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Thresholds, Mode-Switching, and Emergent Pseudo-Equilibrium in Geomorphic Systems

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Many geomorphic systems exhibit mode shifts as they evolve, or react to disturbances, from an initial mode of dynamically unstable, divergent evolution, to a mode of convergent evolution. These trends are often interpreted as progression toward a normative equilibrium. However, these mode shifts are shown to arise from two basic principles: gradient (or resistance) selection, and threshold-mediated modulation. In early stages of system development positive feedbacks associated with gradient selection are dominant, and dynamical instability, chaos, and divergence result. Eventually, however, as the system approaches limiting thresholds, negative feedback associated with the thresholds becomes stronger than the positive feedbacks, and the system becomes stable, with convergent evolution. The unstable-to-stable mode switches are an emergent outcome of the gradient selection and threshold modulation principles, not a goal function of Earth surface systems. These principles are illustrated with two examples—fluvial dissection of the Cumberland Plateau, Kentucky, and channel development in deltas of the Texas coastal plain.