Sensitive soil harvesting - research activities at FFRI

- **Research on several programmes:**
  - **Production forestry in drained peatlands (Jori Uusitalo et al.):**
    - machinery, methods for bearing capacity predicting, peatland forest management alternatives, secondary effects of soil damage, intelligent technogies in planning and implementation
  - **Forestcluster Ltd Less is more and EffFibre -projects (Antti Asikainen et al., Kari Väätäinen et al.):**
    - possibilities and influences of equipping machinery (Kari Väätäinen et al.)
    - Real time measuring of rut formation (Jari Ala-Ilomäki)
  - **Renewing wood product value chains and timber procurement solutions (PUU) 2009–2013**
    - Year round harvesting of Norway spruce stands (Matti Sirén et al.)

New solutions in management and harvesting of peatland forests

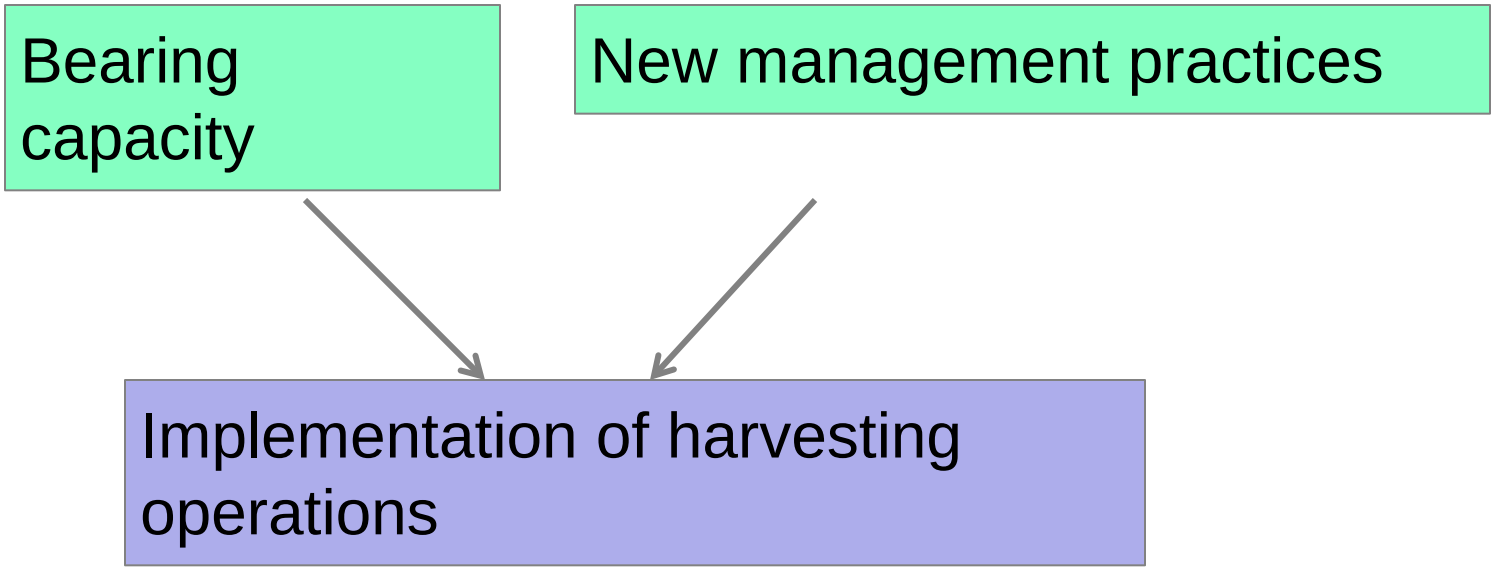
Jori Uusitalo

Jari Ala-ilomäki

Marika Salomäki

Pentti Niemistö

Harvesting under non-frozen conditions?



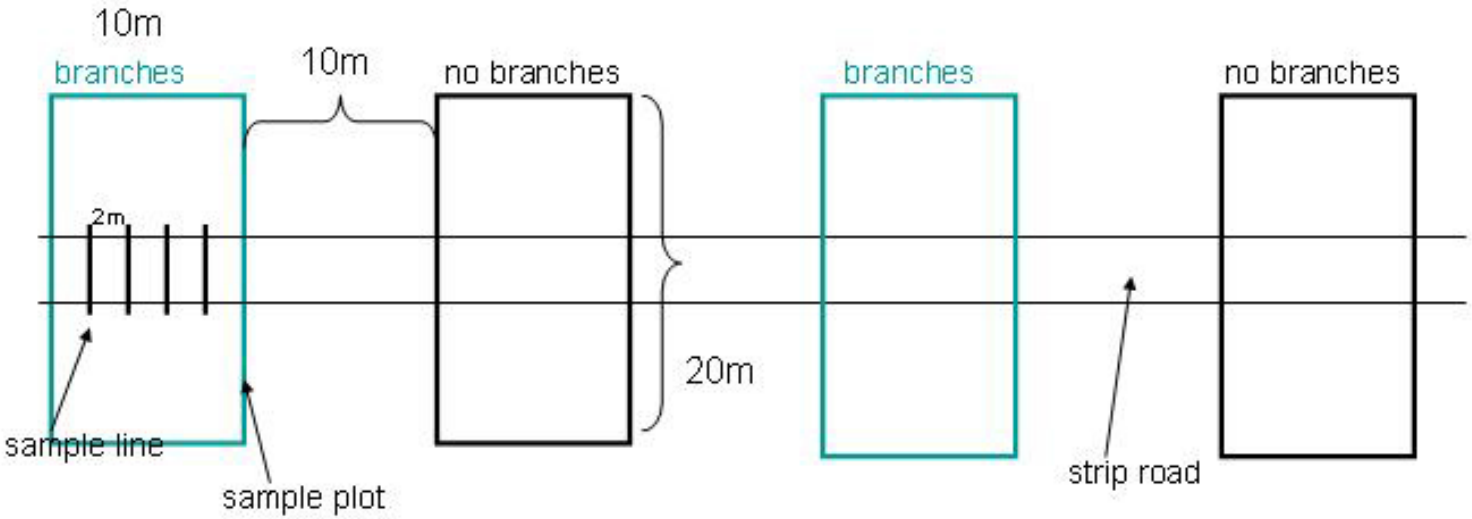
Characteristics of peatland forests – variation in and between stands

- 40 sample plots on drained peatlands
- first thinning stage
- stand measurements in 2007
- bearing capacity measurements in 2008
- permanent plots for bearing capacity (three stands)

Peat properties, shearing resistance

Root measurements

Summertime harvesting experiment



10 m measurement plot

Every 2 meters:

- Moisture
- Shear resistance
- Modulus of elasticity
- Penetration resistance

Harvester: John Deere 1270D

Forwarding

§ John Deere 1210 + tracks back and front

§ ProSilva track-based forwarder

”Intelligent techcniques in harvesting”

Maarit Haavisto
Tomi Kaakkurivaara
Jori Uusitalo
Ilkka Korpela (HY)

Laser scanning in peatland harvesting planning

Vuorijärvensuo

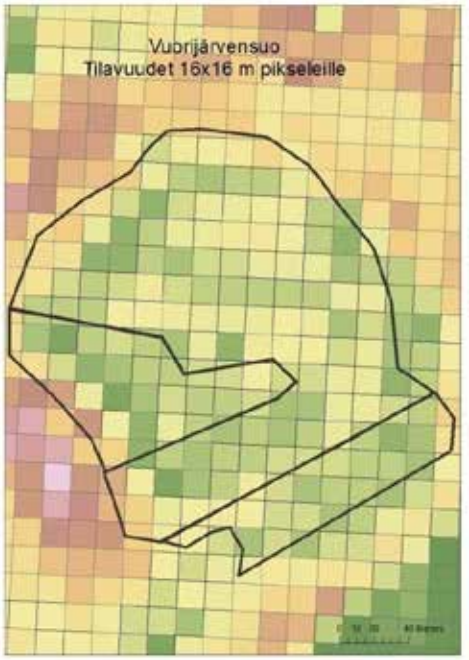
Area: ~ 4 ha

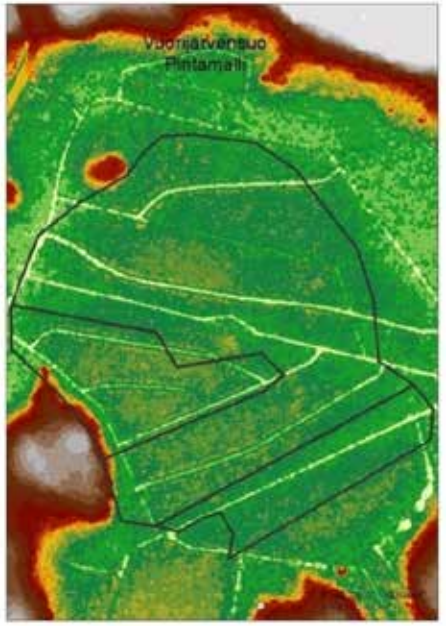
Volume: 138m^3/ha

METSÄHALLITUS

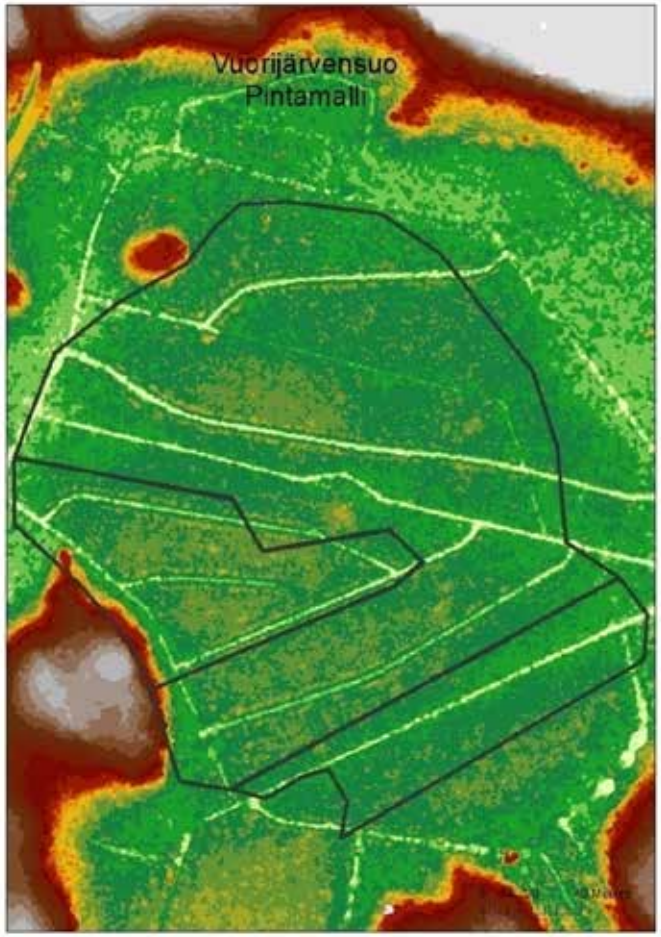
Laser scanning and planning

- Laser scanning can be used in planning
  - Stand volume (BA better than m^3)
  - Other vegetation?
  - Exact location of ditches
  - Ditch sides and mineral soil spots
- Locating strip road network, storage places

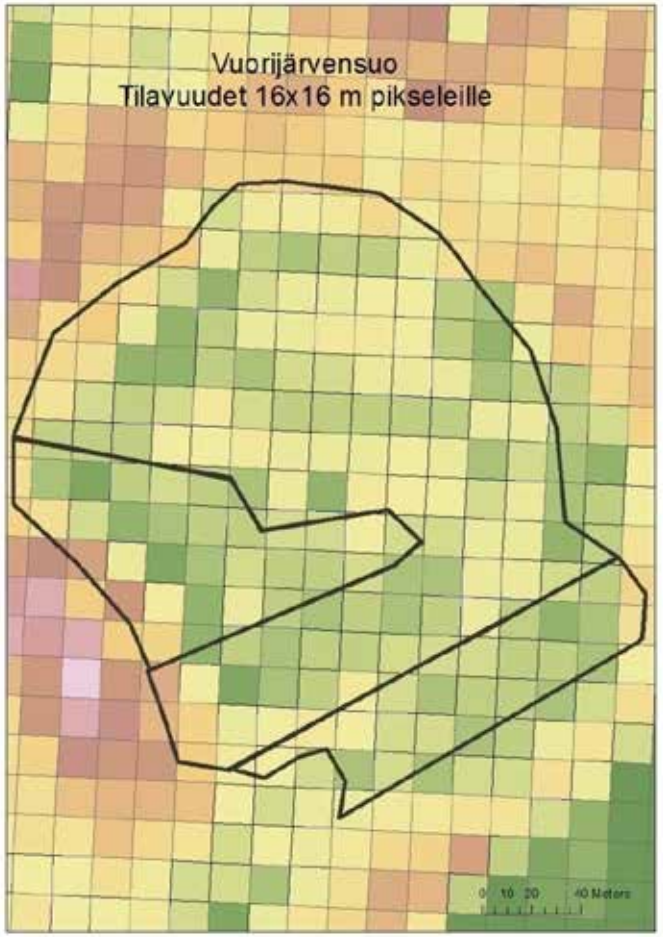




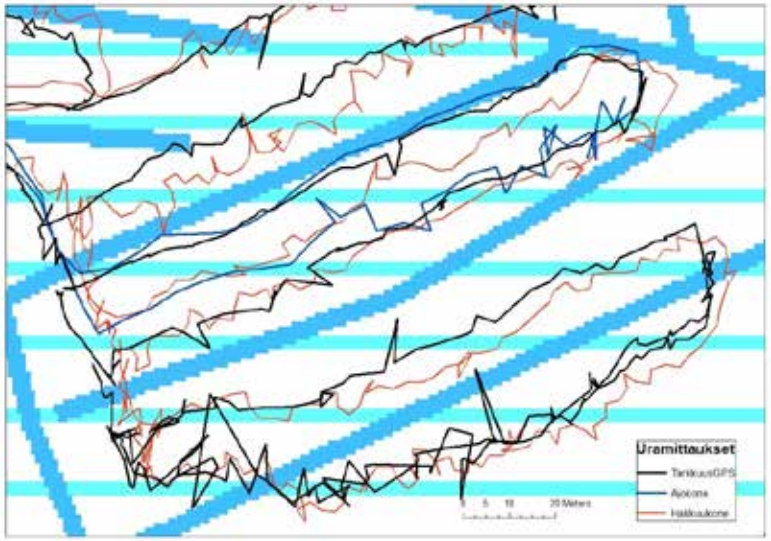
Surface model estimates



Volumes



Field measurements



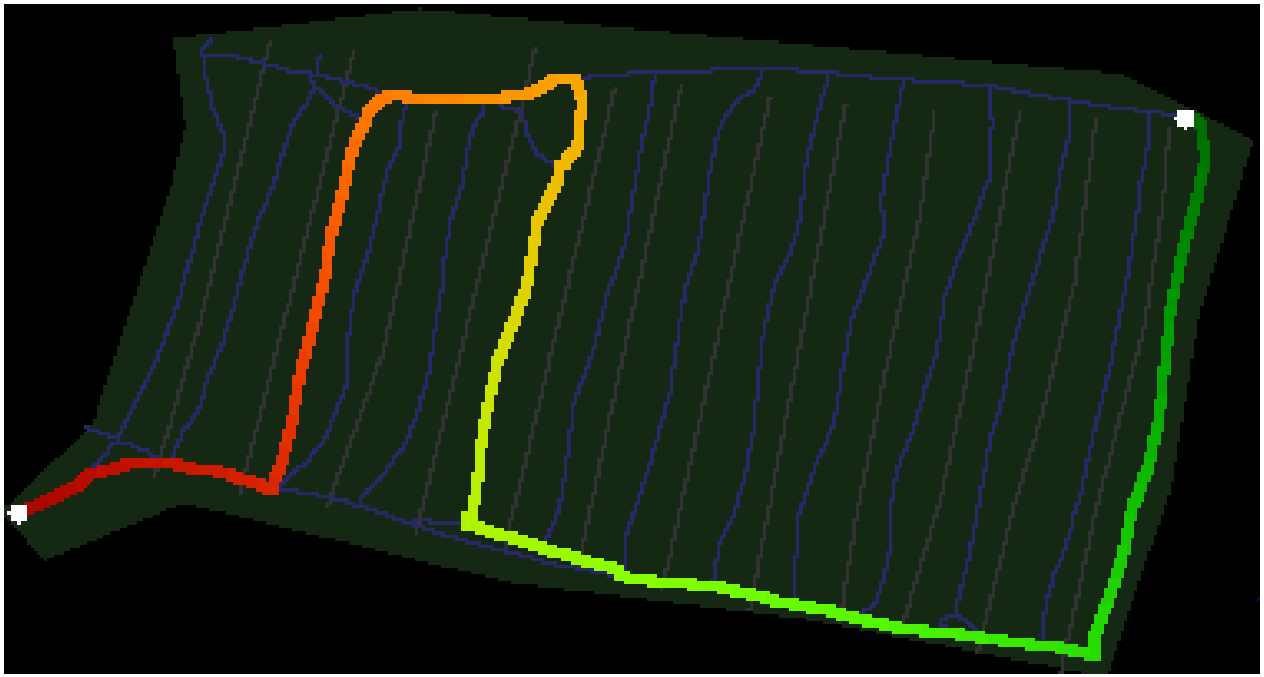
- Rut formation after cutting/forwarding
- GPS-positioning not always reliable

LOGTRACK-simulator

- Simulator
  - lays different timber sortiments on strip road sides
  - formulates possible driving routes
  - uses damage-coefficient to find "optimal" routes
  - simulates forwarding
- Output
  - location of piles
  - forwarding routes
  - soil stress (passed mass) on each point
  - volumes and metres
  - time consumptions

LOGTRACK-prosedure

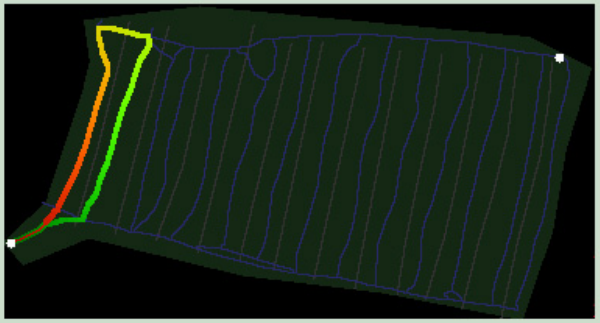
- Simulator generates all possible routes to storage
- “Optimal” way for hauling all timber with minimal soil damage



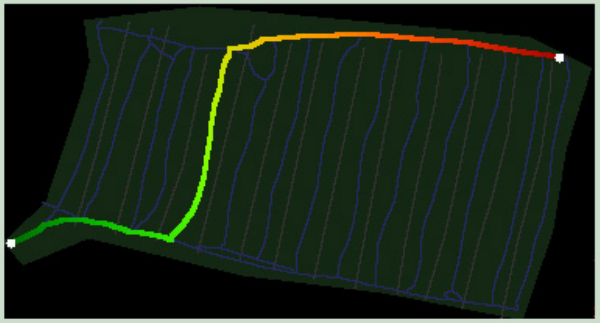
LOGTRACK-procedure: Visualisation

Manty-tukki Hieskoivu-tukki Manty-kuitu Hieskoivu-kuitu

Ajetut kuormat: Manty-kuitu



Kuormanumero 0
Kuorma: 9126.62 dm3
Matka: 368.81 m*
Ajo tyhjällä: 12.66 m*
Ajo vajaalla: 179.66 m*
Ajo täydellä: 176.49 m*
Ajoaika: 10.89 min
Kuormausaika: 18.46 min
Purkuaika: 5.15 min



Kuormanumero 1
Kuorma: 9481.33 dm3
Matka: 452.58 m*
Ajo tyhjällä: 60.97 m*
Ajo vajaalla: 194.09 m*
Ajo täydellä: 197.52 m*
Ajoaika: 12.77 min
Kuormausaika: 19.17 min
Purkuaika: 5.35 min

Kuormanumero 2
Kuorma: 9418.74 dm3
Matka: 450.27 m*
Ajo tyhjällä: 0.00 m*
Ajo vajaalla: 184.20 m*
Ajo täydellä: 266.07 m*
Ajoaika: 12.87 min
Kuormausaika: 19.05 min
Purkuaika: 5.31 min

Bearing capacity of peatlands (Jari Ala-Ilomäki)

- Bearing capacity consists two main components
  - Root system of trees, undergrowth and field layer
  - Peat material on varying degree of decomposition

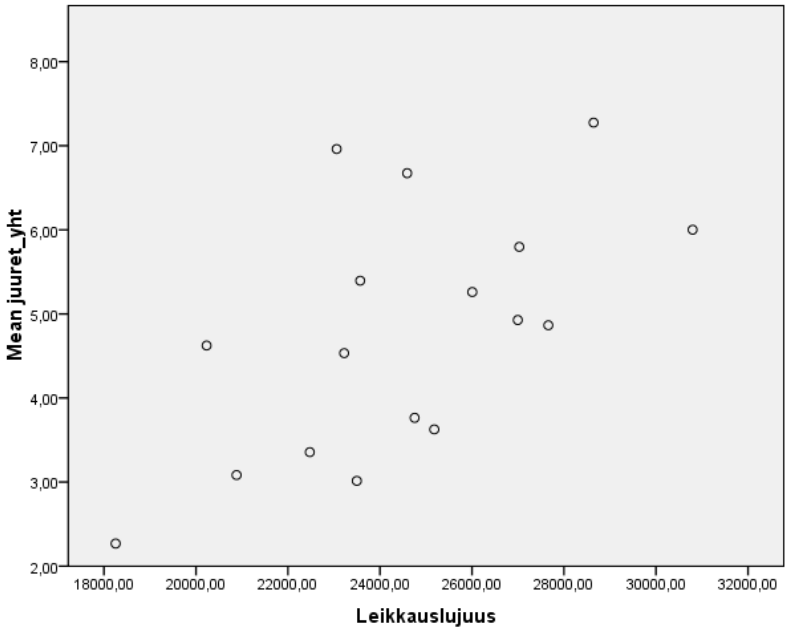
- Characteristics of these two components have influence on total bearing capacity of peatland, the first component usually being crucial

Spiked shear vane developed by Jari Ala-Ilomäki

- Blades of a conventional shear vane replaced with spikes
- Works like usual shear
- Spikes do not damage roots before measuring

Root system measurement

- Amount of root system can be estimated with shear vane
- Amount of roots and shear modulus are positively correlated (0.599, N=17, p=0,011)



Prediction of bearing capasity

- Stand volume and shear modulus of peatland surface layer found most reliable in predicting bearing capasity of peatland

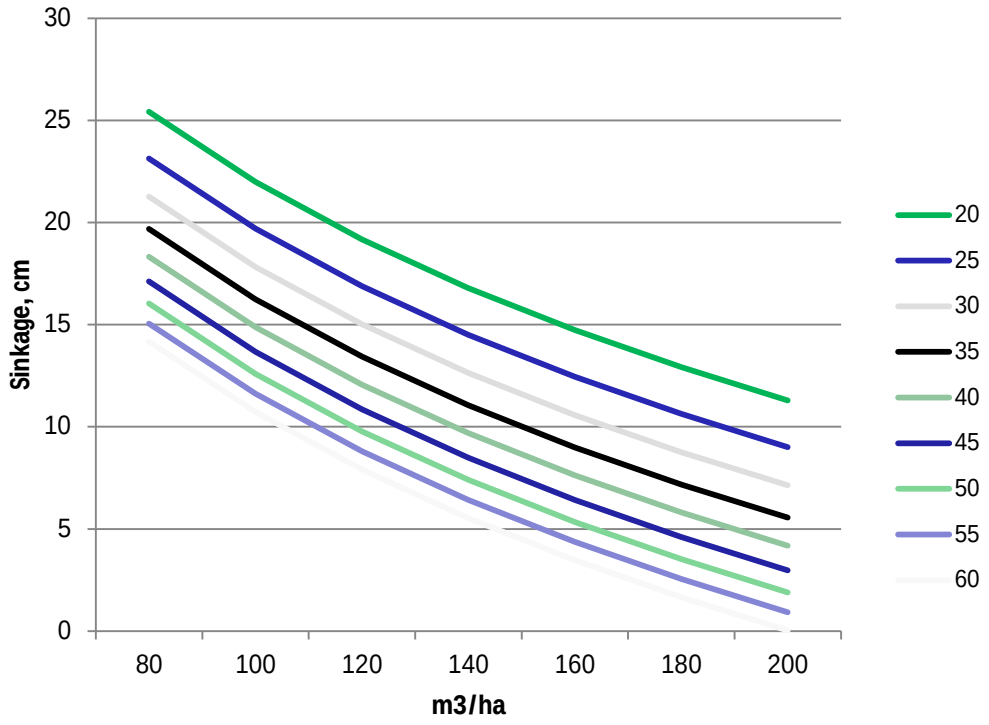
Dependent variable/ Model parameter	Rut depth after harvester, cm	Rut depth after one harvester and two forwarder passes, cm
Fixed		
b_0	68,7 (0,000)	124 (0,000)
Average shear modulus on plot, kPa	-6,93 (0.009)	-15,4 (0,000)
Ln_m3ha	-6,97 (0.014)	-10,3 (0,003)
[Debris=0]	7,51 (0,000)	
[Debris=1]	0	
[Debris=0] [FWD=Deere]*		6,80 (0,003)
[Debris=0] [FWD=ProSilva]*		-0,987 (0,566)
[Debris=1] [FWD=Deere]*		-0,269 (0,916)
[Debris=1] [FWD=ProSilva]*		0
Random		
var(u_l)	0.00	
var(e_{jkl})	43.1	

Estimation of bearing capacity for harvesting operations

Bearing capacity is affected by both stand volume and shear modulus

Example: Rutting after two passes with tracked machinery

Prosilva (residues on strip road) with varying shear modulus (G, kPa)



Allowed removal (m^3) for a particular strip road

	Bearing capasity class	1	2	3
	Shear modulus, kPa (*	20-30 kPa	30-40 kPa	50-60 kPa
	Removal, m^3/ha			
	Wheeled machinery with equipped for peatland (wide tracks)			
1	120-150	20	30	40
2	150-180	30	40	50
3	180-220	40	50	60
	Tracked machinery			
1	120-150	40	60	80
2	150-180	60	80	100
3	180-220	80	100	120

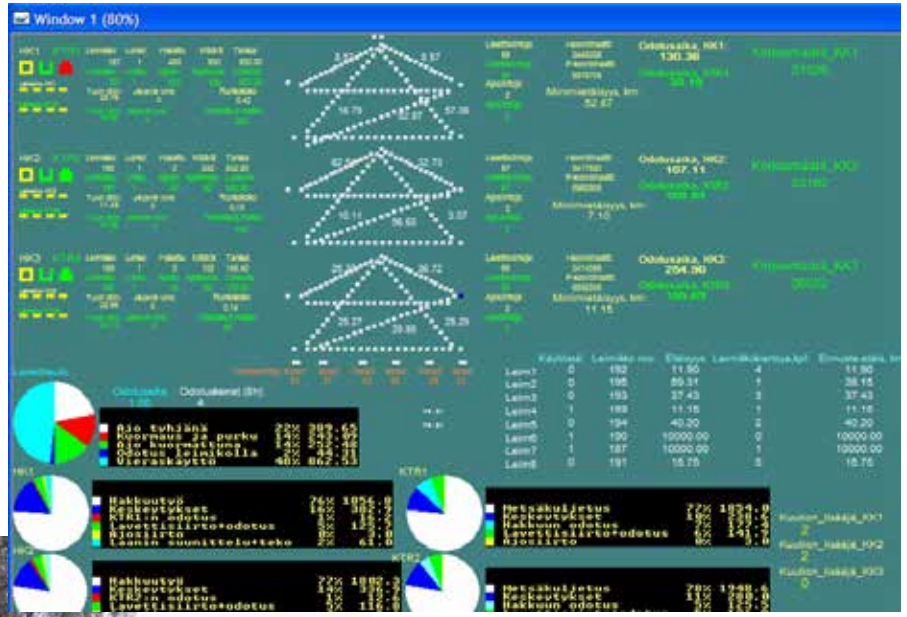
= extra wide primary strip roads

= extra wide secondary and primary strip roads

*= Shear modulus often correlates with the amount of undergrowth:
Class1=scarce Class2=moderate Class3=substantial

Year roud harvesting on peatlands - SIMULATION STUDY

(Kari Väätäinen et al., Less is more/Efftech)



Goal:

To find possible cost effects of machine equipping **on contracting company level**, when a large share of harvesting is on peatlands

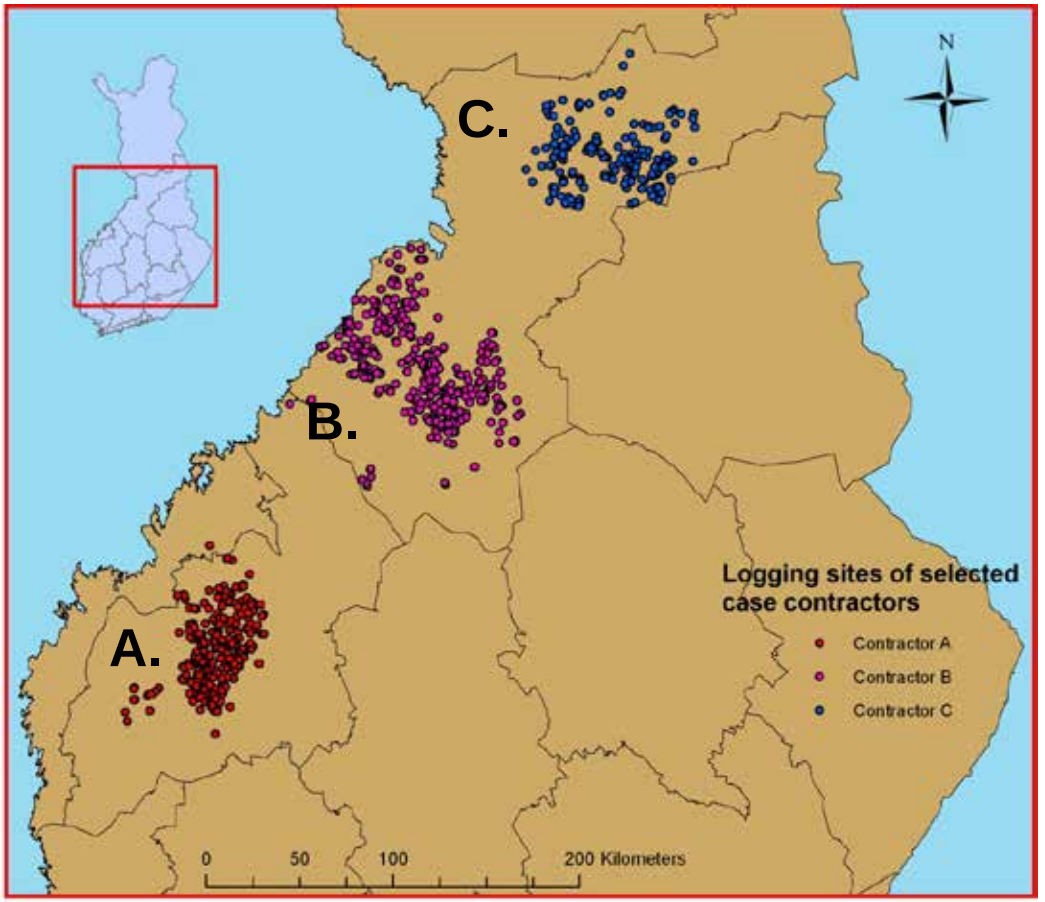
Material

Three machine enterprises,
each having 3 machine chains

Background information
for simulations based
on interviews

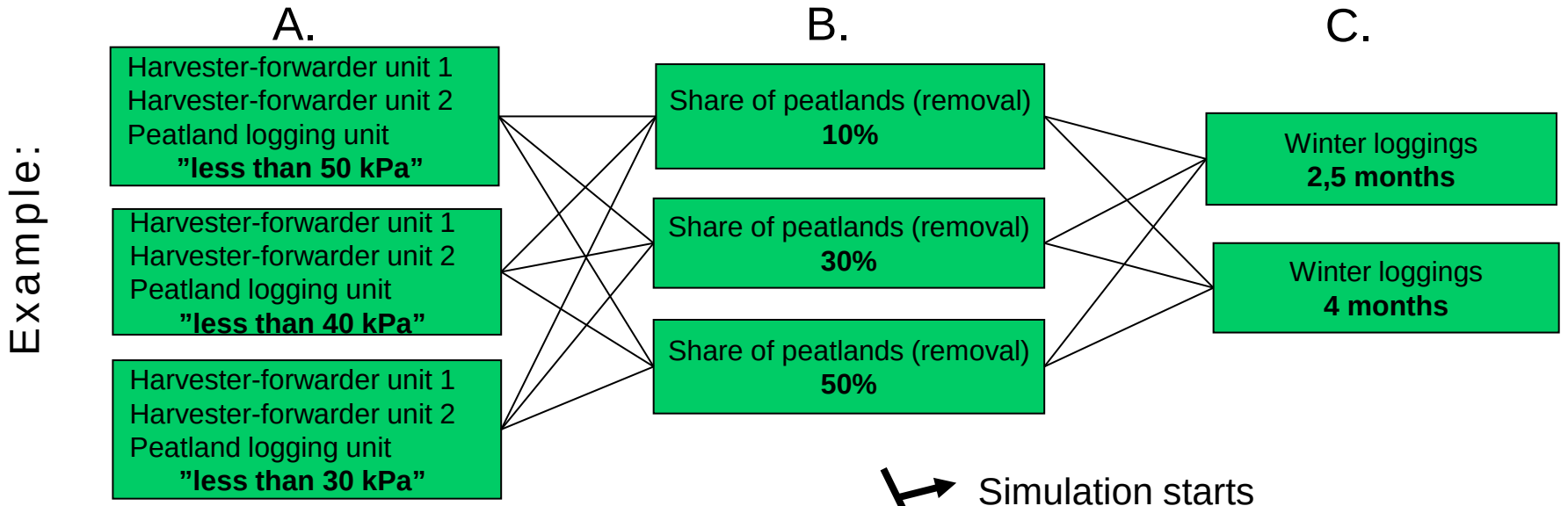
Percentage of volumes
coming from peatlands:

A. 16.3%
B. 22.2%
C. 33,4%

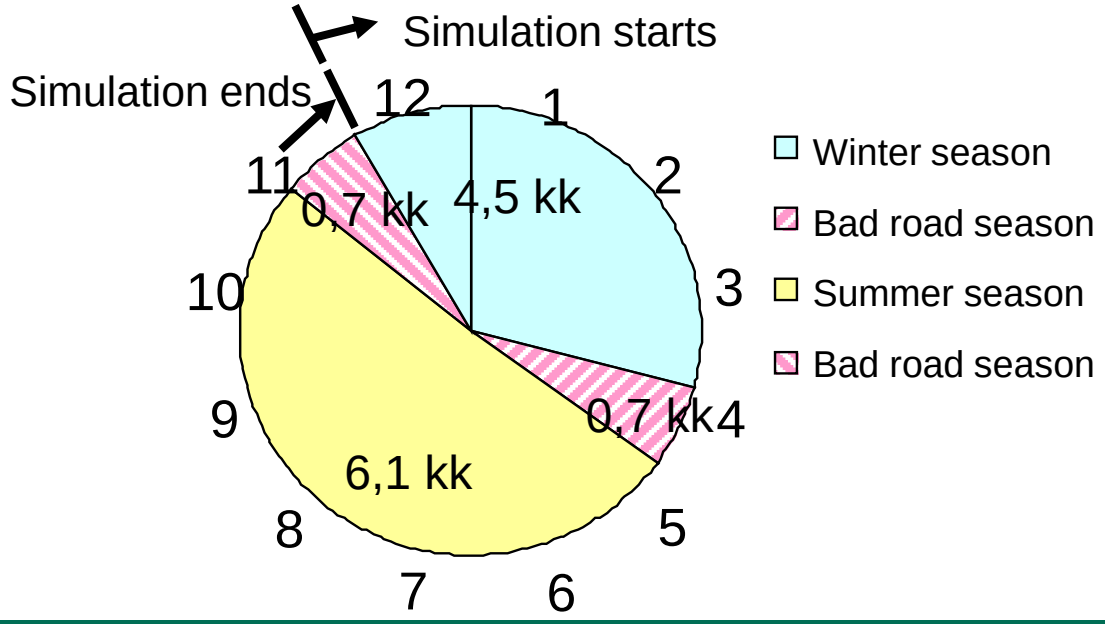


Simulation of year-round harvesting

Scenarios



- Each scenario was simulated by 5 replications/years (stochasticity)
- Simulation period was 344 days (22 holidays removed)



Simulation of year-round harvesting

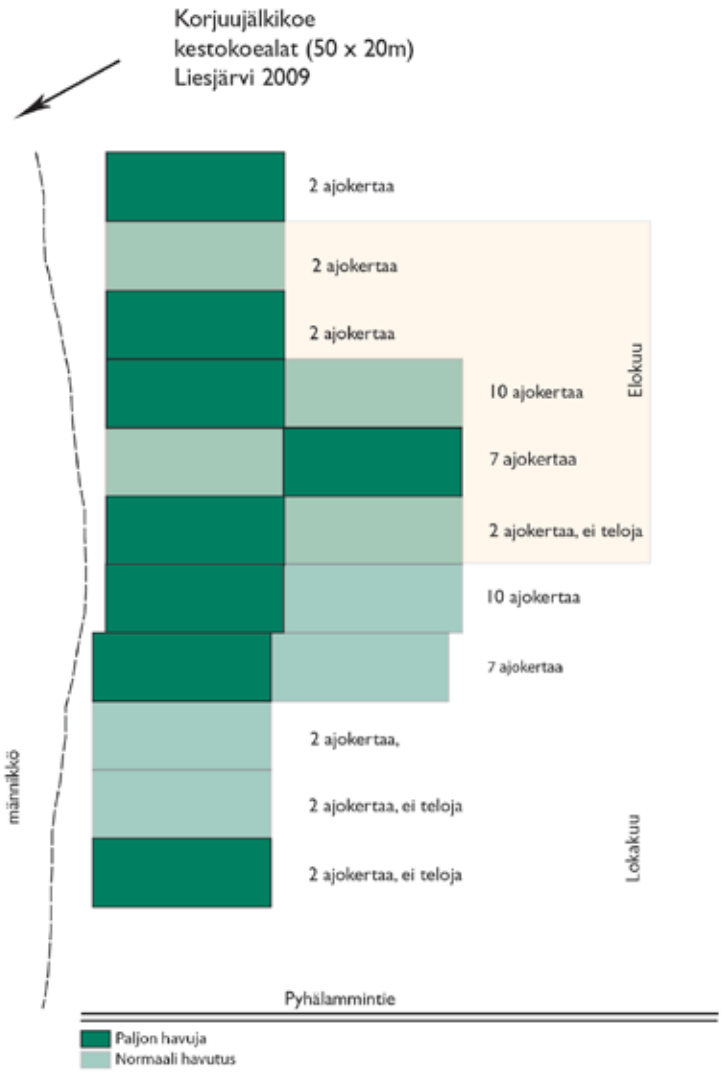
Results

- Unit costs varied from 9.61 €/m³ to 17.24 €/m³ depending the scenario and the case contractor
- Mean productivity in peatland loggings during the wintertime was 12.0 m³/h, Combined productivity in summertime and in wintertime with modification classes:
  - “Improved bearing” = 10.5 m³/h
  - “High bearing” = 10.7 m³/h
  - “Extreme bearing” = 10.9 m³/h
- Limited amount of logging sites during the unfrozen period favoured to harvest some of the peatland logging sites in summertime:
  - Increased logging opportunities
  - Decreased down-times
  - Lowered unit costs

→

- When the share of peatland loggings increased to 30 % and more, there was a compulsory need to modify one logging unit for soft soil loggings during the summertime

Year round harvesting of Norway spruce stands, experiments at Tammela 2009, Tuusula 2010 (Matti Sirén, Jari Ala-Ilomäki, Harri Mäkinen & Sami Lamminen)



- Effects of working method and machine equipping on soil damage in spruce stands
- Permanent sample plots for following possible growth effects and risk of root rot

(Harri Mäkinen, Tuula Piri)

METSÄHALLITUS

Soil properties measurements - soil type, stoniness, spiked shear vane, penetrometer + weight of residues, kg/m^2

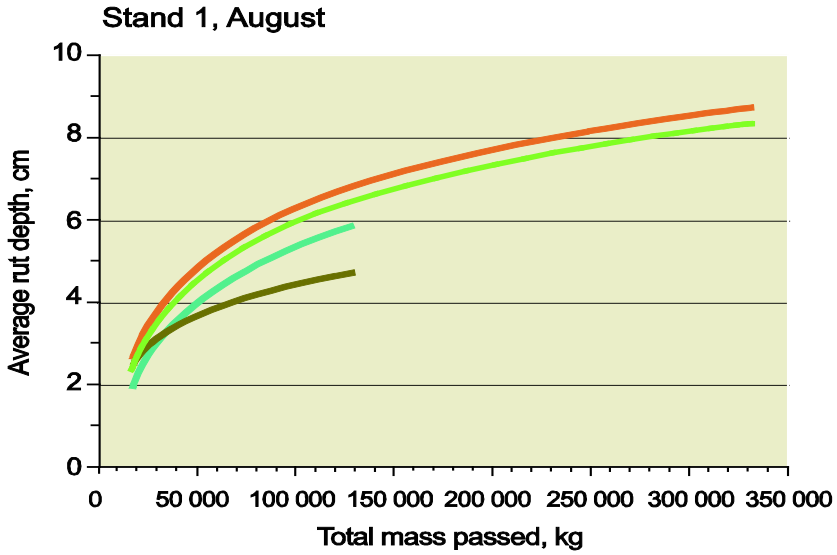
Photos: Erkki Oksanen/Metla

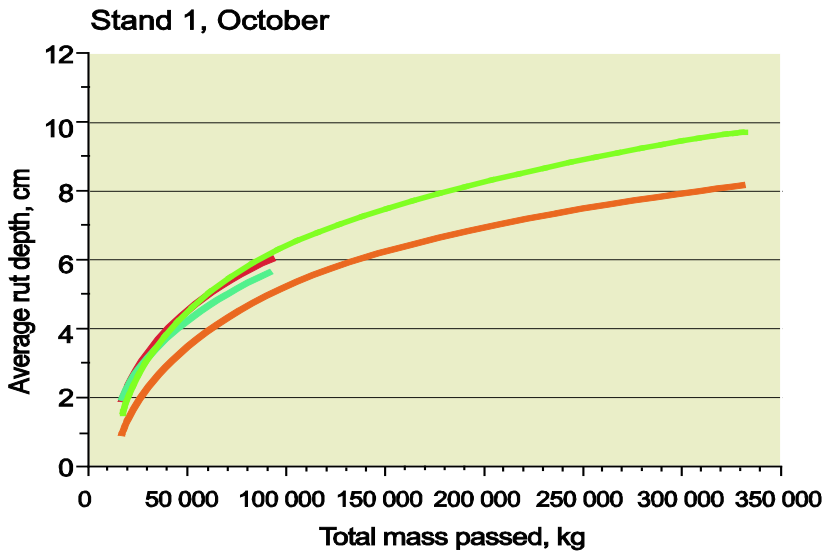
Effect of harvester working technique on the amount of residues studied: Potential 16-25 kg/m^2, of which 14-19 kg/m^2 received on strip roads

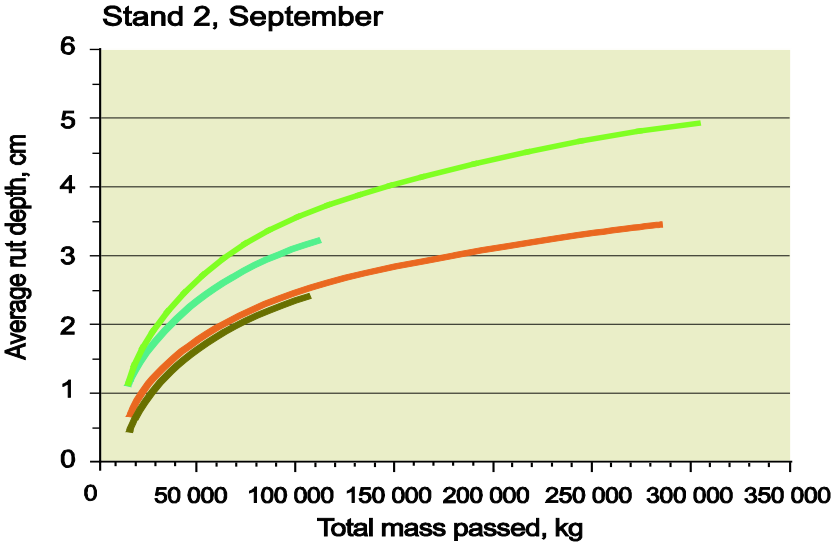
Photos: Erkki Oksanen/Metla

If near all residues are taken to cover strip road, the time consumption of harvester increases 5 % with experienced operator

Rut formation with different harvesting methods/forwarder equipment







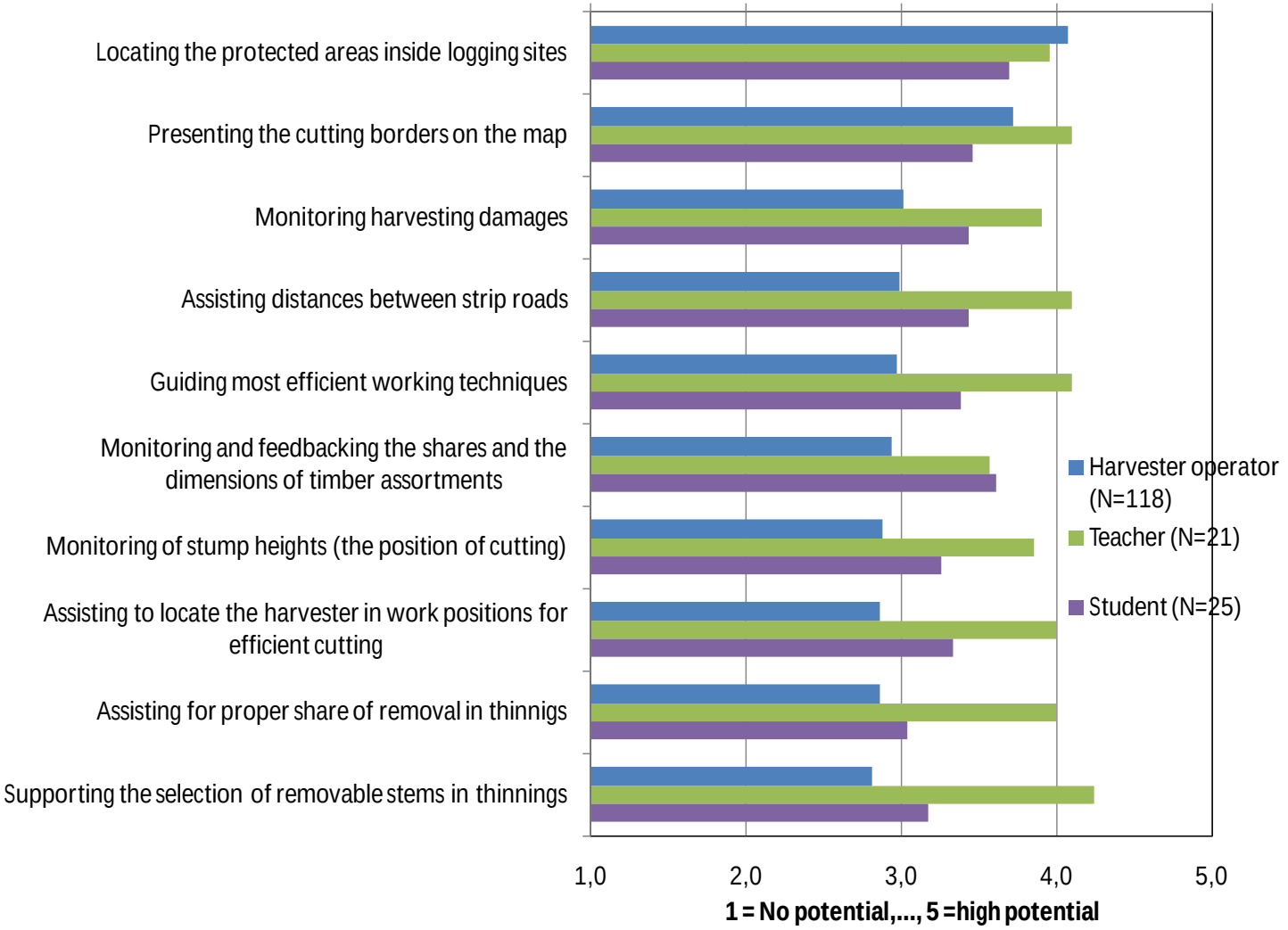
The potential of intelligent operator tutoring systems in mechanised loggings

Kari Väätäinen, Rami Ylimäki, Sami Lamminen, Matti Siren,
Jari Ala-Ilomäki and Antti Asikainen

FORMEC 2011 Symposium: October 9 - 13, 2011 - Graz, Austria

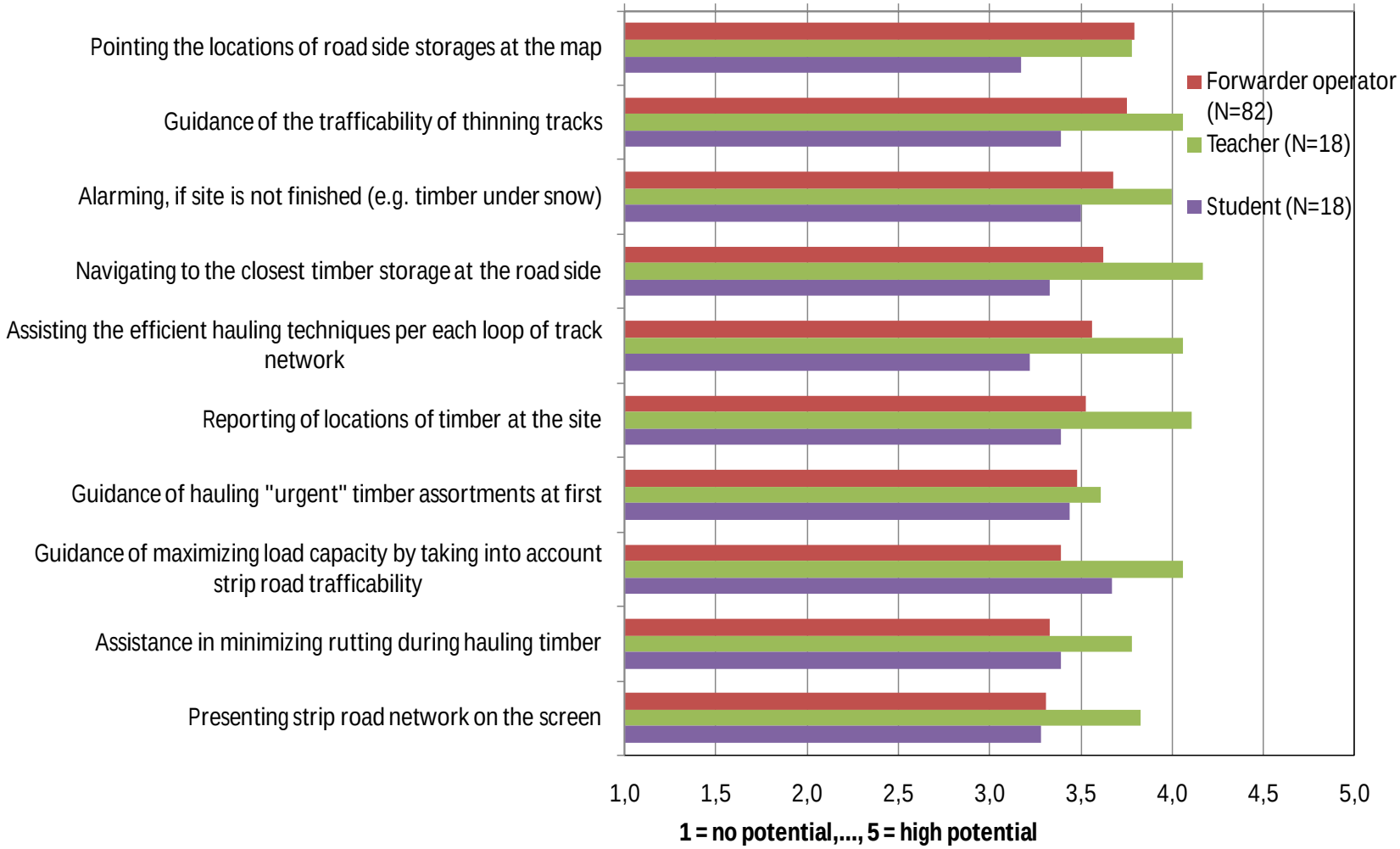
RESULTS

Potential and need of operator tutoring in cutting operations

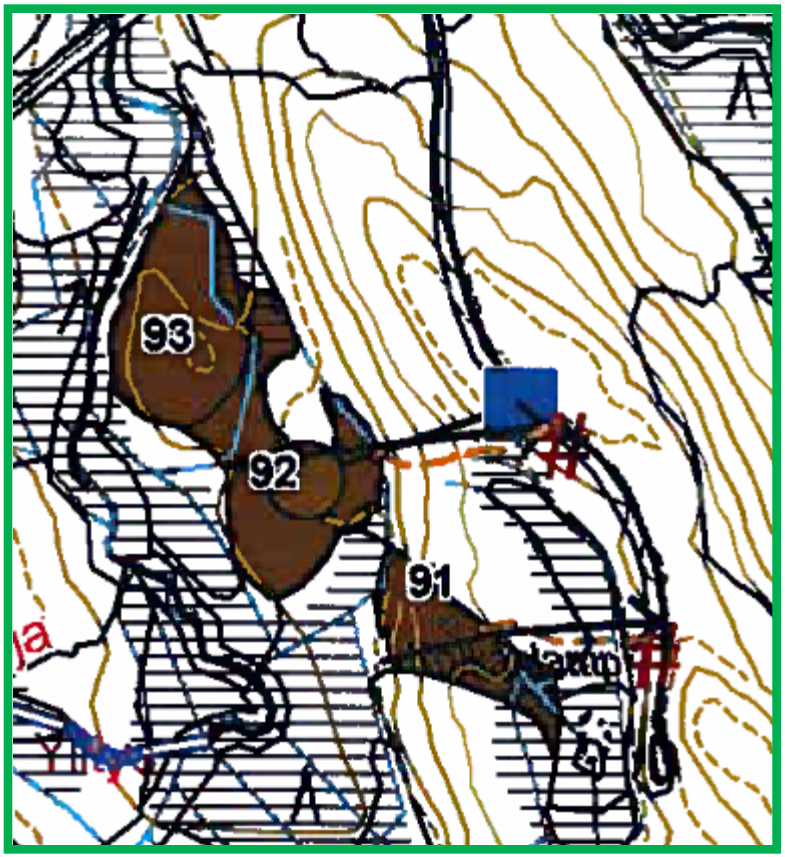


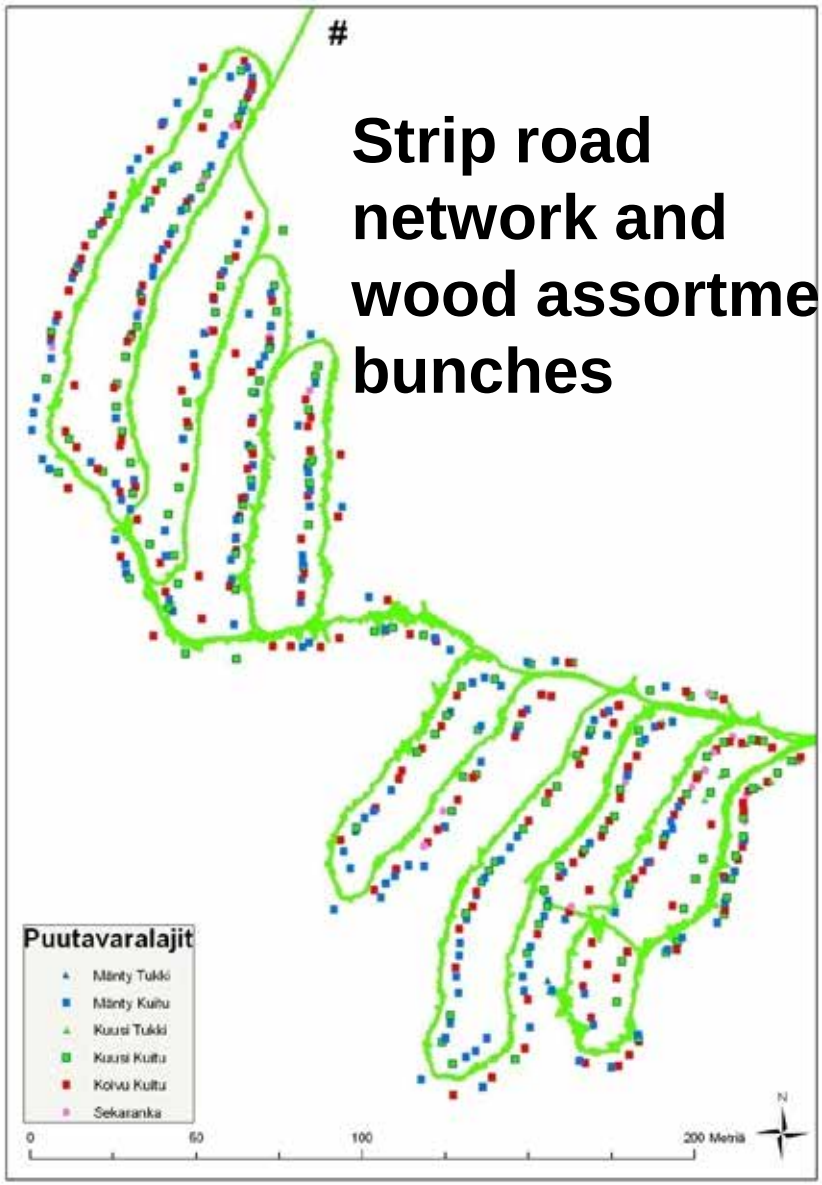
RESULTS

Potential and need of operator tutoring in forwarding operations



Hauling support system





EffFibre-project "Intelligent operator tutoring systems in wood harvesting" – What it's all about?

1) **Collecting background information** of operator-tutoring systems used in other industry branches
   - § Benefits, challenges, experiences
2) **Clarifying the potential and the need** of intelligent tutoring systems among forest machine operators and contractors
   - § Where to direct the development?
3) **Developing demo applications** for testing features for tutoring systems and for acquiring operator feedback
4) **Exploring the potential** of different tutoring systems in wood harvesting
   - § Tests and field surveys in order to magnify benefit potential
5) **Further development studies** of operator tutoring applications together with partners (Ponsse, Creanex)

Forest
METLA
KNOWLED
GE
Well-being
Know-how
Thank you