Skill-For.Action – S4A

Marie Skłodowska-Curie
European Training Network (ETN)

Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

Waldökonomisches Seminar – 2022

# Potential forest harvesting optimization at predictive level: a case study on cable yarding operations

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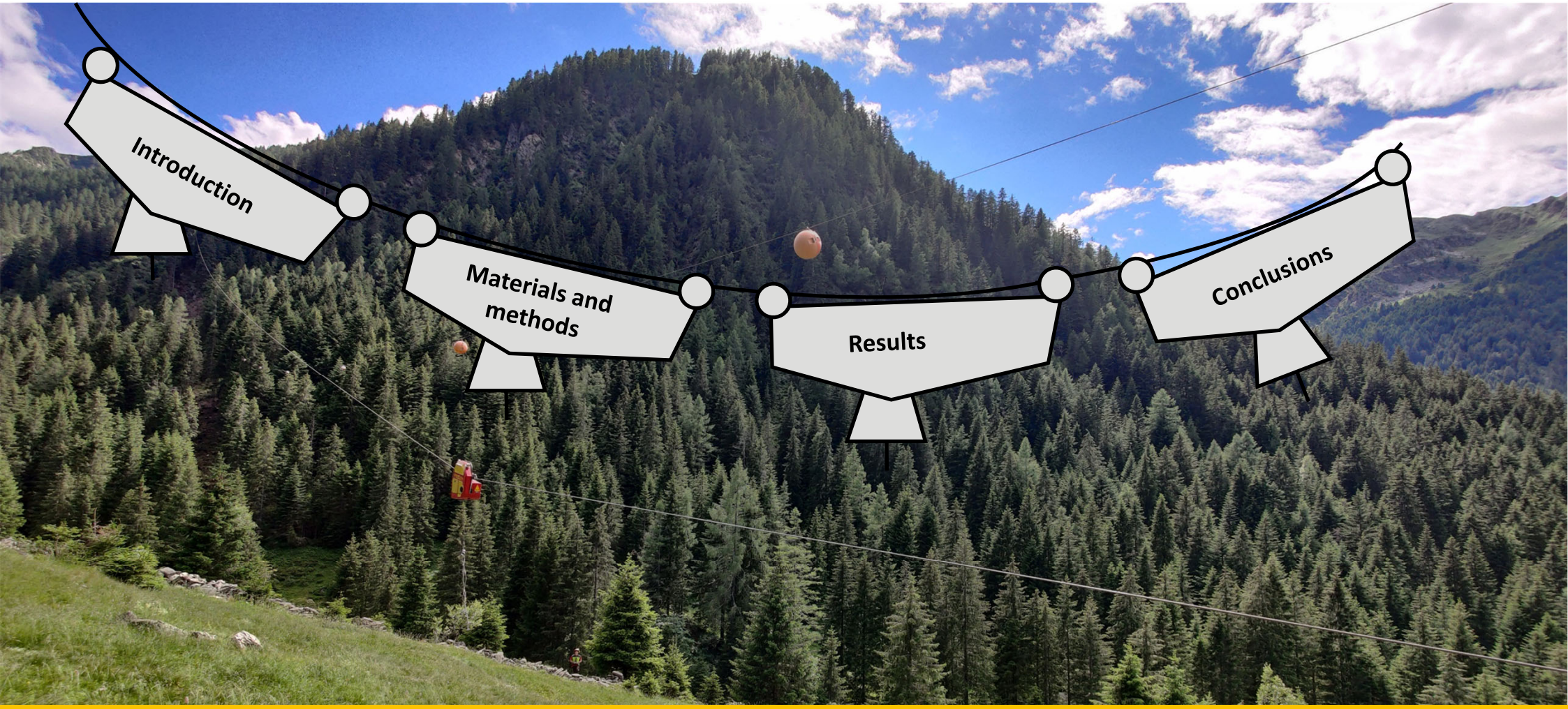
Prof. Dr. Martin Ziesak






## Outline

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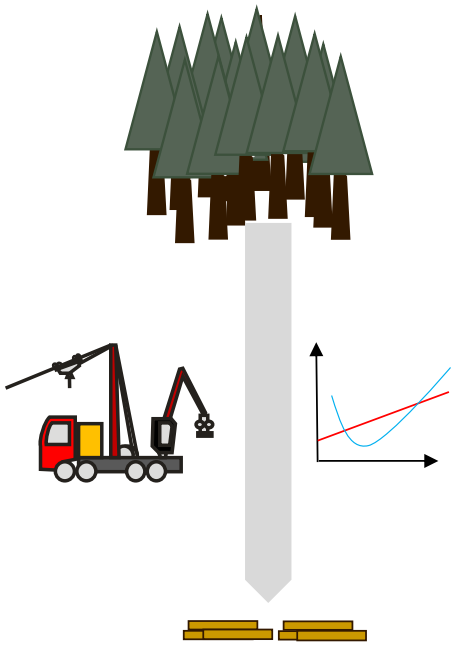


Several European countries show a low competitiveness of the forestry sector: revenues < harvesting costs [Korhonen J., 2016]

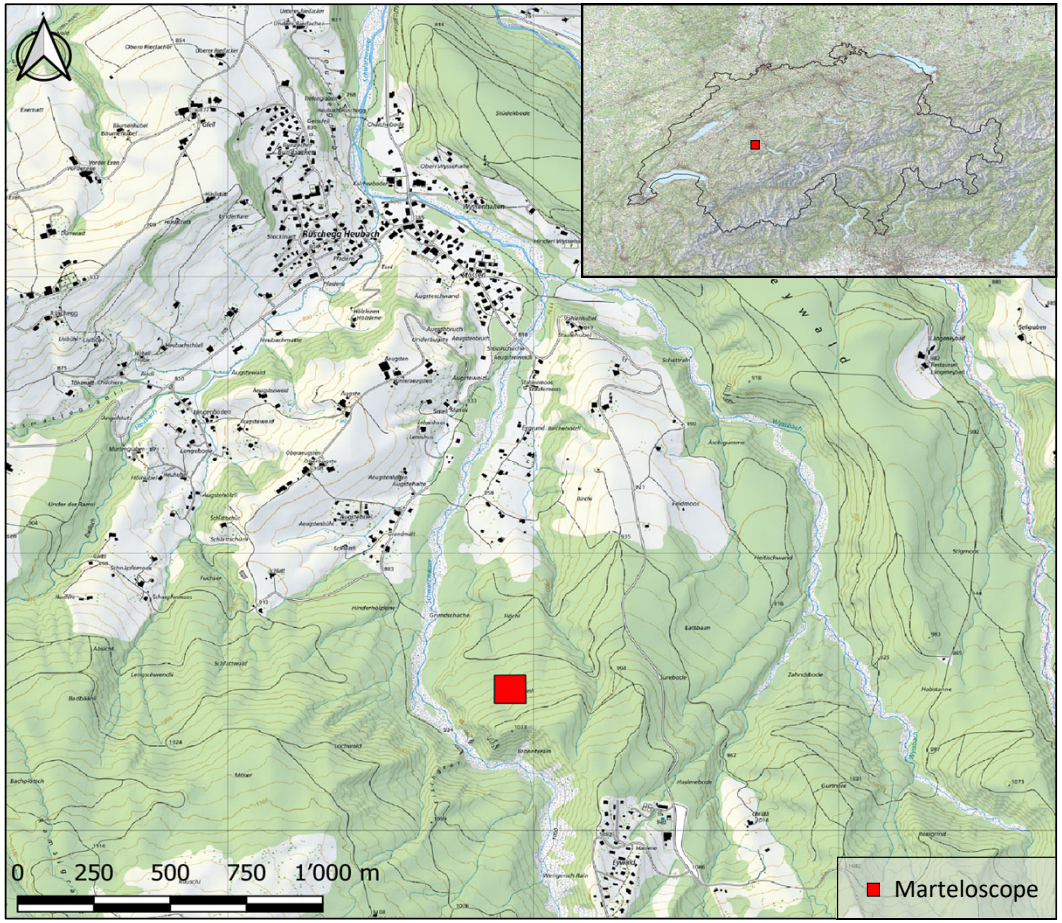
Forests that are not profitable for timber harvesting must still be managed to fulfill their ecosystem services [Bont L. et Church RL., 2018]

When close-to-nature management is adopted higher professionalism in forest operations is required, negatively impacting the system productivity [Orazio et al., 2017, Consola G. et Al., 2016]

Aim: conceptualization of a new approach for optimizing the timber harvesting process through a detailed break-down of production costs and marginal return at single tree level.


Materials and methods

# Case study based on an ex post analysis at Marteloscope Rüschegg




Municipality: Rüschegg (BE)

Area = 1.0 ha

Elevation ≈ 1000 m a.s.l.

Standing trees: 721

- N. spruce: 383
- S. fir: 260
- E. beech: 78

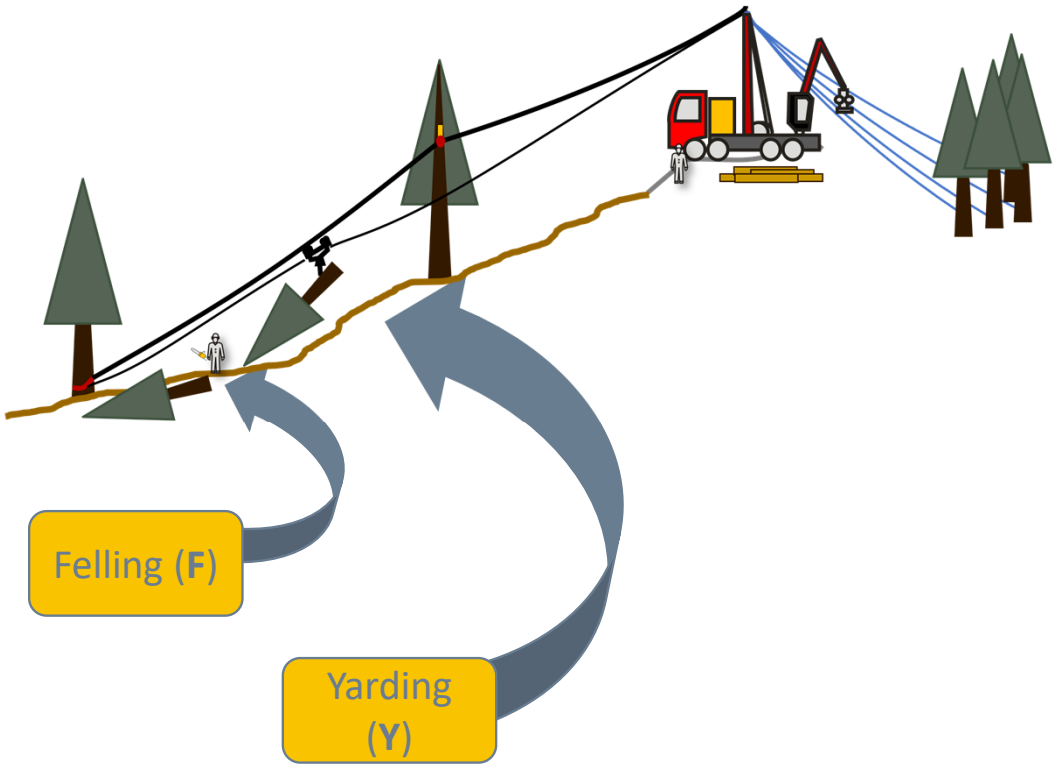
Standing volume: 989.67 m³

Timber marking: 03/05/2018

- Harvested trees: 183
- Harvested volume: 240 m³
- Estimated retail value: 18 077 CHF
- Harvest intensity: 25%
- Aim: promoting the development of an uneven-aged structure

# Harvesting system

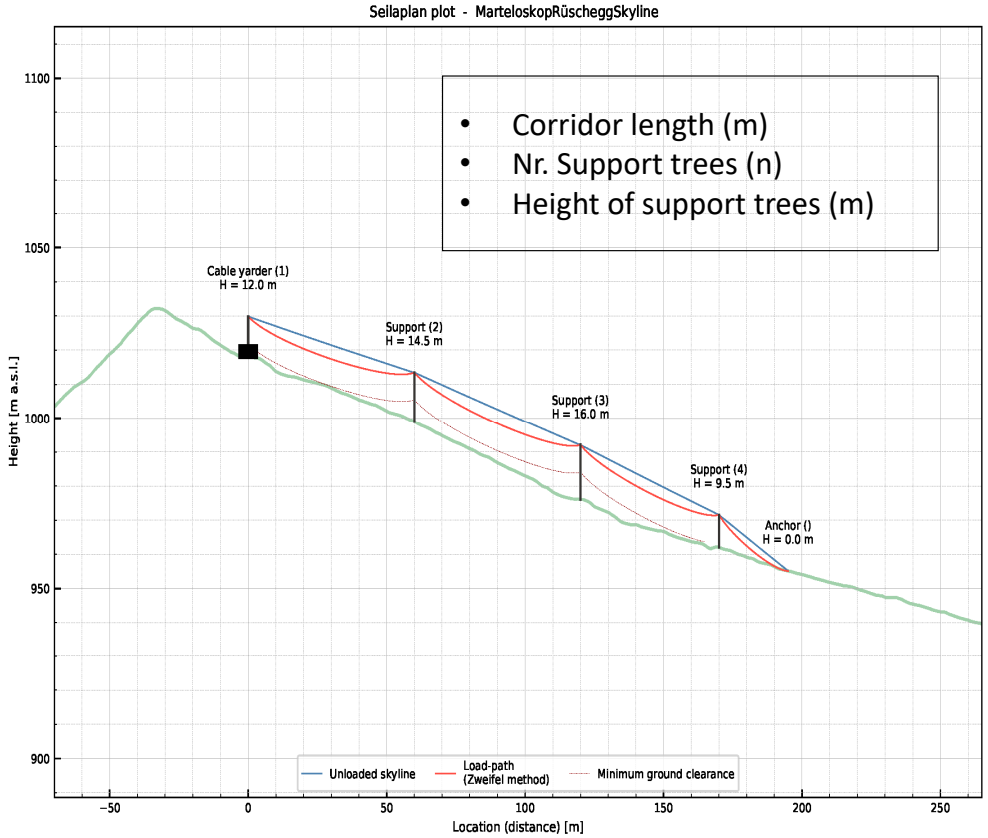
- System: semi-mechanised
- Method: whole tree
- Work elements:
  - **Felling** (**F**)
    - motor-manual operation
  - **Yarding** (**Y**)
    - mountain tower yarder with processor (*Syncrofalke*)
    - Uphill yarding direction




## Syncrofalke

- Power (kW): 235
- Max. tractive force (kg): 3000

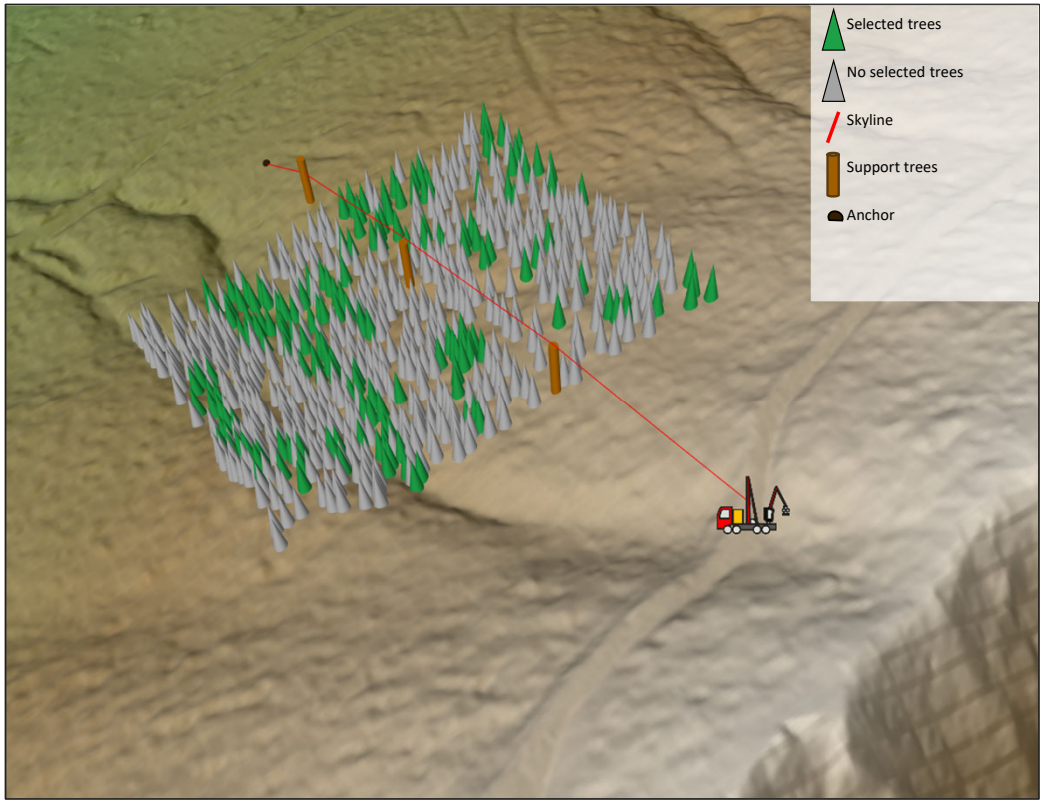
# Cable yarder system – layout




- Corridor length (m)
- Nr. Support trees (n)
- Height of support trees (m)

# Harvesting parameters (x each tree)

1. Yarding distance (m)
2. Lateral skidding distance (m)
3. Average slope (%)



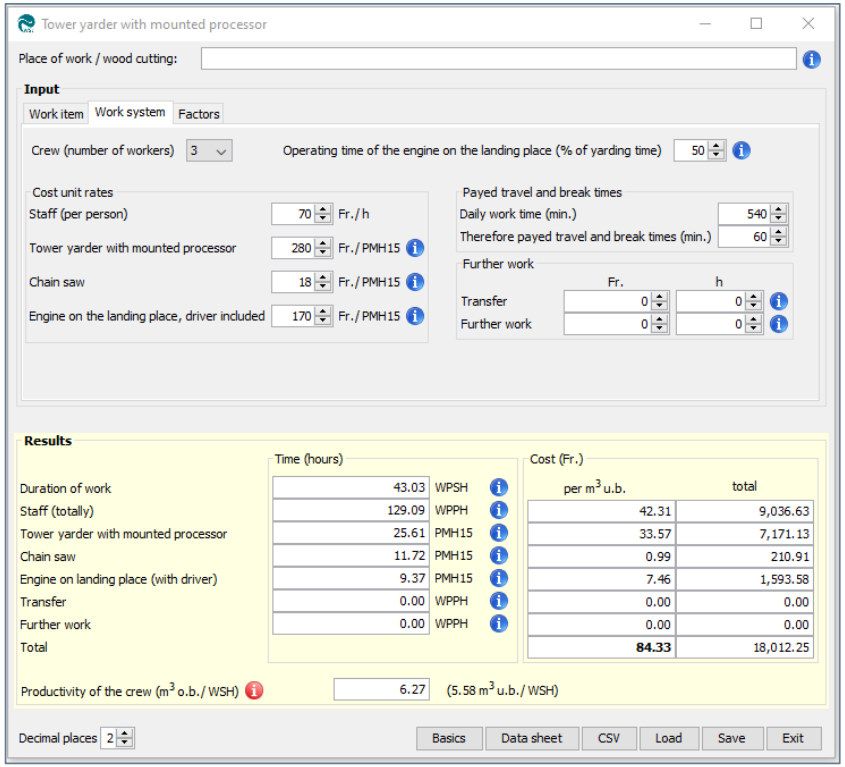
# From the typical harvesting block scale to a detailed break-down by individual tree

## Cable yarder system – Productivity

- Felling operations
  - **Felling time** (min/tree) = *0.0918 x Dbh – 0.1591* [1]
- Cable yarder setting up
  - **Set-up time** (hrs) = *e^(1.42 + 0.0029 x corridor length (m) + 0.03 x int. support height (m) + 0.256 x corridor type – 0.65 x extraction direction + 0.11 x yarder size + 0.491 x extraction direction x yarder size)* [2]
  - **Take-down time** (hrs) = *e^(0.96 + 0.00233 x corridor length – 0.31 x extraction direction – 0.31 x int. support + 0.33 x yarder size)* [3]
- Yarding operations
  - **Yarding Time** (min/cylce) = *0.007 x yarding distance (m) + 0.043 x lateral yarding distance (m) + 1.307 x tree volume^-0.3 ($m^3$) + 0.029 x harvest intensity (%) + 0.038 x slope (%).* [4]

[1] Lemm R. et Al. 2019
[2] Stampfer K. et Al. 2006
[3] Stampfer K. et Al. 2006
[4] Ghaffariyan M. & Al. 2009

## Cable yarder system – harvesting costs




HeProMo – Productivity models for wood harvesting operations. Version 2.5 / August 2021

# Harvest scenarios

Scenario 1 – Timber harvesting (**BAU**)

**Approach 1**: tree selection must be performed only within the marked trees group

Scenario 1.1 – Timber harvesting only positive **F** + **Y**

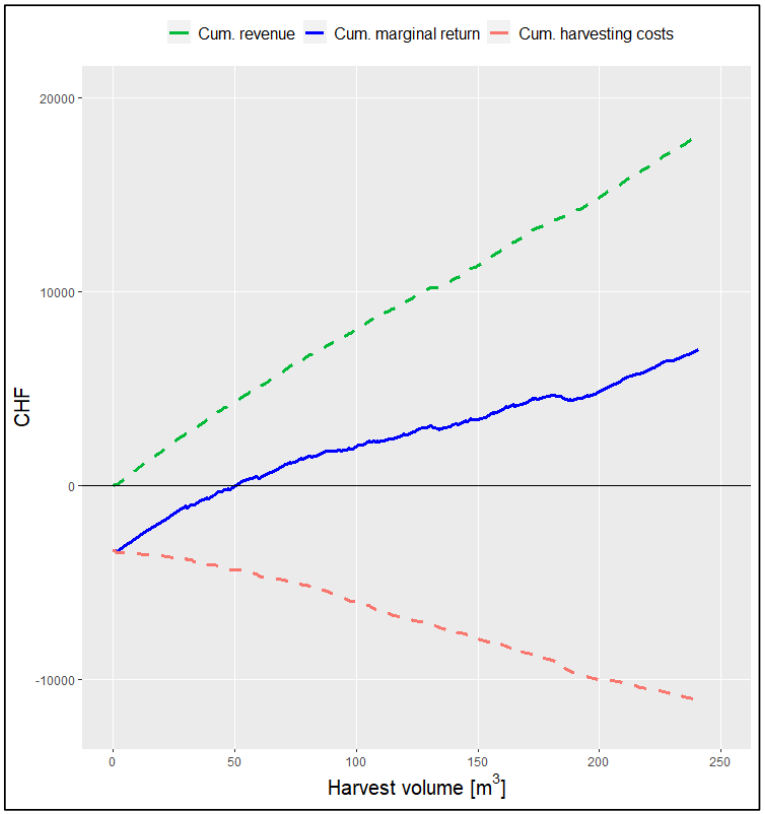
Scenario 1.2 – Timber harvesting only positive **Y** but all **F**

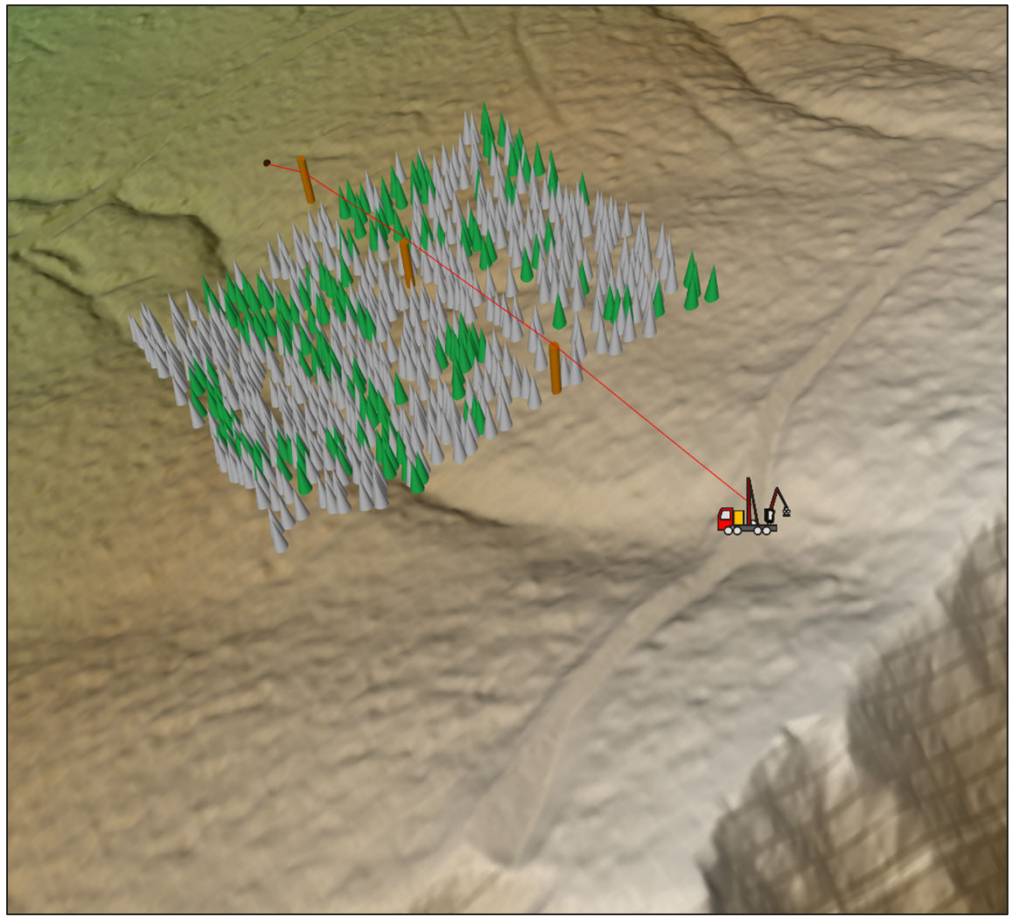
**Approach 2**: tree selection is enlarged to any marteloscope trees

Scenario 2 – Timber harvesting plus


Results

# Scenario 1 – Timber harvesting (BAU)



Felled volume (m³): 240

Harvested volume (m³): 240

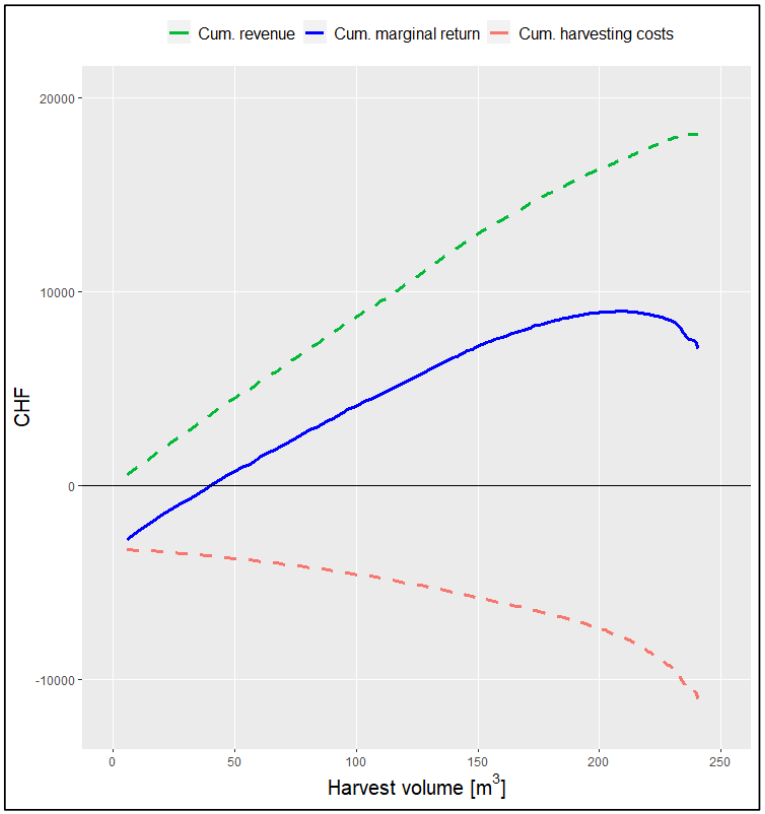
Productivity(m³/hrs): 9.4

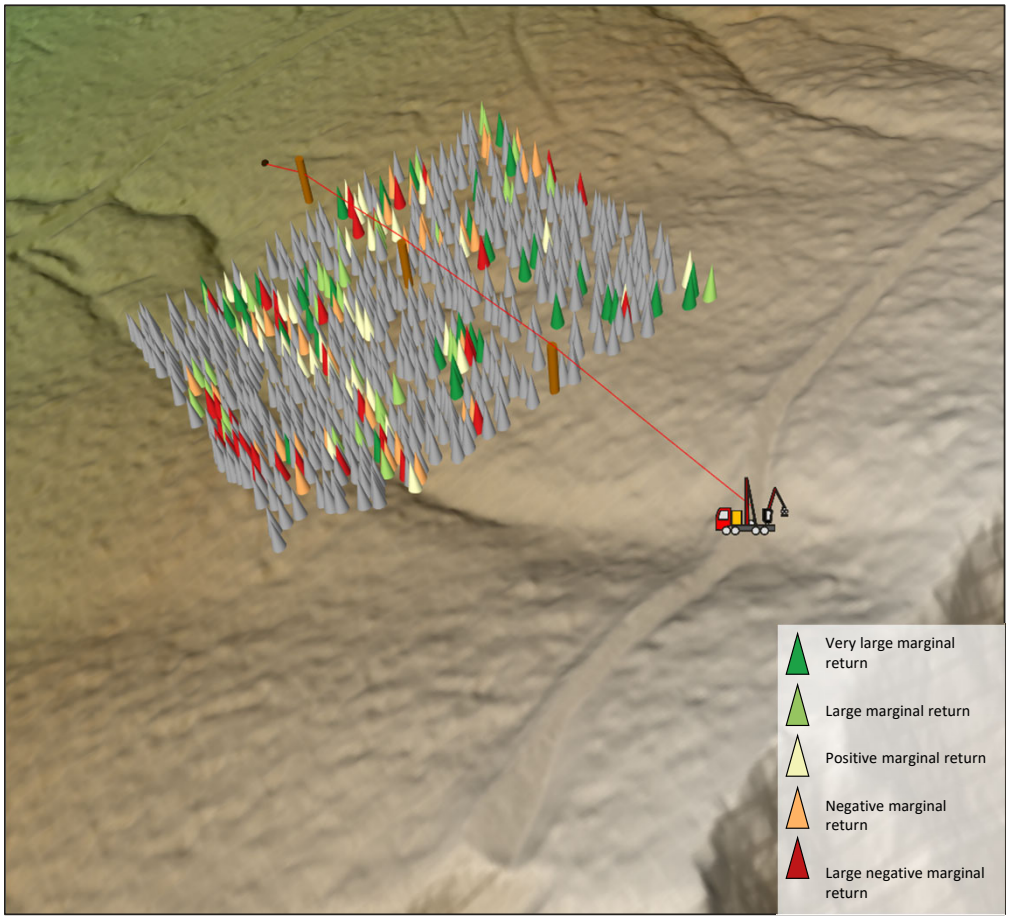
Total working time (hrs): 33.4

Harvesting costs (CHF): 11061

Total profit (CHF): **7016**

# Scenario 1 – Timber harvesting (BAU)

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Harvested volume (m³): 240

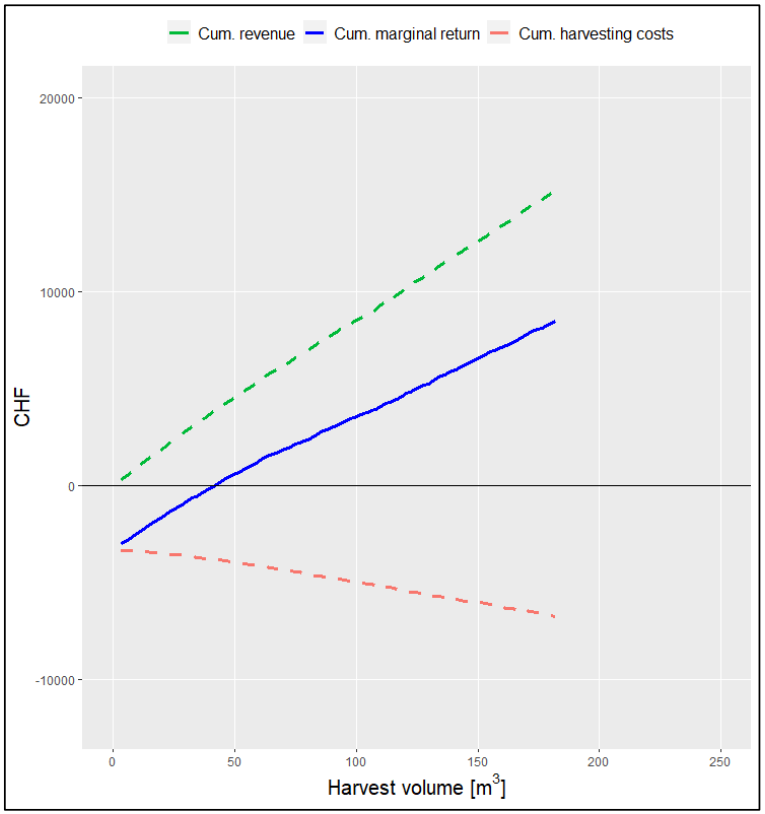
Productivity(m³/hrs): 9.4

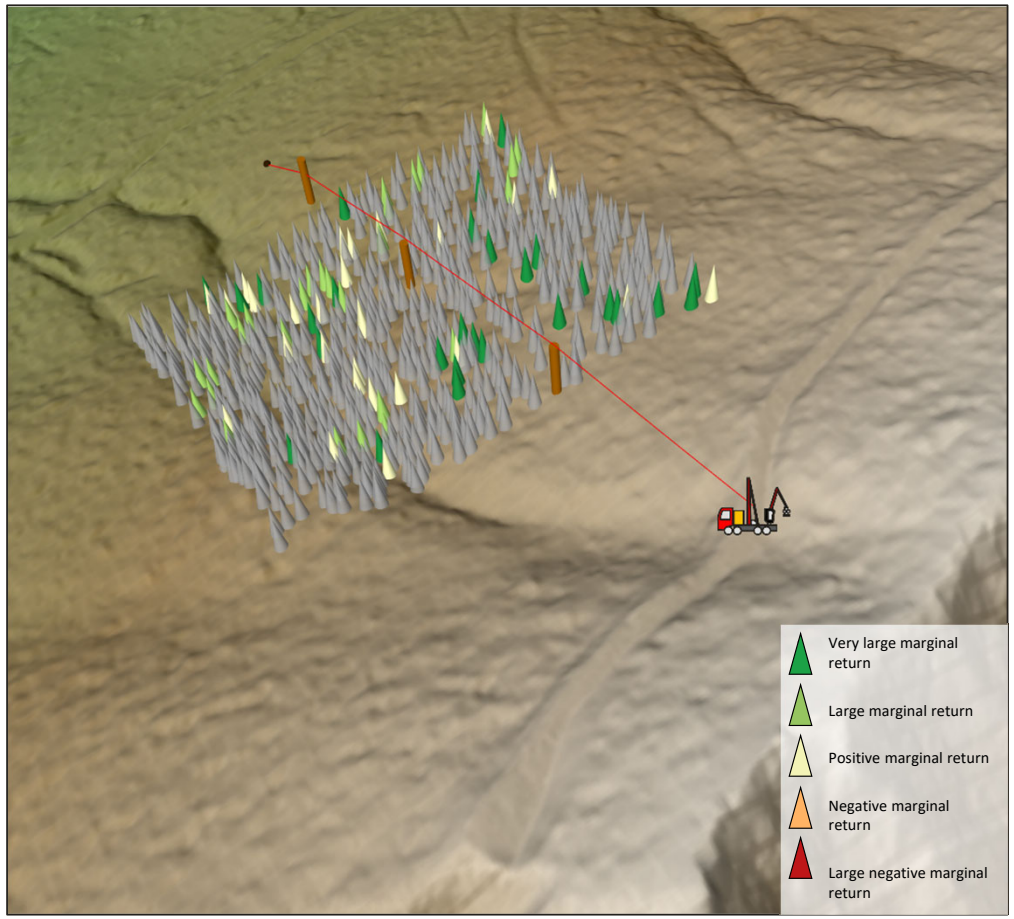
Total working time (hrs): 33.4

Harvesting costs (CHF): 11061

Total profit (CHF): **7016**

# Scenario 1.1 – Timber marking only positive F + Y




Felled volume (m³): 182

Harvested volume (m³): 182

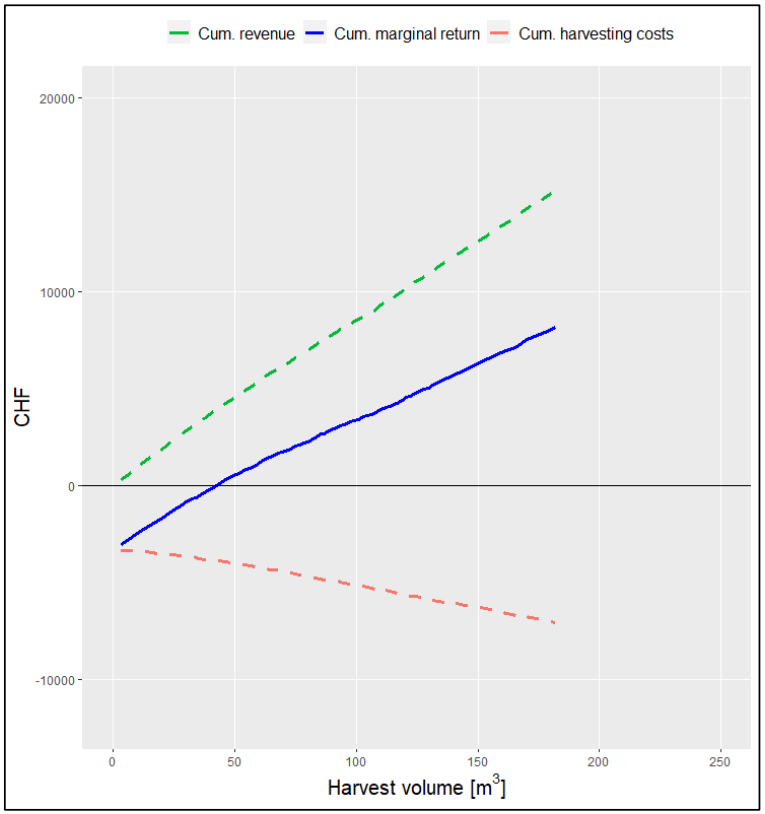
Productivity(m³/hrs): 14.6

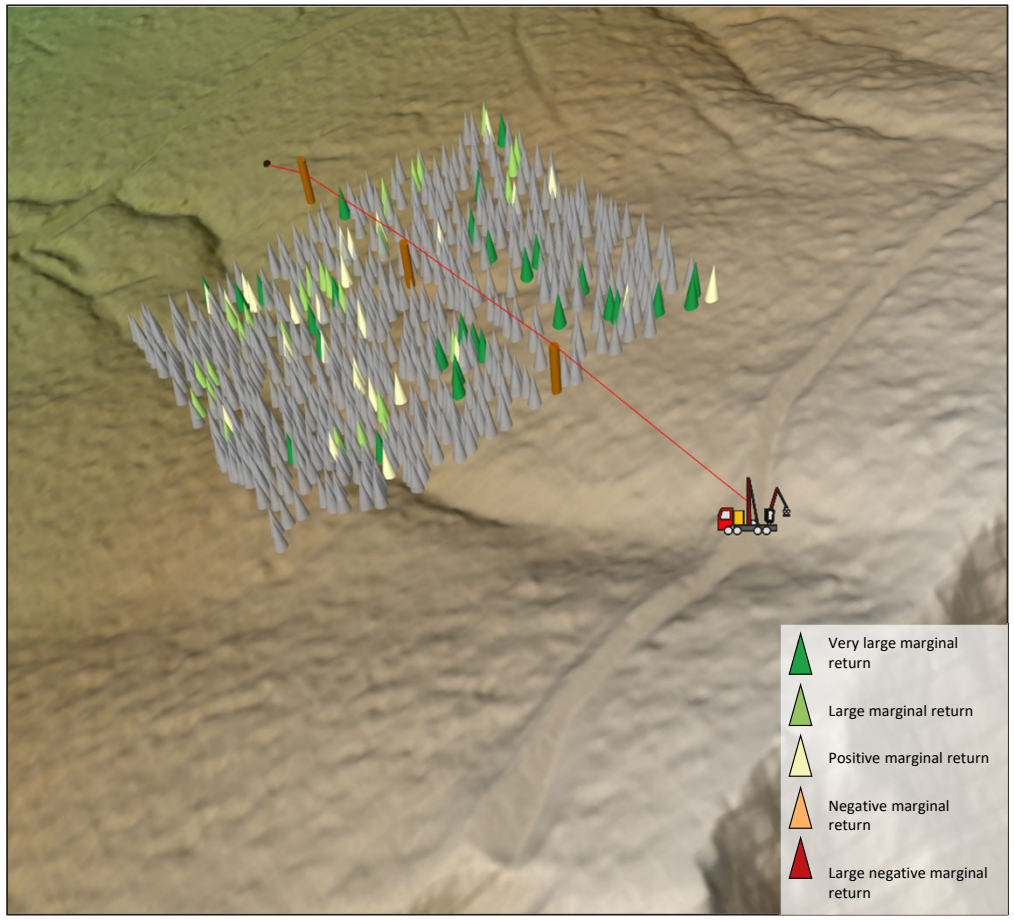
Total working time (hrs): 20.3

Harvesting costs (CHF): 6745

Total profit (CHF): **8460**

# Scenario 1.2 – Timber marking only positive Y but all F




Felled volume ($m^3$): 240

Productivity($m^3$/hrs): 11.4

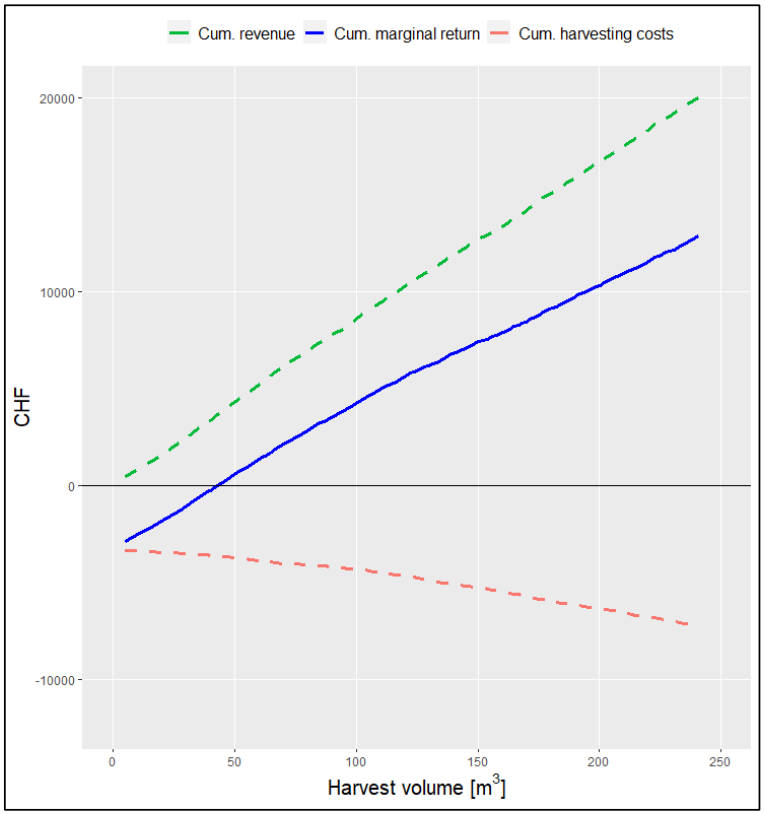
Harvesting costs (CHF): 7058

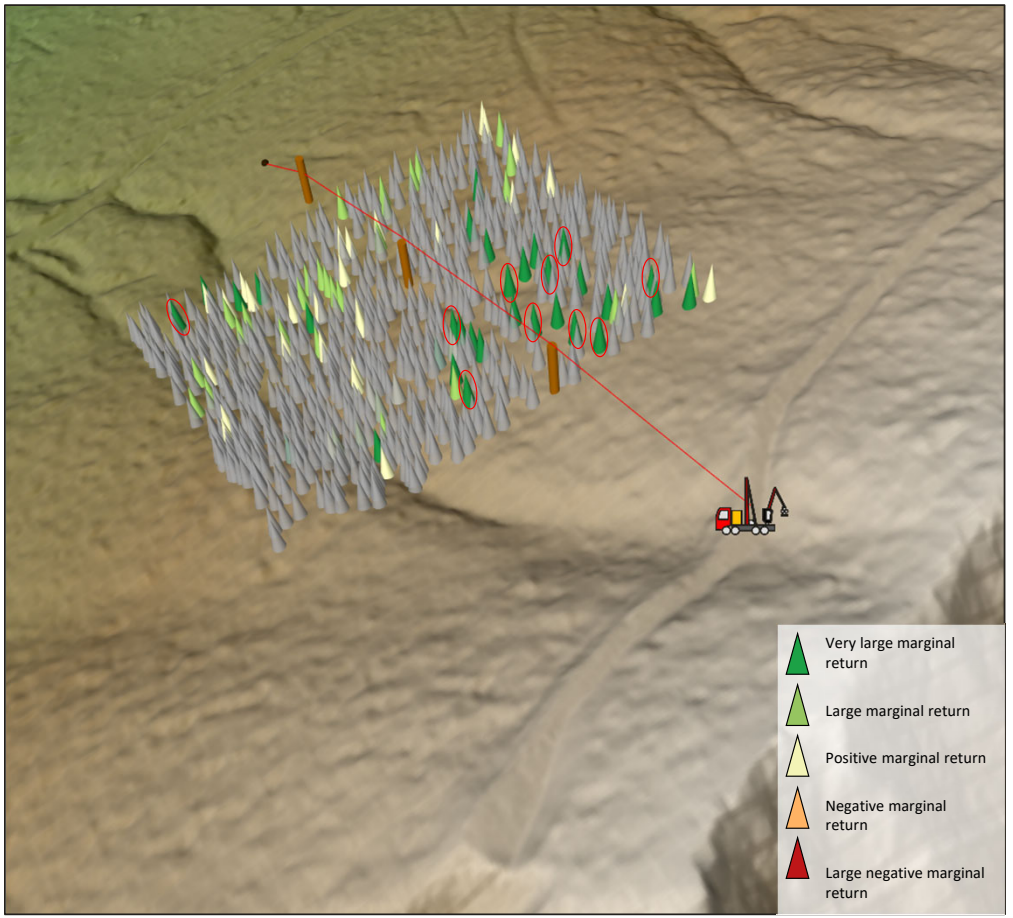
Harvested volume ($m^3$): 181

Total working time (hrs): 23.8

Total profit (CHF): **8147**

# Scenario 2 – Timber marking plus




Felled volume ($m^3$): 241

Harvested volume ($m^3$): 241

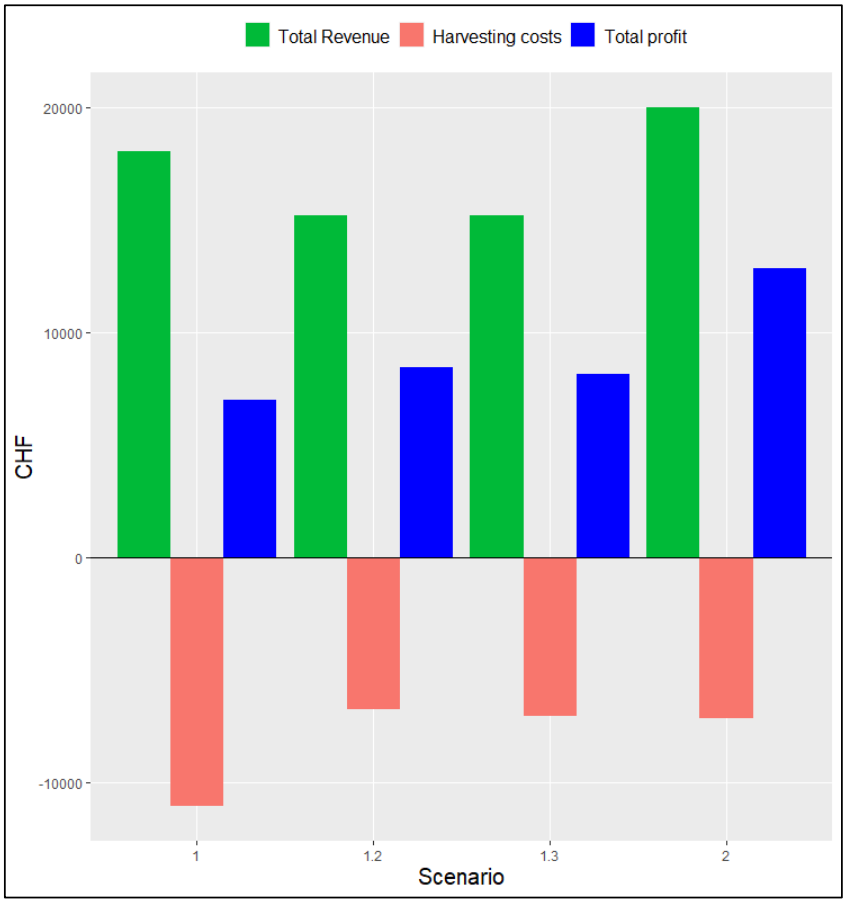
Productivity($m^3$/hrs): 16.9

Total working time (hrs): 22.1

Harvesting costs (CHF): 7161

Total profit (CHF): **12836**

# Scenario comparison




| Scenario | Harvested volume (%) | Harvesting Time (%) | Harvesting Costs (%) | Marginal Return (%) |
|---|---|---|---|---|
| 1.2 | -24.4 | -51.3 | -39.0 | 20.6 |
| 1.3 | -24.4 | -37.4 | -36.2 | 16.1 |
| 2 | 0.1 | -44.1 | -35.3 | 83.0 |

- **Harvesting costs** are significantly reduced when forest operations are planned also considering the marginal return per tree (-39.0%, -36.2%, -35.3%).
- Comparison among scenario 1.2 and 1.3 showed that a remarkable increase in the **total profit** can be achived by avoiding yardering of trees with negative marginal returns (+ 20.6%, + 16.1 %).
- A high increase in total profit can be realised by pre-selecting the most profitable trees while respecting the **timber volume established** (+0.1%) in the harvest plan (+ 83.0%).

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- There is considerable space for improvement in the efficiency of timber harvesting systems provided we have expected revenue and harvesting costs available.

- Timber marking and harvesting pattern can be better arranged:

  - Strict silvicultural treatment:
    - Harvesting of the trees showing positive marginal return → Remaining trees to be harvested when volume is profitable
    - Felling of all the marked trees but harvesting of only positive marginal return ones (when possible) → Protection forests

  - Possibility of more flexible timber marking → wide range for better compromise among silvicultural aim and harvesting profitability (83%)


Thank you for your attention!