Wooden Plants: A New Damage Indicator / Degree of Damage - Matrix

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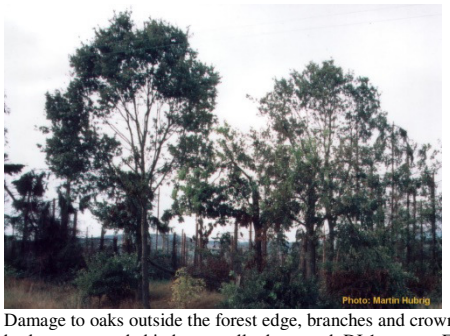
The Damage Indicator (DI) and Degree of Damage (DoD) approach, as it was introduced with the EF-Scale, is not only useful for buildings and engineered structures, but also for wooden plants. In the present EF-Scale only two DI´s are related to trees – no. 27 for hardwood and no. 28 for softwood. In this new proposal similar tree species or genera (major subdivisions of families) with similar capability of resistance are grouped together. The work is based on forest inventories. As a compromise between necessary distinction and high complexity **10 DI groups for trees** are proposed. For each of these DI groups **3 - 6 subdivisions** (**a - f**) are provided for different ground properties and other parameters. The proposed **number of DoD classes is 7 for all DI's**. As the related wind speeds are calibrated to the F-Scale, the F-Scale denotation is used. In general this approach is suitable for an International F-Scale (IF-Scale), as promoted by ESSL.

Uprooted oak on wet, fragile ground, untypically, very flat root-system, DI 1b, lower F1 damage

Uprooted oak on deep brown earth, typical for Central Europe, deep root-system, DI 1d, lower F2 damage



Damage to oaks outside the forest edge, branches and crown parts broken, spruces behind are totally destroyed, DI 1e, upper F1 damage

Nearly totally de-branched stabile oaks (similar to solitaire situation), DI 1f, lower F3 damage.

Local conditions cause different growth behaviour and stability parameters. These are considered in DI a - f.
Above two examples of oaks, below a pine and a spruce which shows abnormal growth behaviour, caused by bad local soil properties.

Stand conditions lead to different habits and stability. The combination of DI, DI Subdivision and DoD one can rate the storm intensity.
Two examples for hardwood are presented above, three examples for softwood below.

Uprooted pine on wet, fragile ground, untypical, very flat root-system, DI 6b, upper F0 damage

Uprooted spruce on firm, rocky ground, untypical, deep root-system, DI 5d, lower F2 damage

Mainly compression failure at spruces with unfavourable H/D-ratio, DI 5b, lower F1 damage

Snapped spruces on medium solid ground, unstable forest stands, DI 5b, upper F1 damage

Snapped spruces in forest edge situation, DI 5e, lower F2 damage

Important note: Trunks with wooden decay complicates the rating or makes it impossible. Rating is also very difficult for trees along streets or in towns - especially if the ground is not natural but artificially piled up. But in most such cases, one has additional building damage to rate the storm intensity.

Debarking due to sandblast effect can start at upper F3 intensity, but usually is seen only at F4 and F5. Debarking at lower intensities is caused by fibre split, other trees or big chunks of debris.

Mighty oak trunk snapped.
It seems like F3 damage, but …

… but a large cross section of rotten wood (detail of the snapped trunk). Other damages nearby are F2.

Uprooted mighty willow with cut back branches and thick trunk, but minor root system. Impossible to rate.

Debarked young maple. Debarking due to fibre split. Sand-blast effect is starting at lower right side, DI 3f, upper F3.

Debarked solitaire tree - debarking mainly due to sandblast effect, DI 3f, F4 damage.

DI 1 - 10	DI Subdivision a - f	DoD 1	DoD 2	DoD 3	DoD 4	DoD 5	DoD 6	DoD 7
Type of Tree	**Stability Parameters**	**small limbs and dead branches broken**	**strong branches and crown parts broken**	**uprooting or compression failure**	**uprooting or trunk snapping**	**intensive debranching or tearing out, transport of big tree parts**	**beginning of debarking due to "sandblast effect"**	**nearly total debarking due to "sandblast effect"**
1 Oak	a - fragile ground AND unstable forest stands	lower F0	upper F0	lower F1	lower F1	upper F2	upper F3	≥F4
	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	F1	F1	upper F2	upper F3	≥F4
	c - average ground, average stock	lower F0	upper F0	F1	lower F2	upper F2	upper F3	≥F4
	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	upper F0	lower F2	lower F2	upper F2	upper F3	≥F4
	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4
	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4
2 Beech	a - fragile ground AND unstable forest stands	lower F0	upper F0	lower F1	lower F1	upper F2	upper F3	≥F4
	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	lower F1	F1	upper F2	upper F3	≥F4
	c - average ground, average stock	lower F0	upper F0	F1	upper F1	upper F2	upper F3	≥F4
	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	upper F0	F1	lower F2	upper F2	upper F3	≥F4
	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4
	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4
3 Other Hardwood	a - fragile ground AND unstable forest stands	lower F0	upper F0	lower F1	lower F1	upper F2	upper F3	≥F4
for example	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	lower F1	F1	upper F2	upper F3	≥F4
maple	c - average ground, average stock	lower F0	upper F0	F1	upper F1	upper F2	upper F3	≥F4
ash	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	upper F0	lower F2	lower F2	upper F2	upper F3	≥F4
elm	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4
elder	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4
4 Soft Hardwood	a - fragile ground AND unstable forest stands	lower F0	upper F0	lower F1	lower F1	lower F2	upper F3	≥F4
for example	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	lower F1	lower F1	lower F2	upper F3	≥F4
popular	c - "average" ground "average stock"	lower F0	upper F0	lower F1	F1	lower F2	upper F3	≥F4
willow	d - forest edge situation & firm ground, only trees with healthy wood	lower F0	upper F0	F1	F1	upper F2	upper F3	≥F4
	e - solitaire trees & firm ground, only trees with healthy wood	lower F0	upper F0	F1	F1	upper F2	upper F3	≥F4
5 Spruce	a - fragile ground AND unstable forest stands	lower F0	upper F0	upper F0	lower F1	lower F2	upper F3	≥F4
	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	upper F0	lower F1	lower F2	upper F3	≥F4
	c - average ground, average stock	lower F0	upper F0	lower F1	F1	lower F2	upper F3	≥F4
	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	upper F0	F1	F1	lower F2	upper F3	≥F4
	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	F1	lower F2	upper F2	upper F3	≥F4
	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	F1	lower F2	upper F2	upper F3	≥F4
6 Pine	a - fragile ground AND unstable forest stands	lower F0	upper F0	upper F0	lower F1	lower F2	upper F3	≥F4
	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	lower F1	lower F1	lower F2	upper F3	≥F4
	c - average ground, average stock	lower F0	upper F0	lower F1	F1	lower F2	upper F3	≥F4
	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	upper F0	F1	lower F2	upper F2	upper F3	≥F4
	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	lower F2	upper F2	upper F3	≥F4
	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	lower F2	lower F2	lower F3	upper F3	≥F4
7 Fir	a - fragile ground AND unstable forest stands	lower F0	upper F0	upper F0	lower F1	lower F2	upper F3	≥F4
	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	lower F1	lower F1	lower F2	upper F3	≥F4
	c - average ground, average stock	lower F0	upper F0	lower F1	F1	lower F2	upper F3	≥F4
	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	lower F1	F1	lower F2	lower F2	upper F3	≥F4
	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	lower F2	upper F2	upper F3	≥F4
	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	lower F2	lower F2	upper F2	upper F3	≥F4
8 Larch and Douglas	a - fragile ground AND unstable forest stands	lower F0	upper F0	upper F0	lower F1	lower F2	upper F3	≥F4
	b - average ground in combination with unstable stands OR vice versa	lower F0	upper F0	lower F1	lower F1	lower F2	upper F3	≥F4
	c - average ground, average stock	lower F0	upper F0	lower F1	F1	lower F2	upper F3	≥F4
	d - firm, rocky ground, stable forest stands, only trees with healthy wood	lower F0	upper F0	F1	F1	lower F2	upper F3	≥F4
	e - forest edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	lower F2	upper F2	upper F3	≥F4
	f - solitaire trees & firm ground, only trees with healthy wood	lower F0	F1	lower F2	lower F2	upper F2	upper F3	≥F4
9 Shrubs	a - fragile soil, fragile plants	lower F0	upper F0	lower F1	lower F1	upper F2	upper F3	≥F4
	b - average ground, average location, average plants	lower F0	upper F0	F1	F1	upper F2	upper F3	≥F4
	c - firm, rocky ground, isolated hedges, only with healthy wood	F0	F1	lower F2	F2	lower F3	upper F3	≥F4
	d - solitaire shrubs & firm ground, only with healthy wood	F0	F1	lower F2	F2	lower F3	upper F3	≥F4
10 Palms	a - fragile soil, fragile trees	lower F0	lower F1	lower F1	lower F1	upper F2	upper F3	≥F4
	b - average ground, average location, average trees	lower F0	lower F1	F1	lower F2	lower F3	upper F3	≥F4
	c - solitaire trees, outside edge situation & firm ground, only trees with healthy wood	lower F0	F1	lower F2	F2	lower F3	upper F3	≥F4