Digitalisation and automation of forest operations

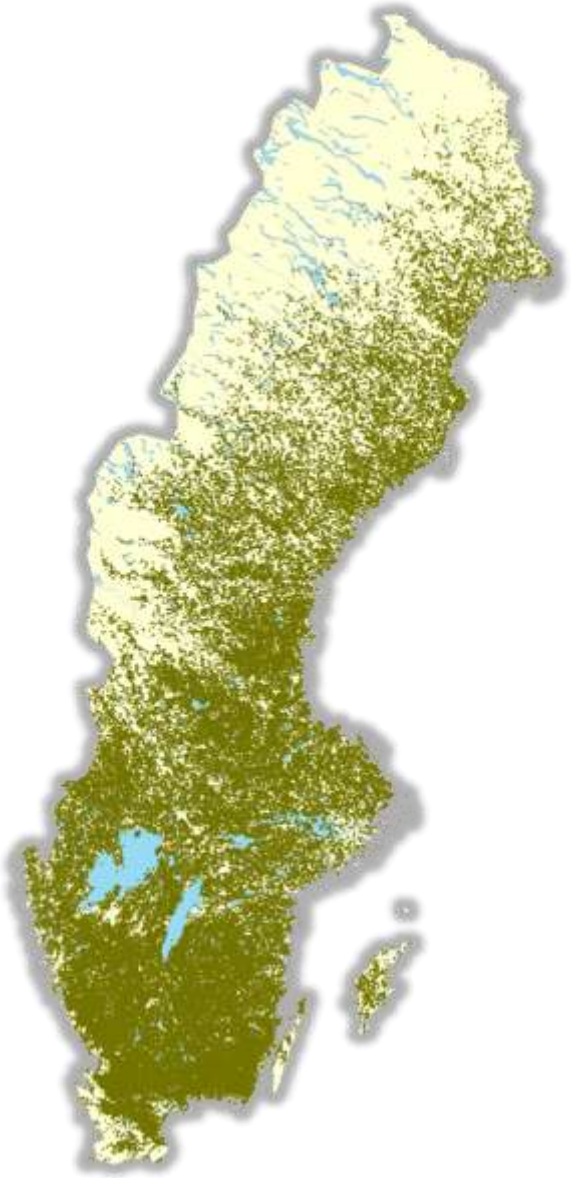
with a focus on silviculture technology

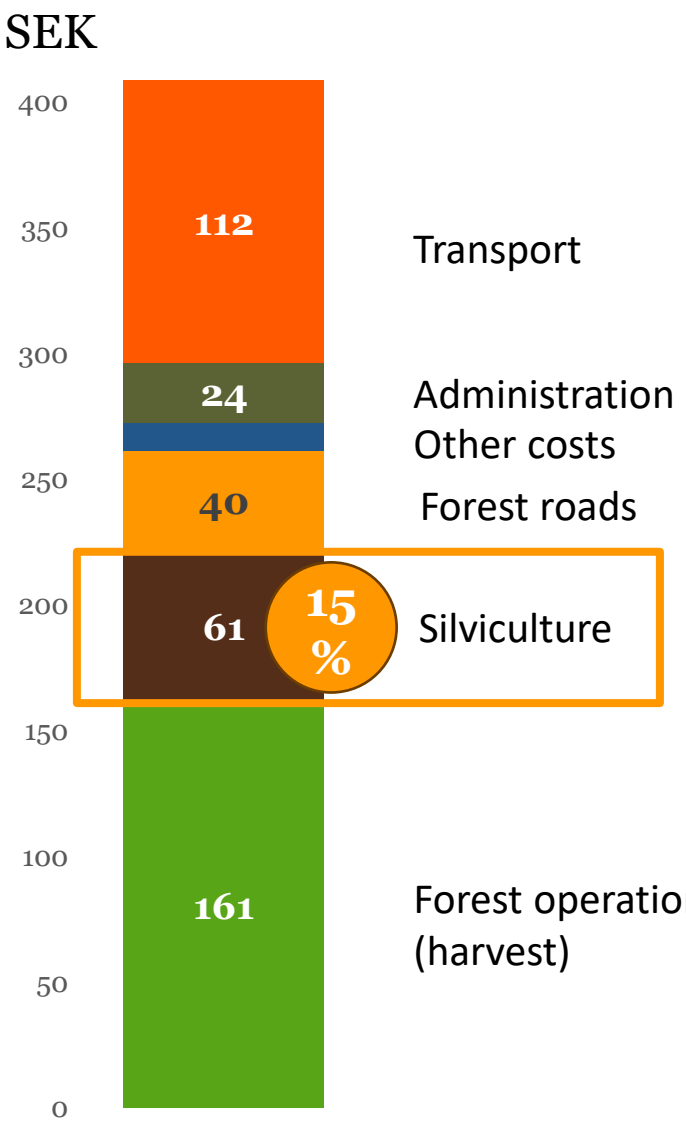
Silviculture 4.0 – smart technology from nursery to field, South Africa
16 October 2024

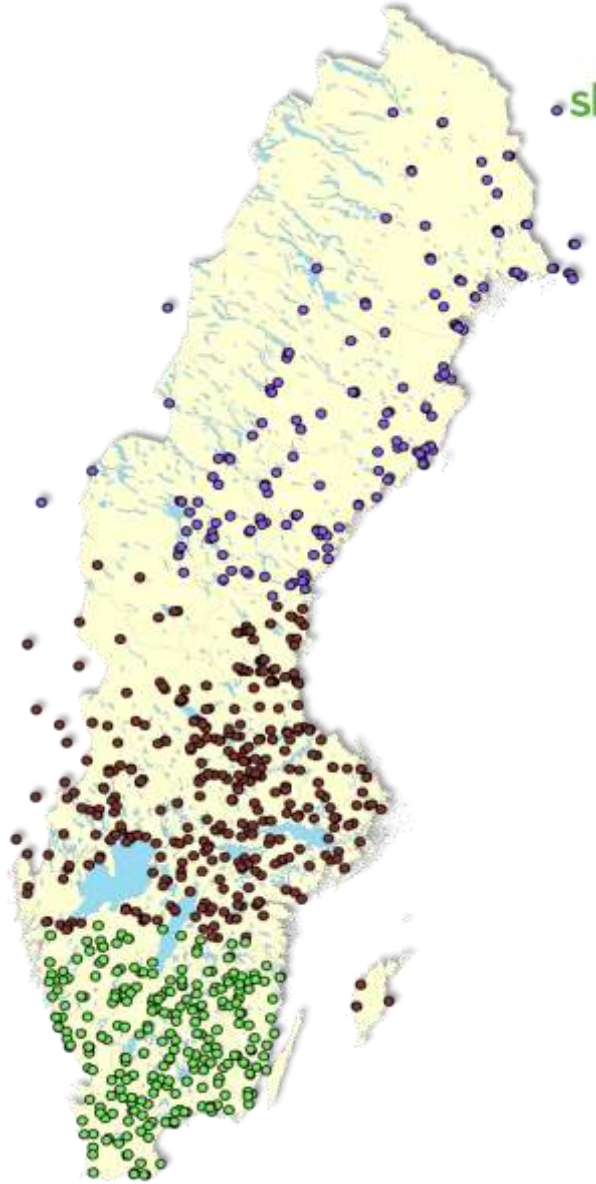
Dr. Linnea Hansson
researcher, Forest Operations

Outline

- Silviculture in Sweden
- Examples of ongoing research projects
  - Autoplant (autonomous soil scarification and planting)
  - Teleoperated soil scarification
  - Traceability in seedling logistics
- Issuses for implementation of the new technology in practical forestry







1 SEK = 1.68 ZAR R

Ref: "Skogsbrukets kostnader och intäkter 2022"

Traditional regeneration methods in Sweden

Traditional regeneration methods in Sweden

Hard manual work


Photo: Skogma


Photo: Bitzer

New focus on planting machines!

- Increased regeneration costs
- Lack of labor – pandemic and war…
- New technology gives new possibilities

  automation, teleoperation, sensors, decision support tools and AI

SÖDRA

AutoPlant

AutoPlant

concepts and tests of autonomous forest regeneration

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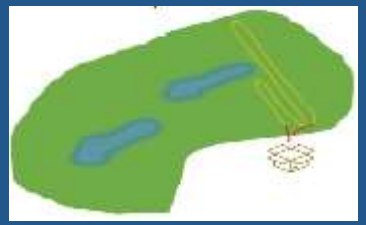
2. Luleå University of Technology

3. KTH, the Royal Institute of Technology

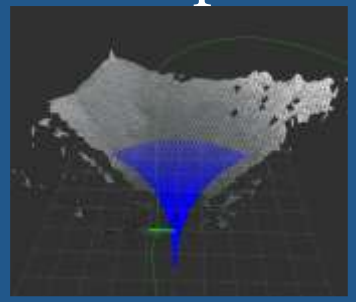
4. Bracke Forest AB

Mission Supervisor

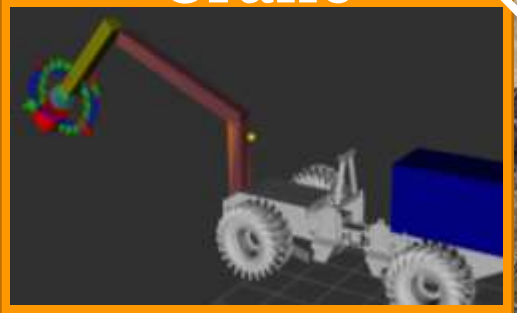
Global plan (Pathfinder)



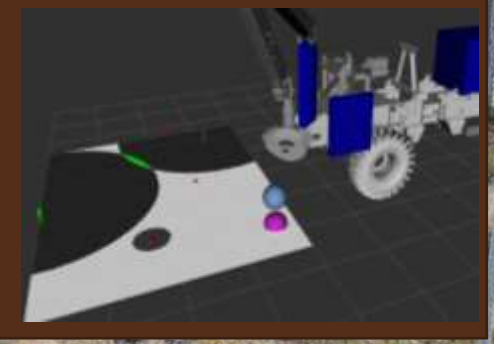
Local plan



Crane



Planting planner



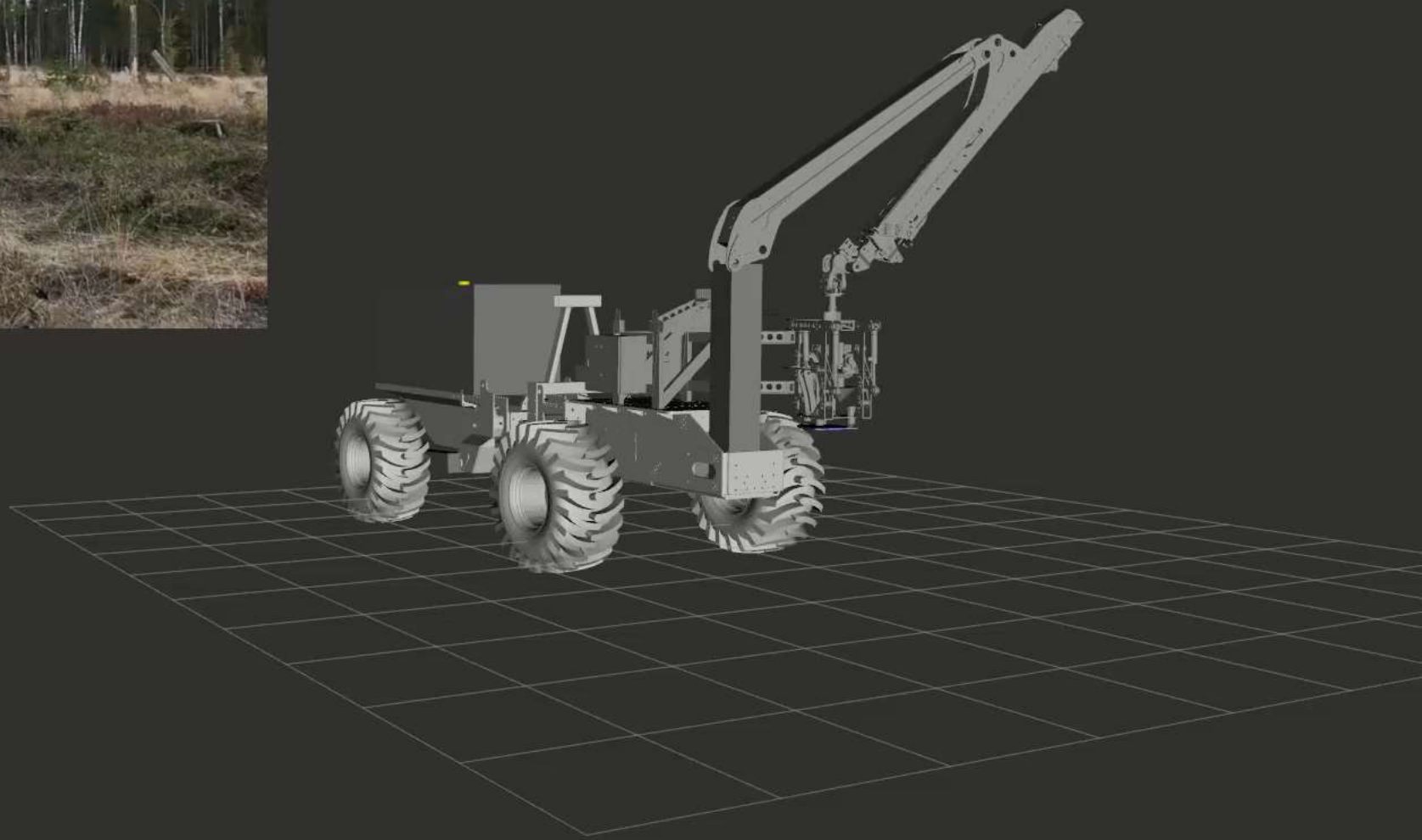
Planter

AutoPlant

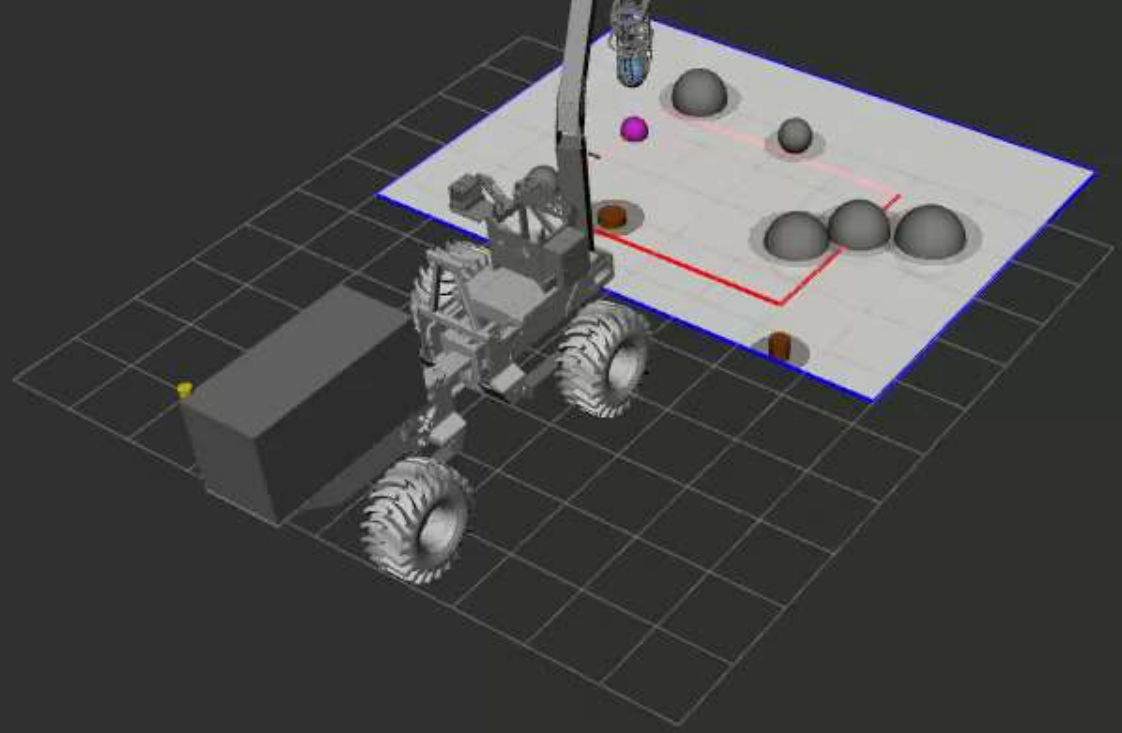
SENSORS

- External sensors
  - Image data and 3D-point clouds
- Internal pressure sensors
  - Boom
  - Pendelum arms
- GNSS recievers with RTK-correction
  - Gives position and heading


AORO



OBSTACLE DETECTION AND POSITIONING



Successful planting

Failed planting

Detected stump

Detected stone

Crane target

Planting target

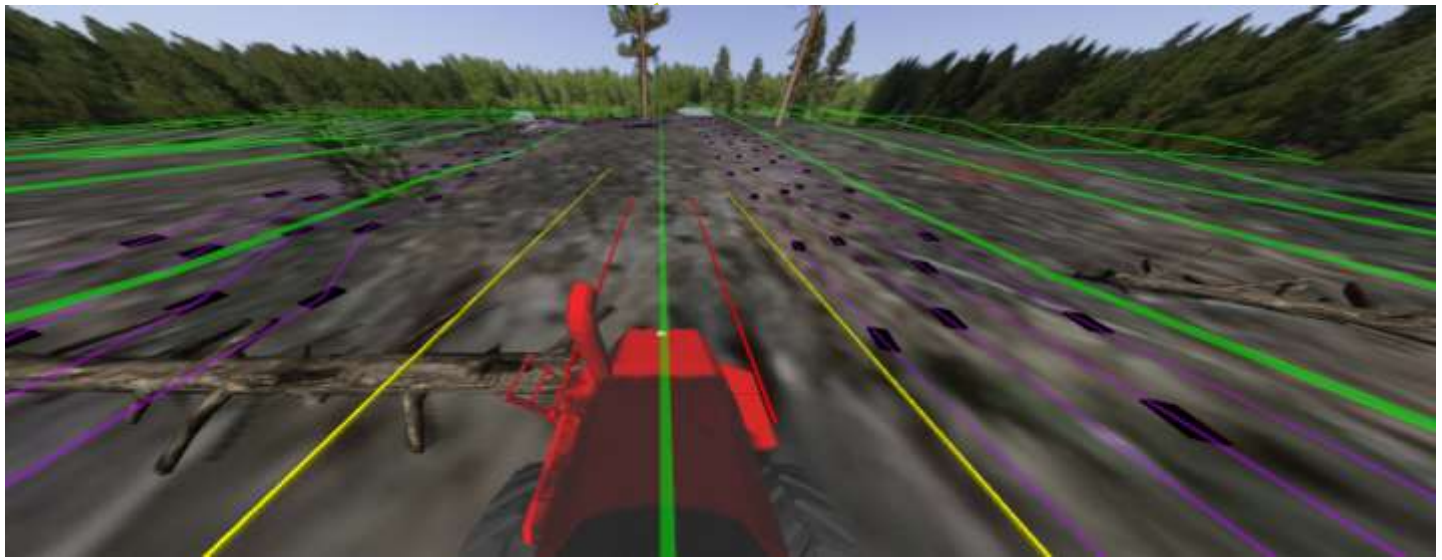
- Projects objects onto a 2D image
- Locates positions free of obstacles
- A packing problem (optimization)
- Updates when seedlings are planted
- Determine when work area is full

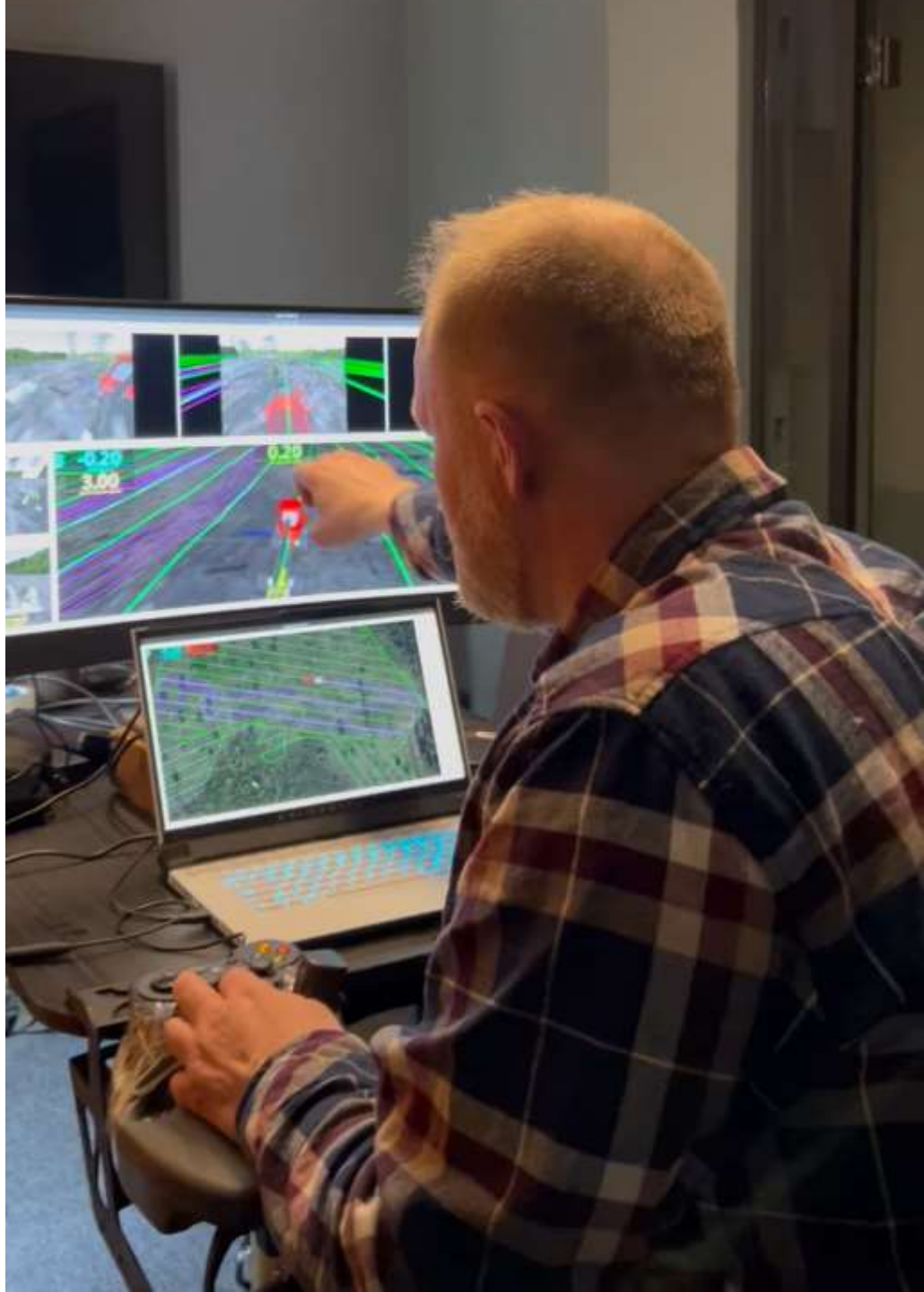
[Autoplant – KIT (youtube.com)]

https://www.youtube.com/watch?v=JuMRDsw12rM

Teleoperated soil scarification

- Teleoperation
  - Wi-Fi, 5G, StarLink
  - Relay station
- Decision support tools
  - User interface
  - Camera angles
- Route planning
  - Pathfinder





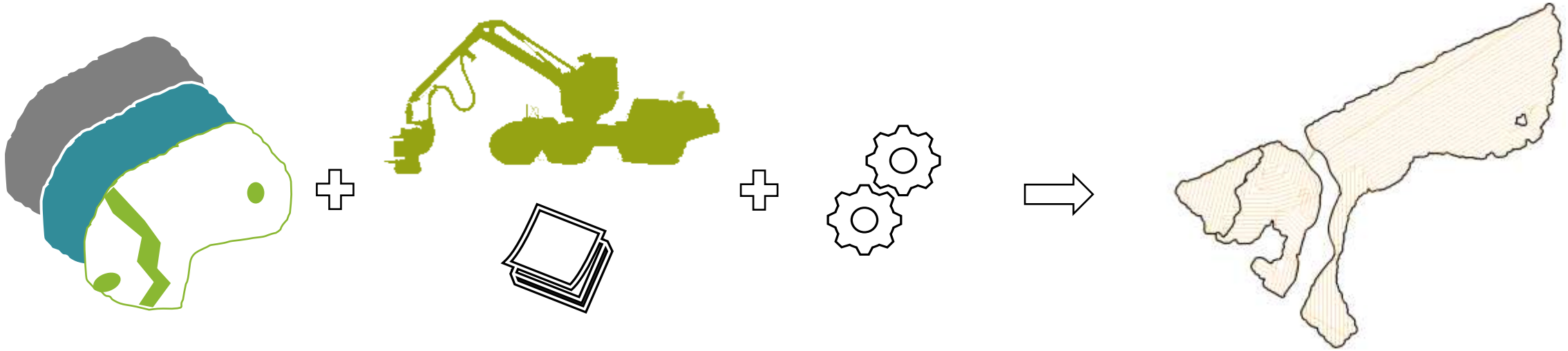
Photos: Bitzer

A film from the project on teleoperated soil scarification (in Swedish)

Fjärrstyrning av markberedare (youtube.com)

https://www.youtube.com/watch?v=eGzbb_z0V0c

Pathfinder – the global planner for driving on the regeneration areas



Input data

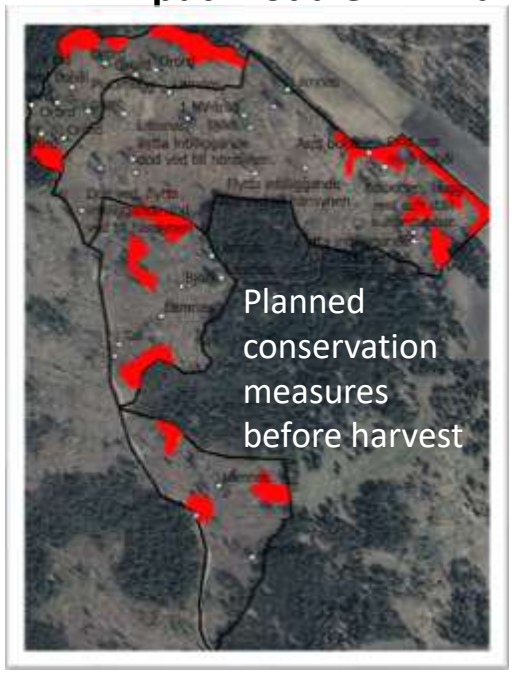
- Harvester data (hpr-files)
- Depth-to-water maps
- Soil type maps
- Machine data
- No-go areas

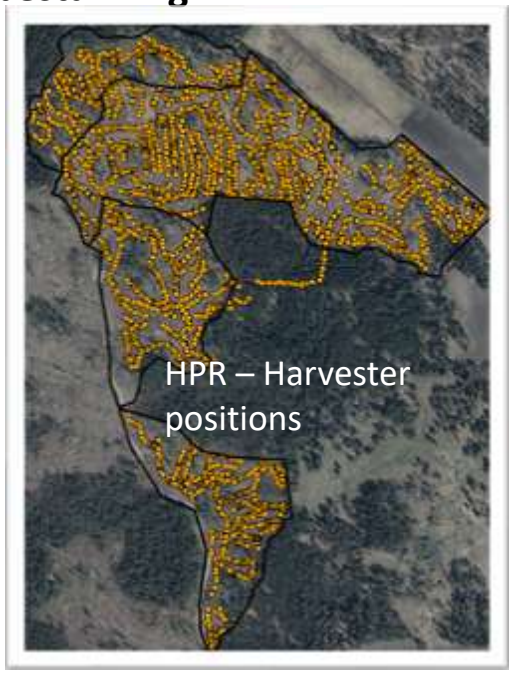
optimization

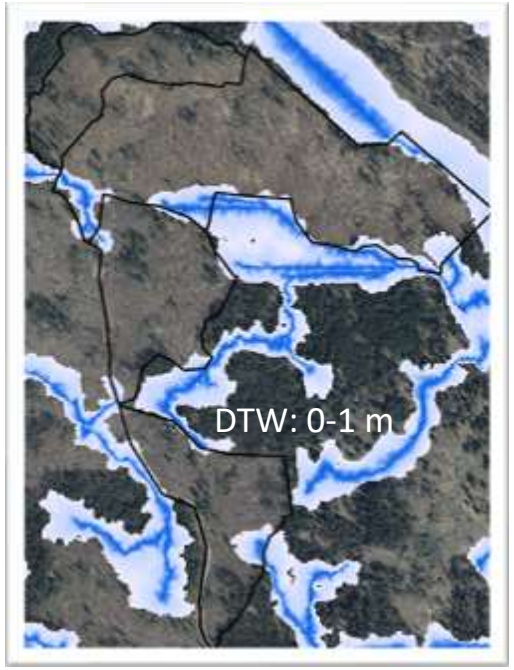
Global plan

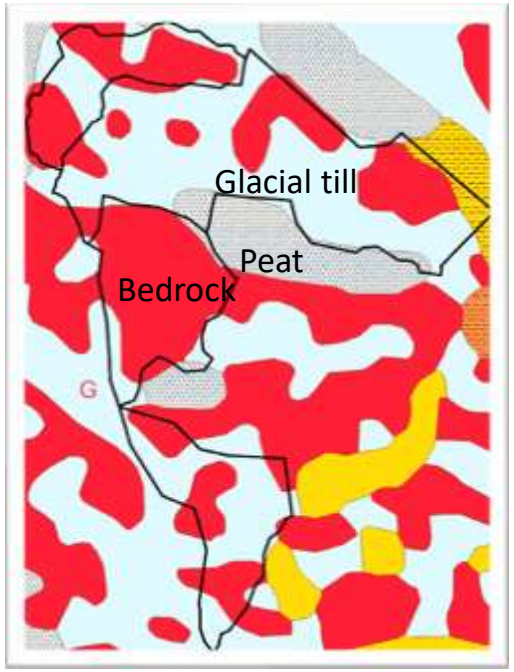
- Net area (too wet or too dry areas are excluded)
- Tree species and density
- Route coordinates

Input Module A – Plantbeställning

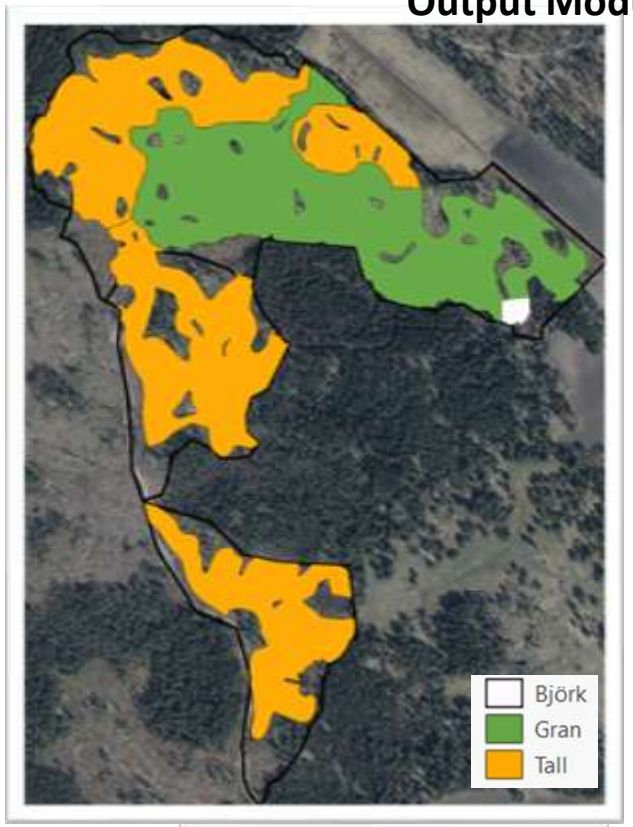






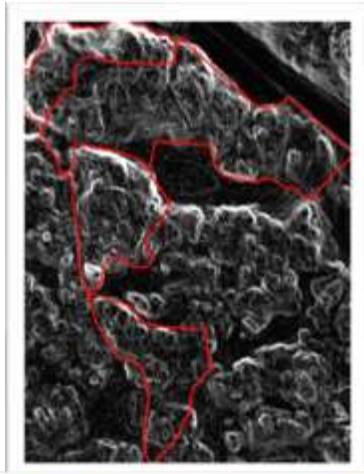


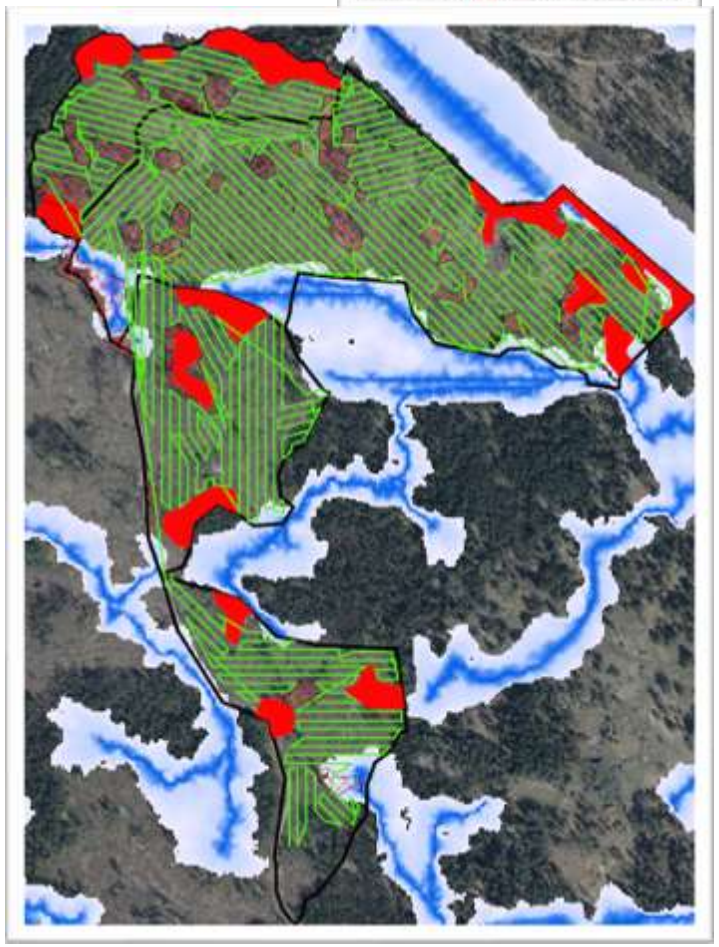
Output Module A – input Modul B



Distance between routes: 11 m

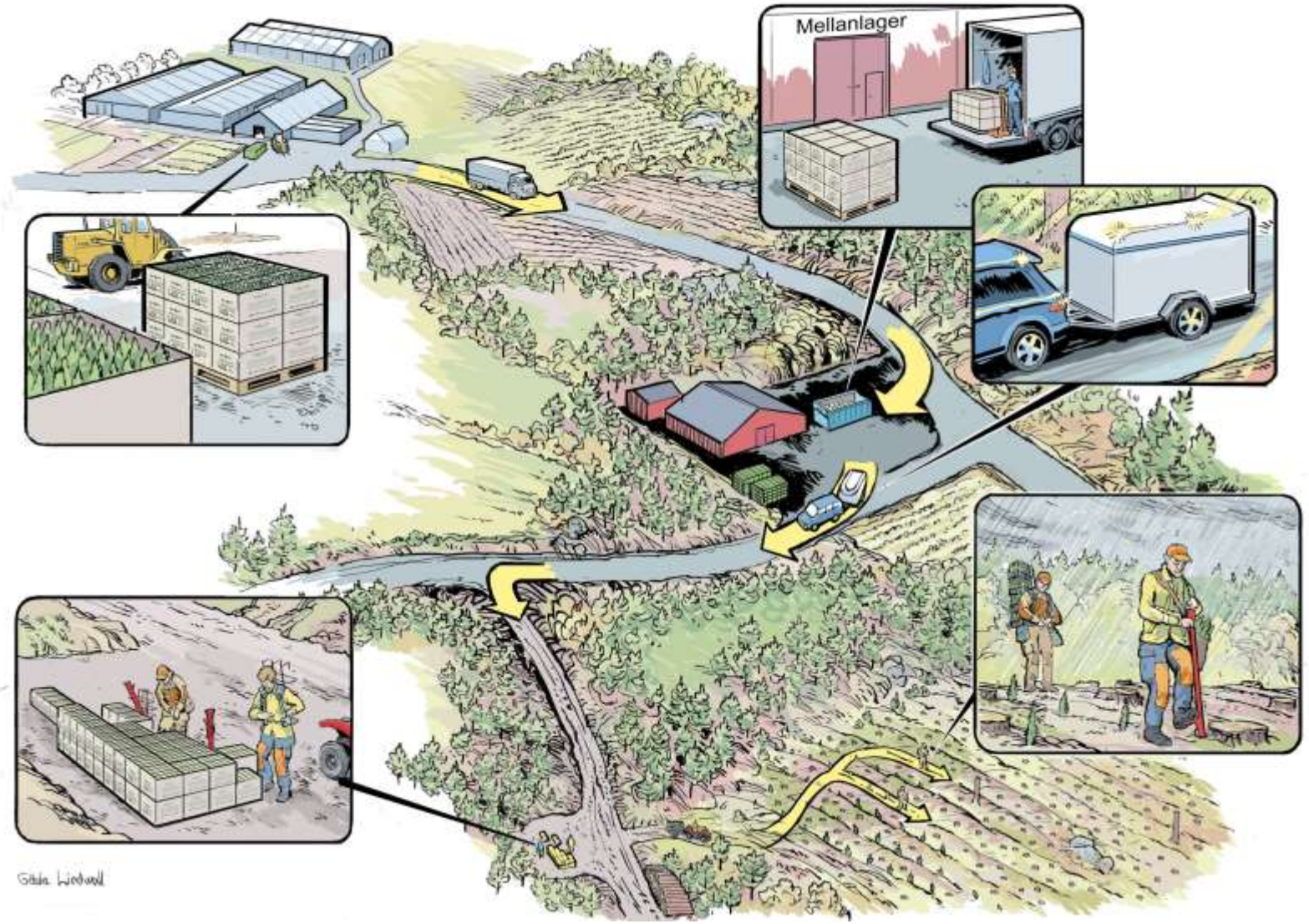
critical sideslope: 27% (15°)



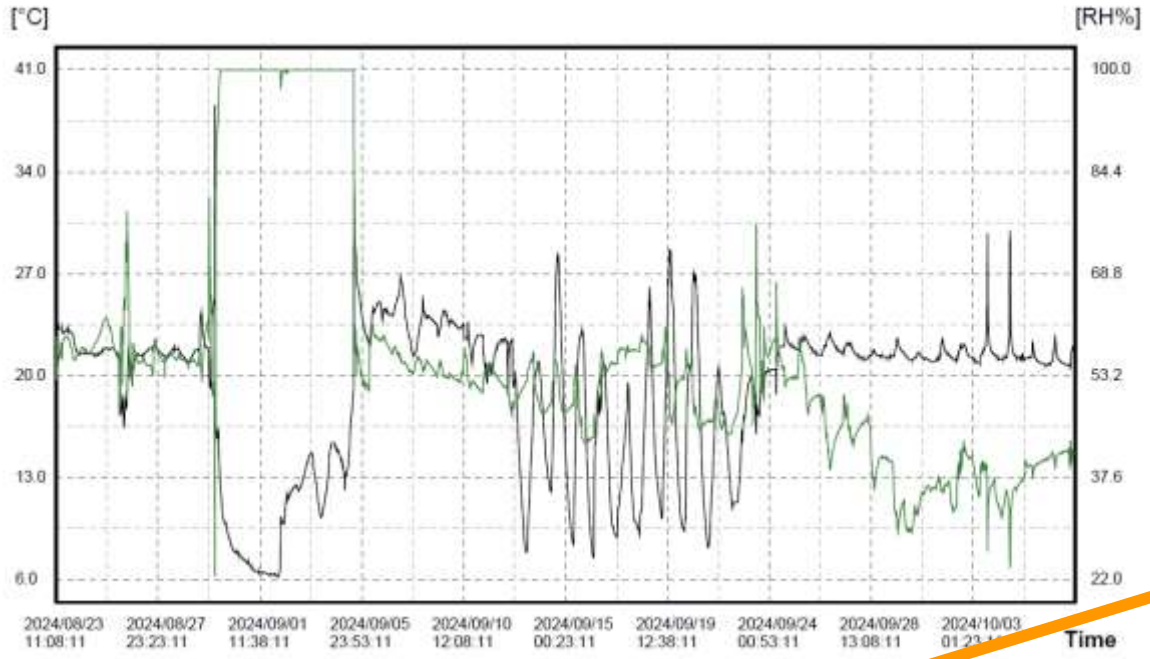


Traceability in seedling logistics – from nursery to field (*Rowell et al*)

- RFID for digital and quick inventory



Tests with temperature and relative humidity sensors in the boxes + GNSS tracking



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☐	Actions	301400000...	2805-272	sgtin-96:0.0...	9-GRÄSBE...		RECEIVE	Aug 27, 2024, 8:16:20 AM G...	last1
☐	Actions	301400000...	2807 - 269	sgtin-96:0.0...	Sör amsberg		CREATE	Aug 26, 2024, 12:51:31 PM ...	

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Issuses for implementation of the new technology in practical forestry

- Increase robustness everywhere
- Ensure security
- The laws have to change! (geofencing…)
- Seedling logistics - nurserys to planting machines
- The ultimate base machine?

Addressed in the new Autoplant project

Thank you!

AutoPlant

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LULEÅ UNIVERSITY OF TECHNOLOGY

KTH VETENSKAP OCH KONST

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SKOGS-TEKNISKA KLUSTRET

SCA

SÖDRA

SVEASKOG

HOLMEN

STORAENSO

VINNOVA
Sveriges innovationsmyndighet

Further reading

- **Hansson et al. 2024** *Autoplant - Autonomous Site Preparation and Tree Planting for a Sustainable Bioeconomy*. Forests
- **Hansson et al. 2024** *Pathfinder – A tool for operational planning of forest regeneration on clearcuts*. (sumbitted to Journal of Forestry Research)
- **Sten et al. 2024** *An efficient trajectory roll-out algorithm for autonomous articulated vehicles in forest terrain*. (submitted to Autonomous Robots)
- **Sten et al. 202?** *Interpolation based fusion for accurate topography estimation using LIDAR and stereo camera*. (submitted)
- ***Li, Rossander & Lideskog 2024*** *Vision based planting position selection system for an unmanned reforestation machine*. Forests
- **Rossander & Lideskog 2023** *Design and Implementation of a control system for an autonomous reforestation machine using finite state machines*. Forests
- **Li & Lideskog 2021** *Implementation of a system for real-time detection and localization of terrain objects on harvested forest land*. Forests

www.skogforsk.se/kunskap/projekt/autoplant/

Fjärrstyrd markberedare visades – verkligt och på film - Skogforsk