Is Site-specific APEX Calibration Necessary for Field scale BMP Assessment ?

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Agricultural Policy Environmental eXtender (APEX)

- Large scale watershed simulations (= SWAT model).

- Best management practices (BMPs, structural) represented virtually and empirically.

Fig. 1: DEM-based APEX subarea delineation

- Plot / field / farm scale simulations.

- Structural BMPs as separate subarea units similar to their physical existence.
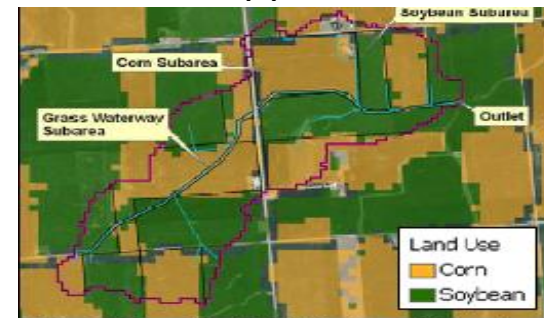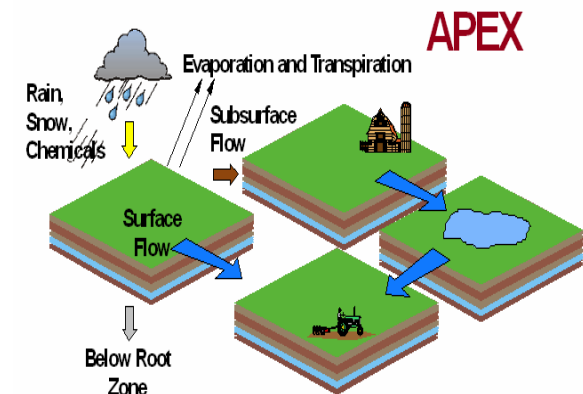
Tuppad et al., 2009

Fig. 2: User-defined APEX subarea delineation

- Capability to route sediment nutrient and other pollutants through different landscape units.

- Appropriate parameterization is essential for reliable prediction for BMPs;

  - **Measurable parameters**:

    - **Watershed characteristics -** topography, soil, land-use / structural BMPs and management

  - **Parameters needed to be decided**:

    - >100 **global parameter values**

      - the equations to be used for major hydrological processes: runoff, peak flow rate, erosion, evapotranspiration – **Control file**

      - and the rates and threshold values - **Parameter file**

Parameterization, Validation and Scenario analysis

- **Global parameter values needed to be decided**:
  - **Best professional judgment** based on experience, previous findings.
  - Use a **calibration & validation process** using measured data.
  - The results might again vary with availability of data:
    - Crop yield, flow, sediment, nutrient etc.,
    - Daily /event/monthly/yearly,
    - Site specific calibration and validation,
    - Site specific validation only,
    - Calibrate on one site and validate on another site.
  - Different sets of parameters may be possible.
  - Are all of these good enough for BMP assessments ?

Objectives

+ Evaluate and compare two off-site specific and one site-specific calibrated parameter sets of the APEX model on a validation watershed.

-Two off-site parameter sets

- On-site parameter set and the validation watershed
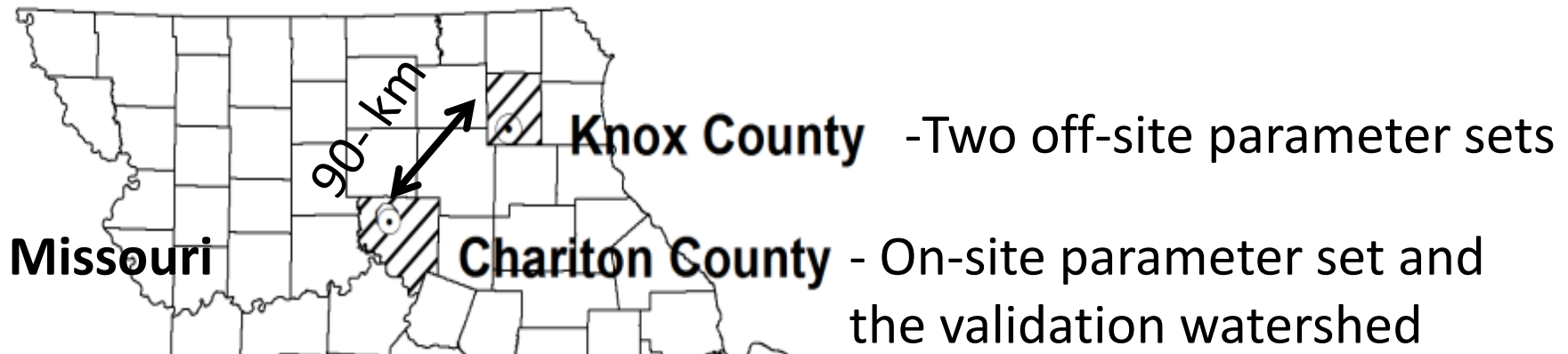
+ Compare their long-term predictions for BMPs of the validation watershed with terraces, a grass waterway and winter cover crop (winter wheat).

First and second off-site param. sets
Center WS, Novelty, Knox county, MO (4.44 ha), no-till, corn-soybean, grass waterway, claypan soils.

Local validation
West WS (3.16 ha).
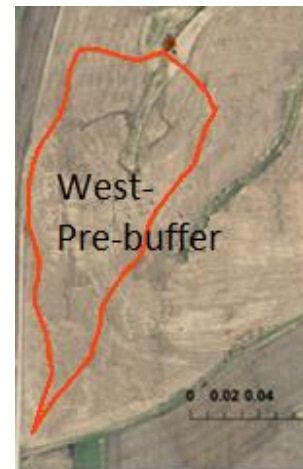
Pre-buffer	**Post-buffer** (agroforestry)	**pre-buffer**	**Post-buffer** (grass)
1993-1997	1998-2008		
47 events	42 events		
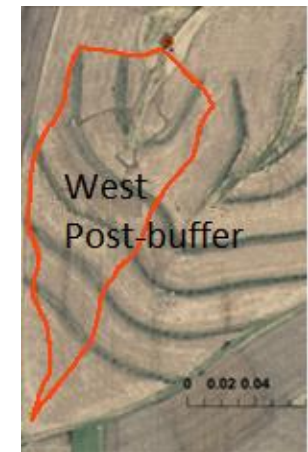
+ Site specific contour maps, land-use maps and measured soil data were available for the model buildup.

Third Calibration & Validation

→ **Third site parameter set**

Chariton 1, MO, (2.69 ha), field-cultivated, corn soybean, **no-BMP** (2012-2013, 10 events).
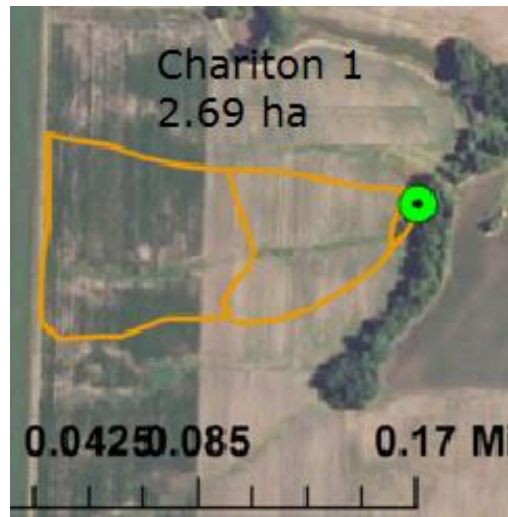
→ **Validation of all three**

Chariton 2, MO,(31.7 ha), field-cultivated**, terraced, a grass waterway, and winter cover-crop**- winter wheat (2011-2013, 15 events).

Chariton 1
2.69 ha

0.04250.085   0.17 Mi

Chariton 2
31.7 ha

0 0.050.1   0.2 Miles

→ **Publicly available databases** for topography, landuse (USGS), and soil data (SSURGO) were used for the model buildup.

Tools of Calibration

- Automated calibration tools;
  - **Parameter Sensitivity (PARSEN)** :
    -Find most sensitive parameters
  - **Parameter Optimization (PAROPT)** :
    -Find optimal combination of most sensitive parameters
- All parameter sets were calibrated for crop yields, event runoff, sediment and TP loads.
- Statistics used to compare measured vs predicted:

Performance indicators	Perfect	Acceptable thresholds	
		Monthly†	**Event**
Coefficient of determination (r^2)	1	≥ 0.6	≥ 0.5
Nash-Sutcliffe Coefficient (NSC)	1	≥ 0.5	≥ 0.4 for runoff ≥ 0.3 for sediment & and TP
Percent bias (Pbias)	0	± 25% for runoff, ± 55% for sediment, ± 70% for TP	

(† Moriasi et al., 2007)

Results of Calibration and Validation

Parameter set		Event runoff			Event sediment load			Event TP load		
		r^2 ≥0.5	NSC ≥0.3	Pbias ±25%	R^2 ≥0.5	NSC ≥0.3	Pbias ±55%	R^2 ≥0.5	NSC ≥0.3	Pbias ±70%
First Pre-buffer	Cal.	0.87	0.85	-7	0.55	0.45	-48	0.64	0.57	12
	LV	0.88	0.77	21	0.43	0.42	-6	0.63	0.48	37
Second Post-buffer	Cal.	0.82	0.79	-4	0.27	0.13	13	0.65	0.52	-14
	LV	0.75	0.74	-4	0.29	0.24	-2	0.63	0.55	11
Third Chariton 1	Cal.	0.88	0.86	-18	0.87	0.74	10	0.92	0.64	33
Validation										
First	V	0.73	0.31	6	0.51	0.49	23	0.88	0.28	70
Second	V	0.80	0.39	-20	0.37	0.27	46	0.94	0.28	71
Third	V	0.78	0.57	18	0.53	0.37	54	0.90	0.50	67

Cal.- Calibration,   LV- Local validation, V-Validation by the Chariton 2
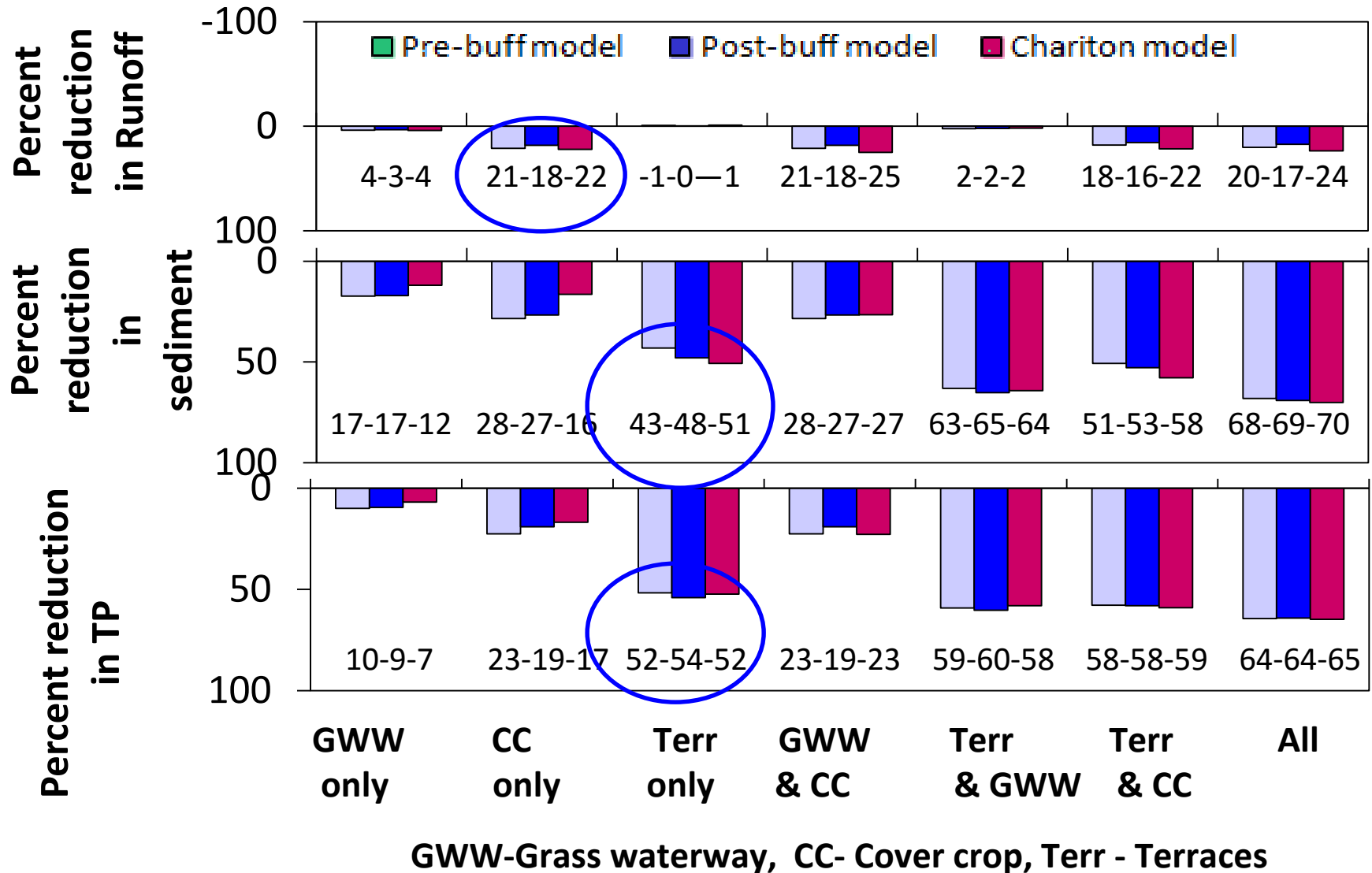
Average Annual Output for 30 year BMP Scenarios

- All three parameter sets showed similar responses for BMPs.
- Cover crop mostly reduced runoff, Terraces mostly reduced sediment and TP.

GWW-Grass waterway, CC- Cover crop, Terr - Terraces
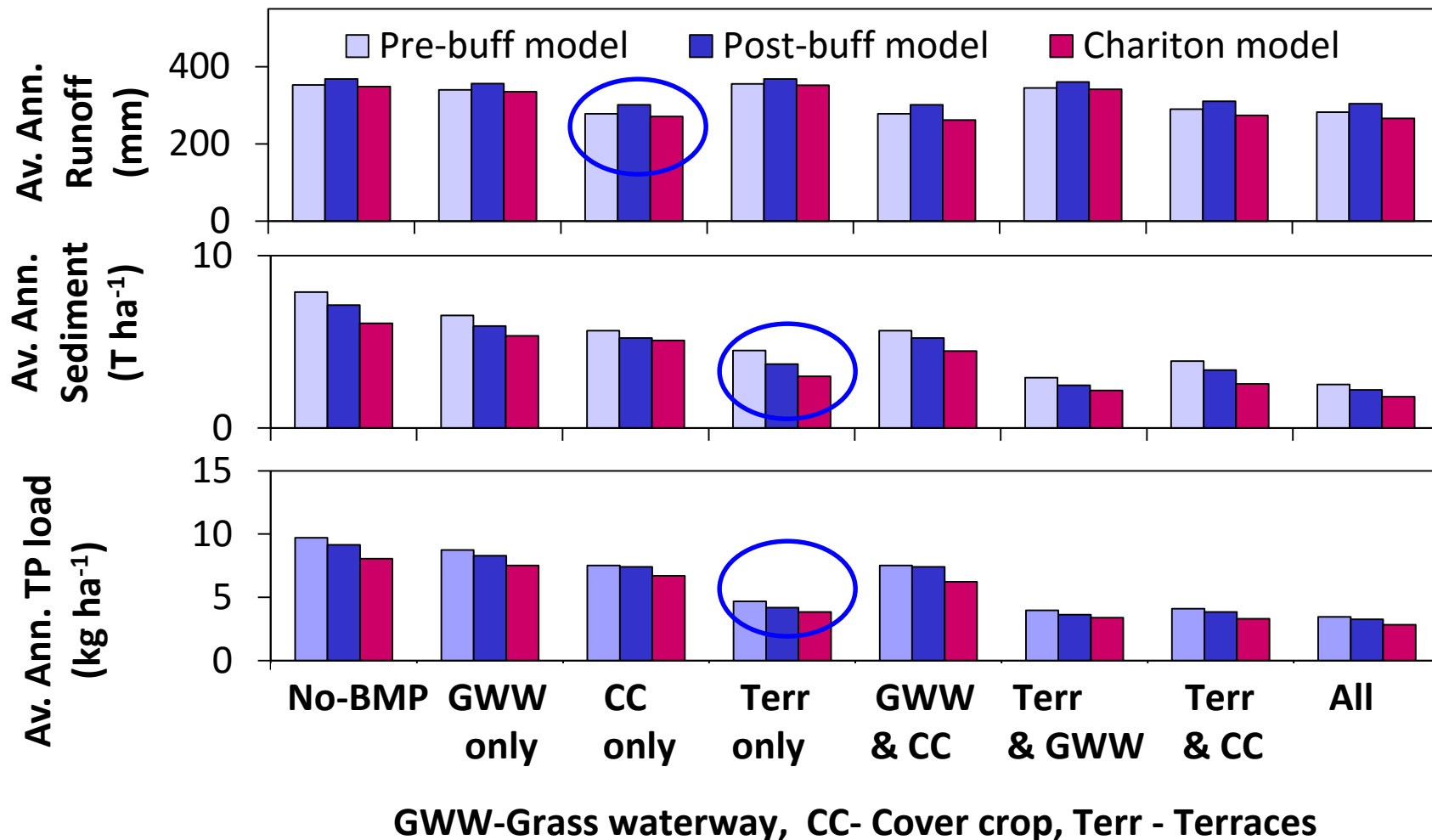
30 year BMP Scenario analysis

- Relative reductions by BMP compared to no-BMP scenario.
- Similar responses among the three parameter sets (± 12%).

Percent reduction in Runoff

| Pre-buff model | Post-buff model | Chariton model |

4-3-4   21-18-22   -1-0—1   21-18-25   2-2-2   18-16-22   20-17-24

Percent reduction in sediment

17-17-12   28-27-16   43-48-51   28-27-27   63-65-64   51-53-58   68-69-70

Percent reduction in TP

10-9-7   23-19-17   52-54-52   23-19-23   59-60-58   58-58-59   64-64-65

| GWW only | CC only | Terr only | GWW & CC | Terr & GWW | Terr & CC | All |

GWW-Grass waterway, CC- Cover crop, Terr - Terraces

Conclusions

- Off-site parameter sets reliable for comparative assessments of BMPs at field scale.

- Site specific calibration is necessary for quantifying the benefits of BMPs at field scale.

- Site specific parameter set developed based on a small watershed using publicly available data and with no-BMP, quantified the BMP benefits of a 12 times larger watershed.

- Monitoring is continuing on the Chariton sites and Additional data will be available in the future.

- Efforts toward a regional parameter set are also on-going with additional sites across several states in the Midwest.

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