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Changes in Soil Aggregate Size and Stability Over Time Under Riparian Vegetation

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Introduction

- Grass filters are a conservation practice designed to protect water quality and prevent soil erosion by improving soil quality, including soil aggregation, in the riparian zone.
- USDA Conservation Reserve Program (CRP) grass filter contracts span 10-15 years. It is known that some soil quality parameters improve under perennial vegetation within a short time span (5-7) years.
- Depending on management, some CRP grass filters may not contain the original mixture of species.

Objective

This study was conducted to (1) establish whether aggregation and carbon storage continues to improve after typical CRP contracts expire and (2) to follow up on previous soil quality work done within the watershed in the late 1990's (Marquez et al., 2004) and mid 2000's (Kim et al., 2010).

Materials and Methods

Location

The Bear Creek watershed (Figure 1) in central Iowa contains a number of CRP riparian forest buffers and grass filters established from 1990-2010.

Fig. 1. Areal view of a portion of the Bear Creek watershed and multispecies riparian buffer systems. Inset: Approximate location of the Bear Creek watershed in central Iowa.

- Samples were collected from the surface 15 cm in two grass filters established in 1990 and previously sampled in 1997 (Marquez et al. 1998, 2004) and 2006-2007 (Kim et al, 2008).
- One grass filter was planted to, and still contains, smooth brome (*Bromus inermis*).
- The other grass filter originally contained switchgrass (*Panicum virgatum* L. 'Cave-in-Rock'), but has since been invaded by smooth brome (Figs. 2a-c).
- An adjacent row crop field (corn-soybean rotation, conservation tillage) was also sampled.
- Major soils types present:
  - Clarion loam (fine-loamy, mixed, superactive, mesic Typic Hapludoll), Coland clay loam (fine-loamy, mixed, superactive, mesic Cumulic Endoaquoll).

Figs. 2a-c. (a) Switchgrass stand in the late 1990's; switchgrass dominates. (b) Switchgrass stand on June 1, 2006; switchgrass is still present, but does not comprise the majority of the filter. (c) Switchgrass stand on July 3, 2013; stand is dominated by smooth brome.

Methods

- Five soil samples were collected from triplicate plots within each vegetation type and composited; plots were sampled 4 times between Nov. 2010 and Nov. 2011.
- Soil samples were wet sieved for slaked aggregate stability distribution (Fig. 3). Aggregate fraction samples were corrected for sand content.
- Aggregate mean weight diameter (MWD) and percent water-stable aggregates >0.25 mm (%WSA) were calculated.
- An unslaked subsample was used to determine total soil texture, carbon and nitrogen, and particulate organic matter (POM).

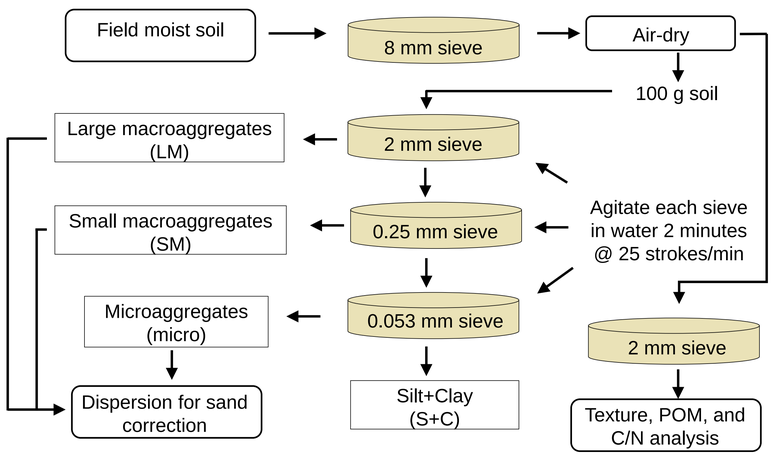
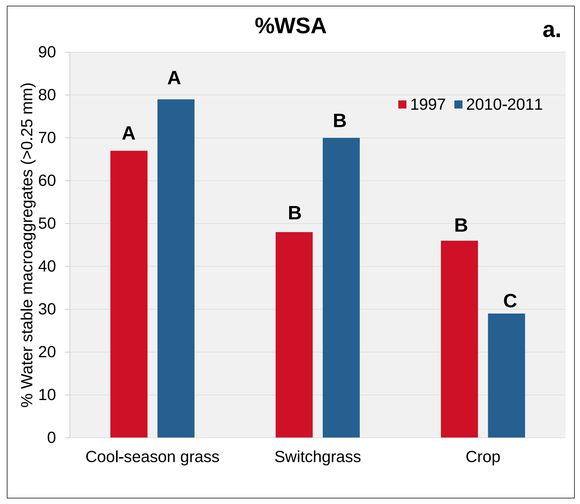


Fig. 3. Slaked aggregate distribution method. Each aggregate fraction was dried at 65°C. A subsample of each fraction was dispersed with 50 mL 5 g L^{-1} sodium hexametaphosphate and rinsed through a 0.053 mm sieve to determine sand content.

Results



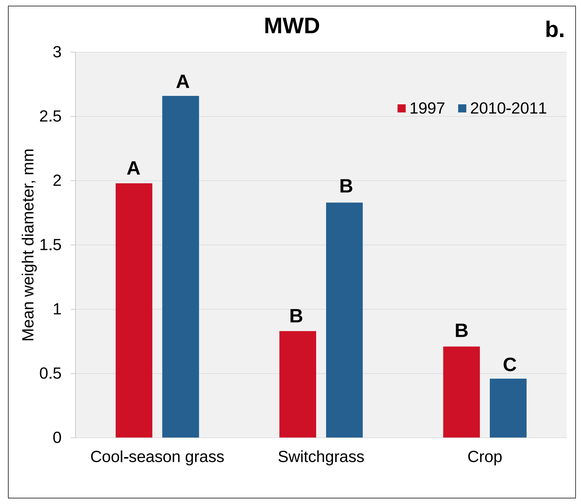


Fig. 4a and b. Percent water-stable macroaggregates (%WSA) and aggregate mean weight diameter (MWD) under riparian vegetation in 1997 and 2010-11. Uppercase letters indicate significant differences (p > 0.05) between vegetation types within years. Statistical comparisons were not made between years due to a lack of raw data from 1997.

- % WSA and MWD **increased** from 1997 to 2010-11 under perennial vegetation regardless of type, but **decreased** in the crop field.
- In 1997, %WSA and MWD ranked in order of cool-season grass > switchgrass = crop.
- In 2010-2011, %WSA and MWD ranked in order of cool-season grass > switchgrass > crop.
- Total soil carbon **increased** significantly in the switchgrass filter between 1998-99 and 2006-07, but did not increase significantly between 2006-07 and 2011-12, indicating potential total carbon saturation.
- Total soil carbon **did not increase or decrease** significantly in the cool-season grass filter between 1998 and 2012. A 3.2% increase in C under cool-season grass from 035 cm was noted between 1991 and 1996 (Marquez et al., 2000.)
- Total soil carbon under annual row crops **decreased** significantly between 2006-07 and 2011-2012.

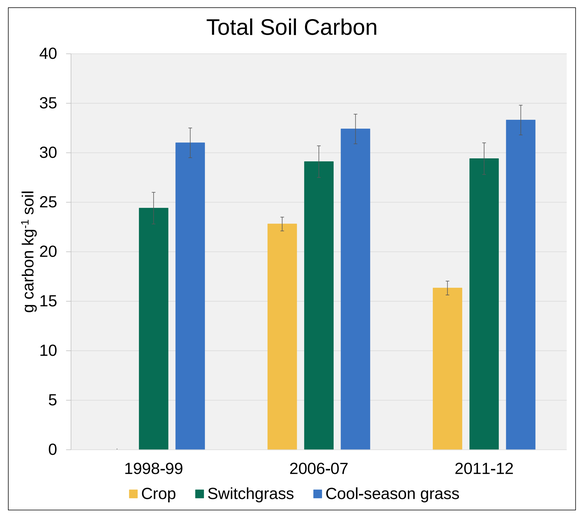


Fig. 5. Total soil carbon (g C kg^{-1}) under riparian vegetation in 1998-1999, 2006-2007 and 2010-2011. Data from the crop field in 1998-1999 was not available.

Conclusions

These results suggest:

- Grass filter soil quality still improves even after CRP contracts would typically expire.
- Switchgrass may take longer to increase aggregation, however it is unclear whether gains in aggregation are as a result of time, or as a result of a plant community shift.
- Characterization of the intra-aggregate particulate organic matter (iPOM) may detect changes in POM inputs between C_4 grasses (switchgrass) and. C_3 grasses (smooth brome).
- Smooth brome increases aggregation in short time periods, but lacks other attributes such as stiff stems to slow water runoff that make switchgrass attractive in a grass filter.
- Annually tilled row crop soils continue to lose aggregate stability and total soil carbon.

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