Analyzing Symmetry of Stream Valleys to Characterize Possible Neogene Uplift in the Blue Ridge Mountains of North Carolina

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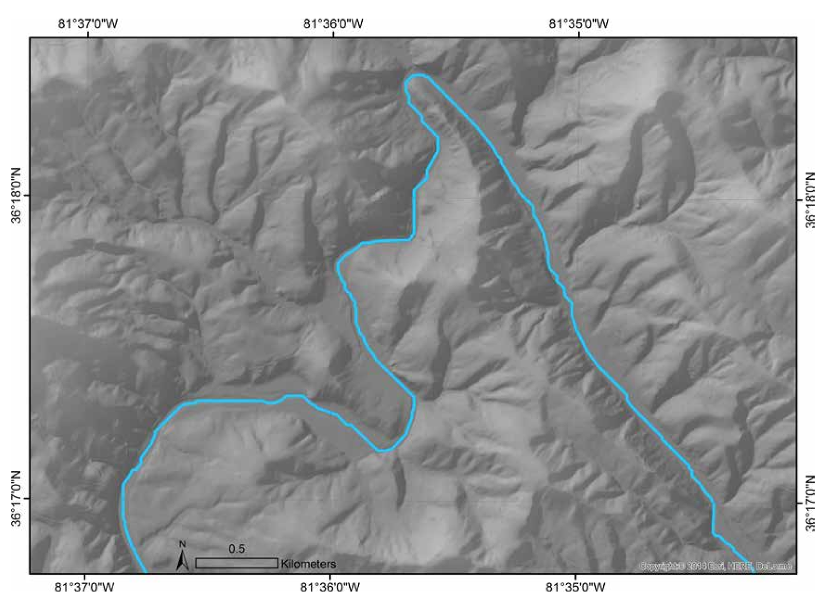
William E. Odom (wodom@live.unc.edu) and Kevin G. Stewart
UNC Chapel Hill Department of Geological Sciences

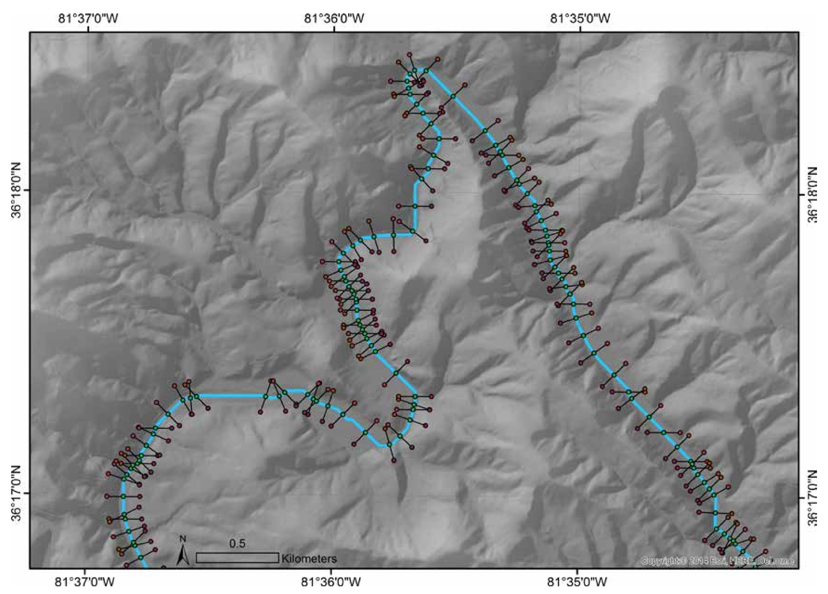
Introduction

The symmetry of valleys has the potential to indicate tectonic activity by revealing migration trends of channels. Tectonic quiescence promotes lateral migration of stream bends. This creates asymmetrical valleys at river bends with gentle point bars and steep cut banks. Uplift promotes downcutting over lateral migration, producing symmetrical valleys. We focused on eight major rivers in the Blue Ridge Mountains of North Carolina and studied their valley symmetry in an effort to expose possible correlations between uplift and channel migration.

Mapping Valley Symmetry



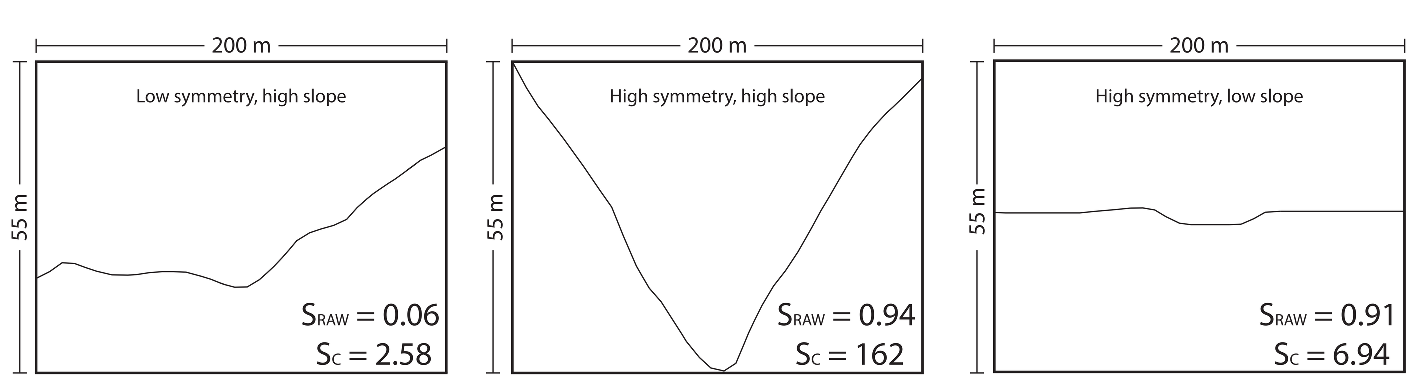
We located channels of interest using a USGS streams and rivers shapefile, and created representative polylines using the cost path tool available in ArcMap.

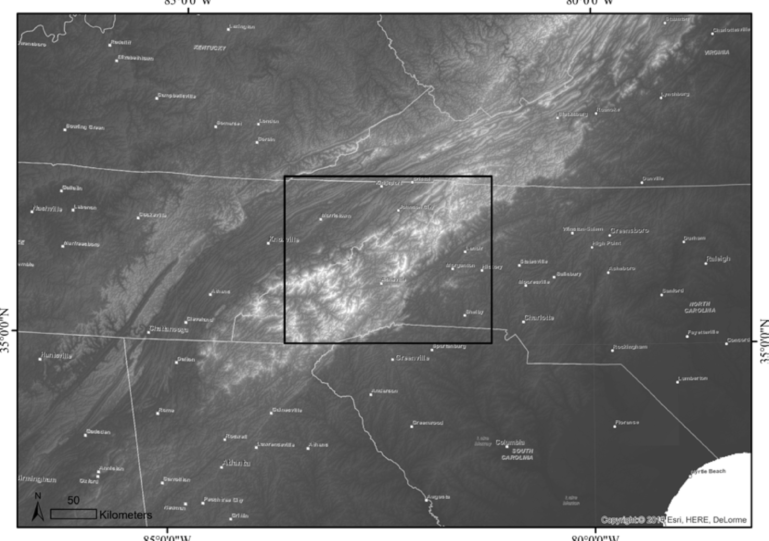


We used a transect tool to create 200-meter long transects, the midpoints and vertices of which were used to quantify the profile of the valley being analyzed.

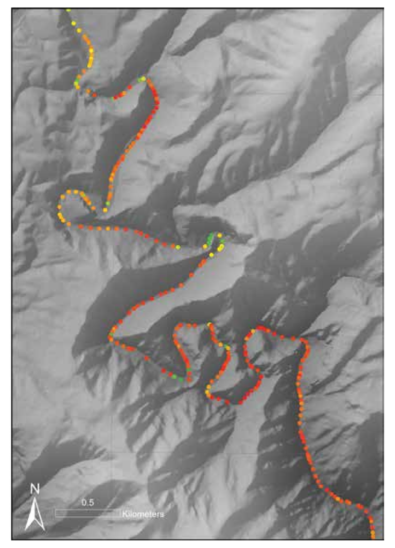
We used elevation data from the transects to calculate valley symmetry. Where the grade of the right bank exceeded the grade of the left bank, we inverted the ratio to maintain a range from 0 (asymmetrical) to 1 (symmetrical). We multiplied the symmetry values by average slope to distinguish symmetric valleys in steep areas from those in gently-sloping flood plains:

$$S_C = \left(\frac{Z_{right}-Z_{middle}}{Z_{left}-Z_{middle}}\right)\left(\frac{Z_{right}+Z_{left}}{2} - Z_{middle}\right)$$

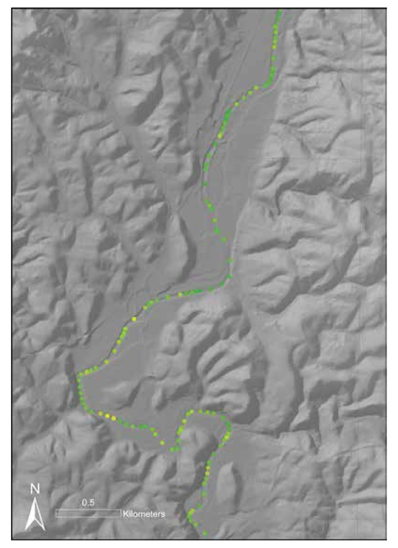




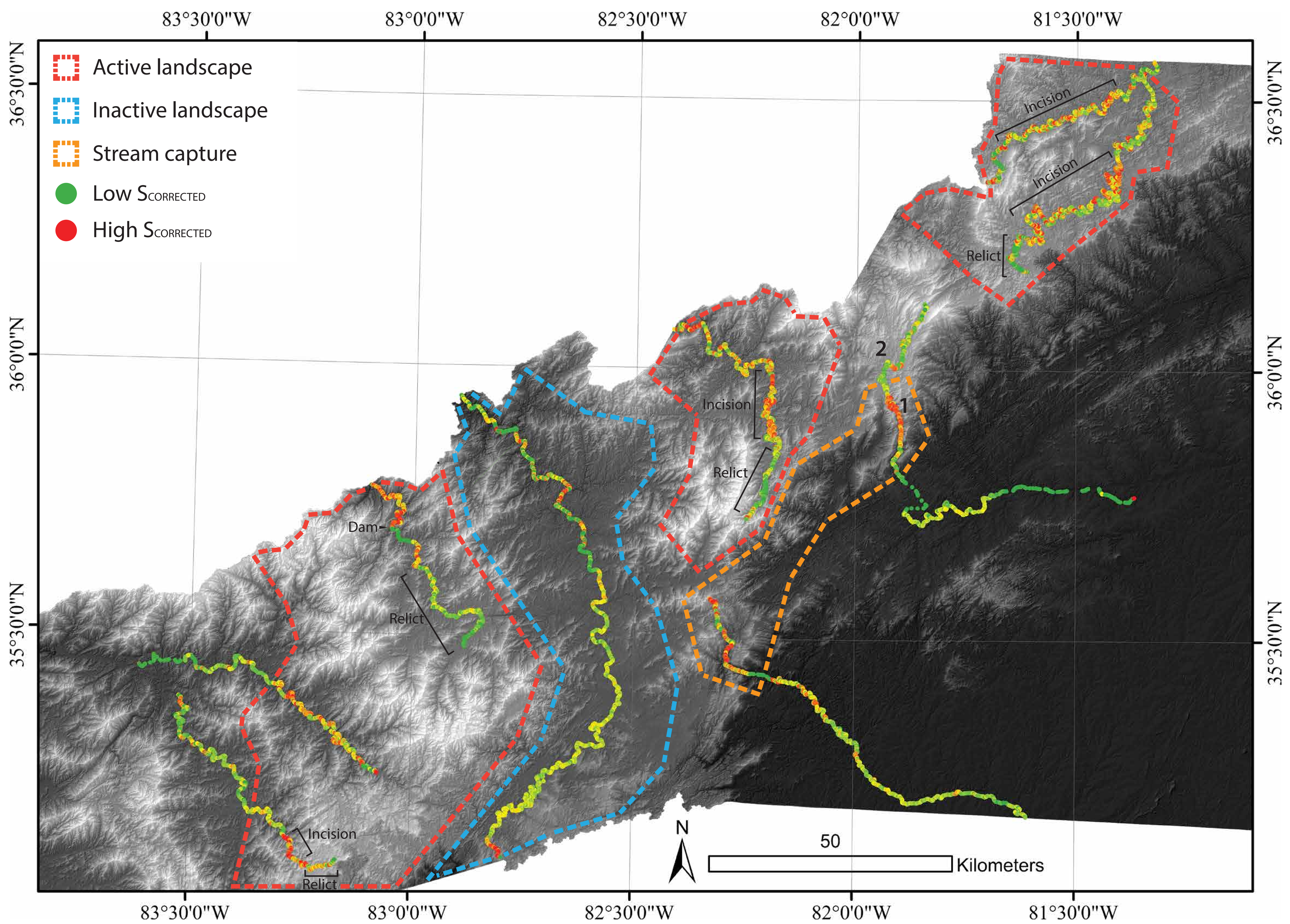
The study covered the western area of North Carolina using LIDAR produced in 2007.



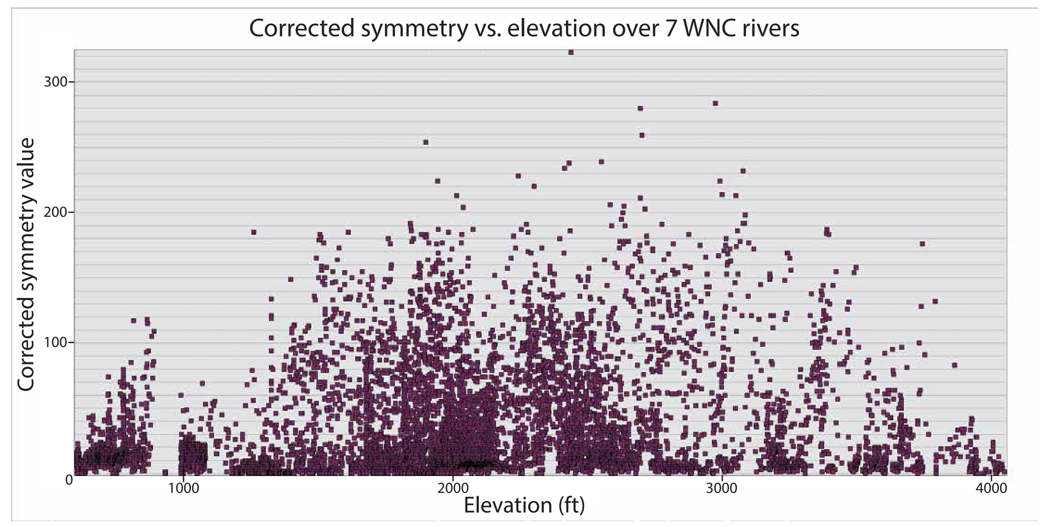
Location 1
This segment of the Linville River in Avery County, NC illustrates an area with highly symmetrical, steeply sloped valleys. An area such as this has mostly undergone downcutting.



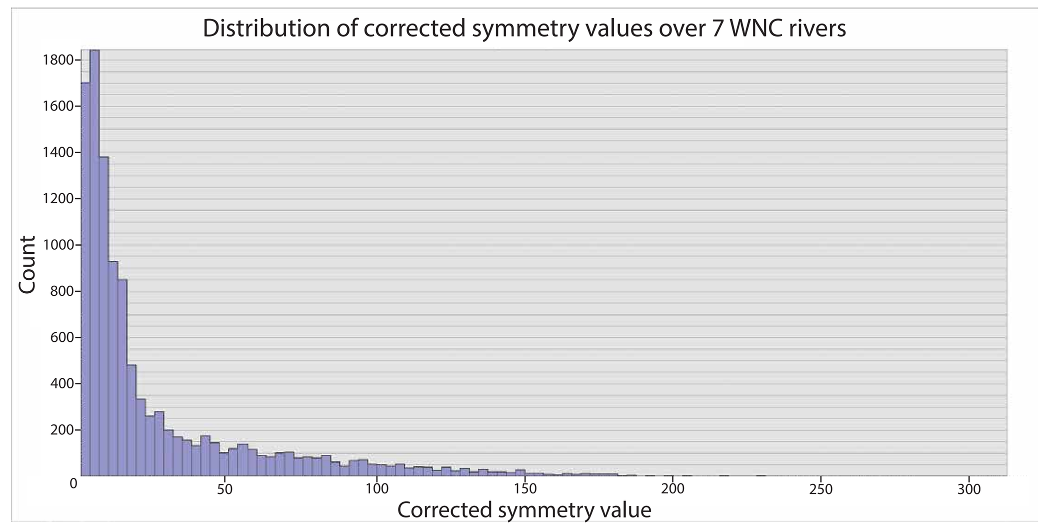
Location 2
This stretch of the Linville River is located upstream of the area on the left. An area such as this contains both symmetrical and asymmetrical valley forms in a broad floodplain.



Illustrated above are corrected symmetry values and their interpretations. Inactive landscapes are hypothesized to be in states of equilibrium, as implied by their asymmetrical channel valleys. Active landscapes contain both incising channels and areas of relict topography, which have yet to achieve equilibration through knickpoint propagation. Areas that experienced stream capture frequently hosted incised valleys, but were not included in the above projections of active landscape locations.



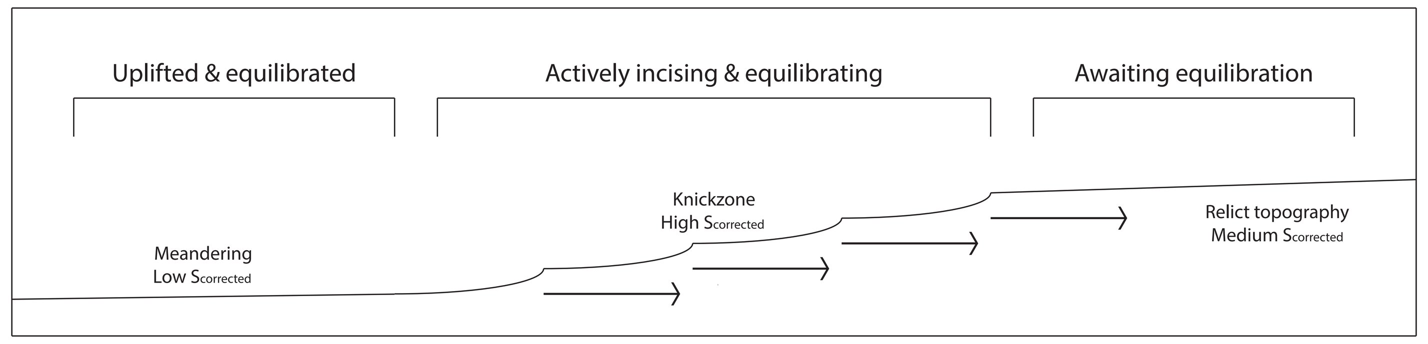
This figure illustrates the relationship between altitude and corrected symmetry. Maximum corrected symmetry values are visible between 1500-3400 ft, indicating that streams at intermediate elevations experience minimal lateral migration.



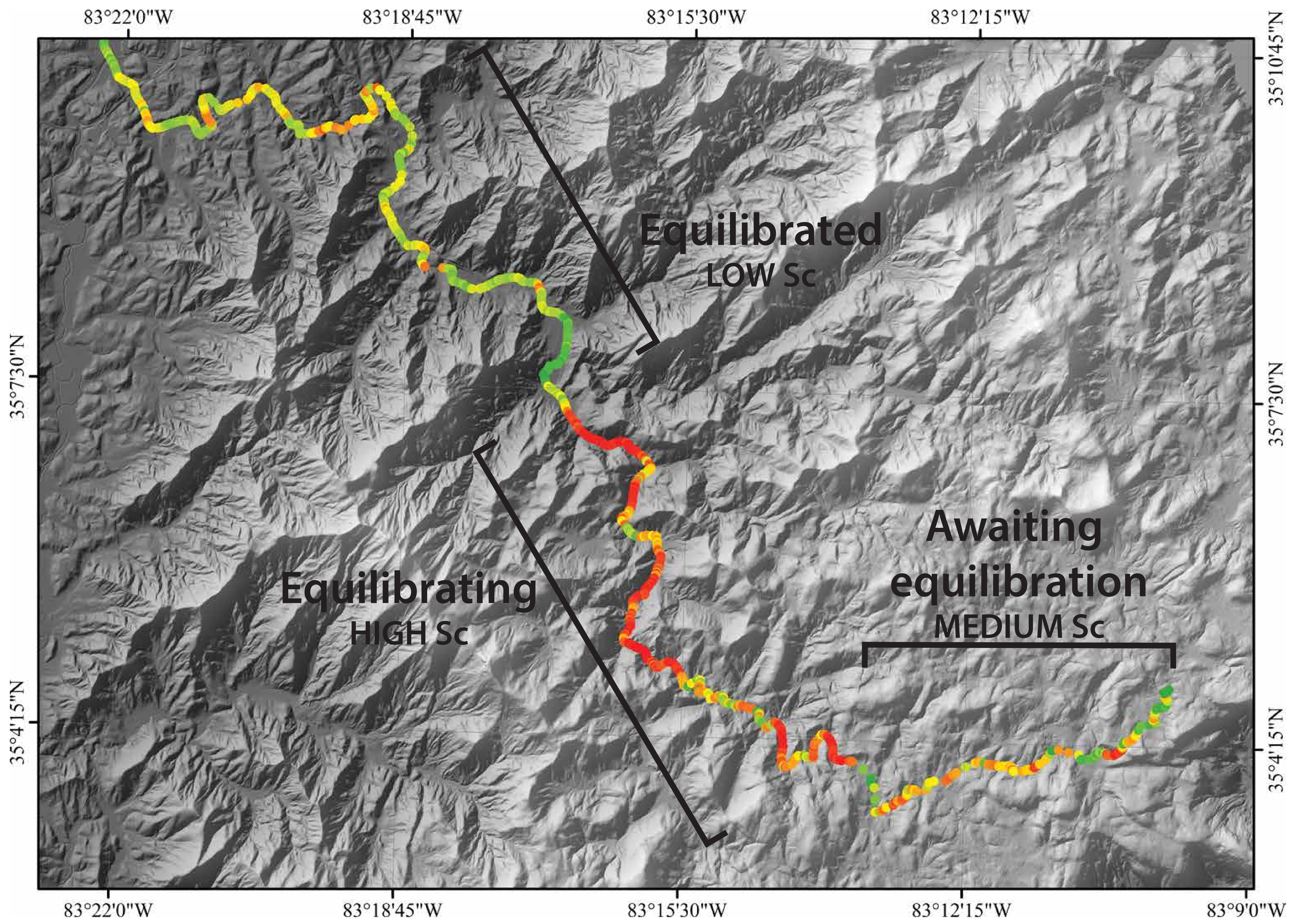
This histogram shows the logarithmic distribution of corrected symmetry values throughout the Blue Ridge mountains. High corrected symmetry values appear infrequently, which implies that most streams lie in broad, asymmetrical valleys.

Results and Conclusions

Our study determined that symmetry of stream valleys reliably determines the degree of a channel's lateral migration. The extent of a channel's lateral migration served in locating areas of incision, a crucial step in characterizing active landscapes as shown below.



We projected active landscape locations throughout the Blue Ridge Mountains, and conclude that a significant portion of the region is equilibrating or will do so as knickzones propagate. Inactive landscapes were either unaffected by Neogene activity or equilibrated more rapidly than the surrounding areas.



Pictured above is the Cullasaja River in Macon County, NC which has been proposed as an area of Miocene uplift based on knickpoint analysis (Gallen et al.,2013) and exhibits a range of corrected symmetry values. Relict landscape and incised valleys are visible.

Acknowledgements

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References Cited

Gallen, S. F., Wegmann, K. W., & Bohnenstiehl, D. R. (2013). Miocene rejuvenation of topographic relief in the southern Appalachians. GSA Today, 23(2), 4-10. doi: 10.1130

LIDAR data available from the NC DOT at https://connect.ncdot.gov/resources/gis/pages/cont-elev_v2.aspx

USGS river map available from ESRI at http://www.arcgis.com/home/item.html?id=8206e517c2264bb39b4a0780462d5be1