c1

NITROGEN BACKGROUNDER

Challenges to Nitrogen Management

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

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: CASE STUDY**

NITROGEN BACKGROUNDER

Module 4:

Emerging Challenges to Nitrogen Management

EPA United States Environmental Protection Agency

Challenges in Nitrogen Management

- New environmental challenges are emerging even as we tackle existing problems.
- New problems may complicate resolution of existing ones.
- New policy approaches may need to be applied to correct both new and old problems.

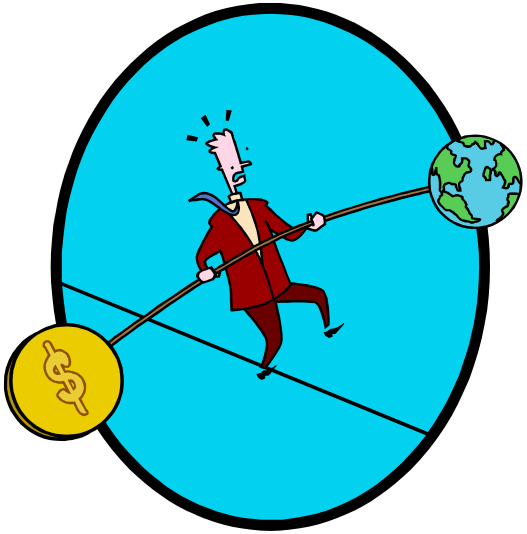
Learning Objectives

- Nitrogen management is a systems issue:
  - Economic development and environmental problems may increase N challenges.
  - Other environmental programs may make N management goals harder to reach.
- Opportunities exist for international action.
- Additional research is needed to properly address these challenges.

EPA United States Environmental Protection Agency

Emerging Challenges Outline

I. The Systems Nature of Nitrogen Management
II. Climate Change
III. Air Emissions of Ammonia
IV. Global Trade in Nitrogen
V. Biofuels Production
VI. International Pressure to Act
VII. Monitoring and Data



EPA United States Environmental Protection Agency

Nitrogen Backgrounder

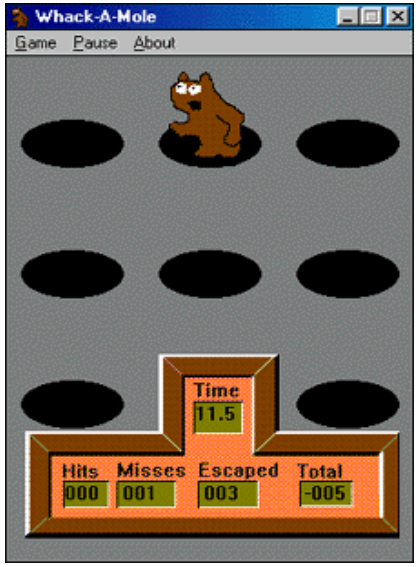
Challenge #1:
A Systems Approach

EPA United States Environmental Protection Agency

A Systems Problem

Unless we manage nitrogen systematically, “fixing” the problem in one medium or location may lead to another nitrogen issue popping up in another media or location — <u>chemical recidivism</u>.

Whack-A-Mole



How Does One Deal with a "Systems" rN Problem?

- Store it
- Reduce its use
- Denitrification, i.e, destroy it
- Do not forget "Recycle" it!

EPA United States Environmental Protection Agency

Water Quality Problems w/ rN: A Systems Issue

SAB Hypoxia Advisory Panel

"Current water quality problems due to nutrients do <u>not</u> result primarily from the mismanagement of fertilizers and manures (although some improvement can and should be made), but are mostly due to landscape and land-use changes (with associated changes in hydrology and economic inputs of nutrients)."

Photo from http://www.accessnoaa.noaa.gov/may0301/happenings.html
Quote from http://www.epa.gov/sab/pdf/5-24-07_hap_draft.pdf

What Land Modifications and Land Uses Is SAB Talking About?

- Tile drainage systems
- River straightening and levee construction and hence detachment of river from its floodplain
- Agricultural land-leveling
- Agricultural monoculture
- Among others

EPA United States Environmental Protection Agency

Transfer of N between Media: Unintended Consequences

- CAFO regulations included mandates for lagoon systems on hog farms to reduce nitrogen losses to surface water.
- Producer Response?

Picture credit: http://h2o.enr.state.nc.us/admin/emc/committees/wq/2000/2000-02wqc.htm

  – Waste storage in large, aerated lagoons
  – Sludge spread onto fields for cover crops

- Unexpected results
  – N transfer to atmosphere
  – N transfer to larger landscape

Systems Solutions Needed

- Perverse outcomes may result from single objective problem-solving in multiple objective situation.
- Solutions must recognize links between nitrogen cycle and carbon, water and other cycles.
- A management policy that integrates multiple objectives (or ecosystem services) into land use decisions.

EPA United States Environmental Protection Agency

Systems

- Systems problems require systems solutions. Where land and nitrogen is involved (the major source of rN to the environment), it means that we ask, what services of the land are we giving up by emphasizing one objective, say crop production, over nutrient recycling or water storage, services that the land also provides.

EPA United States Environmental Protection Agency

Nitrogen Backgrounder

Challenge #2:

Global Warming and Climate Change

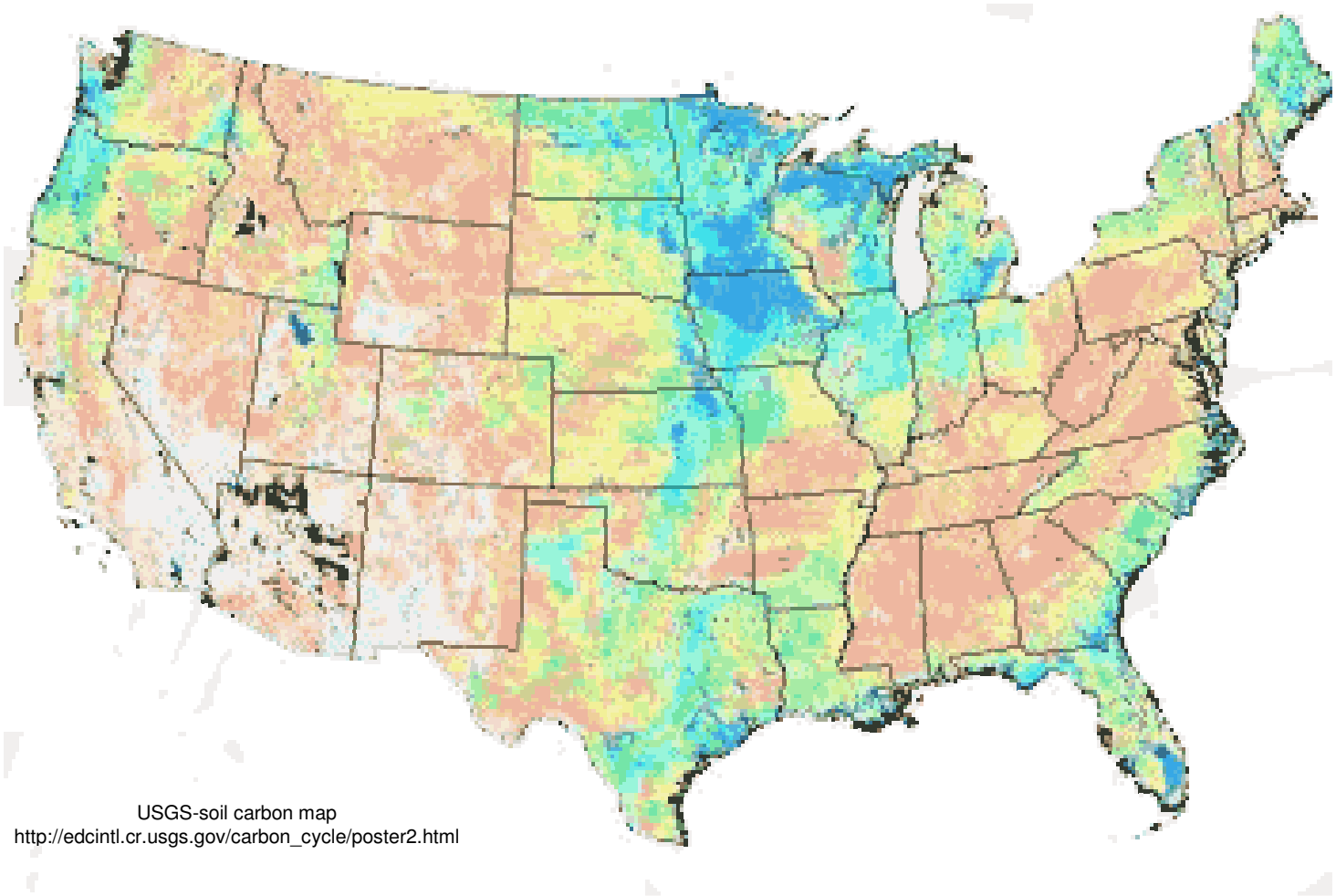
EPA United States Environmental Protection Agency

Amount and Fate of N in Soil Reservoirs — Married to Carbon

- Soil C and N storage (immobilization) in soil reservoirs generally in balance
  - For every ten carbon atoms, there is one nitrogen atom
  - Wetland soils a bit more, twelve carbon atoms to one nitrogen
  - Ratio is fixed, i.e., as carbon is removed, nitrogen is removed at the same ratio
  - The reverse is true as well
- Levels of C (and hence N) stabilize at levels characteristic of climate and topography

EPA United States Environmental Protection Agency

Carbon-Nitrogen Soil Stocks

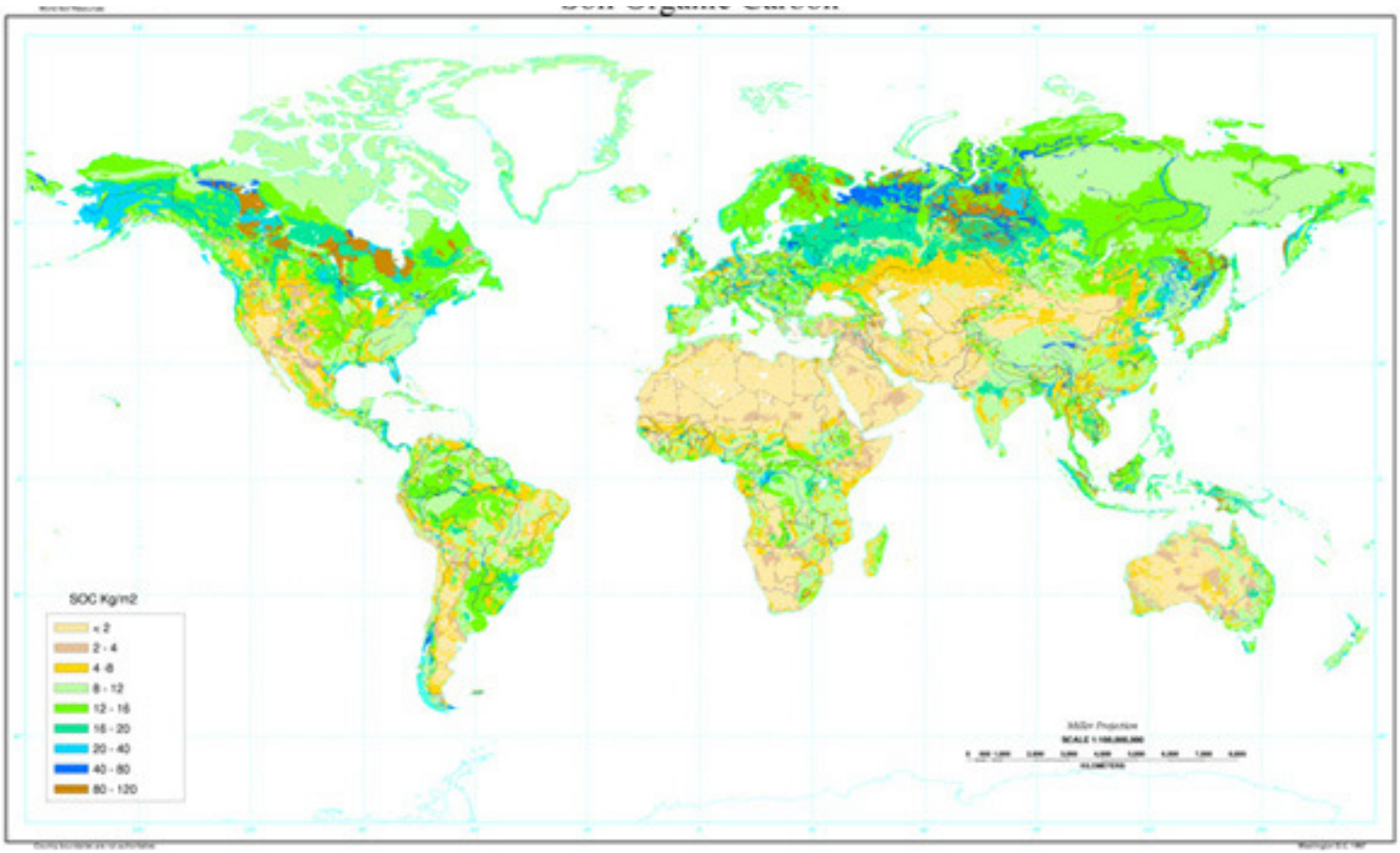


USGS-soil carbon map
http://edcintl.cr.usgs.gov/carbon_cycle/poster2.html

- Blue is more
- Light colors is less

EPA United States Environmental Protection Agency

World Soil C (and thus N) Map



Fate of N in Soil Reservoirs--Depends upon Climate and Management

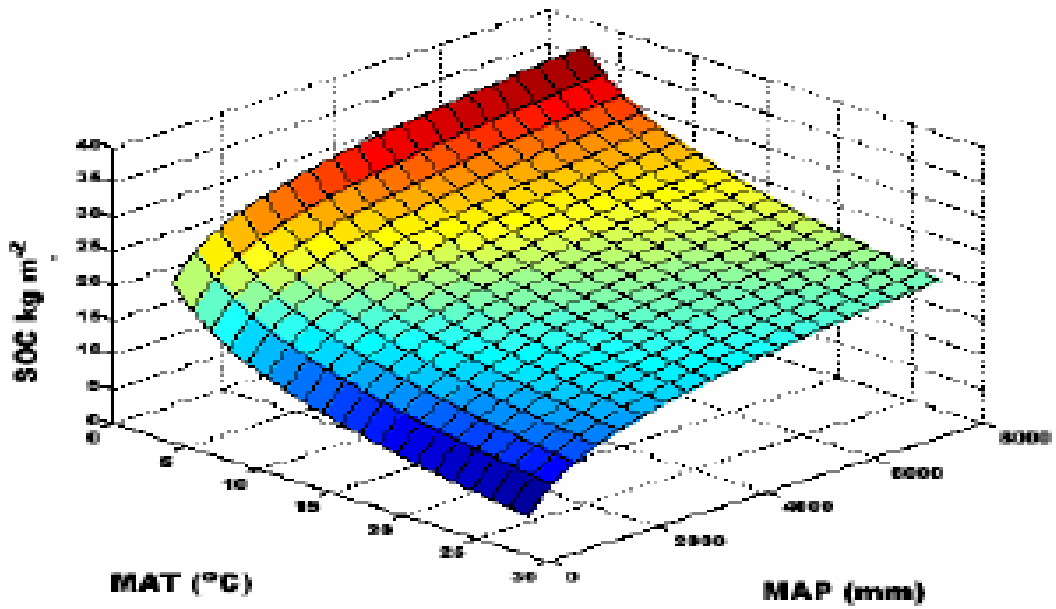
- Soil C (and hence soil N) increases with mean annual precipitation (MAP), i.e., more rain
- But, soil C (and hence soil N) decreases with mean annual temperature (MAT), i.e, global warming
- Management, especially in agricultural soils, can offset loss of soil C by leaving more crop residue

EPA United States Environmental Protection Agency

Soil Carbon (Nitrogen) vs Climate

Soil Carbon vs. Climate

- Soil C increases with Mean Annual Precipitation (MAP) and decreases with Mean Annual Temperature (MAT).
- Pattern is due to balance of inputs and losses as influenced by climate.



Source: Amundson, R. 2001. The Carbon Budget of Soils. Annu. Rev. Earth Planet. Sci. 2001. 29:535–62

EPA United States Environmental Protection Agency

Why Do We Care?

- Large amount of N immobilized in soils in the form of humus
- Release (mobilization) of N can complicate existing efforts to protect water quality
- Release of N as nitrous oxide contributes to global warming
- N_20 has 310 times the warming potential of CO_2

EPA United States Environmental Protection Agency

Estimates of Active N Pools

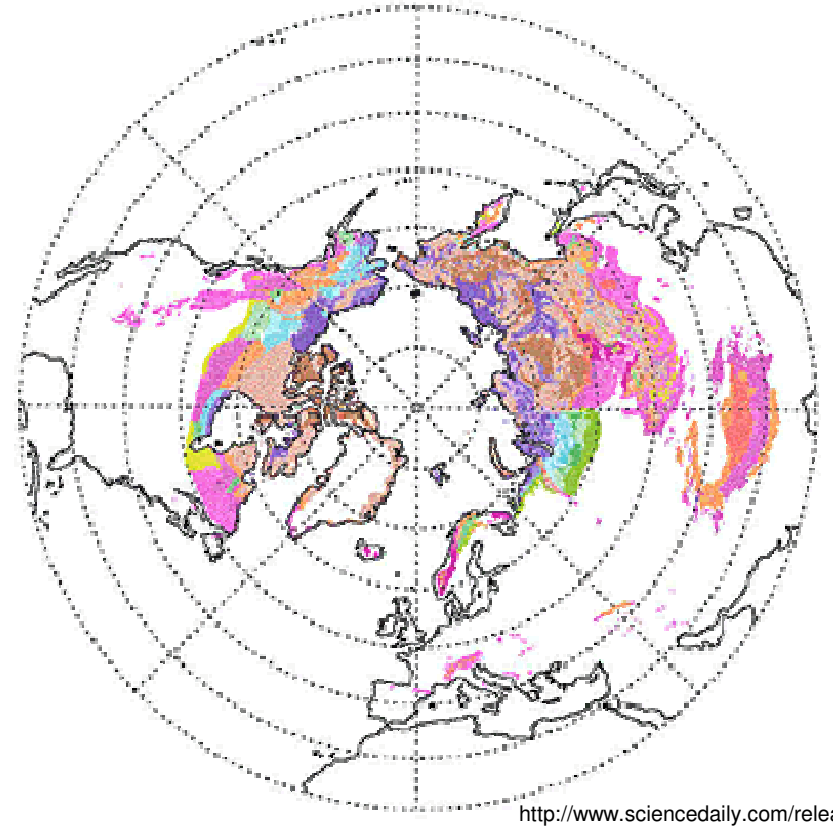
Medium	Form	Pg N
Air		
	N_2	3,900,000
	N_2O	1.4
Land		
	Plant	15
	Animals	0.2
	SOM	1,500
Sea		
	Plant	0.3
	Animals	0.2
	Solution or suspension	1,200
	Dissolved N_2	22,000

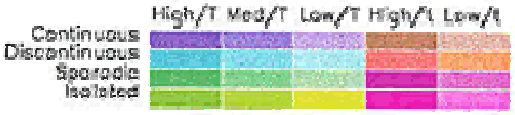
EPA United States Environmental Protection Agency

1500 Pg (petagram) N is equivalent to 1.5 million Tg. One Tg is equivalent to 1 million metric tons. Hence 1500 Pg is equivalent to 1 quadrillion metric tons or 1000 times one billion metric tons or a million times a million metric tons. A lot.

EPA United States Environmental Protection Agency

Thawing of Boreal and Arctic Permafrost

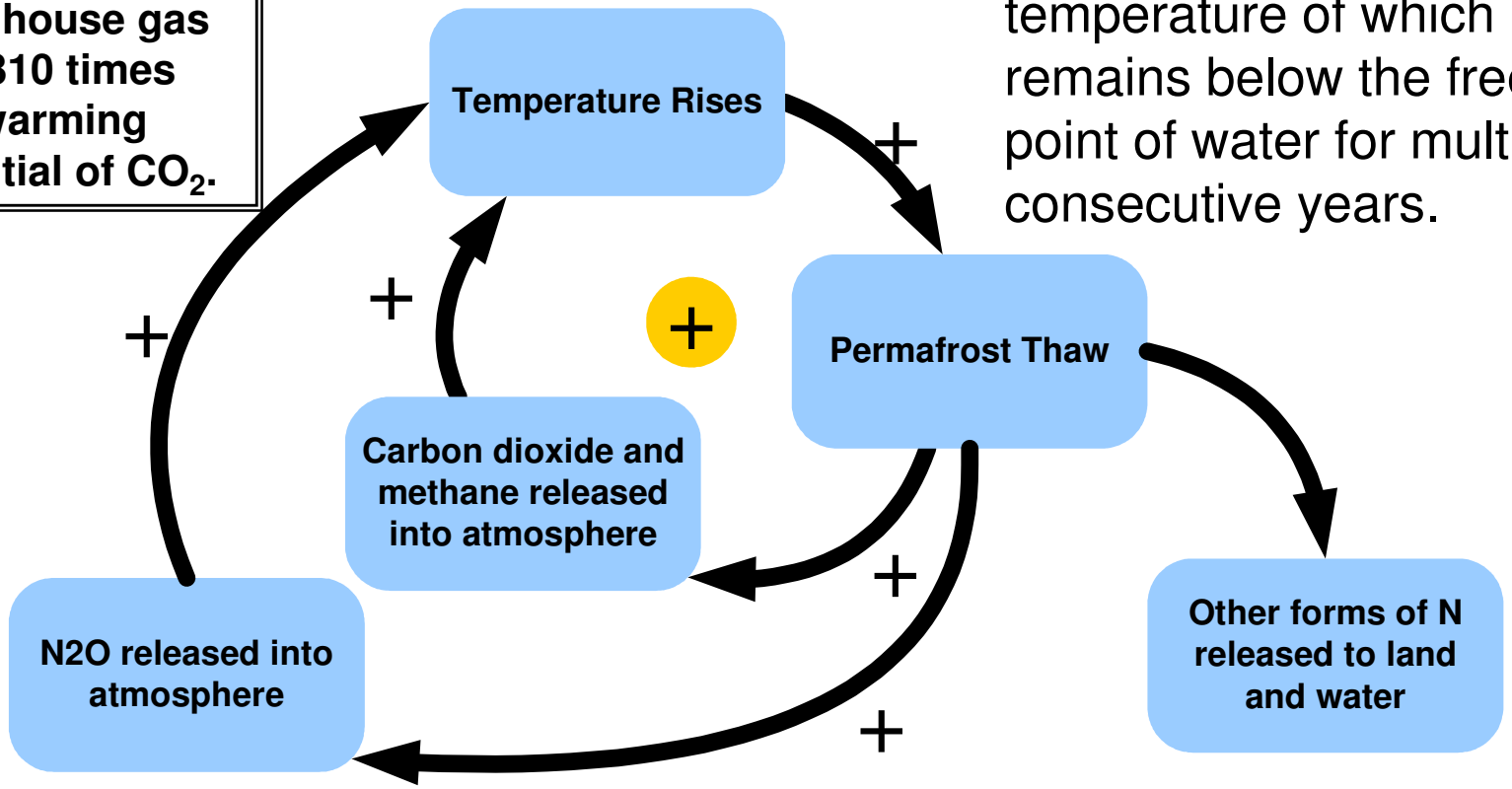




http://www.sciencedaily.com/releases/2006/06/060615180432.htm. Also IPPC report #4
http://www.sciencedaily.com/releases/2005/12/051220085054.htm
http://www.sciencedaily.com/releases/2007/09/070913132927.htm

Thawing of Boreal and Arctic Permafrost

N2O is a greenhouse gas with 310 times the warming potential of CO_2.



Permafrost is soil the temperature of which remains below the freezing point of water for multiple consecutive years.

EPA United States Environmental Protection Agency

- Source: IPCC
- Add cycle of N being released from permafrost, and leakage to air and water, and further warms temperature, etc.
- Adapted from: http://sitemaker.umich.edu/section2_group1/arctic_issues__permafrost

- The N2O box in previous slide should make clear that we do NOT know how much N2O will be released.

Permafrost Nuggets

- 4 million square miles, roughly 30% of global terrestrial carbon.
- Predicted declines by 2100:
  - decline to between 0.4 and 1.5 million sq. miles.
- Permafrost soils in Siberia have potential to release 75 times more carbon than is released from the burning fossil fuels each year
- Given linkage to C, some 50 billion tons of N in reservoir.

EPA United States Environmental Protection Agency

- Roughly 10% of soil organic matter, by weight, is nitrogen. Loss of carbon means loss of Nr from the soil reservoir
- Potential for sudden release of vast quantities of Nr accumulated in soil reservoir over tens and hundreds of thousands of years

- 50 billion tons or 50,000 Tg or 50,000 million metric tons

- Souces of declines: IPCC
- Image source: http://www.alaskareport.com/alaska10020.htm

Implications on Permafrost Melting on Reactive N?

- Amount and composition of the potential release unknown, but:
  - A mere fraction of permafrost N released as nitrate could disturb marine ecosystems
  - Or as Nitrous Oxide (N_2O) contribute to global warming
- Compare to current anthropogenic release of 210 million metric tons N

EPA United States Environmental Protection Agency

The amount of increased N from permafrost melt should be put in context with other nitrogen releases, even though we don't know the composition of the release.

EPA United States Environmental Protection Agency

Where will the Nitrogen go?

- IPCC estimates short-term net of trace greenhouse gases (N_2O)
- Partitioning of freed reactive N to water or air depends upon local conditions
- Research concern because of potential to exacerbate mitigation efforts

Source, bullet 2: http://news.ufl.edu/2004/09/22/arctictundra/

EPA United States Environmental Protection Agency

Need for considering N impacts in GHG Mitigation Efforts

- Carbon trading programs may cause unintended problems with nitrogen in systems.
- Planting more trees or crops for carbon sequestration could lead to increased:
  - N fertilizer use
  - N runoff
  - nitrous oxide emissions
- Need consideration of goal of <u>nitrogen neutrality</u> along with carbon neutrality.

EPA United States Environmental Protection Agency

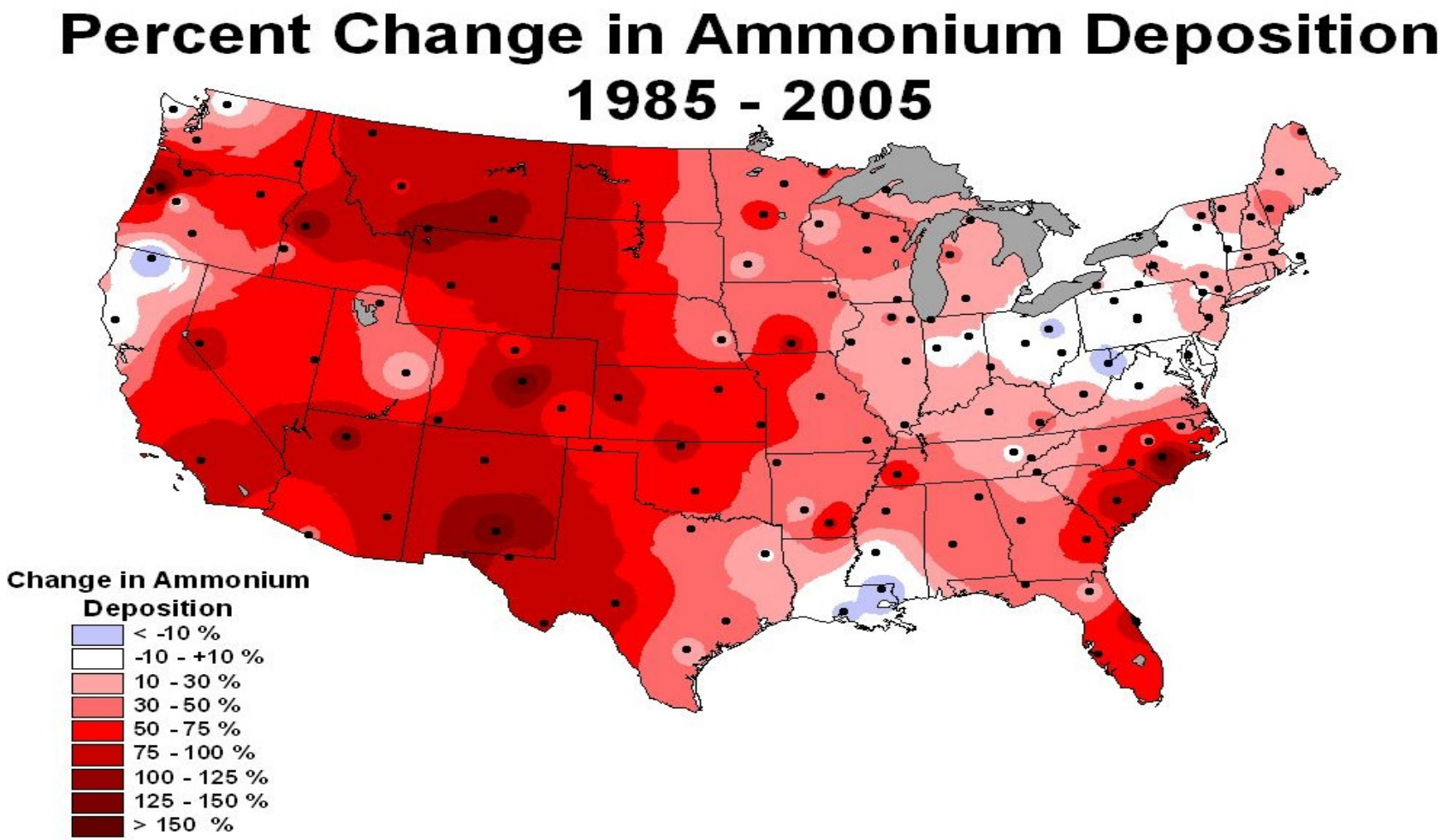
Nitrogen Backgrounder

Challenge #3:

Air Deposition of Ammonia

EPA United States Environmental Protection Agency

NH_4 Increases Despite Reduced NOx Emissions over Time



EPA United States Environmental Protection Agency

Air Deposition of NH_4: A New Air Challenge

- Creates 10-40% of "new" N enrichment of certain coastal and estuarine waters
- Dominant source: agriculture
  - Livestock operations
  - Commercial fertilizer applications

- Air transport may occur over short or long distances
- Key role in forming fine particulate matter ($PM_{2.5}$)
- Ammonia is largely unregulated at present

EPA United States Environmental Protection Agency

- The “fertilizing” aspect alters N-limited ecosystems
- Contributes to loss of suitable habitat for wildlife species
- Supports invasion of exotic (and unwanted) species of plants

Nitrogen Backgrounder

Challenge #4:

Global trade in nitrogen

EPA United States Environmental Protection Agency

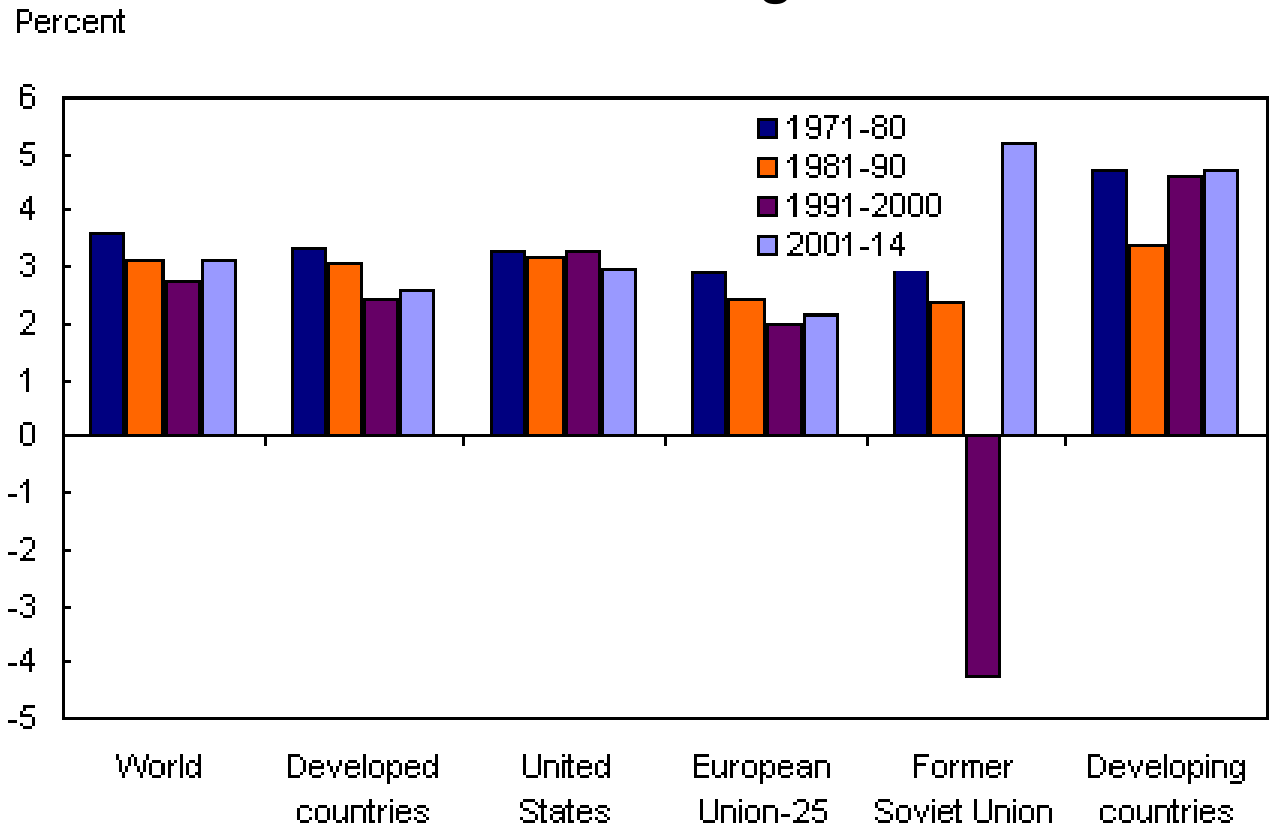
Global Trade and Nitrogen

- With increasing wealth comes increased demand for meat and meat products
- More production of livestock means more reactive nitrogen lost to the environment, unless preventive measures are taken

EPA United States Environmental Protection Agency

Increasing GDP Growth and Trade

World gross domestic product (GDP) growth rates, decade averages



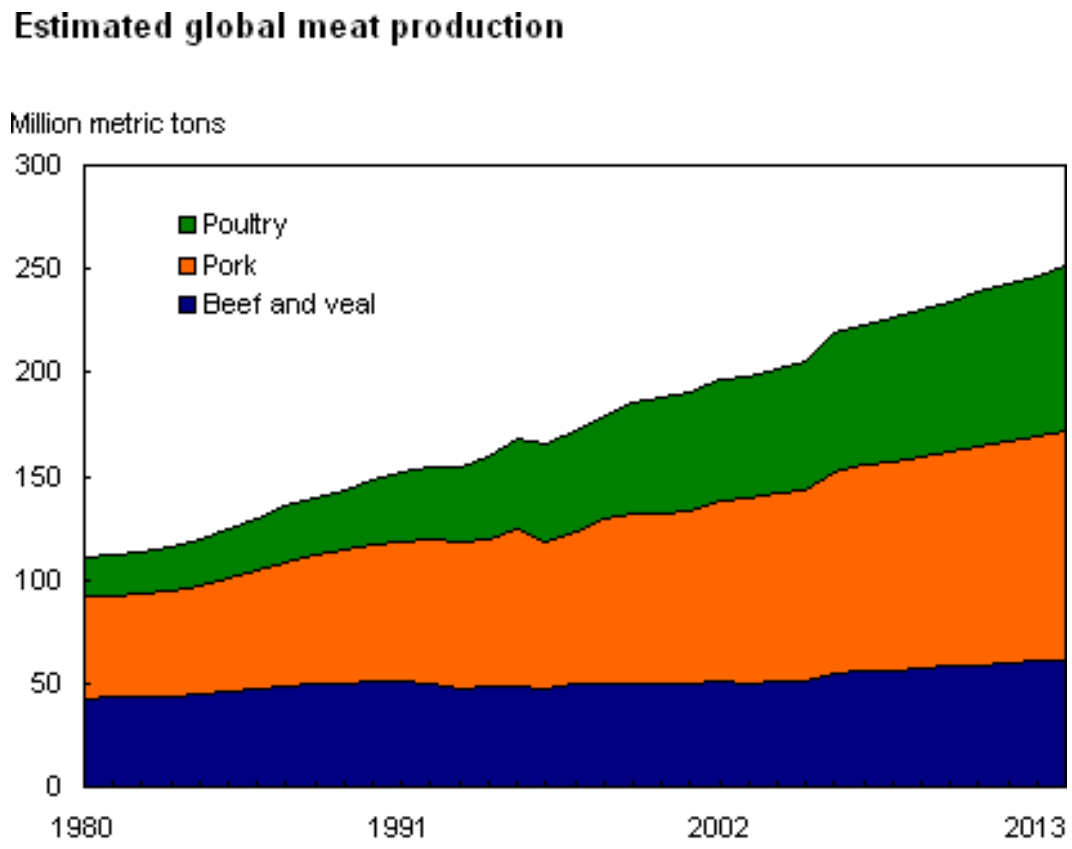
EPA United States Environmental Protection Agency

- Population Growth and growth in GDP is fueling increases in global trade, and changing the nature of the problem from a domestic one to an international one. Current population at 6.7 billion.
- USDA Agricultural Baseline Projections to 2014, February 2005. Economic Research Service, USDA. http://www.ers.usda.gov/Briefing/corn/2005baseline.htm
- "Demand for feed grains is derived from the demand for livestock feed, which is derived from the demand for meat, milk, and eggs.
- **Macroeconomic Growth Indirectly Affects Feed Grain Use**. The baseline assumes that growth in U.S. gross domestic product (GDP) moderates in the near term from the rapid growth in 2004 as the economy moves toward a long-run annual growth rate near 3 percent. Ongoing U.S. technological advances associated with computing and telecommunications will provide support for worldwide economic growth throughout the projection period.
- World economic growth is projected to strengthen from the slow growth of 2001-03, averaging over 3 percent through 2014. Most countries of the world move close to longrun sustainable economic growth rates. Relatively high oil prices in 2004 and beyond will constrain Asia and its manufacturing sector, which is far more dependent on energy for GDP growth than more developed economies."

Future World Demand for Meat

A "demand-driven livestock revolution is under way in the developing world with profound implications for global agriculture, health, livelihoods and the environment."

- ***International Food Policy Research Institute***



- Source of quote: State of the World Population, 2001. http://www.unfpa.org/swp/2001/english/ch02.html

- Source of picture: USDA Agricultural Baseline Projections to 2014, February 2005. Economic Research Service, USDA. http://www.ers.usda.gov/Briefing/corn/2005baseline.htm
- "As economies expand, consumers shift to more meat in their diets and this requires more feed grains for meat production. Diets in the United States already have adequate quantities of meat, but an expanding economy will keep meat consumption brisk. Internationally, expanding economies are likely to change diets, especially in developing economies. As a result, the baseline analysis expands world trade in feed grains and increases exports from the United States."

- Meat demand in the developing world will double between 1995 and 2020 to 190 million metric tons.
- In per capita terms, demand for meat will increase 40 per cent between 1995 and 2020.

Rising Demand for Corn

- Demand for cereals to feed livestock will double in developing countries over the next generation.
- In U.S., 2/3 of grain harvested used for feed production.
- 1/3 of all cereal grains harvested globally used for industrialized livestock operations.

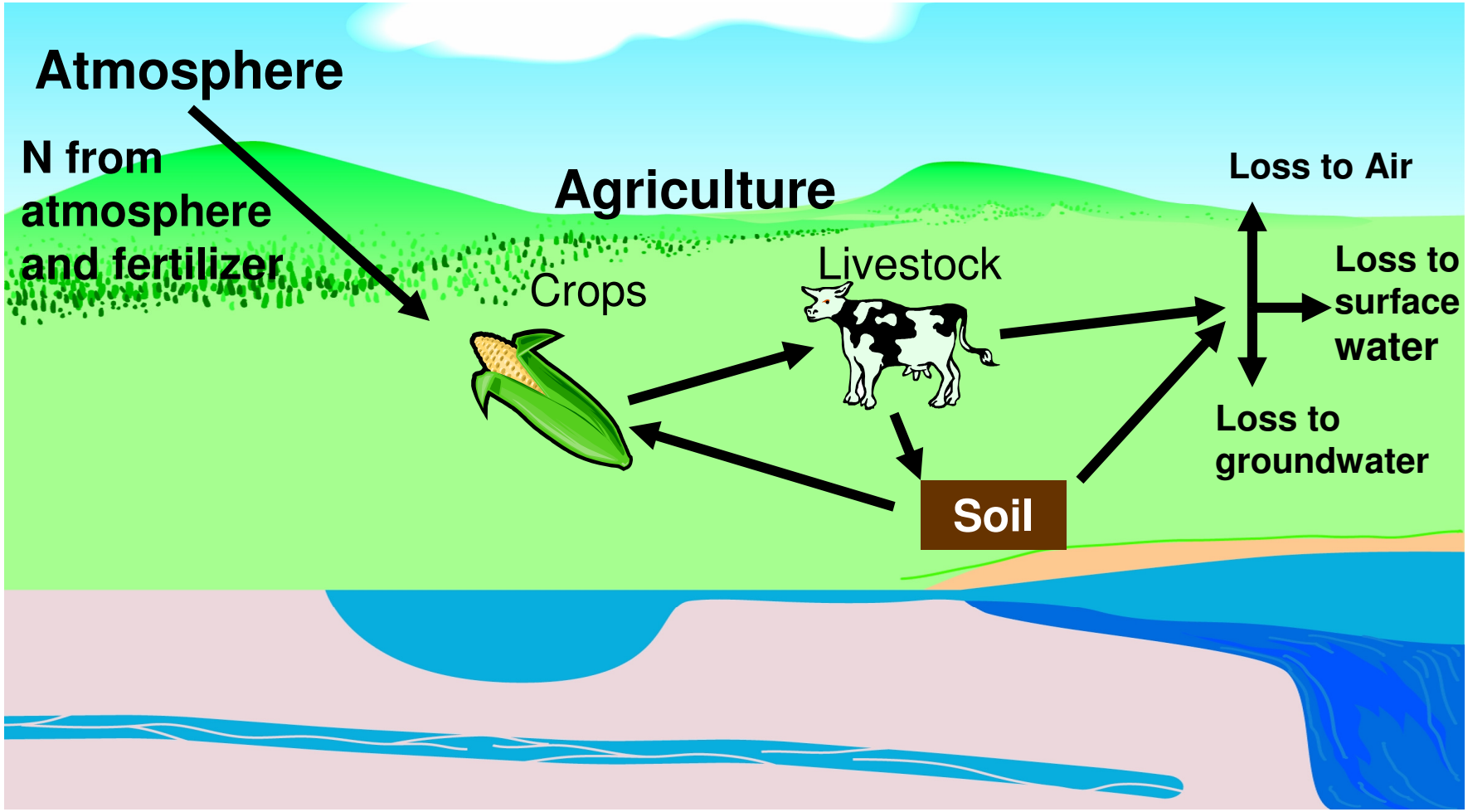
EPA United States Environmental Protection Agency

- Source of first two bullets: State of the World Population, 2001. http://www.unfpa.org/swp/2001/english/ch02.html

- Increasing world demand for livestock products
- More demand for meat means more livestock and more grain to feed livestock
- Increased production largely in confined animal feeding operations (CAFOs)
- Siting of CAFOs generally near urban centers to reduce transportation costs

- photo:
- USDA, NRCS photogallery, Lynn Betts 1999, keyword “corn” used to search for picture.
- http://photogallery.nrcs.usda.gov

Conventional View of Agricultural Production and N Cycle

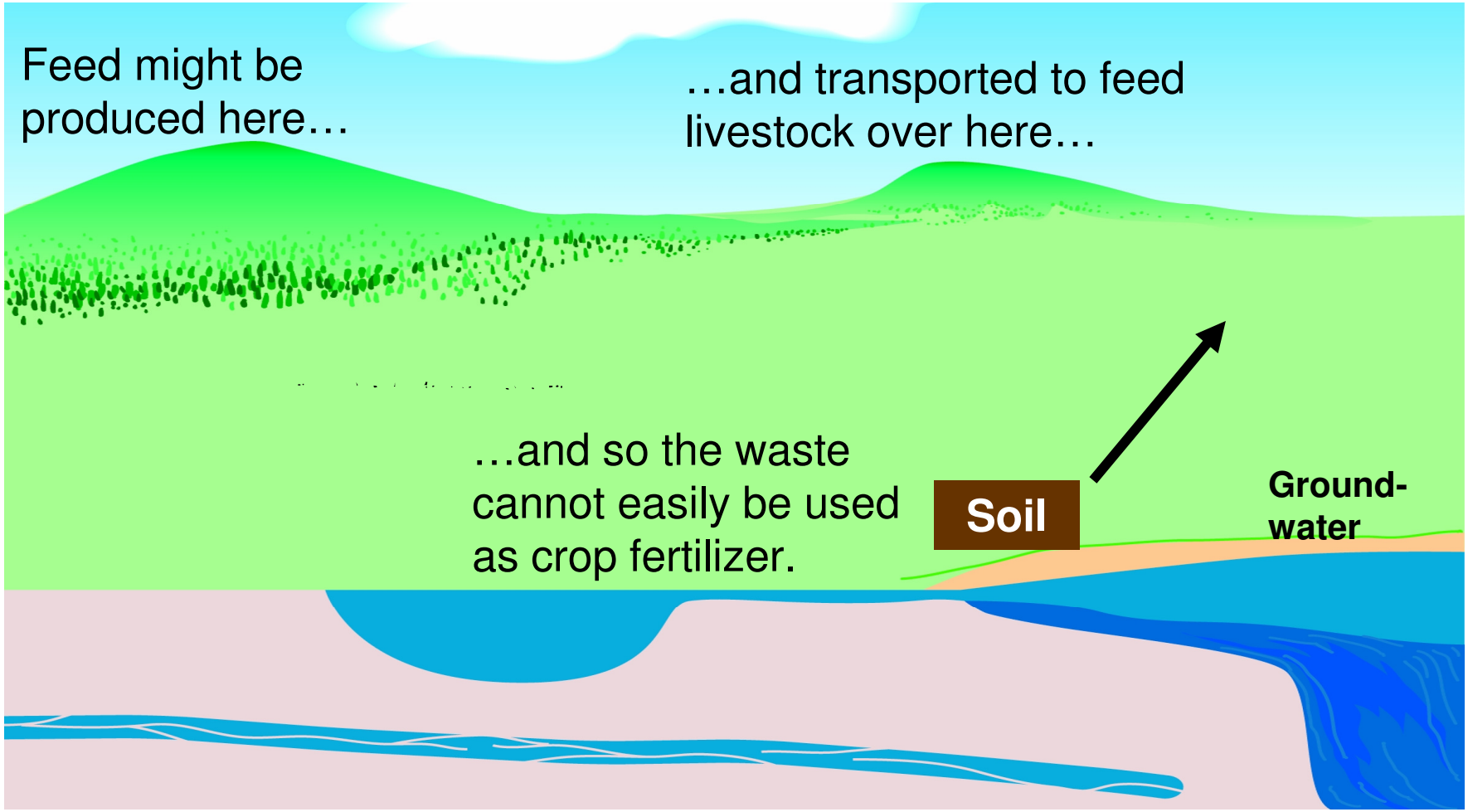


EPA United States Environmental Protection Agency

- With removal of rN in harvested crops, rN was returned, or recycled, through “night soil,” processed food and feed wastes, compost, and animal wastes. This recycling of rN also led to the recycling of carbon and phosphorus, both of which are now also in “imbalance” in the environment.

- N Cycle is used because that is the textbook (conventional) description of the relationship between ag and N.

Geographic Complications: Distance Means More N Loss



EPA United States Environmental Protection Agency

- The human population equivalent for the current amount of waste produced by livestock—18 billion people
- An expanded human population of 8 to 10 billion people by 2030/2050 drives animal waste equivalent of 24-30 billion people

- Increased trade leads to increased feed grain production—half of fertilizer N taken up by plants
- Feed grains containing Nr shipped regionally and globally
- Feed grains fed to animals—only 1/4 of grain N becomes dairy/meat protein
- Without reverse trade in residual N, excess Nr at livestock production sites

- Big arrows to water and air

- Chemical fertilizers have led not only to a separation of crop and livestock agricultures, but also to a precipitous decline in the recycling of wastes (human, animal, and crop). Organic nitrogen (in the form of human or animal wastes) has lost its positive economic value for agriculture and has become a “waste” that has no or even negative economic value.

Global use and trade of feedstuffs and consequences for the nitrogen cycle **A.F. Bouwman1 and H. Booij1http://www.springerlink.com/content/v50m6xx6n8412131/**

Global Trade of Feedstuffs: Consequences for rN

- The current global use of cereals for feed
  - 30% of the total use (57% in developed countries)
  - 17% in developing countries
  - Net trade of cereals and other feedstuffs represents 4–8 Tg N per year,
    - 4–7% of the total N consumption by the world's animal population
    - But growing

EPA United States Environmental Protection Agency

Mitigation Options

- Improved efficiency in N conversion
  - current efficiency is 8:1 for meat and dairy production
- Recycling of N wastes
- Changes in consumption patterns

Photo: Lynn Betts, from USDA NRCS photo gallery, “buffers” file, riparian buffer in Iowa

Nitrogen Backgrounder

Challenge #5: Biofuels Production

United States Environmental Protection Agency

Biofuel Production and Corn

- 2005 Energy Act – Renewable fuels standard (RFS)
  - Promoted ethanol and biodiesel

- Superseded by Energy Independence and Security Act of 2007
  - Promotes renewable fuels more broadly
  - Ethanol use expected to increase to some 13 billion gallons by 2012
  - Establishes goal of 36 billion gallons by 2022
  - 21 billion gallons must be advance biofuel of which 16 bbg of cellulosic

- Global Biofuel Production tripled between 2000 and 2007
  - About 16 billion gallons in 2007
  - Roughly 7 billion gallons in the US

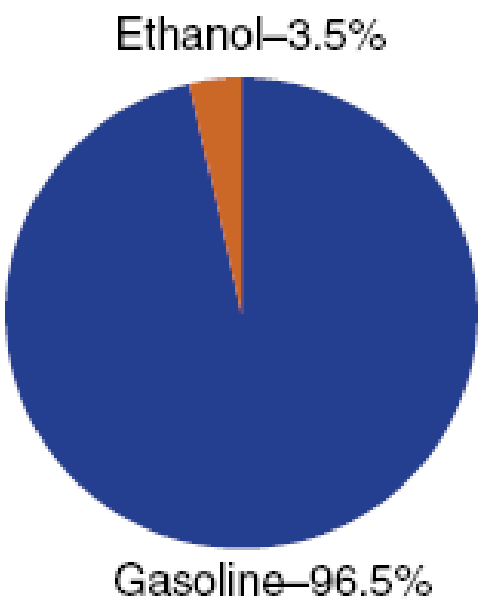
Amber Waves, http://www.ers.usda.gov/AmberWaves/November07/Features/Biofuels.htm

- Predominantly from corn:
  - Fermentation process easy & operational technology exists
  - Makes grain profitable and US farmers like to grow grains

Ethanol's Role in Gasoline and Corn Markets

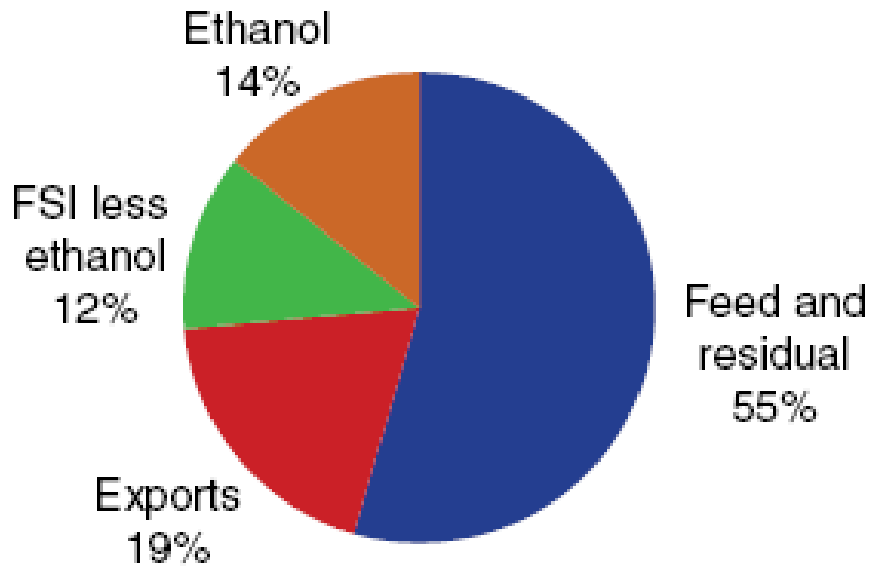
Current relationships

Ethanol is small relative to overall gasoline use



2006

But ethanol accounts for a large and growing share of corn use



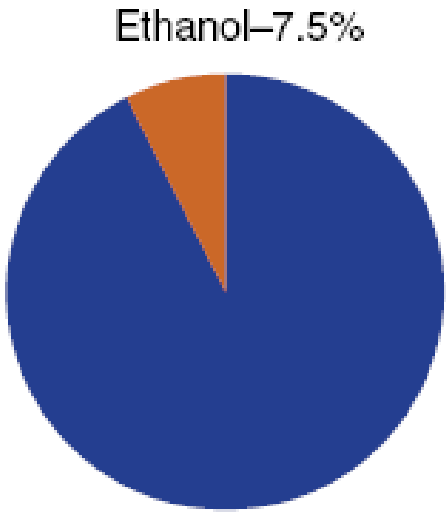
Stocks-to-use ratio, 17.5%

2005/06

http://www.ers.usda.gov/Publications/FDS/2007/05May/FDS07D01/fds07D01.pdf

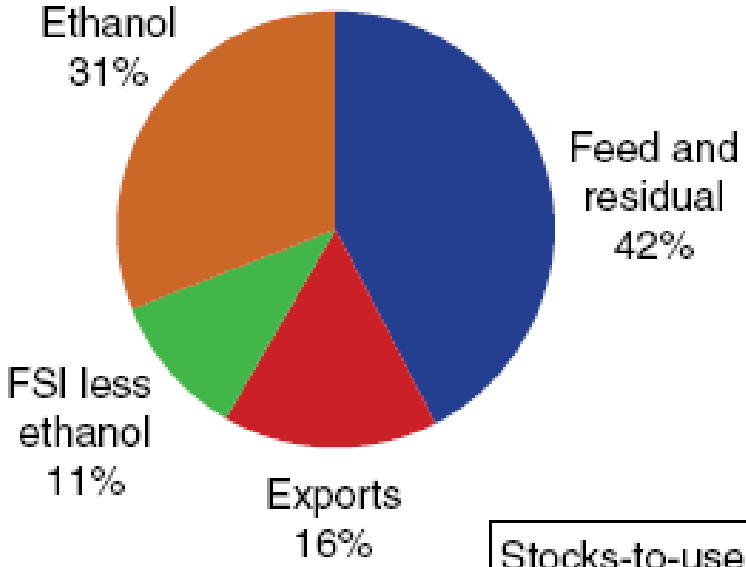
Projected Relationships in 10 Years

Ethanol still small relative to overall gasoline use



2017

Ethanol accounts for over 30 percent of corn use



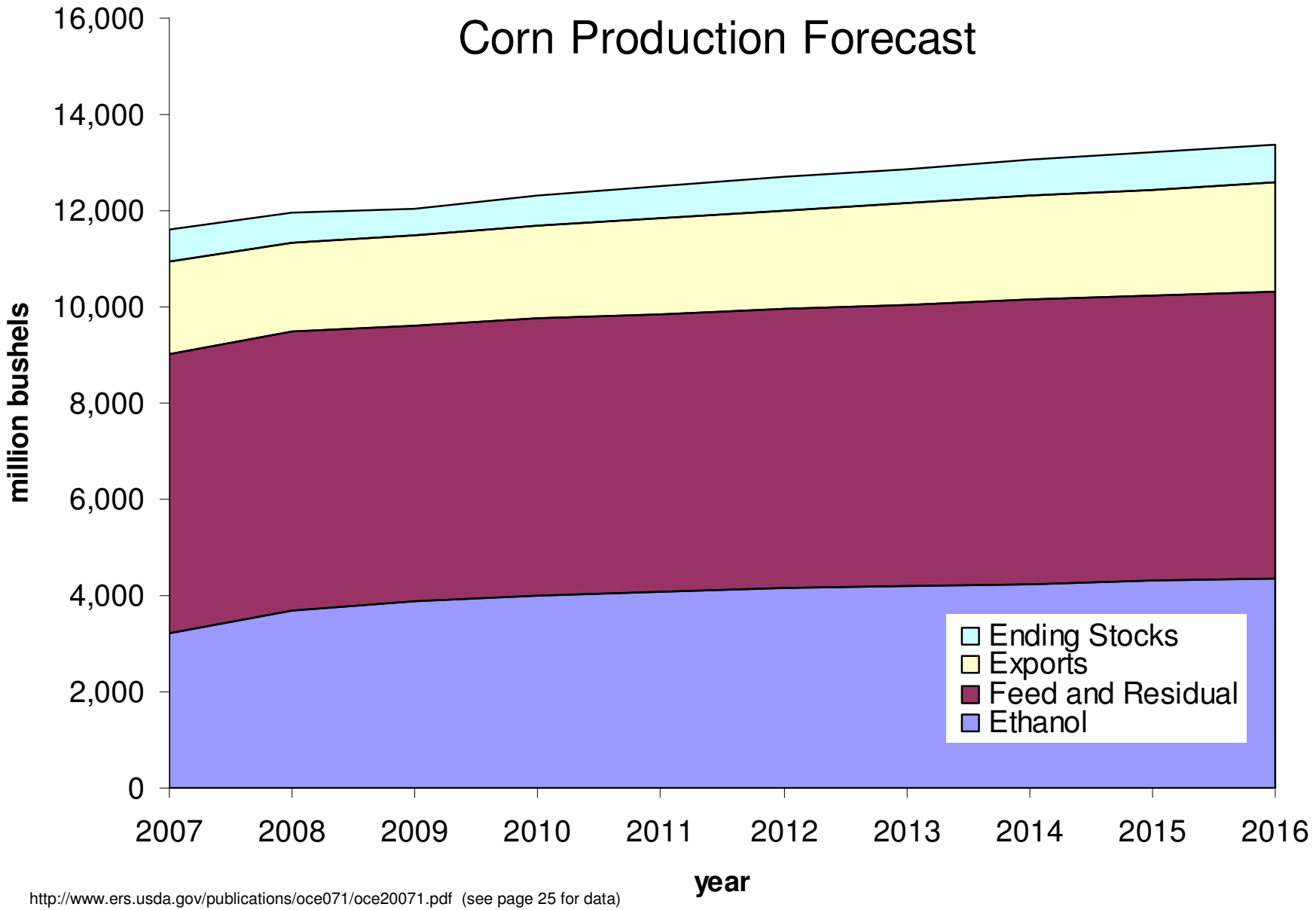
Stocks-to-use ratio, 5.7%

2016/17

Note: FSI = food, seed, and industrial.

http://www.ers.usda.gov/Publications/FDS/2007/05May/FDS07D01/fds07D01.pdf
Source: USDA Agricultural Projections to 2016, February 2007.

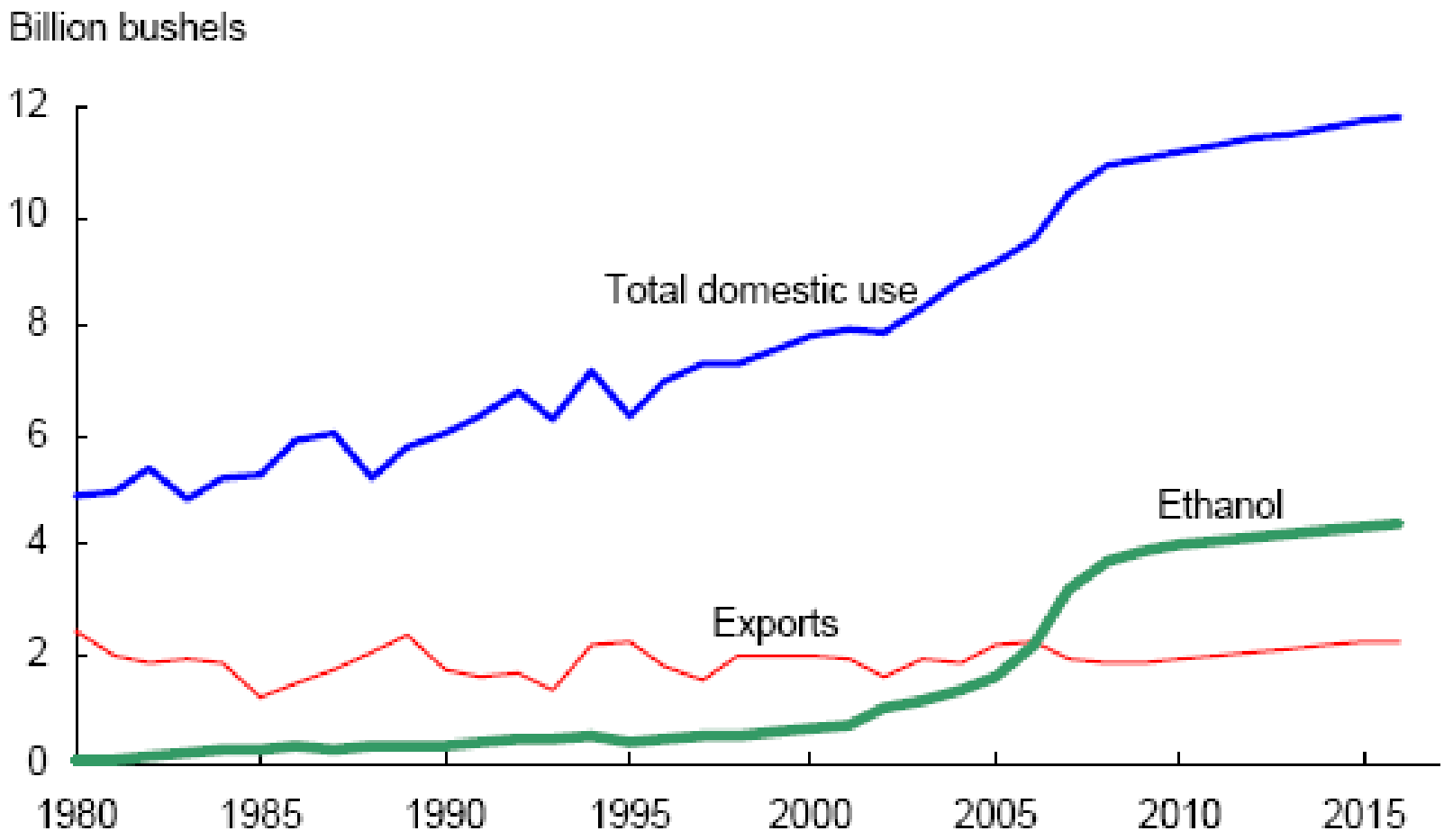
EPA United States Environmental Protection Agency



http://www.ers.usda.gov/publications/oce071/oce20071.pdf (see page 25 for data)

EPA United States Environmental Protection Agency

Corn: Domestic Use and Exports



http://www.ers.usda.gov/publications/oce071/oce20071.pdf (see page 26)

EPA United States Environmental Protection Agency

Impacts on Nitrogen

- Suppose 16 million acres of agricultural land nation-wide were switched from their current use (soybeans, wheat, idle, pasture) to produce corn for ethanol (out of 340 million acres total).
- How will the amount of N lost from that land change?

Previous Use of Land	Acreage (millions)	Expected Increase in N Loss (lbs/A)	Total Increase in N Loss (M lbs)
Soybeans	8	7.5	60
Idle Land	4	27	108
Pasture or Hay	4	24	96
			264

Source: Iowa State University CARD

- This loss is equal to the entire N load from rivers and streams to the Chesapeake Bay in 2000.

EPA United States Environmental Protection Agency

- More corn production generally means
  - More nitrogen fertilizer
  - More nitrogen loss from soils
  - Shift in cropping practices means N loss
    - Likely shift away from early season crops to late season (corn)
    - Affect on water balance and late winter/early spring N loss
- Conversion of land from other uses, including CRP lands

EPA United States Environmental Protection Agency

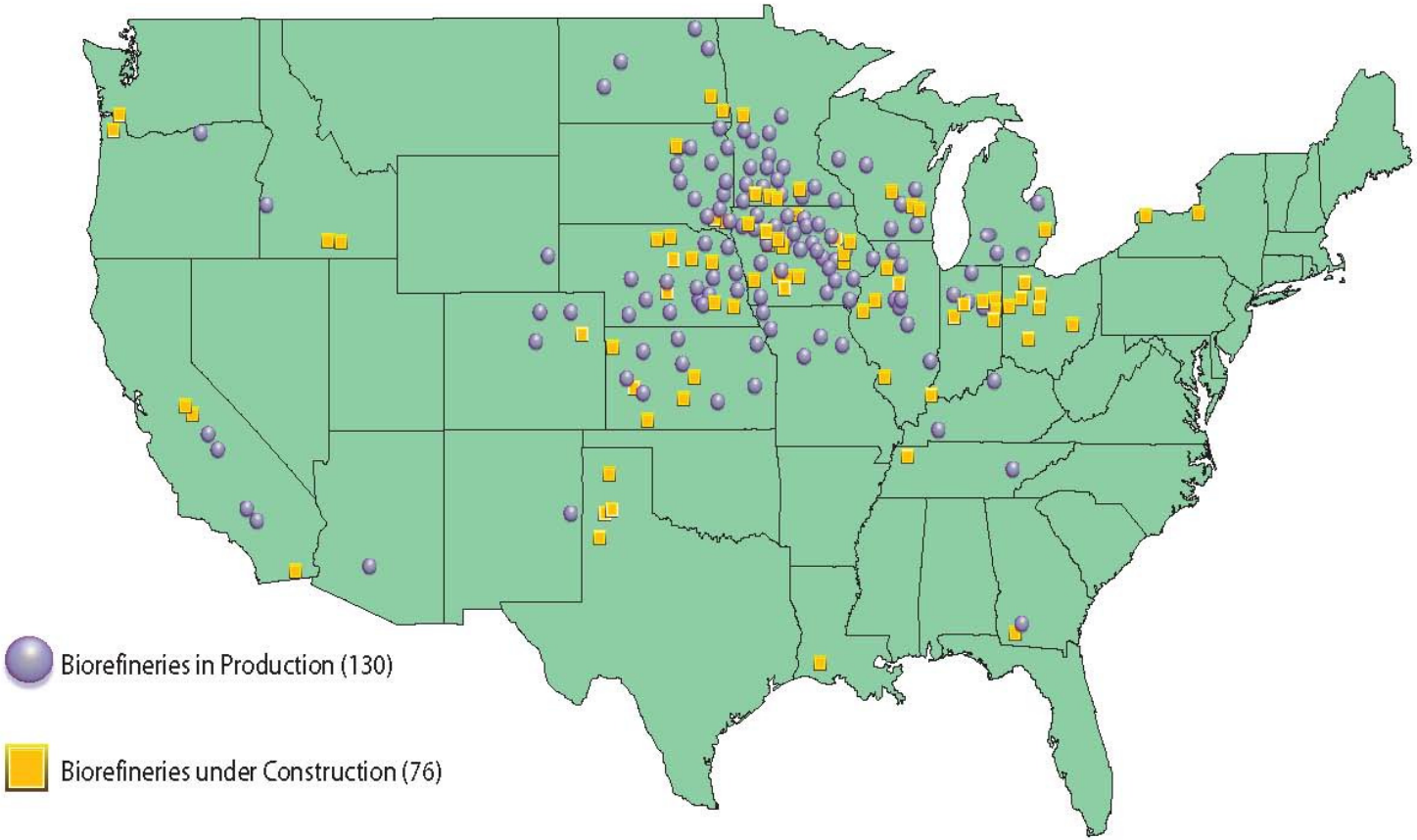
Even Processing of Corn Ethanol Can Have Adverse Nr Impacts

- Location of ethanol facilities can lead to greater corn production in the vicinity of the plants
- To keep down costs, waste products from corn to ethanol conversion (DDG or dry distillers grain) fed to livestock
- Concentration of livestock production leads to a concentration of livestock waste production

EPA United States Environmental Protection Agency

U.S. Ethanol Biorefinery Locations:

Concentration of Production in Mississippi River Watershed



Source: Renewable Fuels Association
10.4.07

Regarding previous slide

- Grain/ nitrogen shipped to facility
- Concentration of livestock production around ethanol plants to utilize conversion byproducts—DDG (dry or wet distillers grain)
- DDG fed to livestock—why? transportation costs can be high
- Concentration in livestock production generally means more imbalance in manure nitrogen—more nitrogen introduced into the environment than can be taken up by crops or transferred economically out of the area
- The map tells us that most biofuel production is concentrated in the Midwest, around the Mississippi valley. This means that more Nr could potentially flow down the MS river, worsening the Gulf hypoxia problem.

Ethanol and the Chesapeake Bay

15 ethanol facilities planned for Mid-Atlantic

Potential N Losses from 1 Million New Corn Acres

Previous Use of Land	Acreage	Expected Increase in N Loss (lbs/A)	Total Increase in N Loss (M lbs)
Soybeans	472,000	7.5	3.5
Cotton	22,000	15.75	0.3
Idle Land	32,000	27	0.9
Hay	503,000	24	12.1
			16.8

- This loss is about 5% of the total N load from rivers and streams to the Bay in 2000.

http://www.washingtonpost.com/wp-dyn/content/article/2007/07/16/AR2007071601845.html?referrer=emailarticle

- 1 million acres represents about 1/8 of the cropland in the midatlantic states
- The study, whose sponsors included the U.S. government and an environmental group, predicted that farmers in the bay watershed will plant 500,000 or more new acres of corn in the next five years. Because fields of corn generally produce more polluted runoff than those of other crops, that's a problem.
- Already, 15 ethanol facilities are either planned or under construction in the mid-Atlantic, according to yesterday's report.
- But ethanol's boom has also produced a variety of unintended, and unwanted, consequences. Because the primary ingredient at U.S. ethanol plants is corn, the price of that grain has shot up, making everything from tortillas to beef to chocolate more expensive.
- In the Chesapeake area, according to the study, the drawback to ethanol's boom is that more farmers have planted cornfields to take advantage of the prices. Corn harvests are expected to increase 12 percent in Maryland this year and 8 percent in Virginia, according to a forecast in March from the U.S. Agriculture Department.
- Although the spike is expected to be greater in Mississippi, where forecasters predict a 179 percent jump, across the vast Chesapeake watershed -- extending from southern Virginia to Cooperstown, N.Y. -- smaller shifts can add up. The authors of the study released yesterday forecast that over the next five years, the area of land newly planted with corn could be as much as 1 million acres, four times the size of Fairfax County.
- Those shifting to corn production included Craig Giese, a farmer with 600 acres on Virginia's Northern Neck. Giese said in a telephone interview yesterday that he planted 50 new acres of corn after prices climbed from about $2.30 per 56-pound bushel last year to about $3.40 this year.
- But Giese said he left many of his acres planted with soybeans to ensure against a disaster if corn prices drop or a drought makes the plants wither.
- "If you put in all corn, you could hit a home run, with the prices we have now," said Giese, whose farm is near Lancaster, about 120 miles from Washington. "But . . . you could also go belly up."
- More cornfields could be trouble, the study warned, because corn generally requires more fertilizer than such crops as soybeans or hay. When it rains, some of this fertilizer washes downstream, and it brings such pollutants as nitrogen and phosphorus, which feed unnatural algae blooms in the bay. These algae consume the oxygen that fish, crabs and other creatures need to breathe, creating the Chesapeake's infamous dead zones.
- Governments around the bay have pledged to cut their output of nitrogen by 110 million pounds by 2010. But the study estimated that an ethanol-driven increase in cornfields could add 8 million to 16 million pounds of pollution.

Chesapeake Bay Impacts

- Exacerbates difficulty of reaching current nitrogen reduction goals for the Bay
- Increase in algae blooms, and dead zones.
- Need to moderate impact with additional BMPs.
- Funds needed to effect adoption of BMPs.

Text source: http://www.washingtonpost.com/wp-dyn/content/article/2007/07/16/AR2007071601845.html?referrer=emailarticle

Nitrogen Backgrounder

Challenge #6: International Pressure to Act

EPA United States Environmental Protection Agency

Great Potential for Action on the International Front

- Growing international attention to reactive N issues
- Possibilities for global N pollution reduction through new and existing international agreements
- Greater attention to reactive N means more possibilities for progress
- Opportunity for U.S. assuming a leadership role

EPA United States Environmental Protection Agency

Likely Calls for International Action

- United Nations Environmental Program (UNEP)
  - UNEP Governing Council
- UN Industrial Development Organization
  - Expert group meeting: "Engaging the Agro industry community on global nitrogen and water pollution reduction strategies," at UNIDO headquarters in Vienna, Fall 2007
- Food and Agriculture Organization of the United Nations (FAO)
  - Numerous programs dealing with everything from increasing the efficiency of use of N, to decreasing contamination of groundwater, to food security issues related to N.

Increased International Attention to N: New Reports on Environmental Threats

- United Nations Environment Program (UNEP):
  - "Reactive Nitrogen in the Environment: Too Much or Too Little of a Good Thing." May 2007
- Organization for Economic Cooperation and Development (OECD)
  - Instrument Mixes Addressing Non-point Sources of Water Pollution (COM/ENV/EPOC/AGR/CA(2004)90/FINAL) February 2007
- United Nations Educational, Scientific and Cultural Organization (UNESCO) Scientific Committee on Problems of the Environment (SCOPE):
  - Human Alteration of the Nitrogen Cycle: Threats, Benefits and Opportunities. April 2007

Existing International Agreements Could Facilitate Further Action

- United Nations Economic Commission for Europe (UNECE)
  - The Convention on Long-Range Transboundary Air Pollution (LRTAP)
    - Parties develop policies and strategies to reduce and prevent air pollution.
    - Facilitates exchange of information, multilateral and bilateral consultations, cooperative research and monitoring.
    - Could/does serve as a framework for addressing air transport issues related to regional dispersion on NO_x.
- United Nations Environment Program:
  - Global Program of Action for the Protection of the Marine Environment from Land-Based Activities
    - Addresses the linkages between freshwater and the coastal environment.

International Opportunities (cont'd)

- International Maritime Organization (IMO):
  - International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78)
    - Annex VI: Prevention of Air Pollution from Ships
    - The regulations
      - set limits on NO_x and other emissions from ship exhausts
      - prohibit deliberate emissions of ozone depleting substances.
    - "NO_x Technical Code" requires that engines installed on ships meet requirements to limit NO_x emissions

EPA United States Environmental Protection Agency

International Opportunities (cont'd)

- Other Treaties and conventions
  - US-Canada Air Quality Agreement of 1996
    - Canada and the United States committed to reductions of nitrogen oxides (NO_x) in Annex 1 of the Agreement.
      - Goals:
        - » 10 percent of national NO_x emissions for both countries by 2000
        - » 100,000 tons in Canada and 2 million tons in the US
      - Mutual concern about the role of nitrogen compounds in the formation of ground-level ozone and acidification processes.
    - Further reduction targets
- There is room for greater international efforts to address the N issues within existing treaties, conventions and other agreements.

EPA United States Environmental Protection Agency

Nitrogen Backgrounder

Challenge #7: Monitoring and Data

EPA United States Environmental Protection Agency

Environmental Monitoring Networks

1. National Atmospheric Deposition Program (NADP)
    - Wet deposition (NO_3, NH_4, and inorganic nitrogen).
    - Oldest network in the U.S

2. Clean Air Status and Trends Network (CASTNet)
    - Dry deposition (gaseous nitric acid, particulate nitrate, and particulate ammonium)
    - Funding cuts of $1.0 millions in the FY08 budget.

- Environmental monitoring is critical to national environmental policy. Monitoring of atmospheric deposition and surface water chemistry provides the only quantitative means of assessing the efficacy of state and federal policy.
- There are several national monitoring networks that provide data to scientists and policymakers on reactive nitrogen.

1. National Atmospheric Deposition Program (NADP)

- The NADP program is a successful interagency network that monitors wet deposition of sulfate and nitrate associated with fossil fuel emissions. The U.S. Geological Survey (USGS) is the lead federal agency and the Environmental Protection Agency (EPA) plays a strong supporting role. The coverage and baseline funding for this program are adequate to ensure a high-quality network. However, as the oldest network in the U.S. This network measures primary wet deposition including NO3, NH4, and inorganic nitrogen.
- Federal support for annual operating costs of ~$3.6 million (Inter-agency - $2,000,000 to USGS; $600,000 to EPA; $600,000 to National Park Service; $400,000 to U.S. Forest Service.)

2. Clean Air Status and Trends Network (CASTNet)

- The CASTnet program, administered by the EPA/CAMD, measures the component of atmospheric deposition that enters the environment in dry forms such as particles and gases. Monitoring dry deposition is critical to determining the total pollution load across the U.S. In some areas, dry deposition contributes as much as 59% of the total sulfur deposition. At present, CASTnet is a sparse network with only 70 sites nation-wide. This network measures dry deposition of gaseous nitric acid, particulate nitrate, and particulate ammonium. Funding has been cut by $ 1.0 millions from the FY08 budget.
- Federal contribution to annual operating costs $3.9 million (EPA)

Environmental Monitoring Networks

3. Temporally Integrated Monitoring of Ecosystems (TIME) and Long-Term Monitoring (LTM)

- Lake and stream chemistry (NO_3 and NH_4)
- Only national network that directly measures the impact of atmospheric deposition
- Funding is discontinued in the FY08 budget

4. Atmospheric Integrated Research Monitoring Network (AIRMon)

- Provides high resolution precipitation and dry deposition chemistry using daily sampling methods

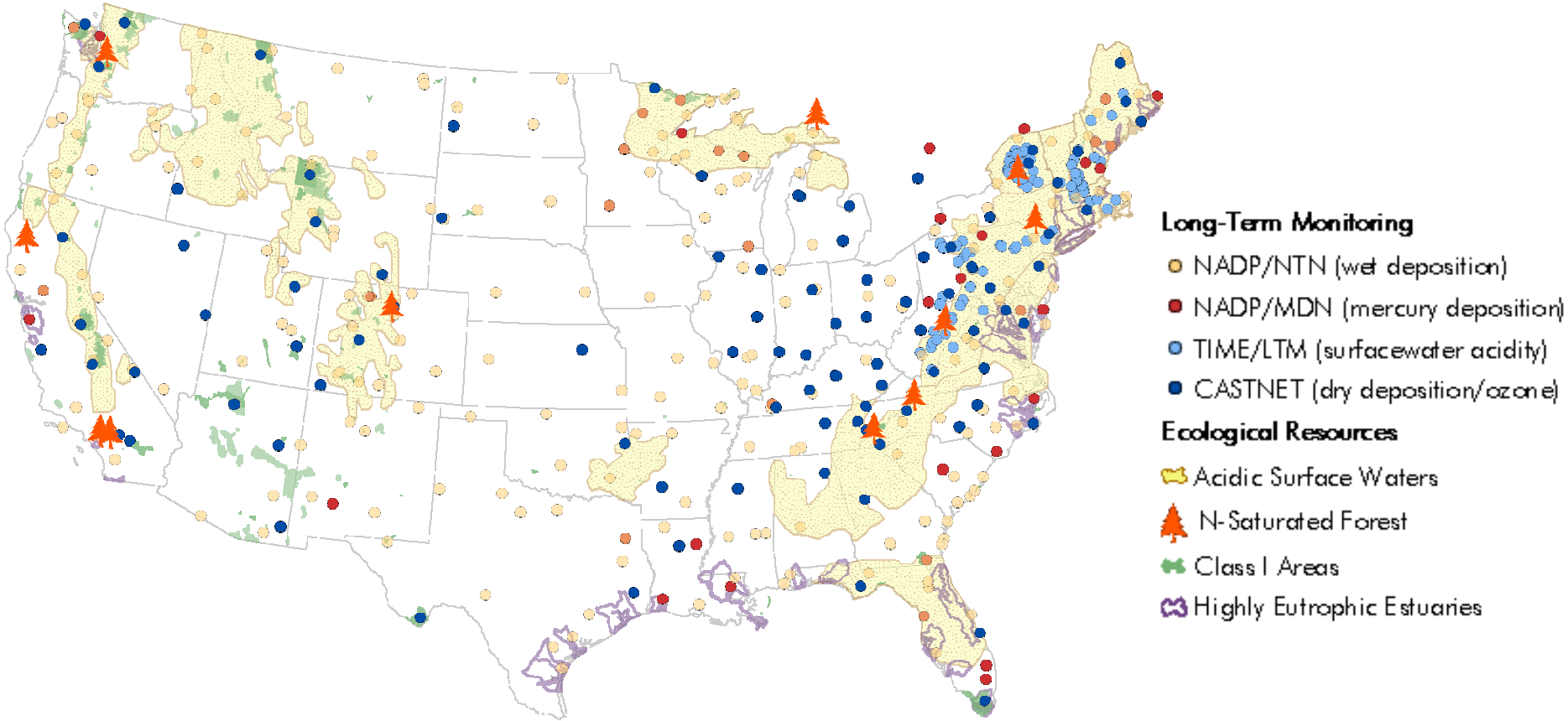
3. Temporally Integrated Monitoring of Ecosystems (TIME) and Long-Term Monitoring

- The TIME/L TM program monitors lake and stream chemistry and documents changes in response to changing emissions and acid deposition. This program is administered through the EPA. TIME/LTM is the only national network that directly measures the impact of atmospheric deposition and quantifies the affect of emissions controls. Funding for the TIME/LTM program is both inadequate and unstable. Funding has been cut 50% over the past two years and the program has been discontinued in the FY08 budget.
- Federal contribution to annual operating costs: $1.0 million (EPA)

4. Atmospheric Integrated Research Monitoring Network (AIRMon)

- The AIRMon program provides high resolution precipitation and dry deposition chemistry using daily sampling methods operated by the National Oceanic and Atmospheric Administration (NOAA). Funding for this program has been flat for ten years resulting in the unfortunate closure of 3 AIRMon dry deposition sites (Sequoia. CA; Panola, GA; and Burlington, VT). AIRMon equipment dates to 1984 and has exceeded its life expectancy. This network measures dry deposition of HNO3 along with other pollutes.
- Federal contribution to annual operating costs $1.5 million (NOAA)

Environmental Monitoring Networks



Monitoring Data and Research Needs

- Need to inventory emission sources beyond those for which EPA has regulatory authority. Otherwise cannot
  - Assess extent of problem
  - Identify opportunities for mitigation
- Need to conduct lifecycle analysis on mitigation options
  - Avoid “transfer” problems
  - Avoid unintended consequences

EPA United States Environmental Protection Agency

Monitoring Data and Research Needs

- Need to inventory sources for which emissions of nitrogen are likely to be affected by climate change and activities associated with adapting to global climate change to avoid programmatic gaps and unintended consequences
- Need to improve the level of confidence in data on both sources and emissions

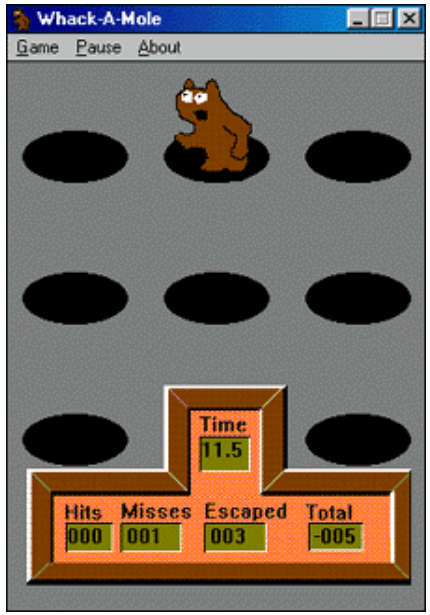
EPA United States Environmental Protection Agency

Take Home Messages

- Nitrogen management is a systems issue affected by:
  - Global climate change
  - Global economic trends in trade and consumption
  - Biofuels policy
- International agreements provide opportunities and pressure for action.
- Additional research and monitoring data needed to properly address these challenges.

EPA United States Environmental Protection Agency

How to whack the mole and keep it whacked?



A systems management approach:

- **Targeting Nr reduction**
- **Promoting environmental and economic benefits**

EPA United States Environmental Protection Agency