c1

NITROGEN BACKGROUNDER

Interventions, Control Options, and Economics

The **Nitrogen Backgrounder** is a set of five presentations (or modules) and a depository of supporting documents on the subject of reactive nitrogen (rN). At the request of the Associate Administrator for the Office of Policy, Economics, and Innovation (OPEI), National Center for Environmental Economics in the Office of Policy, Economics and Innovation (NCEE) organized and led an agency-wide effort to assemble the information and produce the material. Scientists and experts from throughout EPA, with special assistance from the Office of Water (OW), Office of Research and Development (ORD), the Office of Air and Radiation (OAR), and the Office of International Activities (OIA), contributed through a series of workgroup teams that met for almost two years. Staff from OPEI, ORD, and OW presented the material to EPA senior management at an all-day retreat in Annapolis, Maryland on February 21, 2008.

The intent of the Backgrounder is to provide a basic understanding among EPA staff and others of a complex and persistent environmental problem--excess rN in the environment that is not bound up in long-term storage, such as soil complexes. The presentations explain not just the science of rN, but also the sources, the environmental and economic impacts, Federal regulatory and non-regulatory activity to mitigate its adverse impacts, and challenges to successful management.

As is true for most environmental issues, the science is dynamic, as research sheds new light on processes and relationships, and the economic drivers for the generation and removal of rN change over time. Management in response evolves. The Backgrounder thus represents a snapshot in time of what is known about rN and EPA and other federal agencies' actions regarding its origins and control.

EPA United States Environmental Protection Agency

Slide 1

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c1 Draft presentation

ctsuser, 5/12/2009

NITROGEN BACKGROUNDER

1	**OVERVIEW**
2	**THE N-CYCLE IMPACTING HUMAN HEALTH AND THE ENVIRONMENT**
3	**INTERVENTIONS, CONTROL OPTIONS, AND ECONOMICS**
4	**CHALLENGES**
5	**INTEGRATION**

NITROGEN BACKGROUNDER

Module 3:

Interventions, Control Options, and Economics

United States Environmental Protection Agency

Walk Away Points

- There have been a number of successful control programs for nitrogen.
- However, there are gaps in controls:
  - Not all of the nitrogen sources are regulated.
  - Non-regulatory (voluntary) interventions have mixed success.
  - Many interventions shift nitrogen to another medium rather than capture it.
  - Many interventions are outside EPA's jurisdiction.
- This is a systems issue, where sources, sinks, and control options vary across the landscape.
- Economic interests, left unchanged, favors increased generation and emission of reactive nitrogen.

“Systems”

“Systems” means interaction, complex, varying by location. *All interventions link with each other.*

First…
A Pop Quiz!

FACT or Fiction

Nitrogen reaches the environment via air, soil and water sources.

Fact

FACT or Fiction

Interventions on agricultural nitrogen releases will prevent all nitrogen-induced environmental problems.

Fiction

FACT or Fiction

Nitrogen is a pollutant that we can virtually eliminate.

Fiction

FACT or Fiction

EPA is the primary governmental driver for installing interventions on all nitrogen releases.

Fiction

Intervention

- Webster Definition:
  - To come in or between so as to hinder or modify
- Today's Definition:
  - That which alters a reactive nitrogen pathway or reservoir
  - And performed in the context of affecting significant pathways or reservoirs

Intervention Effectiveness

- Webster Definition:
  - Having the intended or expected effect; serving the purpose
- Today's Definition:
  - Reliable (known to work)
  - Quantifiable (can measure results)
  - Permanent (not a temporary effect)

Examples of Interventions

Prevention

Reuse

Treatment

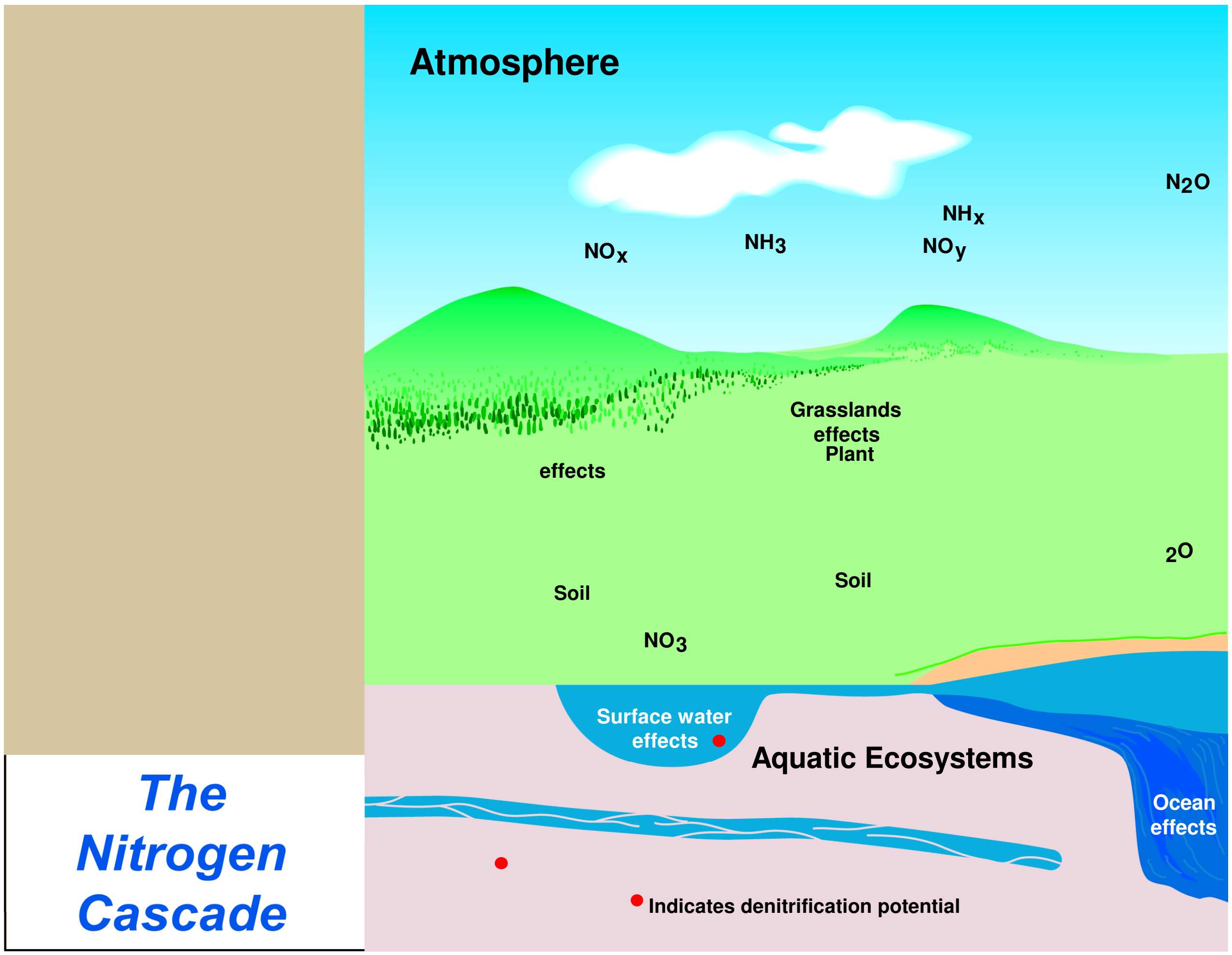
Immobilation

Transfer

EXAMPLES

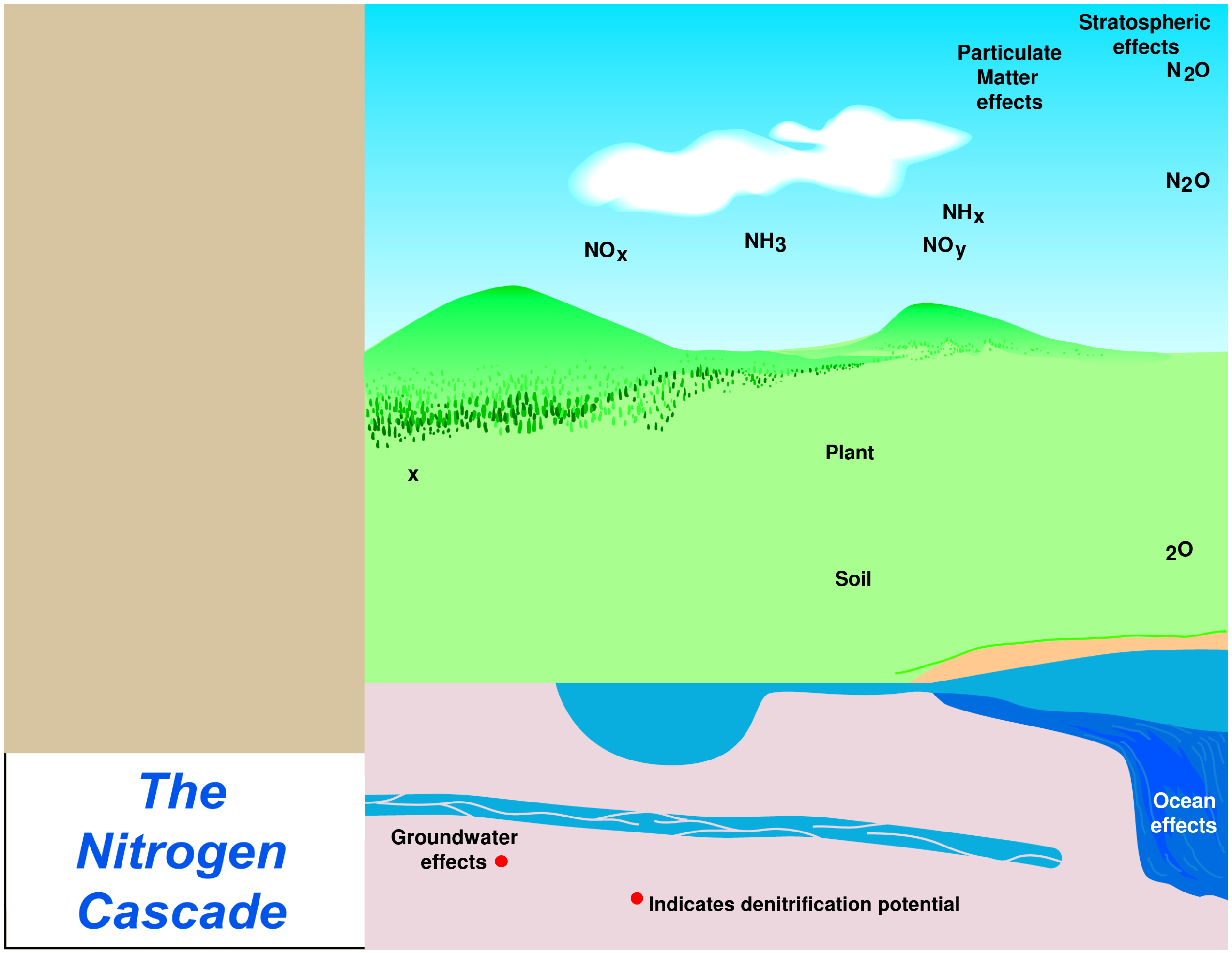
- Prevention--Proper automobile engine performance minimizes NOx
- Reuse--Manure as fertilizer instead of waste
- Treatment--Denitrification treatment of wastewater
- Immobilization--Land disposal of sewage sludge (assuming that the land is properly managed)
- Transfer--CAFO lagoon volatilizes ammonia into air

The "N Cascade" Will Be Our Guide To Explore Interventions



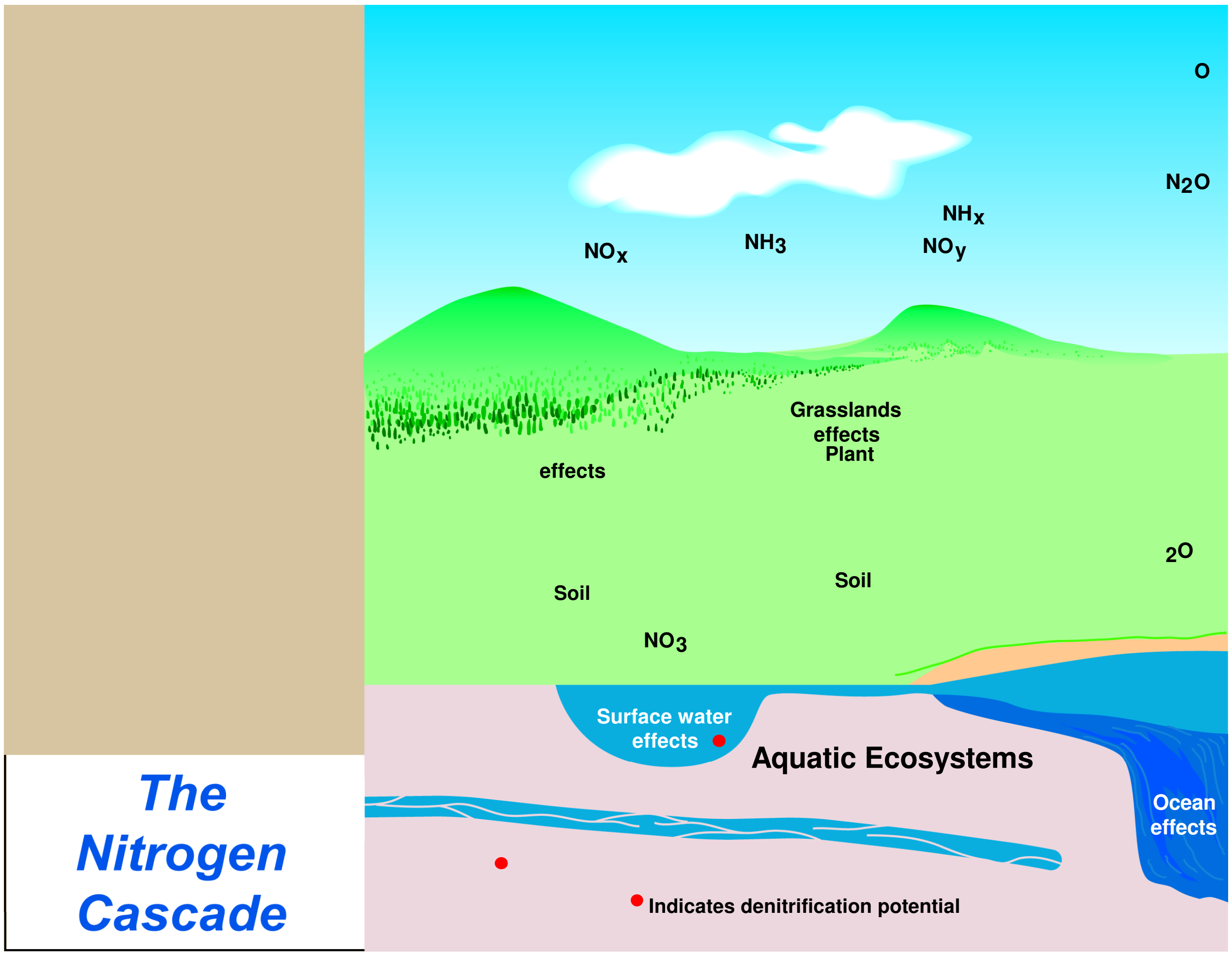
- Where can we intervene?
- How well can we intervene?
- How does one intervention affect another?
- Are there unintended consequences?
- What else could we consider?

Where are the Potential Interventions?



- Energy & transportation emissions (EPA)
- Agricultural releases and transfers (EPA, USDA)
- People releases (EPA)
- Environmental reservoirs (EPA, DOI, ACE)

Interventions on Energy Production and Transportation Emissions



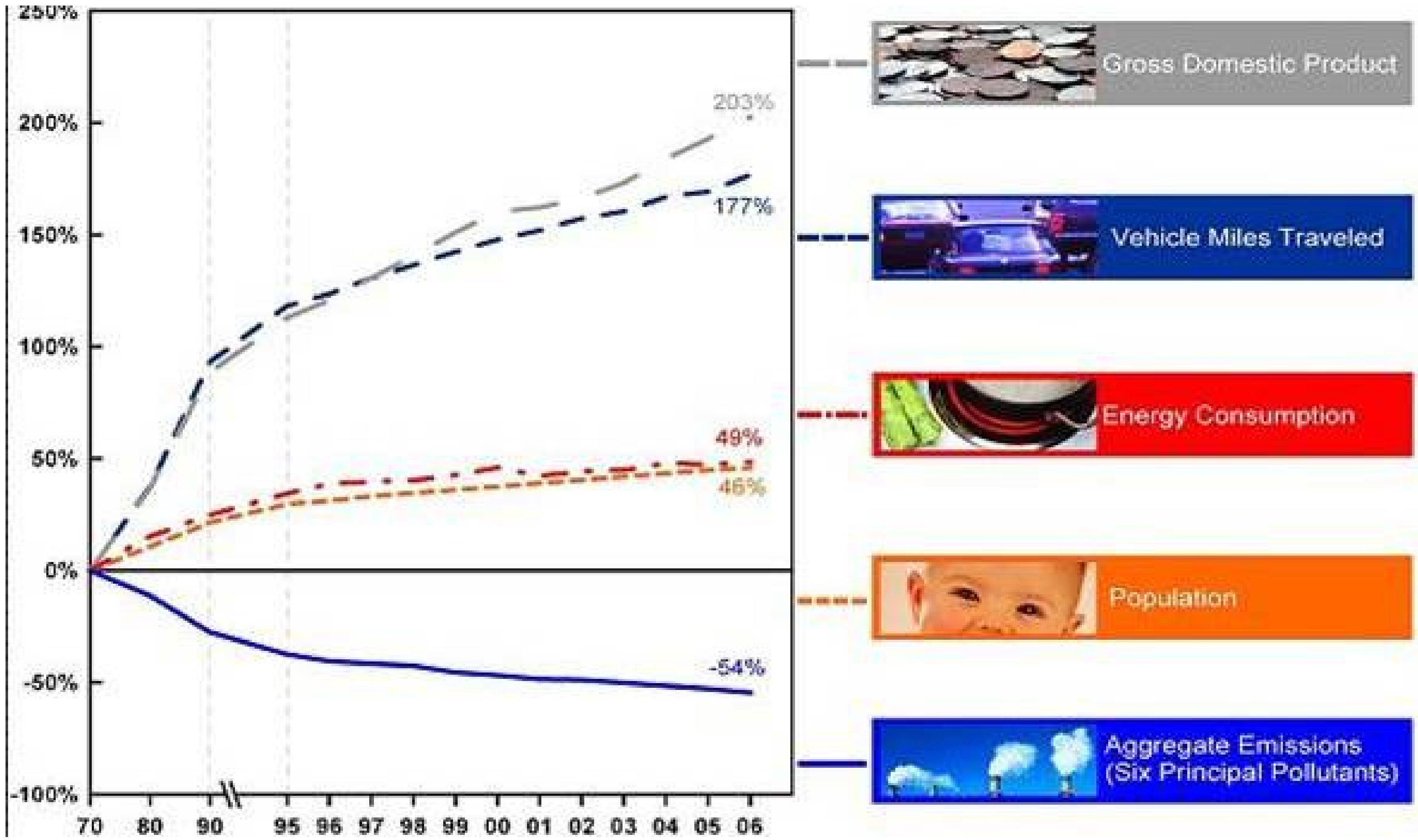
TOPICS

- Big points
- Program results

Energy Production and Transportation Sector Big Points

- Most NOx emissions are covered by EPA rules, some of which have been in effect for 17 to 20 years
- Regulatory programs for stationary sources are moving from command and control to market based
- Interventions primarily prevent NOx formation or capture NOx before release

Comparison of Growth Areas and Emissions



- *The point of this slide is that emissions can do down while economic activity goes up.*

- 1990 Clean Air Act Amendments regulate six criteria pollutants (including NOX).

- Over the past 35 years, with a growing population, we have increased our energy consumption and traveled more miles in our cars. While this has greatly increased the possibility of more NOx emissions, **we have actually reduced NOx emissions by about 40-45% over that period** (close to the aggregated whole for criteria pollutants).

Energy & Transportation N Outputs

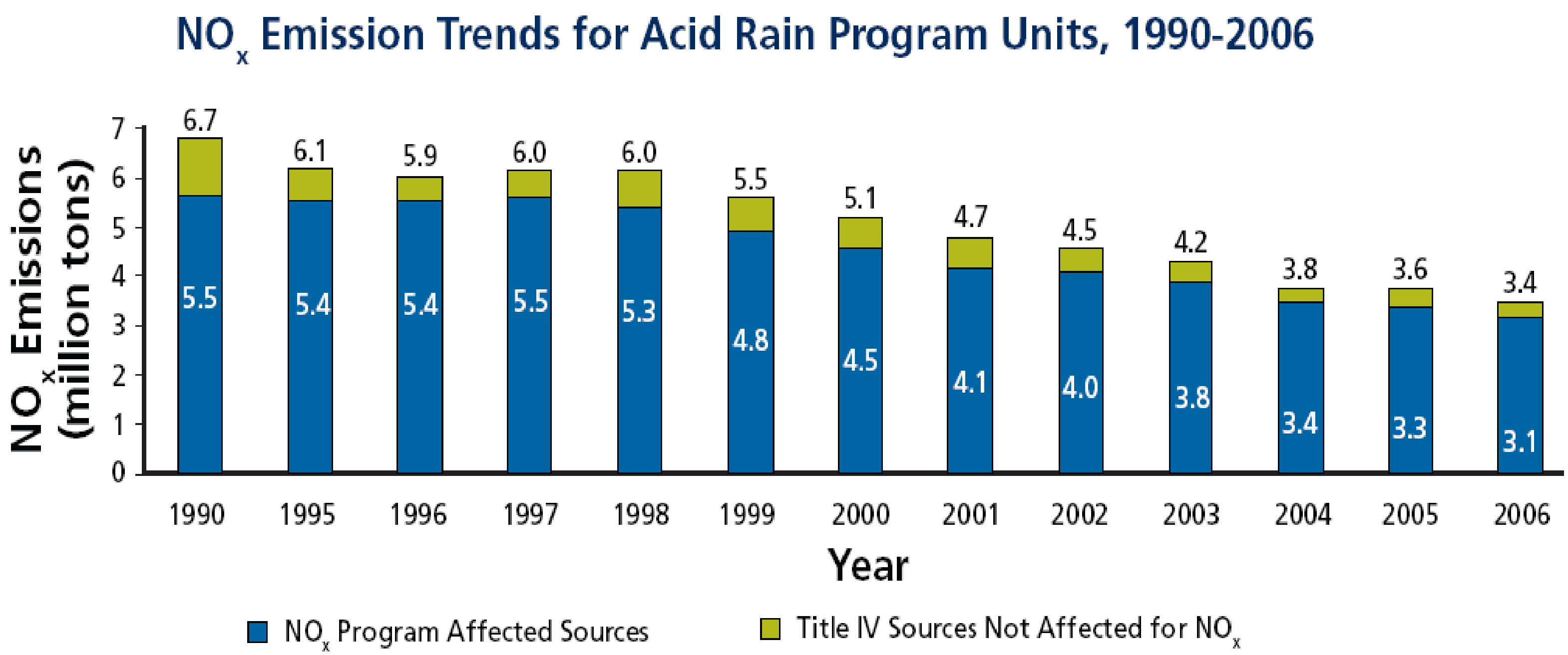
SOURCE	PROGRAM	INTERVENTION
Power Sector	Acid Rain Program NOx Budget Trading Program CAIR	Emissions rate limits Allowance trading Allowance trading
Other Stationary Sources	NOx Budget Trading Program	Allowance trading
New Stationary Sources	New Source Performance Standards	Best Available Control Technology, Lowest Achievable Emission Rate
Automobiles	Mobile Source	Engine Performance, Gas Formulation
Recreational Vehicles	Mobile Source	Engine Performance
Heavy Diesel	Mobile Source	Engine Performance
Non-road Diesel	Mobile Source	Engine Performance
Locomotive, Marine	Mobile Source	TBD
Any	Regional Haze	Best Available Retrofit Technology

- Air program discussion covers regulations that are currently being implemented, which are reflected in this table
- NOX control programs have successfully regulated NOX emissions from stationary and mobile sources, achieving significant environmental results.
- Over time, air programs for large stationary sources have evolved from "command and control to "cap and trade" approaches:
- Acid Rain Program NOx control provisions applied emissions rate limits to a set of coal-fired electricity generating utilities (EGUs)
- The NOx Budget Trading Program is implemented by EPA in cooperation with 20 eastern states and DC – it was the first market-based emissions trading program to reduce NOX emissions from fossil fuel-fired EGUs, large industrial boilers, and turbines
- The Clean Air Interstate Rule, when implemented, will be implemented by EPA in cooperation with 28 eastern states and DC and is a market-based emissions trading program affecting fossil fuel-fired EGUs

NO_X Emission Reductions under the Acid Rain Program

National NO_X emissions from all Acid Rain Program sources were 3.4 million tons in 2006

- 3.3 million tons (49%) below 1990 levels
- 224,000 ton decrease from 2005 levels



Source: EPA, 2007

About 50% reduction

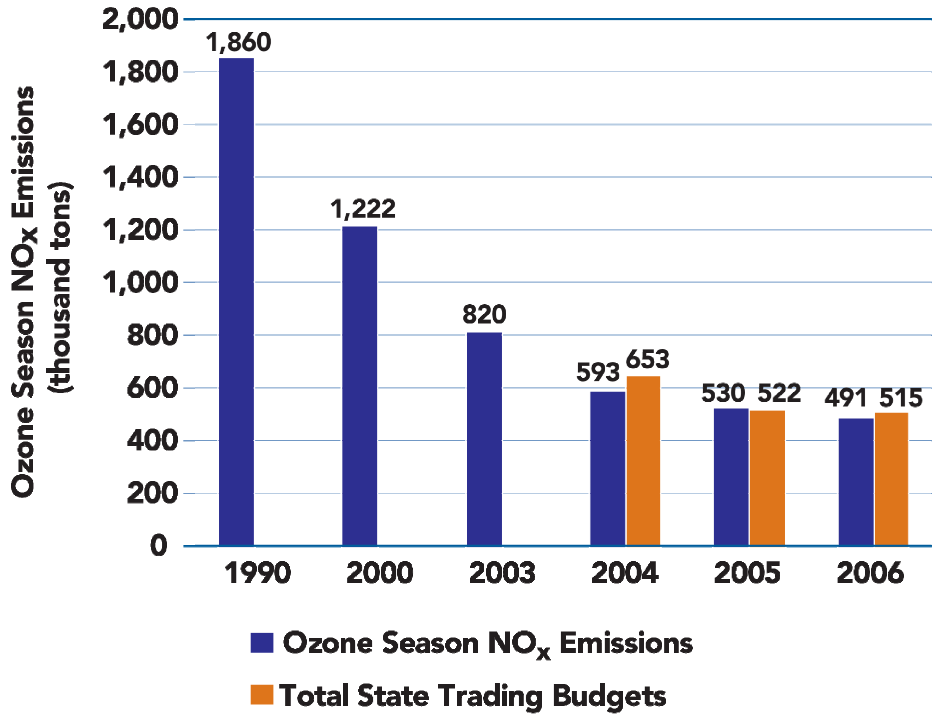
Ozone Season NO_X Emissions Under NO_X Budget Trading Program (NBP)

Total NBP NO_X Emissions in 2006 were 491 thousand tons

NBP states reduced ozone season (May 1 – September 30) NO_X emissions by approximately

- 74% from 1990 (before implementation of the Clean Air Act Amendments)
- 60% from 2000 (before implementation of the NBP)
- 7% from 2005

Ozone Season NO_X Emissions from all NBP Sources



Note: EPA Title IV NO_X program and state actions produced reductions from 1990 to 2003.

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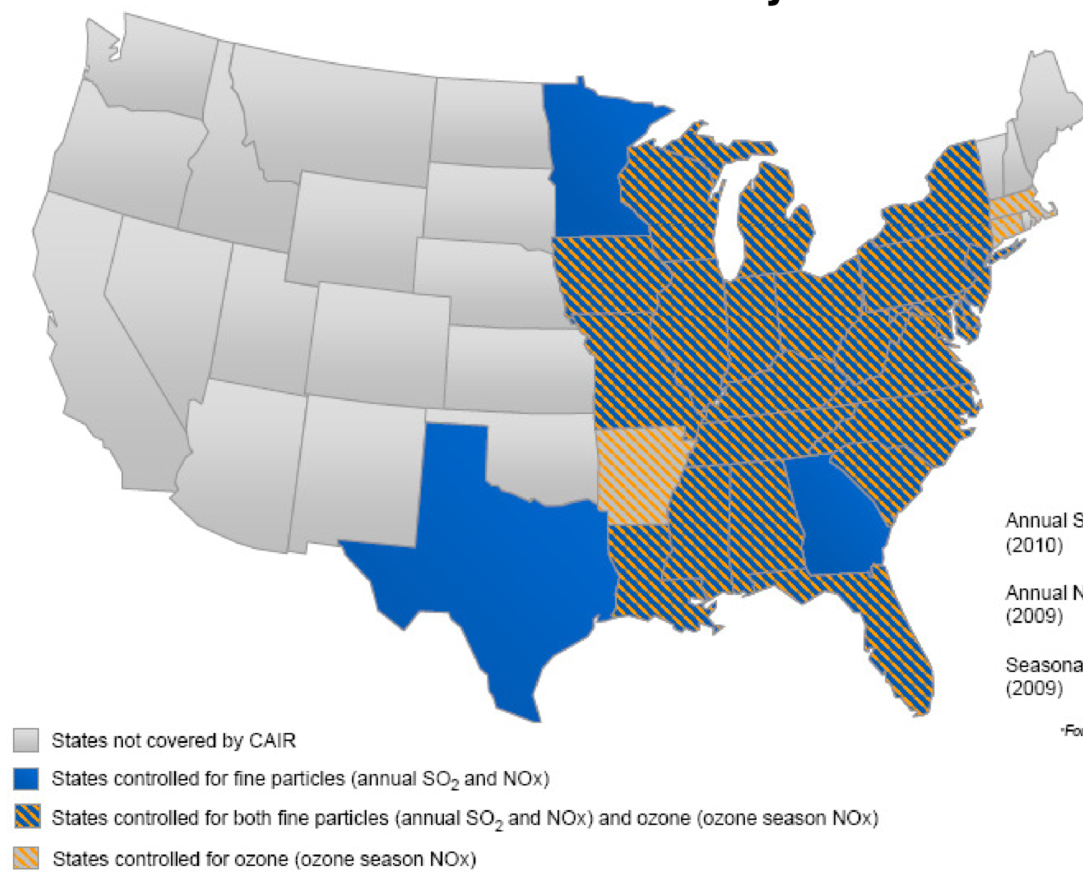
NO_X and the Clean Air Interstate Rule (CAIR)

- **Two phases of reductions for annual NO_X in 2009 and 2015**

- **Reduce (with other existing NO_X programs) power sector annual NO_X emissions by 55% from 2005 levels.**

States Affected by CAIR



Emission Caps*
(million tons)

	2009/2010	2015
Annual SO_2 (2010)	3.7	2.6
Annual NOx (2009)	1.5	1.3
Seasonal NOx (2009)	.58	.48

*For the affected region.

EPA United States Environmental Protection Agency

- **NOx SIP Call and the NOx Budget Trading Program (NBP)** — In 1995, EPA and the Environmental Council of the States formed the Ozone Transport Assessment Group to begin addressing the problem of ozone transport across the entire eastern United States. Based on the group's findings and other technical analyses, EPA issued a regulation in 1998 to reduce the regional transport of ground-level ozone. This rule, commonly called the NOx SIP Call, requires states to reduce ozone season NOx emissions that contribute to ozone nonattainment in other states. The NOx SIP Call does not mandate which sources must reduce emissions. Rather, it requires states to meet emission budgets and gives them flexibility to develop control strategies to meet those budgets.

- Under the NOx SIP Call, EPA developed the NBP to allow states to meet their emission budgets in a highly cost-effective manner through participation in a region-wide cap and trade program for electric generating units and large industrial boilers and turbines. All 19 affected states and the District of Columbia chose to meet their NOx SIP Call requirements through participation in the NBP. While EPA administers the trading program, states share responsibility with EPA by allocating allowances, inspecting and auditing sources, and enforcing the program. Compliance with the NOx SIP Call was scheduled to begin on May 1, 2003 for the full ozone season. However, litigation delayed implementation until May 31, 2004. In 2005, all NBP affected sources were required to comply for the full ozone season, May 1 through September 30.

- **CAIR was designed to help cities and states in the East meet new, more stringent national ambient air quality standards (NAAQS) for ozone and fine particles by reducing SO2 and NOX emissions which contribute to fine particle pollution (PM2.5) and ground level ozone.**

- **Emission caps are divided into state NOX budgets with an optional cap and trade program**

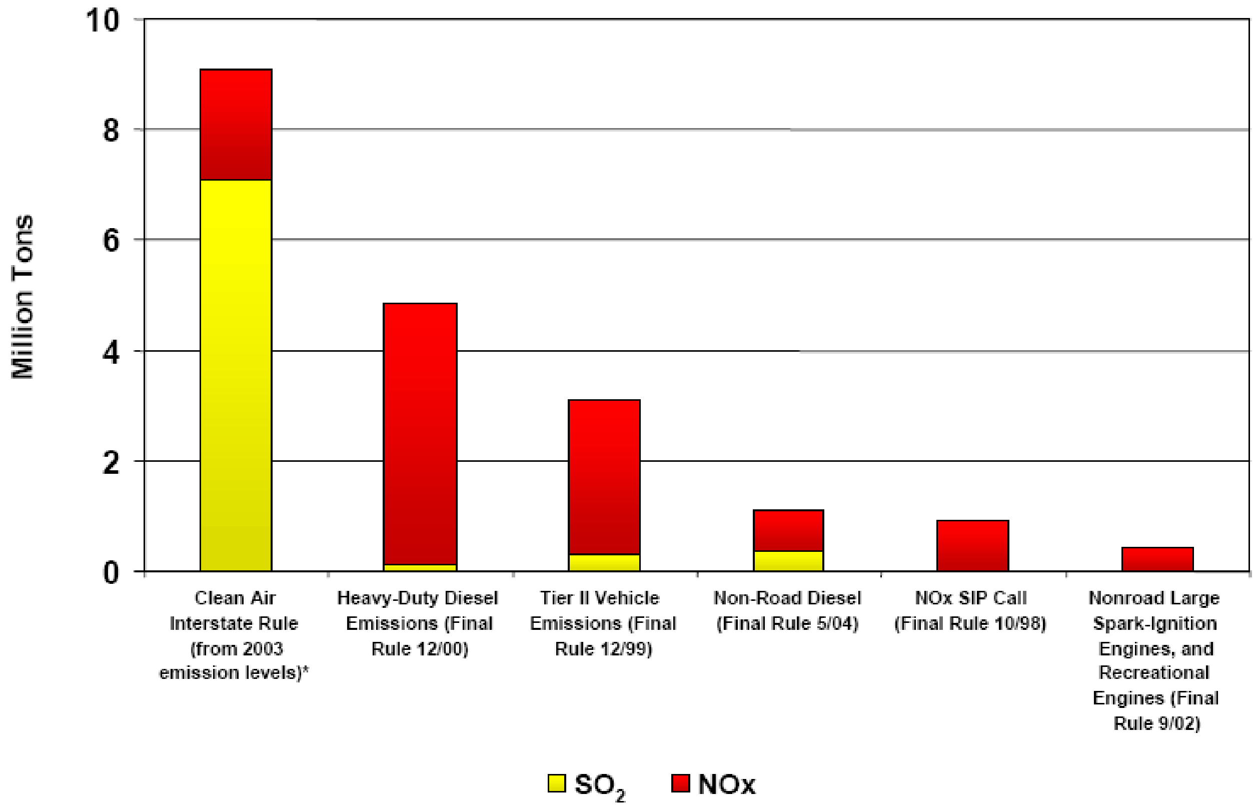
- **Allows states flexibility on how to achieve the reductions, including which sources to control and whether to join the trading program**

CAIR facts

- CAIR is a program that will further control NOx and SO2 emissions from power sector emissions sources
- Like the NBP, it is an eastern regional program intended to help states meet the NAAQS for Ozone and PM2.5
- Also like the NBP, it has an emissions trading program component – if states choose, they can use the trading program as the means for achieving required NOx emissions reductions

NO_X and Recent Rules

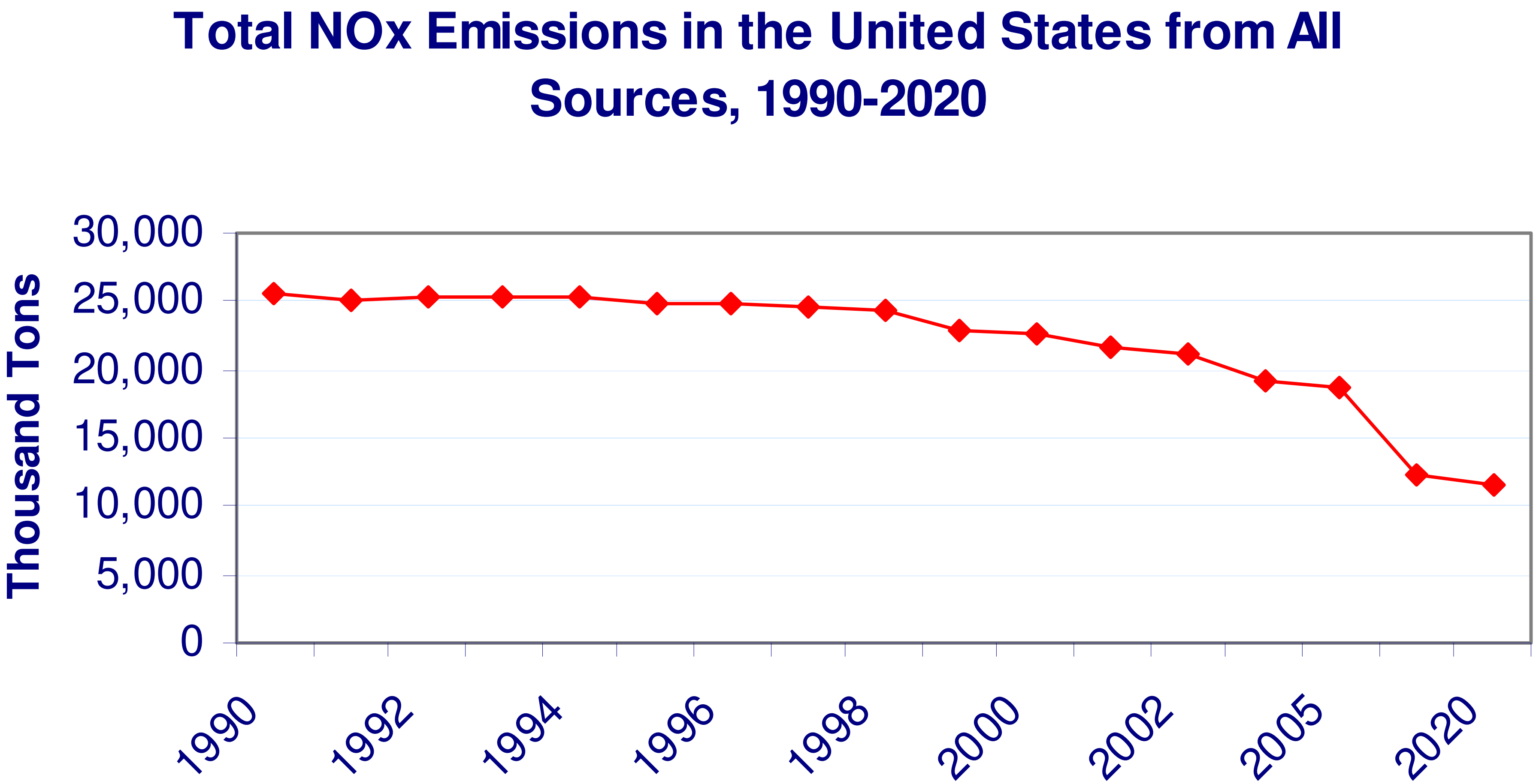
Annual Emission Reductions at Full Implementation* for CAIR and Other Major Air Pollution Rules Since 1990



*These reductions are calculated from 2003 levels and do not reflect the full phase in of the acid rain program.
Full implementation for mobile source rules is 2030. Full implementation for the CAIR is between 2020 and 2025.

- The previous slide attempts to put all of the newest rules together
- It is important to note that the emissions reductions from mobile source programs are substantial, but take longer to achieve due to the length of time necessary for fleet turnover
- *Table showing effects from recent rules, in context. Potential reductions to be gained from each.*

Projected NO_X Emissions from all Sources in 2020



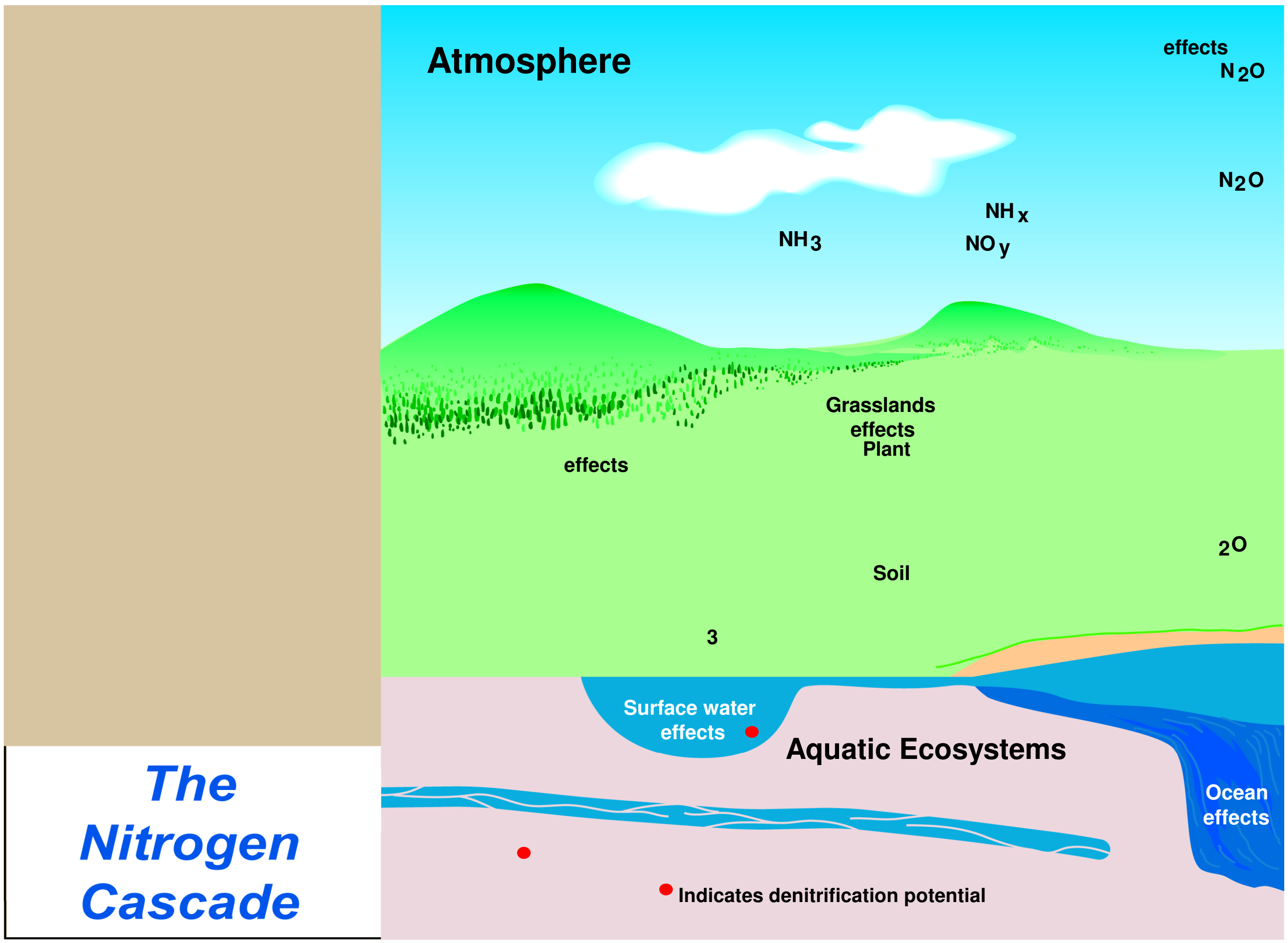
- The previous slide shows the progress in reducing NOx emissions that we expect to achieve through implementing all of these rules and regulations

- It's important to note that the endpoint for this slide is 2020, but the full reductions from mobile sources programs will not be evident until 2030.
- Under current programs, NOx reductions currently look promising well into the future, with even further reductions expected by 2030 from mobile source programs.

Energy Production & Transportation N Gaps & Considerations

- Main driver for NOx control programs has been human health-based NAAQS – ecosystem protection could require more
- Emerging science indicates climate change may increase ground level ozone – harder to attain NAAQS
- Need to better understand the importance of ammonia emissions in combination with NOx emissions related to ecosystem effects

Interventions on Agriculture



TOPICS

- Big points
- Inputs
- Outputs
- Gaps
- Subsidies

United States Environmental Protection Agency

Agricultural Sector Big Points

- Most N emissions are not regulated, but subject to incentive programs
- States/EPA rely heavily on voluntary USDA programs to meet water quality standards and comply with CAFO regulations
- Reactive nitrogen is linked to phosphorus and organic carbon, and interventions on one may interact with the fate of others
- Soil and water management is an important intervention opportunity affecting reactive nitrogen soils

Agriculture

Inputs

- Fertilizer
- Food (for animals)
- Soil
- Irrigation water
- N fixation

Outputs

- Field runoff
- Manure runoff
- Field drainage
- Lagoon discharge & emissions
- Food (produced)

Agricultural N Inputs

Chemical Fertilizer and Manure for Crops

Programs

- •Nonpoint Source
- •Environmental Quality Incentive Program (EQIP)
- •Conservation Reserve Program (CRP)

Interventions

- •BMPs
- •Crop rotations
- •Vegetative buffers
- •Cover crops
- •Drainage management

Agricultural N Inputs

Animal Feed

Programs
- Nonpoint Source
- EQIP

Interventions
- Precision feeding
- Nutrition management

Previous slide

Better Breeding: Develop animals that better use N, or foods that animals can better use, thus requiring less food or fertilizer and resulting in less waste N

Agricultural N Inputs

Soil (reservoir of N)

potential source of rN depending upon how it is managed

Programs

- •Conservation Compliance
- •Swampbuster
- •Wetland Restoration Program (WRP)
- •CRP
- •EQIP

Interventions

- •Soil management
- •Wetland restoration
- •Drainage management

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Agricultural N Inputs

Plant Fixation

Programs
- •None

Interventions
- •Crop rotation involving N-fixing plants

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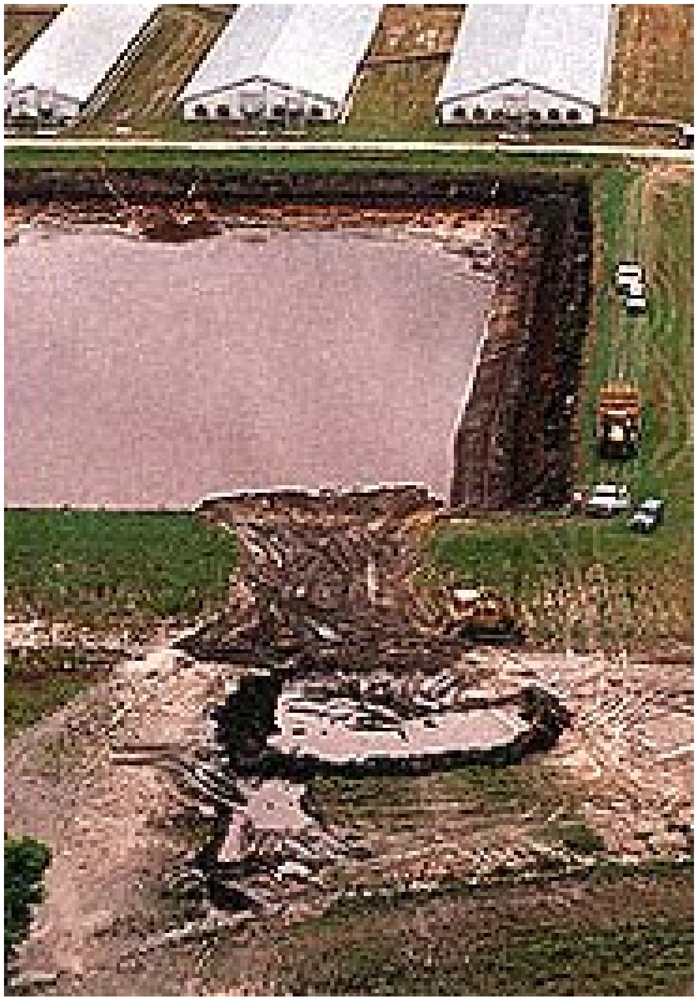
Agriculture



Inputs

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Outputs

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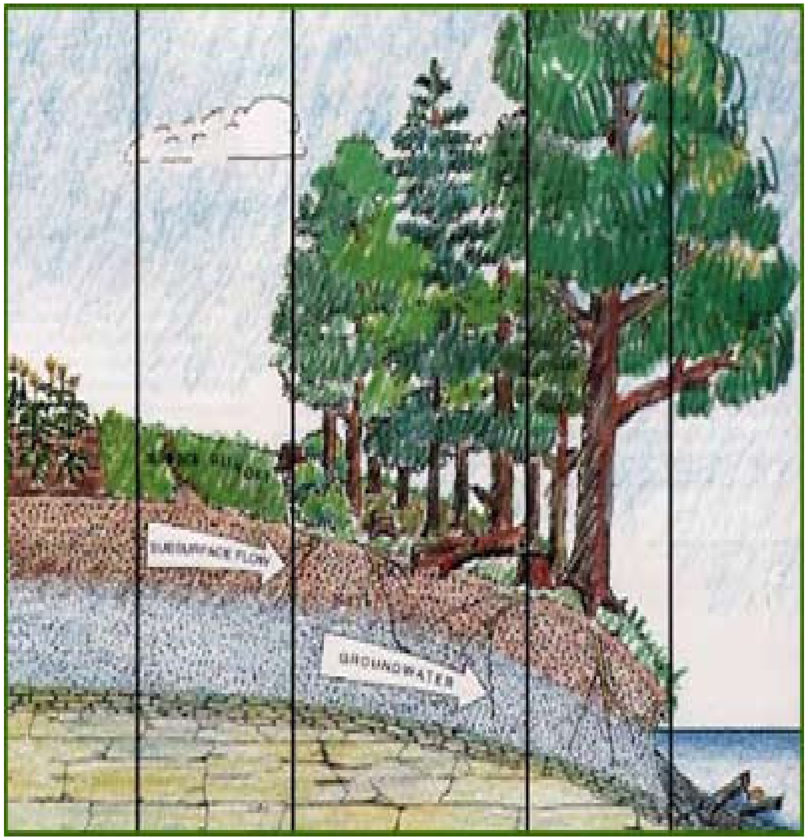
Agricultural N Outputs



Field Runoff

Programs

- Nonpoint Source
- EQIP
- CRP

Interventions

- BMPs
- Drainage management

BMPs

Many different approach for capturing N before it enters water. BMPs (best management practices) are site specific and generally require open land to install.

Agricultural N Outputs

Manure Runoff

Programs
- Nonpoint Source
- EQIP
- CRP
- NPDES (CAFOs only)

Interventions
- BMPs
- Drainage management

Manure recycling

Reusing manure can reduce need for inorganic fertilizers, but agronomic needs (i.e., site-specific requirements for N or P) may lead to over use of manure.

Agricultural N Outputs

Field Drainage

Programs

- Swampbuster
- EQIP
- WRP
- CRP

Interventions

- Soil management
- Wetland restoration
- Drainage management

Wetland Restoration

Retire farm land and build wetlands to hold back water and nutrients

Agricultural N Outputs

Lagoon Discharge & Emissions

Programs

- •Nonpoint Source
- •EQIP
- •NPDES (CAFOs only)

Interventions

- •Operations and maintenance
- •Liners

Lagoon Liners

- Barriers preventing percolation. Not always 100% efficient nor always required.
- Physical/Biological Treatment:
- Mostly convert NH_3 to NO_3, which is a transfer. Also, lagoons volatilize NH_3, which is another transfer.

Agricultural N Gaps & Considerations

- Most releases are not regulated, but instead rely on voluntary programs
- Commodity program payments encourage production, discourage conservation program goals
- Land retirement programs are not permanent
- Some lagoon treatment may result in increased air emissions, which are largely not addressed yet
- Applying manure to meet P needs can result in applying 4 times more N than is needed
- Practices/systems not targeted to highest risks.
- Little data on efficacy of practices at the watershed scale, especially on working lands
- Soil management and tile drainage
  - Will pick these up in discussion of environmental reservoirs

- Commodity program payments distort the market by subsidizing production of these crops. Therefore the crops are planted more in response to the program payments than to the market. The producers doesn't have to spread out their risks by planting a variety of crops. Their risk is minimized by the commodity payments. The $4 billion spent on conservation programs annually cannot begin to make up for the conservation problems caused by the distortions: for example planting crops where they shouldn't be planted (i.e. marginal lands in west Texas), planting every available acre instead of leaving buffers (which tend to be more marginal lands for production), overuse of pesticides, increased agricultural drainage. The ethanol subsidy has started to become more important than the commodity payments for corn, but it still distorts production with the same environmental effects.

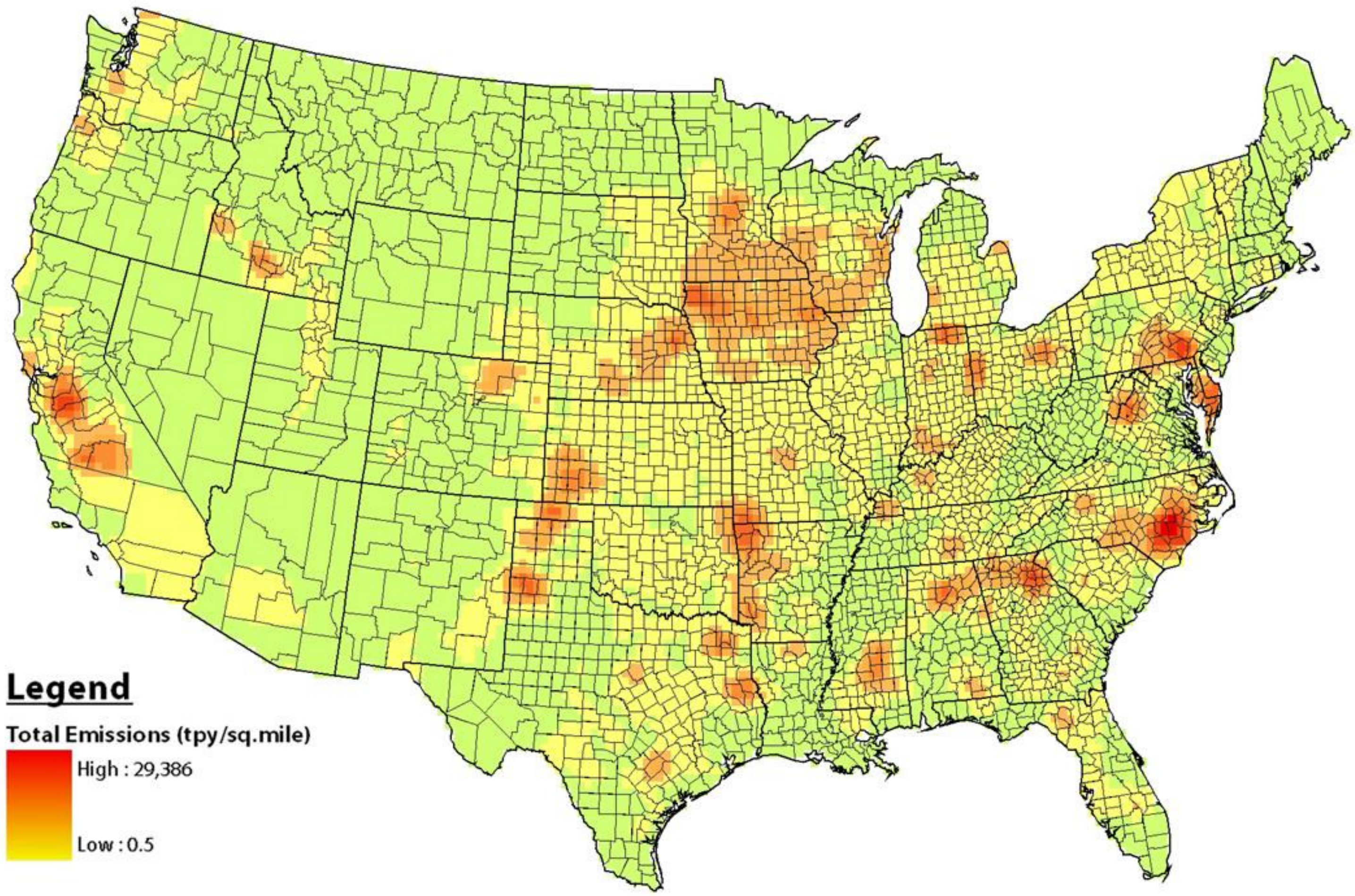
- Since cost-share payments on working lands (i.e. EQIP)are handed out on a first come first served basis, they are not explicitly targeted to the highest environmental benefit. CRP has an environmental benefits index to get at this problem. EQIP could be designed that way, but it isn't. Therefore one of the unspoken goals of EQIP has to be income distribution, since the environmental benefits are seriously diluted by spreading out conservation payments. One of the primary early lessons of CEAP is that the conservation program payments have to betargeted if we want to achieve environmental goals.

- NRCS pays producers to implement one or more of over 160 conservation practices. It does not provide disincentives for practices which speed water movement from the producers' land like drainage, stream channelization, land leveling. Even if a conservation practice like nutrient management reduces fertilizer inputs, the increased drainage will mean that the nitrogen that is not taken up by the crops moves into surface or ground water faster without any potential attenuation on the land. For NRCS to incorporate hydrologic factors into their programs, they would have to look at things from a watershed perspective, not farm by farm.

- Soil erosion is the basis of the majority of conservation practices. It is the reason NRCS was created during the Dust Bowl. Soil quality is a different issue and is evolving.

- In general, N fertilizer that isn't taken up by crops or volatilized will convert to nitrate and move with the water flow.

2002 Ammonia Emissions from AFOs



Based on current emission factor approach

Estimated ammonia emissions

- ***Ammonia is absolutely increasing, which isn't shown here. It relates directly to the number and size of animals. But emissions come from holding lagoons, so animal density does create more blow off of ammonia. This map is based on very crude assumptions.***

- Estimated ammonia emissions based on emission factors applied to AFOs. Slide shows the impact of concentrating animals in close proximity. Slide also demonstrates how concentrating animals could have a direct impact on local Nr. USDA generally claims that the number of animals hasn't necessarily increased, just that they are concentrated on fewer farms. Air monitoring studies are underway to get better estimates of emissions, but this is currently the best information we have.

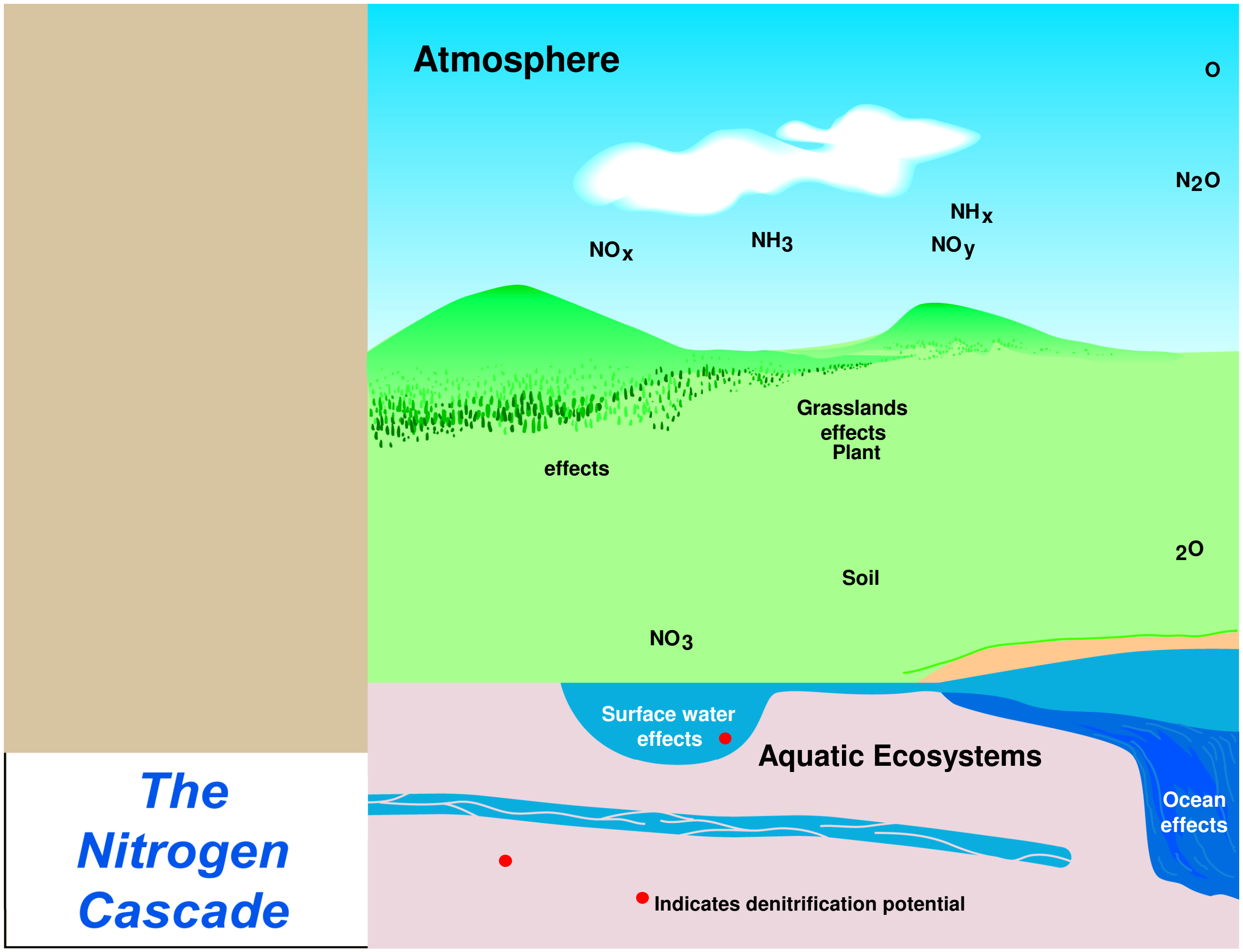
Impacts of Crop Subsidies on N

- Potential increase in fertilizer use to ensure certain production levels.
  - Ag. subsidies often in $/bundle, so total output is key objective.
- Social costs not taken into account by producers/funding agency (e.g. nutrient run-offs into surface water or groundwater).
- Biofuel production/ethanol subsidies drive corn production/increase in fertilizer use.
- Reduction in subsidies tied to bushel yield will:
  1. Lower incentives for the over-application of fertilizers
  2. Lower pressures on the conversion of vulnerable or ecologically significant lands into arable production

[Analysis with 3 points from Vaughan and Patterson (XXXX) and OECD report.]

- However, removing these subsidies does not necessarily result in a reduction in fertilizers and pesticides in long-run (see NZ for example).

Interventions on People Releases



TOPICS

- Big points
- Inputs
- Outputs
- Gaps

People Sector Big Points

- Most N emissions can be regulated, but currently are not
- Effectiveness of stormwater controls is not very well known
- Effectiveness of controls rely on surface water programs working together (standards, assessment, TMDL, permits, enforcement)

People Releases

Inputs
- Food
- Fertilizer
- Fuel

Outputs
- Human waste: wastewater and sludge
- Residential runoff
- Residential trash
- Industrial waste
- Power production
- Automobile emissions

People N Inputs

Food

Programs
- Health programs

Interventions
- Education

United States Environmental Protection Agency

People N Inputs

Fertilizer

Programs

- Local informational (some may be part of stormwater permitting)

Interventions

- Manufacture labeling

HEALTHY LAWN CARE PROGRAM FOR WATERSHED PROTECTION

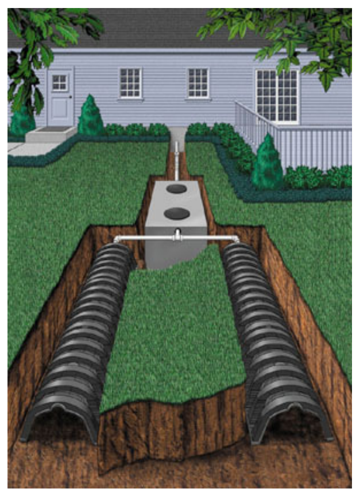
EARTH-FRIENDLY PRODUCTS

People Releases

Inputs
- Food
- Fertilizer
- Fuel

Outputs
- Human waste: wastewater and sludge
- Residential runoff
- Residential trash
- Industrial waste
- Power production
- Automobile emissions

People N Outputs



Wastewater

Programs

- •NPDES
- •State permitting
- •County public health ordinances

Interventions

- •Secondary treatment
- •Septic tanks
- •Land application

- Wastewater that is discharged into water is regulated by NPDES permitting. Non-discharges such as septic tanks or land application of wastewater may be regulated by state permitting or county public health ordinances.

- NPDES regulated discharges generally have secondary treatment. Examples are activated sludge and oxidation ponds. Secondary treatment does NOT remove nitrogen. Some advanced treatment converts ammonia into nitrate, which does NOT remove nitrogen. Only denitrification treatment removes nitrogen. NPDES needs WQS for nitrogen to require denitrification.

- Septic Systems do not remove nitrogen except for that which is taken up into plants. Most nitrogen goes into groundwater

- Land Disposal removes nitrogen by using wastewater as fertilizer to grow crops. However, land application is limited by available land. The Muskegon, MI facility requires 11,000 acres (17 sq.miles) to accommodate 42 MGD. Washington DC has about 10x the wastewater. This means an area the size of the District with nearby parts of Maryland to handle Washington, DC.

People N Outputs

Sludge

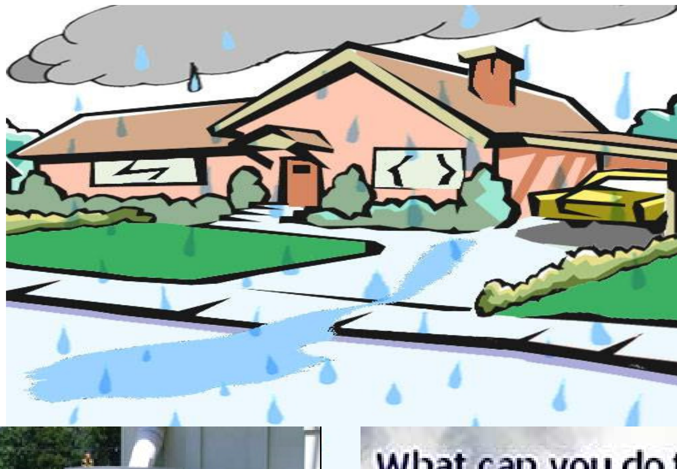
Programs
- NPDES
- State sludge permits

Interventions
- Land application
- Disposal

Sludge Land Application

Typically at agronomic rates. How soils are managed will affect fate of N in sludge applied to the land.

People N Outputs



Runoff

Programs
- •NPDES
- •Nonpoint Source

Interventions
- •BMPs

- Many different approach for capturing N before it enters water.
- BMPs are site specific and generally require open land to install.

People N Outputs

Residential Trash

Programs

- Health programs

Interventions

- Disposal
- Compost

Compost

- Reuses yard waste to reduce need for fertilizers

People N Outputs

CF Industries, Donaldsonville, LA
(Fertilizer Plant)

Industrial Waste

Programs
- NPDES
- MACT

Interventions
- Physical/chemical treatment
- Land application

Physical/Chemical Treatment

Removes NOx from water. Unless there is denitrification used, the treatment only transfers N from one medium to the next.

Water Quality Trading: Can Remove Nitrogen or Could Transfer Nitrogen

Trading

- Example of NPS seller (conservation practices implemented) and WWTP (Wastewater Treatment Plant) or POTW (Publicly Owned Treatment Works) buyer.

- Trading is very site specific, too

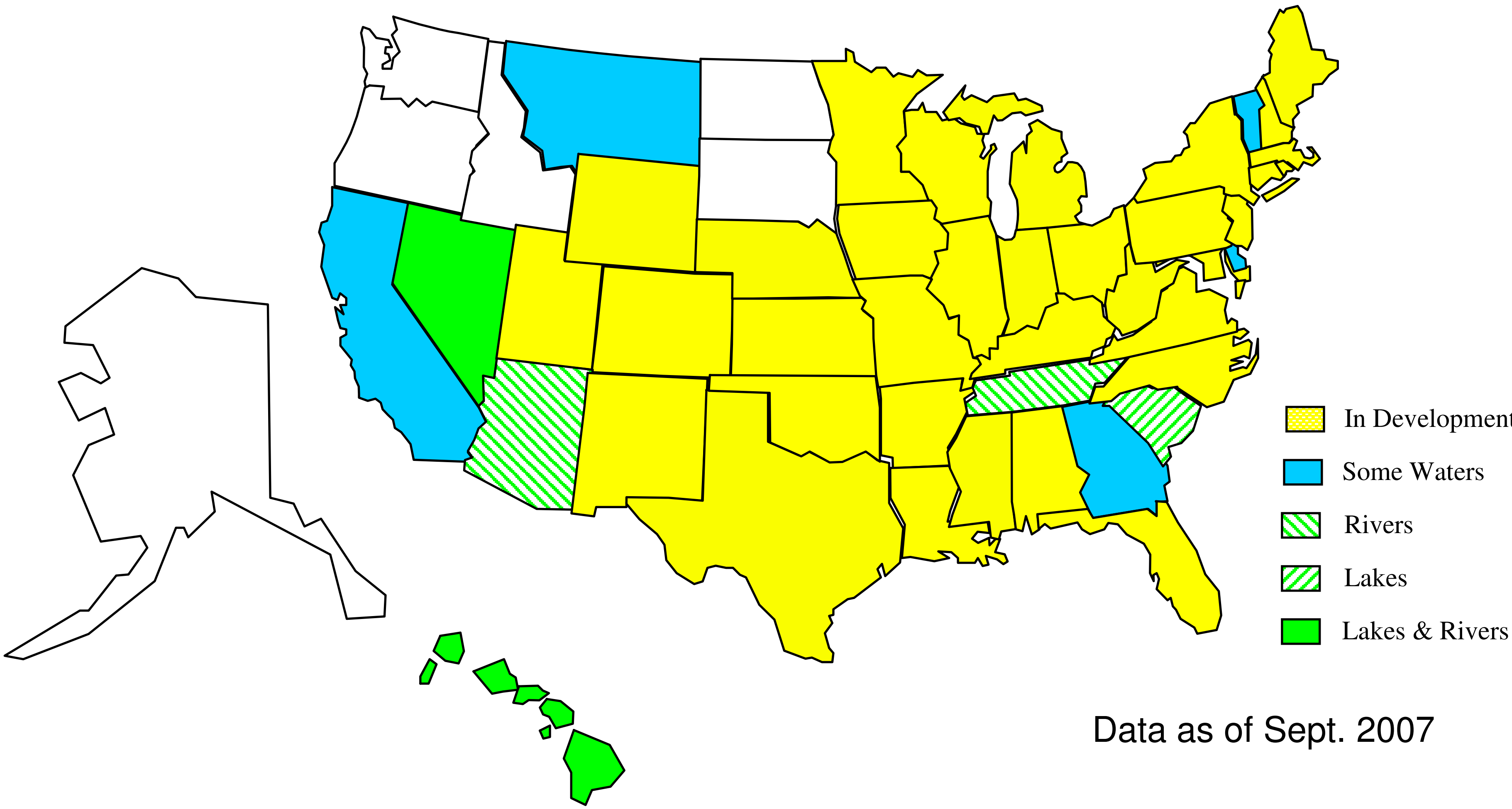
- *Trading is a concept that, if you are required to remove a contaminant from a facility where it will be expensive to do so, you can instead trade the obligation to remove the contaminant to an entity that can do so at less cost.*

  http://www.conservationinformation.org/images/GPfS_FINAL.pdf

Municipal N Gaps & Considerations

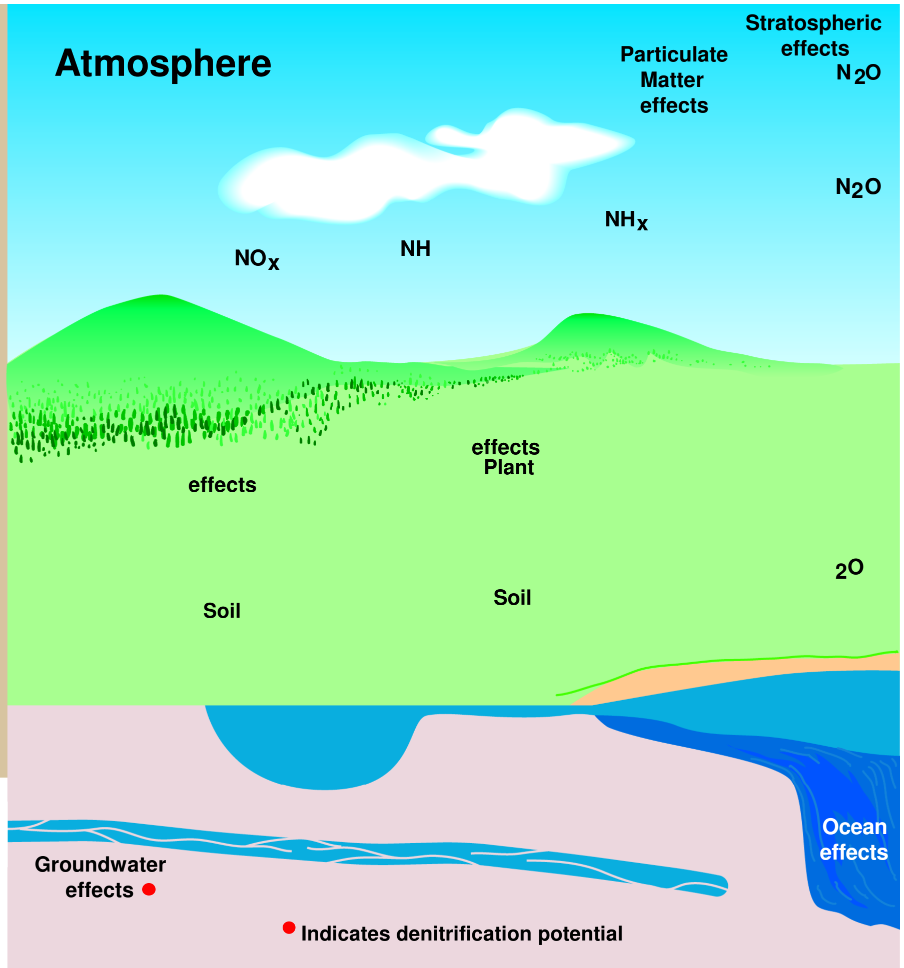
- Water quality standards, the environmental targets for POTWs and nonpoint source programs, are generally outdated for N
- Secondary treatment does not remove N, and most current tertiary treatment only transfers N
- Current tertiary biological treatment achieves 3 to 8 mg/l for N, about 10x above WQC
- Wastewater treatment less effective in colder areas
- Stormwater performance relies on Best Management Practices which effectiveness widely varies depending on the available land and type of BMP
- Biosolids application may overuse N when application is based on meeting P needs

States With N Water Quality Standards Adopted After 1998



Data as of Sept. 2007

Interventions on Environmental Reservoirs



The Nitrogen Cascade

TOPICS

- Project
- Programs

Affecting Rate of Reactive Nitrogen Immobilization or Destruction

- Agriculture
  - Not tilling the soil such as in continuous no-till
  - Conservation buffers
  - Wetland restoration
  - Drainage management
  - Conversion to forests
- Water management
  - Reconnection of rivers with flood plains
  - Restoration of natural habitat
  - Restoration of natural drainage
  - Wetland restoration

- Any action that restores the microbiological conditions for soil generation or increases the rate of carbon capture.

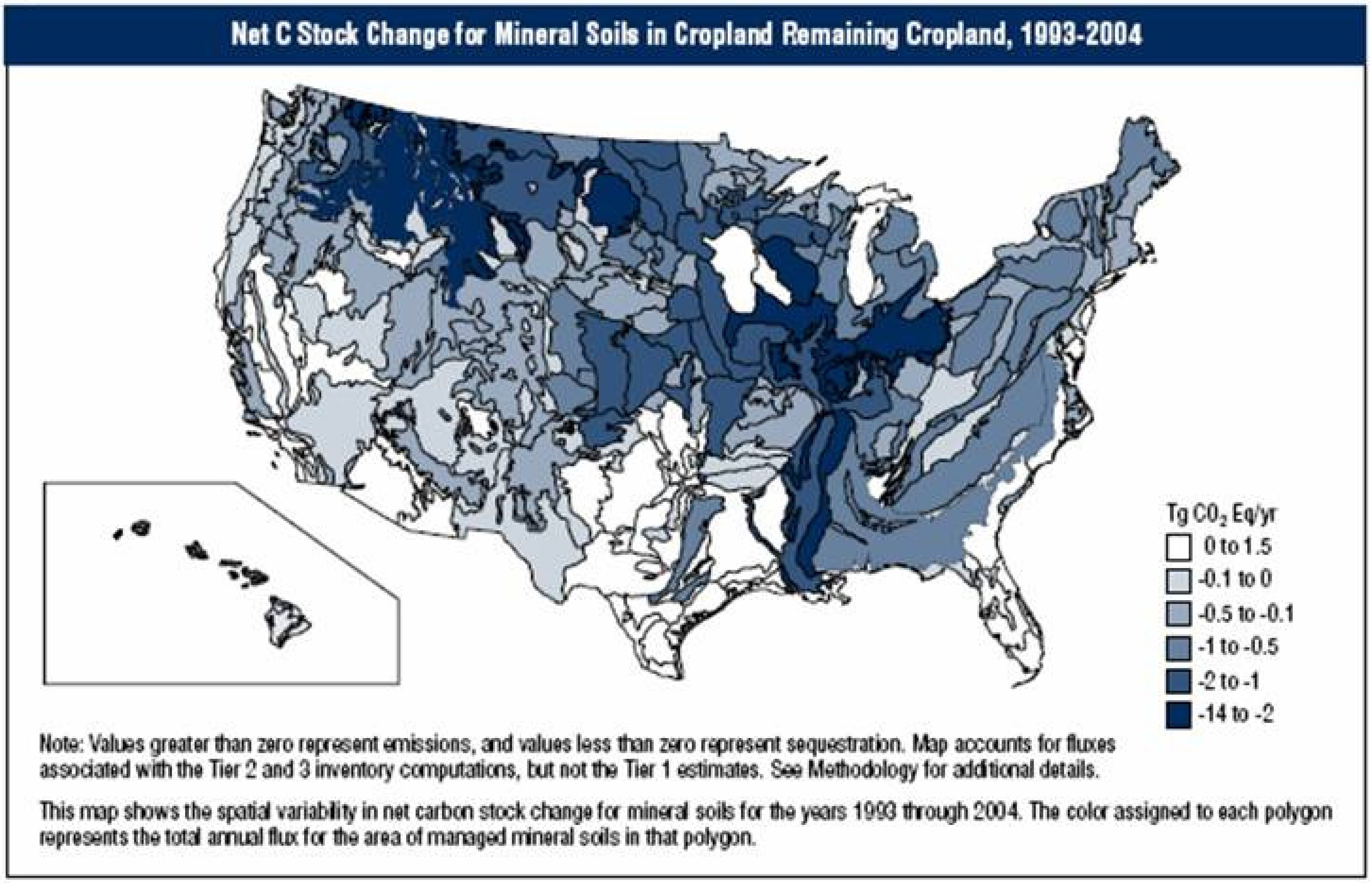
- Rates of mineralization (freeing up reactive nitrogen) versus immobilization (binding nitrogen in longterm sinks) depend upon wetness of soils
- Ratio of nitrogen to carbon and phosphorus constant in most soils.
- Delicate balance among C:N:P and hence links with these other cycles. As one decreases, the others decrease in mass.

Not All Residual Fertilizer N Is Lost To The Cascade

- In the US, depleted soils are being rebuilt with some portion of reactive N
- With every ten ton increase in soil carbon, through management practices or higher yielding crop varieties, roughly one ton of nitrogen sequestered
- Roughly 11 MMT of fertilizer N used per year in the US
- Roughly 1.3 MMT of N immobilized in new soil

Where soil C stocks increase, soil N stocks increase

Figure 7-5



Source: USEPA, 2007. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005, USEPA, Washington, DC, April 15, 2007

Wetlands and Water Quality Trading Research: Project Description

- Research Strategy
  - – Analysis of the assimilative capacity of wetlands for nutrient and sediment removal
  - –Economic feasibility including: verification, costs, market viability
- •Current Activities
  - – LaCrosse, WI - Nutrient and sediment assimilative capacity
  - – Illinois River restored wetlands
  - – Great Salt Lake – looking at unintended consequences of wastewater discharges into natural wetlands
- •Scientific Unknowns
  - – long-term assimilative capacity of wetlands (including O&M)
  - – temporal/spatial variations affect on nutrient removal
  - –methods for monitoring and verification

- Analysis of the assimilative capacity of wetlands will look at:
    - wetland type
    - location in the landscape/watershed
    - risk of unintended consequences (e.g., invasives, ecosystem shifts)

- ORD / OW initiative to evaluate the feasibility of using restored wetlands in water quality trading
- Improve water quality where regulatory mechanisms have been insufficient to achieve goals
- Increase number of acres and quality of wetlands
- Assess the role markets can play in stimulating the use of wetlands in watershed management
- Past Activities
  - Wetlands in WQT Conference, February 2006
  - Completion of report, “Wetlands and Water Quality
  - Trading: Science Needs and the Assessment of Program Feasibility”
  - Development of research strategy, 2007

USDA Conservation Programs Land Retirement

Conservation Reserve Program (CRP)

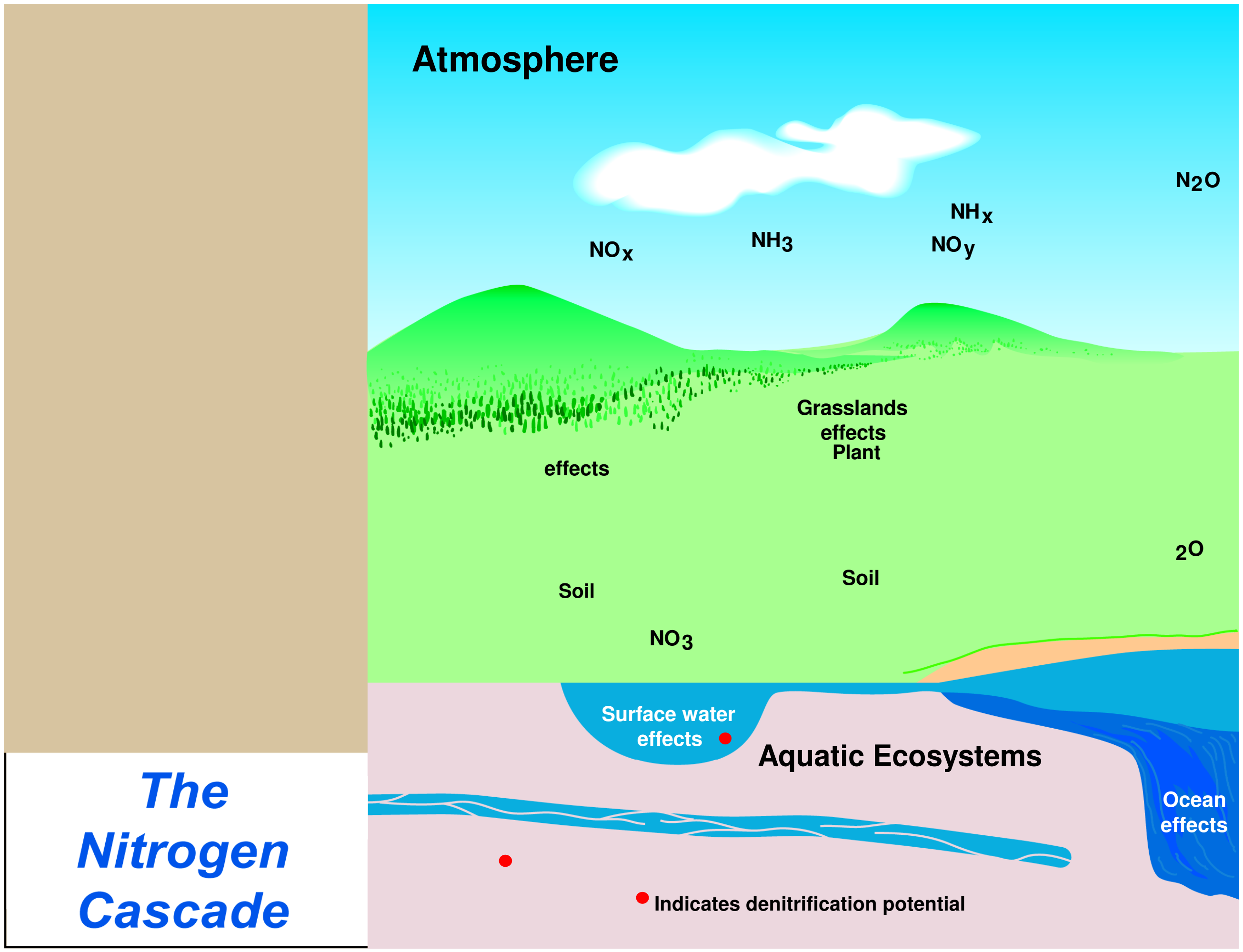
- 10 to 15 year contracts
- Continuous sign-ups for “highly desirable environmental practices”: filter strips, grassed waterways, riparian buffers, public wellhead areas

Wetlands Reserve Program (WRP)

- permanent or 30 year easements
- 2.275 million acre cap

But retirement is not permanent!

Are There Other Interventions We Could Consider?



TOPICS

- US
- Other Countries

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Other Potential US Interventions

Reduce runoff from urban lands by reducing impervious areas (e.g., smart growth)

- Courtyards
- Streets
- Roofs

Impervious: anything that water cannot flow through. Example is roads.

Other Potential US Interventions

Encourage control of reactive nitrogen at point of origin

- Decentralization of wastewater treatment leads to less discharge

Other Potential US Interventions

Encourage expanded areas where denitrification occurs

- Wetlands
- Floodplains
- Healthy aquatic sediments

- Agricultural options
  - Targeted wetlands in tile drained lands
  - Groundwater table management
- Water Resources options
  - Wetland restoration
  - Flood plain restoration and improvement of surface water flows variation
- Also structural options by tertiary sewage treatment

Other Potential US Interventions

Encourage more recycling of wastewater

- Some biosolids now land applied
- Some wastewater now land applied

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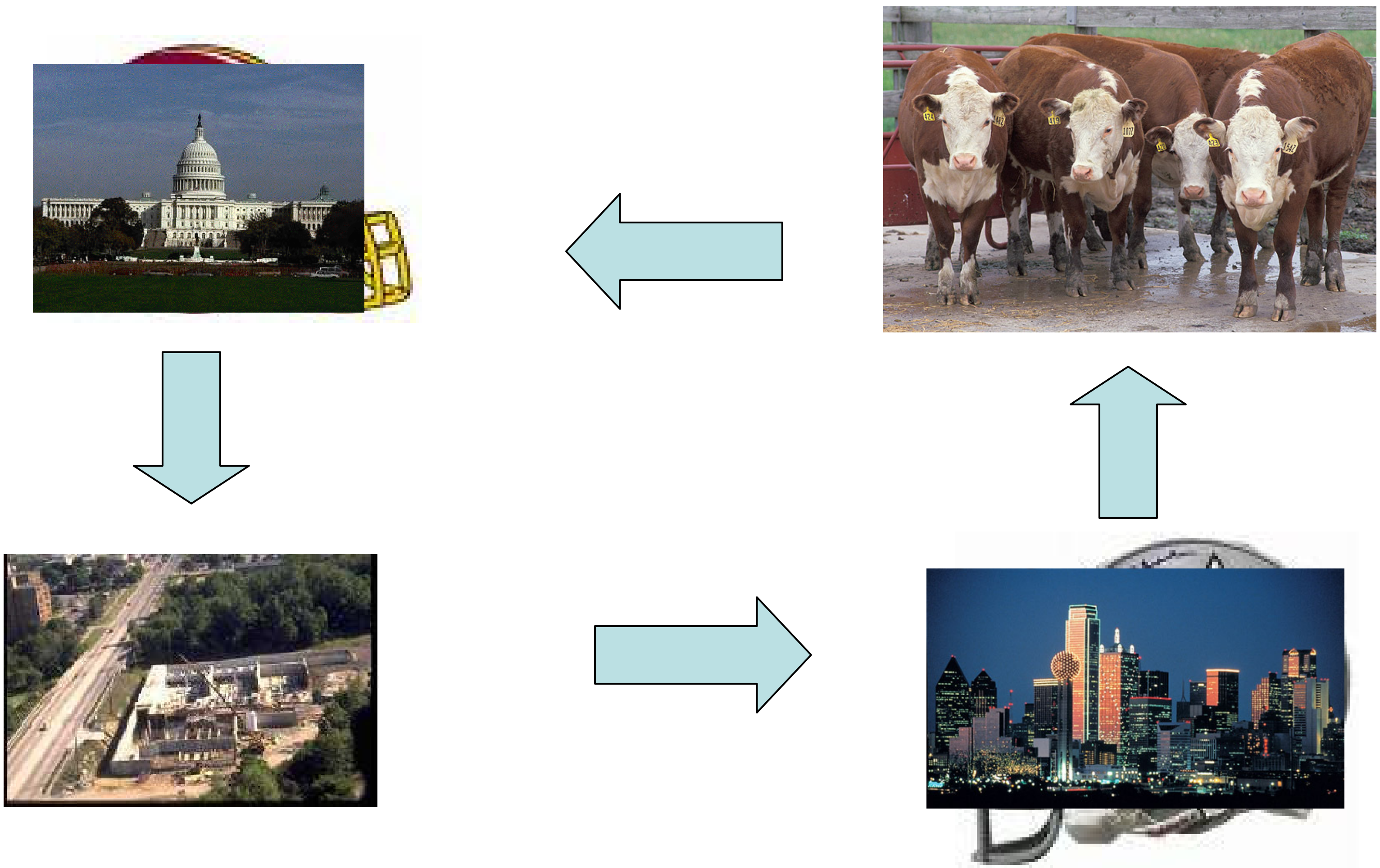
- ***Biosolids application has become a mainstay operation***

- ***Land application: example is Muskegon, MI where wastewater is secondary treated, disinfected, and applied to corn fields which are used to feed dairy cows.***

- ***Some reuse technology being piloted in Germany***

Better Reuse of Wastewater



Humor

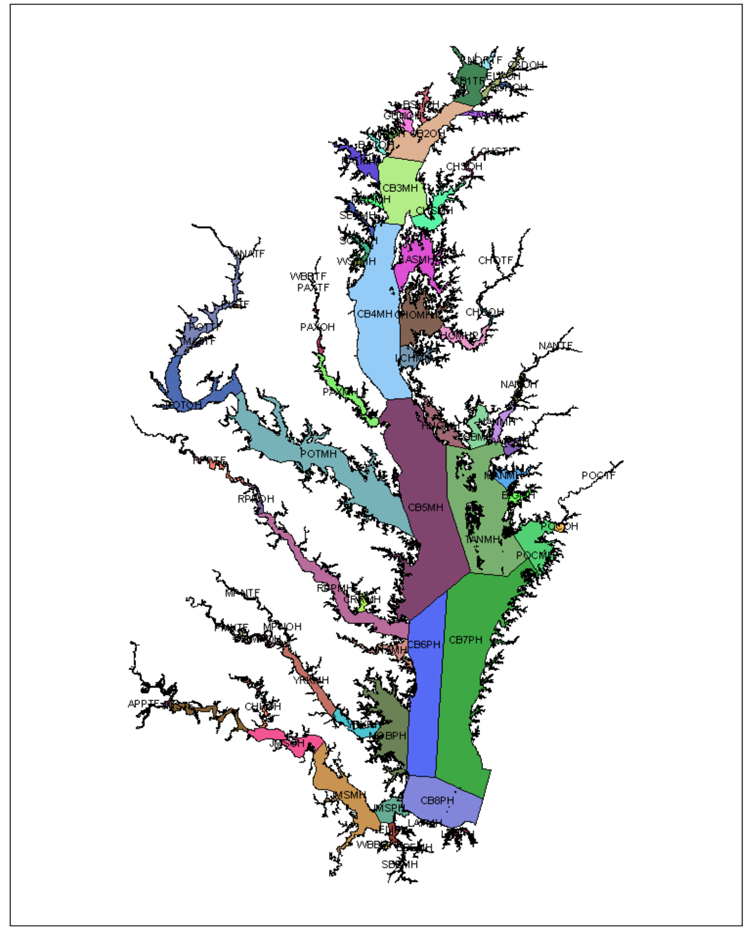
- Ideally a city that generates a lot of human waste can send it to a city that feeds beef cattle.
- This ideal closed cycle reduces N lost.
- It also helps get payback.

Potential Interventions from Other Countries

- Many countries are now addressing N with a new mindset: mass balance
  - Europe and NZ Taxes (proposed)
  - EU Nitrate Directive
  - Great Britain Nitrate Sensitive Areas

Chesapeake Bay Case Study

- How were interventions used?
- What regulations have not been applied?
- What are the challenges to success?
- What are the economics?



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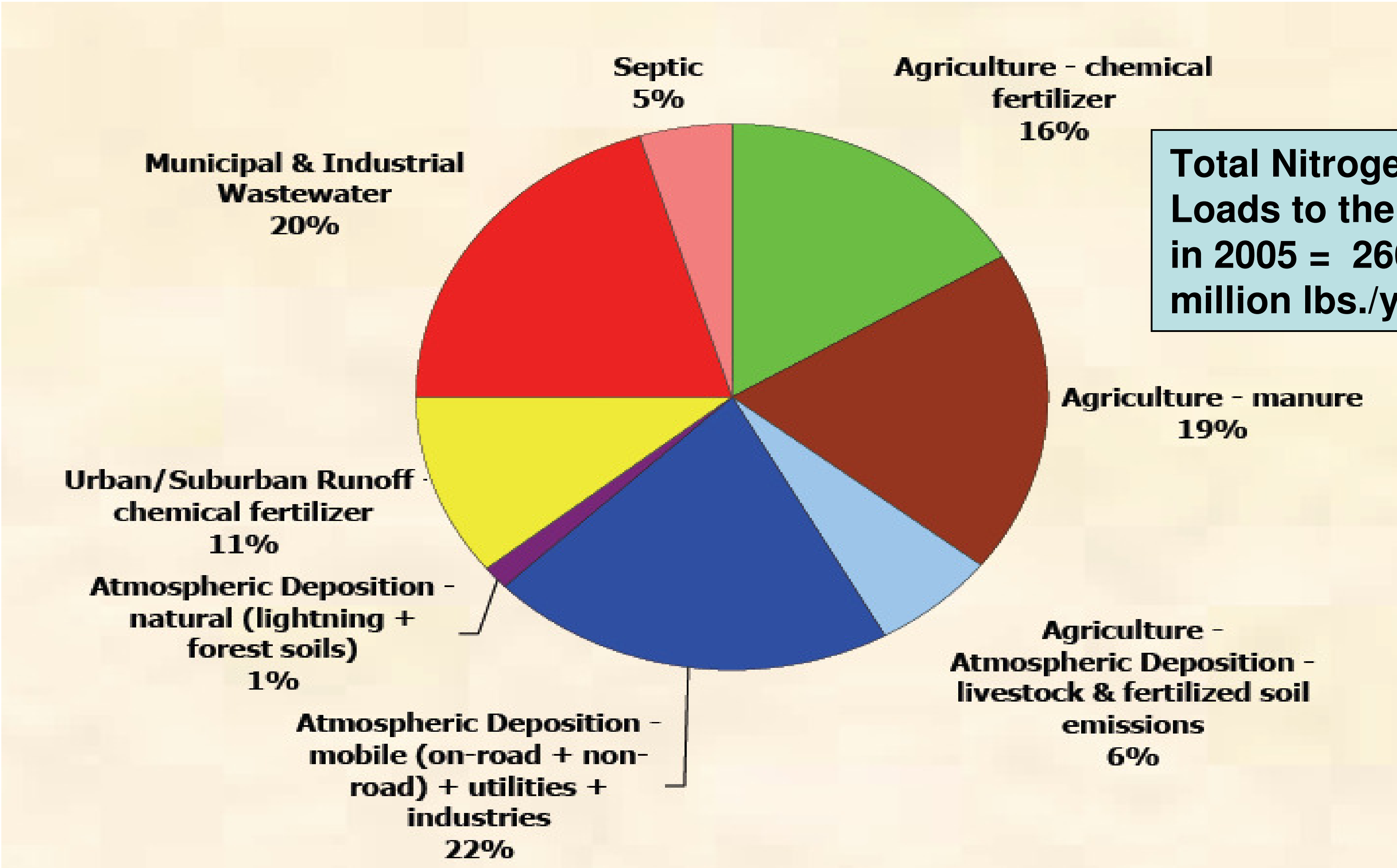
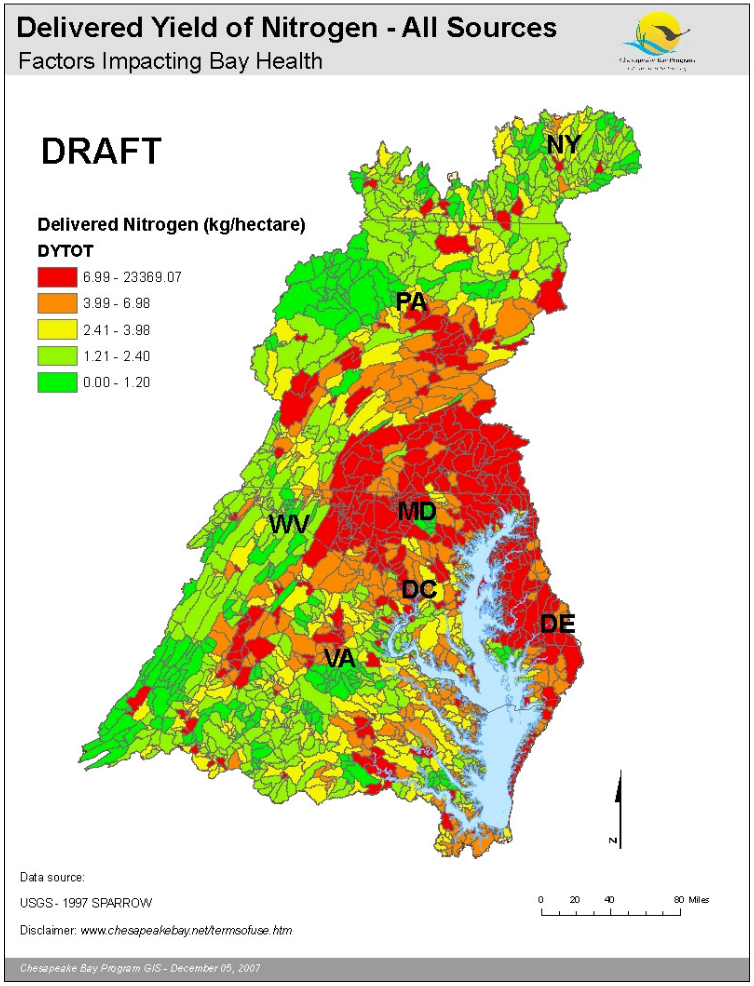
Sources of Nitrogen Loads to Chesapeake Bay Waters



Total Nitrogen Loads to the Bay in 2005 = 266 million lbs./year

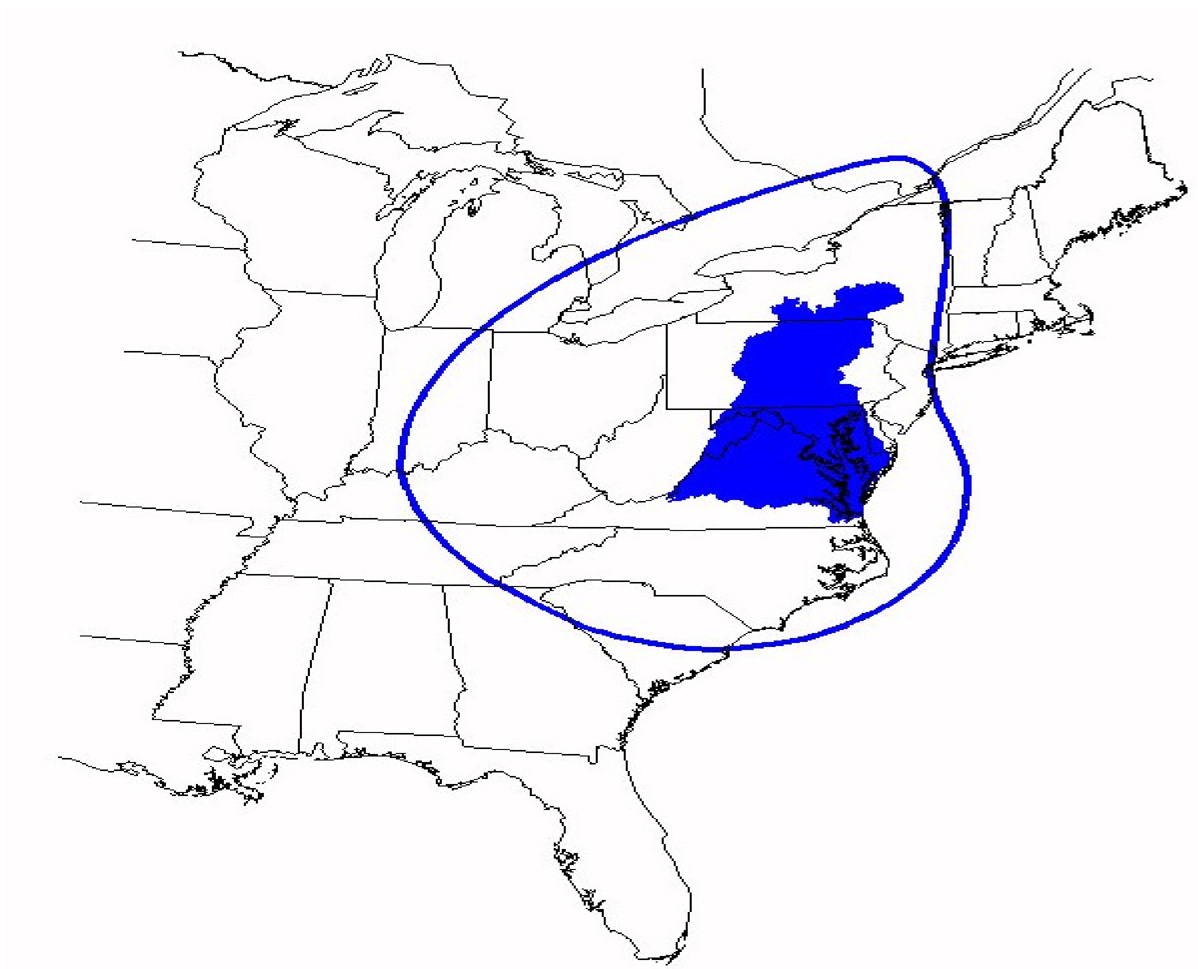
- **According to the Bay watershed model, per-capita nitrogen loads from sewer systems will be about 50% lower than per-capita loads from septic systems (on average).**
- Limit of technology for WWTP (3 mg TN/L) = 1.60 lbs./person-year (5 mg/L = 2.68 lbs./person-year; 8 mg/L = 4.01 lbs./person-year)
- Limit of technology for septic= 0.94 lbs./person-year (assuming BNR, regular pumping and 60% attenuation between edge of septic field and edge of stream)
- LOT for septic and sewer are basically equal but more uncertainty exists in the septic numbers.
- Proximity of septic to stream greatly impacts the assumption of 60% attenuation between edge of septic field and edge of stream.
- Regular maintenance is also very important for septic and is unlikely to occur in most cases. Combined sewer overflows contribute to uncertainty in the sewer load numbers.
- Except for Maryland, no states have plans to upgrade septics when they need to be replaced. All POTW's in the Bay watershed will be upgraded to 3-5 mg/L.
- In the Phase 5.0 watershed model, Bay-average septic loads will remain at 3.67 lbs./person-year until better information is available while the sewer loads will be between 1.6 and 2.7 lbs./person-year based on planned improvements in technology.

Delivered Yield of Nitrogen



Source: USGS
Sparrow Model, 1997

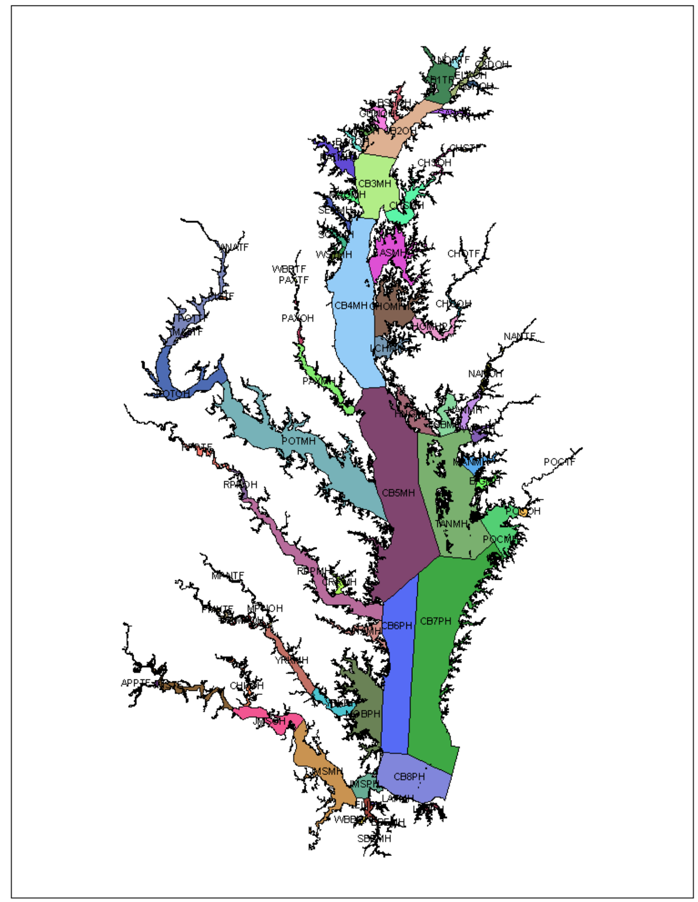
Area Contributing NOx



Bay Criteria, Uses Adopted in State WQS Regulations

- DE (2004), MD (2005), VA 2005/2006), DC (2006)
- Standards adopted in terms of designated use by CBP segment
- WQ criteria, uses, attainment assessment

  methods essentially fully consistent across jurisdictions



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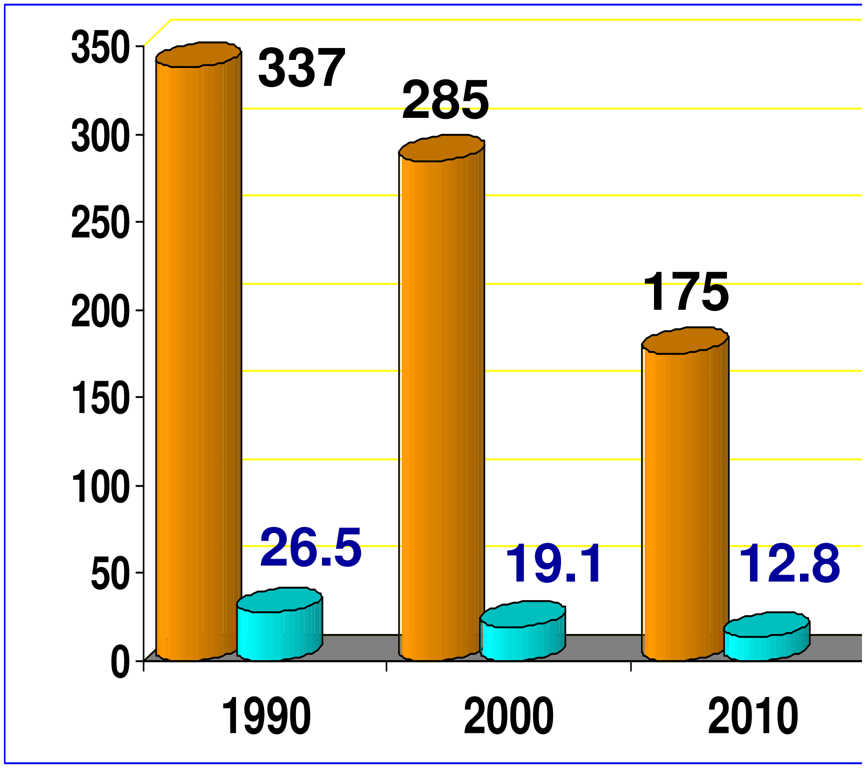
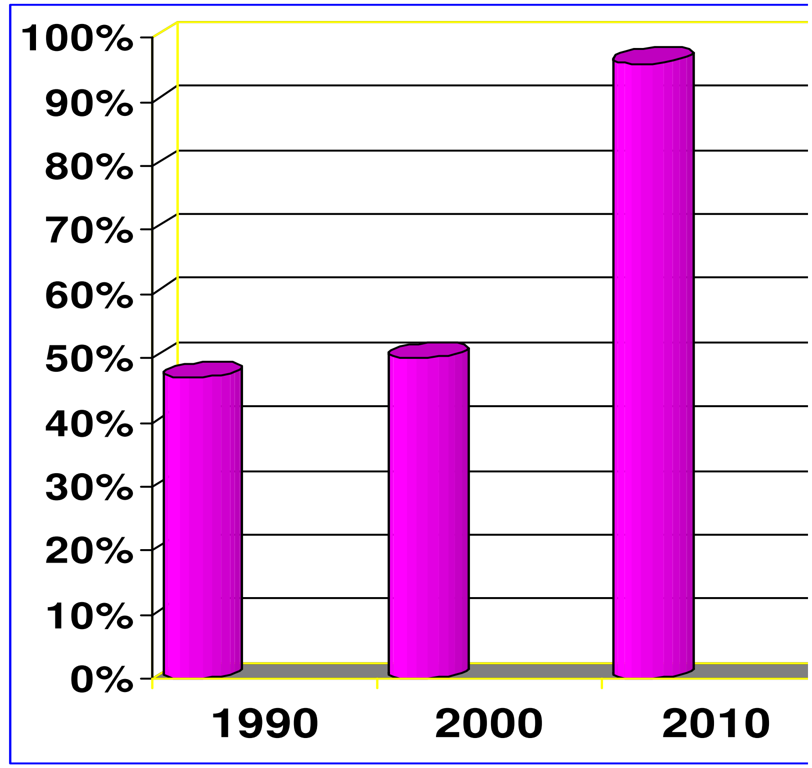
Nutrient Loadings vs. Dissolved Oxygen Criteria Attainment



Millions of pounds per year

nitrogen *phosphorus*



% Dissolved Oxygen Criteria Attainment

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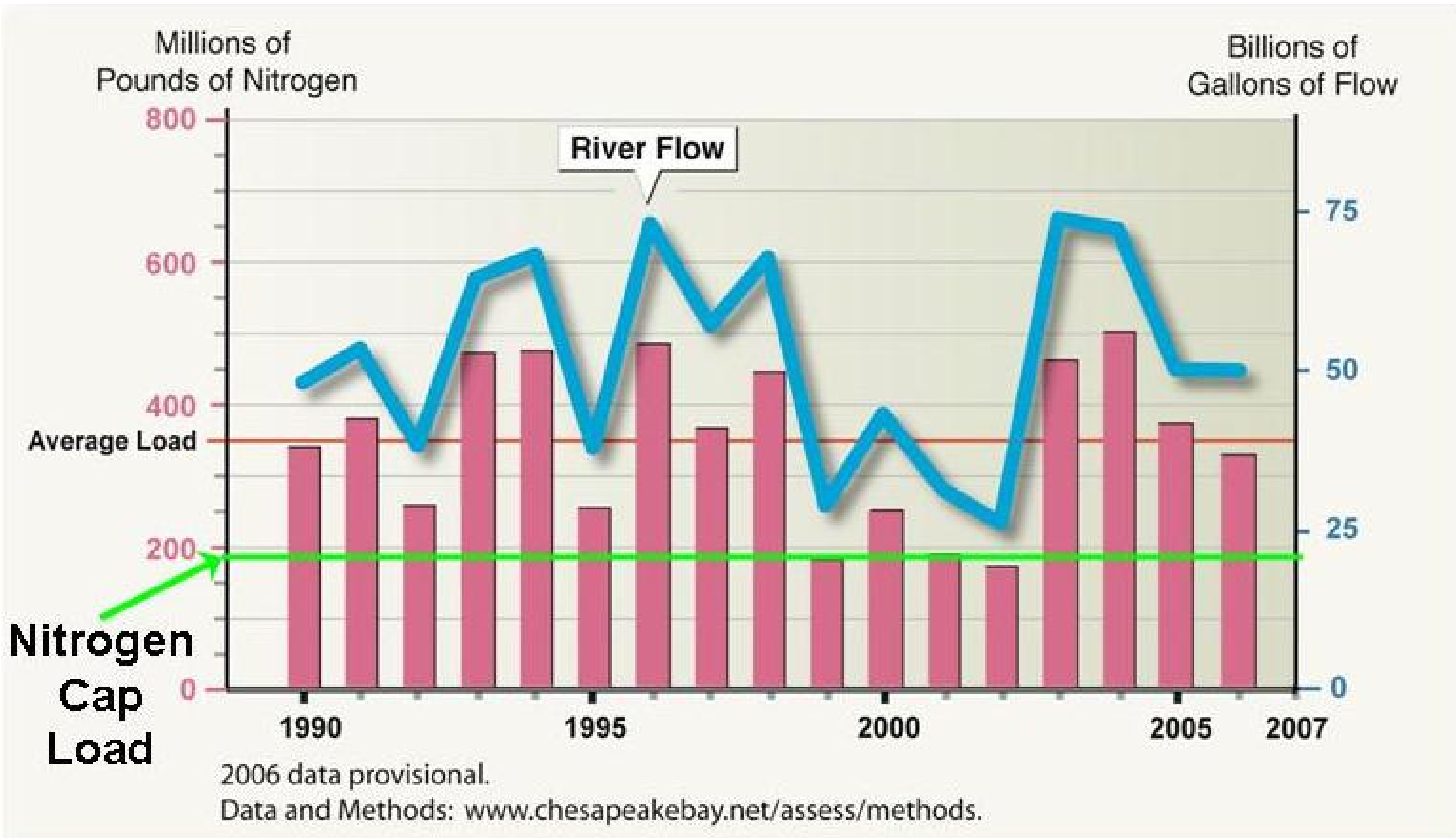
So, what will these reductions achieve, anyhow? You can see in the previous slide, as we reduce the amount of nutrients and sediments entering the Bay, we reduce the amount of impairment as well. The model predicts that the small amount of impairment that remains, 4% of the Bay, will only be impaired 4 months out of the year. (Sediment loads are not graphed here because they are in millions of tons per year, not millions of pounds)

River Flow and Nitrogen Loads Reaching Chesapeake Bay



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Water quantity and N

Nutrient loadings to the Bay are closely tied to water flow. In other words, reduce or slow down the water flow—so that more denitrification and immobilization can occur—the less the mass of N delivered to the Bay. How we manage water on the land is important for what happens to the nitrogen—hence, another example of linkage with other cycles.

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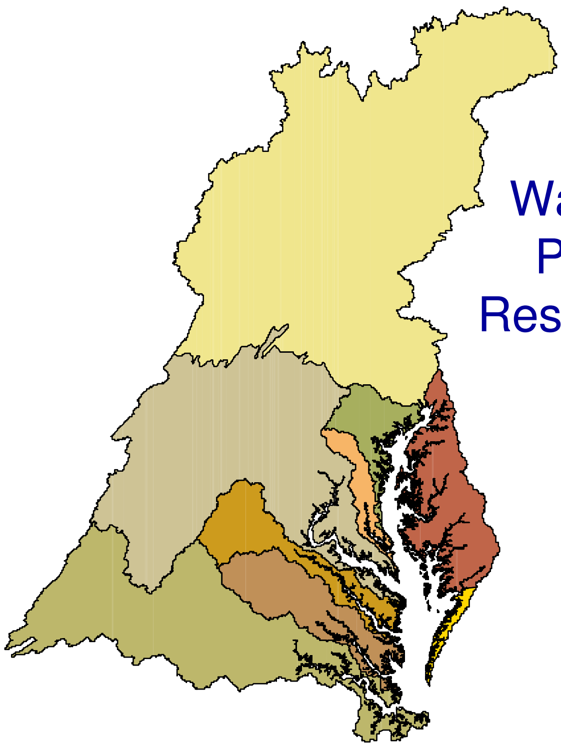
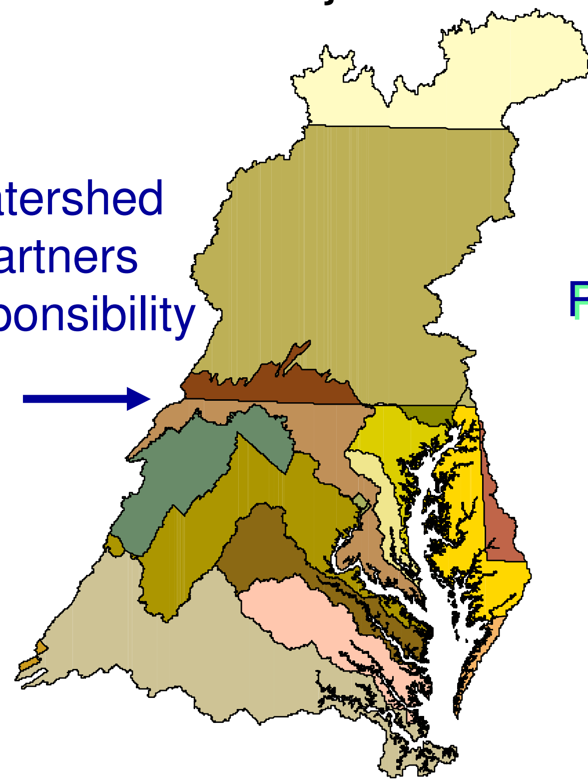
Allocating the Cap Loads

By **9** major river basins



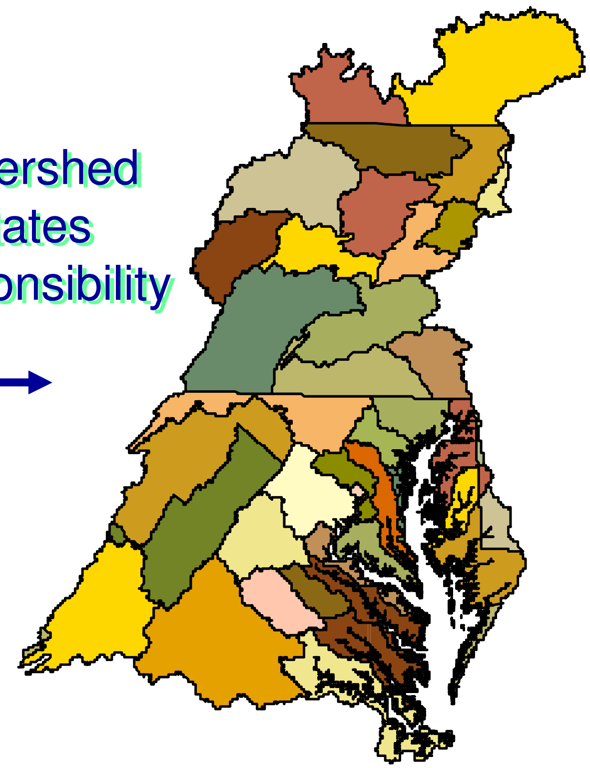
Watershed Partners Responsibility →

...then by **20** major tributary basins by jurisdiction



Watershed States Responsibility →

…then by **44** state-defined tributary strategy subbasins



- The Bay partners have collectively allocated to the 20 basins/jurisdictions
- States will now take 1 year to develop tributary strategies identifying actions necessary to achieve these goals
- will include extensive public input to devise the strategies

What's it Going to Take?

Advanced wastewater treatment for municipalities

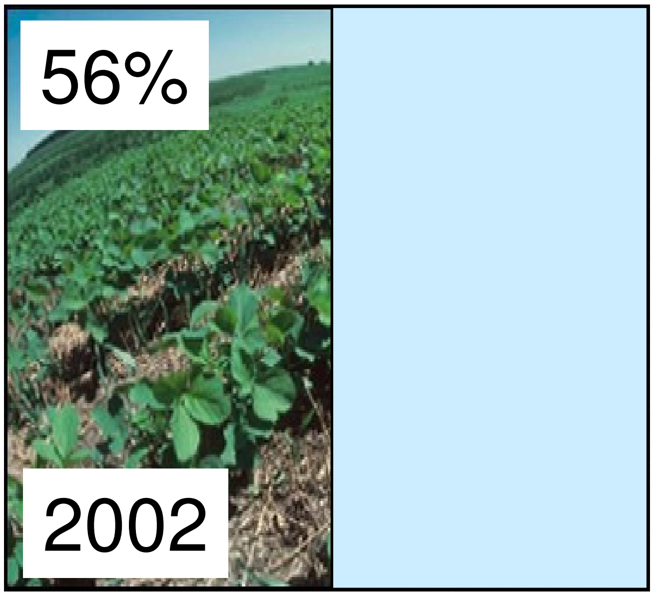
- Secondary treatment effluent ranges 15-35 mg/l as N.
- Biological Nutrient Removal ranges 3-8 mg/l as N.

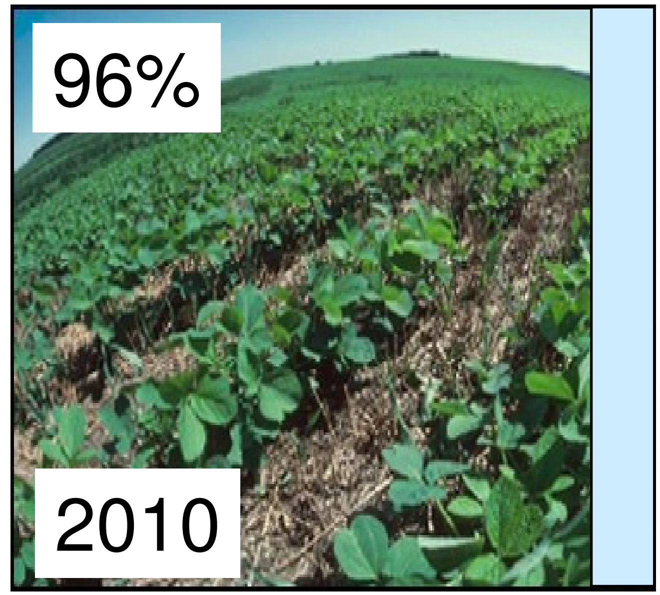
More FUNDING will encourage more action.

Also, actions should lead to minimizing soil disturbance. Land managers should be adopting one or more cost effective BMPs for reducing P and sediment.

What’s it Going to Take?

Unprecedented involvement of our farming communities





Virginia Conservation Tillage Goal

Increase % of cropland under conservation tillage from 56% in 2002 to 96% by 2010 (74,000 more acres).

Interventions Used

- Chesapeake Bay specific water quality criteria, designated uses
- Adopted of Bay specific state water quality standards consistent across all four jurisdictions
- Basinwide approach to NPDES permitting addressing 480+ significant municipal and industrial dischargers
- Clean Air Act regulations and the resultant State Implementation Plans directed towards NOx controls
- Existing state and federal regulations addressing runoff from developed and developing lands
- Existing state and federal regulations addressing runoff from agricultural lands

Interventions Used -- Costs

Source Type	Form of N	$/tonne N
Emissions to the Atmosphere		
Agricultural and Industrial Sources	N_2O	No Estimate
Utilities	NO_X	$6,500
Mobile Sources	NO_X	$15,000
Non-Utility Point Sources	NO_X	$23,000
Area Sources	NO_X	$5,100
Emissions to Terrestrial Ecosystems		
Agricultural Run-off	Various forms	$11,000
Urban/Mixed Open Run-off	Various forms	$101,000
Forest Run-off	Various forms	$22,000
Emissions to Freshwater		
POTWs (sewage treatment plants)	Nitrate	$19,000
Industrial Point Sources	Nitrate	$20,000

- Costs for reducing nitrogen emissions in Chesapeake Bay vary by source and form of nitrogen.
- As technology and information improves, these costs should decline
- One idea is to trade across media (air vs. water) and sources (point vs. non-point)

Costs are estimated costs of treatment from Moomaw and Birch, 2005.

William R Moomaw , Melissa B L Birch. 2005. Cascading costs: an economic nitrogen cycle. *Science in China Series C (Life Science)* Special Edition: 678-96.

Moomaw, W.R. and M.B.L Birch. 2005. Cascading costs of reactive nitrogen damage. *Tufts University Center for International Environment and Resource Policy Working Paper*, 25p.

Interventions Not Used

- Chesapeake Bay Program Considered But Did Not Rely on Going Beyond Existing Regulatory Program in Seeking Reductions
  - Regulatory approaches to controlling runoff from agricultural lands beyond existing state regulations on nutrient management planning
  - Regulatory approaches to address runoff from agricultural animal feeding operations beyond existing state and federal regulations
  - Seeking additional reductions from air emissions beyond those required to achieve existing air quality standards

Interventions Not Considered

- Chesapeake Bay Program Did Not Consider:
  - Intervening with local land use planning, or
  - Regulatory approaches for addressing septic systems

Challenges to Success

- Challenges to Reducing and Then Capping Nitrogen Load from the Big Three Sources: Agriculture, Wastewater and Developing Lands
  - Insufficient levels of cost share funds and technical service providers required to reach 90% of the 55,000 farmers across the Bay watershed (level required in order to achieve the established nitrogen cap load allocations)
  - Existing regulations and approaches are not as effective for nitrogen control than leaving areas undeveloped
  - Maintaining caps on nitrogen loads from municipal wastewater treatment facilities in the face of another projected 1.7 million more Bay watershed residents in the next decade

Observations

- EPA control programs have done a mixed job at controlling N emissions from air and water sources
  - Non-point water sources are difficult to regulate, thus literature is mostly theoretical or focuses on small areas for empirical application
- Non-regulatory interventions have not prevented Nitrogen problems
- Key economic point: No self interest to reduce use of nitrogen because it increases farm production

FACT or Fiction

Addressing excessive nitrogen releases will require coordinated work from federal, state, and local government in air, soil and water media.

Fact

Thanks to Workgroup

- Jim Pendergast (OW)
- Rich Haeuber (OAR)
- Randy Waite (OAR)
- Roberta Parry (OW)
- Andy Manale (OPEI)
- Sabrina Lovell (OPEI)
- Adam Daigneault (OPEI)
- Rich Batiuk (CBPO)

NITROGEN BACKGROUNDER

1	**OVERVIEW**
2	**THE N-CYCLE IMPACTING HUMAN HEALTH AND THE ENVIRONMENT**
3	**INTERVENTIONS, CONTROL OPTIONS, AND ECONOMICS**
4	**CHALLENGES**
5	**INTEGRATION**