Comparison of Non-road Hazardous Air Pollutant Emissions Included in the National Emission Inventory

Roger Chang, Richard Billings, and Heather Perez
ERG
1600 Perimeter Park Drive
Morrisville, NC 27560

Laurel Driver
U.S. Environmental Protection Agency
Emission Factor Inventory Group
Research Triangle Park, NC 27560

Carl Scarbro and Richard Cook
U.S. Environmental Protection Agency
Office of Transportation and Air Quality
Ann Arbor, MI 48105

Background

- The NEI is a comprehensive inventory covering all criteria and hazardous air pollutants for all areas of the United States. The inventory was developed to support the Clean Air Act (CAA), which requires the EPA to identify emission sources of criteria and hazardous air pollutants, quantify emissions, develop regulations for the identified source categories, and assess the public health and environmental impacts after the regulations are put into effect. Uses of the NEI data include:
  - Criteria and HAP emission estimates developed for the NEI are incorporated into the annual EPA publication entitled *National Emissions Trends Report,* which is used to evaluate air pollution trends.
  - The NEI is also a critical component of the EPA's national Air Toxics Program (as described in EPA's July 19, 1999 Federal Register notice, 64 FR 38706). The initial objective of the Air Toxics Program is to make the data available for air quality modeling use in the National Air Toxics Assessment (NATA).

Background (continued)

- The mobile source component of the NEI is composed of on-road, aircraft, CMV, locomotive, and other non-road engines and equipment. Emission estimates were developed for each county in the U.S.

- The non-road mobile source category includes vehicles and equipment that normally are not operated on public roads nor provide transportation and are not considered aircraft, CMVs or locomotives. This includes categories such as lawn and garden equipment, agricultural equipment, logging equipment, construction equipment, airport service vehicles, locomotive maintenance vehicles, and recreational equipment (including recreational marine engines).

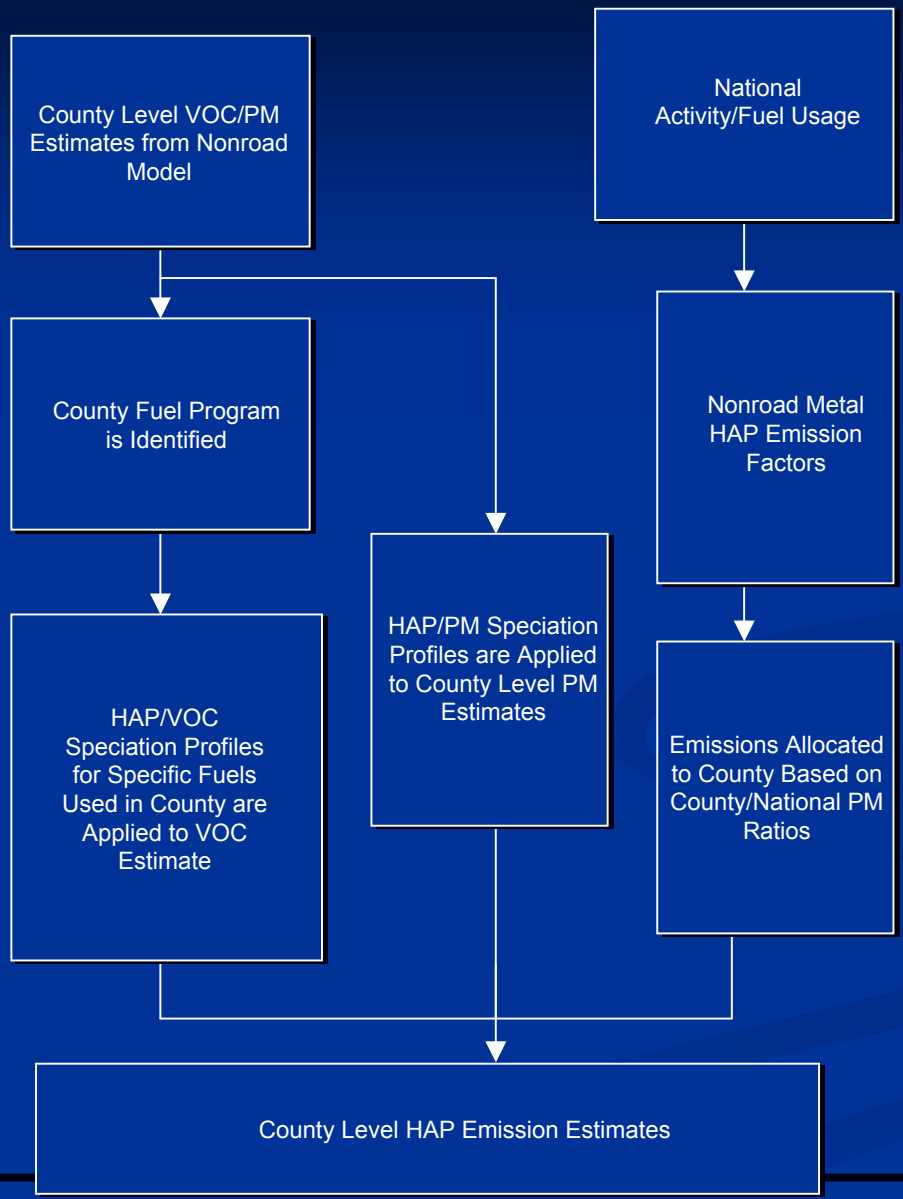
- The non-road vehicles and equipment include both diesel-powered and gasoline-powered engines. Gasoline-powered engines can further be characterized into two engine categories, specifically 2- and 4-stroke engines.

Non-road Hazardous Air Pollutants

- 1,3-Butadiene
- 2,2,4-Trimethylpentane
- Acetaldehyde
- Acrolein
- Arsenic
- Benzene
- Chromium (Hexivalent)
- Chromium (Trivalent)
- Dioxins/Furans
- Ethylbenzene
- Formaldehyde
- Lead
- Manganese
- Mercury
- Methyl Tert-Butyl Ether
- n-Hexane
- Nickel
- PAH
- Propionaldehyde
- Styrene
- Toluene
- Xylenes

ERG

Non-road Methodology



Fuel Considerations

It was assumed that the same fuels used for on-road vehicles were used in other non-road applications. These fuels included:

- Baseline gasoline, conventional lead-free fuel;
- Winter oxygenated gasoline with methyl tertiary butyl ether (MTBE) or tertiary amyl methyl ether (TAME);
- Winter oxygenated gasoline with ethanol;
- Reformulated fuels with MTBE or TAME;
- Reformulated fuels with ethanol;
- Baseline diesel; and
- California reformulated diesel.

ERG

Other Adjustments

- Different HAP/VOC speciation profiles for acetaldehyde, acrolein, formaldehyde, propionaldehyde, and 2, 2, 4-trimethylpentane were used to estimate non-road diesel emissions in California to account for the use of reformulated diesel fuel.
- Dioxin/furans and inorganic HAP emissions for all gasoline engines, regardless of type, were based on the same inorganic emission factors.
- A national estimate of other non-road lead emissions was obtained by multiplying the average lead content of mobile fuel with the amount of fuel used nationally in non-road applications.

Improvements to Previous Versions of NEI

- Developed 2,2,4-trimethylpentane estimates,
- Adjusted the PAH and aldehyde emission estimates to accounted for spillover usage of highway diesel fuel in non-road applications,
- Revised inorganic HAP calculations using activity or fuel consumption,

Improvements (Continued)

- Revised mercury and arsenic emission estimates based on half of the detection limit to more accurately represent expected emission levels,
- Chromium emissions were speciated into trivalent and hexivalent chromium, and
- Dioxin emissions estimates were developed.

Inclusion of State Data

- For the current version of the 1999 NEI only two states provided non-road HAP emission estimates.
  - California
  - Texas
- These state data files replaced the national estimates.

Top 10 States for Non-road HAP Emissions

State	Emissions (TPY)
CA	68,302.46
FL	54,707.30
TX	45,920.72
MI	41,188.90
NY	40,246.91
MN	28,125.03
OH	27,075.43
IL	24,766.03
PA	24,301.44
WI	23,712.81

Top 15 Non-road Hazardous Air Pollutants

Pollutant	Emissions (TPY)
Toluene	211,537.16
Xylene	196,310.20
2,2,4-Trimethylpentane	92,949.00
Benzene	67,178.76
Formaldehyde	43,784.13
Ethyl Benzene	43,340.54
Hexane	29,234.77
Methyl Tert-Butyl Ether	27,457.87
Acetaldehyde	18,242.72
1,3-Butadiene	8,621.96
Styrene	3,983.73
Propionaldehyde	3,976.42
Acrolein	1,989.35
Methanol	887.33
Naphthalene	659.94

Comparison of Rural Vs Urban Non-road Emissions

Pollutant	Rural Emissions (TPY)
Toluene	93,179.204
Xylenes	63,804.998
2,2,4-Trimethylpentane	42,884.146
Benzene	20,529.909
Ethyl Benzene	14,606.160
Formaldehyde	12,245.131
Hexane	10,069.139
Acetaldehyde	5,089.205
Methyl Tert-Butyl Ether	2,345.957
1,3-Butadiene	2,300.444
Propionaldehyde	1,148.137
Styrene	977.436
Acrolein	555.604
Methanol	177.353
Naphthalene	139.964
Chlorine	45.979
Methyl Ethyl Ketone	44.507
Phenanthrene	24.064
Fluorene	13.709
Cumene	13.022

Pollutant	Urban Emissions (TPY)
Xylenes	126,777.333
Toluene	112,455.342
2,2,4-Trimethylpentane	50,064.851
Benzene	44,376.047
Formaldehyde	30,332.876
Ethyl Benzene	27,330.040
Methyl Tert-Butyl Ether	25,111.911
Hexane	17,869.317
Acetaldehyde	12,558.070
1,3-Butadiene	6,119.609
Styrene	2,941.842
Propionaldehyde	2,733.345
Acrolein	1,339.023
Methanol	709.972
Naphthalene	519.980
Methyl Ethyl Ketone	443.303
Chlorine	239.828
Cumene	55.335
Phenanthrene	49.654
Acenaphthylene	29.909

Comparison of HAP Emissions Between Non-road Categories

Emissions (TPY)	Source Category
260,740.73	Pleasure Craft
195,976.63	Lawn and Garden Equipment
145,470.08	Recreational Equipment
47,399.31	Commercial Equipment
40,011.26	Construction and Mining Equipment
23,387.38	Agricultural Equipment
14,702.29	Industrial Equipment
3,775.25	Logging Equipment
425.48	Airport Ground Support Equipment
367.16	Railroad Equipment
176.94	Underground Mining Equipment

Largest 2-Stroke Non-road HAP Emission Sources

SCC	Emissions (TPY)	SCC Description 3	SCC Description 6	SCC Description 8
2282005010	142,540.76	Pleasure Craft	Gasoline 2-Stroke	Outboard
2282005015	80,472.23	Pleasure Craft	Gasoline 2-Stroke	Personal Water Craft
2260001020	66,670.94	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Snowmobiles
2260001010	39,378.84	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Motorcycles: Off-road
2260004021	22,579.99	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Chain Saws < 6 HP (Commercial)
2260004026	20,640.94	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Commercial)
2282005000	20,603.13	Pleasure Craft	Gasoline 2-Stroke	Total
2260004031	20,450.96	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Leafblowers/Vacuums (Commercial)
2260001030	16,884.75	Off-highway Vehicle Gasoline, 2-Stroke	Recreational Equipment	Offroad Motorcycles/ATVs
2260004025	10,048.19	Off-highway Vehicle Gasoline, 2-Stroke	Lawn and Garden Equipment	Trimmers/Edgers/Brush Cutters (Residential)

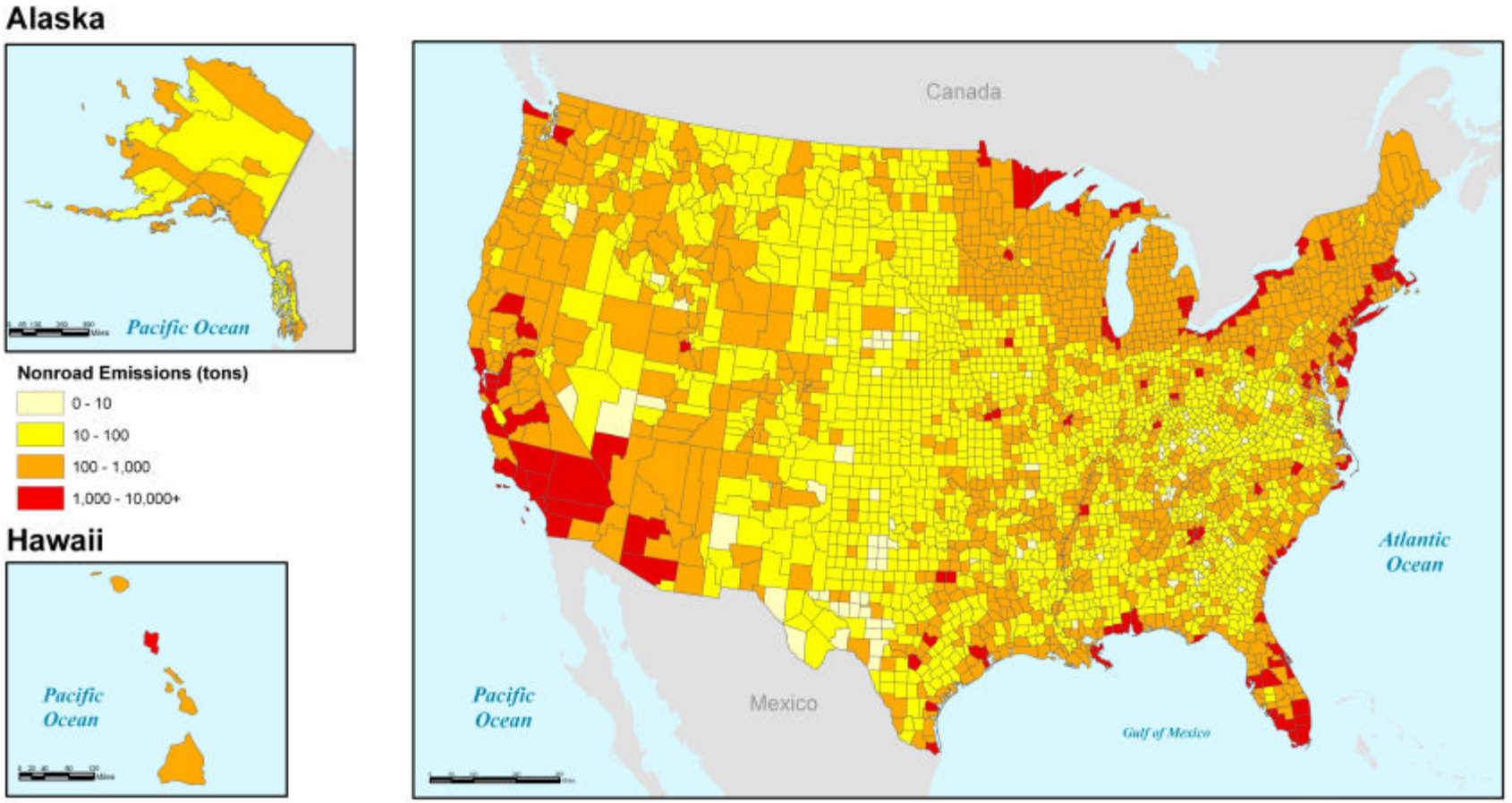
Largest 4-Stroke HAP Emission Sources

SCC	Emissions (TPY)	SCC Description 3	SCC Description 6	SCC Description 8
2265004071	18,218.11	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Turf Equipment (Commercial)
2265004010	15,147.11	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn Mowers (Residential)
2265004055	14,052.29	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn and Garden Tractors (Residential)
2265006005	13,280.16	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Generator Sets
2265004000	9,554.97	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	All
2282010005	8,919.11	Pleasure Craft	Gasoline 4-Stroke	Inboard/Sterndrive
2265004011	8,310.53	Off-highway Vehicle Gasoline, 4-Stroke	Lawn and Garden Equipment	Lawn Mowers (Commercial)
2282010000	7,909.13	Pleasure Craft	Gasoline 4-Stroke	Total
2265006030	7,461.20	Off-highway Vehicle Gasoline, 4-Stroke	Commercial Equipment	Pressure Washers
2265001030	5,304.72	Off-highway Vehicle Gasoline, 4-Stroke	Recreational Equipment	Offroad Motorcycles/ATVs

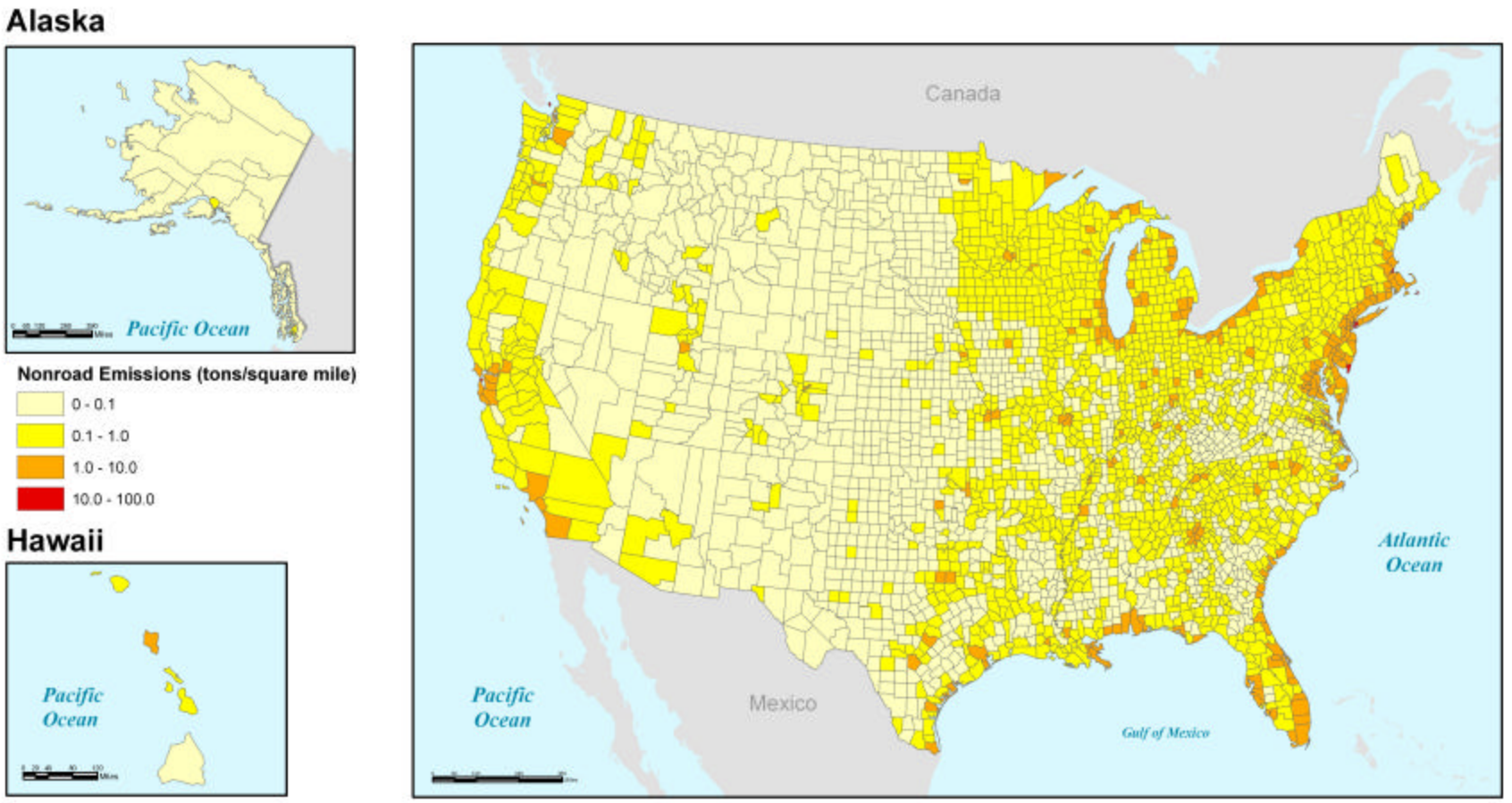
Largest Non-road Diesel Emission Sources

SCC	Emissions (TPY)	SCC Description 3	SCC Description 6	SCC Description 8
2270005015	14,213.72	Off-highway Vehicle Diesel	Agricultural Equipment	Agricultural Tractors
2270002000	6,317.43	Off-highway Vehicle Diesel	Construction and Mining Equipment	Total
2270005000	4,008.83	Off-highway Vehicle Diesel	Agricultural Equipment	Total
2270002066	3,454.93	Off-highway Vehicle Diesel	Construction and Mining Equipment	Tractors/Loaders/Backhoes
2270002072	2,770.45	Off-highway Vehicle Diesel	Construction and Mining Equipment	Skid Steer Loaders
2270002069	2,541.82	Off-highway Vehicle Diesel	Construction and Mining Equipment	Crawler Tractor/Dozers
2270002060	2,309.53	Off-highway Vehicle Diesel	Construction and Mining Equipment	Rubber Tire Loaders
2270002051	1,693.14	Off-highway Vehicle Diesel	Construction and Mining Equipment	Off-highway Trucks
2270002036	1,633.78	Off-highway Vehicle Diesel	Construction and Mining Equipment	Excavators
2270003060	1,335.27	Off-highway Vehicle Diesel	Industrial Equipment	AC\Refrigeration

Non-road HAP Emission Density Clusters



HAP Emissions Normalized to County Area



Conclusions

- Organic HAPs represented 99.8 % of total non-road HAP emissions compared with 0.12 % for PAHs, and 0.04 % for inorganics/metals.

- Recreational vessels and equipment, and lawn and garden equipment account for over 80 percent of non-road HAP emissions. The dominant source of recreational and gardening non-road emissions are 2-stroke equipment.

- Urban emissions are consistently higher than the rural emissions, this is most apparent for counties in the Southeast, Southwest and Northeast.

Conclusions (Continued)

- Improvements can still be made to the non-road emission estimates, particularly in incorporating more representative emission factors and speciation profiles.

- The inclusion of more state and local agency data into the NEI's other non-road component should also lead to more accurate emission estimates.

  Resources can be better focused on specific counties or non-road source categories that have local importance providing better accuracy.

ERG

Reference

U.S. EPA/EFIG, *Documentation for Aircraft, Commercial Marine Vessel, Locomotive, and Other Non-road Components of the National Emission Inventory,* Research Triangle Park, NC, November 2002.

ftp://ftp.epa.gov/EmisInventory/finalnei99ver2/criteria/documentation/nonroad/nonroad_voli_nov2002.pdf