



Smoke Impacts and Smoke Management Practices

*KNRC Burn Plan Workshop
January 2011*

Susan O'Neill, Natural Resources Conservation Service

Overview

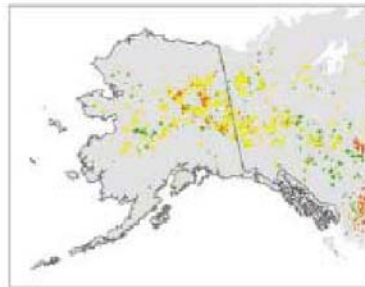
- Why Manage Smoke?
- How do I Manage Smoke?
- Fire Weather and Smoke Management Tools



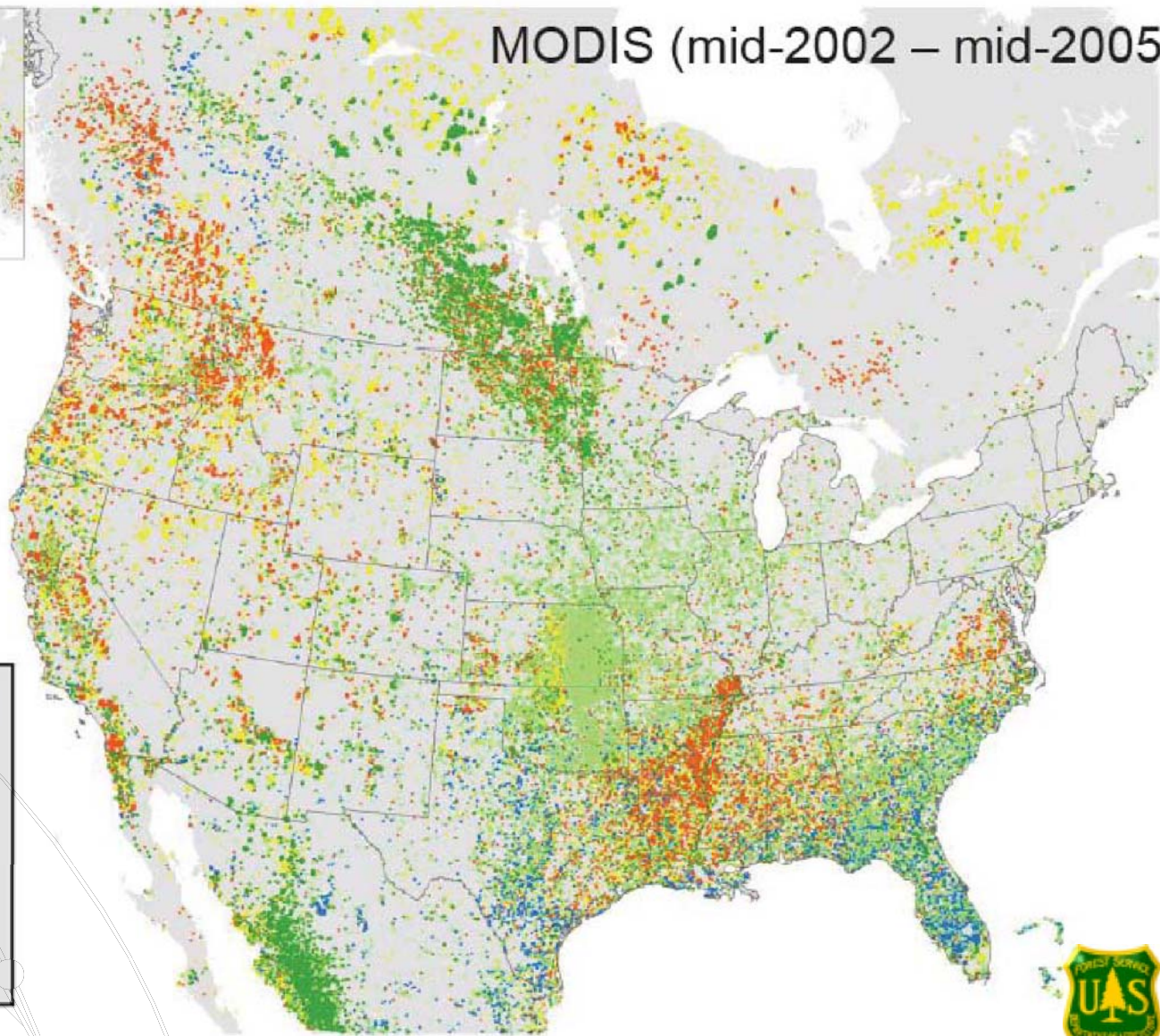
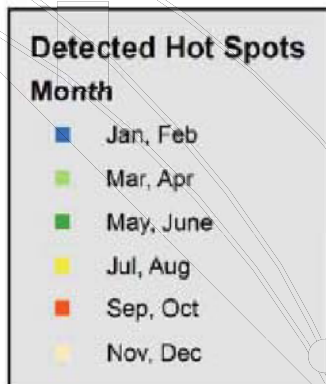
... Fire Happens

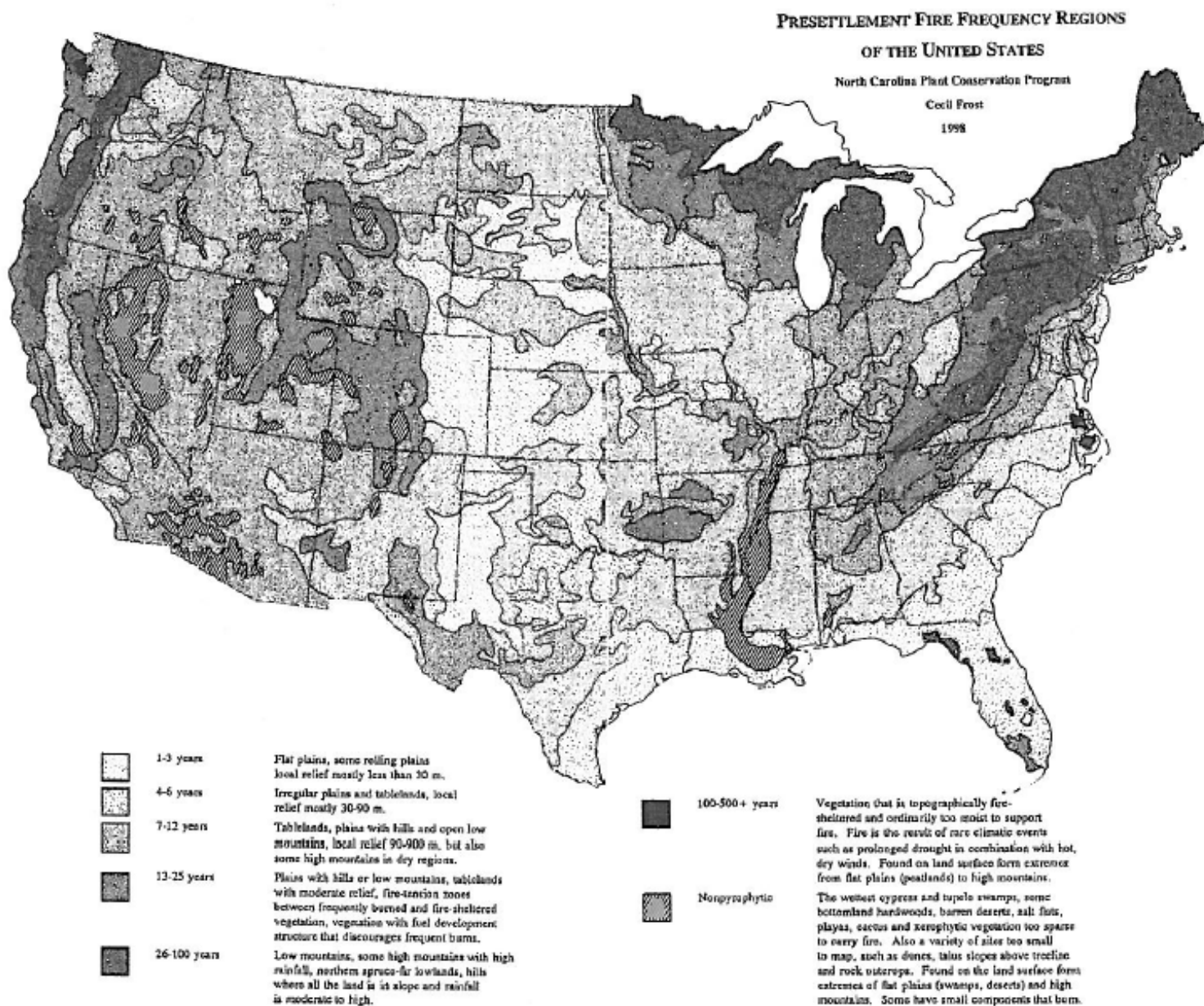
Satellite Detected Fire Seasonality

MODIS (mid-2002 – mid-2005)



Satellite fires
have national
coverage





Frost, Cecil, 1998. Presettlement fire frequency regimes of the United States: a first approximation. Pages 70-81 in Teresa L. Pruden and Leonard A. Brennan (eds.). Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL.

Why manage smoke?

- Health Impacts
- Public Safety and Nuisance
- Visibility – Regional Haze Rule



The Regulatory Process

- National Ambient Air Quality Standards (NAAQS)
- 6 Criteria Pollutants
 - Particulate Matter (PM)
 - Ozone (O₃)
 - Nitrogen Dioxide (NO₂)
 - Sulfur Dioxide (SO₂)
 - Carbon Monoxide (CO)
 - Lead (Pb)
- Five year review cycle
- Nonattainment Area (NAA)
- State Implementation Plan (SIP)
- <http://www.epa.gov/ttn/naaqs/>

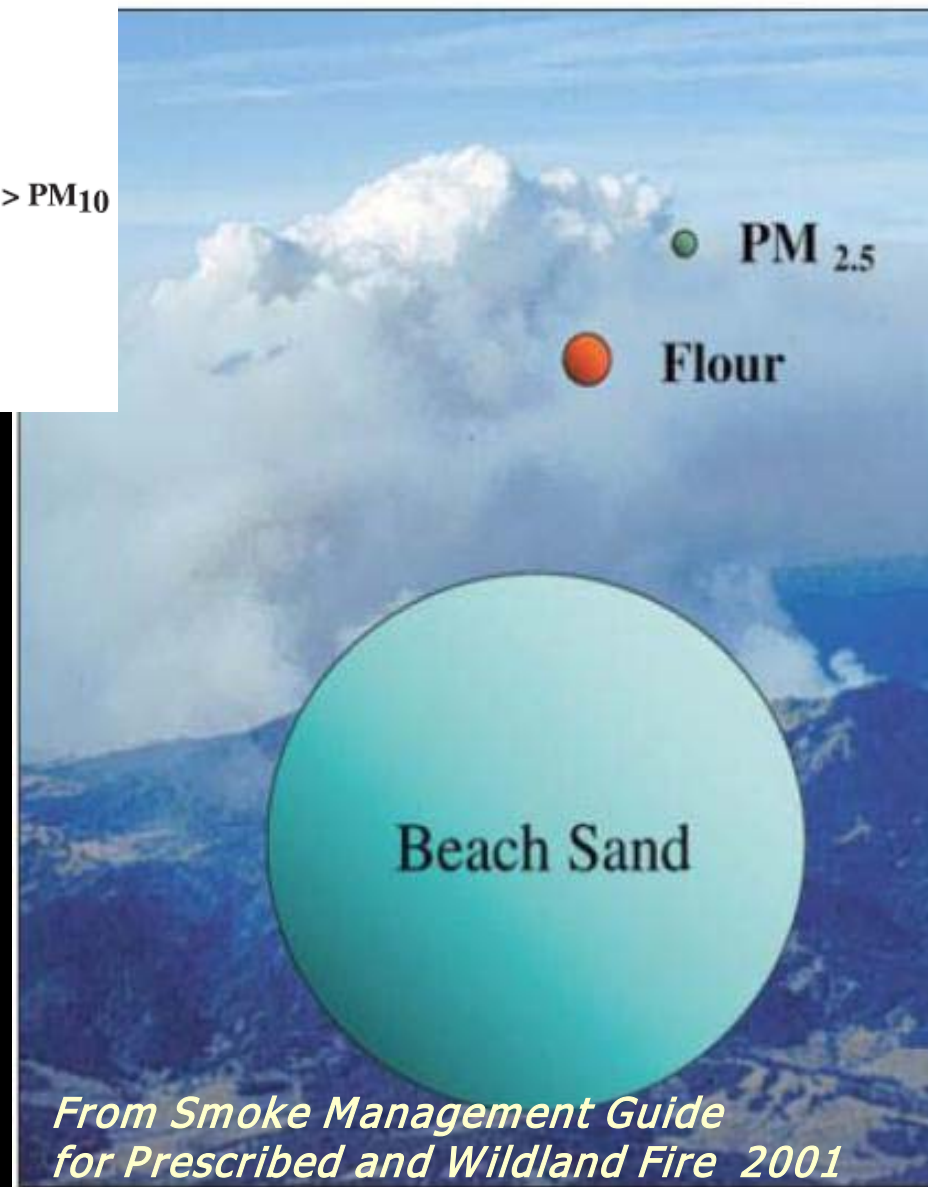
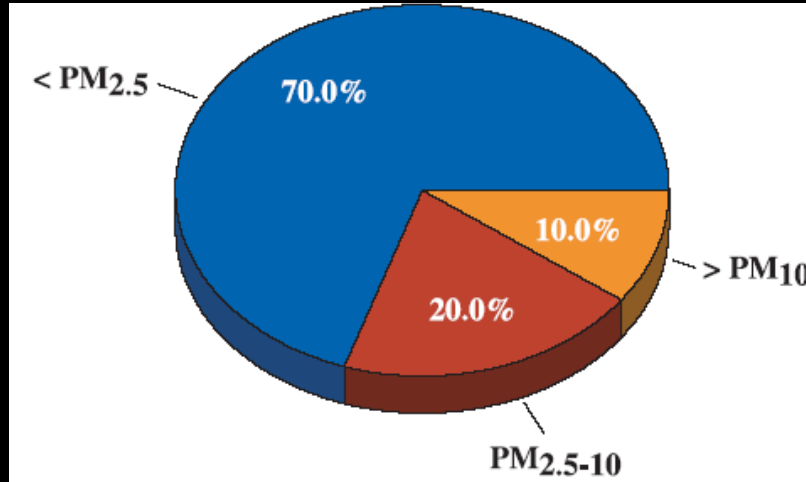


Nonattainment Areas
1-Hour Ozone
8-Hour Ozone (1997)
Carbon Monoxide
Nitrogen Dioxide
Sulfur Dioxide
PM-10
PM-2.5 (2006)
PM-2.5 (1997)
Lead

Standards Review

Basic Info

Particulate Matter (PM)



- **PM_{2.5}**

- Directly emitted (Primary)
- Formed by chemical reaction (Secondary)

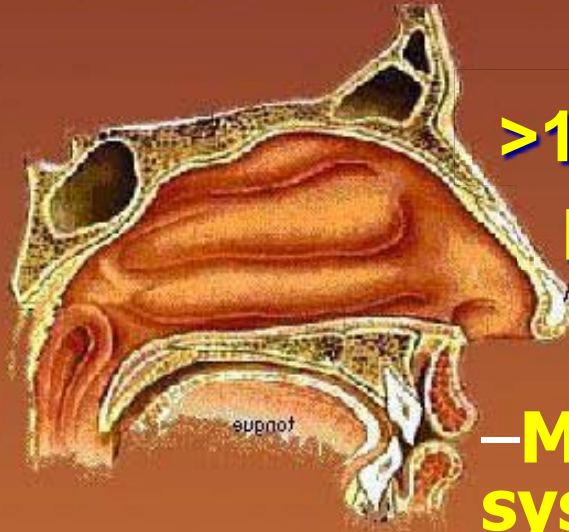
- **PM₁₀**

- Directly emitted (Primary)
- Mostly mechanically generated

- **Larger PM**

- Directly emitted (Primary)
- Mostly geologic in origin (ex. volcanic, crustal)

Where Are Particles Removed or Deposited?



>10 μm : nasal passages

– Mouth (no filter system)

– 5 μm : trachea, bronchi

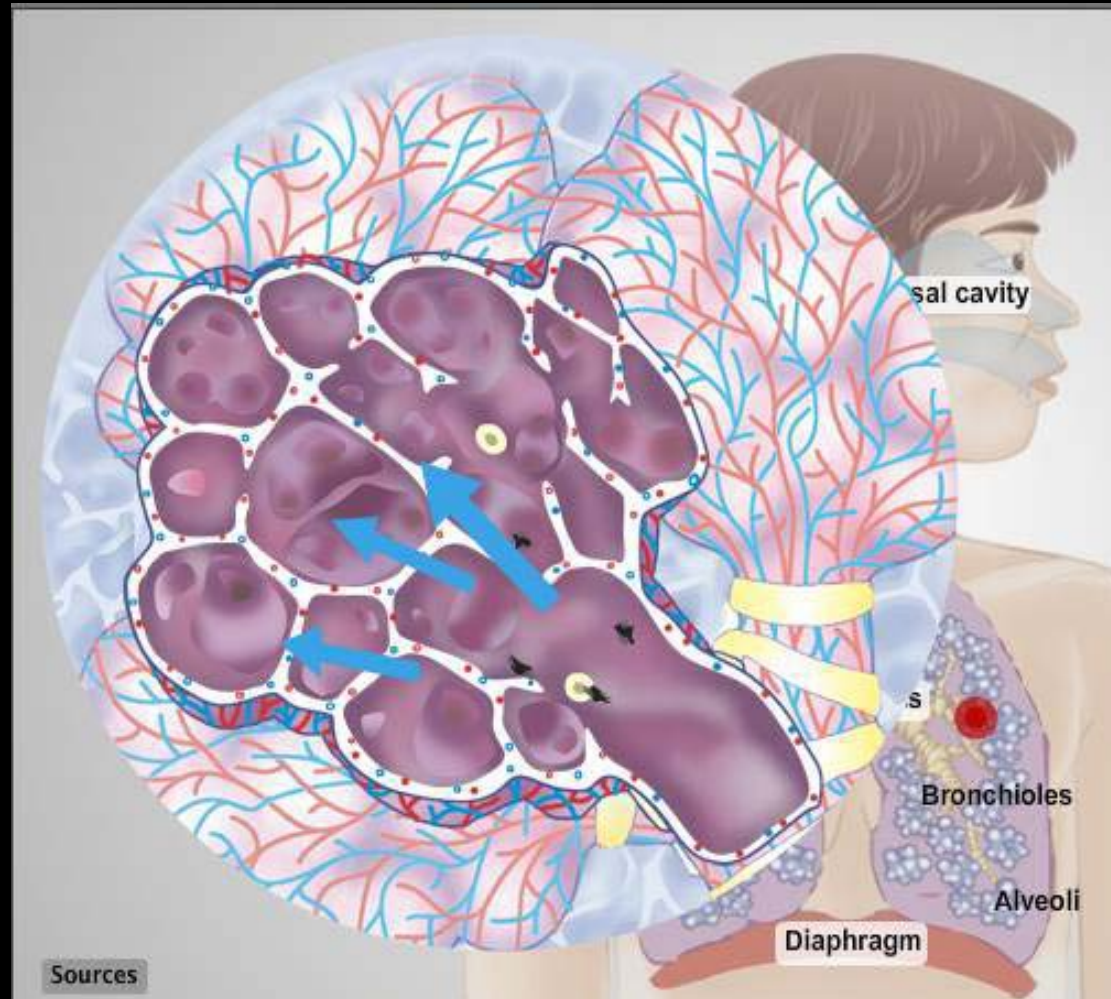
– <2 μm (smoke): bronchioles



– <1 μm : in alveoli

Health Impacts – PM2.5

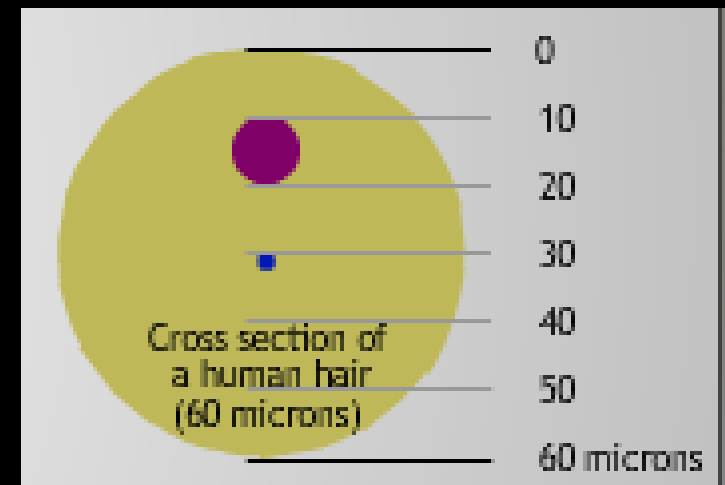
- The immune system sends white blood cells (lymphocytes), to surround the particulates, protecting the body from the foreign objects. The lymphocytes settle on the alveoli walls, causing inflammation and scarring. The built-up scar tissue slows oxygen flow, making transfer of air to capillaries more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



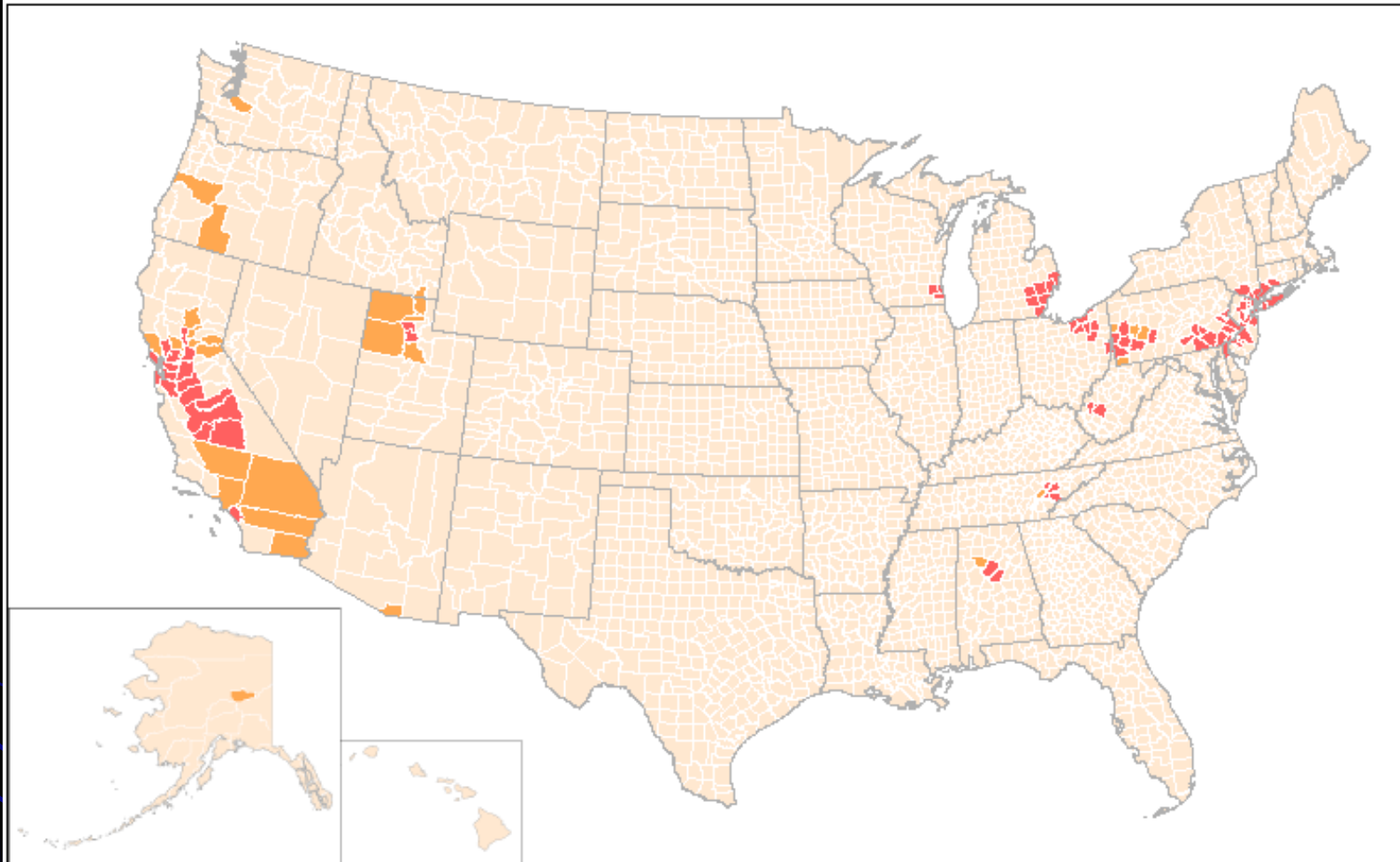
<http://www.fresnobee.com/static/2007/flash/airproject/>

National Ambient Air Quality Standards (NAAQS)

- **PM_{2.5} Standard Revised 9/2006**
 - Old 24-hr Standard = 65 $\mu\text{g}/\text{m}^3$
 - New 24-hr Standard = **35 $\mu\text{g}/\text{m}^3$**
 - Annual Standard = 15 $\mu\text{g}/\text{m}^3$
- **PM₁₀ 24-hr Standard = 150 $\mu\text{g}/\text{m}^3$**



Map of 24-Hour PM_{2.5} Nonattainment Areas

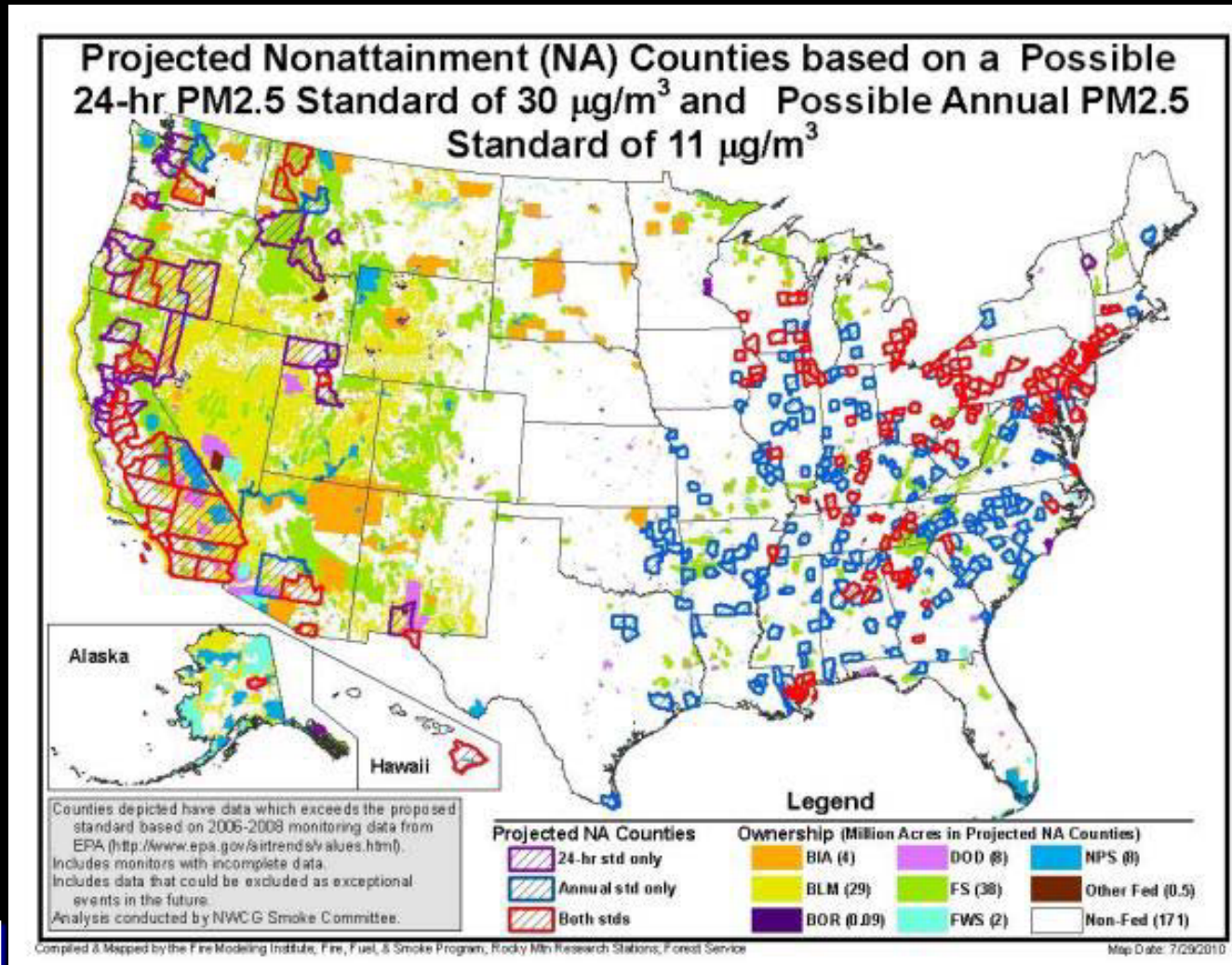


EPA Designation

- Attainment/Unclassifiable
- Nonattainment - Whole County
- Nonattainment - Partial County

PM NAAQS Revision 2011

- PM2.5
 - 30 – 35 $\mu\text{g}/\text{m}^3$ 24-hr std
 - 11-13 $\mu\text{g}/\text{m}^3$ annual std
- PM10 – May be lowered
- New Visibility Standard Based on light extinction
- Draft Rule: 2/2011
- Final Rule: 7/2011



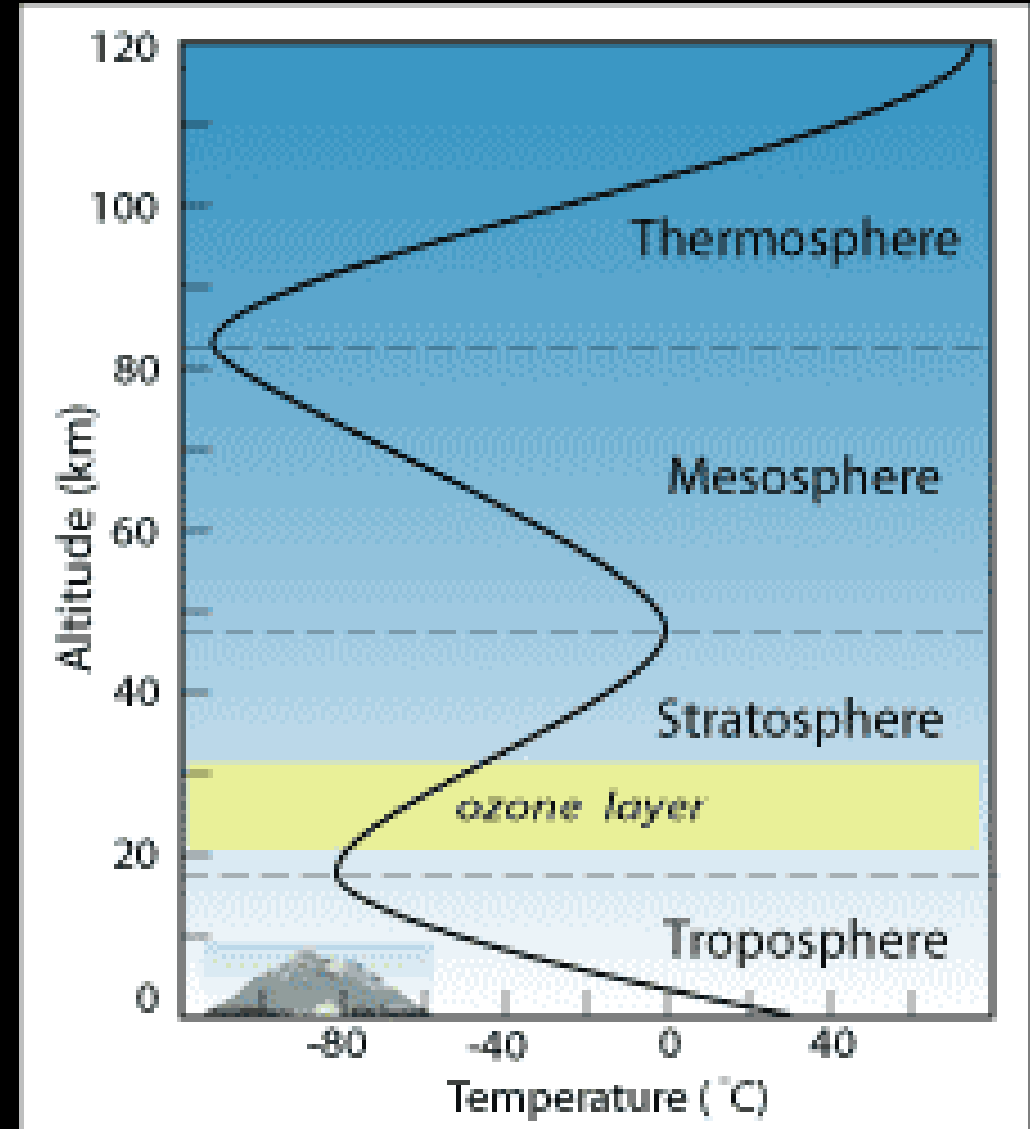
Scales of Particulate Matter Influence

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



Ozone (O₃)

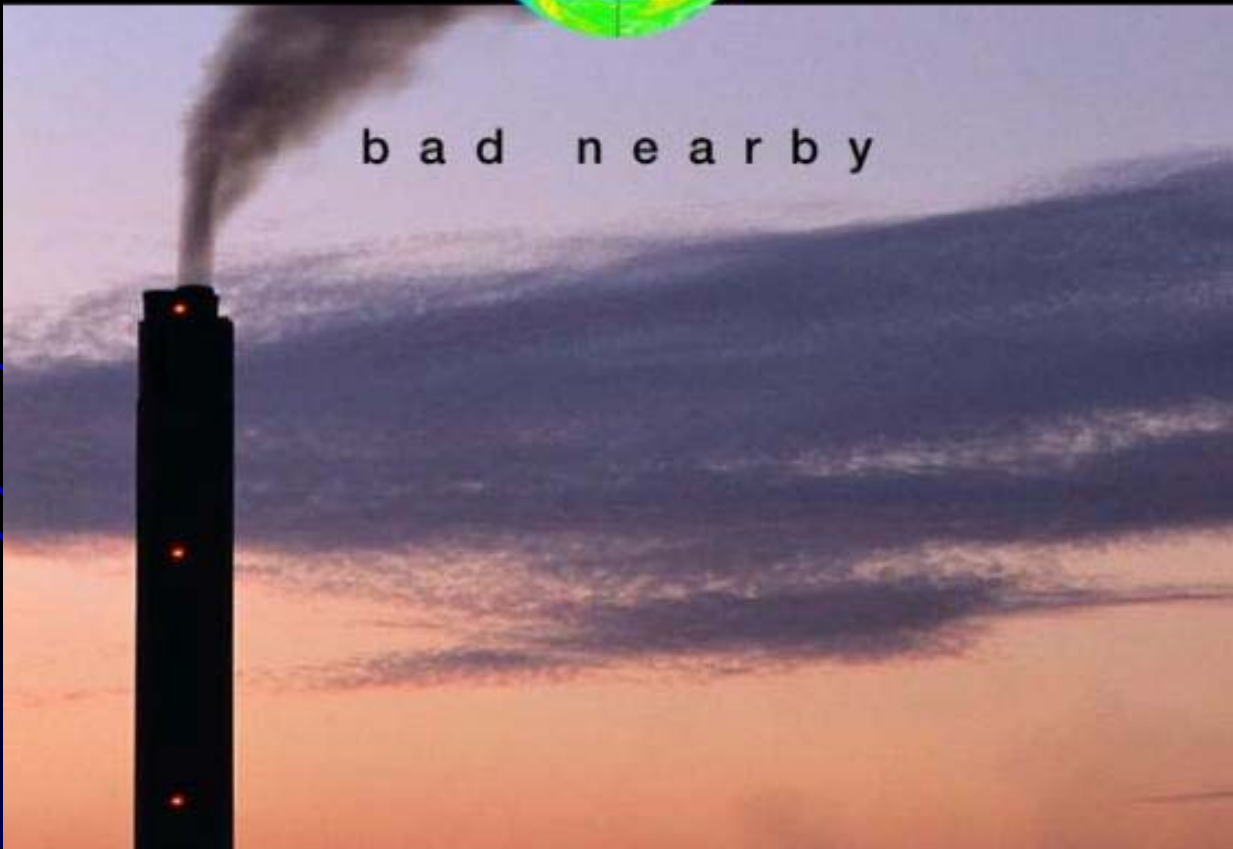
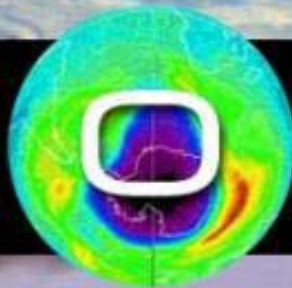
- Two kinds of ozone
 - Stratospheric ozone layer protects us from harmful UV light
 - Tropospheric ozone that is harmful to human health and vegetation



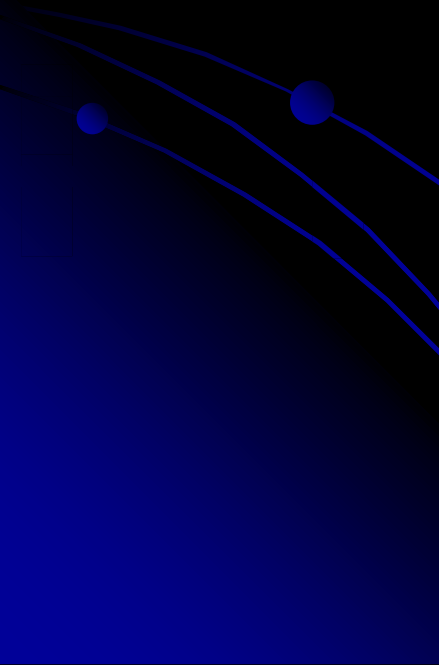


good up high

ozone

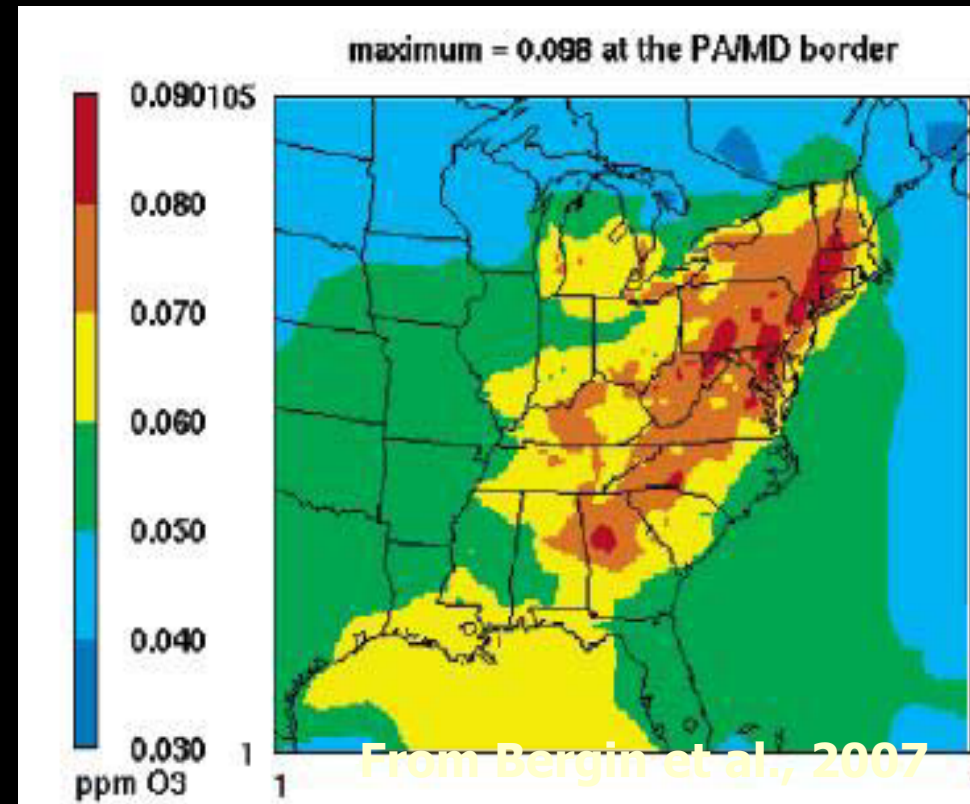


bad nearby



Tropospheric Ozone Chemistry

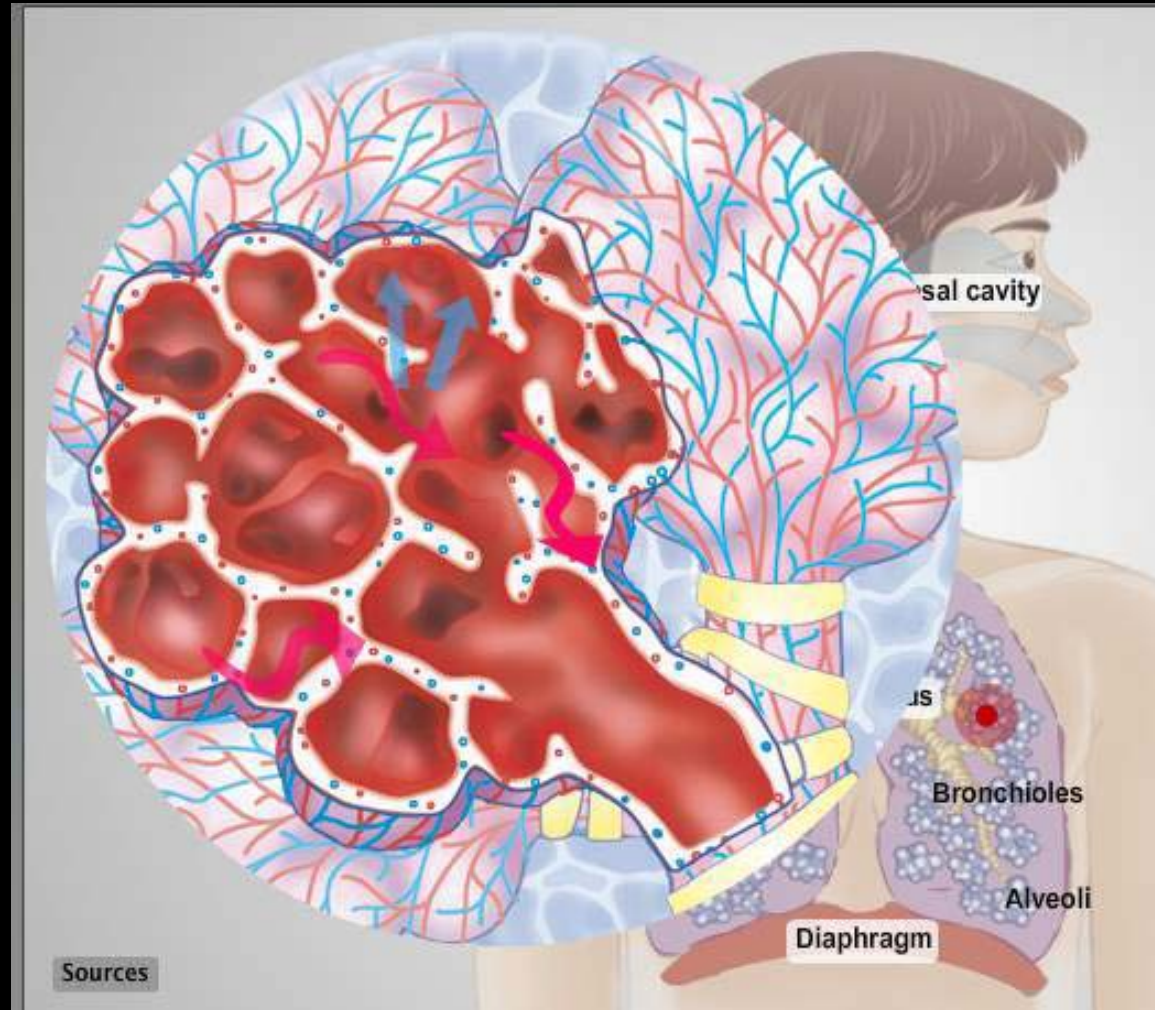
- Ozone is a “secondary pollutant”
 - Not directly emitted
 - Created in the atmosphere
- $\text{VOC} + \text{NO}_x + \text{sunlight} \rightarrow \text{O}_3$
 - NO_x (Oxides of Nitrogen) = NO_2 and NO
 - $\text{VOC} = \text{Volatile Organic Compound}$



- Timescale: 1-2 hours
 - Ozone typically forms downwind of precursor releases

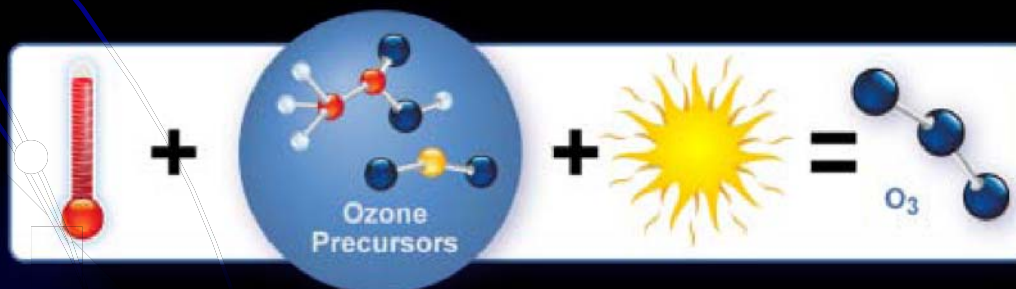
Health Impacts - Ozone

- 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

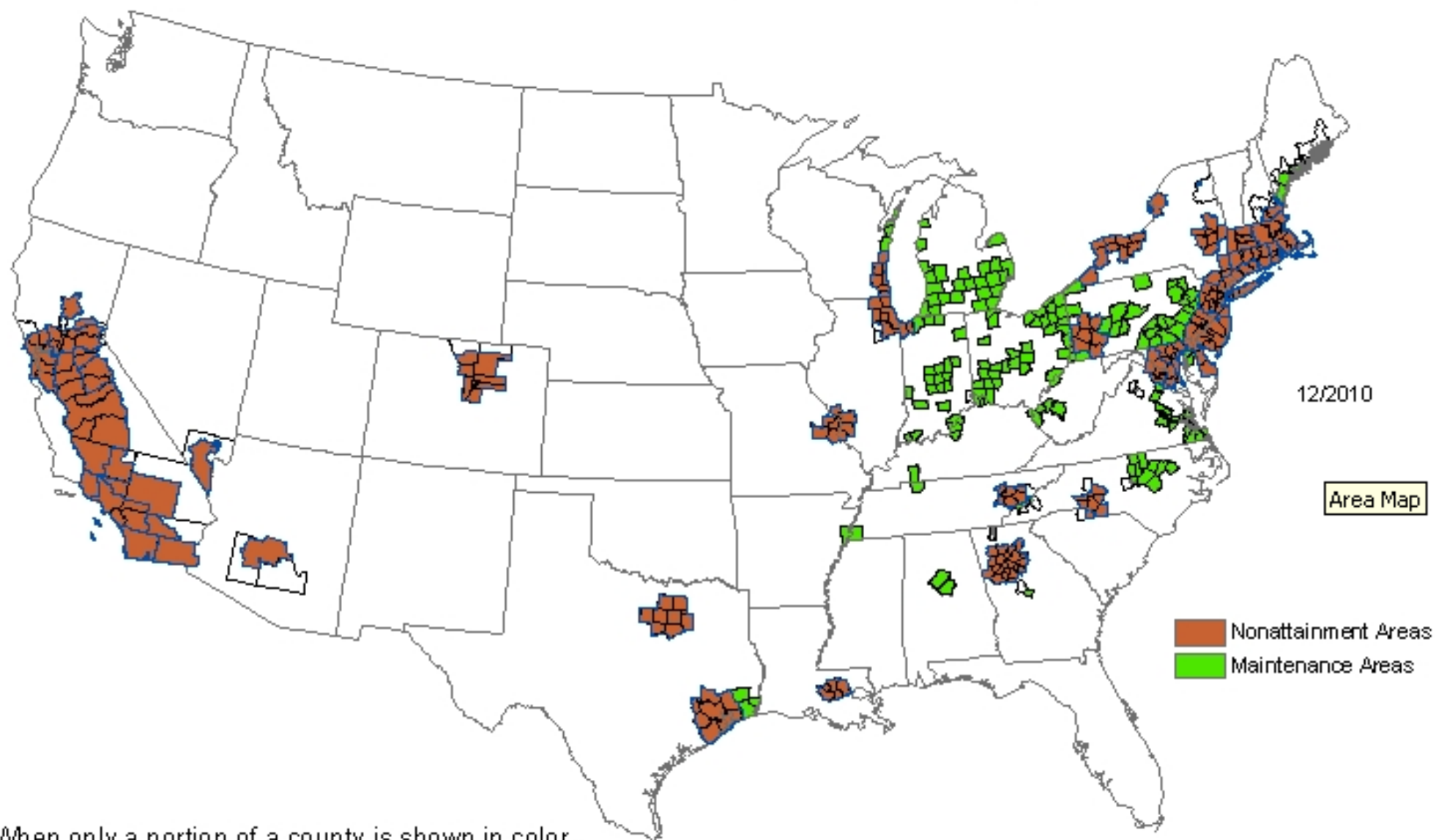


National Ambient Air Quality Standards (NAAQS) - Ozone

- 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 ppm
 - Proposing a Secondary Standard: 7 – 15 ppm-hrs
- New Rule Expected: July 31, 2011



8-Hour Ozone Nonattainment and Maintenance Areas (1997 Standard)

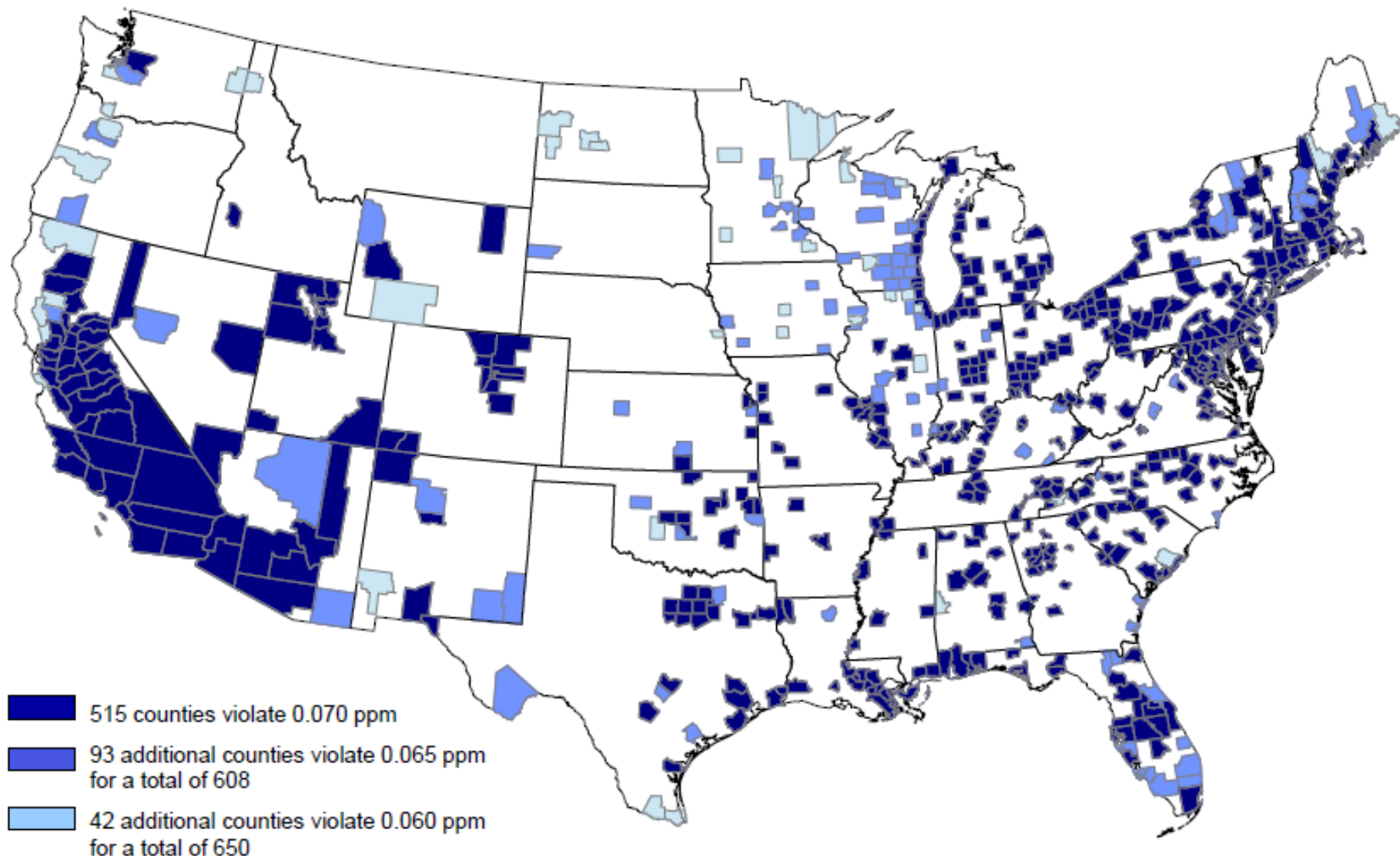


When only a portion of a county is shown in color, it indicates that only that part of the county is within an area boundary.

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.

Exceptional Events Rule (EER)

- Promulgated 3/22/2007
- Monitoring data can be excluded from non-attainment designations if exceedance is due to an Exceptional Event.
- Natural Events
 - High Wind Events
 - Natural Disasters and Associated Clean-up Activities
 - Stratospheric Ozone Intrusion
 - Volcanic & Seismic Activities
 - Wildland Fires
- Prescribed Fires
- Other: Structural Fires, Chemical Spills, Terrorist Attacks, Transported Pollution

How can an event be exceptional?

- The event;
 - (i) Affects air quality;
 - (ii) Is not reasonably controllable or preventable;
 - (iii) Is an event caused by human activity that is unlikely to recur at a particular location or a natural event; and
 - (iv) Is determined by EPA to be an exceptional event.
- clear causal relationship between the measurement and the event,
- unusual measured concentration beyond typical fluctuations including background, and
- there would have been no exceedance but for the event

Documentation is Key!

Prescribed Fires in the EER

- EPA approval of exceedances for prescribed fires used for resource management purposes is contingent upon;
 - The state having a Smoke Management Program (SMP), or
 - Basic Smoke Management Practices (BSMPs) are being employed.
- If exceedances occur under the BSMP approach then development of an SMP should be considered

Basic Smoke Management Practices in the EER

- steps that will minimize air pollutant emissions during and after the burn,
- evaluate dispersion conditions to minimize exposure of sensitive populations,
- actions to notify populations and authorities at sensitive receptors and contingency actions during the fire to reduce exposure of people at such receptors,
- identify steps taken to monitor the effects of the fire on air quality, and
- identify procedures to ensure that burners are using basic smoke management practices.

EPA Interim Air Quality Policy on Prescribed and Wildland Fire

- “Interim Policy”
- Gives EPA’s guidelines on Smoke Management Programs
- Current Interim Policy out of sync with EER
- Revision was to have been completed 7/2008
- Some progress being made



Smoke Management Practices

- Smoke Management is about managing the emissions from fire to reduce downwind impacts.
- Smoke is unlike most other pollutant sources – a control can not be put on it to scrub the emissions.

Smoke Management Guide for Prescribed and Wildland Fire, 2001 (<http://www.treesearch.fs.fed.us/pubs/5388>)

Basic Smoke Management Practices

- #1 Meteorological scheduling and smoke impact evaluation of burning in burn planning and burn operations.
- #2 Monitor the effects of the fire on air quality and document smoke dispersion



Smoke Behavior

Atmospheric Stability

Unstable Atmosphere

- Vertical Mixing
- Smoke not at surface
- Erratic fire behavior possible under very unstable conditions



Stable Atmosphere

- Vertical Mixing limited
- Smoke at surface



Smoke Behavior Valley Flows



- Smoke caught under a valley inversion

- Smoke can be transported by down-valley winds in the morning



Smoke Dispersion and Meteorology

- Mixing Height – height through which the atmosphere will undergo mechanical or turbulent mixing, producing a nearly homogeneous air mass.
 - Minimum 1800 ft (548 m)
- Transport Winds - average wind speed and direction of all winds within the mixing layer.
 - 8 – 20 mph



Ventilation Index

- Category Day based on Ventilation Index
 - VENT = mixing height x transport winds
- Based on “Category Day”
 - Category 1 = no burning
 - Category 2 = burn 11am – 4pm
 - Category 3 = daytime burning
 - Category 4 = burn anytime
 - Category 5 = unstable conditions. Excellent dispersion but burn with caution.

Current Conditions

- Air Quality Index

- Satellite data – Current Active Fires

- Meteorological Observations

Air Quality Index

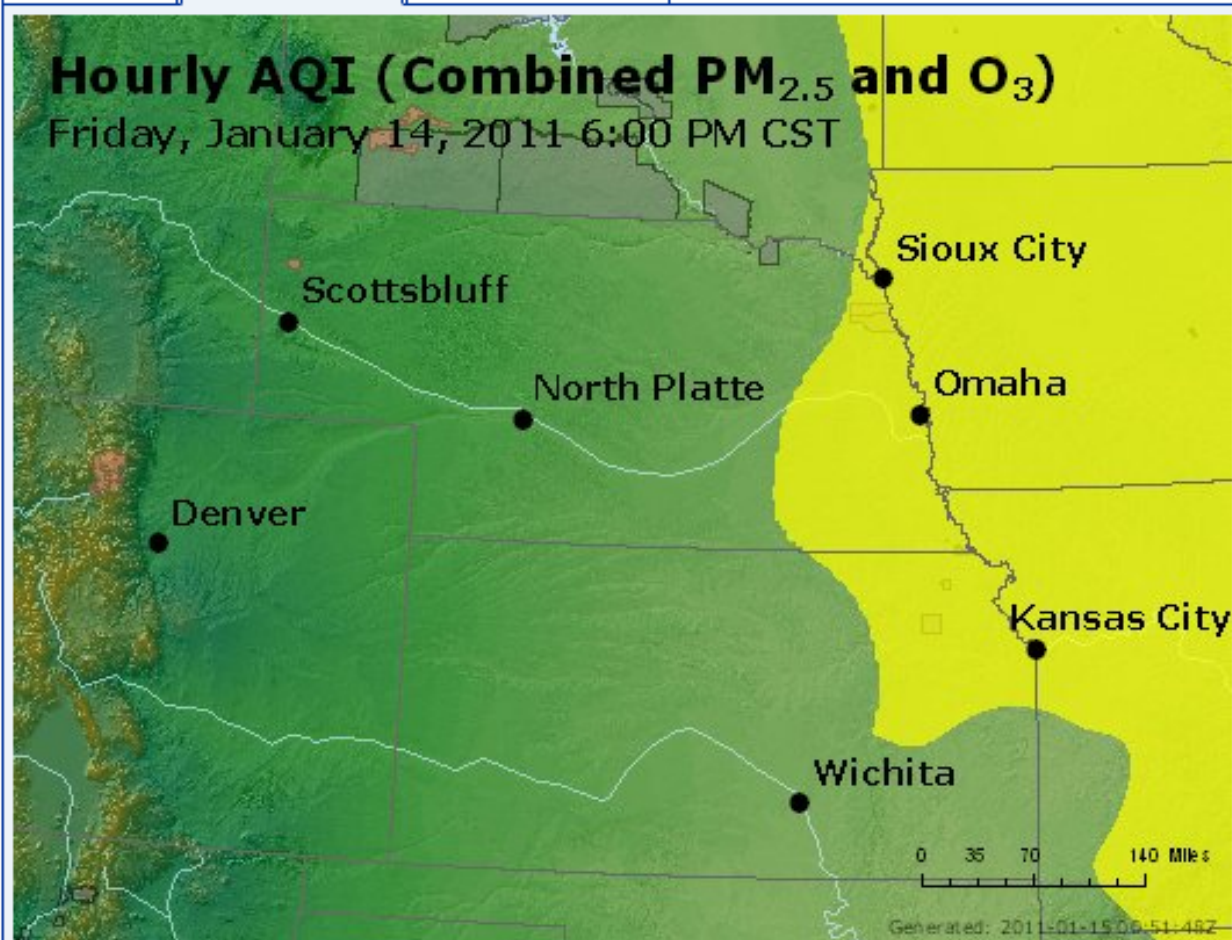
AIRNow Home >> **Kansas**

Data courtesy of: Kansas Department of Health and Environment

Forecast

Current AQI

AQI Animation



Good

Moderate

USG

Unhealthy

Very Unhealthy

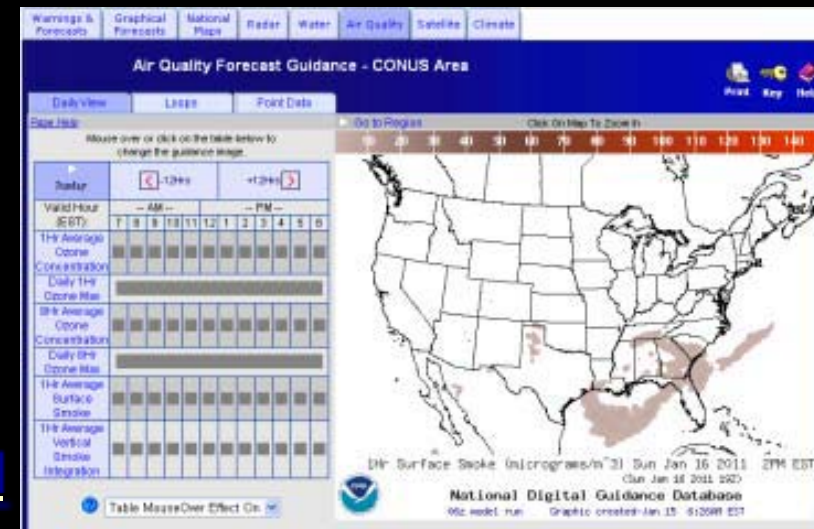
Hazardous

! Action Day

<http://www.airnow.gov/>

Satellite Fire Detections and Smoke Plumes

- NOAA Hazard Mapping System (HMS)
 - Satellite Fire Detections, Plume Analysis
 - Current conditions
- NOAA HYSPLIT Dispersion Model
 - Smoke Plume Forecast
 - Based on Satellite Fire Detections



- <http://www.osdpd.noaa.gov/ml/land/hms.html>
- <http://www.nws.noaa.gov/aq/>

Western Regional Climate Center (WRCC)

← → C www.raws.dri.edu/wraws/ksF.html

RAWS sites
[Cimarron Kansas](#)
[State Line Kansas](#)
[Kirwin Kansas](#)
[Potawatomi Kansas](#)
[Stafford Kansas](#)
[Tallgrass Prairie Kansas](#)
[Rainwater Basin Nebraska](#)

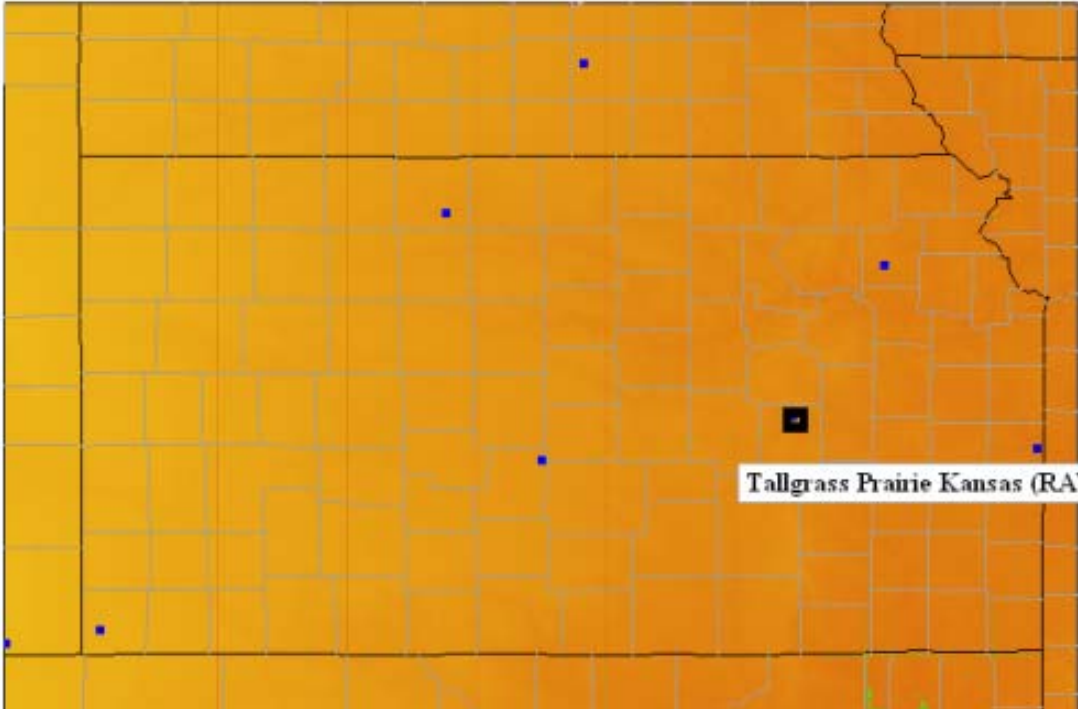
Western Regional Climate Center,
wrc@dra.edu

Select a site by placing mouse cursor over a site. Site name will appear in location box below the map if browser supports pop-up options.

Large boxes indicate stations that had reported during the month when these maps were last generated. Small boxes indicate stations that have not reported.

Map last generated on 01/08/11.

If a location has multiple stations or more than one platform in the near vicinity, overlapping boxes may create difficulty in identifying the list to the left in such cases.



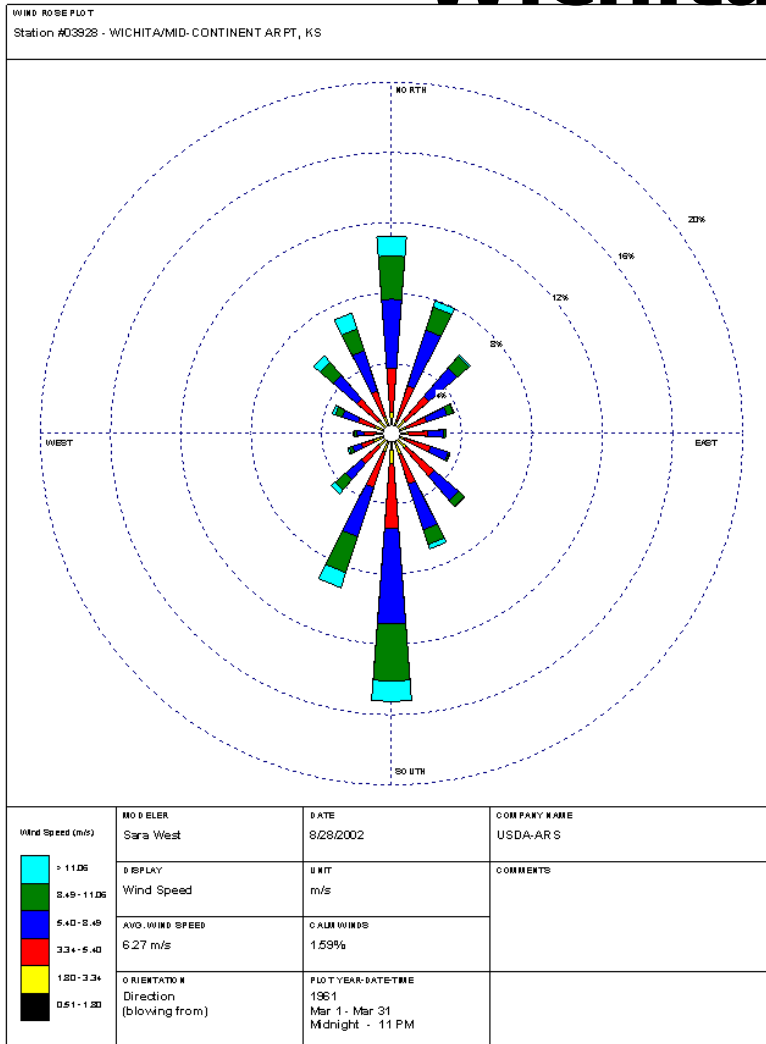
Tallgrass Prairie Kansas (RAWS)

- Remote Automated Weather Stations (RAWS)
- <http://www.raws.dri.edu/>

Water and Climate Center Windroses - March

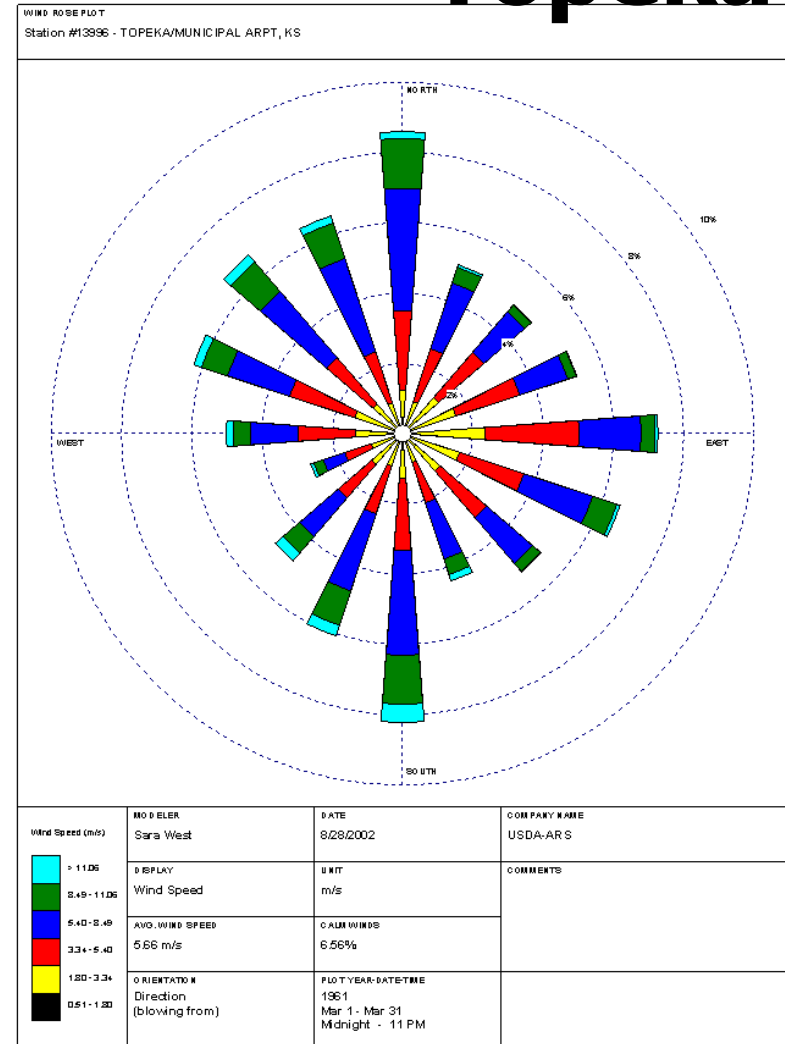
<http://www.wcc.nrcs.usda.gov/ftpref/downloads/climate/windrose/>

Wichita



WIND ROSE PLOT by CATAL Environmental Software - www.catal-environmental.com

Topeka

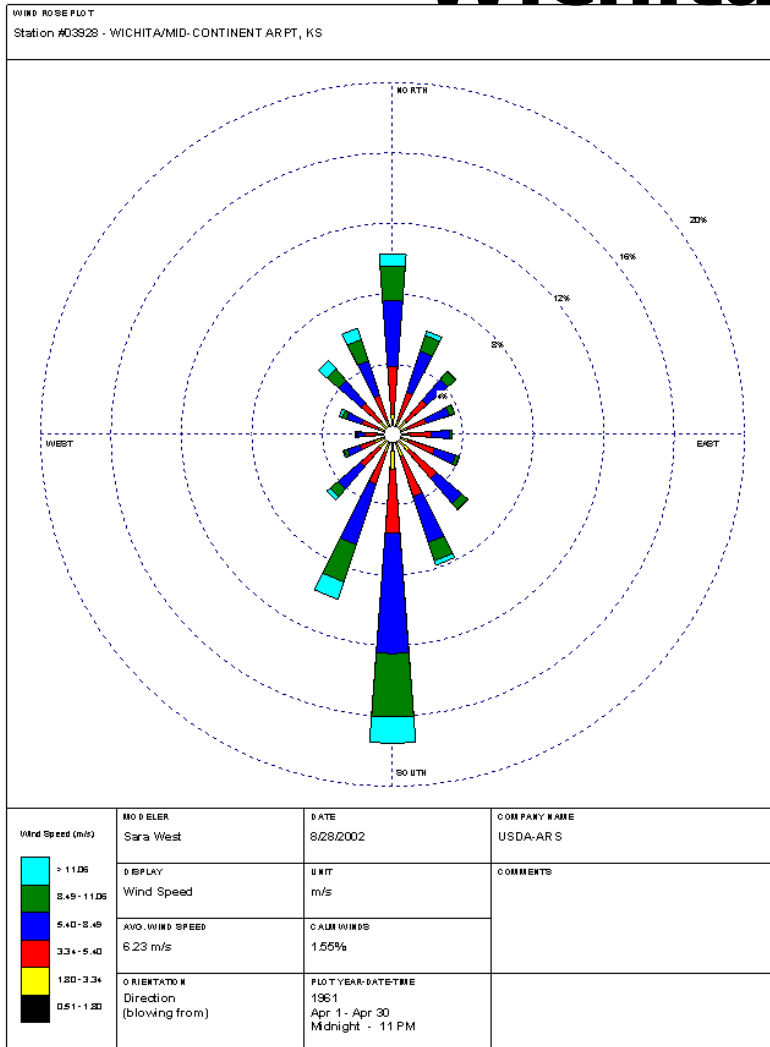


WIND ROSE PLOT by CATAL Environmental Software - www.catal-environmental.com

Water and Climate Center Windroses - April

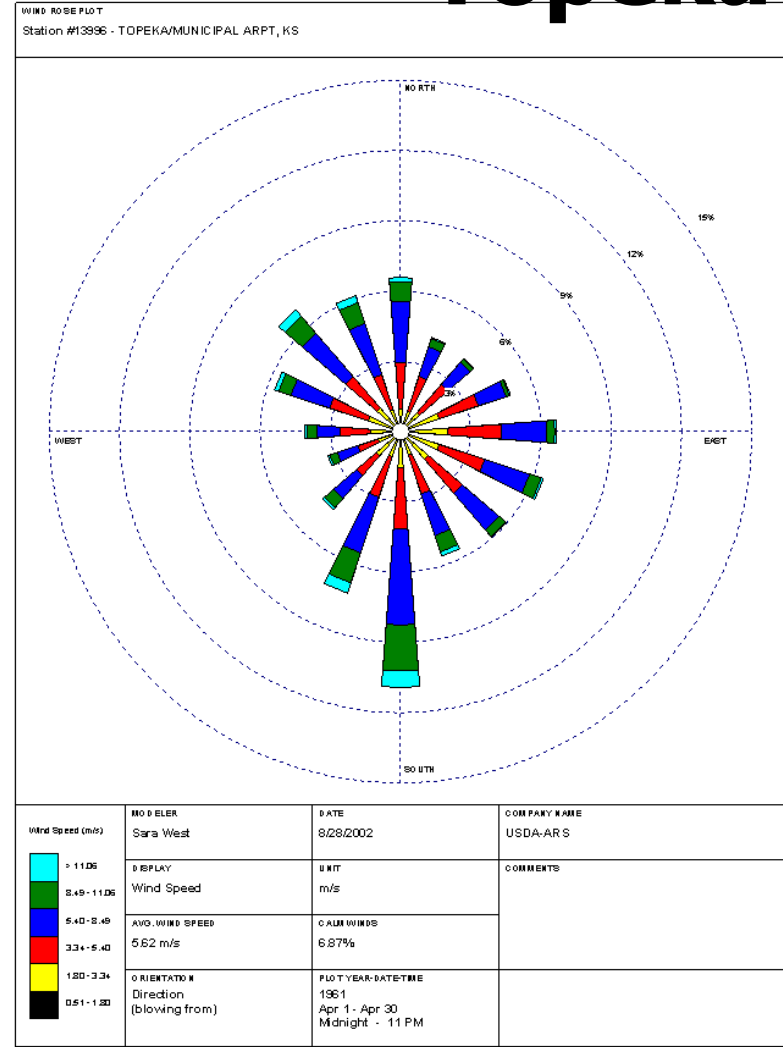
<http://www.wcc.nrcs.usda.gov/ftpref/downloads/climate/windrose/>

Wichita



WIND ROSE Plot 2.3 by Climate Environmental Services - www.blaes-weather.com

Topeka



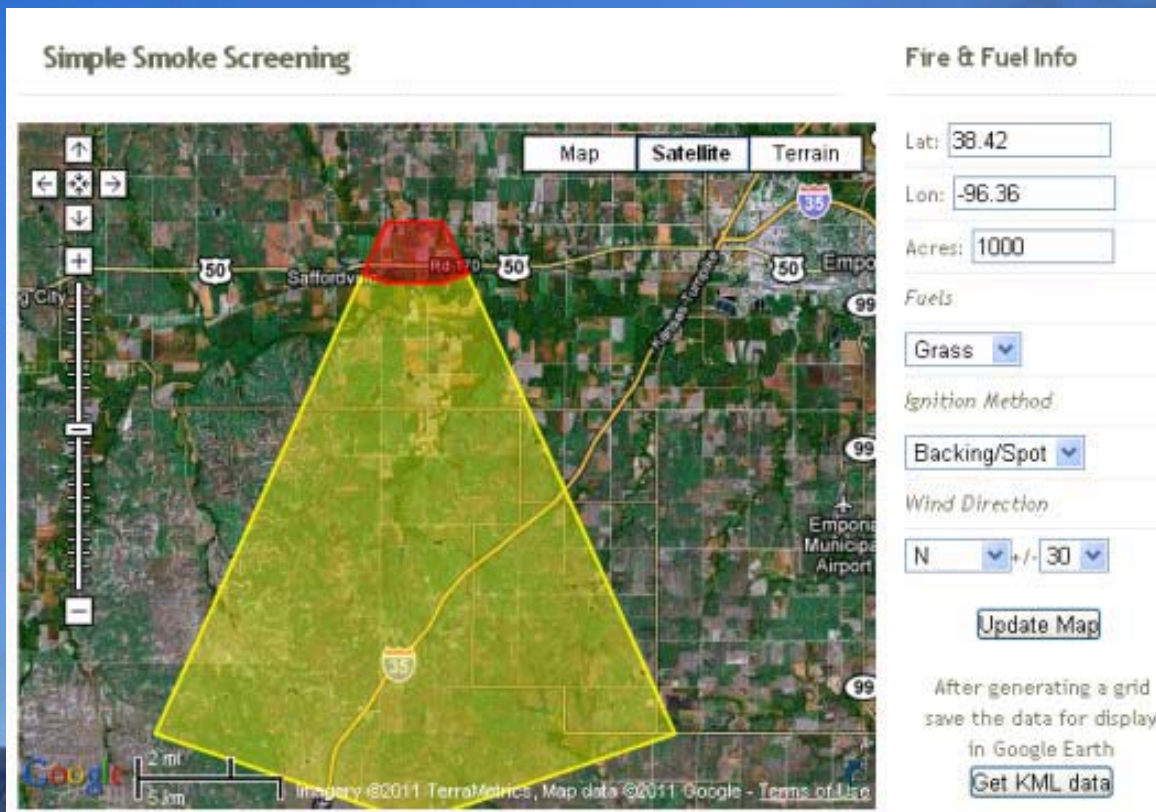
WIND ROSE Plot 2.3 by Climate Environmental Services - www.blaes-weather.com

Smoke Modeling

A person wearing a cowboy hat is seen from the back, looking out over a landscape where a large fire is burning. Thick smoke is rising from the fire into a clear blue sky. The foreground shows some dry brush and grass.

- Answer the questions – Where could my smoke go? How thick could it be? Who/what may be impacted?
 - Simple Smoke Screening Tool
 - Trajectories
 - Standalone Dispersion Models (ex. VSMOKE)
 - Centralized web-based smoke dispersion systems (eg. BlueSky, KSU DSS)

Simple Smoke Screening Tool



<http://shrmc.ggy.uga.edu/>

- Select: Smoke Products -> Smoke Screening
- Google Map application
 - Zoom-in
 - View Smoke Sensitive Areas
- Enter Location, Acres, Fuel type, ignition method, wind direction
- Can also do manually on a map

From the Southern Forestry Smoke Management Guide

<http://www.srs.fs.usda.gov/pubs/viewpub.php?index=683>

Wildland Fire Air Quality Tools

WFDSS Integrated Tools v1.0 (Beta Test)

STATUS: Updated 10/25: 8 of 8 tools linked and running. Help pages online. Products now open in separate tabs.
VCIS table fixed. Some additional development work occurring. See notes below each tool's link for additional information.

STEP 1

Set your fire location:



location used for tailored products.

Latitude °N

Longitude °E

Location is set.

STEP 2

Select Your Tool:

- ▶ Smoke Guidance Point Forecast
- ▶ Smoke Guidance Regional Maps
- ▶ Diurnal Surface Wind Pattern Analysis
- ▶ Climatological Ventilation Index Point Statistics
- ▶ Current Air Quality Conditions Map
- ▶ Fire Information & Smoke Trajectories
- ▶ Customized Fuels, Consumption, & Smoke Modeling
- ▶ Probabilistic Smoke Impacts based on Past Weather

See below for tool description, attributes, and other details.

● <http://firesmoke.us/wfdss/>

Air Parcel Trajectories

- Information about where a parcel of air will travel
- NOAA HYSPLIT Model
- NWS NAM Meteorology (40 km resolution)
- Via the Wildland Fire Decision Support System (WFDDSS) Air Quality Portal
- Plume rise simulated by above ground release height
- No Chemistry, No Particle Concentration
- Each point is one hour out in time, number is the height above ground
- Triangles are satellite fire detections (NOAA HMS, SMARTFIRE)

Trajectories – April 8, 2010

Options Tool Options



Trajectory Parameters

Start Hour

00Z

Hours

24hr Forward

Height (m agl)

100 m

Trajectory cluster

Create trajectory clusters

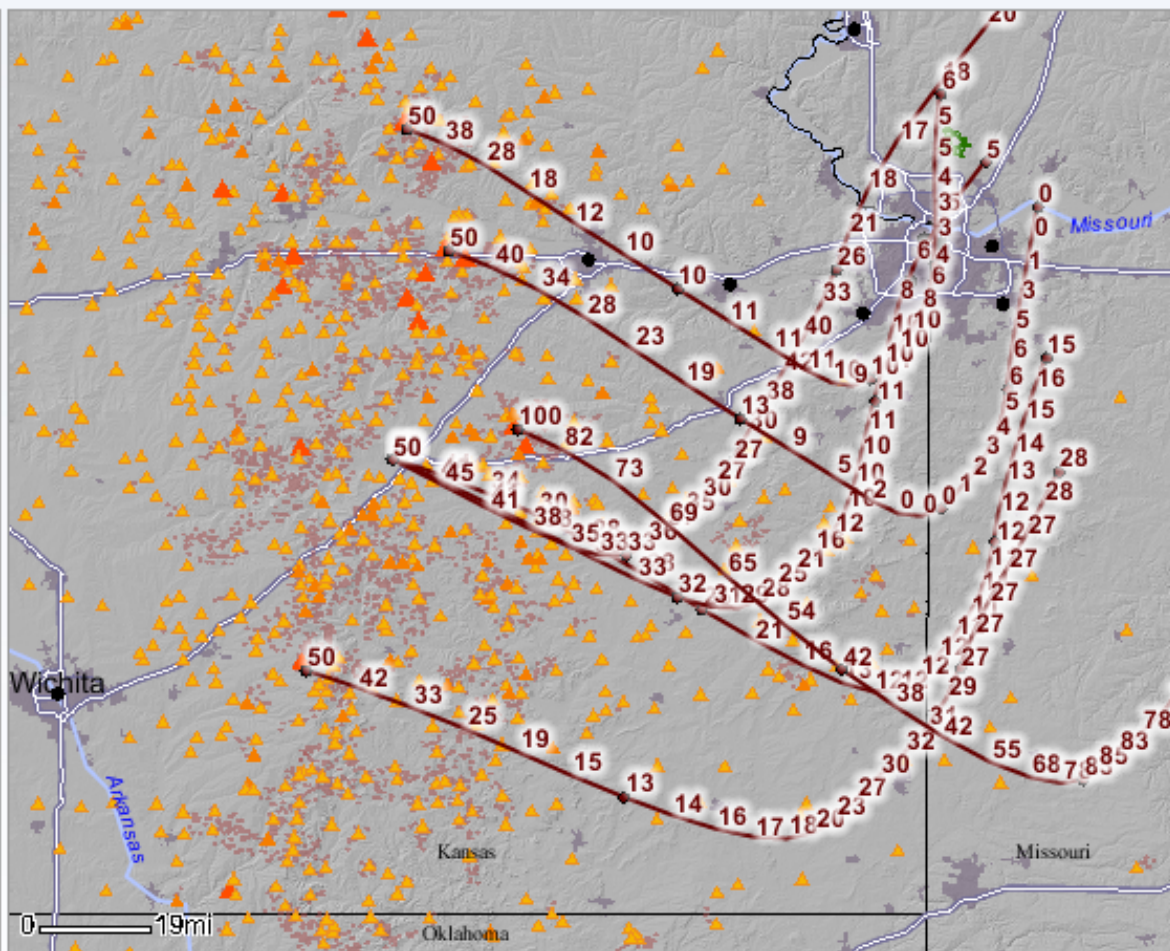
Label

(Only appears when map scale is less than 22 mi)

- Hour
- Height (m agl)
- Pressure (mb)
- None

Source:

[NOAA HYSPLIT model](#)
 NAMNDAS models (40km)
 Most Recent: 17 Jan 2011 00Z
 Model vertical velocity



Legend

Legend

Today's Fire Locations

- ▲ 100 acres or less
- ▲ 100 - 500 acres
- ▲ 500 - 5000 acres
- ▲ more than 5000 acres

Today's Fire Perimeters

- Total Fire Perimeters
- Today's HMS fire detects
- Today's ICS-209 reports

[Additional legend information](#)

Apply Changes

Trajectories – April 9, 2010

Options Tool Options



Trajectory Parameters

Start Hour

00Z

Hours

24hr Forward

Height (m agl)

10 m

Trajectory cluster

Create trajectory clusters

Label

(Only appears when map scale is less than 22 mi)

- Hour
- Height (m agl)
- Pressure (mb)
- None

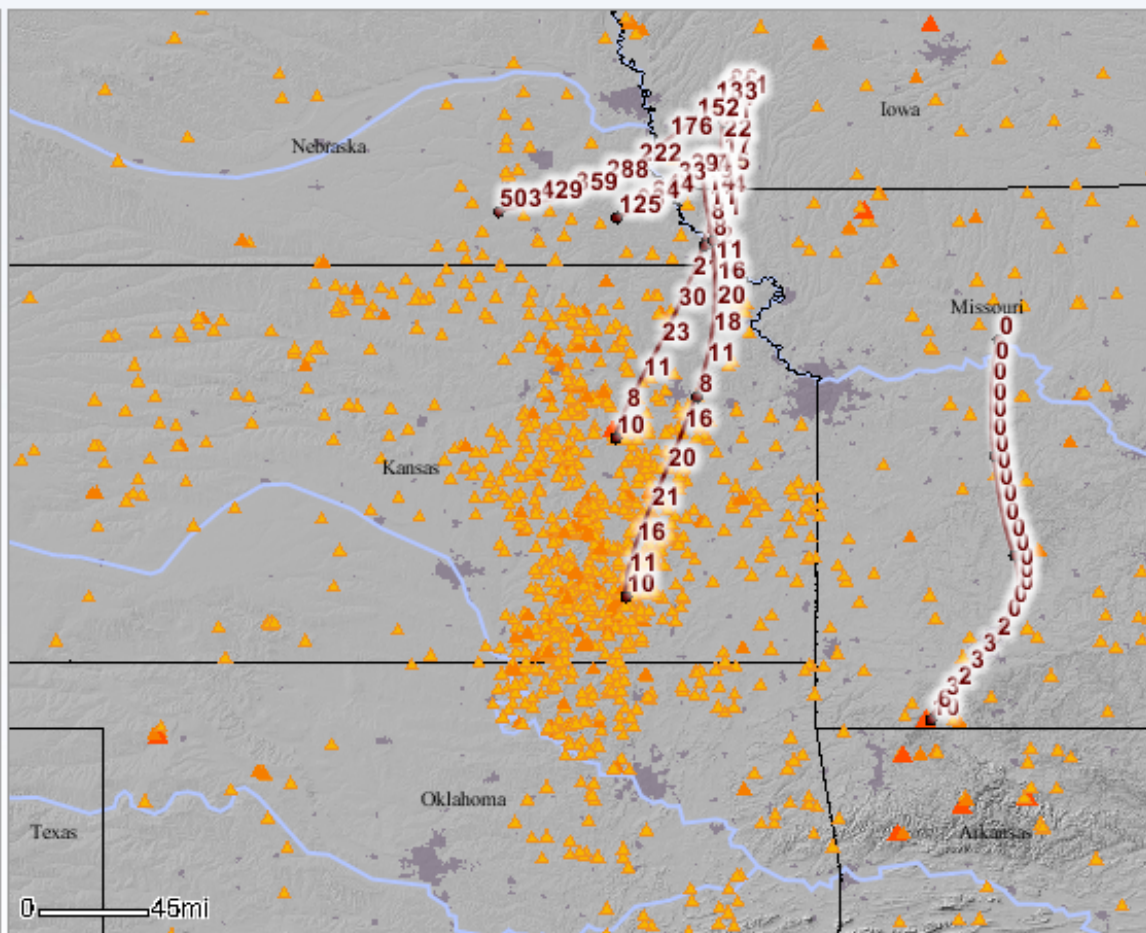
Source:

[NOAA HYSPLIT model](#)

NAMNDAS models (40km)

Most Recent: 17 Jan 2011 00Z

Model vertical velocity



Legend

Legend

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- 100 - 500 acres
- 500 - 5000 acres
- more than 5000 acres

Today's Fire Perimeters

- Total Fire Perimeters
- Today's HMS fire detects
- Today's ICS-209 reports

[Additional legend information](#)

Apply Changes

Trajectories – April 10, 2010

Options Tool Options



Trajectory Parameters

Start Hour

00Z

Hours

24hr Forward

Height (m agl)

10 m

Trajectory cluster

Create trajectory clusters

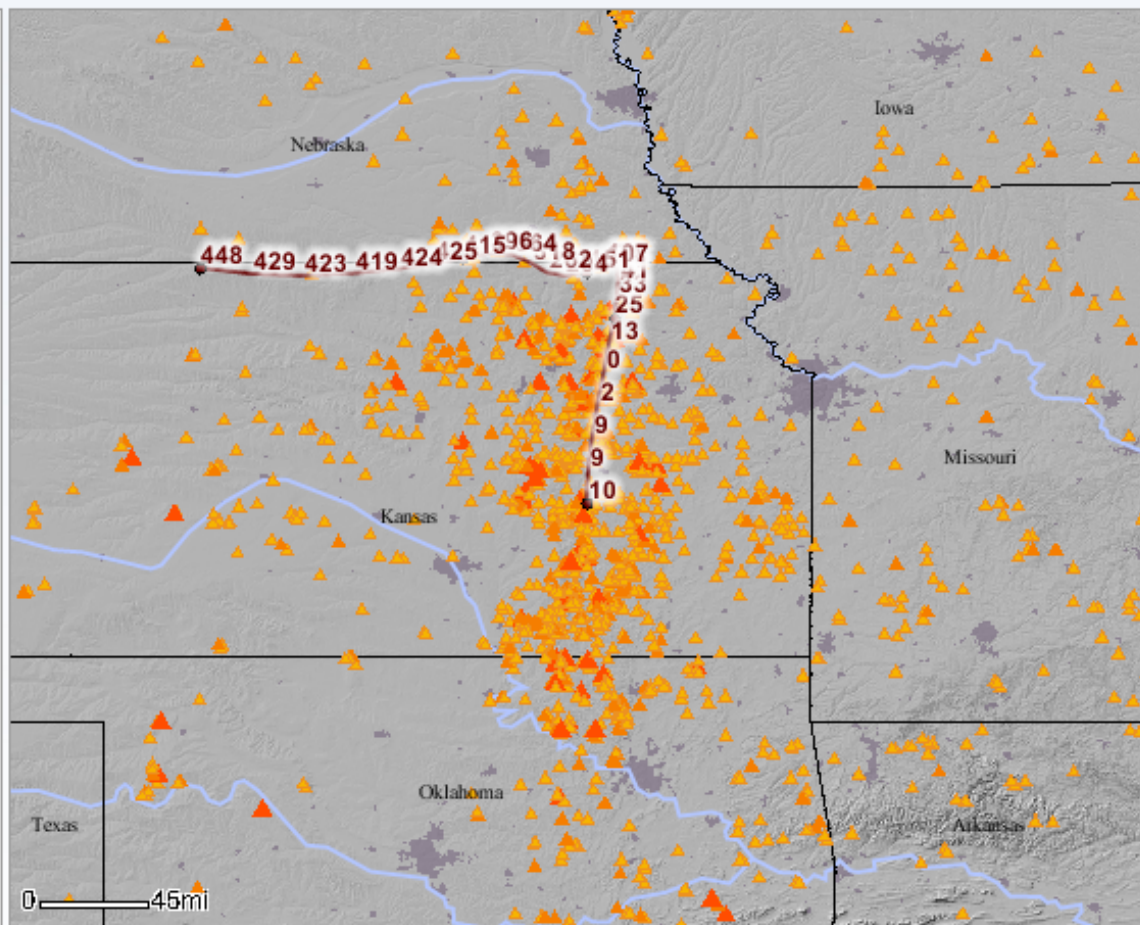
Label

(Only appears when map scale is less than 22 mi)

- Hour
- Height (m agl)
- Pressure (mb)
- None

Source:

[NOAA HYSPLIT model](#)
 NAMNDAS models (40km)
 Most Recent: 17 Jan 2011 00Z
 Model vertical velocity



Legend

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Today's Fire Perimeters

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[Additional legend information](#)

Apply Changes

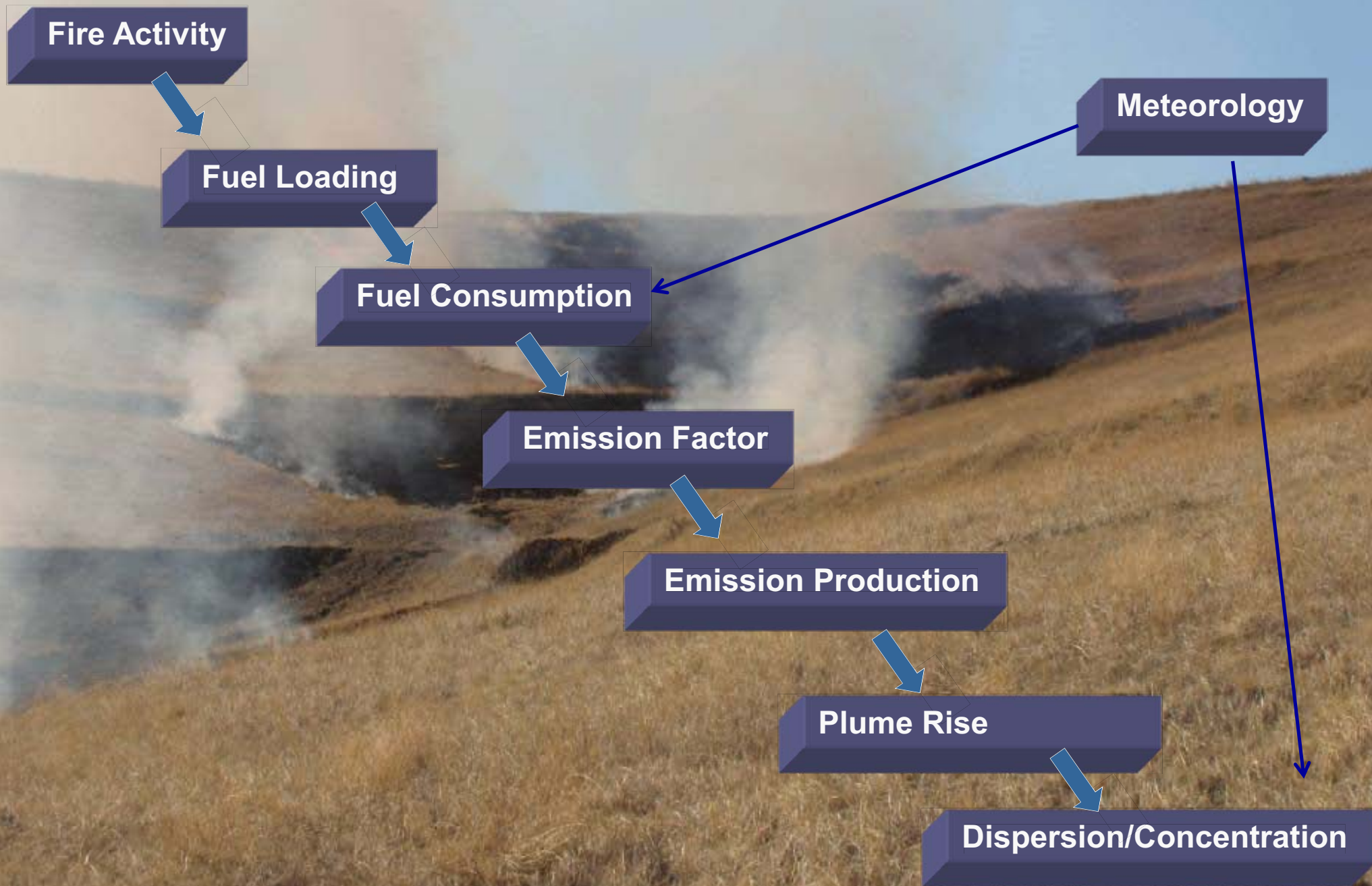
Basic Smoke Management Practices

- #3 Track fire activity on a daily basis
- #4 Document the event and retain relevant records for 3.5 years
- *These items can be very important for exceptional event demonstrations and emission inventory needs*

Basic Smoke Management Practices

- #5 Share the Airshed/Air Basin
 - When multiple fires are occurring within an airshed or any airshed is impacted by ongoing fire events, fire managers should consider the incremental impact to air quality with their specific actions might cause
 - Utilize the AQI forecasts (www.airnow.gov)
 - Communicate with appropriate air quality specialists

Components of Smoke Modeling



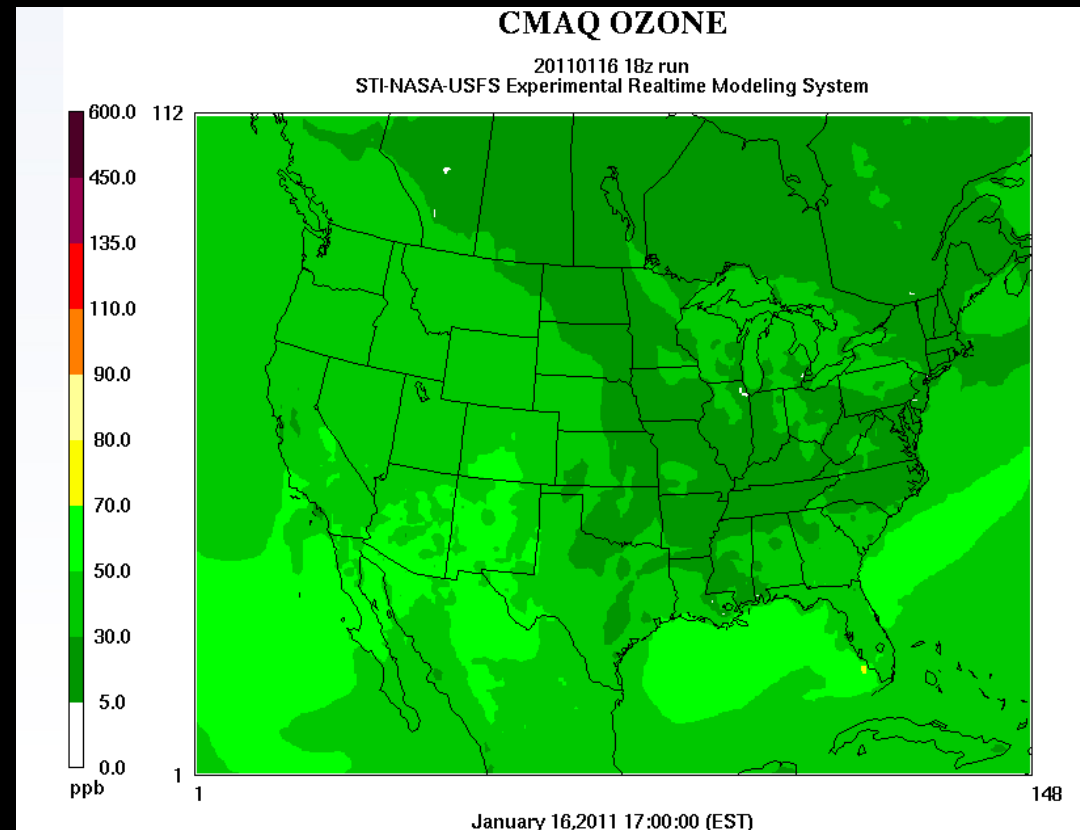
BlueSky



- Daily forecasts of ozone and PM2.5 concentrations
- Includes all emission sources including fire
- Fire activity based on SMARTFIRE
- Forest Service and Sonoma Tech Inc.

Centralized websites under development:

www.blueskyframework.org, www.getbluesky.org



National Smoke Management Website

<http://www.nifc.gov/smoke>



National Interagency Fire Center



Smoke Management - Overview

[Overview](#) | [Tools](#) | [Regulations and Policies](#) | [Emissions](#) | [Training Publications](#) | [Links](#)

The information within these pages is offered by the Interagency Smoke Committee (SmoC). SmoC is chartered by the National Wildfire Coordinating Group (NWCG) to provide leadership, coordination and integration of air resource and fire management objectives.

[NIFC Home](#)

[Aviation](#)

- Tools
 - Smoke/Weather Forecasts
 - Smoke Modeling
 - Smoke Monitoring
 - Remotely Sensed Data
 - After Action Review
 - NEPA
- Regulations and Policies
- Emissions
- Training
- Publications
- Links



NWCG Smoke Committee (SmoC)



- One of 14 Committees chartered under the National Wildfire Coordinating Group (NWCG)
- Current Members: USFS, NPS, FWS, BLM, BIA, NASF, NRCS, NACAA, TNC
- Products, Topics and Issues
 - Training
 - www.nifc.gov/smoke
 - www.myfirecommunity.net “Air Quality and Fire Issues” Neighborhood
 - Fire emissions: Black Carbon, NO₂, GHGs, PM_{2.5}, Ozone precursors
 - Smoke Monitoring
 - Exceptional Events
 - Federal Fire Policy

SmoC Subcommittees

- Smoke Managers
 - Kansas is participating
- Training
 - Online Training
 - Smoke Assessment
 - Effective Communication Workshop
- Technical Smoke Topics
 - Smoke Management Guide Revision
 - Smoke Monitoring



Thank you! Questions, Comments, Discussion

Susan O'Neill, susan.oneill@por.usda.gov
503-273-2438

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