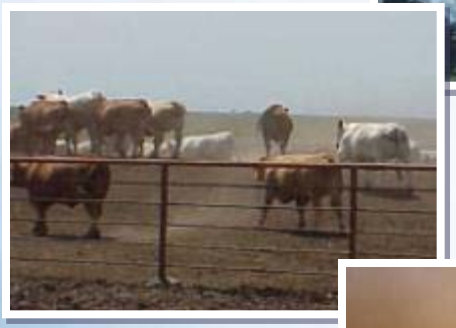
Air Quality and Atmospheric Change Resource Concerns

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 a major concern

NRCS and Air Resources

- 12 of 79 current NRCS resource concerns are related to AQAC
- Effort to consolidate to four main AQAC resource concerns



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

Resource Concerns

- Particulate Matter (PM)
- Ozone (O3) Precursors
- Odors
- Greenhouse Gases (GHG)

The Regulatory Process

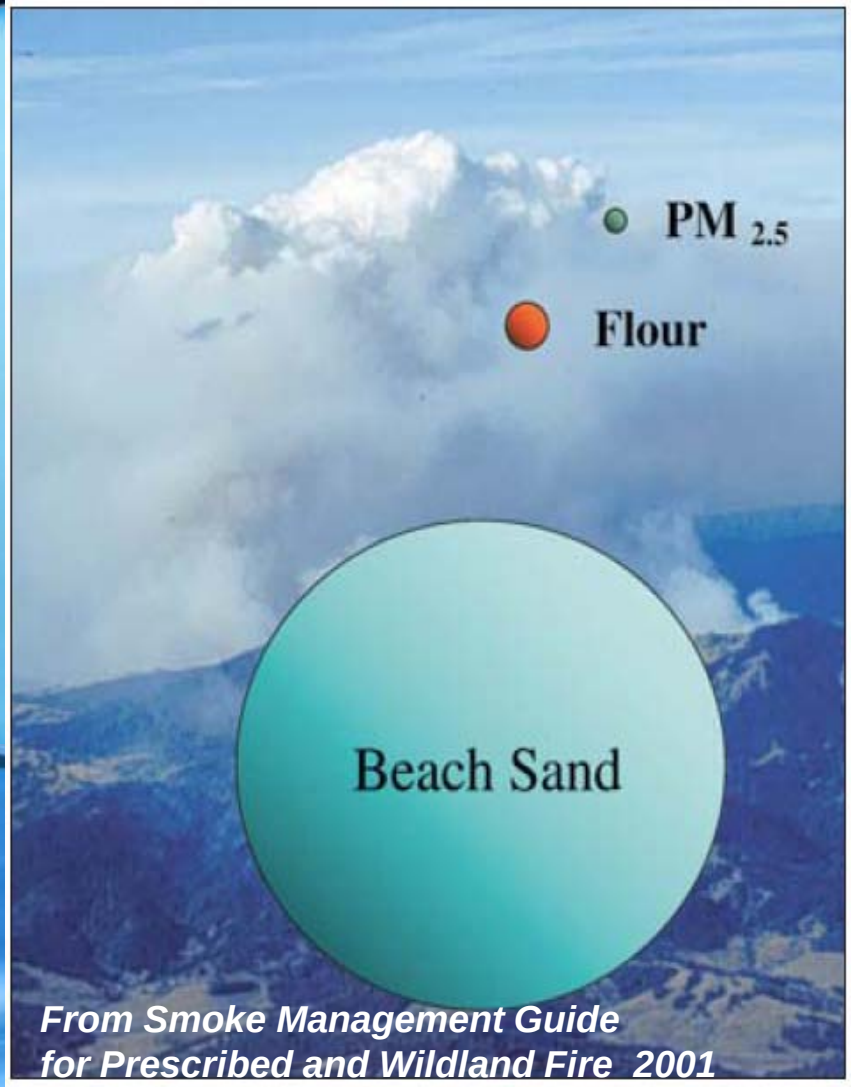
- National Ambient Air Quality Standards (NAAQS)
- 6 Criteria Pollutants
  - Particulate Matter (PM)
  - Ozone (O_3)
  - Nitrogen Dioxide (NO_2)
  - Sulfur Dioxide (SO_2)
  - Carbon Monoxide (CO)
  - Lead (Pb)

- Five year review cycle
- Nonattainment Area (NAA)
- State Implementation Plan (SIP)
- **http://www.epa.gov/ttn/naaqs/**

Particulate Matter

Classes of Particulate Matter (PM)

- How is particulate matter categorized?
  - By its size
- What are the categories of PM?
  - Fine PM (i.e. PM2.5)
  - Inhalable Coarse PM (i.e. PM10)
  - Larger PM



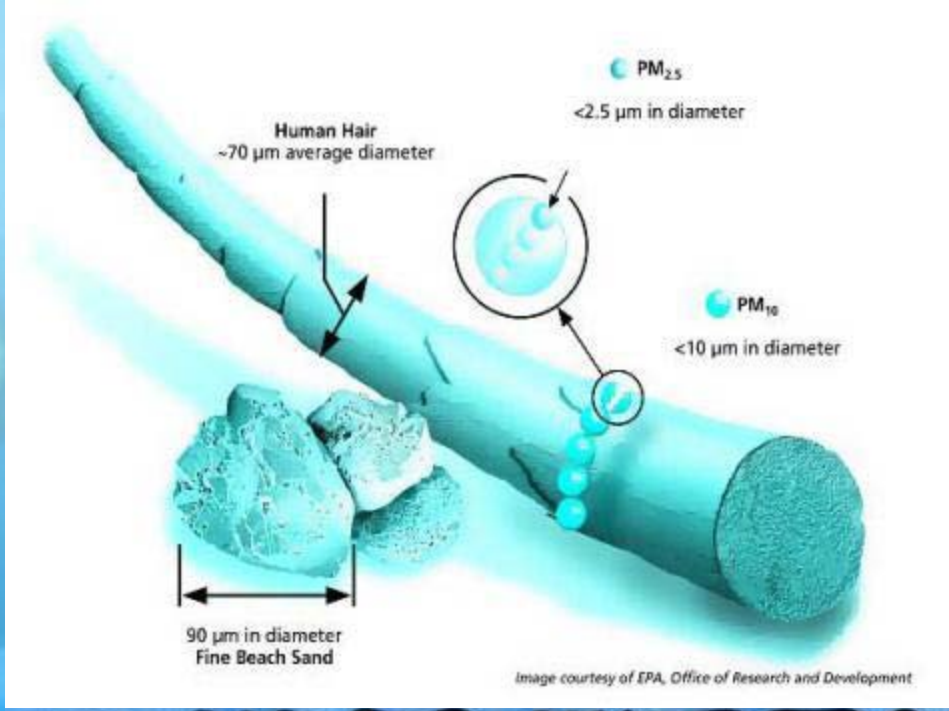
From Smoke Management Guide for Prescribed and Wildland Fire 2001

What are emission source types of PM?

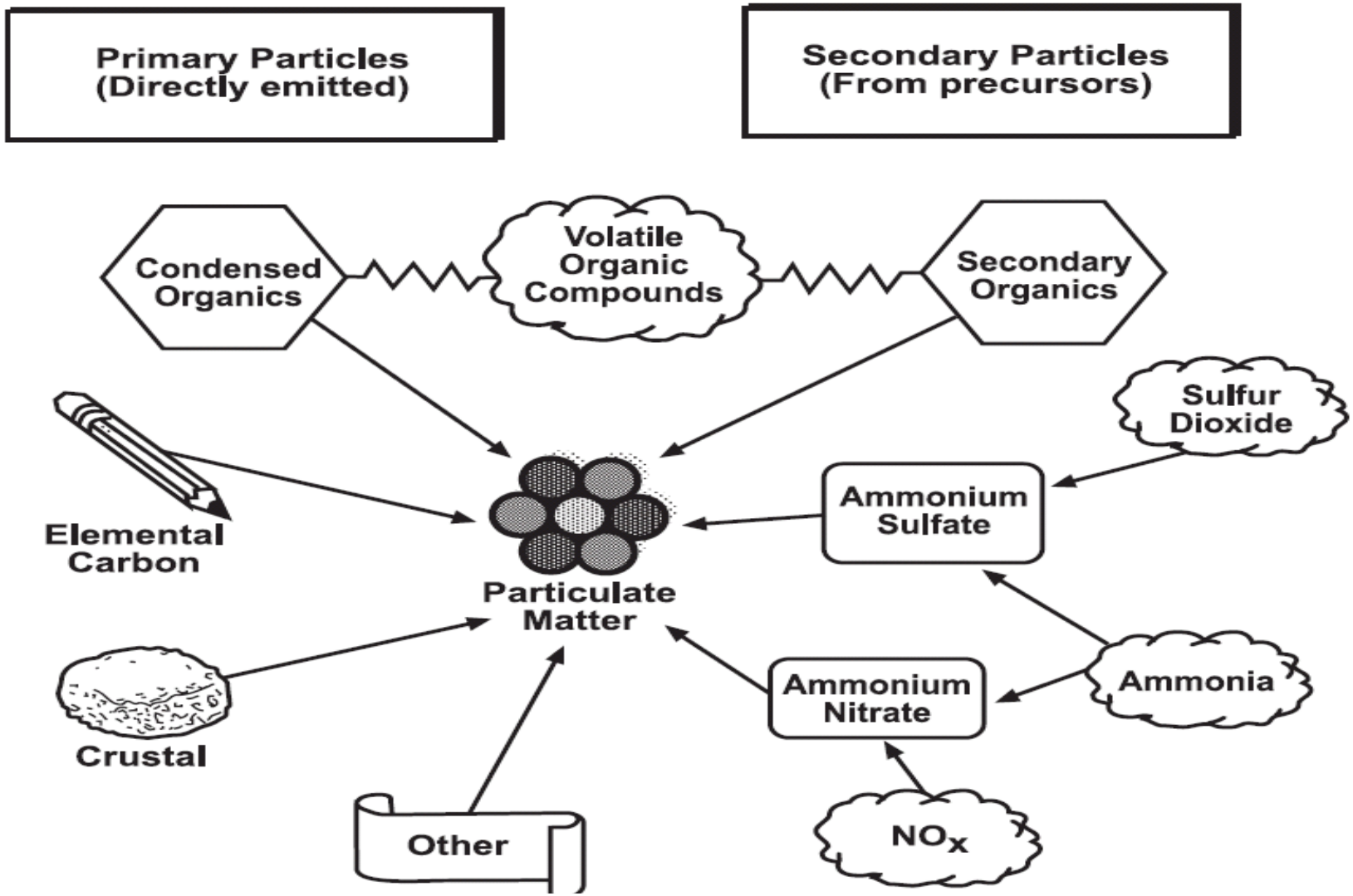
- PM2.5
  - Directly emitted (Primary)
    - mostly through combustion processes, and
    - to a smaller degree by mechanical means (e.g. dust)
  - Formed by chemical reaction (Secondary)
- PM10
  - Directly emitted (Primary)
  - Mostly mechanically generated
- Larger PM
  - Directly emitted (Primary)
  - Mostly geologic in origin (ex. volcanic, crustal)

Fine Particulates (PM2.5)

- Also known as aerosols
- Play a role in:
  - Atmospheric chemistry
  - Human health impacts
  - Visibility impacts
  - Cycling of nutrients and other materials via deposition
- Component of smog



Types of Particle Pollution



Source: Adapted from Dye, T., C. MacDonald and D. Miller. *Air Quality and Meteorology 101*. Sonoma Technology, Inc. Presentation at U.S. Environmental Protection Agency's 2004 National Air Quality Conference, Baltimore, Maryland. Retrieved June 20, 2005, from http://cfpub.epa.gov/airnow/index.cfm?action=conference2004.aq.

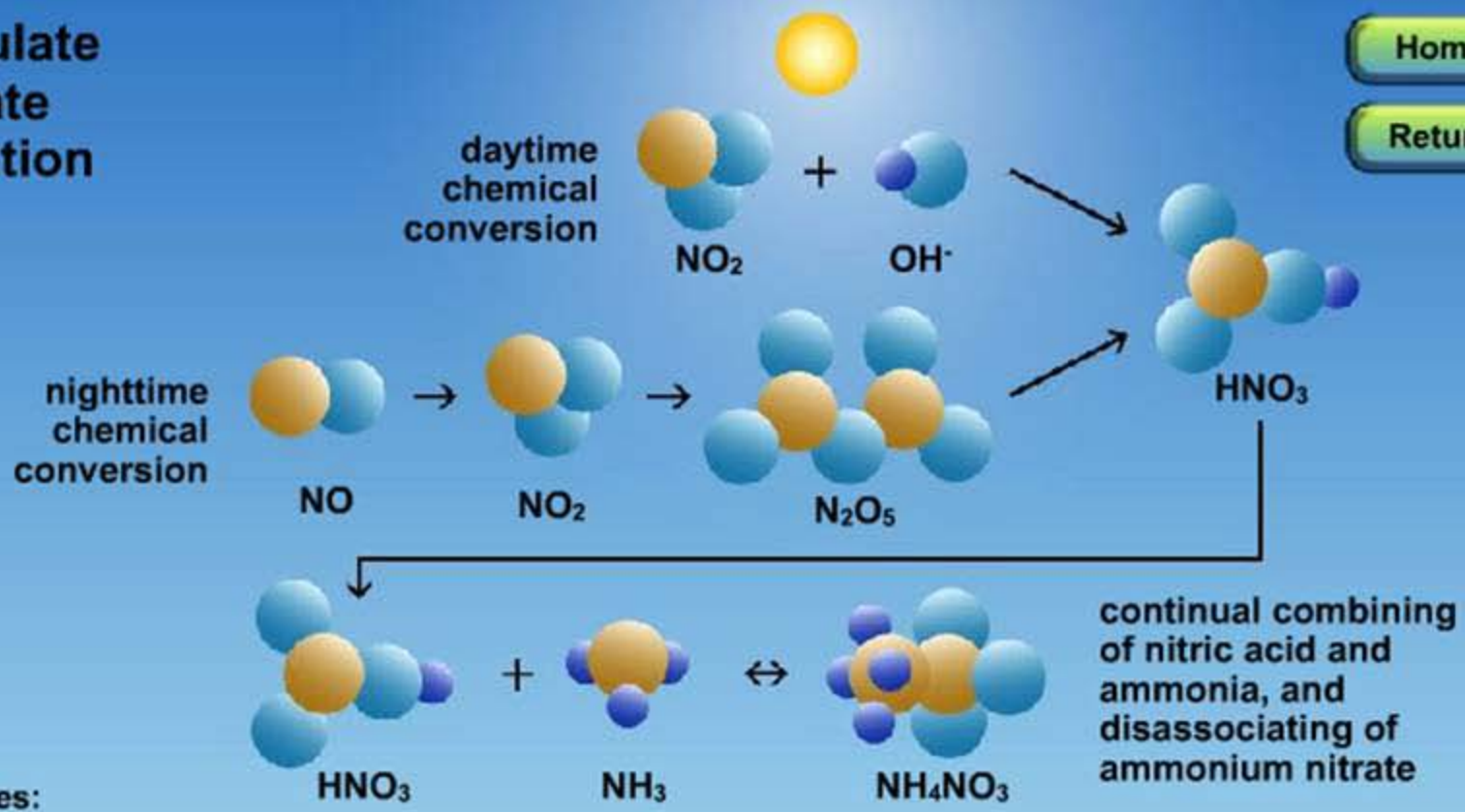
Particulate Matter Chemistry

- Ammonia and Particulate Matter Formation
- $SO_2 + NH_3 + \text{radicals} \rightarrow (NH_4)_2SO_4$
  - Preferential reaction
- $NH_3 + HNO_3 \leftrightarrow NH_4NO_3$
  - If excess ammonia

Particulate Nitrate Formation

Home

Return



Chemical Names:

NO	nitrogen oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
N_2O_5	dinitrate pentoxide
OH^-	hydroxide
HNO_3^-	nitric acid
NH_3	ammonia
NH_4NO_3	ammonium nitrate

Ammonium nitrate molecules can stick to each other, forming haze-producing particles. Water molecules can then stick to these clumps, further increasing their size and ability to obscure visibility.

Back

Courtesy National Park Service

Oxides of Nitrogen, Ammonia, & Nitric Acid Interaction

- $NO_2 + OH \rightarrow HNO_3$ (nitric acid)
  - Nitric acid deposits quickly
- $NH_3 + HNO_3 \leftrightarrow NH_4NO_3$ (ammonium-nitrate)
  - Temperature dependent reaction
    - Cooler temperatures $\therefore$ $NH_4NO_{3\,(p)}$
    - Warmer temperatures $\therefore$ $HNO_{3\,(g)}$
    - Thus, NH_3 controls effective seasonally (winter)
  - Ammonium-nitrate
    - Less affinity to deposit than HNO_3
    - Can be transported longer distances

Particulate Matter Chemistry

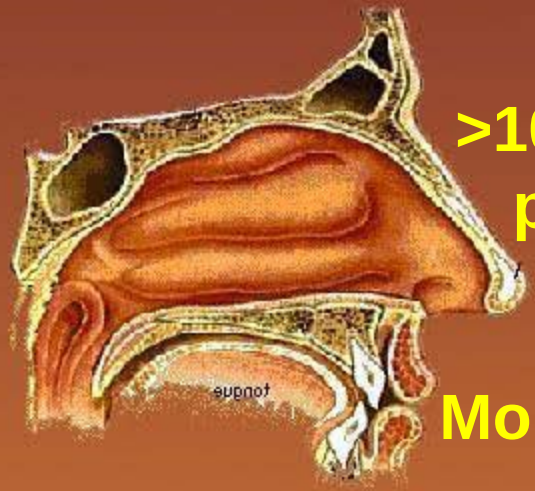
- VOCs can react with radicals to produce particulate matter
- Terpenes are the major biogenic VOC that can yield particulate matter

Why is PM a concern?

- Health
- Visibility
- Deposition

http://earthobservatory.nasa.gov – 4/17/2010

Where Are Particles Removed or Deposited?

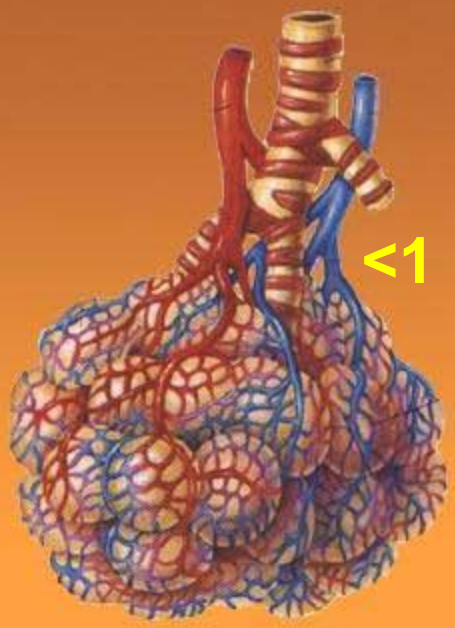


>10 µm: nasal passages

Mouth (no filter system)

5 µm: trachea, bronchi

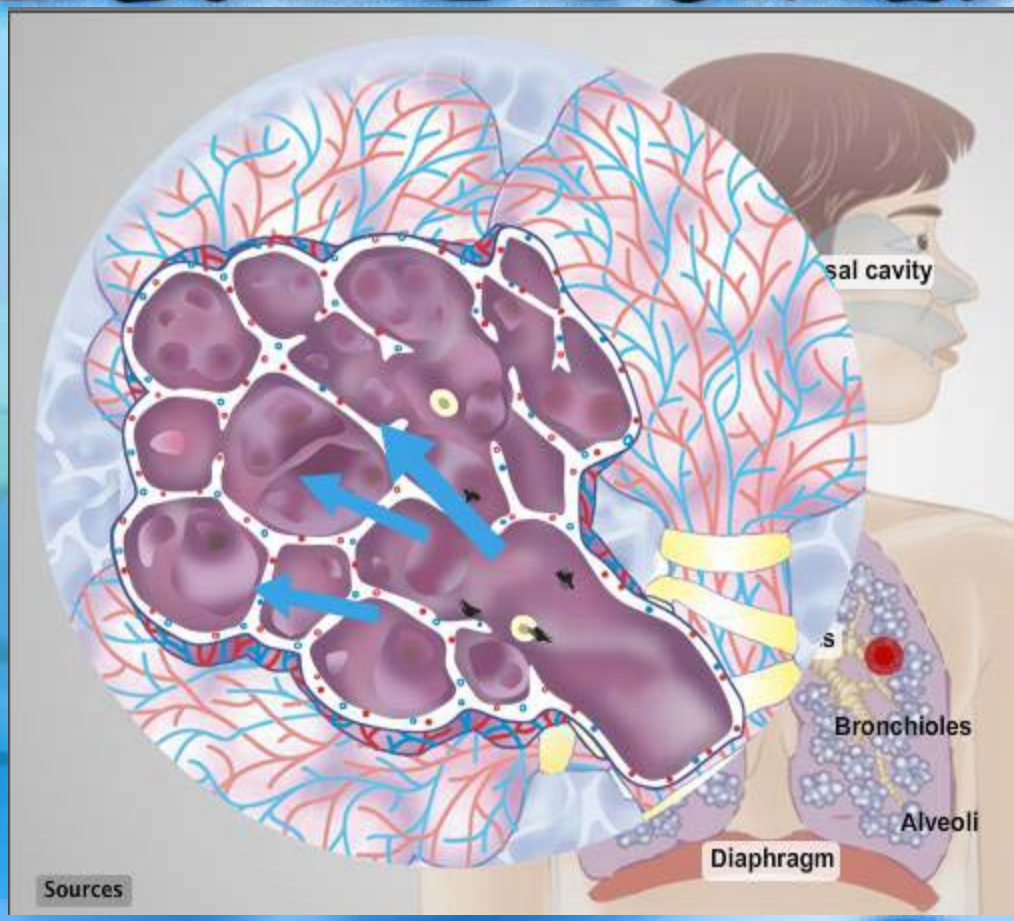
<2 µm (smoke): bronchioles



<1 µm: in alveoli

Health Impacts – PM2.5

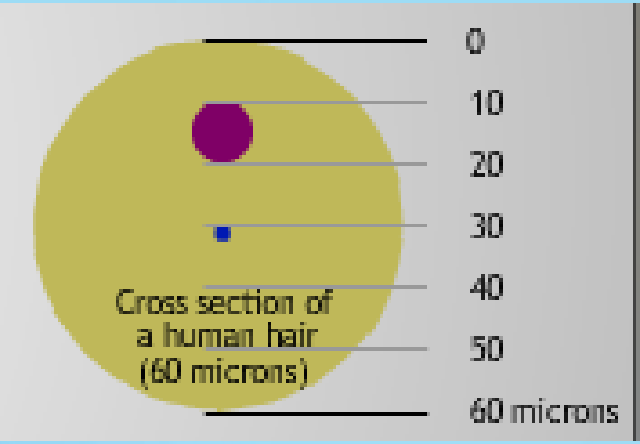
- The immune system sends white blood cells (lymphocytes), to surround the particulates, protecting the body from the foreign objects. The lymphocytes settle on the alveoli walls, causing inflammation and scarring. The built-up scar tissue slows oxygen flow, making transfer of air to capillaries more difficult



Fresno Bee http://www.fresnobee.com/static/2007/flash/airproject/)

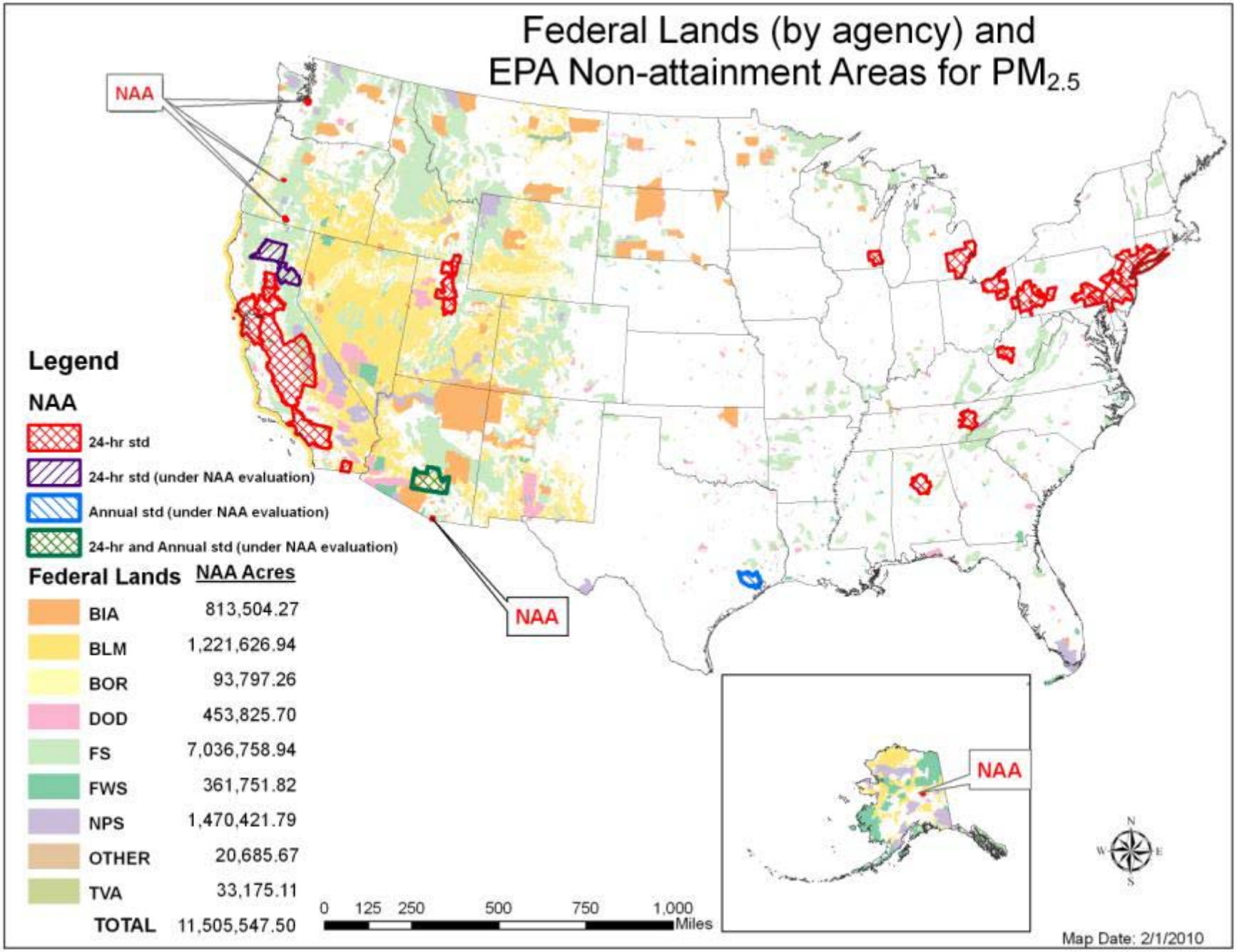
National Ambient Air Quality Standards (NAAQS)

- $PM_{2.5}$ Standard Revised 9/2006
  - Old 24-hr Standard = 65 µg/m^3
  - New 24-hr Standard = **35 µg/m^3**
  - Annual Standard = 15 µg/m^3

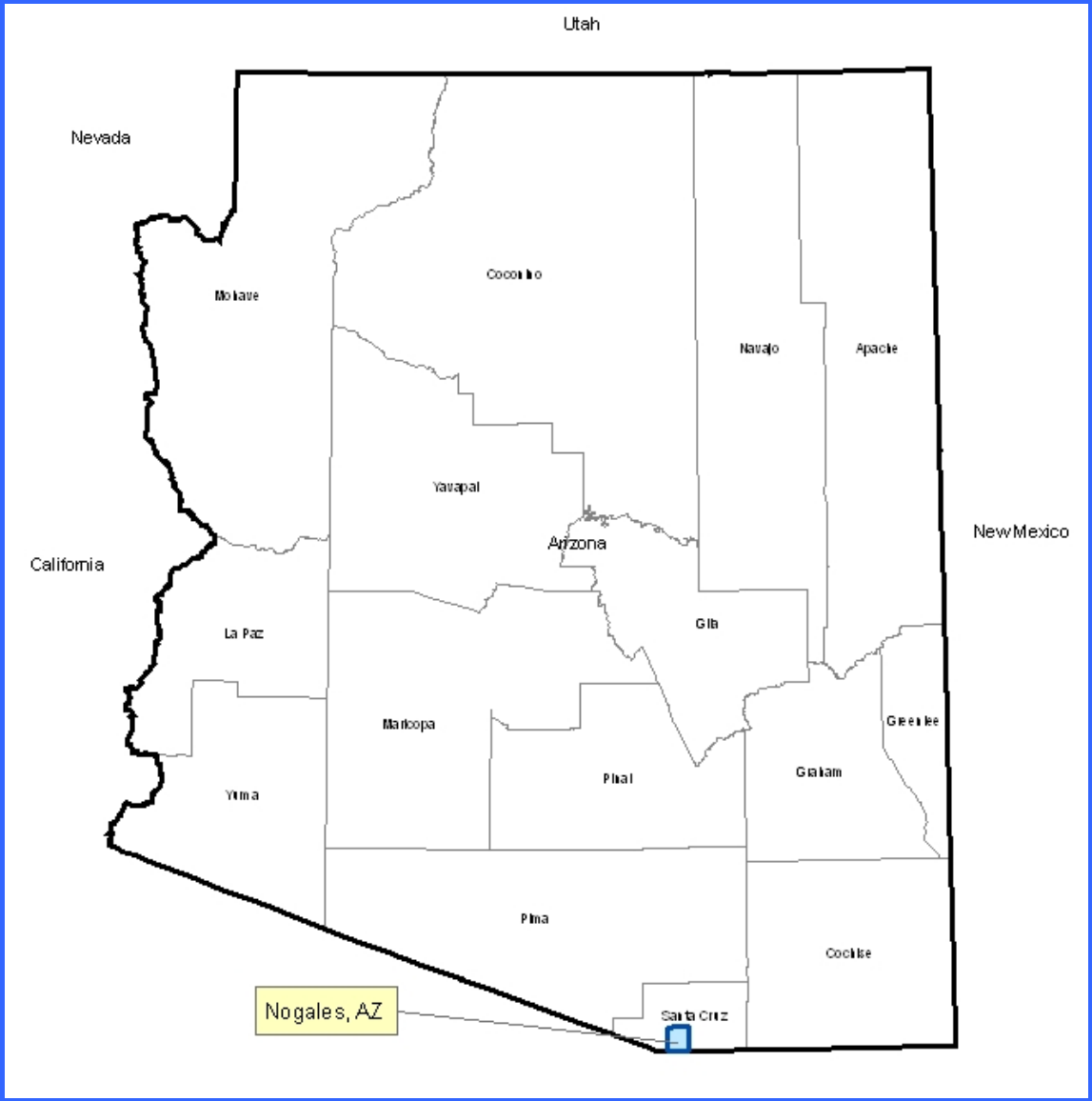


- PM_{10} 24-hr Standard = 150 µg/m^3

Federal Lands (by agency) and EPA Non-attainment Areas for $PM_{2.5}$



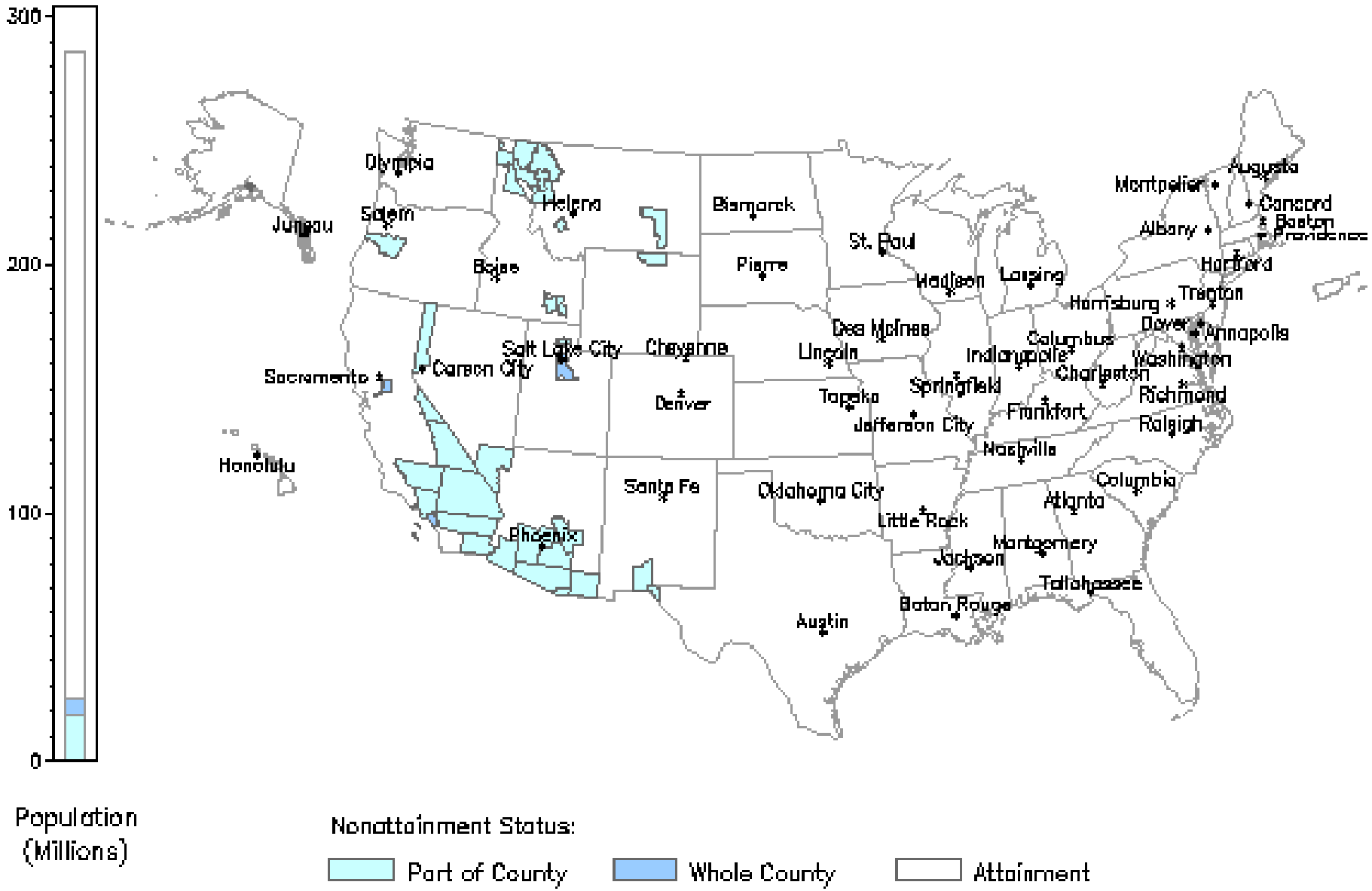
Arizona PM2.5 NAA



Nonattainment Areas Map – Particulate (size < 10 micrometers)

United States

AirData



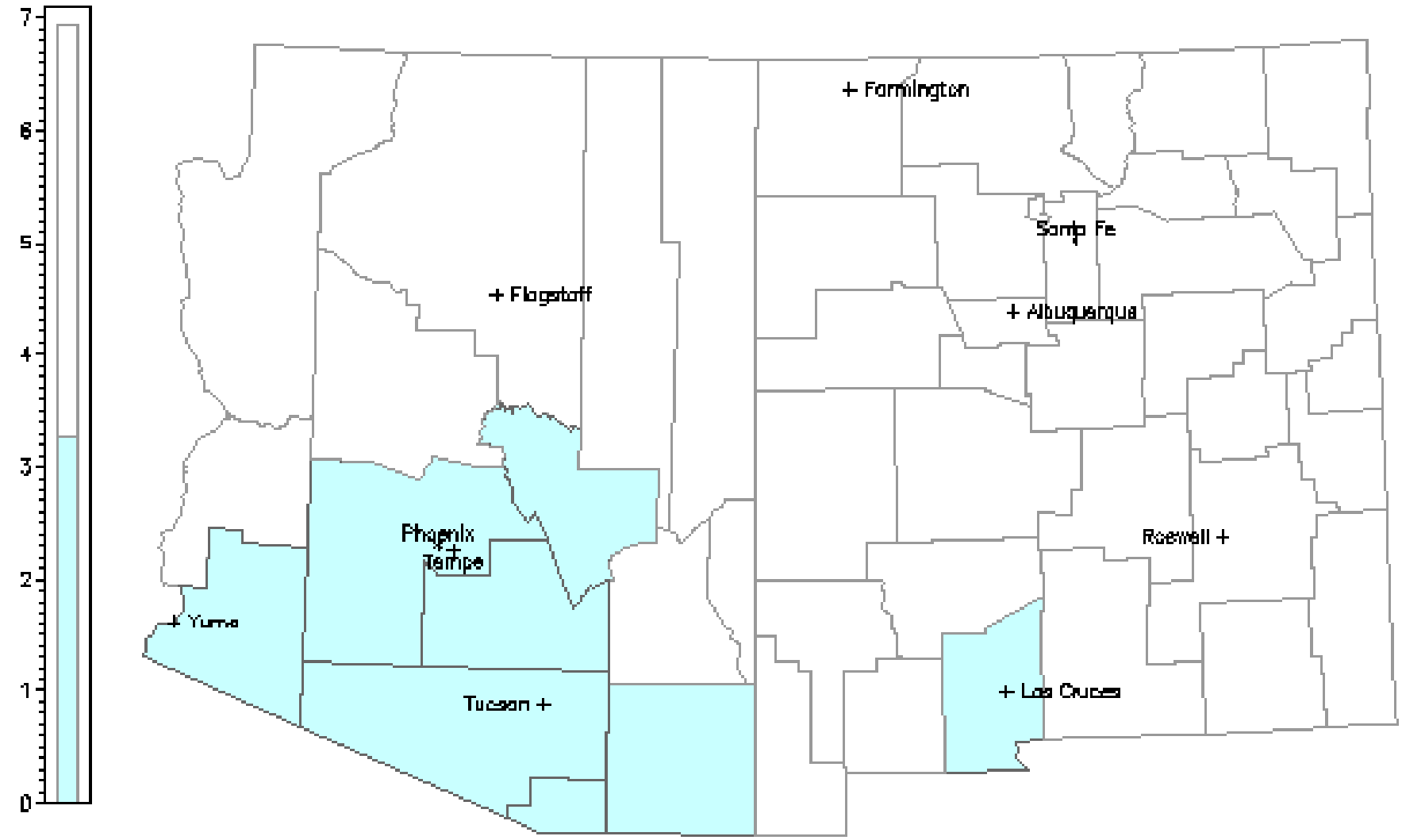
Source: US EPA Office of Air and Radiation, AQS Database

Monday, April 5, 2010

Nonattainment Areas Map – Particulate (size < 10 micrometers)

Arizona or New Mexico

AirData



Population (Millions)

Nonattainment Status:

Part of County | Whole County | Attainment County

Source: US EPA Office of Air and Radiation, AQS Database

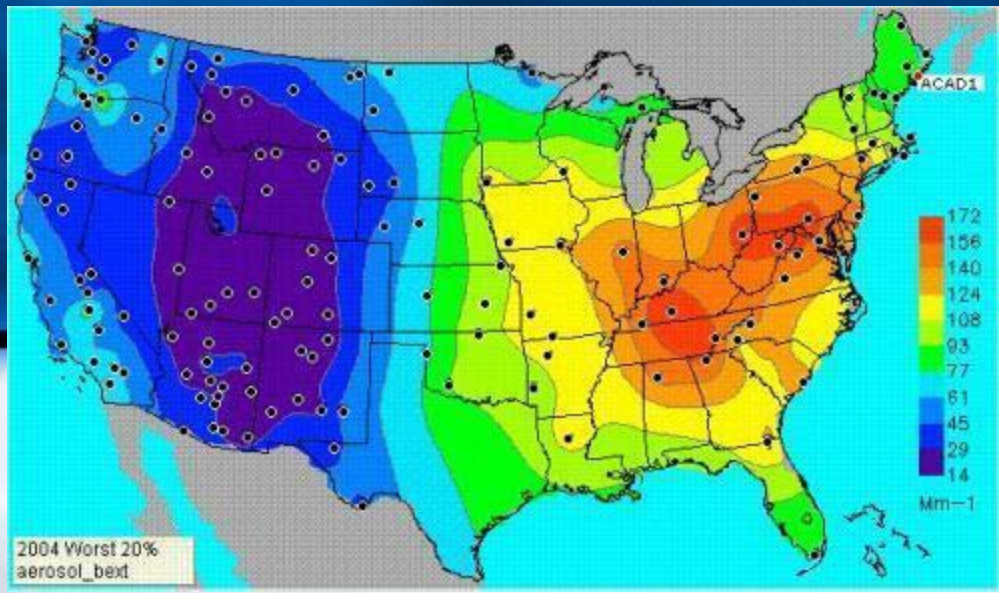
Monday, April 5, 2010

2011 PM NAAQS Revisions

- EPA Releases Draft Policy Assessment in Review of the PM NAAQS (March 15, 2010), comments due 4/12/2010.
- PM2.5: suggested levels:
  - 35 - 30 µg/m3 24-hr std (vs 35 µg/m3), 13 - 12 (µg/m3) annual std (vs 15 µg/m3)
  - 30 - 25 µg/m3 24-hr std (vs 35 µg/m3), 11 - 10 (µg/m3) annual std (vs 15 µg/m3)
- Visibility: Recommends considering a secondary standard
- PM10: Possible revision to the PM10 standard
- Proposed PM Rule by November 2010
- Finalized Rule July 2011

Visibility

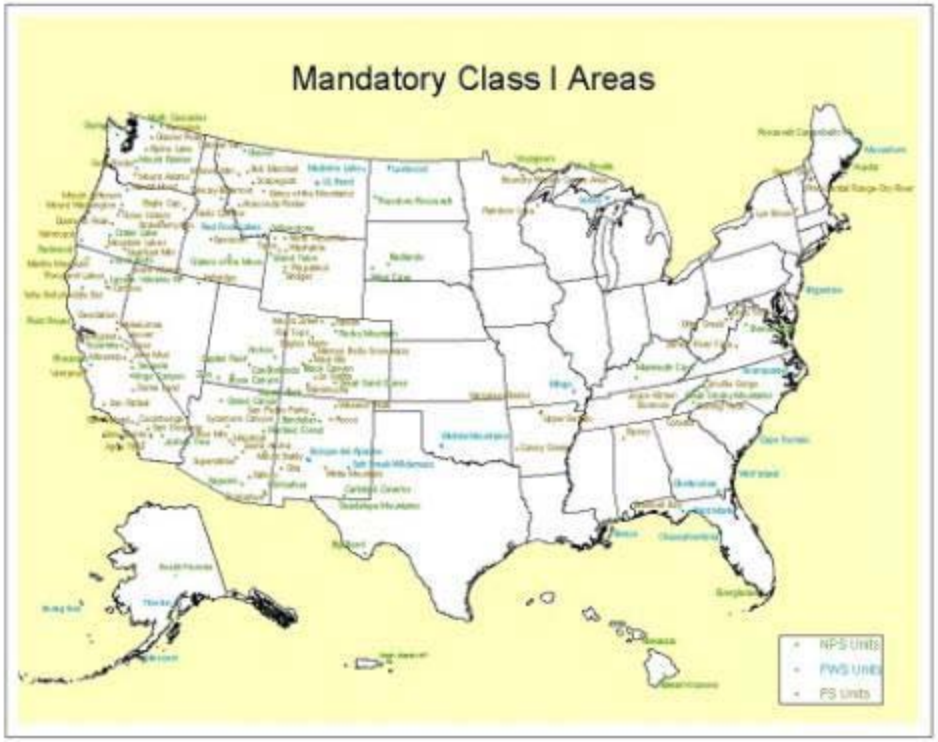
- The extinction of light (β_{ext}) reduces visibility
- Light extinction is due to particles and gases in the atmosphere absorbing and scattering light
- Regional Haze Rule



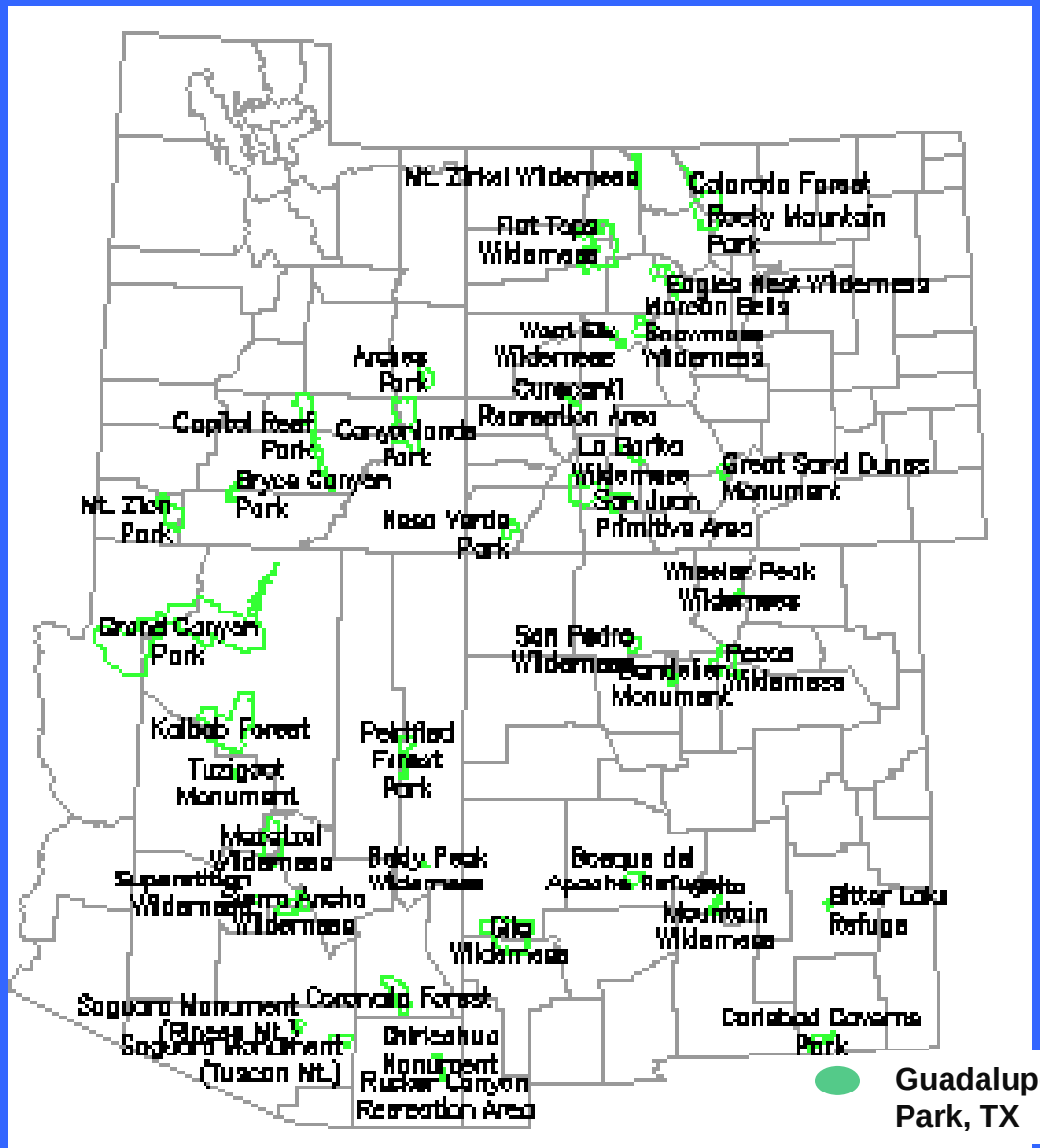
- Rural vs urban light extinction
  - In rural environments:
    - Typically 90% of β_{ext} is from particulates scattering light.
  - In urban environments:
    - Absorption of light by NO_2 can account for up to 50% of β_{ext}

Visibility - Class I Areas

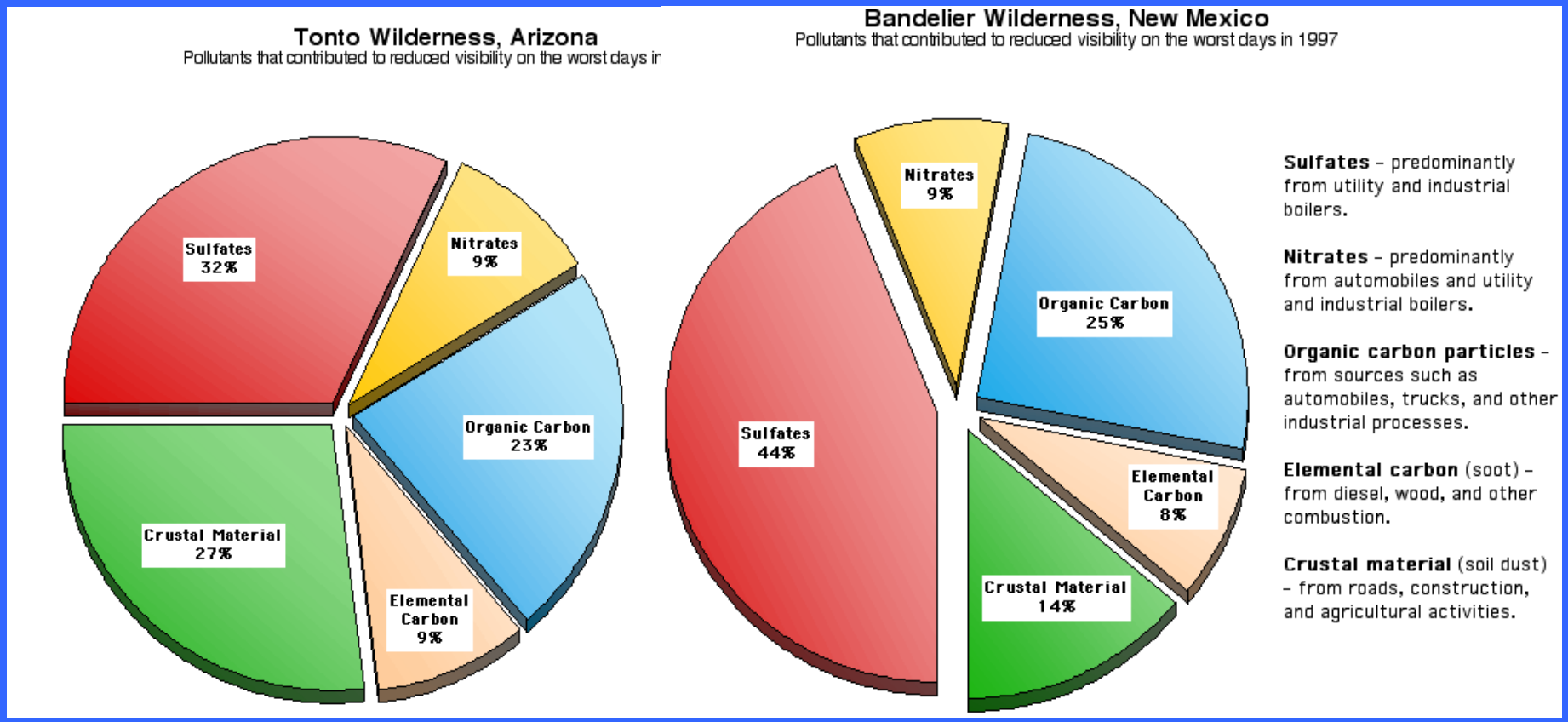
- Regional Haze Rule - Section 169 of the CAA
- Approx 162 areas, for example:
  - National parks
  - National wilderness areas
- Achieve “Natural Background” by 2064

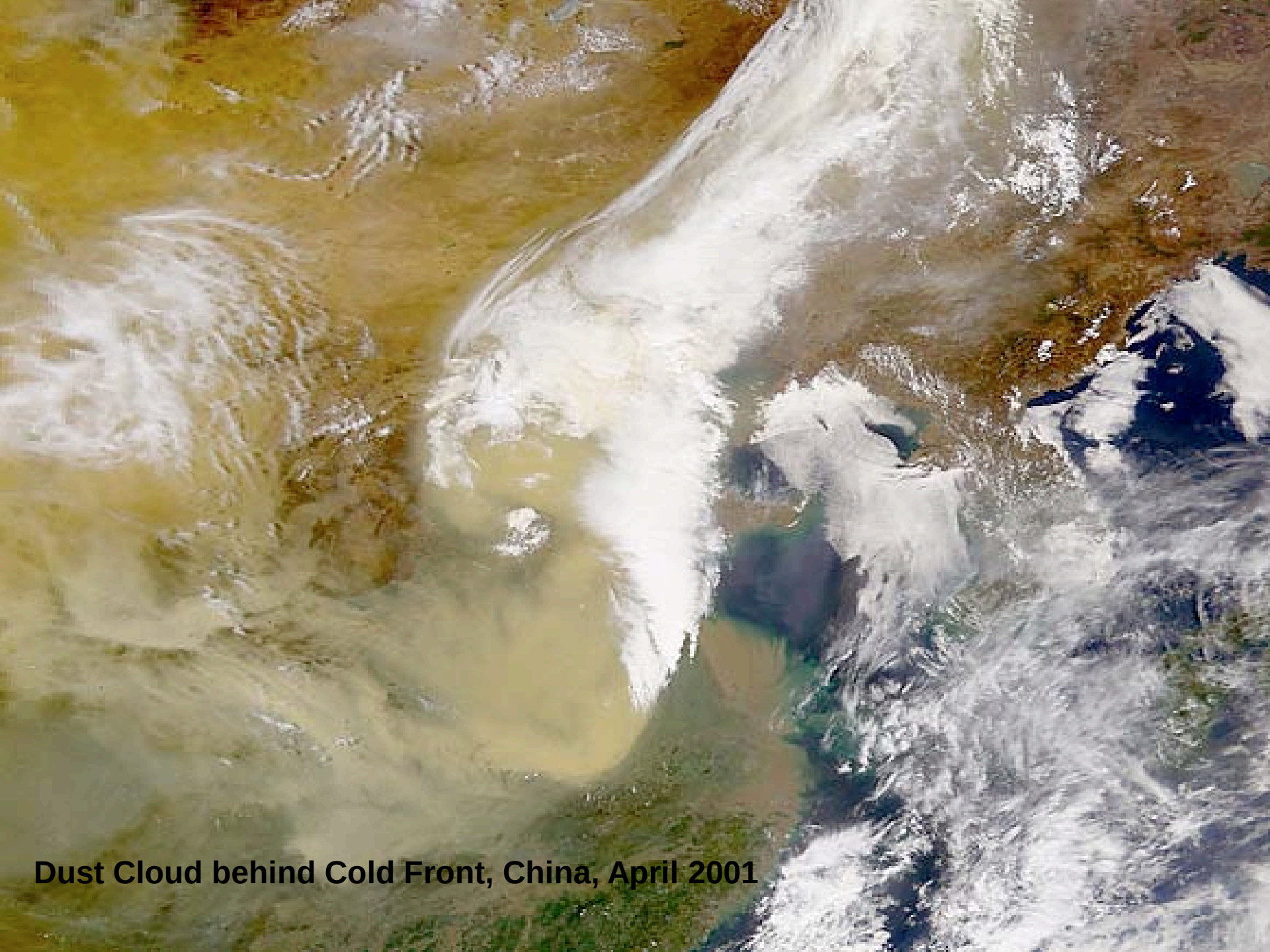


Visibility - Class I Areas (in and around AZ and NM)



http://www.epa.gov/visibility/monitor.html

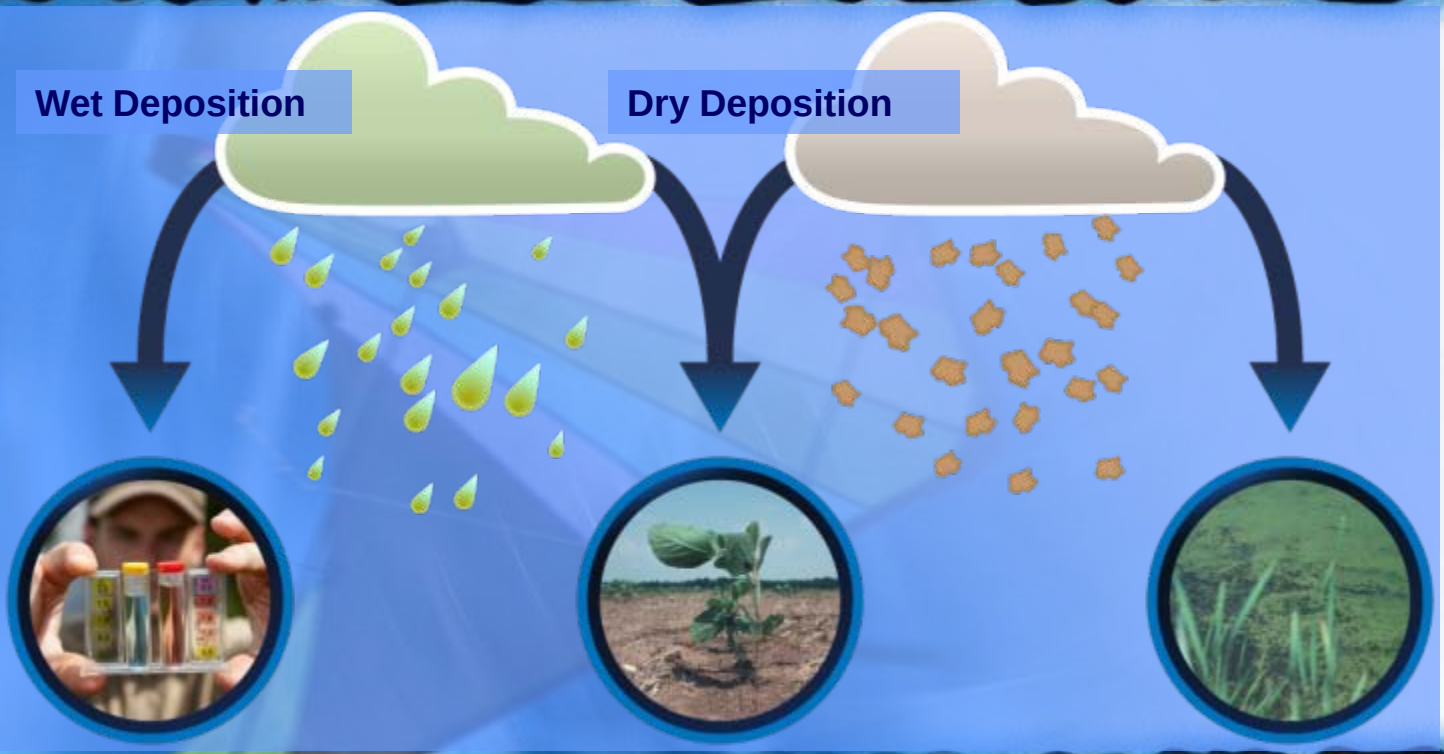




Dust Cloud behind Cold Front, China, April 2001

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

PM Deposition

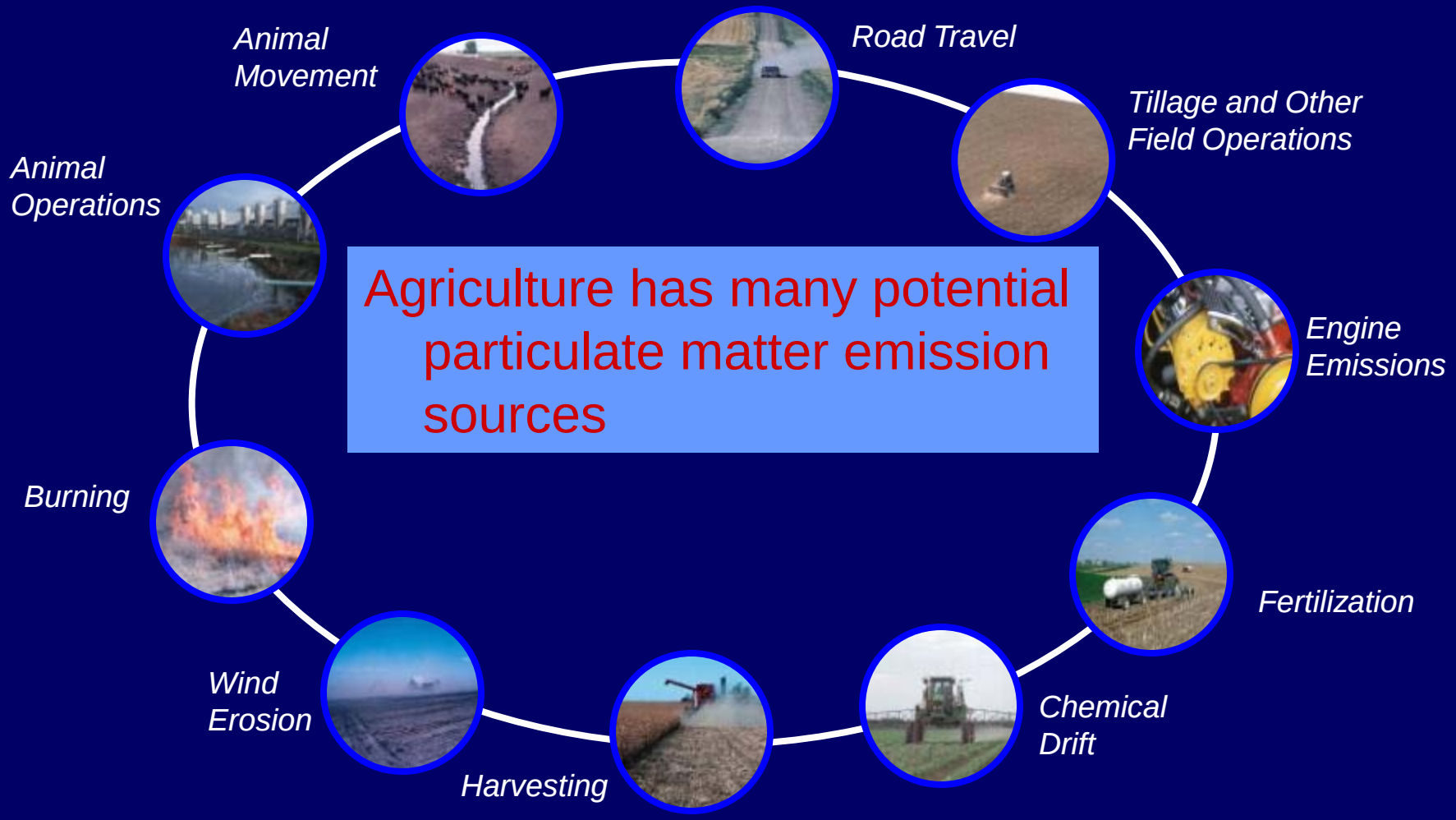


•Deposition can cause:
- nuisance dusting
- change the pH balance
- damage plants
- eutrophication (additional nitrogen)

Scales of Particulate Matter Influence

Particulate matter can cause impacts on local, regional, and even global scales.

Direct PM Emission Sources



Agriculture has many potential particulate matter emission sources

Indirect PM Sources Example: Ammonia

Ammonia (NH_3) participates in atmospheric chemical reactions that can lead to the secondary formation of PM2.5

Ammonia + Other Trace Gases → **$PM_{2.5}$** →

Ammonia

Volatilization during Application

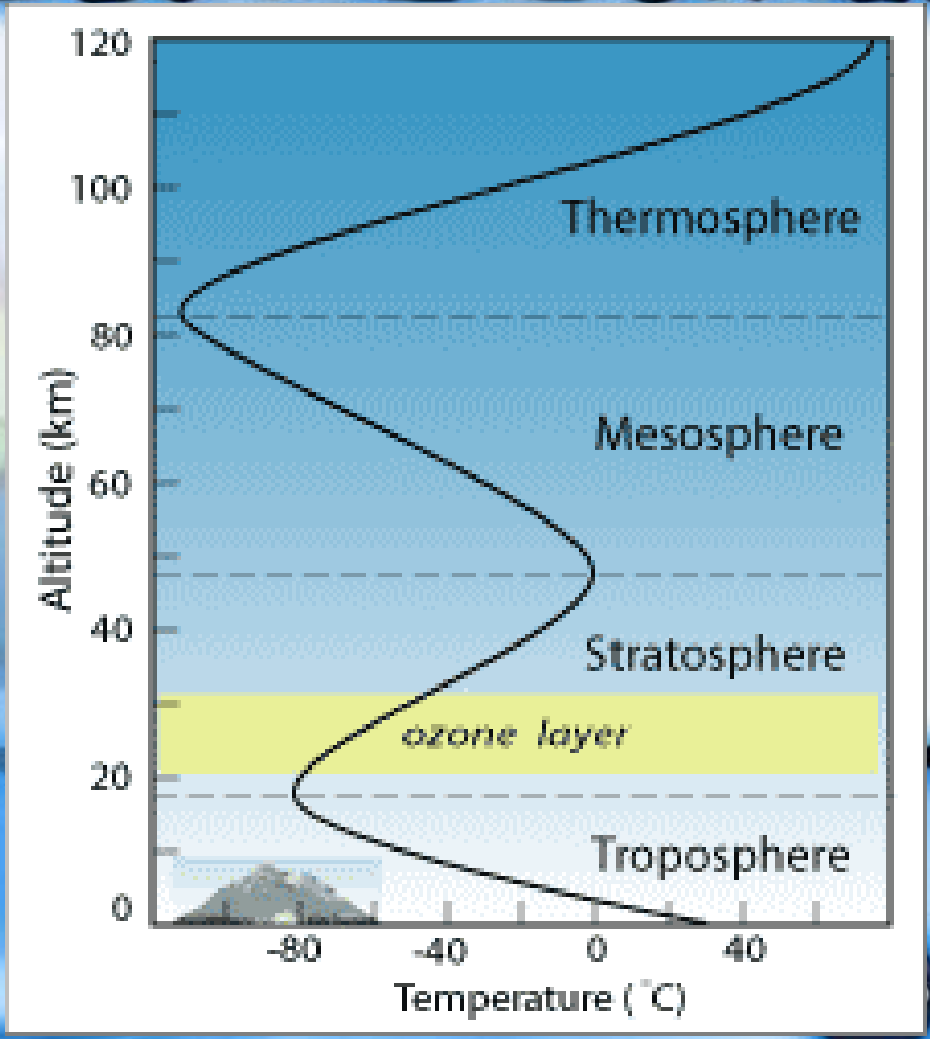
Other Trace Gases (such as nitrates and sulfates already in the atmosphere)

Globally, agriculture accounts for 70% of NH_3 released into the atmosphere

Ozone Precursors

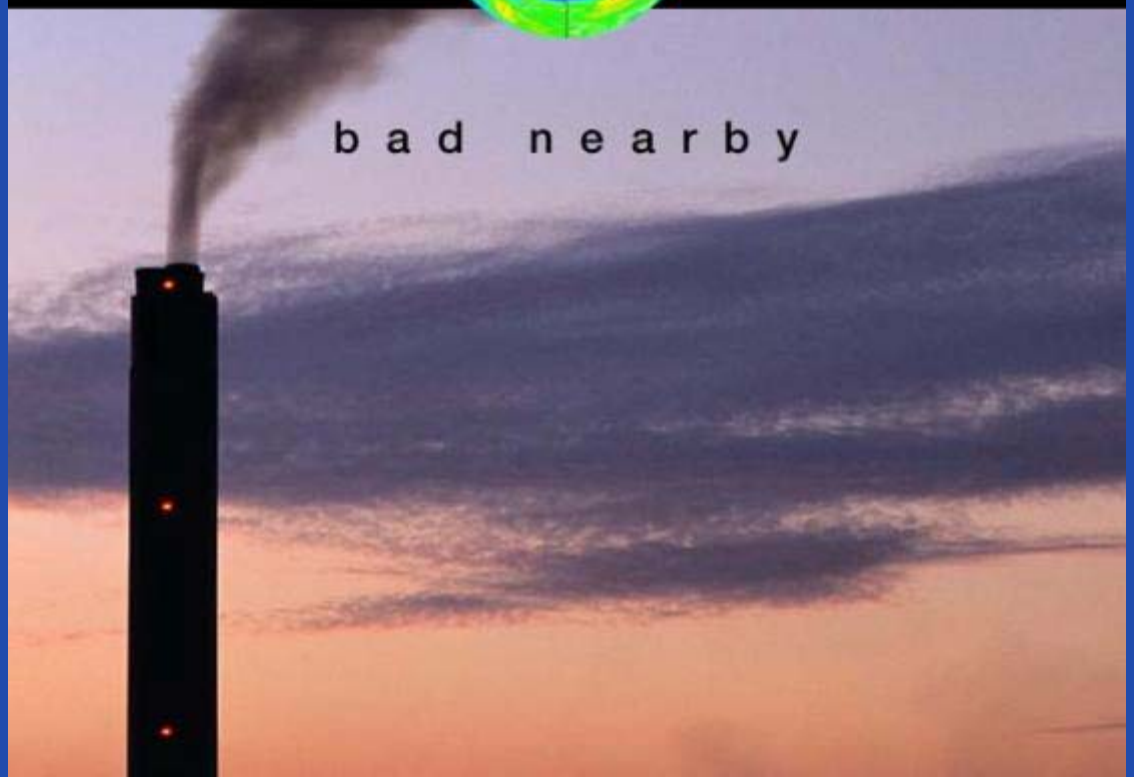
Ozone (O_3)

- Two kinds of ozone
  - Stratospheric ozone layer protects us from harmful UV light
  - Tropospheric ozone that is harmful to human health and vegetation



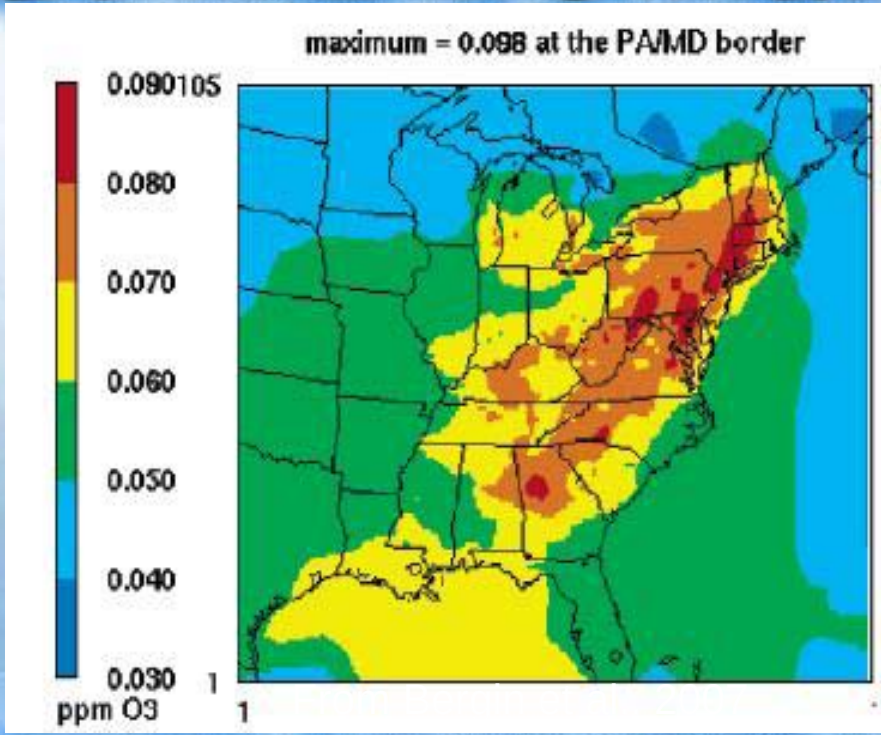
EPA

ozone



Tropospheric Ozone Chemistry

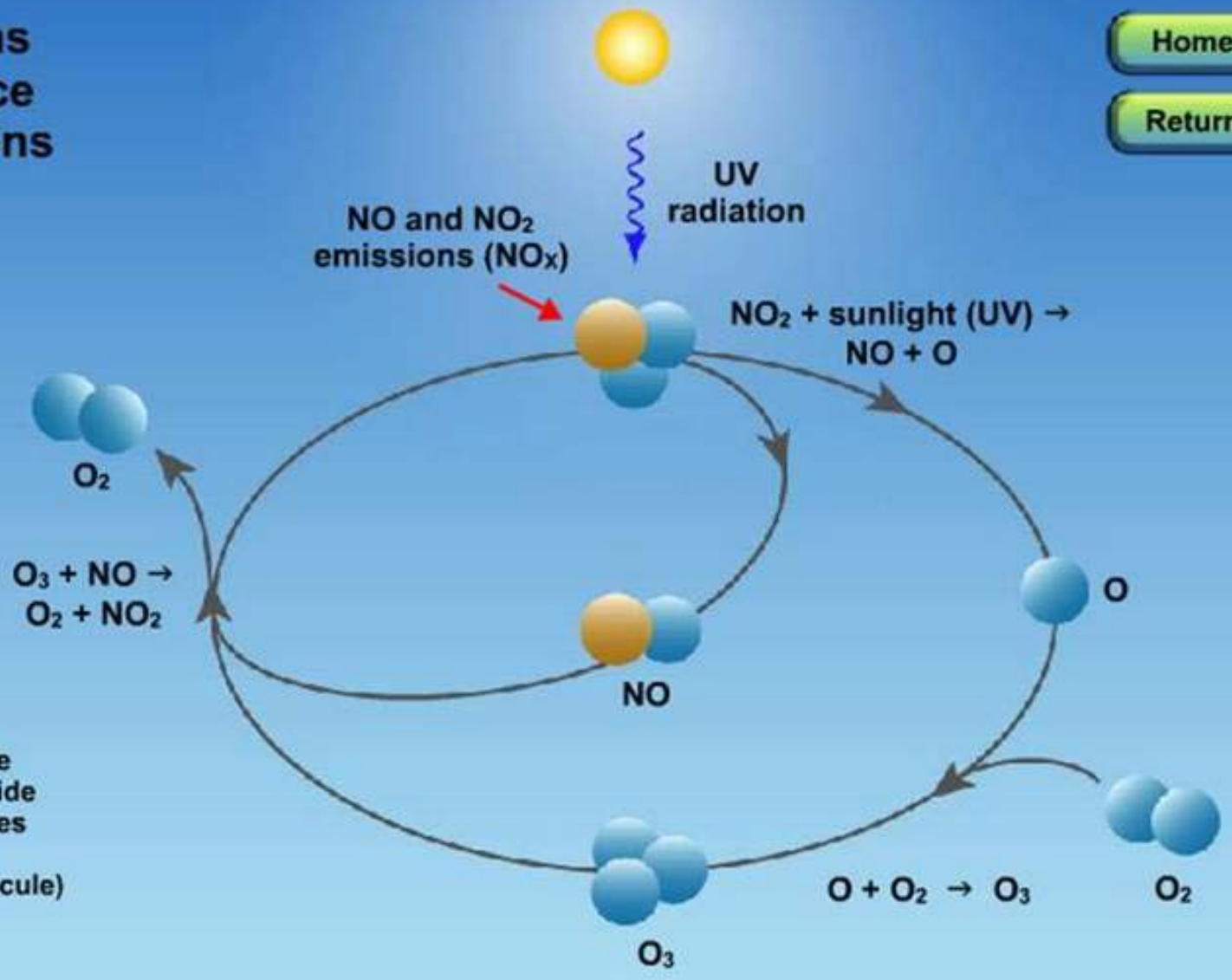
- Ozone is a “secondary pollutant”
  - Not directly emitted
  - Created in the atmosphere
- VOC + NO_X + sunlight -> O_3
  - NOx (Oxides of Nitrogen) = NO2 and NO
  - VOC = Volatile Organic Compound
- Timescale: 1-2 hours
  - Ozone typically forms downwind of precursor releases



NO_X Reactions in the Absence of Hydrocarbons

Home

Return



Chemical Names:

NO	nitrogen oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
O	oxygen atom
O_2	oxygen (molecule)
O_3	ozone

The above cycle is a very simplified series of ongoing reactions involving NO and NO_2, and ozone (O_3). In this model, NO_2 and ozone are in equilibrium with each other and concentrations neither increase nor decrease.

Next

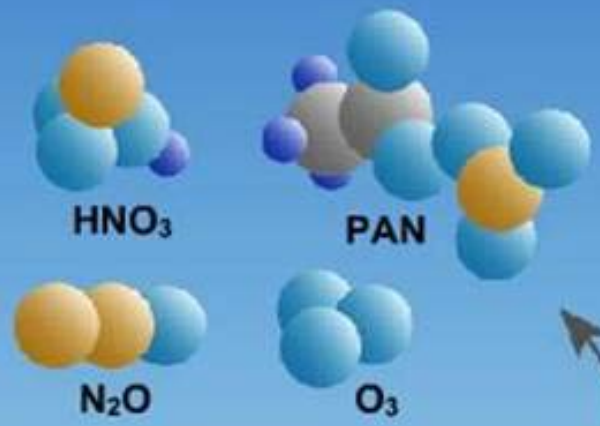
Courtesy National Park Service

Tropospheric Ozone Chemistry

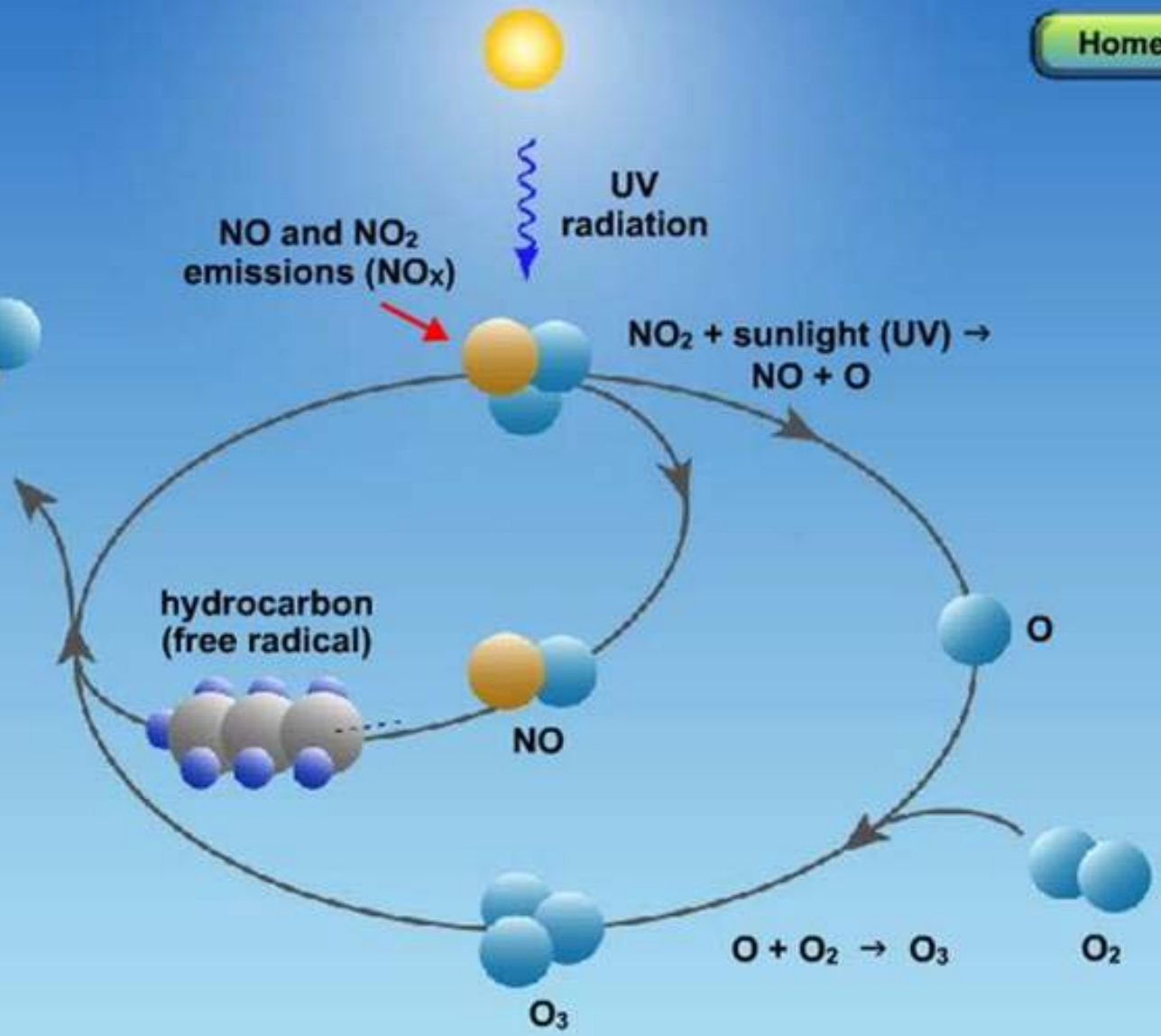
- NO_2 + sunlight -> NO + O
- O + O_2 -> O_3
- O_3 + NO -> NO_2 + O_2
  - Key: Ozone is generated and consumed

NO_X Reactions in the Presence of Hydrocarbons

Home



Particle Formation



Chemical Names:

NO	nitrogen oxide
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NO_X	nitrogen oxides
O	oxygen atom
O_2	oxygen (molecule)
O_3	ozone
HNO_3	nitric acid
PAN	peroxyacetyl nitrate

Hydrocarbons interfere in the above cyclical set of reactions to form excess ozone (O_3), nitric acid vapor (HNO_3), and organic species such as peroxyacetyl nitrate (PAN), and nitrous oxide, a greenhouse gas.

Contents

Courtesy National Park Service

Tropospheric Ozone Chemistry

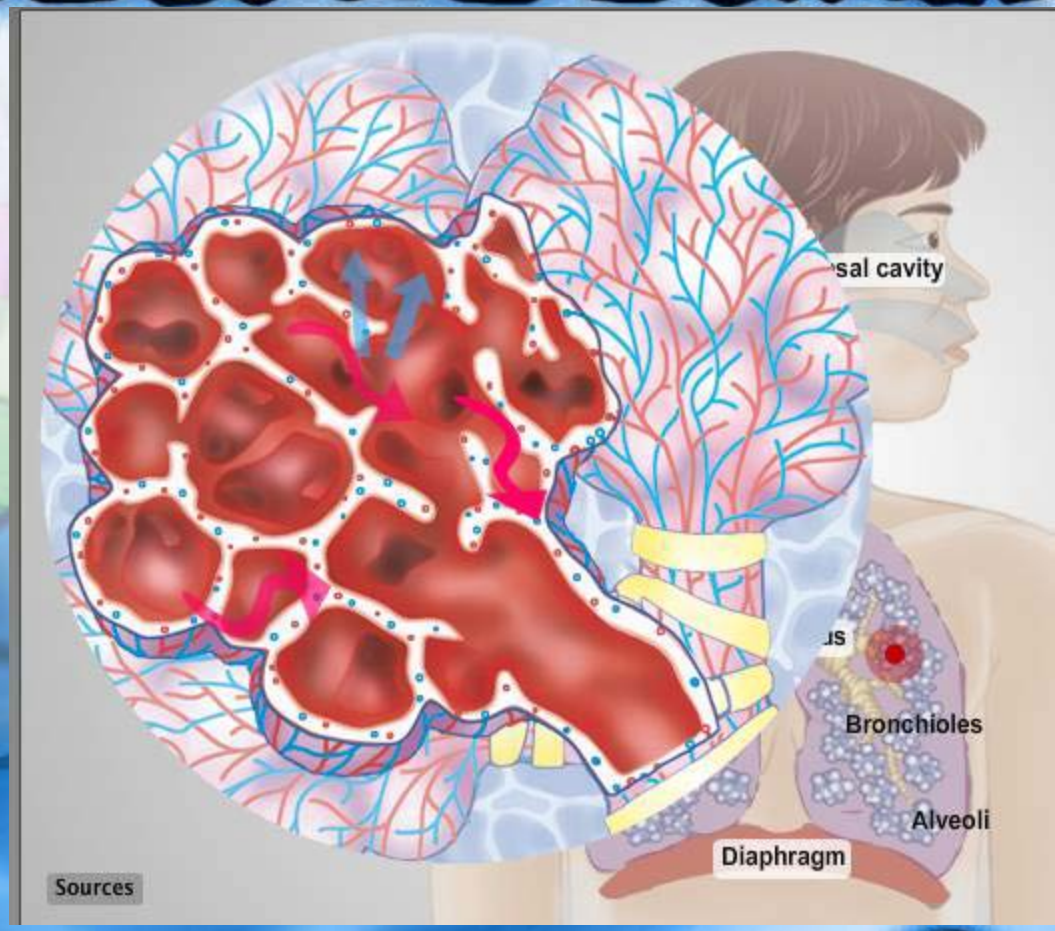
- VOCs + sunlight -> Radicals
- NO + Radicals -> NO_2
  - Key: VOCs provide a pathway to NO_2 regeneration without the destruction of O_3

Scales of Ozone Influence

Ozone impacts are manifested mostly on a regional or local scale.

Health Impacts - Ozone

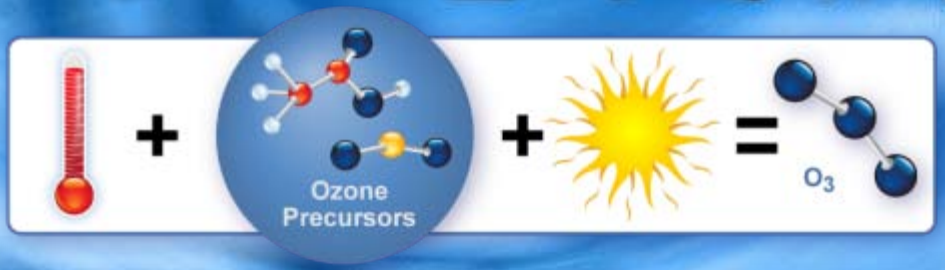
- The alveoli cell walls are burned by ozone, causing scarring and thickening of the tissue, which makes the transfer of air to capillaries more difficult

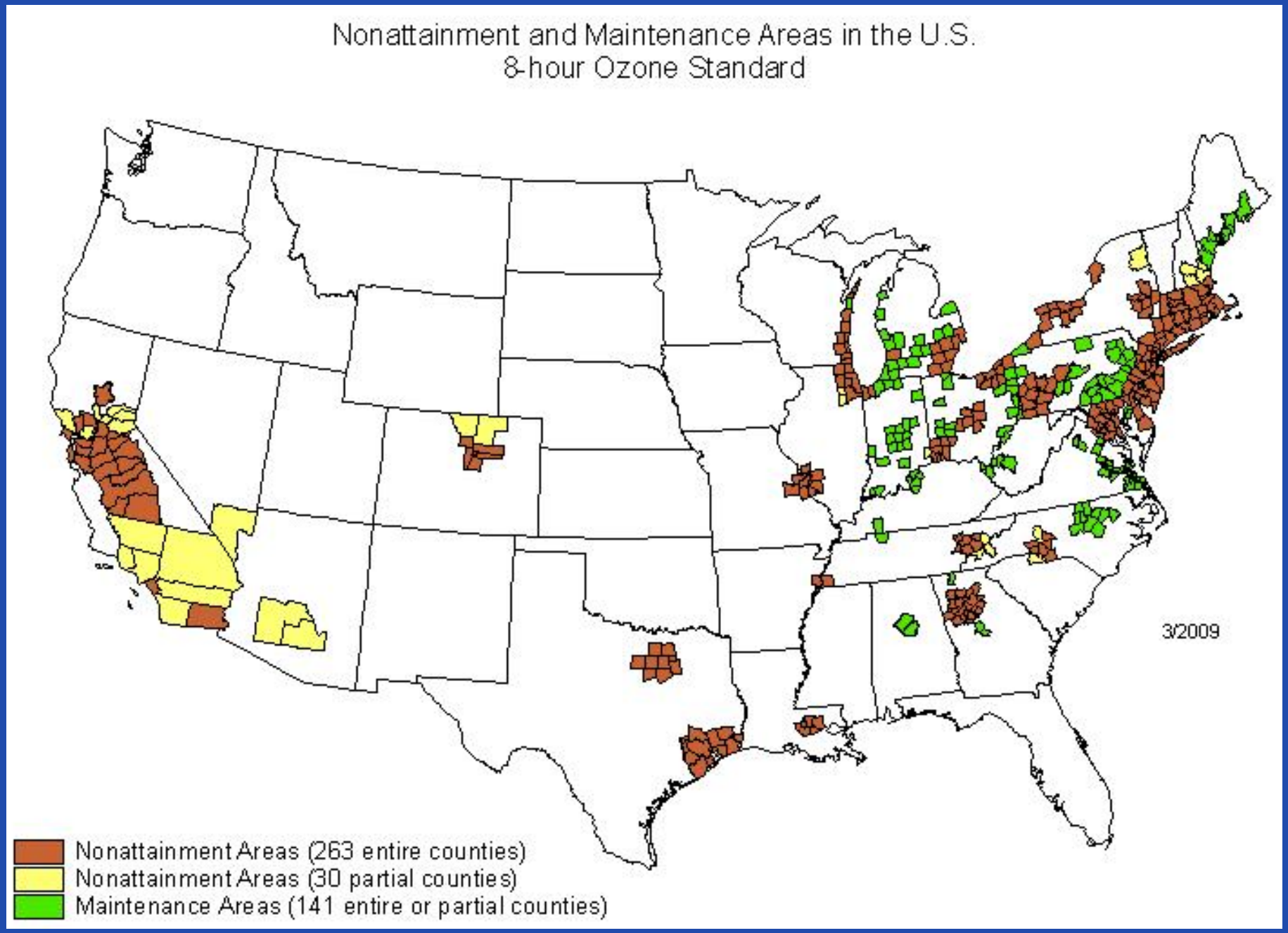


Fresno Bee http://www.fresnobee.com/static/2007/flash/airproject/)

National Ambient Air Quality Standards (NAAQS)

- Ozone Standard Revised 3/2008
  - Old 8-hr Standard = 0.084 ppm
  - New 8-hr Standard = 0.075 ppm
- New Administration Remanded the 2008 Levels
  - Proposing a 8-hr Standard: 0.060 – 0.070
  - Proposing a Secondary Standard: 7 – 15 ppm-hrs

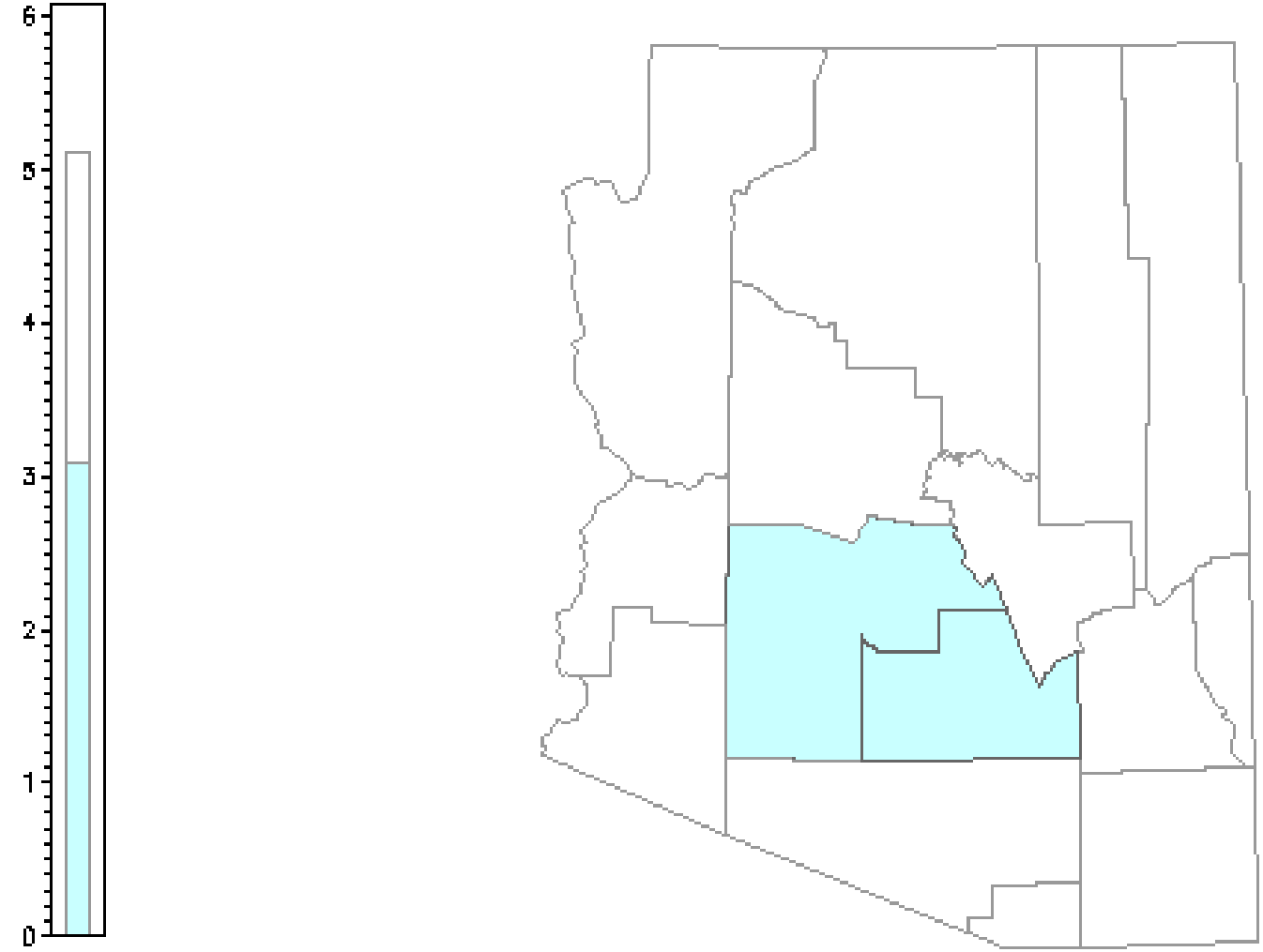



Nonattainment and Maintenance Areas in the U.S.
8-hour Ozone Standard
3/2009
Nonattainment Areas (263 entire counties)
Nonattainment Areas (30 partial counties)
Maintenance Areas (141 entire or partial counties)

Nonattainment Areas Map – Ozone (8-hour)

Arizona

AirData



Population (Millions)

Nonattainment Status:

Part of County | Whole County | Attainment County

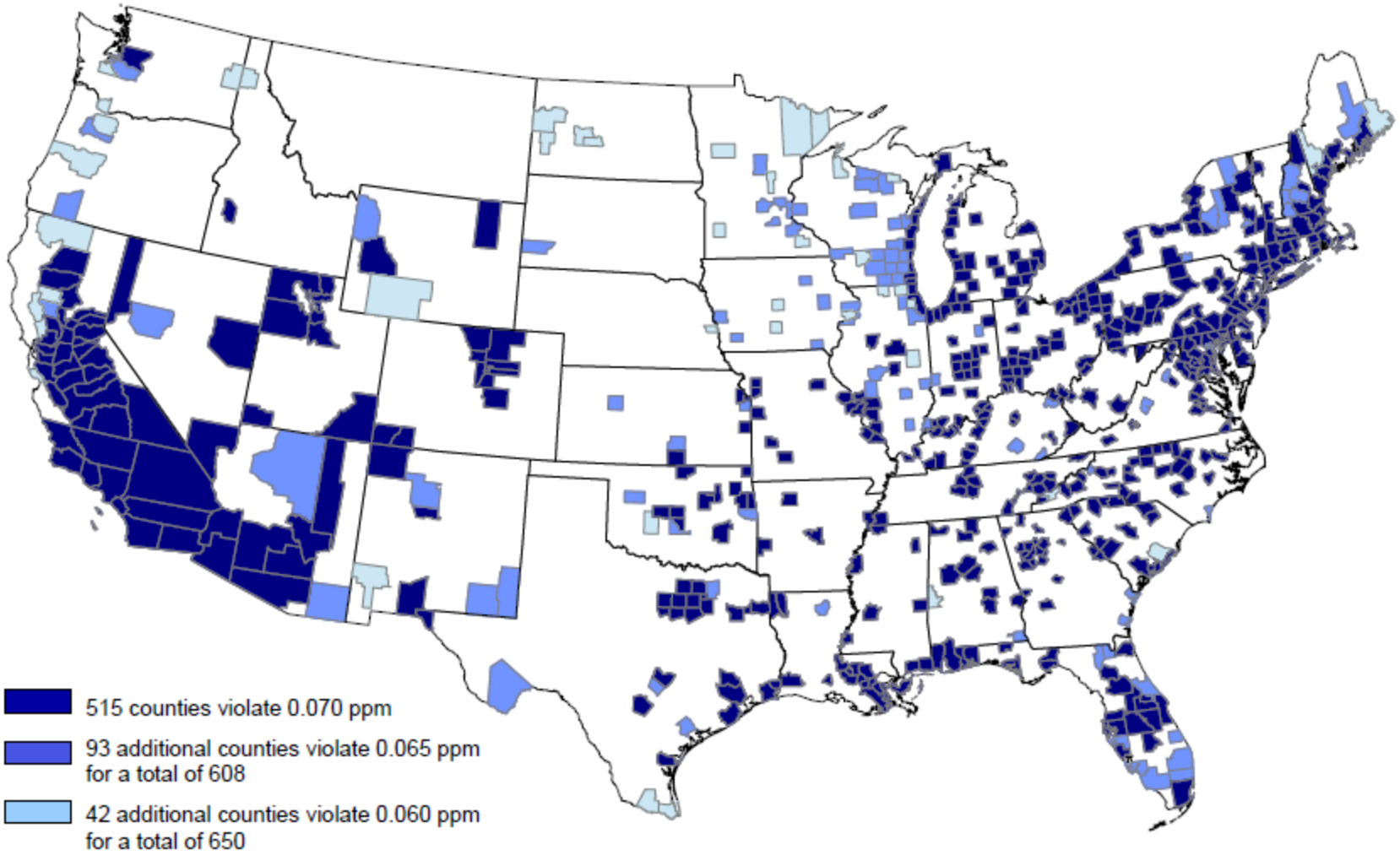
Source: US EPA Office of Air and Radiation, AQS Database

Monday, April 5, 2010

Counties With Monitors Violating Proposed Primary 8-hour Ground-level Ozone Standards
0.060 - 0.070 parts per million

(Based on 2006 – 2008 Air Quality Data)

EPA will not designate areas as nonattainment on these data, but likely on 2008 – 2010 data which are expected to show improved air quality.



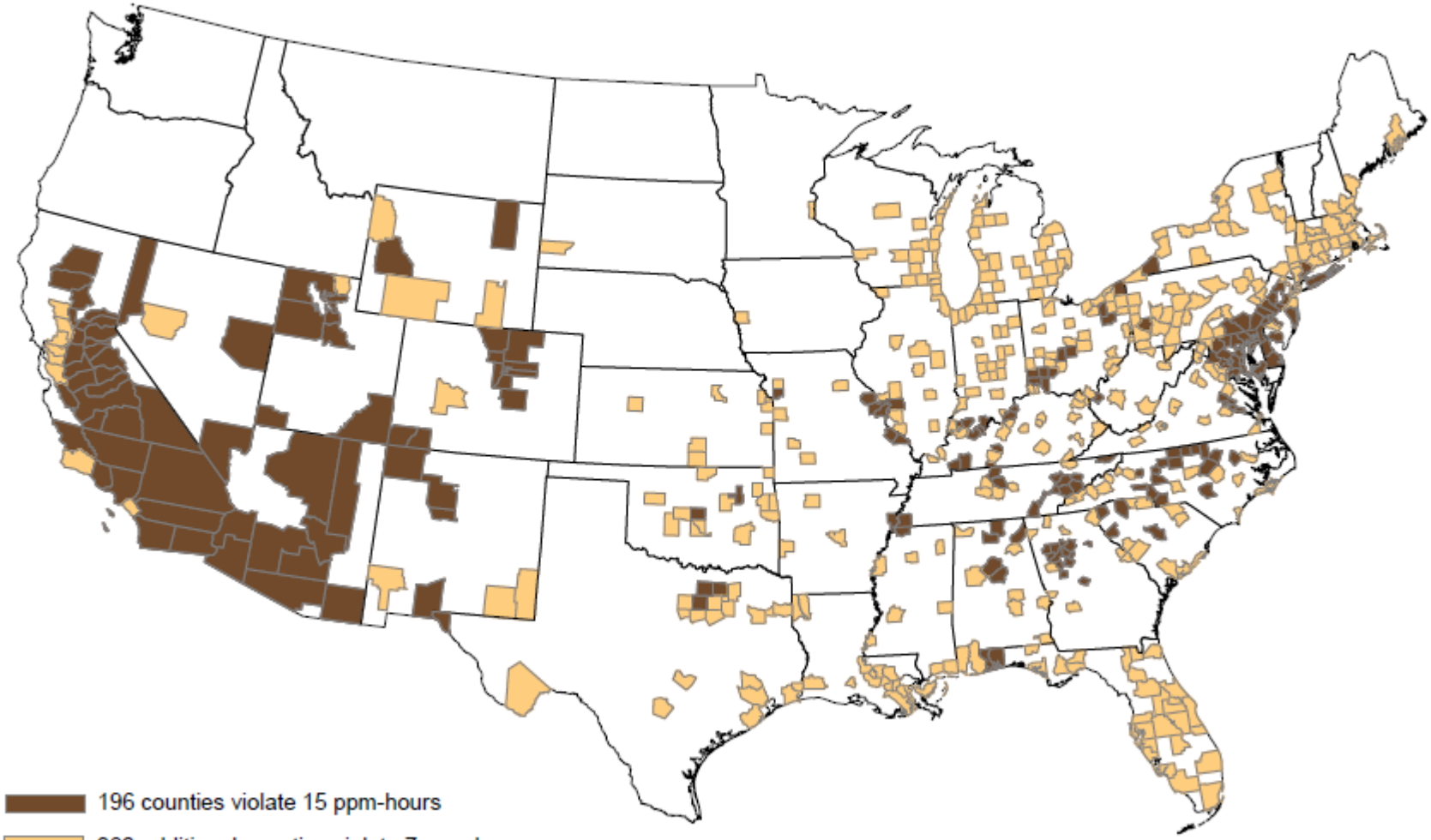
Notes:

1. No monitored counties outside the continental U.S. violate.
2. EPA is proposing to determine compliance with a revised primary ozone standard by rounding the 3-year average to three decimal places.

Counties With Monitors Violating Proposed Secondary Seasonal Ground-Level Ozone Standards
7 – 15 parts per million - hours

(Based on 2006 – 2008 Air Quality Data)

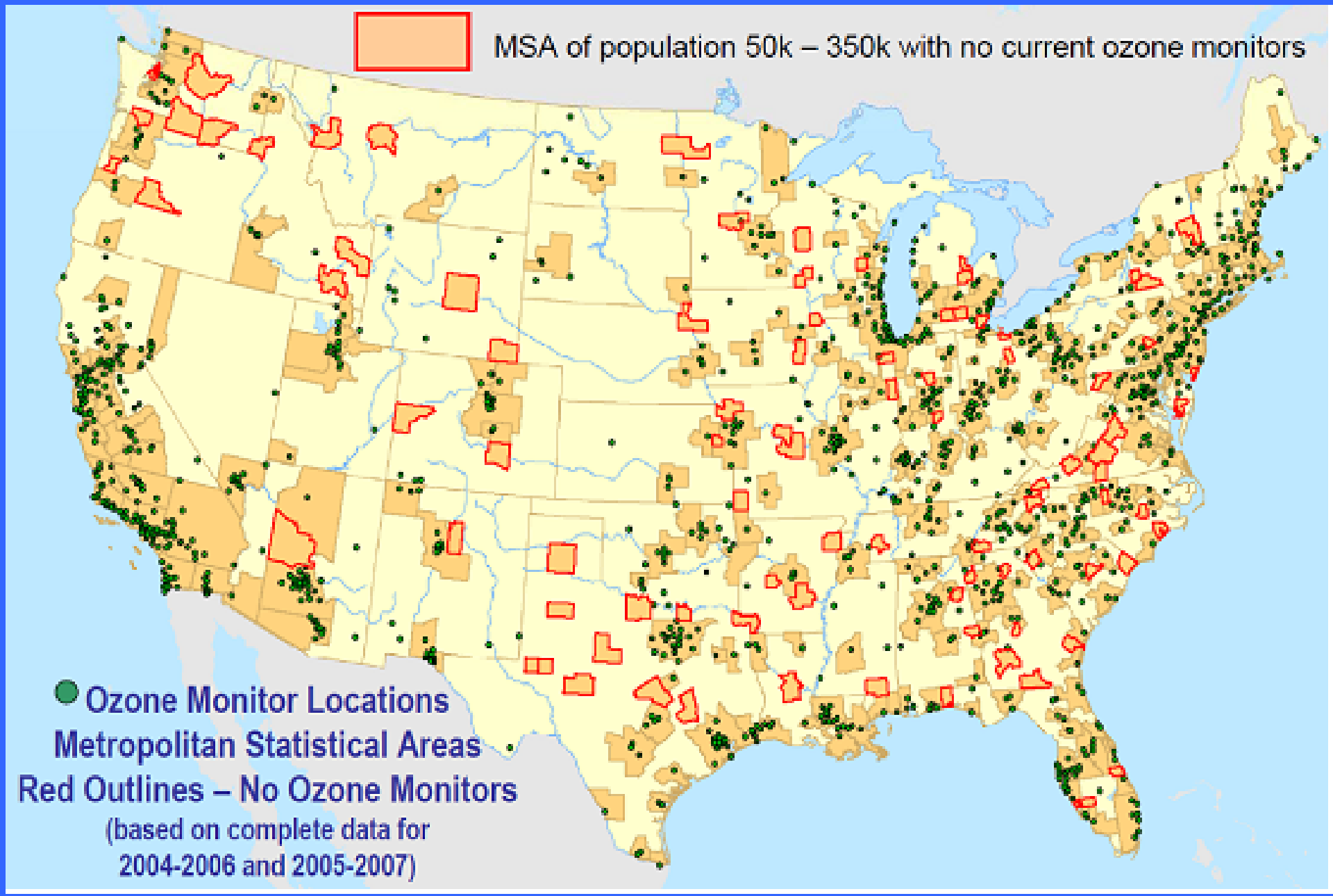
EPA will not designate areas as nonattainment on these data, but likely on 2008 – 2010 data which are expected to show improved air quality.



196 counties violate 15 ppm-hours

383 additional counties violate 7 ppm-hours for a total of 579

No monitored counties outside the continental U.S. violate.


MSA of population 50k – 350k with no current ozone monitors
Ozone Monitor Locations
Metropolitan Statistical Areas
Red Outlines – No Ozone Monitors
(based on complete data for
2004-2006 and 2005-2007)

Agricultural VOC Sources

- Animals
  - Direct
  - Manure
- Plants
- Pesticides

Agricultural NO_x Sources

Burning

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

Manure

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.

Fertilizers

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

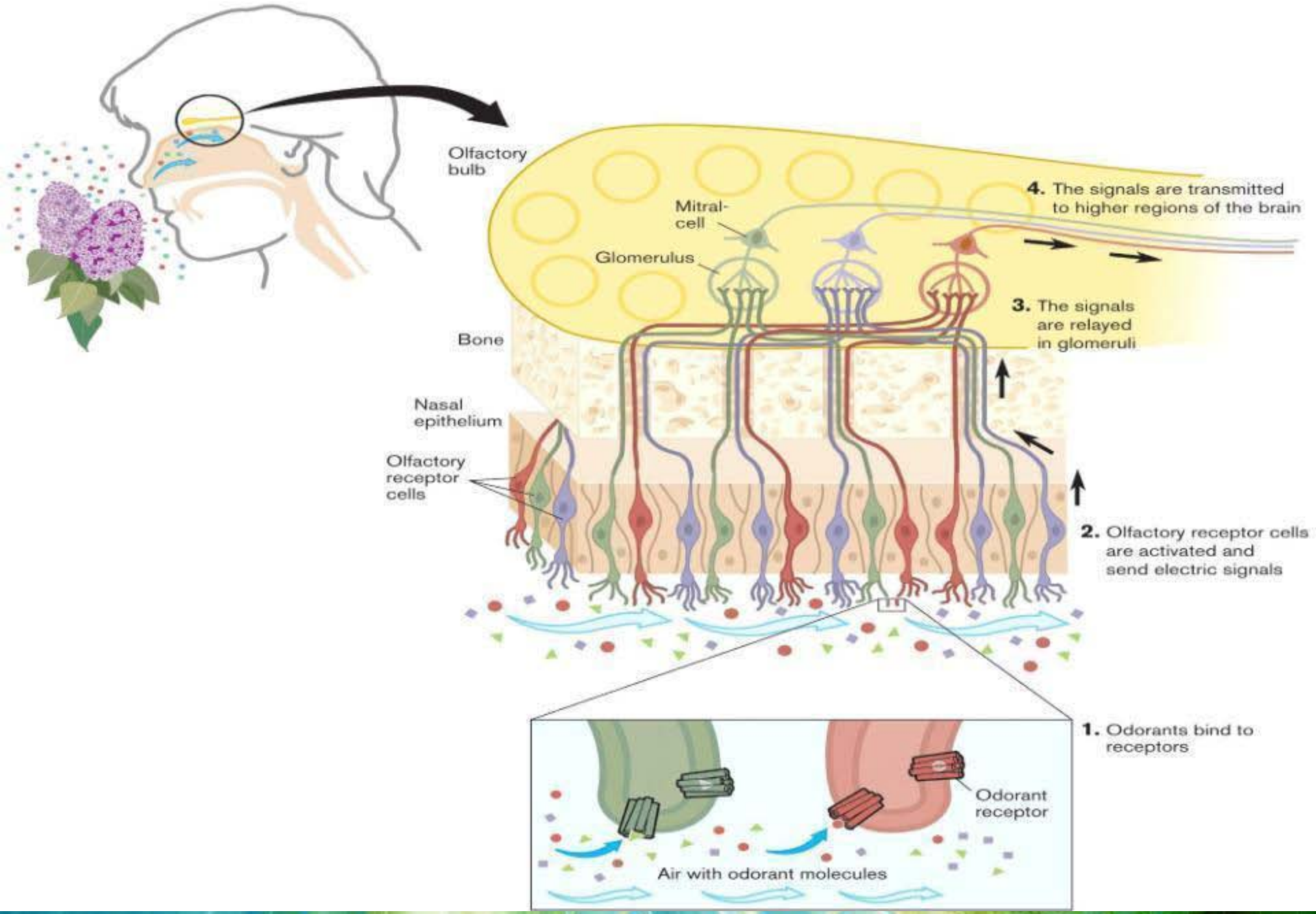
Odors

Overview

- What are odors?
- Why are odors a concern?
- What is the scale of impact of odors?
- What air emissions contribute to odors?
- How do I know if I should address odors?

What Are Odors?

- Stimulation of the olfactory system
  - Caused by volatilized chemical compounds perceived via receptors in the nose
  - Results in highly-variable physiological and psychological responses


Olfactory bulb
Mitral-cell
Glomerulus
4. The signals are transmitted to higher regions of the brain
3. The signals are relayed in glomeruli
Bone
Nasal epithelium
Olfactory receptor cells
2. Olfactory receptor cells are activated and send electric signals
1. Odorants bind to receptors
Odorant receptor
Air with odorant molecules

What Are Odors?

- Humans can recognize more than 10,000 different smells
- Molecules that are chemically similar can have distinctly different smells
- Mixtures of compounds can result in interference or masking of individual compounds

Why Are Odors a Concern?

- Mainly an individual and community perception issue
  - This may or may not lead to local regulations of odors
    - NM – No specific odor regulations for NMED or City of Albuquerque/Bernalillo County
    - AZ – No specific odor regulations for ADEQ or Pinal County
    - AZ – General odor regulations for Pima and Maricopa Counties

Scale of Odors

- Odors are typically a local issue
  - Odorous compounds don't usually travel more than a few miles before they are dilute

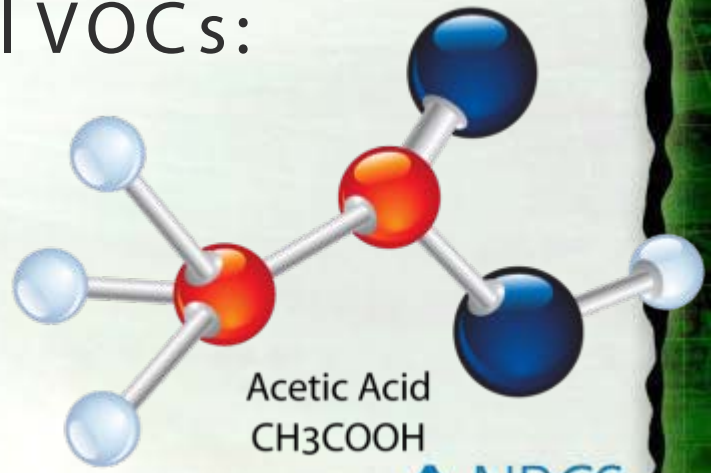
Emissions that Contribute to Odors

- Hundreds of different compounds have been identified with agricultural operations
- These can be generally classified as one of three types:
  - VOCs
  - Odorous sulfur compounds
  - Ammonia

VOCs

- Carbon-based compounds
- Thousands of compounds are classified as VOCs
  - Not all are odorous
- Common odorous agricultural VOCs:

- Volatile fatty acids (VFAs)
- Indoles
- Phenols
- Aldehydes
- Amides
- Amines
- Esters
- Ethers
- Ketones



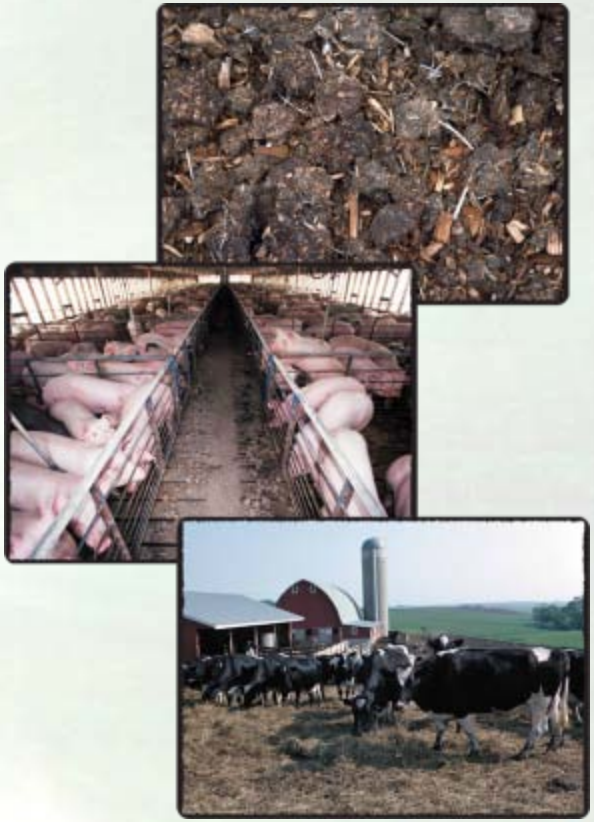
NRCS

Odorous Sulfur Compounds

- Sulfur-based compounds
- Common agricultural odorous sulfur compounds:
  - Hydrogen sulfide (H_2S)
  - Dimethyl sulfide
  - Mercaptans
  - Methanethiol
  - Ethanethiol
  - Propanethiol

Ammonia

- Nitrogen-based compound
- Smells like your ammonia-based household cleaners



Should I Address Odors?

- If the producer identifies odors as an issue to be addressed, it can be considered a resource concern
- Otherwise, answer the following:
  - Have there been previously-identified odor episodes at the farm?
  - Are there activities at the farm that could produce odors?

Previous Odor Episodes

- Some questions to ask the producer:
  - Has the producer received complaints about odor from the operation?
  - Has there been an odor enforcement action taken against the operation by a regulatory agency?
- If yes to either, has the producer addressed those issues?

Previous Odor Episodes

- If the producer has addressed those issues and there have been no more problems, odor is not likely a resource concern
- If the producer hasn't addressed the previous issues or there have been more problems, odor is likely a resource concern

Potential for Odors

- Some questions to ask:
  - Are there livestock and/or poultry on the farm?
  - Does the farm create compost?
  - Does the farm land apply manure?
  - How far away are neighbors, schools, etc.?
  - Does the producer have a plan for managing odors?

Greenhouse Gases and Agriculture

What Are Greenhouse Gases?

- **Greenhouse gases** are gases in an atmosphere that absorb and emit radiation within the thermal infrared range.

Scale of GHG Effects?

Global!

What we do locally can affect weather, climate, and the biosphere around the world

Greenhouse Gases from Agriculture

- Carbon Dioxide (CO_2)
  - Engine Emissions
  - Soil tillage, in particular, organic soils
  - Burning (although net balance needs to be considered)

Greenhouse Gases from Agriculture

- Methane (CH_4)
  - Stored animal manures
    - Digesters
  - Biomass burning

Greenhouse Gases from Agriculture

- Nitrous Oxide (N_2O)
  - Soil nitrogen transformations
  - Manure storage

Nitrogen in the atmosphere is not bad!

- 78% of the atmosphere is nitrogen (N_2)
- Certain nitrogen compounds can be air quality issues (N_2O, NO_x)

Greenhouse Gases from Agriculture – What can we do?

- When should I address greenhouse gases?
  - *Regulatory*
  - *Financial benefit*
  - *Good management practice*

Greenhouse Gases from Agriculture – What can we do?

- *Some Examples:*
  - Reduce tillage
  - Better nutrient and manure management
  - Animal feed management
  - Reduce residue and trash burning

COMET-VR

- **Version 1.1**
- 226 MLRA's
- 20-40 rotation/cropping choices per MLRA
- 12 soil textures
- Century model w/
  improved uncertainty estimate

http://www.cometvr.colostate.edu

Required Responses to Utilize COMET-VR

- Location
  - State and County
- Parcel Information
- Soils Information
  - Soil Texture/Hydric Condition

http://www.cometvr.colostate.edu

Required Responses to Utilize COMET-VR

- **Management History and Projections (crop rotations, tillage systems or grazing systems)**
  - **Pre 1970's**
  - **1970's-1990's**
  - **Base: 1990's-Current**
  - **Reporting Period: Current + 10 years**

http://www.cometvr.colostate.edu

Online Tool for Agriculture & Range, Version 1.1

Go to | Reset | State/County | Parcel | Soil | Rotation | Tillage | Submit | Summary |

Step 1. Enter the State and County Information: Select the State where the parcel is located from the list of State Names then Select the County where the parcel is located from the list of County Names.

State/County Selection: Louisiana,LINCOLN

Select a State: LOUISIANA Go ?

Select a County: LINCOLN ?

Back Reset Save Next

USDA COMET-VR Online Tool Version: 1.1-042007

Selection

Session Information: ?

Enter Session ID: Go

Location Information:

- **State:** Louisiana
- **County:** LINCOLN
- **Fips:** 22061
- **MLRA:** 133B
- **LRR:** PW

Parcel Information:

- **Report Date:** 1/26/2010
- **Name:** Parcel 1
- **Size:** 1 Acres
- **Type:** Agriculture

Soil Information:

Voluntary Reporting
Carbon Management Tool COMET-VR
Carbon Storage Report

Report Year: 2010

Session ID: 905229607

Parcel Description	
Parcel Type:	Agriculture
Total Parcels for this Entity:	1
Parcel Name:	Parcel 1
Parcel Size:	1 Acres
Location:	LINCOLN, Louisiana
Soil:	Non-hydric silt

Parcel Management History	
Historic:	Lowland Non-Irrigated (pre 1970s)
70s to 90s:	Non-Irrigated: continuous cotton; Intensive Tillage
Current:	Non-Irrigated: soybean-cotton; Intensive Tillage
Report Period:	Non-Irrigated: soybean-cotton; No Till Tillage

Predicted Change in Soil Carbon for the Parcel

Annual Change for 2010

	Carbon Change	Uncertainty		
		Avg Percent	Lower Bounds CI*	Upper Bounds CI*
Total Tons Carbon per year:	0.11	35.86 %	0.07	0.15
Total Tons CO2 Equivalent per year:	0.40	35.86 %	0.27	0.56

Values recorded in English units. One **ton** of carbon is equivalent to 3.667 **tons** of carbon dioxide.

AQAC Resource Concern Review

- Particulate Matter (PM)
- Ozone (O3) Precursors
- Odors
- Greenhouse Gases (GHG)

Air Emissions related to NRCS AQAC Resource Concerns

	GHG	PM	O3 Precursors	Odor
CO_2	√			
CH_4	√			
VOC		√	√	√
NO_x		√	√	
NH_3		√		√
N_2O	√			
H_2S				√
PM		√		