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River channel width change: Dynamics and scaling relationships in the upper Midwestern US

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The width of alluvial river channels varies as a function of multiple variables, including flow, sediment supply, bed roughness and riparian vegetation. Changes in channel width are highly variable in space and time, but few have characterized and/or explained the structure and scaling relationships of that variability. Increasing availability of remote sensing data and computational power allows us to measure landscape changes at more detailed spatial and temporal scales than ever. In this study we use historic air photos to study patterns of channel width change and examine the effects data resolution on measurements of channel width change.

We digitized 129 km of (vegetated) channel banks for the Root River in Minnesota, USA, for nearly every decade (excluding the 60s and 80s) spanning 1937-2013. Rates of channel widening were calculated at different spatial and temporal scales. Spatial-scaling effects were examined by measuring width changes from a 10-m window to the reach (∼10 km) scale. The time interval between measurements varied from 1 year to 76 years. Data show that at small (100 m) spatial scales reaches that widen in one time period have a strong propensity to narrow in the following period. The most active reaches typically exhibit short, punctuated periods of change, but the stretches that are most active varied across decades.
When increasing the temporal scale (time period) over which rates are calculated, the rates exhibit an apparent decrease, an effect that is observed for both the recent period and for data from the 1930s-50s. When considering the same time scale, rates are comparable for both periods. In addition to a temporal scaling effect there is also a spatial scaling effect. Changes in width are spatially correlated for distances up to a 3 to 5 times the channel width. Rates measured over shorter stretches are higher than those measured for longer ones. The most extreme changes occurred over shorter time periods along reaches with a maximum length of a few hundred meters, while less extreme changes were exhibited along the main part of the channel.

After accounting for limitations imposed by different spatial and (especially) temporal scales, we studied relationships between changes in channel width and environmental drivers. Overall, channels widened about 15% since the 1930s, but there were phases of widening and narrowing at relatively (decadal) short timescales. Changes in channel width show no correlation with single floods of extreme magnitude. Rather, width changes are correlated to hydrologic changes with a shorter return period, such as the two year return period flood. These results again emphasize the importance of the so-called bankfull flood as effective primary driver of geomorphic channel form. They also demonstrate how changes in channel dimensions appear punctuated in both space and time.