Estimating the Water Quality Benefits of Prairie Strips Using SnapPlus

Prairie strips are taking root as a new agricultural conservation practice across the Midwest. These strips of native perennial vegetation, generally 30 feet or more in width, are placed along the contour within a farm field or at the field edge to retain rainfall and capture soil and nutrient runoff. Results from the Iowa State University STRIPS research trials show that prairie strips comprising just 10% of the land area of a row-crop field can provide disproportionately large benefits for water quality and biodiversity.[1,2]

The Soil Nutrient Application Planner (SnapPlus) is a software tool used on farms across Wisconsin to calculate soil and phosphorus (P) runoff losses on a field-by-field basis. Farmers, crop consultants, and conservation professionals use SnapPlus to account for on-farm nutrients, make informed decisions about manure and fertilizer applications, and protect water quality. SnapPlus is maintained by the University of Wisconsin Soil Science Department.

Sand County Foundation and the University of Wisconsin are using SnapPlus to compare sediment and P losses from Wisconsin farms with and without prairie strips. By estimating the reductions in farm runoff from prairie strips using SnapPlus under common farm scenarios, we can help farmers and conservation planners make decisions based on the potential effectiveness of the practice in their specific situations.

Since 2017 we have:

- Established prairie strips on six farms representing a variety of landforms and cropping systems in southern Wisconsin.
- Modeled soil erosion and P runoff using SnapPlus with input data from the Iowa State University STRIPS trials, and compared modeled results to measured runoff values.
- Estimated sediment and P runoff reductions from prairie strips using SnapPlus on three Wisconsin farms representing strip-till cash grain, no-till cash grain with hay, and organic grain cropping systems.

This document describes results of our evaluation of prairie strips using SnapPlus.

"...it's pretty apparent that they do a fantastic job of holding water back."
-Dan Stoffel, Washington County, Wisconsin Farmer

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Key Findings

Overall, our analysis supports the concept of disproportional benefits: converting a small fraction of an annually cropped field to strips of prairie vegetation yields a much greater proportional reduction in sediment and nutrient runoff leaving the field. Or in other words, a little prairie goes a long way in protecting water quality.

Using SnapPlus to model runoff with prairie strips as installed in the Iowa State University STRIPS trials, we found proportional reductions of sediment and P were similar to the reductions measured in-field.

Using SnapPlus to model runoff with prairie strips as installed on three Wisconsin farms, we found that sediment and P loss reductions were less than the results from the STRIPS trials, ranging from minimal to 60% depending on the farm's physical characteristics, cropping system, and strips design and placement (see attached farm profiles for details).

All six Wisconsin farmers who installed prairie strips through this project report that the practice is compatible with their farming operations. Prairie strips also offer biodiversity and wildlife habitat benefits not evaluated in this report.

Funding Opportunities

The Farm Service Agency now offers a CP-43 Prairie Strips practice within the Continuous Conservation Reserve Program (CRP). This program provides 10-15 year rental agreements for prairie strips at least 30 feet wide placed within a field or along field borders. In 2020, over 11,000 acres of prairie strips have been contracted under CP-43 in 13 states, including Wisconsin.

Prairie strips also provide a new option in watersheds where point-source dischargers have approval from the Wisconsin Department of Natural Resources to use nutrient trading or watershed adaptive management options for P discharge permit compliance. Credits can potentially be earned from both the area converted from annual crops to permanent vegetative cover, and the P reduction benefits on crop acres filtered by the prairie strips. SnapPlus can capture these benefits using the Filter Area function as described in the following pages.

Evaluating the Effectiveness of Prairie Strips in SnapPlus

Between 2007 and 2013, the Iowa State University STRIPS team maintained edge-of-field monitoring devices on small catchments ranging from one to eight acres in size at the Neal Smith National Wildlife Refuge in Jasper County, Iowa (Figures 1 and 2). All catchments were farmed in a soybean and corn rotation with no tillage after the first year, on slopes ranging from 6 to 11 percent.

In July 2007, prairie strips were sown in four treatments: proportions of 20% (in-field and footslope), 10% (in-field and footslope), 10% (footslope only), or zero percent of the land in each catchment. Each treatment was replicated three times, for a total of 12 catchments. Two additional catchments of 100% prairie cover were also monitored. The STRIPS researchers measured edge-of-field surface flow of water, sediment, nitrate-nitrogen, total nitrogen, and total phosphorus during each growing season utilizing H-flumes and automated water sampling devices at the outlet of each catchment.

Figure 1: Layout of six of the 12 prairie strips catchments in the Iowa State University STRIPS research trials. *Photo: Iowa State University STRIPS*

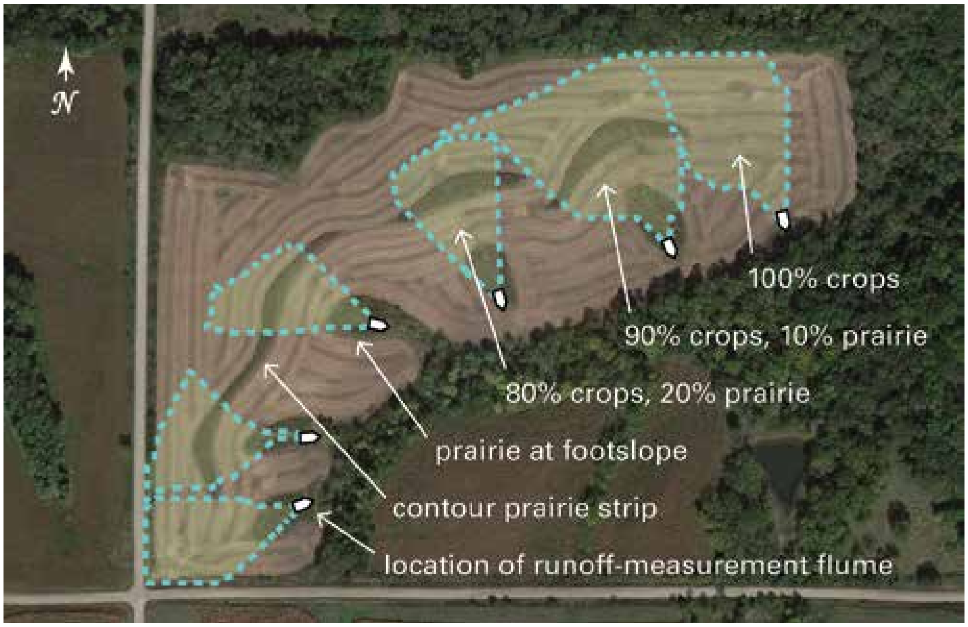


Figure 2: H-flumes comparing runoff between two STRIPS catchments (photo 1 and 2), and a nearby catchment in 100% prairie cover (photo 3). *Photo: Iowa State University STRIPS*

To assess the accuracy of SnapPlus in predicting prairie strip impacts on sediment and P runoff, Dr. Laura Ward Good from the University of Wisconsin Soil Science Department ran the models within SnapPlus on the STRIPS research trial. Dr. Good used the actual soils, slope and field management data recorded from the 12 STRIPS catchments. Long-term average rainfall data was used in place of measured precipitation.

Accounting for prairie strips in SnapPlus

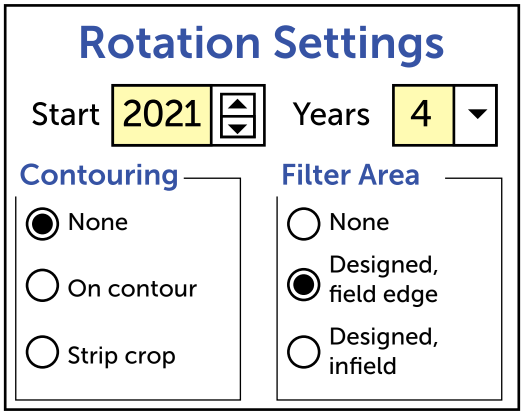
SnapPlus users can account for prairie strips by selecting one or both of the following options in the Filter Area function within the Rotation Settings window:

Turning on "Designed, field edge" assumes a strip of minimum 30 ft width at the footslope (bottom edge) of the field, regardless of the contour of the field.

Turning on "Designed, in field": assumes one or more strips of minimum 15 ft width oriented on the contour within the field, positioned at the midpoint of the dominant critical slope length. This option can only be used when the "on contour" option is also selected.

SnapPlus assumes cool season grass as the vegetation type for both Filter Area options.

Figure 3: Filter Area function in SnapPlus.



Sediment loss: comparing measured values versus RUSLE2 results

SnapPlus uses the Revised Universal Soil Loss Equation, Version 2 (RUSLE2) to calculate field sediment loss. RUSLE2 is embedded within SnapPlus, but SnapPlus does not contain Iowa soils or rainfall data in its database. Therefore, we used the RUSLE2 standalone program with the correct Iowa soil and climate data in our comparison of modeled soil loss and measured values from the STRIPS trials.

To account for year-to-year variability in the timing, amount, and intensity of rainfall, RUSLE2 uses long-term weather averages in its soil loss calculations. In the STRIPS trials, measured precipitation was highly variable and annual averages exceeded the

30-year average for most years monitored. Due to this weather variability, we do not expect RUSLE2 results to precisely match measured values in any given year.

Our RUSLE2 calculations on the STRIPS trials include three years (2004-2006) when catchments were in bromegrass and then mulch-tilled prior to beginning the corn/soybean rotation and seeding the prairie strips. We include these pre-existing conditions to enable more accurate calculations of soil loss during the runoff monitoring period. Only the 2007-2012 monitoring years are included in the averages summarized in Table 1.

Of the nine STRIPS catchments with prairie strips, all included prairie vegetation at the footslope. STRIPS researchers found no statistically significant differences in measured nutrient loss among catchments that included both in-field strips and footslope strips, compared to those with footslope strips only. Therefore, we applied RUSLE2 in accordance with the "Designed, field edge" option in SnapPlus. This represents a 30 ft grass strip added to the bottom of the critical slope, but no in-field strips, to more closely approximate a footslope prairie strip.

A comparison of estimated and measured sediment loss for all STRIPS catchments over six years of monitoring is summarized in Table 1. RUSLE2 estimates of sediment trapping efficiency of the prairie strips were similar to the measured values.

Table 1. Estimated (RUSLE2) and measured (H-flume) average annual sediment delivery for Iowa STRIPS catchments with and without prairie strips at the footslope, 2007-2012.

	Control (3 catchments)	**Treatment (9 catchments)**	**Reductions with prairie strips**
Estimated sediment (ton/ac/yr)	2.1	0.3	87%
Measured sediment (ton/ac/yr)	2.8	0.2	95%

In the STRIPS trials, due to the differences in slopes and soils, the three control catchments (with 100% crops) had a higher average inherent propensity for erosion than the nine treatment catchments (with 10% and 20% prairie). Sediment delivery for the nine treatment catchments modeled in RUSLE2 without the strips present was 1.7 ton/acre/year, compared to 2.1 ton/acre/year for the three control catchments. Taking this into consideration when comparing the same fields with and without prairie strips using RUSLE2, the estimated sediment loss reduction is 83%.

We must note that the STRIPS trials were monitored from April to October each year, missing the colder months, while RUSLE2 estimates erosion for the entire year. However, little erosion is expected to happen during these colder months. For the control catchments, RUSLE2 calculates that 97% of annual erosion occurs during this April to October period.

Phosphorus loss: comparing measured values versus the Wisconsin Phosphorus Index

SnapPlus calculates a Wisconsin Phosphorus Index (WPI) value for each field evaluated. The WPI estimates the average annual loss of total P in runoff at the outlet of a field. It uses RUSLE2 to estimate erosion and also estimates rainfall runoff using a runoff curve number and snowmelt runoff using an empirical method. It then uses information about the soils, soil test values, crop uptake and P additions to a field to estimate the concentrations of P lost in runoff annually. The WPI accounts for both soluble P (dissolved form directly available for algae growth) and particulate P (attached to eroding sediment).

To test whether the WPI is accurately estimating the effects of prairie strips on phosphorus movement, we ran WPI equations using the following data from the STRIPS trials: sediment and water volume runoff measured at the H-flumes; site soil and slope characteristics; 2007 soil test P and organic matter values; and annual crops and P fertilizer application methods, rate and timing.

Similar to the RUSLE2 evaluation, in SnapPlus we applied only the "Designed, field edge" option for the nine catchments treated with prairie strips. We then compared the calculated WPI values with measured total P losses from all STRIPS catchments averaged over a five-year monitoring period. Results are summarized in Table 2.

Table 2. Estimated (WPI) and measured (H-flume) average annual phosphorus (P) delivery from corn/soybean fields in Iowa with and without prairie strips at the footslope, April-October 2007-2011.

	Control (3 catchments)	Treatment (9 catchments)	Average phosphorus reduction
Wisconsin P Index (lb/ac/yr)	7	1.1	85%
Average measured P (lb/ac/yr)	7.4	0.8	89%

The above analysis references the predominant soil type of each catchment rather than the dominant critical soil. This is a more conservative approach to modeling P loss reduction, used by the Wisconsin Department of Natural Resources in calculating P reduction credits for nutrient trading.

One caveat to using results from the STRIPS trials to assess P reductions from prairie strips in Wisconsin is that the STRIPS trials did not conduct runoff monitoring during winter months. While very little soil erosion occurs during the colder months, a substantial proportion of the annual P load can be lost during these months in dissolved form in runoff from frozen and thawing soils.

Recommendations to Improve Quantification of Water Quality Benefits from Prairie Strips

In general, SnapPlus appears to be reasonably accurate in modeling the influence of prairie strips on sediment and P losses during the rainfall runoff season using the "Designed, field edge" Filter Area option currently available in the program. However, there are opportunities to improve the accuracy in modeling prairie strips for Wisconsin farms.

Native grasses and forbs grow slowly, and the runoff protection benefits of deep roots, stiff stems, and perennial cover from prairie strips are not fully present until at least the third year of vegetation growth. Modeling should account for less runoff protection in these establishment years by modifying the Filter Area function to account for reduced effectiveness of prairie strips during a three-year vegetation establishment period. Also, options could be added to customize the vegetation cover of filter strips (currently assumed as cool season grass) to include one or more options for native perennial grass/forb vegetation communities.

Further research can support other enhancements to SnapPlus functionality for prairie strips, including:

Prairie strips configurations: Currently SnapPlus only offers default values representing a 30′ strip at the footslope or one or more 15′ wide in-field strips dissecting the length of the critical slope. Additional research on the effects of differing strips layout configurations on runoff is needed before investing in adding more layout options in the SnapPlus tool.

Nitrogen loss: SnapPlus does not model nitrogen losses. While phosphorus remains the primary concern in Wisconsin in relation to surface runoff, nitrogen is increasingly important, especially for protection of groundwater quality. Research is needed on prairie strips effects on nitrogen leaching and groundwater in priority regions of Wisconsin.

Runoff events on frozen ground: Runoff monitoring data from the STRIPS trials span the growing season (April to October). However, in Wisconsin runoff risk is highest during late winter/early spring snowmelt or rain events over frozen ground, particularly in March. Research is needed on the effects of prairie strips on runoff during these conditions, especially concerning dissolved P.

For more information visit:

Sand County Foundation
www.sandcountyfoundation.org/PrairieStrips

Iowa State University's STRIPS project
www.prairiestrips.org

Or contact Craig Ficenec, Sand County Foundation Program Director, 608.663.4605 x22, cficenec@sandcountyfoundation.org

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[1] Schulte et al., 2017. Proceedings of the National Academy of Sciences. 114:50(11247-11252), https://www.pnas.org/content/114/42/11247

[2] X. Zhou, M.J. Helmers, H. Asbjornsen, R. Kolka, M.D. Tomer and R.M. Cruse. Journal of Soil and Water Conservation January 2014, 69 (1) 54-64; DOI: https://doi.org/10.2489/jswc.69.1.54

Prairie Strips Farm Profile

Stoffel Grain Farm

Dan Stoffel grows corn, soybeans and alfalfa on rolling terrain in Washington County with his brothers, Lee and Tim. Prior to returning home to farm, Dan worked as a biochemist. He is also a beekeeper. The Stoffels farm with no-till and cover crops, but Dan still observed water flow on his fields that concerned him. He decided to try prairie strips both to intercept runoff and provide forage for his bees.

In June 2017, Eco-Resource Consulting, Inc. seeded three prairie strips with a Great Plains drill; and in June 2018, Sand County Foundation seeded a fourth strip with an ATV-driven Kasko drill seeder provided by Wings over Wisconsin. All three fields receiving strips were between soybeans and oats/alfalfa in their rotation—an ideal situation as soybeans leave minimal residue to interfere with strips seeding, and alfalfa minimizes runoff during the first three years of establishment for the slower growing native vegetation in the strips.

These four prairie strips on three fields provide good examples of how different placements of strips can be evaluated in SnapPlus. The two strips in Field A follow the contour while the single strips in Field B and Field C are straight and do not follow the contour. All strips were placed to maintain efficient field operations, allowing Dan to make full passes with his planter and sprayer on his crops adjacent to the strips without leaving any point rows.

"They meet the contour as the contour lays, so that any water running down them is intercepted by any part of the field that the water happens to be flowing on. It's pretty apparent that they do a fantastic job of holding water back."

– Dan Stoffel

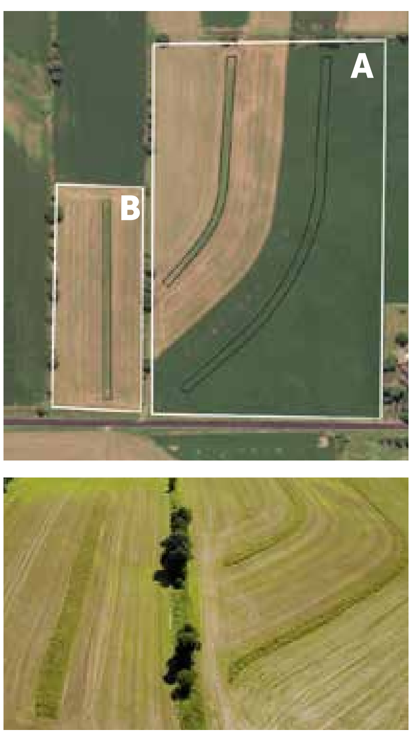
Table 1. Expected reductions in soil and P loss following prairie strip installation.

						Soil loss (Ton/acre/year)		P index on critical slope (lb/acre/year)	
Field	**Field acres**	**Strips acres**	**Strips dimen-sions**	**% of field in strips**	**Average field slope**	**No strips**	**With strips**	**No strips**	**With strips**
A	14.1	1.4	25 x 2450	10%	12%	0.21	0.16	1	1
B	5.8	0.4	25 x 680	5%	10%	No change		No change	
C	8.9	0.6	25 x 1080	7%	8%	No change		No change	

SnapPlus Evaluation:

This well-managed no-till farm already had comparatively low soil and phosphorus (P) runoff loss rates prior to installing prairie strips. In Field A, two prairie strips in series reduce the sediment losses even further. This field is divided into contour strips but because some of the field is planted to continuous row crops with no years of hay, the field cannot be considered as a strip crop system in SnapPlus.

Since the prairie strips are on the contour and have a width of at least 15 feet (both strips are 25′ wide), they can be counted as “Designed, in field” under the Filter Area function in SnapPlus. Using the field’s historical rotations and manure and fertilizer applications, we ran SnapPlus to estimate erosion and runoff phosphorus loss (P Index) on the field with and without strips. Both soil loss and the P Index are calculated for the most erosion prone area making up at least 10% of the field, following the NRCS dominant critical slope concept for estimating erosion for conservation planning.



Field A with two in-field strips on contour, and Field B with one in-field strip not on contour.

Field C with one in-field strip, not on contour.

We calculated the area-weighted averages of the soil loss and the P Index for each field treated by the prairie strips (Table 1). We also added the strips as exclusion areas in SnapMaps (the spatial mapping tool within SnapPlus), thus removing the strip acres from the cropped acres accounted for in SnapPlus.

We found that the prairie strips reduce soil loss even further, but the P Index does not change noticeably. The reason for no reduction in estimated P losses on the dominant critical slope is because erosion was already so low that the majority (60%) of estimated P losses from the field are in the dissolved form rather than attached to eroding particles. Much of the dissolved phosphorus load is expected to come at the time of snowmelt and runoff from thawing soil. As we do not have evidence that prairie strips reduce dissolved phosphorus runoff losses in frozen conditions, we assume the strips have no impact on this portion of P loss.

The prairie strips seeded in Field B and Field C do not meet the criterial for the "Designed, in field" option under the Filter Area function of SnapPlus because they do not follow the contour. In addition, the strip in Field C is intersected by an area prone to concentrated flow, potentially bypassing the filtering benefit of the prairie vegetation. While these strips likely do still have value for filtering sediment and phosphorus losses from upslope cropped areas, SnapPlus cannot account for this.

Regardless of the Filter Area function designation in SnapPlus, all strips do remove some of the steeper, more erodible parts of the fields from production, and give them year-round vegetative cover. SnapPlus does account for phosphorus and sediment loss reductions that result from putting these areas of the fields into perennial cover. This is demonstrated in the SnapPlus "P Trade" report comparing these fields with and without the prairie strips. Table 2 shows this small annual phosphorus loss reduction from the strips as calculated in the P Trade report. These reductions are in proportion to the area converted to prairie and are small because the baseline annual P losses on this farm are already low.

Table 2. Results from SnapPlus P Trade Report.

Field	**Average "P Trade" (lb P per field per year)**
A	2.8
B	0.2
C	0.3

Prairie StripsFarm Profile

Hammer-Kavazanjian Farm

Charlie Hammer and Nancy Kavazanjian farm 1,900 acres in Dodge County, Wisconsin, growing corn, soybeans, wheat, and barley. Charlie has been refining strip tillage, no-till and cover crop practices for over 20 years. He has served as a director on the Wisconsin Corn Growers Association and shares his experiences frequently at field days and events. Nancy has served as a representative on the United Soybean Board and the U.S. Farmers & Ranchers Alliance. In 2020 she received the American Soybean Association's Conservation Legacy Award.

Charlie and Nancy sought to address soil erosion on approximately 60 acres where a drumlin bisects a field. With help from their agronomist, Bill Stangel, Charlie and Nancy seeded 6 acres of prairie strips with a native seed drill in December 2019. The majority of the field had been recently seeded to winter wheat, which was then clipped over the footprint of the strips in the spring to allow sunlight to reach the germinating prairie species below.

Concurrent with determining a layout for the prairie strips, Charlie and Bill re-designed the planting pattern on this field to follow the contour and align with the orientation of the strips to the extent practical. The farm utilizes precision technology to turn off the planting and application equipment when necessary to cross the prairie strips.

Layout of prairie strips is visible as mowed paths through soybeans and recently harvested winter wheat. Newly emerging prairie vegetation is not yet visible beneath wheat stubble.

Field with two prairie strips on contour and additional strips on headlands.

Table 1. Expected reductions in soil and P loss following prairie strip installation

					Soil loss (Ton/acre/year)		P index on critical slope (lb/acre/year)	
Field acres	**Strips acres**	**Strips dimensions**	**% of field in strips**	**Average field slope**	**No strips**	**With strips**	**No strips**	**With strips**
63	6	60 x 4,500	8%	6%	1.5	0.6	2	1

SnapPlus evaluation:

Due to minimal tillage, soil and phosphorus (P) losses in the field prior to seeding the strips was relatively low despite the drumlin slopes. Soil test values for P were optimal and fertilizer P applications were in balance with crop uptake across the rotation. Soil loss and P Index calculations were made for the steeper part of the drumlin with a Mendota silt loam soil and 9% slope. Estimated soil loss from the drumlin area in the absence of prairie strips was 1.5 T/acre/year and the P Index was 2.

The two 60′ wide prairie strips are located on-contour within the field, meeting NRCS criteria for the Contour Buffer Strip 332 practice standard. To account for these strips, we utilized the "Designed, in field" grass filter area option in SnapPlus. Establishing a contour prairie strip on the slope lowered the estimated soil loss on the dominant critical slope from 1.5 to 0.6 T/acre/year (a 60% reduction) and cut the P Index value in half, from 2 to 1.

Another method to examine the effect of prairie strips is to use the "P Trade" calculation in SnapPlus. This uses P Index equations to estimate per-acre runoff P loss from the soil type that makes up the majority of the field, which is then multiplied by the cropped acres in the field. The resulting P Trade Report shows reductions that can be utilized by a regulated wastewater utility in the same watershed to receive a P reduction credit under the Wisconsin DNR Nutrient Trading permit compliance option. P Trade phosphorus loss reductions from this field result from both the cropland runoff control provided by the prairie strips and the removal of the area in strips from the cropped acres. For this field, the P trade reduction was 54% (36 lbs P).