Kiln gains: Automating Species Separation

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OUTLINE

1. Improvement needs in kiln drying

Improve drying outcome

- Improve final moisture content (MC) distribution

- Improve grade recovery

    - Reduce percentage of "wets"
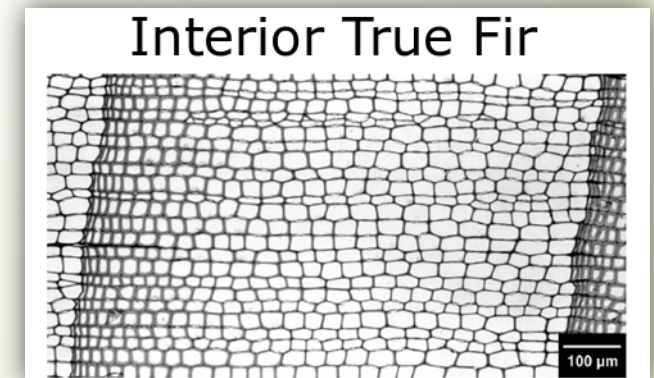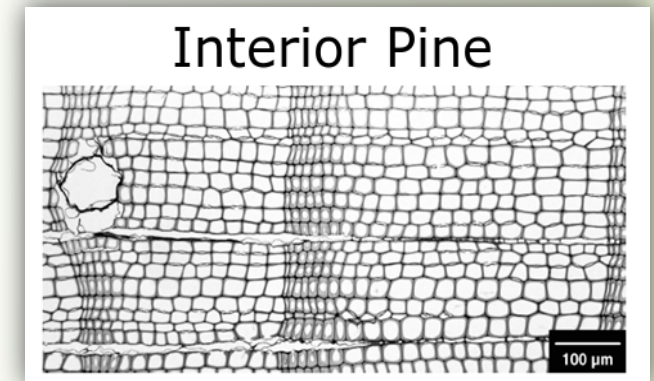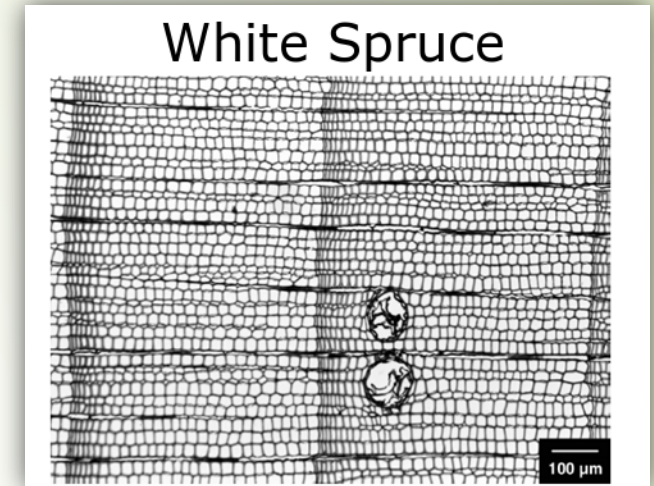
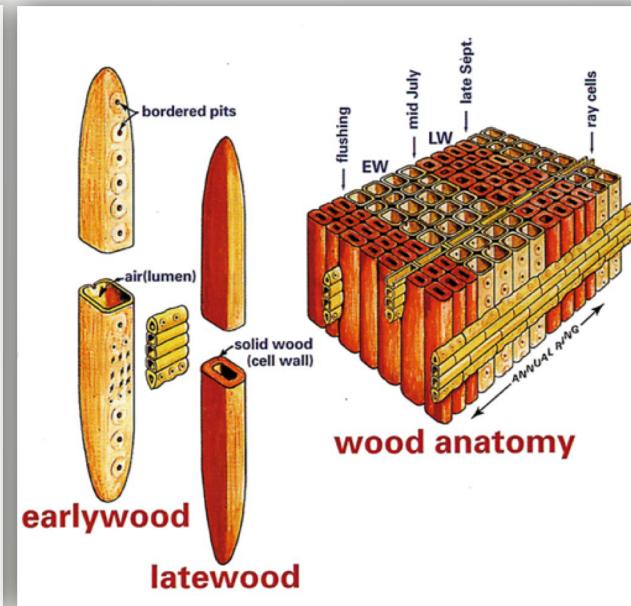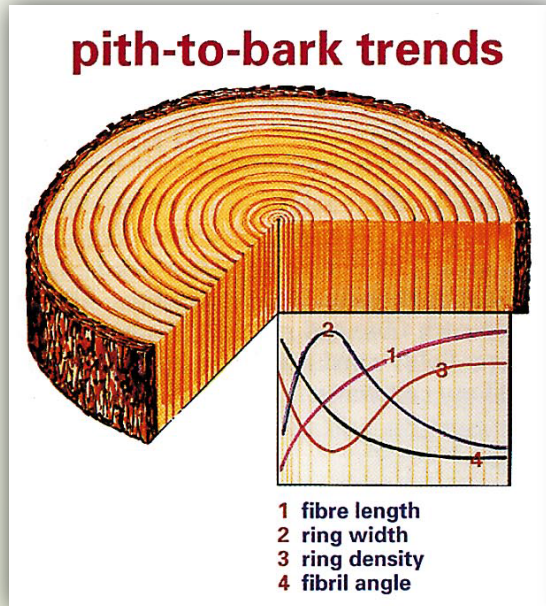   - Reduce drying degrade from over-drying

Reduce drying cost and increase throughput

- Reduce drying time for a load → increase kiln productivity

- Reduce energy consumption

2. Why species separation is important for drying

Key wood properties affecting drying are species specific

- Initial MC and its variability

- Wood permeability

- Sapwood versus heartwood proportion

- Basic density and its variability

- Growth rate

White Spruce

Interior Pine

Interior True Fir

pith-to-bark trends

1 fibre length
2 ring width
3 ring density
4 fibril angle

bordered pits

air(lumen)

solid wood (cell wall)

flushing
EW
mid July
LW
late Sept.
ray cells
ANNUAL RING

wood anatomy

earlywood

latewood

2. Why species separation is important for drying

drying curves
High MC sort
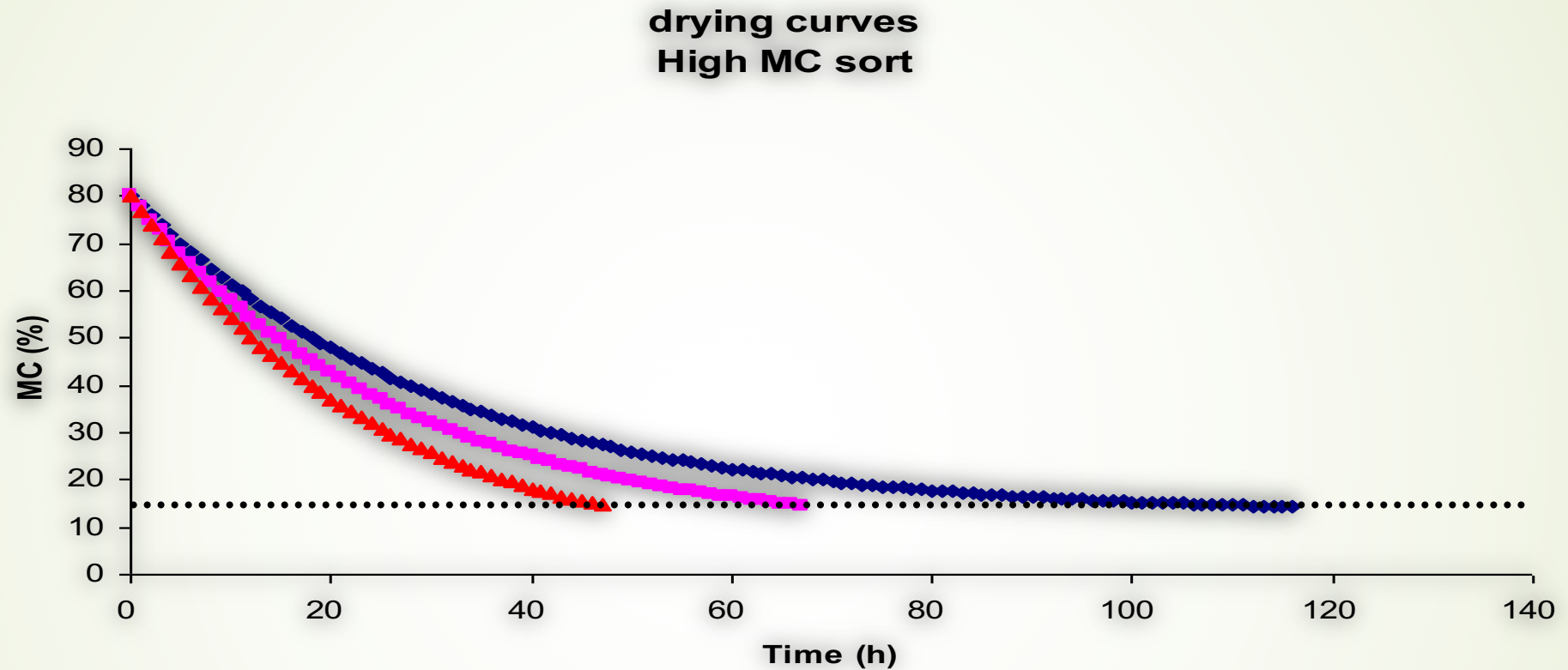
= Spruce

= Pine

= Subalpine fir

2. Why species separation is important for drying

Sometimes, initial moisture content and density are not good indicators for drying time

Initial MC: 93.4%

Final MC: 15.43%
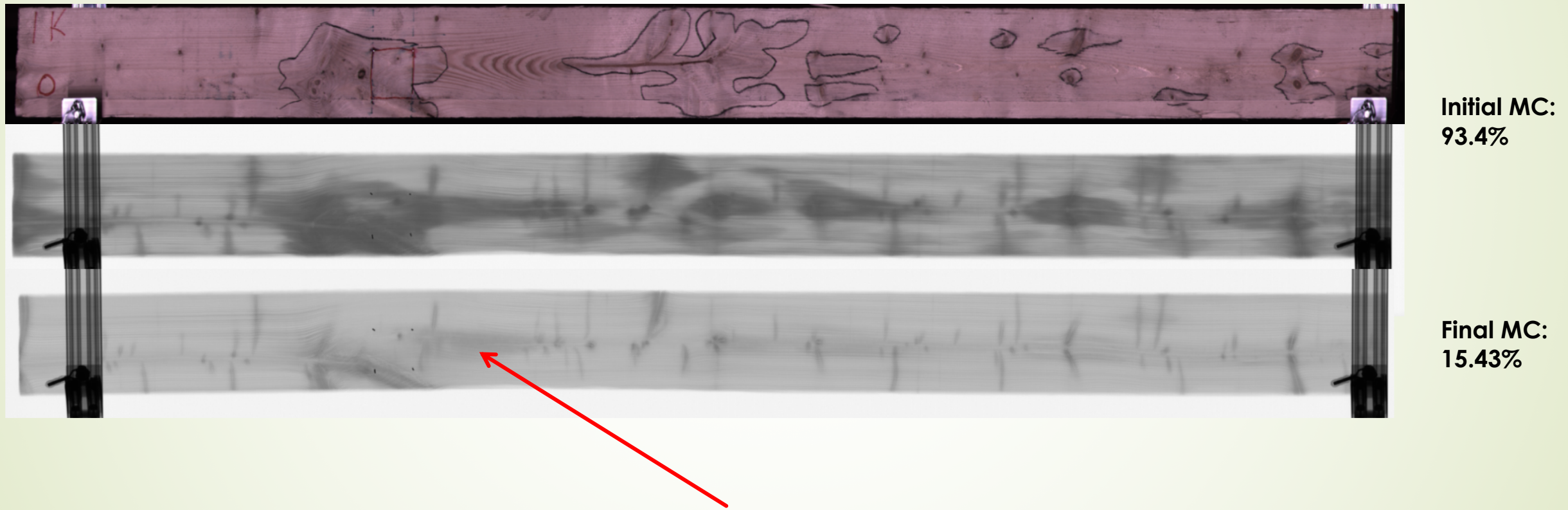
X-Ray image of a piece of fir showing the presence
of wet pockets even after drying and at 15% average MC

2. Why species separation is important for drying

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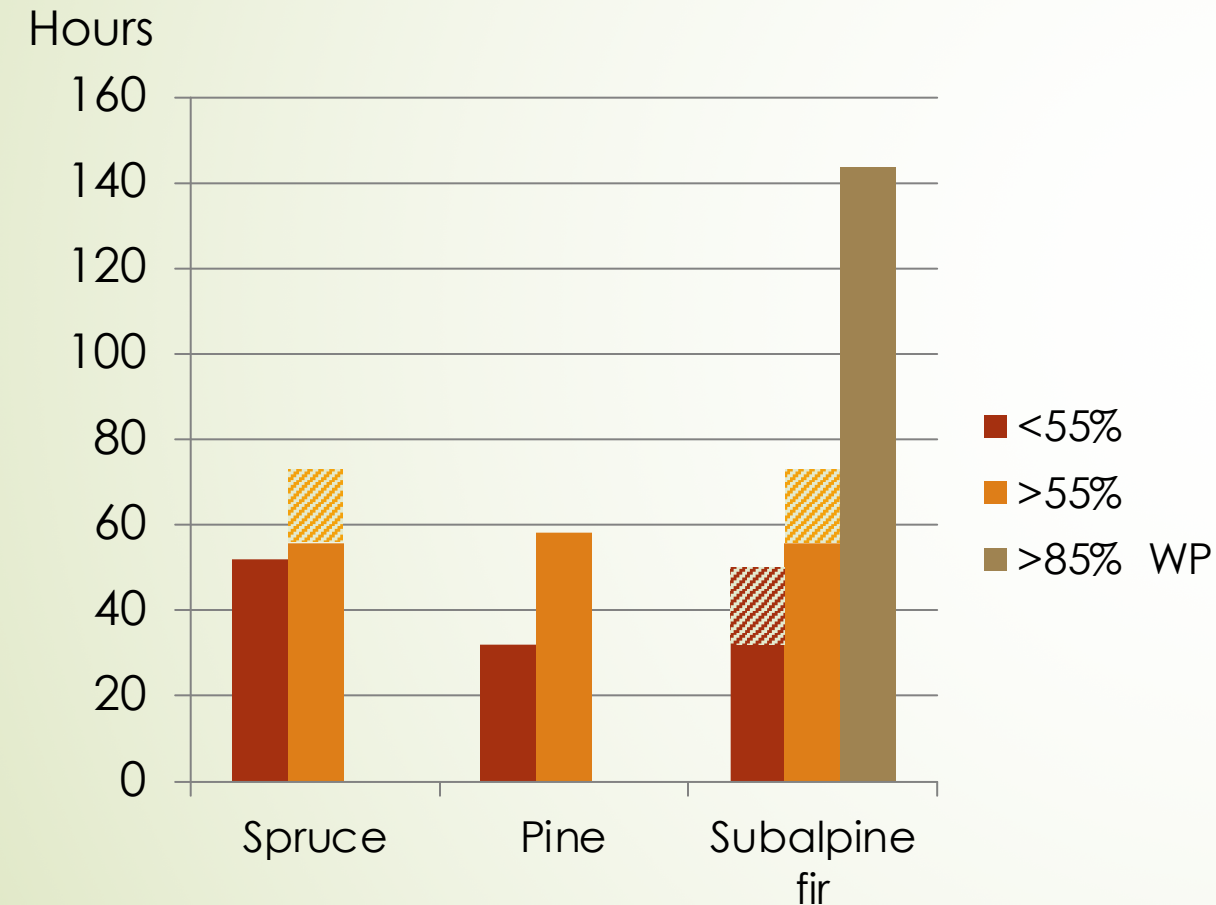

Initial MC: 113.93%

Final MC: 19.1%
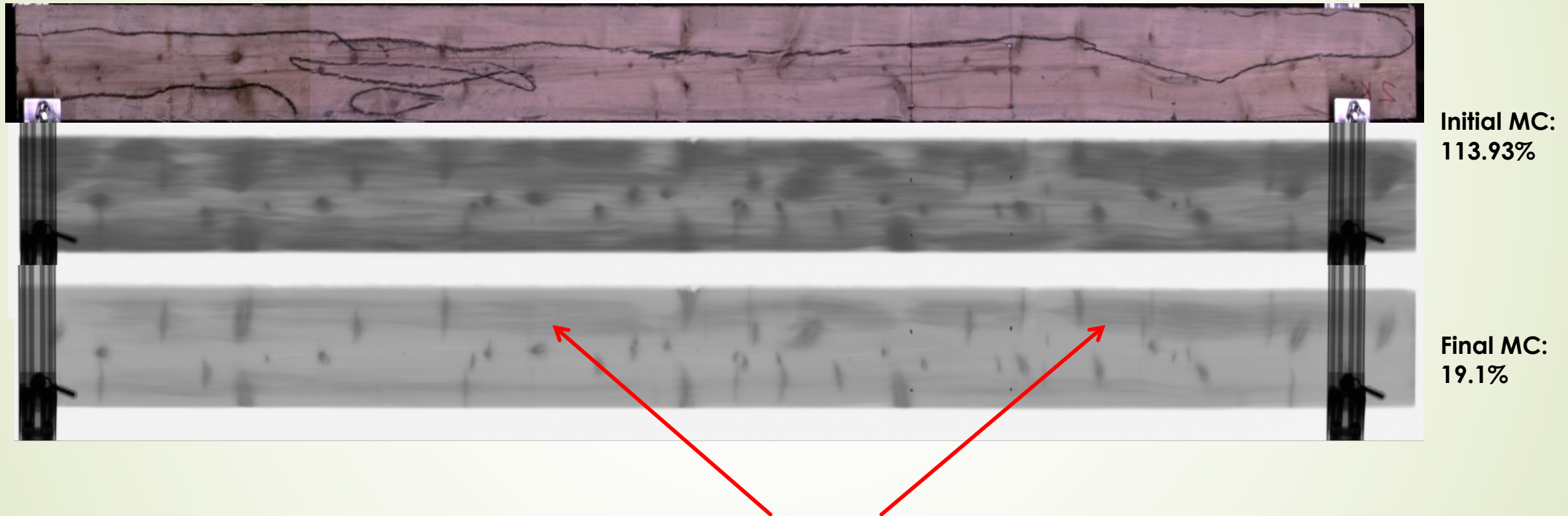
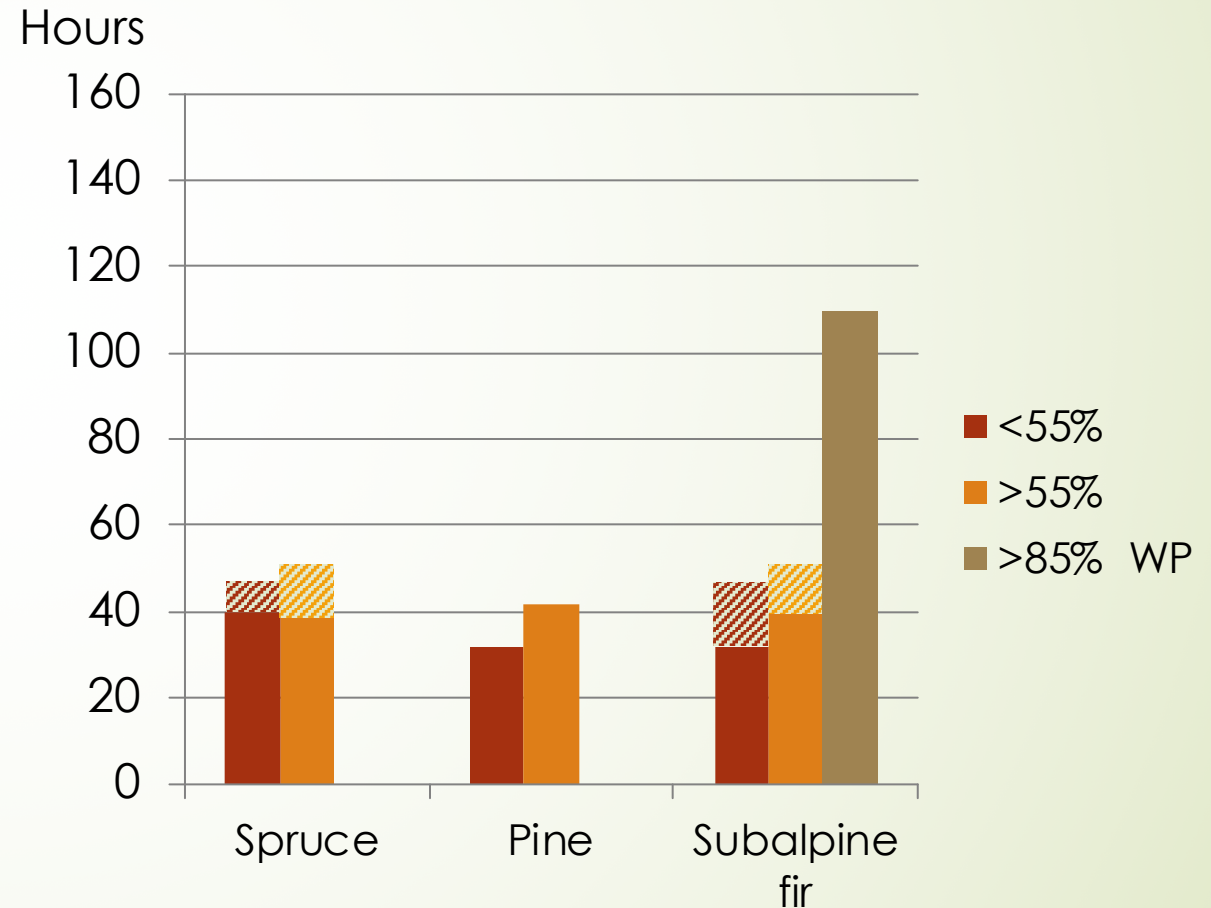X-Ray image of a piece of fir showing the presence of wet pockets even after drying and at 19% average MC

2. Why species separation is important for drying

Optimum drying strategies require a combination of species and MC sorting

Approximate drying times for 2" SPF based on schedules discussed in SPF Drying Manual (FPInnovations, 2008)

2. Why species separation is important for drying

According to FPInnovations study, using OASIS simulation software combined with real data from a sawmill:

- The optimum two-way sorting strategy for drying SPF is species based

- An efficient system that can sort Fir vs Spruce/Pine into 2 lots can bring a productivity gain of 31.7%

Sorting Criteria	Optimal Separation Value	Drying Productivity Gain
Species (Spruce/Pine vs Fir)	Spruce/Pine vs Fir	31.7%
Initial MC	71%	26.4%
Initial Mass	6.70 kg	15.5%

- Spruce avg. drying time: **45 h**

- Fir avg. drying time: **111 h**

2. Why species separation is important for drying

- For mixed species, initial MC and mass typically don't correlate well with drying time

- This was the motivation for the creation of SAPTEK, a pH based system to separate fir

- Fir has a particularly large distribution in drying times, which can be reduced by weight or MC sorting

Images courtesy of FPInnovations (2012): "Identification des strategies optimales de triage des bois EPS – Évaluation des technologies de prétriage."
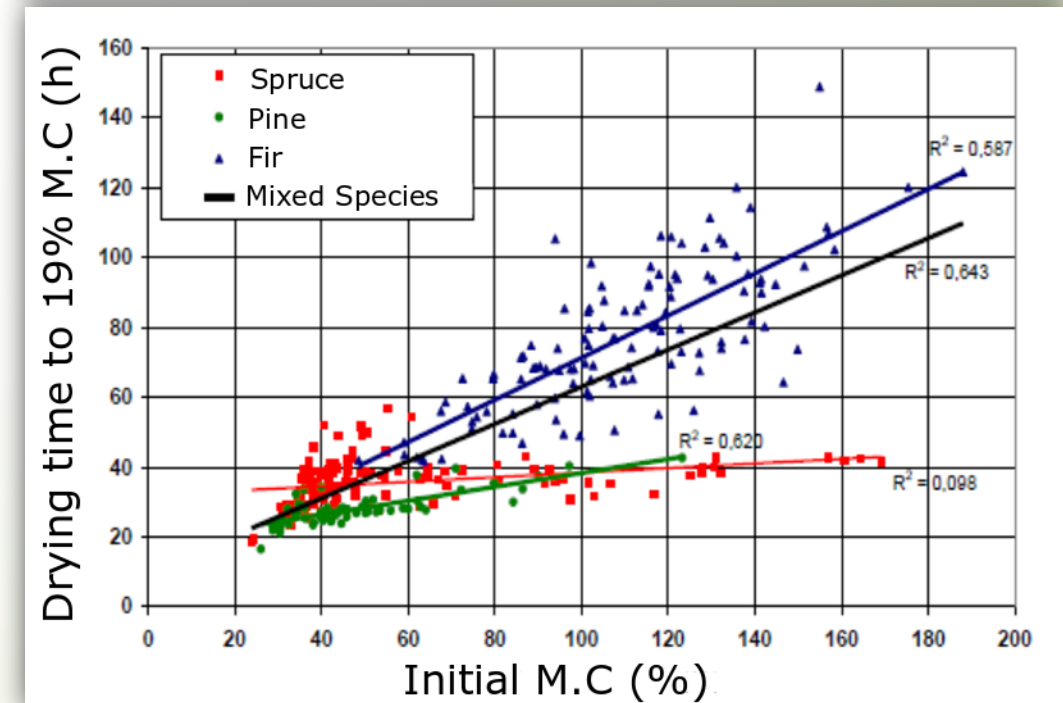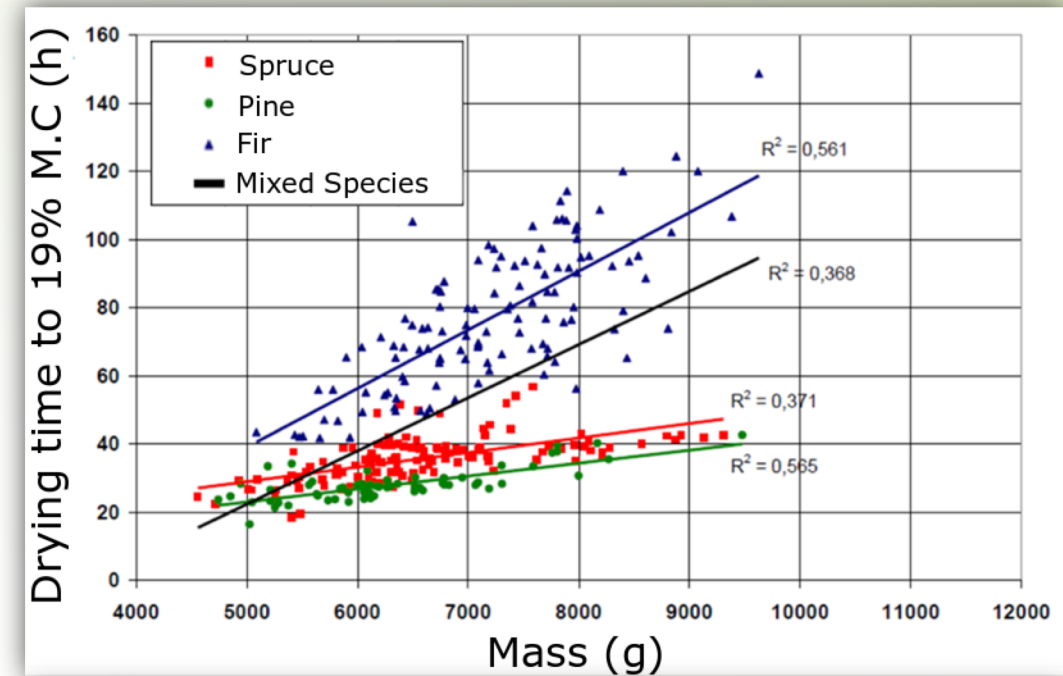
2. Why species separation is important for drying

Plethora of ways to sort wood based on various wood properties

	PROS	CONS
Dielectric	• Non-contact • Non-destructive	• Affected by both moisture and density • System reacts poorly when wood is frozen • Limited moisture range
Resistive	• Accurate localized measurement • MC range less limited than dielectric systems	• Contact measurement • Limited moisture range • No on-line solution
Volumetric mass	• Ease of use	• Contact measurement • Sorting accuracies lower than all other systems when dealing with mixed species
pH level	• Works across all seasons	• Need to spray a chemical solution • Need a fresh cut • Does not work for all species

Some systems work by using a combination of these properties

2. Why species separation is important for drying

What is the best way to pre-sort for drying?

- Sorting logs based on species is practical for some mills, but the added cost (1.75 – 7 $ Mbf) or the need to balance inventory, log diameter for mill flow, or chip production, makes log sorting undesirable for many mills

- Sorting boards on-line (for example using NIRS) could be a suitable option for these mills

3. What is NIR?

- Near-infrared is a narrow band on the electromagnetic spectrum between visible light and infrared

- Absorption efficiency at different near-Infrared wavelengths depends on material (molecular bond) and surface properties (species dependent!)
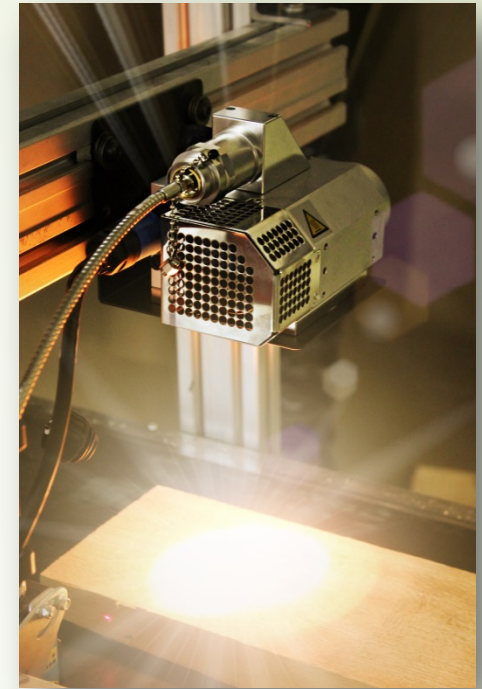
Why NIR spectroscopy?

- High-speed, non-contact and non-destructive method

- External effects can be handled by careful spectral analysis
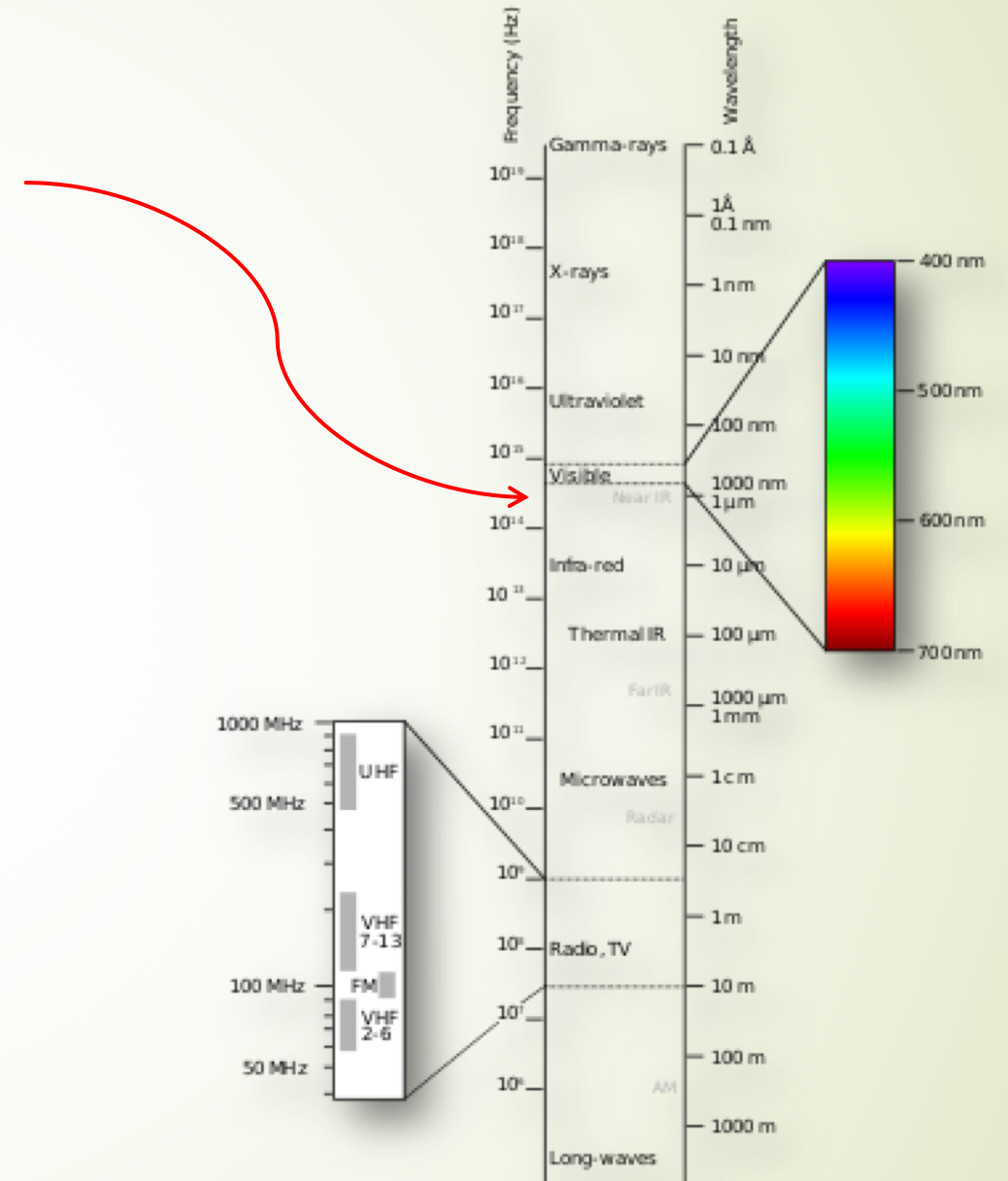
NIRS – Basic measurement concept:

- Illuminate the board

- Collect the reflected near-infrared light and send it to a spectrometer via a fiber optic cable

- The spectrometer separates the light into its spectral components

NIRS – It has been used on wood:

- To detect chip, pulp properties (FPI Biomass moisture sensor, Liquor analyzer)

- To detect veneer and OSB properties (veneer moisture and OSB resin detection)

- For wood species identification (various researchers)
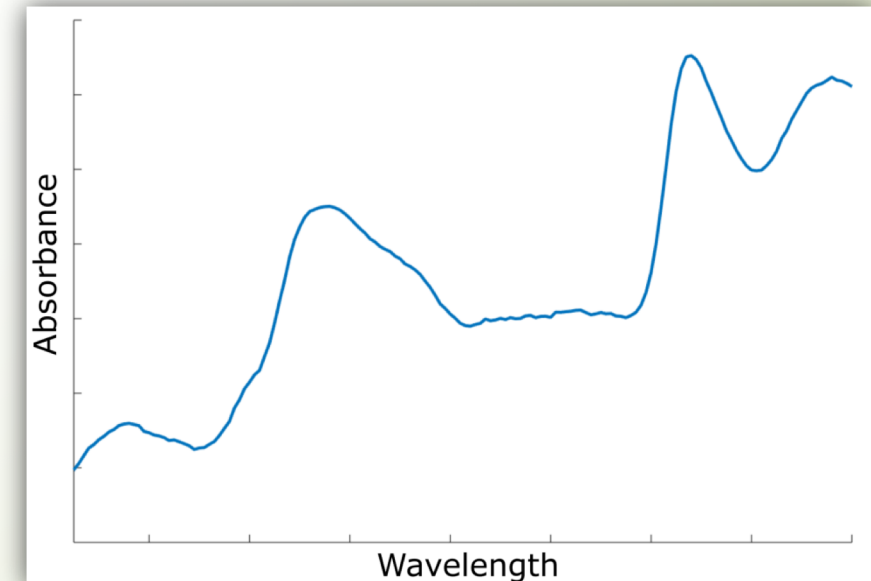
4. Results:

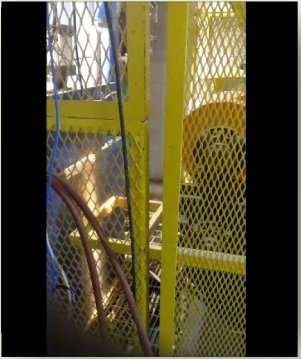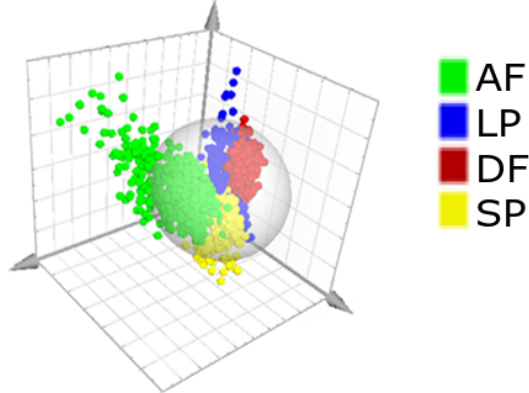Clustering of data for a 4-way species sort of (green) fresh sawn log inside surface

- AF (green)
- LP (blue)
- DF (red)
- SP (yellow)

Sort Type For Drying Optimization	Samples	Scan Type	Test Type	Prediction Accuracy
Hem-Fir	48 trim blocks -green	Linear	Lab	> 95%
DF-Larch separation	100 rough trim blocks -green	Linear	Lab	> 95%
Eastern Spruce-Fir	200 trim blocks -dry	Linear	Lab	> 95%
Subalpine Fir vs Spruce, Pine, Douglas Fir	100 mix samples -dry	Linear	Lab	~ 95%

Sort Type for Grading and Other Needs	Samples	Scan Type	Test Type	Prediction Accuracy
SPF-DF	36,000+ boards, data from mill over 6 months (many lab & mill test leading to the prototype)	Linear prototype integrated into mill system 1600 – 2500 fpm	Mill	> 95% for matching model and board conditions
Spruce, Pine, Subalpine Fir, Douglas Fir – 4 way	360 boards -dry	Offline	Mill	> 89%
Hem-Fir	40 veneer samples (and other tests on dry boards)	-	Lab	> 95%
3-way separation of 7 species into SPF-DFL-He	81 SPF, DF, hemlock, larch trim blocks -green	Linear	Lab	> 95%
2-way separation of 5 species into SPF-He	58 SPF, DF, hemlock, larch trim blocks -green	Linear	Lab	> 95%
SPF-DF	665 boards -dry	Transverse 160 – 240 fpm	Mill	> 85%

4. Results:

- System installed at GDS mill in Matane, QC, August 2018

- Data collected during the last ~ 3 months

- Performance validation visit in November:

Date and species scanned	Number of boards	Prediction accuracy
November 5th - Spruce	7,835	97.68%
November 6th - Fir	17,124	95.16%
November 7th - Spruce	4,218	95.33%
November 7th - Fir	11,477	94.21%
November 8th - Spruce	4,174	96.41%

➢ Spruce prediction accuracy over 4 days: 96.74%

➢ Fir prediction accuracy over 4 days: 94.78%

5. Current work to industrialize the process:

We have a system installed in a mill to sort spruce and fir:

- We plan visits to monitor the system accuracy and stability

- We are extending the model database with new scans regularly

- We are developing our own sensor head to give us more flexibility over commercially available products

6. Future work:

- Extend the database to include other species

- Let the system operate all year long in a sawmill and monitor accuracies throughout all seasons

7. Questions?

THANK YOU!

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Special thanks to: