

COST FP 1303 Cooperative Performance Test – Results after two years outdoor exposure

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Background

- Performance test – organized in the frame of COST Action FP 1303
- Start of the field test 15 september 2014
- 27 locations

AIM

Better understanding of performance aspects of bio-based materials in the building sector under the influence of geographical and climatic differences



Experimental



Partners which provide data after 2 years exposure

Partner	Abbreviation	City	Country
Holzforschung Austria	WIE	Wien	Austria
Danish Technological Institute	DTI	Taastrup	Denmark
Tallinn University of Technology	TAL	Tallinn	Estonia
Groupe ESB École supérieure du bois	NTE	Nantes	France
Thünen-Institut für Holzforschung	HAM	Hamburg	Germany
Leibniz Universität Hannover, Institut für Berufswissenschaften im Bauwesen (ibw)	HAN	Hannover	Germany
CNR IVALSA	ITA	Florence	Italy
Norwegian Forest and Landscape Institute	ÅS	Ås	Norway
Norwegian Institute of Wood technology	OSL	Oslo	Norway
University of Ljubljana, Biotechnical Faculty	ULJ	Ljubljana	Slovenia
Silvaprodukt d.o.o.	SIL	Ig	Slovenia
Área de Innovación y Tecnología, Centro de Innovación y Servicios Tecnológicos de la Madera	SCI	San Cibrao das Viñas	Spain
Tecnalia R&I	TEC	Azpeitia - Gipuzkoa	Spain
Berner Fachhochschule - Architektur, Holz und Bau	BIE	Biel-Bienne	Switzerland
Building Research Establishment (BRE)	BRE	Garston	UK



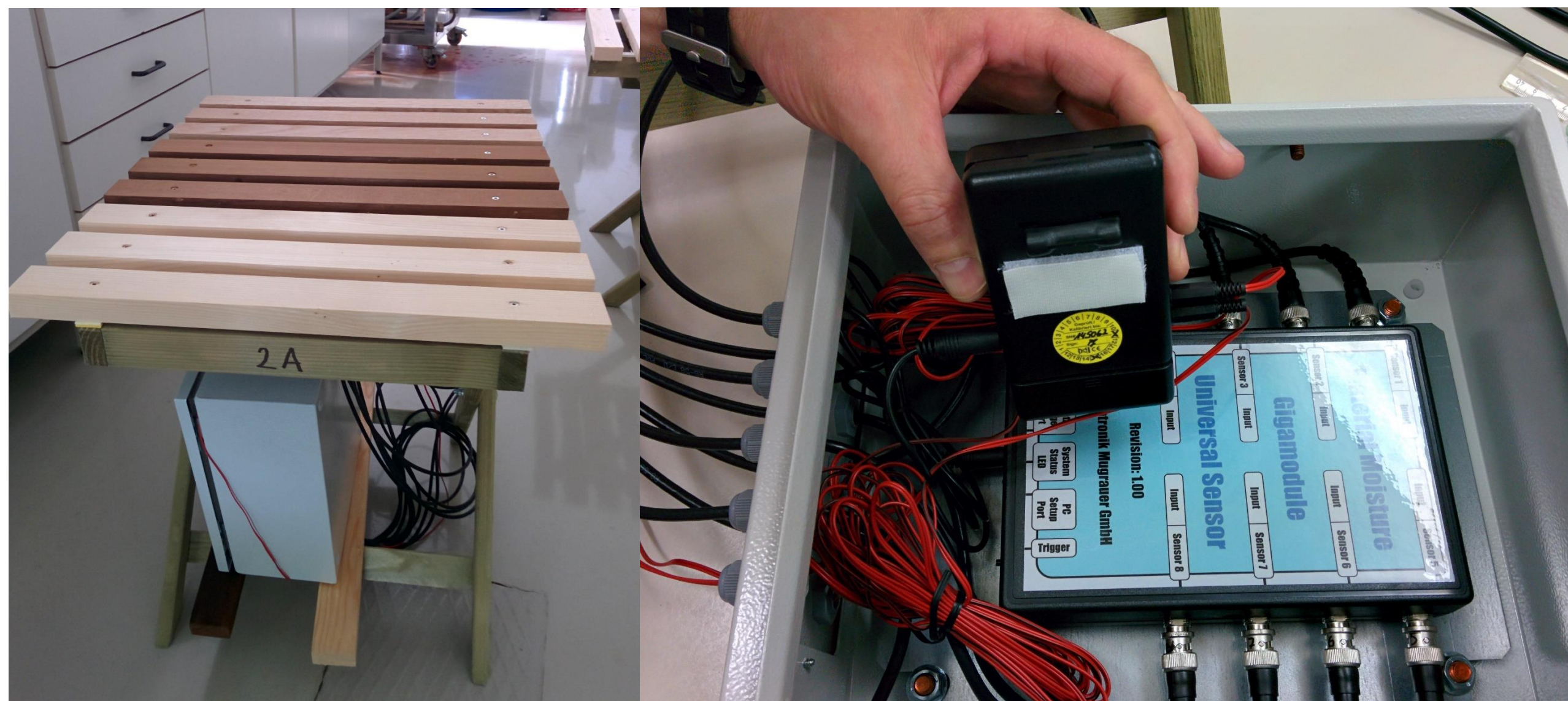
Experimental

Versions of the tables

Version A: table with MC data logging device

Version B: table without MC data logging device

Version C: table without MC data logging device, extra material regional preference



Experimental – wood species



Wood species – versions A and B

Norway spruce

**Thermally modified Norway
spruce**

English oak



Assessment and evaluation

- **Decay**
- **Discoloration**
- **Development of mould and other staining fungi**
- **Corrosion**
- **Formation of cracks**
- **Moisture performance (if data logging device is included)**

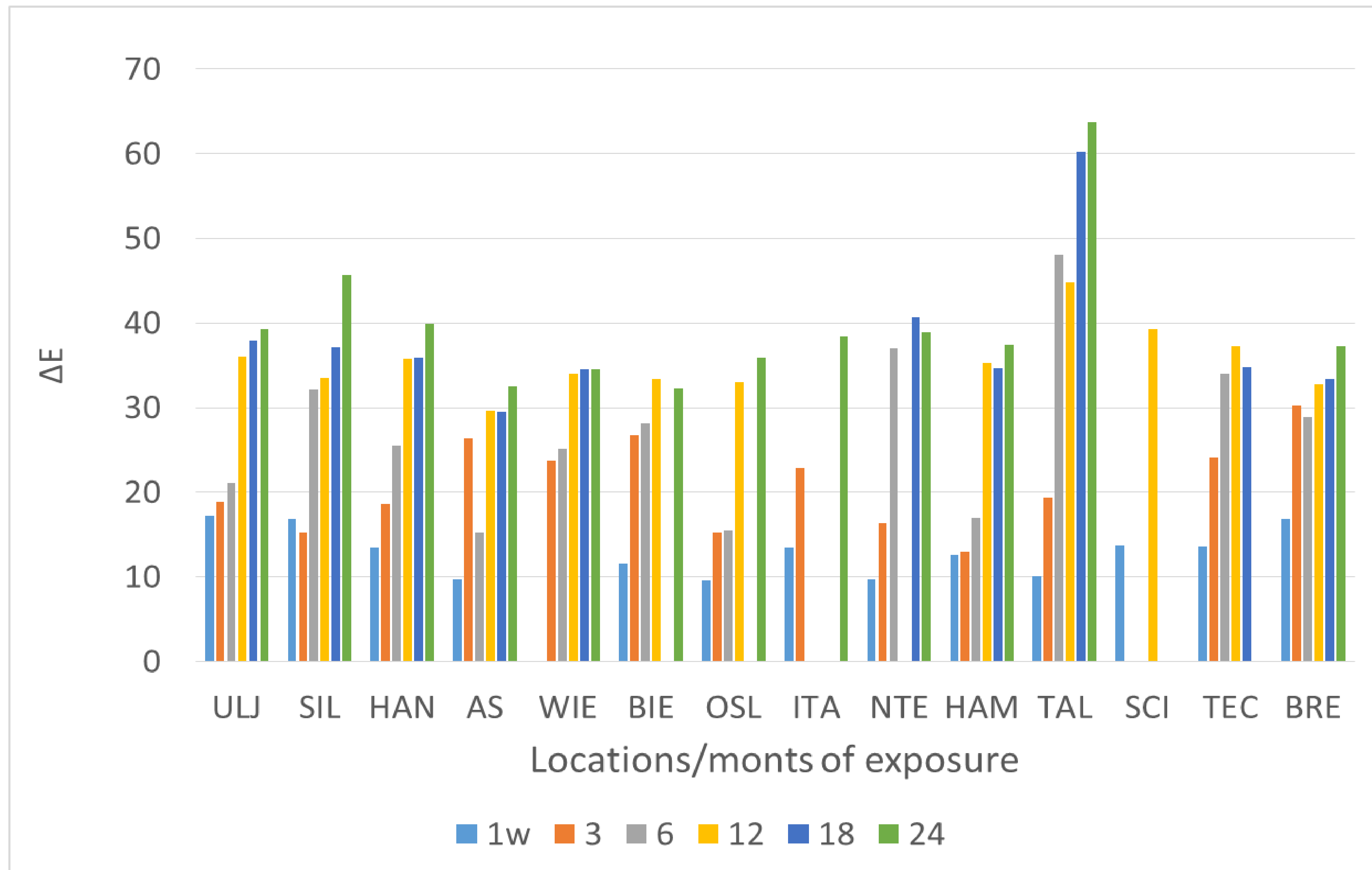


Assessment and evaluation - Discoloration

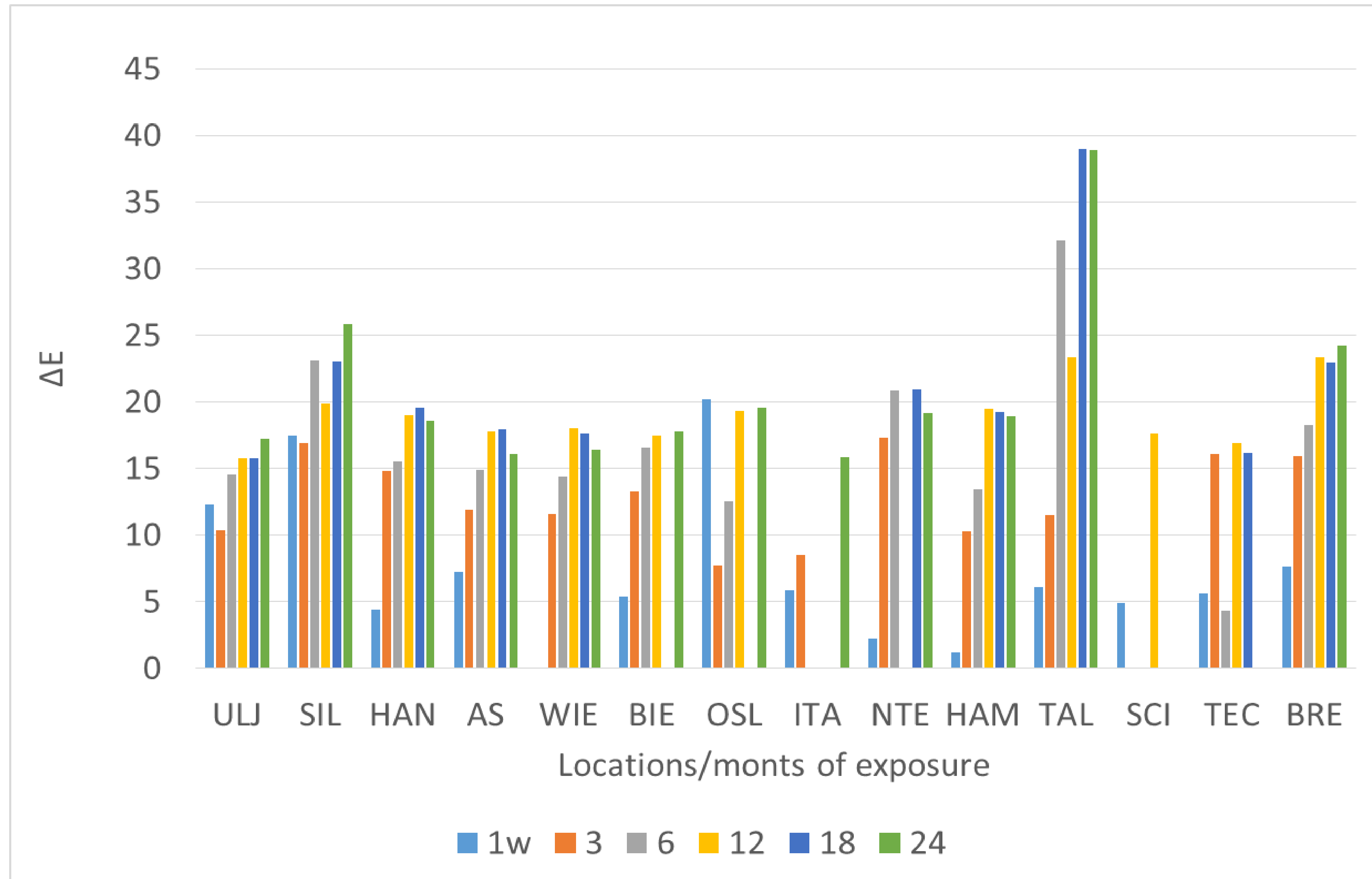
- **CIE L*a*b* colour measurements – colorimeter**
 - 3 measurements per specimens
 - Upper surface



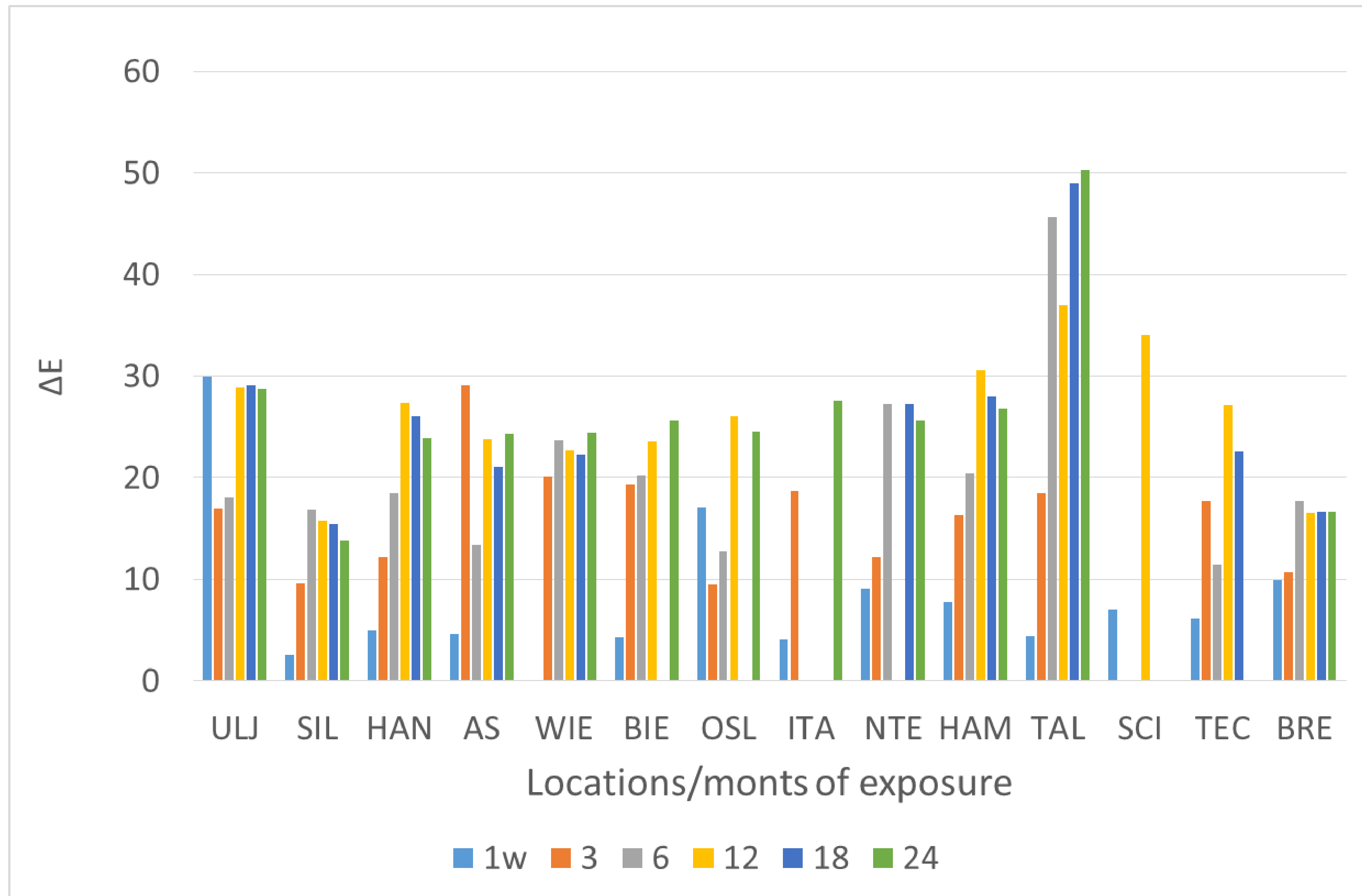
Results - Colour change ΔE – Norway spruce



Results - Colour change ΔE - TMT NS



Results - Colour change ΔE - Oak



Colour change ΔE

0 months

12 months

24 months



Visual assessment of blue staining and moulds

According to modified standard EN 152

Rating	Classification	Definition
0	No disfigurement	No surface disfigurement can be detected visually on the surface.
1	Slight disfigurement	The surface exhibits only a few individual small colonies none larger than 1.5 mm in width and 4 mm in length.
2	Moderate disfigurement	The surface is colonized up to a maximum of one third of the total area.
3	Severe disfigurement	More than one third of the surface area is colonised.
X	Grey surface	Surface disfigurement caused by blue stain fungi can not be resolved from greying caused by weathering.

0



1



2



3



X



Surface disfigurement due to mould and staining fungi – upper surface -1

Location	Wood species	Weeks of exposure						Moths of exposure			
		0	4	8	12	16	20	24	12	18	24
Average fungal disfigurement rating											
ULJ	NS	0,0	2,0	3,0	3,0	0,0	0,0	3,0	x	x	x
	O	0,0	1,0	3,0	3,0	0,0	0,0	3,0	0,0	x	x
	TM	0,0	0,0	0,3	0,0	0,0	0,0	0,0	1,3	2,3	x
SIL	NS	0,0	1,0	3,0	3,0	0,0	0,0	3,0	0,0	x	x
	O	0,0	0,3	1,7	2,7	2,7	0,0	2,7	0,0	x	x
	TM	0,0	0,0	0,3	0,3	0,0	0,0	0,7	0,3	1,7	x
HAN	NS	0,0	0,0	1,0	2,0	3,0	3,0	3,0	0,0	0,0	0,0
	O	0,0	0,7	0,7	1,3	1,3	1,3	1,0	1,0	1,0	1,0
	TM	0,0	0,0	0,0	0,3	0,3	1,0	1,0	1,0	1,0	1,0
AS	NS	0,0	1,0	1,3	2,3	2,3	3,0	3,0	3,0	3,0	3,0
	O	0,0	1,0	2,0	2,0	2,0	3,0	3,0	3,0	3,0	3,0
	TM	0,0	1,0	1,0	2,0	2,0	3,0	3,0	3,0	3,0	3,0
WIE	NS	0,0	1,3	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	O	0,0	2,3	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	TM	0,0	0,0	1,0	1,3	1,7	1,7	2,0	3,0	3,0	3,0
BIE	NS	0,0	2,7	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	O	0,0	1,0	1,3	2,3	2,3	3,0	3,0	3,0	3,0	3,0
	TM	0,0	0,3	1,3	2,3	2,3	2,3	3,0	3,0	3,0	3,0



Surface disfigurement due to mould and staining fungi – upper surface - 2

Location	Wood species	Weeks of exposure							Moths of exposure		
		0	4	8	12	16	20	24	12	18	24
Average fungal disfigurement rating											
OSL	NS	0,0	1,0	1,0	2,0	2,0	0,0	2,0	0,7	0,0	0,0
	O	0,0	1,0	2,0	2,0	2,3	0,0	2,0	2,0	1,7	1,3
	TM	0,0	0,3	0,7	1,0	1,0	0,0	0,7	0,7	0,3	0,3
ITA	NS	0,0	0,0	1,0	1,0	1,0					
	O	0,0	0,0	1,0	1,0	1,0					
	TM	0,0	0,0	0,0	0,0	0,0					
HAM	NS	0,0	1,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	O	0,0	2,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	TM	0,0	0,0	0,0	x	0,3	1,0	1,0	x	x	x
TAL	NS	0,0	1,0	1,0	2,0	2,0	2,0	3,0	2,0	0,0	2,3
	O	0,0	1,0	1,0	2,0	2,0	2,0	3,0	2,0	0,0	2,0
	TM	0,0	0,0	0,0	0,0	0,0	0,3	1,0	1,0	0,0	0,3
SCI	NS	0,0	2,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	O	0,0	1,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
	TM	0,0	0,0	0,0	1,0	1,0	2,0	2,0	2,0	3,0	3,0
DTI	NS	0,0	0,0	1,0	2,0	2,0	3,0	3,0	3,0	3,0	
	O	0,0	0,0	0,0	1,0	1,0	1,0	2,0	3,0	3,0	
	TM	0,0	0,0	0,0	0,0	1,0	1,0	2,0	3,0	3,0	



Surface disfigurement due to mould and staining fungi – Boothom surface - 1

Location	Wood species	Weeks of exposure							Moths of exposure		
		0	4	8	12	16	20	24	12	18	24
Average fungal disfigurement rating											
ULJ	NS	0,0	0,0	1,7	1,7	0,0	0,0	1,3	0,0	1,3	2,0
	O	0,0	0,0	2,0	2,0	0,0	0,0	2,0	0,0	0,0	0,0
	TM	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,7	0,0	0,0
SIL	NS	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	1,0	0,3
	O	0,0	0,0	0,3	2,0	0,0	2,0	1,0	1,0	1,0	0,3
	TM	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	0,0
HAN	NS	0,0	0,0	0,0	1,0	2,0	2,0	2,0	0,0	0,3	0,3
	O	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,0	2,0
	TM	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,0	1,0
AS	NS	0,0	0,0	0,3	1,0	1,0	2,0	2,0	2,0	2,0	2,0
	O	0,0	0,0	0,0	1,0	1,0	2,0	2,0	3,0	3,0	3,0
	TM	0,0	0,0	0,0	1,0	1,0	1,0	2,0	3,0	3,0	3,0
WIE	NS	0,0	0,0	1,0	1,3	2,3	2,3	2,3	2,3	2,3	2,7
	O	0,0	0,0	1,0	2,0	2,3	2,7	3,0	3,0	3,0	3,0
	TM	0,0	0,0	0,0	0,3	1,3	1,3	1,3	2,3	2,7	3,0
BIE	NS	0,0	1,0	1,0	1,3	1,3	1,3	2,0	2,3	2,7	3,0
	O	0,0	0,0	1,0	1,0	1,0	2,0	2,7	3,0	3,0	3,0
	TM	0,0	0,3	0,3	1,0	1,3	1,3	1,3	2,3	3,0	3,0



Surface disfigurement due to mould and staining fungi – Boothom surface - 2

Location	Wood species	Weeks of exposure							Moths of exposure		
		0	4	8	12	16	20	24	12	18	24
Average fungal disfigurement rating											
OSL	NS	0,0	0,0	0,0	0,0	0,3	0,0	0,7	1,0	0,0	0,0
	O	0,0	0,0	1,0	1,0	1,0	0,0	1,3	2,3	2,0	1,7
	TM	0,0	0,0	0,0	0,0	0,0	0,0	1,0	1,0	0,7	0,7
ITA	NS	0,0	0,0	0,0	1,0	1,0					
	O	0,0	0,0	0,0	1,0	1,0					
	TM	0,0	0,0	0,0	0,0	0,0					
HAM	NS	0,0	0,0	1,0	1,7	2,0	2,0	2,0	2,3	3,0	3,0
	O	0,0	0,0	1,0	2,3	3,0	3,0	3,0	3,0	3,0	3,0
	TM	0,0	0,0	0,0	0,0	0,0	0,7	0,7	1,7	2,0	2,0
TAL	NS	0,0	1,0	1,0	2,0	2,0	2,0	2,0	2,3	0,0	2,3
	O	0,0	1,0	1,0	2,0	2,0	2,0	3,0	3,0	0,0	2,3
	TM	0,0	0,0	0,0	0,0	0,0	0,0	1,0	1,7	0,0	0,3
SCI	NS	0,0	0,0	1,0	2,3	2,7	3,0	3,0	3,0	3,0	3,0
	O	0,0	0,0	0,0	2,7	2,0	3,0	3,0	3,0	3,0	3,0
	TM	0,0	0,0	0,0	0,3	0,3	1,0	2,0	2,0	3,0	3,0
DTI	NS	0,0	0,0	0,0	1,0	2,0	2,0	2,0	2,0	2,0	
	O	0,0	0,0	0,0	0,0	1,0	1,0	1,0	1,0	1,0	
	TM	0,0	0,0	0,0	0,0	1,0	1,0	1,0	1,0	1,0	



Surface disfigurement due to mould and staining fungi – Boothom surface after 3 months exposure

Oak, TMT NS , NS

Pine, Larch, Cu terated wood



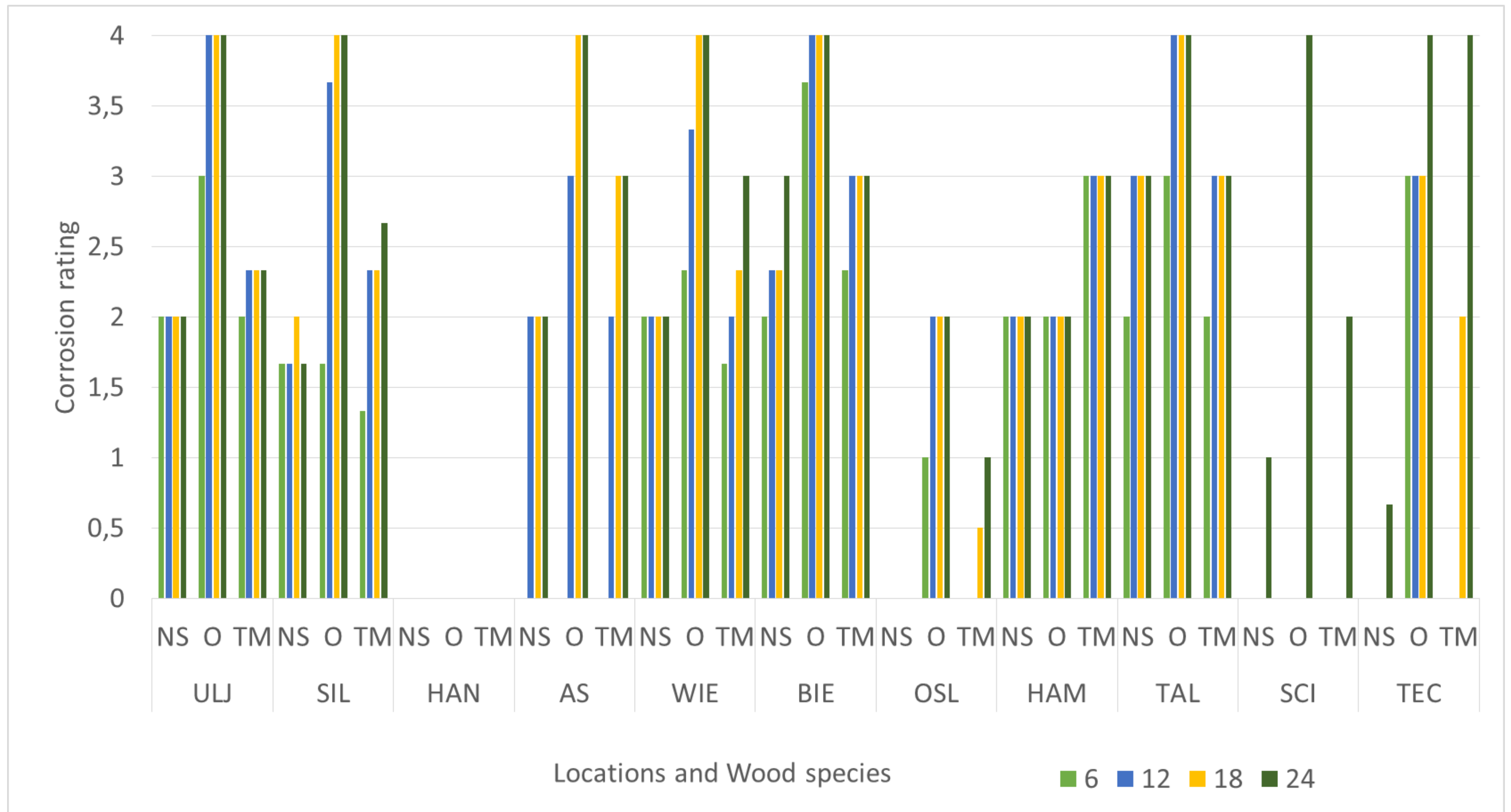
Assessment and evaluation - Corrosion

- Galvanized screws
- Stainless-steel screws

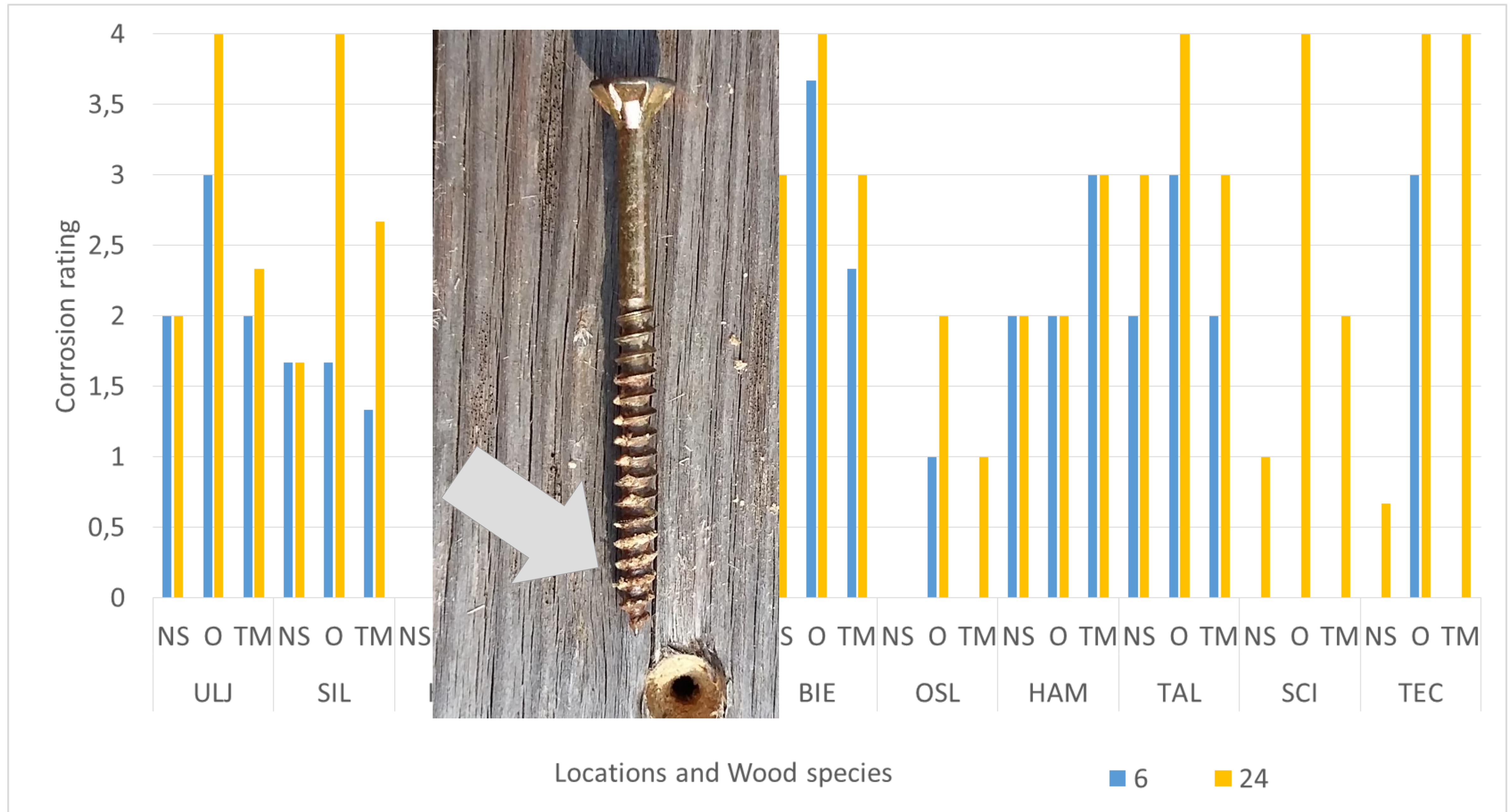
Rating	Description	Definition
0	No attack	
1	Insignificant attack	<5 % of surface attacked
2	Slight attack	5-50 % of surface attacked
3	Serious attack	50-95 % of surface attacked
4	Completely attacked	>95 % of surface attacked



Results – Corrosion galvanized screws



Results – Corrosion Galvanized screws after 6 and 24 months

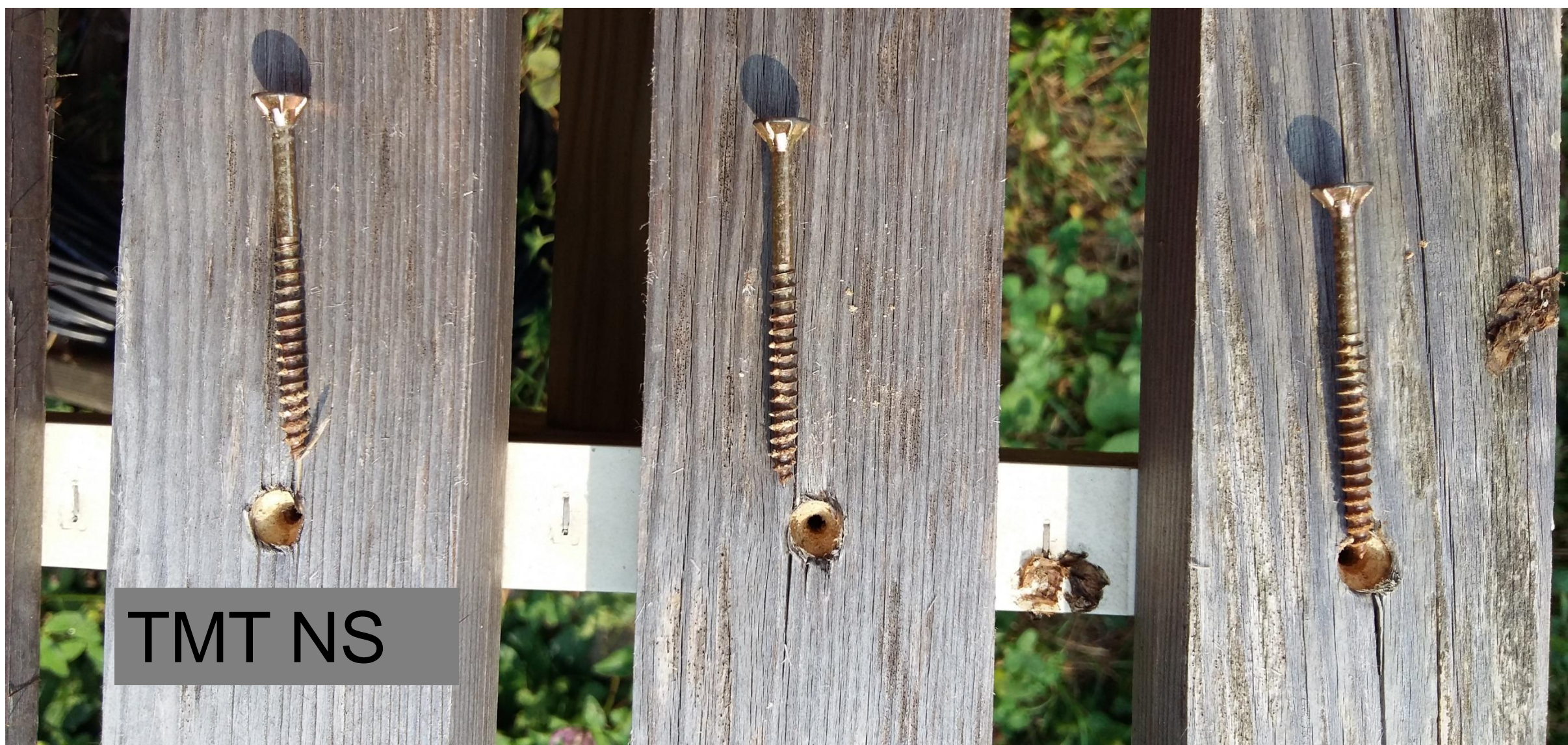


Results – Corrosion Galvanized vs. Stainless screws – Ljubljana, version C

Cooper treated Norway spruce

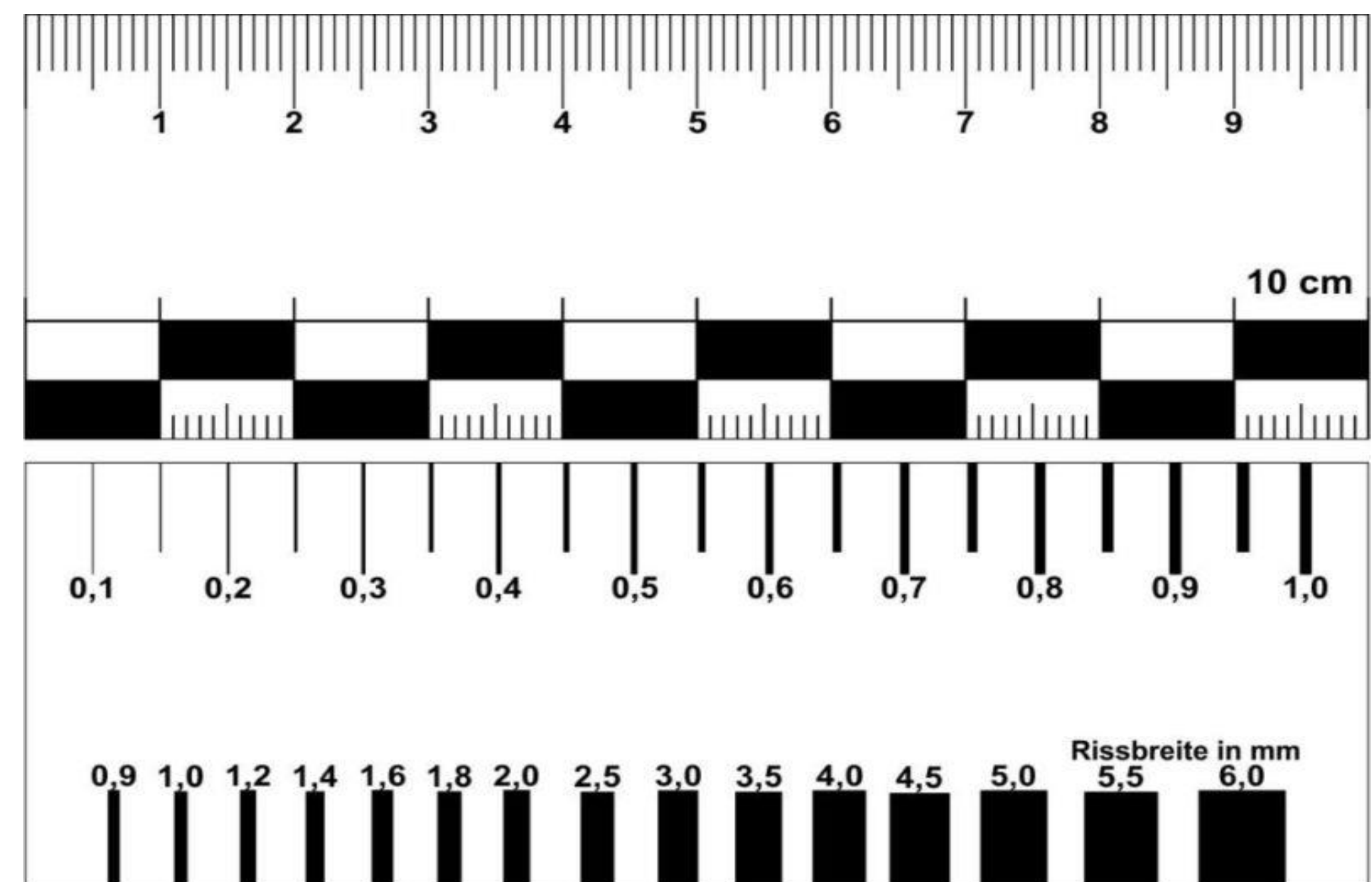
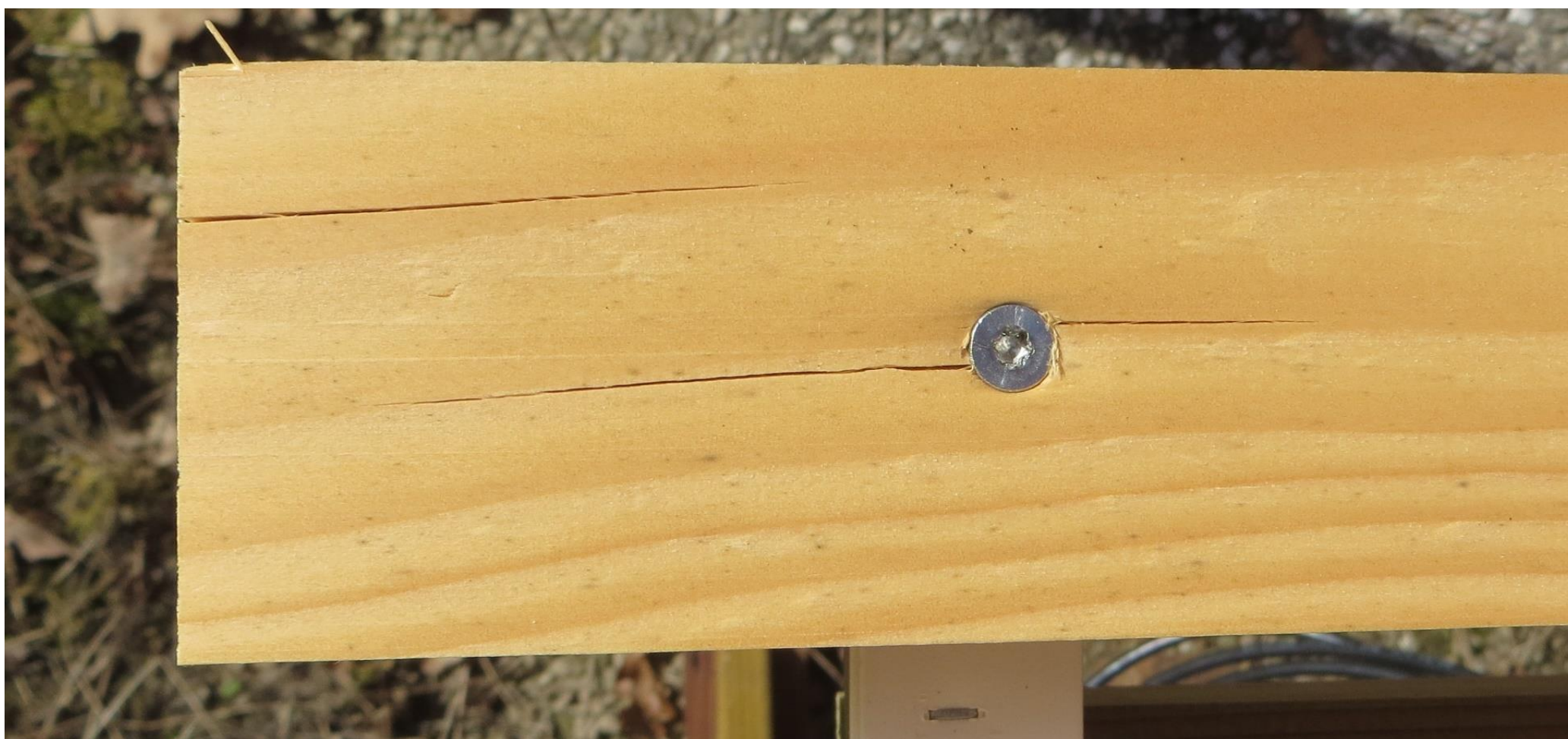


Results – Corrosion Galvanized vs. Stainless screws – Ljubljana version A



Assessment and evaluation - Crack formation

- Total crack length (total length of cracks with length of more than 5 mm)
- Number of cracks (longer than 5 mm)
- Mean maximum crack width
- Evaluation every 3 months



Results - Crack formation 1

		Months of Exposure									
		0		6		12		18		24	
Location	Wood species	Total crack length	# cracks	Total crack length	# cracks	Total crack length	# cracks	Total crack length	# cracks	Total crack length	# cracks
ULJ	NS	0,0	0,0	258,7	2,7	445,3	5,3	445,3	5,3	596,7	7,7
	O	0,0	0,0	0,0	0,0	72,7	5,7	72,7	5,7	103,3	3,3
	TM	0,0	0,0	290,7	3,0	334,3	4,3	334,3	4,3	502,7	6,0
SIL	NS	0,0	0,0			174,0	3,3	174,0	3,3	181,7	3,7
	O	0,0	0,0			27,7	2,7	27,7	2,7	181,0	8,0
	TM	0,0	0,0			122,7	2,0	122,7	2,0	247,7	4,0
HAN	NS	0,0	0,0	0,0	0,0	2,5	1,0	7,4	2,7	10,7	4,0
	O	0,0	0,0	0,0	0,0	2,7	2,0	10,0	4,0	55,8	15,0
	TM	0,0	0,0	0,0	0,0	2,6	1,5	8,7	3,3	33,3	9,5
AS	NS	0,0	0,0	0,3	0,0	9,0	1,7	21,9	7,7	20,8	5,0
	O	0,0	0,0	0,7	0,0	29,0	6,3	60,9	8,7	51,5	9,0
	TM	0,0	0,0	0,0	0,0	26,2	3,7	55,8	7,0	66,2	6,7
WIE	NS	0,0	0,0	11,2	13,0	56,3	21,0			101,5	32,3
	O	0,0	0,0	0,2	0,3	1,8	1,3			4,2	3,3
	TM	0,0	0,0	35,6	6,7	63,3	12,0			87,7	16,0
BIE	NS	0,0	0,0	0,0	0,0	100,6	3,0	138,2	3,7	ful	
	O	0,0	0,0	0,0	0,0	171,6	4,3			ful	
	TM	0,0	0,0	221,7	2,3	422,3	4,3	503,9	4,7	558,0	6,3



Results - Crack formation 2

		Months of Exposure									
		0		6		12		18		24	
Location	Wood species	Total crack length	# cracks	Total crack length	# cracks	Total crack length	# cracks	Total crack length	# cracks	Total crack length	# cracks
OSL	NS	0,0	0,0	2,4	3,0	6,6	3,7	9,6	5,7	13,6	8,7
	O	0,0	0,0	3,2	1,7	6,9	2,3	7,5	2,7	7,3	3,3
	TM	0,0	0,0	5,4	3,3	8,2	3,3	12,9	4,7	21,7	5,7
ITA	NS	0,0	0,0							20,7	3,7
	O	0,0	0,0							39,8	8,3
	TM	0,0	0,0							24,5	1,7
HAM	NS	11,7	3,0					0,7	1,0	1,0	1,0
	O	3,0	1,3					5,9	2,0	18,5	6,0
	TM	25,0	5,7					6,2	2,0	6,3	2,0
TAL	NS	0,0	0,0		0,0	8,1	3,0			29,3	7,0
	O	0,0	0,0		0,0	22,5	9,0			32,7	9,0
	TM	0,0	0,0	9,8	5,3	14,6	3,7			12,6	1,3
SCI	NS	0,0	0,0							4,6	1,7
	O	0,0	0,0							11,7	3,0
	TM	0,0	0,0							8,0	3,0
TEC	NS	0,0	0,0	0,0	0,0	0,0	0,0	0,8	0,3	12,0	1,7
	O	0,0	0,0	0,0	0,0	0,0	0,0	1,8	1,3	9,0	1,3
	TM	0,0	0,0	0,0	0,0	21,7	2,3	27,3	3,0	28,7	3,3



Results - Crack formation vs. time - Hamburg

TMT specimens at **11:30 am; 8th of September 2016**

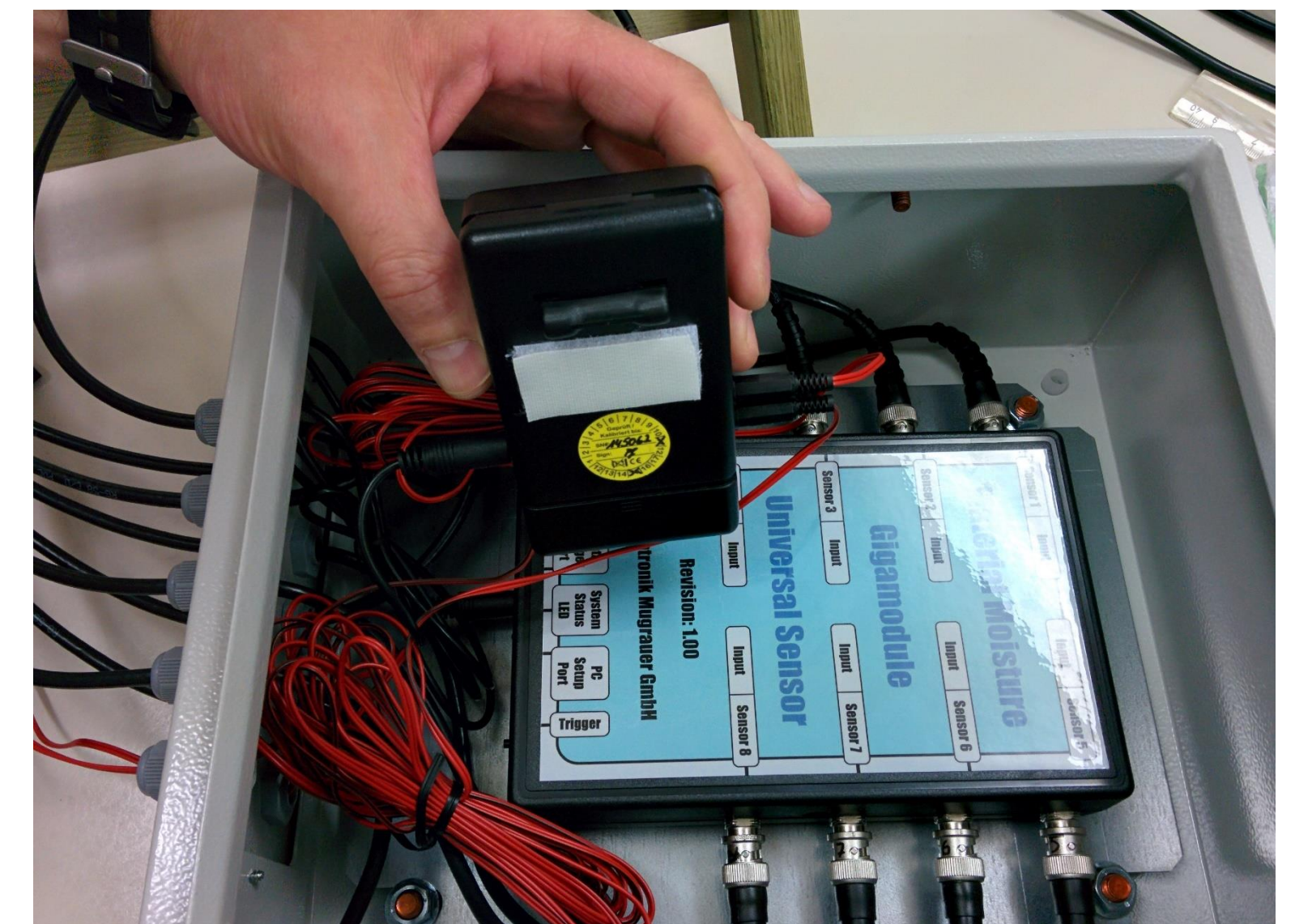


TMT specimens at **11:30 am; 8th of September 2016**



Assessment and evaluation - Moisture content and temperature (version A)

- Electrical resistance measurements and recording
- central part of the specimen
- 8 measurements per table (version A)



Results - moisture content of Norway spruce

	HAN	HAM	TEC	AS	ITA	ULJ
Count	1208	1066	77	364	137	1462
Average	21,4	22,4	27,2	27,1	20,9	28,0
Median	19,3	20,8	22,5	24,3	17,2	28,5
MIN	9,4	9,1	11,1	17,1	11,1	5,8
MAX	90,5	63,2	75,4	71,8	102,4	54,2
U>20%	535	556	46	317	43	1226
U>30%	159	179	23	91	11	660
U>20% and T<20° C	52	36	6	30	8	181
U>20% and T<20° C [%]	4,3	3,3	8,3	8,2	5,8	12,4
No. of days per year U>20% and T<20° C	16	12	30	30	21	45



Results - moisture content of TM Norway spruce

	HAN	HAM	TEC	AS	ITA	ULJ
Count	794	1066	80	365	202	1462
Average	25,9	27,3	29,7	42,0	17,7	22,3
Median	24,8	26,1	27,8	42,5	13,8	21,3
MIN	3,5	7,4	3,6	16,8	3,7	10,8
MAX	65,3	57,1	67,8	73,3	73,6	48,4
U>20%	484	710	49	349	69	1029
U>30%	281	423	37	300	41	159
U>20% and T<20° C	40	63	8	33	15	140
U>20% and T<20° C [%]	5,0	5,9	10,4	9,0	7,4	9,6
No. of days per year U>20% and T<20° C	18	22	38	33	27	35



Results - moisture content of Oak

	HAN	HAM	TEC	AS	ITA	ULJ
Count	792	1066	81	365	202	1462
Average	17,0	16,0	23,6	25,2	12,8	16,5
Median	15,9	14,9	21,6	25,5	11,2	16,4
MIN	6,8	7,1	10,3	11,0	4,1	5,3
MAX	38,7	32,4	75,2	40,9	30,3	35,0
U>20%	235	200	42	248	19	445
U>30%	30	3	21	105	2	25
U>20% and T<20° C	13	8	6	20	2	21
U>20% and T<20° C [%]	1,6	0,8	7,4	5,5	0,7	1,4
No. of days per year U>20% and T<20° C	6	3	27	20	3	5



Assessment and evaluation - Decay

Decay reating scale according to EN 252 (2012)

Rating	Classification
0	No attack
1	Slight attack
2	Moderate attack
3	Severe attack
4	Failure



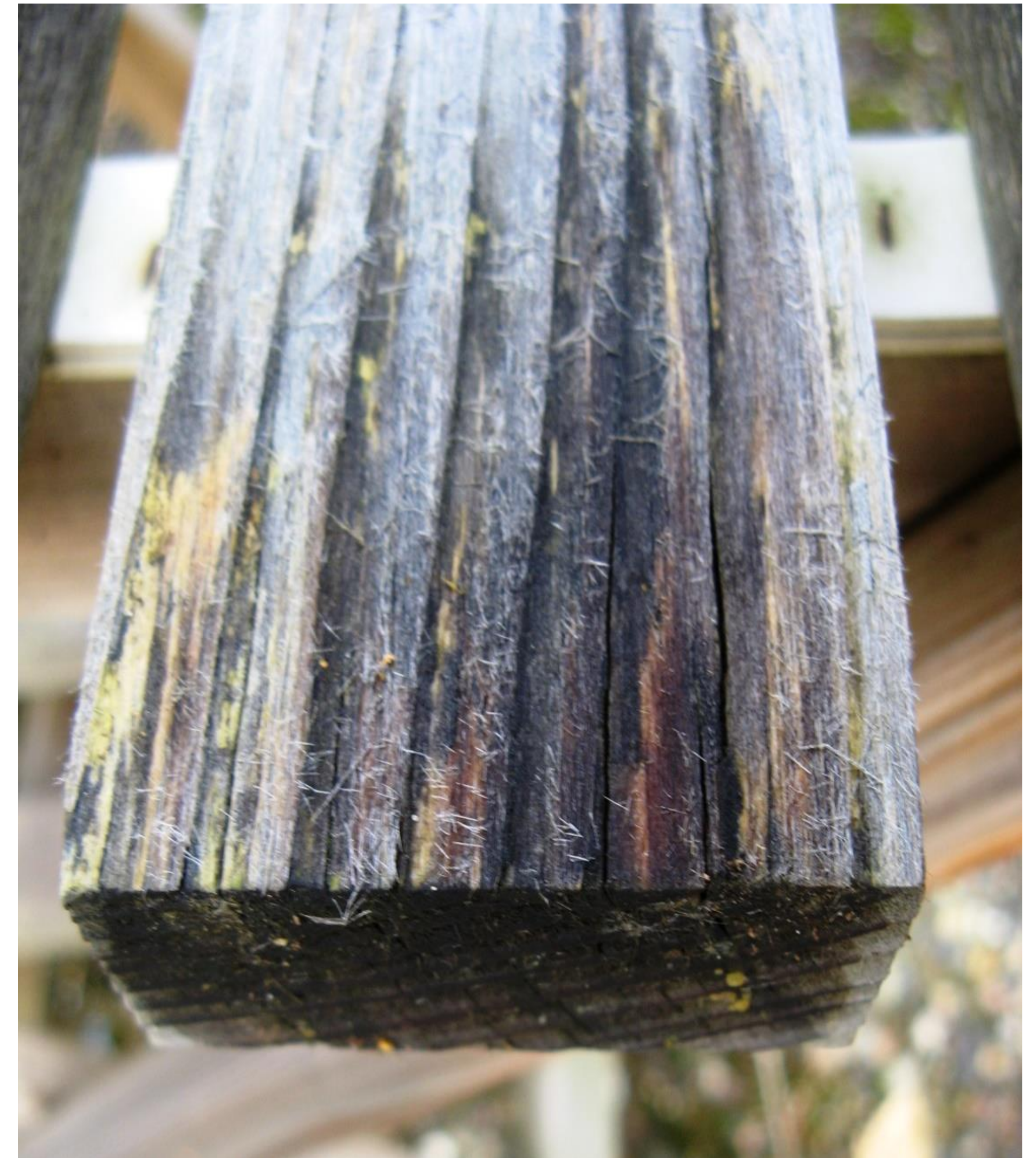
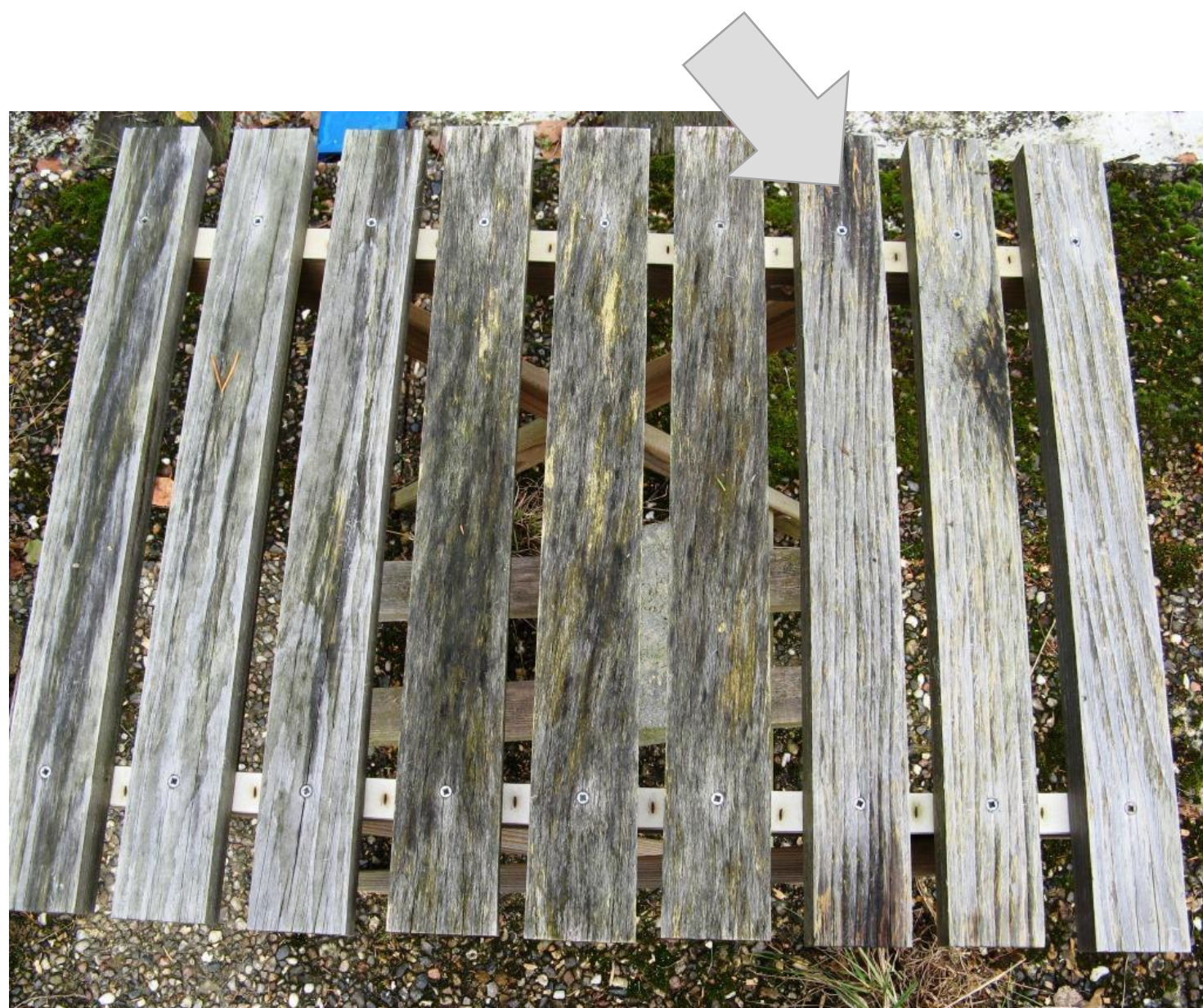
Results - decay Norway spruce in Hamburg

- Only in Hamburg (Photos from novembre 2016)
- Norway spruce and fir specimens



Results – decay of Fir in Hamburg

- Only in Hamburg (Photos from novembre 2016)
- Fir hardwood specimen with fruit bodies of *Dacrymyces* spp. s



Conclusions

- At the beginning slightly faster were colour changes fast of the TMT NS than NS or Oak
- Evaluation of disfigurement was in good coloration with colour change
- Crack formation is more relegated with sample orientation than the locations of the table
- Results of MC between locations are not comparable because of low number of measurements from some locations
- First decay was observe after two years on Norway spruce and Fir samples in Hamburg
- Galvanized screws corrode in Oak and slightly in TMT NS



Issues

- To receive evaluation and weather data from all tables
- Crack evaluation
- Moisture measurements

To do next

- Connect weather data with results from tables
- Evaluation and assessment will continue



Thank to all partners

Thank you for your attention

