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Moving from field observations of catchment hydrologic connectivity to new modeling conceptualizations

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Hydrologic connectivity between catchment upland and near stream areas is essential for the transmission of water, solutes, and nutrients to streams. Not surprisingly, this topic has received widespread attention in recent years. While significant progress has been made in experimental hydrology to observe and quantify landscape scale hydrologic connectivity, new model conceptualizations based on these observations have lagged. While numerous models are able to recreate observed hydrographs at the catchment outlet, few are consistent with or comparable to internal catchment observations of hydrological processes. It is critical that experimental studies and model development and evaluation be accomplished in concert with one another. This call to action is not new, yet it is rarely pursued and accomplished. Here we present a new modeling framework that appropriately represents hydrologic patterns and drivers of connectivity at the catchment scale. More specifically, the distribution of upslope accumulated area (UAA) along the stream network is a template by which landscape-scale hydrologic connectivity and catchment runoff can be simulated. We applied the model to the Stringer Creek watershed of the Tenderfoot Creek Experimental Forest (TCEF), located in central Montana, USA. We independently tested model consistency with internal catchment behavior and field observations of shallow groundwater connectivity across 30 hillslope-riparian-stream transects (180 groundwater wells). This parsimonious model was able to represent streamflow dynamics well and more importantly was consistent with internal catchment observation of hydrological connectivity through space and time. This new model structure, informed by catchment structure and emergent patterns of hydrological processes, represents a realization of the promise of integrated field – model development.