Hydrologic response to forest treatment practices for wildfire mitigation in a Sierra Nevada watershed

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BOARD OF FORESTRY AND FIRE PROTECTION

“The age of the Megafire”

- “Megafire” is a fire that burns more than 100,000 acres
- Before 1950 no megafires were documented but in 2020 alone the United States experienced 11
- Since 2003 California has experienced 17 of its 20 largest fires on record

Source: Reuters 2020

Caldor Fire, South Lake Tahoe ~222,000 acres

Forest treatments- methods to reduce fuel loads

Are forest treatments a triple win?

1. Forest treatments mitigate wildfire impacts

2. Forest treatments increase biodiversity

3. **Forest treatments increase runoff**

Wildfires are known to increase runoff

Mechanism- altering the forest structure leads to an altering of water partitioning across the landscape

Annual Water Budget Approach

$$\text{Storage} = \text{Inputs - outputs}$$

$$\Delta S = P - (R + ET)$$

$$P = R + ET$$

P = Precipitation
R = Runoff
ET = Evapotranspiration

Idea: If we can show a change ET due to a change in forest structure we can use a water budget approach to predict the increase in runoff depth

Research Question

How do forest treatments impact runoff? At what spatial scale?

Specifically, do forest treatments impact water yield?

Water yield- total amount of water collected in a watershed in a given year

Sagehen Watershed- Eastern Sierra's, CA

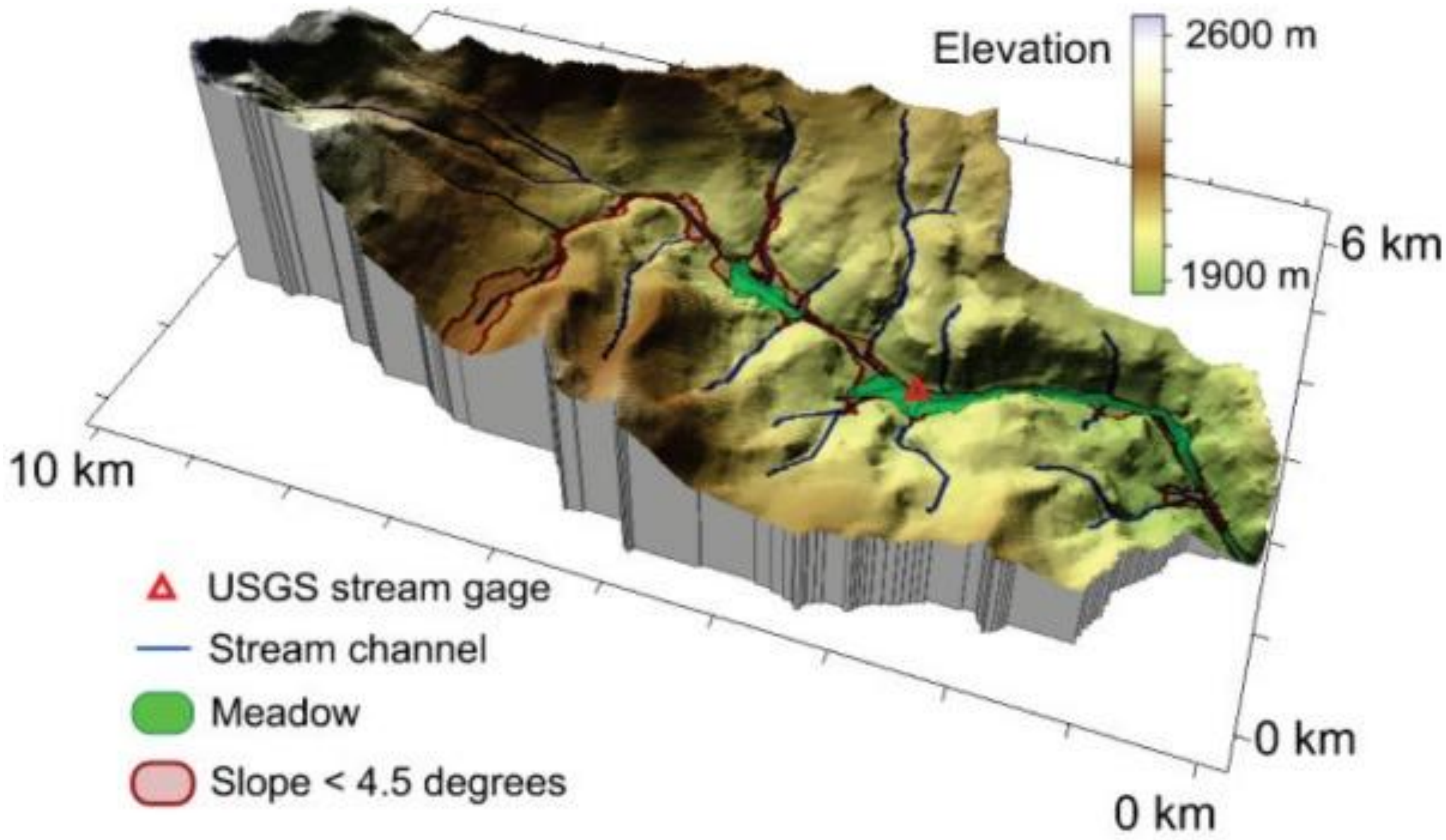
Area: 30 km^2

Average Precipitation: 800 mm

Snowfall: 80% of precipitation

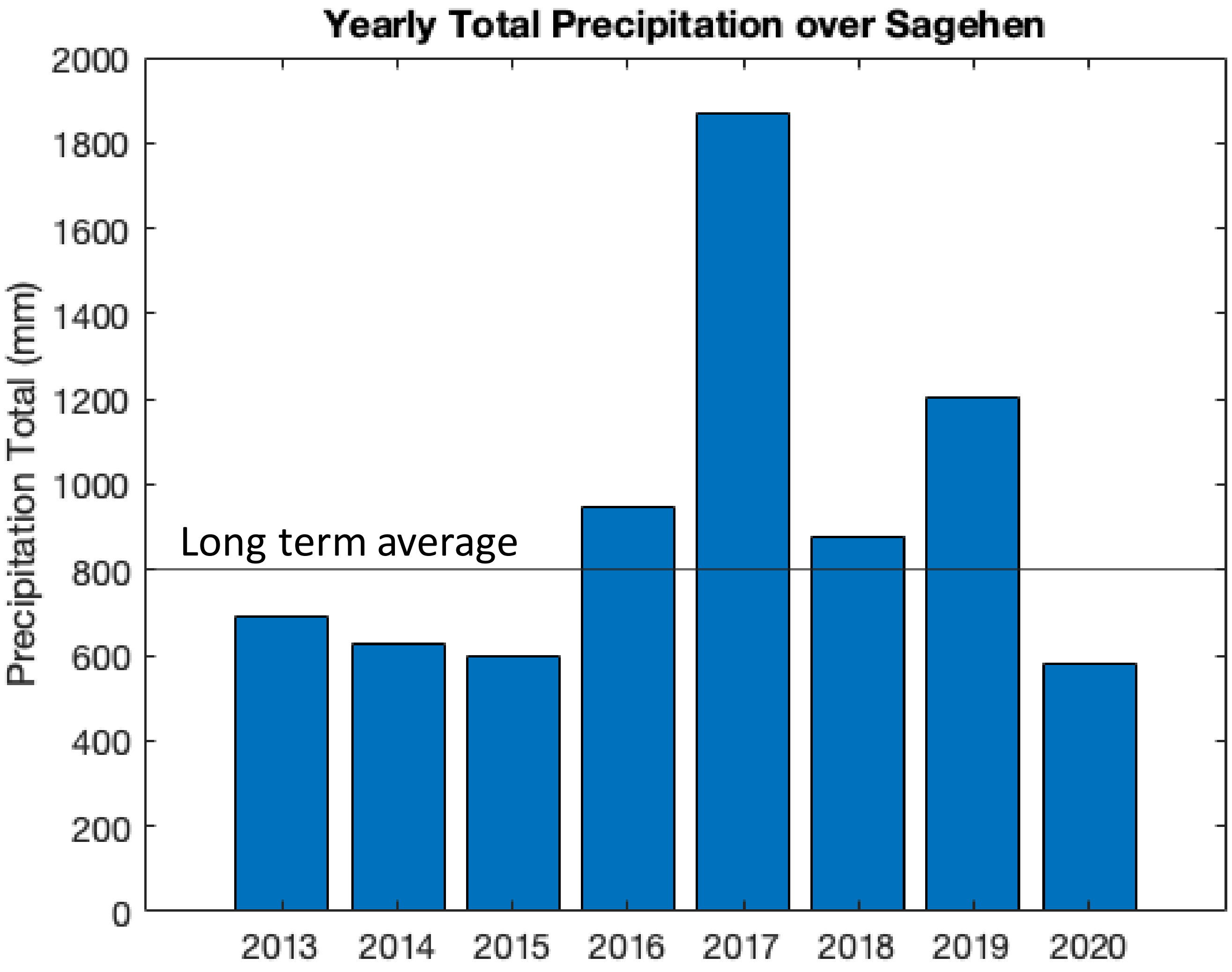
Peak flow: May

Min flow: September



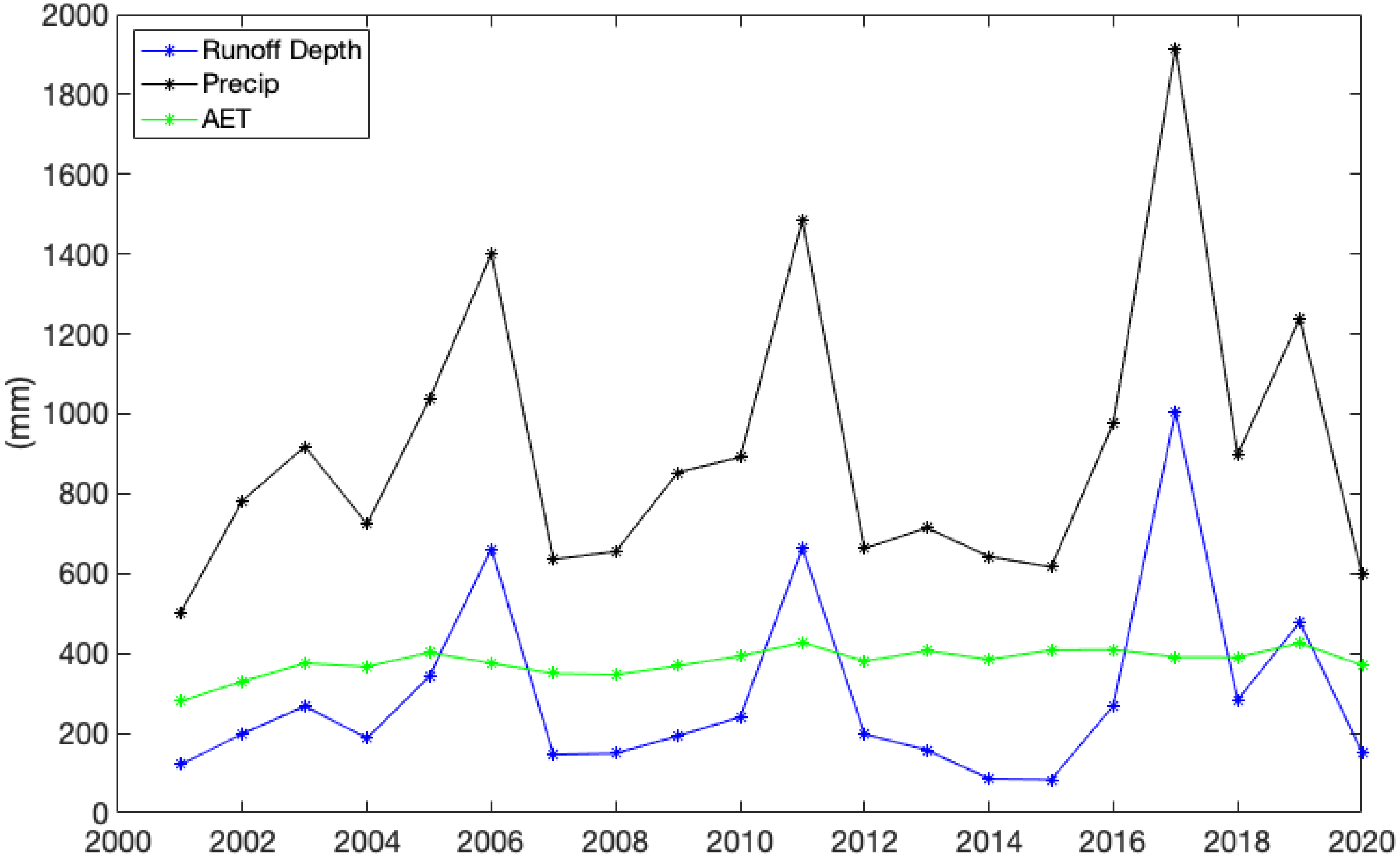
Water Resources Research, Volume: 50, Issue: 3, Pages: 2657-2678, First published: 27 February 2014, DOI: (10.1002/2013WR014420)

Variable precipitation over Sagehen during period of study



Sagehen Basin Water Budget

High variability in Precip and low variability in ET



Sagehen Basin Water Budget

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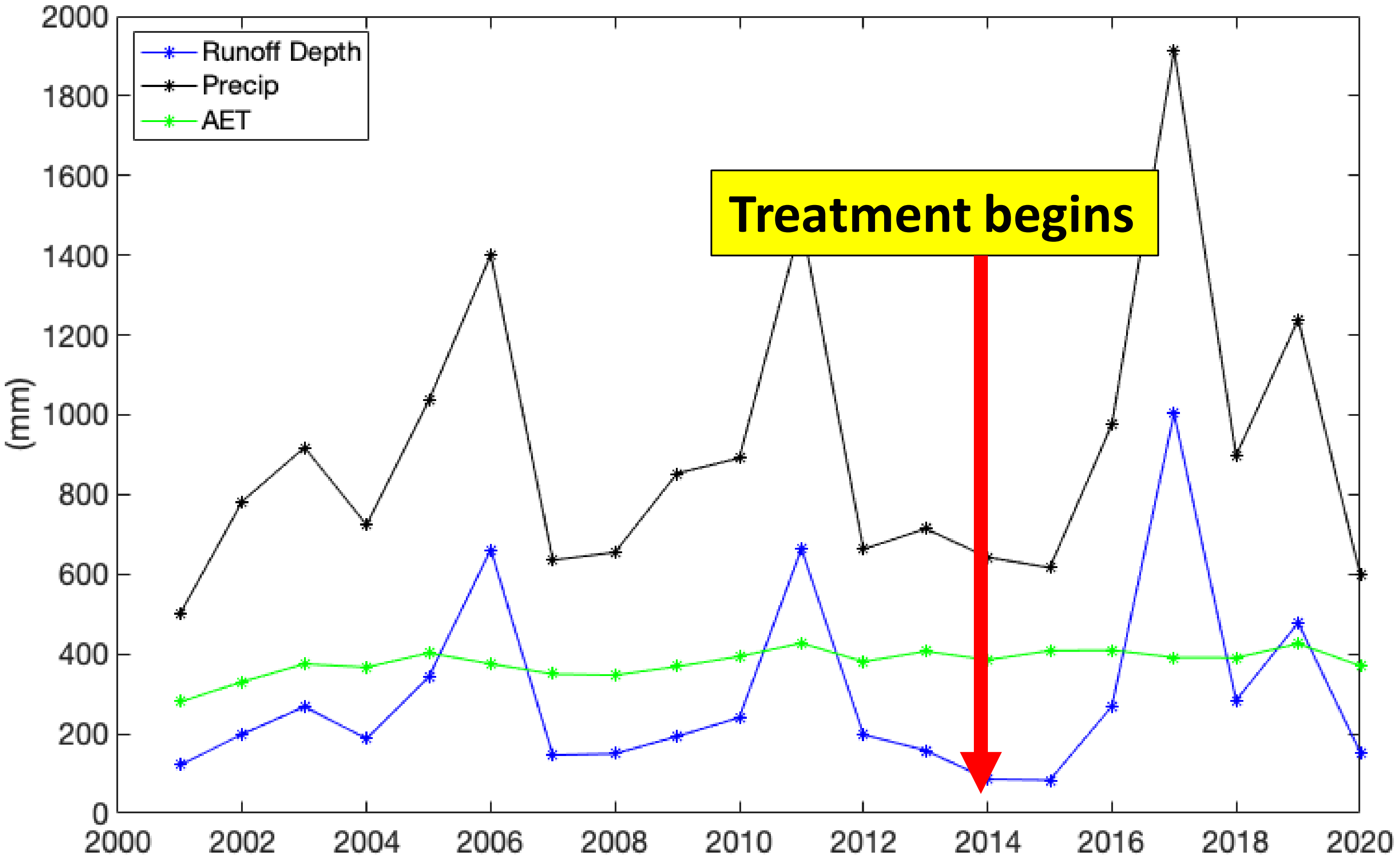
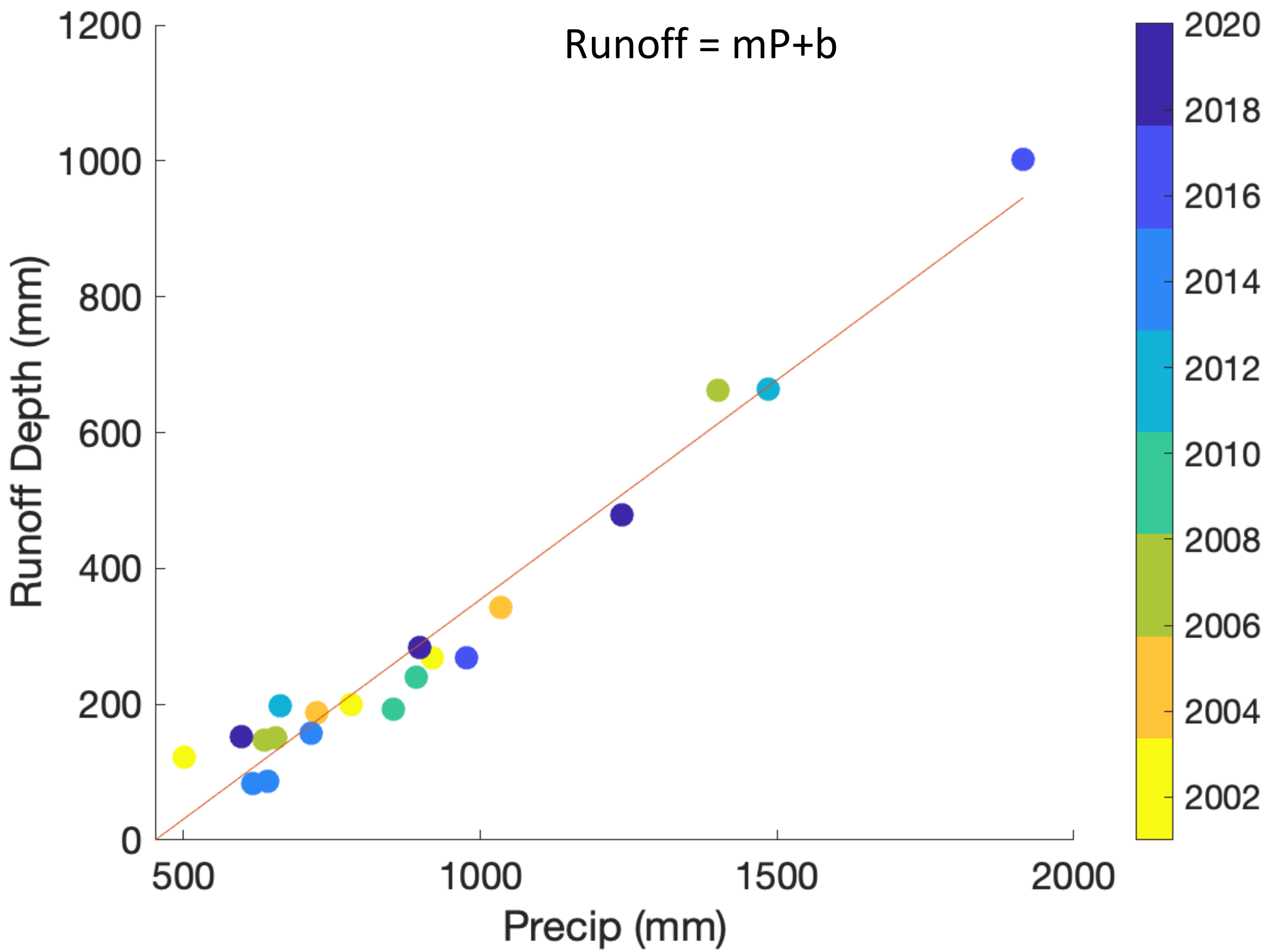


Changes in runoff is explained by precipitation

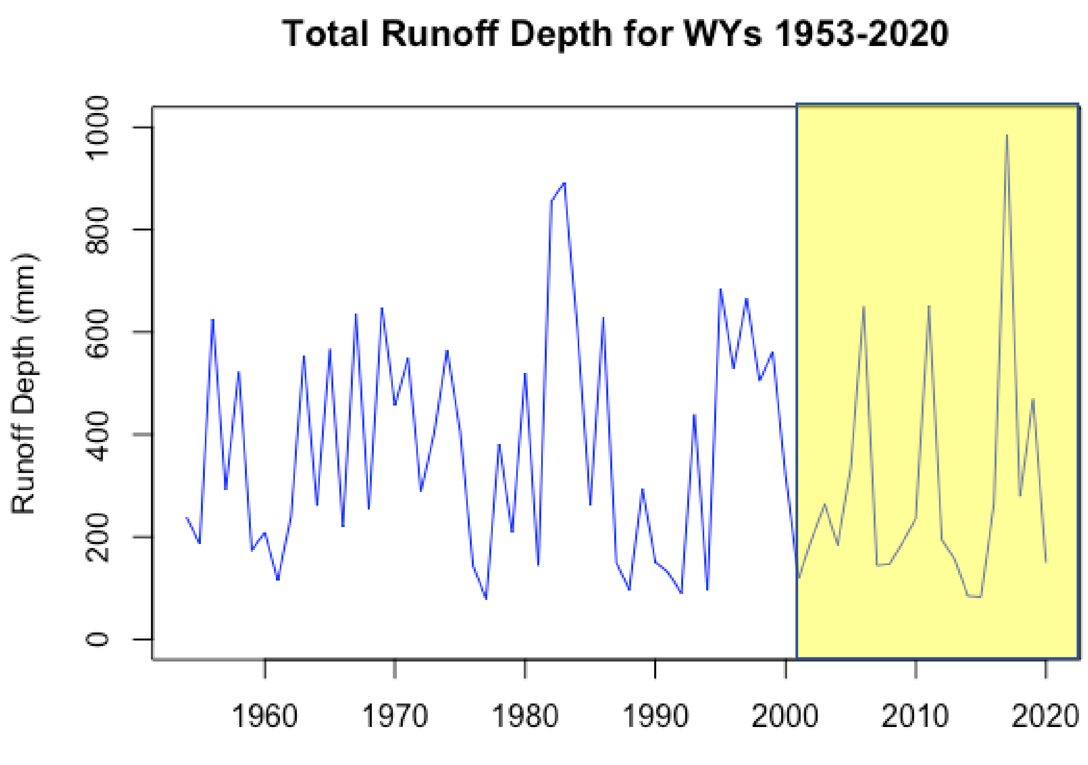
Simple Linear Regression

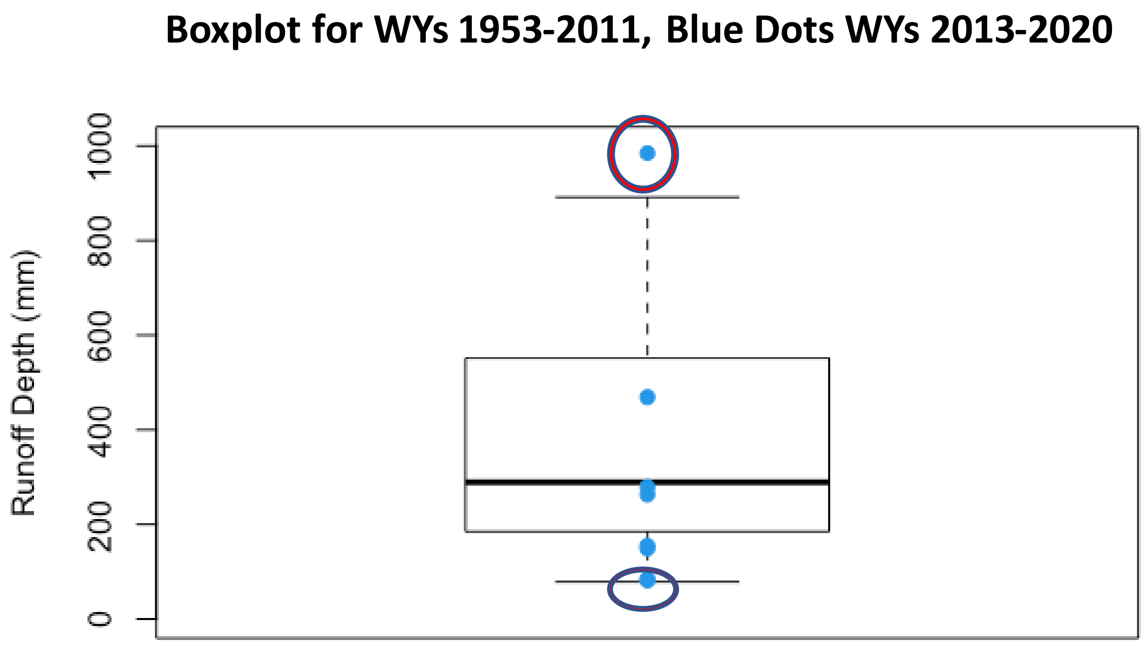
$R^2 = 0.96$

m = 0.63
b = -292.3

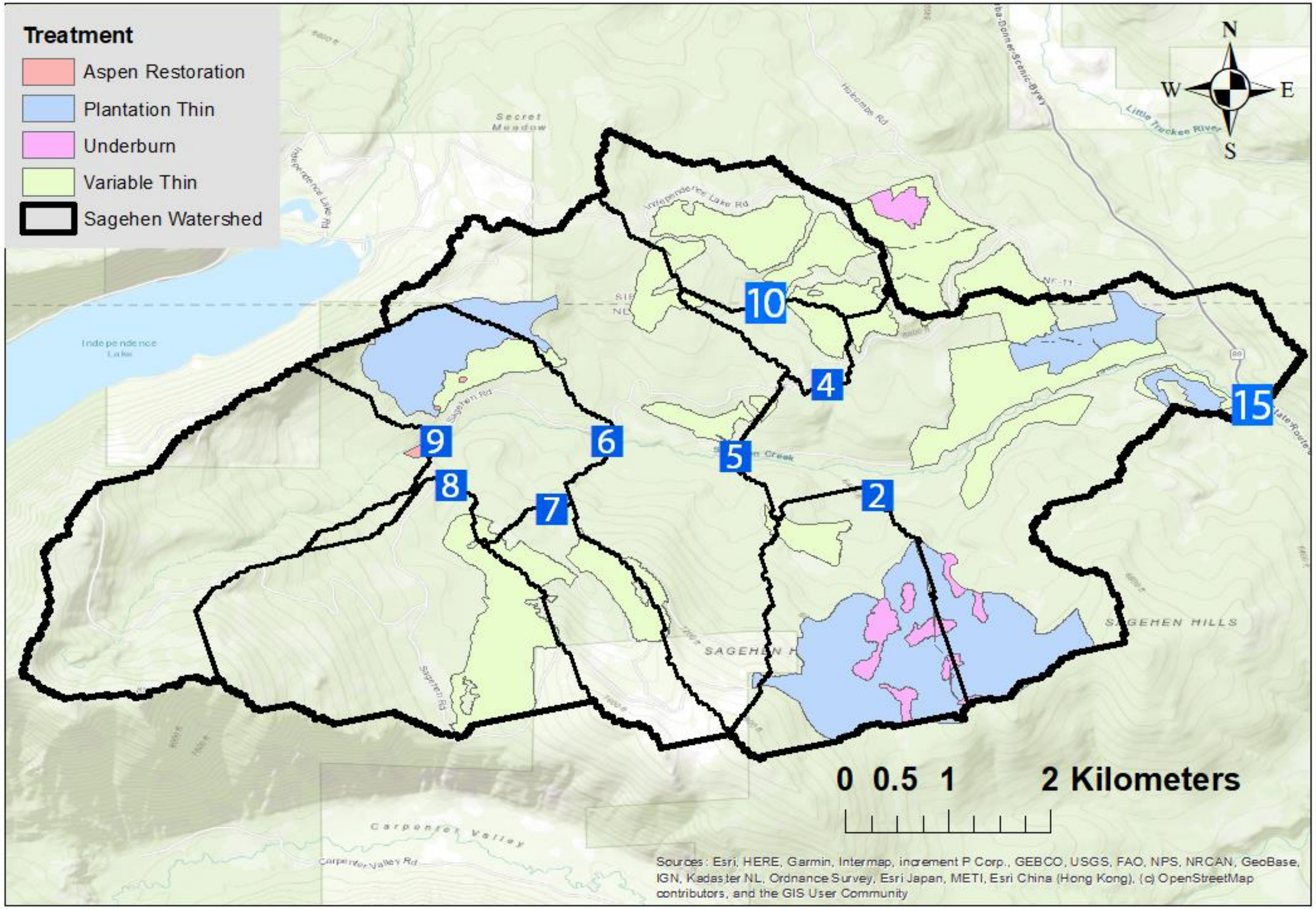


Highly variable runoff depth between 2001-2020

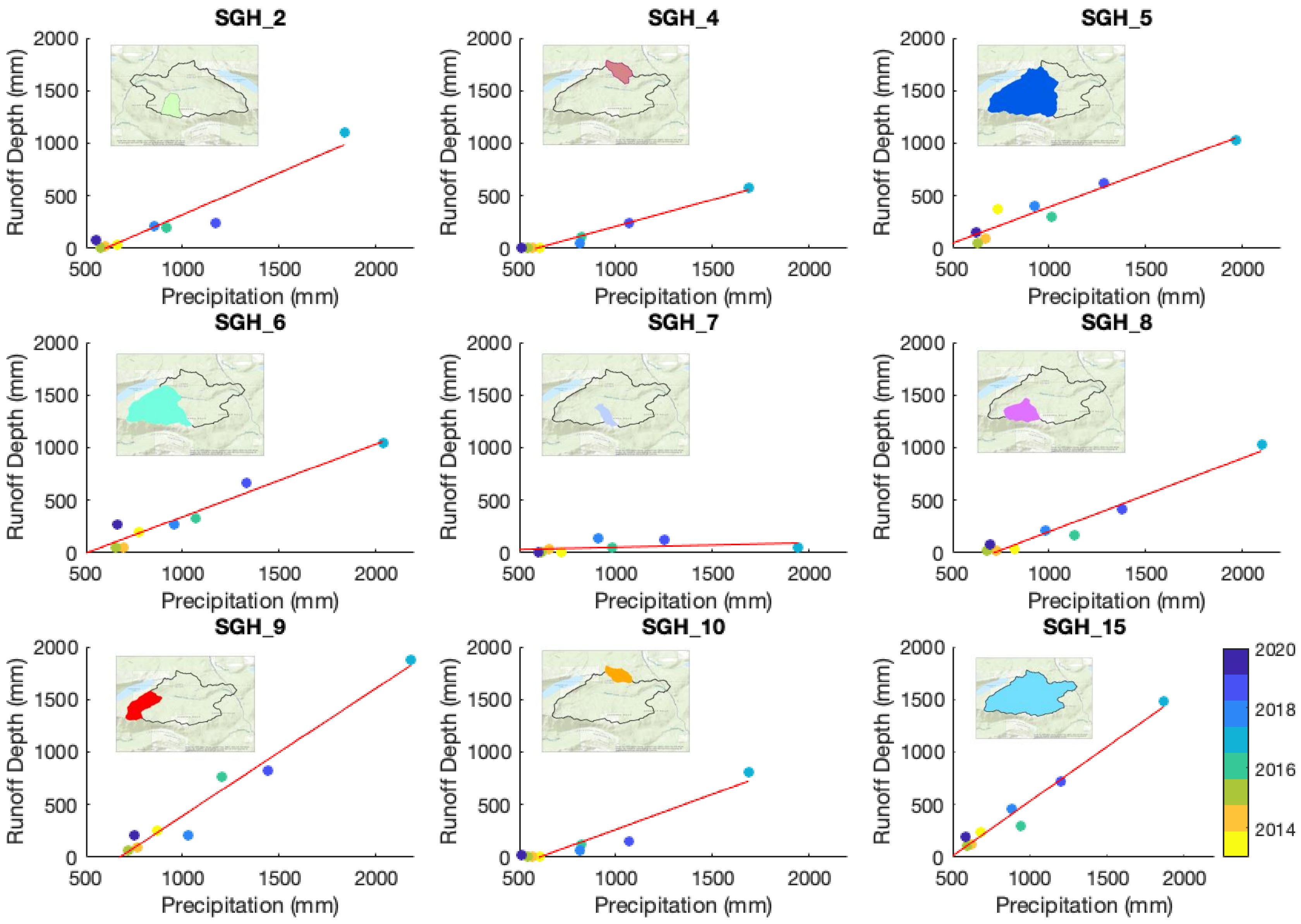




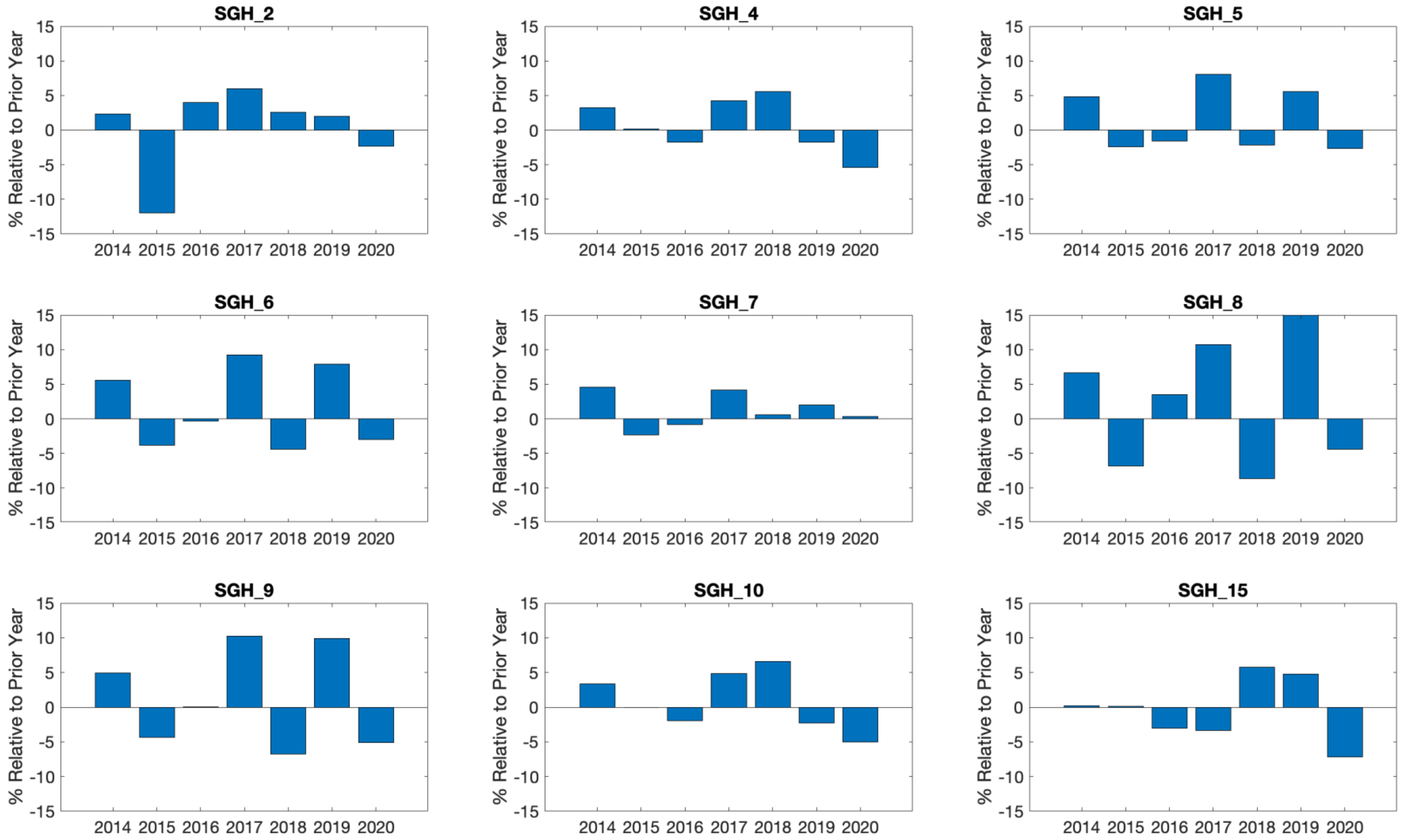
Sub-basin	Area (km^2)
2	3.02
4	2.95
5	19.96
6	13.79
7	1.71
8	4.48
9	4.87
10	2.36
15	24.22



Changes in runoff at sub-basin scale is explained by precipitation alone



Significant change in ET not observed at sub-basin scale



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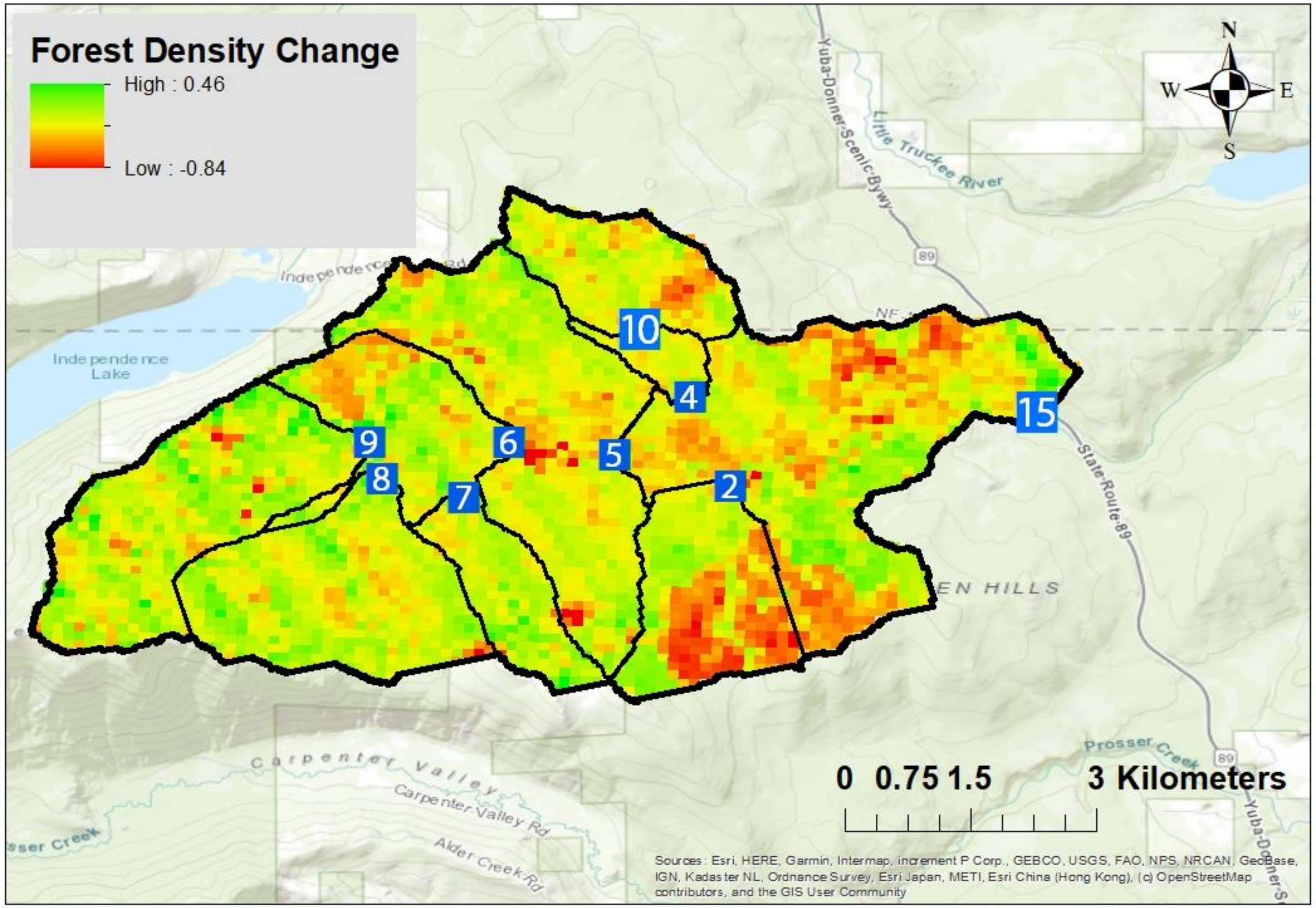
Relative Change in Forest Density 2014-2018

100m x 100m LiDAR Pixels



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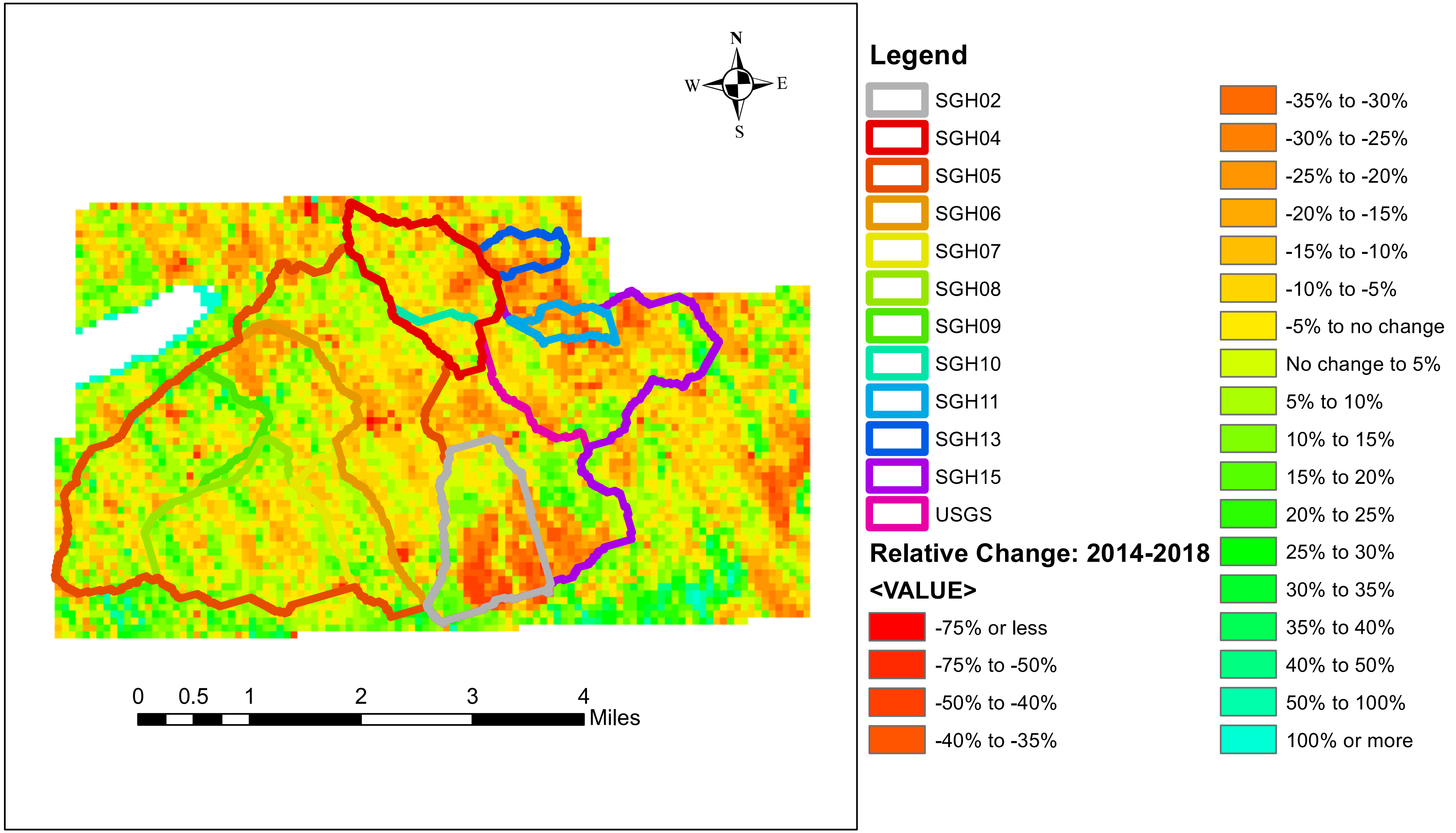
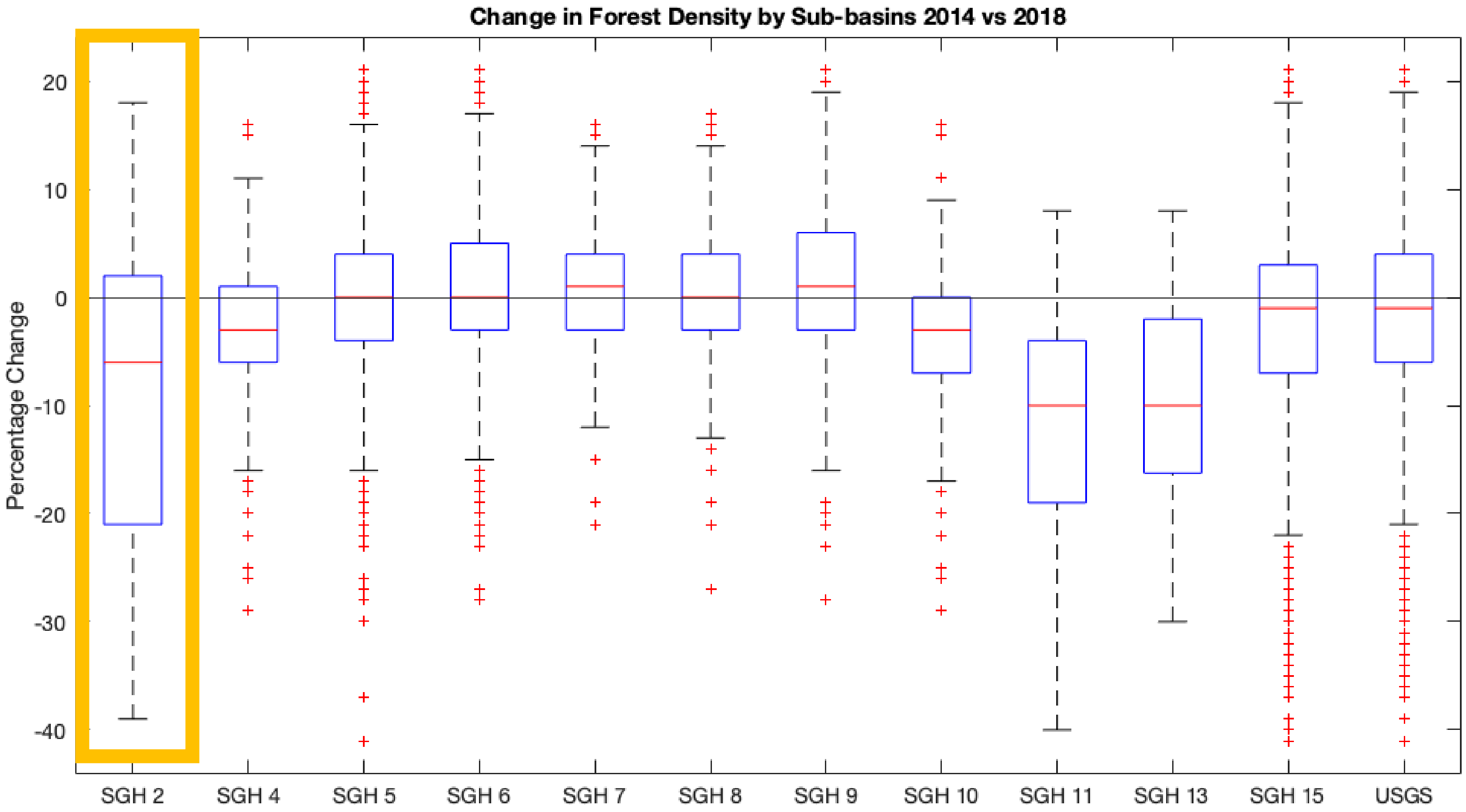
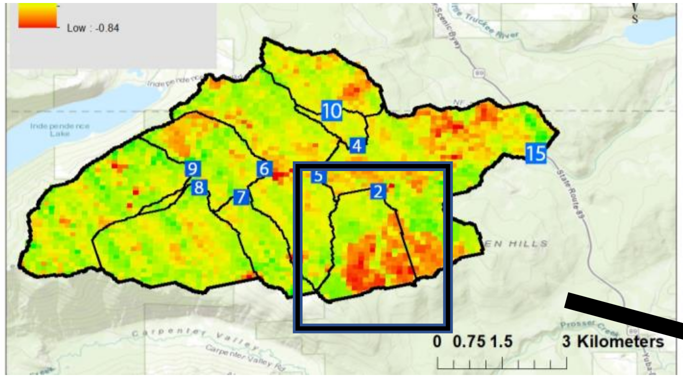


Median forest density change in sub-basins is minimal but there is significant variation

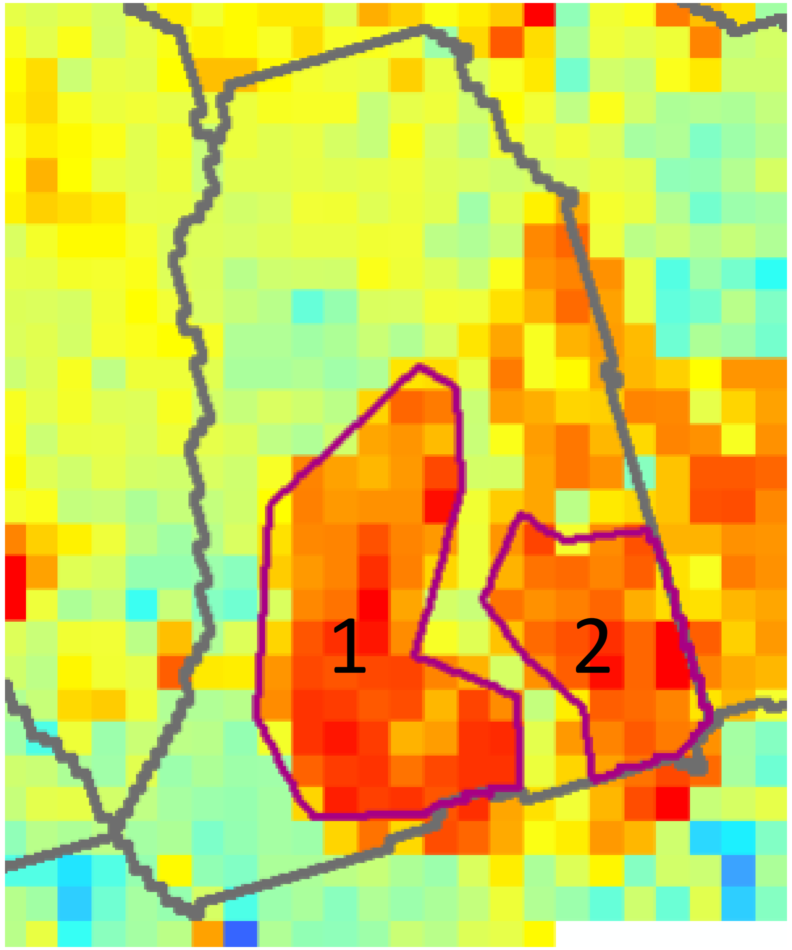


Number of Pixels	294	302	2017	1407	185	433	480	238	70	77	3501	2994

Change in forest density "hot spots" can be linked with change in ET



Basin	SGH 15	SGH 2
Total Area (km^2)	34.22	3.02
Median Forest Density Change	-0%	-5%
Median ET Change	< 1 %	< 1 %



Hotspots	1	2
Area of change (km^2)	~0.5	~0.3
Median Forest Density Change	-25%	-22%
Median ET Change	-25%	-12%

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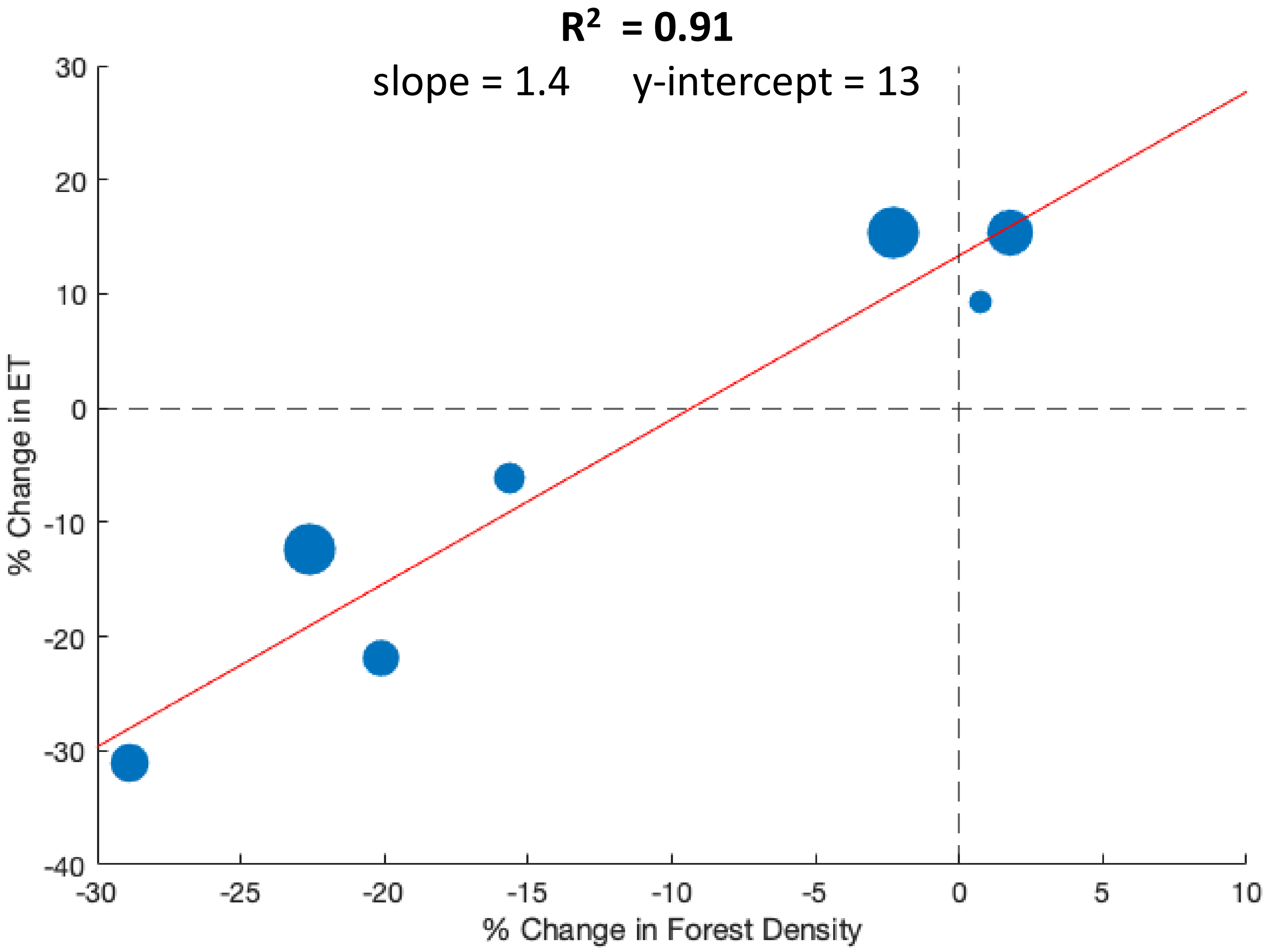
Strong correlation when sub-dividing sub-basin 2 into 7 sub-sub basins

● = 0.6 km^2

Largest hot spot found is less than 2% of the area of the watershed



Concluding Thoughts

No measurable increase in water yield due to forest treatments. Potential reasons for this…

1. **Forest treatments were just too small**
   - < 15% median change in ET in all sub-basin

2. **Precipitation variability dominates ET variability**
   - simple bivariate regressions are sufficient in explaining changes in runoff depth

However, zooming in to hot spots reveals that forest density change, measured with LiDAR can be correlated to ET.

An extrapolation of this may be able to be used in conjunction with a water budget approach to predict increase in runoff due to > 15% change in ET.

Thanks!