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Do Anthropogenic Impacts Reduce Catchment Complexity?

Suresh Rao (1), Nandita Basu (2), and Sally Thompson (3)

(1) Purdue University, West Lafayette, IN, United States (pscr@purdue.edu), (2) University of Iowa, Iowa City, IA 52242, United States (nandita-basu@uiowa.edu), (3) Duke University, Durham, NC 27701, United States (set8@duke.edu)

Landscapes have evolved over geologic time scales and have been shaped by the long sequence of natural processes that control the co-evolution of the spatial patterns of soils and geology (land resources), vegetation (habitats and ecological services), hydrology (surfaces and groundwater), and biogeochemistry (mineral resources) at all scales of interest. Of particular interest here are the catchment modifications over the past century under stochastic, non-stationary hydro-climatic forcing (e.g., precipitation, net radiation, etc.) and usually monotonically increasing anthropogenic impacts (e.g., intensification of land use and drastic changes in land cover). Thus, catchments we observe now reflect the combined outcomes of their natural and anthropogenic legacies, with the altered catchment responses revealing an overall reduction in complexity, and alteration of the dominance of internal processes. Our contention, based on recent data and modeling synthesis efforts, is primarily that persistent anthropogenic forcing has (1) overwhelmed the internal bio-geochemical heterogeneities (e.g., build up of legacy stores), (2) severely modified "natural" hydrologic responses (e.g., more flashy hydrographs), (3) impacted the relative dominance of hydrologic and biogeochemical processes in controlling catchment responses, and (4) escalated adverse ecological impacts. These changes have lead to loss of catchment complexity, as indicated by evolution of “functional homogeneity” and a reduction in “structural complexity”. This, in turn, enables us to use simpler, parsimonious models for reliable predictions of hydrologic-biogeochemical responses in modified catchments. Examination of data from several catchments shows that exported nutrient loads increase linearly, beyond some threshold, with increasing human impacts (e.g., urbanization, intensive cropland, population). Thus, an improved understanding of the socio-economic drivers that determined the spatiotemporal changes landscape modifications is essential for predicting the catchment forward trajectories from “pristine” to “engineered” states, and how we might reverse the course for recovering ecological services. We present synthesis of data from large catchments in North America, Europe, and Asia as case studies to illustrate the impacts of anthropogenic forcing on catchment responses.