Cut to Length loggings and machine relocations in Eastern-Finland - discrete event simulation study

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Background


Photo: Koneviesti

- In Finland, the share of relocation time (incl. waiting of the relocation) from the total working time of the logging machine is 3-6 %.
- The requirements for the relocation trucks to meet sufficient trafficability and operating permits have increased.
  - Increased total mass of logging machines
  - 5 axle chassis is most used (investment prize roughly 220 k€, VAT-0)
- Entrepreneurs have their own relocation trucks, even with smaller ones
- In addition, joint owned trucks, co-operation of entrepreneurs operating in the same area and relocation service are the alternative and/or supplement methods
- Waiting for the coming relocations and relocation time cuts effective working time of logging machines

Objectives of the study

- Explore the interactions of harvesting machines and a relocation truck and clarify the impact of

  a) the size of the logging fleet,

  b) the size of the logging reserve, and

  c) work shift mode of a relocation truck,

  on the **work time distributions and logging costs**.

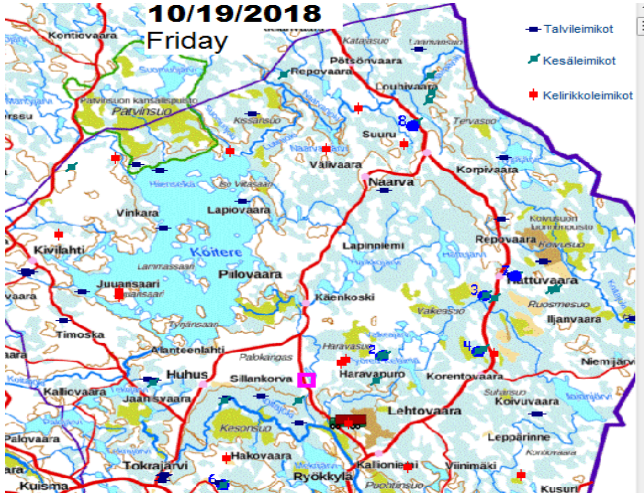
- In regards to time distributions, special interest was in time share of a) machine relocation and b) waiting for the relocation of total working time.

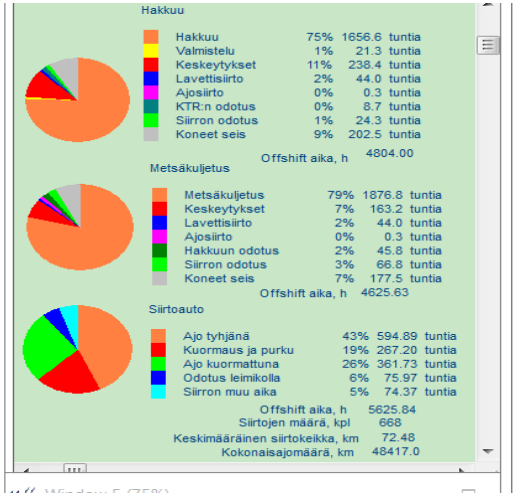
Holistic system analysis model for logging operations

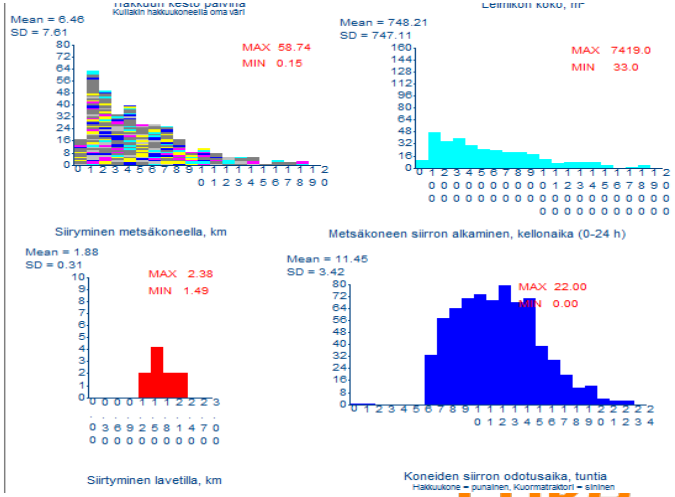
- By discrete event simulation (DES) method
  - dynamic, stochastic, comparability of logging scenarios
  - several probability distributions in use
- Flexibility in obtaining the logging site data a) from National Forest Inventory, b) from logging site history data of wood purchasing company or c) from purchased logging site data (standing sites)
- The ordering and selection of sites (i.e. site sequencing) for logging over the year is controlled by
  - Meet the demand of wood assortments of forest industry
  - Location of logging sites
  - Accessibility classification of logging sites
  - Time of the purchase date

DES-model of CTL-loggings

- Input data
  - Site data generated from the National Forest Inventory data, number of harvester-forwarder units, operation parameters, distributions and timing functions for the logging machines and the relocation truck, cost-accounting values, operational scheduling in weekly level, wood demand of forest industry
- Simulation of one year with 7 replications



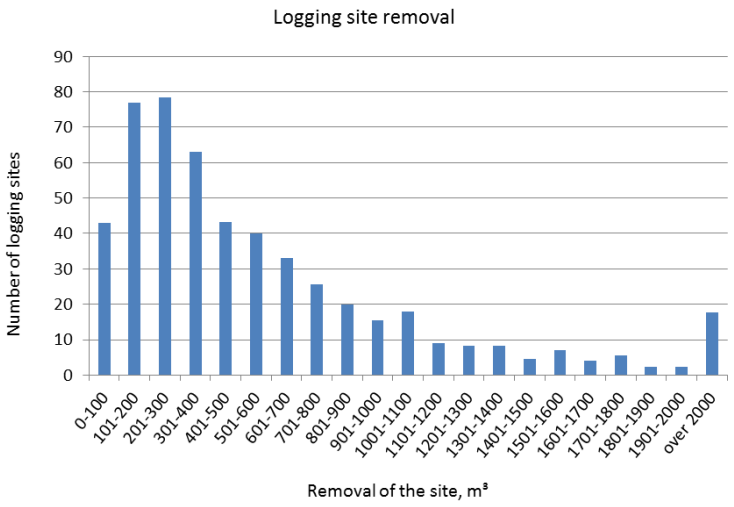


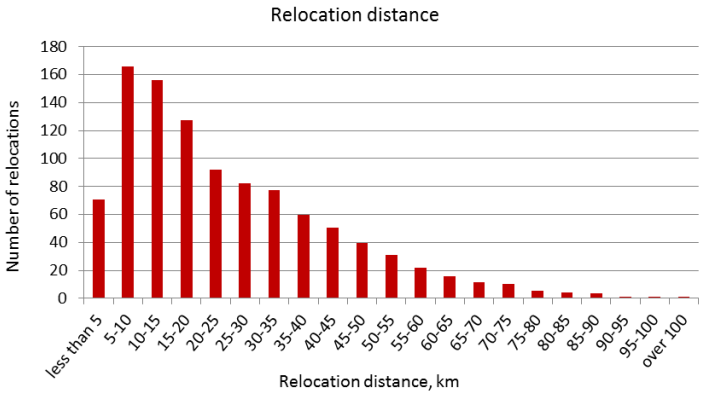


BAU-scenario descriptive data

BAU scenario was set to 8 H-F units (with one low bed truck)

- 1.5 months cuttings (39,150 m³ = 65 logging sites) of logging reserve in average over the year
- 604 m³ of mean site removal
- 0.25 m³ of mean stem size
- 358 m of mean forwarding distance
- 39,623 m³ of harvesting removal per year per H-F chain
- 8.7 (harvester) and 9.5 (forwarder) of mean working hours per day (adjustable work shift mode)
- 7.4 of active working hours per low-bed truck (avg.)
- 72,759 km of driving with low-bed truck per year
- 22.6 km of average relocation distance
- 2.1 hours of average trip time for relocation





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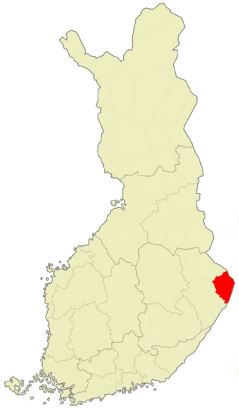
Simulation scenarios

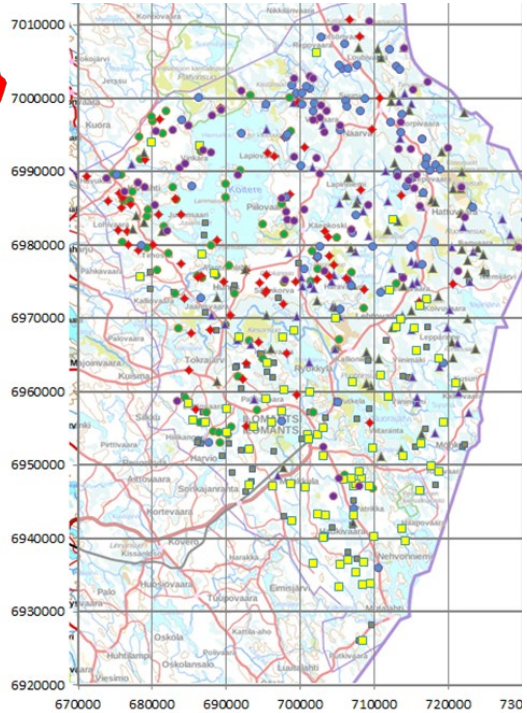
A. Size of the logging fleet
   - 2 harvester-forwarder (HF) units
   - 4 HF-units
   - 6 HF units
   - 8 HF units

B. Size of the logging reserve both for 4 and 8 H-F units
   - 0.6-0.8 months of cuttings
   - 1.3 months of cuttings
   - 2.8 months of cuttings

C. Work shift modes of relocation truck for 8 H-F units
   - 400 m³ of mean logging site
     - One 12 hours work shift
     - One 12 hours work shift plus extra shift if required
   - 600 m³ of mean logging site
     - One 12 hours work shift
     - One 12 hours work shift plus extra shift if required

– One low-bed truck was used in all scenarios





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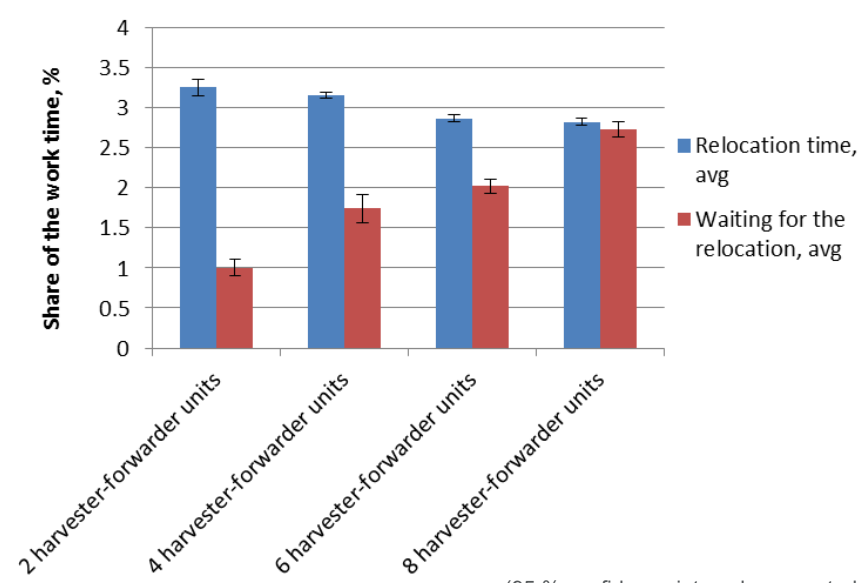
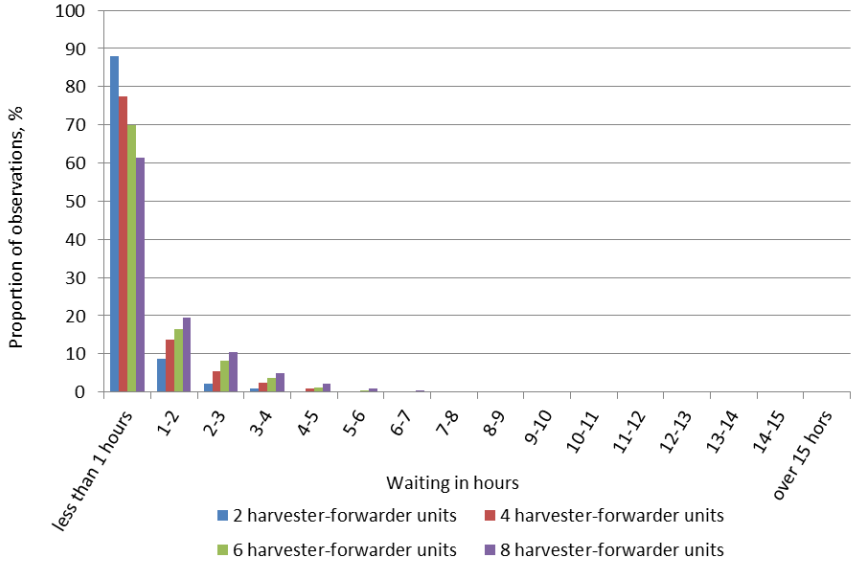
Results – Size of the logging fleet

- Time of machine relocation decreased due to shorter relocation distances
- Machines' waiting for the relocation increased due to relocation truck being more busy in scenarios with more machines

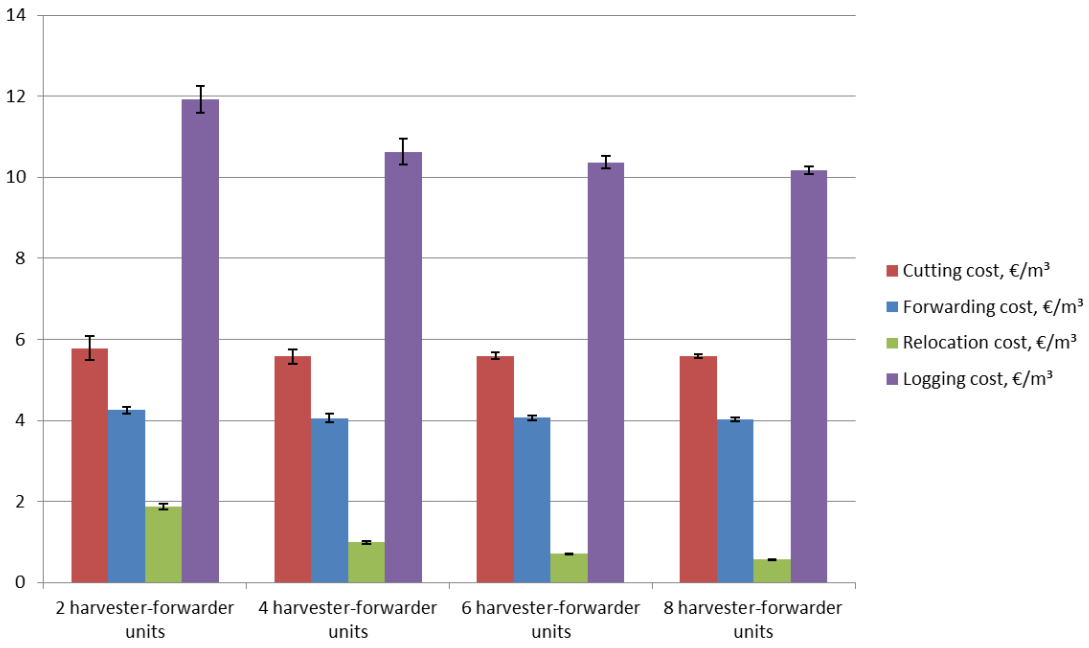




(95 % confidence intervals presented in bars)

Results – Size of the logging fleet

- Relocation cost decreased due to higher truck utilization and thus, fixed cost of relocation truck was divided to higher cutting removal per annum
  - from 2 H-F unit to 8 HF unit: -70%
- Cutting and forwarding costs decreased a bit mainly due to the diminishing of fixed costs (adm., maintenance, buildings) and shorter driving to work
  - from 2 H-F unit to 8 HF unit: -4.2%
- Decrease in harvesting cost from 2 H-F unit to 8 H-F unit: -14.6%



(95 % confidence intervals presented in bars)

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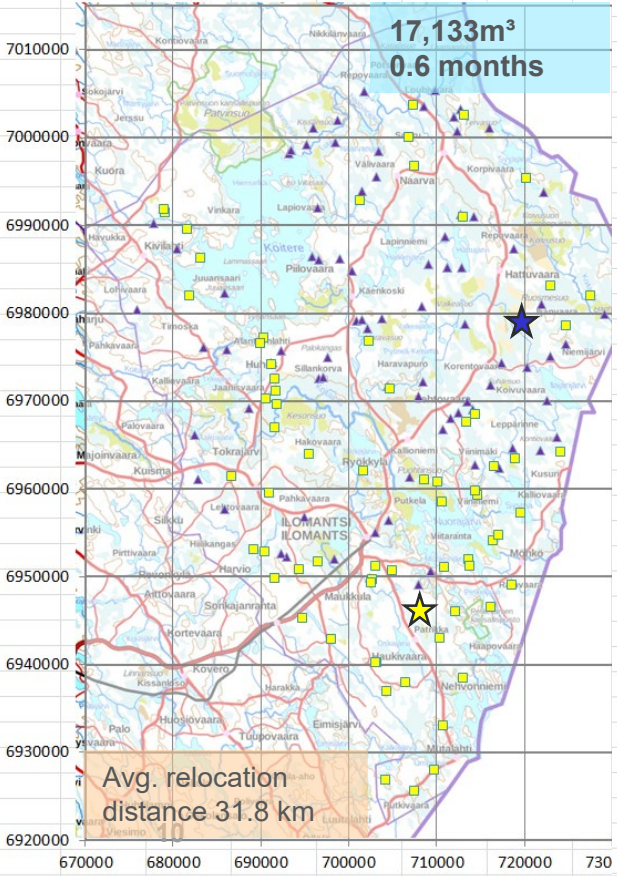
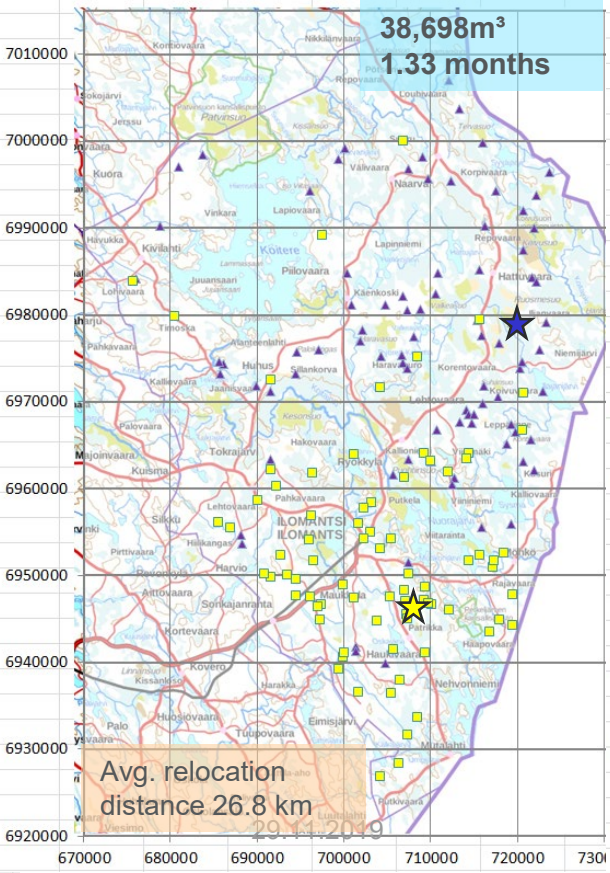
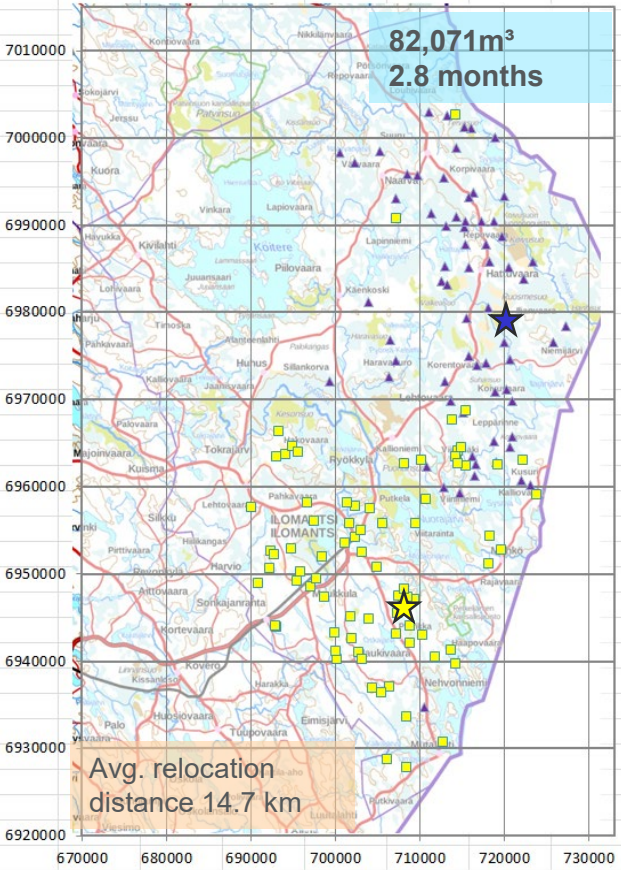
Results – Size of the logging reserve

Harvesting sites of the year operated by two harvester-forwarder chains in scenario of 8 H-F chains and one relocation truck (result of one replication)

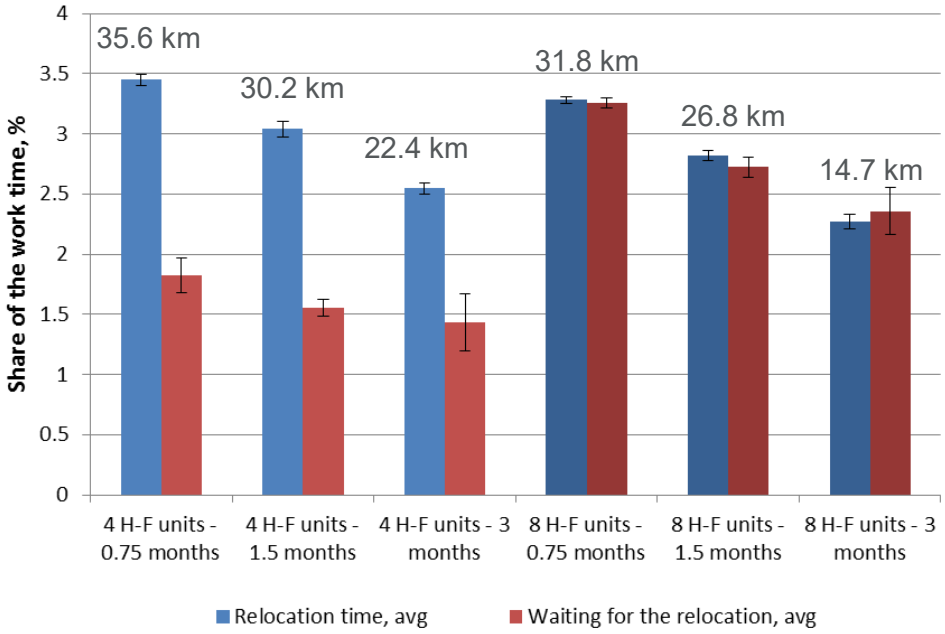






Results – Size of the logging reserve

- Machine relocation time and waiting of relocation decreased due to the increased logging site reserve in both cases of entrepreneur size (4 H-F and 8 H-F units)



Average relocation distances presented on top of bars

; presented in bars)

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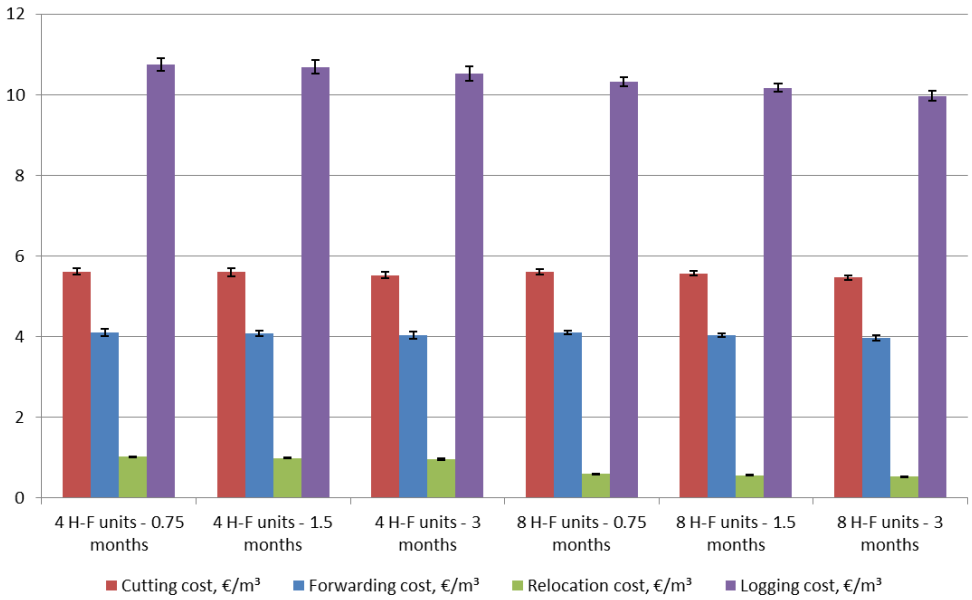
Results – Size of the logging reserve

- Decrease in logging costs while logging reserve increased from 0.75 to 3 months:
  - 4 H-F units: 2.0%
  - 8 H-F units: 3.3%



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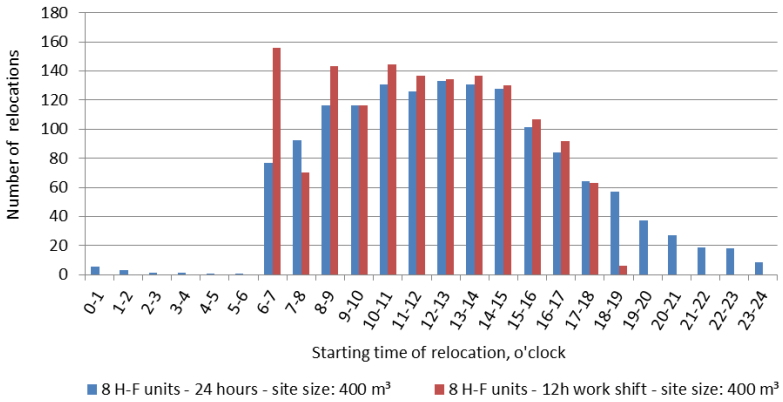
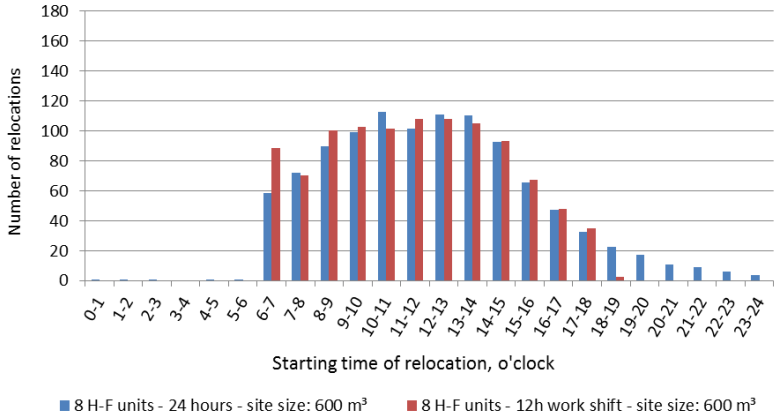
Results – Work shift modes of low-bed truck

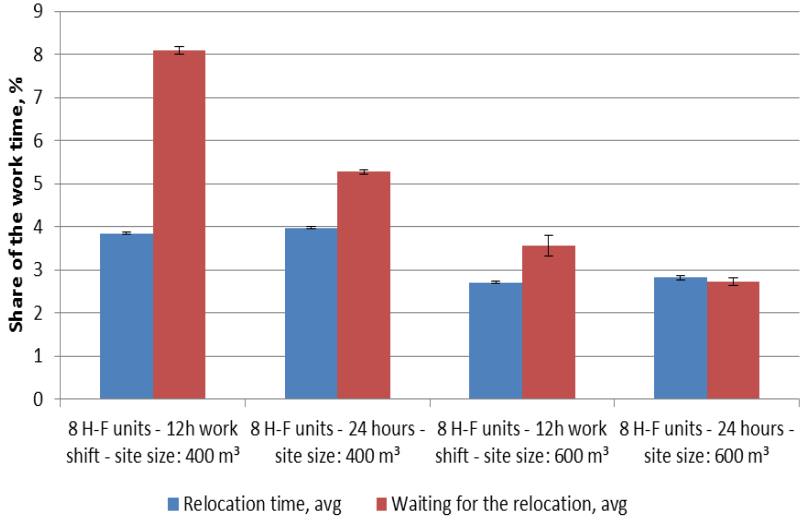
- Distribution of starting times of machine relocations
  - If work shift mode of relocation truck was 12 hours, peak of relocations occurred at start of the shift with the scenario: avg. site size of 400 m³
  - Use of the extra shift remained quite low in both avg. site size scenarios (400m³ and 600 m³)

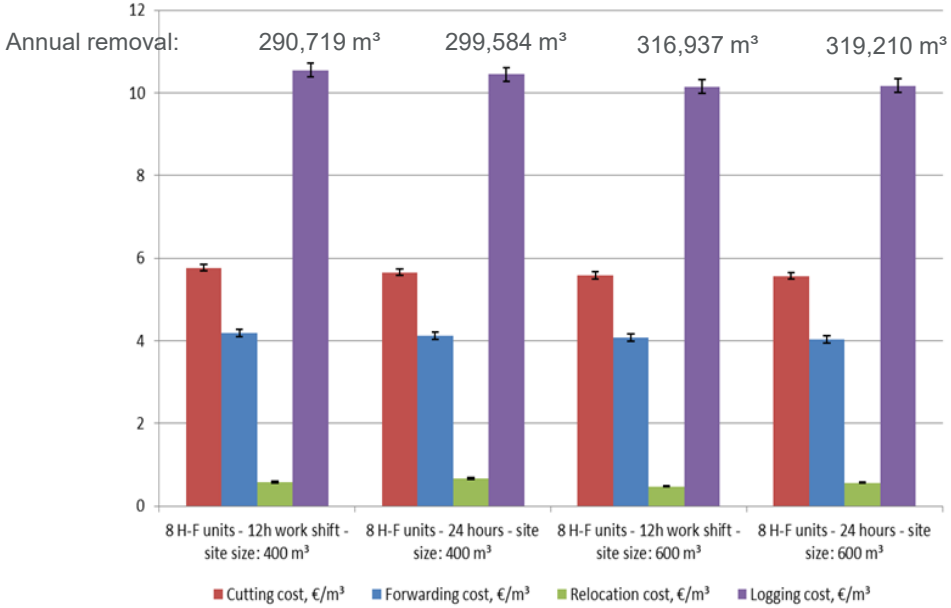




Results – Work shift modes of low-bed truck

- 12 hour work shift mode and smaller site size resulted highest time shares in waiting for the relocation (8 %)
- Extra shift added relocation costs 15-17%, machine costs decreased 1-2%
  - → No (statistical) difference in logging costs





Conclusions

- DES-model of CTL-loggings enabled to investigate interactions of logging machines and relocation truck
- Logging entrepreneurs having less than 4 H-F units tend to have quite much of free capacity for the relocation truck
  - Avg. operation hours per day 2.4 and 4.4 hours in 2 H-F and 4 H-F units scenarios
  - Price of relocation 17% and 10% of total logging costs in 2 H-F and 4 H-F units scenarios
- Bigger logging reserve enables better site sequencing, thus decreasing relocation distances between sites
  - Time duration for relocation and time for waiting of upcoming relocation decreased
  - Machine utilization increased 2-3 % while logging reserve increased from 0.6 to 2.8 months when average logging site was 400m³
- Work shift adjustment of relocation truck driver had a clear influence in waiting time for upcoming relocations while the number of relocations per day goes up

Conclusions

- Model can be used to test cost efficient operation models in specific fleet setup and logging conditions (logging sites)
- In each replication ordering of logging sites was randomly rearranged
  - Variation in regards to logging conditions
- The average size of logging site reserve was inquired from one logging entrepreneur
  - Variation within year, between regions and entrepreneurs
- In coming project model development will be conducted and logging cases are settled in different places in Finland

- Effective and efficient solutions for sequencing of logging sites for the each H-F unit are asked by logging entrepreneurs
- Nation vide relocation service of forest machines: www.siirrot.fi
  - Free capacity of relocation trucks can be sold via internet portal

Thank you!

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