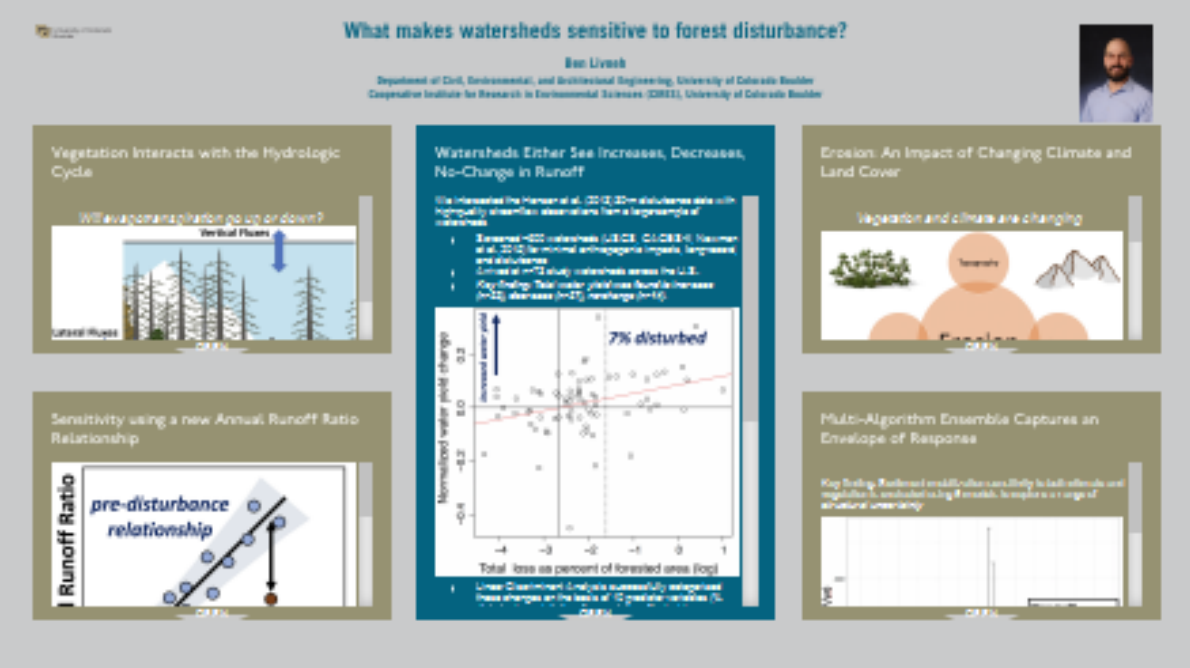
What makes watersheds sensitive to forest disturbance?



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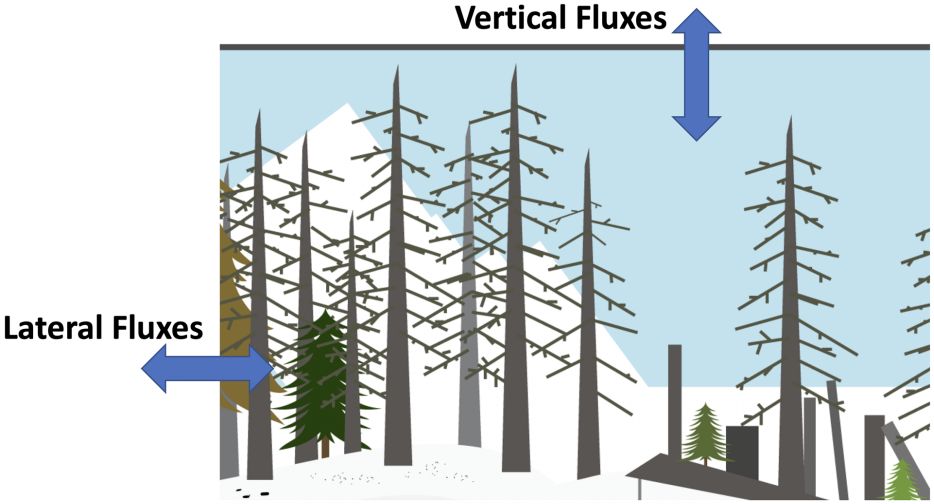
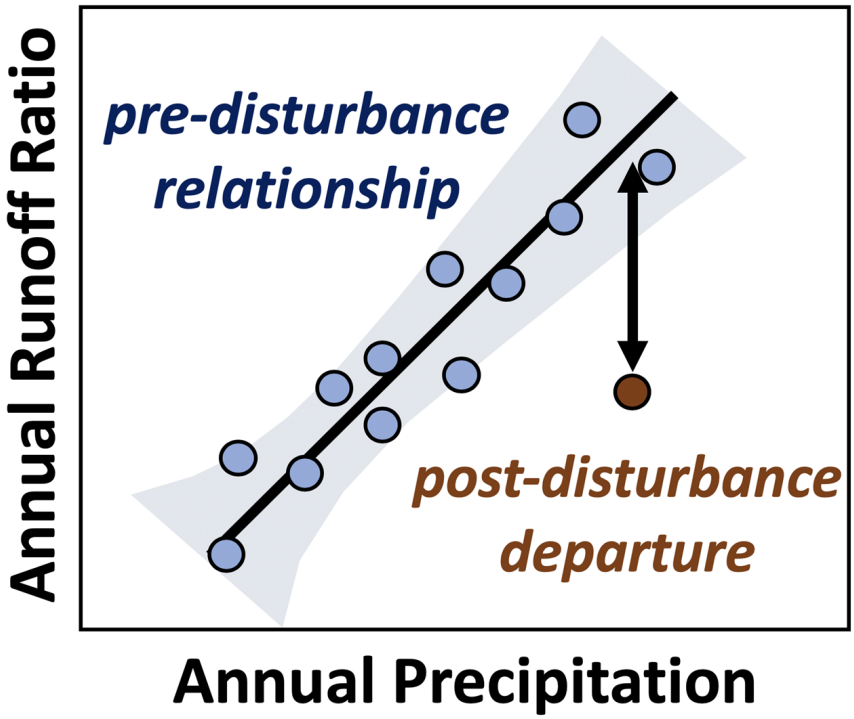
PRESENTED AT:

VEGETATION INTERACTS WITH THE HYDROLOGIC CYCLE

Will evapotranspiration go up or down?



SENSITIVITY USING A NEW ANNUAL RUNOFF RATIO RELATIONSHIP



Buma, B., & Livneh, B. (2017). Key landscape and biotic indicators of watersheds sensitivity to forest disturbance identified using remote sensing and historical hydrography data. *Environmental Research Letters*, 12(7), 074028.

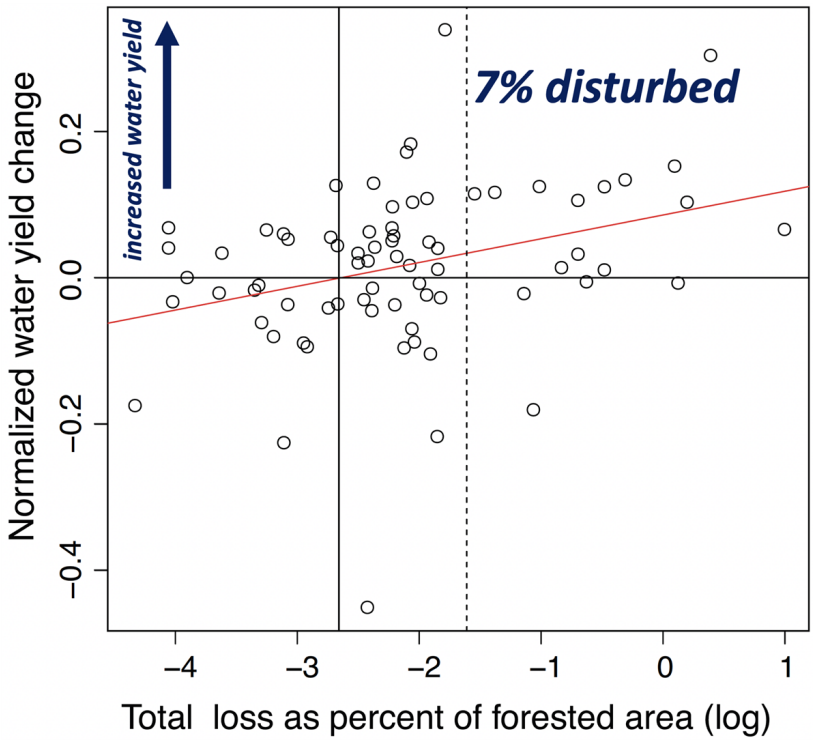
This method was first applied (Livneh et al., 2015) as an observational estimate of forest mortality sensitivity to compare with hydrologic model sensitivities.

Livneh, B., Deems, J. S., Buma, B., Barsugli, J. J., Schneider, D., Molotch, N. P., K. Wolter, & Wessman, C. A. (2015). Catchment response to bark beetle outbreak and dust-on-snow in the Colorado Rocky Mountains. *Journal of Hydrology*, 523, 196-210.

WATERSHEDS EITHER SEE INCREASES, DECREASES, NO-CHANGE IN RUNOFF

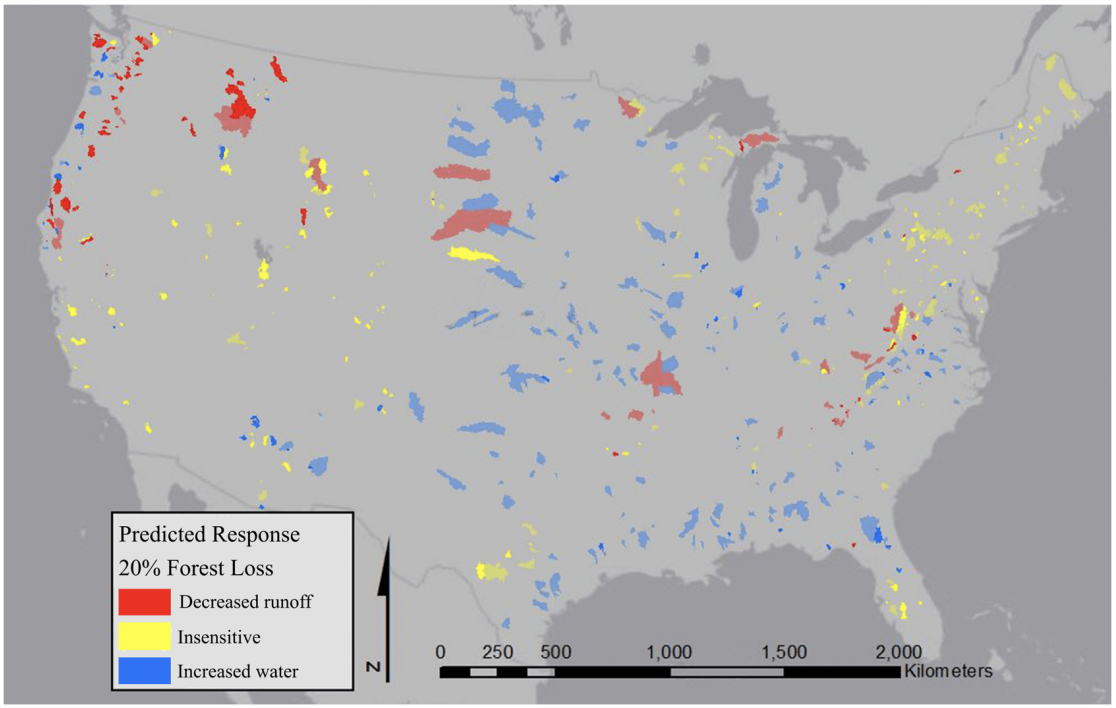
We intersected the Hansen et al. (2013) 30-m disturbance data with high-quality streamflow observations from a large-sample of watersheds

- Screened ~600 watersheds (USGS, GAGES-II, Newman et al.,2015) for minimal anthropogenic impacts, long-record, and disturbance
- Arrived at n=73 study watersheds across the U.S.
- ***Key finding: Total water yield was found to increase (n=22), decrease (n=37), no-change (n=14).***



- Linear Discriminant Analysis successfully categorized these changes on the basis of 10 predictor variables (% disturbed, precipitation, fragmentation, % deciduous cover, baseflow index)
- Classification accuracy 84% for predicting water yield change significantly better than the null hypothesis of no response
- **Key finding: Water yield increases significantly ($p < 0.05$) for basins with greater disturbance (>7%).**

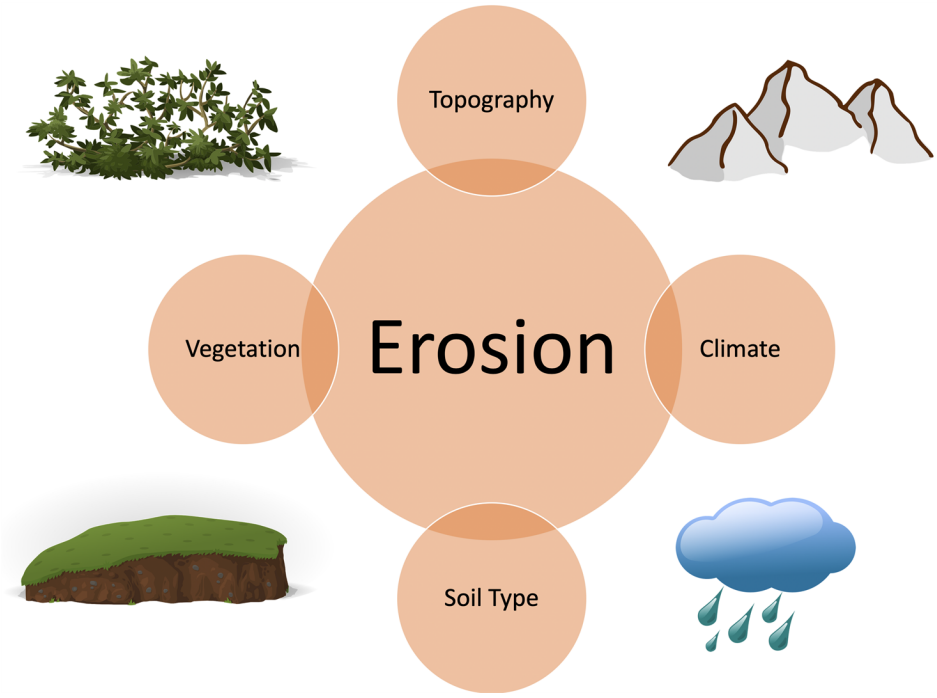
- Applied to all basins with some disturbance, regional patterns emerge



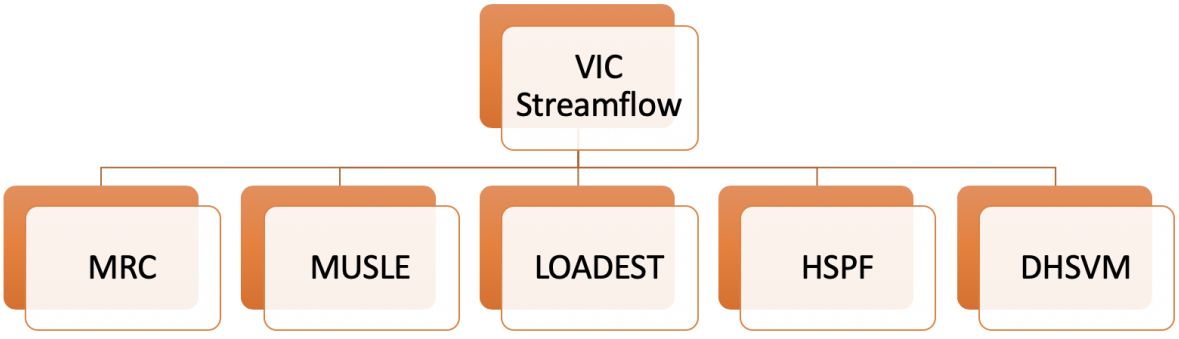
- Applied the same approach to the timing of water yield with similar classification accuracy.
- Snow dominated watersheds were found to be more insensitive to streamflow timing change, with other indications that timing change was less related to static features like slope.

EROSION: AN IMPACT OF CHANGING CLIMATE AND LAND COVER

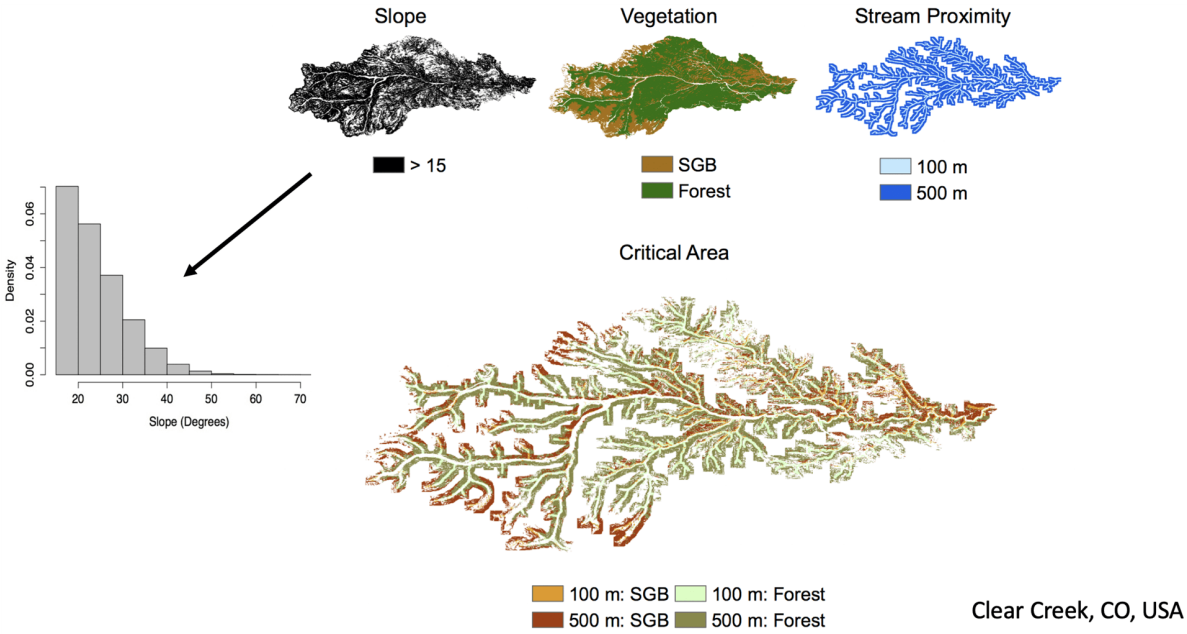
Vegetation and climate are changing



Stewart, J. R., Livneh, B., Kasprzyk, J. R., Rajagopalan, B., Minear, J. T., & Raseman, W. J. (2017). A multialgorithm approach to land surface modeling of suspended sediment in the Colorado Front Range. *Journal of Advances in Modeling Earth Systems*, 9(7), 2526-2544.

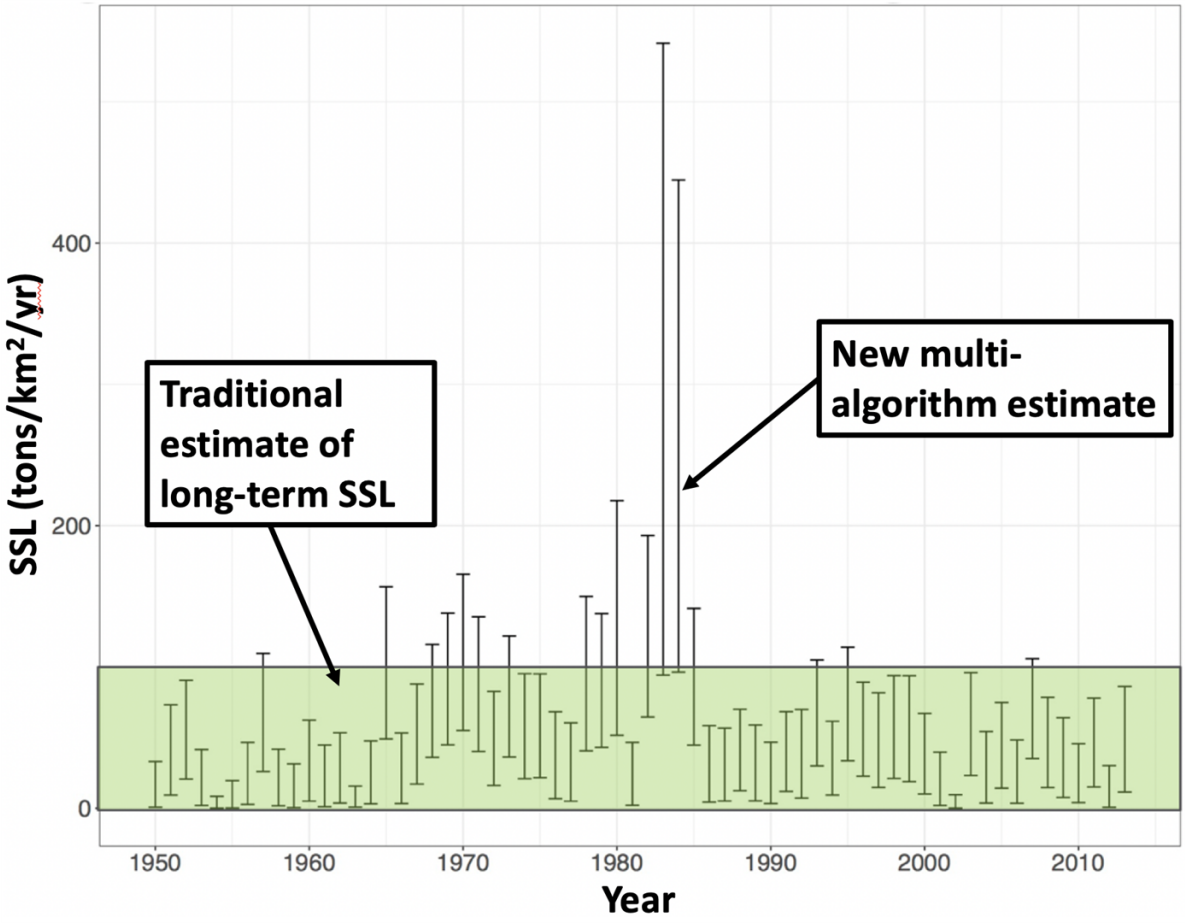


Applied the multi-algorithm ensemble over ***representative hillslopes*** most likely to produce suspended sediment.


Slope
Vegetation
Stream Proximity
> 15
SGB
Forest
100 m
500 m
Density
0.00
0.02
0.04
0.06
20
30
40
50
60
70
Slope (Degrees)
Critical Area
100 m: SGB
100 m: Forest
500 m: SGB
500 m: Forest
Clear Creek, CO, USA

MULTI-ALGORITHM ENSEMBLE CAPTURES AN ENVELOPE OF RESPONSE

Key finding: Sediment mobilization sensitivity to both climate and vegetation is evaluated using 5 models to capture a range of *structural uncertainty*



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The two primary citations relevant to this presentation:

Buma, B., & Livneh, B. (2017). Key landscape and biotic indicators of watersheds sensitivity to forest disturbance identified using remote sensing and historical hydrography data. Environmental Research Letters, 12(7), 074028.

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ABSTRACT

This presentation will explore land cover change impacts on hydrology, starting by posing the question: What makes a watershed sensitive to forest disturbance? Despite a long appreciation of the significance of forested watersheds to water supplies—supplying water to more than 180 million people in the U.S.—watershed sensitivity to forest disturbances remains difficult to predict. Individual studies have often contradicted long-standing understanding that forest disturbance leads to increases in total water yield. This research seeks to address the above question by linking a national-scale watershed database with high-resolution forest disturbance imagery. Results indicate that disturbance can caused significant changes (both increases and decreases) in water yield and streamflow timing. Watersheds exhibiting post-disturbance increases or decreases in water yield were found to be distinct from each other ($p<0.05$) and regional patterns of sensitivity are explored in the context of observable climatic and physiographic variables.

The last part of the presentation will explore the development of a multi-algorithm sediment modeling system motivated towards understanding the impacts of changing climate and land cover on sediment yield. Sediment loading driven by current and future hydrological extremes challenges drinking water utilities' ability to treat water to meet regulatory and public health protection goals. This framework is tested over medium sized (~1000 sq. km) watersheds, with the aim of a larger-scale analysis over the western U.S.

REFERENCES

Supporting References:

Buma, B., & Livneh, B. (2017). Key landscape and biotic indicators of watersheds sensitivity to forest disturbance identified using remote sensing and historical hydrography data. Environmental Research Letters, 12(7), 074028.

Stewart, J. R., Livneh, B., Kasprzyk, J. R., Rajagopalan, B., Minear, J. T., & Raseman, W. J. (2017). A multialgorithm approach to land surface modeling of suspended sediment in the Colorado Front Range. Journal of advances in modeling earth systems, 9(7), 2526-2544.

Additional References:

Hansen MC, et al., (2013), High-resolution global maps of 21st-century forest cover change. Science, 342(6160): 850-853.

Newman AJ, et al. (2015) Development of a large-sample watershed-scale hydrometeorological data set for the contiguous USA: data set characteristics and assessment of regional variability in hydrologic model performance. Hydrol. Earth Sys. Sci., 19 (1): 209-223.