High resolution forwarding data and evaluation of operator differences by use of TimberLink data

Jussi Manner, Tomas Nordfjell and Ola Lindroos

This study is a part of the PhD dissertation by

Jussi Manner

that will be defended 11th of December 2015

at SLU in Umeå, Sweden

The general problem in forwarder work studies

- Time studies can gives detailed data about work element proportions, driven distances, number of crane cycles etc., but lack in representativity

The general problem in forwarder work studies

- Time studies can gives detailed data about work element proportions, driven distances, number of crane cycles etc., but lack in representativity
- Foollow-up studies can give representative data on overall productivity (many machines, many loads, many operators, different stand and terrain conditions), but lack in details

The general problem in forwarder work studies

- Time studies can gives detailed data about work element proportions, driven distances, number of crane cycles etc., but lack in representativity
- Foollow-up studies can give representative data on overall productivity (many machines, many loads, many operators, different stand and terrain conditions), but lack in details
- This study is about to combine the two study methods with new technique!

Objective

- **Present representative values on fuel and time consumption, speed and distances at load level for large forwarders in final felling**

Material and methods

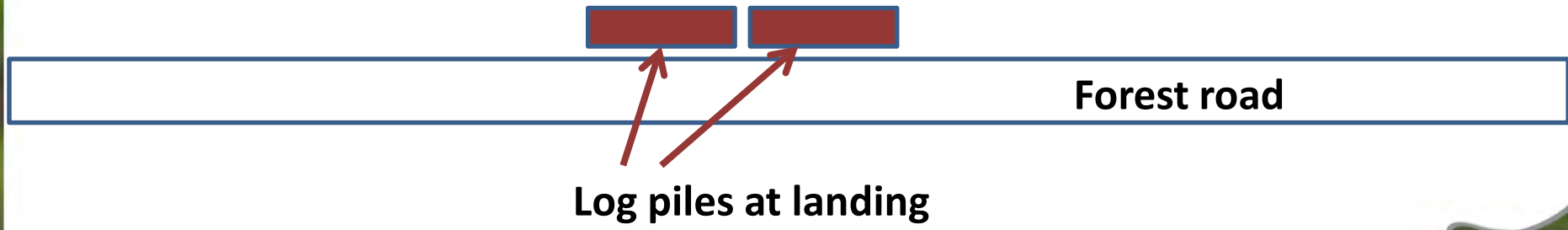
- The John Deere TimberLink **automatic machine monitoring system** was used. In this study also the newest TimberLink's algorithm versions were used, which were not yet in commercial use (when preparing a paper and this presentation)

Material and methods

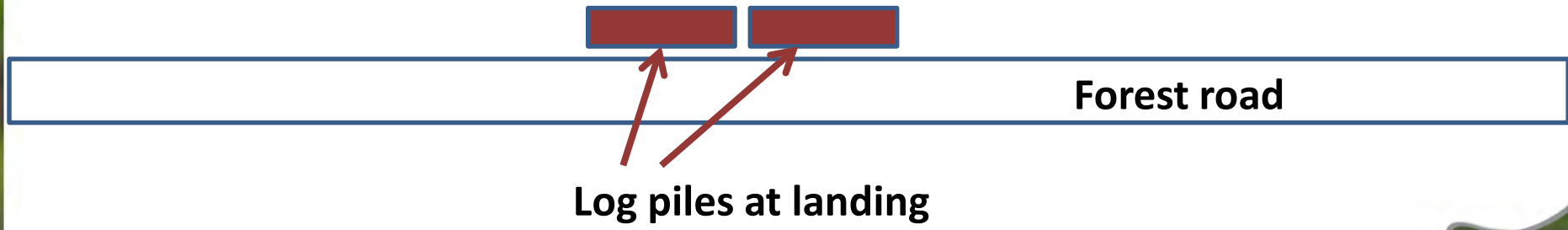
- The John Deere TimberLink **automatic machine monitoring system** was used. In this study also the newest TimberLink's algorithm versions were used, which were not yet in commercial use (when preparing a paper and this presentation)
- However, the volume on loads were not known!

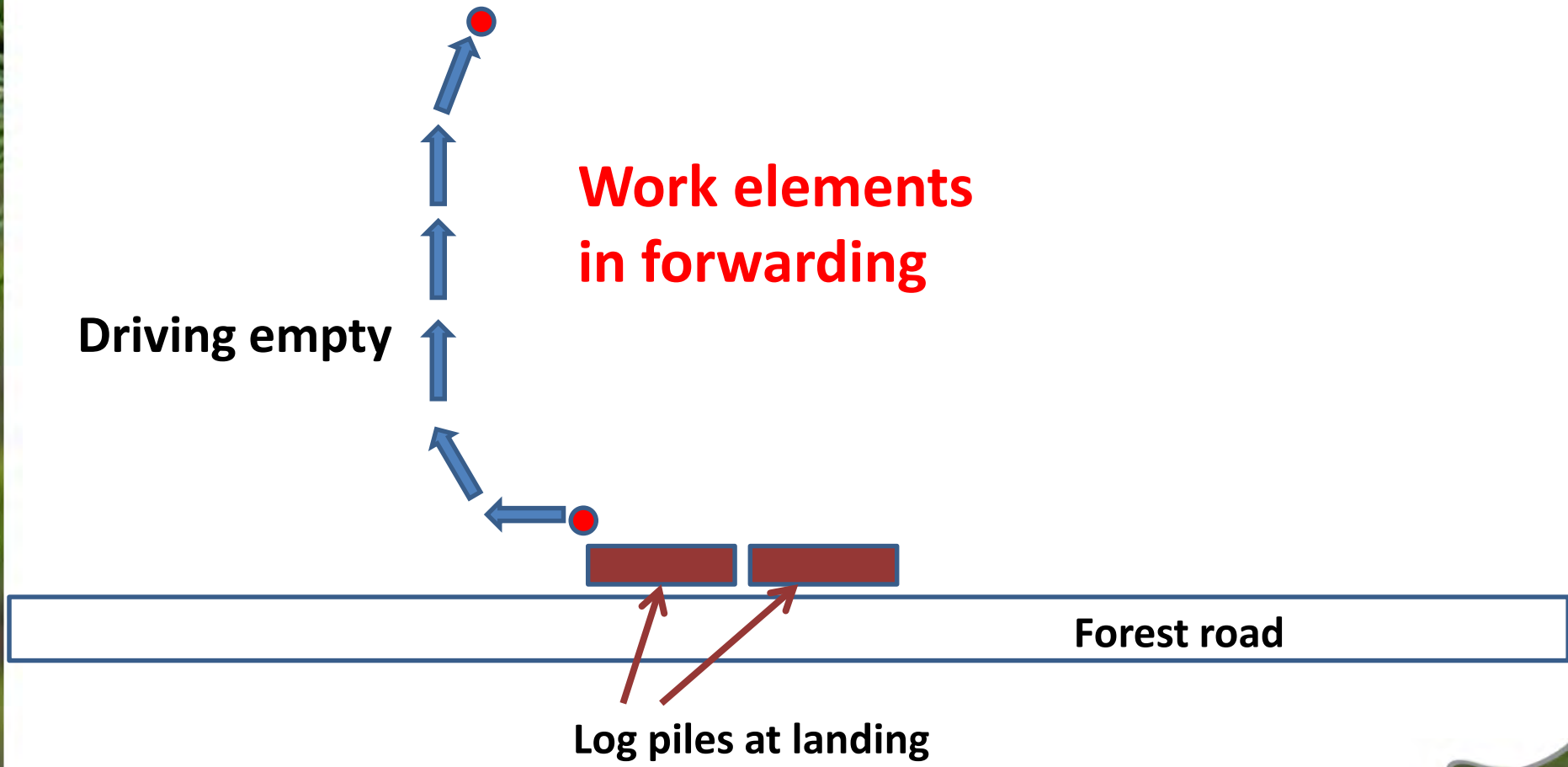
Material and methods

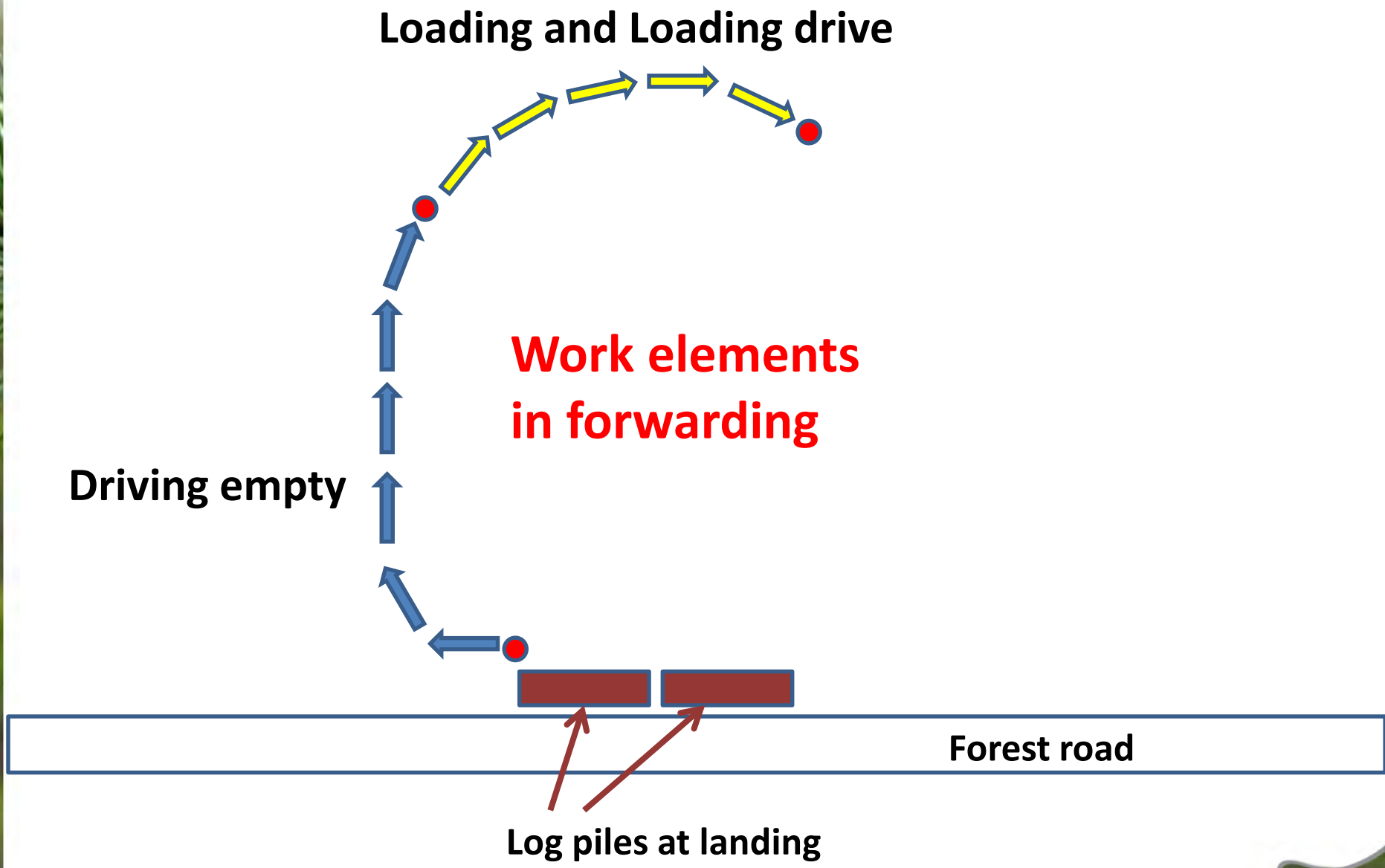
Two brand new John Deere 1910E forwarders (21.8 tonnes, 19 ton load capacity). In total 9 experienced operators and 8800 -15 300 loads collected during two years of forwarding in final fellings with terrain conditions typical for mid-Sweden

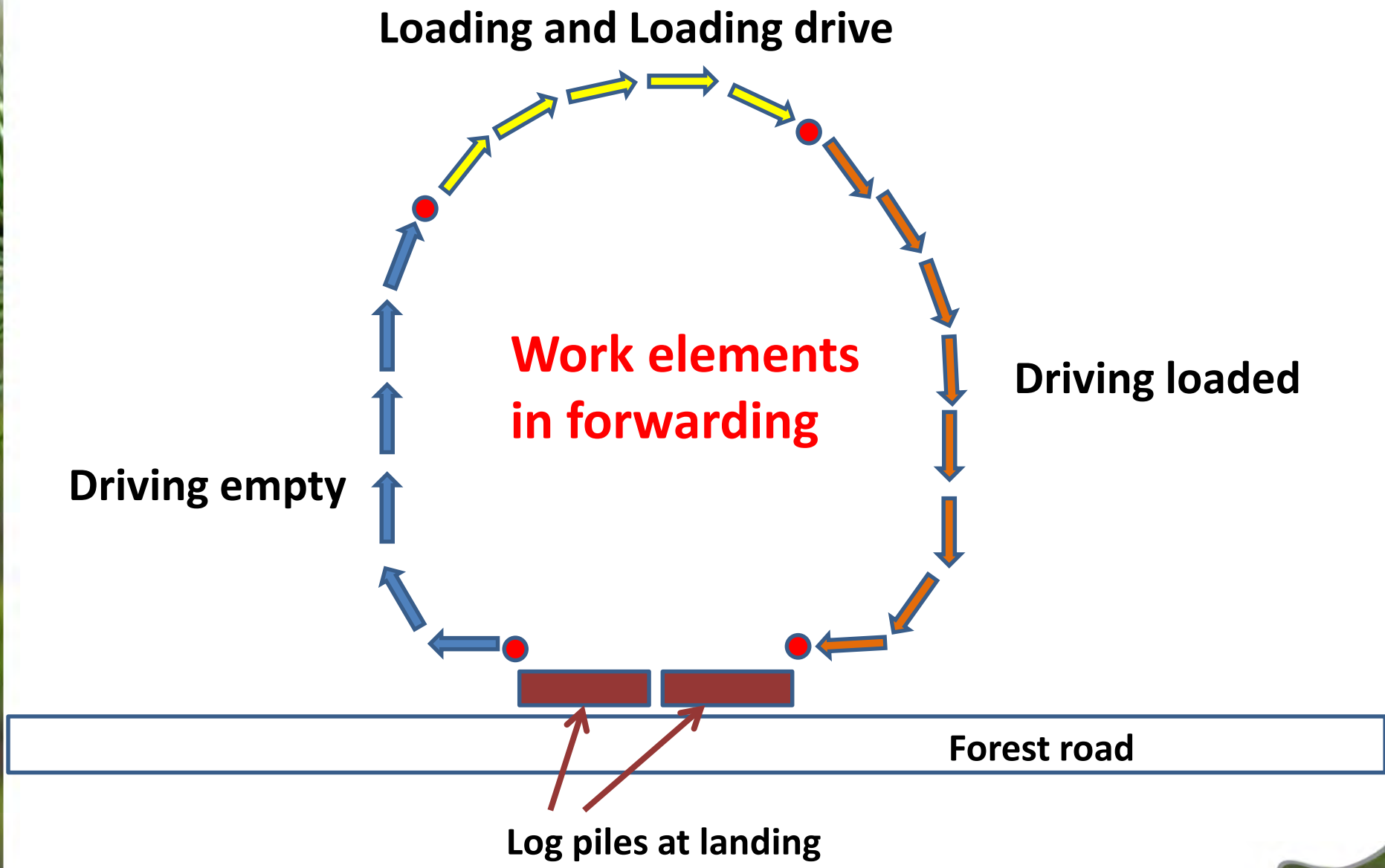

Forest road
Log piles at landing

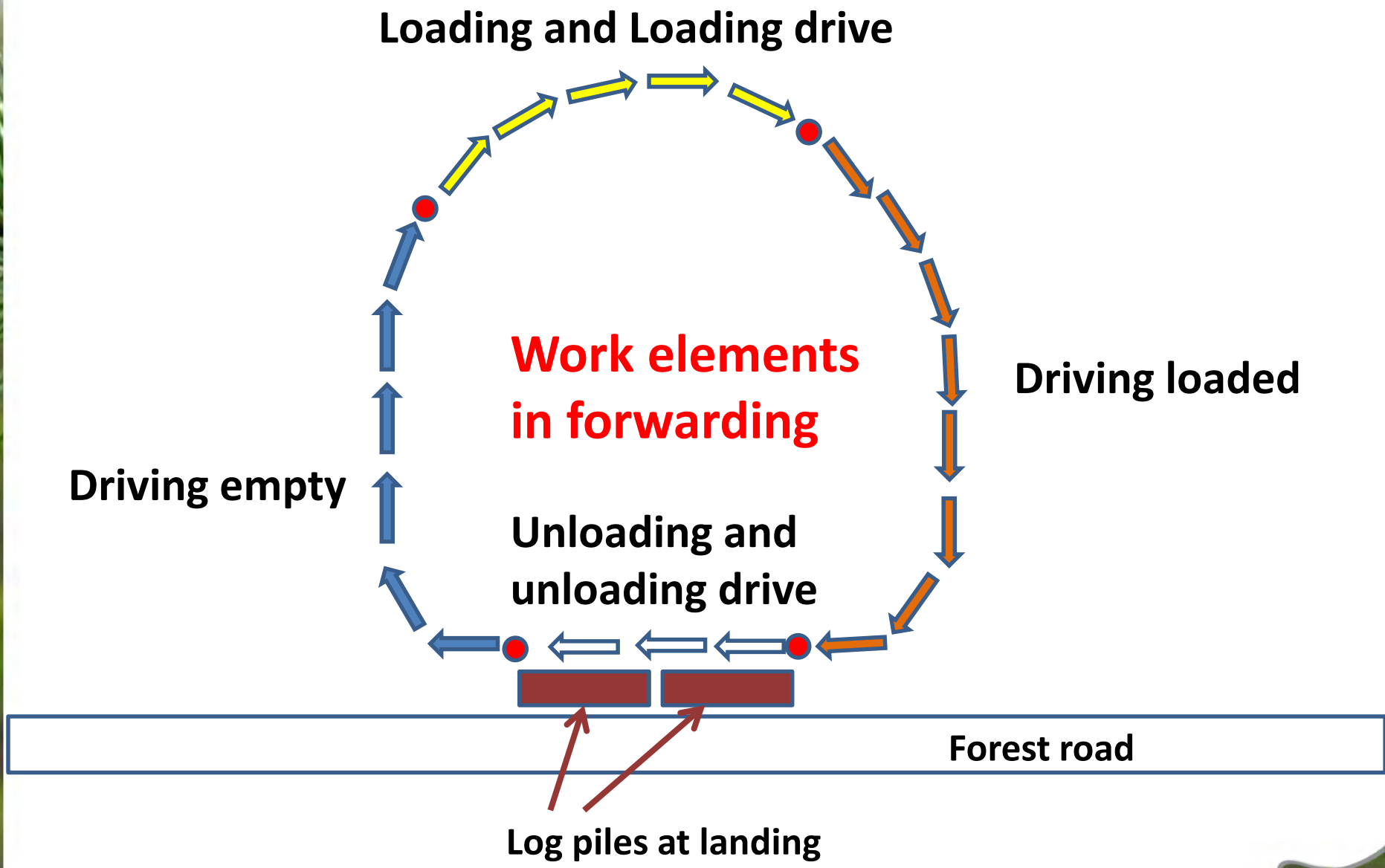
Work elements in forwarding

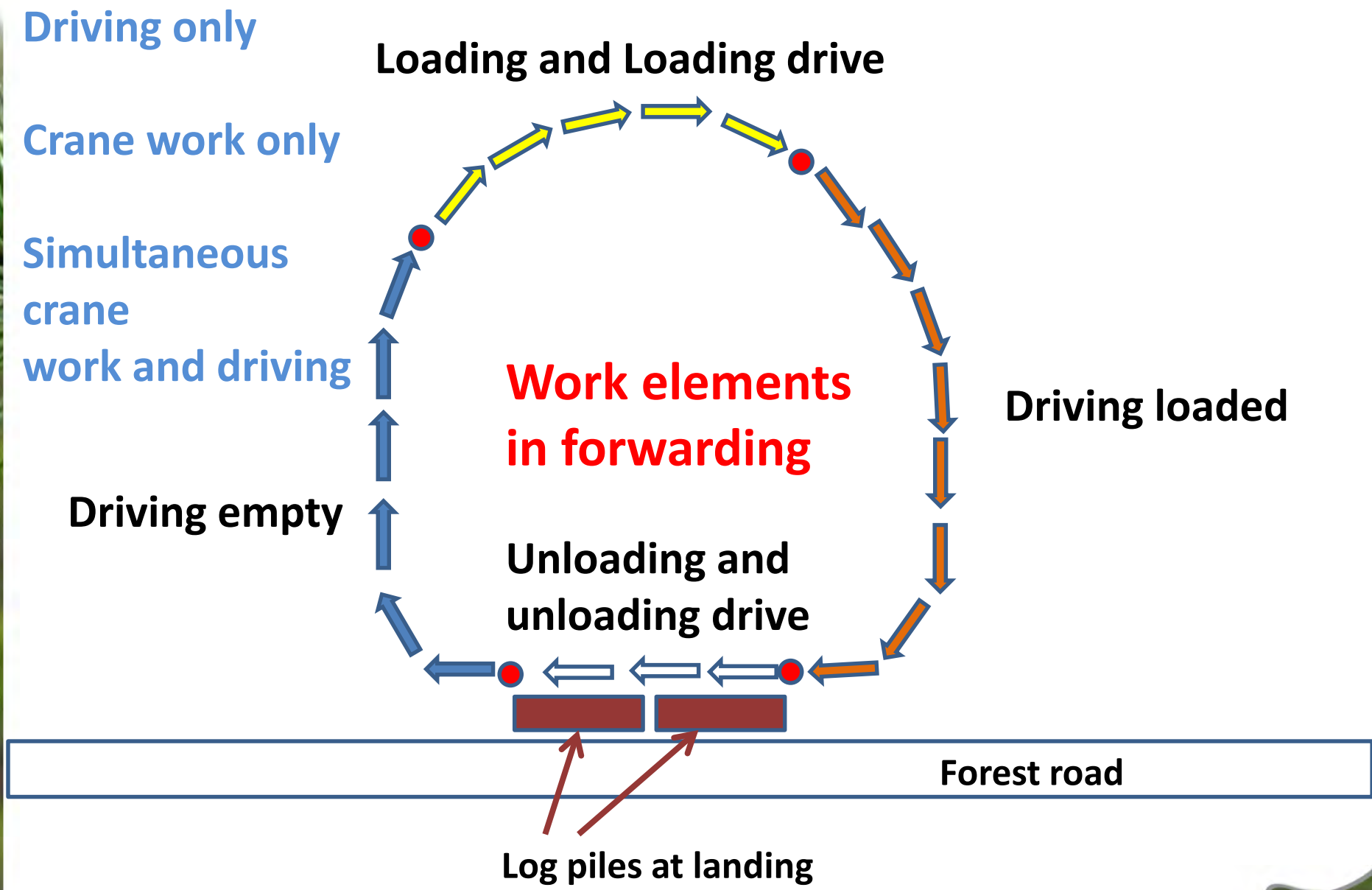


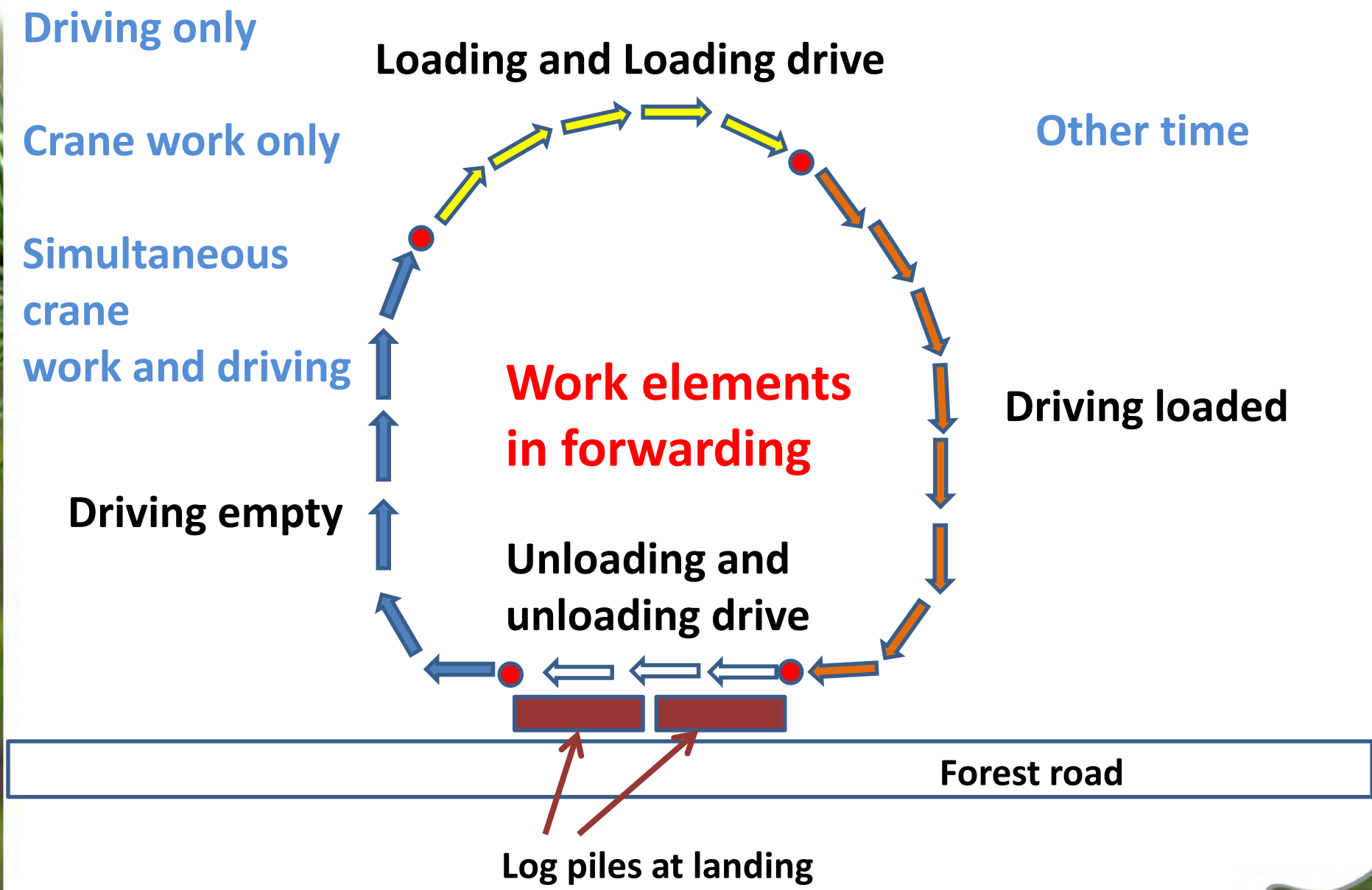

Work elements
in forwarding
Driving empty
Forest road
Log piles at landing

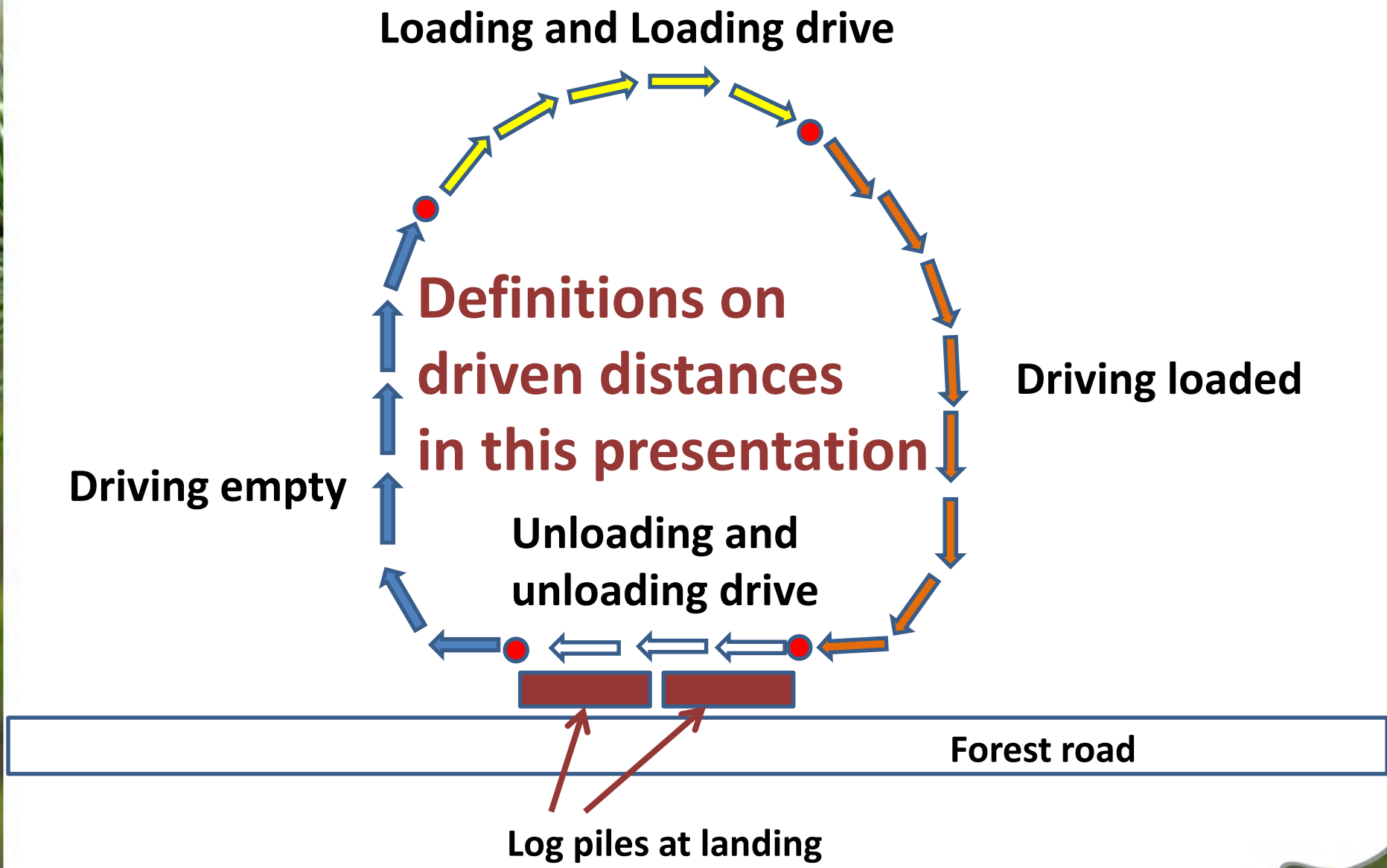

Loading and Loading drive
Work elements
in forwarding
Driving empty
Forest road
Log piles at landing

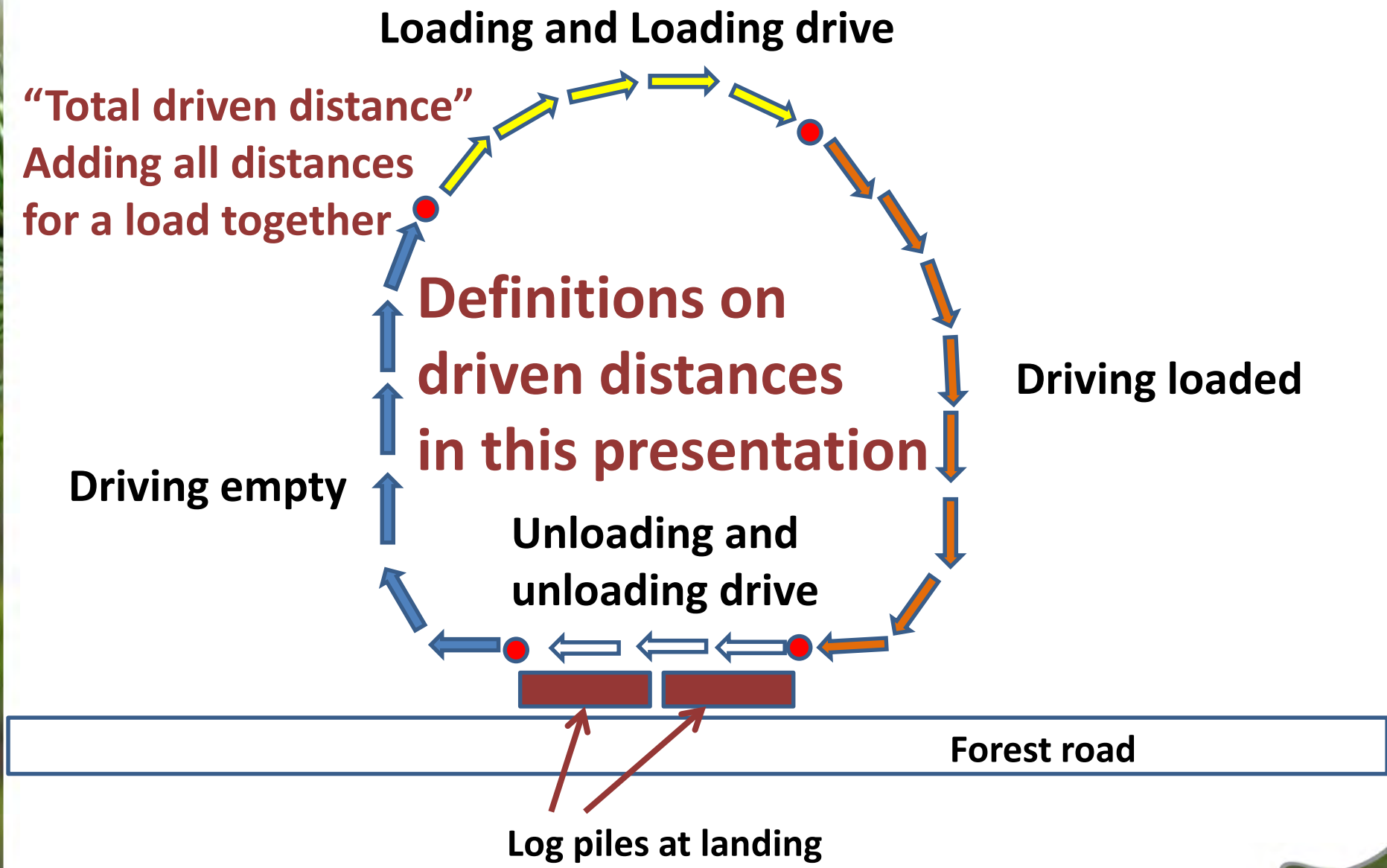

Loading and Loading drive
Work elements in forwarding
Driving loaded
Driving empty
Forest road
Log piles at landing

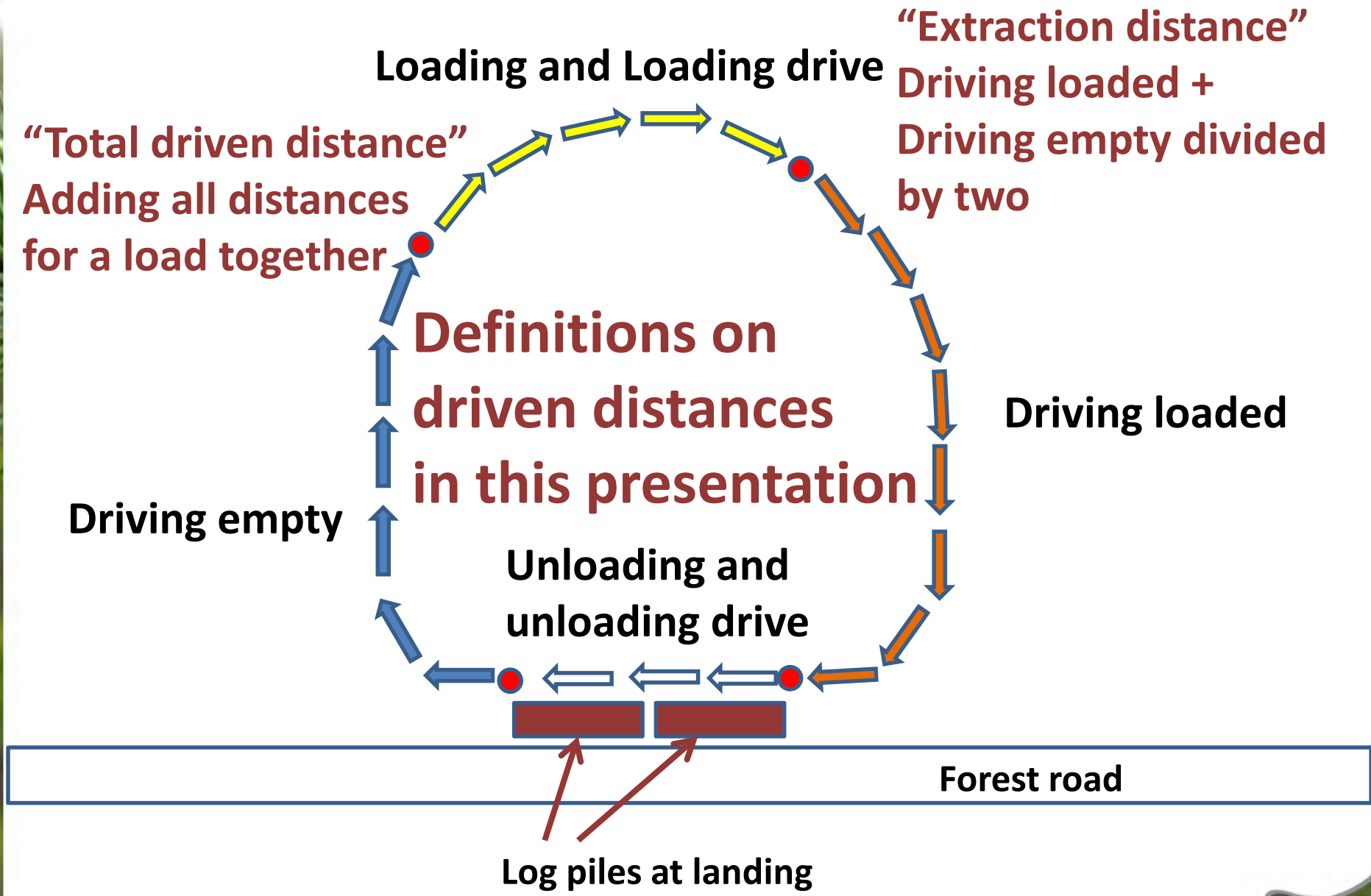

Loading and Loading drive
Work elements in forwarding
Driving loaded
Driving empty
Unloading and unloading drive
Forest road
Log piles at landing


Driving only
Crane work only
Simultaneous crane work and driving
Loading and Loading drive
Work elements in forwarding
Driving loaded
Driving empty
Unloading and unloading drive
Forest road
Log piles at landing


Driving only
Loading and Loading drive
Crane work only
Other time
Simultaneous crane work and driving
Work elements in forwarding
Driving loaded
Driving empty
Unloading and unloading drive
Forest road
Log piles at landing

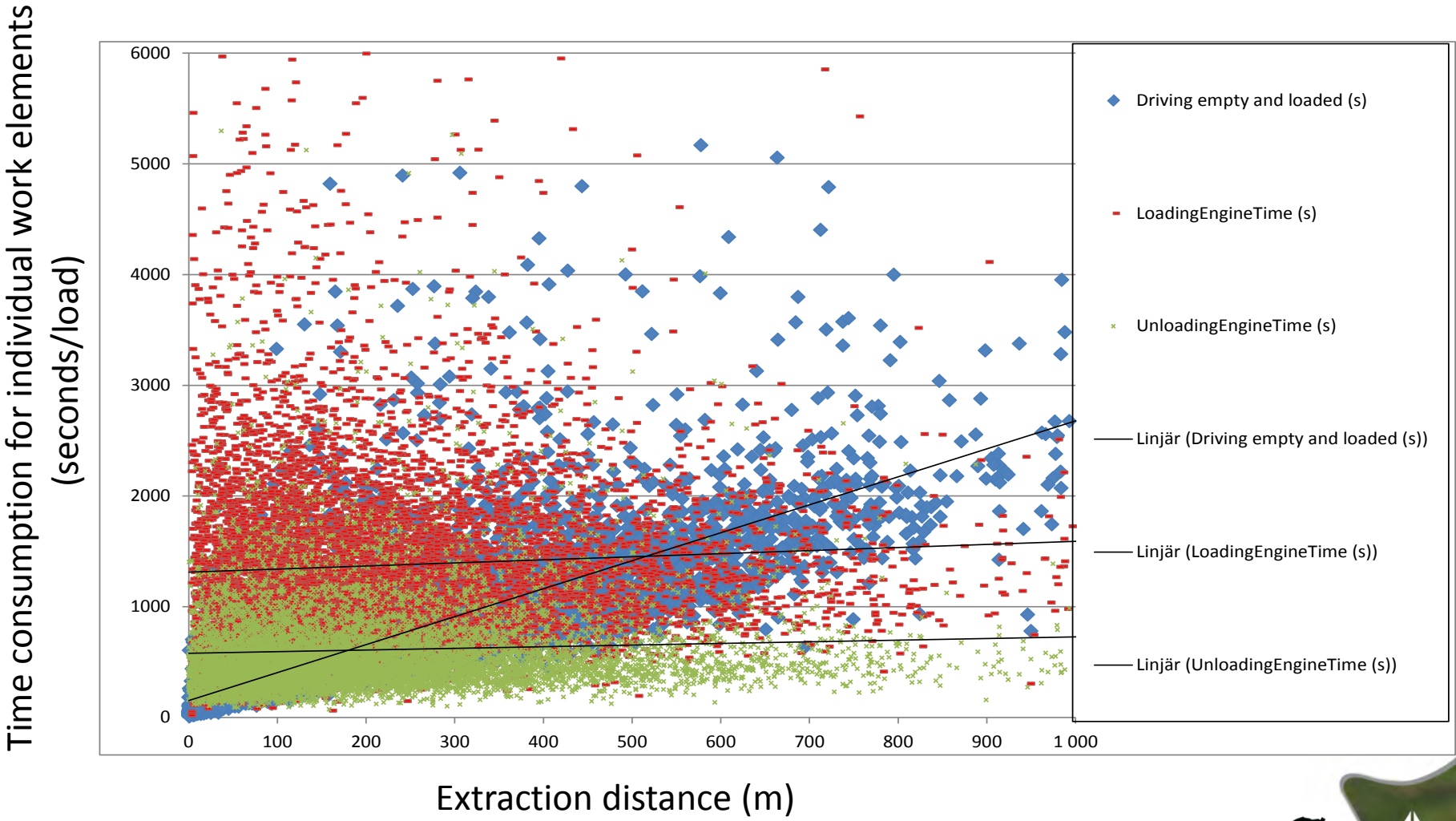

Loading and Loading drive
Definitions on driven distances in this presentation
Driving loaded
Driving empty
Unloading and unloading drive
Forest road
Log piles at landing


Loading and Loading drive
"Total driven distance"
Adding all distances
for a load together
Definitions on
driven distances
in this presentation
Driving loaded
Driving empty
Unloading and
unloading drive
Forest road
Log piles at landing


Loading and Loading drive
"Extraction distance"
Driving loaded +
Driving empty divided
by two
"Total driven distance"
Adding all distances
for a load together
Definitions on
driven distances
in this presentation
Driving loaded
Driving empty
Unloading and
unloading drive
Forest road
Log piles at landing

Results

If just looking on some raw data plotted for each load, it is obvious that the variation is big, but also that are some connections between variables



Results

Some average values for the whole dataset

The median total driven distance was 666 m/load

The median extraction distance was 174 m/load

Results

Some average values for the whole dataset

The median total driven distance was 666 m/load

The median extraction distance was 174 m/load

The median forwarding time was 42.1 minutes/load

Results

Some average values for the whole dataset

The median total driven distance was 666 m/load

The median extraction distance was 174 m/load

The median forwarding time was 42.1 minutes/load

The median fuel consumption was 8.5 l/load, or 12.4 l/km during driving

Results

Some average values for the whole dataset

The median total driven distance was 666 m/load

The median extraction distance was 174 m/load

The median forwarding time was 42.1 minutes/load

The median fuel consumption was 8.5 l/load, or
12.4 l/km during driving

The average speed was 3.3 km/h during Driving empty
2.8 km/h during Driving loaded
2.2 km/h during Loading drive

Results

Some average values for the whole dataset

The median total driven distance was 666 m/load

The median extraction distance was 174 m/load

The median forwarding time was 42.1 minutes/load

The median fuel consumption was 8.5 l/load, or
12.4 l/km during driving

The average speed was

3.3 km/h during Driving empty
2.8 km/h during Driving loaded
2.2 km/h during Loading drive

Results

The average fuel consumption for all loads together on the two forwarder was:

17.3 – 23.1 l/hour during *Driving loaded*

19.0 – 20.3 l/hour during *Driving empty*

11.5 – 12.8 l/hour during *Loading* (including *Loading drive*)

10.8 – 11.7 l/hour during *Unloading* (including *Unloading drive*)

Results

The average fuel consumption for all loads together on the two forwarder was:

17.3 – 23.1 l/hour during *Driving loaded*

19.0 – 20.3 l/hour during *Driving empty*

11.5 – 12.8 l/hour during *Loading* (including *Loading drive*)

10.8 – 11.7 l/hour during *Unloading* (including *Unloading drive*)

Driving consumes about 70% more fuel per hour than loading and unloading

Time consumption

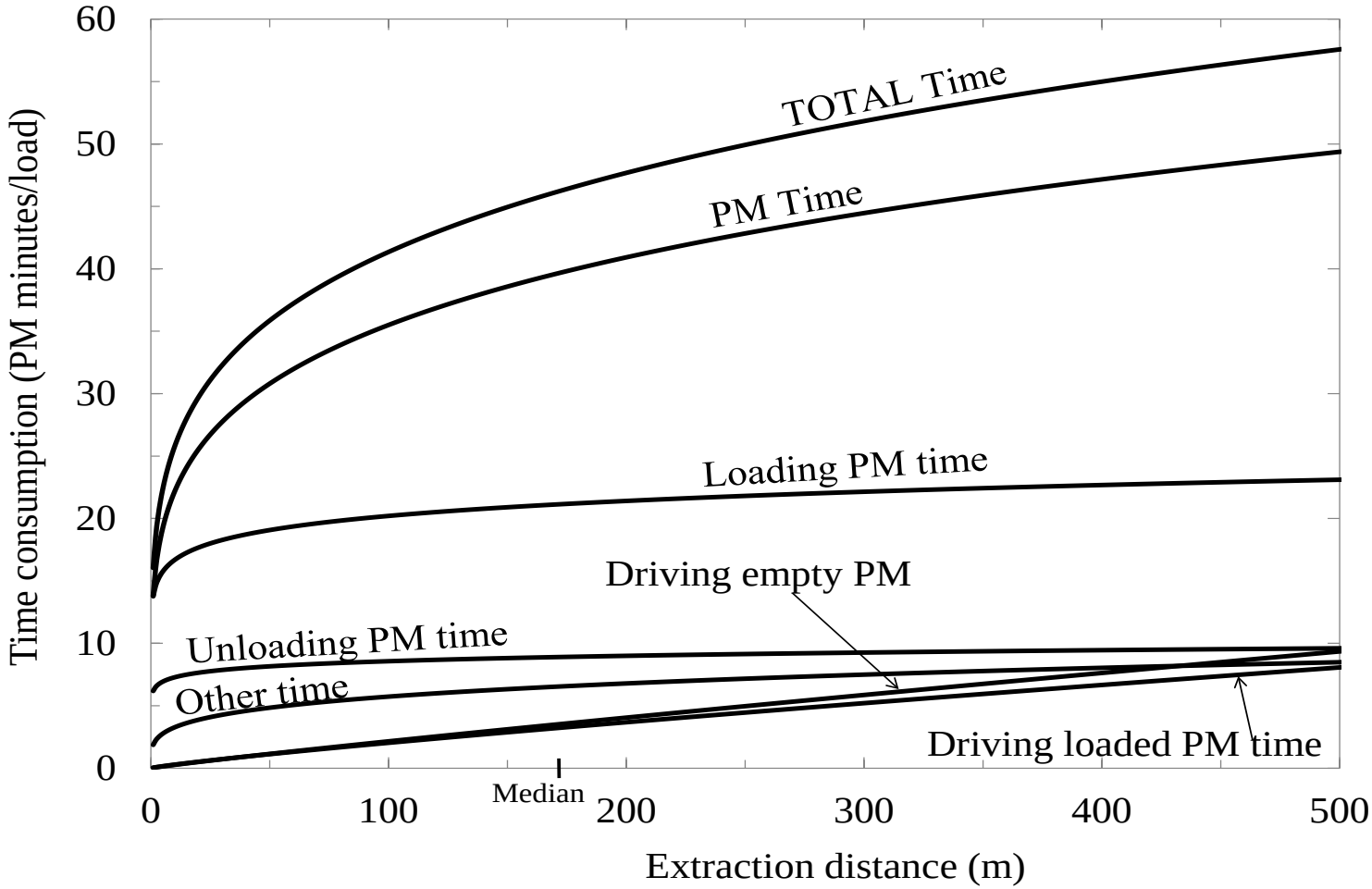


Figure. The total and productive machine time (PM time) consumption per load as function of extraction distance (mean of *Driving loaded* and *Driving unloaded* distances).

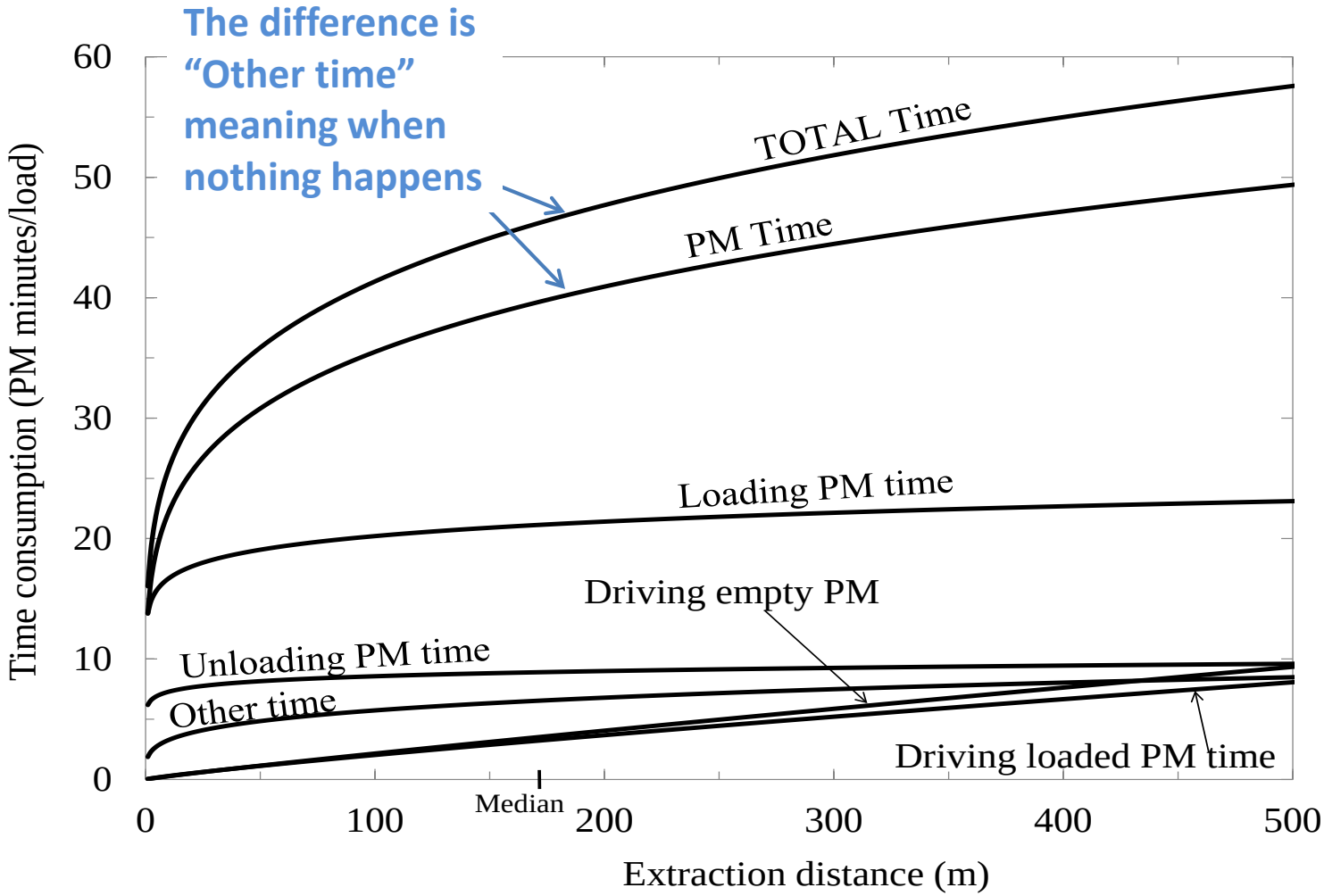


Figure. The total and productive machine time (PM time) consumption per load as function of extraction distance (mean of *Driving loaded* and *Driving unloaded* distances).

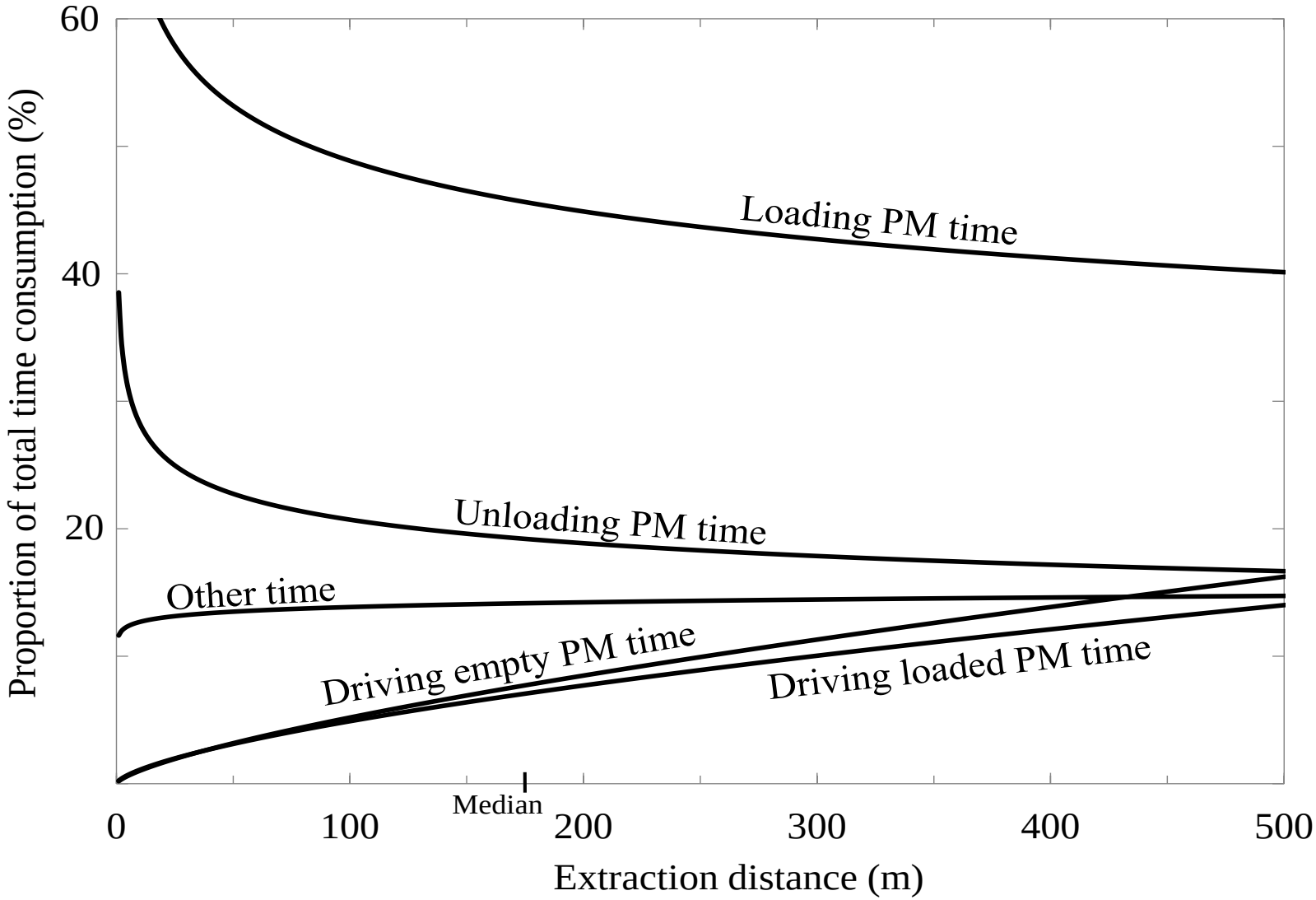


Figure. The proportion of time consumption for work elements as function of extraction distance (mean of *Driving loaded* and *Driving unloaded* distances).

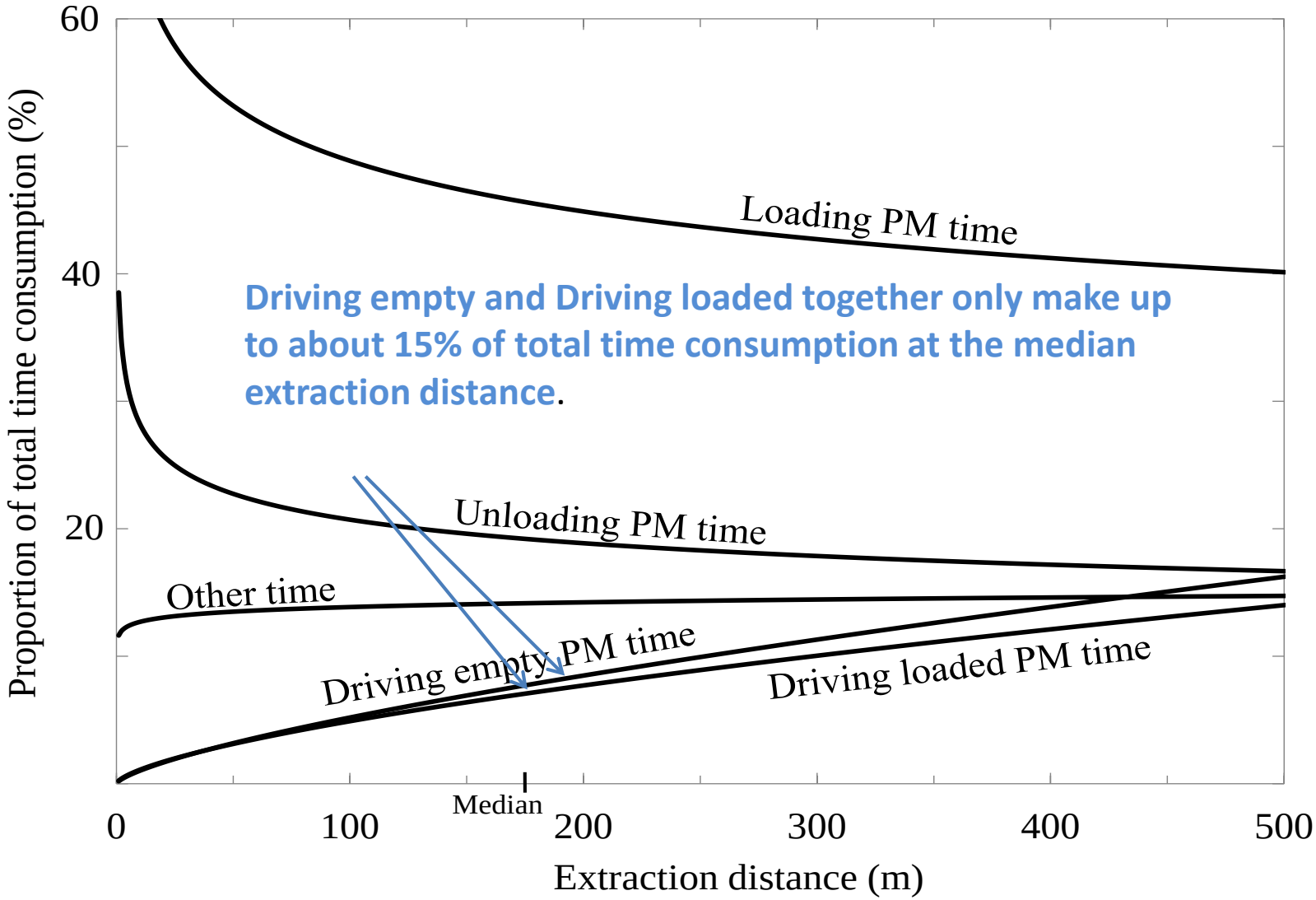


Figure. The proportion of time consumption for work elements as function of extraction distance (mean of *Driving loaded* and *Driving unloaded* distances).

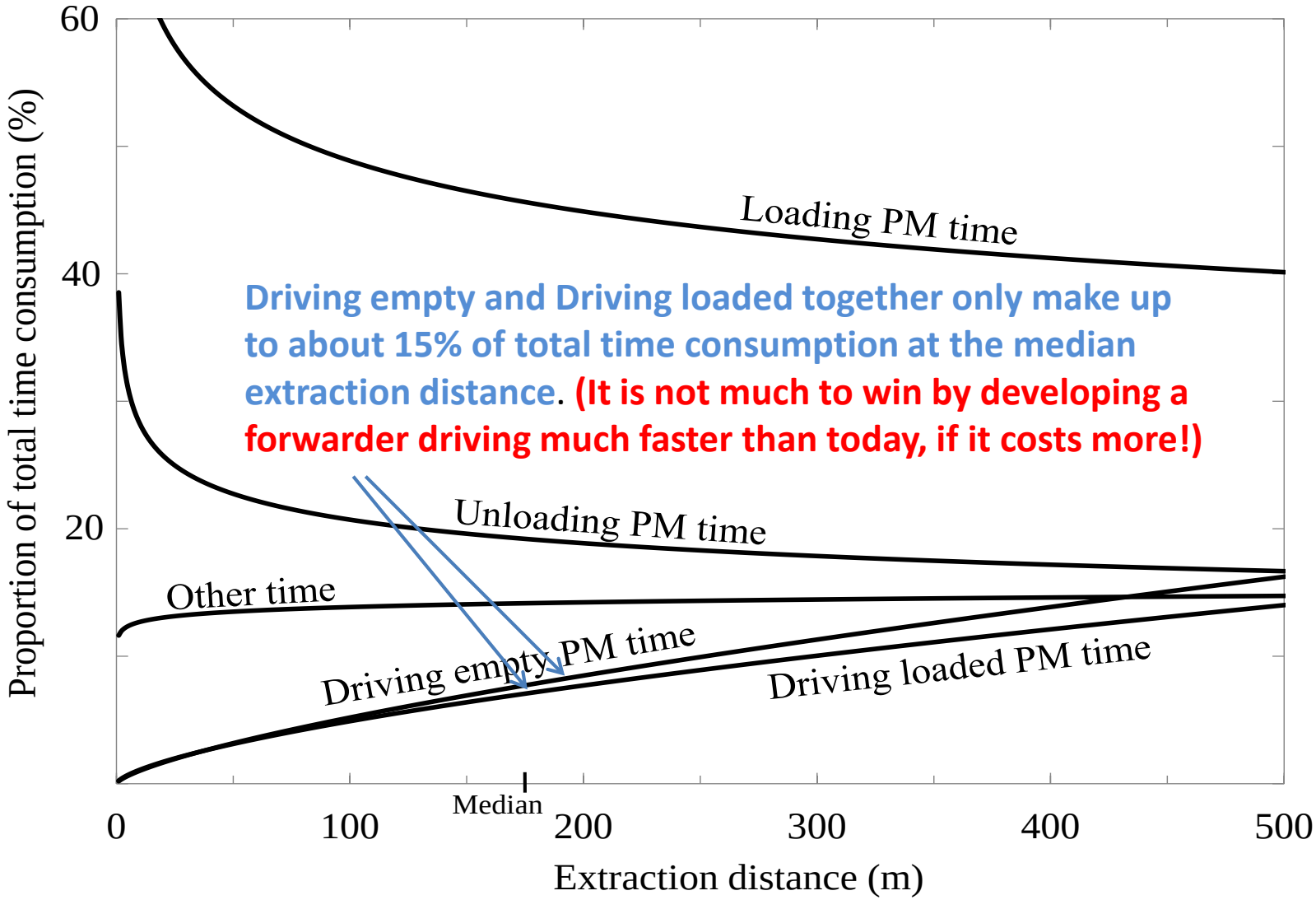


Figure. The proportion of time consumption for work elements as function of extraction distance (mean of *Driving loaded* and *Driving unloaded* distances).

Fuel consumption

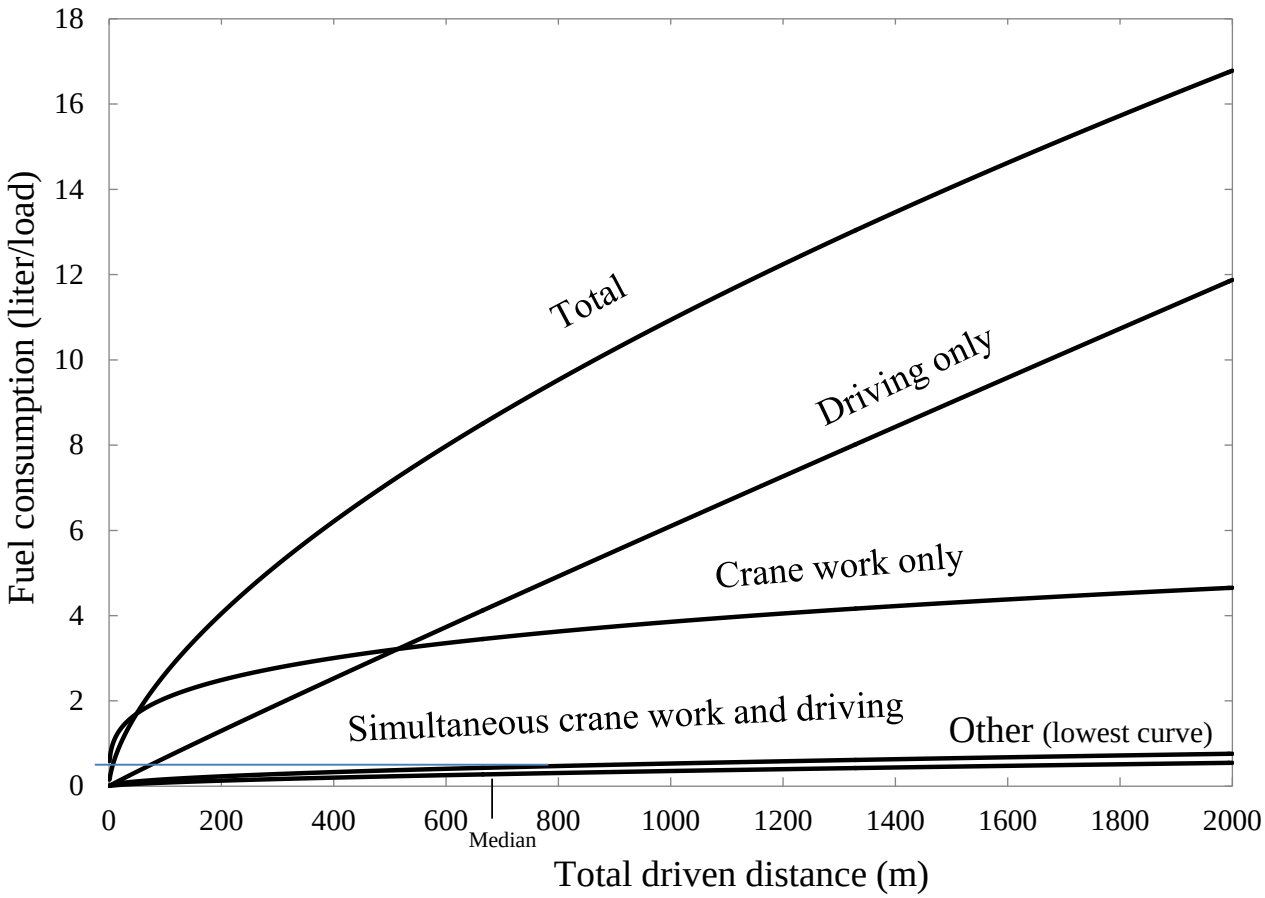
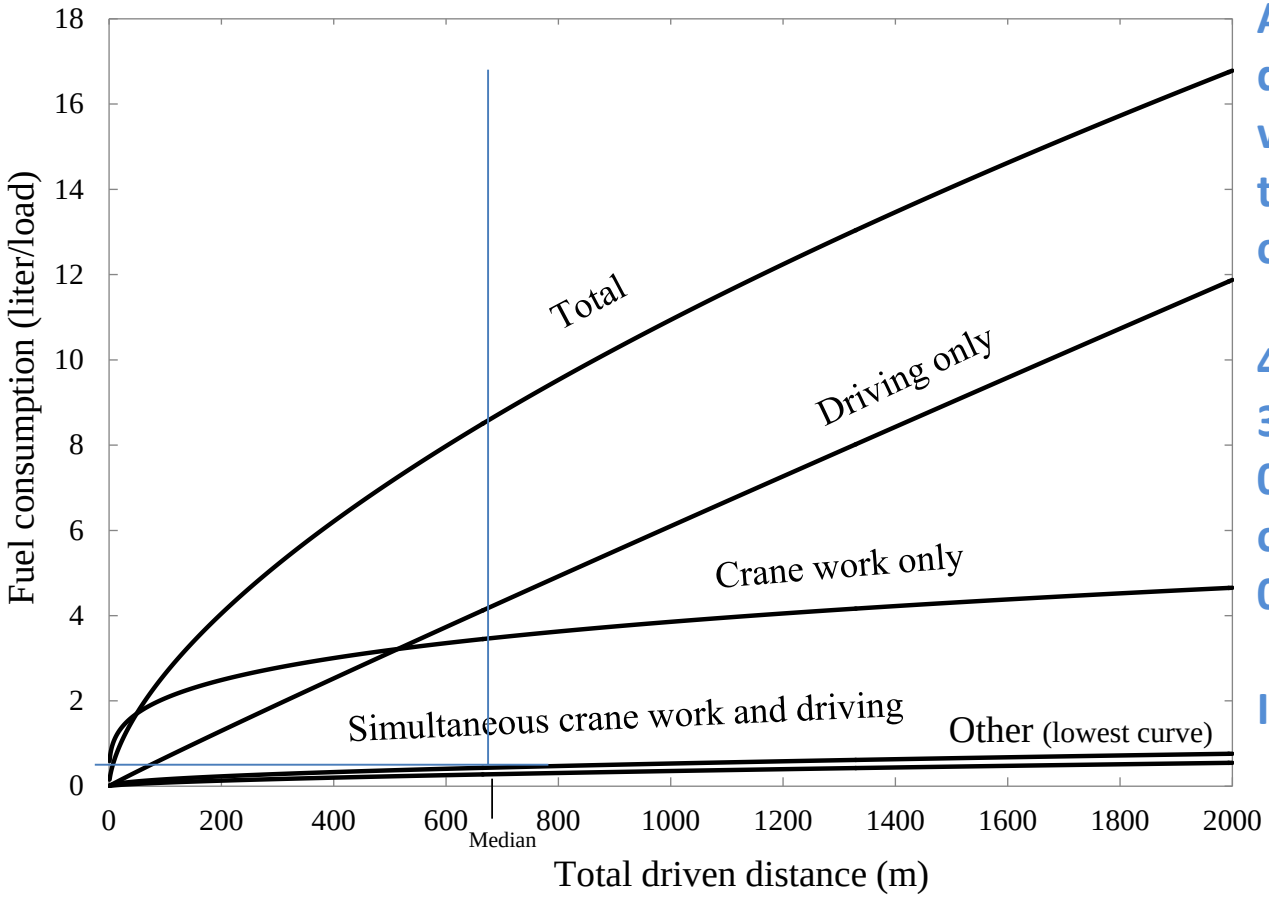


Figure. Fuel consumption (l/load) as function of total driven distance (m) during separate work elements and in total.



At median total driven distance and for a load with a large forwarder, the typical fuel consumption per load is:

4.3 l for "Driving only"
3.6 l for "Crane work only"
0.5 l for "Simultaneous crane work and driving"
0.2 l for "Other time"

In total 8.5 l/load

Figure. Fuel consumption (l/load) as function of total driven distance (m) during separate work elements and in total.

Conclusions

This study contribute both with new knowledge on possibilities with this new way of data gathering technology, and also with representative data on forwarding time consumption in a up to now unmatched quantity and resolution.

Conclusions

This study contribute both with new knowledge on possibilities with this new way of data gathering technology, and also with representative data on forwarding time consumption in a up to now unmatched quantity and resolution.

Such information is crucial e.g. for simulation studies, costing and developing forwarding decision support systems.

Conclusions

This study contribute both with new knowledge on possibilities with this new way of data gathering technology, and also with representative data on forwarding time consumption in a up to now unmatched quantity and resolution.

Such information is crucial e.g. for simulation studies, costing and developing forwarding decision support systems.

The variation between different operators was large, and this concerned all variables

Conclusions

This study contribute both with new knowledge on possibilities with this new way of data gathering technology, and also with representative data on forwarding time consumption in a up to now unmatched quantity and resolution.

Such information is crucial e.g. for simulation studies, costing and developing forwarding decision support systems.

The variation between different operators was large, and this concerned all variables

(A presentation dealing with operator behaviour is given tomorrow afternoon:
Evaluation of the educational influence on forwarder planning capacity
- Ola Lindroos)

Final Words

And, if you are interested in more details from the studies behind this presentation, just attend to the PhD dissertation by

Jussi Manner

11th of December 2015 at SLU in Umeå, Sweden

Tomas Nordfjell

Professor: Forest Technology

SLU, Umeå, Sweden