Applications of TBET for P Loss Assessment and P-Index Evaluation

David Radcliffe, Adam Forsberg, Dan Storm, Aaron Mittelstet, Carl Bolster, and Deanna Osmond

TBET model overview

Distributed, deterministic and continuous simulation model run on a daily time step

- Field-scale version of SWAT 2009

Easy to use

- Conservation planners and farmers

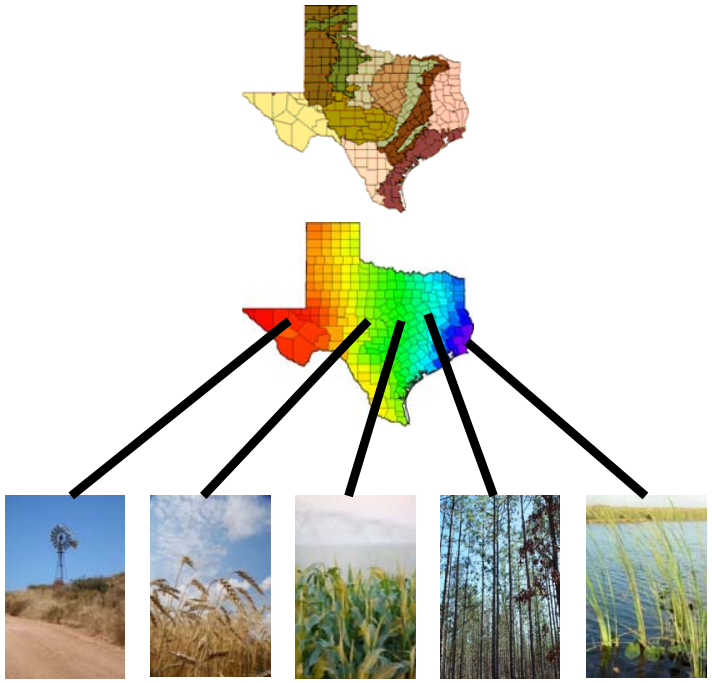
Identify effective conservation practices

Reduce inputs & account for local conditions

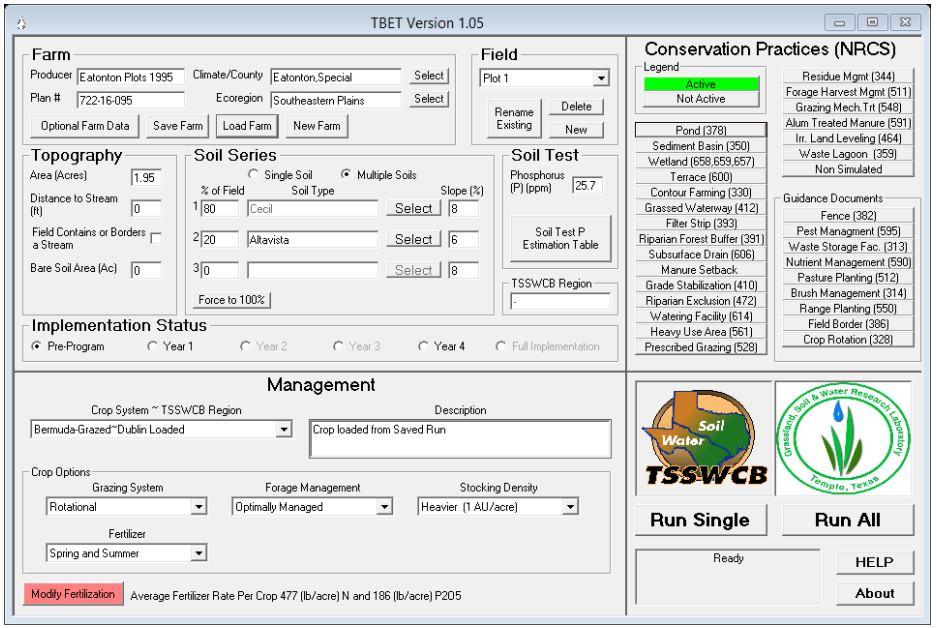
- Climate
- Soils
- Topography

Predictions

- Runoff
- Sediment
- N & P



Required Inputs



Climate

- Daily rainfall & max/min temperature

Soils

- Up to 3 series

Land use

- Crop system

Topography

- Field area
- Field slope
- Distance to stream

Soil Test P

- Mehlich III

Fertilizer & manure

Southern Field Sites

State	# Plots	Date range	Site-years	Crop	STP range (ppm)	Soil Series (hydro group)			
						1	*2*	*3*	*4*
AR	7	2009 – 2011	21	Pasture	81 - 183	Captina (C)			
GA	6	1995 – 1998	24	Pasture	14 - 142	Cecil (B)	Altavista (C)	Sedgefield (C)	Helena (C)
NC	5	2011-2013	15	Corn with wheat cover	44-121	Delanco (C)			
MS	2	1996-1999	8	Cotton or soybens with wheat cover	37-79	Dubbs (B)	Tensas (D)	Alligator (D)	Dundee (C)
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OK	1	2006-2007	1.17	Pasture	50	Clarksville (B)			
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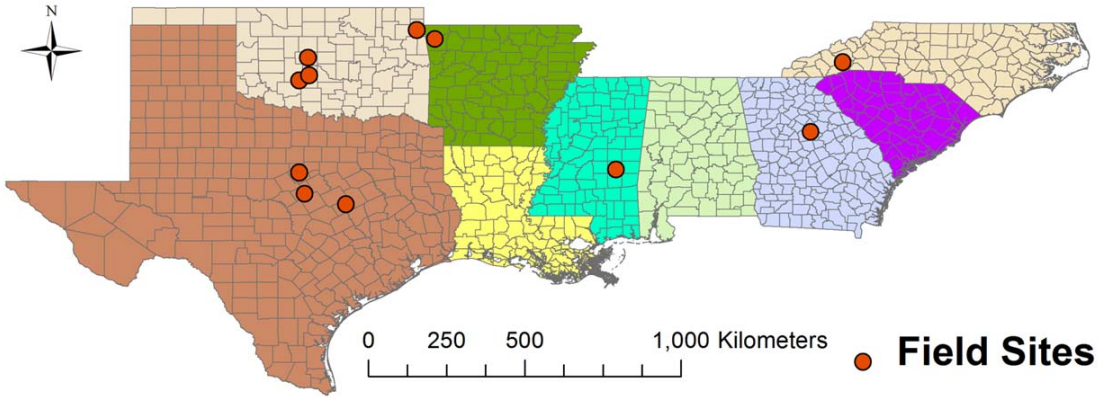
OK	1	1980-1985	6	Wheat	35	Norge (B)			
TX	1	1998-2001	4	Hay	435	Duffau (B)			
TX	1	2005-2008	4	Sorghum/Oats	34	Topsey (C)	Brackett (C)	Krum (D)	
TX	1	2005-2008	4	Native grass	10	Nuff (C)			
TX	1	2001-2008	7	Corn with wheat cover	51	Houston Black (D)			



Objectives

- Determine if TBET is an acceptable model for comparison with P-Indices
  - Can it be run uncalibrated or does it have to be calibrated (by region, or by state)?
- Demonstrate how it can be used by comparing predictions to P-Indices and measured multi-year losses

TBET runs

- AR, GA, and NC – Adam Forsberg / David Radcliffe – UGA
- MS, OK, and TX – Aaron Mittelstet / Dan Storm – OK State

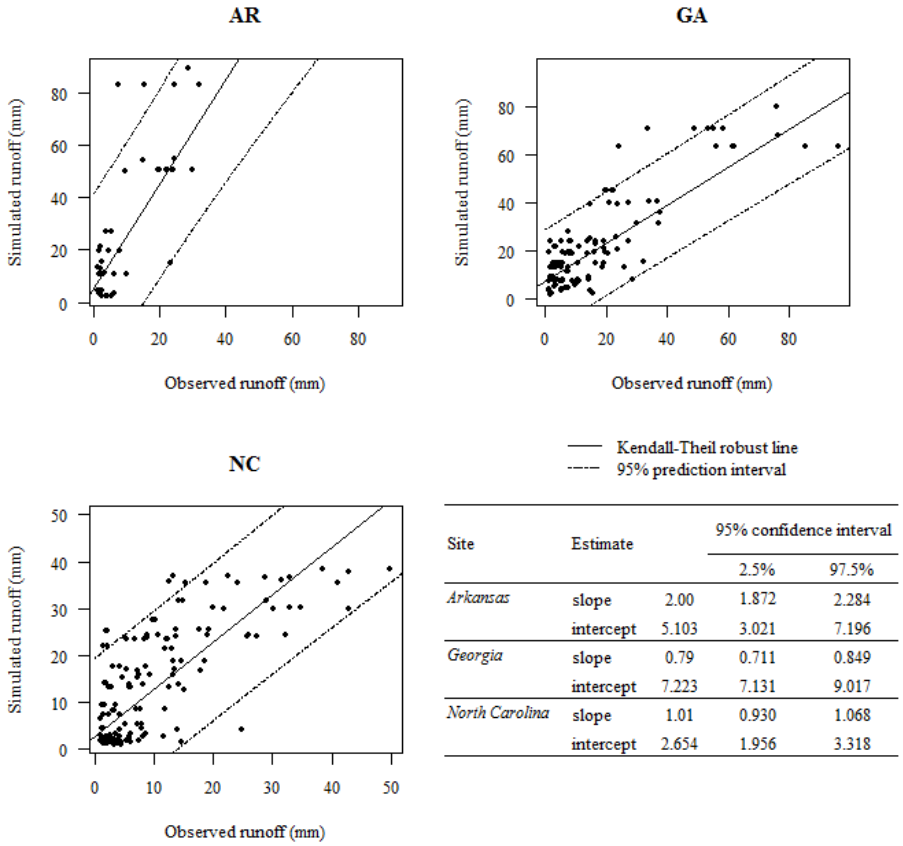
Criteria for an acceptable model prediction

- Nash-Sutcliffe efficiency (NSE)
  - $NSE = 1 - \left[\frac{\sum_{i=1}^{n}(e_i)^2}{\sum_{i=1}^{n}(O_i - O_{mean})^2}\right]$
  - Ranges from -∞ to 1.0
- NSE criteria for monthly stream flow > 0.50 (Moriasi et al., 2007)
- Criteria should be relaxed for daily stream flow
- We used NSE > 0.30 for event based predictions

TBET uncalibrated results

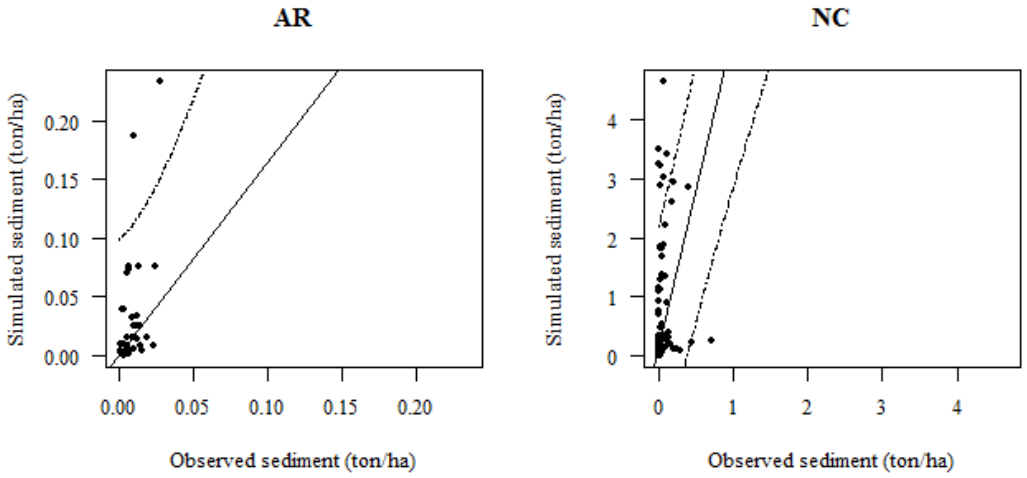
		NSE	
	AR	GA	NC
Runoff	-7	0.57	0.23
Sediment	-59	-	-88
DP	-1.6	0.19	-0.08
TP	-1.5	0.34	-78

Uncalibrated runoff



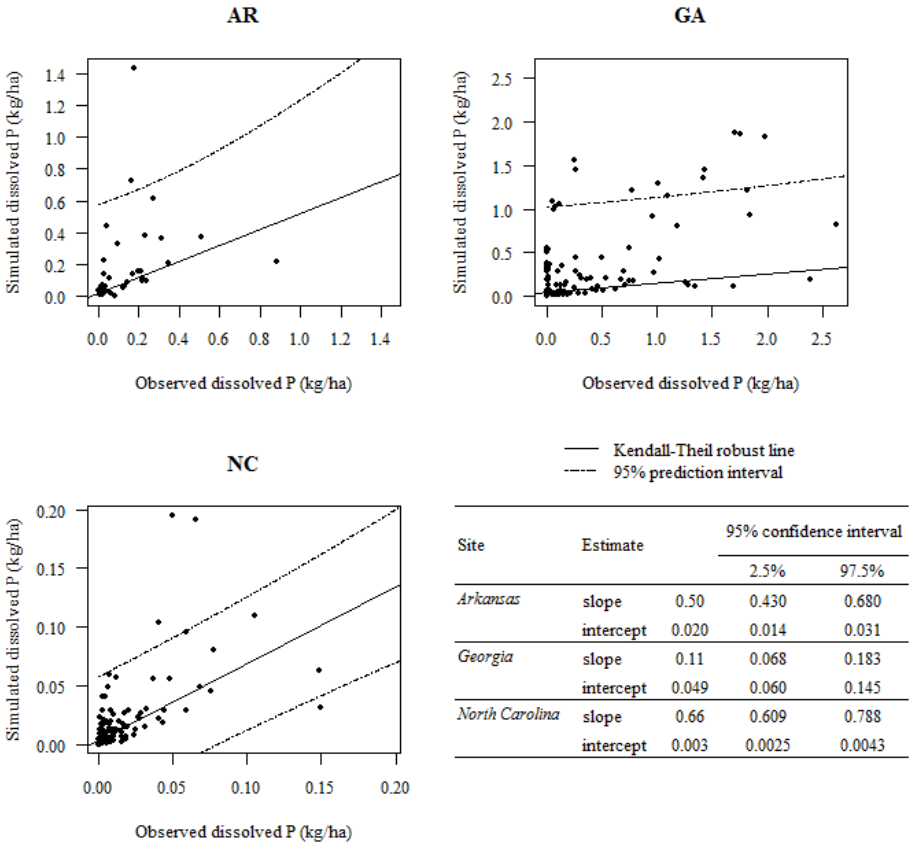
Site	Estimate		95% confidence interval	
			2.5%	97.5%
Arkansas	slope	2.00	1.872	2.284
	intercept	5.103	3.021	7.196
Georgia	slope	0.79	0.711	0.849
	intercept	7.223	7.131	9.017
North Carolina	slope	1.01	0.930	1.068
	intercept	2.654	1.956	3.318

Uncalibrated sediment



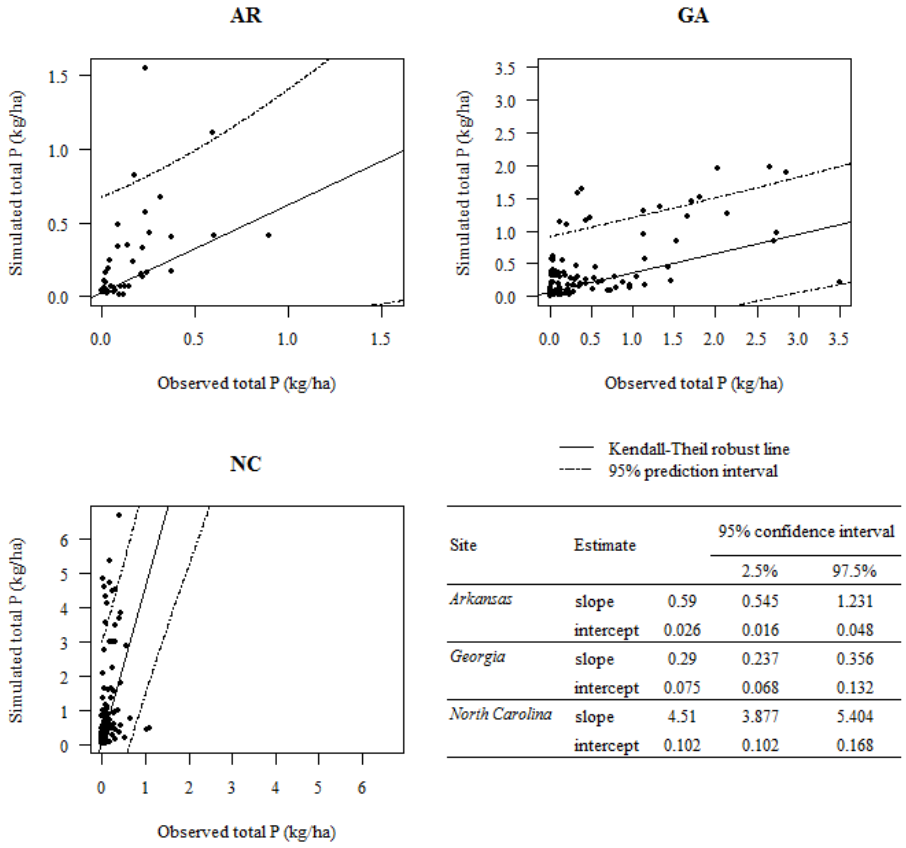
Site	Estimate		95% confidence interval	
			2.5%	97.5%
Arkansas	slope	1.65	1.1997	2.6445
	intercept	0.001	-0.001	0.005
North Carolina	slope	5.38	4.296	6.909
	intercept	0.100	0.087	0.117

Uncalibrated dissolved P



Site	Estimate		95% confidence interval	
			2.5%	97.5%
Arkansas	slope	0.50	0.430	0.680
	intercept	0.020	0.014	0.031
Georgia	slope	0.11	0.068	0.183
	intercept	0.049	0.060	0.145
North Carolina	slope	0.66	0.609	0.788
	intercept	0.003	0.0025	0.0043

Uncalibrated total P



Site	Estimate		95% confidence interval	
			2.5%	97.5%
Arkansas	slope	0.59	0.545	1.231
	intercept	0.026	0.016	0.048
Georgia	slope	0.29	0.237	0.356
	intercept	0.075	0.068	0.132
North Carolina	slope	4.51	3.877	5.404
	intercept	0.102	0.102	0.168

Uncalibrated discussion

Runoff predictions were not bad in GA and NC, but poor in AR

- Large over prediction in AR

Sediment predictions were very poor when losses were high

- Over-predicted in AR and NC
  - Losses were small in AR (pasture)
  - In NC TBET may not credit no-tillage effect sufficiently
- Sediment was not measured in GA where losses were low

Dissolved P predictions were poor when losses were high

- Lack of manure P pool
- Lack of testing on fields with high losses (manured pastures)

Total P predictions were poor when losses were high

- In NC over-prediction of sediment resulted in over-prediction of TP
- In GA under-prediction of DP resulted in under-prediction of TP
- A lot of scatter in AR

Calibration

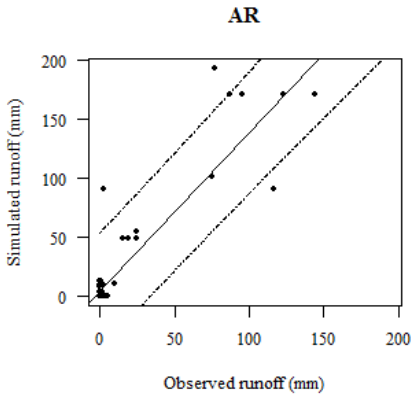
Parameter*	AR	GA	NC
CN_{II}	-16	+8	-16
C_{min}	-60%	default	-60%
SLSBBSN	+60%	default	-60%
ADJ_PKR	0.75	default	0.25
USLE_K	-60%	default	-60%
PPERCO	5	default	5
PHOSKD	200	200	200

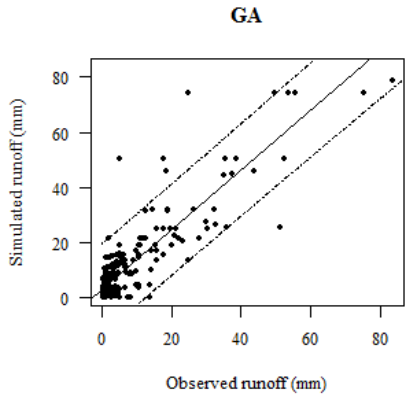
*CN_{II}, Curve number (moisture condition II); C_{min}, USLE minimum crop factor; SLSBBSN, subbasin slope length; ADJ_PKR, Peak rate adjustment factor; USLE_K, USLE erosion factor; PPERCO, phosphorus percolation coefficient; PHOSKD, phosphorus soil partitioning coefficient.

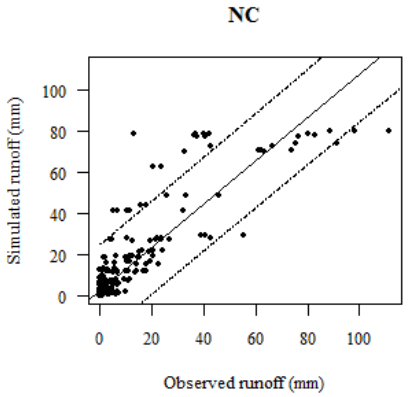
TBET validation results

		NSE	
	AR	GA	NC
Runoff	0.35	0.57	0.65
Sediment	0.24	-	0.31
DP	0.27	0.38	0.32
TP	0.37	-0.02	0.35

Validation runoff



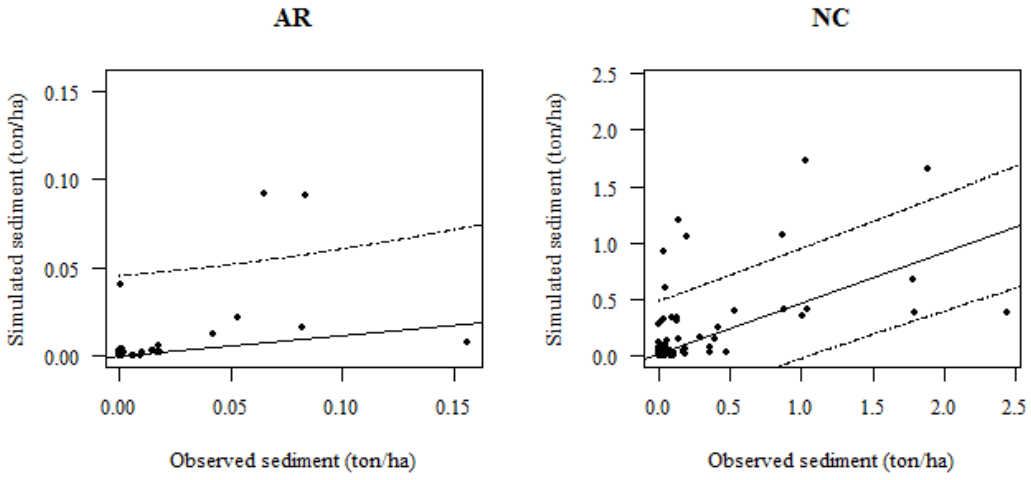




Kendall-Theil robust line
95% prediction interval

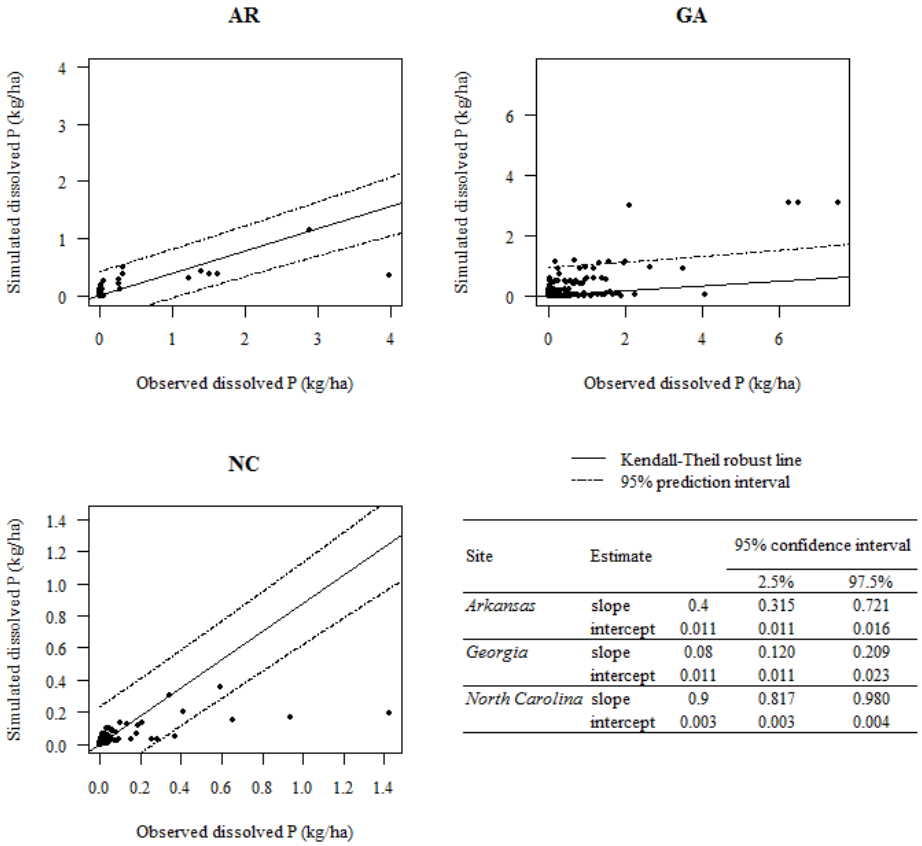
Site	Estimate		95% confidence interval	
			2.5%	97.5%
Arkansas	slope	1.34	0.954	1.568
	intercept	4.303	4.133	5.864
Georgia	slope	1.09	0.998	1.122
	intercept	2.812	2.434	3.150
North Carolina	slope	1.06	1.015	1.123
	intercept	2.126	1.800	2.358

Validation sediment



Site	Estimate		95% confidence interval	
			2.5%	97.5%
Arkansas	slope	0.12	0.131	0.231
	intercept	0.000	0.000	0.001
North Carolina	slope	0.45	0.419	0.578
	intercept	0.011	0.009	0.014

Validation dissolved P



Site	Estimate		95% confidence interval	
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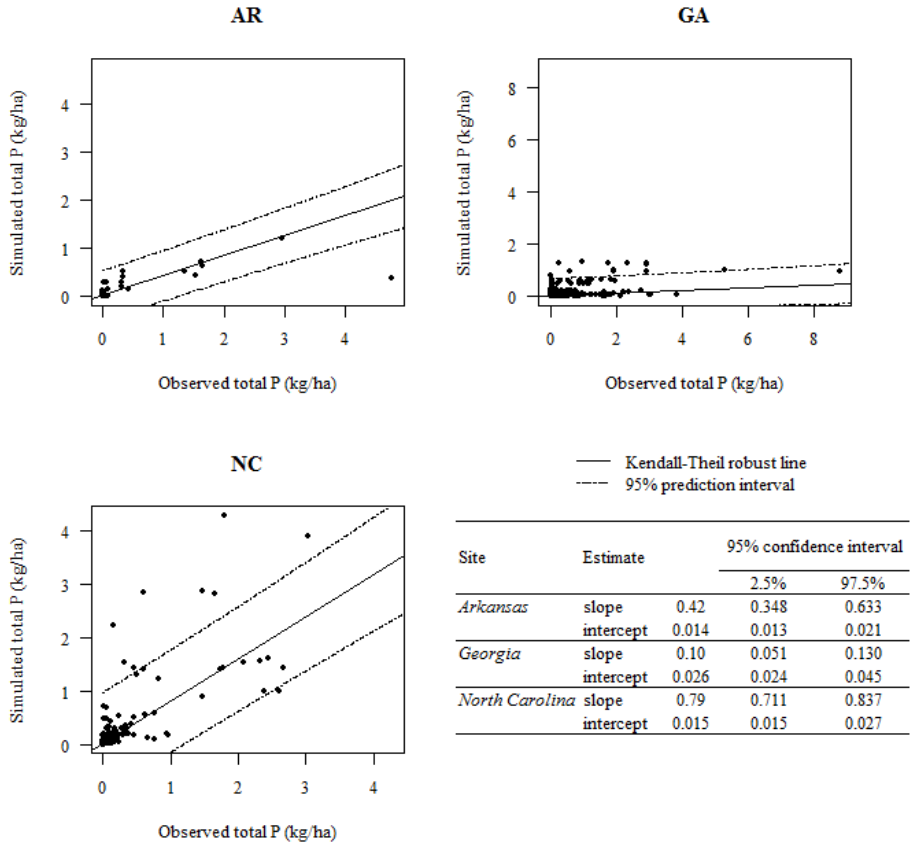
Arkansas	slope	0.4	0.315	0.721
	intercept	0.011	0.011	0.016
Georgia	slope	0.08	0.120	0.209
	intercept	0.011	0.011	0.023
North Carolina	slope	0.9	0.817	0.980
	intercept	0.003	0.003	0.004

Validation total P



Site	Estimate		95% confidence interval	
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Arkansas	slope	0.42	0.348	0.633
	intercept	0.014	0.013	0.021
Georgia	slope	0.10	0.051	0.130
	intercept	0.026	0.024	0.045
North Carolina	slope	0.79	0.711	0.837
	intercept	0.015	0.015	0.027

Validation discussion

Runoff predictions improved and were good at all sites

Sediment predictions improved

- Went from large over-prediction to small under-predicted when losses were high (NC)

Dissolved P predictions improved somewhat

- Still under-predicted when losses were high

Total P predictions improved

- Still under-prediction in GA where DP losses were high
- Sharply improved in NC due to better sediment prediction

TBET and the P-indices

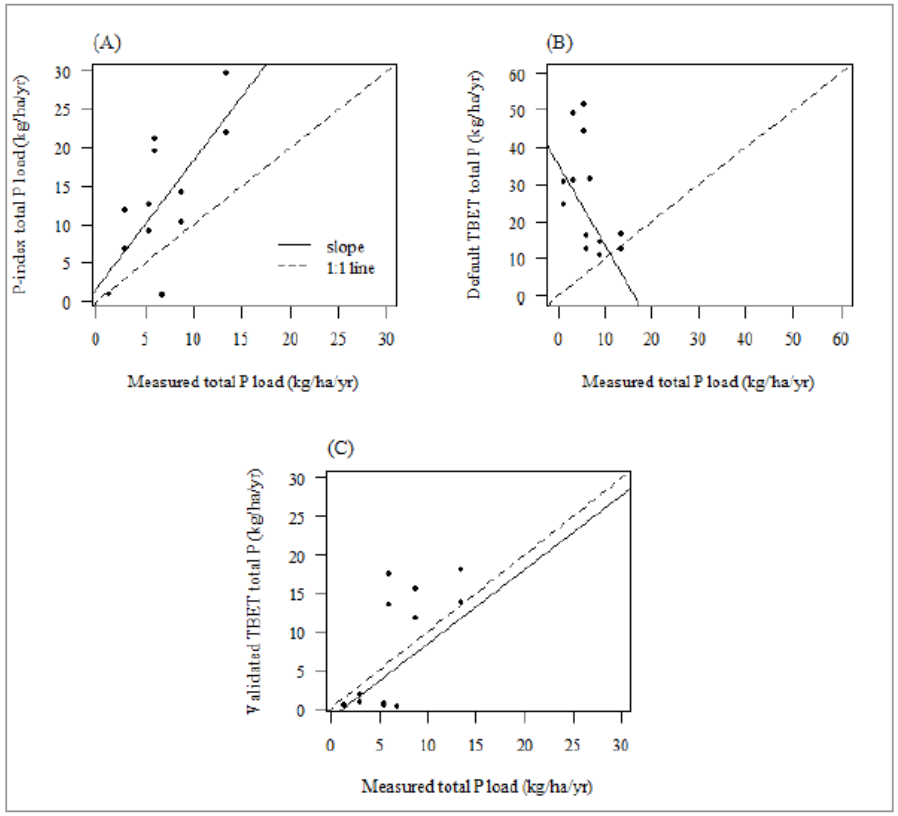

Figure 2.5. Measured average annual P loss versus P-index (A), default (B) and validated (C) Texas Best Management Practice Evaluation Tool 25-year average annual total phosphorus loss for Putnam Co., GA and Henderson Co., NC

Statistics*		P-index	Uncalibrated TBET	Validated TBET
KTR	slope	1.67	-2.2	0.96
	intercept	1.65	35.63	-1.26
MAE, kg ha^{-1}		6.9	20.6	4.4
PBIAS, %		-78	-320	-6.3

*KTR, Kendall-Theil robust line; MAE, mean absolute error; PBIAS, percent bias

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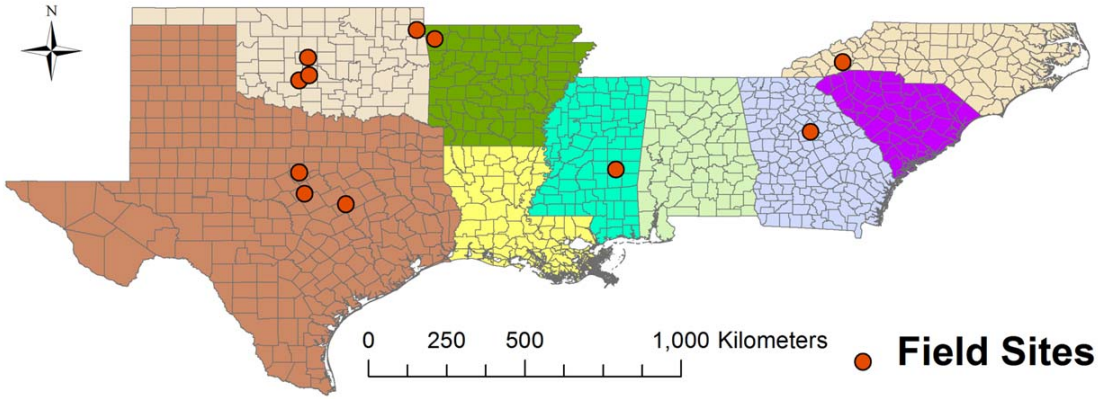
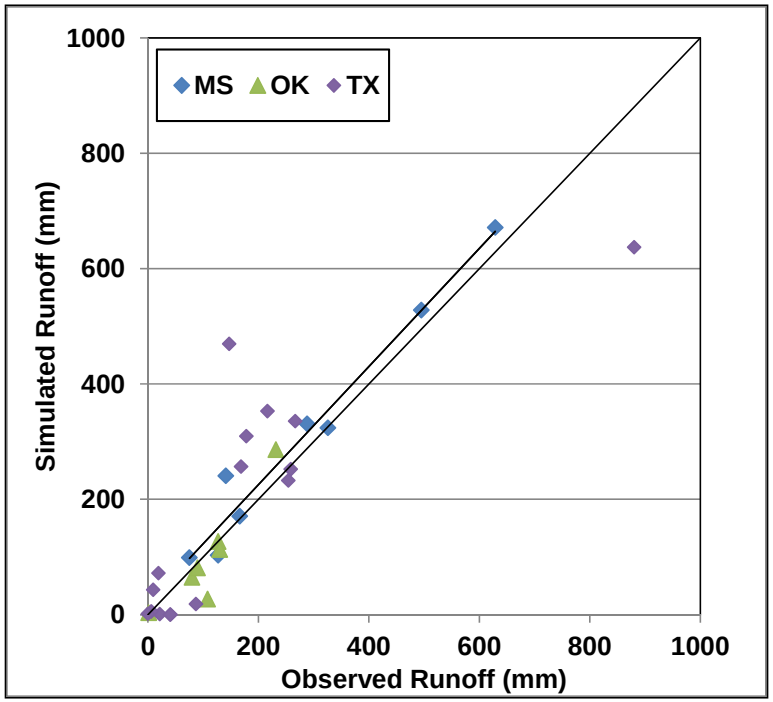


Runoff Calibration

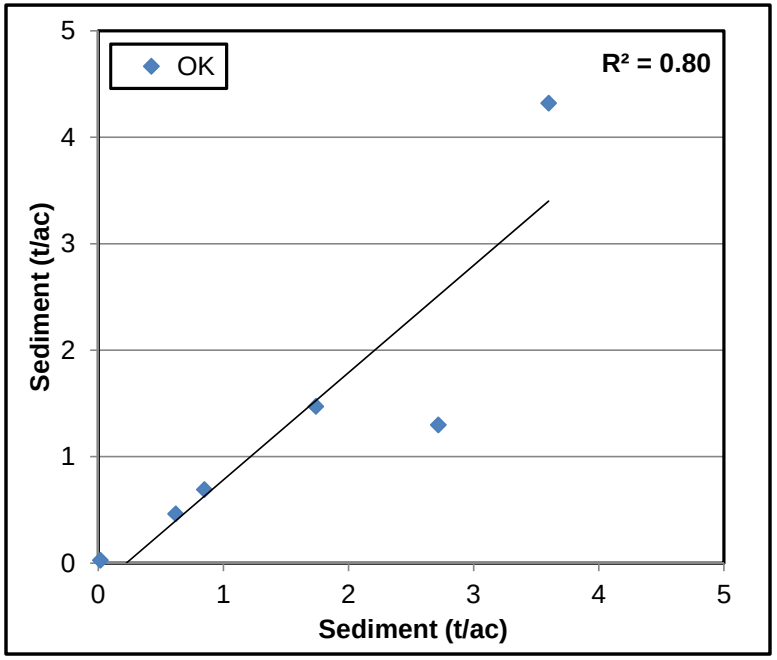
State	Calibrated CN	R^2	NSE
Mississippi	-8	0.97	0.94
Oklahoma	+8	0.85	0.65
Texas	+8	0.70	0.72



Sediment Calibration

State	Calibrated ADJ_PKR	R^2	NSE
Oklahoma	0.50	0.80	0.71

Finishing up Texas and Mississippi



Phosphorus Calibration

- All sites under predicting total and dissolved P
- Will finish P calibration in December

Conclusions

- TBET was able to produce satisfactory event-based predictions (NSE ≥ 0.3) of runoff, sediment, total P, and dissolved P in the southern region with site-specific calibration
- The validated TBET model provided satisfactory predictions of long-term P loss that were similar to P-Index predictions
- The variation in best-fit parameters, goodness-of-fit, and estimated uncertainties in TBET predictions among study sites suggests TBET may not be appropriate for applying a regional parameter set for the South
- To set up TBET models for each state would require a tremendous amount of work
  - This has been done for TX and OK
  - State specific calibration would be required
  - Management files have to be developed for all possible scenarios
  - 25-year weather files and soils files for each site would need to be prepared