# OPTIMIZING LOGISTICS OF SAW LOGS FOR A MEDIUM SIZED SAWMILL


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# SAWLOGS ARE IMPORTANT

# BUT THE VALUE MAY DETERIORATE

**Storage over a longer time can cause**

- **Discoloration**
- **Fungal decay**
- **Cracks**

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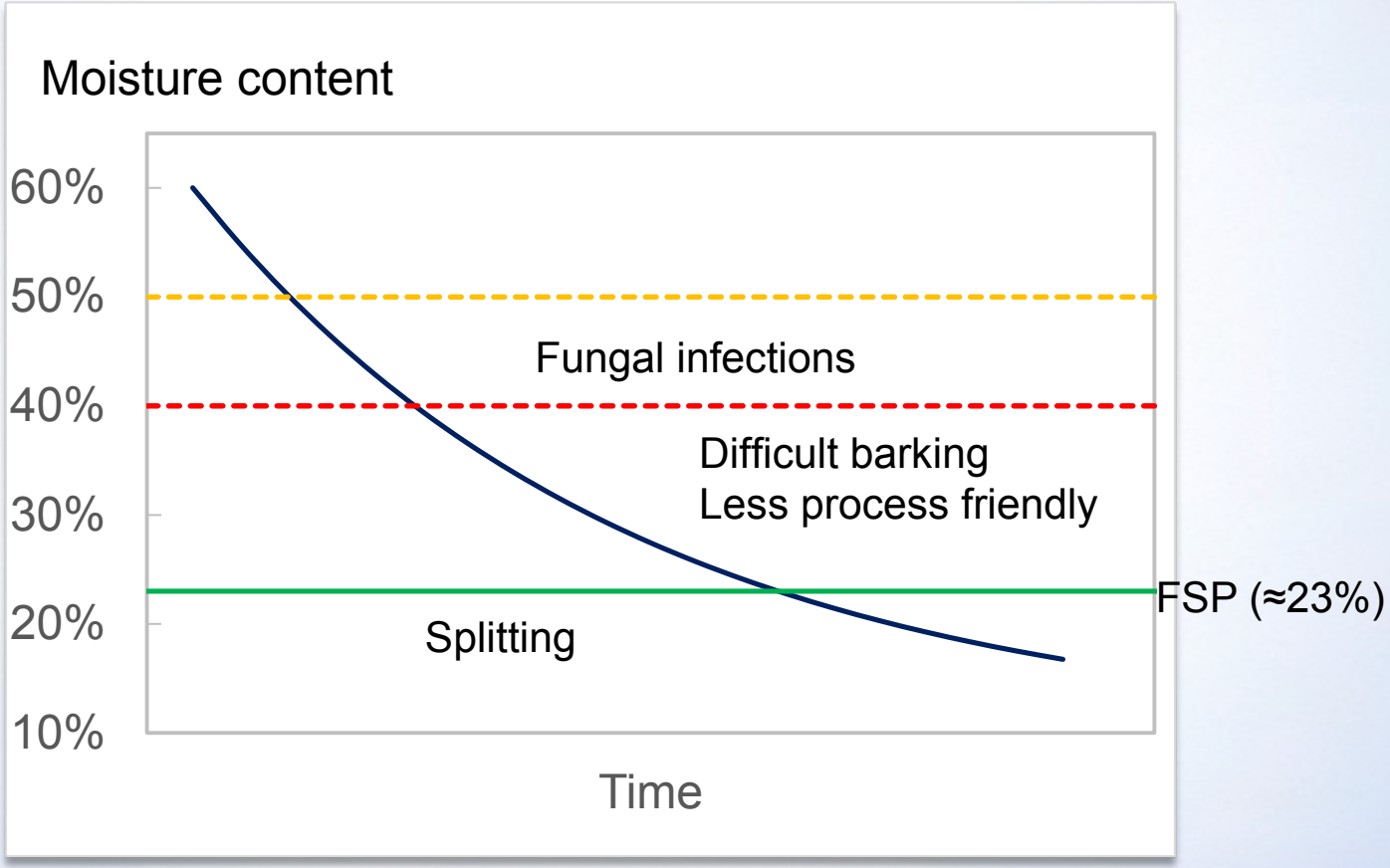
# THE PROBLEM: LOSS OF MOISTURE CONTENT



# SPRINKLING HELPS, BUT…

Photo: Per Österman

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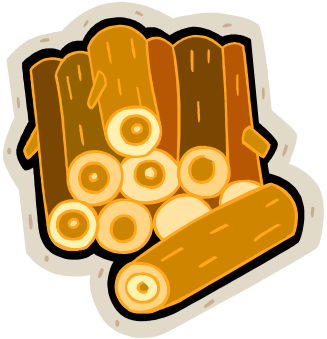
# IS NOT ALLOWED IN MANY PLACES

# WEATHER DETERMINES THE DRYING PROCESS



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# DRYING-RATE OF ROUNDWOOD CAN BE PREDICTED

$$MC_l = c_1 \sum_{1}^{n} (daytemp_i \times daydry_i) + c_2 \times \exp \sum_{1}^{n} (daytemp_i \times daydry_i)$$

where

| | |
|---|---|
| $MC_l$ : | Loss of moisture content |
| $daytemp_i$: | Average temperature during day *i* (0 if < 0) |
| $daydry_i$: | 100% - average relative air humidity (%) during day *i* |
| exp: | Exposure to sun and wind (can vary between 0% and 300%) |
| $c_1$: | Constant = 0.000216 |
| $c_2$: | Constant = 0.000253 |

from Persson et al. 2003

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# YOU CAN CHANGE THE EXPOSURE

Photo: Juha Rikala

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Above figures: U-C Coatings Corporation

# MODEL SAWMILL:

- Central Finland
- Total production: 220 000 $m^3$ /a
- Total roundwood consumption: 440 000 $m^3$ /a
- Production 11 months / year (closed July)

# SUPPLY CHAIN

**Storage**
***Time:***

**On site**
***3 days***

**Roadside**
***Varying***

**Sawmill**
***2 weeks***

***Operation:*** **Harvest** **Forwarding** **Road transport**

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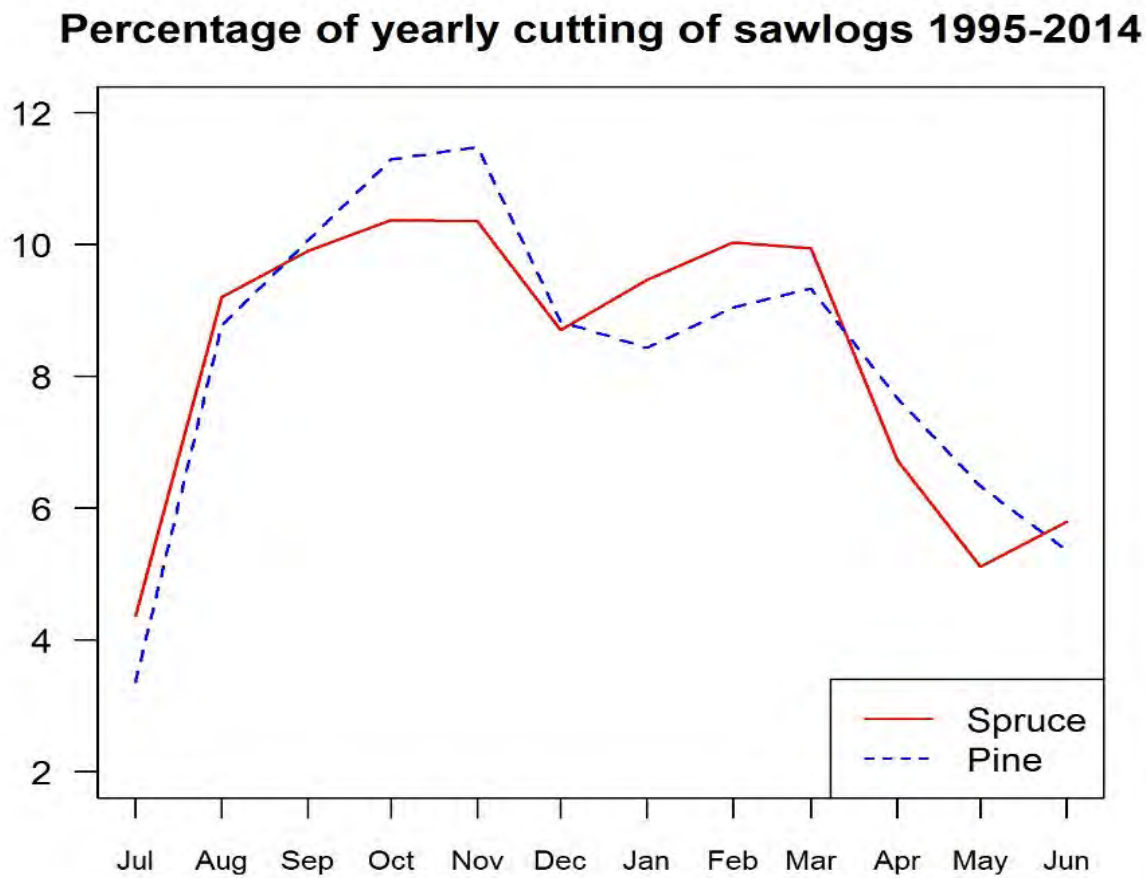
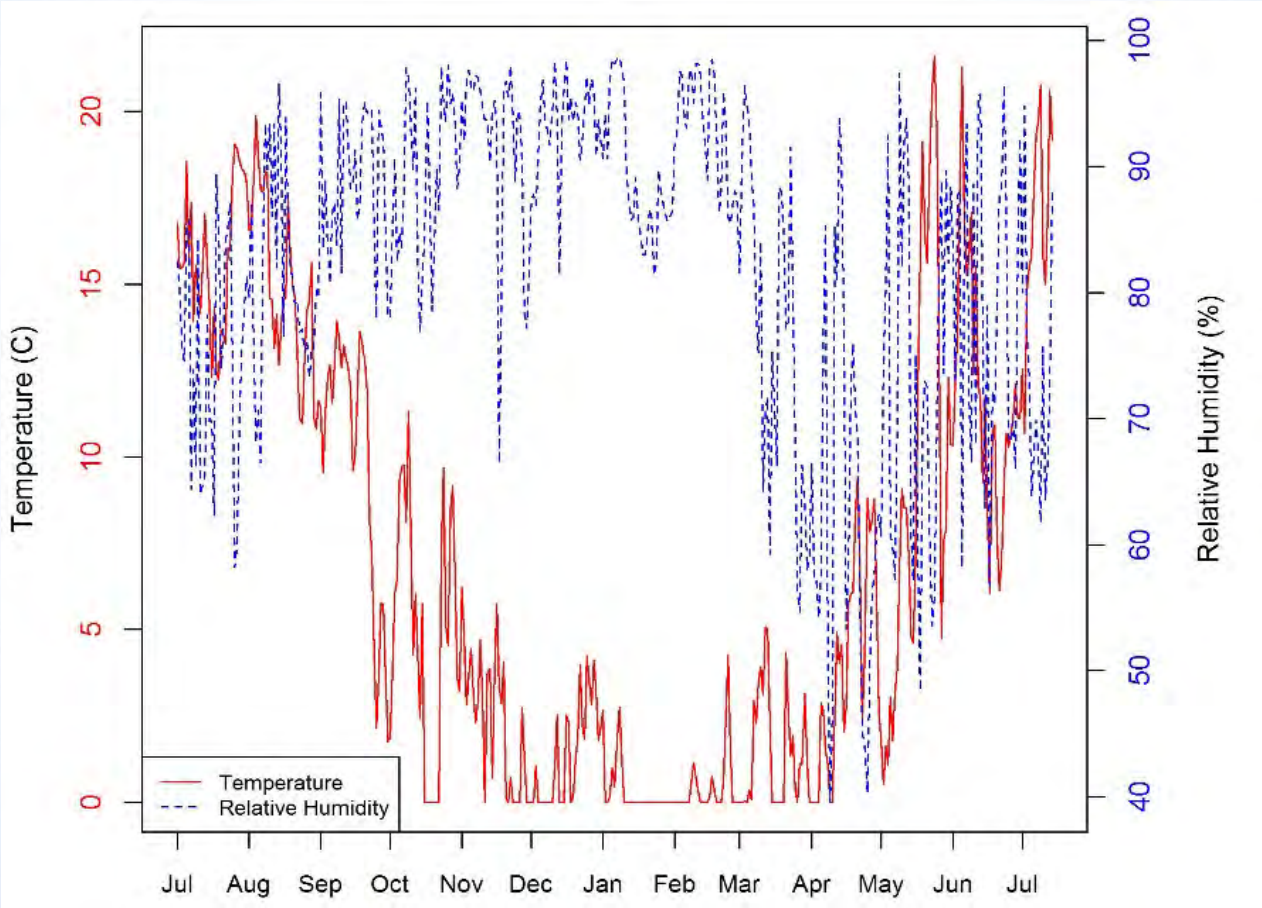
# MONTHLY HARVESTING OF SAWLOGS




from LUKE 2015

# WEATHER DATA



# USED EXPOSURE RATES

| Place of storage | Exposure [%] |
|---|---|
| On harvest site | 200 |
| Exposed pile | 80 |
| Covered pile | 20 |
| At sawmill | 80 |

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# COSTS USED IN STUDY

| Item | Cost [€/m$^3$] |
|---|---|
| Cover pile | 1 |
| MCl* 5−10% | 5 |
| MCl 10−15% | 10 |
| MCl >15% | 15 |

*MCl = Moisture content loss

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# OPTIMIZATION: GOAL PROGRAMMING MODEL

$$\min z = \sum_{d=1}^{\#D} \sum_{i=1}^{\#I} \sum_{t=1}^{\#T} s_{dit} y_{di} x_i \, p_t + \sum_{i=1}^{\#I} \sum_{t=1}^{\#T} s_{dit} w_i x_i \, p_t + \sum_{i=1}^{\#I} c_i$$

$\#D$ = total number of days
$\#I$ = total number of piles
$\#T$ = total number of penalties

$x_i$ = quantity of timber at pile *i* (harvested at time *i*)
$y_{di}$ = fraction of pile *i* processed at day *d*
$p_t$ = penalty associated with threshold *t*
$s_{dit} = \begin{cases} 0 \text{ if } \mathrm{MCl}_{di} < t \\ 1 \text{ otherwise} \end{cases}$
$w_i$ = proportion of pile *i* left unprocessed
$c_i$ = cost associated with covering pile *i*

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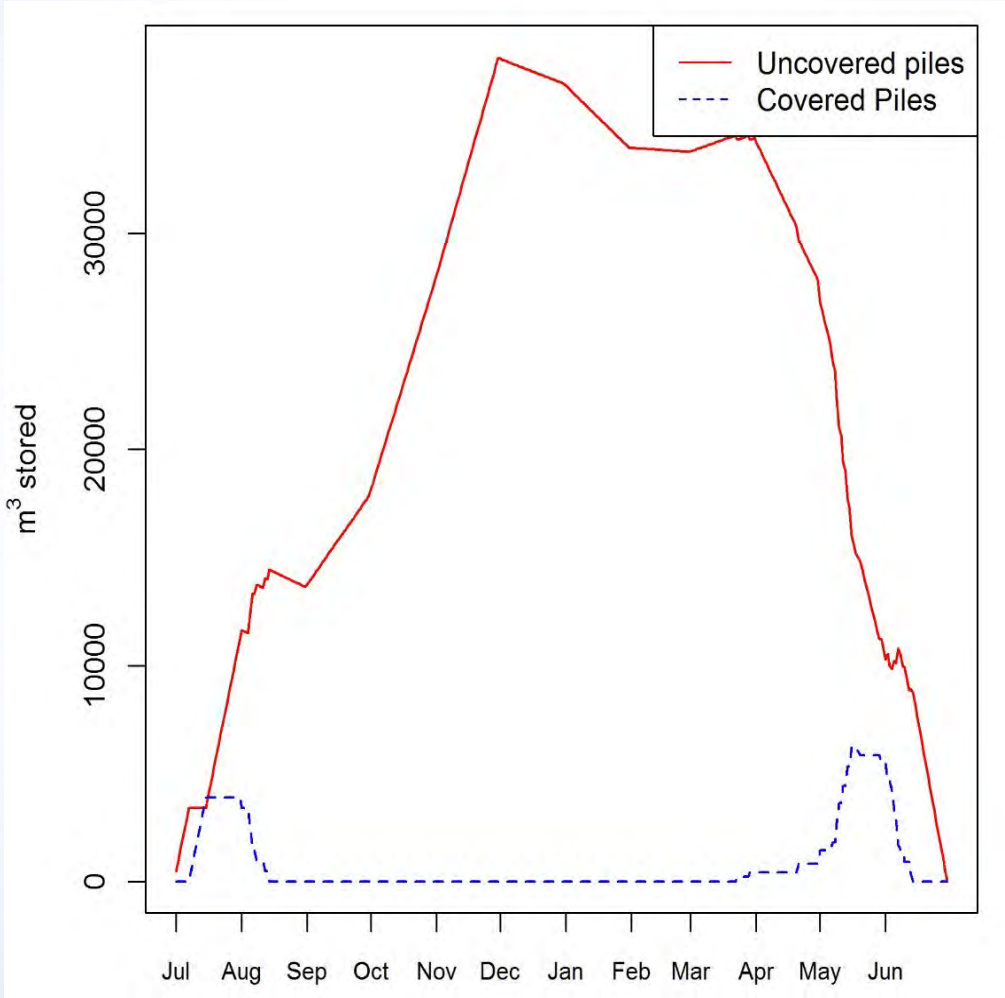
# RESULTS


Uncovered piles
Covered Piles
m3 stored
0
10000
20000
30000
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun

# CONCLUSIONS

- By covering a portion of piles in May – August the effects of drying could be controlled
- The amount needed to be covered was 2,3%
- The maximum Moisture Content loss was 12%
- Technical solutions for changing the exposure needs to be developed and studied

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# THANKS FOR YOUR ATTENTION!

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