Quantifying the Influences of Ecological Drift, Selection and Dispersal in Subsurface Microbial Communities

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J.C. Stegen, X. Lin, J.K. Fredrickson, X. Chen, D.W. Kennedy, C.J. Murray, M.L. Rockhold, A.E. Konopka (PI)-*PNNL* (allan.konopka@pnnl.gov)

The microbes that reside within the sediments and groundwater in the Hanford 300 Area can be thought of as a meta-community; that is, a set of ecological communities connected to each other through organismal dispersal. Ecological theory posits that turnover in composition is governed by (ecological) Drift, Selection, and Dispersal Limitation. Quantitative estimates of these processes remain elusive, but would represent a means to evaluate systems-level processes in subsurface environments. Using a novel analytical framework we quantitatively estimate the relative influences of Drift, Selection, and Dispersal Limitation on subsurface, sediment-associated microbial meta-communities. The analysis includes both the Hanford and Ringold formation sediments within the Hanford IFRC well field (~12,500m^3). We find that Drift consistently governs ~25% of spatial turnover in community composition; Selection dominates (governing ~60% of turnover) across spatially-structured habitats associated with fine-grained, low permeability Ringold sediments; and Dispersal Limitation is most influential (governing ~40% of turnover) across spatially-unstructured habitats associated with the Hanford formation's coarse-grained, highly-permeable sediments. Quantitative influences of Selection and Dispersal Limitation may therefore be predictable from knowledge of environmental structure. To develop a system-level conceptual model we extend our analytical framework to compare process estimates across formations, characterize measured and unmeasured environmental variables that impose Selection, and identify abiotic features that limit dispersal. Insights gained here suggest that subsurface microbial community ecology can benefit from a shift in perspective; the quantitative approach developed here goes beyond the 'niche vs. neutral' dichotomy by moving towards a strategy in which estimates of Selection, Dispersal Limitation and Drift can be described, mapped and compared within and across definable elements (e.g., lithofacies) of large-scale subsurface systems.