Improving the Temporal and Spatial Characterization of Usage for Nonroad Equipment

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2023 International Emissions Inventory Conference
September 26-29, 2023 | Seattle, WA

Background

- **The MOVES-Nonroad model**
  - Estimates emissions inventory for nonroad equipment
    - From numerous equipment types
  - Used by myriad stakeholders and EPA

- **For multiple pollutants**
  - Greenhouse gases, energy consumption
  - Gaseous emissions, criteria air pollutants
  - Particulate matter
  - Toxics, hazardous air pollutants

- **Equipment Activity (hours/year) is a key model input**
  - Current model assumptions are dated
  - Current activity inputs are simple
    - Do not account for equipment size, region, or economic sector

Improvements

- **Engaged in multi-year effort**
  - to redesign and update the model
- **Acquiring and analyzing data from new sources**
  - **Auction house records**
    - Hour-meter readings at time of sale (see 2019 IEIC presentation)
  - **Portable instruments**
    - Portable Activity Measurement Systems (PAMS) deployed in research programs
  - **Telematics**
    - Increasingly used by equipment fleets
- **Leveraging partnerships to acquire new data**
  - Cooperative Research and Development Agreement with Texas A&M Transportation Institute (TTI)

Telematics

- **Has been used in onroad emissions inventory work**
  - To inform key inputs
- **Increasingly used by nonroad fleets**
  - For large equipment
- **Potential to improve current inputs**
  - Annual hours of operation
  - By month, day and hour
- **Potential to inform new and different processes**
  - Engine idle
  - Engine starts

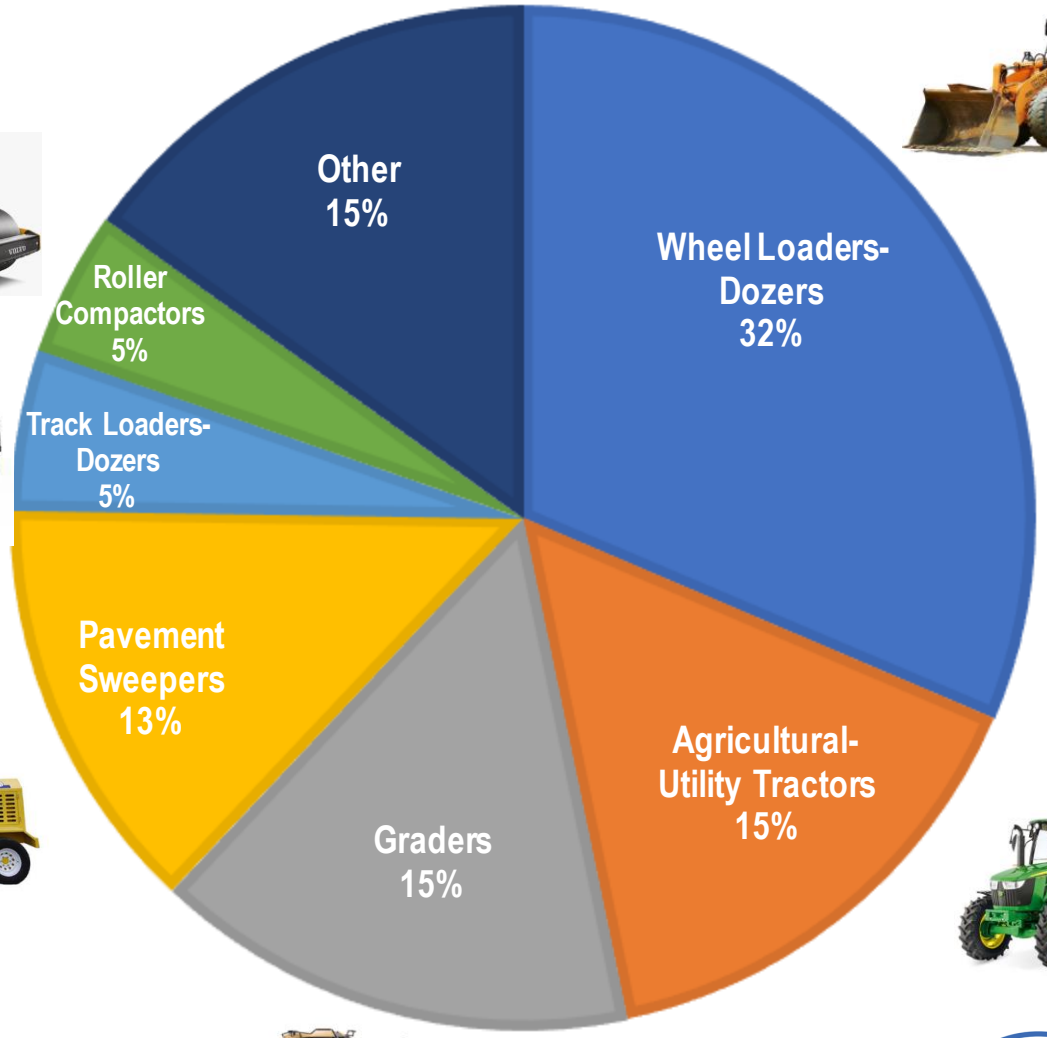
Recent Data Acquisition

- **Recently acquired telematics datasets**
  - Through collaboration with TTI
- **Representing four fleets**
  - **Three State Departments of Transportation**
    - Arkansas DOT
    - Wyoming DOT
    - California DOT (CalTrans)
  - **One private fleet**
    - Operating in civil engineering and road construction
    - Throughout the southern U.S.
- **These analyses represent our first attempt**
  - To incorporate telematics in nonroad inventory

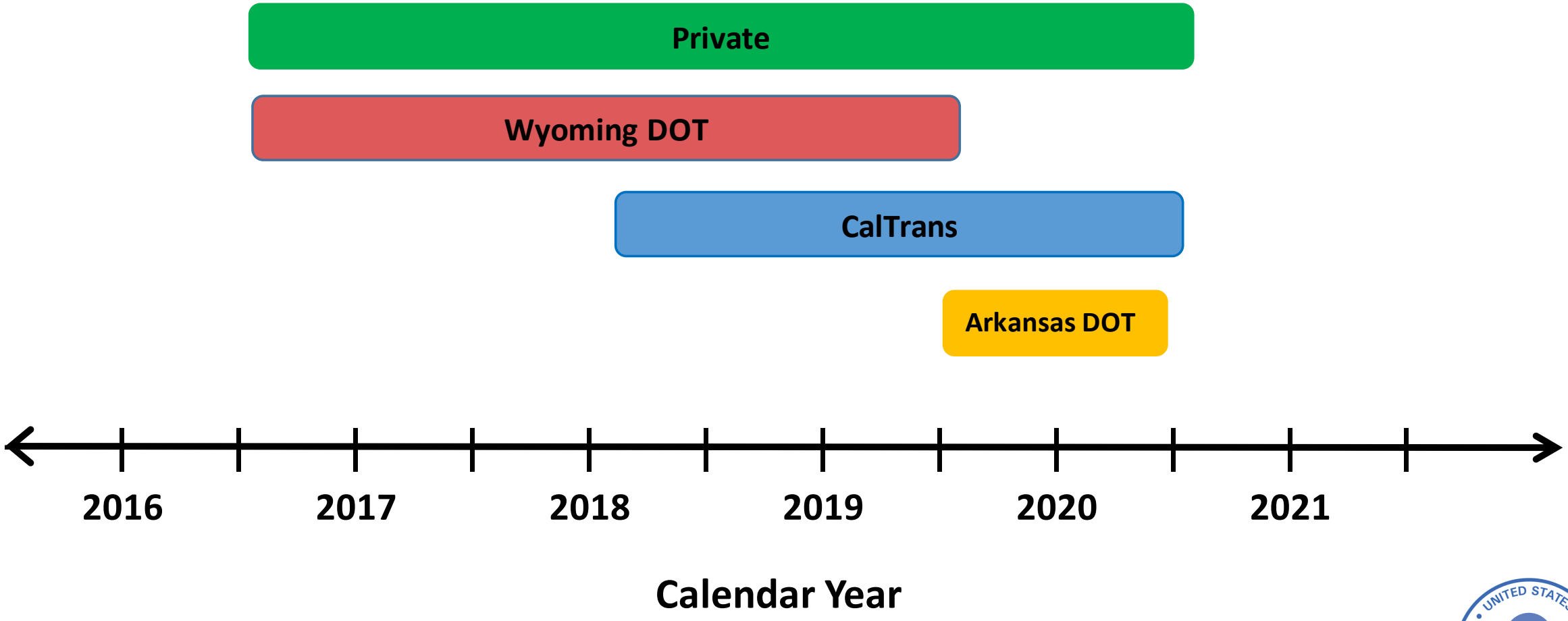
Equipment Types

- **AR:** 11 pieces in 2 types
- **WY:** 51 Pieces in 4 types
- **CA:** 826 pieces in 22 Types
- **Private:** 118 Pieces in 16 types

- **Following analyses focus on**:
  - Wheel loaders, utility tractors,
  - Dozers, graders, roller compactors



Historic Depth

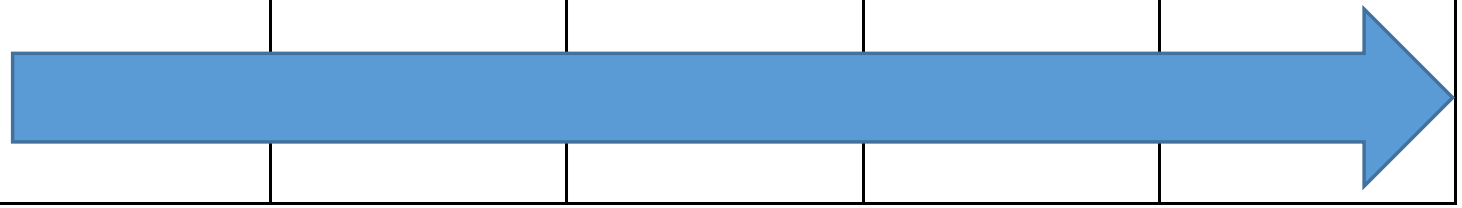


Temporal Level-of-Detail (based on reporting frequency)

Fleet	Hour	Day	Week	Month	Year
Wyoming					
Arkansas					
Private					
California					

Geographic Level of Detail

Fleet	GPS	City	County	State	Region
Private					
Wyoming					
Arkansas					
California					



Types of Operation

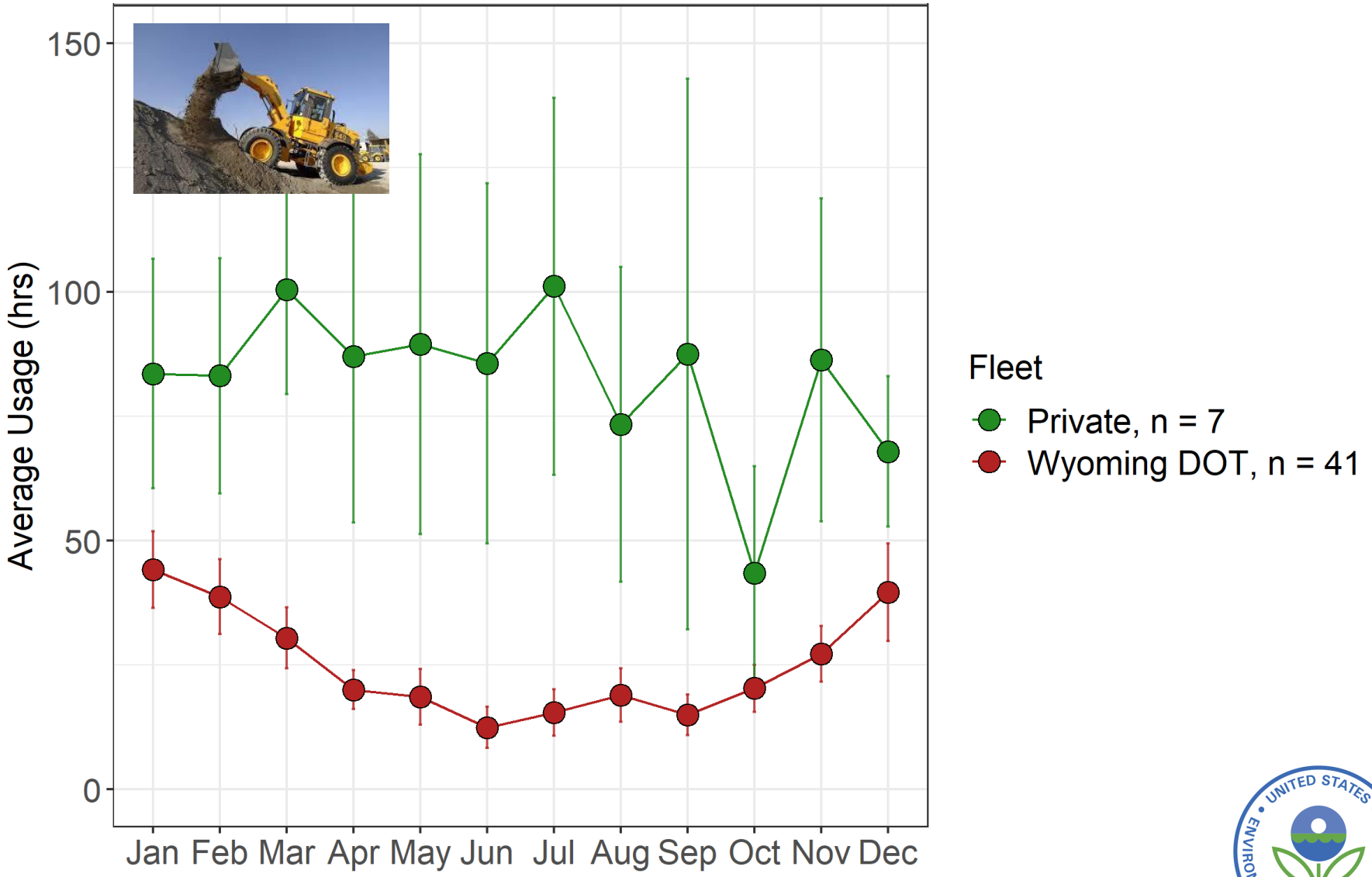
Fleet	Engine-On	Idle	Trips
Arkansas	✖		
Wyoming	✖	✖	
California	✖		✖
Private	✖	✖	

Activity by Month-of-Year

Month-of-Year: Wheel Loaders (75-130 kW)

Private: activity fairly uniform throughout the year

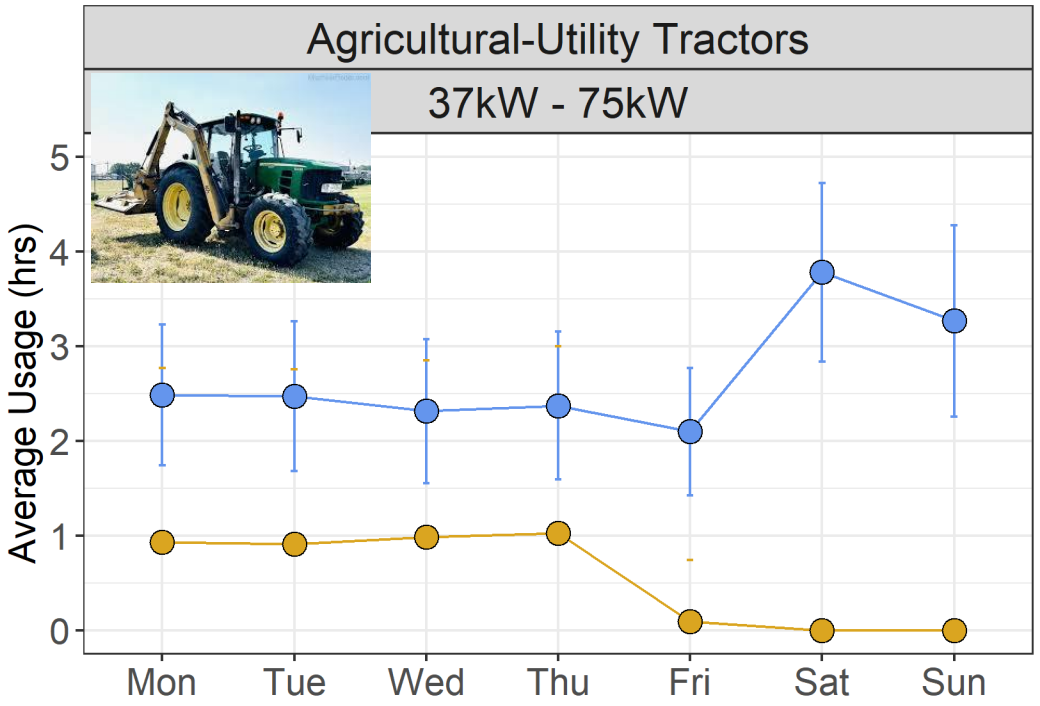
WY: most activity during the winter

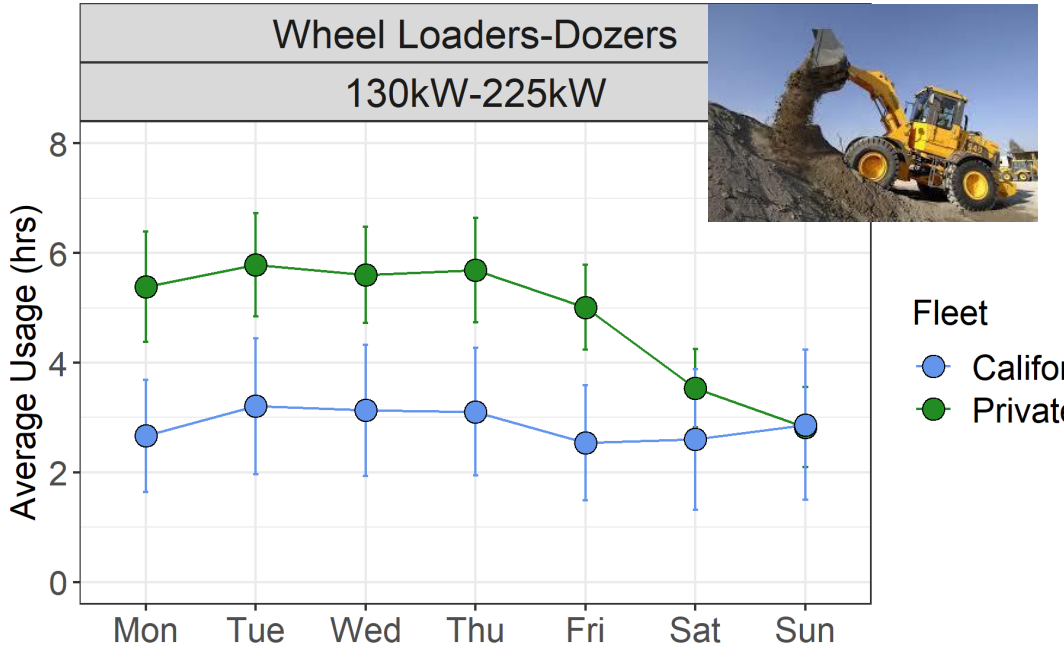


Activity by Day-of-Week

Day-of-Week: Wheel Loaders and Agricultural Tractors

CA: equipment works 7 days/week





Fleet
- California DOT, n = 50(wd); ~30(we)
- Arkansas DOT, n = 7

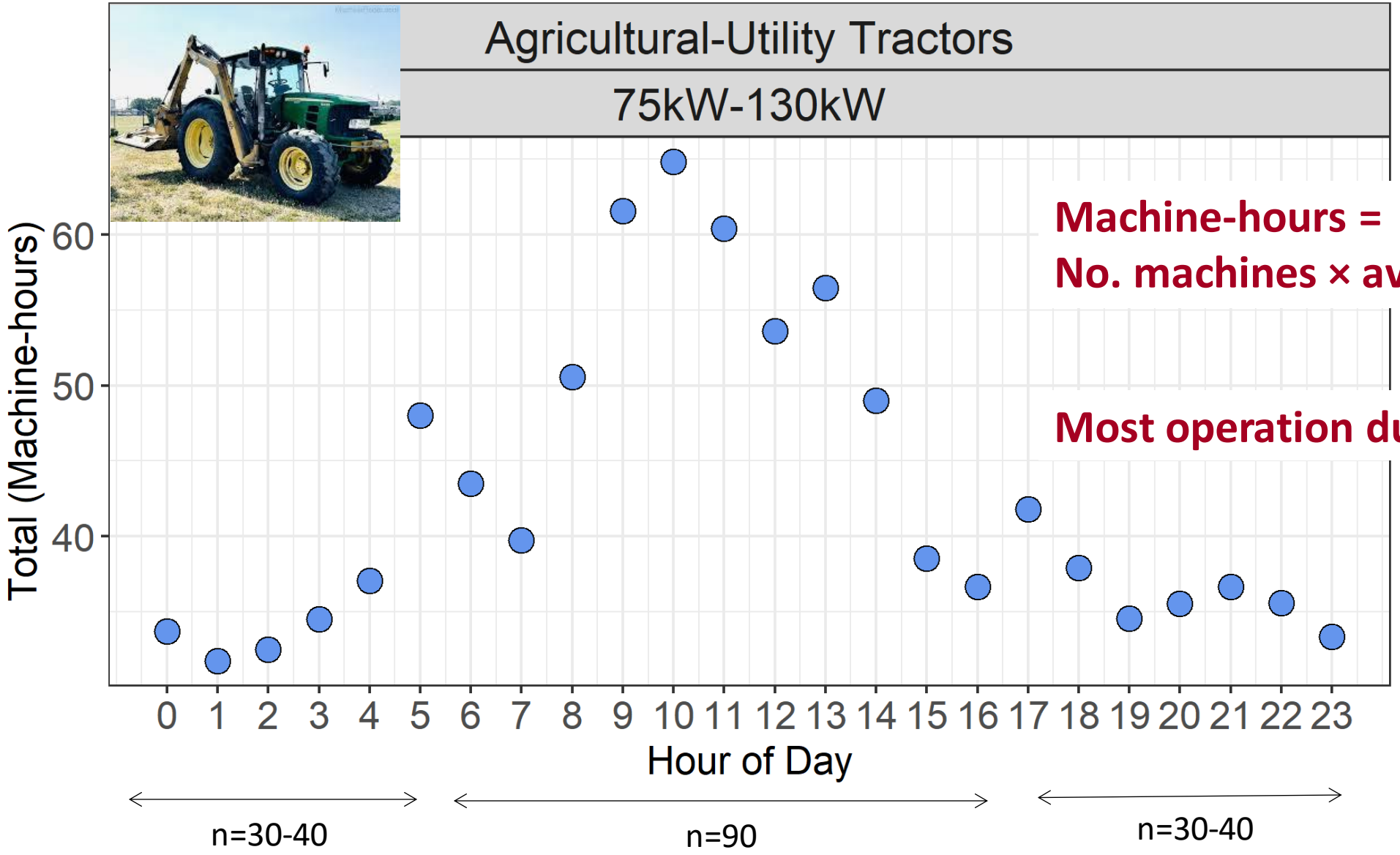
Private: operates more during work week

AR: tends to operate 4 days/week

Activity by Hour-of-day

Based on CA data

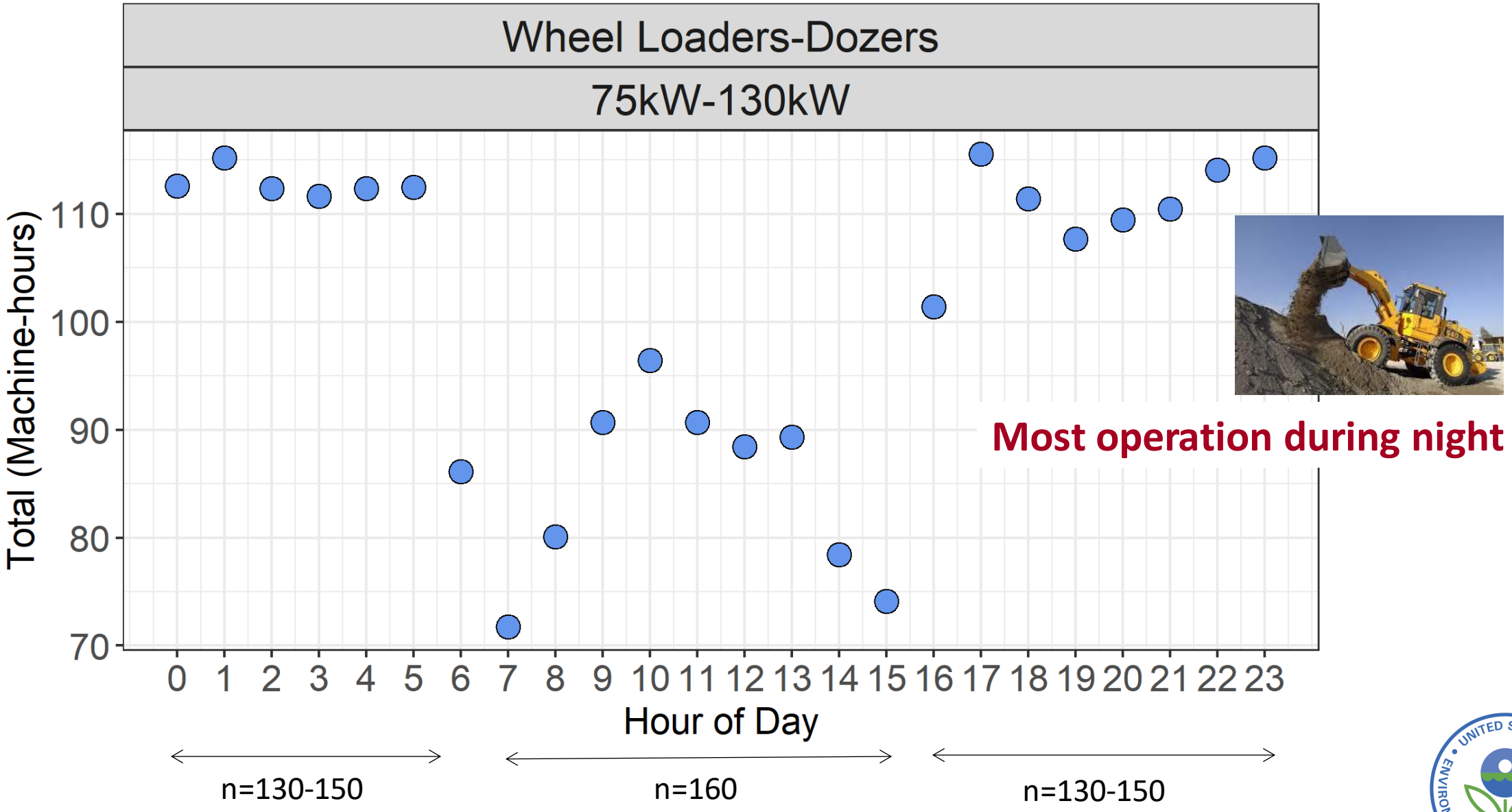
Hour-of-Day: Agricultural-Utility Tractors



Machine-hours =
No. machines × average op. time

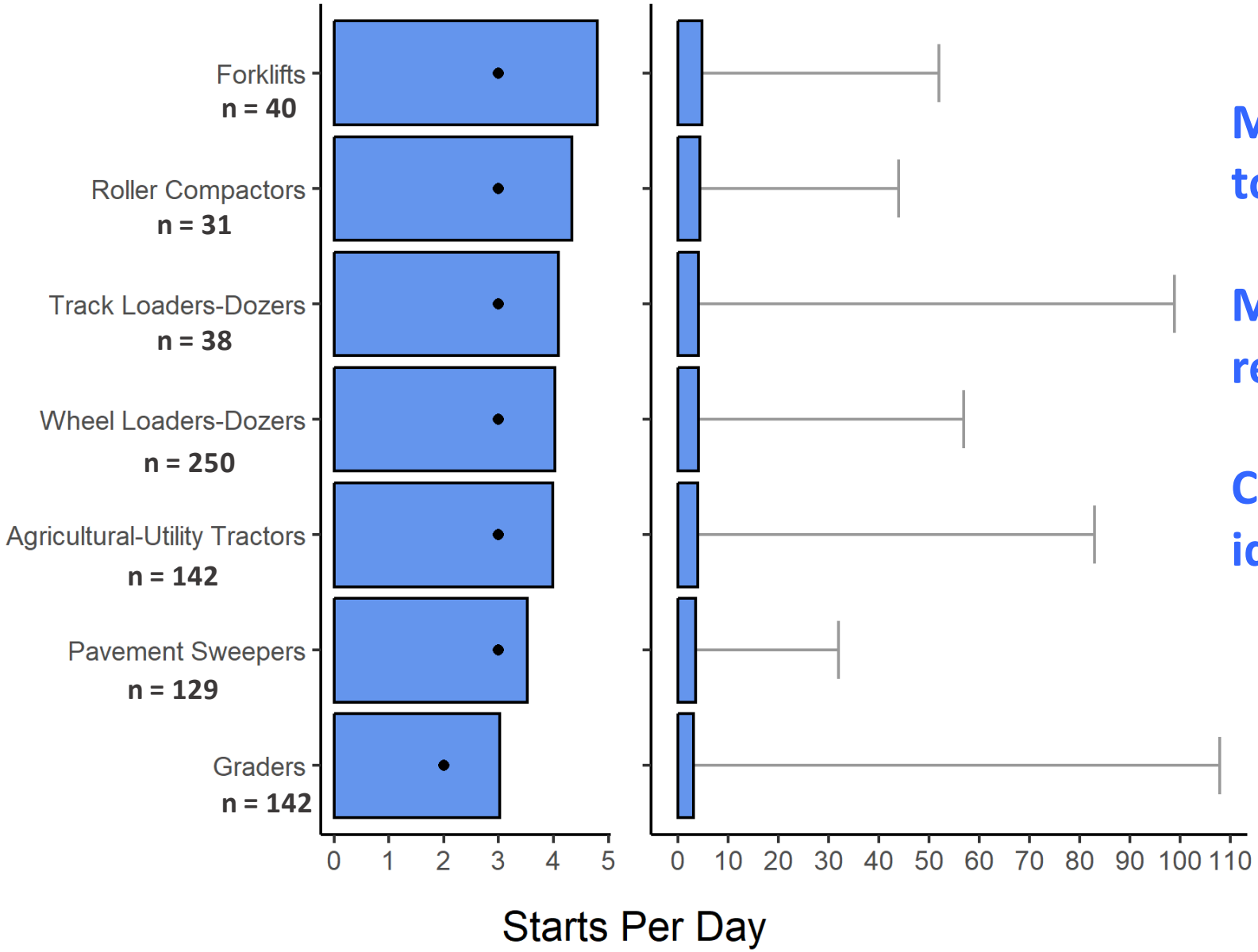
Most operation during day

Hour-of-Day: Wheel Loaders



Most operation during night

Starts-per-Day: by Equipment Type



Means/Medians similar to onroad

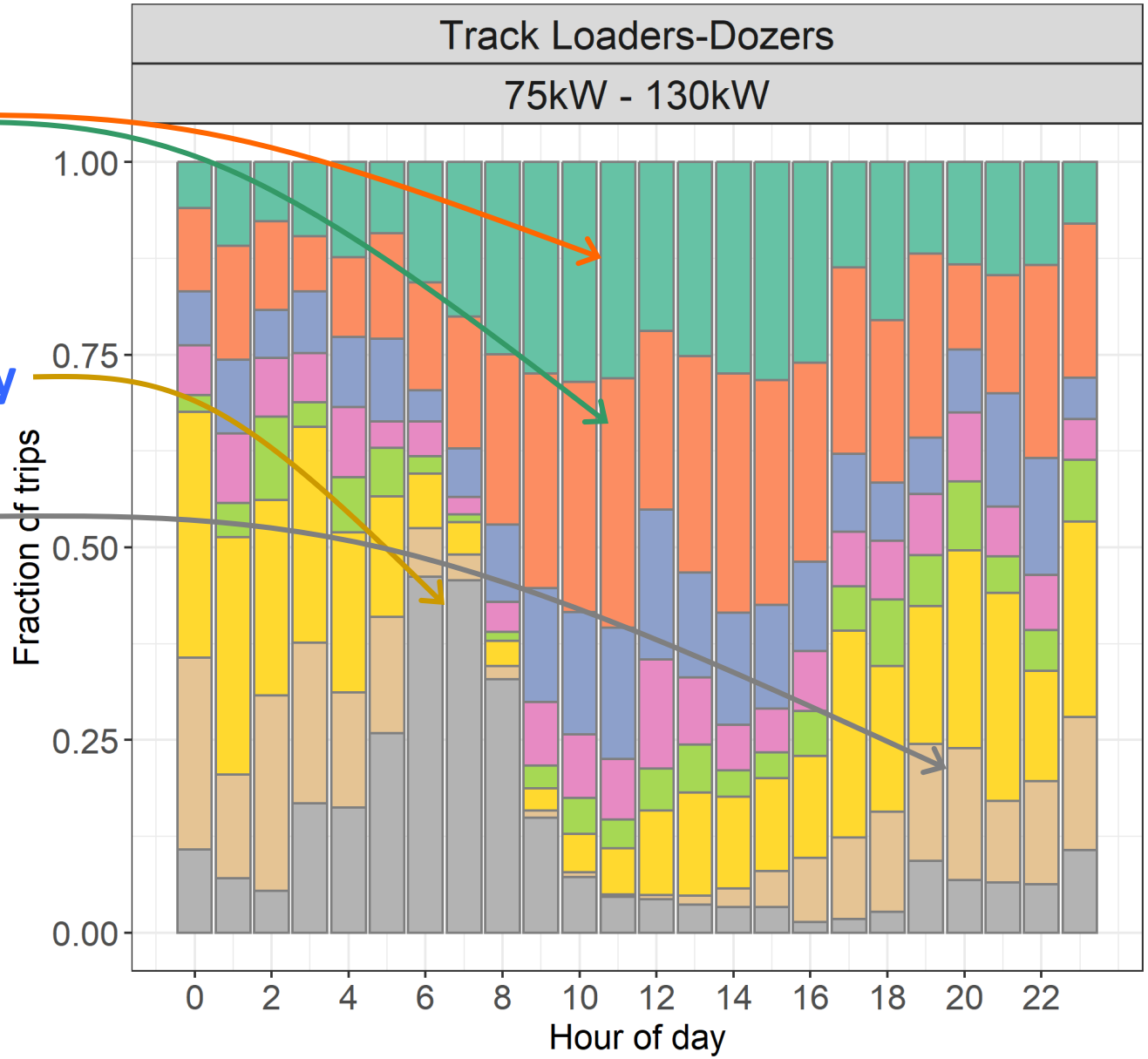
Maxima are remarkably high

Could be due to local idle restrictions?

Soak Distributions: Track Dozers

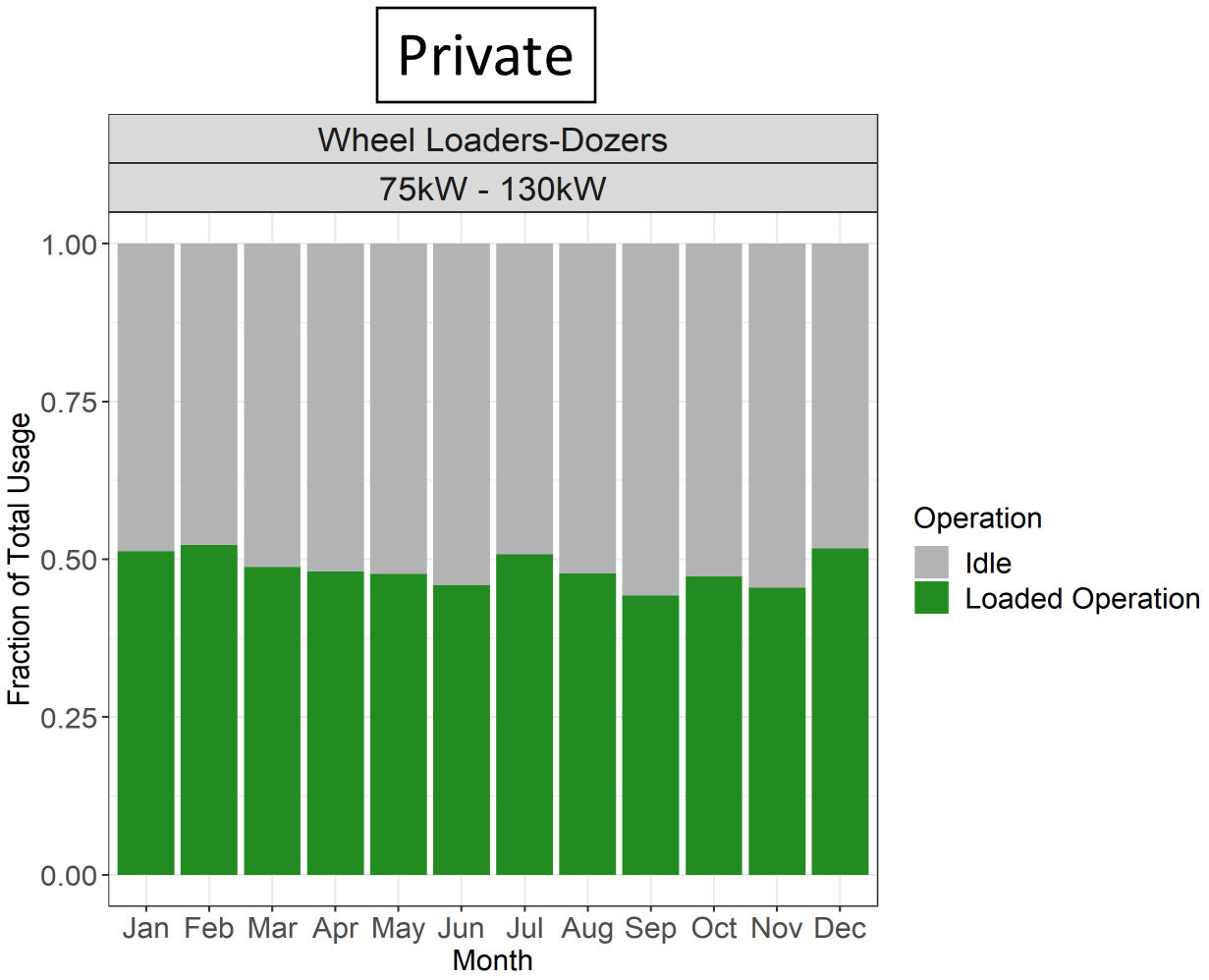
Most short soaks during the work day

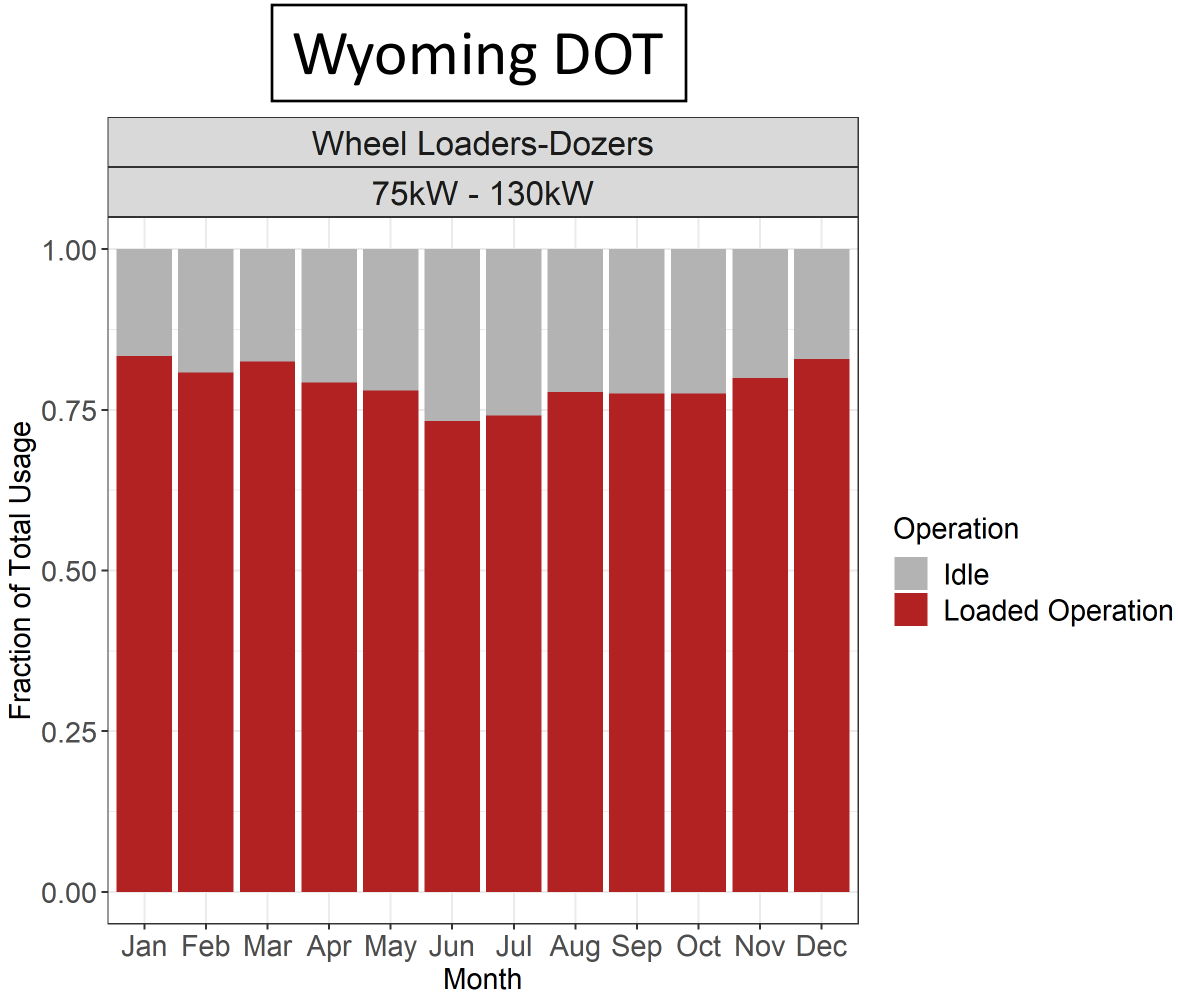
Longest soaks in early morning; with a 2nd peak in the evening



Idle Activity

Idle Activity by Month

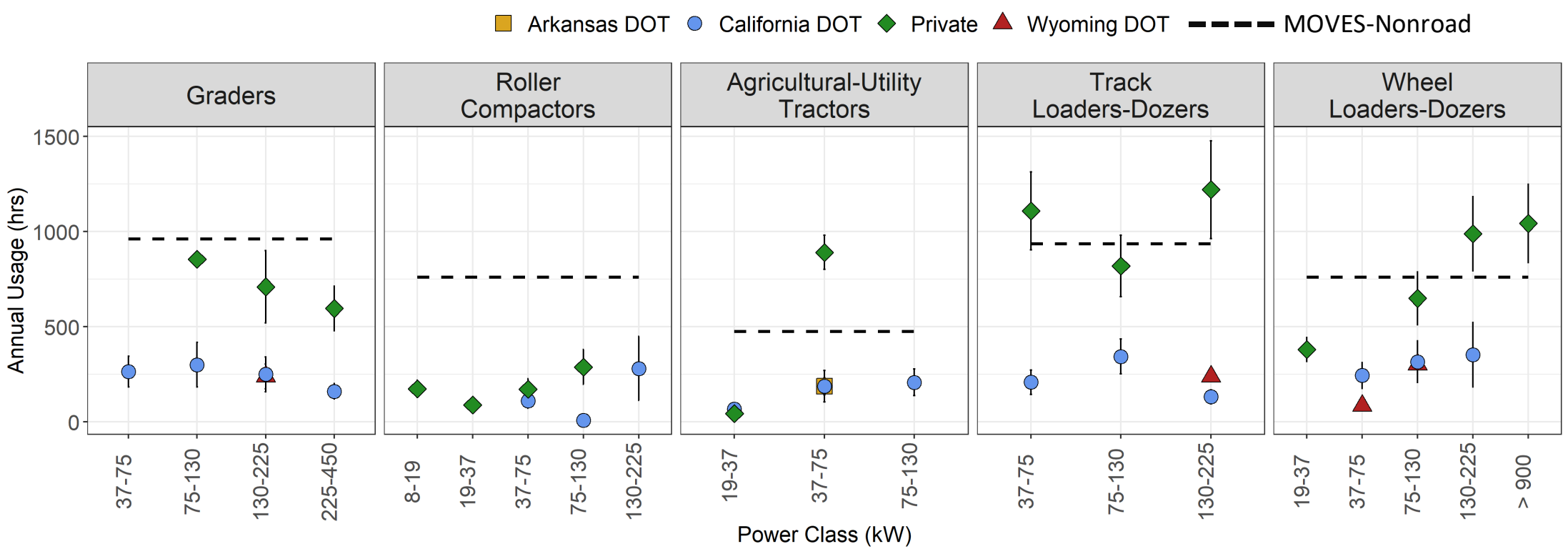




Privately-owned loaders idle twice as much as Publicly owned

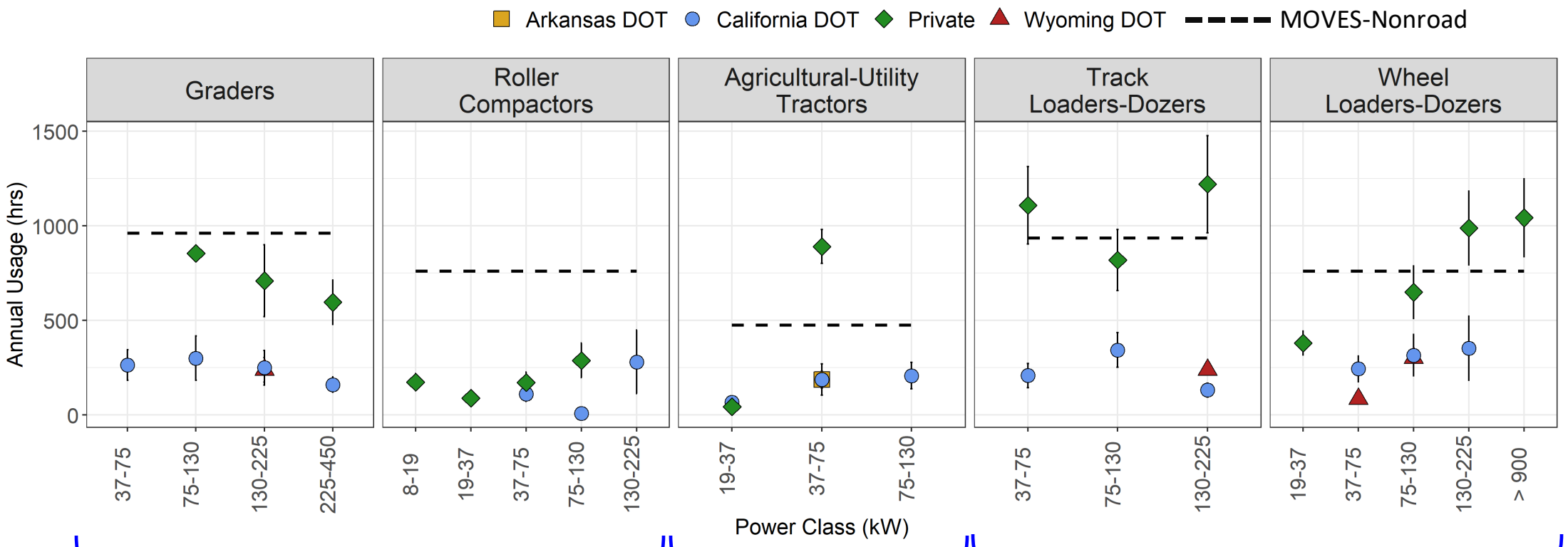
Annual Activity and Comparison to MOVES-Nonroad

Annual Activity: Five Equipment Types



Privately-owned equipment generally operates more than publicly owned.

Annual Activity: Five Equipment Types



Lower than current

Public Lower
Private higher

Private
Approximately similar

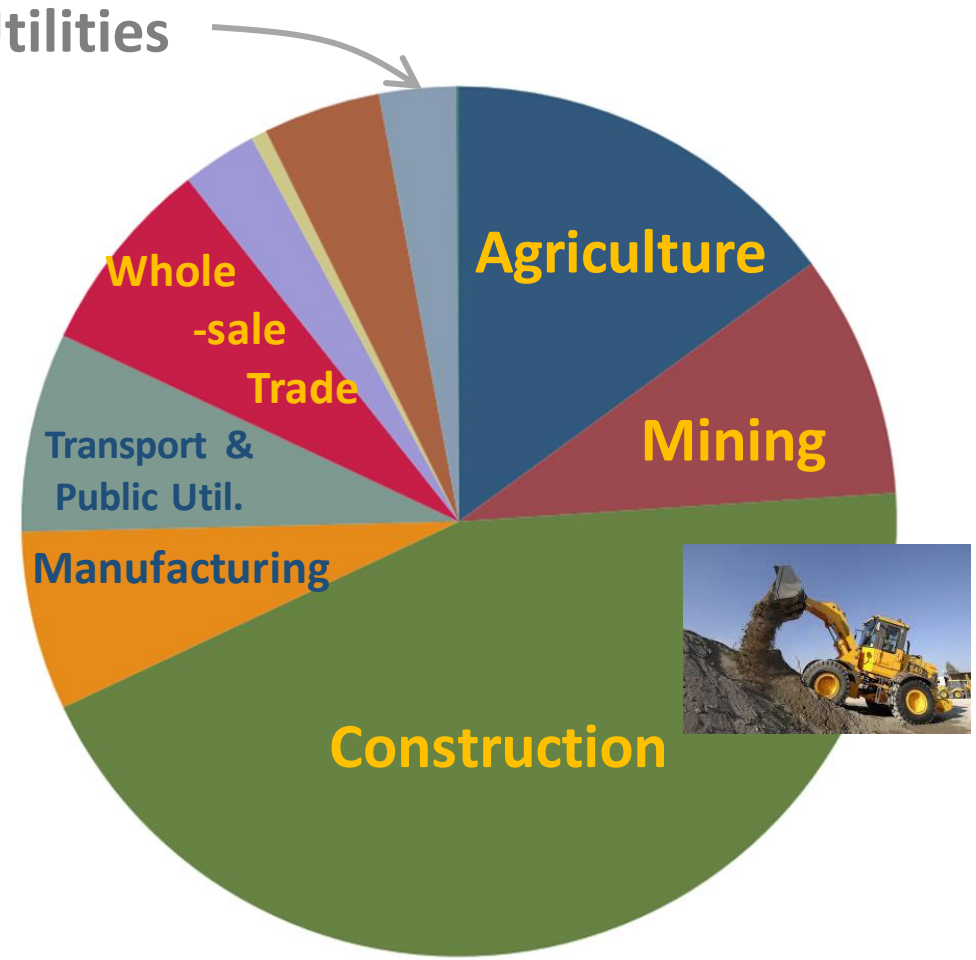
Summary and Conclusions

Capabilities

- **Telematics can be very powerful tool for understanding nonroad equipment activity usage**
  - Provides more detail than any other source
    - Except portable instruments
- **Gives insight into detailed usage patterns**
  - Temporal (month, day, hour)
  - Spatial (region, state, county, city)
  - By economic sector
    - Construction, agriculture, mining, public utilities, etc.

Limitations

- **These datasets are detailed, but**
  - Narrow in scope
    - Two economic sectors, one minor
  - Shallow in depth
    - No more than three years coverage
  - Samples small
    - When sliced by equipment size
- **Nonroad different from onroad**
  - Operation not defined by movement
    - Speed, acceleration
  - Telematics may not include engine operating parameters
- **Acquisition of broad, deep datasets may be difficult**
  - Must acquire from data owners
  - What they are willing to share varies



Wheel Loaders

Applications

- **Telematics may be applied as model inputs in supplementary roles**
  - Developing allocation distributions
    - seasonal, weekly, hourly, etc.
- **Telematics enables estimation of new types of activity**
  - Idle operation
  - Engine starts
- **We plan to continue**
  - Leveraging partnerships to acquire new data

Acknowledgements

- **Texas A&M Transportation Institute (TTI)**
  - Jeremy Johnson, Phil Lewis, Joe Zietsman
- **Eastern Research Group (ERG):**
  - Michael Sabisch, Sandeep Kishan
- **U.S. EPA Office of Transportation and Air Quality**
  - Carl R. Fulper, Sarah Roberts