# CEAP: Cumulative Effects Modeling and Interdisciplinary Analyses

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USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

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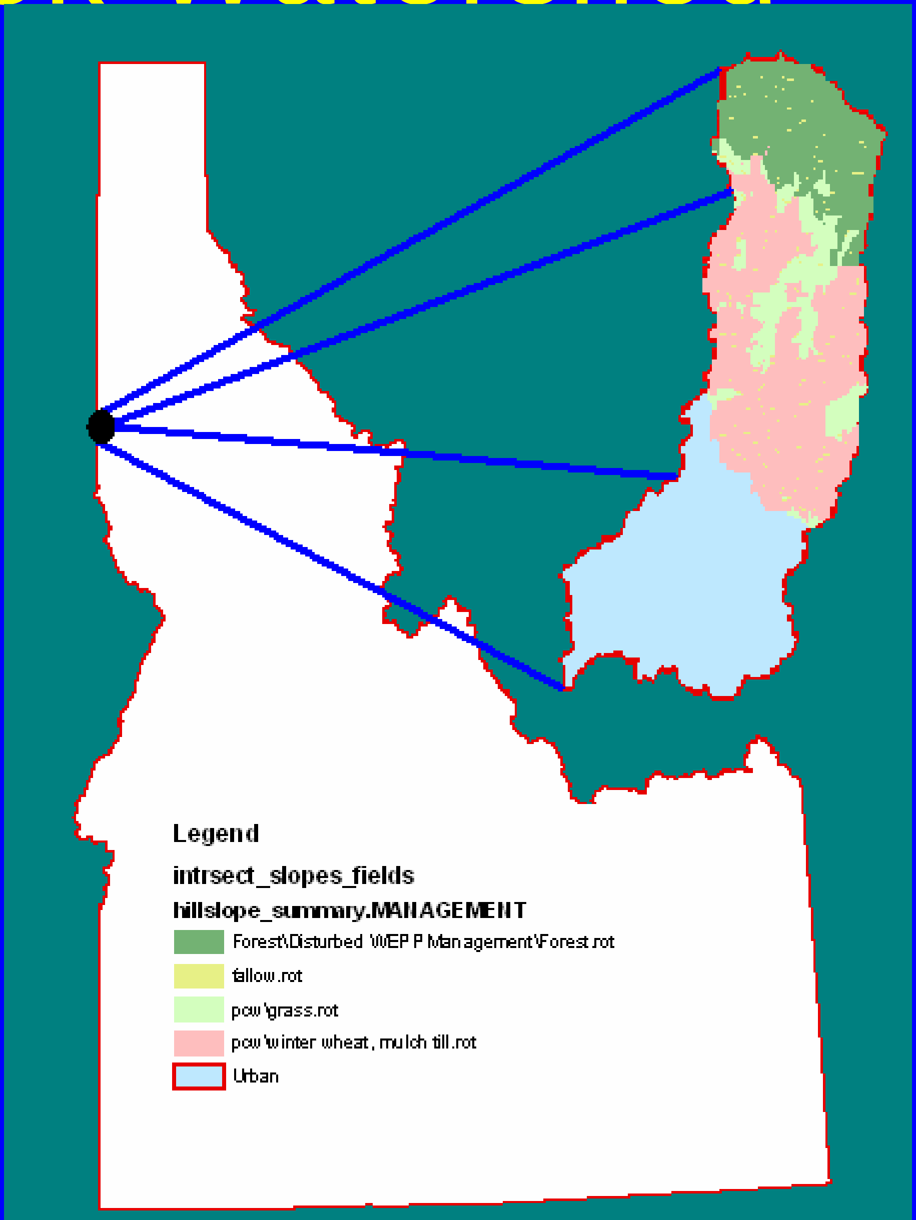
# Paradise Creek Watershed

- 5000 ha watershed
- Mixed land use watershed with urban, agricultural and forested lands
- Exceeds TMDL for sediment loading (need 85% reduction)



# Research & Objectives

Our research includes: 1) combination of monitoring and modeling, 2) participatory component with local operators/managers

## Objectives:

–To use monitoring data to calculate loading

–To target agricultural fields from physical data (➔ distributed erosion model)

–To apply cumulative effects modeling at watershed scale (➔ field and stream erosion model)

–To target agricultural fields using physical and economic data (➔ optimization)

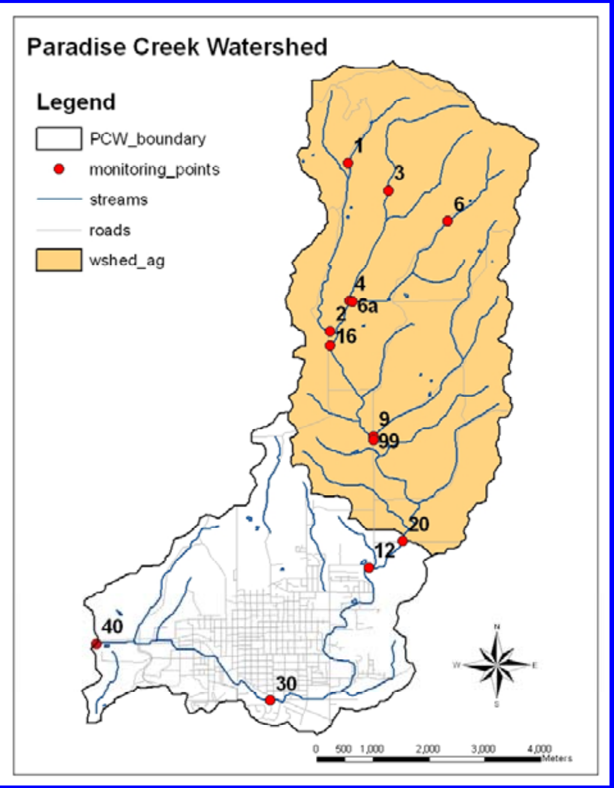
# Project Components

- Monitoring & sediment loading
- Effectiveness of agricultural conservation practices and structures using distributed erosion model: WEPP
- Cumulative effects modeling: WEPP & CONCEPTS
- Integrated analysis: optimization

# Monitoring
# Q, TUR, TSS



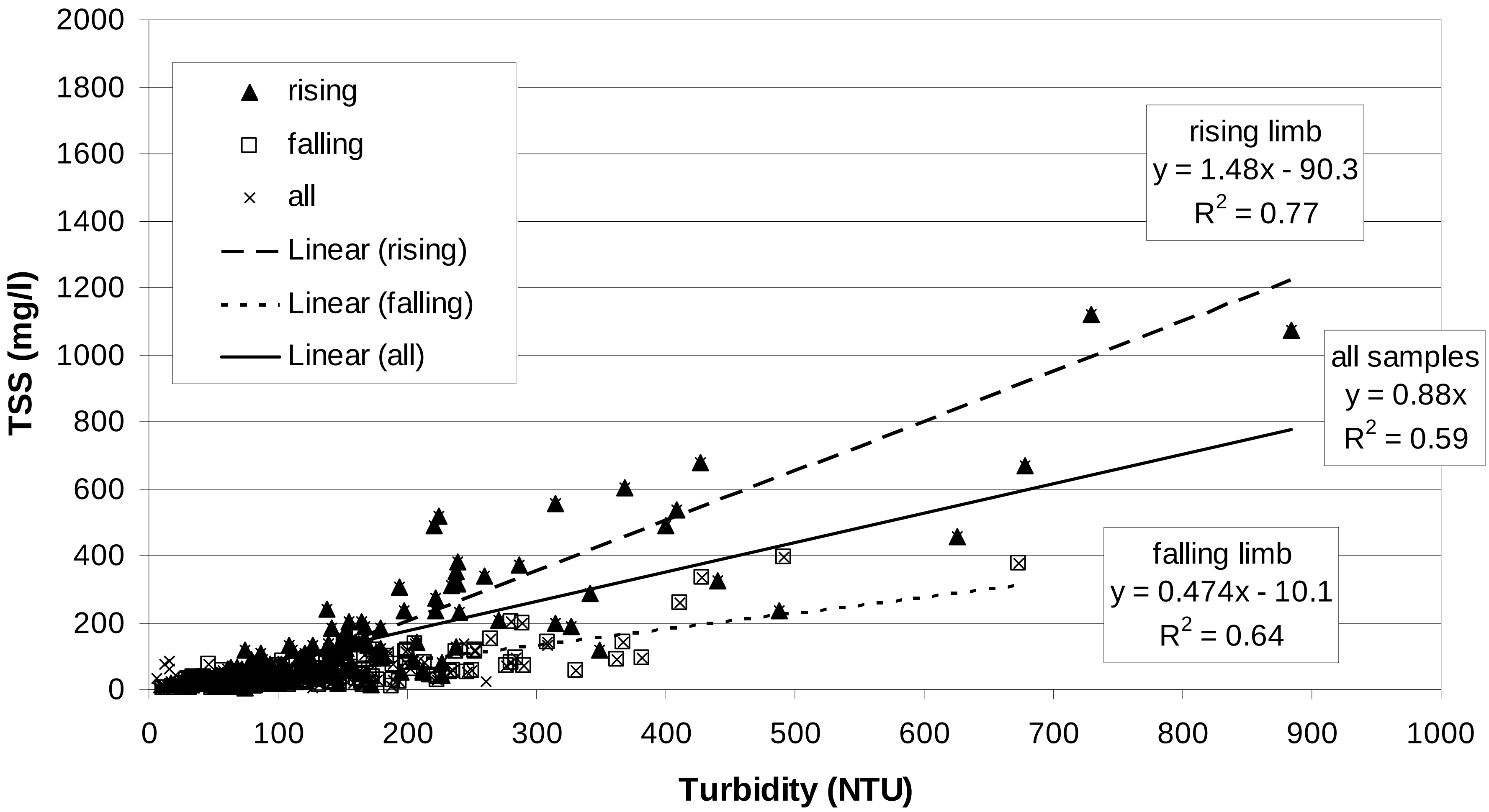


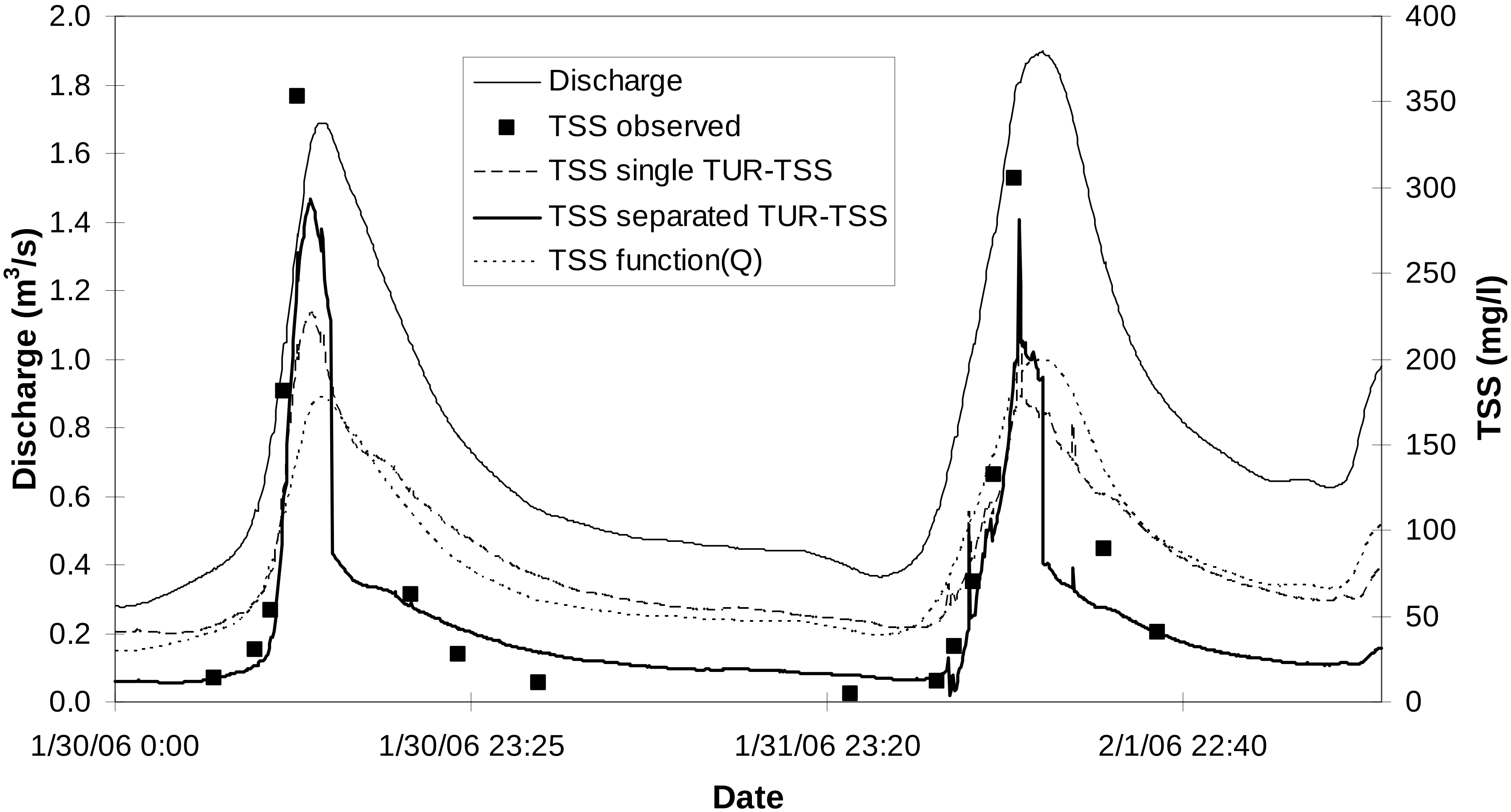



# Load=Q*TSS

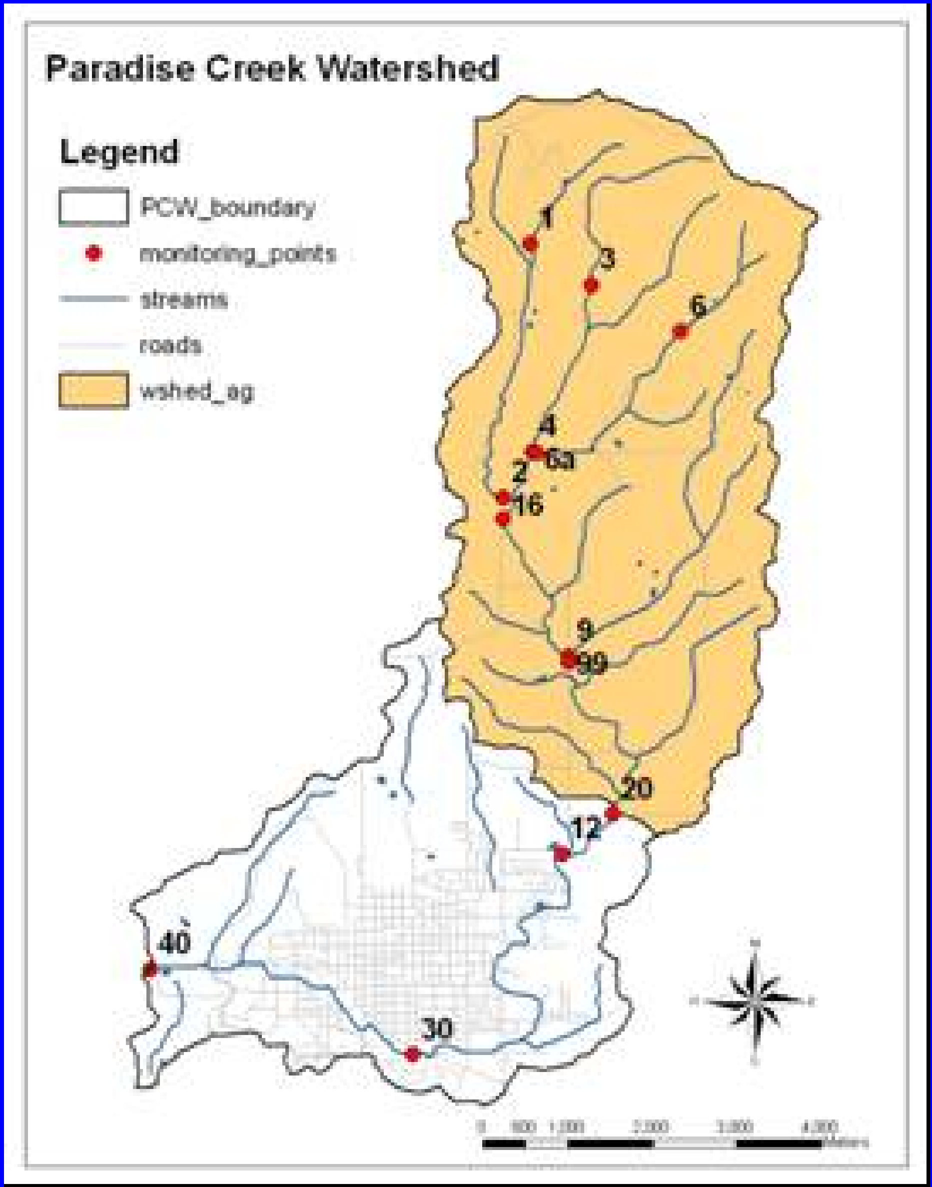
# Sediment Concentration vs. Turbidity



# Discharge & Sediment Concentration



# Sediment loading



# Sediment loading

| Station number | Mainstem (M) or Tributary (T) | Sediment load (tons) | Error in sediment load (tons) |
|---|---|---|---|
| 2 | M | 12.7 | - |
| 4 | T | 27.5 | - |
| 6a | T | 14.5 | - |
| 16 | M | 48.7 | - |
| 99 | M | 276.3 | - |
| 9 | T | 35.1 | - |
| 20 | M | 248.1 | +/- 105.4 |
| 12 | M + T | 545.1 | - |
| *30* | *M* | *273.3* | - |
| 40 | M + T | 734.5 | +/- 197.9 |

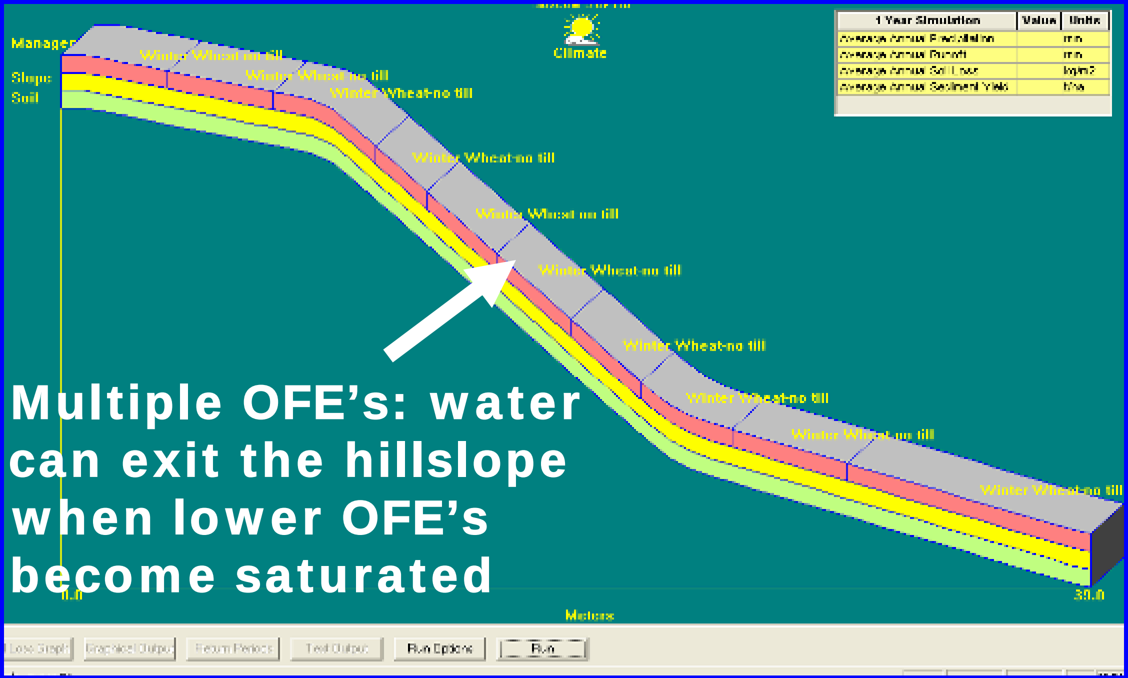



# Water Erosion Prediction Project (WEPP) Model

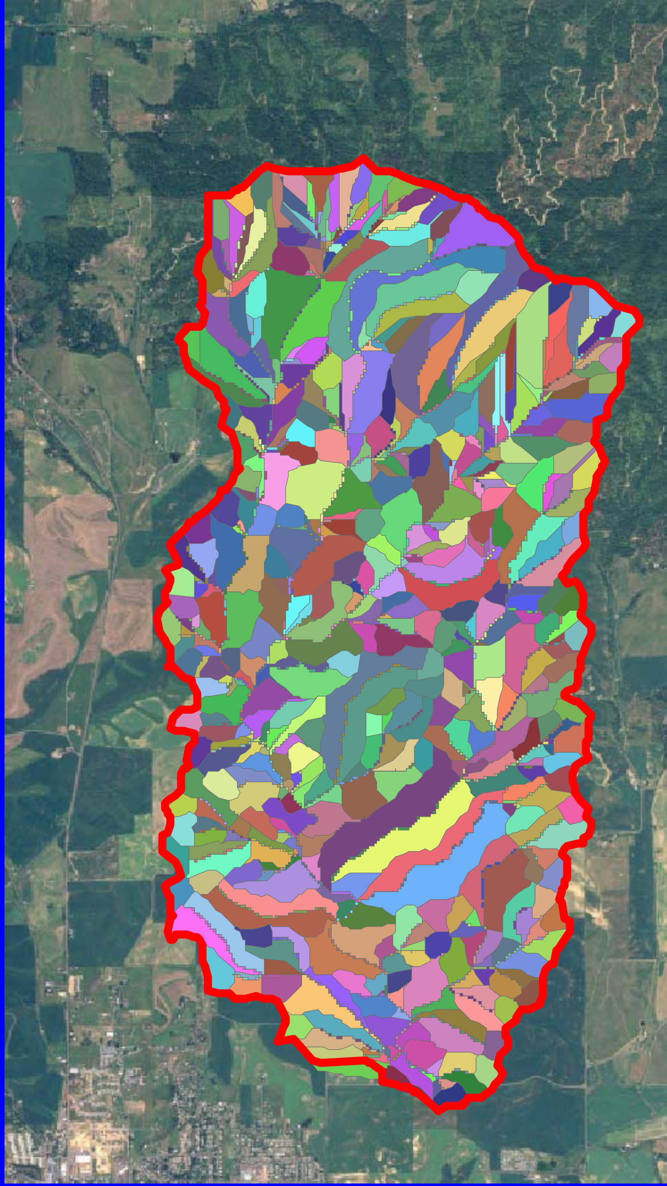
- Uses readily available data sources (DEM, soils, land use, climate)
- We modified WEPP to simulate variable source area hydrology
- Subsurface lateral flow becomes surface runoff at toe slopes

# GeoWEPP generated hillslopes

- Up to 1000 hillslopes allowed per watershed
- 20 Overland flow elements per hillslope (maximum)



**Multiple OFE's: water can exit the hillslope when lower OFE's become saturated**

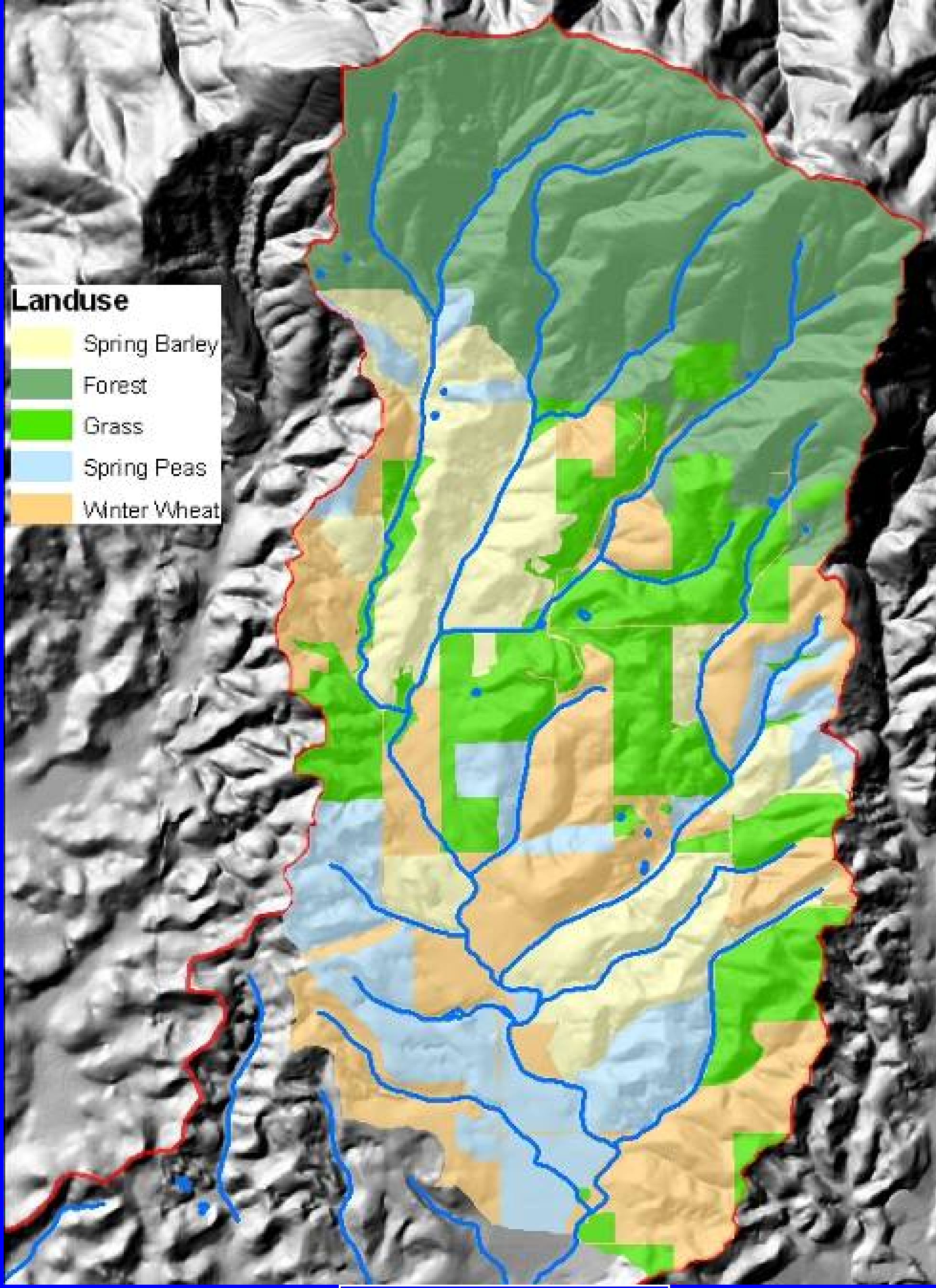


# 5 crops:

- winter wheat
- spring wheat
- barley
- peas
- lentils

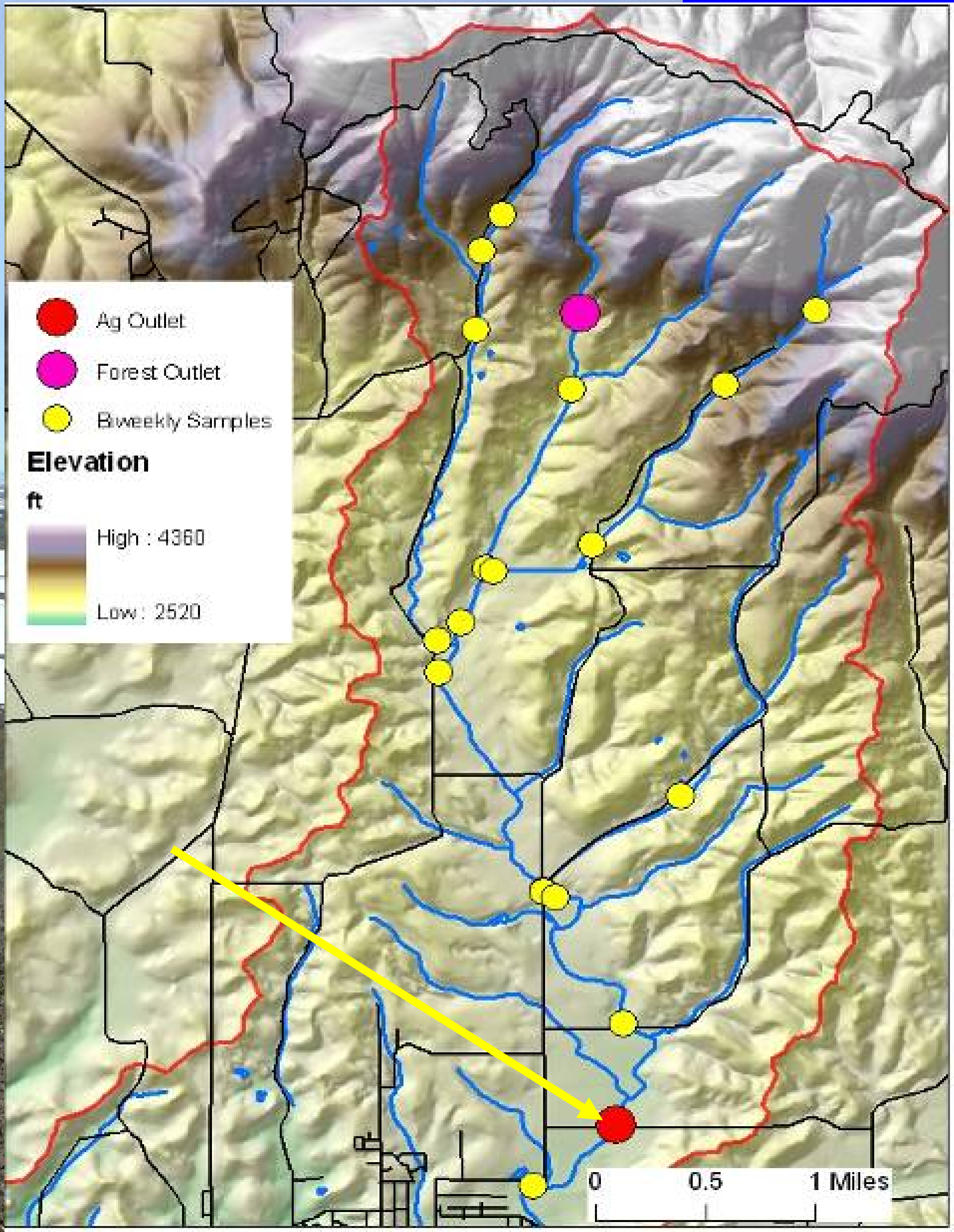
# 3 tillage practices:

- conventional
- conservation (mulch till)
- direct seed (no-till)
- CRP

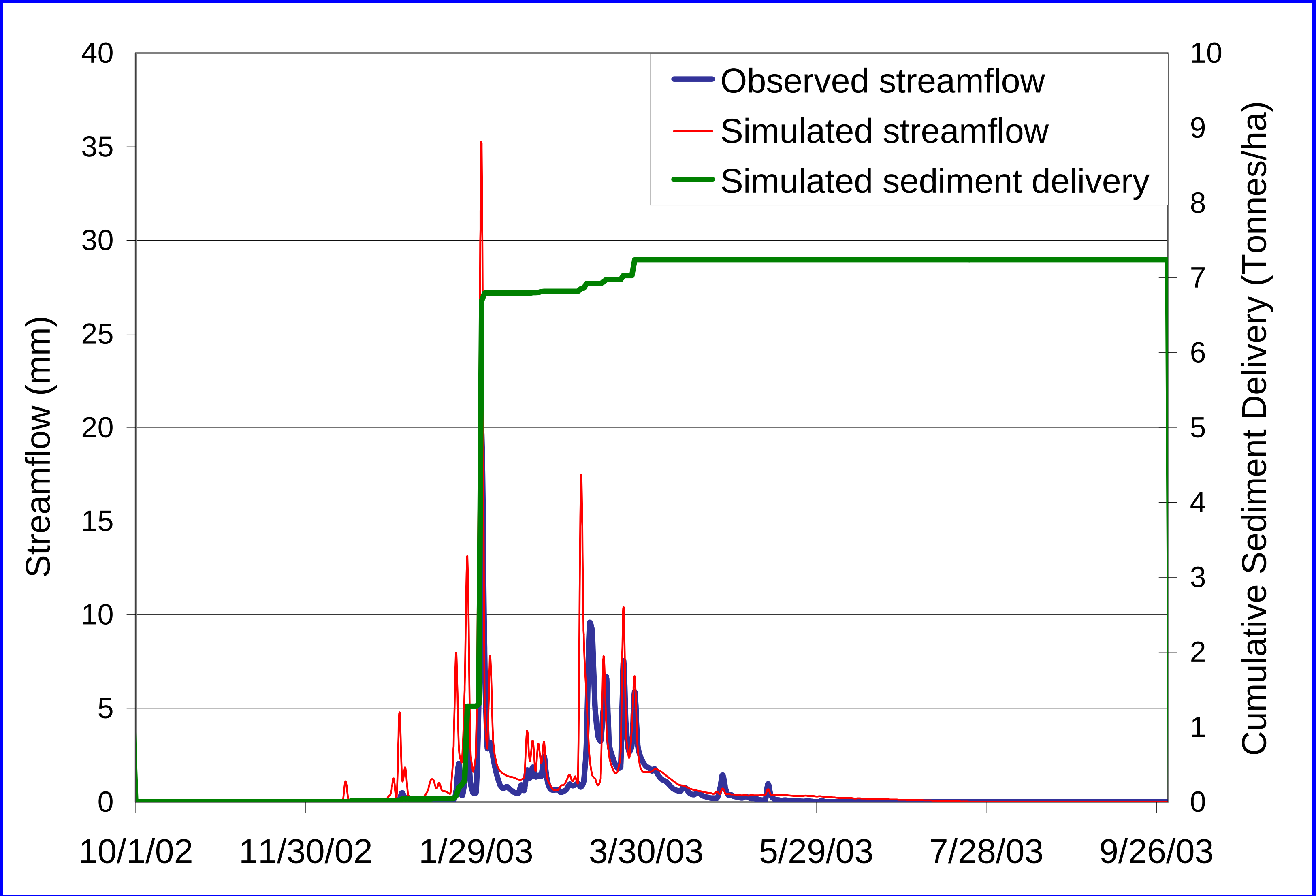


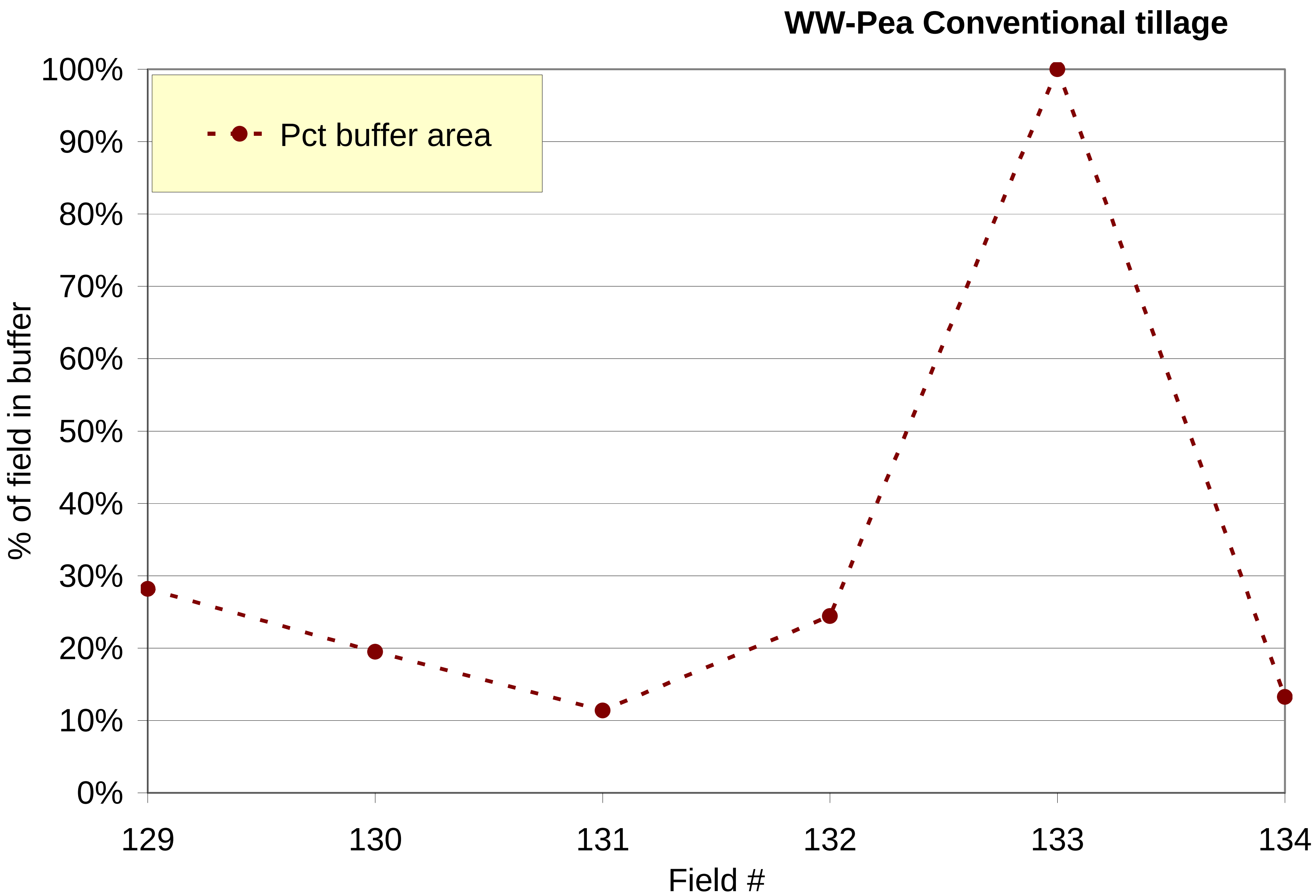

Land use map

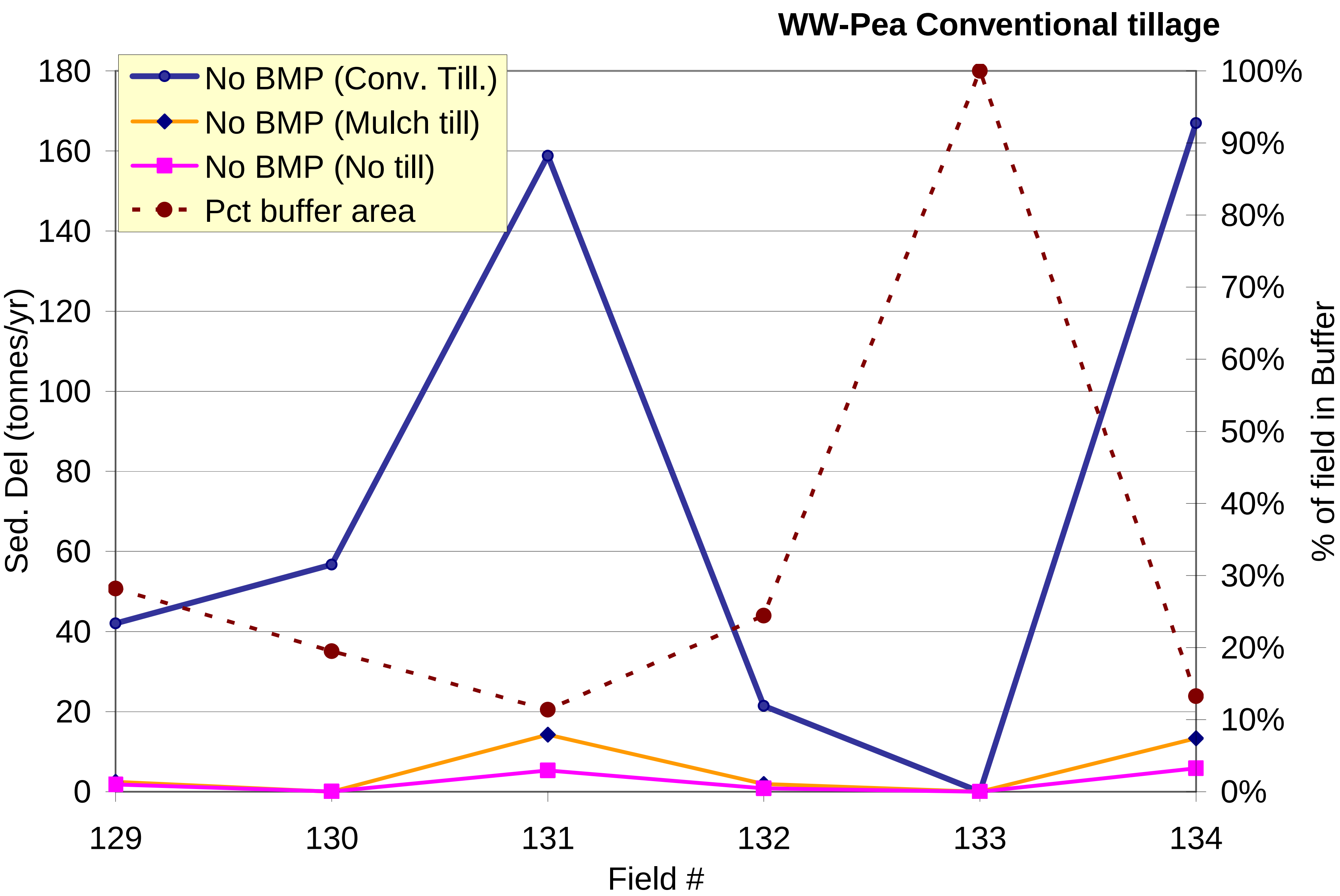
# Application to Paradise Creek

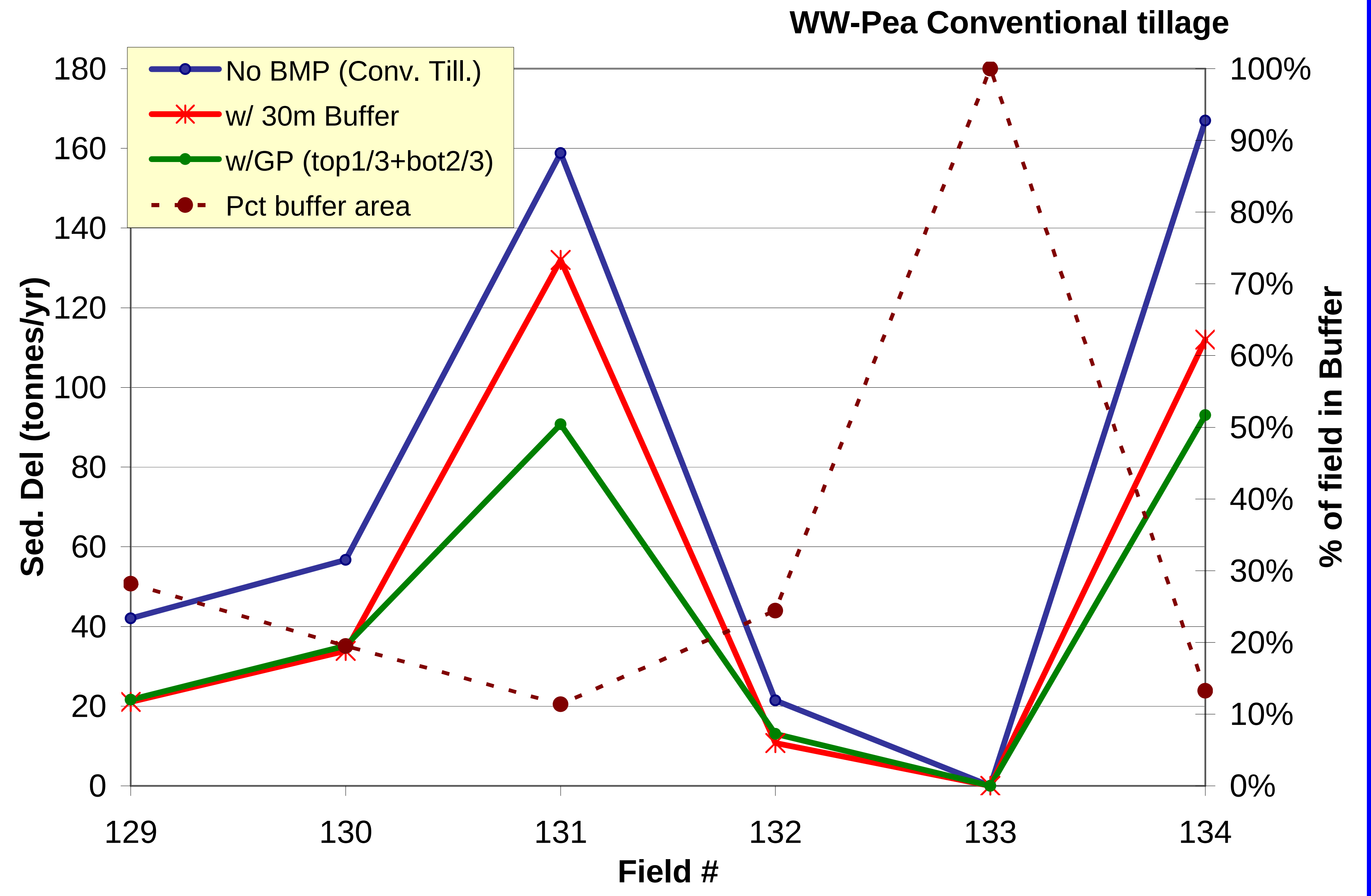


# WEPP Application to Paradise Creek

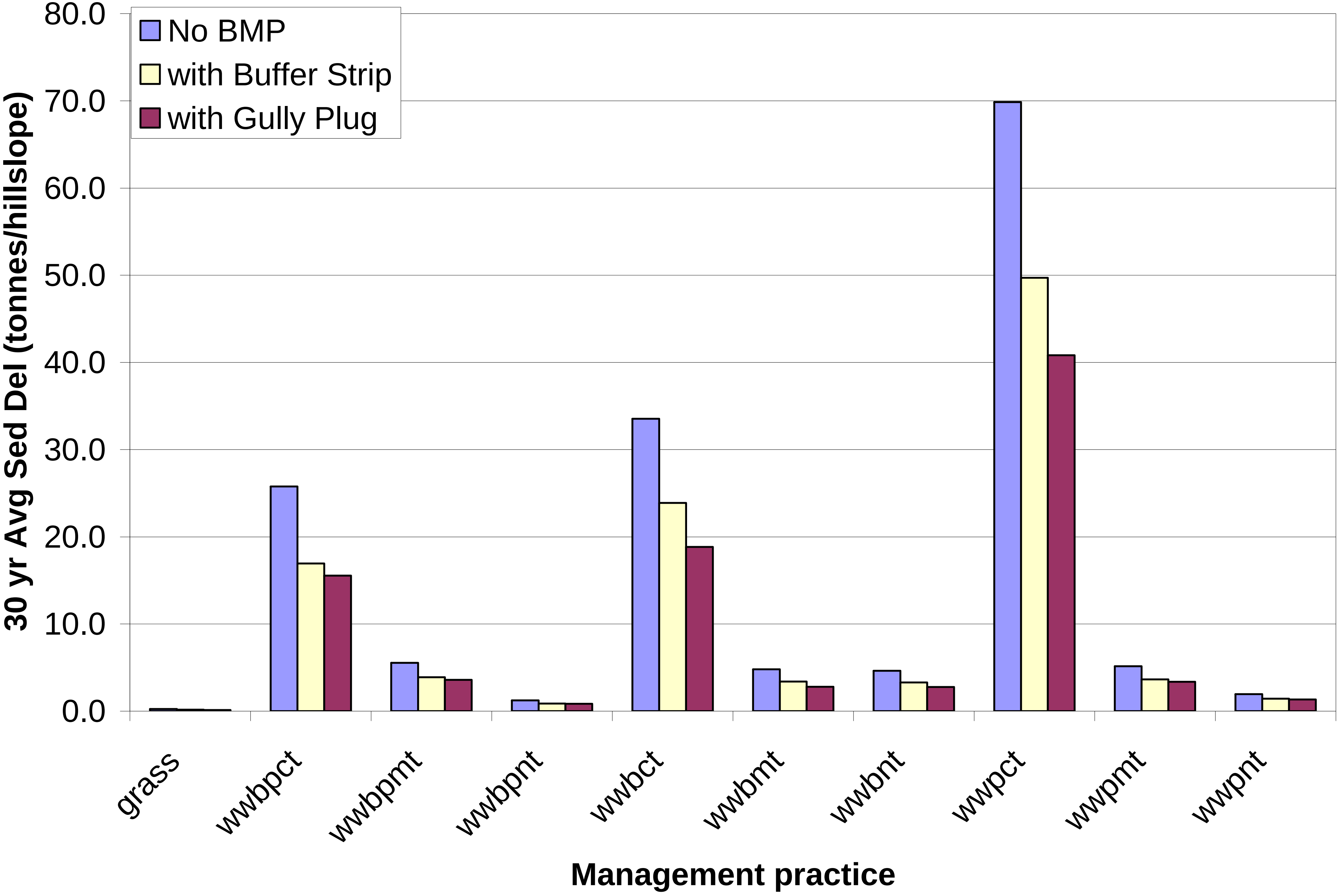



WW-Pea Conventional tillage
Pct buffer area
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
% of field in buffer
129
130
131
132
133
134
Field #

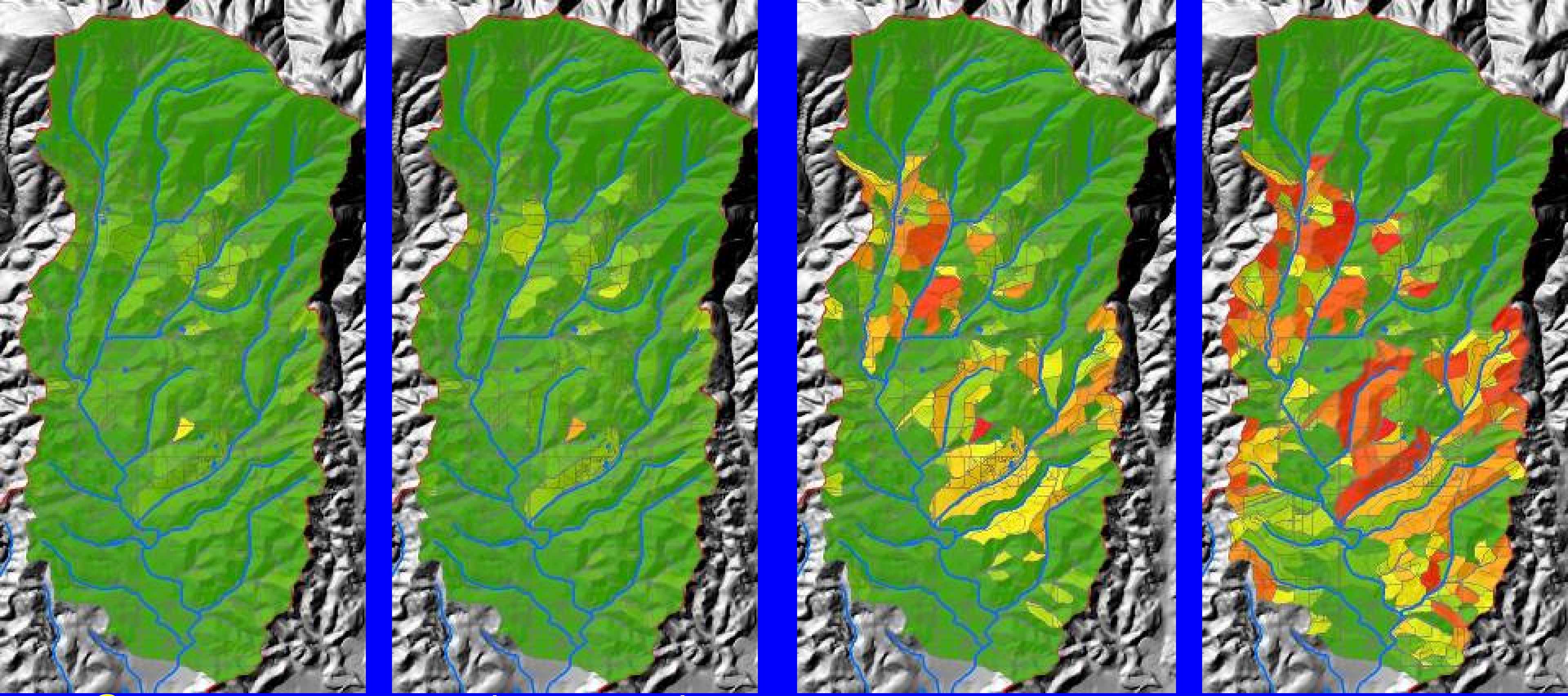

WW-Pea Conventional tillage
No BMP (Conv. Till.)
No BMP (Mulch till)
No BMP (No till)
Pct buffer area
Sed. Del (tonnes/yr)
% of field in Buffer
Field #
0
20
40
60
80
100
120
140
160
180
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
129
130
131
132
133
134



WW-Pea Conventional tillage
No BMP (Conv. Till.)
w/ 30m Buffer
w/GP (top1/3+bot2/3)
Pct buffer area
Sed. Del (tonnes/yr)
% of field in Buffer
Field #
180
160
140
120
100
80
60
40
20
0
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
129
130
131
132
133
134



80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
No BMP
with Buffer Strip
with Gully Plug
30 yr Avg Sed Del (tonnes/hillslope)
grass
wwbpct
wwbpmt
wwbpnt
wwbct
wwbmt
wwbnt
wwpct
wwpmt
wwpnt
Management practice

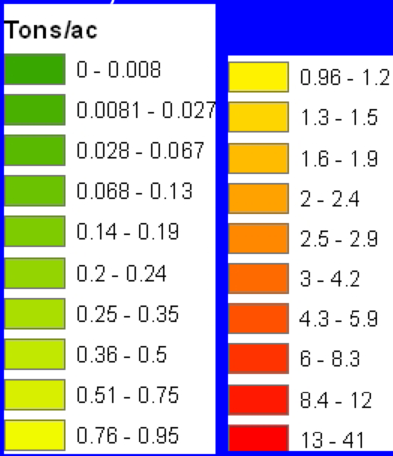


**Grass**
0.07 Tons/ac
614 Tons

**Direct Seed**
0.1 tons/ac
1100 tons

**Mulch Till**
0.9 tons/ac
10,000 tons

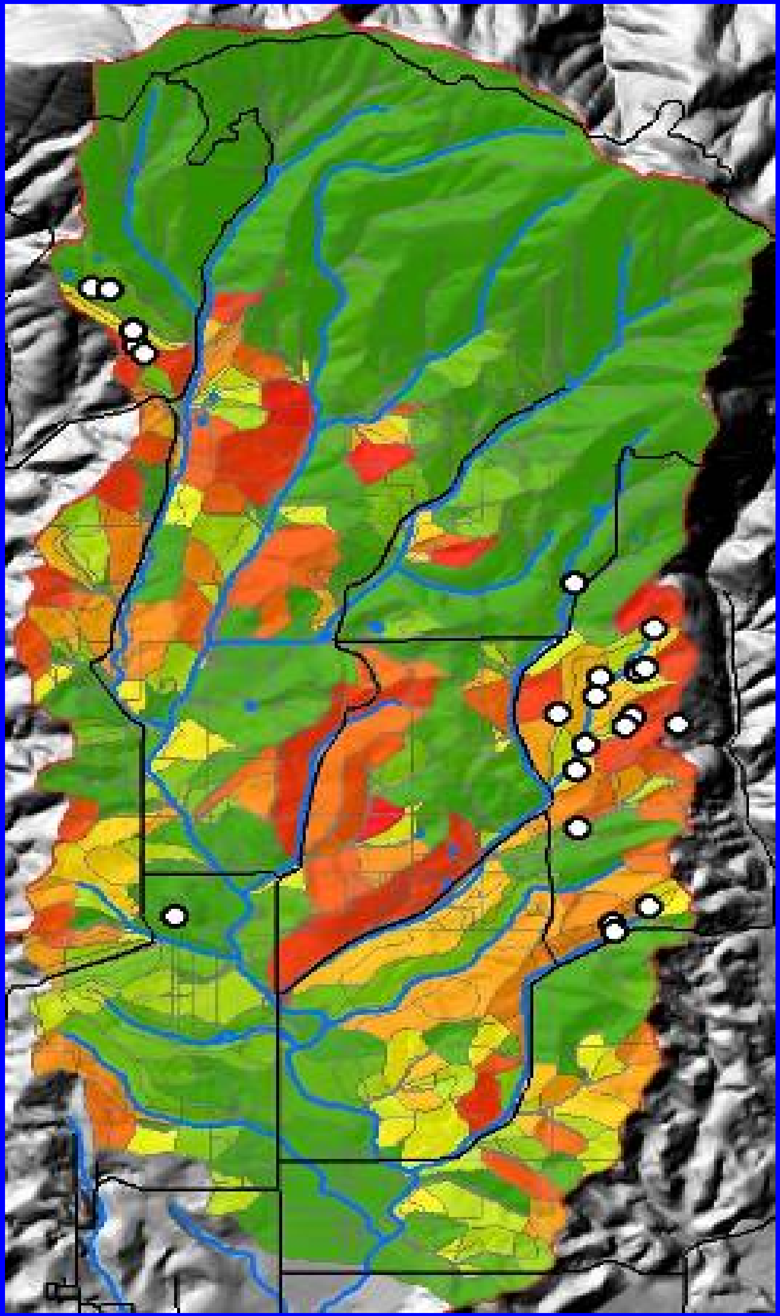
**Conventional**
2.5 tons/ac
24,000 tons




# Sediment Delivery by Hillslope

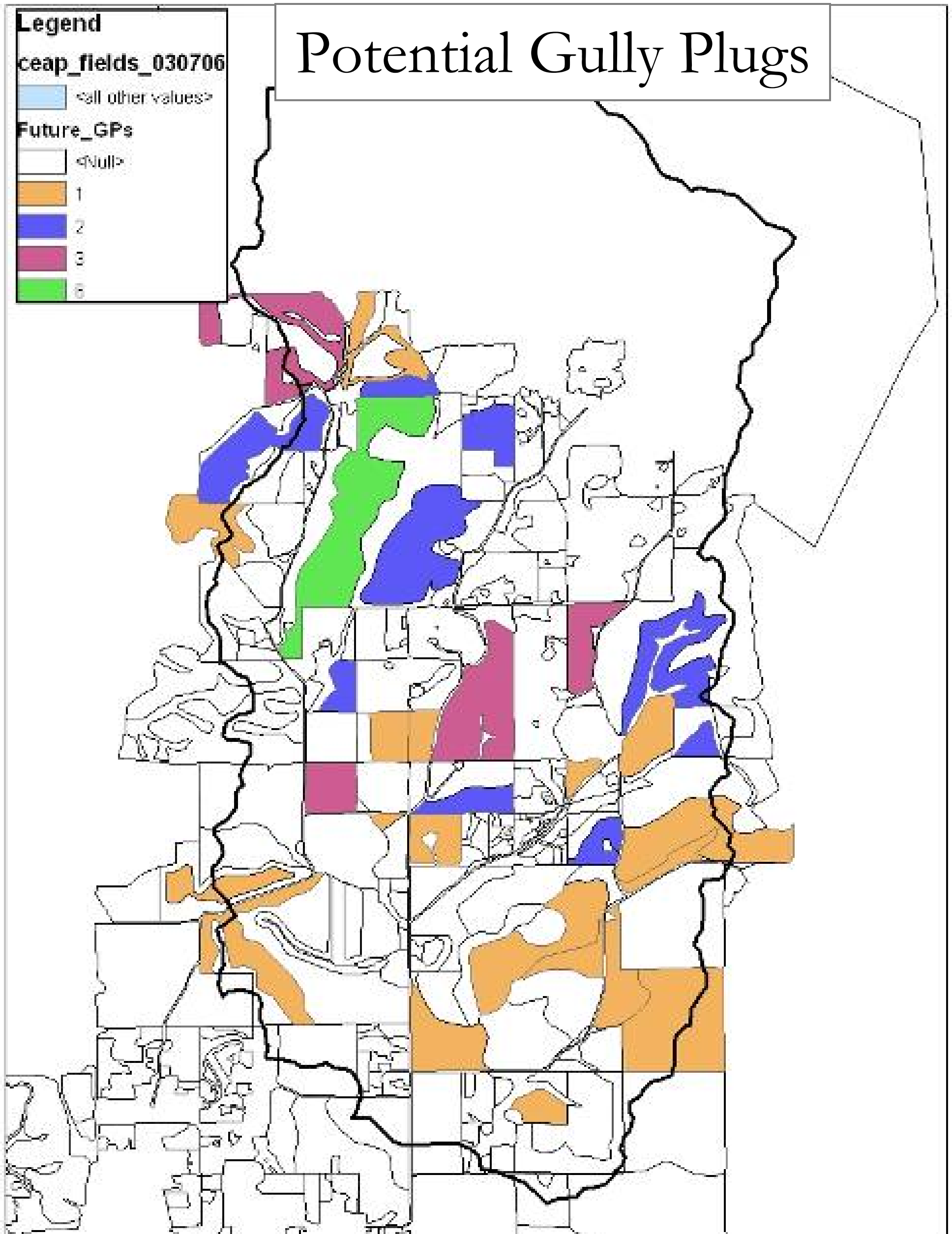
Winter Wheat
Spring Barley
Spring Peas
Rotation

***30 year Averages

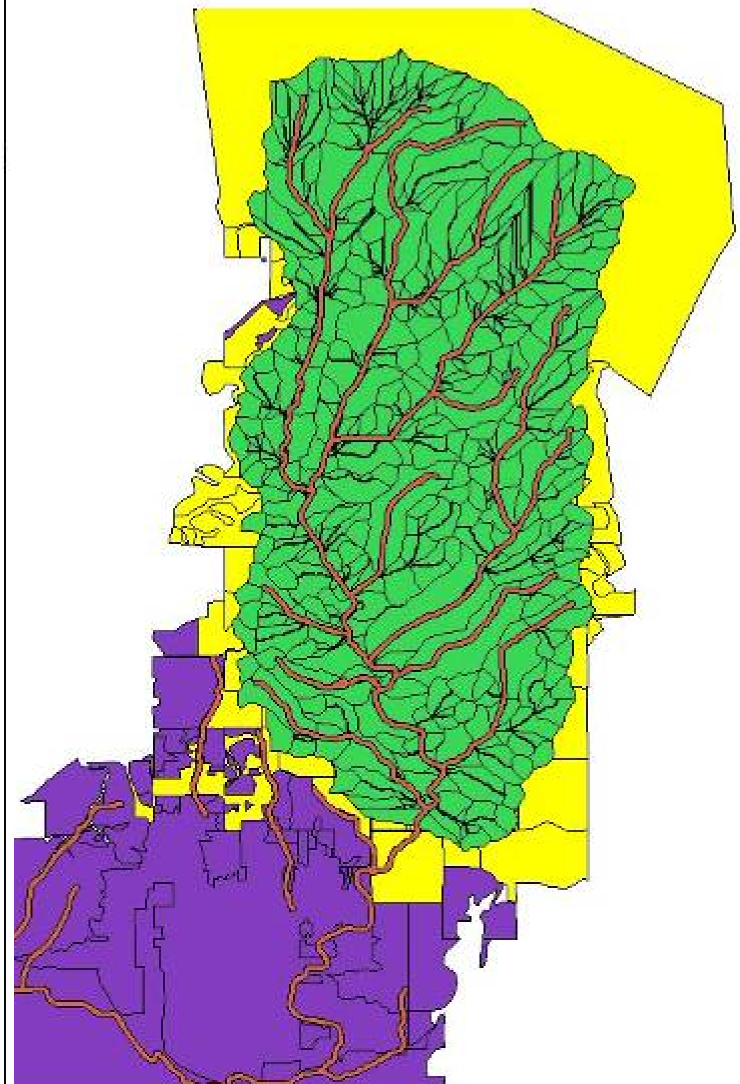


Gully Plugs

## Potential Gully Plugs




## Potential Stream Buffers



# CONCEPTS – CONServational Channel Evolution and Pollutant Transport System

Simulates long-term response of channels to loadings of water and sediments

- Input:
  - Channel geometry
  - Composition of bed and bank materials
  - Erosion resistance and shear strength of bed and bank materials
  - Rates of flow and sediments entering the channel
- Output:
  - Changes in channel geometry
  - Time series of hydraulic variables and sediment yield

Eddy J. Langendoen

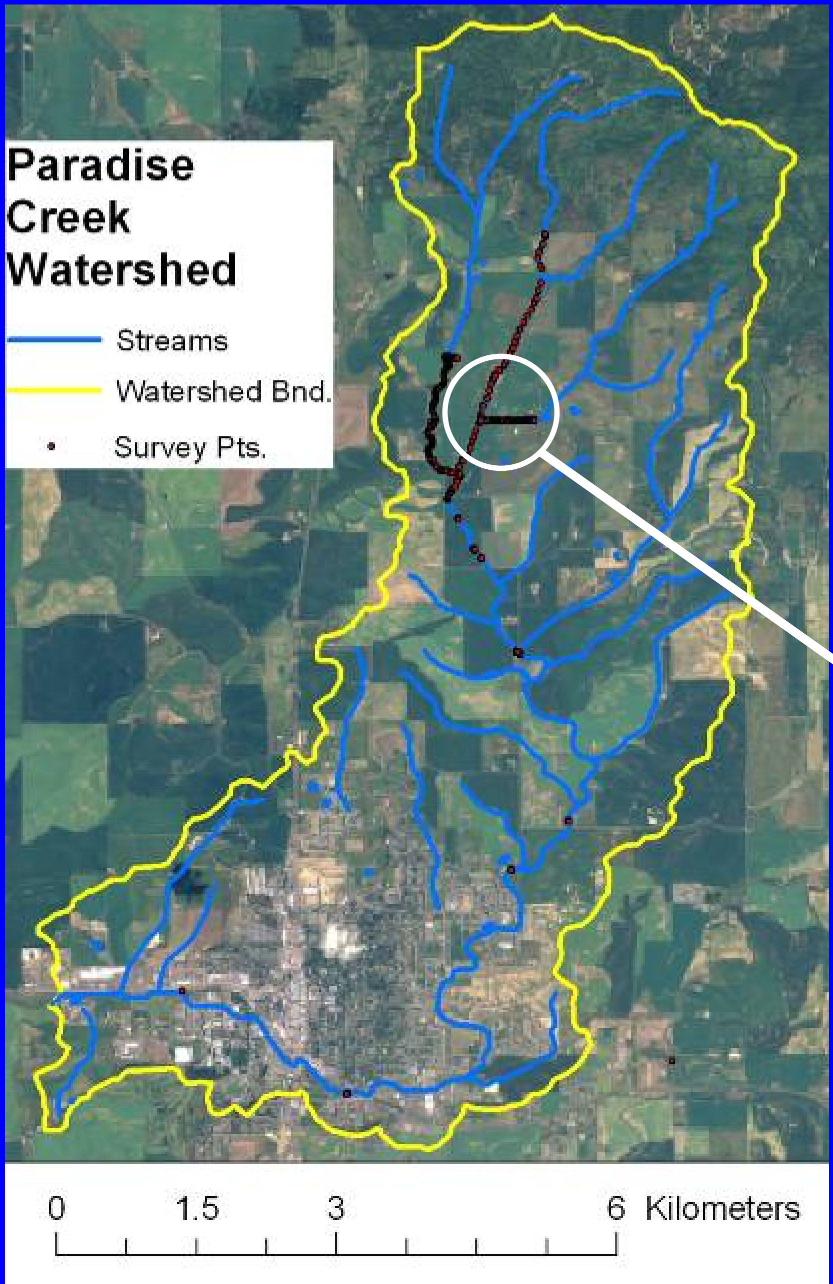
USDA Agricultural Research Service

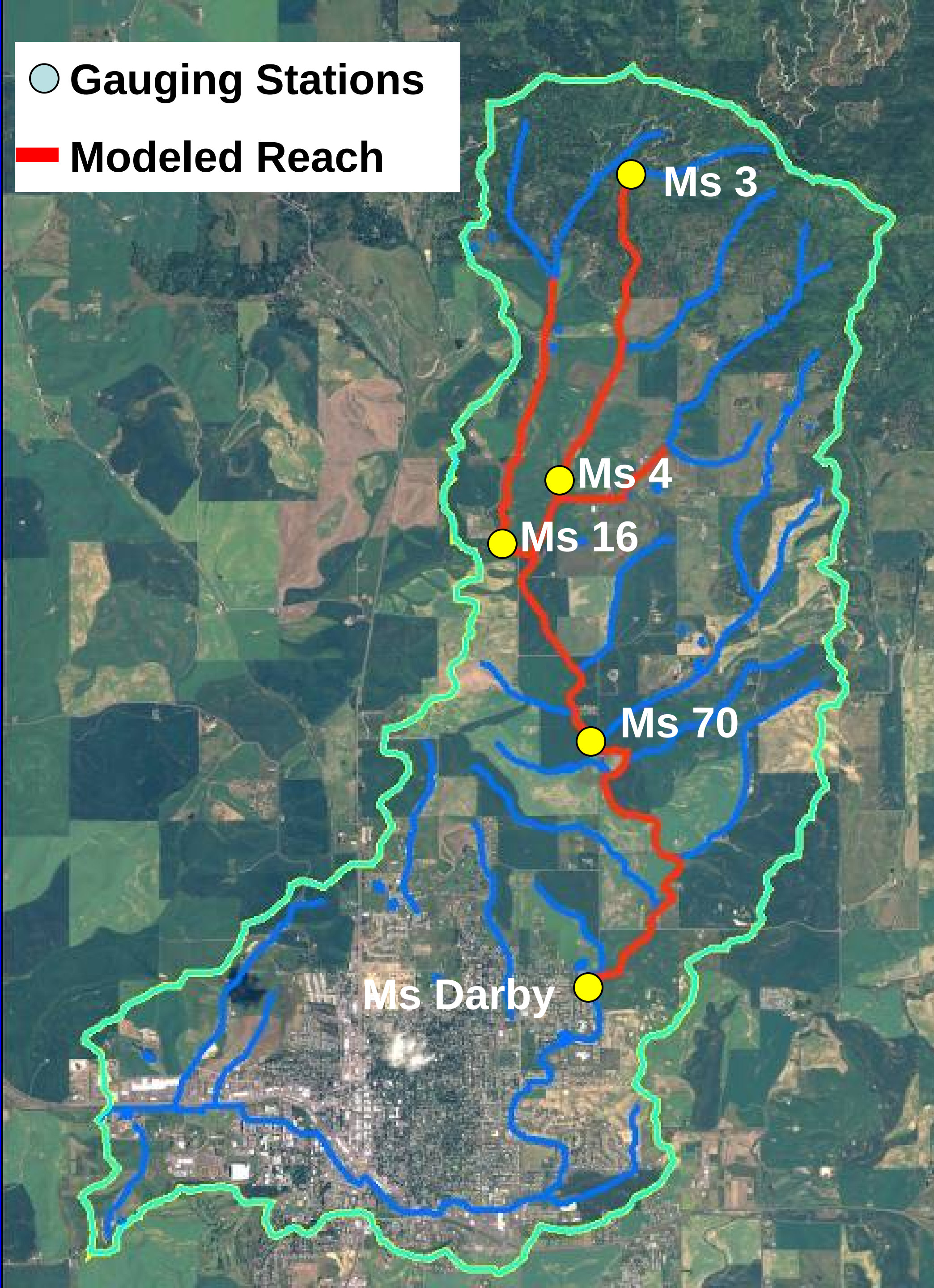
National Sedimentation Laboratory

Oxford, Mississippi

Slide adapted from Eddy J. Langendoen

# Cross-section data




# CONCEPTS: Stream modeling

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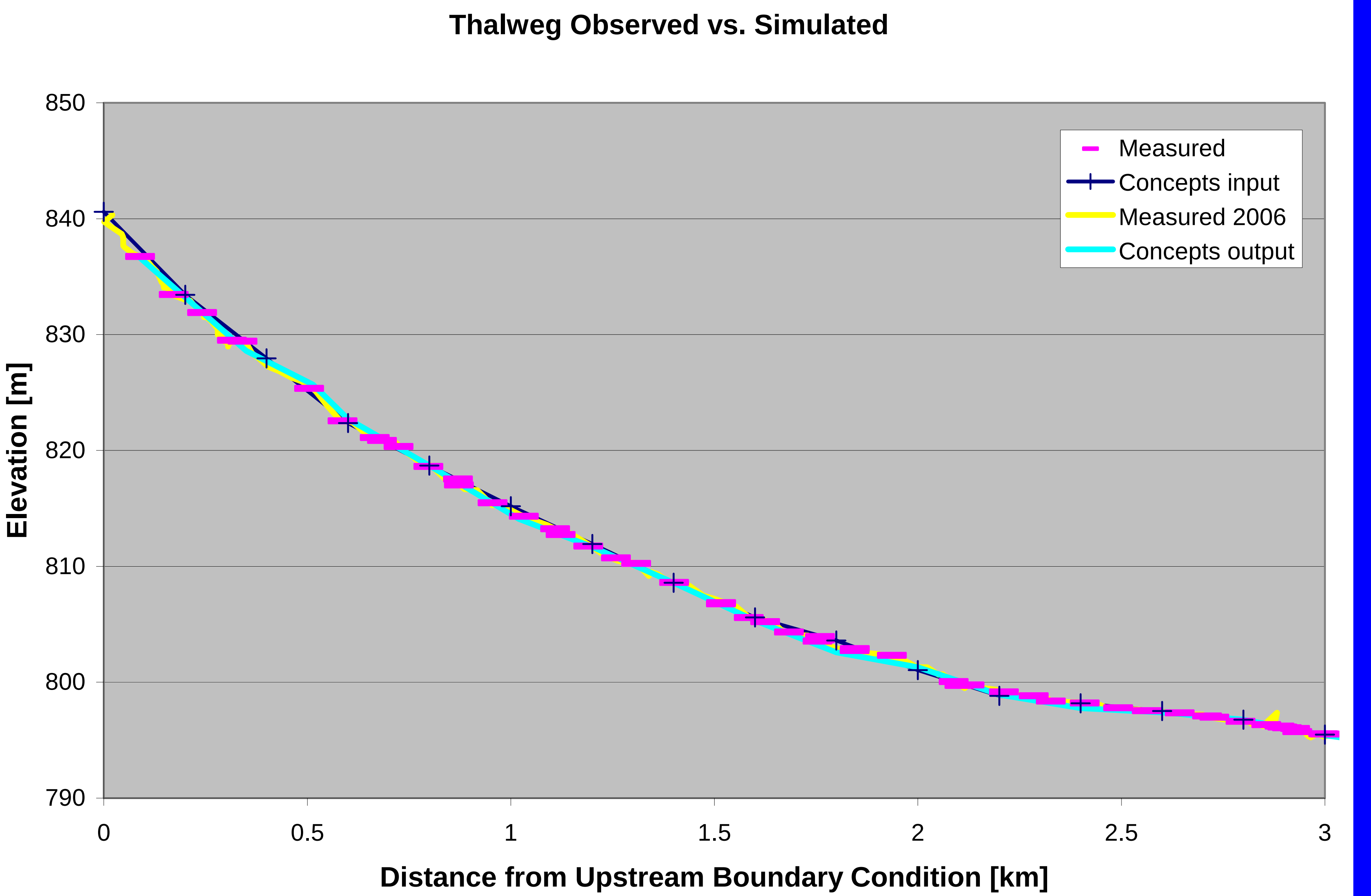
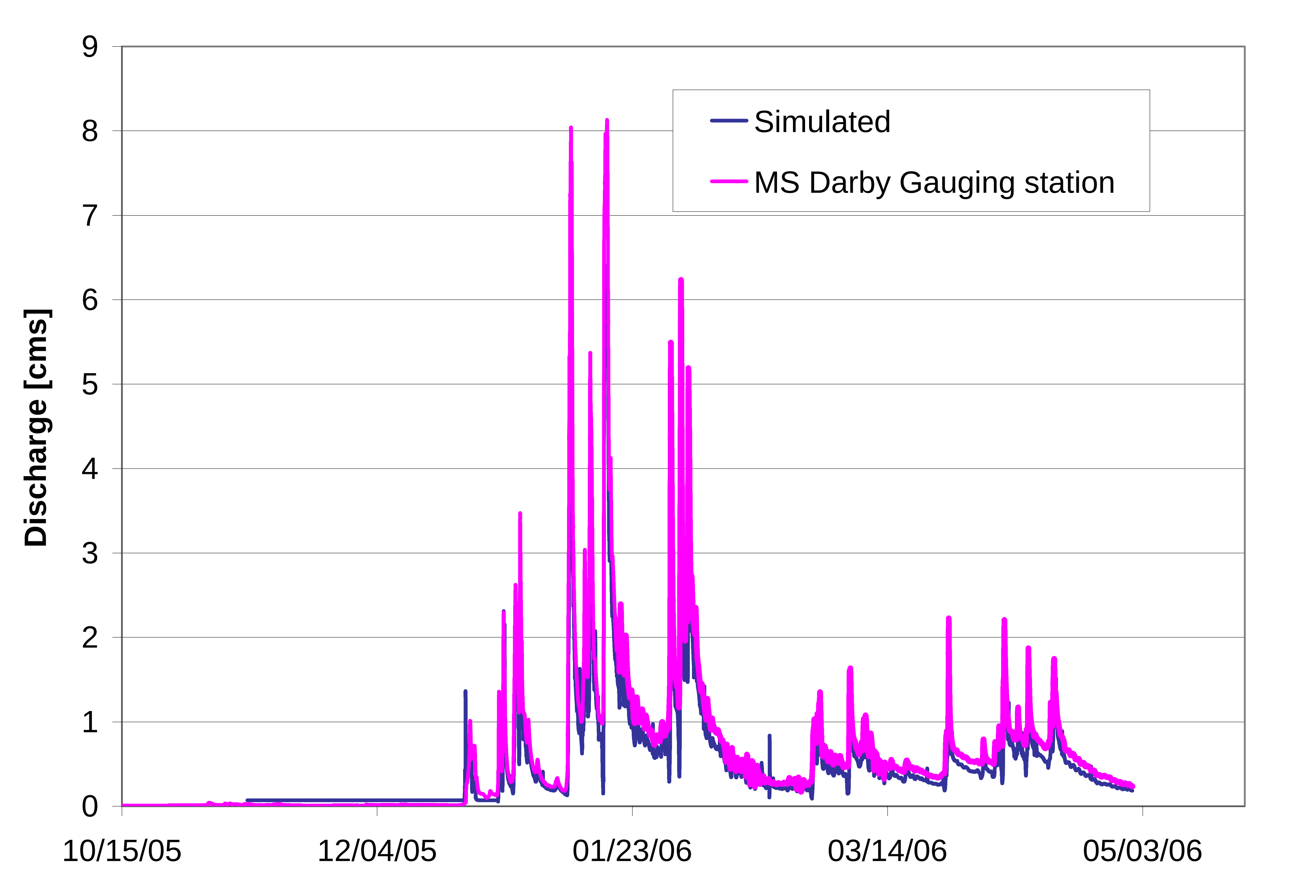
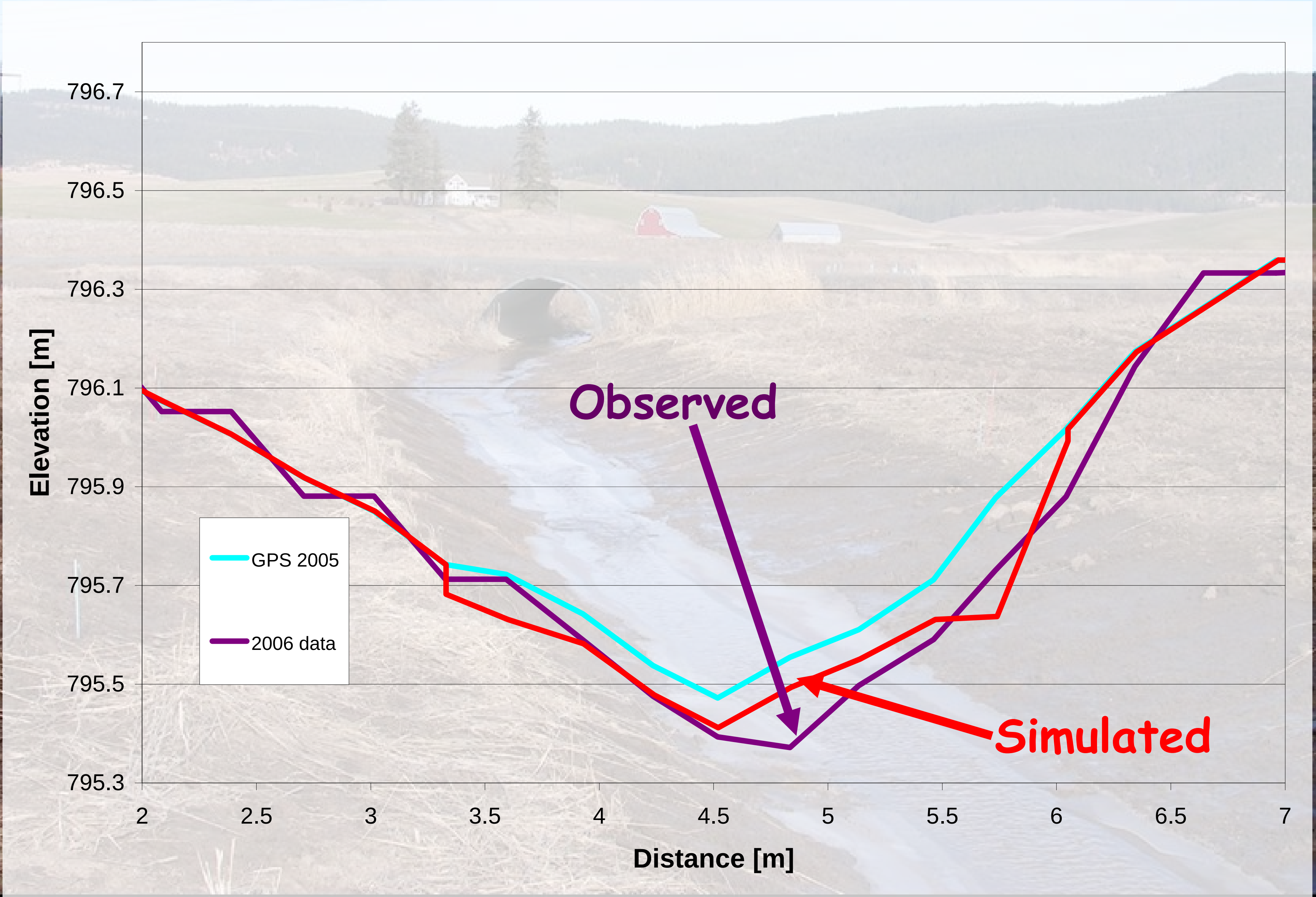


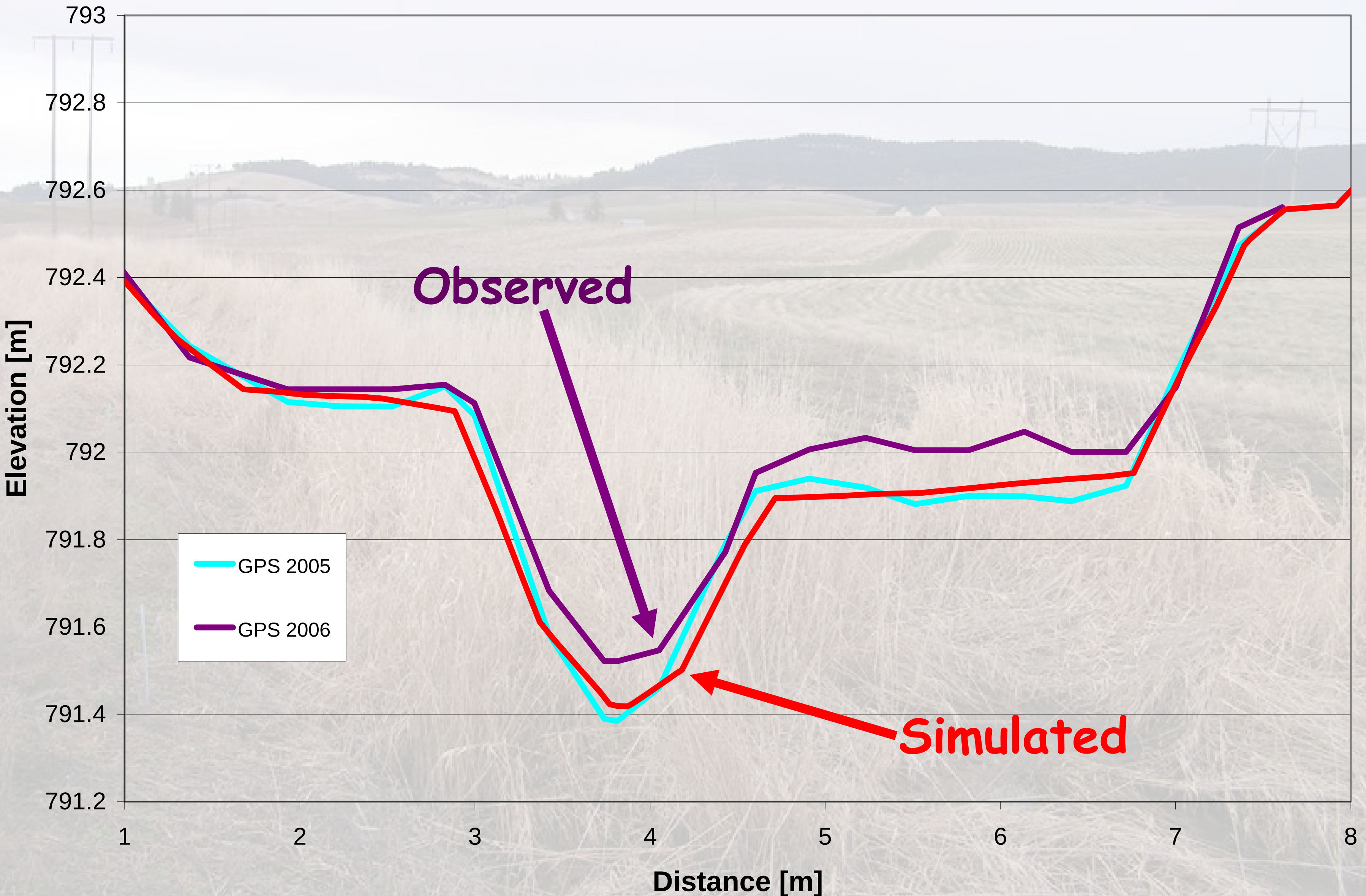
# CONCEPTS: Stream modeling

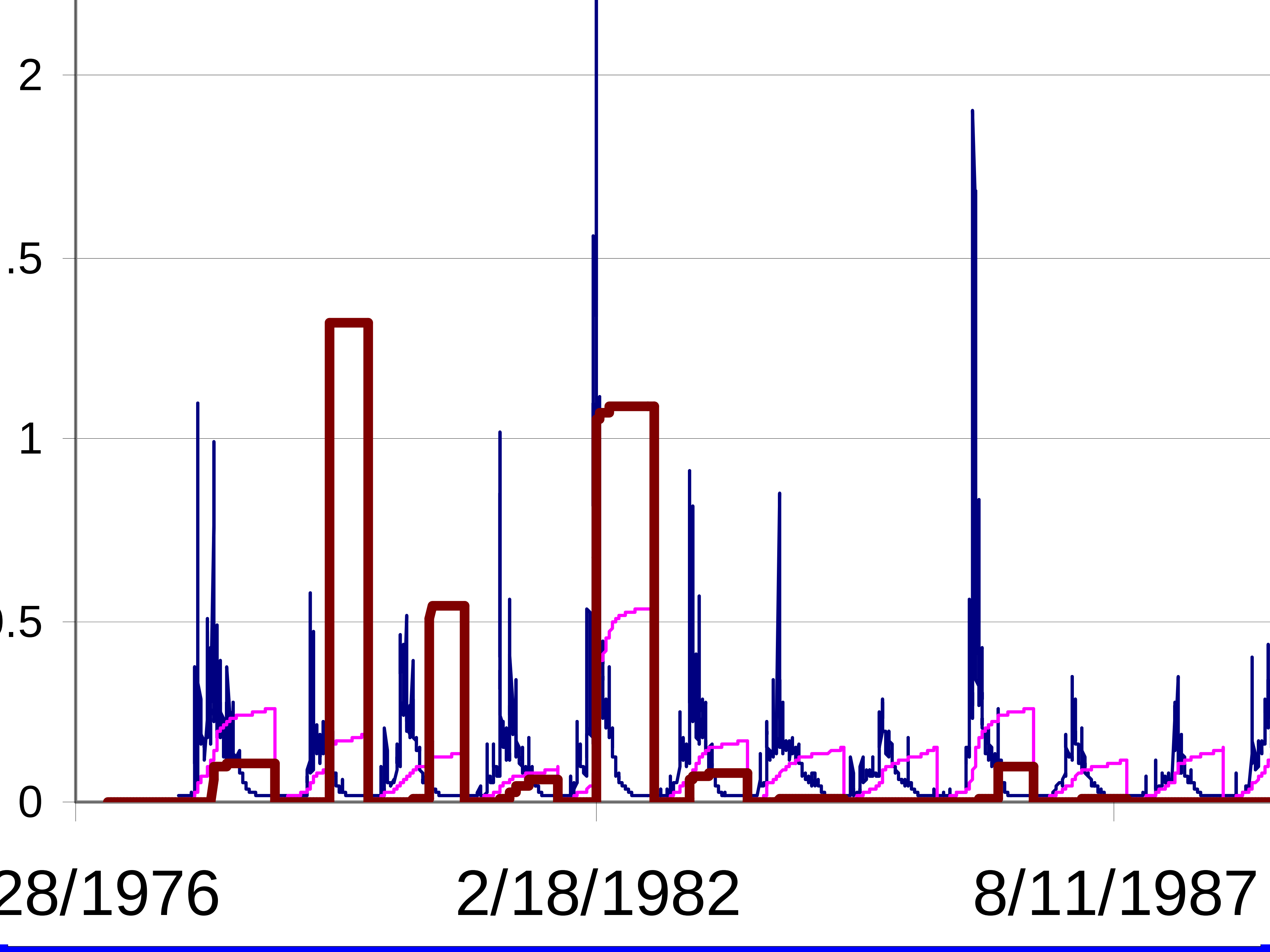


# CONCEPTS: Stream modeling



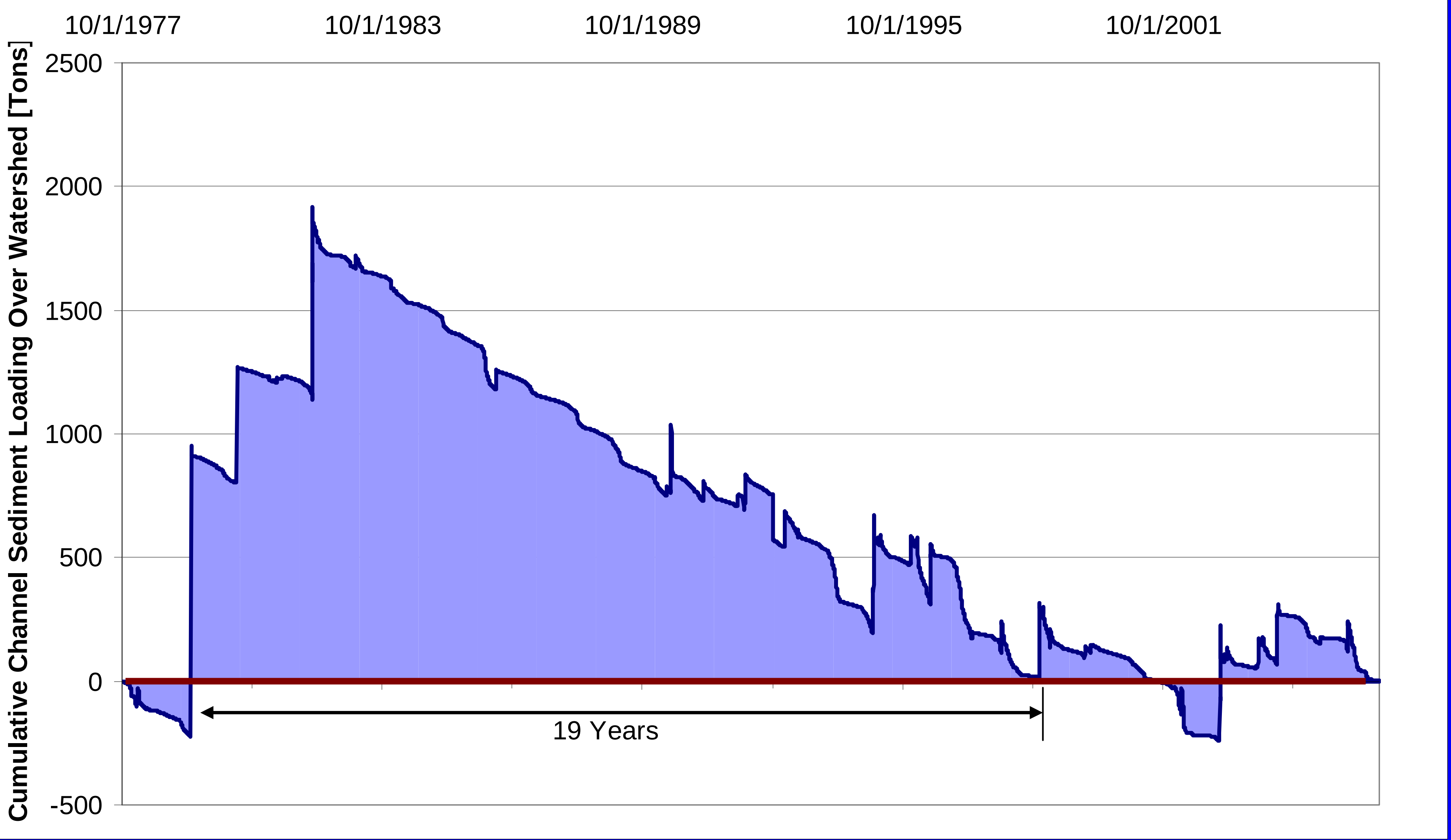
# CONCEPTS: Stream modeling





2
.5
1
0.5
0
28/1976
2/18/1982
8/11/1987

# CONCEPTS Simulation 1977-2006



# Optimization

- Field-by-field operating and ownership costs for each of operators in the watershed.

- Yield data:
  - CROPSYST simulation model

- Sediment delivery data:
  - WEPP model

# Optimization Model

- Maximize net returns to ownership:

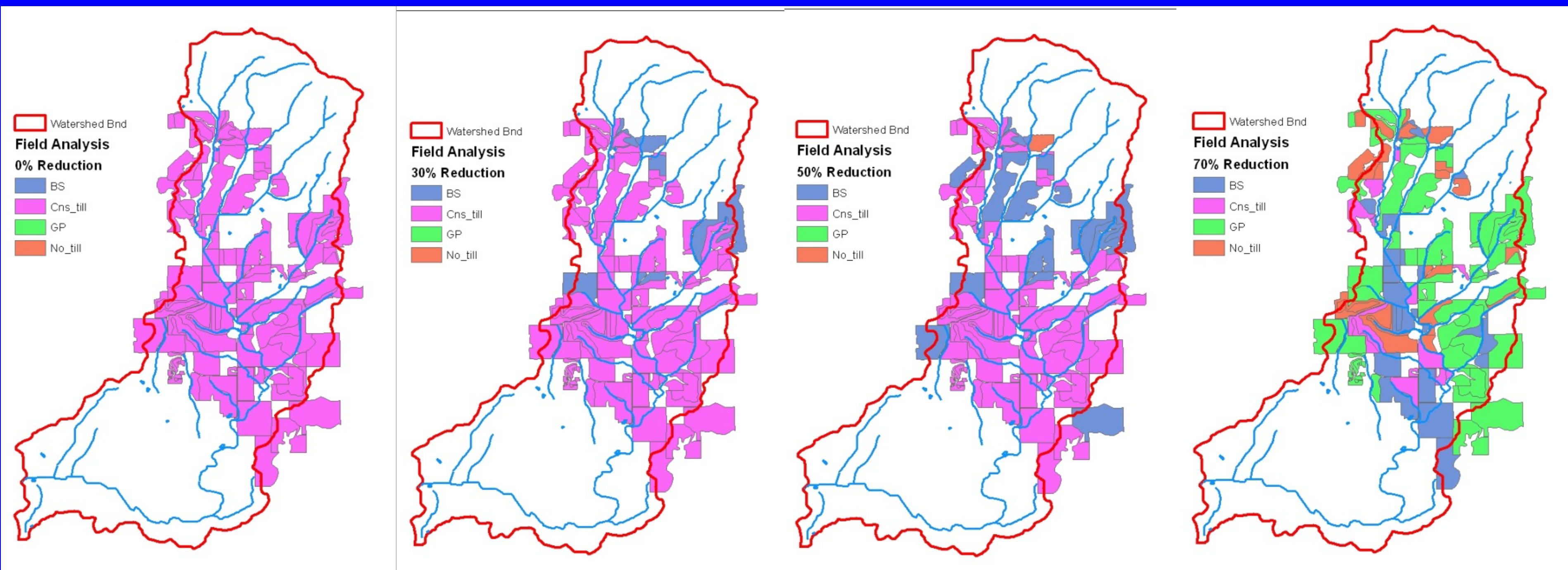
$$Max\Pi_F = \Sigma_{C,R,S}(P_C * Y_{F,C,R} - CP_{F,C,S})X_{F,R}$$

- s.t. land availability and soil loss levels:

$$\sum_{C,R} X_{F,R} = L_F$$

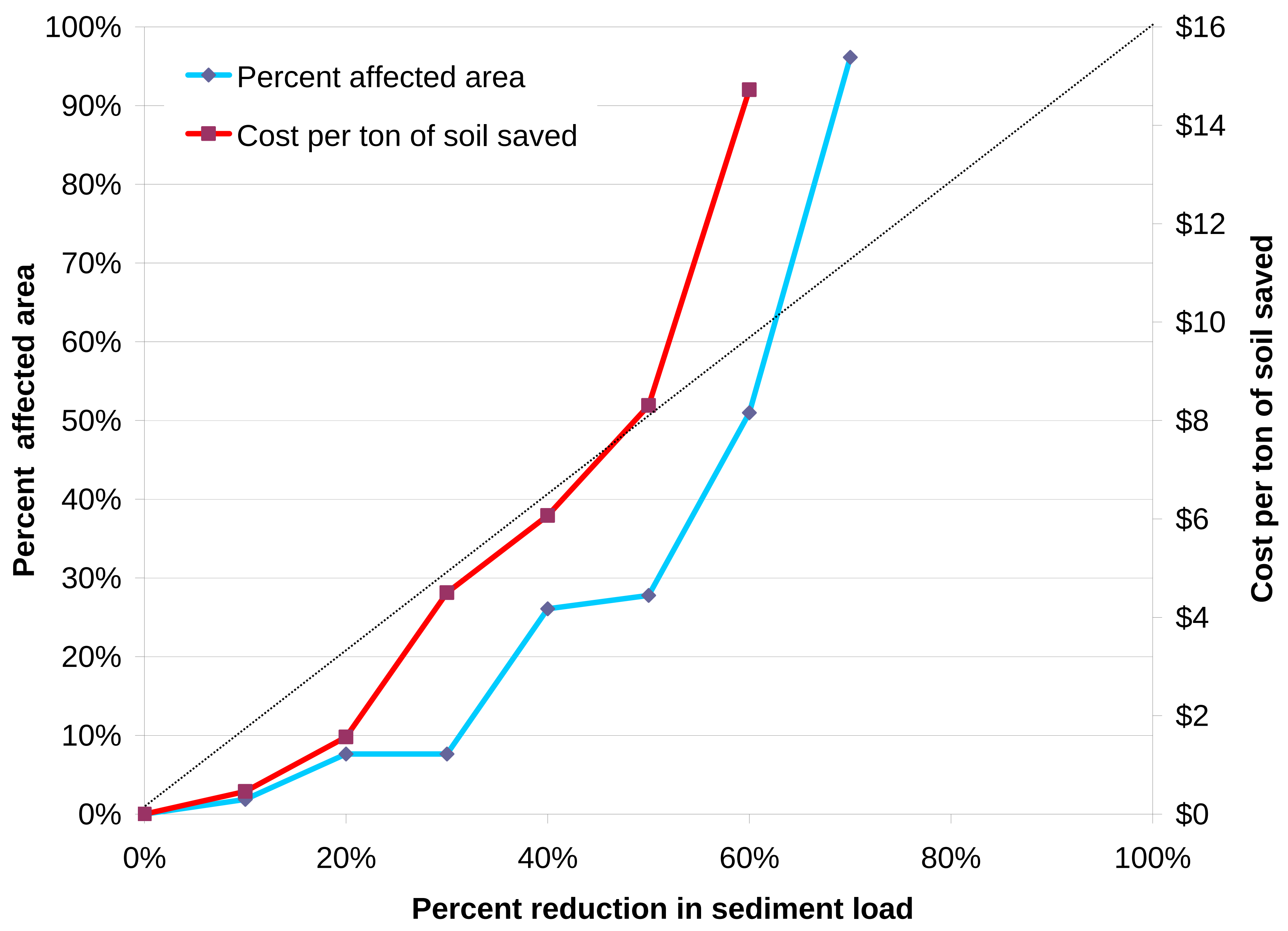
$$\sum e_{C,F,R} X_{F,R} \leq E$$

# % sediment load reduction




0% 30% 50% 70%

# $$/ton vs. % load reduction



# Investigators

- Jan Boll*, Erin Brooks*, Kzrysztof Ostrowski, Brian Crabtree, Jeremy Newson: Biological and Agricultural Engineering
- JD Wulfhorst*, Larry Van Tassell*, Naga Srinivasa Tosakana: Agricultural Economics and Rural Sociology
- Robert Mahler*: Plant, Soil, and Entomological Sciences
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# Thank you!