Evaluation of Forest Road Scenarios Using Field Measurements and the Distributive Hydrology Soil Vegetation Model (DHSVM)

South Fork of Caspar Creek

California Board of Forestry
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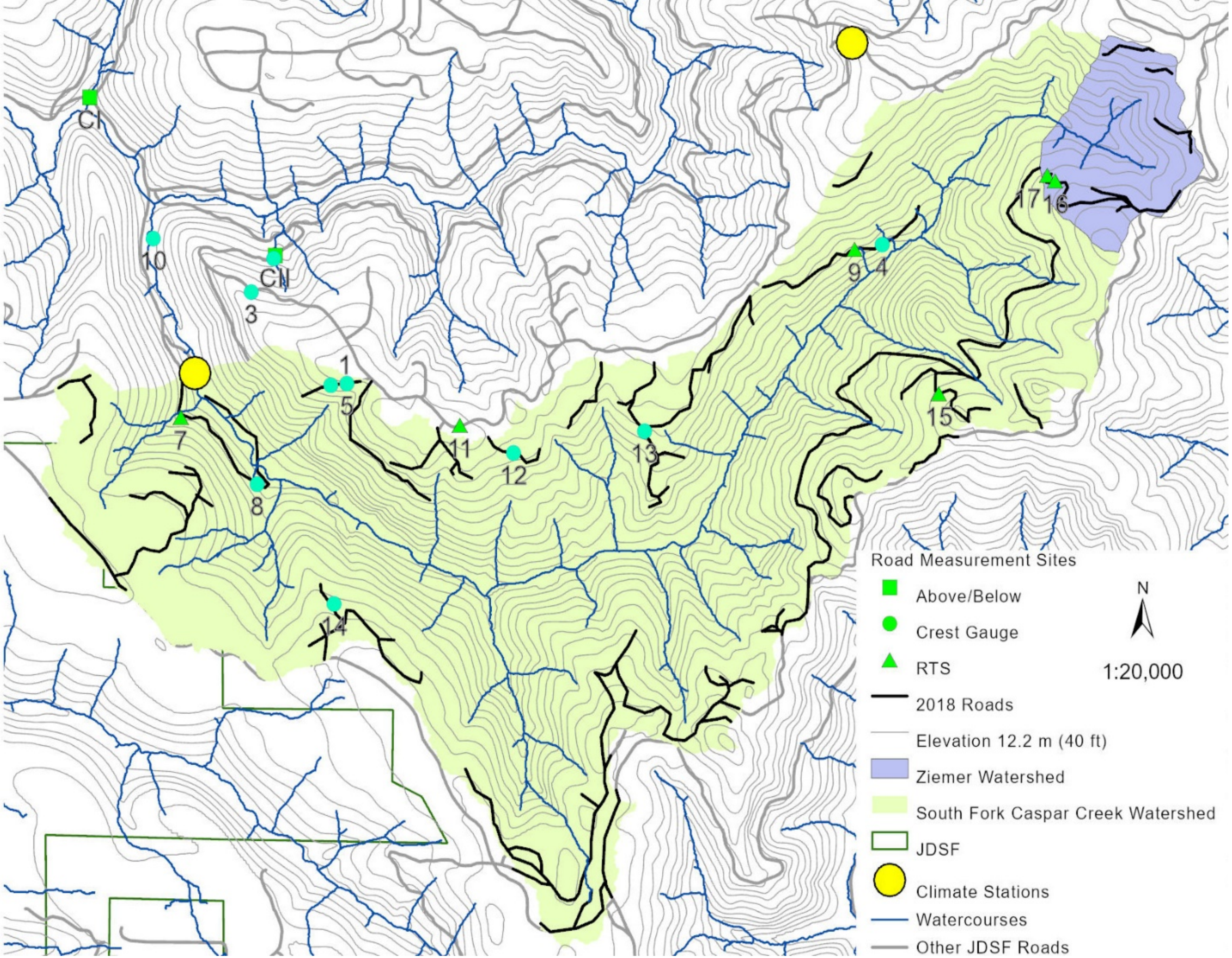
Field Measurements



16 Road Flumes:

6 - Runoff, Turbidity, Suspended Sediment Measurement (RTS)

10 - Crest Stage Gauges

Measured road runoff from November 2018 – March 2019

22 Road Runoff events

Turbidity and Stage

- Above/below Class I watercourse crossing.
- Above/below Class II watercourse crossing.

Runoff, Turbidity, Suspended Sediment Measurement Site 16

Site 12

Site 4

Total Suspended Sediment Load by Road Surface Type

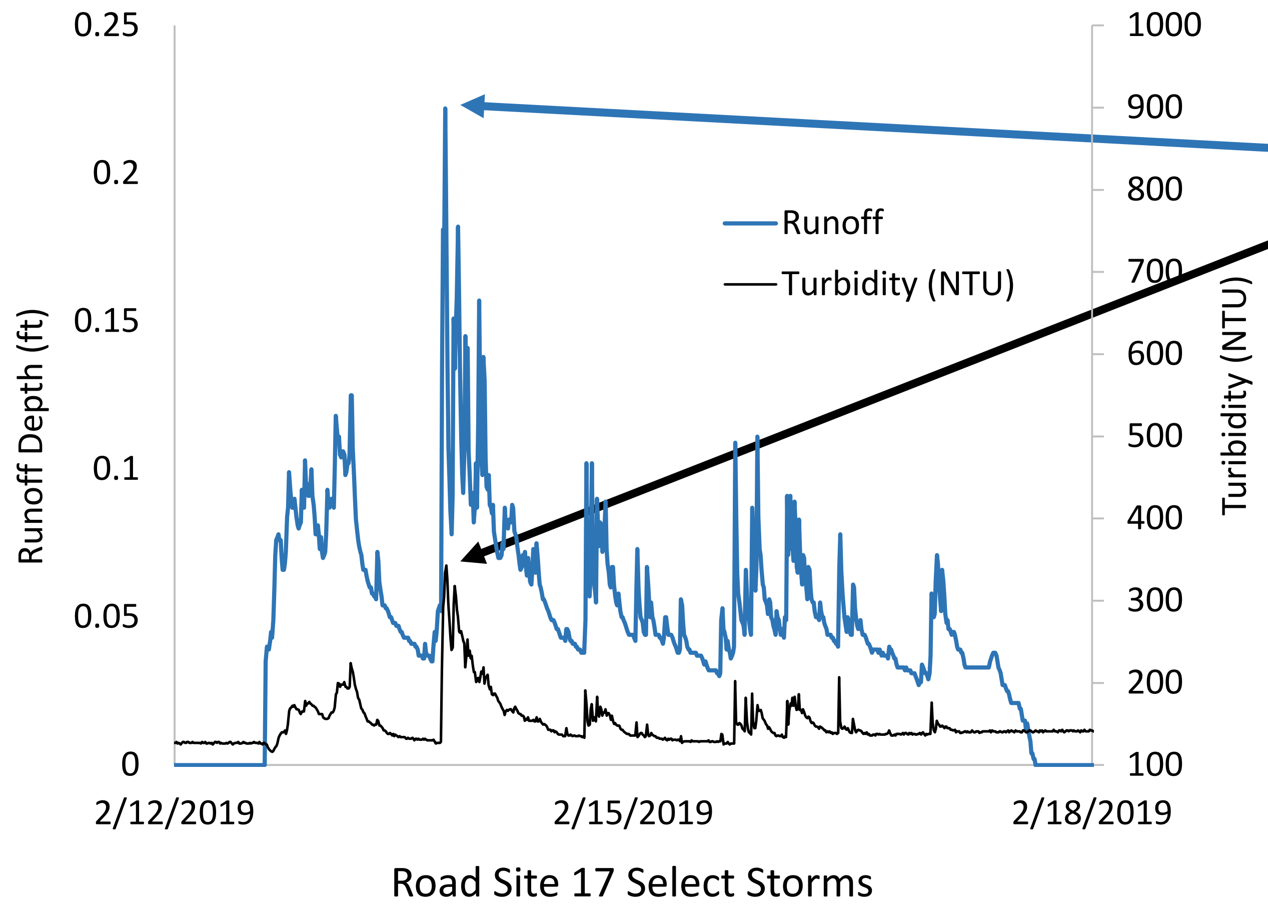
Surface Type	This Study	Barrett et al. 2012
Rock	0.01 – 0.85 kg/m²/yr	0.02 – 0.8 kg/m²/yr
Native	17.8 – 41.0 kg/m²/yr	0.1 – 4.5 kg/m²/yr

Reid and Dunne (1984) 130 X for heavily used roads
Megahan and Kidd (1972) 750 X for newly constructed roads
Coe (2006) 3-4X for recently graded compared to ungraded

Rock

Native

Prediction of Suspended Sediment Load (Log_{10} SSL)



Predictors

Peak flow (from road storm runoff) Adj. $R^2 = 0.80$

Maximum turbidity $^{1/3}$

Prediction improved by addition of:

Cutslope cover Adj. $R^2 = 0.84$

or

Road surface type Adj. $R^2 = 0.86$

Road dimensions and Precipitation to Predict Suspended Sediment Load (SSL) or Peak Flow

Log Suspended Sediment Load (kg) =

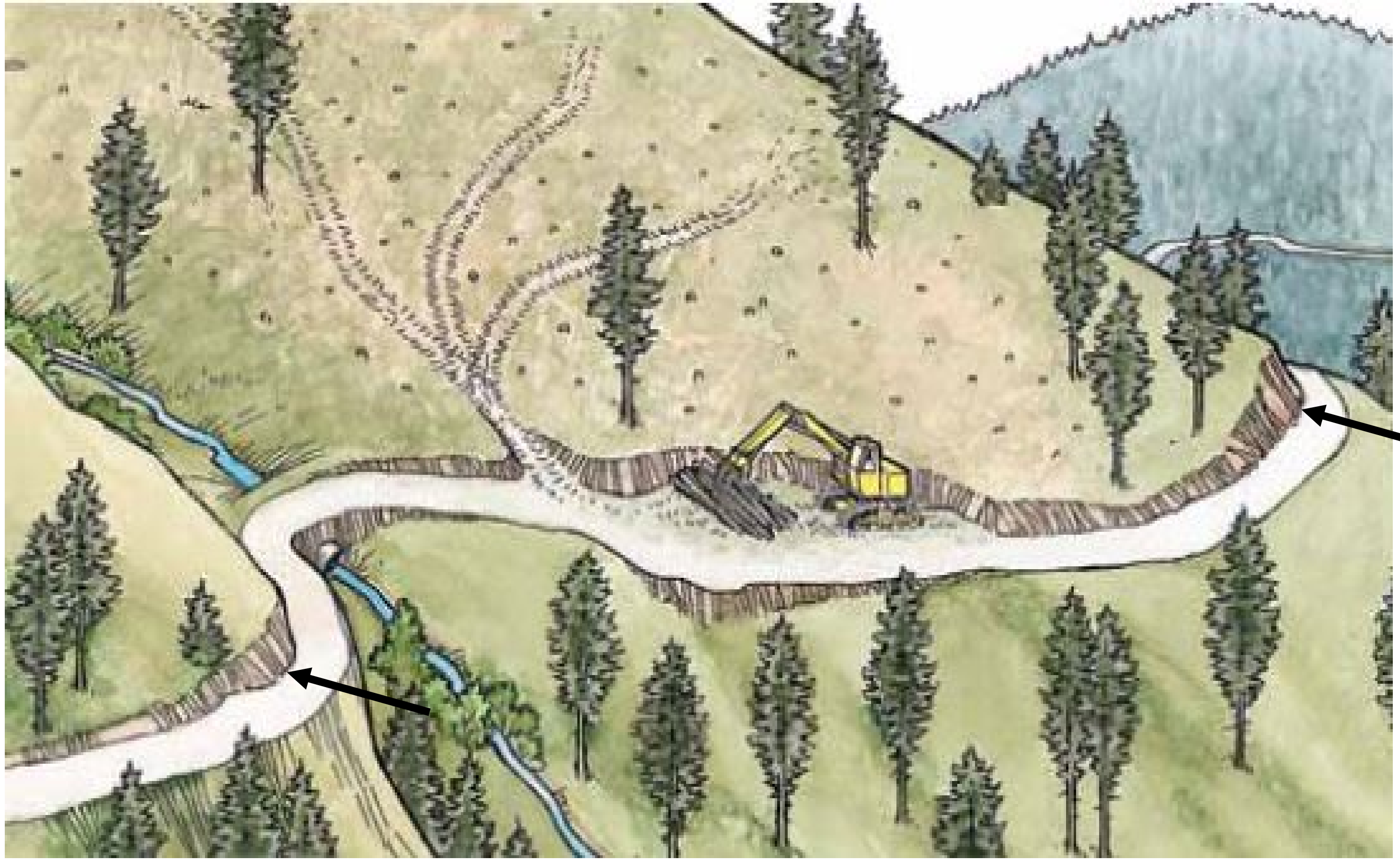
(+) Length x $Slope^2$

(+) Road surface type (native or rocked)

(-) Cutslope area

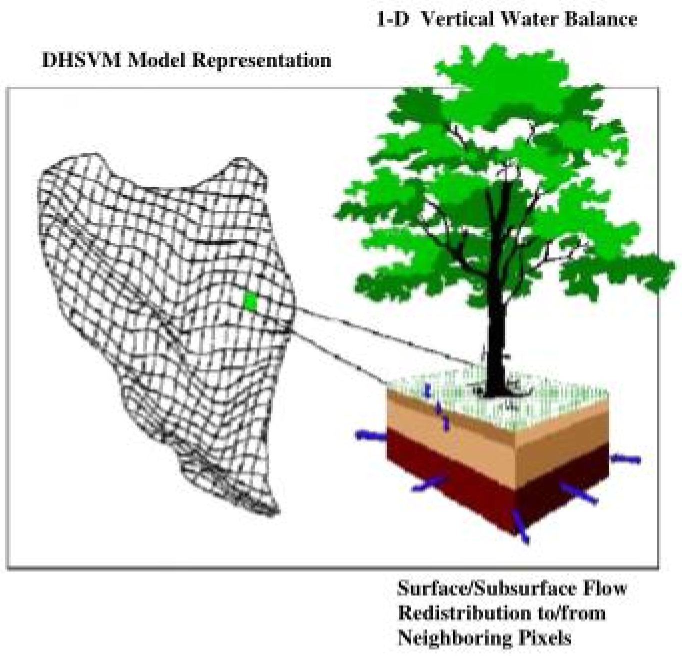
(+) Storm Precipitation Total.

Adj R^2 = 0.81



(Image from Oregon Forest Resources Institute, 2011)

Distributed hydrology-soil-vegetation model (DHSVM)



- Physically based hydrologic model that represents the effects of
  - Topography
  - Soil
  - Vegetation
- Solves the energy and water balance at each grid cell at each timestep

Calibration and Uncertainty

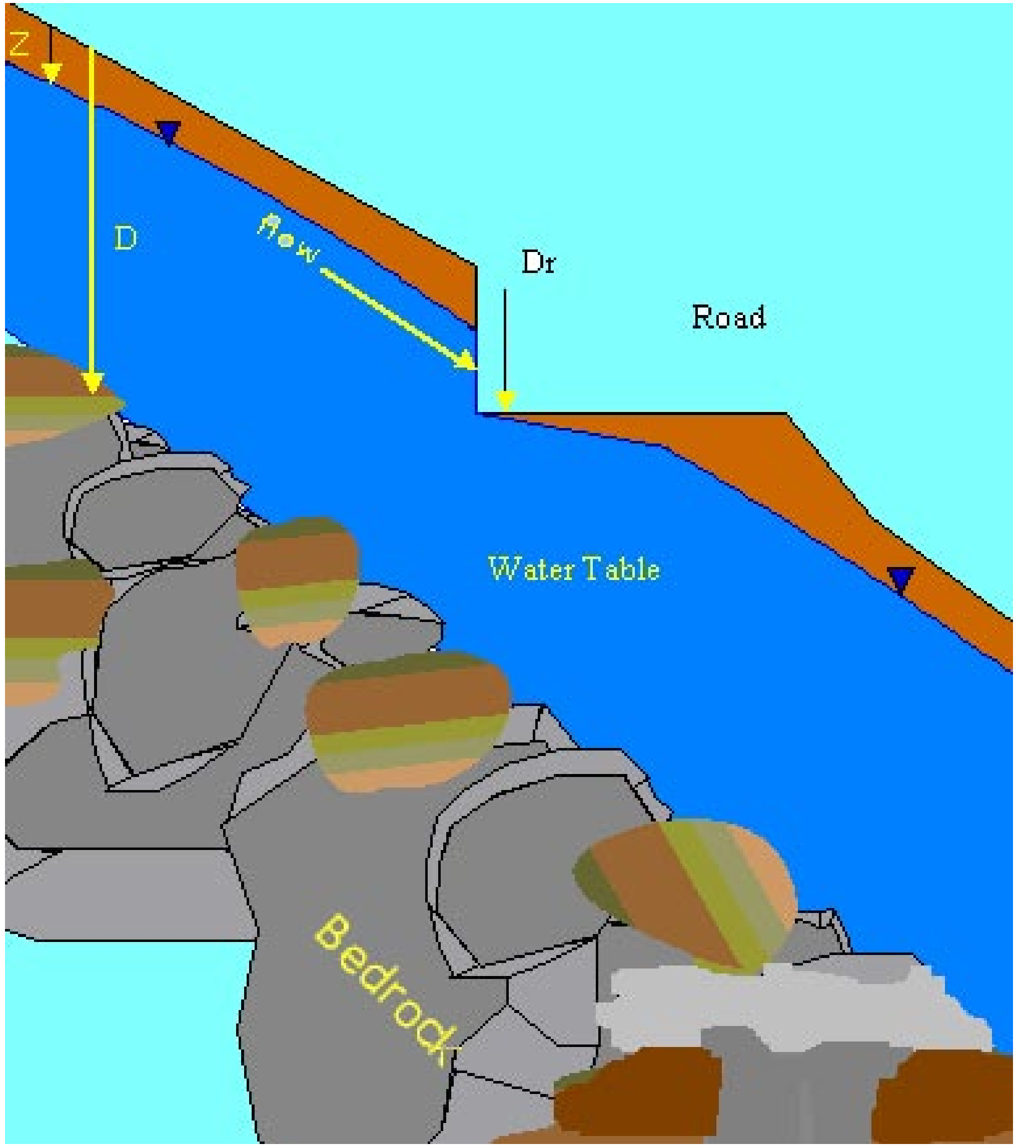
Monte Carlo 10,000 Simulations

2015-2018 hydrologic years

Result is a range of model outputs that provide reasonable models

Adriance, A. (2018). Optimizing the Distributed Hydrology Soil Vegetation Model for Uncertainty Assessment with Serial, Multicore and Distributed Accelerations. Master of Science thesis. California Polytechnic State University, San Luis Obispo.

DHSVM Road Modelling



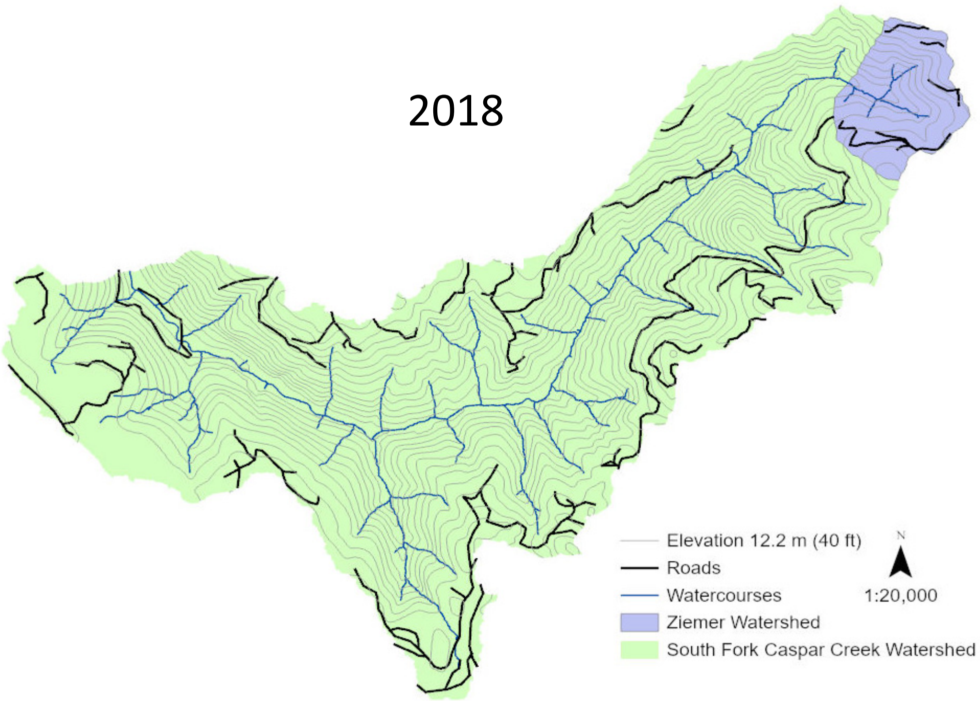
- Road interception model
- Road overland flow to sink points

- Calibration based on trial and error adjustments of road length, width, infiltration rate, cutslope height.

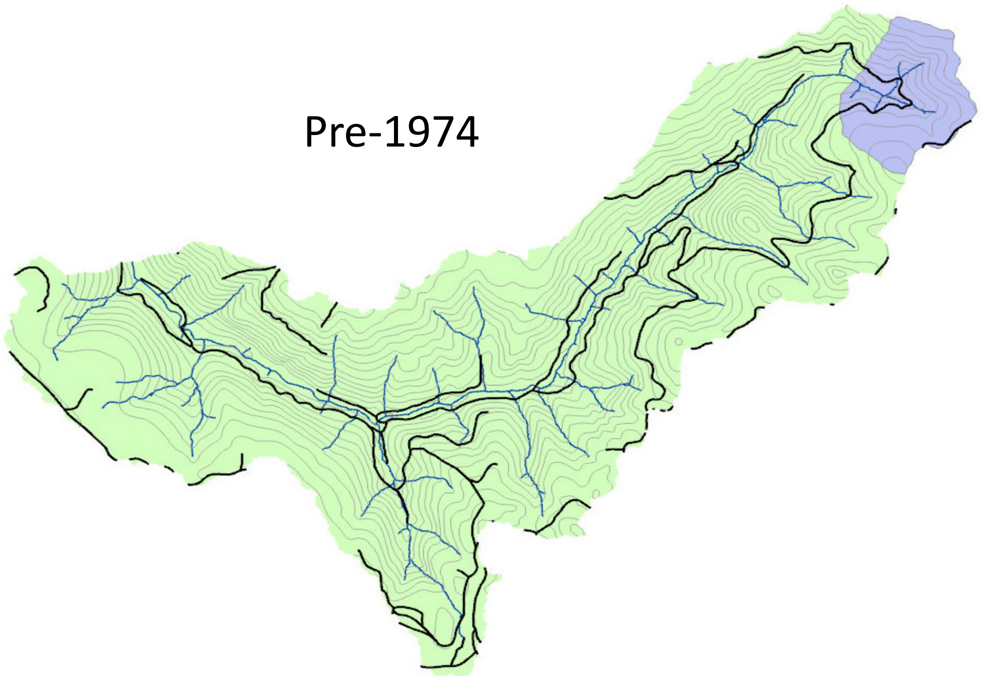
Road Scenarios Modelling

-All models used 2015-2019 Climate

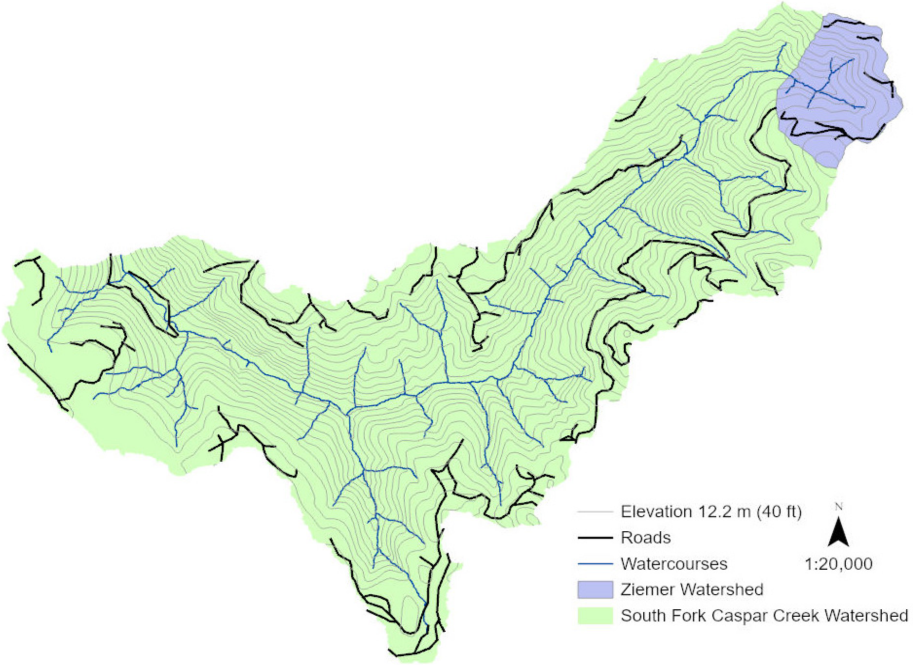
2018



Pre-1974

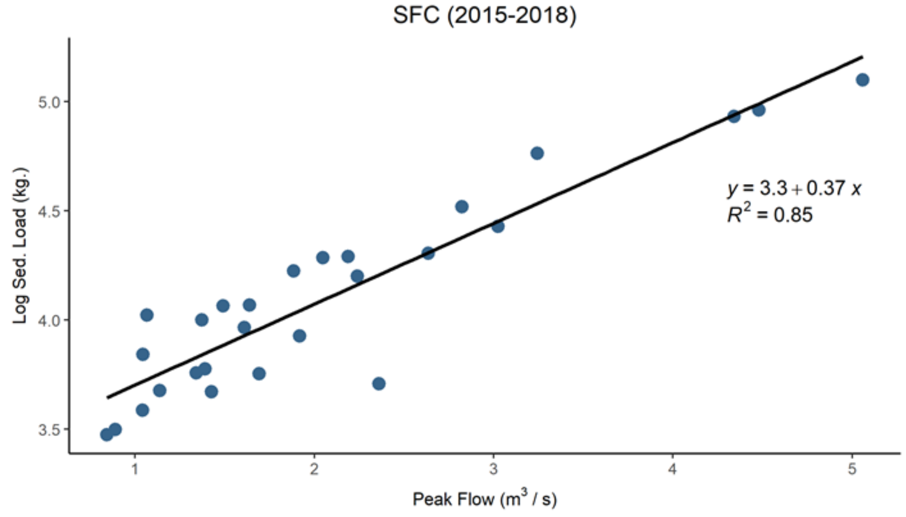


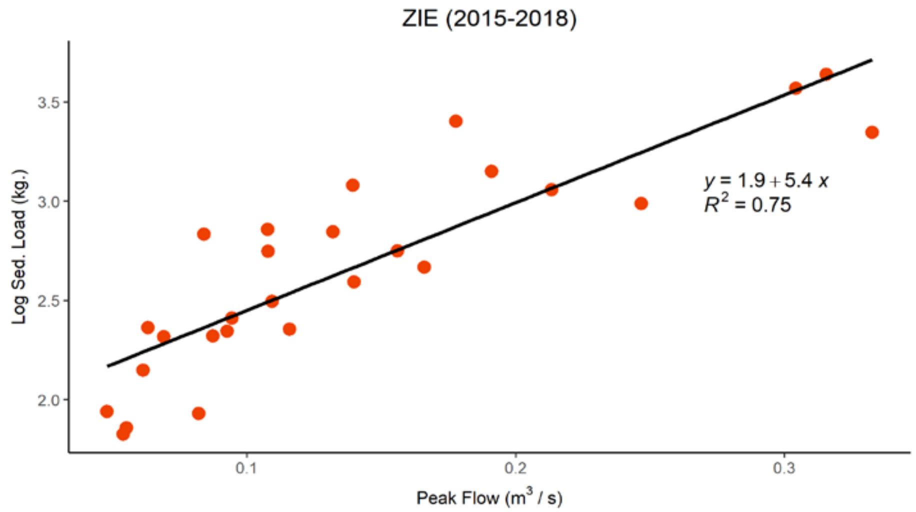
Road Network	Road Scenario	Min. Length m (ft)	Max. Length m (ft)	Average Length m (ft)	Road Density m/ha (mi/ mi^2)	Percent Road* Length within 60 m of watercourses (200 ft)
2018	2018 CFPR Roads	8 (26)	19 (62)	14 (45)	42.3 (6.8)	13% (3%*)
2018	Pre-2010 Roads**	14 (46)	39 (128)	27 (87)	42.3 (6.8)	13% (3%*)
Pre-1974	2018 CFPR Road Rules	6 (20)	23 (76)	17 (57)	45.7 (7.3)	58%
Pre-1974	Pre-2010 Roads**	14 (46)	35 (115)	24 (92)	45.7 (7.3)	58%
Pre-1974	Pre-1973 CFPRs	186 (610)	317 (1040)	237 (780)	45.7 (7.3)	58%

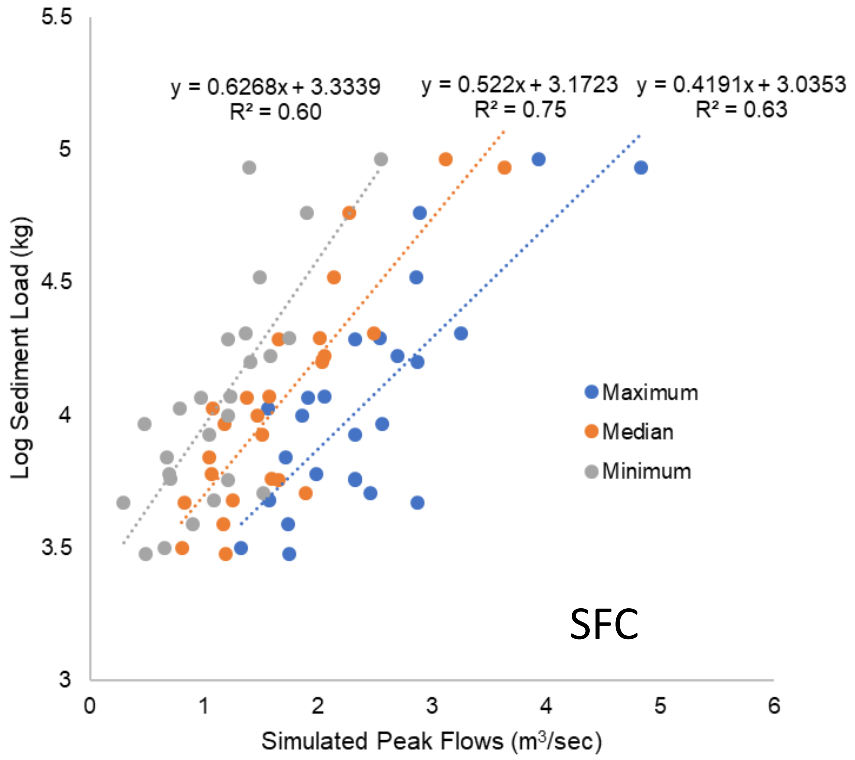


Drone view of Ziemer watershed post- harvest (photo credit Ryan McGrath, June 2018)

Suspended Sediment Load Predicted by Simulated Runoff







Roads

Log storm sediment load (kg) = 2.42 + 0.0483 * low peak flows -1.804 * surface type

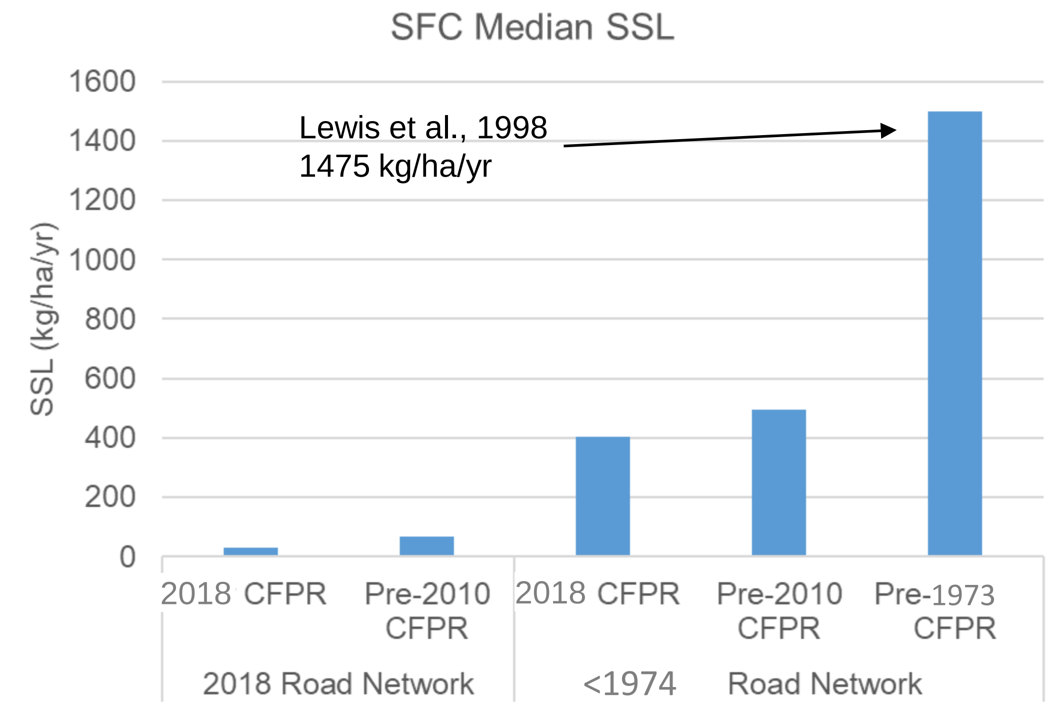
Log storm sediment load (kg) = 2.33 + 0.0342 * median peak flows -1.773 * surface type

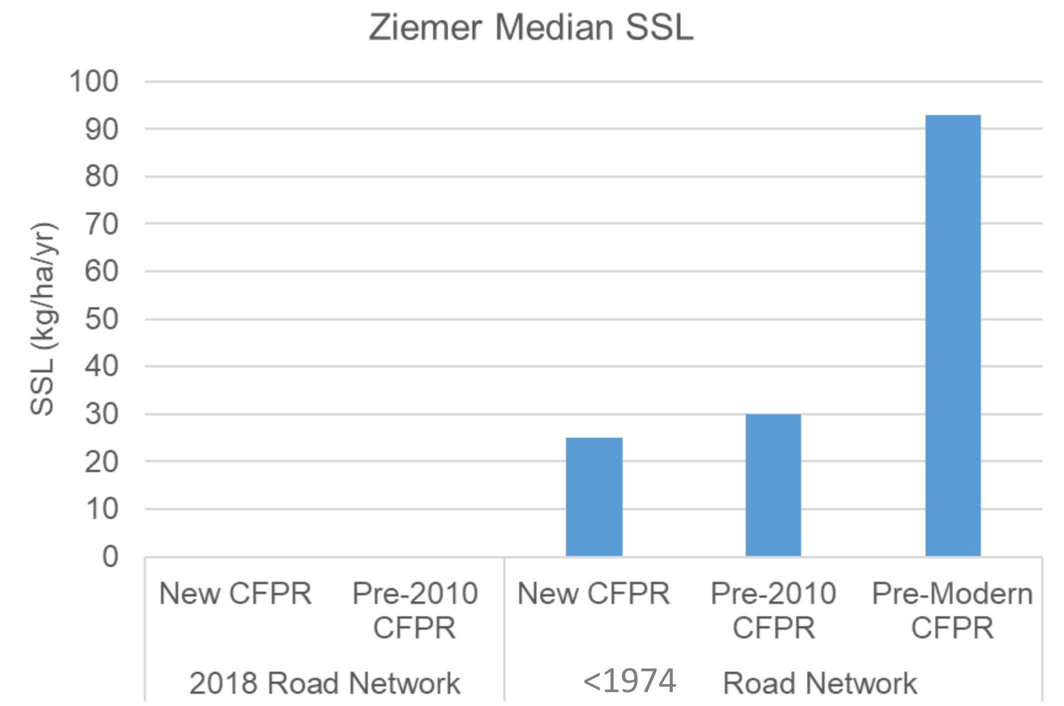
Log storm sediment load (kg) = 2.25 + 0.0256 * high peak flows -1.724 * surface type

coefficient p values = 0.03 to <0.0001; adj. R^2 = 0.65 to 0.78

Road Suspended Sediment Load by Scenario

Forest Vegetation and Road Network	Road Scenario	South Fork Caspar Mean Annual Road Only SSL kg/ha/yr	Ziemer Mean Annual Road Only SSL kg/ha/yr
Post-harvest Veg. 2018 Roads	2018 CFPR	22.9 – 35.1	0
Post-harvest Veg. 2018 Roads	Pre-2010 CFPR	52.8 – 85.8	0
Post-harvest Veg. Pre-1974 Roads	2018 CFPR	346.9 – 469.4	20.8 – 28.2
Post-harvest Veg. Pre-1974 Roads	Pre-2010 CFPR	409.6 – 594.3	24.6 – 35.7
Post-harvest Veg. Pre-1974 Roads	Pre-1973 CFPR	954.8 – 2158.2	57.3 – 129.5

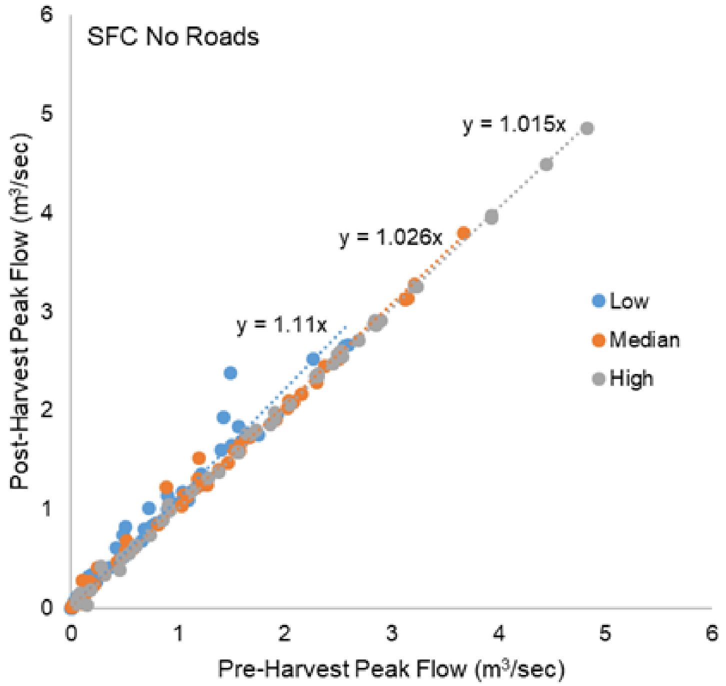


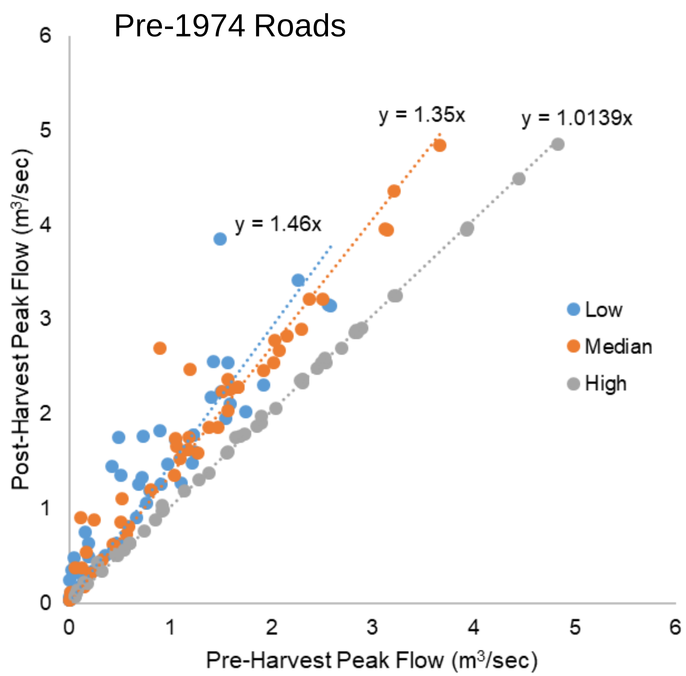


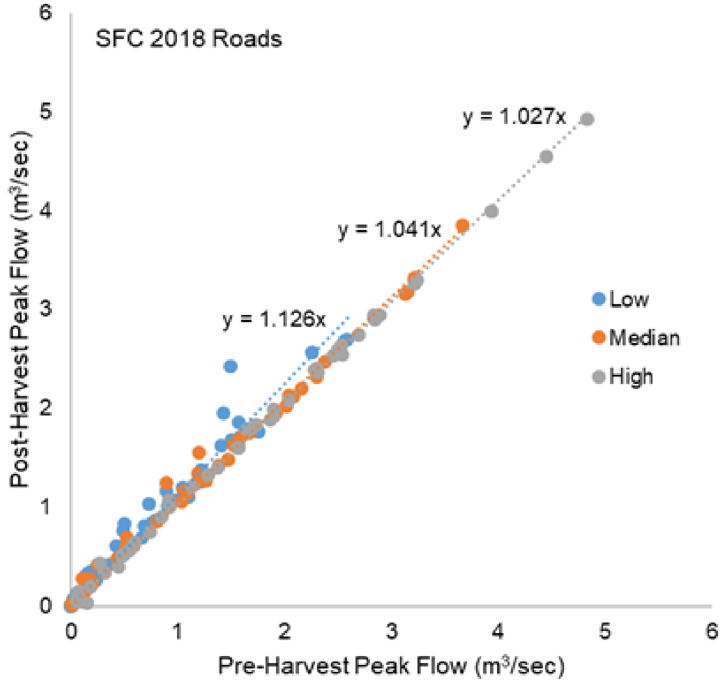
Peak Flow Changes

Road Network	Scenario	South Fork Caspar Peak Flow Increase	Ziemer Peak Flow Increase
No Roads	No roads	1.5% - 11%	2.6% - 17.6%
2018	2018 CFPR	2.7% - 12.6%	2.6% - 18.0%
2018	Pre-2010 CFPR	2.7% - 12.6%	2.4% - 18.1%
Pre-1974	2018 CFPR	1% - 35%	5% - 40%
Pre-1974	Pre-2010 CFPR	1% - 40%	5% - 53%
Pre-1974	Pre-1973 CFPR	15% - 46%	5% - 87%

Largest event 4 year return interval







Conclusions

- Suspended sediment load was best predicted by the peak flow and the maximum turbidity of road runoff events.

- The statistical model was improved by including measures of soil cover:
  - road surface type (rocked or native)
  - cutslope cover percentage

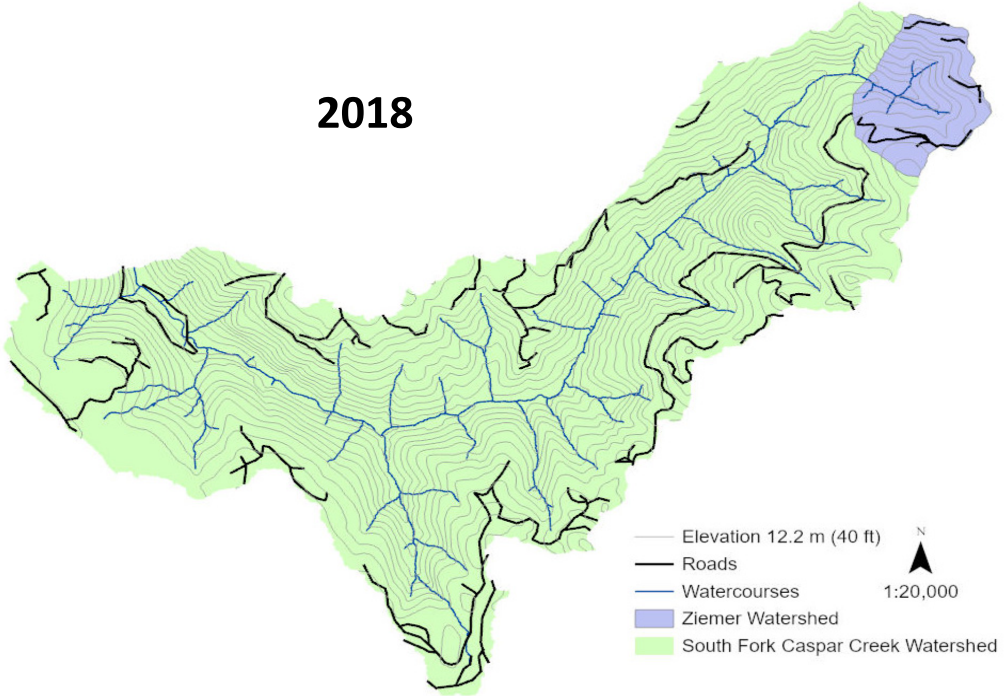
- Suspended sediment load was best predicted with only road dimensions (no runoff or turbidity) by:
  - Road length x $slope^2$
  - Road surface type (rock or native)
  - Road cutslope height

  (indicates proximity to hillslope drainage was important)

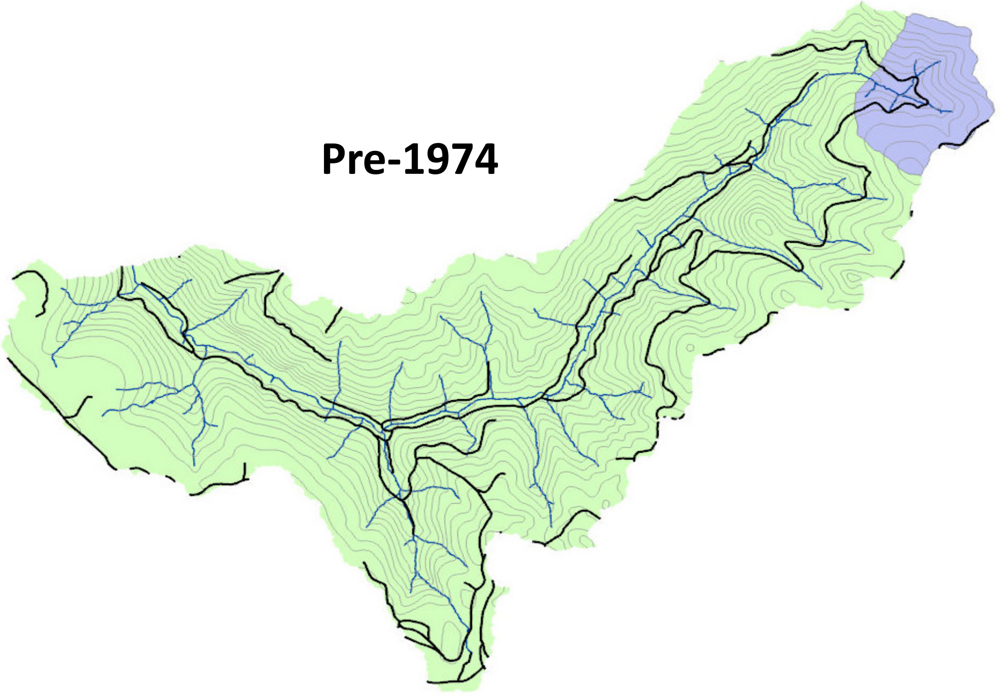
Conclusions (Continued)

- Peak flows and suspended sediment loads were estimated to increase following forest harvest.
- The peak flow increases were larger for the Ziemer watershed. Due to higher harvest level.
- The South Fork Caspar Creek 2018 road network was very effective in reducing peak flow and suspended sediment impacts.
- A road network with a high proportion of streamside roads, even with hydrologic disconnection practices, will still contribute to cumulative watershed impacts.

2018



Pre-1974



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Questions ?