Preparation of Fine Particulate Emissions Inventories

Chapter 9 – Combustion Area Sources

MANE-VU 2002 RWC Emission Inventory

- Objective
  - Prepare 2002 EI based on survey of household equipment usage and wood consumption patterns
- Survey Method – stratified, random-sampling
- Data Collected for Each Household
  - Wood consumption at equipment level (both real wood and artificial logs)
  - Wood type for real wood
  - Temporal activity to calculate monthly, weekly, and daily emissions

Sample Frame Construction

- Sampling designed to address major sources of variability in activity (i.e., wood consumption)
- Sources of variability include:
  - Location and type of housing
  - Heating demand (expressed as heating degree days (HDDs))
  - Availability of wood

Sample Frame Construction (cont.)

- Sample Stratification
  - Housing Data – 2000 Census tract data used to stratify sample by:
    - Urban, suburban, and rural single-family and "other" homes (other homes = multi-family units such as apartments, condos, mobile homes)
    - Rural category stratified by forested and non-forested areas using USGS GIS data (i.e., Forest Fragmentation Index Map of North America)
  - Heating Demand – Total annual HDDs used to stratify sample into 3 zones

Sample Frame

	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
Geographic Zone	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDD	Cell 1 61 (173)	Cell 2 61 (64)	Cell 3 61 (87)	Cell 4 61 (66)	Cell 5 61 (61)	Cell 6 61 (72)	Cell 7 61 (69)	Cell 8 61 (69)
Low HDD	Cell 9 61 (150)	Cell 10 61 (62)	Cell 11 61 (118)	Cell 12 61 (69)	Cell 13 61 (76)	Cell 14 61 (67)	Cell 15 61 (75)	Cell 16 61 (62)
Med HDD	Cell 17 61 (87)	Cell 18 61 (60)	Cell 19 61 (91)	Cell 20 61 (64)	Cell 21 61 (71)	Cell 22 61 (60)	Cell 23 61 (63)	Cell 24 61 (68)

Survey Instrument

- Questionnaire developed to gather activity data for:
  - Indoor equipment (fireplaces, woodstoves, pellet stoves, furnaces, and boilers)
  - Outdoor equipment (fire pits, barbeques, fireplaces, and chimineas)
- Pilot survey performed to test the instrument
- Survey conducted using computer-assisted telephone interviewing
  - Completed 1,904 surveys across all 24 cells

Survey Data Reduction/Analysis

- QA reviewed each survey
- Calculated/summarized for each cell:
  - User fraction (fraction of total household population that burns wood in indoor and outdoor equipment)
  - Annual activity (cords of wood by equipment and wood types)
  - Temporal data
- Conducted statistical analyses to identify significant differences between cells for:
  - User fraction
  - Annual Activity

Indoor Wood-Burning Equipment Preliminary Survey Results (% Burners)

Geographic Zone	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDD	Cell 1 FP= 34 WS= 67 F/B= 21 PS= ***4***	Cell 2 FP= 75 WS= 75 F/B= 0 PS= 0	Cell 3 FP= 43 WS= 76 F/B= 7 PS= 0	Cell 4 FP= 33 WS= 67 F/B= 0 PS= 0	Cell 5 FP= 36 WS= 64 F/B= ***18*** PS= 0	Cell 6 FP= 0 WS= 0 F/B= 0 PS= 0	Cell 7 FP= 80 WS= 30 F/B= 0 PS= 0	Cell 8 FP= 100 WS= 0 F/B= ***50*** PS= 0
Low HDD	Cell 9 FP= 60 WS= 65 F/B= 5 PS= ***2***	Cell 10 FP= 100 WS= 0 F/B= 0 PS= 0	Cell 11 FP= 61 WS= 54 F/B= ***4*** PS= 4	Cell 12 FP= 50 WS= 50 F/B= 0 PS= 0	Cell 13 FP= 70 WS= 35 F/B= 0 PS= 5	Cell 14 FP= 67 WS= 0 F/B= 0 PS= 33	Cell 15 FP= 90 WS= 10 F/B= 0 PS= 0	Cell 16 FP= 100 WS= 0 F/B= 0 PS= ***20***
Med HDD	Cell 17 FP= 55 WS= 66 F/B= 7 PS= 7	Cell 18 FP= 60 WS= 60 F/B= 0 PS= 0	Cell 19 FP= 59 WS= 45 F/B= 0 PS= 9	Cell 20 FP= 100 WS= 0 F/B= 0 PS= ***25***	Cell 21 FP= 81 WS= 27 F/B= ***8*** PS= 4	Cell 22 FP= 50 WS= 50 F/B= 0 PS= 0	Cell 23 FP= 100 WS= 0 F/B= 0 PS= 0	Cell 24 FP= 0 WS= 0 F/B= 0 PS= 0

FP = fireplace; WS = woodstove; F/B = furnace/boiler; PS = pellet stove; Totals do not always add to 100 since some respondents use more than one type of equipment. Values in ***bold italics*** are derived from responses that were identified as wood consumption outliers (equipment could be miss-categorized by the respondent).

Preliminary Results/Observations

- Indoor Equipment
  - Geographic distribution of equipment
    - Rural Areas:
      - Higher diversity of equipment types than in urban areas
      - Higher percentage of stoves and furnaces than in urban areas
    - Urban/Suburban Areas:
      - Lower diversity of equipment types than in rural areas
      - Higher percentage of fireplaces than in rural areas
  - Heating Demand
    - High HDD Zone:
      - Rural Areas – higher percentage of stoves and furnaces
    - Low HDD Zone:
      - Rural Areas – higher percentage of fireplaces

Preliminary Results/Observations (cont.)

- Indoor Equipment
  - For urban areas, it was difficult to find households that burned wood for the sample size taken
  - The urban sample size was not increased because of budget constraints **and** priorities for obtaining a representative sample for three instead of two HDD zones
  - The equipment- and fuel-based survey results were used to estimate emissions (e.g., lb $PM_{2.5}$/household-yr) for each household surveyed
  - A household-based statistical model is being developed to estimate emissions for each cell

Preliminary Results/Observations (cont.)

- Outdoor Equipment
  - Equipment-based emissions will be estimated using survey results

Annual Emissions = Fraction of outdoor equipment users per cell x annual activity x emission factor

Emission Inventory Development

- Emissions were:
  - Estimated for all criteria pollutants/precursors and several dozen toxic air pollutants
  - Estimated at the census tract level (summed to county, State, region)
  - Temporally allocated to support modeling using profiles developed from the survey

Lessons Learned

- Survey Instrument: for regional surveys, tailor it to suit the usage patterns in rural, suburban, urban areas
- Difficult to find wood burners in urban areas – minimum sample sizes need to reflect this

Lessons Learned (cont.)

- For indoor equipment, to keep resources manageable:
  - Consider the use of a statistically-derived emissions-based model (household level) instead of an equipment-specific method
  - Concern: Approach aggregates emissions for different types of wood burning equipment needed to support control measure analysis

Documentation for MANE-VU EI

- Technical memoranda and Work Plan for a Survey to Determine Residential Wood Combustion and Open Burning Activity (July 31, 2001)

  (MANE-VU Web Site: http://www.manevu.org/pubs/index.asp)

How are RWC Emissions Estimated in the '02 NEI?

- SCCs
  - FIREPLACES
    - 2104008001 Without Inserts
    - 2104008002 With Inserts; Non-EPA Certified
    - 2104008003 With Inserts; Non-Catalytic, EPA Certified
    - 2104008004 With Inserts; Catalytic, EPA Certified
  - WOODSTOVES
    - 2104008010 Non-EPA Certified
    - 2104008030 Catalytic, EPA Certified
    - 2104008050 Non-Catalytic, EPA Certified

How are RWC Emissions Estimated in the '02 NEI? (cont.)

- Pollutants
  - PM10-PRI, PM25-PRI, NO_x, CO, VOC, SO_x
  - HAPs (number of pollutants)

Emission Factors for Fireplaces Without Inserts (lbs pollutant/ton of dry wood)

- NO_x, SO_x, VOC, & HAPs
  - AP-42, Chapter 1.9, Table 1.9-1
- PM10-PRI, PM25-PRI, & CO
  - Houck, J.E., et al, "Review of Wood Heater and Fireplace Emission Factors," NEI Conference, May 1-3, 2001
  - Based on test data more current than AP-42
  - PM25-PRI assumed to be same as

Emission Factors for Woodstoves & Fireplaces With Inserts (lbs pollutant/ton of dry wood)

- Criteria Pollutants: AP-42, Chapter 1.10, Table 1.10-1
  - PM10-PRI, PM25-PRI, & CO EFs are average for all woodstoves
  - PM25-PRI assumed to be same as PM10-PRI
- HAPs: AP-42, Chapter 1.10, Tables 1.10-2, -3, & -4
  - AP-42 EFs for Polycyclic Aromatic Hydrocarbons (PAH) reduced by 62% based on recent test data (Houck, et al, 2001)
- Conversion Factor: One cord of wood equals 1.163 tons

Activity Data

- Develop separate national wood consumption estimates for fireplaces with inserts, fireplaces without inserts, & woodstoves to account for:
  - Different emission factors
  - Different usage patterns (climate zones; urban vs. rural)
- National wood consumption estimated using:
  - Number of combustion units
  - Average wood consumption rates
- Spatial allocation of wood consumption to county level performed to reflect usage patterns

Estimating Emissions from Fireplaces Without Inserts

- Step 1: Determine national number homes with usable fireplaces (with and without inserts)
  - Reference: Table 2-25 of 2001 American Housing Survey (AHS) for the United States (U.S. Census Bureau)
- Step 2: Adjust to account for homes with more than one fireplace (multiply Step 1 by 1.17)
  - Reference: 1989 U.S. Consumer Product Safety Commission report

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 3: Adjust for fireplaces that burn wood (74% wood, 26% gas)
  - References: Industry trade associations/experts, market surveys (Houck, et al, 2001)
- Step 4: Subtract out fireplaces not being used (42% not used)
  - References: Local surveys, industry market surveys, government publications (Houck, et al, 2001)

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 5: Determine number of homes with usable fireplaces with inserts used for heating
  - Used to determine the number of homes with usable fireplaces without inserts
  - Reference: Table 2-4 of 2001 AHS
- Step 6: Adjust to account for homes with more than one fireplace (multiply Step 5 by 1.10)
  - Reference: 1989 U.S. Consumer Product Safety Commission report

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 7: Determine number of fireplaces without inserts used for heating and aesthetic purposes
- The amount of wood burned in each device is determined by assuming wood consumption rates
  - 0.656 cords burned /unit/year for fireplaces used for heating
  - 0.069 cords/unit/year for fireplaces used for aesthetics

Estimating Emissions from Fireplaces Without Inserts (cont.)

- In 1997, EPA estimated that 2.94 million cords of wood were burned in the former and 0.483 million cords of wood were burned in the latter

Spatial Allocation of National Residential Wood Consumption to Counties

- National activity is allocated to counties using:
  - Climate zone (i.e., temperature)
  - Demographics/population (i.e., number of single-family homes)
  - Usage patterns for each device (i.e., urban versus rural)

Spatial Allocation of National Residential Wood Consumption to Counties (cont.)

Climate Zone Consumed	Percent of Wood
1 (>7000 HDD)	36
2 (5500-7000 HDD)	19
3 (4000-5499 HDD)	21
4 (<4000 HDD and <2000 CDD)	15
5 (<4000 HDD and >2000 CDD)	9

Spatial Allocation of National Residential Wood Consumption to Counties (cont.)

- Urban/Rural Apportionment
  - Designate each county as either urban or rural, sum activity for climate zone, and adjust county activity so climate zone total matches the following proportions :

	Rural	Urban
Woodstoves	65%	35%
Fireplaces with inserts	43%	57%
Fireplaces without inserts	27%	73%

Estimating Emissions from Fireplaces With Inserts and Woodstoves

- Determine the number of woodstoves and fireplaces with inserts
  - Data obtained from the Department of Census
- Adjust for homes with more than one stove
- Obtain total cords of wood consumed by residential section
  - Energy Information Administration (EIA)
- Adjust for use – heating or aesthetics

Estimating Emissions from Fireplaces With Inserts and Woodstoves (cont.)

- Allocate to climate zones
- Allocate to individual counties
- Sum wood consumption and compare to urban/rural split

Estimating Emissions from Fireplaces With Inserts and Woodstoves (cont.)

- Wood consumption for woodstoves and fireplaces with inserts were apportioned as follows:

Type of Device	Percent of Total Wood Consumption
Non-certified	92
Certified non-catalytic	5.7
Certified catalytic	2.3

Temporal Allocation of Residential Wood Consumption Emissions

- Default temporal allocation profiles by climate zone
  - S/L/T agencies should adjust allocations to better fit seasonal usage patterns
- Seasonal throughput percentages assigned to each climate zone are:

Climate Zone	Winter	Spring	Summer	Fall
5	100	0	0	0
4	70	15	0	15
3	50	25	0	25
2	40	30	0	30
1	33.33	33.33	0	33.33

How Can You Improve the NEI for Your Area?

- Preferred Method: Residential Wood Survey
  - Obtain locally representative information on the amount of wood fuel use specifically for woodstoves & fireplaces (with and without inserts)
  - This will require a local survey, or activity data generated by State & local governments
  - Reduces uncertainties in estimates associated with allocating national activity to counties
- Alternative Method: Census Bureau and EIA Data Method
  - Use if resources are limited or emphasis is on preparing summer season inventory

How Can You Improve the NEI for Your Area? (cont.)

- Rule Effectiveness/Rule Penetration
  - Incorporate effects of S/L/T rules and level of compliance
  - NEI methodology does not account for S/L/T rules

Comparison of MANE-VU Approach to NEI Method

- MANU-VU EI is a bottom-up methodology
- NEI is a top-down methodology
- MANE-VU EI provides for:
  - Better estimates by geographic area (rural, suburban, urban) and census tract (sub-county) level
  - Accounts for differences in housing type (single- and multi-family homes)
  - Better estimates of usage patterns based on HDDs
  - Includes outdoor equipment not included in NEI estimates
  - Provides temporal data

Residential Wood Combustion Case Study - Overview

- Case Study: County level emissions inventory for residential wood combustion
  - See Case Study Number 9-1

Residential Wood Combustion Case Study - Solution

- Case Study: County level emissions inventory for residential wood combustion
  - See Handout 9-1

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

Residential Open Burning NEI Methods for Residential MSW

- Activity Data (tons of waste burned)
- Step 1 - Estimate 2002 rural population by county
  - County-level rural population estimated by applying rural/urban percentages from 2000 Census data to 2002 population
- Step 2 - Multiply per capita waste factor by rural population
  - Used national average per capita waste generation factor of 3.37 lbs/person/day (noncombustibles and yard waste subtracted out).

Residential Open Burning
NEI Methods for Residential MSW (cont.)

- Step 3- Estimate amount of waste burned
  - Assume 28% of total waste generated is burned
- Step 4 - Account for burning bans
  - For counties where urban population exceeds 80 percent of the total population, the amount of waste burned was assumed to be zero, therefore zero open burning assigned to these counties

Residential Open Burning
NEI Methods for Residential Yard Waste

- Activity Data (tons of waste burned)
- Step 1 - Estimate 2002 rural population by county
  - County-level rural population estimated by applying rural/urban percentages from 2000 Census data to 2002 population
- Step 2 - Multiply per capita waste factor by rural population
  - Used national average per capita yard waste generation factor of 0.54 lbs/person/day.

Residential Open Burning
NEI Methods for Residential Yard Waste (cont.)

- Step 3 - Estimate amount of leaf, brush and grass yard waste
  - Multiply total yard waste mass by 25% to estimate leaf waste, 25% for brush waste, and 50% for grass waste
- Step 4 - Estimate amount of waste burned
  - Assume 28% of total leaf and brush waste generated is burned; assume 0% of grass is burned

Residential Open Burning
NEI Methods for Residential Yard Waste (cont.)

- Step 5 - Adjust for variations in vegetation
  - Used the following ranges to make adjustments to the amount of yard waste generated per county:

Percent forested acres per county	Adjustment for yard waste generated
< 10%	Zero out
>=10%, and <50%	Multiply by 50%
>=50%	Assume 100%

Residential Open Burning
NEI Methods for Residential Yard Waste (cont.)

- Step 6 - Account for burning bans
  - For counties where urban population exceeds 80 percent of the total population, the amount of waste burned was assumed to be zero, therefore zero open burning assigned to these counties.

Residential Open Burning
NEI Methods for Residential MSW and Yard Waste

$$E = A * EF * (1 - CE * RP * RE)$$

where: E = Controlled Emissions, lbs pollutant per year
A = Activity, tons of MSW or leaves/brush burned per year
EF = Emission Factor, lbs per ton burned
CE = % Control Efficiency/100
RP = % Rule Penetration/100
RE = % Rule Effectiveness/100

- 100% CE assumed for counties where urban population exceeds 80% of the total population
- Assumed 100% RE and RP
- All other counties, assumed 0% CE, RE, and RP

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

- 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

Residential Open Burning Improvements to NEI Methods (cont.)

- Sources
  - Solid Waste Agency
  - Air Agency
  - Health Department
  - Solid Waste Management Organization
  - Local Survey

Residential Open Burning Improvements to NEI Methods (cont.)

- 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
- Rule penetration (RP) to reflect duration of seasonal bans relative to annual activity profile, exempt activities

Residential Open Burning MANE-VU Example

- Development of 2002 residential open burning inventory for MANE-VU States
- Multi-state RPO developed inventory following EIIP procedures

Residential Open Burning MANE-VU Example (cont.)

- Developed survey instrument to collect:
  - Number/percentage of households that burn waste
  - Burn frequency
  - Amount per burn
  - Seasonal Activity
- 3 separate surveys for:
  - Residential MSW
  - Brush
  - Leaf

Residential Open Burning MANE-VU Example (cont.)

- Survey results were used to estimate emissions for each survey jurisdiction
- For non-surveyed areas, default activity data derived from survey responses were applied

Residential Open Burning MANE-VU Example (cont.)

- To estimate the mass of waste burned for residential MSW and yard waste, the following equation was used:

$$Wt = HH * Bt * M$$

where: Wt = Mass of waste burned per time period
HH = Number of households that burn
Bt = Number of burns per time period
M = Mass of waste per burn

Residential Open Burning MANE-VU Example (cont.)

- Developed control database to establish area-specific control efficiency (CE), rule effectiveness (RE), and rule penetration (RP)
- Performed rule effectiveness (RE) survey to determine level of compliance with state or local open burning prohibitions
- To estimate default RE values, the survey data was statistically analyzed resulting in one value for all non-surveyed areas

Residential Open Burning MANE-VU Example (cont.)

- Emissions estimated for all criteria pollutants/precursors and several toxic air pollutants
- Emissions estimated at the census tract level (summed to county, State, region)
- Emissions temporally allocated to support modeling using profiles developed from the survey

Lessons Learned

- If leaf burning is significant, perform separate surveys in targeted areas for leaf waste and brush waste burning
- Perform MSW surveys separate from yard waste surveys, instead of combined to reduce survey length
- A larger sample may have allowed for greater geographic distinction

Lessons Learned (cont.)

- Sub-county emissions estimates serve as the basis for a more spatially refined inventory
- Regional survey provides greater consistency
- Better accounting of controls results in decreased emissions relative to NEI

Land Clearing Debris Burning What Sources are Included?

SCCs:

2610000500 - Land Clearing Debris Burning

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

Land Clearing Debris Burning NEI Method

- Activity Data
- Estimate the county-level total number of acres disturbed by residential, non-residential and roadway construction
  - Used number of acres disturbed from fugitive dust construction emissions activity calculations
- Apply loading factor to number of acres to estimate the amount of material or fuel subject to burning

Land Clearing Debris Burning NEI Method (cont.)

- Weighted, county-specific loading factors developed based on acres of hardwoods, softwoods, and grasses (BELD2 data base in BEIS)
- Multiplied average loading factors by percent contribution of each type of vegetation class to the total county land area

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Land Clearing Debris Burning NEI Method (cont.)

- Average loading factors for hardwood and softwood further adjusted by 1.5 to account for mass of tree below the surface

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

Land Clearing Debris Burning NEI Method (cont.)

- Fuel Loading Factor Equation

$$L_w = F_h * L_h + F_s * L_s + F_g * L_g$$

where: L_w = County-specific weighted loading factor
F_h = Fraction of county acres classified as hardwoods
L_h = Average loading factor for hardwoods
F_s = Fraction of county acres classified as softwoods
L_s = Average loading factor for softwoods
F_g = Fraction of county acres classified as grasses
L_g = Average loading factor for grasses

Land Clearing Debris Burning NEI Method (cont.)

- Emission Calculation

$$E = A * LF * EF$$

where: E = Emissions, lbs pollutant per year
A = No. of acres of land cleared per county (residential + commercial + road construction)
LF = County-specific loading factor, tons per acre
EF = Emission factor, lbs pollutant per ton

- Represents an upper-bound emissions estimate
- Assume all fuel loading on land cleared is burned; no controls or bans

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
- Develop improved estimate of the “average loading factor”

Land Clearing Debris Burning Improvements to NEI Method (cont.)

- Identify specific counties with burning bans, and specification of counties where wastes are burned
- State or local estimates of the percentage or amount of waste burned per construction event

Land Clearing Debris Burning Northern Virginia Example

- Performed RE survey to determine the level of compliance with rules for:
  - Land clearing debris burning
  - Residential waste burning
- Developed RE to apply to ozone season open burning emission estimates for the Virginia portion of the Washington DC-MD-VA Ozone Nonattainment Area

Land Clearing Debris Burning Northern Virginia Example (cont.)

- Reviewed conditions of existing open burning rules
  - Time period of ban
  - Exemptions and special provisions
- Surveyed local open burning officials responsible for tracking and enforcing open burning rules

Land Clearing Debris Burning Northern Virginia Example (cont.)

- Started with EPA questionnaire from RE guidance, modified for open burning
- Responses to questions are assigned specific point values that add up to a maximum of 100 points, considered equivalent to a RE percentage value

Land Clearing Debris Burning Northern Virginia Example (cont.)

- RE values analyzed by county and for 5-county region
  - Estimated regional RE of 93 percent
- If area comprised of counties and jurisdictions with significantly different population densities, analyze responses by urban and rural areas

Lessons Learned

- Local officials may defer to higher officials (e.g., county or state-level) for enforcing open burning rules
- RE may be high for time period that ban is in effect, but need to account for duration of ban (RP) if less than annual or seasonal
- It is important to account for when the ban is taking place

Agricultural Burning - Overview

- SCC 2801500000
- PM10-PRI and PM2.5-PRI
- Both condensibles and filterables

Agricultural Burning - General Method

- Activity
  - Acres of crop burned
- Loading Factor (tons of biomass or vegetation per acre burned)
- Emission Factor
  - Pounds $PM_{2.5}$ per ton of vegetation burned (crop-specific)

Wheat Stubble Burning Example

- 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

Wheat Stubble Burning Example (cont.)

- Emission Factors
  - PM10: 8.82 pounds per ton of wheat stubble burned
  - PM2.5: 8.34 pounds per ton of wheat stubble burned
- Resolution
  - Spatial – county
  - Temporal – monthly

Wheat Stubble Burning Example (cont.)

- Sample Calculation
  - PM2.5-PRI Emissions
    - = Acres Burned per month * Loading Factor * Emission Factor

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.)

- 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*

Agricultural Burning Case Study - Overview

- Case Study: County level emissions inventory for burning of wheat stubble
  - See Case Study Number 9-2

Agricultural Burning Case Study - Solution

- Case Study: County level emissions inventory for burning of wheat stubble
  - See Handout 9-2

Overview of Wildland Fire Inventory

- Wildland Burning
  - Types: Wildfires, Managed (Prescribed) Burns
  - Burners:
    - NPS, USFS, BLM, USFWS, State & Tribal Forests, Private burners
- Prescribed Burning
  - Habitat improvement
  - Managing undergrowth and understoring of the forest
  - Reducing risk of wildfires

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

- Pollutants
  - PM_{10}, $PM_{2.5}$, NO_x, CO, VOC, SO_2, 30 HAPS
- Emission Factors (AP-42)
- State-specific fuel consumed per acre burned
- 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 are the RPO's Doing?

- The Regional Planning Organizations (RPOs) are working on:
  - Treating most fires as point sources
  - Using fire-specific fuel consumption
  - Providing a much improved emission estimate

What are Future Plans for Improving the Approach to Estimating Fire Emissions?

- Future plans include the following:
  - Incorporate satellite observations
  - Improve locational data
  - Improve fuel characterization
  - Use actual fire weather conditions that effect emissions

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 Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions? (cont.)

- Fire Events Database Development
- Federal MOU
  - 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 Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions? (cont.)

- 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 Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions? (cont.)

- 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
    - 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)

Wildland Fire Emissions Module (under development) (cont.)

- Outputs: Gridded hourly emissions, plume characteristics
- Integrate, Test & Release Module (late 2004)