Landscape Indicators for Pesticides in Mid-Atlantic Coastal Streams

A. M. Pitchford, U.S. EPA, National Exposure Research Laboratory, Environmental Sciences Division, Las Vegas, NV

Overview

Abstract:

The toxicity that makes pesticides useful in agriculture, silviculture, and disease vector and nuisance control also poses potential risks for humans and the environment under certain exposure conditions. The mission of EPA includes the responsibility for solving this policy and regulatory dilemma, and balancing society's short term needs with short and long term environmental and health risks particularly through a process of registering pesticides. Current pesticide risk assessments have focused on the scale of individual agricultural fields, farm ponds, and shelter belts with aggregation by individual crop type and selected communities. However, recent improvements in availability of highly detailed satellite imagery and derivative land use data, combined with the Geographic Information System technology and ancillary data on soils, human population, topography, roads, and streams, make development of landscape indicators for assessing environmental vulnerability possible. EPA began applying the principles of landscape ecology to the issue of ecosystem vulnerability in the Mid-Atlantic Region of the U.S. in 1995, and to assessing vulnerability to pesticides in 1997. The Mid-Atlantic Coastal Plain Landscape Indicators for Pesticides Study (LIPS) now in progress (1998 - 2002) will evaluate landscape indicators for estimating stream and watershed vulnerability to pesticides. It is a joint EPA-USGS project. Table 1 lists program goals; Figure 1 shows study area.

Figure 1. Location of Mid-Atlantic Coastal Plain

Table 1. Goals for the Landscape Indicators for Pesticides Study

National	
	Develop and test landscape indicators for pesticides and nutrients, nationwide.
Mid-Atlantic Coastal Stream Study	
	Develop and test landscape indicators for pesticides and nutrients in first order, freshwater streams.
	Evaluate the performance of the hydrogeologic framework.
	Conduct hydrogeologic and multimedia modeling for selected sites to corroborate results.
	Develop landscape indicator analysis models for the Mid-Atlantic Coastal Plain.
	Involve States and other stakeholders in the development process.

LIPS Design Considerations

The main focus of the Landscape Indicator Pesticides Study-Mid-Atlantic Coastal StreamS (MACSS) is identifying and testing landscape indicators.

Controlling for conditions such as soil type, physiography, surficial geology, and ecoregions is key to isolating the landscape influence. These physical factors mentioned above were used by USGS to identify areas with relatively consistent natural processes which affect the occurrence and movement of chemicals. The result is the hydrogeologic framework for the Mid-Atlantic Coastal Plain (Figure 2).

This one-time study in March and April 2000 is timed to measure baseflow conditions in streams, and optimized for in-stream macroinvertebrate population. Baseflow provides an integrated, long-term average of watershed conditions, and is not subject to as much variability as overland stormflow.

Testing landscape indicators for pesticides and nutrients relies on having data for a gradient of land cover types, based on proportions of agriculture versus forest, and agriculture versus urban as determined for first order watersheds, from MRLC data (Figure 3).

Photos of first order stream segments from the Delmarva Penninsula RF3 hydrography at 1:100,000 scale, and the corresponding Euclidean watersheds are shown in Figure 4.

Since the emphasis is on fresh water streams, the portion of streams with tidal influence must be removed from the study population (Figure 5).

Figure 6 (a, b, c) depicts agricultural chemical use for the counties in the Coastal Plain.

Approximately two hundred sites will be selected from freshwater start reaches to provide balanced data sets which consider agriculture and urban gradients, hydrogeology, and agrochemical inputs. Table 2 summarizes the measurements to be made at each site.

Figure 2. Hydrogeologic framework

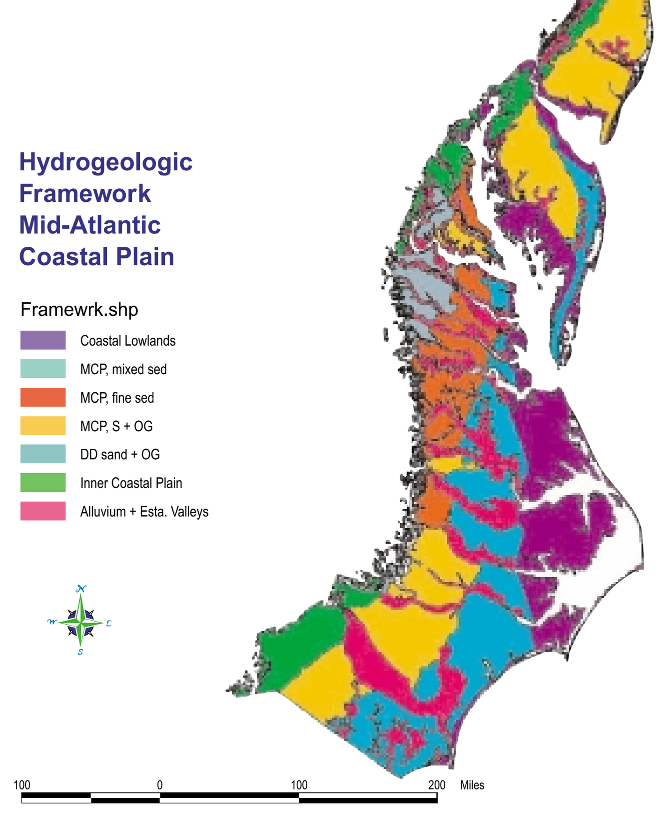


Figure 3. MRLC Land Use

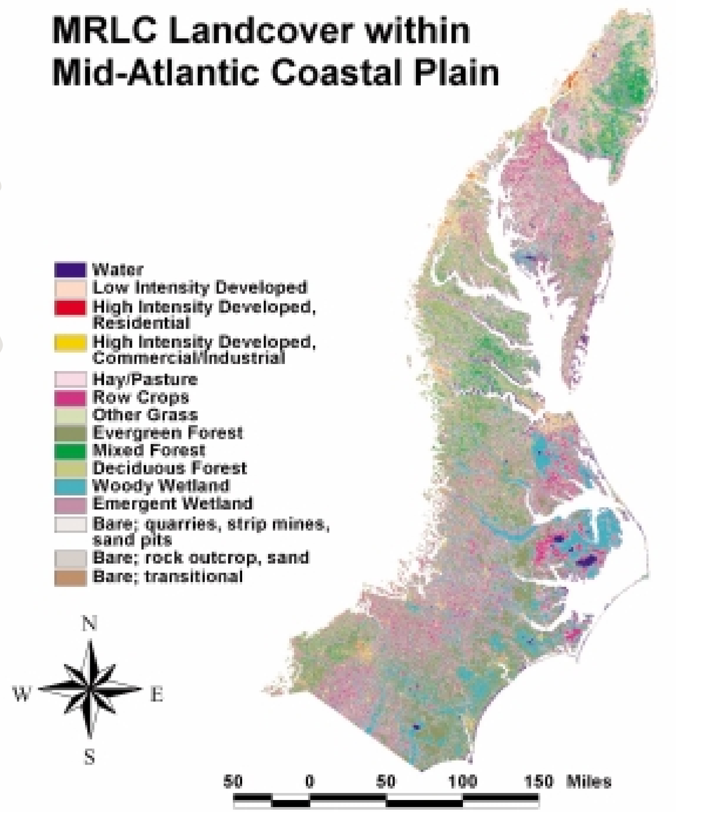


Figure 4. Example of Euclidean watersheds

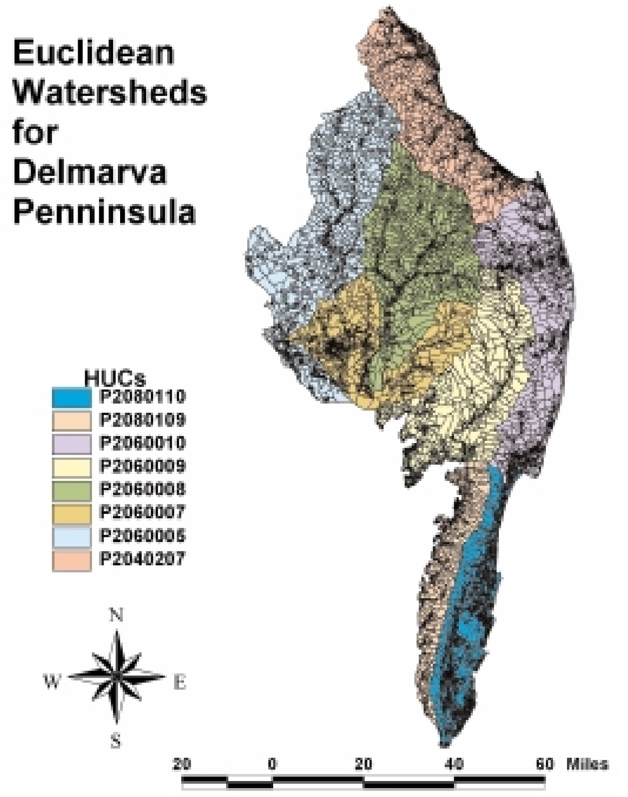


Figure 5. Zones of Tidal Influence

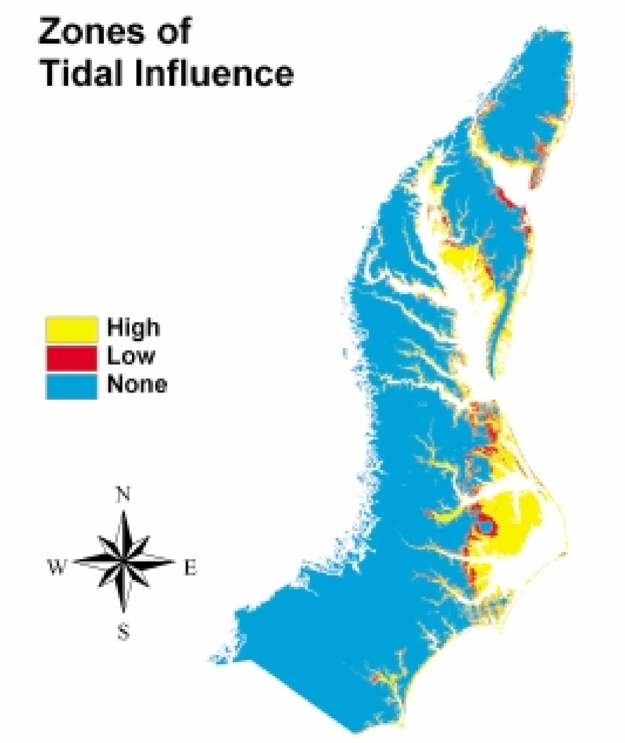
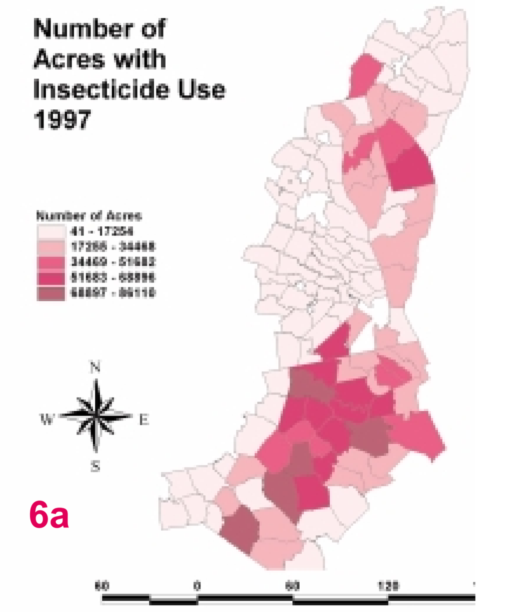
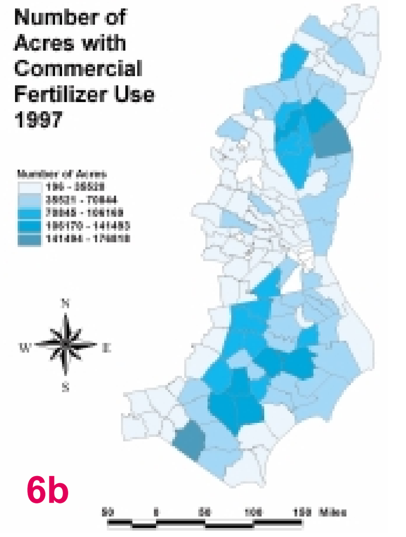
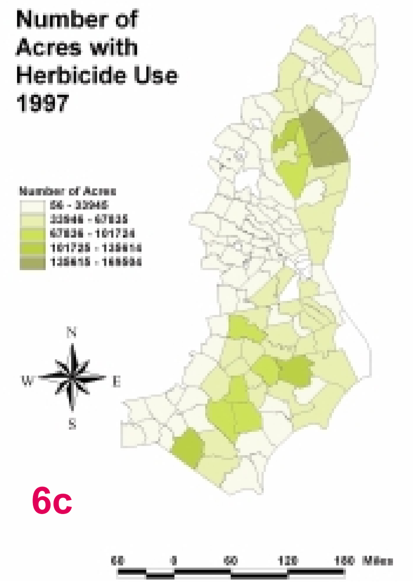


Figure 6. Agricultural Chemical Application Rates by County







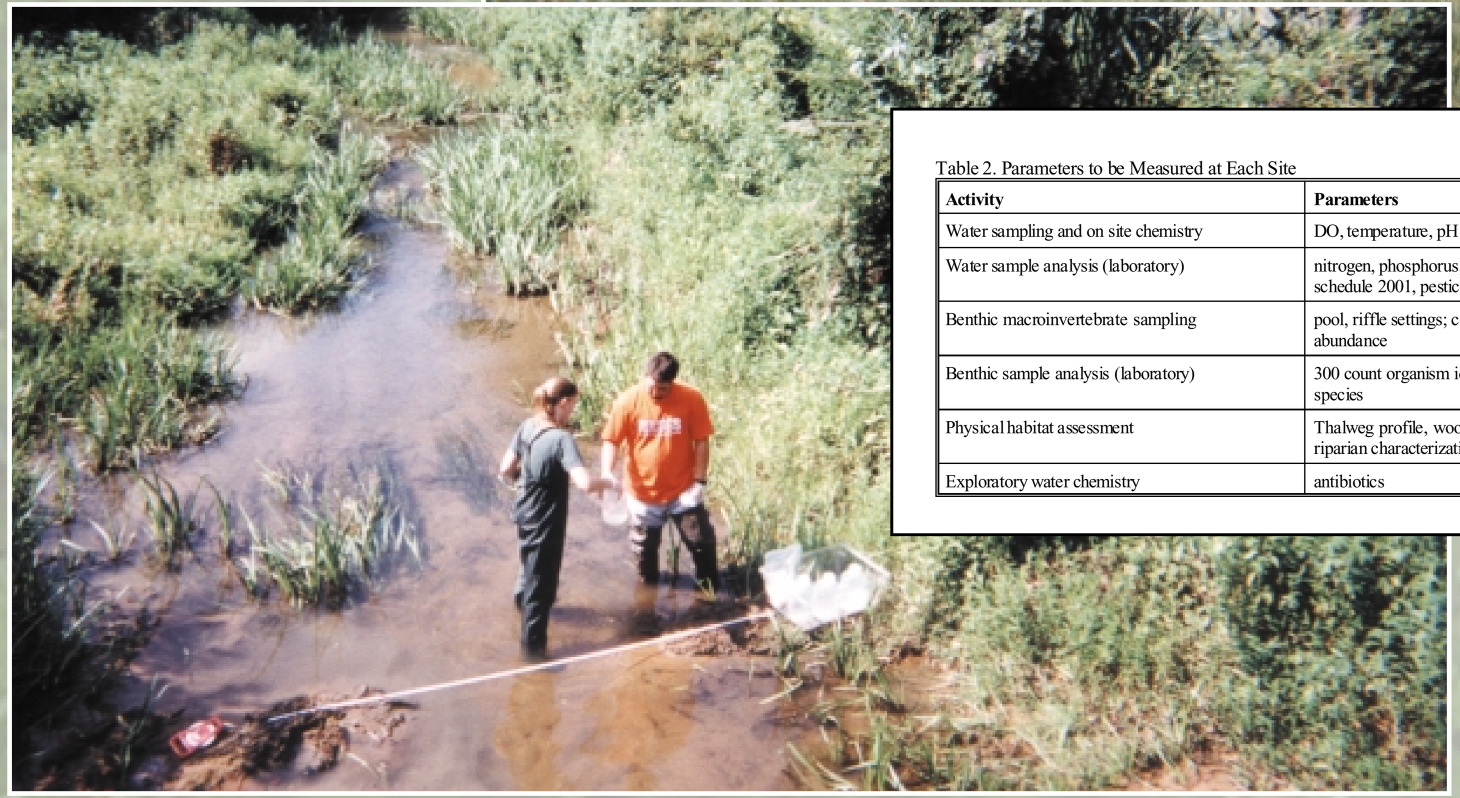


Table 2. Parameters to be Measured at Each Site

Activity	Parameters
Water sampling and on site chemistry	DO, temperature, pH
Water sample analysis (laboratory)	nitrogen, phosphorus, major ions, pesticide schedule 2001, pesticide metabolites
Benthic macroinvertebrate sampling	pool, riffle settings; community composition and abundance
Benthic sample analysis (laboratory)	300 count organism identification to genus and species
Physical habitat assessment	Thalweg profile, woody debris tally, channel and riparian characterization, discharge
Exploratory water chemistry	antibiotics

Next Steps

Landscape Indicator Analysis

Once the data are collected, the next steps are as follows:

Test landscape indicators singly and in combination, for both agricultural and urban land cover gradients, using water quality data for the entire study area.

Compare the indicator performance using data for the entire study area and within hydrogeologic units to estimate the importance of the physical setting.

Evaluate the behavior of the indicators for different types of pesticides with differing physical characteristics, such as water solubility and partioning coefficients.

Repeat these analyses using macroinvertebrate data.

Model selected watersheds to further evaluate the above results using both a multimedia compartmental model and a combined surface water-ground water model.

Assess the condition of the baseflow in first order streams for nutrients and pesticides, by applying the indicators selected above over the entire area.

Provide guidance on the application of these indicators to potential users.

A timetable for the study is provided in Table 3.

Table 3. List of milestones

Year	Event	Responsibility
1998	Analyzed existing pesticide data for Mid-Atlantic	EPA, USGS
	Reviewed literature	EPA
	Initiated USGS IAG	EPA
1999	Complete hydrogeologic framework	USGS
	Acquire GIS coverages; characterize Euclidean watersheds	EPA
	Develop statistical sampling design and select sites	USGS, EPA
	Select ground water-surface water and multimedia models	EPA, USGS
2000	Complete site selection	USGS, EPA
	Collect and analyze water and macroinvertebrate samples	USGS
	Prepare database for water sample, macroinvertebrate, and physical habitat data; derive interpretive measures and include in database; prepare meta data	EPA, USGS
	Evaluate landscape indicators with new data	EPA
	GPRA Deliverable: Theory and Application of Landscape Indicators of Pesticide and Toxic Risk, due 9/00	EPA
2001	Complete landscape indicator analysis	USGS
	Evaluate hydrogeologic framework with new data	EPA
	Complete modeling	EPA, USGS
	Develop Mid-Atlantic Coastal Stream assessment using indicators	EPA
	GPRA Deliverable: Estimating Vulnerability of Streams and Ground Water to Nutrients and Pesticides, due 9/01	EPA
2002	Make data available on Internet	EPA
	Deliverable: Integration of a Hydrogeologic Framework, Landscape and Water Quality Parameters, and Landscape Indicators for a Regional-Scale Water Quality Assessment, 6/02	EPA

Landscape Ecology Branch, Environmental Sciences Division, National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, P.O. Box 93478, Las Vegas, NV 89193-3478, pitchford.ann@epa.gov