Contribution of Nutrients and *E. coli* to Surface Water Condition in the Ozarks

Part II. Using Landscape Ecology and Partial Least Squares Predictions to Map Watersheds That Are Vulnerable to Non-Point Source Pollution

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Overview

The U.S. EPA's Office of Research and Development and U.S. EPA Region 7 have collaborated to map and interpret landscape-scale (i.e., broad-scale) ecological metrics among watersheds of the Upper White River (Figure 1) and have produced the first geospatial models of water quality vulnerability in the Ozarks. These models have been developed by using Partial Least Squares (PLS) analyses, existing field water quality monitoring data, remote sensing information, *a priori* information about landscape conditions, and the water quality of streams and rivers in the associated watershed(s). The analyses were conducted at multiple geographic scales, from site-specific water quality measurements (fine-scale) to broader scale watershed analyses. The broad-scale results are reported for 8-digit U.S. Geological Survey hydrologic units and 244 customized subwatersheds. The customized subwatersheds represent the drainage area where water quality measurements were conducted and were used to increase the precision and accuracy of water quality vulnerability predictions. Using PLS, we determined the following four different (surface) water quality condition states among the 244 customized subwatersheds of the Ozarks that may be useful for important management decisions in the region: (1) subwatersheds that have high concentrations of total ammonia, high concentrations of total phosphorus, and high cell counts of *Escherichia coli*; (2) subwatersheds that have high concentrations of total ammonia, low concentrations of total phosphorus, and high cell counts of *E. coli*; (3) subwatersheds that have low concentrations of total ammonia, low concentrations of total phosphorus, and high cell counts of *E. coli*; and (4) subwatersheds that have moderate concentrations of both total ammonia and total phosphorus and moderate *E. coli* cell counts. The results of this project provide watershed managers with the first broad-scale predictions that can be used to explain how land cover type, land cover configuration, environmental change, and human activities may affect the chemical and biological characteristics of surface water in the Upper White River region.

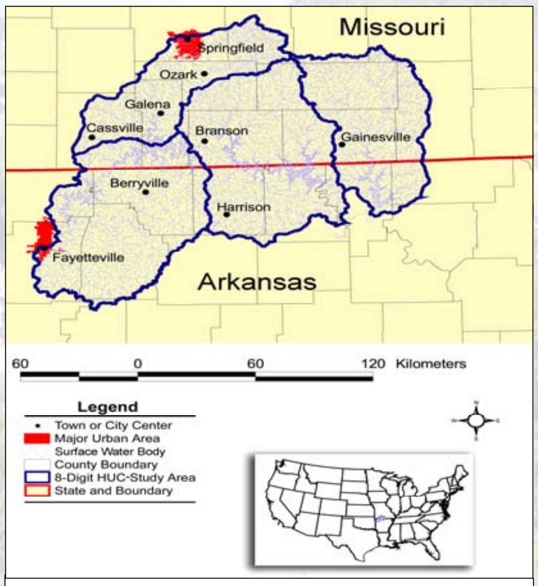

Figure 1. White River Study Area, shown as four 8-digit U.S. Geological Survey hydrologic unit code ("HUCs").

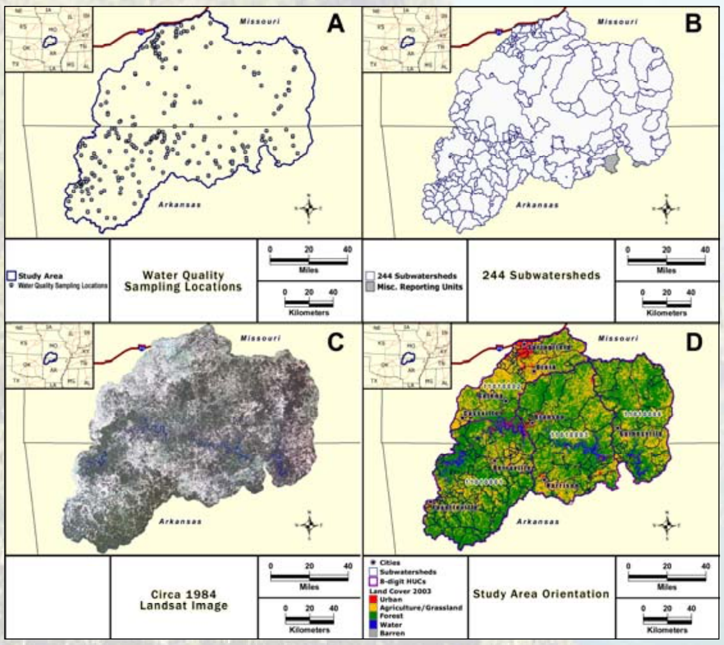

Figure 2. The Upper White River study area is in the Ozarks of Missouri and Arkansas, where 244 water quality sampling locations were sampled (A) and used as "pour-points," from which 244 contributing subwatersheds were delineated (B). A combination of multiple Landsat Thematic Mapper imagery (C) and digital aerial photography was used to produce a 2003 land cover map of the study area (D), which was used to calculate landscape metrics.

Methodology (Figure 2)

The 244 water quality sampling locations were used to delineate 244 subwatersheds. The study area can be depicted as a grouping of the 244 subwatersheds, each of which contains a single hydrologic outlet (sometimes called a "pour point"). The value of using this unconventional view of the landscape is that the cumulative effects of landscape condition on water quality can be assessed, thereby increasing the predictive power of any determined relationships between land cover and water quality parameter. The Missouri and the Arkansas land cover data sets were created and aggregated to evaluate the unified land cover map for 2003 and used for statistical analyses of landscape metrics. For each of the selected sites, the watershed support area was delineated and a suite of landscape metrics was calculated. Ecologically relevant (e.g., previous correlative relationships demonstrated in other biophysical regions or at finer scales) landscape metrics were calculated for 2003 landscape conditions using remote sensing and geographic information systems data. Landscape metrics were then compared to surface water constituents, averaged over a period from 1997 to 2002, using Partial Least Squares analyses (see accompanying poster Part 1 for details about PLS analyses).

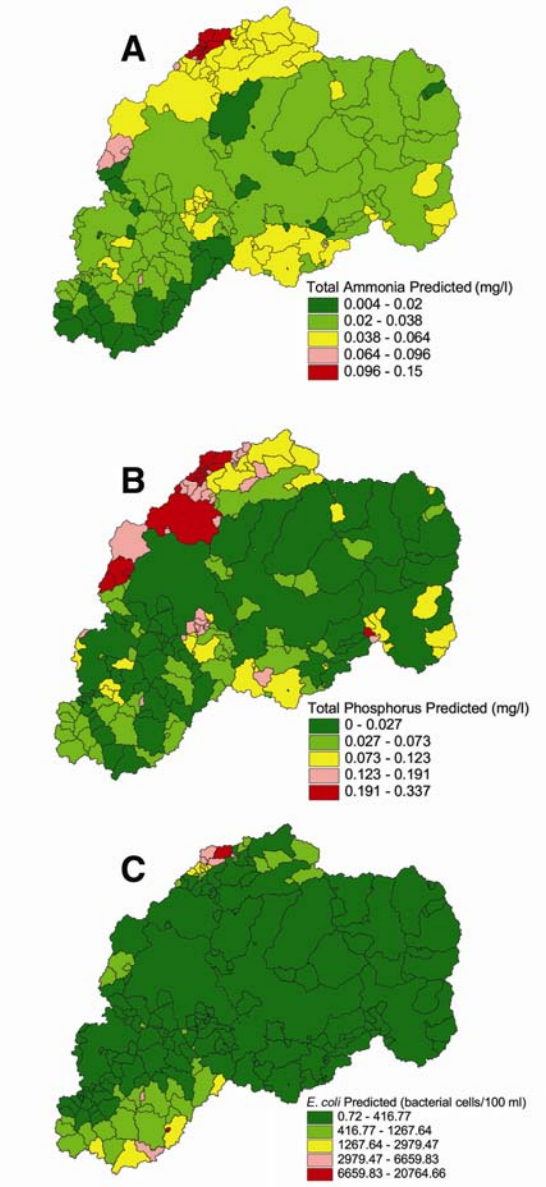

Figure 3. Study area water quality vulnerability prediction maps for (A) total ammonia, (B) total phosphorus, and (C) *Escherichia coli.*

Results/Discussion

Ammonia: The total ammonia PLS model resulted in one significant factor explaining 93% of the variability in the total ammonia. Percent forested land cover in close proximity to streams has a negative effect on total ammonia loading, whereas urban has a positive effect (Figure 3A).

Phosphorus: The total phosphorus PLS model resulted in one significant factor explaining 59% of the variability in the total phosphorous. The most significant contributors are the watershed percent barren and stream density. While the stream density relates inversely with total phosphorous, percent barren enhances total phosphorous in surface water. The forest-related variables contribute equally with a negative effect on the total phosphorous. Urban enhanced total phosphorous but mostly in close proximity of streams effect (Figure 3B).

***Escherichia coli*:** The *E. coli* PLS model resulted in two significant factors explaining 81% of the variability in the *E. coli* cell count. Urban in close proximity to streams was positively correlated with *E. coli* cell count (Figure 3C).

The water quality vulnerability maps and metrics associated with this research will be available in a compact disk "browser" format during the summer of 2006.

This research is a collaborative effort between U.S. EPA's Office of Research and Development and U.S. EPA Region 7. We thank our many local, state, and regional partners in Arkansas and Missouri, and U.S. EPA Region 7 for their support during this research.

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