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Capturing geomorphologial patterns in ecological resources: fractal dimensions describe fluvial rock distributions

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Measuring the physical complexity of habitats or resources is often achieved using specific methods that make comparisons across ecosystems difficult. One measure that is applicable across multiple ecosystems and scales is the fractal dimension. This study evaluated the use of box-counting and entropy fractal dimensions for characterising the complexity of emergent rock distributions of six streams across Scotland and Australia. Emergent rocks are an important ecological resource, including as oviposition sites for aquatic insects and cover for fish. Longitudinal emergent rock distributions of all six streams exhibited fractal behaviour (self-similarity), suggesting that fractals can be used to measure the complexity of this system in a way that is scale-independent. Entropy was a superior measure due to its ability to differentiate among the six streams where box-counting could not. Variation in the fractal dimensions among streams was found to be related to the sedimentology and morphological characteristics of the streams. Larger fractal dimensions were seen in streams with fewer (and shorter) stream segments without emergent rocks, with greater emergent rock densities and larger, more spherical submerged rocks. Numerical simulation of synthetic streams allowed direct testing of individual characteristics, which revealed the strong influence of pool-riffle structure on fractal dimension. Fractal dimension was driven by the relative difference in emergent rock density between pools and riffles as well as the relative length of pools and riffles. Fractal dimensions, therefore, are a promising measure of physical complexity that may reflect underlying patterns in geology and land use, of use in both geomorphological and ecological studies.