Evaluation of Conservation Practices: Interdisciplinary Analyses & Modeling

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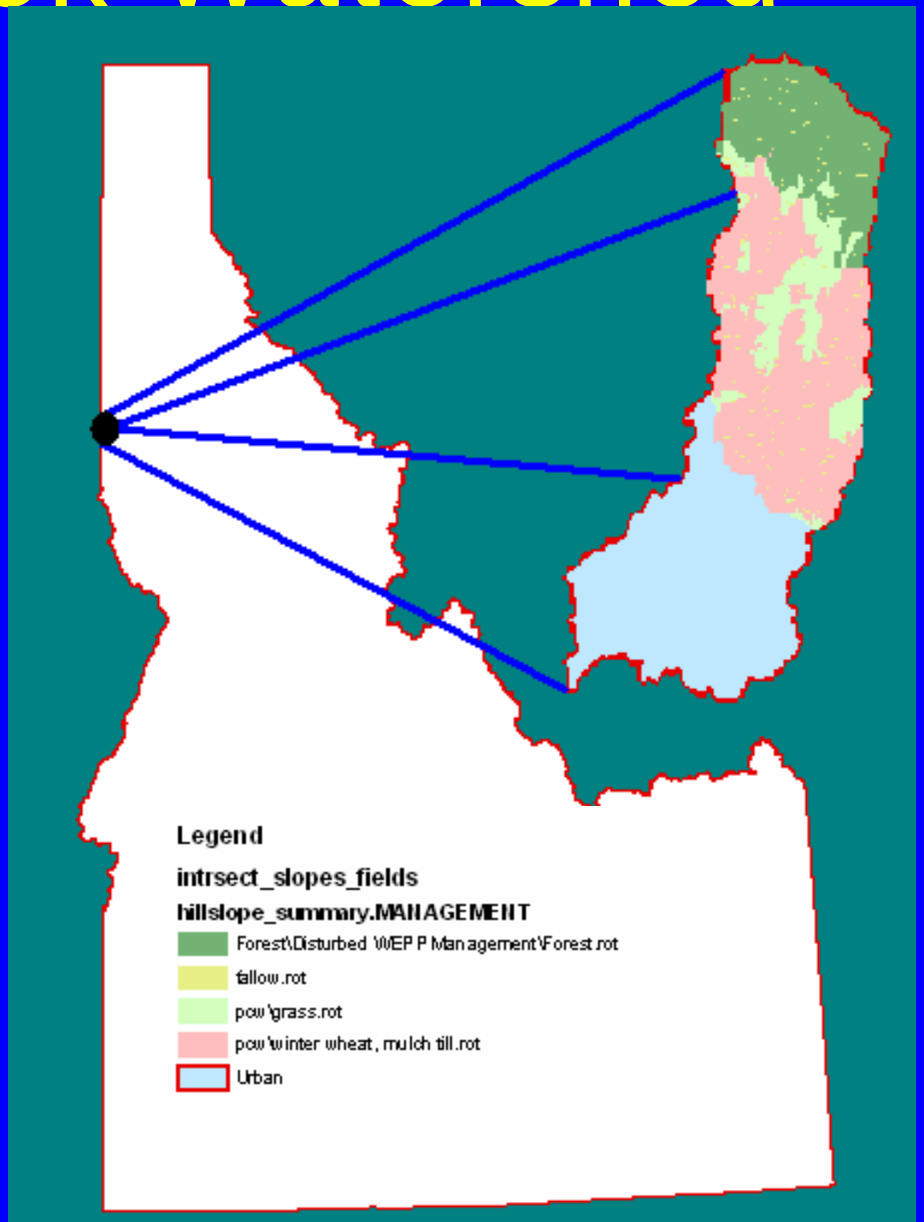
Jan 28 – Feb 1, 2007

Paradise Creek Watershed

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



Funded by USDA-CSREES-Conservation Effectiveness Assessment Program (CEAP)

Research & Objectives

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

Objectives:

To modify a distributed erosion model to improve hydrology, and to understand stream dynamics

To target agricultural fields from physical data (➔ sediment transport model)

To give preliminary results of a regional survey

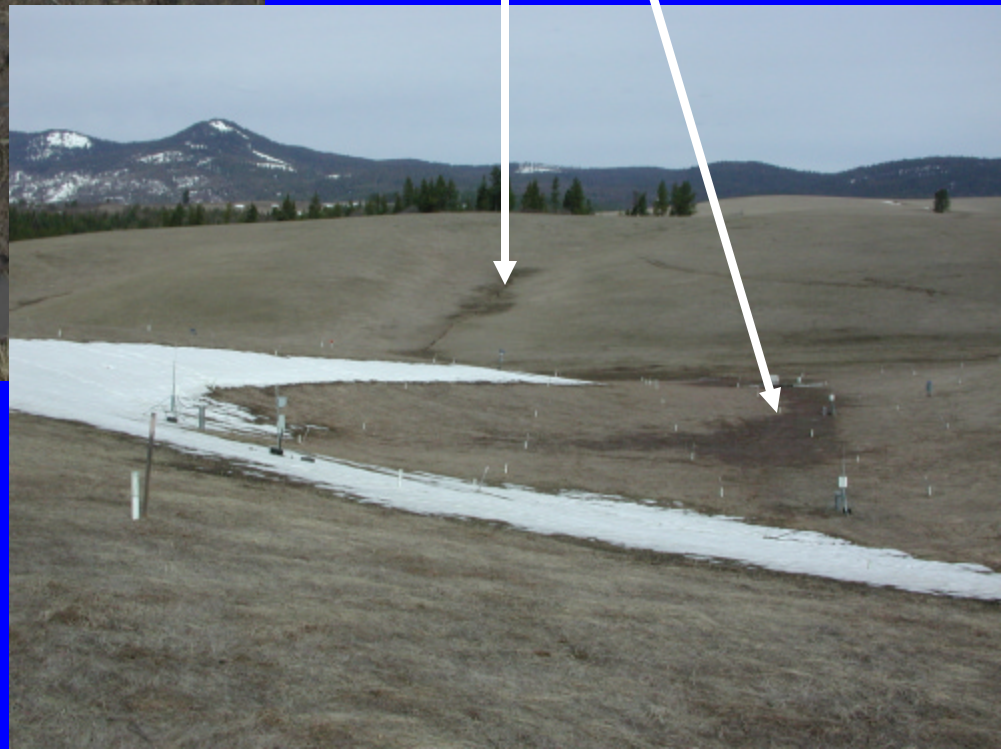
To target agricultural fields using physical and socio-economic data (➔ optimization)

Methods

- WEPP modeling
- CONCEPTS: stream dynamics
- Regional survey on Effectiveness of Agricultural Conservation Practices and Structures
- Economics and optimization

Variable Source Hydrology

Saturated areas

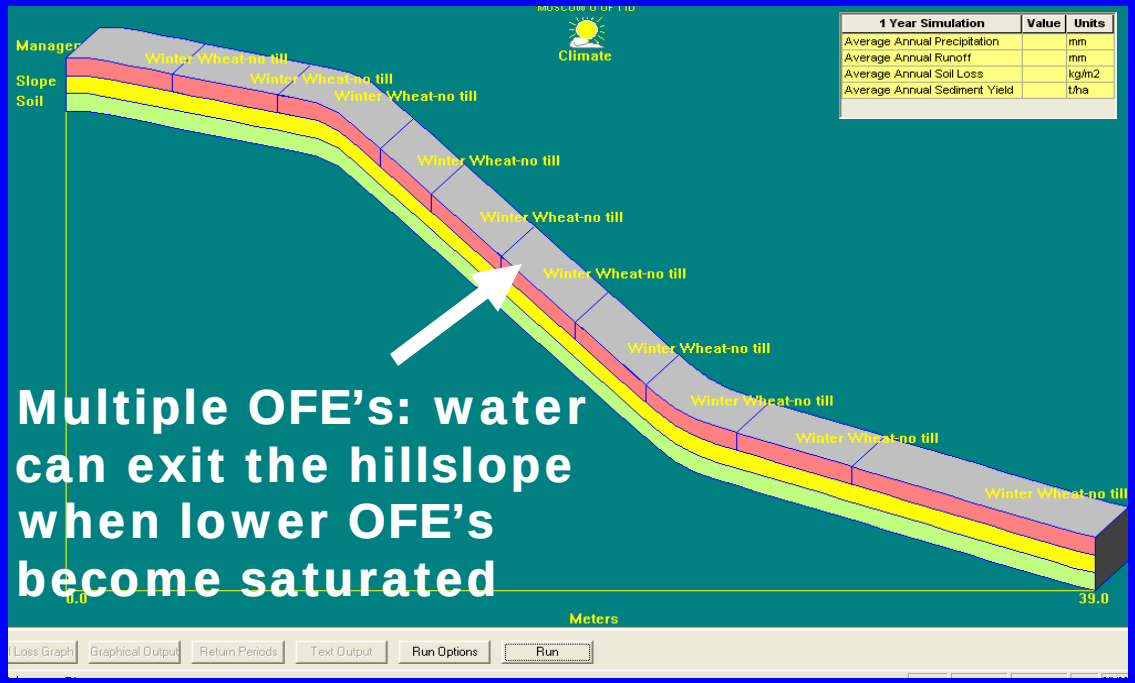


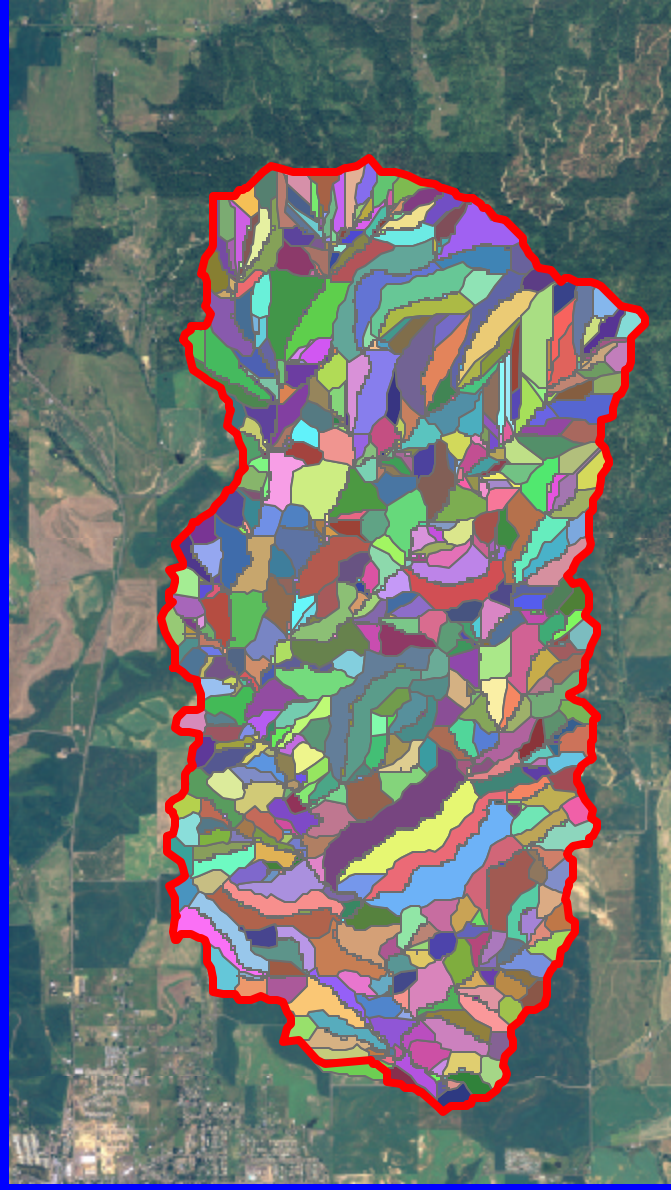
Water Erosion Prediction Project (WEPP) Model

- 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)





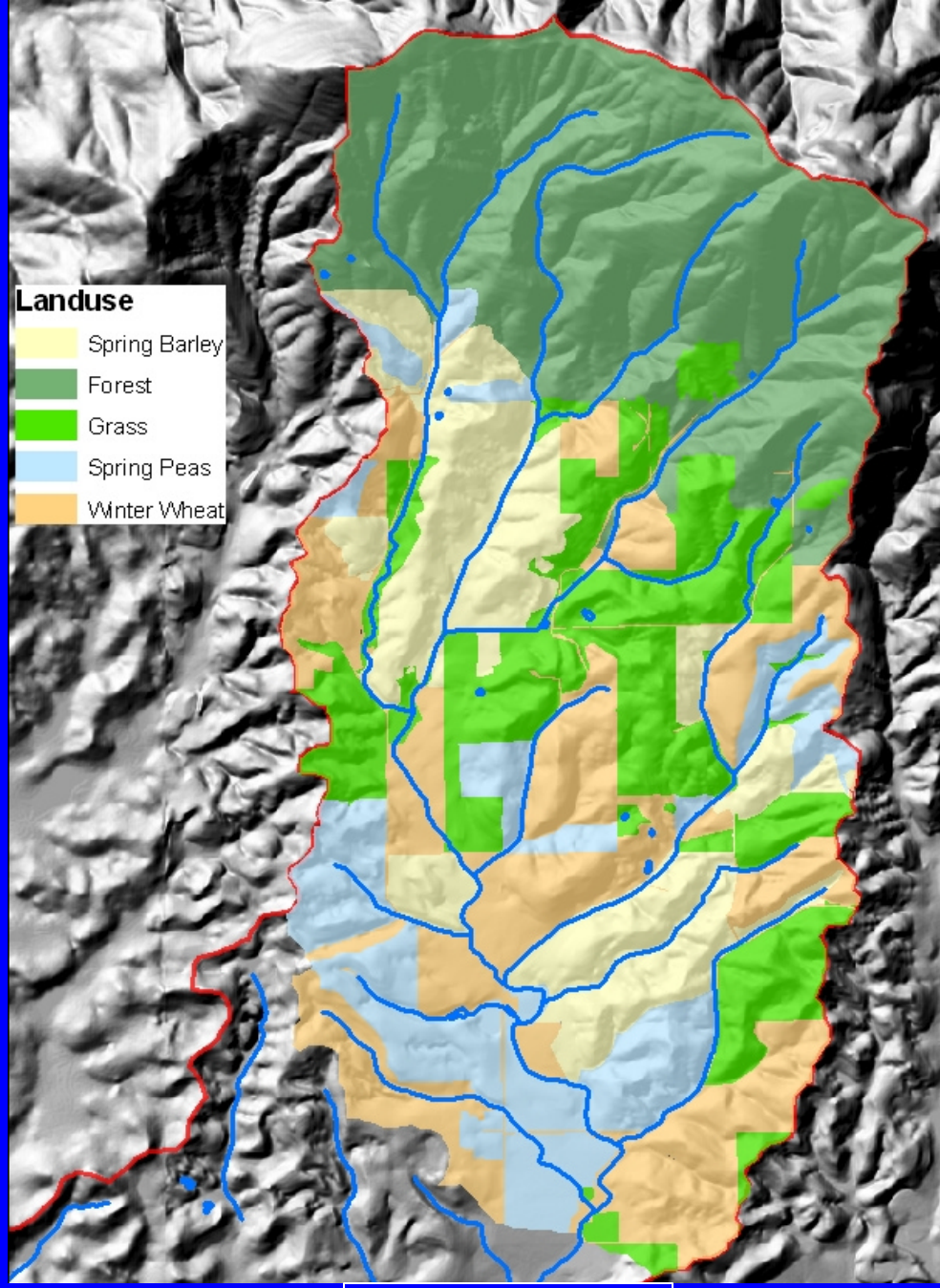
5 crops:

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

3 tillage practices:

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

- CRP



Land use map

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

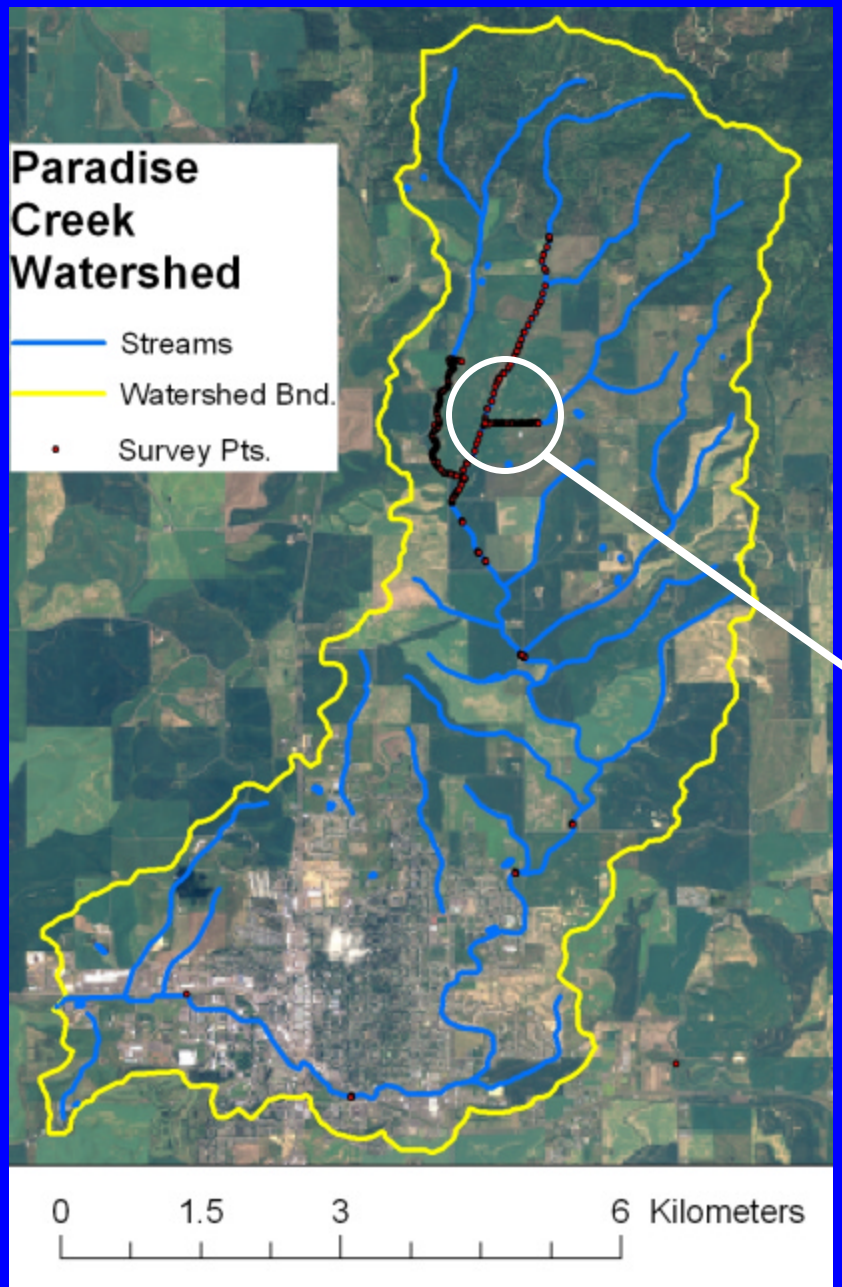
National Sedimentation Laboratory

Oxford, Mississippi

Slide adapted from Eddy J. Langendoen

Field data collection

Cross-section data



Regional Survey

- Washington Counties: Spokane, Whitman, Asotin
- Idaho Counties: Kootenai, Benewah, Latah, Idaho, Lewis, Nez Perce, Clearwater
- Response Rate: 43%, but ongoing follow-ups to non-respondents continue to reveal ineligible dispositions for some, suggesting the final response rate will be higher at the end of the project.
- Developed with PCW operators

Results

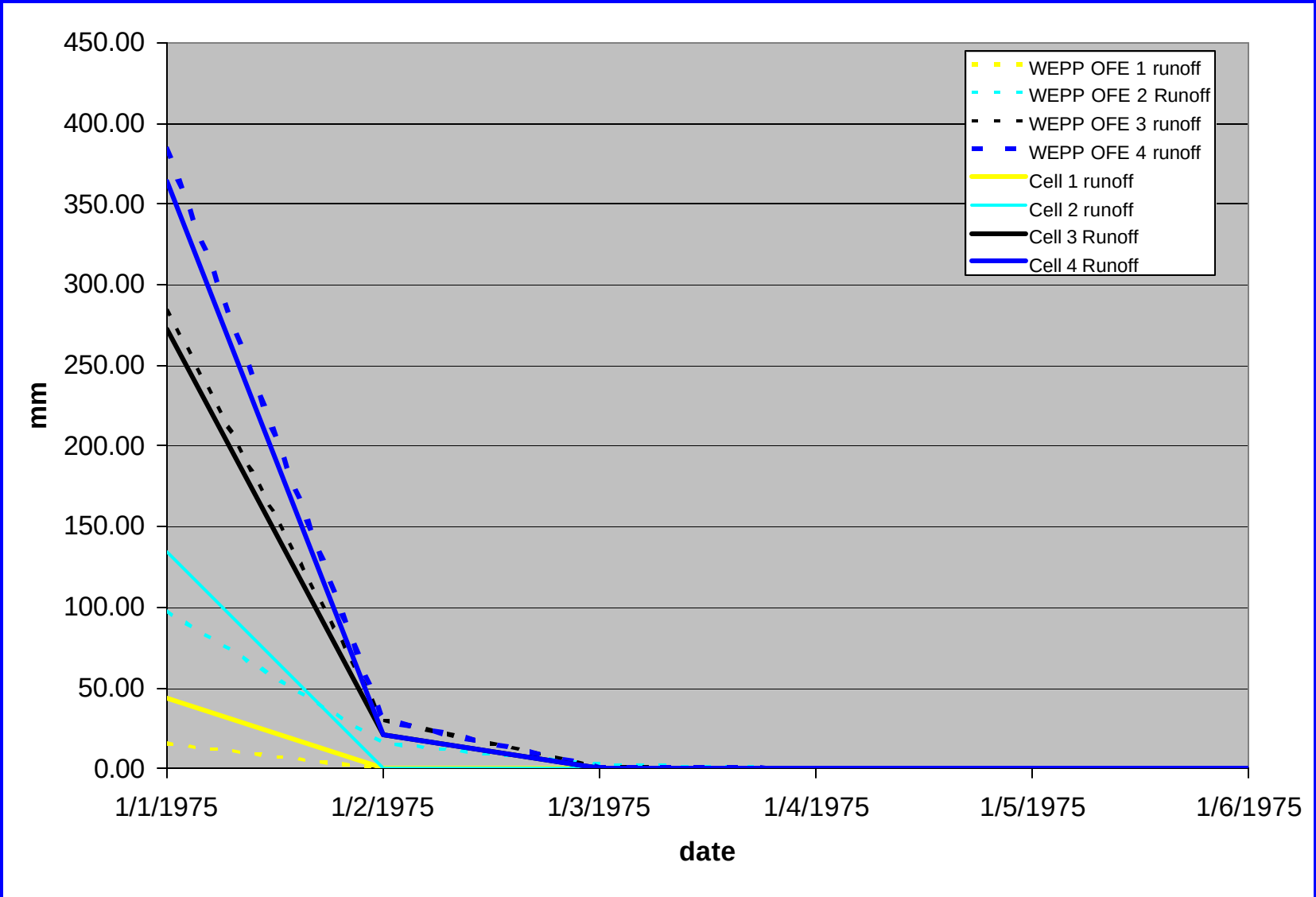
- WEPP: Single Hillslope
- WEPP: Application to Agricultural Watershed (Paradise Creek)
- CONCEPTS: stream dynamics
- Regional survey

Single Hillslope

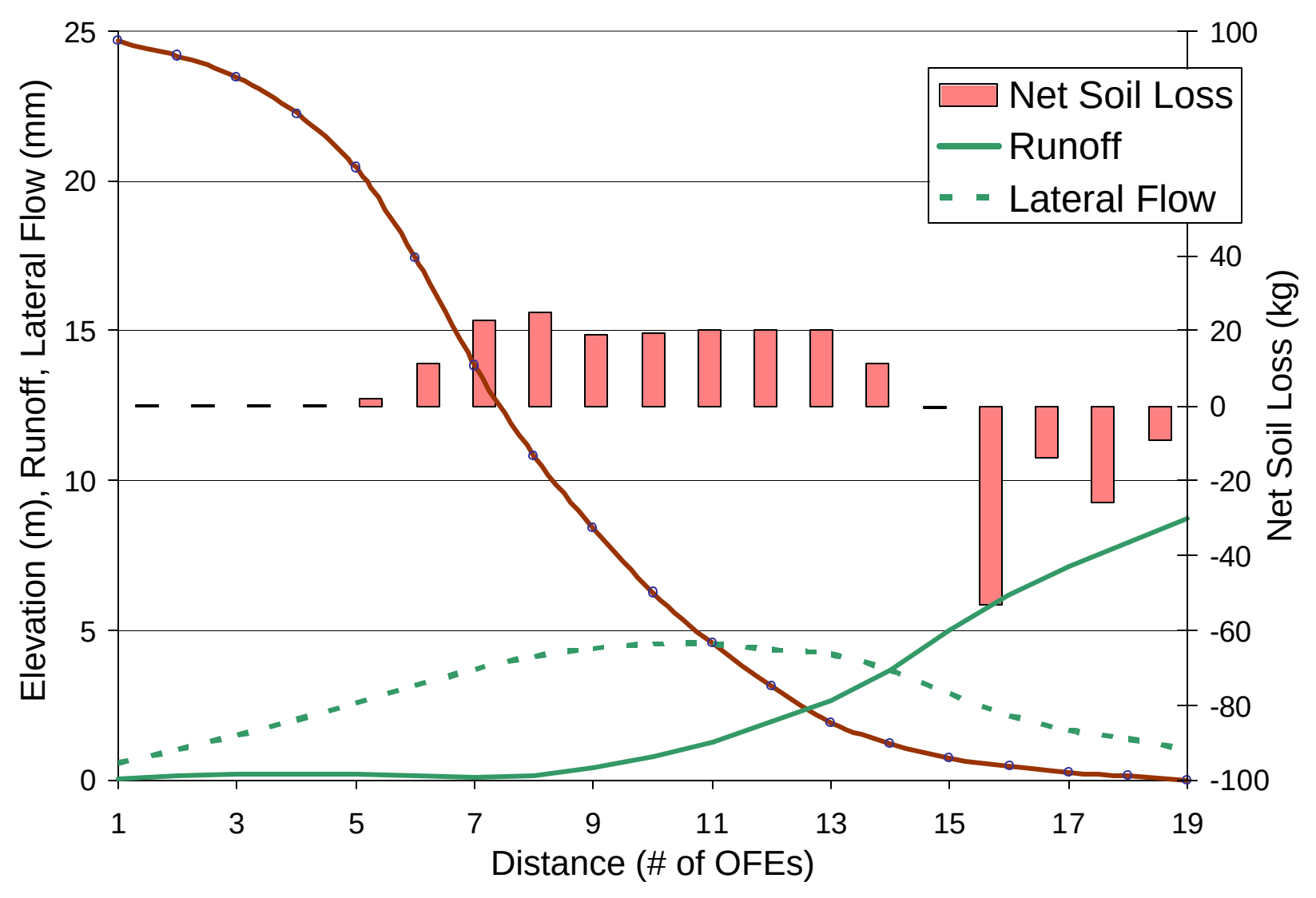
- Comparison with cell-based mass balance model
- WEPP simulation assuming lateral flow with restrictive layer, up to 19 Overland Flow Elements (includes lateral convergence)

Single Hillslope: Comparison

hourly time step, daily output

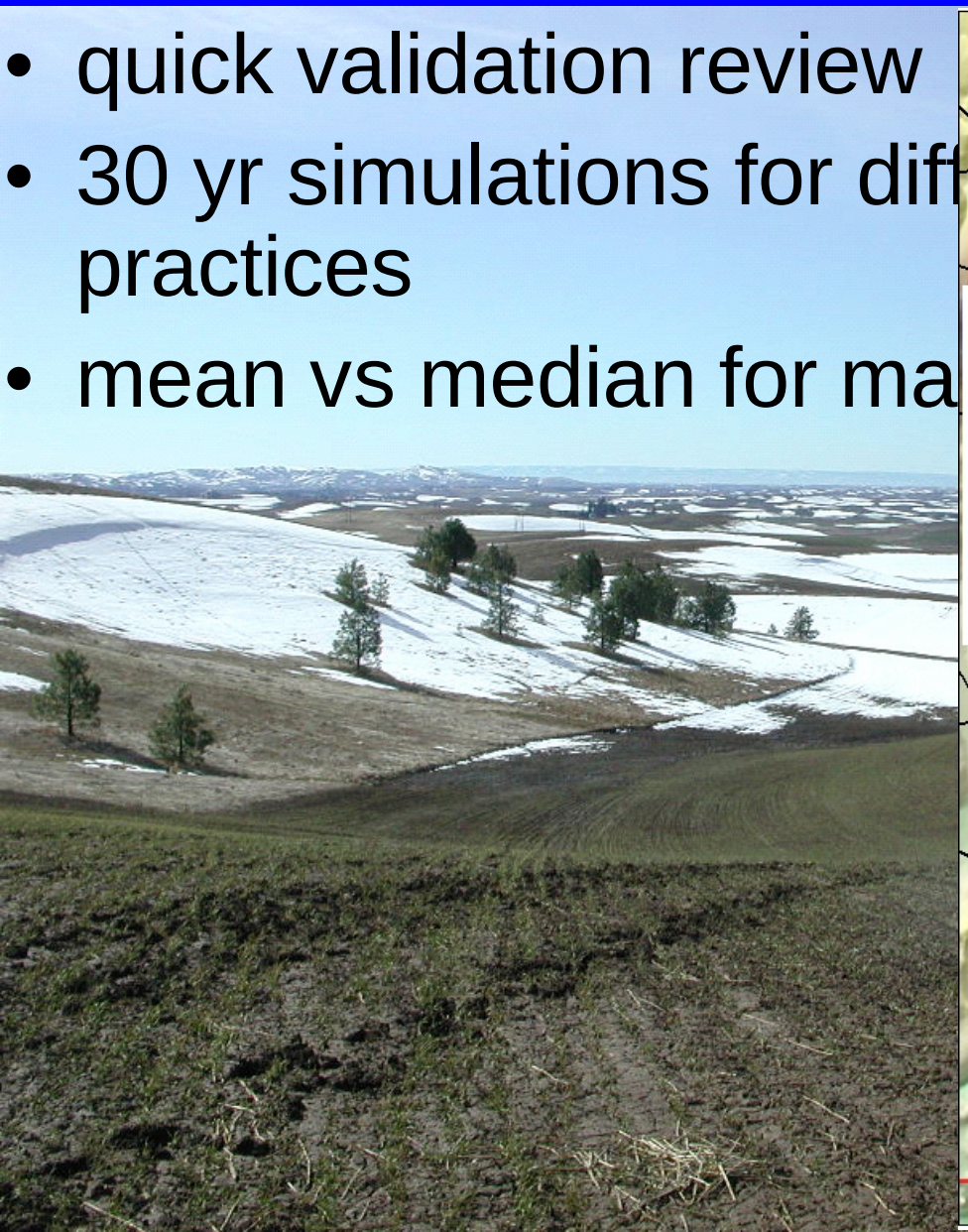


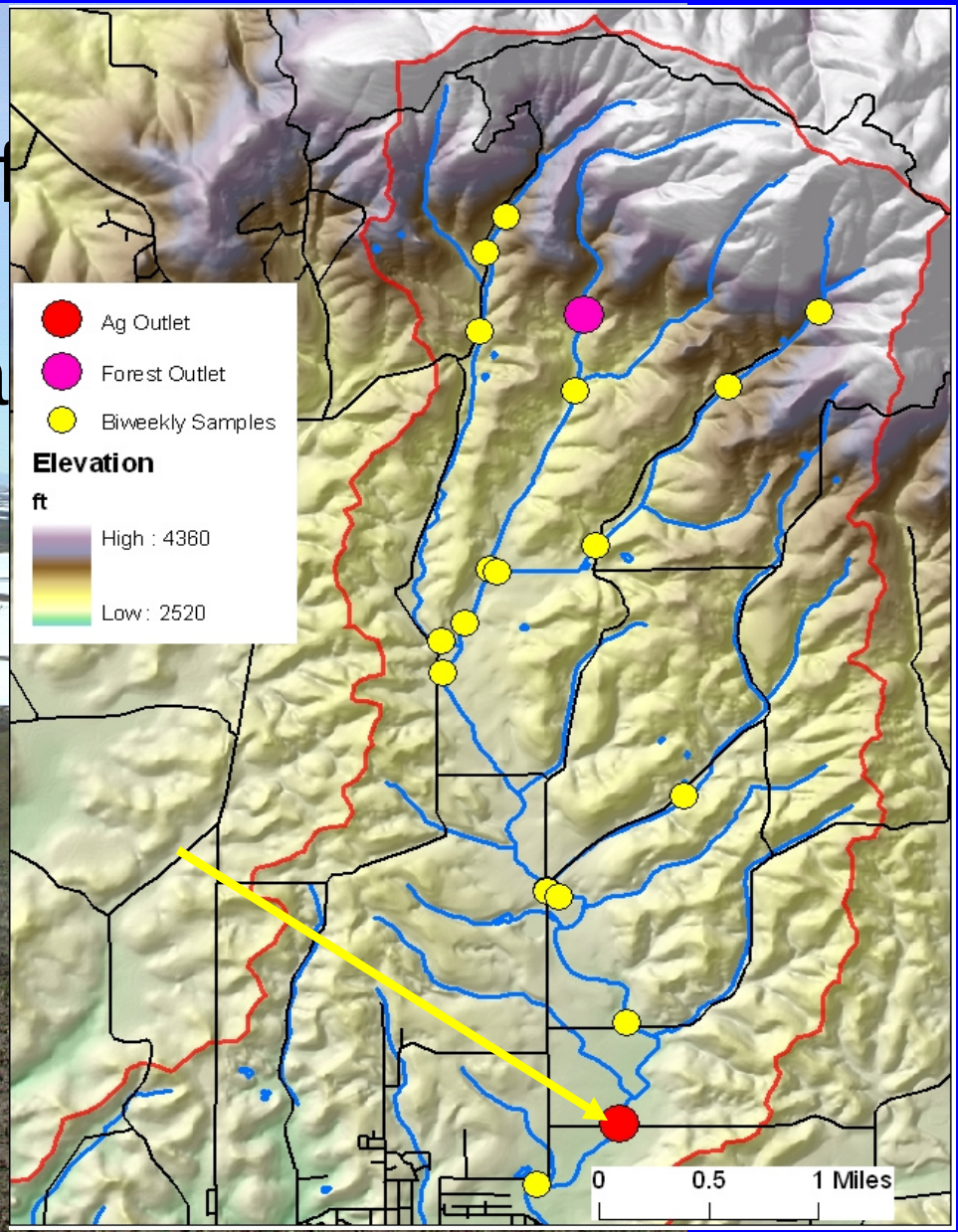
Single Hillslope: Lateral flow, Runoff, Erosion and Deposition



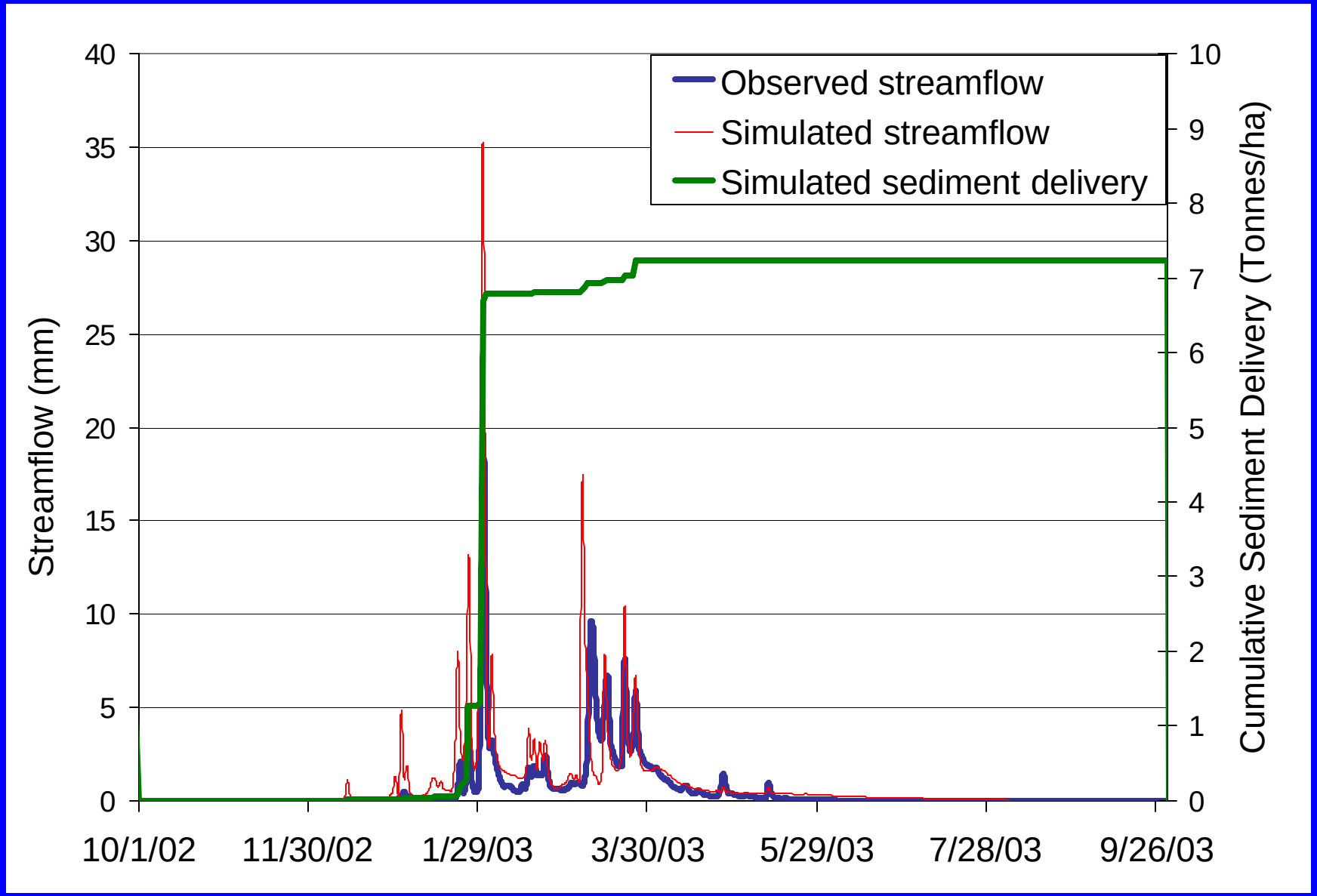
Application to Paradise Creek

- quick validation review
- 30 yr simulations for diff practices
- mean vs median for ma

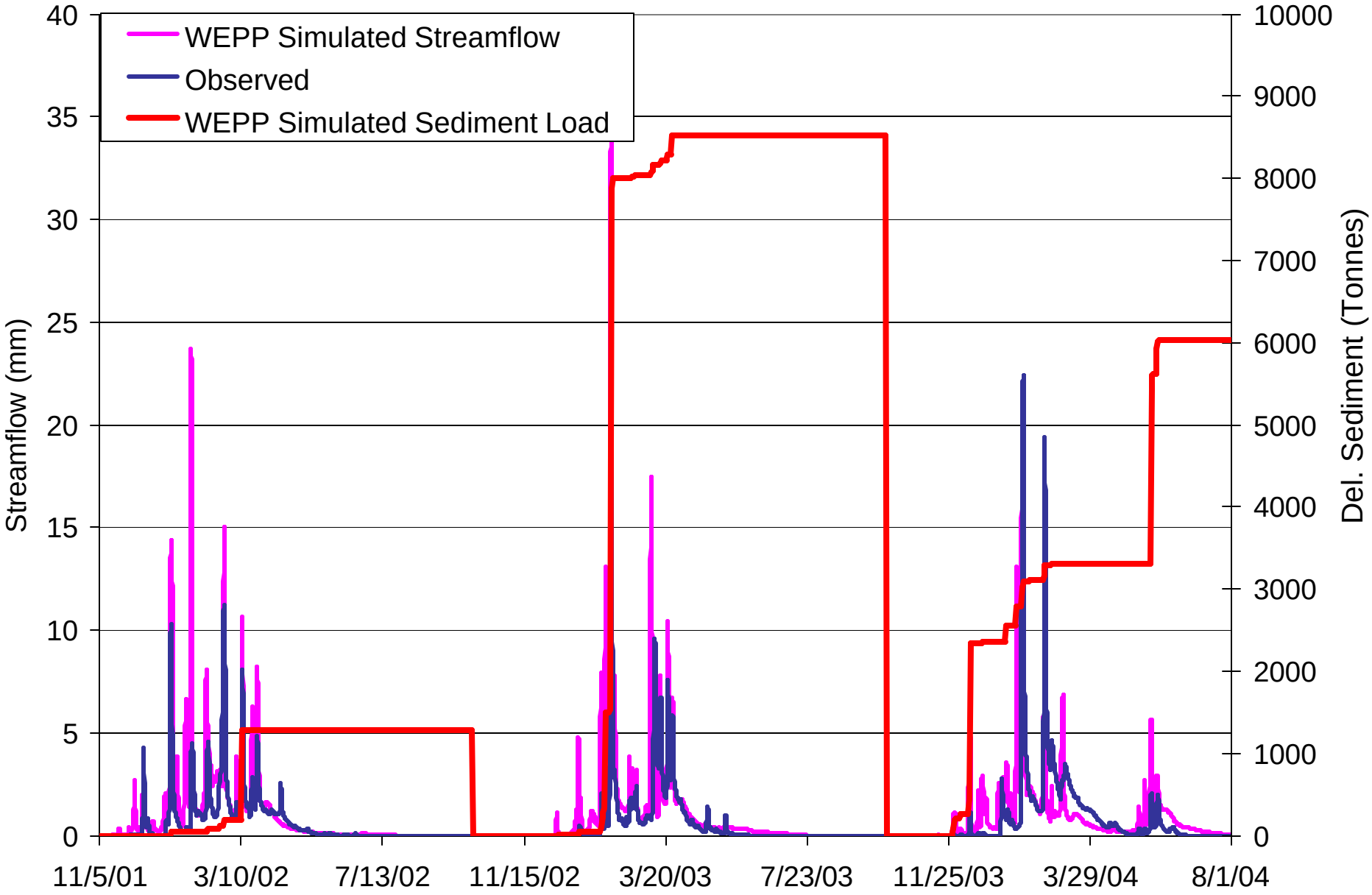


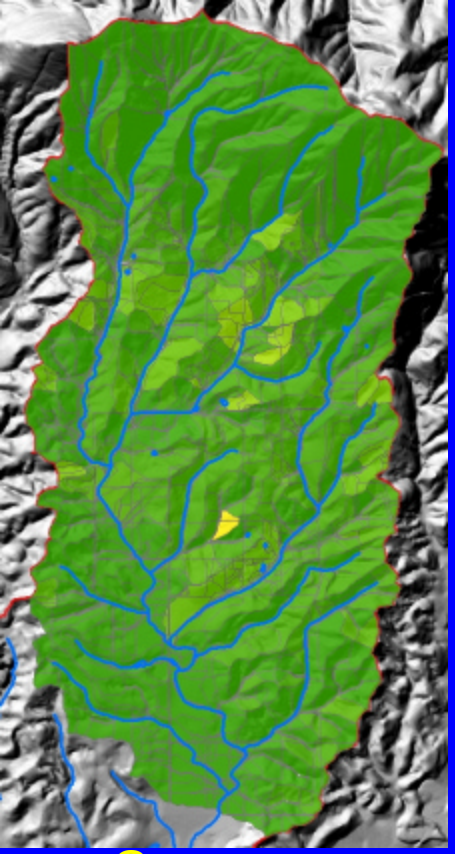


Application to Paradise Creek



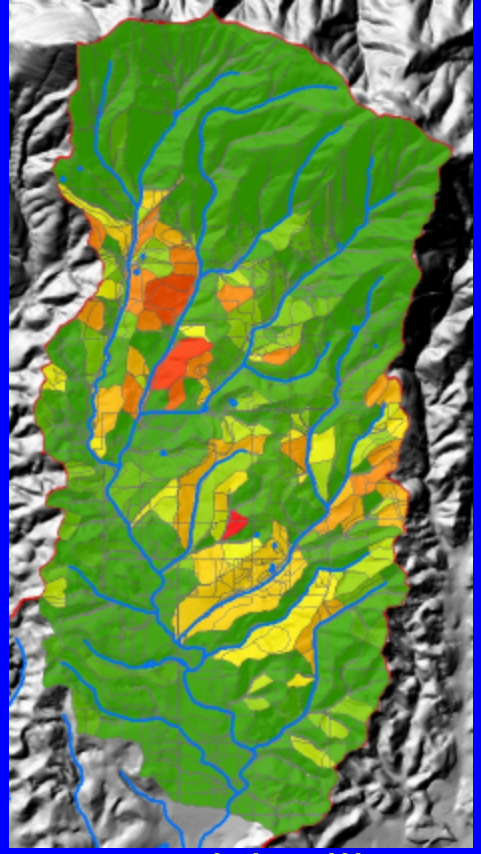
Streamflow and Sediment Load



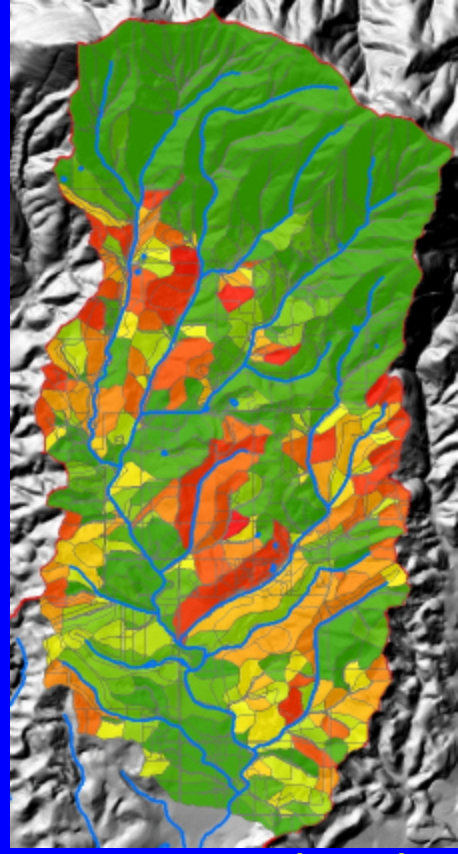


Grass
0.07 Tons/ac
614 Tons

Direct Seed
0.1 tons/ac
1100 tons



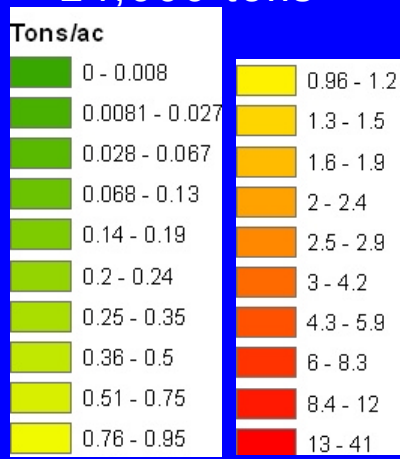
Mulch Till
0.9 tons/ac
10,000 tons



Conventional
2.5 tons/ac
24,000 tons

Winter Wheat
Spring Barley
Spring Peas
Rotation

Sediment Delivery by Hillslope



***30 year Averages

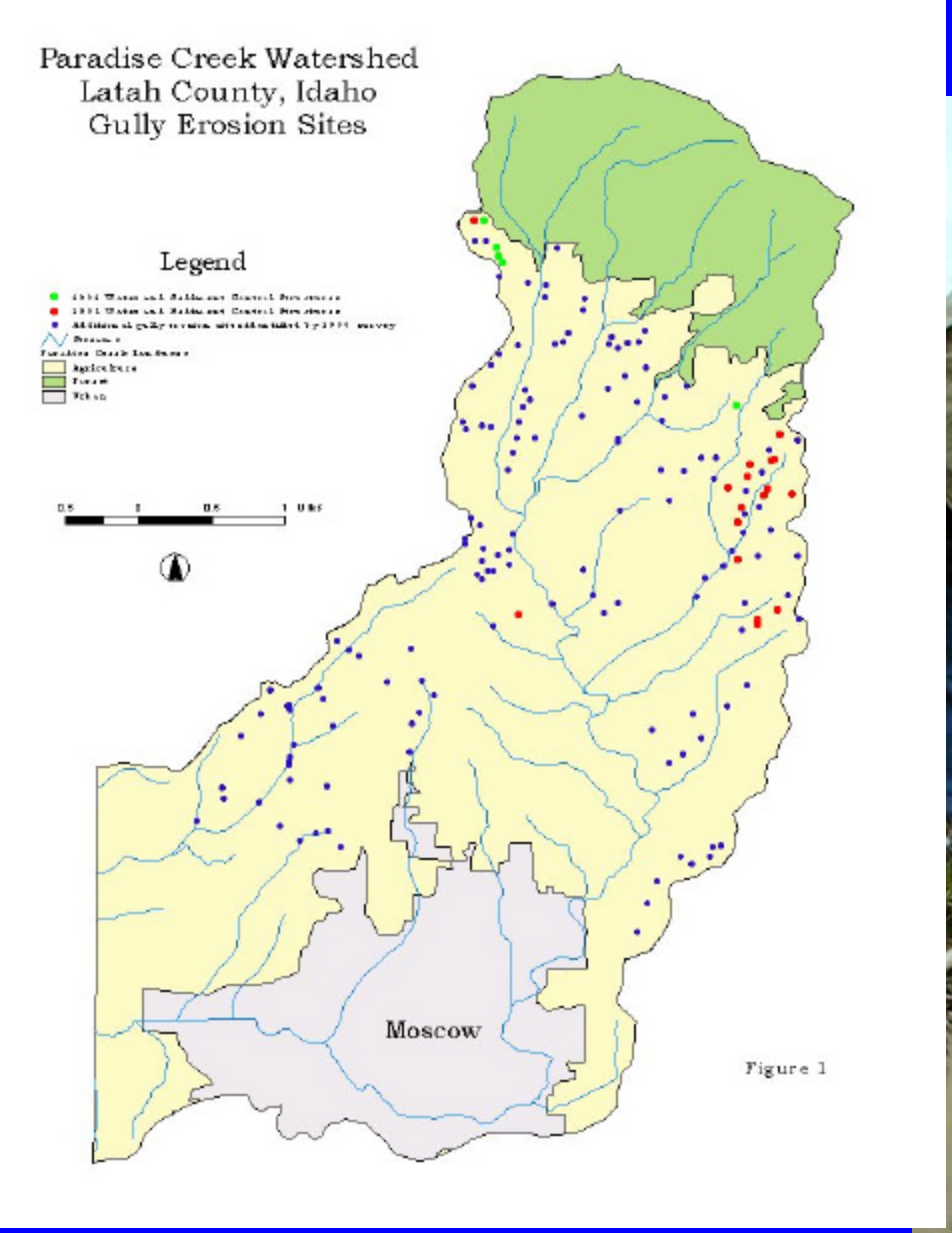
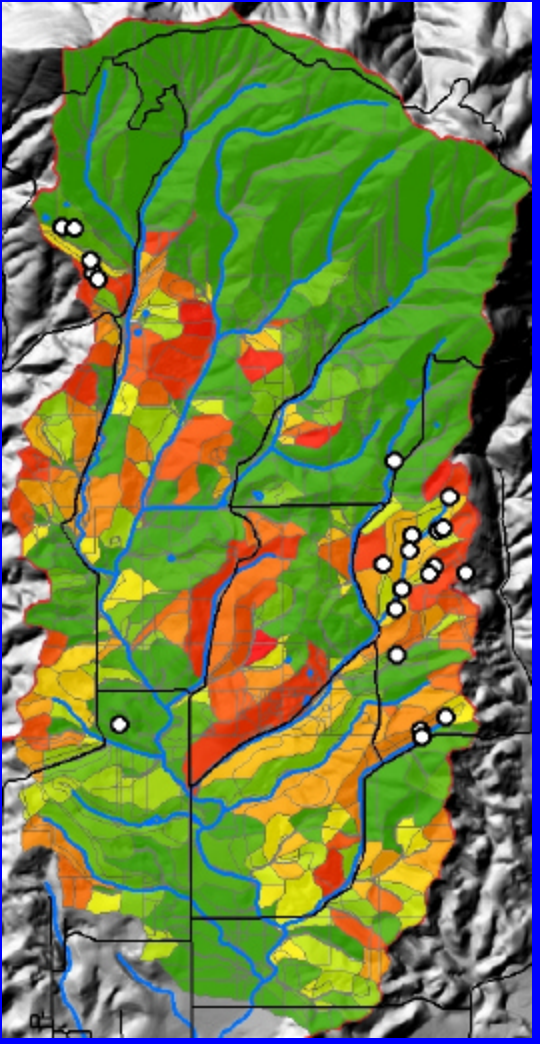
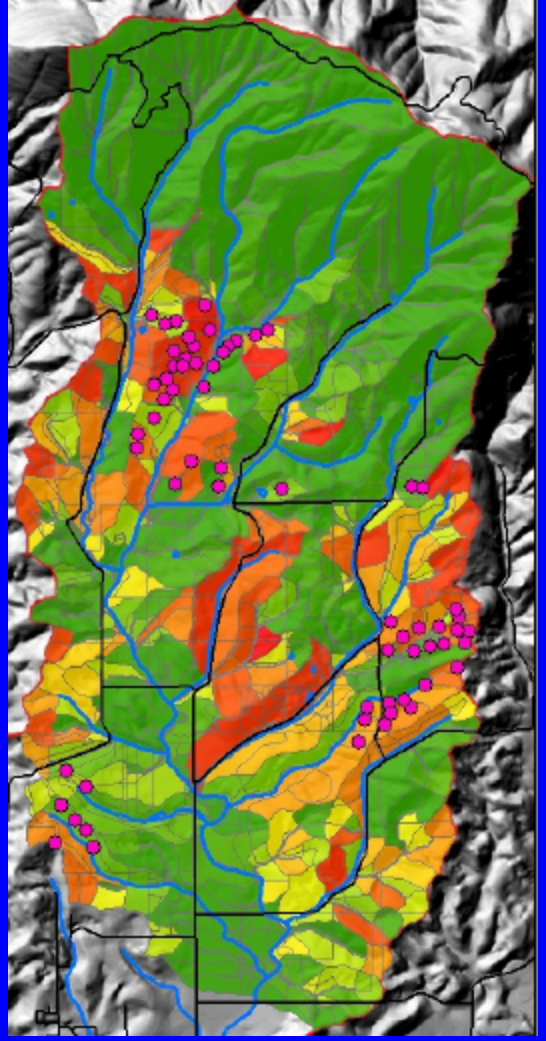


photo: Bill Dansert ISCC

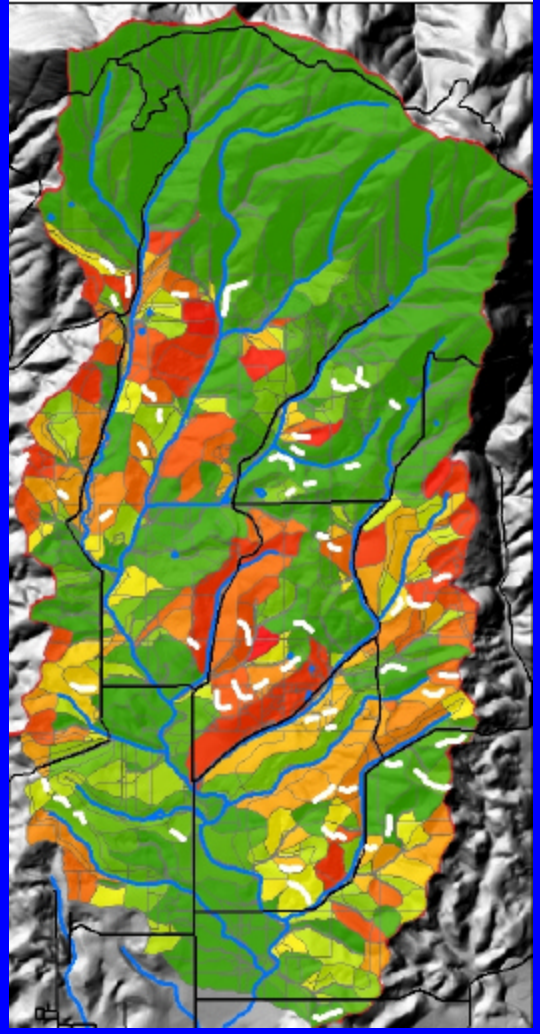


Gully Plugs



Severely eroded spots

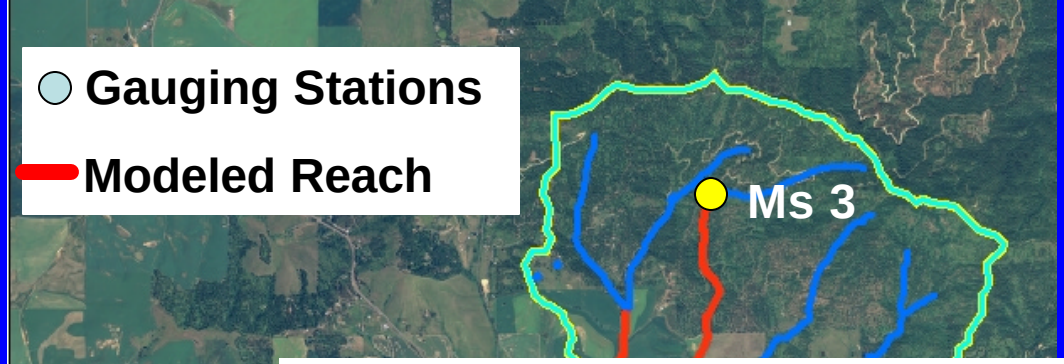
- Areas where on the average 75 percent or more of the original surface layer has been lost from accelerated erosion. Typically 2 to 5 acres.

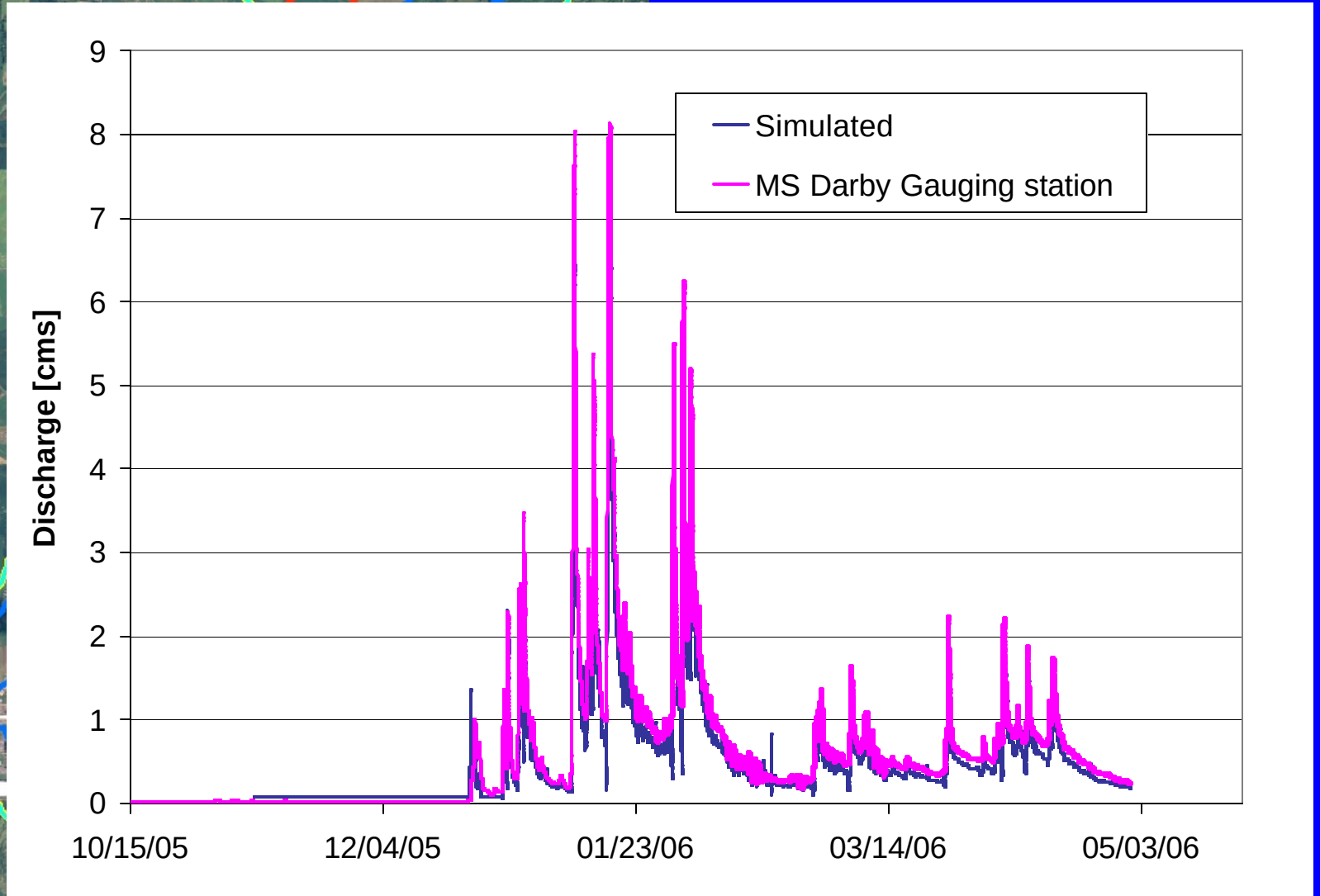


Escarpments

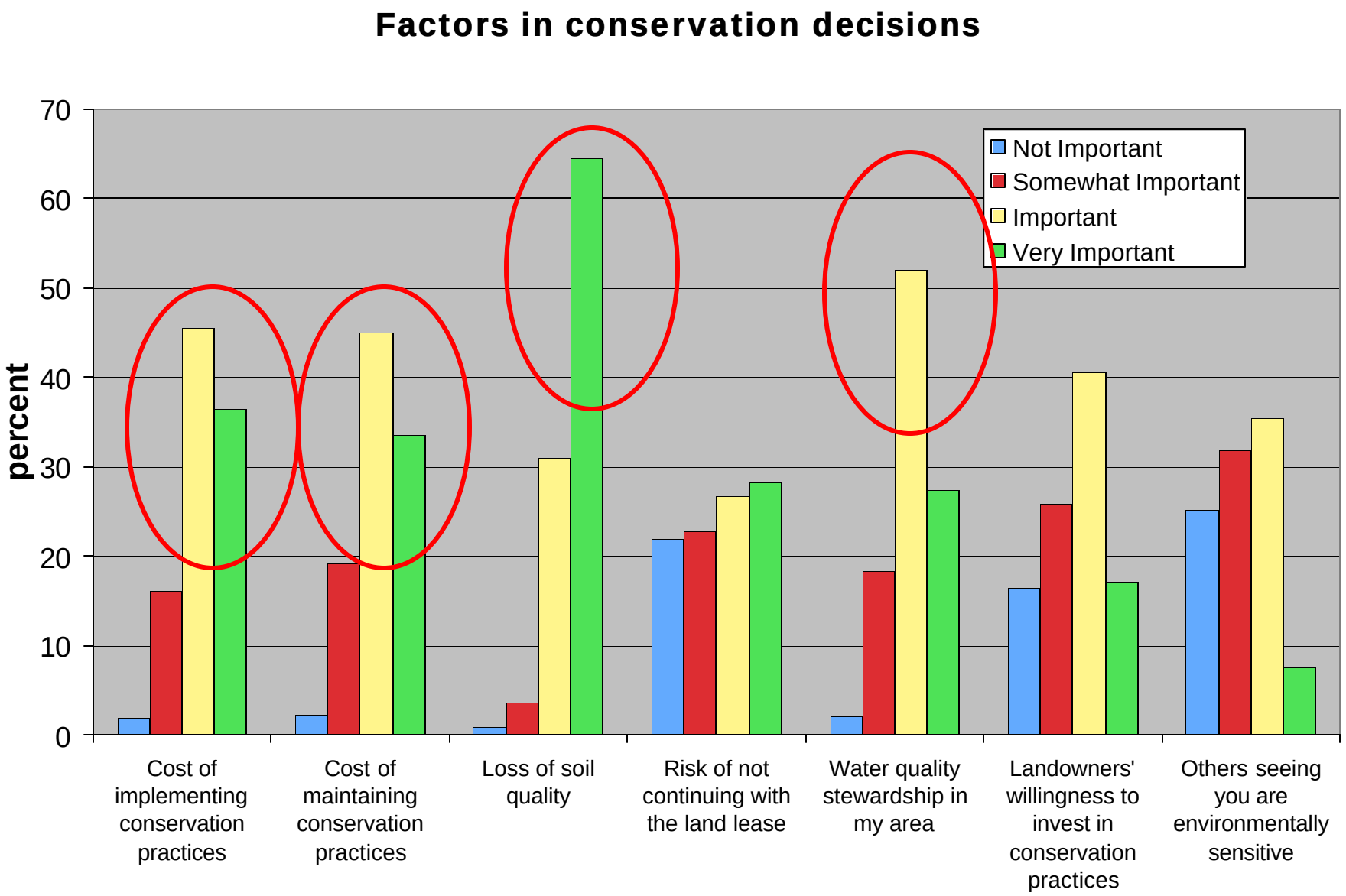
A relatively continuous and steep slope or cliff generally produced by erosion, but can be produced by faulting, breaking the continuity of more gently sloping land surfaces.

CONCEPTS: Stream modeling





Regional Survey



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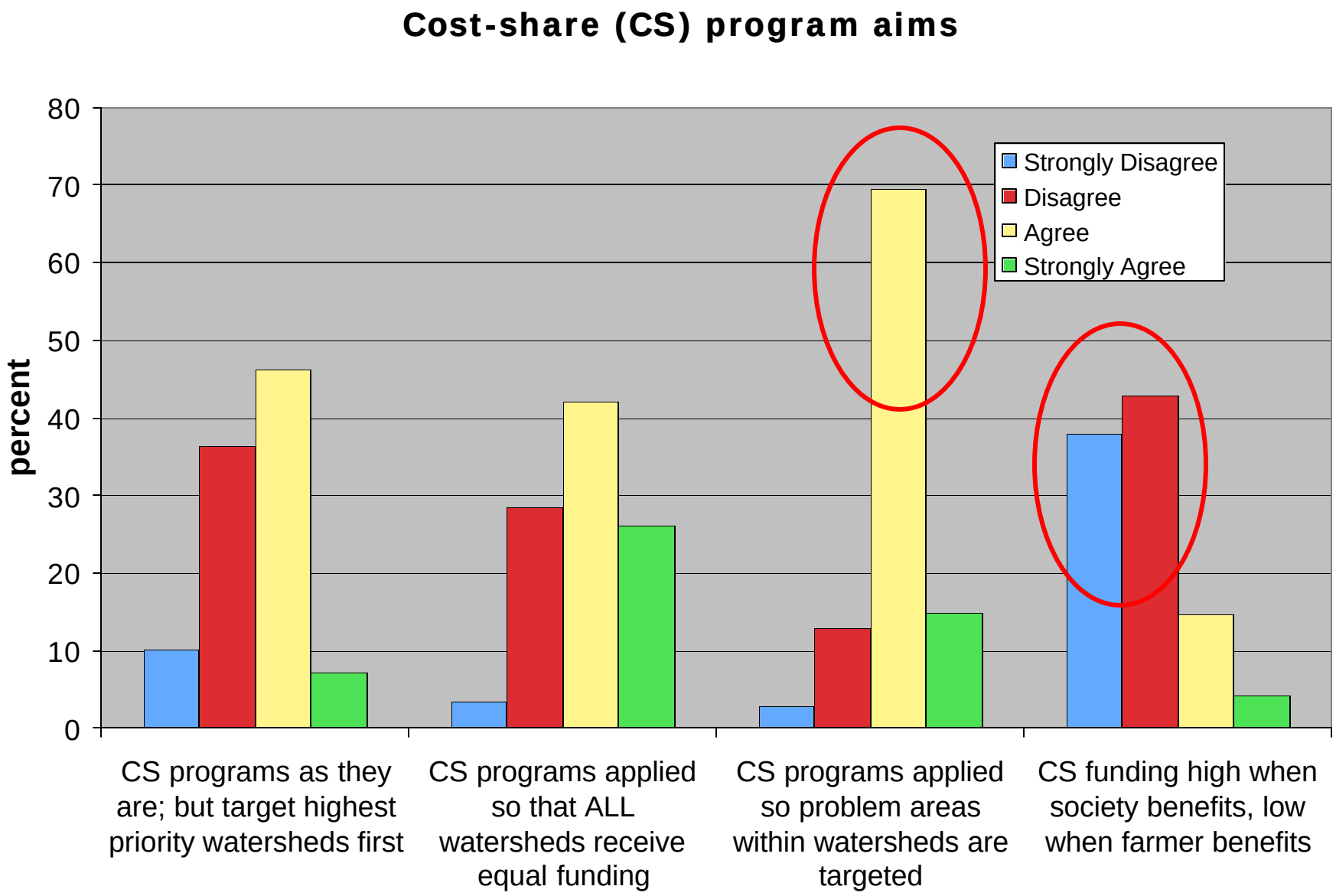
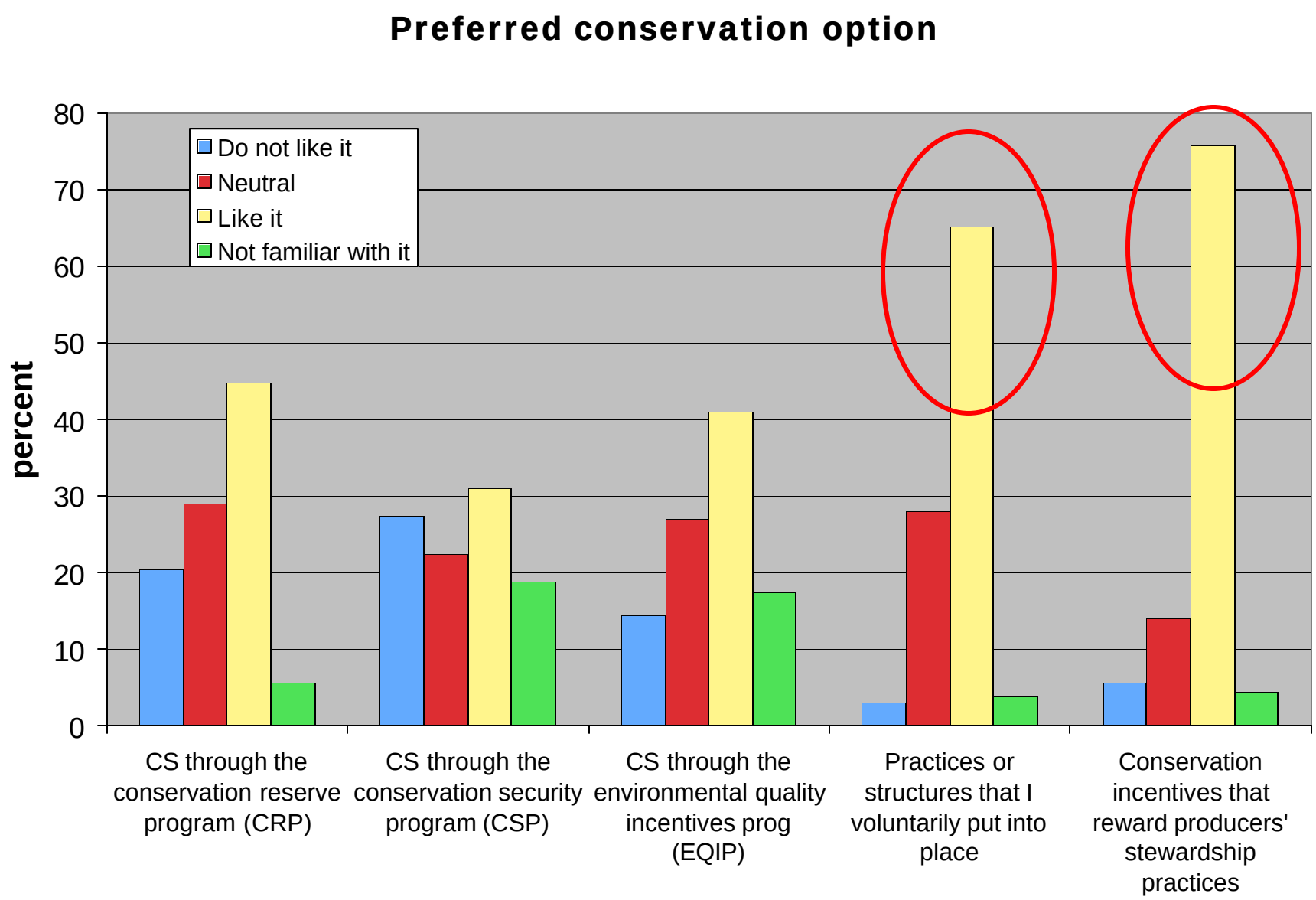


Regional Survey



Data

- Field-by-file operating and ownership costs for each of the 4 operators in the watershed.

- Yield data:
  - CROPSYST simulation model

- Sediment delivery data:
  - WEPP model

Operator Costs/Acre, Winter Wheat

	Oper 1	Oper 2	Oper 3	Oper 4	UI budget
Seed	23.20	29.00	26.10	29.00	12.80
Fertilizer	82.00	75.80	61.32	72.45	62.65
Chemicals	27.31	41.26	10.50	20.45	27.30
Repairs	2.77	8.84	12.97	5.04	7.28
Fuel	7.62	4.44	13.17	4.48	26.82
Labor	5.12	1.35	5.32	4.49	20.52
Ownership	54.10	27.47	11.05	14.99	67.09
Total	**$202**	**$188**	**$140**	**$151**	**$224**
Total Acres	**1,606**	**1,998**	**691**	**1,508**	**n/a**

Optimization Model

- Maximize net returns to ownership:

$$Max \prod_{C,F} = (P_C * Y_{C,F} - C_{C,F}) X_{C,F}$$

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

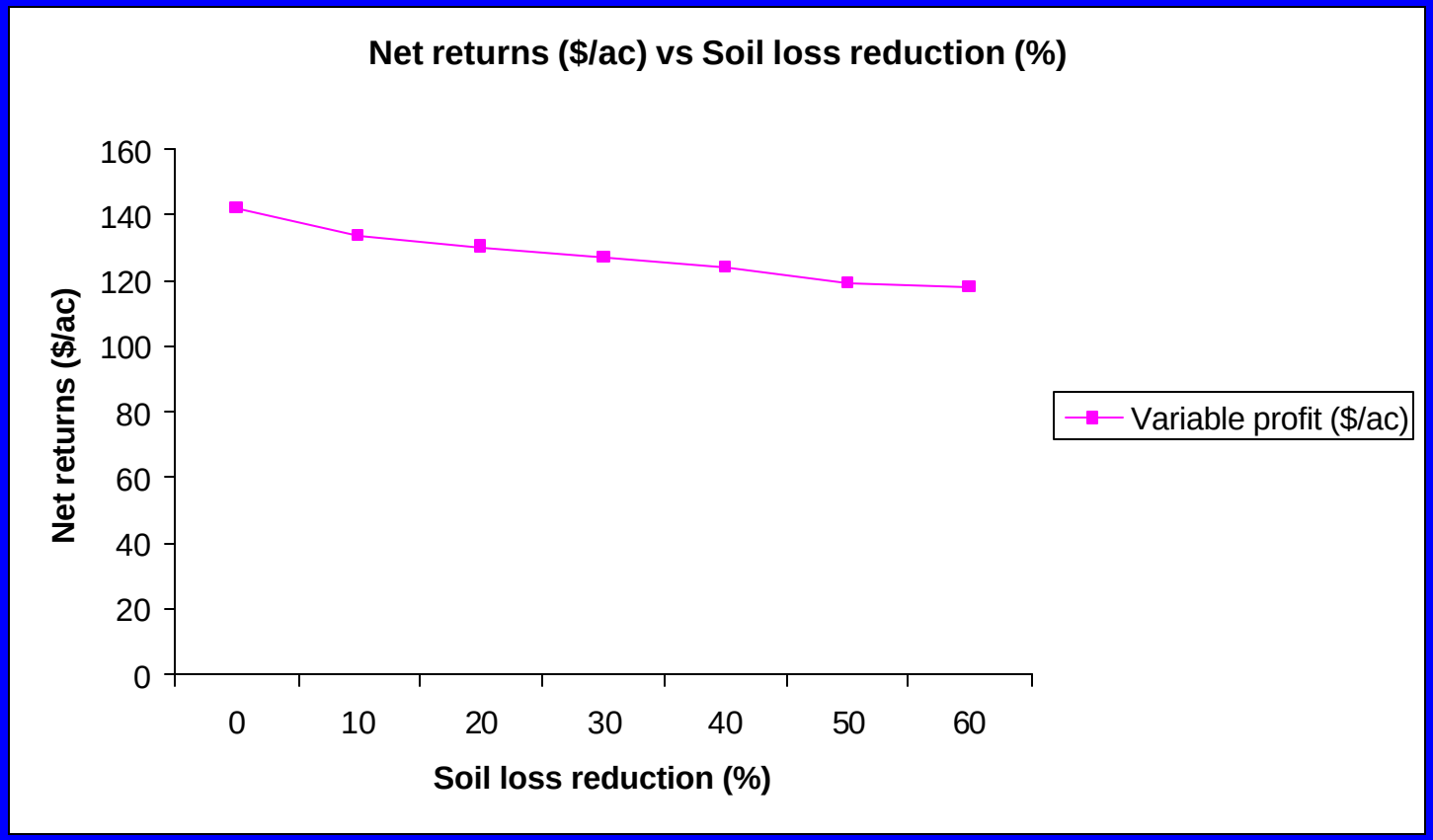
$$\sum_C X_{C,F} = L_F$$

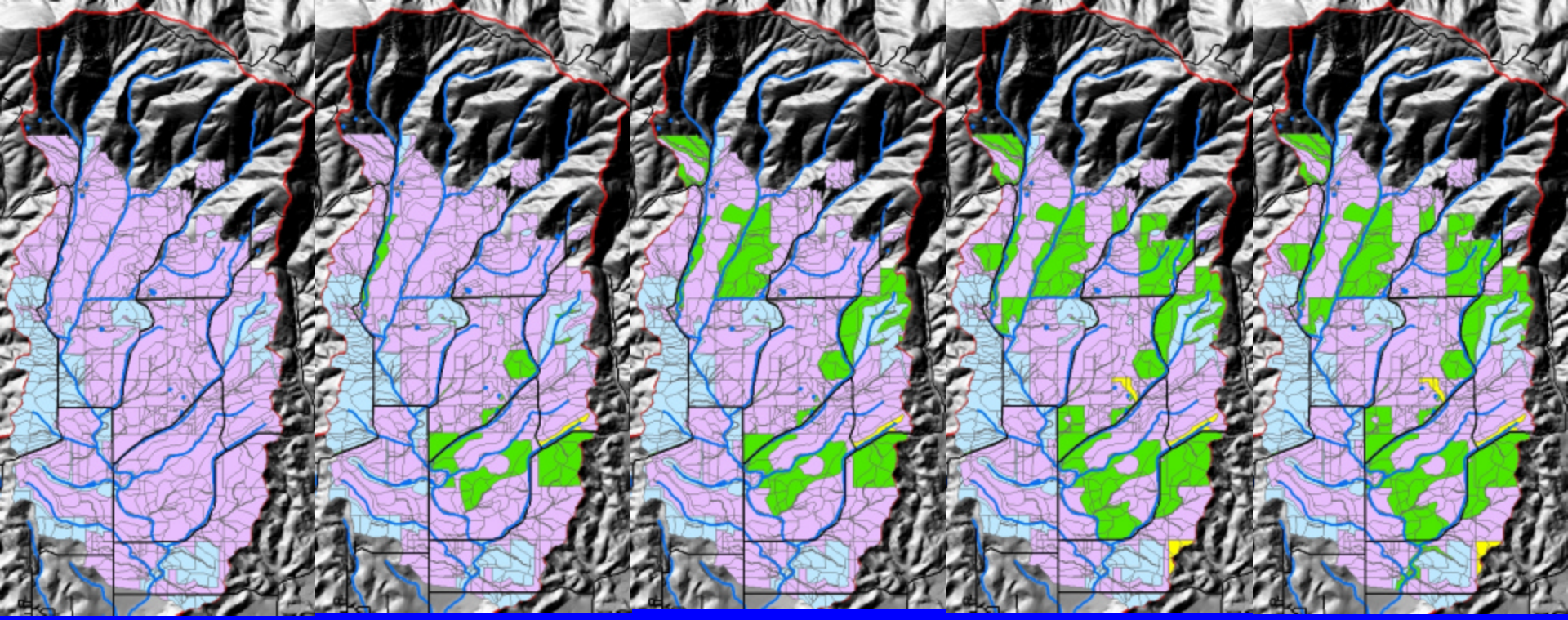
$$\Sigma e_{C,F} X_{C,F} \leq E$$

Optimization Results

			Crop distribution				
Soil loss reduction (%)	Area (ac)	Returns to Ownership($/ac)	Winter wheat (ac)	Barley (ac)	Lentil (ac)	Peas (ac)	CRP (ac)
0	4943	142	2471	0	2016	461	0
10	4943	133	2237	9	1772	456	469
20	4943	131	2178	9	1700	468	587
30	4943	127	2039	9	1562	468	865
40	4943	124	1913	9	1448	461	1128
50	4943	119	1837	23	1377	438	1268
60	4943	118	1837	23	1359	456	1311

Optimization Results





0% Reduction	10% Reduction	30% Reduction	50% Reduction	60% Reduction
0% CRP	9% CRP	18% CRP	26% CRP	27% CRP

Optimization

-maximize profit while reducing sediment load

Available Options

- Winter Wheat, Spring Wheat, Barley, Peas, Lentils, CRP
- Mulch Tillage

Next

- Yield expectations:
  - Conventional Tillage
  - Conservation Tillage
  - No-till
- Time and cost of BMP’s
- Comparison
  - regional survey and budgets with watershed

Next

- Manage for median conditions or extreme events?
  - MOTAD and Safety-First constraints
- Landowner/operator relationships
- What level of cost-share is needed to adequately target ‘hot spots’ in the watershed?

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
- Tom Lamar, Greg Fizell, David Vollmer: Palouse Clear Water Environmental Institute, Moscow, ID

Thank you!

University of Idaho