OREGON 2017 NON-ROAD DIESEL ENGINE INVENTORY STUDY FINDINGS

Presented by
Rick Baker
Eastern Research Group, Inc. (ERG)

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OVERVIEW

- Project Team
- Project Scope
- Data Collection Approach
- Emissions Modeling
- Key Findings
- Validation of Results
- Conclusions/Recommendations

PROJECT TEAM

- **Eastern Research Group**
  - **Lead Contractor**
- Good Company
  - Public fleet survey lead
- Oak Leaf Environmental
  - Logging sector survey lead, technical support for validation of study findings

PROJECT SCOPE

- Authorized by House Bill 5006 in 2017
- Study conducted September 2018 – April 2020

- Estimate non-road diesel equipment emissions for Oregon
  - Replace current EPA MOVES-Nonroad model defaults
    - Key inputs - # units, hp, hours/year, age distribution
  - Improve accuracy using bottom-up activity estimates
  - Provide updates for emission reporting requirements and air quality modeling
  - Provide basis for future year emission estimates

- Characterize equipment owners/operators
  - Identify targets for potential grant/subsidy programs (retrofit, repower/replacement)

PROJECT SCOPE

- Diesel non-road equipment > 25 hp operating in Oregon during 2017
  - 65 equipment types (e.g. tractors, backhoes, portable generators)
  - Excludes locomotives, commercial marine vessels, aircraft

- Characterize activity and emissions (criteria, GHGs, toxics)
  - 2017 calendar year
  - County-level
  - Temporal resolution – annual, typical summer weekday

DATA COLLECTION APPROACH

- 3-pronged approach tailored to operator/industry categories

- *Approach #1 - Public Fleet Surveys*
  - City, county, airports, marine ports, special districts, other agencies, schools/colleges/universities, municipal solid waste/material recovery
  - Known locations, easy to ID/contact
  - Attempt a full "census"

DATA COLLECTION APPROACH

- *Approach #2 - Random Sample Surveys*
  - Agriculture, logging, surface mining, crane/rigging companies
  - Numerous operators, difficult to generalize equipment use
  - Strong emphasis on data confidentiality
  - *Active trade association support was key to encouraging participation and ensuring validity of results for each category*

DATA COLLECTION APPROACH

- *Survey Details – Approaches 1 and 2*
  - Equipment type
  - Engine HP
  - Model year
  - Annual hours / temporal allocation
  - Location - challenging for some equipment
  - Fuel consumption – generally fleet-level

DATA COLLECTION APPROACH

- *Approach #3 - Industry-Specific Profiles*
  - Primarily construction sectors – highway/road, commercial buildings, single family homes, utility work
  - Also well drilling and agricultural support services
  - Detailed project information available (e.g. # single family housing permits issued by county in 2017)
  - Develop standardized project task lists and equipment productivity profiles
  - Combine with available project details to estimate total activity

DATA COLLECTION APPROACH

- *Approach #3 – Data Collection Process*
- Developed standardized task lists and equipment productivity estimates in consultation w/ AGC, other industry stakeholders
- Solicited subject matter expert input to account for
  - Oregon-specific practices and task frequencies
  - Equipment type preferences
  - Regional variations (e.g. blasting/crushing required for site prep in Central Oregon)

DATA COLLECTION APPROACH

- *Approach #3 – Data Collection Process Continued*
- Conservatively estimate equipment needs for each task element
- Link activity profiles with physical quantities such as
  - Bid-item quantities for highway projects – ODOT
  - New single-family housing units – Census Bureau permit records
  - Square feet of building installation – Dodge Analytics
  - Well drilling depths - OWRD
- Estimate hours of use by equipment type and hp for each project
- Combine with engine age distributions (based on a separate industry survey) to estimate emissions

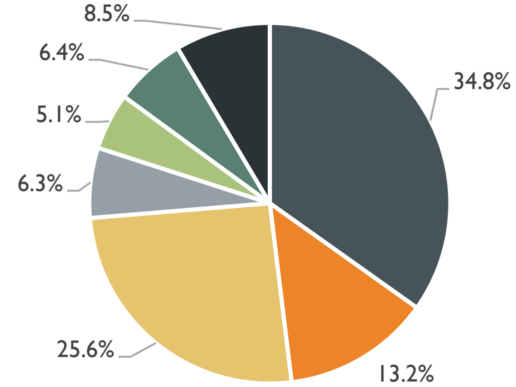
EMISSIONS MODELING

- Process survey and industry profile information (QA, gap-fill)
- Apply scaling factors and extrapolate activity to state level
- Allocate to county level by industry sector
- Adjust engine load factors where possible
- Run EPA MOVES-Nonroad model using updated hours of use, hp, and model year distributions
- Compare estimates from the current study with EPA MOVES model defaults

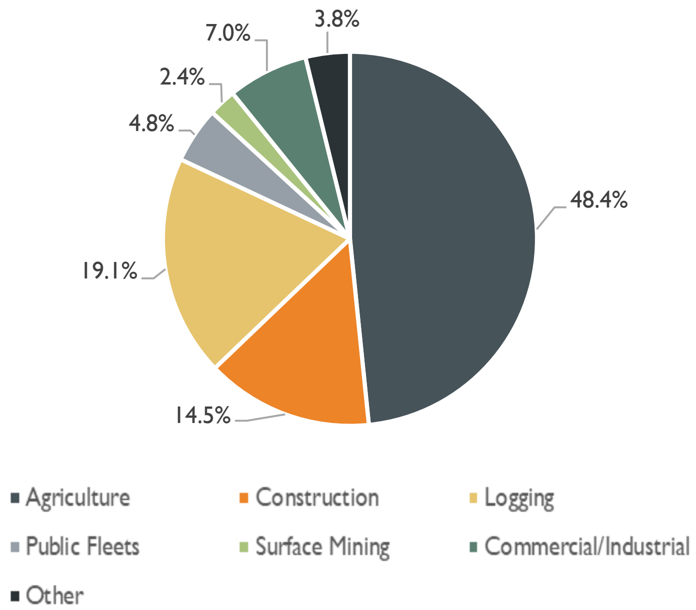
KEY FINDINGS

- Agriculture has the highest fuel consumption at the state level, followed by logging and construction
- Other sectors < 10% each
- Average agricultural tractor age (22 years) results in a relative increase in criteria pollutant emissions

2017 Statewide Annual Fuel Consumption by Sector



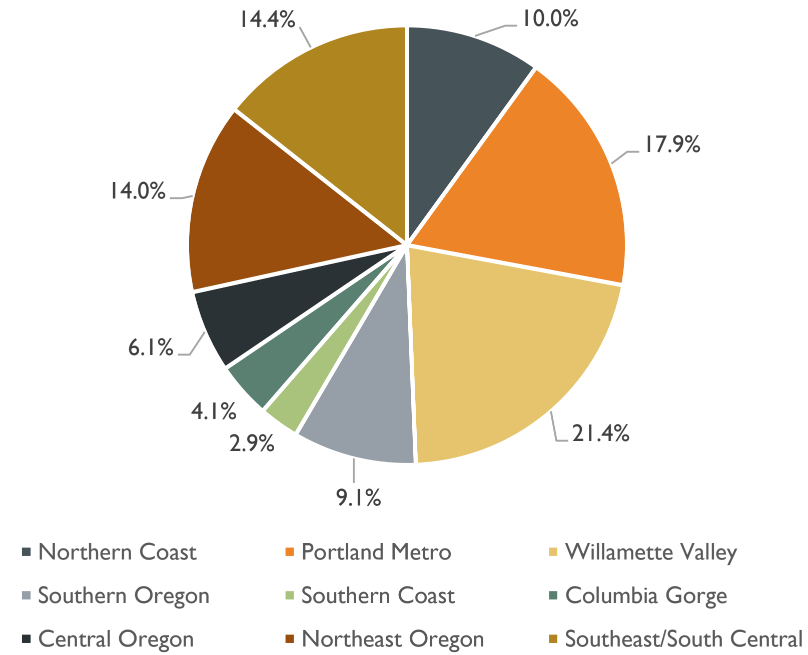
2017 Statewide Annual $PM_{2.5}$ Emissions by Sector



KEY FINDINGS

- Geographic regions contribute various amounts to statewide emission totals
  - Portland Metro and Willamette Valley regions have the highest contributions to $PM_{2.5}$ emissions, followed by Southeast/South Central and Northeast regions

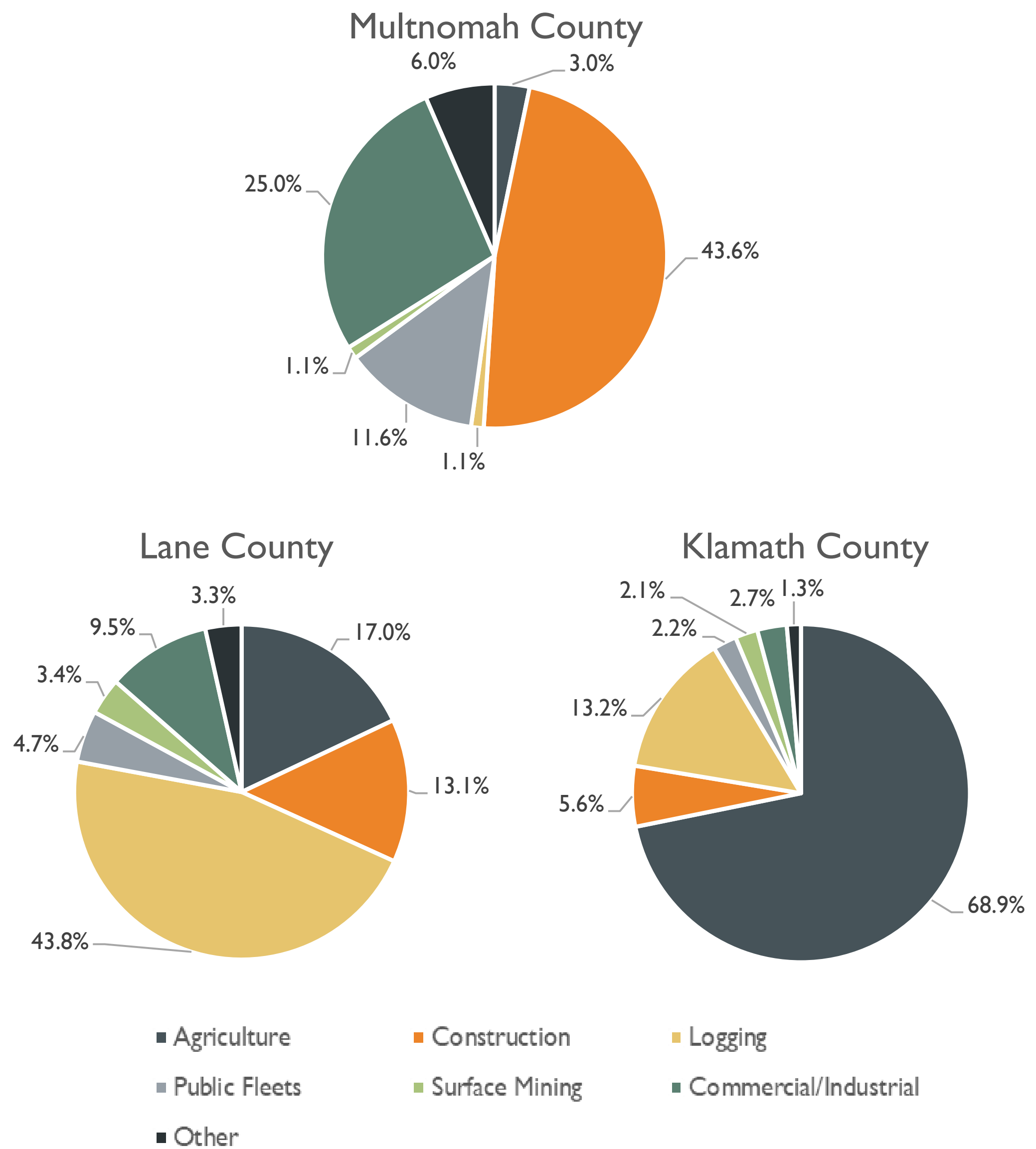
2017 Statewide Annual $PM_{2.5}$ Emissions by Region



KEY FINDINGS

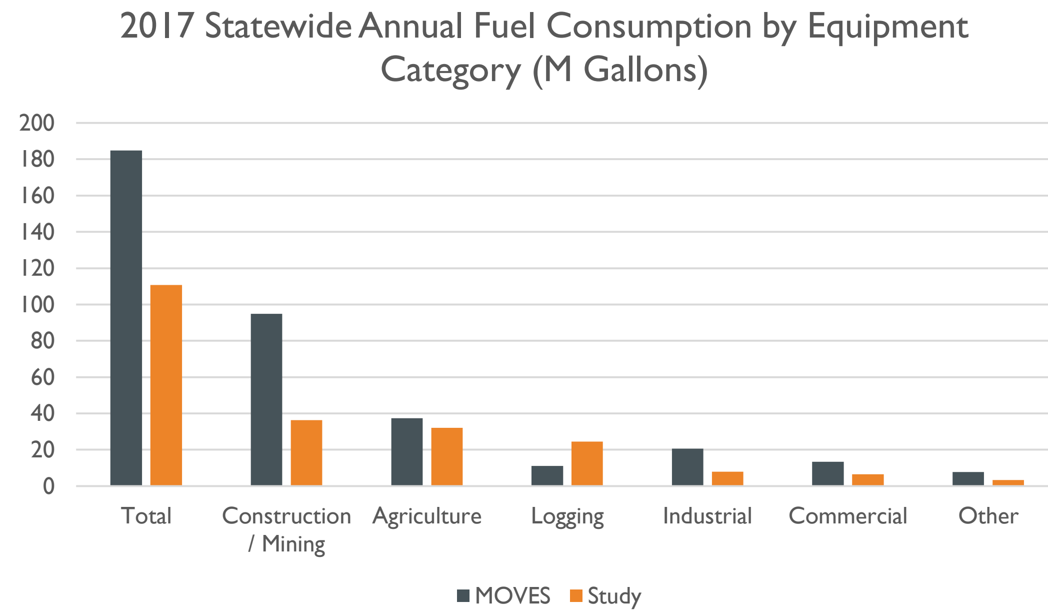
- The relative contributions to activity and emissions can vary substantially across counties
- Examples demonstrate prevalence of different industries
  - Multnomah – Construction
  - Lane – Logging
  - Klamath – Agriculture

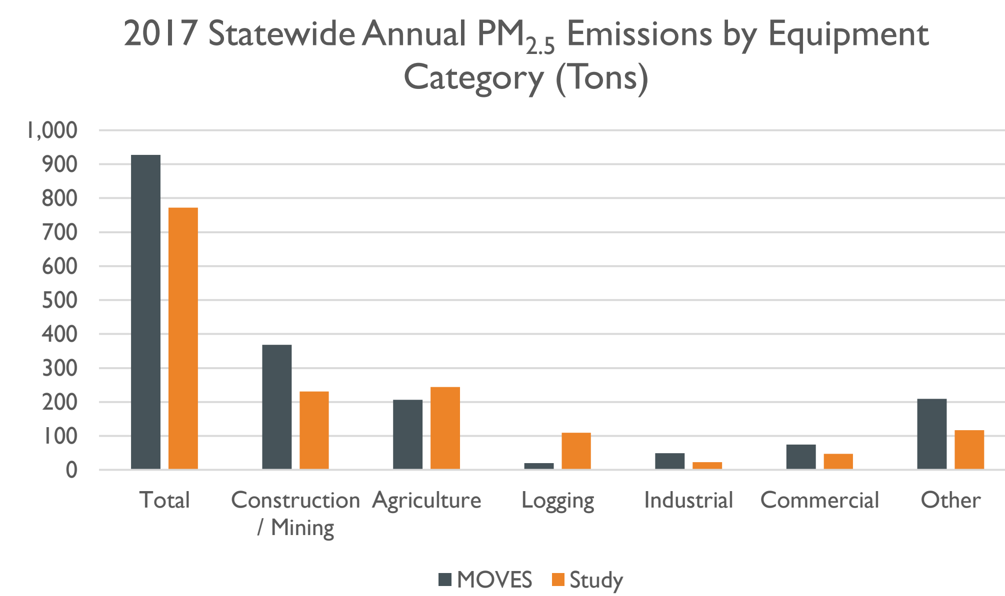
Annual $PM_{2.5}$ Emissions by Sector – Selected Counties



KEY FINDINGS

- Total statewide fuel consumption substantially lower than EPA defaults
- Total criteria pollutant emissions similar to EPA defaults
- Key differences across equipment categories
  - Construction/Mining
  - Logging
  - Industrial

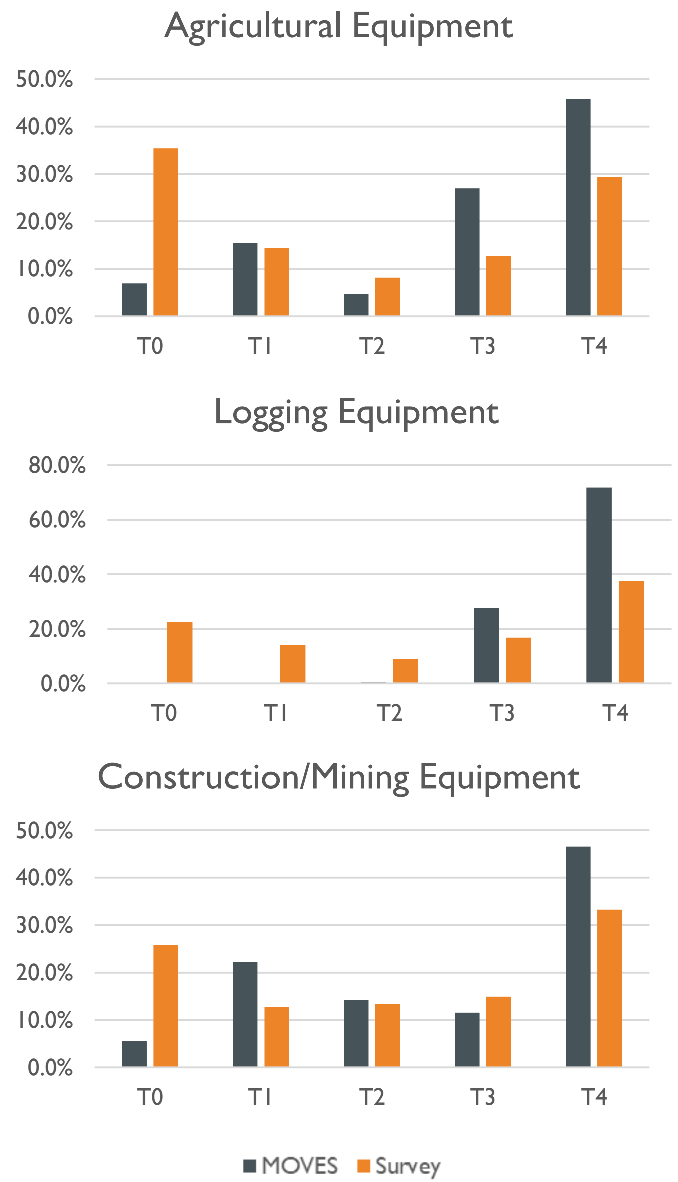




KEY FINDINGS

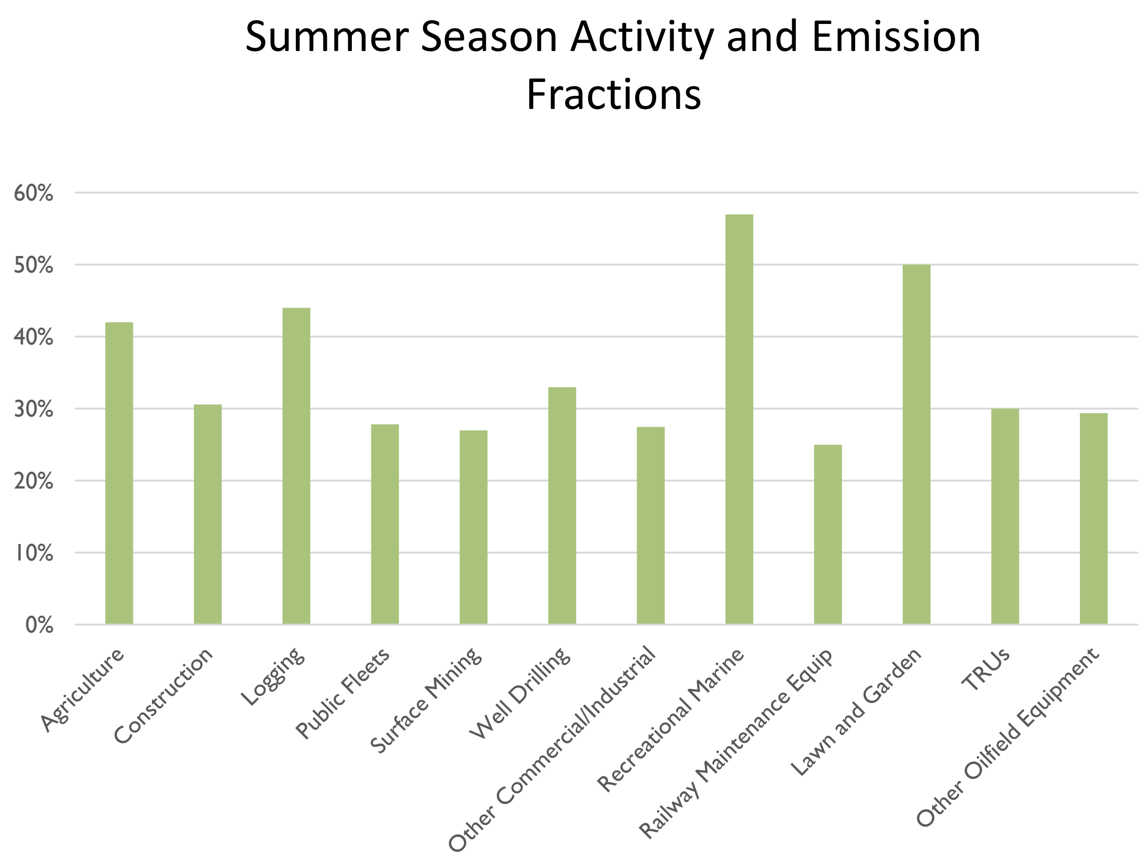
- Engine tier level distributions have a substantial impact on emissions
- Survey data shown for key sectors
- MOVES tends to overestimate fraction of Tier 4s, underestimate Tier 0s
- Differences vary by industry sector

2017 Engine Tier Level Distributions – Key Sectors



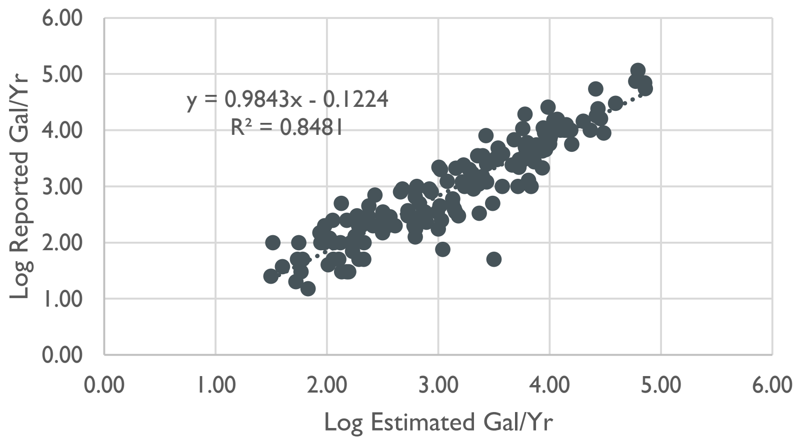
KEY FINDINGS

- Summer season fractions estimated by sector
- Most sectors have a third or more of their activity during summer
- Strongest summer peaks seen for agriculture, logging, boating and lawn & garden



VALIDATION

- Validation ensures study results are consistent & reasonable
- Two types of validation
- I. Internal consistency checks
  - e.g. compare reported vs calculated fuel consumption
  - Example from Agriculture survey

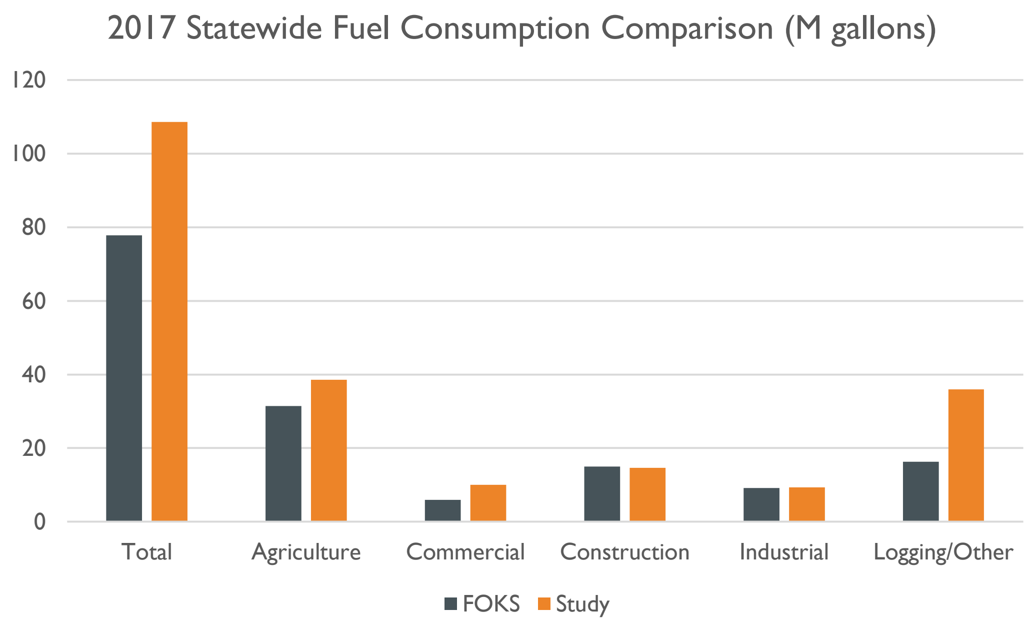


VALIDATION

- II. External consistency checks
  - Compare study's fuel consumption and activity estimates at the sector level with independent data sources
    - EIA Fuel Oil and Kerosene Sales Survey (FOKS)
    - Agricultural Census
    - Economic Census for Construction
    - Other sources – e.g. FAA data for airport activity, USCOE data for marine ports

VALIDATION

- Comparison with FOKS nonroad diesel fuel sales estimates



- Study estimates somewhat higher fuel consumption than FOKS
    - Primary difference in the Logging/Other sector

CONCLUSIONS

- The study provides a comprehensive assessment of nonroad diesel equipment activity and emissions for Oregon
- Oregon is just the third state to develop a bottom-up, state-wide profile for these equipment
- The findings represent a substantial improvement to the activity and emission estimates used by the State compared with EPA's MOVES-Nonroad model

CONCLUSIONS

- Key findings
  - MOVES generally over-estimates activity/GHGs
  - Total CAP emission estimates generally consistent with MOVES at the state level, but findings shed light on county and region level distributions
  - Agriculture sector dominates at the state level, followed by logging and construction
  - MOVES substantially underestimates logging activity and emissions
  - MOVES substantially overestimates construction activity and emissions, but sector is still notable in certain counties

CONCLUSIONS

- Remaining Uncertainties
  - Certain emission estimates were based on limited data
    - Large landfill operations
    - Surface mining fuel efficiency factors (tons produced/gallon)
  - Lacking Oregon-specific operation information for Transportation Refrigeration Units (~6% of total gallons)
  - Significant uncertainty for railway maintenance equipment activity and emissions (~0.5% of total gallons)
  - ***Future year activity and emissions projections are needed***
    - Determine which industries and regions are expect to grow rapidly, which equipment are turning over the fastest, etc.

SUPPLEMENTARY SLIDES

EMISSIONS MODELING PARAMETERS

- Fundamental emissions equation

$$\textit{Emissions}_p/yr = \sum(MYR)\sum(SCC)\sum(HP)\; Pop * Power * LF * A * EF_p$$

Where:

Pop = Number of engines

Power = Average hp (for specific hp group)

LF = Load factor (% of rated power)

A = Activity (hr/year)

EF_p = Emissions for pollutant p (grams/bhp-hr) – function of model year

∑(SCC) = summation over each equipment type

∑(HP) = summation over each equipment hp group

∑(MYR) = summation over each equipment model year