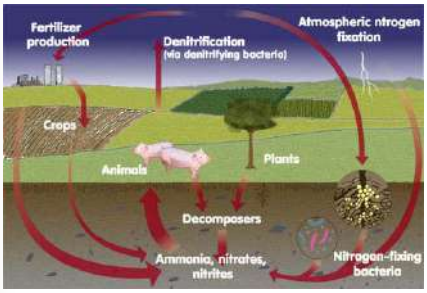
Human Alteration of the Global Nitrogen Cycle

Heather McGraw, Mandy Williams, Suzanne Heinzel, and Cristen Whorl, Give SIUE Permission to Put Our Presentation on E-reserve at Lovejoy Library.

What is Nitrogen?

- Nitrogen is the most abundant element in the Earth's atmosphere.
- Nitrogen makes up 78% of the troposphere.
- Nitrogen cannot be absorbed directly by the plants and animals until it is converted into compounds they can use. This process is called the Nitrogen Cycle.

The Nitrogen Cycle



How does the nitrogen cycle work?

- Step 1- **Nitrogen Fixation-** Special bacteria convert the nitrogen gas (N_2) to ammonia (NH_3) which the plants can use.
- Step 2- **Nitrification-** Nitrification is the process which converts the ammonia into nitrite ions which the plants can take in as nutrients.
- Step 3- **Ammonification-** After all of the living organisms have used the nitrogen, decomposer bacteria convert the nitrogen-rich waste compounds into simpler ones.
- Step 4- **Denitrification-** Denitrification is the final step in which other bacteria convert the simple nitrogen compounds back into nitrogen gas (N_2), which is then released back into the atmosphere to begin the cycle again.

How does human intervention affect the nitrogen cycle?

- Nitric Oxide (NO) is released into the atmosphere when any type of fuel is burned. This includes byproducts of internal combustion engines.
- Nitrous Oxide (N_2O) is released into the atmosphere through bacteria in livestock waste and commercial fertilizers applied to the soil.
- Removing nitrogen from the Earth's crust and soil when we mine nitrogen-rich mineral deposits.
- Discharge of municipal sewage adds nitrogen compounds to aquatic ecosystems which disrupts the ecosystem and kills fish.

Production and Use of Nitrogen Fertilizers

Nitrogen Fertilizer

- #1 Contributor to new nitrogen in the global cycle
- First developed during WWI
- Use has grown exponentially
- Can actually increase the nitrogen so much that soil fertility actually ***decreases***

The Need for Nitrogen

- Plants lacking sufficient nitrogen become yellow and stunted, with smaller than average flowers and fruits

- Without nitrogen fertilizers, an estimated one-third of our current agricultural production would be lost.

Nitrogen as Fertilizer

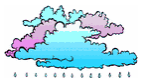
- Nitrogen is found naturally in manures and other organic fertilizers
- Nitrogen is a key nutrient for plant growth
- Four forms of nitrogen are used as fertilizer:
  - **Nitrate**
  - **Ammonia**
  - **Ammonium**
  - **Urea**

How Nitrogen Fertilizers Works

- Urea is broken down by enzymes in the soil to become ammonia
- Ammonia is broken down into ammonium through *mineralization*
- Ammonium is broken down into nitrite and then nitrate through *nitrification*
- Nitrate is used by plants

Problems with Nitrogen Fertilizers

- Ammonia can escape into the air
- Ammonium clings to organic matter in the soil
- Rainfall after the application of any nitrogen fertilizer causes *leaching* of nitrate and other nutrients from the soil



Because of the potential loss, farmers typically add more than twice the needed amount of nitrogen fertilizer to the soil

This excess nitrate pollutes the drinking water supply and vastly changes the nitrogen cycle

By-Products of Internal Combustion Engines

Fossil Fuel Burning

- The burning of fossil fuels releases previously fixed nitrogen from long-term storage back to the atmosphere in the form of nitrogen-based gases such as nitric oxide.

- Automobiles
- Power Generation Plants
- Industries

The emissions of motor vehicles contributes to more than 1/3 of the nitrogen released into the atmosphere- World Bank

Internal Combustion Engines

- Nitrogen oxides are formed in the combustion process by oxidation of nitrogen (from the atmosphere and fuel) to NO and NO2

To reduce NOx emissions:

Prevent formation in the cylinder

Remove from exhaust gases in an after-treatment

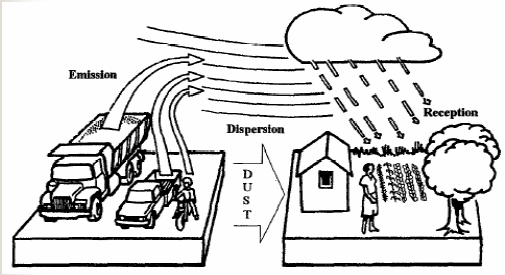
Most effective: introduction of water/steam because it cuts the temperature peaks in the combustion process

- water-in-fuel emulsions
- humidification of the combustion air
- direct water injection into the combustion space

NOx Emission Control

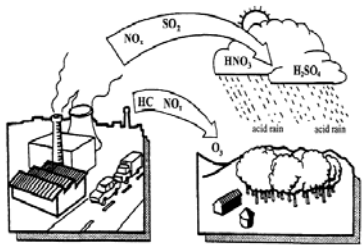
Subject of extensive development work by the gas turbine manufacturers during the 1980s

Allowable NOx levels in dense cities are only 10 ppm by volume



Acid Rain

- Depositions of sulfur and nitrogen
- Transport acid aerosols formed in the atmosphere from a mixture of hydrochloric, sulfuric, and nitric acid
- Infiltrates soils, groundwater, rivers, and lakes



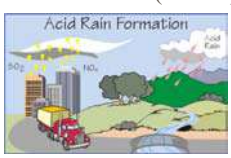
- Power Generation Plants
- Industry

What does all this mean?

- We are greatly increasing the amount of nitrogen cycling between the living world and the soil, water and atmosphere.
- We have already doubled the rate of nitrogen entering the land-based nitrogen-cycle.
- This is having a serious impact on ecosystems around the world.
- These additions can pollute ecosystems and alter ecological functioning and the living communities that they support.

Impacts on the Atmosphere

- Nitrous oxide contributes to overall greenhouse warming.
- Deplete and thin the ozone layer.
- Formation of photochemical (brown) smog.
- Acid rain.



Effects on the Ecosystem

- Nitrogen saturation
- Acidification of the soil
- Increase in tree deaths
- Reduction in overall species diversity
- Loss of biodiversity
- Acidification of lakes and streams
- Eutrophication in estuaries and coastal waters

For Further Information

Public Affairs Office
Ecological Society of America

This information was largely reproduced from the "Human Alteration of the Global Nitrogen Cycle: Causes And Consequences," published by the Ecological Society of America, in the journal *Ecological Applications* (Volume 7, August 1997) with detailed citations to the original scientific literature.