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Impacts of Incorporating Prairie Vegetation within Row Crop Production on Soil Hydraulic Properties

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***Abstract*.** Runoff from agricultural land is a concern for downstream water quality. Soil hydraulic properties influence infiltration which influences surface runoff and, as a result, downstream water quality. Implementation of vegetative filter strips (VFS) has the potential to reduce downstream pollutant loading by slowing runoff velocities, which allows particulates to settle out, as well as allowing for infiltration. Since soil hydraulic properties influence infiltration there is a need to evaluate the impacts VFS have on physical properties of the soil, which will allow for a better understanding of the mechanisms by which VFS provide benefits. The objective of this study was to determine if differences in soil hydraulic properties exist under different land uses. Variations in surface infiltration between VFS, restored prairie, and agriculture row crop areas were determined utilizing tension infiltrometers for in-situ measurement of infiltration rate at the upslope and foot slope positions under various land cover in three small watersheds at the Neal Smith Wildlife National Refuge (NSNWR) near Prairie City, IA. Results did not show statistically significant differences in treatment at any of the tensions tested. There were significant differences in conductivity between the two landscape positions at tensions -6 & -12 cm. Although there were no significant differences collectively results did show higher conductivity within the VFS compared to the row crop and restored native prairie in two of three watersheds. Higher conductivity in the VFS of the two watersheds shows that over time VFS may influence soil hydraulic properties within a watershed. However the low conductivity in the restored native prairie does not seem to support the idea of long term effectiveness of VFS which warrant further investigation.

Keywords. Tension infiltrometer, hydraulic conductivity, vegetative filter strips, restored native prairie

Introduction

Cereal grain production is very important in the U.S. especially in the Corn Belt region, where a reported 81.5 million acres (33 million ha) of cropland is harvested each year (USDA, 2007). Increasing demand for cereal grains (primarily corn and soybeans) due to emerging markets such as biofuels as well as feed markets is making increased production economically feasible to producers (Zhou et al., 2010) There are several methods in which a producer can increase production, one method is by returning land once in Conservation Reserve Program (CRP) and other such programs back into production (Hart, 2006; Secchi et al., 2008; Zhou et al., 2010). While these practices increase grain production and are economically feasible to the producer they have also come with increases in non-point source pollution impacts (Zhou et al., 2010) The majority of agricultural non-point pollution in the form of sediment and phosphorus is delivered via runoff (Harper et al., 2008; Moore and Kroger, 2011). One natural process by which runoff occurs is when rainfall intensity is greater than soil surface infiltration and profile transmission. However, the conversion of permanent vegetation to row crop production over time along with certain management practices have altered the soil surface properties resulting in increased runoff from agricultural lands during rainfall events (Harper et al., 2008). The use of heavy farm equipment causes compaction and reduced land coverage by residue of vegetation leaves the soil surface vulnerable to raindrop impact. Compaction and rain impact cause reduction in soil infiltration due to reduced pore size and surface crusting via particle detachment and deposition both of which affect pore size distribution (Grismer, 1986). Infiltration depends greatly on pore size distribution and the migration towards smaller pore sizes under row crop production has reduced infiltrability (Grismer, 1986). Grismer (1986) reported that pore size distributions skewed towards smaller pores causes a greater resistance to water flow thus reducing infiltration.

In agricultural settings poor infiltration causes soil and nutrient loss by increasing erosion. Ultimately, the loss of highly productive surface soil due to erosion leads to reduced field productivity for producers (Haghighi et al., 2010). The end result is the need for increased producer inputs (fertilizer) to maintain fertility (Moore and Kroger, 2011). Producers maintain fertility with the addition of phosphorus and nitrogen, the two primary limiting nutrients in production agriculture. These large sources of available nutrients provide higher potential for increased non-point source loading. Increased quantities of agro-chemicals and sediment are also transported from agricultural fields through erosion and can affect water sources vital to humans and aquatic life. Poor water quality leaving an area is not only of concern for water quality locally but nationally as well where excess nitrates and phosphorus have been shown to cause eutrophication and hypoxic conditions as far away as the Gulf of Mexico (Carpenter et al., 1998; Alexander et al., 2008). Changes in land use and management practices may have the ability to reverse the changes in soil physical properties that have resulted from row crop production (Schilling and Spooner, 2006).

Incorporation of the appropriate mixture of perennial vegetation as filter strips has the potential to increase infiltration, increase water storage, and create greater pore size distribution than is generally found in agricultural fields. The root systems of VFS create pores which serve as pathways for increased infiltration. Dense year round cover protects the soil from surface crusting providing runoff protection by slowing overland flow which provides the opportunity for deposition of soil particles carried from upslope fields and increased infiltration (Dosskey et al., 2005; Jiao et al., 2011). Anderson et al. (2009) found that agroforestry buffers used more water during the growing season thus there was more room available for water storage during periods when the cropped area was fallow. Increased infiltration was a result of increased water storage capacity which is important in preventing runoff. Also due to the plant mixture in the filter strips, root development create a variety of pore sizes, greater pore connectivity, and soil aggregate stability (Unger, 2001) which can also positively impact infiltration.

Permanent vegetation specifically restored native permanent vegetation benefits both surface and subsurface water quality as delivered to a stream (Dabney et al., 2006). Schilling and Spooner (2006) found that converting row crop to grass reduced nitrate concentrations over time but when the reverse was done and grassland were converted back to row crop nitrate concentration rose quickly. VFS within row crop production provides a compromise to converting an entire field to perennial vegetation that serves to provide some of the benefits in water quality protection that would be provided by an entire field in permanent vegetation.

The objective of this study was to compare soil hydraulic properties of a no till row crop site with native prairie vegetation strips at varied landscape positions to determine *i*)if soil hydraulic properties were impacted by land cover(row crop or restored native prairie) and *ii*)if topographic position impacted soil hydraulic properties.

Materials and Methods

Site description

The study was conducted at the Neal Smith National Wildlife Refuge NSNWR in Jasper County, IA managed by the U.S. National Fish and Wildlife Service (Figure 1). Amongst the refuge there are several reestablished areas containing native perennials along with farmland that is leased out while it awaits restoration. Prior to the start of the overall experiment which began in 2006 all of the experimental areas were under brome grass for at least 10 years. In August 2006, twelve small research watersheds were created at three different locations (Basswood (6), Interim (3), Orbweaver (3)) within the refuge. The watersheds were tilled in preparation for the experiment. In the Spring of 2007, row crop areas of the watersheds were planted in soybeans. The small watersheds have since been managed under a no-till corn-soybean rotation. Each watershed contains 0%, 10%, or 20% perennial vegetation area planted with a native perennial mixture. In watersheds containing filter strips, the strip areas were seeded on July 7, 2007 using broadcast seeder with a mixture of native prairie forbs and grasses.

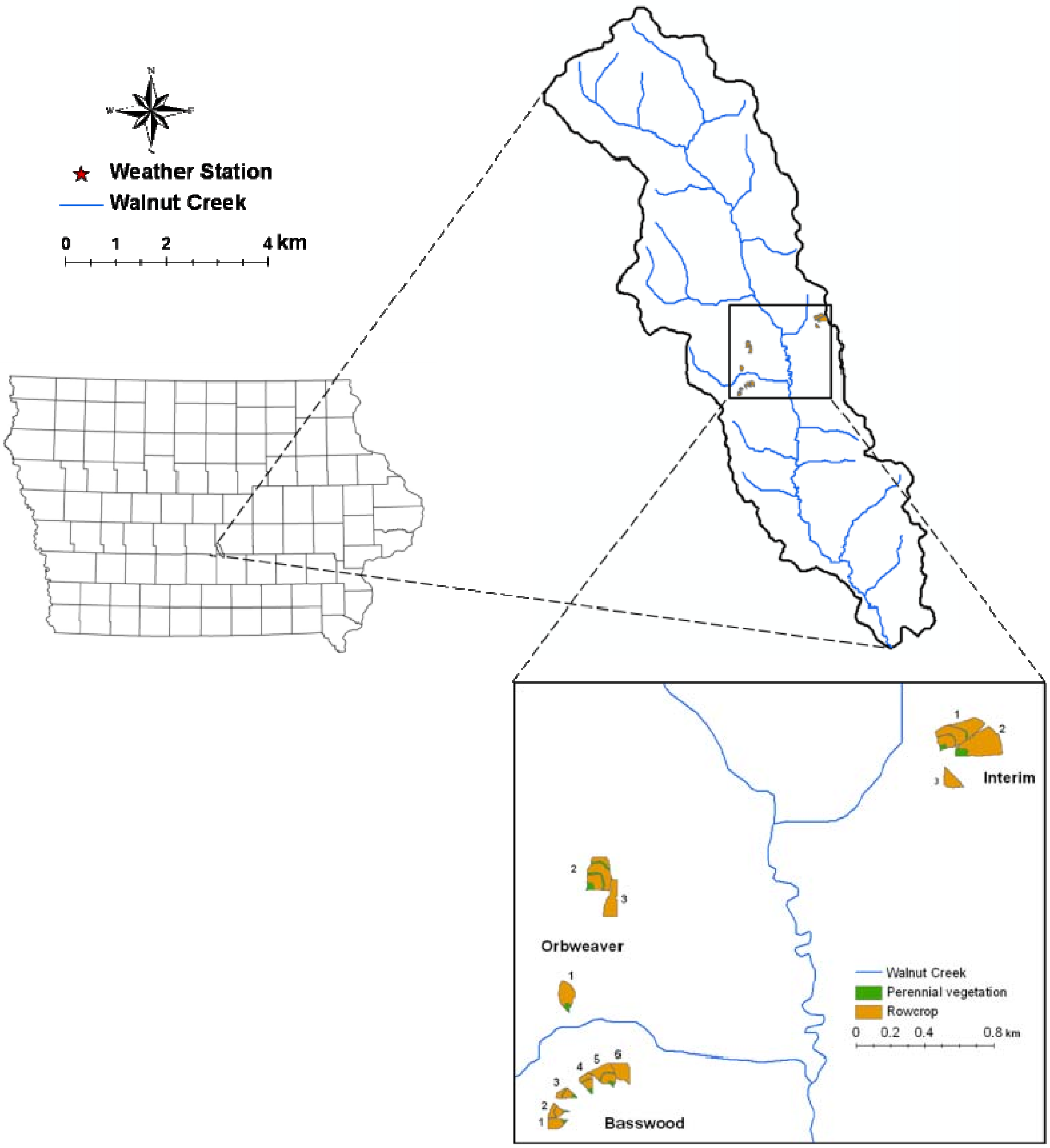

Figure 1. Watersheds at Neal Smith National Wildlife Refuge (NSNWR)

For this experiment three of the twelve watersheds were used. The watersheds used were Basswood-4, Interim-1, and Orbweaver-2. The three sites chosen range in size from 0.55 ha to 3.0 ha each of which contains at least 2 strips within the row crop one upslope at the summit and the other down slope at the footslope position (Table 1). Soil series at the research sites consist of primarily Ladoga (Mollic Hapludalf) or Otley (Oxyaquic Argiudolls) soils with slopes ranging from 5 – 14 %. Soil samples were sent to Ward Laboratories, Inc. Kearney, Nebraska for particle size analysis obtained using hydrometer method. Soil texture information by position and depth are provided in Table 2.

Table 1. Watershed and filter strip area.

Location	**Watershed**	**No. of filters in**	**% of watershed in**	**Filter Strip**

	Area (ha)	watershed	Filter Strip	Area (ha)
Basswood–4	0.55	2	20	0.11
Interim–1	3.00	3	10	0.30
Orbweaver–2	2.40	3	10	0.24

Table 2. Watershed soil texture.

Location	Slope Position	Depth (cm)	Soil Particle Size Distribution (%)		
			Sand	Silt	Clay
Basswood-4	Upslope	0-15	10.5	52.8	36.7
		15-30	9.7	53.8	36.5
		30-60	8.2	56.5	35.3
	Foot slope	0-15	11.7	58.2	30.2
		15-30	11.3	58.7	30.0
		30-60	11.0	54.8	34.2
Interim-1	Upslope	0-15	15.6	50.8	33.6
		15-30	15.0	50.6	34.4
		30-60	14.3	53.1	32.6
	Foot slope	0-15	27.1	42.8	30.1
		15-30	25.0	44.1	30.9
		30-60	21.1	45.8	33.1
Orbweaver-2	Upslope	0-15	10.3	55.3	34.3
		15-30	10.5	53.5	36.0
		30-60	10.5	53.3	36.2
	Foot slope	0-15	11.2	57.2	31.7
		15-30	12.5	57.8	29.7
		30-60	11.2	56.5	32.3
Prairie	Upslope	0-15	12.0	51.0	37.0
		15-30	12.8	53.8	33.5
		30-60	16.0	52.8	31.3
	Foot slope	0-15	31.5	39.3	29.3
		15-30	29.3	40.5	30.3
		30-60	25.8	42.0	32.2

Tension Infiltrometer Experiment

Tension infiltrometer testing began in mid July 2010 due to wet soil conditions from the high amount of rainfall during the early portion of the season and was completed in October 2010. Tension infiltrometers (0.20 m diameter) (Figure 2 and 3) were used for determination of unsaturated and field saturated surface infiltration rates within restored native prairie, VFS and row crop at the upslope and foot slope position of each watershed. Tests were carried out at two locations within each treatment*position combination at each watershed. The tests were conducted in triplicate (three tension infiltrometers running simultaneously unless equipment issues prevented) at each location for a total of six replicates for each treatment*position combination. Tensions were chosen to remain close to or somewhat consistent with published literature (Lin et al., 1997; Zhou et al., 2008; Holden, 2009). There were four tensions (-2, -3, -6, and -12 cm H_2O) tested at all locations.

Infiltration measurements were taken approximately 3.66 m (12 feet) from the row crop, VFS interface. The row crop measurement was 3.66 m upslope of the interface in a non-trafficked inter-row and the VFS measurement was 3.66 m into the strip directly down slope of the row crop measurement. The experiment was set up and run using the soil infiltration protocol recommended by Soil Moisture Equipment Corporation, modifications to the protocol were done as needed to suit existing field characteristics and equipment availability. In the row crop area surface residue was brushed away and in the VFS the vegetation was removed by clipping it at the soil surface. A metal ring was placed where the vegetation and residue was removed. A piece of cheese cloth was place over the metal ring and moistened using a spray bottle filled with water. Afterwards a thin layer of fine silica sand was placed on the cheese cloth in the ring and leveled to help create good hydraulic contact between the soil and the tension infiltrometer disc and ensure the entire cross sectional area is contributing to water movement. The tension disc with the membrane was then placed on the sand and the tests were run sequentially from -12 cm H_2O down to -2 cm H_2O. Each experiment started at the lowest tension (-12 cm) and was run until quasi steady state was reached, indicated by a consecutive equal change in water level over a specific time period, before moving on to the next tension. Tests at each location lasted approximately two and a half hours. Tests for paired locations (e.g. VFS upslope location and row crop upslope location) within the same watershed were completed on the same day so that all conditions were the same or as similar as possible so a direct comparison of the sites could be done statistically.

Data collected from the experiments were used to determine hydraulic conductivity, pore radii, and pore size distribution.

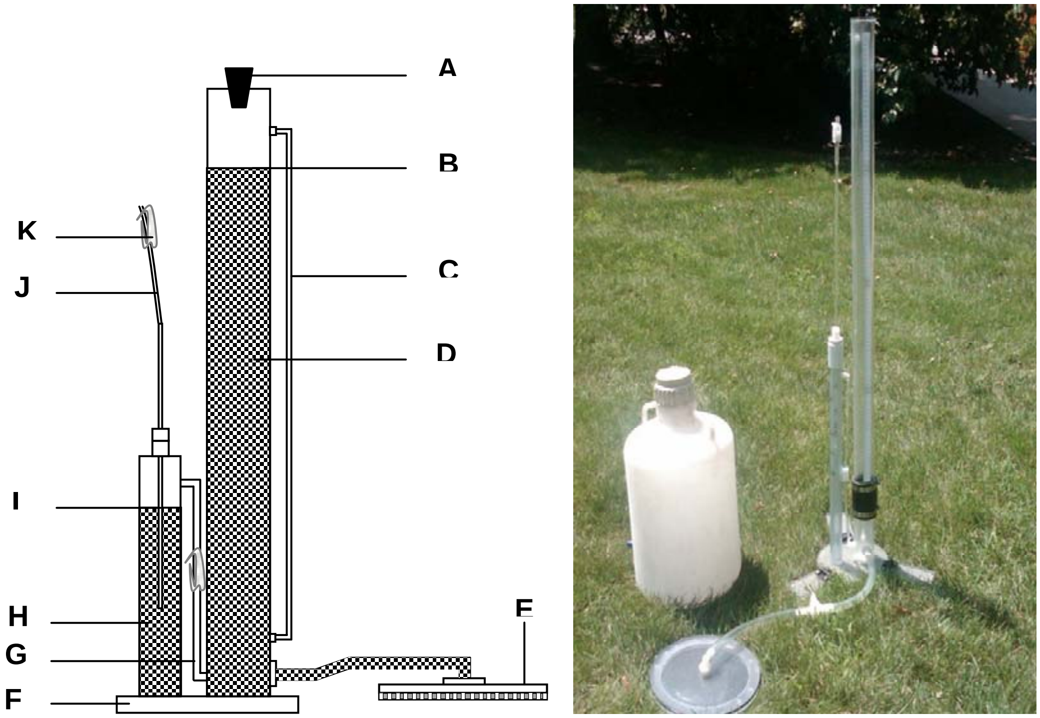

Figure 2. Schematic of Tension Infiltrometer; a)Rubber stopper, b)Water level, c)Tygon tubing for pressure transducer, not used in 2010, d)Reservoir, e)Infiltration disc, f)Base, g)Air bubbling tube, h)Air bubble tower, i) Water level, j) Air entry tube, and k) hose clamp and Picture of actual tension infiltrometer used.

Data Analysis

Hydraulic conductivity, K(ψ)

Infiltration rates were determined by manually measuring change in water level, Δh (L) in the infiltrometer reservoir over time, t (T), which were then translated into an infiltration flux, Q (L^3T^{-1}). The calculated infiltration fluxes were then used to determine hydraulic conductivity, K(*ψ*) ($L T^{-1}$) following the method described by Ankeny at el. (1991) which uses a combination of Wooding (1968) equation [Eq. 1] for infiltration of water from a circular source, Gardner (1958) equation [Eq. 2] for matrix flux potential and equation [Eq. 3] assuming constant ratio $\frac{K(\psi)}{\phi(\psi)}$ throughout a pressure range supported by Philip (1985)

$$Q = \pi r^2 K + 4r\phi \qquad [1]$$

$$\phi(0) = \int_{\psi_i}^{0} K(\psi)d\psi \qquad [2]$$

$$A = \frac{K(\psi)}{\phi(\psi)} = \text{constant } (L^{-1}) \qquad [3]$$

Where Q (L^3T^{-1}) is the steady infiltrating flux, r (L) is the radius of the infiltration disc, K ($L\ T^{-1}$) is the field saturated hydraulic conductivity, ϕ (L^2T^{-1}) is the matrix flux potential, ψ (L) is the water potential, and A is a constant (L^{-1}).

Number of Macropores per square area, N(r)

Macropore flow can be a major factor in infiltration. Data obtained for the tension infiltration experiments were used to calculate the number of macropores per square area within the watersheds to determine if macropore flow is present and whether different locations or land uses have different numbers of macropores. The number of macropores per square area was calculated using the method by Watson and Luxmoore (1986).

$$r = \frac{-2\,\sigma \cos\alpha}{\rho g h} \qquad [4]$$

$$N(r) = \frac{8\mu K_m}{\pi \rho g r^4} \qquad [5]$$

Where for equation 4 r (L) is the pore radius, σ ($M\ T^{-2}$) is the surface tension, α(°) is the contact angle (assumed to be zero), ρ($M\ L^{-3}$) is the density of water, g($L\ T^{-2}$) is gravity, and h (L) is the applied tension. For equation 5 N(r) is the number of macropores per square area, μ ($M\ L^{-1}T^{-1}$) is the dynamic viscosity, K_m (LT^{-1}) is the difference in conductivities between tensions.

Statistical Analysis

Two separate analyses were conducted. First, a block design with paired data, was used for analysis of treatment and position at all the sites. The second, a single block design also with paired data, was used for the analysis of treatment and position at only the Interim-1 site. The analysis was done in this manner due to the Interim-1 site having restored native prairie vegetation located directly adjacent to the watershed that could be included as part of the block being tested whereas Basswood and Weaver did not.

Statistical analyses were conducted using Statistical Analysis Systems (SAS) software (SAS Institute Inc., Cary, NC). Data was log transformed to facilitate statistical analysis. An analysis of variance (AVONA) using the Proc Mixed procedure was utilized for determination of significance between treatment effects (block, land use, and position) as well as their interactions.

Results and Discussion

Hydraulic Conductivity

All watersheds (short term treatment effects-row crop vs vegetative filter strips)

In the analysis of the row crop compared to the VFS, no significant differences between the two treatments were detected for all tensions (Table 3 & 4). It is highly probable the lack of significant differences in hydraulic conductivity is due to the experiments being conducted over a wide range of time. Schwartz et al. (2003) found that conductivities were similar between 10 year old CRP and no-till suggesting that longer than 10 years is needed for changing soil properties. Zhou et al. (2008) found measurement time had the greatest impact on measured hydraulic conductivity.

There was a significant difference between landscape position at the ψ = -6 and -12 cm tensions (Table 3 & 4). Hydraulic conductivity at the foot slope was greater than the upslope position. The larger conductivity at the foot slope position is likely a result of higher clay content present at the upslope position for the surface (0-15 cm depth) within all the watersheds (Table 2) due to erosion and deposition of the more conductive sand and silt at the foot slope from the upslope position which too can be seen in the surface (0-15 cm) particle size analysis (Table 2) with the exception of Interim and Prairie which both have higher silt content upslope. After one large storm event in particular sediment deposition at the foot slope position within the VFS was very noticeable.

Overall, there were no significant differences in the hydraulic conductivity between the VFS and the row crop, however results for the lower tensions (e.g. ψ = -2, -3, -6, -12 cm) did show that VFS had greater conductivity than row crop (Table 4). Individual watersheds on the other hand varied greatly two watersheds showed that the conductivity was larger in the VFS at some if not all tensions while one showed the opposite (Figure 4a-f). At the foot slope of Basswood and Interim for all tensions hydraulic conductivity was higher in VFS then row crop (Figure 4a & e) whereas in Orbweaver (Figure 4c) the row crop had higher conductivity. At the upslope position at tensions ψ = -2 and -3 in Basswood (Figure 4b) and all tensions in Interim (Figure 4f) VFS showed greater conductivity however just as was shown at the foot slope Orbweaver (Figure 4d) showed higher conductivity in the row crop than the VFS.

Many different vegetation types have been employed to positively influence field soil hydraulic properties on vastly different soil types. As such the effect of VFS influence on infiltration has been shown to vary greatly. Some researchers have found that permanent vegetation's effect on soil hydraulic properties reduces infiltration (Gish and Jury, 1983), while others have found that vegetation increases soil hydraulic properties (Rachman et al. 2004). Overall our results tend to be consistent with these previous results.

Table 3. Analysis of surface hydraulic conductivity measured from tension infiltrometers at -2, -3, -6, and -12 cm tension in all watersheds showing effect of block, land use, position, and position*land use.*

		ψ = -2		ψ = -3		ψ = -6		Ψ = -12	
Effects		F	*p*	F	*p*	F	*p*	F	*p*
	All watersheds								
Block	(excluding prairie)	8.73	0.02**	5.36	0.05**	1.47	0.30	0.98	0.43
Land use		0.22	0.66	1.19	0.32	2.01	0.21	0.88	0.38
Position		0.74	0.42	1.20	0.32	5.01	0.07*	8.38	0.03*
Position* Land use		0.23	0.65	0.01	0.91	0.32	0.59	1.19	0.32
	Interim Only								
Land use		4.25	0.19	2.94	0.25	0.84	0.54	0.32	0.76
Position		0.20	0.70	1.51	0.34	2.06	0.29	0.90	0.44

*F is the F-value of the effect. Asterisks imply different significant levels for *p* value. (***p*<0.05, **p*<0.1)

Table 4. Comparison of Hydraulic conductivity, K(ψ) (cm/hr) for treatment and slope position in all watersheds at tensions of -2, -3, -6, and -12 cm.*

		K(-2)	K(-3)	K(-6)	K(-12)
Treatment					
	Row Crop	11.10a	4.50a	0.52a	0.19a
	Filter Strip	12.71a	7.31a	0.89a	0.22a
Slope Position					
	Upslope	10.42a	4.49a	0.42a	0.16a
	Foot slope	13.38a	7.32a	1.00b	0.25b

*Table shows the pair wise analysis of treatment and position from the SAS determined Least squares mean (LSM) estimates calculated from the hydraulic conductivity, K(ψ) (cm/hr) values measured in Basswood-4, Interim-1, and Orbweaver-2 watersheds. Values with corresponding letters next to them indicate a lack of significant difference at the $p<0.10$ level.

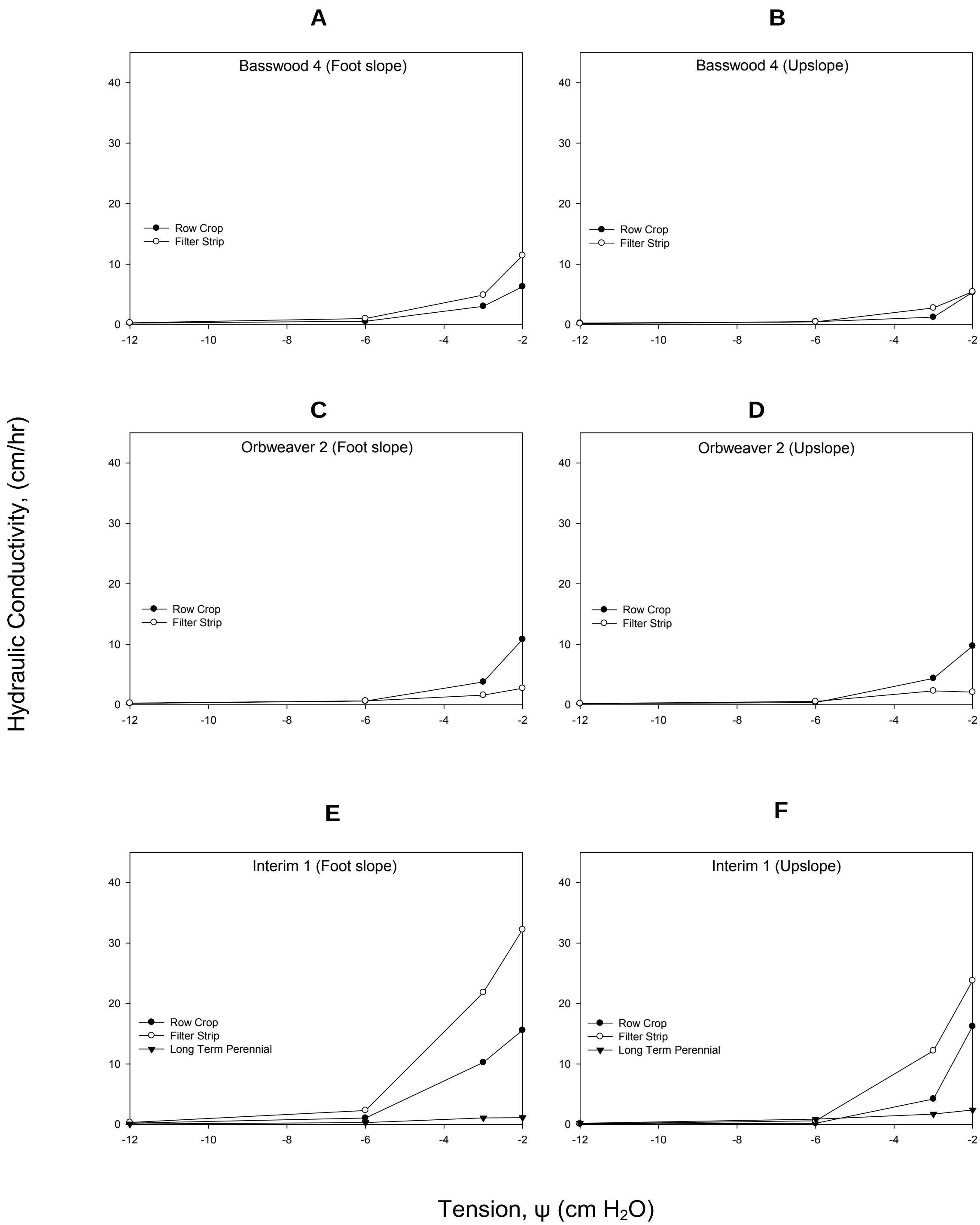

Figure 4. Mean Hydraulic conductivity of each watershed and position from ψ = -12 – -2 cm tension. *A*) basswood foot slope; *B*) basswood upslope; *C*) orbweaver foot slope *D*) orbweaver upslope *E*) interim foot slope *F*) interim upslope

Interim and restored native prairie (Long term treatment effects- Row crop, vegetative strips, and restored prairie)

There were no significant differences found between treatments for all tensions in the Interim only analysis however the hydraulic conductivity in the VFS was noticeably higher than the row crop and the restored prairie at all tensions (Table 5). Conductivity at the lowest tensions (ψ = -6, and -12) was lowest in the row crop and ranged as follows, row crop < restored prairie < VFS. At the ψ = -2 and -3 cm tension restored native prairie hydraulic conductivity measured lower than row crop. Closer to the saturated condition conductivity could have been lower due to the large surface cracks in the row crop area. Also vegetation in the restored prairie was well established and very dense by the time testing started, an explanation for the lower conductivities in the restored prairie could be that the roots were actively growing and utilizing pores that would be available for profile transmission limiting water movement. (Gish and Jury, 1983; Rachman et al., 2004)

Conductivity at the two slope positions showed no significant differences however at the foot slope position, conductivity was higher than the at the upslope positions at all tensions once again likely due to deposition of particles washed down from upslope.

Table 5. Comparison of Hydraulic conductivity, K(ψ) (cm/hr) for Restored Prairie and Interim at tensions of -2, -3, -6, and -12 cm.*

Treatment		K(-2)	K(-3)	K(-6)	K(-12)
	Row Crop	16.36a	7.24a	0.62a	0.14a
	Filter Strip	27.71a	16.82a	1.43a	0.23a
	Restored Native Prairie	2.20a	2.07a	0.70a	0.15a
Slope Position					
	Upslope	13.91a	5.69a	0.50a	0.12a
	Foot slope	16.94a	11.73a	1.33a	0.22a

*Table shows the pairwise analysis of treatment and position from the SAS determined LSM estimates calculated from the hydraulic conductivity, K(ψ) (cm/hr) values measured in the Interim-1 watersheds. Values with corresponding letters next to them indicate a lack of significant difference at the $p<0.10$ level.

Number of Macropores

Basswood and Orbweaver

At the Basswood site the number of macropores within all three size ranges was highest in the VFS at the foot slope position (Table 6) and lowest at the upslope position within the VFS at pore size range 0.05-0.075 cm and the row crop for pore size range 0.025-0.05 cm and 0.01-0.025 cm.

At Orbweaver the number of macropores was greatest in the row crop for all pore sizes at both the upslope and foot slope position (Table 6).

Table 6. Macroporosity estimated from tension infiltrometer data at Basswood and Orbweaver.*

		No. of pores per m^2			
Tension	Pore radius, cm	BFSU	BFSF	BRCU	BRCF
2-3	0.05-0.075	32	79	49	39
3-6	0.025-0.05	444	748	147	480
6-12	0.01-0.025	872	2170	745	919

		No. of pores per m^2			
Tension	Pore radius, cm	WFSU	WFSF	WRCU	WRCF
2-3	0.05-0.075	2	14	64	85
3-6	0.025-0.05	336	184	772	606
6-12	0.01-0.025	1081	1098	1115	1228

*Abbreviations: Basswood filter strip upslope (BFSU), Basswood filter strip foot slope (BFSF), Basswood row crop upslope (BRCU), Basswood row crop foot slope (BRCF), Orb(weaver) filter strip upslope, (WFSU),Orb(weaver) filter strip foot slope, (WFSF), Orb(weaver) row crop upslope, (WRCU), Orb(weaver) row crop foot slope, (WRCF).

Interim and restored native prairie

The number of macropores of all pore radius sizes was lowest in the restored native prairie (Table 7) except for in the pore size range of 0.01-0.025 at the upslope position where there were more pores than the row crop and VFS. The VFS had the highest number of macropores at each position (upslope and foot slope) for all pore size ranges when compared to row crop. At pore sizes in the range of 0.01-0.025 and 0.025-0.05 cm, the number of macropores was greatest at the foot slope positions compared to the upslope for VFS and row crop treatments whereas at the 0.05 – 0.075 pore size range the upslope had the greater number of macropores compared to the foot slope position for the VFS and row crop treatments.

Table 7. Macroporosity estimated from tension infiltrometer data at Interim and restored native prairie.*

		No. of pores per m^2					
Tension	Pore radius, cm	IFSU	IFSF	IRCU	IRCF	PRAU	PRAF
2-3	0.05-0.075	180	125	145	64	8	1
3-6	0.025-0.05	1447	3764	777	1775	163	147
6-12	0.01-0.025	1499	6071	371	2631	2073	774

*Abbreviations: Interim filter strip upslope (IFSU), Interim filter strip foot slope (IFSF), Interim row crop upslope (IRCU), Interim row crop foot slope (IRCF), Restored native prairie upslope, (PRAU), Restored native prairie foot slope, (PRAF).

Conclusion

The objective of this study was to compare soil hydraulic properties of a no till row crop site with native prairie vegetation strips at varied landscape positions to determine if soil hydraulic properties were impacted by land cover (row crop, VFS, and restored native prairie) and if topographic position impacted soil hydraulic properties. Variations in surface infiltration were measured for the VFS, restored prairie, and agriculture row crop areas.

While significant differences in the conductivity of the treatments were not yet observed in either analysis, the results obtained from the Interim-1 and Basswood-4 analyzes were promising. Two of the three watersheds tested showed greater, while not significant, conductivity in the VFS compared to the row crop. The general consensus is that VFS do tend to increase soil hydraulic properties thus reducing runoff, decreasing soil erosion and non-point source loading. VFS performance is highly sensitive to landscape characteristics. Mixed results on the influence of VFS on soil hydraulic properties warrant further investigation in addition there continues to be a need to study the impact land use has on soil hydraulic properties in Iowa at large scales.

The lowest conductivity of all the land uses tested was the restored native prairie. There are several explanations that can be given to explain the reasons why we saw lower hydraulic conductivity in the restored native prairie compared to the VFS and cropped areas. At the time of experimentation the restored prairie had well-established dense vegetation and roots that could have been plugging pores thus restricting water movement. The higher hydraulic conductivity of the other two treatments suggests that the dense living roots may have restricted the flow of water effectively reducing infiltration. The larger conductivity found within the row crop and VFS versus the restored native prairie could also be due to the fact that there were large surface cracks located within both the row crop and VFS, more so within the row crop, which could not be avoided during the experiments that were not present in the restored native prairie.

Laboratory experiments are currently being conducted to measure saturated hydraulic conductivity and soil water retention on soil cores taken from the same locations as where the tension infiltration tests occurred. This information will be used to compare with field results and determine if the same relationships remain true. Further in-situ experimentation using tension infiltrometers began in May 2011 to compare with the 2010 results to investigate the potential temporal variability of hydraulic properties that may have occurred.

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