Evaluating the Effects of Perennial Grass Filter Strips on Potentially Mineralizable Carbon

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Topic Background

Erosion is one of the most important environmental problems in agricultural regions today and is a serious threat to soil fertility. As such, it is necessary to evaluate different techniques in erosion control across areas with intensive activity. Scientists at Iowa State University experimented with different treatments of Perennial Grass Filter Strips (PFS) at Neal Smith National Wildlife Refuge (NSNWR) in Jasper County, IA and were able reduce sediment loss from 12 predodominantly row-cropped hillslope watersheds[1].

Will adding PFS also minimize loss of potentially mineralizable carbon, the active amount of soil organic carbon (SOC) cycling, in the same watersheds? Possibly...although it is unsure whether erosion sequesters carbon in the soil matrix or mineralizes it to CO2. To summarize, some agronomists argue that erosion breaks down soil aggregates and exposes carbon to the surface, allowing it to mineralize. Sedimentologists claim that erosion stores carbon in depositional basins, slowing down decomposition and mineralization[2].

Understanding the from erosion within these watersheds is crucial in understanding the role of PFS in carbon cycling. Does erosion alter carbon fluxes in a way that carbon transport rates are disproprtionatly larger than inputs? This is important: erosion can drastically reduce the amount of carbon needed to grow crops and sustain soil microbes. We hypothesize that adding PFS at NSNWR stores more carbon in watersheds and reduces loss from erosion. Thus, it is expected that mineralization increases in watersheds with PFS because soil erosion is less intense. Specifically, we are interested in discovering spatial patterns in mineralization depending on PFS location in the watershed.

Methods

I. Sample Collection & Preliminary Work

- Soil samples collected on July 11, 2013 in 6 watersheds with varying PFS at NSNWR (Table 1).
- Collected at 2 depths, 5 cm and 10 cm, across 5 locations along the hillslope per watershed.
- Labeled based on watershed ID, location, and depth. For example, O2 S1-5cm is the sample taken in watershed O2, site 1 (top of slope), and at 5 cm depth.
- Samples taken back to the labratory and stored at 5 C until Janurary 2014.
- 60% of water holding capacities were determined.
- 10 g of each oven-dried sample was placed into a 120 ml or 165 ml glass bottle.

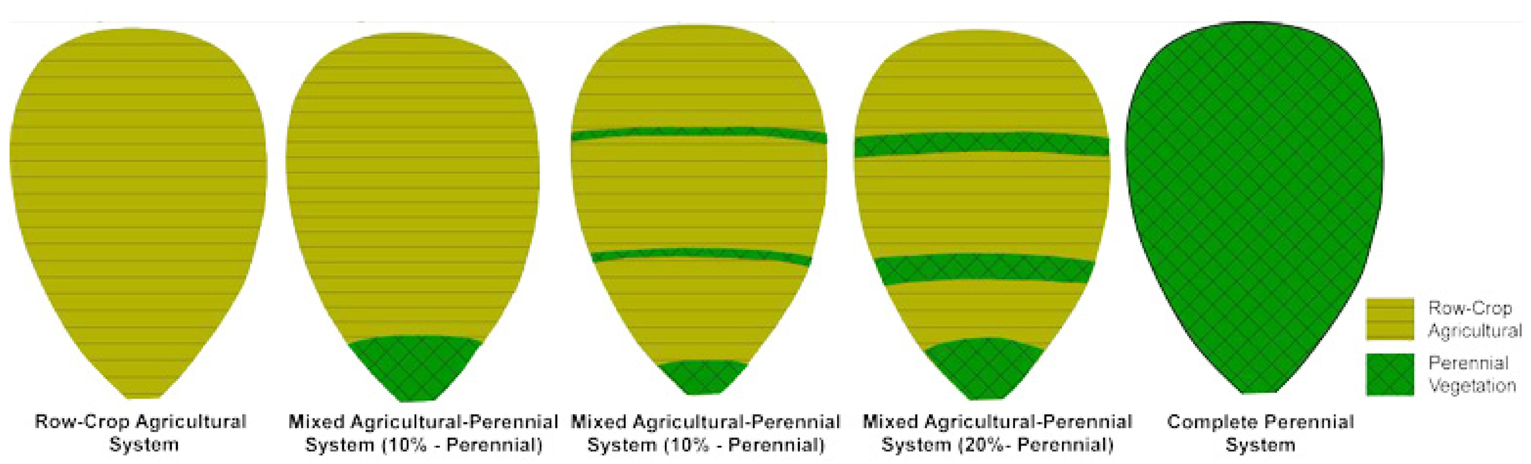

Figure 1: Various PFS treatments used in study except 100% perennial. Image courtesy of website *Strips at Neal Smith*

II. Incubation Period

Watershed & ID	PFS Treatment
Orbweaver 1 (Or61)	10% PFS at Toe Slope
Orbweaver 2 (O2)	3.3% Top, 3.3% Side, 3.3% Toe Slope
Orbweaver 3 (O3)	All rowcrops
Interm 1 (I1)	6.66% Top, 6.66% Side, 6.66% Toe Slope
Interm 2 (I2)	10% PFS at Toe Slope
Interm 3 (I3)	All rowcrops

Table 1: Watersheds sampled and their PFS treatment

The incubation period lasted 25 days. Measurements done using LI-COR infrared gas analyzer. <u>For each day:</u>

- All samples were saturated to 60% of water holding capacity.
- Linear calibration curve determined using a reference concentration of 1000 ppm CO2.
- Capped each jar. Injected 1 ml of air from each into septa connected to LI-COR.
- Recorded the times capped and sample injected. Also recorded displayed intergal.
- Jars stored at room temperature and in the dark.
- 4-6 hours later, injected air sample into septa. Recorded new intergal and time injected.
- Relocated samples in darkness until next sampling day and kept them capped.

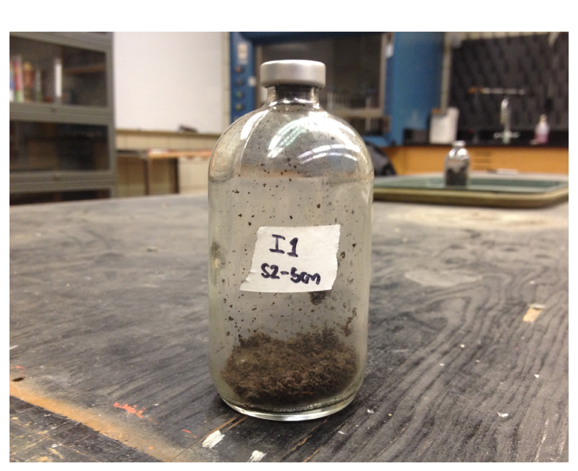

Photo: Typical glass bottle with sealed cap used for incubation. Samples appropriately labeled by watershed ID, location, and depth.

Results

For each measurement, used recorded integral as input into daily linear calibration equation. Mineralization rates calculated by subtracting the initial and final mg C for each day. Results pooled into database and used linear interpolation to calculate cumulative potentially mineralizable carbon for each day. Summed daily values to get total accuulation for 25 day period.

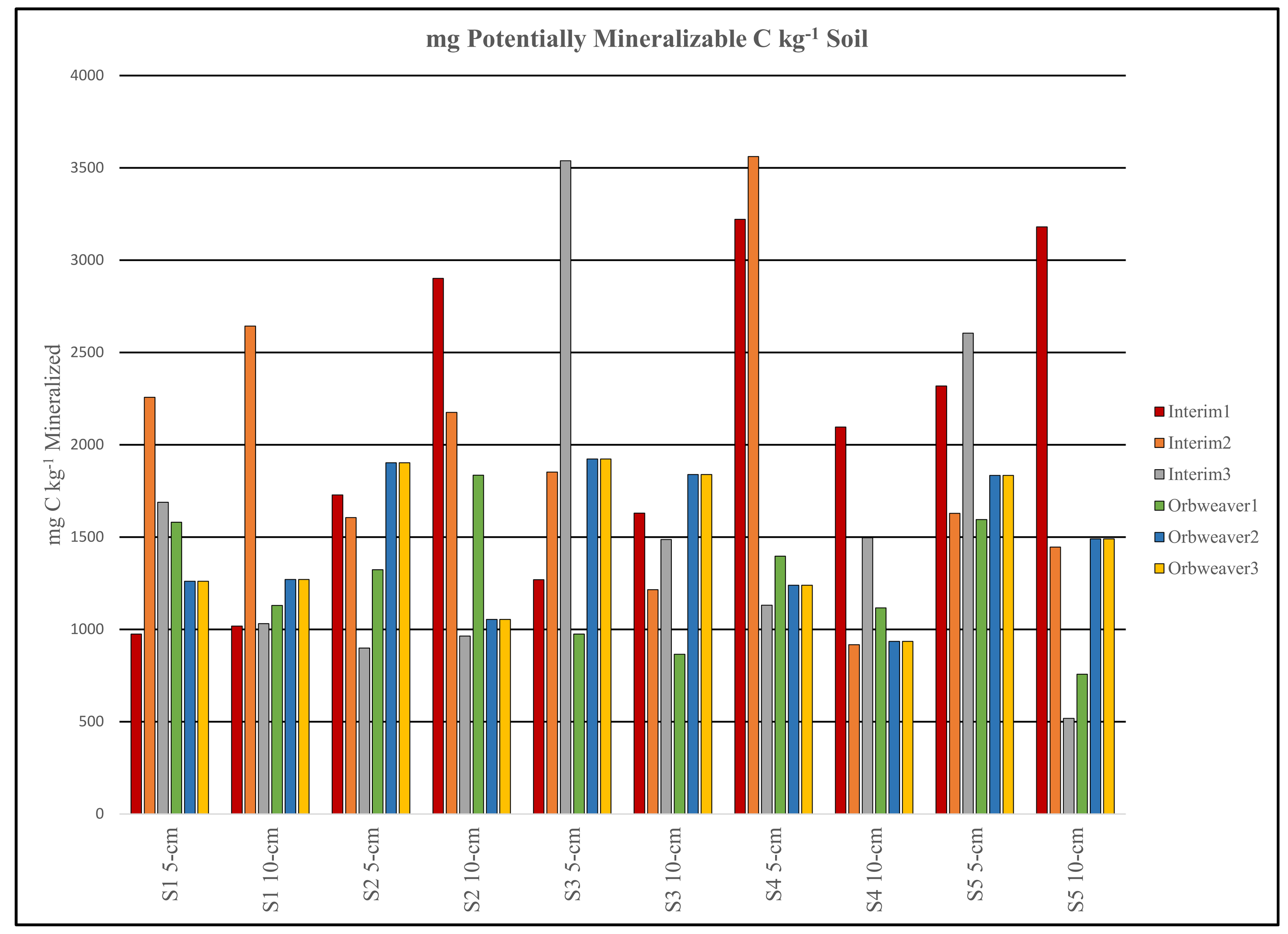

Figure 2: Mineralized carbon sorted by location sampled in watershed and depth. Values represent total sums from the 25 day incubation period. Potential mineralization appears to be concentrated at the side slope and at more shallow depths, particularly in locations S3-5cm and S4-5cm.

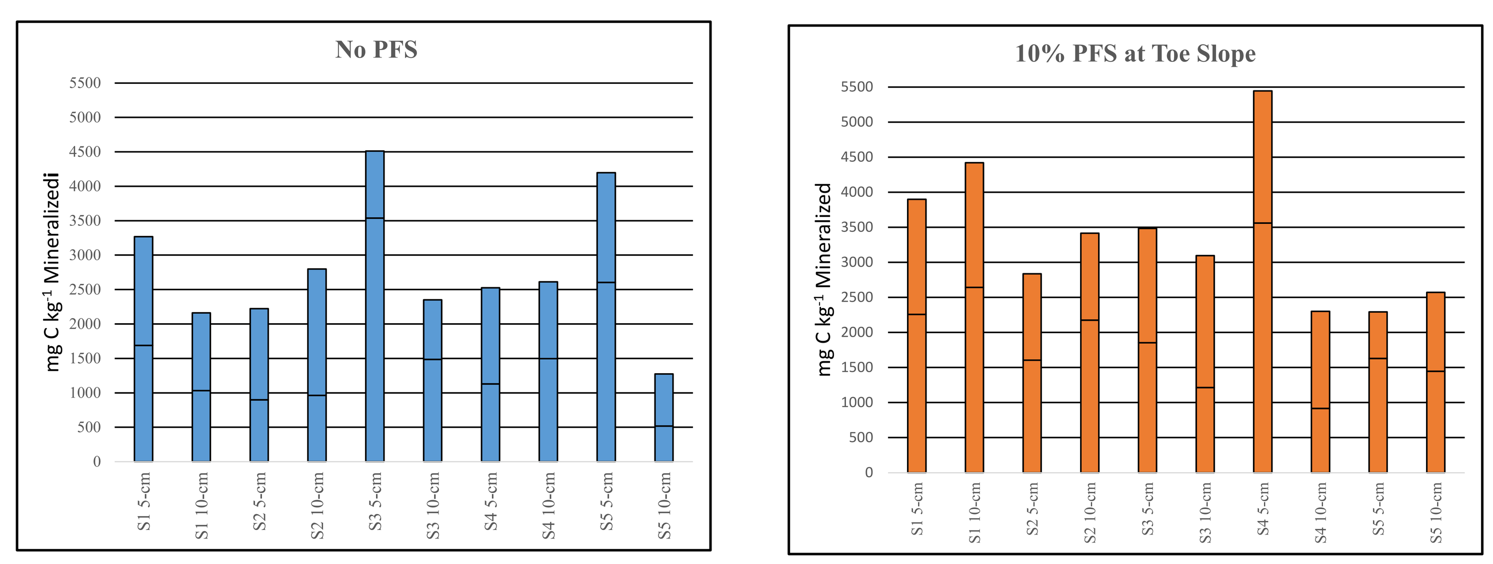

Figure 3: Comparison in amount of cumulative potentially mineralizable carbon between watersheds with no PFS and 10% PFS at toe slope. More SOC is trapped in areas above the location of the 10% toe slope PFS.

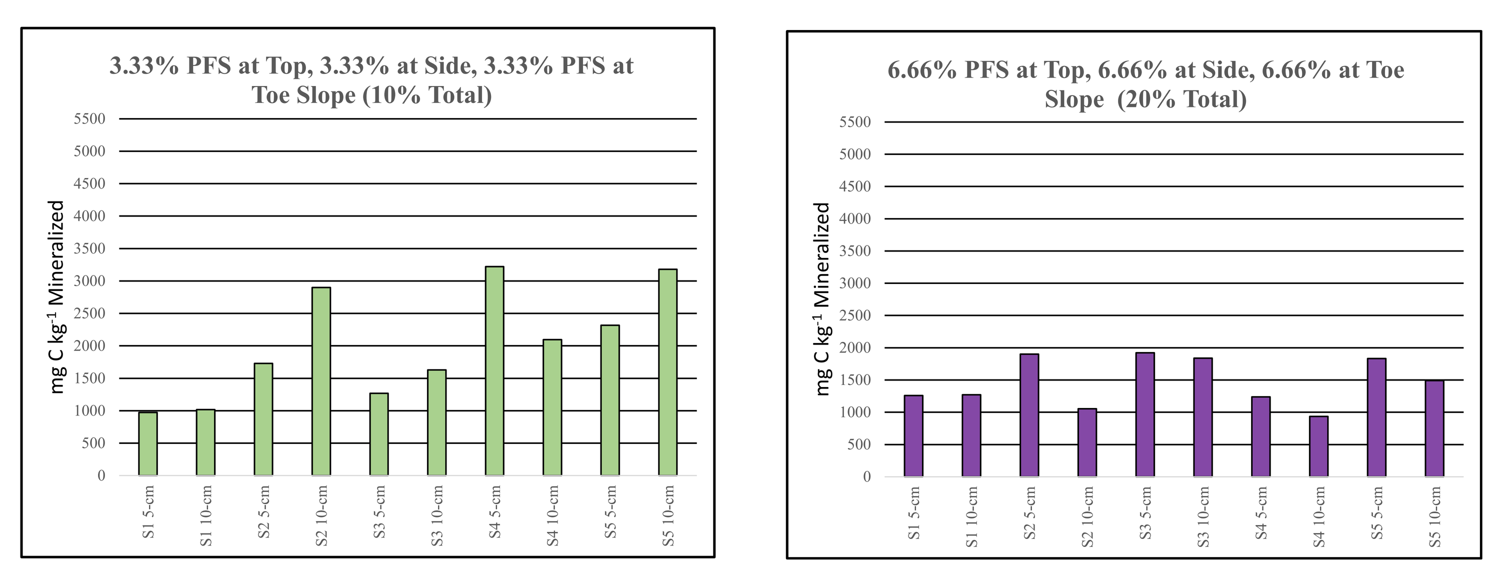

Figure 4: Comparison in amount of cumulative potentially mineralizable carbon between the percentage of PFS distributed at the top, side, and toe slope of the watershed, 3.33% vs. 6.66%.

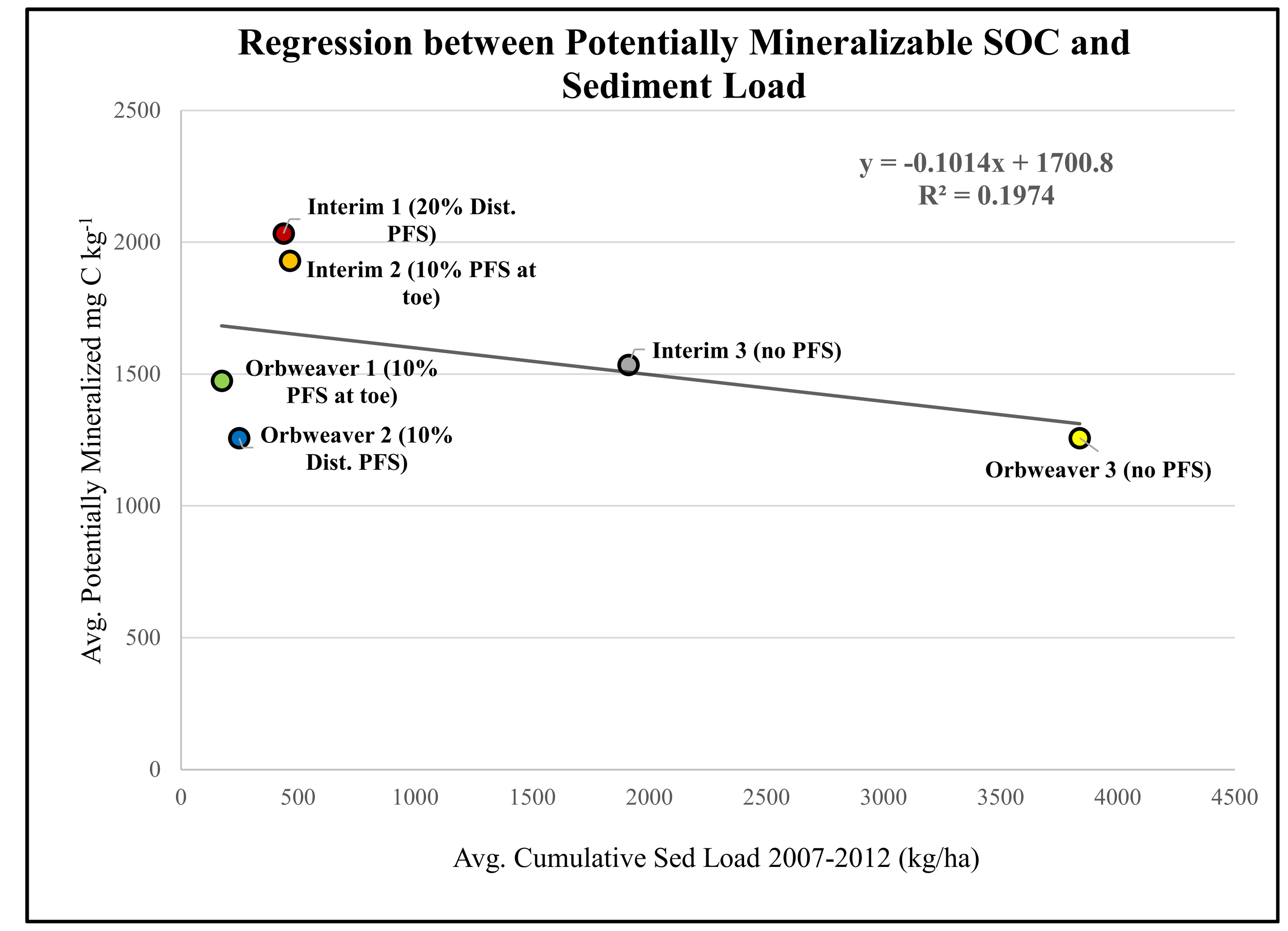

Figure 5: Weak correlation between average potentially mineralizable SOC and average sediment load at NSNWR from 2007-2012. Decrease in mineralization is much less than increase in sediment load for watersheds with no PFS, skewing linear relationship. Controlling for other variables related to SOC cycling may improve regression results.

Conclusions & Future Work

- For individual analysis, mineralization is higher at the side slope and at shallow depths of 5-cm for most watersheds. External factors related to SOC may be responsible.
- PFS is ineffective in storing carbon in watersheds where it is distributed across top, side, and toe slopes. Less spatial variability in PFS effects on carbon mineralization than predicted.
- Concentrating PFS at toe slope is more effective in trapping carbon across watershed than equally distributing it. Mineralization is higher at the top and side slopes, suggesting less soil and carbon transport to the toe slope.
- Unexpectingly consistent, high mineralization for watersheds with no PFS. However, mineralization is low at the toe slope, suggesting rapid transport of carbon at the depositional site.
- Poor correlation between expected increase in average culumative sediment load and decrease in average potentially mineralizable carbon. PFS may not actually improve SOC retention in soil as much as it improves reduction in soil loss.
- Interim watersheds with PFS saw higher mineralization rates than corresponding Orbweaver sites. The effects of PFS on improvement in sustaining available mineralized carbon may be site-specific.
- Difficult to extrapolate findings and apply them to analysis of larger-scale watersheds in different ecosystems.
- Future work may include expanding sites to include all NSNWR watersheds, increasing and using multiple time periods of incubations, and incorporating different PFS treatments.
- Additional work may involve comparing proportions of total carbon to the amount that is actually mineralizable for each watershed.
- Study results have a limited application to understanding dynamic carbon cycling: they do not address the primary mechanisms that cause carbon loss through transport from a real-time perspective.

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Primary References

1. Asborjensen H, Cruse M.R., Helmers J.M., Kolka R., Tomer D.M., Zhou X. 2012. Sediment Removal by Prairie Filter Strips in Row-Cropped Ephemeral Watersheds. Journal of Environmental Quality. 41: 1531-1539. Print.
2. Berhe A.A., Harden W.J., Harte J., Torn S.M. 2007. The Significance of the Erosion-induced Terrestrial Carbon Sink. BioScience 57:4 337-346. Print.