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U.S. Department of Agriculture  
Office of the Assistant Secretary for Civil Rights  
1400 Independence Avenue, SW  
Washington, D.C. 20250-9410; or

**fax:**  
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(833) 256-1665 o (202) 690-7442; o

**correo electrónico:**  
[program\\_intake@usda.gov](mailto:program_intake@usda.gov).

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A R M O P

# Natural Resources & Environmental Stewardship

## Fundamentals of Nutrient Management

Chuck Schuster  
Senior Agent Emeritus  
University of Maryland Extension  
College Of Agriculture and Natural Resources  
[cfs@umd.edu](mailto:cfs@umd.edu)  
410-596-2159



# Plan for this segment...

- Water pollution and the hydrologic cycle
- Unique challenges in the Chesapeake Bay region
- Farm nutrient balance
- Best Management Practices (BMPs)



# Modern life leads to soil-water pollution

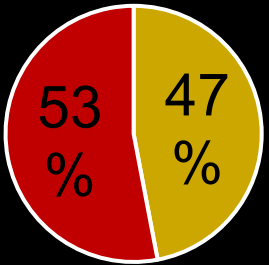
- Intensive crop and animal production-
  - nutrients, sediments, pathogens, pharmaceuticals
- Growth of towns and cities-
  - sediments, nutrients, pharmaceuticals, PCPs
- Transport of people and goods-
  - hydrocarbons, fuel additives, NO<sub>x</sub>, metals-
- Manufacture of consumer and industrial goods-

solvents, metals, PFAS



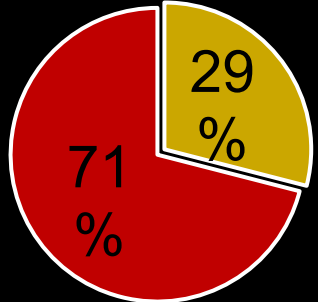
# Water quality impairment is widespread in the U.S.

## Streams/Rivers



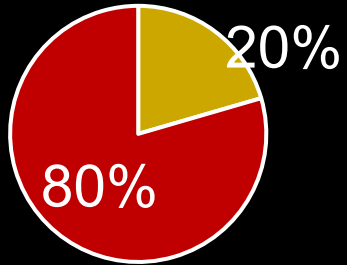
1,110,961 miles assessed (31% of total)

## Lakes/Ponds



18,629,795 acres assessed (45% of total)

## Estuaries/Bays

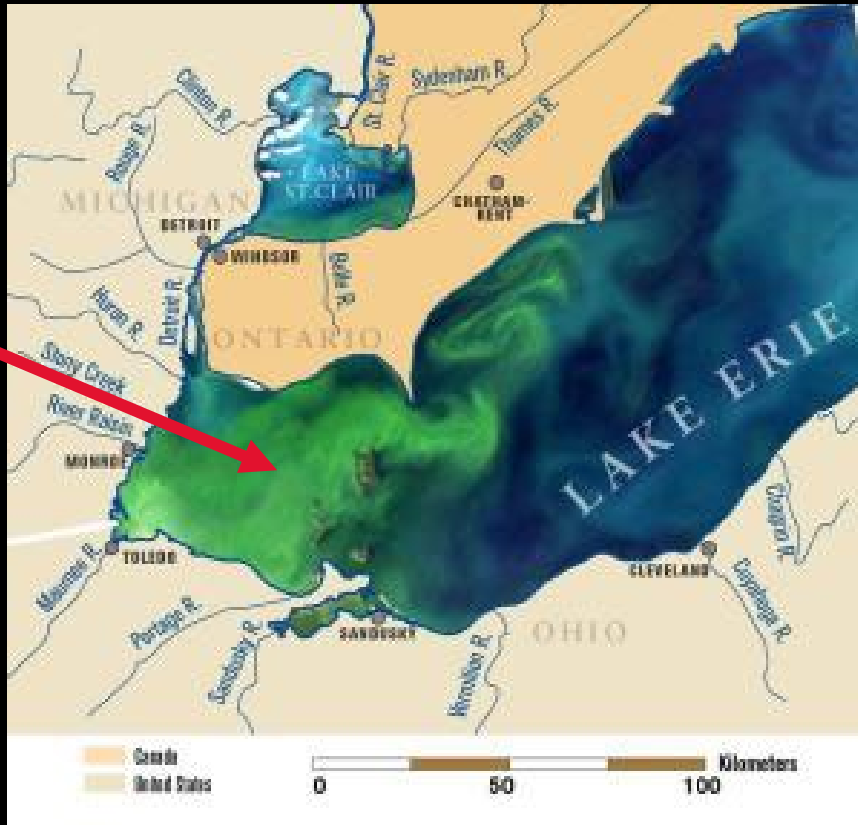


56,141 sq. miles assessed (64% of total)

■ Good ■ Impaired

Information from: EPA. 2019.  
[https://ofmpub.epa.gov/waters10/attains\\_nation\\_cy.control#STREAM/CREEK/RIVER](https://ofmpub.epa.gov/waters10/attains_nation_cy.control#STREAM/CREEK/RIVER)





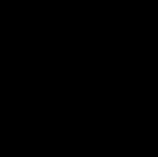
Algal bloom that can be seen from space (map overlaid on imagery)  
Microcystis – high levels of the toxin – can't drink, can't touch (shower)

So why do these blooms occur  
Heavy rainstorms → pulses of nutrients into waterbodies  
Those additional nutrients create favorable environment for algae growth

Short lifespan – quick growth and die fast also.



Not a good color – should it be green?





# Types of Pollution

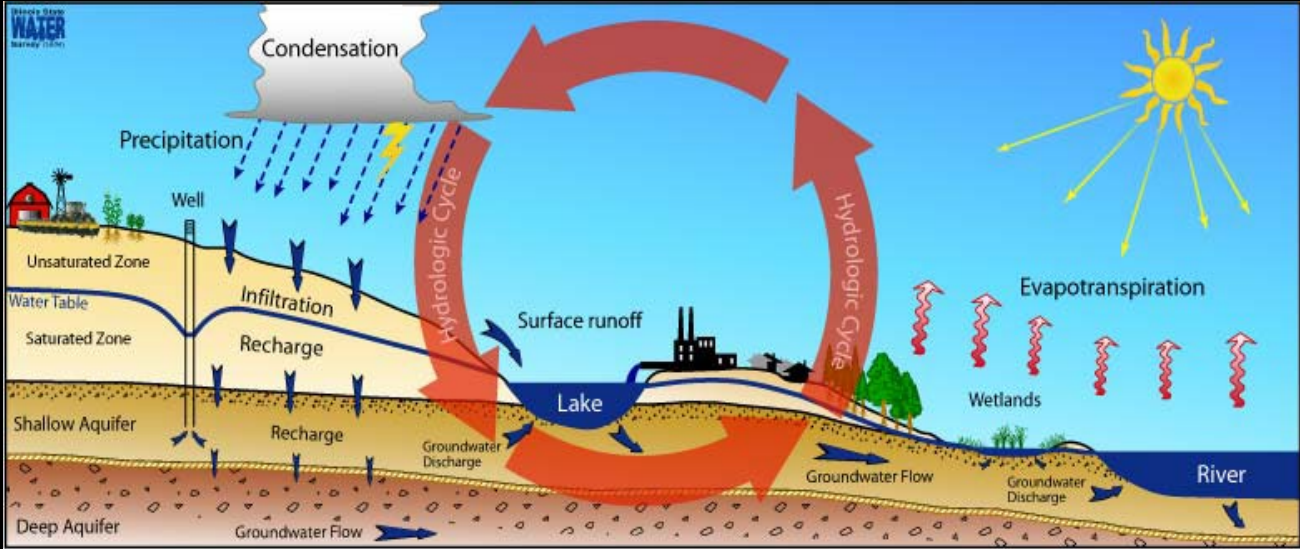
- Point source – source is easily identified; control is straightforward; “end of pipe”
  - Wastewater treatment plants
  - Confined Animal Feeding Operations
- Nonpoint (diffuse) source – arises over landscapes from various land uses; occurs during and after rainfall
  - cropland and pastureland

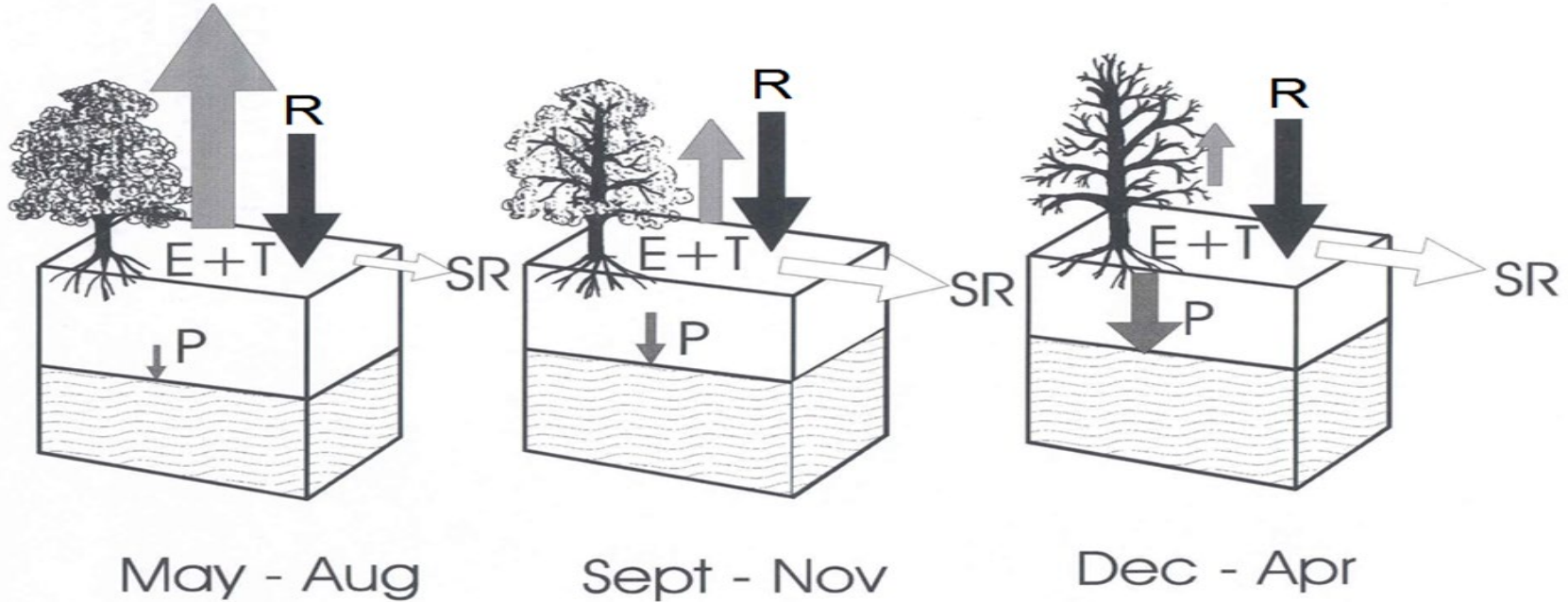
# And more!

- Runoff and sediment



The large amount of pavement and stormwater drainage in cities and suburbs provides a direct route for nutrients and other pollutants to enter streams, rivers and the Bay.





 Ground Water  
E Evaporation

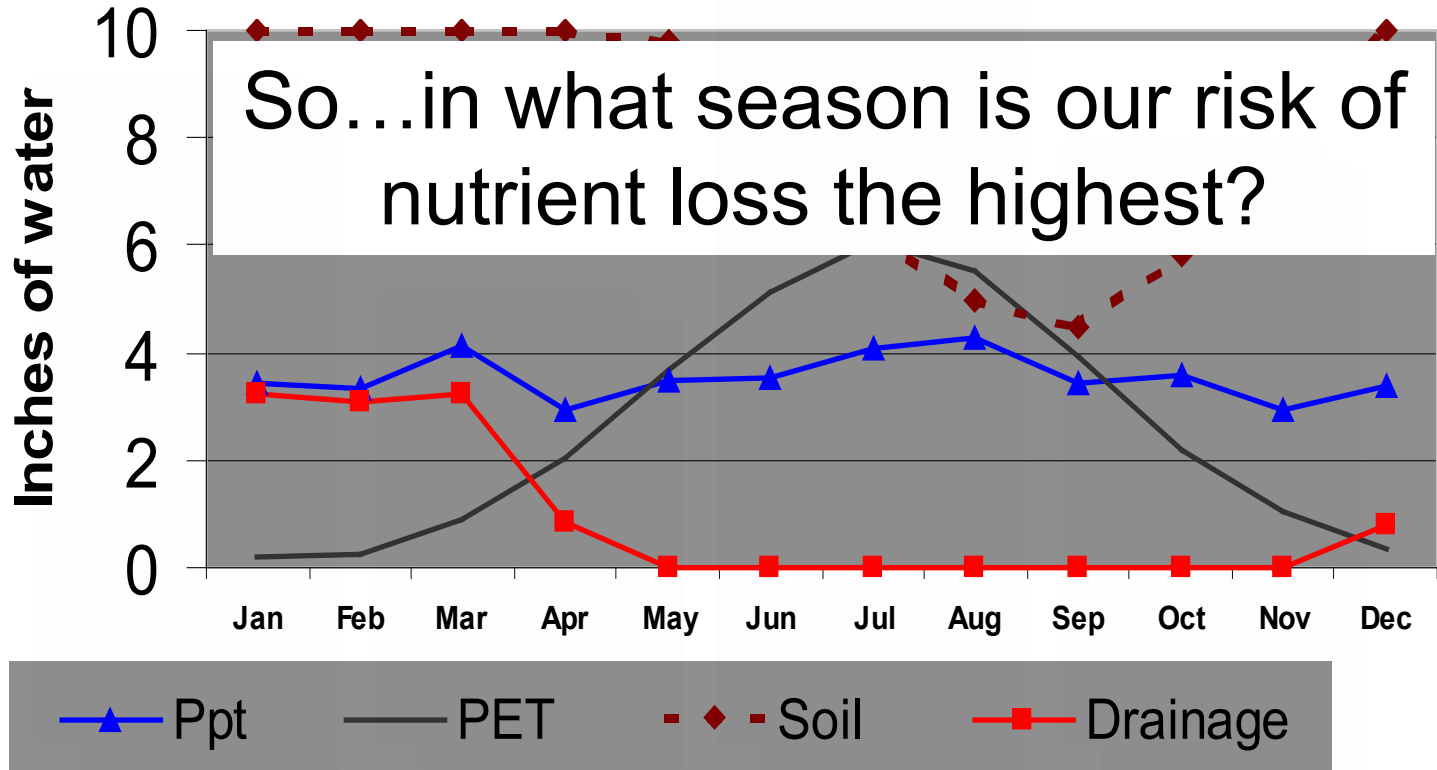
R Rainfall  
T Transpiration

SR Surface Runoff  
P Percolation

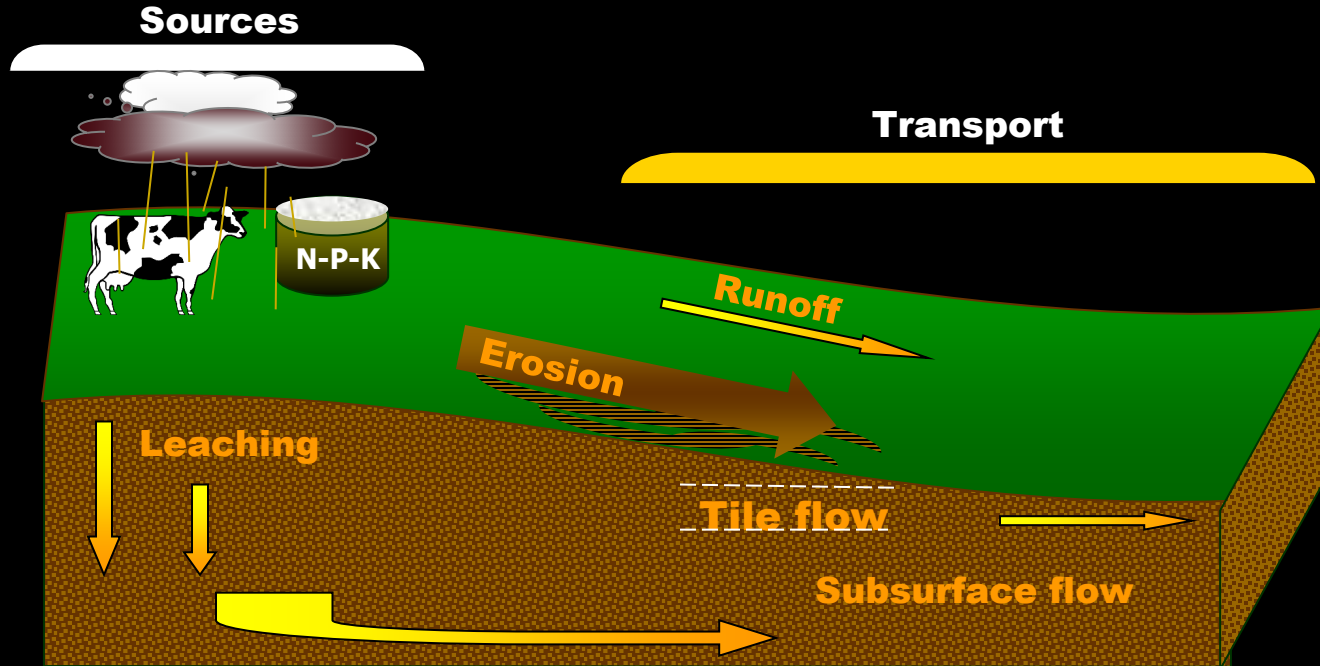




## Soil-Hydro. Cycle, Lower Eastern Shore



# Sources & Transport



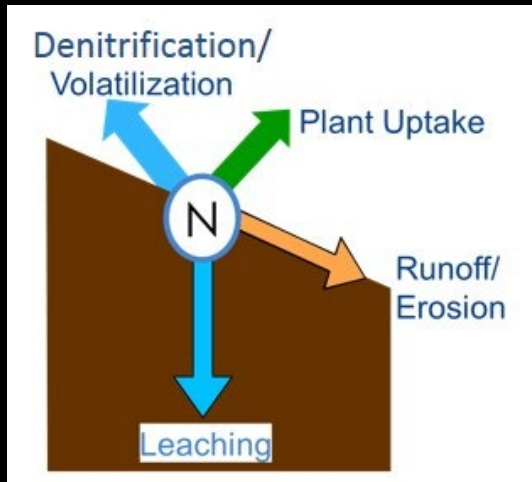


# N & P from a water quality perspective...

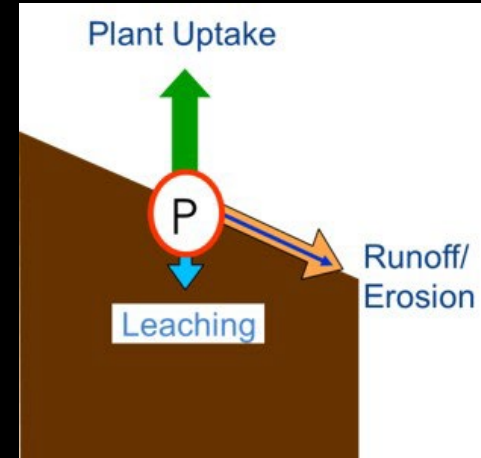
- Nitrogen (as nitrate)
  - is lost to leaching
  - contaminates ground water
- Surface waters are contaminated during ground water discharge
- Phosphorus
  - soluble P is lost in runoff or subsurface drainage (tile/ditch drains)
  - sediment-bound P is lost during erosion
- P losses are surface water issues

# N & P from a water quality perspective...

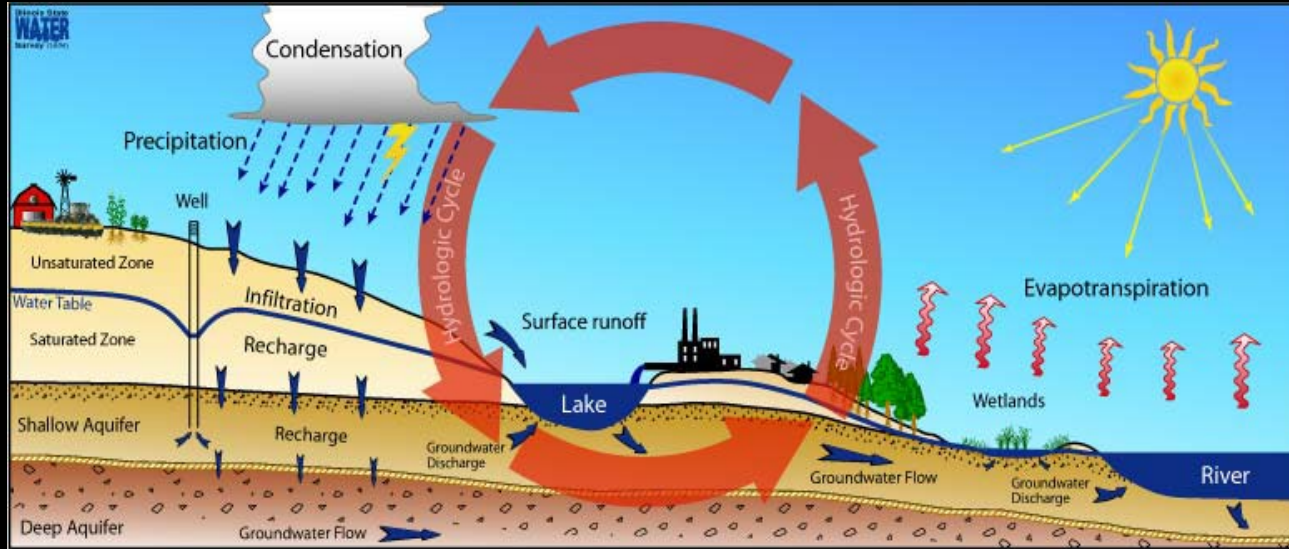
- Nitrogen (as nitrate)



- Phosphorus



# The Water Cycle



Illinois State Water Survey

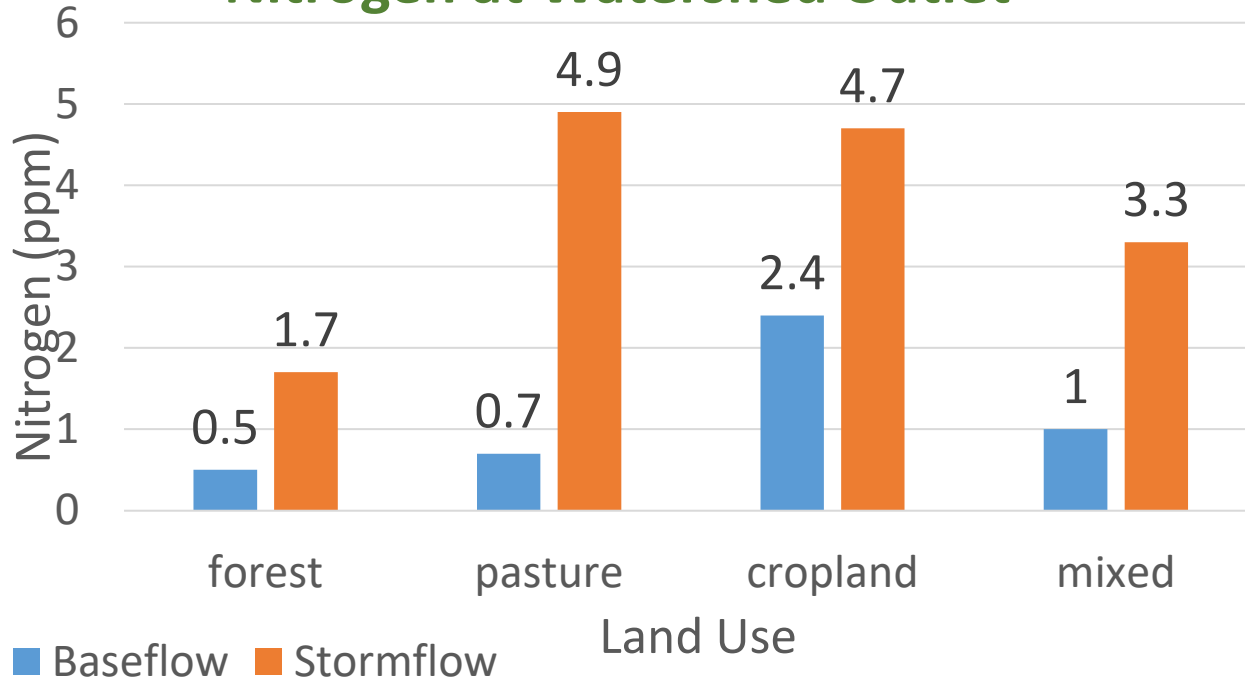
**Baseflow & stormflow are important**

So one needs to consider both seasonality and the water cycle in general.

Consider further about regular baseflow vs. stormflow.

Baseflow fed by groundwater flow, but then you get stormflow, typically with higher levels of N and P.

## Nitrogen at Watershed Outlet

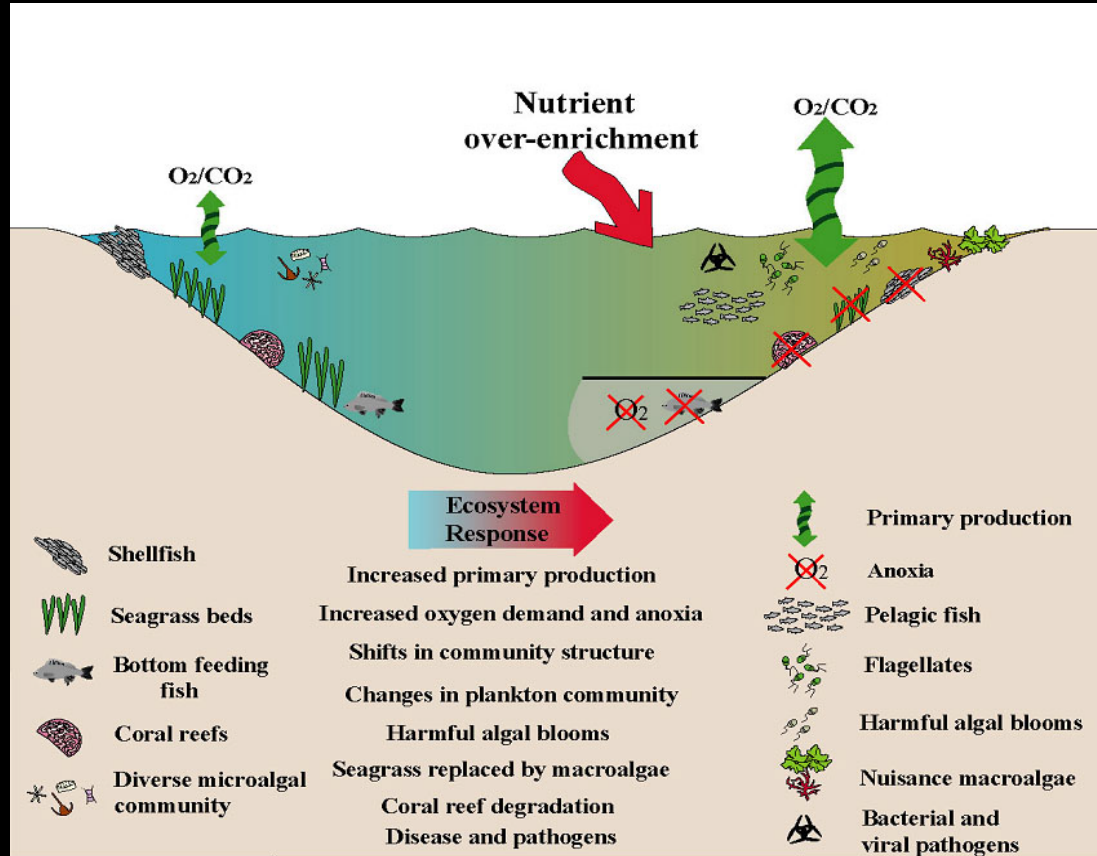


# Nutrient Pollution: Grand Challenge of the 21<sup>st</sup> Century

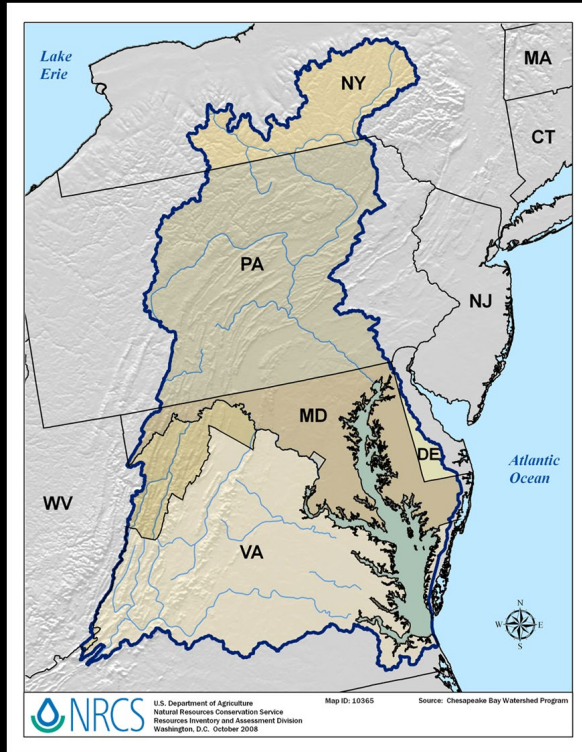


Healthy

Eutrophic



# The Chesapeake Bay Watershed













- **Bay area:** 4,480 mi<sup>2</sup> (the largest estuary in the U.S.)
- **Average depth:** 21 ft.
- **Basin area:** 64,000 mi<sup>2</sup>
- **Ratio of watershed area to bay area:** 14:1
- **19 major rivers flow into the bay**
- **Basin is in 6 states and the District of Columbia**
- **Population:** 18+ million (in 2020)
- **Value of fisheries harvest:** \$2,000,000,000 per year!
- **Major pollutants:** nutrients (N and P)

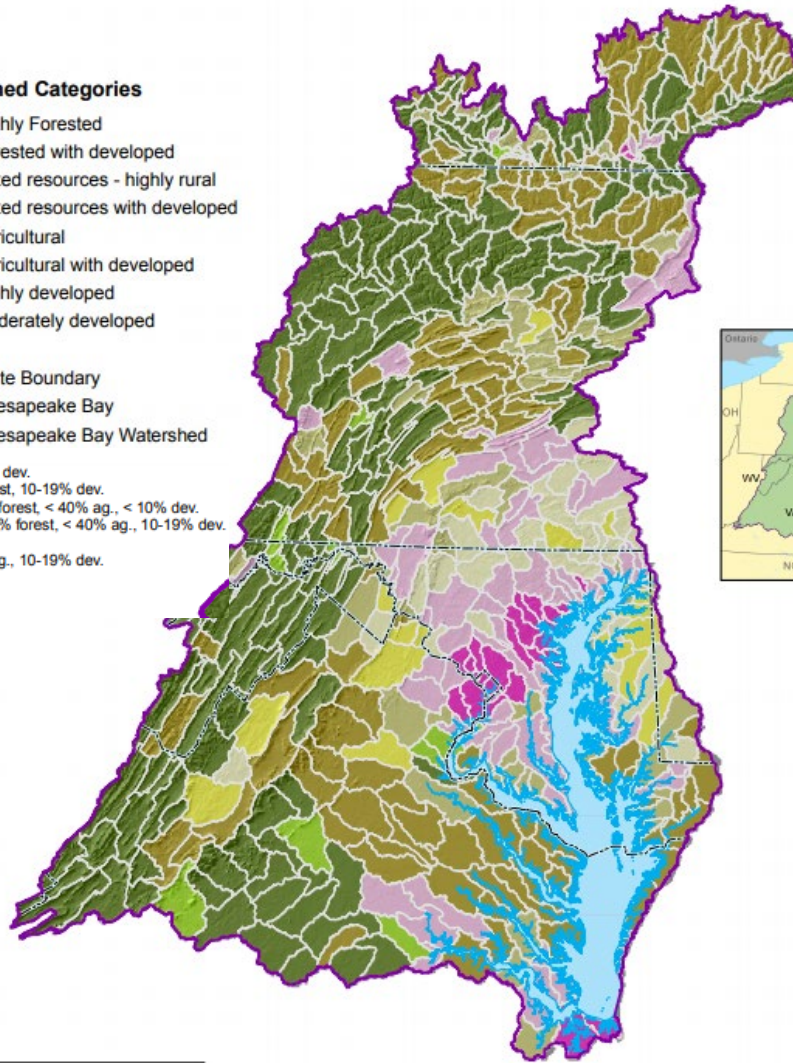




### Watershed Categories

-  Highly Forested
  -  Forested with developed
  -  Mixed resources - highly rural
  -  Mixed resources with developed
  -  Agricultural
  -  Agricultural with developed
  -  Highly developed
  -  Moderately developed
- State Boundary  
 Chesapeake Bay  
 Chesapeake Bay Watershed

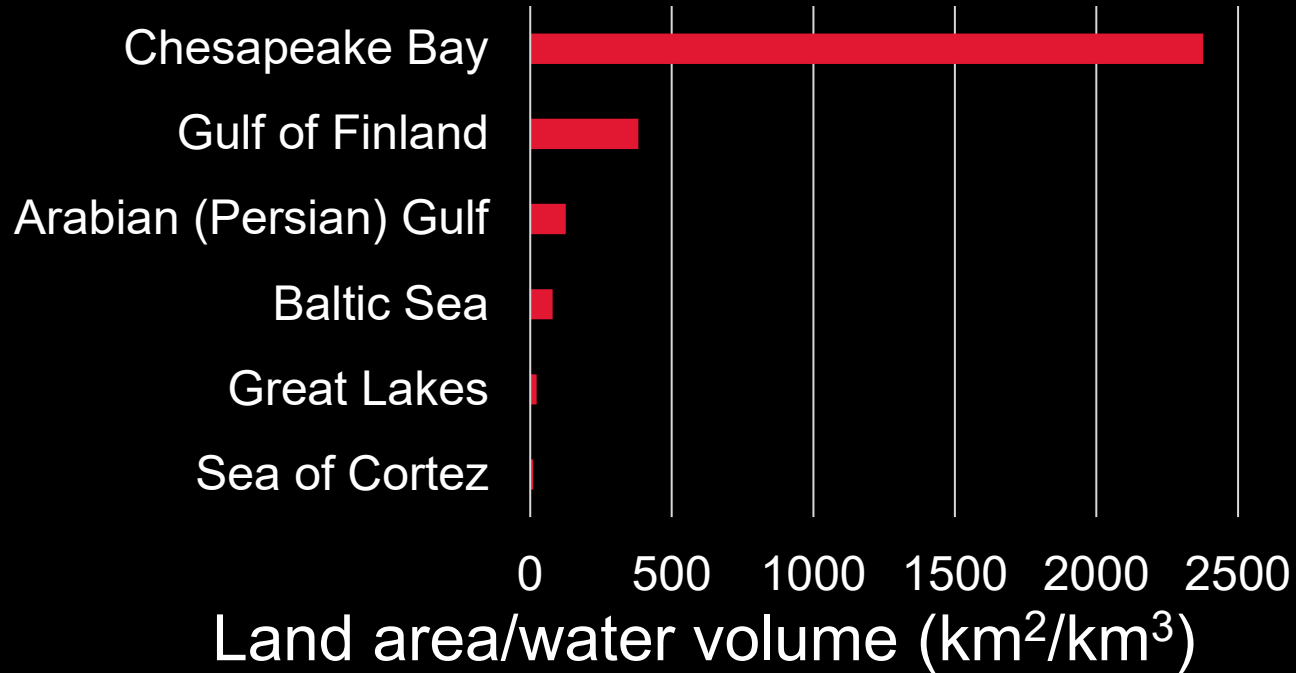
Highly forested:  $\geq 75\%$  forest,  $< 10\%$  dev.  
Forested with developed:  $\geq 75\%$  forest, 10-19% dev.  
Mixed resources - highly rural:  $< 75\%$  forest,  $< 40\%$  ag.,  $< 10\%$  dev.  
Mixed resources with developed:  $< 75\%$  forest,  $< 40\%$  ag., 10-19% dev.  
Agricultural:  $\geq 40\%$  ag.,  $< 10\%$  dev.  
Agricultural with developed:  $\geq 40\%$  ag., 10-19% dev.  
Highly developed:  $\geq 50\%$  dev.  
Moderately developed: 20-49% dev.



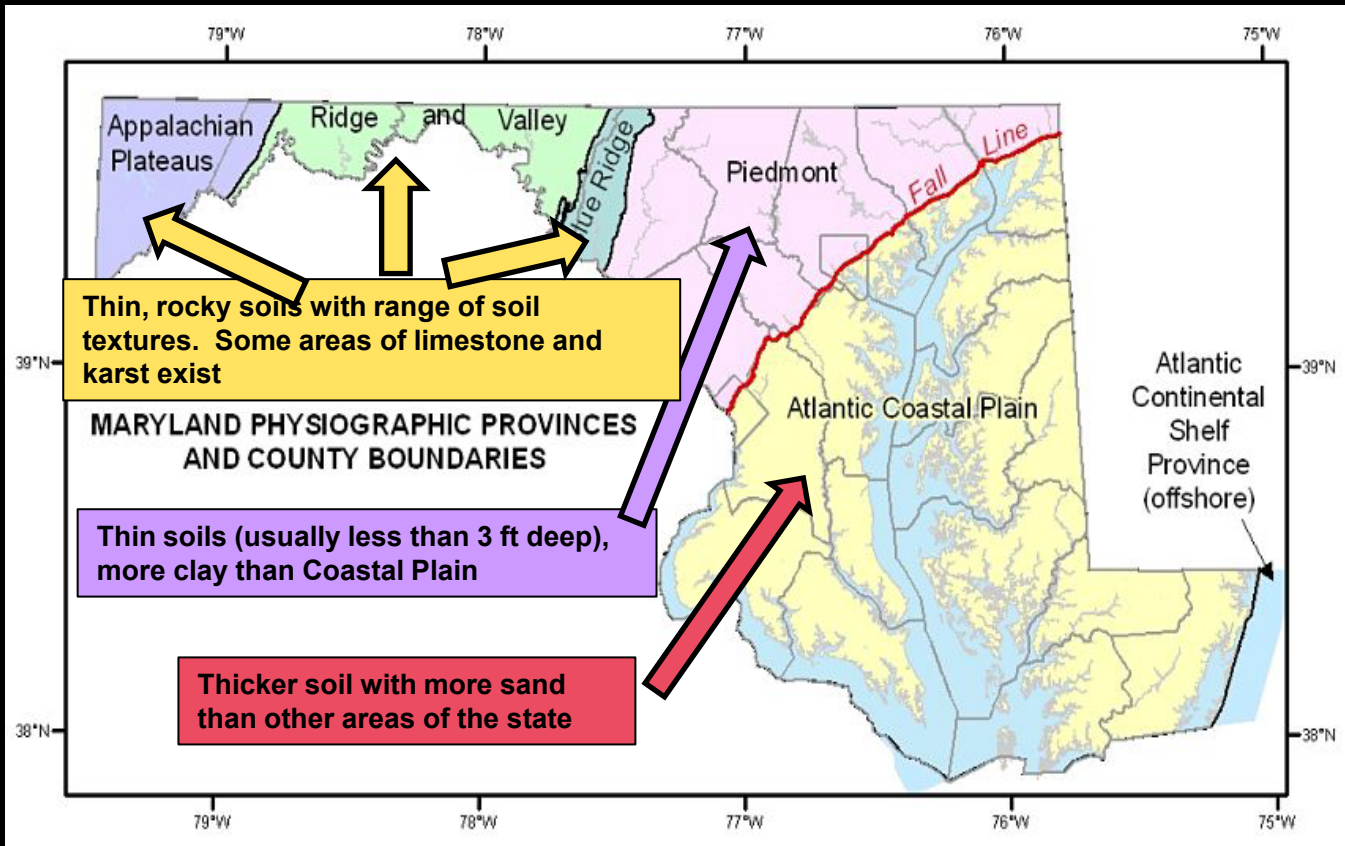
Chesapeake Bay Program.  
[https://www.chesapeakebay.net/what/maps/classification\\_of\\_watersheds\\_based\\_on\\_2000\\_land\\_cover](https://www.chesapeakebay.net/what/maps/classification_of_watersheds_based_on_2000_land_cover)



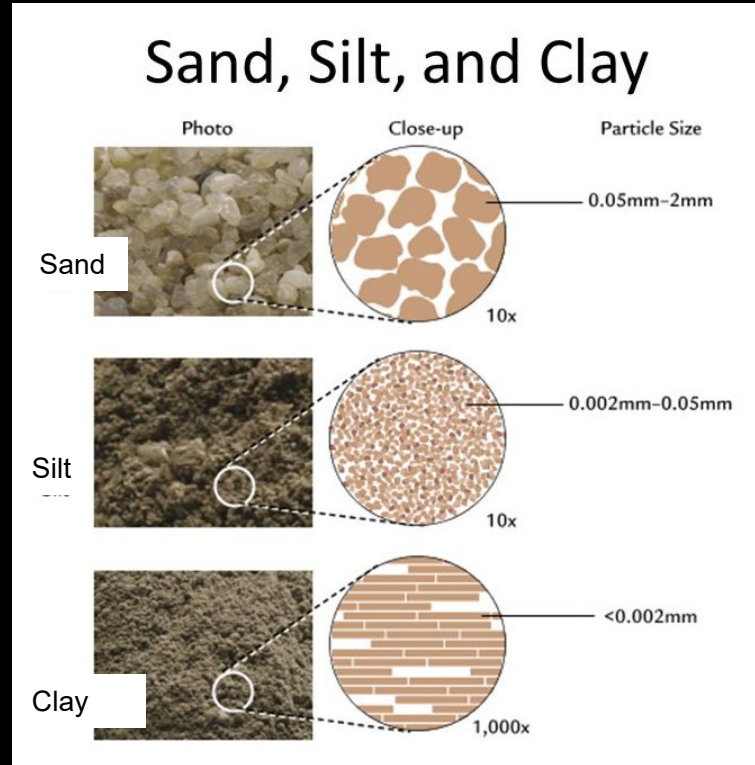
# Ratio of watershed land area to water volume

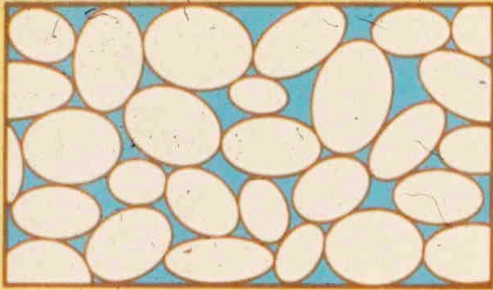


Reproduced from Ann Swanson. 2011. Congressional Briefing: The Chesapeake Bay Commission.



- How quickly water moves through the soil depends on the soil texture

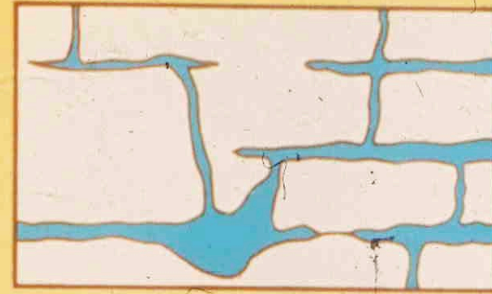




## INTERPARTICLE POROSITY

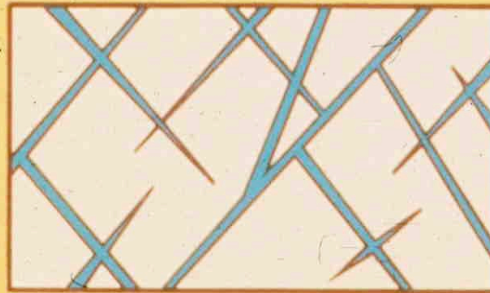
Coastal Plains

Both  
Ridge and Valley  
And Piedmont



## SOLUTION ENHANCED POROSITY

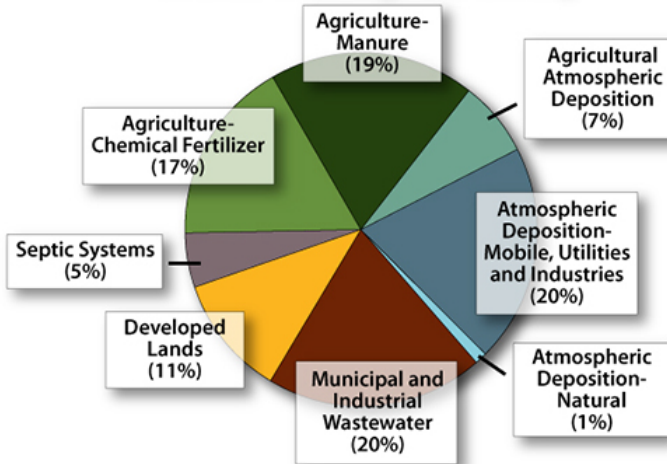
karst -highly weathered  
limestone



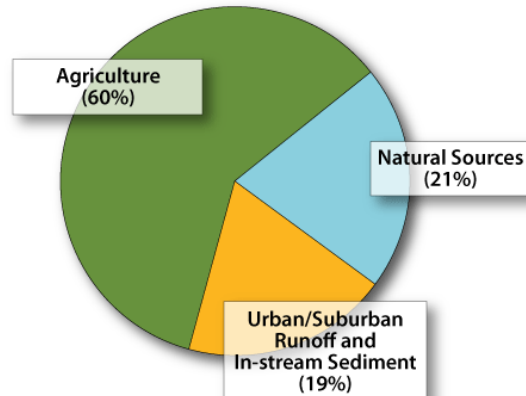
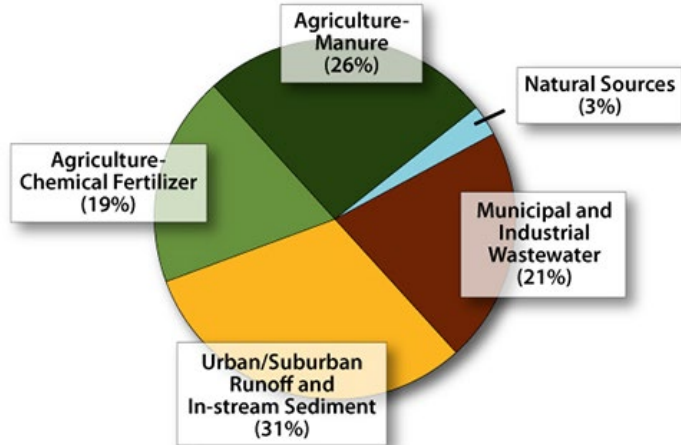
## FRACTURE POROSITY



## Sources of Nitrogen to the Bay



## Sources of Phosphorus to the Bay



## Sources of Sediment to the Bay

Information from: Chesapeake Bay Program. 2009.

[http://www.chesapeakebay.net/blog/post/question\\_of\\_the\\_week/what\\_are\\_the\\_main\\_sources\\_of\\_pollution\\_to\\_the\\_bay](http://www.chesapeakebay.net/blog/post/question_of_the_week/what_are_the_main_sources_of_pollution_to_the_bay)





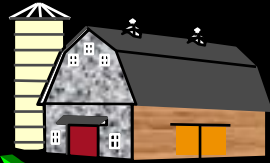
## How can improvements be made? What is the cost to do so?

### Reducing Pollution from Agriculture has the Smallest Price Tag



SOURCE: WORLD RESOURCES INSTITUTE, 2011

Fall 2016, CBF, *Save the Bay Magazine*



Crops

Animals

Local

Soil







Crops

Soil



Feed mill



Animals

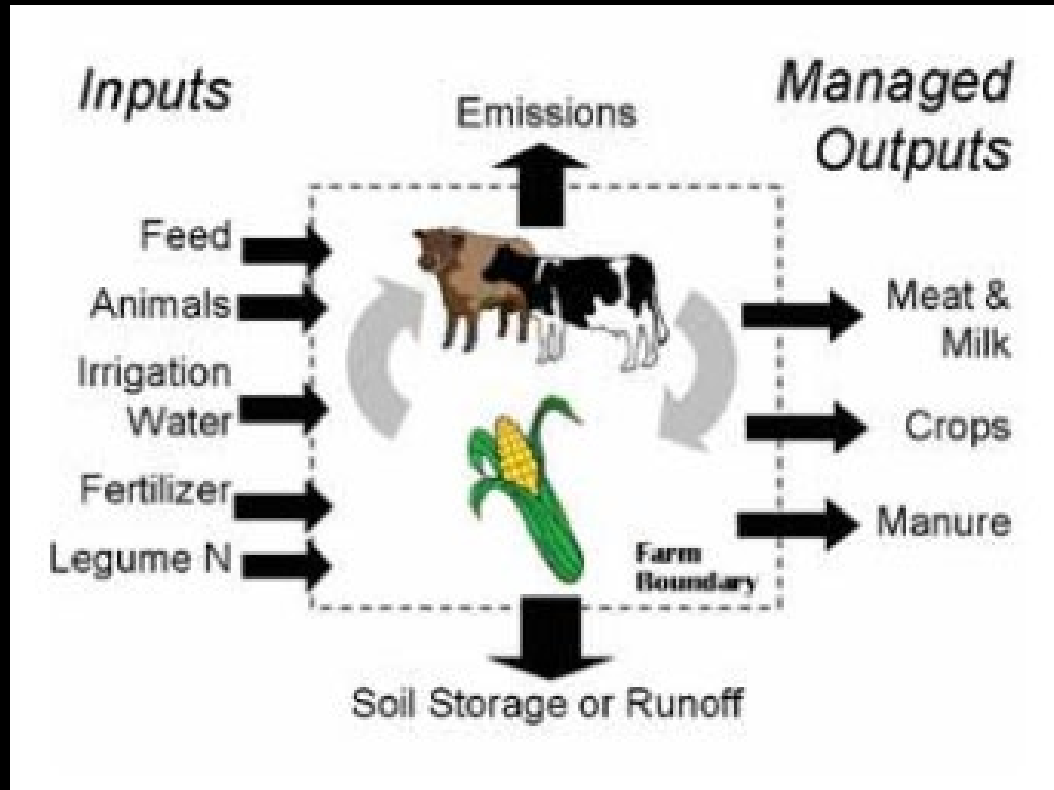


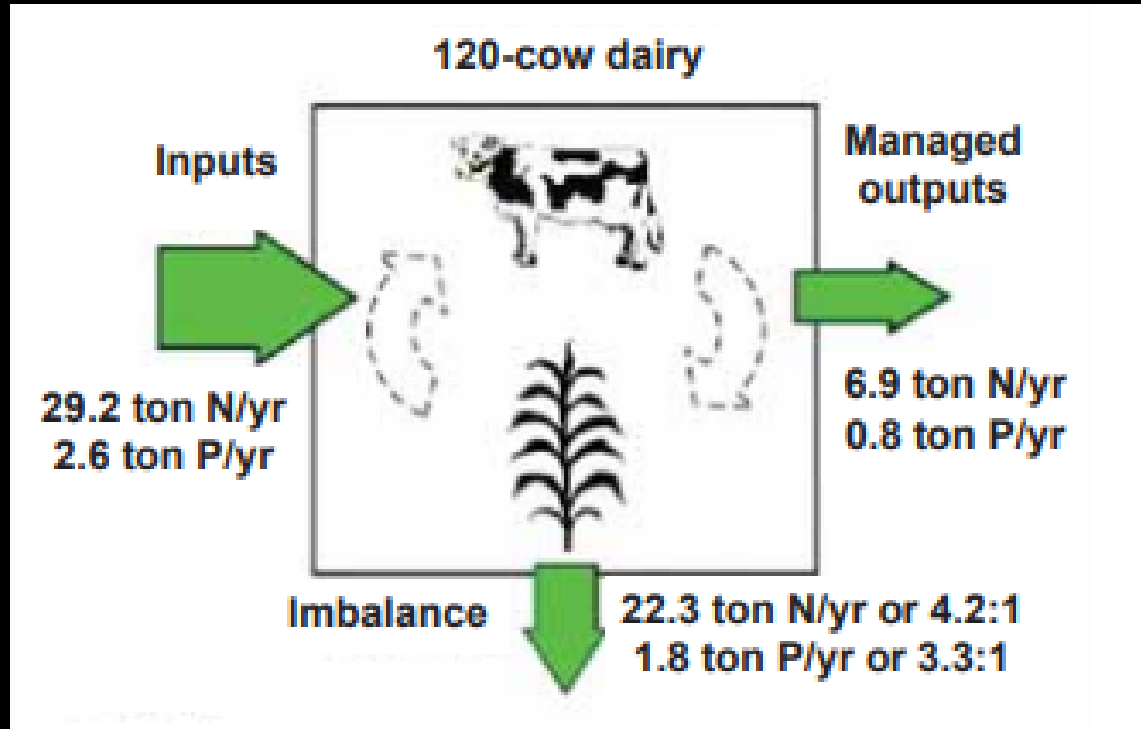
Global



Manure

???





# What is the role of nutrient management?

Effectively and efficiently utilize nutrients to **adequately supply crop needs** while **minimizing the transport of nutrients to ground and surface water**

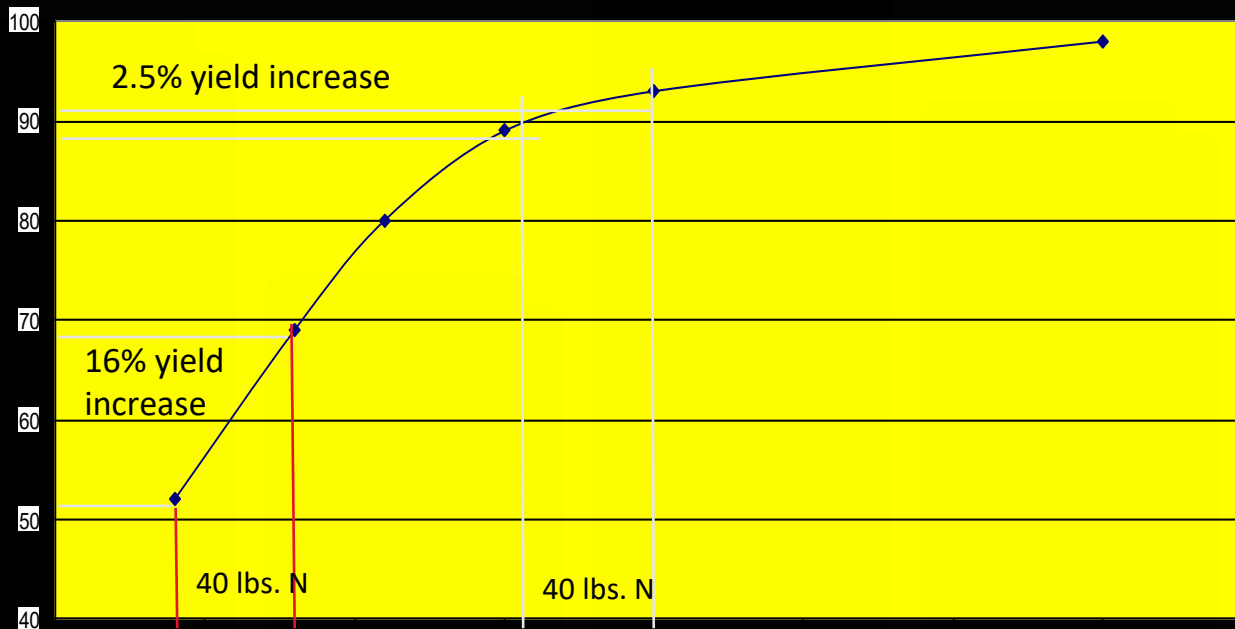


# How can ag-related N and P pollution be minimized?

- Apply manure and fertilizers at the appropriate rate and the proper time
- Avoid manure usage on P-enriched soils near streams and rivers
- Consider realistic production potential
- Utilize other BMPs



# Yield Response



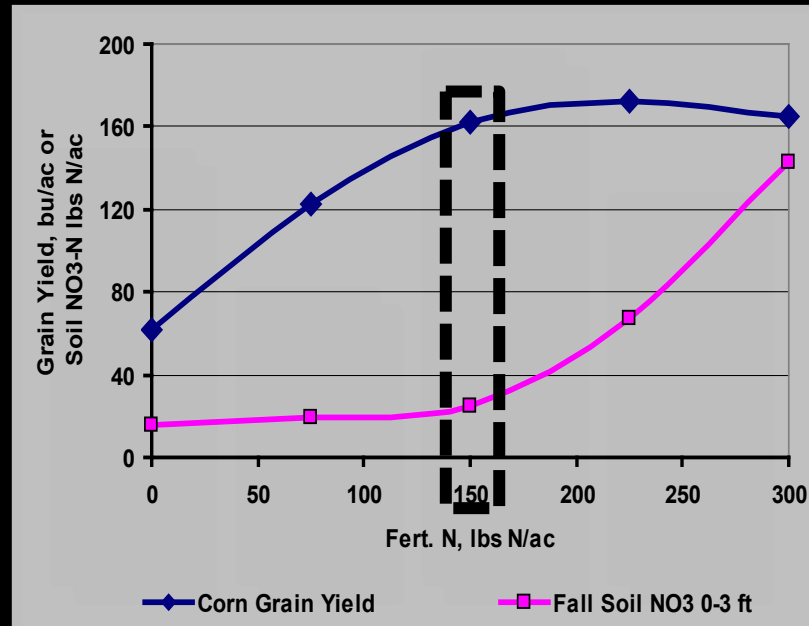


We also want to consider economic yield – we don't necessarily want the highest yield, but the highest economic yield. ROI

Let's say you are considering applying an additional 40 lbs of N, up to 80 lbs total. Is that extra 40 lbs going to be beneficial economically – without seeing the prices, we can say probably, potentially boosting your yield 16%

But, we've applied 150 lbs N and considering applying another 40 lbs, will this be economically beneficial – considering we may only get another 2.5% yield increase toward our maximum, so depending on prices, it may not be as beneficial economically – this is the concept of diminishing returns

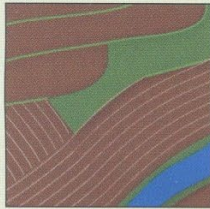
# Corn Yield and Valuable End-of-season Nitrate in Maryland





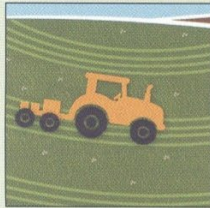
## Methods to Reduce Pollution from Agriculture

### Cropland:



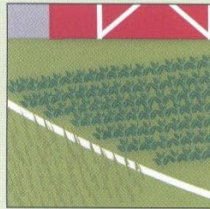
#### Field Buffers

Field buffers are planted areas around farmland that help filter polluted runoff before making its way to our streams, rivers, and ultimately, the Bay.



#### No Till/Conservation Tillage

Practices that do not disturb the soil, reduce erosion, and improve soil quality, benefit productivity and reduce pollution and costs.



#### Cover Crops

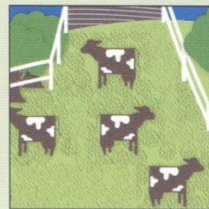
Crops planted after the primary crop is harvested, help reduce erosion from wind and rain and take up nitrogen remaining in fields after harvest. They also can improve soil health and provide forage.



#### Proper Use of Fertilizer

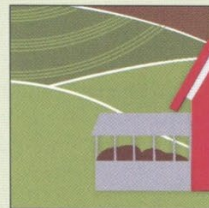
Nutrient Management Plans guide farmers' decisions on the correct rate, timing, and method of manure and fertilizer application. In doing so, they can help the farmer's bottom line.

### Livestock:



#### Stream Exclusion

Fencing livestock out of streams prevents stream bank erosion and direct pollution from animal manure. Keeping livestock from standing in the water also improves herd health, lowers veterinarian bills, and can improve a farmer's bottom line.



#### Manure Management

Manure management is capturing, storing, treating, and utilizing animal waste for distribution on fields in amounts that enrich soils without causing water pollution or unacceptably high levels of phosphorus and nitrogen. Manure management is a component of nutrient management.



#### Forested Buffers

Planting trees around the edge of crop fields, pastureland, and stream banks traps and absorbs pollution and prevents erosion. They also cool streams and provide wildlife habitat.



#### Rotational Grazing

Converting livestock operations from grain-fed systems to grazing systems improves soil's ability to retain excess nutrients, and rotating animals between pastures reduces erosion. These practices also lower costs and labor.

# Classic Peanuts



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**Curtis**