United States Department of Agriculture
Natural Resources Conservation Service

Air Quality and Atmospheric Change Resource Concerns

Air as a Resource

- We are a conservation agency for natural resources
  - Air is the first “A” in SWAPA + H
- Air Quality was one of the original drivers for the creation of our agency
- We must protect this resource—it can be quickly renewed, but also can quickly deteriorate in quality
- Health effects are major concern

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NRCS and Air Resources

- 12 of 79 current NRCS resource concerns are related to AQAC
- Effort to consolidate to one main AQAC resource concern with various components

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Current 12 AQAC Resource Concerns

- PM_{10}
- $PM_{2.5}$
- Excessive Ozone
- Excessive GHG – CO_2
- Excessive GHG – CH_4
- Excessive GHG – N_2O
- Objectionable Odors
- Ammonia
- Chemical Drift
- Reduced Visibility
- Undesirable Air Movement
- Adverse Air Temperature

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Proposal: One Overall AQAC Resource Concern, with 4 Components (The FINAL FOUR)

- Particulate Matter
- Ozone Precursors
- Greenhouse Gases
- Odors

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Question:
What emissions lead to these issues?

- Direct PM emissions (PM)
- Ammonia (PM, Odors)
- Volatile Organic Compounds (Ozone Precursors, Odors, PM)
- Oxides of nitrogen (Ozone Precursors, PM)
- Odorous sulfur compounds (Odors)
- Carbon dioxide (GHGs)
- Methane (GHGs)
- Nitrous oxide (GHGs)

Particulate Matter (PM)

- 3 categories: fine, inhalable coarse, and larger PM
  - Fine PM = $PM_{2.5}$ (<=2.5 micrometers AED)
    - Greatest health effects; mainly combustion and chemical reactions; some dust
  - Inhalable Coarse PM (2.5 - 10 µm)
    - Mostly mechanically generated; dust (geologic); some health effects
    - Typical notation is PM10, but this includes inhalable plus $PM_{2.5}$
  - Larger PM (> 10 µm)
    - Largest geologic; fewest health effects

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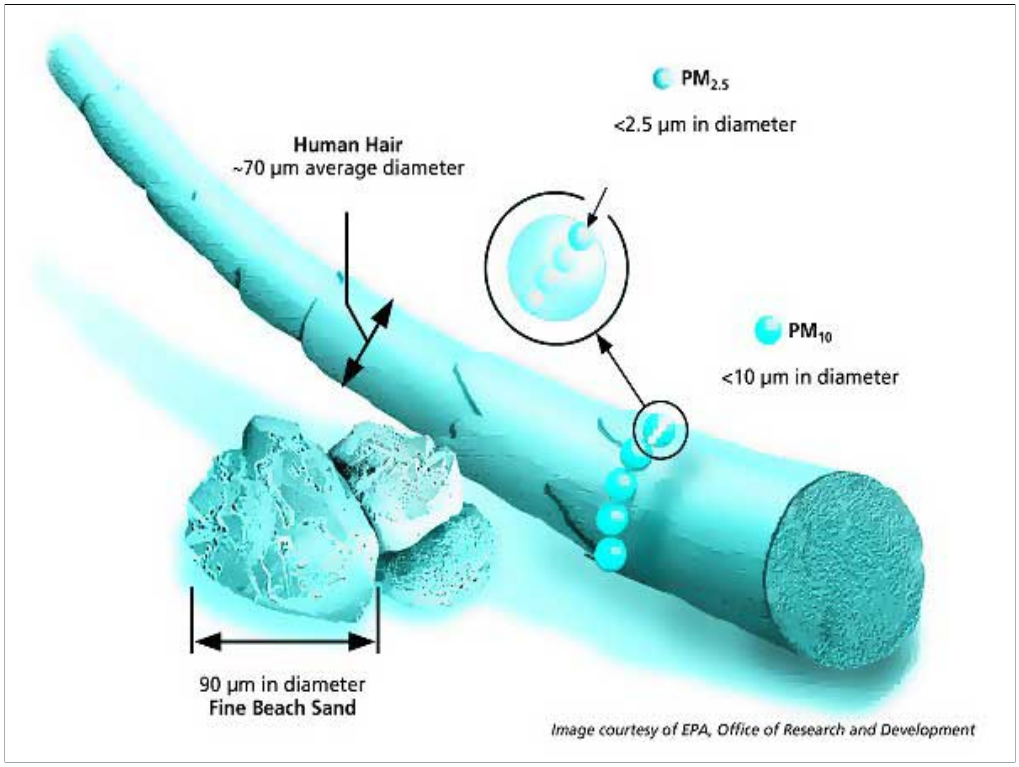
PM2.5
<2.5 µm in diameter
Human Hair
~70 µm average diameter
PM10
<10 µm in diameter
90 µm in diameter
Fine Beach Sand
Image courtesy of EPA, Office of Research and Development

Particulate Matter (cont.)

- Main Issues:
  - Health
  - Visibility
  - Deposition
- Forms:
  - Liquid
  - Solid
    - Includes gas to particle conversion

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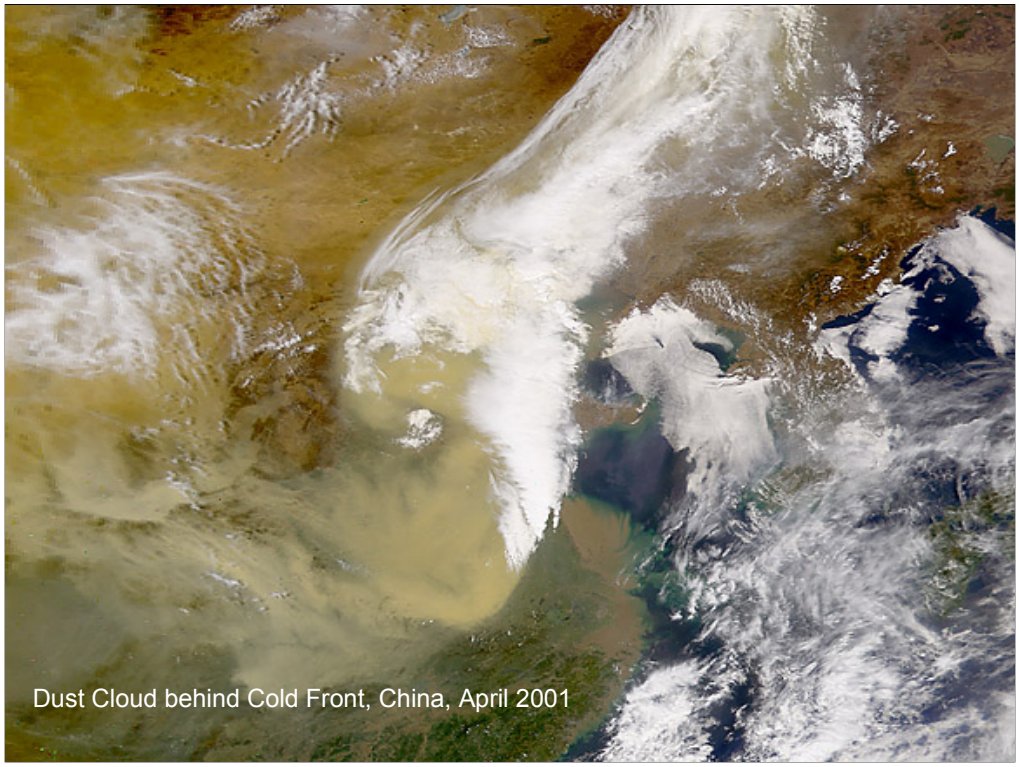
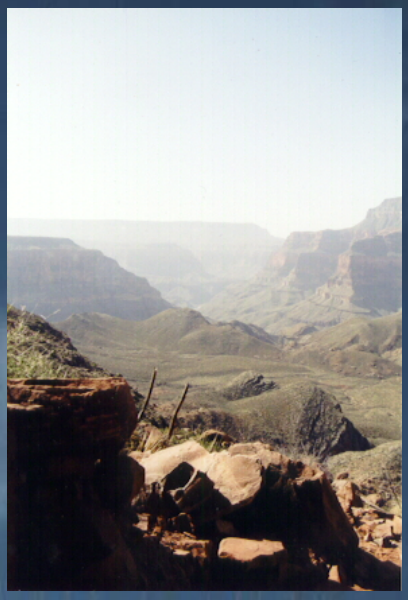
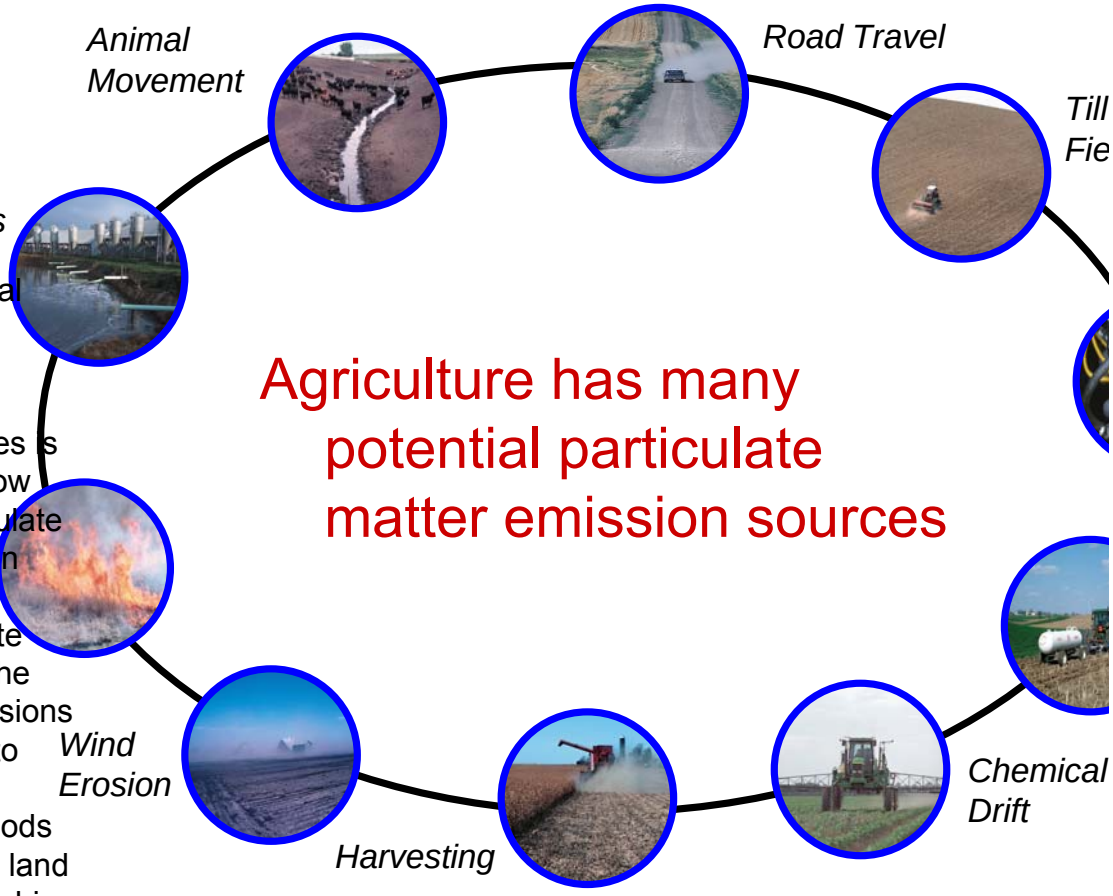

Dust Cloud behind Cold Front, China, April 2001



Grand Canyon view with no haze (left) and particulate from Gobi Desert, China dust cloud, April 15, 2001 (right)

Direct PM Emission Sou

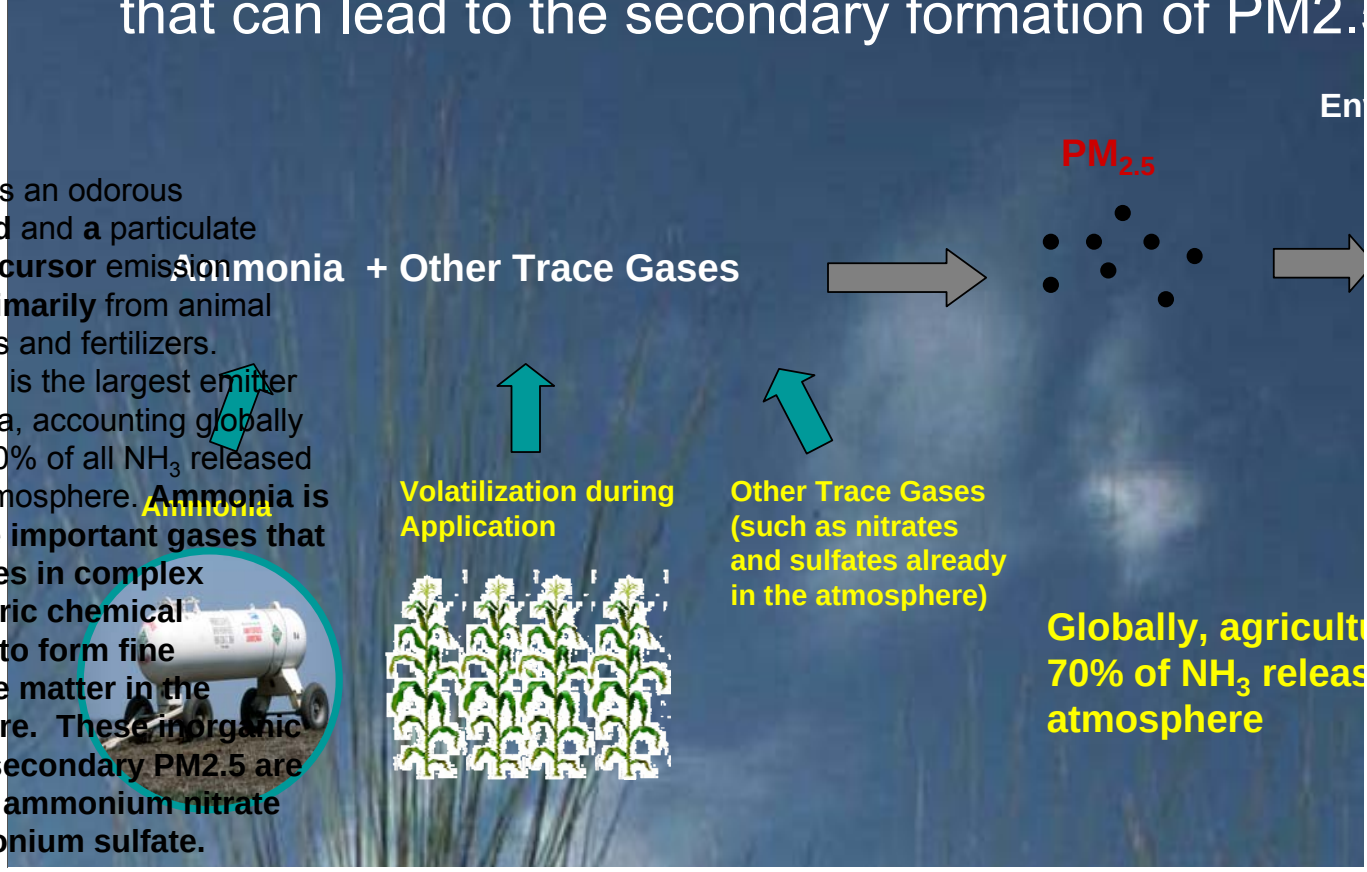


Agriculture has many potential particulate matter emission sources. Although stopping particulate matter emissions completely from these sources is impossible, understanding how each source produces particulate matter can aid in conservation plans that greatly reduce the amount and type of particulate matter emitted or formed in the atmosphere. Reducing emissions involves a holistic approach to SWAPA and must consider alternative and multiple methods of reduction. For example, a land manager might consider switching from diesel fuel to biodiesel along with increasing the number of no-till acres. The combination of reduced engine emissions, less time in the field and different tillage practices will result in a greater reduction of PM than choosing only one method.

Indirect PM Sources Example: Ammonia

Ammonia (NH_3) participates in atmospheric chemica
that can lead to the secondary formation of PM2.

Ammonia is an odorous **compound** and **a** particulate matter **precursor** emission derived **primarily** from animal **operations** and fertilizers. Agriculture is the largest emitter of ammonia, accounting globally for up to 70% of all NH_3 released into the atmosphere. **Ammonia is one of the important gases that participates in complex atmospheric chemical reactions to form fine particulate matter in the atmosphere. These inorganic forms of secondary PM2.5 are known as ammonium nitrate and ammonium sulfate.**



More about Ammonia

- Many animals are fed high-protein diets that contain relatively high concentrations of nitrogen, which are metabolized into animal proteins such as milk, eggs and meat.
- Excess nitrogen is excreted in the form of urea.
- The rate of ammonia volatilization and disbursement is influenced by temperature, wind velocity, and manure properties, such as nitrogen content, pH, and moisture content.

In livestock production, ammonia is emitted as a result of the microbial conversion of nitrogen. Many animals are fed high-protein diets that contain **relatively** high concentrations of nitrogen, which are metabolized into animal proteins such as milk, eggs and meat. Excess nitrogen is excreted in the form of urea. The rate of ammonia volatilization and disbursement is influenced by temperature, wind velocity, and manure properties, such as nitrogen content, pH, and moisture content.

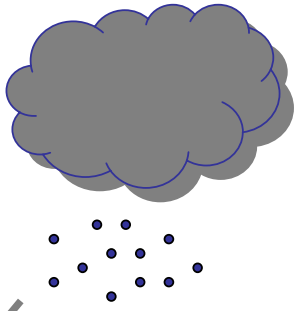
PM Environmental Effe
Example: Depositior

Deposition can adversely affect ecosystems by causing nuisance dusting, changing the p
plants or by adding additional nitrogen to the environment, resulting in an increase in

Deposition is the removal of particulate matter from the atmosphere. This occurs through either precipitation, also known as wet deposition, or through gravitational or inertial settling, which is called dry deposition. Deposition may adversely affect ecosystems by causing nuisance dusting, changing the pH balance, damaging plants or by adding additional nitrogen to the environment, resulting in an increase in eutrophication.

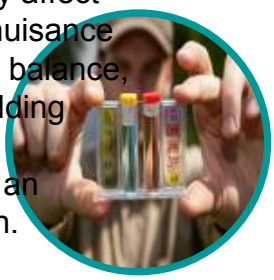
Wet Deposition

Example: *Ammonia-based fine PM deposits during a precipitation event*



Dry I

Exan
depo



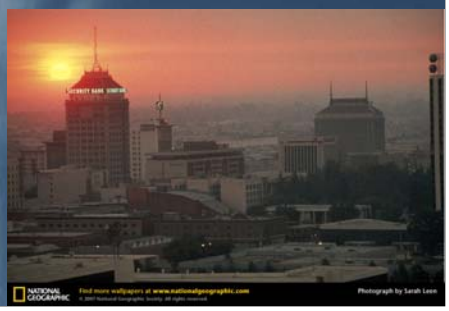
Change in pH balance

Plant Damage

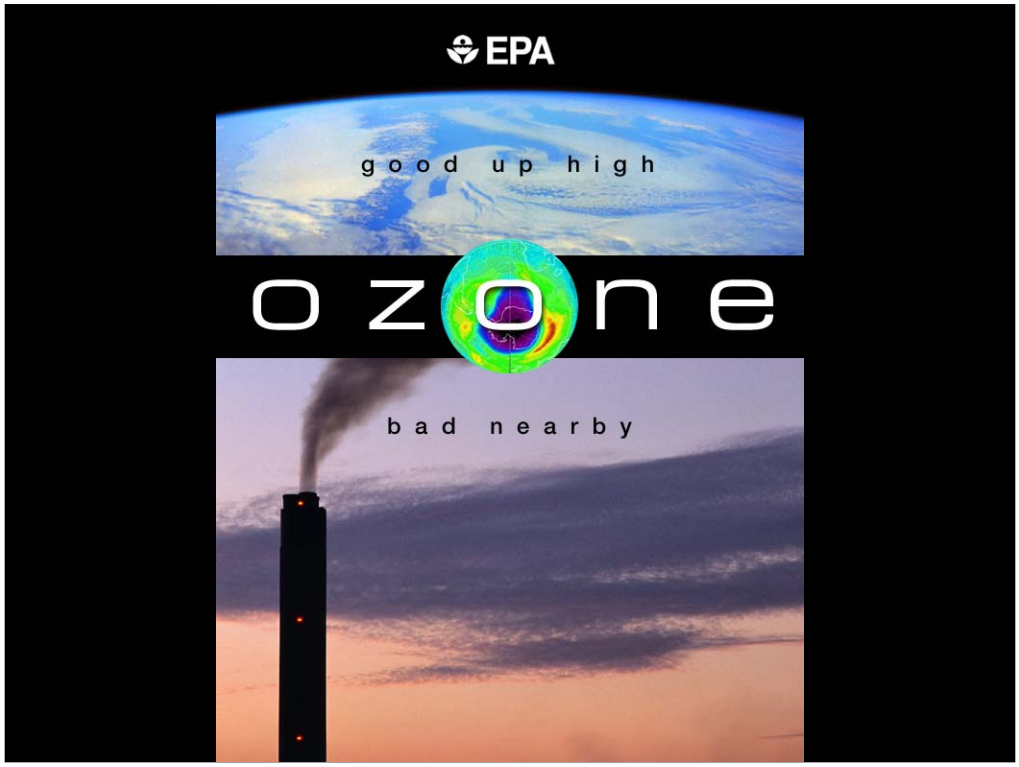
Eutro

Ozone

- Concern here is with surface ozone (O_3)
- NOT the ozone hole! (Stratospheric Ozone)
- Can be a significant health issue: New ozone standard changed to 0.075 ppm
- Can cause visibility problems



Ozone "smog" over Fresno


EPA
good up high
ozone
bad nearby

Ozone Precursors

- Volatile Organic Compounds (VOCs)
- Oxides of Nitrogen (NO_x)
- Combine in sunlight to produce O_3
- Reaction greater in warmer temperatures
- Ozone and fine PM form “smog”

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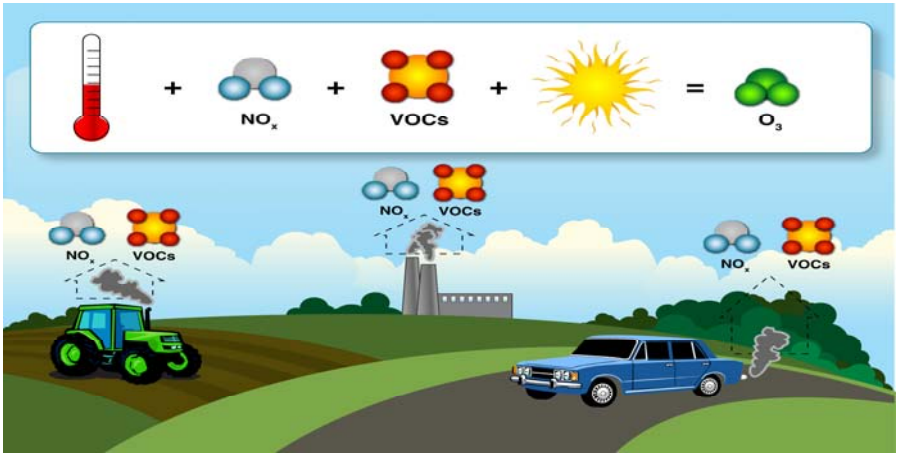
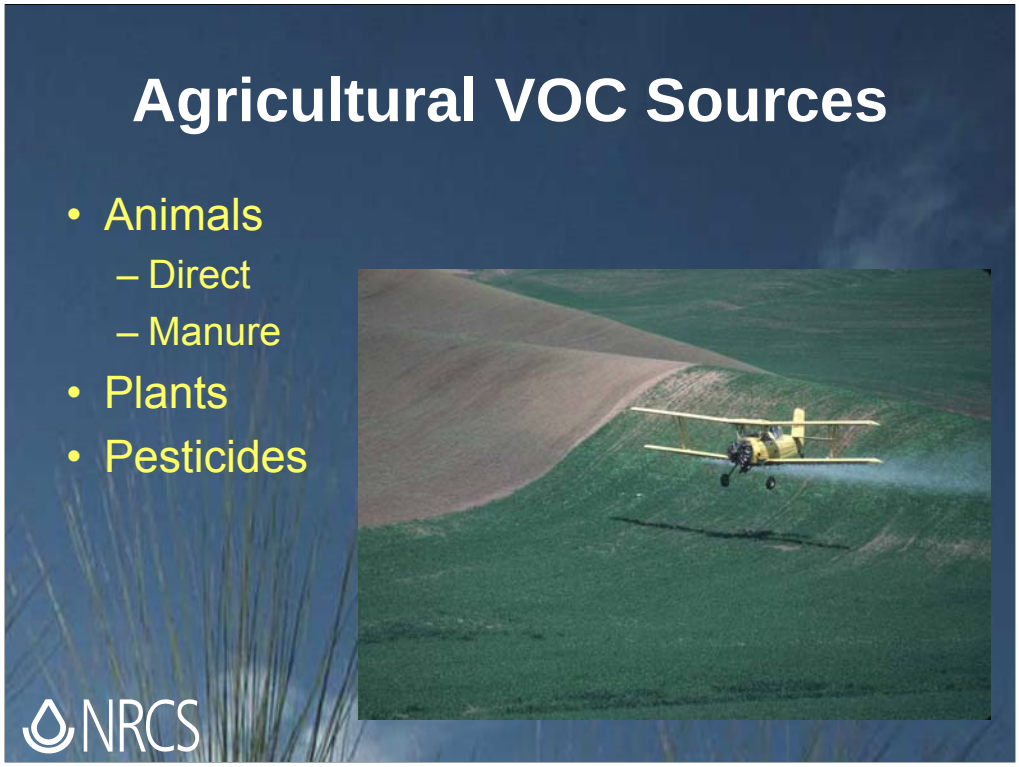
The Formation of Ozone



Many natural as well as anthropogenic sources of VOCs



All living organisms produce VOCs. VOCs from animal operations are generally produced from the decomposition of longer-chain carbon compounds. Animals can produce VOCs through the natural digestion process, and the decomposition of manure can also produce VOCs. Some of the most common VOCs produced by animal operations are alcohols and volatile fatty acids. Land managers can reduce emissions of VOCs from animal operations via feed, manure, and nutrient management.

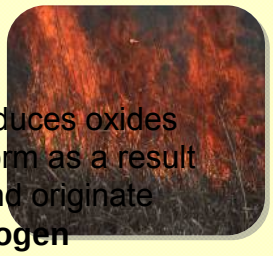
All living organisms produce VOCs. Plants can produce VOCs through the conversion and production of carbon compounds. Some of the most common VOCs produced by plants are isoprenes and terpenes. Plant VOC emissions are typically natural emissions, although different types of plants emit different types and amounts of VOCs.

Many pesticides are VOC-based. Emissions of VOCs from pesticide use is largely driven by weather conditions. Good management practices and the use of technology (i.e., precision agriculture methods) can reduce VOC emission potential from pesticides.

Agricultural NO_x Sourc

Agriculture also produces oxides of nitrogen. They form as a result of several factors and originate from **microbial nitrogen conversion in manure and the application of nutrients or fertilizers, as well as in the combustion process in fires and engines**. In fires, oxides of nitrogen emissions are primarily dependent upon the nitrogen levels in the fuels. For the engine, oxides of nitrogen emissions are a result of **nitrogen in the air and fuel combining with oxygen in the air during combustion**.

Burning



NOx emissions are dependent upon the nitrogen levels in the fuels.

Natural biological processes that breakdown manure can produce NOx.

Engines

NOx emissions are a result of nitrogen in the air and fuel combining with oxygen in the air during combustion.

Nitrogen fertilization increases the potential of NOx emissions via natural biological processes in the soil.

Odors

- Mainly an individual and a community perception issue
  - 3 main sets of odorous compounds:
    - VOCs
    - Reduced (non-oxygenated) sulfur compounds (including H_2S)
    - Ammonia
- Sources: Mainly animal-related (AFOs, Manure)

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Odorous Sulfur Compou

- Odorous sulfur compounds are generated from the anaerobic decomposition of sulfur compounds, mainly in manure.

- During times of manure agitation, the release of odorous sulfur compounds in solution in the manure can increase.

- Feed management is one of the most effective methods of reducing the formation and emission of odorous sulfur compounds.

Odorous sulfur compounds such as hydrogen sulfide also contribute to odors. These compounds are generated from the anaerobic decomposition of sulfur compounds, mainly in manure. During times of manure agitation, the release of odorous sulfur compounds in solution in the manure can increase. Feed management is one of the most effective methods of reducing the formation and emission of odorous sulfur compounds.

Odorous Sulfur Compo
Sources

Two main sources of odorous su
compounds exist

The main agricultural sources of odorous sulfur compounds include manure treatment and storage facilities and land application of manure.

Manure Treatment and Storage Facilities

Manure Applicati

Greenhouse Gases (GH

- There are three common greenhouse gases from agricult
- Alter atmospheric characteristics—principal culprits in glo change
- Water Vapor most important

Nitrous
(N_2O) =
equival

Methane
(CH_4) = ~20
CO_2
equivalents

Carbo
(CO_2)
equiva

Of the main greenhouse gases, water is the most abundant and most important, but also the most inconsequential in terms of human-produced emissions. The most common greenhouse gases emitted from agriculture are carbon dioxide, methane, and nitrous oxide. Carbon dioxide is the natural end-product of respiration and aerobic decomposition of biological material. It is important to note that not all greenhouse gases affect the atmosphere in the same manner. Greenhouse gases are described in units of carbon dioxide equivalents as a measure of their potential to warm the atmosphere, that is sometimes referred to as global warming potential. On an individual basis, nitrous oxide is nearly 300 times more potent **at warming the atmosphere** than carbon dioxide, and methane is nearly 20 times more potent. However, carbon dioxide is produced in much greater quantities than methane or nitrous oxide.

Greenhouse Gases (GHGs)

- Greenhouse gases alter atmospheric characteristics and are the principal culprits in global climate change.
- Greenhouse gases absorb heat emitted from the earth and radiate part of that heat back to the surface, which may increase global mean surface temperature.
- Due to the global mixing characteristics of greenhouse gases, the environmental effects are observed on a global scale, rather than on local or regional scales.

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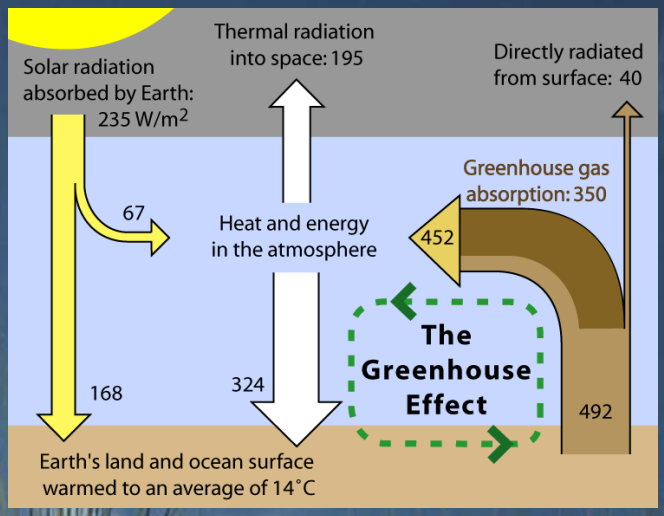
The “Greenhouse” Effect



Agriculture's Greenhou
Gas Sources

Slide

Fertilizers

Tillage

Engines

Animals

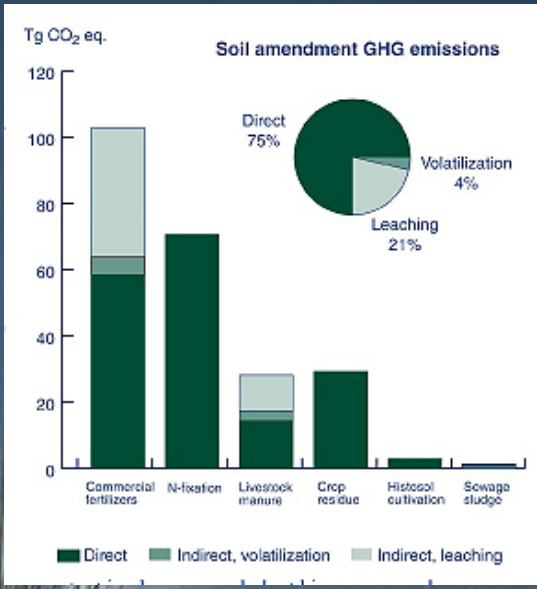
Nitrogen fertilization and manure utilization increases the potential for N_2O emissions from soil.

The three main greenhouse gases produced by agricultural and natural resource systems are emitted through four main sources. Slide the bar to learn how each source contributes to greenhouse gas emissions.

GZ: The Slide Box text should read "Nitrogen fertilization and manure utilization can increase the potential for N_2O emissions from soil by supplying more nitrogen than can be used or stored in the soil ecosystem."

Click and learn activity discussing sources of greenhouse gases

Soil N_2O Emissions



Agriculture's Greenhou
Gas Sources

Slide

Fertilizers

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Tillage aerates the soil, which then promotes biological activity producing CO_2.

The three main greenhouse gases produced by the agricultural and natural resource systems are emitted through four main sources. Slide the bar to learn how each source contributes to greenhouse gas emissions.

In the picture text, replace "producing CO2" with "which releases stored carbon as CO_2".

Click and learn activity discussing sources of greenhouse gases

Agriculture's Greenhou Gas Sources

Slide

Fertilizers

Tillage

Engines

Animals

Engines burn fuels and emit CO_2.

The three main greenhouse gases produced by the agricultural and natural resource systems are emitted through four main sources. Slide the bar to learn how each source contributes to greenhouse gas emissions.

GZ: The Slide Box text should read "Engines burn fuels and emit CO2 as a result of the conversion of carbon compounds in the fuel during the combustion process. Good combustion should actually produce more CO2."

Click and learn activity discussing sources of greenhouse gases

Agriculture's Greenhou
Gas Sources

Slide

Fertilizers

Tillage

Engines

Animals

Nitrogen fertilization and manure utilization increases the potential for N2O emissions from soil.

The three main greenhouse gases produced by the agricultural and natural resource systems are emitted through four main sources. Slide the bar to learn how each source contributes to greenhouse gas emissions.

Change Picture Text to:
Manure management and manure utilization can increase the potential for N_2O emissions if there is excess nitrogen and a mixture of aerobic and anaerobic conditions. Anaerobic manure management systems promote methane generation. Animals, particularly ruminants such as cattle and sheep, can also produce intestinal methane naturally through digestion.

Click and learn activity discussing sources of greenhouse gases

Chemical Drift

- Pesticides are the focus
- Can produce VOCs, PM (2.5, esp.), Odors
- Can be health issue
- Issue with adjoining fields and beyond
- Strongly weather related
- Management technologies available

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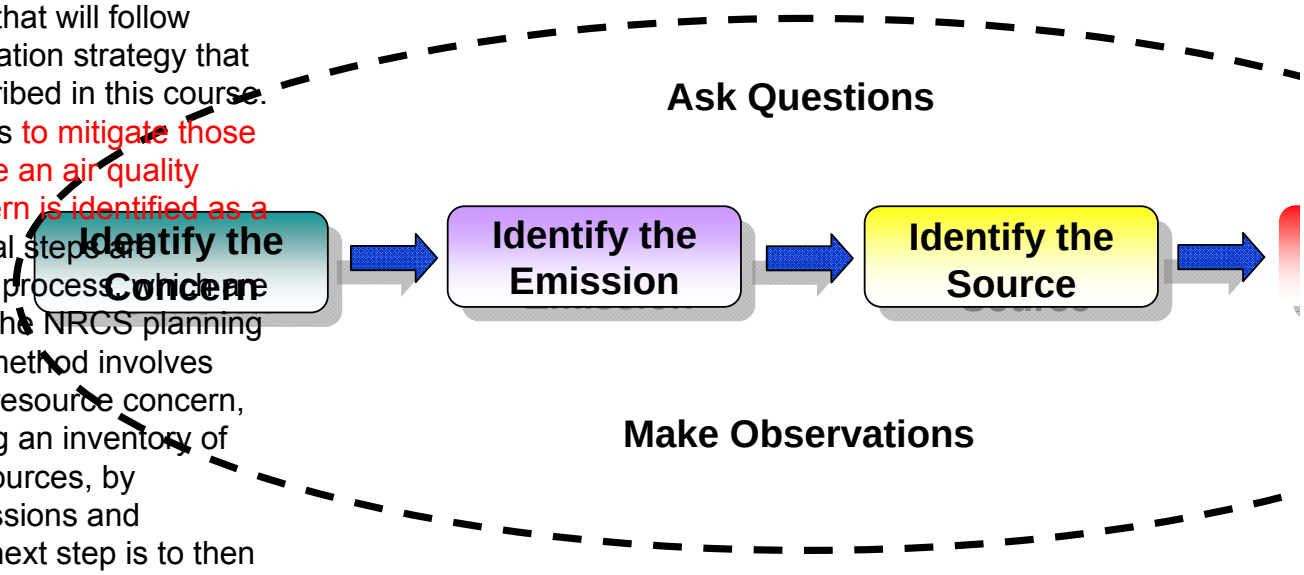
Air Quality Resource Cor
Mitigation Strategy

The examples that will follow utilize the mitigation strategy that has been described in this course. The approach is to mitigate those concerns where an air quality resource concern is identified as a priority. Several steps are involved in this process which are directly tied to the NRCS planning process. This method involves identifying the resource concern, then conducting an inventory of the natural resources, by identifying emissions and sources. The next step is to then develop a strategy that addresses the resource concern, resulting in a workable solution.