Virginia Department of Conservation & Recreation

Environmental Management of Nutrients

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VA DCR

- The Virginia Department of Conservation and Recreation (DCR) coordinates and directs programs and services to prevent degradation of the commonwealth's water quality caused by nonpoint source pollution.

Environmental Management of Nutrients Knowledge Areas:

- Factors causing decline of Chesapeake Bay
- Effects of nutrients in ground and surface waters
- Hydrologic cycle
- Nutrient loss mechanisms to ground and surface waters
- Identification and management of environmentally sensitive sites
- Seasonal nutrient loss patterns
- Use of cropping systems to reduce nutrient loss

Introduction

- Background: Education/Experience
- Involvement with Nutrient Management

The Chesapeake Bay Watershed

- Is the largest estuary in the US and 3rd largest in the World.
- Supports more than 17 million people.
- Covers 64,000 square miles.
- Includes parts of Virginia, Maryland, Delaware, West Virginia, Pennsylvania, New York, and Washington, D.C.
- Has 11,684 miles of shoreline, more than the entire US West Coast.
- Contains more than 100,000 rivers and streams.
- Helps filter and protect the drinking water of 75% of Bay watershed residents.

DCR

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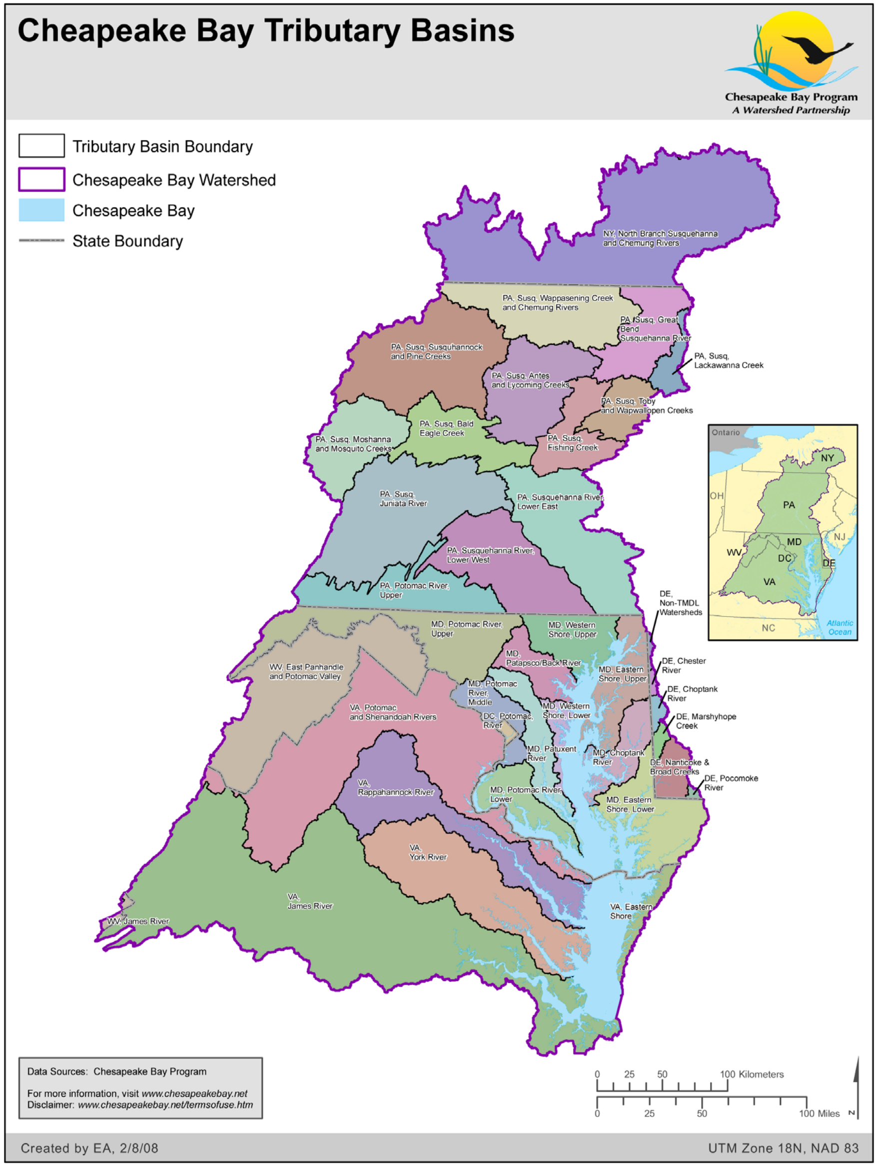

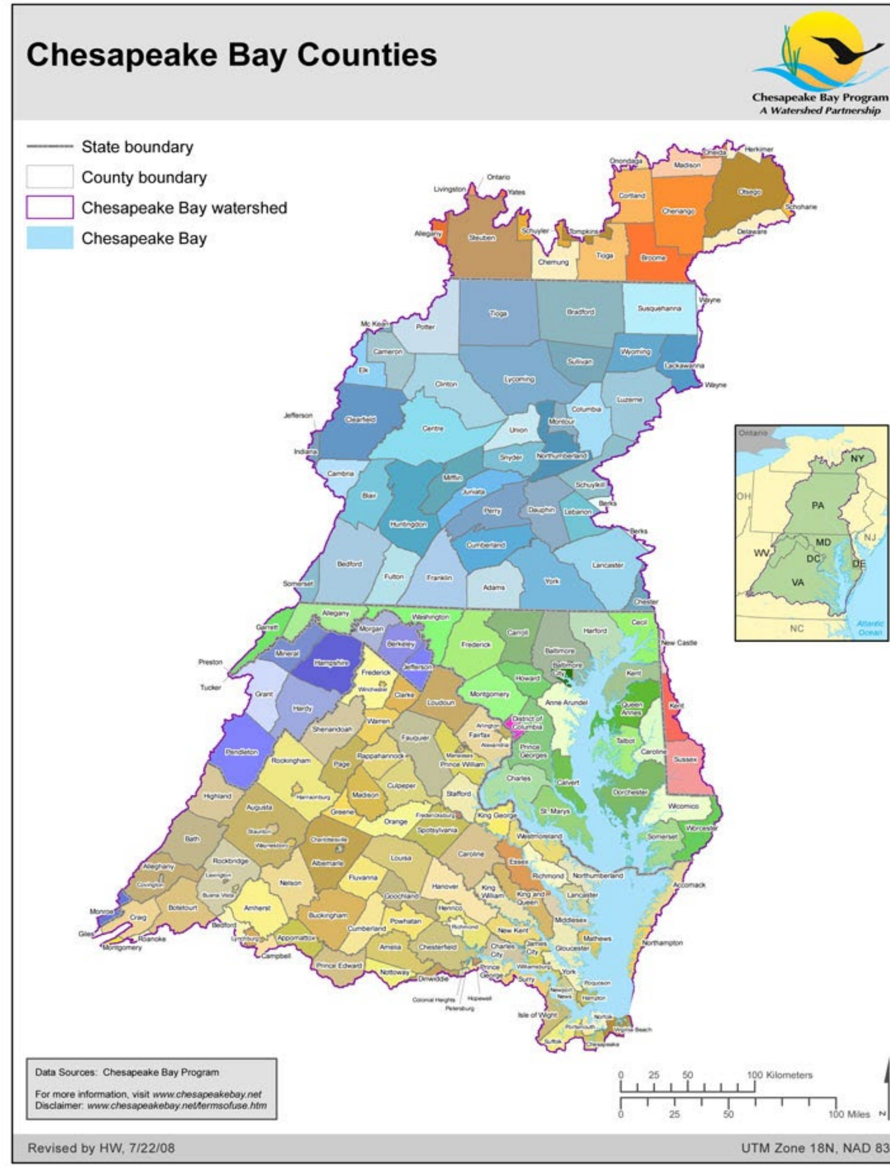

The Chesapeake Bay Watershed

- In 2010, the U.S. Environmental Protection Agency established the Chesapeake Bay Total Maximum Daily Load, a comprehensive cleanup plan to guide federal, state, local, and individual actions to reach the goal of a clean Chesapeake Bay and connecting waterways by 2025.
- In Virginia, the TMDL calls for:
  - 20.5% reduction in Nitrogen
  - 25.2% reduction in Phosphorous
  - 20.8% reduction in Sediment delivered to the bay
- Cleanup efforts will reduce flooding, protect groundwater, increase property value, restore fish and wildlife habitats, and improve air quality

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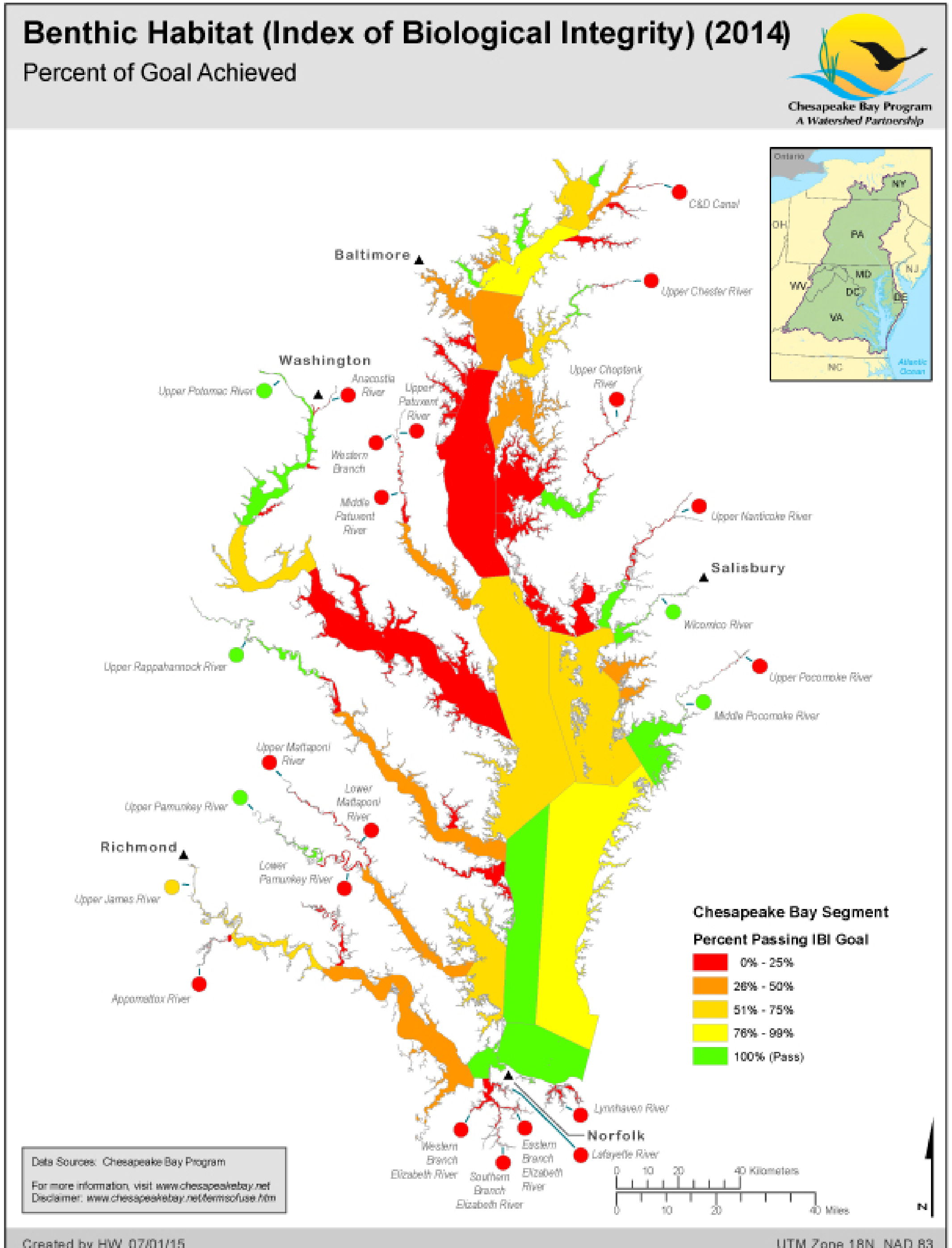
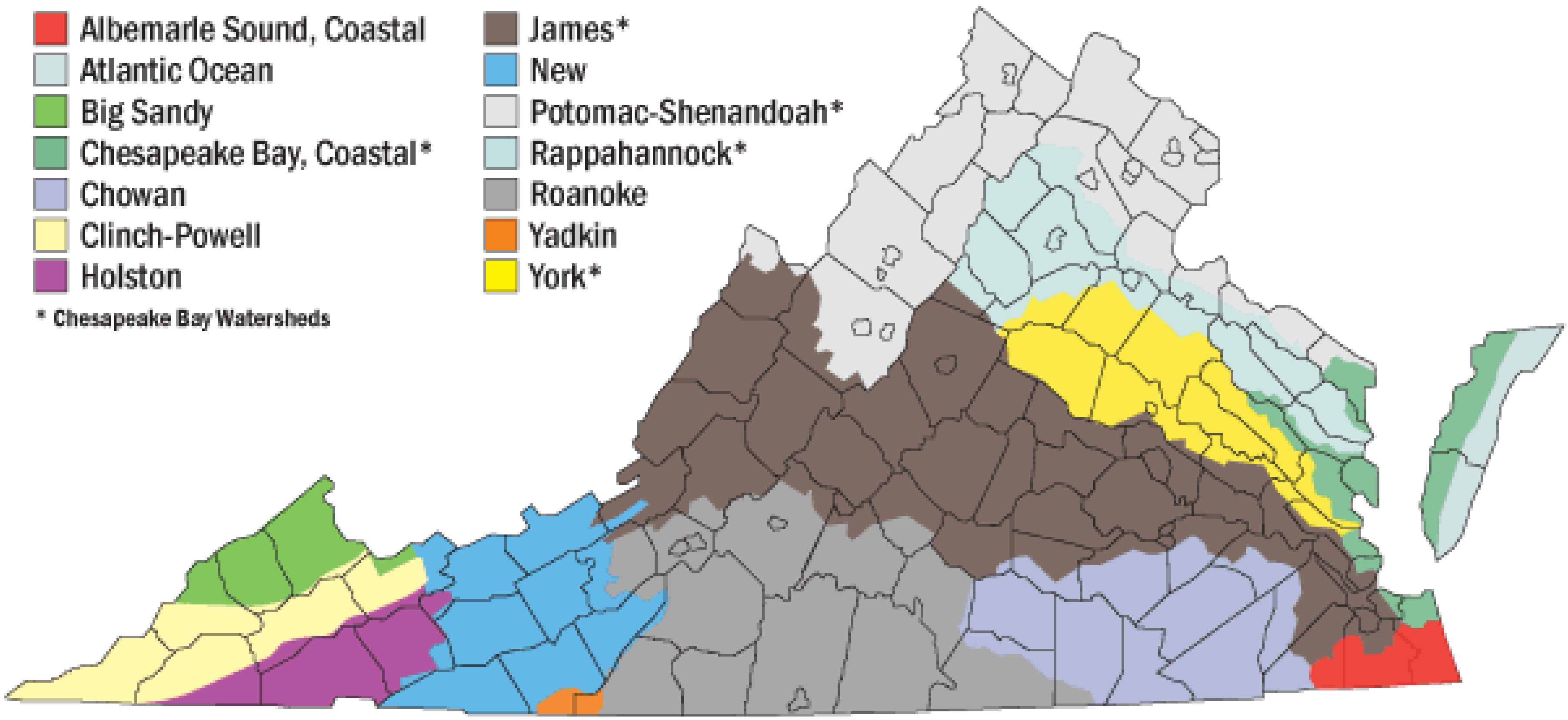


- CBF's health index, called the *State of the Bay Report*, estimates that the Chesapeake Bay watershed rated **100 on a scale of 100** in the *1600s*. In *2018*, the report rated the Bay at **33 out of 100**. Water quality is so poor that the Chesapeake Bay is on the Environmental Protection Agency's "dirty waters" list. (https://www.cbf.org/issues/agriculture/nitrogen-phosphorus.html)

Bay health stressed due to elevated temperatures


Albemarle Sound, Coastal
Atlantic Ocean
Big Sandy
Chesapeake Bay, Coastal*
Chowan
Clinch-Powell
Holston
* Chesapeake Bay Watersheds
James*
New
Potomac-Shenandoah*
Rappahannock*
Roanoke
Yadkin
York*

Plans for Improved Water Quality

- Implementing nutrient management and conservation plans
- Planting cover crops

Plans for Improved Water Quality

- Fencing animals out of streams
- Installing and maintaining grassed or forested buffer strips along farm fields


Plans for Improved Water Quality

- Important natural filters such as forests, oysters, wetlands, and underwater grasses need to be protected and restored.
- Overall, the Bay has lost 98 percent of its oysters, about 80 percent of grasses, and nearly 50 percent of forest buffers.

Effects of nutrients in ground and surface waters

- Almost **40%** of U.S. waters that have been assessed have **not met water quality standards** (Zygmunt, 2000).
- About 15,000 water bodies are impaired from siltation, nutrients, bacteria and other pathogens, oxygen-depleting constituents, trace elements, pesticides, and other organic chemicals (EPA).

Non-point source pollution

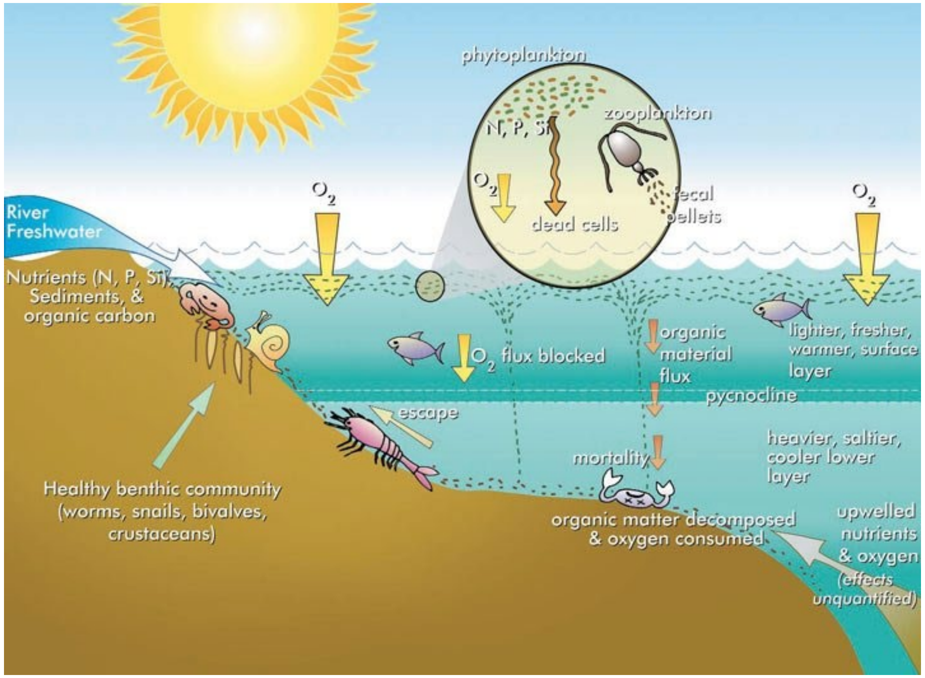
- Many of these pollutants **do not come from a single point** such as a sewage outfall or an industrial discharge pipe and are thus termed *non-point source* pollution.

Non-point source pollution

- Nitrogen (**N**) and phosphorus (**P**), are the **major pollutants** in lakes and estuaries and the second leading source of pollution in rivers.
- **Life** within rivers, streams, lakes, and bays **could not exist without nutrients**; however, an <u>excess</u> of nutrients (*eutrophication*) may cause ecological problems and can harm aquatic life.

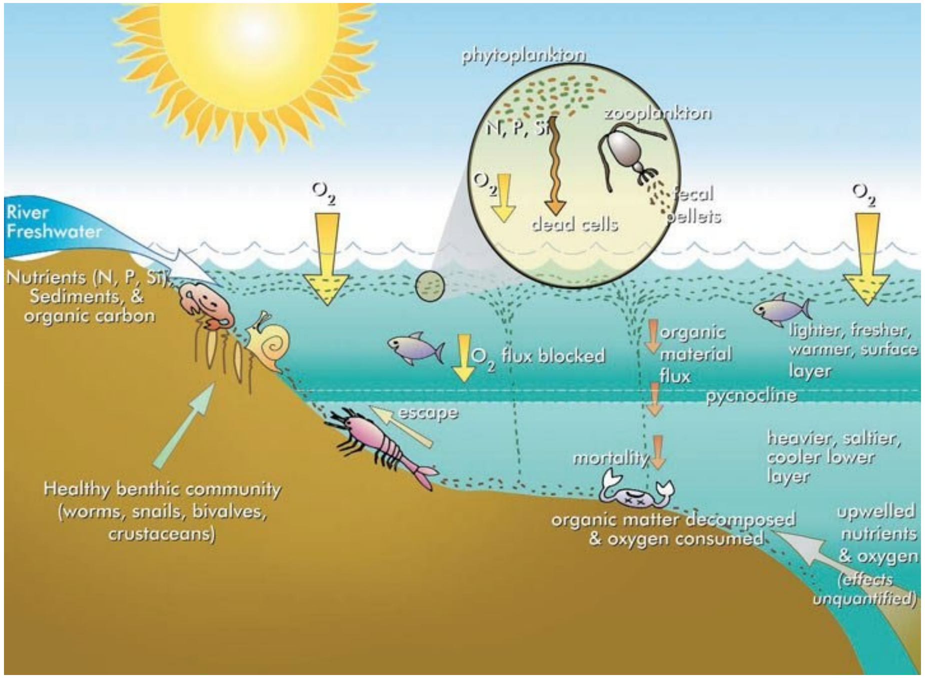
Eutrophication

- Eutrophication occurs when **excessive nutrients** cause a dense growth of algal blooms that can be seen. As algae ultimately die off and decompose, oxygen is consumed resulting in low levels of oxygen in the water.



Eutrophication

- Nutrients can come from many sources, including any of the following:
  - Fertilizers from agriculture, golf courses, and suburban lawns
  - Erosion of soil full of nutrients
  - Discharges from sewage treatment plants
  - Deposition of atmospheric nitrogen



Environmental Impact on Water Quality

- **Nearly all of the N and** P exported from watersheds in the Mid-Atlantic are from non-point sources, to which fertilizer and animal manures used in agriculture contribute significantly.
- A six-year study by the U.S. EPA (1983) revealed that *runoff from farmland was a major source of pollution* contributing to water quality decline in the Chesapeake Bay.

Environmental Impact on Water Quality

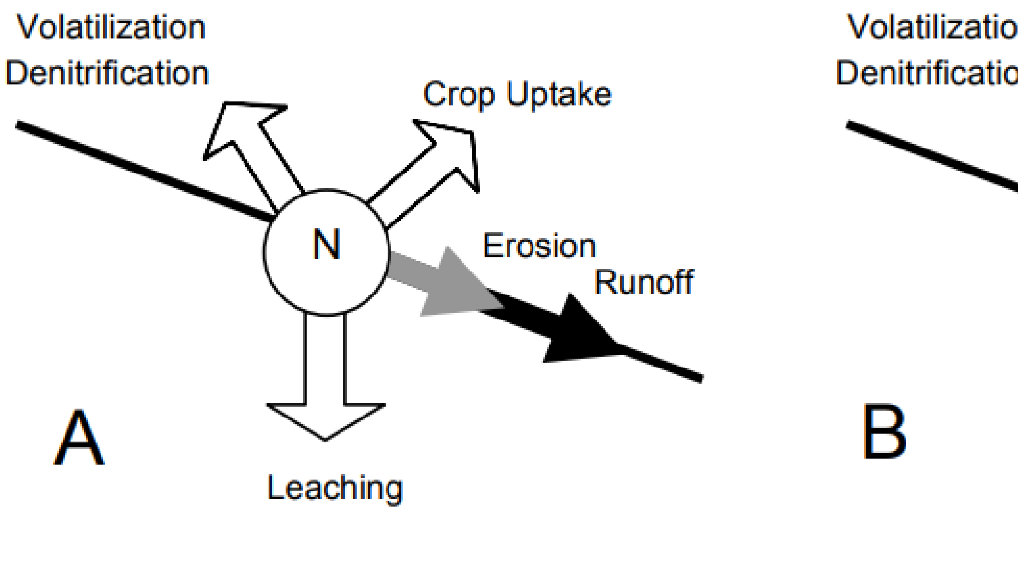
- The largest source of pollution to the Bay comes from **agricultural runoff**, which contributes roughly **40 percent** of the **nitrogen** and **50 percen**t of the **phosphorus** entering the Chesapeake Bay.

Table 1.1. Point and non-point source contributions to total nitrogen and phosphorus export from Mid-Atlantic watersheds.

			Non-point source			
Nutrient	**Total export**[a]	**Point source**	Fertilizer	Animal agriculture	Atmosphere	Non-agricultural runoff
	kg/ha/yr	------------------	------------------	Median, as % of total export	------------------	------------------
Nitrogen	9.0	4	14	16	32	22
Phosphorus	0.68	14	19	25	NA	22

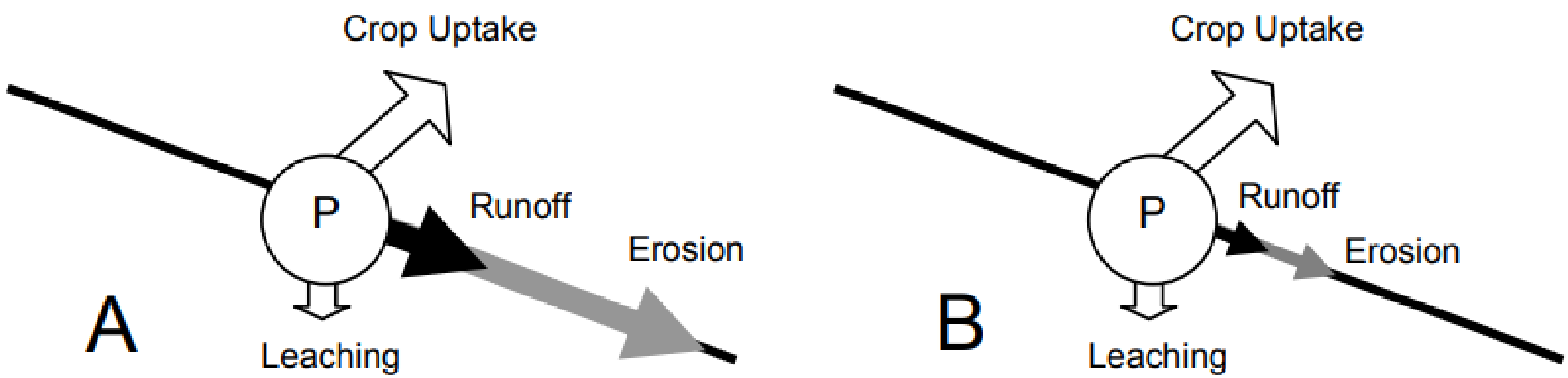
[a] Total export is the median export from hydrologic cataloging.

Figure 1.1. (A) General fate of N and (B) how adopting processes to reduce erosion and runoff increases N leaching losses.

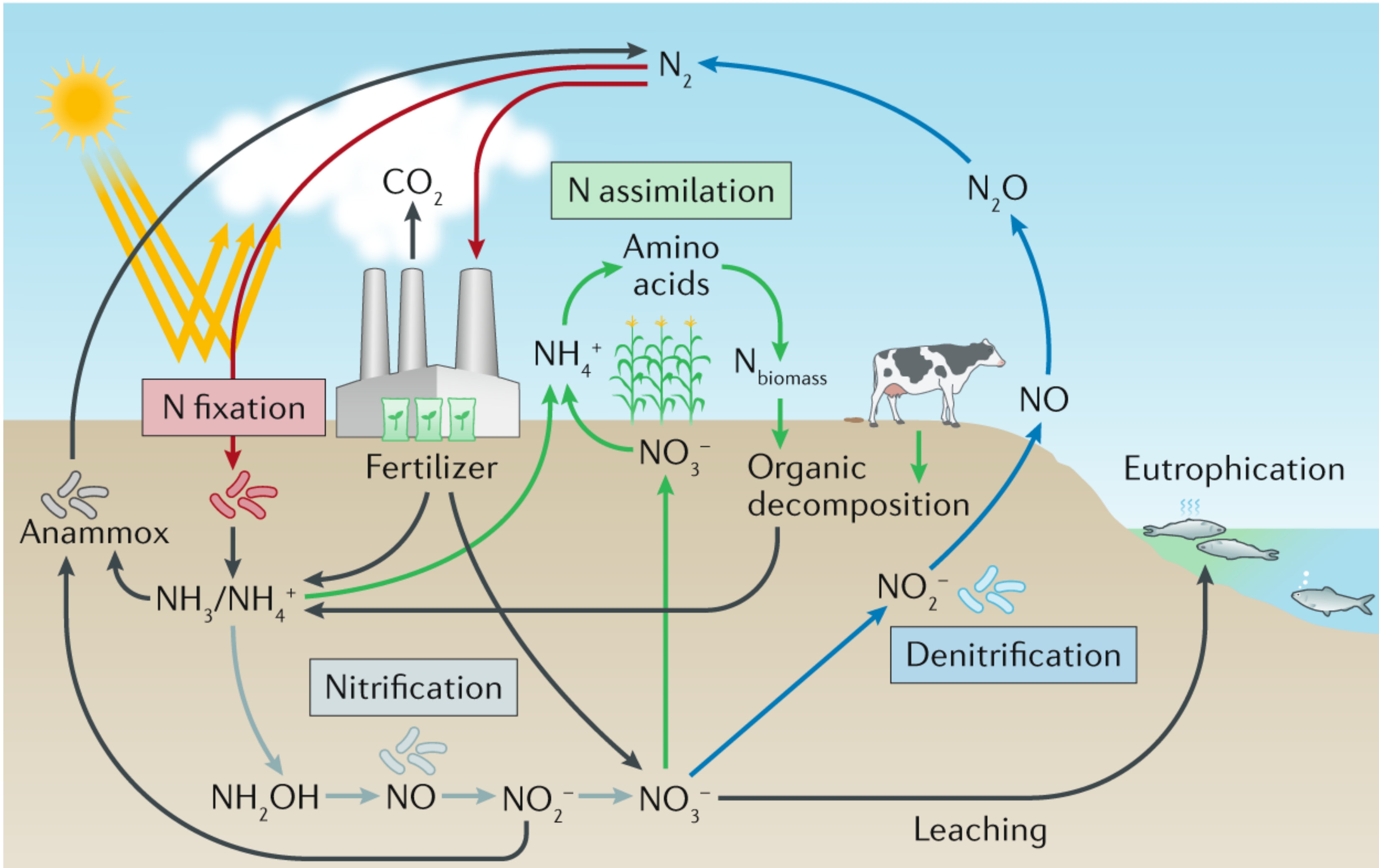


- Managing N to minimize NO3 - losses is very difficult because of the many possible loss pathways. For example, increased water infiltration may increase leaching of nitrate if practices to reduce runoff and erosion, such as no-till, are adopted

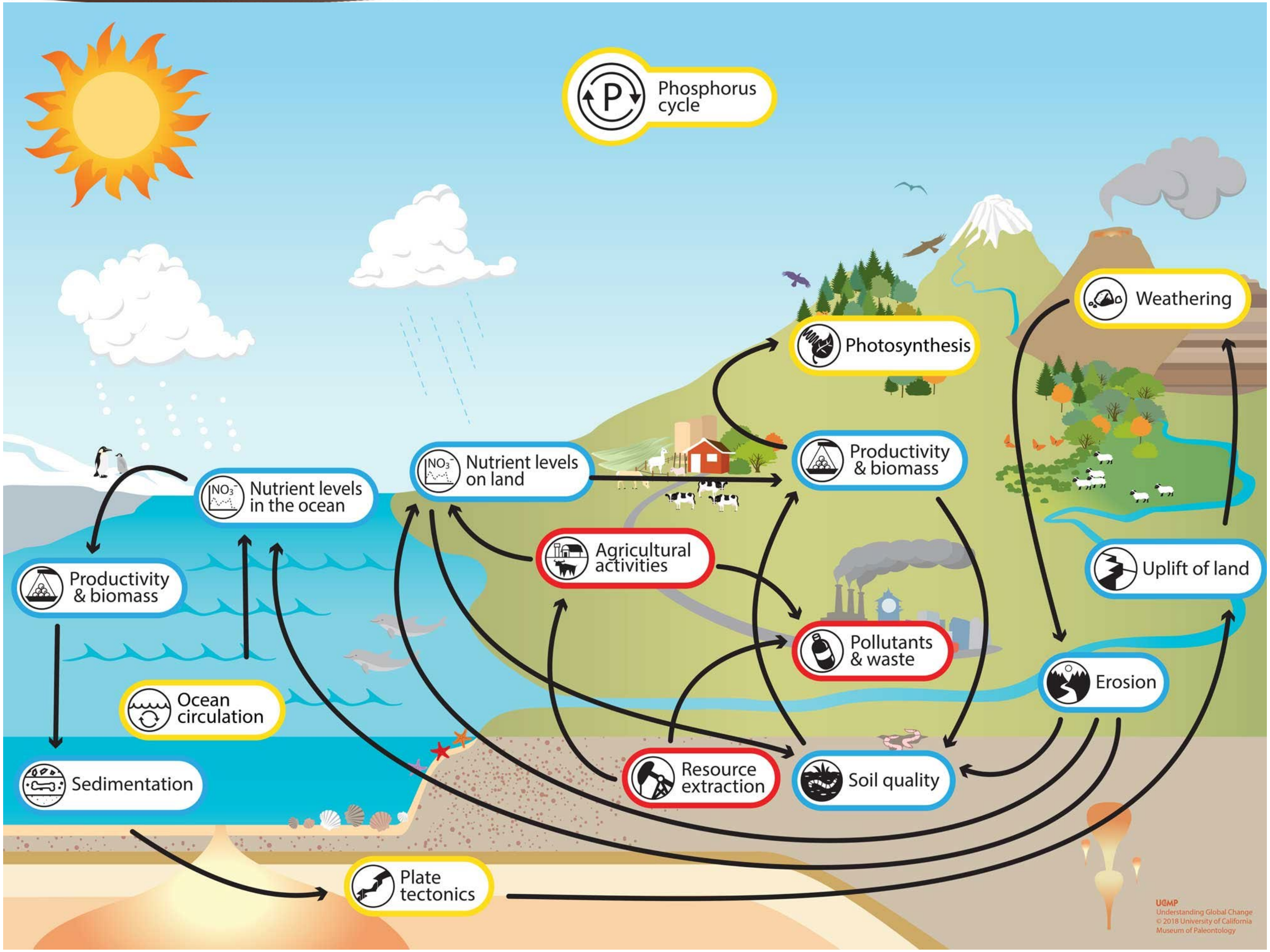
Figure 1.2. (A) General fate of P and (B) how adopting processes to reduce erosion and runoff does not usually increase P leaching losses.



- Phosphorus is typically immobile in soil and seldom migrates downward with soil water to any great extent because it is strongly adsorbed by and/or precipitated as highly insoluble soil mineral phases.



N_2
CO_2
N assimilation
N_2O
Amino acids
NH_4^+
$N_{biomass}$
NO
N fixation
Fertilizer
NO_3^-
Organic decomposition
Eutrophication
Anammox
NH_3/NH_4^+
NO_2^-
Denitrification
Nitrification
NH_2OH
NO
NO_2^-
NO_3^-
Leaching


Phosphorus cycle
Weathering
Photosynthesis
Productivity & biomass
Nutrient levels on land
Nutrient levels in the ocean
Agricultural activities
Uplift of land
Pollutants & waste
Productivity & biomass
Erosion
Ocean circulation
Resource extraction
Soil quality
Sedimentation
Plate tectonics
UCMP
Understanding Global Change
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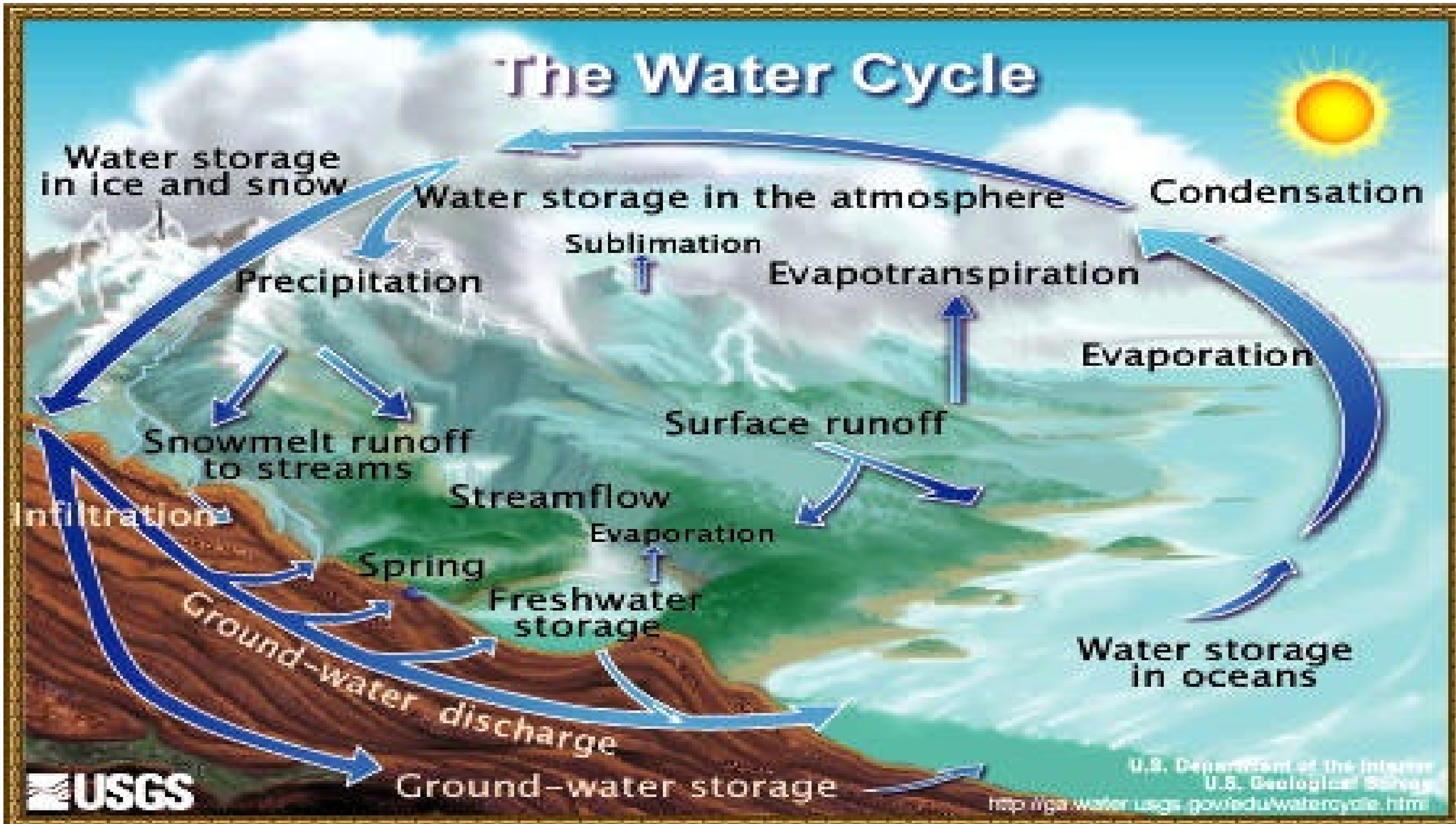
Museum of Paleontology

Hydrologic Cycle

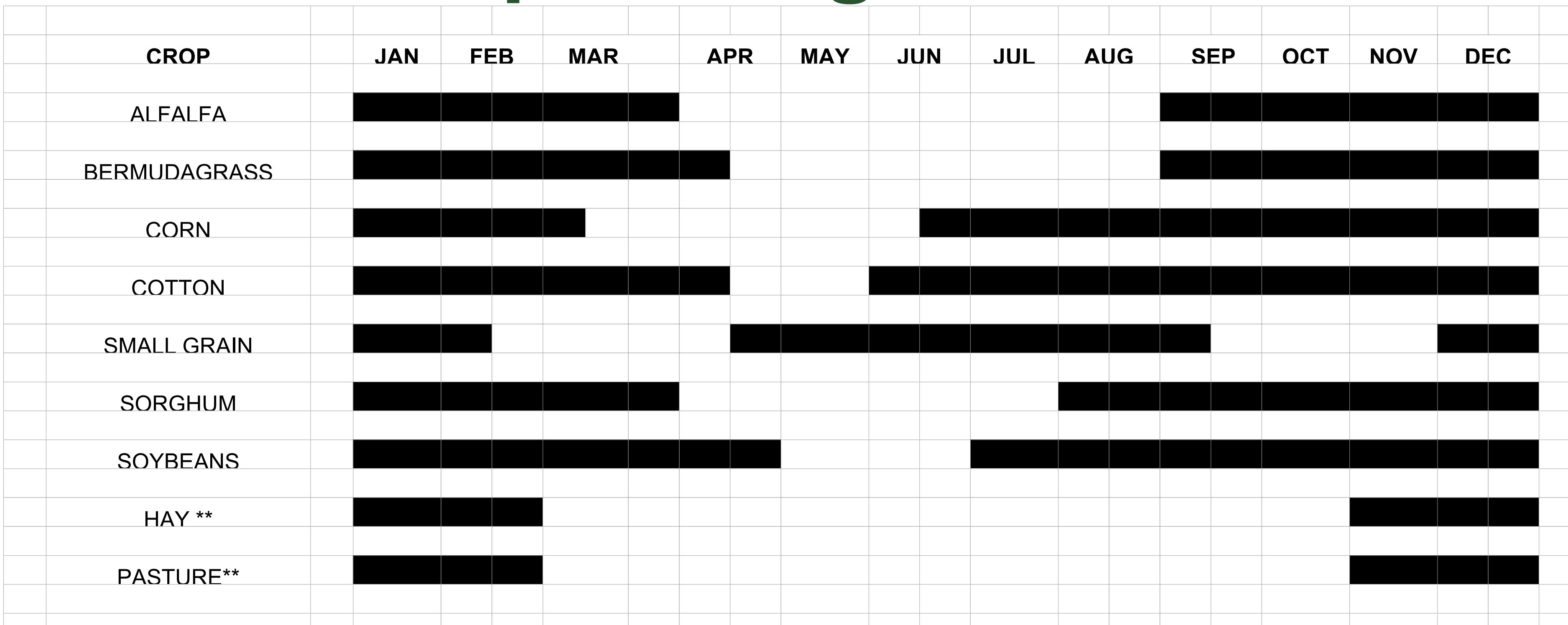


Seasons of Greatest Leaching

- Leaching potential increases during times of low evapotranspiration and little plant growth & uptake

- Late fall
- Winter
- Early spring

Manure Spreading Schedule



** Except for Alfalfa, Bermuda grass and other warm season grasses.

Do not spread during these periods.

Poultry litter may be applied during these times provided soil conditions are

Do not apply manure to frozen, ice or snow covered, or saturated ground.

Nutrient Cycling on Farms

- Different types of farming operations have different ways to cycle nutrients.

Figure 1.3. Nutrient flows in modern animal agriculture.

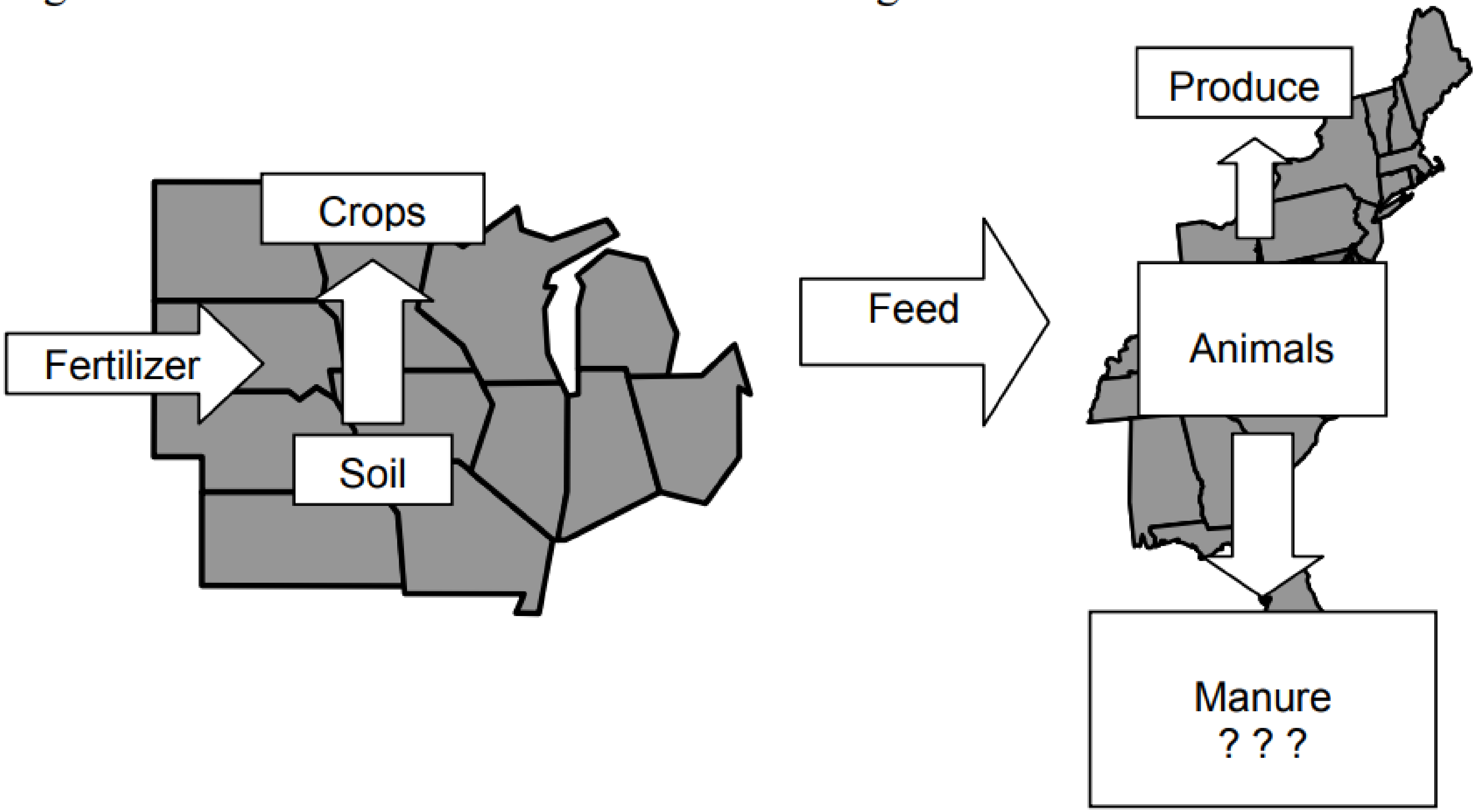


Figure 1.4. Nutrient cycles on cash crop farms.

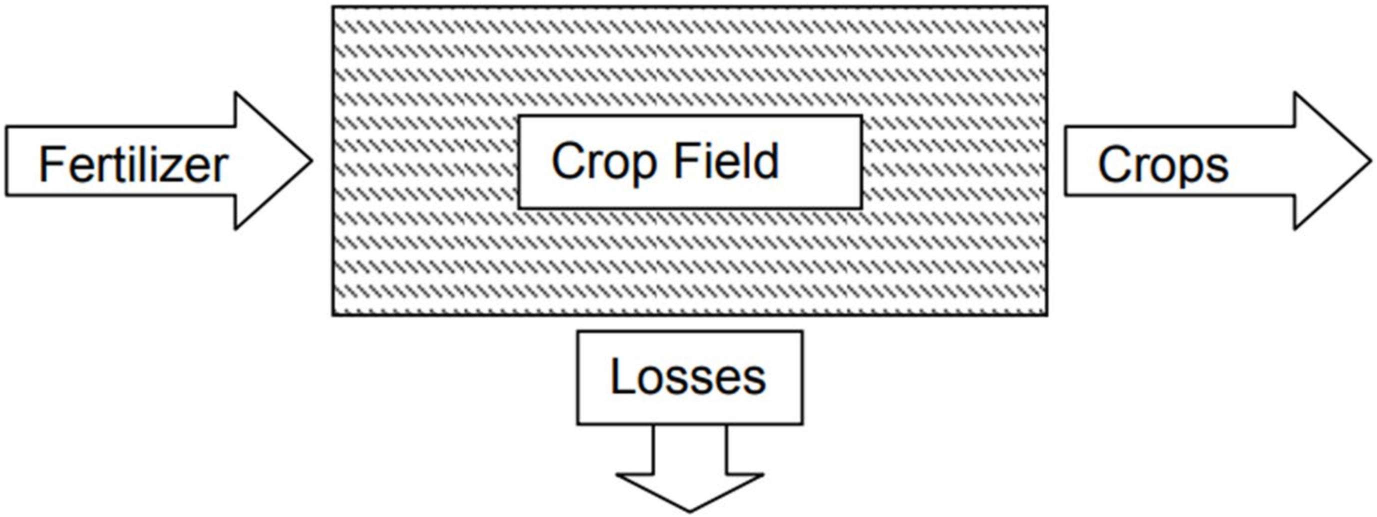


Table 1.2. Example of nutrient balance (P_2O_5) on a cash-crop farm in Pennsylvania.

Input:	**lb P_2O_5/A/yr**
Fertilizer	36
Output:	
Crop removal	32
Balance	+4

Figure 1.5. Nutrient cycles on a modern crop and livestock farm.

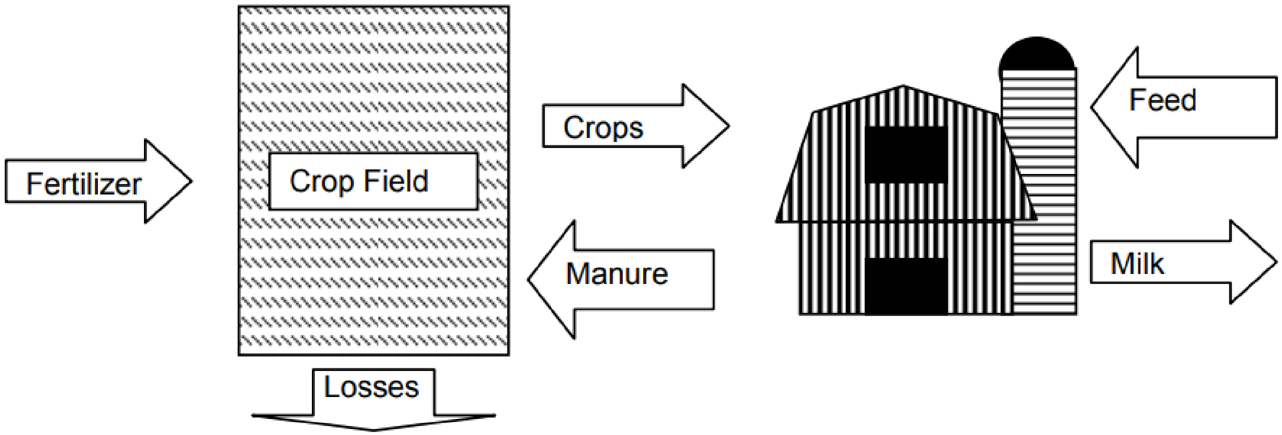


Table 1.3. Example of nutrient balance on a dairy farm in Pennsylvania.

Inputs:	**lb P_2O_5/A/yr**
Fertilizer	22
Feed	60
Output:	
Milk	24
Balance	+58

Figure 1.6. Intensive animal production farm with limited crop production.

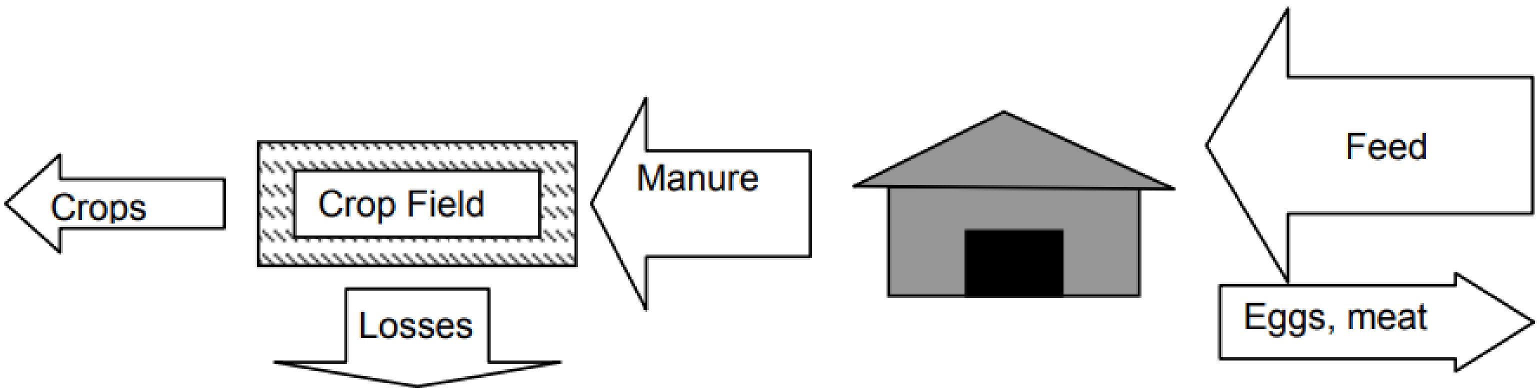


Table 1.4. Example of nutrient balance on a poultry layer farm in Pennsylvania.

Inputs:	**lb P_2O_5/A/yr**
Fertilizer	0
Feed	3380
Output:	
Eggs	1030
Balance	+2350

Nutrient Impact in Surface Waters

Sedimentation

- Occurs when water carrying eroded soil particles slows long enough for soil particles to settle out.
- Effects water quality physically, chemically and biologically
- Destroys fish spawning beds, reduces useful storage volume in reservoirs, clogs streams, and make expensive filtration necessary for municipal water supplies.

Sediment

- Carries organic matter, animal or industrial wastes, nutrients, and chemicals.
- Most troublesome is phosphorous from fertilizers, organic matter and animal manure.
- May carry pesticides such as herbicides and insecticides that are toxic to plants & animals

Groundwater

Groundwater wells

- 21 percent of all Virginians have their own private water systems such as wells
- Homeowners are totally responsible for water quality testing
- The Virginia Household Water Quality Program through Virginia Cooperative Extension & BSE at VT provides water testing and education to private landowners
- Reach a minimum of 60 counties each year, conducting clinics and water sample kits

Household Water Quality Program

- Water samples are tested for 12 chemical constituents and for coliform bacteria
- In 2019, 64 such clinics were conducted covering 88 counties
- VT- BSE performed tests on 2294 wells in 2019

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Water Quality Program Results

- 42% of all wells sampled did Not meet EPA Water Quality Standards for Coliform Bacteria
- 8% exceeded limits for Lead
- 71% of all participants stated that they had never tested their water
- Copper tested high in 18%

Nitrogen Groundwater Concerns

- Nitrate-nitrogen is mobile in the soil
- Can leach to groundwater
- Nitrate form most problematic
- 10.0 ppm nitrate + nitrite nitrogen EPA drinking water standard
- Consumption of high nitrate water by infants potentially dangerous
- "Blue Baby Syndrome" is a lack of oxygen transport to brain.
  There have been reported cases of Blue Baby Syndrome in Va.
- Evidence of livestock reproductive problems
- Drinking Water Nitrate Violations have doubled in the last 8 yrs.

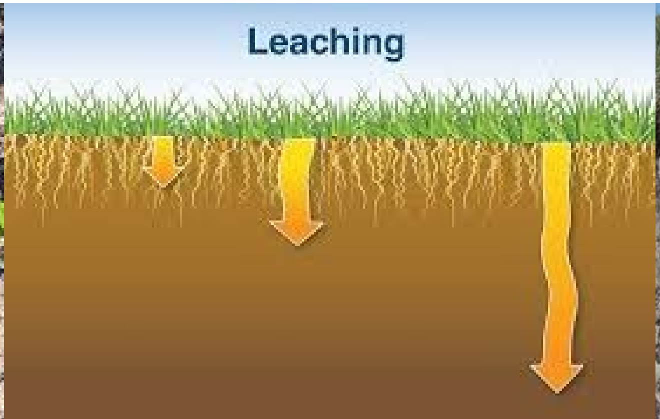
Runoff and Leaching

- Dissolved nutrients and pesticides can reach groundwater by moving down through the soil. Nitrogen moves this way.
- Certain pesticides are highly mobile and have been detected in groundwater. Aldicarb (Temik), alachlor (Lasso), and triazines (Atrazine) are just a few.

Environmentally Sensitive Site

Environmentally sensitive site" means any field which is particularly **susceptible to nutrient loss** to groundwater or surface water since it contains, or drains to areas which contain, *sinkholes, or where **at least 33% of the area** in a specific field contains **one** or* **any *combination* of the following features**:

1. Soils with *high potential for leaching* *based on soil texture or excessive drainage*;
2. *2.* Shallow soils *less than 41 inches* deep likely to be located over fractured rock or limestone bedrock;



Environmentally Sensitive Site

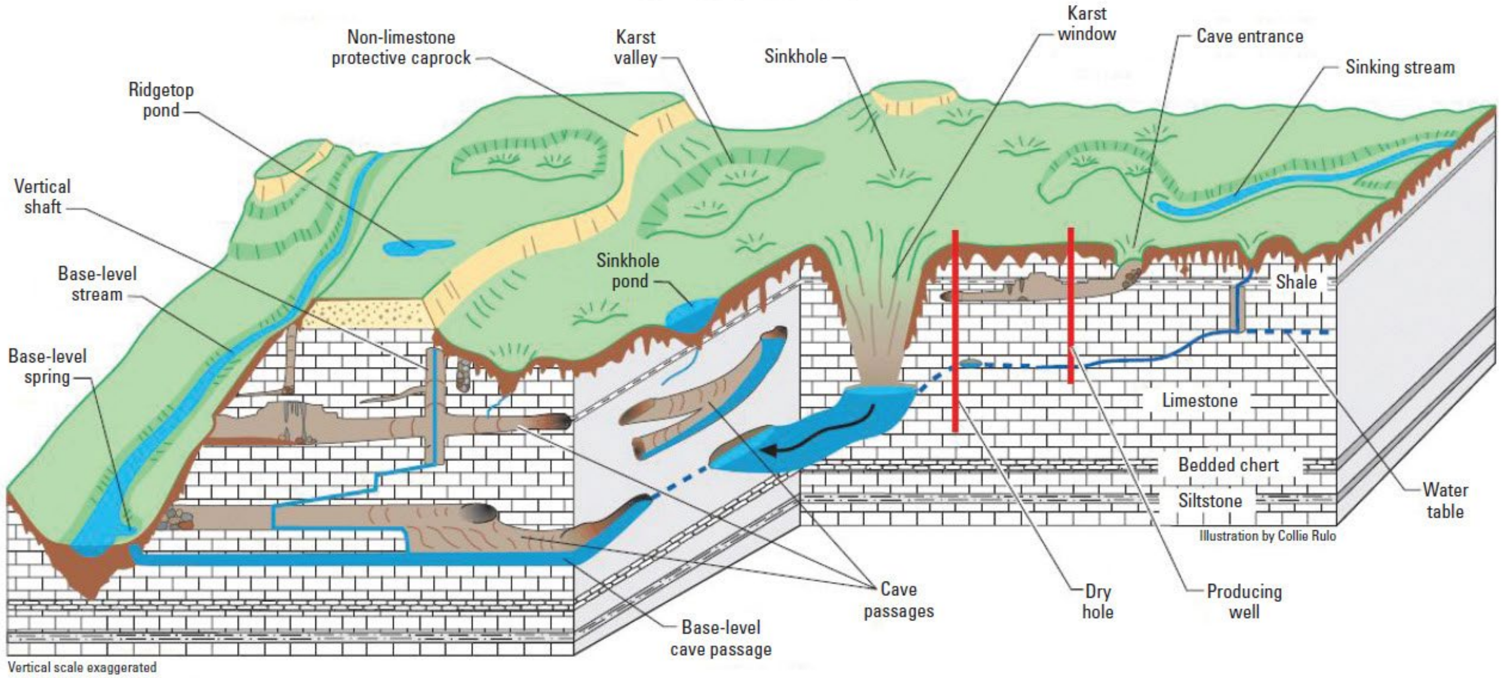
3. Subsurface tile drains;

4. Soils with high potential for subsurface lateral flow based on soil texture and/or ***poor drainage****;*

5. Floodplains as identified by soils **prone to frequent flooding** in county soil surveys; or

6. Lands with **slopes greater than 15%.**

Karst Topography



- **Underlying limestone** formations which may be characterized by solution cavities or "<u>*sinkholes*</u>" which form a ***direct connection between surface and groundwater*** due to collapse of the soil profile into the cavity.
- Pollution sources can be some distance away

Karst Topography where multiple issues occur

Determining Environmentally Sensitive Sites

Use site visit and soil survey - Do areas of the field have one or more sinkholes or does part of the field drain to a sinkhole?

Or does at least 33% of the field have any combination of the following:

From Table 1-4 Standards and Criteria pages 28- 36

- soils with a "H" for environmental sensitivity

a. Leaching

b. Shallow soils

c. Drainage - Soils with high potential for subsurface lateral flow

(continued on next slide)

Determining Environmentally Sensitive Sites - Continued

From site visit –

d. Subsurface tile drains

e. Soils with very slow permeability rates/high run off potential

From soil survey –

f. Floodplains - soils prone to “frequent” flooding (usually in soil and water features table)

g. Lands with slopes greater than 15%

- “E” slope or greater in Coastal Plain
- “D” slope or greater in other regions

Nitrogen Loss Forms & Pathways

- NH_4^+ bound to eroding sediment or organic matter
- Organic N suspended in runoff water
- Soluble NO_3^- in runoff water
- NO_3^- leaching to groundwater

Degree of Nitrate Leaching

- Precipitation amounts and timing
- Physical properties of soil
- Nitrate levels in soil

Nutrient Practices to Reduce Nitrogen Pollution Potential

- Rate of application
- Timing of application
- Placement of nutrients
- Cover crops (Trap crops)

Timing of Applications

- When is the best time to apply nutrients to crop?

- When it needs it Most!

Phosphorus Loss Forms & Pathways

- Particulate P complexes eroded from soil with sediment. The smaller the particle, the longer it stays in suspension.
- Organic P suspended in runoff water
- Soluble HPO_4^{-2} or $H_2PO_4^{-}$ in runoff water
- Soluble P in subsurface flow and tile drains (mainly course textured poorly drained soils)

Nutrient Practices to Reduce Phosphorus Pollution Potential

- Keep Soil Surface P Saturation Levels Below Environmentally Critical Levels
- Reduce Soil Erosion on Land With Extreme Levels of Soil Test P and on Highly Erodible or Highly Leachable Land
- Keep P Applications Below Crop Removal Rates in High Risk Situations

Nitrogen vs Phosphorous Management Strategies

- Nitrogen
  - Rate- based upon Crop Needs
  - Timing- when plants most need
  - Placement- in root zone or banding
  - Cover crops- scavenge residual N from previous crop

Nitrogen vs Phosphorous Management Strategies

- Phosphorous
  - Erosion Control- particulate P- Target
  - Manage runoff -organic P + Plant Avail P
    - Contour Farming - Terraces
  - Concentrations of soil test P – Source
    - Reduce P applications – incorporate to reduce P concentrations