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

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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).
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
Non-road Methodology

County Level VOC/PM Estimates from Nonroad Model

County Fuel Program is Identified

HAP/VOC Speciation Profiles for Specific Fuels Used in County are Applied to VOC Estimate

HAP/PM Speciation Profiles are Applied to County Level PM Estimates

National Activity/Fuel Usage

Nonroad Metal HAP Emission Factors

Emissions Allocated to County Based on County/National PM Ratios

County Level HAP Emission Estimates
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.
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,
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

<table>
<thead>
<tr>
<th>State</th>
<th>Emissions (TPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>68,302.46</td>
</tr>
<tr>
<td>FL</td>
<td>54,707.30</td>
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<tr>
<td>TX</td>
<td>45,920.72</td>
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<tr>
<td>MI</td>
<td>41,188.90</td>
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<tr>
<td>NY</td>
<td>40,246.91</td>
</tr>
<tr>
<td>MN</td>
<td>28,125.03</td>
</tr>
<tr>
<td>OH</td>
<td>27,075.43</td>
</tr>
<tr>
<td>IL</td>
<td>24,766.03</td>
</tr>
<tr>
<td>PA</td>
<td>24,301.44</td>
</tr>
<tr>
<td>WI</td>
<td>23,712.81</td>
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## Top 15 Non-road Hazardous Air Pollutants

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emissions (TPY)</th>
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<tbody>
<tr>
<td>Toluene</td>
<td>211,537.16</td>
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<tr>
<td>Xylene</td>
<td>196,310.20</td>
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<tr>
<td>2,2,4-Trimethylpentane</td>
<td>92,949.00</td>
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<tr>
<td>Benzene</td>
<td>67,178.76</td>
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<tr>
<td>Formaldehyde</td>
<td>43,784.13</td>
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<tr>
<td>Ethyl Benzene</td>
<td>43,340.54</td>
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<tr>
<td>Hexane</td>
<td>29,234.77</td>
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<tr>
<td>Methyl Tert-Butyl Ether</td>
<td>27,457.87</td>
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<tr>
<td>Acetaldehyde</td>
<td>18,242.72</td>
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<tr>
<td>1,3-Butadiene</td>
<td>8,621.96</td>
</tr>
<tr>
<td>Styrene</td>
<td>3,983.73</td>
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<tr>
<td>Propionaldehyde</td>
<td>3,976.42</td>
</tr>
<tr>
<td>Acrolein</td>
<td>1,989.35</td>
</tr>
<tr>
<td>Methanol</td>
<td>887.33</td>
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<tr>
<td>Naphthalene</td>
<td>659.94</td>
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## Comparison of Rural Vs Urban Non-road Emissions

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Rural Emissions (TPY)</th>
<th>Pollutant</th>
<th>Urban Emissions (TPY)</th>
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<tbody>
<tr>
<td>Toluene</td>
<td>93,179.204</td>
<td>Xylenes</td>
<td>126,777.333</td>
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<tr>
<td>Xylenes</td>
<td>63,804.998</td>
<td>Toluene</td>
<td>112,455.342</td>
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<tr>
<td>2,2,4-Trimethylpentane</td>
<td>42,884.146</td>
<td>2,2,4-Trimethylpentane</td>
<td>50,064.851</td>
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<tr>
<td>Benzene</td>
<td>20,529.909</td>
<td>Benzene</td>
<td>44,376.047</td>
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<tr>
<td>Ethyl Benzene</td>
<td>14,606.160</td>
<td>Formaldehyde</td>
<td>30,332.876</td>
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<tr>
<td>Formaldehyde</td>
<td>12,245.131</td>
<td>Ethyl Benzene</td>
<td>27,330.040</td>
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<tr>
<td>Hexane</td>
<td>10,069.139</td>
<td>Methyl Tert-Butyl Ether</td>
<td>25,111.911</td>
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<tr>
<td>Acetaldehyde</td>
<td>5,089.205</td>
<td>Hexane</td>
<td>17,869.317</td>
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<tr>
<td>Methyl Tert-Butyl Ether</td>
<td>2,345.957</td>
<td>Acetaldehyde</td>
<td>12,558.070</td>
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<tr>
<td>1,3-Butadiene</td>
<td>2,300.444</td>
<td>1,3-Butadiene</td>
<td>6,119.609</td>
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<tr>
<td>Propionaldehyde</td>
<td>1,148.137</td>
<td>Styrene</td>
<td>2,941.842</td>
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<tr>
<td>Styrene</td>
<td>977.436</td>
<td>Propionaldehyde</td>
<td>2,733.345</td>
</tr>
<tr>
<td>Acrolein</td>
<td>555.604</td>
<td>Acrolein</td>
<td>1,339.023</td>
</tr>
<tr>
<td>Methanol</td>
<td>177.353</td>
<td>Methanol</td>
<td>709.972</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>139.964</td>
<td>Naphthalene</td>
<td>519.980</td>
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<tr>
<td>Chlorine</td>
<td>45.979</td>
<td>Methyl Ethyl Ketone</td>
<td>443.303</td>
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<tr>
<td>Methyl Ethyl Ketone</td>
<td>44.507</td>
<td>Chlorine</td>
<td>239.828</td>
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<tr>
<td>Phenanthrene</td>
<td>24.064</td>
<td>Cumene</td>
<td>55.335</td>
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<tr>
<td>Fluorene</td>
<td>13.709</td>
<td>Phenanthrene</td>
<td>49.654</td>
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<tr>
<td>Cumene</td>
<td>13.022</td>
<td>Acenaphthylene</td>
<td>29.909</td>
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### Comparison of HAP Emissions Between Non-road Categories

<table>
<thead>
<tr>
<th>Emissions (TPY)</th>
<th>Source Category</th>
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<tbody>
<tr>
<td>260,740.73</td>
<td>Pleasure Craft</td>
</tr>
<tr>
<td>195,976.63</td>
<td>Lawn and Garden Equipment</td>
</tr>
<tr>
<td>145,470.08</td>
<td>Recreational Equipment</td>
</tr>
<tr>
<td>47,399.31</td>
<td>Commercial Equipment</td>
</tr>
<tr>
<td>40,011.26</td>
<td>Construction and Mining Equipment</td>
</tr>
<tr>
<td>23,387.38</td>
<td>Agricultural Equipment</td>
</tr>
<tr>
<td>14,702.29</td>
<td>Industrial Equipment</td>
</tr>
<tr>
<td>3,775.25</td>
<td>Logging Equipment</td>
</tr>
<tr>
<td>425.48</td>
<td>Airport Ground Support Equipment</td>
</tr>
<tr>
<td>367.16</td>
<td>Railroad Equipment</td>
</tr>
<tr>
<td>176.94</td>
<td>Underground Mining Equipment</td>
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## Largest 2-Stroke Non-road HAP Emission Sources

<table>
<thead>
<tr>
<th>SCC</th>
<th>Emissions (TPY)</th>
<th>SCC Description 3</th>
<th>SCC Description 6</th>
<th>SCC Description 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2282005010</td>
<td>142,540.76</td>
<td>Pleasure Craft</td>
<td>Gasoline 2-Stroke</td>
<td>Outboard</td>
</tr>
<tr>
<td>2282005015</td>
<td>80,472.23</td>
<td>Pleasure Craft</td>
<td>Gasoline 2-Stroke</td>
<td>Personal Water Craft</td>
</tr>
<tr>
<td>2260001020</td>
<td>66,670.94</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Recreational Equipment</td>
<td>Snowmobiles</td>
</tr>
<tr>
<td>2260001010</td>
<td>39,378.84</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Recreational Equipment</td>
<td>Motorcycles: Off-road</td>
</tr>
<tr>
<td>2260004021</td>
<td>22,579.99</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Lawn and Garden Equipment</td>
<td>Chain Saws &lt; 6 HP (Commercial)</td>
</tr>
<tr>
<td>2260004026</td>
<td>20,640.94</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Lawn and Garden Equipment</td>
<td>Trimmers/Edgers/Brush Cutters (Commercial)</td>
</tr>
<tr>
<td>2282005000</td>
<td>20,603.13</td>
<td>Pleasure Craft</td>
<td>Gasoline 2-Stroke</td>
<td>Total</td>
</tr>
<tr>
<td>2260004031</td>
<td>20,450.96</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Lawn and Garden Equipment</td>
<td>Leafblowers/Vacuums (Commercial)</td>
</tr>
<tr>
<td>2260001030</td>
<td>16,884.75</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Recreational Equipment</td>
<td>Offroad Motorcycles/ATVs</td>
</tr>
<tr>
<td>2260004025</td>
<td>10,048.19</td>
<td>Off-highway Vehicle Gasoline, 2-Stroke</td>
<td>Lawn and Garden Equipment</td>
<td>Trimmers/Edgers/Brush Cutters (Residential)</td>
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</table>
# Largest 4-Stroke HAP Emission Sources

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

<table>
<thead>
<tr>
<th>SCC</th>
<th>Emissions (TPY)</th>
<th>SCC Description 3</th>
<th>SCC Description 6</th>
<th>SCC Description 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>2270005015</td>
<td>14,213.72</td>
<td>Off-highway Vehicle Diesel</td>
<td>Agricultural Equipment</td>
<td>Agricultural Tractors</td>
</tr>
<tr>
<td>2270002000</td>
<td>6,317.43</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Total</td>
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<tr>
<td>2270005000</td>
<td>4,008.83</td>
<td>Off-highway Vehicle Diesel</td>
<td>Agricultural Equipment</td>
<td>Total</td>
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<tr>
<td>2270002066</td>
<td>3,454.93</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Tractors/Loaders/Backhoes</td>
</tr>
<tr>
<td>2270002072</td>
<td>2,770.45</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Skid Steer Loaders</td>
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<tr>
<td>2270002069</td>
<td>2,541.82</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Crawler Tractor/Dozers</td>
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<tr>
<td>2270002060</td>
<td>2,309.53</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Rubber Tire Loaders</td>
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<tr>
<td>2270002051</td>
<td>1,693.14</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Off-highway Trucks</td>
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<tr>
<td>2270002036</td>
<td>1,633.78</td>
<td>Off-highway Vehicle Diesel</td>
<td>Construction and Mining Equipment</td>
<td>Excavators</td>
</tr>
<tr>
<td>2270003060</td>
<td>1,335.27</td>
<td>Off-highway Vehicle Diesel</td>
<td>Industrial Equipment</td>
<td>HVAC/Refrigeration</td>
</tr>
</tbody>
</table>
Non-road HAP Emission Density Clusters

Alaska

Hawaii
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.
Reference
