System Pinpoints Nonpoint Source Pollution

UNIVERSITY PARK (Centre Co.) — Researchers at Penn State are using Geographic Information Systems to rank areas in Pennsylvania by their potential for producing nonpoint source pollution.

"The rankings developed by this project will be used to identify critical watersheds in Pennsylvania that have the greatest agricultural nonpoint source pollution potential, and where the maximum water quality benefits from implementation of irritigation programs are possible," said Dr. James M. Hamlett, assistant professor of agricultural and biological engineering. "The information can then be used to guide future nutrient management programs and allocations for the State Nonpoint Source Management Program."

Identifiable and locatable pollution sources, such as factories with effluent streams or sulfur dioxide-releasing smokestacks, are considered point source polluters. Pollution caused by runoff from agricultural land, suburban areas, and forests is classified nonpoint source because no individual site is the cause of the problem.

"Most of the information we needed for this project was already available, but we had to key it to geographic location and build up the individual layers to see the whole picture," said Hamlett.

Geographic Information Systems manipulate information both visually and numerically. They can incorporate information from various layers and visually show the results on a map.

The researchers created seven layers for this project. The first layer, the boundaries of the 104 watersheds, was adopted from the State Water Plan of the Pennsylvania Bureau of Water Resources Management. The next level, land use, was accessed from the U.S. Geological Survey's (USGS) Land Use Data Analysis program.

"This land use data did not differentiate between crop land and pasture," said Hamlett. "We arbitrarily set everything on a slope of less than 1 percent and greater than 15 percent as pasture and left the rest as crop land."

A third layer indicated the topography and was also drawn from USGS data. Soil information from the Soil Conservation Service's State Soil Geographic Data Base made up the fourth layer.

The animal density, used to determine nitrogen loading from manure, was taken from the U.S. Census Bureau for 1987 and made up the fifth layer.

"This data set caused a slight problem because it was organized by zip code, while the other data sets were provided by county or watershed," said Hamlett. "We had to do some matching of zip codes to watersheds to make this layer work with the others."

The final two layers, precipitation and rainfall-runoff factor, were developed by ZedX Inc., a commercial firm specializing in databases for agricultural decision making. The precipitation layer was a combination of 24-hour and monthly precipitation information.

The rainfall-runoff factor, or the erosion index layer, was derived from average annual and regional cumulative erosion indices.

To rank the watersheds, the team used four indices — the Sediment Production Index, which assesses erosion and sediment delivery to streams; the Runoff Index, which predicts potential to produce surface runoff; the Animal Loading Index, which ranks potential manure nitrogen production from livestock; and the Chemical Use Index, which ranks potential for pollution from commercial chemical applications to agricultural land.

Each of these indices was derived from a combination of GIS information. The Animal Loading Index, for example, comes from the animal density layer, number and type of animals and, the expected manure production spread over the watershed.

In each of the 104 watersheds, these four indices were weighted either for all land or only agricultural land and added together to produce the Agricultural Pollution Potential index. The watersheds were then ranked.

"Looking at the rankings, its not surprising to find the number 1 and 2 watersheds in the Lancaster area," said Hamlett. "These are intense agricultural areas with high animal populations.

"In some other cases, we may have a high ranking because the topography is incredibly steep, producing large amounts of runoff and sediment, even if there are no animals and little nitrogen or phosphorous loading."

Results of this one-year study were presented to the Pennsylvania Department of Environmental Resources. The GIS layers developed for the project at Penn State's Office for Remote Sensing of Earth Resources can be used for other studies and additional layers can be added to answer other questions.

The research team included Hamlett; Dr. Gary W. Petersen, professor of soil genesis and morphology and co-director of ORSER; George M. Baumer and Douglas A. Miller, research assistants, ORSER; Rick L. Day, department of agronomy; and Joseph M. Russo, research scientist, ZedX, Inc. The team plans to use data collected in the Susquehanna basin to verify the information generated using the GIS. They will compare the watershed rankings determined by actual values to those determined by the GIS and verify that the rankings match.

Hamlett believes there are improvements and additions that can be made to the program.

"We were asked to do agricultural land assessment, so we really didn't consider urban land and its runoff and nonpoint source pollution potentials," he said. "We also did not consider runoff from acid mine drainage throughout the state."