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USING A BAYESIAN NETWORK TO MODEL THE INTERACTING ECOLOGICAL PATHWAYS LEADING TO IMPAIRED STREAM BIOLOGY IN URBAN WATERSHEDS

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ABSTRACT: Urbanization causes myriad changes in hydrological, physical, and chemical processes in watersheds, which ultimately disrupt stream ecosystems. These complex, interacting changes and their impacts are challenging to model. Traditional regression techniques that calculate empirical relationships between pairs of environmental factors do not capture the interconnected web of multiple stressors, while urbanization effects are not yet understood at the detailed scales required to make mechanistic modeling approaches feasible. Instead of using either a fully deterministic or fully statistical modeling approach, a Bayesian network model can be used as a hybrid approach to represent known general associations between variables while acknowledging uncertainty in the specifics. A Bayesian network is a graphical model that quantifies a network of probabilistic relationships between variables. This type of model is flexible in accommodating many model structure configurations and input information types; efficient in storing and manipulating complex information, and to parameterize; and transparent both in the relationships it describes with nodes and arrows and in the uncertainties it describes with discrete probability distributions for each variable. Taking advantage of these assets, a Bayesian network model was constructed to characterize the impact of urbanization on aquatic invertebrate stream communities through three simultaneous, interacting ecological pathways affecting stream hydrology, habitat, and water quality across watersheds. This model systematically incorporates both expert knowledge from ecologists, hydrologists and urban planners and data from the U.S. Geological Survey';s (USGS) Effect of Urbanization on Stream Ecosystems (EUSE) studies for the National Water-Quality Assessment (NAWQA) program. The parameterized Bayesian network model can calculate the probabilities of attaining desired aquatic ecosystem conditions assuming different levels of urban stress, environmental conditions and management options. This approach to evaluating urbanization-induced perturbations in watersheds integrates statistical and mechanistic perspectives, different information sources, and several ecological processes into a comprehensive description of the system.

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