Application of the Water Erosion Prediction Project (WEPP) model to simulate streamflow in a forested watershed, PNW

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Introduction

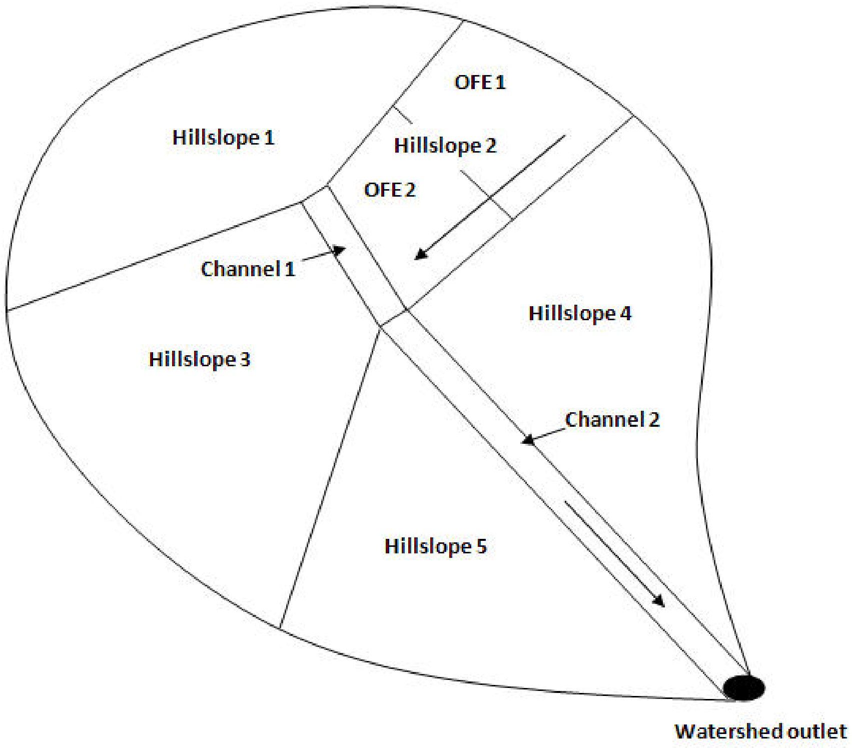
- Assessing water yields from watersheds into streams is critical to supporting aquatic life and meeting water demands for domestic and commercial purposes

- Streams are usually formed from three components of flow: surface runoff, subsurface lateral flow, and baseflow

- Baseflow plays a major role in the contribution to runoff as the size of watershed increases

Introduction

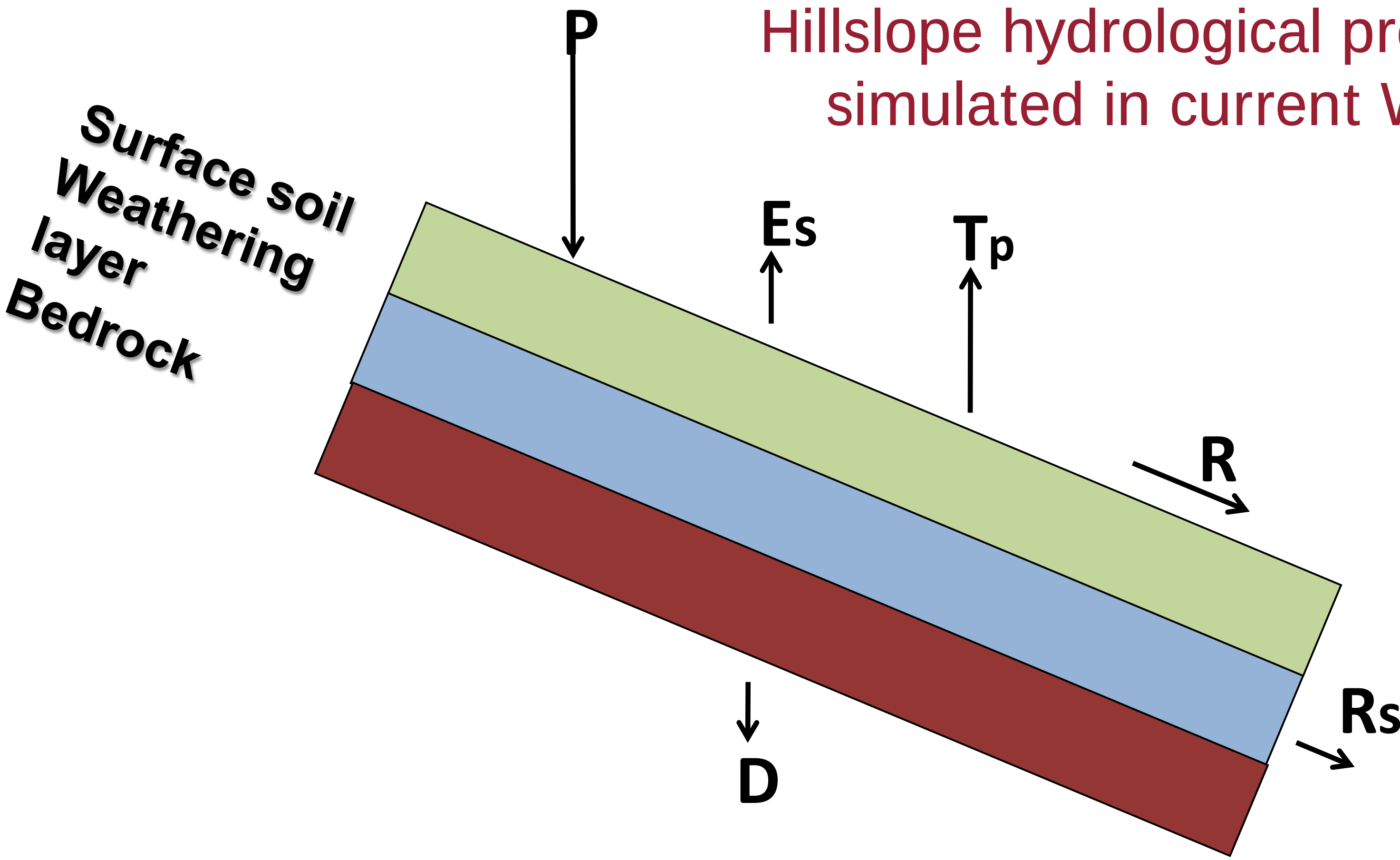
- WEPP (Water Erosion Prediction Project) is a process-based, continuous-simulation, distributed-parameter model
- WEPP is based on the fundamentals of hydrology, hydraulics, plant science, and erosion mechanics
- WEPP has a geospatial user interface, GeoWEPP, allowing for efficient pre- and post-processing



Watershed discretization into hillslopes and channels in WEPP

Introduction

Hillslope hydrological processes simulated in current WEPP

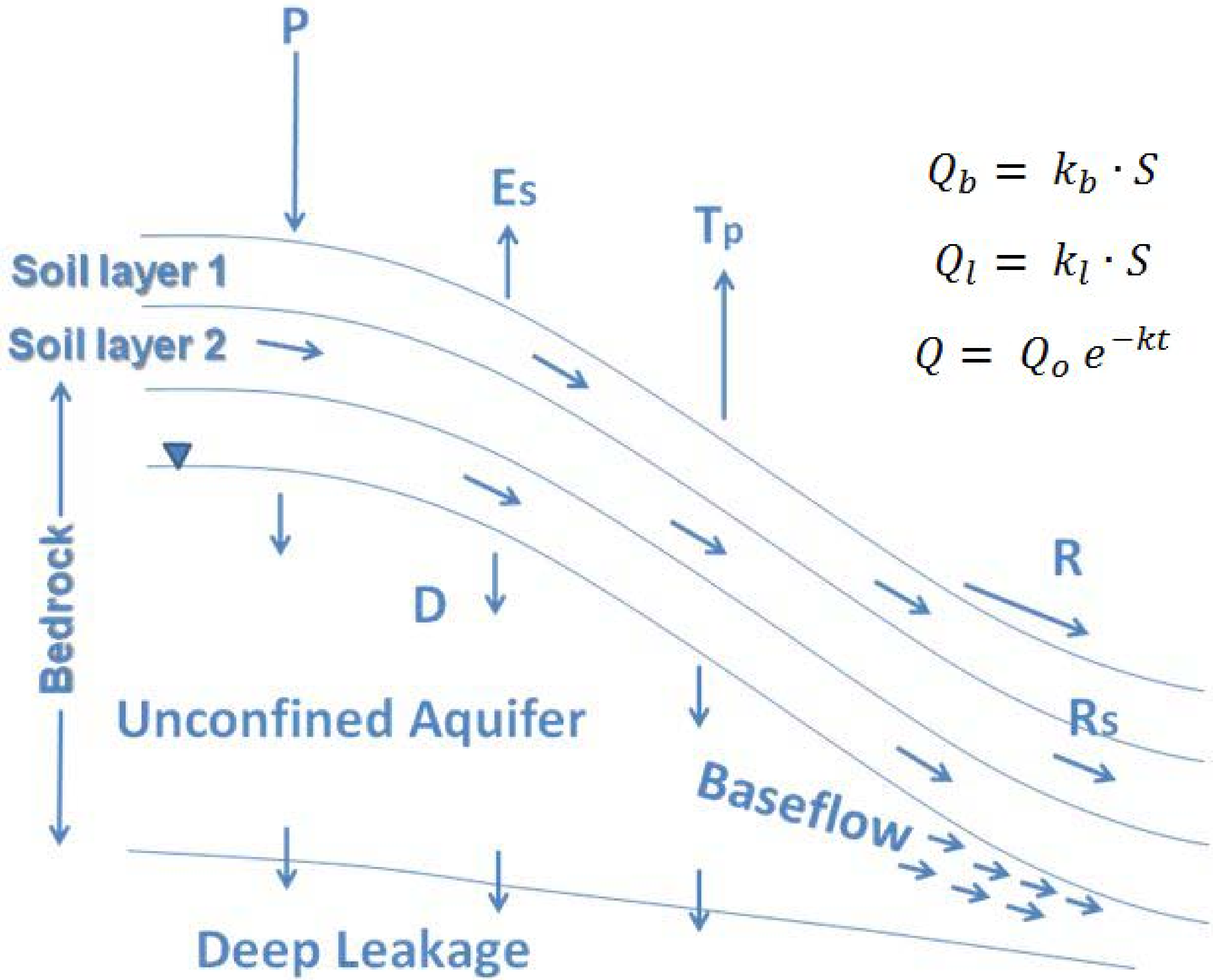


Adapted from *Dun et al*. (2009)

Goal and Objectives

- To ultimately improve the WEPP v2010.1 so that it is applicable to watersheds with substantial baseflow
  - To incorporate a baseflow subroutine into WEPP using a linear reservoir model
  - To evaluate the performance of the improved WEPP model by applying it to forested watersheds

Methodology



$$Q_b = k_b \cdot S$$

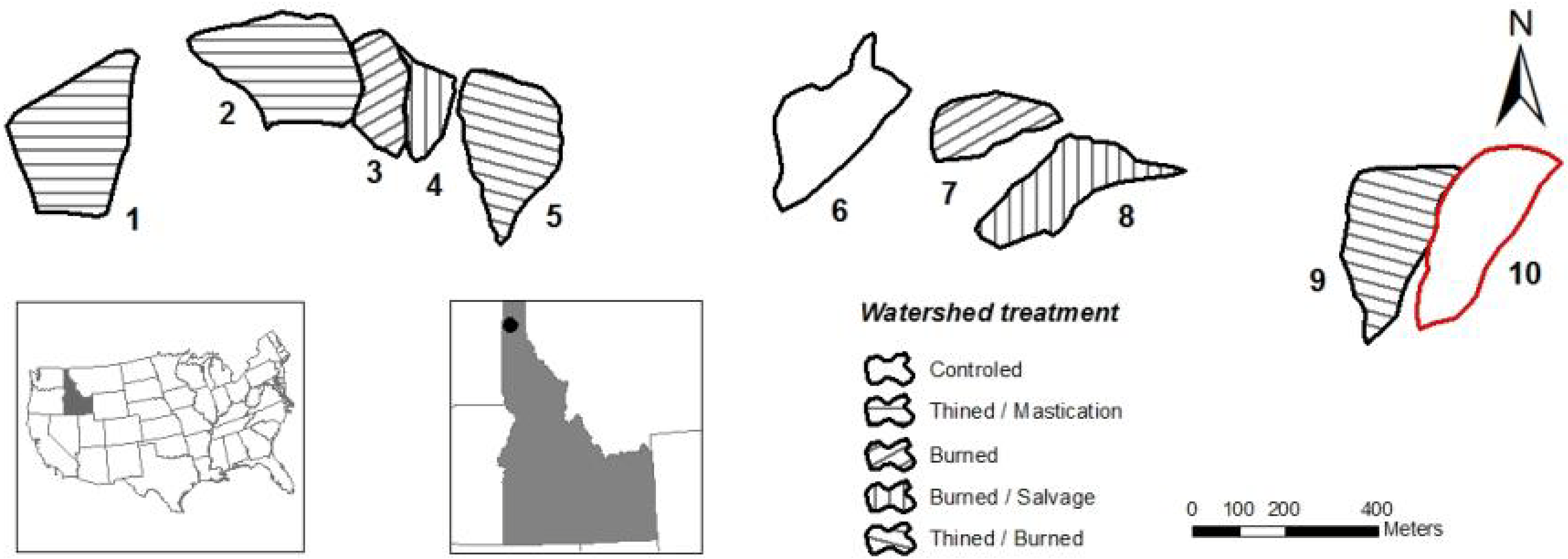
$$Q_l = k_l \cdot S$$

$$Q = Q_o e^{-kt}$$

Baseflow Incorporation in WEPP

Application

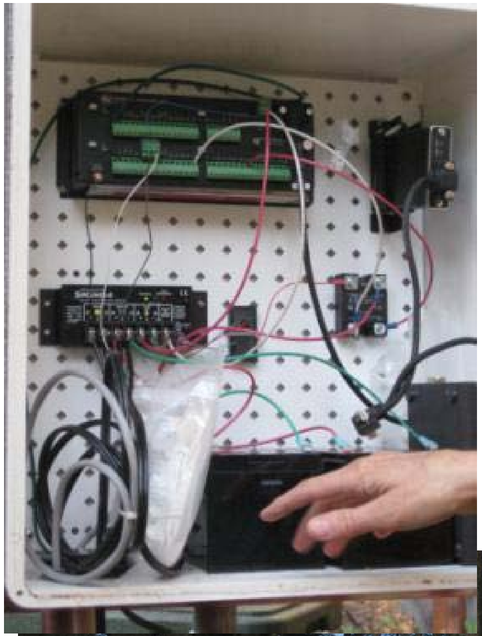
Study Site: Priest River Experimentation Station, Idaho



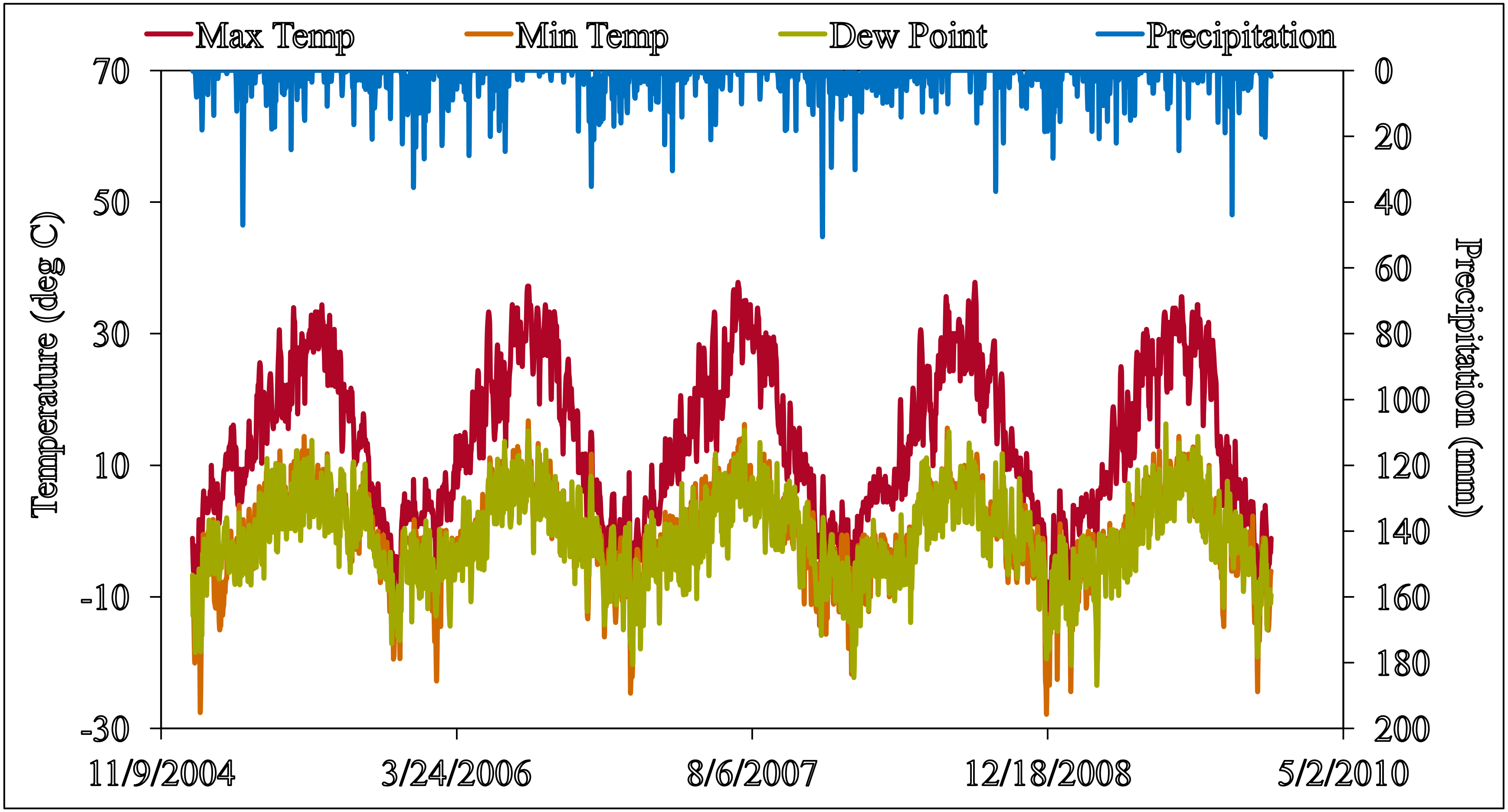
Site Characteristics (Undisturbed Forest)

- Area: 5.52 ha (WS-10)
- Soil: forest silt loam
  (Vay soil series)
- Avg slope: 29%
- Avg obs. Precip: 794 mm (2005–09)
- Avg. obs. max Temp (14 C), min T (0 C)

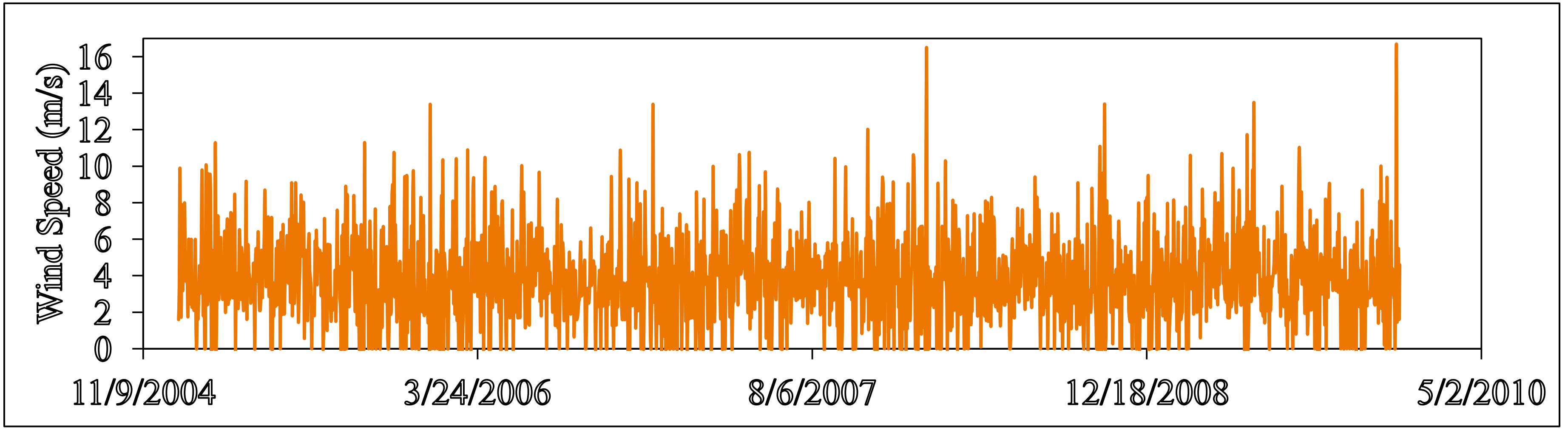
Streamflow Monitoring

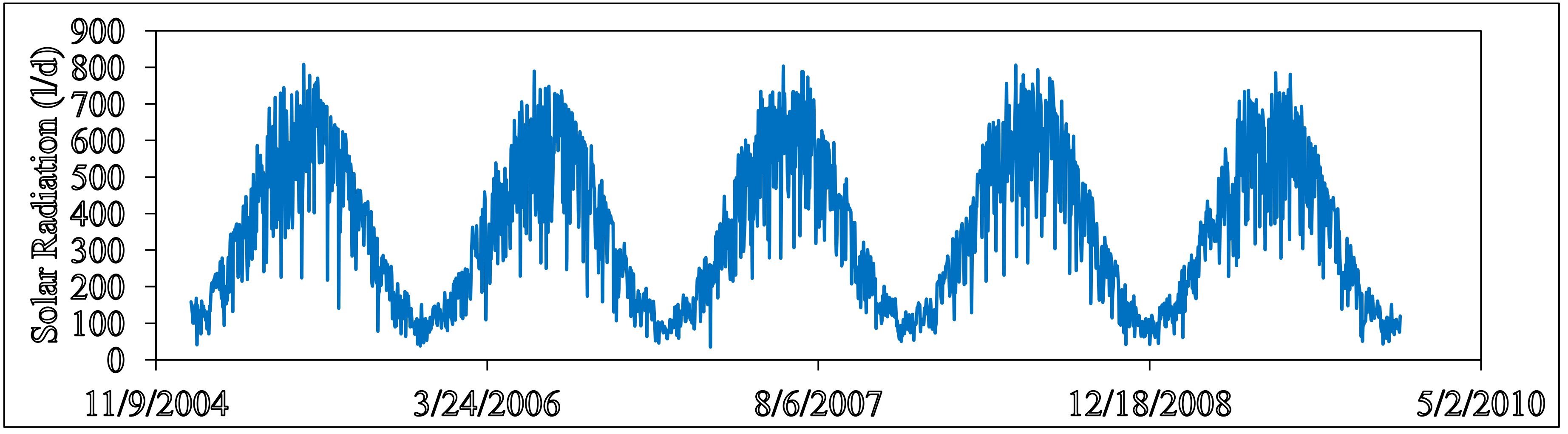




Daily Precip, Max and Min Temp (NCDC)



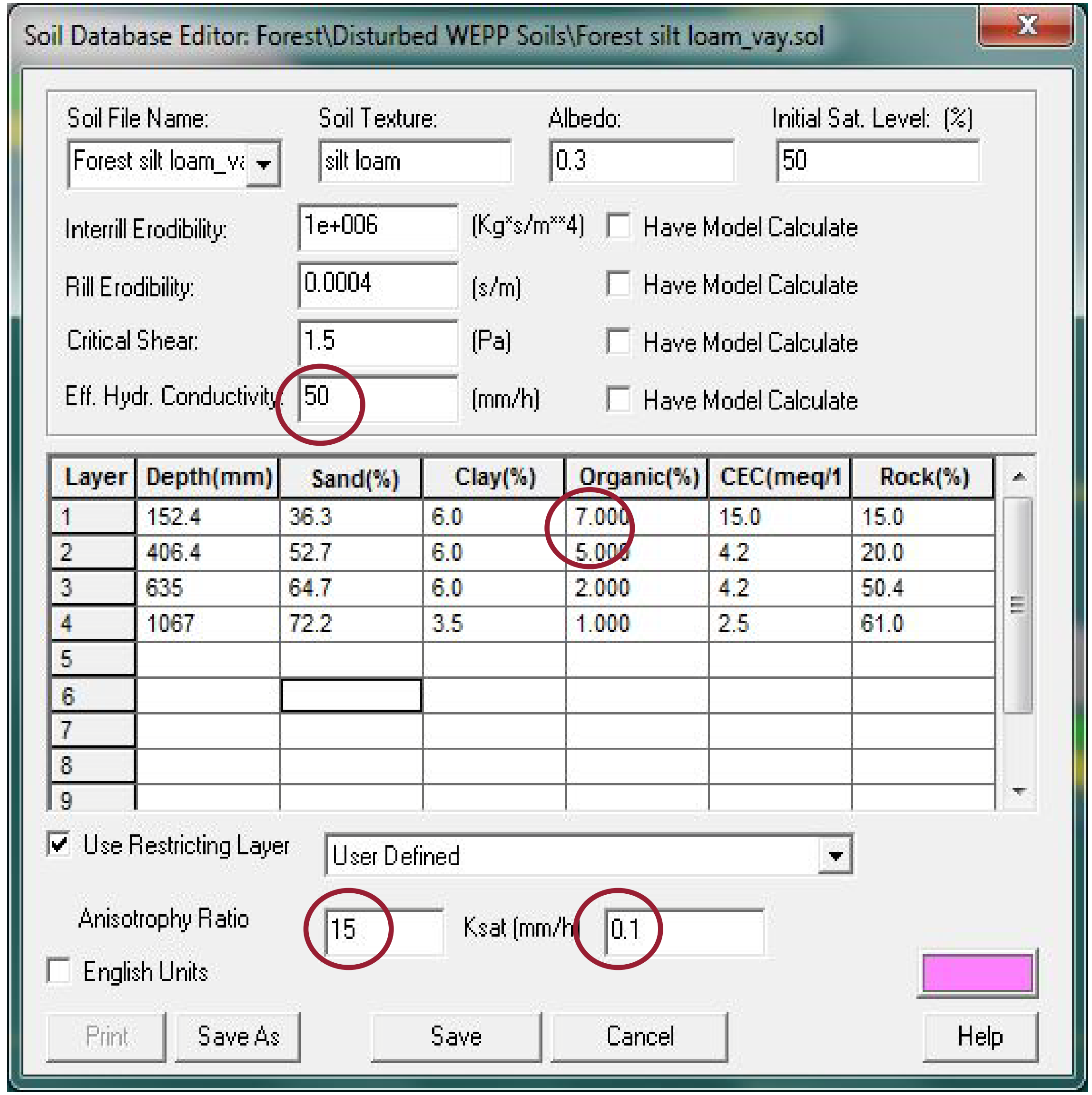
Daily Wind Speed and Solar Radiation (CLIGEN-generated)





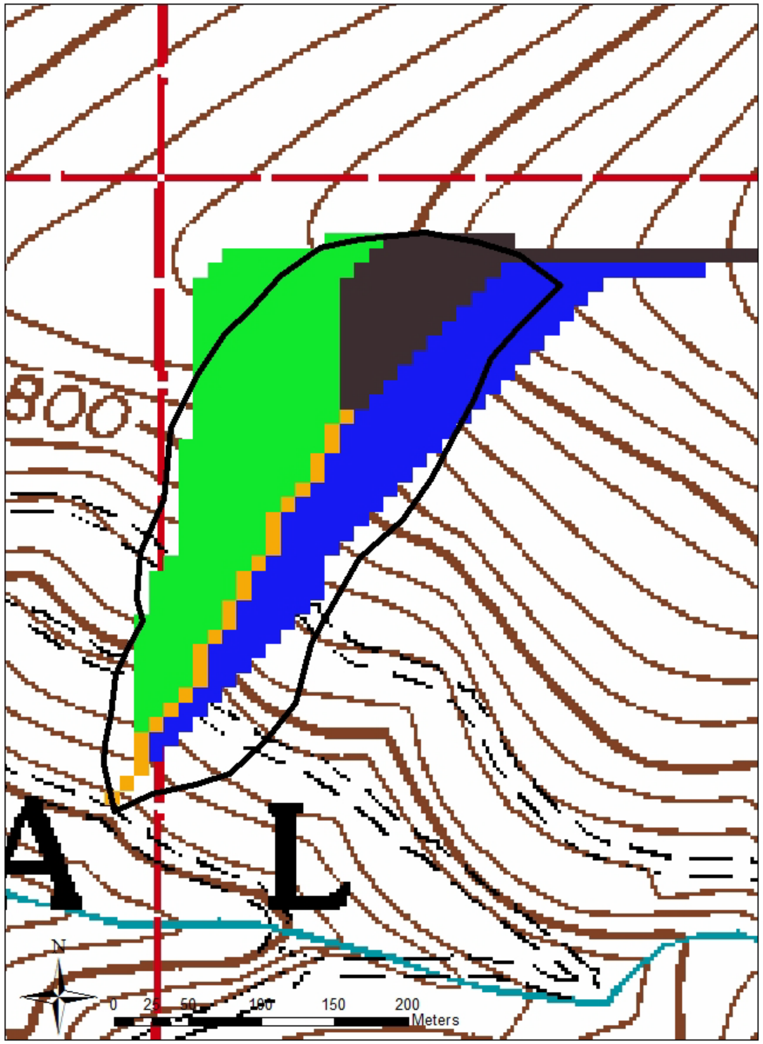
Soil and Management Inputs

- Soil inputs were from WEPP database, STATSGO, and literature values
- Forest perennial file selected for undisturbed forest



GeoWEPP Delineated Watershed

- Watershed structure and slope file created by GeoWEPP

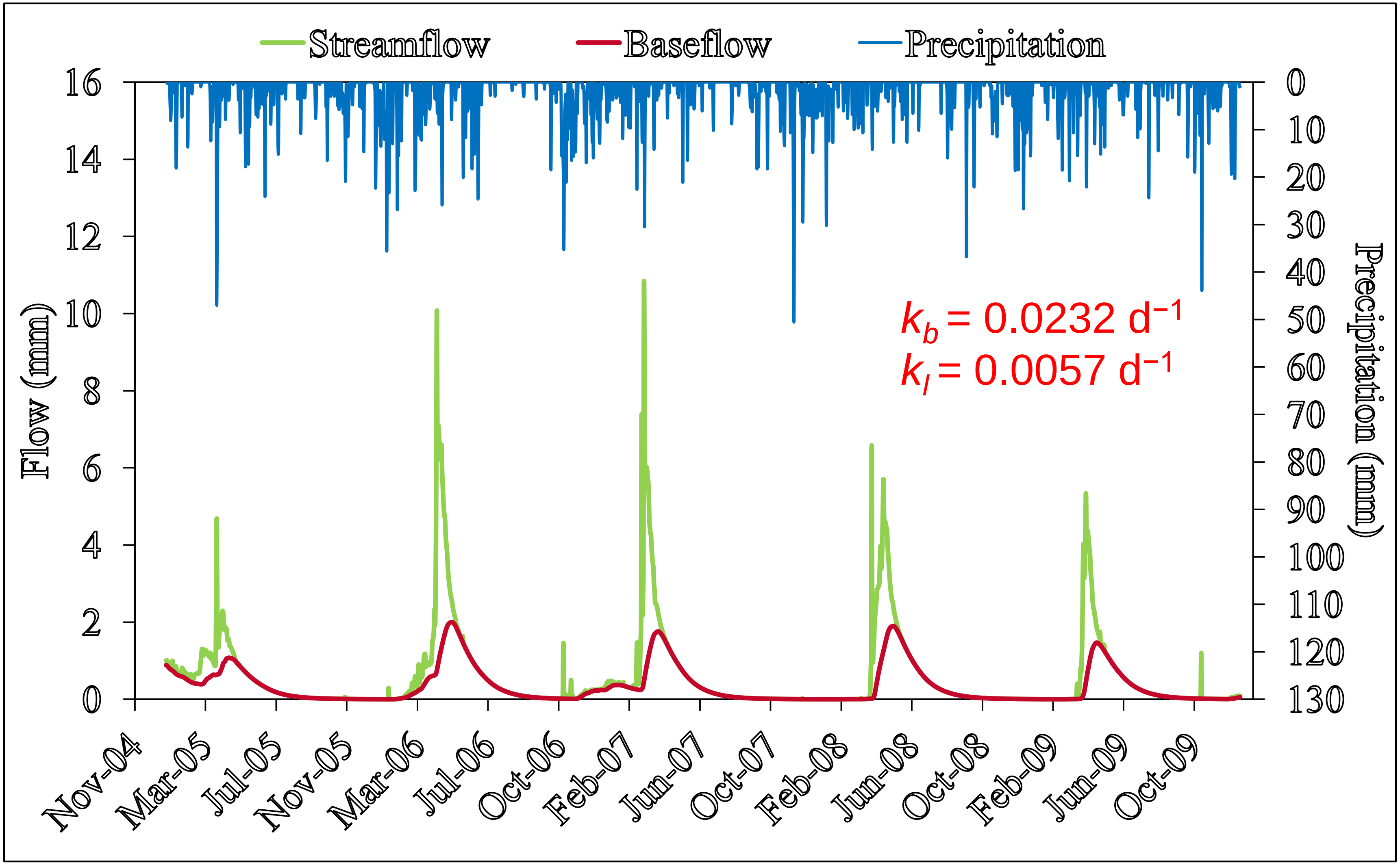


Watershed Configuration

Hillslope	SW-facing Hillslope	SE-facing Hillslope	NW-facing Hillslope	SW-facing Channel
Length, m	253	66	67	250
Width, m	86	250	250	1
Avg slope, m m^{-1}	0.245	0.186	0.433	0.424
Area, m^2	21,700	16,500	16,800	250
Aspect, degree	210	120	300	210

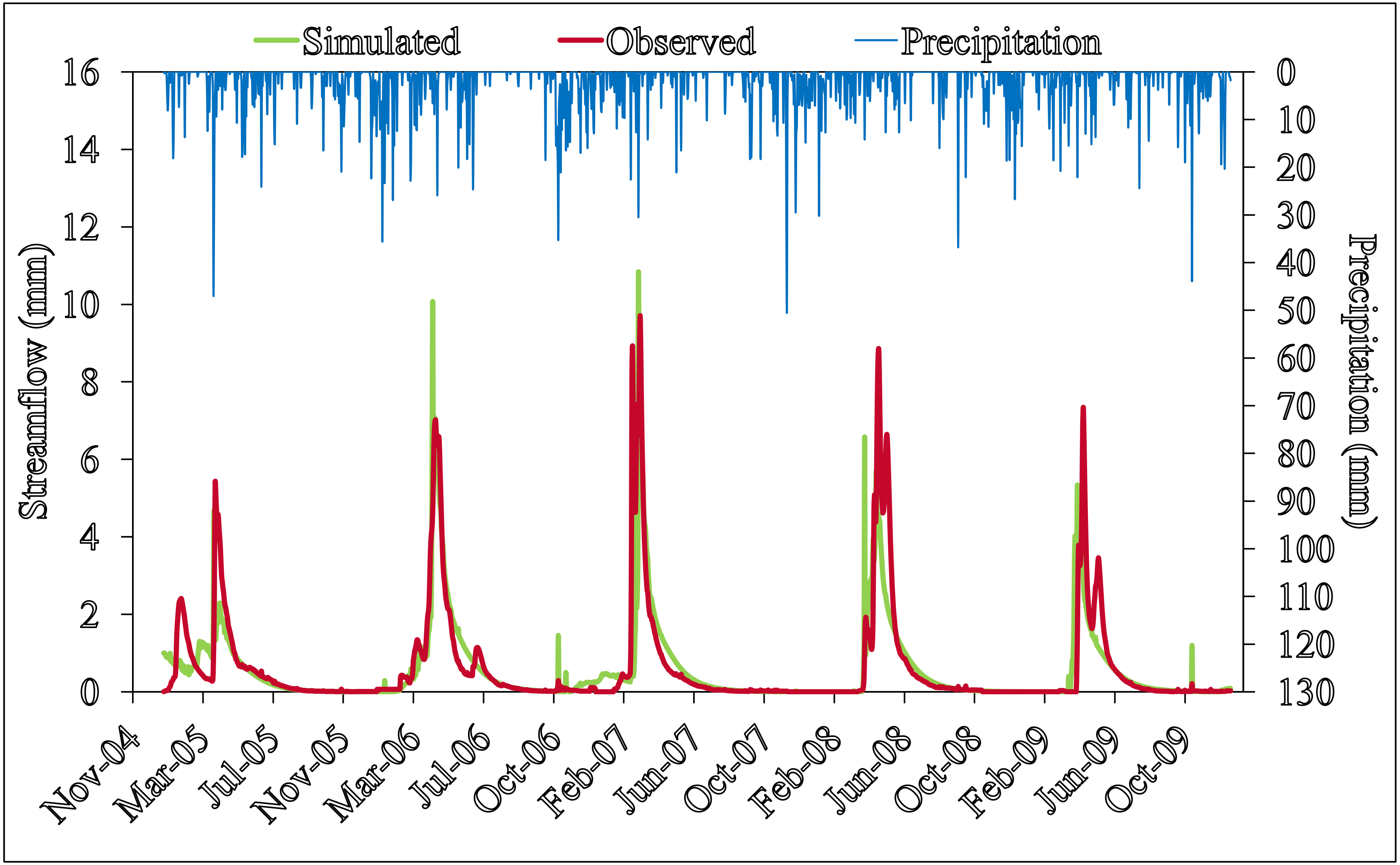
Results

WEPP-simulated baseflow from the linear reservoir model



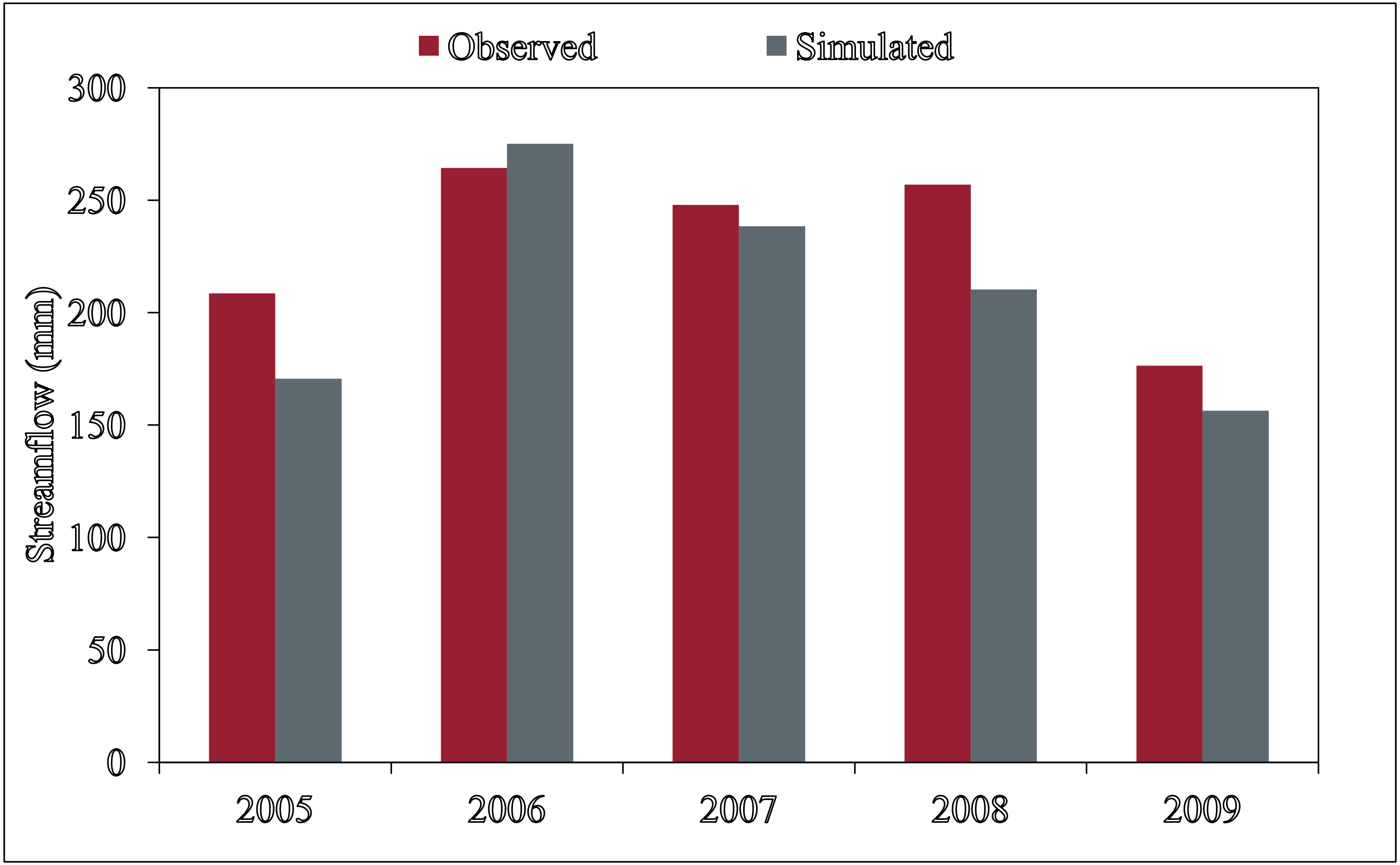
Results

Observed vs WEPP-simulated streamflow



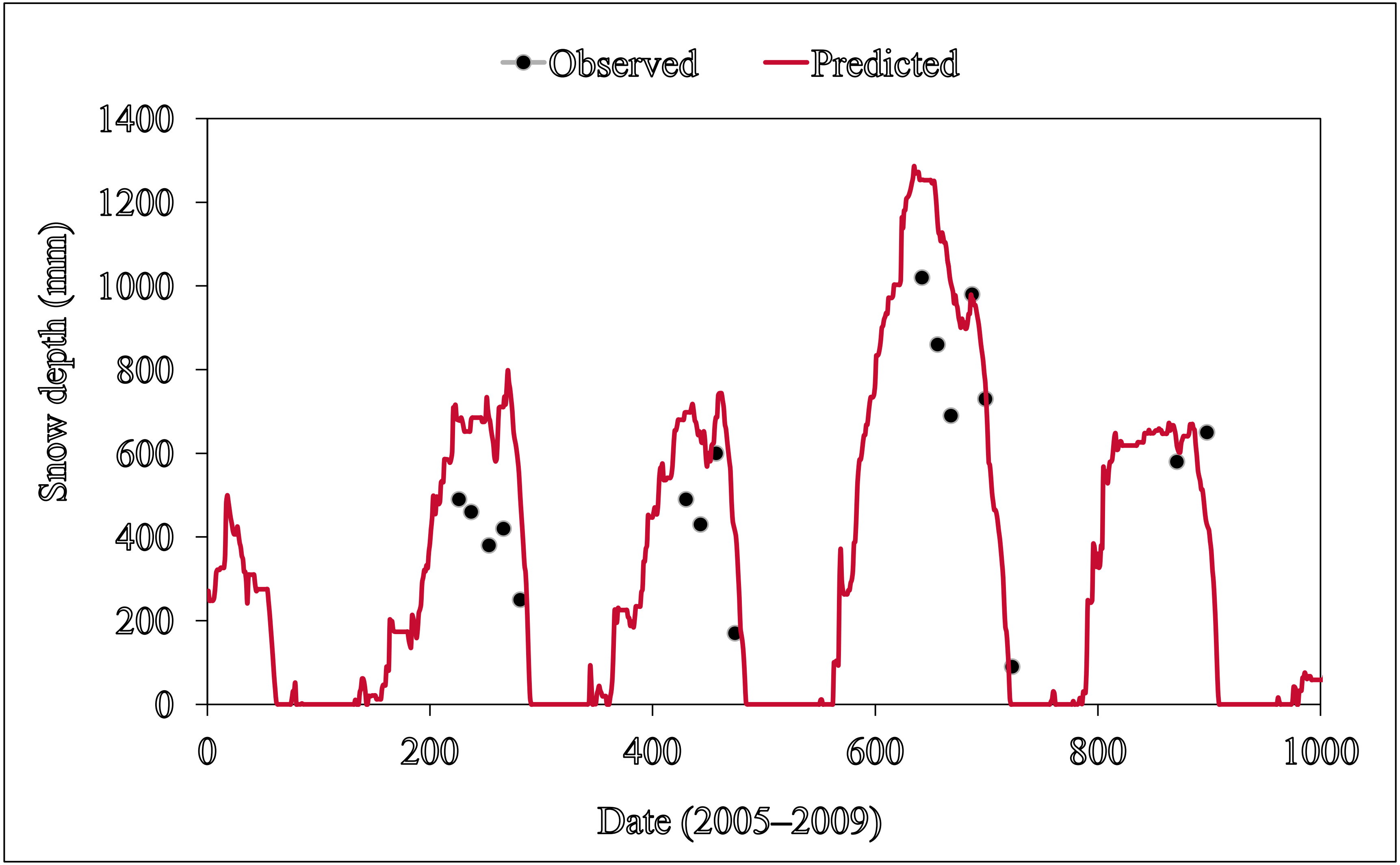
Results

Observed vs WEPP-simulated annual streamflow



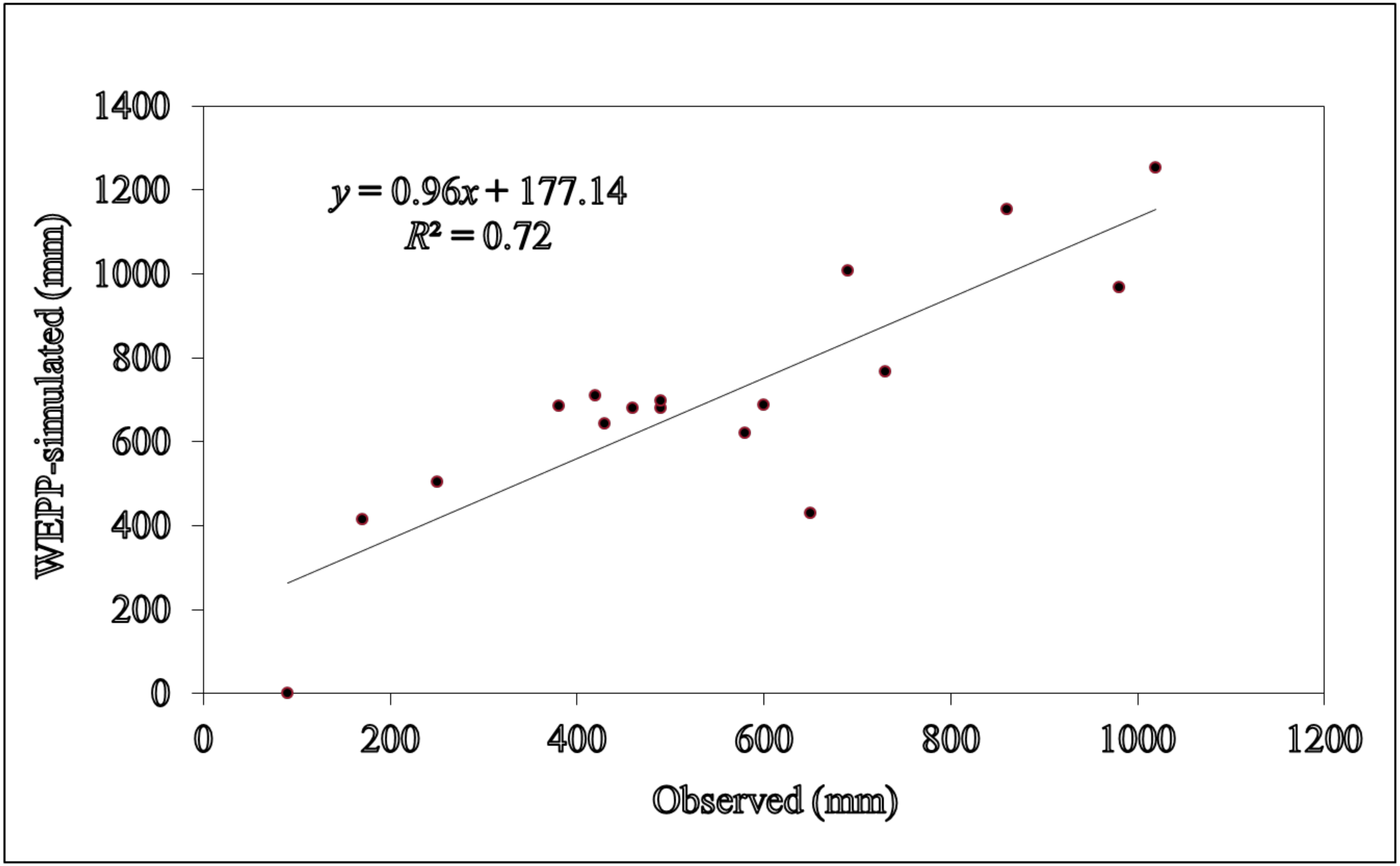
Results

Observed and WEPP-simulated snow depth



Results

Observed vs WEPP-simulated snow depth



Results

Annual watershed water balance from WEPP in mm

Year	P	R	R_s	ET	SW	Q_b	Q_l	BFI
2005	744	0	71	518	42	120	30	70
2006	957	0	150	475	−56	150	38	55
2007	769	0	126	419	46	133	34	56
2008	768	0	102	533	19	123	31	58
2009	729	0	81	490	−26	88	22	57
Avg.	794	0 (**0**)	106 (**13**)	487 (**61**)	5 (**0.6**)	123 (**15**)	31 (**4**)	**59**

Results

Statistical analysis of observed and WEPP-simulated streamflow

Year	NSE	D_V (%)
2005	0.50	18
2006	0.89	−4
2007	0.62	4
2008	0.70	18
2009	0.55	11
Overall (2005–09)	**0.67**	**9**

Summary and Conclusions

- Incorporation of a linear ground-water reservoir model in the WEPP model allows WEPP to be applicable to watersheds with significant amounts of baseflow

Model performance assessment

- Nash-Sutcliffe Efficiency (R^2) of 0.67 indicates satisfactory model performance
- Deviation of runoff volume (D_V) of 9% indicates under-prediction of total streamflow

Ongoing Work

- We are analyzing observed and WEPP-simulated snow accumulation and snowmelt to better understand baseflow generation in a snow-hydrology-dominant environment

Acknowledgement

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Thank you

Questions ?

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