

Controls on Spatial Patterns of Soil Moisture in a Semiarid Montane Catchment with Aspect-Dependent Vegetation

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Abstract. Soil moisture exerts significant control over the partitioning of latent and sensible energy fluxes, the magnitude of both vertical and lateral water fluxes, the physiological and water-use characteristics of vegetation, and nutrient cycling. Considerable progress has been made in determining how vegetation, soil, and topography influence spatial patterns of soil moisture in humid environments at the catchment, hillslope, and plant scales. However, understanding of the controls on soil moisture patterns beyond the plant scale in semiarid environments remains more limited. This study examines the relationships between the spatial patterns of near surface soil moisture (upper 5 cm), terrain indices, vegetation indices, and soil properties in a small, semiarid, montane catchment. The 8 ha catchment, located in the Cache La Poudre River canyon in north-central Colorado, has a total relief of 115 m and an average elevation of 2193 m. It is characterized by steep slopes and shallow, gravelly/sandy soils with scattered granite outcroppings. North-facing hillslopes are predominately vegetated by ponderosa pines, while south-facing slopes are mostly vegetated by shrub species. Percent canopy cover was determined using a multispectral digital camera, and litter depth was manually measured at a 15 m resolution. Soil samples were collected at a 30 m resolution to characterize soil texture and bulk density. Nine spatial patterns of soil moisture consisting of more than 350 point measurements at a 15 m resolution were collected using time domain reflectometry (TDR) over a two month period containing 2 precipitation events of greater than 3 cm in the spring of 2008. Variation in both percent canopy cover and litter depth are best explained by $\cos(\text{aspect})$ among the terrain indices considered ($\cos(\text{aspect})$ is highly correlated with winter potential solar radiation index values). Results from soil textural analysis performed with sieving and the ASTM standard hydrometer method show that $\cos(\text{aspect})$ is the best univariate predictor of silts, while elevation and slope are the best predictors for coarse fractions. When the catchment average soil moisture is low, the variance of soil moisture increases with the average. When the average is high, the variance remains relatively constant. Little of the variation in soil moisture is explained by topographic indices when the catchment is either very wet or dry. However, when the average soil moisture takes on intermediate values, $\cos(\text{aspect})$ is consistently the best predictor among the terrain indices considered. The amount of variation explained increases when soil texture and vegetation indices are included in multiple linear regression models. As the catchment dries, the amount of variation explained by vegetation indices greatly increases.