Modeling Non-Road Agricultural Tractor Emissions in Central Texas

2015 EPA Emissions Inventory Conference

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Presentation Overview

- Agricultural Equipment Overview
- Central Texas Overview
- Default EPA & Texas NONROAD Modeling Approaches
- CAPCOG Approach for Central Texas
- Population & Activity Data Updates
- Emissions Modeling Results and Comparisons
- Spatial Allocation for Photochemical Modeling
- Conclusion
Central Texas Overview - Geography
Central Texas Overview – Agricultural Production

- % of Farmland in Harvested Cropland
- % of Farms = Beef Cattle Establishments

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Default EPA NONROAD Modeling Approach

### National Base Year Equipment Population
- Diesel: 1,428,980 (2000)
- Gas: 2,617 (1998)

### Project to Target Year (2012)
- Diesel: 1,867,572
- Gas: 3,265

### Allocate to States Based on % of Harvested Cropland, 2002
- US: 302,697,252 Acres
- TX: 17,750,938 Acres (5.9%)

### Allocate to Counties Based on % of Harvested Cropland, 2002
- Williamson County: 217,331 Acres (1.2% of Texas)

### County-Level Equipment Population: Williamson County
- Diesel: 1,343 Tractors
- Gas: 2 Tractors
Default Texas NONROAD Modeling Approach

- Based on Statewide 2007 Survey
- Production-Based Equipment Ratios
  - Cotton: 0.003195 tractors/acre harvested
  - Hay: 0.010257 tractors/acre harvested
  - Wheat: 0.004091 tractors/acre harvested
  - Other: 0.005326 tractors/acre harvested
  - Beef: 0.003114 tractors/head of cattle
- Apply Ratios to County-Level Production Data to Get Equipment Populations
- Activity: Hrs Per Week Used * Weeks Per Yr Used
CAPCOG Approach for Central Texas

- **Equipment Populations**: Census of Agriculture
- **Fuel Type Distribution**: Regional Survey
- **Horsepower Distribution**: Census of Agriculture, Regional Equipment Sales Data, Regional Survey
- **Average Horsepower**: Census of Agriculture, Regional Equipment Sales Data, Regional Survey
- **Age Distribution**: Regional Survey & Census of Agriculture
- **Annual Activity**: Regional Survey by HP Grouping
- **Emissions Model**: Texas NONROAD (TexN) Model
- **Sub-County Spatial Allocation**: 2012 CROPSCAPE Data
Census of Agriculture

- Conducted Every 5 Years
- County-Level Data
- Machinery
  - Tractors
  - Combines
  - Forage Harvesters
  - Cotton Pickers/Stripppers
- Fuel Expenses
- Farms by NAICS Codes
- Farm and Ranch Irrigation Survey
2012 ERG Survey

• Sample Frame:
  – 1,508 farms
  – 27 Farm Management Companies
• Stakeholder Recruitment
• Survey Conducted August-September 2012
• 108 Farmers Surveyed (9.4% MOE)
• 312 Tractors Total Surveyed (5.5% MOE)
• Other Equipment Types Included
• Production Data
Population Data Updates – Tractor Counts

- NONROAD, 2012
- TexN, 2012
- Census of Agriculture, 2012

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Population Data Updates – Fuel Type Distributions

NONROAD, 2012

- Diesel: 99.8%
- Gasoline: 0.2%
- LPG: 0.0%
- CNG: 0.0%

Texas, 2007 (Pechan)

- Diesel: 90.5%
- Gasoline: 6.7%
- LPG: 2.6%
- CNG: 0.2%

Central Texas, 2012

- Diesel: 84.3%
- Gasoline: 13.3%
- LPG: 2.4%
- CNG: 0.0%
Population Data Updates – Horsepower Profile

- NONROAD Survey
  - 100+ HP: 46%
  - 40-99 HP: 34%
  - <40 HP: 20%

- Central Texas Census of Agriculture
  - 100+ HP: 34%
  - 40-99 HP: 51%
  - <40 HP: 15%

- Census of Agriculture
  - 100+ HP: 15%
  - 40-99 HP: 54%
  - <40 HP: 34%
### Agricultural Tractor Average Annual Activity (hours/year)

<table>
<thead>
<tr>
<th></th>
<th>NONROAD</th>
<th>TexN</th>
<th>2012 Central Texas Survey</th>
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</thead>
<tbody>
<tr>
<td>Gasoline Tractors</td>
<td>550</td>
<td>362</td>
<td></td>
</tr>
<tr>
<td>Diesel Tractors</td>
<td>1,086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40 HP</td>
<td>117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-99 HP</td>
<td>254</td>
<td></td>
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</tr>
<tr>
<td>100+ HP</td>
<td>351</td>
<td></td>
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</tbody>
</table>

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Activity Updates – Annual Activity

Regression Analysis of 2012 Central Texas Survey

Annual Activity = $\beta_0 + \beta_1 \times [\text{Row Crop}] + \beta_2 \times [\text{Age}] + \beta_3 \times [\text{HP}]$

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient (hrs/yr)</th>
<th>P-Value</th>
<th>Significant at 95% CL?</th>
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</thead>
<tbody>
<tr>
<td>Intercept ($\beta_0$)</td>
<td>191.52</td>
<td>0.114</td>
<td>No</td>
</tr>
<tr>
<td>Row Crop ($\beta_1$, 1=yes)</td>
<td>3.27</td>
<td>0.972</td>
<td>No</td>
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<tr>
<td>Age ($\beta_2$)</td>
<td>0.43</td>
<td>0.786</td>
<td>No</td>
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<tr>
<td>Horsepower ($\beta_3$)</td>
<td>1.49</td>
<td>0.007</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Activity Updates – Age Distribution

% of Tractors Manufactured 2008-2012

- NONROAD Default
- TexN Default
- Census of Agriculture

- <40 HP: 46%, 86%, 10%
- 40-99 HP: 38%, 58%, 15%
- 100+ HP: 31%, 48%, 13%
Activity Updates – Age Distribution

y = 0.0227x - 0.0277
R² = 0.9661
Comparison of Emissions Estimates - Region

2012 Ozone Season Weekday Emissions

Tons Per Day

<table>
<thead>
<tr>
<th></th>
<th>NOx</th>
<th>PM</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>NONROAD Default</td>
<td>3.30</td>
<td>0.28</td>
<td>0.17</td>
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<tr>
<td>TexN-Default</td>
<td>6.71</td>
<td>0.60</td>
<td>0.65</td>
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<tr>
<td>TexN-CAPCOG Update</td>
<td>6.72</td>
<td>1.12</td>
<td>1.62</td>
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</tbody>
</table>

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Comparison of Emissions Estimates - NO$_x$
Comparison of Emissions Estimates - PM

Tons Per Day

- NONROAD Default
- TexN-Default
- TexN-CAPCOG Update

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Comparison of Emissions Estimates - VOC

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Spatial Allocation
Conclusions

• Tractors are a significant source of emissions
• Significant regional variability
• Equipment populations much higher than NONROAD model estimates
• Activity levels vary by HP rating
• Distinctive (and older) age distributions
• Challenges & opportunities
Questions?
THANK YOU!

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