Environmental Management of Nutrients

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Environmental Management of Nutrients

Knowledge Areas:

- Effects of nutrients in ground and surface waters
- Factors causing decline of Chesapeake Bay
- 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

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Water Resources

- Water covers 70% of earth's surface

- Only **3%** of all water is fresh water!
  - Two thirds of all fresh water is locked up in glaciers and ice caps - **1.98%**
  - Lakes, rivers, and streams contain **0.5%** of all freshwater worldwide.
  - 30% of all freshwater is "Groundwater" - **0.3%**

Water Resources

- Some aquifers have been so heavily pumped that their water levels have dropped too low for people to economically tap as a source.
- According to a new report from the Director of National Intelligence, US will outgrow its water capacity by 2040. Nine areas around the world will become national security risks by 2030 due to severe water shortages
- Most groundwater worldwide is too deep to be economical to reach.
- Quantity is not the only concern, the Quality is also under constant assault from a variety of sources

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Nutrients Impact in Surface Waters

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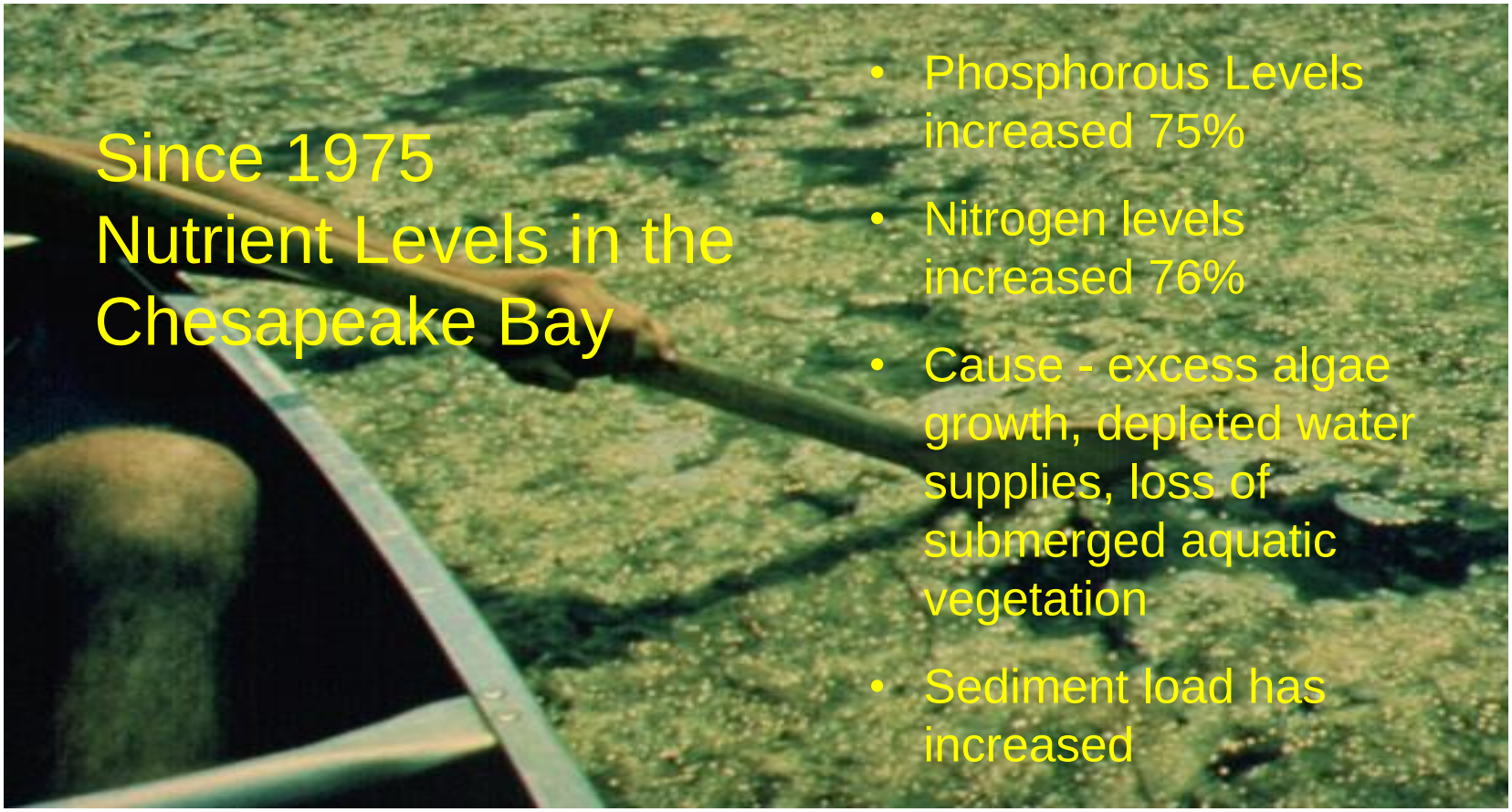

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Scope of Nitrogen and Phosphorus

- 16,000 waters in US are impaired by nutrient related pollution. Every state effected.
  - 101,461 miles of rivers and streams
  - 2.5 million acres of lakes and reservoirs
  - 833 sq. mi. of bays and estuaries
  - 47% of all US streams have medium to high levels of P
  - 53% of all streams have high level of N
  - 78% of all coastal waters exhibit eutrophication
  - Nitrate Drinking Water Violations have doubled in 8 yrs.

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

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Household Waste Disposal

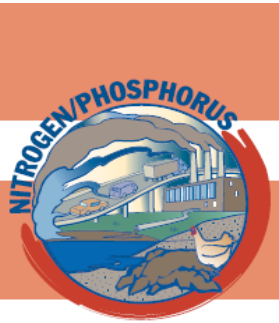
- One half of all houses in Virginia depend on septic systems (soil adsorption) for treatment and disposal of household wastes.
- Over 1 million houses in Virginia use on-site sewage systems. 25,000 new septic systems are installed each year.
- 100 million gallons of septic effluent is discharged into the soils of Virginia each day!

Nutrient Concentrations in ppm Related to Surface Water Quality Classifications

	Good	Fair	Poor	Severe
NO_3 - N	.01-.60	.61-2.0	2.1-9.9	>9.9
Total P	.01-.10	.11-.59	.60-1.2	>1.2

Totals in Parts per Million

Primary Pollutants



F 16 ↓ Nitrogen

-1 from 2008

D- 23 ⟷ Phosphorus

no change from 2008

Nitrogen and Phosphorus are the “Limiting Factor” to Achieving Bay Health

Limiting Factor: anything that tends to make it more difficult for a species to live, grow, or reproduce in its environment

All other health score areas are affected by excess nutrients

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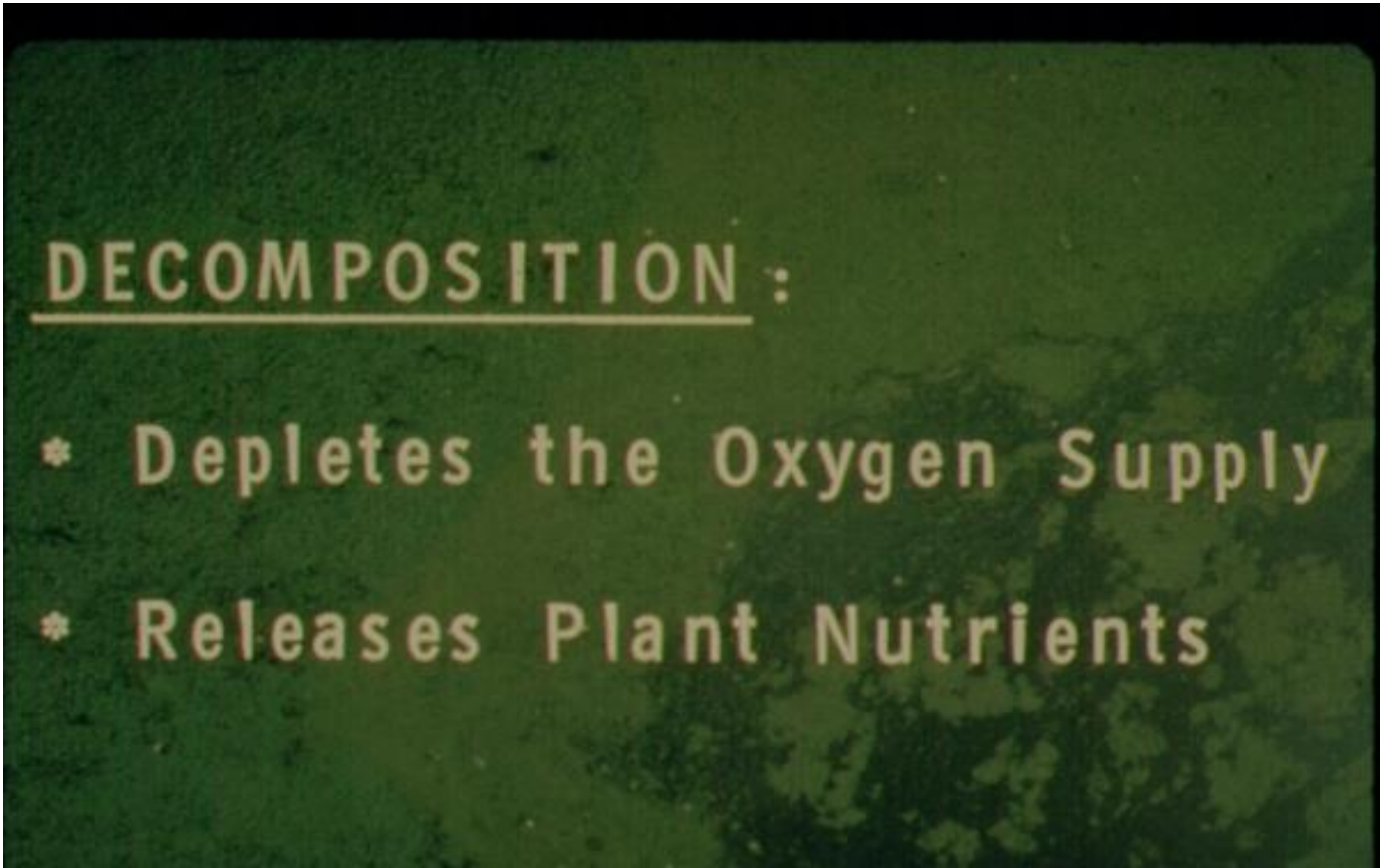
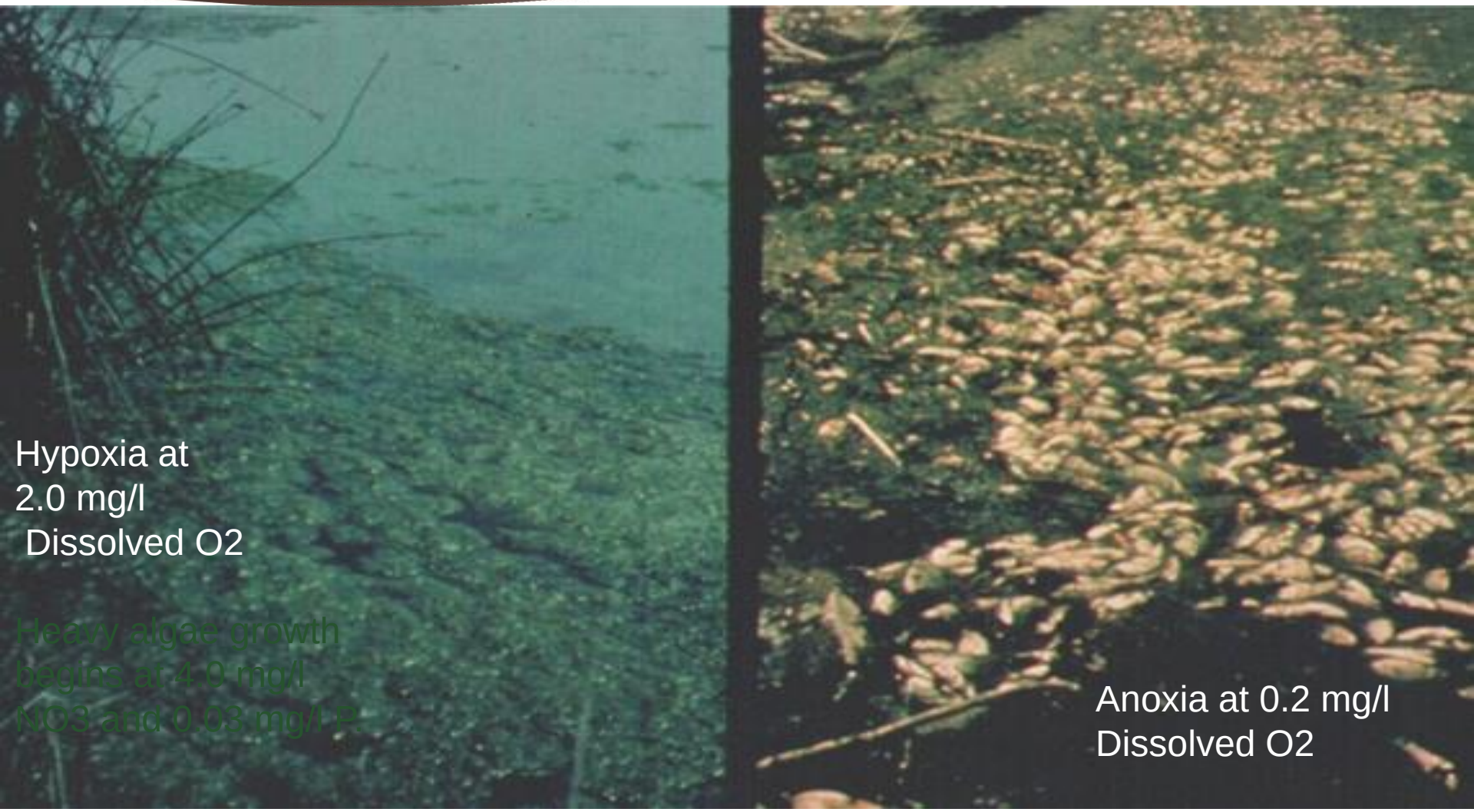
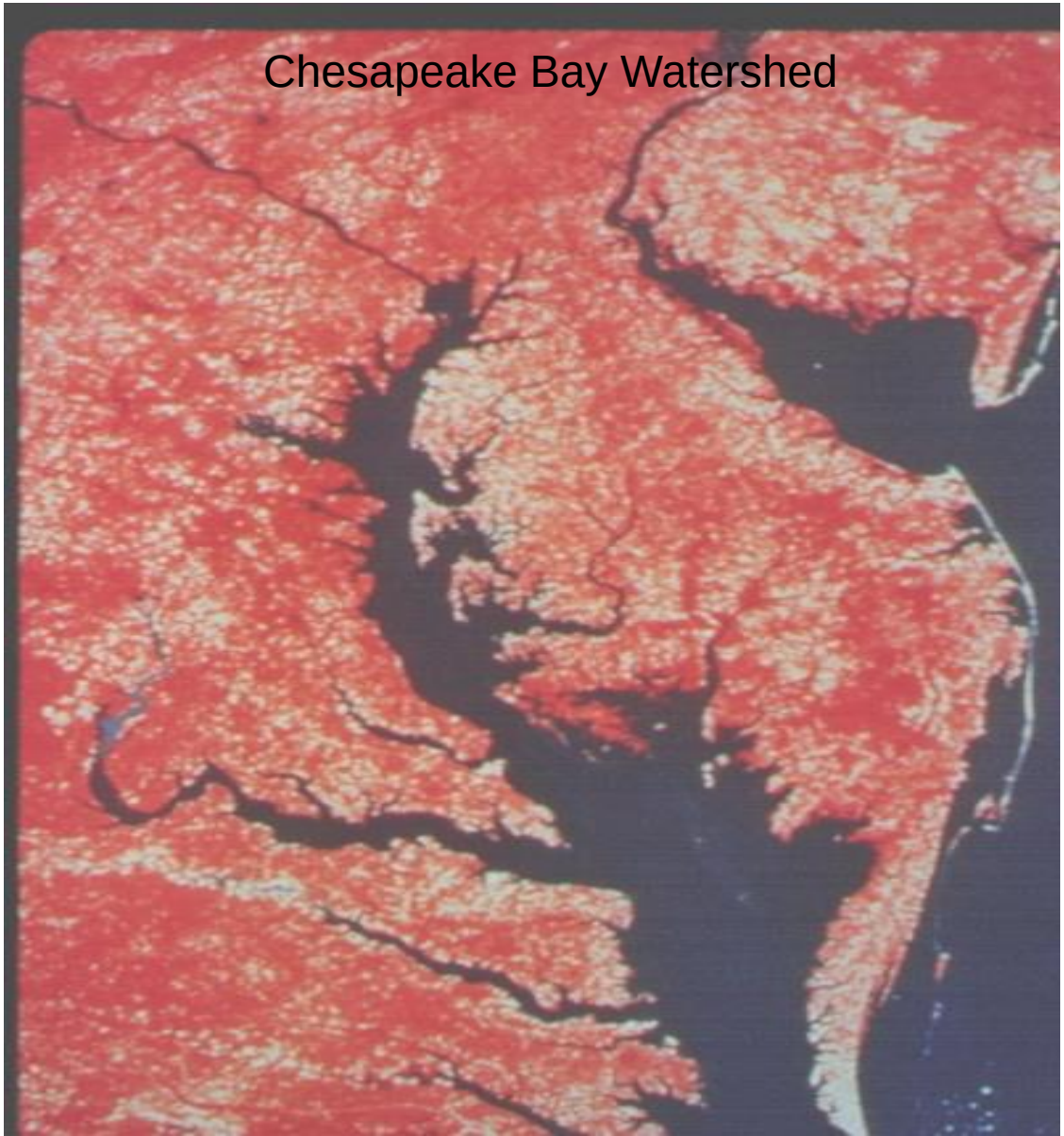
Nitrogen and Phosphorus
Surface Water Concerns

- Algae growth fertilized by nutrients esp. Phosphorous
- As algae die, decomposition process depletes dissolved oxygen needed by fish and other aquatic life
- Extreme cases cause fish kills
- Algae can cause taste and odor problems in drinking water and increased treatment costs
- Excessive phytoplankton (algae) growth in Chesapeake Bay cuts out light needed by bottom grasses (S.A.V.)


DECOMPOSITION:
* Depletes the Oxygen Supply
* Releases Plant Nutrients


Hypoxia at
2.0 mg/l
Dissolved O2
Heavy algae growth
begins at 4.0 mg/l
NO3 and 0.03 mg/l P.
Anoxia at 0.2 mg/l
Dissolved O2


Chesapeake Bay Watershed

Chesapeake Bay

- Congressional appropriation of $27 million for six year EPA study to determine the reasons for the decline of the Chesapeake Bay
- Final report printed in 1982 found three major problems:
- Nitrogen and phosphorus levels causing excess algae growth
- Sediment from ag and urban soil erosion
- Toxic compounds (Ag pesticides not found to be a major problem)

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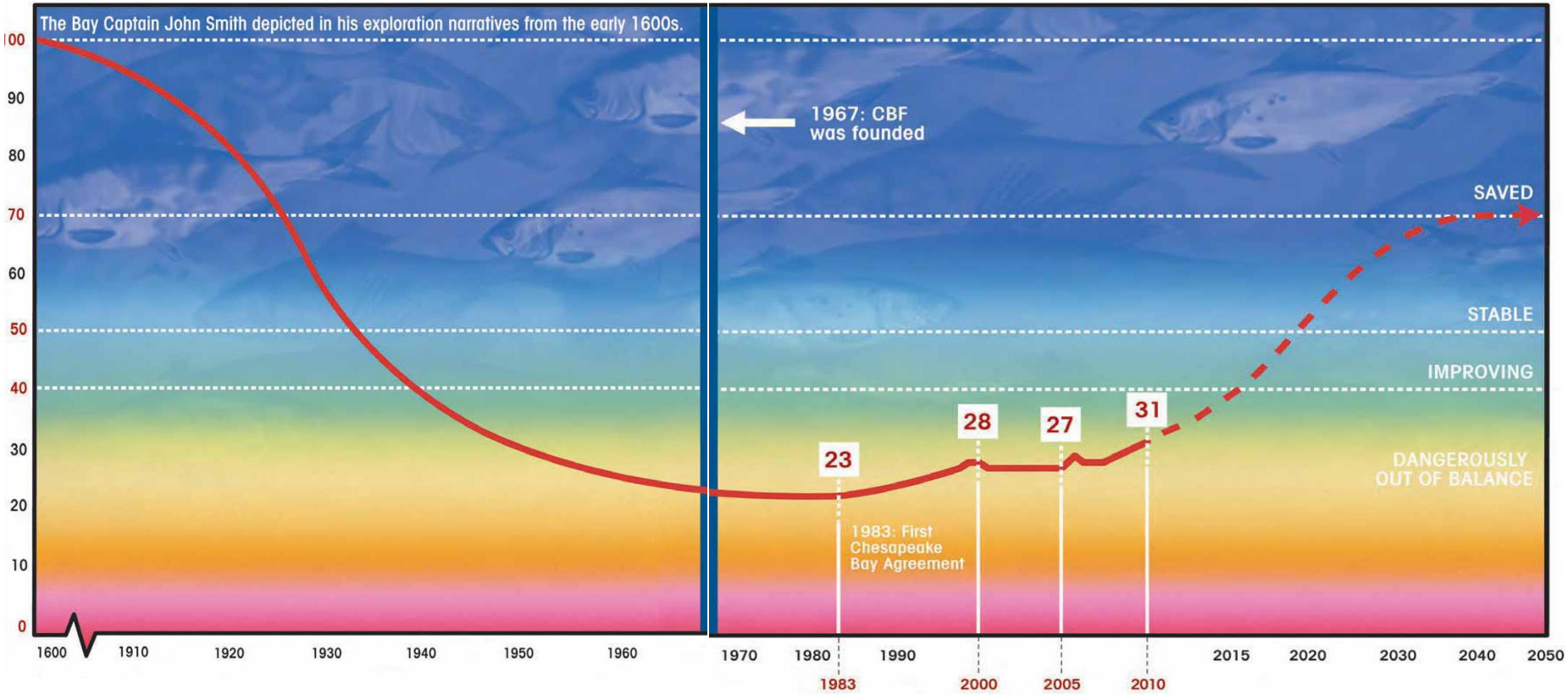
Bay Health



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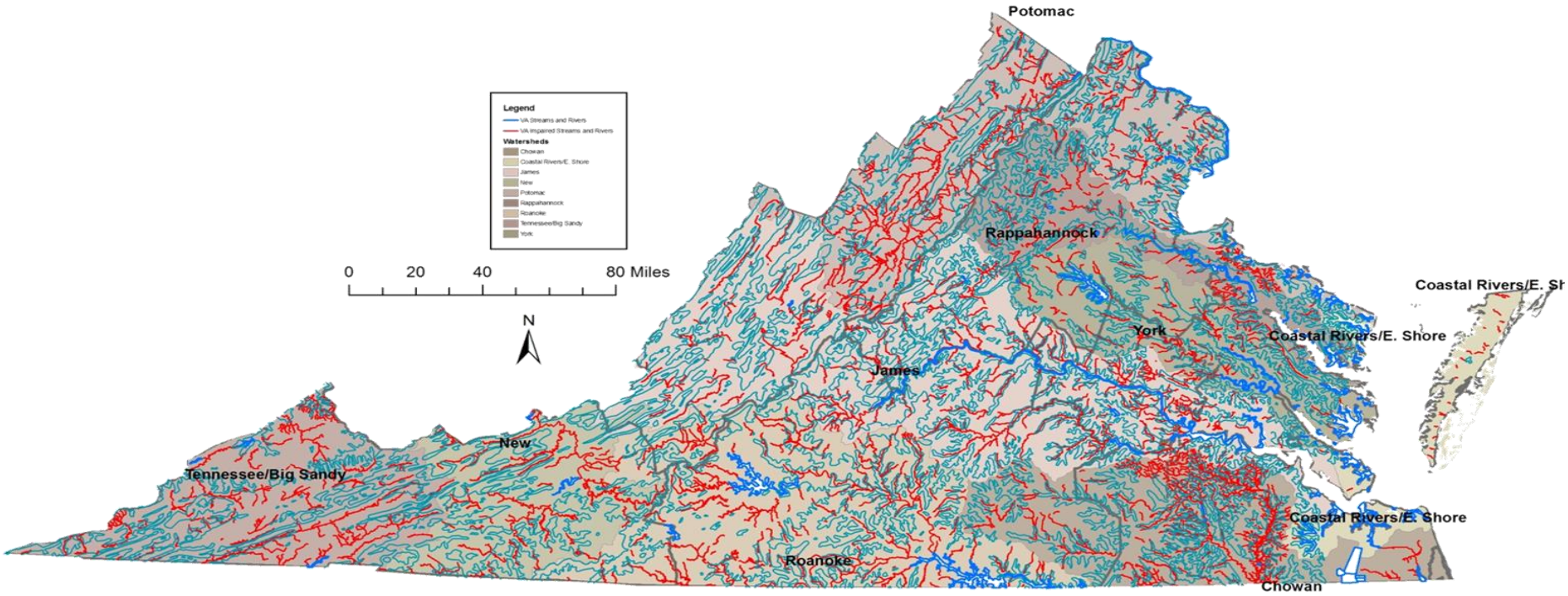
Impaired Waters



While most Legislation and Policy deal directly with the Health of The Chesapeake Bay Local Waters are Improved as Well.

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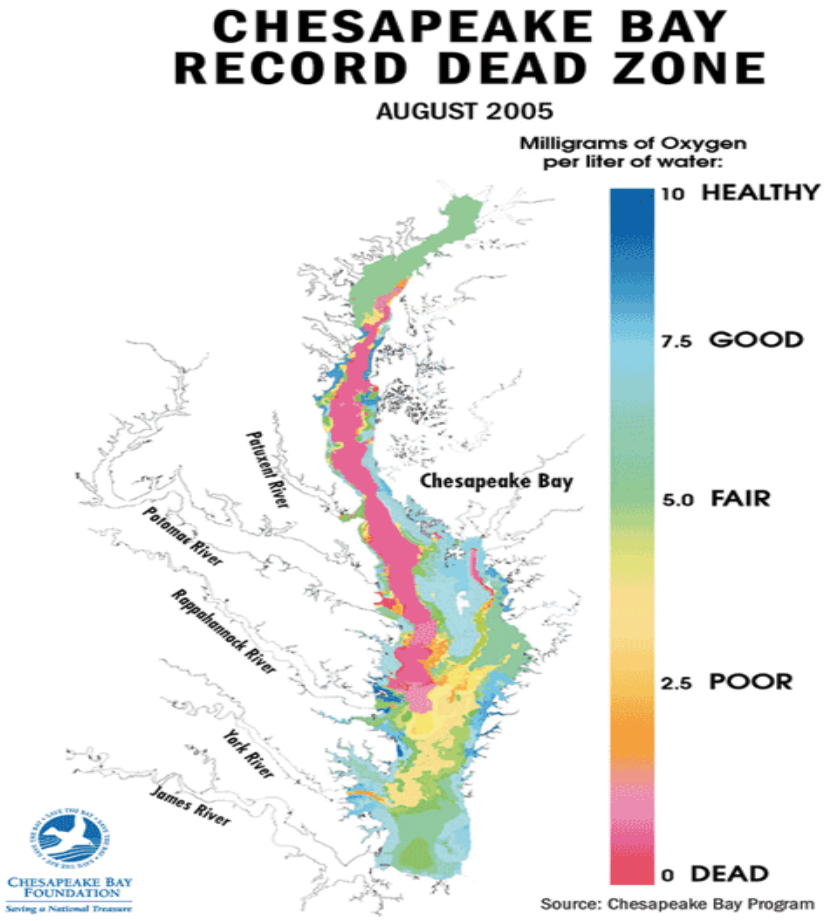
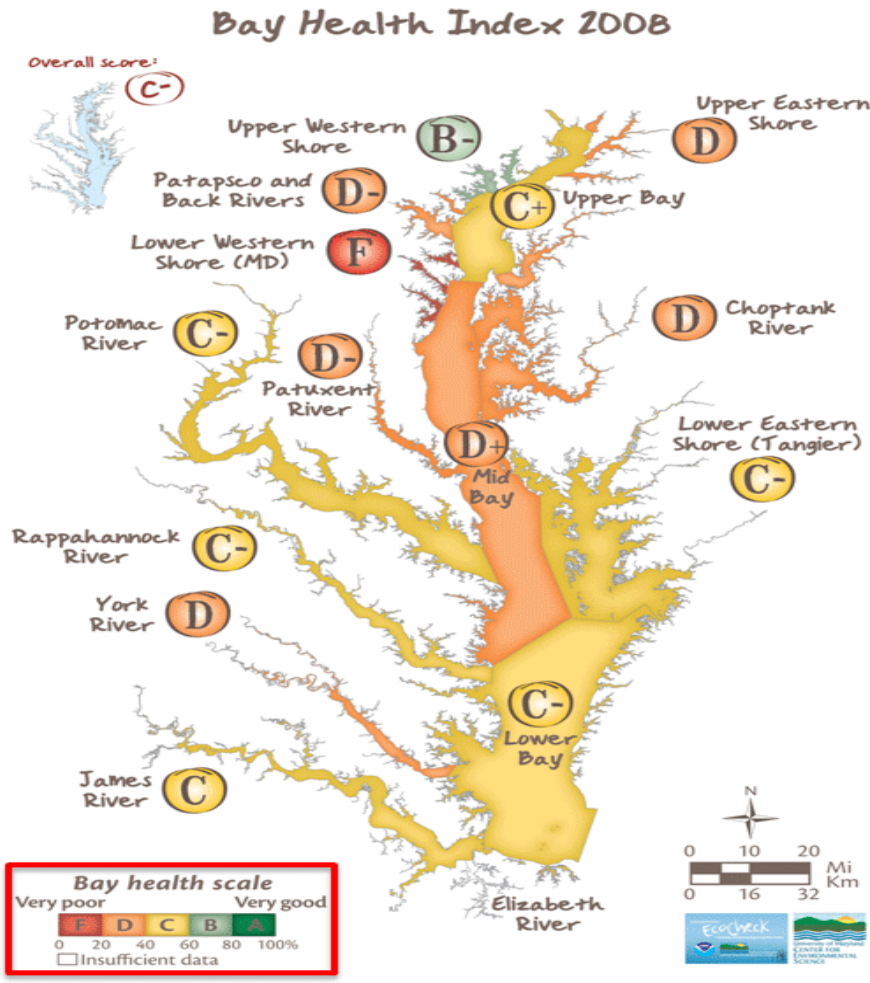
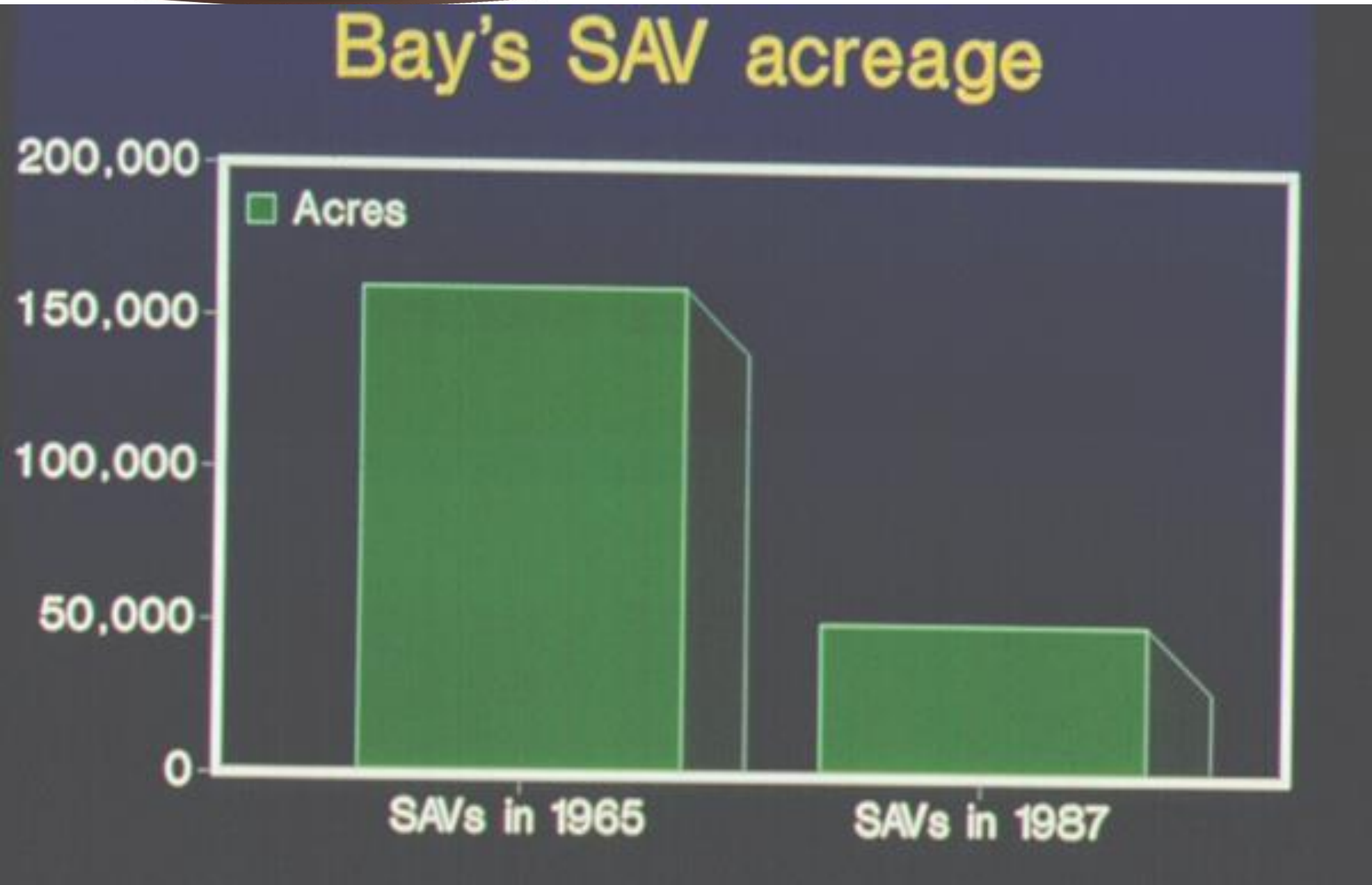
Condition of Chesapeake Bay



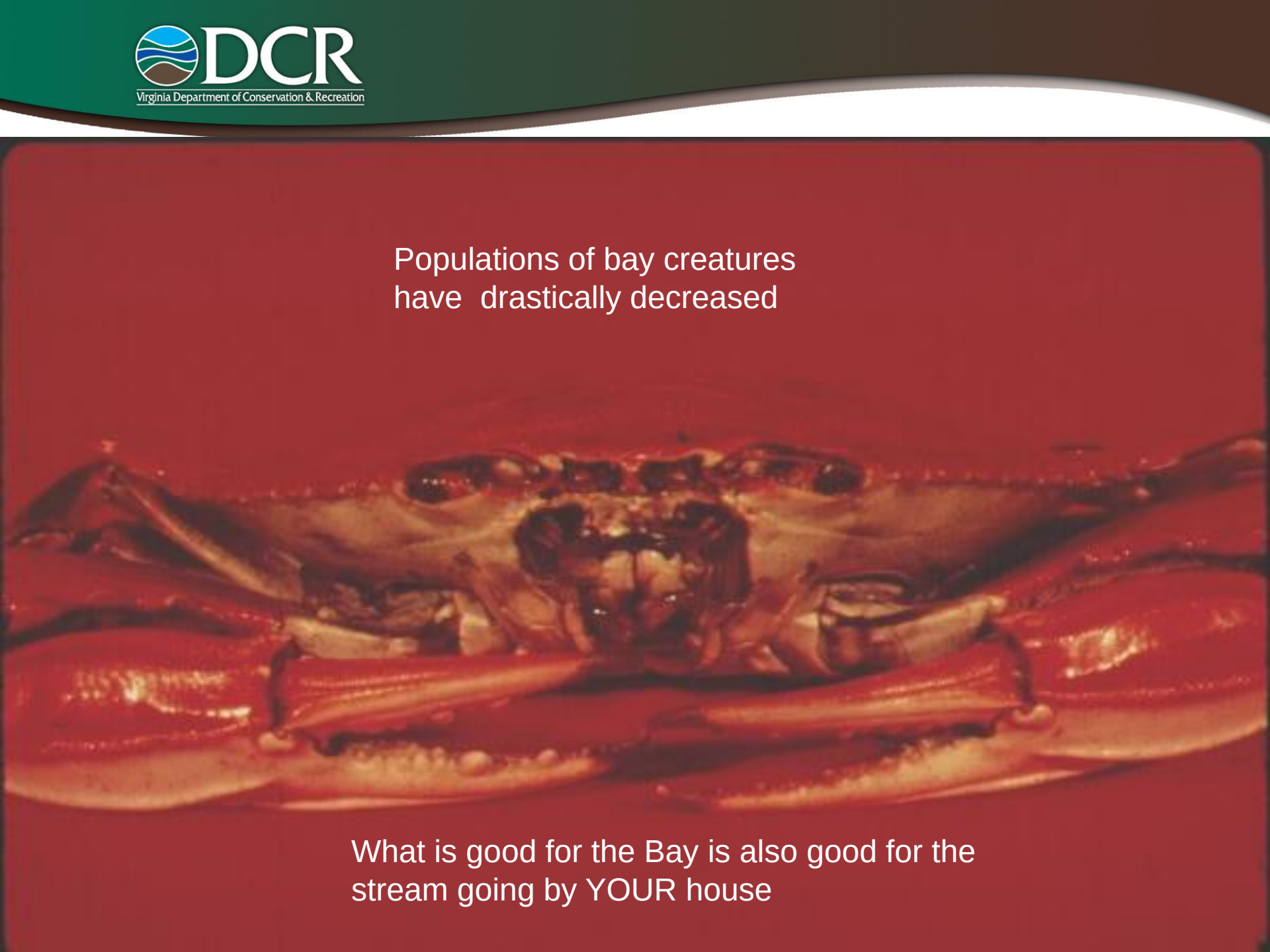



Clear Water assisted by
Wind wave action
Phytoplankton release of O_2 - photosynthesis
Aquatic grasses release of O_2 - photosynthesis
Bottom dwellers most effected by O_2 concentrations


Bay's SAV acreage
200,000
150,000
100,000
50,000
0
Acres
SAVs in 1965
SAVs in 1987

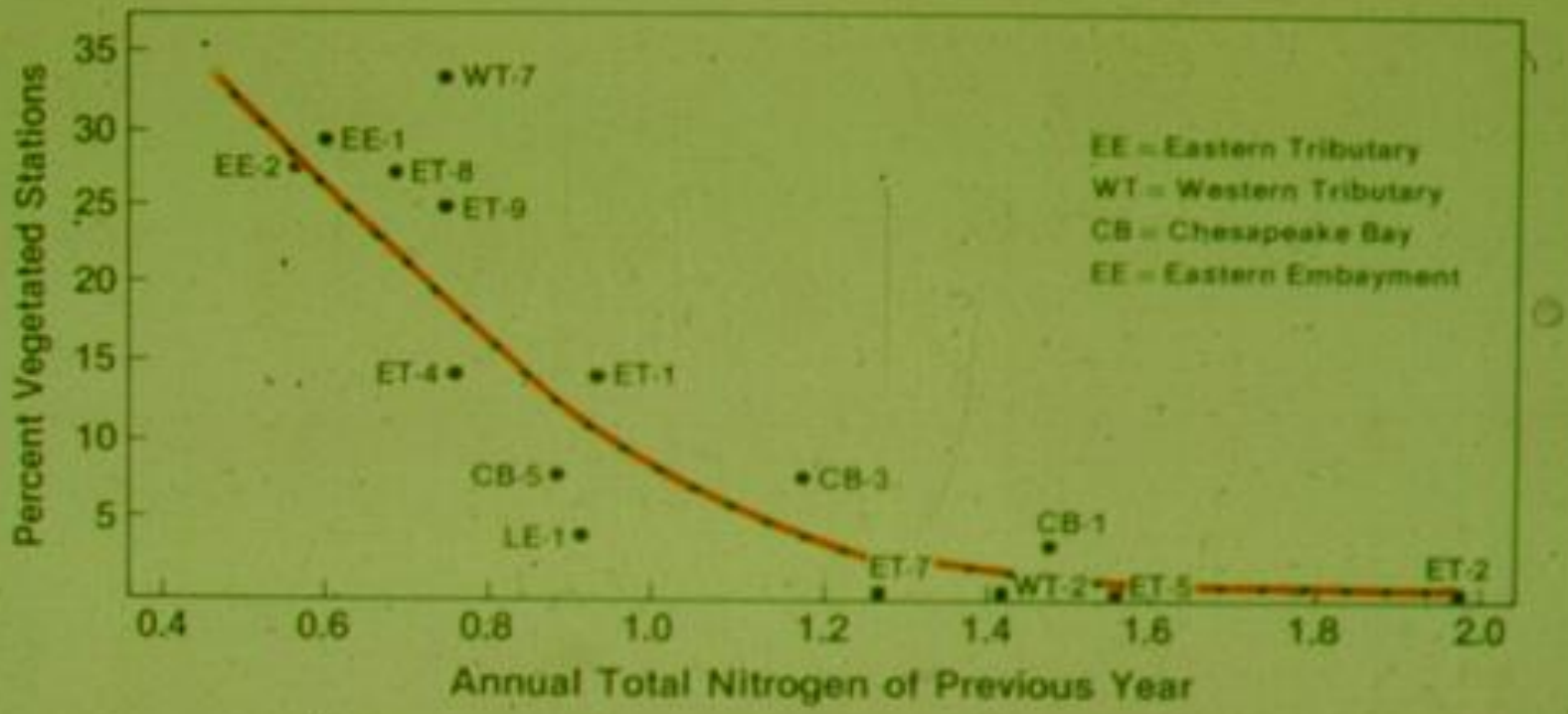
Virginia Department of Conservation & Recreation

Populations of bay creatures have drastically decreased



What is good for the Bay is also good for the stream going by YOUR house

SAV and Nutrients



Increases in nutrients correlate with decreases in SAV. Areas of the Bay that are highly enriched with nutrients have the greatest SAV losses.

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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%

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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.

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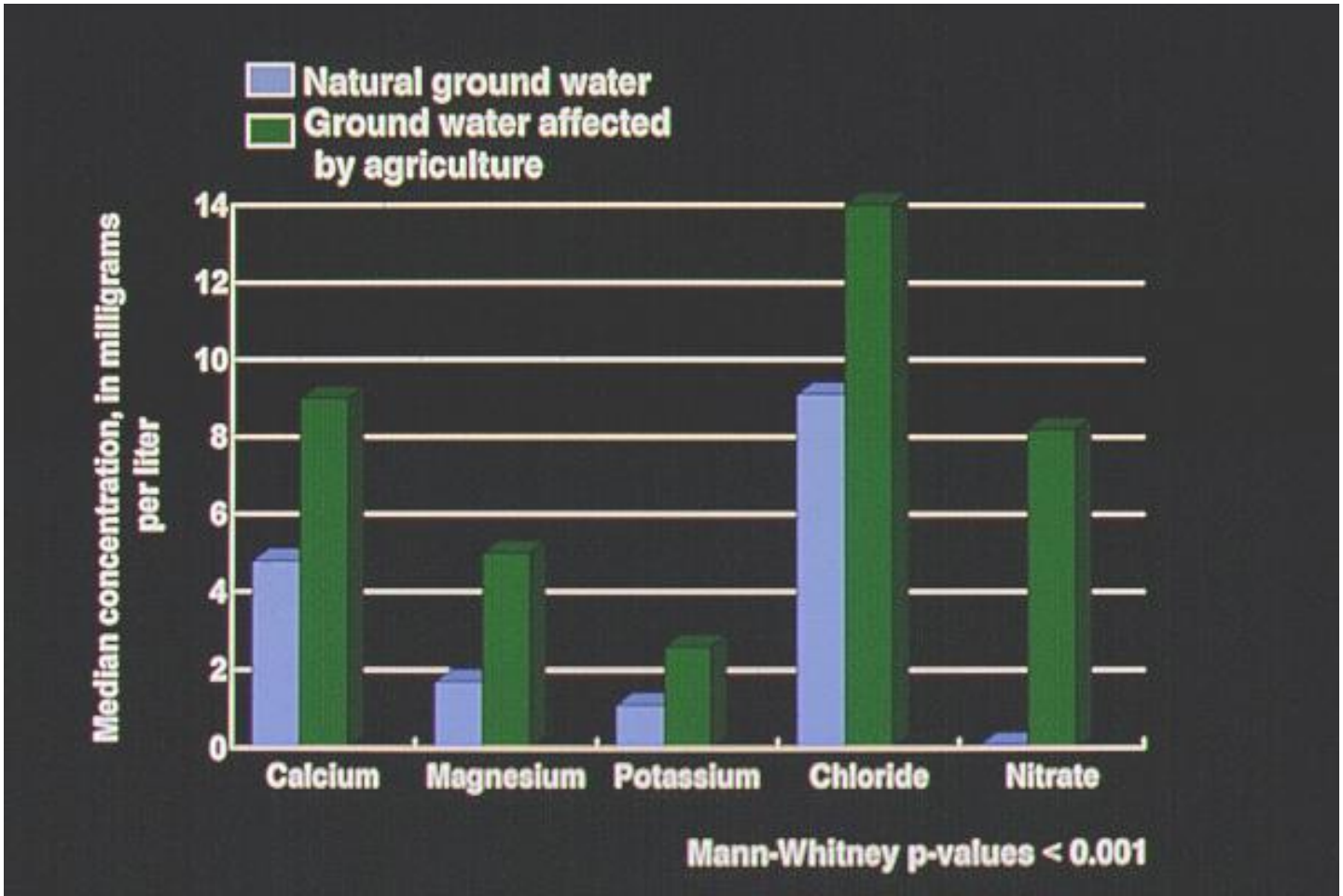
Runoff and Leaching

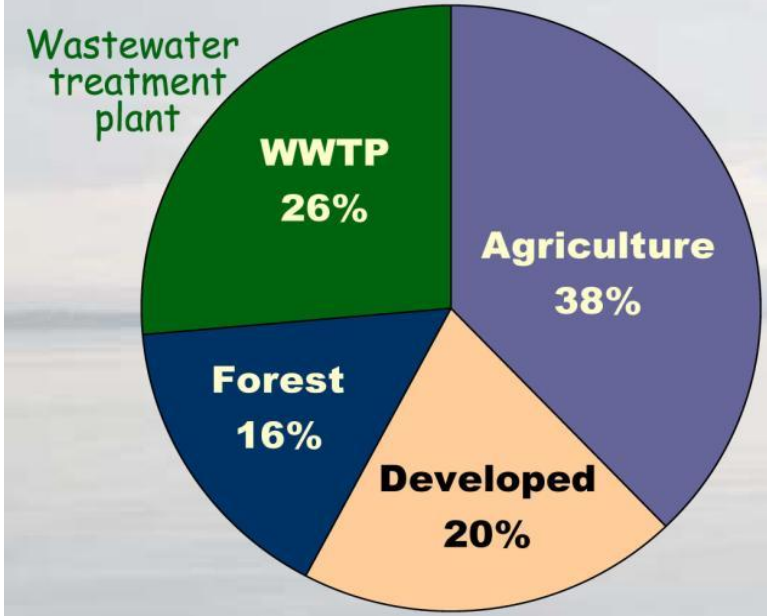
- Dissolved nutrients and pesticides can reach groundwater by moving down through the soil. Nitrogen moves this way.
- Certain pesticides are highly mobile and have been detected in groundwater. Aldicarb (Temik), alachlor (Lasso), and triazines (Atrazine) are just a few.

USGS Delmarva Study 1992

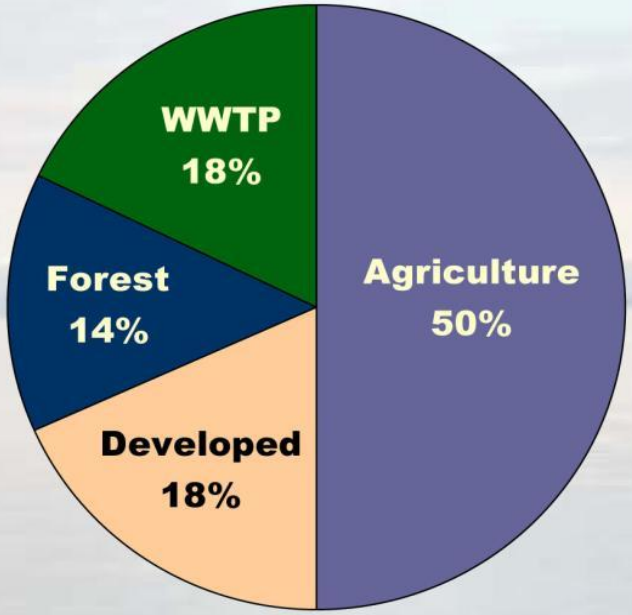


Nutrient Sources of VA

Sources of Nitrogen from Virginia



Sources of Phosphorus from Virginia



N and P values from 2008 Scenario of Phase 5.2 Watershed Model

Degree of Nitrate Leaching

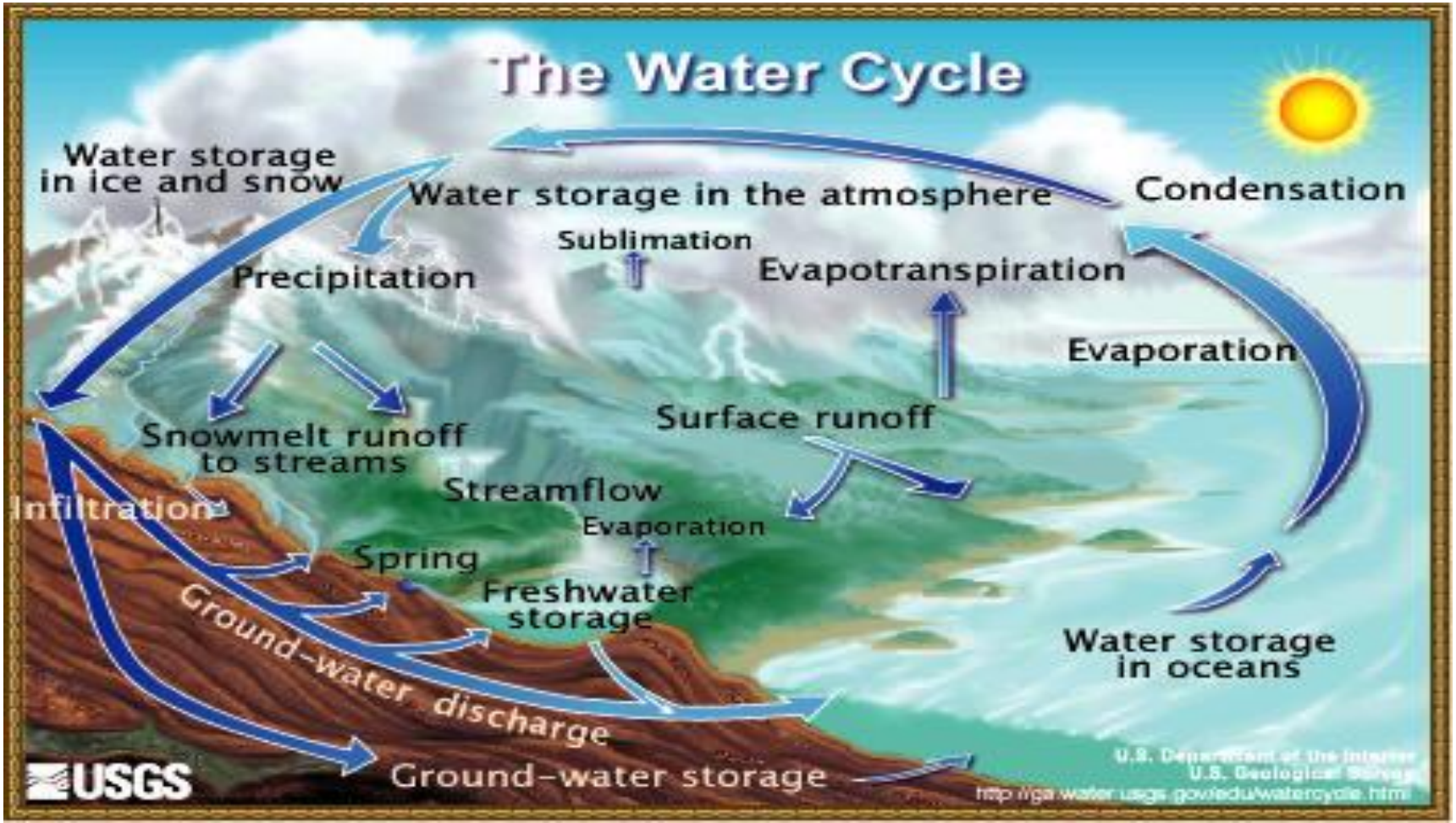
- Precipitation amounts and timing
- Physical properties of soil
- Nitrate levels in soil

USGS Delmarva Study 1992

More Nitrate Facts……

- Range: 0.46 to 48mg/l N concentrations found in groundwater.
- Groundwater in 26 percent of all wells tested exceed EPA drinking water standard of 10.0 mg/l as N
- Highest Nitrate concentrations commonly found at the base of the aquifer.

Hydrologic Cycle



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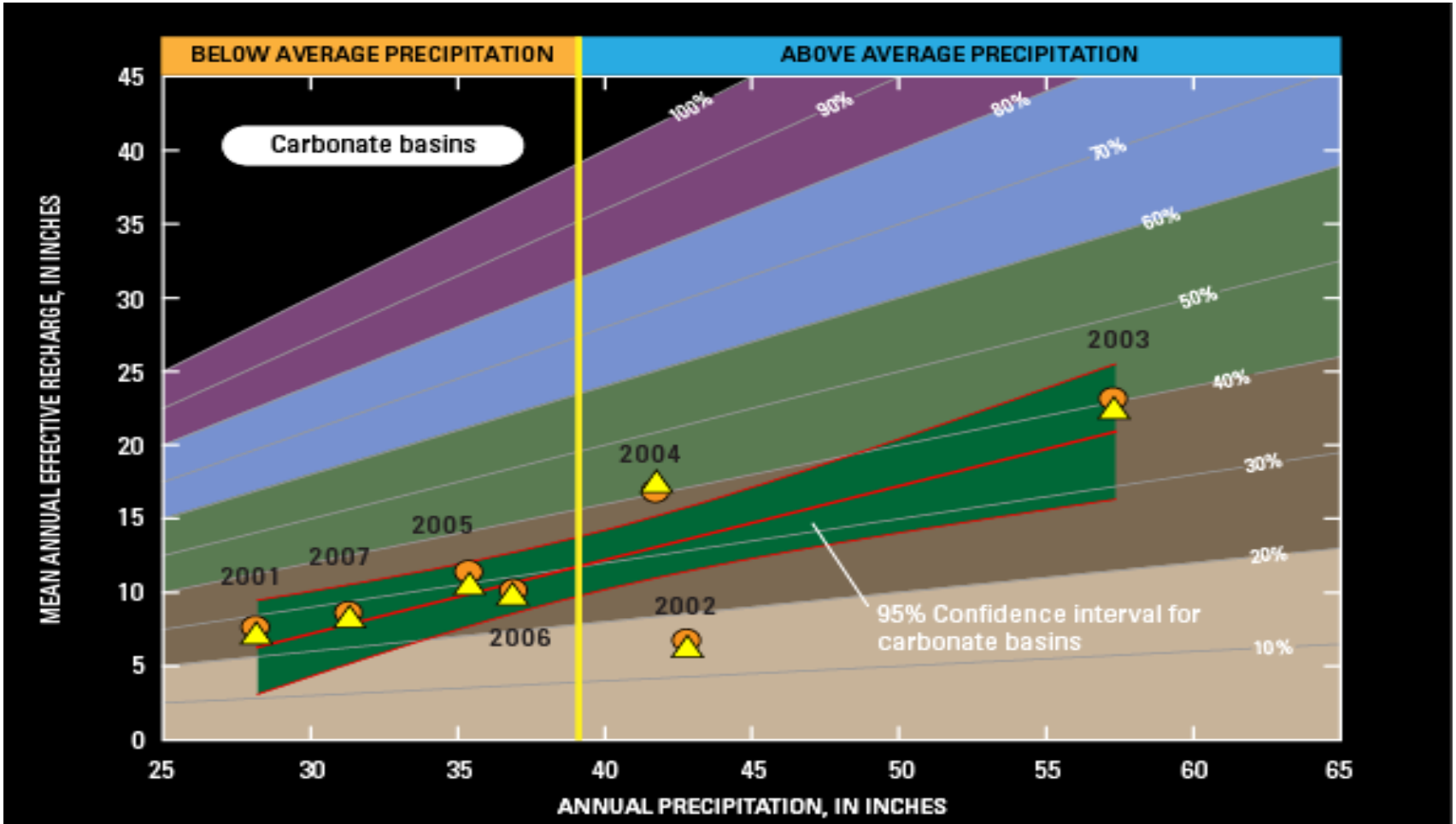
Annual Precipitation and Mean Annual Effective Recharge

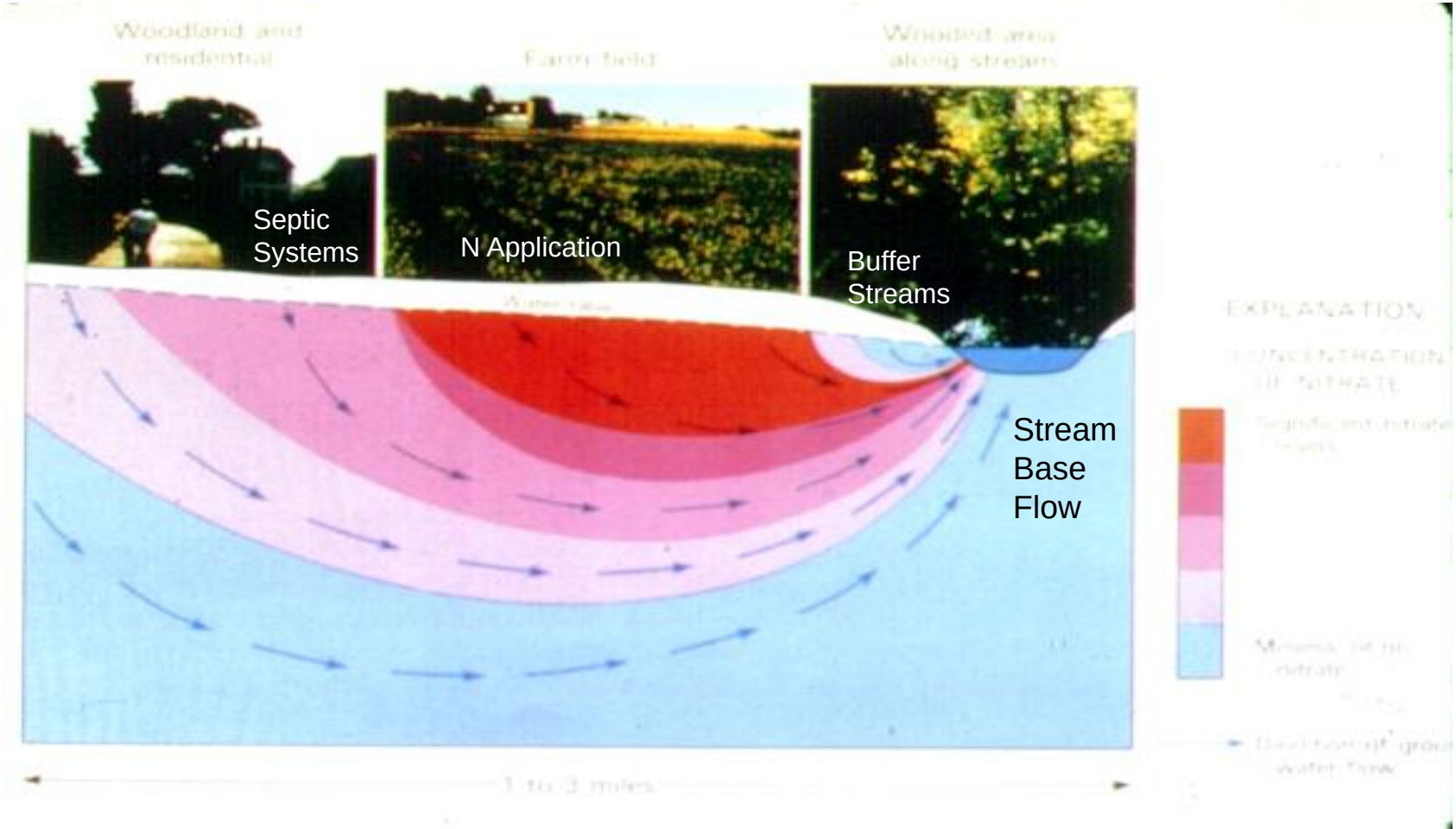


Seasons of Greatest Leaching

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

- Late fall
- Winter
- Early spring

How Groundwater and Nitrate Moves Below Ground to Impact Surface Waters



Ground and Surface Water Connections

- Springs
- Seeps
- Drain tile outlets
- Some stream or river beds act as recharge to aquifer system by cutting overbearing confining layer
- Sinkholes
- Wetlands and marshes
- Which way is the net flow ?

Nitrogen Loss Forms & Pathways

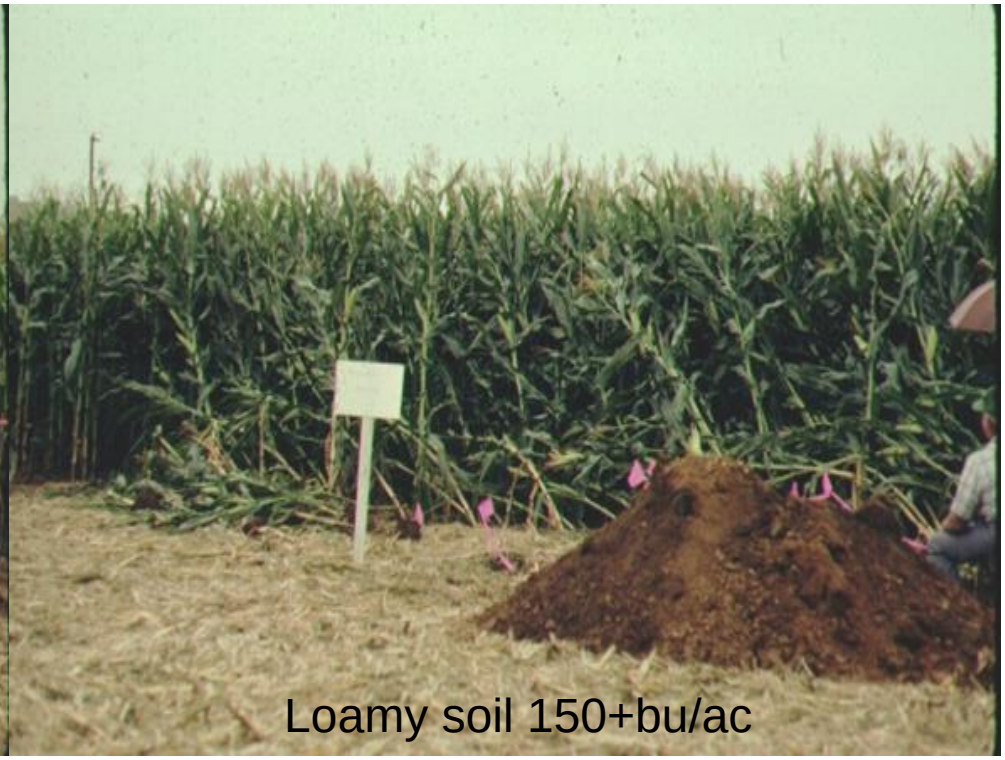
- NH_4^+ bound to eroding sediment or organic matter
- Organic N suspended in runoff water
- Soluble NO_3^- in runoff water
- NO_3^- leaching to groundwater

Nutrient Practices to Reduce Nitrogen Pollution Potential

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

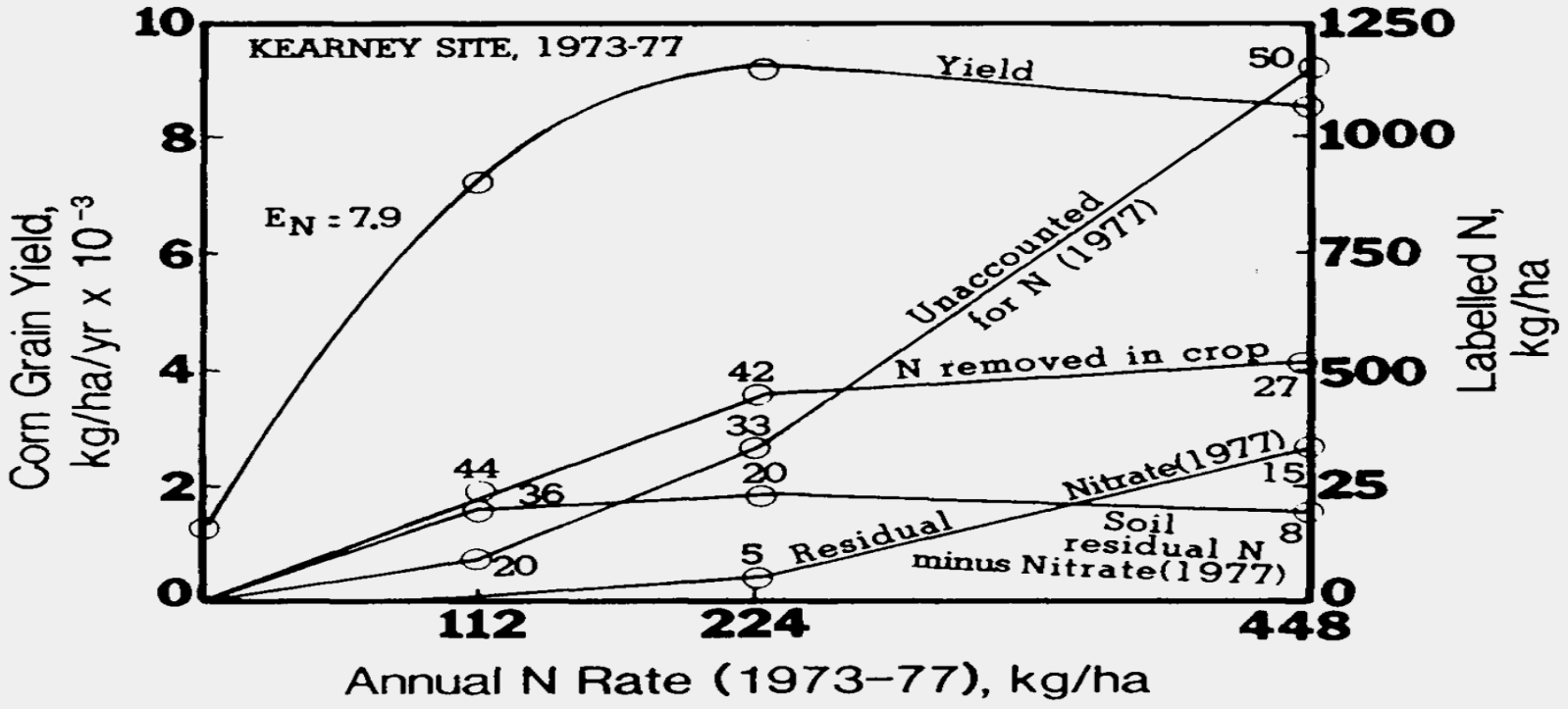
Yield Capability of Soil and Nitrogen Rate

Sandy soil 80 bu/ac



Loamy soil 150+bu/ac

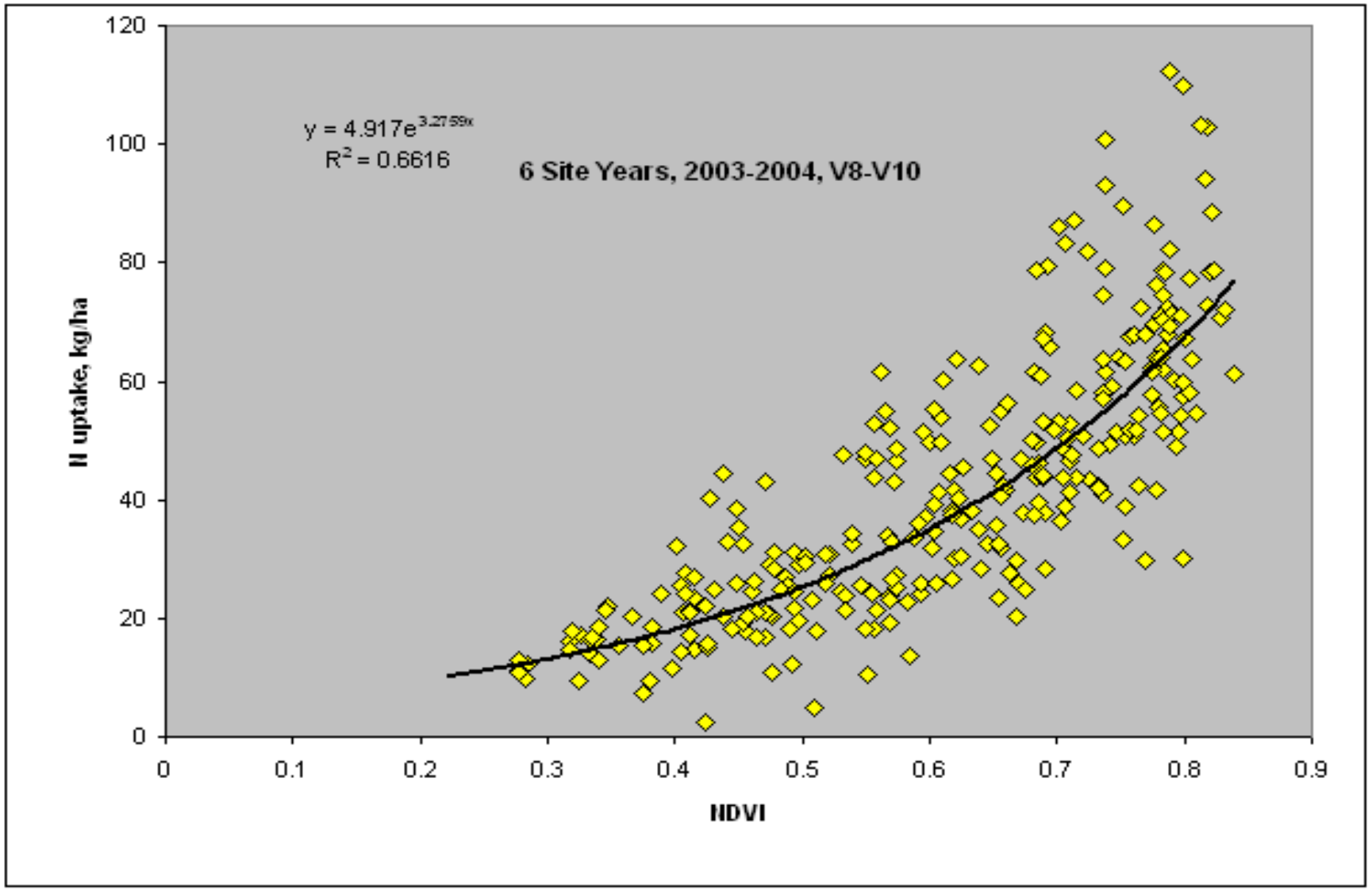
N Rate Impact on N Losses



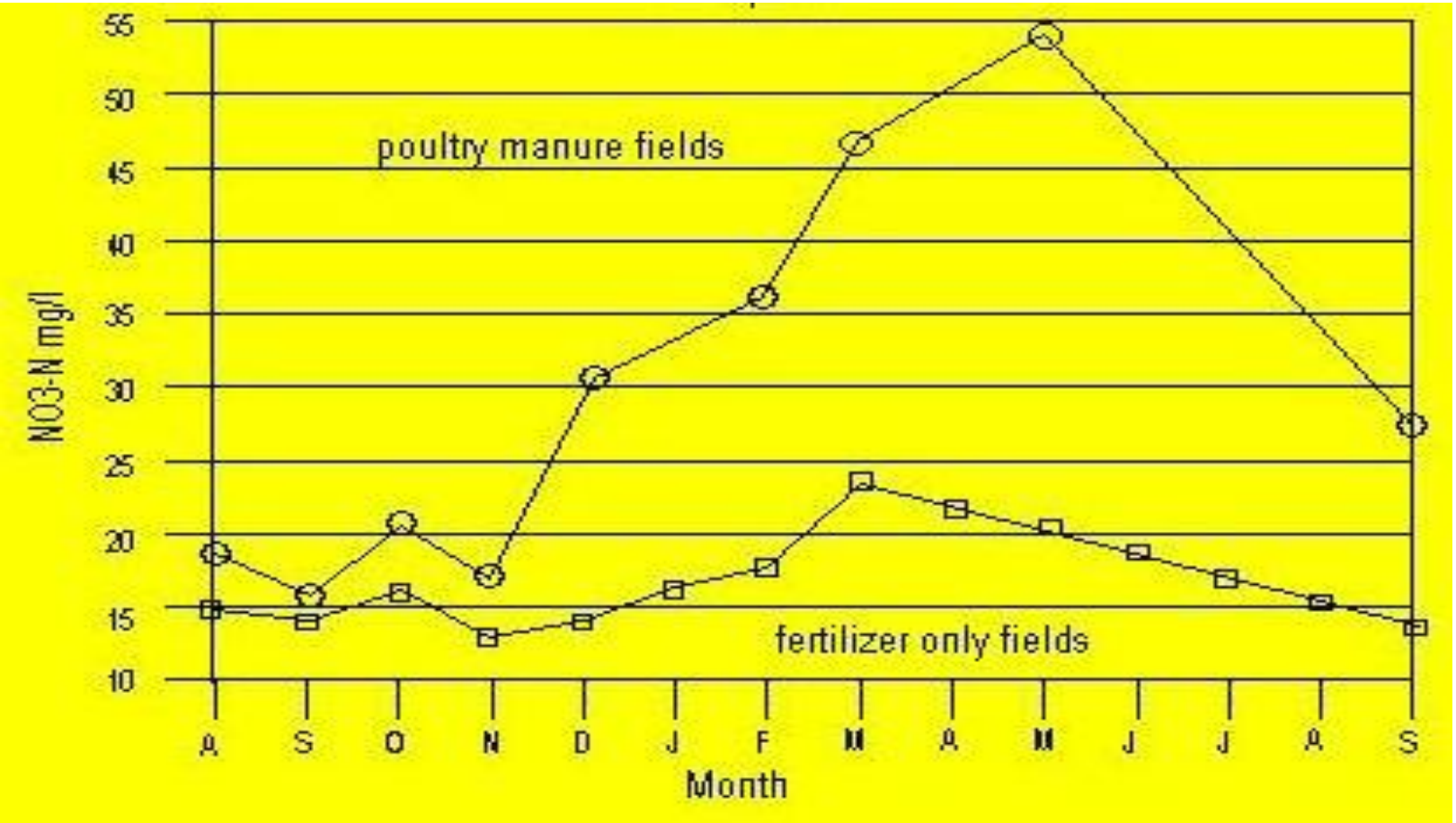
Timing of Applications

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

- When it needs it Most!


y = 4.917e^3.2759x
R² = 0.6616
6 Site Years, 2003-2004, V8-V10
N uptake, kg/ha
NDVI
0
20
40
60
80
100
120
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

$N0_3$-N Concentration in Groundwater as affected by improperly timed poultry manure oncorn Weil, 1990



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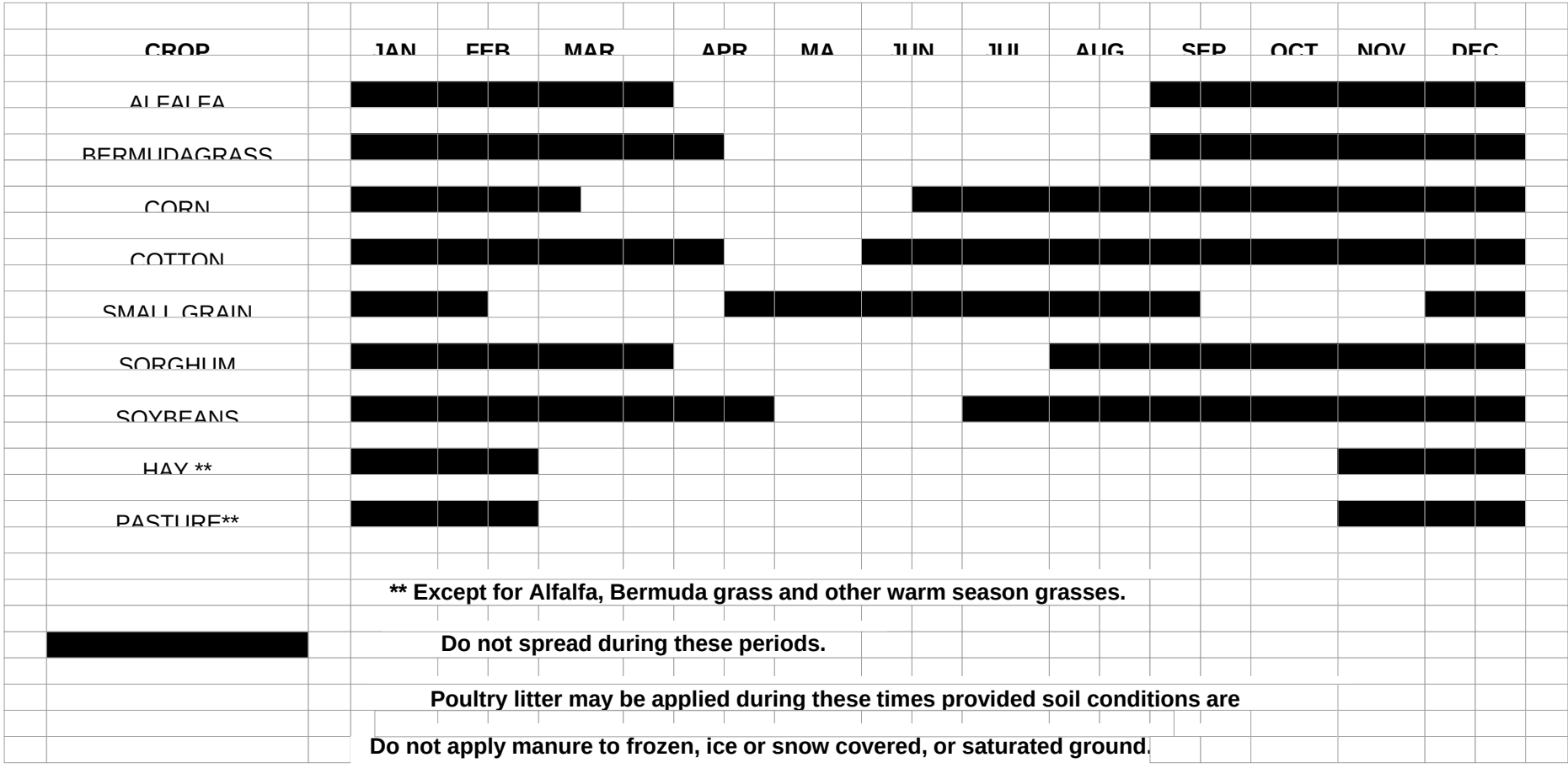
Manure Spreading Schedule



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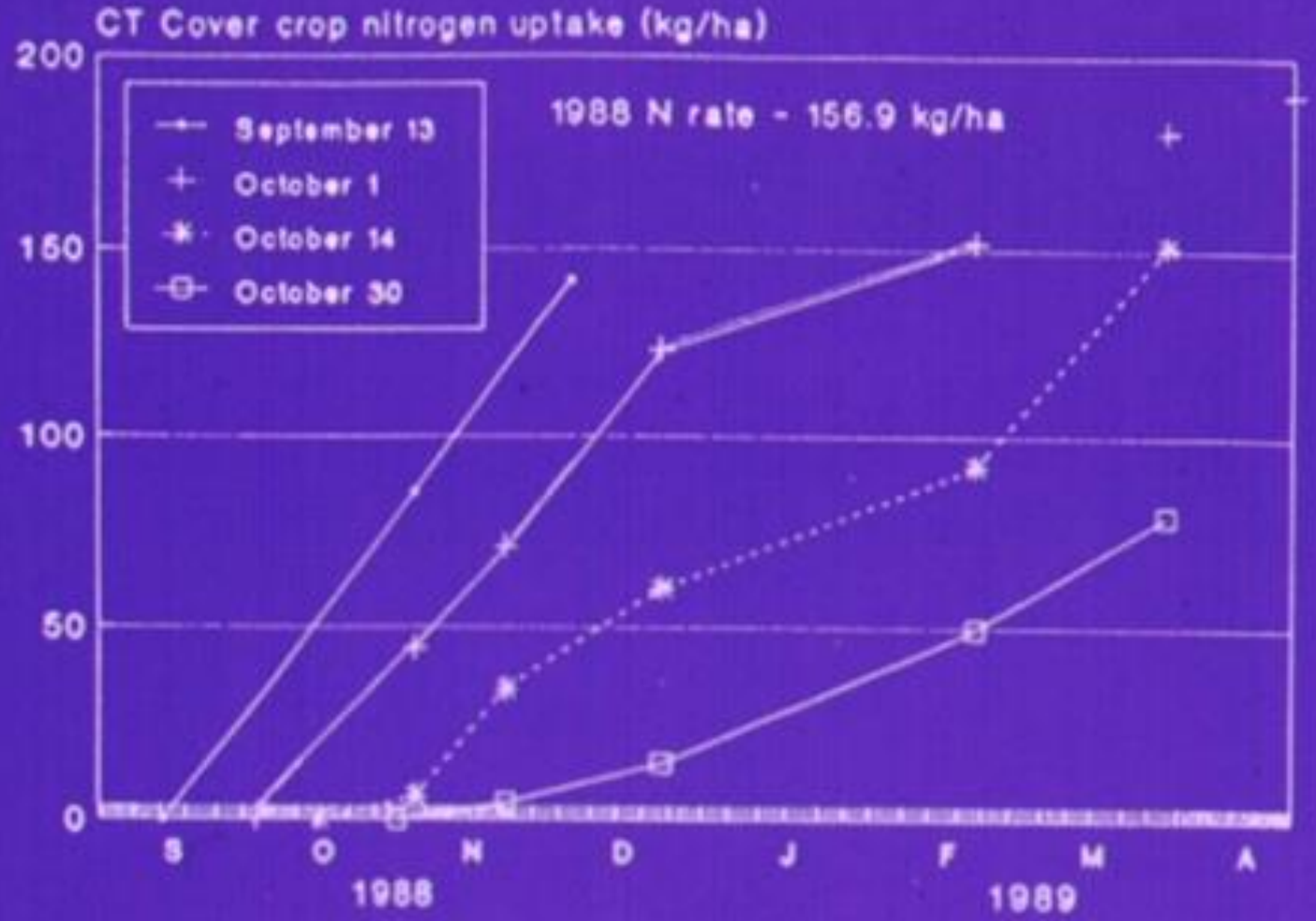
Cover Crops

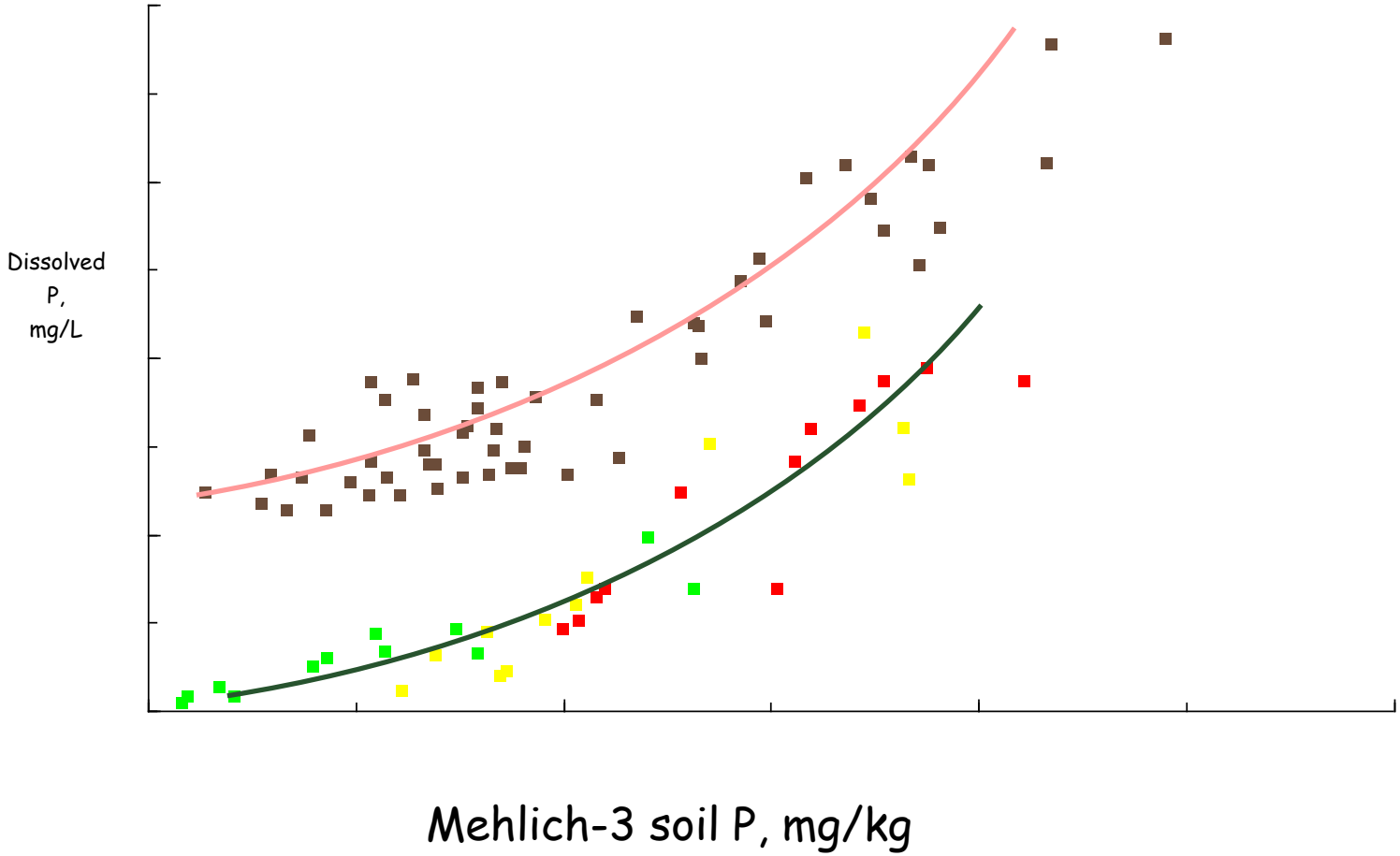


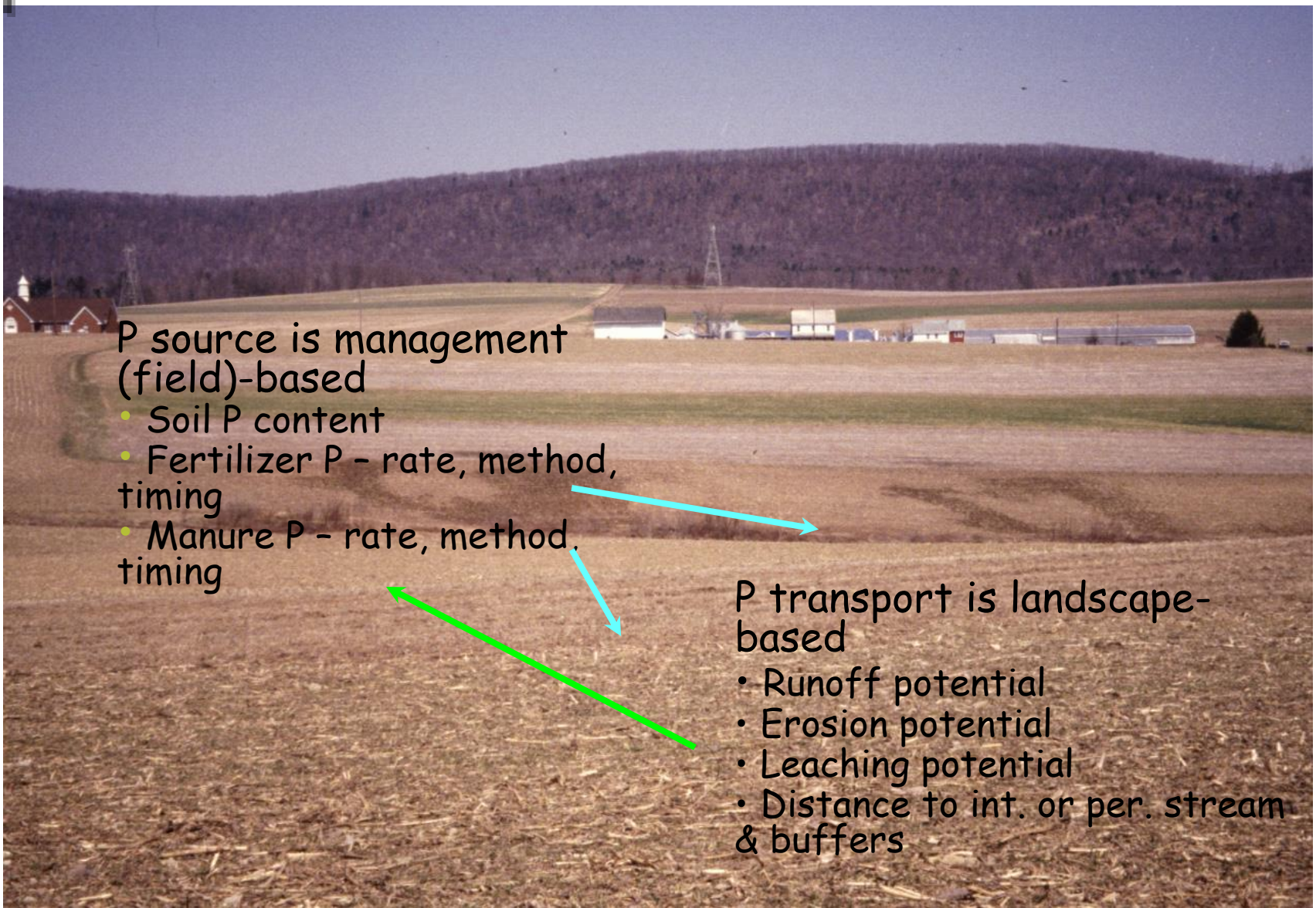
Above-ground cover crop nitrogen assimilation in the CT treatment area as a function of planting date following the 1988 corn harvest.

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)

Relating Soil P to Runoff P




P source is management (field)-based
• Soil P content
• Fertilizer P – rate, method, timing
• Manure P – rate, method, timing
P transport is landscape-based
• Runoff potential
• Erosion potential
• Leaching potential
• Distance to int. or per. stream & buffers

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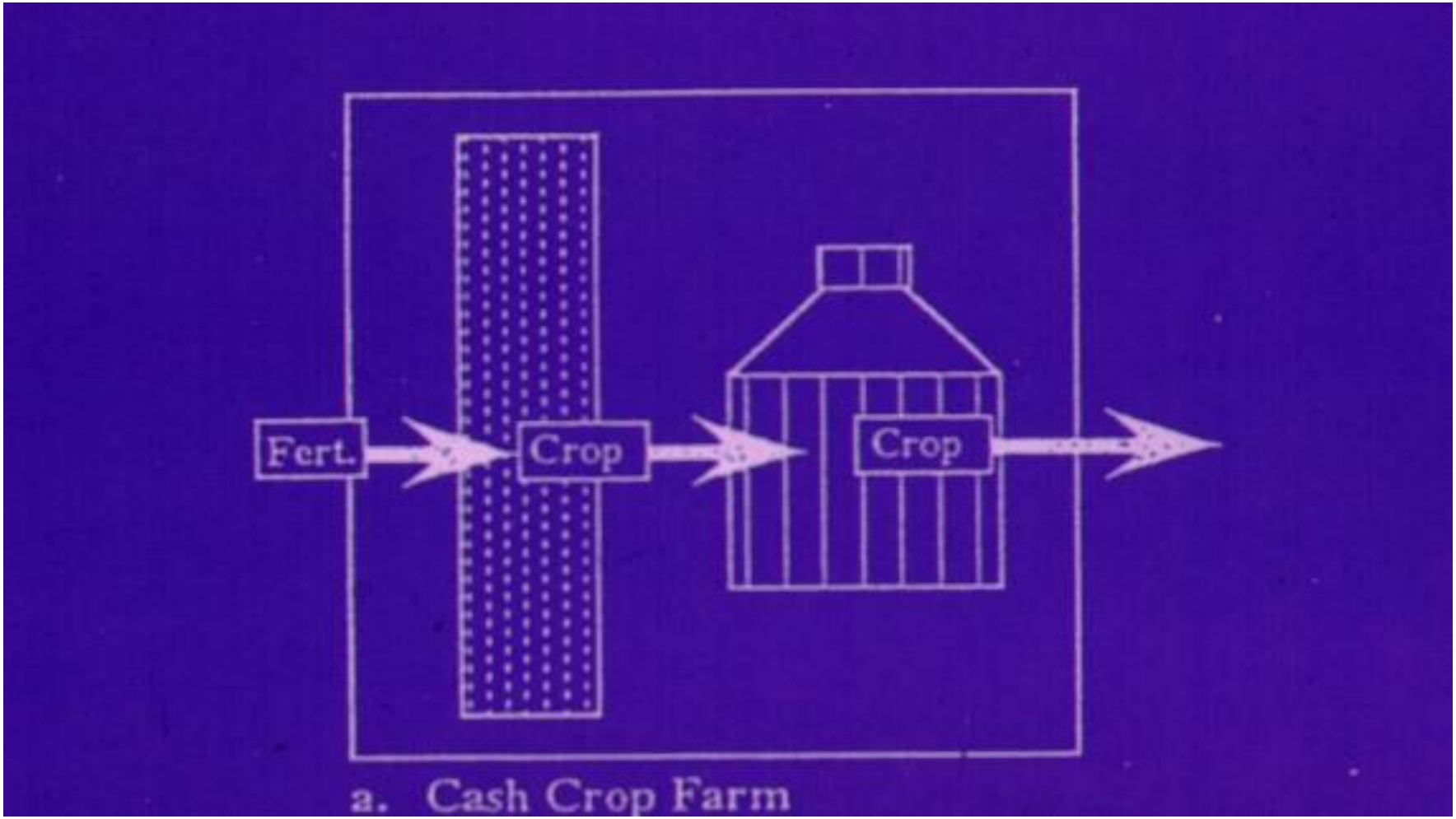
Nutrient Practices to Reduce Phosphorus Pollution Potential

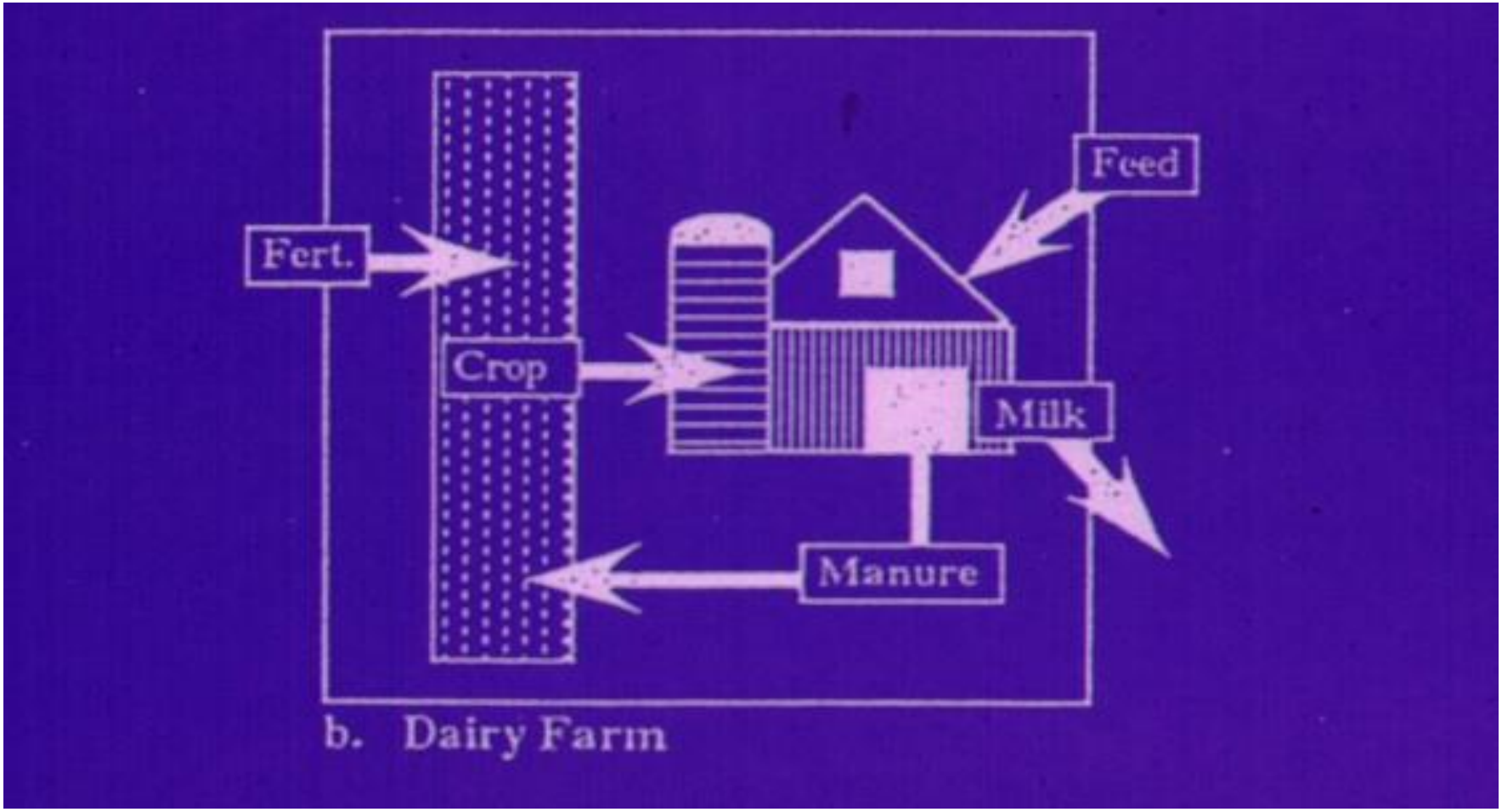
- Keep Soil Surface P Saturation Levels Below Environmentally Critical Levels
- Reduce Soil Erosion on Land With Extreme Levels of Soil Test P and on Highly Erodible or Highly Leachable Land
- Keep P Applications Below Crop Removal Rates in High Risk Situations

Nutrient Cycling on Farms

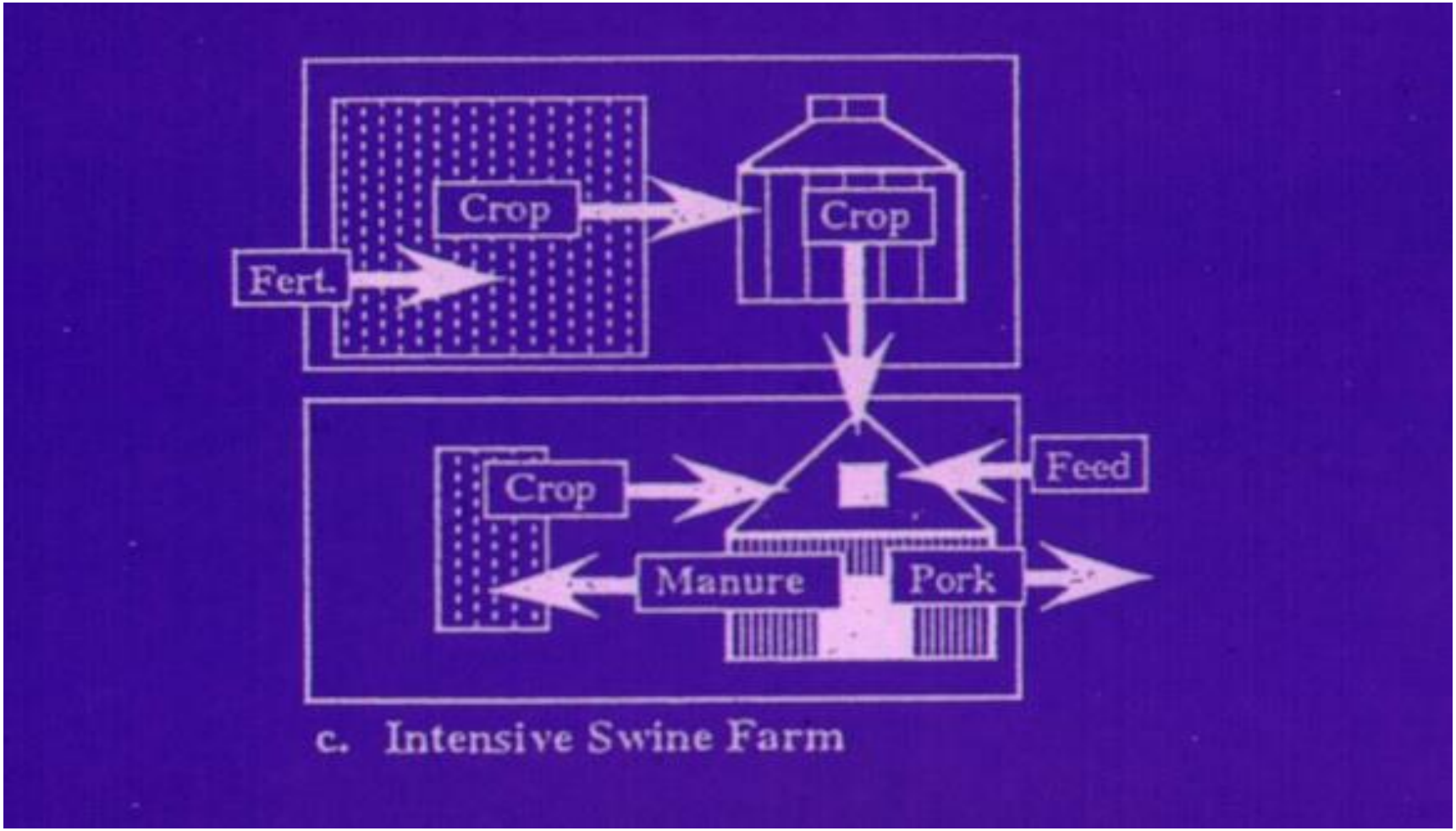
- Different types of farming operations have different ways to cycle nutrients.



a. Cash Crop Farm



b. Dairy Farm



c. Intensive Swine Farm

Environmentally Sensitive Sites
4 VAC 5-15-10

Field contains or drains to sinkholes OR

Any field containing 33% or more:

- Soils with a high potential for leaching
- Soils shallow to rock < 40”
- Poorly drained with coarse textured soils or tile drained
- Frequently flooded soils
- Slope > 15%

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. Shallow soils less than 41 inches deep likely to be located over fractured rock or limestone bedrock;
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 “sinkholes” 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

Table 1-4 (page 28)
Nitrogen Loss Risk and Environmental Sensitivity Ratings for Virginia Soils & Soil Series Associated With Environmentally Sensitive Sites

Soil Series	Environmental Sensitivity	Category
Abell	L	
Ackwater	L	
Acredale	L	
Aden	L	
Airmont	L	
Alaga	H	Leaching
Alamance	H	Leaching
Alanthus	M	Leaching
Albano	L	
Albemarle	M	Leaching
Alderflats	L	
Aldino	L	
Allegheny	H	Shallow
Alonemill	H	Leaching
Alonzville	M	Leaching
Altavista	L	
Altavista variant	L	
Alticrest	H	Shallow
Angie	L	
Appling	L	
Appling gritty	L	
Appomattox	L	
Aqualfs	L	
Aquents	H	Drainage

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
- 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

Review Question

Most of the water quality problems in the Chesapeake Bay are attributed to _____.

A. Nitrogen
B. Phosphorus
C. Ag. Chemicals
D. Sediment

Review Question

Nitrogen is managed in which of the following ways:

A. Nitrogen concentration in soil
B. Rate, timing, placement, cover crops
C. Erosion Control Practices
D. Structural BMP's

Review Question

What is the percentage of freshwater worldwide that is available?

A. 30%

B. 3%

C. 1.02 %

D. 0.19%

Questions?

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- 804-371-0061