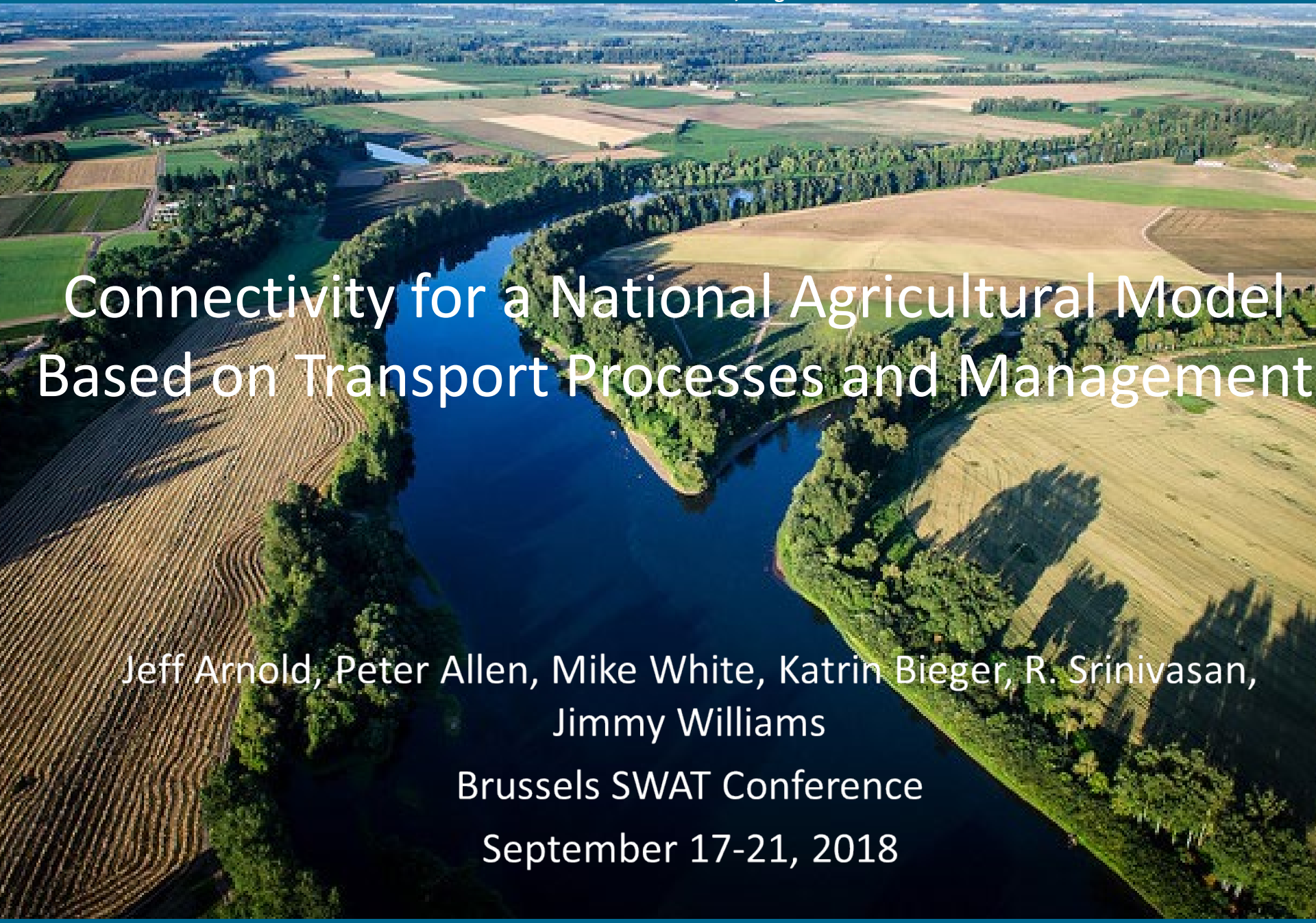


Connectivity for a National Agricultural Model Based on Transport Processes and Management

Jeff Arnold, Peter Allen, Mike White, Katrin Bieger, R. Srinivasan, Jimmy Williams

Brussels SWAT Conference

September 17-21, 2018

Introduction to SWAT+

New, completely restructured version (Bieger et al., 2017)

SWAT+
SOIL & WATER ASSESSMENT TOOL

- MODULAR – Extensive use of data structures and modules. Easier to maintain, link to other models, and add process subroutines.
- RECODING - Spatial objects with new input/output data structure is complete. Continue recoding process subroutines and modules.
- VERSION CONTROL – Bit Bucket
- FACILITATE - maintenance of code and input files, linkage of SWAT and other models, addition of new process subroutines

SWAT+ input files

SWAT Soil & Water Assessment Tool

5 HRUs = 5 *.gw files

5000 HRUs = 5000 *.gw files

SWAT+ SOIL & WATER ASSESSMENT TOOL

5 HRUs = 1 aquifer.aqu file

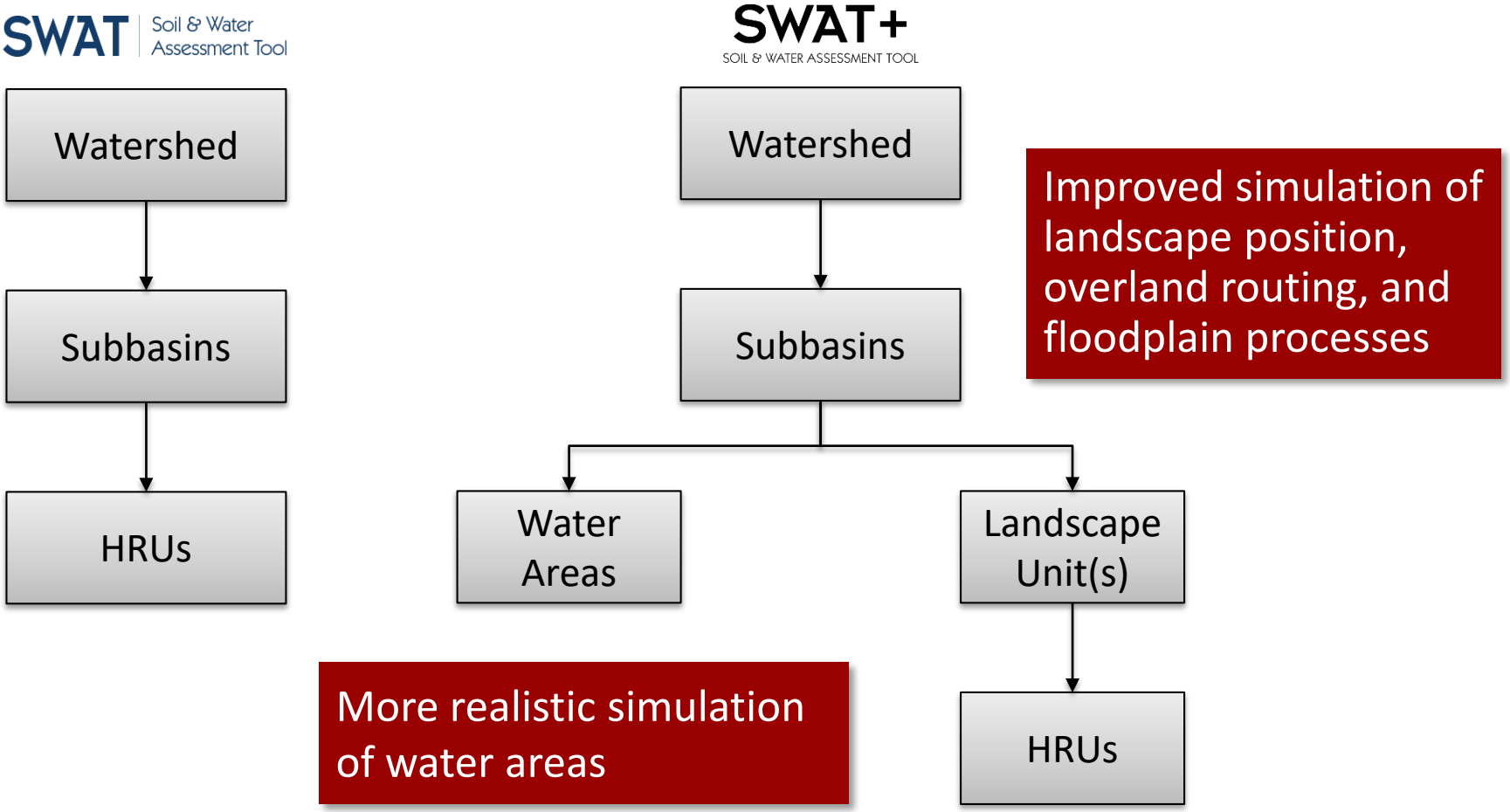
5000 HRUs = 1 aquifer.aqu file

harv.ops: Harvest operations - LREW Sub Water

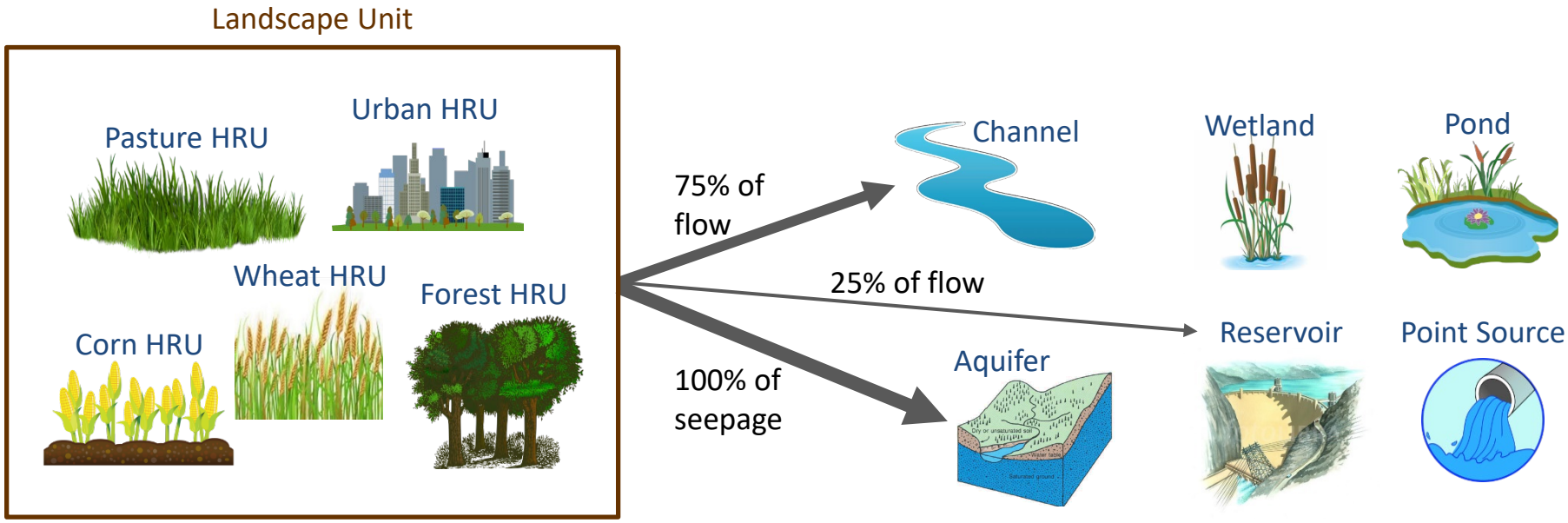
HARV_OP_NAME	HARV_TYPE	HARV_INDEX	HARV_EFF	HARV_BIO_MIN
forest_cut	tree	0.95	0.99	0
grain	grain	0	0.95	0
grass_bag	biomass	0.5	1	2000
grass_mulch	biomass	0.5	0	2000
hay_cut_high	biomass	0.8	1	3000
hay_cut_low	biomass	0.8	1	1000
orchard	biomass	0.01	1	0
peanuts	peanuts	1.1	0.95	0
potatoes	tuber	1.1	0.95	0
silage	biomass	0.9	0.95	0
stover_high	residue	0.9	1	1000
stover_los	residue	0.3	1	3000
stover_med	residue	0.6	1	2000
vegetables	biomass	0.5	1	2000
cotton_strip	stripper	0.0	1	0
cotton_pick	picker	0.0	1	0

- Reduced number of input files
- Data files can be maintained as databases

Watershed configuration



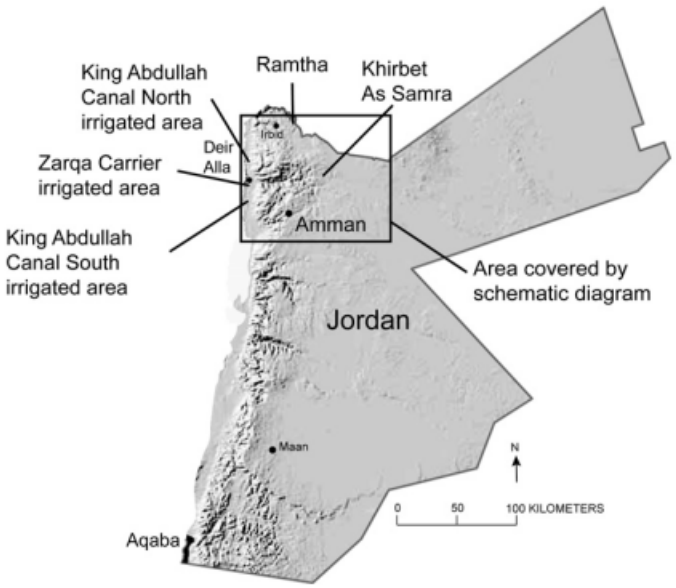
Spatial objects and connections in SWAT+

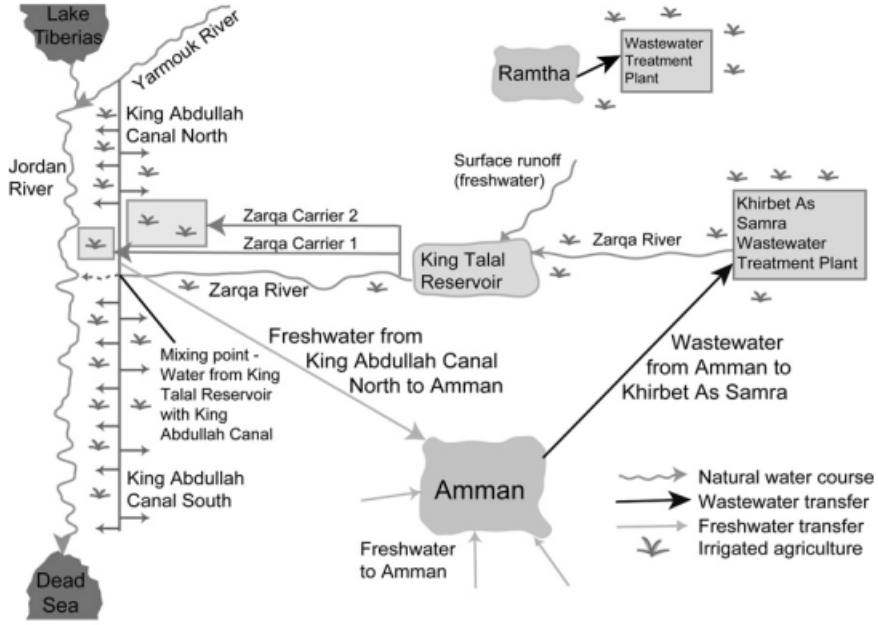


- Flexible spatial representation of connectivity within a watershed using "connect" files
- New spatial objects: pumps, canals, water rights, animal herds

Natural and managed flow systems

Integration of natural stream network with water management systems (drainage, irrigation canals, water transfers, urban areas)





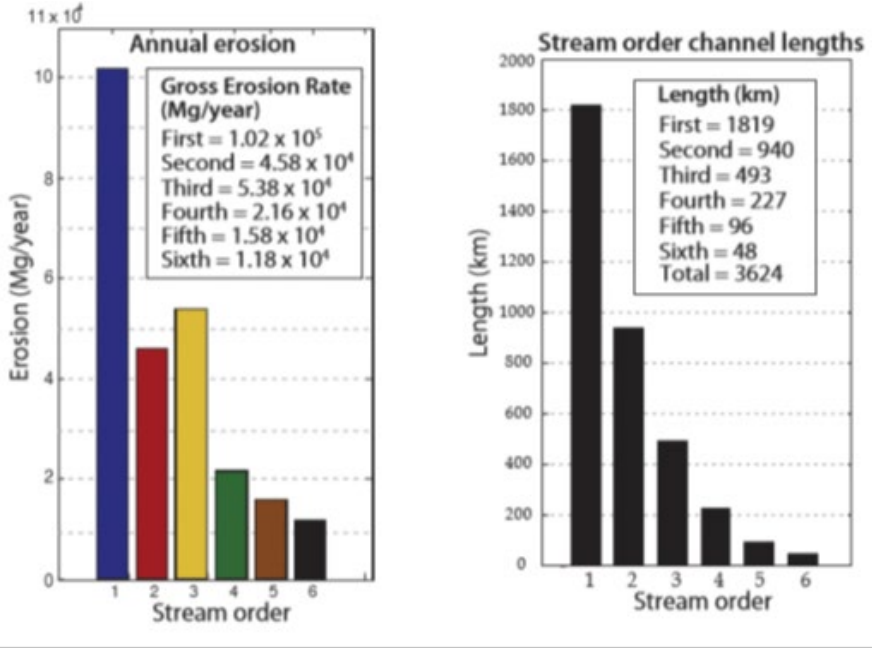
Carr et al. (2011)

Realistic simulation of water transfers and irrigation canals in a highly managed watershed like the Zarqa River Basin

Motivation

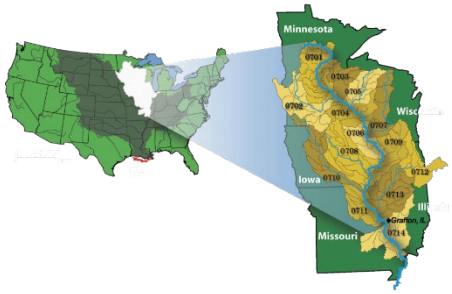
- Processes based watershed delineation
  - Delivery ratio and lumped MUSLE miss important processes and management
  - Simulate processes on lower order streams

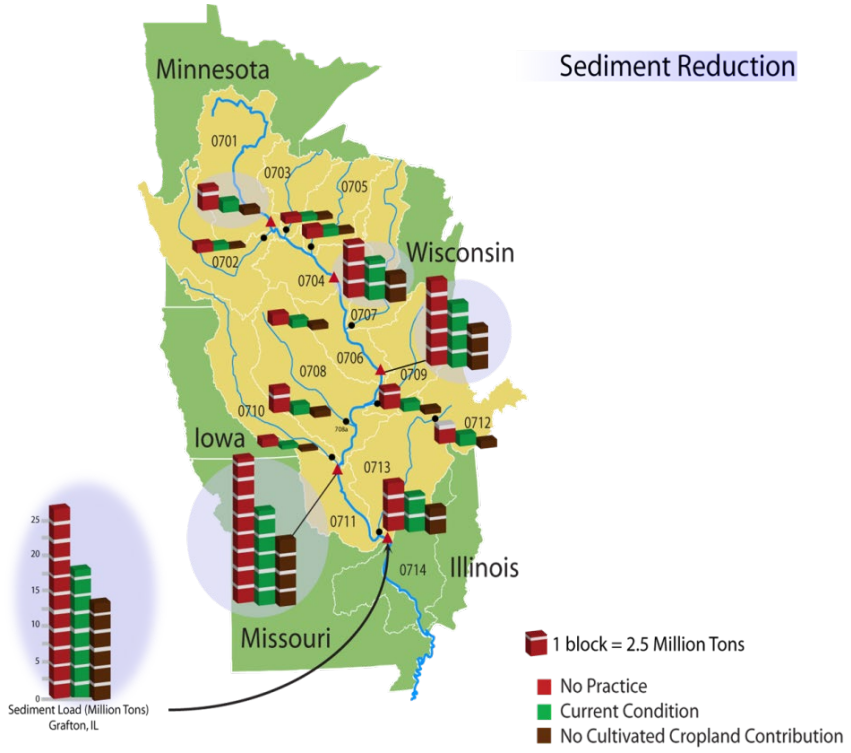
- Importance of transport processes on lower order streams

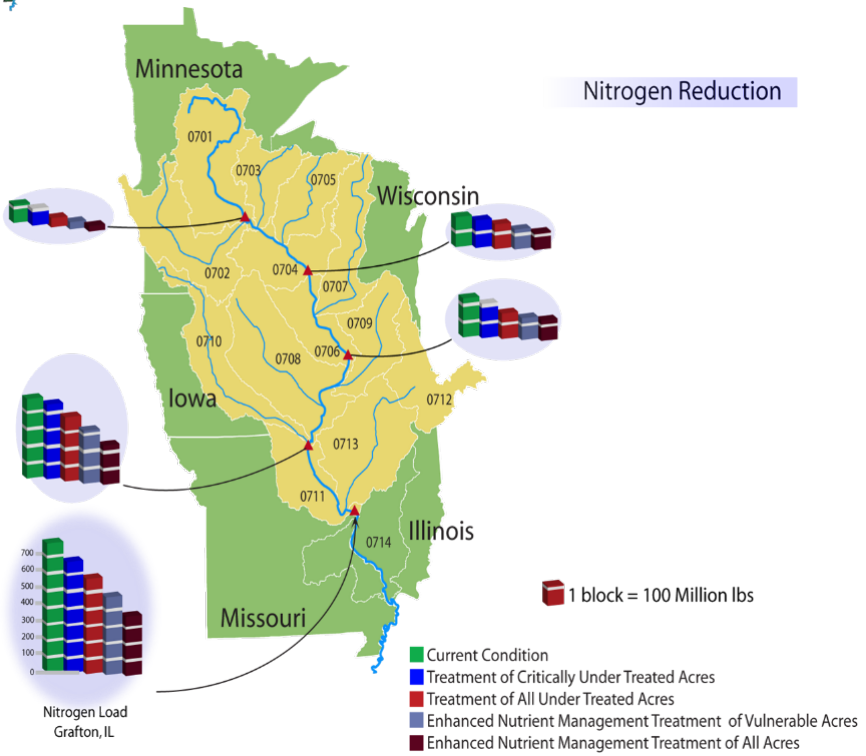


Motivation

USDA CEAP – Final reports for all 2-digit river basins east of and including the Mississippi River Basin are on-line. USGS 8-digit huc's with delivery ratio



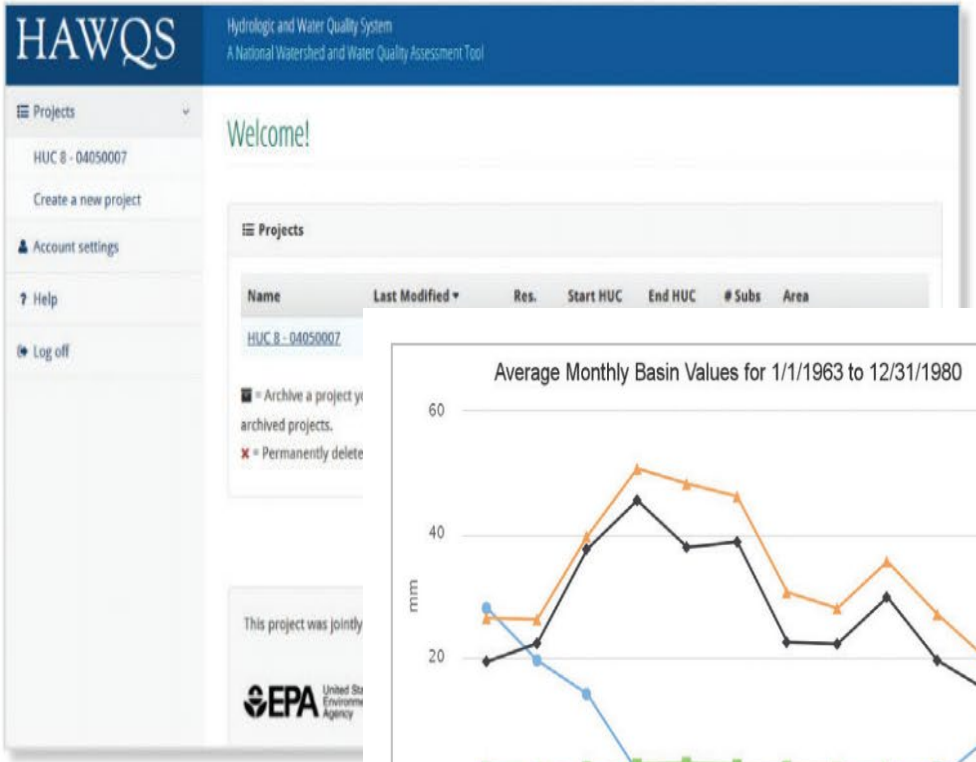


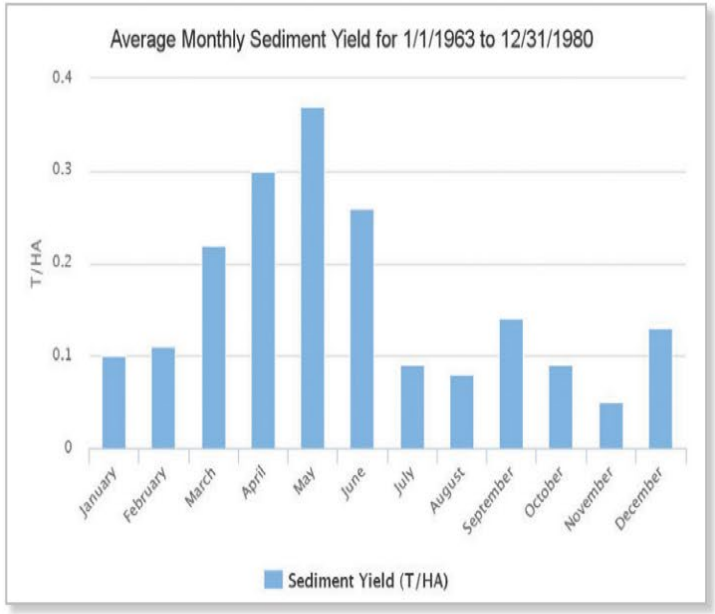


Motivation

HAWQS - Hydrologic and Water Quality System

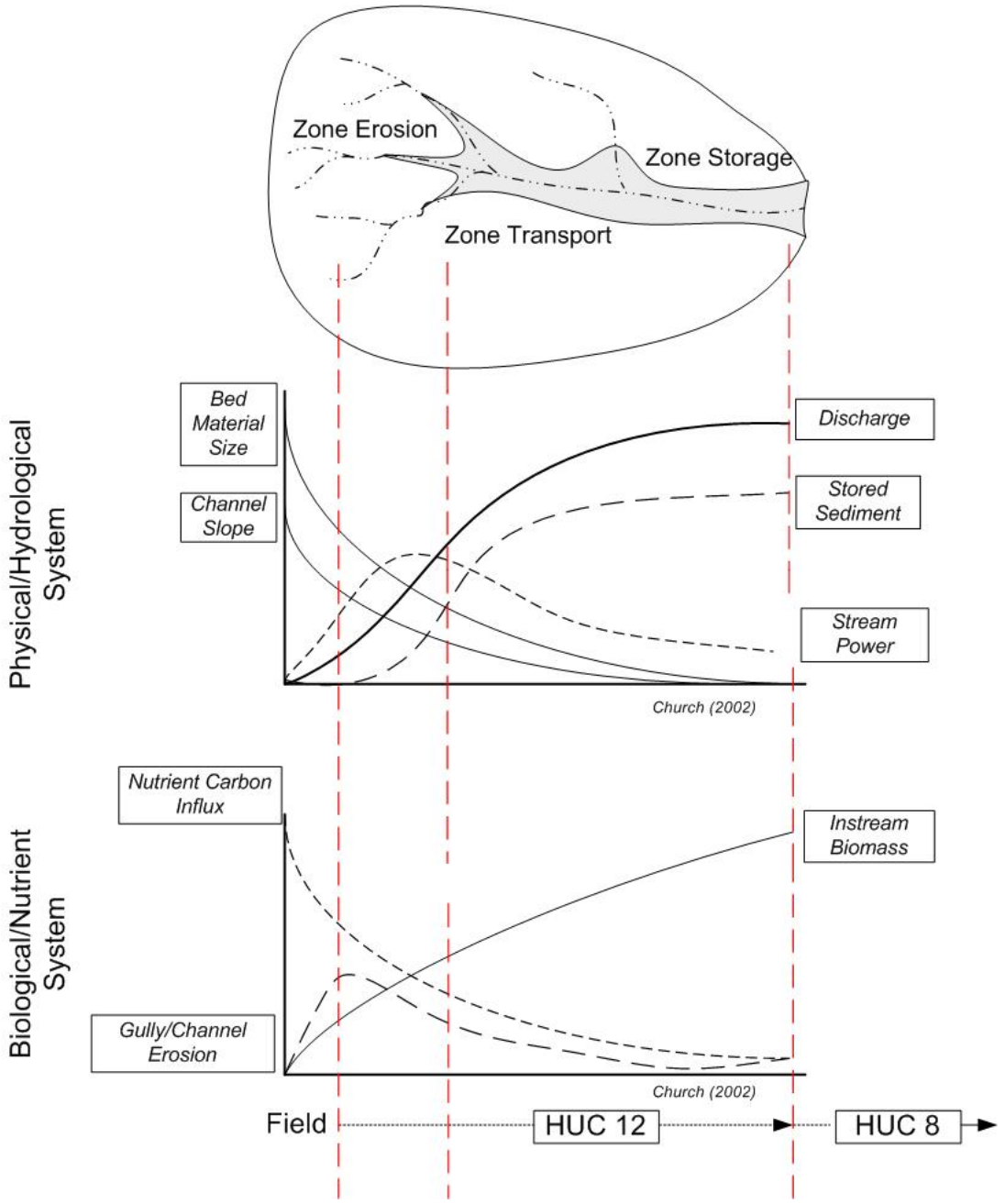
- Web-based interactive water quantity and quality modeling system that employs SWAT as its core modeling engine



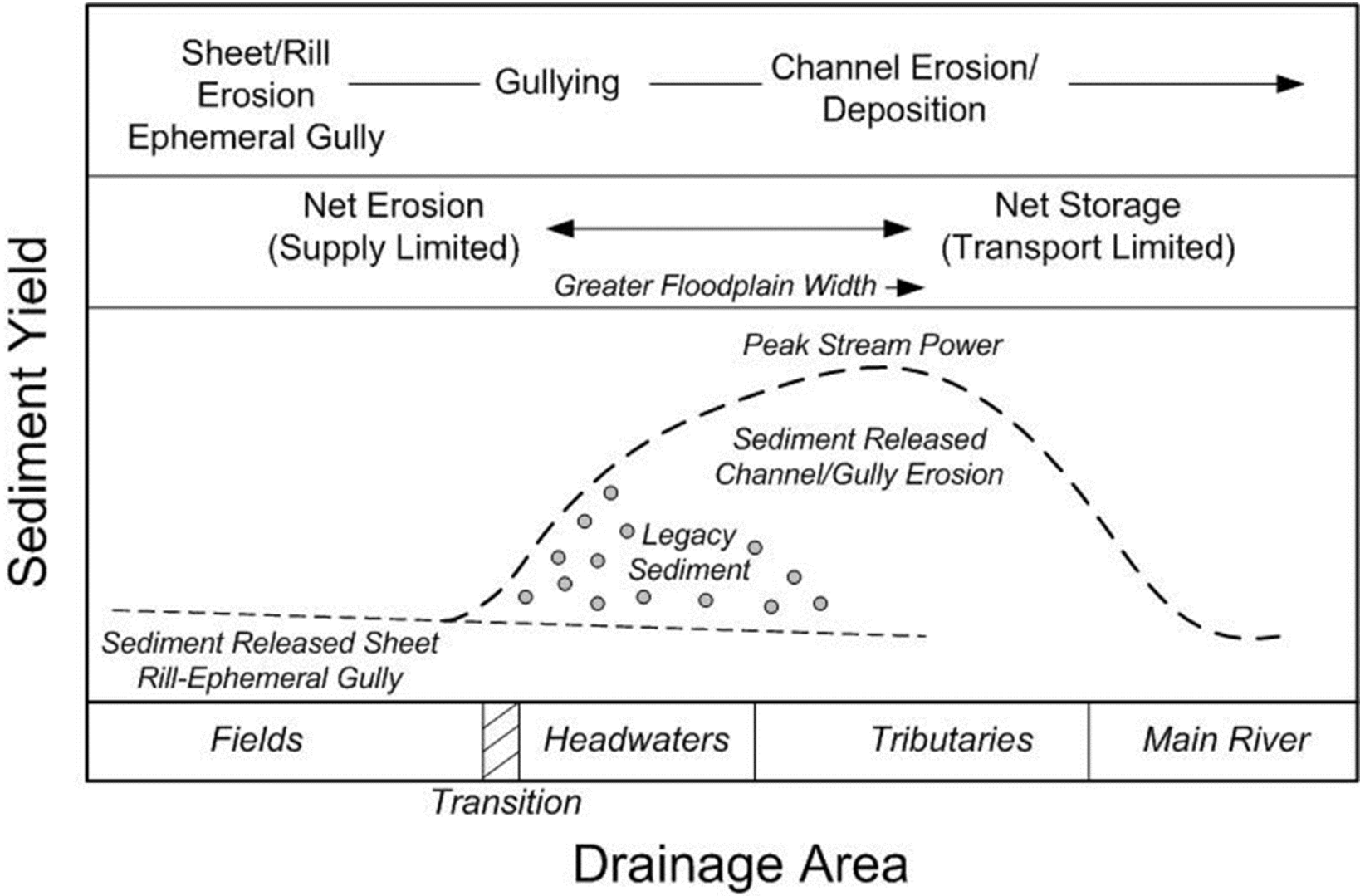


Process Domains

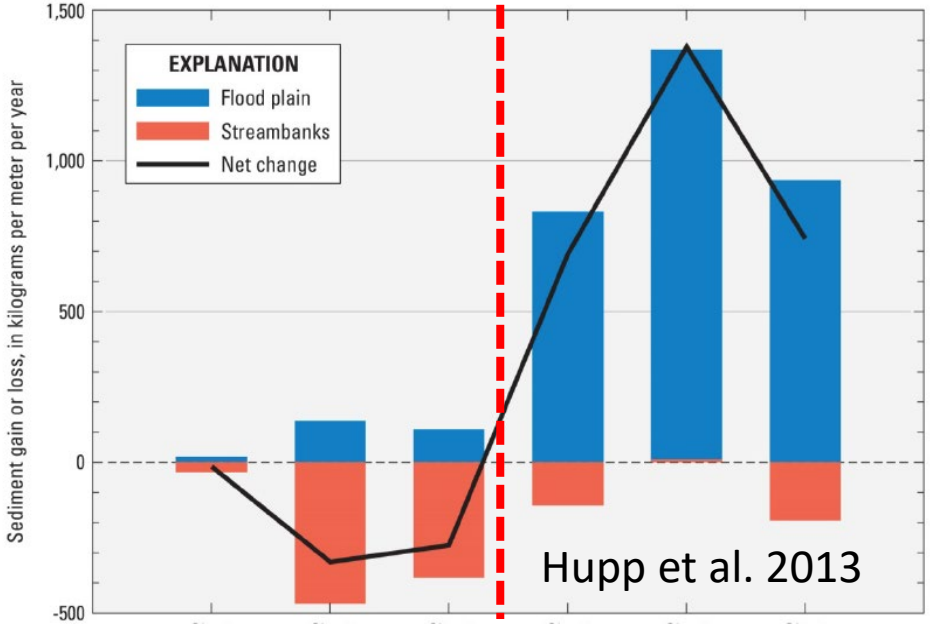
1. Fields
2. Transition
3. Headwaters
4. Tributary
5. Main River



Process Domains

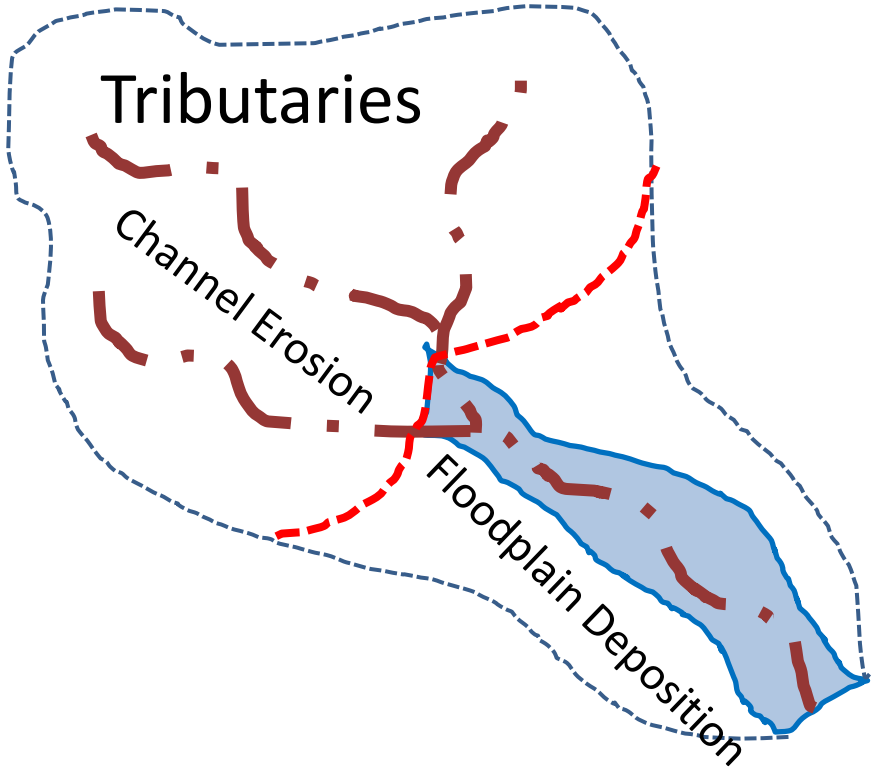


Process Domains



Net Erosion Streambanks

Net Deposition



	Area	NHD Segment	Hydrologic Connectivity
Field	5-50 ha		Connected
Transition	0.2-2 km^2		Connected
Headwater	1-15 km^2	12-digit tributary	Connected
Tributaries	10-150 km^2	12-digit main channel	Partially Connected
Main River	>150 km^2	8-digit main channel	Unconnected

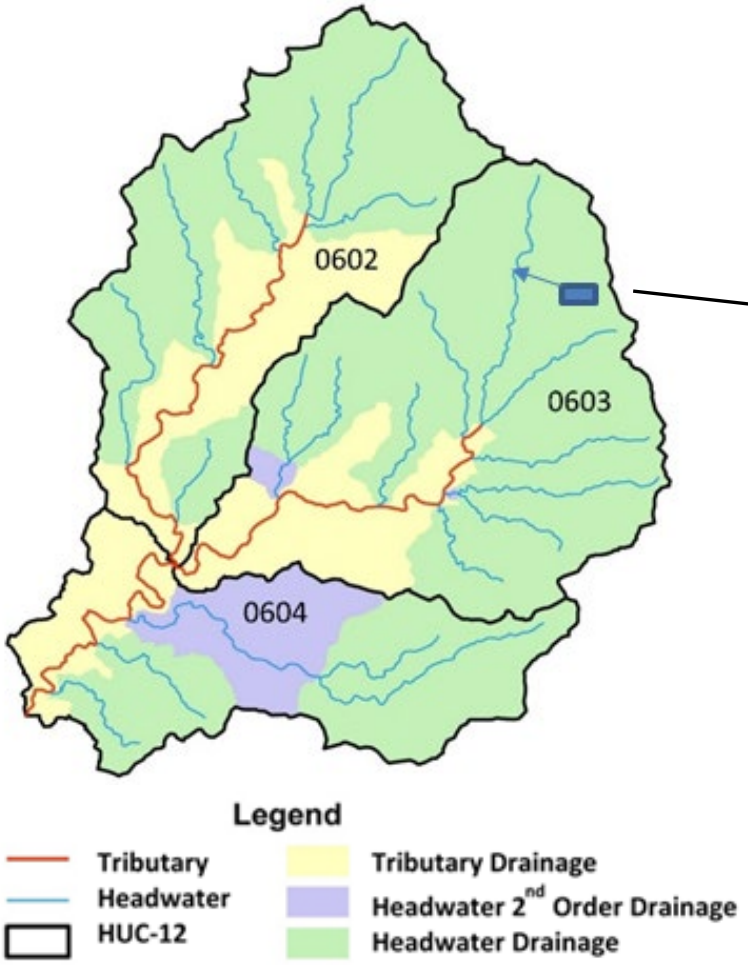
	Area	Model Domain	Processes Erosion
Field	5-50 ha	Hillslope	Sheet and Rill
		Soil	Emphemeral gully
		Plants	
Transition	0.2-2 km^2	Ditches	Headward
		Gullies	gully erosion
		Swales	
Headwater	1-15 km^2	Channel/Minor	Channel: aggradation/
		Floodplain	degradation widening
Tributaries	10-150 km^2	Channel and Floodplain	Channel Processes;
			Floodplain overbank
			deposition
Main River	>150 km^2	Channel and Floodplain	Channel Processes;
			Floodplain; overbank
			deposition

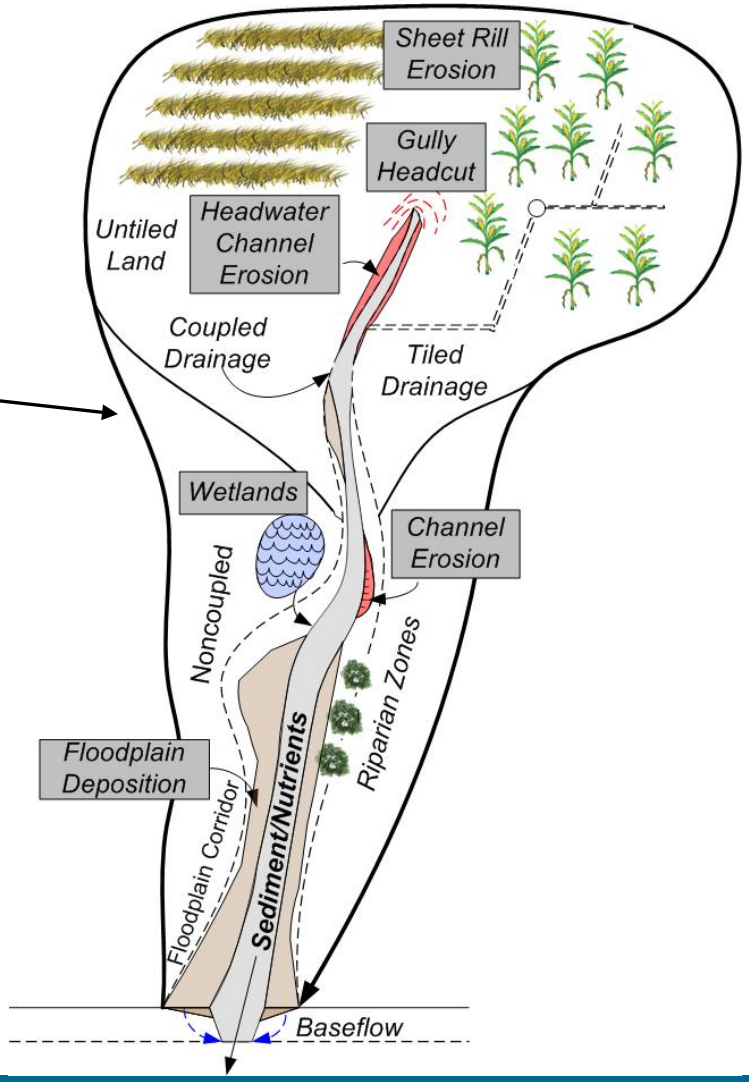
	Area	Processes Water	Sediment Model Approaches
Field	5-50 ha	Soil Water Budget	MUSLE
			WEPP Hillslope
Transition	0.2-2 km^2	Routing field runoff	Gully Model
Headwater	1-15 km^2	Continuous simulation flow/seepage/soil flow and baseflow	Excess Shear Model
Tributaries	10-150 km^2	Continuous simulation flow/seepage and baseflow	Excess Shear; Bed material transport and Overbank Deposition
Main River	>150 km^2	Continuous simulation flow/seepage and baseflow	Excess Shear; Bed material transport and Overbank Deposition

	Area	Agricultural Management Practices
Field	5-50 ha	Tillage; Irrigation;
		Fertilizer/Manure;
		Pesticides; Grass waterways;
		Terracing; Contouring;
		Drainage Water Management
Transition	0.2-2 km^2	Gully Restoration; Buffers;
		Saturated Buffers; 2-stage Ditches
Headwater	1-15 km^2	Constructed Wetlands; Riparian Buffers;
		Legacy Sediment Removal;
		PL-566 Structures
Tributaries	10-150 km^2	Riparian buffers; PL-566 Structures;
		Irrigation Withdrawal
Main River	>150 km^2	Irrigation Withdrawal

Simulation of small-scale processes

- Simulate processes from edge-of-Field to Headwater. Gully/ditch leaving field.



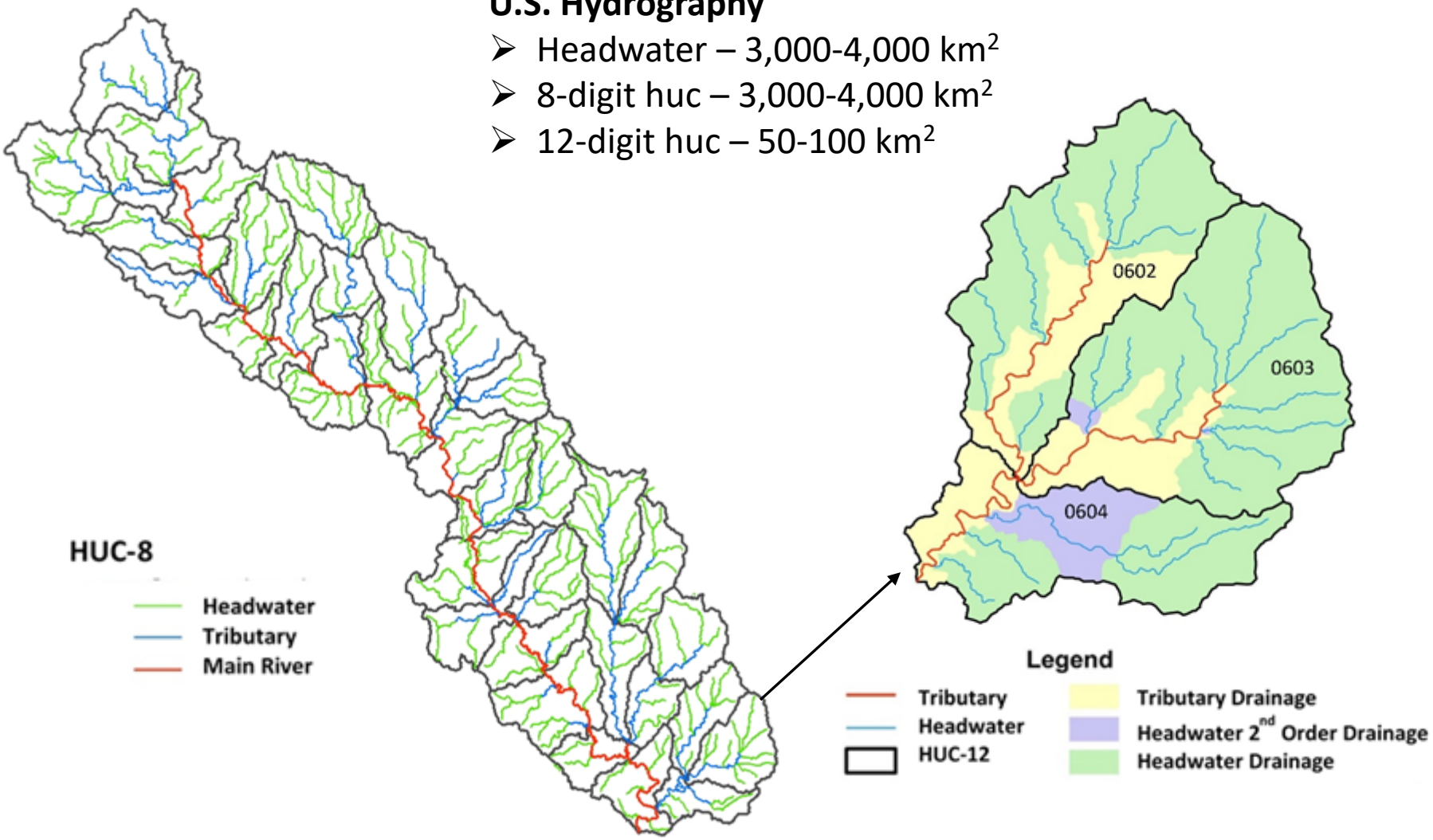



Main River
(Iroquois River)
Transition
Tile
Field
Road Ditch
Headwater
1000 m
5000 ft


Beemis Creek
Dancer Ave
Beemis Creek
Tributary
Headwater
Dancer Ave
Transition
Field

U.S. Hydrography

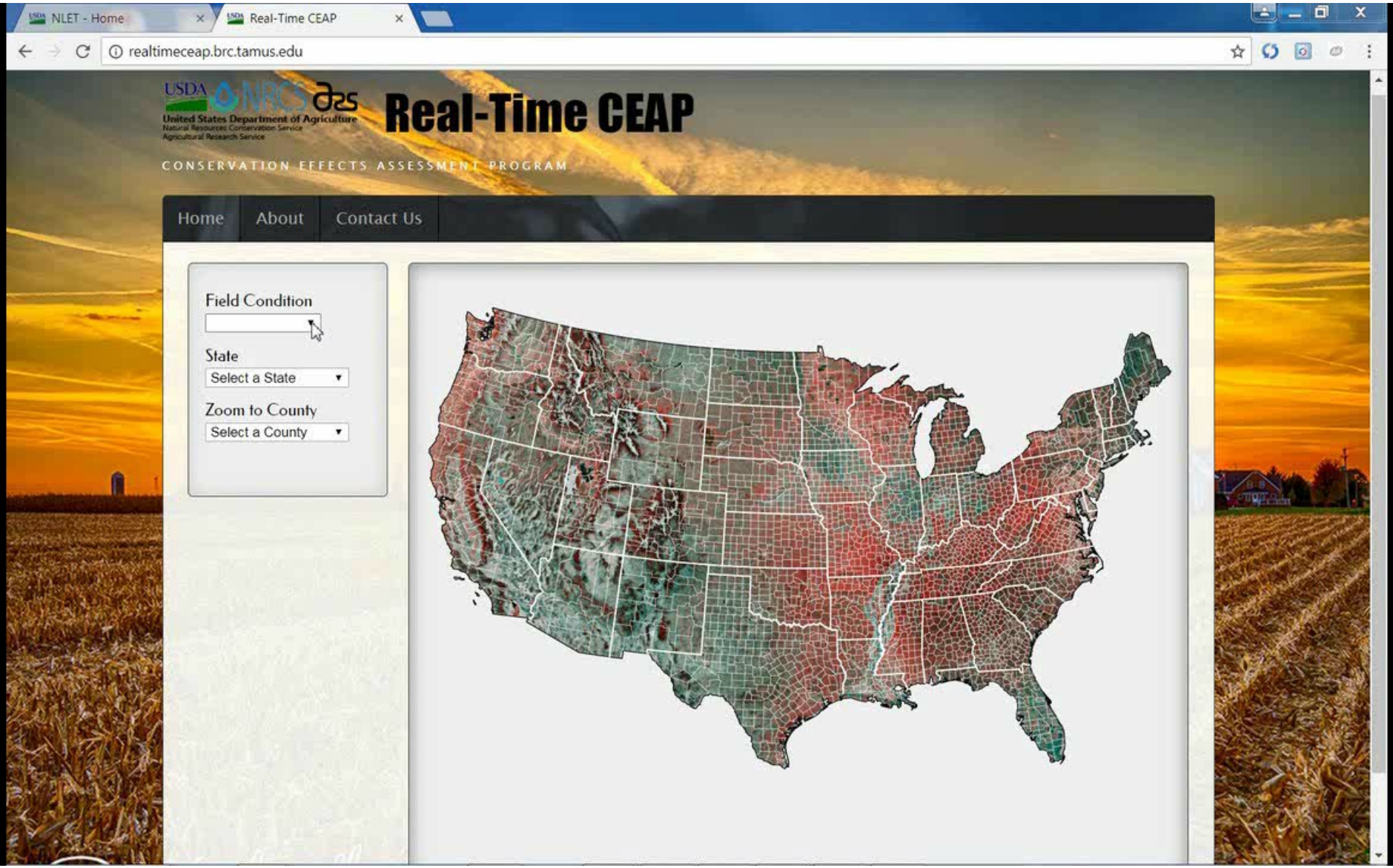
- Headwater – 3,000-4,000 km^2
- 8-digit huc – 3,000-4,000 km^2
- 12-digit huc – 50-100 km^2



Challenges

- Field map of U.S. derived from satellite data – 4.2 million fields in U.S. - Average size 20-30 ha – Average 3,000 hru per 8-digit
- Representative transition channel
- NHD+ connectivity issues (National Hydrography Data)
- Rotation from satellite data – assign regional management
- Mike has field data and is developing all hru files. Then all connections will be made.

Real-Time CEAP



SWIFT


NLET - Home
Real-Time CEAP
Secure | https://nlet.brc.tamus.edu
Google Chrome isn't your default browser.
Set as default
NATIONAL LOAD ESTIMATING TOOL
Home
About
Contact Us
Soil-Water Hub
Select a HUC...
Region HUCs
07
07010101
Reset Sliders
Landuse
Cultivated Crops
Conservation Practices
Baseline Landuse
8.9%
13%
72.6%
Cropland: 72.6%
Forest: 3.0%
Pasture: 8.9%
Rangeland: 2.5%
Urban: 13.0%
Baseline Crops
56.2%
43.3%
Corn: 43.3%
Other: 0.5%
Sorghum: 0.0%
Soybeans: 56.2%
Wheat: 0.0%
Baseline Conservation
Percent
37.7
11.2
10.3
15.1
Filter Strips
Tillage
Terraces
Waterways
Runoff
Sediment
Nitrogen
Phosphorus
Load Differences at 50th Percentile
Water Yield
Runoff
Sediment
Nitrogen
Phosphorus
Scenario Landuse
Scenario Crops
Scenario Conservation
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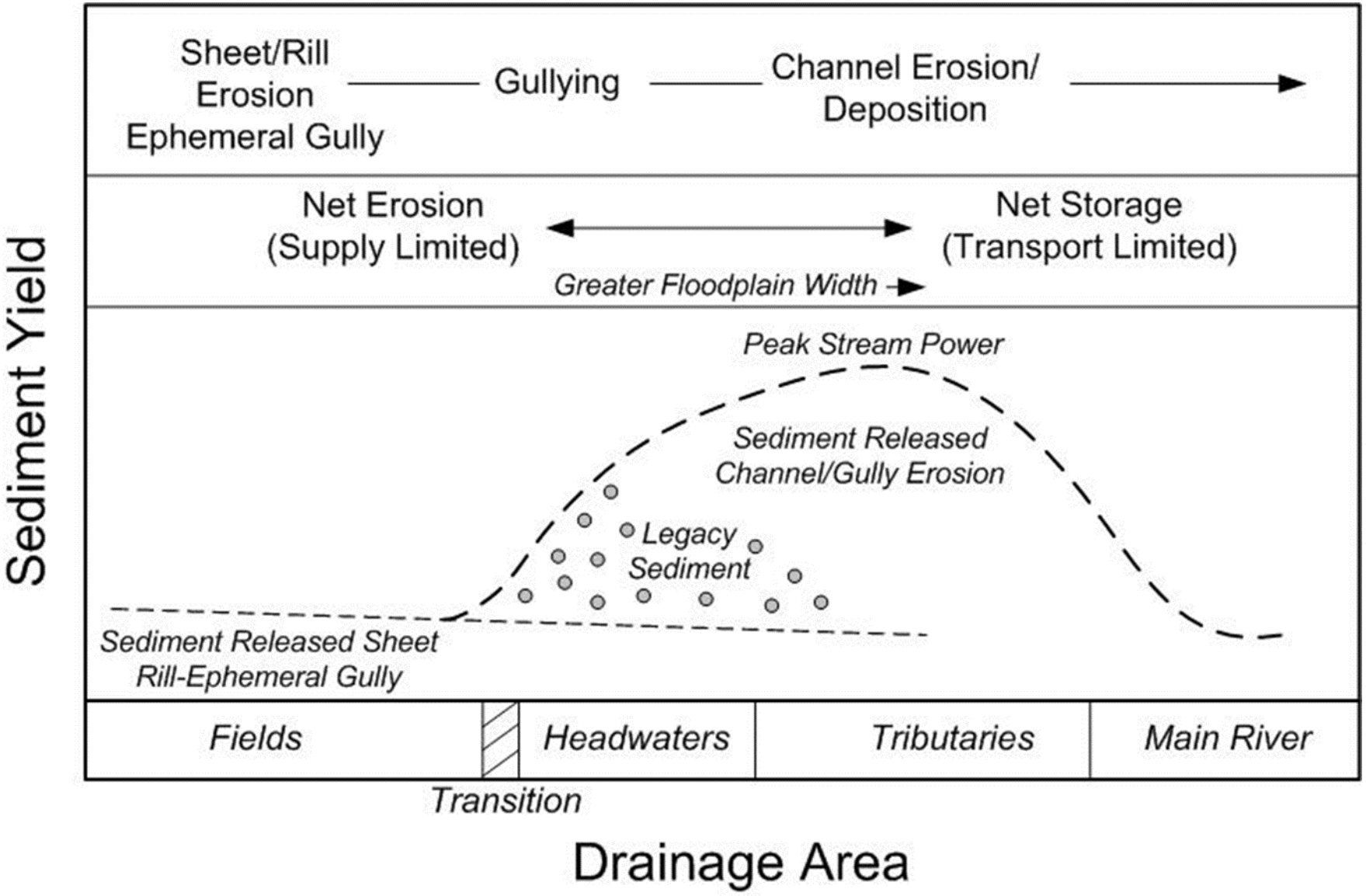
Disclaimer


Thank You


Sheet/Rill Erosion Ephemeral Gully
Gullying
Channel Erosion/ Deposition
Net Erosion (Supply Limited)
Net Storage (Transport Limited)
Greater Floodplain Width
Peak Stream Power
Sediment Released Channel/Gully Erosion
Legacy Sediment
Sediment Released Sheet Rill-Ephemeral Gully
Fields
Headwaters
Tributaries
Main River
Transition
Sediment Yield
Drainage Area

Decision tables

Precise, compact way to model complex rule sets and their corresponding actions

Current Uses in SWAT+

- Land management
- Reservoir release
- Land use change

- The structure of a decision table can be easily understood by model users
- Decision tables more accurately represent complex, real world decision making
- Decision tables can be easily maintained and supported

Auto Irrigation Example

Name	Conditions	Alternatives	Actions			
auto_irr	1	1	1			
VAR	OBJ	OB_NUM	LIM_VAR	LIM_OP	LIM_CONST	ALT1
w_stress	hru	0	null	-	0.8	<
ACT_TYP	NAME	OBJ	OB_NUM	TYPE	CONST	OUTCOME
irrigate	stress_0.8	hru	0	sprinkler	25.	y

Calibration

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL
Changes of parameter values made in the original data file(s)	Changes of parameter values listed in calibration file that overrides original values

- Rapid model calibration
- Better tracking of modified parameters
- Share calibration files with collaboration partners

Variable	Change_Type	Change	HRUs
CN2	ABS_VAL	-4	1-2000

Conditions

Land Use = 'Forest'

HSG = 'A'

Soft calibration

Hard Data

- Long term, measured time series, typically at a point in the watershed
- Visual comparison of hydrographs, model evaluation statistics

Issues

- A model can show excellent statistical agreement with measured stream gauge data, while misrepresenting processes (water balance, nutrient balance, sediment source/sinks) within a field or watershed
- This will cause errors when running management and climate scenarios

Soft Data

- Information on individual processes within a budget. May not be directly measured within a study area. May be an average annual estimate and entail considerable uncertainty
- Incorporation of soft data constraints into calibration routines
- Simple heuristic procedure has been included in SWAT+


Tributary
Headwater
Cedar Hills Park
Field
Transition
Grassed waterway