Phosphorus Loss From Ephemeral Gully Erosion

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Introduction

Ephemeral gullies (EGs) are responsible for a considerable portion of soil and associated phosphorus (P) loss from a field. However the sediment loss from EGs represent soil from a concentrated area that erodes deeper in the profile. The P sorption characteristics of the sediment loss from the EG is likely different then that of sediment loss from sheet and rill erosion. By limiting EGs there could be a resulting change to dissolved P in runoff. Understanding the full impact of EGs would help land managers implement best management practices to fully control P loss from fields.

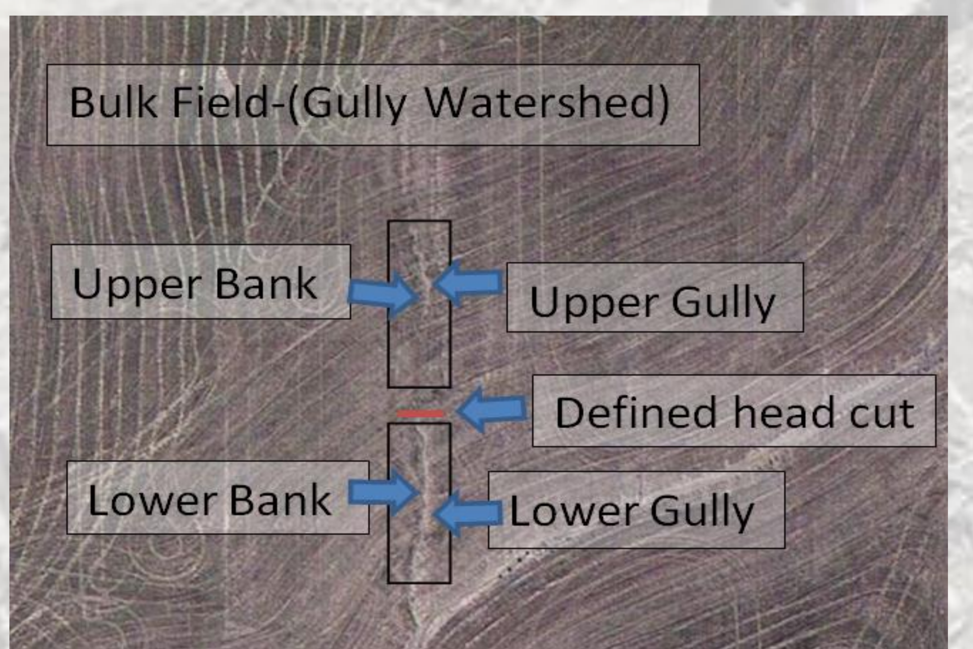
Objective

- Determine resulting dissolved P concentration when the eroded subsoil of EGs mix with surface soil of sheet and rill erosion

Middle Turkey Creek of Little Arkansas Watershed McPherson County, Kansas

W field
- No-till for 12 years
- Currently sorghum
- Previously wheat
- Silty clay loam

S field
- No-till 4-5 years
- Continuous wheat
- Sandy clay loam



Sampling example W field

- Watershed of gully --- bulk field
- Within well formed gully --- lower gully
- Within forming gully --- upper gully
- Along bank of well formed gully --- lower bank
- Along bank of forming gully --- upper bank
- All 5 sample location per field had same depth fractions --- 0 to 2, 2 to 5, 5 to 15, and 15 to 30 cm
- All sampling taken in triplicate

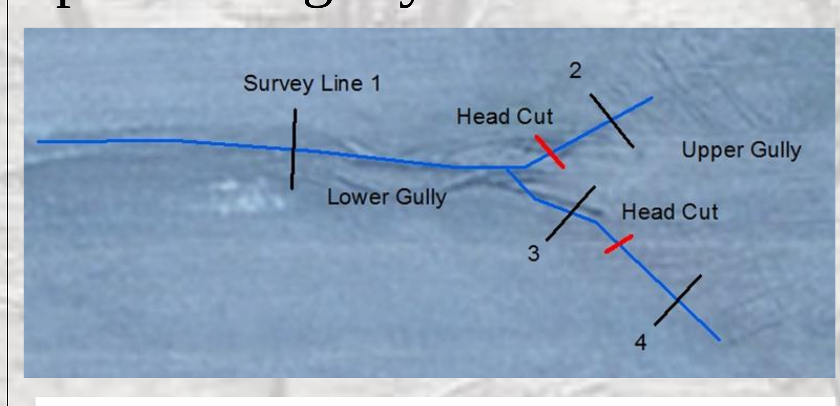
Acknowledgements

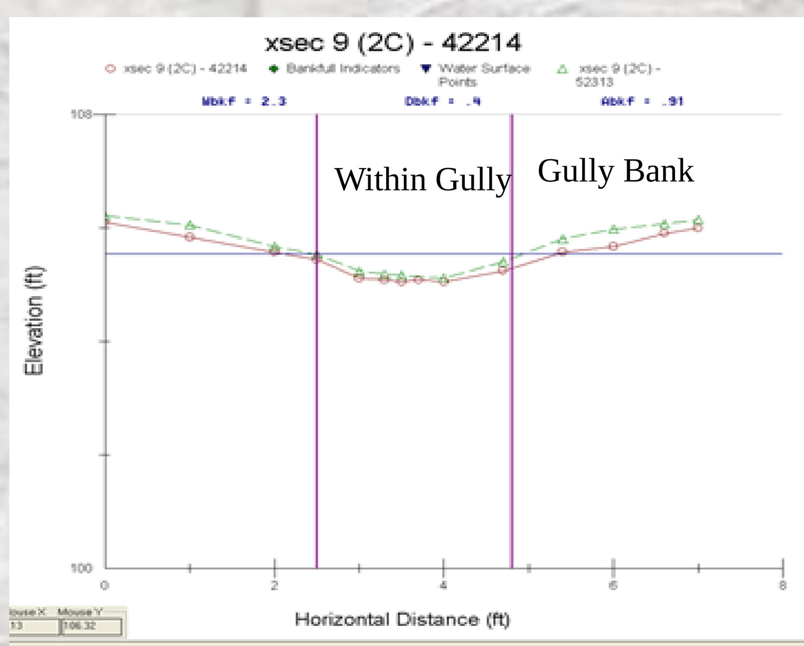
KSU Soil Testing Lab

USDA NIFA
United States Department of Agriculture National Institute of Food and Agriculture

Methods- Soil loss estimation

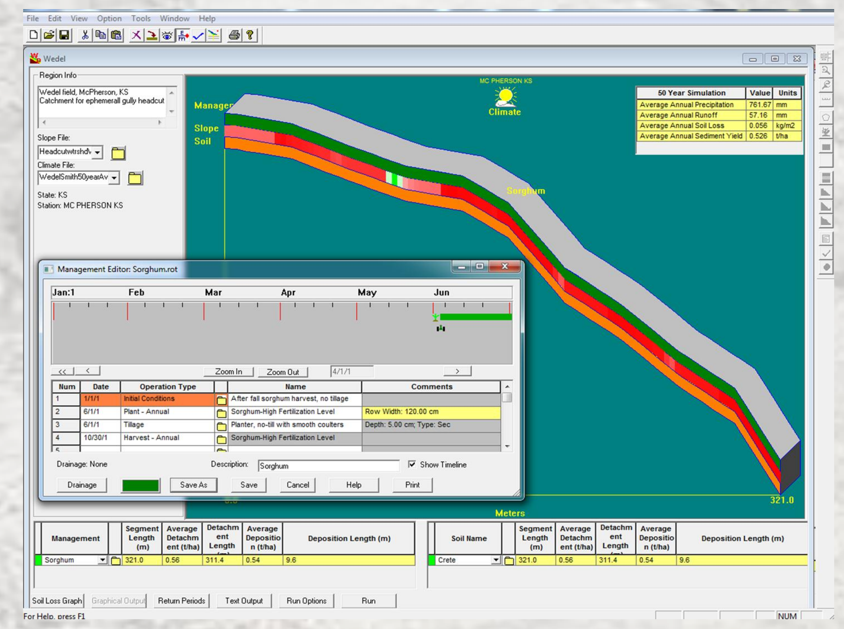
Ephemeral gully soil loss





Field survey examples
- Averaged cross-sectional area under survey lines multiplied length of gully
- Done below and above head cut
- Cross-sectional area found with Rivermorph v 5.1
- Assumed even erosion across gully sections
- W field surveyed June 2013 to April 2014
- S field surveyed June 2012 to March 2013

Sheet and rill soil loss



WEPP mechanistic modeling
- WEPP model uses infiltration, soil hydraulics, and runoff theory
- Based upon hillslope and impoundments

Methods- dissolved P in runoff

- Soil samples tested for total P
- Anion exchange P (AEP) – desorbable liable P
- Sorption isotherm determined by P sorption/desorption with increasing concentrations of dissolved P
- Equilibrium Phosphorus Concentration and Zero Net Sorption (EPC_0) found by fitting the sorption isotherm to a Freundlich curve $Q = K_f C^b$
- EPC_0 is an expectation of dissolved P concentration in solution desorbed from sediment in solution

Freundlich Mass Balance of Phosphorus (FMBP) model
- Initial condition (P sorbed before soil is eroded) -- (T_i)
- Final condition (expectation of P sorbed after mixed) -- (T_f)

$$T_i = T_f \qquad m_1 Q_{i1} + m_2 Q_{i2} + \cdots + m_n Q_{in}$$
$$= C_f v + m_1 K_{f_1} C_f^{\,b_1} + m_2 K_{f_2} C_f^{\,b_2} + \cdots + m_n K_{f_n} C_f^{\,b_n}$$

- Quantity of P sorbed in initial must equal quantity of P in final.
- 1 – n - Soil fraction (by depth and landscape position)
- m- mass of soil fraction loss by erosion
- Q_i- quantity of P in initial condition (AEP)
- C_f- P concentration in runoff
- v- volume of runoff (determined by WEPP)
- k and b- Freundlich fitting parameter and constant

Results

Table 1- W field soil and total P loss

Landscape Position	Depth	EPC_0 of soil fraction	Surveyed area of loss	Length of gully	Volume of sediment loss	Sediment loss mass†	Soil total P	Total P loss‡
	cm	mg L^{-1}	m^2	m	m^3	kg	mg kg^{-1}	g
Upper Bank	0 to 2	0.082	0.4505	26.2128	1.1822	1620	242.3	392.4
Upper Bank	2 to 5	0.003	0.03412	26.2128	1.3395	1835	210.9	387.0
Upper Bank	5 to 15	0.000	0.0235	26.2128	0.6946	952	150.6	143.3
Upper Gully	0 to 2	0.051	0.0353	26.2128	0.464	636	232.9	148.0
Upper Gully	2 to 5	0.001	0.0474	26.2128	0.6212	851	211.4	179.9
Upper Gully	5 to 15	0.000	0.0061	26.2128	0.1599	219	137.0	30.0
Lower Bank	0 to 2	0.043	0.0056	33.6804	0.1886	258	251.9	65.1
Lower Bank	2 to 5	0.001	0.0144	33.6804	0.485	664	212.2	141.0
Lower Bank	5 to 15	0.000	0.0901	33.6804	1.519	2081	159.7	332.4
Lower Bank	15 to 30	0.000	0.00605	33.6804	0.5187	711	135.9	96.5
Lower Gully	0 to 2	0.013	0.0089	33.6804	0.2998	711	213.8	151.9
Lower Gully	2 to 5	0.000	0.0093	33.6804	0.3132	429	165.3	70.9
Lower Gully	5 to 15	0.000	0.0070	33.6804	0.2358	323	138.0	44.6
Total Bank and Gully					8.02	11289		2183
Bulk Field	0 to 2	0.118				518	327.4	174.7

Table 2- S field soil and total P loss

Landscape Position	Depth	EPC_0 of soil fraction	Sediment loss mass¶	Soil test total P	Total P loss§
	cm	mg L^{-1}	kg	mg kg^{-1}	g
Upper Bank	0 to 2	0.0919	38.48	174.0	6.7
Upper Bank	2 to 5	0.0401	32.33	132.4	4.3
Upper Bank	5 to 15	0.0033	193.03	139.6	27.0
Upper Bank	15 to 30	0.0002	151.25	146.2	22.1
Lower Bank	0 to 2	0.0724	572.66	128.6	73.6
Lower Bank	2 to 5	0.0253	658.97	114.3	75.3
Lower Bank	5 to 15	0.0034	549.78	105.2	57.8
Lower Bank	15 to 30	0.0001	98.64	151.6	15.0
Lower Gully	0 to 2	0.0583	98.64	119.1	11.7
Lower Gully	2 to 5	0.0119	408.12	129.6	52.9
Total Bank and Gully			2801.9	118.1	346.4
Bulk Field	0 to 2	0.0376	1494.5	237.4	379.6

† Bulk density - 1.37 kg m^{-3}
‡ Enrichment ratio bulk field- 1.03
¶ Bulk density - 1.37 kg m^{-3}
§ Enrichment ratio bulk field- 1.03

- W field nearly all soil and total P loss through EG
- S field more soil loss by EG, even total P loss

Figure 1- W field change in dissolved P with EG reduction

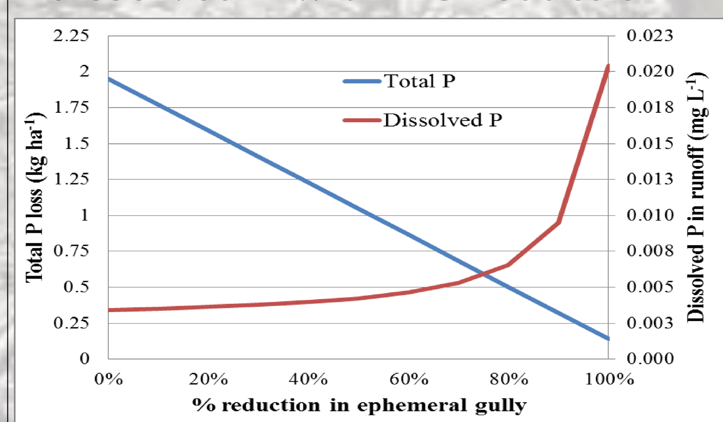
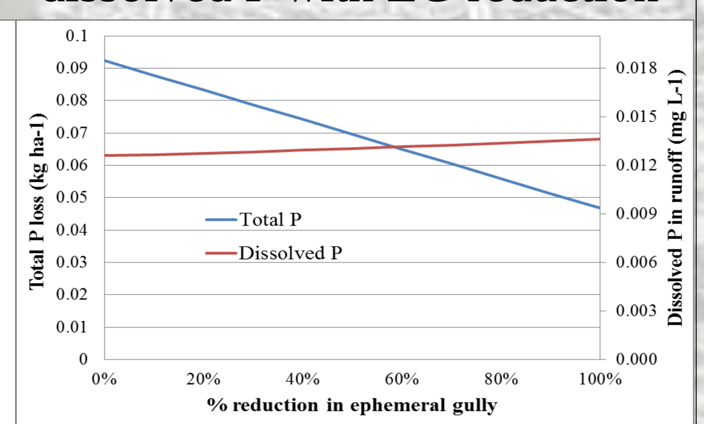


Figure 2- S field change in dissolved P with EG reduction



- W field- Small reductions in EG caused large dissolved P changes. Overall large increase in dissolved P.
- S field- Reductions in EG caused little change to dissolved P
- W field had a much larger EG sediment contribution and higher P sorption disparity between sheet and rill to EG sediment.

Conclusions and future research

- Best management practices such as grass waterways that limit EG erosion could increase dissolved P, leading to environmental degradation.
- Best management practices need to be combined. (ex. conservation tillage with grass waterways)
- Model validation over a larger range of field types needs to be done to confirm the EG effect on dissolved P.