

hazi



Vulnerability to wind and to fire forest maps for the Basque Country, based on Lidar 2012

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Which is our objective?

To have a (cheap, fast) methodology to calculate the main forest parameters taking advantage of free, available information in Spain:

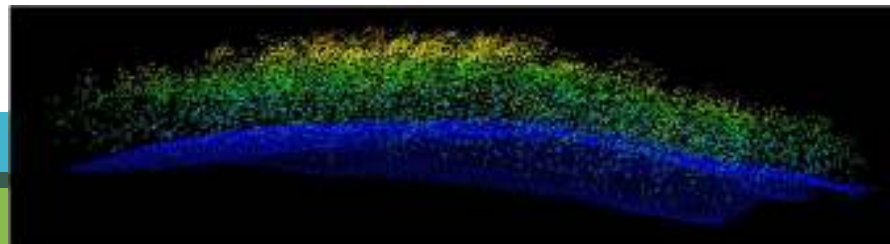
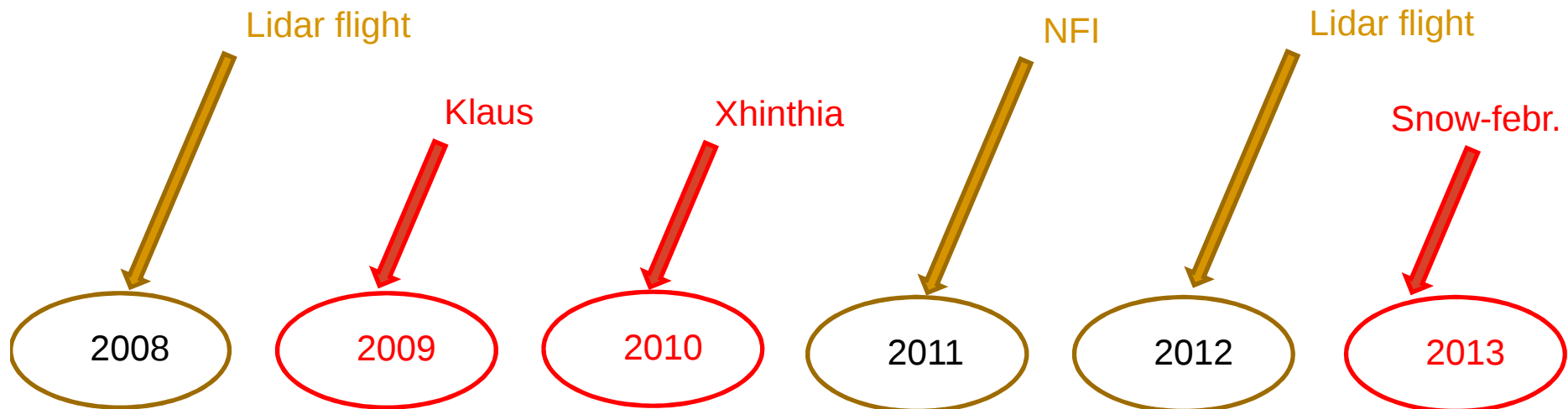
- National Forest Inventory (NFI): plots remeasured each 10 years and located in a 1 km*1 km net, all around Spain
- Lidar flight for all Spain: PNOA programme 2008-2012



Which tools have we got in Basque Country?

Two National Forest Inventory (NFI). Previous NFI in 2005, with 4.000 permanent plots. Last NFI in 2011, with remeasurement of 2.000 plots of them, included in the 4th Spanish NFI (2008-2018).

Two Lidar flights for all the Basque Country: 2008 (4 points/m²) and 2012 (2 points/m²).



First model: wind risk – Available data (1)

National Forest Inventory (2011 NFI) provides wind and snow damages in each plot, located in a 1 km*1 km net all around the Basque Country

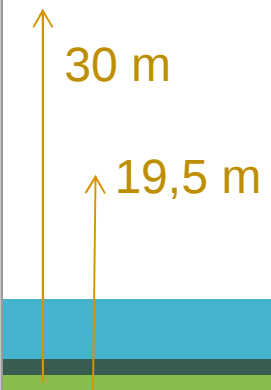
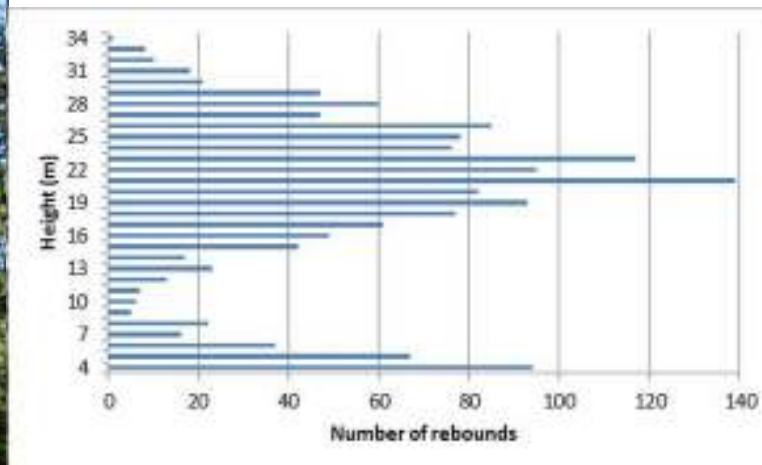
In each NFI plot, a circle with 25-m radius is built to analyse the relationship between each forest variable and 2012 Lidar rebound distribution («center of gravity» at several height intervals)

So, in each forest type of the Basque Country, several models are built to calculate these relationships with rebounds above of 4 m



Example: radiata pine NFI plot

Mean tree height=30 m, Gravity center=19,5 m

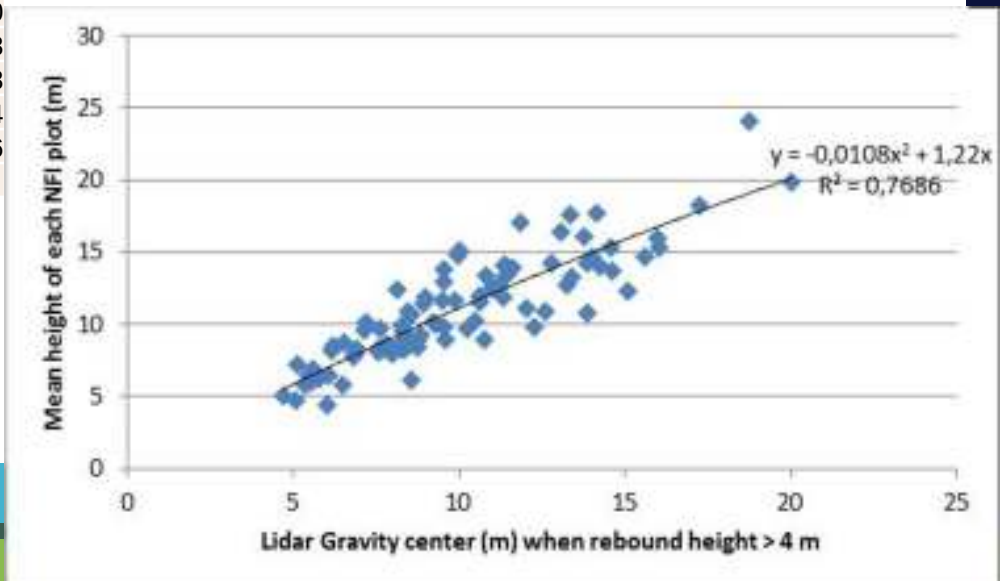


First model: wind risk – Available data (1)

Different models built for main forest types of the Basque Country:

Main type	Nb. of plots	Equation for Mean height	R2
Lawson cypress	6	$-0,0565x^2 + 2,0966x$	0,1700
Scot pine	90	$-0,0108x^2 + 1,22x$	0,7686
Laricio pine	72	$-0,0188x^2 + 1,4759x$	0,7916
Pinaster pine	49	$-0,011x^2 + 1,3428x$	0,8061
Radiata pine	514	$-0,0169x^2 + 1,5755x$	0,6048
Douglas fir	23	$-0,0199x^2 + 1,4747x$	0,7153
Larix	170	$0,0056x^2 + 1,126x$	0,8711
Oak	72	$-0,0059x^2 + 1,057x$	0,6236
Quercus pyrenaica	68	$-0,0187x^2 + 1,2489x$	0,4358
Quercus faginea	108	$-0,042x^2 + 1,4212x$	0,5180
Green oak	970	$0,0013x^2 + 1,0011x$	0,7588
Eucalyptus	56	$-0,0086x^2 + 1,1861x$	0,6118
Beech	223	$-0,0354x^2 + 1,7121x$	0,5594
Other broadleaves	158	$-0,0196x^2 + 1,2742x$	0,5746
Total	1553		

Example: Scot pine plots



First model: wind risk – Available data (1)

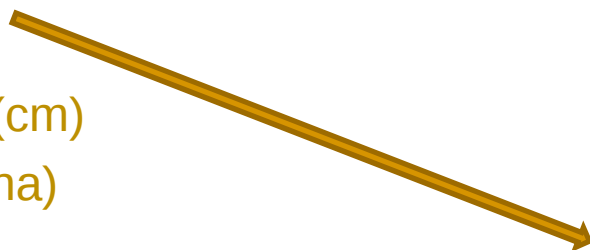
Models built for main forest types of the Basque Country:

Main parameters

Mean height, h (m)

Mean diameter, d_g (cm)

Growing stock (m^3/ha)



Secondary parameters

Slenderness coefficient h/d (-)

Dominant height, h_o (m)

Basal area, g (m^2/ha)

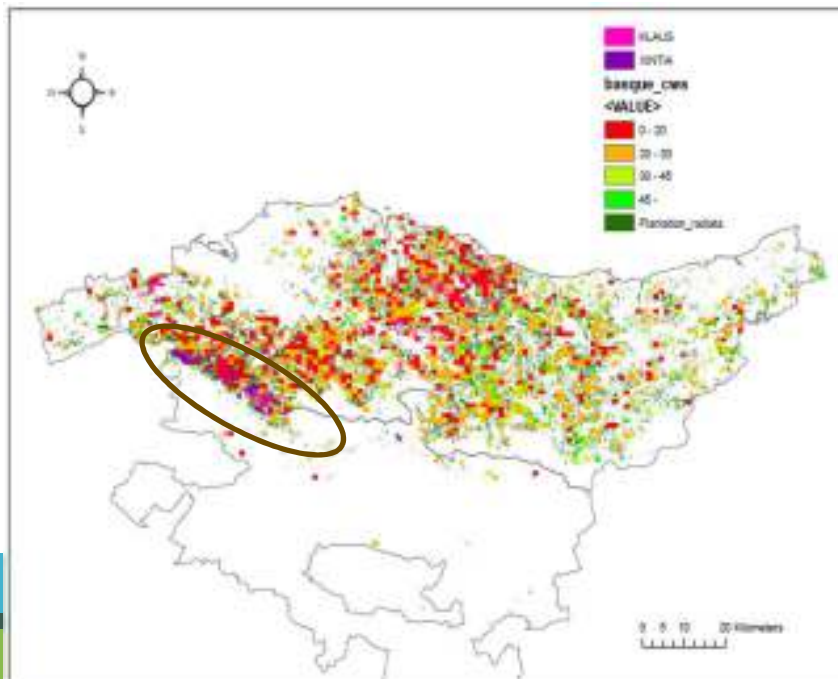
Density (stems/ha)

Unitary volume ($m^3/stem$)

First model: wind risk – Available data (2)

« Cantabrica Alavesa » Region:

- several strong winds last year
- Database with affected parcels by wind
- National Forest Inventory (NFI) provides 100 plots with several degrees of forest cuts caused by wind in 2005-2011
- good region to study the damages caused by wind in radiata pine stands



First model: wind risk – Available data (2)

So, this « Cantabrica Alavesa » Region is a good place to test our wind risk models: 11.500 hectares of radiata pine, whose 2.000 ha are damaged by Klaus or Xinthia, under several degrees of damages and located in different altitudes, slopes, orientations, types of soil,...

Ayala
Council



Amurrio
Council

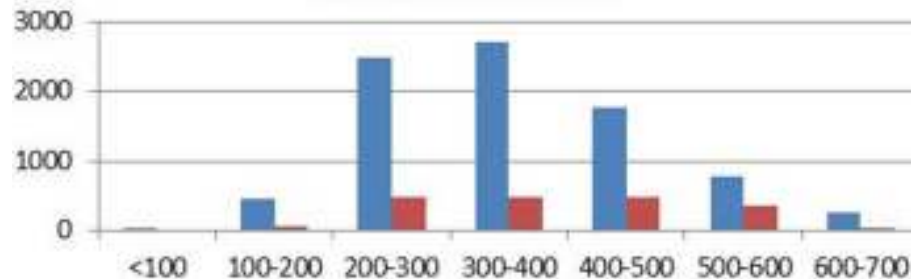
First model: wind risk – Conclusions

Two models tested for radiata pine probability of damages IN EACH 1-HECTARE CELL:

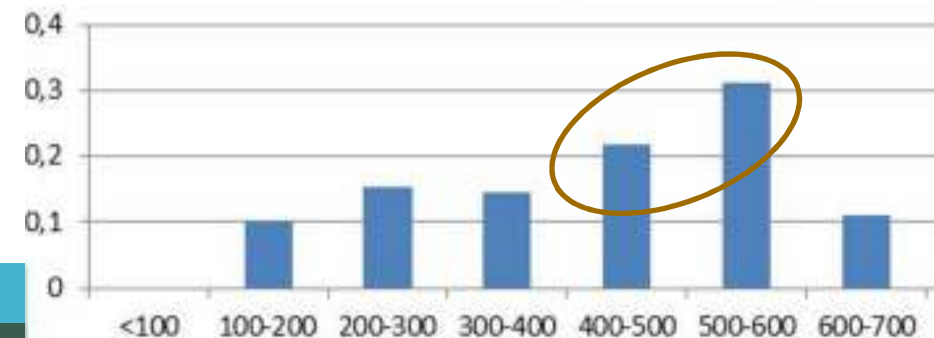
- Model 1 / Based on stand density: Wind risk = f (Slenderness coefficient h/d, Basal area)
- Model 2 / Based on trees mean dimensions: Wind risk = f (Slenderness coefficient, Mean height/Mean diameter)

Both of them depend on Altitude: more Altitude, more Probability of damages

Damaged surface (ha), in red, vs. undamaged surfaces, in blue



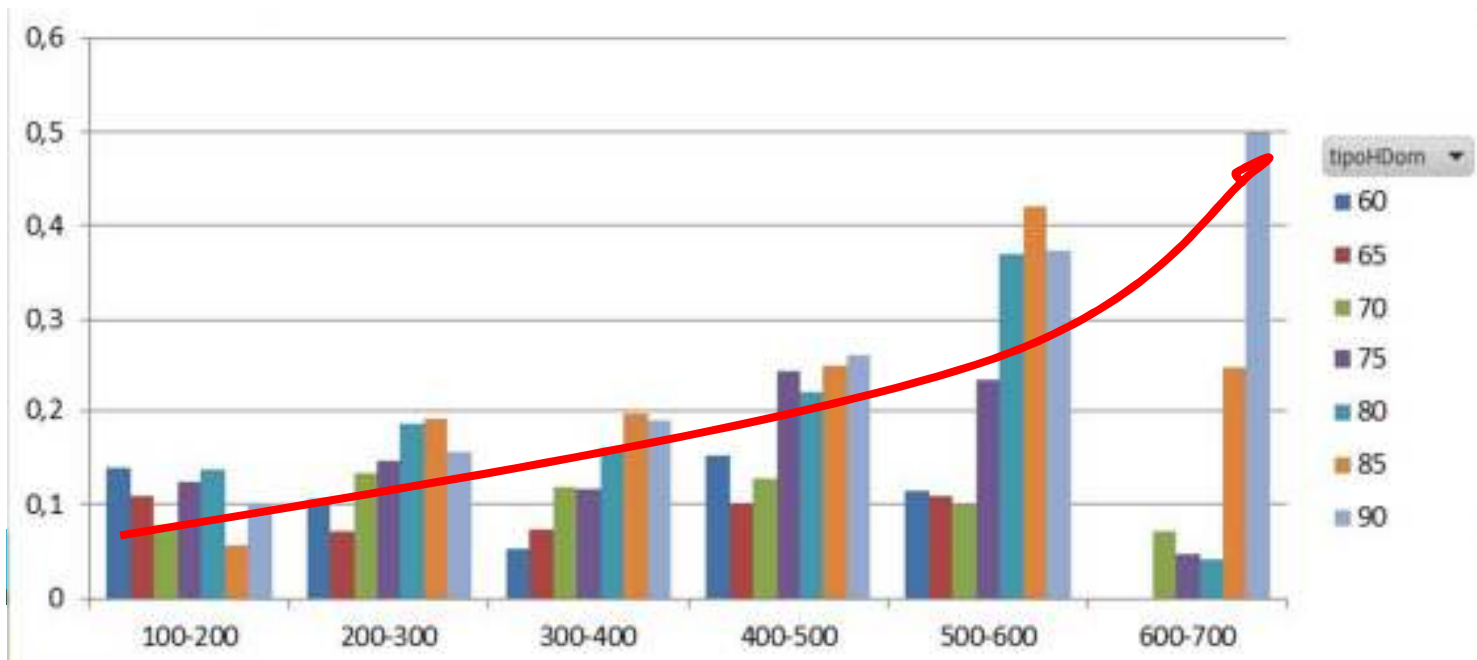
Probability of damages



First model: wind risk – Conclusions

In radiata pine stands:

- Wind risk increases according on Altitude and Slenderness coefficient h/d
- Wind risk increases according on Altitude and Basal area
- Wind risk increases according on Altitude and Mean/dominant height



First model: wind risk – Conclusions

These models for radiata pine are adapted for other three species present in the Basque Country.

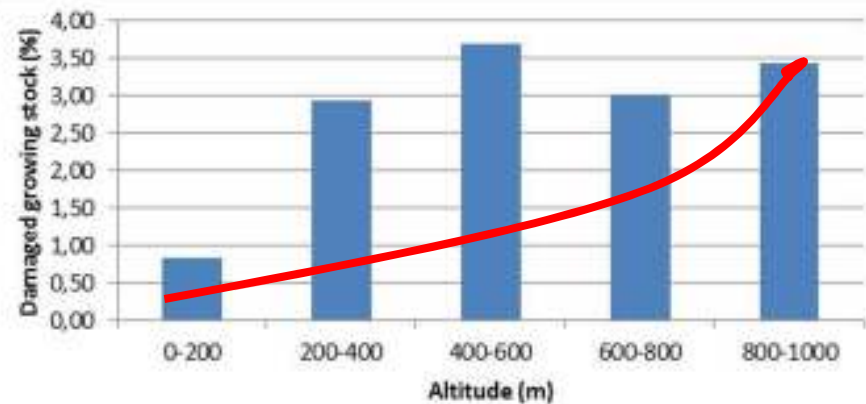
They have perennial leaves (maximum risk in winter).

Table 1. A ranking of the vulnerability of important tree species of European forests to wind damage. Adapted from Colin et al (2009).

Vulnerable	Intermediate	Resistant
<i>Picea abies</i>	<i>Pinus nigra</i>	<i>Larix decidua</i>
<i>Picea sitchensis</i>	<i>Pinus nigra</i> ssp <i>laricio</i>	<i>Abies alba</i>
<i>Pinus pinaster</i>	<i>Pinus sylvestris</i>	<i>Cedrus atlantica</i>
<i>Pseudotsuga menziesii</i>	<i>Fagus sylvatica</i>	<i>Quercus robur</i>
<i>Pinus contorta</i>	<i>Pinus avium</i>	<i>Quercus petraea</i>
<i>Populus nigra</i> , <i>P. trichocarpa</i> , and hybrids	<i>Betula pendula</i>	<i>Tilia cordata</i>
<i>Populus tremula</i>	<i>Betula pubescens</i>	<i>Carpinus betulus</i>
<i>Pinus radiata</i>	<i>Castanea sativa</i>	<i>Fraxinus excelsior</i>
<i>Eucalyptus globulus</i>		<i>Acer pseudoplatanus</i>

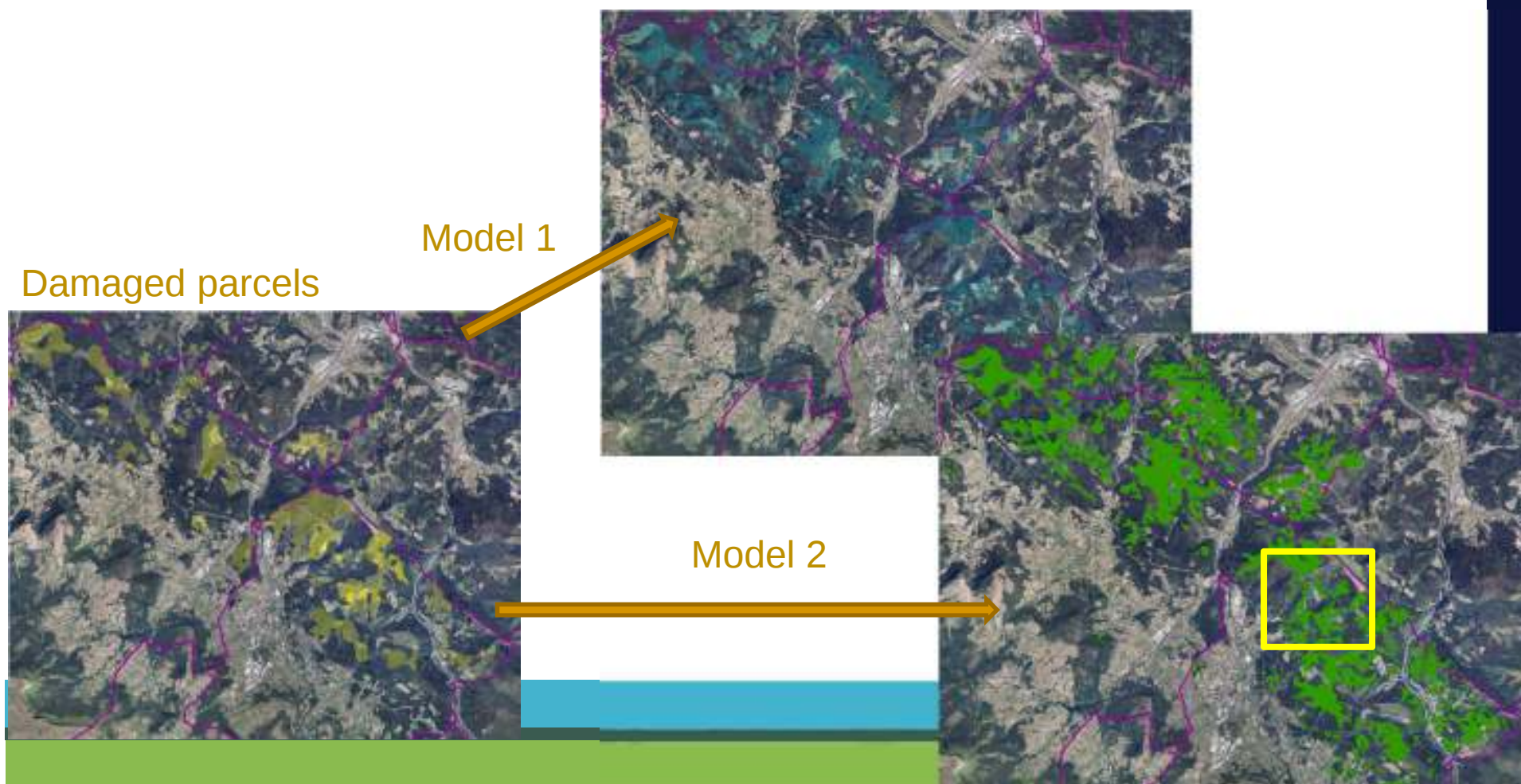
% damages depend on Altitude

Main type	0-200	200-400	400-600	600-800	800-1000	Mean %
Pinaster pine	0,00	1,76	3,89	0,72	3,42	2,03
Radiata pine	1,93	4,41	6,67	7,75		4,68
Douglas fir		3,62	3,09	0,59		2,13
Eucalyptus	0,56	1,89	1,08			1,10
Total species	0,83	2,92	3,68	3,02	3,42	2,75

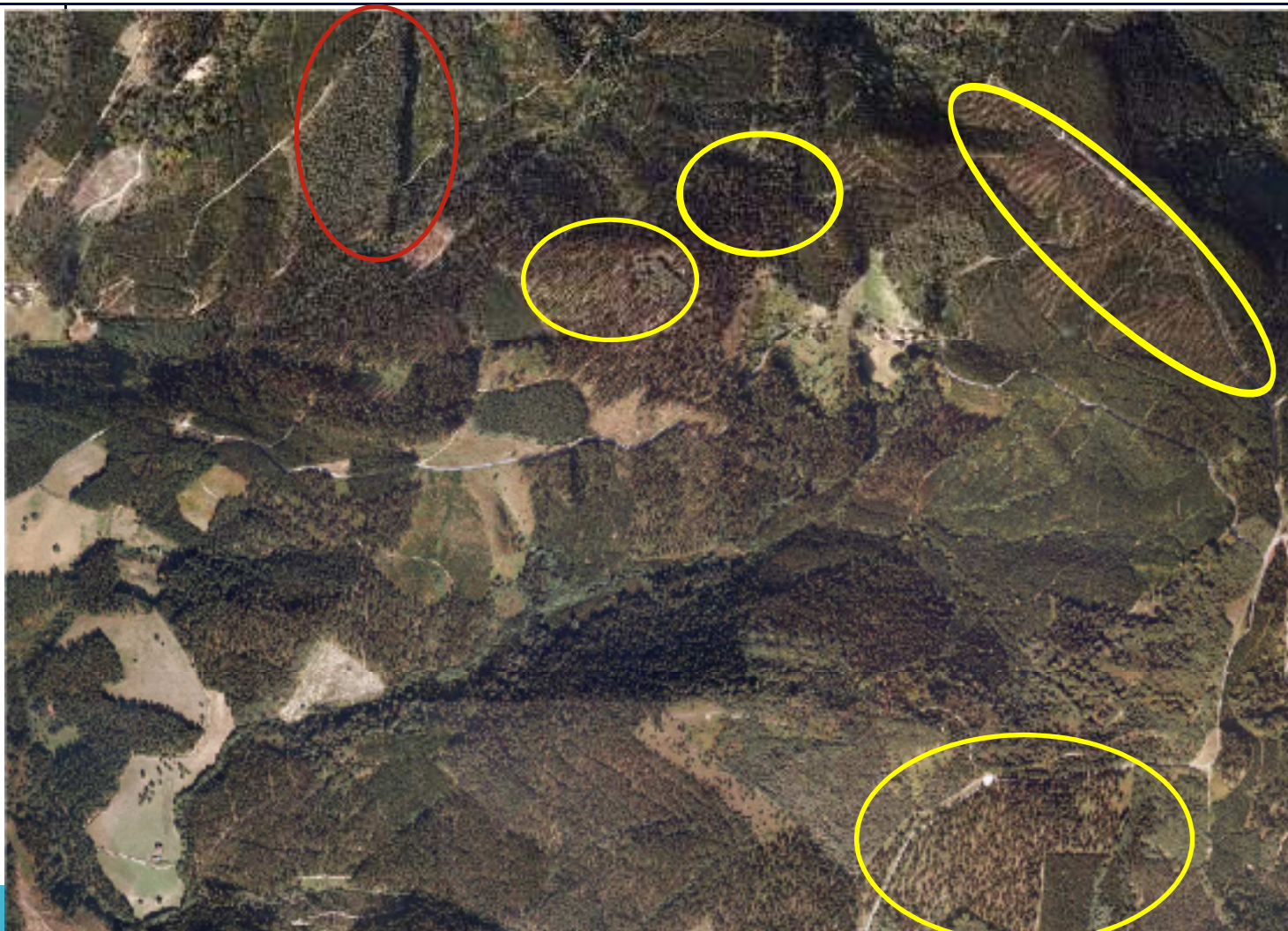


First model: wind risk – Results

More than 60% of success with these models (with variable damage degree)



First model: wind risk – Results



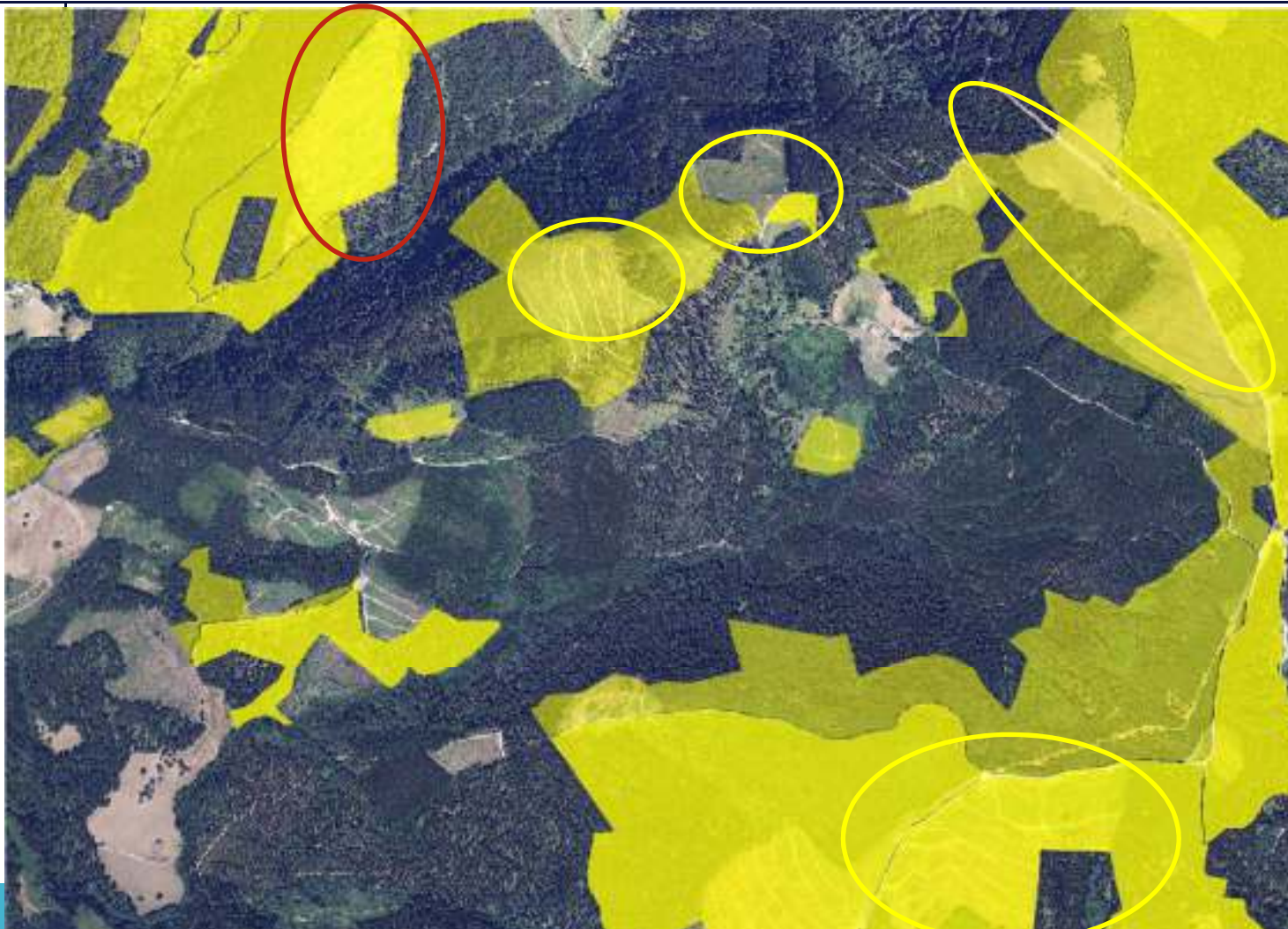
Amurrio in 2008, before Klaus and Xynthia damages

First model: wind risk – Results



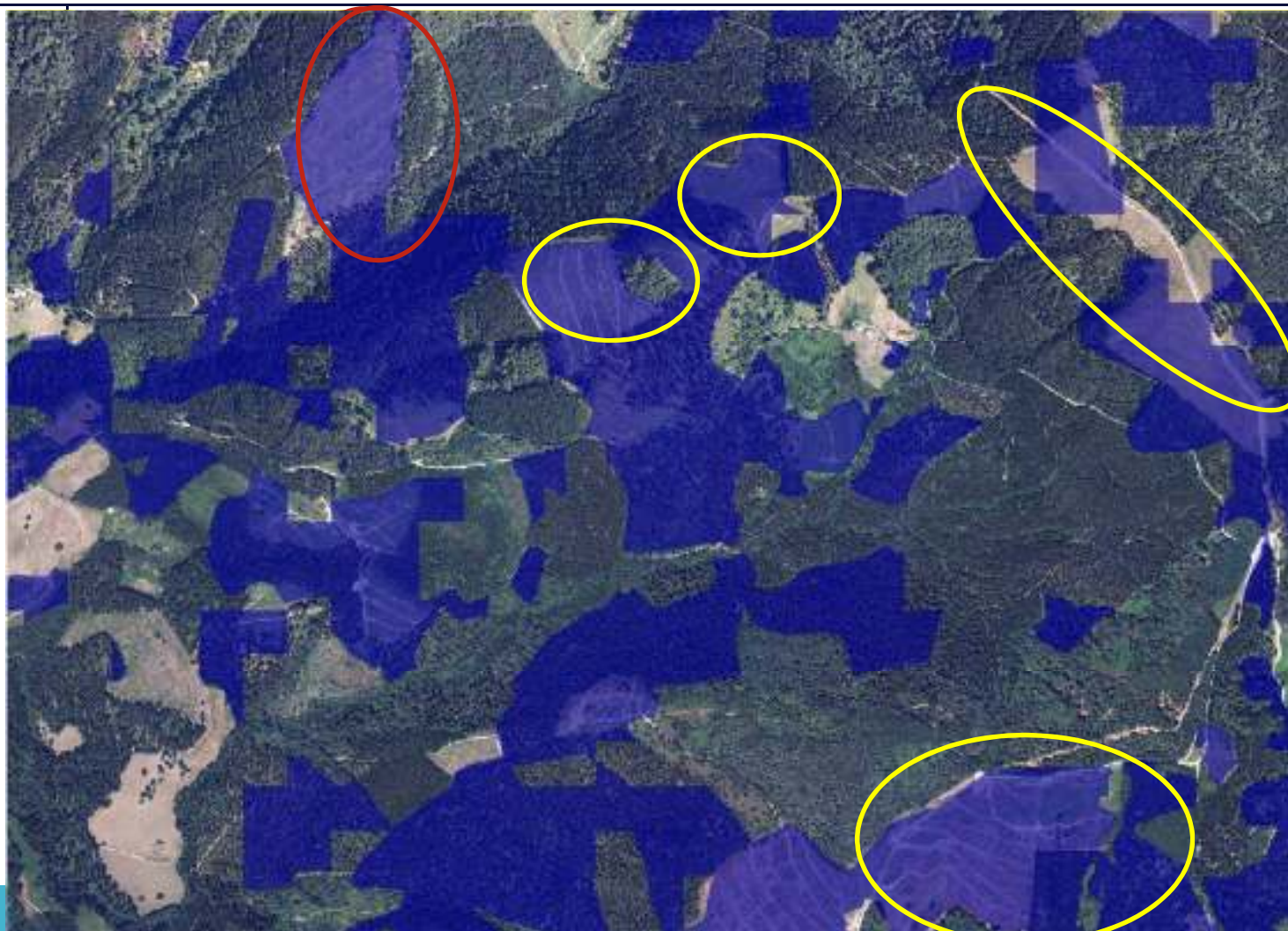
Amurrio in 2013, after Klaus and Xynthia damages

First model: wind risk – Results



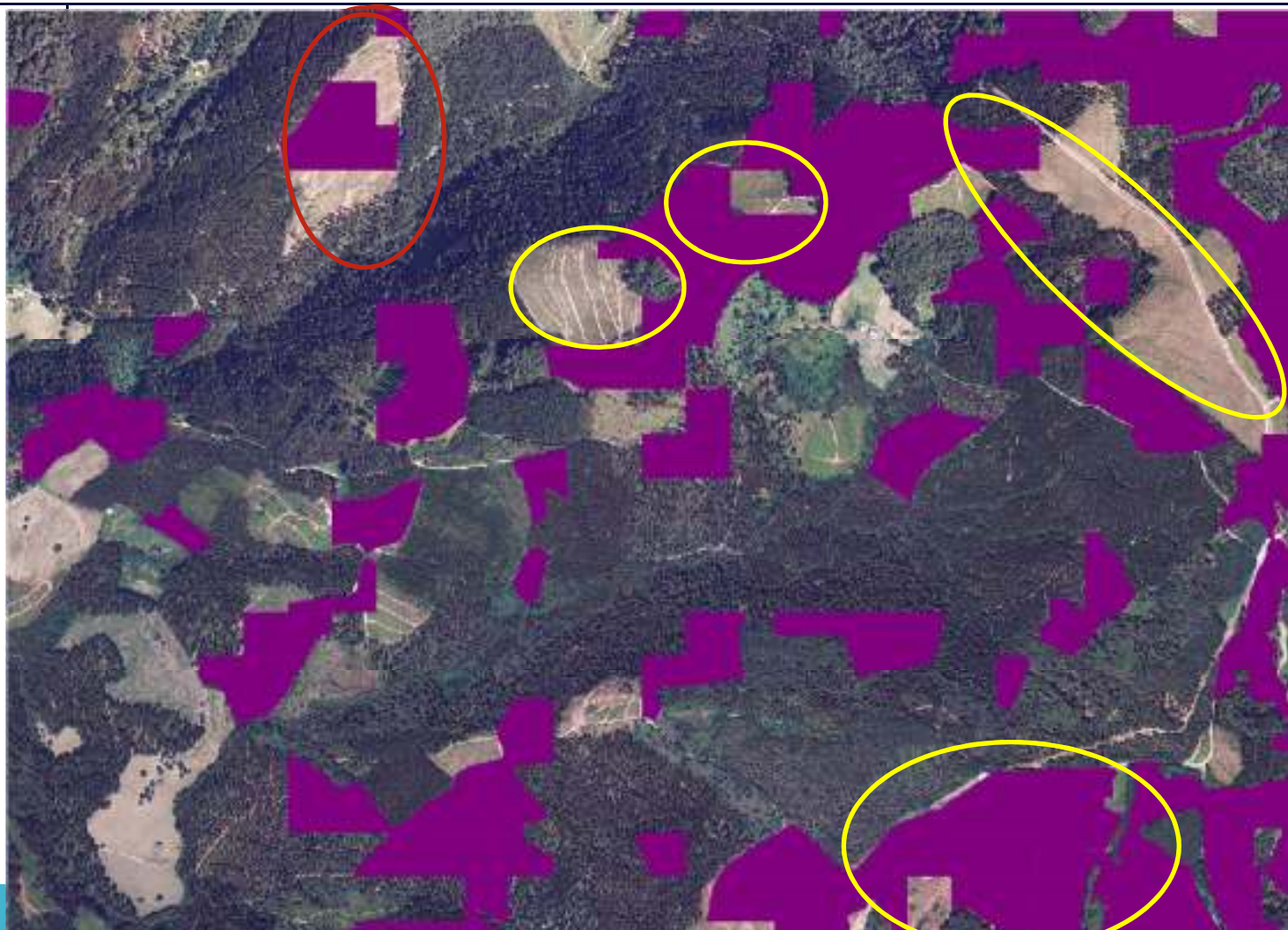
«Official» Parcels with Klaus and Xynthia damages

First model: wind risk – Results



FORRISK Wind risk model-2008 Lidar (before Klaus and Xinthia)

First model: wind risk – Results

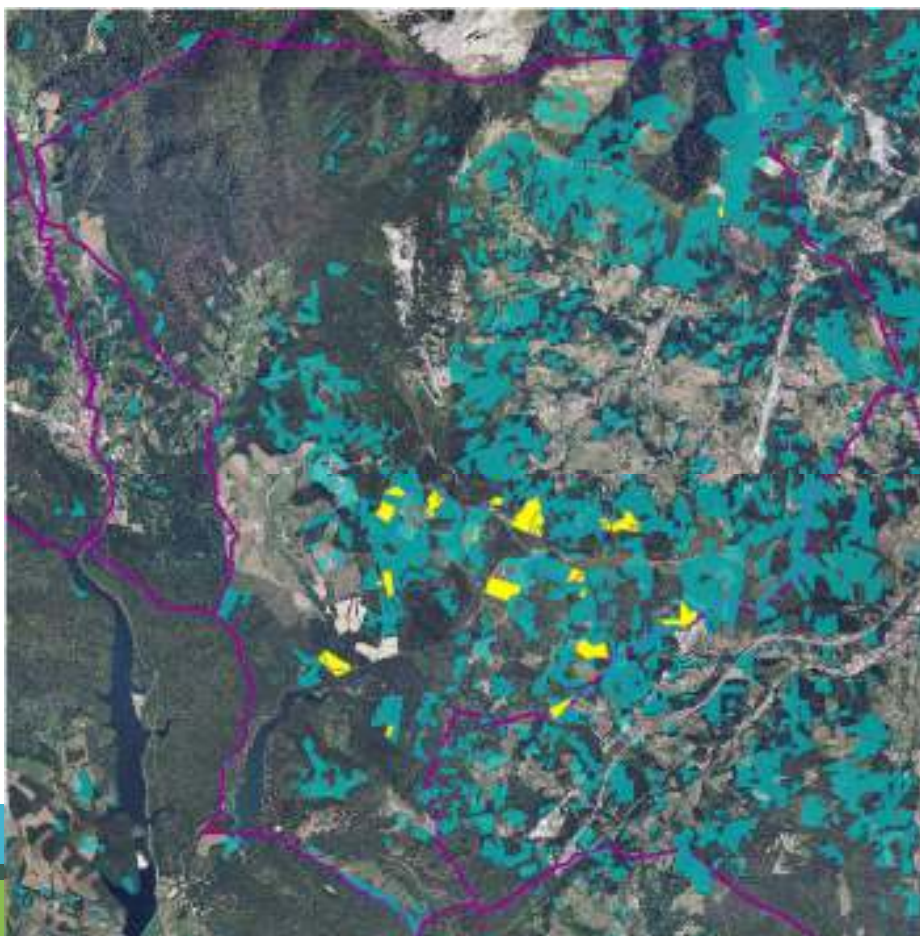


FORRISK Wind risk model-2012 Lidar (after Klaus and Xinthia)

First model: wind risk – Results

Using these models, 28% of the radiata pine surface in Basque Country has high wind risk

Example of prediction: damages caused by frozen snow in radiata pine stands of Aramaio Council (february 2013)



Second model: fire risk – Available data

National Forest Inventory (2011 NFI) provides height and coverage shrub (under trees) in each plot, located in a 1 km*1 km net all around the Basque Country

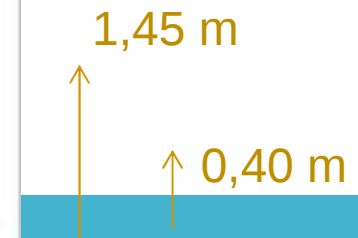
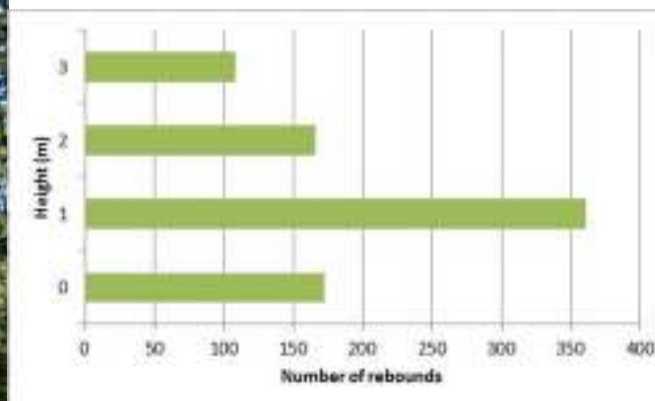
In each NFI plot, a circle with 25-m radius is built to analyse the relationship between shrub growth and 2012 Lidar rebound distribution («center of gravity» at 0-3 m height)

So, in each forest type of the Basque Country, several models are built to calculate these relationships with rebounds located between 0 and 3 m



Example: radiata pine NFI plot

Mean shrub height=40 cm, Gravity center=1,45 m

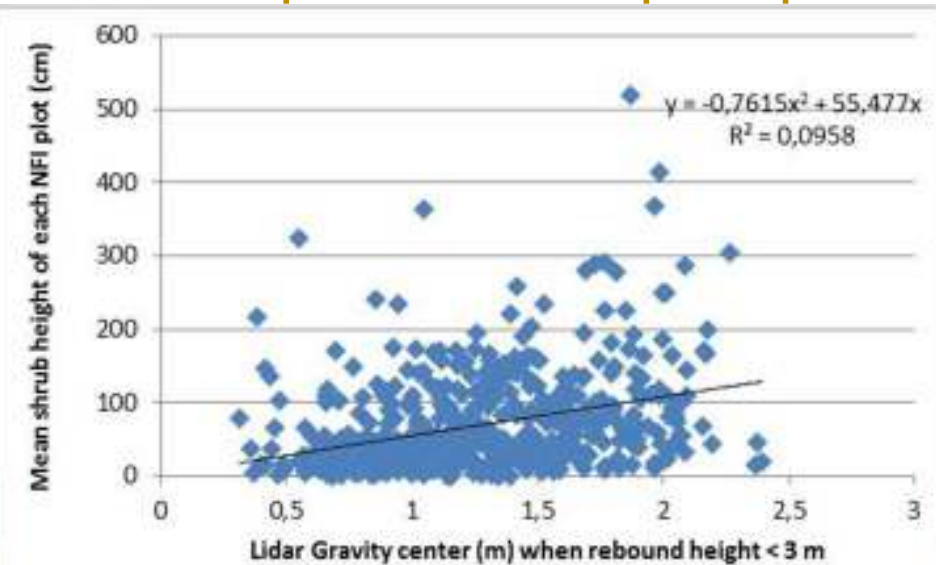


Second model: fire risk – Available data

«Mean shrub height» models built for main forest type of the Basque Country:

Main type	Nb. of plots	Equation for Mean height	R2
Lawson cypress	7	$2,672x^2 + 16,159x$	0,1500
Scot pine	91	$1,397x^2 + 48,96x$	0,0402
Laricio pine	72	$15,157x^2 + 28,724x$	0,1233
Pinaster pine	50	$0,9644x^2 + 44,409x$	0,1197
Radiata pine	51	$-0,7615x^2 + 55,477x$	0,0958
Douglas fir	26	$-14,36x^2 + 53,876$	0,0475
Larix	19	$0,5371x^2 + 43,919x$	0,0803
Oak	74	$25,894x^2 + 30,464x$	0,1600
Quercus pyrenaica	69	$-10,308x^2 + 52,787$	0,0974
Quercus faginea	111	$-2,3188x^2 + 95,792x$	0,1055
Green oak	100	$10,276x^2 + 16,1x$	0,0415
Eucalyptus	60	$-33,77x^2 + 121,91$	0,0719
Beech	228	$16,689x^2 + 5,6106x$	0,1418
Other broadleaves	165	$-23,608x^2 + 89,568x$	0,0678
Total	1589		

Example: Radiata pine plots



Second model: fire risk – Available data

Models built for main forest types of the Basque Country:

Main parameters

Mean shrub height, h_{mat} (cm)

Mean dry shrub weight, P_{mat} (T/ha)

Wind model parameters

Mean height, h (m)

Basal area, g (m²/ha)

Secondary parameters

Shrub coverage, $scov$ (%)

First branch height, CBH (m)

Flame length, L_f (m) (under typical fire conditions in the Basque Country according to bibliography)

Second model: fire risk – Conclusions

Two models tested for probability of crown fire risk IN EACH 1-HECTARE CELL:

- Model 1 / Based on relative height among trees and shrub: Risk=1 if (Lidar rebound mean height) – (Mean shrub height) < 2 meters
- Model 2 / Based on shrub and branch relative differences: Risk=1 if Flame length > First branch height

Results show that high fire risk forest types are the same that models predict:

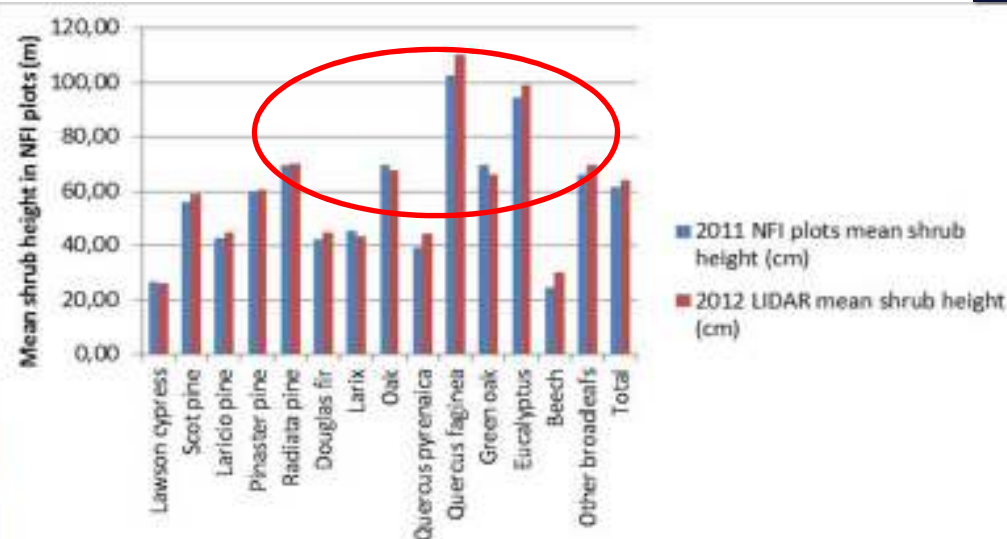
- Coppice of *Quercus faginea* and *Quercus ilex*
- Young plantations of *Eucalyptus*, *Pinus radiata* or *Pinus pinaster*



Second model: fire risk – Conclusions

Main type	Nb. of plots	2011 NFI plots mean shrub height (cm)	2012 LIDAR mean shrub height (cm)
Lawson cypress	7	26,67	25,90
Scot pine	91	55,82	58,78
Laricio pine	72	42,94	44,68
Pinaster pine	50	59,51	60,75
Radiata pine	517	69,61	69,97
Douglas fir	26	42,18	44,97
Larix	19	45,46	43,07
Oak	74	69,62	67,48
Quercus pyrenaica	69	39,39	44,13
Quercus faginea	111	102,65	109,88
Green oak	100	69,59	65,86
Eucalyptus	60	94,24	98,80
Beech	228	24,79	29,93
Other broadleaves	165	66,23	69,54
Total	1589	61,51	63,98

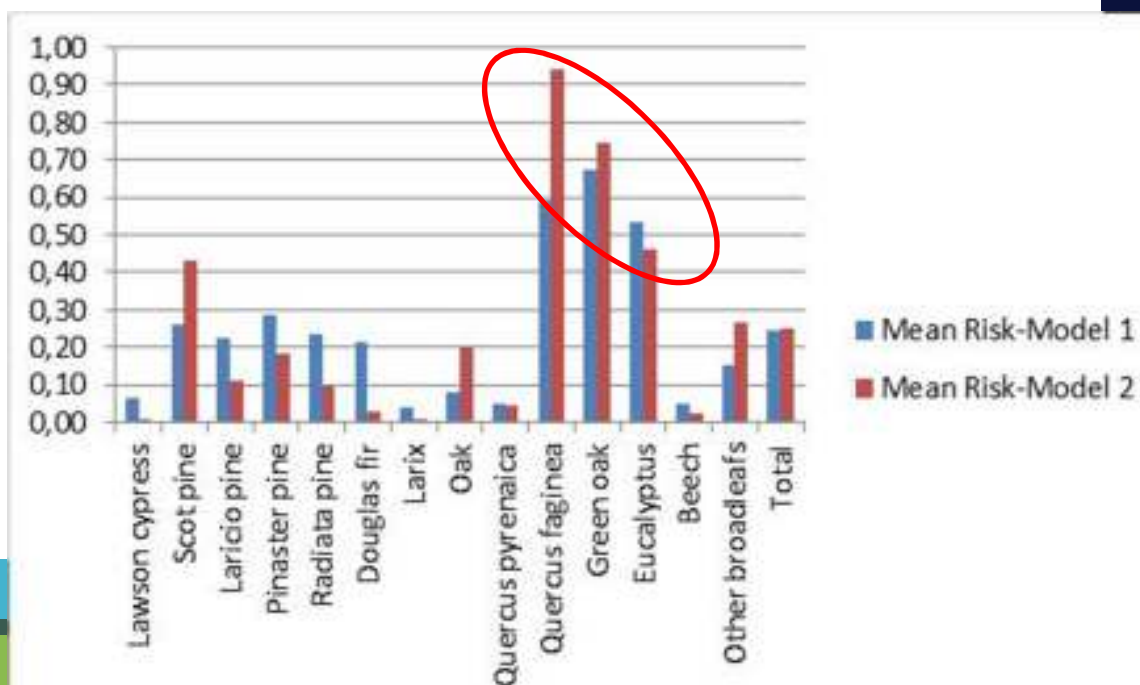
Mean shrub height (cm)



Second model: fire risk – Conclusions

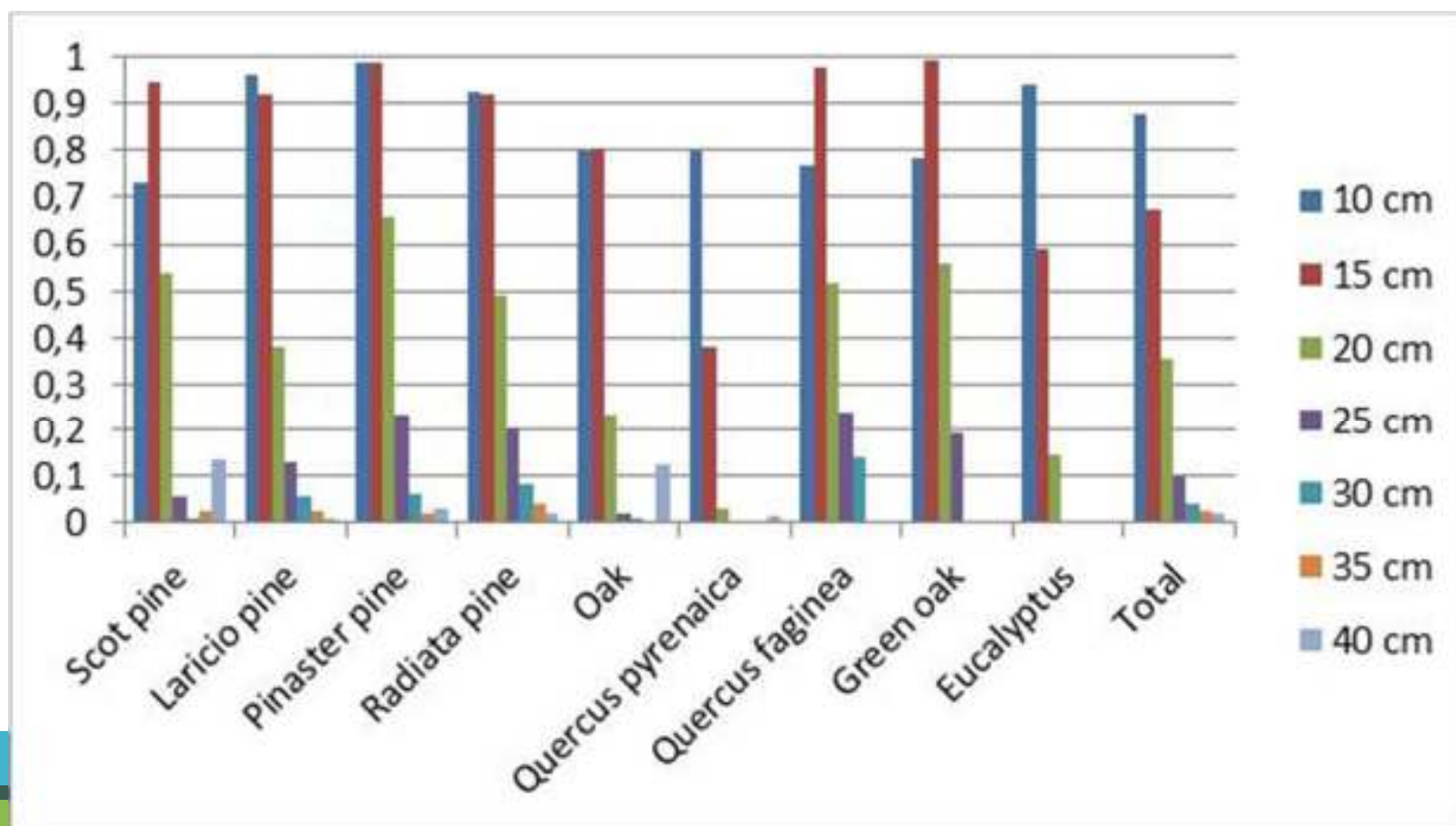
Main type	Mean Risk-Model 1	Mean Risk-Model 2
Lawson cypress	0,06	0,00
Scot pine	0,26	0,43
Laricio pine	0,23	0,11
Pinaster pine	0,29	0,18
Radiata pine	0,23	0,09
Douglas fir	0,22	0,03
Larix	0,04	0,01
Oak	0,08	0,20
Quercus pyrenaica	0,05	0,04
Quercus faginea	0,59	0,94
Green oak	0,67	0,74
Eucalyptus	0,53	0,46
Beech	0,05	0,02
Other broadleaves	0,15	0,26
Total	0,24	0,25

Crown fire probability (%)



Second model: fire risk – Conclusions

Model 1 / Fire risk (%) varies depending on species and decreases with mean diameter of trees (cm)



Second model: fire risk – Results



Risk models: to finish...

We have to complete (with the aid of other partners, of course):

- Integration with physical maps: for example, topography maps (wind and fire), frequency maps (wind and fire), orientation maps (fire), ...
- Map of forest zones without trees: “pure” shrub zones risk
- A guide to basque forest owners to advise their silviculture adapted to risks (adapted species, thinnings, clearing, pruning, age of final cut,...)
- Preparation of a web-visor to advise basque forest owners
- Automatical mensurations with Laser 3D

