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Influence of spatial patterns of fire severity on gully erosion thresholds

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Spatial configurations of burned and unburned vegetation patches influence post-fire overland flow response and erosion thresholds. However, the broad-scale relationships between fire severity, the patterns and structural connectivity of burn mosaics, and post-fire erosion response remain largely unexamined. We mapped 227 primarily first order catchments across four burned watersheds in the northern Rocky Mountains and identified 90 cases of channel incision that led to gully rejuvenation. We applied landscape pattern indices to remotely sensed satellite data to quantify the relationships between the spatial structure of burn mosaics and the probability of gully rejuvenation following wildfire. As the mean fire severity of a catchment increased, the percent of the landscape in high severity fire classes increased non-linearly, and large, connected, and more severely burned patches increasingly dominated the catchment area. Concomitantly, the probability of gully rejuvenation was positively correlated (R2=0.93) with catchment areas severely burned. Statistical analysis revealed a threshold for erosion whereby a transition zone of high patch fragmentation preceded the threshold and after which progressively larger contiguous patches of severely burned areas and gully rejuvenation were observed. These observations suggest that progressive loss of vegetation due to wildfire leads to critical thresholds of structural connectivity that may enhance the hydrologic connectivity of overland flow pathways that lead to gully rejuvenation.