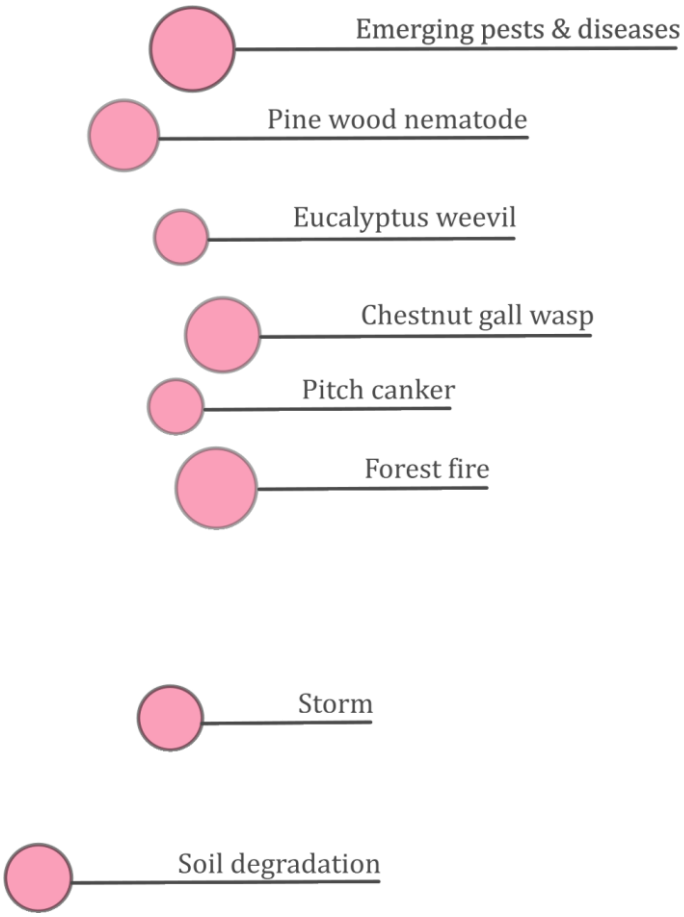
Minutes of the storm risk workshop

Wind risk model for Euskadi
&
Forest management adapted to wind damage



Asociación de Forestalistas de Bizkaia, Galdakao, Bizkaia, Spain
11 September 2017

Casa de Cultura, Eskoriatza, Gipuzkoa, Spain
12 September 2017

Minutes of the storm risk workshop

Author of the minutes: Eduard Mauri (EFIATLANTIC)

Reviewers of the minutes: Alejandro Cantero (HAZI), Barry Gardiner (EFIATLANTIC), Tommaso Locatelli (Forest Research)

Workshop organisers: Alejandro Cantero (HAZI), Barry Gardiner (EFIATLANTIC)

Table of contents

Agenda

PROYECTO **PLURIFOR** *PROJECT*
TALLER **BASAIZE** *WORKSHOP*:
WIND RISK MODEL FOR EUSKADI
MODELO DE RIESGO DE VIENTO PARA EUSKADI

MONDAY **11 SEPTEMBER 2017**	**Organiser:** Barry Gardiner, EFIATLANTIC, +33 (0)5 35 38 52 50, barry.gardiner@ef.int Alejandro Cantero, HAZI, +34 6 51 70 52 75, acantero@hazi.eus **Language:** English (software and technical support in Spanish) **Venue:** Asociación de Forestalistas de Bizkaia Barrio Gumuzio 19 A (Cruce Erletxe) 48960 GALDAKAO, Bizkaia, Spain

9:45	**Welcome**	
10:00	**WIND RISK MODEL FOR EUSKADI DEMONSTRATION**	**Barry Gardiner (EFIATLANTIC)**
	Presentation of the **Basaize risk model**, an adaptation for the Basque Country of ForestGALES, a computer based decision support tool that enables forest managers to estimate the probability of wind damage to forest stands (single or multiple stands). Main topics: • Model demonstration, • How the model was adapted for Euskadi, • How to adapt the model for other regions, • Questions and discussion.	
13:00	**Lunch break** (in a restaurant nearby, at each partner's own expense)	
14:30	**PRACTICAL EXERCISES**	**Barry Gardiner/Eduard Mauri (EFIATLANTIC)**
	The participants will use the model through practical exercises in Euskadi forested areas. **Note**: each participant must bring his or her own Windows PC or Mac laptop (with a Windows emulator such as Crossover©) to execute the exercises with the **Basaize risk model** for Euskadi, which will be provided to all participants.	
16:30	**End**	

Register for the workshop before 1st September 2017. Limited places.

EFIATLANTIC

hazi

EUSKO JAURLARITZA
GOBIERNO VASCO

PROYECTO **PLURIFOR**

TALLER : **GESTIÓN FORESTAL ADAPTADA A DERRIBOS POR VIENTO**

Este taller es una **versión práctica** del taller del 11 de setiembre "Modelo de riesgo de viento para Euskadi", donde se verán aplicaciones del modelo de riesgo Basaize (una adaptación de ForestGALES para el País Vasco) en las tablas de producción. Está **destinado** a propietarios forestales, a técnicos e ingenieros forestales y a gestores.

MARTES **12 SEPTIEMBRE 2017**	**Organizadores:** Alejandro Cantero, HAZI, +34 6 51 70 52 75, acantero@hazi.eus Barry Gardiner, EFIATLANTIC, +33 (0)5 35 38 52 50, barry.gardiner@ef.int **Idioma:** castellano **Lugar:** Casa de cultura de Eskoriatza Hidalga kalea, 1 – 20540 Eskoriatza, Gipuzkoa, Spain

9:45	Acogida	
10:00	**INTEGRACIÓN DEL RIESGO DE VIENTO EN LA SELVICULTURA DE EUSKADI**	**Alejandro Cantero (HAZI)** **Barry Gardiner (EFIATLANTIC)**
	Entender el riesgo de viento en el manejo forestal. Cómo predecir el riesgo de daños por viento según el riesgo de cada lugar y tipo de arbolado y según la selvicultura prevista: tabla de producción a densidad variable para el pino radiata y tablas de producción a densidad fija para las otras especies de plantación.	
12:00	**SALIDA AL MONTE**	**Alejandro Cantero (HAZI)** **Barry Gardiner (EFIATLANTIC)**
	Visita de una parcela de pino radiata dañada en los vendavales de febrero de 2017. Se discutirá como se podrían haber predicho los daños y como se podría haber disminuido su impacto gracias la integración del riesgo de viento en la selvicultura del rodal. *Desplazamiento en vehículos particulares.*	
14:00	Almuerzo (en un restaurante cercano, a cargo de cada participante)	

Inscripciones al taller antes del 1 de septiembre de 2017. Taller gratuito, plazas limitadas.

PROJET **PLURIFOR**

ATELIER : **AMÉNAGEMENT FORESTIER ADAPTÉ AUX CHABLIS**

Cet atelier est une **version pratique** de l'atelier du 11 de septembre "Wind risk model for Euskadi", où l'on explorera l'application du modèle de risque Basaize (une adaptation de ForestGALES pour le Pays Basque) dans les tables de production. Il est **orienté** vers les propriétaires forestiers, techniciens et ingénieurs forestiers et aménagistes.

MARDI **12 SEPTEMBRE 2017**	**Organisateurs:** Alejandro Cantero, HAZI, +34 6 51 70 52 75, acantero@hazi.eus Barry Gardiner, EFIATLANTIC, +33 (0)5 35 38 52 50, barry.gardiner@ef.int **Langue:** espagnol (avec soutien en français si besoin) **Lieu:** Casa de cultura de Eskoriatza Hidalga kalea, 1 – 20540 Eskoriatza, Gipuzkoa, Spain

9:45	Accueil	
10:00	**INTEGRATION DU RISQUE DE VENT DANS LA SYLVICULTURE EN EUSKADI**	**Alejandro Cantero (HAZI)** **Barry Gardiner (EFIATLANTIC)**
	Comprendre le risque de vent dans l'aménagement forestier. Comment prédire les dommages causés par le vent selon les aleas liés à chaque emplacement et au type de peuplement forestier et selon la sylviculture prévue : table de production à densité variable pour le pin radiata et tables de production à densité fixe pour d'autres essences en plantation.	
12:00	**VISITE EN FORÊT**	**Alejandro Cantero (HAZI)** **Barry Gardiner (EFIATLANTIC)**
	Visite d'un peuplement de pin radiata endommagé par le vent en février 2017. On discutera comment les dommages auraient pu être prédits et comment leurs impacts auraient pu être diminués grâce à l'intégration du risque de vent dans la sylviculture du peuplement. *Déplacement en véhicules privés.*	
14:00	**Déjeuner (dans un restaurant à proximité, à charge pour chaque participant)**	

Inscriptions à l'atelier avant le 1er septembre de 2017. Atelier gratuit, places limitées.

Storm risk WP2 objectives

Storm risk partners and associated partners

Region	Organisation	Contact person	Associated partners
Euskadi	HAZI	Alejandro Cantero	Diputación Foral de Álava Diputación Foral de Bizkaia Diputación Foral de Gipuzkoa Gobierno Vasco - Departamento de Desarrollo Económico y Competitividad
Nouvelle-Aquitaine	EFIATLANTIC	Barry Gardiner	Direction régionale de l'alimentation, de l'agriculture et de la forêt Nouvelle-Aquitaine Association Régionale de Défense des Forêts Contre l'Incendie

Tools and risk management plans to be developed within PLURIFOR project

As decided by the PLURIFOR Technical committee n°2 meeting (25-26 January 2017 at NEIKER, Parque Tecnológico de Bizkaia, Parcela 812, calle Berreaga 1, Derio, Spain), the following tools and risk management plans will be developed by the storm risk team in WP2:

- Develop a draft storm risk management plan for Euskadi based on the best components of the Nouvelle-Aquitaine, Wallonian, Scottish and English plans
- Work with colleagues in Nouvelle-Aquitaine and Euskadi to create vulnerability maps for storm damage to be updated annually
- Develop vulnerability maps for each species of interest for situations where spatial species information is not available
- Make vulnerability maps available via smart phones to allow interaction with stakeholders and people responsible for forest management
- Make wind risk models available online in French and Spanish
- Organise expert exchanges between Euskadi and Nouvelle-Aquitaine for demonstrating crisis management and rehabilitation tools and procedures, e.g. wood storage, team coordination, tracking and managing different actions in the forest, etc. (this is not the workshop)
- Write best practice forest guidelines concerning storm damage for Nouvelle-Aquitaine and Euskadi to be available as an appendix to risk management plans

Attendees

Attendees

Participants

First name	Last name	Organisation [a]	Workshop Monday 22 May	Field trip Tuesday 23 May
Aitor	Omar Aspiazu	DFB/BFA Diputación	Yes	-
Aitor	Onaindia Bereziartua	BASOEKIN, S.L.	Yes	-
Aitziber	Sarasketa Gartzia	Forest owner	-	Yes
Alberto	Agiriano Bergaretxe	Forest owner	-	Yes
Amélie	Castro	CRPF Nouvelle-Aquitaine	-	Yes
Ander	Arias-González	NEIKER	Yes	-
Andoni	Urteaga	DFA/AFA	-	Yes
Ángel	Guisasola Elgezua	Forest owner	-	Yes
Antonio	Arrillaga Ibarluzea	Forest owner	-	Yes
Belén	Agra Burgos	Diputación Foral de Álava	-	Yes
Bixente Xabier	Unzurrunzaga Uribesalgo	Euskalmet, Gobierno Vasco	-	Yes
Carlos	Uriagereka	Diputación Foral de Bizkaia	Yes	-
Edurne	Lacalle Galdeano	USSE	Yes	Yes
Eusebio	Jayo Otazua	Forest owner	-	Yes
Fermín	Lezeta Belategi	Forest owner	-	Yes
Fernando	Azurmendi	BASOEKIN, S.L.	Yes	-
Fernando	Otazua Mendizabal	Forest owner	-	Yes
Gaëlle	Burlot	Caisse Phyto Forêt	Yes	Yes
Gorka	Altuna	USSE	Yes	-
Guido Raúl	Taricuarima Caicedo	Forest owner	-	Yes
Inmaculada	Lizaso Sánchez	Diputación Foral de Gipuzkoa	-	Yes
Iñaki	Etxebeste Larrañaga	Self-employed	-	Yes
Iñigo	Iriarte Rodríguez	Forest owner	-	Yes
Ismael	Mondragon	Diputación Foral de Gipuzkoa	-	Yes
Jabier	Olaetxea Elosegi	Forest owner	-	Yes
Jesús	San Vicente Bengoa	Forest owner	-	Yes
Jon	Ugarte Ugarte	Forest owner	-	Yes

First name	Last name	Organisation [a]	Workshop Monday 22 May	Field trip Tuesday 23 May
José	Urrutia Zubizarreta	Forest owner	-	Yes
José Antonio	Aranda Eguia	Euskalmet, Gobierno Vasco	-	Yes
José Ignacio	Ulibiarrana Errasti	Forest owner	-	Yes
José Ramón	Ocaranza Otadui	Forest owner	-	Yes
Josu	Azpitarte Andrinua	BaskEgur	-	Yes
Leire	Salaberria Isasi	USSE	Yes	Yes
Leire	Serna García	Diputación Foral de Álava	-	Yes
Maialen	Galparsoro Odriozola	Diputación Foral de Gipuzkoa	-	Yes
Maialen	Guridi Loidi	Forest owner	-	Yes
Marta	Fernandez de Zañartu	Diputacion Foral de Álava	-	Yes
Miren	Oianguren Martínez	Deba-Garaia	-	Yes
Nahia	Gartzia-Bengoetxea	NEIKER	Yes	-
Saray	Del Brío Castañeda	Forest owner	-	Yes
Tomás	Garai Markaide	Forest owner	-	Yes
Valentín	Mugarza Martínez	Diputación Foral de Gipuzkoa	-	Yes
Unai	Viteri Vitorica	Forest owner	-	Yes

[a] Forest owners were invited by Hazi as continuous training.

Organisers

First name	Last name	Organisation	Workshop Monday 22 May	Field trip Tuesday 23 May
Alejandro	Cantero	HAZI	Yes	Yes
Barry	Gardiner	EFIATLANTIC	Yes	Yes

Guest speakers

First name	Last name	Organisation	Workshop Monday 22 May	Field trip Tuesday 23 May
Tommaso	Locatelli	Forest Research UK	Yes, as speaker	Yes

Absent

First name	Last name	Organisation
Aitor	Idoiagabeitia Anakabe	BASOLUR
Harriet	Umerez	Self-employed
Iñigo	Lizarralde	Föra Forest Technologies
Paco	Rodriguez	Föra Forest Technologies
Amelia	Uria Peña	BASOEKIN, S.L.

The following associated partners we invited but didn't register for the workshop:

From Nouvelle-Aquitaine:

- Direction Régionale de l'Alimentation, de l'Agriculture et de la Forêt
- Association Régionale de Défense des Forêts Contre l'Incendie

11 September - Wind risk model for Euskadi: demonstration and practical exercises

Tools for wind damage risk in Euskadi

Alejandro Cantero

Goal

Introduce PLURIFOR project and WP2 tools.

Content

Why Euskadi is involved in storm risk?

Wind damages in Euskadi are mainly caused by northern winter winds (especially during January and February). The most exposed areas are mountain crests and summits. They are mainly in the public domain and without trees.

Several storms have hit Basque forests in the past: storms Klaus (2009) and Xinthia (2010) and some wind damage associated with snow (2013 and 2017). The Basque timber market suffered from the impact of windblown timber in SW France following the 1999 and 2009 storms. For these reasons it is important that Euskadi develops a storm risk management plan within the PLURIFOR project.

Wind is a hazard that will become more frequent in the future due to climate change. In Euskadi, a lot of past weather information is freely available thanks to Euskalmet (the Basque Meteorological Agency) weather stations covering the whole territory. The information is enough to create an accurate wind climate atlas and to predict the wind pattern in future events. Moreover, LiDAR flights and forest inventories provide detailed information about the forest composition and structure across Euskadi.

Even if Euskadi does not have a storm risk management plan, several official tools and procedures are available to manage this risk:

- Prevention: Civil protection plan for Euskadi (LABI); preventive forest regulation: “Prevention of forest from damages caused by fires, natural disturbances and disasters”.
- Early warning: weather warnings issued by Euskalmet including strong winds: warnings include the level of hazard and specify which areas are exposed or not; wind measurements are provided in real time every 10 minutes.
- Rehabilitation: field visits to evaluate damages, tracking of historical forest damages caused by strong winds, restorative forest regulation: “Restoration of forest from damages caused by fires, natural disturbances and disasters”.

Other non-official tools and procedures are available (developed by the FORRISK project) or will be available (through the PLURIFOR project) to manage this risk:

- Prevention: wind risk maps according to taper, based on LiDAR and field data (FORRISK); identification of the most exposed areas according to different wind directions using Flammap and WindNinja (PLURIFOR; preliminary results are similar to those obtained by Barry Gardiner of EFIATLANTIC using statistical modelling); Basque yield tables linked to wind damage risk (PLURIFOR); storm risk management plan for Euskadi (PLURIFOR); silvicultural good practices guidelines to reduce wind damage risk (PLURIFOR).
- Early warning: storm risk management plan for Euskadi (PLURIFOR).
- Crisis management: storm risk management plan for Euskadi (PLURIFOR).
- Rehabilitation: storm risk management plan for Euskadi (PLURIFOR).

Conclusions

Good baseline information is available to analyse and predict the future effects of wind on Basque forests. The expected results with simulators such as WindNinja and the new 2017 LiDAR flight will hopefully provide a better delimitation of the risk areas, although there will always be some uncertainty due to unknown factors.

The available results can be downloaded from the PLURIFOR project website and at www.geo.euskadi.eus

Management of wind damage to forests

Barry Gardiner

Outline of presentation

- Wind as the major disturbance in European forests
- Impacts of wind damage
- Risk management in forestry
- Factors affecting forest vulnerability to wind
- Development of tree/stand level risk model (ForestGALES)
- Validation of the wind risk model
- Modelling forest risk at stand/regional/European scale
- Potential impact of the changing climate on wind risk to forests

Content

Wind damage is the main forest disturbance in Europe, causing more than 50% of the total volume loss. This disturbance has been increasing over the last few decades and climate change models forecast an increase in the intensity of strong wind episodes. Some storms damage up to half of the annual felling in certain areas. In some small countries (e.g. Denmark), up to 20% of the forest growing stock is affected by a single big storm event.

Wind damage ranges from small scale (affecting leaves and branches) to large scale (tree breakage or uprooting, gap formation within forest stand or successional change at regional level). Damage is increased when the wind occurs with snow or ice on trees. In such cases permanent bending of the stem can occur.

Currently, the wind risk management cycle is better adapted to the warning and response phases, but less good at dealing with the recovery phase and the risk mitigation cycle. The recovery phase must include forest ecosystem recovery as well as measures that help the forest-timber sector to regain its usual operations. The objective of the risk mitigation cycle is to reduce the impacts of wind storms. The cycle is:

Collect data → Identify hazard → Calculate the level of risk (hazard x susceptibility x value) → Assess alternatives (reduce the risk, spread the risk, accept the risk) → Implement the plan

ForestGALES is a forest wind risk management model to assess this risk in forest stands. The following factors influence wind vulnerability of forest stands:

- **Wind factors**: speed, direction, gustiness.
- **Tree factors**: species, age, spacing, height, dbh, knots, stem strength and flexibility, stem taper, stem weight, crown dynamic motion, crown streamlining and drag, crown weight, crown clashing, root fusion, root strength, root diameter.
- **Soil factors**: rooting depth, soil strength and weight, soil moisture content, frozen soil, winter water table, restrictions to rooting.
- **Stand factors**: forest edges, thinning, gaps, damage propagation.

The model needs a series of inputs from the user, and returns four outputs:

Inputs:

- Tree species
- Tree height
- Tree diameter (1.3 m)
- Spacing
- Soil type
- Rooting Depth
- Latitude and Longitude (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)

The model uses tree-pulling experiments to provide tree parameters about how a tree resists the wind on different soils. Forest inventory data provides stand information. Tree parameters and stand information are combined into equations that provide a measure of the susceptibility of the stand to the wind, expressed as the critical wind speed at which the stand begins to suffer damage from the wind. However, the probability of the wind to attain this critical speed depends on location. Wind climate data and digital terrain maps are combined to create a local wind climate maps. Knowing the location of the stand within a wind climate map and the critical wind speed of the forest allows the assessment the risk of wind damage, expressed as the probability of attaining a given critical wind speed at the particular stand location.

ForestGALES provides the return period (average number of years) in which the critical wind speed will be attained or passed. Shorter return periods imply higher risk. As local wind climate cannot be influenced by humans, foresters can only reduce the risk by managing the stand so they tolerate higher critical wind speeds (reduced susceptibility) or reduce the value at risk (e.g. less valuable trees). Risk spread (e.g. insurance, heterogeneous forests) and risk acceptance are the other two available strategies.

Validation of the model is crucial. ForestGALES have been validated in Scotland (2012 storm, Sitka spruce, high wind exposure, moderate topography), in Aquitaine (1999 and 2009 storms, maritime pine, moderate wind exposure, flat topography) and Euskadi (2009 and 2010 storm, radiata pine, moderate wind exposure, severe topography). Further improvements of the model can be obtained through use of airborne LiDAR data (with allows critical wind speeds to be calculated for all forests in a region), more accurate wind climate and soil data, and tree pulling on additional species and soil combinations.

Current predictions are that climate change will result in probably less frequent but more intense storms. This is particularly true for the region around the Bay of Biscay due to more intense hurricanes crossing the Atlantic.

Summary:

- Wind damage is the major disturbance in temperature and boreal forests
- Wind damage is increasing in direct correlation to the increase in European forest growing stock but also due to climatic change
- It is crucial to have a risk management plan and a risk mitigation plan as part of forest management
- Wind risk models are available for predicting the vulnerability of forests and new species are being added all the time
- LiDAR gives unprecedented levels of data as model input
- Possible to make initial predictions of forest vulnerability and risk at regional scale across Europe

Coupling ForestGALES with an airflow model and a yield model in QGIS

Tommaso Locatelli (in collaboration with Barry Gardiner and Bruce Nicoll of Forest Research)

Goal

Manually coupling ForestGALES with WAsP airflow model and a growth model within QGIS.

Content

Forest Research was contacted by UNIQUE, a German forest management company with operations in Vietnam and other tropical countries, to assess the potential for parametrising ForestGALES for *Acacia* spp. and estimate the risk of wind damage to Vietnamese plantations of these species.

Vietnam has a very complex terrain, complex wind climate regime due to typhoons and monsoonal cycles, and complex and fragmented land ownership patterns, which make it difficult to promote concerted efforts to manage plantations to reduce risk of wind damage.

UNIQUE were looking for a scoping exercise on the feasibility of tailored tools to calculate risk and inform management practices to reduce risk to *Acacia* plantations in Vietnam. As explained by Barry Gardiner, both in his introduction to ForestGALES and his description of the challenges for the creation of a Basque Country ForestGALES (Basaize, see next section), species not currently available in the model require extensive field work to obtain data for parametrisation. For this reason, the initial scoping phase of this project focussed on *Eucalyptus globulus* (Labill.), a plantation species widely used in Vietnam for which a ForestGALES parametrisation exists. This allowed a demonstration of the coupling between ForestGALES, the GLOBULUS growth model for *E. globulus* (Tomé et al., 2006), and the WAsP airflow model within QGIS. The objective of the case study was to build a spatially explicit wind risk decision support tool (DST) for commercial plantations.

The process for building the DST was as follows:

1. For the area of interest, obtain:
    a. Digital Elevation Model;
    b. Map of forest areas/types;
    c. Wind data from either a local weather station (~20 to 30 years of data required), or from a resource such as the Global Wind Atlas (http://globalwindatlas.com/)
2. Digitise the forest map in QGIS
3. Simulate growth of *E. globulus* stands with GLOBULUS
4. Use ForestGALES to:
    a. Calculate aerodynamic roughness of *E. globulus* plots with ForestGALES, based on mean tree height and species, for use in WAsP;
    b. Calculate the critical wind speeds for the *E. globulus* stands
5. Digitise WAsP contour and roughness map
6. Run WAsP simulations to produce raster maps of Weibull A and k parameters (similar to mean and variance of the wind speed). The resolution (grid size) of the raster depends on the extent of the area of interest and on the available computational power. For our case study

we adopted a 'mosaic' approach that allowed us to break down the area of interest in a number of smaller areas, thereby reducing the computational strain.

7. Use the Weibull parameters raster maps to calculate the risk of wind damage with ForestGALES

This exercise demonstrated the potential of coupling ForestGALES with tree/stand growth models and airflow models to inform modern forest management within a free and open source GIS platform. Map visualisation and statistical analysis of ForestGALES outputs allow users to investigate the effect of terrain and stand characteristics on the localised airflow and the resulting risk of damage. Similarly, forest managers are able to visualise on a map (both 2D and 3D) the areas at higher risk of wind damage, and to respond to this with appropriate silvicultural practices to minimise such risk.

Summary:

- Wind damage risk is a concern to commercial plantations in other parts of the world (e.g. Southeast Asia)
- This widespread concern has generated interest in ForestGALES for forest management against wind damage beyond European countries
- Tree pulling for exotic tree species of commercial importance is required to provide a service that goes beyond that of 'proof of concept'
- Spatially-explicit, manual coupling of ForestGALES with a growth model and the WAsP airflow model is effective for small to medium sized areas due to computational constraints
- A very advantageous trait of this coupling is that it can make use of the forest roughness element calculator module in ForestGALES to complement the WAsP roughness maps
- Displaying 2D and 3D maps of wind risk areas can be an intuitive and user-friendly tool for modern forest management.

Adaptation of the wind risk model ForestGALES to the Basque Country

Barry Gardiner (in collaboration with Christopher Poette and Tommaso Locatelli)

Goal

Explain how the ForestGALES wind risk model has been adapted for Euskadi.

Content

ForestGALES is a wind risk management model developed by Forest Research UK, originally for the United Kingdom. See the summary of the presentation "Management of wind damage to forests" for further details about the model. ForestGALES 2.5 has been modified to work in the Spanish Basque Country and the new model is called Basaize 1.1.

To adapt it to another location, changes are required to the following: species' parameter files, yield (growth) models, and local wind climate map.

Species' parameters and yield models:

Wood parameters (Modulus of Rupture, Modulus of Elasticity and wood density) are already known from laboratory test for Basque tree species. Growth models provide the crown width and crown depth equations, the taper equation (for calculating stem weight). However, rooting resistance (function of tree size, rooting depth and soil type) requires tree pulling. Instruments are used to measure the maximum force that is necessary to break the stem or uproot trees during artificial pulling experiments.

To calibrate the model, it is necessary to spend approximately one person month per species and type of soil. After repeated measurements on different trees (>9), a linear function can be constructed, per species and soil type, that estimates the maximum resistive moment as function of stem weight.

Basque yield models have been used to allow assessments of the change in risk to stands with time. Parameters are not available currently for some species that have been included in the Basaize model and parameters from other similar species have been substitute. In these situations a message warns the user that caution is required when using the results.

Local wind climate to generate a new wind climate map:

In Euskadi, a lot of past weather information is freely available thanks to the Euskalmet (the Basque Meteorological Agency) weather stations covering all the territory. The level of information was enough to create an accurate wind climate map. In ForestGALES, local wind climate in a given location is described by a Weibull frequency distribution. The Weibull distribution is defined by two parameters: A and k. The A parameter is related to the distance from the ocean, the elevation and the shelter provided by nearby topography (TOPEX10) and the k parameter by TOPEX10 and elevation. Both parameters were already available for Euskadi through the FORRISK project.

Basaize can create maps of wind risk at the regional scale if data on the forest are available (e.g. from LiDAR).

Validation:

A full validation of Basaize is needed. In Euskadi, validation has only been performed for radiata pine. Validation was performed with radiata pine forest plots for which the critical wind speed was calculated at the time of recent storms (Xynthia and Klaus).

Radiata pine, maritime pine and eucalyptus are the species with full parameter values and therefore have the most reliable predictions. For other species, more tree pulling in Euskadi is needed.

To get an accurate wind climate map, ideally at least 20 years of wind measures are required, in order to capture less frequent events. In Euskadi, some weather stations are no more than five years old, so the A and k Weibull parameters used in Basaize should be updated as longer time series of wind data become available.

Summary:

To date:

1. ForestGALES 2.5 has been modified to work in the Euskadi and the new model is called Basaize 1.1.
2. Tree pulling experiments in Northern Spain on radiata pine and *Eucalyptus globulus* have been used to parameterise the model.
3. Tree pulling of *Fagus sylvatica* in north-eastern France have been used to parameterise the model for beech.
4. Other species parameterisations are based on data from other tree pulling experiments.
5. A map of Weibull A and Weibull k wind climate parameters for Euskadi has been produced from more than 70 meteorological stations (function of elevation, topographic shelter & distance from the sea).
6. Initial validation of Basaize using wind damage to radiata pine from storms Klaus and Xynthia.

In the future:

1. Further tree-pulling *Fagus sylvatica* in Euskadi.
2. Full validation of Basaize with data from Storms Klaus and Xynthia.

ForestGALES - Single tree approach

Tommaso Locatelli (in collaboration with Barry Gardiner, and Sophie Hale and Bruce Nicoll of Forest Research)

Goal

Introduce the new single-tree version of ForestGALES (ForestGALES-TMC), compare it with the traditional stand level version, and discuss pros and cons in relation to practical applications for forest management.

Content

History and development of ForestGALES:

Traditional forestry in Britain was developed and based on fast-growing conifers on large and uniform plantations managed in 'plantation-to-clearfelling' cycling. For the traditional (i.e. 'roughness') version of ForestGALES, each stand is formed of virtual clones of the same mean tree. This has proven to be adequate for monospecific plantations characterised by a small range of tree sizes.

However, with changes in forestry policy and practice, stands are becoming more complex and are valued for purposes other than timber or pulp productivity: aesthetics and recreation, resilience against climate change and pests and diseases. As a consequence, forests now display a higher structural complexity, and often a mixture of species (e.g. in continuous cover forestry settings). ForestGALES-TMC differs from the roughness version in that the effect of the force of the wind on the trees is not calculated at the stand level, but can be done directly for each tree, provided its size is known. This allows the calculation of wind damage risk for structurally complex stands composed of a mosaic of tree species (amongst those for which ForestGALES has been parametrised, of course).

ForestGALES "roughness" vs ForestGALES-TMC approach:

The new method consists of calculating the turning moment coefficient (TMC) for each tree within a stand, relating the wind speed at canopy top with the size of the tree. The value of TMC for any given tree can be modified with knowledge of the effect of its neighbours on its vulnerability to wind, as calculated with competition indices. This relationship also allows incorporation of the effect of silvicultural practices such as thinning on the changes in competition amongst trees within a stand.

Pros vs Cons of Single tree approach:

Advantages:

- It is designed for complex forest stands, allowing for the modelling of different forest structures, species-mosaics, and thinning regimes.
- Can incorporate the effect of tree competition with Competition Indices.
- Tested as a central part of a modelling infrastructure with landscape simulators at high spatial resolution (up to 10 m cells).
- Computationally faster. It can make better use of tree-level LiDAR data for higher resolution spatial modelling.

Disadvantages:

- Not fully tested yet.
- Requires more scenario testing and parametrisation.
- More empiricism introduced, so extra field measurements are necessary to export the model outside the calibration area. Parametrisation must be done properly (e.g. avoid tree pulling after a storm, as only more resistant trees remain standing, thus introducing bias in the empiricism).

Applications of Single tree approach:

ForestGALES-TMC allows the modelling of wind risk to complex forest management approaches, e.g.: when using short rotation species as nurse crops for longer rotation species, will nurse species resist long enough to protect the other species when in the understory phase? Will longer rotation species be sufficiently windfirm when the nurse trees are harvested?

By allowing simulation of wind risk to more complex stand management regimes, ForestGALES-TMC provides forest managers with a tool to assess the vulnerability of complex business models. As demonstrated in Seidl et al. (2014), ForestGALES-TMC works well in modelling the dynamic spread of damage during a storm. More vulnerable trees are identified which would be expected to fail first under wind loading, and open a gap that can subsequently initiate a domino effect. The dynamic plasticity of ForestGALES-TMC means that it lends itself well to being used to model effects of wind disturbance on forest ecosystems, e.g. for the estimation of the carbon balance of trees and soil in areas prone to wind damage.

Discussion on wind risk management models

See “Conclusions” section.

Basaize exercises: investigating species and silvicultural choices with the Basaize wind risk model for the Basque Country

Installing Basaize

1. System Requirements
    a. Windows OS (Windows 3 to 8) or Apple OS (if software such as Bootcamp, VMWare Fusion or Parallels Desktop 6 for Mac has been installed to allow the computer either to boot in Windows mode or for Windows to run in parallel).
    b. 35 MB of available hard-disk space (if wind climate data not installed on hard-disk) or 150 MB for full installation.
    c. The system requirements are minimal and Basaize makes no use of the Registry, in order to reduce problems with Windows security. In Windows 7 and 8 there may be some issues installing and running Basaize due to security settings. This is discussed and options are presented below.
2. Other Programs
    a. It is recommended to have Microsoft Excel and Word installed to help produce reports. Results can be exported to Excel, Word or as ASCII text files.
3. Installing Basaize
    a. Basaize can be installed in two ways, depending on your computer's security settings.
    b. *Method 1* (this should work on most computers): Run the installation file called Basaize11_SetUp.exe. By default the program will be installed into the directory C:\Program Files (x86)\Forest Research\Basaize1.1. However, it can be placed elsewhere if required during the installation process. The installation program will automatically place all the files where they are needed, and add an option to run Basaize1.1 from the Programs list (see how this might appear below), or on the Start screen in Windows 8.
    c. *Method 2* (if Method 1 does not work). Unzip all the files required from the self-extracting file Basaize11_Extract.exe. This file can be put anywhere on your hard disk. The only difference from *Method 1* above is that there is no dialog during extraction. This method does not make a link to the Programs list but you can add a Shortcut to the Desktop. An example Shortcut (Basaize.lnk) is provided in the folder \Basaize1.1\Templates, which links to Basaize.exe extracted to the Desktop. The shortcut must be placed on the Desktop and its Target properties edited to match with the particular user and extraction location of Basaize1.1 (see image below).
    d. Windows 7 and 8: Potential security issues. The level of security has increased in Windows 7 and 8 compared with previous versions. This means that there can be problems in installing, running or saving files if Windows requires Administrator rights. The installation program described in Method 1 above has been set up to try to minimise these problems and give the User control over all the files in the installation file space. However, if you have any problems with lack of privileges you have three options:

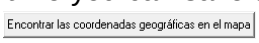
   i. Install the program to an area of the hard disk where you know you have Read, Write and Execute privileges
   ii. Install the self-extracting version (*Method 2* above) to an area of the hard disk where you know there are no requirements for Administrator privileges (the Desktop is a good location). This should avoid most security issues.
   iii. Try running the installation file or Basaize1.1 as an Administrator. Right mouse click on the executable file and choose Run as administrator from the menu (see below)
4. Help Files (In English at the moment). By default Basaize accesses all help information from the file forestgales25_help_manual.chm. This is a compiled html file and should work in all versions of Windows. If you are having problems with forestgales25_help_manual.chm an optional alternative version of the help information is provided as the file forestgales25_help_manual.hlp, which is the classic type of Windows help file. This can be set as the default help file in Basaize under the Help drop-down menu in the Main form (see below). This file should work:
   a. for versions of Windows earlier than Windows 7.
   b. for Windows 7 (and Windows 8 under most circumstances) after downloading and installing the Windows Help program (WinHlp32.exe) from http://www.microsoft.com/en-us/download/details.aspx?id=91.

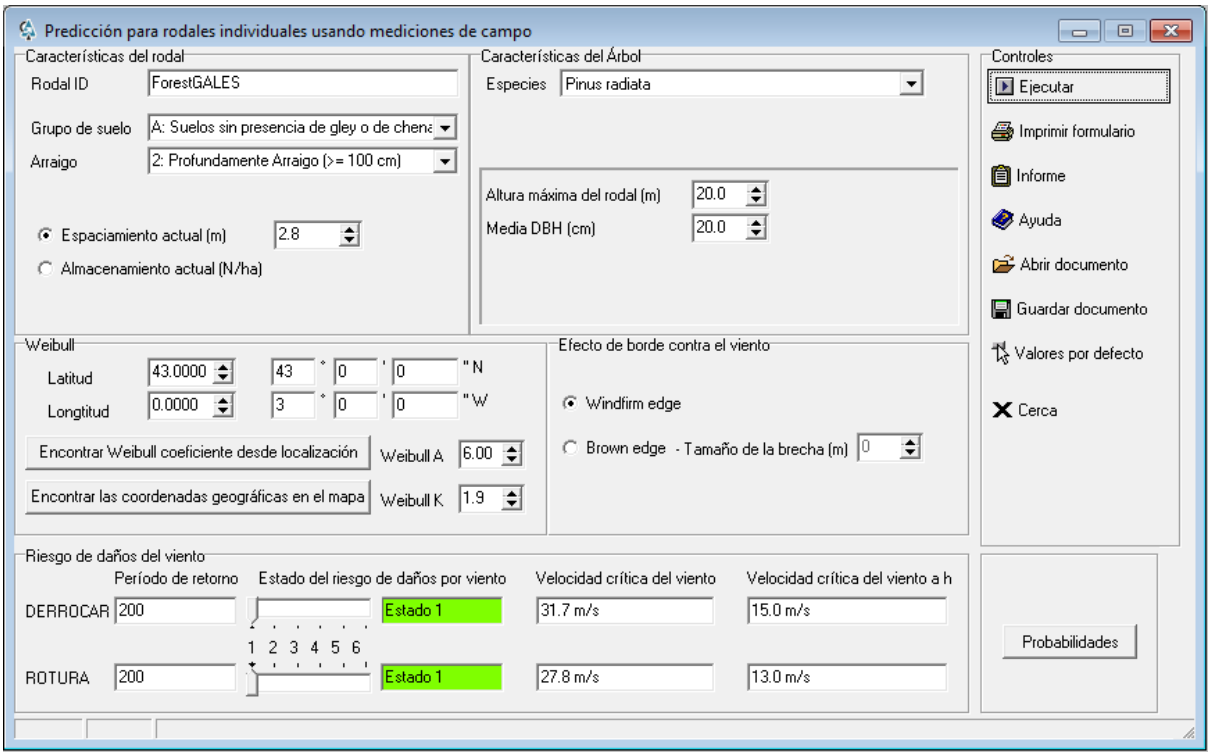
Getting started

1. Start Basaize.
2. Select the Single Stand predictions using field measurements button from the toolbar, which will open a new query form. This form has a range of pre-selected options. However, no value will be initially present in the Wind Damage Risk box.
3. Set:
   a. Species to "*Pinus radiata*"
   b. Soil to Soil type A
   c. Rooting depth to "2: Deep Rooting (>= 100 cm)"
   d. Current spacing to 2.8 m
   e. Top Height to 20 m
   f. DBH to 20 cm
   g. Weibull A to 6.0
   h. Weibull k to 1.9

4. Press the RUN button and the Return Period, Wind Damage Risk Status and Critical Wind Speeds for overturning and breakage will appear in the previously empty boxes at the bottom of the form. The critical wind speeds will be 31.7 m/s for overturning and 27.8 m/s for breakage. Return periods will be 200 years for both overturning and breakage.
5. Change the tree height to 22 m using the up arrow next to the tree height edit box and press the RUN button again. The return periods will change to 122 years for overturning and 7 years for breakage. The risk of wind damage can increase rapidly with tree height for a given DBH.
6. Change soil type and rooting depth. See how the risk changes.

Other parameters can be changed in a similar way and the effect on wind risk observed.

At any time you can save the current parameters as the default parameters with the Defaults button 

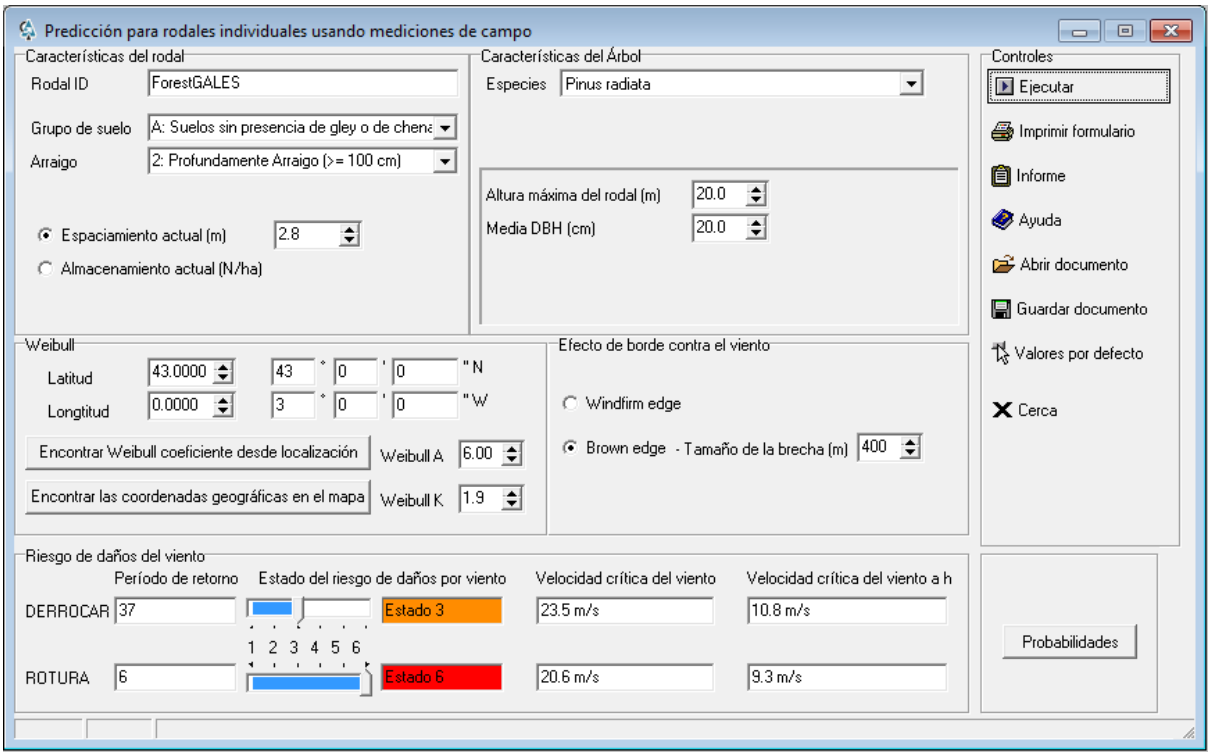


Effect of a new edge

This example shows how creating new edges affects the risk of damage.

1. Start Basaize and open a query form for Single stands predictions using field measurements in the same way as the previous example.
2. Set:
    a. Species to "*Pinus radiata*"
    a. Soil to Soil to Soil type A
    b. Rooting depth to "2: Deep Rooting (>= 100 cm)"
    c. Current spacing to 2.8 m
    d. Top Height to 20 m
    e. DBH to 20 cm
    f. Weibull A to 6.0
    g. Weibull k to 1.9

3. Click on Run. This will give the return periods for damage (200 years) with no new edge.
4. Select the Brown Edge radio button to activate the Size of gap control.
5. Change the Size of gap to 400 m and click on Run. The values in the Probabilities boxes will change and should become 37 years for Return period for overturning and 6 years for Return period for breakage. This indicates that the risk of damage is much greater if a new edge is present, than if no new edge is present. Try increasing the gap to 600m and see if there is an effect. The maximum impact happens at 10 x the mean tree height. Gap widths greater than this have no additional effect on stability.
6. Try changing the size of the gap to 20 m and Click on Run. The values in the Probabilities boxes will change and should become 77 years for Return period for overturning and 9 years for Return period for breakage.



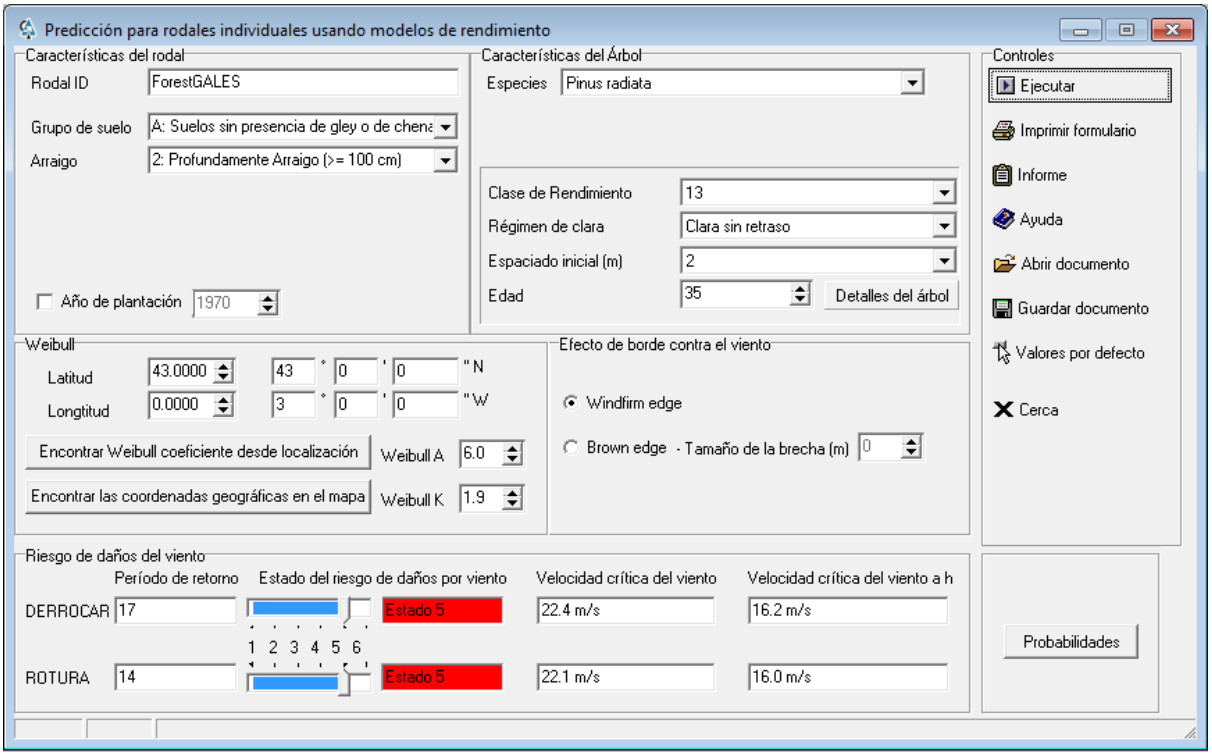
Using yield tables

This example shows how to use yield tables to provide input data for the model.

1. Open a Single Stand Predictions using yield models query form. This form has Tree Characteristics Controls for Yield Class (maximum mean annual increment in m^3/ha), Thinning regime, Initial spacing and age.
2. Set:
    a. Species to "*Pinus radiata*"
    b. Soil to Soil to Soil type A
    b. Rooting depth to "2: Deep Rooting (>= 100 cm)"
    c. Yield class to 13
    d. Thinning regime to "Intermediate thinning with no delay"
    e. Initial spacing to 2.0 m
    f. Age to 20
    g. Weibull A to 6.0
    h. Weibull k to 1.9
    i. Windfirm edge

3. Click on Run. This will give the probabilities of damage for a stand of YC 13 *pinus radiata*, planted at 2.0 m spacing with an intermediate thinning regime (thinning from below) at an age of 20. The values in the Probabilities boxes will change and should become 200 years for Return period for overturning and 200 years for Return period for breakage. The size and spacing of the modelled trees can be viewed using the Tree Details button.
4. Change the age to 40 and Click on Run. The model will tell you that you have exceeded the maximum age in the yield table and set it to 35 years. The values in the Probabilities boxes will change and should become 17 years for Return period for overturning and 14 years for Return period for breakage. This indicates that the risk is increasing with stand

age.
5. Click on the down arrow to the right of “Yield Class”. A menu of “Yield Class” options will appear.
6. Select Yield Class = 28.
7. Click on Run. The values in the Probabilities boxes will change and should become 7years for the Return period for overturning and 4 years for the Return period for breakage. For the same age trees growing at a higher yield class are more vulnerable because they are taller. Check the size in the Tree Details button.

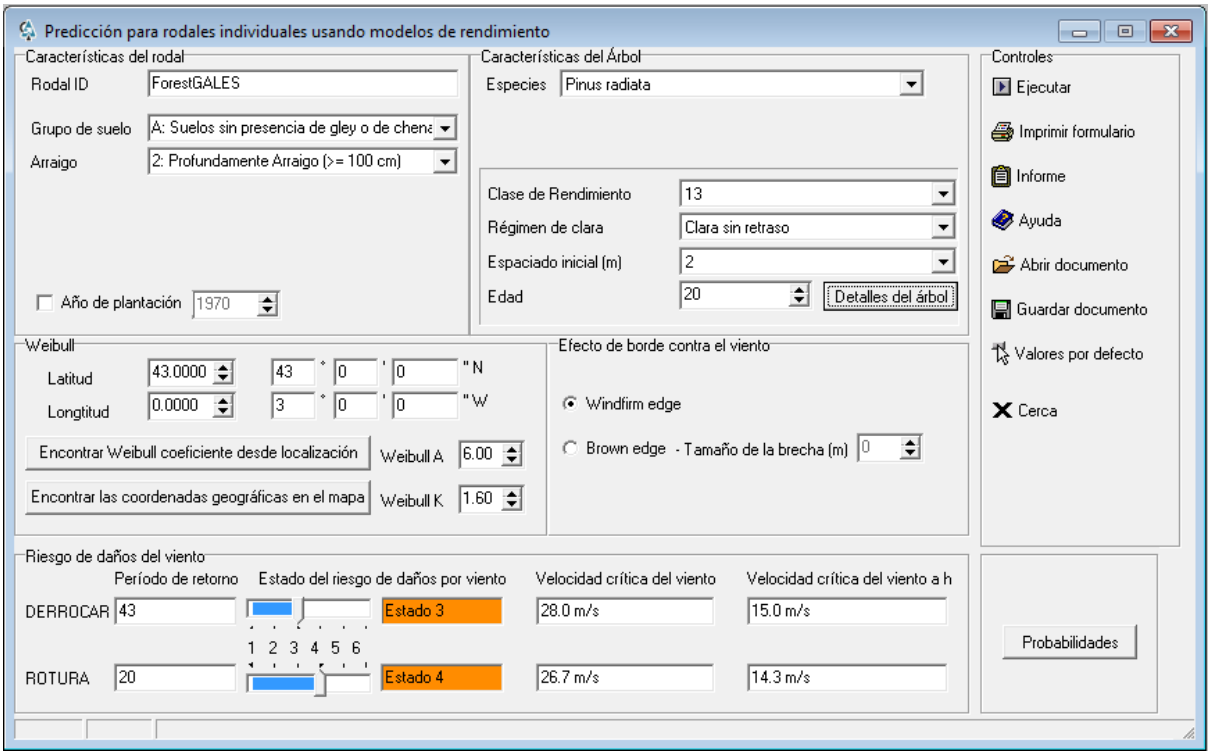


Weibull A and Weibull k Parameters

This example demonstrates the use of Weibull A and Weibull k values as wind climate input for the model.

1. Select the Single stands predictions using yield models in the same way as the previous example.
2. Set:
    a. Species to “*Pinus radiata*”
    c. Soil to Soil to Soil type A
    b. Rooting depth to "2: Deep Rooting (>= 100 cm)"
    c. Yield class to 13
    d. Thinning regime to “Intermediate thinning with no delay”
    e. Initial spacing to 2.0 m
    f. Age to 20
    g. Weibull A to 6.0
    h. Weibull k to 1.9
    i. Windfirm edge

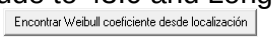
3. Click on Run. The values in the Probabilities boxes will change and should become 200 years for Return period for overturning and 200 years for Return period for breakage.
4. Within the Weibull A box, use the up and down arrows to select 7.0 as the value for Weibull A. The higher the Weibull A the windier the site.
5. Leave the other options as they are and Click on Run. The return periods should change to 52 years for the Return period for overturning and 24 years for Return period for breakage.
6. Change Weibull A back to 6.0 and click on Run. The values in the Probabilities boxes will change back to 200 years for Return period for overturning and 200 years for Return period for breakage.
7. Now change Weibull k to 1.6. Weibull k is a measure of the shape of the wind speed probability distribution. A smaller number means a lower probability of low wind speeds but a higher probability of high wind speeds. Click on Run. The return periods should change to 43 years for the Return period for overturning and 20 years for Return period for breakage.
8. Now



Getting Wind Climate from Latitude and Longitude

This example demonstrates how to obtain the Weibull A and Weibull k values from pre-calculated maps using Latitude and Longitude.

1. Select the Single stands predictions using yield models in the same way as the previous example.
2. Set:
    a. Species to "*Pinus radiata*"
    d. Soil to Soil to Soil type A
    b. Rooting depth to "2: Deep Rooting (>= 100 cm)"
    c. Yield class to 13
    d. Thinning regime to "Intermediate thinning with no delay"
    e. Initial spacing to 2.0 m
    f. Age to 20
    g. Weibull A to 6.0
    h. Weibull k to 1.9
    i. Windfirm edge

3. Click on Run. The values in the Probabilities boxes will change and should become 200 years for Return period for overturning and 200 years for Return period for breakage.
4. Now set the Latitude to 43.0 and Longitude to -2.5. Hit the "Find Weibull Coefficients from Location" button. 

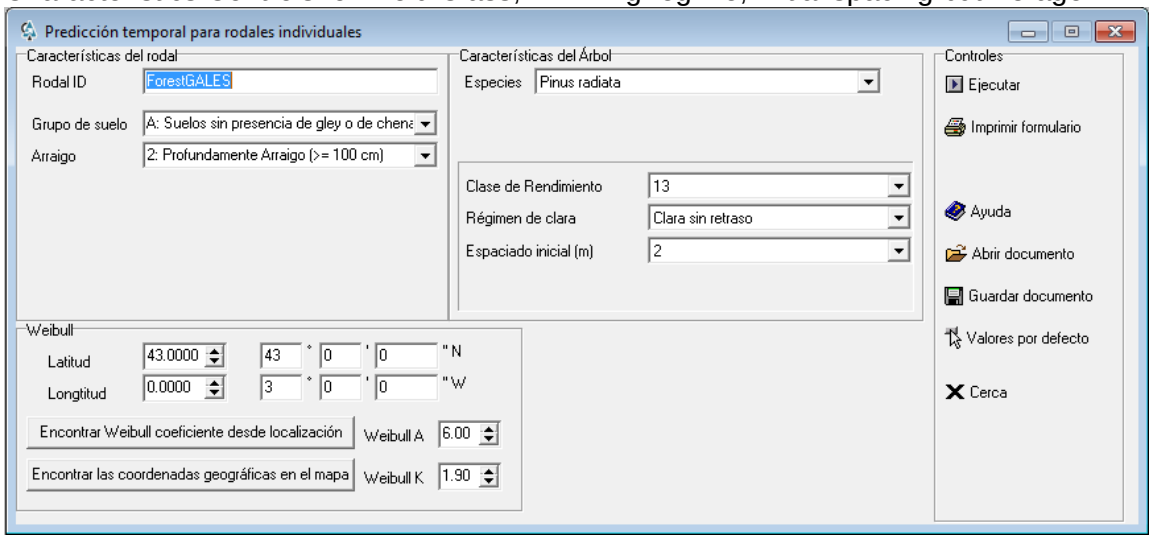
5. There will be a short pause while the computer searches the database and then you should see a Weibull A value of 5.1 and a Weibull k value of 1.5.
6. Click on Run. The values in the Probabilities boxes should remain at 200 years for Return period for overturning but reduce to 112 years for Return period for breakage.
7. Now set the Latitude to 42.6 and Longitude to -2.65. Hit the "Find Weibull Coefficients from Location" button.
8. There will be a short pause while the computer searches the database and then you should see a Weibull A value of 8.08 and a Weibull k value of 1.37.
9. Click on Run. The values in the Probabilities boxes should change to 1 year for Return period for overturning and 1 year for Return period for breakage. Your trees are on top of a mountain and you would not be able to grow trees there!!
10. If you have internet try clicking on the "Find geographic coordinates on map" button. 

You will be presented with a map of Spain. Find a location of interest in the Basque Country. Then copy and paste the Latitude and Longitude into Basaize. Note that Basaize does not use *ctrl-c* for copy so use the right mouse button instead (or *Shift-Ins*).

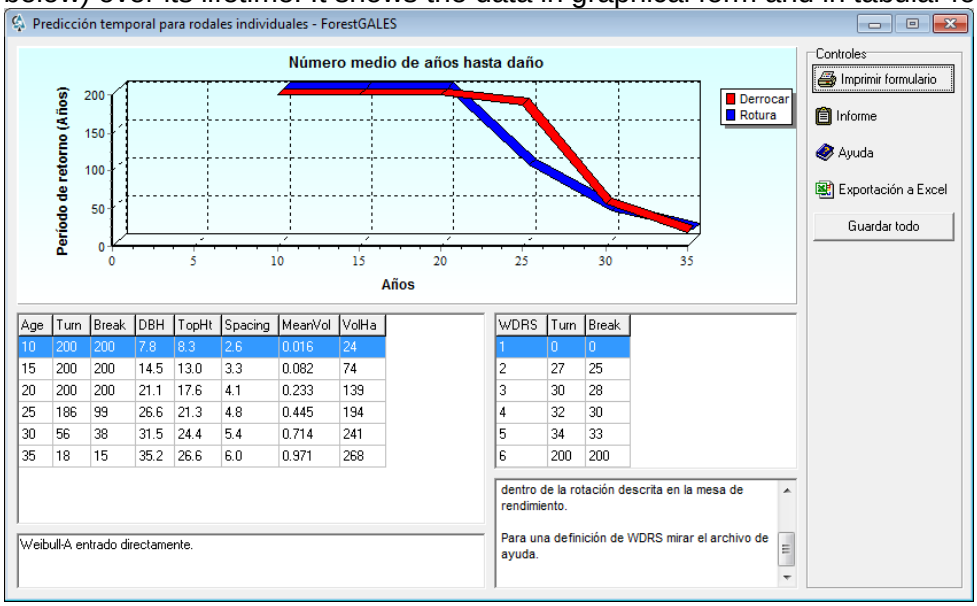
Using Yield Tables over Time

This example shows how to use yield tables over time to show how risk changes

1. Open a Single Stand Predictions through Time query form. This form has Tree Characteristics Controls for Yield Class, Thinning regime, Initial spacing but **no** age.



2. Set:
    a. Species to "*Pinus radiata*"
    e. Soil to Soil to Soil type A
    b. Rooting depth to "2: Deep Rooting (>= 100 cm)"
    c. Yield class to 13
    d. Thinning regime to "Intermediate thinning with no delay"
    e. Initial spacing to 2.0 m
    f. Weibull A to 6.0
    g. Weibull k to 1.9
3. Click on Run. This will give the probabilities of damage for a stand of YC 13 *Pinus radiata*, planted at 2.0 m spacing with an intermediate thinning regime (thinning from below) over its lifetime. It shows the data in graphical form and in tabular form

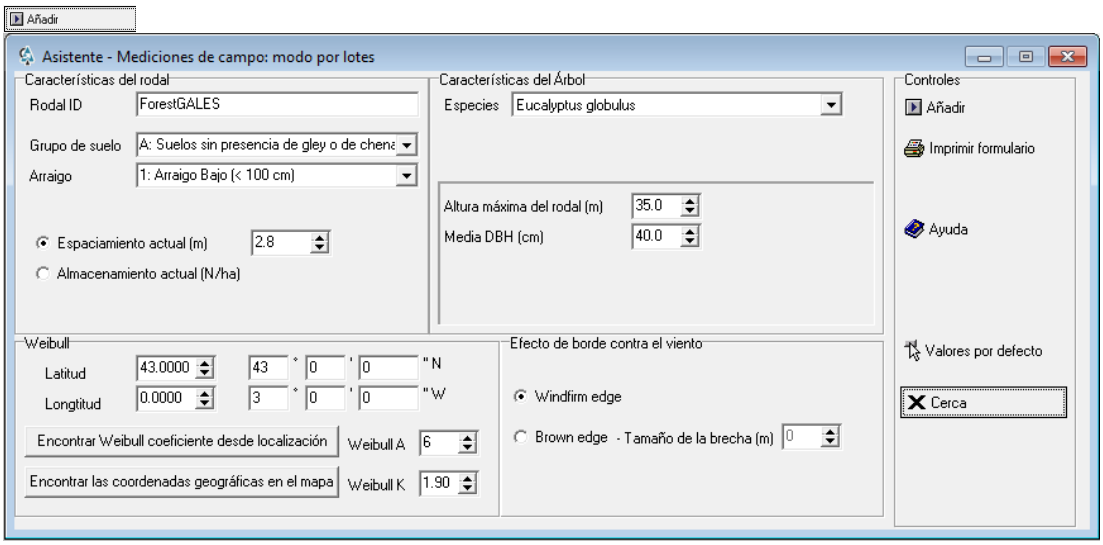


4. Go back to the query form and change the YC to 28. Click on Run. See how the risk now becomes high earlier in the life of the stand.
5. Try changing species and see how the level of risk changes. You can change the species in the Helper screen and see the results directly on the chart.

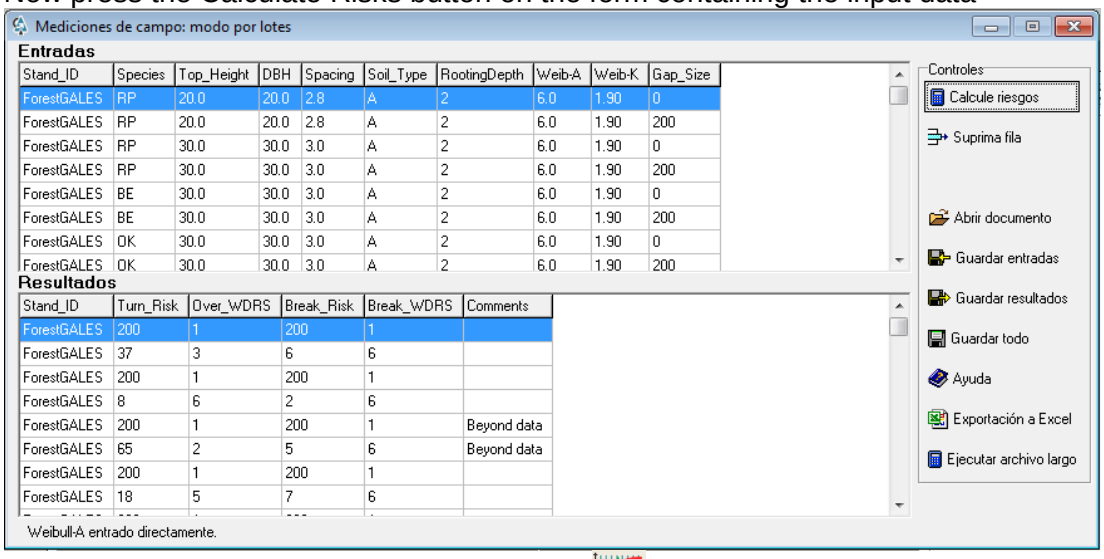
Batch Mode

This example demonstrates how to run Basaize for multiple stands.

1. Open a Mutiple Stand predictions using field measurements query form 
2. In the Helper form set:
    a. Species to “Pinus radiata”
    b. Soil to Soil type A
    c. Rooting depth to "2: Deep Rooting (>= 100 cm)"
    d. Current spacing to 2.8 m
    e. Top Height to 20 m
    f. DBH to 20 cm
    g. Weibull A to 6.0
    h. Weibull k to 1.9
3. Press the Add button
4. Add other lines with different species, soils, rooting, spacing (or stocking), top height, dbh and with and without a Windfirm edge. For each choice press the Add button.



5. Now press the Calculate Risks button on the form containing the input data



6. Try running Batch mode for the Yield models  and the Yield models through time  .

Example Stands

1. Use Batch mode to look at stability of three *pinus radaiata* stands near Aretxabaleta (see Table below). Assume that the soil is Type A.

Stand Number	Mean Diameter (cm)	Top Height (m)	Density (trees/ha)	Type of Soil	Observations
1	43	27.9	250	Shallow	Nearly intact
2	25	23.0	450	Deep	Completely blown down and salvaged
3	15	16.2	650	Deep	2/3 of the pines blown down and salvaged

2. The location is 43.04 N and 2.52 W. Find the Weibull A and k parameters using the "Find Weibull coefficient from location" button 

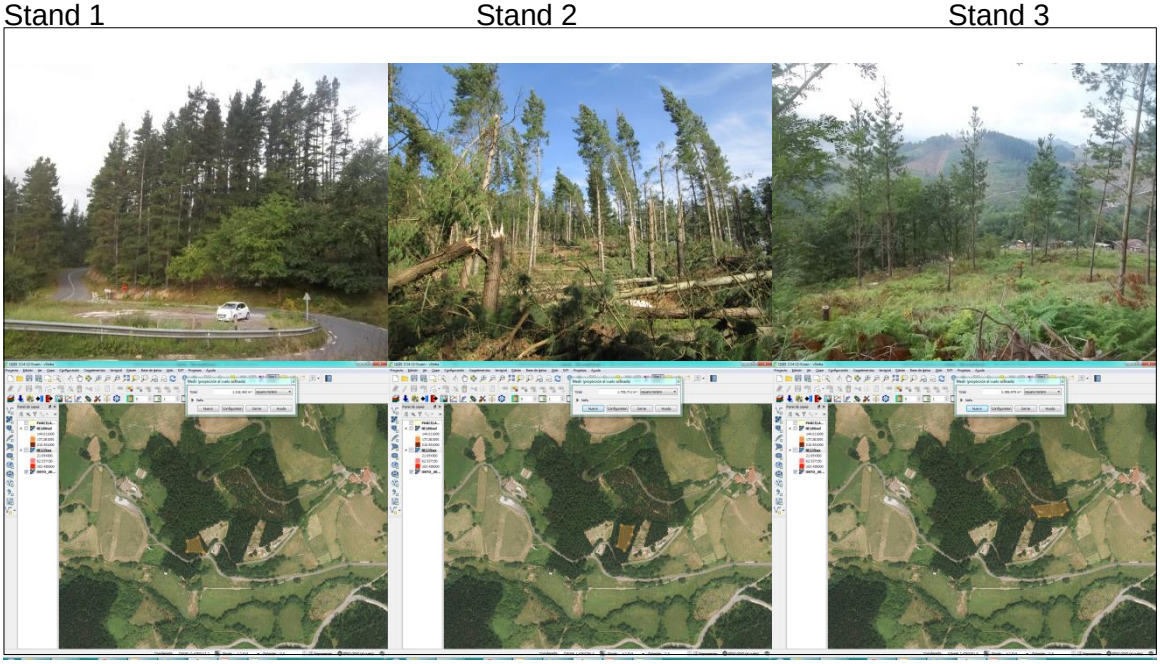
3. Enter the details as 3 entries into the "Multiple Stand Predictions using Field Measurements" button 
4. Run the program 

5. Save the outputs to a text file using the Save All button 

with a name like Aretxabaleta.txt.
6. Open the text file you have just saved in Excel (ideally) or a text editor and look at the critical wind speeds for damage. Do the critical wind speeds correspond to the observed damage?
7. Does the return Period for damage surprise you?

Here are pictures of the damage and aerial pictures of the stands.

Stand 1 Stand 2 Stand 3



Feedback on Basaize Version 1.1

It will be very helpful to us to have your feedback on the model so that we can improve it and make it more applicable to the problems facing forestry in the Basque Country and other parts of Spain.

1. Did you find the model easy to use (Yes/No)?
2. If you answered No (difficult to use) what did you find difficult?
3. What features did you like in the model?
4. What features were not useful?
5. What would you like us to change in the model?
6. What features would you like us to add to the model
7. Do you think you have a use for the model (Yes/No)?
8. If you answered Yes, for what purpose would you use the model?

Would you use the model in a stand-alone mode or integrated into an existing software platform (e.g. GestFore)?

Feedback is summarised in the “Conclusions” section.

12 September – Integrating wind risk model in Basque silviculture

Integrating wind risk model in Basque silviculture

Alejandro Cantero and Barry Gardiner

Note: both presentations were very similar to those of the previous day (11 September). Only extra material is reported here.

Goal

Both presentations were at aimed forest owners, with limited scientific and computer modelling backgrounds, and forest managers.

The main goal was to show how Basaize results will be integrated into Basque yield tables available in MS Excel.

Content

Euskadi foresters have access to two kinds of yield tables: fixed (where the only variable parameter is the yield class) and variable (where the user can adjust several parameters of the plantation/stand). Variable yield tables are only available for radiata pine. In both cases, extra columns will be added with the two critical wind speeds calculated by Basaize: the breakage critical win speed and the uprooting one, for each appropriate soil type. Return period cannot be provided as it depends on the wind climate of the location. User would need to consult a separate wind map in order to enter the Weibull A and Weibull k parameters for their specific location.

Barry introduced the use of Basaize, and concentrated on:

- the stand information needed to feed the model: species, dominant tree height, mean dbh, spacing, soil type, rooting depth and location;
- the outputs: critical wind speed that causes stem breakage or tree uprooting, and their return periods.

Barry also showed the method to create your own yield tables using Basaize and to calculate the outputs from the model.

12 September - Field trip

General plan

The **goal** was to visit three radiata pine stands that were hit by a strong SE winds on February 2017.

Where	Who	What
Private forest, aspect S and SE, near Aretxabaleta (Gipuzkoa)	With Alejandro Cantero (HAZI)	Three radiata pine plantations hit by strong winds from SE on February 2017

Visit

Stand	Mean dbh (cm)	Top height (m)	Density (trees/ha)	Type of soil	Observations
1	43	27.9	250	Shallow	Nearly intact
2	25	23.0	450	Deep	Completely thrown and harvested
3	15	16.2	650	Deep	2/3 of trees thrown

Stand number 1, the tallest, the oldest and the only one growing on shallow soil, suffered no damage. According to Basaize, this stand has the highest critical wind speed (CWS): 24 m/s. That may be mainly due to its highly tapered trees. During the visit, participants were able to see that the stand had its southern border adjacent to a road and its eastern border adjacent to a field, so the trees were acclimatised to wind from the SE. Moreover, the understory was composed of dense scrubs and shrubs. Barry stated that a thick understory could reduce the wind loading on the canopy trees by up to 20%.

Stand number 2 was completely damaged. Its trees were moderately tapered and older than trees from stand number 3. Therefore, they had less juvenile wood, and were therefore less flexible. They mostly broke in the stem. CWS was 19 m/s.

In stand number 3, two thirds of the trees were damaged. The trees had very little taper and were a ratio of height to diameter >100. Compared to stand number 2, it had less damage because trees were younger, with more juvenile wood, so more flexible. However, the remaining trees were badle bent during the storm, creating internal cracks that would reduce timber quality and potentially make them more vulnerable to wind in the future. CWS 16 m/s.

Field trip discussions

Barry Gardiner, Tommaso Locatelli and Alejandro Cantero were questioned by attendees concerning wind risk forest management topics. A video with various interviews with the speakers is available on the web http://basoa.org/es/comunicacion/videos

How to **spread the risk**: Barry proposed to forest owners to mitigate the risk by spreading it. For a forest owner this could mean a diversification of species planted or a diversification of silvicultural regimes implemented.

Effects of **microtopography**: although Euskadi has 70 meteorological stations, even this high density of observations cannot provide a wind climate with a spatial resolution that can consider all microtopographic elements. The terrain in Euskadi is extremely variable and this reduces the accuracy of the wind climate map.

Stand structure limitations of Basaize: as with ForestGALES, Basaize was developed for even-aged monospecific stands, as it assumes a uniform roughness all over the stand. A new model is being developed by Tommaso Locatelli for uneven-aged stands and/or mixed species stand. However, this model will need more inputs to describe the stand than Basaize needs (i.e. diameter and height and species of every tree in a stand). According to Alejandro Cantero, these inputs could be obtained from airborne and terrestrial LiDAR.

Impact of **pruning**: according to Barry, standard pruning has little effect on wind vulnerability. However, removal of the bottom part or top part of the canopy (crown pruning) can have stability benefits.

Impact of **rain**: wet soils reduce soil cohesion and root attachment. Therefore, strong winds after a period of rain may cause more damage than the same winds when the soil is dry.

Impact of **snow**: snow has a high impact on wind vulnerability by increasing the crown load of trees. Currently, ForestGALES can handle the presence of snow on trees. However, this option has been disabled in Basize because obtaining the joint probabilities of snow, temperature and wind required to do the calculation is extremely difficult.

Impact of **climate change**: climate change is expected to the intensity of extreme wind events.

Conclusions

Discussion on wind risk management models

Alejandro Cantero would like to know if forest managers could use Basaize from GestFore (instead of a stand-alone software), a website platform for professional foresters to make forest management plans.

Diputación Foral de Bizkaia is interested in calculating wind risk for trees beside roads. Barry said that it is possible with the current version of Basaize.

Feedback on Basaize Version 1.1

After the exercises, organisers requested attendees to provide their feedback on the software through a questionnaire. Eight people answered, in five questionnaires. Summary of the answers (*notes of the author in italic*):

1. Did you find the model easy to use? If not, what did you find difficult?

All participants found the model easy to use. One participant found some parts (not specified which) were not so easy to use.

2. What features did you like in the model?

The input forms are very easy to understand and can be filled in quickly.
The return periods and the critical wind speeds as outputs of the model.

3. What features were not useful?

The relation between the Weibull coefficients and the geographical coordinates of the stand.

4. What would you like us to change in the model?

Upper icons are too similar; they should be more different.
Silvicultural regimes should be more flexible.
It would be better to use site index instead of yield classes. *This answer appears in two questionnaires answered by four people.* Units should be specified.
Increase the maximum age of some species. E.g.: for oak species it is not possible to put more than 35 years.
The arrangement of the outputs windows should be improved. *By default, new output windows completely overlap the older windows, so users think that they have been closed. Cascade arrangement could solve this and allow users to easily compare different outputs, as comparing different scenarios of the same stand.*
The translation to Spanish has to be improved.

5. What features would you like us to add to the model?

It would be interested to show the altitude, slope and aspect of the coordinates.
Perhaps it would be useful to be able to choose just one dominant wind (one direction among the eight wind aspects).
Show the graphical frequency distribution of the wind speed for the requested location.
In batch mode, it would be useful to modify the inputs after batch mode modelling has been launched. *Through the GUI instead of having to do it in the text file.*

6. Do you think you have a use for the model? If yes, for what purpose would you use the model?

All participants found the model useful. Model usage purposes are:

- To forecast the wind risk in forested areas.
- To choose the best sites for plantations in the public forest areas *(the sites with lowest wind risk)*; and to locate the best sites for non-production forests *(the sites with highest wind risk)*.
- To simulate and compare wind risk between different silvicultural regimes.
- To evaluate and locate potential damage areas.
- For forest owners and administrations: to evaluate risks and identify the most suitable silvicultural regimes.
- To integrate wind risk in forest management plans.

7. Would you use the model in a stand-alone mode or integrated into an existing software platform (e.g. GestFore)?

- Both: 4 answers (depending on the use)
- Into GestFore: 3 answers
- Stand-alone: 1 answer

Decisions on Basaize

This first version of Basaize will be improved by Barry with the requests from the attendees (11 September workshop). When the final version will be ready, Eduard will correct the Spanish and translate the Help file from English to Spanish. Afterwards, Alejandro (or someone from HAZI) will translate the whole into the Basque language.

HAZI will be the responsible organisation to disseminate Basaize in Euskadi.

Decisions on Basque yield tables

For fixed yield tables and for the radiata pine variable yield table, Barry will initially add extra columns with the critical wind speed for stem breakage and tree uprooting at each stand age and for different soil and rooting depths.

General workshop evaluation questionnaire

Questions

Workshop content

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
1.	I was well informed about the objectives of this workshop and they were clear to me.			6	4		
2.	This workshop fulfilled my expectations.			6	3		1
3.	The content is relevant to my job tasks concerning forest risks management.		2	4	4		
4.	The quality and depth of knowledge of this workshop were appropriate and represented state-of-the-art tools/technologies.			5	5		

Workshop design

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
5.	The workshop activities/case studies stimulated my learning.			7	3		
6.	The activities/case studies in this workshop gave me sufficient practice and feedback.		1	7	2		
7.	The difficulty level of this workshop was appropriate.			7	3		
8.	The pace of this workshop was appropriate.			6	4		

Workshop instructor/facilitator/lecturer

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
9.	The instructor/facilitator/lecturer was well prepared.			3	7		
10.	The instructor/facilitator/lecturer was helpful.			3	7		

Workshop results

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
11.	I accomplished the objectives of this workshop.			8	2		
12.	I would be able to use the tools that I learned in this workshop on my tasks concerning forest risks management.		1	7	2		
13.	The exchanges with other professionals/instructors/lecturers were fruitful and will be useful for accomplishing my tasks concerning forest risks management.			8	2		

Self-paced delivery

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
14.	The workshop was a good way for me to learn its content.			5	5		

Field trip

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
15.	The field trip was appropriate for the content of the workshop.			4	2		4
16.	The exchanges with the professionals during the field trip were relevant and helped me to understand the issues about this forest risk management.			5	1		4

Improvements and values

How would you improve this workshop? (Check all that apply)

_2_Provide better information before the workshop.
___Clarify the workshop objectives.
___Reduce the content covered in the workshop.
___Increase the content covered in the workshop.
___Update the content covered in the workshop.
___Improve the instructional methods.
___Make workshop activities more stimulating.
___Improve workshop organization.
___Make the workshop less difficult.
___Make the workshop more difficult.
___Slow down the pace of the workshop.
___Speed up the pace of the workshop.
_1_Allot more time for the workshop.
___Shorten the time for the workshop.
___Improve the tests used in the workshop.
_2_Add (more) video to the workshop.

What other improvements would you recommend in this workshop? *The order of the answers is not relevant.*

-

What is least valuable about this workshop? *The order of the answers is not relevant.*

-

What is most valuable about this workshop? *The order of the answers is not relevant.*

Opinion exchange between professionals.