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FORRISK

INRA SCIENCE & IMPACT

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New Models for Wind Damage Risk to Broadleaves

Barry Gardiner[1,2] and Tomasso Locatelli[1,3]

and Kana Kamimura[1,4], Didier Garigou[1] and Jean-Marc Bonnefond[1]

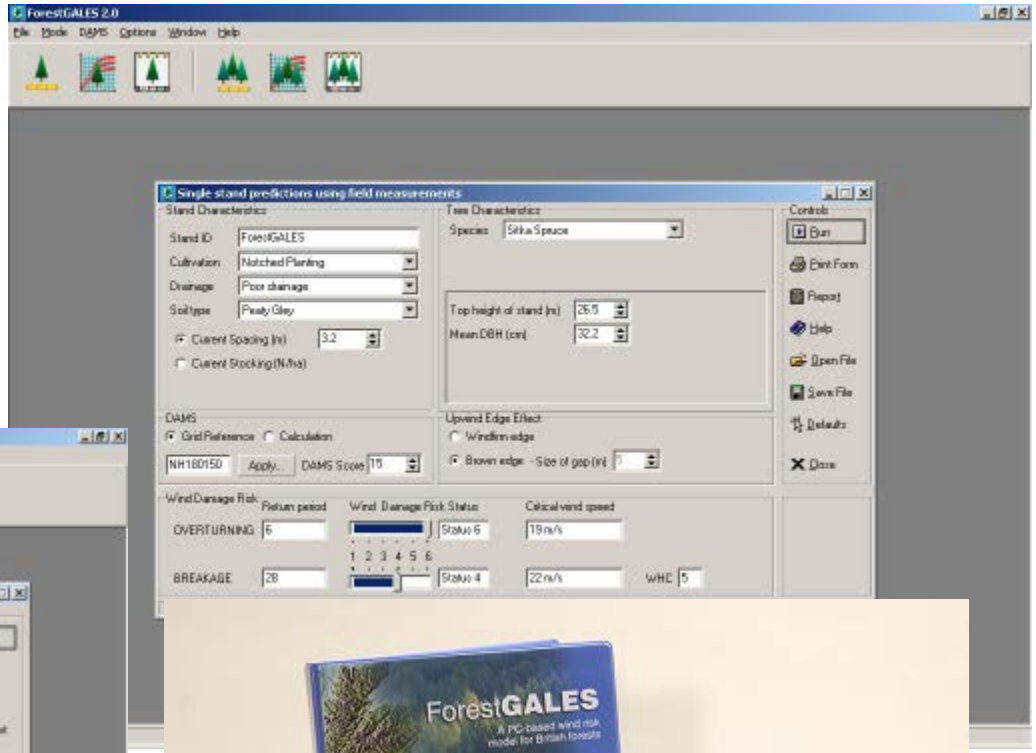
1. INRA-ISPA, Bordeaux, France
2. EFI ATLANTIC, Cestas, France
3. Forest Research, Roslin, Scotland
4. Shinshu University, Nagano, Japan

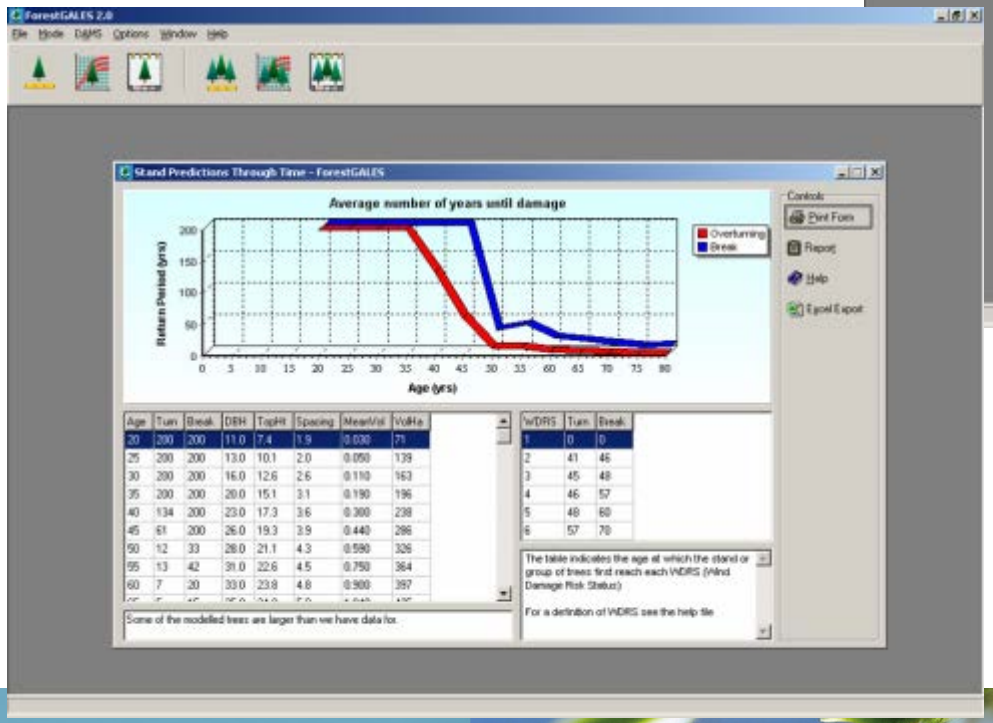
Wind Damage

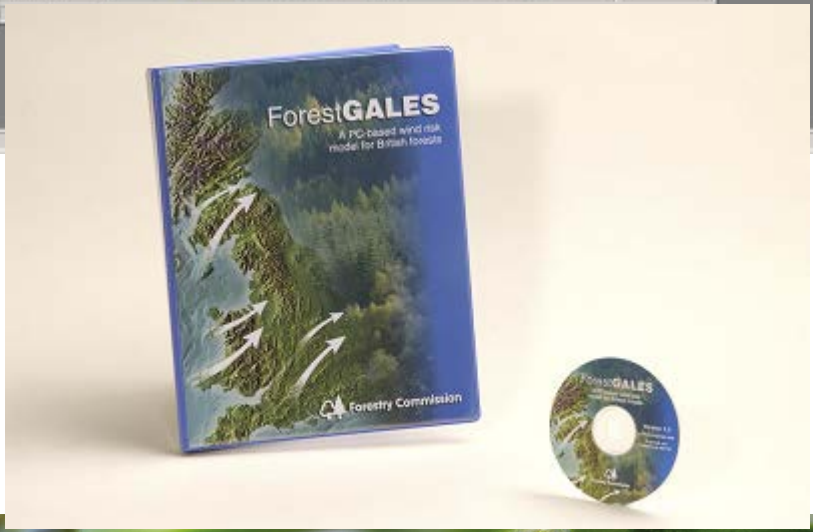
Broadleaf Wind Damage

ForestGALES 2:

A Wind Risk Management Model (WRMM)



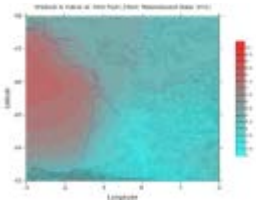




Tree-pulling Experiments

Forest Inventory

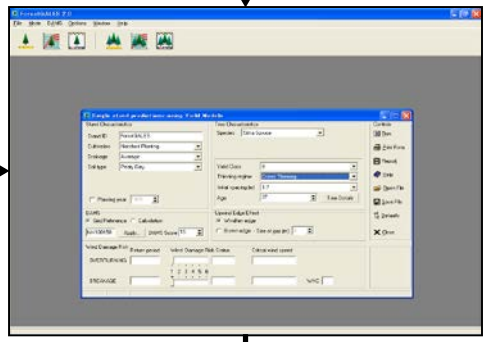
Wind Climate



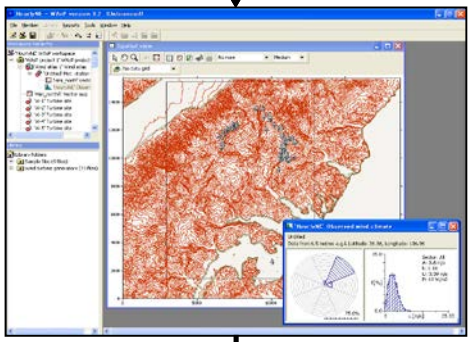
Terrain Conditions

Growth/yield model

parameters

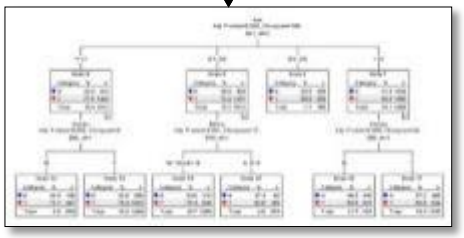


ForestGALES



Airflow Model

GIS



Decision-tree Analysis

Kamimura et al. 2008 (*Forestry*)

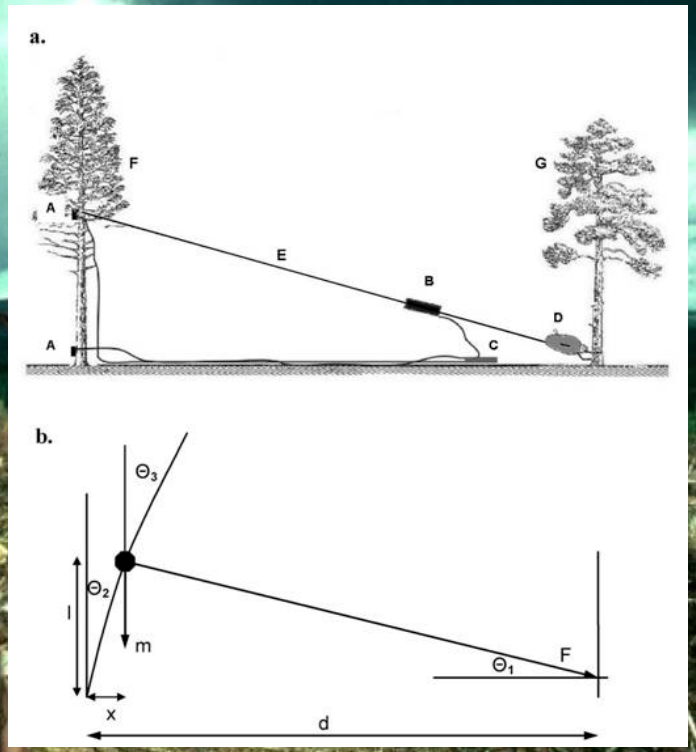
Parameterising ForestGALES

- Inputs
  - Tree species
  - Tree height
  - Tree diameter (1.3 m)
  - Spacing (for Roughness Method)
  - Soil type
  - Rooting Depth
  - Location (for wind climate information)
- Outputs
  - Critical wind speed for overturning
  - Critical wind speed for breakage
  - Return period for overturning (if wind climate data available)
  - Return period for breakage (if wind climate data available)
- Other Requirements (in external parameter files)
  - Crown width equation
  - Crown depth equation
  - Stem taper equation (for calculating stem weight)
  - Wood Modulus of Rupture (MOR)
  - Wood Modulus of Elasticity (MOE)
  - Wood density (for calculating stem weight)
  - Rooting resistance (function of tree size, rooting depth and soil type)

Model Inputs and Outputs

Wind Climate

Wood Strength



Tree Pulling

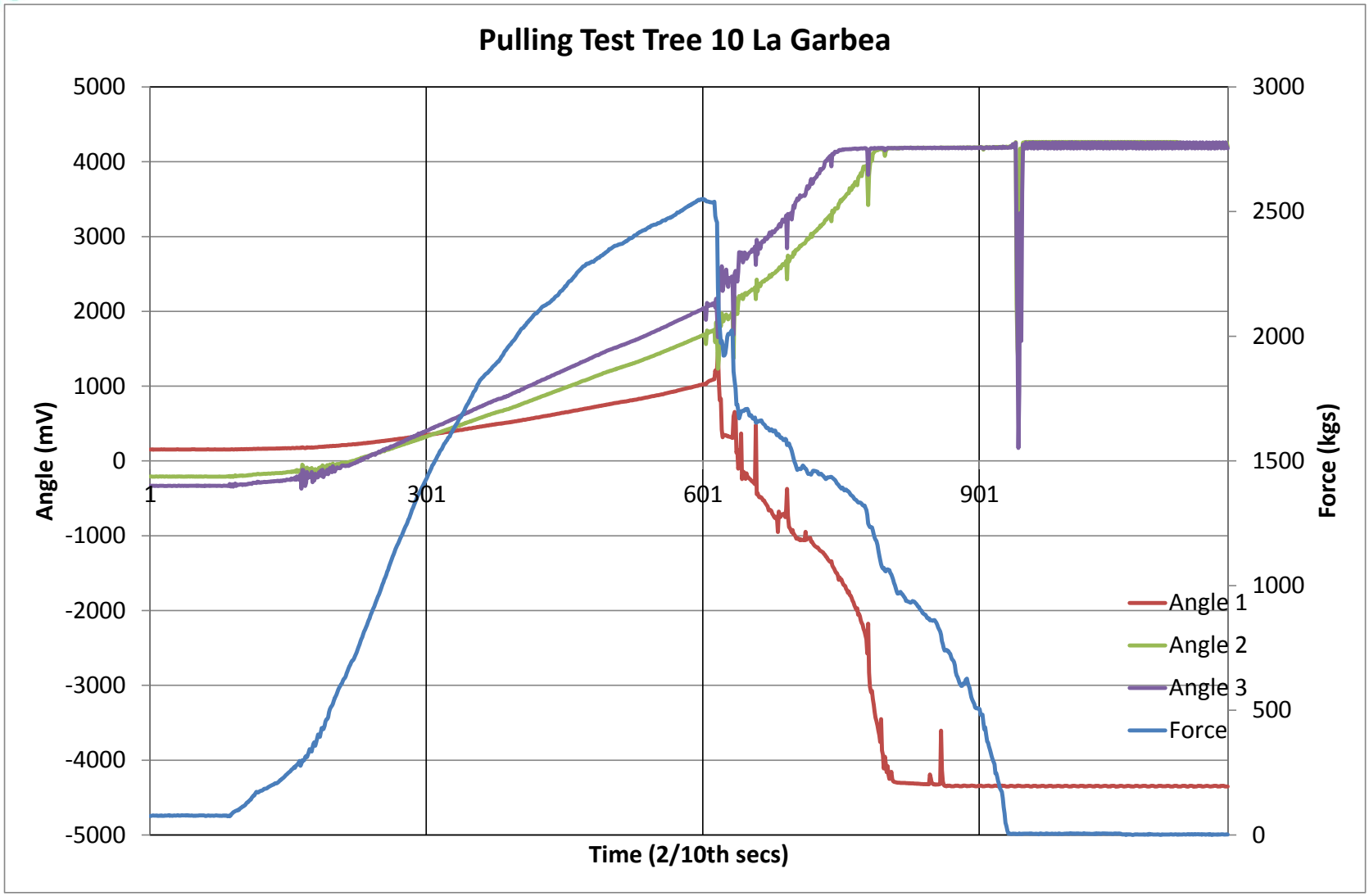
Tree Pulling

Tree Pulling

Eucalyptus

Tree Pulling

Beech



Tree Pulling

A mechanistic model for assessing the risk of wind and snow damage to single trees and stands of Scots pine, Norway spruce, and birch

H. Peltola, S. Kellomäki, H. Väisänen, and V.-P. Ikonen

Abstract: A mechanistic model for assessing the risk of wind and snow damage to single trees and stands of Scots pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* (L.) Karst.), and birch (*Betula* spp.) is presented. The model predicts the critical turning moment and wind speed at which the trees will be uprooted or break at forest margins. The resistance to uprooting is predicted using the estimate of the root–soil plate weight to derive a resistive moment, while the resistance to stem breakage relies on values for the modulus of rupture determined for different species of timber. A tree is assumed to be uprooted if the total turning moment exceeds the support provided by the root–soil plate anchorage. Similarly, a tree is assumed to break if the breaking stress acting on the stem exceeds a critical value of the modulus of rupture. The model is in general quite sensitive to parameter changes, which partly results from the location in the forest to which it was designed to apply (the stand edge). The predictions of the critical turning moments needed to uproot and break trees nevertheless give a good agreement on average with the Finnish tree-pulling data for Scots pine, Norway spruce, and birch.

Résumé : Cet article présente un modèle mécaniste permettant d'évaluer le risque de dommages causés par le vent et la neige pour des arbres individuels et des peuplements de pin sylvestre (*Pinus sylvestris* L.), d'épinette de Norvège (*Picea abies* (L.) Karst.) et de bouleau (*Betula* spp.). Le modèle prédit le moment de flexion critique et la vitesse du vent à laquelle les arbres à la lisière des forêts seront déracinés ou casseront. La résistance au renversement est prédite en utilisant des estimés du poids de la plaque formée par le sol et les racines pour dériver un moment de résistance, alors que la résistance de la tige à la rupture se base sur les valeurs de module de rupture pour les différentes espèces. Le modèle assume qu'un arbre sera déraciné si le moment de flexion total dépasse le support fourni par l'ancrage de la plaque de racines et de sol. De la même façon, on assume qu'un arbre cassera si la contrainte dans la tige dépasse la valeur critique du module de rupture. Le modèle est en général assez sensible à des modifications des paramètres, ce qui découle en partie de la portion de forêt pour laquelle le modèle est conçu, soit la lisière. Néanmoins, les prédictions des moments critiques requis pour déraciner ou casser les arbres concordent en moyenne avec les données finlandaises de treuillage pour le pin sylvestre, l'épinette de Norvège et le bouleau.

[Traduit par la rédaction]

Introduction

The structure and functioning of the boreal forest ecosystem is greatly affected by wind and snow, and wind and snow damage to trees is a continuing cause of economic loss in managed forests (Quine 1995). Furthermore, broken and uprooted trees left unharvested can lead to detrimental insect attacks on the remaining stand because of an increase in the amount of breeding material (Bakke 1989; Ravn 1985; Schroeder and Eidmann 1993).

Several studies have indicated that the susceptibility of a stand to wind and snow damage in terms of critical wind speed and (or) snow loading is controlled by tree and stand characteristics such as tree species, tree height, tree diameter, crown area, rooting depth and spread, and stand density, which are in turn determined by stand management (Persson 1972; 1975; Petty and Worrell 1981; Petty and Swain 1985; Rottmann 1985; Coutts 1986; Lohmander and Helles 1987; Valinger et al. 1993; Solantie 1994; Quine 1995; Nykänen et al. 1997). Local wind and snow conditions (extremes of climate) and topography determine how probable such a wind speed and (or) snow loading is. Vast differences can thus be observed in the risk of wind and snow damage between regions or locations that have different topography and climates.

A risk of wind and snow damage is most likely to occur where there are sudden changes in wind loading to which the trees are not acclimated, as in stands thinned intensively or stands adjacent to recently clear-felled areas (Alexander 1964; Neustein 1965; Kolstock and Lockow 1981; Laiho 1987; Lohmander and Helles 1987; Peltola 1996*a*, 1996*b*; Stacey et al. 1994; Gardiner et al. 1997). The reason for this is that, following thinning for example, the wind is able to penetrate deeper into the stand canopy with a subsequent increase in the wind load imposed on the trees, while dense stands dissipate incoming winds (Lohmander and Helles 1987; Stacey et al. 1994; Peltola 1996*a*, 1996*b*). On the other hand, trees in unthinned stands have also been found

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H. Peltola,[1] S. Kellomäki, H. Väisänen, and V.-P. Ikonen. Faculty of Forestry, University of Joensuu, P.O. Box 111, FIN-80101 Joensuu, Finland.

[1]Author to whom all correspondence should be addressed. e-mail: heli.peltola@joensuu.fi

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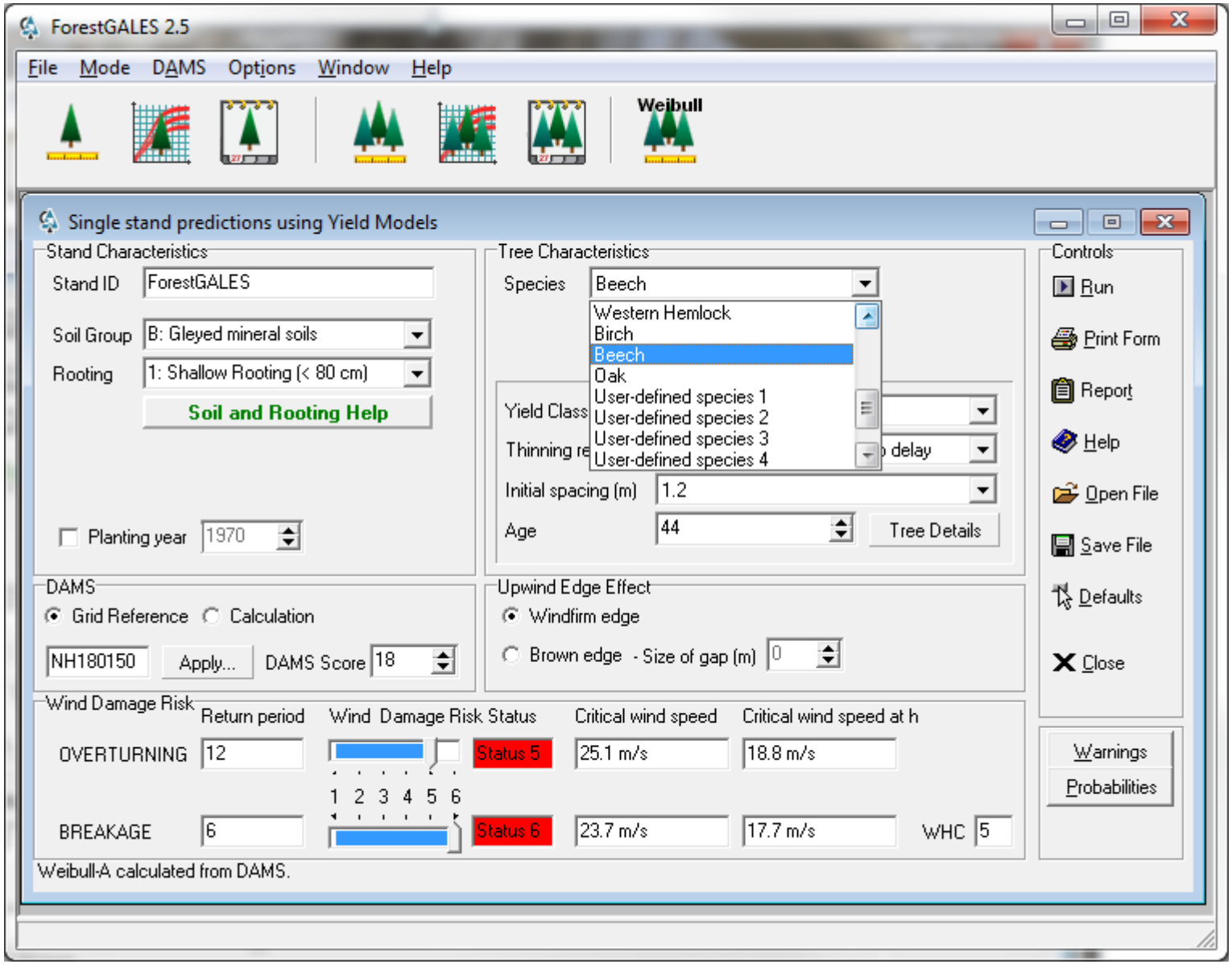
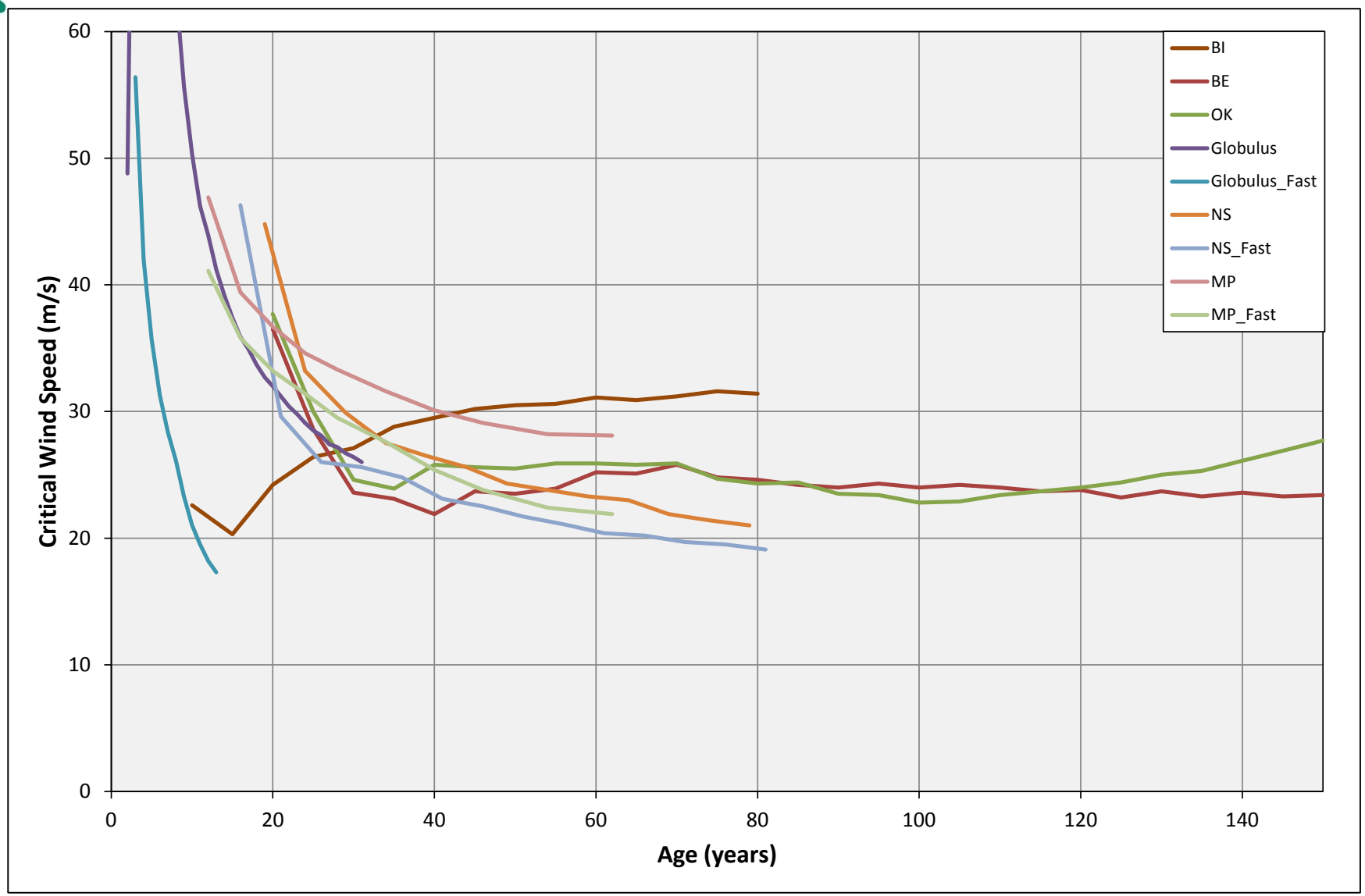
Birch Data

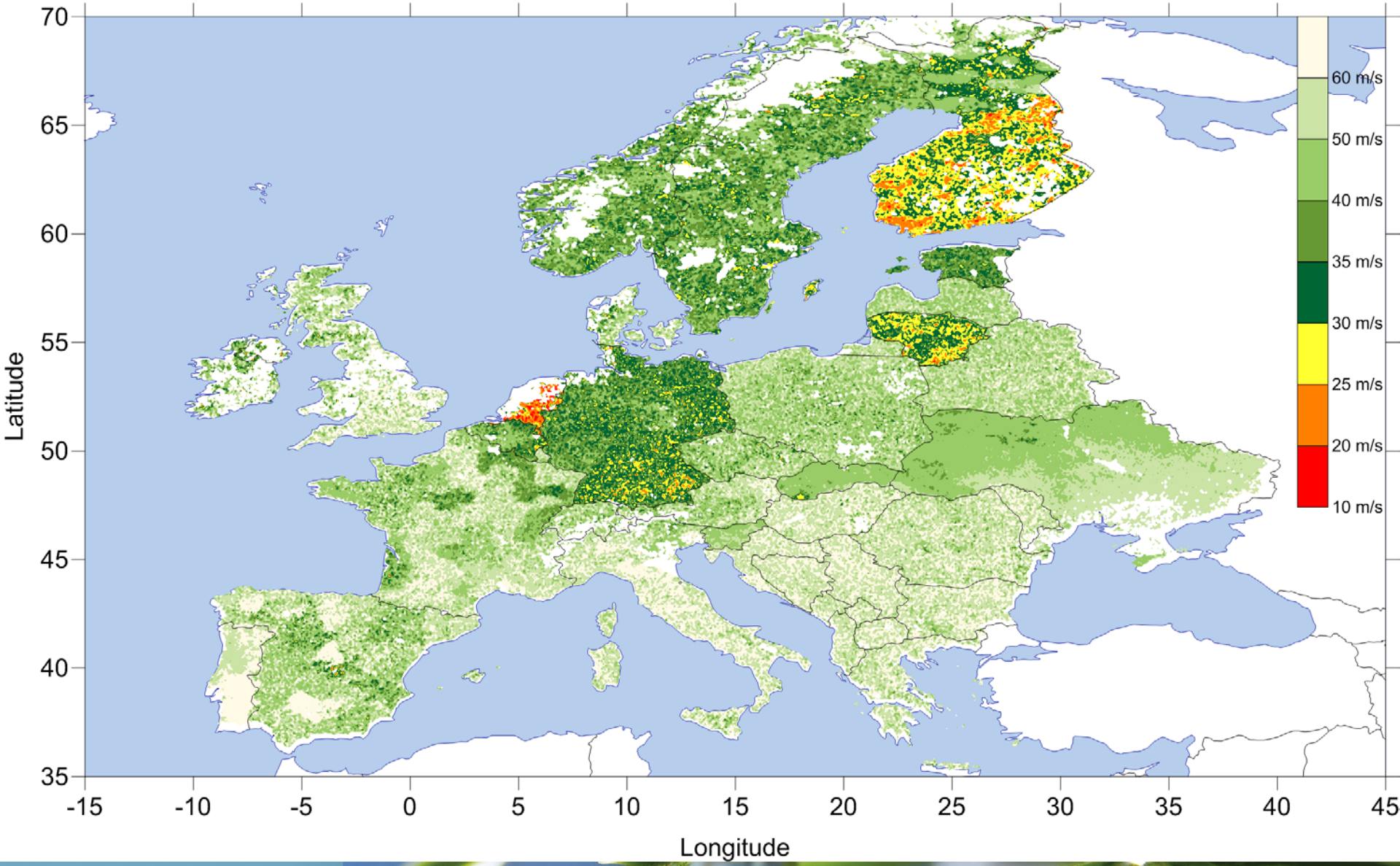


ForestGALES & Broadleaves



Critical Wind Speed

Predicted Critical Wind Speeds for Forest Damage from NFI Data



European CWS

Summary

1. ForestGALES 2.5 latest version available online http://www.forestry.gov.uk/forestgales
2. ForestGALES wind risk model now parameterised for following broadleaves: *Eucalyptus globulus, Betula spp.*, *Fagus sylvaticus*, and *Quercus robur/petraea*.
3. Maps of critical wind speed and wind risk created for whole of Europe using new model and EFISCEN Space (NFI data from across Europe)
4. ForestGALES validated in UK, Japan, Canada and south-west France for conifers

Future Activities

1. Validation of broadleaf predictions required
2. Broadleaf parameterisation to be added to ForestGALES in CAPSIS
3. Single tree version of ForestGALES to be added to CAPSIS
4. Single tree version of ForestGALES being written in R and linked to QGIS