European Forest Risk Network

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

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

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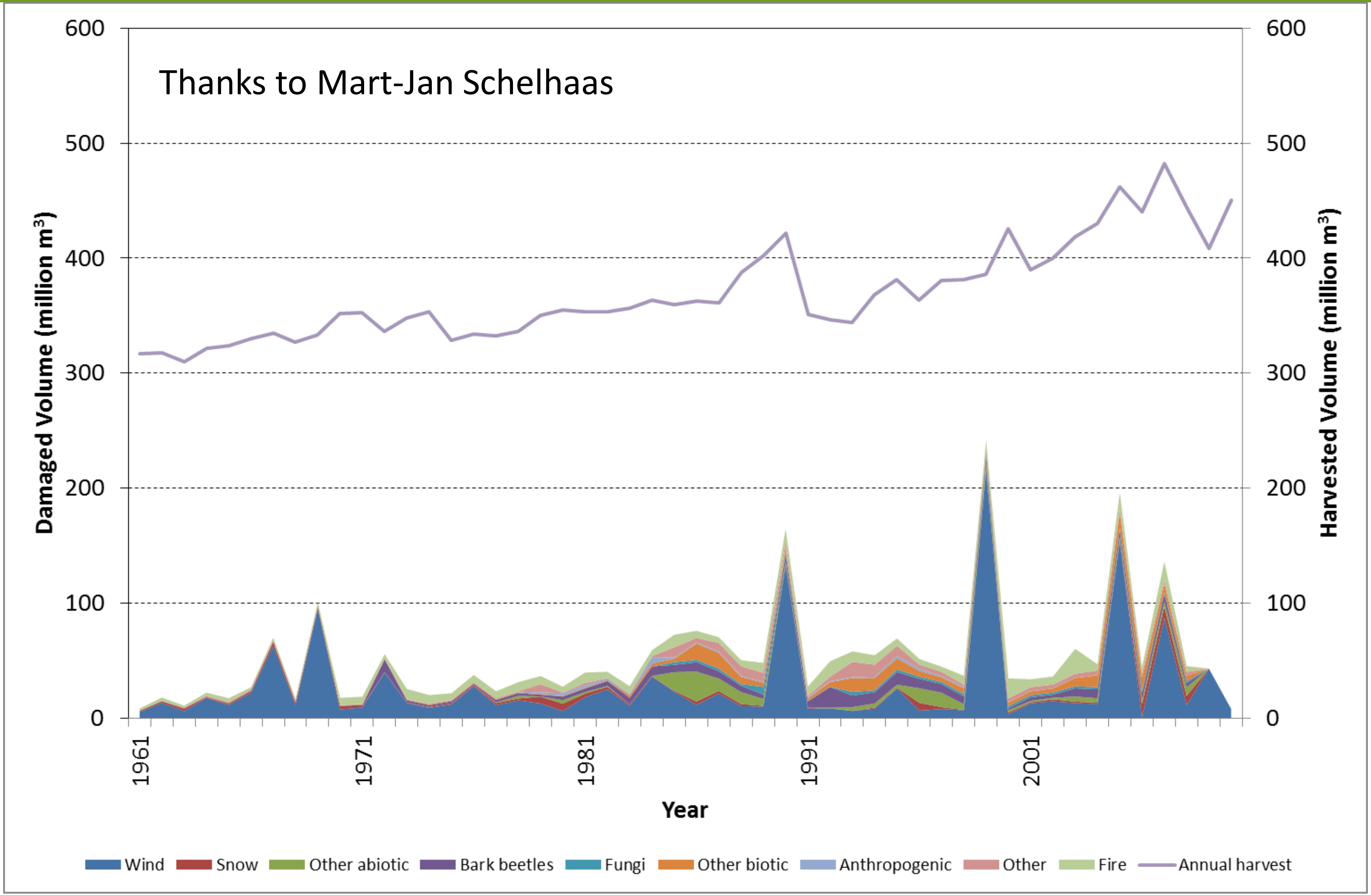
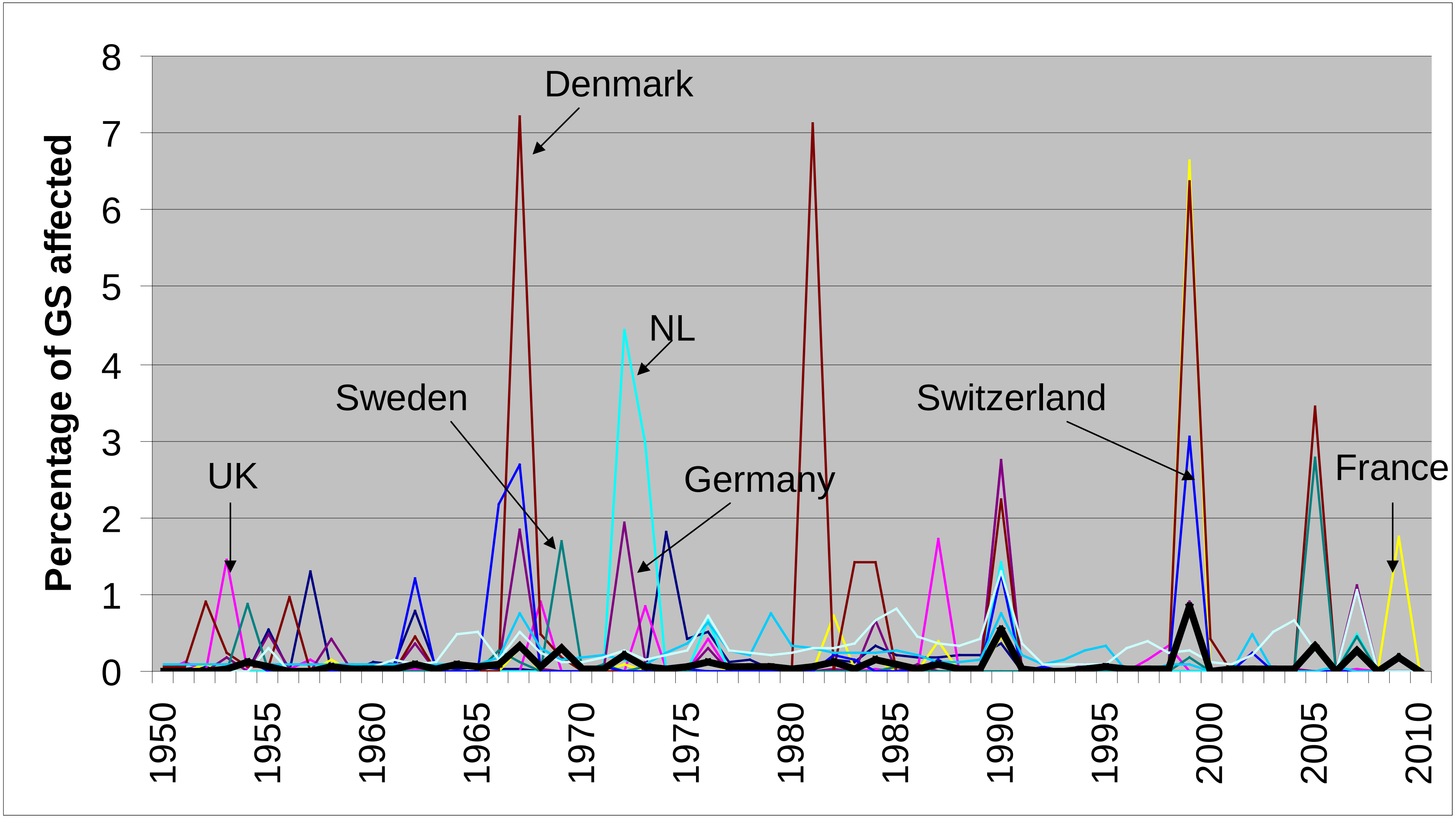
Storm Damage to European Forests

- Storms (wind and snow) cause more than 50% of all damage to European forests
  - 38 million m^3/year by wind
  - 4 million m^3/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 Mm^3 timber (14% of the standing volume)
  - > 5 Mm^3 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



Storm Damage as Percentage of Growing Stock



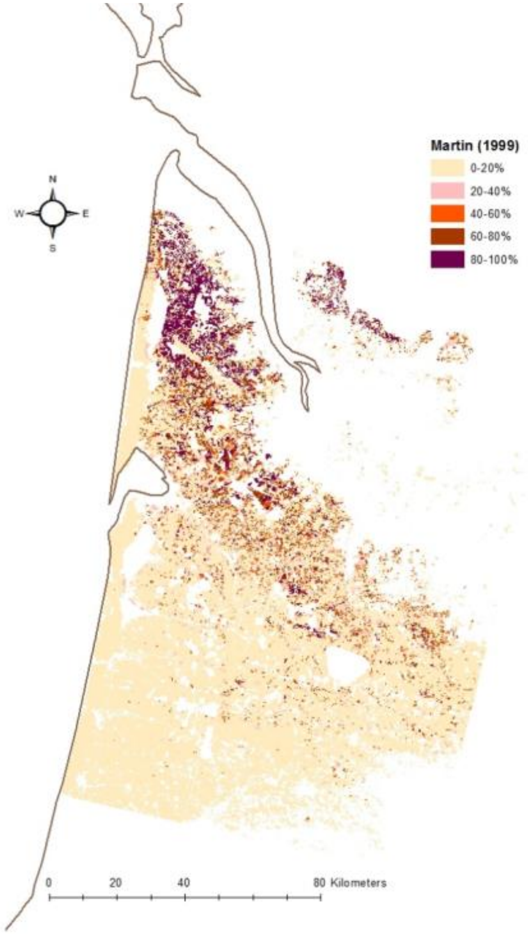
Major Hazards to European Forests

- Wind 
- Fire 
- Bark beetles 
- Snow/Ice 
- Drought 
- Pathogens 
- Other biotic pests 

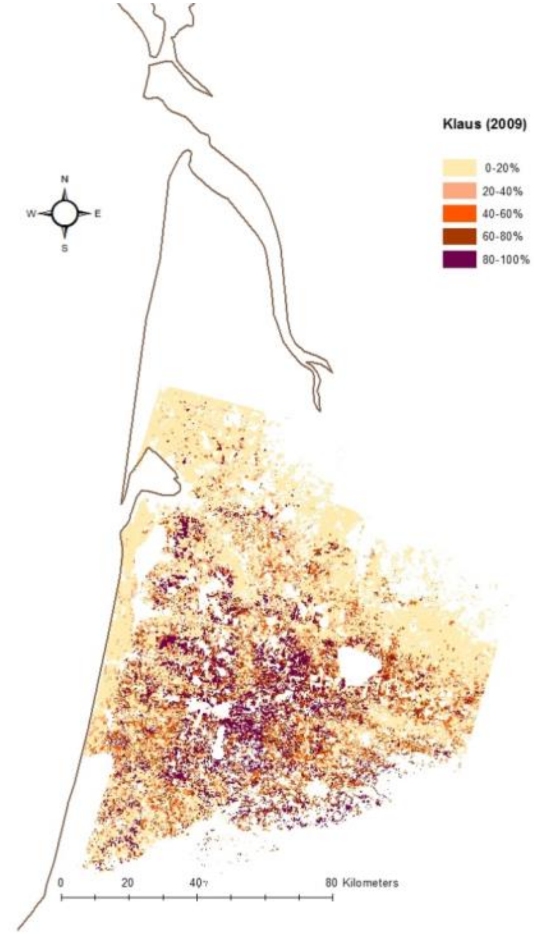
Forest Damage - Wind

The Two Most Damaging Storms in South-west France

Tempête Martin, 27-28 Décembre 1999



Tempête Klaus, 24 Janvier 2009



~75 million m^3 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†

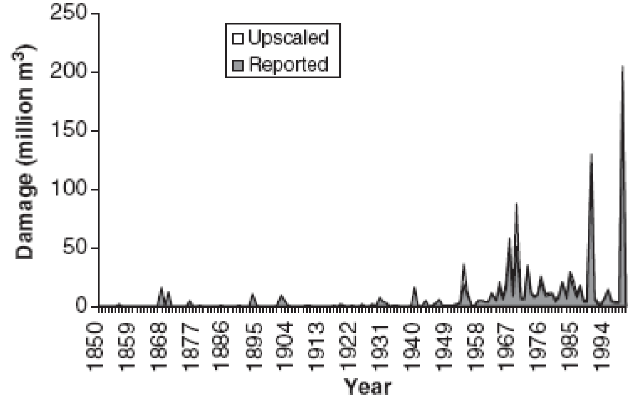


Fig. 5 Volumes of wood damaged by storms as reported in European countries for 1850–2000 and as scaled up for total Europe for 1950–2000.

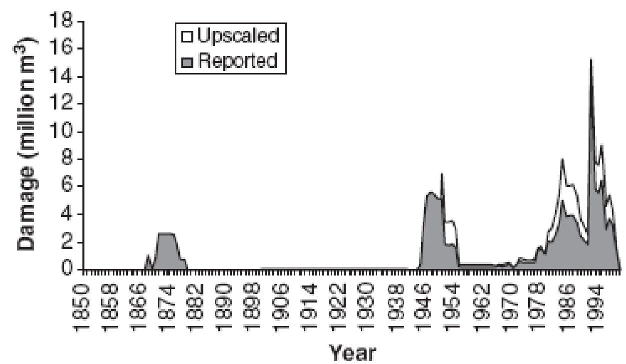


Fig. 8 Volumes of wood damaged by bark beetles, as reported in European countries for 1850–2000 and as scaled up for total Europe for 1950–2000.

Increasing Damage Levels from Bark Beetles after Wind

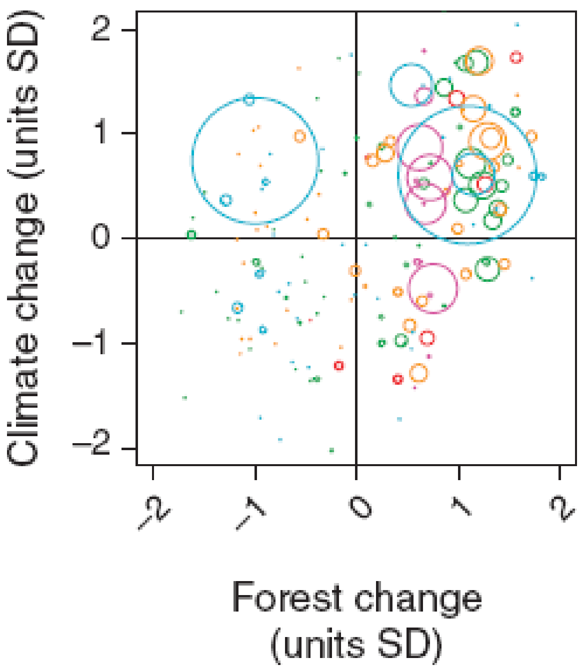
Increased volume of vulnerable forests, e.g. fast growing conifers

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

Resultant bending moment coefficient

0

0

0

12

Size of clearing/h

Streamling of Leaves, Branches and Trees

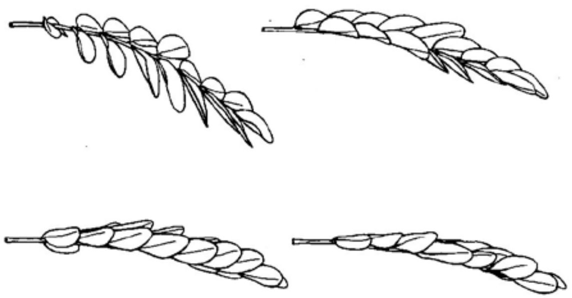


FIGURE 5.8. *The compound leaf of a black locust in still air and winds of 11, 33, and 44 miles per hour (5, 15, and 20 ms).*

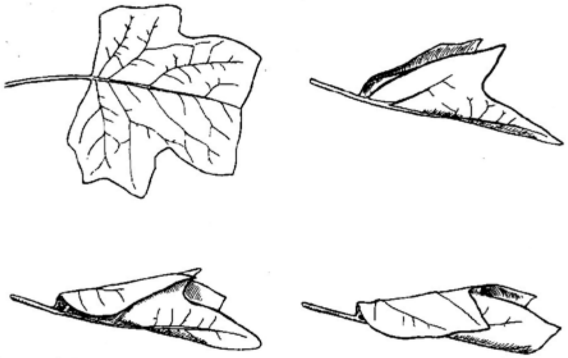


FIGURE 5.7. *The leaf of a tulip poplar (also called a tulip tree or yellow poplar) in still air and winds of 11, 33, and 44 miles per hour (5, 15, and 20 ms).*

After Vogel

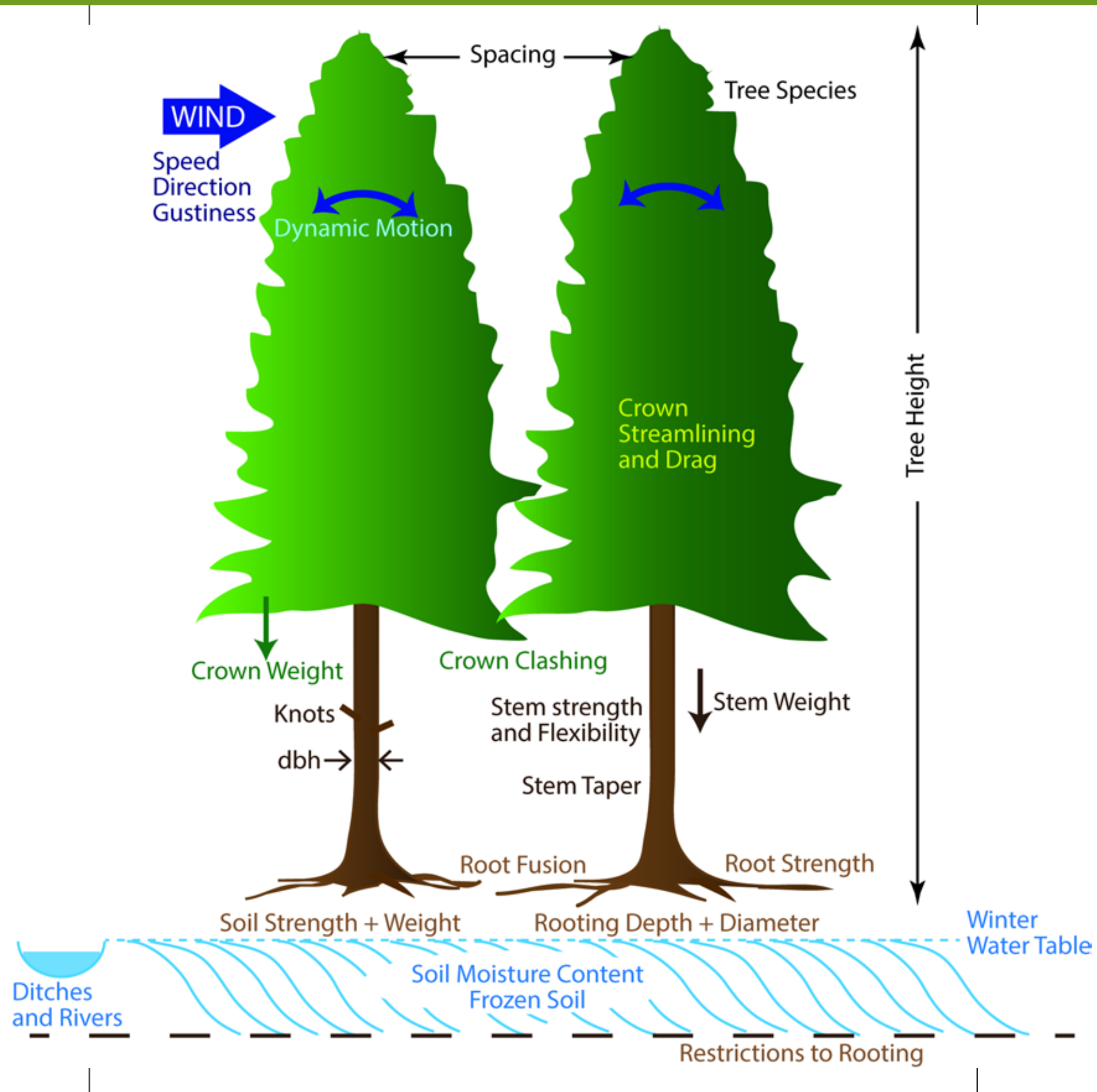
Coconut

Birch

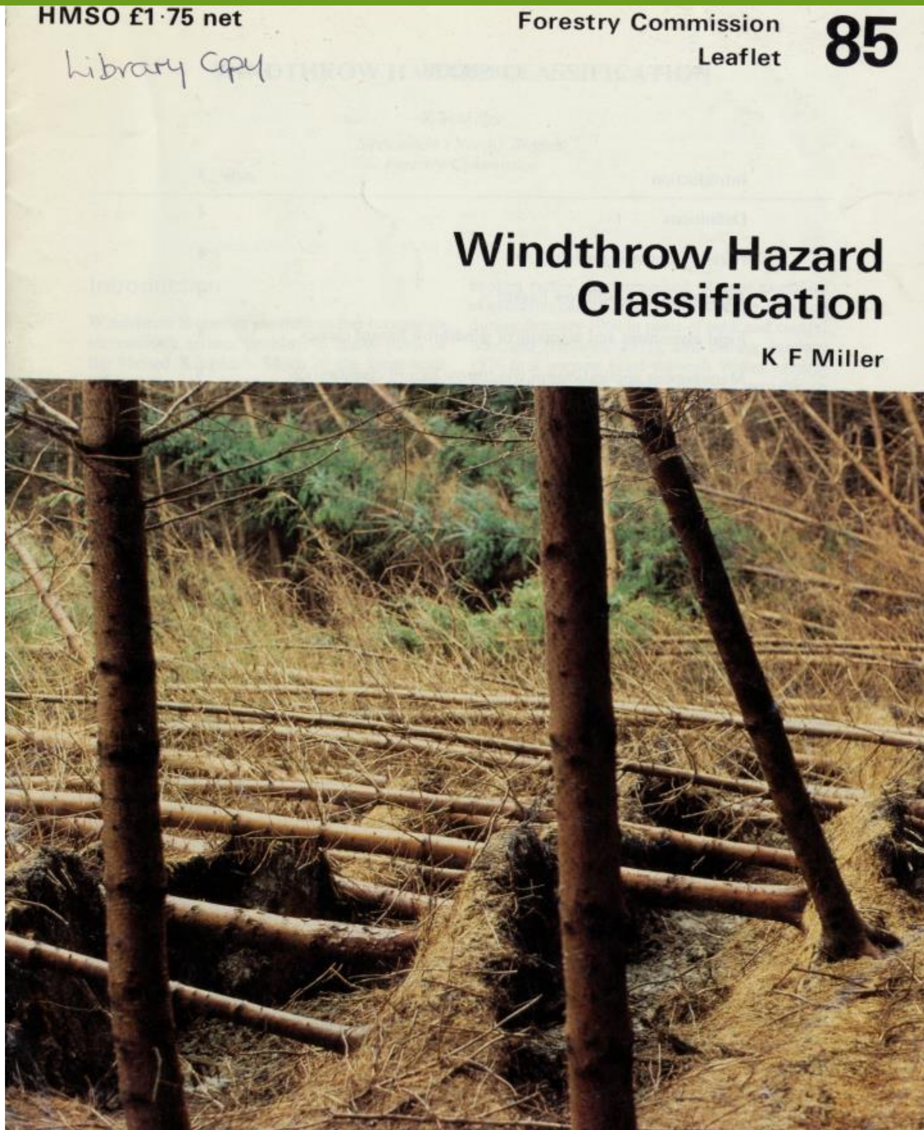
Scots pine

Aspen

Components Affecting Wind Risk of Trees

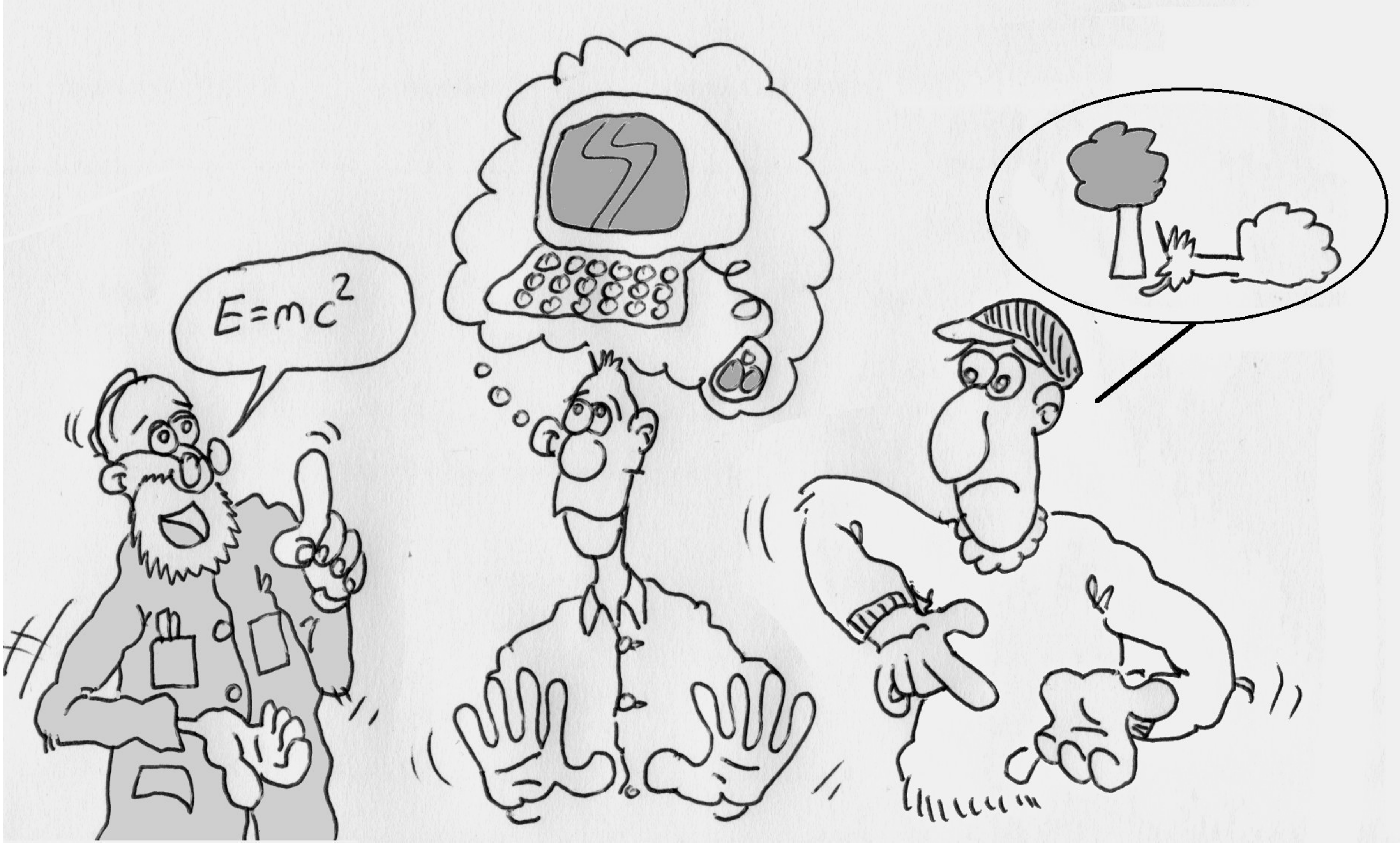


Windthrow Hazard Classification

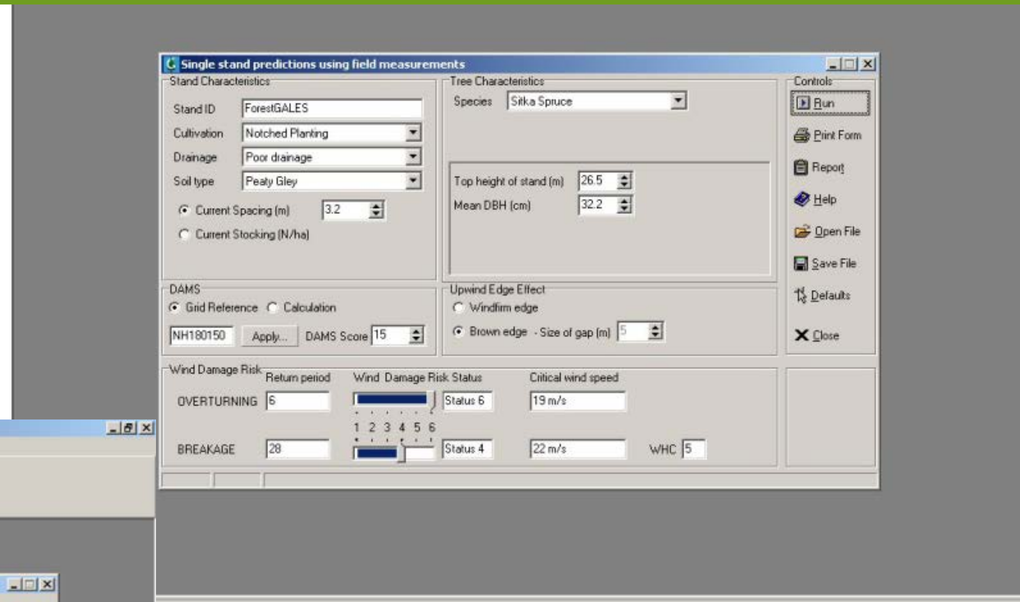


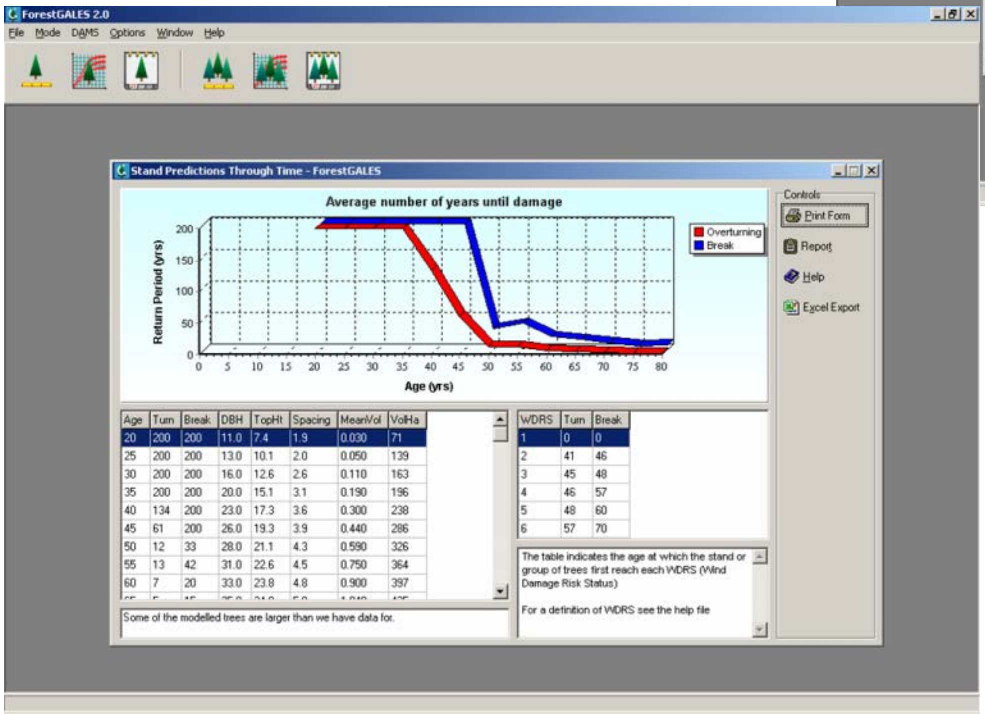
- Windiness Scores
  - Region
  - Elevation
  - Topographic Shelter (Topex)
- Soil Score
  - Rooting Depth

Decision Support Systems (Linking Knowledge to Problems)



ForestGALES 2.5: Wind (and Snow) Risk Modelling

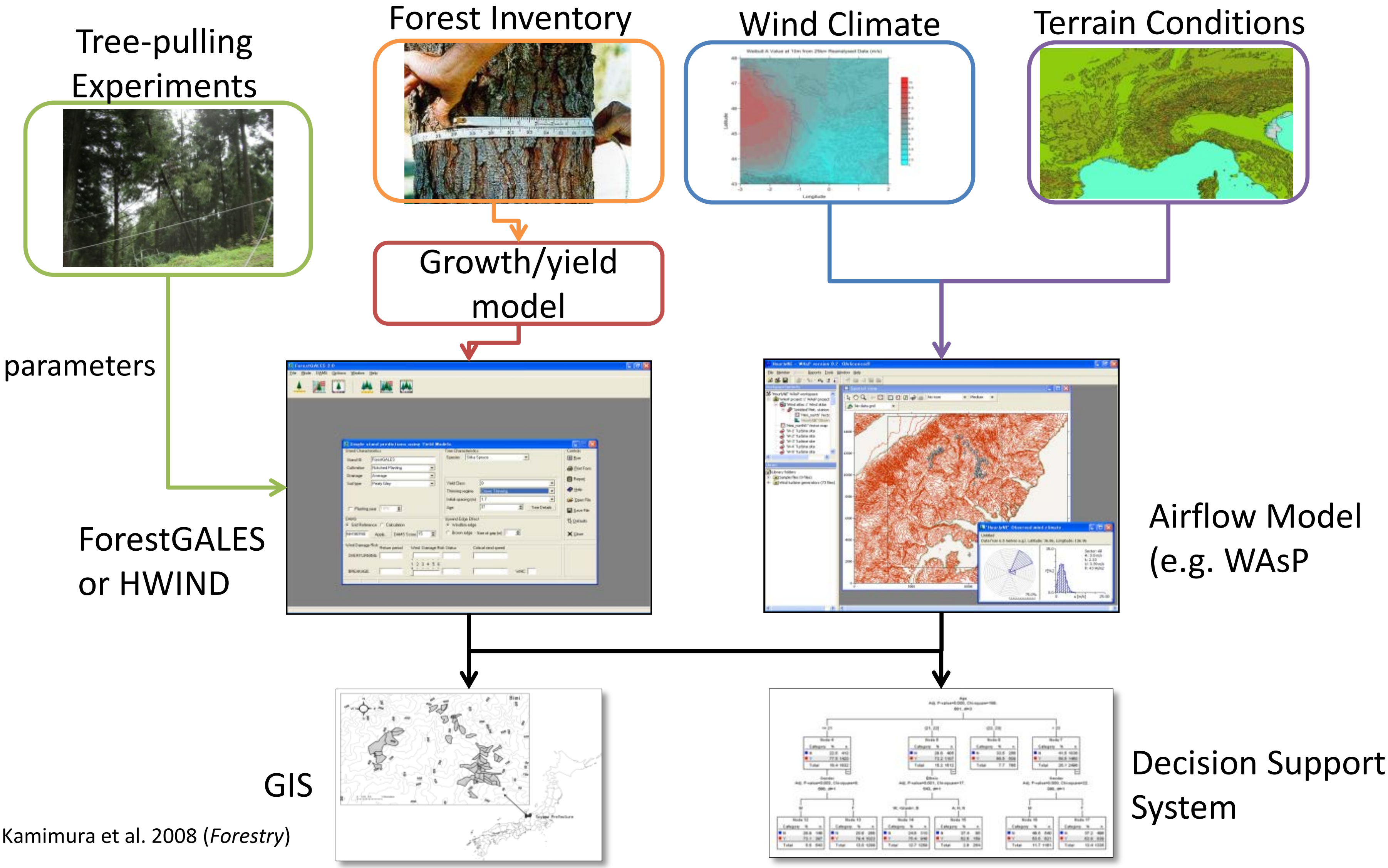




Age	Turn	Break	DBH	TopHt	Spacing	MeanVol	VolHa
20	200	200	11.0	7.4	1.9	0.030	71
25	200	200	13.0	10.1	2.0	0.050	139
30	200	200	16.0	12.6	2.6	0.110	163
35	200	200	20.0	15.1	3.1	0.190	196
40	134	200	23.0	17.3	3.6	0.300	238
45	61	200	26.0	19.3	3.9	0.440	286
50	12	33	28.0	21.1	4.3	0.590	326
55	13	42	31.0	22.6	4.5	0.750	364
60	7	20	33.0	23.8	4.8	0.900	397

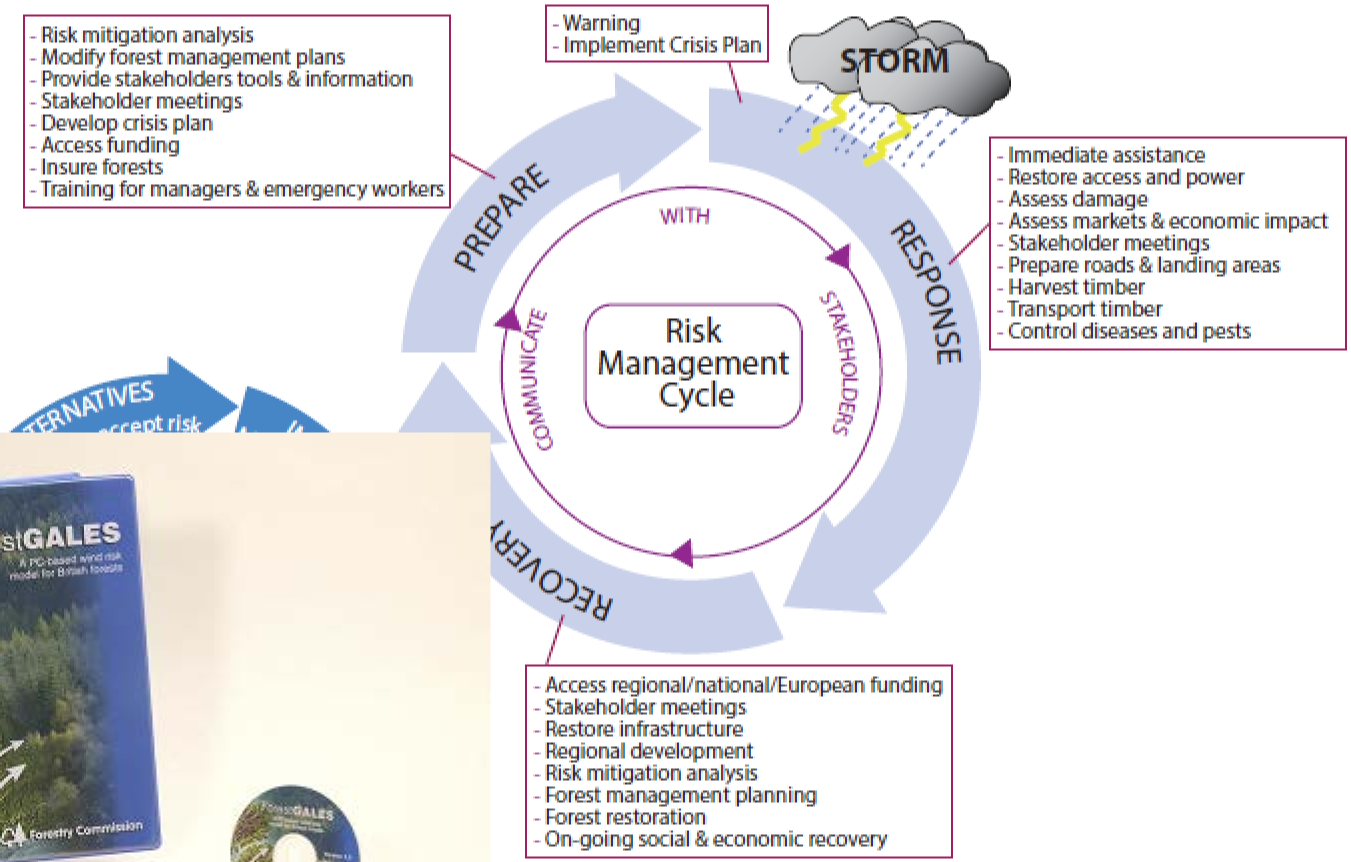
WDRS	Turn	Break
1	0	0
2	41	46
3	45	48
4	46	57
5	48	60
6	57	70

Predicting Wind Damage Risk

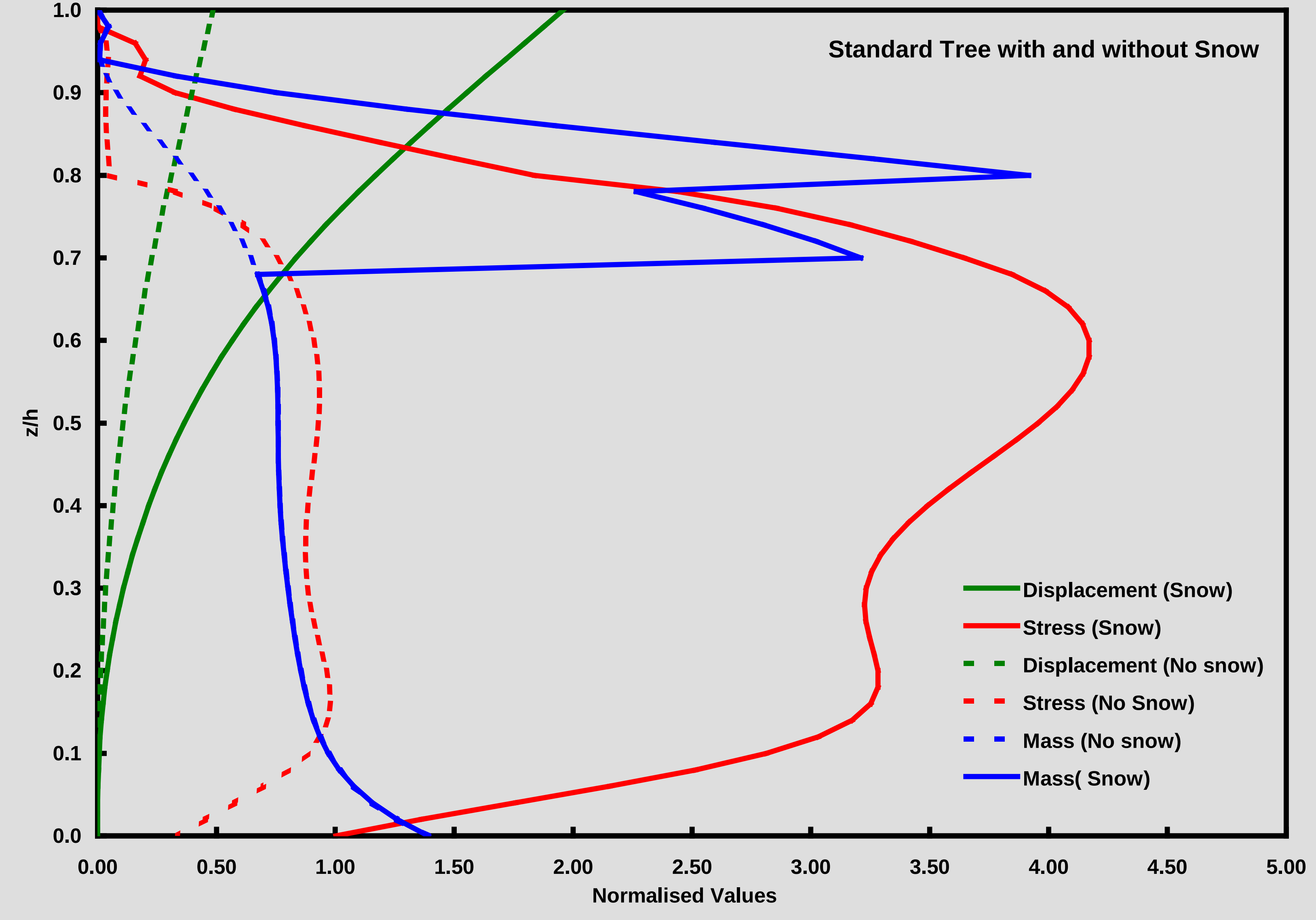


Kamimura et al. 2008 (*Forestry*)

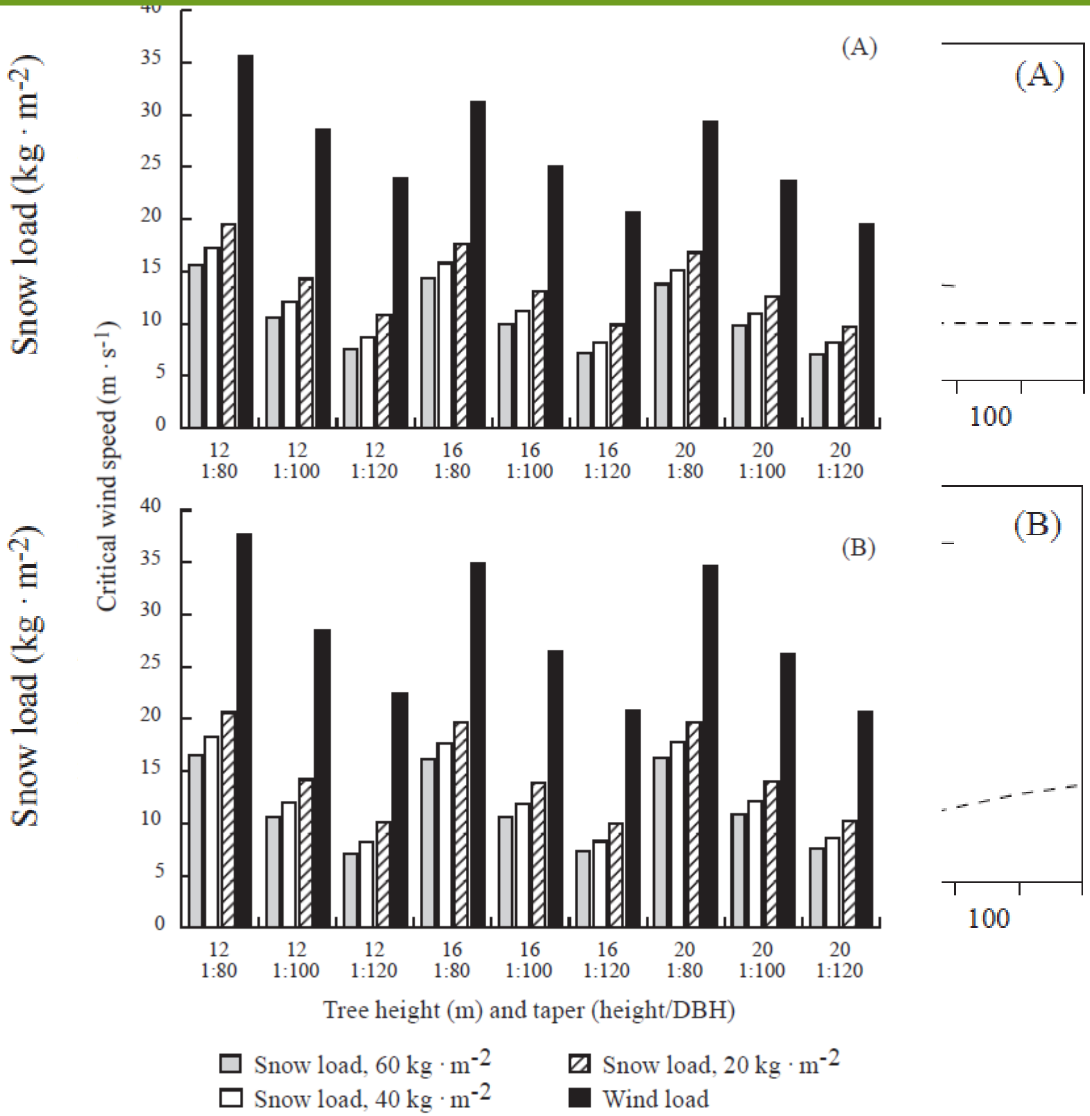
Risk Modelling, Mitigation and Management Cycle



The Bending and Stress in Trees with and without Snow



Effect of Tree Shape and Stand Density on Snow Damage

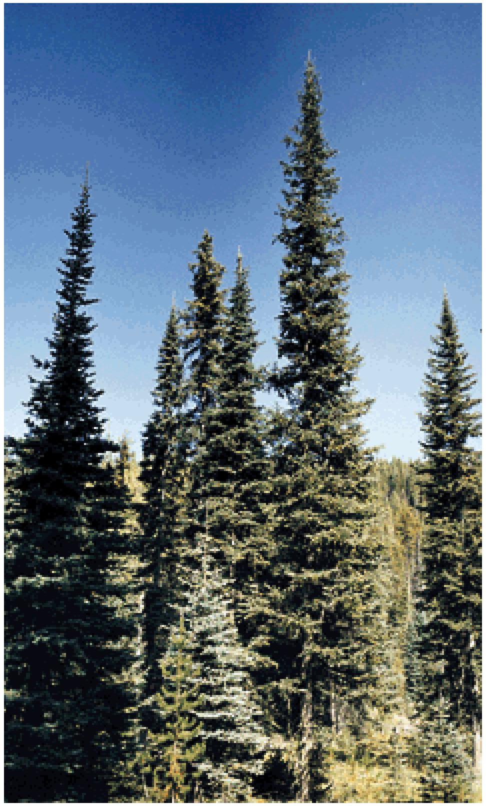


A: Uprooting
B: Breakage

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

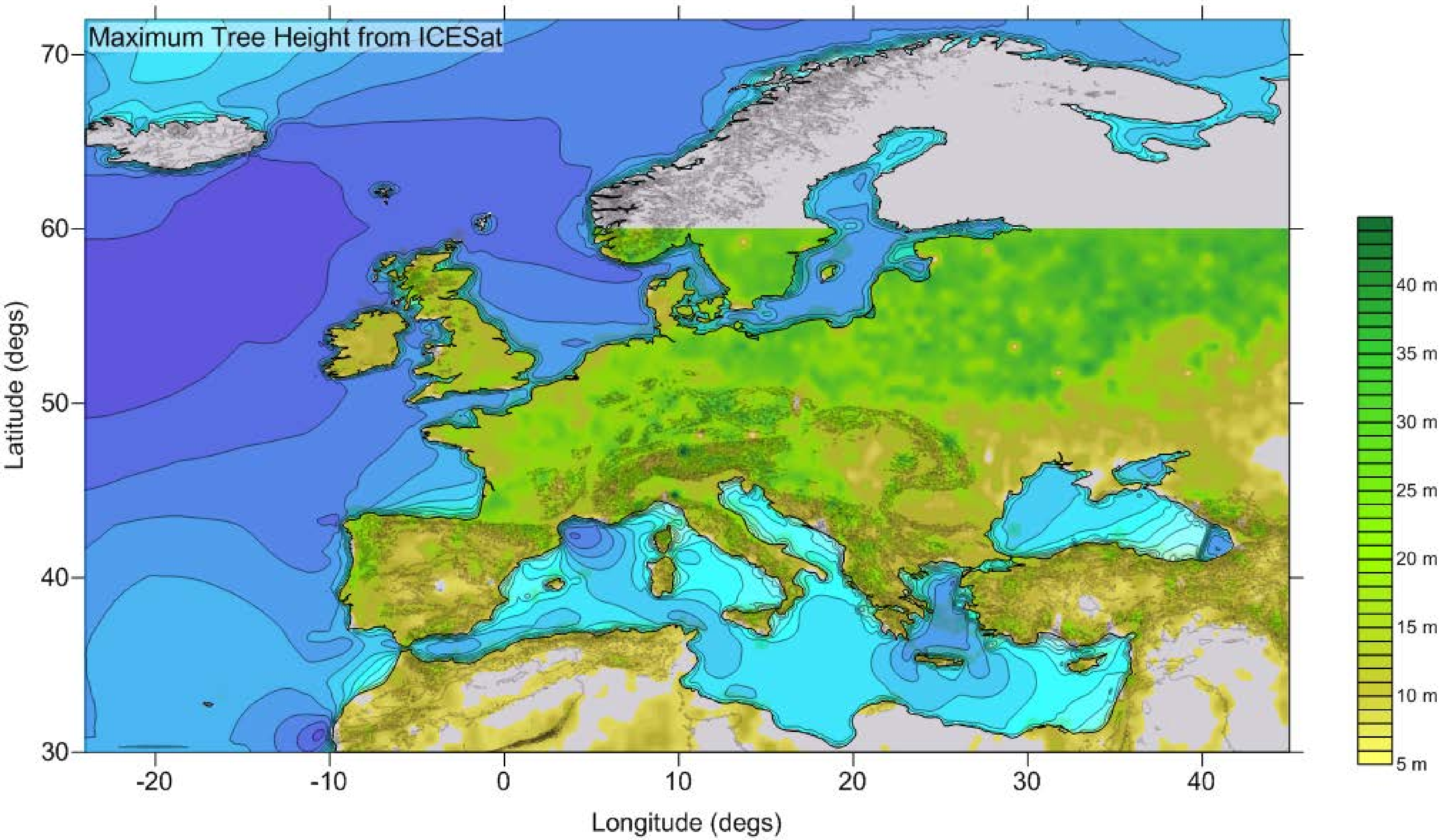
Table 2. Relative risks of various tree species to each other to snow damage in Europe according to some authors (see below).

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

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

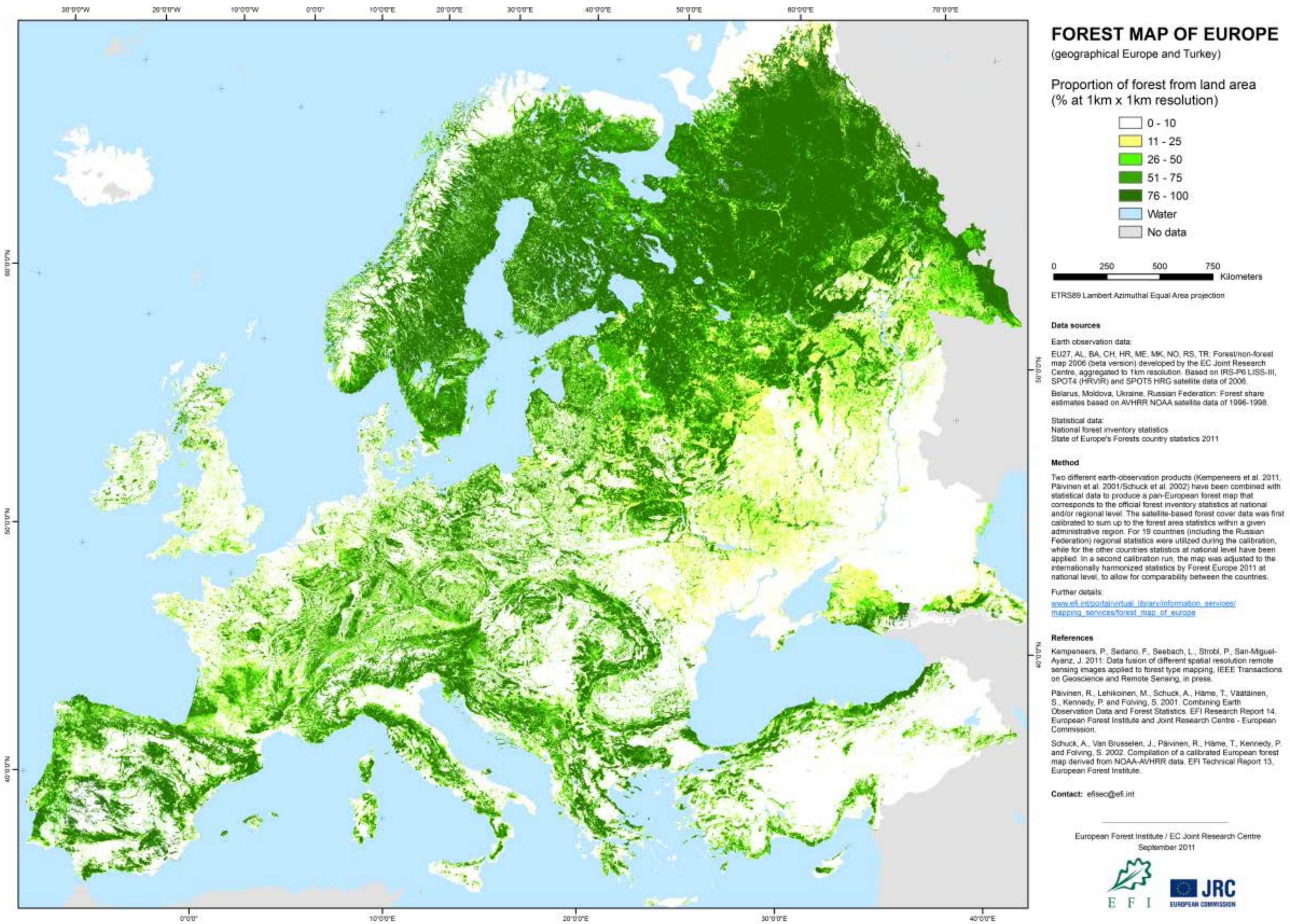
From Nykänen et al. 1997, Silva Fennica

Forest Data from ICESat (Satellite LiDAR)

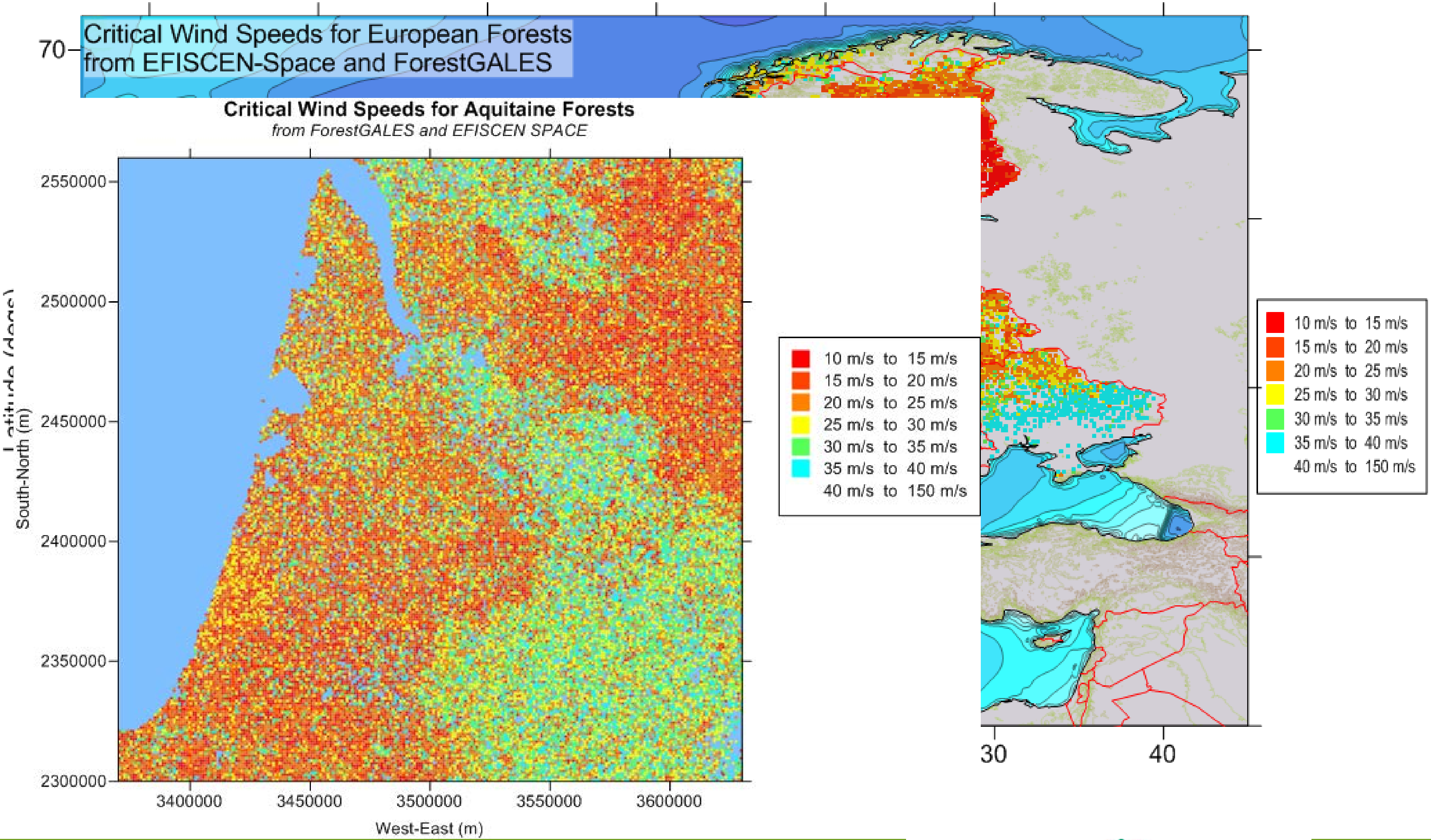


Los et al. 2012. *Geoscientific Model Development,* 5**,** 413-432.

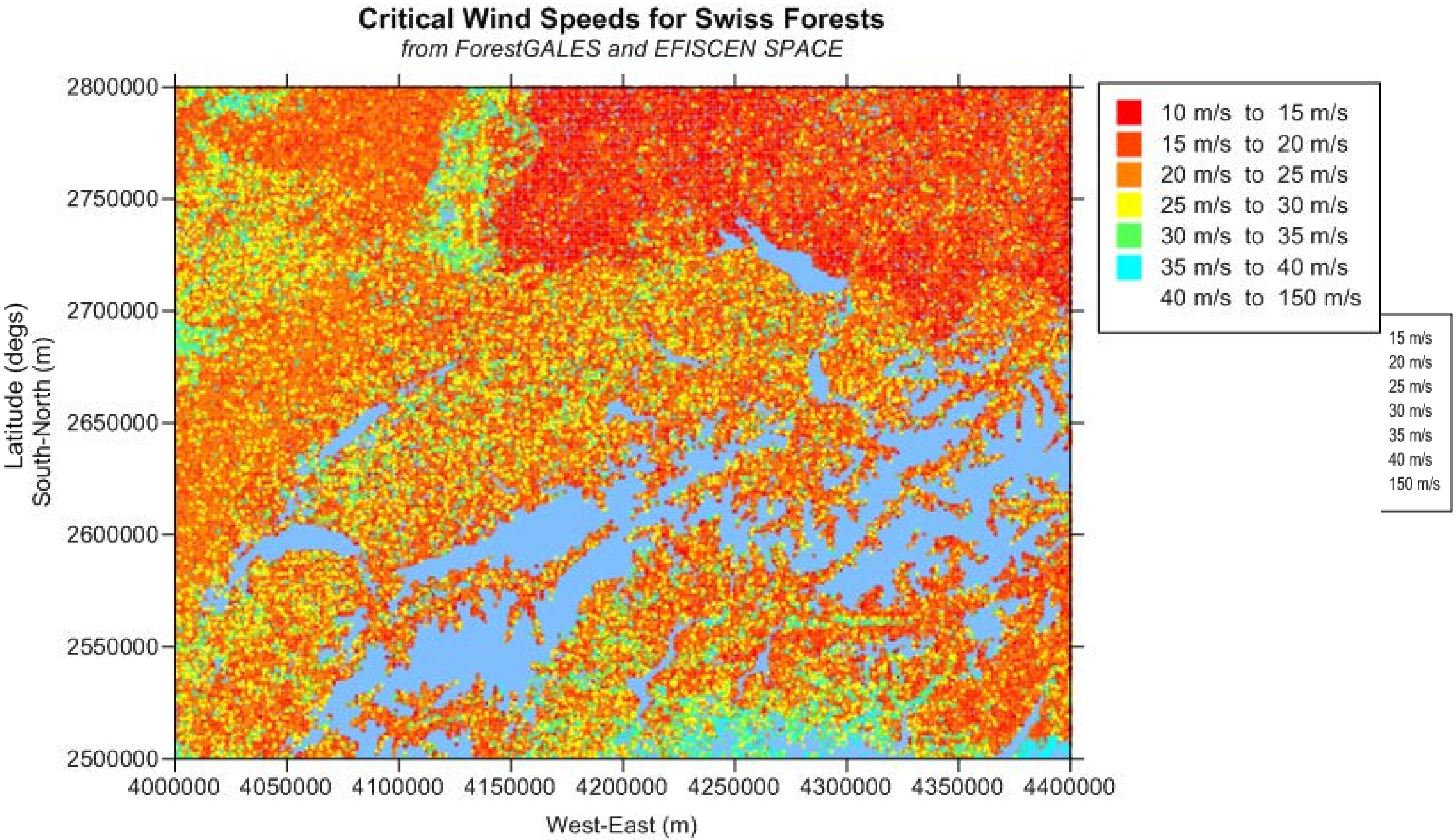
Forest Data from National Inventories: EFISCEN-Space



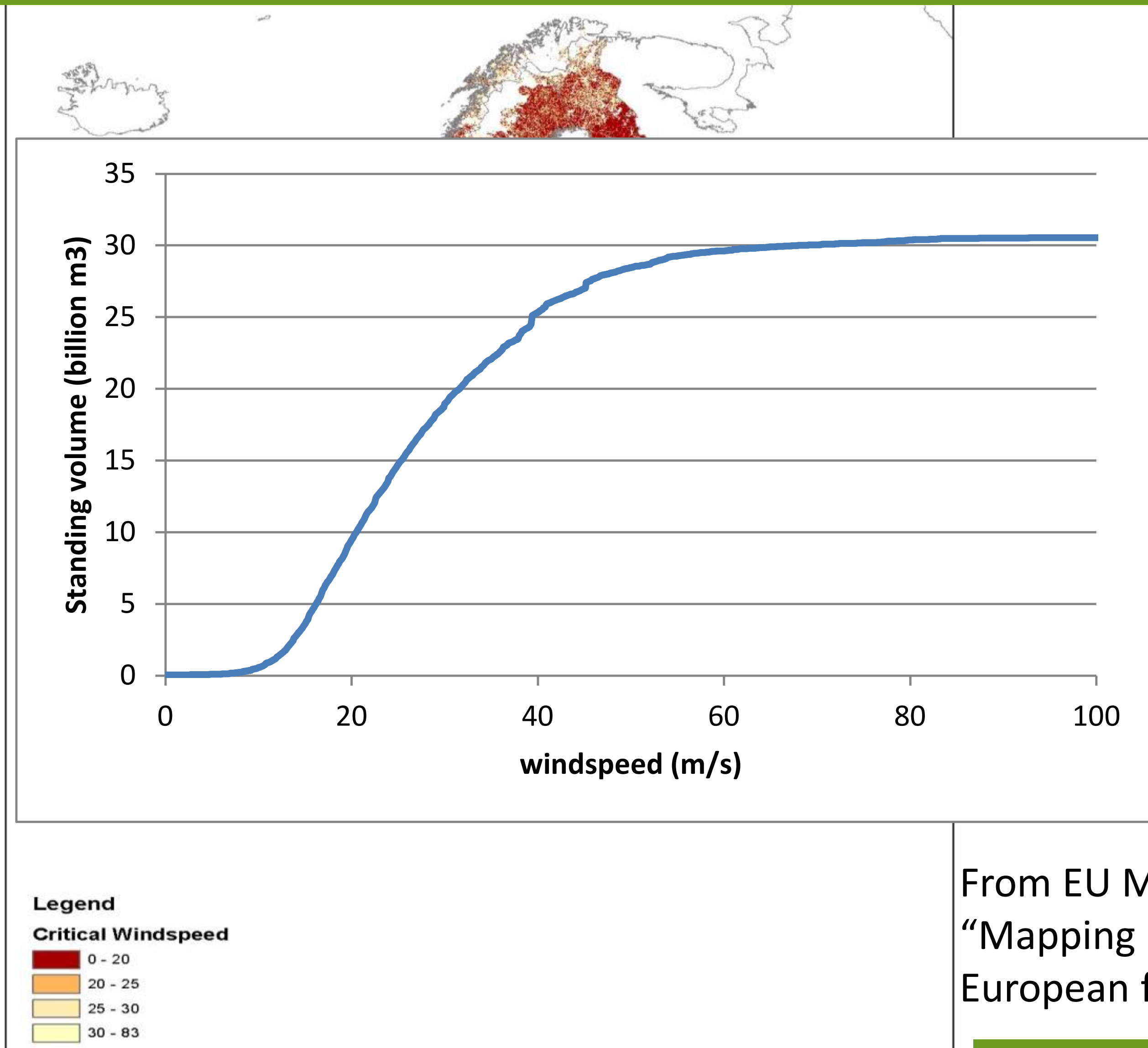
EFISCEN + ForestGALES→Critical Wind Speeds



Critical Wind Speeds→ EFISCEN + ForestGALES

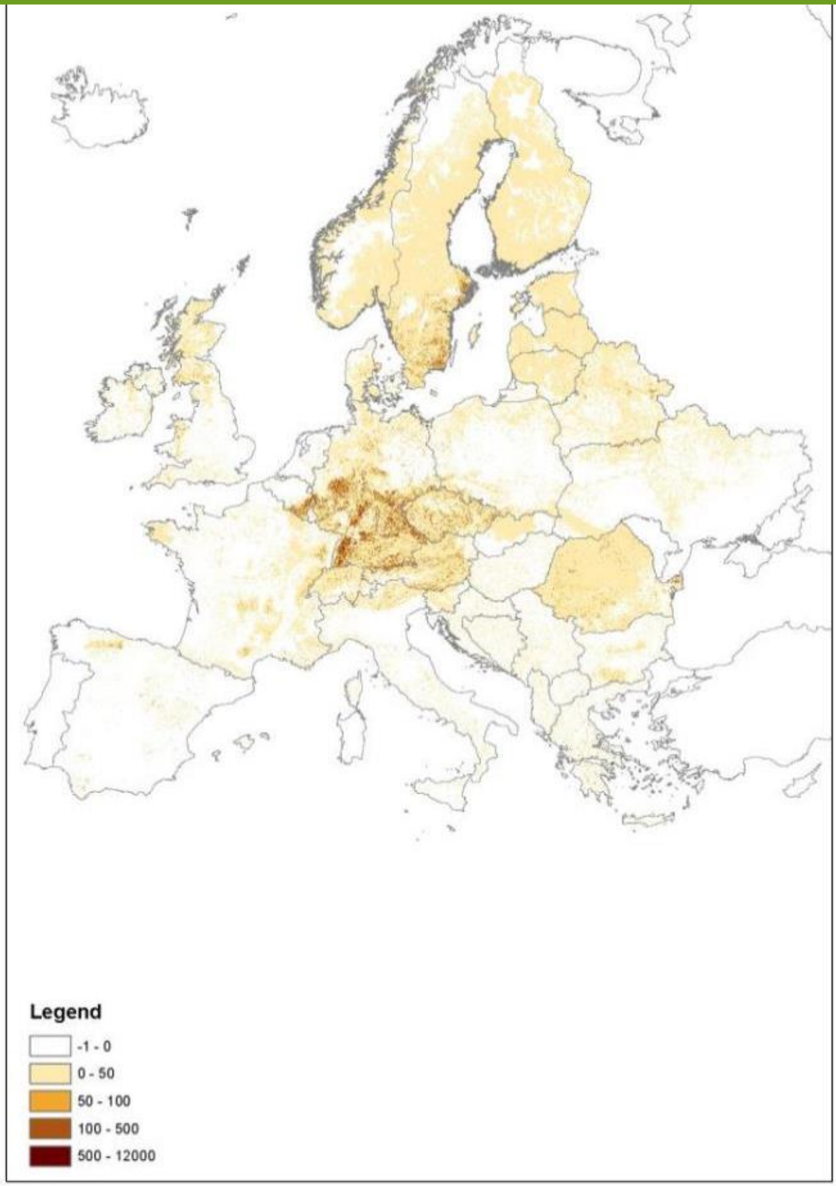


European Forest at Risk from Wind



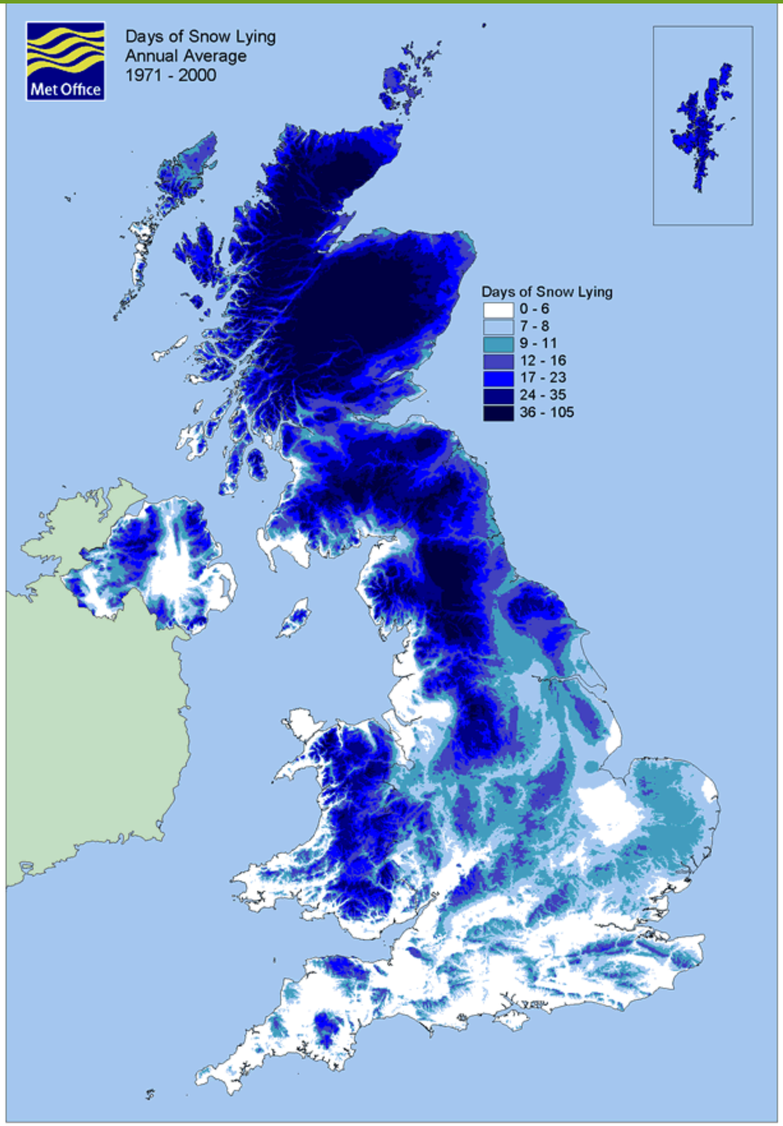
From EU MOTIVE Project Deliverable 4.1B "Mapping current and projected key European forest risks"

European Forests at Risk from Bark Beetles

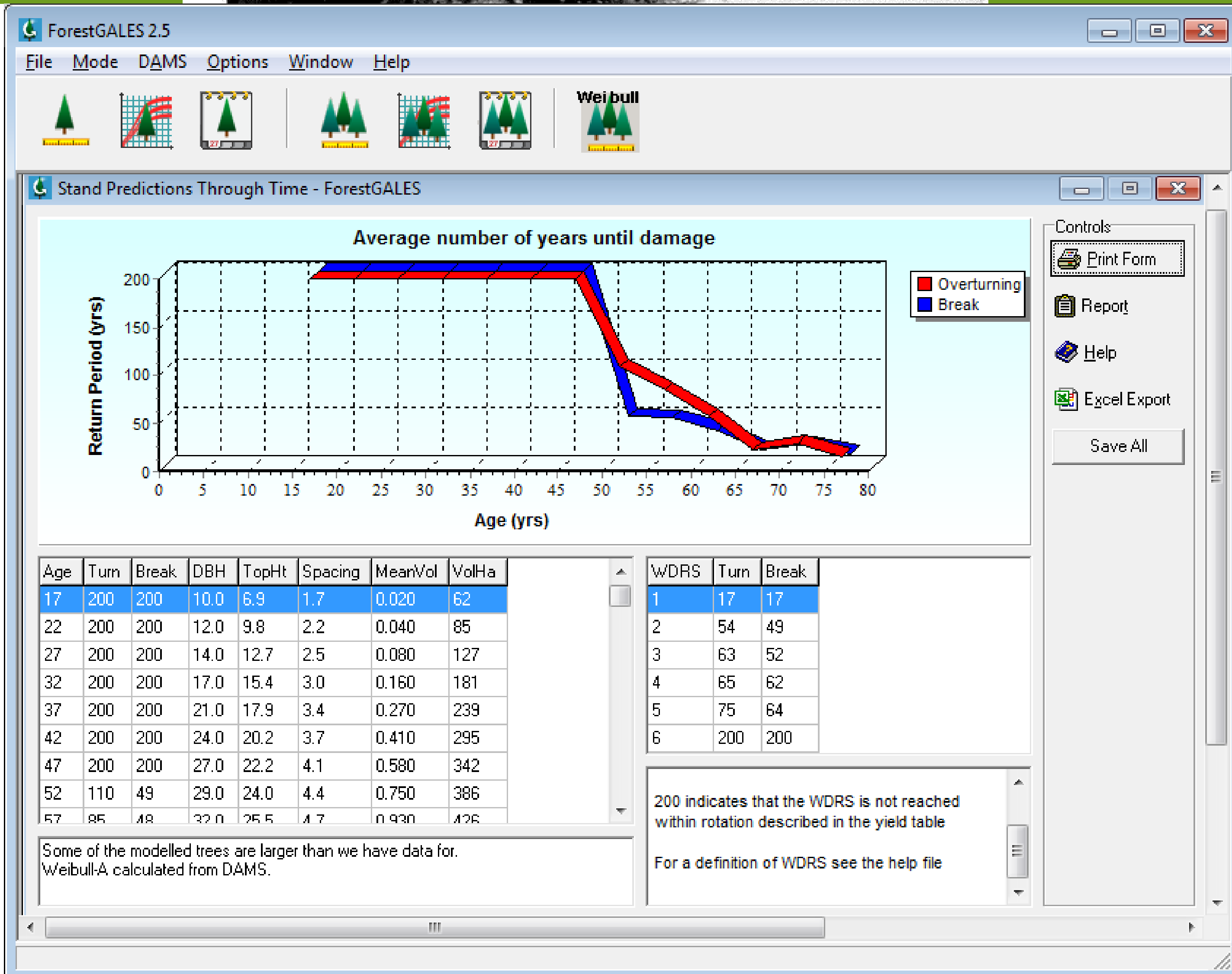


From EU MOTIVE Project Deliverable 4.1B "Mapping current and projected key European forest risks"
Based on Seidl *et al*. (2009)

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



Tools for Managing Wind Storm Damage



Online Support to Forest Managers and Owners

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

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^{o}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