Session I
PM Overview and Sources

WESTAR PM EI Workshop,
Denver, CO
March 2004

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US EPA

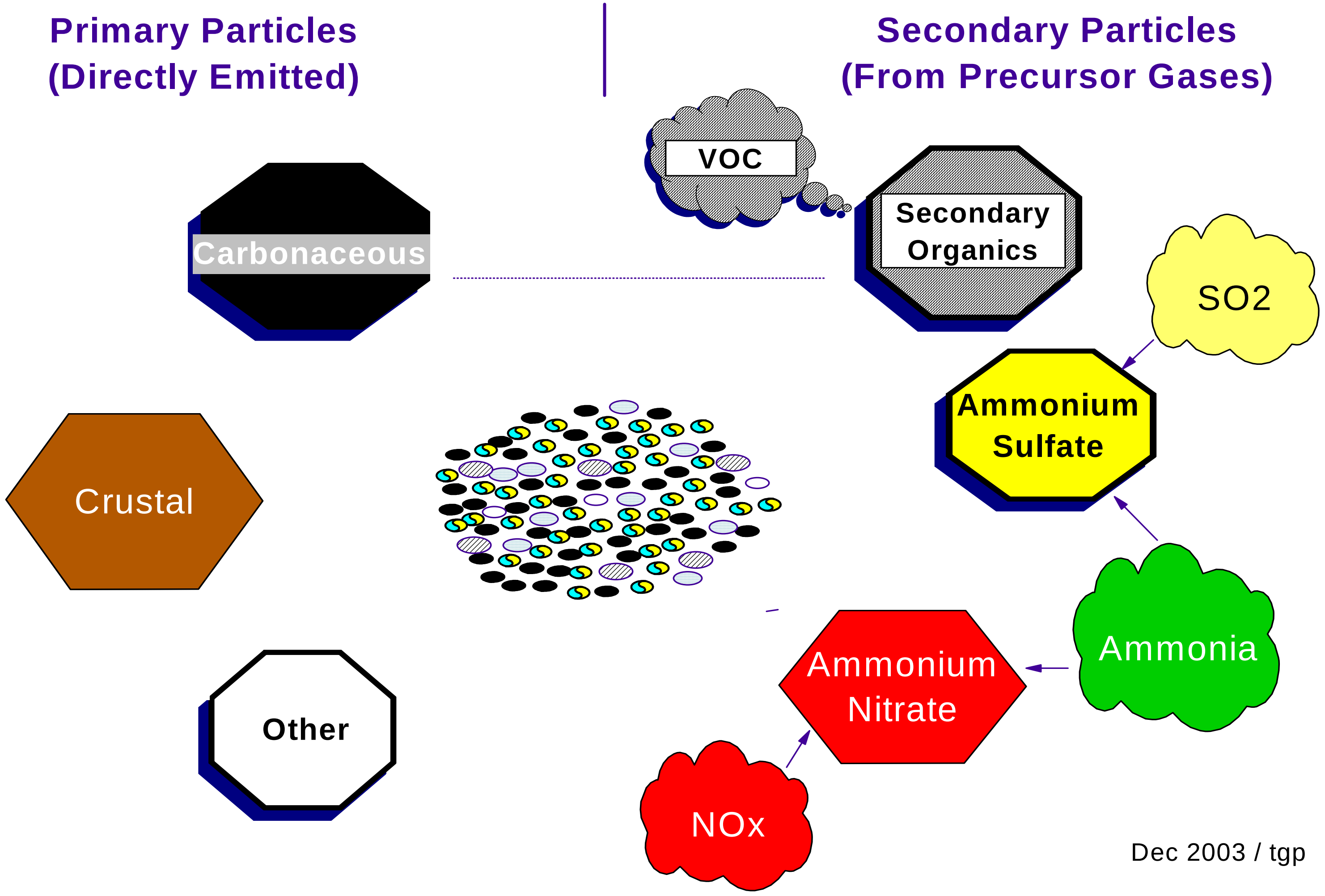
Topics to be Covered

- **PM2.5 Sources & Composition**
  - **Ambient Composition**
  - **What are the Important Sources**
- **The NEI & Emission Inventory Tools**
  - **What is Contained in the NEI**
  - **Emissions Inventory Tools**
  - **Process-based Emissions Models**
  - **Emissions Processing**
- **Emissions Overview**

PM2.5 Sources and Composition

Thompson G Pace
US EPA
March 2004

PM 2.5 In Ambient Air - A Complex Mixture



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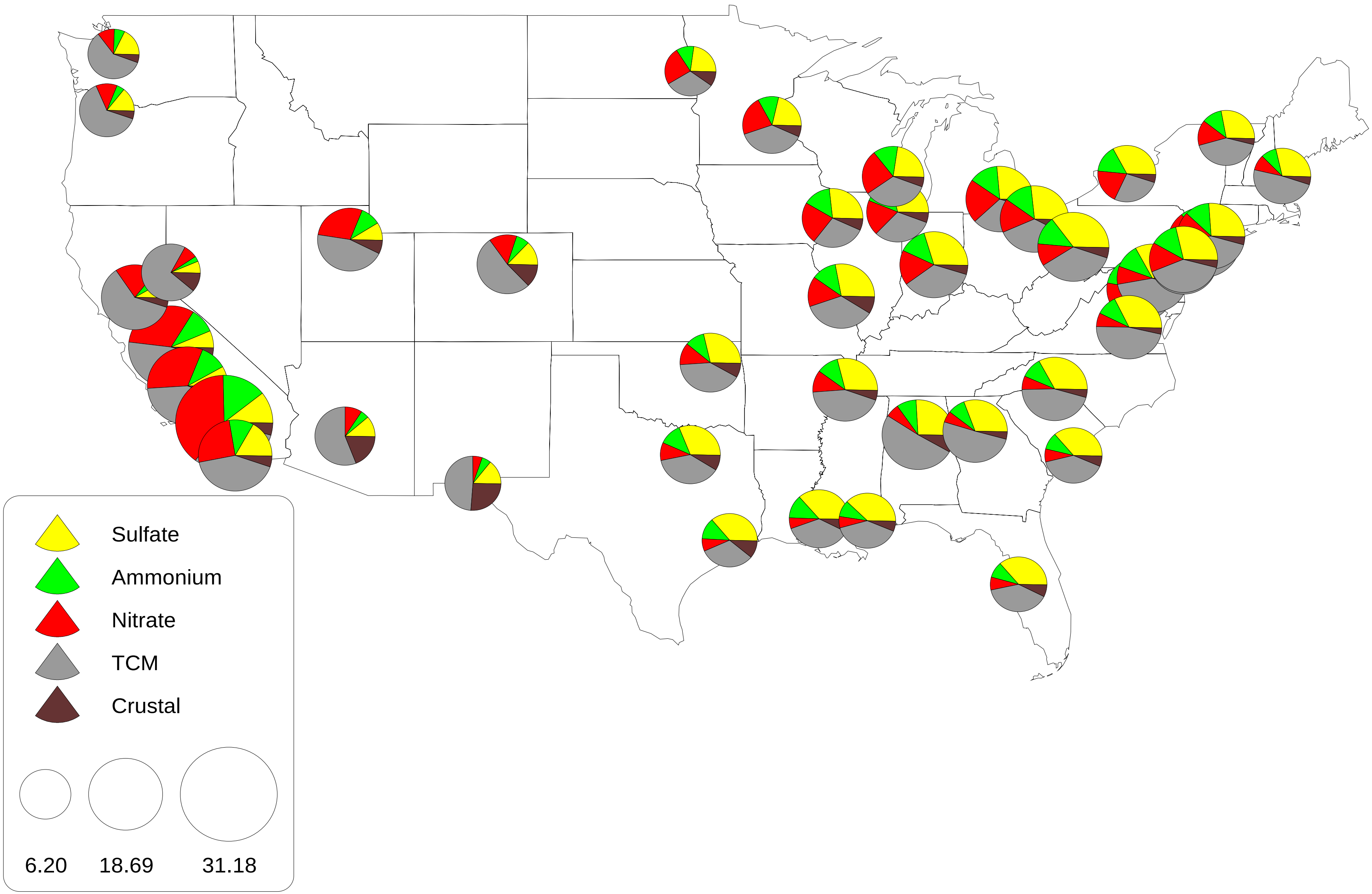
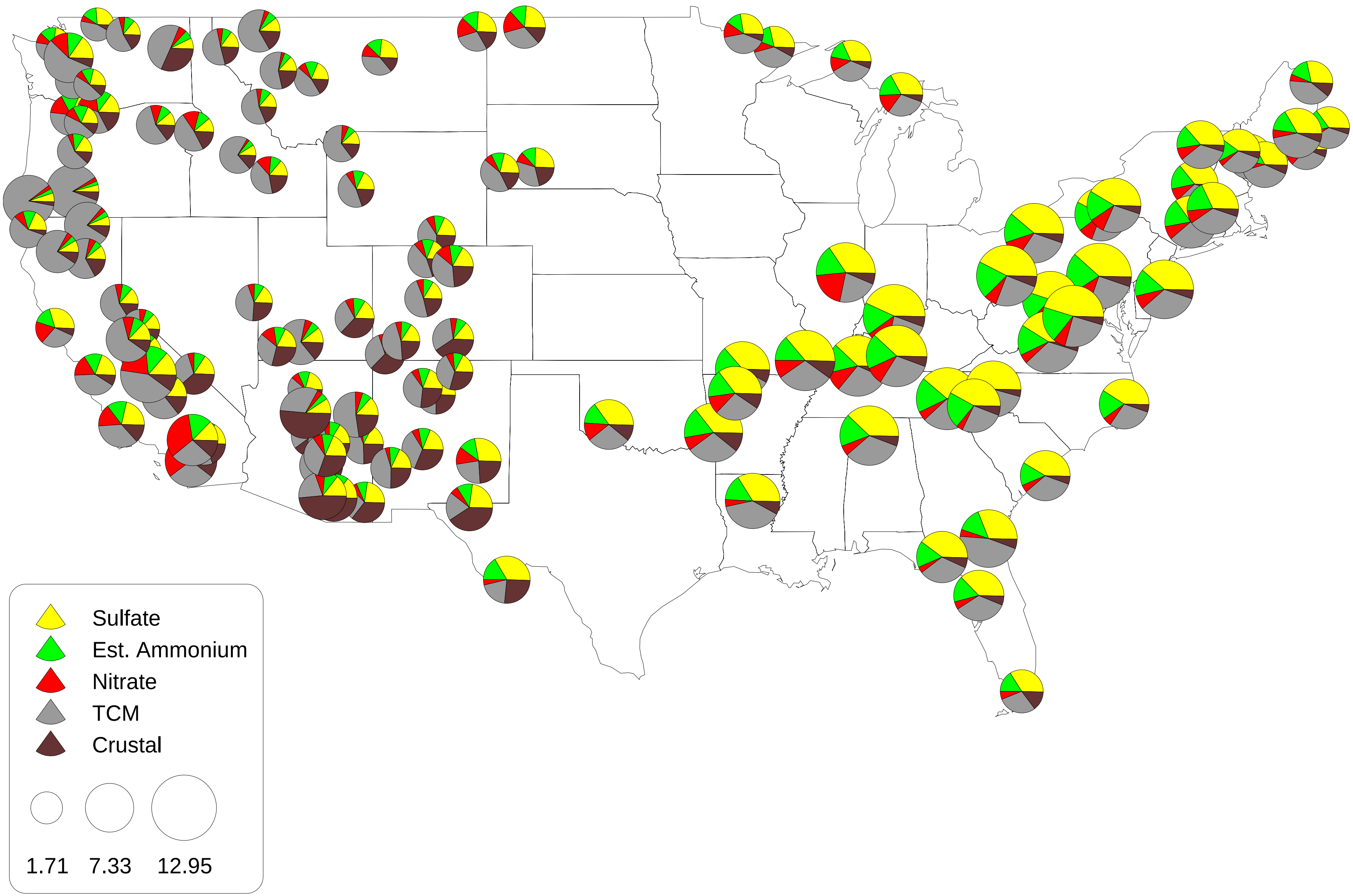
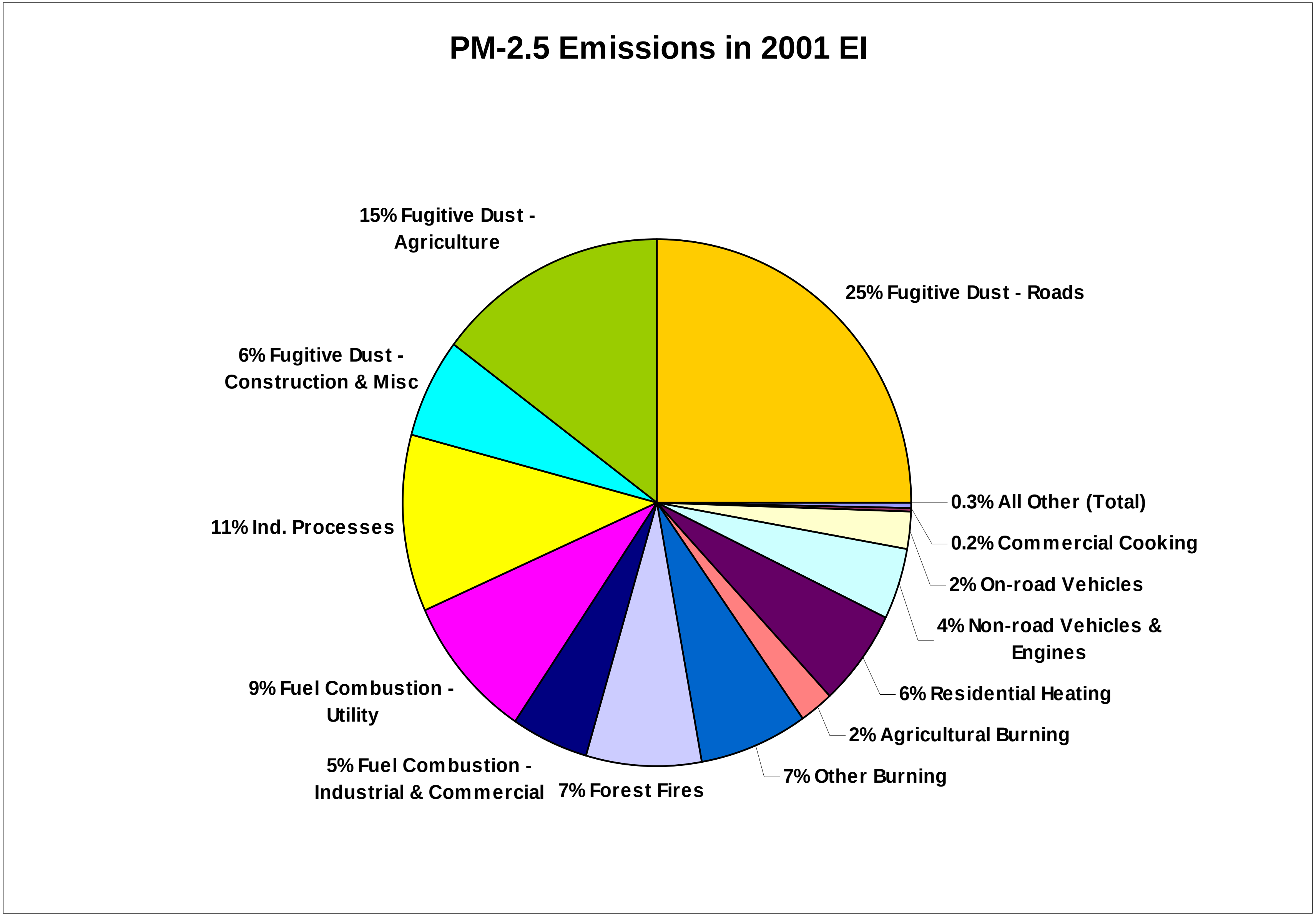
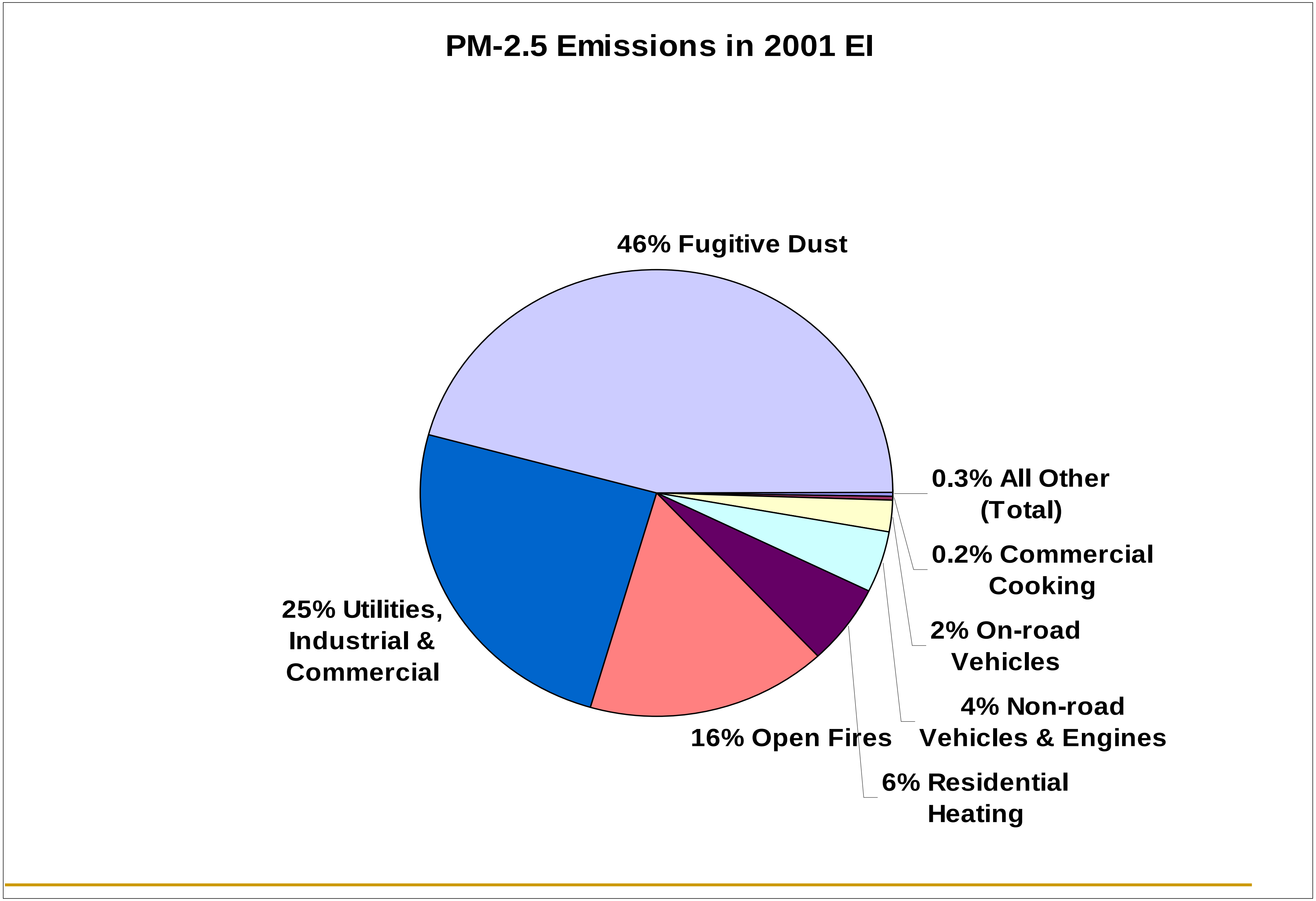
URBAN (EPA STN) ANNUAL AVERAGES
Sep 2001--Aug 2002



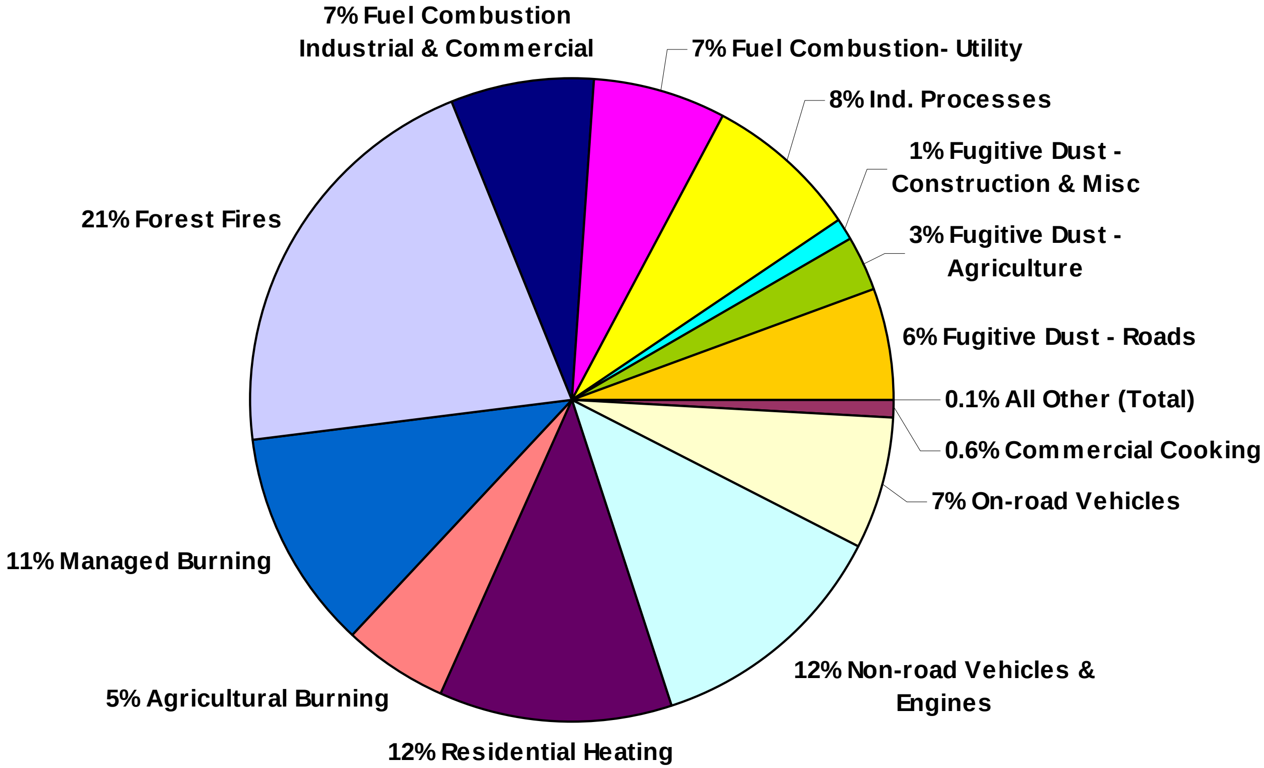
RURAL (IMPROVE) ANNUAL AVERAGES
Sep 2001--Aug 2002

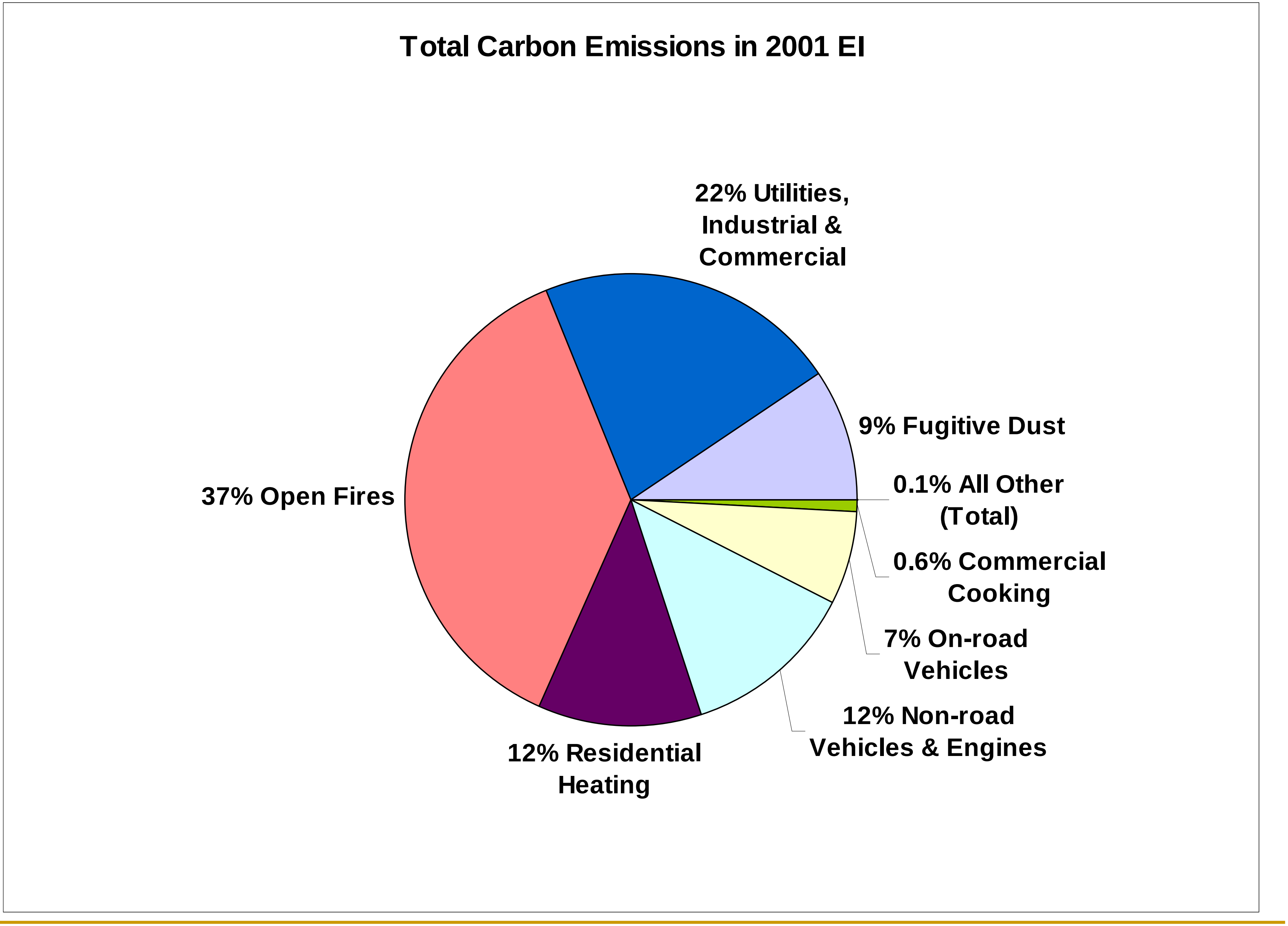



PM-2.5 Emissions in 2001 EI
15% Fugitive Dust - Agriculture
25% Fugitive Dust - Roads
6% Fugitive Dust - Construction & Misc
11% Ind. Processes
0.3% All Other (Total)
0.2% Commercial Cooking
2% On-road Vehicles
4% Non-road Vehicles & Engines
6% Residential Heating
2% Agricultural Burning
9% Fuel Combustion - Utility
7% Other Burning
5% Fuel Combustion - Industrial & Commercial
7% Forest Fires


PM-2.5 Emissions in 2001 EI
46% Fugitive Dust
0.3% All Other (Total)
0.2% Commercial Cooking
2% On-road Vehicles
4% Non-road Vehicles & Engines
6% Residential Heating
16% Open Fires
25% Utilities, Industrial & Commercial

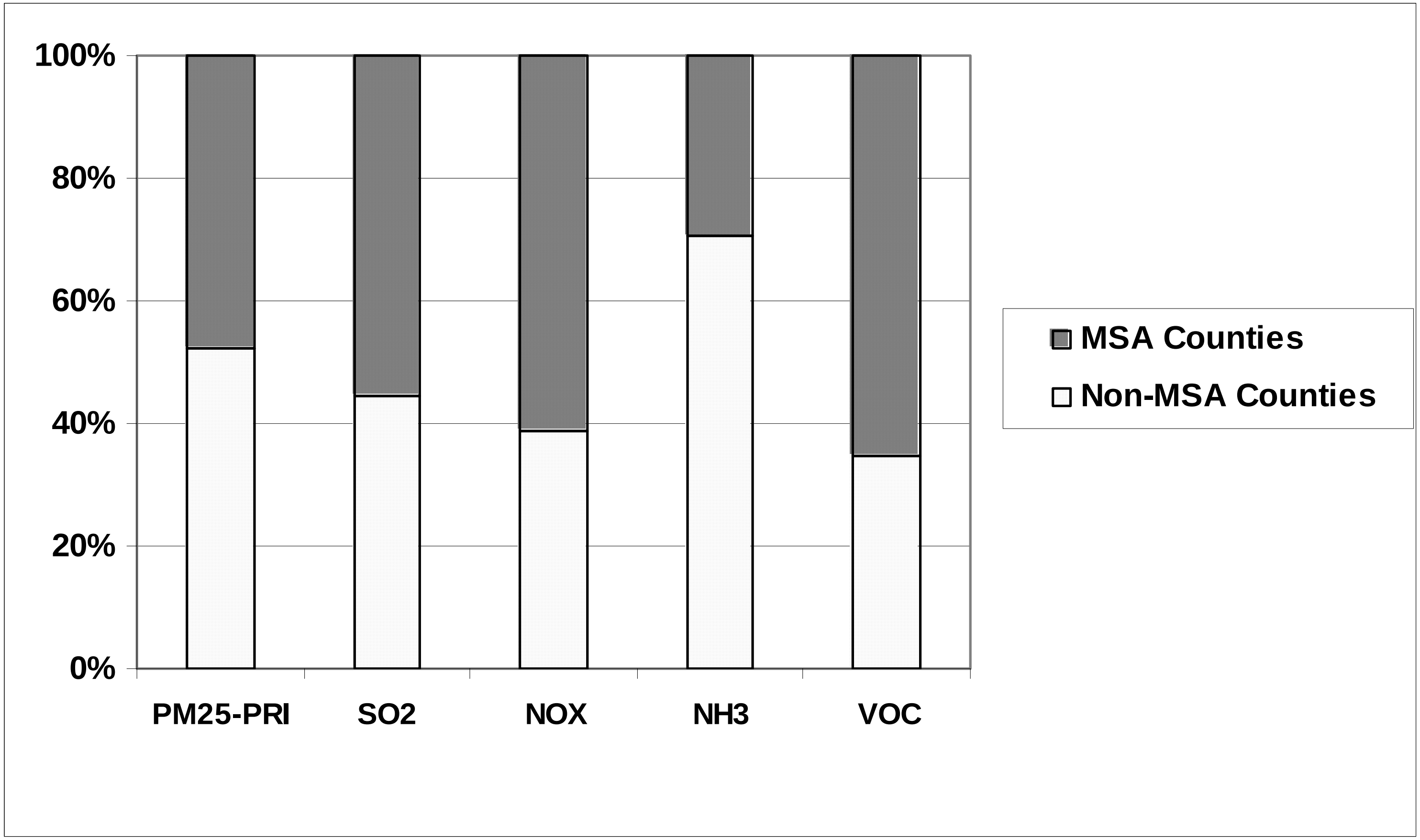
Total Carbon Emissions in 2001 EI




Total Carbon Emissions in 2001 EI
22% Utilities, Industrial & Commercial
9% Fugitive Dust
0.1% All Other (Total)
0.6% Commercial Cooking
7% On-road Vehicles
12% Non-road Vehicles & Engines
12% Residential Heating
37% Open Fires

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

(MSA to Non MSA Comparison)

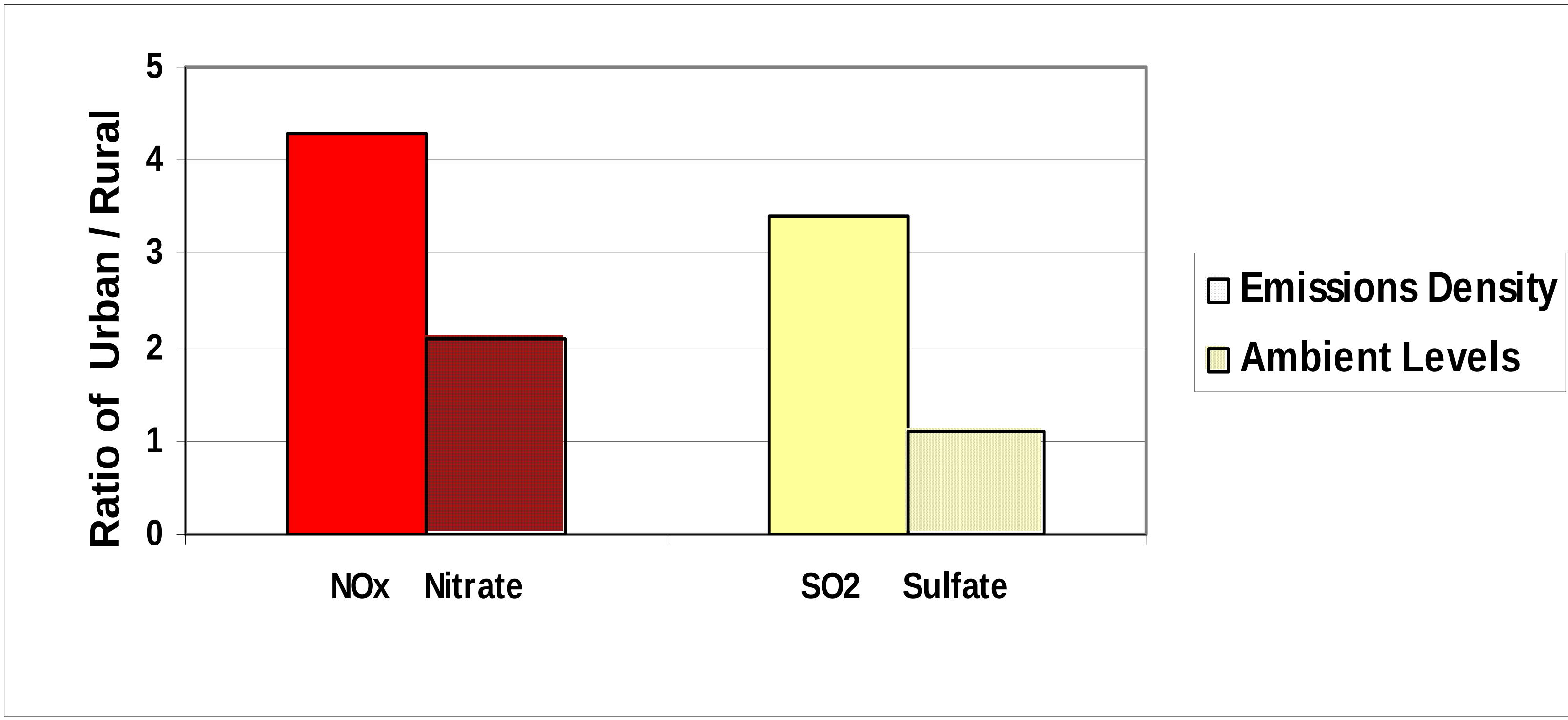


Urban areas responsible for most PM2.5 & precursor emissions – except NH3

Sulfates, Nitrates & Ammonia

Sources and Spatial Extent

Comparison of Urban~Rural Ratios of SO_2, NO_x Emissions & Ambient Sulfate, Nitrate

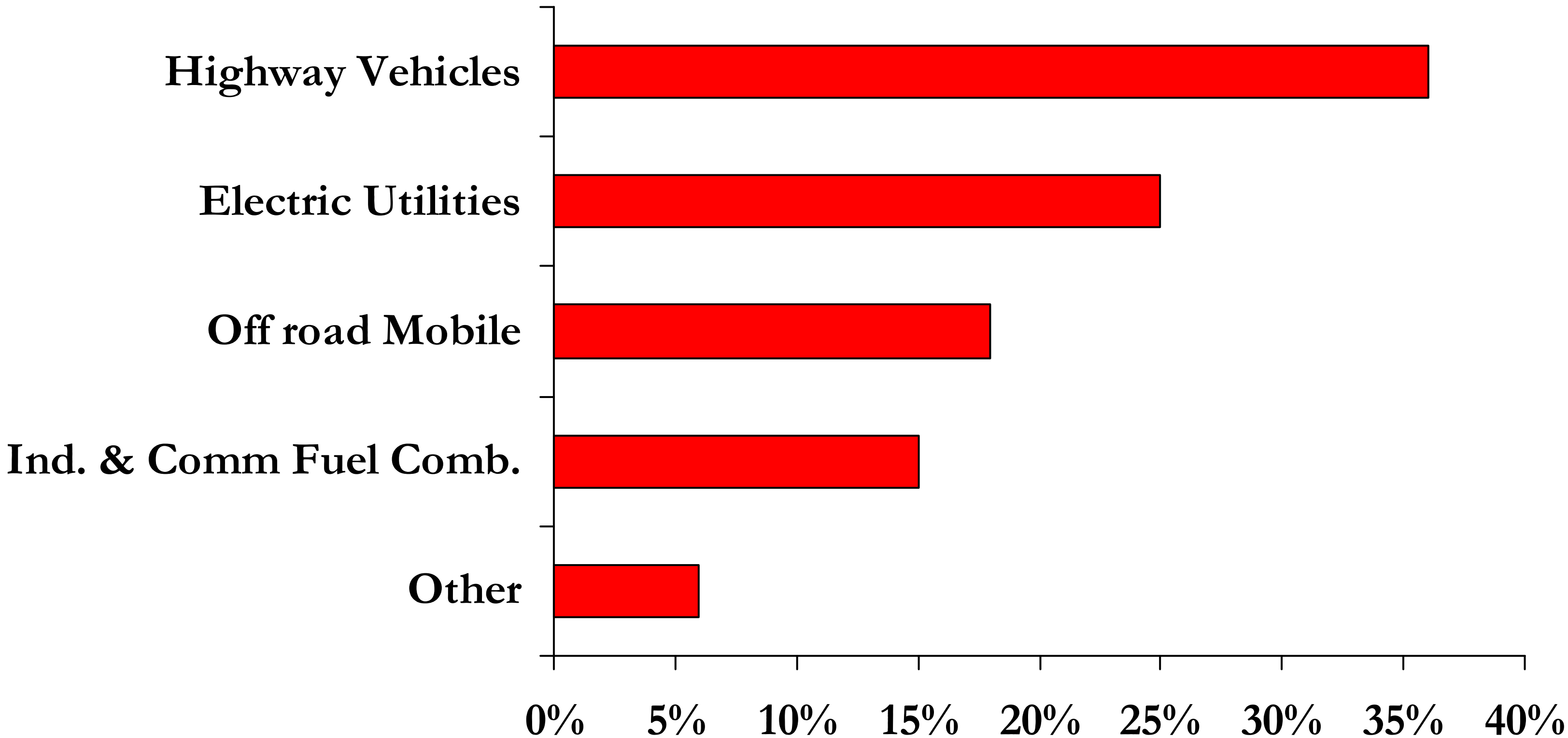


Note: Sulfate particles are more stable and thus have longer lifetime in the atmosphere than Nitrate. Sulfate is therefore more subject to transport

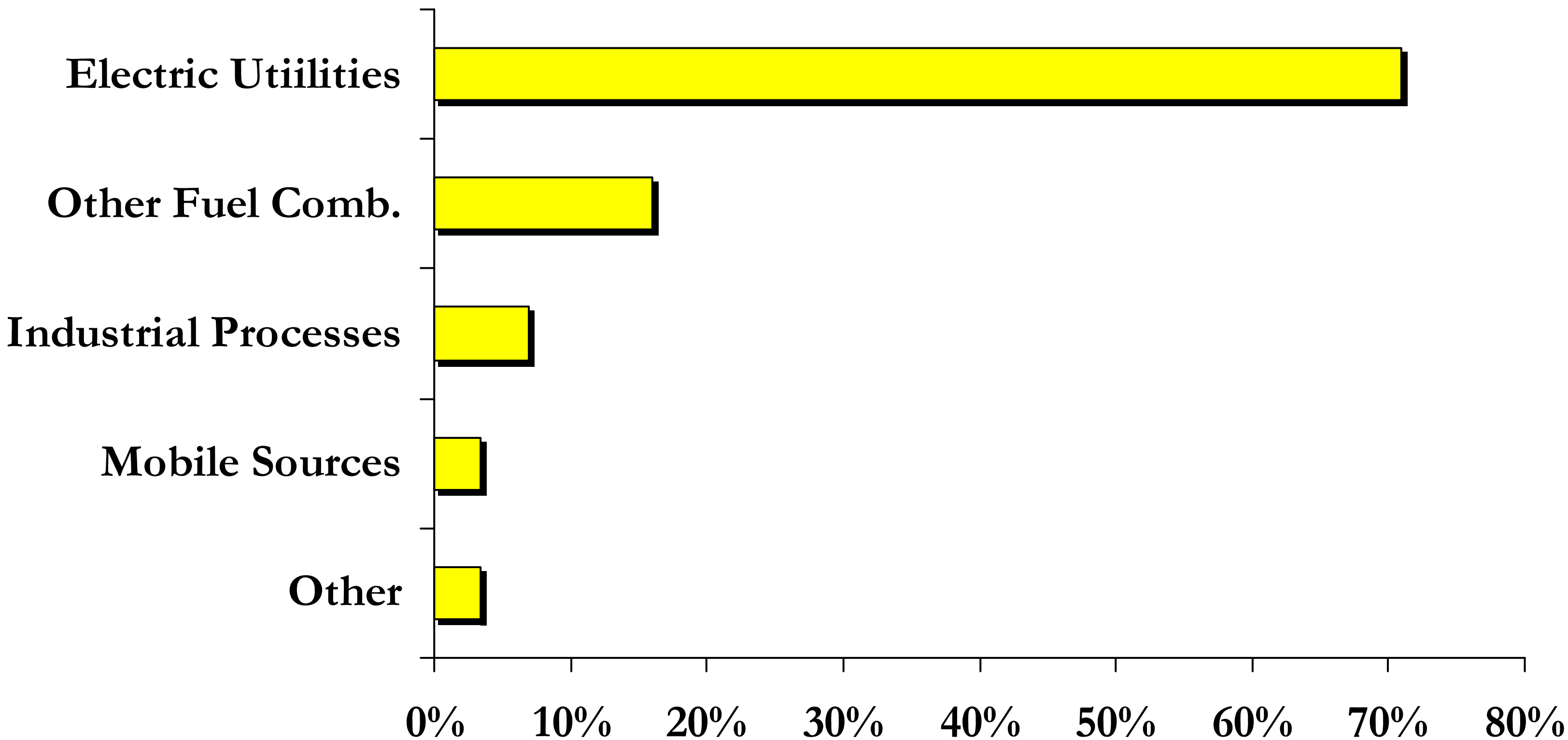
Sulfates & Nitrates

- Formed in atmosphere from SO_2 & NO_x
- Usually found as Ammonium Sulfate / Nitrate
- Urban ~ Rural Patterns
  - Emission densities of both SO_2 & NO_x:
    - > 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”

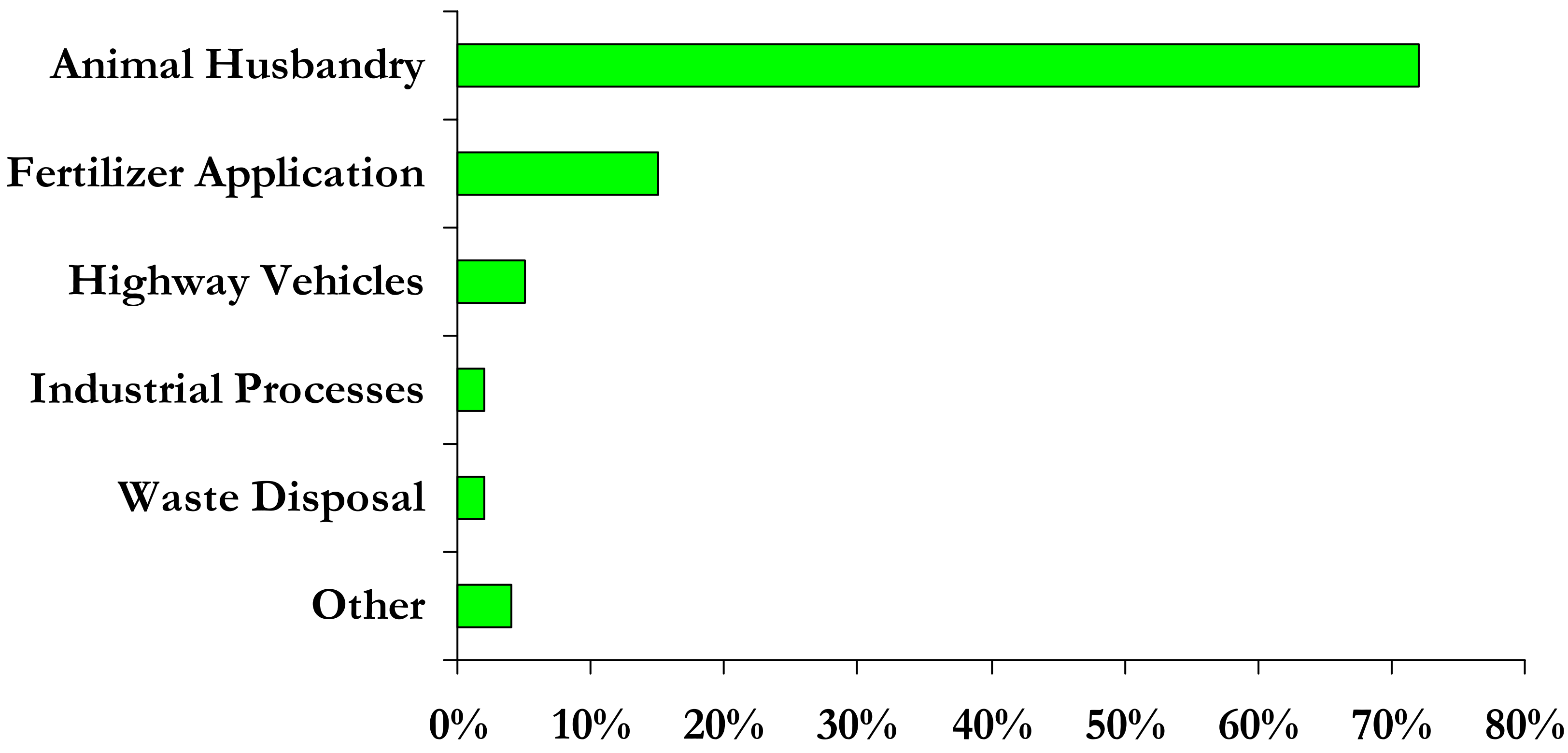
NOx – Precursor to Ammonium Nitrate and Ozone (National Emissions ~ 23M TPY)



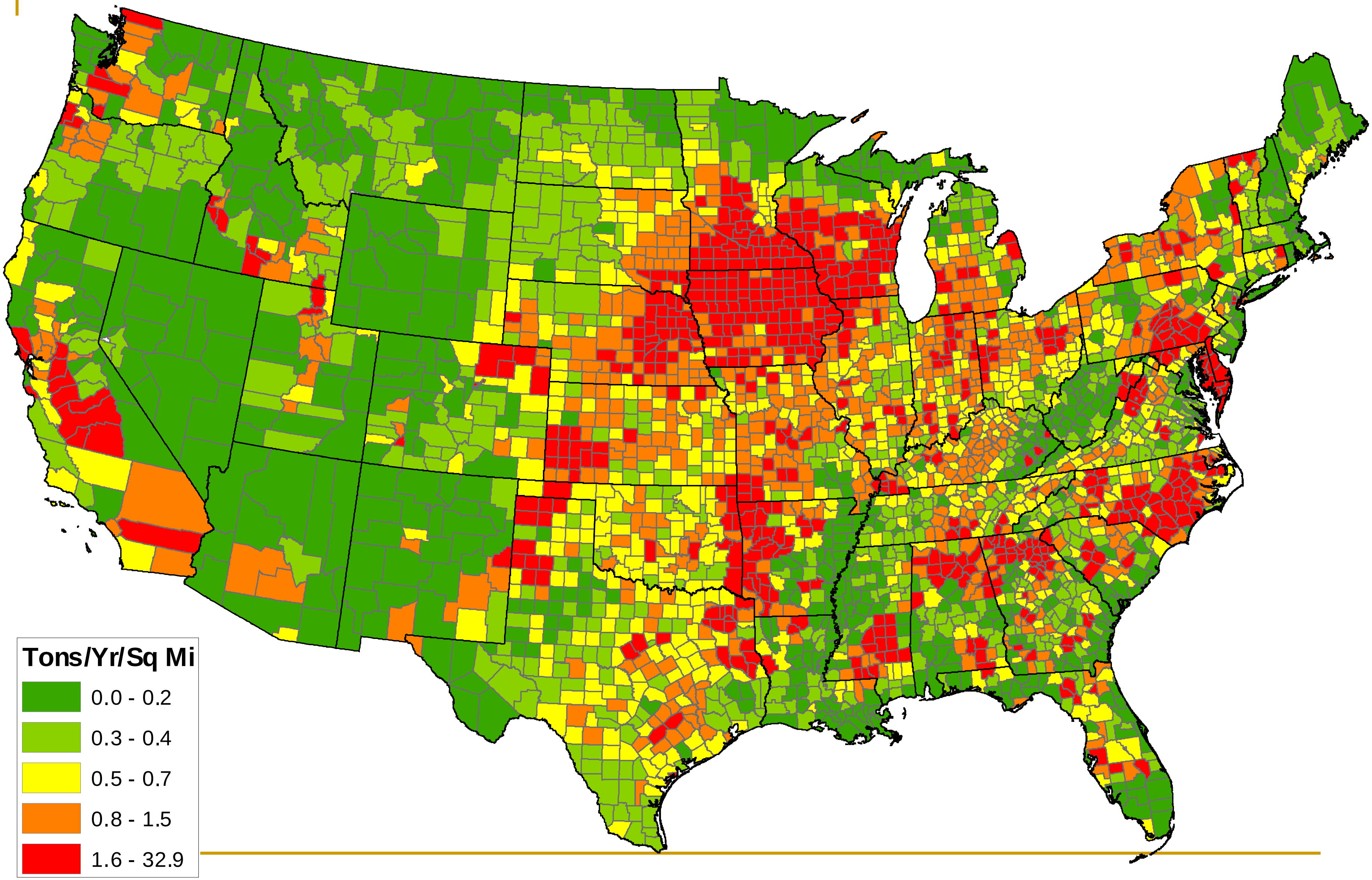
SO2 – Precursor to Ammonium Sulfate Formation (National Emissions ~ 17.6 M TPY)

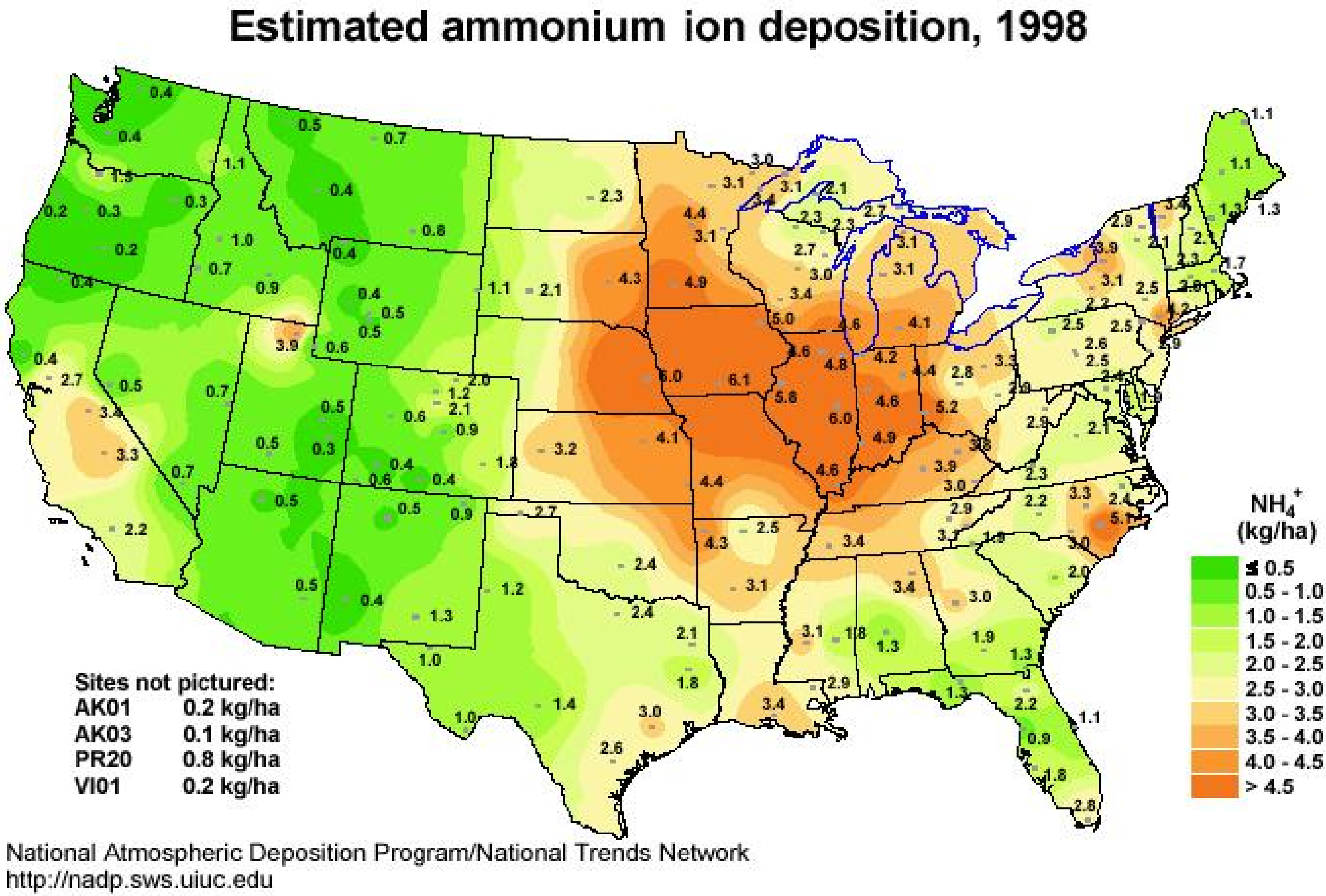


NH3 – Precursor to Ammonium Sulfate & Nitrate (National Emissions ~ 4.8 M TPY)



2002 NH3 Emissions from Animal Husbandry




Estimated ammonium ion deposition, 1998
NH_4^+ (kg/ha)
≤ 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
> 4.5
Sites not pictured:
AK01 0.2 kg/ha
AK03 0.1 kg/ha
PR20 0.8 kg/ha
VI01 0.2 kg/ha
National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

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

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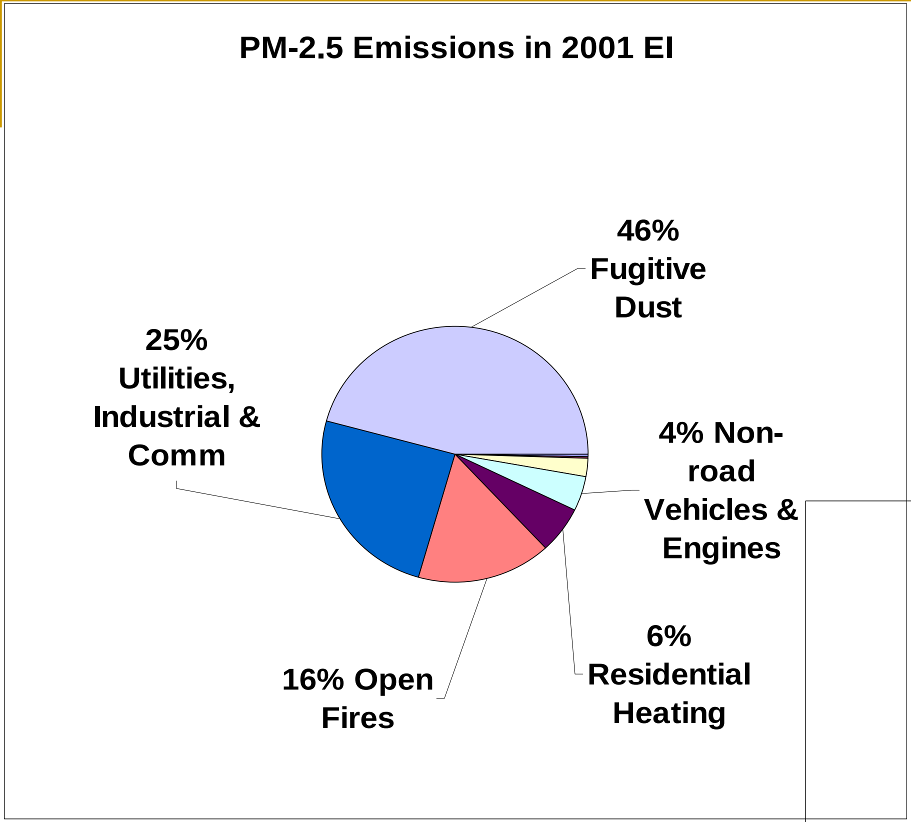
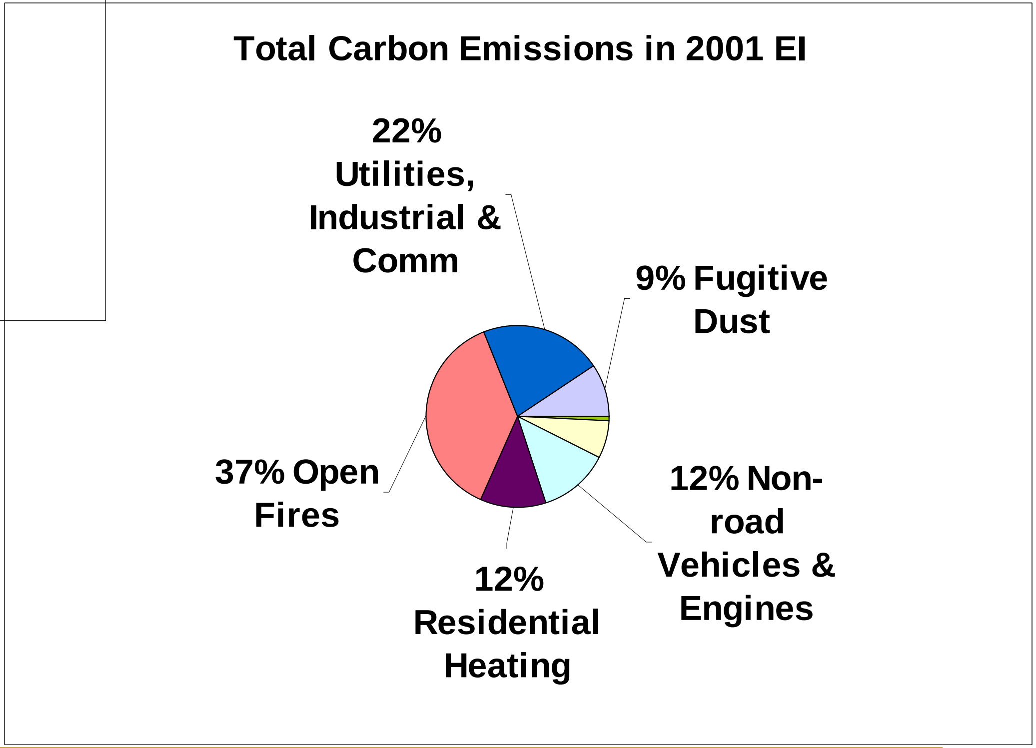
- **Fugitive Dust has low "Transportable Fraction"**

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….)

Identifying the Key Sources of **Carbon** From within the PM2.5 Emissions Inventory



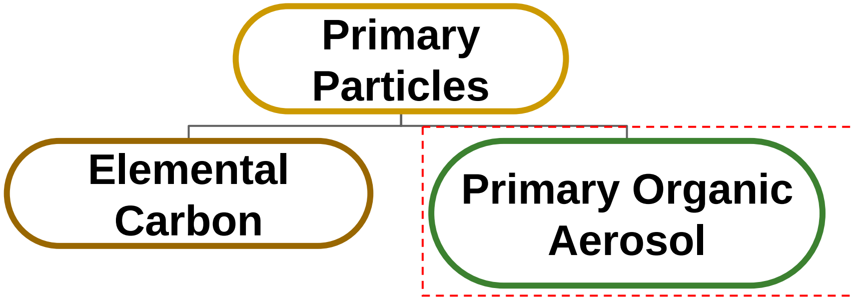


Carbon Particles

Primary Particles + Secondary Particles

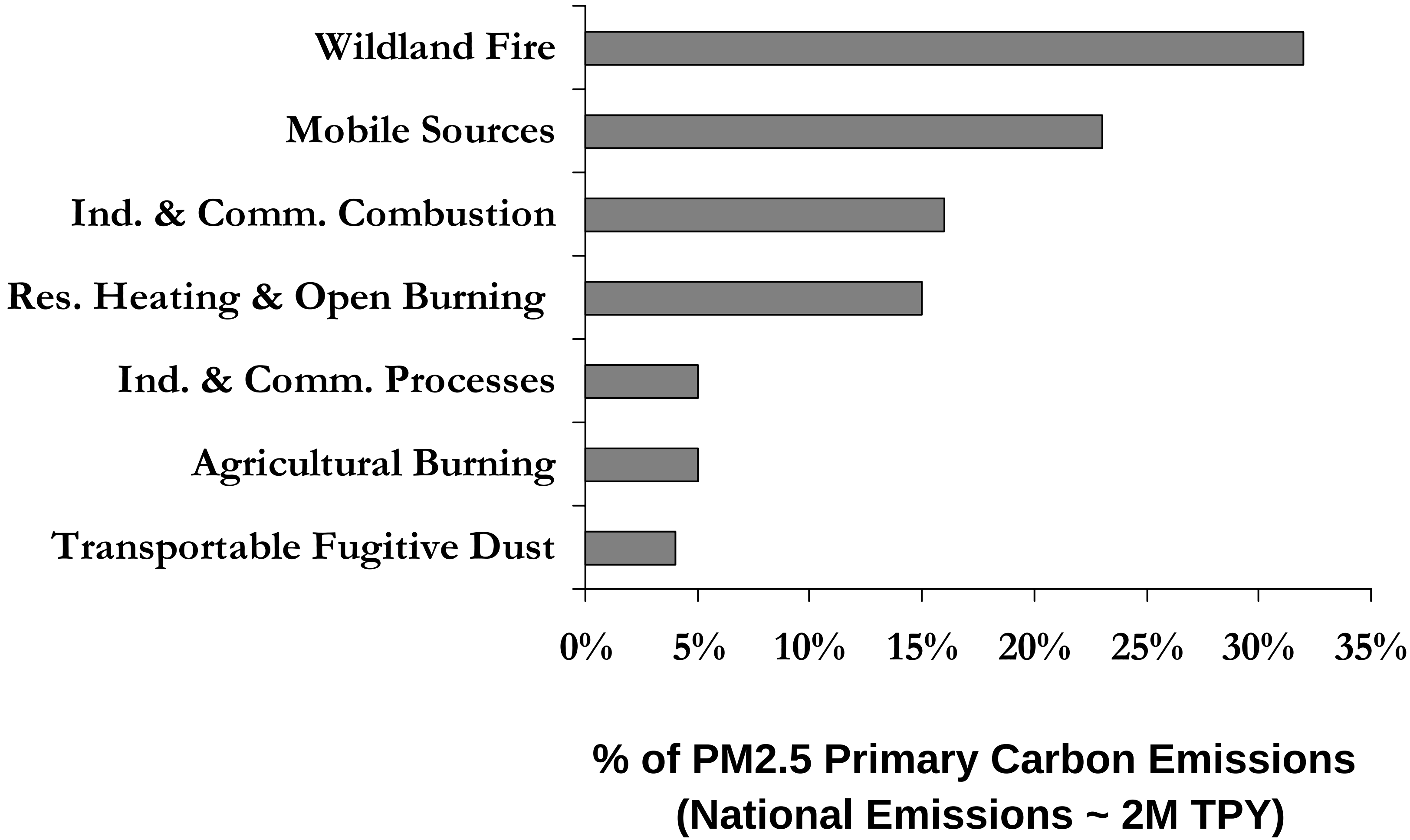
- **Primary & Secondary Particles**

Carbon Particles: Composition & Terminology



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

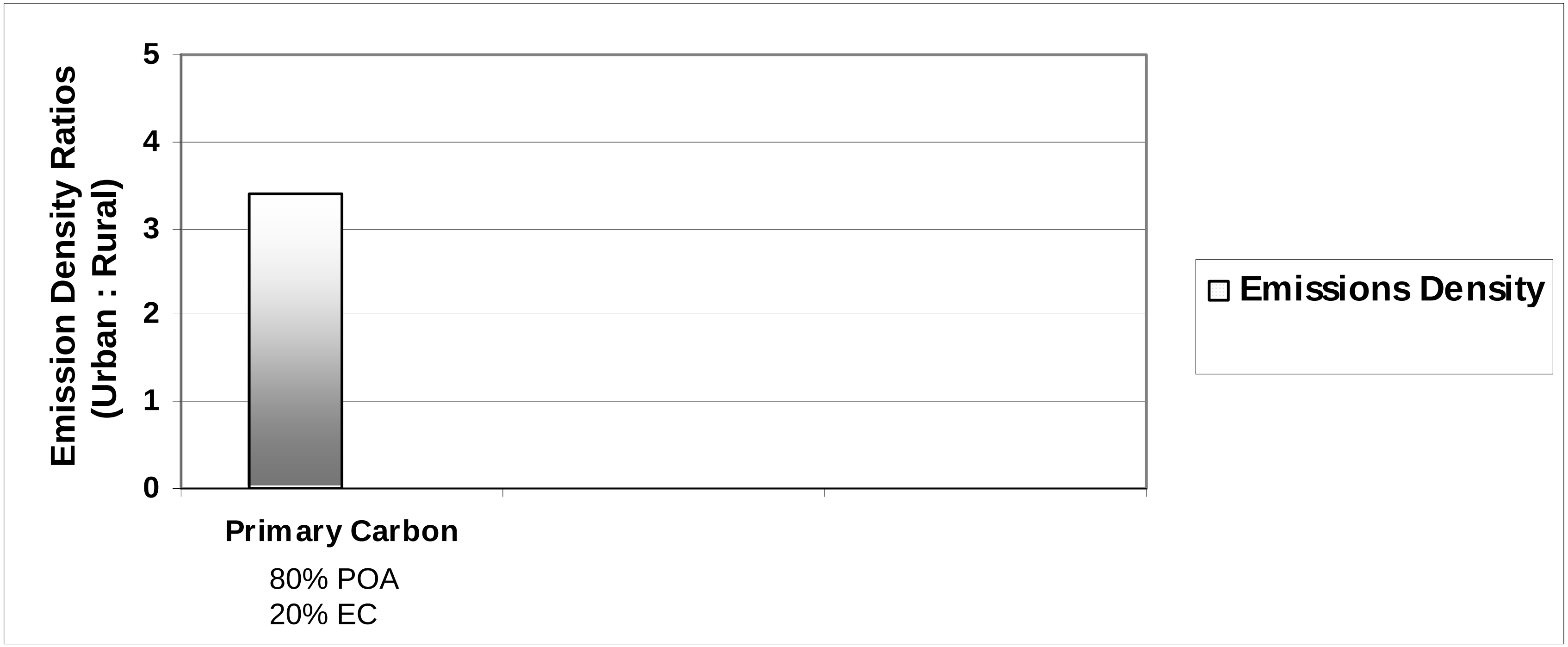
Primary Carbon in PM2.5



POA & EC Characteristics of Primary Carbon Emissions

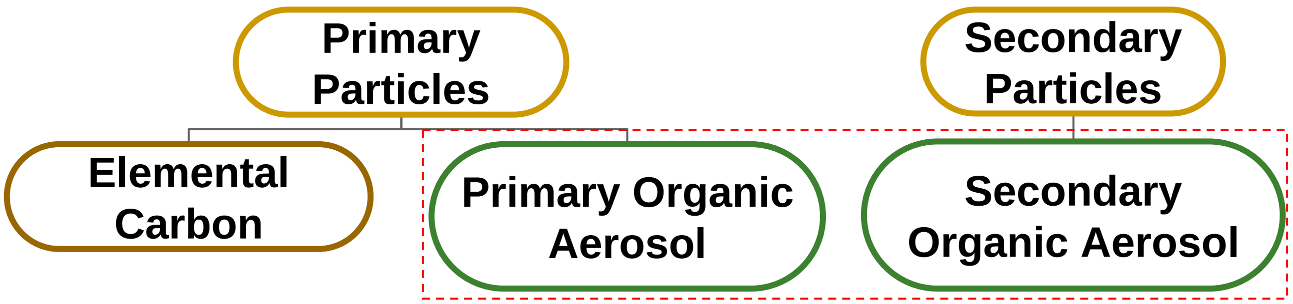
Category	Ratio of organic carbon mass* to elemental carbon mass (average)	Potential range of ratios
Forest Fires	9.9	6 – 28
Managed Burning	12	6 – 28
Agricultural Burning	12	2.5 – 12
Open Burning - Debris	9.9	
Non-road Diesel Engines & Vehicles	**0.4**	**0.4 – 3**
On-road Diesel Vehicles	**0.4**	**0.4 – 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

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



* Eastern US

Carbon Particles: Composition & Terminology



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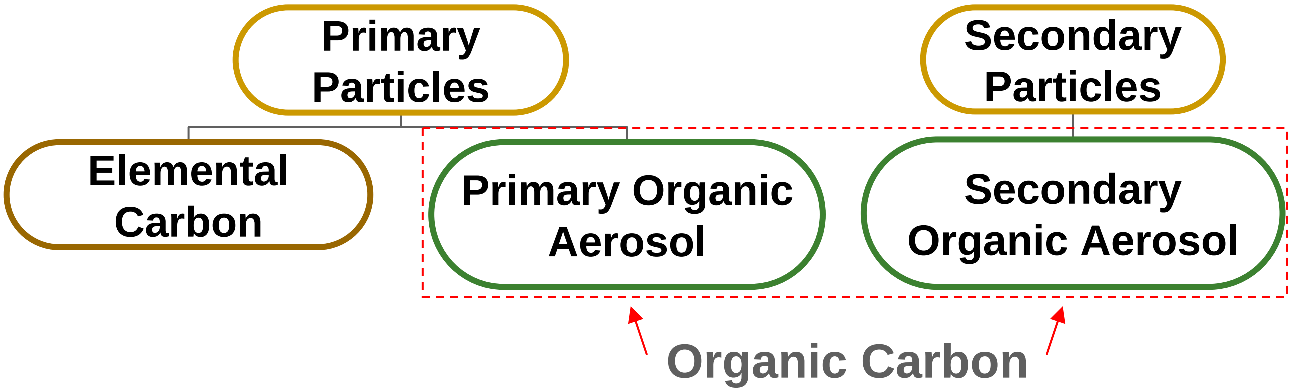
- **Secondary Particles**
  - **Secondary Organic Aerosol (SOA)**

Carbon Particles: Composition & Terminology



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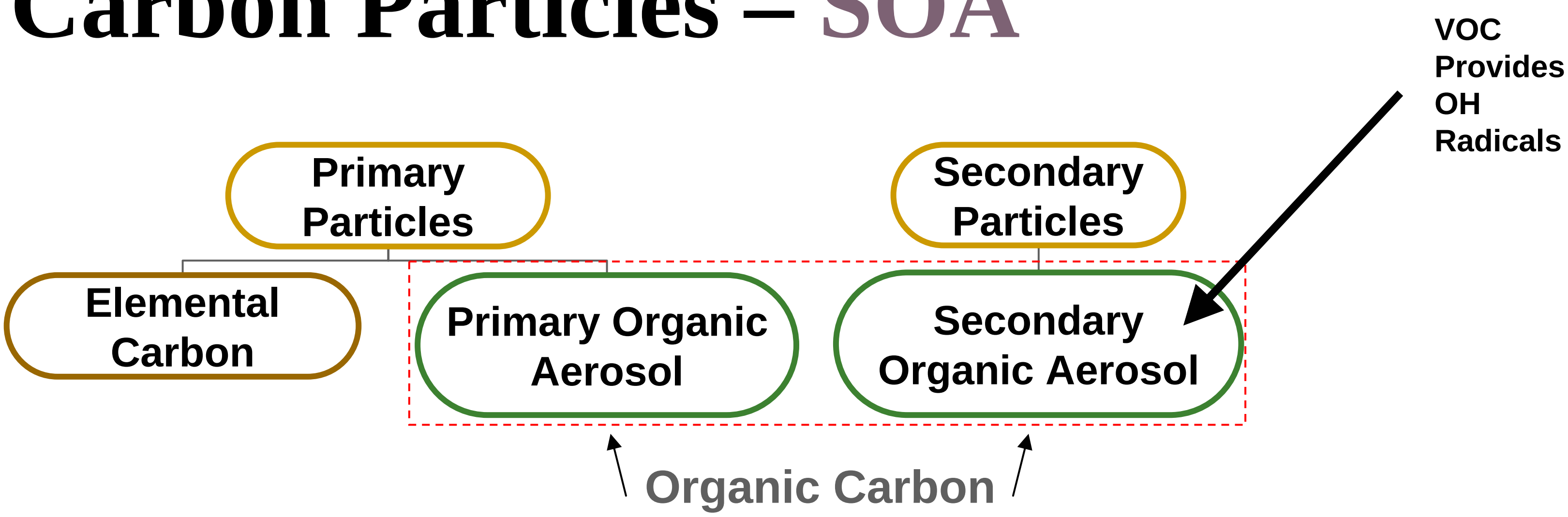
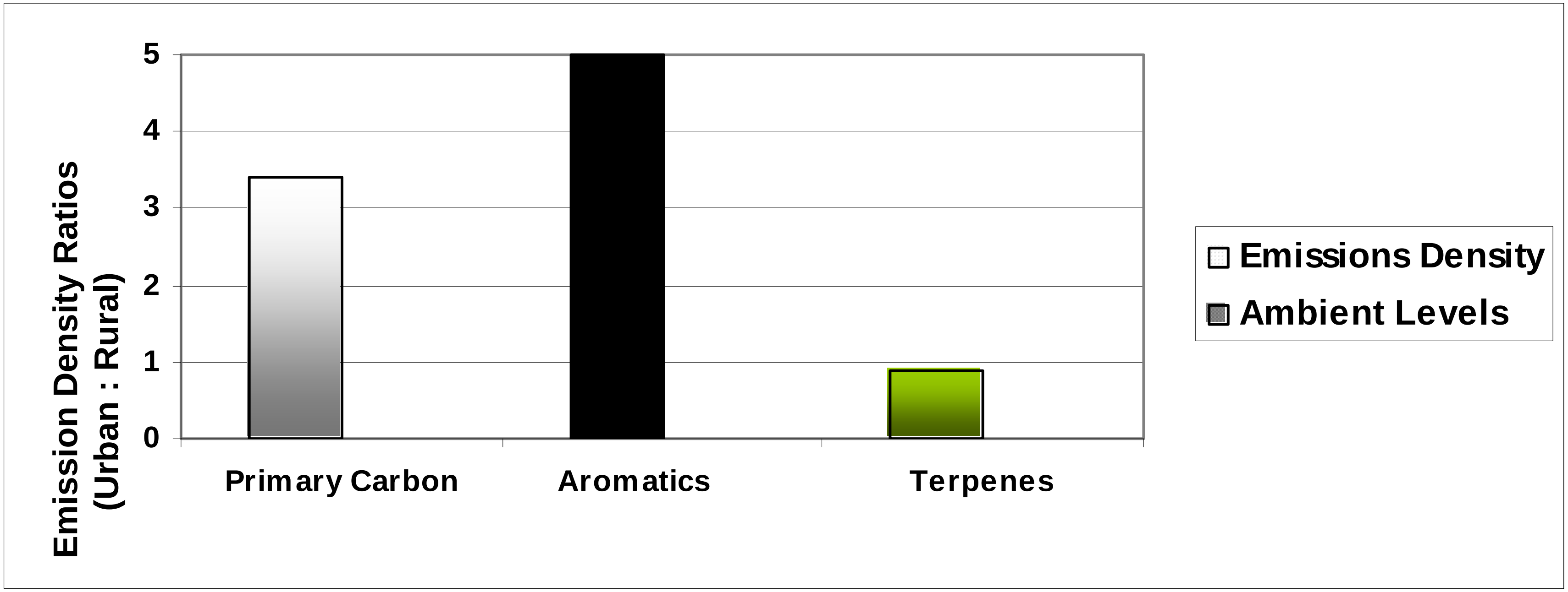
  - **Primary Carbon = EC (BC) +** Primary Organic Aerosol (POA)
- Secondary Particles
  - Secondary Organic Aerosol (SOA)
- Organic Carbon = POA & Secondary Organic Aerosols

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



80% POA
20% EC

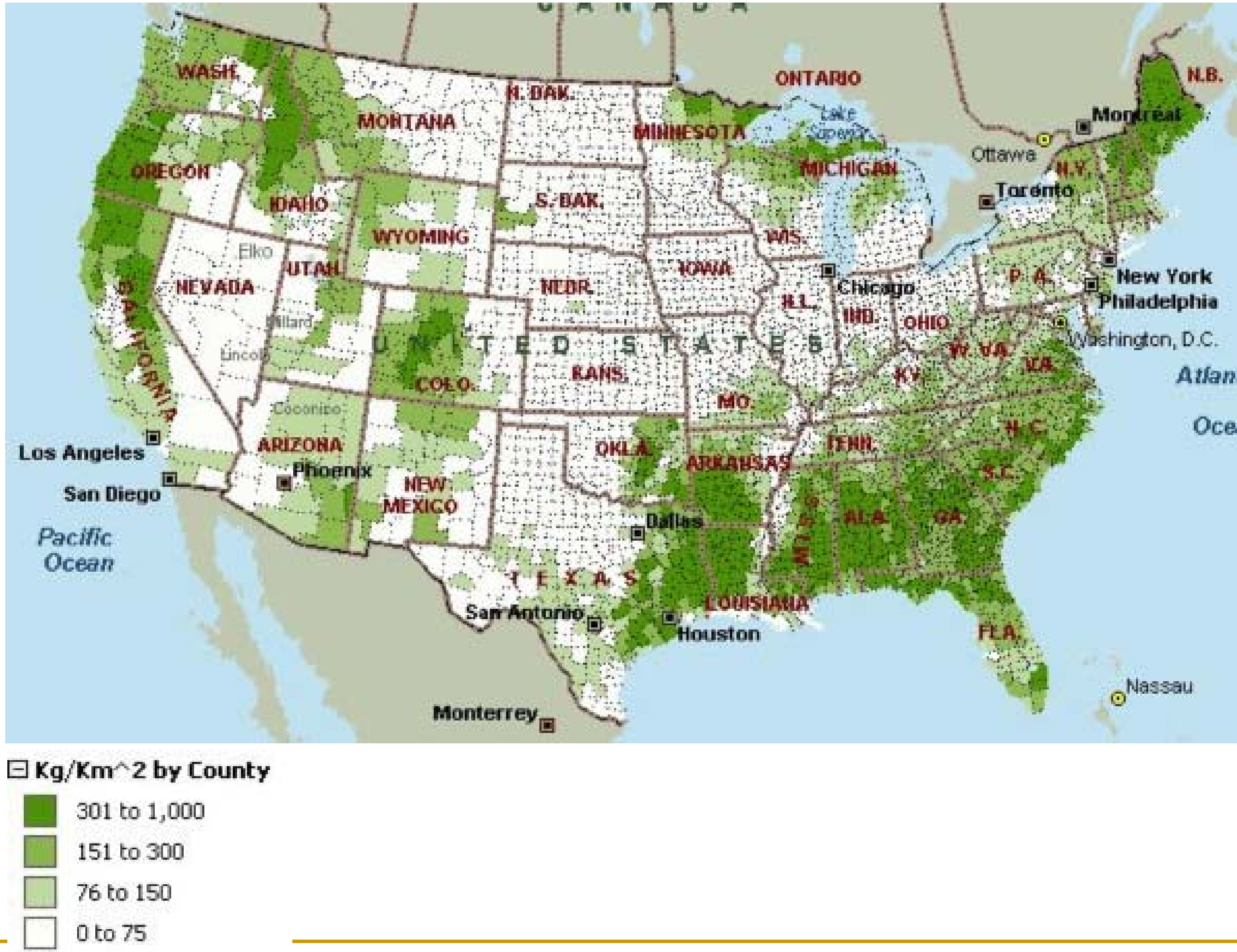
70% Mobile

Biogenic

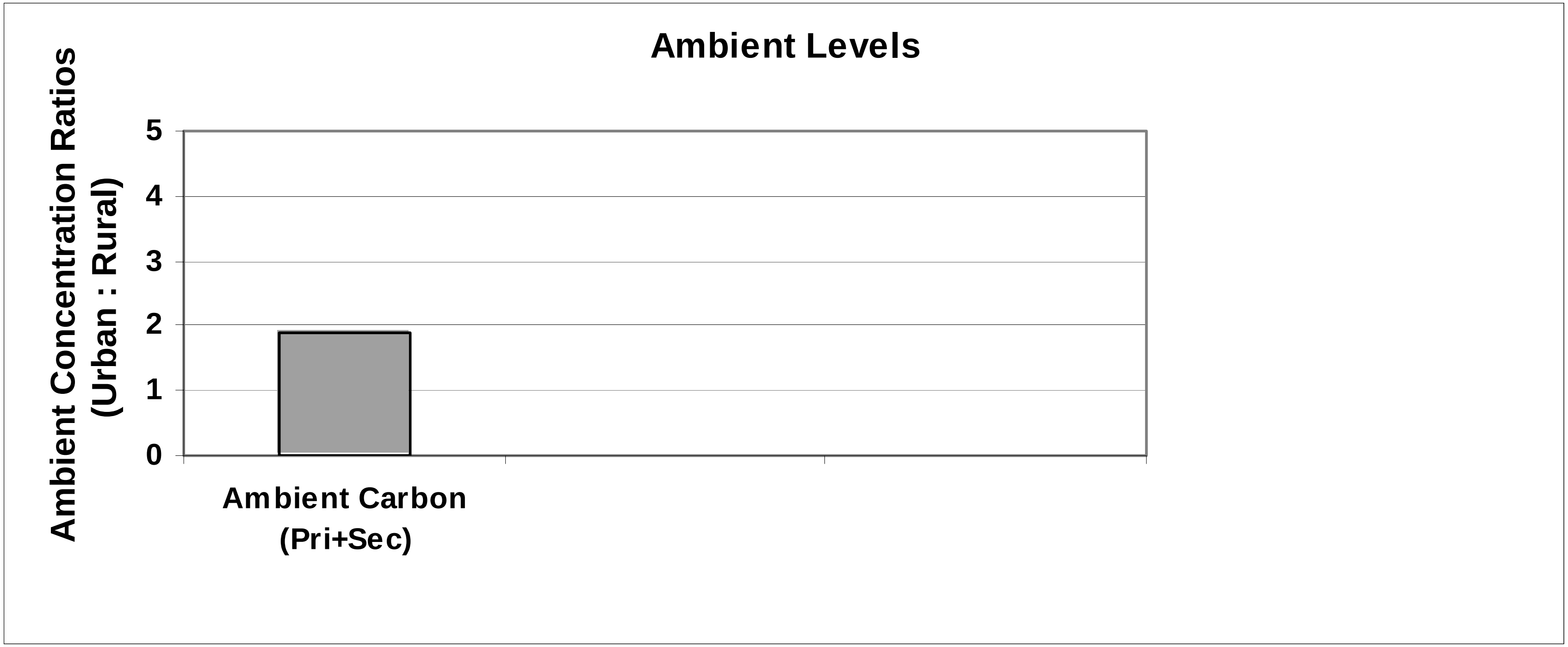
Emissions: 2.2M tpy (Ann) 3.7 M tpy (Ann) .35 M tpy (July)

* Eastern US

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



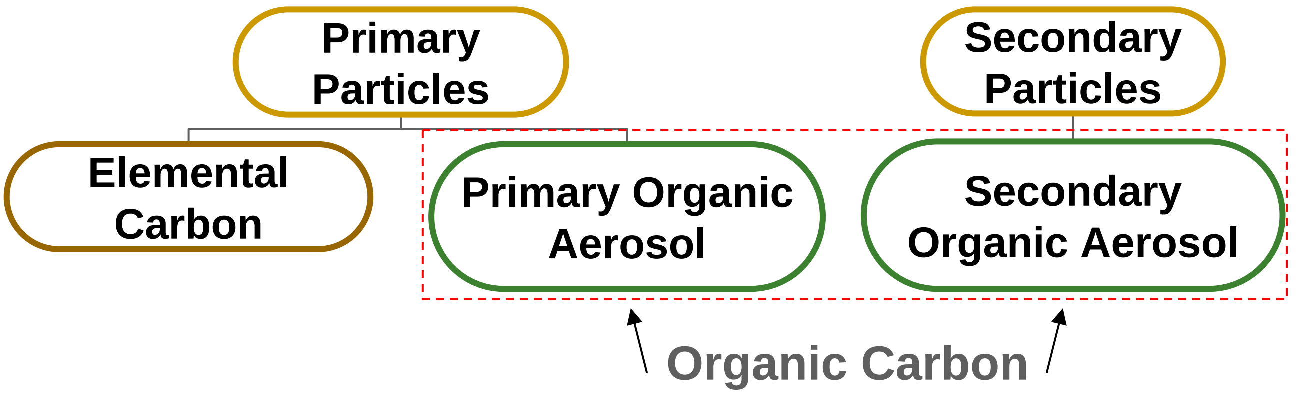
Urban Ambient Carbon vs Rural Ambient Carbon*
(Ambient Carbon = EC + POA + SOA)



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

**** Eastern US***

Carbon Particles – *"Urban Increment"*



- **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

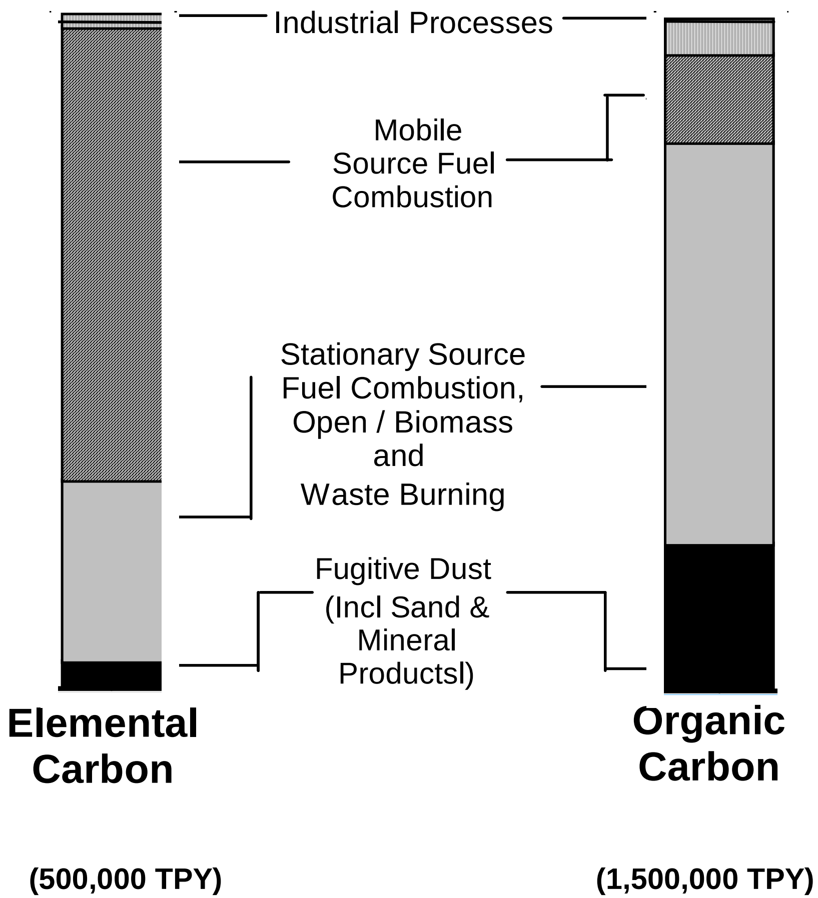
Lets Review

- Carbon: POA & SOA
- Precursor Interrelationships

PM2.5 Primary Emissions Sources - Summary

Directly Emitted (Primary) PM2.5

Emisson Sources of Carbonaceous & Crustal Materials



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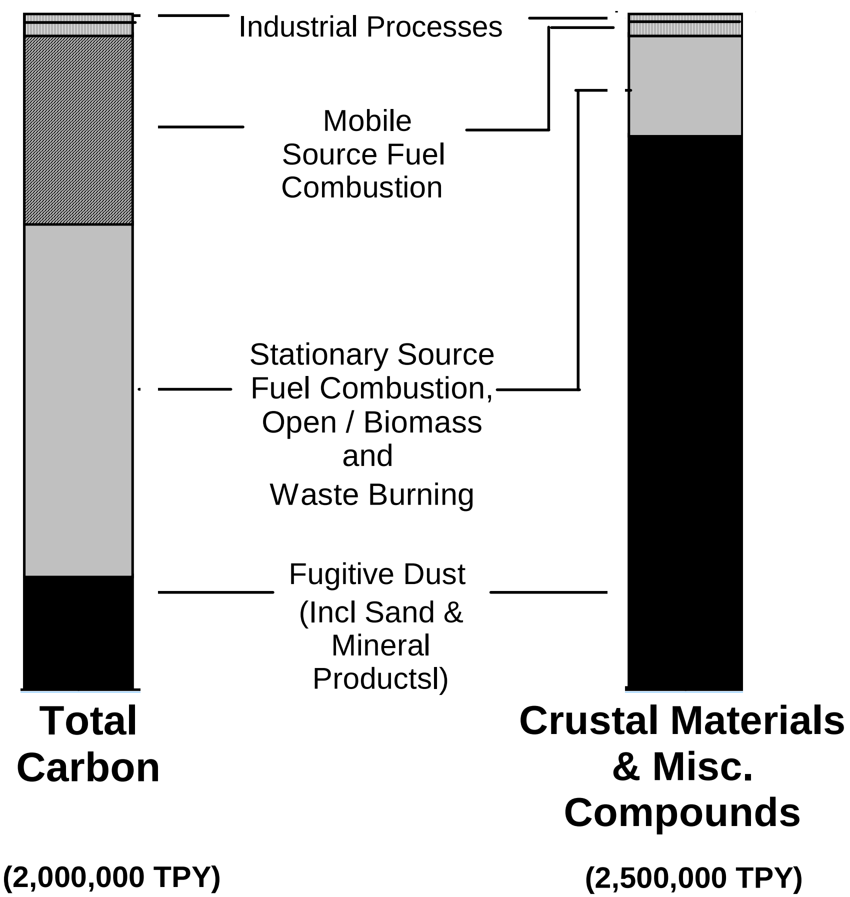

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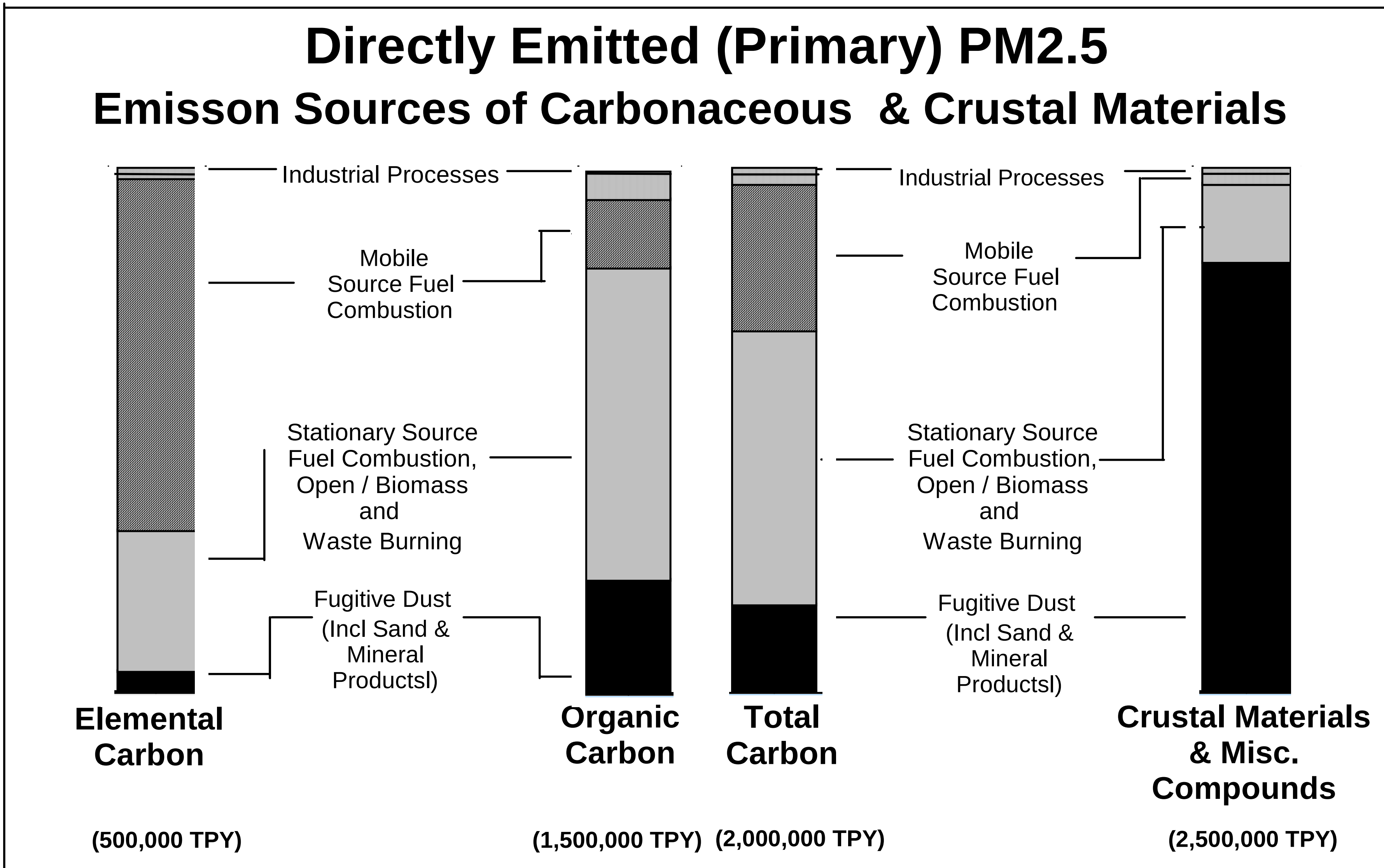
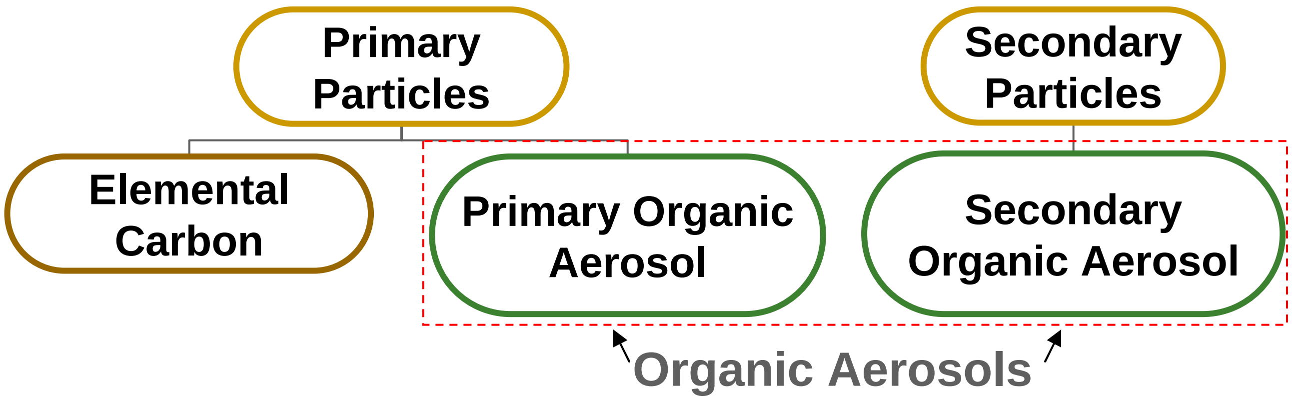


Carbon Particles – POA ~ SOA Summary



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.)

PM 2.5 In Ambient Air - A Complex Mixture

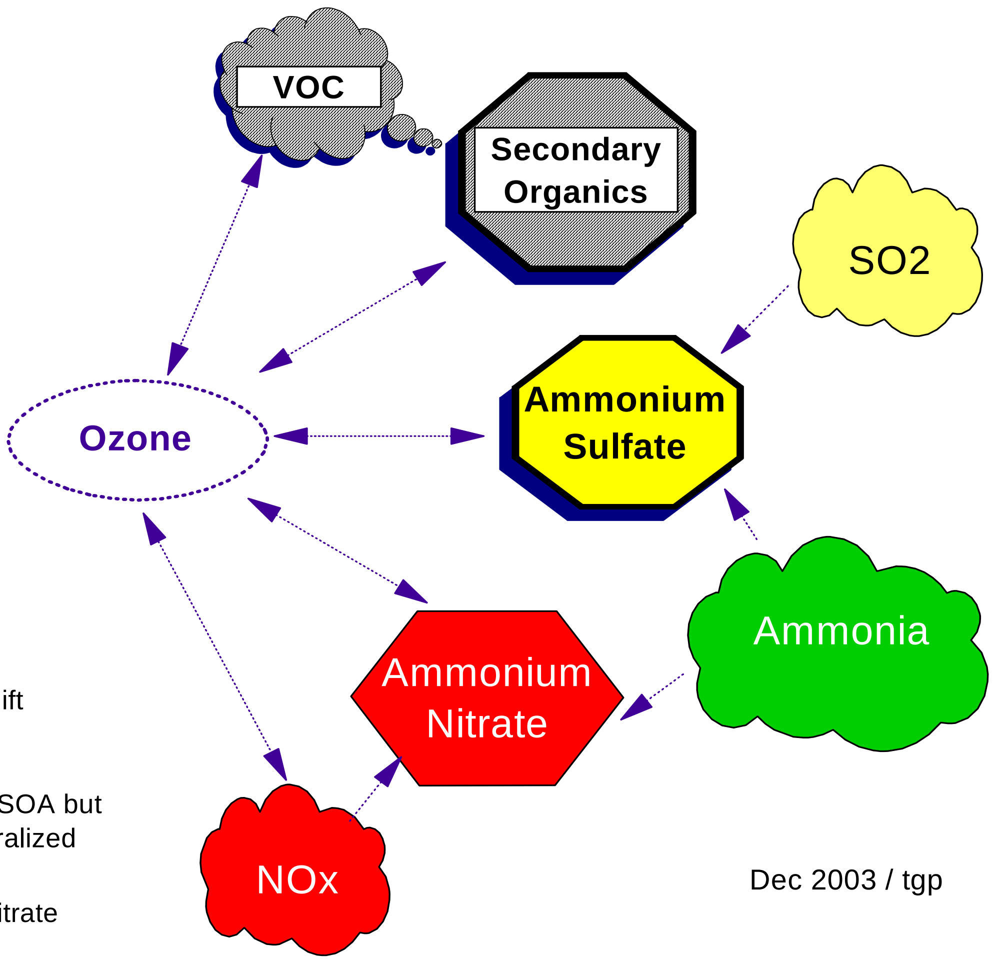
Review of Precursor Interrelationships

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

Ammonium Sulfate
- SO2 from Sulfur in Fuels
- Compared to Ozone:
  - Sulfate forms & deposits more slowly
- If insufficient Ammonia ~
  - Ammonium bisulfate or
  - Sulfuric acid
- Reducing SO2 >> 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



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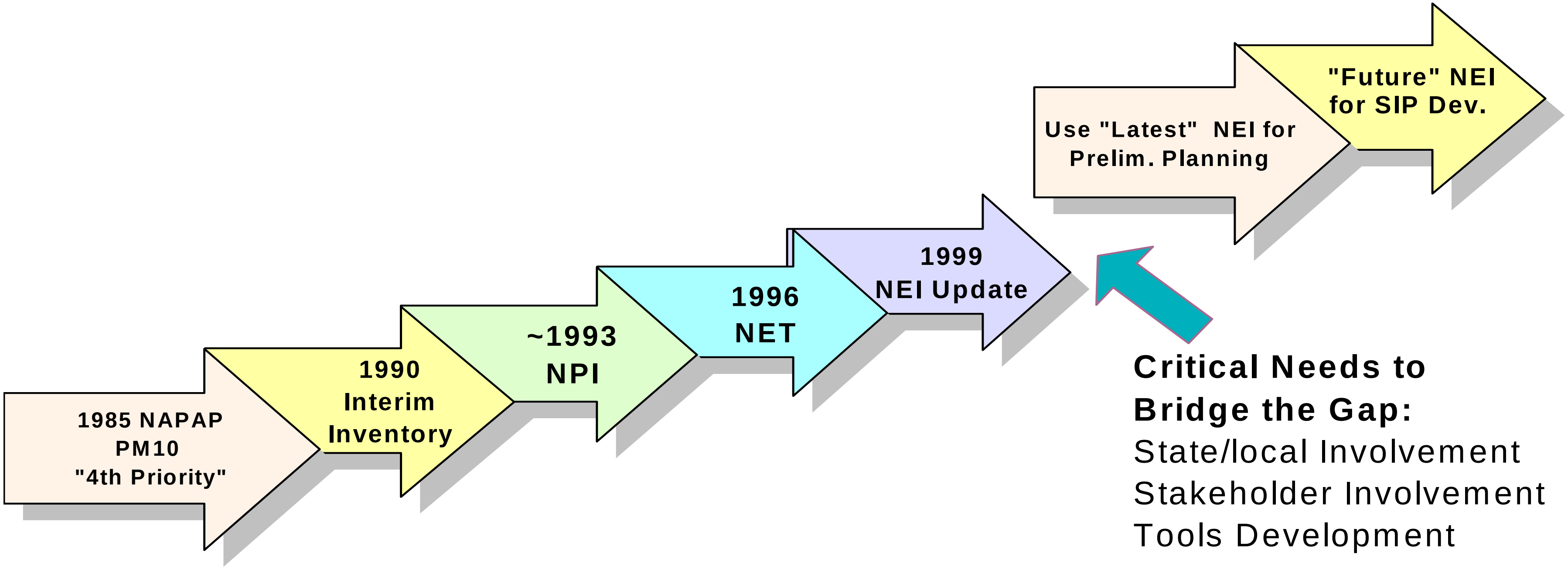
PM is Complex -- Any Questions ?

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

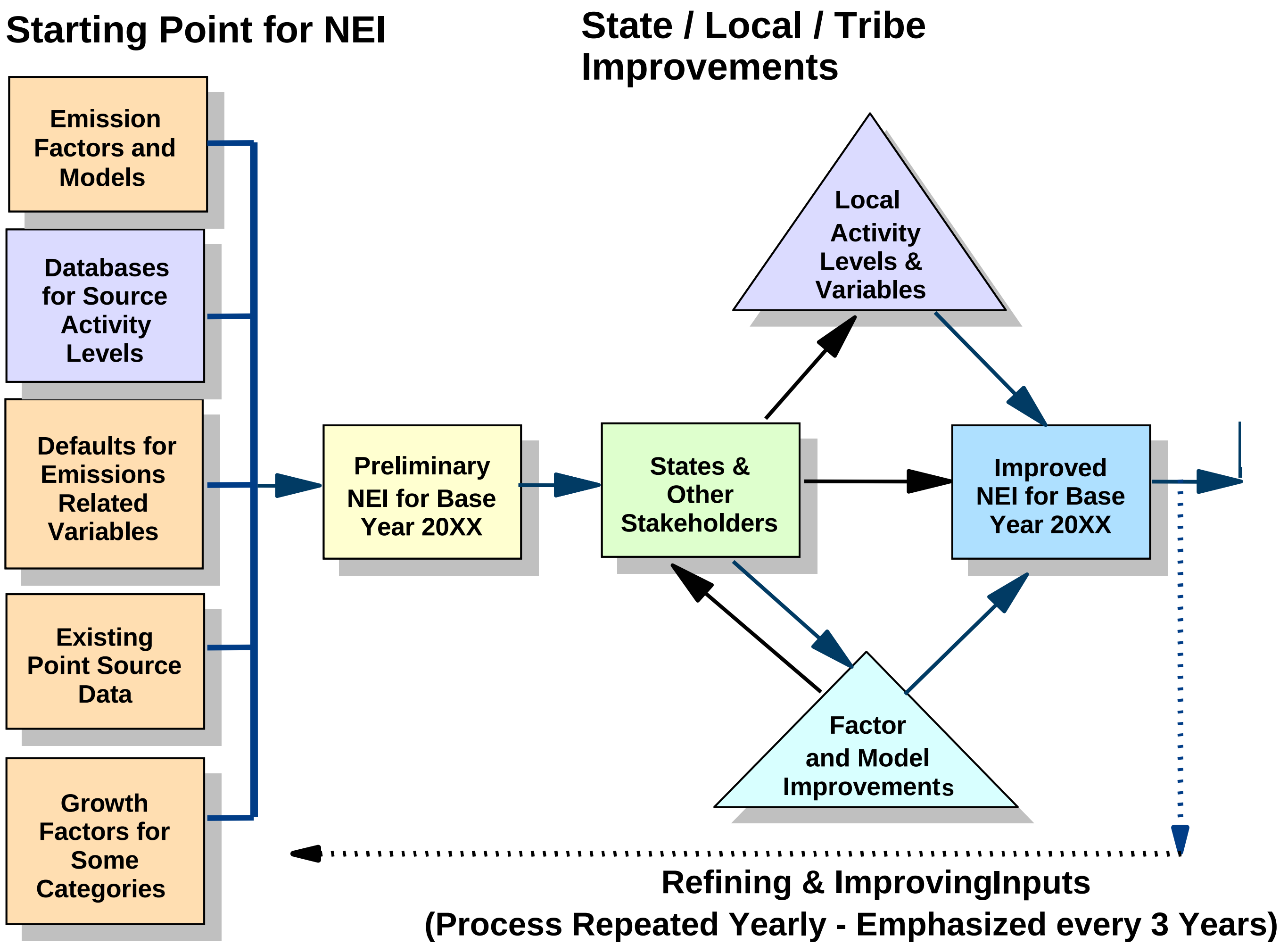
What Info is Contained in the NEI ?

- **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

Why have the NEI ?

- **Inventories are Needed to Support:**
  - Federal Emission Standards (Criteria and HAPs)
  - Preliminary Control Strategy Explorations:
    - National Air Toxics Assessment, Residual Risk rules for HAPs, Urban Air Toxics Strategy
    - PM, Regional Haze
  - Tracking Trends
  - Public information Requests
- **The NEI is essential** in planning for attainment of the National Ambient Air Quality Standards (NAAQS)
- **RPO's & State / Local / Tribes** may have more detailed information.

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

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

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 (integrated with emissions processing)
- **Spatial Characterization & Locator Aides**
  - GIS
  - GPS
  - Satellites

Inventory Preparation Tools

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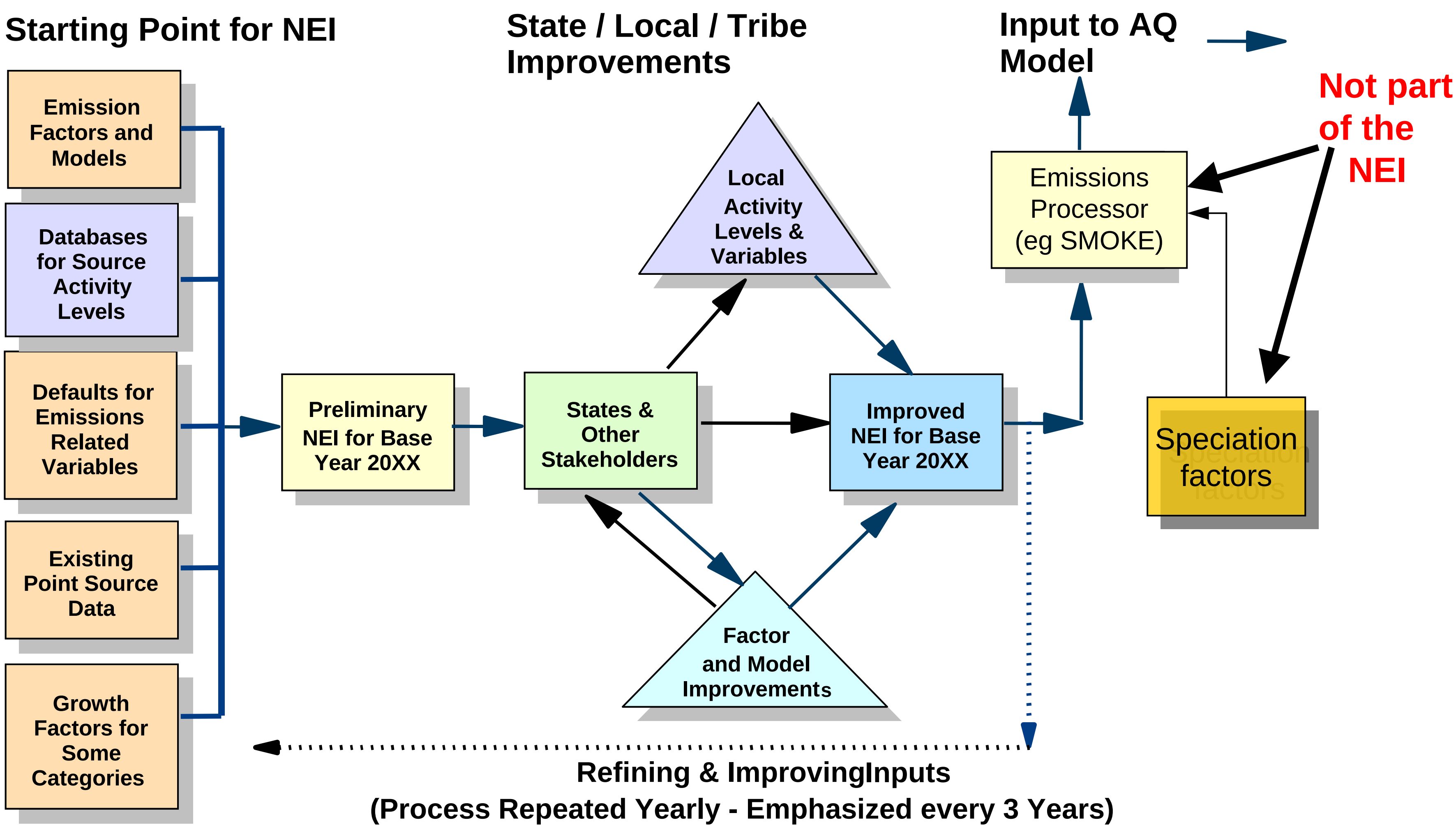
- **Spatial Locator Aides**
  - GIS
  - GPS
  - Satellites
- **Emissions Processing, including Speciation**

NEI Development ~ Cooperative, Iterative



Overview of Emissions Processing

- **Processors include:**
  - SMOKE, EPM
- **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 EC & POA*

- **Speciation Profiles** ~ estimate of the EC & POA portion of each PM2.5 source’s emissions
  - All PM2.5 sources “assigned” to 1 of 73 “profiles”
  - Current project to update…
    - profiles assigned to categories in emissions processor, and
    - database of receptor modeling source profiles
- **EC, POA**
  - 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

Inventory Preparation Tools

- **Emission Factors & Activity Data**
  - (~ 20,000 factors in FIRE)
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  - Tanks
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  - GIS
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- **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, MOBILE6
  - No other categories currently linked to real time conditions

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 ?**

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

- **Biogenics** (always integrated w/ EP)
- **On-Road** (optional integration w/ EP)
- **Ammonia** (development just began)
- **Fugitive Dust** (under development)
- **Wildland Fire** (under development)

Wildland Fire Emissions Module
(under development)

- **Modular input to Emission Models (e.g., SMOKE, OpEM) to interface with the CMAQ modeling system.**
- **User Inputs:** Fire locations, duration, size
- **Model Components**
  - Fuel loading default: NFDRS / FCC map
  - Fuel Moisture: Calculates using MM5 met data
  - Fuel Consumption: CONSUME2.1 / FOFEM
  - Emissions, Heat Release & Plume Rise: EPM & Briggs (modified)
- **Outputs:** Gridded hourly emissions, plume characteristics
- **Integrate, Test & Release Module (late 2004 earliest – w/ funding)**

Fugitive Dust Emissions Module
(under development)

- **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 (mid 2004 earliest – w/ funding)**

Inventory Preparation Tools

- **Emission Factors & Activity Data**
- **Emissions Models**
  - Tanks
  - Non-Road
  - Others
- **Spatial Locator Aides**
  - GIS
  - GPS
  - Satellites
- **Emissions Processing**
- **Process-based Emissions Models**
- **Receptor Models**
  - Inventory refinement, bounding uncertainties
    - Fossil vs Contemporary Carbon
    - Gas vs diesel
    - Cold starts, smokers

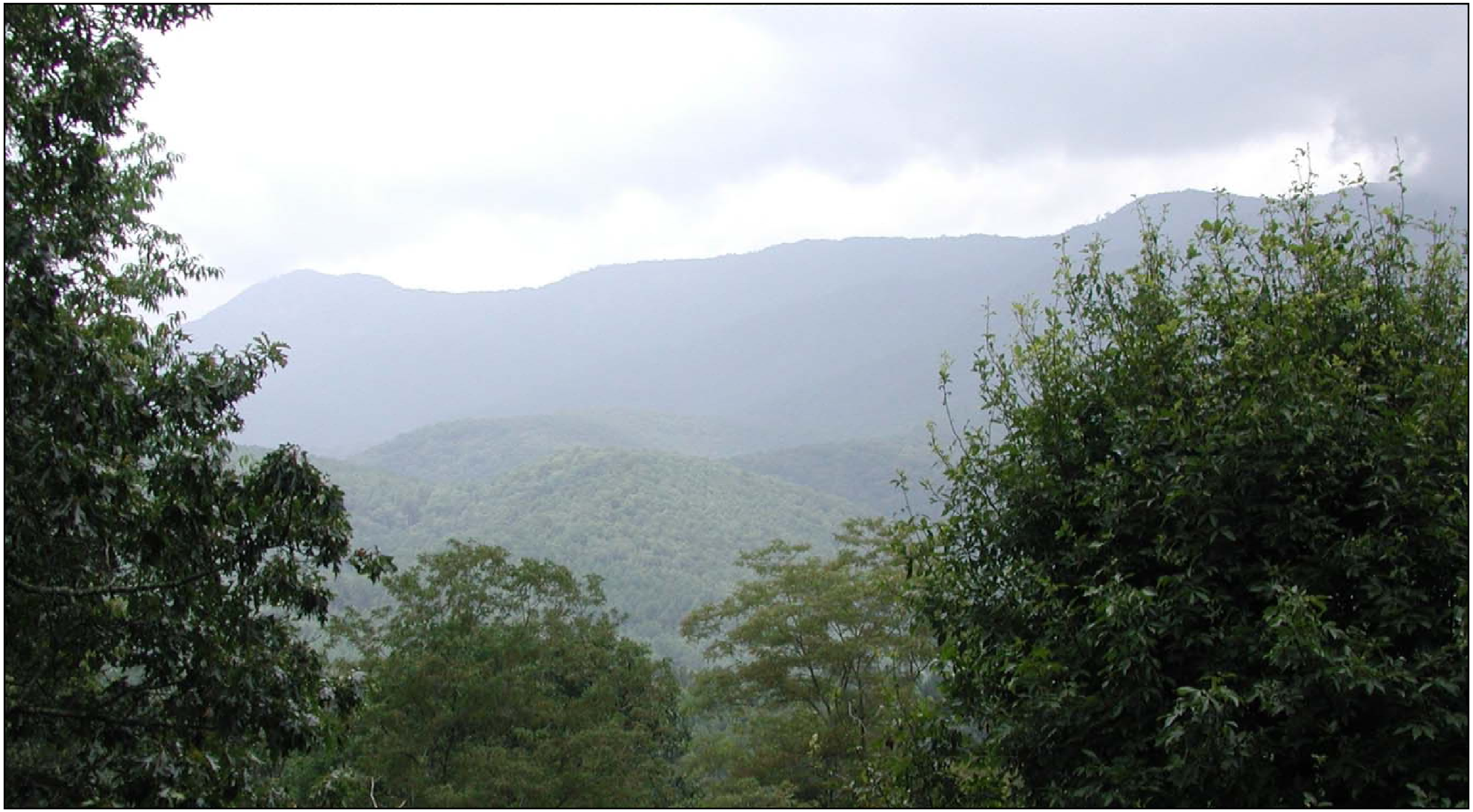
Summary of Key Issues in PM2.5 EI

- **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
- **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**
  - Fire Emissions, Fugitive Dust, Ammonia from CAFO's & Soils

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*
- **Area-specific industrial process sources**
- **Fugitive Dust as indicated by local conditions**

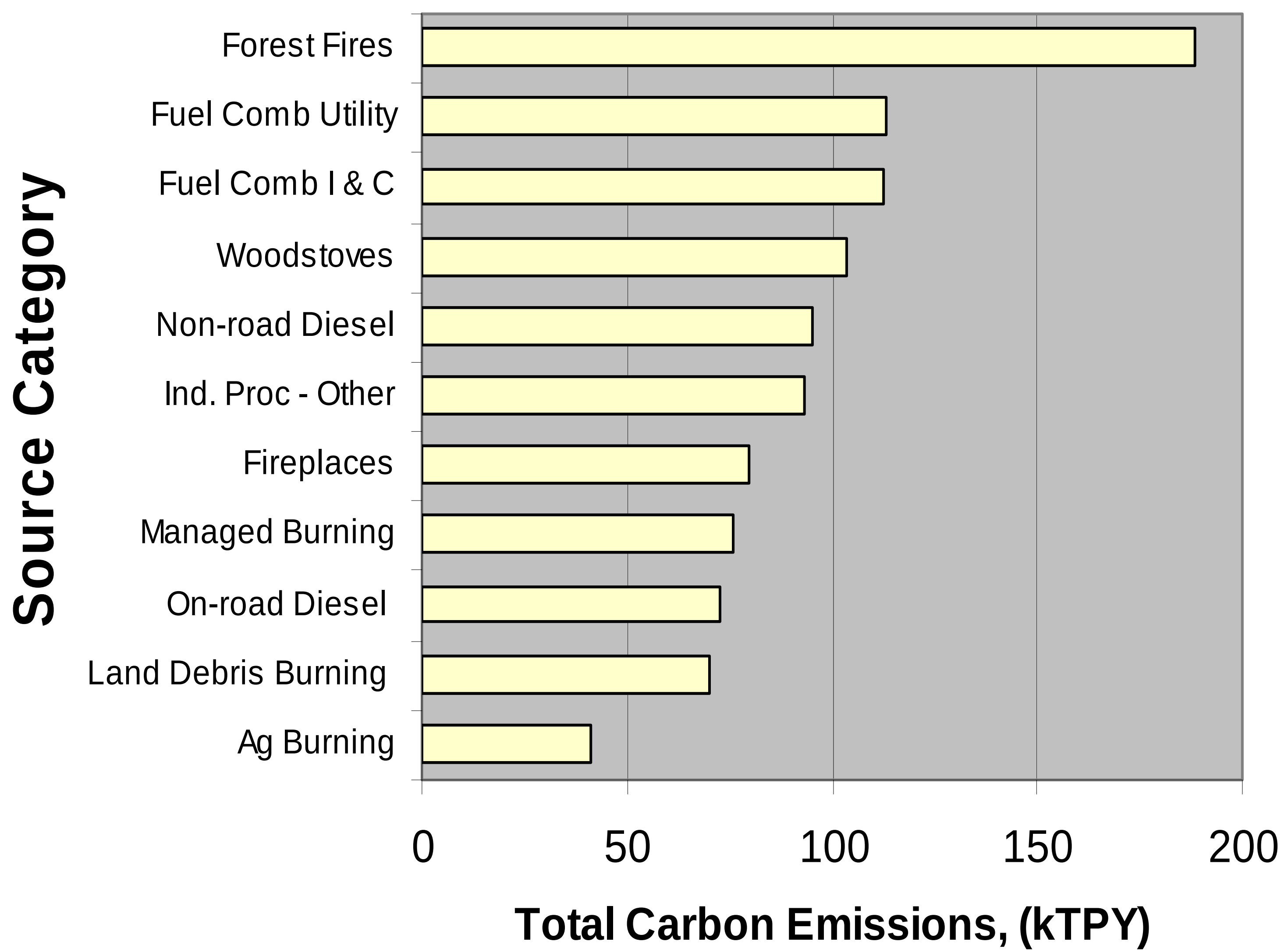
Questions ?



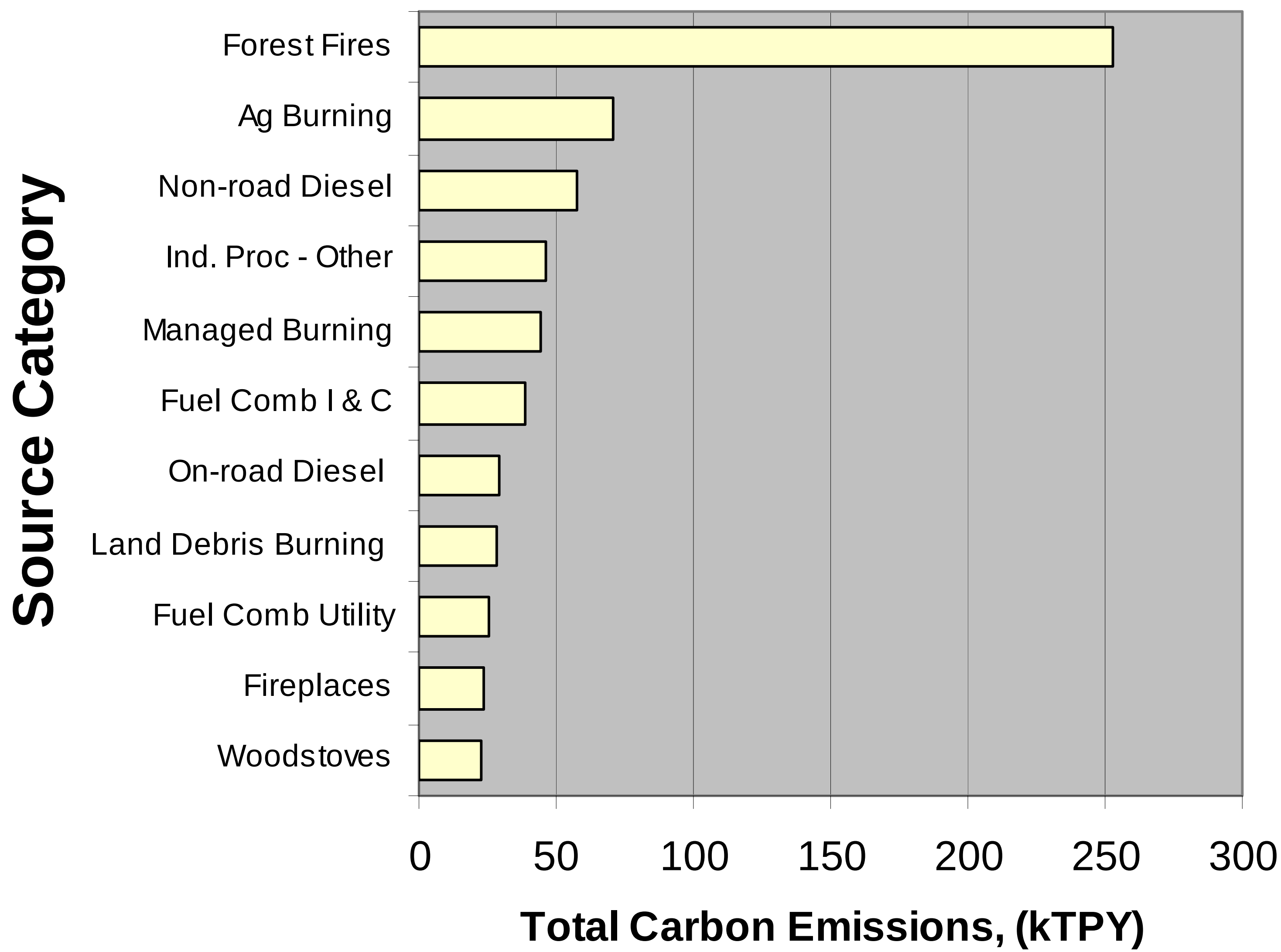
Session III
Western & Central States Emissions Overview

Thompson G Pace
US EPA
January 12-13, 2004

Key Sources of Carbon in Eastern US

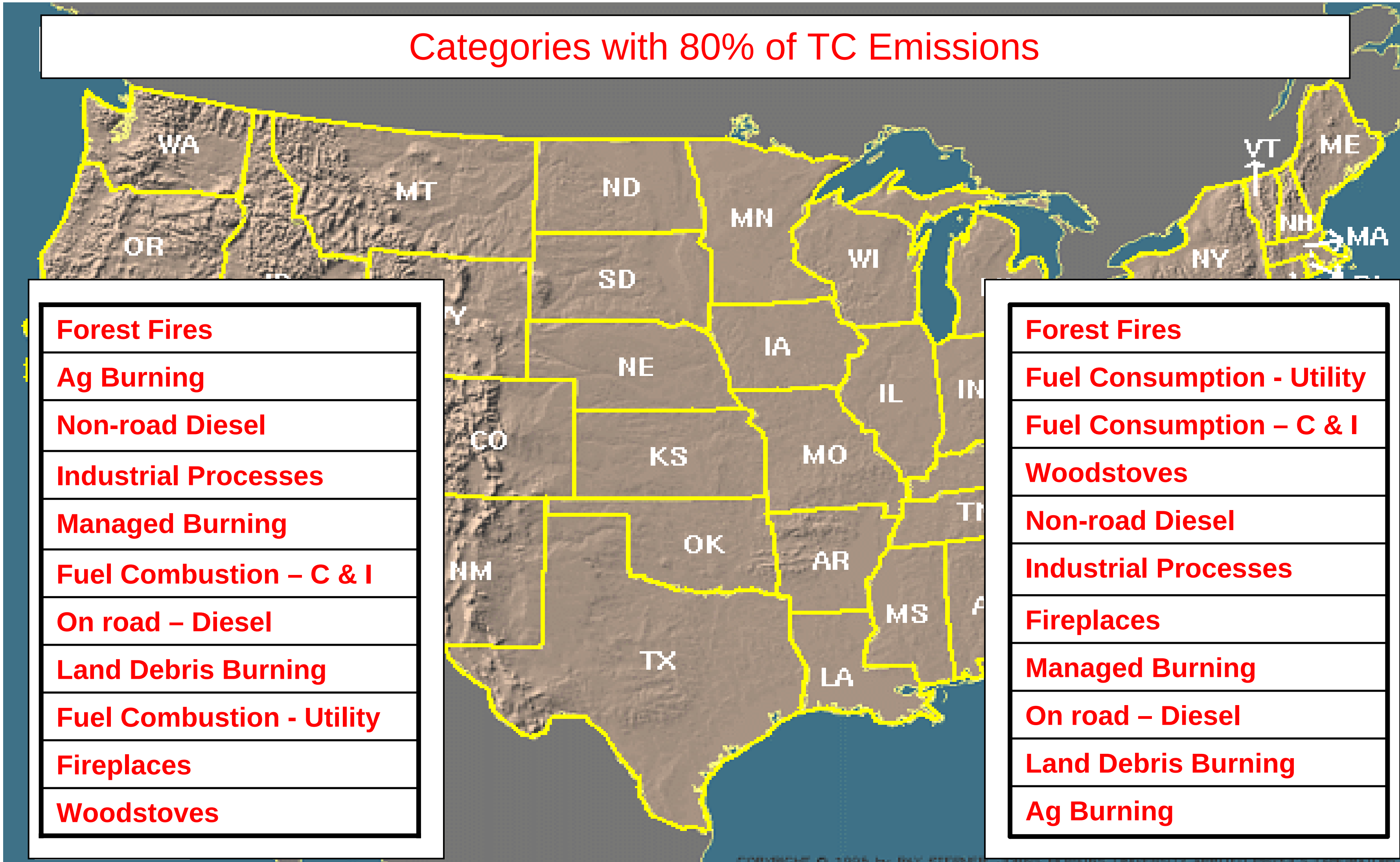


Key Sources of Carbon in Western US



Comparison of Key Sources of Carbon in Eastern and Western US

Categories with 80% of TC Emissions



Forest Fires
Ag Burning
Non-road Diesel
Industrial Processes
Managed Burning
Fuel Combustion – C & I
On road – Diesel
Land Debris Burning
Fuel Combustion - Utility
Fireplaces
Woodstoves

Forest Fires
Fuel Consumption - Utility
Fuel Consumption – C & I
Woodstoves
Non-road Diesel
Industrial Processes
Fireplaces
Managed Burning
On road – Diesel
Land Debris Burning
Ag Burning

What are the PM2.5 EI Priorities in the West?

- **Wildland Burning**
  - *Forests, Rangeland & especially private & State / tribal burners*
  - *(acreages burned, fuel loadings for largest fires, timing)*
- **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*
- **Area-specific industrial process sources**
- **Fugitive Dust as indicated by local conditions**

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.
  - You *may* want to 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 !

Links & Contact Info for PM

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Bill Kuykendal	CERR & Fug Dust	919-541-5372
Laurel Driver	Mobile Sources	919-541-2859
Roy Huntley	NEI ‘02 & Combustion	919-541-1060
Marc Houyoux	Emissions Modeling	919-541-3649
Dallas Safriet	Agriculture	919-541-5371
Ron Ryan	Speciation, SCC’s	919-541-4330
Ann Ingram	Info CHIEF Help Desk	919-541-1000

- All emails are last.first@epa.gov
- *Its all on CHIEF:* http://www.epa.gov/ttn/chief

CHIEF Site Map - Part 1

Emission Inventories	Emission Factors
Air Pollutant Emission Trends	AP-42 Vol. 1 (Stationary Sources) •Draft Sections •Supplement Information •Frequently Asked Questions (FAQ)
Consolidated Emission Reporting Rule	Mobile Sources
Emission Inventory Improvement Program	Industry Source Codes
Emission Inventory Publications	Related Emission Factor Documents
Emission Inventory Training	
General Emission Inventory Resources	
Industry Source Codes	
National Emission Inventory (NEI) Data	
National Emission Inventory Format (NIF)	
North American Emission Inventories	
PM2.5 Inventory Resources	

CHIEF Site Map - Part 2

Software & Tools	Emissions Modeling	General
Air CHIEF CD-ROM	Modeling Clearinghouse	Conferences
Area Source Emission Model (ASEM)	Inventory Modeling	Contact Us
FIRE	Projections Modeling	Listservs
National Emission Inventory Format (NIF)	Speciation Assignments	Publications
PM Calculator	Spatial Assignments	Related Sites
SPECIATE	Temporal Assignments	
TANKS	Related Models	
Related Software & Tools		

Questions ?

Session IV:
Onroad Mobile Sources

Laurel Driver
US EPA

ONRoad SOURCES

Overview

- **Use MOBILE6.2 model for emission factors**
  - » $PM_{2.5}$, SO_2, NO_x, NH_3, PM_{10}, VOC, and CO and HAPs
  - » $PM_{2.5}$ and PM_{10} emission factors are for primary emissions (PM25-PRI and PM10-PRI)
- **Use vehicle miles traveled (VMT) data for activity**
- **Map VMT data to corresponding MOBILE6.2 emission factors**
- **Emission Calculations**

ONROAD SOURCES

MOBILE 6.2 Overview

- **Data and algorithms previously in PART5 (with updates where applicable) have been integrated into the MOBILE6.2 model**
- **Fugitive dust emission factors included in PART5 (i.e., re-entrained road dust) removed from MOBILE6.2**
- **MOBILE6.2 also includes emission estimates for Gaseous SO_2 and Ammonia (NH_3)**

ONROAD SOURCES
MOBILE6.2 Modeling Inputs

- Use same inputs for MOBILE6.2 model as used for MOBILE6.0 model for same time period
  - Registration distribution
  - Ambient conditions
  - Speeds/speed distribution
  - Fuel parameters
  - Control programs
  - VMT mix

ONROAD SOURCES
MOBILE6.2 Modeling Inputs

- Additional data required for MOBILE6.2
  - » Diesel sulfur content (in parts per million [ppm])
- Additional commands needed for MOBILE6.2
  - » Described in MOBILE User's Guide
- $PM_{2.5}$ and PM_{10} emission factors cannot be calculated in same scenario—particle size must be specified in each scenario

ONROAD SOURCES
Sources of VMT Data

- State Department of Transportation
- Metropolitan Planning Organization
- 1999 NEI VMT Data based on:
  - » State/local-provided VMT (12 Agencies)
  - » FHWA HPMS data summaries
    - – By roadway type and State
    - – By roadway type and Urban Area
    - – Nationally by Vehicle Type

ONRoad SOURCES

VMT Approach

- Distributions of VMT by roadway type, vehicle type, by hour of day can be applied directly to VMT or included within MOBILE6.2 input files
- Also need to have speeds matched to roadway types either as average speeds or as speed distributions by speed ranges

ONROAD SOURCES

Level of Detail of VMT Data

- By county
- By roadway type (or link level)
- By vehicle type
- Appropriate time period

ONROAD SOURCES

Calculating Onroad Emissions

- Match VMT to corresponding MOBILE6.2 emission factor
  - » Map according to speed, roadway type (RT), vehicle TYPE (VT), time period

- Emis= VMT * EF * K
  - – Emis = emissions in tons by RT, VT
  - – VMT = vehicle miles traveled on RT by VT in miles
  - – EF = emission factor in grams/mile by RT, VT
  - – K = conversion factor

ONROAD SOURCES
Additional Resources

- **User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model, EPA420-R-02-028, October 2002**

  http://www.epa.gov/otaq/m6.htm

- **MOBILE6.1 Particulate Emission Factor Model Technical Description, Draft, EPA420-R-02-012, March 2002**

  http://www.epa.gov/OMS/models/mobile6/r02012.pdf

- **Links to MOBILE6 Training Materials**

  http://www.epa.gov/otaq/m6.htm#m6train

Questions ?

Session V: Nonroad Mobile Sources

Laurel Driver
US EPA

NONROAD SOURCES

Overview

- NONROAD Model Engines
- Aircraft
- Commercial Marine Vessels
- Locomotives

NONROAD Model

What Sources are Included?

SCCs (4-digit SCC denotes engine type)

2260xxxxxx	2-Stroke Gasoline
2265xxxxxx	4-Stroke Gasoline
2267xxxxxx	Liquefied Petroleum Gasoline (LPG)
2268xxxxxx	Compressed Natural Gas (CNG)
2270xxxxxx	Diesel

Two exceptions:

2282xxxxxx	Recreational Marine
2285xxxxxx	Railroad Maintenance

NONROAD Model

What Sources are Included?

Equipment Category (7-digit SCC denotes equipment)

- Airport ground support
- Agricultural
- Construction
- Industrial
- Commercial
- Residential/commercial lawn and garden
- Logging
- Recreational marine vessels
- Recreational equipment
- Oil field
- Underground mining
- Railway maintenance

10-digit SCC generally denotes specific application within equipment category

NONROAD Model

What Sources are Included?

- Pollutants
  - PM10-PRI, PM2.5-PRI, CO, NO_x, VOC, SO_2, and CO_2
    - PM_{10} and $PM_{2.5}$ emission factors represent Primary PM
    - NH_3 not a direct output of NONROAD, can be estimated based on fuel consumption and EPA emission factors derived from light-duty onroad vehicle emission measurements
    - Model estimates exhaust and evaporative VOC components

NONROAD Model
NEI Method

- EPA OTAQ developing preliminary 2002 NONROAD model NEI

- 2002 Emission Estimates, Data Input Files, and Documentation to be posted in January 2004

NONROAD Model
Emission Equation

$$I_{exh} = E_{exh} * A * L * P * N$$

where:	I_{exh}	=	Exhaust emissions, (ton/year)
	E_{exh}	=	Exhaust emission factor, (ton/hp-hr)
	A	=	Equipment activity, (hours/year)
	L	=	Load factor, (proportion of rated power used on average basis)
	P	=	Average rated power for modeled engines, (hp)
	N	=	Equipment population

NONROAD Model
Emission Equation (Cont'd)

- Emission Factors
  - » Dependent on engine type and engine size (horsepower)
    - – Future year emission controls or standards reflected in emission factor value
  - » SO_2, CO_2, and evaporative VOC emissions based on fuel consumption
  - » PM_{10} assumed to be equivalent to total PM
    - – For gasoline and diesel-fueled engines, $PM_{2.5} = 0.92 * PM_{10}$
    - – For LPG and CNG-fueled engines, $PM_{2.5} = PM_{10}$

NONROAD Model

Emission Equation (Cont'd)

- Equipment activity (A)
  - Hours of operation per year
- Load factor (L)
  - Proportion of rated power used on average basis
- Horsepower (P)
  - Average rated power for modeled engines
- Equipment population (N)
  - Number of pieces of equipment

Variables obtained for majority of SCCs from Power Systems Research (PSR), an engine market research firm, by telephone survey of equipment owners and operators, with some exceptions

NONROAD Model
Geographic Allocation

- County-level allocation of equipment population
  - National or state-level equipment populations from PSR or alternate sources, reported by equipment type (SCC) and horsepower range
  - Allocates populations to counties using surrogate indicators that correlate with nonroad activity for specific equipment types

NONROAD Model

Temporal Allocation

- NONROAD accounts for temporal variations in activity
  - Monthly activity profiles by equipment category according to 10 geographic regions
  - Typical weekday and weekend day activity profiles by equipment category; do not vary by region

NONROAD Model
Improving Inputs

- Specify local fuel characteristics and ambient temperatures
- Replace NONROAD model default activity inputs with State or local inputs
  - Perform local survey
- Obtain local information to improve geographic allocation indicators and temporal profiles

NONROAD Model
Improving Inputs (Cont'd)

- Significant PM Fine Equipment Categories include:
  - » Diesel construction
  - » Diesel farm
  - » Diesel industrial
  - » Gasoline lawn and garden
  - » Gasoline recreational marine

NONROAD Model
Resources

http://www.epa.gov/otaq/nonrdmdl.htm

» From this web site, there are links to:
  - Downloadable version of NONROAD2002a model
  - Documentation
    - User's Guide
    - Technical Reports to describe the sources and development of all model default input values

AIRCRAFT
Overview

- SCCs
  - » 2275020000 – Commercial Aircraft
  - » 2275050000 – General Aviation
  - » 2275060000 – Air Taxis
  - » 2275001000 – Military Aircraft
- Activity Data – landing and take-off operations (LTOs)
- Emission Factors – aircraft/engine-specific or fleet average

AIRCRAFT
Overview (Cont'd)

- Definitions of Aircraft Categories:
  - Commercial - Aircraft used for scheduled service to transport passengers, freight, or both.
  - Air taxis - Smaller aircraft operating on a more limited basis to transport passengers and freight.
  - General aviation - aircraft used on an unscheduled basis for recreational flying, personal transportation, and other activities, including business travel.
  - Military aircraft - aircraft used to support military operations.

AIRCRAFT
Overview (Cont'd)

- Aircraft operations are defined by landing and take-off operation (LTO) cycles, consisting of five specific modes:
  - 1) Approach
  - 2) Taxi/idle-in
  - 3) Taxi/idle-out
  - 4) Take-off
  - 5) Climb-out
- The operation time in each of these modes (TIM) is dependent on the aircraft category, local meteorological conditions, and airport operational considerations.

COMMERCIAL AIRCRAFT
NEI Method

- Activity/Emissions Developed at National Level
  - » Commercial Aircraft Emissions
    - – Calculated using national-level FAA LTO data by aircraft type and emission rates from Emissions and Dispersion Modeling System (EDMS) Version 4.0.
    - – Used default engines for each aircraft type and default time-in-mode values.

General Aviation, Air Taxi and Military Aircraft – *NEI Method*

» National Emissions for General Aviation, Air Taxi, and Military Aircraft calculated using equation:

$$\textit{National Emissions}_{c,p} = \textit{National LTOs}_{c} * EF_{c,p}$$

where:	*LTOs*	=	landing and take-off operations;
	EF	=	emission factor;
	c	=	aircraft category; and
	p	=	criteria pollutant.

General Aviation, Air Taxi and Military Aircraft – *NEI Method*

- LTO-based PM Emission Factors
  - General Aviation
    - PM10-PRI: 0.2367 lbs/LTO
  - Air Taxi and Military Aircraft
    - PM10-PRI: 0.60333 lbs/LTO
  - PM2.5-PRI Emissions
    - Estimated by applying particle size multiplier developed for related engines to PM_{10} emissions estimate
    - PM2.5-PRI = 0.92 * PM10-PRI

AIRCRAFT
NEI Method

- Emission Calculations (continued)
  - National Emissions Allocation for Each Aircraft Category

$$Airport\ Emissions_{c,p,x} = National\ Emissions_{c,p} * AF_{c,p,x}$$

where: *AF* = allocation factor; and
x = airport (e.g. La Guardia)
c = aircraft category; and
p = criteria pollutant.

$$AF_{c,x} = LTOs_{c,x}/National\ LTOs_{c}$$

AIRCRAFT
NEI Method

- Documentation on the procedures used to develop criteria pollutant (as well as HAP) aircraft emission estimates is available at:

ftp://ftp.epa.gov/EmisInventory/finalnei99ver3/criteria/documentation/nonroad/

99nonroad_voli_oct2003.pdf

AIRCRAFT
General Approach

- 1) Determine the mixing height to be used to define the LTO cycle.
- 2) Define the fleet make-up for each airport.
- 3) Determine airport activity in terms of the number of LTOs by aircraft/engine type.
- 4) Select emission factors for each engine model associated with the aircraft fleet.

AIRCRAFT
General Approach (Cont'd)

- 5) Estimate the time-in-mode (TIM) for the aircraft fleet at each airport.
- 6) Calculate emissions based on aircraft LTOs, emission factors for each aircraft engine model, and estimated aircraft TIM.
- 7) Aggregate the emissions across aircraft.

COMMERCIAL AIRCRAFT
Improvements to NEI

- Commercial Aircraft:
  - » Determine engine types associated with local aircraft types, to replace default aircraft/engine assignments in EDMS
  - » Obtain information on climbout/takeoff/approach times, as well as taxi/idle times

COMMERCIAL AIRCRAFT
Improvements to NEI (Cont'd)

- For PM_{10} and $PM_{2.5}$, match few emission factors from EPA's 1992 Volume IV, Mobile Sources Procedures document, to the aircraft engines in their fleet as best as possible
- EPA OTAQ working with FAA to develop updated aircraft PM emission factors
- Regional inventories have used PM-10/NO_x emission factor ratios for air taxi applied to commercial aircraft NO_x emissions

GA, AT and Military Aircraft *Improvements to NEI*

- Obtain local estimates of LTOs for these categories (to obtain LTOs not covered by FAA data)

- Obtain information on the aircraft/engine types that comprise the aircraft fleet for these categories. Apply EPA engine-specific emission factors or EDMS, if available

Sources: Local airports (airport master plans or records), Federal Aviation Administration

COMMERCIAL MARINE VESSELS
Overview

- Commercial Marine Vessel SCCs
  - 2280002100 – Diesel, In Port
  - 2280002200 – Diesel, Underway
  - 2280003100 – Residual, In Port
  - 2280003200 – Residual, Underway
- NEI Method
- Alternative Methods

COMMERCIAL MARINE VESSELS
NEI Method

- National Diesel and Residual Emissions split into port and underway components
- Port and underway activity allocated separately, assigned to counties
- Port emissions assigned to a single county in port area

COMMERCIAL MARINE VESSELS

NEI Method (Cont'd)

- Documentation on the procedures used to develop criteria pollutant (as well as HAP) commercial marine emission estimates is available at:

ftp://ftp.epa.gov/EmisInventory/finalnei99ver3/criteria/documentation/nonroad/

99nonroad_voli_oct2003.pdf

COMMERCIAL MARINE VESSELS
Improvements to NEI

- Review 1999 NEI emission estimates for representativeness
- Allocate port emissions to ports other than 150 largest
- Allocate port emissions to appropriate counties, since port emissions assigned to a single county in port area

COMMERCIAL MARINE VESSELS
Improvements to NEI (Cont'd)

- Obtain activity estimates at the local or State-level from Department of Transportation, Port Authority
  - » Fuel consumption
  - » Categories of vessels
  - » Number and size (hp) of vessels in each category
  - » Number of hours at each time-in-mode
    - – Cruising
    - – Reduced speed zone
    - – Maneuvering
    - – Hotelling

COMMERCIAL MARINE VESSELS
Emission Calculation

- Emission Equation

Emissions = Pop * HP * LF * ACT * EF

where:

Pop	= Vessel Population or Ship Calls
HP	= Average Power (hp)
LF	= Load Factor (fraction of available power)
ACT	= Activity (hrs)
EF	= Emission Factor (g/hp-hr)

COMMERCIAL MARINE VESSELS

Activity

- 1999 EPA studies:
  - » *Commercial Marine Activity for Deep Sea Ports in the United States*
  - » *Commercial Marine Activity for Great Lake and Inland River Ports in the United States*
- Studies provide activity profiles for select ports, and present method for an inventory preparer to allocate detailed time-in-mode activity data from a Typical Port to another similar port.

COMMERCIAL MARINE VESSELS
Activity (Cont'd)

- Activity profiles for Typical Port include:
  - » Number of vessels in each category;
  - » Vessel Characterization, including propulsion size (horsepower), capacity tonnage, and engine age;
  - » Number of hours at each time-in-mode associated with cruising, reduced speed zone, maneuvering, and hotelling.

COMMERCIAL MARINE VESSELS
Activity (Cont'd)

- Data on the number of trips and the tons of cargo handled by vessel type are provided for Top 95 Deep Sea Ports and Top 60 Great Lake and Inland River Ports.

- More detailed activity for these ports can then be estimated based on the data calculated for a Typical Port.

COMMERCIAL MARINE VESSELS
Emission Factors

- Depending on activity data obtained:
  - Horsepower-based emission factors
  - Fuel-based emission factors

- EPA performing studies to develop updated emission rates
  - RSD for Category 3 Engine Final Rulemaking, January 2003

COMMERCIAL MARINE VESSELS
PM10-PRI Emission Factors

- **PM10-PRI EFs for Category 1 and Category 2 Engines:**

Engine Category	**PM10 [g/kW-hr]**
Category 1: 37-75 kW	0.90
Category 1: 75-225 kW	0.40
Category 1: 225+ kW	0.30
Category 2 (5-30 l/cylinder)	0.32

Reference: EPA, 1999. "Final Regulatory Impact Analysis: Control of Emissions from Marine Diesel Engines," US EPA, Office of Mobile Sources, Engine Programs and Compliance Division, EPA420-R-99-026, November 1999.

COMMERCIAL MARINE VESSELS
PM10-PRI Emission Factors

- **PM10-PRI EFs for Category 3 Engines (> 30 l/cylinder):**

Mode: Engine	**PM10 [g/kW-hr]**
Cruise and Reduced Speed Zone: 2-stroke	1.73
Cruise and Reduced Speed Zone: 4-stroke	1.76
Maneuvering: 2-stroke	2.91
Maneuvering: 4-stroke	2.98
Hotelling: 2-stroke	0.32
Hotelling: 4-stroke	0.32
All Modes: Steam Generators	2.49

EPA, 2003: "Final Regulatory Support Document: Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Liters per Cylinder", US EPA, OTAQ, EPA420-R-03-004, January, 2003.

COMMERCIAL MARINE VESSELS
Emission Factors

- Emission factors in grams per gallon fuel consumed also available from *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d (Revised), U.S. EPA, OAQPS, July 1989.

- PM2.5-PRI = 0.92 * PM10-PRI emissions

LOCOMOTIVES

Overview

SCCs:

- » 2285002006 – Diesel Class I Line Haul
- » 2285002007 – Diesel Class II/III Line Haul
- » 2285002008 – Diesel Passenger (Amtrak)
- » 2285002009 – Diesel Commuter
- » 2285002010 – Diesel Switchyard Locomotives

- ❖ NEI Method
- ❖ Improvements to NEI Method

LOCOMOTIVES
NEI Methods

- PM Emission Factors (represent Primary PM)
  - » Line-Haul
    - – PM_{10}: 6.7 g/gallon
    - – $PM_{2.5}$: 6.03 g/gallon
  - » Yard
    - – PM_{10}: 9.2 g/gallon
    - – $PM_{2.5}$: 8.28 g/gallon

(Reference: *Emission Factors for Locomotives, Technical Highlights*, EPA/420-F-97-051, U.S EPA, Office of Mobile Sources, December 1997.)

LOCOMOTIVES
NEI Methods (Cont'd)

- Activity Data (Gallons of distillate fuel oil consumed)
- National Activity
  - 1999 year U.S. distillate consumption by railroads
    - Class I
    - Class II/III
    - Passenger
    - Commuter
- Class I Line-Haul versus Yard (Switch) Operation Activity
  - Multiplied National Class I consumption by estimated line-haul percentage of total fuel consumption

LOCOMOTIVES
NEI Methods (Cont'd)

- County-level emissions allocation
  - National emissions allocated to counties based on ratio of county to national rail activity.
  - Rail activity measured as product of density (gross ton miles per mile) on each rail line and mileage for the associated rail line in county determined through GIS analysis.

(Reference: *National Transportation Atlas Databases - National Rail Network 1:2,000,000,* GIS data from Bureau of Transportation Statistics, 2001. Available from http://www.bts.gov/gis/ntatlas/networks.html.)

LOCOMOTIVES
NEI Methods (Cont'd)

- Detailed documentation on the procedures used to develop criteria pollutant locomotive emission estimates for the 1999 NEI are available at:

ftp://ftp.epa.gov/EmisInventory/finalnei99ver3/criteria/documentation/nonroad/

» 99nonroad_voli_oct2003.pdf

LOCOMOTIVES
Improving the NEI

- Review NEI emission estimates for representativeness
- Obtain more representative fuel consumption estimates at the local or State-level
- Determine relative contribution of line-haul versus yard activity at local or State-level

Sources: Local Railroads, State Department of Transportation, Bureau of Rail Freight

Quick update on Mobile Source Tools: What is NMIM?

- The **N**ational **M**obile **I**nventory **M**odel is a consolidated emissions modeling system for EPA's MOBILE and NONROAD models.
- NMIM combines a Java framework with MOBILE, NONROAD, and a national county database.
- Generates monthly, county inventories for years from 1999 to 2050.

Why NMIM?

- Consistency
  - » between NEI and OTAQ rulemaking
  - » between criteria pollutants and HAPS
- Improved access
  - » to inventory input information
  - » to inventory building tools

County Specific Inputs

- Min, max, average temperatures
- Fuel characteristics
- Base year VMT, monthly allocation
- VMT growth
- Local emission control programs
- Many others

NMIM and the NEI

- Previously, EPA generated inventories based on default inputs and States could replace those *inventories* in the NEI.
- Now, States will supply *inputs* and documentation to NMIM database.
- Hence, rulemaking inventories, including projections, will be consistent with NEI.

Questions?

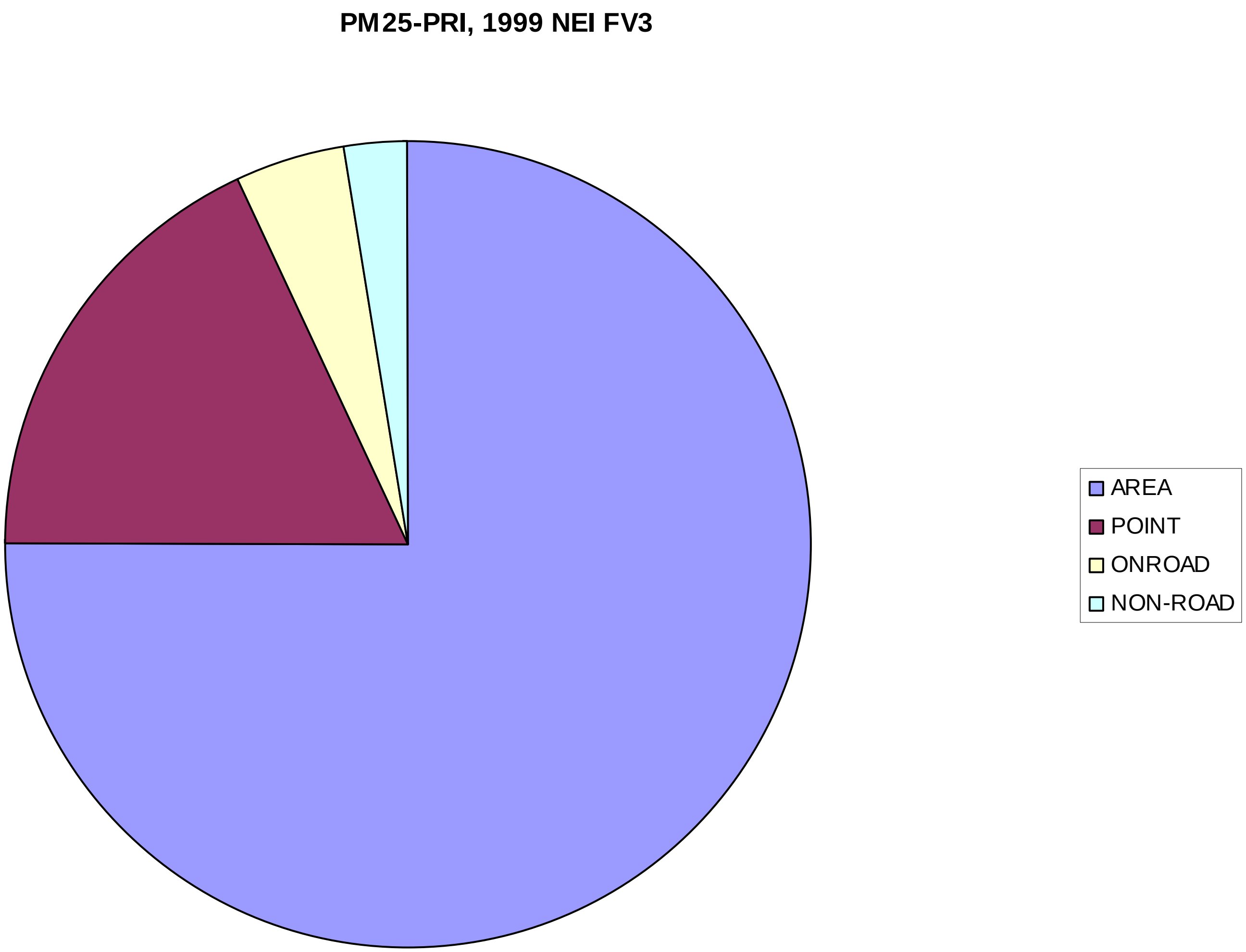
Session VI:
Point Sources of Fine PM

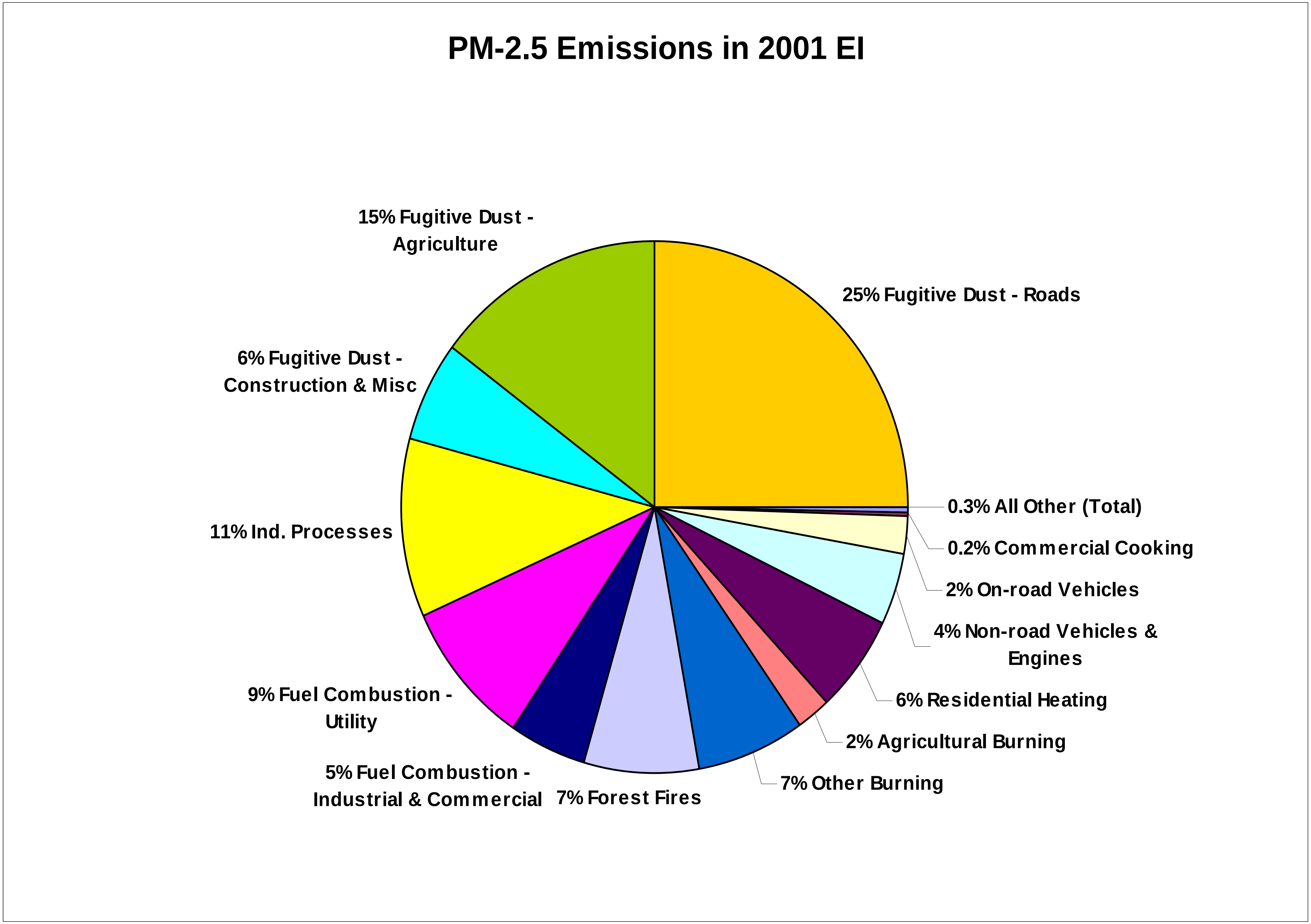
Roy Huntley
EPA, OAQPS, EFIG

Presented at the PM Fine EI Workshop
Denver, CO

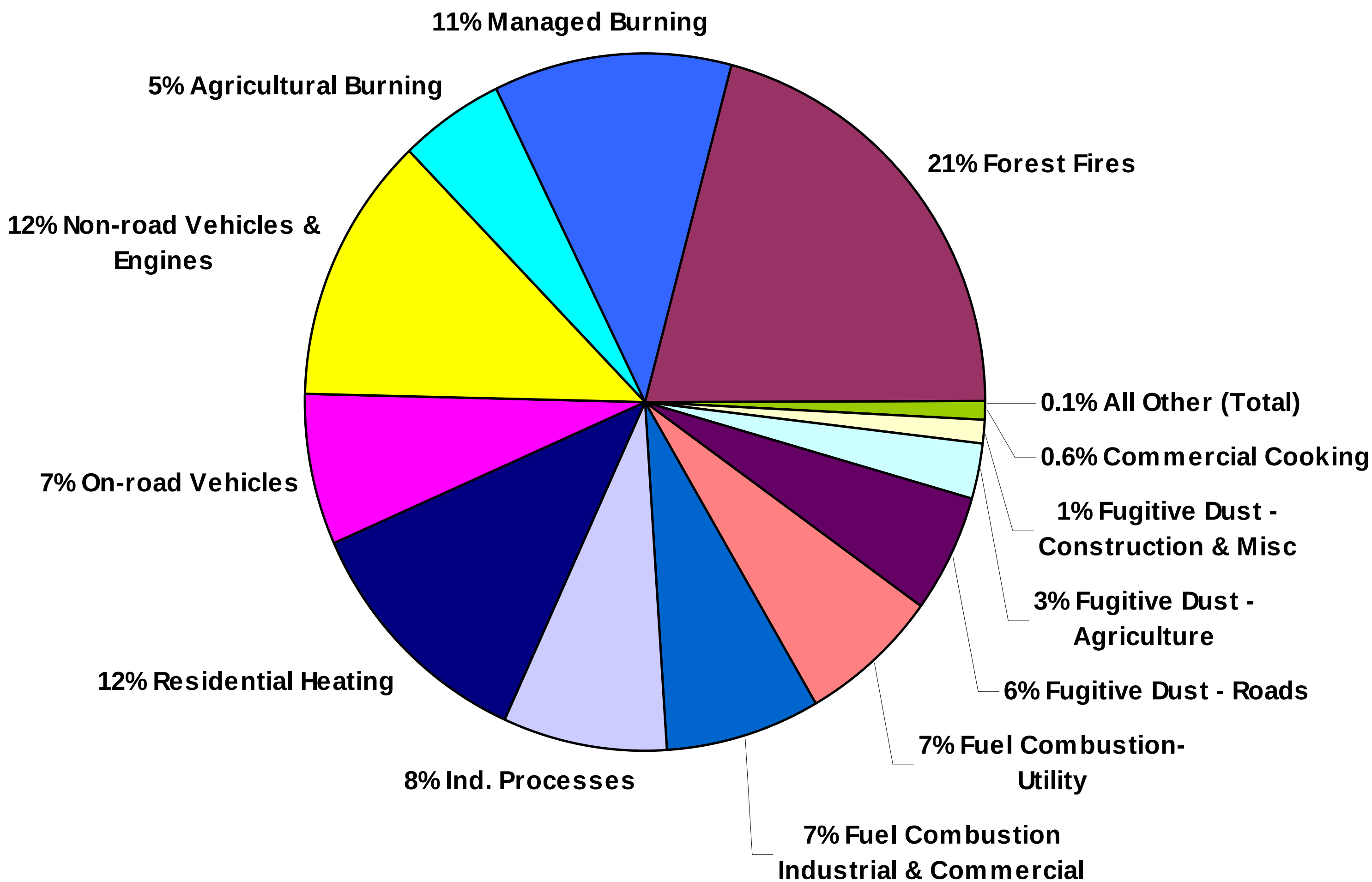
Overview

- Point sources of:
  - PM
    - filterable versus condensible emissions
  - NH_3 emissions
- Definitions of forms of PM for the NEI
- Verification of the form of PM in your emissions inventory (EI)
- Point and area source EI overlap issues


PM25-PRI, 1999 NEI FV3
AREA
POINT
ONROAD
NON-ROAD


PM-2.5 Emissions in 2001 EI
15% Fugitive Dust - Agriculture
25% Fugitive Dust - Roads
6% Fugitive Dust - Construction & Misc
0.3% All Other (Total)
11% Ind. Processes
0.2% Commercial Cooking
2% On-road Vehicles
4% Non-road Vehicles & Engines
9% Fuel Combustion - Utility
6% Residential Heating
2% Agricultural Burning
5% Fuel Combustion - Industrial & Commercial
7% Forest Fires
7% Other Burning

Total Carbon Emissions in 2001 EI



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

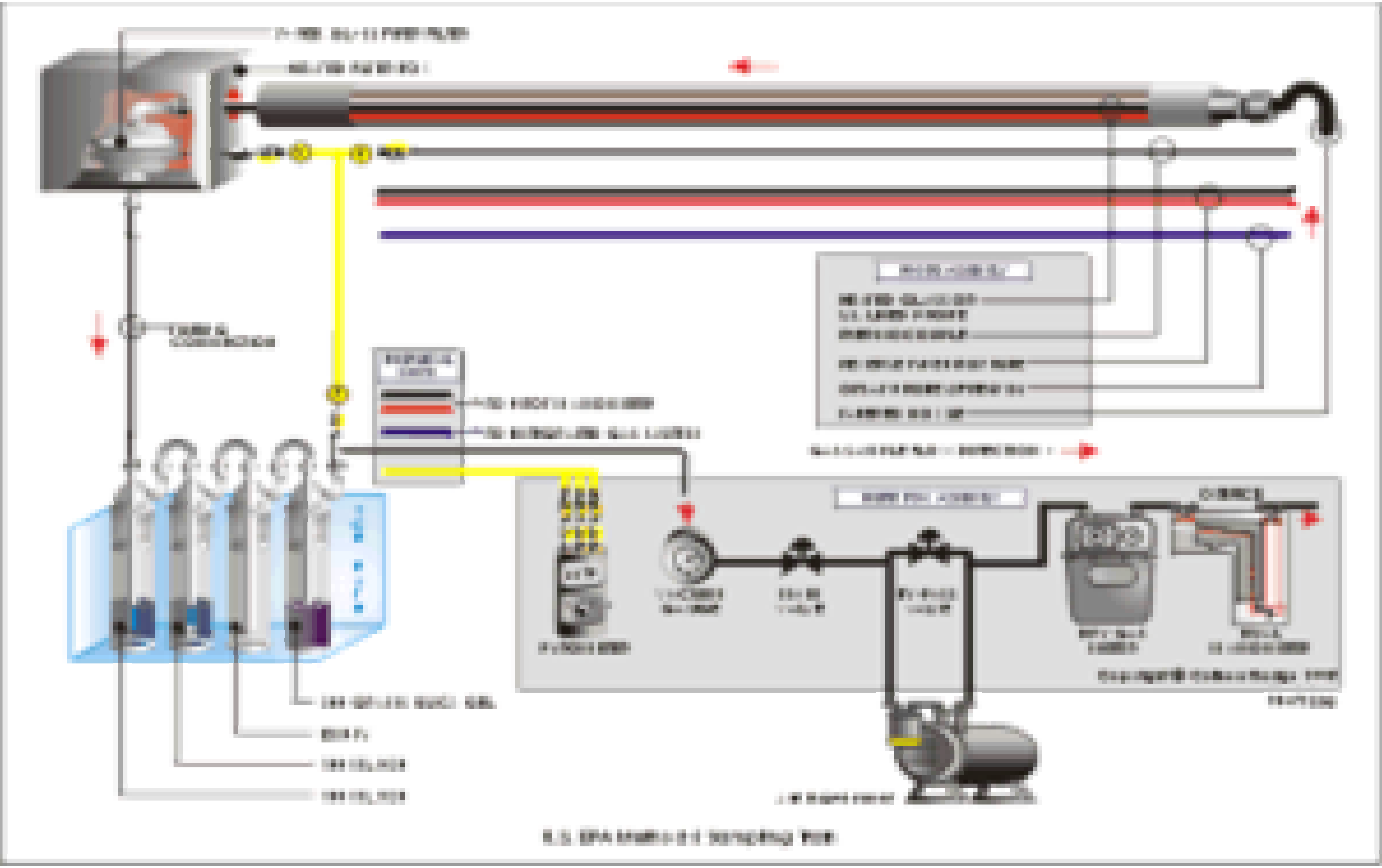
- Point sources are stationary source that are included in a point source inventory.

- Total plant (facility) emissions for a given pollutant is usually the criterion for deciding what sources to include 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)

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

Resources for Identifying Point Sources of PM Fine and NH_3

- EIIP Point Source Guidance (Volume II)
  - List documents applicable to PM fine categories
- AP-42
- Existing Inventories
  - National Emissions Inventory
  - Toxics Release Inventory (TRI) for NH_3

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. Condensible PM is almost always $PM_{2.5}$.

- **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.

What to Report to EPA

- 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)

- In addition, States may also choose to report the following:
  - Total Primary PM Measured (or Filterable Total Primary PM Measured and Condensible PM individually)

Implications

- 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

How Do I Identify the PM Form?

- Test Methods upon which emission factors or emissions are based determine the form of PM:
  - PM-FIL:
    - EPA Reference Method 5 series, Method 17
  - PM10-FIL/PM25-FIL:
    - Particles-size analysis of PM-FIL (e.g., AP-42 EFs)
    - EPA Method 201/201A (PM10 only)
    - Preliminary Method 4 being developed by EPA to measure both
    - EPA dilution method being evaluated
  - PM-CON:
    - EPA Reference Method 202

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/OQAPS CHIEF web site
    - http://www.epa.gov/ttn/chief/

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
  - March 2004 (Version 6.24)

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/OQAPS CHIEF web site
  - http://www.epa.gov/ttn/chief/software/index.html

Point & Area Source Emissions Inventory (EI) Overlap Issues

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

Total Area Activity = Total Activity – Σ 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

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

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)

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/publications.html)
- *Introduction to Stationary Point Source Emission Inventory Development*, EIIP Vol. 2, Chapter I, May 2001
- *How to Incorporate Effects of Air Pollution Control Device Efficiencies and Malfunctions into Emission Inventory Estimates*, EIIP Vol. 2, Chapter 12, July 2000

Session VII: Non-Point Sources

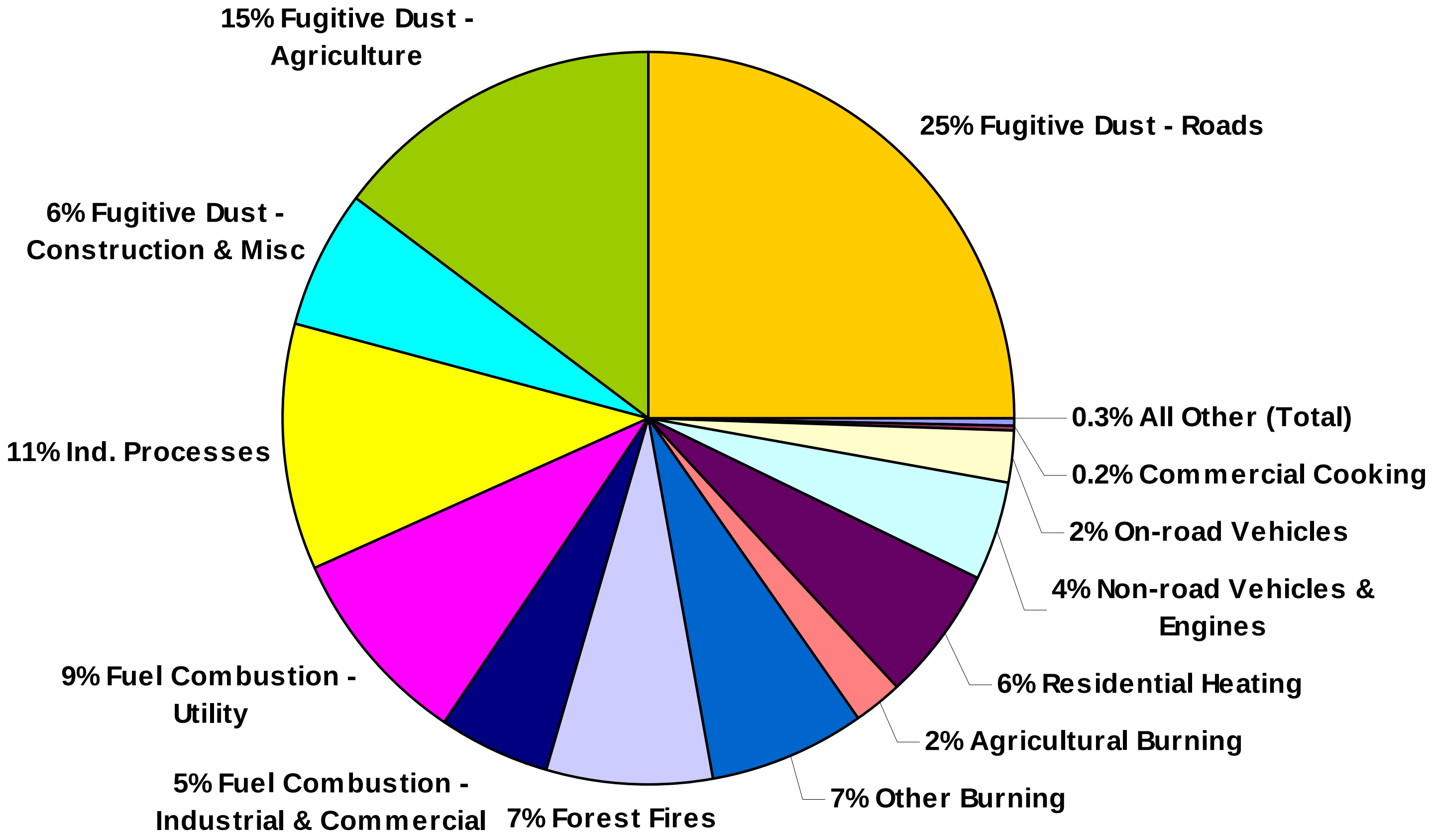
Roy Huntley
EPA, OAQPS, EFIG

Presented at the PM Fine EI Workshop
Denver, CO

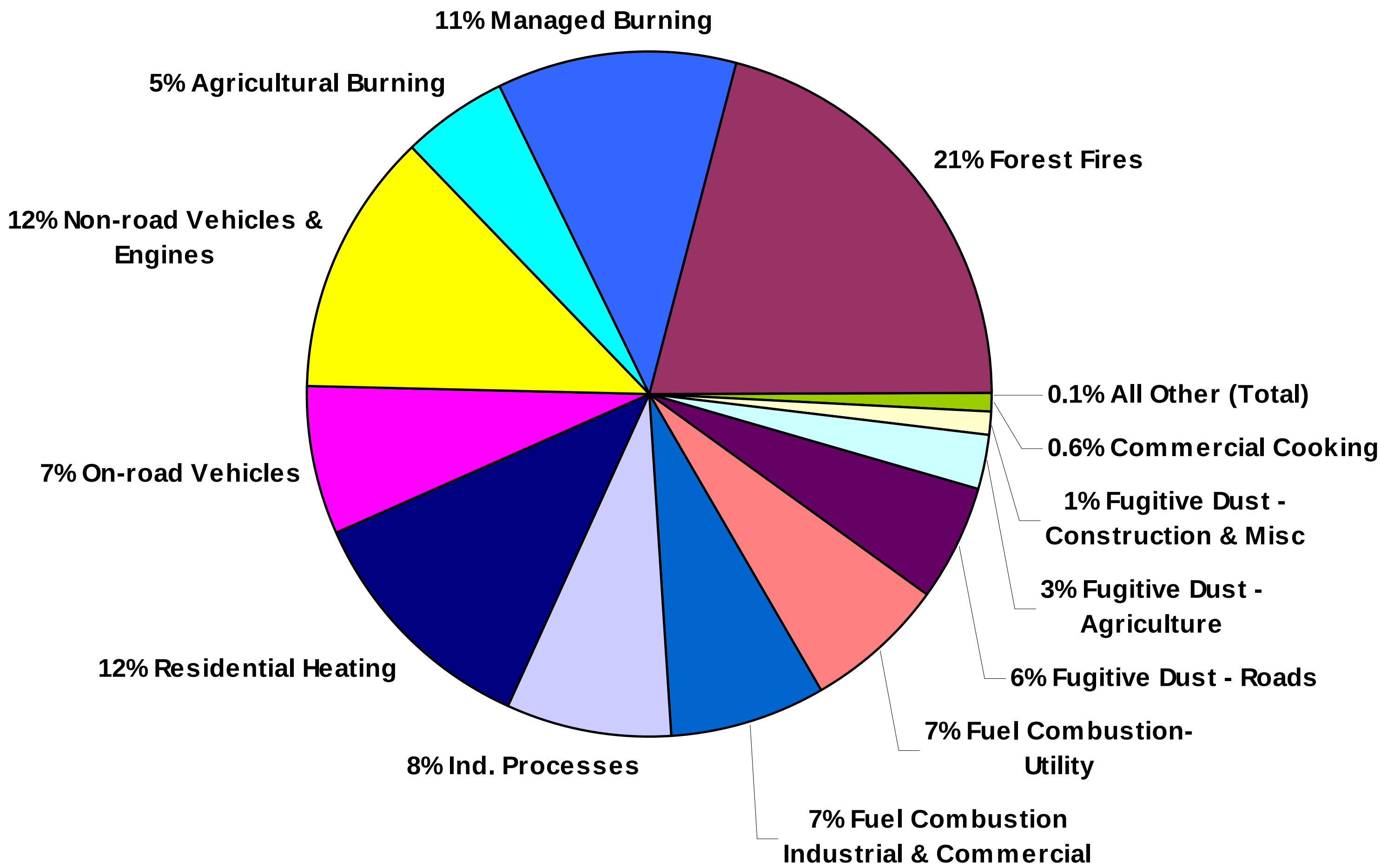
Overview

- What to include in the stationary non-point sector?
  - Federal reporting requirements (CERR)
- Definition and identification of PM fine and NH_3 non-point sources
- How to estimate non-point source emissions
- EI development approaches

PM-2.5 Emissions in 2001 EI



Total Carbon Emissions in 2001 EI



What to Include?

- 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, & open burning of waste

What to Include? (Cont'd)

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)

Identifying Non-point Sources of PM Fine or NH_3 Emissions

- EIIP - Introduction to Area Source Emission Inventory Development (Volume III)
  - Lists PM fine categories for which EIIP guidance is available; on your CD-ROM
  - Table 1.2-1 lists potential Non-point sources
- AP-42
  - Available on Chief website – http://www.epa.gov/ttn/chief/
- Existing inventories
  - National Emission Inventory (NEI)
    - 99NEI data summaries on your CD-ROM
  - Toxics Release Inventory (TRI)

Identifying Non-point Sources of PM Fine or NH_3 Emissions? (Cont'd)

- EIIP Area Source Guidance (Volume III) for Sources of PM Emissions
  - 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

Identifying Non-point Sources of PM Fine or NH_3 Emissions? (Cont'd)

- 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 1-Pagers: Non-point Sources

- PM 1-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 1-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 1-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 1-Pagers: Non-point Sources (Continued)

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

Questions?

Typical Source Categories of Filterable PM Emissions

- Fugitive Dust Sources (Crustal PM Fine)
  - Construction
  - Mining and quarrying
  - Paved/unpaved roads
  - Agricultural tilling
  - Beef cattle feedlots

Typical Categories of Filterable and Condensible PM Emissions

- Open Burning Sources (Carbonaceous PM Fine)
  - Open burning
    - Residential municipal solid waste burning
    - Yard waste burning
    - Land clearing debris burning
  - Structure fires
  - Prescribed fires
  - Wildfires
  - Agricultural field burning

Typical Categories of Filterable and Condensible PM Emissions (Cont'd)

- External/Internal Fuel Combustion (Carbonaceous PM Fine):
  - Residential wood combustion
  - Other residential fuel combustion
  - Industrial fuel combustion
  - Commercial/institutional fuel combustion

Typical Source Categories of NH_3 Emissions

- Typical source categories of NH_3 emissions include:
  - Animal husbandry
  - 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

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

Point & Non-point Source Emissions Inventory (EI) Overlap Issues

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

Total Non-point Activity = Total Activity – Σ 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 & Non-point Source EI Overlap Issues (Cont'd)

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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
  - 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
  - Use NEI default estimates

Triage Approach to Improving the EI

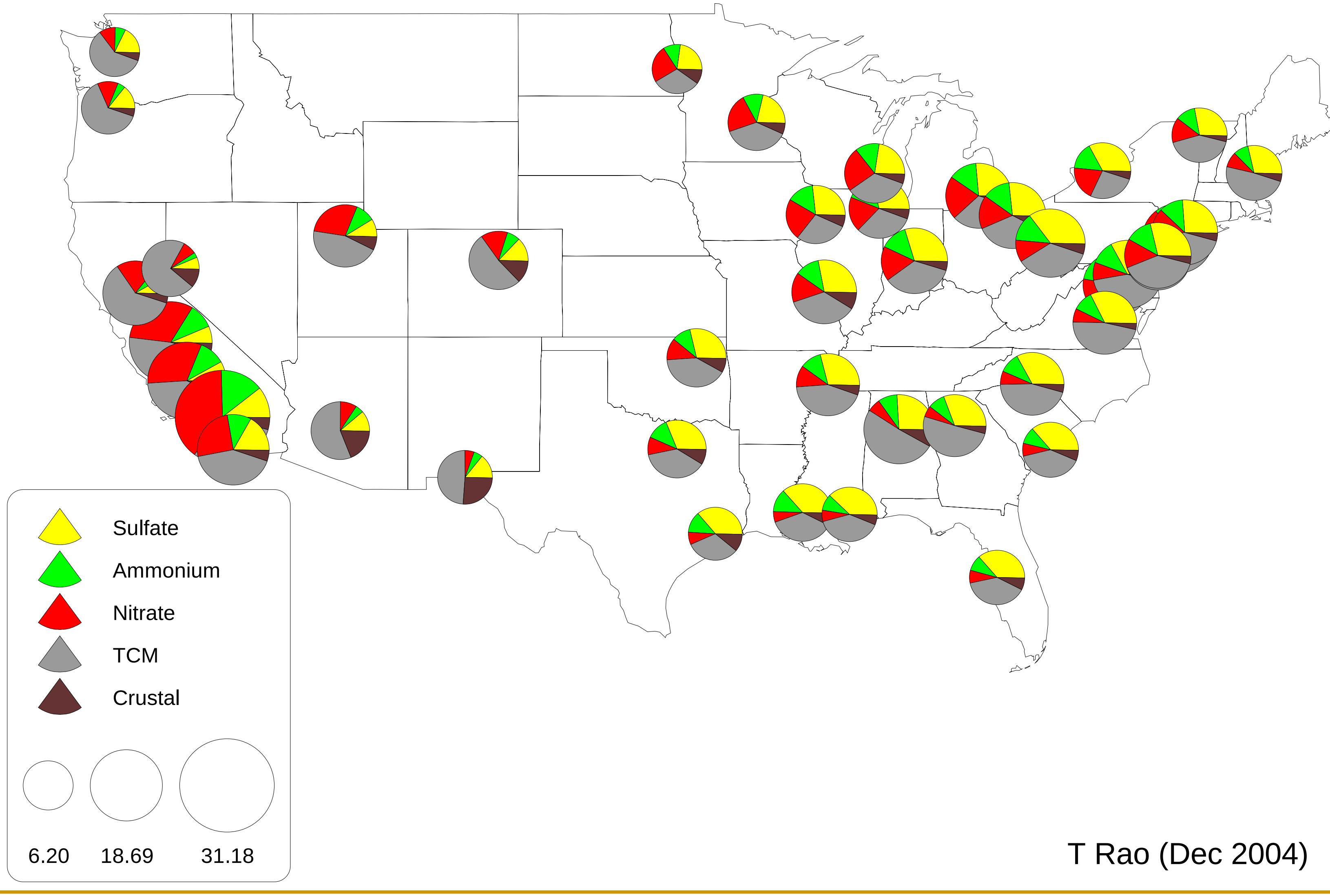
- Consider each NEI Category - Is it important ?
  - What's its potential impact on AQ, considering emissions, receptor modeling & other available info.
  - May give *some weight* to emission reductions potential
- If yes, what does the Workshop suggest on where to focus improvement efforts
- Can you 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 VII
Reconciling Fugitive Dust Emissions w/ Ambient Data

Thompson G Pace
US EPA

Denver, CO
March, 2004

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



T Rao (Dec 2004)

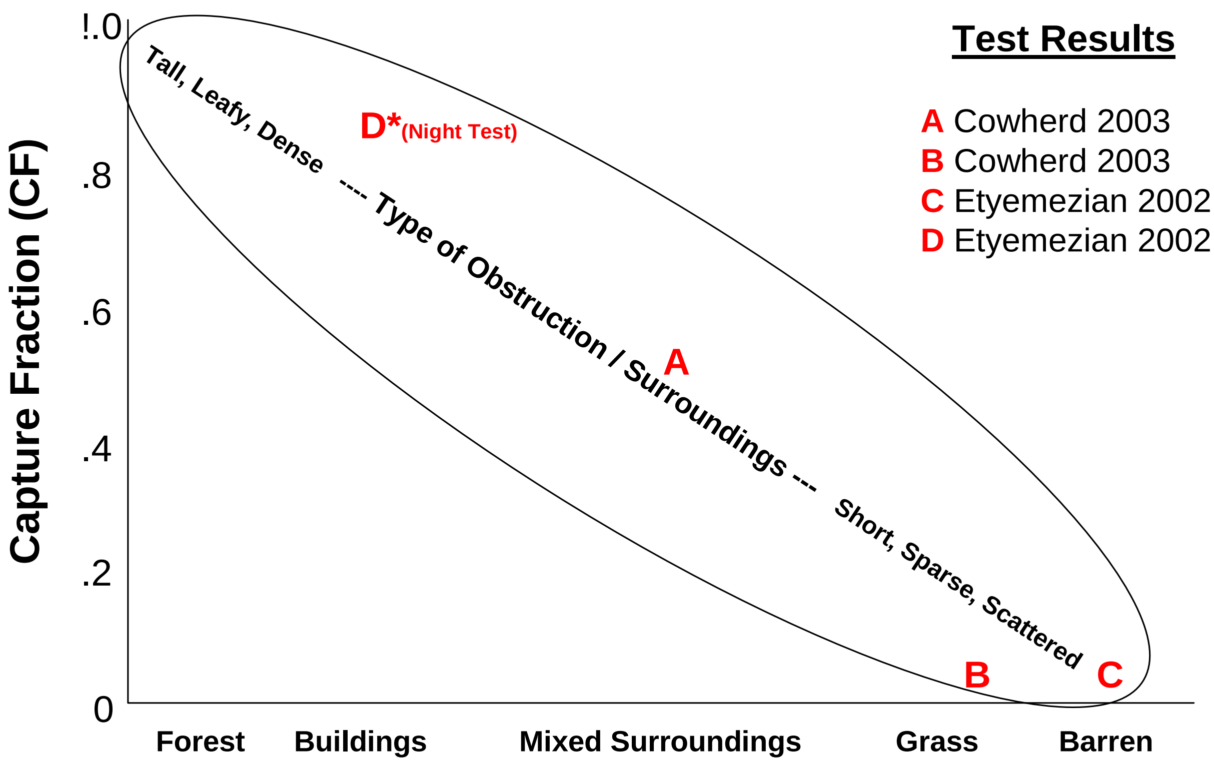
Crustal Materials (Mainly Fugitive Dust)

- **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 Fugitive Dust Emissions (FD) removed by nearby surface cover
- **Transport Fraction (TF)**
  - Portion that is transported from the source area

Capture Fraction ~ Conceptual Model and Field Measurement Results



Estimates of CF for Specific Surface Conditions

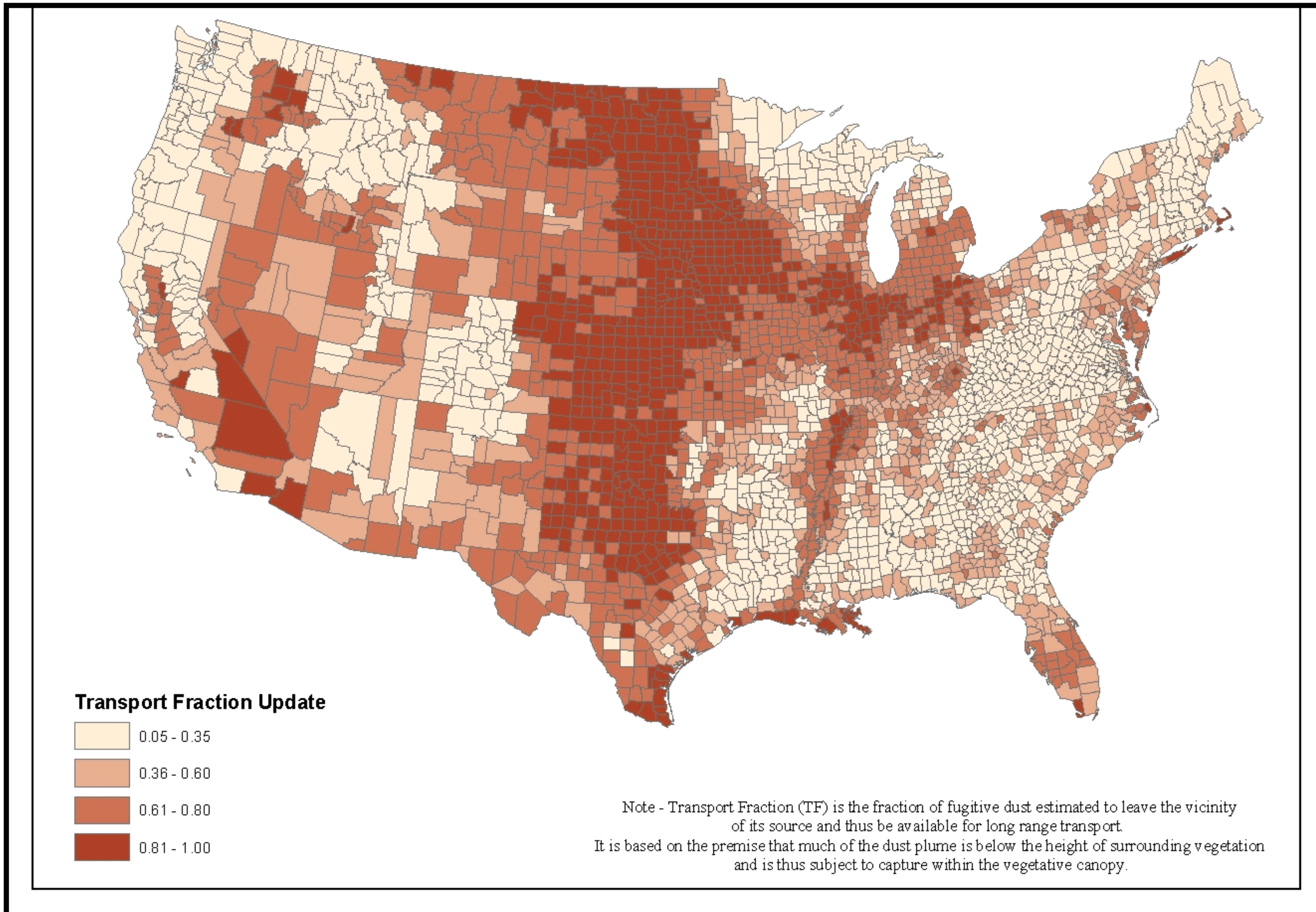
Surface Cover Type	CF (Estimated)
Smooth, Barren or Water	0.03 – 0.1
Agricultural	0.1 - 0.2
Grasses	0.2 - 0.3
Scrub and Sparsely Wooded	0.3 - 0.5
Urban	0.6 - 0.7
Forested	0.9 - 1.0

Example CF's for Counties in NV & GA

- **CF (County) = ∑ CF (Land Use Types) * County Fractional Land Use Types**
- **TF = 1 - CF**

Land Use Type	Barren & Water	Agri-culture	Grass	Urban	Scrub & Sparse Vegetation	Forest	CF	TF
CF	.03	.15	.2	.6	.3	.95		
Fractional Land Use in Churchill Co NV	.33	.03	.2	0	.36	.05	0.23	0.77
Fractional Land Use in Oglethorpe Co GA	0	.1	.14	0	0	.76	0.76	0.24

Transport Fraction by County



Fugitive Dust Modeling Issues

- **Gaussian Models**
  - Have many CF removal mechanisms 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)

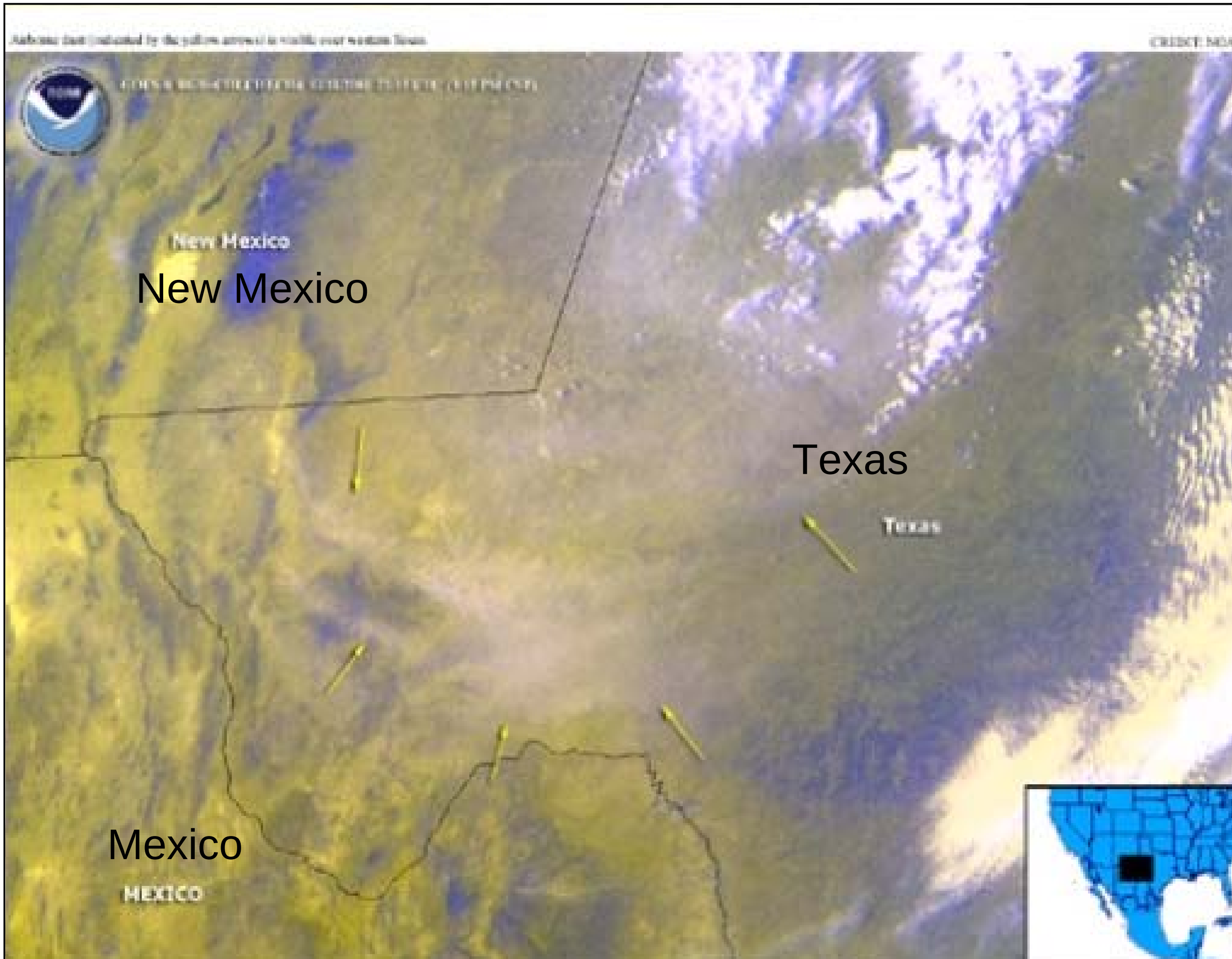
Cautions on Use of the TF in Emissions Inventory & Modeling Applications

- 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

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
  - There is much work to do to refine the concept

Questions ?



Session VII:
Fugitive Dust Area Sources

Agricultural Tilling

AGRICULTURAL TILLING

Overview

- SCC
  - 2801000003
- Pollutants
  - Filterable PM_{10}, $PM_{2.5}$
- Activity Data
- Emission Factor
- Emission Calculations

AGRICULTURAL TILLING

NEI Method

- Activity Data (no. of acres of land tilled)
  - 1998 County-Level Activity Data
    - Acres of crops tilled in each county by crop type and by tilling method obtained from CTIC
    - Five tilling methods include:
      - no till
      - mulch till
      - ridge till
      - 0 to 15 percent residue
      - 15 to 30 percent residue

(Reference: *National Crop Residue Management Survey*, Conservation Technology Information Center (CTIC))

AGRICULTURAL TILLING

NEI Method (Cont'd)

- Emission Factor (mass of TSP per acre tilled)
  - Emission factor is comprised of:
    - Constant of 4.8 lbs/acre pass
    - Silt content of the surface soil
    - Number of tillings per year (conservation and conventional use)
    - Particle size multiplier for PM_{10} and $PM_{2.5}$

AGRICULTURAL TILLING

NEI Method (Cont'd)

- Emission Factor (continued)
  - Silt content

Soil Type	**Silt Content (%)**
Silt Loam	52
Sandy Loam	33
Sand	12
Loamy Sand	12
Clay	29
Clay Loam	29
Organic Material	10-82
Loam	40

  - Soil types assigned to counties by comparing USDA surface soil and county maps

(References: *Soil Texture Classification Triangle, The Nature & Properties of Soils*, 8th Edition, New York, MacMillan, 1974.

Spatial Distribution of PM-10 emissions from Agricultural Tilling in the San Joaquin Valley, Shimp, D.R. Campbell, S.G., and Francis, S.R. California Air Resources Board, 1996.)

AGRICULTURAL TILLING

NEI Method (Cont'd)

- Emission Factor (continued)
  - Number of Tillings

Crop	Conservation Use	Conventional Use
Corn	2	6
Spring Wheat	1	4
Rice	5	5
Fall-Seeded Small Grain	3	5
Soybeans	1	6
Cotton	5	8
Sorghum	1	6
Forage	3	3
Permanent Pasture	1	1
Other Crops	3	3
Fallow	1	1

(Reference: *Agricultural Activities Influencing Fine Particulate Matter Emissions*, Midwest Research Institute, March 1996.)

AGRICULTURAL TILLING

NEI Method (Cont'd)

- Emission Factor (continued)
  - Acres reported in the CTIC database for no till, mulch till, and ridge till are classified as conservation tillage
  - Acres reported in the CTIC database for 0 to 15 percent residue, and 15 to 30 percent residue are considered conventional tillage

AGRICULTURAL TILLING
NEI Method (Cont'd)

- Emission Calculation

$$E = c * k * s^{0.6} * p * a$$

where:

E	=	PM emissions, lbs per year
c	=	constant 4.8 lbs/acre-pass
k	=	dimensionless particle size multiplier (PM_{10}= 0.21; $PM_{2.5}$ = 0.042)
s	=	silt content of surface soil, defined as the mass fraction of particles smaller than 75 µm diameter found in soil to a depth of 10 cm (%)
p	=	number of passes or tillings in a year
a	=	acres of land tilled

AGRICULTURAL TILLING
NEI Method (Cont'd)

- Emission Calculation
  - Emission equation used for years prior to 1999
  - For 1999/2002, number of acres tilled for each of the five tillage types was estimated based on linear interpolation of national-level data available for 1998 and 1999/2002
  - Developed national growth factors by tillage type for 1999/2002, using 1998 as basis
  - Growth factors applied to county level emissions for 1998 to estimate county level emissions for 1999/2002
  - Assumed no controls

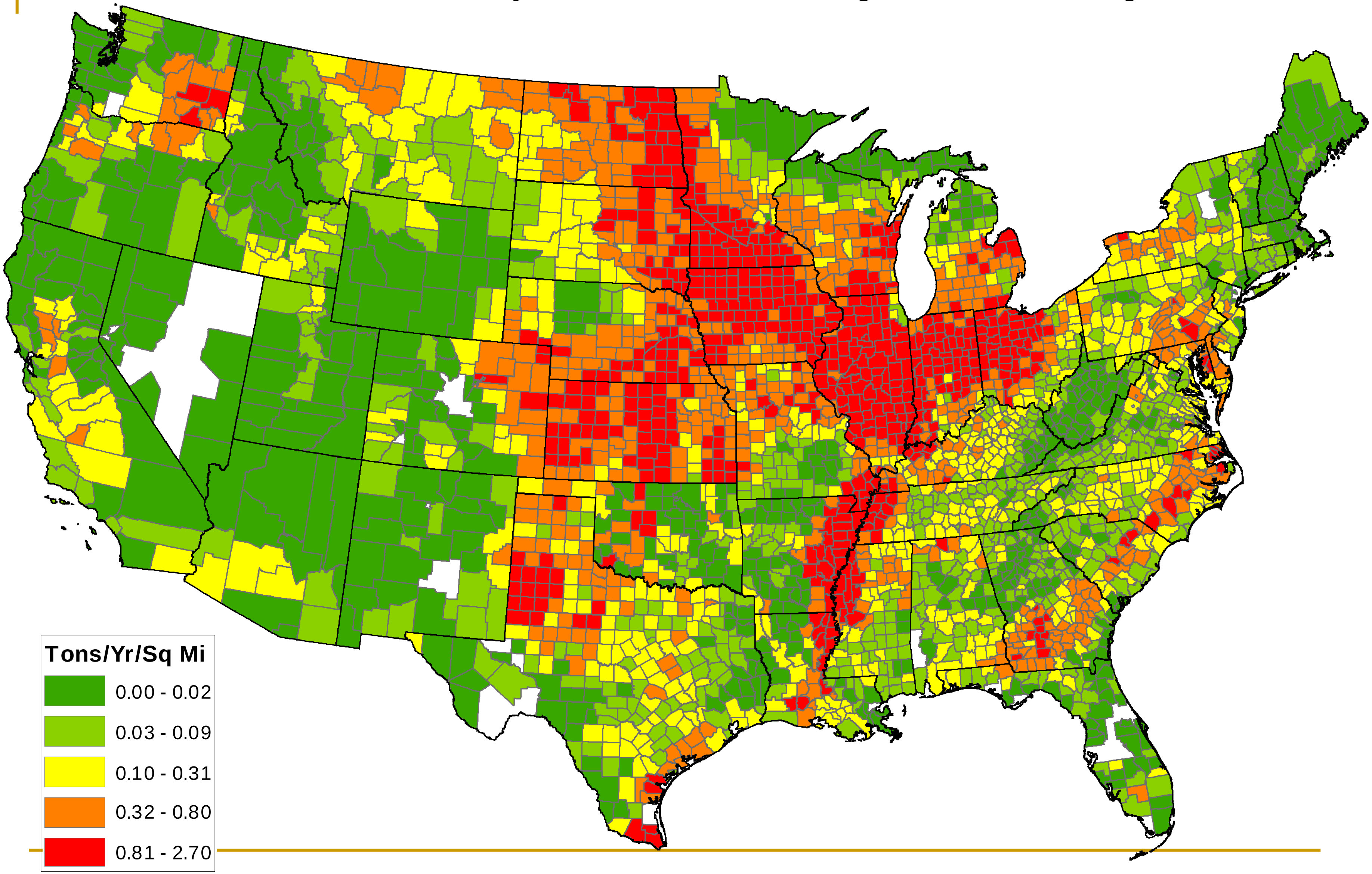
AGRICULTURAL TILLING

Improving the NEI

- Use crop-specific acreage and tilling practice data from State/local agencies
- Use State/local emission factors
- Perform field study to determine local silt content percentage of surface soil
- Crop Calendars: Develop using State/local data to determine time and frequency of activities (e.g., land prep., planting, and tilling)

Sources of Data: State Department of Agriculture or Agricultural Extension Service

1999 PM2.5 Primary Emissions from Agricultural Tilling



Case Study: California Air Resources Board (CARB)

- Reference
  - *Computing Agricultural PM_{10} Fugitive Dust Emissions Using Process Specific Emission Rates and GIS*
    - Patrick Gaffney and Hong Yu, CARB
  - Presented at 12th International Emission Inventory Conference, San Diego, CA, April 29 May 1, 2003
  - Paper and slides available in PDF files:

http://www.epa.gov/ttn/chief/conference/ei12/index.html

Case Study: CARB (Cont'd)

- Statewide PM_{10} EI for:
  - Land preparation activities
  - Harvest activities
- Goals:
  - Obtain current, crop-specific acreage data
  - Develop crop-specific temporal profiles (crop calendars)
  - Develop emission factors for all crops

Case Study: CARB (Cont'd)

- Crop-Specific Acreage Data
  - County-level data from CA Dept. of Food and Agriculture
  - Data generated annually by crop and by county
  - Includes over 200 crops and 30 million acres

Case Study: CARB (Cont'd)

- Crop Calendars
  - Developed for 20 most important crop types
    - Importance based on acreage and potential emissions
  - Define temporal periods of farming operation activities by crop type

Example Crop Calendar for Corn

Farming Operations	Crop Cycles Per Year	Passes Per Crop Cycle	Fraction of Acreage Per Cycle	Passes During Month											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land Preparation															
Stubble Disc	1	1	1.0												
Finish Disc	1	1	1.0												
List & Fertilize	1	1	1.0												
Mulch Beds	1	1	1.0												
Planting	1	1	1.0												
Cultivation	1	2	1.0												
Harvesting	1	1	1.0												

(Reference: *Computing Agricultural PM_{10} Fugitive Dust Emissions Using Process Specific Emission Rates and GIS*, prepared by Patrick Gaffney and Hong Yu from California Air Resources Board for U.S. EPA 2003 Annual Emission Inventory Conference.)

Case Study: CARB (Cont'd)

- Emission Factors (EFs)
  - Previous EIs:
    - Land Preparation: AP-42 Tilling factor (4.0 (lbs PM_{10}/acre-pass) applied to all operations
    - Harvesting: Estimated for only 3 crop types for which EFs were available
  - Improvements:
    - Conducted field testing to develop EFs for more operations
    - Crop & operation specific (for crop calendars)

Case Study: CARB (Cont'd)

Land Preparation Emission Factors

	(lbs PM_{10}/acre-pass)
Root Cutting	0.3
Discing, Tilling, Chiseling	1.2
Ripping, Subsoiling	4.6
Land Planning & Floating	12.5
Weeding	0.8

- EFs used as surrogates for other land prep. operations

Case Study: CARB (Cont'd)

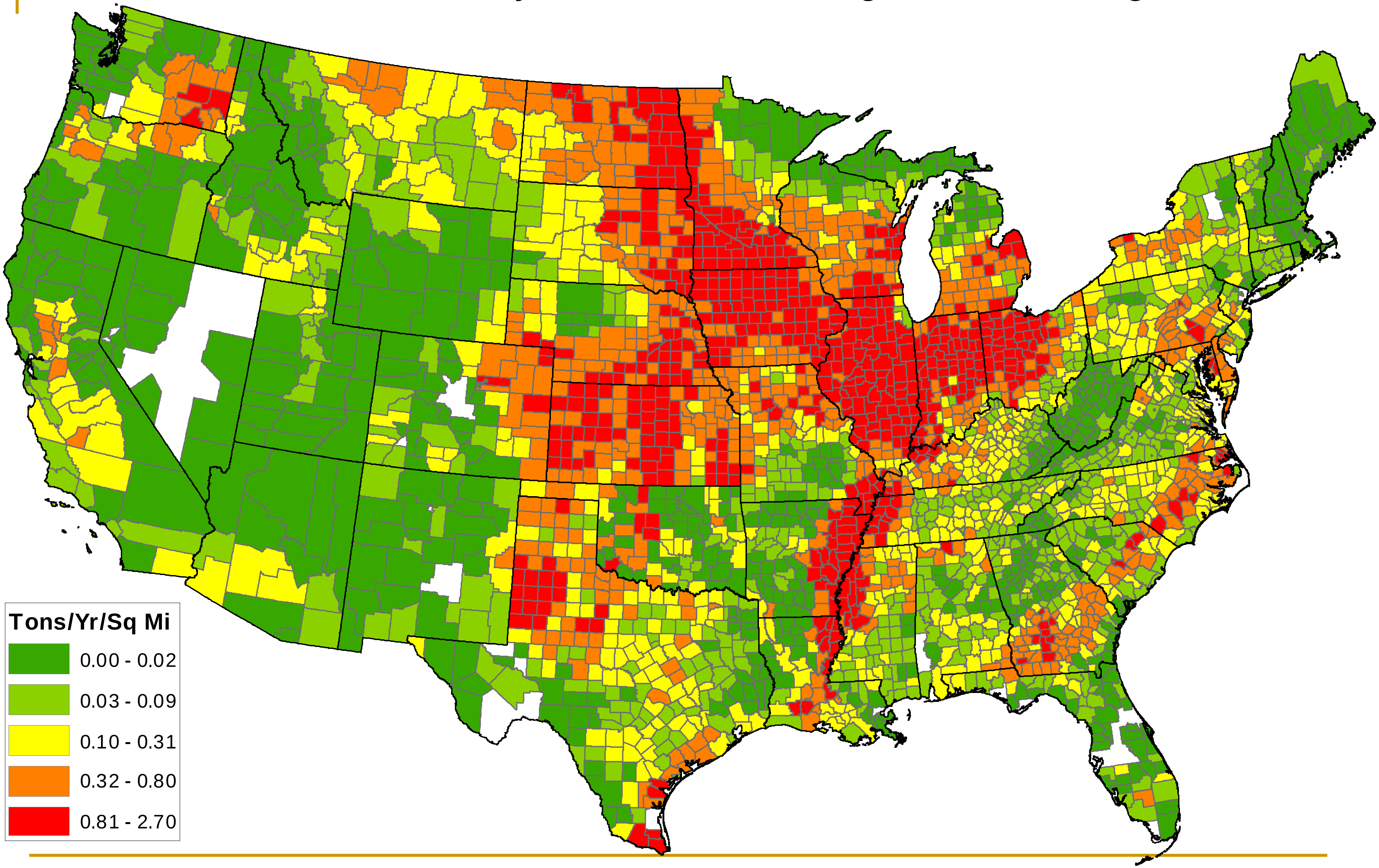
Harvest Emission Factors

(lbs PM_{10}/acre-pass)

Cotton Harvest	3.4
Almond Harvest	40.8
Wheat Harvest	5

- Assigned to over 200 crop types and adjusted using a "division factor" based on consultation with agricultural industry

1999 PM2.5 Primary Emissions from Agricultural Tilling



Questions ?

Session VII: Fugitive Dust Area Sources

Paved and Unpaved Roads

PAVED ROADS
Overview

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

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

    - Because of differences in methodology between the calculation of total and unpaved VMT, there may be cases where unpaved VMT is higher than total VMT.
    - In these cases, unpaved VMT is reduced to total VMT, and paved road VMT is assigned a value of zero.

  - Paved road VMT temporally allocated by month using NAPAP temporal allocation factors for total VMT.

PAVED ROADS
NEI Method (Cont'd)

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

$$PAVED = PSDPVD * (PVSILT/2)^{0.65} * (WEIGHT/3)^{1.5}$$

where:

PAVED	=	paved road dust emission factor for all vehicle classes combined (grams per mile)
PSDPVD	=	constant for particles of less than 10 microns in diameter (7.3 g/mi for PM_{10})
PVSILT	=	road surface silt loading (g/m^2)
WEIGHT	=	average weight of all vehicle types combined (tons)

PAVED ROADS

NEI Method (Cont'd)

- Emission Factor (continued)
  - Paved road silt loadings assigned to each of the twelve functional roadway classifications
    - Local functional class roads = 1 g/m^2
    - Road types with average daily traffic volume (ADTV) < 5,000 vehicles per day = 0.20 g/m^2
    - Road types with ADTV > or = 5,000 vehicles per day = 0.04 g/m^2
  - Average vehicle weight assumed to be 6,360 pounds
  - Fleet average emission factor includes PM from tailpipe exhaust, brake wear, tire wear, and ambient background particulate concentrations.

PAVED ROADS
NEI Method (Cont'd)

- Emission Factor (continued)
  - » Adjustments for precipitation

    Emission factor multiplied by a rain correction factor, calculated as follows:

$$(365 - p * 12 * 0.5) / 365$$

where: *p* = the number of days in a given month with greater than 0.01 inches of precipitation.

  - » Precipitation data used in the paved road emission factor calculations were taken from stations representative of urban areas in each state
  - » Final emission factors developed by month at the State and road type level for the average vehicle fleet

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

$$PM_{2.5} = PM_{10} \text{ emissions} \times 0.25$$

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

Revisions to AP-42 Equation

- EPA posted revisions to AP-42 Paved Roads Emission Factor Equation in December 2003
  - » New version of the emission factor equation only estimates PM emissions from resuspended road surface material
  - » PM emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOBILE6.2
  - » Eliminates the possibility of double counting emissions

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
Overview

- SCC 2296000000
- PM10-PRI/FIL and PM25-PRI/FIL
- No condensible material, so PM-PRI = PM-FIL
- 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)

$$\textit{Unpaved VMT}_{Roadtype} = \textit{Mileage}_{Roadtype} * ADTV * DPY$$

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)

- Non-local functional classes including:
  - Rural minor collector, rural major collector, rural minor arterial, rural other principal arterial, urban collector, urban minor arterial, and urban other principal arterial
  - ADTV not available for non-local roads, estimated from local urban and rural VMT and mileage:

UNPAVED ROADS
NEI Method (Cont'd)

ADTV = VMT/Mileage

Where:

ADTV	=	average daily traffic volume for State and federally maintained roadways
VMT	=	urban/rural VMT on county-maintained roadways (miles/year)
MILEAGE	=	urban/rural state-level roadway mileage of county-maintained roadways (miles)

UNPAVED ROADS
NEI Method (Cont'd)

- Add Non-local functional class VMT to local functional class VMT to determine State total unpaved VMT by road type
- Unpaved road VMT temporally allocated by month using NAPAP temporal allocation factors for total VMT

UNPAVED ROADS
NEI Method (Cont'd)

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

$$EF = \frac{(k/2000) * (s/12)^{0.8} * (W/3)^{0.4}}{(M_{dry}/0.2)^{0.3}} * [(d - p)/d]$$

where:

EF	=	size specific emission factor (tons per mile)
k	=	empirical constant (2.6 lb/mile for PM10-PRI, 0.38 lb/mile for PM25-PRI)
s	=	surface material silt content (%)
W	=	mean vehicle weight (tons)
M_{dry}	=	surface material moisture content under dry, uncontrolled conditions (%)
d	=	number of days in a particular month
p	=	number of days in month with > 0.01 inches of precipitation

UNPAVED ROADS
NEI Method (Cont'd)

- **NEI Default Emission Factor Input Values**
  - » Surface material silt content(s)
    - – Average state-level values developed available at ftp://ftp.epa.gov/EmisInventory/finalnei99ver2/criteria/documentation/xtra_sources/
  - » Mean vehicle weight (W)
    - – National average value of 2.2 tons (based on typical vehicle mix)
  - » Surface material moisture content (M_{dry})
    - – 1 percent
  - » 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
Revisions to AP-42 Equation

- EPA posted revisions to AP-42 Unpaved Roads Emission Factor Equation in December 2003
- New version of the emission factor equation only estimates PM emissions from resuspended road surface material
- PM emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOBILE6.2
- Vehicle exhaust, brake wear, and tire wear component relatively much less for unpaved roads than paved roads

UNPAVED ROADS

Improvements to NEI

- **Summary**
  - » Review NEI 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 VII
Area Source Overview - Construction

Roy Huntley
OAQPS
US EPA

Fugitive Dust from Construction Activities

Construction - The Way We Were

- Pre 1999 NEI
  - Dollars spent on construction
  - Convert dollars to acres disturbed
  - Use emission factor to determine emissions

Construction Categories

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

Adjustments

- Soil Moisture
- Silt Content

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
- Regionally specific building practice
- Obtain number of new houses built with full or partial basements from DOC

Needs Improvement

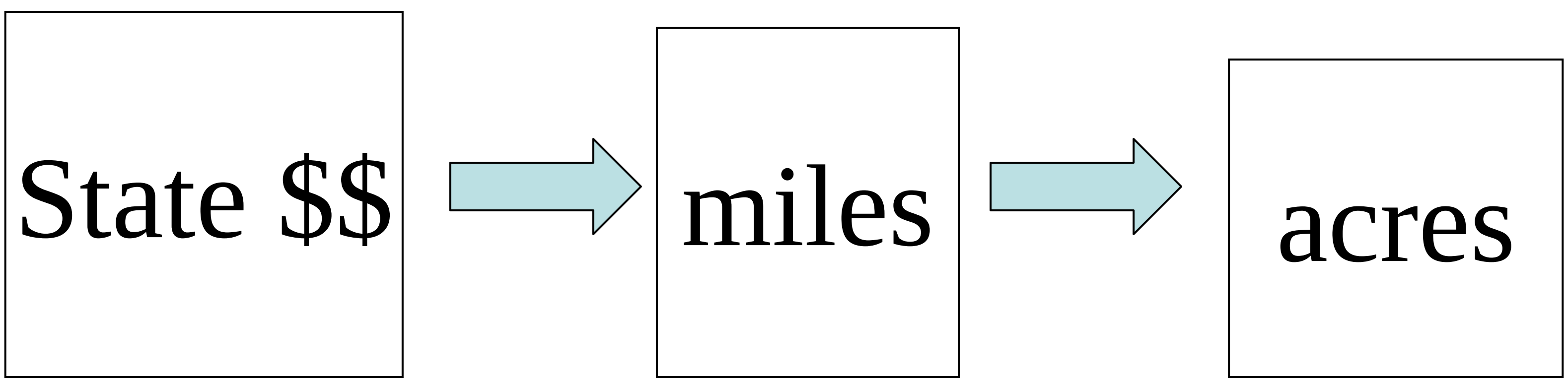
- Does not include trackout
- Double counts diesel emissions

Road Construction

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

Needs Improvement

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

Non-Residential Construction

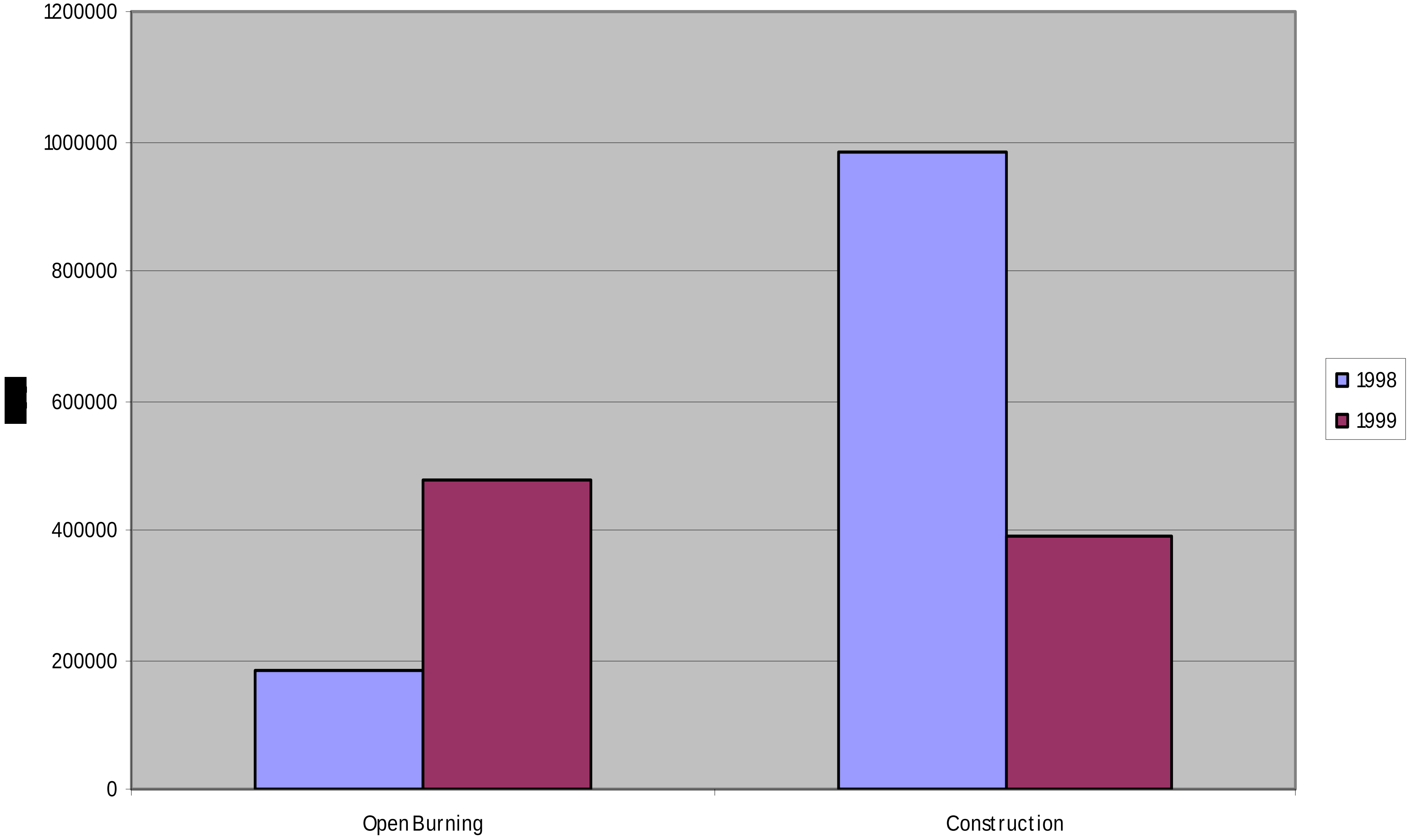
Non-Residential

- 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
- **m** = duration (11 months)

PM2.5 National Emission Estimates, from 1998 to 1999



Last Point

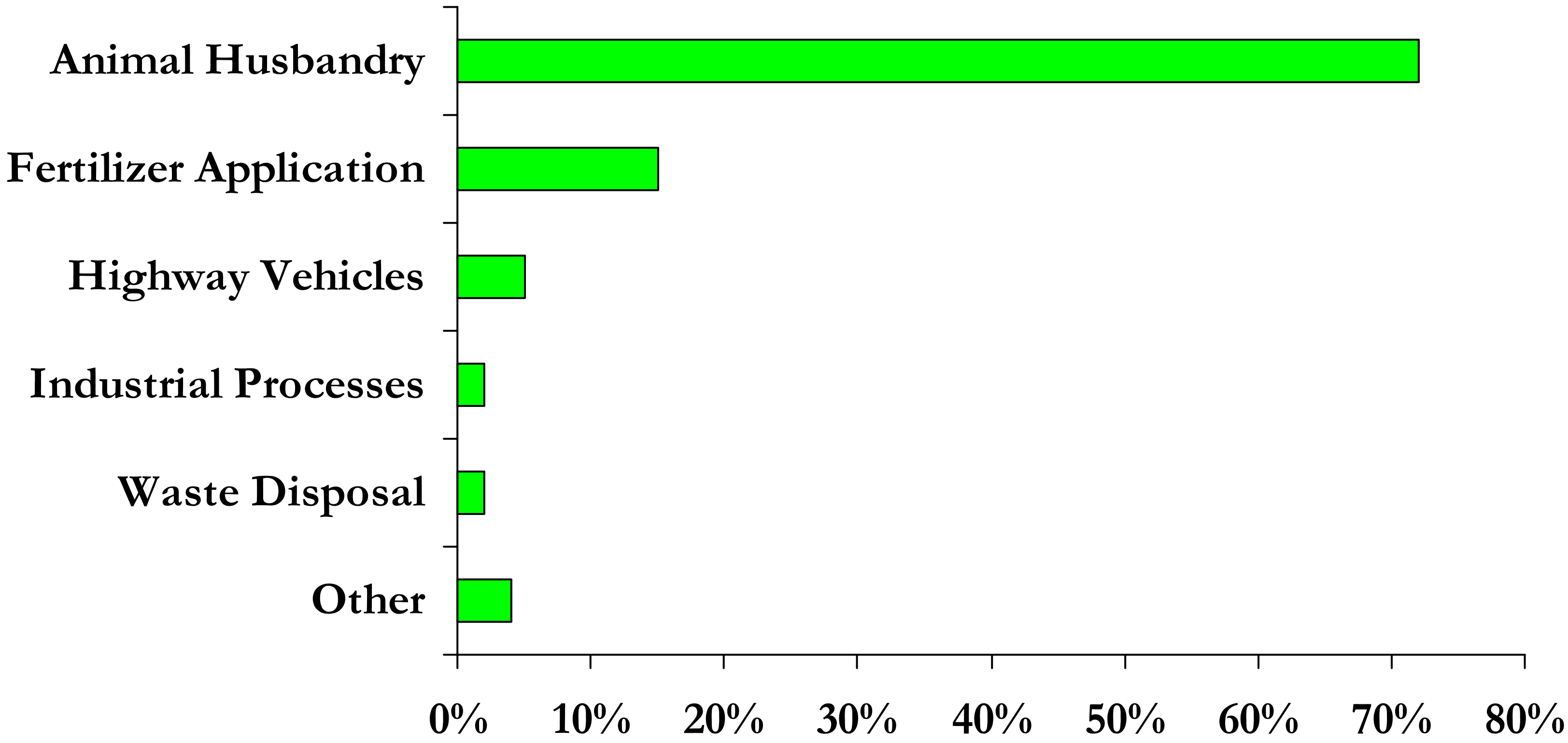
- Some opportunities for improvement
  - Improve methods
  - State/local data

Session VII
Recent Improvements to the National Emissions Inventory of Ammonia From Animal Husbandry

Tom Pace,
US EPA

Presented at the Denver PM2.5 EI Workshop
March, 2004

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



Update to Ammonia from Animal Husbandry is Timely

- **Inverse modeling** suggests overestimation of ammonia.
- **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.

Update to Ammonia from Animal Husbandry is Timely (cont.)

- **Effluent Guidelines** project provided information on production & waste handling practices (new).
- **Confusion** and questions by others about what EPA recommends.
- **New air quality modeling** efforts starting soon.
- **National Academy of Science** (NAS) committee recommended a long data gathering effort.
  - **Old NEI estimates** are not the best we can do in the interim (while this data gathering is undertaken).

ERG Report Provides an Improved Basis for Update in 2002 NEI

- Provides improved data on populations, practices, and emissions.
- Allows a switchover to a process-based framework that is common, transparent and that allows partial updating as more data becomes available.
- Motivates and provide structure for relevant data collection.
- Opportunity to educate users about data limitations, proper use.
- Goal: Higher animal production States will begin to adopt / offer improvements to new method.
- Draft Report
  - ftp://ftp.epa.gov/EmisInventory/draftnei2002/nh3inventorydraft_jan2004.pdf

Overview of Draft Estimation 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.

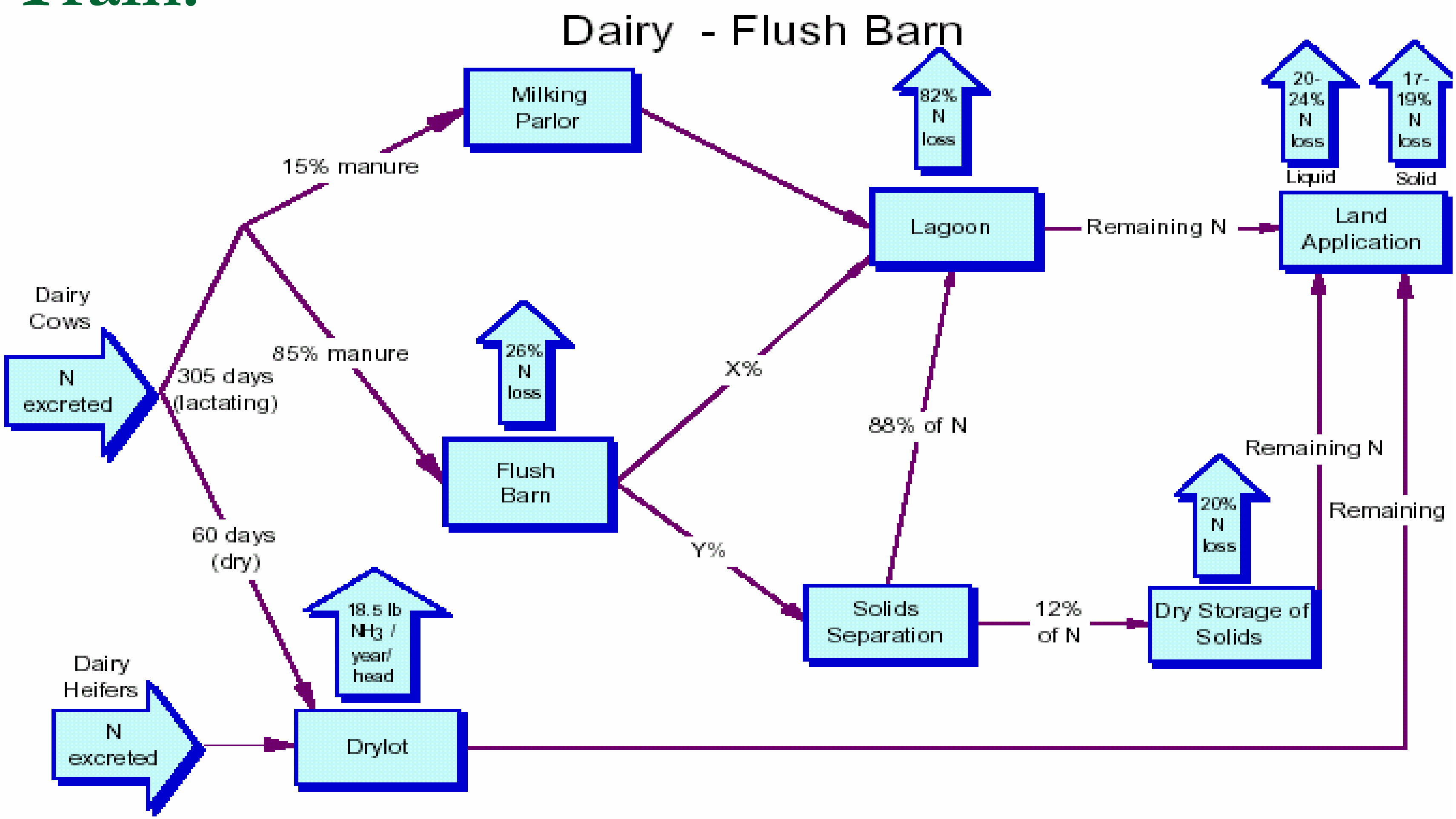
Step 1: Population Estimates

- **Animals:** Dairy, beef, swine, and poultry.
  - Keep weight groups & animal types distinct.
- **State-level population:** 2002 NASS.
- **County apportionment:** using 1997 Census of Agriculture.
  - Privacy Issue - Where state and/or county is not disclosed, divide equally.
- ***Near term "opportunity"*** *to use county-level 2002 Census of Ag*

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.

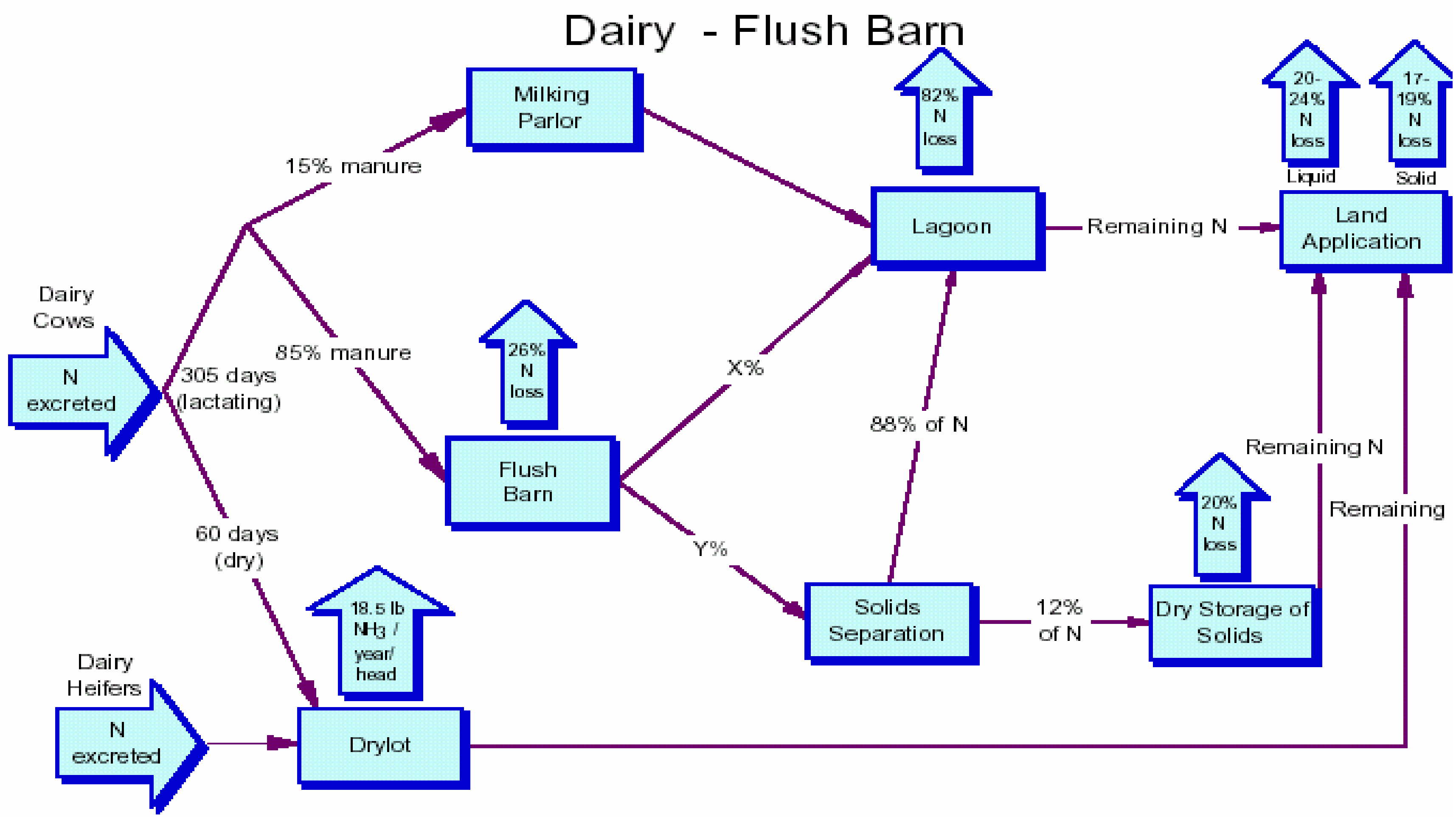
Step 3: Nitrogen Excreted

- Typical animal weights (within a type and weight range)
- Nitrogen per 1000 kg of live weight from NRCS *Agricultural Waste Management Field Handbook*
- Local ag experts could help improve this
  - Land Grant Univ Researchers / Extension Agents

Step 4: Emission Factors

- Select the emission factor for each stage of each manure management train.
  - Some are lb/animal, some are percent air release of input ammonia.
  - Both kinds also determine ammonia transferred to next stage.
  - Selected as average of the relevant literature, updated to May 2003.
  - Some copying between animal types and trains to fill in blanks in the literature.
- Air emissions can never be higher than original manure content.
- Using stage-specific emission factors sets the stage for applying temporal profiles (& process-related variability) later.

Advanced Example of Manure Management Train:



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X% and Y% vary by size of operation, and represent the proportion of production using each type of system.

Step 5: Apply for 2002

- **Track ammonia release** through each manure management train for each animal type, calculating air releases and transfers to next stage.
- **Assumes no air emission controls** at this time.
  - But can add control assumptions later, and see downstream consequences.
- **Emissions are summed** up to animal type and county
- **Database is preserved** with full detail for transparency and later revisions.
- **"Opportunity"** to begin to characterize the MMT's used by agriculture in your local area so improvements can be made in future EI cycles. Begin bringing animal experts onto your EI team.

Step 6: Future Years Projections

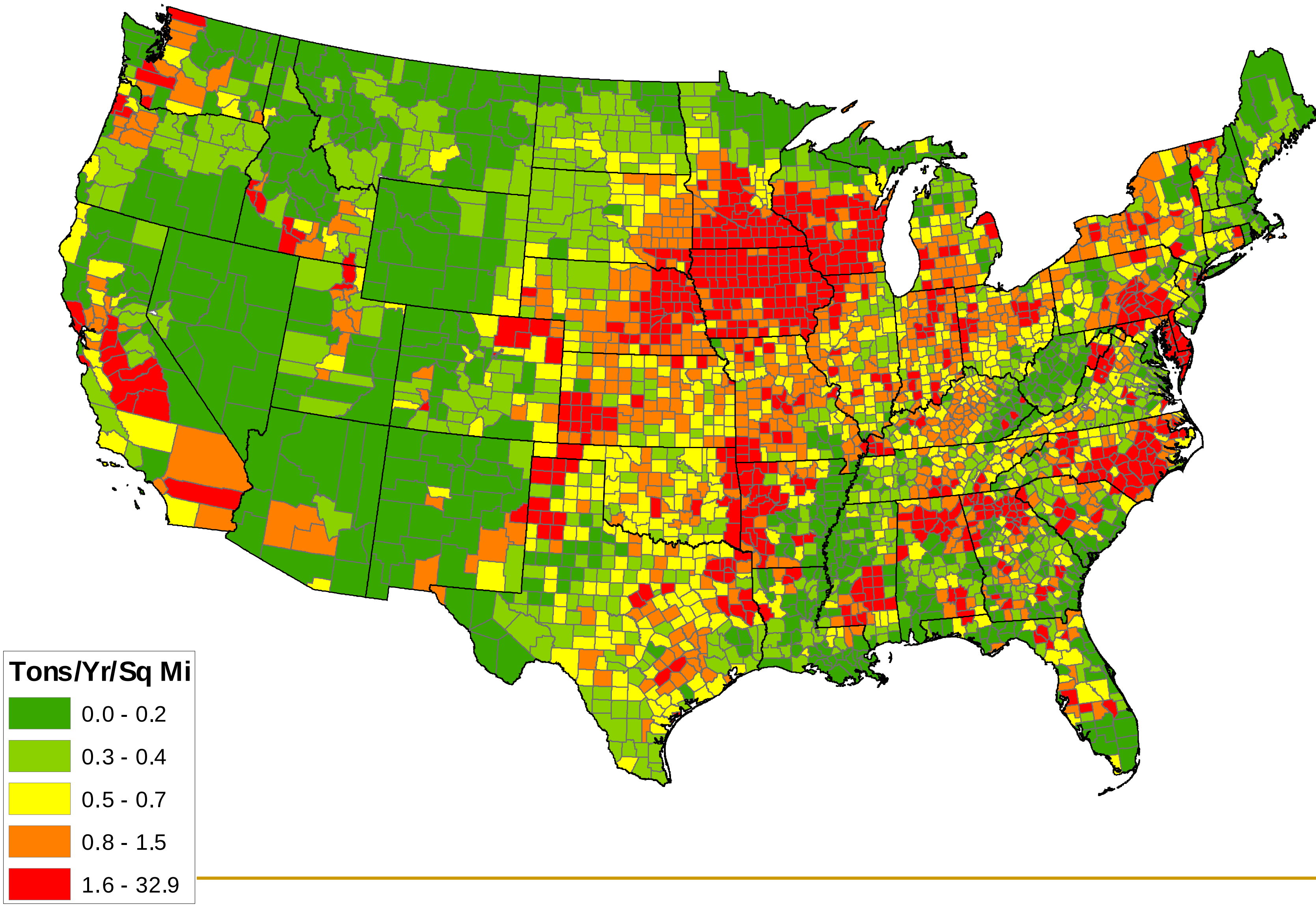
- 2010, 2013, 2020, and 2030.
- USDA and Food and Agricultural Policy Research Institute.
- Accounts for past observed cyclical populations.
- State-by-state population pattern.
  - Changes with time for dairy.
  - Fixed for others.

New Draft Emission Estimates are Lower

Comparison of 1999 and 2002 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



Opportunities for States, Locals & Tribes:

- **States submit their own estimates of:**
  - 2002 population,
  - nitrogen excreted,
  - farming practices / MMT’s,
  - E.F.’s)

- **Timing:**
  - June 2004 State submittal
  - Second version of 2002 NEI for comment - Fall or winter 2004.
  - Final second version of 2002 NEI - Summer 2005.

Ongoing Additional Improvements (National & Regional Level)

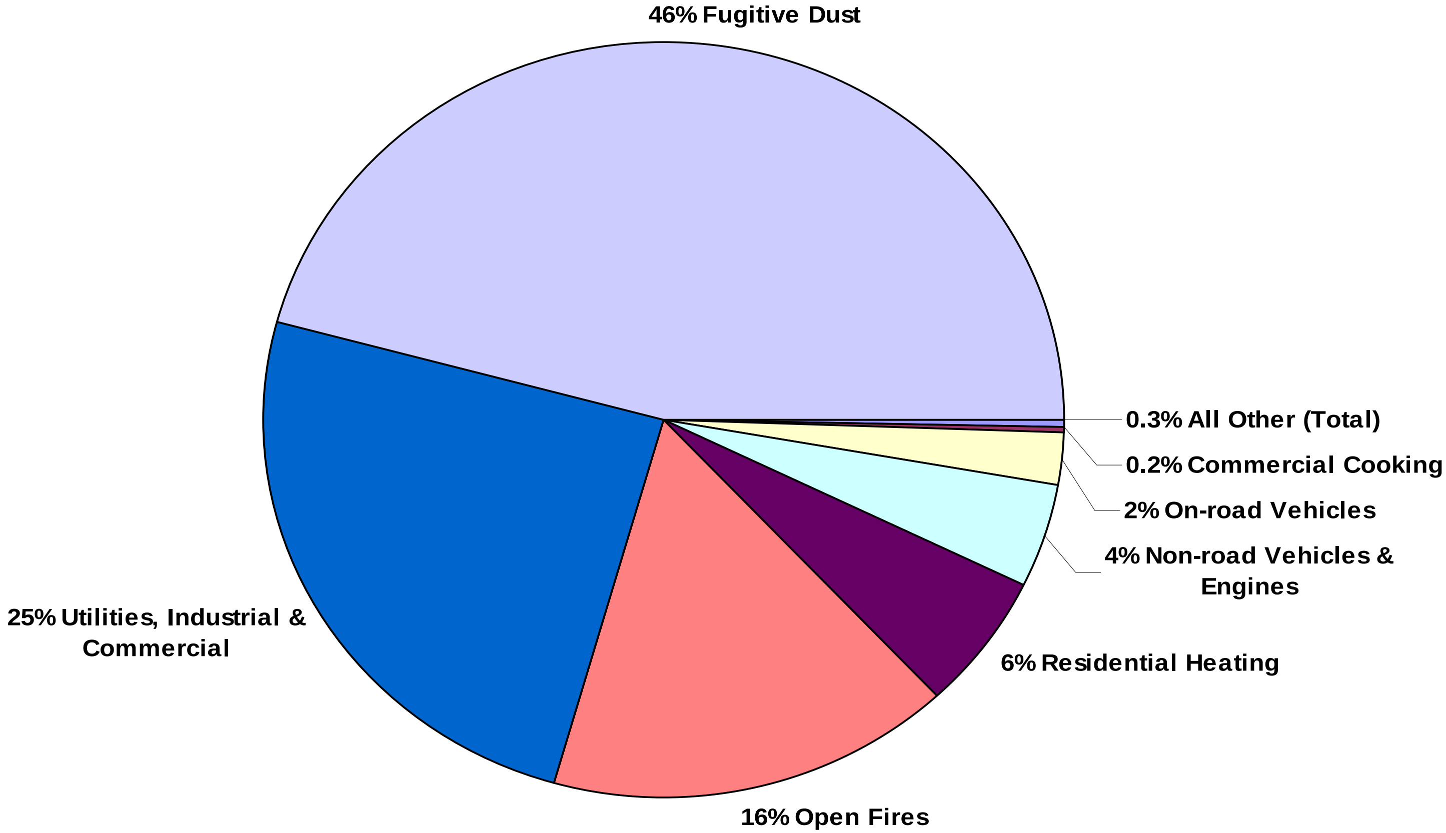
- Plan to incorporate emission estimates for sheep, ducks, goats, and horses
- Looking at more recent manure production and excretion rates by animal types and weight (may provide lower overall estimates than currently indicated in draft report).
- Looking into ways to better address spatial, seasonal, and regional differences in emissions.
- Ammonia process-based emissions model for animal husbandry
  - Inter-RPO funded
  - Fall 2005 delivery

Questions ?

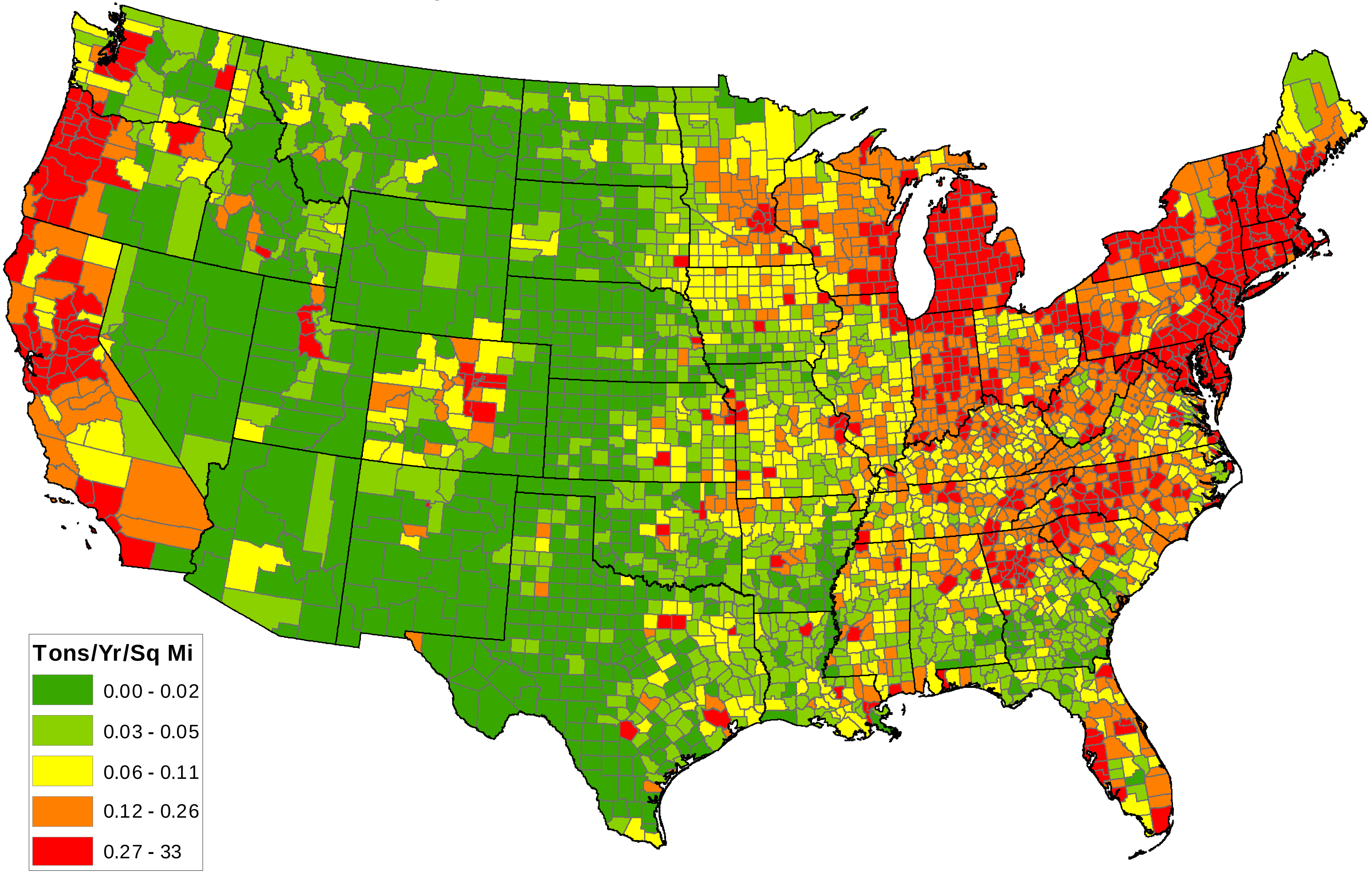
Session VII:
Combustion Area Sources

Residential Wood Combustion

PM-2.5 Emissions in 2001 EI



1999 PM2.5 Primary Emissions from Residential Wood Combustion



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
- 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

Modifications to Wood Stoves to Meet EPA Standard

- Catalyst
  - catalyst lasts 3-5 years, then needs replacing
- Non-catalytic stoves
  - reduce emissions with the use of geometry, secondary air, heat retaining material, and insulation.
- Advantages/Disadvantages to both technologies

Key Facts

- About 9.3 million cordwood stoves in use in US
  - 8.3 million are conventional, 1.0 million certified.
  - Cordwood stove sales in 1997 less than half than in 1990
  - WS population could be different locally
- Fireplaces exempt from NSPS (>35:1 air to fuel ratio)

Key Facts (continued)

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

Key Facts (continued)

- Pellet stoves use wood pellets made from sawdust as fuel
  - Low emissions, exempt from NSPS
  - ~350,000 pellet stove in use
- Masonry heaters
  - Exempt from NSPS
  - Not many of these

Many Factors Affecting Emissions

- Hundreds of 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

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

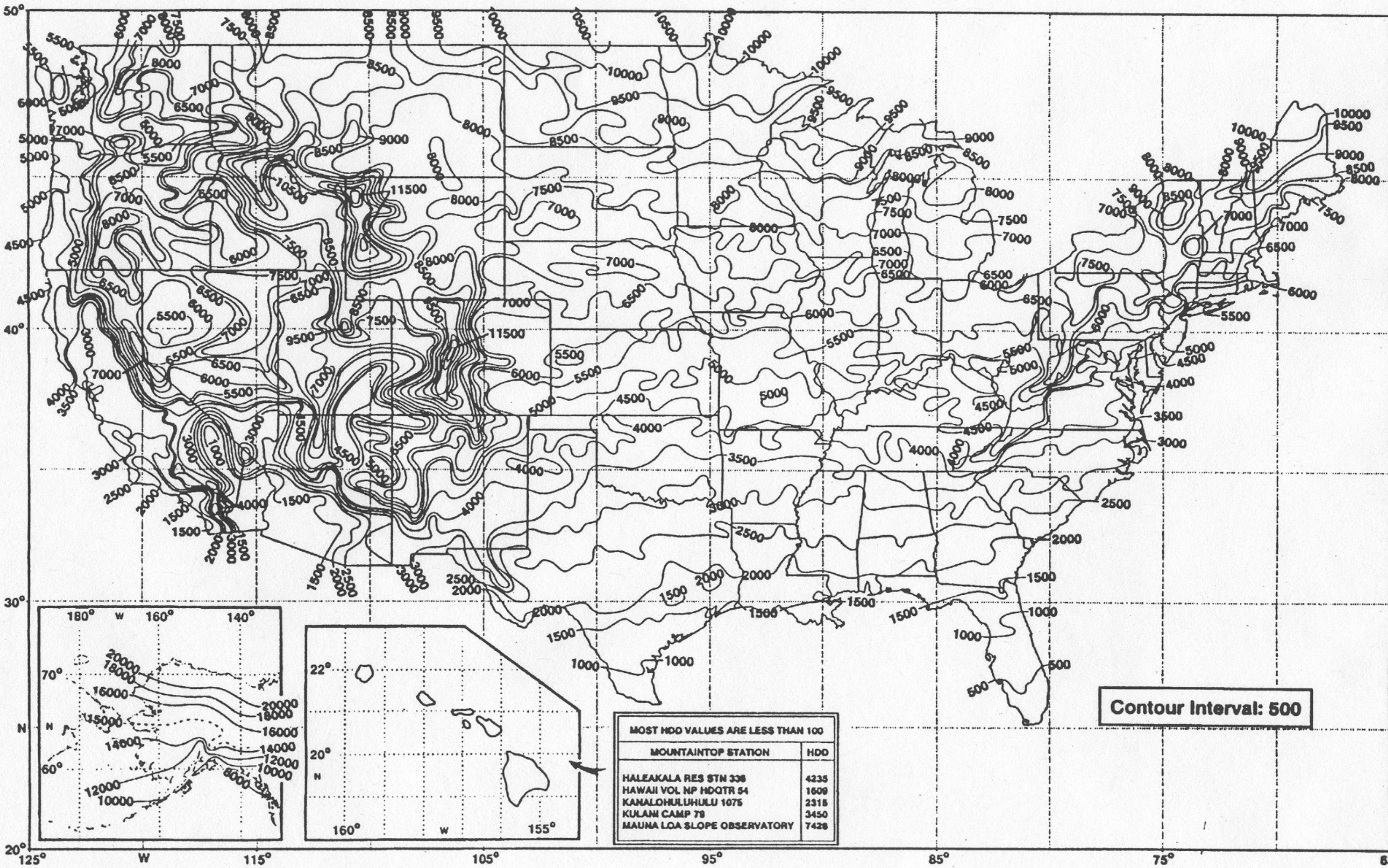
- Determine wood consumption for each fireplace type
  - Assume wood consumption rates
    - 0.656 cords/unit/year for heating
    - 0.069 cords/unit/hear for aesthetics
- Allocate wood consumption to climate zone and then to county

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

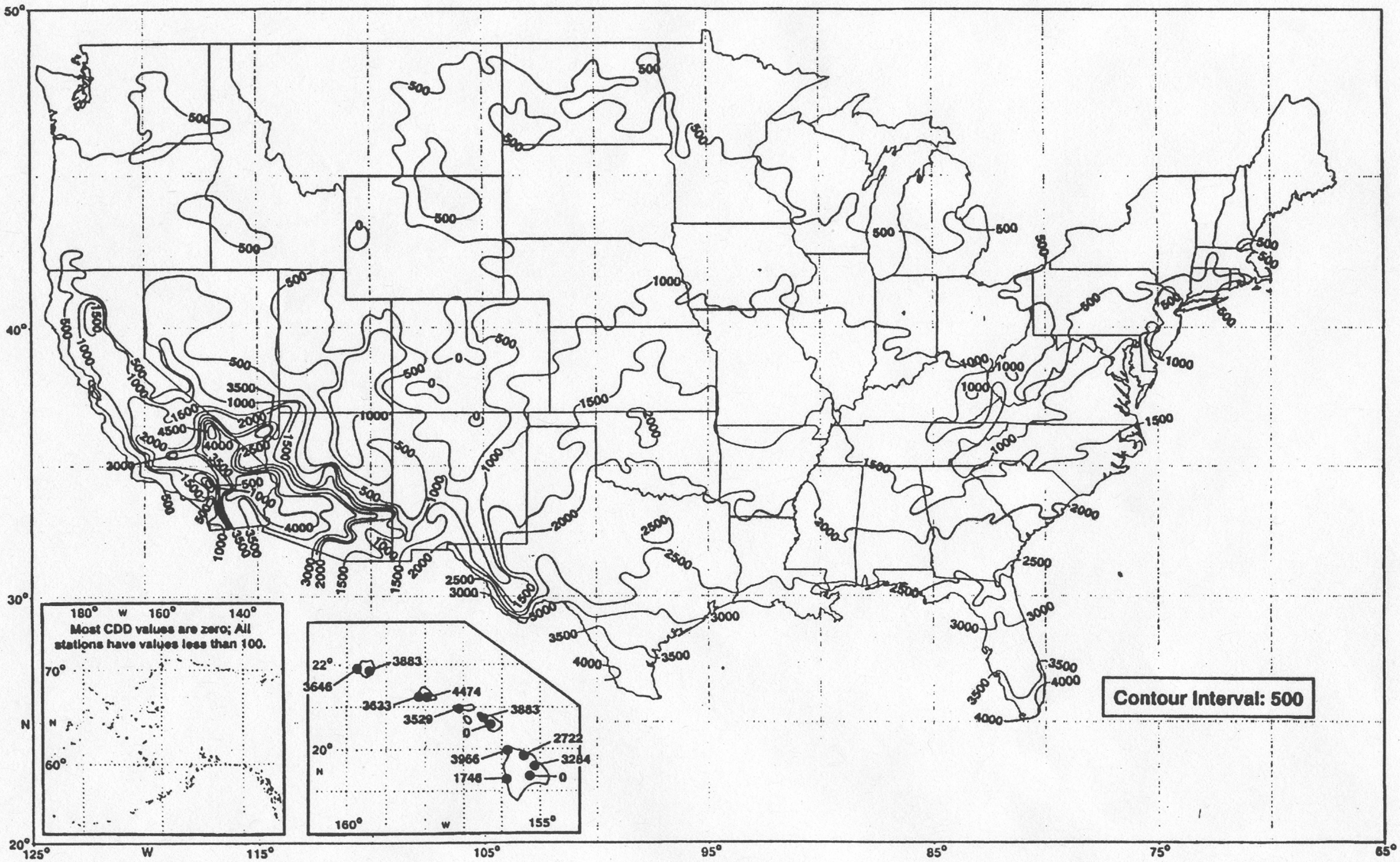
ANNUAL HEATING DEGREE DAYS

BASED ON NORMAL PERIOD 1961-1990



ANNUAL COOLING DEGREE DAYS

BASED ON NORMAL PERIOD 1961-1990



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

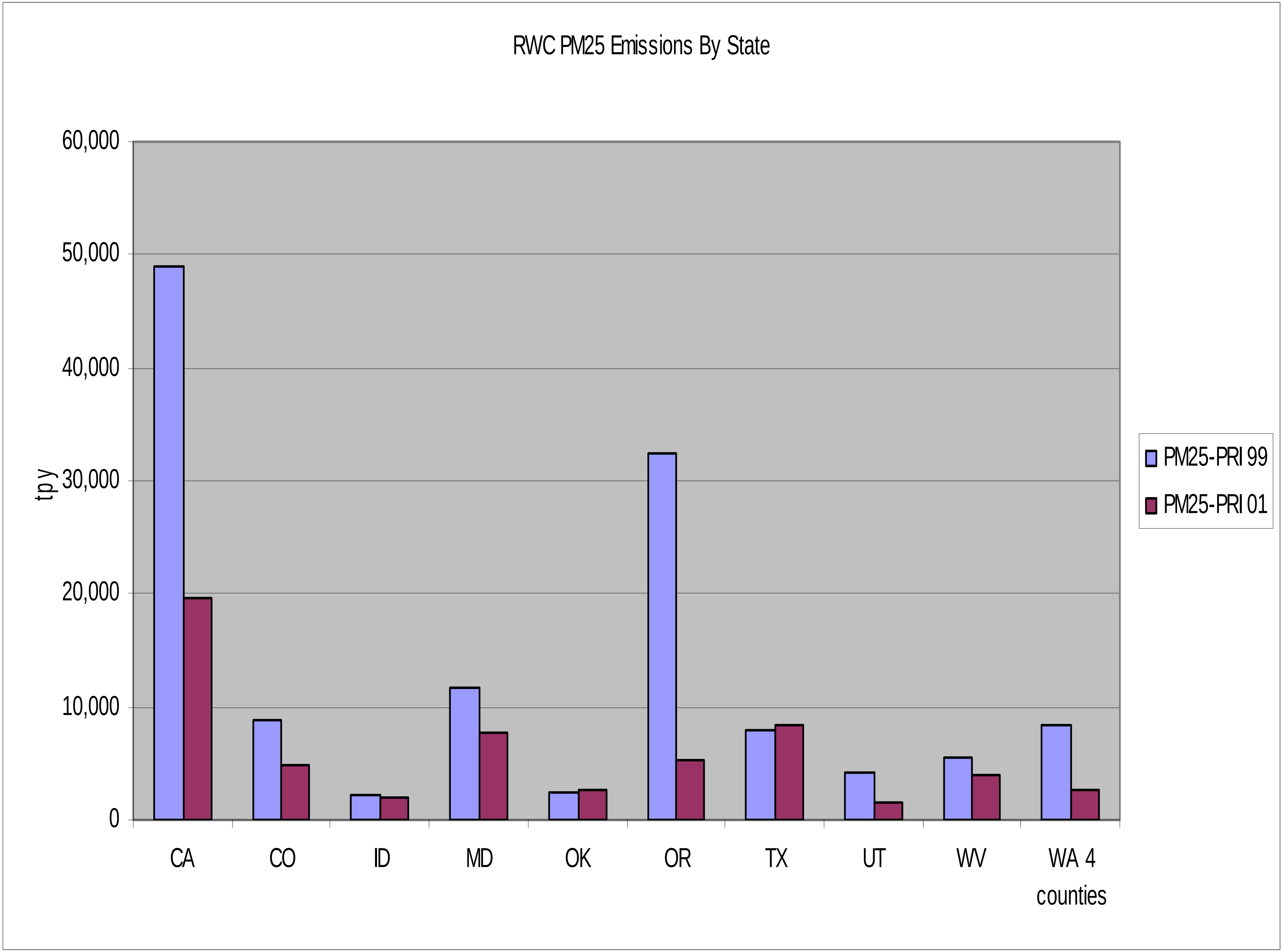
- Start with total wood burned and subtract out wood burned in fireplaces
- Allocate wood consumption to climate zones
  - Use # of single family detached homes as surrogate

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


RWC PM25 Emissions By State
60,000
50,000
40,000
30,000
20,000
10,000
0
tpy
CA
CO
ID
MD
OK
OR
TX
UT
WV
WA 4 counties
PM25-PRI 99
PM25-PRI 01

Session VII
Area Source Overview – Opening Burning

Roy Huntley
OAQPS
US EPA

PM2.5 Emissions from Residential Open Burning

Residential Open Burning
What Sources are Included?

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

EFIG’s Needs

- Top down inventory
- Inexpensive data sources

Open Burning - The Way We Were

- Grown from 1985 NAPAP unless States provided data

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

Res. 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

- No changes made. Continue to use 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

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, and specification of counties where wastes are burned.

  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*

Emissions Estimation for Agricultural Burning

PM2.5 Emissions Inventory Workshop
Denver, CO
March 2004

Thompson G. Pace
USEPA

Agricultural Burning

AGRICULTURAL BURNING

Overview

- SCC 2801500000
- PM10-PRI and PM25-PRI
- Both condensibles and filterables
- NEI contains *ONLY* State-submitted estimates
  - 10 States for 1999 - AL, CA, DE, GA, ID, KS, ME, OR, TX, UT
- General Approach
  - Activity (acres of crop burned)
  - Loading factor (tons of biomass or vegetation per acre burned)
  - Emission factor (pounds per ton)
- Case Study

CASE STUDY
Wheat Stubble Burning

- **Method -** Develop inventory using county-specific data when available
  - **Activity**
    - Acres of wheat burned by month obtained from burn permits issued by county fire department
    - Fuel loading for wheat stubble from county agricultural extension office

CASE STUDY
Wheat Stubble Burning (Cont'd)

- **Emission Factors**
  - PM10: 8.82 pounds per ton of wheat stubble burned
  - PM2.5: 8.34 pounds per ton of wheat stubble burned

Reference: Jenkins, B.M. *et al.*, *Atmospheric Pollutant Emission Factors from Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations, Volume 2, Results, Cereal Crop Residues*, California Air Resources Board Project No. A932-126.

- **Resolution**
  - Spatial – county
  - Temporal - monthly

CASE STUDY

Wheat Stubble Burning (Cont'd)

- Sample Calculation
  - June PM2.5-PRI Emissions

= Acres Burned in June * Loading Factor * Emission Factor

= 1,950 acres/month * 1 ton/acre * 8.34 lbs/ton

= 16,263 pounds/month

= 8.13 tons/month

Annual PM2.5-PRI Emissions = $\sum$ Monthly Emissions

AGRICULTURAL BURNING

Improvements

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

AGRICULTURAL BURNING

Improvements (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
  - National defaults available from Chapter 2.5 in *AP-42*


Questions?

Questions?

Emissions Estimation for Wildland Fires

PM2.5 Emissions Inventory Workshop
Denver, CO
March 2004

Thompson G. Pace
USEPA

Wildland Fires

Overview of Wildland Fire Inventory

- **Wildland Burning**
  - **Burners:**
    - **NPS, USFS, BLM, USFWS, State & Tribal Forests, Private burners**
  - **Types: Wildfires, Managed (Prescribed) Burns**
- **Focus of this Section of Workshop**
  - **How are Wildland Burning emissions estimated in NEI ?**
  - **What's Happening Nationally & Regionally ?**
  - **Suggestions for State & Tribal focus ?**
  - **Fire Links & Contacts**

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 Regional / National Databases & Models:

- **Fire Event: area burned, when, where**
- **Develop, refine national & regional models & databases to estimate pre-burn fuel loading**
- **Refine, expand use of fuel consumption models**
- **Provide guidance on estimating impact of mitigation measures on emissions**

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

Fire Events Database Development

Federal MOU (FYI)

- **Includes: EPA, DOI, USDA**
- **Broad Scope: *Fire Management Activities***
- **Status: In Progress**

Investigation of the role of national databases

- **USDA / DOI efforts**
- **NEISGEI http://capita.wustl.edu/NEISGEI/**
- **B-RAINS (Pacific NW Database)**
- **Much more work is needed to move toward real time data collection, QA & sharing**

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

Investigating the Potential Use of Satellites

- **EPA**
  - **EIIP-funded Overview of Using Satellites in AQ**
    - **http://www.epa.gov/ttn/chief/eiip/pm25inventory/remsens.pdf**
  - **Collaboration w/ NASA**
- **Interagency**
  - **NIFC**
  - **Work at Missoula Fire Research Center & Salt Lake City**
  - **Collaboration w/ NASA**
- **Others**
  - **CAMFER**

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

Emission Estimation Tools & Inventories

- **EPA**
  - **Recent Report: Fire Emission Estimation Methods**
- **USFS**
  - **Work at the Fire Sciences Lab (Missoula)**
  - **Work at Pacific NW Research Station (Corvallis)**
- **Collaboration**
  - **WRAP - Fire Emissions Joint Forum**
  - **RPO-led 2002 Wildland Fire EI development**
  - **Nat'l Fire Emissions Workshop (in planning stages)**
  - **Nat'l FCC coverage @ 1 km2 resolution**
  - **Emissions model to interface with grid models**

Wildland Fire Emissions Module

(under development)

- **Modular input to Emission Models (e.g., SMOKE, OpEM) to 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 & Plume Rise: EPM & Briggs (modified)
- **Outputs:** Gridded hourly emissions, plume characteristics
- **Integrate, Test & Release Module (late 2004)**

Questions ?