop Production Region to account for geographical and cropping variability.

Conservation Systems Approach

To obtain the greatest benefits, conservation practices should be implemented in a systems approach to address the field or farm's resource concerns fully. Complementary practices applied together provide greater benefits than when practices are applied alone. The WQBE procedure assigns each NRCS conservation practice to one of seven functional groups (Appendix B: Table 1) to account for the benefits associated with systems of practices, and these groups are applied to both NPAD and CEAP data in the analysis.

The seven **functional groups** include:

- Overland flow control, such as terraces and contour farming,
- Concentrated flow control, such as grassed waterways and grade stabilization structures,
- Trapping practices, such as filter strips and riparian forest buffers,
- Wind erosion management, such as windbreaks and hedgerow plantings,
- Residue management including no-till and other conservation tillage management,
- Nutrient management, and
- Cover crops including conservation cover.

Because NRCS conservation planning encourages suites of practices to address multiple resource concerns on a field, 128 combinations of the functional groups were developed for the WQBE procedure to estimate the benefits of combinations of practices. These combinations are called **practice groups** and include 63 practice groups without cover crops, 64 combinations with cover crops, and one no-practice group (Appendix C: Table 2). Cover crops were treated differently because they do not fit in every cropping system and can only be incorporated into a rotation if adequate time is available for the cover crop to become established and provide the intended benefits before it is terminated in preparation for the next cash crop.

To estimate the benefits of the suites of practices, each CEAP cropland point was assigned a practice group based on the conservation practices (e.g., terraces, filter strips, windbreaks, etc.) and management practices (e.g., tillage, nutrient management, cover crops, etc.) reported by producers in the CEAP Farmer Survey. In addition to the combination of practices implemented at a point, the location (which provides the climate variables) and soils (which provide leaching and runoff vulnerability) on the CEAP point influenced the degree of benefits provided by the conservation practices.

As previously mentioned, the NRCS NPAD data do not include information on existing practices before NRCS assistance at the field level. To account for the benefits of the existing practices in combination with the practices reported in the NPAD database, the benefits of a reported conservation practice are estimated as an average of the practice groups including the functional group for which that practice is included in. For example, if a terrace (part of the overland flow functional group) is reported as applied on cropland without the inclusion of cover crops, the benefits will be calculated as an average of the benefits associated with any practice group including the overland flow control functional group and without cover crops. In this case, that would be the average of the benefits of practice groups 33-64 since each of those practice groups includes overland flow control but not cover crops. Importantly, the benefits of all combinations of functional groups are weighted by the NRI CEAP weights to account for all practices applied, including those not reported in NPAD. Using NRI CEAP weights ensures estimates are statistically representative of the total cropland conservation levels and prevents a particular combination from being overrepresented in comparison to CEAP Farmer Survey data.

Per-Acre Benefit Estimates

Benefit estimates (i.e., erosion, sediment, and nutrient loss reductions) for each CEAP point are calculated using APEX modeled loss estimates. These loss estimates are determined by the combination of functional groups (which make up a practice group) on the point as well as the climate, agronomic factors, and soil vulnerability at the specific location. To determine the weighted average annual per-acre benefits for a given practice group within a Crop Production Region, the benefits of the applied conservation practices are calculated for each point and averaged across all points within the Crop Production Region with the practice group. Returning to the terrace example above, a point with a terrace alone would be in practice group 33, for overland flow control. The per-acre benefits for that practice group are the weighted average of the benefits of practice groups 33-64 since each of those practice groups includes overland flow control but not cover crops. These weighted average benefit estimates help to consider practice combinations that may be common so that those existing benefits are associated with the reported NRCS-funded practice adoption data from NPAD.

Benefits are estimated for each practice group using a “with-and-without practices” comparison. The “with practices” loss estimates were assessed from the APEX simulations of the “baseline” scenario comprised of the conservation and management practices reported by farmers in the CEAP surveys (2003-2006 and 2013-2016). To estimate benefits for practice groups containing cover crops, all CEAP points were also modeled in APEX with cover crops added to the baseline scenario (this is referred to as the Bcc “baseline + cover crop” scenario). More detailed information about modeling treatment scenarios is available in Appendix D.

The “without-practices” loss estimates were assessed from the APEX simulations of the “no-practice” scenarios. These scenarios represent the maximum losses that would be expected without any conservation practices in use. In the “no-practice” scenarios conservation practices are removed, or their effects are reversed in the model simulations to simulate the lack of conservation efforts, while maintaining modern farming practices. The “no-practice” scenarios are detailed in Appendix D.

From the practice group assigned to the point based on the conservation practice functional groups present on the CEAP survey point, the calculation of the benefits of the combination of practices implemented on a particular point were calculated as the losses under the "no-practice" scenario minus the losses under the "with-practices" scenario.

To determine the benefits of a group of practices, the acreage-weighted average of the difference in losses between the "with-practices" and "without-practices" scenarios were calculated for all the points in a particular practice group for each crop production region. For cases where no CEAP points occurred in a region for a particular practice group, no benefit estimate was able to be calculated. As more data become available through future CEAP surveys, these estimates will be updated to include additional region and practice group combinations.

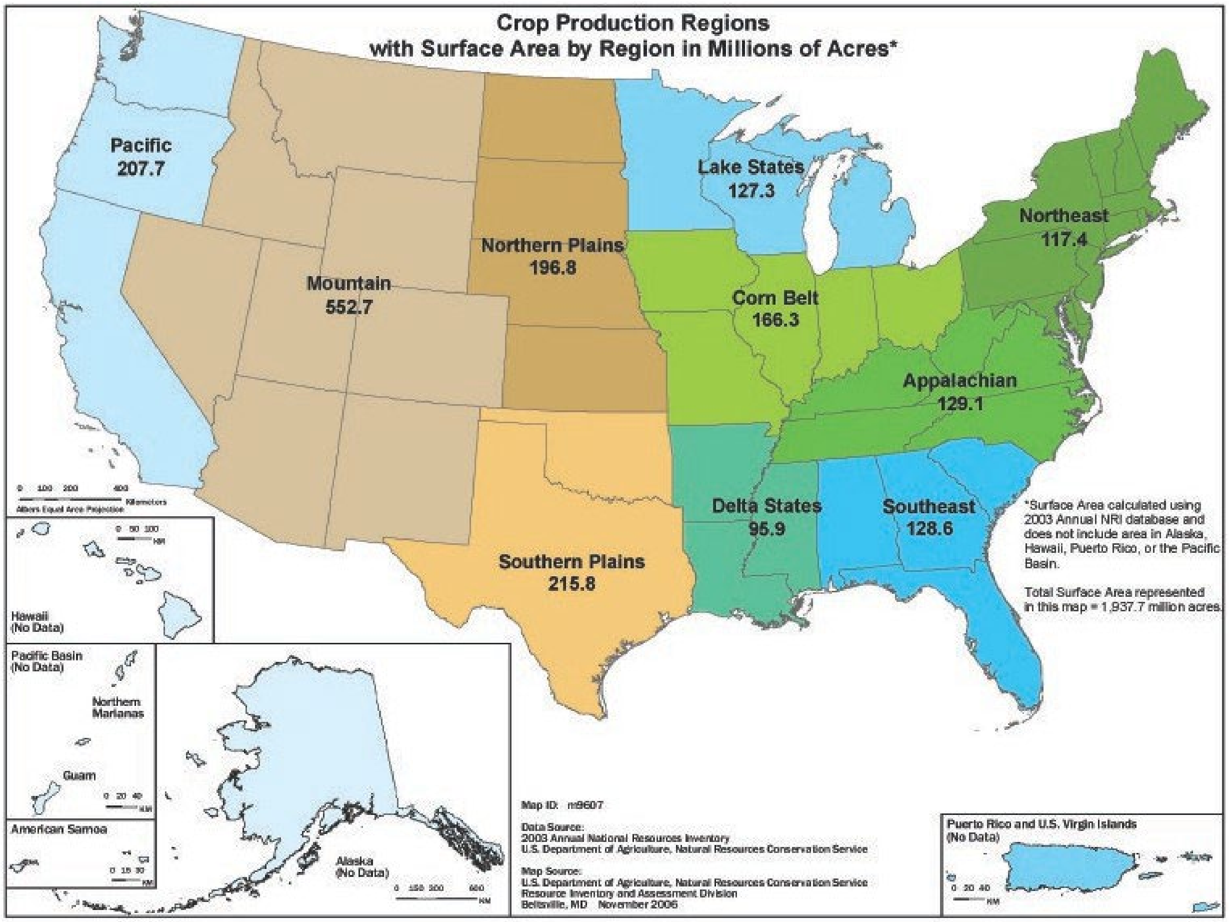
Application of Benefit Outcomes

To calculate the benefits of conservation practices applied through various NRCS programs each year, the number of land unit acres treated each year with a practice or combination of practices must first be determined from NPAD data. Based on the practices identified in NPAD for a particular land unit, a practice group is assigned to the land unit acreage as described in the Conservation Systems Approach section. The benefits provided by those practices can then be calculated by multiplying the total treated acres in the land unit by the appropriate regional average annual per-acre benefit estimate provided through the benefit estimate calculations previously described. These values represent the total savings in terms of sediment, nitrogen, phosphorus, and soil loss via wind erosion prevented from leaving the edge of the field and entering the stream systems.

The WQBE application presents results representing all NPAD practices within the specified timeframe, regardless of which conservation programs were used to provide assistance. To calculate program-specific benefits, the same procedure can be used for per acre benefits, and the total acreage by which the per-acre benefits are multiplied can be restricted to the NPAD data for the chosen program.

Appendix A. Crop Production Regions

Map 1. Crop Production Regions as determined by the USDA Economic Research Service.



Appendix B. Classification of NRCS Conservation Practices into Seven Functional Groups

Table 1. NRCS Practice Classification by Functional Group.

1=functional group assigned to practice.

NRCS Practice	Practice Code	Functional Groups						
		Control: Overland Flow	Control: Conc. Flow	Trap	Wind	Residue MGMT	Nutrient MGMT	Cover Crops
Alley Cropping	311	1	0	0	0	0	0	0
Conservation Cover	327	0	0	0	0	0	0	1
Residue and Tillage Management, No Till/Strip Till/Direct Seed	329	0	0	0	0	1	0	0
Contour Farming	330	1	0	0	0	0	0	0
Contour Orchard and Other Fruit Areas	331	1	0	0	0	0	0	0
Contour Buffer Strips	332	0	0	1	0	0	0	0
Cover Crop	340	0	0	0	0	0	0	1
Critical Area Planting	342	0	0	1	0	0	0	0
Residue and Tillage Management, Seasonal	344	0	0	0	0	1	0	0
Residue and Tillage Management, Mulch Till	345	0	0	0	0	1	0	0
Residue and Tillage Management, Ridge Till	346	0	0	0	0	1	0	0
Sediment Basin	350	0	0	1	0	0	0	0
Diversion	362	0	1	0	0	0	0	0
Multi-Story Cropping	379	1	0	0	0	0	0	0
Windbreak/Shelterbelt Establishment	380	0	0	0	1	0	0	0
Field Border	386	1	0	0	0	0	0	0
Riparian Herbaceous Cover	390	0	0	1	0	0	0	0
Riparian Forest Buffer	391	0	0	1	0	0	0	0
Filter Strip	393	0	0	1	0	0	0	0
Grade Stabilization Structure	410	0	1	0	0	0	0	0
Grassed Waterway	412	0	1	0	0	0	0	0
Hedgerow Planting	422	0	0	0	1	0	0	0
Hillside Ditch	423	0	1	0	0	0	0	0
Anionic Polyacrylamide (PAM) Erosion Control	450	1	0	0	0	0	0	0

NRCS Practice	Practice Code	Functional Groups						
		Control: Overland Flow	Control: Conc. Flow	Trap	Wind	Residue MGMT	Nutrient MGMT	Cover Crops
Row Arrangement	557	0	0	0	1	0	0	0
Runoff Management System	570	1	0	0	0	0	0	0
Stripcropping	585	1	0	0	0	0	0	0
Structure for Water Control	587	0	1	0	0	0	0	0
Cross Wind Ridges	588	0	0	0	1	0	0	0
Cross Wind Trap Strips	589C	0	0	0	1	0	0	0
Nutrient Management	590	0	0	0	0	0	1	0
Terrace	600	1	0	0	0	0	0	0
Vegetative Barrier	601	0	0	1	0	0	0	0
Herbaceous Wind Barriers	603	0	0	0	1	0	0	0
Tree/Shrub Establishment	612	0	0	1	0	0	0	0
Water and Sediment Control Basin	638	0	0	1	0	0	0	0
Windbreak/Shelterbelt Renovation	650	0	0	0	1	0	0	0

Appendix C. Combination of Functional Groups into Practice Groupings

Table 2. Practice Groups for Combinations of Functional Groups

Practice Group ID	CONTROL Overland	CONTROL Concentrated	TRAP	Wind	Residue MGMT	Nutrient MGMT	Cover Crops
1	0	0	0	0	0	0	0
2	0	0	0	0	0	1	0
3	0	0	0	0	1	0	0
4	0	0	0	0	1	1	0
5	0	0	0	1	0	0	0
6	0	0	0	1	0	1	0
7	0	0	0	1	1	0	0
8	0	0	0	1	1	1	0
9	0	0	1	0	0	0	0
10	0	0	1	0	0	1	0
11	0	0	1	0	1	0	0
12	0	0	1	0	1	1	0
13	0	0	1	1	0	0	0
14	0	0	1	1	0	1	0
15	0	0	1	1	1	0	0
16	0	0	1	1	1	1	0
17	0	1	0	0	0	0	0
18	0	1	0	0	0	1	0
19	0	1	0	0	1	0	0
20	0	1	0	0	1	1	0
21	0	1	0	1	0	0	0
22	0	1	0	1	0	1	0
23	0	1	0	1	1	0	0
24	0	1	0	1	1	1	0
25	0	1	1	0	0	0	0
26	0	1	1	0	0	1	0
27	0	1	1	0	1	0	0
28	0	1	1	0	1	1	0
29	0	1	1	1	0	0	0
30	0	1	1	1	0	1	0
31	0	1	1	1	1	0	0
32	0	1	1	1	1	1	0
33	1	0	0	0	0	0	0
34	1	0	0	0	0	1	0
35	1	0	0	0	1	0	0
36	1	0	0	0	1	1	0
37	1	0	0	1	0	0	0
38	1	0	0	1	0	1	0
39	1	0	0	1	1	0	0
40	1	0	0	1	1	1	0
41	1	0	1	0	0	0	0
42	1	0	1	0	0	1	0
43	1	0	1	0	1	0	0
44	1	0	1	0	1	1	0

Practice Group ID	CONTROL Overland	CONTROL Concentrated	TRAP	Wind	Residue MGMT	Nutrient MGMT	Cover Crops
45	1	0	1	1	0	0	0
46	1	0	1	1	1	0	0
47	1	0	1	1	1	1	0
48	1	1	0	0	0	0	0
49	1	1	0	0	0	1	0
50	1	1	0	0	1	0	0
51	1	1	0	0	1	1	0
52	1	1	0	1	0	0	0
53	1	1	0	1	0	1	0
54	1	1	0	1	1	0	0
55	1	1	0	1	1	1	0
56	1	1	1	0	0	0	0
57	1	1	1	0	0	1	0
58	1	1	1	0	1	0	0
59	1	1	1	0	1	1	0
60	1	1	1	1	0	0	0
61	1	1	1	1	0	1	0
62	1	1	1	1	1	0	0
63	1	1	1	1	1	1	0
64	1	0	1	1	0	1	0
65	0	0	0	0	0	1	1
66	0	0	0	0	1	0	1
67	0	0	0	0	1	1	1
68	0	0	0	1	0	0	1
69	0	0	0	1	0	1	1
70	0	0	0	1	1	0	1
71	0	0	0	1	1	1	1
72	0	0	1	0	0	0	1
73	0	0	1	0	0	1	1
74	0	0	1	0	1	0	1
75	0	0	1	0	1	1	1
76	0	0	1	1	0	0	1
77	0	0	1	1	0	1	1
78	0	0	1	1	1	0	1
79	0	0	1	1	1	1	1
80	0	1	0	0	0	0	1
81	0	1	0	0	0	1	1
82	0	1	0	0	1	0	1
83	0	1	0	0	1	1	1
84	0	1	0	1	0	0	1
85	0	1	0	1	0	1	1
86	0	1	0	1	1	0	1
87	0	1	0	1	1	1	1
88	0	1	1	0	0	0	1
89	0	1	1	0	0	1	1
90	0	1	1	0	1	0	1
91	0	1	1	0	1	1	1
92	0	1	1	1	0	0	1

Practice Group ID	CONTROL Overland	CONTROL Concentrated	TRAP	Wind	Residue MGMT	Nutrient MGMT	Cover Crops
93	0	1	1	1	0	1	1
94	0	1	1	1	1	0	1
95	0	1	1	1	1	1	1
96	1	0	0	0	0	0	1
97	1	0	0	0	0	1	1
98	1	0	0	0	1	0	1
99	1	0	0	0	1	1	1
100	1	0	0	1	0	0	1
101	1	0	0	1	0	1	1
102	1	0	0	1	1	0	1
103	1	0	0	1	1	1	1
104	1	0	1	0	0	0	1
105	1	0	1	0	0	1	1
106	1	0	1	0	1	0	1
107	1	0	1	0	1	1	1
108	1	0	1	1	0	0	1
109	1	0	1	1	1	0	1
110	1	0	1	1	1	1	1
111	1	1	0	0	0	0	1
112	1	1	0	0	0	1	1
113	1	1	0	0	1	0	1
114	1	1	0	0	1	1	1
115	1	1	0	1	0	0	1
116	1	1	0	1	0	1	1
117	1	1	0	1	1	0	1
118	1	1	0	1	1	1	1
119	1	1	1	0	0	0	1
120	1	1	1	0	0	1	1
121	1	1	1	0	1	0	1
122	1	1	1	0	1	1	1
123	1	1	1	1	0	0	1
124	1	1	1	1	0	1	1
125	1	1	1	1	1	0	1
126	1	1	1	1	1	1	1
127	0	0	0	0	0	0	1
128	1	0	1	1	0	1	1

Appendix D. CEAP Cropland Scenario Descriptions

Baseline (B): The baseline scenario represents the practices already in place. Structural practices are modeled as determined by the CEAP Farmer Survey, NRCS Field Office supplemental survey and NRI data. Practice 590 (Nutrient Management) is modeled based solely on the Nitrogen and Phosphorus Management Rating determined by the rate, timing, and method of application on each point. A point must have a rating of Moderately High or higher in both nitrogen and phosphorus management for CP590 to be modeled for that point.

Cover Crop Scenario (Bcc): Two important functions of cover crops are (1) to provide soil surface cover and reduce soil erosion, and (2) to utilize and convert excess nutrients remaining in the soil from the preceding crop into plant biomass, thereby reducing nutrient leaching and minimizing the amount of soluble nutrients in runoff during the non-crop growing season. Cover crops also contribute to soil quality by capturing atmospheric carbon in plant tissue and adding it to the soil carbon.

- Cover crops were added to each point's rotation where able in the APEX simulations.
- Cover crop added for all cases is crop #500 (Cover crop winter cover which is essentially rye)
- Cover crops are terminated using very minimal soil disturbance (STIR<5) unless otherwise specified by the producer.

No Practice (NP): Baseline practices with the benefits of nutrient management, structural practices, conservation tillage, cover crops, and irrigation practices removed.

The no-practice field condition for structural practices is simply the removal of the structural practices from the modeling process. In addition, the soil condition is changed from "Good" to "Poor" for the determination of the runoff curve number for erosion prediction.

- **Overland flow.** This group includes such practices as terraces and contouring which slow the flow of water across the field. For the practices affecting overland flow of water and therefore the P factor of the USLE-based equations, the P factor was increased to 1. Slope length is also changed for practices such as terraces to reflect the absence of these slope-interrupting practices.

- **Concentrated flow.** This group of practices is designed to address channelized flow and includes grassed waterways and grade stabilization structures. These practices are designed to prevent areas of concentrated flow from developing gullies or to stabilize gullies that have developed. The no-practice protocol for these practices removes the structure or waterway and replaces it with a "ditch" as a separate subarea. This ditch, or channel, represents a gully; however, the only sediment contributions from the gully will come from downcutting. Head cutting and sloughing of the sides are not simulated in APEX.

- **Edge of field.** These practices include buffers, filters, and other practices that occur outside the primary production area and act to mitigate the losses from the field. The no-practice protocol removes these areas and their management. When the practices are removed, the slope length is also restored to the undisturbed length that it would be if the practices were not in place. (When simulating a buffer in APEX, the slope length reported in the NRI is adjusted.)

  Wind control. Practices such as windbreaks or shelterbelts, cross wind ridges, strip-cropping or trap strips, and hedgerows are examples of practices used for wind control. The unsheltered distance reflects the dimensions of the field as modeled, 400 meters or 1,312 feet. Any practices reducing the unsheltered distance are removed and the unsheltered distance set to 400 meters.

The no-practice tillage protocols are designed to remove the benefits of conservation tillage. For all crops grown with some kind of reduced tillage, including cover crops, the no-practice scenario simulates conventional tillage, based on the STIR (Soil Tillage Intensity Rating) value. Conventional tillage for the purpose of estimating conservation benefits is defined as any crop grown with a STIR value above 80. (To put this in context, no-till or direct seed systems have a STIR of less than 20, and that value is part of the technical standard for Residue Management, No-Till/Strip Till/Direct Seed [NRCS Practice Standard 329]). Those crops grown with a STIR value of less than 80 in the baseline scenario had tillage operations added in the no-practice scenario.

Simulating conventional tillage for crops with a STIR value of less than 80 requires the introduction of additional tillage operations in the field operations schedule. For the no-practice scenario, two consecutive operations, one tandem disking and one chisel plow operation, were added prior to planting. In addition to adding tillage, the hydrologic condition for assignment of the runoff curve number was changed from good to poor on all points receiving additional tillage. Points that are conventionally tilled for all crops in the baseline condition scenario are also modeled with a “poor” hydrologic condition curve number.

The two most common types of tillage operation in the survey with large STIR values were the tandem disk and chisel plow. The tandem disk has a STIR value of 33 for a single use, and the chisel plow has a STIR value of 66. Having one use of each of these consecutively will add 99 to the existing tillage intensity, which allows for all the crops to exceed a STIR of 80 and yet maintain the unique suite and timing of operations for each crop in the rotation. These additional two tillage operations were inserted in the simulation one week prior to planting.

To simulate the removal of nutrient management, the application timing, rate, and method of application were modified to remove proper nutrient management. All fertilizer applications occurring within three weeks of the planting date were moved back to occur three weeks prior to planting. Split applications which occurred within the three-week window before or after plant date were moved to a single application three weeks before planting. All fall applications of fertilizer for a spring planted crop remained. This protocol removes the good practice of applying nutrients closer to when the plant needs them without the risk of overestimation of benefits by applying nutrients in the fall or other off-planting season dates.

The amount of nitrogen applied was adjusted accordingly. If no commercial N or manure was applied, then one operation was added 21 days preplant at a rate of N ratio * crop removal rate (see Table 3) using a surface broadcast fertilizer applicator. Procedures were developed to ensure each crop received sufficient nutrients for crop growth in the “baseline” scenario. For the No Practice Scenario, N applications were increased based on the following criteria:

- (N applied/total N) x (N ratio*crop removal rate)
- N ratio is set according to HUC2.

If no manure was applied and total N applied > (N threshold * crop removal rate), then the N application did not change. Additionally, if manure was applied and the total N applied > (N threshold * crop removal rate), then the N application amount did not change for commercial or manure applications. If, however, manure was applied and the total N applied < (N threshold * crop removal rate), then the N application was increased for commercial and manure applications based on the formula: (N applied/total N) x (N ratio*crop removal rate)

Table 3. N and P ratios and thresholds by HUC2

HUC2	N ratio	P ratio	N threshold*	P threshold
01	1.98	2.2	1.4	1.1
02	1.98	2.2	1.4	1.1
03	1.85	2.7	1.4	1.1
04	1.83	1.71	1.4	1.1
05	1.7	1.8	1.4	1.1
06	1.7	1.8	1.4	1.1
07	1.64	1.6	1.4	1.1
08	1.9	2.3	1.4	1.1
09	1.83	1.71	1.4	1.1
10	1.68	1.57	1.4	1.1
11	1.9	2	1.4	1.1
12	1.9	2	1.4	1.1
13	1.9	2.3	1.4	1.1
14	1.9	2.3	1.4	1.1
15	1.9	2.3	1.4	1.1
16	1.9	2.3	1.4	1.1
17	2	2.05	1.4	1.1
18	1.9	2.3	1.4	1.1

* N threshold for cotton is 2.9