Session I
PM Composition & Sources

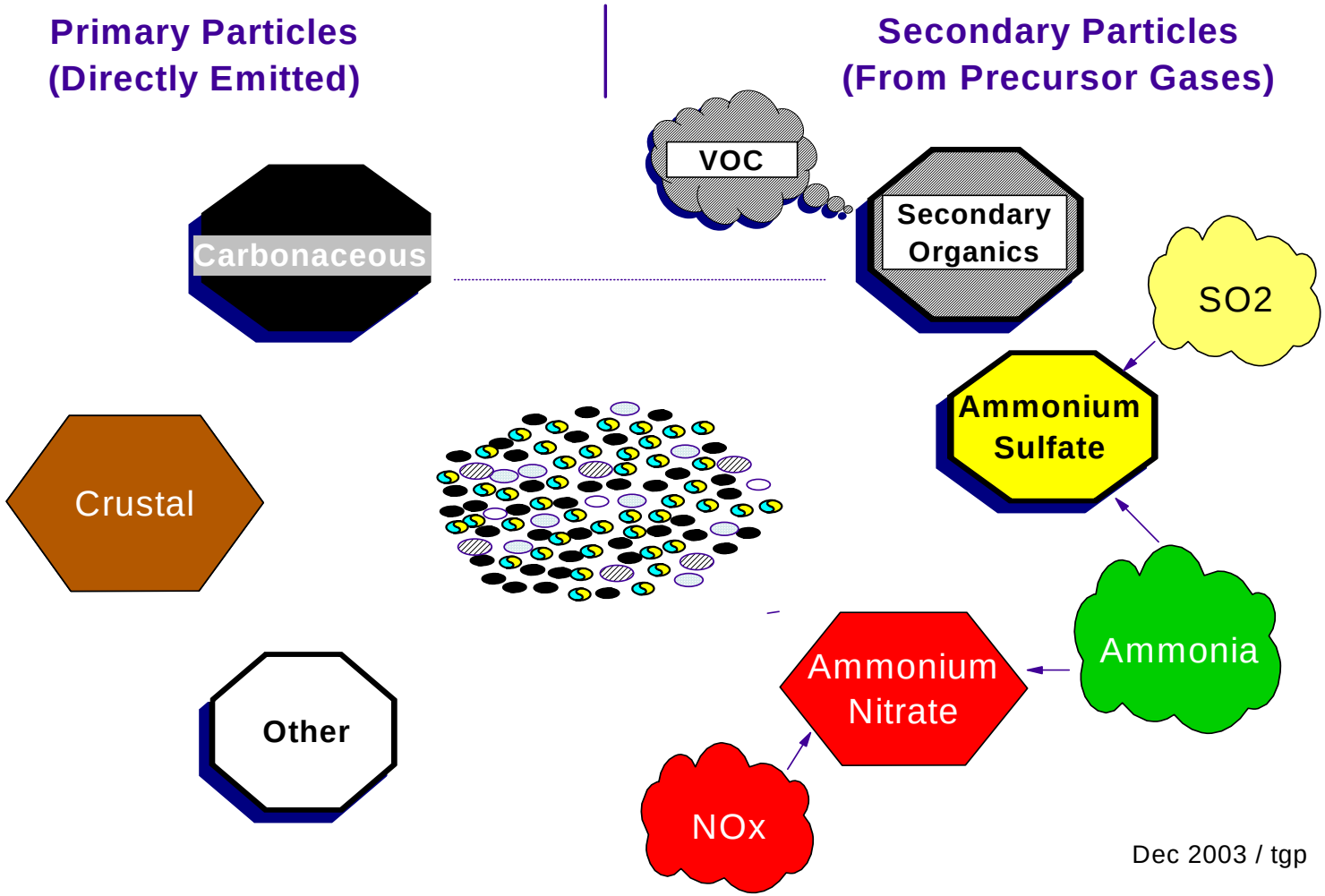
Ambient Composition

What are the Important Sources

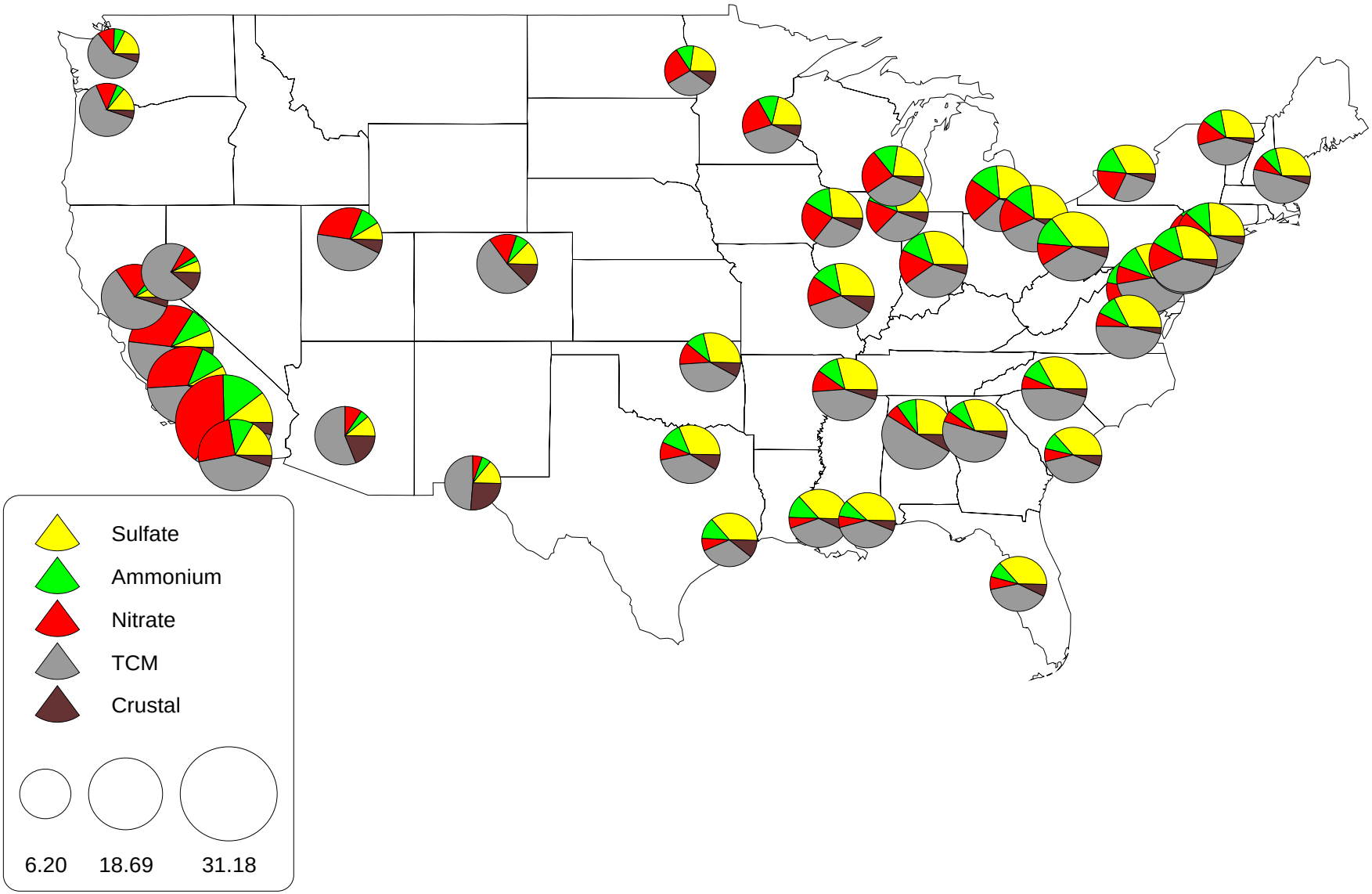
EPA Nat'l EI Conference
Las Vegas, NV
April 11, 2005

Thompson G. Pace
OAQPS
US EPA

PM 2.5 In Ambient Air - A Complex Mixture



URBAN (EPA STN) ANNUAL AVERAGES
Sep 2001--Aug 2002



RURAL (IMPROVE) ANNUAL AVERAGES
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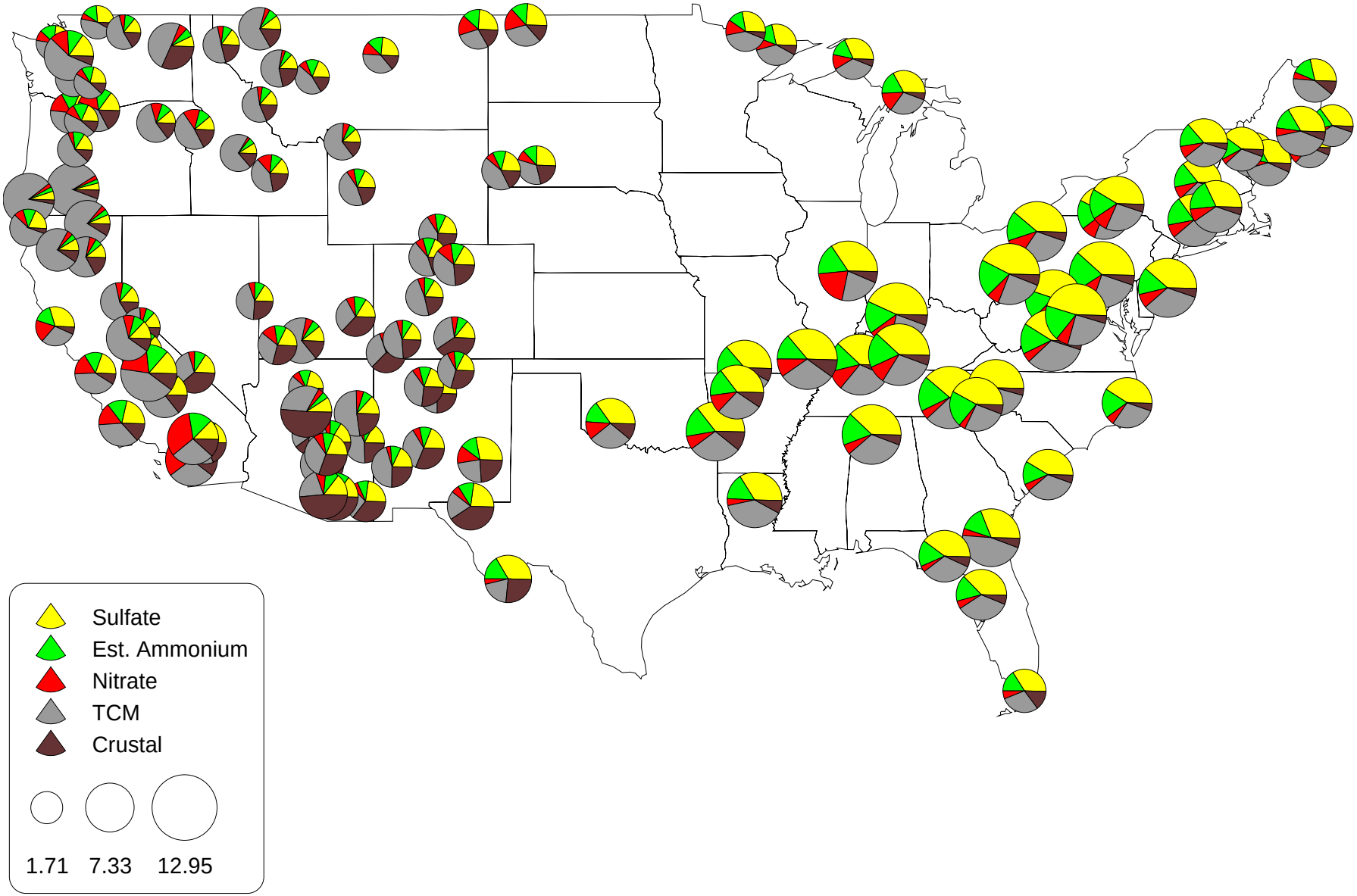
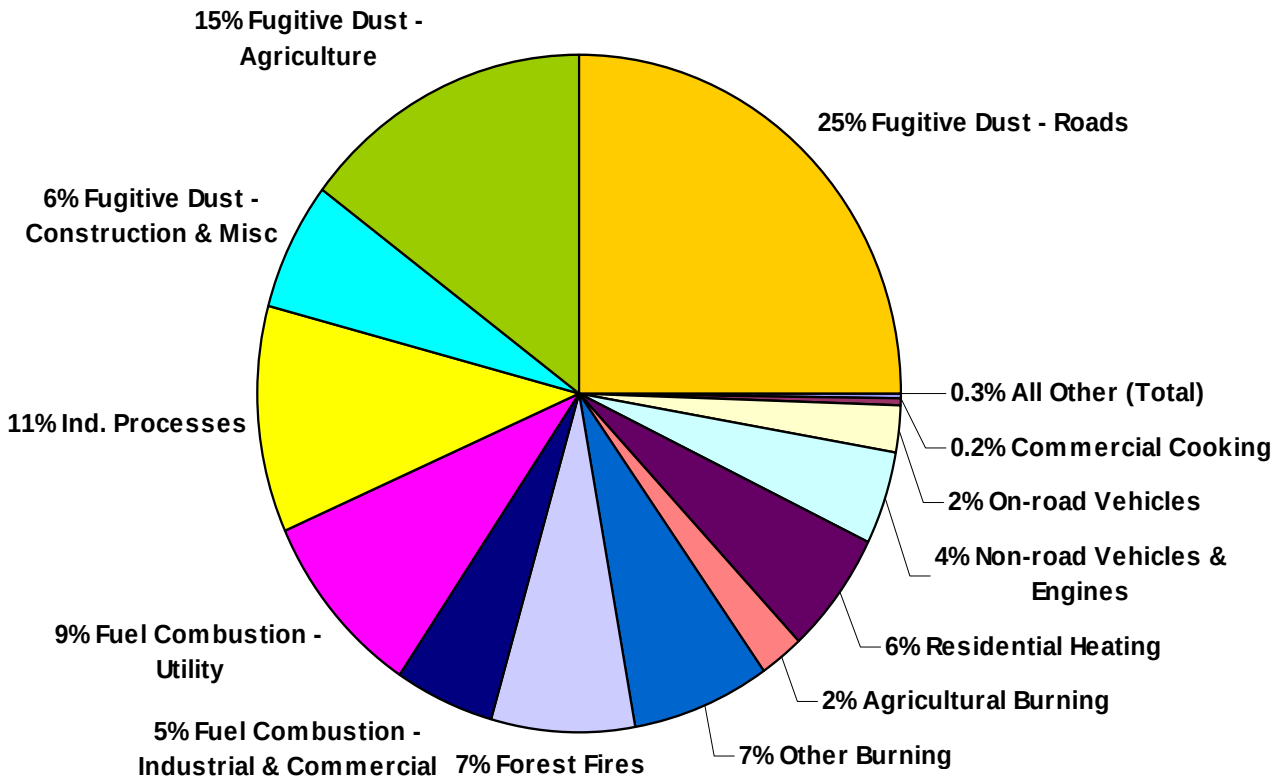


PM-2.5 Emissions in NEI



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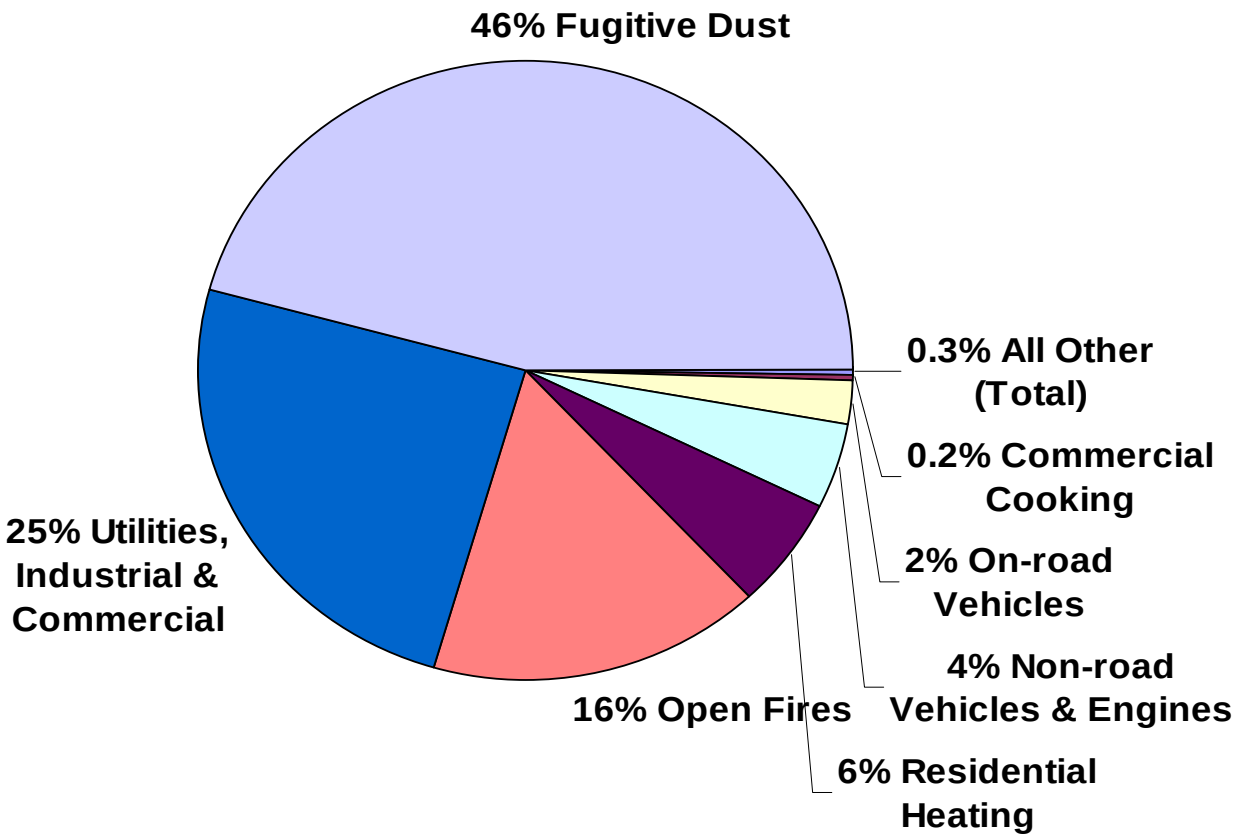
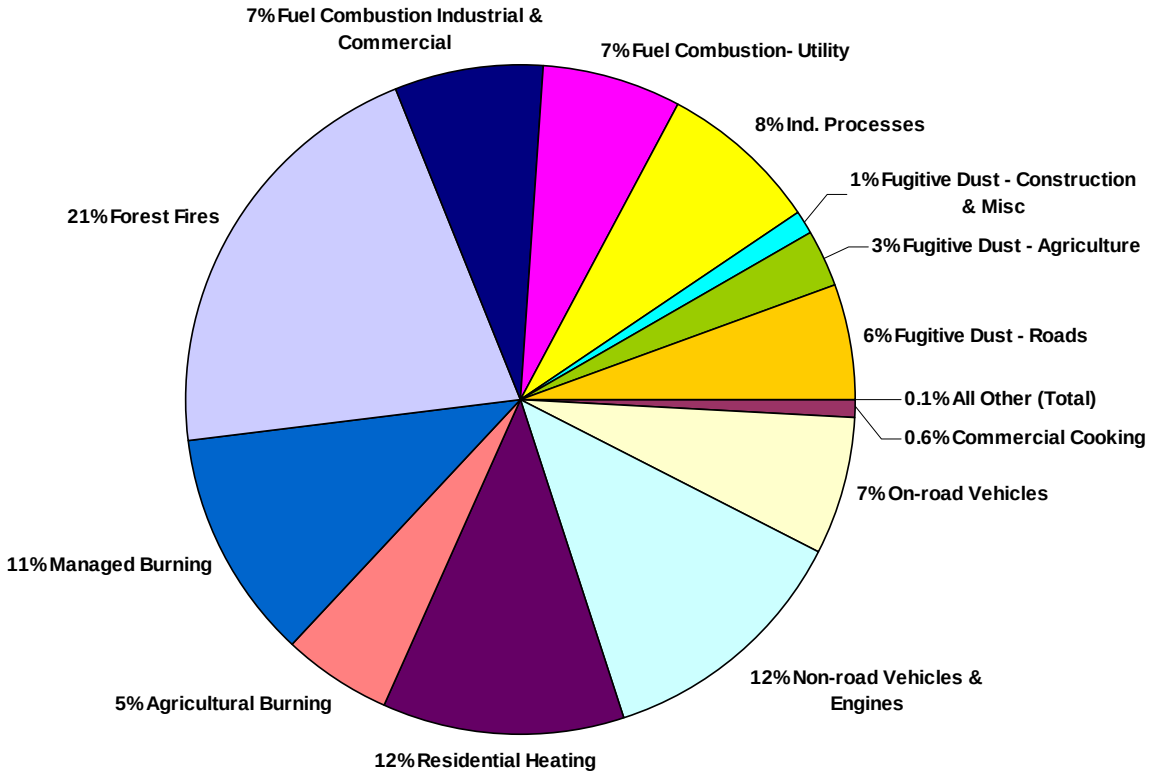


Total Carbon Emissions from Sources in NEI



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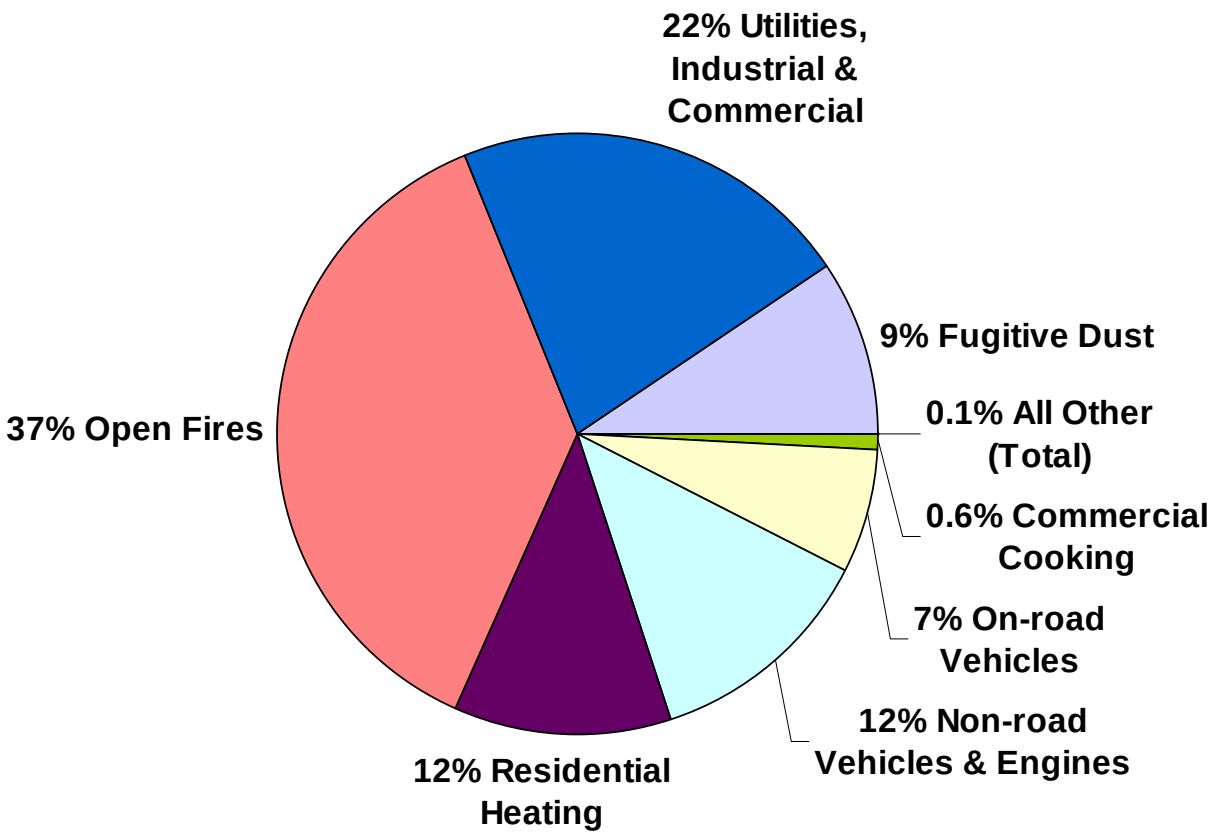
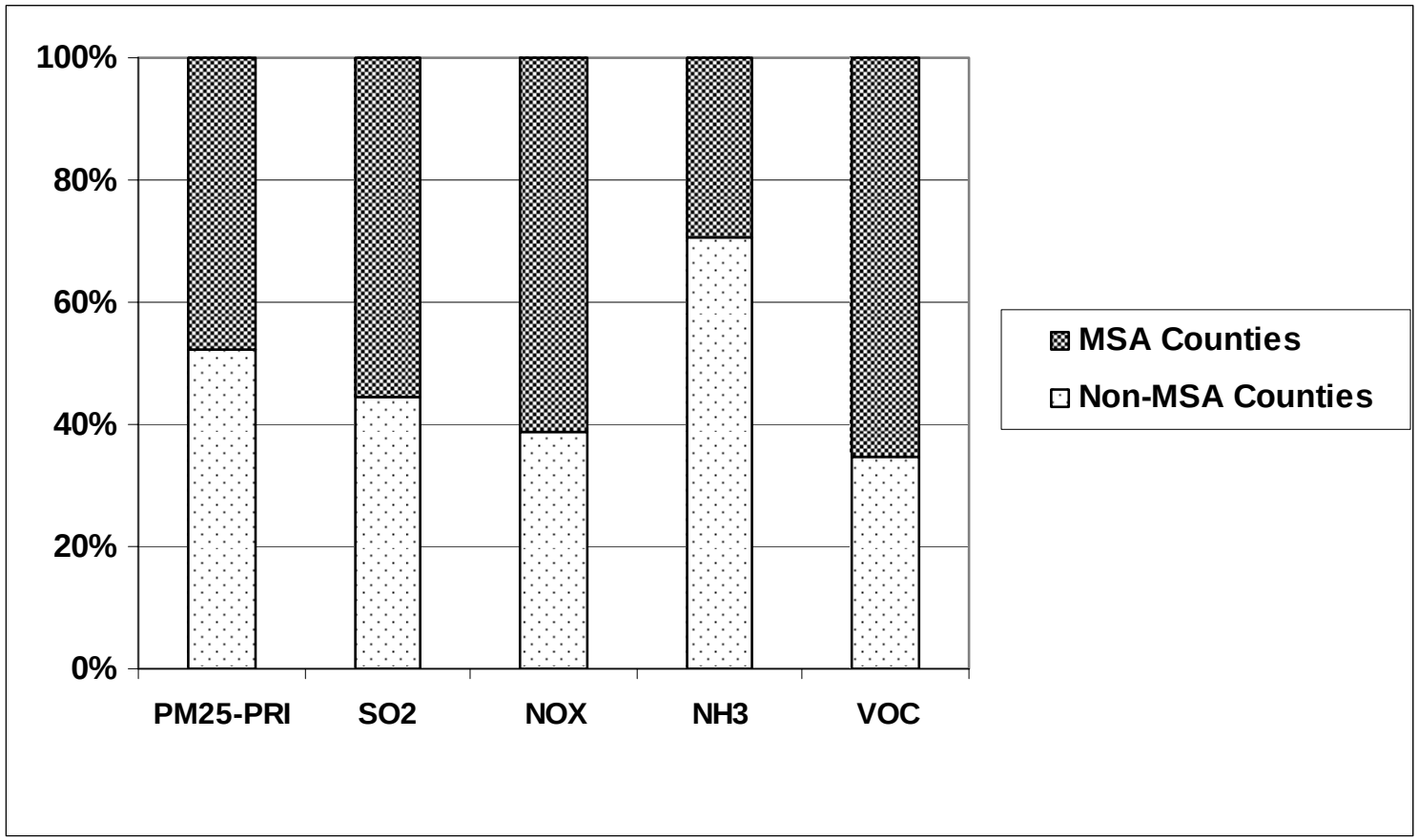


37-State(+DC) Emissions in '99 NEI

(MSA to Non MSA Comparison)



Urban areas responsible for most PM2.5 & precursor emissions – except NH3

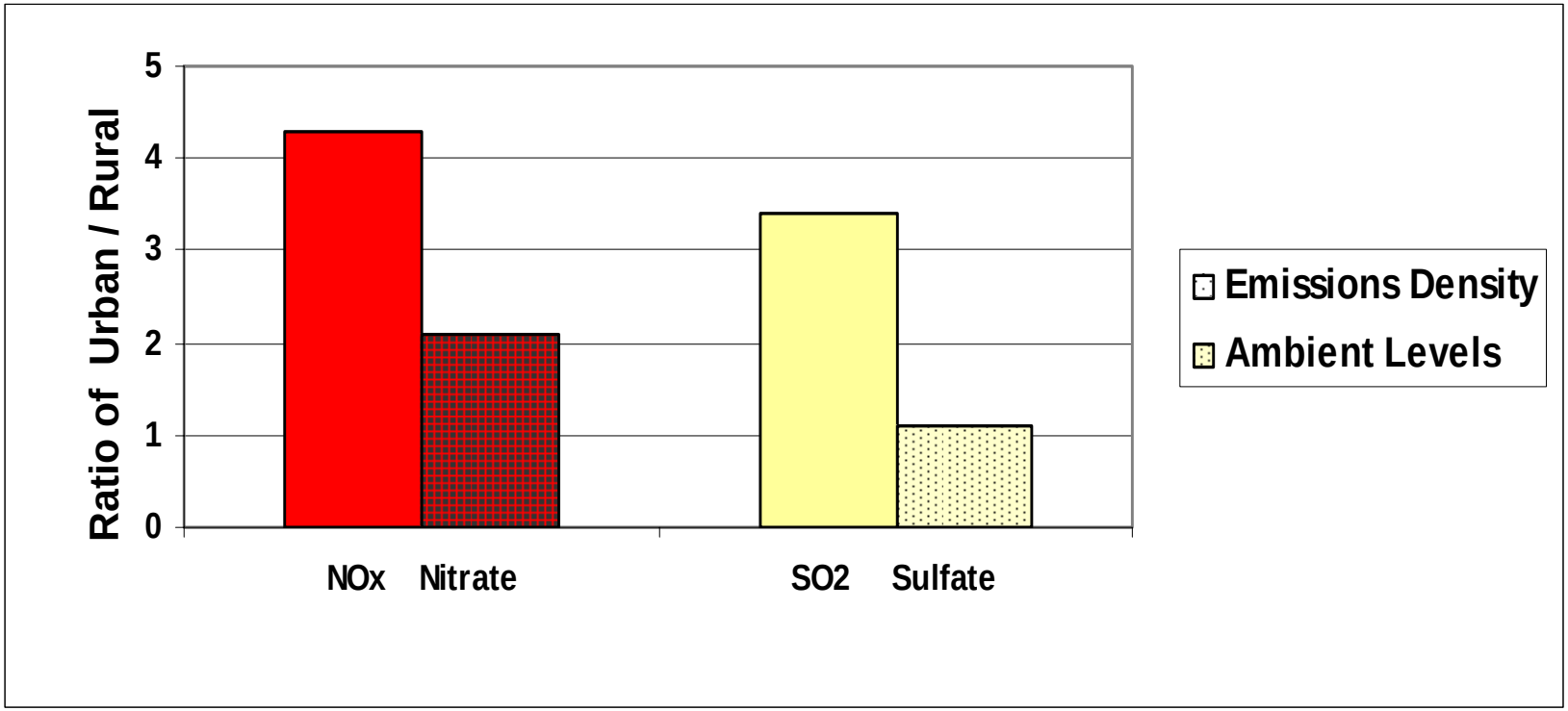
Sulfates, Nitrates & Ammonia

Sources and Spatial Extent

Sulfates & Nitrates

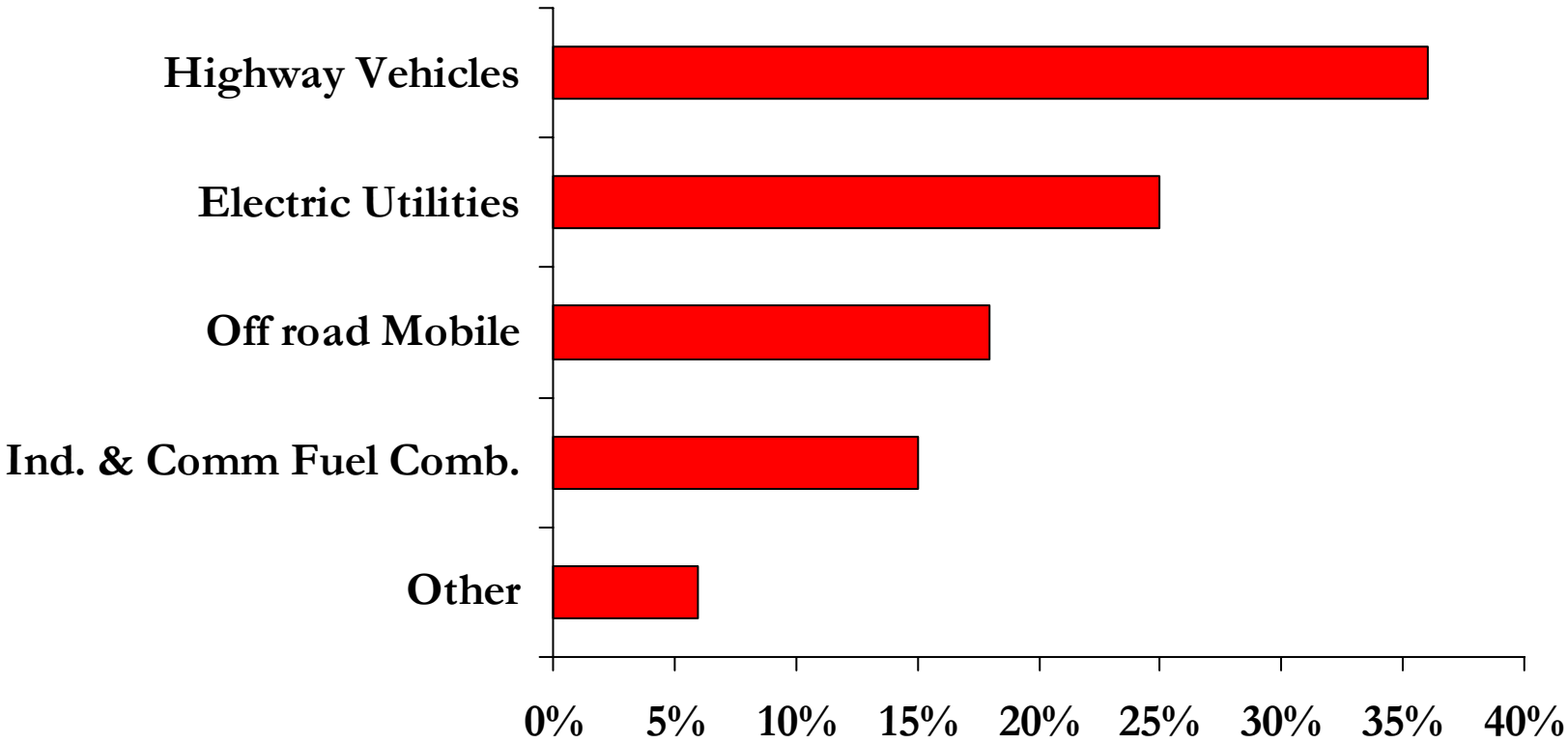
- Formed in atmosphere from SO2 & NOx
- Usually found as Ammonium Sulfate / Nitrate
- Urban ~ Rural Patterns
  - Emission densities of both SO2 & NOx:
    - > in urban than in rural areas
  - Ambient Nitrate:
    - has an “urban excess” (as does Carbon)
  - Ambient Sulfate:
    - NO “urban increment” (flat across large regions)
    - Why ? Sulfate is more stable ~ longer “lifetime”

Comparison of Urban~Rural Ratios of SO2, NOx Emissions & Ambient Sulfate, Nitrate

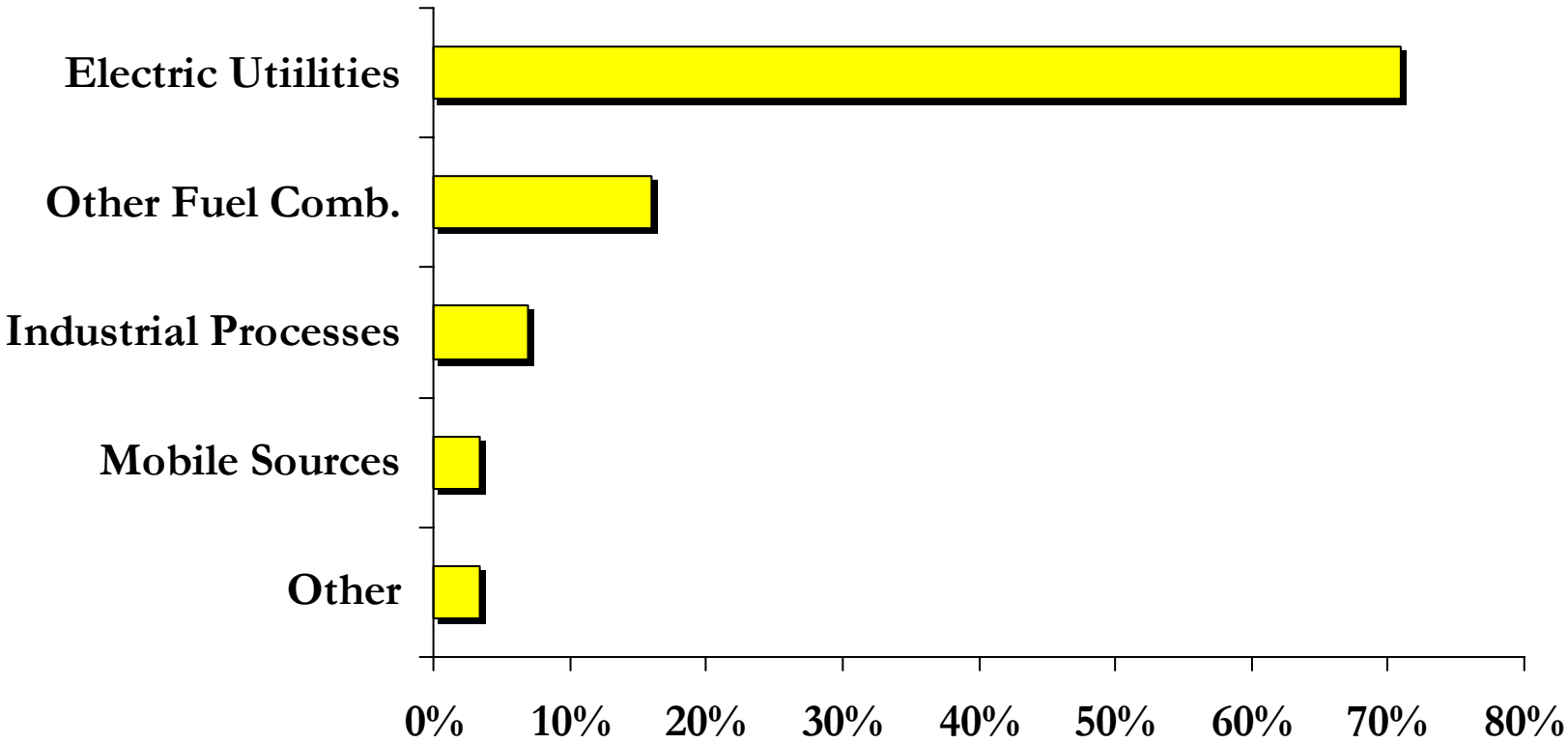


Note: Sulfate particles are more stable and thus have longer lifetime in the atmosphere than Nitrate. Sulfate is therefore more subject to transport

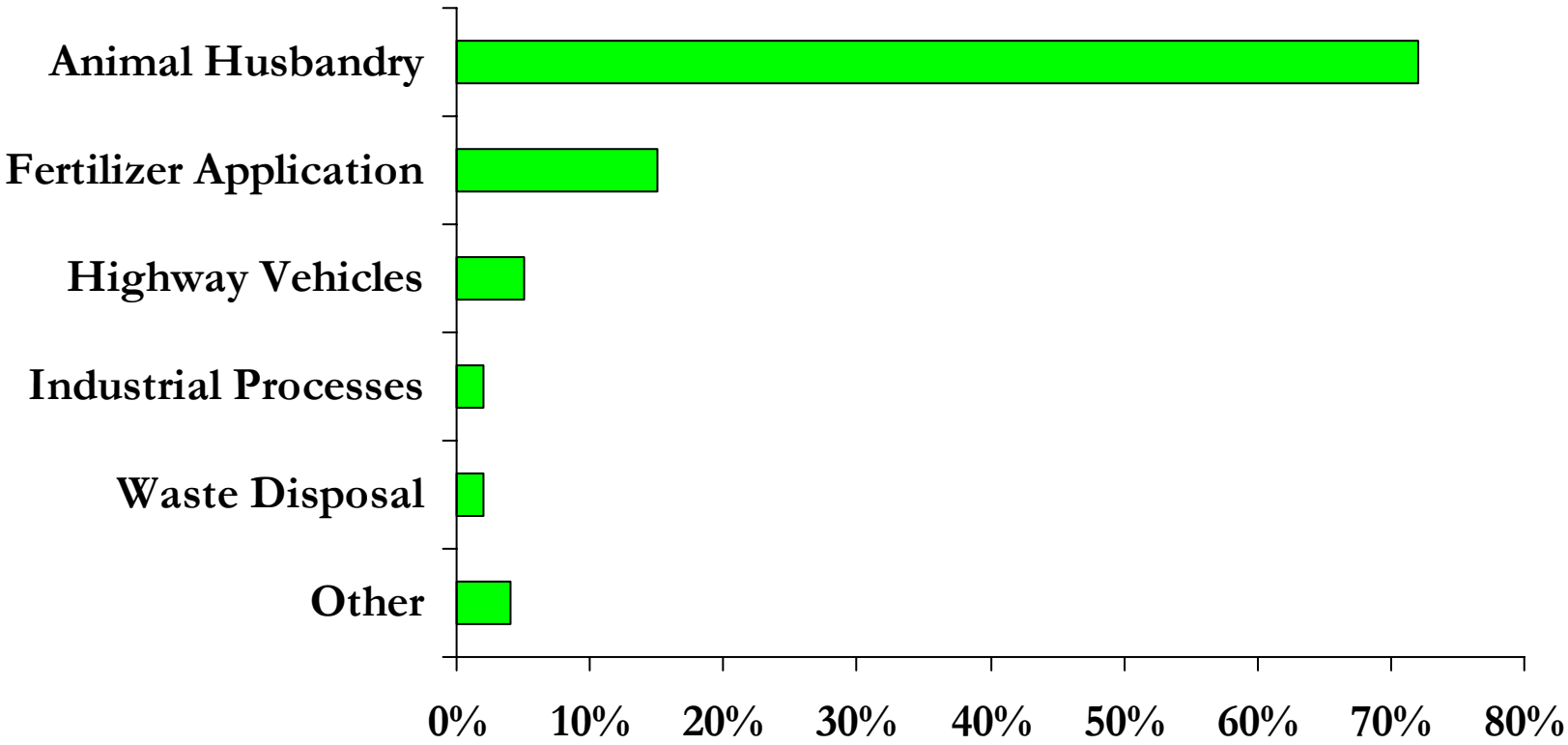
NOx – Precursor to Ammonium Nitrate and Ozone (National Emissions ~ 23M TPY)



SO2 – Precursor to Ammonium Sulfate Formation (National Emissions ~ 17.6 M TPY)



NH3 – Precursor to Ammonium Sulfate & Nitrate (National Emissions ~ 4.8 M TPY)



Crustal & Carbon

Their Sources & Regional Extent

Crustal Materials (Mainly Fugitive Dust)

- **Main Sources:**
  - Unpaved roads
  - Agricultural tilling
  - Construction
  - Windblown dust, Fly ash

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- **Huge Disparity Between EI & Ambient Data**
  - Ambient Data
    - < 1 ug/m3 in most of US
    - Exception: > 1 ug/m3 in much of Southwest, California
  - Emissions: 2.5M TPY (comparable to Carbon Emissions)

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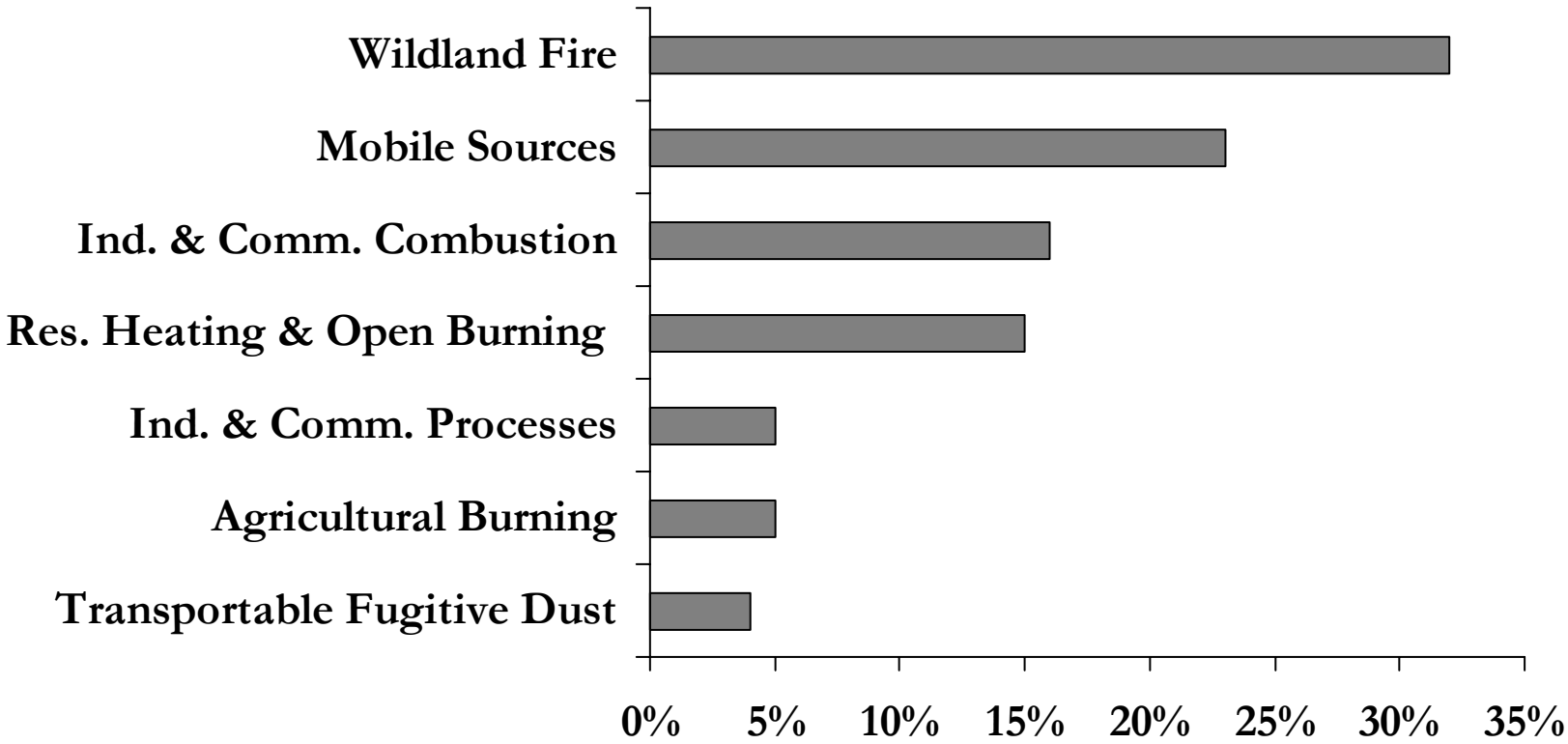
- **Fugitive Dust has low "Transportable Fraction"**

Crustal Materials

- Crustal materials are a relatively small part of PM2.5 in the ambient air
- Fugitive dust is released near the ground and surface features often capture the dust near its source
- As much as 50-90% may be captured locally. (More on this later….)

Primary Carbon in PM2.5

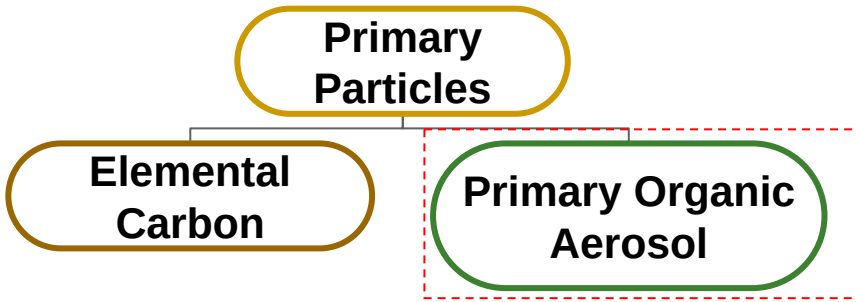


% of PM2.5 Primary Carbon Emissions
(National Emissions ~ 2M TPY)

Carbon Particles

- **Primary & Secondary Particles**

Carbon Particles: Composition & Terminology



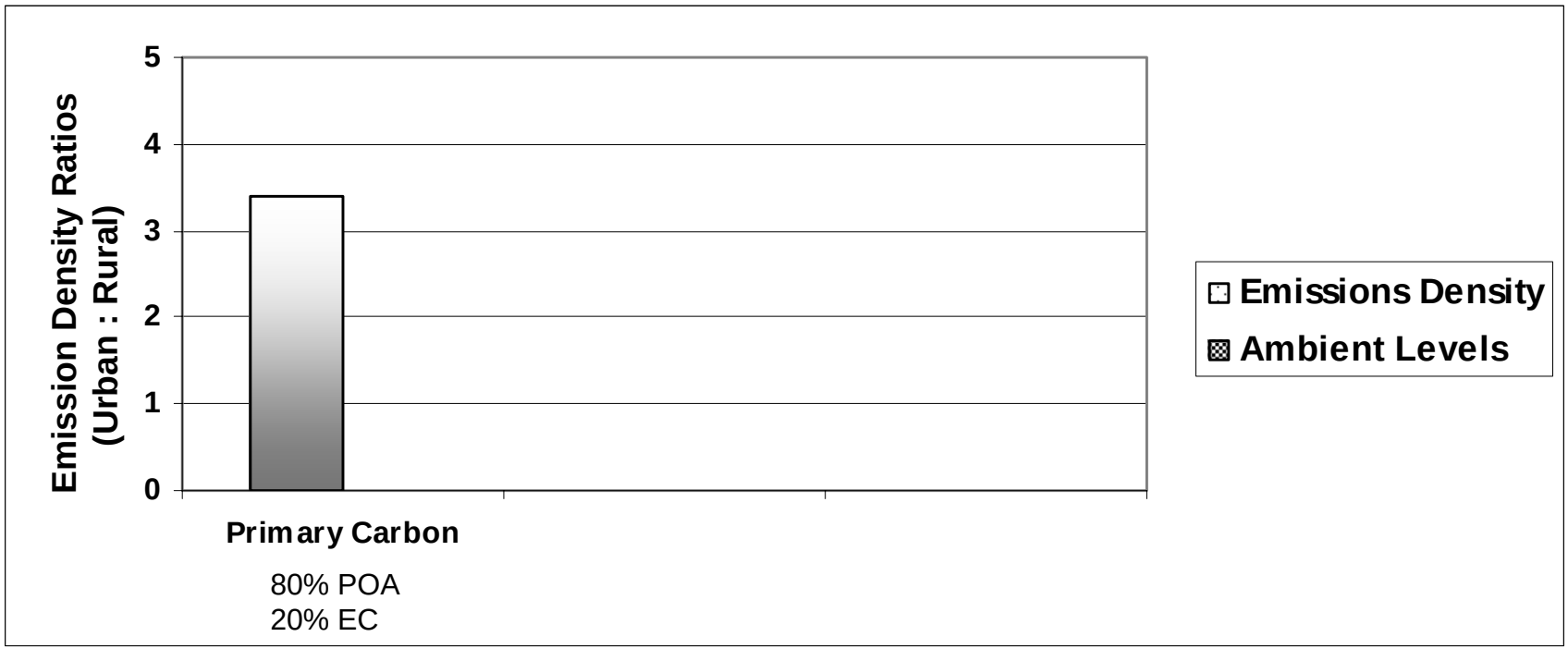
- **Primary Particles**
  - **Elemental (Black) Carbon**
  - **Primary Organic Aerosol (POA)**
  - **Primary Carbon = EC (BC) + Primary Organic Aerosol (POA)**

POA & EC Characteristics of Primary Carbon Emissions

Category	Ratio of organic carbon mass* to elemental carbon mass (average)	Potential range of ratios
Forest Fires	9.9	6 – 28
Managed Burning	12	6 – 28
Agricultural Burning	12	2.5 – 12
Open Burning - Debris	9.9	
Non-road Diesel Engines & Vehicles	**0.4**	**0.4 – 3**
On-road Diesel Vehicles	**0.4**	**0.4 – 3**
Trains, Ships, Planes	**0.4**	**0.4 – 25**
Non-road Gas Engines & Vehicles	14	0.25– 14
On-road Gas Vehicles	4.2	0.25 – 14
Fugitive Dust - Roads	22	3 – 65
Woodstoves	7.4	3 – 50
Fireplaces	7.4	3 – 50
Residential Heating - Other	26	
Commercial Cooking	111	13 – 111

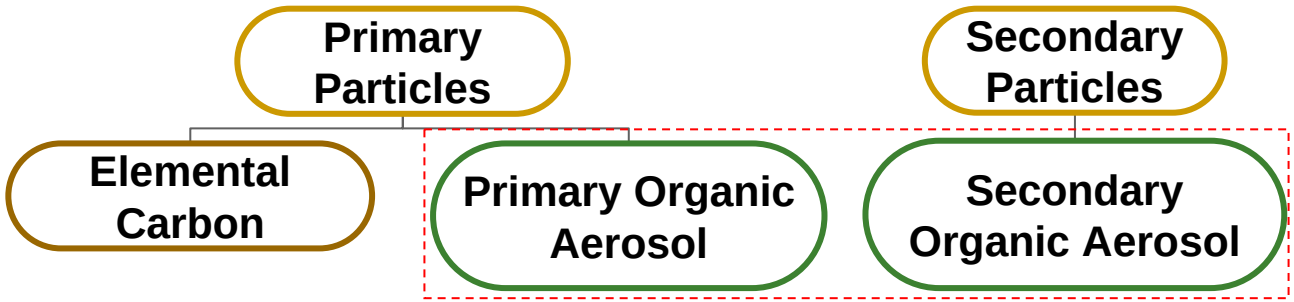
Overall POA = 80% of Primary Carbon EI (20% is EC)

Comparison of Emission Density Ratios (Urban~Rural) ~ Primary Carbon Emissions in Eastern US



Primary Carbon emissions are concentrated in *Urban Areas* in the Eastern US

Carbon Particles: Composition & Terminology



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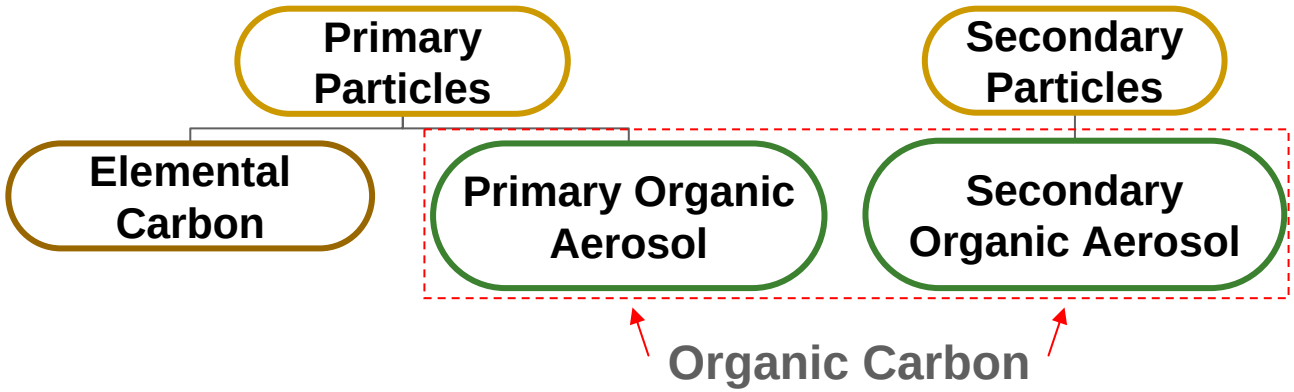

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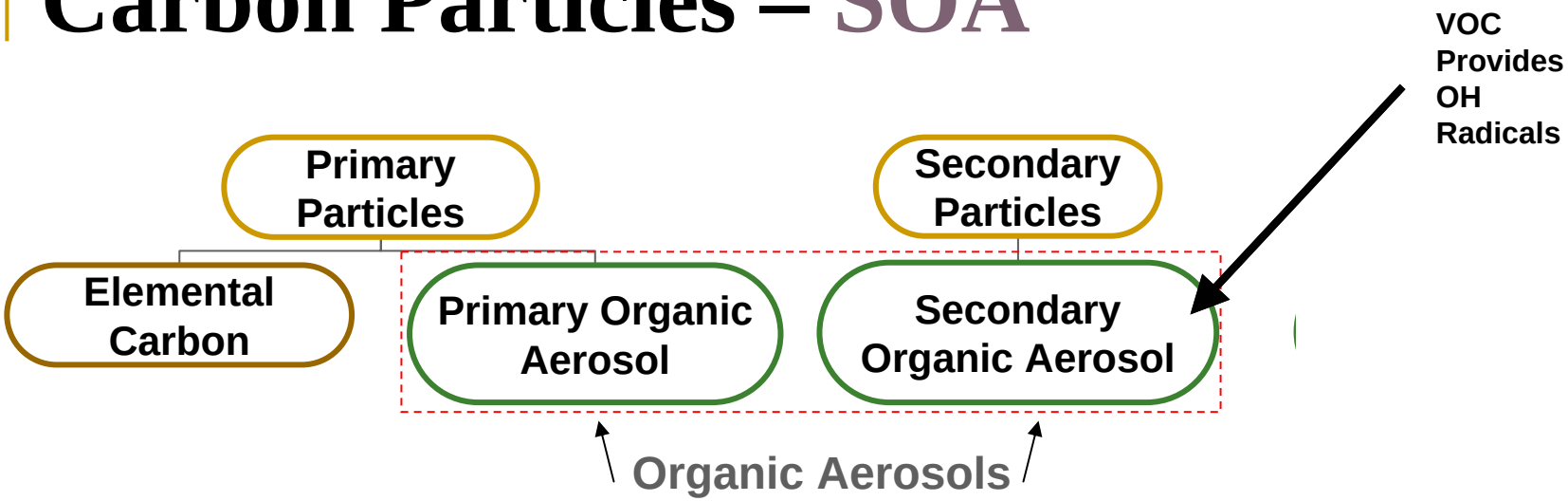
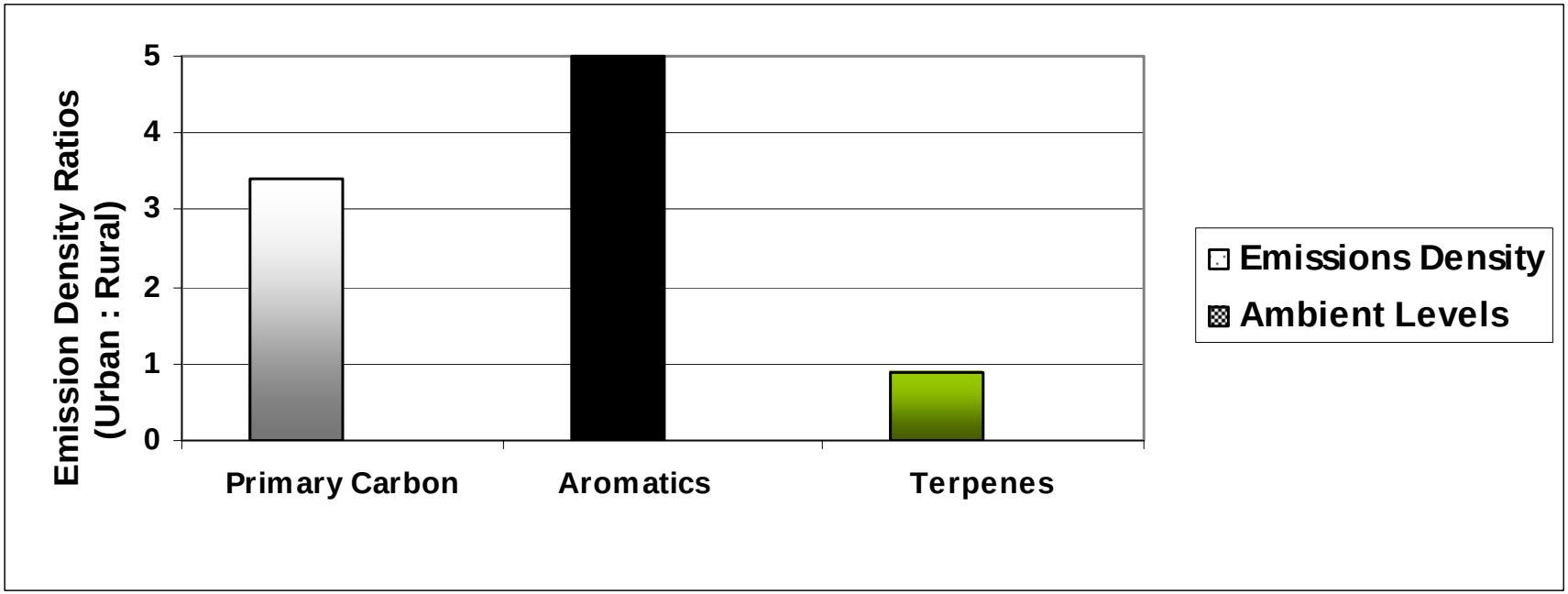
- **Secondary Particles**
  - **Secondary Organic Aerosol (SOA)**
- **Organic Carbon = POA & Secondary Organic Aerosols**

Carbon Particles – SOA



- SOA formed in atmosphere from VOC's
- Lighter VOC's provide the oxidants (OH)
- Heaviest organic gases may condense to form OC
  - Condensibles considered Primary ~ Not SOA
- Acidic particles may increase SOA formation
- Aromatics & Terpenes provide the reactants

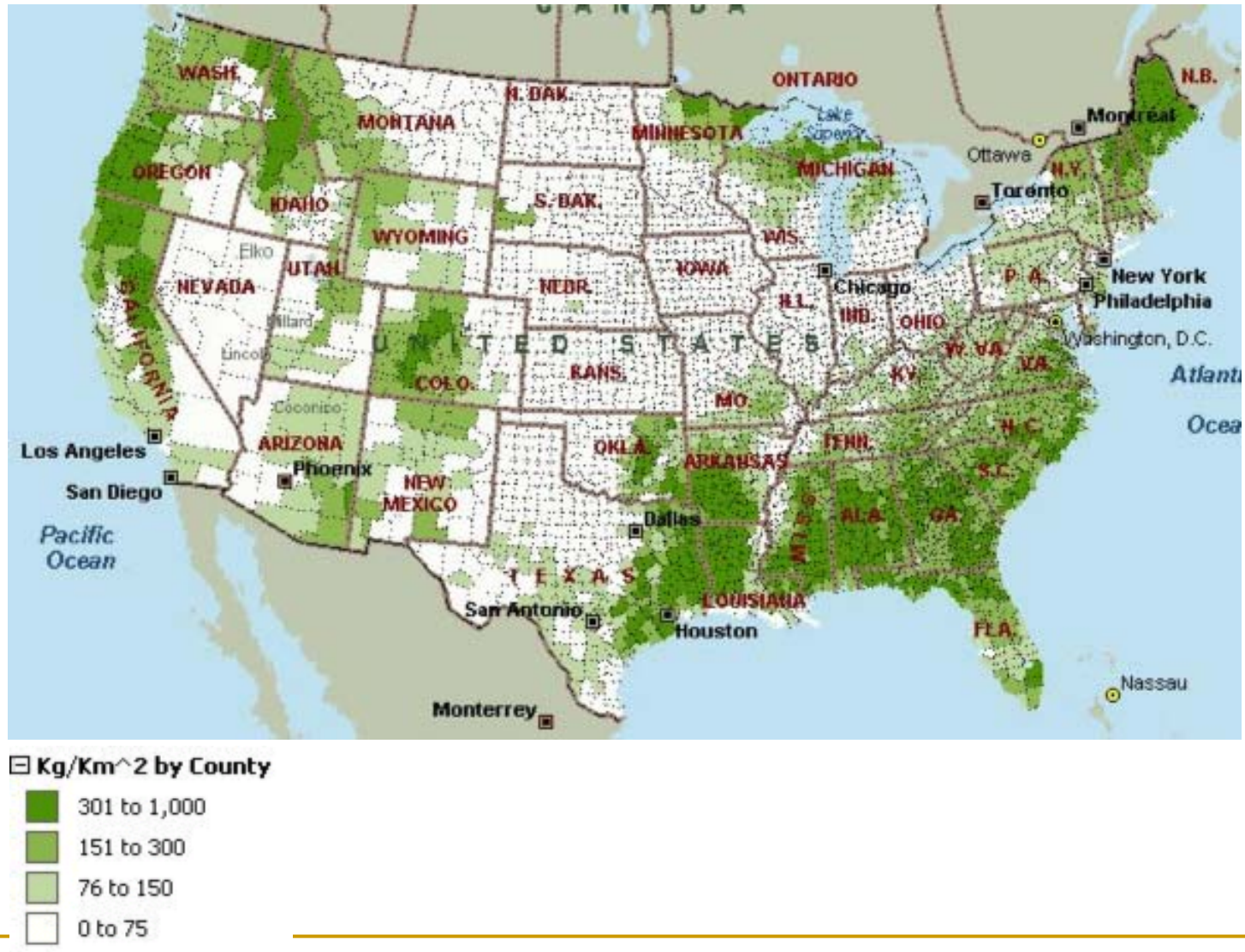
Comparison of Emission Density Ratios (Urban~Rural) ~ Primary Carbon vs Precursor Emissions



	Primary Carbon	Aromatics	Terpenes
	80% POA 20% EC	70% Mobile	Biogenic
Emissions:	**2.2M tpy (Ann)**	**3.7 M tpy (Ann)**	**.35 M tpy (July)**

In East, Aromatics are concentrated in urban areas ~ NOT true for Terpines

Monoterpene Emission Densities by County, kg/m2: - July



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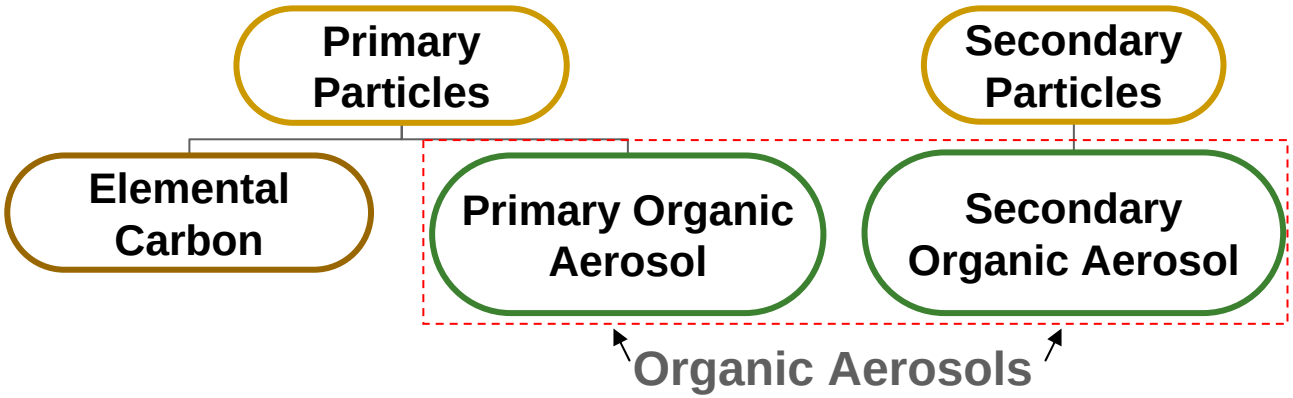
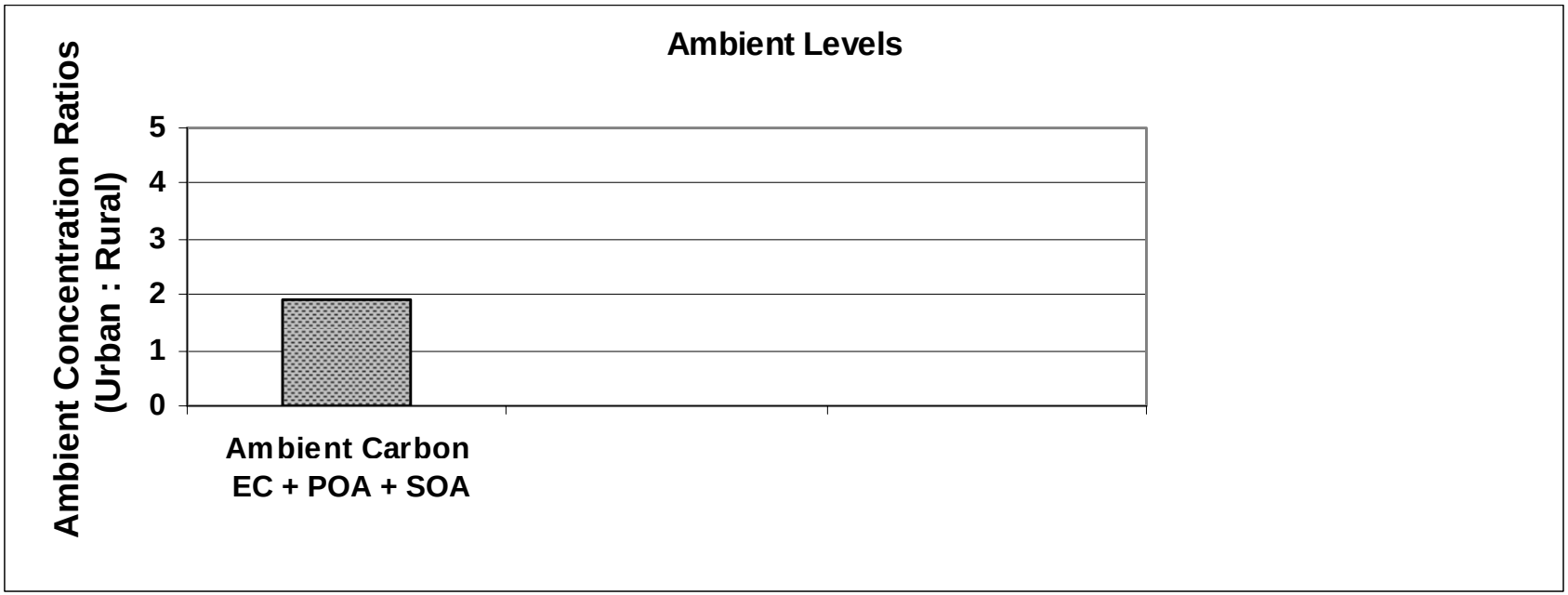


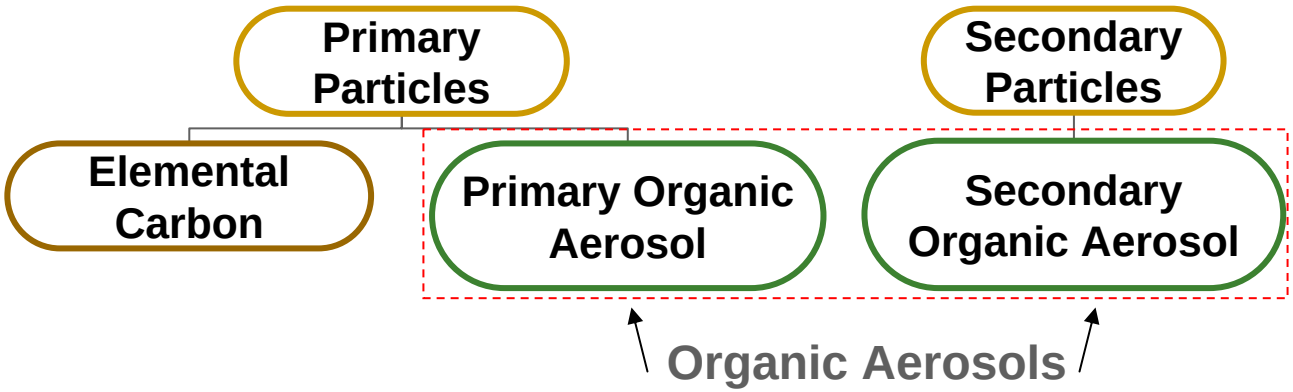
Compound	VOC Precursor – Chemical Formula	Description
VOC (provides free radicals)	C1 – C6 (formaldehyde – hexane)	Promotes O3 and SOA formation by providing oxidizing free radicals (OH)
Precursor to secondary organic aerosol (SOA)	C7 – C15 (toluene, xylene, biogenic terpenes, etc.)	Precursor that reacts with oxidizing agents to produce secondary aerosols. SOA formation increases with higher temperatures.
Primary organic aerosol	C16 +	Direct emissions of organic carbon particles or heaviest organic gases which condense as liquids onto existing particles (e.g. from combustion sources, meat cooking, etc.)

Urban Excess of Ambient Carbon in Eastern US (Ambient Carbon = EC + POA + SOA)



- What we breathe is comprised of EC, POA & SOA
- Ambient Carbon is 2x Higher in Urban Areas
- We call this the Carbon *"Urban Excess"*

Carbon Particles – *"Urban Excess"*

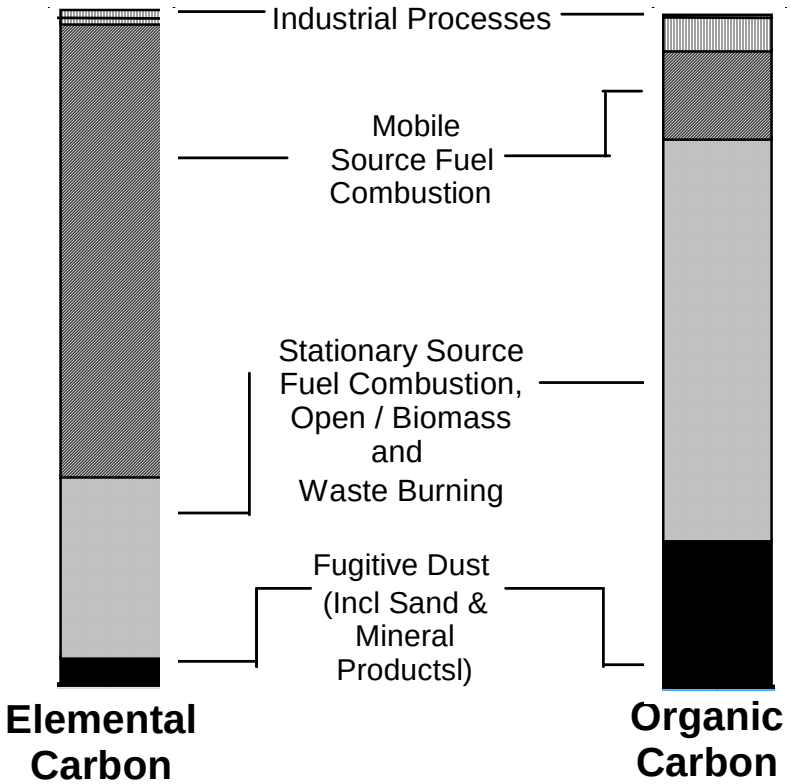


- **Urban vs Rural ~ Total Carbon's *"Urban Excess"***
  - Ambient Measurements ~ 2X higher in Urban Areas
  - Emission Density
    - Primary ~ 3 to 4 X higher in urban areas
    - Aromatics ~ 5 X higher in urban areas
    - Terpines ~ emissions density is flat

PM2.5 Primary Emissions Sources - Summary

Directly Emitted (Primary) PM2.5

Emisson Sources of Carbonaceous & Crustal Materials



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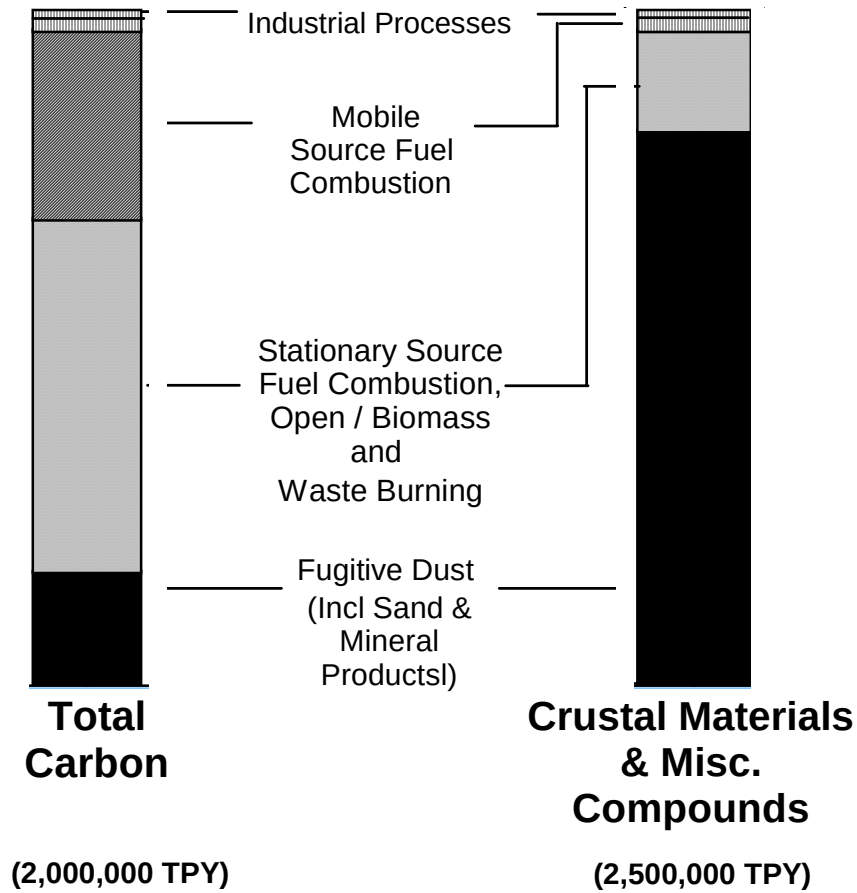

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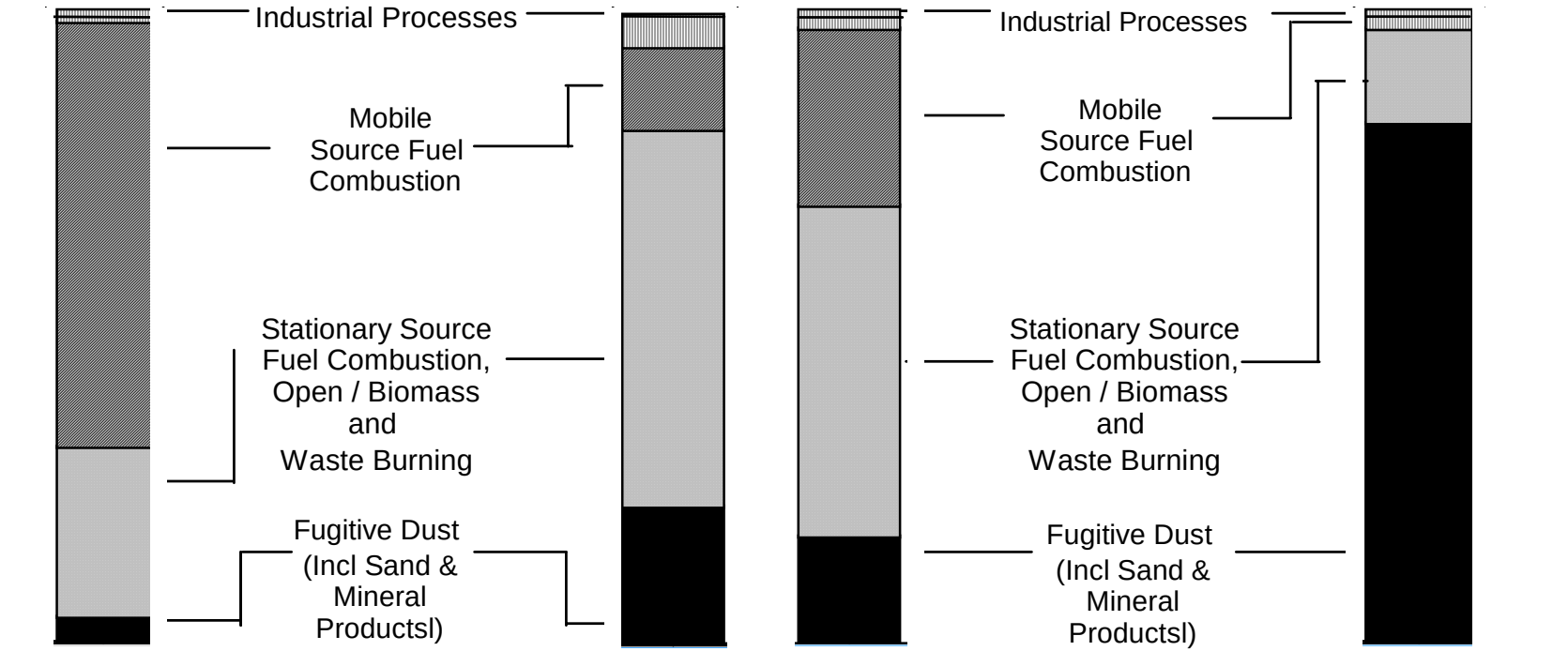


PM 2.5 In Ambient Air - A Complex Mixture

Review of Precursor Interrelationships

Secondary Organics

- VOC from Vegetation (Terpenes)
  - Relatively fast reaction
- VOC from Mobile Sources (Aromatics)
  - Slower than Terpenes
- Reducing Aromatics >> lower SOA

Ammonium Sulfate

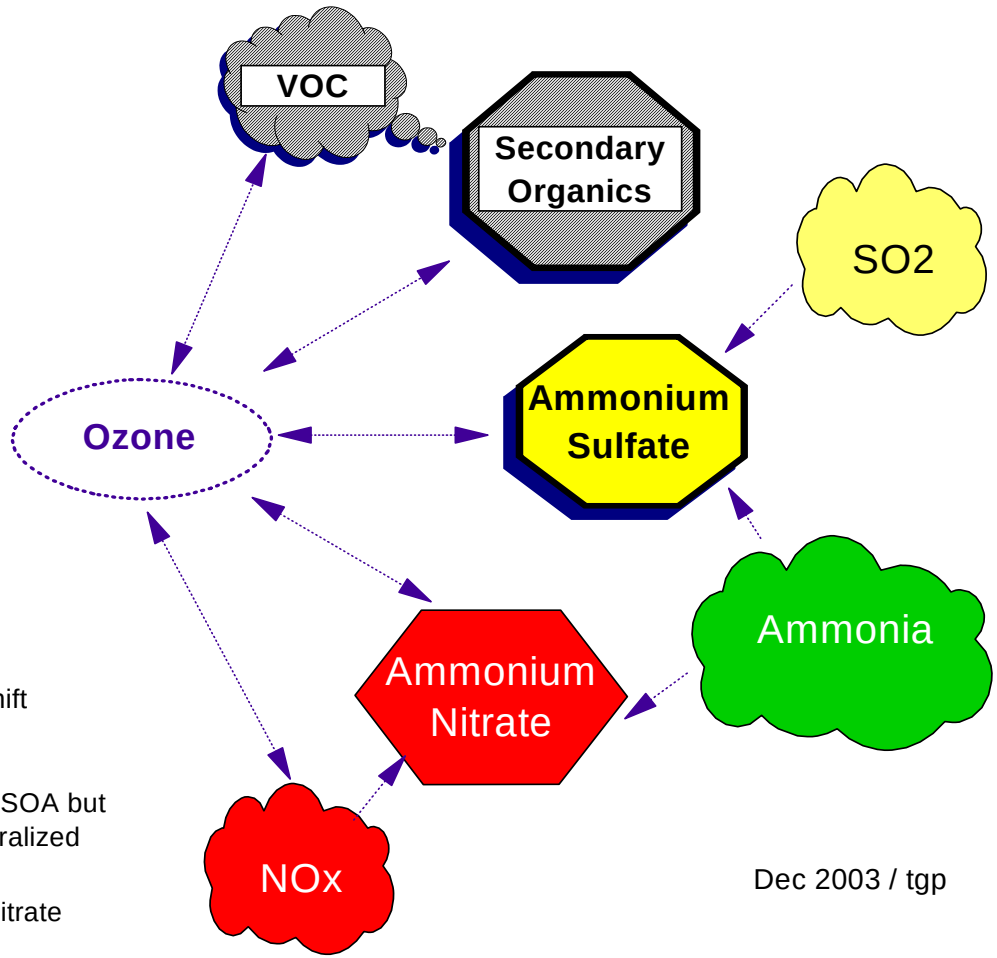
- SO_2 from Sulfur in Fuels
- Compared to Ozone:
  - Sulfate forms & deposits more slowly
- If insufficient Ammonia ~
  - Ammonium bisulfate or
  - Sulfuric acid
- Reducing SO_2 >> lower Ammonium Sulfate

Ammonium Nitrate

- NOx from fuel combustion
  - Relatively fast reaction
- If insufficient Ammonia ~
  - Sulfate formed before nitrate
- Higher temperatures, lower rH >> Equilibrium shift
  - Less nitrate - more nitric acid
  - Sampling losses
- Reducing NOx **may** reduce Nitrates, Sulfates & SOA but outcomes very complicated, cannot be generalized

Ozone

- Generally, less Ozone >> less SOA, Sulfate & Nitrate



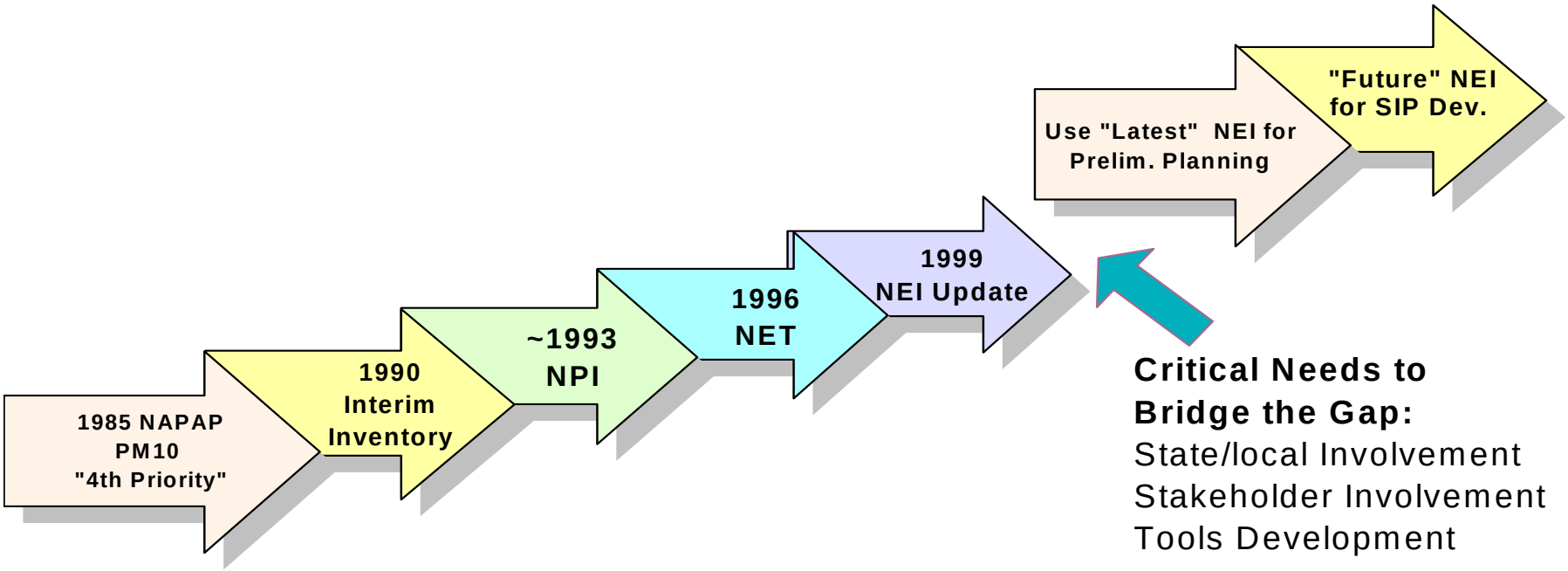
Dec 2003 / tgp

PM is Complex -- Any Questions ?

Session II
The NEI & Emission Inventory Tools

- What is contained in the NEI
- Emissions Inventory Preparation Tools
- Emissions Processing
- Process-based Emissions Models

Evolution of EPA's National Emission Inventory



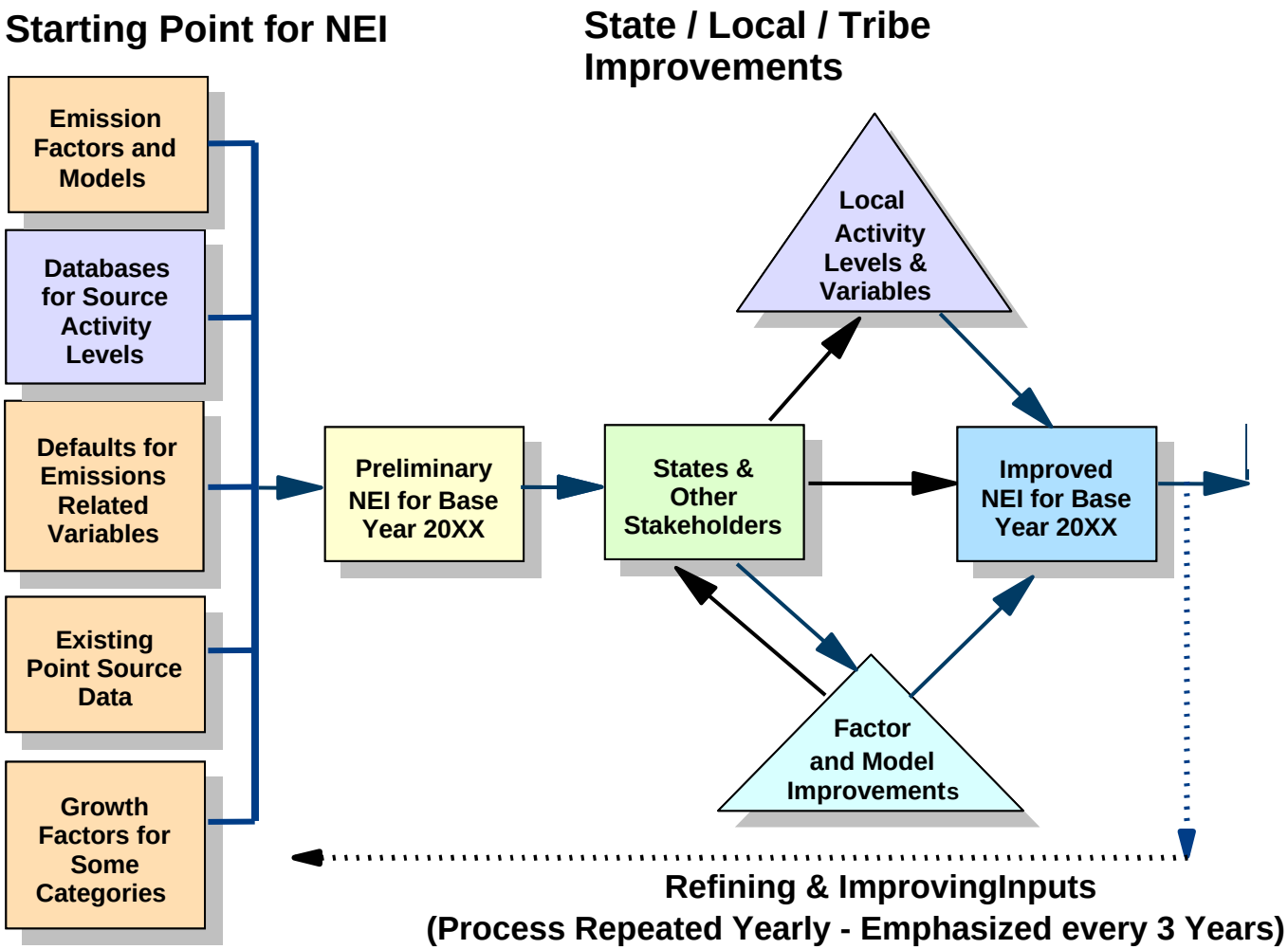
Critical Needs to Bridge the Gap:
State/local Involvement
Stakeholder Involvement
Tools Development

NAPAP - National Acidic Precipitation Assessment Program
NPI National Particulate Inventory
NET National Emission Trends Inventory
NEI Merger of NET and Nat'l Toxics EI

What Info is Contained in the NEI ?

- **Nat'l tabulation of emissions of PM2.5, SO2, NOx, Ammonia and VOC.**
  - Point sources by Lat-long: 52,000 facilities, each containing multiple emission points.
    - Over 4500 types of processes represented
    - Available CEM data
  - Area & Mobile by County: 400 categories of Highway & Non road Mobile and over 300 categories of Area sources
- **Annual emissions, start / end dates, stack parameters**
- **Estimates for each year (some years "grown")**
- **Also, in the NEI**
  - HAPs emissions for over 6000 types of processes
- **Currently Available:** 1999, 2000, 2001, 2002 v1

NEI Development ~ Cooperative, Iterative



Inventory Preparation Tools

- **Emission Factors & Activity Data**
  - (~ 20,000 factors in FIRE)
  - Processes vary over time ~ Factor representiveness issue

Inventory Preparation Tools

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  - (~ 20,000 factors in FIRE)
  - Processes variable ~ Factor representiveness is an issue
- **Emissions Models**
  - Tanks
  - Non-Road
  - Others

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- **Emission Factors & Activity Data**
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- **Emissions Models**
  - Tanks
  - Non-Road
  - Others (integrated with emissions processing)
- **Spatial Characterization & Locator Aides**
  - GIS
  - GPS
  - Satellites

Inventory Preparation Tools

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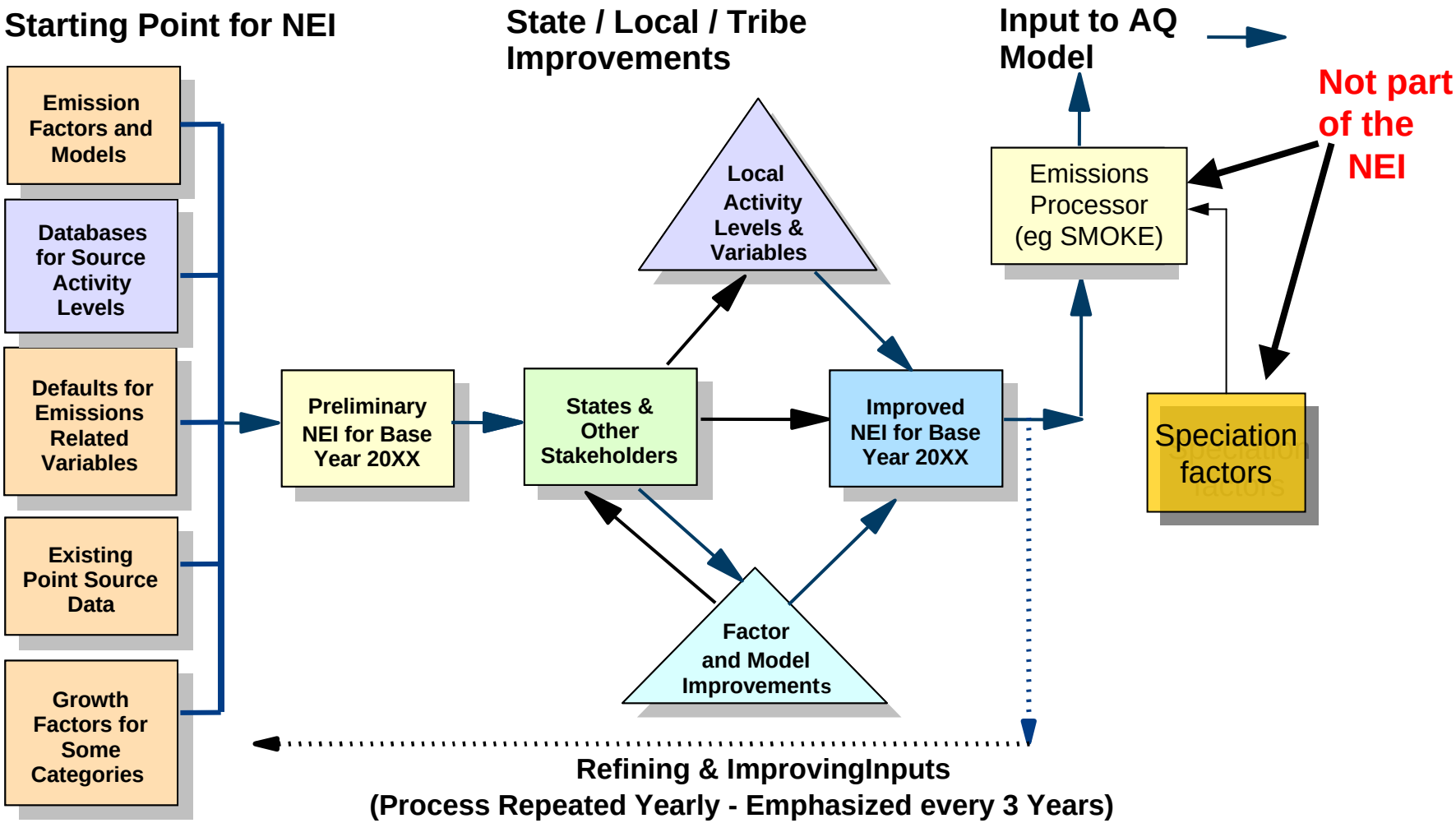
- **Spatial Locator Aides**
  - GIS
  - GPS
  - Satellites
- **Emissions Processing, including Speciation**

NEI Development ~ Cooperative, Iterative



Overview of Emissions Processing

- **Processors include:**
  - SMOKE, EPM, CONCEPT
- **Processor output**
  - Gridded, hourly emissions file
  - Speciation of Primary Emissions (EC, Organics, SO4, Nitrates)
  - Model-ready
- **Processor inputs**
  - Annual, county-level area source EI
  - Annual point source data (except for CEM data)
- **Alternative Input files from:**
  - CEM database
  - Process-based emissions models (new approach)
- **Processor contains default factors & profiles, including:**
  - County-to-Grid Allocation Factors
  - Temporal Allocation Profiles (hourly & seasonal)
  - Speciation Profiles

Speciation *of* PM2.5 & VOC

- **EC, POA, *Primary* Sulfate, *Primary* Nitrate, PM "Other"**
  - Derived *within the Emissions Processor* from PM2.5 using speciation profiles
  - NOT part of the NEI
- **Current Issues**
  - EC – POA Split, carbon analysis methods
  - OC – POA compound adjustment
  - Speciation of **PM "Other"** into Crustal, Other
- **Updating of Speciation Database & Profiles**
  - EPA-ORD / Pechan project
  - Updates for PM & VOC by late summer 2005 (MS Access)
  - 3 to 4 times more profiles than in Speciate 3.2
  - Also, over 1000 new species included in the new profiles
  - Work underway to develop Speciation Profiles – cross ref'd to SCCs
  - New database also very useful to Receptor Modelers
  - Website / users forum being established
    - Contact: beck.lee@epa.gov

Inventory Preparation Tools

- **Emission Factors & Activity Data**
  - (~ 20,000 factors in FIRE)
  - Processes vary over time ~ Factor representiveness issue
- **Emissions Models**
  - Tanks
  - Non road
  - Others
- **Spatial Locator Aides**
  - GIS
  - GPS
  - Satellites
- **Emissions Processing**
- **Process-based Emissions Models**

Process-based Emissions Models

- **Space- & time-** sensitive emissions reflective of real time conditions, e.g.,
  - wind, temperature,
  - RH, vegetation types,
  - soil type & moisture
- **Linkages:**
  - MM5,
  - GIS coverages,
  - Emission algorithms
- **Currently** ~ BEIS3, On road (optional)
  - No other categories currently linked to real time conditions
  - Model speed is an issue with the mobile models

Process-based Emissions Models

- Process-based emission model ***needs*:**
  - **Ammonia** (fertilizer application, animal husbandry, removal)
  - **Fugitive Dust** (wind, unpaved roads, construction, tilling, removal)
  - **Wildland Fires** (fuels, fuel consumption, plume rise)
  - **Residential Wood Burning ?**
  - **Evaporative Loss**
  - **Others ?**
- Stay tuned ~ More discussion later in the day

Status of Process-based Emissions Models (Integrated w/ Emissions Processor)

- **Biogenics** (always integrated w/ EP)
- **On-Road** (optional integration w/ EP)
- **More info later today on Status of:**
  - **Ammonia** (under development - WRAP)
  - **Wildland Fire** (under development – EPA/ORD)
  - **Windblown Dust** (under development - WRAP)
  - **Other Fugitive Dust** (on hold)

Inventory Preparation Tools

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- **Emissions Models**
  - Tanks
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  - Others
- **Spatial Locator Aides**
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  - GPS
  - Satellites
- **Emissions Processing**
- **Process-based Emissions Models**
- **Receptor Models**
  - Inventory refinement, bounding uncertainties
    - Fossil vs Contemporary Carbon
    - Gas vs diesel
    - Cold starts, smokers

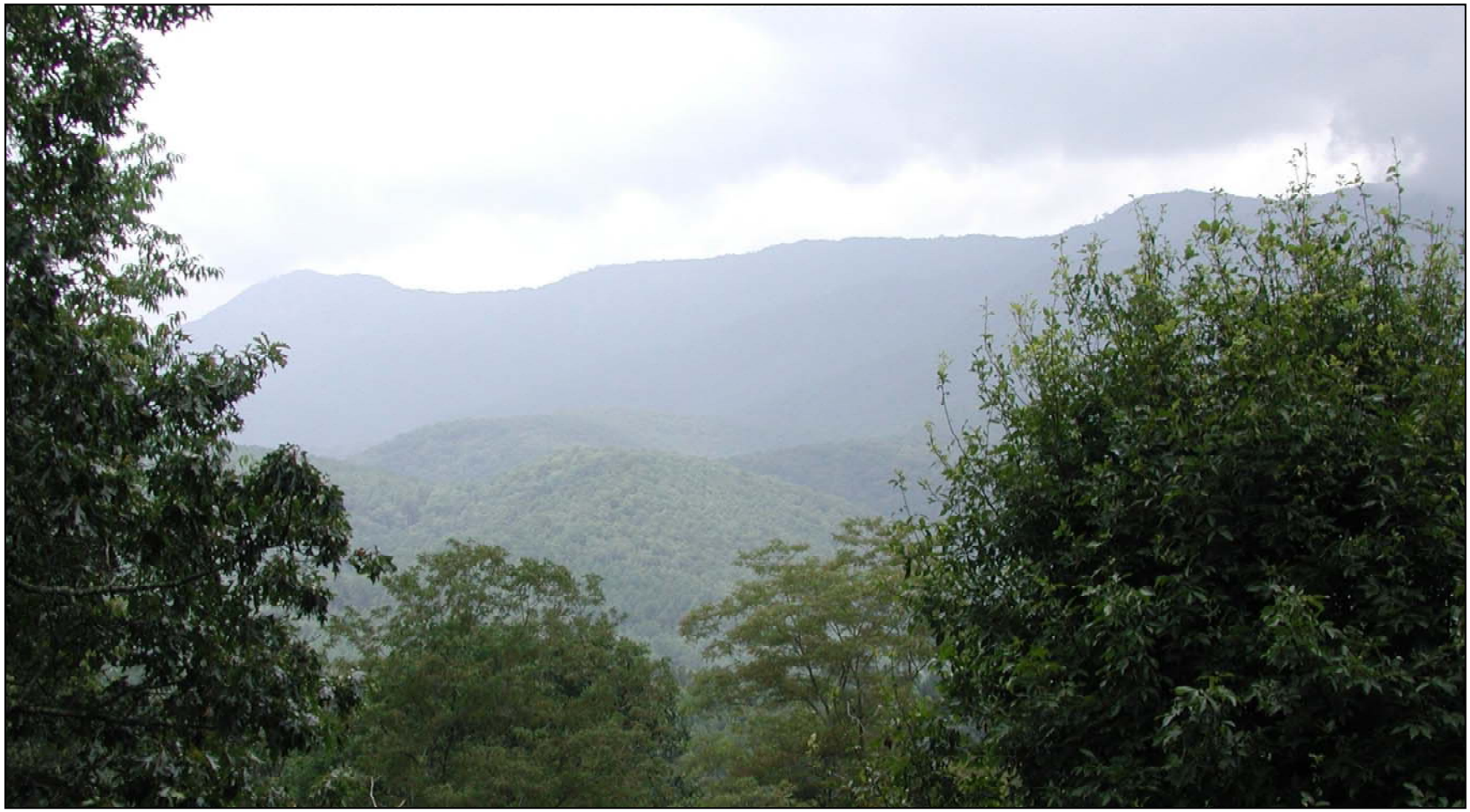
Summary of Key Issues in PM2.5 EI

- **Near-source Removal processes**
  - Crustal Materials
- **Spatial & Temporal Allocation**
  - County to grid; Annual to daily, hourly
- **Speciation Issues**
  - Carbon ~ EC / OC Split & OC to Organic Aerosol Conversion
  - PM "Other"
- **Receptor Models**
  - Carbon ~ Fossil vs Contemporary; Gas vs Diesel; Smokers; Cold Starts
- **Representativeness of Emission Factors**
  - Especially Industrial Processes
  - Transient, Cyclic & Atypical Operation
- **Process Models & "*real time*" Effect of Meteorology, Climatology**
  - BEIS, Wildland Fires, Windblown Dust, Ammonia

Specific PM2.5 Categories Generally Needing Input from Federal / State / Local / Tribes

- **Wildland Burning**
  - *Forests, Rangeland & especially private & State / tribal burners*
  - *(acreages burned, fuel loadings for largest fires, timing)*
- **Residential Open Burning**
  - *Household Waste, Yard waste (volumes & burning practices)*
  - *Regulations & their effectiveness, local surveys of burn activities)*
- **Construction Debris & Logging Slash**
  - *Regulations & their effectiveness, local surveys of burn activities*
- **Agricultural Field Burning**
  - *Acreages, fuel loadings, timing*
- **Residential Wood Combustion**
  - *Fireplaces, Wood Stoves*
  - *local surveys of fuel burned, fireplace vs wood stoves, local regulations*
- **Specific industrial process sources (as needed locally)**
- **Fugitive Dust as indicated by local conditions**

Questions ?



Point Sources of Fine PM & NH3

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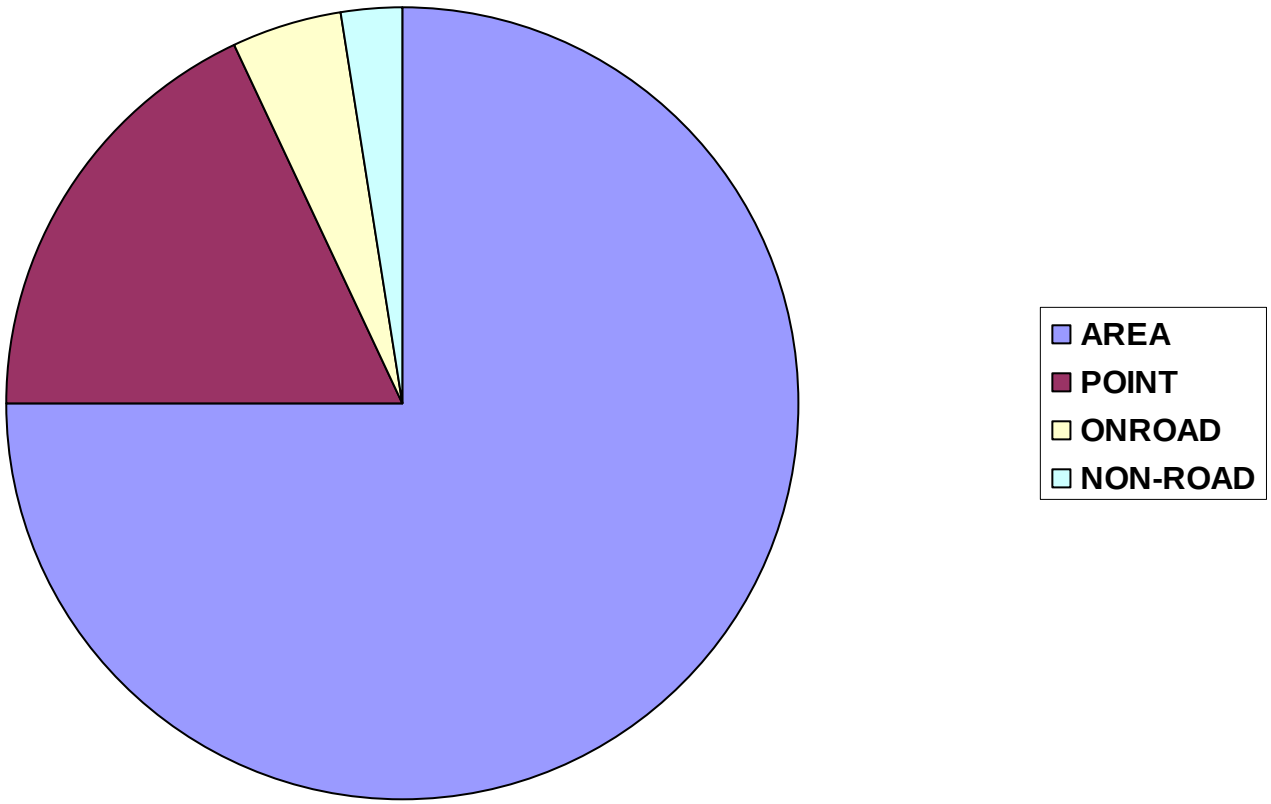
How Do I Define a Point Source of PM Fine or NH_3 Emissions?

- Point sources are stationary sources that are included in a point source inventory.
- Criteria for including a stationary source in a point source inventory is either determined by:
  - State, Local, or Tribal regulations or policy; and/or
  - Consolidated Emissions Reporting Rule (CERR)
- Total facility emissions for a given pollutant is usually the criterion for deciding what sources to include in a point source inventory.

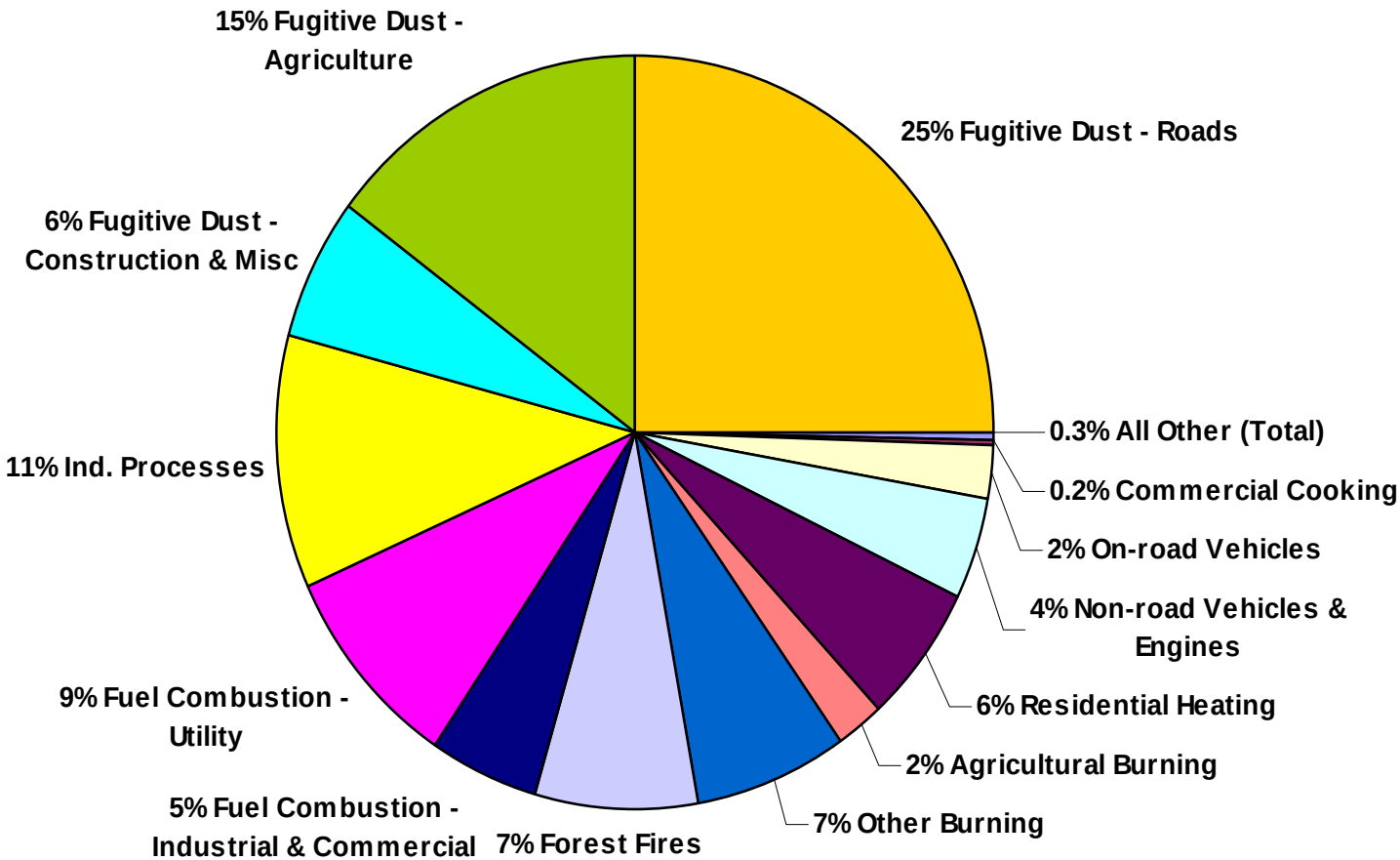
PM25-PRI, 1999 NEI FV3



Overview

- Point sources of:
  - PM & NH3
- Definitions of forms of PM for the NEI
  - Filterable vs Primary; Condensible
- Verification of the form of PM in your emissions inventory (EI)
- Point and area source EI overlap issues

PM-2.5 Emissions in 2001 EI



Sources of PM Emissions

- Fuel Combustion
- Industrial Processes
  - Pulp and Paper
  - Petroleum Refinery
  - Cement Manufacturing
  - Fiberglass Manufacturing
  - Etc.

Sources of NH_3 Emissions

- Industrial NH_3 emissions can be placed into 3 broad categories related to the nature of the emissions source:
  - Emissions from industrial processes
  - Use of NH_3 as a reagent in NO_x control
  - Refrigeration losses

Reference

- **Estimating Ammonia Emissions From Anthropogenic Nonagricultural Sources**
  - EIIP document
  - EI guidance for sources such as Industrial refrigeration, POTW's, composting, Bakeries, pulp&paper, landfills, portland cement, and combustion of fossil fuels
  - http://www.epa.gov/ttn/chief/eiip/techreport/volume03/eiip_areasourcesnh3.pdf

Sources of NH_3 Emissions (Cont'd)

- Examples of industrial processes that emit NH_3 include:
  - Combustion sources
  - Ammonium nitrate & ammonium phosphate production
  - Petroleum refining
  - Pulp and paper production
  - Beet Sugar Production
- These industrial processes represent the more significant emitters of NH_3 in 2000 Toxics Release Inventory (TRI) http://www.epa.gov/tri/tridata/index.htm)

PM Definitions for the NEI

- **Filterable (PM-FIL):**

  Particles directly emitted as a solid or liquid at stack or release conditions and captured on the filter of a stack test train. Filterable PM may be $PM_{2.5}$ or PM_{10}.

- **Condensible (PM-CON):**

  Material that is vapor phase at stack conditions, but condenses and/or reacts upon cooling and dilution in the ambient air to form solid or liquid PM immediately after discharge from the stack. EPA considers condensible PM = $PM_{2.5}$.

- **Primary (PM-PRI) = (PM-FIL) + (PM-CON):**

  All particles directly emitted from a stack or an open source.

- **Secondary (PM-SEC):**

  Particles that form through chemical reactions in the ambient air well after dilution and condensation have occurred. Secondary PM formed downwind of source.

  Precursors to **PM-SEC** are in the NEI: SO2, NOx, NH3, VOC

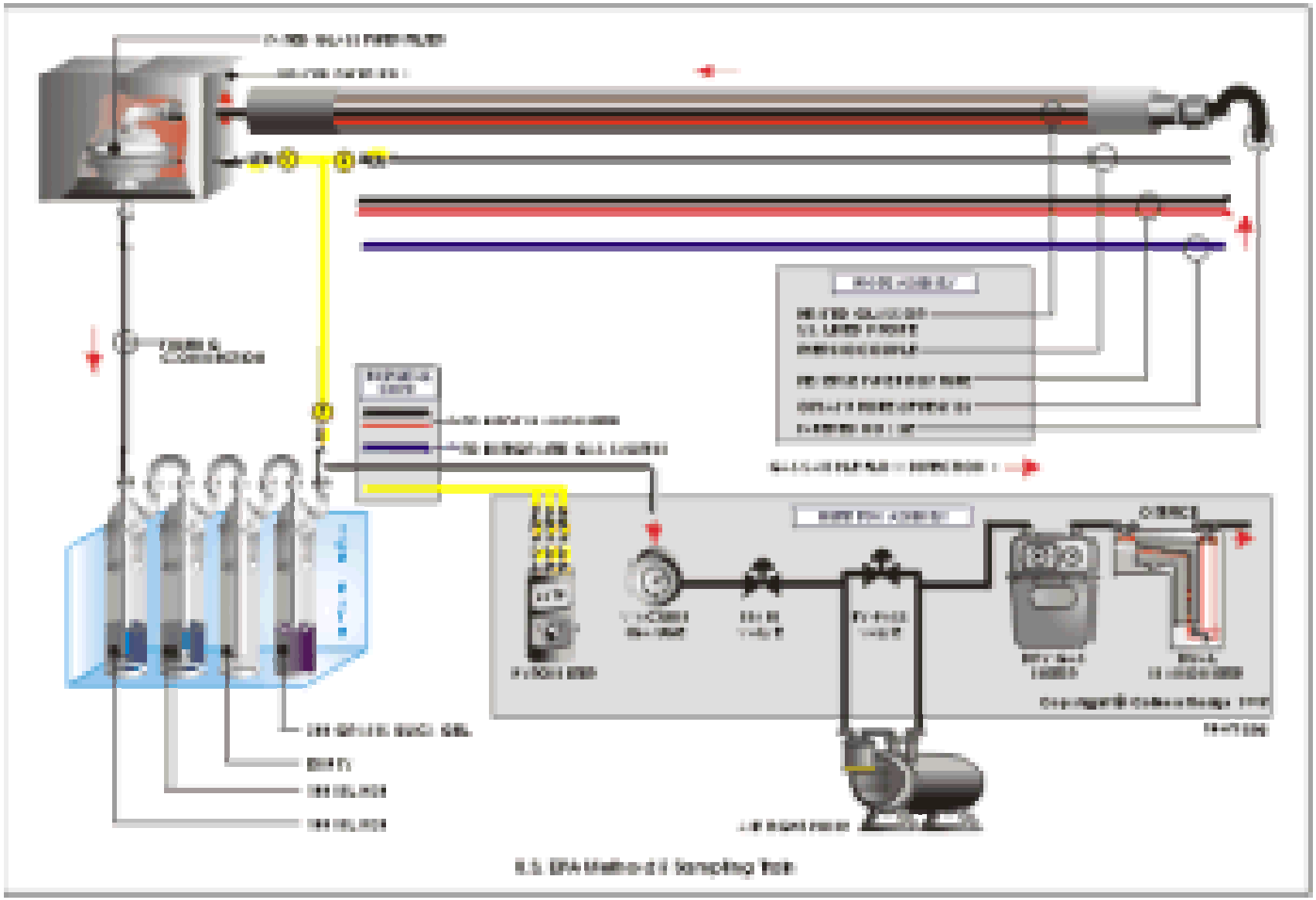
  PM-SEC should **NOT** be reported in the emission inventory.

Sources of Filterable versus Condensible Emissions

- Combustion sources typically emit both filterable and condensible PM emissions
  - Boilers
  - Furnaces/kilns
  - Internal combustion engines (reciprocating & turbines)

Sources of Filterable versus Condensible Emissions

- Fugitive dust sources emit filterable emissions only
  - Storage piles
  - Unpaved roads at industrial sites



How Do I Identify Point Sources of PM Fine and NH_3?

- EIIP Point Source Guidance (Volume II)
  - Table 1.3-1 list potential point sources for each criteria pollutant (http://www.epa.gov/ttn/chief/eiip/techreport/volume02/ii01_may2001.pdf)
- AP-42 (http://www.epa.gov/ttn/chief/ap42/index.html)
- Existing Inventories
  - National Emissions Inventory (http://www.epa.gov/ttn/chief/net/)
  - Toxics Release Inventory (TRI) for NH_3 (http://www.epa.gov/tri/)

What to Report to EPA

- EPA can take all forms of PM, but prefer Primary
  - PM25-PRI (or PM25- FIL & PM-CON individually)
    - Note that all PM-CON is assumed to be $PM_{2.5}$ size fraction)
  - PM10-PRI (or PM10-FIL & PM-CON individually)
- If submit other than Primary, then EPA creates PM10-PRI and PM25-PRI records

- EPA does not keep or track “PM” anymore

Implications

- Need to use the NIF 3.0 PM pollutant code extensions that identify the forms of PM (i.e., –PRI, –FIL, or –CON)
- Verify the form of the PM:
  - Emission factors you use to calculate emissions; and
  - PM emissions facilities report to you.
- Update your database management system to record these pollutant codes in NIF 3.0

AP-42 Particle Size Data

- **Provides particle size distribution data and particle-size-specific emission factors**
  - Use AP-42 if source-specific data are not available
    - Use data in chapters for specific source categories first
    - Use Appendix B-1 data next
    - Use Appendix B-2 data last
  - AP-42 chapters not always clear on what source test methods were used to develop particle size data
    - See background documents for AP-42 chapters for details
  - AP-42 available on EPA/OAQPS CHIEF web site
    - http://www.epa.gov/ttn/chief/ap42/index.html

AP-42 Particle Size Data (Cont'd)

- **Appendix B-1 (Particle Size Distribution Data and Sized Emission Factors for Selected Sources)**
  - Based on documented emission data available for specific processes
- **Appendix B-2 (Generalized Particle Size Distributions)**
  - Based on data for similar processes generating emissions from similar materials
  - Generic distributions are approximations
  - Use only in absence of source-specific distributions

Factor Information REtrieval (FIRE) Data System

- Newest version now available
  - Sept 2004 (Version 6.25)

http://www.epa.gov/ttn/chief/software/fire/index.html

PM Calculator

- EPA tool for calculating uncontrolled/controlled filterable $PM_{2.5}$ and PM_{10} emissions using AP-42 particle size distributions
- For point sources only
- Contains 2,359 SCCs with PM_{10} emissions in 1996 NEI
- Limitations
  - AP-42 particle size data not available for many sources; generic AP-42 profiles are used for many source categories
- Available on EPA/OAQPS CHIEF web site
  - http://www.epa.gov/ttn/chief/software/index.html

Point & NonPoint Source Emissions Inventory (EI) Overlap Issues

- For categories included in Point and NonPoint EIs:
  - Must subtract total point activity from total state activity to obtain total nonpoint activity (see EIIP Area source document)

$$\text{Total NP Activity} = \text{Total Activity} - \Sigma\ \text{Total Point Activity}$$

- Example for Fuel Combustion Sources:
  - Point activity: fuel throughput from point source EI survey
  - Total activity: fuel throughput from State/local gov. agencies or U.S. DOE/EIA State Energy Data reports

Point & Area Source EI Overlap Issues (Cont'd)

- Basis of Point Source Subtraction
  - Activity-based calculation is preferred
  - Emissions-based calculation is acceptable when activity is not available:
    - Total source category activity and point activity need to be on same control level (usually uncontrolled)
    - Back-calculation of uncontrolled emissions for controlled processes may overstate uncontrolled emissions

Point & Area Source EI Overlap Issues (Cont'd)

- Geographic level of calculation may affect results:
  - Issue when using surrogate activity data (e.g., employment, housing, population) to allocate total State activity to counties
  - Subtracting county totals may produce negative results due to inaccuracy of allocation method
  - Subtracting State totals less likely to produce negative results at county level
  - Point source adjustments to surrogate allocation data (e.g., employment) should be done if available from point EI survey

Point & Area Source EI Overlap Issues (Cont'd)

- QA/QC Results
  - Review county-level area source estimates for reasonableness
  - Make adjustments based on experience of your agency's personnel:
    - For example, if allocation method places area source activity in a county for which you know there is no activity, exclude the county from your allocation, or
    - If all of a county's activity is covered by the point EI, set the activity for the county to zero.

Point & Area Source EI Overlap Issues (Cont'd)

- Reporting of small point sources in area CERR submittal:
  - If your point EI includes sources with emissions below the CERR point EI reporting thresholds, you may include the emissions for these small sources in the area EI
  - To avoid double counting in the area EI, subtract total point source activity or emissions from total State-level activity or emissions before rolling up emissions for small point sources to be included in your area EI

Reading List

- *Stationary Source Control Techniques Document for Fine Particulate Matter*, EPA/OAQPS, Oct. 1998

  http://www.epa.gov/ttn/oarpg/t1/meta/m32050.html

- *Emission Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) AND Regional Haze Regulations, EPA/OAQPS*

  http://www.epa.gov/ttn/chief/eidocs/eiguid/index.html

- *Introduction to Stationary Point Source Emission Inventory Development*, EIIP Vol. 2, Chapter I, May 2001

  http://www.epa.gov/ttn/chief/eiip/techreport/volume02/index.html

- *How to Incorporate Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates*, EIIP Vol. 2, Chapter 12, July 2000

  http://www.epa.gov/ttn/chief/eiip/techreport/volume02/index.html

Non Point Sources

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April 11, 2005

Overview

- What is the Non Point Sector?
  - What to Report to EPA?
    - Federal reporting requirements
- Resources for Inventory Developers
- What are the Major Sources in the NP Sector?
- How to Estimate Emissions
- EI development approaches

What is the Non Point Sector?

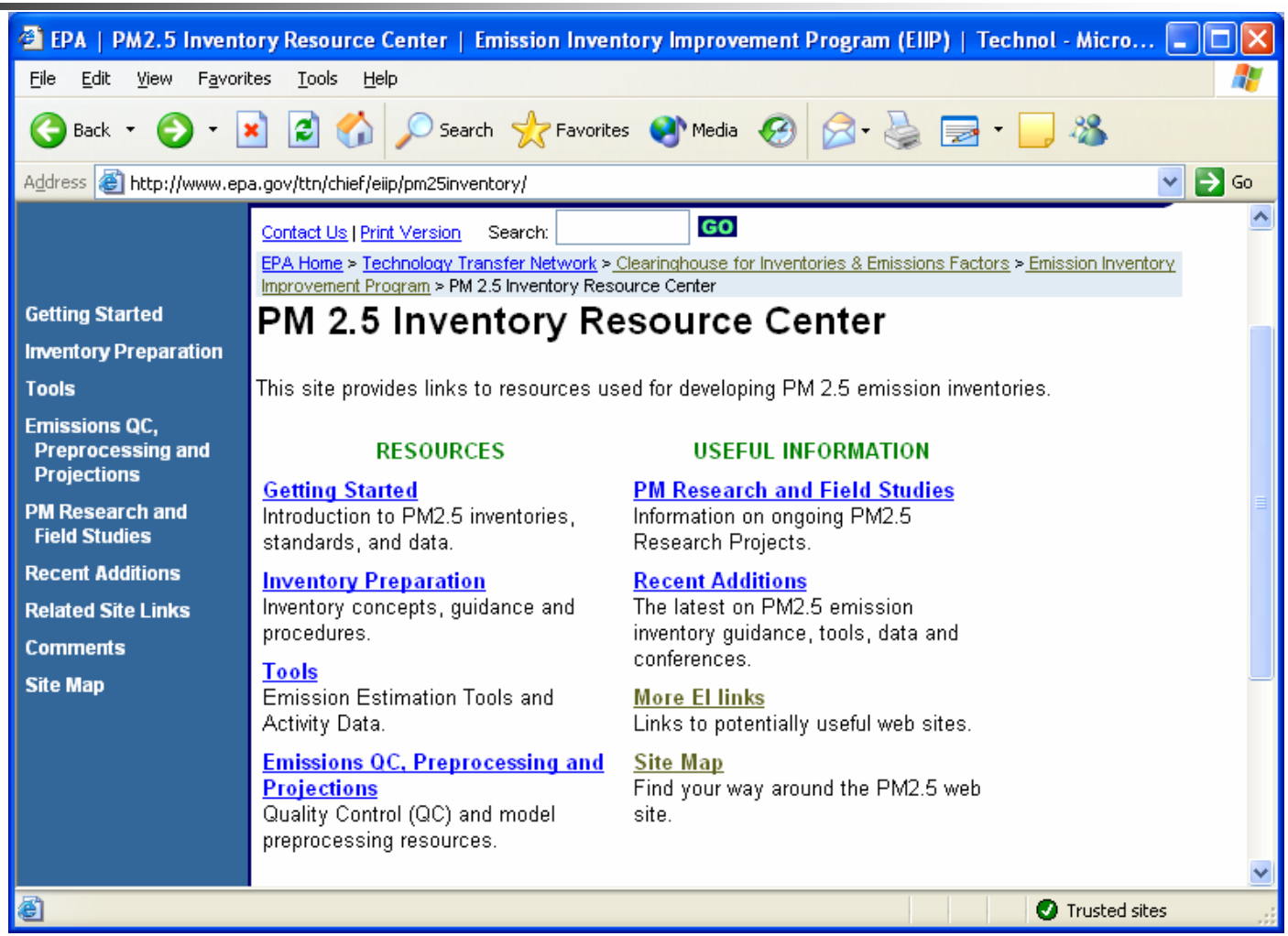
- The non-point source inventory includes stationary sources that are not included in the point source inventory
- Non-point source tend to be small but numerous
  - Commercial & residential fuel combustion
  - Paved & unpaved roads
  - Animal husbandry
  - Fires; wild, prescribed, RWC, construction debris, Ag burning, & open burning of waste
  - Gasoline Service Stations

What to Report to EPA?

Consolidated Emissions Reporting Rule (CERR)

- Must report actual annual emissions/data elements
- Must report non-point sources for entire State triennially (3-year cycle)
- First Reporting for Base Year 2002
  - Inventories due June 1, 2004
  - Criteria Pollutants & Precursors (including PM_{10}, $PM_{2.5}$, NH_3)
- AERR will supercede the CERR

Resources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Getting Started
Inventory Preparation
Tools
Emissions QC, Preprocessing and Projections
PM Research and Field Studies
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Related Site Links
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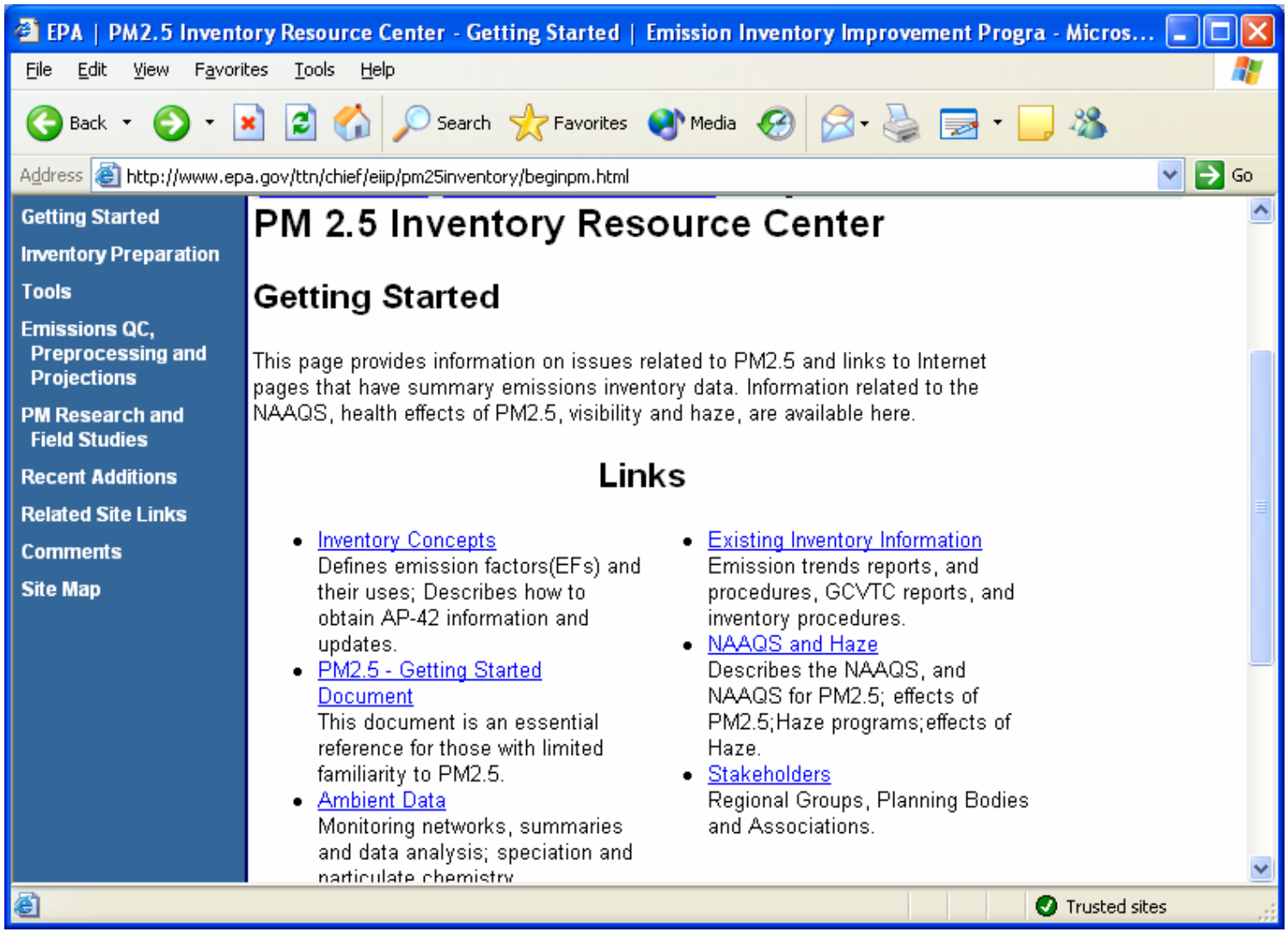
Site Map
PM 2.5 Inventory Resource Center
This site provides links to resources used for developing PM 2.5 emission inventories.
RESOURCES
Getting Started
Introduction to PM2.5 inventories, standards, and data.
Inventory Preparation
Inventory concepts, guidance and procedures.
Tools
Emission Estimation Tools and Activity Data.
Emissions QC, Preprocessing and Projections
Quality Control (QC) and model preprocessing resources.
USEFUL INFORMATION
PM Research and Field Studies
Information on ongoing PM2.5 Research Projects.
Recent Additions
The latest on PM2.5 emission inventory guidance, tools, data and conferences.
More EI links
Links to potentially useful web sites.
Site Map
Find your way around the PM2.5 web site.
Trusted sites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PM 2.5 Inventory Resource Center
Getting Started
This page provides information on issues related to PM2.5 and links to Internet pages that have summary emissions inventory data. Information related to the NAAQS, health effects of PM2.5, visibility and haze, are available here.
Links
Inventory Concepts
Defines emission factors(EFs) and their uses; Describes how to obtain AP-42 information and updates.
PM2.5 - Getting Started Document
This document is an essential reference for those with limited familiarity to PM2.5.
Ambient Data
Monitoring networks, summaries and data analysis; speciation and particulate chemistry
Existing Inventory Information
Emission trends reports, and procedures, GCVTC reports, and inventory procedures.
NAAQS and Haze
Describes the NAAQS, and NAAQS for PM2.5; effects of PM2.5;Haze programs;effects of Haze.
Stakeholders
Regional Groups, Planning Bodies and Associations.
Trusted sites


EPA | PM2.5 Inventory Resource Center - More Links | Emission Inventory Improvement Program (EI - Micros...
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Illinois
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Kentucky
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New Mexico
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North Carolina
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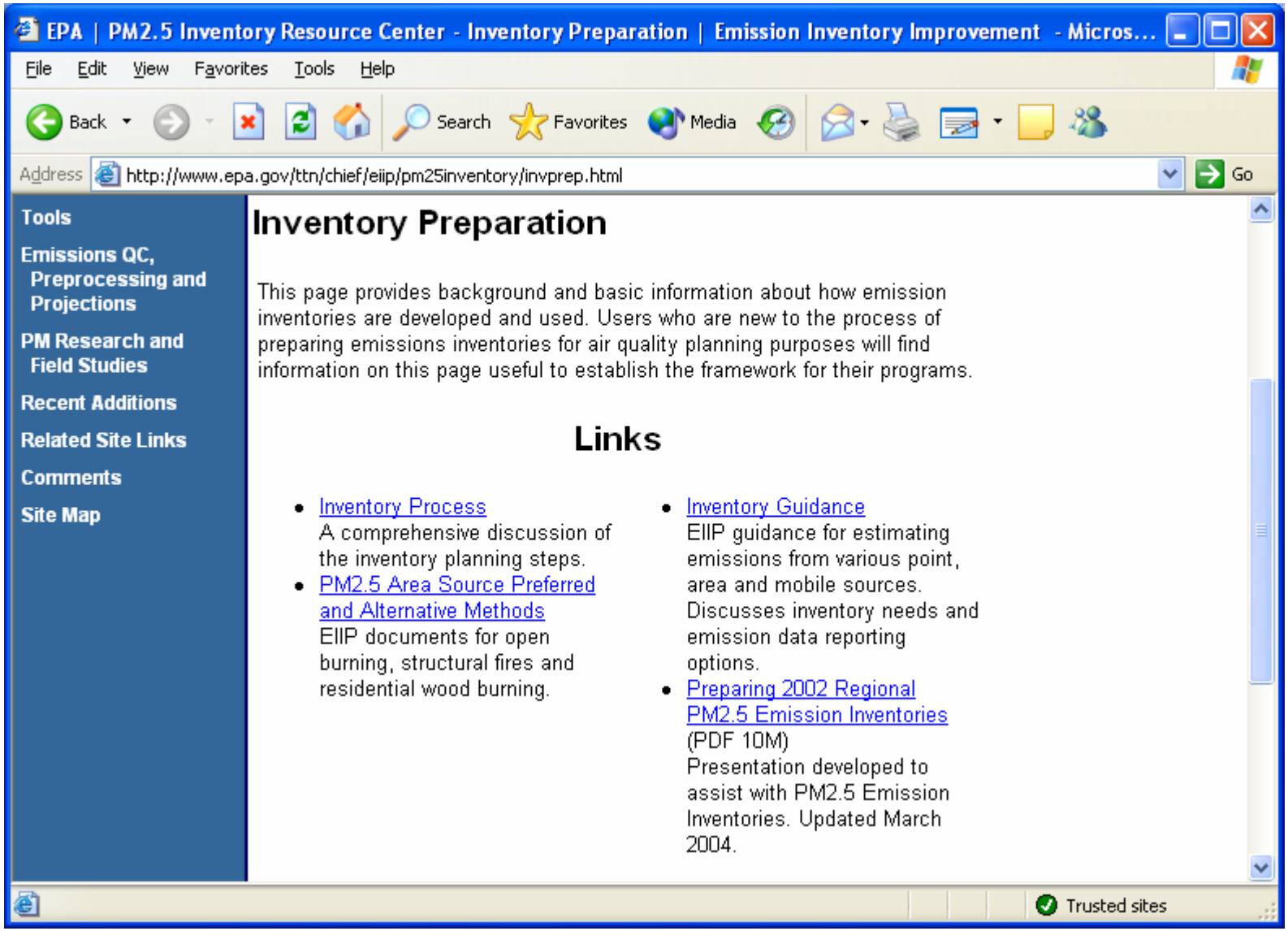
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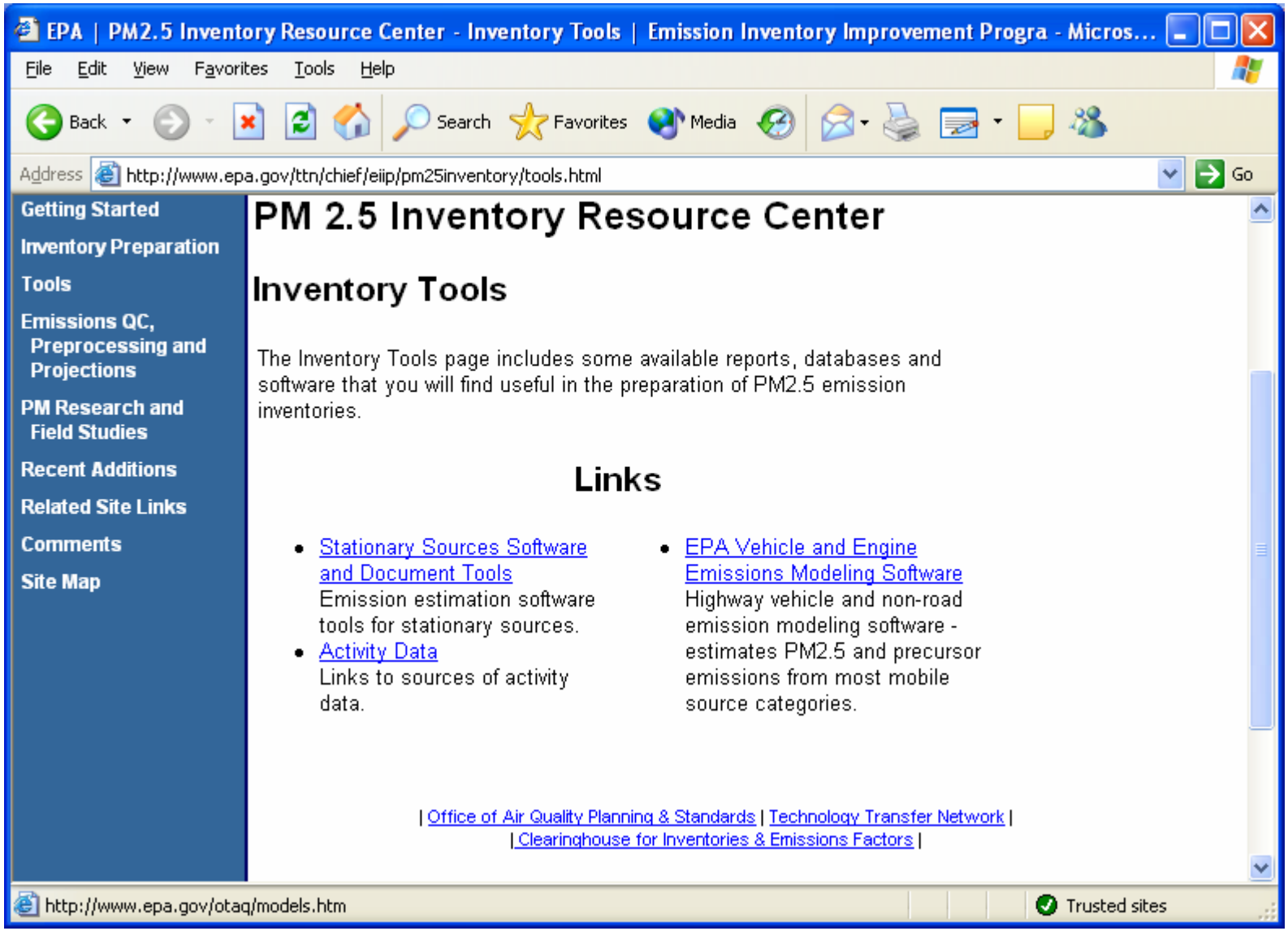
Inventory Preparation
This page provides background and basic information about how emission inventories are developed and used. Users who are new to the process of preparing emissions inventories for air quality planning purposes will find information on this page useful to establish the framework for their programs.
Links
Inventory Process
A comprehensive discussion of the inventory planning steps.
PM2.5 Area Source Preferred and Alternative Methods
EIIP documents for open burning, structural fires and residential wood burning.
Inventory Guidance
EIIP guidance for estimating emissions from various point, area and mobile sources. Discusses inventory needs and emission data reporting options.
Preparing 2002 Regional PM2.5 Emission Inventories (PDF 10M)
Presentation developed to assist with PM2.5 Emission Inventories. Updated March 2004.
Trusted sites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Site Map
PM 2.5 Inventory Resource Center
Inventory Tools
The Inventory Tools page includes some available reports, databases and software that you will find useful in the preparation of PM2.5 emission inventories.
Links
Stationary Sources Software and Document Tools
Emission estimation software tools for stationary sources.
Activity Data
Links to sources of activity data.
EPA Vehicle and Engine Emissions Modeling Software
Highway vehicle and non-road emission modeling software - estimates PM2.5 and precursor emissions from most mobile source categories.
| Office of Air Quality Planning & Standards | Technology Transfer Network |
| Clearinghouse for Inventories & Emissions Factors |
http://www.epa.gov/otaq/models.htm
Trusted sites

Resources

- EIIP - Introduction to Area Source Emission Inventory Development (Volume III)
  - Lists PM fine categories for which EIIP guidance is available - http://www.epa.gov/ttn/chief/eiip/
- AP-42
  - Available on CHIEF web site – http://www.epa.gov/ttn/chief/
- Existing inventories
  - National Emission Inventory (NEI) - http://www.epa.gov/ttn/chief/net/
  - Toxics Release Inventory (TRI) - http://www.epa.gov/tri/

Resources

- EIIP Area Source Guidance (Volume III) for Sources of PM Emissions
- Introduction to Area Source Emission Inventory Development
  - http://www.epa.gov/ttn/chief/eiip/
  - Table 1.2-1 lists potential Non-point sources
- Other Documents
  - Chapter 2: Residential Wood Combustion, Revised Final, Jan. 2001
  - Chapter 16: Open Burning, Revised Final, Jan. 2001
  - Chapter 18: Structure Fires, Revised Final, Jan. 2001
  - Chapter 24: Conducting Surveys for non-point Source Categories, Dec. 2000

Resources

- Non-point Source Category Method Abstracts for Sources of PM Emissions
  - Charbroiling, Dec. 2000
  - Vehicle Fires, May 2000
  - Residential and Commercial/Institutional Coal Combustion, April 1999
  - Fuel Oil and Kerosene Combustion, April 1999
  - Natural Gas and Liquefied Petroleum Gas (LPG) Combustion, July 1999

PM One-Pagers: Non-point Sources

- PM One-Pagers: Overview
  - Location: PM Resource Center
    - Web site: http://www.epa.gov/ttn/chief/eiip/pm25inventory/areasource.html
  - Purpose:
    - Summarize non-point source NEI methods for specific categories of PM_{10}, $PM_{2.5}$, and NH_3

PM One-Pagers: Non-point Sources (Continued)

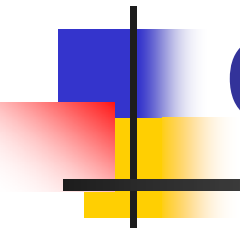
- Contents:
  - Source Category Name, SCC
  - Pollutants of Most Concern
  - Current NEI Methodology
  - How can States, Locals, and Tribes improve upon methodology?
  - Uncertainties/Shortcomings of Current Methods
  - Activity Variables Used to Calculate Emissions:
  - Current Variables/Assumptions Used
  - Suggestions for Improved Variables
  - Where can I find Additional Information and Guidance?
  - References

PM One-Pagers: non-point Sources (Continued)

- Open Burning
  - Residential Yard Waste (Leaves) and Household Waste
  - Residential, Nonresidential, and Road Construction Land Clearing Waste
  - Structure Fires
  - Wildfires & Prescribed Burning
  - Managed Burning - Slash

PM One-Pagers: Non-point Sources (Continued)

- Fugitive Dust
  - Paved and Unpaved Roads
  - Residential Construction
  - Mining and Quarrying
- Residential Combustion - Fireplaces and Woodstoves



Questions?

What are Major Sources of PM in NP Sector?

- Fugitive Dust Sources (Crustal PM Fine)
  - Unpaved Roads
  - Agricultural tilling
  - Construction Activities
  - Beef cattle feedlots

What are Major Sources of PM in NP Sector? (Cont.)

- Fires/Burning
  - Wild & Prescribed Fires
  - Open burning
    - Residential municipal solid waste burning
    - Yard waste burning
    - Land clearing debris burning
  - Agricultural field burning
  - Structure Burning

What are Major Sources of PM in NP Sector? (Cont.)

- External/Internal Fuel Combustion
  - Residential wood combustion
  - Other residential fuel combustion
  - Industrial fuel combustion
  - Commercial/institutional fuel combustion

What are Major Sources of NH3 in NP Sector?

- Typical source categories of NH_3 emissions include:
  - Animal husbandry (cattle, swine, poultry, etc)
  - Agricultural fertilizer application
  - Agricultural fertilizer manufacturing
  - Wastewater treatment

How Do I Estimate Emissions?

- Emissions data prepared and reported by Source Classification Code (SCC)
  - 10-digit SCC defines an non-point emission source
  - EPA SCCs located at: http://www.epa.gov/ttn/chief/codes/index.html#scc
- Report actual emissions; not allowable or potential emissions
- PM2.5 is a subset of PM10

How Do I Estimate Emissions? (Continued)

- Calculate emissions using:
  - Activity data
  - Emission factors
  - Control efficiency data
  - Rule effectiveness/rule penetration
- Follow EIIP methods when available
  - Provides preferred and alternative methods for collecting activity data and use of emission factors
  - Improve on existing inventory methods

How Do I Estimate Emissions? (Continued)

- Emission estimation equation:

$$CAE_A = (EF_A)(Q)\ [(1- (CE)(RP)(RE)]$$

CAE_A = Controlled non-point source emissions of pollutant A

EF_A = Uncontrolled emission factor for pollutant A

Q = Category activity

CE = % Control efficiency/100

RE = % Rule effectiveness/100

RP = % Rule penetration/100

How Do I Estimate Emissions? (Continued)

- Obtain activity data from:
  - Published sources of data
    - National, regional, or state-level activity data often require allocation to counties using county-level surrogate indicator data
  - Survey performed to obtain local estimate of activity

How Do I Estimate Emissions? (Continued)

Sources of PM and NH_3 emission factors

- Factor Information Retrieval (FIRE) System

  (http://www.epa.gov/ttn/chief/software/fire/index.html)
- AP-42

  (http://www.epa.gov/ttn/chief/ap42/index.html)
- Emission factor ratios
  - $PM_{2.5}$ emissions calculated from PM_{10} emissions using ratio of $PM_{2.5}$-to-PM_{10} emission factors
- State or local emission factors are preferred

How Do I Estimate Emissions? (Continued)

- Control efficiency (CE)
  - Percentage value representing the amount of a source category's emissions that are controlled by a control device, process change, reformulation, or management practice
  - Typically represented as the weighted average control for an non-point source category

How Do I Estimate Emissions? (Continued)

- Rule effectiveness (RE)
  - Adjustment to CE to account for failures and uncertainties that affect the actual performance of the control
- Rule penetration (RP)
  - Percentage of the non-point source category that is covered by the applicable regulation or is expected to be complying with the regulation
- EPA guidance specifically excludes applying EPA default RE/RP assumption values for PM inventories

Spatial and Temporal Allocation

- Available national, regional, or state-level activity data often require allocation to counties or subcounties using surrogate indicators
- S/L/T agencies should review estimates developed in this manner (e.g., NEI) for representativeness
- Available temporal profiles to estimate seasonal, monthly, or daily emissions for specific categories may be limited
- States are encouraged to reflect local patterns of activity in their emission inventories

EI Development Approaches

- Approaches Available to State, Local, and Tribal (S/L/T) Agencies:
  - S/L/T Agency develops its own inventory following EIIP procedures
  - Use NEI default estimates
- Hybrid Approach
  - Compare S/L/T activity data and assumptions to NEI Defaults – Use S/L/T data to replace NEI defaults if data will improve estimates

Triage Approach to Improving the EI

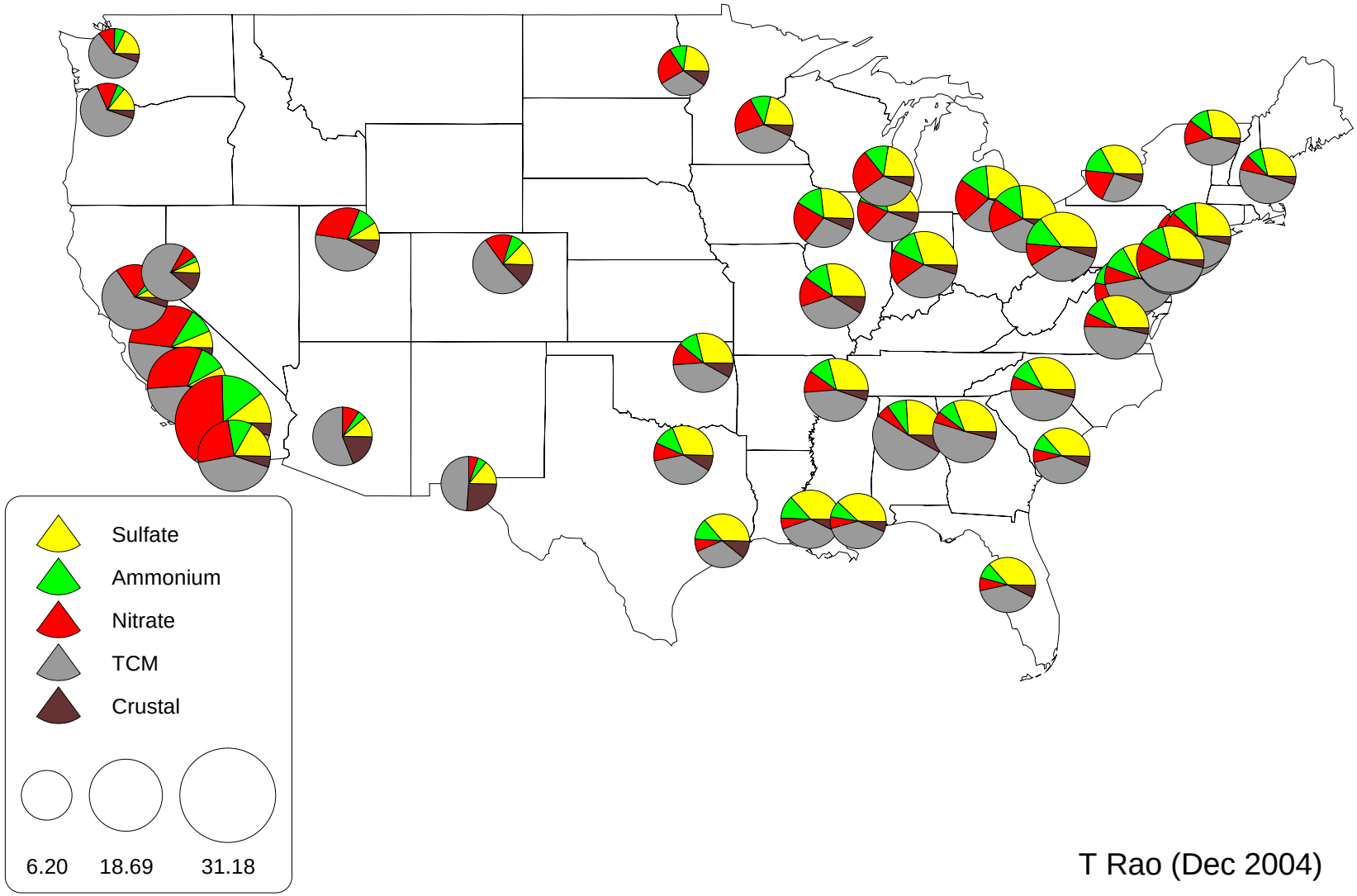
- Consider each NEI Category - Is it important ?
  - What's its potential impact on AQ, considering emissions, receptor modeling & other available info.
  - May give *some weight* to emission reductions potential
- If yes, what does the Workshop suggest on where to focus improvement efforts
- Can you make real improvements to the NEI 2002 V1 approach?
- Review the available guidance (Workshop materials, one pagers, EIIP guidance).
- Decide what's doable in the near and longer term.
- Get to work !

Session V
Reconciling Fugitive Dust Emissions w/ Ambient Data

Thompson G Pace
US EPA

Las Vegas, NV
April 11, 2005

URBAN (EPA STN) ANNUAL AVERAGES
Sep 2001--Aug 2002



T Rao (Dec 2004)

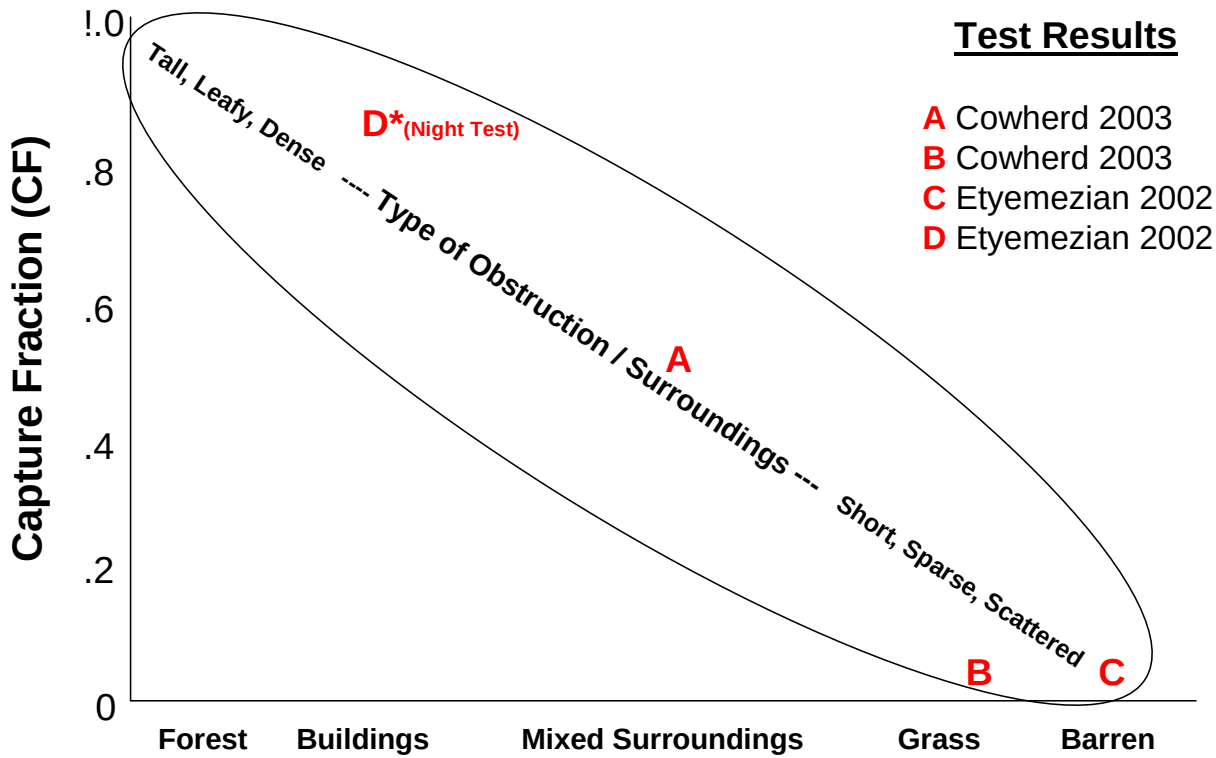
Crustal Materials (Mainly Fugitive Dust)

- **Main Sources:**
  - Unpaved roads
  - Agricultural tilling
  - Construction
  - Windblown dust, Fly ash
- **Huge Disparity Between EI & Ambient Data**
  - Ambient Data
    - < 1 ug/m3 in most of US
    - Exception: > 1 ug/m3 in much of Southwest, California
  - Emissions: 2.5M TPY (comparable to Carbon Emissions)
- **Fugitive Dust has low "Transportable Fraction"**

Role of Surface Cover (Vegetation & Structures) in Fugitive Dust Removal

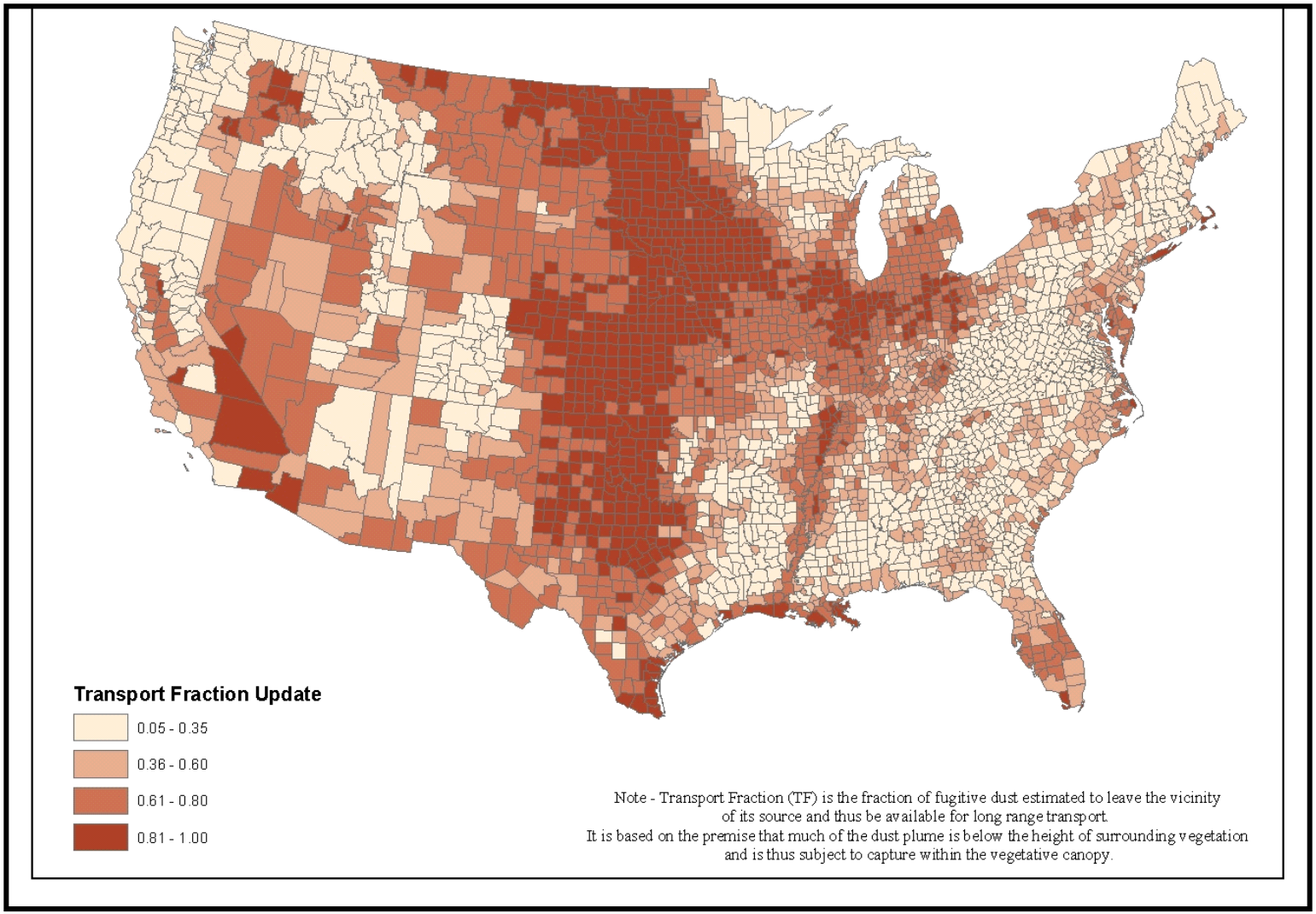
- **Early work by AQ Modelers**
  - Stilling Zone – Lower 3/4 of canopy
- **Windbreaks** – wind erosion "staple"
  - Traditionally to slow wind on leeward side
  - Research by Raupach
    - Entrapment effects
    - Dust transmittance through a windbreak is close to the optical transmittance
- **Capture Fraction (CF)**
  - Portion of FD Emissions removed by nearby surface cover
- **Transport Fraction (TF)**
  - Portion that is transported from the source area

Capture Fraction ~ Conceptual Model and Field Measurement Results



See: http://www.epa.gov/ttn/chief/emch/invent/statusfugdustemissions_082203.pdf
Also: http://www.epa.gov/ttn/chief/emch/invent/

Transport Fraction by County



Fugitive Dust Modeling Issues

- **Gaussian Models**
  - Many CF removal mechanisms are “built-in”
    - rarely utilized
  - Application requires empirical coefficients ~
    - limited data & guidance
- **Grid Models**
  - Remix particles w/in lowest layer at each time step (underestimates removal by gravitational settling)
  - Ignore removal processes in initial grid
    - Very significant omission (unless grid is VERY small)
    - This is where the TF concept is applicable

Cautions on Use of the TF in Emissions Inventory & Modeling Applications

- Do NOT use to reduce the emissions inventory
- Do NOT use with Gaussian Models
  - Instead, use features of model properly
- Use with Grid Models (with proper caveats)
  - There ARE other issues with the inventory – the TF concept should NOT be expected to fully account for overestimation of crustal fraction of ambient measurements.
- TF concept is evolving
  - Grid Model modifications could (over time) eliminate need for TF concept

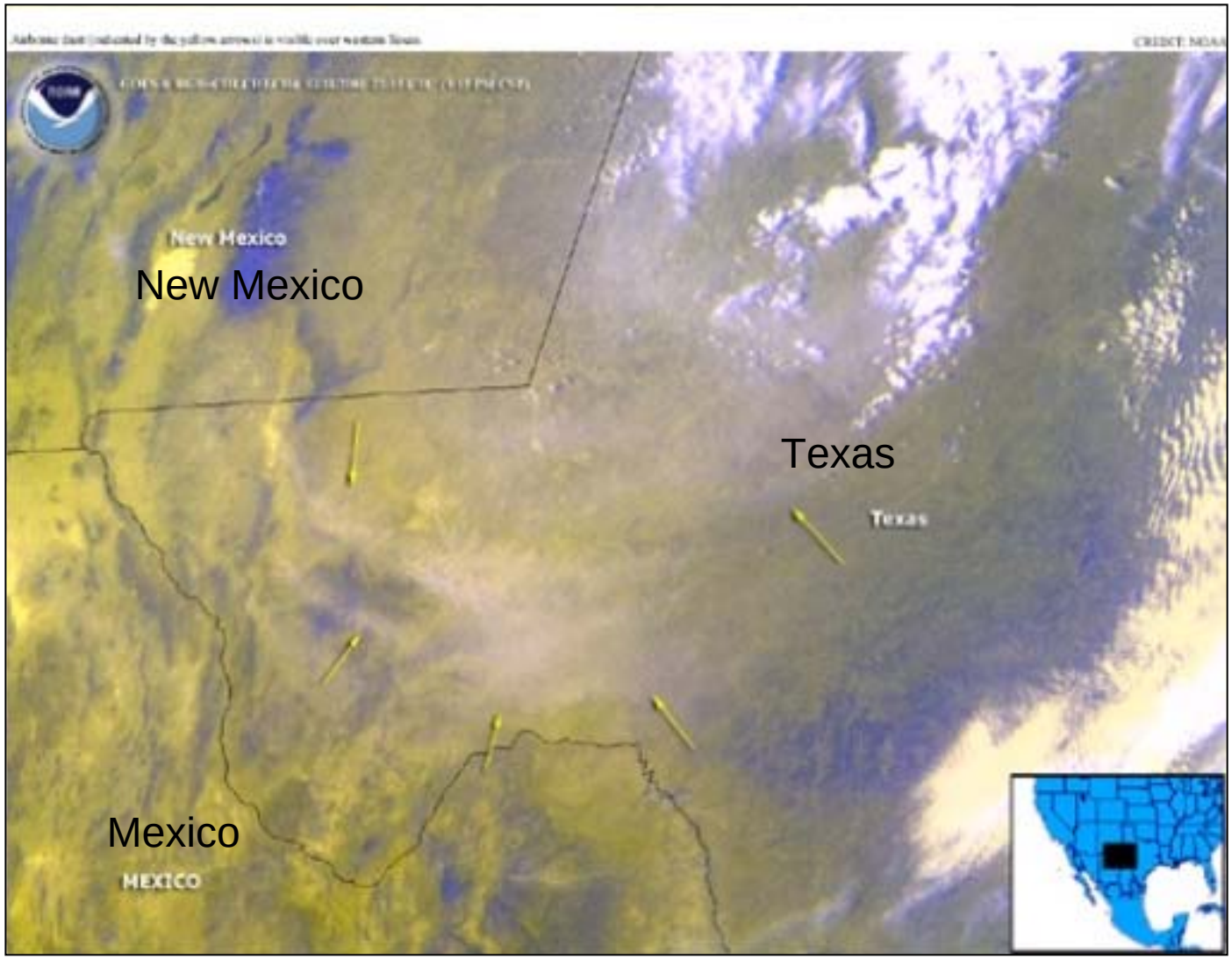
Fugitive Dust Emissions Model
(on hold)

- **Modular input to Emission Models (e.g., SMOKE, OpEM) to interface with the CMAQ modeling system. It will**
  - establish consistent database of resource info (soil map, land use, vegetation cover, moisture, precipitation, wind speed) for making emission estimates for use with grid models.
  - demonstrate proof-of-concept of emission models for wind erosion, unpaved roads, construction, other dust sources,
- **Evaluate the capability of the Fugitive Dust Emissions Module**
  - Sensitivity testing & identify key areas for improvement.
- **Integrate, Test & Release Module (lacks funding)**

Crustal Materials ~ Conclusions

- Crustal materials are a relatively small part of PM2.5 in the ambient air
- Fugitive dust is released near the ground and surface features often capture the dust near its source
- The **Capture / Transport Fraction** concept *does* provide a useful way to account for near source removal when used with Grid Models
  - This area of research offers many opportunities to improve model performance
- **Process-based Modeling** would improve dust EI (especially Windblown Dust)

Questions ?



PM2.5 Emissions from Residential Open Burning, Construction Activities

Roy Huntley
Huntley.Roy@EPA.gov
EIG, USEPA
April 11, 2005
Las Vegas, NV

Residential Open Burning

New as of 1999

SCCs:

2610030000 - Residential Municipal Solid Waste (MSW) Burning

Pollutants: PM10, PM2.5, CO, NOx, VOC, SO2, 32 HAPs

2610000100 - Residential Leaf Burning

2610000400 - Residential Brush Burning

Pollutants: PM10, PM 2.5, CO, VOC, 6 HAPs

Residential MSW Combustors

- Aka, Backyard Barrel Burning
  - 55-gallon drum

Residential MSW Combustors

- Emissions from BYB burning of residential solid waste are released at ground level resulting in decreased dilution by dispersion.
- The low combustion temperature and oxygen-starved conditions result in incomplete combustion and increased pollutant emissions.
- In contrast, modern refuse combustors have tall stacks, specially designed combustion chambers, and high efficiency flue gas cleaning systems

Emissions from BYB of MSW

- Emissions are higher on a per Unit Mass Refuse Burned Basis
  - PM emissions may be 40 times higher than from an uncontrolled incinerator.
  - PCDDs/PCDFs - up to 17 times higher than a controlled MW incinerator
  - Metal emissions are many times higher than those of a controlled incinerator

Residential MSW Burning

- Ecty = (Pcty x Rfrac) x W x Bfrac x (EF)
- **Pcty** is pop of county
- **Rfrac** is fraction of county that is rural
- **W** is per capita waste gen (0.60 tons/person/year)
- **Bfrac** is fraction of waste gen (0.28) that is burned
- **EF** is 34.8 lbs PM2.5/tons waste burned

Residential MSW (cont.)

- Accounts for Burning Bans
  - No burning in county if urban population exceeds 80 percent of total population

Residential Yard Waste Combustion

Leaves and Brush

Thank you Bob West of Yakima County

Residential Yard Waste Burning

- Ecty = (Pcty x Rfrac) x (YW x Ywfrac) x CF x Bfrac x EF
- **YW** is per capita yard waste gen (0.10 tons/person/year)
- **Ywfrac** is fraction of yard waste components (0.25 for leaves, 0.25 for brush)
- **CF** is correction factor

Residential Yard Waste Burning (Cont.)

- Ecty = (Pcty x Rfrac) x (YW x Ywfrac) x CF x Bfrac x EF
- **Bfrac** is fraction of waste burned (0.28)
- **EF** is 38 for leaves, 17 for brush (lbsPM2.5/tons burned)

CF - Differences in Biomass Ground Cover

- Used BELD3 database from BEIS to determine # of acres of forest, ag land, and miscellaneous vegetation per county
- Subtract out Ag lands before determining percent forested acres.
- Determine % forested

Correction Factor (CF)

Percent Forested Acres per county	Correction Factor (CF)
<10%	Zero
>=10% & <50%	0.5
>=50%	1.0

Slash Burning

(Burning of logging waste)

- EPA uses state-supplied data.

Land Clearing Debris Burning

- Emissions = Acres x LF x EF
- Acres cleared for Construction
- LF is fuel loading factor
- EF is emission factor

Land Clearing Debris Burning (cont.)

- Acres Cleared
  - discuss later (fugitive dust from construction)

Fuel Loading for Land Clearing Debris Burning

- Used BELD3 database to determine proportion of hardwoods, softwoods, and grass in each county
- USFS factors for piled residue.
  - Fuel loading factors from Forest Service for hardwoods, softwoods, and grass
- Adjusted USFS fuel loading factors by 1.5 to account for additional mass (tree roots)

Fuel Loading Factors
(US Forest Service)

Fuel Type	**Fuel Loading (tons/acre)**
Hardwood	99
Softwood	57
Grass	4.5

Emission Factors

- Obtained from US Forest Service
- PM10=PM2.5
- 17 lbs PM2.5/ton of fuel

Improvements to NEI Estimates

How can State/Local Agencies Improve on the NEI Estimates?

Land Clearing Debris Burning

Improvements to NEI Method

- Review EIIP section on Open Burning
  - EIIP Volume III, Ch. 16
  - Preferred methods rely on direct measure of mass of waste or debris burned
  - Mass amounts may be available from permits issued
- Improve estimates of the acres cleared (see fugitive dust construction categories for suggestions).
- Develop improved estimate of the “average loading factor”

Sources: Local Foresters, Construction Companies

Land Clearing Debris Burning

Improvements to NEI Method

- Identify specific counties with burning bans
  - *Sources: Air Agency, Solid Waste Management Organization*
- State or local estimates of the percentage or amount of waste burned per construction event.
  - *Source: Solid Waste Management Organization*

Residential Open Burning

EIIP Alternative for Yard Waste

Identify records of burning permits or violations, coupled with data (or assumptions) on typical volumes and material composition

Residential Open Burning

Improvements to NEI Methods

- Identify rules prohibiting or limiting open burning, and the organization that enforces those rules
- For areas that have burning prohibitions, consider performing rule effectiveness (RE) surveys
- Level of enforcement/compliance can be a significant variable in calculating controlled emissions

Residential Open Burning

Improvements to NEI Methods

- Review EIIP Volume III, Ch. 16 Open Burning
- Obtain State/local estimates of per-capita waste generation
- Use State/local estimates for amount or percentage of waste burned
- Obtain State/local estimates of months when yard wastes are burned
- Sources
  - *Solid Waste Agency*
  - *Air Agency*
  - *Health Department*
  - *Solid Waste Management Organization*
  - *Local Survey*

End of Open Burning Discussion

Fugitive Dust from Construction Activities

Construction Categories

- Residential
- Road
- Non-residential (commercial, industrial, government, public works)

Adjustments

- Soil Moisture
- Silt Content


Tyvek
HomeWrap
LEADER
HOME CENTERS

Residential Construction

- SCC = 2311010000
  - Industrial Processes Construction: SIC codes 15-17, General Building, Construction, Total

Residential Construction

- Ecty = EF x B x f x m
- **EF** = Emission factor
- **B** = # of units by county
- **f** = building-to-acres conversion factor
- **m** = duration of construction activity (months)

Buildings to Acres Conversion Factor

Housing Type	**Acres Disturbed**
Single-Family	‘1/4 acre/building
Two-Family	‘1/3 acre/building
Apartment	‘1/2 acre/building

Duration

Housing Type	Duration
Single-Family	6 months
Two-Family	6 months
Apartment	12 months

Adjustment for Basements

- Houses built with basements move more dirt
  - Assume 2000 ft2 footprint, basement depth of 8 feet, add 10% more dirt for peripherals (652 cubic yards)
  - Add to equation
- Regionally specific building practice
  - DOC has % of houses with basements per census region

Known Shortcomings

- Does not include trackout
- Double counts diesel emissions from construction equipment

Road Construction

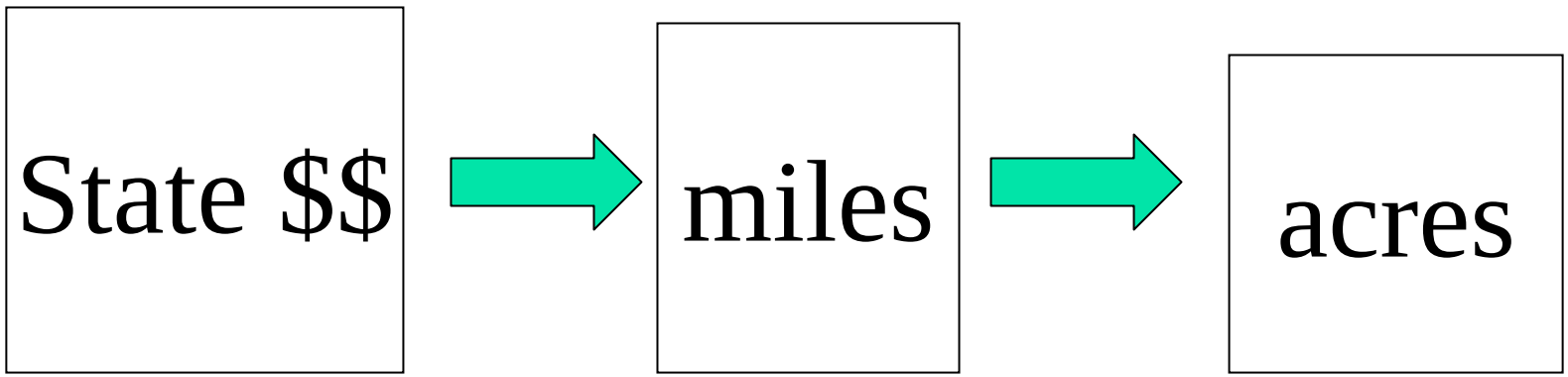
Road Construction

- SCC = 2311030000
  - Industrial Processes, Construction: SIC codes 15-17, Road Construction, Total

Roadway Construction

- E = EF x $ x f1 x f2 x m
- **EF** = emission factor
- **$** = State Expenditures for road construction
- **f1** = $ to miles conversion
- **f2** = miles to acres conversion
- **m** = duration (12 months)

Roadway Construction



FHWA State Expenditure Data for Capital Outlay

- Interstate; urban
- Interstate; rural
- Other arterial; urban
- Other arterial; rural
- Collectors; urban
- Collectors; rural

FHWA Data includes:

- Buying right of way
- Road construction
- Major widening
- Building bridges
- NO RESURFACING
- NO PRIVATE ROAD CONSTRUCTION

$$ to Miles

- $4 million/mile for interstates
- $1.9 million/mile for arterial and collectors

Miles to Acres

- 15.2 acres/mile for interstates and urban arterial
- 12.7 acres/mile for rural arterial
- 9.8 acres/mile for urban collectors
- 7.9 acres/mile for rural collectors

Assumptions

- Uses North Carolina cost figures
- Does not include privately constructed roads

Non-Residential Construction


Marriott
Texas Children's Hospital

Non-Residential

- Uses the **National** value of construction put in place
- $$ allocated to counties using construction employment data

Non-Residential Construction

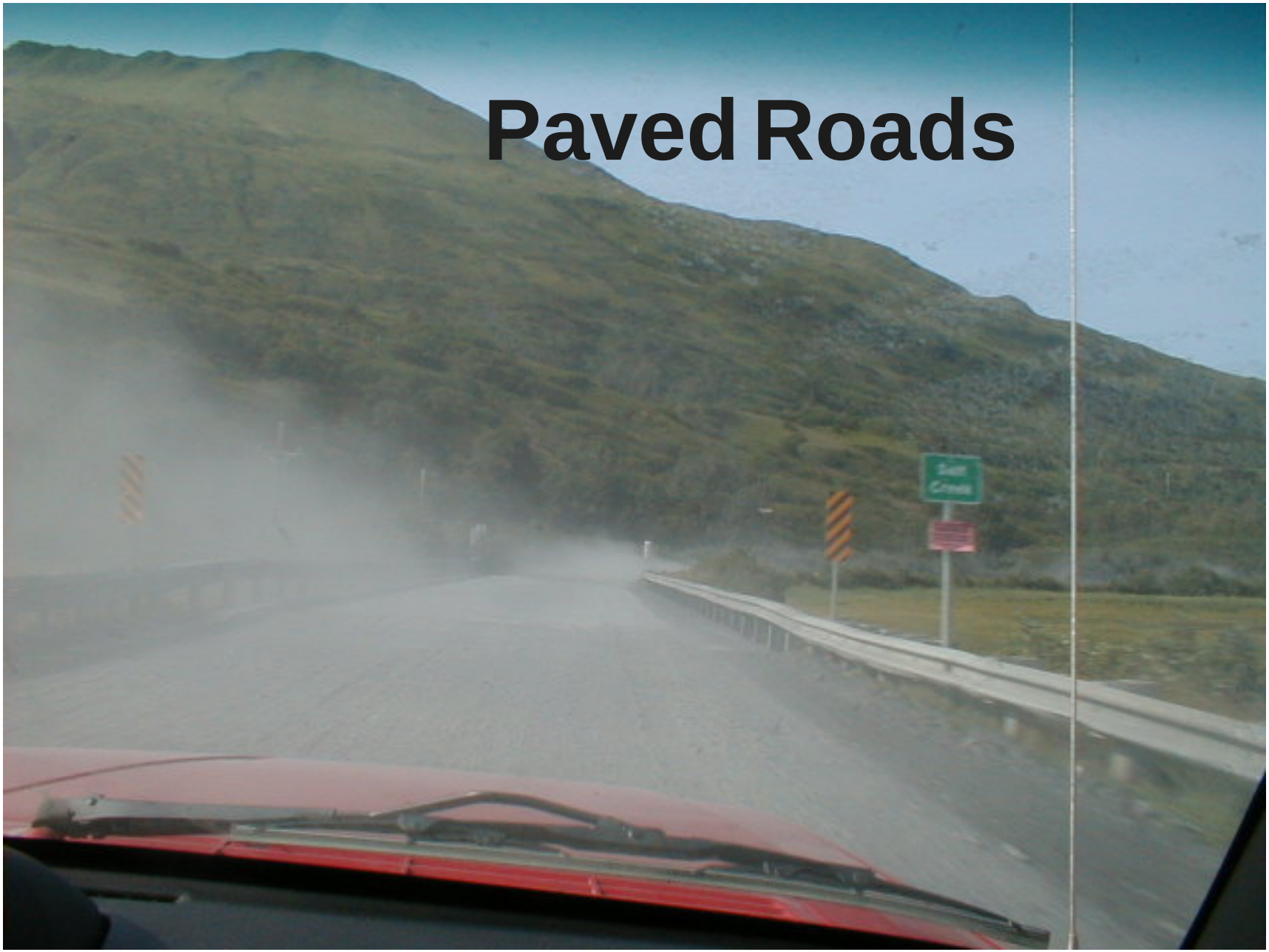
- E = EF x $ x f x m
- **EF** = Emission factor (tons/acre/month)
- **$** = county $
- **f** = dollars-to-acres conversion (1.6 acres/million dollars (1992 value adjusted for inflation to 1999)
- **m** = duration (11 months)

Last Point

- Some opportunities for improvement
  - State/local data

Fugitive Dust Non Point Sources

Paved and Unpaved Roads


Paved Roads

PAVED ROADS

Overview

- SCC: 2294000000
- Pollutants -- PM_{10}, $PM_{2.5}$
- Method
- Activity Data
- Emission Factors
- Emissions Allocation to Counties

PAVED ROADS

NEI Method (Cont'd)

- Emission Factor
  - Empirical emission factor equation from AP-42

$$EF = k * (sL/2)^{0.65} * [(W/3)^{1.5} - C] * [1 - P/(4*N)]$$

where:

- EF = paved road dust emission factor for all vehicle classes combined (grams per mile)
- k = constant for particles of less than 10 microns in diameter (7.3 g/mi for PM_{10}, 1.8 g/VMT for $PM_{2.5}$)
- sL = road surface silt loading (g/m^2)
- W = average weight of all vehicle types combined (tons)
- C = Constant to account for EF fraction that is vehicle fleet brake, tire, and exhaust (lb/VMT)
- P = number of days in the month with at least 0.01 inches of precip
- N = number of days in the month

PAVED ROADS

NEI Method

- Activity Data [vehicle miles traveled (VMT) on paved roads]
  - State-Level Activity Data

State/road type level VMT from paved roads = Total State/road type-level VMT - State/road type-level unpaved road VMT

PAVED ROADS

NEI Method (Cont'd)

- Emission Calculation

$$EM_{s,r,m} = VMT_{s,r,m} * EF_{s,r,m}$$

where:
- EM = PM_{10} emissions, tons per month
- VMT = VMT, miles per month
- EF = tons per mile
- m = month
- s = State
- r = road type class

PAVED ROADS

NEI Method (Cont'd)

- Allocation of State Emissions to County Level
  - Paved road emissions are allocated to the county level according to the fraction of total State VMT in each county for the specific road type.

$$PVDEMIS_{X,Y} = PVDEMIS_{ST,Y} * VMT_{X,Y}/VMT_{ST,Y}$$

where:
- $PVDEMIS_{X,Y}$ = paved road PM emissions (tons) for county x and road type y
- $PVDEMIS_{ST,Y}$ = paved road PM emissions (tons) for the entire State for road type y
- $VMT_{X,Y}$ = total VMT (million miles) in county x and road type y
- $VMT_{ST,Y}$ = total VMT (million miles) in entire State for road type y

PAVED ROADS
NEI Method (Cont'd)

- Controls
  - Control efficiency of 79 percent applied to:
    - Urban and rural roads in serious PM NAAs; and
    - Urban roads in moderate PM NAAs
      - Corresponds to vacuum sweeping on paved roads twice per month
  - Rule penetration varies by road type and NAA classification (serious or moderate).

PAVED ROADS

Improvements to NEI Method

- VMT on paved roads for local area

(Source: State Dept. of Transportation, Mobile Source Section of Environmental Dept)

- Local registration data representing the average weight of vehicles (since this variable is weighted most heavily)

(Source: State Dept. of Motor Vehicles, Mobile Source Section of Environmental Dept)

- Perform sampling to refine value used for silt content
  - Only consider if you can collect enough samples to give a good representation of roads in your area

- Obtain and use local precipitation values

(Source: National Weather Bureau)

Unpaved Roads

UNPAVED ROADS

Overview

- SCC 2296000000
- Pollutants - PM_{10} and $PM_{2.5}$
- NEI Method
  - Activity (VMT on unpaved roads)
  - Emission factor (tons per mile)

UNPAVED ROADS

NEI Method

- **Activity**
  - State level VMT from U.S. DOT, Federal Highway Administration allocated to counties by population
  - Activity Data (VMT on unpaved roads)
  - State-level activity for urban and rural local functional classes

UNPAVED ROADS

NEI Method (Cont'd)

$$Unpaved\ VMT_{Roadtype} = Mileage_{Roadtype} * ADTV * DPY$$

Where:

Unpaved VMT	=	road type specific unpaved VMT (miles/year)
Mileage	=	total number of miles of unpaved roads by functional class (miles)
ADTV	=	Average daily traffic volume (vehicle/day)
DPY	=	number of days per year

UNPAVED ROADS

NEI Method (Cont'd)

- **Emission Factor**
  - AP-42 emission factor equation

$$EF = \frac{(k * (s/12)a * (SPD/30)b}{(M/0.5)c} - C$$

where:

k, a, b, and c are empirical constants given in AP-42 by particle size (PM_{10} and $PM_{2.5}$)

EF = size specific emission factor (lb/VMT)

s = surface material silt content (%)

SPD = mean vehicle speed (mph)

M = surface material moisture content (%)

d = number of days in a particular month

C = Constant to account for EF fraction that is vehicle fleet brake, tire, and exhaust (lb/VMT)

UNPAVED ROADS

NEI Method (Cont'd)

- Correction Factor for Precipitation

$$E_{corr} = E^*[D - p\_/D]$$

E_{corr}	=	unpaved factor for precip
E	=	uncorrected emission factor
D	=	# days in month
p	=	# days in month with .01 in rain or more

UNPAVED ROADS

NEI Method (Cont'd)

- Allocation to Counties:

$$EMIS_{x,y} = (CL_x/SL)*EMIS_y$$

EMISx,y = emissions for county x and roadway class y

CLx = rural population in county x

SL = rural populatin in the state

EMISy = unpaved road emission in entire state for roadway class y

UNPAVED ROADS

NEI Method (Cont'd)

- **NEI Default Emission Factor Input Values**
  - Surface material silt content (s)
    - Average state-level values developed are available in the 2002 nonpoint documentation appendix C http://www.epa.gov/ttn/chief/net/2002inventory.html#nonpoint
  - Vehicle Speed (SPD)
    - Nonpoint doc gives speeds assumed by roadway type
  - Surface material moisture content (M)
    - 0.5% was used as national default in 2002 NEI
  - Number of days exceeding 0.01 inches of precipitation (p)
    - Precipitation data from one meteorological station in state used to represent all rural areas of the state
    - Local climatological data available from National Climatic Data Center at http://www.ncdc.noaa.gov/oa/ncdc.html

UNPAVED ROADS

Improvements

- **Summary**
  - Review defaults for representativeness
  - Use local data when possible for activity and emission factor inputs
  - If resources are limited, focus on collecting data for:
    - Local precipitation data
    - Local VMT estimates

Session VIII
Update on Ammonia Emission Estimation

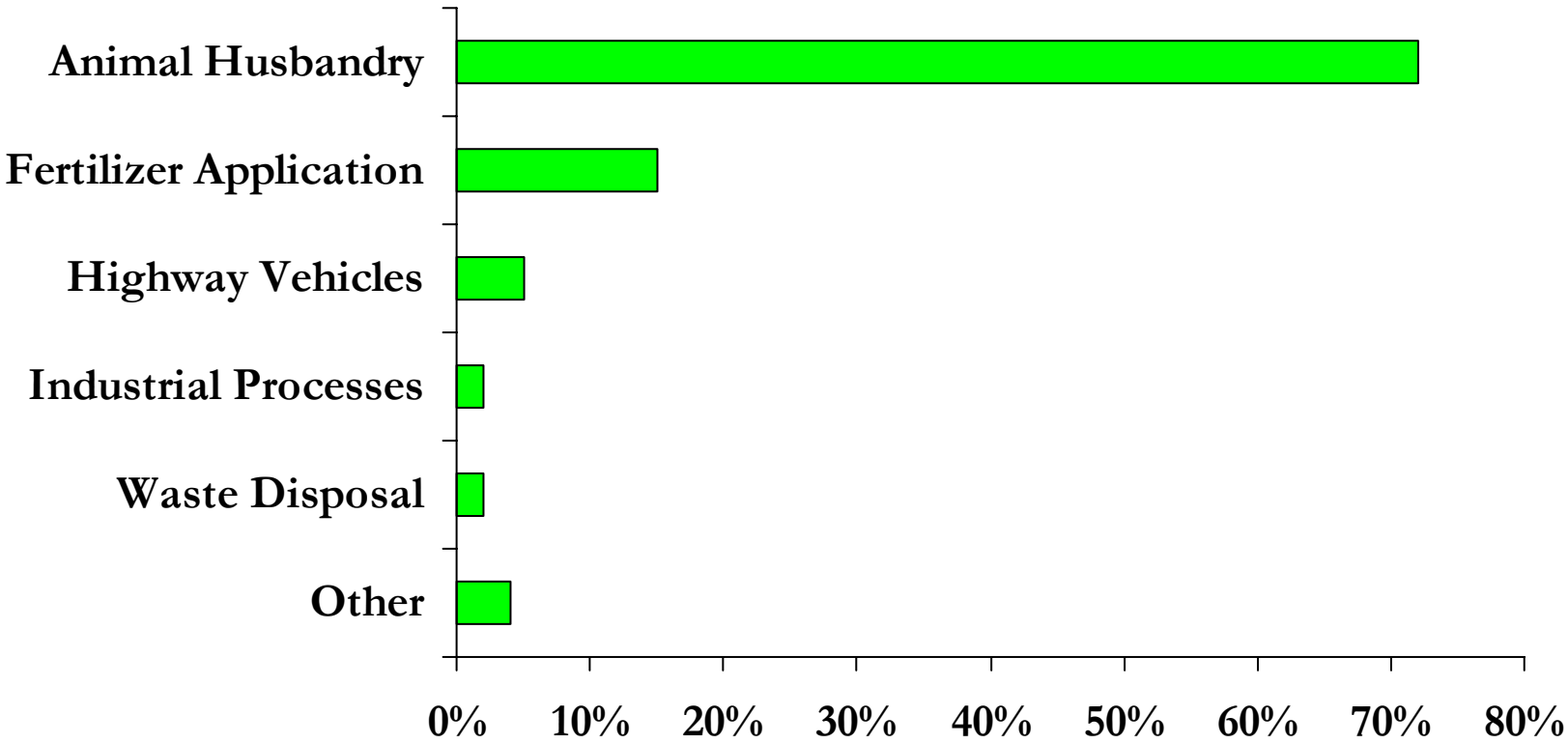
Tom Pace,
US EPA

Las Vegas, NV
April 11. 2005

Ammonia - Key Sources & Issues

- **Key categories in current EI**
  - Animal Husbandry (80%)
  - Fertilizer Application (10%)
  - Point Sources (could be large locally), Mobile Sources
- **Missing Sources** (May not all be major sources)
  - Humans, Domestic and wild animals
  - Open burning
- **Soils and Vegetation**
  - Can be source or sink -- Work ongoing: TX, CA, EPA/ORD
- **Ammonia is Important to AQ Analyses**
  - Involved in formation of Sulfate, Nitrate
  - SO2, NOx may be subject to regulation
- **New:**
  - **ERG EI (Animals)**
  - **WRAP Ammonia EI**
  - **Inter-RPO Ammonia Model**

NH3 – Precursor to Ammonium Sulfate & Nitrate (National Emissions ~ 4.8 M TPY)



Updates to EI of Ammonia from Animals are Underway

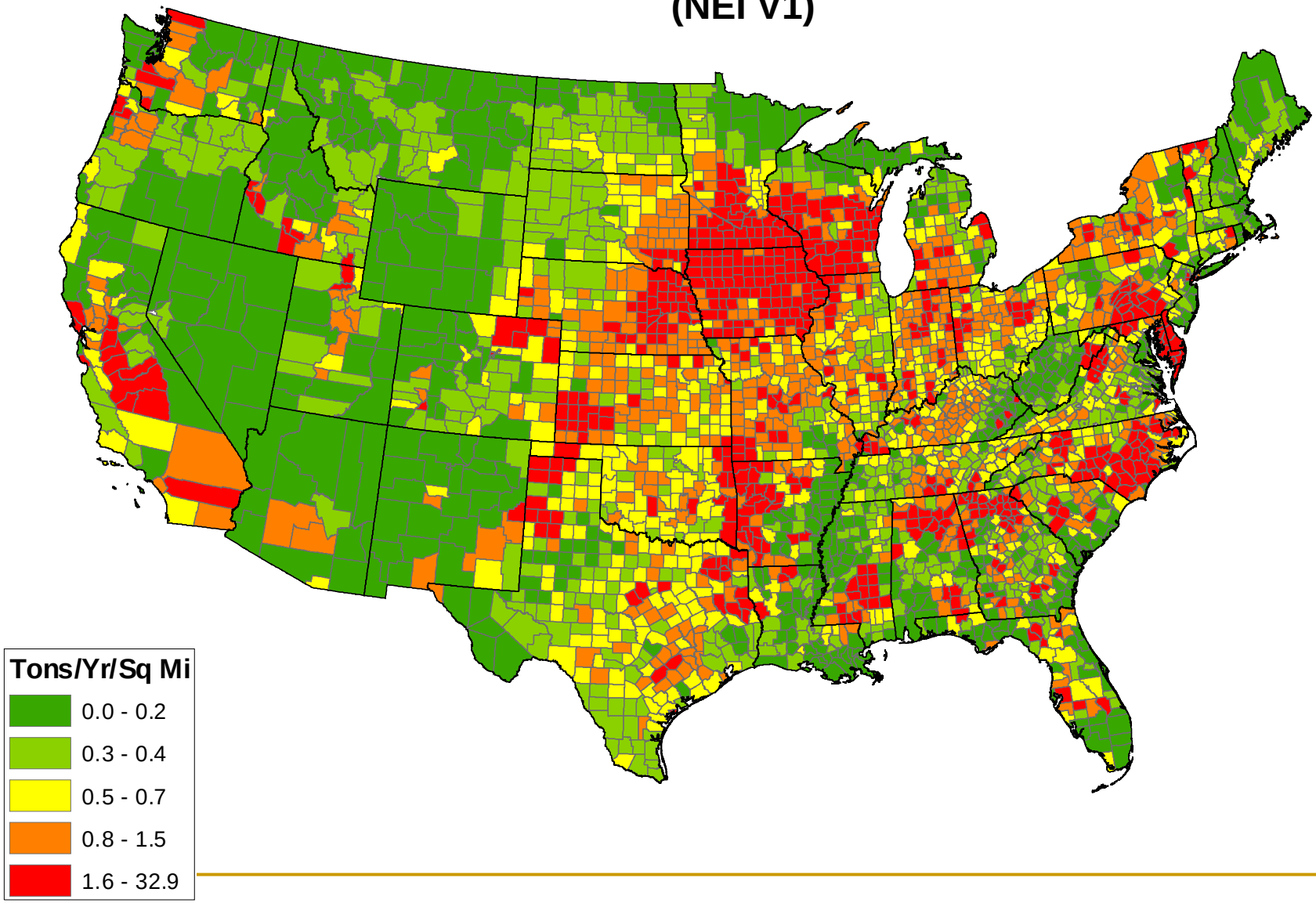
- **Shortcomings of 1999 NEI**
  - Probable errors in emission factor selections, especially for beef.
  - Does not use information on variability of emissions due to different manure handling practices within a given animal industry.
  - Does not make total use of information of available National Agricultural Statistics Service (NASS) data on different animal populations, by average live weight.
- **Inverse modeling** suggests overestimation of ammonia.
- **2002 NEI V1** makes some improvements over 1999 NEI

New Draft Emission Estimates are Lower

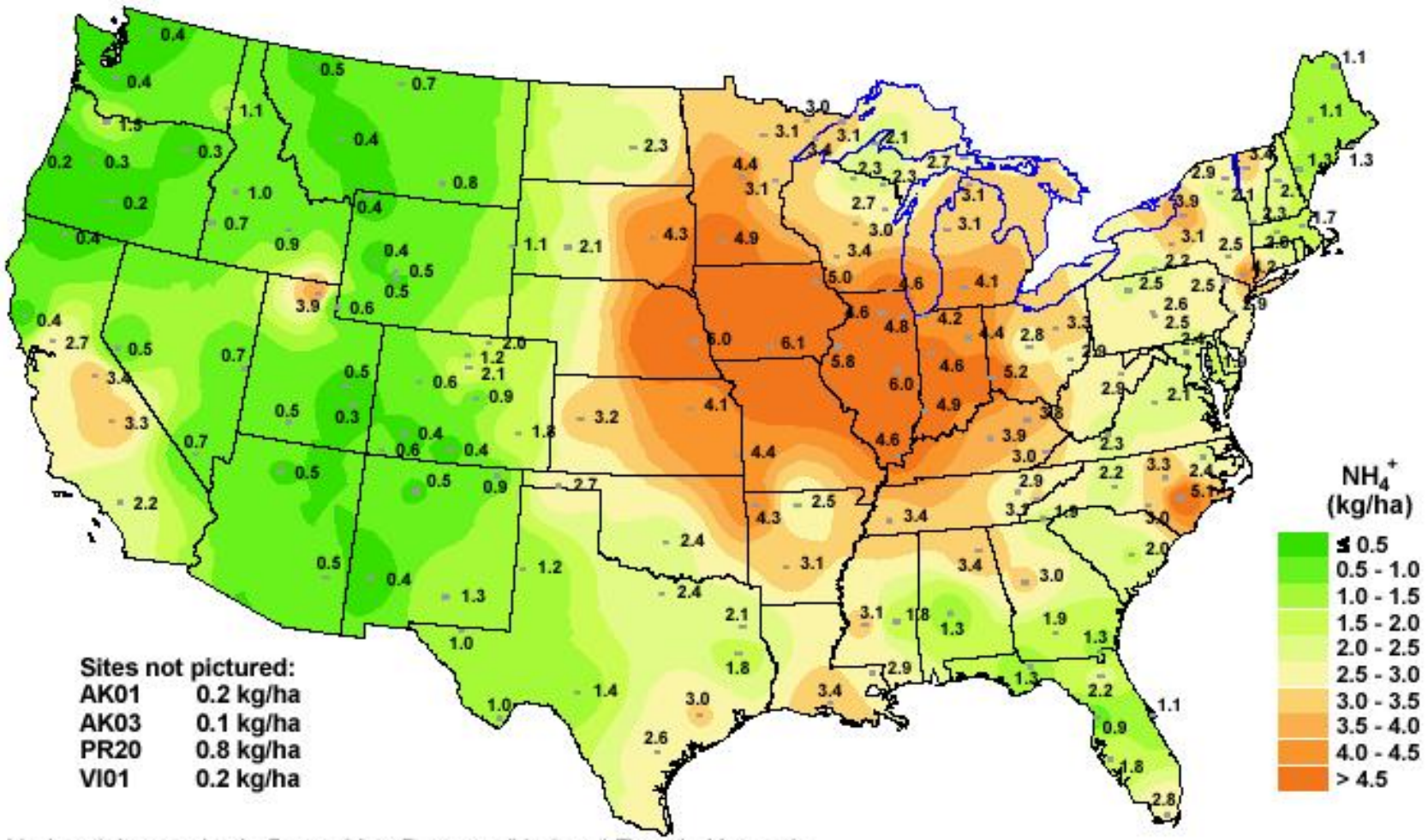
Comparison of 1999 and 2002 V1 Ammonia NEIs

Animal Group	1999 NEI			2002 NEI		
	Population	Emission Factor lb/head /yr	Emissions Tons/year	Population	Emission Factor lb/head /yr	Emissions Tons/year
Cattle and Calves Composite	100,126,106	50.5	2,476,333	100,939,728	23.90	1,205,493
Hogs and Pigs Composite	63,095,955	20.3	640,100	59,978,850	14.32	429,468
Poultry and Chickens Composite	1,754,482,225	0.394	345,325	2,201,945,253	0.60	664,238
Total	1,917,704,286	N/A	**3,461,758**	2,362,863,831	N/A	**2,299,199**

2002 NH3 Emissions from Animal Husbandry
(NEI V1)



Estimated ammonium ion deposition, 1998



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

Recent Work & Works-in-Progress for Ammonia Emissions

- **ERG Draft Reports (Animals only – MMT approach)**
  - Contact – schrock.bill@epa.gov
  - ftp://ftp.epa.gov/EmisInventory/draftnei2002/nh3inventorydraft_jan2004.pdf
  - Updated draft due March 25th based on 2002 Census of Ag (small changes expected)

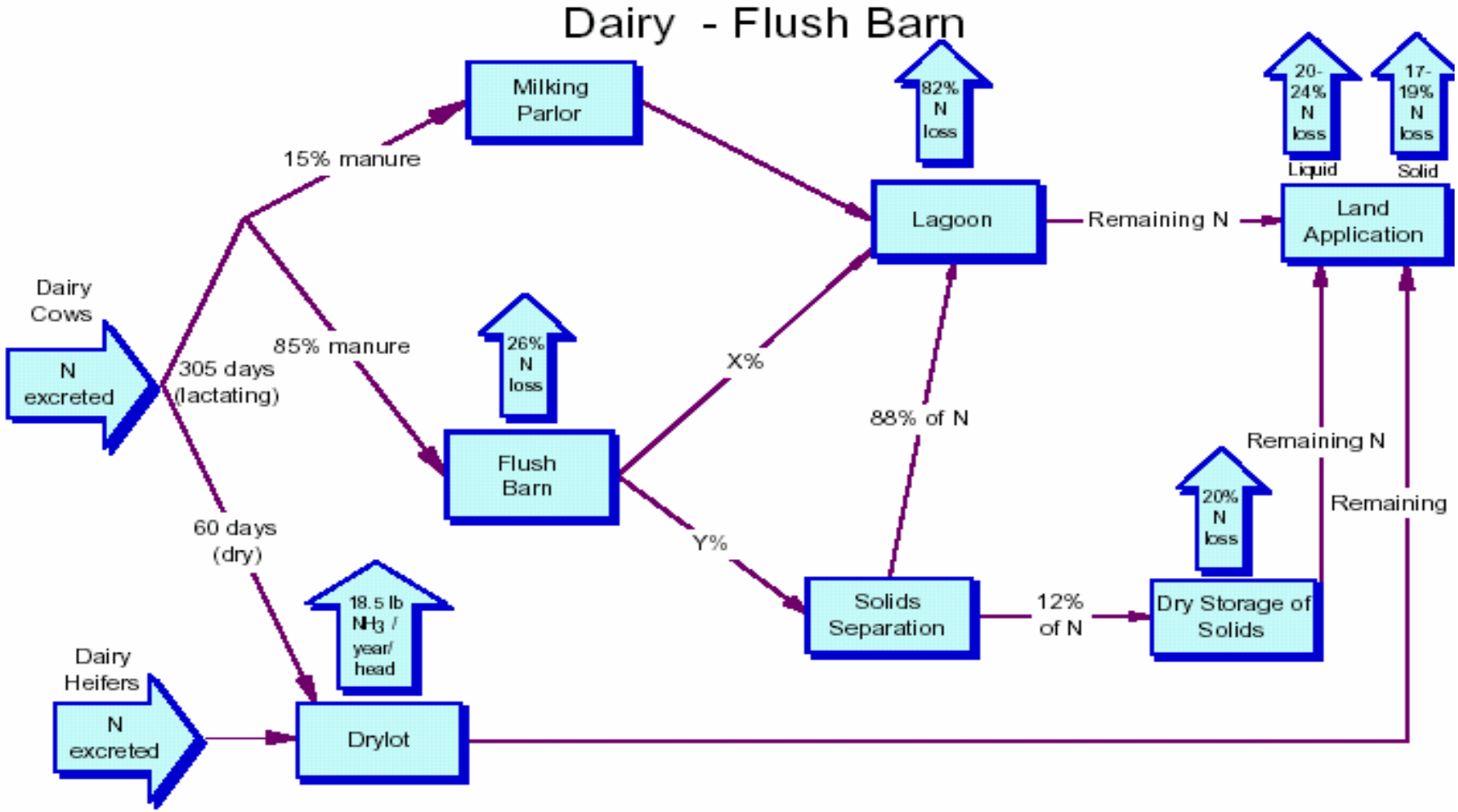
Overview of MMT Approach Methodology

- **Step 1:** Estimate average annual animal **populations** by animal group, state, and county.
- **Step 2:** Identify **Manure Management Trains (MMT)** used by each animal group and then estimate the distribution of the animal population using each MMT.
- **Step 3:** Estimate the amount of **nitrogen excreted** from the animals using each type of MMT, using general manure characteristics.
- **Step 4:** Identify or develop **emission factors** for each component of each MMT.
- **Step 5: Estimate ammonia emissions** from each animal group by MMT and county for 2002.
- **Step 6:** Estimate **future ammonia emissions** for years 2010, 2015, 2020, and 2030.

Step 2: Manure Management Trains

- **15 MMT's** plus permutations (similar to "model farms" used in past approaches).
  - E.g., Housing, waste storage, land application type.
  - Non-feedlot outdoor confinement (e.g. pasture) is one of the trains for swine, dairy, and beef.
  - MMT's represent different pathways for escape of ammonia to the air.
  - MMT "mix" varies by state, not within a State.
    - *Another "opportunity" for improvement*
- **Animal population,** etc. is allocated among the applicable trains.
- **Note:** Final stage in each train is land application.

Advanced Example of Manure Management Train:



The percentage of nitrogen lost is calculated based on the amount of nitrogen managed in that component.
The amount of nitrogen leaving the solids separator is based on the amount of nitrogen managed in the separator.
X% and Y% vary by size of operation, and represent the proportion of production using each type of system.

Recent Work & Works-in-Progress for Ammonia Emissions (Cont'd)

- **ERG Draft Reports (Animals only – MMT approach)**
  - Contact – schrock.bill@epa.gov
  - ftp://ftp.epa.gov/EmisInventory/draftnei2002/nh3inventorydraft_jan2004.pdf
  - Updated draft due March 25th based on 2002 Census of Ag (small changes expected)
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  - Lower than ERG for animals by 20% (poultry & dairy)
- **RPO Ammonia Emissions Model Due end of March**
  - Contact Janssen@LADCO.org
  - UC-R & UC/Davis
  - Process-based
    - MMT-capable & includes some environmental drivers
    - lacks info to run w/ MMTs

Questions ?

Combustion Area Sources

Residential Wood Combustion

Roy Huntley
Huntley.Roy@EPA.gov
EIG/OAQPS/US EPA
April 11, 2005
Las Vegas, NV

Conventional Wood Stoves

Slide from Wood Heat Organization Inc

Advanced Wood Stoves (EPA Certified)

Slide from Wood Heat Organization Inc

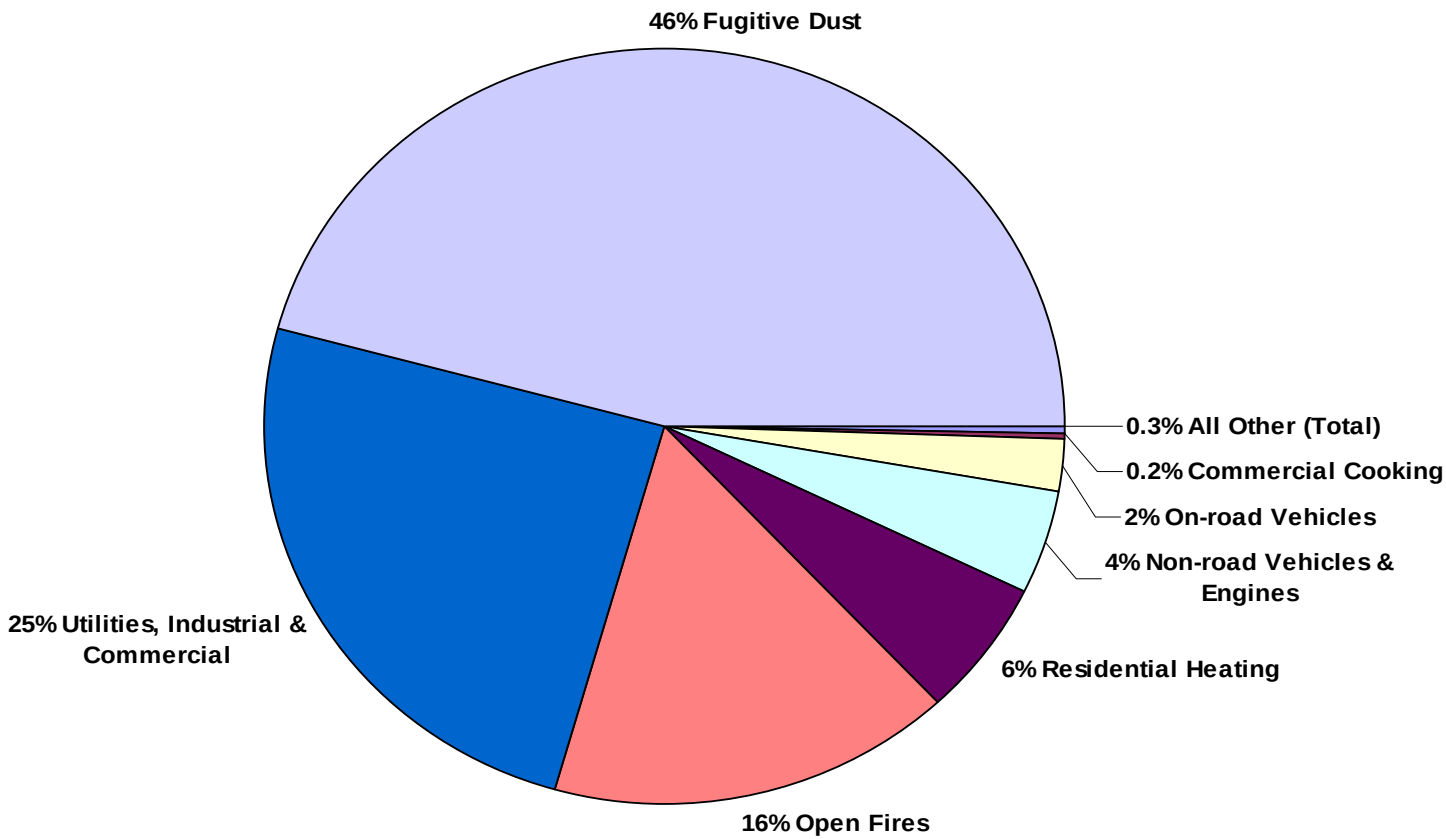
Fireplace

Pellet Stove

Hydronic Heaters

Hydronic Heaters 2

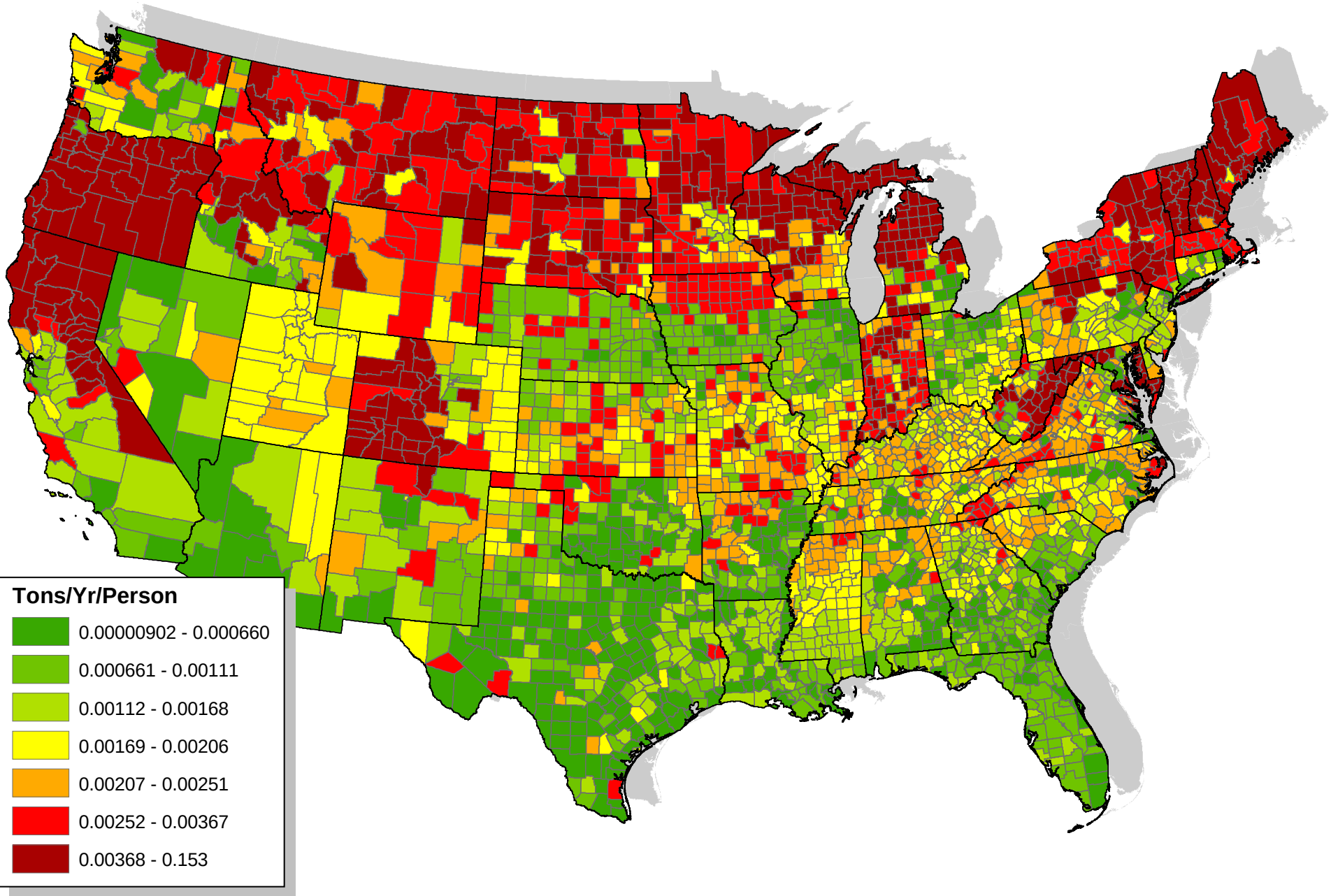
PM-2.5 Emissions in 2001 EI



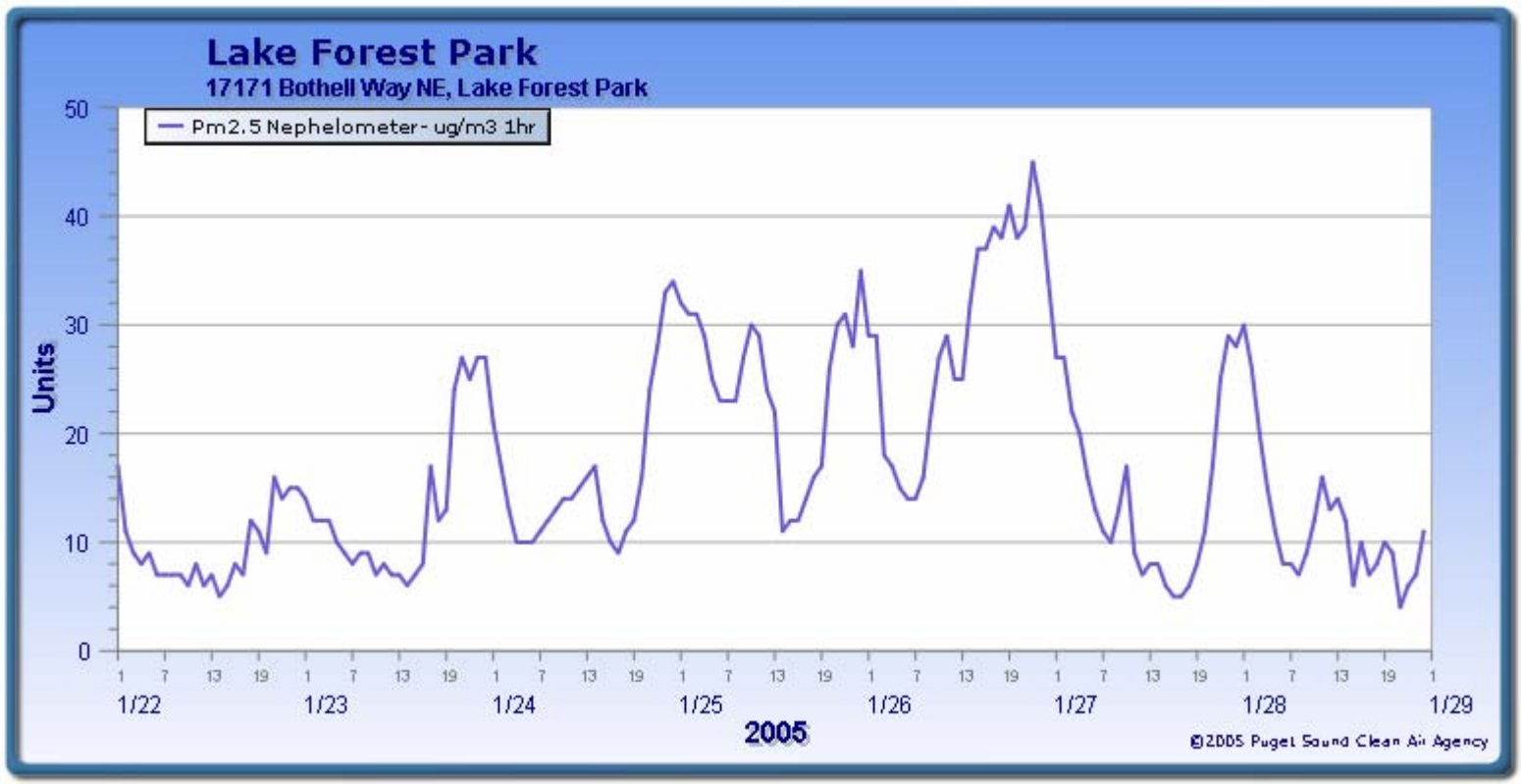
What's in wood smoke?

- Organics
  - Benzene
  - Toluene
  - Formaldehyde
  - Polycyclic organic matter
  - Dioxin
- CO, NOx, and SO2

1999 PM2.5 Primary Emissions from Residential Wood Combustion



Diurnal Variations in Air Quality



EPA's RWC New Source Performance Standard

- Phase I Stoves - All stoves manufactured after 07/01/88 and sold after 07/01/90 had to be certified to Phase I PM emission levels
- Phase II Stoves - All stoves manufactured after 07/01/90 and sold after 07/01/92 had to be certified to Phase II PM emission levels
  - All certified WS have tag
- WS made and sold prior to NSPS dates called "conventional"
  - WS have life of 40+ years
- Exempt - cookstoves, furnaces, appliances with air-to-fuel ratio >35:1, & appliances weighing more than 800 kilograms, (masonry heaters, outdoor boilers)

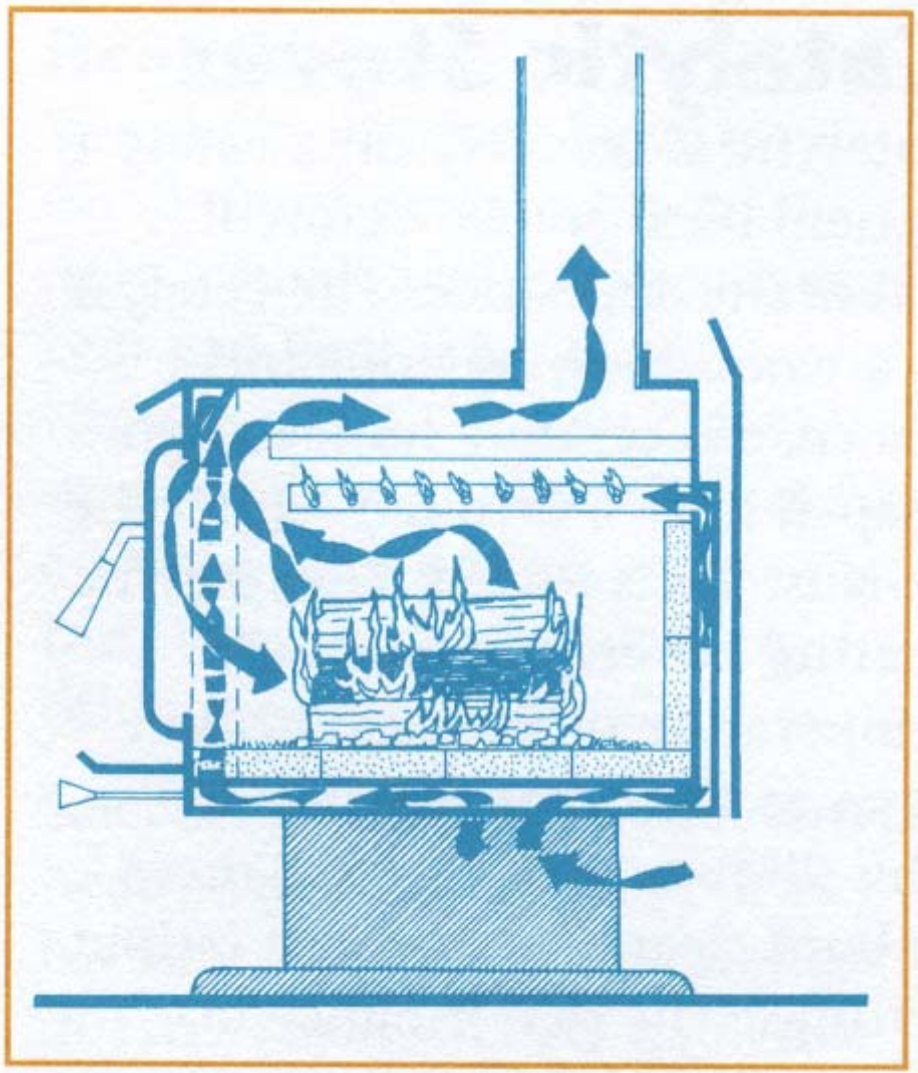
Revise NSPS?

- EPA considering revising NSPS
  - Possibly include outdoor wood-fired boilers

EPA Certified Woodstove *Non-Catalytic*

- Non-catalytic Woodstoves
  - Increase temperature of fire
    - Insulate firebox
    - Preheat combustion air
  - Increase retention time
    - Use of baffles
  - Introduce secondary combustion air
    - More complete burn

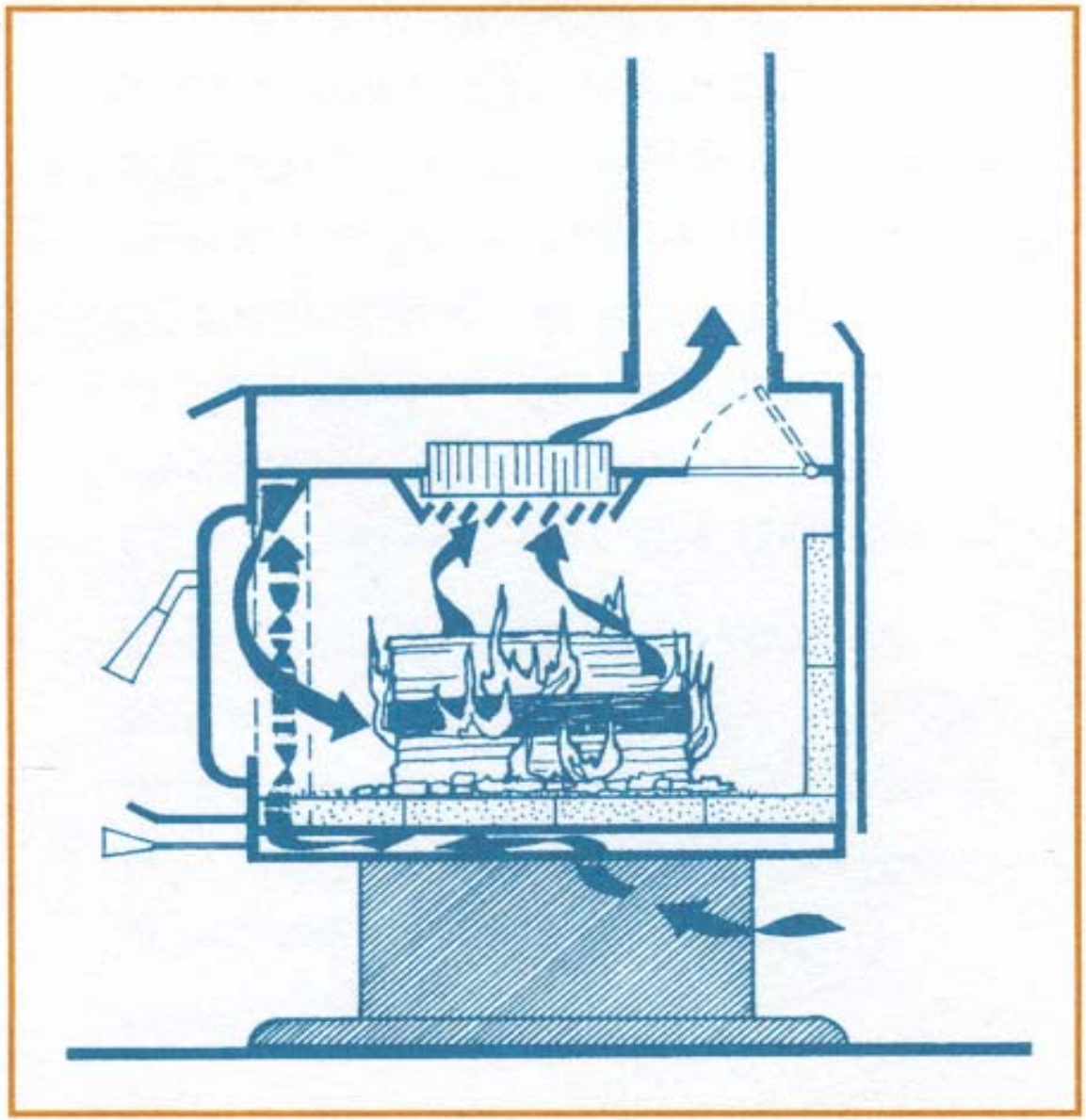
Non-Catalytic Woodstove



EPA Certified Woodstove *Catalytic*

- Catalyst
  - Low emissions, but catalyst needs replacing in 3-5 years
  - Catalyst needs to be hot before it works
  - Can operate stove in bypass mode
  - Not as popular, does not sell as well as the non-catalytic WS

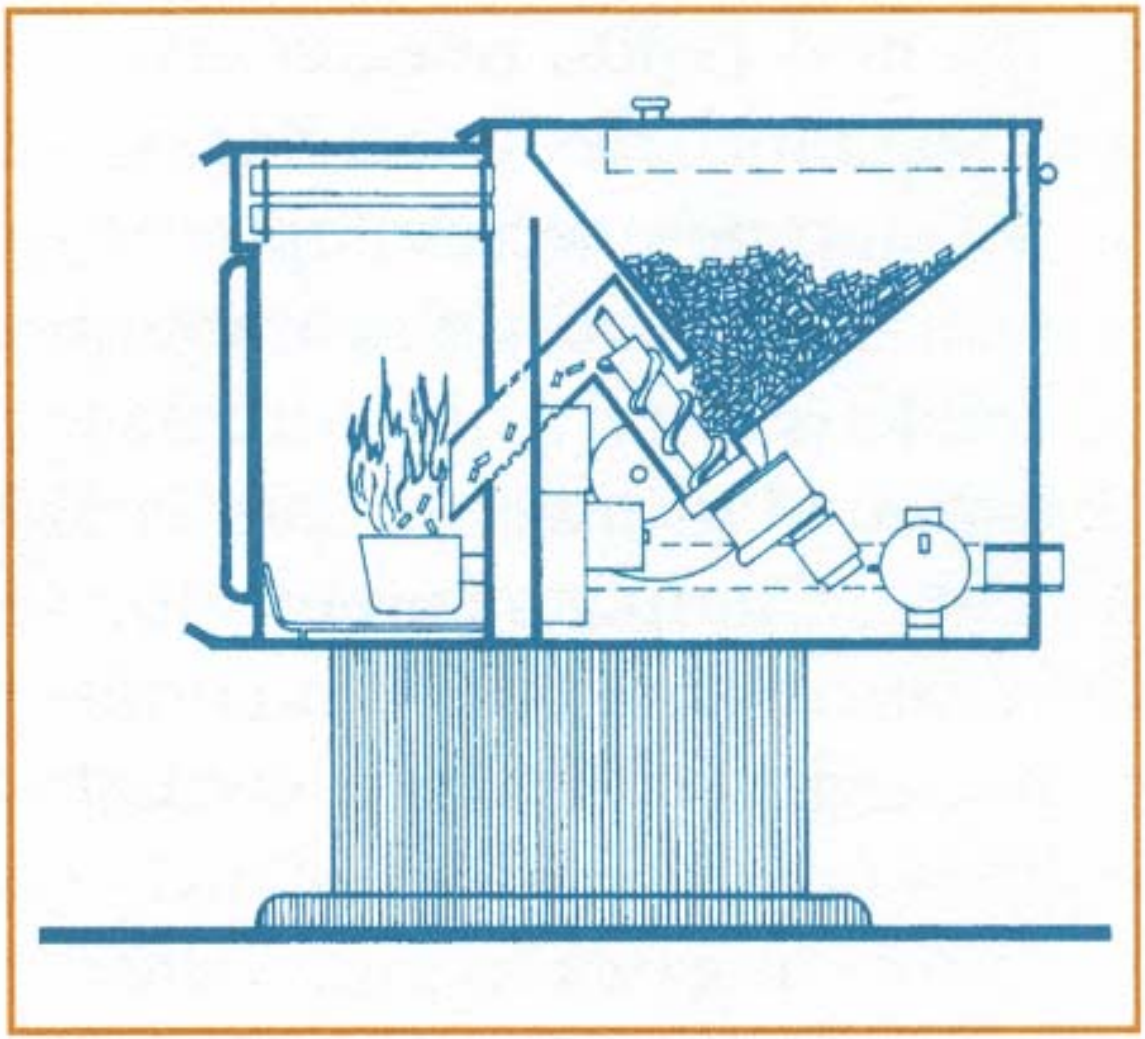
Catalytic Woodstove



Pellet Stove

- Burns pelletized wood
  - sawdust, shavings and fines leftover after processing trees for lumber and other wood products.
  - the material is dried, compressed, and formed into small eraser-sized bits

Pellet Stove



Key Facts

- 40-45 million wood burning appliances in U.S
- 15 million of those are wood stoves, either free standing or fireplace inserts
  - 80% - 90% are pre-NSPS (prior to 1988)
  - WS population could be different locally
  - Some vendors report strong pellet stove sales
  - Cordwood stove sales in 1997 less than half than in 1990
- Fireplaces exempt from NSPS (>35:1 air to fuel ratio)

Key Facts (continued)

Masonry heaters

- Exempt from NSPS
- Not many of these

- Fireplace inserts treated like woodstoves
- All RWC PM emissions are PM10
  - PM2.5 (~93%)
  - About 50% of PM emissions occur during startup

Many Factors Affecting Emissions

- Many types and models of RWC units
  - As of 1997, 121 non-catalytic WS models and 87 catalytic WS models (including fireplace inserts) were listed as certified to Phase II standards
- Different types of fuel (i.e. tree species)
  - Variation in wood seasoning and storage practices
- Draft characteristics vary considerably
  - Chimney and temperature conditions
- Household altitude varies
- Wide variation in operating practices
  - Burn rate, burn duration, damper setting, kindling approach, etc.

Fireplace SCC's

- 2104008000-Total; FP & WS
- 2104008001-FP, General
- 2104008002-FP, w/insert, catalytic
- 2104008003-FP, w/insert, non-cat,certified
- 2104008004-FP, w/insert, cat, certified

Woodstove SCC's

- 2104008010-WS, general
- 2104008030-WS, catalytic
- 2104008050-WS, non-cat, EPA certified
- 2104008051-WS, non-cat, non-certified
- 2104008052-WS, non-cat, Low Emitting
- 2104008053-WS, non-cat, Pellet Fired
- 2104008070-Outdoor Wood Burning Equipment (hydronic heaters)

Do Not Double Count Your Emissions!

NEI Method; Fireplaces

- Start with Total Wood Burned in Residential Sector (DOE)
- Determine FP consumption by counting fireplaces and assuming activity
  - Determine the # of homes w/fp (DOC)
  - Some homes have more than 1 fp (multiply by 1.17)
  - Some people burn gas (74% burn wood, 26% burn gas)

NEI Method; Fireplaces

- Some fp not used (42% not used)
- Subtract out fp with inserts (DOC)
  - Fp with inserts treated like woodstoves
- Divide into 2 categories; fp used for heating, fp used for aesthetics

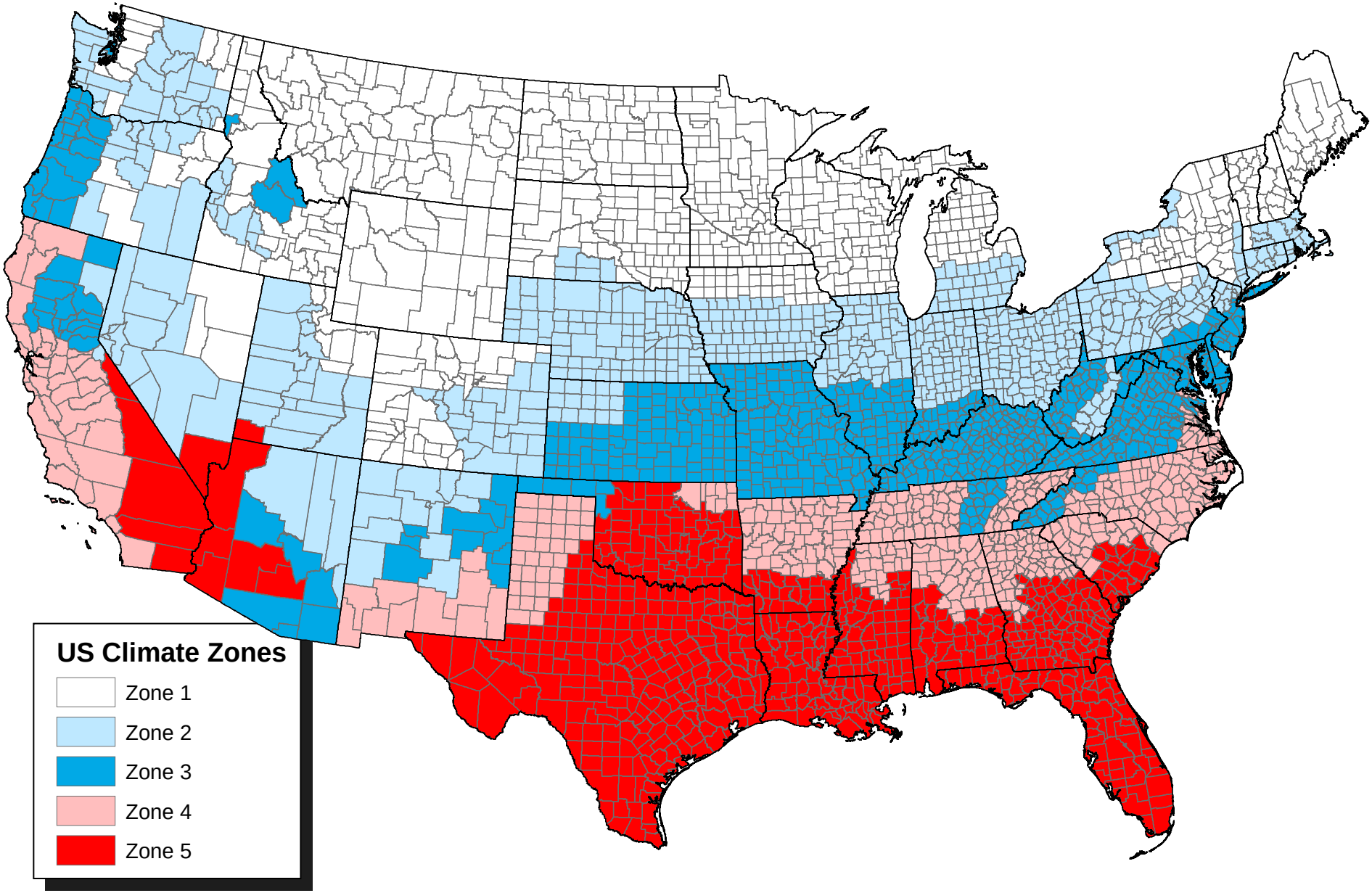
NEI Method; Fireplaces

- Determine wood consumption for each fireplace type
  - Assume wood consumption rates
    - 0.656 cords/unit/year for heating
    - 0.069 cords/unit/hear for aesthetics
- Allocate wood consumption to climate zone and then to county

Climate Zone Definition Criteria

Climate Zone Number	Heating Degree Days	Cooling Degrees Days
1	>7000	
2	5500-7000	
3	4000-5499	
4	<4000	<2000
5	<4000	>2000

US Climate Zones



Allocating Wood Consumption to Climate Zones

Climate Zone	Wood Burned (EIA/DOE Residential Energy Consumption Database)
1	36%
2	19%
3	21%
4	15%
5	9%

NEI Method; Fireplaces

- Adjust urban and rural wood consumption to match DOC data (73% of wood burned in fireplaces is burned in urban counties)
- Use iterative procedure until urban/rural split is 68/32.

NEI Method; Woodstoves and Fireplaces with Inserts

- Start with total wood burned and subtract out wood burned in fireplaces
- Allocate wood consumption to climate zones
  - Use # of single family detached homes as surrogate

NEI Method; Woodstoves and Fireplaces with Inserts

- Sum the wood consumption in each zone and compare to the urban/rural split
  - For WS, 65% rural, 35 urban
  - For inserts, 43% rural, 57% urban
- Adjust until split matches

NEI Method; Woodstoves and Fireplaces with Inserts

- Now have cordwood consumption
- Conversion; 1 cord = 1.163 tons wood
- Woodstove Population (Hearth Products Association Data)
  - 92% conventional ws
  - 5.7% non-catalytic ws, EPA-certified
  - 2.3% catalytic ws, EPA-certified
- Use emission factors to determine emissions

Session XI
Emissions Estimation for Biomass Fires

US EPA Emissions Inventory Conference
Las Vegas, NV
April 11, 2005

Thompson G. Pace
USEPA

Agricultural Burning

AGRICULTURAL BURNING

- SCC 2801500000 (135k TPY)
- SCC 2801500xxx (143k TPY)
- PM10-PRI and PM25-PRI
- Both condensibles and filterables
- NEI contains *ONLY* State-submitted estimates
  - 19 States submitted for 2002 (up from 10 in '99) - AL, AR, CA, FL, IA, ID, KS, LA, MN, MO, MS, NE, NJ, OK, OR, SC, TX, UT, WA
- General Approach
  - Activity (acres of crop burned)
  - Loading factor (tons of biomass or vegetation per acre burned)
  - Emission factor (pounds per ton)

AGRICULTURAL BURNING
What can you do?

- Coordinate with burners and permit authorities
- Start building a system and relationships with the burners/ permitting authorities to enable such an inventory in the future
- Focus on larger fires (> 100 acres) as events with a start and stop date and time; lump smaller fires into monthly acreages

AGRICULTURAL BURNING

What can you do? (Cont'd)

- Obtain local acres of crops burned data from:
  - Burn permits
  - Survey of county agricultural extension offices
- Verify that burns actually occurred
- Obtain fuel loading data
  - Local data preferred from county agricultural extension offices, local Natural Resources Conservation Service Center

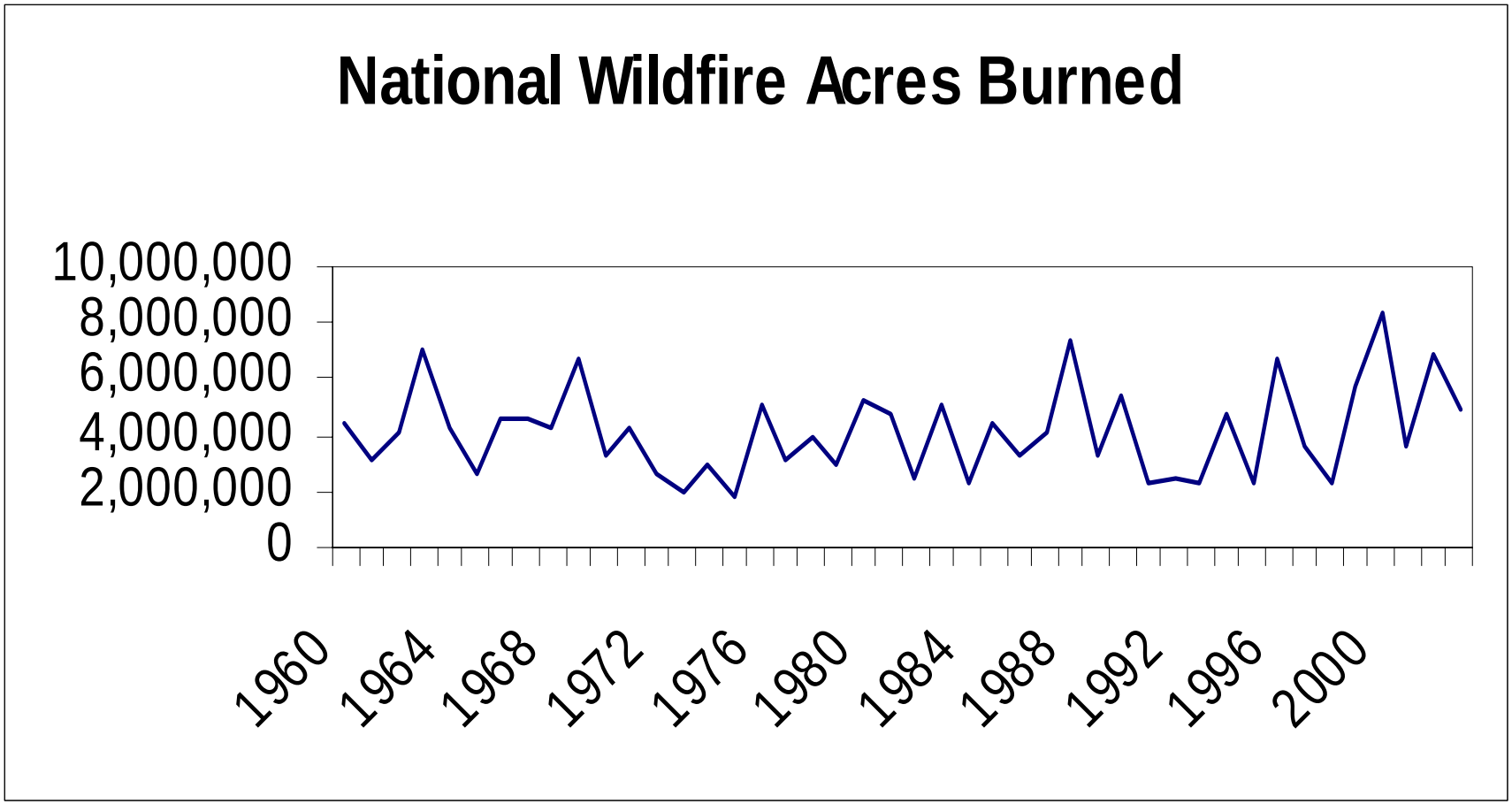
Wildland Fires

Overview of Wildland Fire Inventory

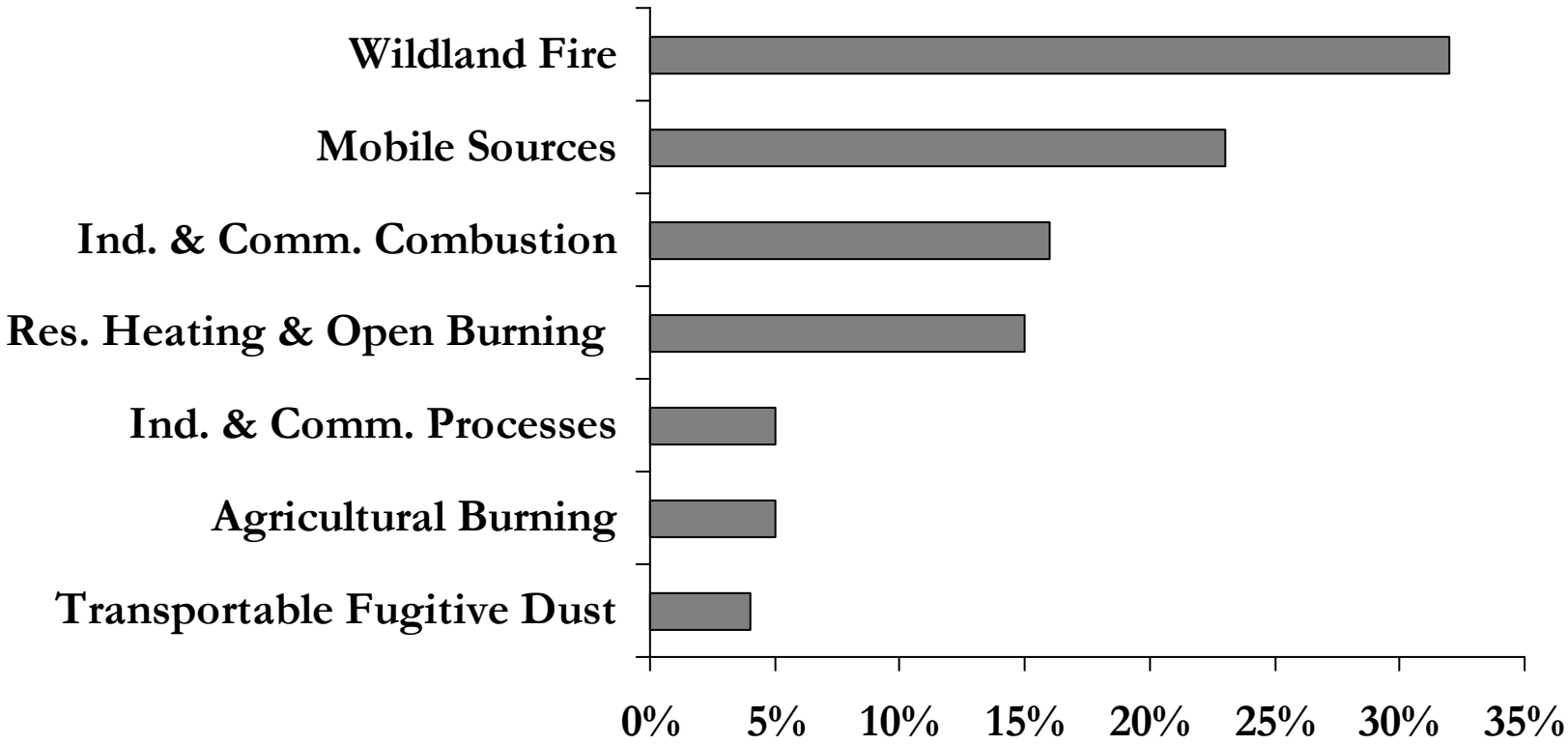
- **Who Burns ?**
  - **NPS, USFS, BLM, USFWS, State & Tribal Forests, Private burners**
  - **Fire Types: Wildfires, Managed (Prescribed) Burns**
- **Why is this so complicated / important**

Summary of Wildfire Occurrence in VISTAS States 2002

Acre range	# of fires	# %	Acres	Acres %
0-1	14,657	49.00%	6,251	1.30%
1-5	8,606	28.80%	24,275	5.20%
5-10	2,486	8.30%	19,413	4.10%
10-50	3,166	10.60%	74,911	15.90%
50-100	547	1.80%	41,119	8.70%
100-1000	431	1.40%	97,570	20.70%
>1000	32	0.10%	207,341	44.00%
Totals	29,925		470,879	


National Wildfire Acres Burned
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000

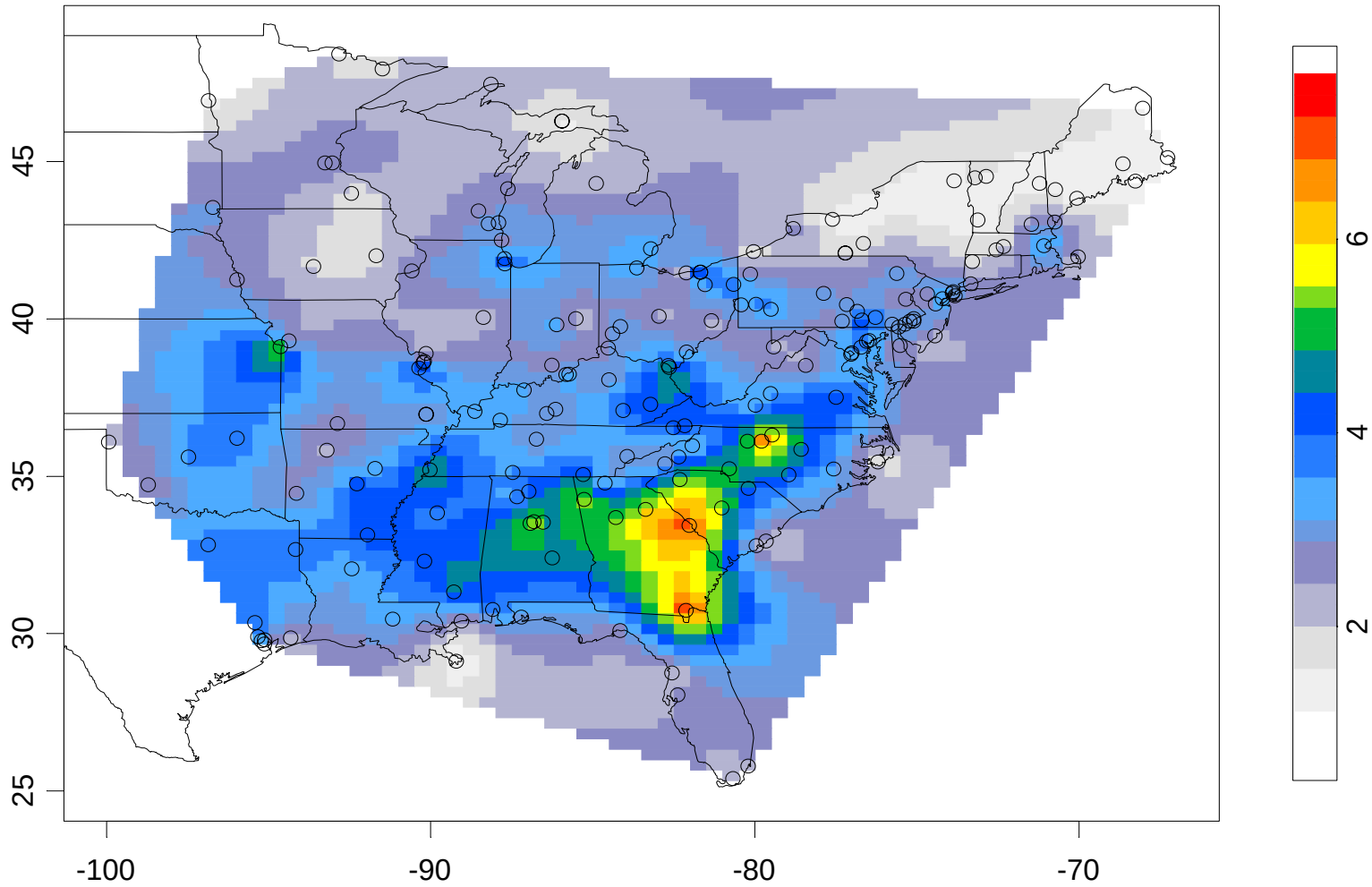
Primary Carbon in PM2.5



% of PM2.5 Primary Carbon Emissions (National Emissions ~ 2M TPY)

Seasonal Average Ambient Concentration of OC in Eastern US

Organic Carbon (April - June 2002)



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  - **Fire Types: Wildfires, Managed (Prescribed) Burns**
- **Why is this so complicated / important**
- **What's being done?**
  - **How are Wildland Burning emissions estimated in NEI ?**
  - **What's Happening Nationally & Regionally ?**
  - **BlueSkyRAINS**
  - **Wildfire Emissions Module / CMAQ**

How are Wildfire Emissions Estimated in the '99 – '02V1 NEI?

A very rudimentary approach

Note: Prescribed fire approach is similar (but not identical)

- **Pollutants**
  - PM_{10}, $PM_{2.5}$, NO_x, CO, VOC, SO_2, 30 HAPS
- **Emission Factors (AP-42)**
- **Regional Fuel Loading Factors (AP-42)**
- **Annual Activity Data ~ State (or regional) level**
  - USFS, BIA, BLM, NPS, FWS
  - Some States provide private / State burn data
  - Spatial allocation to counties using forested area
- **Emissions Processor ~ Allocates Diurnal & Monthly**

What *Needs to Happen* Nationally / Regionally to Improve Wildland Fire Emissions?

Improve Fire Event Databases & Emissions Models:

- **Fire Events: area burned, when, where**
- **Develop, refine national & regional models & databases to estimate pre-burn fuel loading**
- **Refine, expand use of fuel consumption models**
- **Linkages to Regional Grid Modeling**

What *Is* Happening Nationally / Regionally to Improve Wildland Fire Emissions ?

Fire Events Database Development

Wildland Fire Activity Data Sets Availability for 2002 Final

- **WRAP**
- Federal Lands data for all States
- Non-fed lands data *may* be available from CA, CO, NM, OR, UT, WY
- **MWRPO**
- All States except IL (will use IL ’03 as surrogate for ’02)
- **VISTAS**
- All States (MS no fuels info avail.)
- **MANE-VU**
- All data from CT, DC, ME, MA, NH, NJ, NY, PA
- Data requested from DE, MD, RI & VT
- **CENRAP**
- All data from MN, MO, IA
- AK, KA, LA, NB, OK, TX - fire locations by County
- Data requested from LA

What *Is* Happening Nationally / Regionally to Improve Wildland Fire Emissions (Cont'd)?

Fire Location & Fuel Consumption

- **Spatial:** Lat / Long w/ TRS & County Centroid as fall-back
- **Fuels:** NFDRS (Regional default if location non-specific)
  - Fuel Moisture:
  - Default moisture (smaller fires)
  - GIS-based fuel moisture / FEPS (larger fires)
- **Fuel Loading / Consumption Hybrid Approach:**
  - Regional-specific loading / FEPS Consumption / Expert Review

What *Is* Happening Nationally / Regionally to Improve Wildland Fire Emissions (Cont'd)?

Emissions and Plume Rise

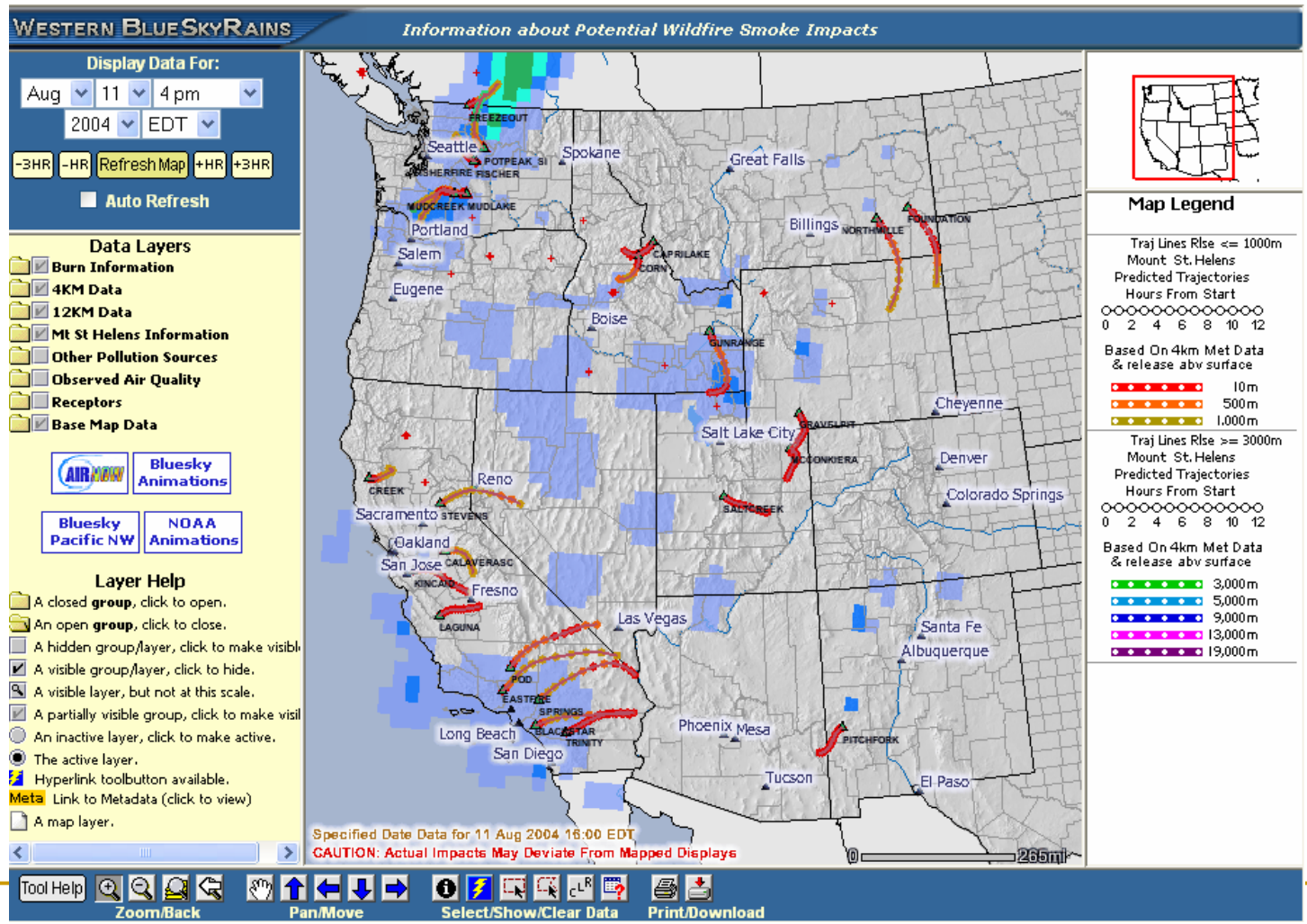
- **Emission Factors:**
  - **From Battye (2002) & Nat'l Fire WS (New Orleans)**
- **Plume Rise:**
  - **Calculated for each event & included in EI File**

What About Prescribed Burning ?

- **Activity Data Sets** ~ *less availability ~ major effort required to "do it right"*
  - What *CAN* (should) be done w/ limited funding?
- **Fuel Consumption:** will be different from wildfires
  - *Could use WF Fuel Consumption work as a starting point*
- **Emissions:** factors are available
- **Plume Rise:** will be different from wildfires
  - *Some new work req'd*
  - *Outside scope of NEI*

BlueSkyRAINS Western Prototype

- **Fire Forecasting Tool – Western Prototype Shakedown 2005-6**



Wildland Fire Emissions Module

(under development by EPA / ORD)

- **Module to enable Emission Models (e.g., SMOKE, OpEM) to Estimate Fire Emissions AND…**

  Will interface with the CMAQ modeling system.

- **User Inputs:** Fire locations, duration, size
- **Model Components (Modules from the BlueSky system)**
  - Fuel loading default: NFDRS / FCC map
  - Fuel Moisture: Calculates using MM5 met data
  - Fuel Consumption: CONSUME / FOFEM
  - Emissions & Heat Release: FEPS technology
  - Plume Rise (improved plume rise algorithms under development)
- **Outputs:** Gridded hourly emissions, plume characteristics
- **Integrate, Test & Release Module (late 2005)**

Questions?