Watershed monitoring across the snow transition zone: An east slope-west slope collaboration

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Introduction

In Colorado, snowpack contributes a majority of the water to the state's water supply, yet monitoring of snow occurs primarily in the higher elevation snowpack that persists throughout the winter, while streamflow monitoring is generally focused in streams and rivers at lower elevations. The lack of combined snow and streamflow monitoring in watersheds along the transition from intermittent to persistent snow creates a gap in our understanding of snowmelt and runoff within the intermittent-persistent snow transition. Through a new collaborative research effort between Colorado Mesa University and Colorado State University, we established hydrologic monitoring sites that span the gradient of snow conditions in Colorado from high elevations where snow lasts through the winter to lower elevation snowpack that is more sensitive to drought and warming temperatures. The initial phase of study established hydrologic monitoring watersheds in intermittent, transitional, and persistent snow zones on the east slope and west slope of the Rocky Mountains in Colorado, and uses this monitoring network to improve understanding of how snow accumulation and melt affect soil moisture and streamflow generation under different snow conditions.

Monitoring Network

In March 2016, three monitoring stations were installed on the Grand Mesa (Figure 1), which along with the three existing east slope sites, created a network of six sites for the first two seasons of monitoring (Table 1 and Figure 2). In 2017, the intermittent site on the Grand Mesa was removed because the stream did not flow from March 2016 through August 2017, and two new sites were installed in the transitional and persistent snow zones in the Uncompahgre River watershed in the San Juan Mountains, with data collection beginning on October 1st (Figure 2).

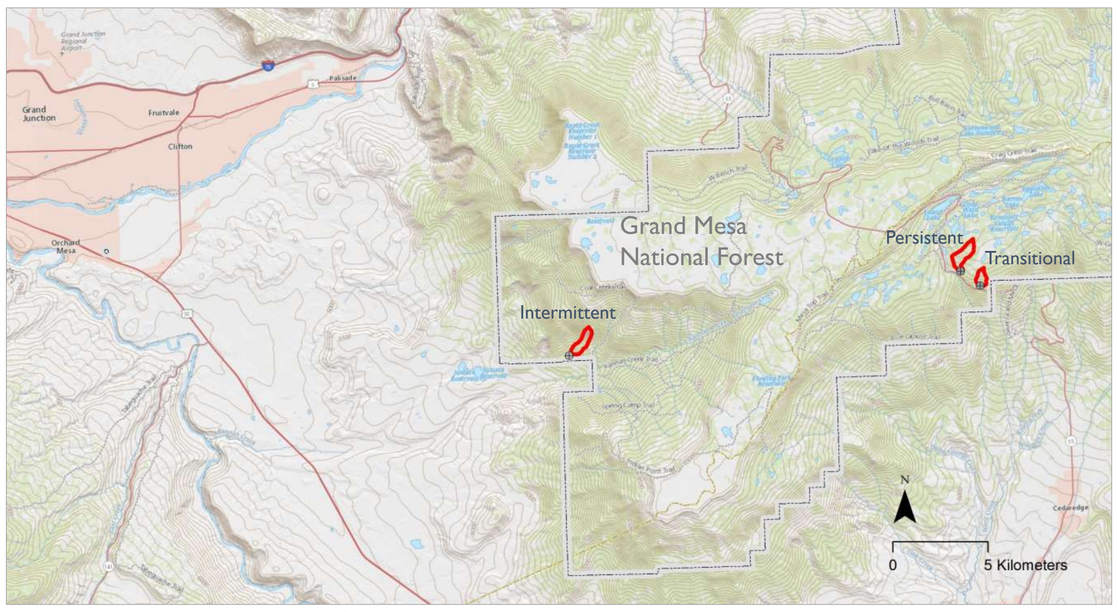


Figure 1. Locations of Grand Mesa monitoring watersheds

Table 1. Original six east and west slope monitoring watersheds (from Hammond et al. 2017)

Watershed	Snow Zone	Region	Precipitation (mm)	Precipitation (in)	Mean Elevation (m)	Mean Elevation (ft)
Michigan River	Persistent	Front Range	1087	43	3437	11273
Lazy D	Transitional	Front Range	507	20	2702	8863
Mill Creek	Intermittent	Front Range	462	18	1947	6386
Ward Creek Trib 1	Persistent	Grand Mesa	1028	40	3019	9902
Ward Creek Trib 2	Transitional	Grand Mesa	877	35	2939	9640
Shirtail Creek Trib	Intermittent	Grand Mesa	415	16	2189	7180

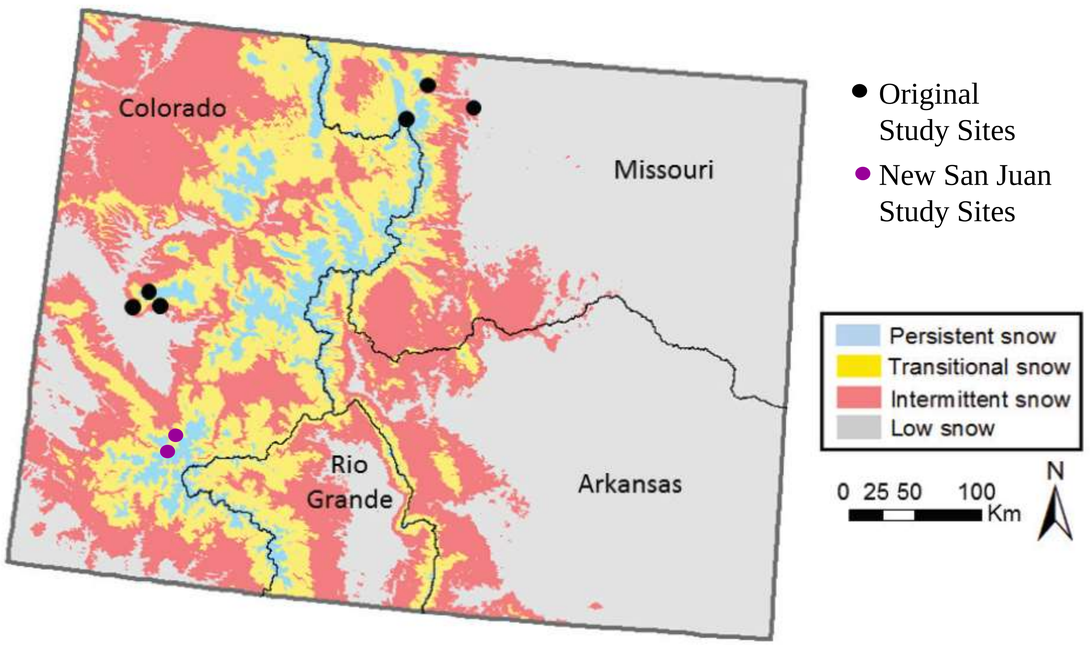
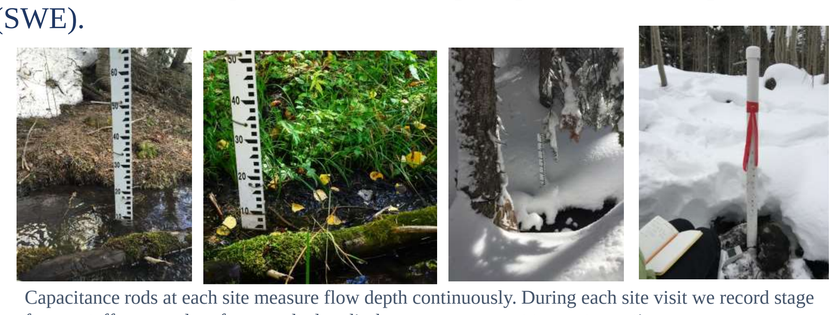


Figure 2. Locations of monitoring watersheds (Map from Hammond et al. 2017)

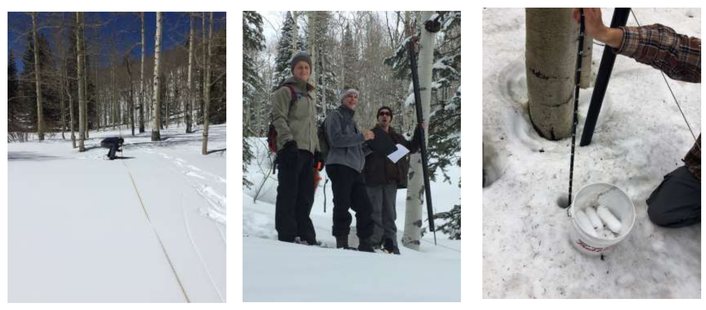
Monitoring Network (con'd)

At each site, we measure: streamflow, snow depth, soil moisture, precipitation, air temperature, and snow water equivalent (SWE).

A wildlife camera at each site photographs snow stakes for hourly snow depth measurements.



Capacitance rods at each site measure flow depth continuously. During each site visit we record stage from a staff gage and perform a salt slug discharge measurement to create a rating curve.



Regularly during the winter we perform 100-meter snow transects measuring snow depth and snow water equivalent (SWE).

Soil moisture sensors at 10, 20 and 50 cm depths are connected to data loggers which record soil moisture, soil temperature, air temperature and relative humidity. When the snow melts, we measure soil moisture along the 100-meter transect at each site.

A tipping bucket rain gage at each site records rainfall.

Finding our equipment was quite a challenge after the snowfall in January 2017.

Results from First Season (from Hammond et al. 2017)

- During the 2016 water year, the east slope sites generally had deeper snowpack and longer snow duration than the Grand Mesa sites.
- Snow cover remained at the east slope persistent site into June, whereas much of the snow at the persistent site on the Grand Mesa had already melted by early June (Figure 3).
- Instrument failures at some of the Grand Mesa sites led to some data loss
- The west slope persistent and transitional sites had more mid-winter melt and infiltration, shorter snowpack duration, and lower peak SWE than the east slope sites
- With our ongoing watershed monitoring across a broad range of snow conditions in Colorado, we continue to learn about the factors that increase or decrease streamflow in the headwater streams that supply the state's major rivers.

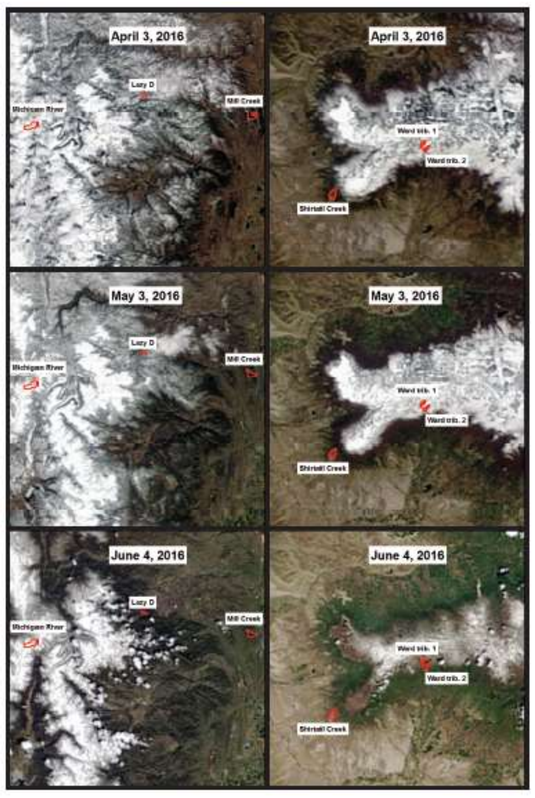


Figure 3. MODIS satellite imagery showing changes in snow at Front Range (left) and Grand Mesa (right) study watersheds from April to June 2016 (from Hammond et al. 2017).

References

Hammond, J., C. Moore, S. Kampf, and G. Richard, 2017. Watershed Monitoring Across the Intermittent Persistent Snow Transition Zone, *Colorado Water*, Vol. 34, Issue 3, pp. 6-11.

Acknowledgements

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