

Long-Term Water Quality Response to Conservation Practices in Nested Coastal Plain Watersheds

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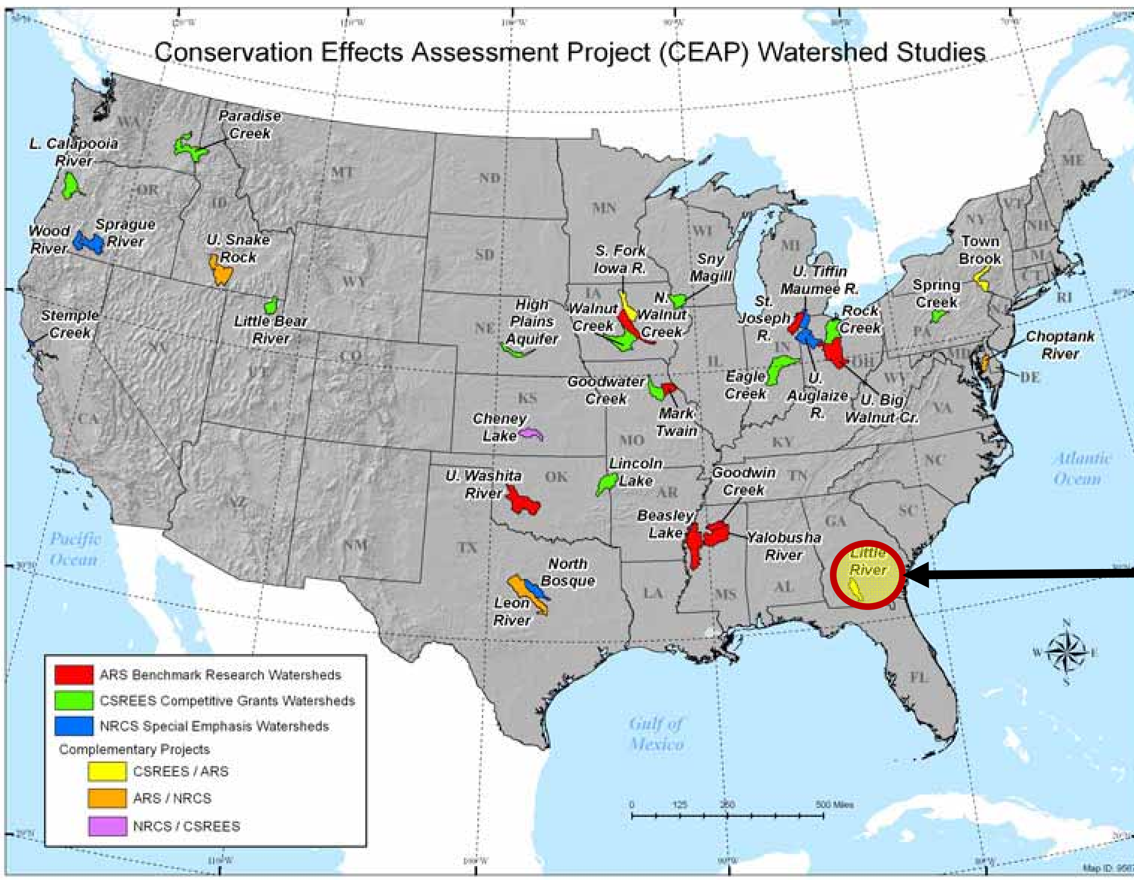
Outline

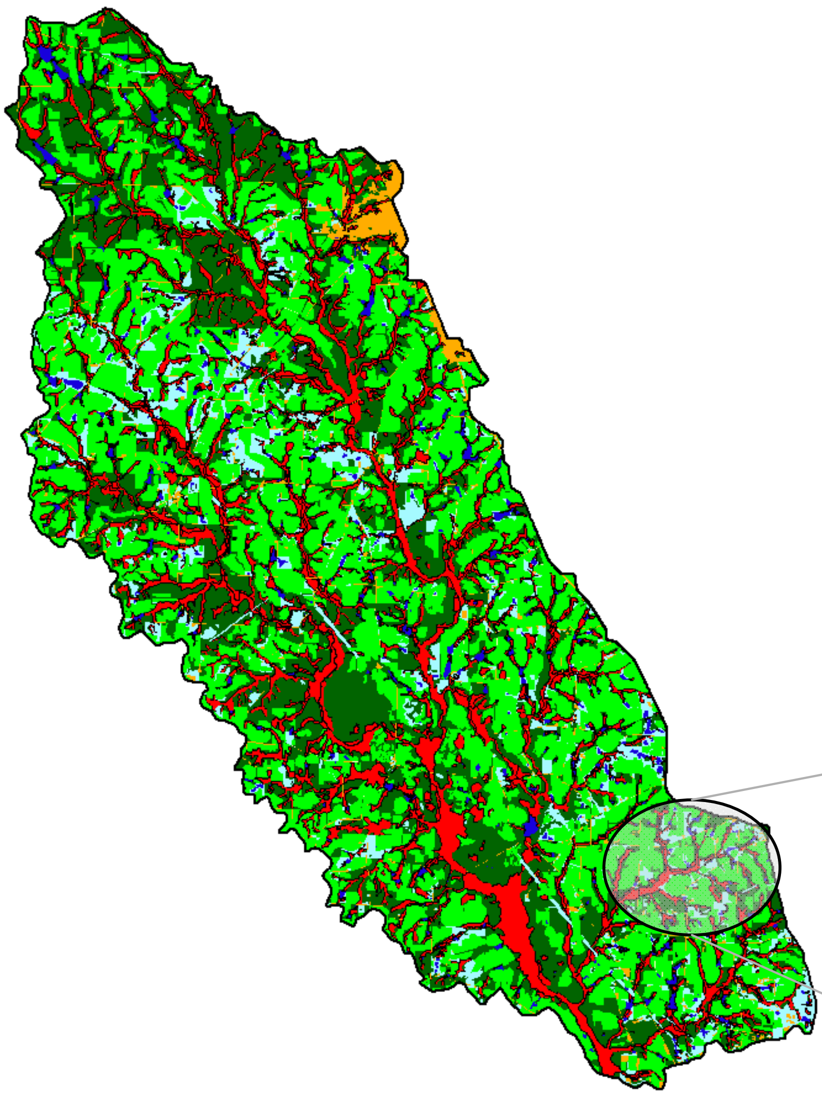
- Background on
  - Little River watershed (LREW)
  - Soil & Water Assessment Tool (SWAT)
- Modeling procedures
  - Calibration and validation
  - Modeling current CPs
  - Modeling alternative scenarios
- Results and Summary

Background

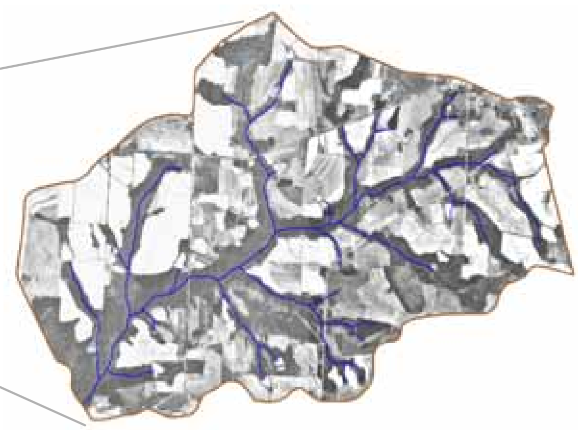


Little River Experimental Watershed in CEAP

Little River Watershed



- 8 streamgages (LRB: 334 km^2)
- Flat area (Elevation: 82 m ~ 148 m)
- Dense dendritic network of stream channels
- Agricultural: 41%, Forest: 47%, Urban: 3%, Pasture: 7%, Water: 2%
- Shallow and impermeable Hawthorne formation
- Channels bordered by riparian forest

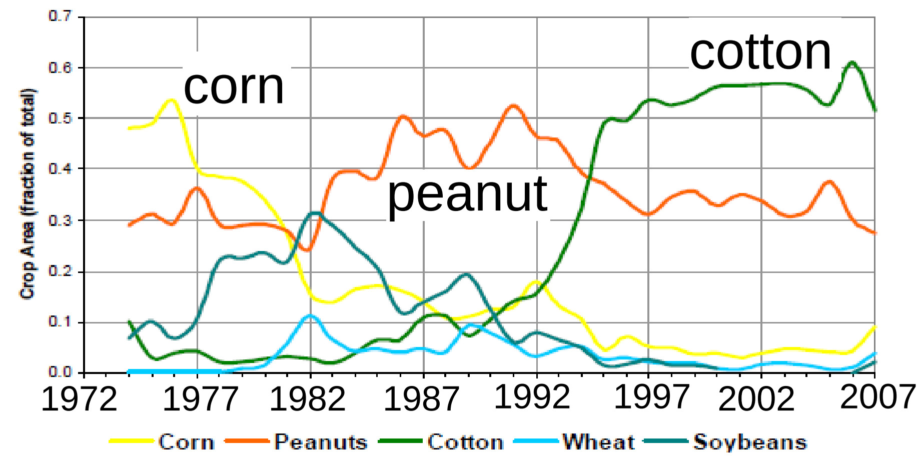


Long-term changes in...

- land cover, crop rotation, conservation practice -

Land in CP: 1981

- Land cover: minor changes
- Crop rotation: major changes in crops (cotton, peanut, corn)

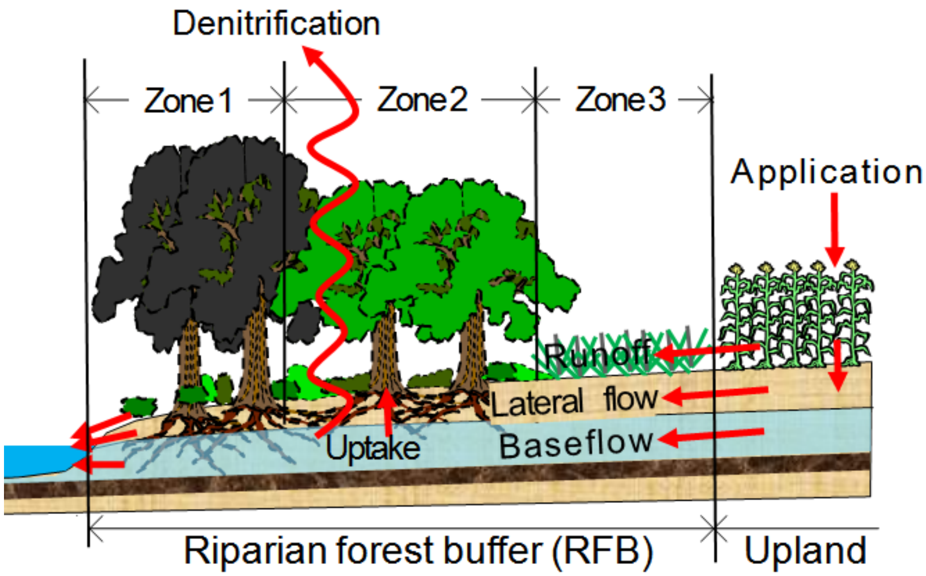


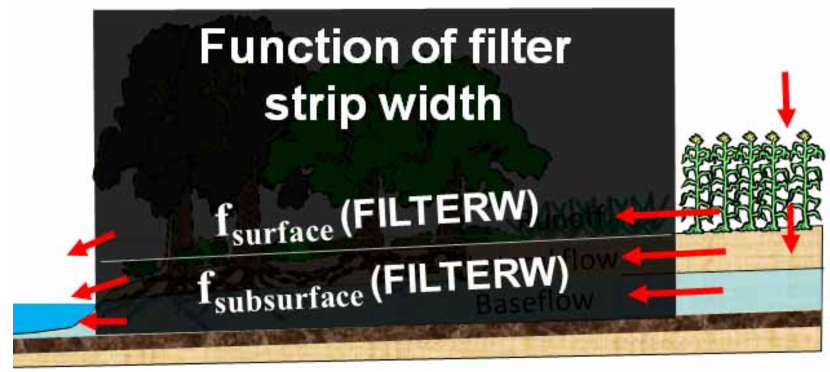
Tift, Turner, and Worth County Harvested Area

- Spatial distribution of CPs
- Temporal changes in CPs: multiple applications within in a field

Difficulties in representing CPs using SWAT

- **Spatial representation**



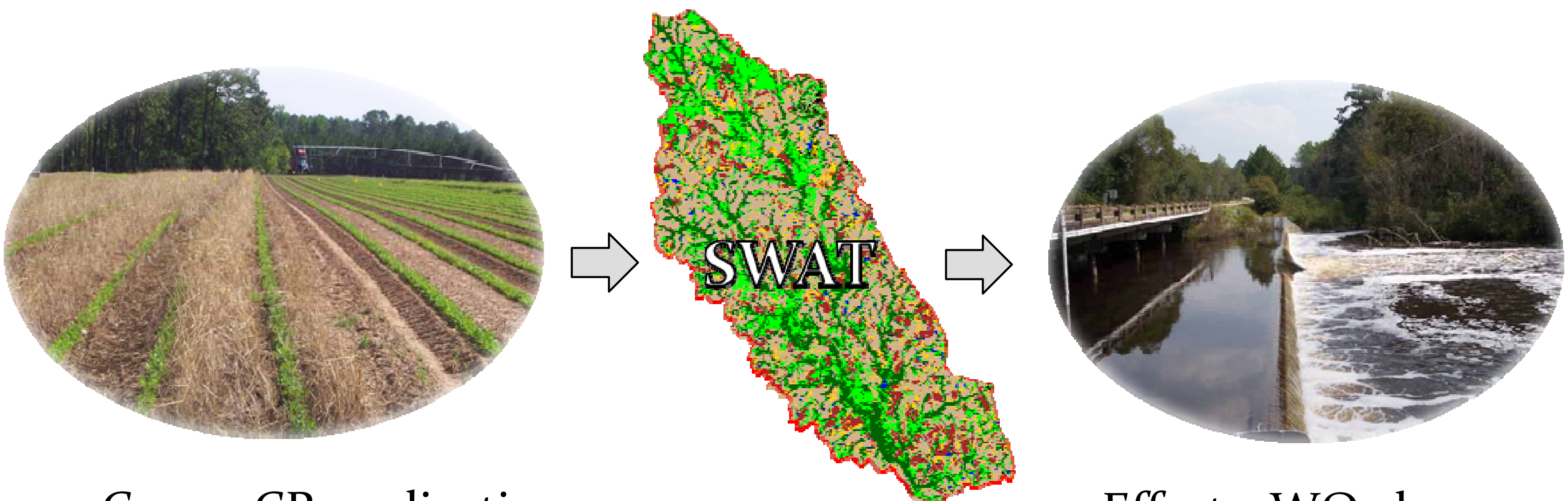


No interactions between upland and RFB, no dynamic nutrient conversion and reduction in RFB

- **Temporal representation**
  - Difficult to consider actual year of CP application and changes in crop rotations within a simulation
- **Parameterization**: empirically-based parameters (CN & USLE)

Objectives

- Evaluate cause and effect relationships between water quality trends and CP applications using SWAT:
  - Evaluate impacts of current CPs.
  - Evaluate potential impacts of alternative scenarios.



Cause: CP application

Effects: WQ changes

Modeling procedure

Calibration and Validation

- Decide **general parameters** for representing hydrology and pollutant transport process, which are stable for a long-term: **calibration & validation**

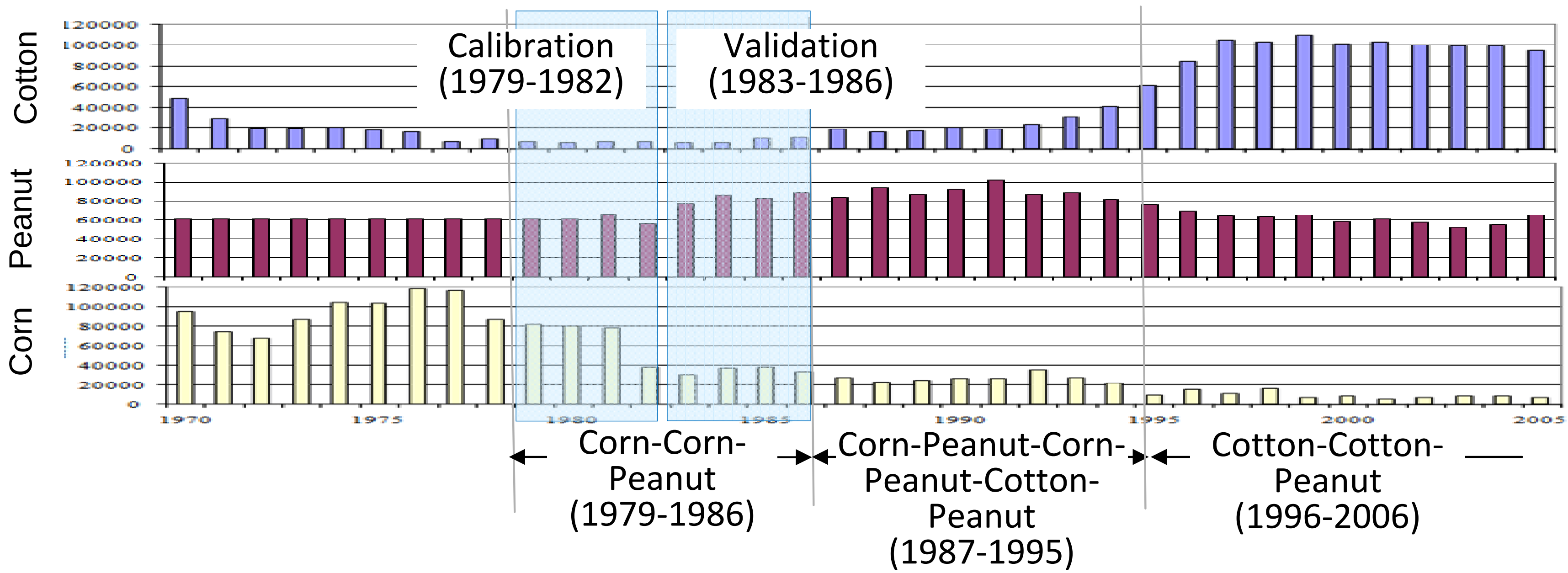
Impacts of current CPs

- Decide **CP-related parameters** for representing pollutant reduction process by CPs: **literature review**
- Compare simulated results: without CPs vs. current CPs

Impacts of alternative scenarios

- Major CPs are applied to no-CP crop areas
- Compare simulated results with current CPs

Calibration and validation

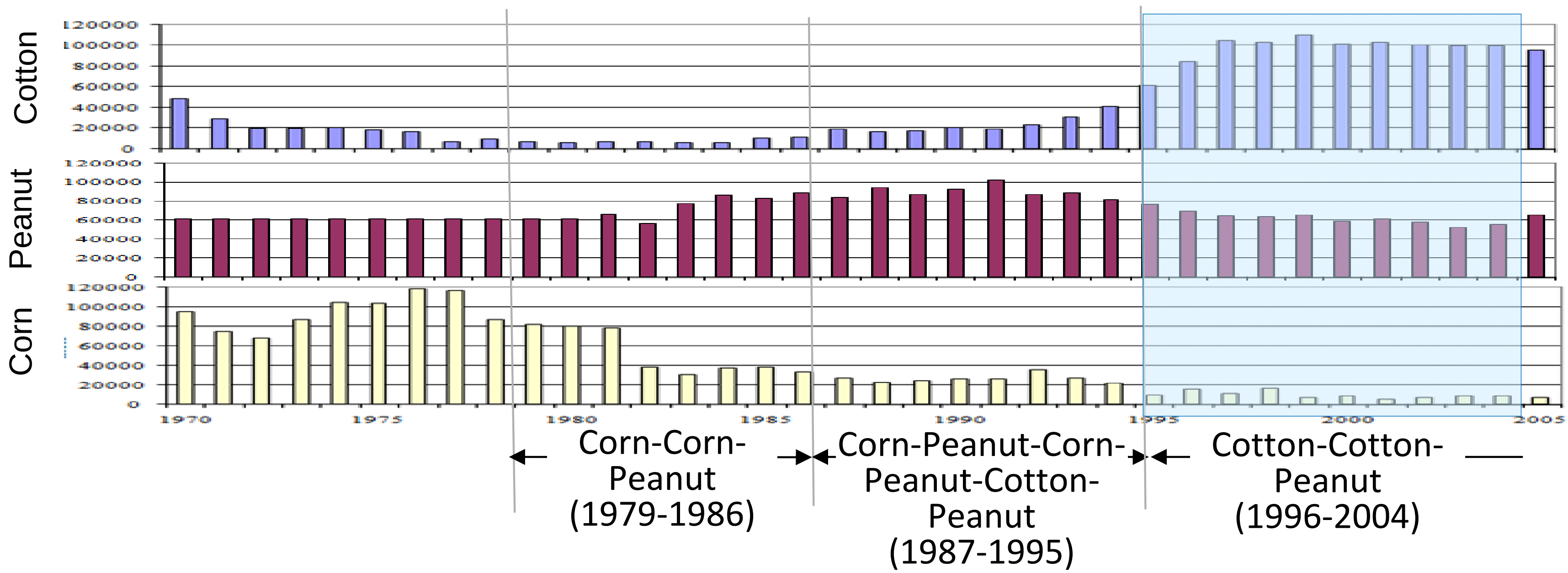


- Corn-corn-peanut rotation: 4 years of calibration and validation.
- CPs were ignored for both calibration and validation period.

Performance	PE	NSE
Satisfactory	PE < ±25	0.50 < NSE
Unsatisfactory	PE≥±25	NSE≤0.50

- Nash-Sutcliffe Efficiency Index: $NSE = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2}$

Modeling current CPs



- Cotton-cotton-peanut rotation for 1996-2004.
- Compare simulated results between current CPs and without considering CPs.
- Only major CPs were considered.

Modeling current CPs
- Selected major CPs-

- **Nutrient management practice (NMP)**
  - 30 % of decrease in nutrients amount applied without considering split application.
- **Forest establishment practice (FEP)**
  - Land use changes from crop land to forest was considered.
- **Crop management practice (CMP)**
  - Contour farming (C), grassed waterway (G), terrace (T), and residue management (R, conservation tillage) are grouped together (CGTR).
  - A half of CGTR consider nutrient management (N) as a set.

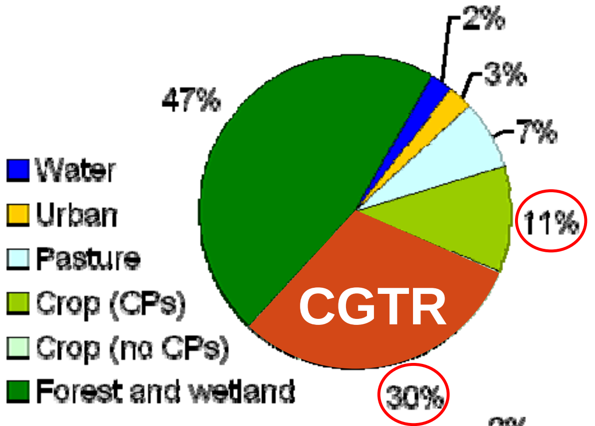
  → CGTR-N or CGTR

Modeling current CPs
- CP related parameters -

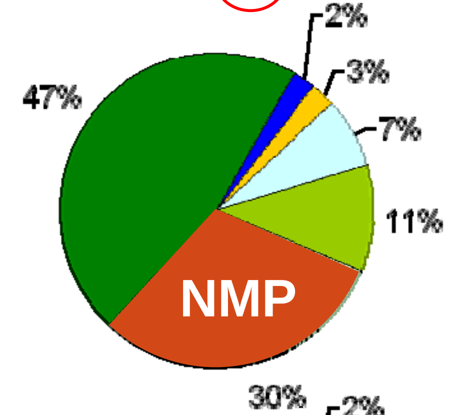
CPs	Functionality/Objectives	parameters
Contour farming, Grassed waterway, Terrace (CGT)	– Retain runoff for moisture conservation – Reduce channel erodibility, slope length, sheet and rill erosion, transport of other water-borne contaminants	**CNOP** CH_N SLSUBBSN USLE_P
Residue management (R)	– Improve soil organic matter content – Increase plant-available moisture – Reduce sheet and rill erosion – Manage excess nutrients in the soil profile – Provide supplemental forage	**CNOP** TILL_ID
Nutrient management (NMP)	– Manage the amount, source, placement, form and timing of the application of nutrients – Minimize agricultural NPS pollution of surface and ground water resources	FRT_KG
Forest establishment (FEP)	– Long-term erosion control – Improvement of water quality	Change LU CODE

Modeling alternative scenarios

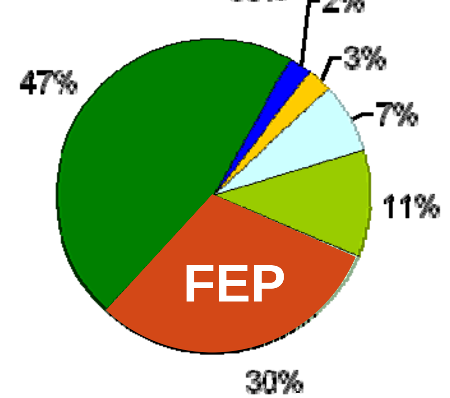
- **Scenario 1**: apply crop management practice without considering nutrient management(CGTR) to all no-CP crop areas.



- **Scenario 2:** apply nutrient management practice (NMP) to all no-CP crop areas.



- **Scenario 3:** apply forest establishment practice (FEP) to all no-CP crop areas.

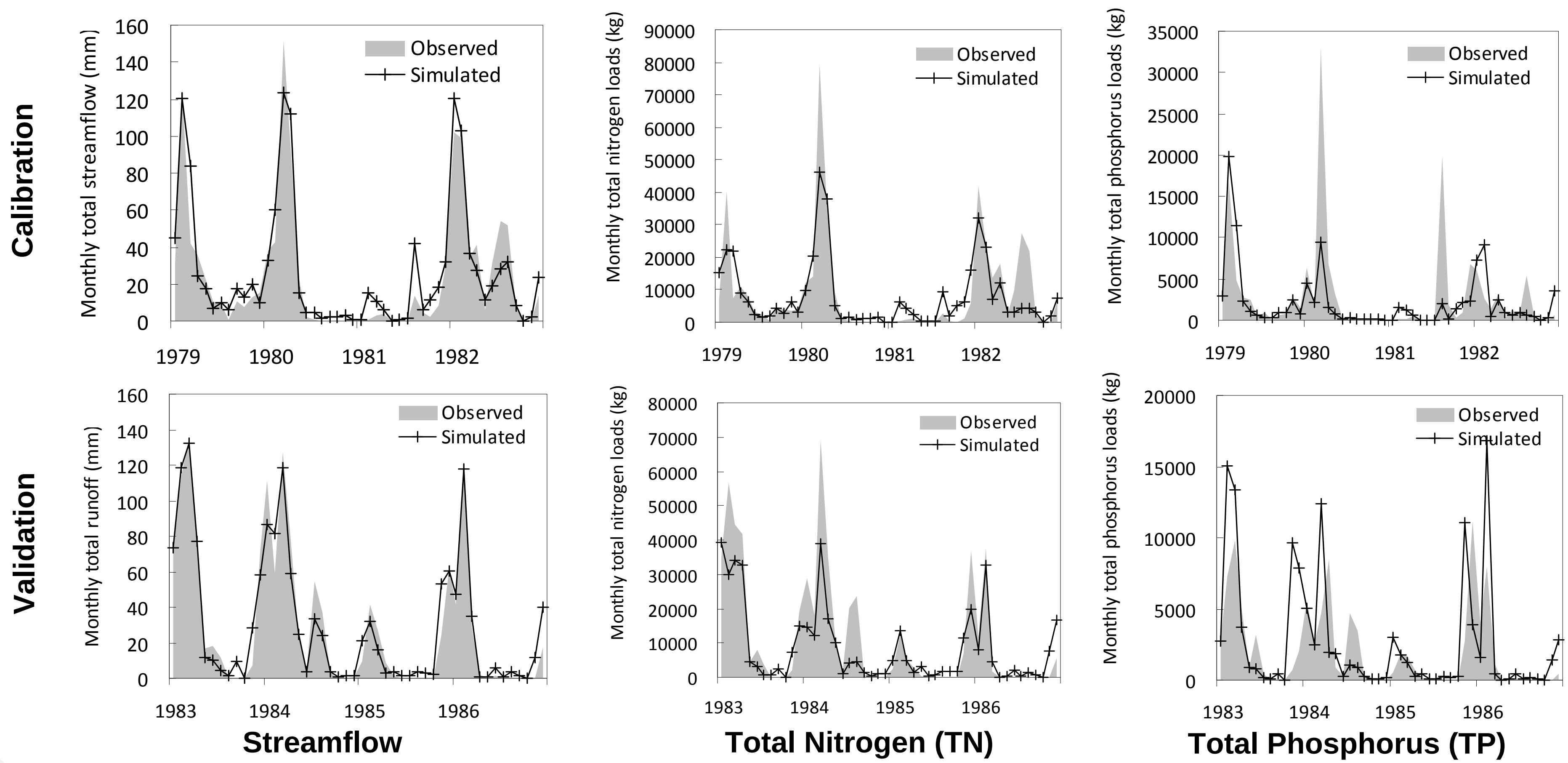


Modeling Results

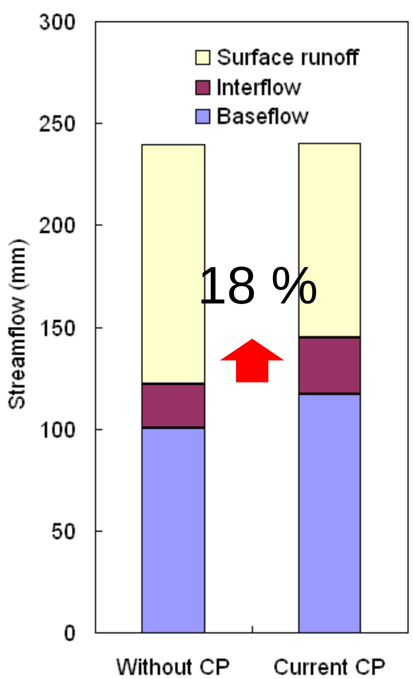
- Calibration and validation
- Impacts of current CPs
- Impacts of alternative scenario

Calibration and Validation

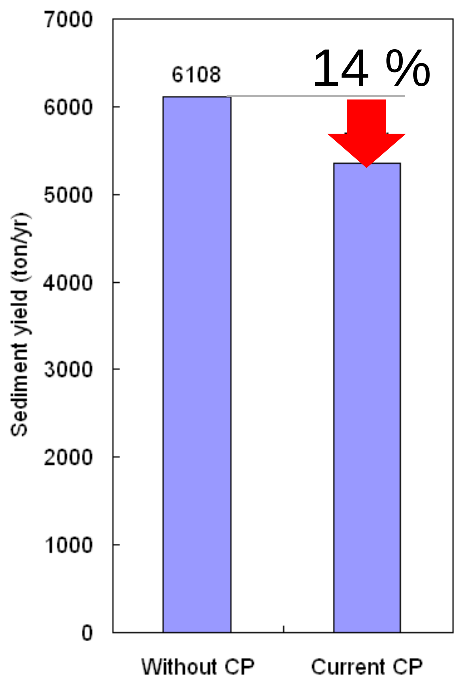
Criteria	Streamflow (mm/yr)		TN (kg/ha/yr)		TP (kg/ha/yr)	
	Calibration	Validation	Calibration	Validation	Calibration	Validation
Observed/Simulated	296 / 323	355 / 358	3.18 / 2.83	4.09 / 3.11	1.05 / 0.76	0.72 / 0.95
% error	9.3	0.7	-11.0	-24.1	-27.5	33.3
Monthly NSE	0.88	0.93	0.70	0.73	0.35	-0.36



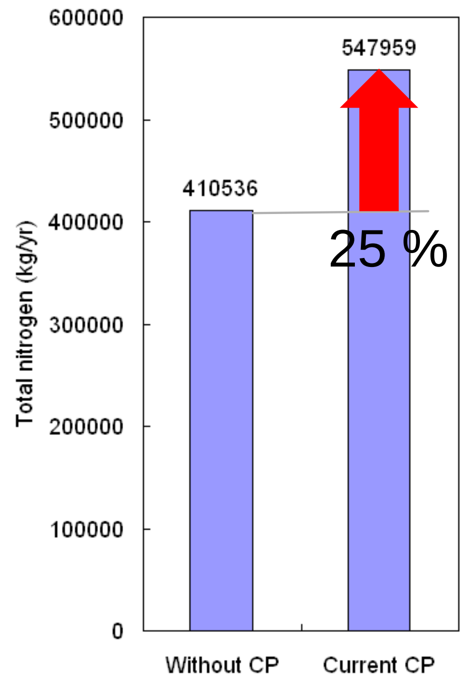
Impacts of current CPs
- Yields at the watershed outlet -



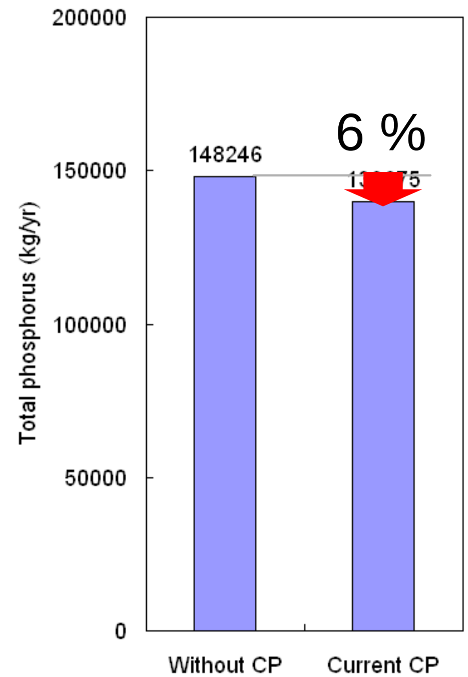
Streamflow



Sediment

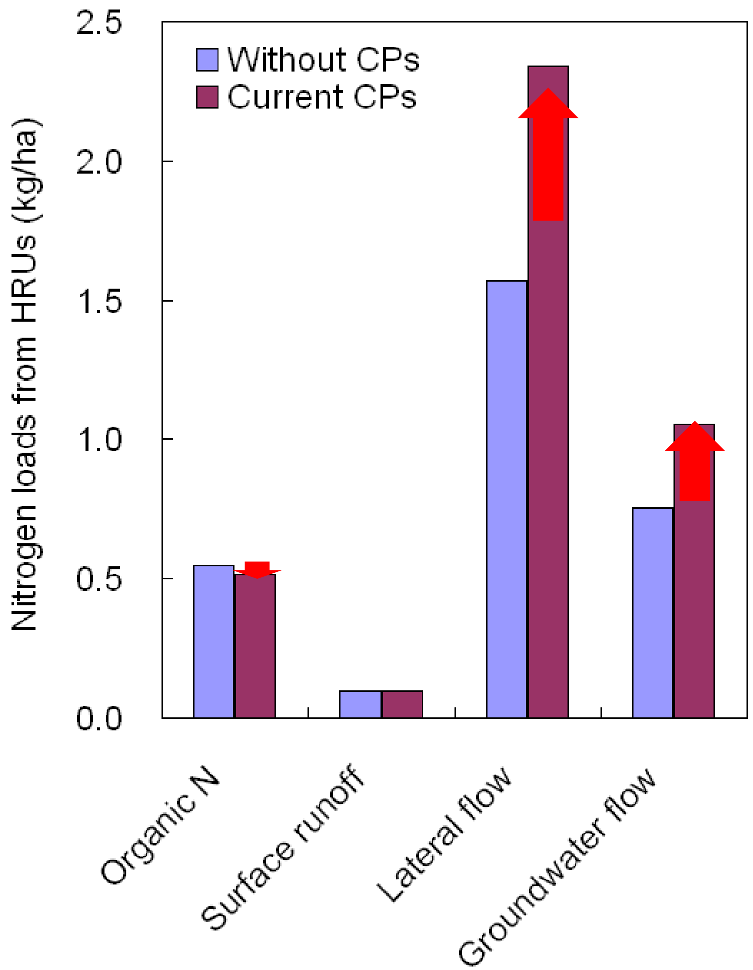


TN

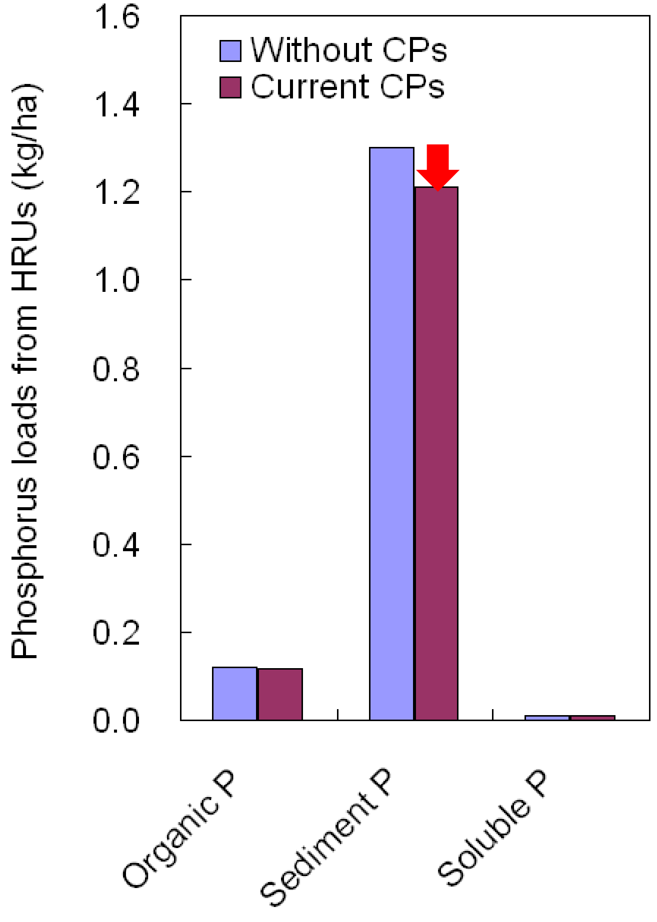


TP

Impacts of current CPs
- Load from HRUs -

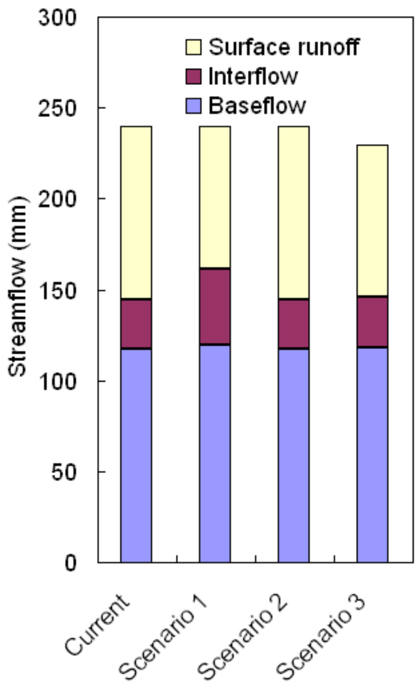


Nitrogen

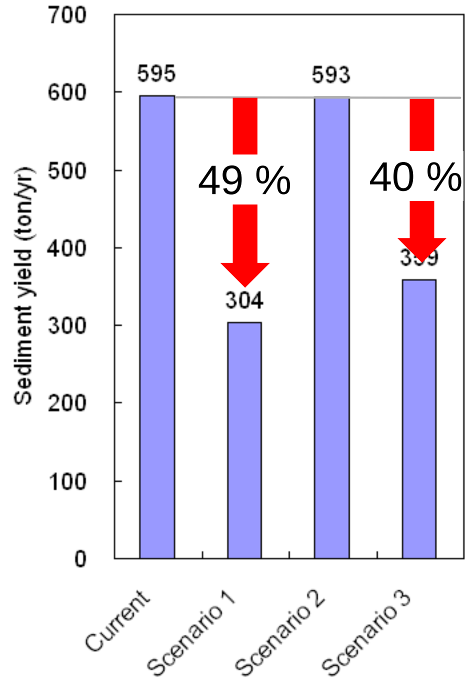


Phosphorus

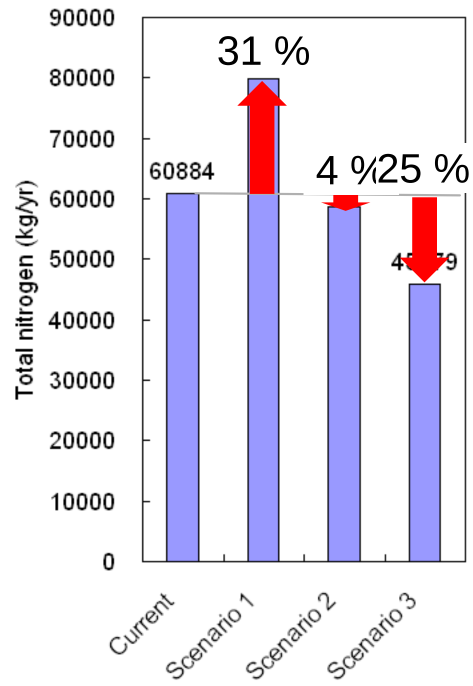
Impacts of alternative scenarios
- Yields at the watershed outlet -



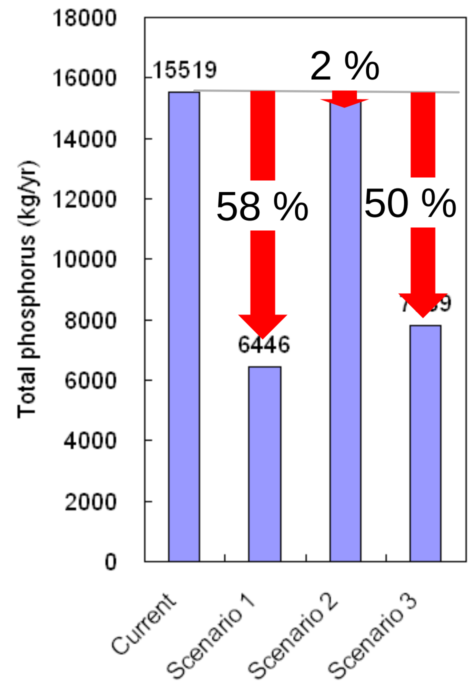
Streamflow



Sediment



TN



TP

Scenario 3: apply forest establishment practice (FEP) to all remaining crop areas.
watersned area).

Summary

- Impacts of Current CPs.
  - Sediment and TP yields decreased 14 % and 6 %, respectively.
  - TN yields increased 25 %.
- Impacts of alternative scenarios
  - Forest establishment shows significant impacts on sediment, TN, and TP.
  - Crop management practice was effective for sediment and TP.
  - Impact of nutrient management practices was not significant by showing less than 10 % of reduction rates.

Questions?

Background

- Little River watershed: Long-term changes
- SWAT: overview, difficulties
- Objective

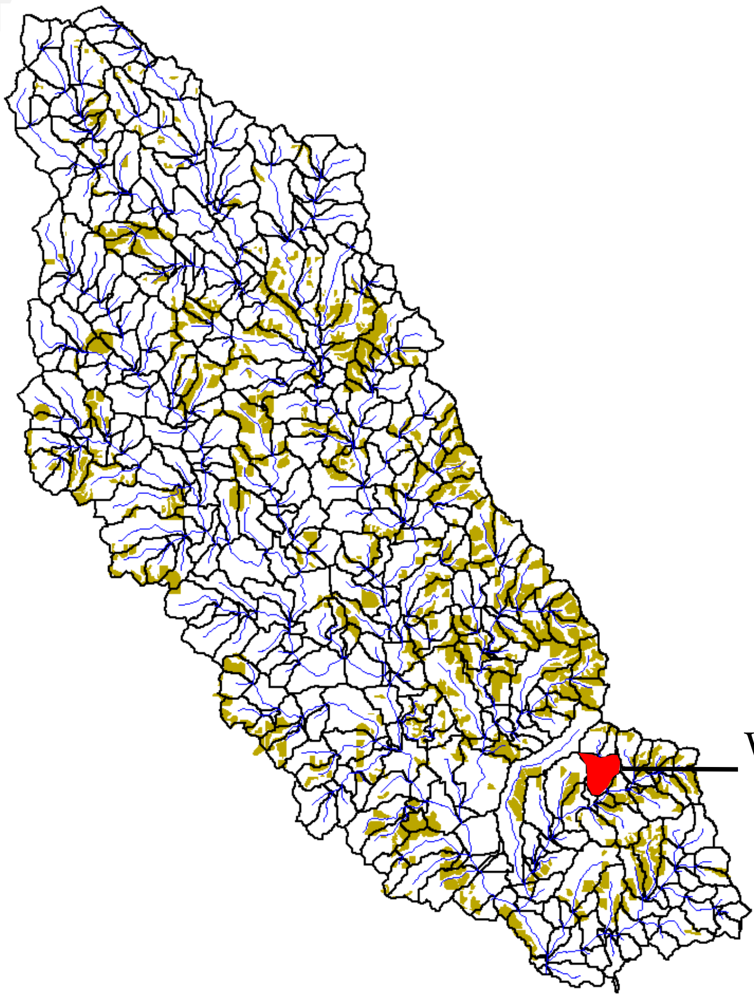
Modeling procedures

- Calibration and validation: parameters
- Modeling current CPs: major CPs, parameters
- Modeling alternative scenarios

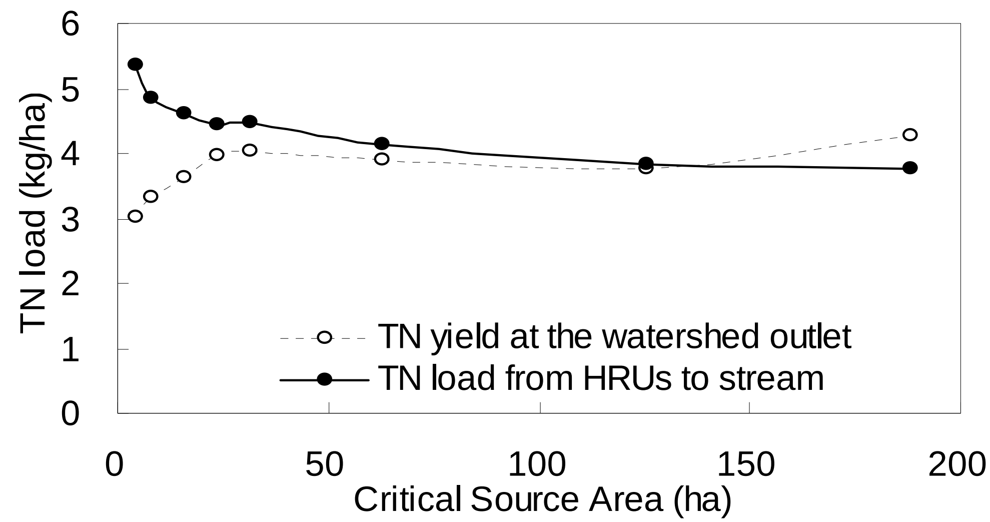
Results and Summary

- Calibration and validation
- Impacts of current CPs: watershed outlet, HRU
- Impacts of alternative scenarios: watershed outlet, HRU

SWAT modeling overview

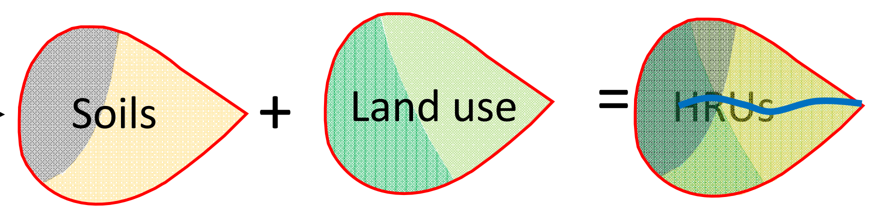


1. Divide subbasins (connected through streams)



2. Define HRUs (Hydrological Response Unit)

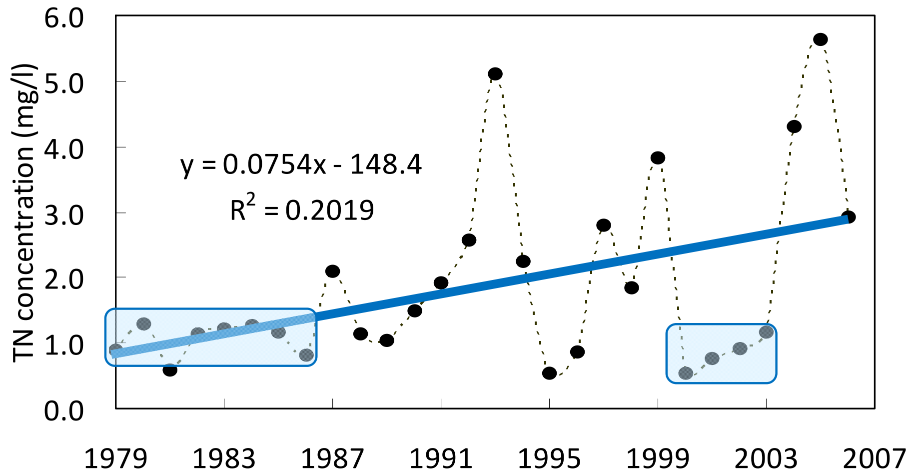
Within each subbasins



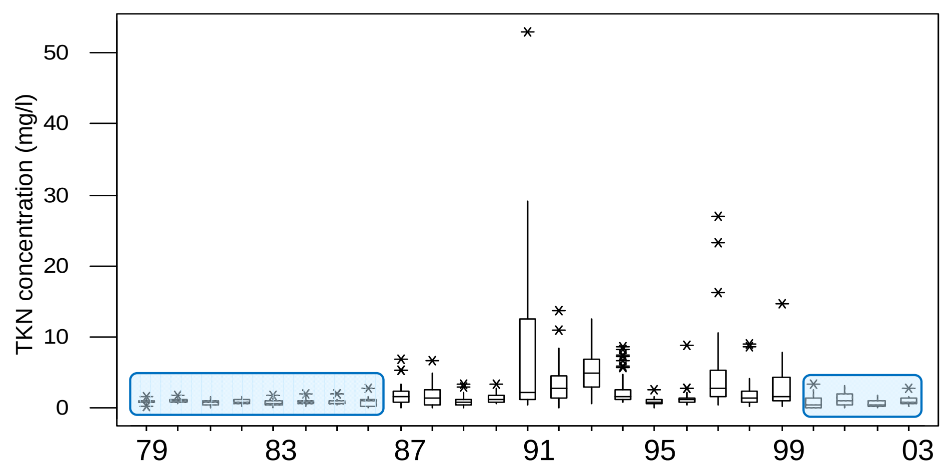
3. Hydrology and WQ processes are simulated in each HRU
4. In-stream process is simulated

Measured WQ trend in LREW

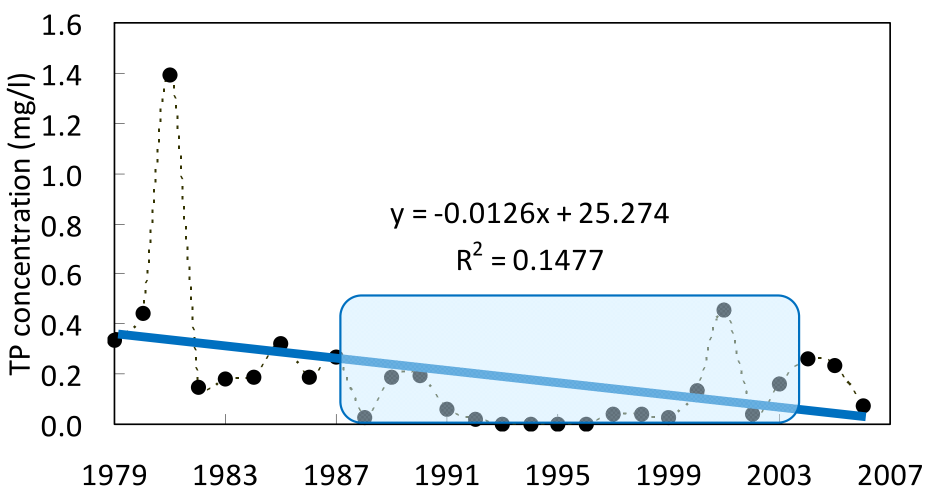
- Uncertainties in measured TN and TP-



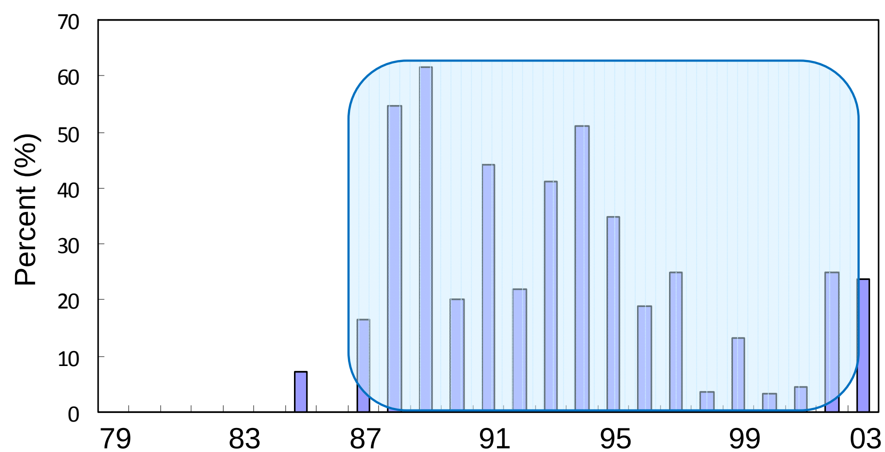
TN conc. = Annual TN load/Annual total flow



Outliers in TKN concentration



TP conc. = Annual TP load/Annual total flow



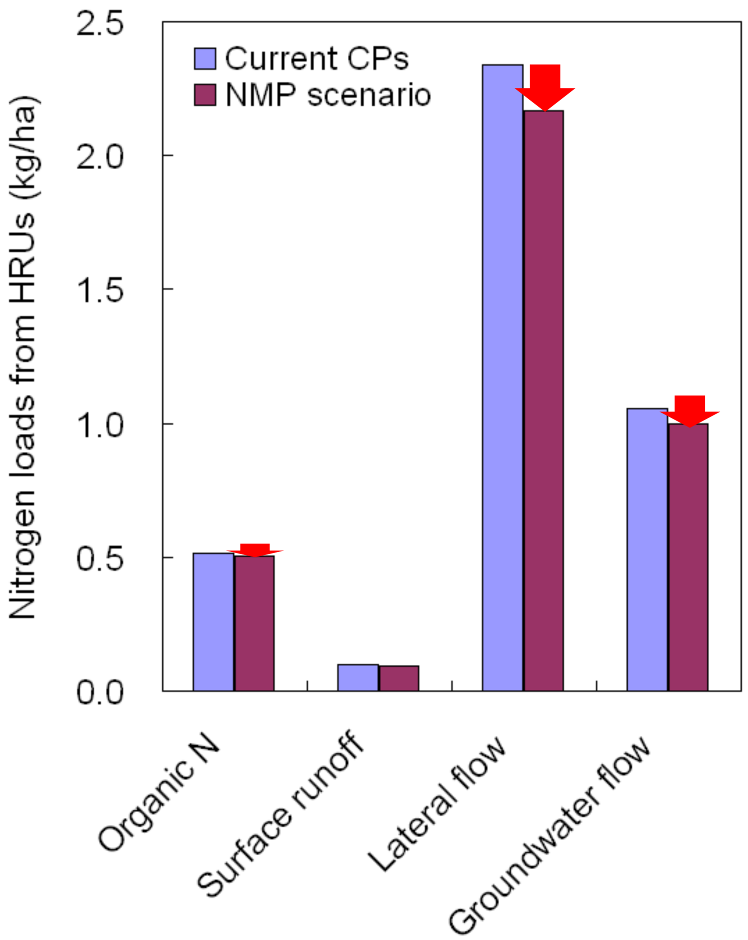
Samples with Ortho-P conc. > TP conc.

Calibration and Validation

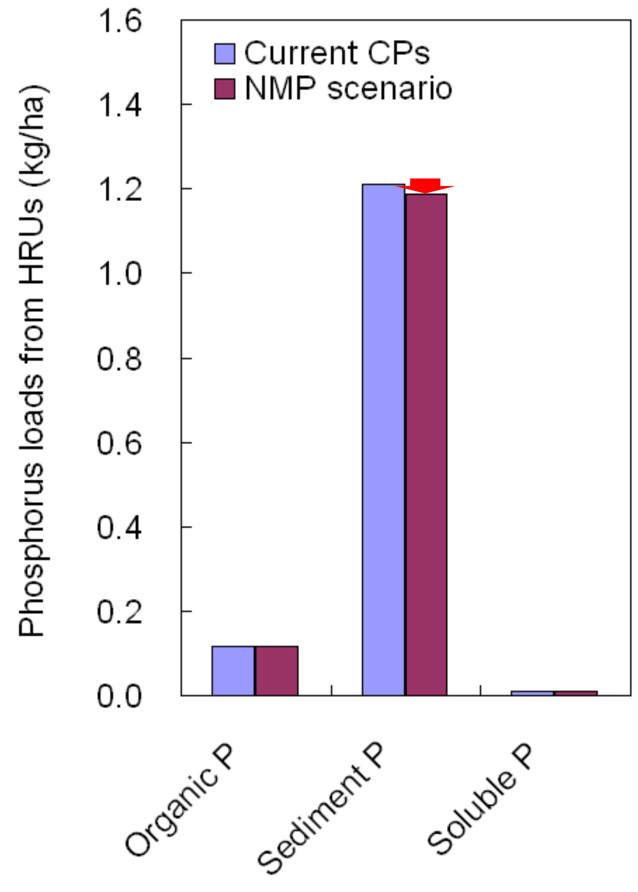
- Selected general parameters -

Parameters	Descriptions	
ESCOn	Soil evaporation compensation factor	Hydrology
CN2	Curve number	
GW_REVAP	Rate of transfer from shallow aquifer to root zone	
GW_DELAY	Time required for water leaving the bottom of the root zone to reach the shallow aquifer	
GWQMN	Threshold water depth in shallow aquifer for return to reach	
ADJ_PKR	Peak rate adjustment factor for sediment routing in the subbasin	Sediment
SPEXP	Exponent parameter for channel sediment routing	
SPCON	Linear parameter for calculating the maximum amount of sediment that can be reentrained during channel sediment routing	
FILTERW	Width of edge-of-field filter strip	
CH_N(2)	Manning's "n" value for the main channel	
PSP	Phosphorus availability index	Nutrient
AI0	Ratio of chlorophyll-a to algal biomass	
RHOQ	Algal respiration rate at 20º C	
AI1	Fraction of algal biomass that is nitrogen	
AI2	Fraction of algal biomass that is phosphorus	
RS5	Organic phosphorus settling rate in the reach at 20º C	
HLIFE_NGW	Half-life of nitrate in the shallow aquifer	
ANION_EXCL	Fraction of porosity from which anions are excluded	
ERORGP	Phosphorus enrichment ratio for loading with sediment	

Impacts of alternative scenarios
- Load from HRUs -

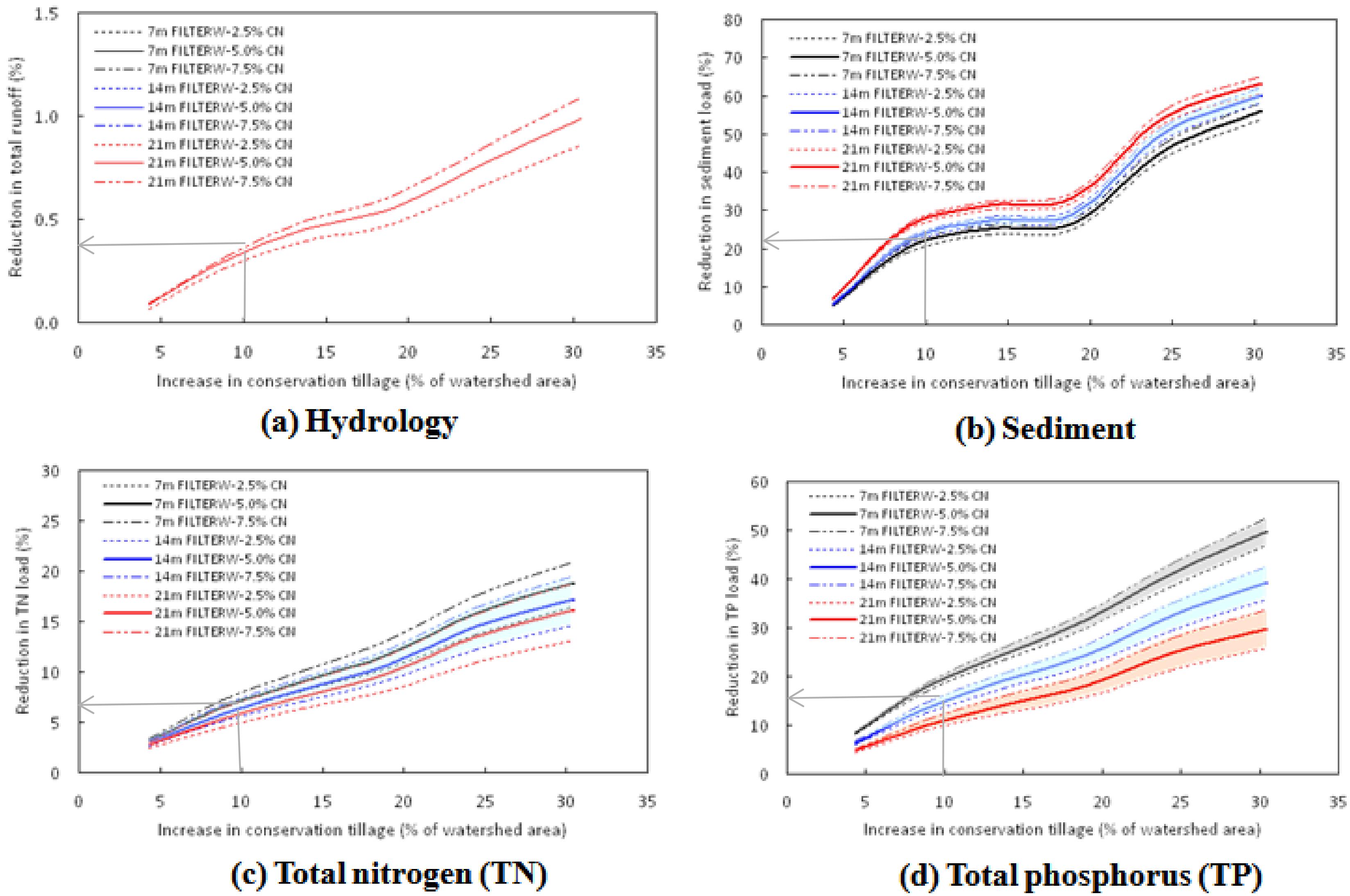


Nitrogen



Phosphorus

Residue management and manure cover crop on LRK



(a) Hydrology

(b) Sediment

(c) Total nitrogen (TN)

(d) Total phosphorus (TP)