Nonlinear and Threshold Responses to Environmental Stressors in Land-River Networks at Regional to Continental Scales

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Ecosystems of the United States are subject to a variety of human-caused stressors, including changes in: climate, the chemistry of the atmosphere, the chemistry of precipitation, and land cover and land use. These stressors can act singly or together to elicit nonlinear and threshold responses in freshwater ecosystems and alter their capacity to deliver ecosystem services such as sufficient quantities of clean water. In this research project, the investigators will explore how a set of environmental stressors acts to affect the physical, chemical, and biological integrity of linked land-river networks using a coupled terrestrial-aquatic ecosystem model that is process-based and is applied in a georeferenced context within drainage basins across the United States. The research project will have two parts: building the linked land-river network model, and using the model in both retrospective and prospective studies. Use of the model will be guided by two hypotheses: (1) nonlinear and threshold responses in the coupled land-water systems are key to defining the observed variations in water quality across the United States during the last 100 years, transforming and intensifying local and in some cases regional-scale problems to fully continental-scale syndromes; and (2) future policy interventions can slow and sometimes reverse these problems and syndromes, but the interventions will be complicated by the reality of new stable states and the heritage of existing threshold responses requiring many years to reverse. The research plan includes two workshops involving the science team, resource managers, and policy makers. At the first workshop, the investigators will develop a set of "what if" scenarios that include specific policy interventions and use them in simulations. At the second workshop, the investigators will analyze how these interventions affect nonlinear and threshold behaviors in the freshwater ecosystems within drainage basins, and what the consequences will be for ecosystem services. This research will contribute significantly to the development of a theoretical basis for effectively protecting and managing ecological systems that exhibit nonlinear and threshold responses to environmental stressors. The successful development of research and management tools, such as the ones we are proposing, will help scientists to predict ecological thresholds before they are observed. These research tools also will help resource managers and policy makers select among alternative courses of action as they work to maintain, and in some cases enhance, the services provided to us by ecosystems.