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Laws, Place, History and the Interpretation of Earth Surface Systems

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The state of an Earth surface system (ESS is determined by three sets of factors: Laws, place, and history. Laws (L = L1, L2, . . . , Ln) are the n general principles, relationships, and representations applicable to any such system at any time. Place factors (P = P1, P2, . . . , Pm) are the m relevant properties or characteristics of the local or regional environment—e.g., climate, tectonic setting, geology, traits of the local biota, etc. History factors (H = H1 , H2, . . . , Hq) include the previous evolutionary pathway of the ESS, its stage of development, past disturbance, and in some contexts initial conditions. Geoscience investigation may be focused on laws (e.g., theoretical deductions, process modeling, laboratory experiments), place (e.g., regional geology or geography, soil-landscape studies), or history (e.g., paleoenvironmental studies, environmental history, historical geology or geography). Ultimately, however, all three sets of factors are necessary to fully understand and explain ESS. Beyond providing a useful checklist (analogous to the factorial models often used in pedology and ecology), the LPH framework gives us analytical traction to some difficult research problems. For example, studies of the avulsions of three southeast Texas rivers showed substantial differences in avulsion regimes and resulting alluvial morphology, despite the proximity and superficial similarity of the systems. Avulsion dynamics are governed by the same laws in all three cases [L(A) = L(B) = L(C)], and the three rivers, once part of a single system at lower sea-levels, have undergone the same sea-level, climate, and tectonic histories, as well as the same general types of anthropic impacts [$H(A) \approx H(B) \approx H(C)$]. Though the regional-scale environmental controls are similar, local details such as the location of the modern main channel relative to Pleistocene meander channels differ, and thus these place factors explain the differences between the rivers. The LPH framework can also be used to determine the source of similarities among disparate systems. A classic example is the topology of fluvial channel networks, which have similar characteristics despite a great variety in place and history factors. Since $P(i) \neq P(j)$, $H(i) \neq H(j)$, this points to L factors as the controls of the similarities. Similar trends are emerging in the study of root-rock interactions in forest regoliths, where similar phenomena occur despite variations in underlying geology, vegetation, and disturbance regimes. The LPH framework, or very similar types of reasoning, is implicit in many types of geoscience analysis. More explicit attention to the triad can help us solve or address many specific problems and remind us of the importance of all three sets of factors.