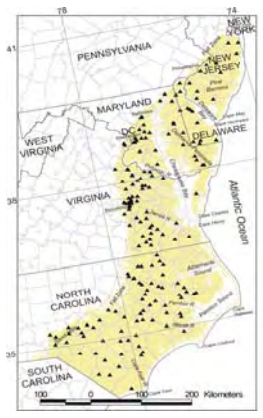
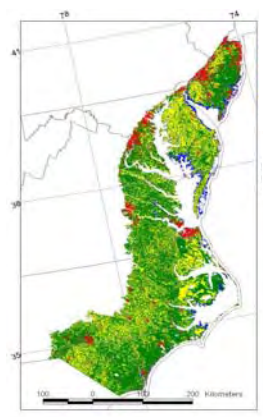
Characterization and prediction of nutrients and pesticides in base flow conditions of first order streams in the Mid-Atlantic Coastal Plain - a collaborative effort

Ann M. Pitchford, Anne C. Neale, USEPA/ORD/NERL/ESD/LEB
Judith M. Denver, Scott W. Ator, USGS MD-DE-DC Water Science Center

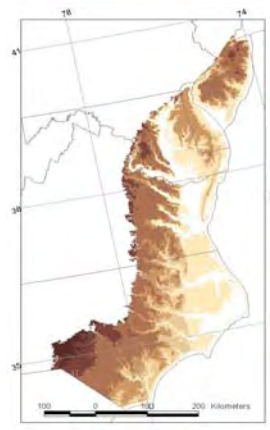


Study Area in Mid-Atlantic Coastal Plain



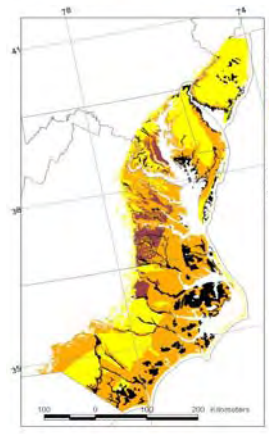
Land use and Land cover (early 1990s)

Urban
Forest
Agriculture
Barren
Water
No Data



Topography

Elevation (m)
0 - 6
6 - 12
12 - 20
20 - 50
50 - 100
100 - 215
No Data



Predominant texture of surface sediments

Clay and Silt
Mixed
Mixed with Peat
Sand and Gravel

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1. Goals

The Landscape Indicators for Pesticides Study in Mid-Atlantic Coastal Streams (LIPS-MACS) goals:

- Characterize levels of pesticides and nutrients in headwater stream base flow and associated stream biota.
- Predict water quality in small streams throughout the Coastal Plain using geographic information such as land use, geology, soil types, and land forms.

2. Methods

a. Sampling

From a total of 10,144 first-order streams, 174 streams were selected across a gradient of hydrogeologic and land-use settings. Water samples were collected from all 174 streams and analyzed for selected pesticides, pesticide metabolites, nutrients, and major ions. Benthic-community and habitat assessments were also conducted at each stream.

b. Landscape Metrics

Landscape metrics were computed using data for soils, land use, and topography for each stream's watershed.

Land Cover- % agriculture (ag) total, forest, urban, wetland, barren, ag on slopes >3%
Human Stresses- Road density, roads crossing streams, roads in close proximity to streams
Riparian Buffer Land Cover- % ag, forest, urban, or wetland in stream grid cell
Topography- Elevation mean, range, slope mean, slope curvature
Soil-related Metrics- % clay, % organic matter, % sand, available water capacity, mean bulk density, moisture content, permeability, water table depth

Principal components grouped these metrics:

Principal Components
PC1- upland (vs. low-relief) areas
PC2- urban and road influences
PC3- soil texture, well-drained soil
PC4- agriculture
PC5- wetland influences
PC6- barren land influences
PC7- mixed: low-organic-matter wetlands and roads crossing streams
PC8- soil organic matter and non-barren land

c. Making the Maps

Stepwise logistic regression for binary data was used to predict the likelihood of selected nutrients or pesticide compounds occurring in streams in late winter or spring base flow at or above certain concentrations. Variables considered included principal components above and geologic setting, as well as sample date and stream latitude.

3. Characterization Results

a. Nutrients

Nutrient concentrations vary regionally with differences in land use, soils, hydrogeology, and other factors that control the occurrence and fate of these compounds.

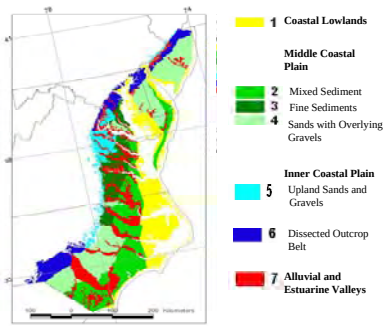
Nitrogen

- Nitrate is the predominant form of nitrogen in streams in well-drained watersheds. The median nitrate concentration among Coastal Plain streams during base flow is 0.4 mg/L.
- Ammonia and organic nitrogen are the predominant nitrogen species in streams in poorly drained watersheds.

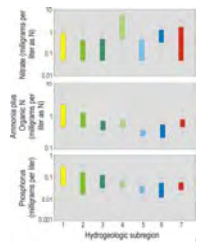
Phosphorus

- Phosphorus concentrations are generally lower in streams in watersheds with well-drained sediments;
- Phosphorus concentrations are higher in poorly drained watersheds.

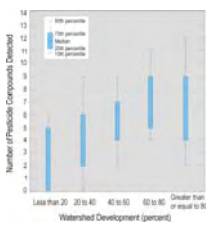
Hydrogeologic Subregions



Concentrations of selected nutrients in streams in different hydrogeologic subregions during base flow.



Relation of pesticide occurrence in streams during base flow and watershed land use.

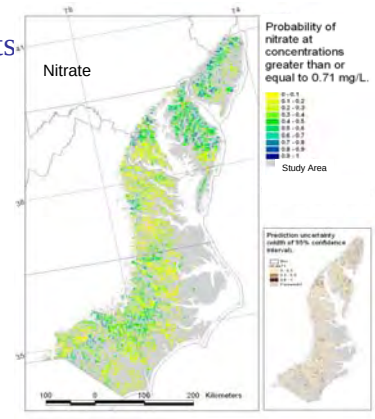


b. Pesticides

- Low concentrations of pesticides or pesticide degradates were detected in about three-quarters of the streams in the Coastal Plain during winter and spring base flow.
- Very few of the detections were above levels considered harmful to aquatic life, although these levels have not been determined for many of the compounds detected.
- Although concentrations were typically low, multiple pesticide compounds were commonly present.
- Metolachlor and its two common degradates, metolachlor ESA and metolachlor OA, were the most frequently detected pesticide compounds in the Coastal Plain; concentrations of metolachlor degradates were generally much higher than those of metolachlor.

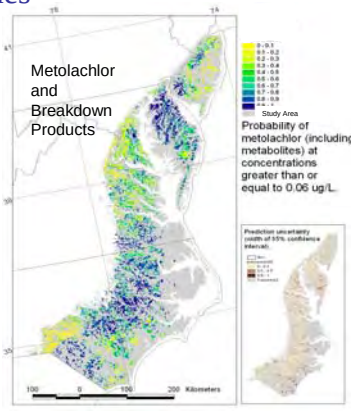
4. Maps of Predictions

a. Nutrients



Although nitrate is common in Coastal Plain streams during base flow, concentrations greater than 0.71 mg/L are relatively unlikely. Areas with the highest likelihood of nitrate greater than 0.71 mg/L occur in highly agricultural or urban areas with well-drained soils.

b. Pesticides



Metolachlor compounds (including metolachlor, metolachlor ESA, and metolachlor OA) occur in stream base flow in most areas of the Coastal Plain. Concentrations of total metolachlor above 0.06 µg/L are most likely to occur in agricultural areas of southern New Jersey, the Delmarva Peninsula, southern Virginia, and North Carolina; they are least likely in forested areas.

5. Potential Applications

- Assessing pesticide and nutrient occurrence and vulnerability within a wide area;
- Allocating resources for additional, focused monitoring;
- Protecting source waters;
- Assessing statewide waters compared to designated uses;
- Evaluating best management practice options.

6. Collaborators

- U.S. Environmental Protection Agency
- U.S. Geological Survey's National Water Quality Assessment Program; and
- Multi-Resolution Landscape Characteristics Consortium.

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