WEPP—A Process-Based Hydrology and Erosion Model for Watershed Assessment and Restoration

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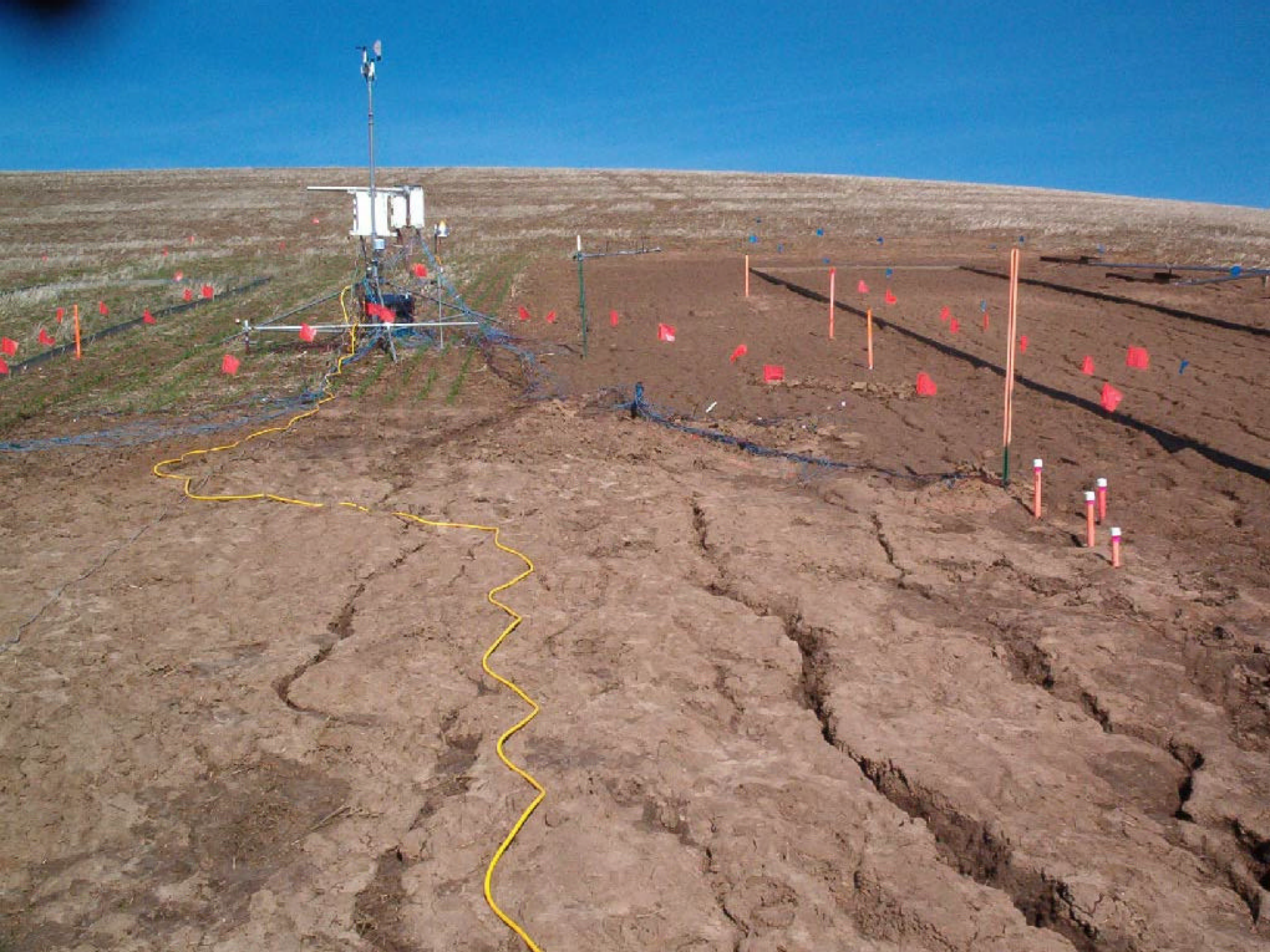
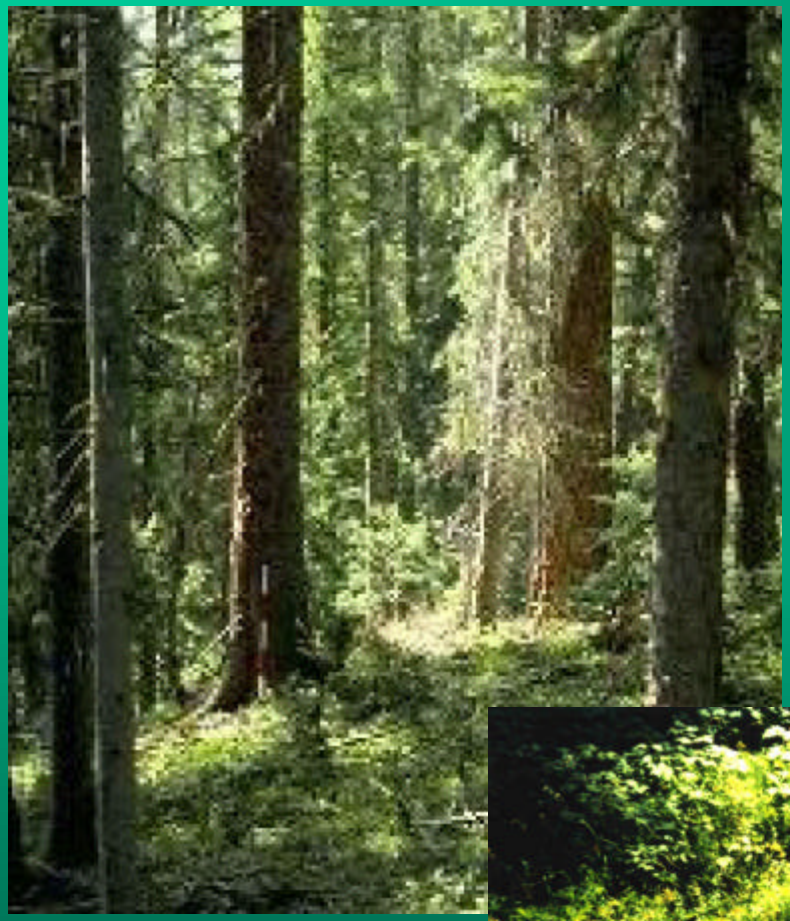
The Needs

- Protecting and improving water quality in agricultural watersheds are major goals of the CSREES NWQ and NRI Programs
- For many watersheds, sediment is the greatest pollutant
- In watershed assessment, it is key to understand sedimentation processes and their impacts on water quality
- To successfully implement erosion control practices, it is necessary to determine the spatiotemporal distribution of sediment sources and potential long-term effectiveness of sediment reduction by these practices





- Surface runoff and erosion from undisturbed forests are negligible
- Stream formed due to subsurface flow has low sediment

- Both surface runoff and erosion can increase dramatically due to disturbances
- Models are needed as a tool for forest resource management

The WEPP Model

- WEPP: Water Erosion Prediction Project
  - a process-based erosion prediction model developed by USDA ARS
  - built on fundamentals of hydrology, plant science, hydraulics, and erosion mechanics
- WEPP's unique advantage: it models watershed-scale spatial and temporal distributions of soil detachment and deposition on event or continuous basis
- Equipped with a geospatial processing interface, WEPP has great potential as a reliable and efficient tool for watershed assessment

Long-term Research Efforts

Goal

- Continuously refine and apply the WEPP model for watershed assessment and restoration under different land-use, climatic and hydrologic conditions

Objectives

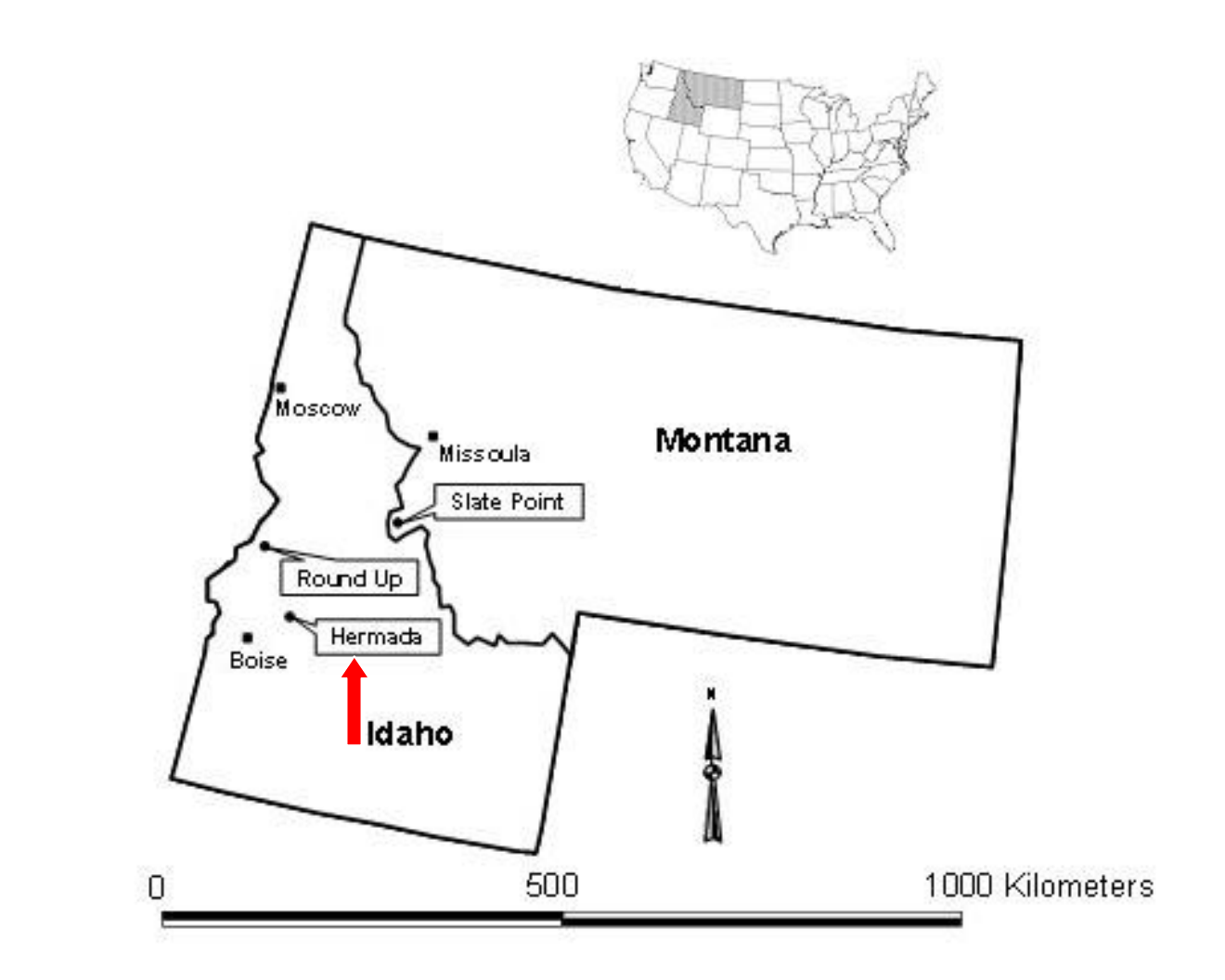
- Improve the winter hydrology and erosion routines through combined experimentation and modeling so that WEPP can be used for quantifying water erosion in the US PNW and other areas where winter hydrology is important
- Improve the subsurface hydrology routines so that WEPP can be used under both infiltration-excess and saturation-excess runoff conditions in crop-, range- and forestlands
- Continually test the suitability of WEPP using data available from different localities across the world

Progress

- Numerous modifications to WEPP have been made to
  - Correct the hydraulic structure routines
  - Improve the water balance algorithms
  - Incorporate the Penman-Monteith ET method (FAO standard)
  - Improve the subsurface runoff routines
  - Expand and improve winter hydrology routines to better simulate
    - Freeze-thaw processes
    - Snow redistribution processes
- WEPP newest release accessible at NSERL's website **http://topsoil.nserl.purdue.edu/nserlweb/index.html**

A Case Application:
Modeling Forest Runoff and Erosion

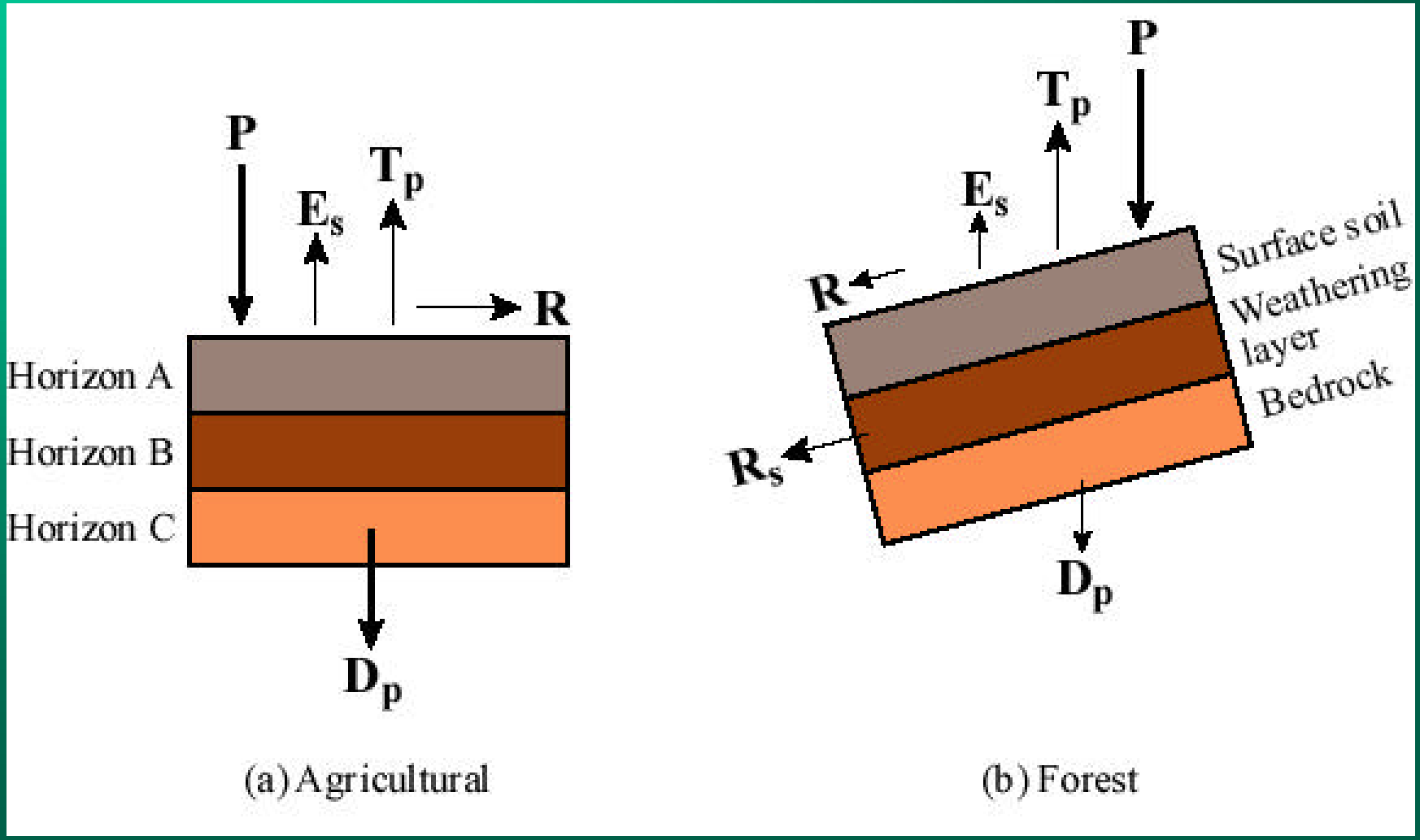
Study Site: Hermada Watershed



Physical Setting

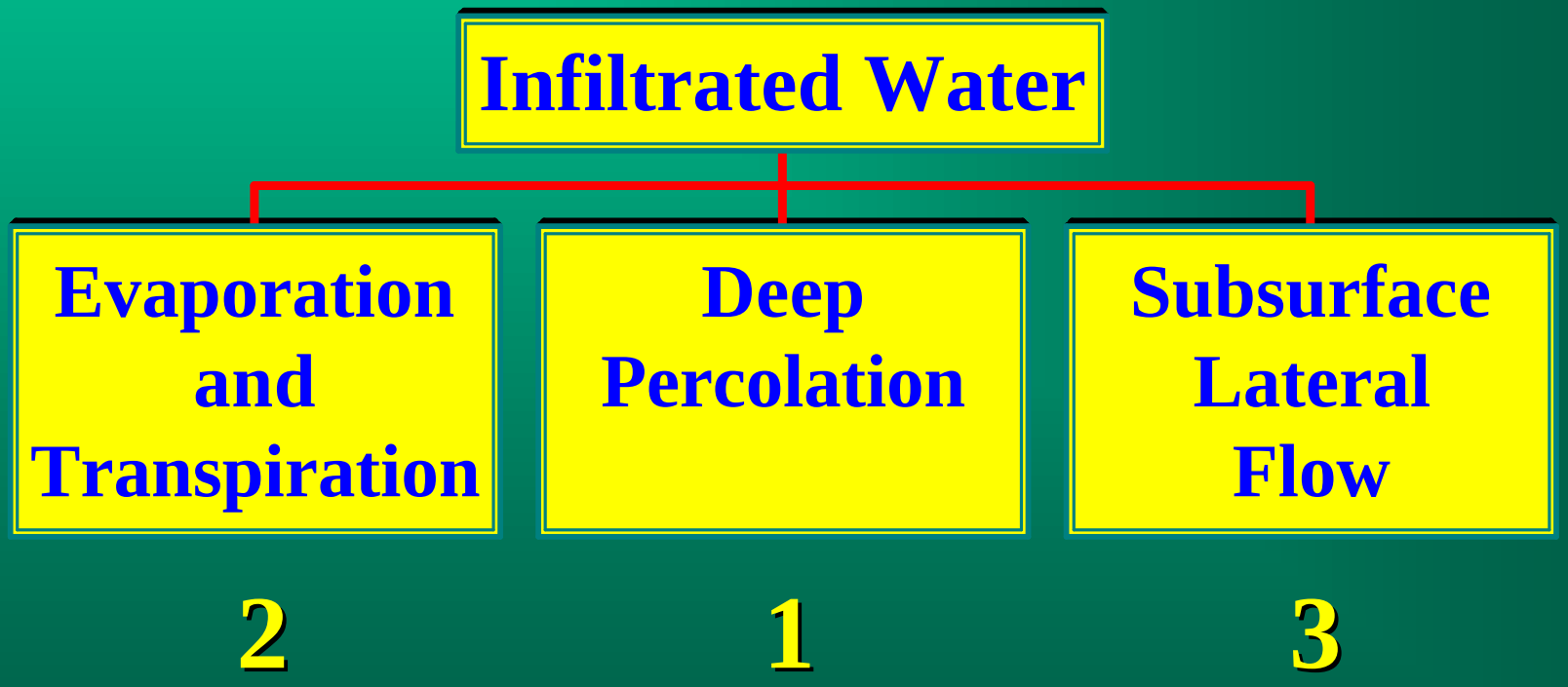
- Located in the Boise National Forest, SE Lowman, ID
- Instrumented during 1995- 2000 to collect whether, runoff and erosion data
- 5-yr observed data showing an average annual runoff of 160 mm out of 790 mm precipitation

Comparison of Processes

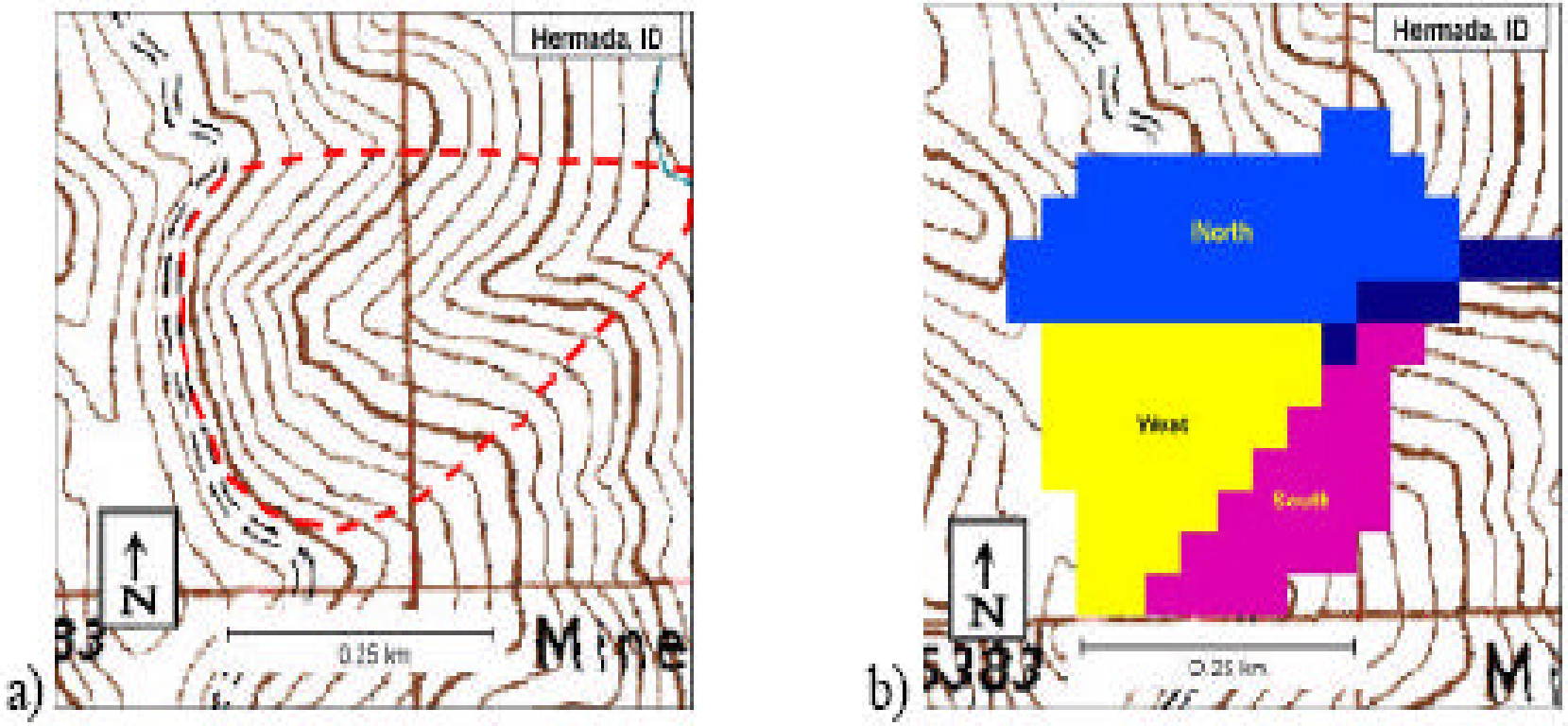


* WEPP previously tended to overestimate D_p

Redistribution of Infiltration Water in WEPP

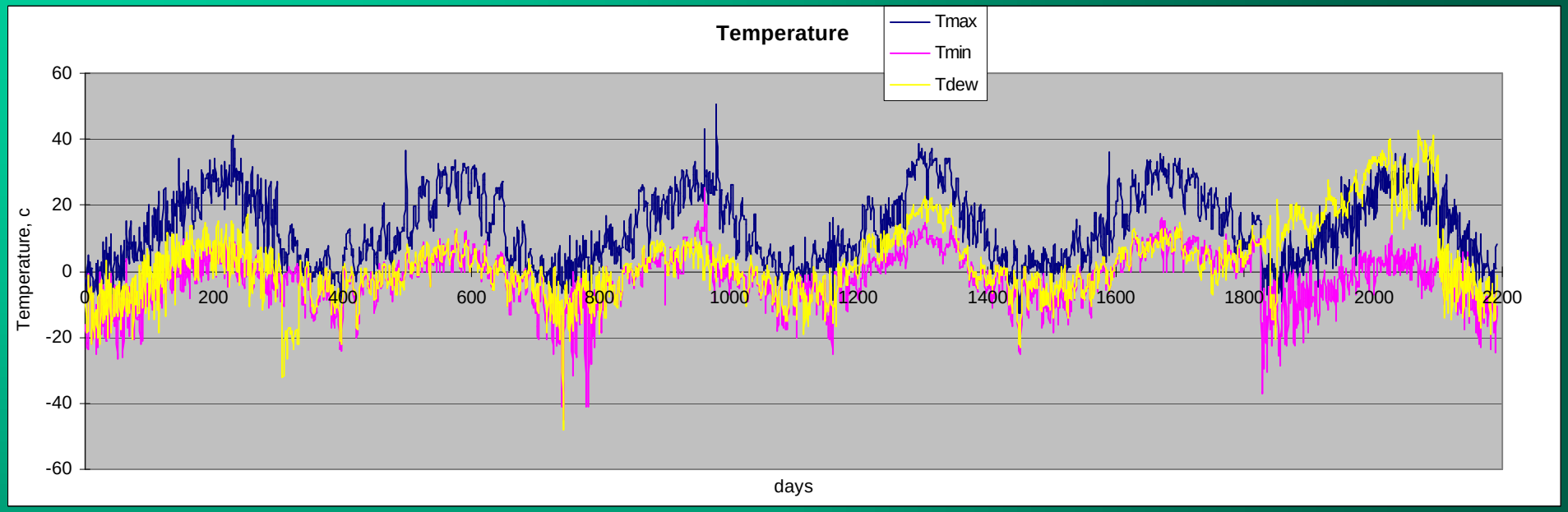


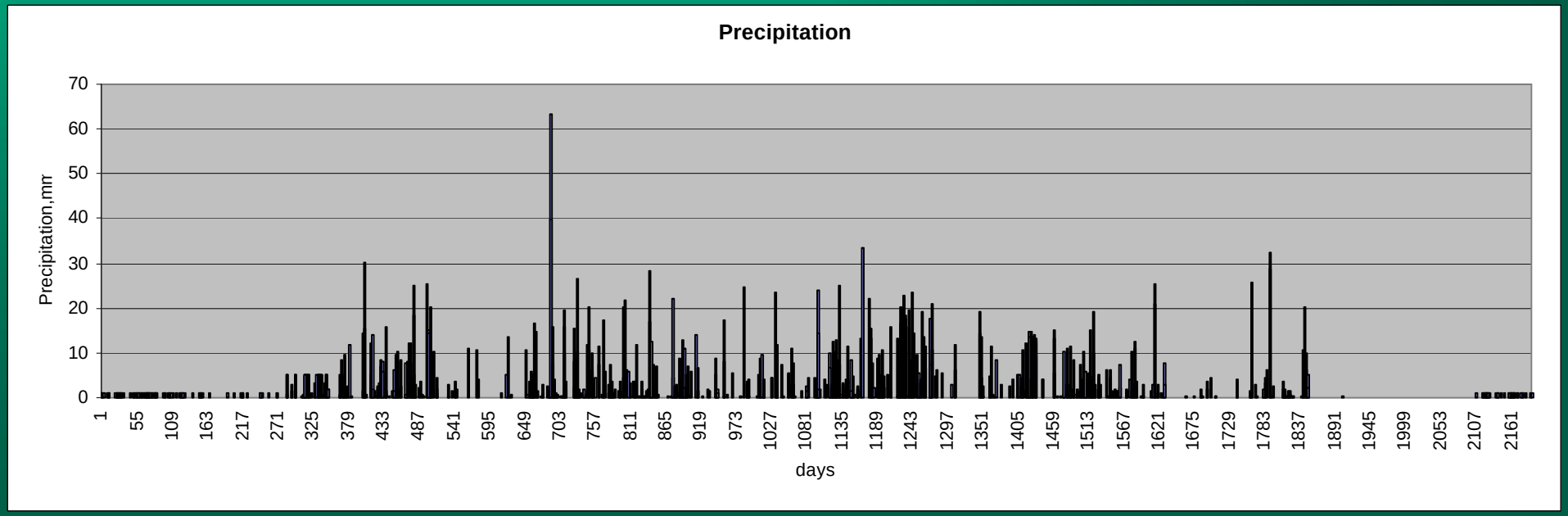
Watershed Discretization



Model Inputs

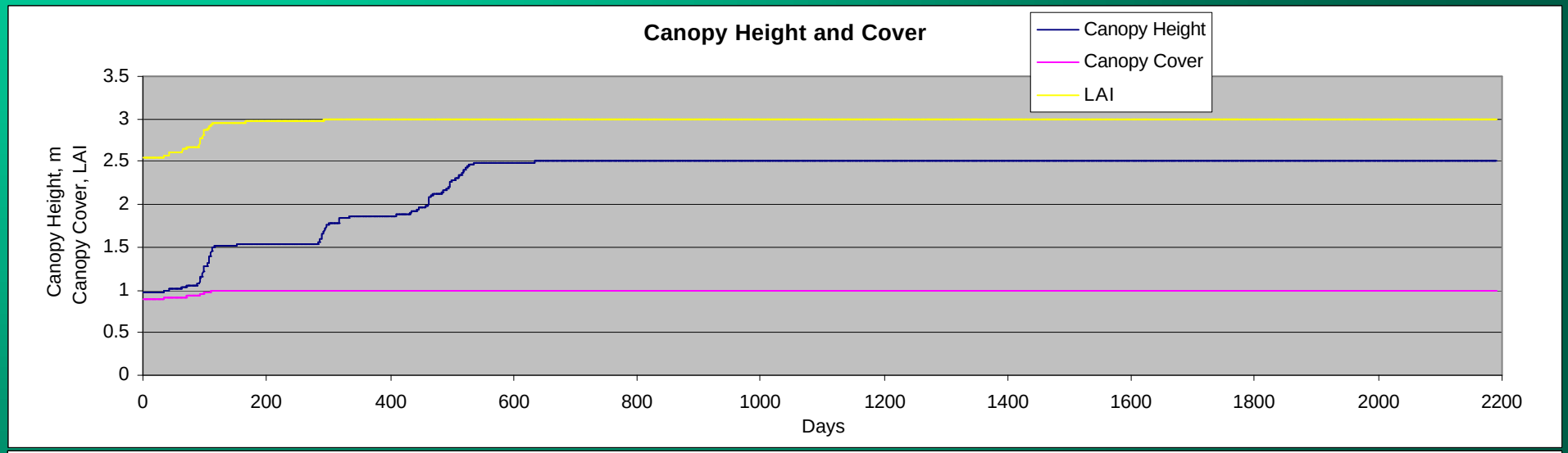
- Topography
  - 9-ha area, 3 hillslopes and 1 channel
  - 40 - 60% slope
- Soil
  - Typic Cryumbrept loamy sand
  - underlying weathered granite
- Management
  - 1992 cable–yarding harvest
  - 10/17/1995 prescribed fire on W and N slopes
- Climate
  - 11/1995 - 09/2000 observed data

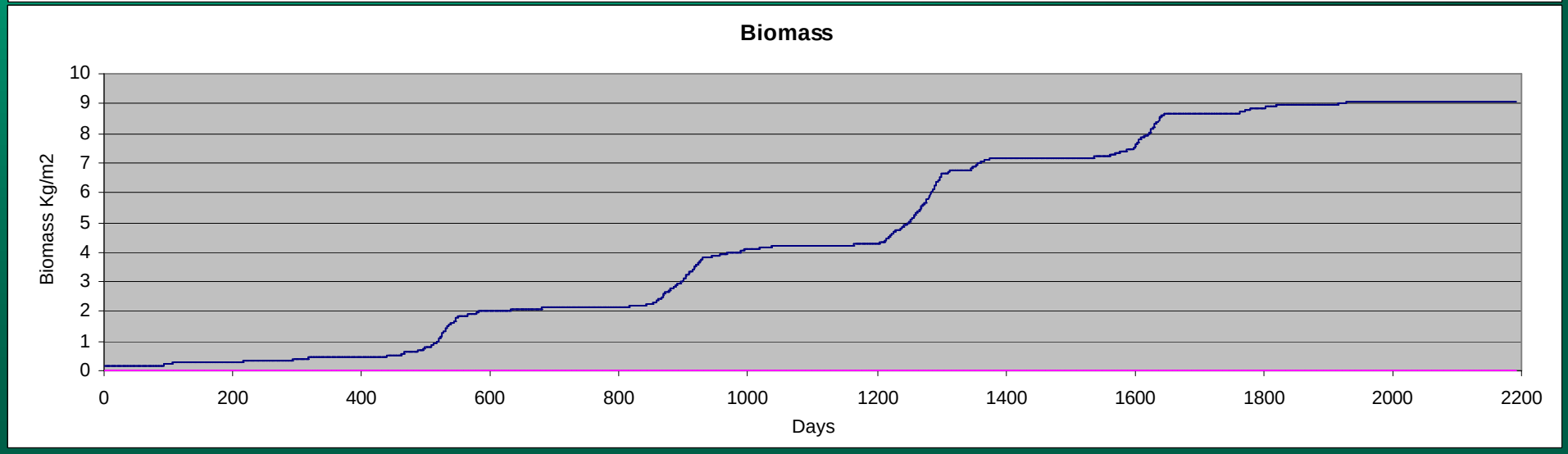

Temperature
Tmax
Tmin
Tdew
Temperature, c
60
40
20
0
-20
-40
-60
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
days


Precipitation
Precipitation,mm
70
60
50
40
30
20
10
0
1
55
109
163
217
271
325
379
433
487
541
595
649
703
757
811
865
919
973
1027
1081
1135
1189
1243
1297
1351
1405
1459
1513
1567
1621
1675
1729
1783
1837
1891
1945
1999
2053
2107
2161
days

Simulated Vegetation

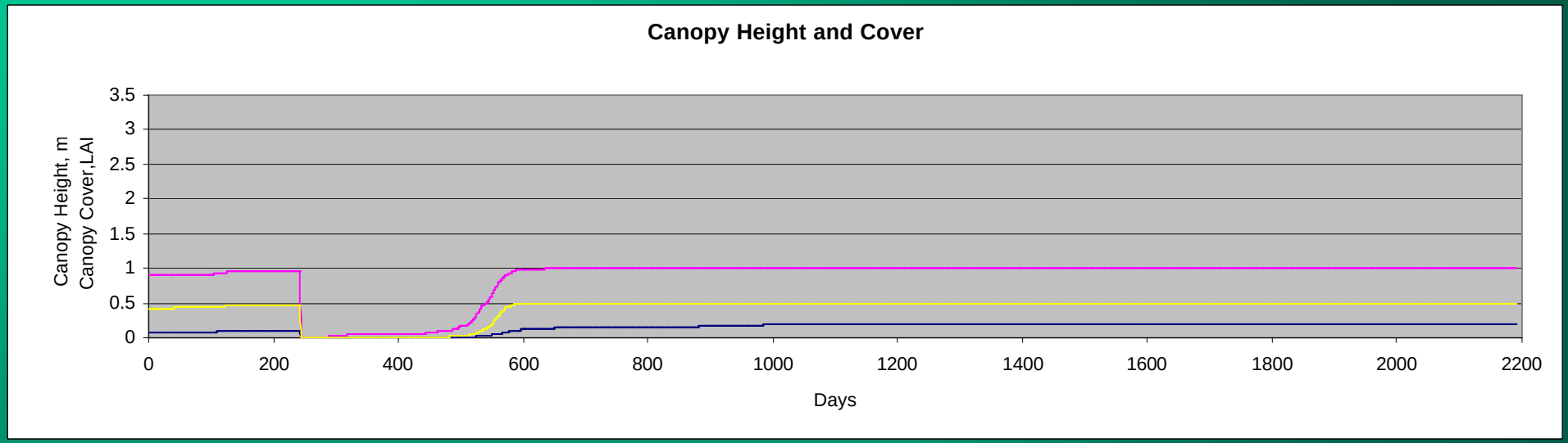
(S Slope: unburned; 5-yr trees)

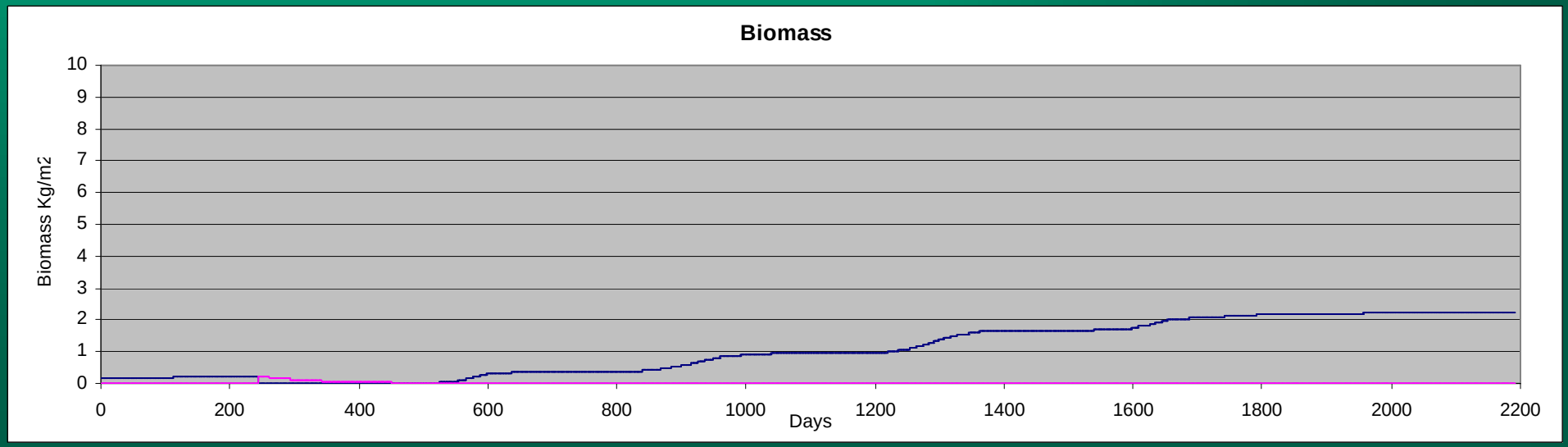




Simulated Vegetation

(N and W Slopes: low severity burn; shrubs)





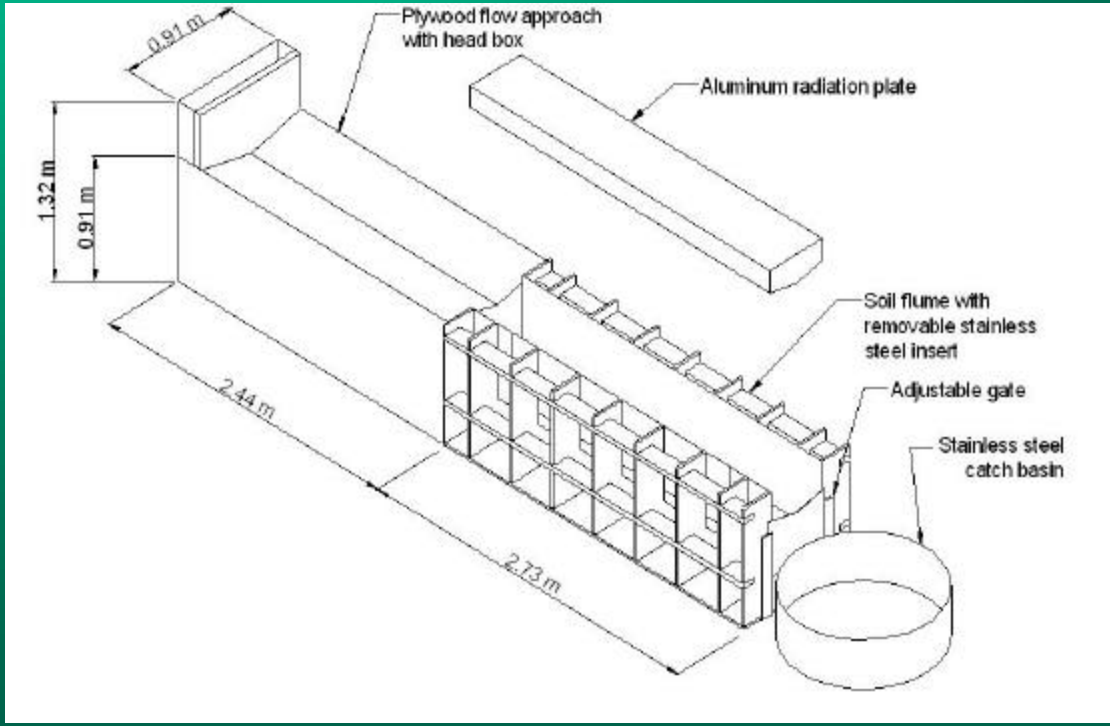
Runoff and Erosion: Obs vs Pre

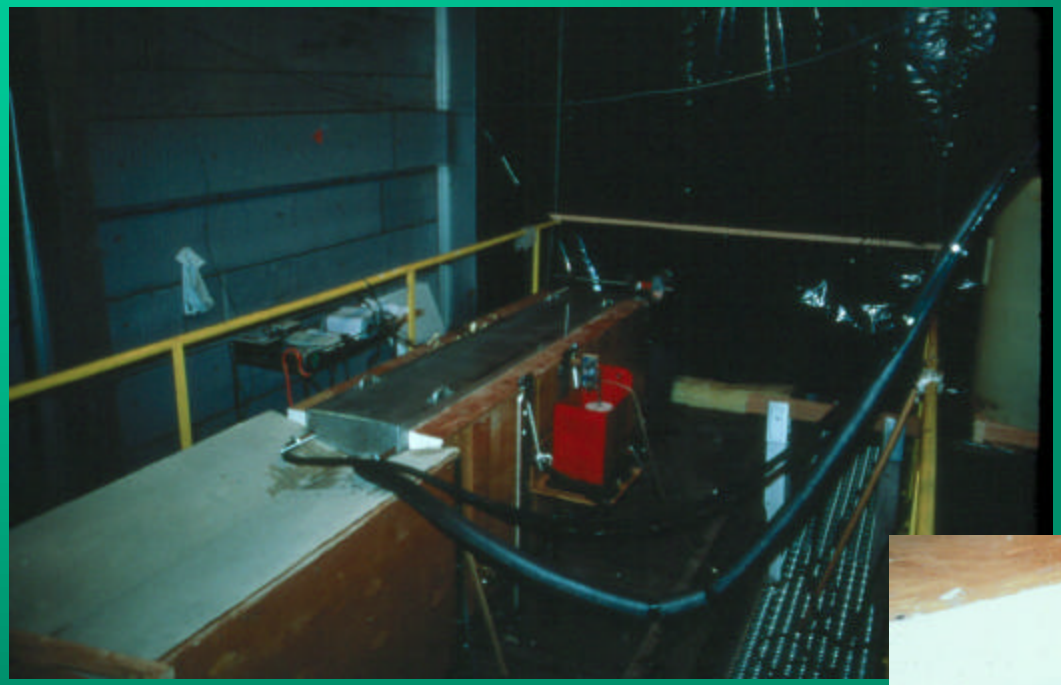
Year	Precipitation (mm)	Observed Runoff (mm)	Observed Sediment (t/ha)	Simulated Hillslope Avg. Runoff (mm)	Simulated Hillslope Avg. Sediment (t/ha)	Simulated Watershed Runoff (mm)	Simulated Watershed Sediment (t/ha)
1995	207	8	0				
1996	870	78	0	130	0.0	134	0.1
1997	673	89	0	103	0.0	107	0.0
1998	1196	322	0	289	0.0	296	0.1
1999	474	179	0	66	0.0	68	0.0
2000	528	136	0				
Average	790	162	0	147	0	151	0.1

Observation Period: 11/3/1995- 9/30/2000

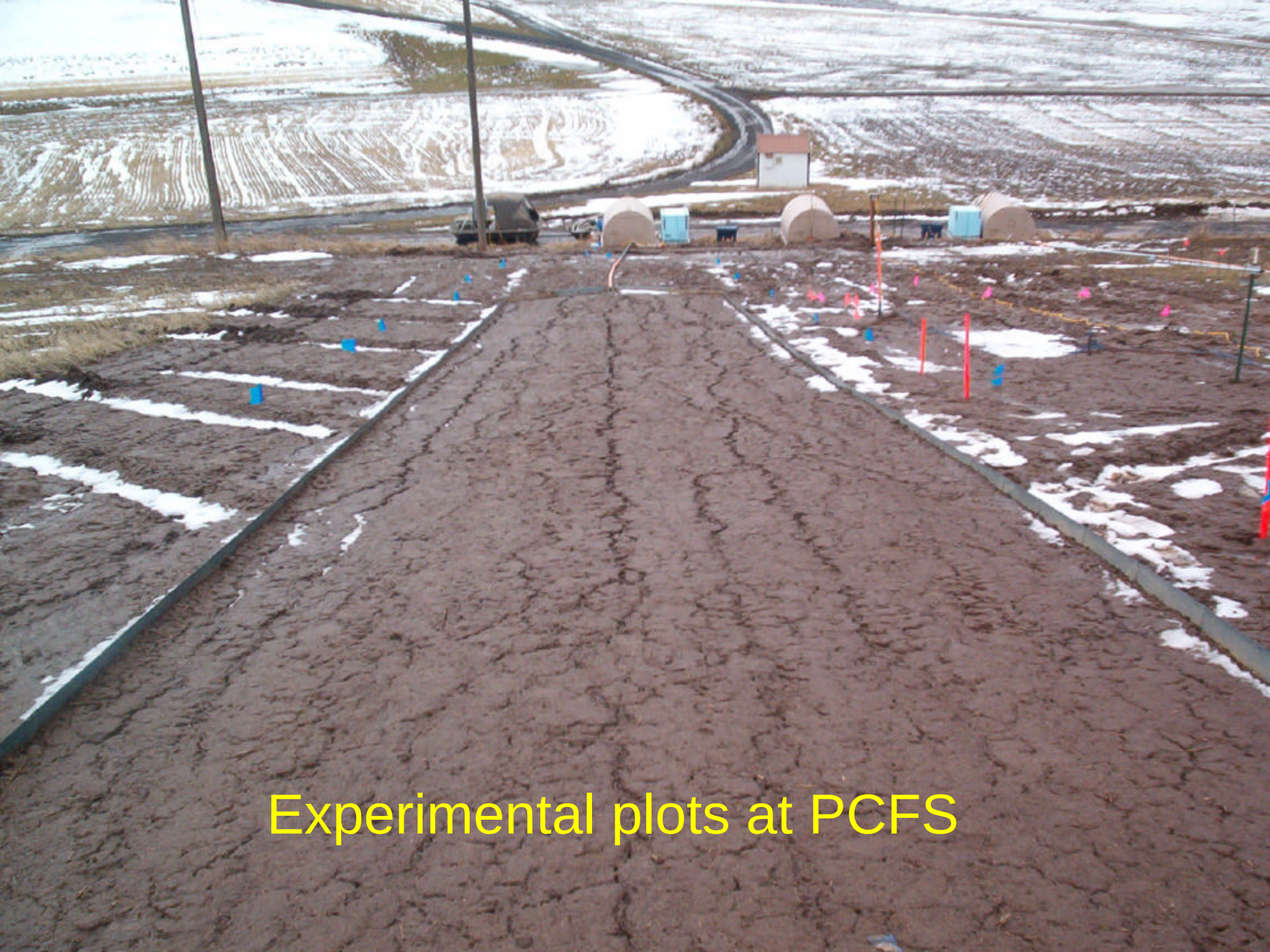
Ongoing Efforts

- Laboratory and field experimentation on runoff and erosion as affected by freezing and thawing of soils





Tilting flume at PCFS

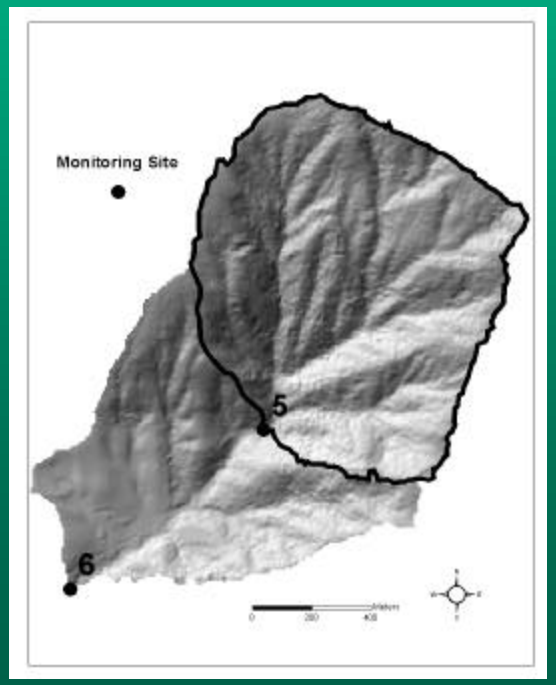

Experimental plots at PCFS

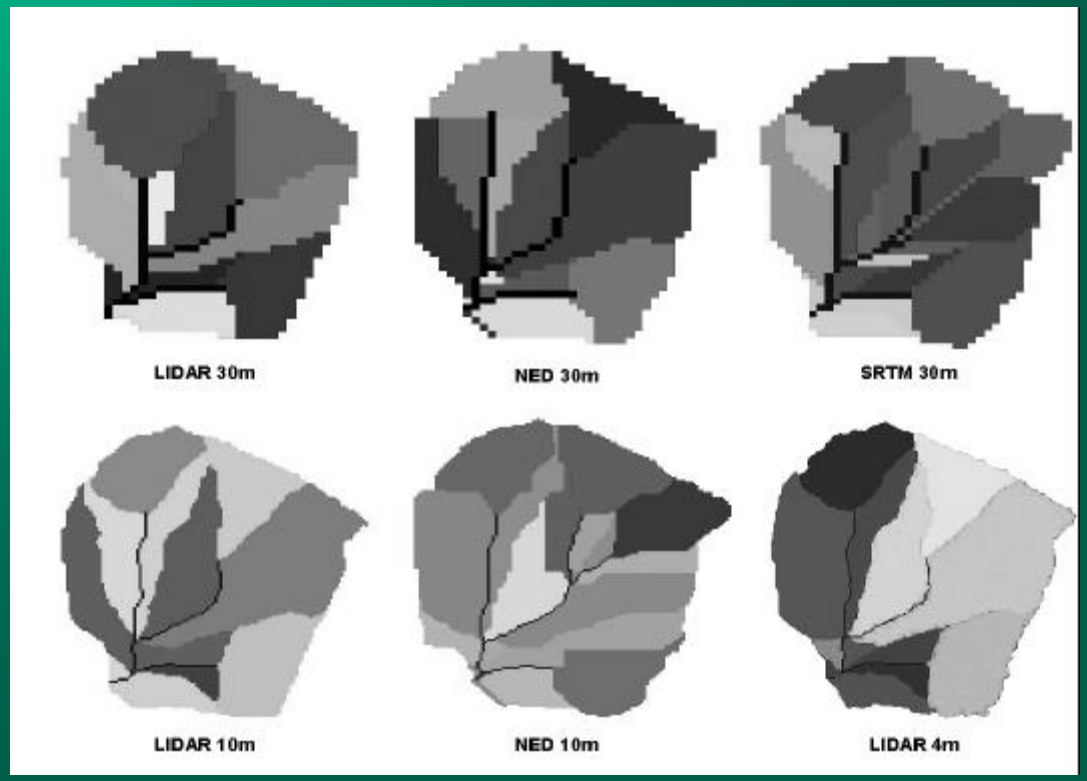
Ongoing Efforts

- Testing WEPP using data collected at
  - USDA ARS CPCRC, Pendleton, OR (Dr. John Williams)
  - Ag Exp Farm, University of Bologna, Italy (Dr. Paola Rossi Pisa)

Ongoing Efforts

- Testing and applying WEPP for evaluating DEM effect on soil erosion prediction
  - Paradise Creek Watershed, ID (Dr. Jan Boll)
  - Mica Creek Watershed, ID (Dr. Tim Link)





Thank You!

Questions?

Code Modification

- Provide options for agricultural or forest watershed applications
  - a flag added to the soil input file
- Default or user-specified vertical hydraulic conductivity K_{slaat} for the added insulating layer in forest applications
  - e.g., 0.05 mm/hr;
  - basalt (*Domenico and Schwartz*, 1998);
- User-specified anisotropy ratio for soil saturated hydraulic conductivity
  - horizontal $K_{sh} \geq$ vertical K_{sv}, *e.g.*, $K_{sh}/K_{sv} = 25$

Code Modification cont'd

- Subroutines modified to properly write the "pass" files
  - WEPP's approach to pass information;
  - subsurface flow not "passed" previously
- Simplified hillslope-channel relation
  - all subsurface runoff from hillslopes assumed to enter the channel;
  - flow added and sediment neglected

Important Parameters

Parameters	Values
Surface Soil Effective K, mm/hr	16.6
Bedrock K, mm/hr	1.0E-2
Anisotropy Ratio	25