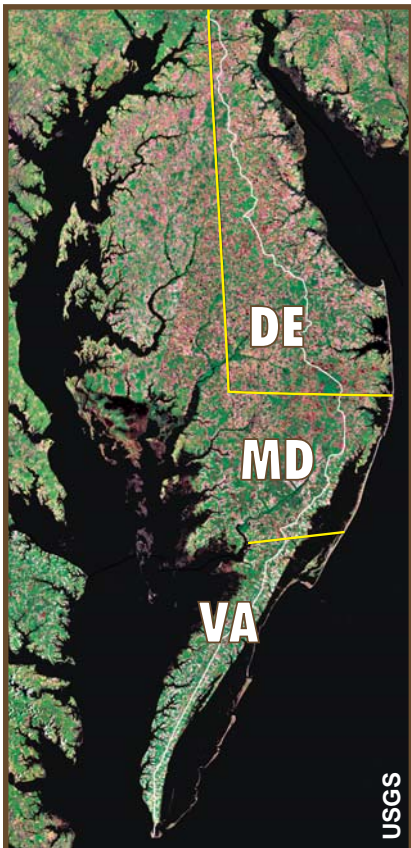


NUTRIENT MANAGEMENT OF DELMARVA SOILS & WATERS

Based on *Status of nutrients in Delmarva soils, groundwaters, creeks and tributaries forum*, October 21, 2003

Extensive poultry operations and associated feed grain production on the Delmarva peninsula have resulted in elevated nutrient levels in soils, groundwaters, creeks and tributaries of the Chesapeake Bay. Laws passed by state legislatures in 1998 and 1999 required nutrient management for nearly all farms and large-scale urban nutrient applications in Maryland and Delaware, and for poultry operations in Virginia. These laws were passed in an attempt to reduce nitrogen and phosphorus losses from agricultural production systems to state waters, particularly Chesapeake Bay. A science forum of regional soils, hydrology and marine experts was convened on October 21, 2003 to explore recent information and reach consensus on the status of nutrients in soils, groundwaters, creeks, and tributaries on the Delmarva peninsula. Scientific information derived from the forum is summarized here to inform future management decisions regarding nutrients on Delmarva and elsewhere. The 15 assembled experts concluded that on the nutrient-enriched Delmarva peninsula, nutrient application rates should be defined to provide reasonable environmental protection while maintaining crop yield optimization. Future management policy must be formulated to value water quality improvement along with crop yields, without imposing unreasonable economic hardships on the farmer. This could be facilitated with the help of subsidized activities already in place, such as cost share incentives.

CHICKENS, CORN AND SOY GROWN ON DELMARVA



Elevated nutrients on the Delmarva peninsula (Delaware, Maryland, Virginia) are a result of extensive poultry operations and associated feed grain production.

Forty-four percent or 1.66 million acres of Delmarva is farmland, which produced 13 million bushels of soybeans and 35 million bushels of corn in 2002.¹ There are more than 2300 poultry growers on Delmarva, who produced 585 million broiler chickens in 2002.²



a) Poultry houses; b) poultry production; c) corn; d) soybeans.
Photos b) and c) courtesy of the University of Maryland College Park.

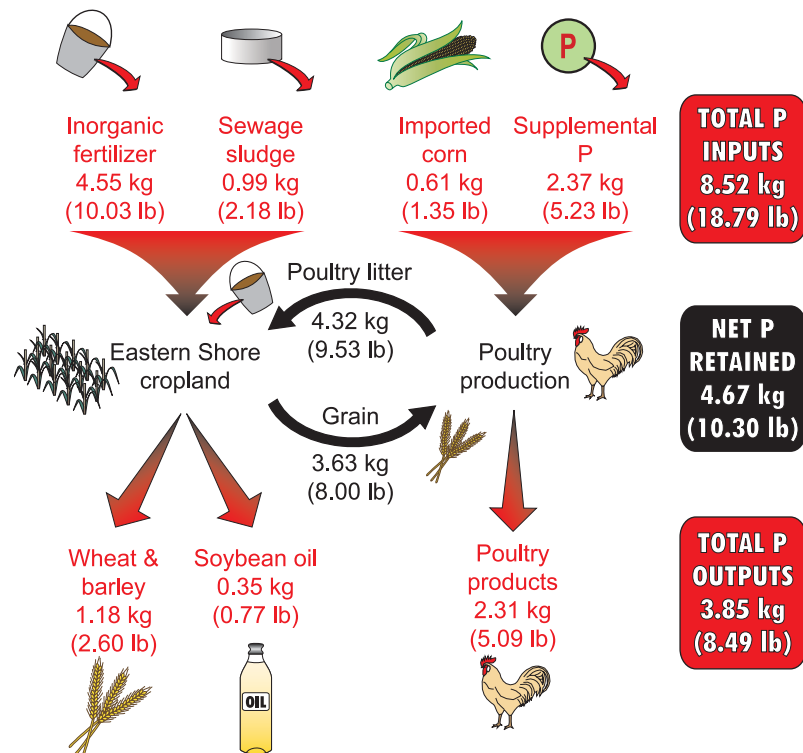
ELEVATED NUTRIENTS EVIDENT

Soil nitrogen (N), including nitrate (oxidized nitrogen; NO_3^-) has increased in many areas in surface and groundwaters and is present at elevated concentrations throughout the surface aquifer on Delmarva. Similarly, N concentrations in tributaries increased through the 1990s and have remained elevated. Ammonium (NH_4^+) and urea (reduced nitrogen) are also seasonally elevated to significant levels in some streams and tributaries.

Soil phosphorus (P) levels have increased in Delmarva soils resulting in agronomically excessive levels of soil P, increasing on average by 10 lbs/acre/year.

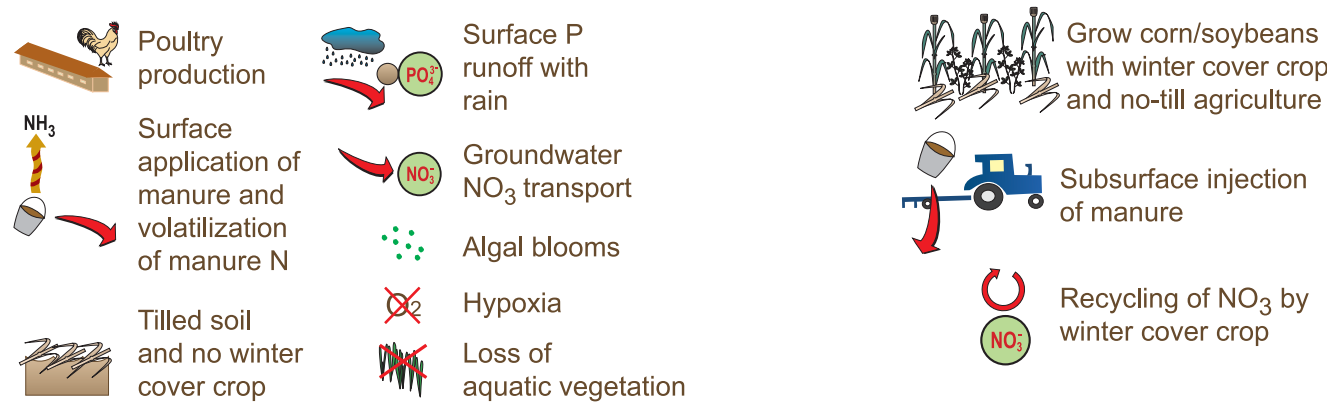
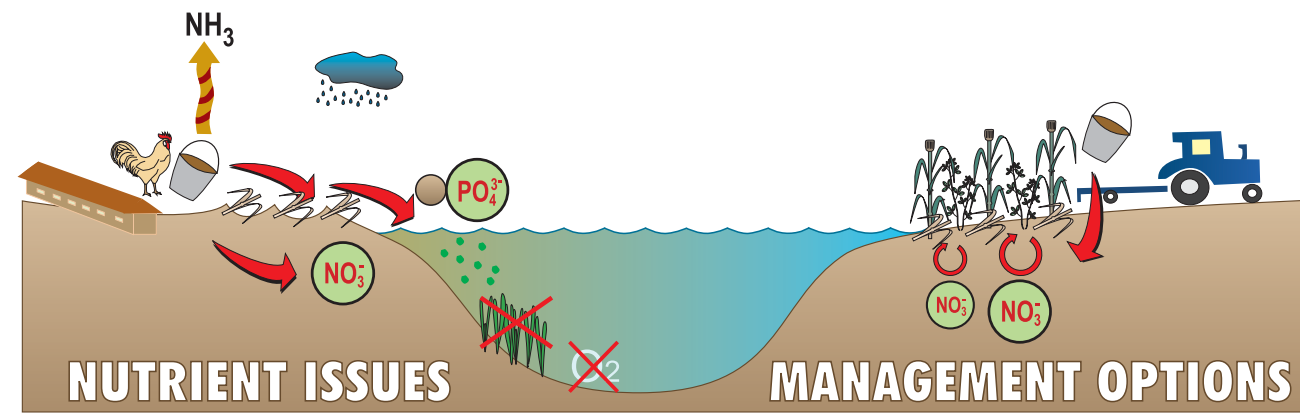
Soil nutrient levels and associated soil characteristics indicate potential problems for nutrient export in surface and groundwater. There is a strong relationship between soil P levels and losses of P in runoff on Delmarva. This is likely attributable to P enrichment of the most easily erodible sediments, and to dissolved P originating from high P surface soils, plant residues, and manure and fertilizer application. P-enriched surface soils may also lose P through shallow subsurface export to ditches and tile lines during drainage. Further, surface application of manure without incorporation into the soil by tillage favors the runoff of P and N and the volatilization of ammonia (NH_3). Fall and winter fertilizer and livestock waste applications, particularly of organic sources such as manures, could result in major losses of both nutrients to surface and groundwater. Winter cover crops can substantially reduce transport of sediment-bound P to surface waters by reducing the potential for soil erosion, and reduce N losses to both surface and groundwater by reducing nitrate leaching.

P BUDGET



Major annual phosphorus flows on the Maryland Eastern Shore in 10^6 kg.³

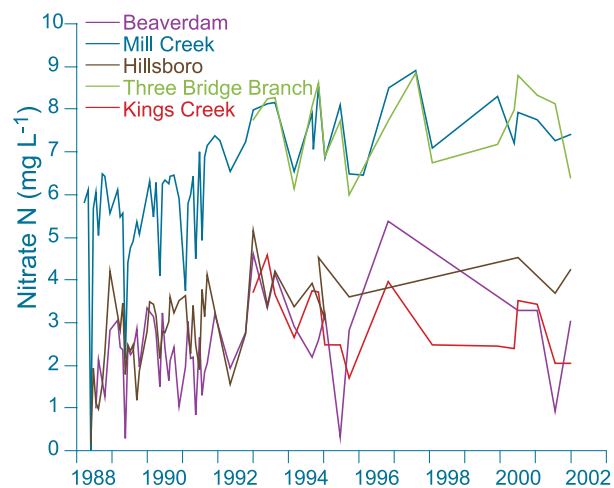
COVER CROPS CAN REDUCE NUTRIENT EXPORT



Conceptual diagram outlining the issues and management options for nutrients on the Delmarva peninsula.



Agricultural runoff draining from a field.



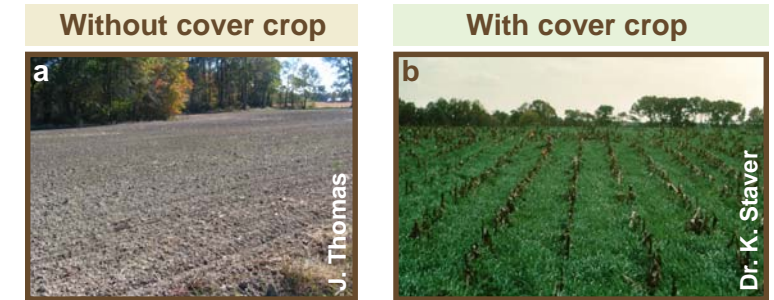
Increasing volume of nitrate in five Delmarva streams. Data courtesy Kenneth Staver.

RECOMMENDATIONS

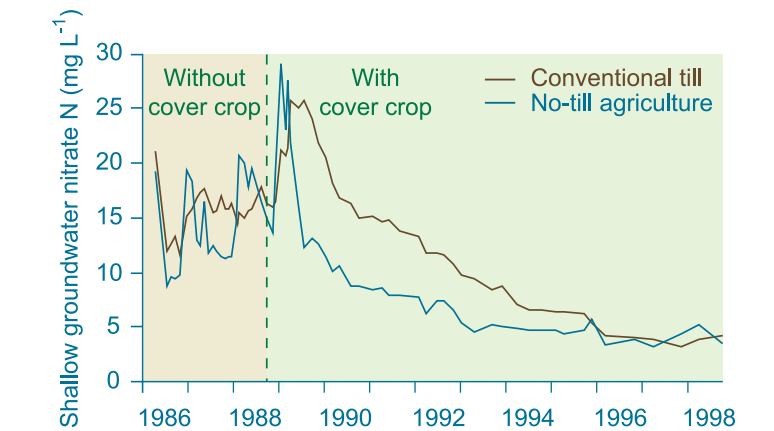
The high levels of nitrogen and phosphorus observed on Delmarva provide an impetus for an integrated nutrient management approach, where the regional outputs of N and P (crops, livestock, acceptable nutrient discharges to water and the atmosphere) are in better balance with regional inputs (imported feeds and fertilizers). Increased efforts should be made to develop integrated nutrient management plans and accurate assessment methods that strive to balance farm-level and regional nutrient flow by involving interactions between livestock industries, farm managers, and the users of the Chesapeake Bay watershed.

The following management recommendations were made by forum participants, supported by scientific studies of nutrient levels over the past several years:

- Cover crops:** Nitrate losses to groundwater, and eventually to receiving waters, can be substantially reduced by the timely planting of fall cover crops. Winter fallow corn or soybean acres are characterized by substantial N leaching losses to groundwater, particularly where manure has been applied or when applied N exceeds crop uptake.
- Incorporate animal manures and urea-containing fertilizers:** Surface application of manures should be followed immediately by incorporation through tillage, while liquid waste should be injected directly into the soil to reduce N and P in runoff and volatilization. Incorporation should be done in a manner that is consistent with controlling soil erosion.



a) Winter fallow corn field without cover crop; and b) full season corn with a rye cover crop.



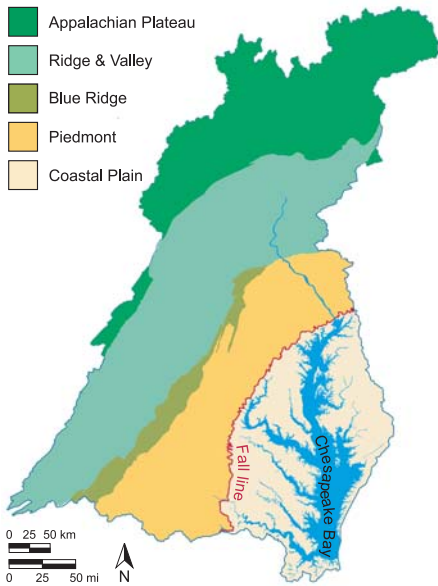
Shallow groundwater nitrate N in tilled and no-till watersheds, before and after use of winter cover crops.⁴

	Without cover crop	Rye cover crop	Reduction (%)
Corn	25.5	3.7	85
Soybean	34.0	18.6	45
Double-crop (dc) soybean	22.6	8.9	60
Corn/wheat	nd	5.9	76
Corn/corn	28.3	2.6	90
Corn/soybean	28.8	8.6	70
Corn/wheat/dc-soybean	15.4	6.5	57

Annual nitrate N leaching losses (lb acre^{-1}). Data courtesy Kenneth Staver.

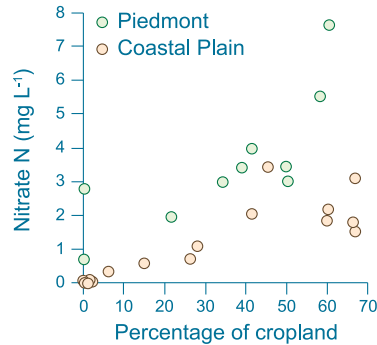
- Animal manure application timing:** Fall and winter application of manure should be discouraged, as nutrient uptake by crop plants is minimal at this time.
- Regional integrated animal manure management:** Regional infrastructure must be developed to effectively manage nutrient flows to and from animal enterprises. Current activities must remain focused on waste management, rather than optimal use of these materials in crop production, as land application should not be the long-term sink for nutrients on Delmarva. Efforts should be directed toward achieving an agronomically- and environmentally-sound approach to managing organic nutrients. This approach should balance the substantial amounts of nutrients that are imported into the region as feed with a regional integrated management system for animal wastes. Opportunities include reducing P content of manures, establishing environmentally sound on-site temporary storage capabilities, and developing regional manure transport capacity.

NUTRIENTS IN CHESAPEAKE WATERSHED REGIONS

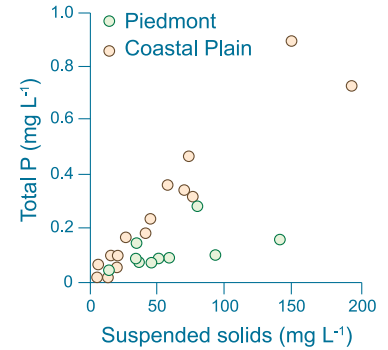


Physiographic regions of the Chesapeake Bay watershed.⁵

The Chesapeake Bay watershed is comprised of five different physiographic regions (see map, left). The two regions closest to the Bay, the Coastal Plain and the Piedmont, differ substantially in their relative discharges of nitrogen and phosphorus. Coastal Plain croplands discharge less N per acre than do Piedmont croplands, possibly because of the increased groundwater flow in the Piedmont leaching more nitrate out of the soil (see graph, below left). Conversely, Coastal Plain watersheds discharge more P than do Piedmont watersheds, because discharges from the Coastal Plain have higher concentrations of suspended solids, which carries with it higher concentrations of P (see graph, below right).⁶



Cropland area and nitrate N discharges from Piedmont and Coastal Plain watersheds (left) and suspended solids and total P in discharges from Coastal Plain and Piedmont watersheds (right).⁶



Workshop participants (in alphabetical order)

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Some of the participants in the Status of nutrients in Delmarva soils, groundwaters, creeks and tributaries forum.

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The *Integration and Application Network (IAN)* is a collection of scientists interested in **solving**, not just studying environmental problems. The intent of IAN is to inspire, manage and produce timely syntheses and assessments on key environmental issues, with a special emphasis on Chesapeake Bay and its watershed. IAN is an initiative of the faculty of the University of Maryland Center for Environmental Science, but will link with other academic institutions, various resource management agencies and non-governmental organizations.

PRIMARY OBJECTIVES FOR IAN

- **Foster** problem-solving using integration of scientific data and information
- **Support** the application of scientific understanding to forecast consequences of environmental policy options
- **Provide** a rich training ground in complex problem solving and science application
- **Facilitate** a productive interaction between scientists and the broader community

FURTHER INFORMATION

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SCIENCE COMMUNICATION

Based on *Status of nutrients in Delmarva soils, groundwaters, creeks and tributaries* forum, October 21, 2003.
Graphics, design and layout by Jane Thomas

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