



European Forest Risk Network

Wind and Snow/Ice Damage to Forests and the Secondary Impact of Bark Beetles

Barry Gardiner

with thanks to Kana Kamimura, Mart-Jan Schelhaas, Heli Peltola, Hervé Jactel

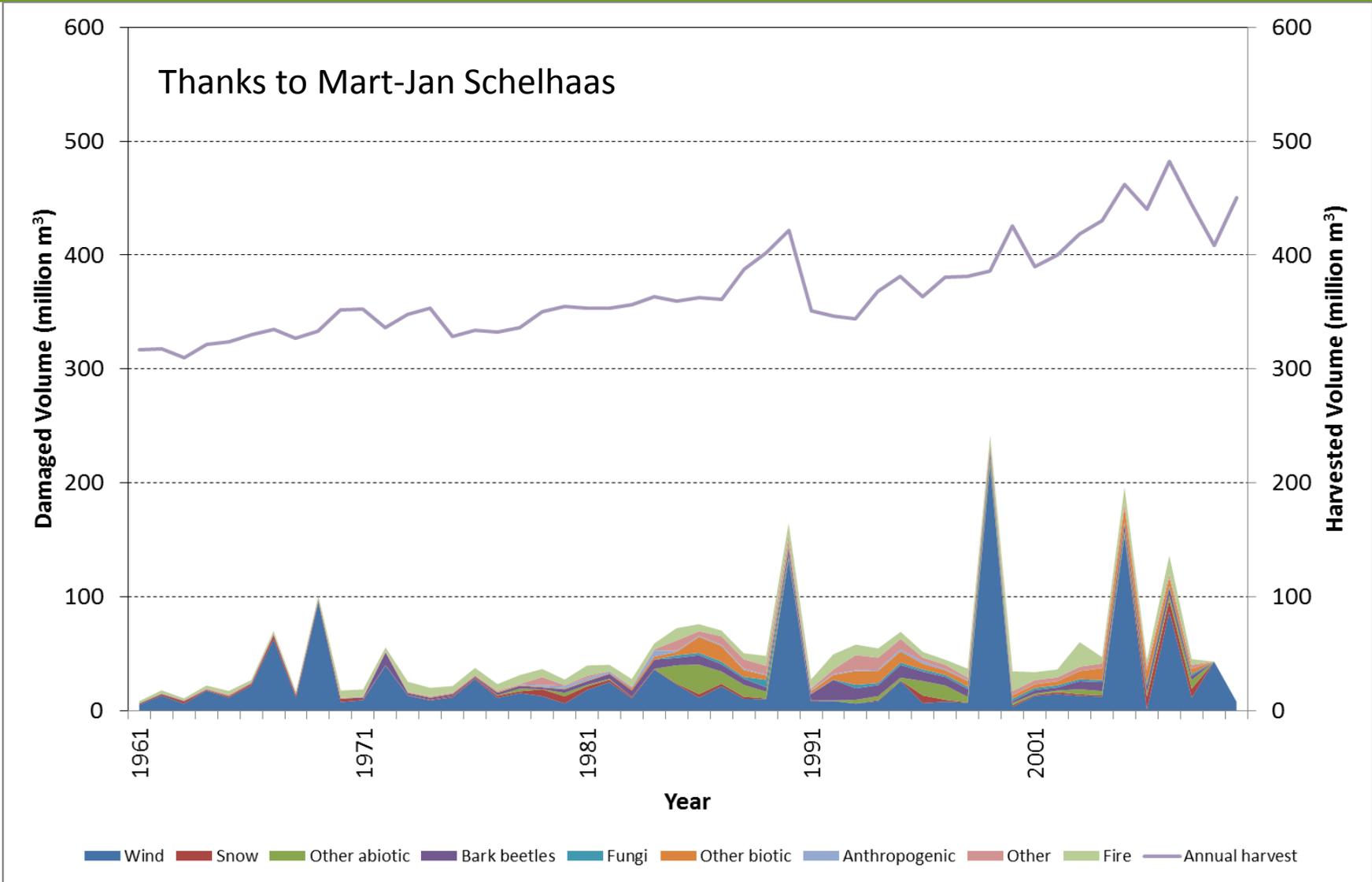
INRA, Bordeaux, France



Storm Damage to European Forests

- Storms (wind and snow) cause more than 50% of all damage to European forests
 - 38 million m³/year by wind
 - 4 million m³/year by snow
- 2 major wind storms affect Europe every year
- Snow/ice damage occurs every 1-10 years in different parts of Europe
- Example from Storm Klaus:
 - Directly destroyed 43.1 Mm³ timber (14% of the standing volume)
 - > 5 Mm³ subsequent insect damage
 - 31 fatalities (12 in France, 15 in Spain, 4 in Italy)
 - 1.7 million homes in SW France experienced power cuts
 - Direct cost to sector > €1 billion, total economic loss was ~ €3 billion.
- Storm damage leads to increased risk of insect attack and fire
- Storm damage in Europe is expected to increase this century because of increasing volume of standing trees, fewer but more intense storms and a reduction in periods of frozen soil

Damage Trends in European Forests



Major Hazards to European Forests

- Wind



- Fire



- Bark beetles



- Snow/Ice



- Drought



- Pathogens



- Other biotic pests

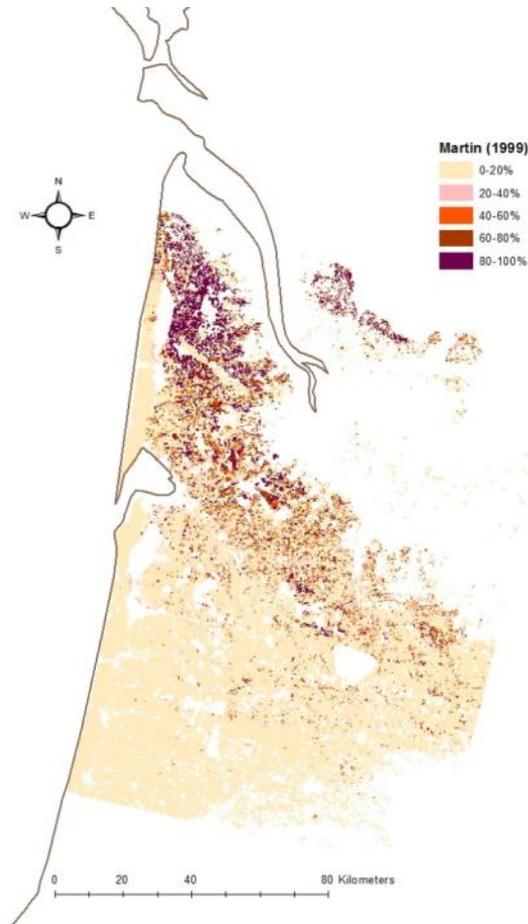


Forest Damage - Wind

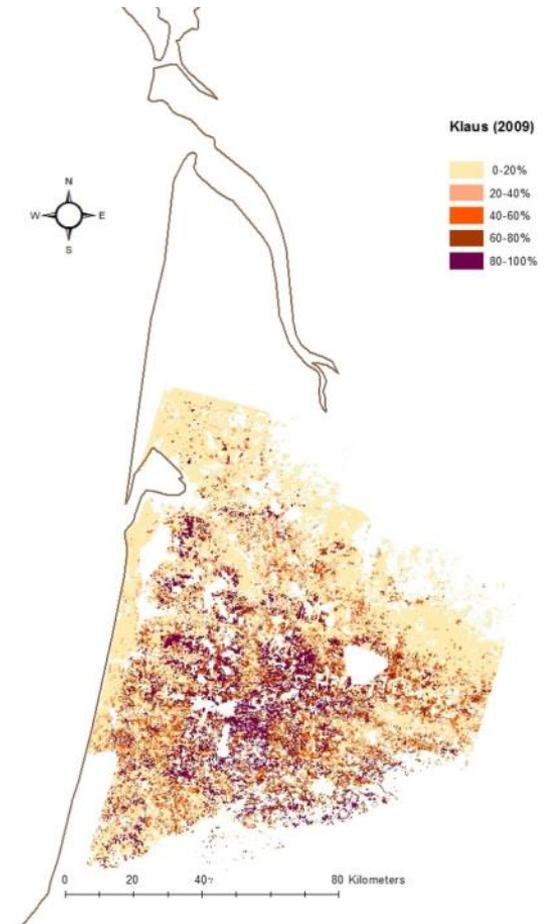


The Two Most Damaging Storms in South-west France

Tempête Martin, 27-28 Décembre 1999



Tempête Klaus, 24 Janvier 2009



~75 million m³ timber destroyed, ~40 people killed

Damage during Storm Lothar 1999



Forest Damage – Snow/Ice (Tree Bending)



Forest Damage – Snow/Ice (Snapping)



Forest Disturbance –Avalanche and Snow Sliding



Coupled Forest Damage – Bark Beetle after Wind



Stadelmann et al. (2013). *Forest Ecology and Management*, 305

Interaction between Abiotic and Biotic Hazards

More frequent **interactions between abiotic and biotic hazards**
- windstorm almost always trigger bark beetle outbreaks

Global Change Biology (2003) 9, 1620–1633, doi: 10.1046/j.1529-8817.2003.00684.x

Natural disturbances in the European forests in the 19th and 20th centuries

MART-JAN SCHELHAAS*†, GERT-JAN NABUURS*† and ANDREAS SCHUCK†

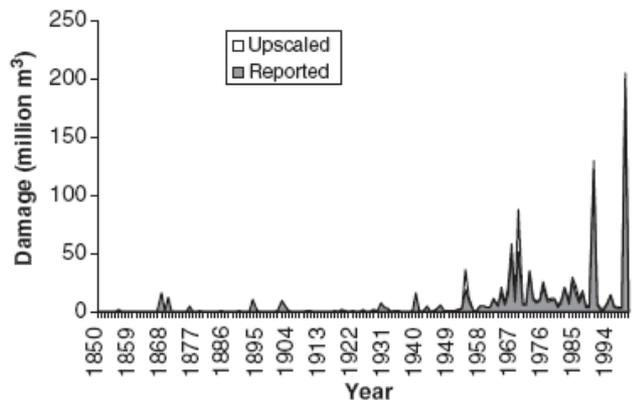


Fig. 5 Volumes of wood damaged by storms as reported in European countries for 1850–2000 and as scaled up for total Europe for 1950–2000.

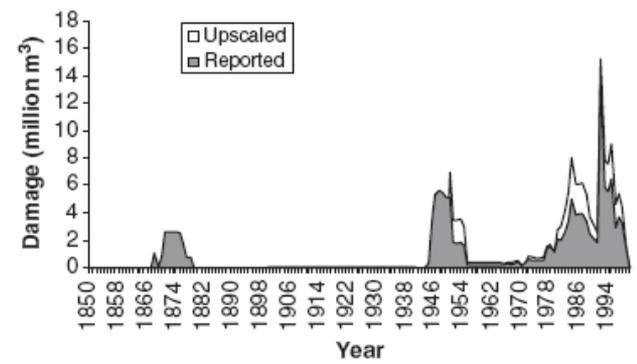


Fig. 8 Volumes of wood damaged by bark beetles, as reported in European countries for 1850–2000 and as scaled up for total Europe for 1950–2000.

Increasing Damage Levels from Bark Beetles after Wind

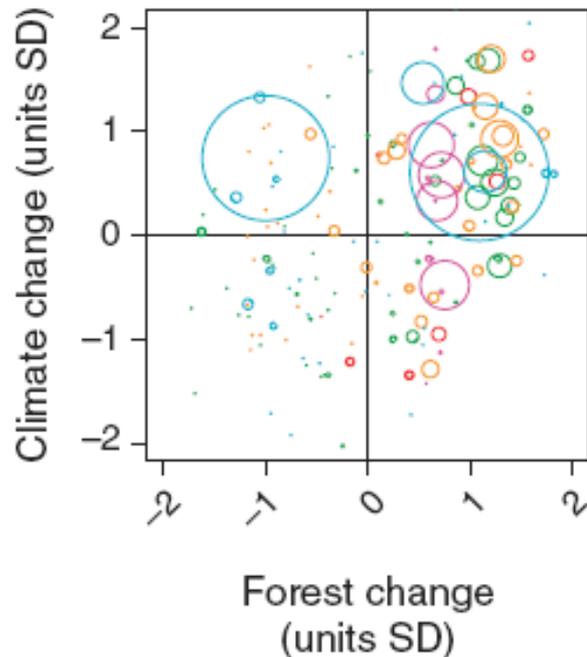
Increased volume of vulnerable forests, e.g. fast growing conifers

Global Change Biology

Global Change Biology (2011), doi: 10.1111/j.1365-2486.2011.02452.x

Unraveling the drivers of intensifying forest disturbance regimes in Europe

RUPERT SEIDL*†, MART-JAN SCHELHAAS‡ and MANFRED J. LEXER†



Insect Attack after Snow Damage

Table 1. Species most commonly associated with consequential insect attack after snow damage.

Insect	Tree species	References
<i>Tomicus</i> sp. (pine shoot beetles)	<i>Pinus sylvestris</i> (Scots pine)	Juutinen 1953, Persson 1972 Rottmann 1985a
<i>Pissodes</i> sp. (pine weevils)	<i>Pinus sylvestris</i>	Rottmann 1985a
<i>Rhizophagidae</i> sp. (Rhizophagidae-beetles)	<i>Pinus sylvestris</i>	Rottmann 1985a
<i>Pityogenes chalcographus</i> (Pityogenes-beetle)	<i>Picea abies</i> (Norway spruce)	Persson 1972, Rottmann 1985a
<i>Ips typographus</i> (spruce bark beetle)	<i>Picea abies</i>	Persson 1972, Rottmann 1985a
<i>Siricidae</i> sp. (wood wasps)	<i>Pinus sylvestris</i> & <i>Picea abies</i>	Rottmann 1985a
<i>Trypodendron lineatum</i> (spruce ambrosia)	<i>Pinus sylvestris</i> & <i>Picea abies</i>	Rottmann 1985a
<i>Cerambycidae</i> sp. (longhorn beetles)	<i>Pinus sylvestris</i> & <i>Picea abies</i>	Rottmann 1985a

From Nykänen et al. 1997, *Silva Fennica*

Components Affecting Wind Risk of Trees: Forest Edges



Components Affecting Wind Risk of Trees: Thinning



Components Affecting Wind Risk of Trees: Gaps



Streamlining of Leaves, Branches and Trees



FIGURE 5.8. The compound leaf of a black locust in still air and winds of 11, 33, and 44 miles per hour (5, 15, and 20 ms).

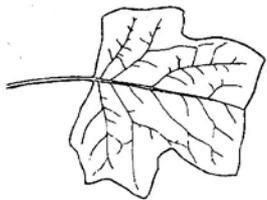


FIGURE 5.7. The leaf of a tulip poplar (also called a tulip tree or yellow poplar) in still air and winds of 11, 33, and 44 miles per hour (5, 15, and 20 ms).



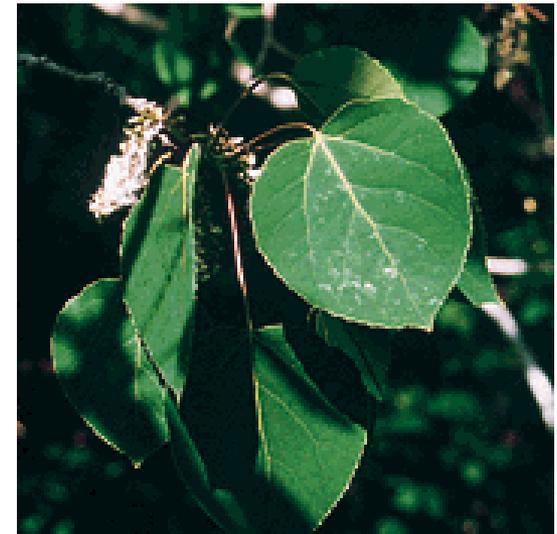
Coconut



Birch



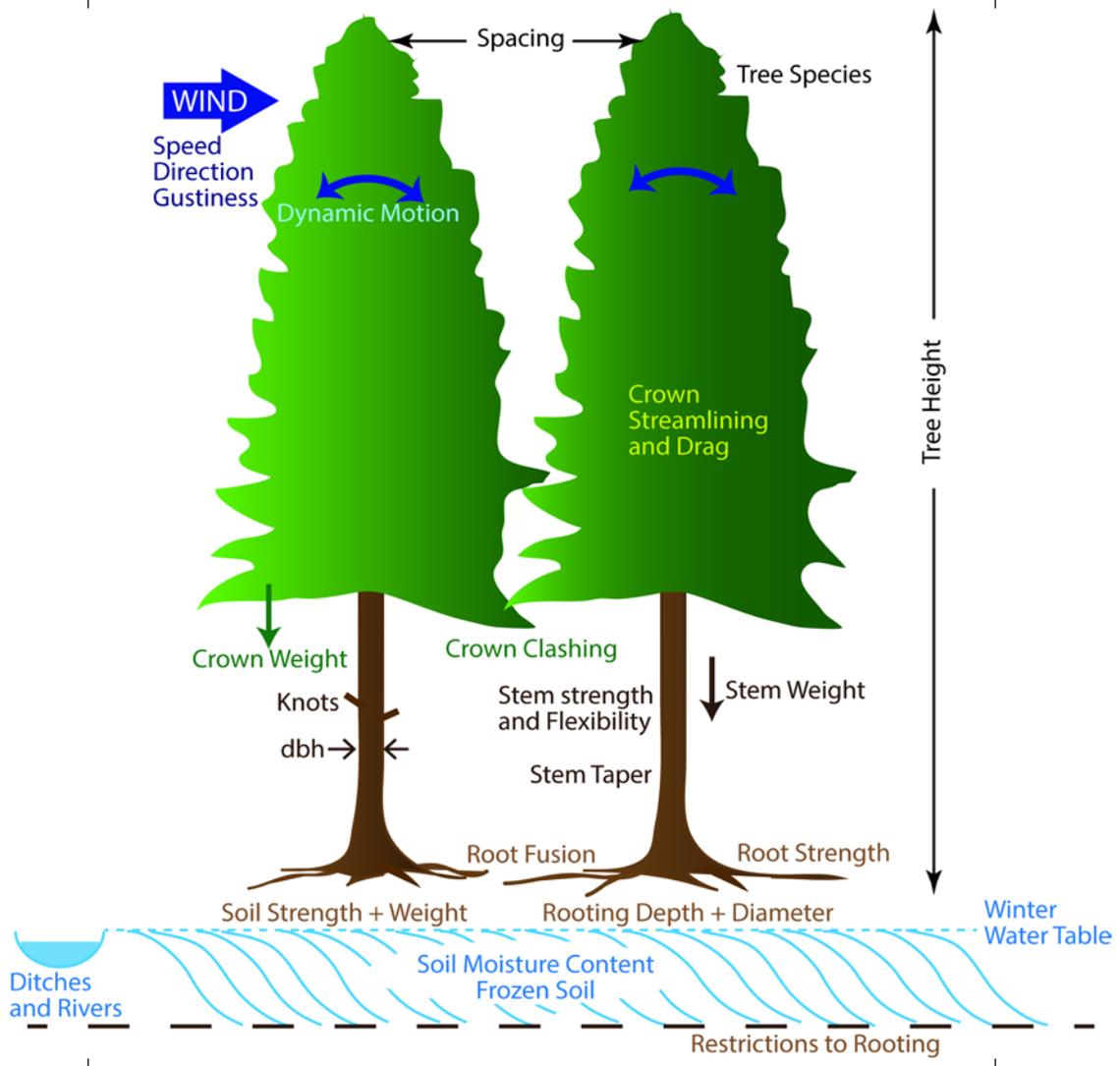
Scots pine



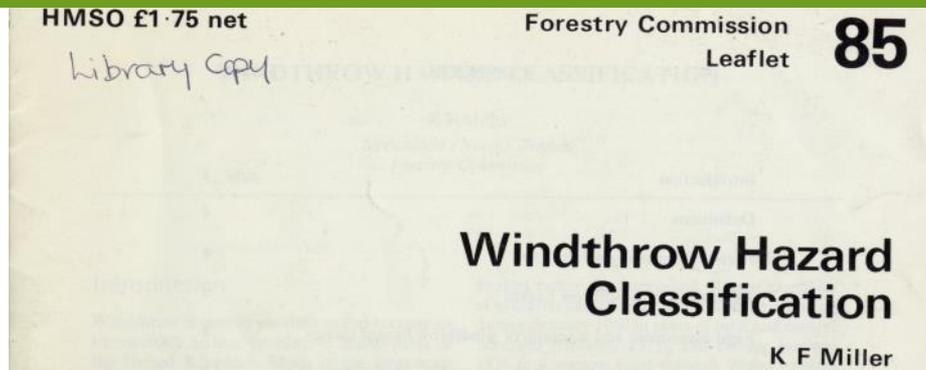
Aspen

After Vogel

Components Affecting Wind Risk of Trees

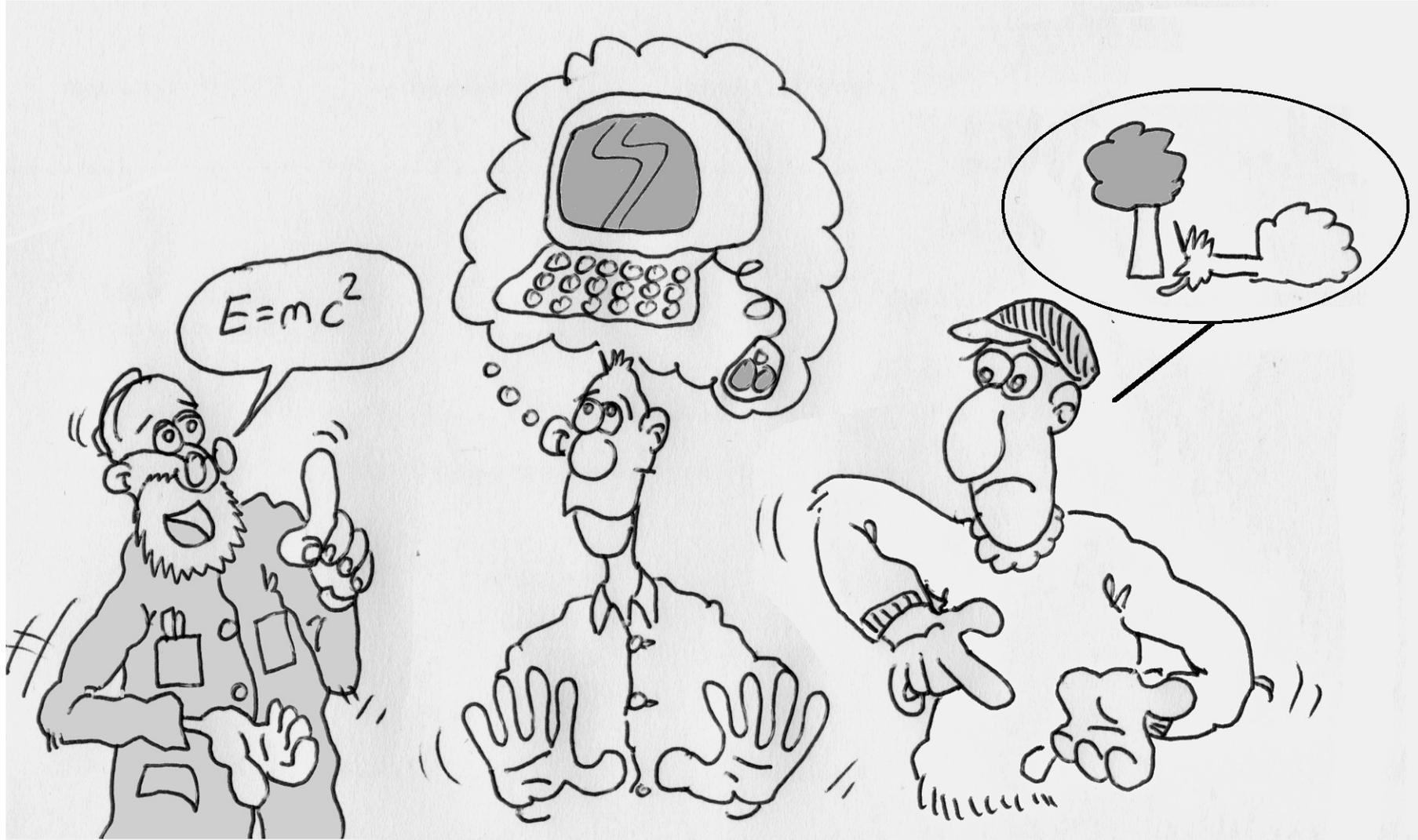


Windthrow Hazard Classification



- Windiness Scores
 - Region
 - Elevation
 - Topographic Shelter (Topex)
- Soil Score
 - Rooting Depth

Decision Support Systems (Linking Knowledge to Problems)



ForestGALES 2.5: Wind (and Snow) Risk Modelling

Single stand predictions using field measurements

Stand Characteristics

Stand ID: ForestGALES
 Cultivation: Notched Planting
 Drainage: Poor drainage
 Soil type: Peaty Gley
 Current Spacing (m) 3.2
 Current Stocking (N/ha)

Tree Characteristics

Species: Sitka Spruce
 Top height of stand (m): 26.5
 Mean DBH (cm): 32.2

DAMS

Grid Reference Calculation
 NH180150 Apply... DAMS Score: 15

Upwind Edge Effect

Windlim edge
 Brown edge - Size of gap (m): 5

Wind Damage Risk

	Return period	Wind	Damage Risk	Status	Critical wind speed
OVERTURNING	6			Status 6	19 m/s
BREAKAGE	20			Status 4	22 m/s

WHC: 5

ForestGALES 2.0

File Mode DAMS Options Window Help

Stand Predictions Through Time - ForestGALES

Average number of years until damage

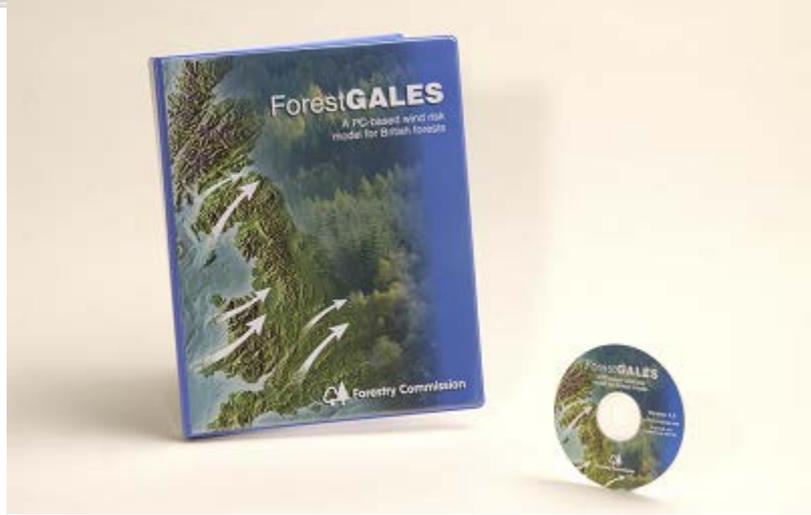
Age	Turn	Break	DBH	TopHt	Spacing	MeanVol	Vol/Ha
20	200	200	11.0	7.4	1.3	0.030	71
25	200	200	13.0	10.1	2.0	0.050	139
30	200	200	16.0	12.6	2.6	0.110	163
35	200	200	20.0	15.1	3.1	0.190	196
40	134	200	23.0	17.3	3.6	0.300	238
45	61	200	26.0	19.3	3.9	0.440	286
50	12	33	28.0	21.1	4.3	0.590	326
55	13	42	31.0	22.6	4.5	0.750	364
60	7	20	33.0	23.8	4.8	0.900	397

WDRS Table:

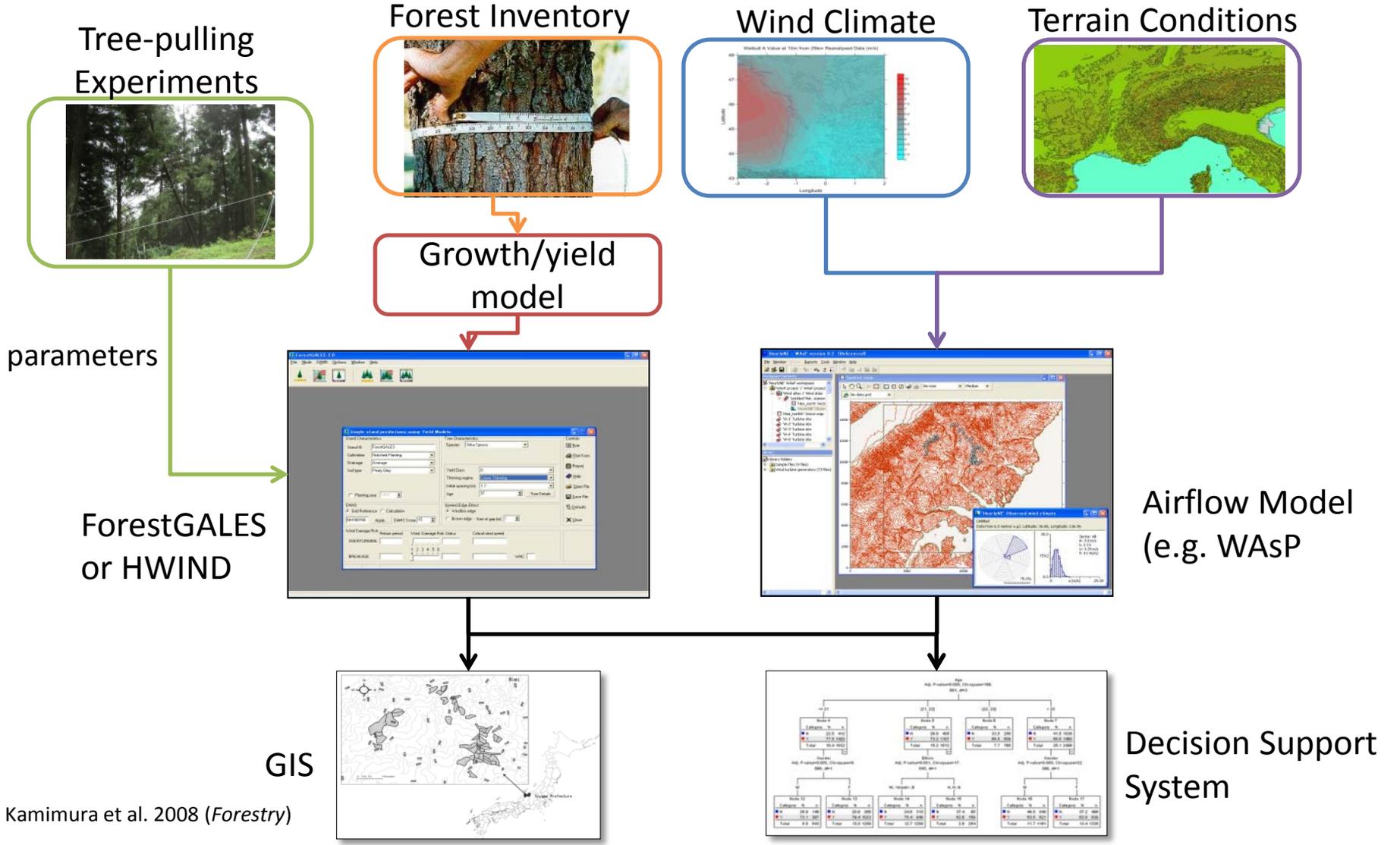
WDRS	Turn	Break
1	0	0
2	41	46
3	45	48
4	46	57
5	48	60
6	57	70

The table indicates the age at which the stand or group of trees first reach each WDRS (Wind Damage Risk Status).
 For a definition of WDRS see the help file.

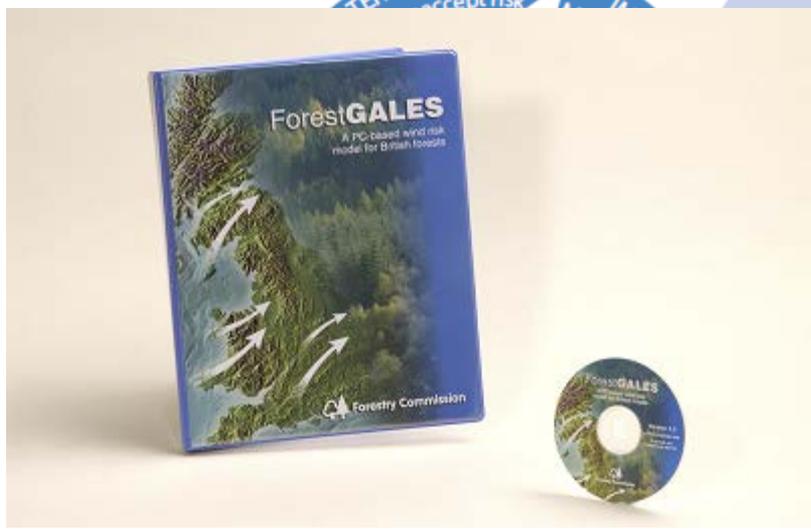
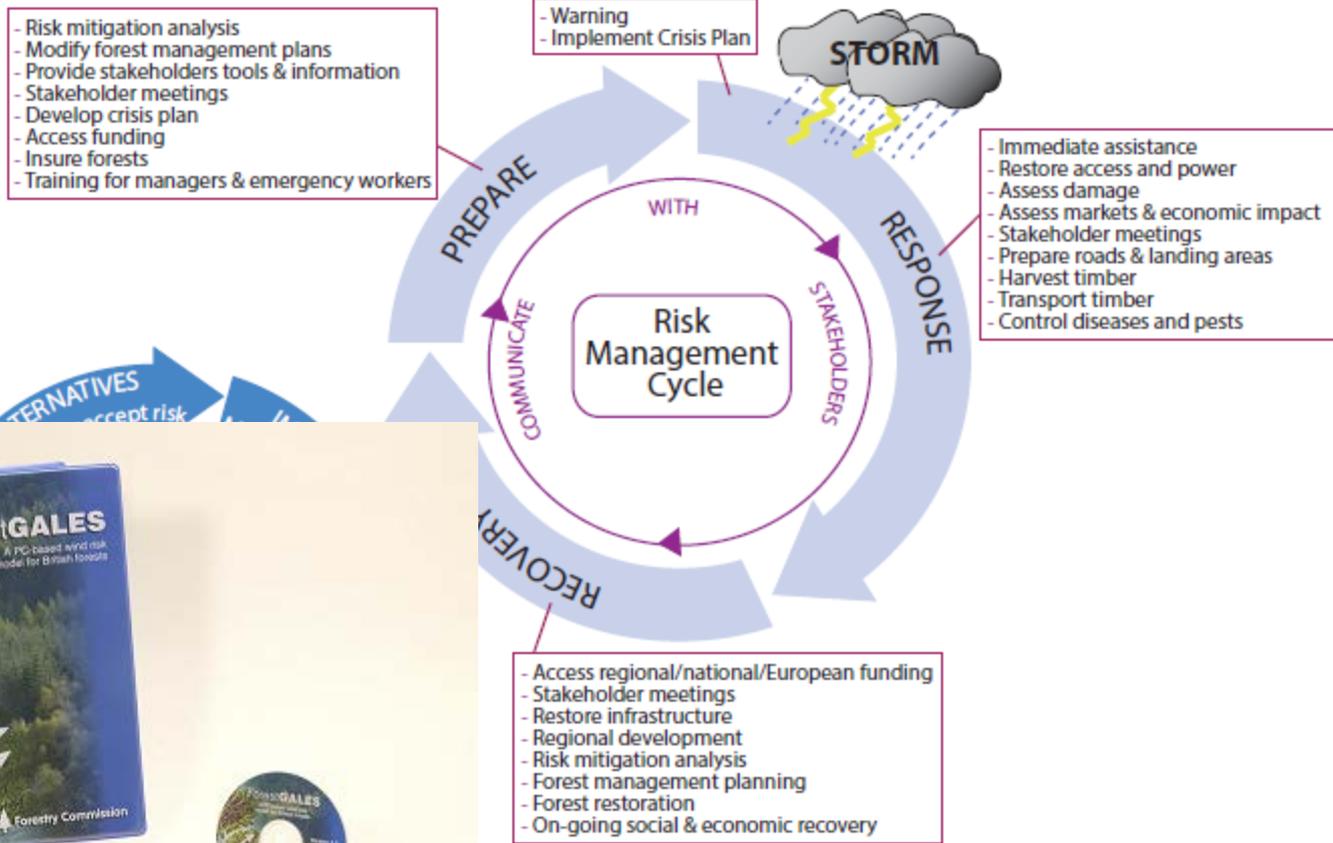
Some of the modelled trees are larger than we have data for.



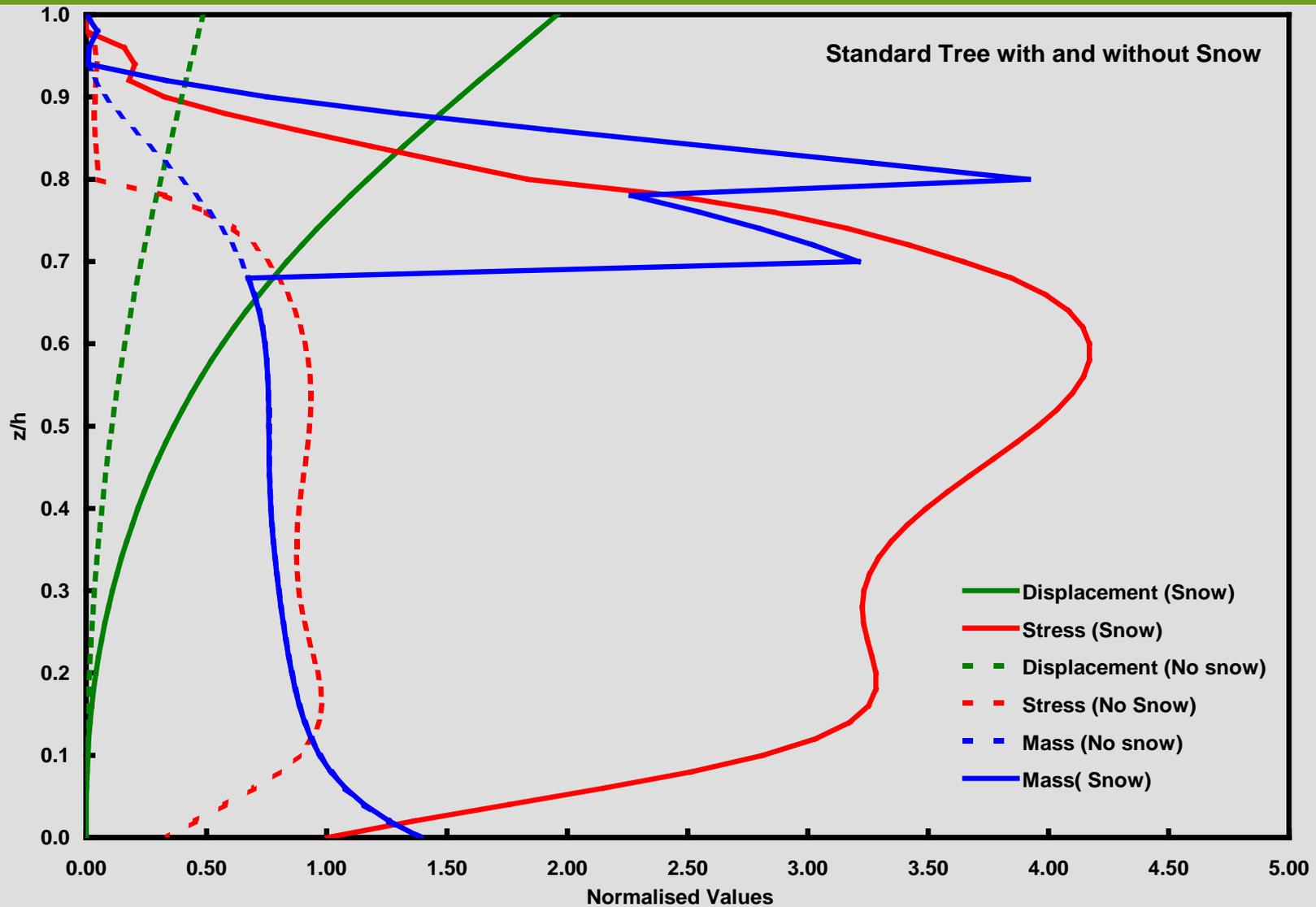
Predicting Wind Damage Risk



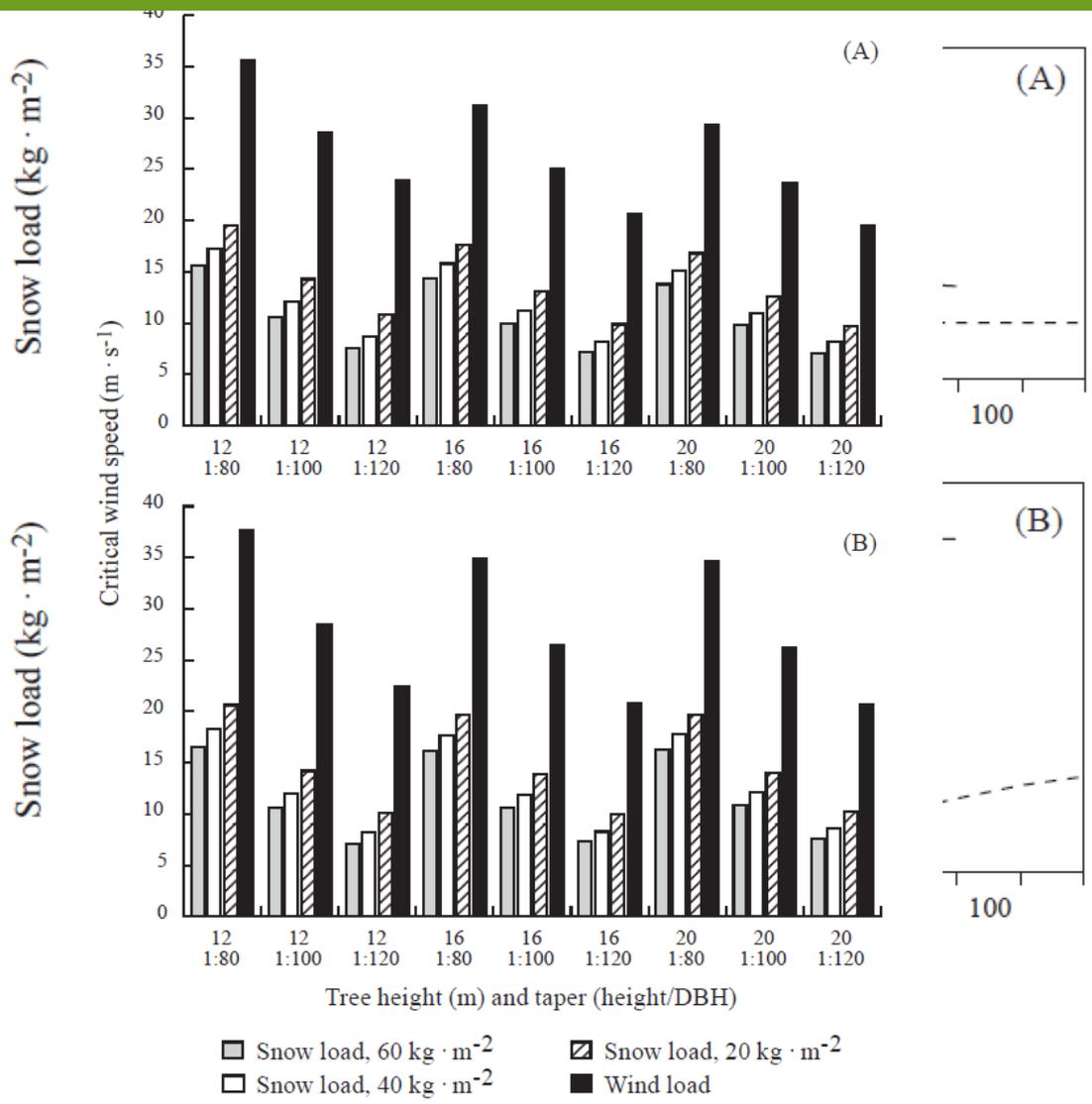
Risk Modelling, Mitigation and Management Cycle



The Bending and Stress in Trees with and without Snow



Effect of Tree Shape and Stand Density on Snow Damage



A: Uprooting
B: Breakage

H. Peltola, S. Kellomäki, H. Väisänen, and V.-P. Ikonen. (1999) CJFR

Adaptation to Snow



Engelmann spruce



Sub-alpine fir

Species Vulnerability to Snow Damage

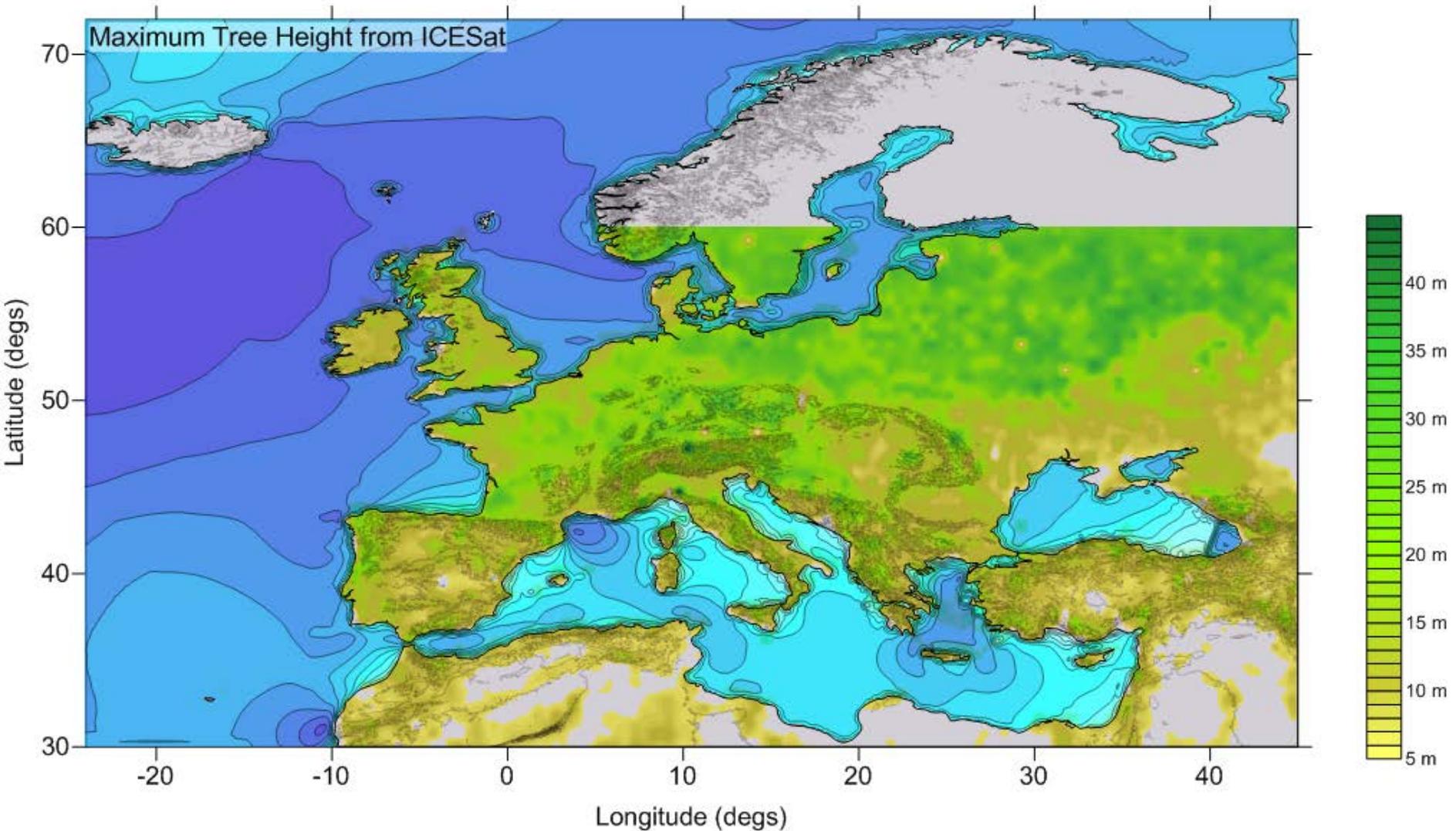
Table 2. Relative risks of various tree species to each other to snow damage in Europe according to some authors (see below).

Severity of damage	Tree species	
	Latin name	English name
Low damage	<i>Betula sp.</i>	Birch sp. ^{4), 6)}
	<i>Picea abies</i>	Norway spruce ^{1), 6), 9), 10)}
	<i>Pseudotsuga menziesii</i>	Douglas fir ⁷⁾
	<i>Larix sp.</i>	Larch sp., without needles ^{7), 5)}
	<i>Quercus sp.</i>	Oak sp., leafless ⁷⁾
	<i>Acer pseudoplatanus</i>	White maple, - ⁹⁾ - ⁷⁾
Moderate damage	<i>Picea abies</i>	Norway spruce ^{4), 5)}
	<i>Pinus sylvestris</i>	Scots pine ^{4), 5)}
	<i>Betula sp.</i>	Birch sp. ⁷⁾
	<i>Abies alba</i>	Silver fir ⁷⁾
	<i>Picea omorica</i>	Serbian spruce ⁷⁾
	<i>Larix sp.</i>	Larch sp., with needles ⁷⁾
	<i>Quercus sp.</i>	Oak sp., with leaves ⁷⁾
	<i>Acer pseudoplatanus</i>	White maple, - ⁹⁾ - ⁷⁾
	<i>Fagus sylvatica</i>	Common beech, leafless ⁷⁾
	<i>Fraxinus excelsior</i>	European ash, - ⁹⁾ - ⁷⁾
Severe damage	<i>Pinus sylvestris</i>	Scots pine ^{1), 2), 6), 8), 10), 11)}
	<i>Picea abies</i>	Norway spruce ^{4), 7)}
	<i>Larix sp.</i>	Larch sp., with needles ⁷⁾
	<i>Pinus contorta</i>	Lodgepole pine ⁵⁾
	<i>Picea sitchensis</i>	Sitka spruce ⁵⁾
	<i>Betula sp.</i>	Birch sp. ^{3), 4), 7)}
	<i>Populus sp.</i>	Poplars sp. ^{1), 7)}
	<i>Fagus sylvatica</i>	Common beech, with leaves ⁷⁾
	<i>Fraxinus excelsior</i>	European ash, - ⁹⁾ - ⁷⁾

References used in Table 2: 1) Heikinheimo 1920, 2) Mikola 1938, 3) Kangas 1959, 4) Suominen 1963, 5) Wornell 1979, 6) Norokorpi 1981, 7) Rottmann 1985a, 8) Norokorpi and Kärkkäinen 1985, 9) Perttälä 1987, 10) Valinger and Lundqvist 1992a and 11) Norokorpi 1994

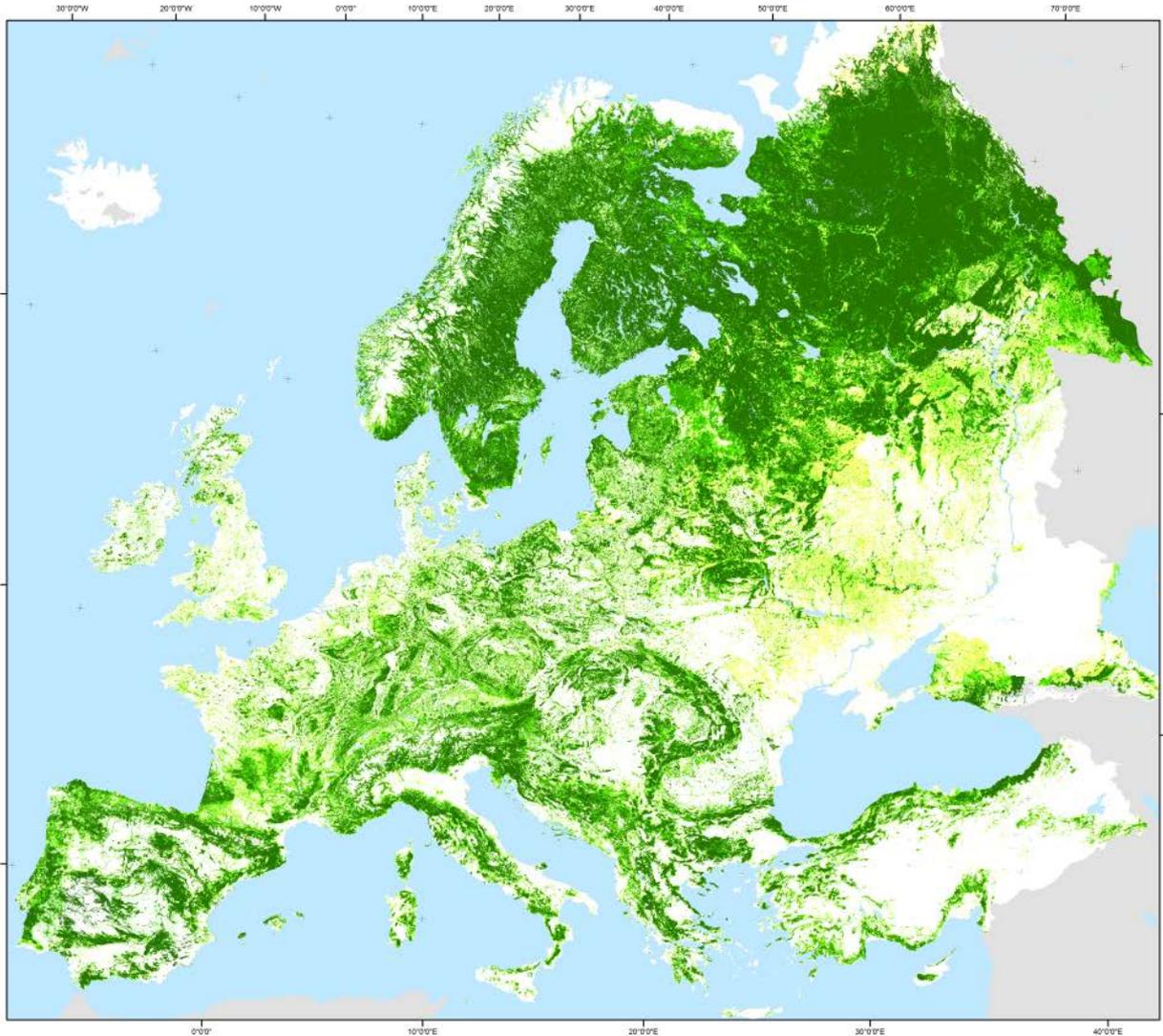
From Nykänen et al. 1997, *Silva Fennica*

Forest Data from ICESat (Satellite LiDAR)



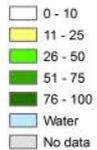
Los et al. 2012. *Geoscientific Model Development*, 5, 413-432.

Forest Data from National Inventories: EFISCEN-Space



FOREST MAP OF EUROPE (geographical Europe and Turkey)

Proportion of forest from land area
(% at 1km x 1km resolution)



ETRS89 Lambert Azimuthal Equal Area projection

Data sources

Earth observation data:
EU27, AL, BA, CH, HR, ME, MK, NO, RS, TR: Forest-non-forest map 2006 (beta version) developed by the EC Joint Research Centre, aggregated to 1km resolution. Based on IRS-P6 LISS-III, SPOT4 (HRVIR) and SPOT5 HRG satellite data of 2006.
Belarus, Moldova, Ukraine, Russian Federation: Forest share estimates based on AVHRR NOAA satellite data of 1996-1998.

Statistical data:
National forest inventory statistics
State of Europe's Forests country statistics 2011

Method

Two different earth-observation products (Kempeneers et al. 2011, Páivinen et al. 2001/Schuck et al. 2002) have been combined with statistical data to produce a pan-European forest map that corresponds to the official forest inventory statistics at national and/or regional level. The satellite-based forest cover data was first calibrated to sum up to the forest area statistics within a given administrative region. For 19 countries (including the Russian Federation) regional statistics were utilized during the calibration, while for the other countries statistics at national level have been applied. In a second calibration run, the map was adjusted to the internationally harmonized statistics by Forest Europe 2011 at national level, to allow for comparability between the countries.

Further details:
www.efi.int/global/virtual_forest/information_services/mapping_services/forest_map_of_europe

References

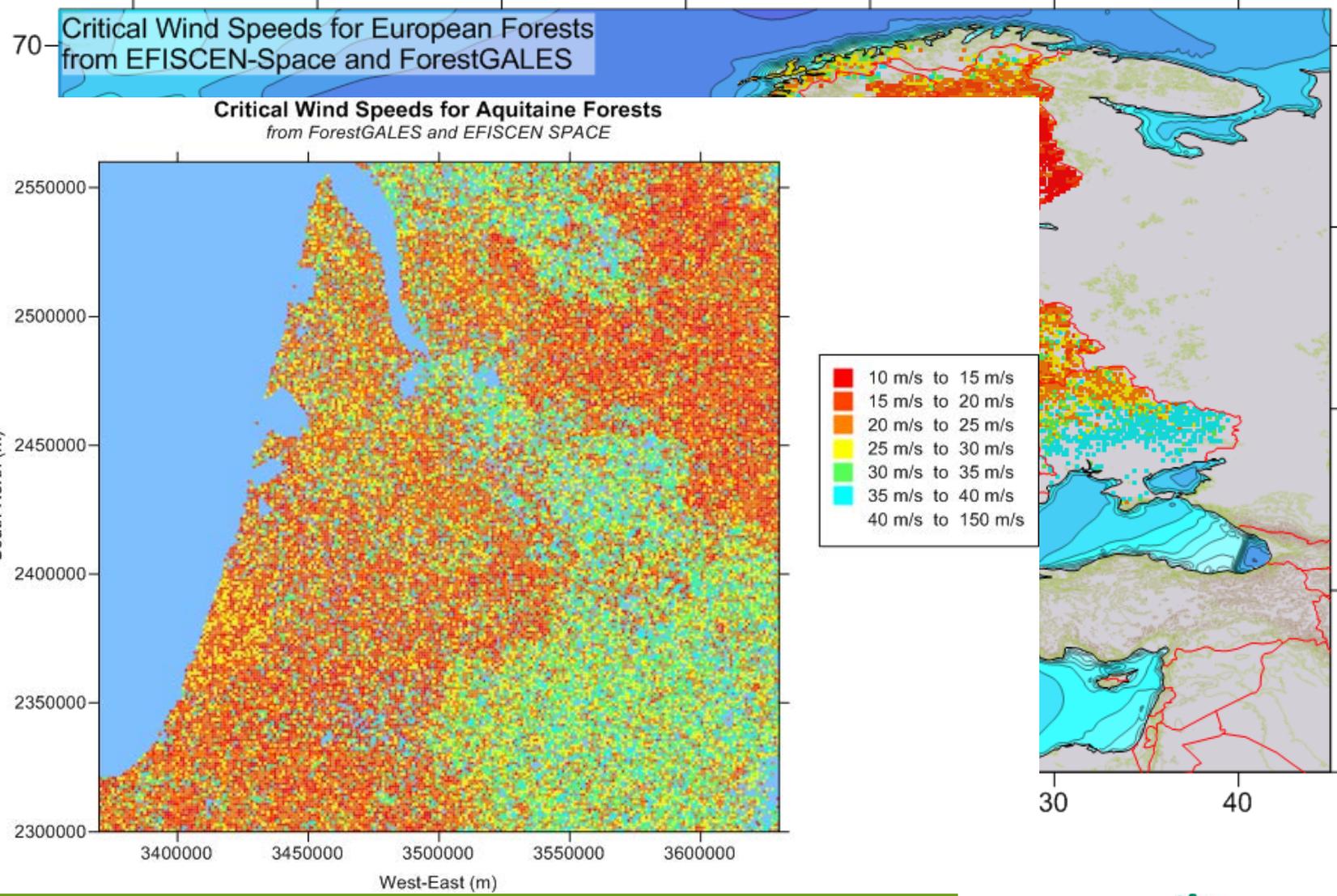
Kempeneers, P., Sedano, F., Reebach, L., Stroh, P., San-Miguel-Ayanz, J. 2011. Data fusion of different spatial resolution remote sensing images applied to forest type mapping. IEEE Transactions on Geoscience and Remote Sensing, in press.
Páivinen, R., Lehtinen, M., Schuck, A., Häme, T., Vaattainen, S., Kennedy, P. and Förling, S. 2001. Combining Earth Observation Data and Forest Statistics. EFI Research Report 14, European Forest Institute and Joint Research Centre - European Commission.
Schuck, A., Van Brusselen, J., Páivinen, R., Häme, T., Kennedy, P. and Förling, S. 2002. Compilation of a calibrated European forest map derived from NOAA-AVHRR data. EFI Technical Report 13, European Forest Institute.

Contact: efiscen@efi.int

European Forest Institute / EC Joint Research Centre
September 2011

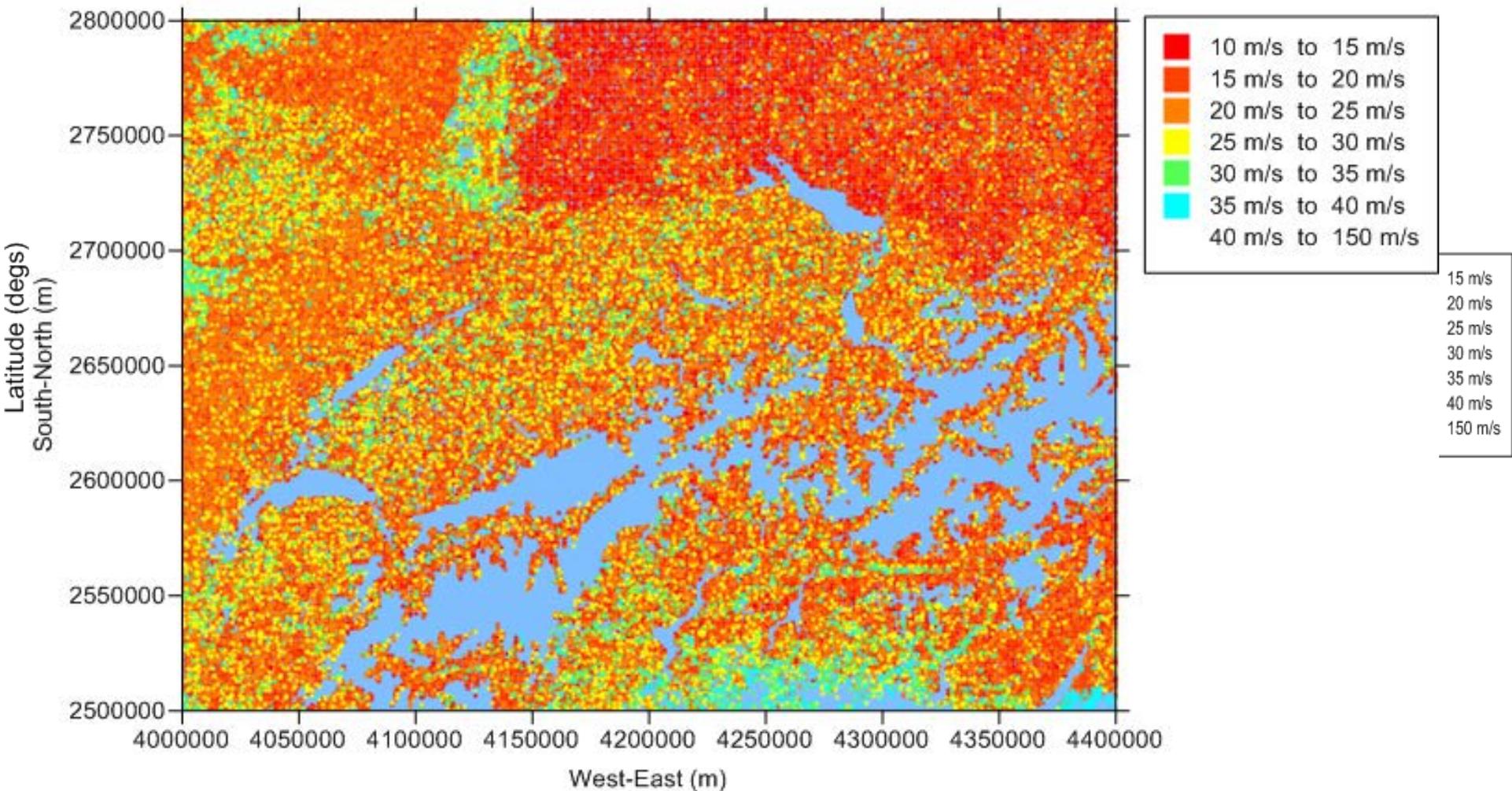


EFISCEN + ForestGALES → Critical Wind Speeds

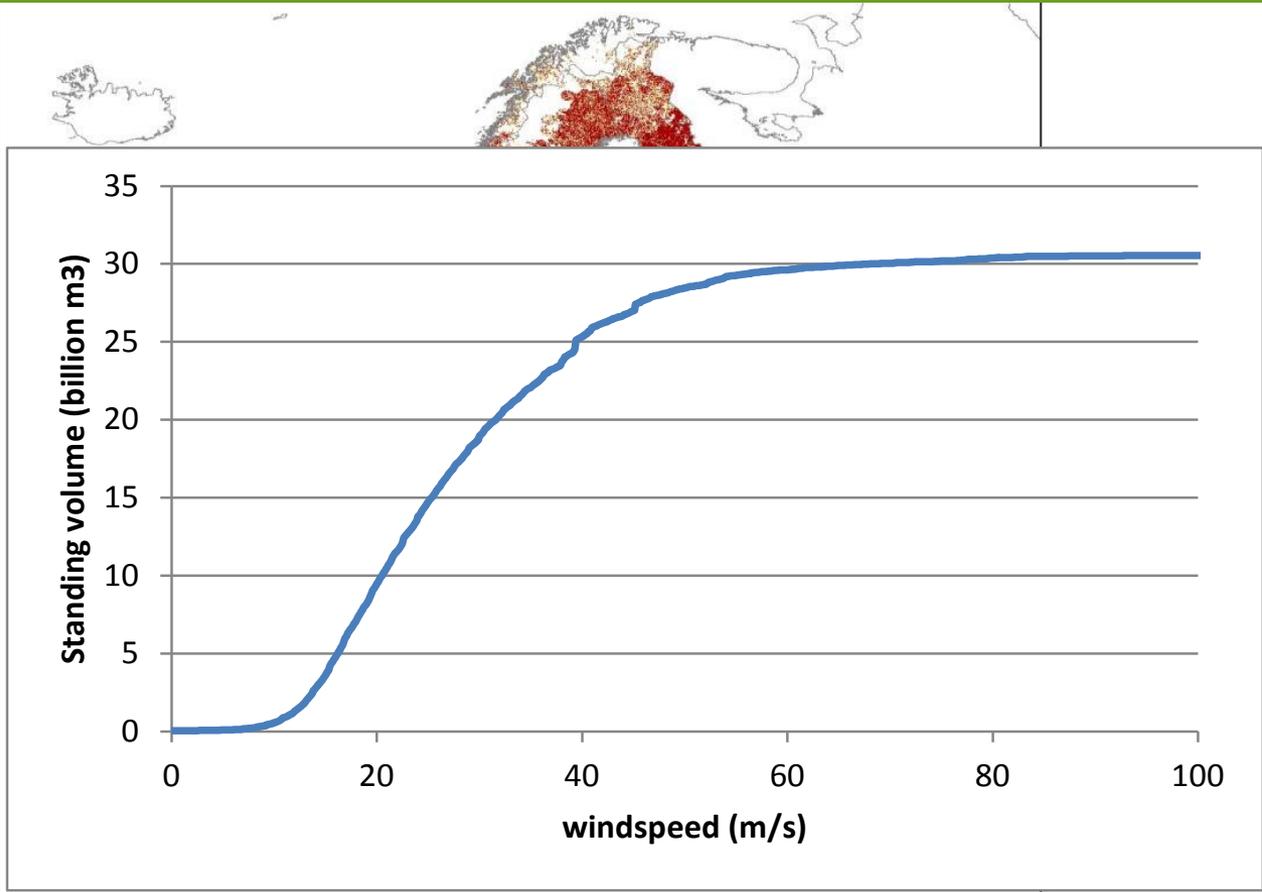


Critical Wind Speeds → EFISCEN + ForestGALES

Critical Wind Speeds for Swiss Forests
from ForestGALES and EFISCEN SPACE



European Forest at Risk from Wind

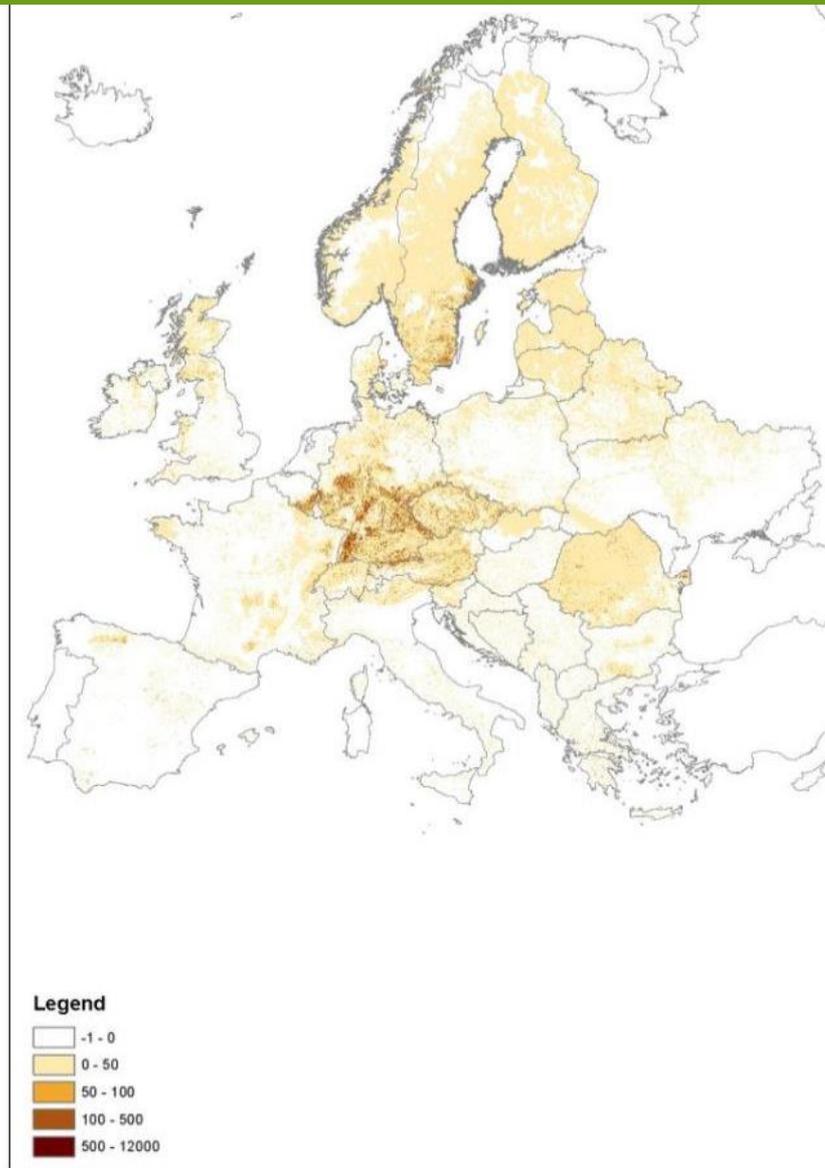


Legend
Critical Windspeed

- 0 - 20
- 20 - 25
- 25 - 30
- 30 - 83

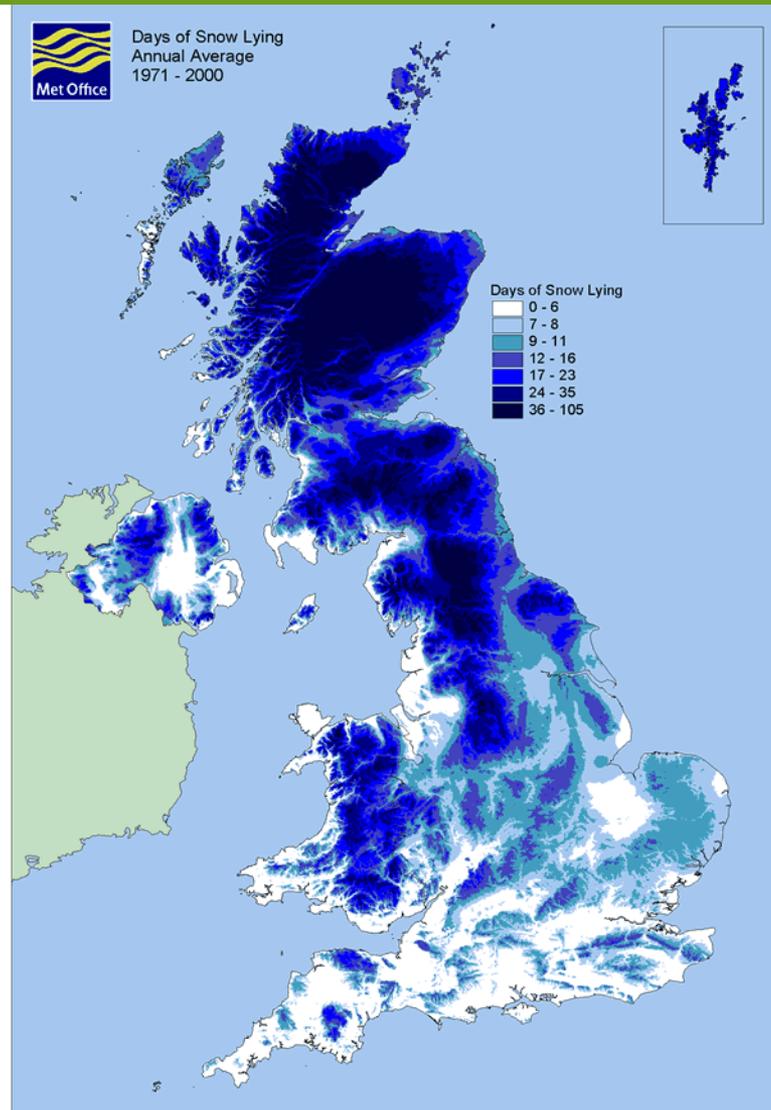
From EU MOTIVE Project Deliverable 4.1B
“Mapping current and projected key European forest risks”

European Forests at Risk from Bark Beetles

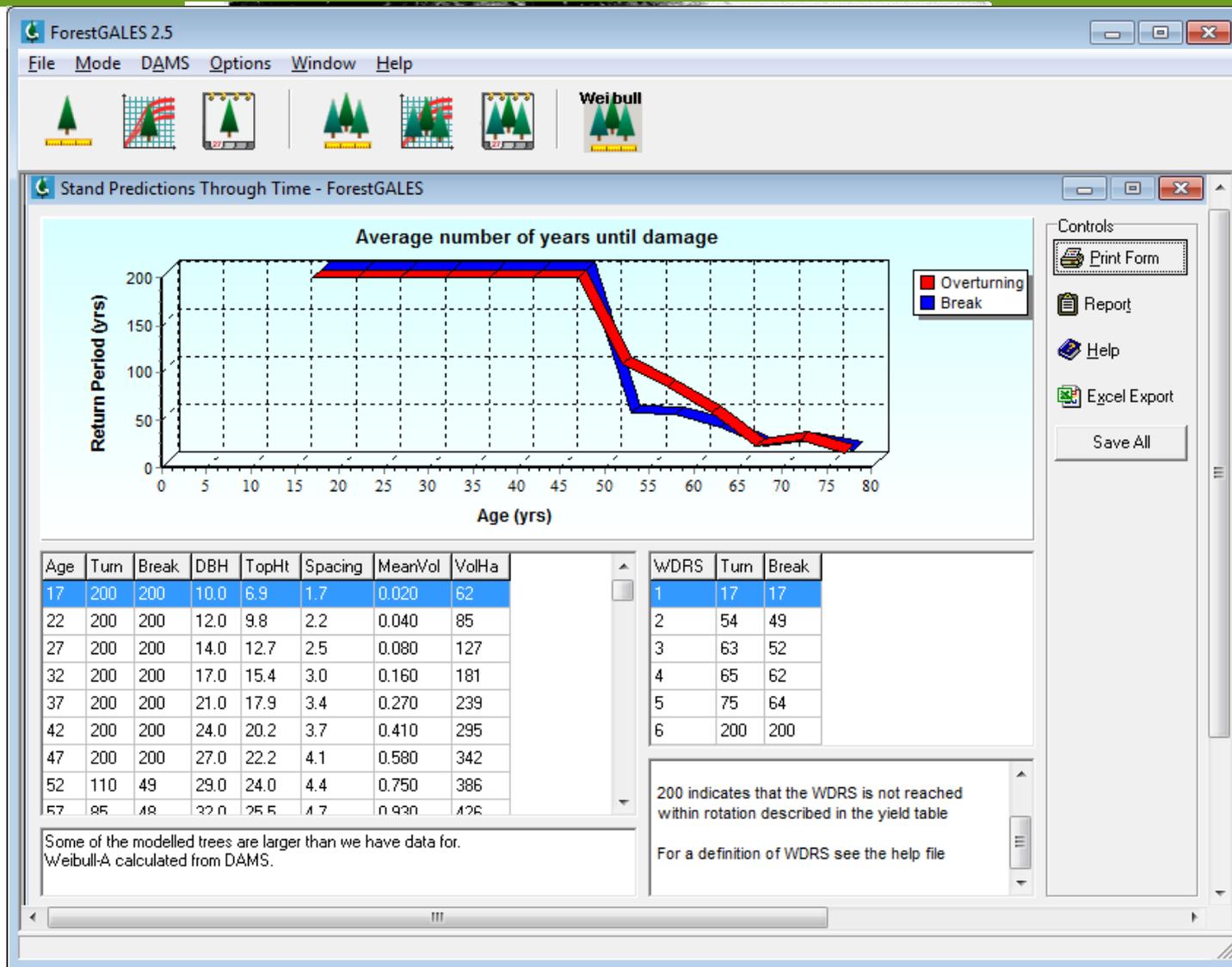


From EU MOTIVE Project Deliverable 4.1B
“Mapping current and projected key
European forest risks”
Based on Seidl *et al.* (2009)

Snow Climatology for UK (available for whole of Europe?)



Tools for Managing Wind Storm Damage



Online Support to Forest Managers and Owners

PLAN DU SITE | CONTACT | ESPACE

http://www.foretpriveefrancaise.com/quelques-conseils-479391.html index_DE

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TEMPÊTE : QUELQUES CONSEILS

- 1. Les organismes professionnels à votre service
- 2. Inventorier les produits pour les valoriser au mieux
- 3. La sécurité
- 4. Préserver le sol
- 5. Sortez couvert avec le TESA (Titre emploi simplifié agricole)
- 6. Aires de façonnage-stockage
- 7. la conservation
- 8. la valorisation
- Plus d'infos

1. LES ORGANISMES PROFESSIONNELS À VOTRE SERVICE

Le premier conseil sur lequel nous souhaitons insister, c'est la prudence. N'allez pas en forêt.

La situation est trop dangereuse actuellement. Les arbres (et leurs branches) sont fragilisés et sous tension : ils risquent de céder brusquement et de vous blesser très gravement.

Ne faites rien vous-mêmes ! Faites appel à des professionnels !

Contactez un des organismes professionnels forestiers pour vous conseiller, vous aider à trouver les bons interlocuteurs locaux : bûcherons, entrepreneurs, exploitants forestiers.

2. INVENTORIER LES PRODUITS POUR LES VALORISER AU MIEUX

La seule estimation possible est souvent celle de la surface abattue par le vent, et le type de produits (sciage, industrie, trituration, etc.). Il faudra préciser si les bois sont cassés ou déracinés.

Attention, les **peupliers** et **pins** sont sensibles aux dégradations. Les pins exploités bleussent rapidement et doivent être usinés après exploitation.

L'expérience des tempêtes précédentes montrent que les arbres déracinés d'autres essences, avec la moitié ou le tiers de leurs racines en terre, et dont le houppier n'est pas façonné, peuvent attendre en l'état.

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Factors Affecting Wind Damage to Forests

- Storm damage is affected by:
 - Topography can have large impact on wind speeds and damage location
 - Tree height
 - Soil moisture
 - Soil acidity
 - Recent thinning or creation of new edges. But early and regular light thinning reduces risk
 - Species with conifers generally more vulnerable than broadleaves (but sometimes contradictory evidence)
 - Silvicultural systems (but not always straightforward to interpret)
- Storm damage is a dynamic process with the gustiness and spatial variability of the wind a key factor.
- Models exist to predict the probability of wind damage as function of tree size, silviculture, soil, and species. These work best at the forest level (too much variability to work precisely at stand or tree level)

Factors Affecting Snow Damage to Forests

- Snow damage is affected by:
 - Species: conifers most badly affected (species differences are less clear)
 - Pole age stands (young to mid-aged)
 - High height to diameter ratio (this is well accepted)
 - Thinning: Heavy and late thinning leads to higher damage, early and regular light thinning from below reduces damage risk
 - Fertiliser and thinning combined increase risk of damage
 - Broadcast sowing increases risk, planting seedlings reduces risk
 - Asymmetric crowns
 - Wet/heavy snow (meteorological conditions: temperature close to 0C, low wind speeds < 9m/s)
 - In Central Europe snow damage mainly occurs between 500-900m (this could rise with changing climate)
- Models exist to predict the probability of snow damage as function of tree size, silviculture, and species. However, these have not been well validated because of the lack of good snow damage data
- Major difficulty is having accurate predictions of occurrence of meteorological factors leading to heavy wet snow

What we don't know

- There is little knowledge of wind and snow risk to broadleaves.
- There are no risk models currently for silvicultural systems other than clearfell/replant.
- Predicting probability of different levels of damage within individual forest management units is not currently possible.
- Predicting airflow over complex forested terrain is extremely difficult to do in a practical way (rapidly and easily implemented)
- Predicting conditions for snow damage (heavy snow, temperatures close to 0°C and light winds is difficult)
- There are very few measurements during damaging storms.
- The adaptive capacity of trees to their environment needs to be better understood.
- Current and future wind and snow climate over Europe at the required spatial scale for forest management (< 1km) is not available