Developing Updated Nonroad Activity Inputs

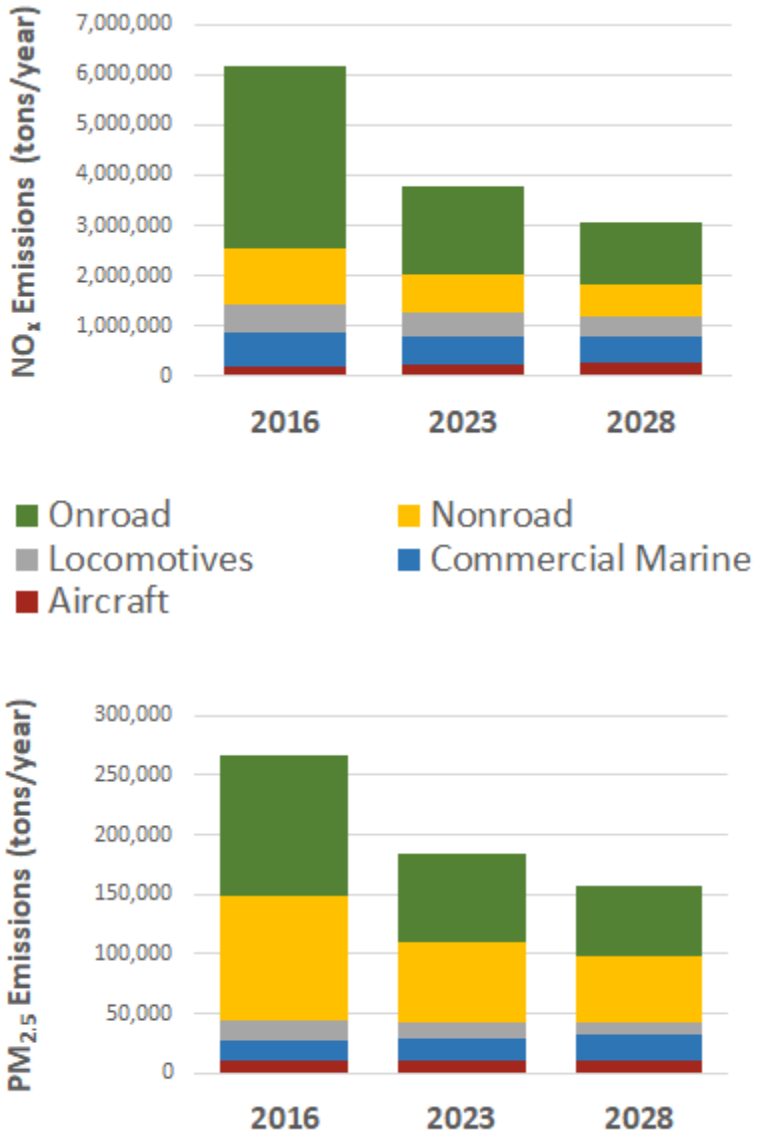
Sarah Roberts[1], Carl Fulper[1], James Warila[1], Jeremy Johnson[2], Reza Farzenah[2], Phil Lewis[2], Michael Sabisch[3], Sandeep Kishan[3]

[1] U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Ann Arbor, Michigan
[2] Texas A&M Transportation Institute, Bryan, Texas
[3] Eastern Research Group, Austin, Texas

MARAMA Mobile Sources Training Workshop
March 16-18, 2021

Mobile Nonroad Emissions

Source: 2016v1 Emissions Modeling Platform, http://views.cira.colostate.edu/wiki/wiki/10202 5



- Projected declines in overall mobile sector emissions are driven primarily by the penetration of cleaner onroad vehicles
- Emissions from nonroad sources will continue to comprise a significant share of the mobile sector emissions inventory

Nonroad Share of Total Mobile Emissions Inventory

	2016	2023	2028
NO_x	18%	20%	20%
VOC	36%	41%	45%
$PM_{2.5}$	39%	37%	35%
CO	34%	42%	49%

Nonroad Model Development

- Given the importance of the nonroad sector to the overall mobile emission inventory, EPA has embarked on a multi-year effort to update the Nonroad model
  - Released as a stand-alone model in 1998; incorporated into MOVES platform in 2014

Nonroad Equipment Sectors:

Construction	Underground Mining
Agricultural	Airport Support
Industrial	Oil Field
Commercial	Logging
Lawn & Garden	Pleasure Craft
Recreational	Railroad Support

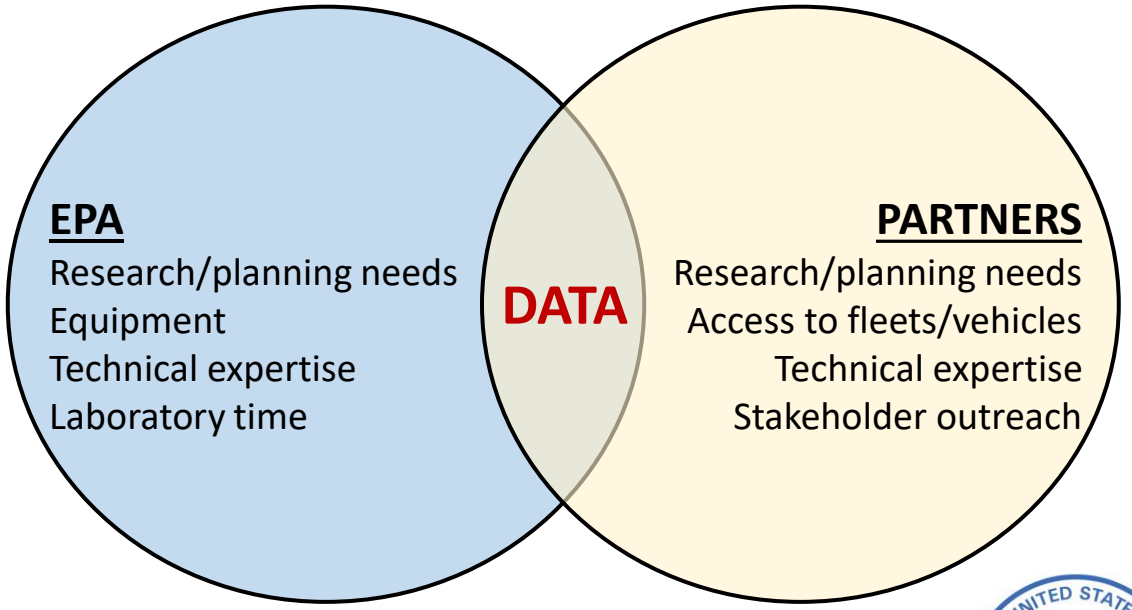
Nonroad Model Scope:

- Temporal coverage: 1990, 1999-2060
- Spatial coverage: county and national
- Over 80 distinct equipment types
- Over 1200 fuel + equipment type + horsepower combinations
- Emissions processes: exhaust, evaporative, refueling
- Over 200 pollutant + process combinations

- Much of Nonroad's source data – e.g., equipment populations, spatial and temporal allocations, annual activity rates, emission rates – date to the model's first public release
- As part of the model update effort, EPA is exploring new sources of activity data, such as telematics and auction house records

Data Partnerships

- Collecting real-world mobile source data requires substantial investment in equipment, data, computing, and staff
- Collaborating with state and local agencies, academic institutions, and private fleets allows EPA and its partners to leverage resources in order to meet respective research needs
- Partners work together to:
  - Develop data and testing procedures and protocols
  - Gather data
  - Develop new sampling methodologies
  - Test/develop measurement equipment
  - Enhance modeling efforts
- Results in a data "win-win"
- EPA's support mechanisms include **Cooperative Research and Development Agreements (CRADAs)**, Interagency Agreements, and contractor support



EPA-TTI CRADA: Construction Equipment Activity Data

- Collecting and analyzing real-world nonroad activity data is a focus of a CRADA between EPA and the Texas A&M Transportation Institute (TTI)
- Working with state DOTs and private fleets to access fleet information and telematics data for Construction equipment
  - Texas Department of Transportation
  - California Department of Transportation
  - Private construction firm operating primarily in Texas

Over 6,700 pieces of nonroad equipment

Wheel Loaders: 781

Graders: 622

Compactors/Rollers: 564

Skid Steer Loaders: 204

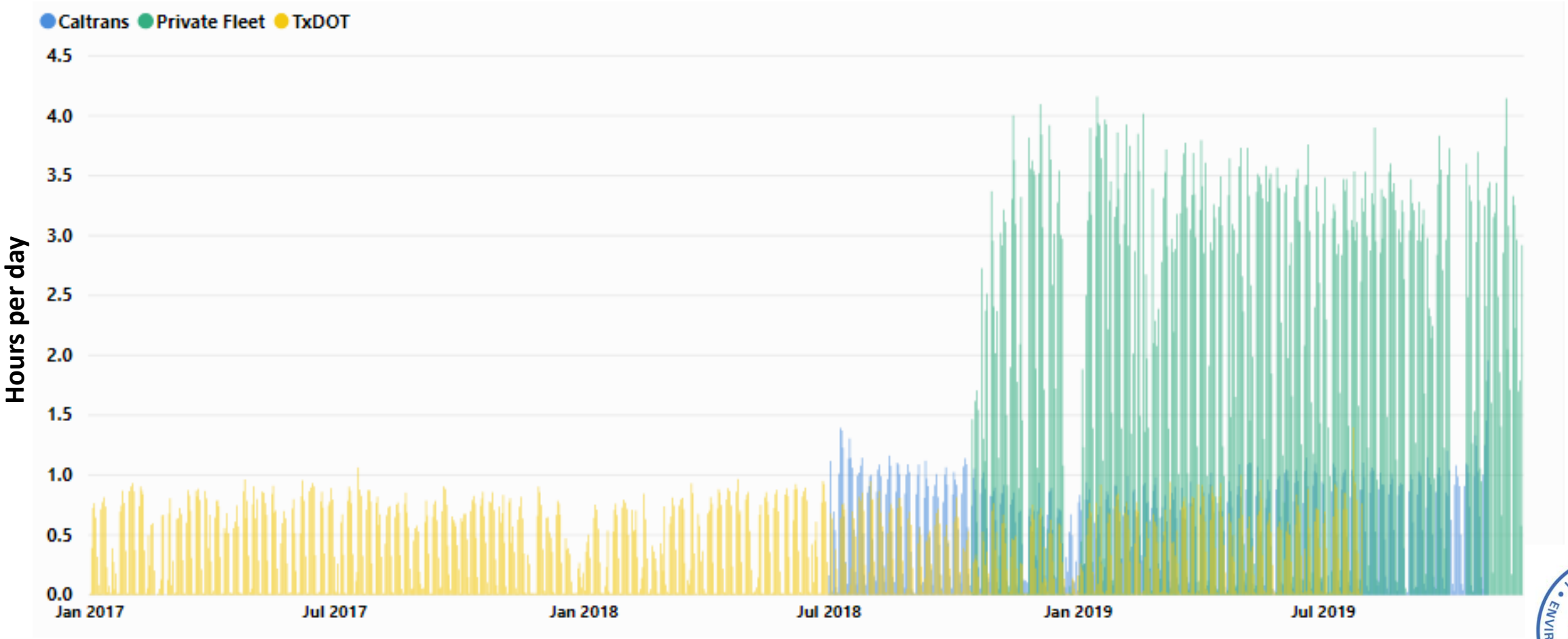
EPA-TTI CRADA: Construction Equipment Activity Data

- Data fields include:
  - **Equipment specifications:** make, model, model year, VIN, purchase date, description, fuel type, hour meter reading at delivery
  - **Engine specifications:** make, model, model year, serial number, horsepower (gross, net), displacement, engine family, engine tier
  - **Usage information:** reporting period start and end date/time; number of trips, hours of use, distance traveled, and hours idled over reporting period; odometer reading at end of reporting period, lifetime run hours, fuel purchases (date, fuel type, volume purchased)

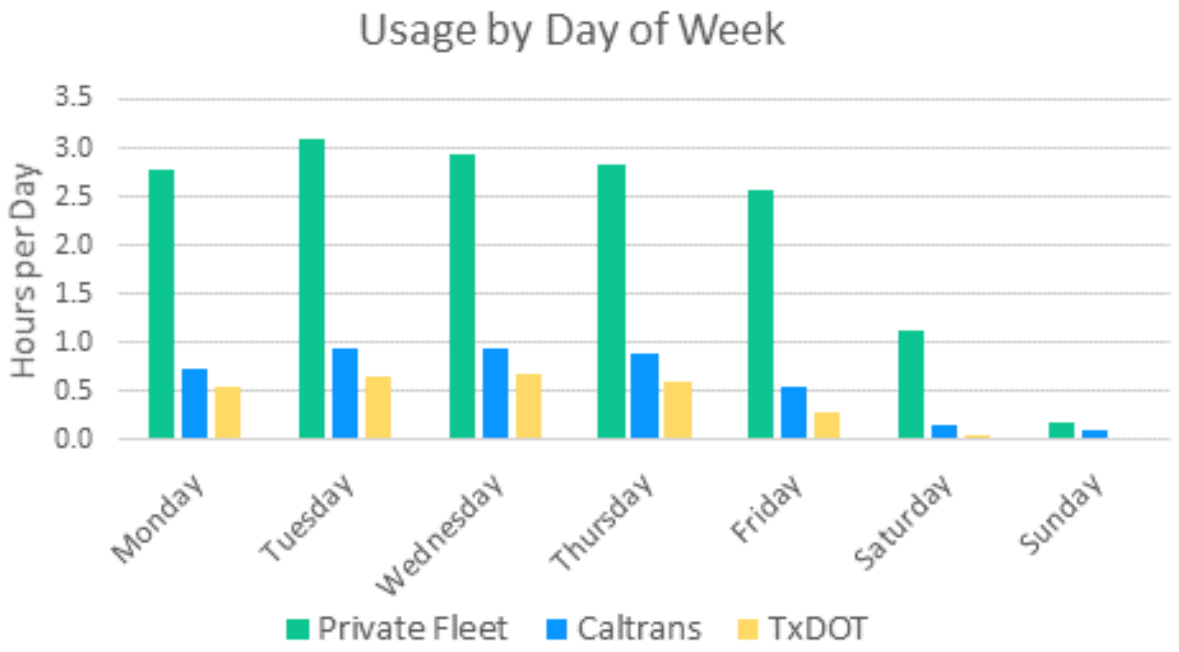
Data Provider	# of pieces	Data Coverage
Texas Department of Transportation	4574	Summary data for 2014-6/2018; quarterly data from 6/2018
California Department of Transportation	2072	Weekly data from 7/2017-10/2018; daily data from 10/2018
Private construction firm in Texas	144	Weekly data from 6/2016-10/2018; daily data from 10/2018

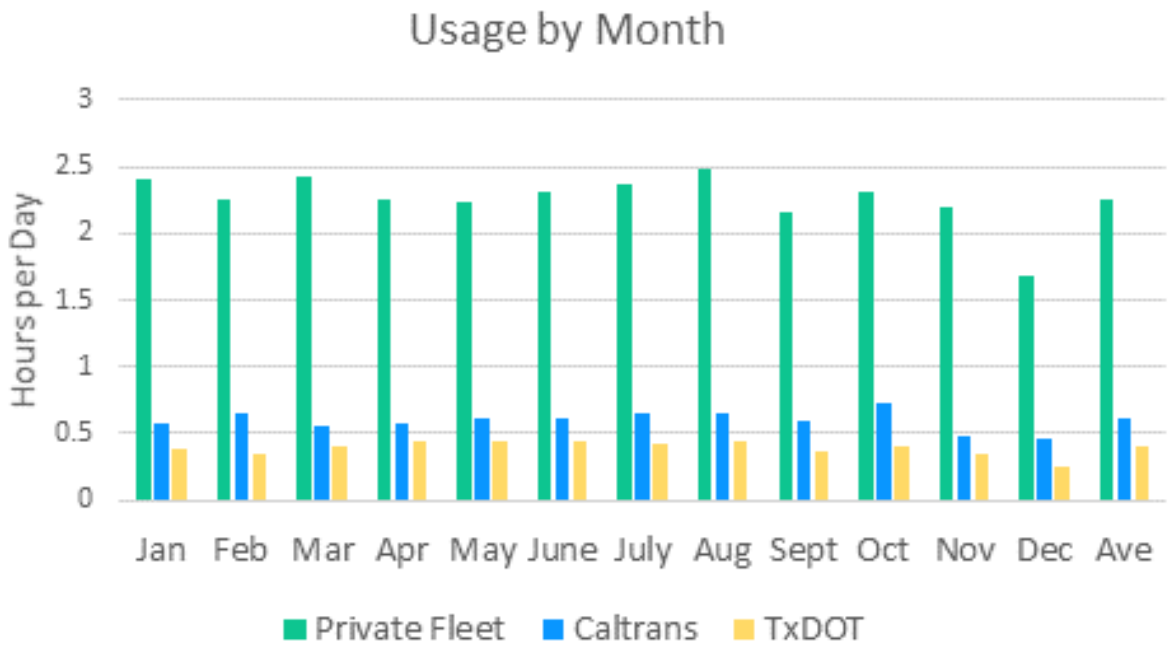
EPA-TTI CRADA: Example Construction Activity Data

- Average daily usage by fleet, all nonroad equipment



EPA-TTI CRADA: Example Construction Activity Data





Estimating Activity from Auction House Records

- EPA is analyzing auction house records to gain new insights into equipment usage
  - Provides hour-meter readings at time of sale
  - Data supplemented with power ratings, to enable analysis by engine size

- Gives life-time average at age of reading

$$\text{Activity} = \frac{\text{hour-meter}}{CY_{sale} - MY} = \frac{\text{hours}}{\text{year}}$$

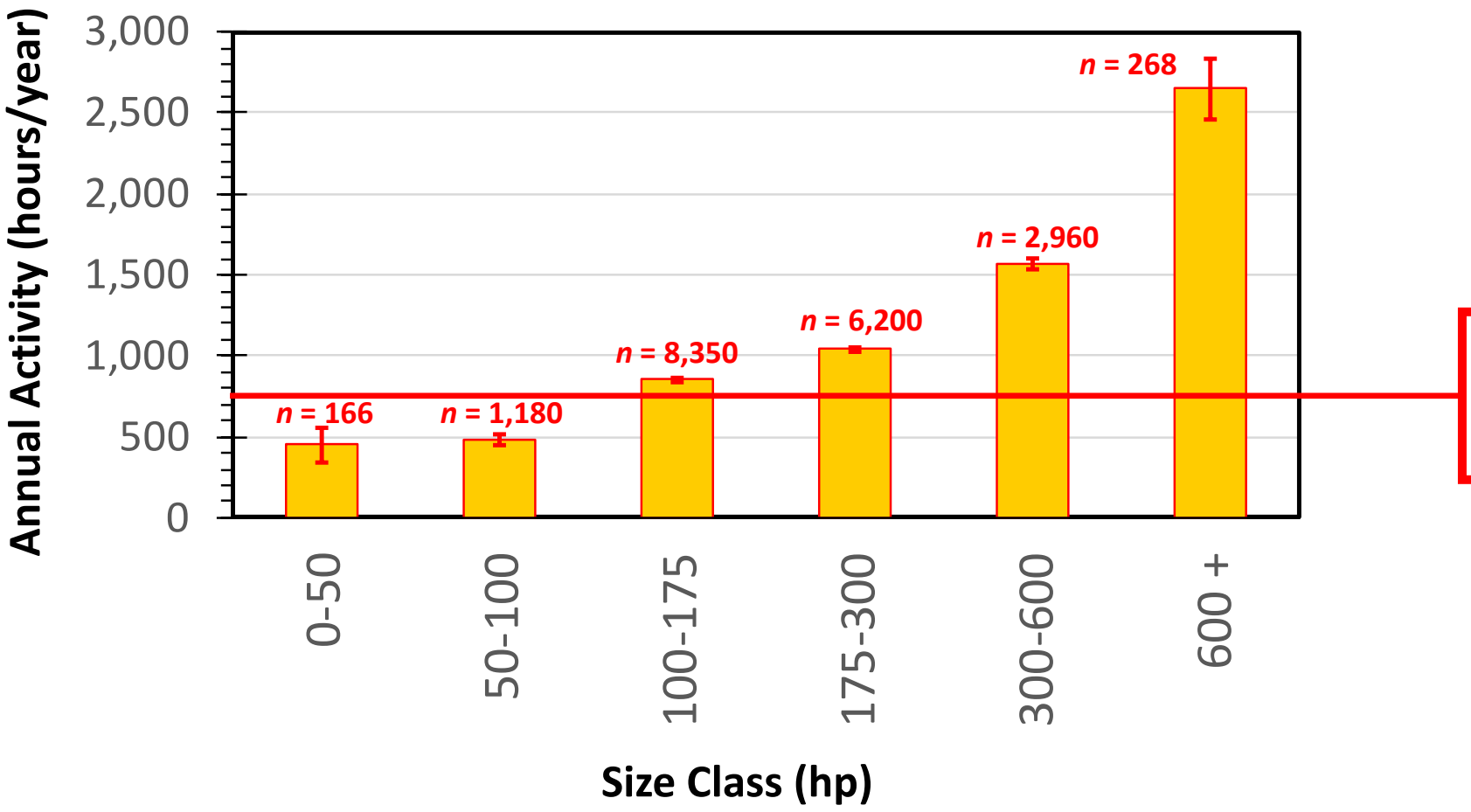
- Estimated variances by empirical bootstrap
  - Simple random sampling with replacement
  - Thousands of replications

- Preliminary results for diesel-powered wheel loaders, excavators, and skid-steer loaders

Current Model Assumptions:

- Annual activity rate varies by equipment type
- Activity rate is constant by engine size and fuel type
- Activity rate is constant over time (populations vary, but not activity levels)
- Activity rate is constant by region (same in all states, counties)

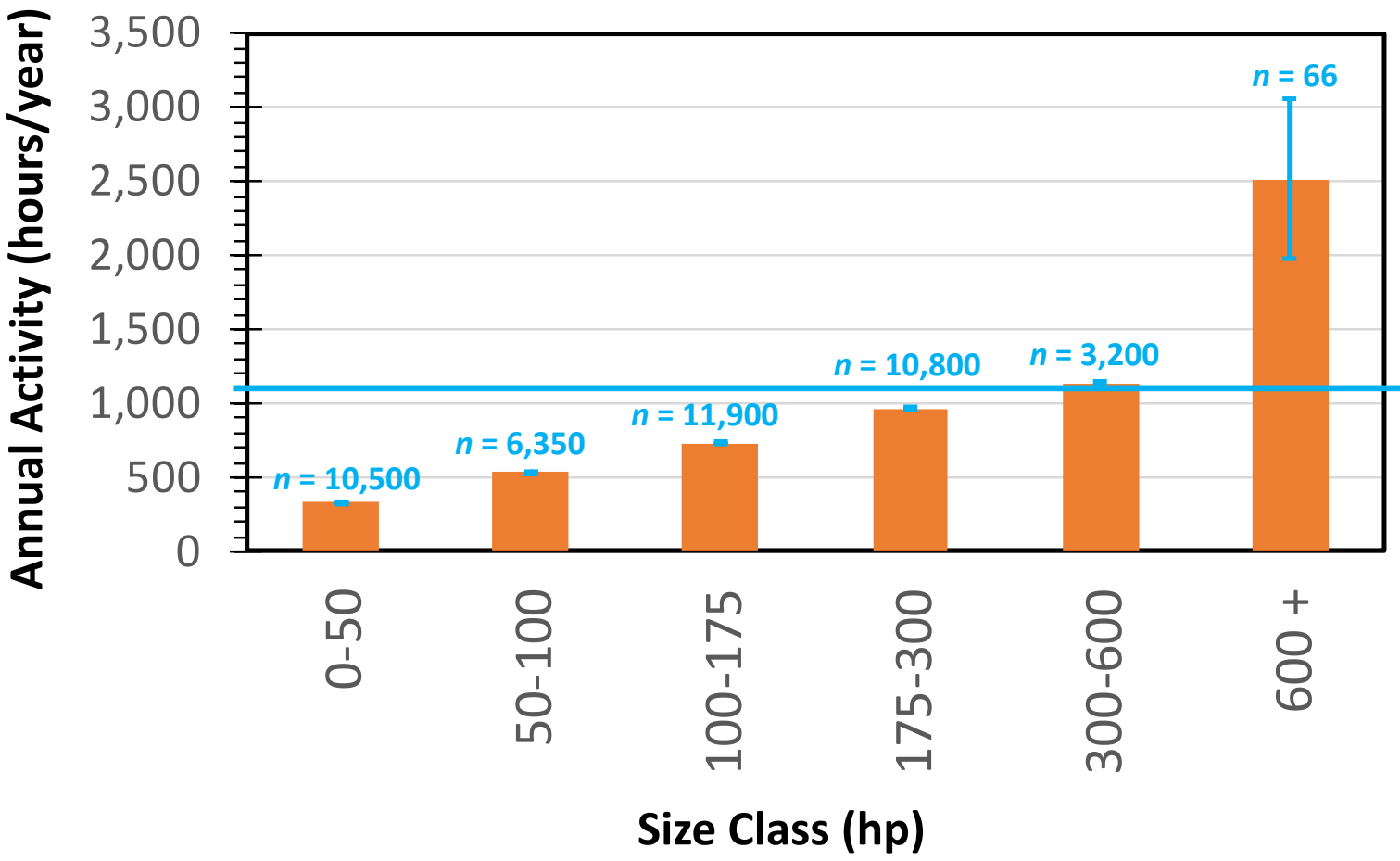
Activity by Size Class: Wheel Loaders



Current Model:
761 hours/year

- The current Nonroad model tends to underestimate activity for the largest wheel loaders; overestimates activity for smaller wheel loaders

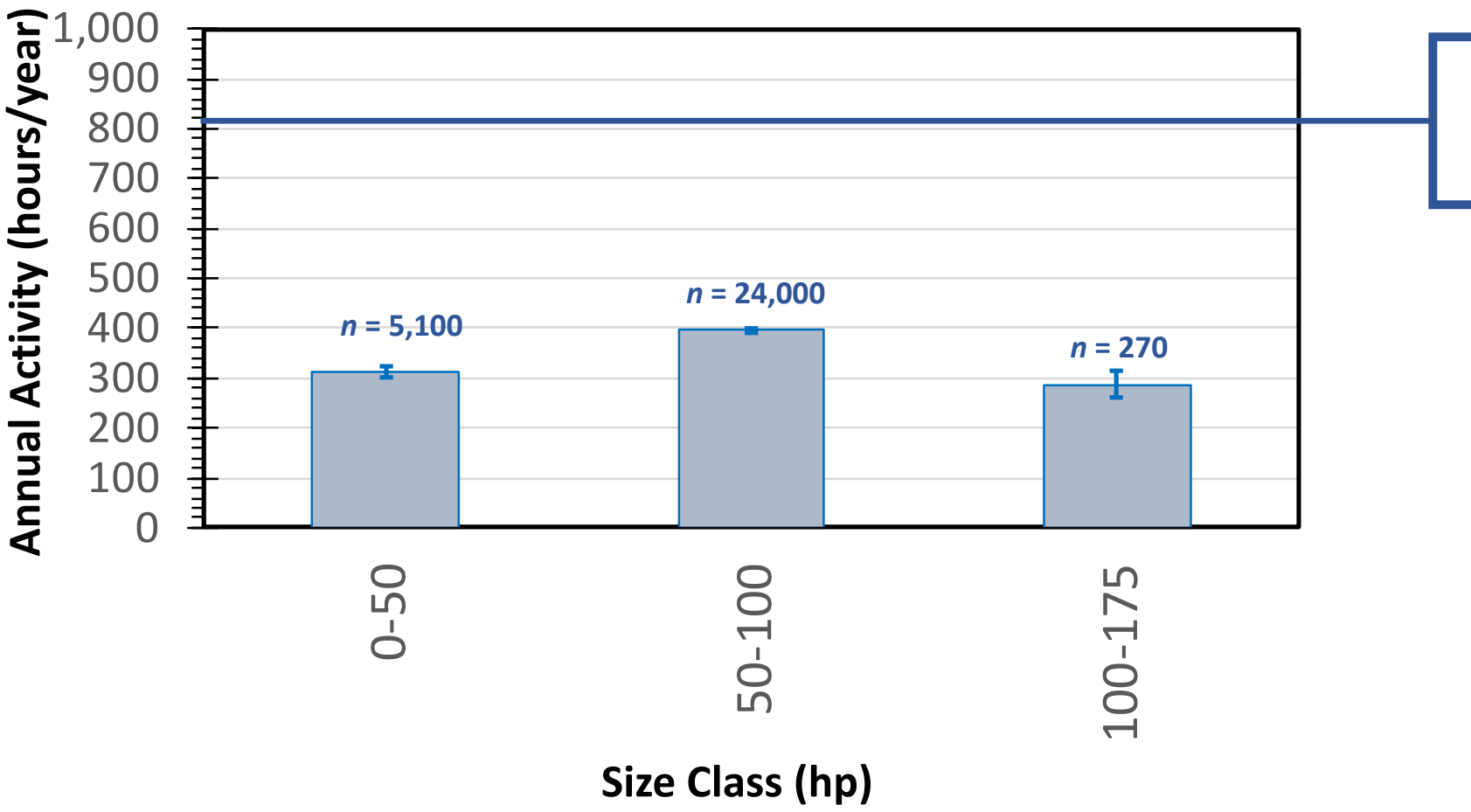
Activity by Size Class: Excavators



Current Model:
1,092 hours/year

- Similar to wheel loaders, Nonroad tends to underestimate activity for the largest excavators and overestimates activity for smaller excavators, with better agreement in the middle hp ranges

Activity by Size Class: Skid-Steer Loaders



Current Model:
818 hours/year

- Current nonroad model tends to overestimate activity for skid-steer loaders

Informing Model Design and Assumptions

- The limited availability of nonroad activity and emissions data continues to pose a challenge to nonroad emissions model development
- EPA's efforts to update the Nonroad model are enhanced by leveraging data partnerships to explore new data sources such as in-use and fleet management data and auction house records
  - Better account for variability in usage patterns of nonroad equipment, e.g.:
    - Temporal and spatial variability (diurnal, weekend/weekday, seasonal, regional)
    - Engine size (how does usage vary with engine size?)
    - Equipment/engine age (what is the decline in usage as equipment/engines age?)
    - Vocation, fuel type
  - Estimates of idle versus non-idle time → building block for possibly incorporating modal emissions into the model
  - Better characterization of the relationship between fuel consumption/emissions and engine load
  - Better understanding of maintenance practices → can inform scrappage and deterioration assumptions in the model

Contacts

- EPA is actively seeking partnerships to help gather better data to address current and future research needs and improve our data analysis and modeling capabilities
  - ➢ Utilizing real-world activity data to improve our ability to model nonroad emissions is a priority

- Primary Contacts:
  - Sarah Roberts, Roberts.Sarah@epa.gov
  - Carl Fulper, Fulper.Carlr@epa.gov
  - James Warila, Warila.James@epa.gov

- For more information on MOVES and Nonroad, please visit: https://www.epa.gov/moves

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency. Additionally, photos used in this presentation are the property of their respective copyright owners and are used here for educational purposes only.