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

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.
- Lakes, rivers, and streams contain 0.5% of all freshwater worldwide.
- 30% of all freshwater on the planet is "Groundwater"

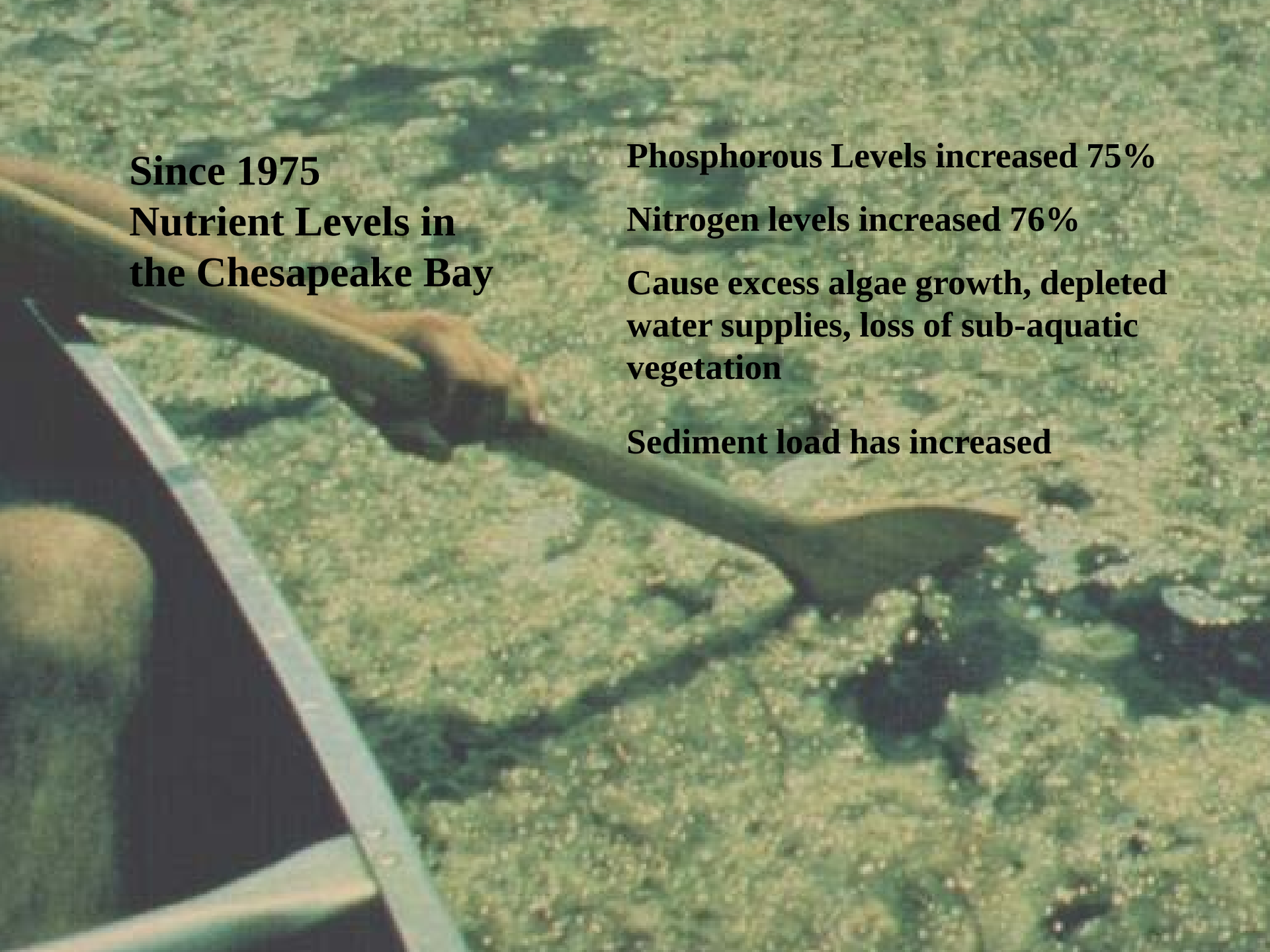
Water Resources

- Most groundwater is too deep to be economical to reach.
- Some aquifers have been so heavily pumped that their water levels have dropped too low for people to tap as a source.
- Quantity is not the only concern, the Quality is also under constant assault from a variety of sources.

Water Resources

- Humans pose the biggest threat to many aquifers and to the people who drink from them.
- Cities and farms are not the only groundwater polluters, natural gas drilling, mining, military bases, and saltwater intrusion, highway road banks, and construction sites.

Nutrient Impacts in Surface Waters



Since 1975
Nutrient Levels in the Chesapeake Bay

Phosphorous Levels increased 75%

Nitrogen levels increased 76%

Cause excess algae growth, depleted water supplies, loss of sub-aquatic vegetation

Sediment load has increased

Scope of Nitrogen and Phosphorus

- 16,00 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.

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

In parts per million or mg/l

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

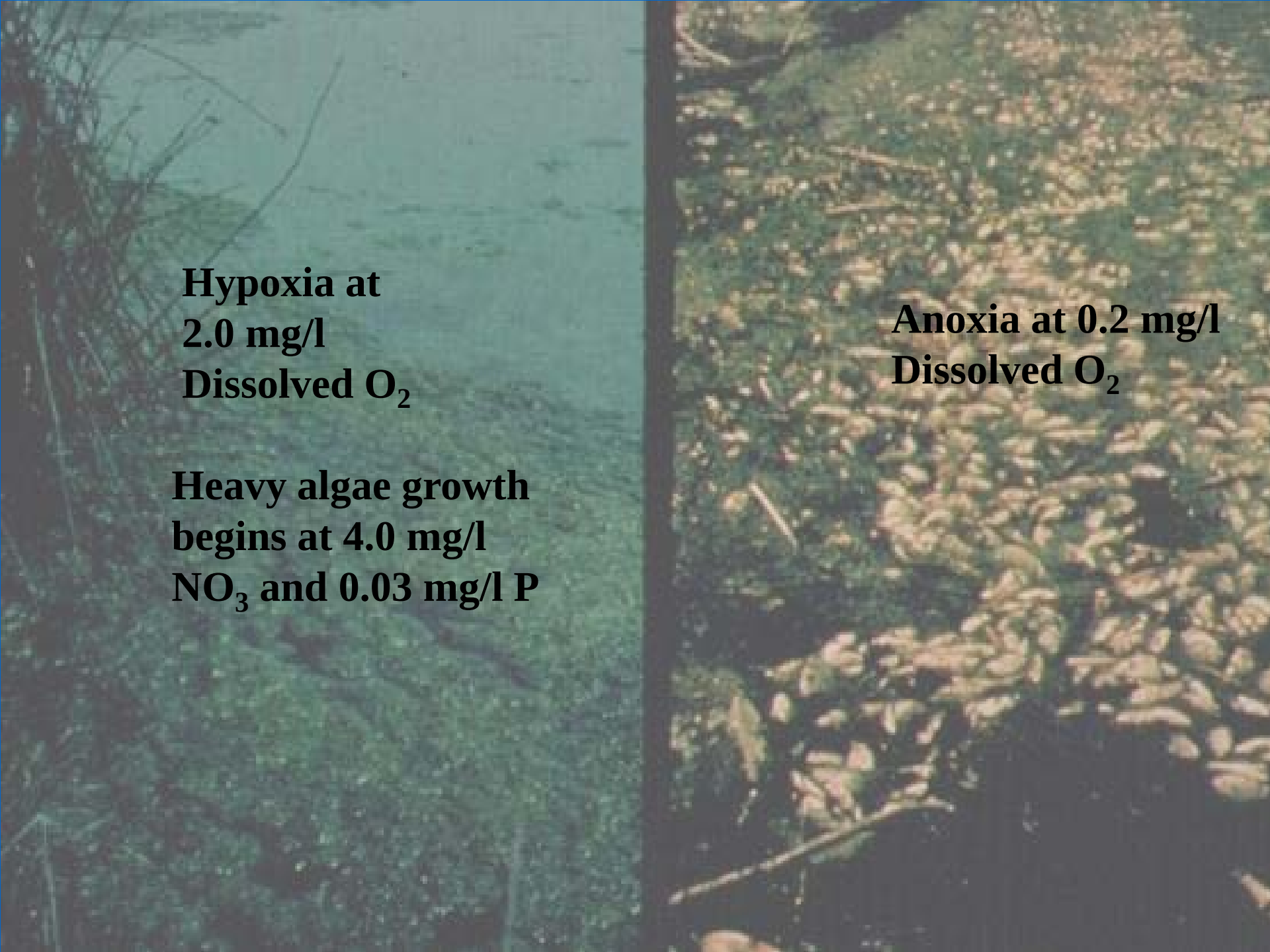
Nitrogen and Phosphorus

Surface Water Concerns

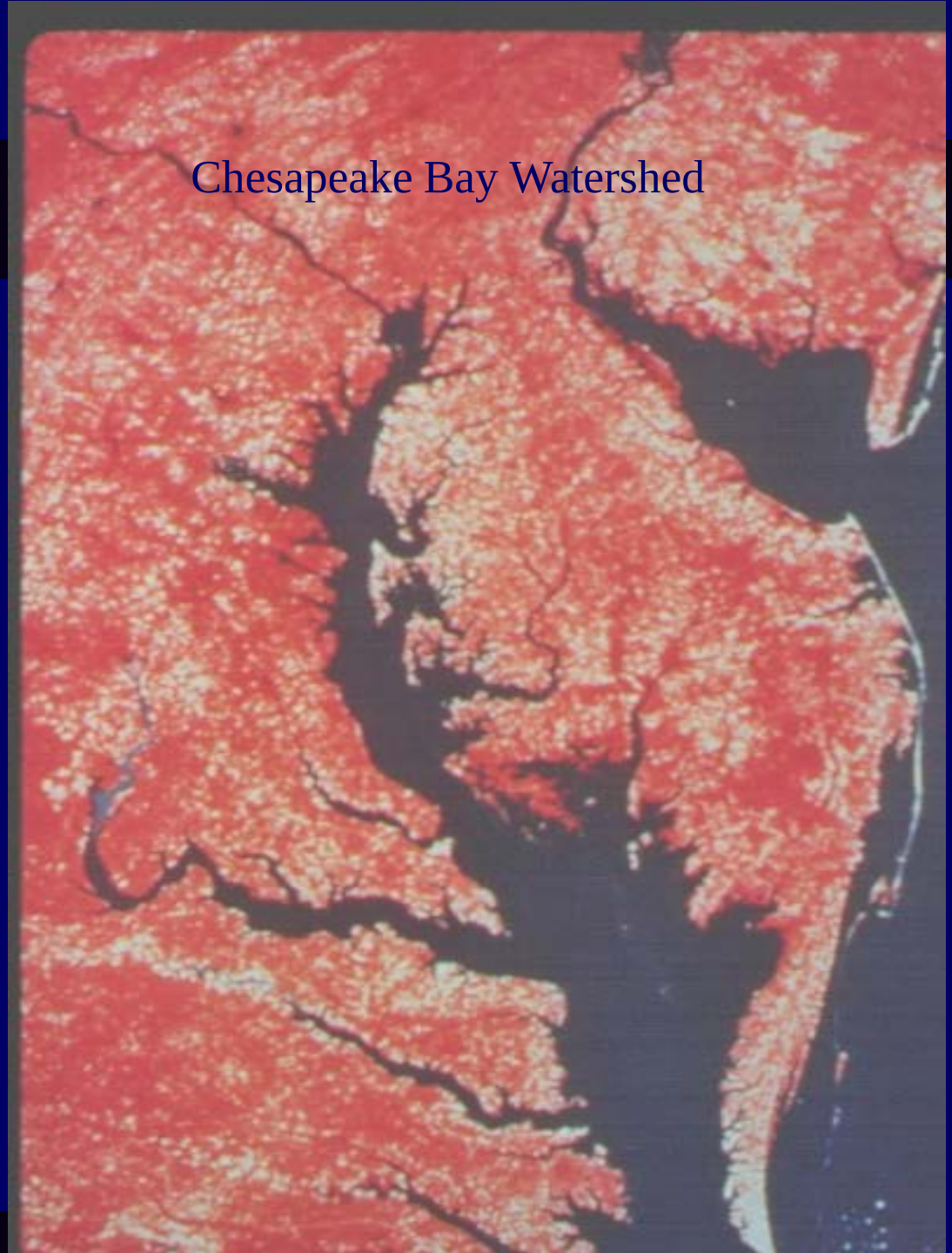
- Algae growth fertilized by nutrients esp. Phosphorous
- As algae die, decomposition process depletes dissolved oxygen needed by fish and other aquatic life
- Extreme cases cause fish kills
- Algae can cause taste and odor problems in drinking water and increased treatment costs
- Excessive phytoplankton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

DECOMPOSITION:

* Depletes the Oxygen Supply
* Releases Plant Nutrients

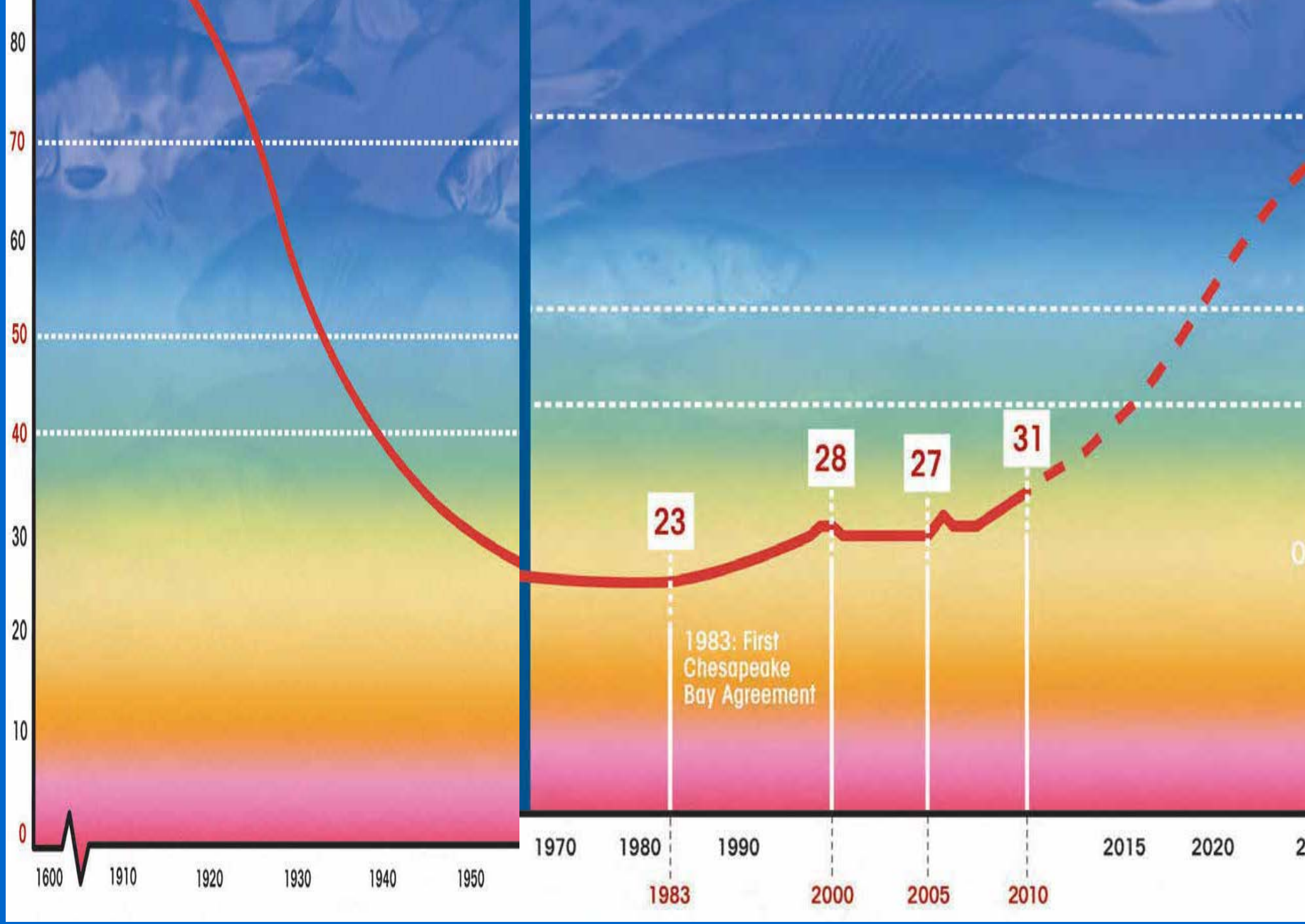

Hypoxia at
2.0 mg/l
Dissolved O_2
Heavy algae growth
begins at 4.0 mg/l
NO_3 and 0.03 mg/l P
Anoxia at 0.2 mg/l
Dissolved O_2

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)

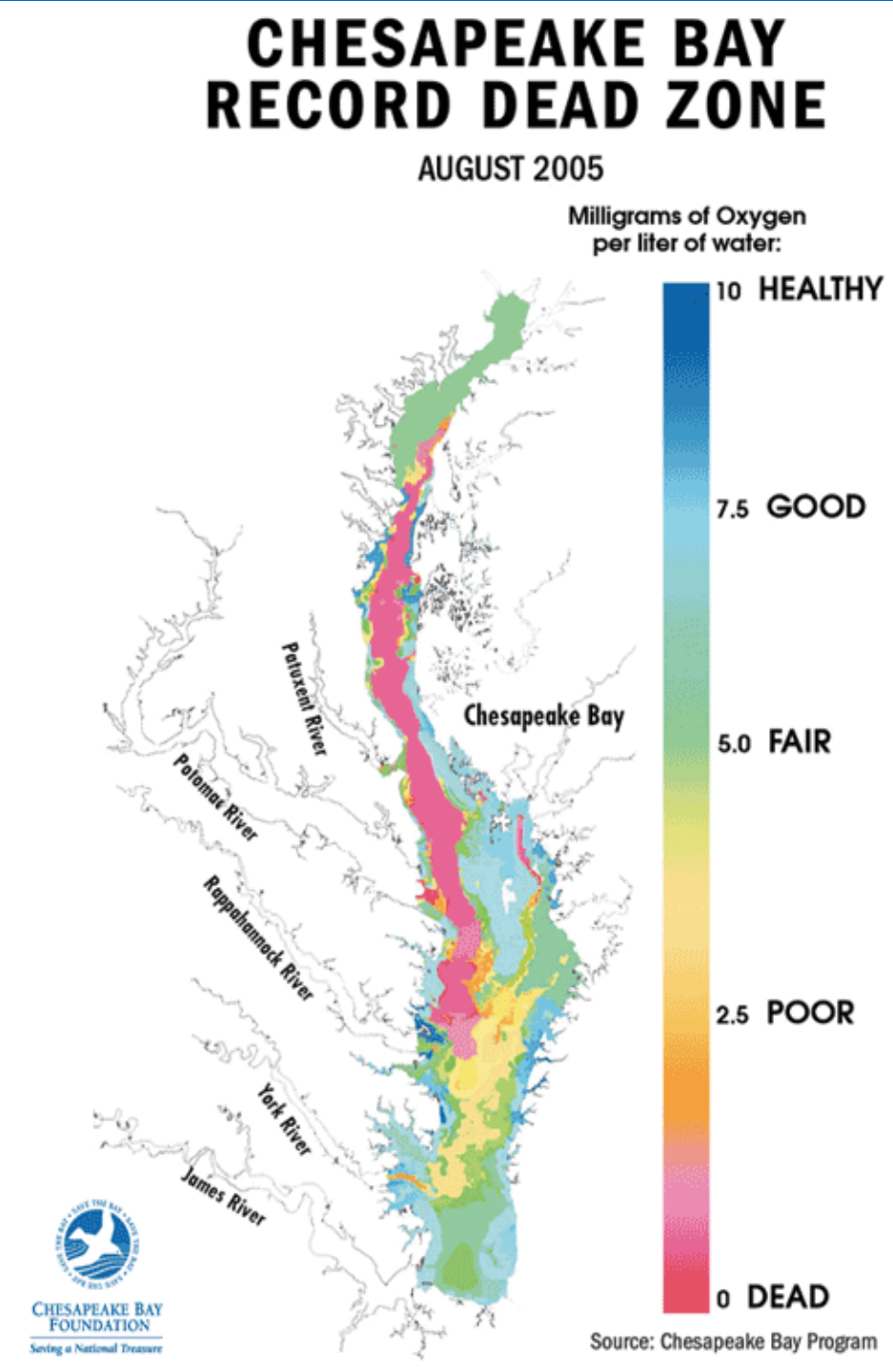

80
70
60
50
40
30
20
10
0
1600
1910
1920
1930
1940
1950
1970
1980
1990
2015
2020
23
28
27
31
1983: First Chesapeake Bay Agreement
1983
2000
2005
2010

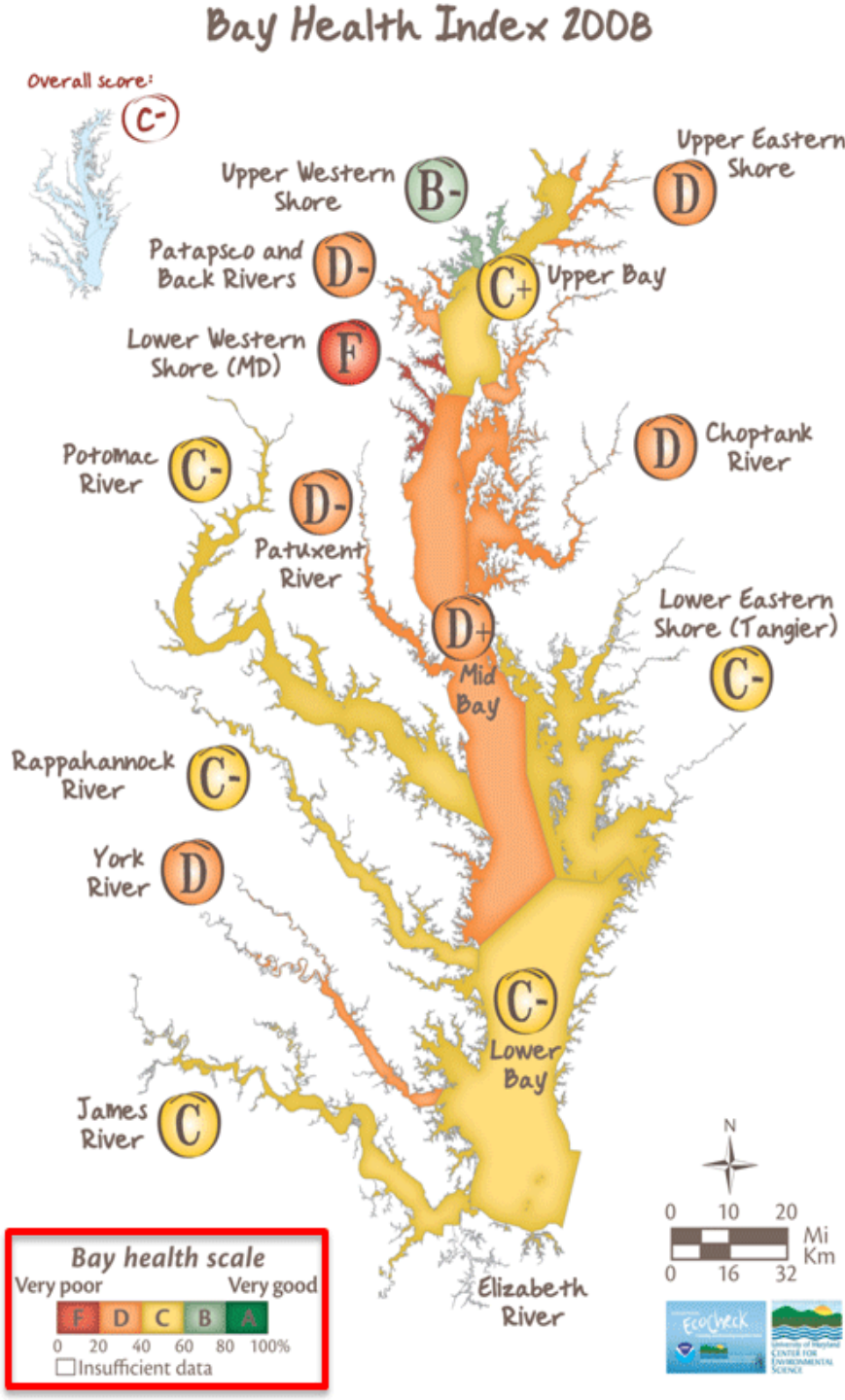
Impaired Waters

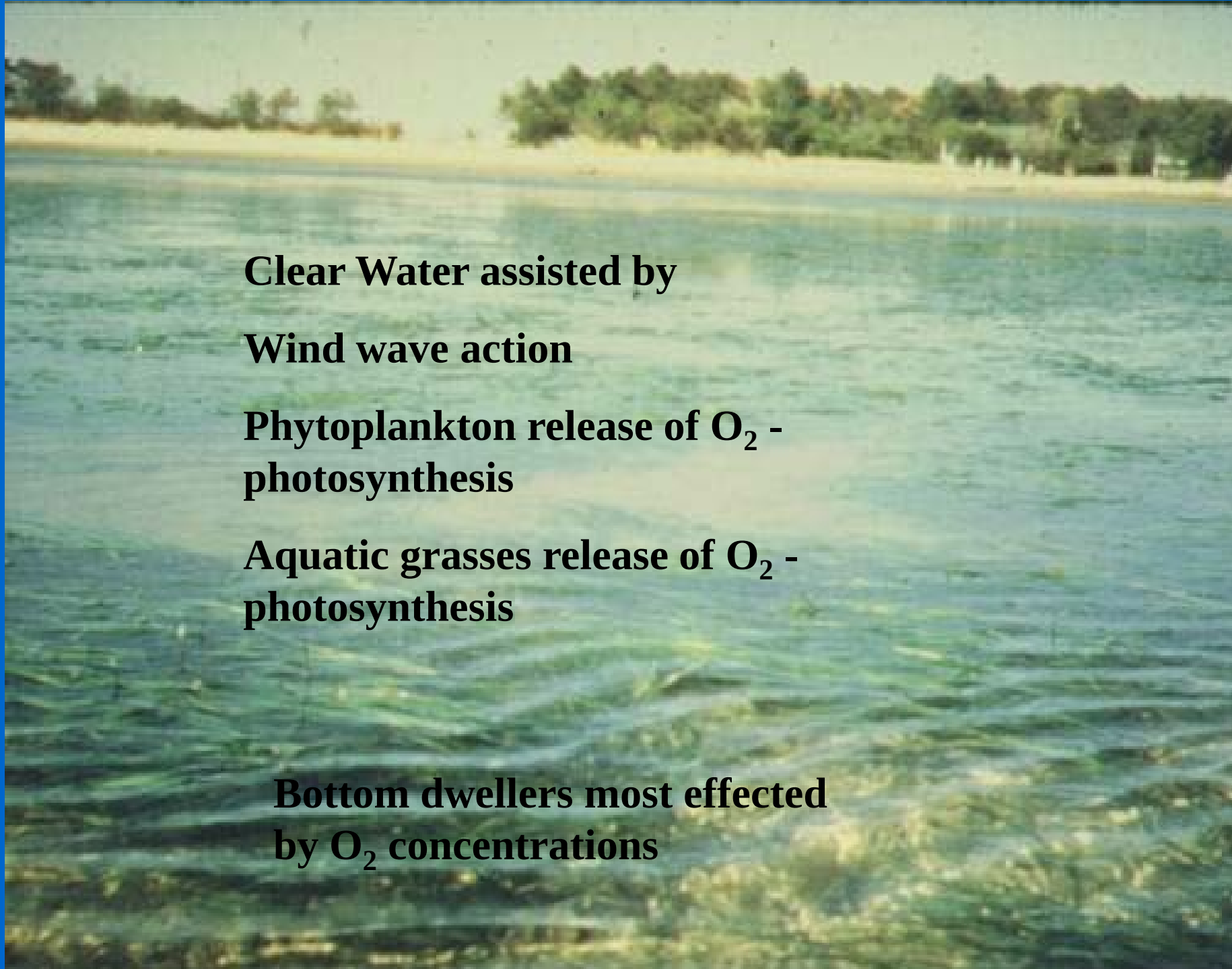
While most Legislation and Policy deal directly with the Health of The Chesapeake Bay Local Waters are Improved as Well.

CHESAPEAKE BAY RECORD DEAD ZONE

AUGUST 2005







Clear Water assisted by

Wind wave action

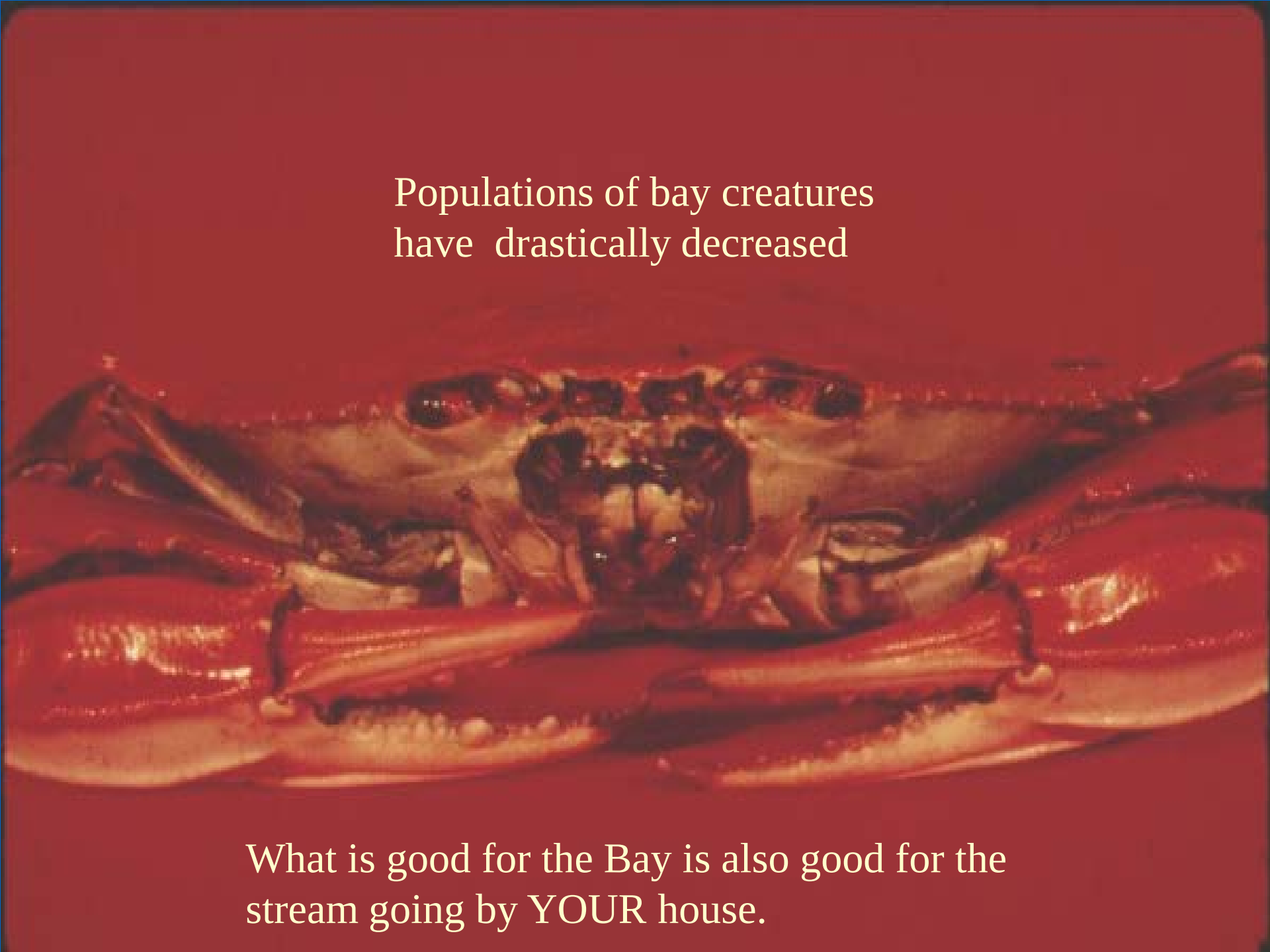
Phytoplankton release of O_2 - photosynthesis

Aquatic grasses release of O_2 - photosynthesis

Bottom dwellers most effected by O_2 concentrations

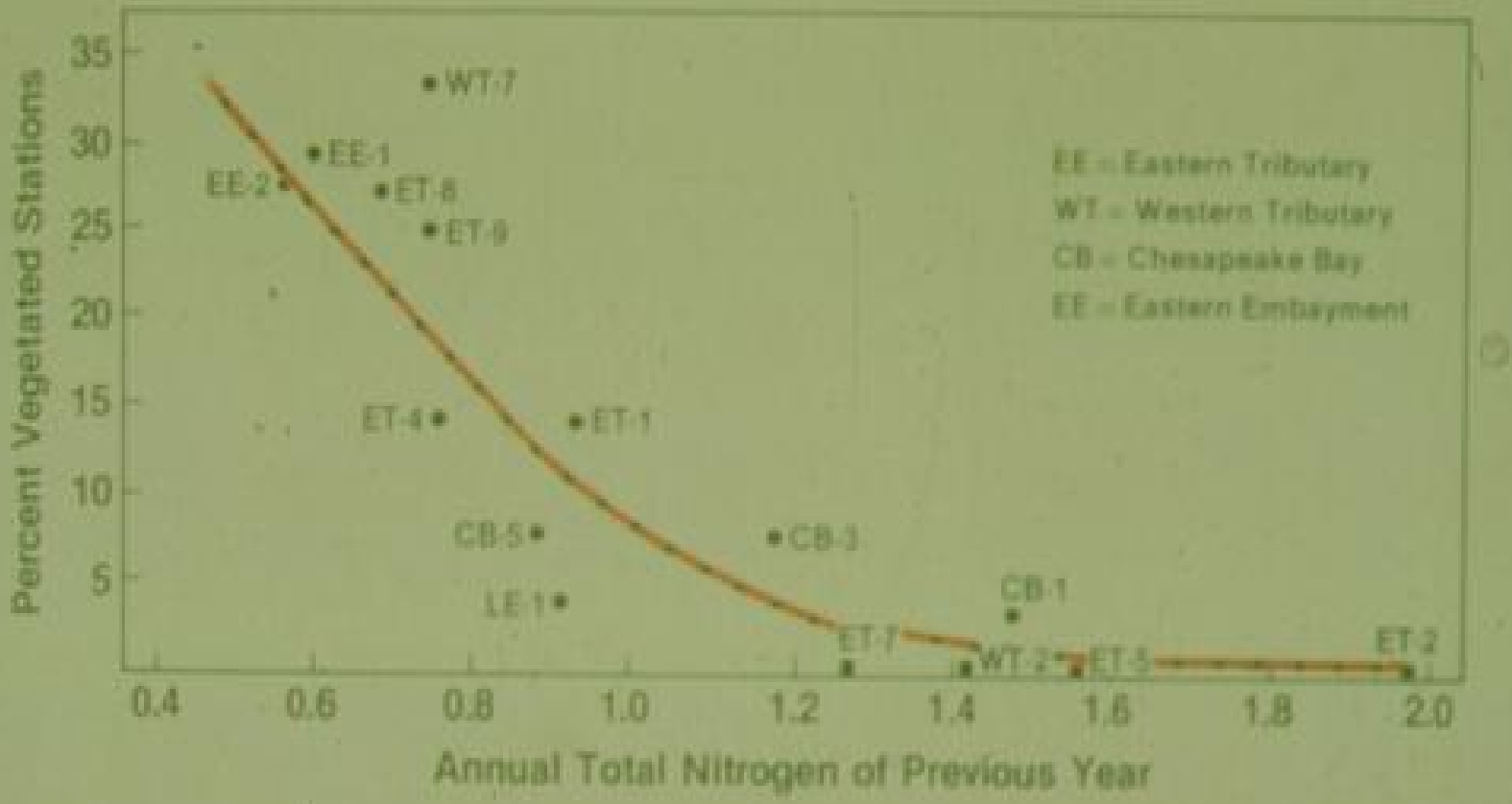
Bay's SAV acreage

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.

Groundwater

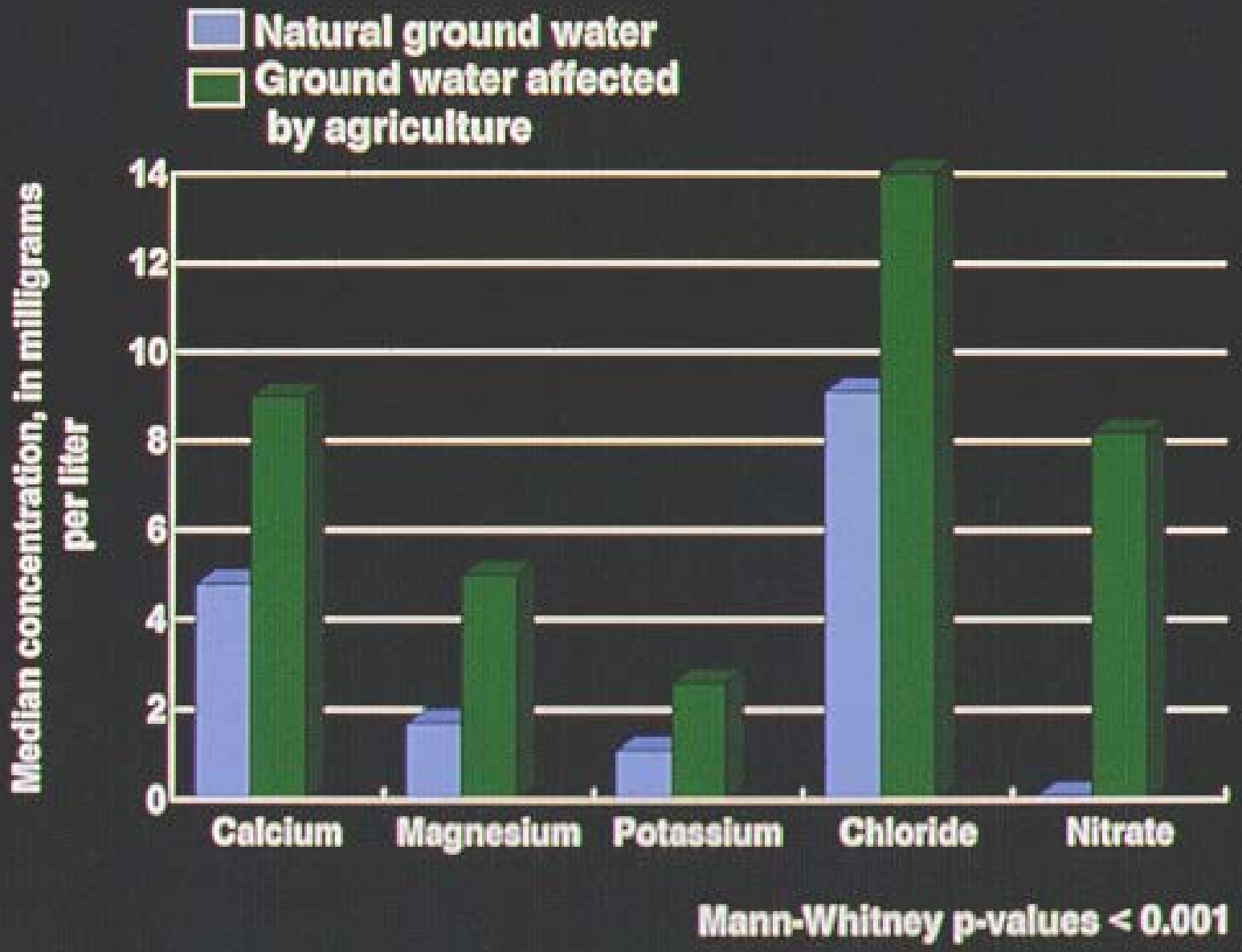
Nitrogen
Groundwater Concerns

- 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.
- Some evidence of livestock reproductive problems
- Drinking Water Nitrate Violations have doubled in the last 8 yrs.

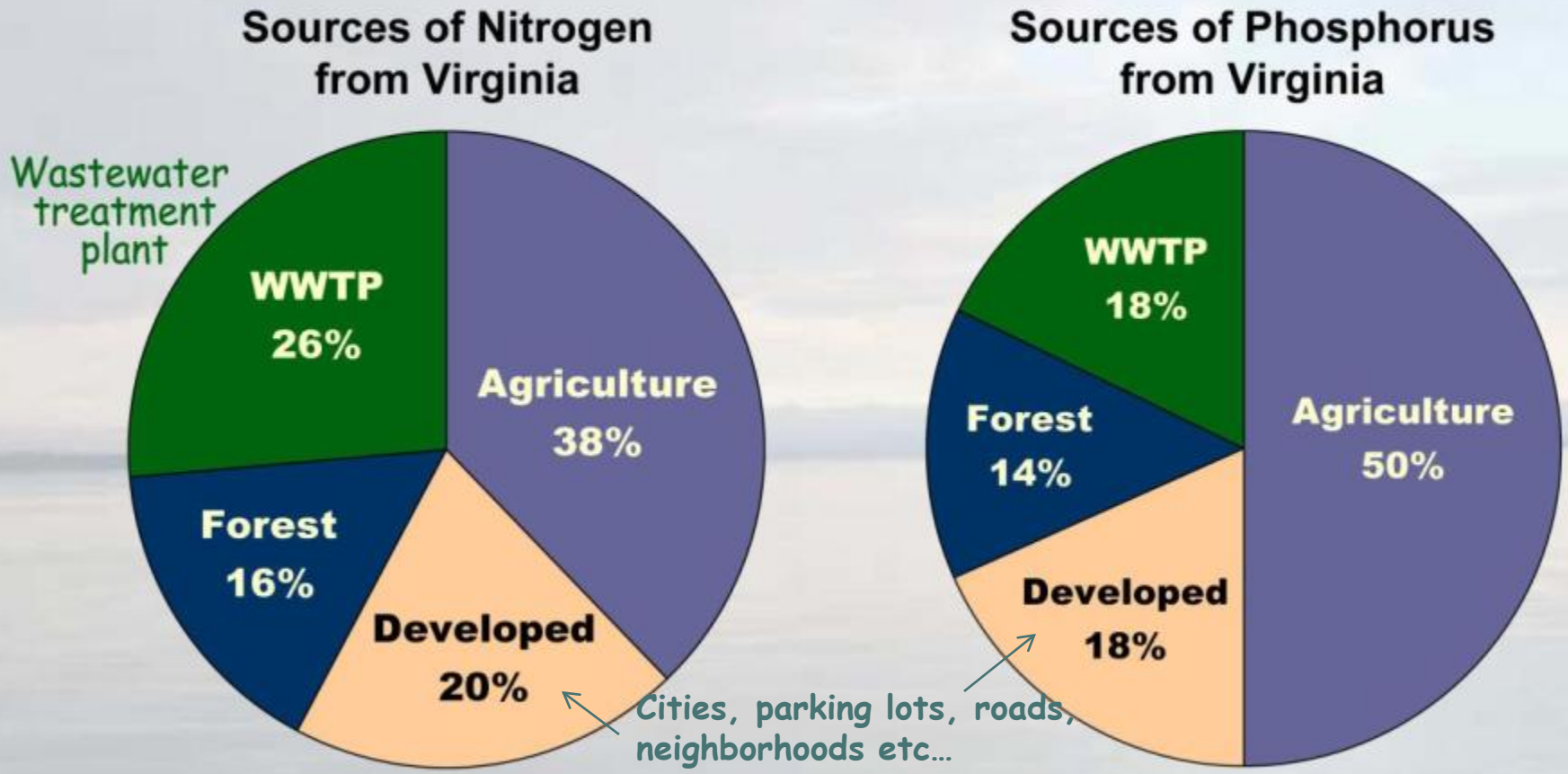
Runoff and Leaching

- 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.

USGS Delmarva Study 1992



Nutrient Sources of VA



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

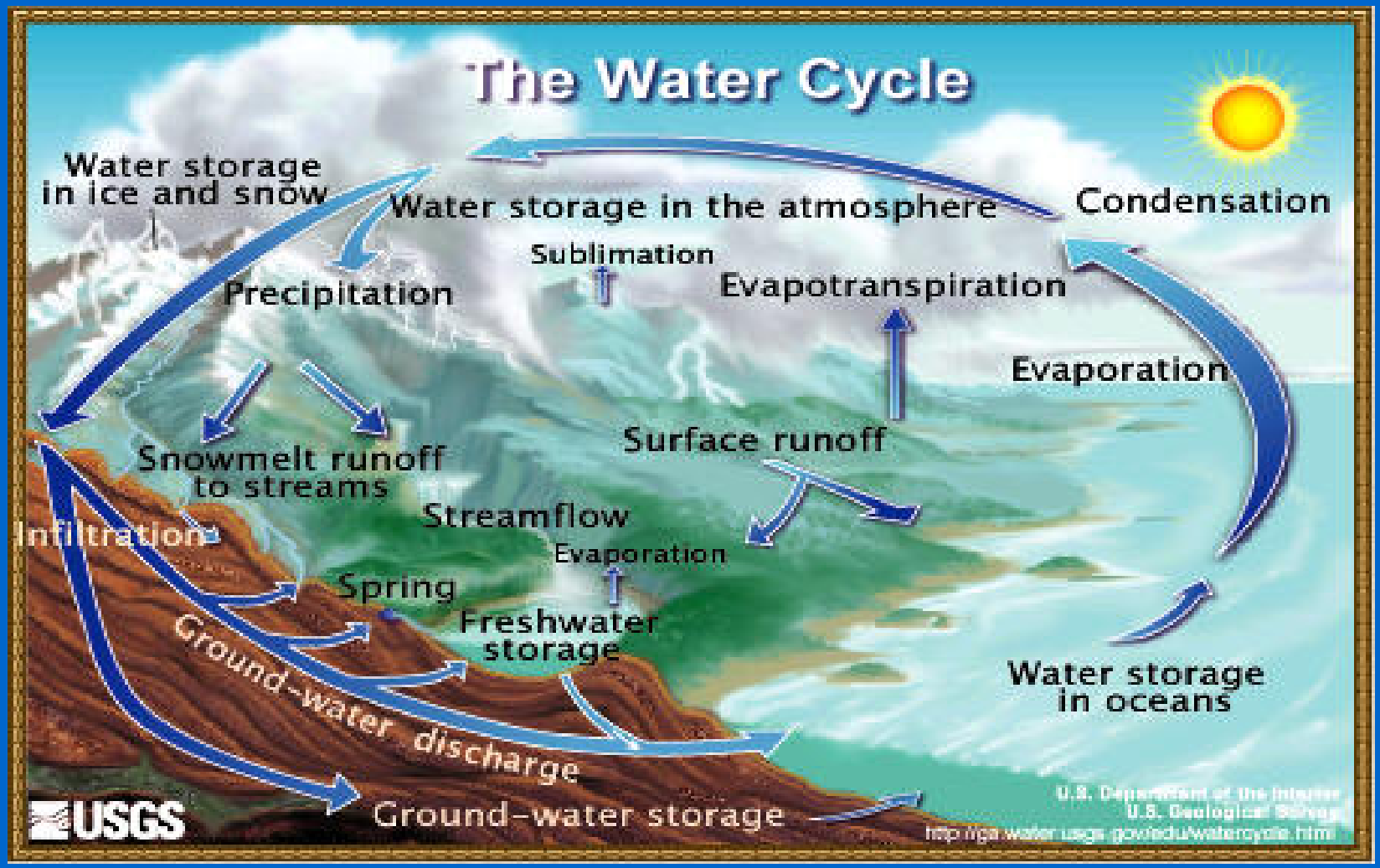
More Nitrate Facts……

Range: 0.46 to 48mg/l N concentrations found in groundwater.

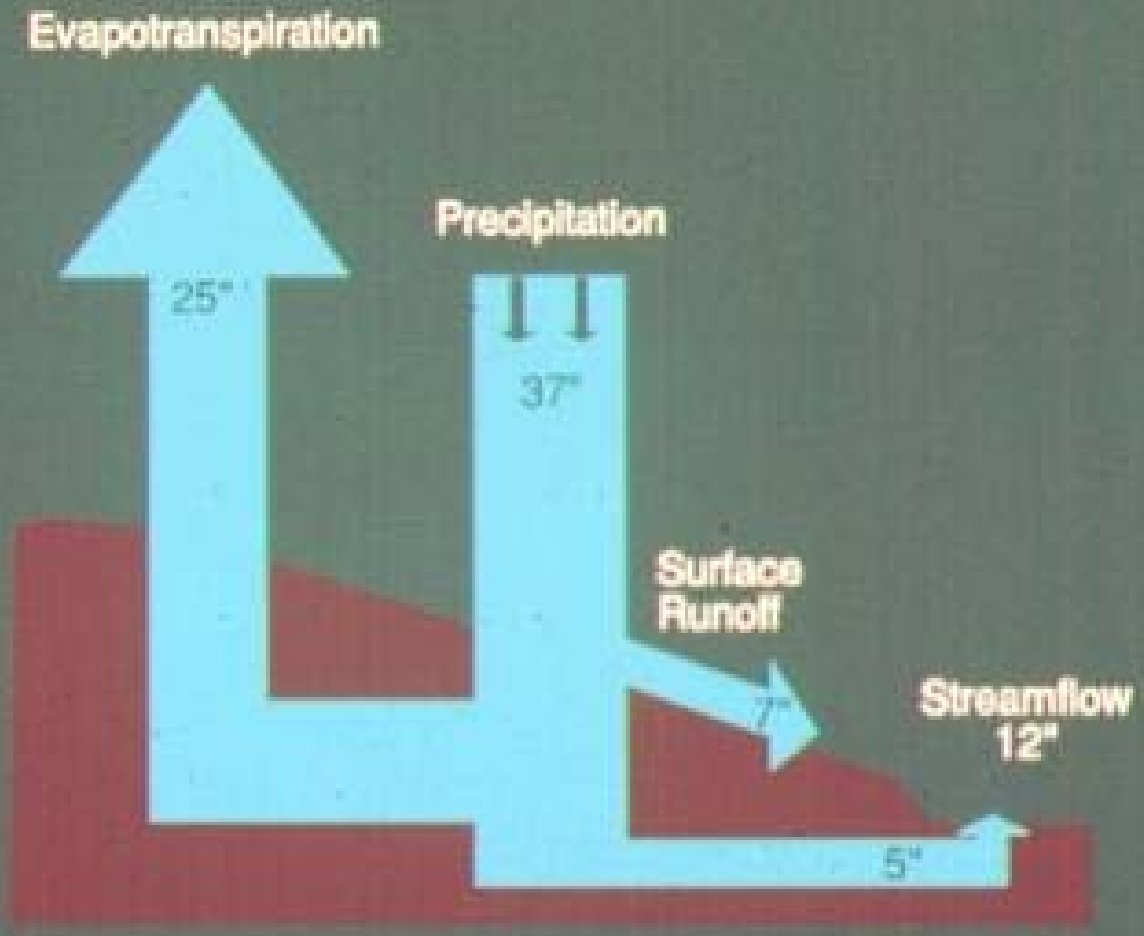
Groundwater in 26 percent of all wells tested exceed EPA drinking water standard of 10.0 mg/l as N

Highest Nitrate concentrations commonly found at the base of the aquifer.

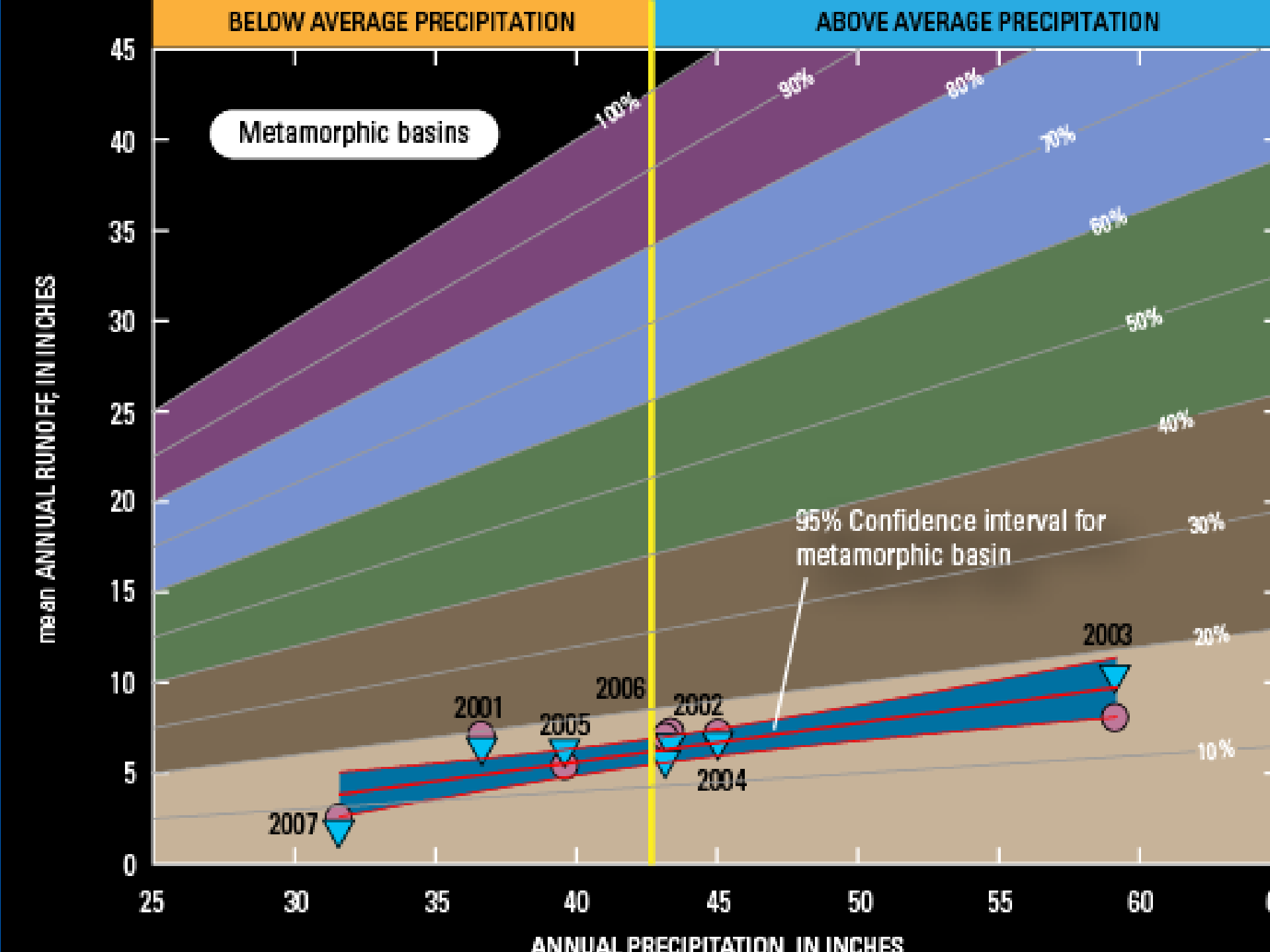
Hydrologic Cycle



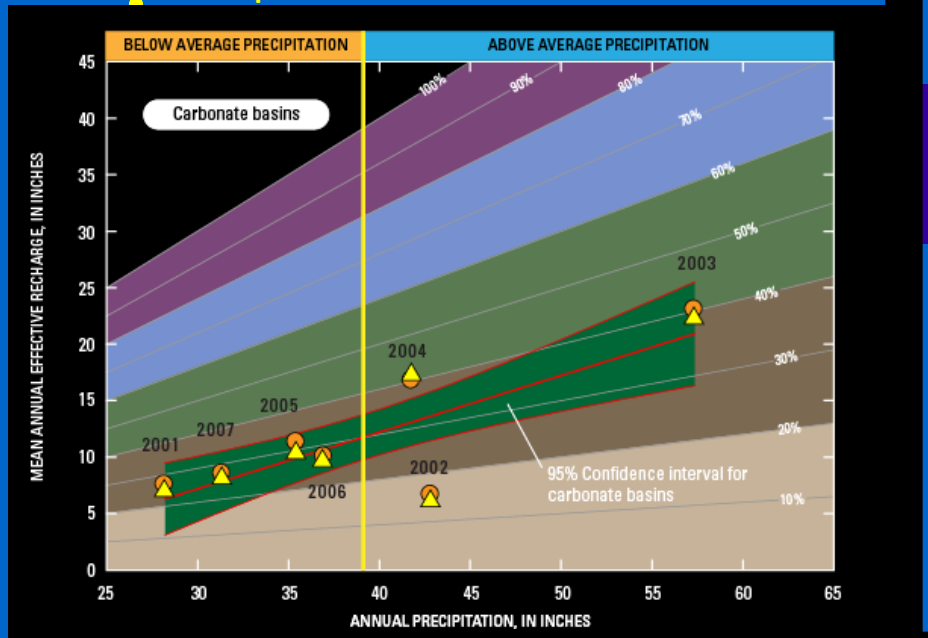
General Water Budget
Upper South Fork Shenandoah River Subarea

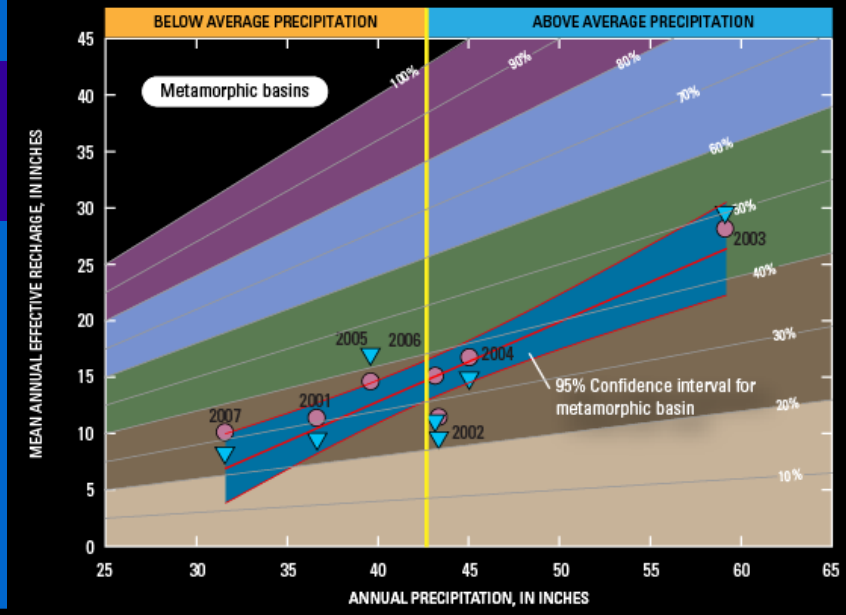


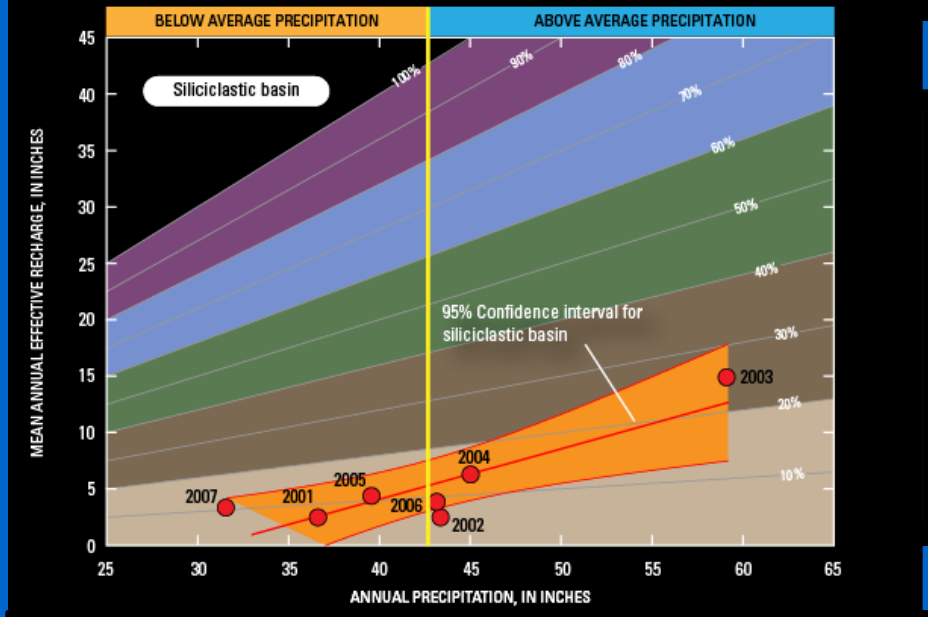
State Water Control Board, 1991


BELOW AVERAGE PRECIPITATION
ABOVE AVERAGE PRECIPITATION
Metamorphic basins
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
95% Confidence interval for metamorphic basin
2001
2005
2006
2002
2003
2004
2007
mean ANNUAL RUNOFF, IN INCHES
0
5
10
15
20
25
30
35
40
45
25
30
35
40
45
50
55
60
ANNUAL PRECIPITATION, IN INCHES

Annual Precipitation and Mean Annual Effective Recharge







Clarke County Carbonate Basins

01616100 Dry Marsh Run at Route 645 near Berryville, Va.
01636316 Spout Run at Route 621 near Millwood, Va.

Warren County Metamorphic Basins

01630700 Gooney Run at Route 622 near Glen Echo, Va.
0163626650 Manassas Run at Route 645 near Front Royal, Va.

Warren County Siliciclastic Basin

01636242 Crooked Run below Route 340 at Riverton, Va.

USGS science for a changing world

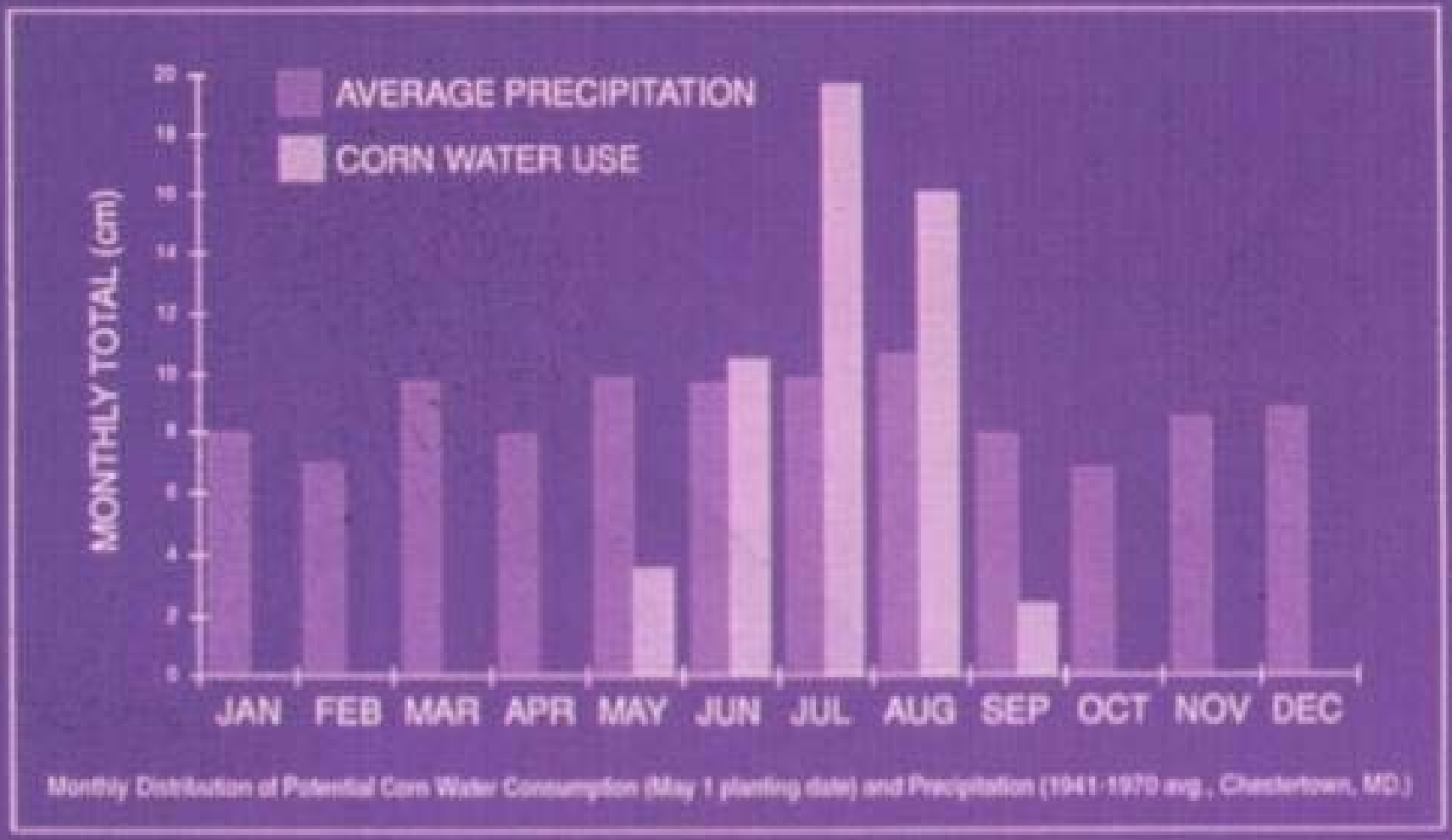
USGS Study Results

- 85 percent of a Virginia's streams get more than 50% of their base flow from ground water.

Personal Communication: David Nelms, USGS

Figure 4 - 3

Monthly Corn Water Use in the Mid-Atlantic Region



Monthly Distribution of Potential Corn Water Consumption (May 1 planting date) and Precipitation (1941-1970 avg., Chestertown, MD.)

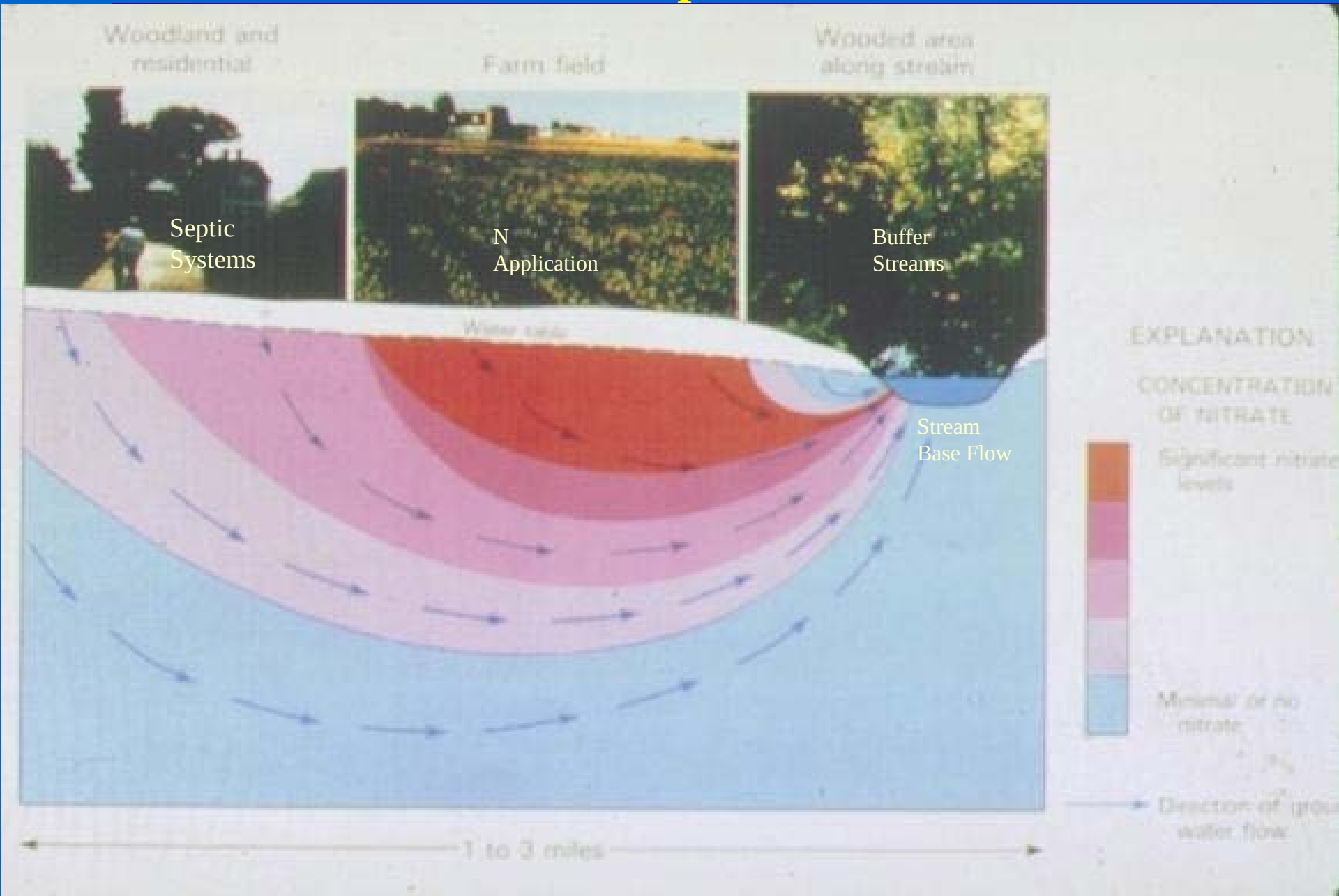
Source: Staver, Stevenson, and Brinsfield, 1988

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

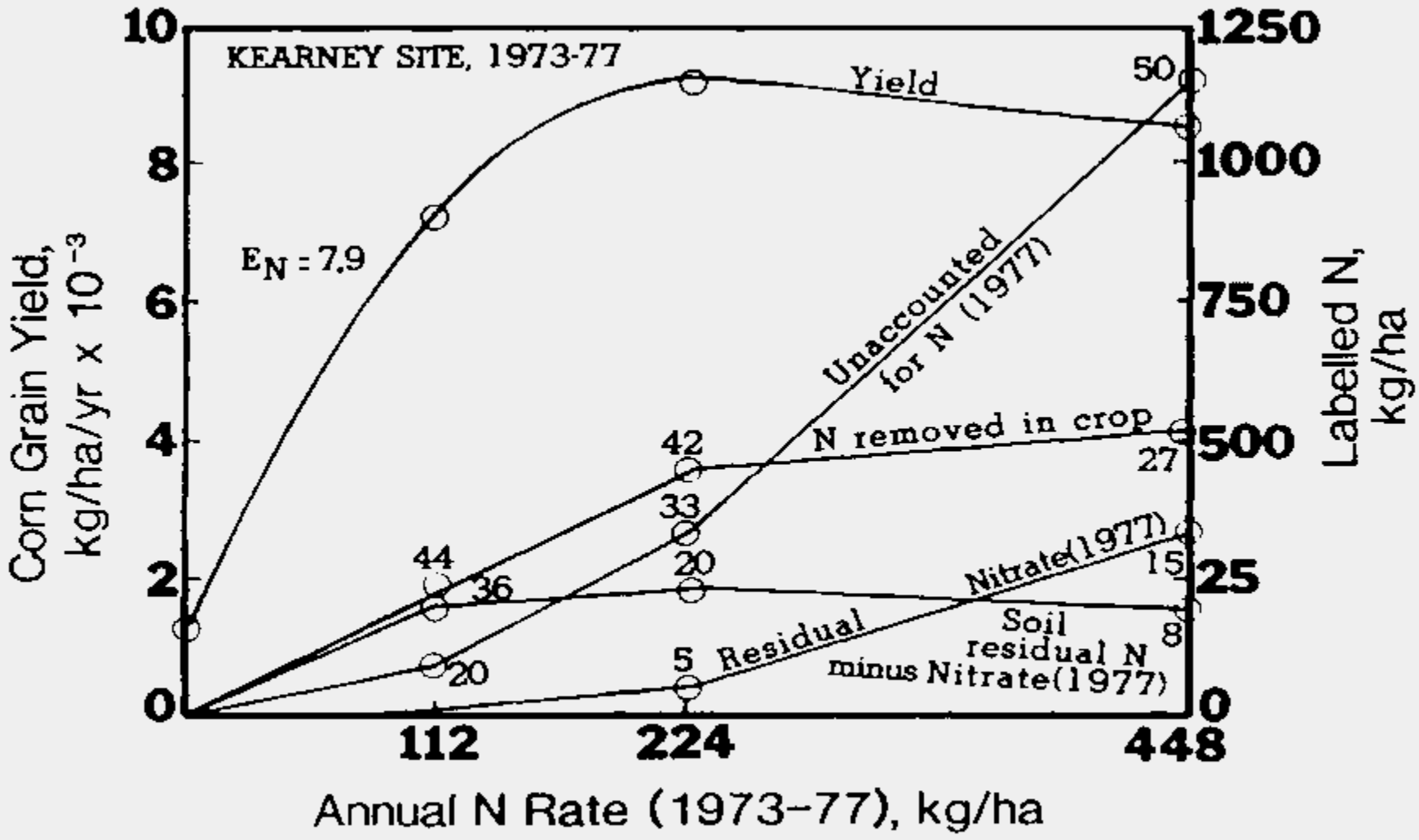
- Rate of application
- Timing of application
- Placement of nutrients
- Cover crops (Trap crops)

Yield Capability of Soil and Nitrogen Rate

Sandy soil 80 bu/ac

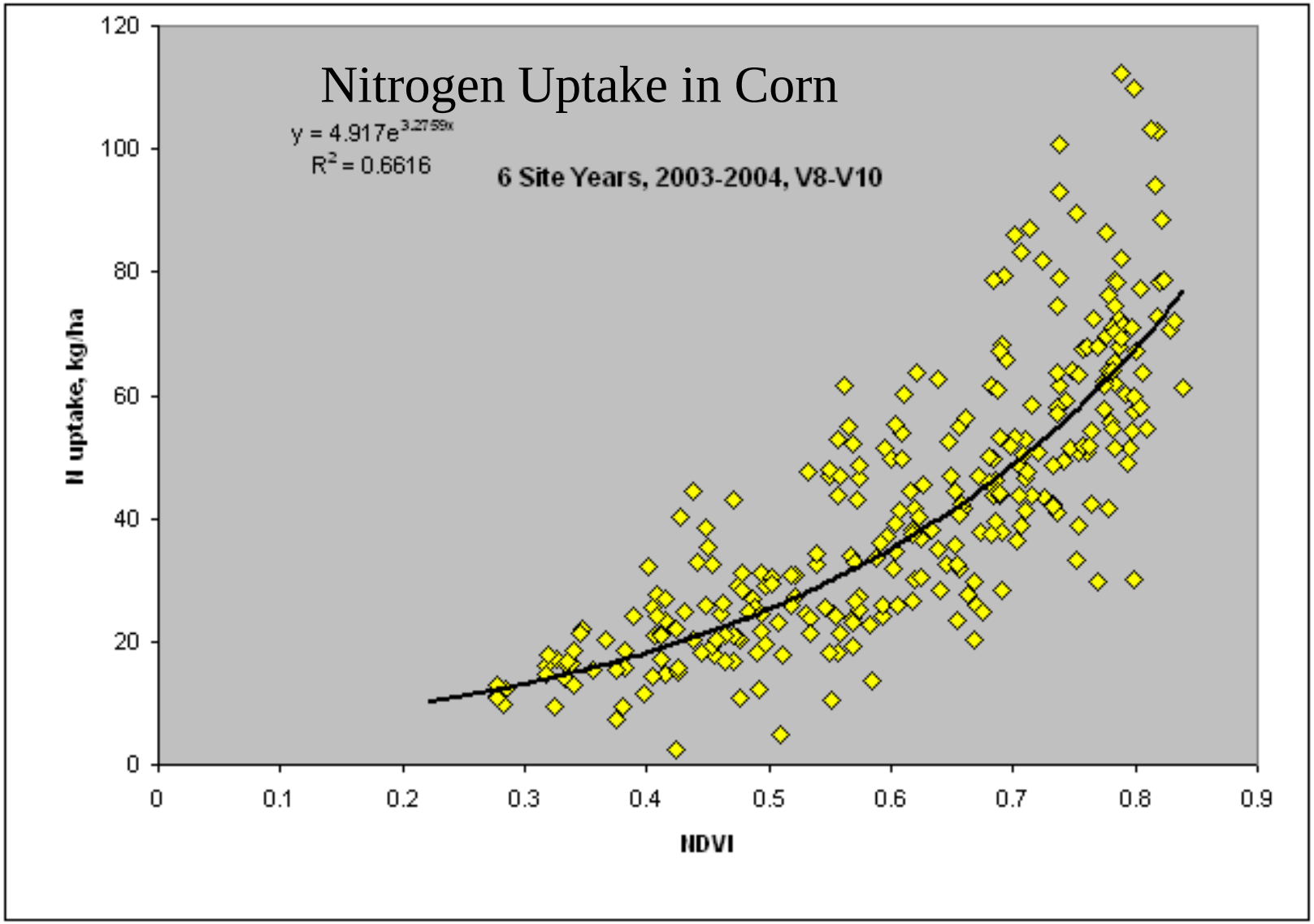
Loamy soil 150+bu/ac

N Rate Impact on N Losses



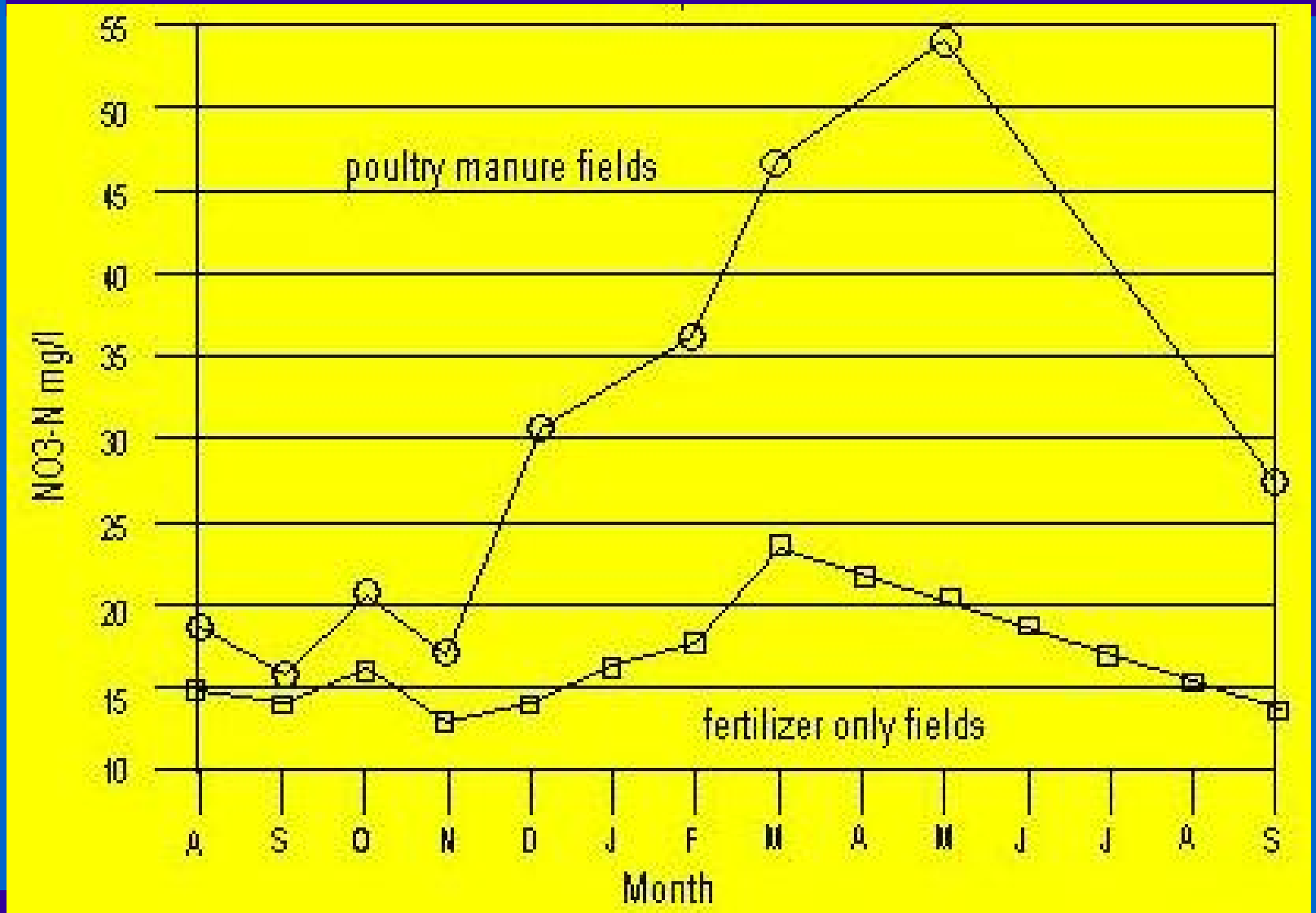
Timing of Applications

When is the best time to apply nutrients to crop?

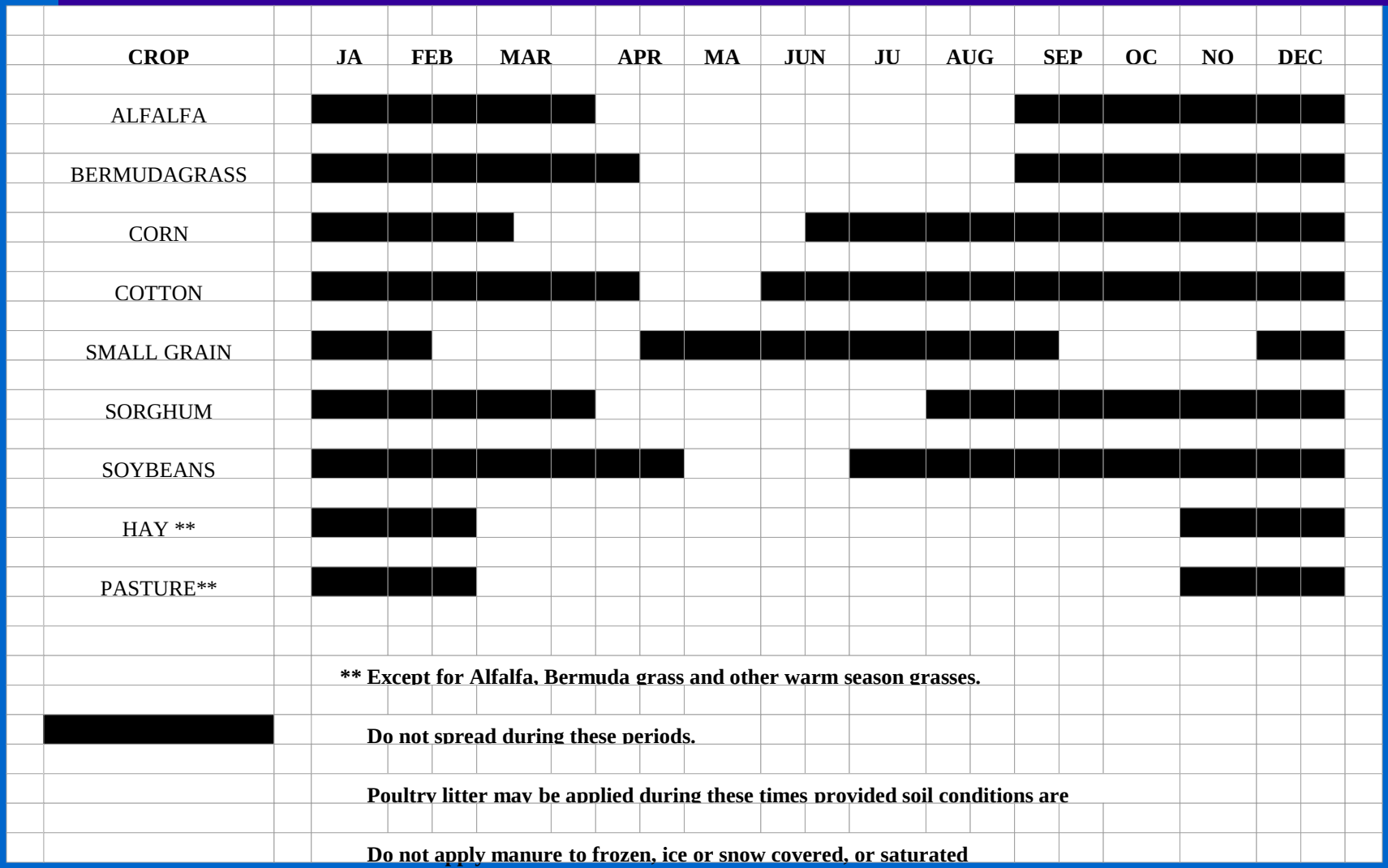

Nitrogen Uptake in Corn
y = 4.917e^3.2759x
R² = 0.6616
6 Site Years, 2003-2004, V8-V10
N uptake, kg/ha
NDVI
0
20
40
60
80
100
120
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

NO_3-N Concentration in Groundwater

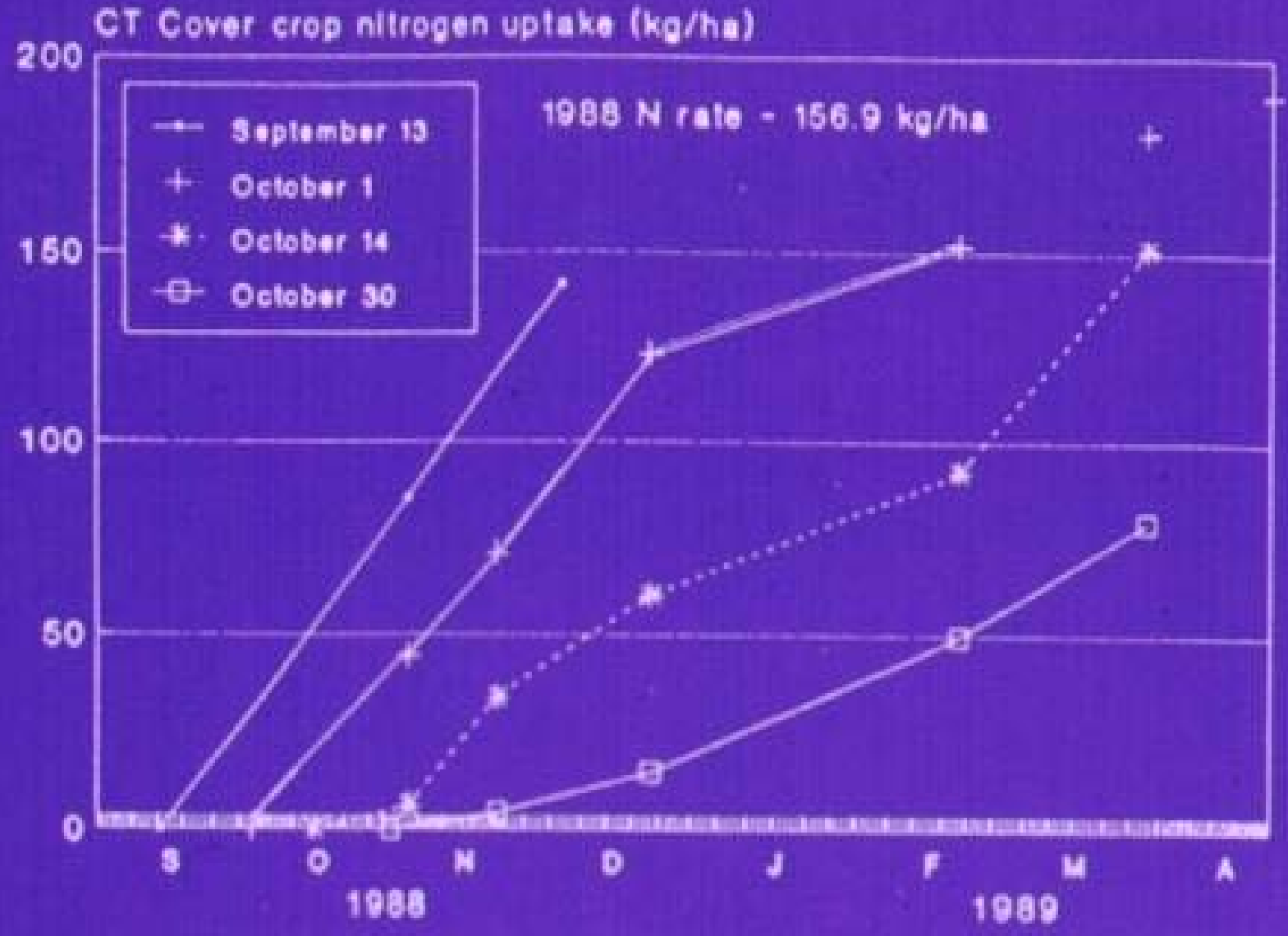
as affected by **improperly timed** poultry manure on corn
Weil, 1990



Manure Spreading Schedule



Cover Crops



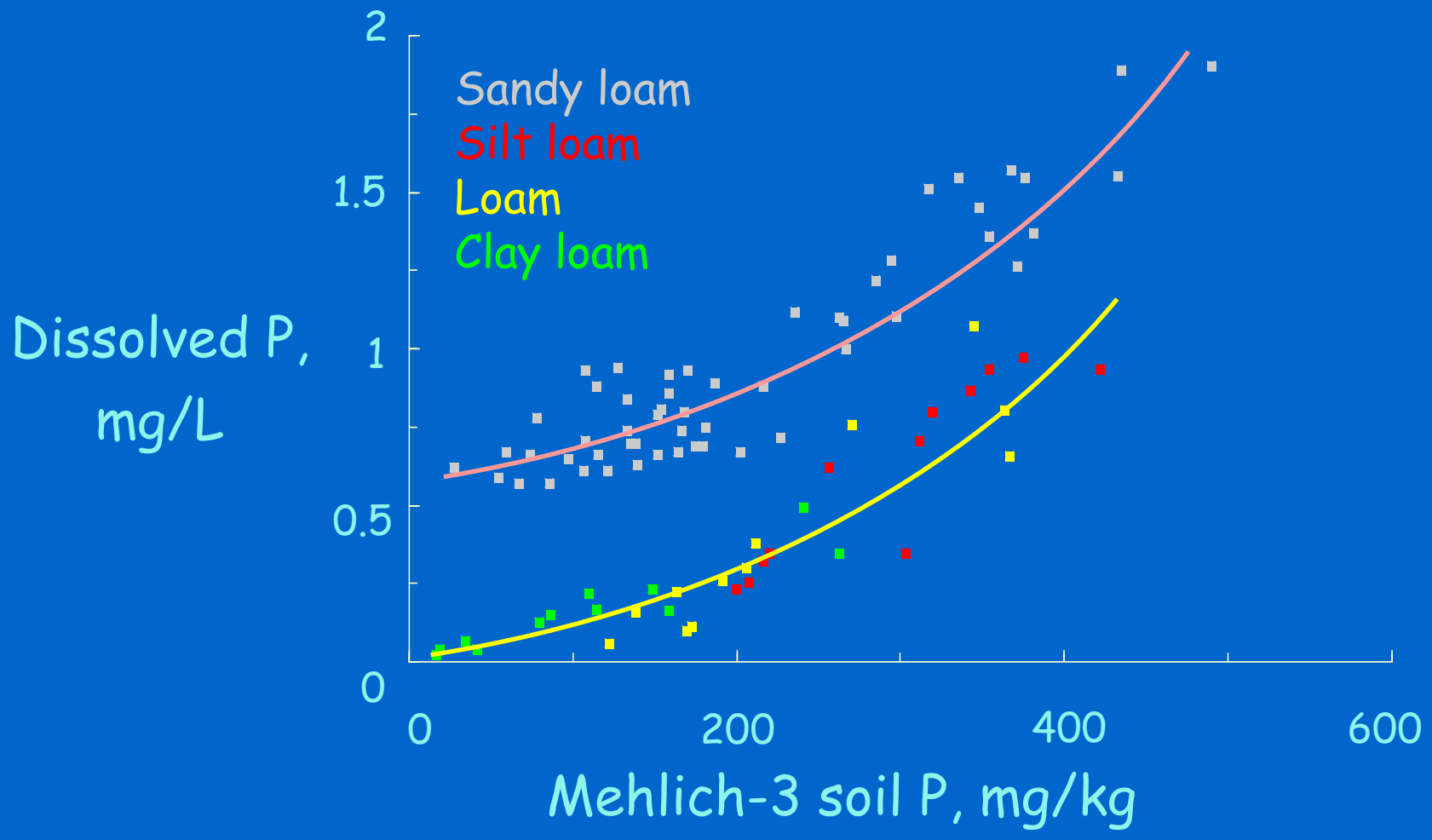
Above-ground cover crop nitrogen assimilation in the CT treatment area as a function of planting date following the 1988 corn harvest.

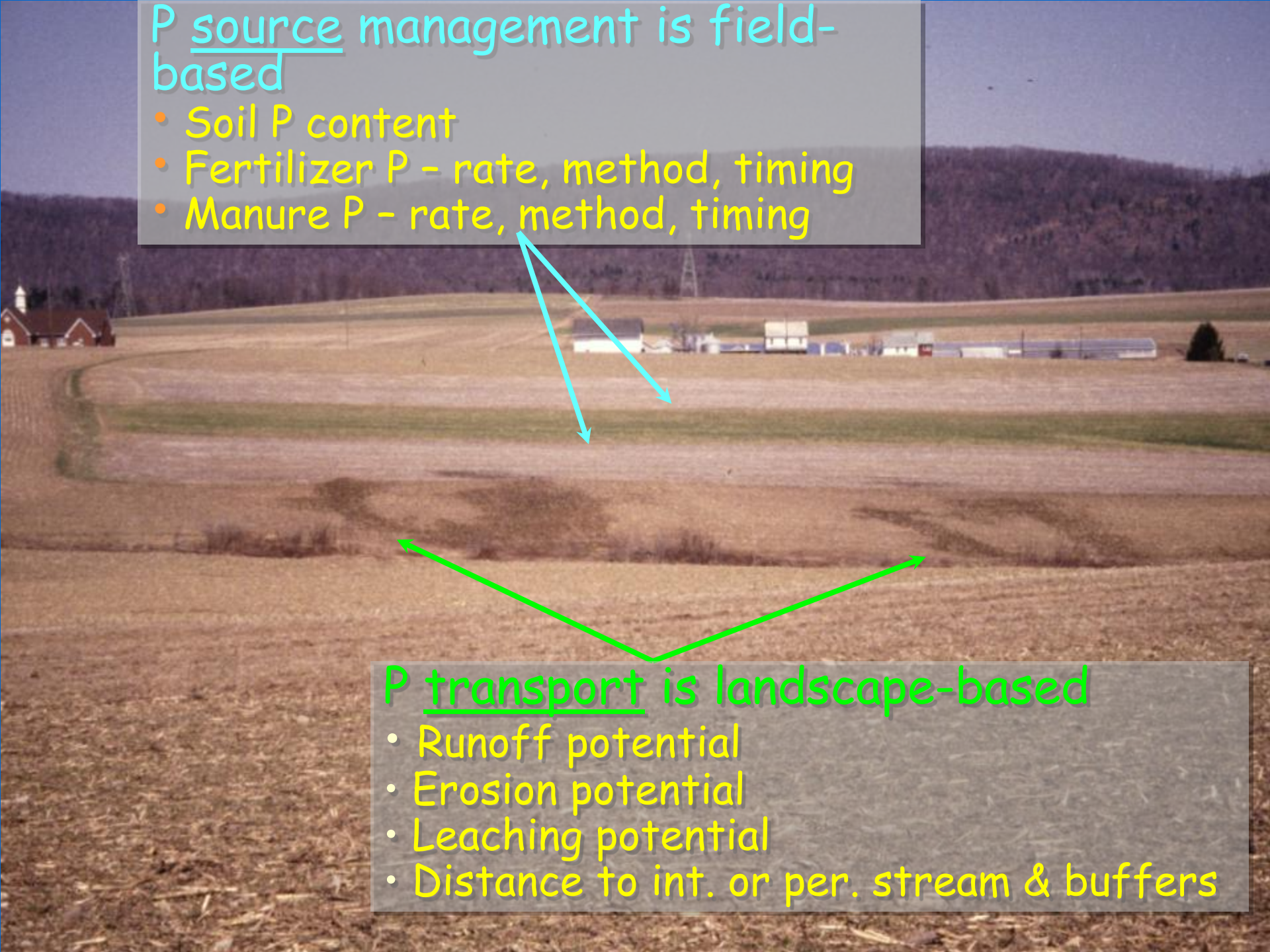
Phosphorus Management

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

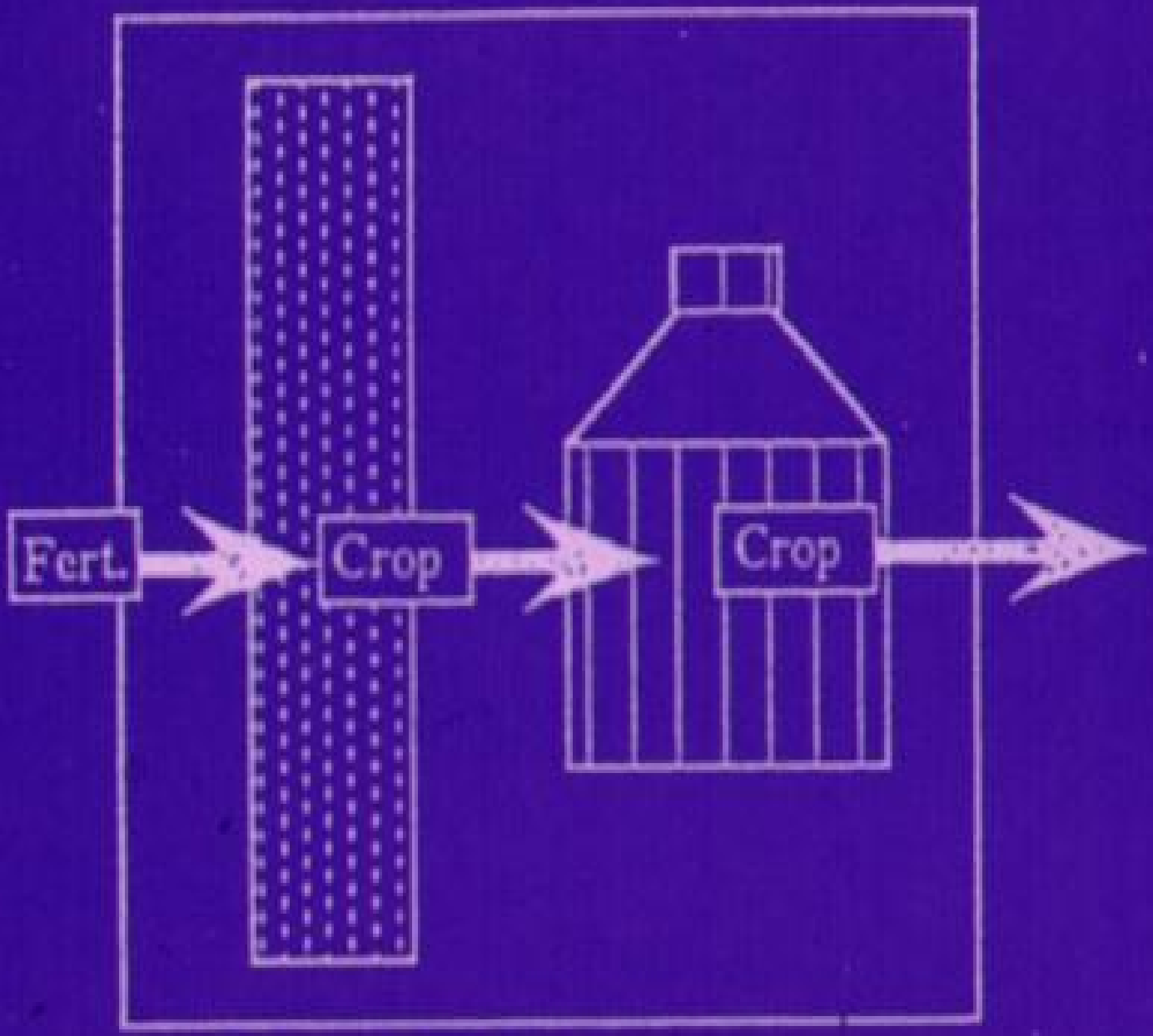



P source management is field-based
• Soil P content
• Fertilizer P – rate, method, timing
• Manure P – rate, method, timing
P transport is landscape-based
• Runoff potential
• Erosion potential
• Leaching potential
• Distance to int. or per. stream & buffers

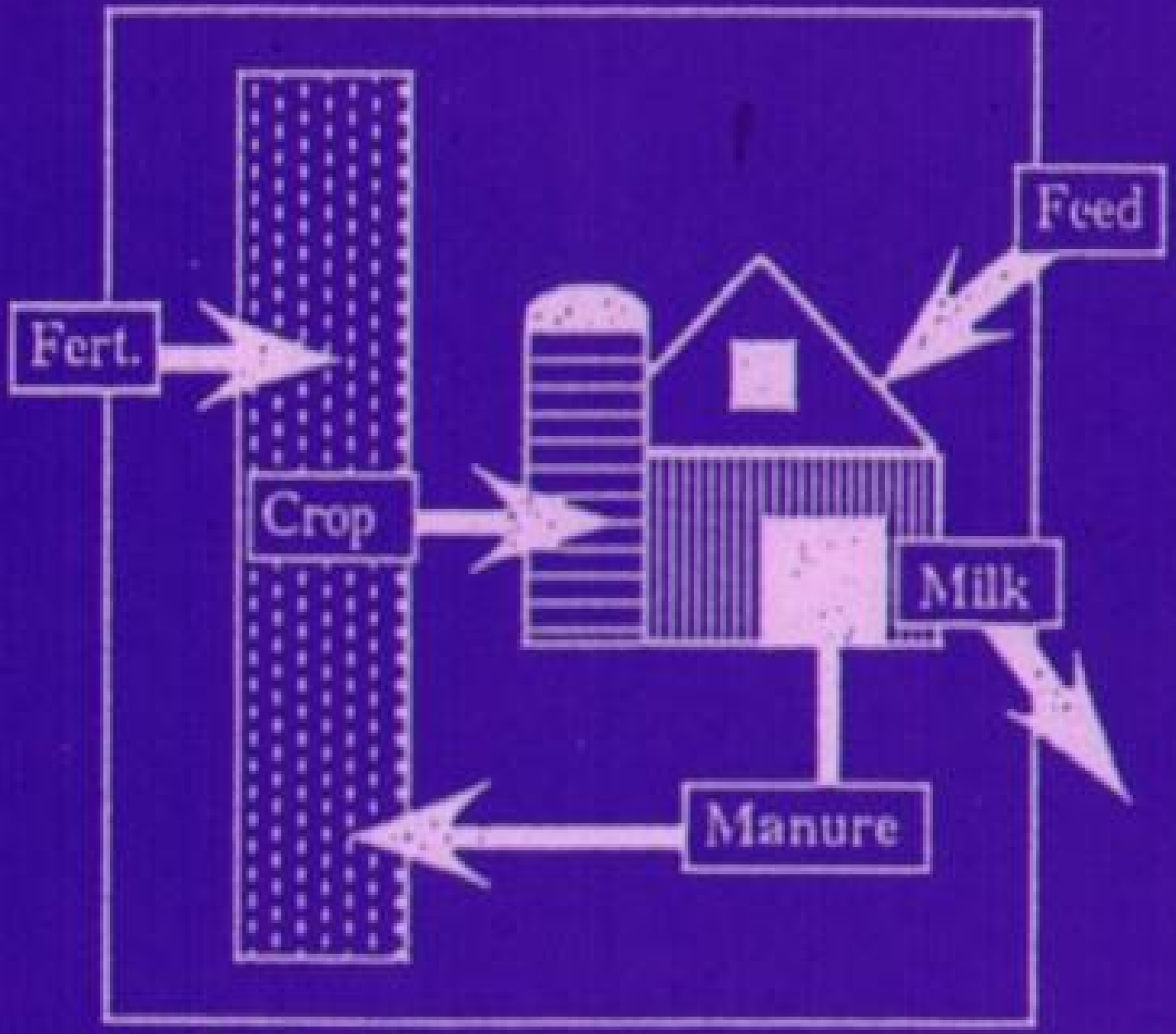
Nutrient Practices to Reduce Phosphorus Pollution Potential

- 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

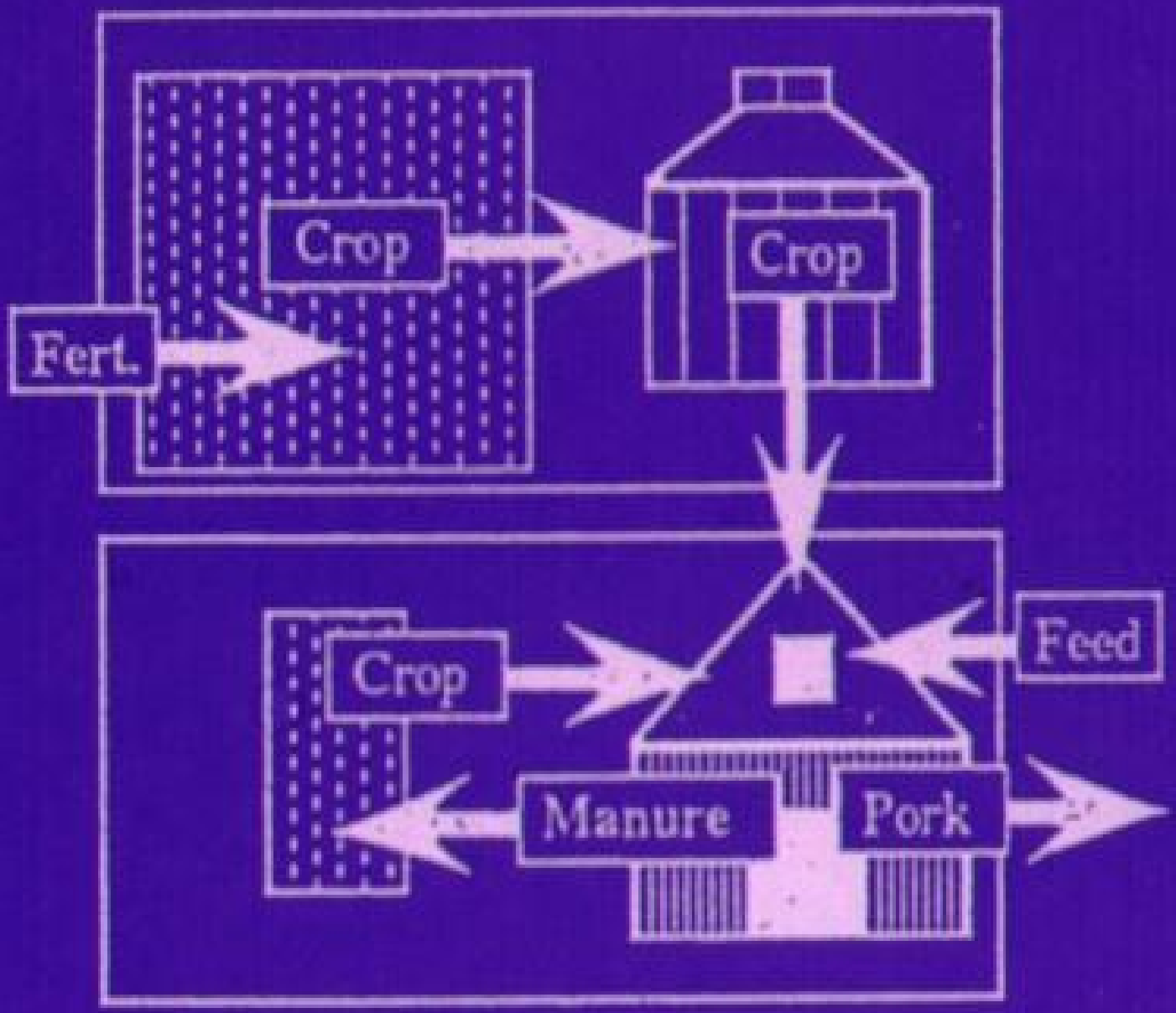
Nutrient Cycling on Farms



a. Cash Crop Farm



b. Dairy Farm



c. Intensive Swine Farm

Environmentally Sensitive Sites

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 – pg 2

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


< Sinkholes
Rock Outcrop >

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

Importance of Good Soil Management

- Reduce soil erosion by matching technology to situation
- Conservation tillage/No-till reduces soil disturbance and preserves cover
- Strip cropping, contour farming, filter strips are beneficial and economical
- Grassed waterways and terraces may be required
- Careful use of fertilizers, animal wastes, & pesticides

Conclusion

- Many agricultural and industrial practices can threaten OUR water quality if soil properties are poorly understood or ignored. These threats are serious, but are manageable. Water quality can be improved while protecting the productivity and value of the soil for all uses.
- We can have both healthy soil and clean water by applying Good Soil Management Practices!
- Timothy.Sexton@dcr.virginia.gov
- 804-371-0061

DCR

Department of Conservation & Recreation

CONSERVING VIRGINIA'S NATURAL AND RECREATIONAL RESOURCES