The Appalachian stream syndrome: complex local conditions and regional metacommunity degradation caused by the accumulation of multiple stressors[1]

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Abstract: We surveyed 170 streams throughout the mountaintop-mining region of West Virginia to characterize local (i.e., chemical degradation) and regional (i.e., metacommunity processes) controls over aquatic resource degradation. We first characterized and quantified the relative contribution of specific land use activities to regional chemical degradation. We then used a series of modeling techniques to test the hypothesis that local (observed water quality) and neighborhood (predicted water quality within a 5km buffer) conditions combine to control macroinvertebrate assemblages through alteration of metacommunity structure (organism tolerance) and processes (dispersal). We identified 3 important dimensions of variation in water chemistry associated with contemporary surface mining (elevated dominant ions, sulfate, alkalinity, and selenium), abandoned mine lands and coal geology (elevated trace metals), and residential development (elevated sodium and chloride). Development-related chemistries were predicted to be the most prevalent on the landscape; however, the combination of all 3 sources of pollutants resulted in complex contaminant mixtures, particularly in larger streams. Local conditions (i.e., habitat and water chemistry) were the dominant driver of community composition, with development-related chemistries having the strongest effect on state-adopted indices of biotic integrity (i.e., West Virginia Stream Condition Index). However, mining-related chemical degradation was strongly related to the loss of sensitive taxa (e.g., EPT richness). The accumulation of mining- and development-related degradation at the neighborhood-scale further acted to decrease the occurrence and abundance of moderately sensitive and poor dispersing taxa and to facilitate the proliferation of tolerant taxa. Thus, aquatic resource degradation within this region can be attributed to the accumulation of contaminants from multiple land use activities that degrade aquatic communities through disruption of large-scale metacommunity processes. Future management will require a multi-stressor approach that addresses both local and neighborhood effects of current and future land use and mitigation activities.

Additional Key Words:

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