# K-STATE **Research and Extension**

## Phosphorus Loss From Ephemeral Gully Erosion James Coover, Nathan O. Nelson, Timothy Keane, Katie Burke, Aleksey Sheshukov, Vladimir Karimov and Philip Barnes Kansas State University, Manhattan, KS

### 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.

# Methods-Soil loss estimation

Ephemeral gully soil loss



### Results

#### Table 1- W field soil and total P loss

Landscape		EPC <sub>0</sub> of	Surveyed	Length of	Volum	e of Sediment	Soil	Total F	
Position	Depth	soil	area of	gully	sedim	ient loss	total P	loss‡	
		fraction	$\frac{10ss}{2}$		$\frac{\log}{2}$	s mass†	1 1		
	cm	$\frac{\text{mg } L^{-1}}{2}$	$\frac{m^2}{m^2}$	m	m <sup>3</sup>	y kg	mg kg <sup>-1</sup>	g	
Upper Bank	0 to 2	0.082	0.4505	26.2128	1.18	22 1620	242.3	392.4	
Upper Bank	2 to 5	0.003	0.03412	26.2128	1.33	95 1835	210.9	387.0	
Upper Bank	5 to 15	0.000	0.0235	26.2128	0.69	46 952	150.6	143.3	
Upper Gully	0 to 2	0.051	0.0353	26.2128	0.46	636	232.9	148.0	
Upper Gully	2 to 5	0.001	0.0474	26.2128	0.62	12 851	211.4	179.9	
Upper Gully	5 to 15	0.000	0.0061	26.2128	0.15	99 219	137.0	30.0	
Lower Bank	0 to 2	0.043	0.0056	33.6804	0.18	86 258	251.9	65.1	
Lower Bank	2 to 5	0.001	0.0144	33.6804	0.48	85 664	212.2	141.0	
Lower Bank	5 to 15	0.000	0.0901	33.6804	1.51	.9 2081	159.7	332.4	
Lower Bank	15 to 30	0.000	0.00605	33.6804	0.51	87 711	135.9	96.5	
Lower Gully	0 to 2	0.013	0.0089	33.6804	0.29	98 711	213.8	151.9	
Lower Gully	2 to 5	0.000	0.0093	33.6804	0.31	32 429	165.3	70.9	
Lower Gully	5 to 15	0.000	0.0070	33.6804	0.23	58 323	138.0	44.6	
Total Dank									
and Gully					8.0	2 11289		2183	
Bulk Field	0 to 2	0.118				518	327.4	174.7	
Table 7	S field	a oil an	d total T		1		1200		
Table 2-	5 Held	son and	u lotal P	1055		and the second			
Landscape		EPC <sub>0</sub> of	Sediment	Soil test	Total	• W field	nearly	y all	
Position	Depth	soil	loss	total P	P	soil and	l total	P los	
		traction	mass		loss§	through		1 105	
Llee ou Doult	$\frac{\text{cm}}{2}$	$\frac{\text{mg L}^{1}}{0.0010}$	Kg 	$\frac{\text{mg kg}^{1}}{174.0}$	g (7	unougi	ILU		
Upper Bank	0 to $2$	0.0919	38.48	174.0	0./				
Upper Bank	2 to $5$	0.0401	32.33 102.02	132.4	4.5	• S field	more s	soil	
Upper Dalik	5 to 15	0.0003	195.05	139.0	27.0	loss by	EG, e	ven	
Upper Dalik	15 to 30	0.0002	572.66	140.2	22.1 72.6	total P	loss		
Lower Dank	0 to $2$	0.0724	J/2.00	120.0	/ 3.0 75 2	total I	1000		
Lower Bank	2 to 5	0.0233	038.97	114.5	13.3				
Lower Bank	5 to 15	0.0034	549.78	105.2	J7.8 15.0				
Lower Bank	15 to 30	0.0001	98.64	151.0	15.0				
Lower Gully	0 to 2	0.0583	98.64	119.1	11./	† Bulk density -	- 1.37 kg	m <sup>-3</sup>	
Lower Gully		0.0119	408.12	129.6	52.9	‡ Enrichment ra	nrichment ratio bulk field- 1		
 T 1 D 1	2 to 5					<b>TD</b> 11 1 '	1 07 1		
Total Bank	2 to 5		2801.9	118.1	346.4	¶ Bulk density - & Enrichment ra	1.37 kg	m <sup>-</sup> Tield_ 1	
Total Bank and Gully	2 to 5	0.0076	2801.9	118.1	346.4	¶ Bulk density - § Enrichment ra	- 1.37 kg a atio bulk f	m <sup>-5</sup> Field- 1.	
Total Bank and Gully Bulk Field	2 to 5 0 to 2	0.0376	2801.9 1494.5	118.1 237.4	346.4 379.6	¶ Bulk density - § Enrichment ra	1.37 kg atio bulk f	m <sup>-5</sup> Tield- 1.	
Total Bank and Gully Bulk Field Figure 1	2 to 5 0 to 2 - W fiel	0.0376	2801.9 1494.5 ge in	118.1 237.4 Fig	346.4 379.6 ure 2	¶ Bulk density - § Enrichment ra	1.37 kg atio bulk f	m <sup>-5</sup> Tield- 1.	
Total Bank and Gully Bulk Field Figure 1 dissolved	0 to 2 - W fiel 1 P with	0.0376 ld chang n EG ree	2801.9 1494.5 ge in duction	118.1 237.4 Fig diss	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EQ	1.37 kg atio bulk f ange i G redu	n n n	
Total Bank and Gully Bulk Field Figure 1 dissolved	0 to 2 - W fiel 1 P with	0.0376 ld chang n EG ree -Total P	2801.9 1494.5 ge in duction	118.1 237.4 Fig diss	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EQ	1.37 kg atio bulk f ange i G redu	n n ction	
Total Bank and Gully Bulk Field Figure 1 dissolved	0 to 2 - W fiel d P with	0.0376 ld chang n EG re -Total P -Dissolved P	2801.9 1494.5 ge in duction 0.023 0.020 0.018	118.1 237.4 Fig diss 0.1 0.09 0.08 1007	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EQ	1.37 kg atio bulk f ange i G redu	n field- 1. n ction	
Total Bank and Gully Bulk Field Figure 1 dissolved	0 to 2 - W fiel d P with	0.0376 ld chang I EG real -Total P -Dissolved P	2801.9 1494.5 ge in duction 0.023 0.020 0.018 0.015 0.013	118.1 237.4 Fig diss 0.1 0.09 0.08 (1-1 0.07 0.08 (1-1 0.07 0.06 0.05	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EQ	1.37 kg h atio bulk f ange i G redu	m <sup>-5</sup> Field- 1. n ction 0.018 0.012	
Total Bank and Gully Bulk Field Figure 1 dissolved 2.25 2 1.75 1.5 1.25 1.25	0 to 2 - W fiel d P with	0.0376 ld chang n EG re -Total P -Dissolved P	2801.9 1494.5 ge in duction 0.023 0.020 0.018 0.015 0.013 0.010	118.1 237.4 <b>Fig</b> diss 0.09 0.08 (1-1 0.09 0.08 (1-1 0.07 0.06 0.05 0.05 0.04	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EC	1.37 kg h atio bulk f ange i G redu	m <sup>-5</sup> Field- 1. n ction 0.018 0.012 0.009	
Total Bank and Gully Bulk Field Figure 1 dissolved 2.25 2 1.75 1.25 1.25 1.25 0.75 0.5	0 to 2 - W fiel d P with	0.0376 ld chang Dissolved P	2801.9 1494.5 ge in duction 0.023 0.020 0.018 0.015 0.013 0.010 0.018 0.015 0.013 0.010 0.008 0.005	118.1 237.4 <b>Fig</b> diss 0.0 0.1 0.09 0.08 (1-0.07 0.08 0.07 0.06 0.07 0.06 0.07 0.06 0.07 0.05 0.05 0.04 0.03 0.02	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EQ -Total P -Dissolved P	1.37 kg h atio bulk f ange i G redu	m <sup>-5</sup> Field- 1. n ction 0.018 0.015 0.012 0.009 0.009	
Total Bank and Gully Bulk Field Figure 1 dissolved 2.25 2 1.75 1.25 1.25 0.5 0.5 0.25	0 to 2 - W fiel d P with	0.0376 ld chang Dissolved P	2801.9 1494.5 <b>ge in</b> duction 0.023 0.020 0.018 0.015 0.013 0.010 0.008 0.005 0.003	118.1 237.4 <b>Fig</b> diss 0.09 0.08 (1-0.07 0.06 0.08 (1-0.07 0.06 0.06 0.04 0.05 0.05 0.04 0.03 0.02 0.01	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EC -Total P -Dissolved P	1.37 kg h atio bulk f ange i G redu	m <sup>-5</sup> Field- 1. n ction 0.015 0.012 0.005 0.006 0.006	
Total Bank and Gully Bulk Field Figure 1 dissolved 2.25 2 1.75 1.5 1.25 1.25 0.5 0.25 0% 20%	0 to 2 - W fiel d P with	0.0376 ld chang Dissolved P Dissolved P	2801.9 1494.5 <b>ge in</b> duction 0.023 0.020 0.018 0.015 0.013 0.010 0.003 0.000 0.003	118.1 237.4 <b>Fig</b> diss 0.0 0.0 1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EC - Total P - Dissolved P 6 40% 60%	1.37 kg h atio bulk f ange i G redu	$n \\ ction \\ 0.018 \\ 0.012 \\ 0.009 \\ 0.006 \\ 0.000 \\ $	
Total Bank and Gully Bulk Field Figure 1 dissolved 2.25 2 1.75 1.5 1.25 1.25 0.5 0.5 0.25 0% 20%	0 to 2 - W fiel d P with A P with 40% reduction in e	0.0376	2801.9 1494.5 ge in duction 0.023 0.020 0.013 0.015 0.013 0.010 0.003 0.000 4 0.005 0.003 0.000 4 0.005	118.1 237.4 <b>Fig</b> diss 0.09 0.08 (1-1) 0.09 0.08 (1-1) 0.07 0.06 0.07 0.06 0.07 0.06 0.07 0.03 0.05 0.04 0.03 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.01 0.02 0.02	346.4 379.6 ure 2 solve	¶ Bulk density - § Enrichment ra - S field ch d P with EC - Total P - Dissolved P 6 40% 60% 6 40% 60%	1.37 kg hatio bulk fatio bulk	m <sup>-5</sup> Field- 1 n ction 0.018 0.012 0.009 0.009 0.009	

Understanding the full impact of EGs would help land managers implement best management practices to fully control P loss from fields.

## Objective

and a start and

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

Continuous wheat

Sandy clay loam

Sheet and rill soil loss



d cut	Upper Gully	2 to 5	0.001	0 0/17/	26 2128	0 6212	851	211 <i>A</i>	179.9
ss-sectional area	Upper Gully	2 to 3	0.001	0.0474	26.2128	0.0212	219	137.0	30.0
nd with	Lower Bank	0 to 2	0.043	0.0056	33.6804	0.1886	258	251.9	65.1
ermorph v 5.1	Lower Bank	2 to 5	0.001	0.0144	33.6804	0.485	664	212.2	141.0
umed even erosion	Lower Bank	5 to 15	0.000	0.0901	33.6804	1.519	2081	159.7	332.4
oss gully sections	Lower Bank	15 to 30	0.000	0.00605	33.6804	0.5187	711	135.9	96.5
Tield surveyed June	Lower Gully	0 to 2	0.013	0.0089	33.6804	0.2998	711	213.8	151.9
2  to  A  pril  2014	Lower Gully	2 to 5	0.000	0.0093	33.6804	0.3132	429	165.3	70.9
5 to April 2014	Lower Gully	5 to 15	0.000	0.0070	33.6804	0.2358	323	138.0	44.6
2 to March 2013	Total Bank and Gully					8.02	11289		2183
	Bulk Field	0 to 2	0.118				518	327.4	174.7
EPP mechanistic modeling VEPP model uses	Table 2-      Landscape      Position	S field Depth	soil and EPC <sub>0</sub> of soil fraction	d total P Sediment loss mass¶	P loss Soil test total P	Total P loss§	W field soil and	l nearly d total	y all P loss
nfiltration, soil	Upper Bank	$\frac{\text{cm}}{0 \text{ to } 2}$	$\frac{\text{mg } L^{-1}}{0.0919}$	Kg 38.48	$\frac{\text{mg kg}^{-1}}{174.0}$	<u>g</u> 67	unougi	IEU	1.7.6
ydraulics, and	Upper Bank	0 to 2	0.0919	30.40	174.0	0.7	<b>G C</b> 11		
unoff theory	Upper Bank	5 to 15	0.0033	193.03	132.4	27.0	S field	more s	SO11
Based upon	Upper Bank	15 to 30	0.0002	151.25	146.2	22.1	loss by	ven	
illslope and	Lower Bank	0 to 2	0.0724	572.66	128.6	73.6	total P	loss	200
moundments	Lower Bank	2 to 5	0.0253	658.97	114.3	75.3			51.2
mpoundments	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	States.		
	Lower Gully	0 to 2	0.0583	98.64	119.1	11.7	Bulk density	- 1.37 kg	m <sup>-3</sup>
runoff	Lower Gully Total Bank and Gully Bulk Field	2 to 5	0.0119	408.12 2801.9 1494 5	129.6 118.1 237.4	52.9 346.4 § 379.6	Enrichment r Bulk density Enrichment r	atio bulk f - 1.37 kg atio bulk f	field- 1.03 m <sup>-3</sup> field- 1.03
P		<b>XXX (* 1</b>	-	2.243			$\alpha \alpha 1 1 1$	11	1000
desorption with	Figure I-	- W fiel	d chang	ge in	F1g	ure 2-	S field ch	lange 1	n
acsorption with	dissolved	l P with	EG re	duction	diss	solved	P with E	G redu	ction
Zero Net Sorption to a Freundlich	2.25 2 1.75 4 1.5 5 5 5 6 1.25 1.25 5 5 6 1 1 2 1.25 1.25 1.25 1.25		-Total P Dissolved P	0.023 0.020 0.018 0.015 0.013 0.010 0.008	ved P in runoff (mg L <sup>-1</sup> ) ved P in runoff (mg L <sup>-1</sup> ) ve		Total P Dissolved P		0.018 (1) 0.015 00.012 00.00 0.009 00.00 0.006 00.00
tration in solution	0.25 0% 0% 20% %	40% reduction in ep	60% 80%	0.005 0.003 0.000 0.000 0.000 0.000 vo 100%	<b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b> <b>10</b>	% 20% <b>%</b> r	40% 60% eduction in ephemei	80% r <b>al gully</b>	0.003 0.000 0.000 100%
P) model ed) $(T_i)$ r mixed) $(T_f)$	<ul> <li>W field change</li> <li>S field</li> </ul>	d- Smal es. Ove - Reduc	l reduc rall larg ctions in	tions in ge increa n EG ca	EG cau ase in c used lit	used la lissolve tle cha	rge dissol ed P. .nge to di	lved P ssolve	d P





#### 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

## Methods- dissolved P in

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

#### Freundlich Mass Balance of Phosphorus (FMBP

- Initial condition (P sorbed before soil is erode
- Final condition (expectation of P sorbed after
  - $m_1 Q_{i1} + m_2 Q_{i2} + \dots + m_n Q_{in}$  $T_i = T_f$

W field had a much larger EG sediment contribution and higher P sorption disparity between sheet and rill to EG sediment.

All sampling taken in triplicate

Acknowledgements

**KSU Soil Testing Lab** 



 $= C_f v + m_1 K_{f_1} C_f^{b_1} + m_2 K_{f_2} C_f^{b_2} + \dots + m_n K_{f_n} C_f^{b_n}$ 

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<sub>i</sub>- quantity of P in initial condition (AEP)
- C<sub>f</sub>- P concentration in runoff
- v- volume of runoff (determined by WEPP)
- k and b- Freundlich fitting parameter and constant

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.