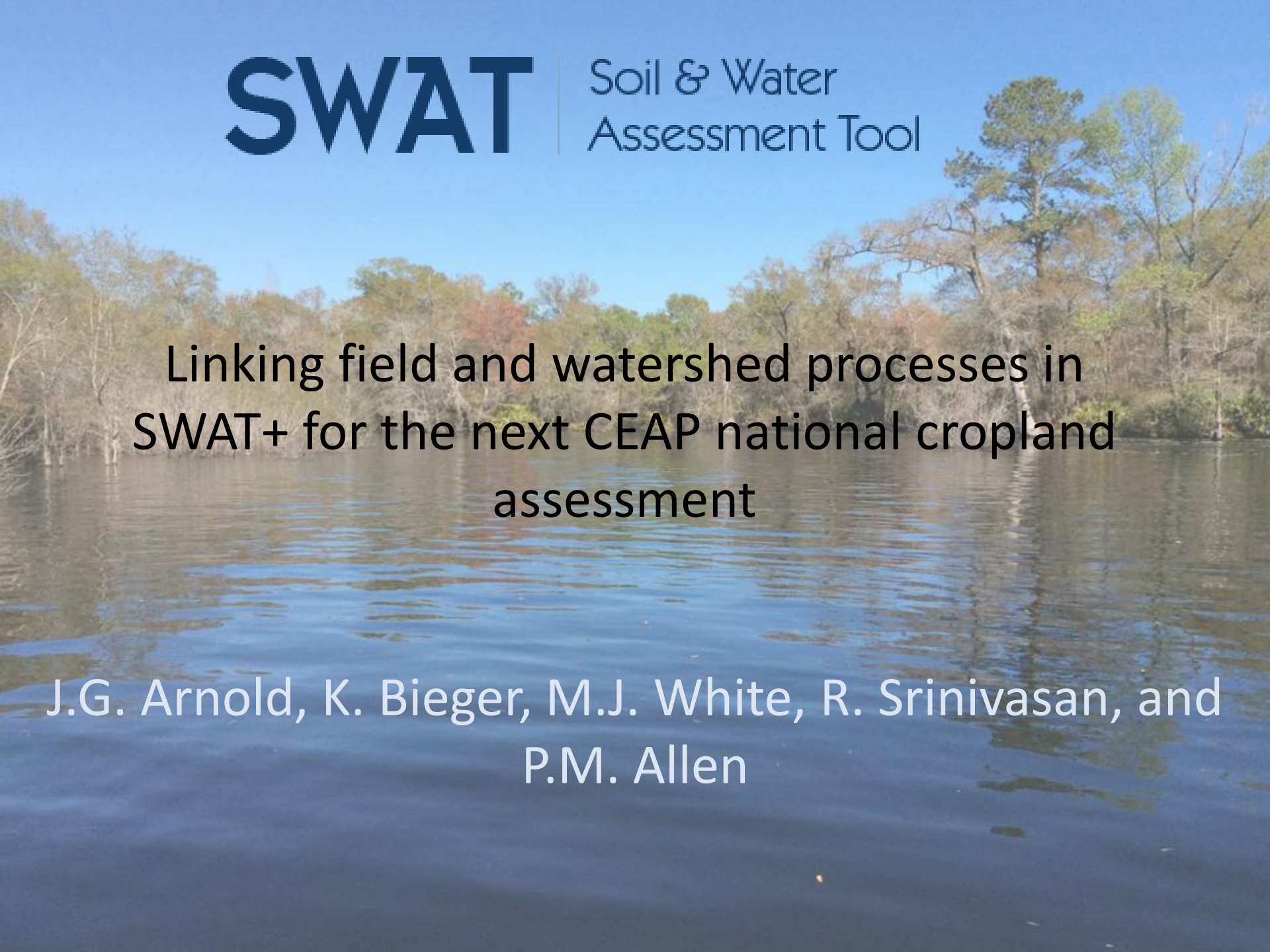


Linking field and watershed processes in SWAT+ for the next CEAP national cropland assessment

J.G. Arnold, K. Bieger, M.J. White, R. Srinivasan, and P.M. Allen

Soil & Water Assessment Tool | SWAT

Outline

- Modular Code
- Object Connections
- File Input/Output – Relational Structure
- Calibration File
- 3 Tier Approach
- Decision Table for Management
- Use in USDA National Conservation Assessment (CEAP)

SWAT+ Modular Code

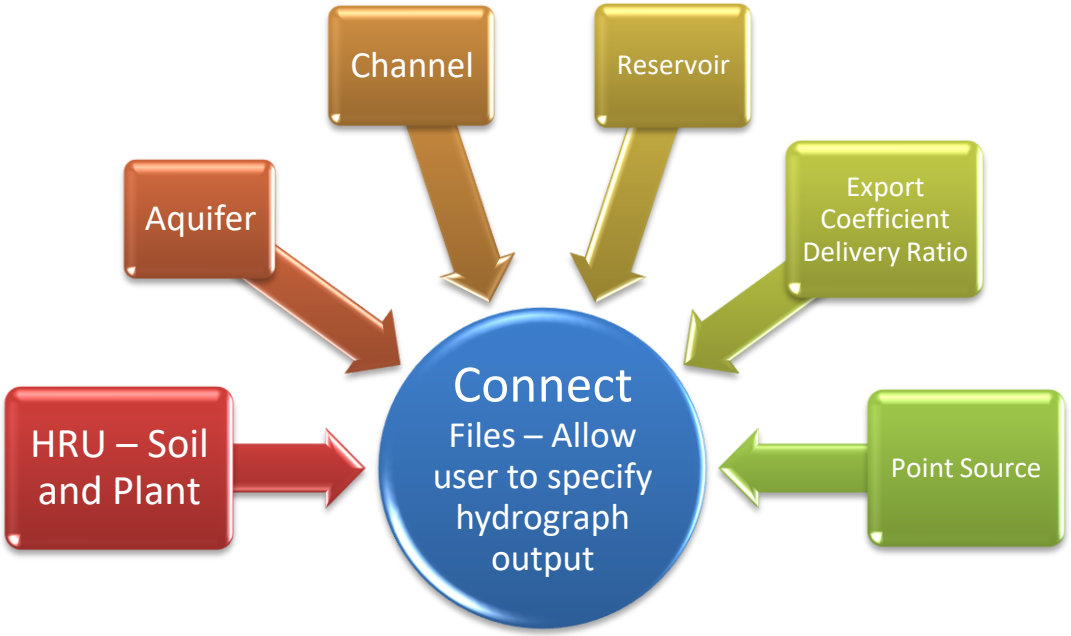
SOIL & WATER ASSESSMENT TOOL

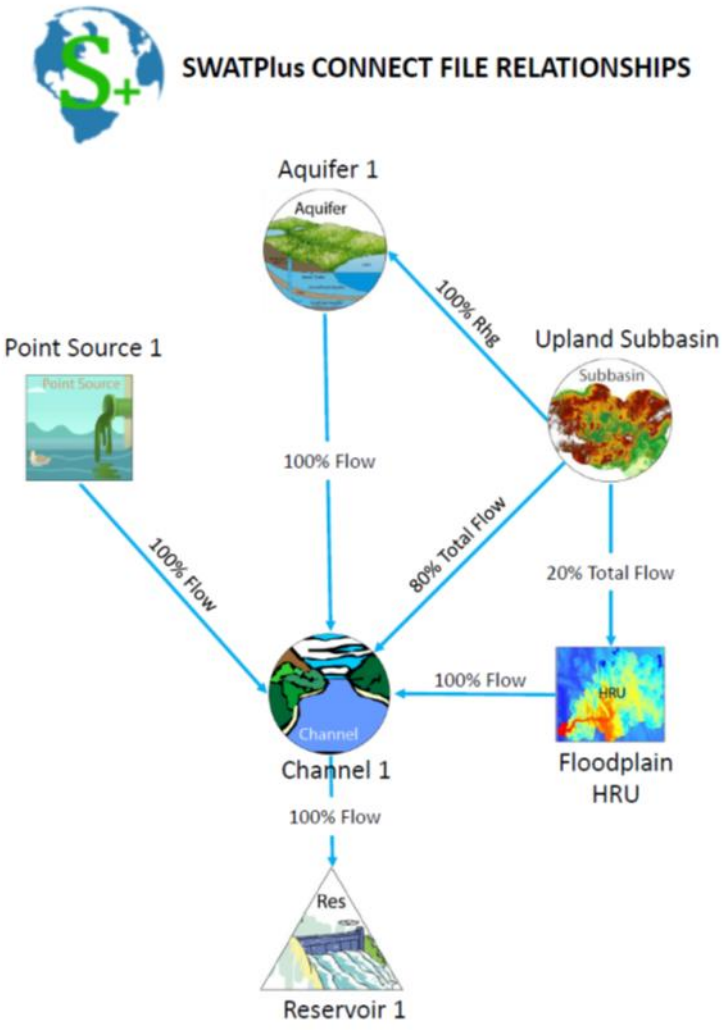
- FORTRAN - continue as language of choice for scientists/engineers.
- MODULAR – Extensive use of data structures and modules. Easier to maintain, link to other models, and add process subroutines.
- RECODING - Spatial objects with new input/output data structure is complete. Continue recoding process 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+
SOIL & WATER ASSESSMENT TOOL

Object Connections

- HRUs, aquifers, channels, reservoirs, etc. are separate spatial objects → flexible spatial representation of interactions and processes within a watershed using "connect" files




SWATPlus CONNECT FILE RELATIONSHIPS
Aquifer 1
Aquifer
100% Rhg
Upland Subbasin
Subbasin
Point Source 1
Point Source
100% Flow
100% Flow
80% Total Flow
20% Total Flow
100% Flow
HRU
Channel
Channel 1
Floodplain
HRU
100% Flow
Res
Reservoir 1

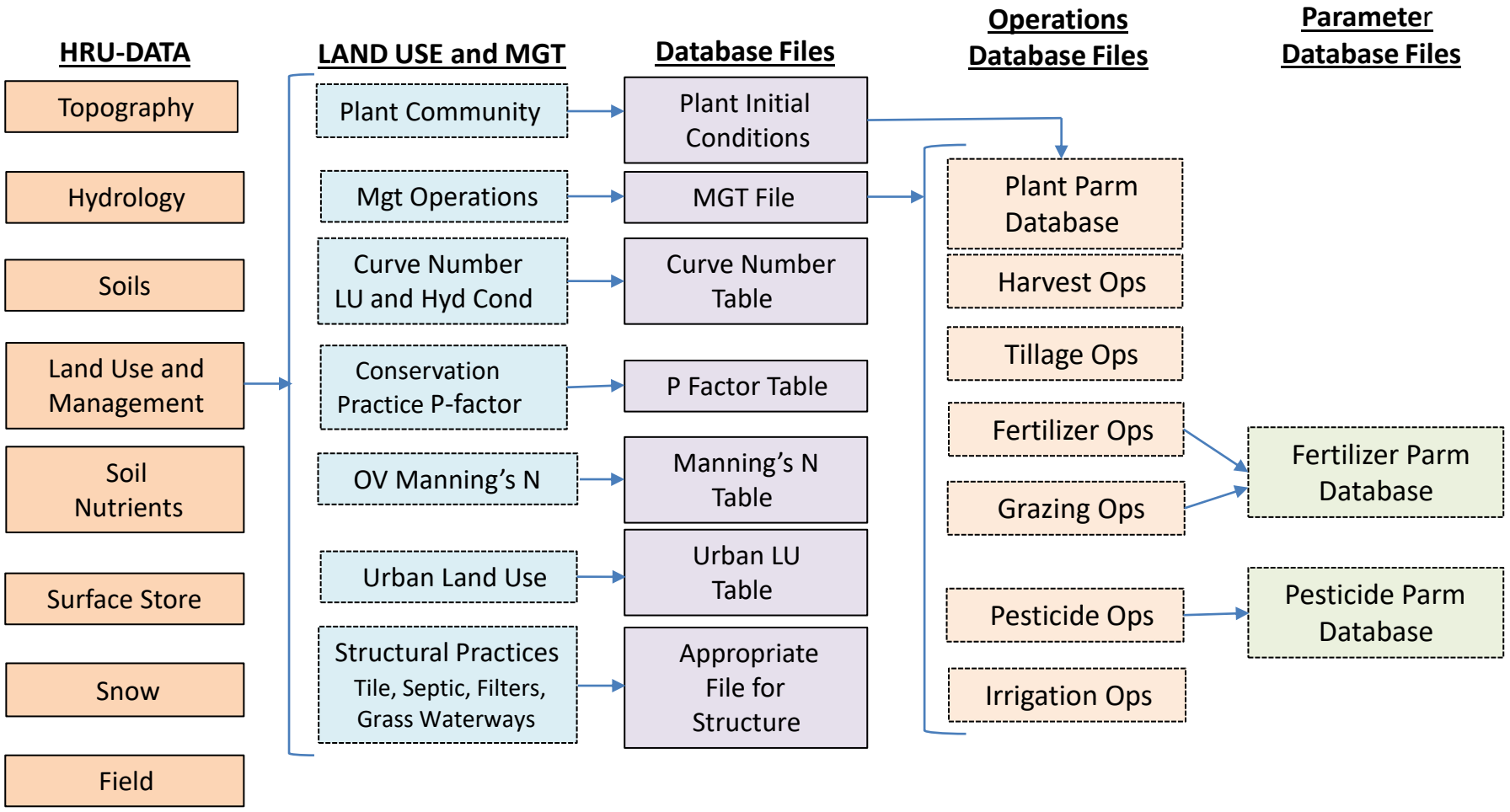
SWAT+ Input files

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	Advantages of SWAT+
• One file for each data type for each object	• One file for each data type with one line for each object	• Reduced number of input files • Decrease in run time • Data files can be maintained as databases

SWAT+ Output files

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	Advantages of SWAT+
• One file for each object • Select variables • Select output time step	• Splits hru output into water balance, nutrient balance, losses, and plant/weather	• Basin, subbasin, and hru files are identical • Output multiple time steps in same run • All output files are spreadsheet ready

Relational Land Use Data



Calibration

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	Advantages of SWAT+
• Changes of parameter values made in the original data file(s)	• Changes of parameter values listed in cali-bration file that over-rides original values	• Rapid model calibration • Better tracking of modified parameters • Conditional changes based on land use and soil texture

Variable	Change_Type	Change	HRU's
CN2	ABS_VAL	-4	1-2000

Conditions

Land Use = 'Forest'

HSG = 'A'

SWAT+
SOIL & WATER ASSESSMENT TOOL

3 Tier Approach

Tier 3: HRU – Full carbon, nutrient and constituent simulation. Comprehensive management.

Tier 2: HRU-LTE – Water balance and plant growth. Computationally efficient with minimal input. Currently developing a simple nutrient component.

Tier 1: Export coefficients and delivery ratios - Average annual loads and deliveries through channels and reservoirs. Commonly used in optimizing location of conservation practices.

All Tiers are modules in SWAT+, use the same connect files, and can be utilized in the same simulation.

Decision Tables

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

CONDITIONS	ALTERNATIVES
ACTIONS	ACTION ENTRIES

Actions

irrigate
release
fertilize
plant
harvest
tillage
fire
grow_init
grow_end
drainage
lu_change

Alternatives

< > =

Action Entries

yes no

Conditional Variables

soil_water
w_stress
month
jday
hu_plant
hu_base0
year_rot
year_cal
year_seq
prob
land_use
ch_use
n_stress
soil_n
soil_p
n_applied
biomass
cover
lai
vol
flow
lat
long
elev
day_len
plant
plant_type

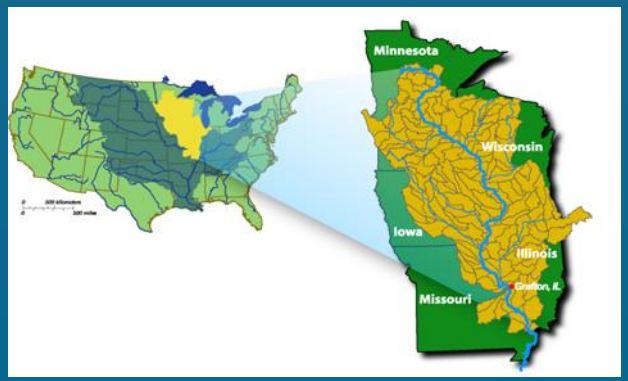
Advantages of Decision tables

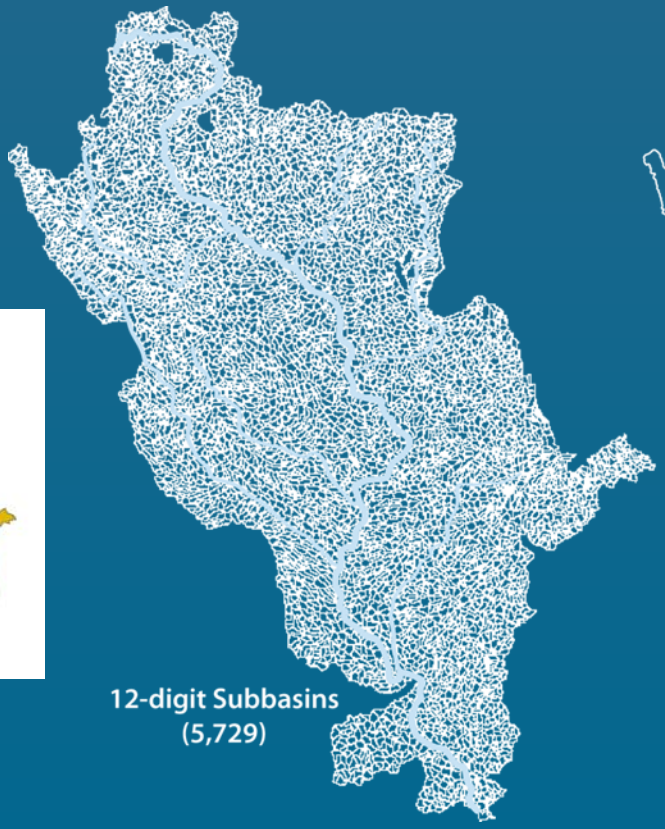
1. The structure of a decision table can be easily understood by model users. Decision tables were developed over 50 years ago, and there is considerable literature and tutorials available on-line related to developing decision tables.
2. Decision tables more accurately represent complex, real world decision making.
3. The code is more modular and easier to maintain than code to simulate management in existing land management models.
4. The code to implement decision tables is more efficient than languages developed for specific river and reservoir models.
5. Decision tables can be easily maintained and supported.

CEAP II National Cropland Assessment

(SWAT+ Input File Structure)

- Downscaling from 8-digit subwatersheds (3,500 km^2) to 12-digits (75 km^2)





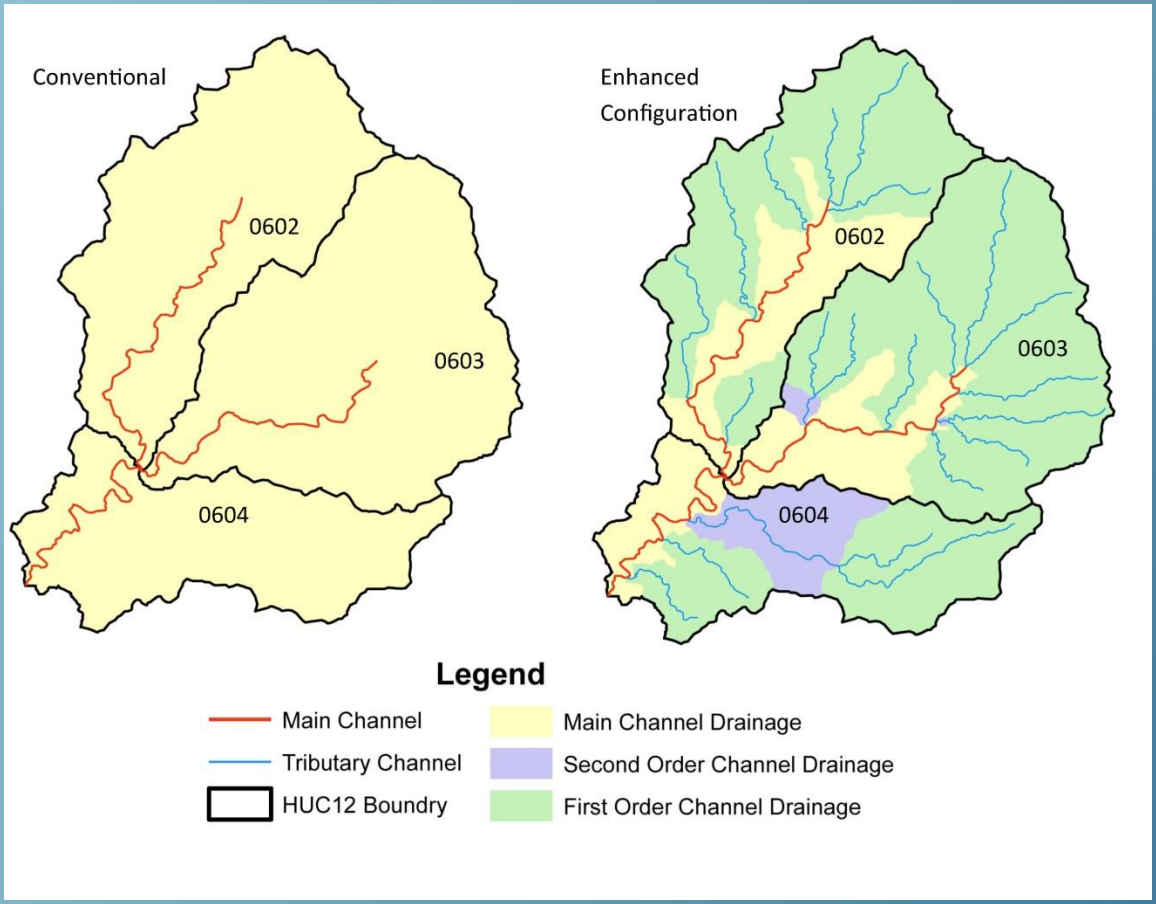
CEAP II National Cropland Assessment

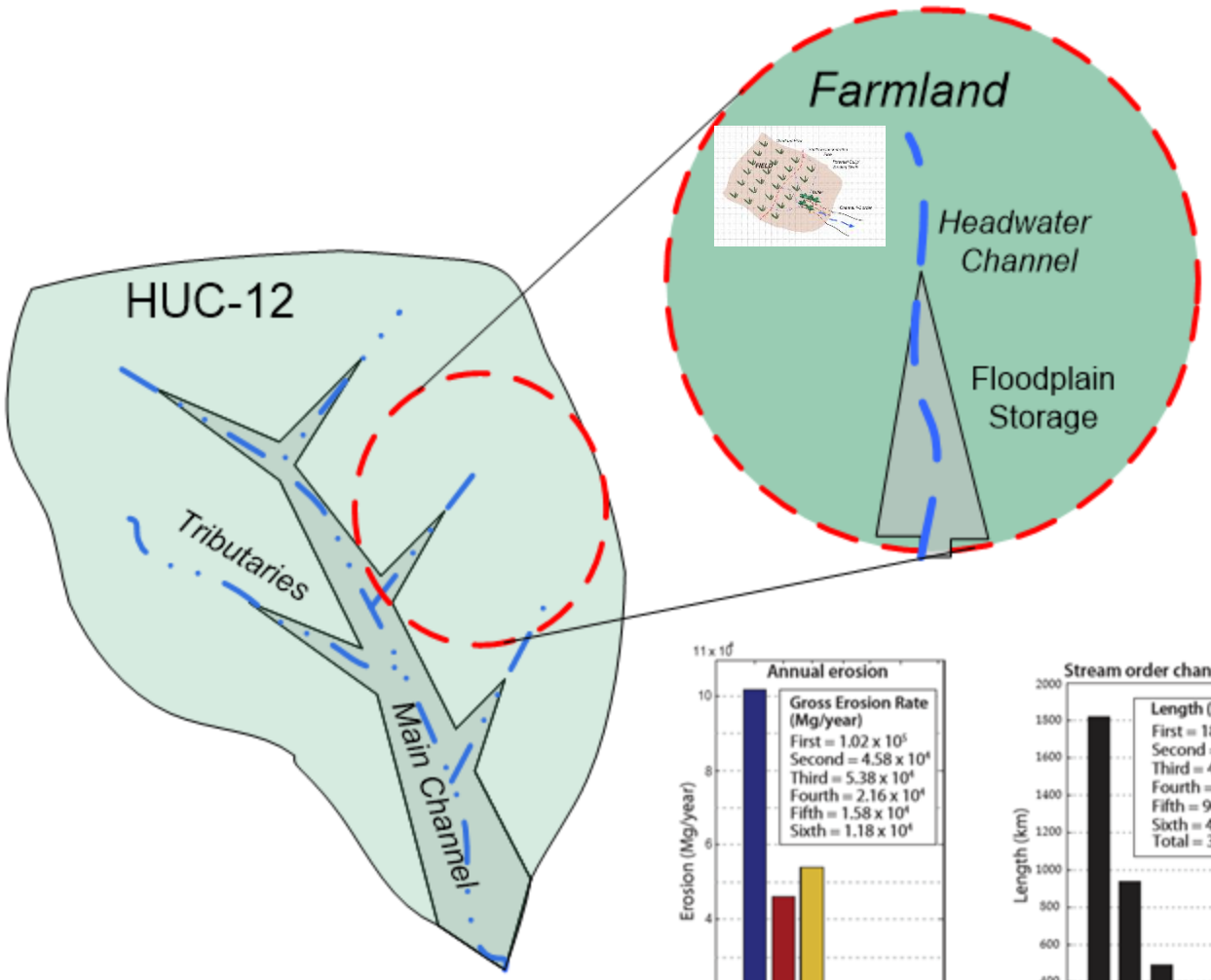
- Use individual rain gages
- Model channel processes on lower order streams
- Model channel erosion and valley bottom deposition within the 12-digits

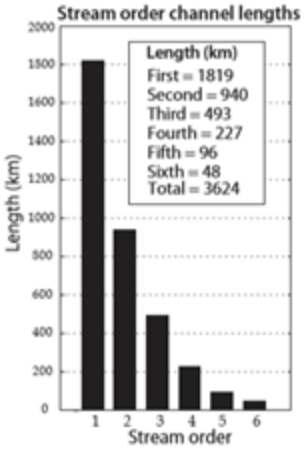
Example: 8-digit vs. 12-digit Subwatershed Configurations for the Raccoon River Watershed in West Central Iowa

CEAP II National Cropland Assessment

- Elimination of 8-digit Delivery Ratio
- Simulate processes from edge-of-field to 12-digit outlet.
- Channel (gully/ditch) leaving field, each first order channel, higher orders, and main routing channel



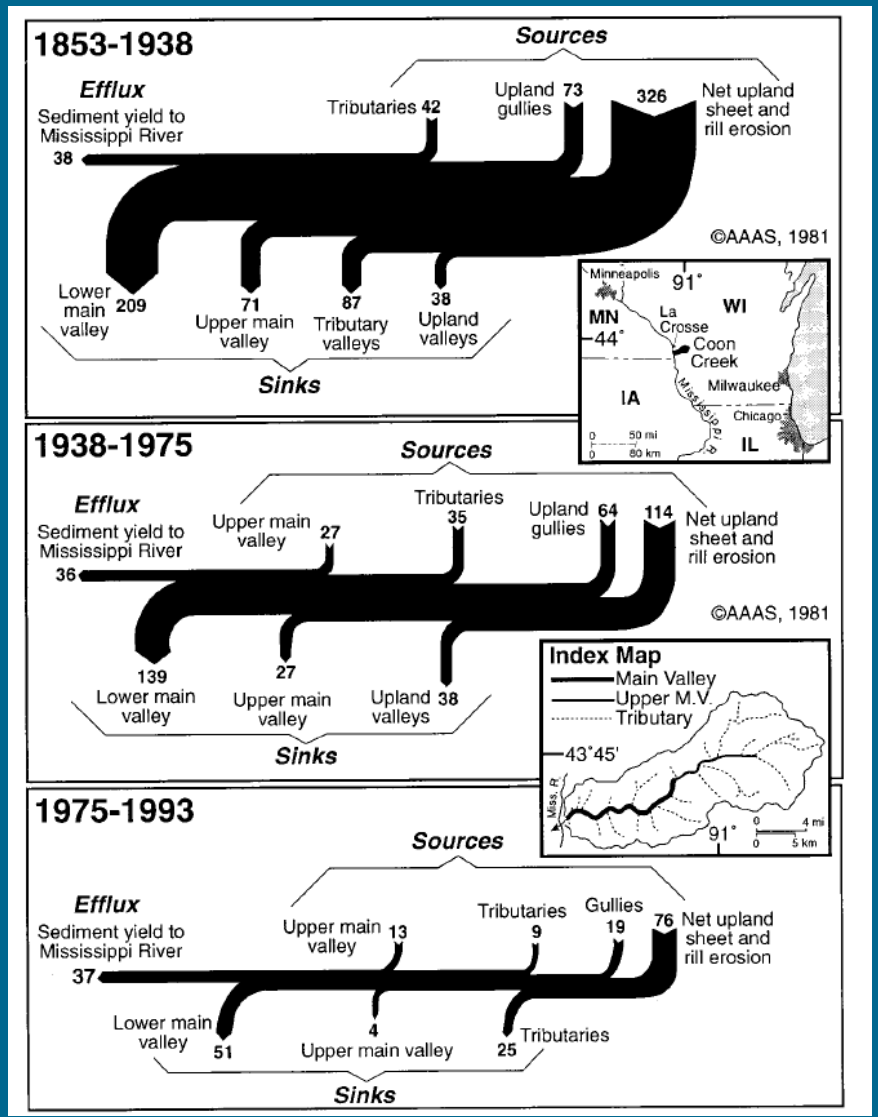




Most Sediment and Nutrients from Tributaries

CEAP II National Cropland Assessment

Detailed output of budgets within the 8-digit
including Sankey diagram from Trimble.



SWAT+ Future

SOIL & WATER ASSESSMENT TOOL

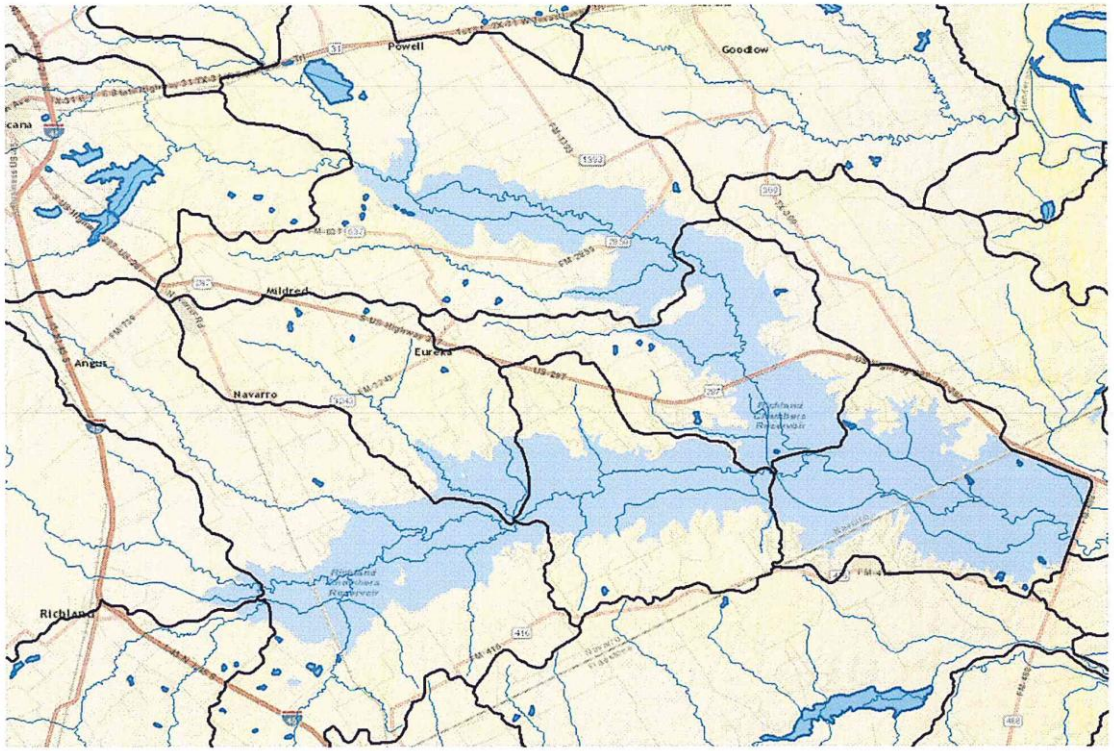
- Dynamic Land Use Updates and Scenario Analysis – Using decision tables
- Soft Calibration – Water, Sediment and Nutrient budgets
- Real Time Simulation - 10 km^2 grid of the U.S. using NEXRAD inputs to current day. Short term projecting future with weather forecasts
- QGIS and SWAT+CUP release this year


Thank you for your attention!
jeff.arnold@ars.usda.gov
kbieger@brc.tamus.edu

CEAP II National Cropland Assessment

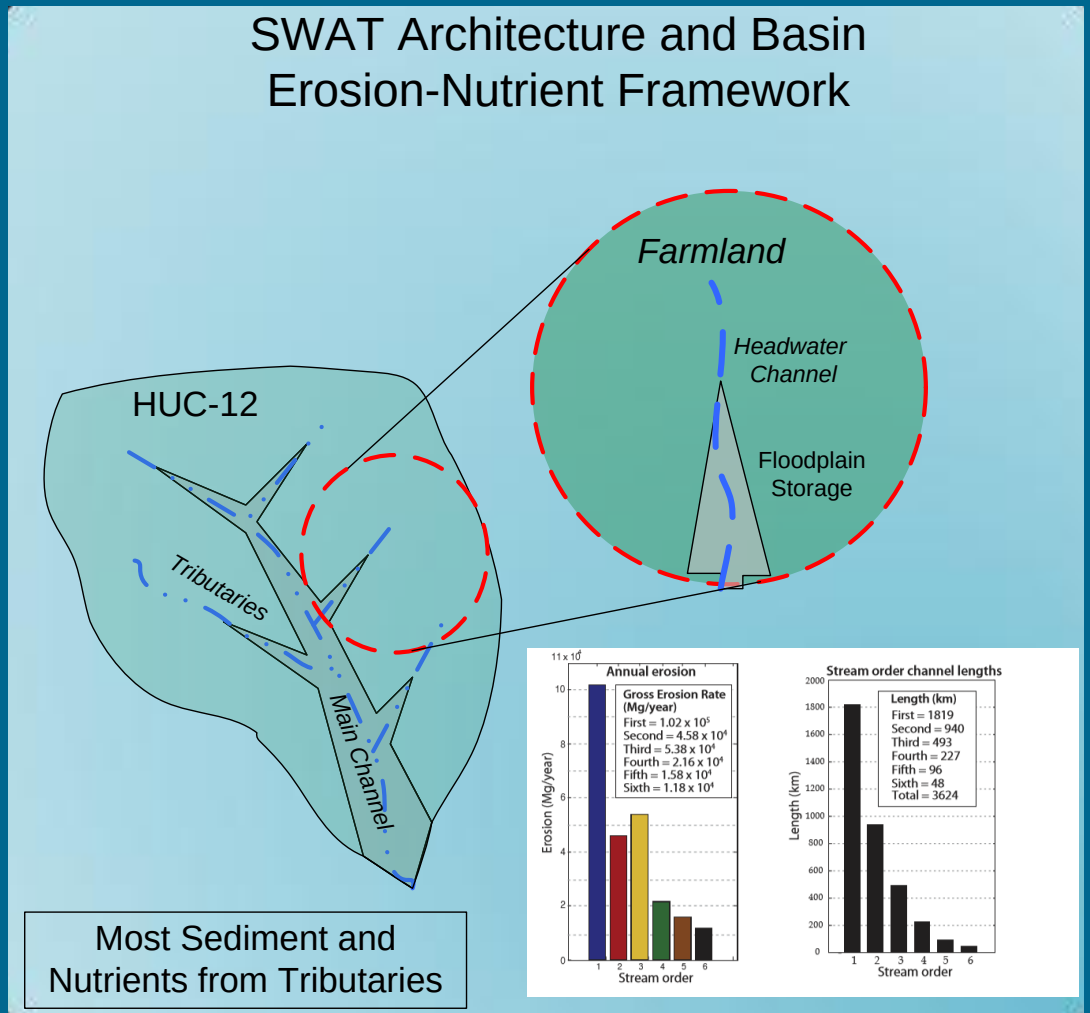
Simulation of “non-classical” hydrography.

Playa lakes, non-draining lakes, no hydrography, all wetland, etc.



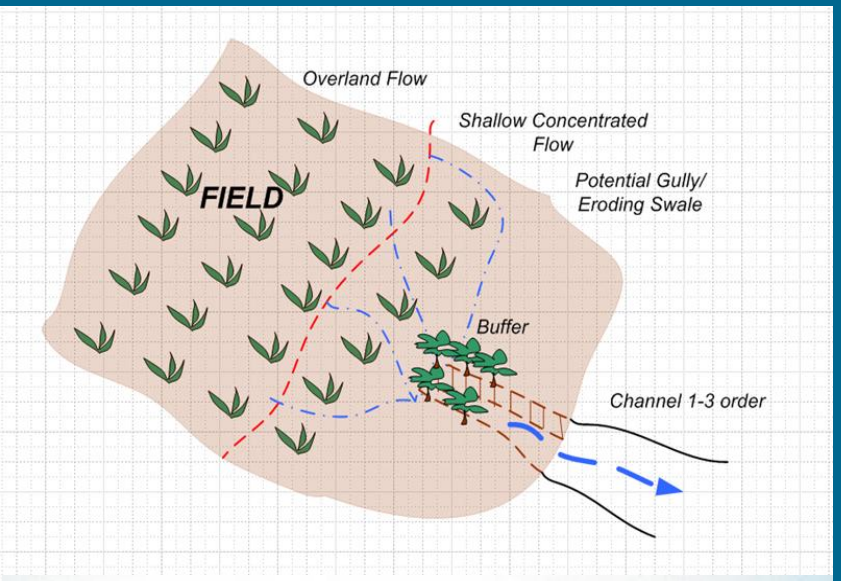
CEAP II National Cropland Assessment

New SWAT+ structure will allow simulation of legacy sediment and nutrients.

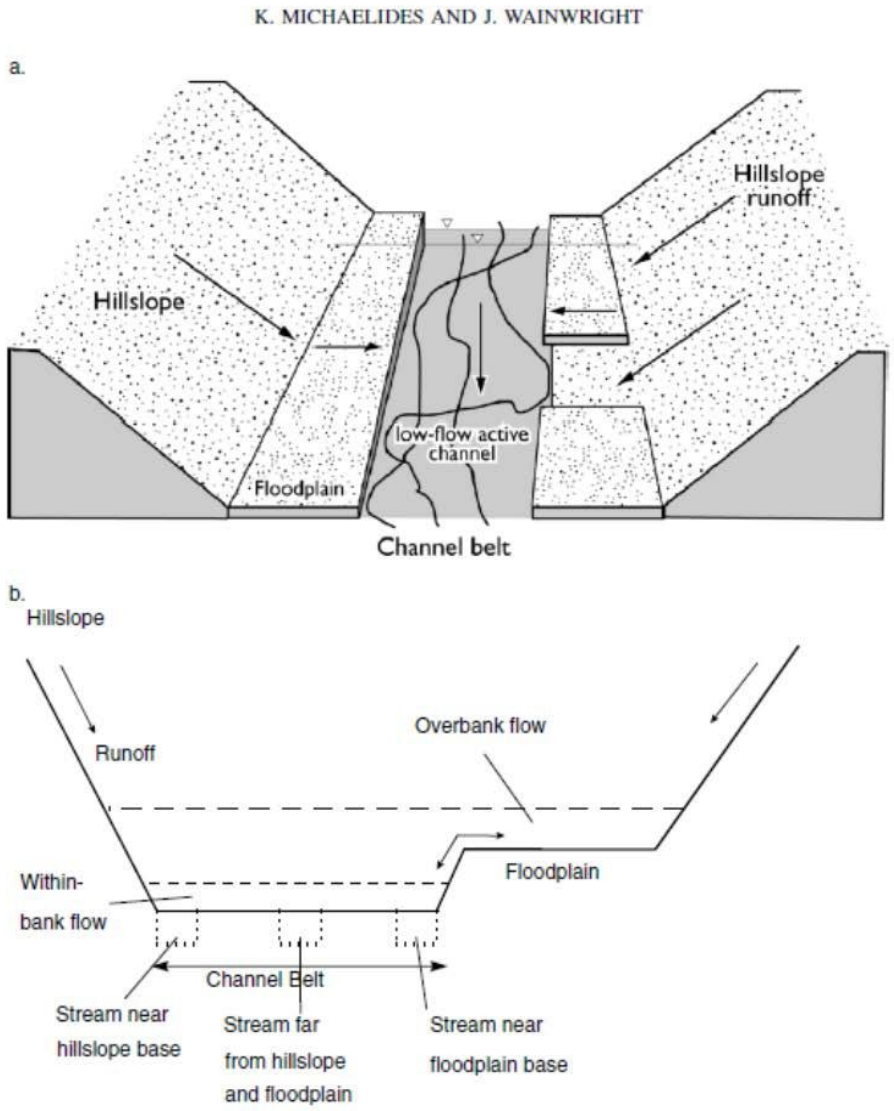


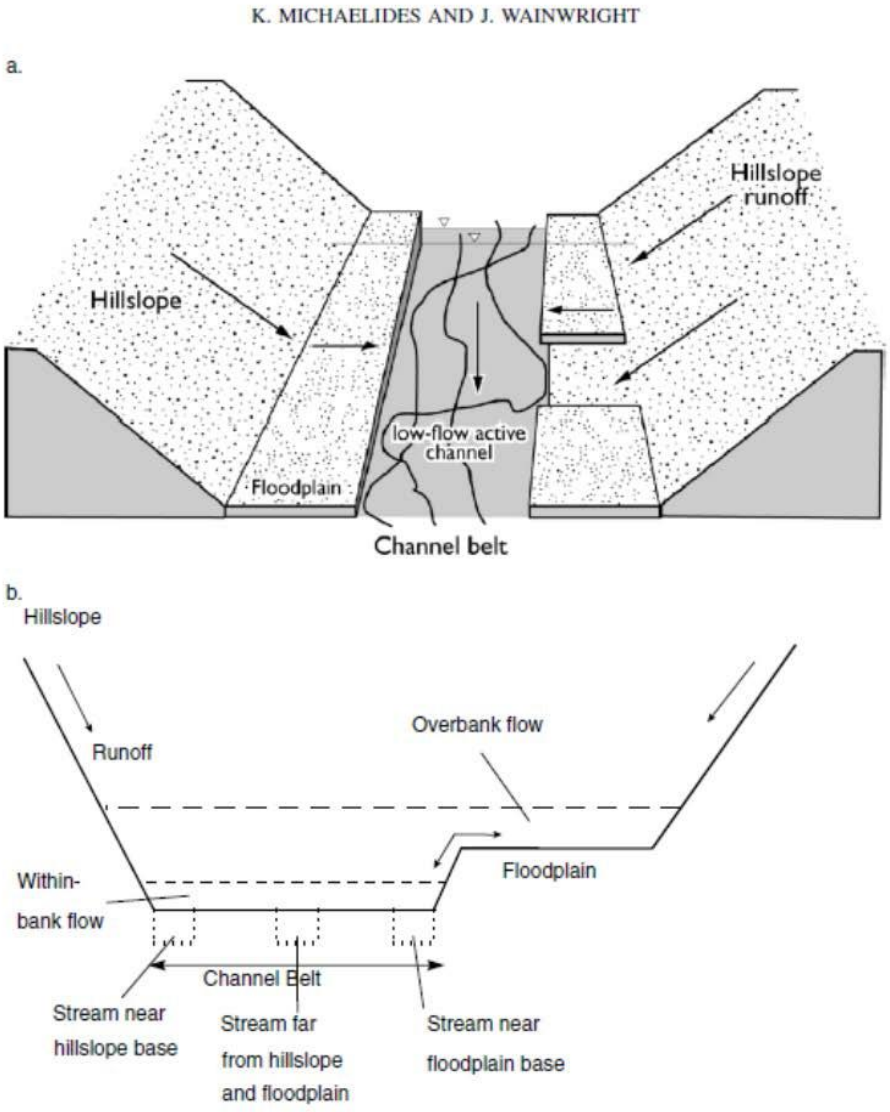
New Processes in SWAT+

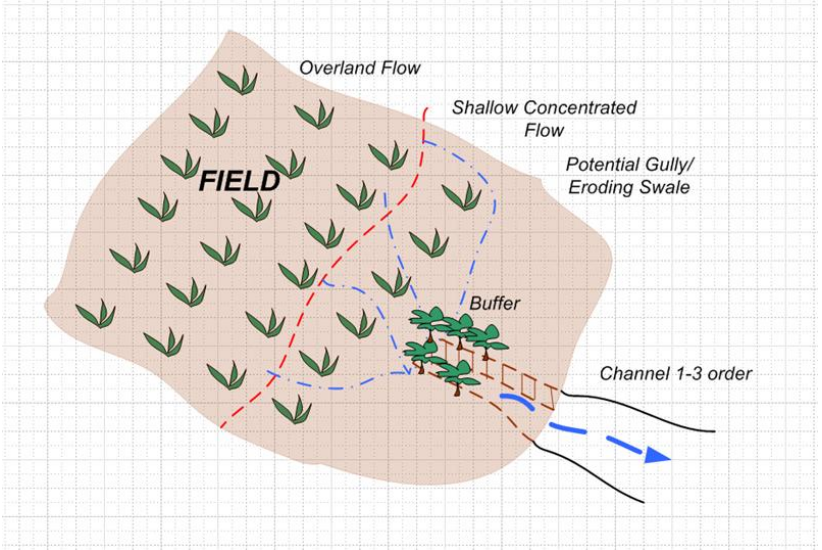
Channel Downcutting and Widening
Gully Headcut



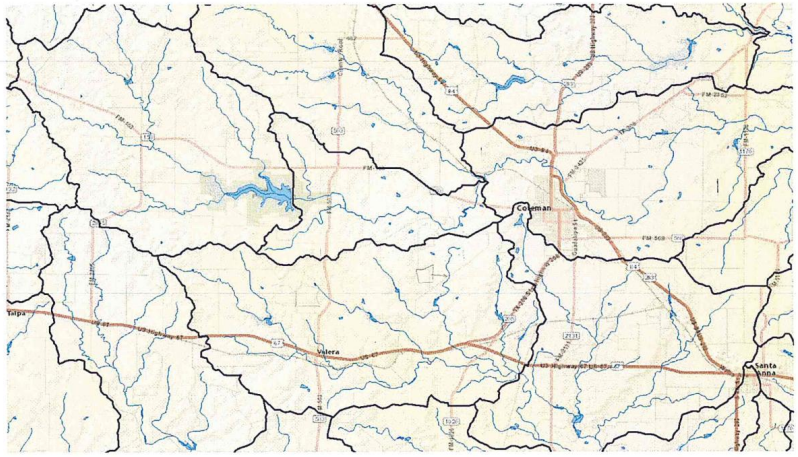
Flood Plain – Overbank

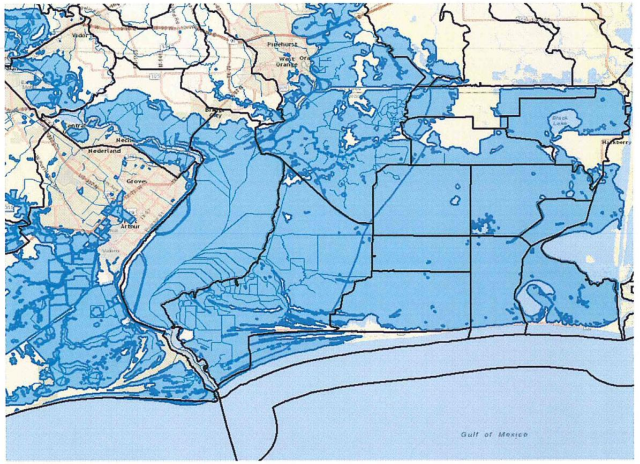


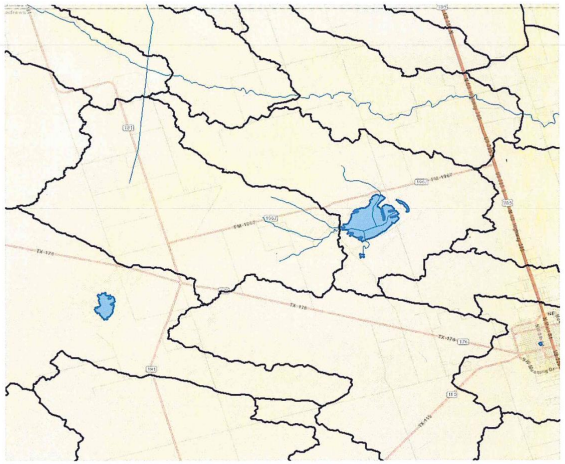

K. MICHAELIDES AND J. WAINWRIGHT
a.
Hillslope
Hillslope runoff
low-flow active channel
Floodplain
Channel belt
b.
Hillslope
Runoff
Overbank flow
Floodplain
Within-bank flow
Channel Belt
Stream near hillslope base
Stream far from hillslope and floodplain
Stream near floodplain base

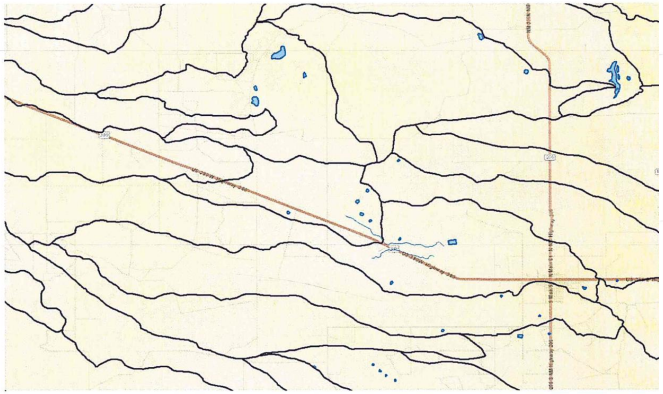

Overland Flow
Shallow Concentrated Flow
FIELD
Potential Gully/ Eroding Swale
Buffer
Channel 1-3 order

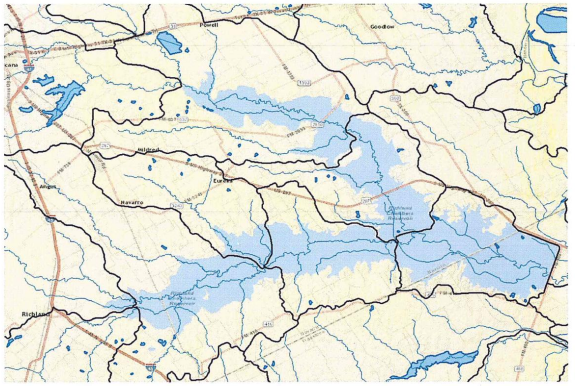
Simulation of “non-classical” hydrography. Playa lakes, non-draining lakes, no hydrography, all wetland, etc







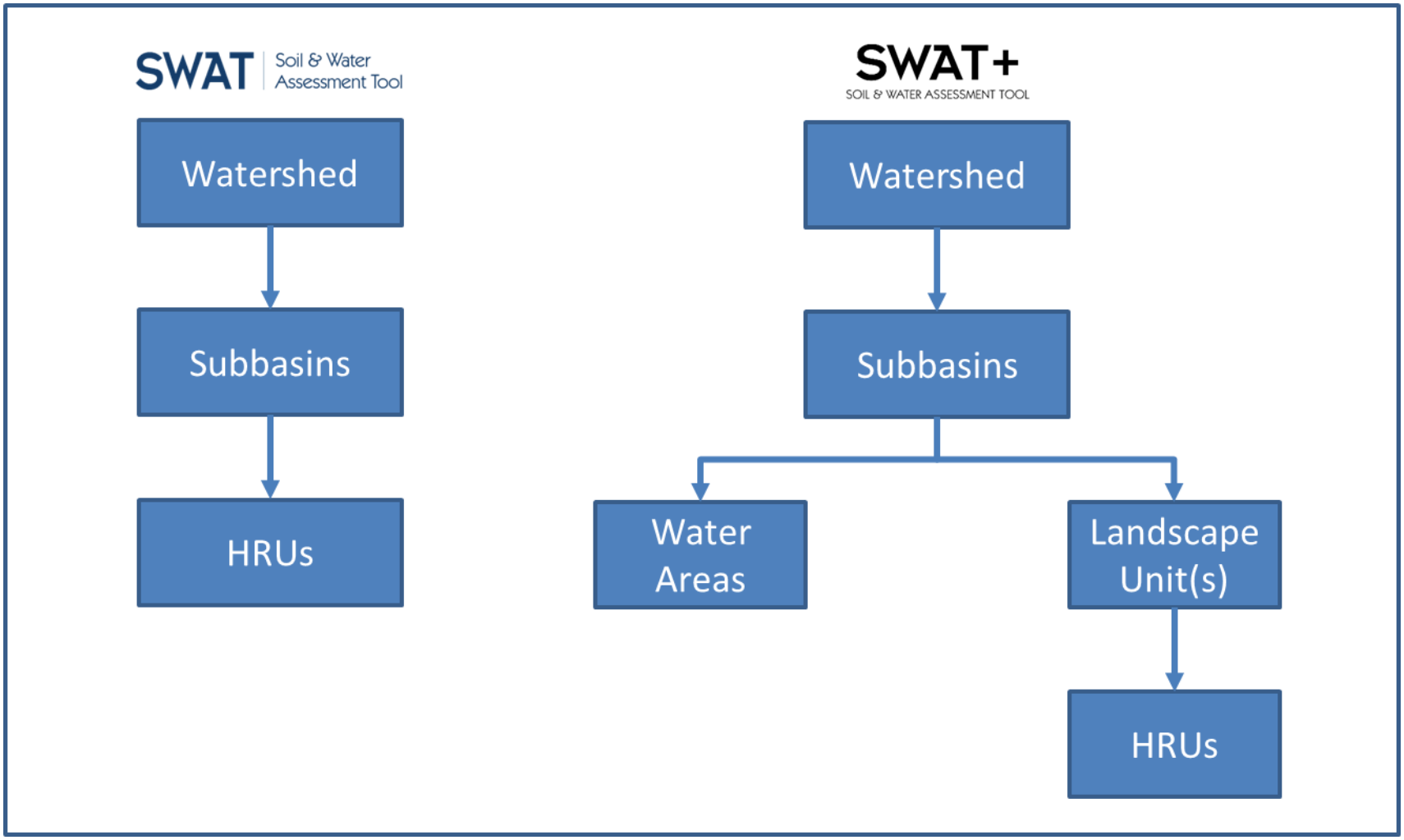




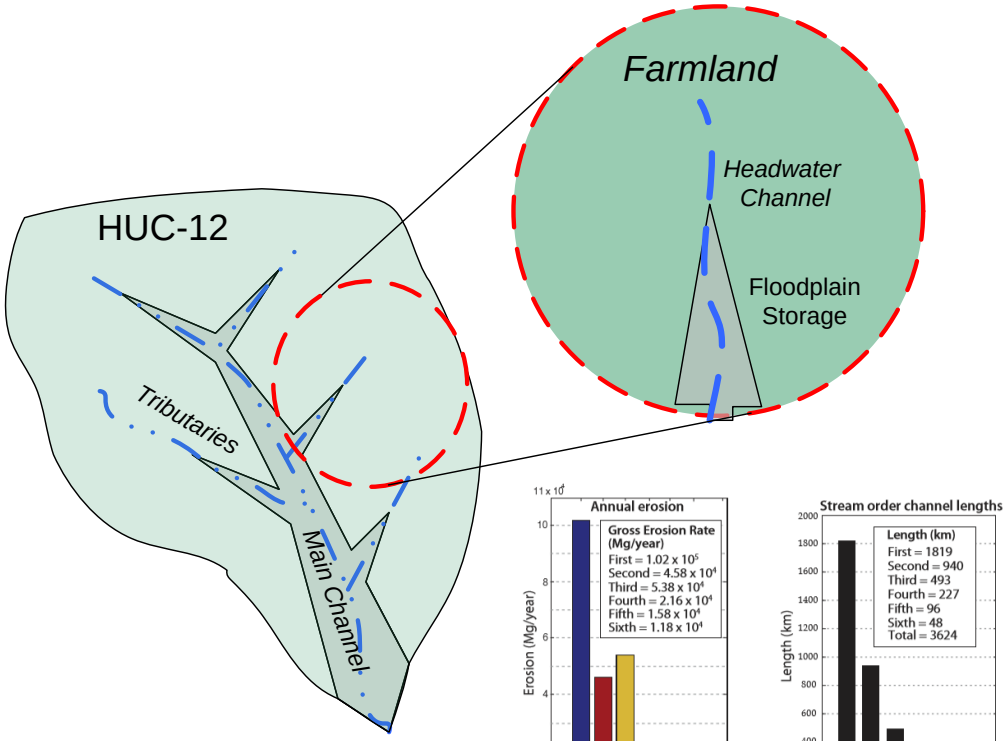
Simulating Constituents
Pesticides, Pathogens, Metals and Salts

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	**Advantages of SWAT+**
• Limited number of constituents that can be simulated and routed at the same time • No simulation of salt	• Definition of suites of constituents that will be simulated for each object • Simulation of salt as a constituent	• More comprehensive simulation of constituents • Routing of more than one pesticide at the same time

Watershed configuration



SWAT Architecture and Basin Erosion-Nutrient Framework



Most Sediment and Nutrients from Tributaries

Watershed configuration

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	Advantages of SWAT+
• Subdivision of subbasins into HRUs • Water areas defined as HRUs	• Separation of water and land areas within subbasins • Water areas defined as ponds/ reservoirs • Definition of LSUs to aggregate HRUs	• More realistic simulation of water areas • Improved simulation of landscape position, overland routing, and floodplain processes
• HRUs represented by their entire area within a LSU during calculation of land phase processes	• HRUs represented by a contiguous field with user-defined dimensions, actual HRU area used as expansion factor	• Calculation of land phase processes independent of HRU area

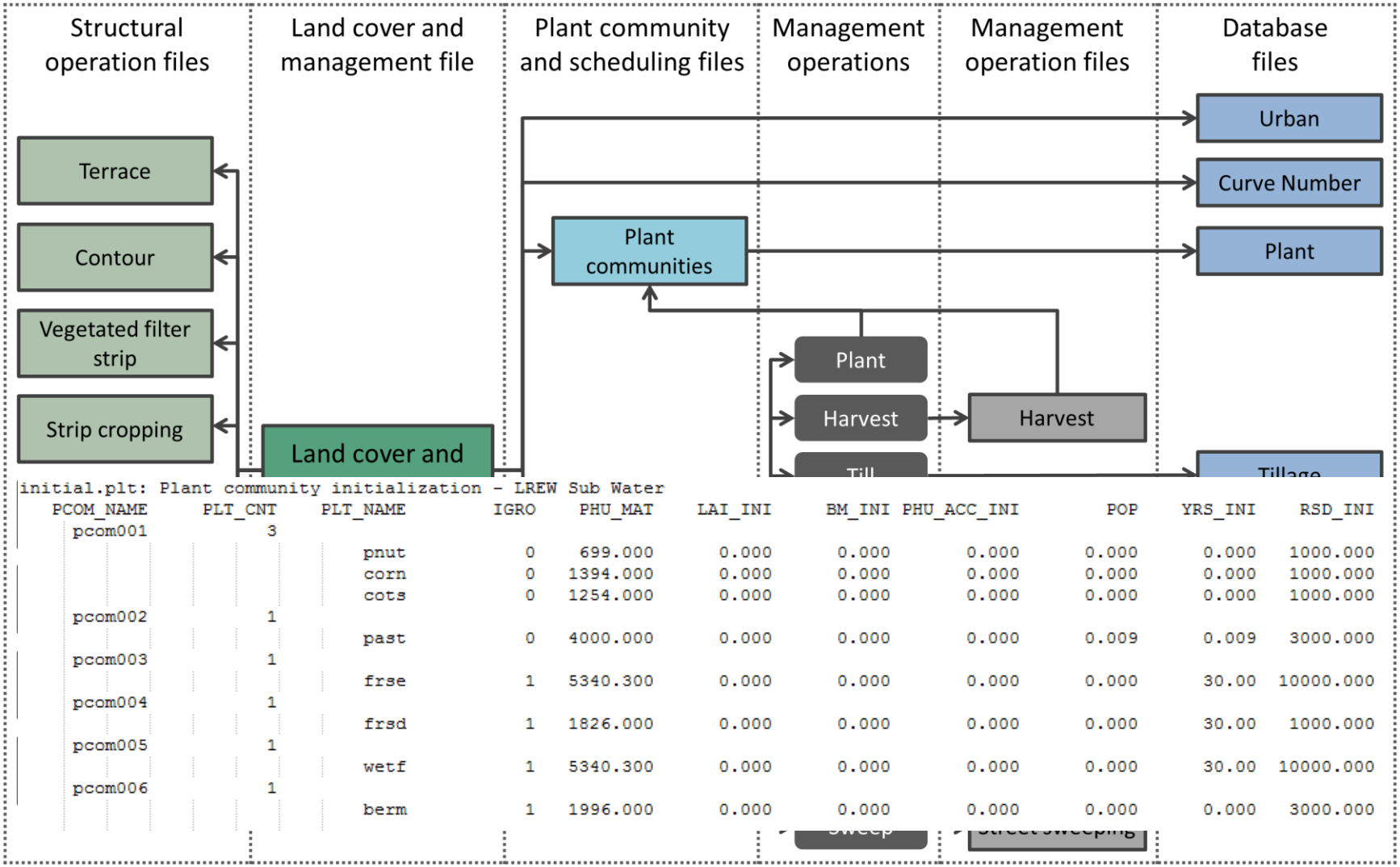
Printing output

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	**Advantages of SWAT+**
All output printed at simulation time step	User-defined time step for printing output for each object	Printing of output according to needs of user
Varying layout of output files	Standardized layout of output files in database format	Easy loading and editing in any text editor, spread-sheet or database program
Specification of additional print commands in fig.fig file	Specification of additional print commands in separate file	Easier printing of user-defined output files

Aquifers and reservoirs

SWAT Soil & Water Assessment Tool	SWAT+ SOIL & WATER ASSESSMENT TOOL	**Advantages of SWAT+**
• Aquifers tied to HRUs • Definition of one aquifer per HRU	• Aquifers independent from HRUs	• Any number of aquifers can be defined • Facilitation of SWAT-MODFLOW linkage
• Placement of reservoirs on main channel at subbasin outlet	• Placement of reservoirs anywhere in the watershed	• More realistic representation of reservoir position and interactions with the landscape

Land cover and management



initial.plt: Plant community initialization - LREW Sub Water

PCOM_NAME	PLT_CNT	PLT_NAME	IGRO	PHU_MAT	LAI_INI	BM_INI	PHU_ACC_INI	POP	YRS_INI	RSD_INI
pcom001	3									
		pnut	0	699.000	0.000	0.000	0.000	0.000	0.000	1000.000
		corn	0	1394.000	0.000	0.000	0.000	0.000	0.000	1000.000
		cots	0	1254.000	0.000	0.000	0.000	0.000	0.000	1000.000
pcom002	1									
		past	0	4000.000	0.000	0.000	0.000	0.009	0.009	3000.000
pcom003	1									
		frse	1	5340.300	0.000	0.000	0.000	0.000	30.00	10000.000
pcom004	1									
		frsd	1	1826.000	0.000	0.000	0.000	0.000	30.00	1000.000
pcom005	1									
		wetf	1	5340.300	0.000	0.000	0.000	0.000	30.00	10000.000
pcom006	1									
		berm	1	1996.000	0.000	0.000	0.000	0.000	0.000	3000.000

Spatial connections