IMPROVING SCOTS PINE REGENERATION ON STAGNATING SITES THROUGH SOIL PREPARATION

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Introduction

Post-Clearcutting Challenges

- Hydrological Changes
  - Elevated groundwater levels impede root aeration
- Soil Chemistry Issues
  - Non-optimal pH in coniferous forests can limit nutrient uptake
- Scots Pine Regeneration Requirements
  - Requires full sunlight exposure ⇒ clear-cutting is preferred practice
- Role of Soil Preparation:
  - **Enhances Site Conditions**
    - Improves soil aeration
    - Increases nutrient availability
    - Optimizes water management
  - **Reduces Competition**
    - Limits the regrowth of grasses and shrubs
  - **Boosts Early Growth & Survival**

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Introduction

Soil Preparation Methods

- Spot Mounding (Excavator Bucket)
  - Creates a raised hill and adjacent pit
  - Organic layer remains inside mound for nutrient supply
  - Improves drainage and aeration
- Inverting
  - Flips organic topsoil to expose mineral soil
  - Buries competitive vegetation under organic layer
  - Creates mineral surface to reduce weed pressure

Operational Considerations

- Work Productivity
  - Need to cover large areas under limited resources
- Site Topography & Water Table

Spot mound

Inverted planting spot

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Material and methods

- Study Sites
  - Four young Scots pine stands
  - Location: Northwestern Latvia (*Vacciniosa* forest types, mineral soils)
- Soil Preparation Methods
  - Spot Mounding
    - Excavator bucket forms raised mound + adjacent pit
  - Inverting (Turf Flip)
    - Flips organic layer upside down to expose mineral soil
  - Control
    - No soil preparation

Productivity Tracking

Activity	Definition
Moving in site	Machine track movement between stopping points (excl. site entry/exit)
Manipulator movements	Non-preparation arm movements (excl. spot creation, other tasks)
Planting spot creation	From bucket's first soil contact to lifting after mound/pit completion
Other activities	Minor repairs, inspections, technical pauses
Pauses	Breaks, phone calls, non-work rest

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Material and methods

Measurements & Sampling

- Planting Spots
  - Mound: length, width, height; pit: length, width, depth
  - Inverted spots: length & width
- Seedling Performance
  - Survival rate: annually for 3 years post-planting
  - Height: measured each year for 3 years
  - Diameter at root collar: measured after 3rd growing season
- pH measurements
  - Groundwater wells (1.5 m depth) installed July 2021
  - Seasonal groundwater pH: sampled each autumn

A – control, B – spot mounding, C – inverting

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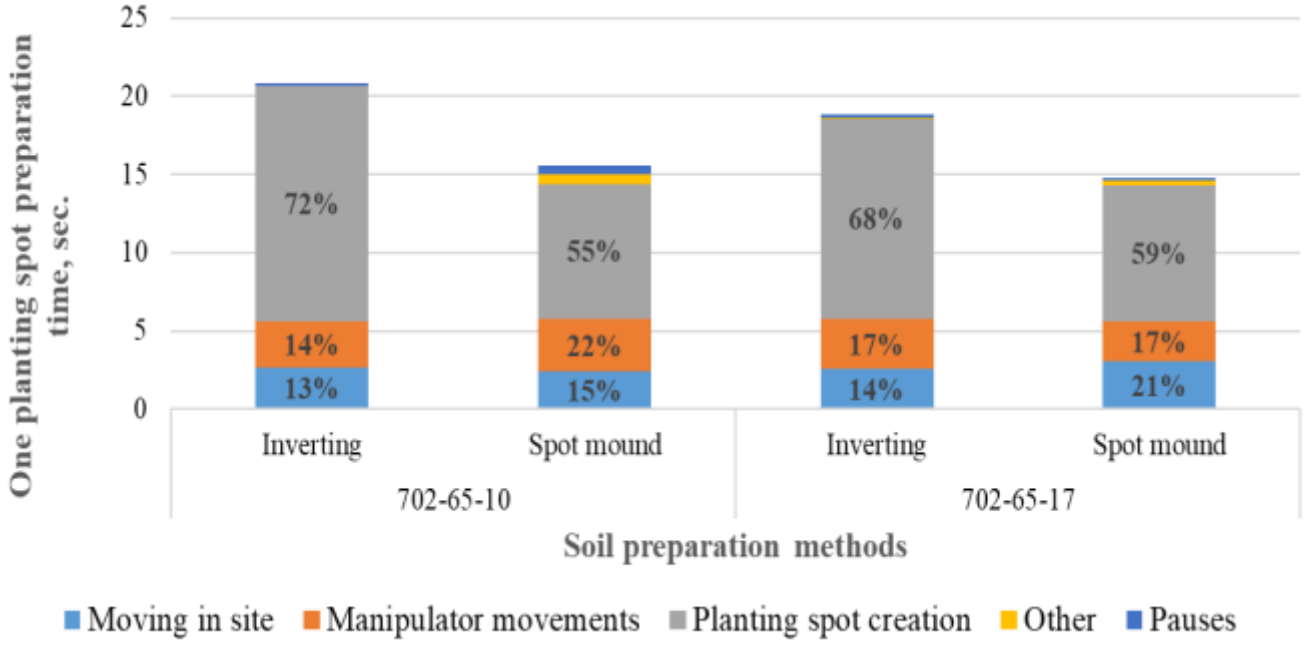
Results – pH and Productivity of Soil Preparation

Groundwater pH Trends

- Overall acidity
  - pH ranged from **3.86 to 5.87** (2021–2024)
  - Lowest measurements just below 4.0; highest just above 5.0
- Implications for Scots pine
  - Optimal pH: **5.0–5.5** → acidic conditions limit nutrient uptake



Time productivity preparing plating spots.

Projected for 1 600 spots

- Spot mounds: **6.7 h**
- Inverted spots: **8.8 h** (+2.1 h; +23.5%)

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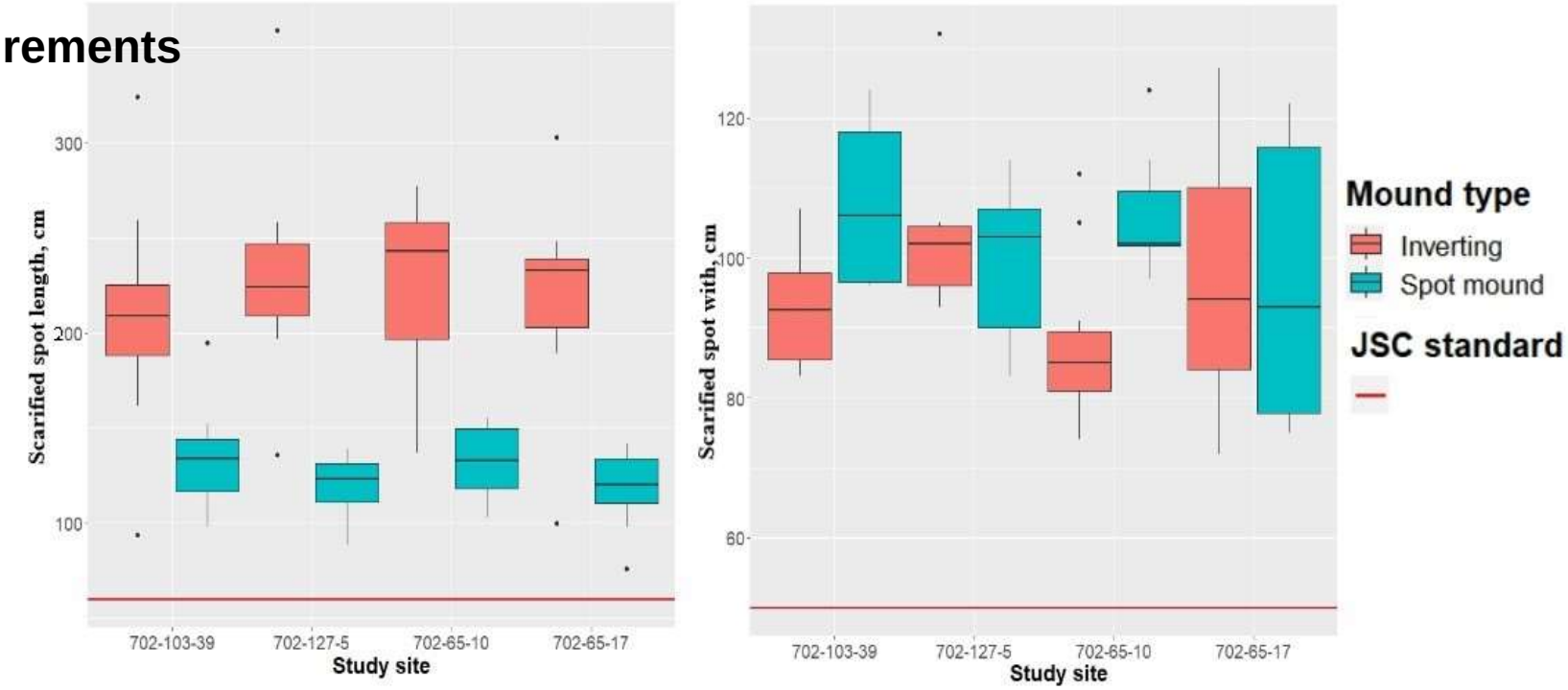
Results – Planting Spot Dimensions

- **Spot Mounds vs. JSC Minimal requirements**
  - Length: 1.26 m (min 0.60 m) ⇒ +111 %
  - Width: 1.03 m (min 0.50 m) ⇒ +105 %
  - Height: 0.30 m (min 0.15 m) ⇒ +100 %
- **Inverted Spots vs. JSC Minimal requirements**
  - Length: 2.21 m (min 0.60 m) ⇒ +268 %
  - Width: 0.95 m (min 0.50 m) ⇒ + 89 %



Length and width of planting spots.

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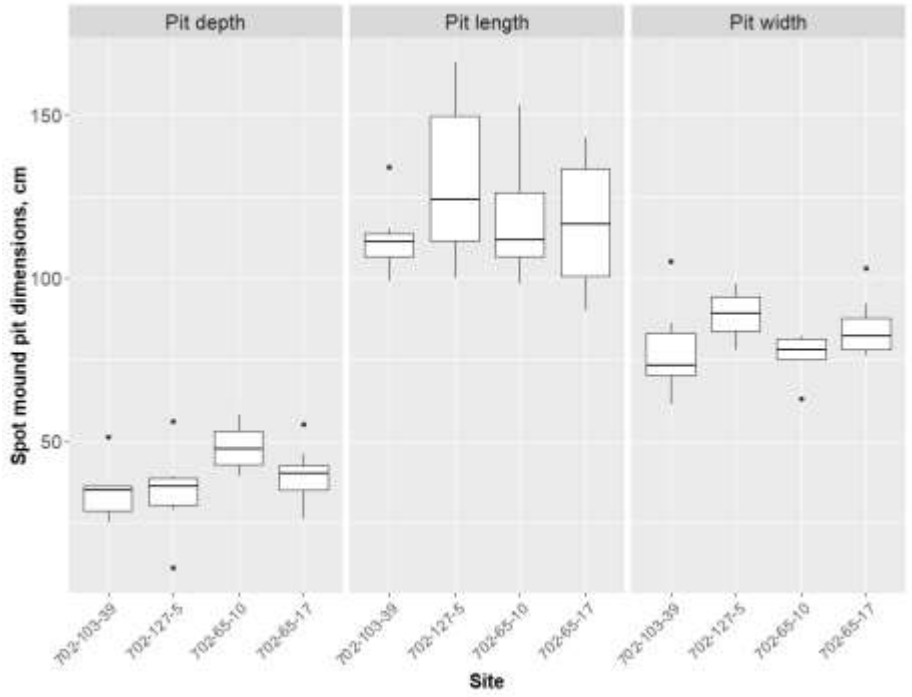
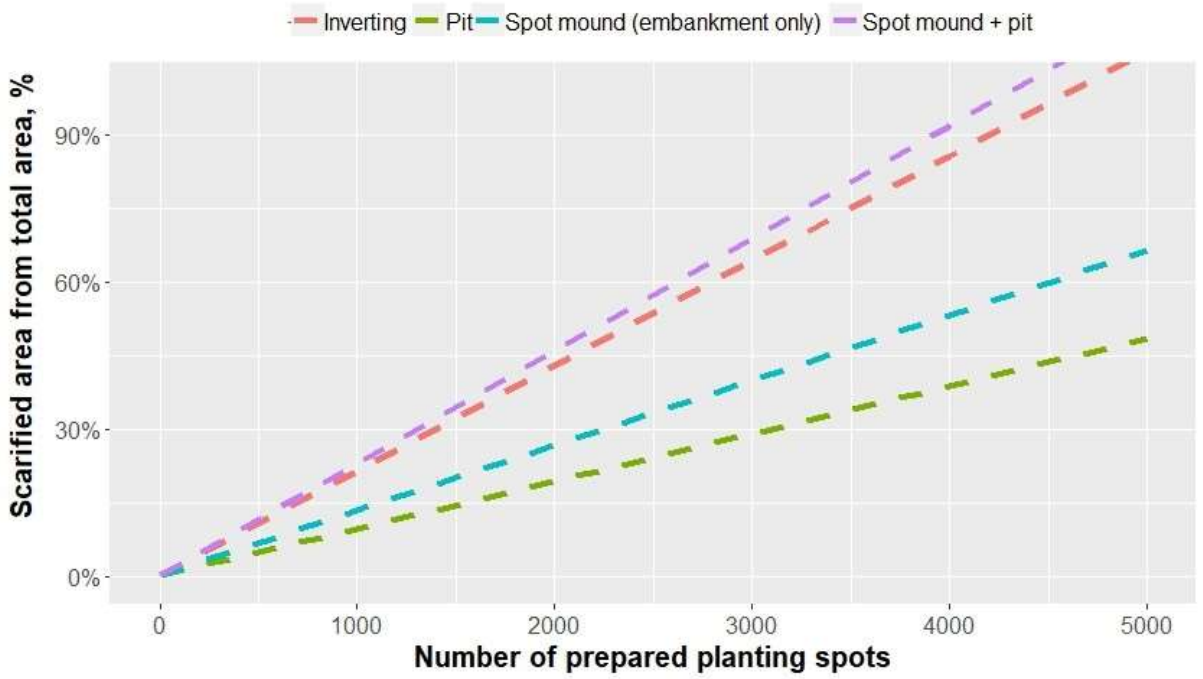
Results – Pit Dimensions and Scarified Area



Dimensions of spot mound pit.



Scarified area depending on the number of planting spots.

- **Measured averages**
  - Length: 1.19 m
  - Width: 0.82 m
  - Depth: 0.40 m

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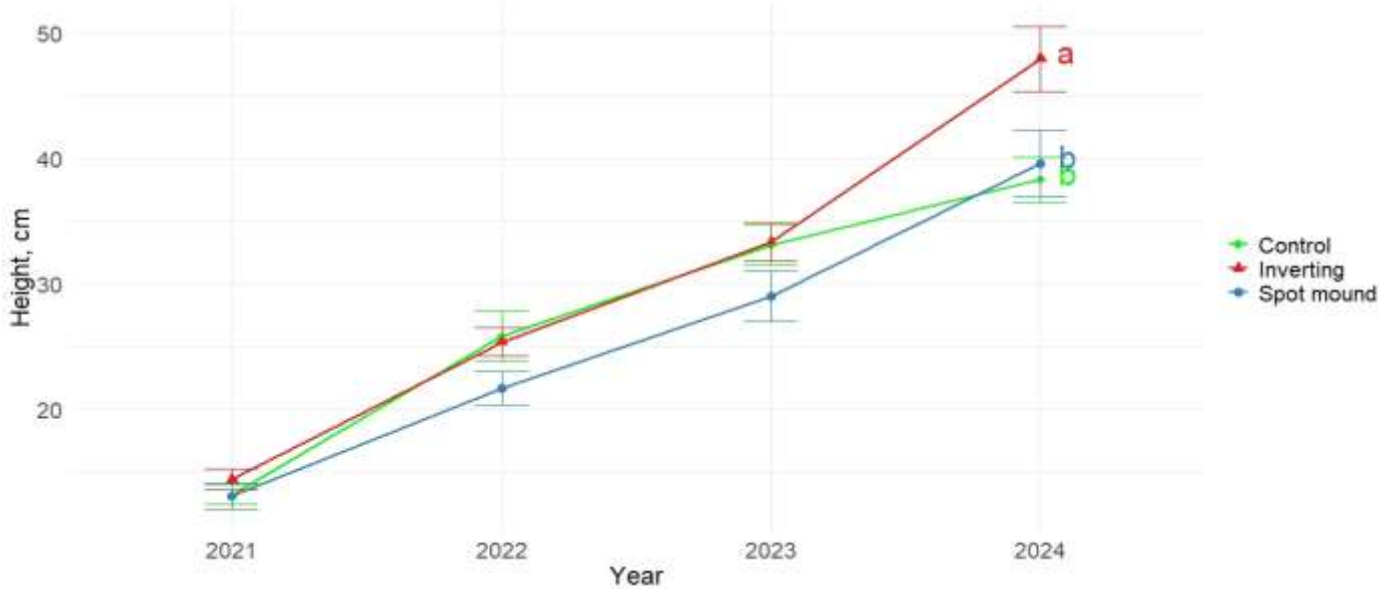
Results – Pine Survival & Growth

- **Survival rate after 3 years**
  - Spot mounds: 96 %
  - Inverted: 92 %
  - Control: 71 %
- **Root-collar diameter (3rd year)**
  - Inverted: 10.6 mm
  - Spot mound: 8.8 mm
  - Control: 5.2 mm
- **Height (3rd year)**
  - Inverted: 47.9 cm
  - Spot mound: 39.6 cm
  - Control: 38.3 cm



Tree height depending on the soil preparation method used, significant differences are indicated by different letters ($p<0.05$)

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Conclusions

- Soil preparation increases Scots pine survival in stagnant stands.
- In inverted mounds Scots pine reaches larger height and diameter dimensions compared to unprepared soil and spot mounds.
- Soil preparation in spot mounding can be completed more rapidly than in inverted scarified spots. Mounding is, on average, 23.5% faster than inverting, with the most significant time difference observed during the preparation of the planting spot itself.
- There is no significant variation between the two methods in terms of the scarified area produced, and both methods surpass the minimum planting spot standards established by JSC Latvia's State Forests. The preparation of 2000 planting spots results in a scarified area of 46% when using spot mounding, whereas the same number of inverted planting spots produces a scarified area of 43%.

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