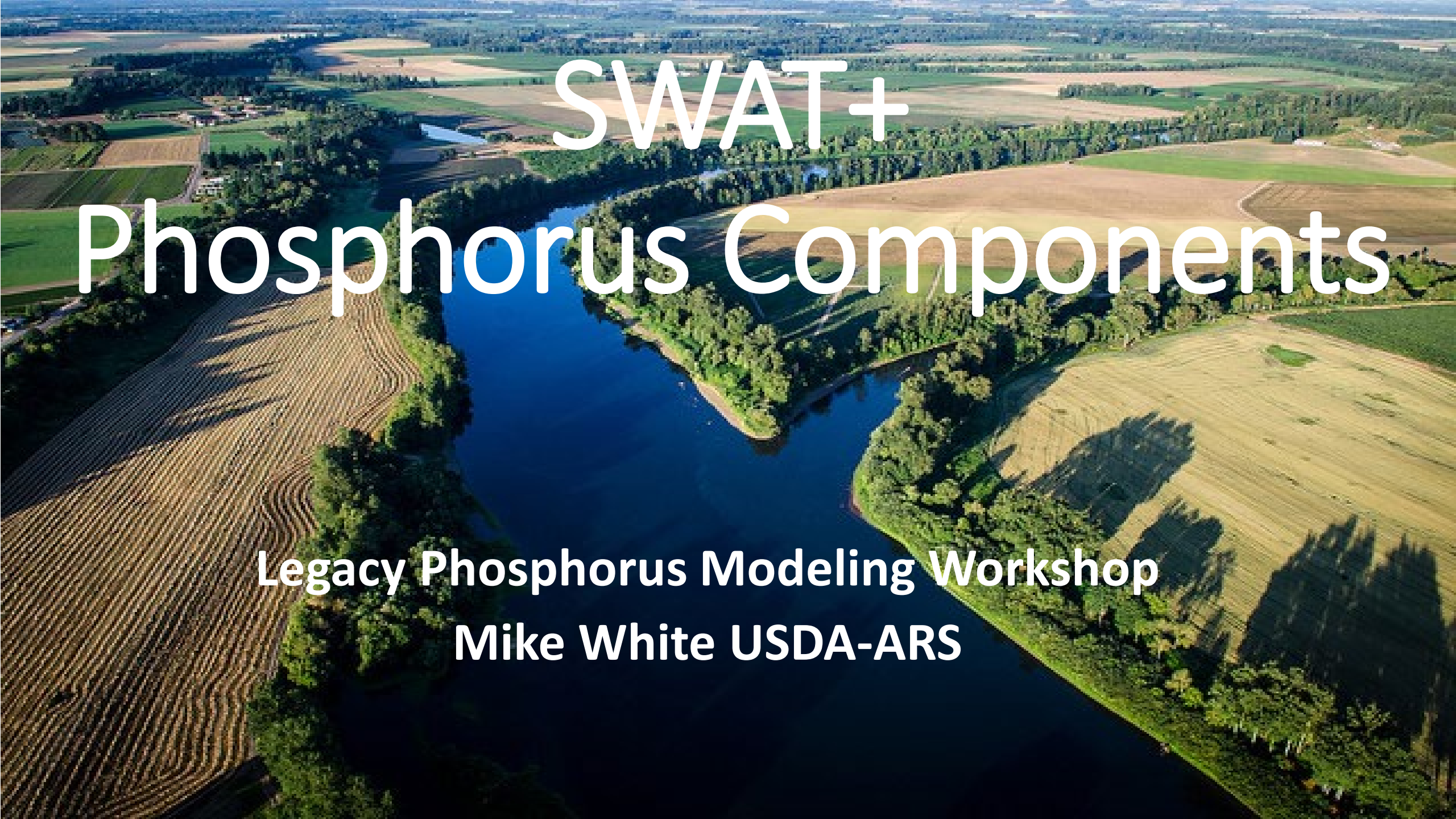


SWAT+ Phosphorus Components

Legacy Phosphorus Modeling Workshop

Mike White USDA-ARS

What is a Model?

ALL MODELS ARE APPROXIMATIONS. ESSENTIALLY, ALL MODELS ARE WRONG, BUT SOME ARE USEFUL. HOWEVER, THE APPROXIMATE NATURE OF THE MODEL MUST ALWAYS BE BORNE IN MIND...

- GEORGE E. P. BOX -

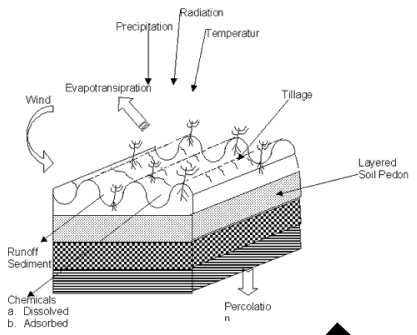
- A simplified mathematical representation of a complex reality

- SWAT
- Process based model
  - Hydrologic balance
  - Nitrogen and phosphorus cycles
  - Plant growth
  - Ponds and reservoirs
  - Instream
- Daily time step

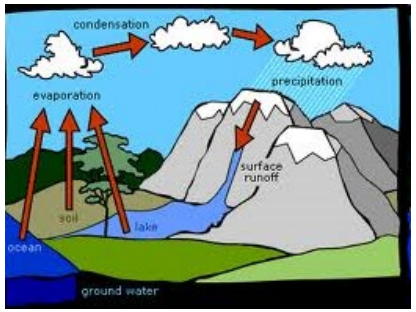
Process Based Model Development

Field Research

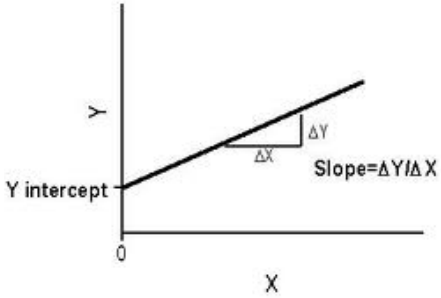
Existing Models



Define Physical Process Theory



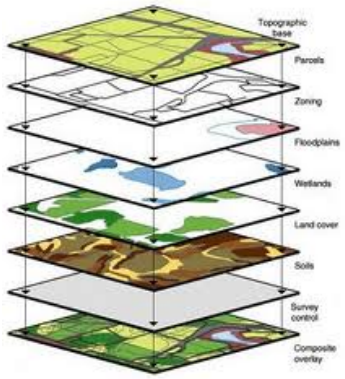
Establish Relationships



SWAT+ Model

Typical SWAT Application

GIS Data



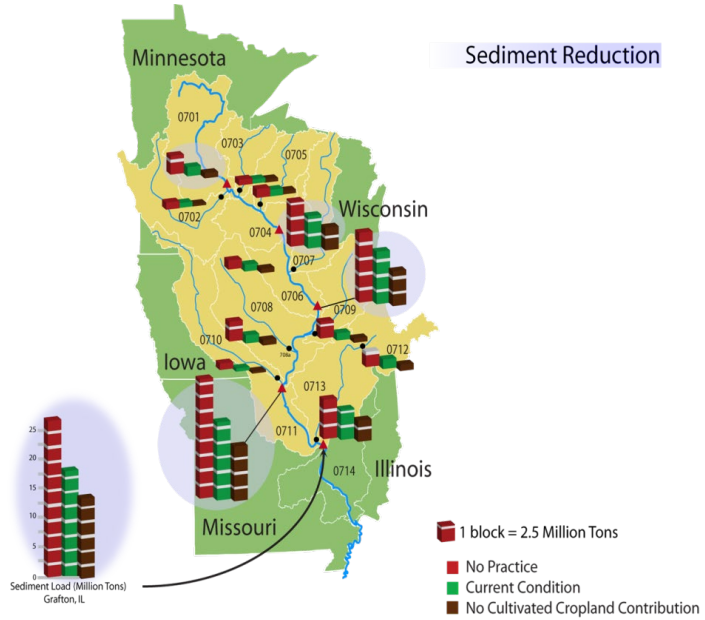
Measured Data

Tabular Data

Calibrate & Validate

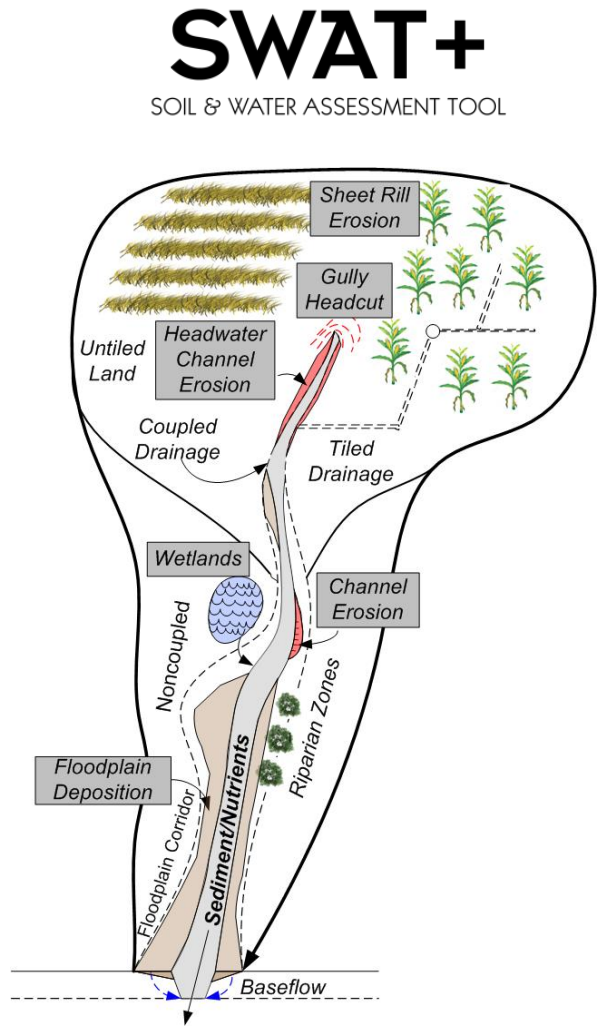
SWAT+ Model

Predictions



SWAT+ Recent Advancements

- New, completely restructured version
- Improved simulation of small-scale processes
- Flexible connectivity between objects
- Relational file input structure
- MODULAR – Extensive use of data structures and modules. Easier to maintain, link to other models, and add process subroutines.



Phosphorus Process Classes

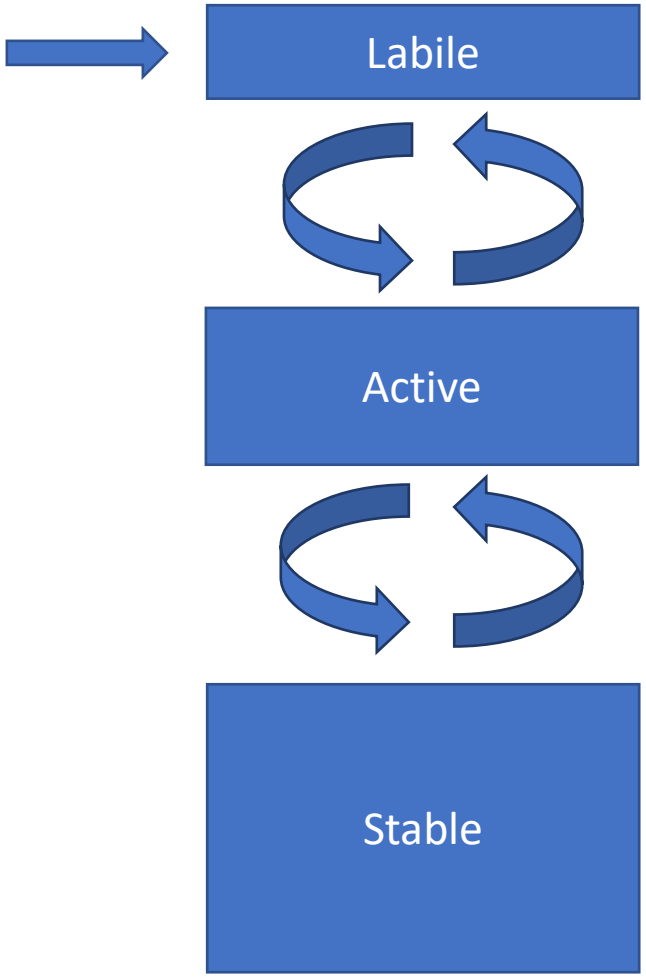
Soil and Plant Cycling

Runoff and Leaching

Instream Processes

Lakes and Reservoirs

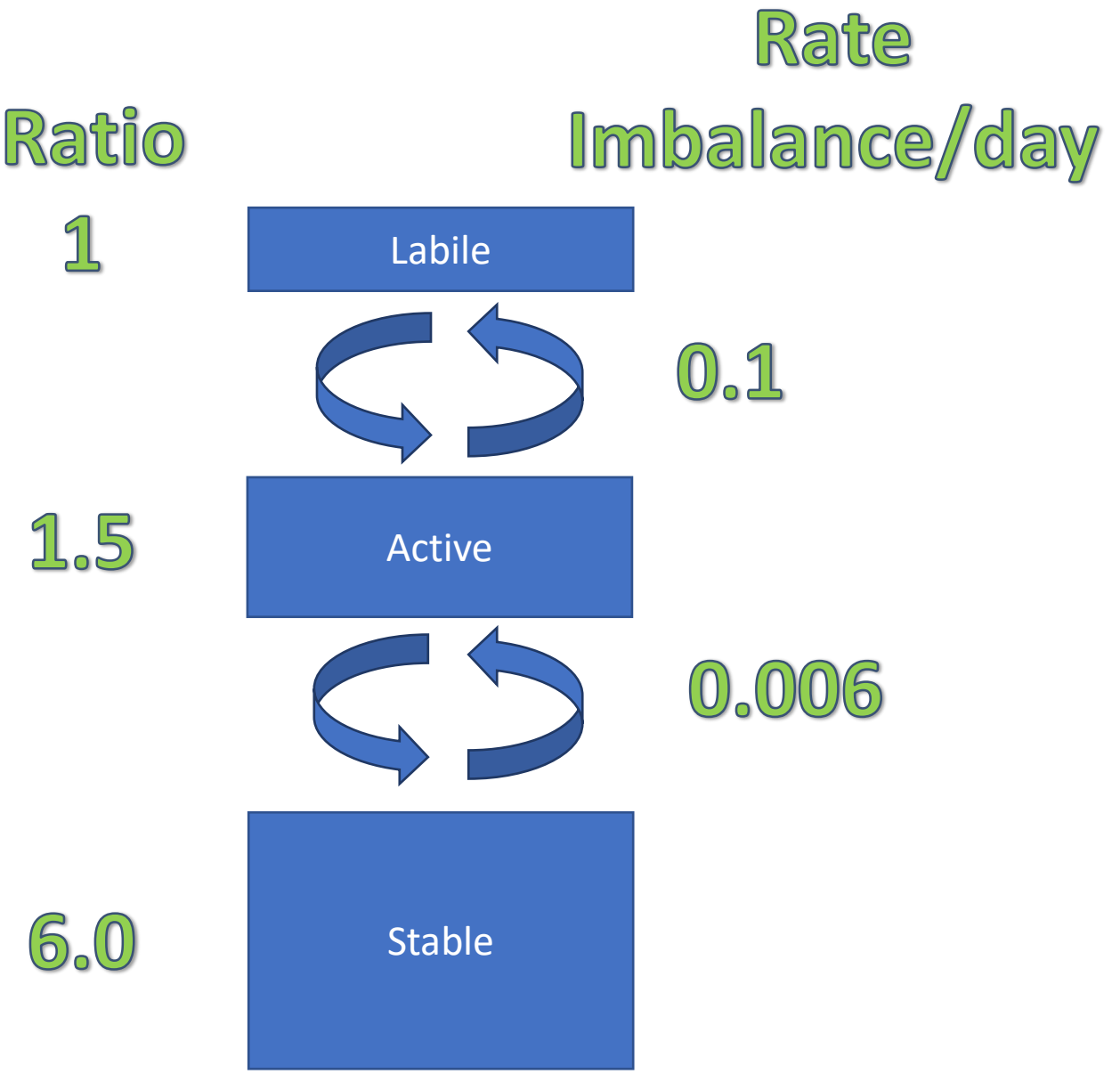
SWAT Soil Mineral P Model



- 3 interactive pools – mid 1980's
- Dynamic equilibrium between pools
- Pools not strictly tied to soil tests
- Various Initialization strategies
  - Mehlich or Bray = Labile + Active
  - Resin or Olsen = Labile
  - Default – 90%+ users

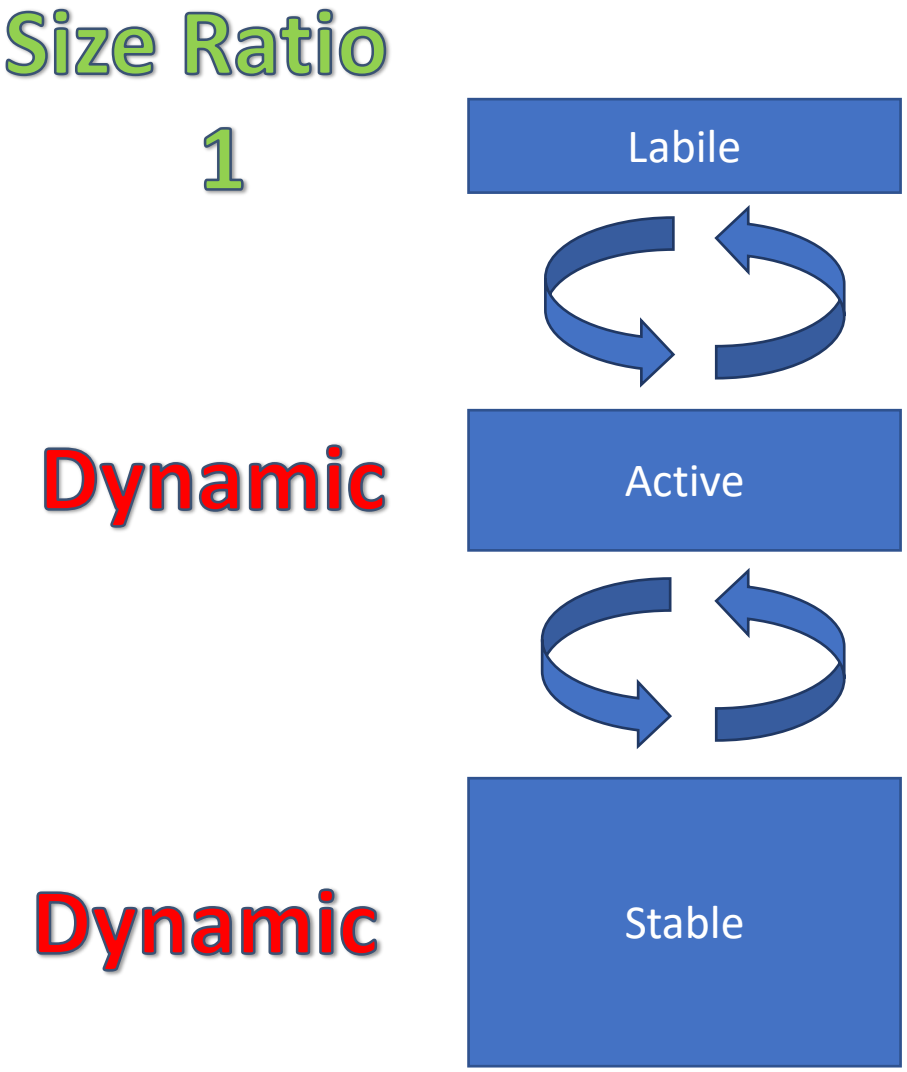
Original Model

- Fixed ratios between pools
- Fixed Transformation rates



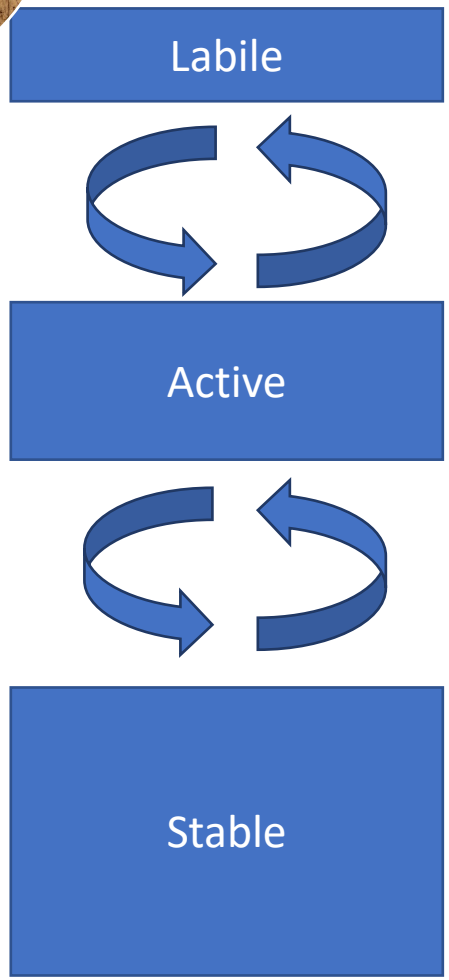
Alternate P Model

- Based on Vadas et al. (2006;2010) and Sharpley et al. (2004)
- Dynamic Labile/Active Ratios
  - Clay content
  - Organic carbon
  - Labile phosphorus
- Dynamic Active/Stable Ratios
  - Total soil phosphorus



Alternate P model

Rates



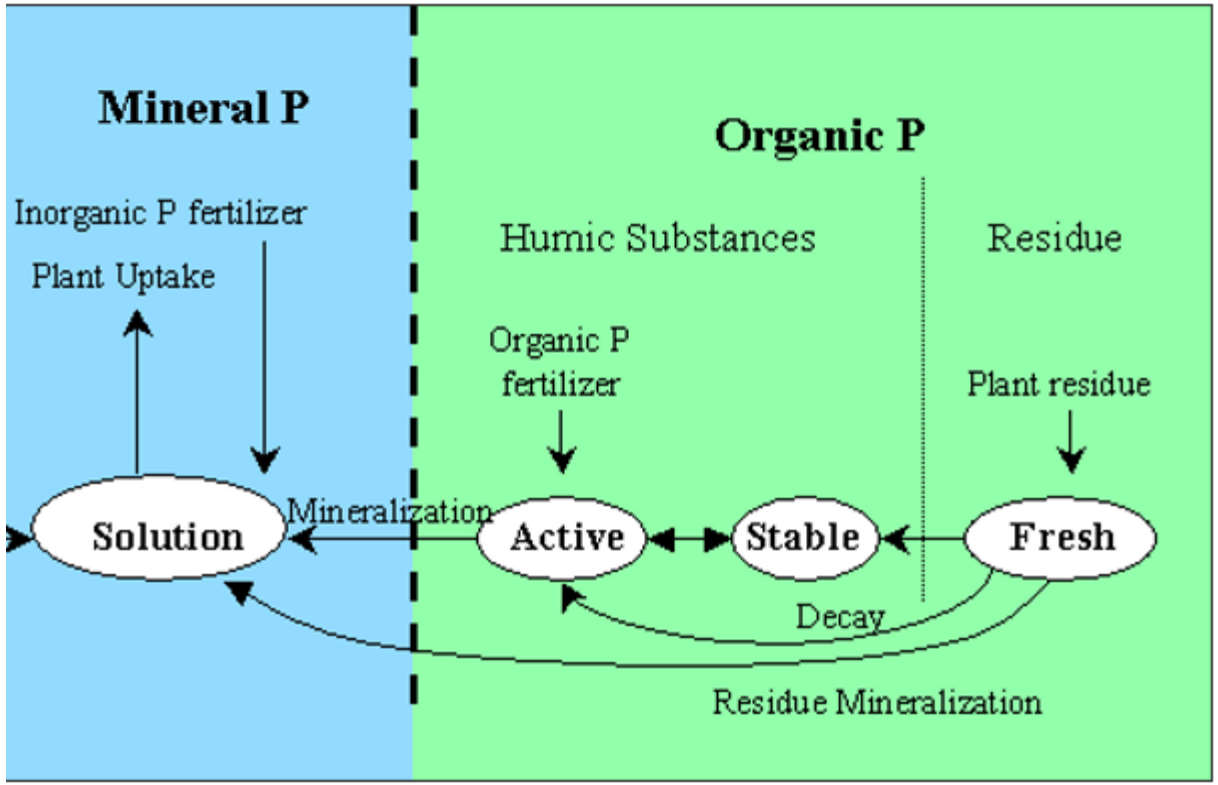
Dynamic

Dynamic

- Labile/Active Transformations
  - Days since pool imbalance
  - Fertilization
- Active/Stable Transformations
  - Soil calcium carbonate content
- Soil Water Content (All Transformations)
  - No transformations in dry soil
  - Linear scaling as a fraction of field capacity

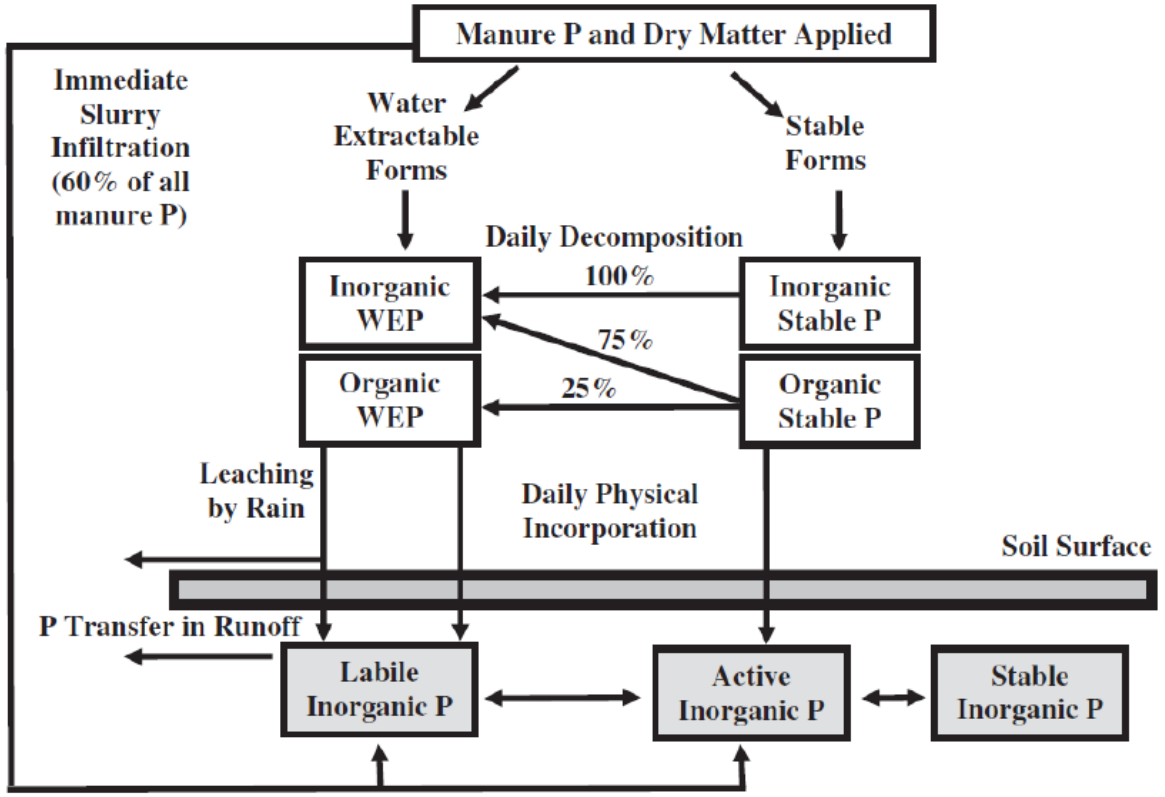
SWAT Organic P Model

- 3 Pools
  - Active, Stable, Fresh
  - C:N:P ratios 1:10:80
- Versions with CENTURY components



SWAT P Manure Version

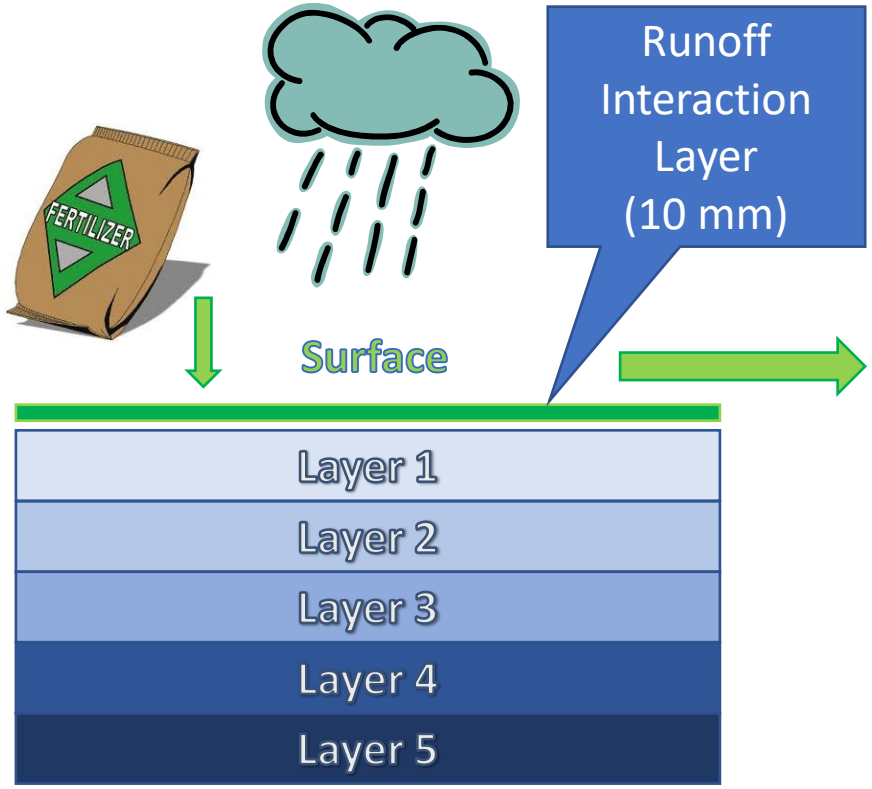
- Branch version, not included in SWAT+
- Needs integrated nitrogen & carbon components



Vadas PA, Gburek WJ, Sharpley AN, Kleinman PJ, Moore PA Jr, Cabrera ML, Harmel RD. 2007. A model for phosphorus transformation and runoff loss for surface-applied manures. J Environ Qual .36(1):324-32.

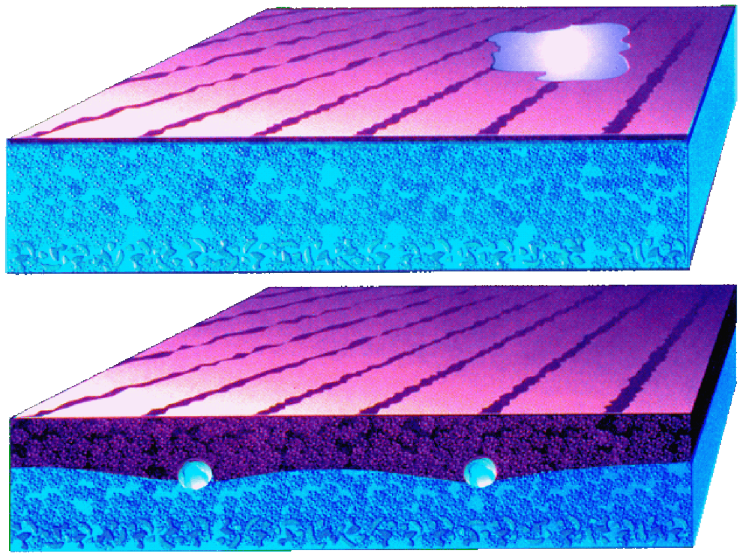
Surface Runoff

- Losses Controlled by:
  - Labile P Concentration in top 10mm
  - Runoff Volume
  - P Soil Partitioning Coefficient (PhosKD)
  - P Percolation Coefficient (PPERCO)
- Soil Layers Simulated Separately
  - Mixed with tillage and biological activity



Tile Losses

- P movement between soil layers
- Second simple percolation coefficient allow P movement with leachate
- Have tried a couple of preferential crack flow models



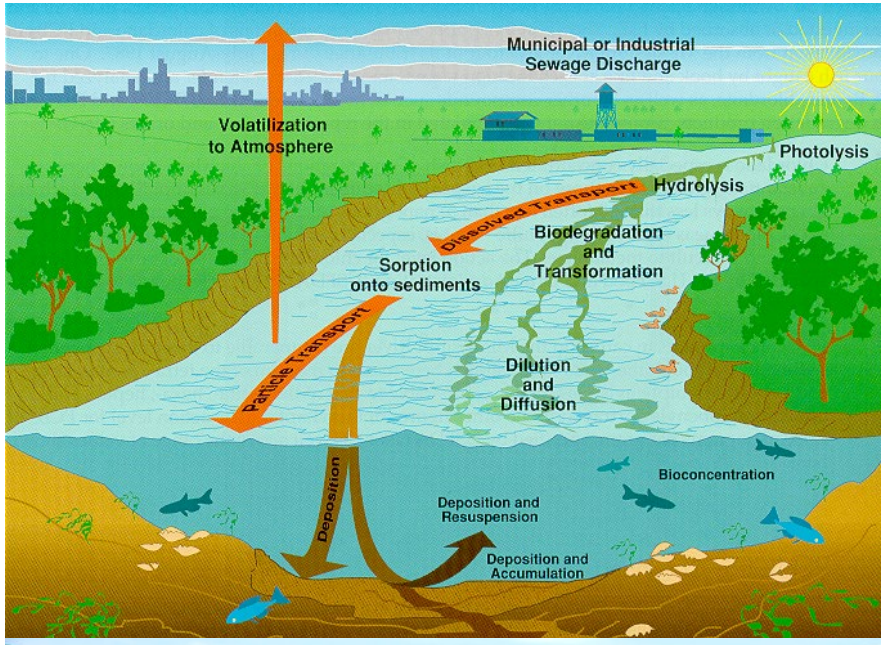
Adapted from: Zucker, L.A. and L.C. Brown (eds.). 1998. Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest. Ohio State University Extension Bulletin 871. The Ohio State University.

Instream Phosphorus Model 2 Versions

- Original Model
  - Included in all versions
  - Based on QUAL2E

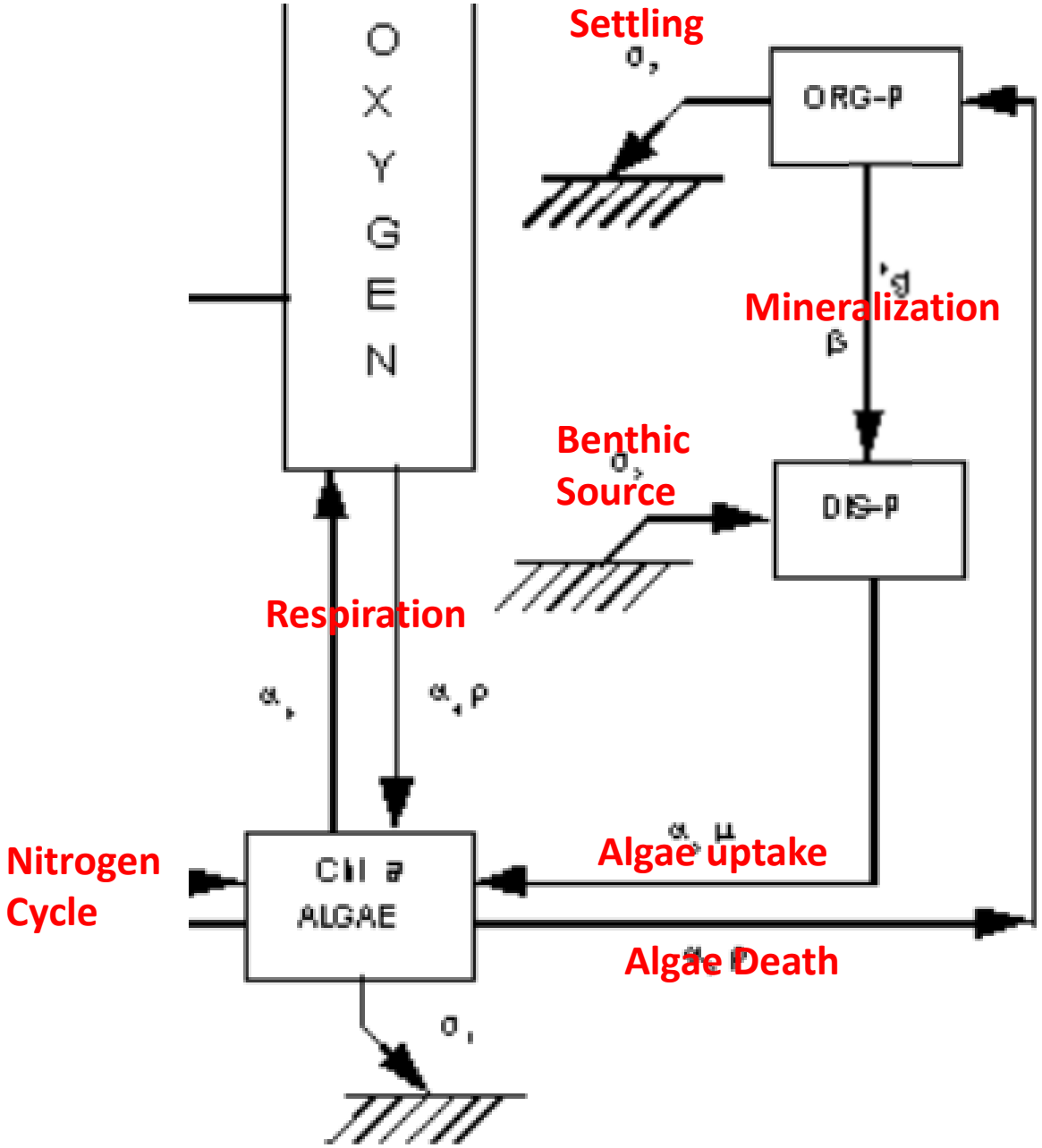
- Alternate Model
  - Branch version
  - Based on Equilibrium Phosphorus Concentration (EPC)

- SWAT+ Enhancements
  - New instream sediment erosion routines
  - P contributions based on bank concentrations



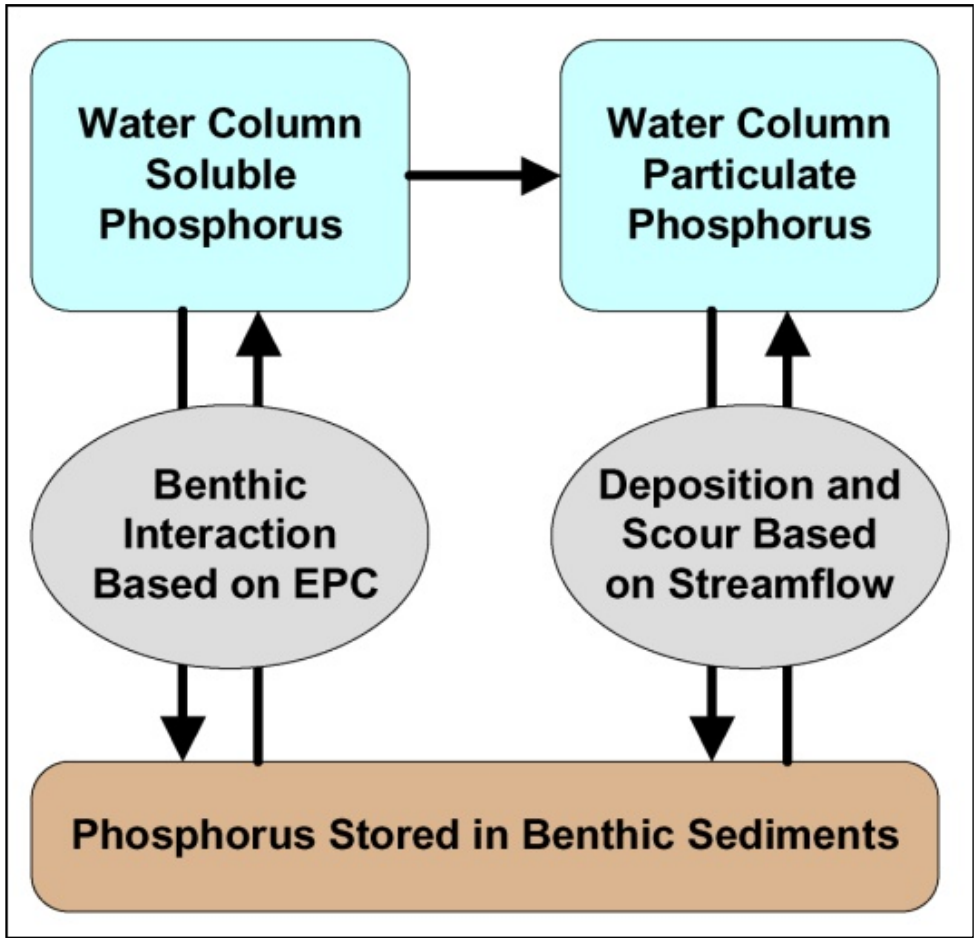
QUAL2E

- Algal update and respiration
- Linked to N cycle
- Organic P decay & settling
- Dissolved P from benthic P sources
- Limitations
  - No mass balance
    - Benthic pools not tracked
  - Does not consider attached algae
  - Not linked to instream sediments



Alternate Instream Phosphorus Model

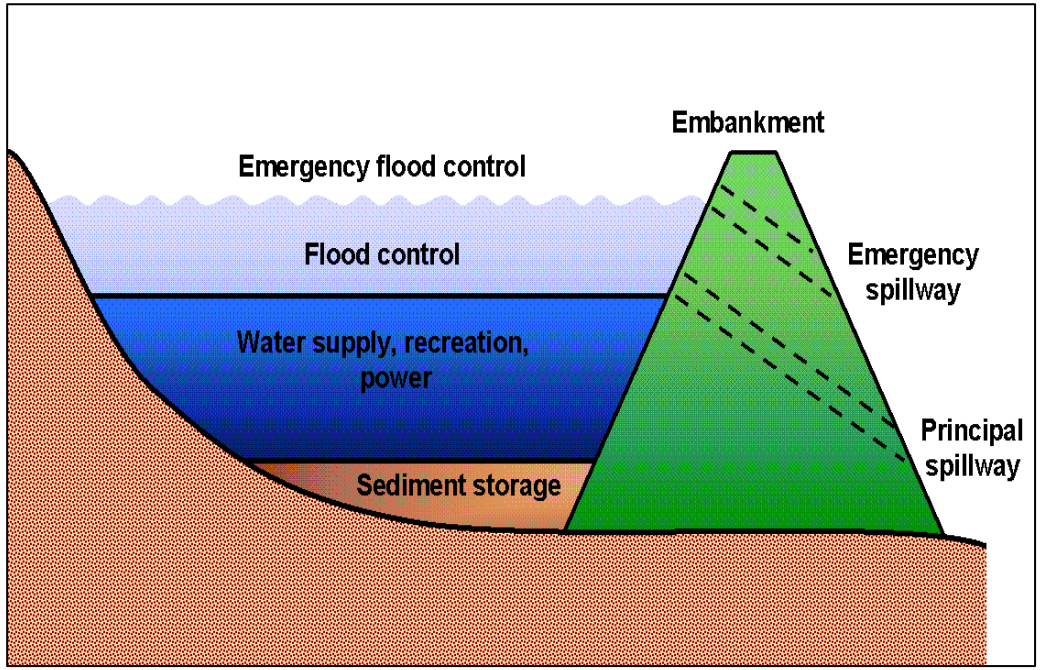
- EPC is derived from long term P concentration in reach.
- P is transferred to and from the streambed pool concentration closer to the EPC for that reach
- Deposition and scour based on streamflow
- Benthic P is tracked and conserved
- Limitations
  - More parameters
  - Not linked to channel erosion



White, Michael J., et al. "Development and testing of an in-stream phosphorus cycling model for the soil and water assessment tool." Journal of environmental quality 43.1 (2014): 215-223.

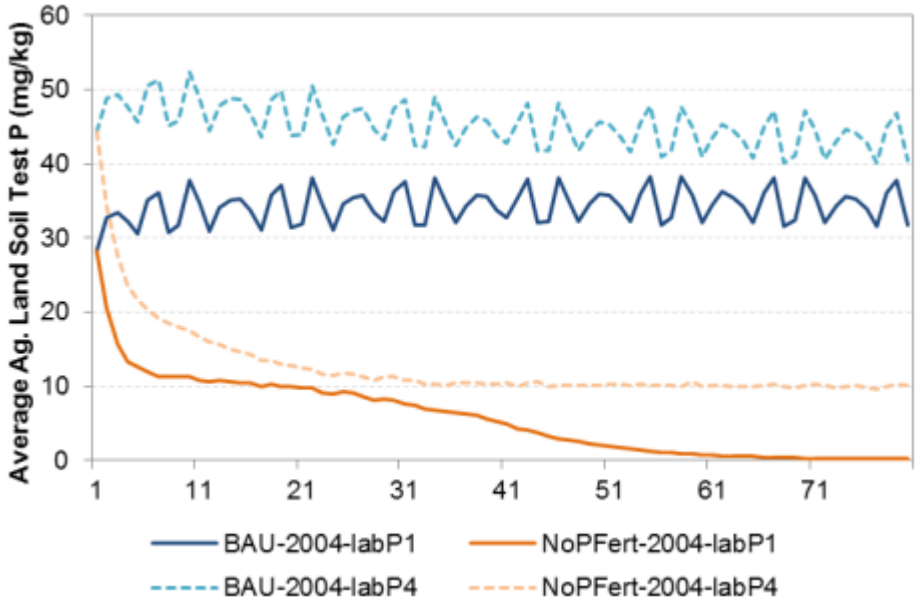
Ponds and Reservoirs

- Very simple model
- Based on collective settling rate for both particulate and soluble forms.
- Limitations
  - No overall lake mass balance
  - No anoxic sediment P release

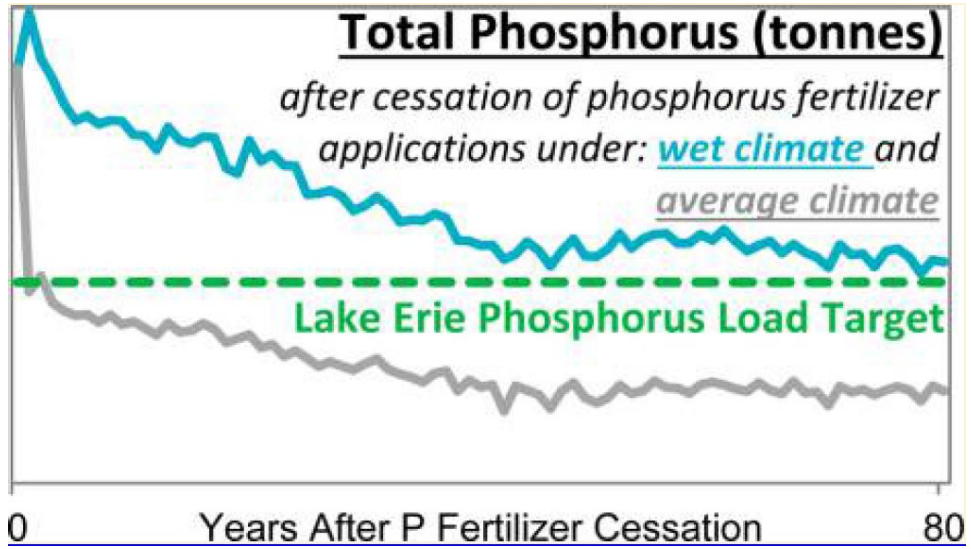


SWAT Response to Soil P Legacy Maumee River Watershed

- SWAT responsive to slow drawdown of legacy soil P



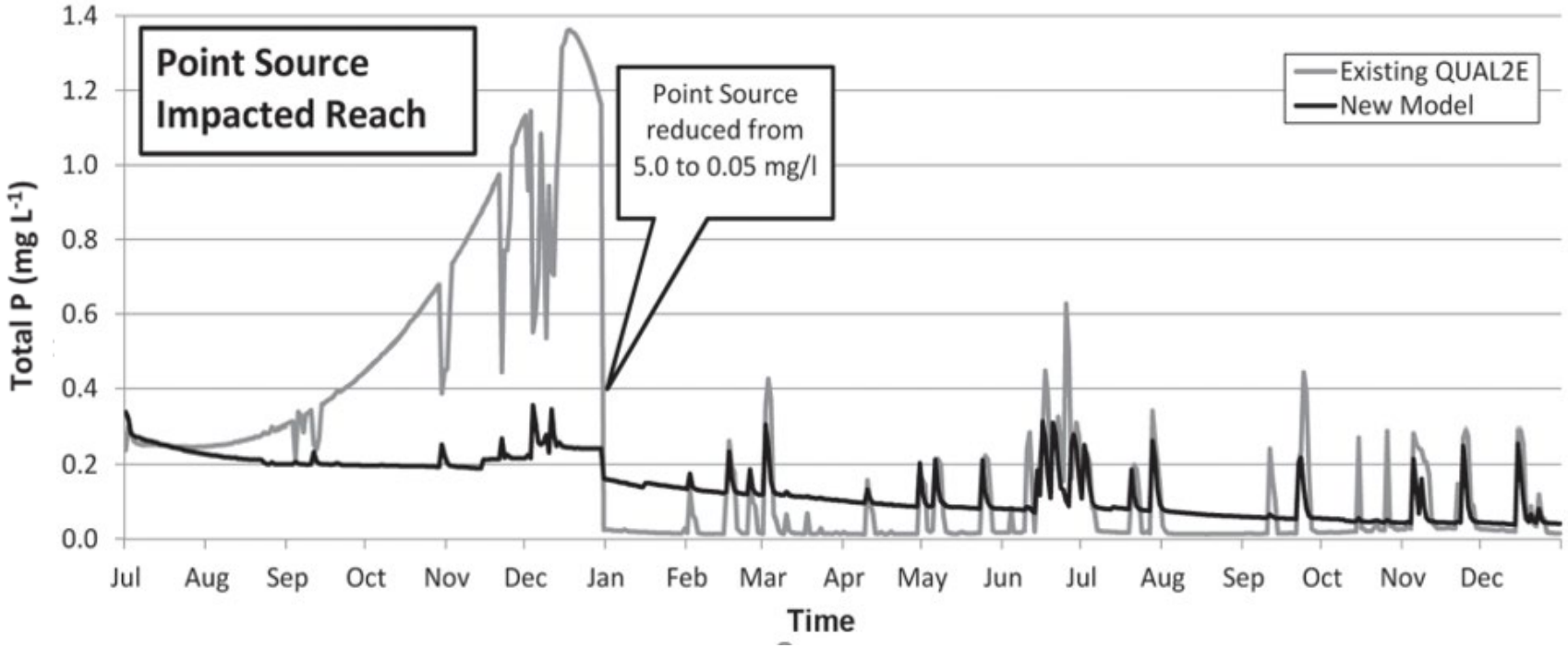
Maumee River Watershed

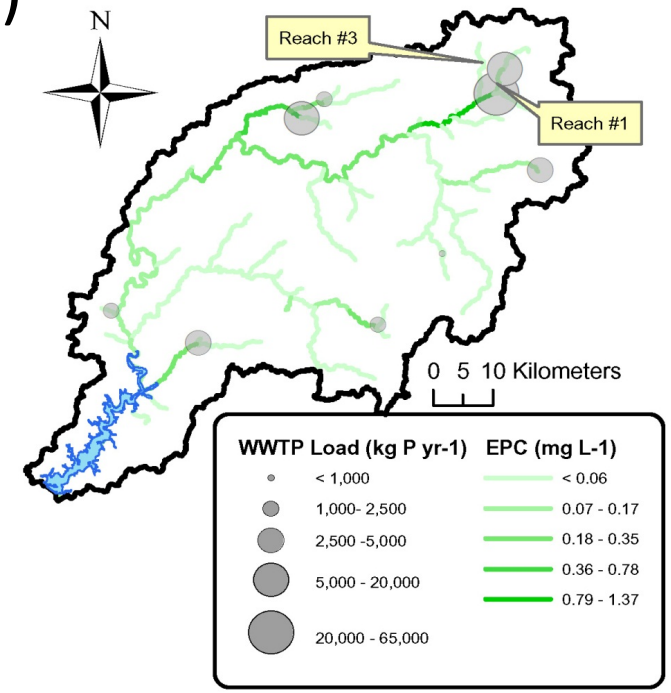


Evaluating the Impact of Legacy P and Agricultural Conservation Practices on Nutrient Loads from the Maumee River Watershed
Rebecca Muenich, Margaret Kalcic, and Donald Scavia Environ. Sci. Technol. 2016, 50, 8146−8154

Alternate Instream Model Testing

- Tested in Illinois River Basin (Oklahoma/Arkansas)
- Improved response to sudden change





White, Michael J., et al. "Development and testing of an in-stream phosphorus cycling model for the soil and water assessment tool." Journal of environmental quality 43.1 (2014): 215-223.

Please Ponder

What are the most critical P processes you did not see?

How can those be represented with a minimum of added complexity?