Snowmelt, infiltration, and soil moisture in Red Fir forest ecosystems of the Sierra Nevada

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Introduction

Snowmelt and soil moisture

Measurements from the Wolverton basin in Sequoia National Park and the Teakettle Experimental Forest in the Red Fir zone of the southern Sierra Nevada (2,300-2,600 m elevation) evaluate our hypothesis that topography and vegetation cover are the most important variables affecting snowmelt and soil moisture. The global variables of slope, aspect, and topography influence large-scale patterns of snow and soil moisture but vegetation also has a significant influence on the small-scale distribution of both. Slope canyons have multiple effects on the accumulation and ablation of snow and the distribution of the subsequent soil moisture. Snow, as opposed to rain, generally accounts for 70% of the annual precipitation received by these ecosystems and determines a clear seasonal signal in snowpack evolution. Our strategy is to combine specific surveys and instrumental data from both sites to describe these processes across broad temporal and spatial scales.

Snow melt

Synoptic snow surveys of a 0.6 sq km area in the Wolverton Basin were conducted in April 2007 and 2008. Annual precipitation was below average in 2007 and above in 2008. Depths and densities were measured at 36 grid points, four times under the canopy of the nearest mature Red Fir tree and four times in the closest canopy gap. The mean snow water equivalent (SWE) for all measurements was 26.9 ± 8.6 cm in 2007 and 49.4 ± 14.4 cm in 2008 and the 14 and 54 percent difference, respectively, between the canopy and open measurements.

Spatial heterogeneity in SWE, snowmelt, and soil moisture timing are all influenced by orientation to and proximity with tree canopies. Differences between the open and under canopy are most prevalent in locations that have high solar incidence during ablation. Conversely, snow forms in forest gaps that are shaded by large canopy. Interpolation of the percent difference between open and under canopy SWE measurements show the largest variations are found in locations with the highest solar incidence following the last major storms of the accumulation period. However, modeled clear-sky irradiance does not fully explain the distribution since the lowest SWE is found under canopies (Fu and Rich 2002). This illustrates the importance of the vegetation in the process of snowmelt infiltration and subsequent soil moisture in the early season.

Despite the difference in melt stage and total precipitation between 2007 and 2008 the spatial influence of tree cover on SWE demonstrates some seasonality between years.

Conclusion

Synoptic snow surveys of peak accumulation demonstrate consistent ablation patterns between above and below average years and significant differences between open and under canopy locations. The timing of infiltration from snowmelt in a forest is largely determined by the distance from and shading by tree canopies. Soil moisture prior to dry-down is inversely related to canopy shade that in open locations and converges at half-wetness. Differences in snowmelt and soil moisture between above and below average years are significant drivers in the vadose zone hydrology.

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Location, aspect and contour maps of Wolverton Basin study areas.

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