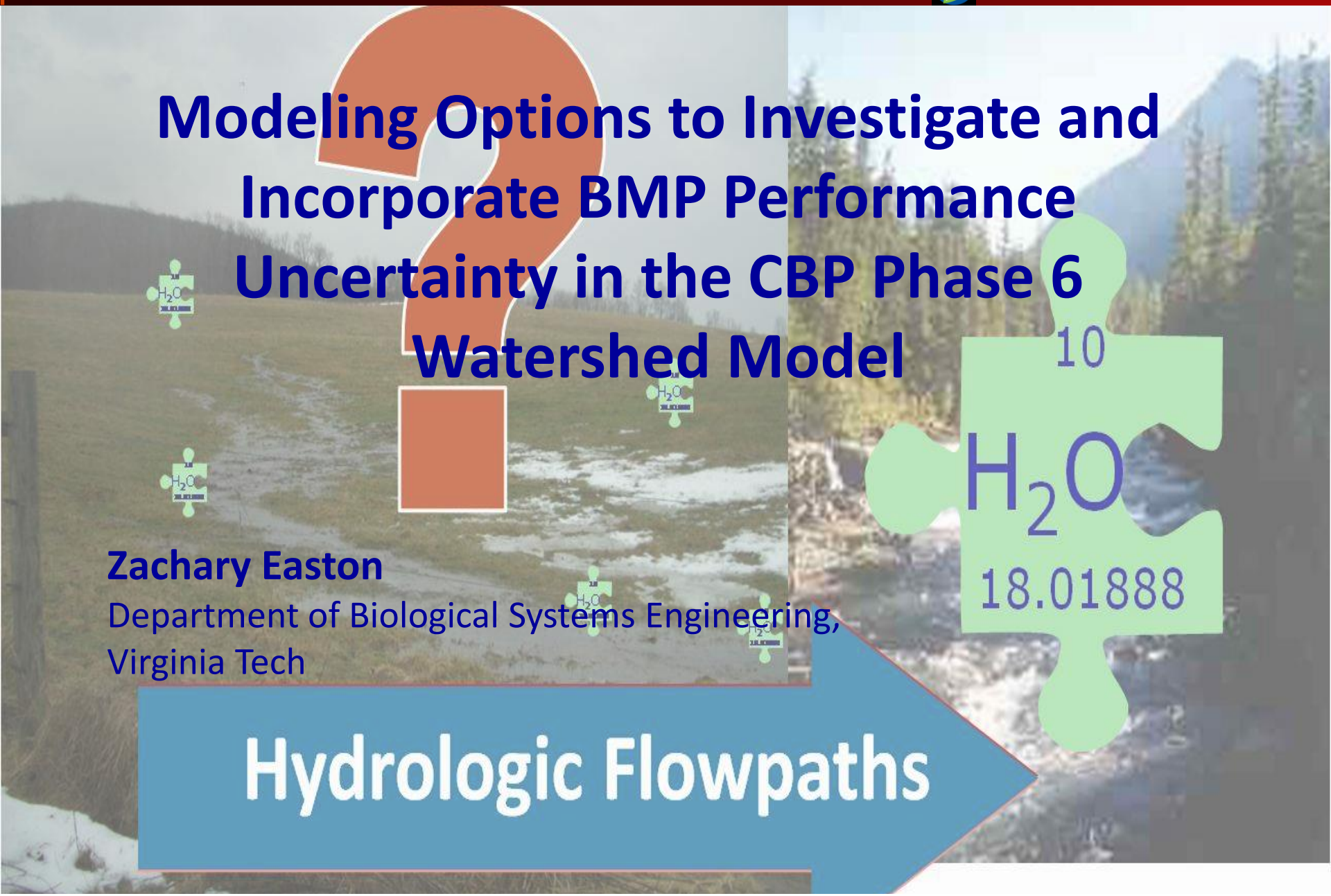
Modeling Options to Investigate and Incorporate BMP Performance Uncertainty in the CBP Phase 6 Watershed Model

Zachary Easton
Department of Biological Systems Engineering,
Virginia Tech



Motivation

- Determine feasibility of using existing Phase 6 Watershed Model to evaluate and incorporate BMP performance uncertainty
- Improve decisions of land managers when planning and installing BMPs

But First Some Background from P6 WSM Review

- Transition from a multi-level model approach (e.g., several models providing a single point of input to the larger watershed model, which results in a single model realization) to a true ensemble
  - Allow for a Bayesian model analysis and a more thorough quantification of uncertainties

Scientific and Technical Advisory Committee
Chesapeake Bay Watershed Model Phase 6 Review

Zach Easton[1], Don Scavia[2], Richard Alexander[3], Lawrence Band[4], Kathleen Boomer[5], Peter Kleinman[6], James Martin[7], Andrew Miller[8], James Pizzuto[9], Douglas Smith[6], Claire Welty[8]

[1]Virginia Tech, [2]University of Michigan, [3]USGS, [4]University of Virginia, [5]The Nature Conservancy, [6]USDA-ARS, [7]University of Mississippi, [8]University of Maryland Baltimore County, [9]University of Delaware

But First Some Background from P6 WSM Review

- Uncertainty analyses should be developed for each model component; a natural extension of the ensemble model approach

But First Some Background from P6 WSM Review

- Use of expert panels for establishing BMP efficiencies should develop an explicit approach to evaluating uncertainty in the estimates
  - This information could constitute priors for the Bayesian analysis.

But First Some Background from P6 WSM Review

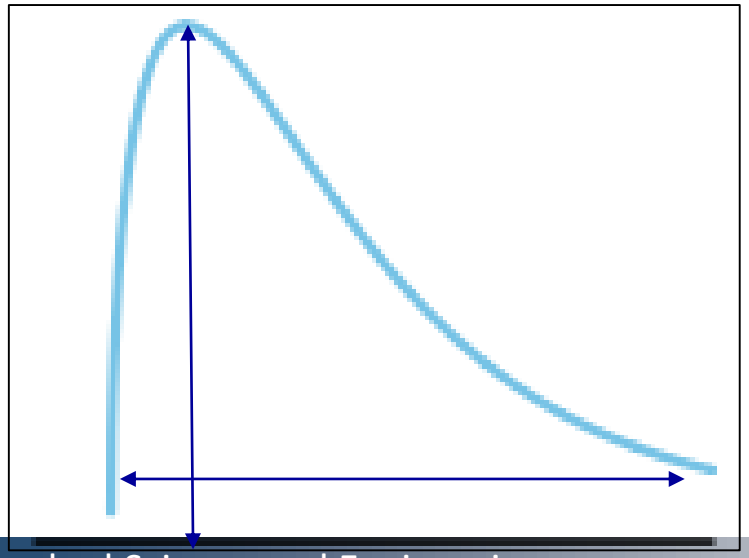
- The CBP should encourage the development of sub-models that attempt to down-scale the watershed models while also exploring process-based mechanisms affecting water quality

Outline

- Operational Types of Uncertainty
- P6 WSM and BMPs
- Options for evaluating and incorporating BMP uncertainty with the P6 model
  1. Panel provides distribution of BMP performance
  2. Panel defines site/operational characteristics and resultant BMP performance
  3. Leverage process based models to evaluate BMP performance under a range of conditions

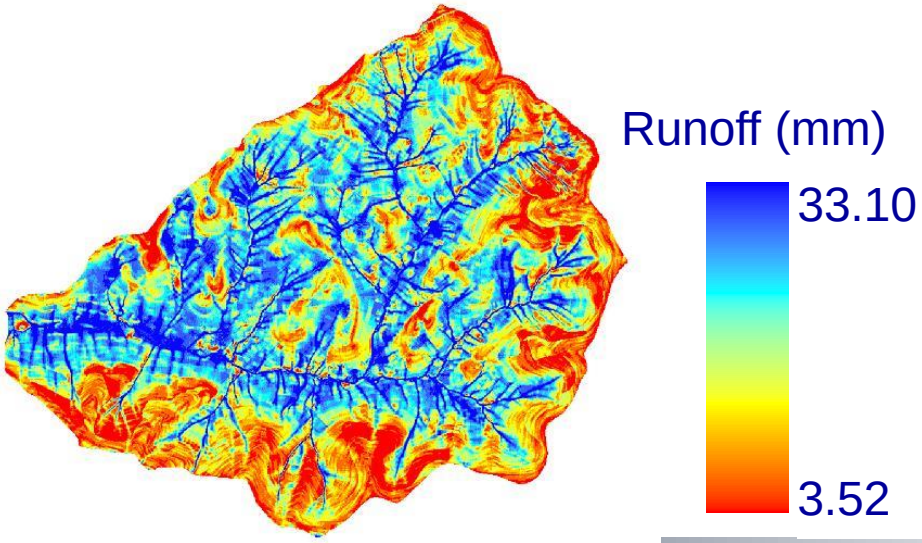
Operational Types of Uncertainty

- Uncertainty in the mean effectiveness
  - Do cover crops result in a 20% reduction in the total load from all fields all the time?
  - How well do we know this number?



Operational Types of Uncertainty

- Spatial Uncertainty and Variability
  - Some BMPs perform better in certain conditions
  - There is a high degree of uncertainty even if the mean effectiveness is known

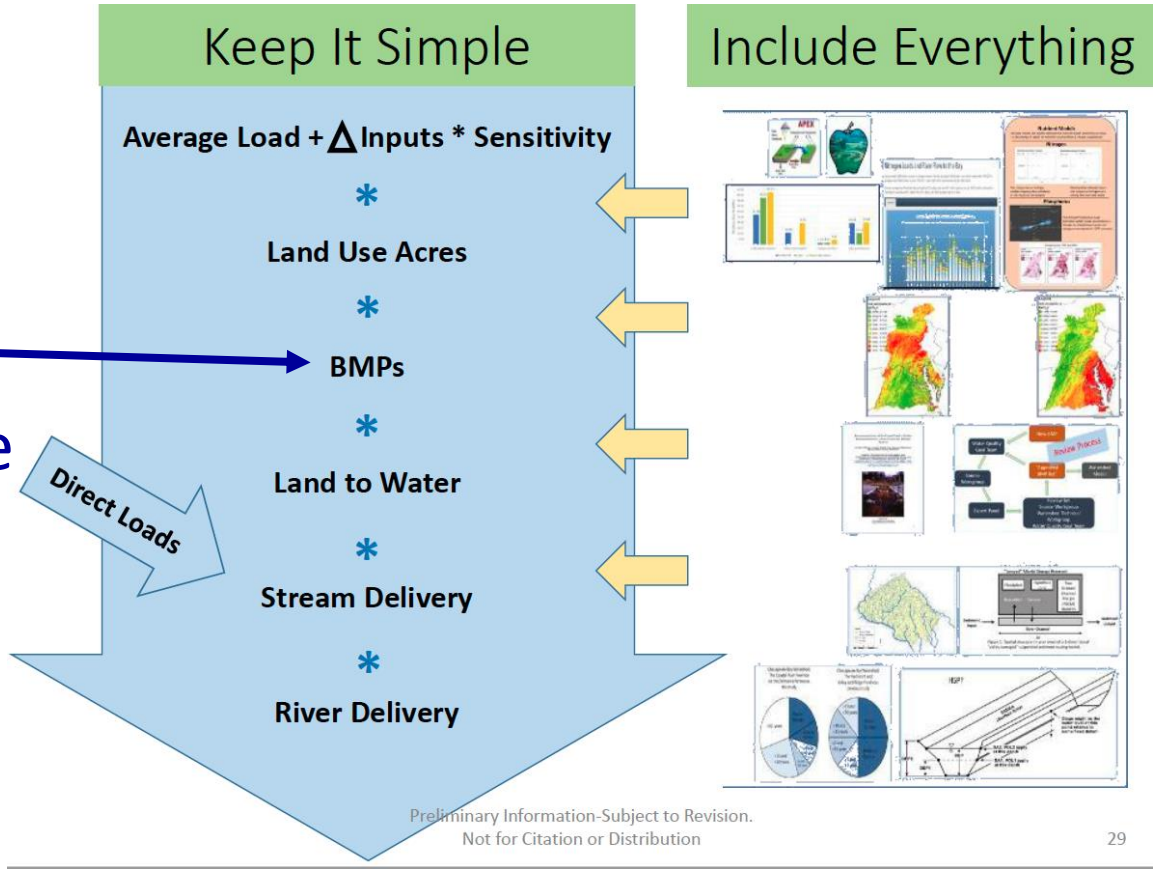


Operational Types of Uncertainty

- Temporal or flow-related uncertainty
  - The 20% reduction would not occur every day, It may be 100% some days and 0 or negative other days
  - Temporal delay-cover crops might be 20% effective, but the effect will not show up for several years

P6 WSM and BMPs

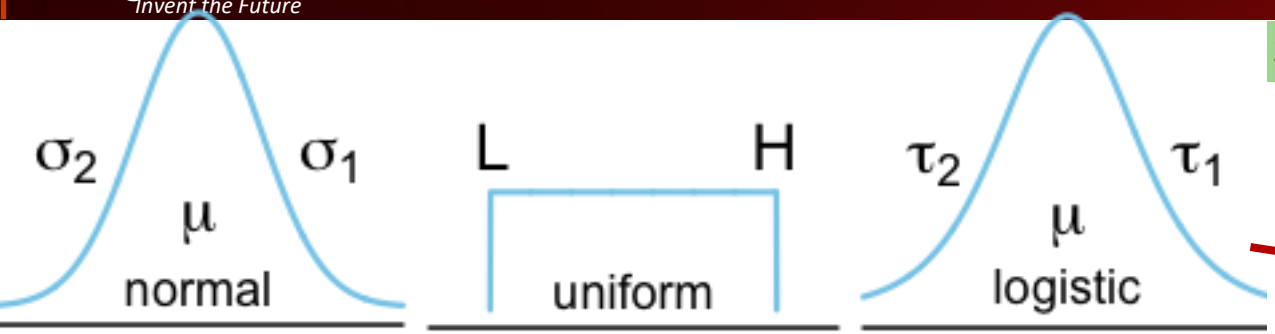
- In P6 WSM BMPs are modeled several ways:
  - Effectiveness Value
  - Landuse Change
  - Load Reduction

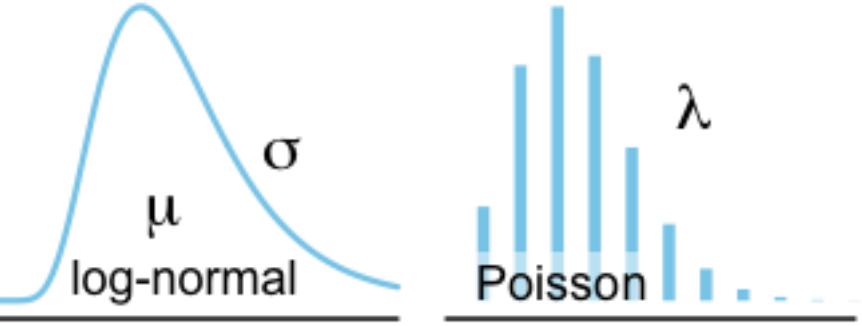


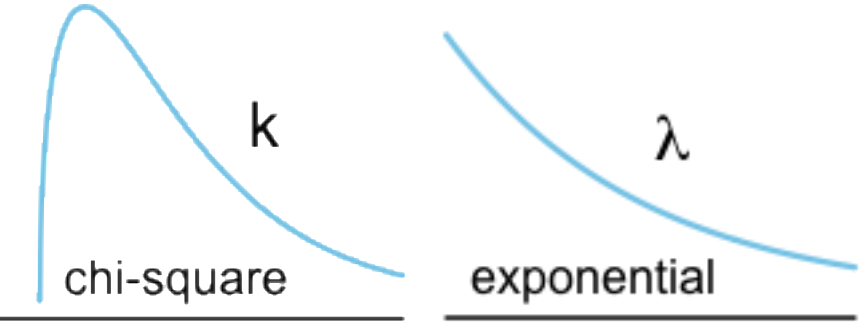
Options for Evaluating and Incorporating BMP Uncertainty

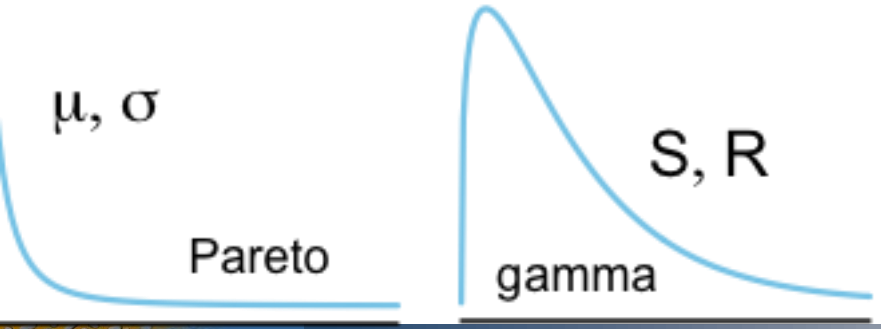
1. Panel provides distribution of BMP performance
   - This could then be used to vary the efficiencies in the model, which would result in a distribution of performance
     - This would result in the same distribution the panel defined (e.g. it is a linear effect)
   - But if there were many of these distributions interacting, depending on implementation location and level, the model would find the aggregate effect of different BMP mixes

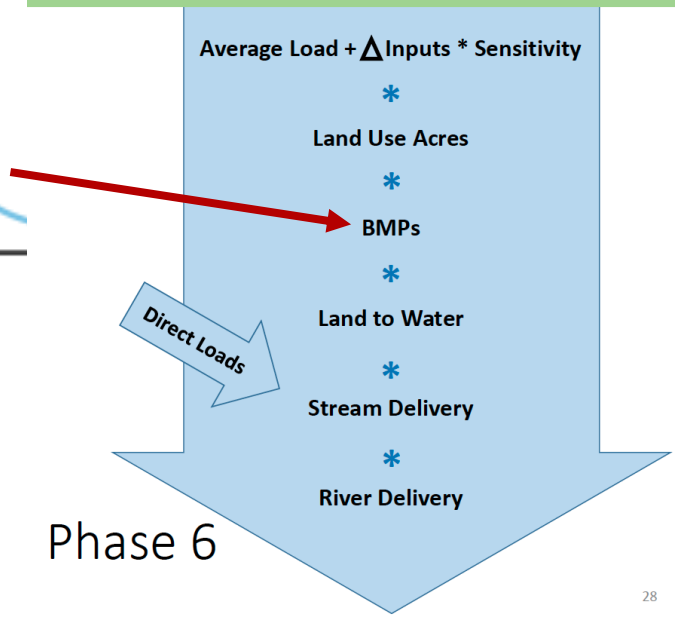
Steady State Phase 6 Model Structure

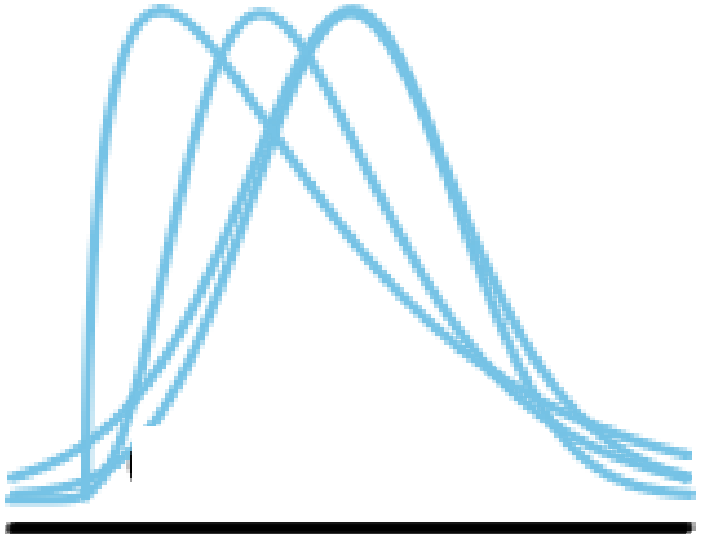








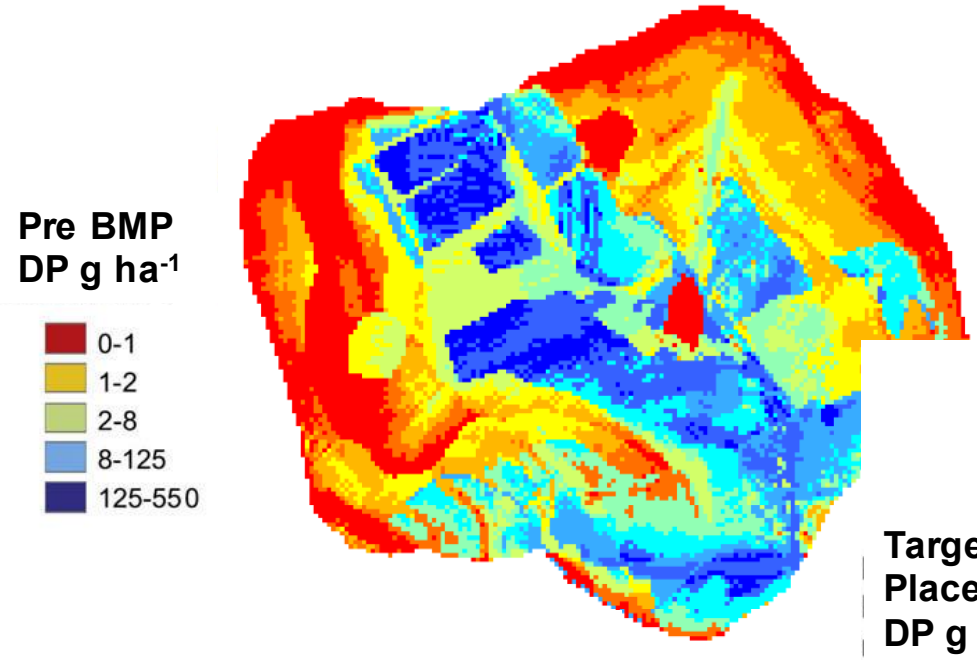


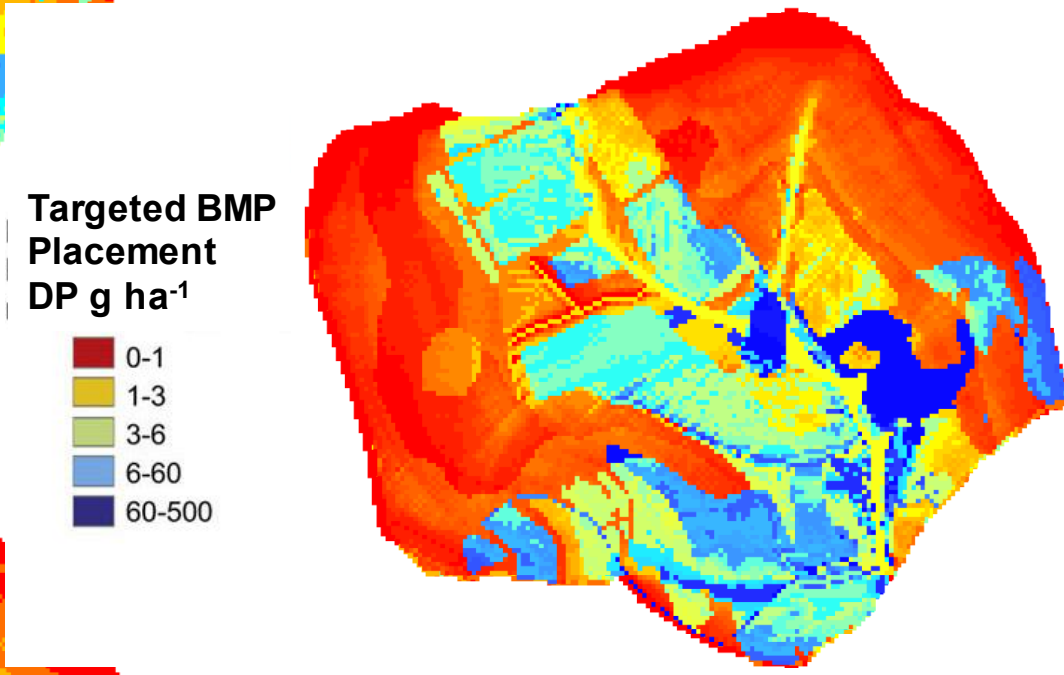


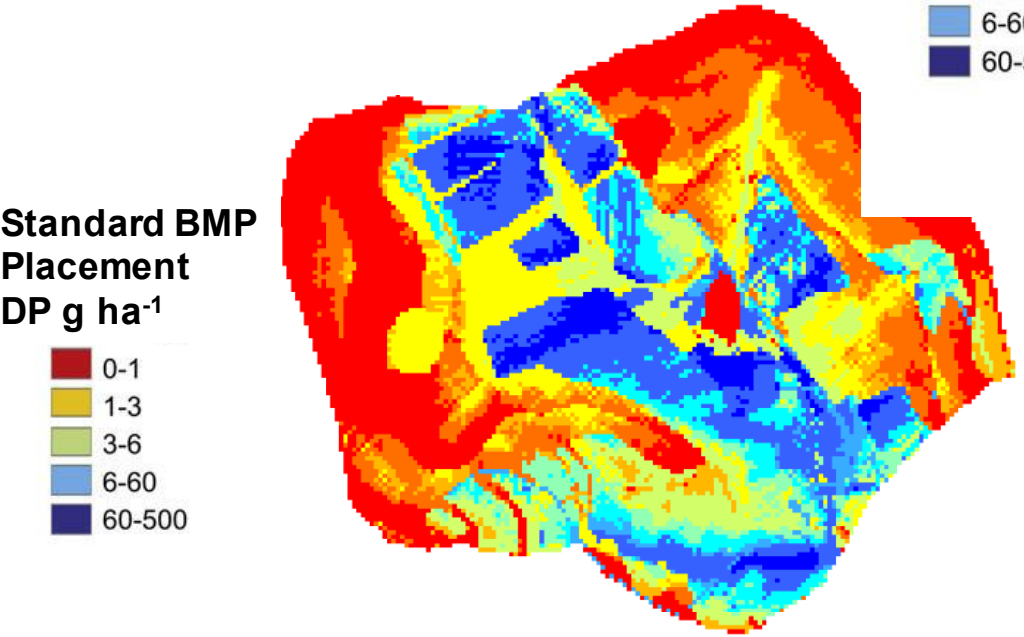
Options for Evaluating and Incorporating BMP Uncertainty

2. Panel defines site/operational characteristics and resultant BMP performance
   - This could be used to assess BMP performance that may vary across different soil, topography, climate etc, of the basin

Targeting

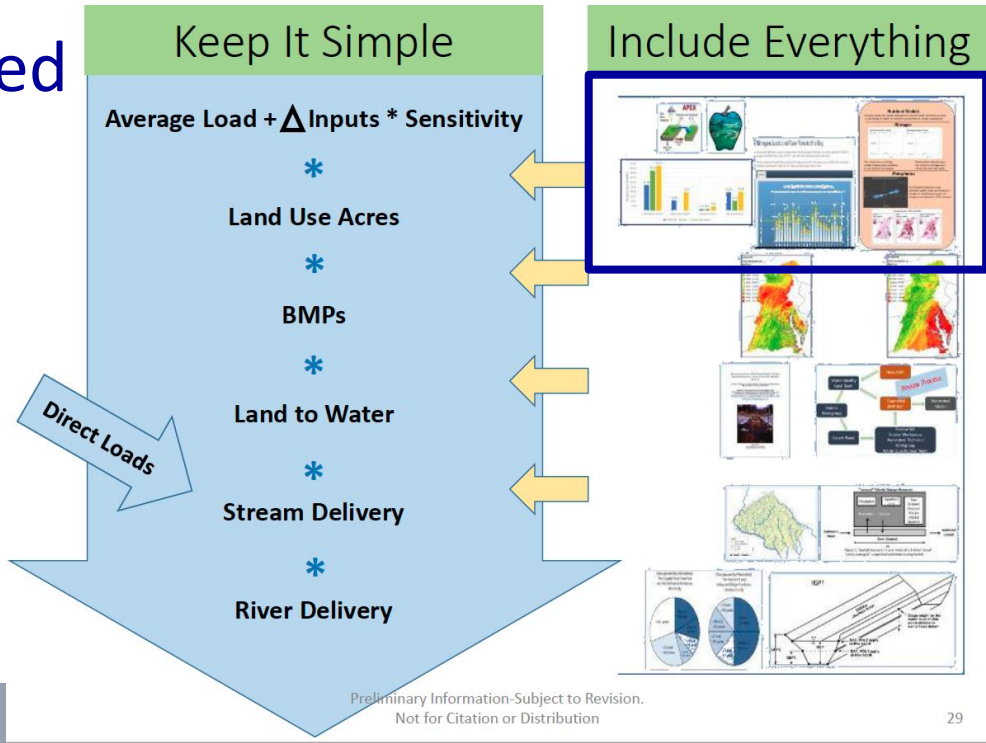

Pre BMP
DP g ha-1
0-1
1-2
2-8
8-125
125-550


Targeted BMP
Placement
DP g ha-1
0-1
1-3
3-6
6-60
60-500


Standard BMP
Placement
DP g ha-1
0-1
1-3
3-6
6-60
60-500

Options for Evaluating and Incorporating BMP Uncertainty

3. Leverage process based models (APEX, APLE, CEAP) to evaluate BMP performance under a range of conditions
   - Results could then be used directly in the model by running scenarios that bracket the variability



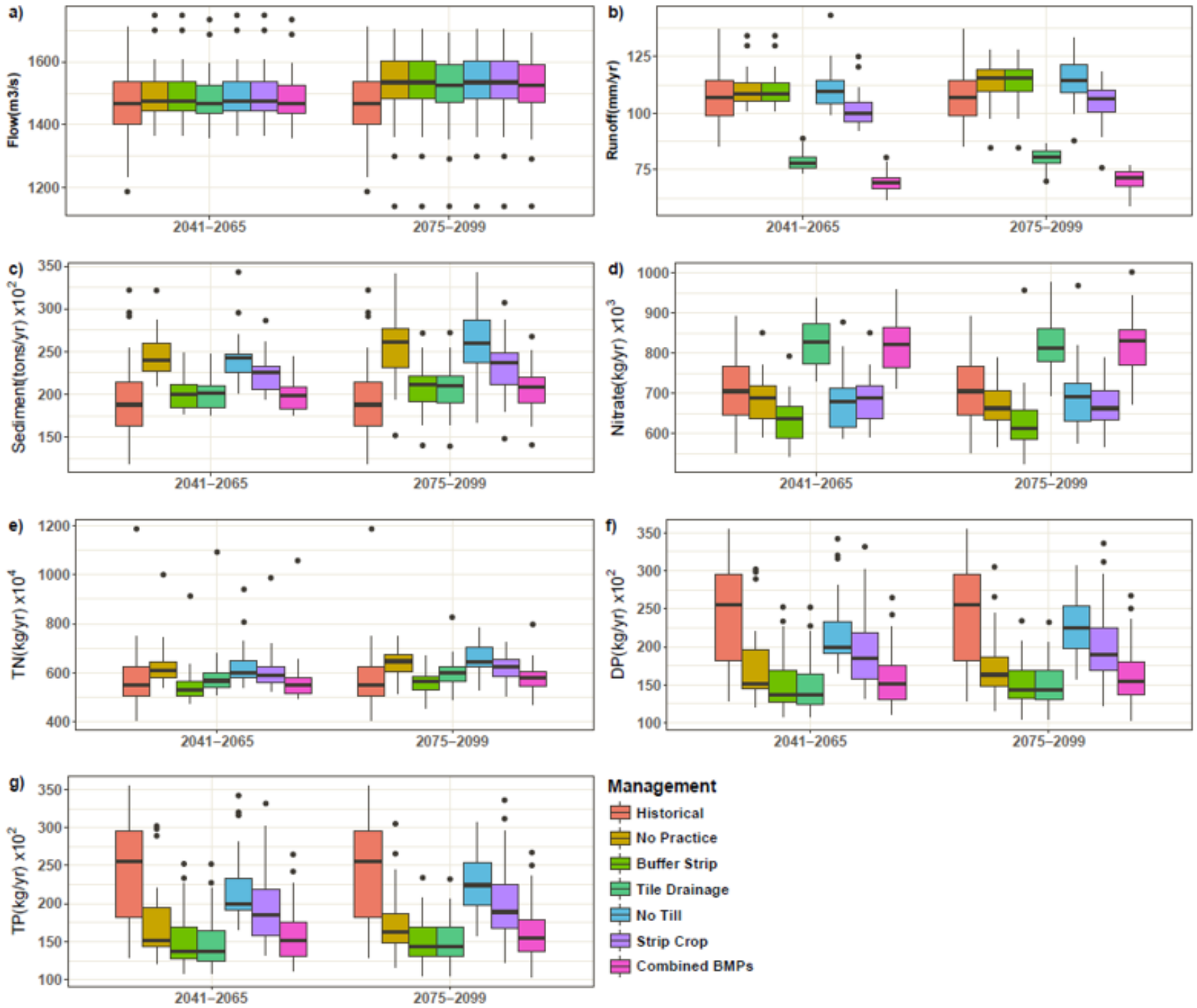
CEAP Model

- CEAP = APEX-SWAT hybrid can simulate many conservations practices mechanistically

Structural
Check Dam
Diversion Dike
Filter Strips
Grade Stabilization Structure
Grassed Waterway
Green Roofs
Infiltration Trench
Interceptor Swale/ Rain Garden
Organic (Compost) Filter Berm
Pipe Slope Drain
Porous Pavement
Porous Pavement with Grass
Sediment Basin
Silt Fence
Stone Outlet Sediment Trap
Terraces
Triangular Sediment Dike
Wetland Creation

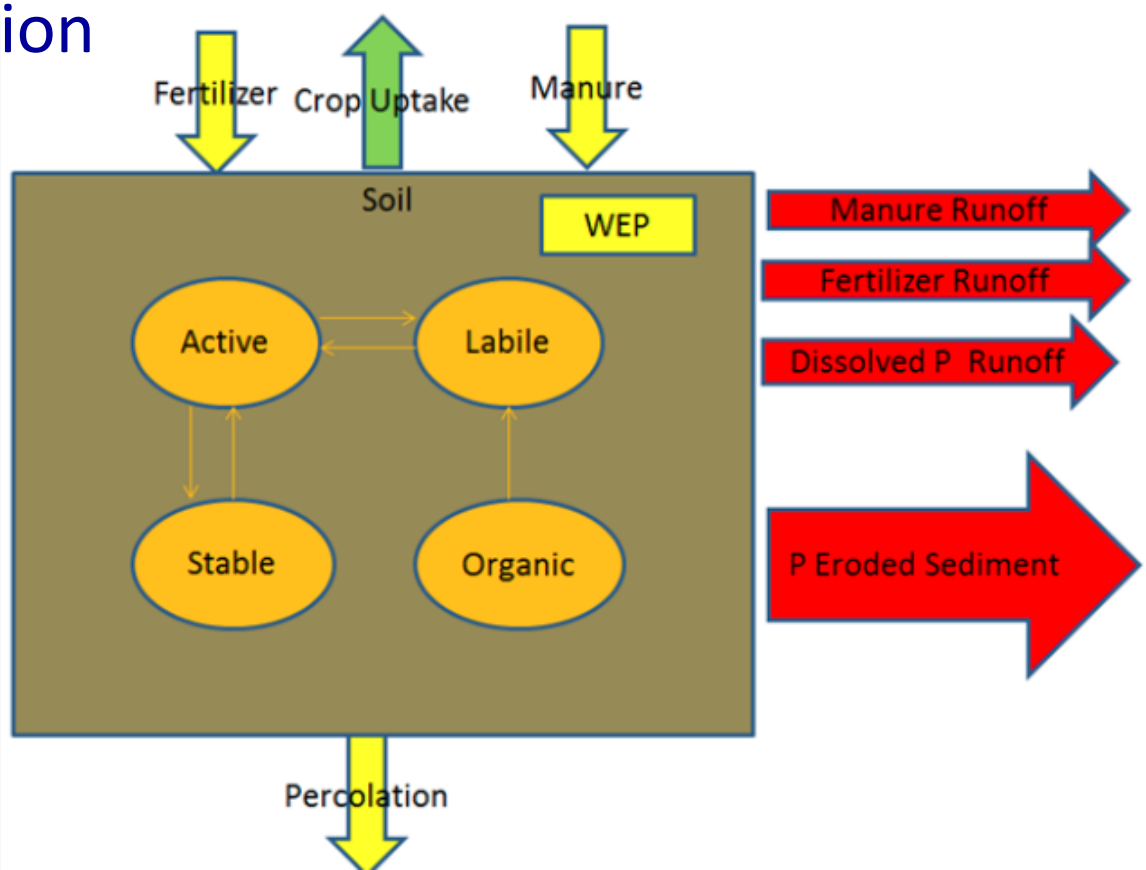
Non Structural
Alum Addition
Conservation Reserve Program (Cropland Conversion to Pasture)
Incorporate Manure with Tillage
No Till (Residue and Tillage Management)
Pet Waste Management
Rainwater Harvesting
Resource Efficient Landscaping- Ornamentals
Resource Efficient Landscaping- Trees
Resource Efficient Landscaping- Turfgrass
Vegetation

On Channel
Channel Protection
Erosion Control Blankets
Riparian Forest Buffer
Mulching
Stream Restoration

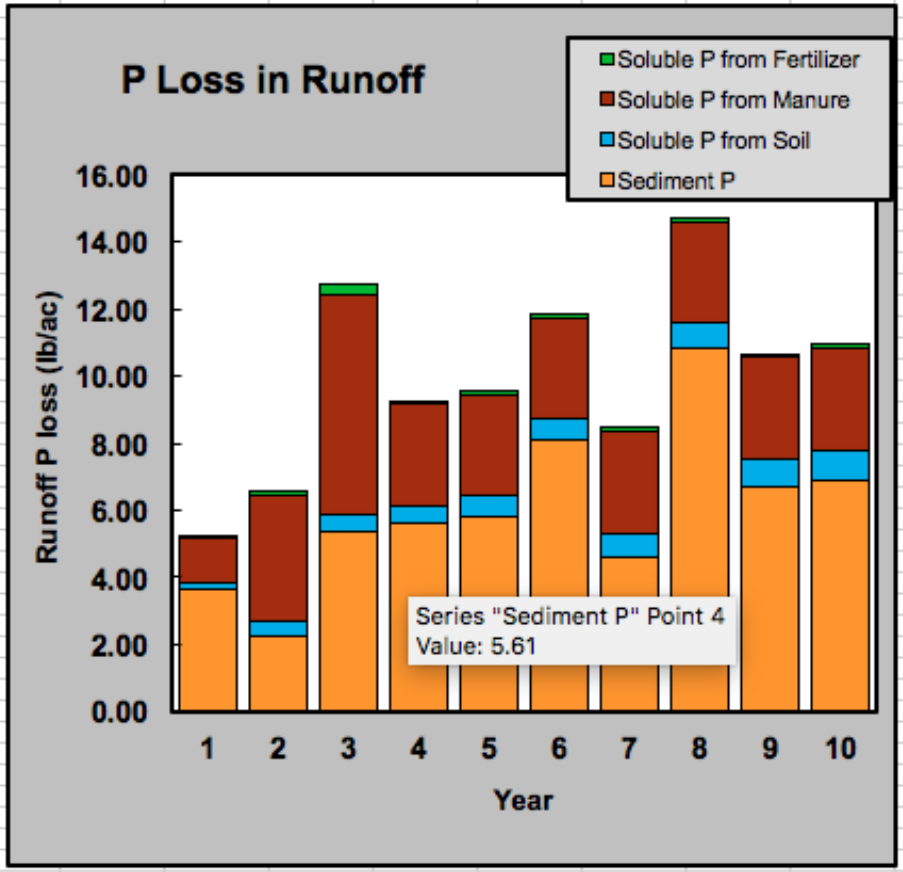

a)
Flow(m3/s)
1600
1400
1200
2041–2065
2075–2099
b)
Runoff(mm/yr)
125
100
75
2041–2065
2075–2099
c)
Sediment(tons/yr) x10^2
350
300
250
200
150
2041–2065
2075–2099
d)
Nitrate(kg/yr) x10^3
1000
900
800
700
600
2041–2065
2075–2099
e)
TN(kg/yr) x10^4
1200
1000
800
600
400
2041–2065
2075–2099
f)
DP(kg/yr) x10^2
350
300
250
200
150
100
2041–2065
2075–2099
g)
TP(kg/yr) x10^2
350
300
250
200
150
100
2041–2065
2075–2099
Management
Historical
No Practice
Buffer Strip
Tile Drainage
No Till
Strip Crop
Combined BMPs

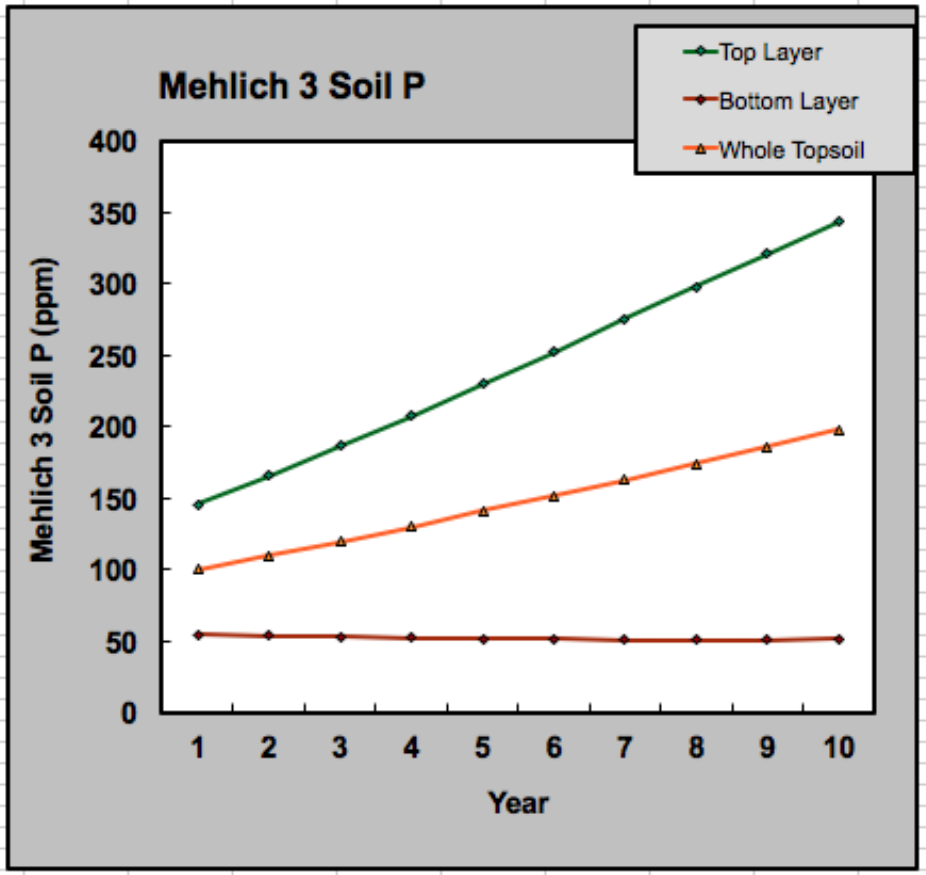
APLE Model

- Annual Phosphorus Load Estimation
  - Nutrient Management
  - Manure Incorporation
  - Manure Transport
  - Cover Crops
  - Tillage

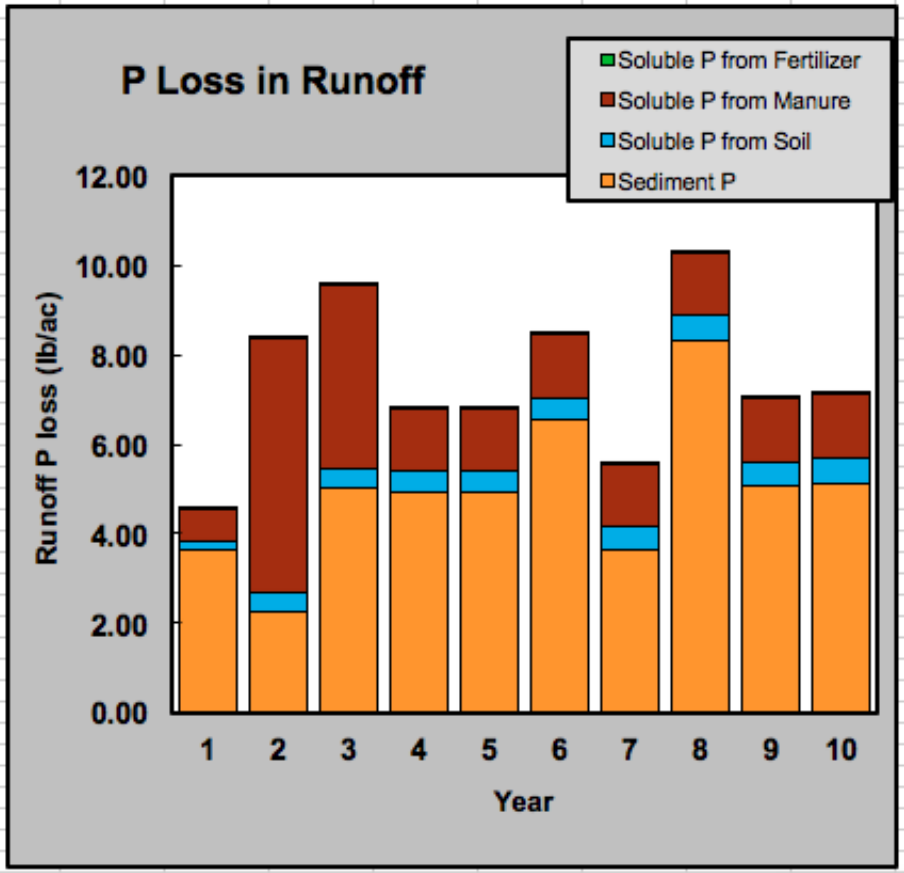


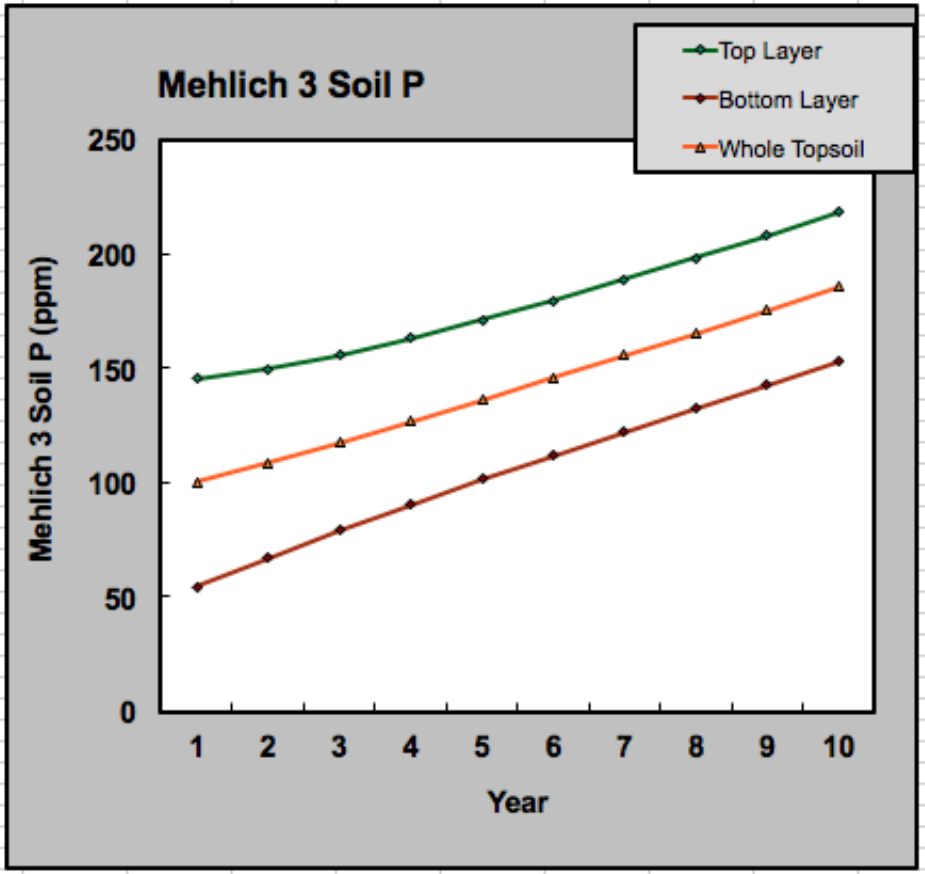
200 head dairy, All manure land applied, No-Till



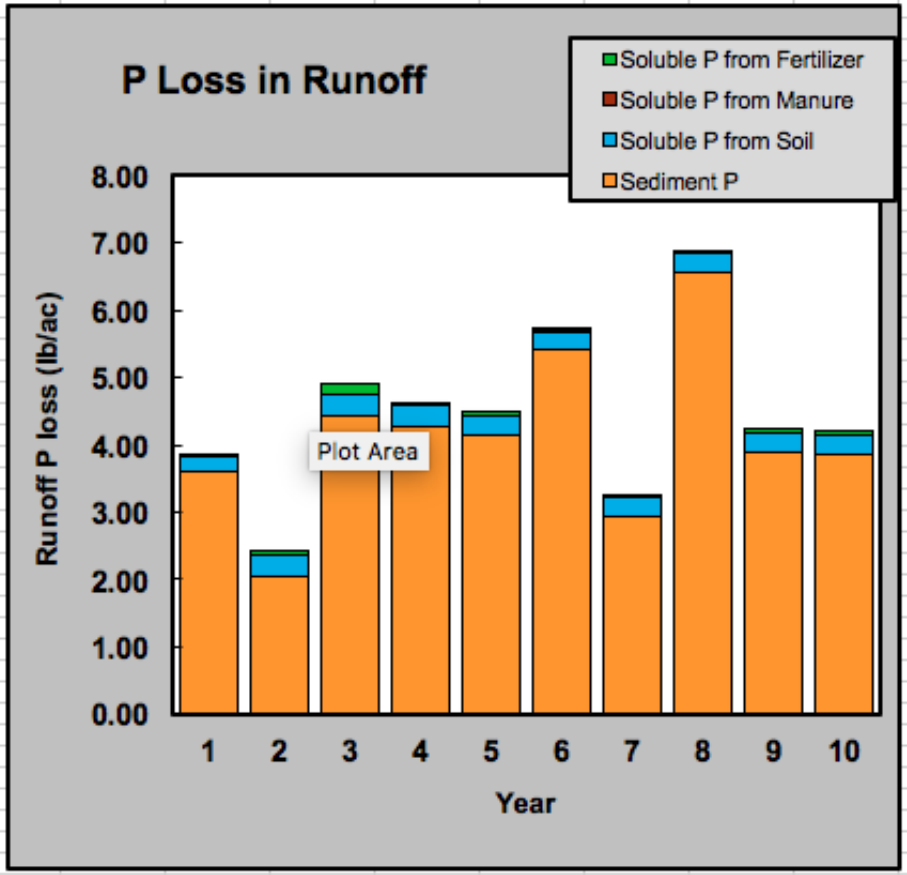


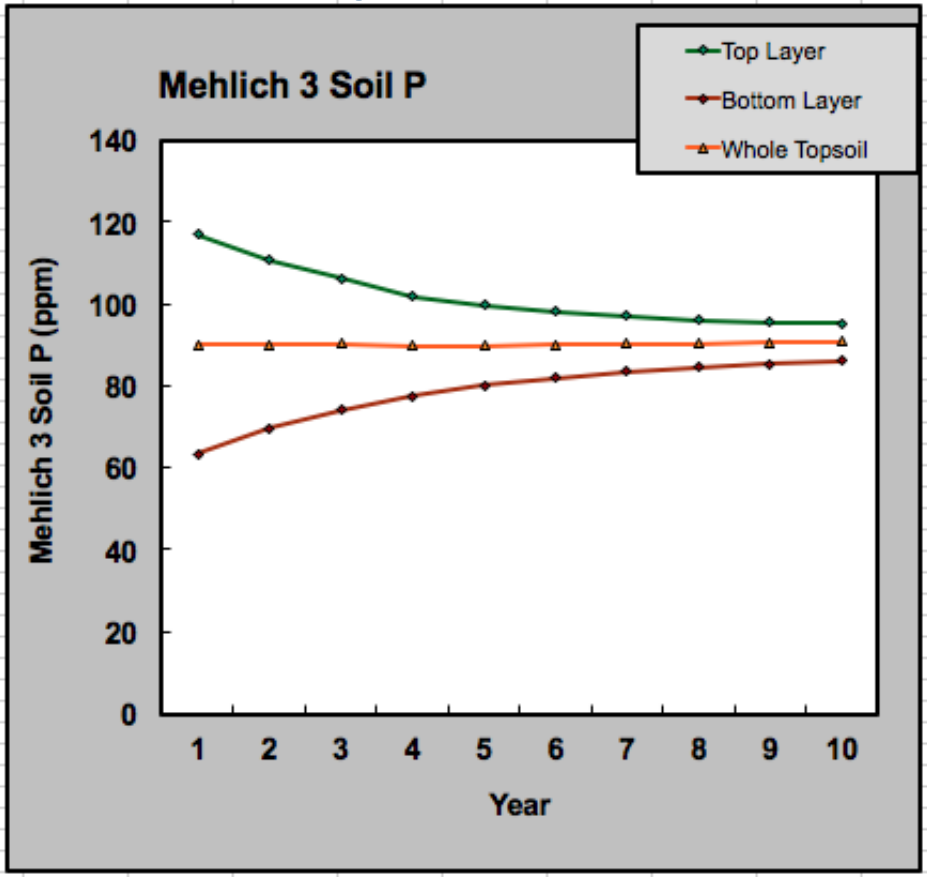
200 head dairy, All manure land applied, Incorporated



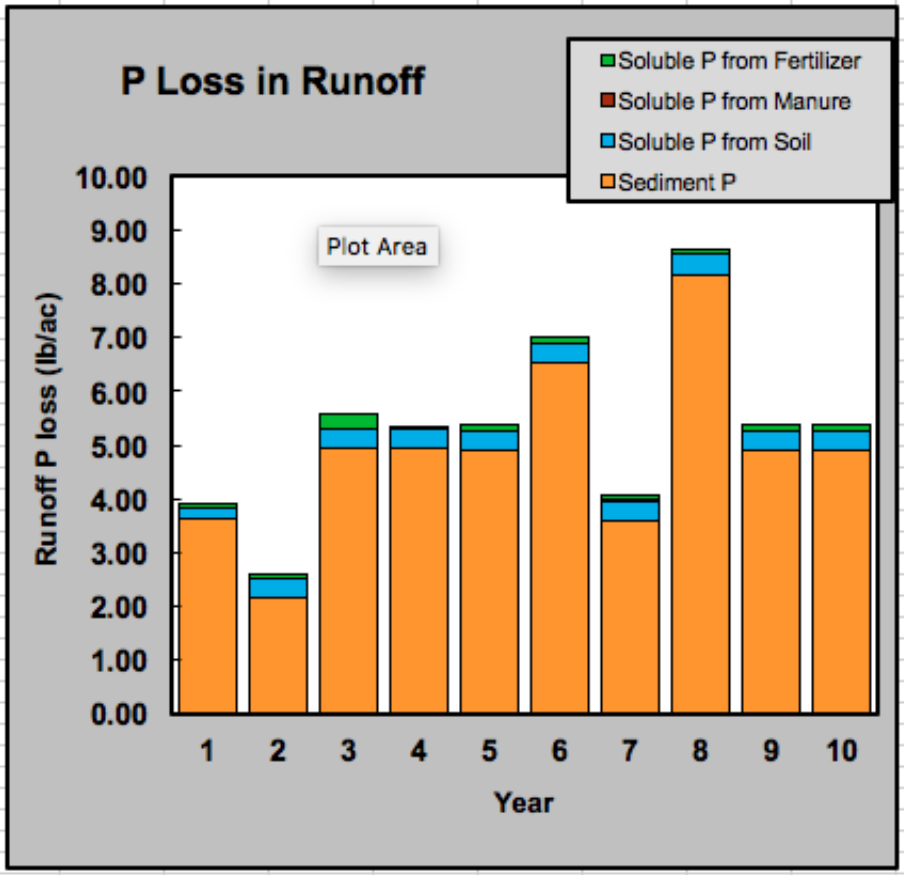


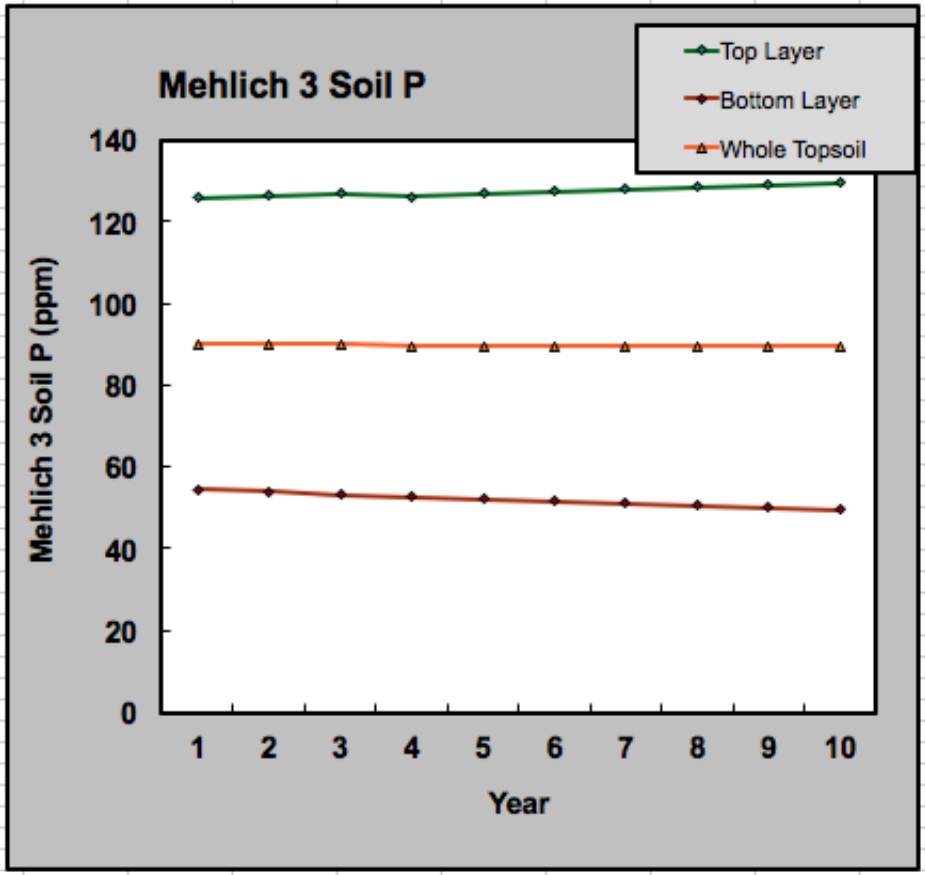
200 head dairy, All manure transported, Commercial fertilizer, Incorporated



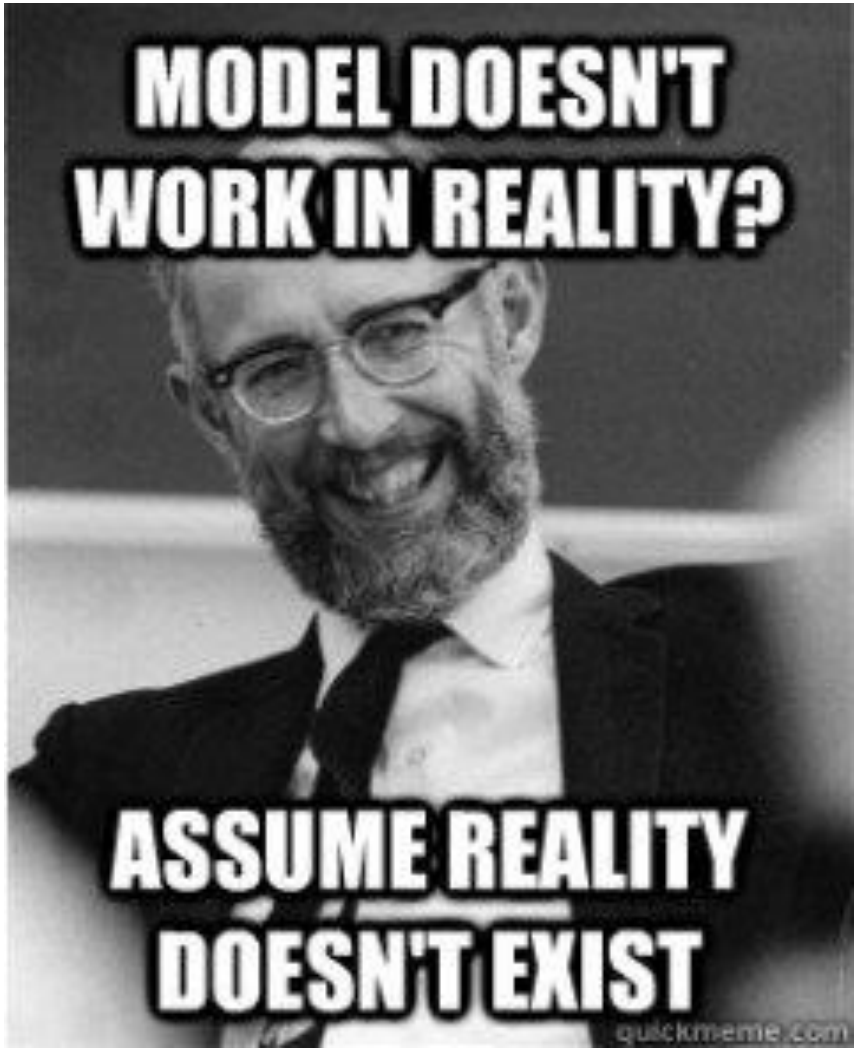


200 head dairy, All manure transported, Commercial fertilizer, No-Till





Discussion


MODEL DOESN'T WORK IN REALITY?
ASSUME REALITY DOESN'T EXIST
quickmeme.com