

Comparing hyperspectral imaging technology and visual assessment for mould growth on wooden surfaces

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Quantification of mould growth on wooden surfaces

Visual assessment (mould index)

- Subjective
- Ordinal scale
- Visual detection - including magnifying glass, stereo microscopes
- Many different scales
(e.g. EN927-3, BS3900-G6, EN152, EN15457)



Digital quantification (percentage)

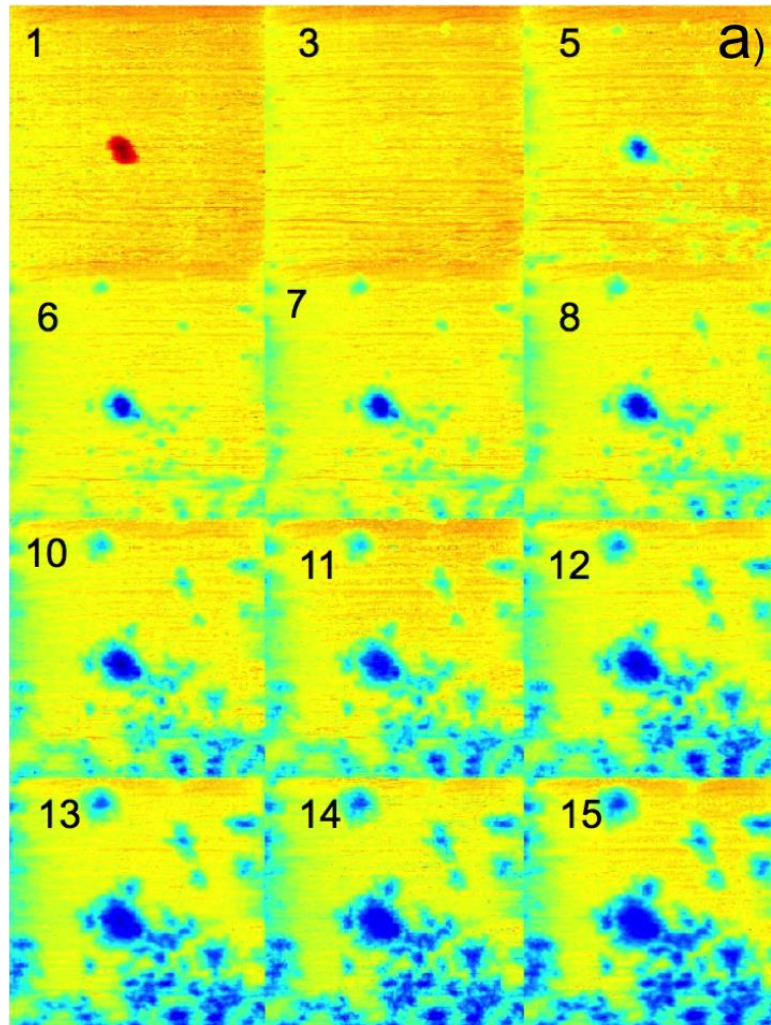
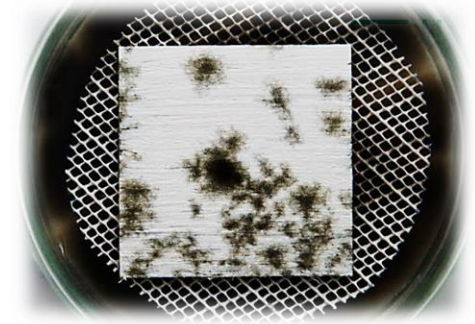
- Objective
- Resolution depends on pixel size
- Results can depend on analysis technique and threshold

What is the purpose of the evaluation?

- Depend on type and size of area/object
- Predict mould growth rate (substrates, climatic conditions, fungal species)
- Determine mould growth pattern
- Fungal growth or color
- Change in color over time
- Predict distribution of mould growth/weathering given the geometry
- Testing of products – susceptibility (bio-based materials, coatings etc.)

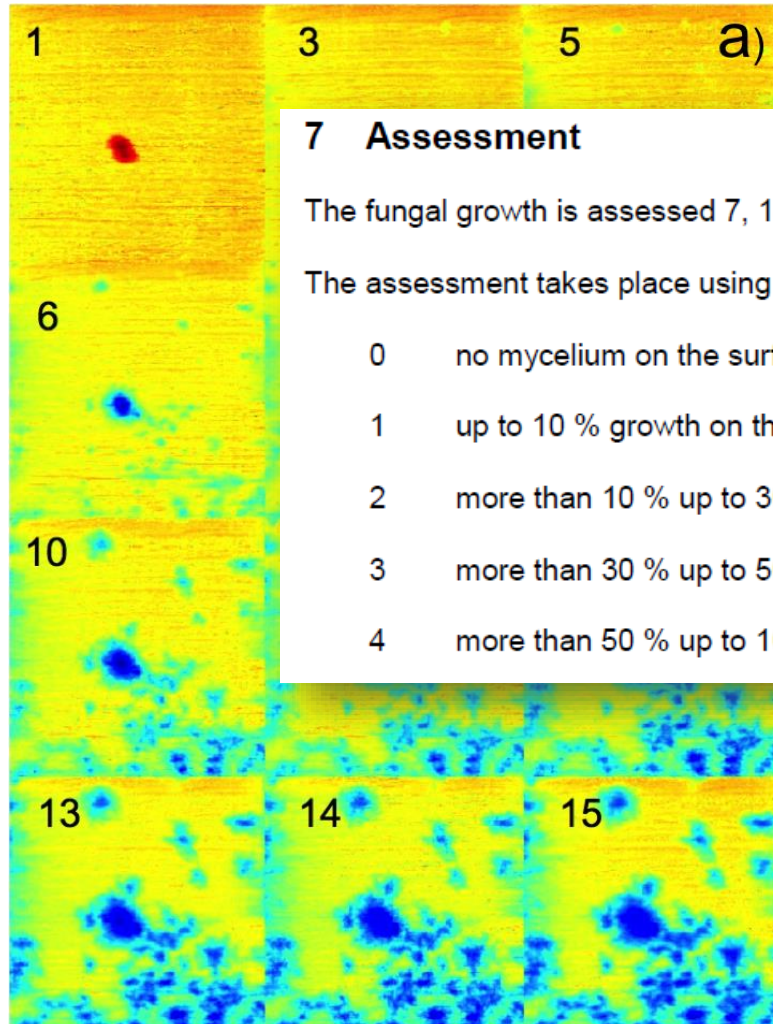
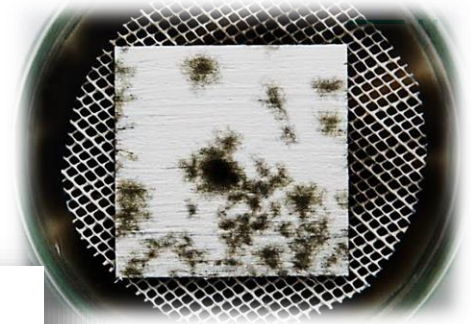


Time series of mould growth on wood in lab



day	EN15457	ISO4628-1 Q	ISO4628-1 S	percentage
1	0	0	0	0 %
3	1	1	2	0.5 %
5	1	2	3	1 %
6	2	3	4	2 %
7	2	3	4	3 %
8	3	3	4	3 %
10	3	4	5	5 %
11	3	4	5	8 %
12	4	4	5	13 %
13	4	4	5	13 %
14	4	4	5	17 %
15	4	4	5	19 %

Time series of mould growth on wood in lab



7 Assessment

EN 15457

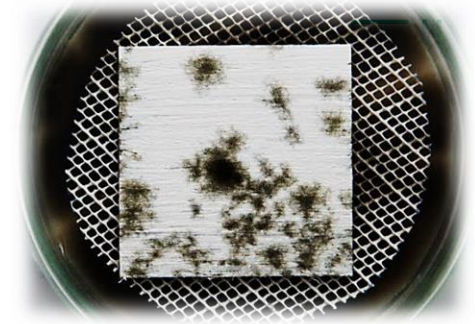
The fungal growth is assessed 7, 14 and 21 days after the inoculation.

The assessment takes place using the following scale:

- 0 no mycelium on the surface of the replicate
- 1 up to 10 % growth on the surface of the replicate
- 2 more than 10 % up to 30 % growth on the surface of the replicate
- 3 more than 30 % up to 50 % growth on the surface of the replicate
- 4 more than 50 % up to 100 % growth on the surface of the replicate

				SO4628-1	percentage
					0 %
					0 %
					1 %
					2 %
					3 %
					3 %
10	3	4	5		5 %
11	3	4	5		8 %
12	4	4	5		13 %
13	4	4	5		13 %
14	4	4	5		17 %
15	4	4	5		19 %

Time series of mould growth on wood in lab



ISO 4628-1:2003(E)

3.2 Designation of quantity of defects

The quantity of defects in the form of discontinuities or other local imperfections in the coating, scattered over the test area in a more or less even pattern, is designated in accordance with Table 1. The ratings shall be expressed as a whole number unless otherwise specified (see Clause 2).

Table 1 — Rating scheme for designating the quantity of defects

Rating	Quantity of defect
0	none, i.e. no detectable defects
1	very few, i.e. small, barely significant number of defects
2	few, i.e. small but significant number of defects
3	moderate number of defects
4	considerable number of defects
5	dense pattern of defects

3.3 Designation of size of defects

The average size (order of magnitude) of defects is designated, if required and meaningful, in accordance with Table 2.

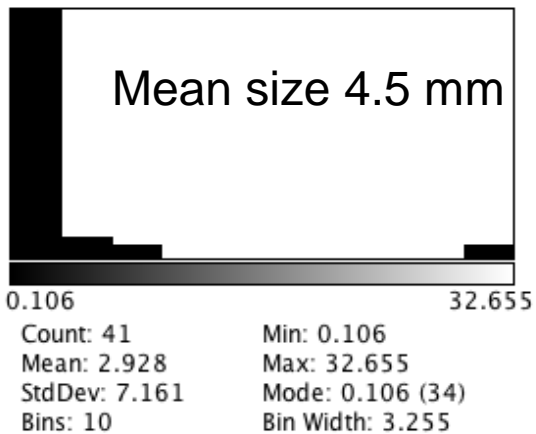
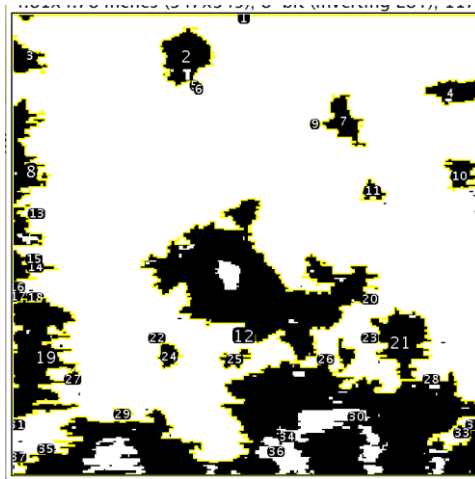
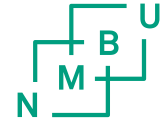
Table 2 — Rating scheme for designating the size of defects

Rating	Size of defect ^a
0	not visible under $\times 10$ magnification
1	only visible under magnification up to $\times 10$
2	just visible with normal corrected vision
3	clearly visible with normal corrected vision (up to 0,5 mm)
4	0,5 mm to 5 mm
5	larger than 5 mm

^a Unless otherwise specified in subsequent parts of this International Standard.

ISO4628-1 Q	ISO4628-1 S	percentage
0	0	0 %
1	2	0 %
2	3	1 %
3	4	2 %
3	4	3 %
3	4	3 %
4	5	5 %
4	5	8 %
4	5	13 %
4	5	13 %
4	5	17 %
4	5	19 %

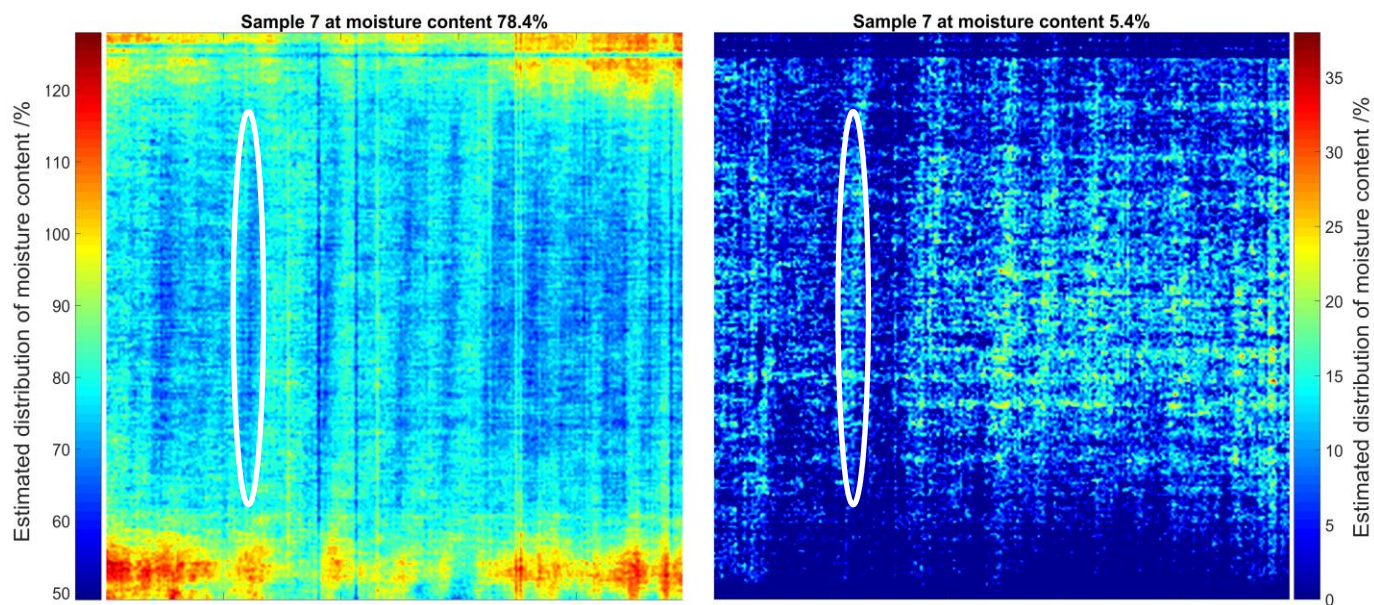
Time series of mould growth on wood in lab

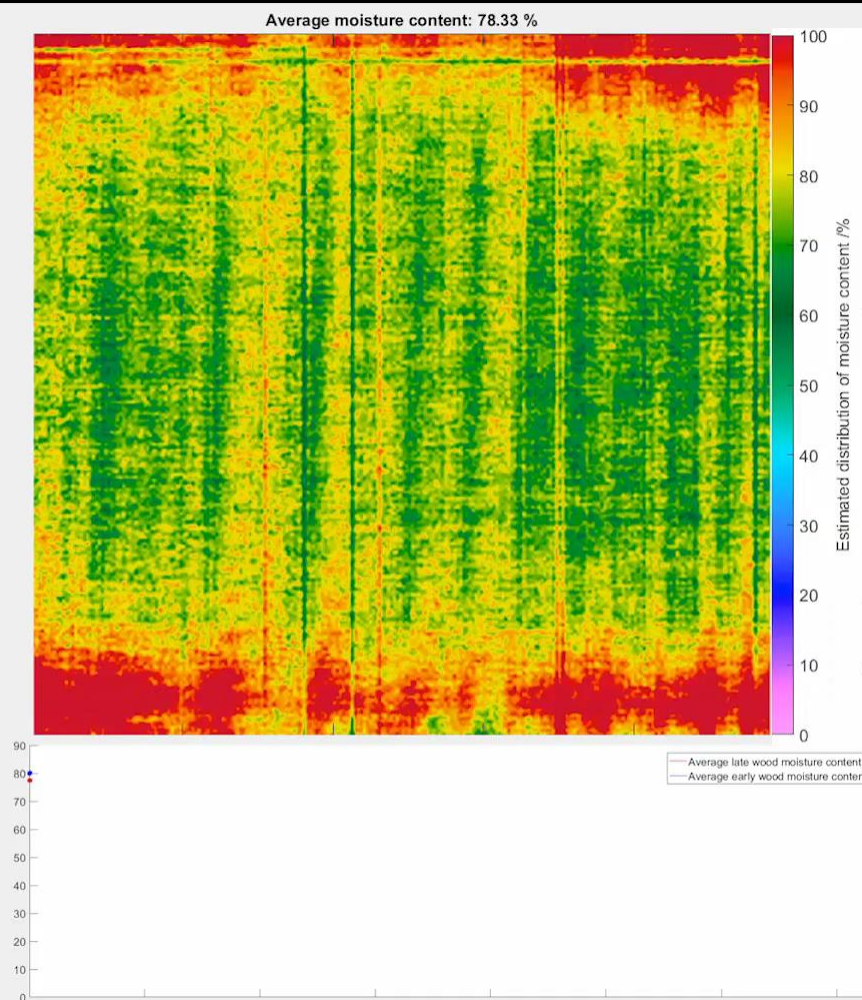


day	EN15457	ISO4628-1 Q	ISO4628-1 S	percentage
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13	4	4	5	13 %
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Hyperspectral imaging – versus RGB imaging

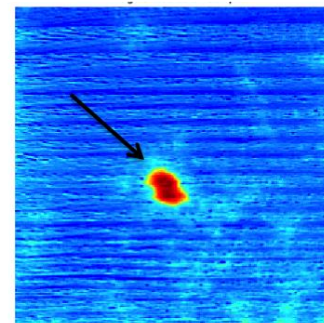
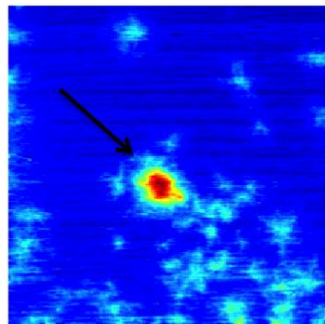
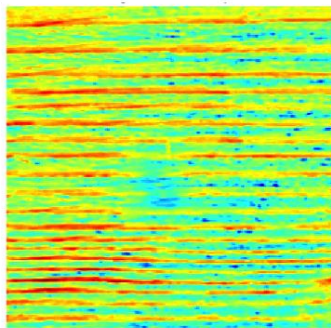
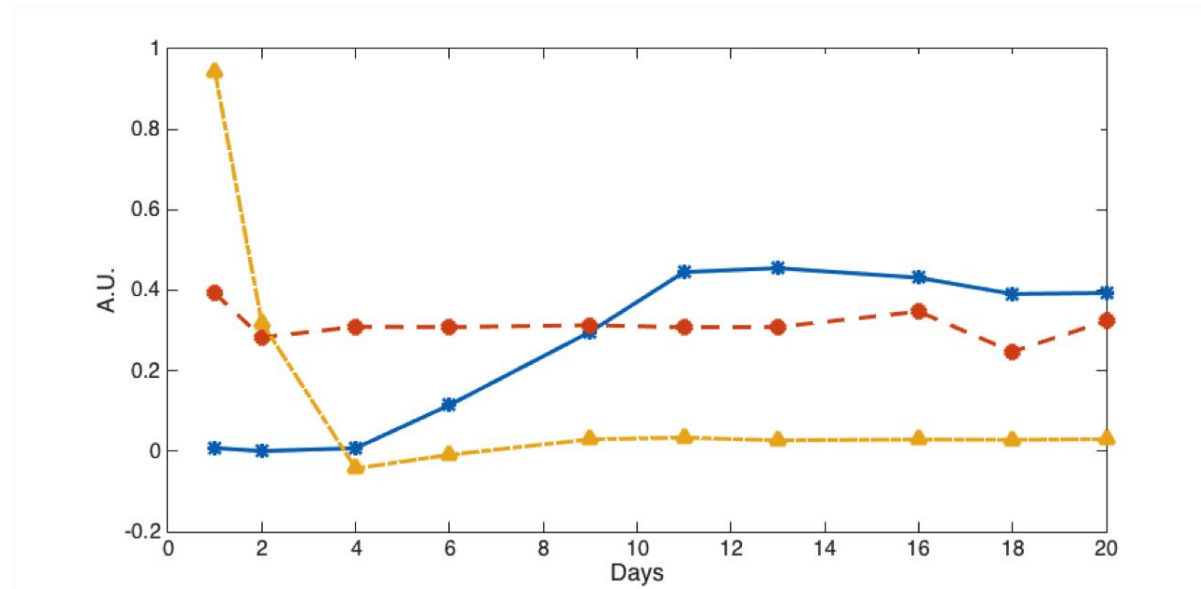
Example : Moisture content





Hyperspectral NIR imaging

Multivariate statistics



Outdoor experiment



Wood substrates:

Painted spruce

Spruce

Pine

Aspen

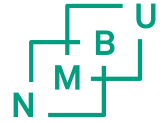
Acetylated SYP

Exposed against
north and south



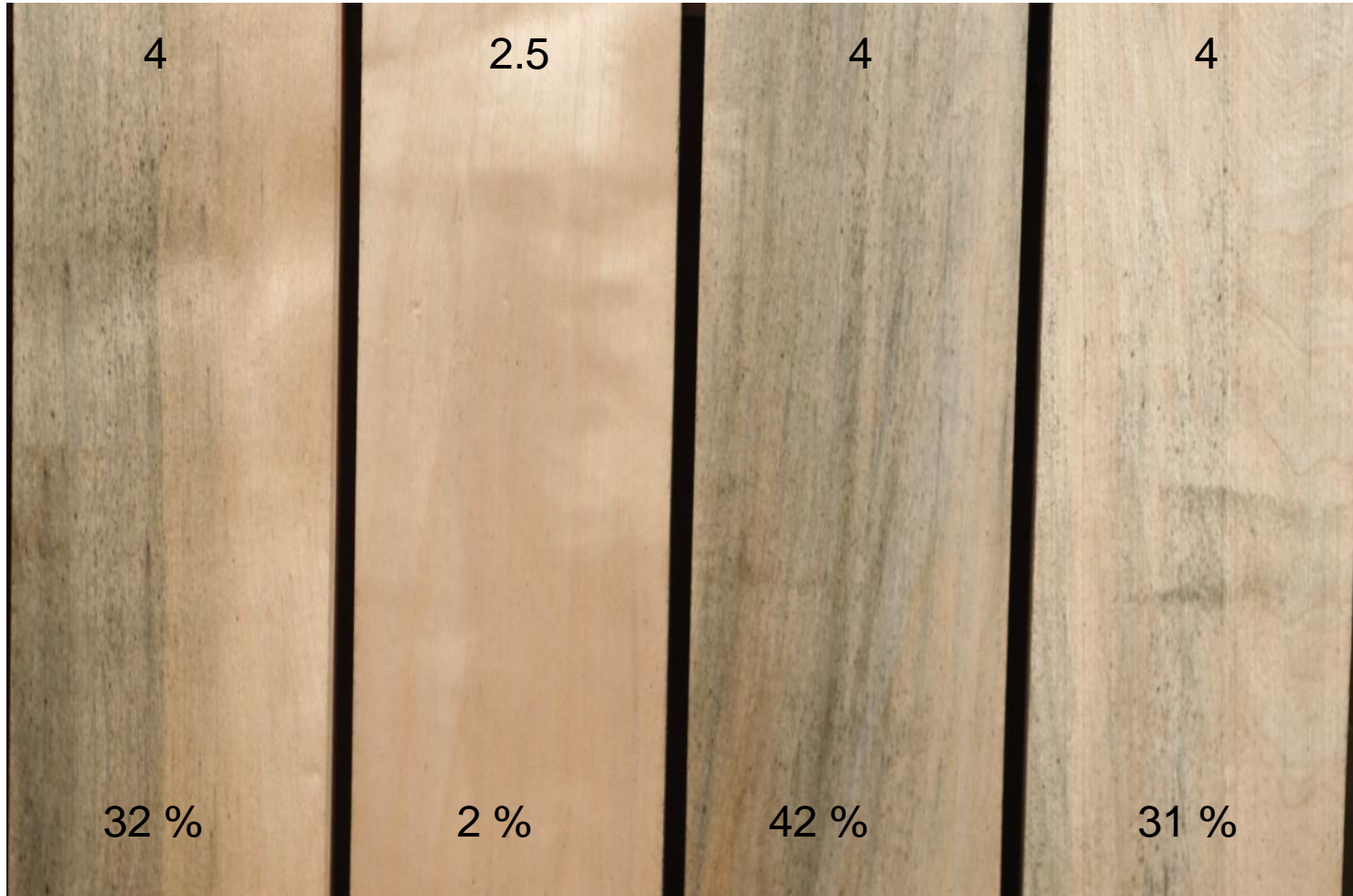
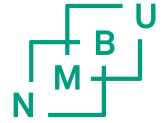
Mould evaluation:
Visual assessment
Hyperspectral NIR imaging

Aspen South



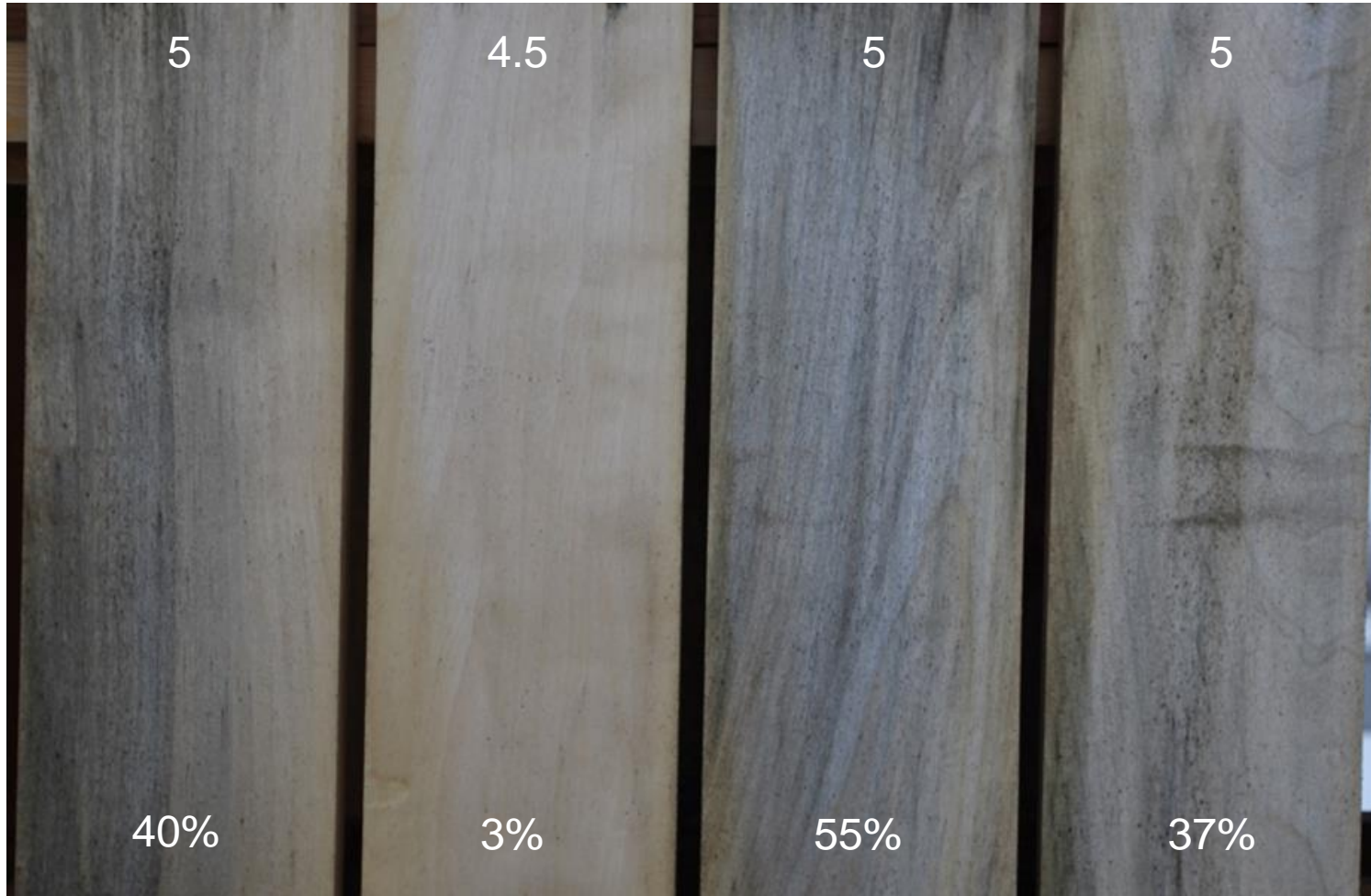
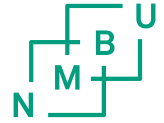
Sep 26

Aspen South



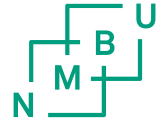
Nov 8

Aspen South

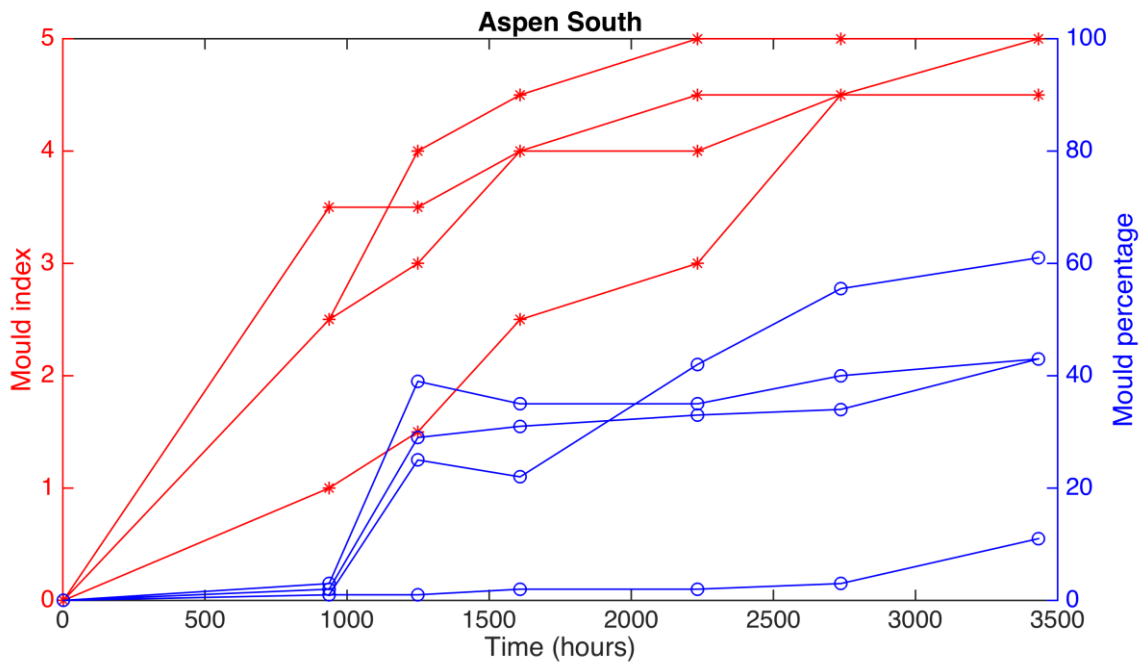
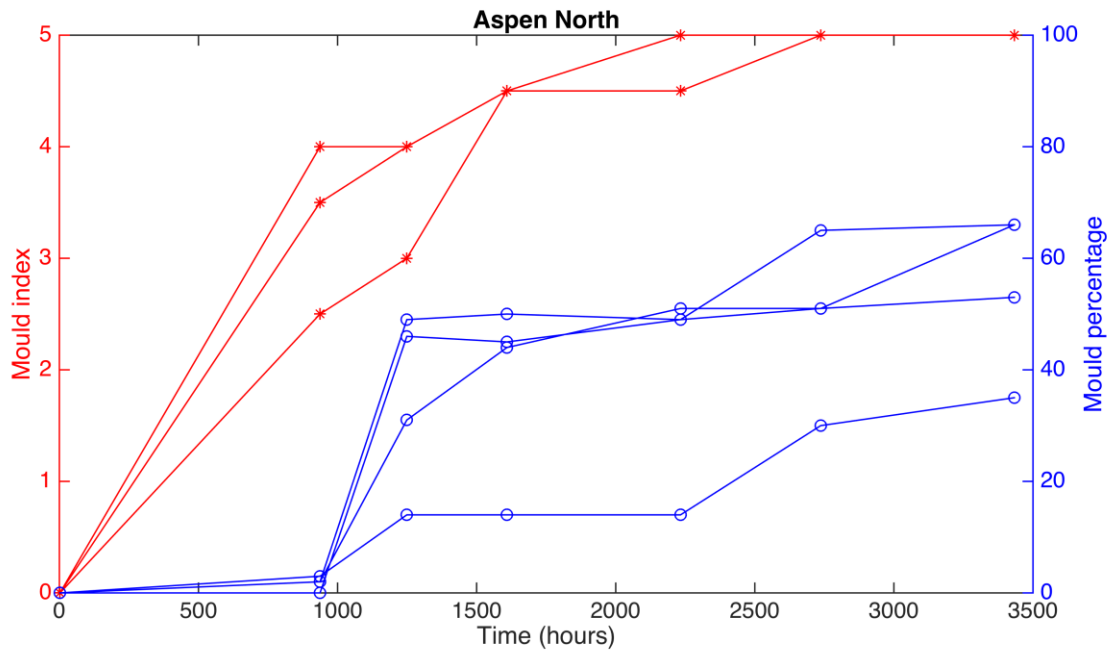


Dec 10

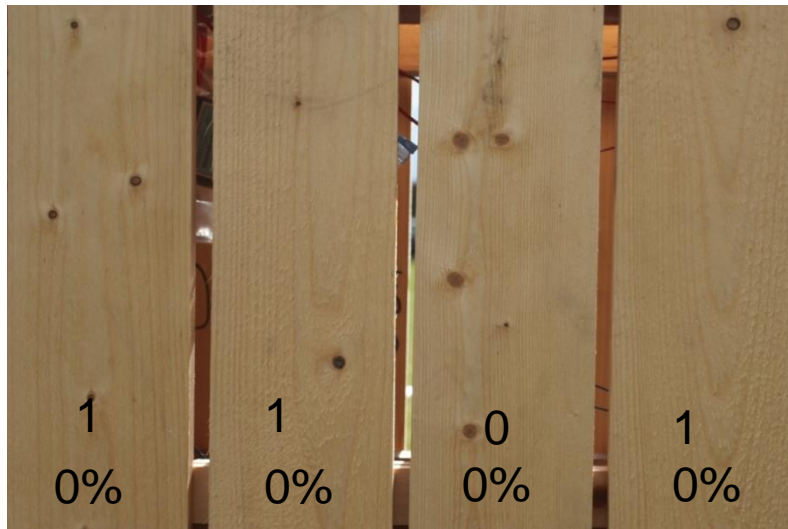
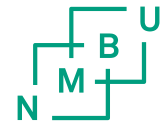
Aspen South



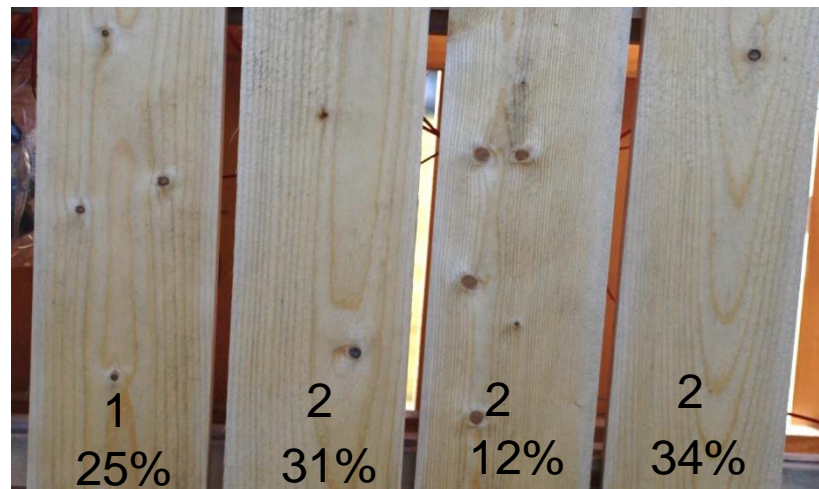
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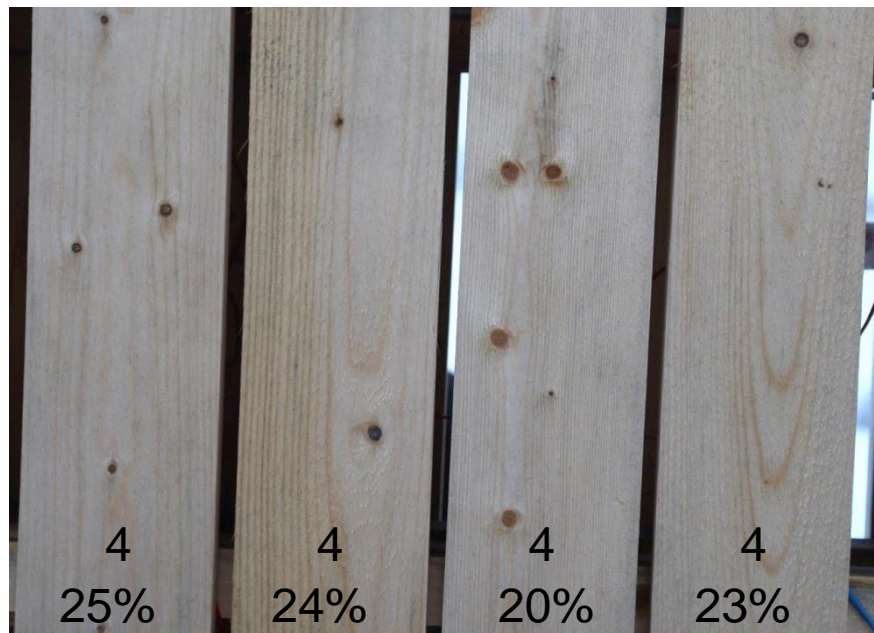
Spruce North



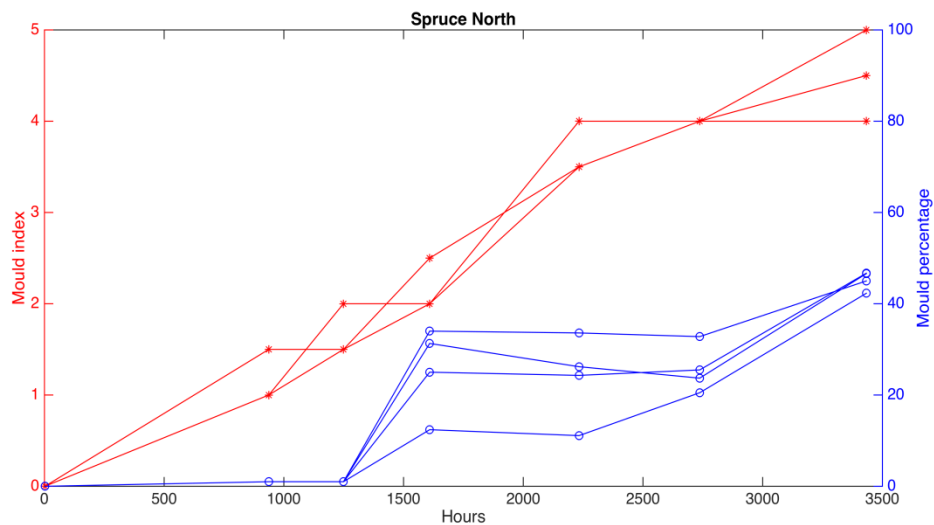
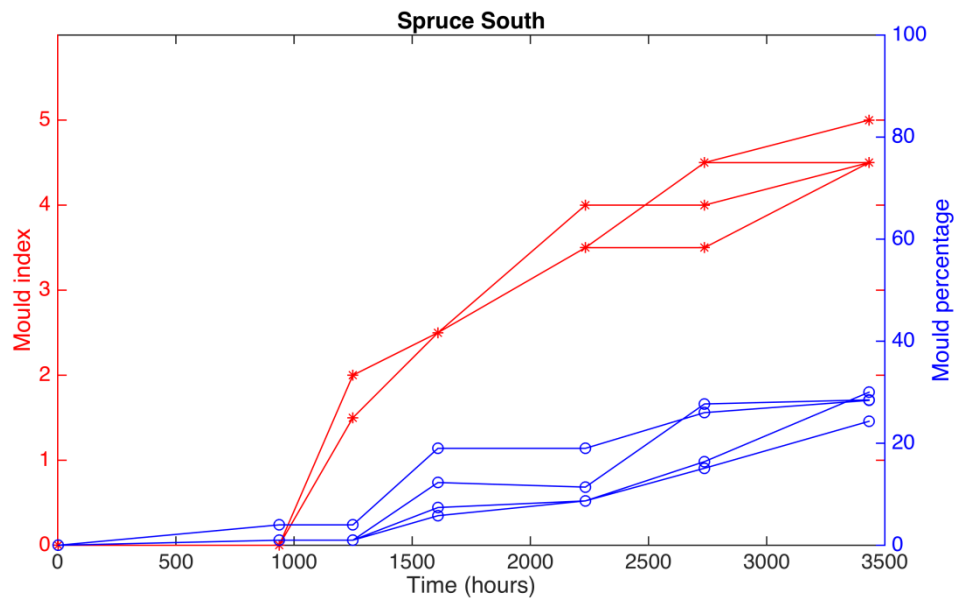
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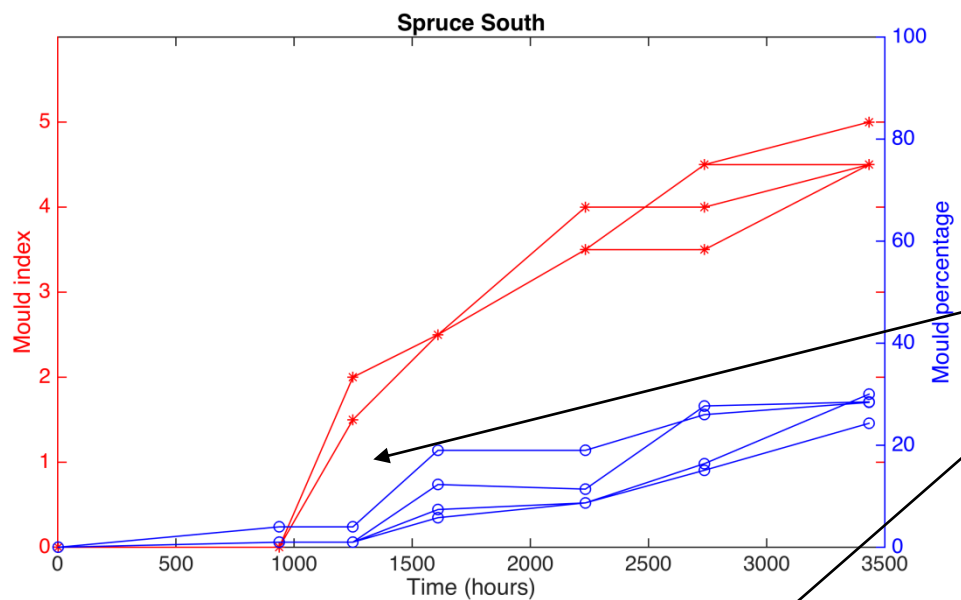


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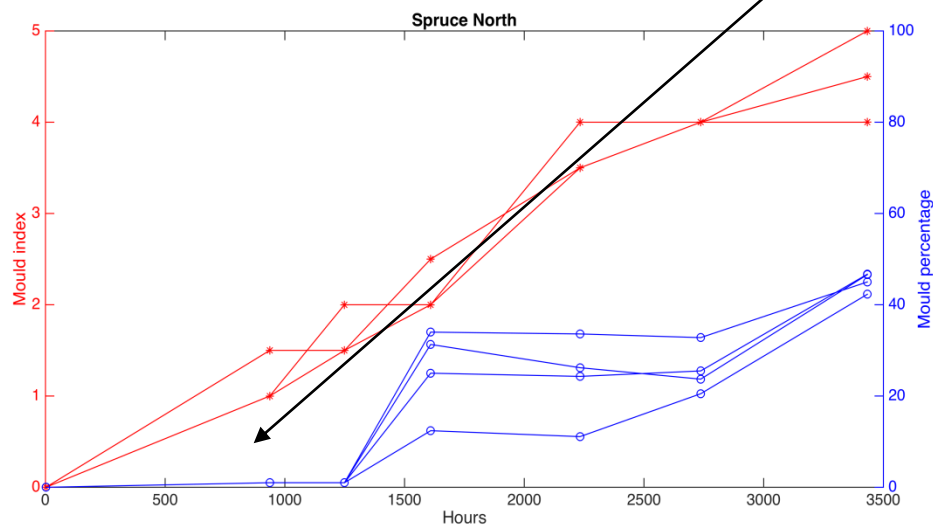


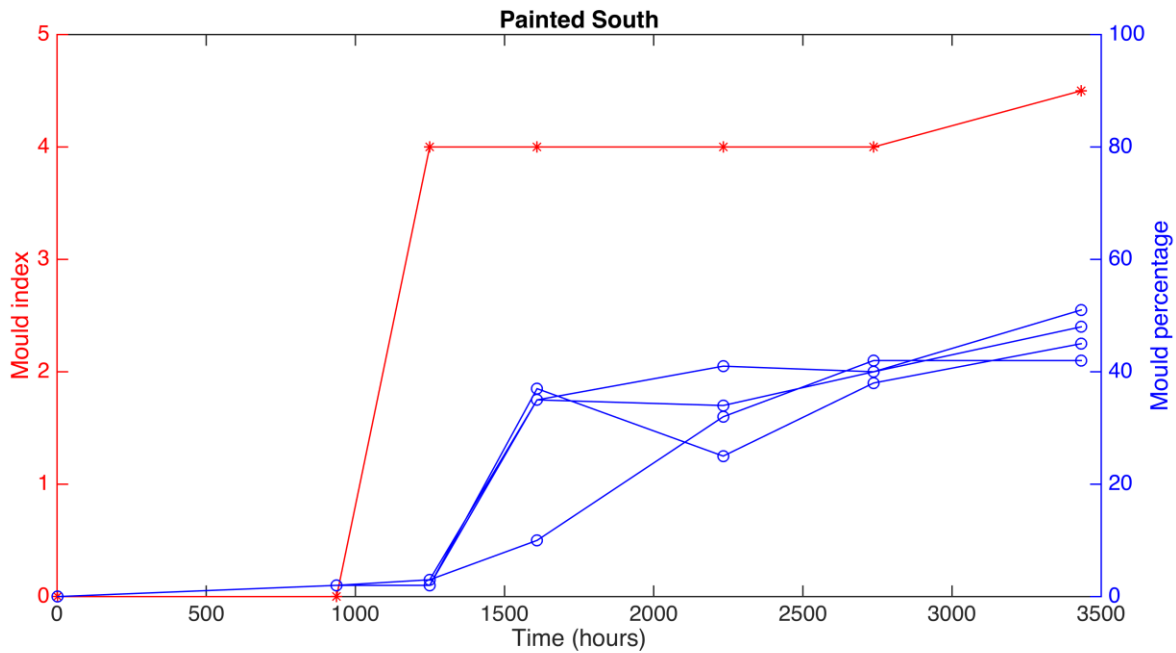
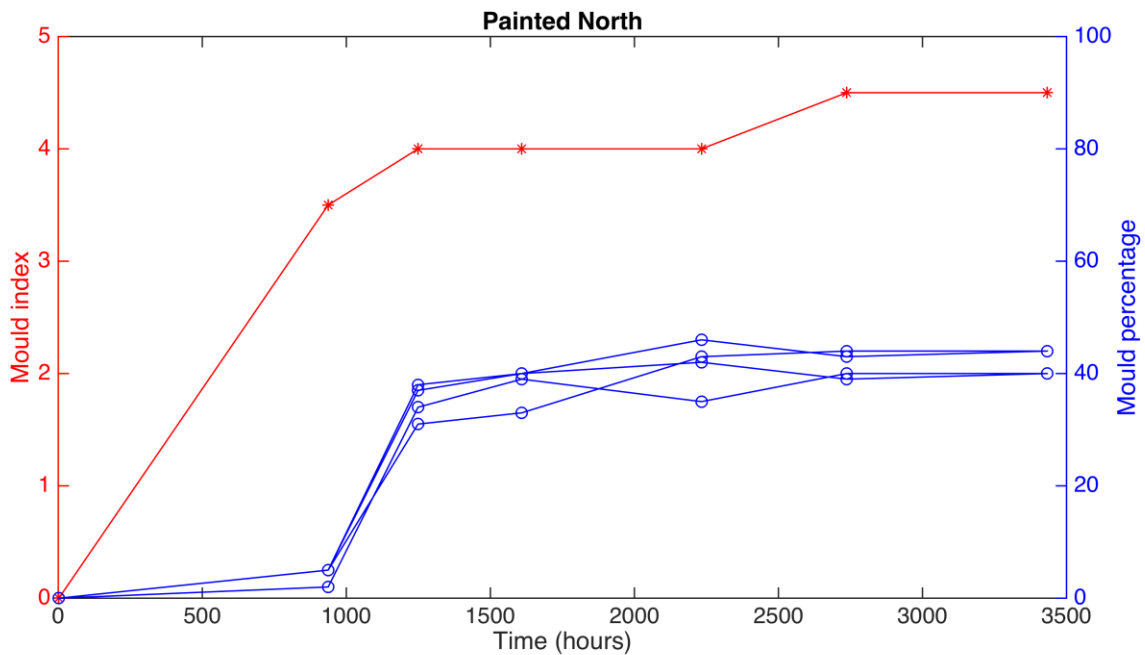
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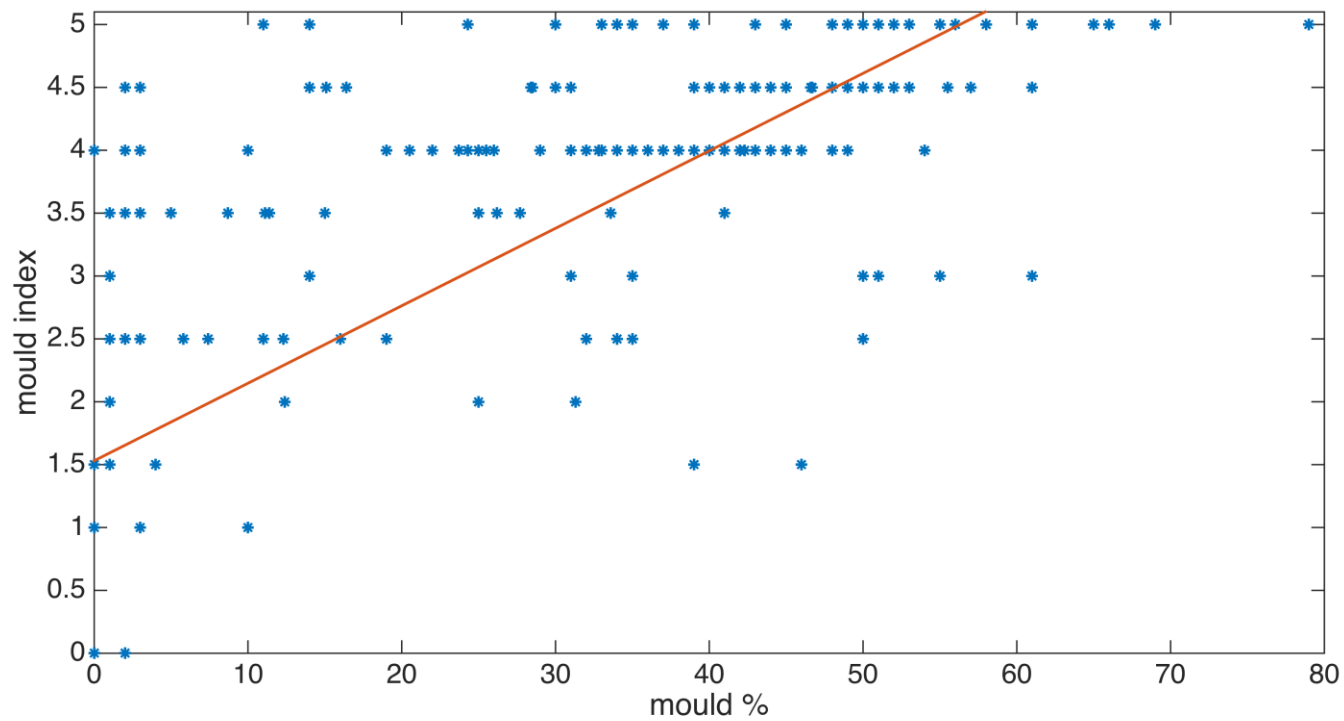




Is the time lag due to low resolution in the images ?







Summary

- Visual assessment detects mould growth earlier than RGB/hyperspectral NIR (resolution, stereo microscope/magnifying glass, color on hyphae/spores)
- Visual assessment can 'overrate' mould growth – when amount/density of color is sought for
- Digital imaging; dependent on resolution and analysis technique
- RGB image versus hyperspectral NIR images – chemical information – how can we use this to understand mould growth ?

