Assessing the potential distribution of insect pests under current and future climatic conditions in European forests

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Joint EFSA-EPPO Workshop on Data collection and information sharing in plant health
Parma, Italy – 1-3 April 2014

FISE: Forest Information System for Europe

Joint Research Centre

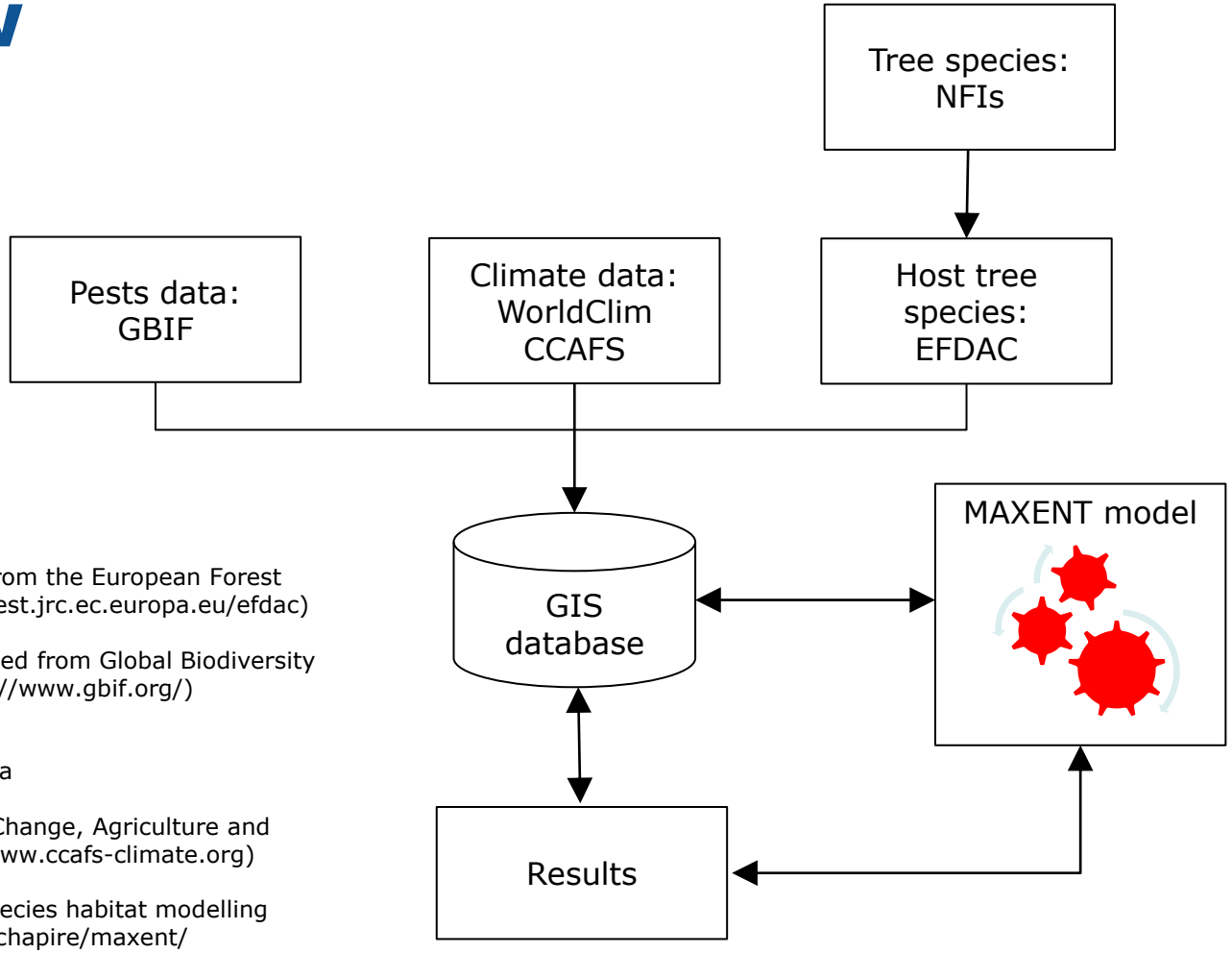
Introduction

- We propose a methodology for assessing forest vulnerability to insect pests at pan-European level

- Pilot study using two insect pests for testing and validating a methodology that could be extended to other pests
  - Large Pine Weevil (*Hylobius abietis*)
  - Horse Chestnut Leaf Miner (*Cameraria ohridella*)

- Our results highlight the strengths of the approach, facilitate information sharing with decision makers and discuss the limitations, including data availability of forests insect pests

Overview



Host tree species data sourced from the European Forest Data Centre – EFDAC (http://forest.jrc.ec.europa.eu/efdac)

Insect pests presence data sourced from Global Biodiversity Information facility - GBIF (http://www.gbif.org/)

Climate data sourced from:
- WorldClim - Global Climate Data (http://www.worldclim.org)
- Research Program on Climate Change, Agriculture and Food Security – CCAFS (http://www.ccafs-climate.org)

MAXENT: Maxent software for species habitat modelling http://www.cs.princeton.edu/~schapire/maxent/

MAXENT software for species habitat modelling

- Maxent (v.3.3.3e) is a general purpose habitat modelling algorithm for estimating probability of distributions based on presence-only data (Phillips et al., 2004, 2006)

- The model is non-linear, nonparametric, and not sensitive to multicollinearity

- Freeware [!]

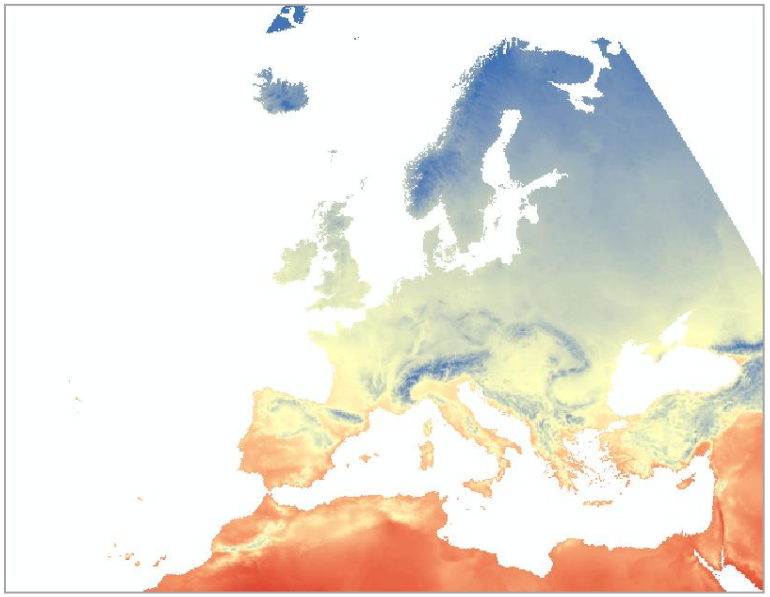
- Input data:
  - Environmental covariates (climate, etc.)
  - Presence data (usually point data)

Climate datasets

- WorldClim – Observed Global Climate Data: 1960-1990
- Research Program on Climate Change, Agriculture and Food Security (CCAFS) – A1B IPCC SRES Scenario: 2100
  - Max Planck Institute (MPI): ECHAM5 (GCM)
  - Canadian Centre for Climate Modelling and Analysis (CCCMA): CGCM3 (GCM)
- Disaggregated: 10km spatial resolution

BIOCLIM variables:
BIO1 = Annual Mean Temperature
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO5 = Max Temperature of Warmest Month
BIO6 = Min Temperature of Coldest Month
BIO7 = Temperature Annual Range (BIO5-BIO6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Month
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter
BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter Annual average temperature

BIO1: Annual mean temperature

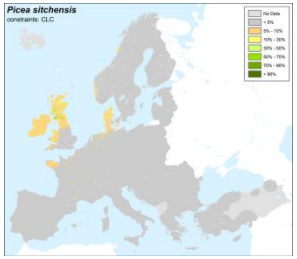


Climate data sourced from WorldClim http://www.worldclim.org

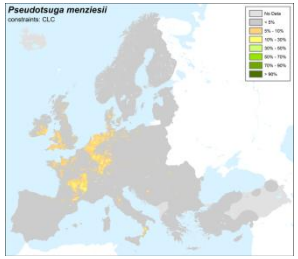
EFDAC - Tree species distribution

Host tree species of Large Pine Weevil (*Hylobius abietis*)

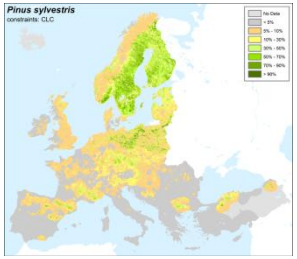
Probability of presence



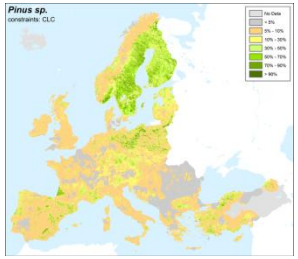
Picea sitchensis



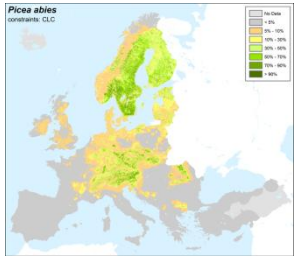
Pseudotsuga menziesii



Pinus sylvestris



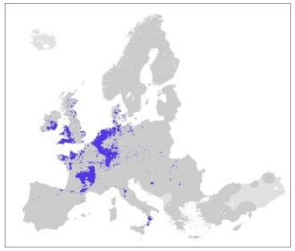
Pinus sp.



Picea abies

10th percentile training presence (10-TP)

Picea sitchensis



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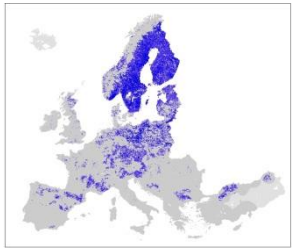

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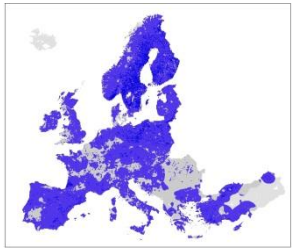
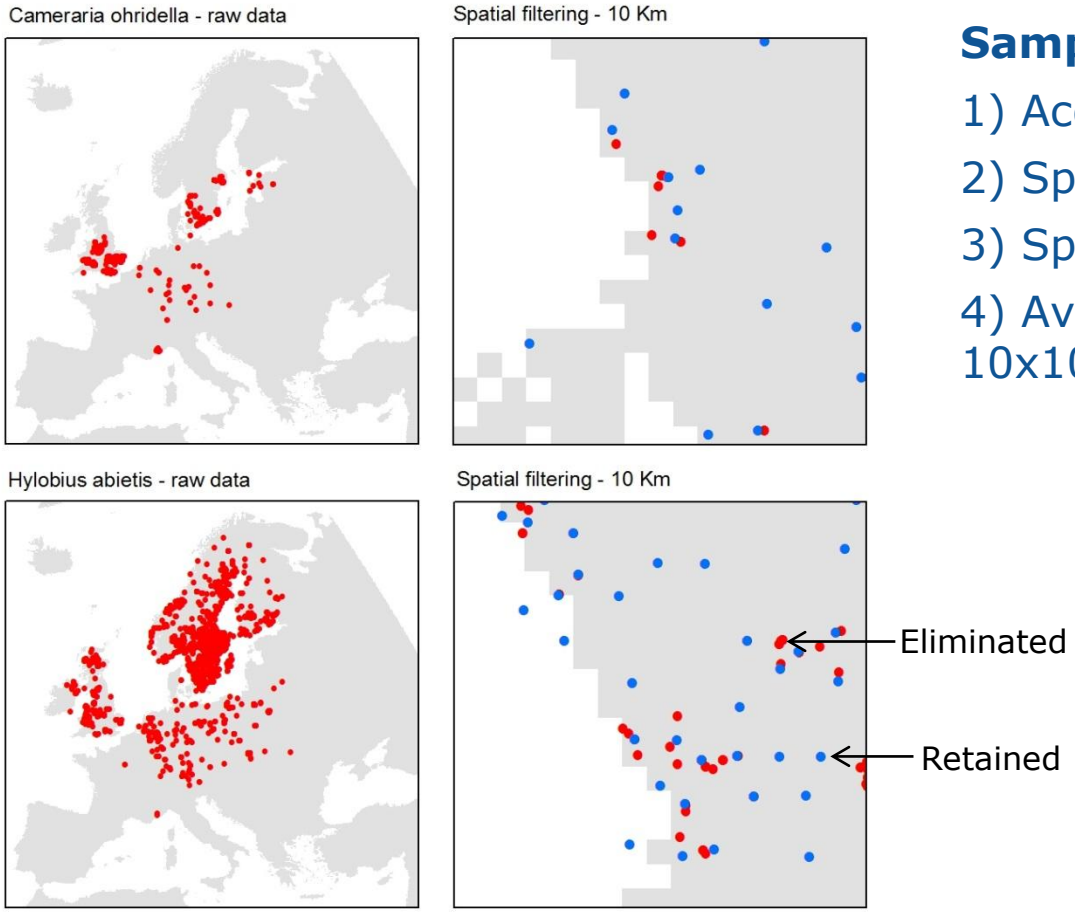


Pinus sp.

Picea abies

Maps sourced from EFADC http://forest.jrc.ec.europa.eu/efdac

Pests data – Spatial filtering (sampling bias)



Sample data pre-processing

1) Acquisition: download
2) Spatial accuracy >= 0.1 DD
3) Spatial filtering
4) Avoid replication (inside 10x10km grid size)

Cameraria ohridella

Raw: 1188

Final: **152**

Hylobius abietis

Raw: 2868

Final: **677**

Sample data sourced from GBIF http://www.gbif.org

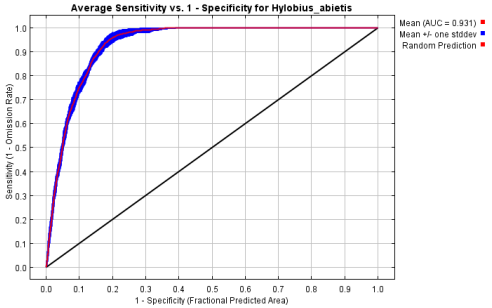
Results

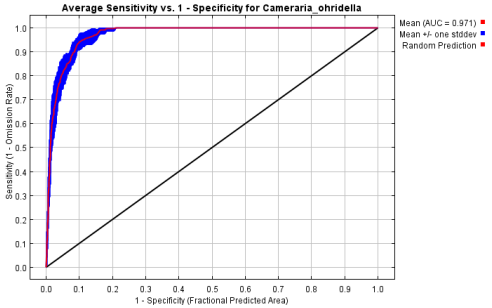
Maxent calibration (CTR): 10 replications; 20% test data

Regularisation multiplier		*Hylobius a.*	*Cameraria o.*
b=1.0 standard model	AUC:	0.931	0.971
b=2.5 smooth model	AUC:	0.928	0.969

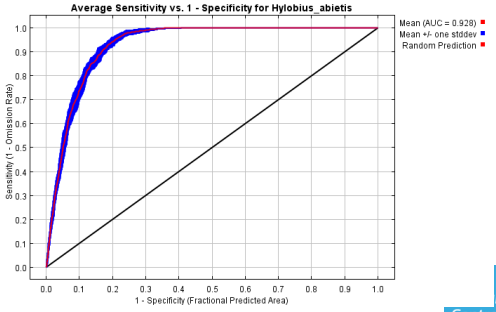
Hylobius abietis | *Cameraria ohridella*

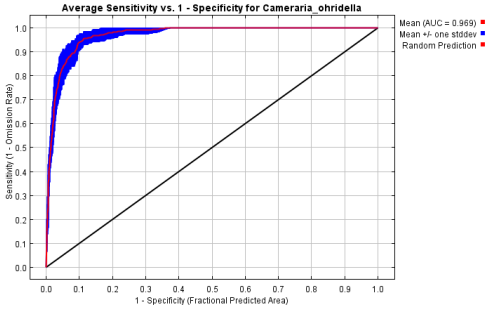
b=1.0



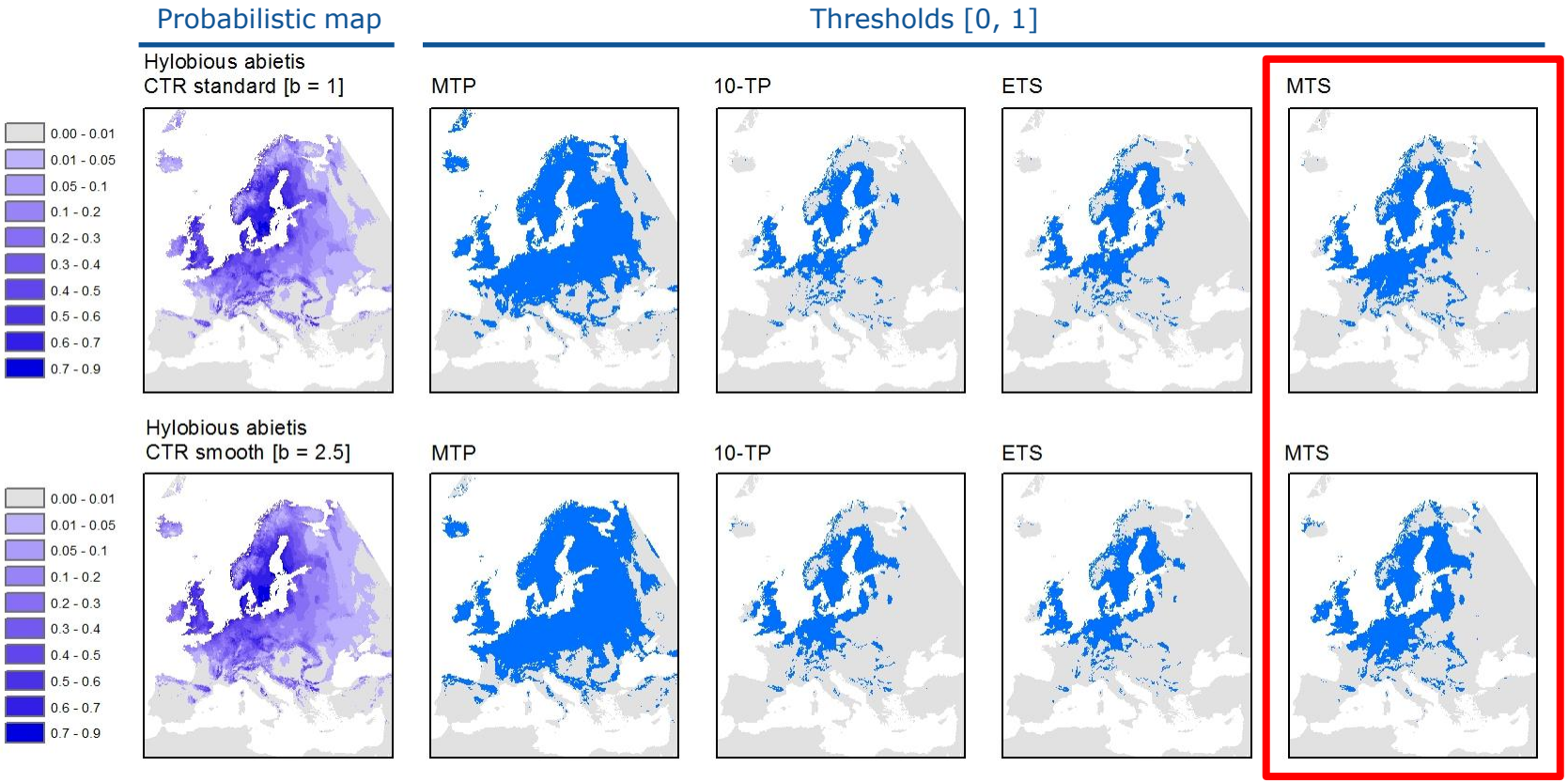


b=2.5





Large Pine Weevil (*Hylobius abietis*) Simulated habitat – Current climate



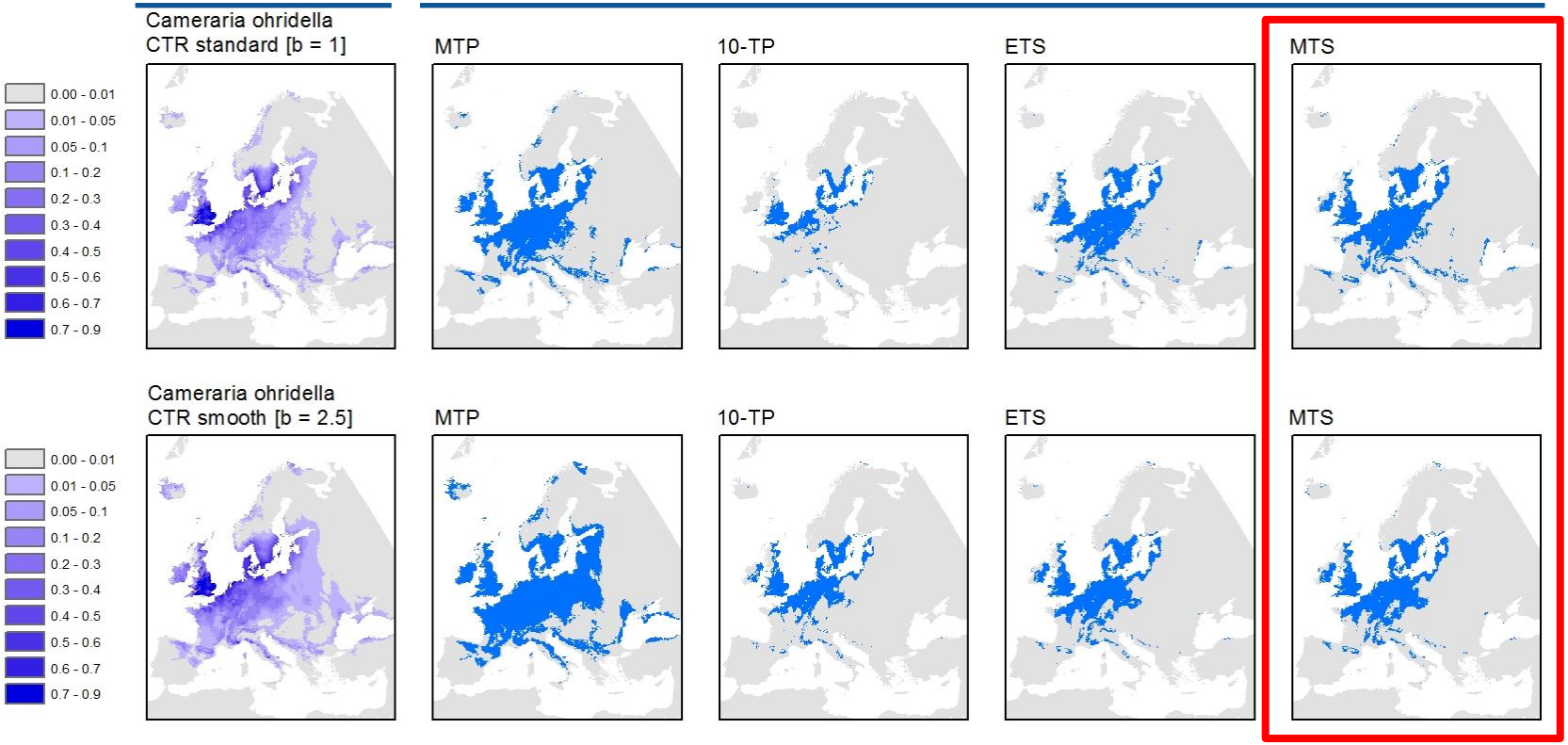
MTP: Minimum training presence
10-TP: 10th percentile training presence
ETS: Equal test sensitivity and specificity
MTS: Maximum test sensitivity plus specificity (used as reference)

Climate data sourced from WorldClim (http://www.worldclim.org)

Horse Chestnut Leaf Miner (*Cameraria ohridella*) Simulated habitat – Current climate

Probabilistic map

Thresholds [0, 1]



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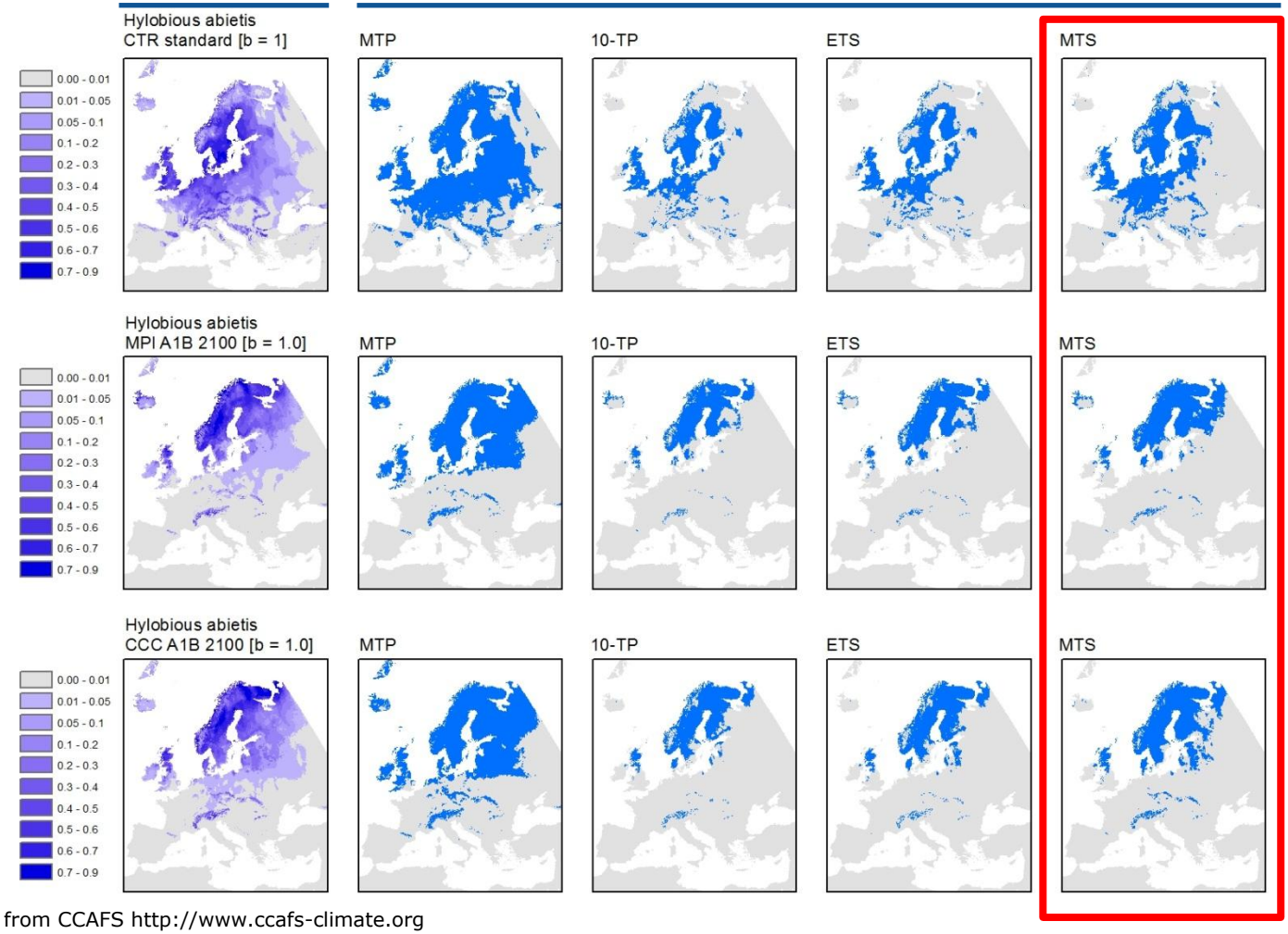
Large Pine Weevil (*Hylobius abietis*) Simulated habitat and future scenarios



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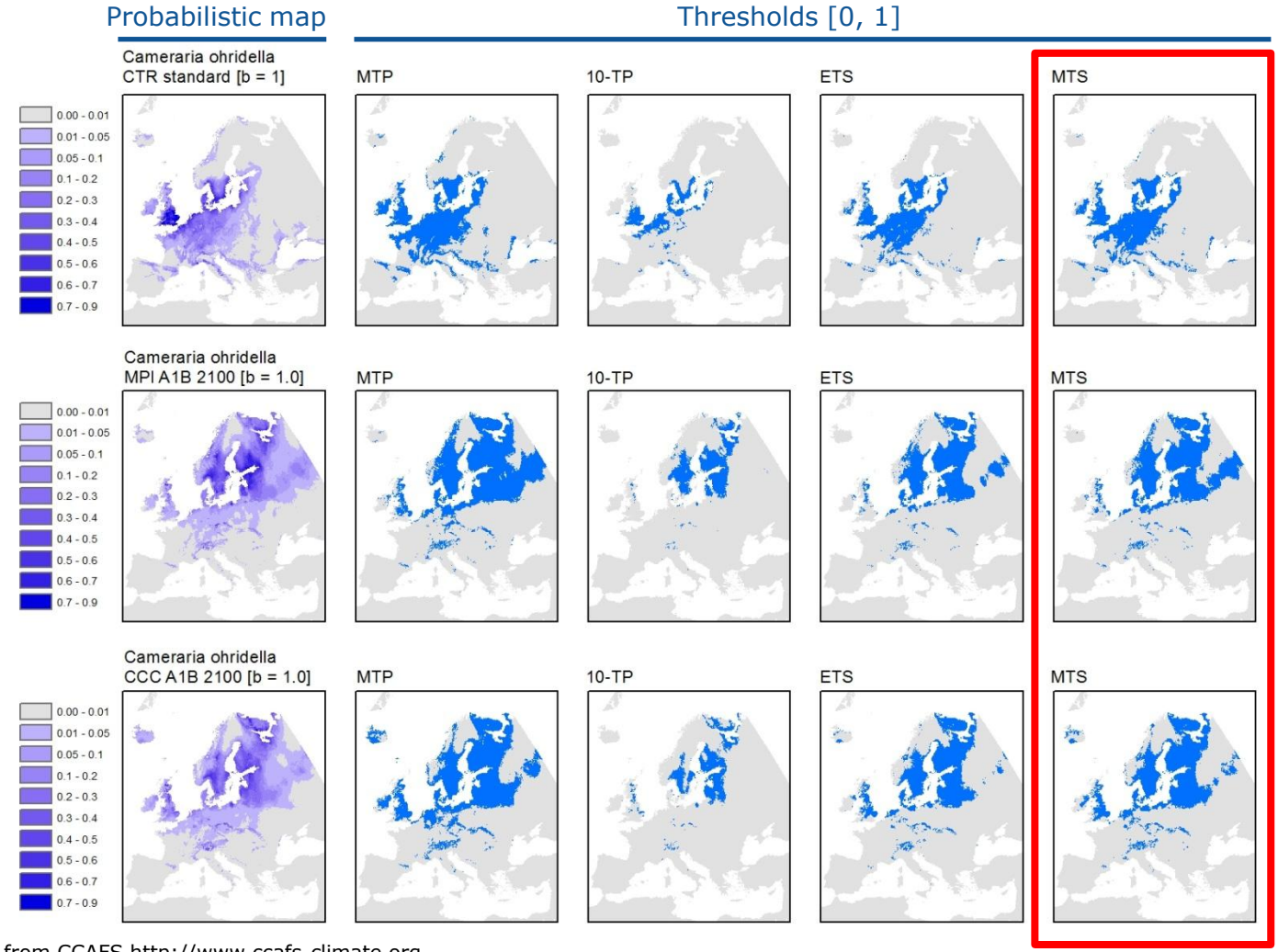
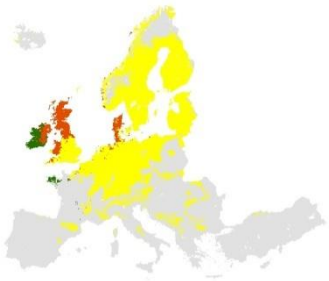
Horse Chestnut Leaf Miner (*Cameraria ohridella*) Simulated habitat and future scenarios



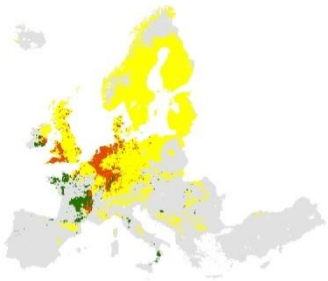
Climate data sourced from CCAFS http://www.ccafs-climate.org

Hylobius abietis: current vs A1B-MPI 2100 habitat and current host tree species

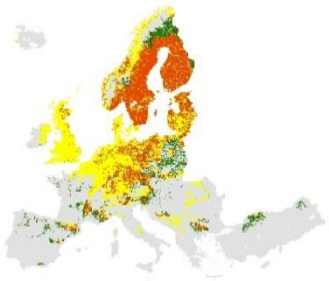
Hylobius abietis – Current habitat (MTS) on host tree species domain (10-TP)



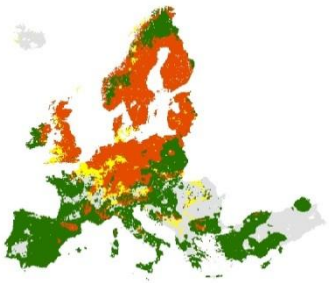
Picea sitchensis



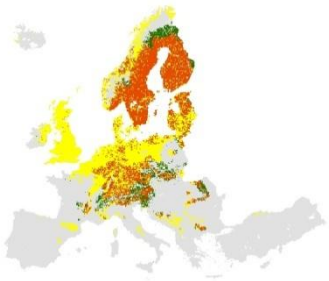
Pseudotsuga menziesii



Pinus sylvestris

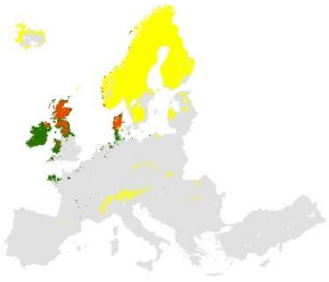


Pinus sp.

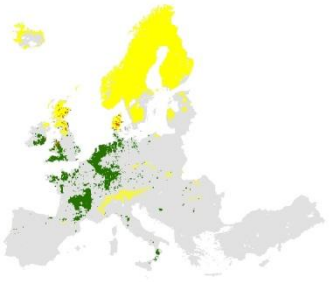


Picea abies

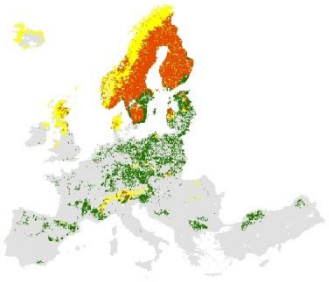
Hylobious abietis – A1B-MPI 2100 habitat (MTS) on current host tree species domain (10-TP)



Picea sitchensis



Pseudotsuga menziesii



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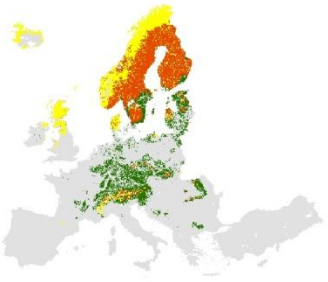
Pinus sp.



Picea abies

Hylobius abietis: habitat yes / host no

Hylobius abietis: habitat yes / host yes

Hylobius abietis: habitat no / host yes

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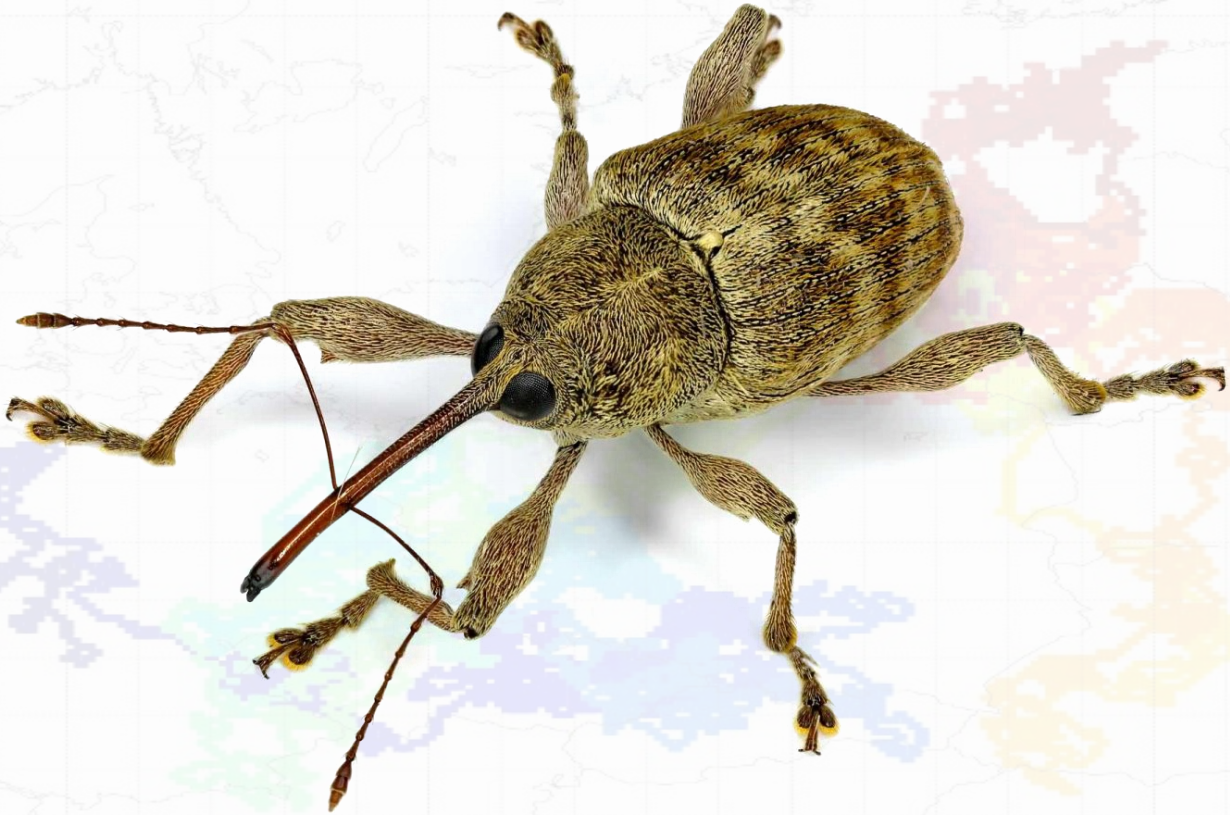
Conclusions

- GBIF data limitations: coordinate precision, time of observation, amount of observations, sampling bias, lack of data for most insect pests
- Uncertainty (many sources): model, climate data, pests data
- More climate runs/models, bias correction, ensemble approach
- Suitable habitats for *Hylobius abietis* will decrease under future climate conditions …
- **Need of a public database on forest pests**: georreferenced data of observed presences, X and Y coordinates, standard format, open dissemination, metadata, Country/Region input data, other providers…

Pest Spread Dynamic Modelling



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1) The user selects a pest

2) Niches of known hosts for the selected pest are combined in order to model the pest niche

3) The pest niche is then used to identify local environmental suitability

4) The user selects a starting point for the spread and setups a parameters about pest dispersal ability

5) A dynamic model based on pest movements through suitable area is then built

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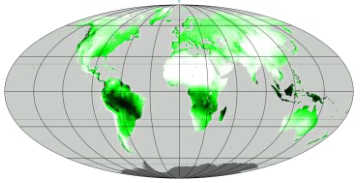
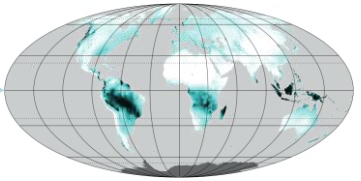
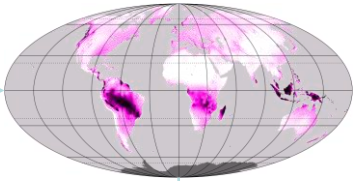
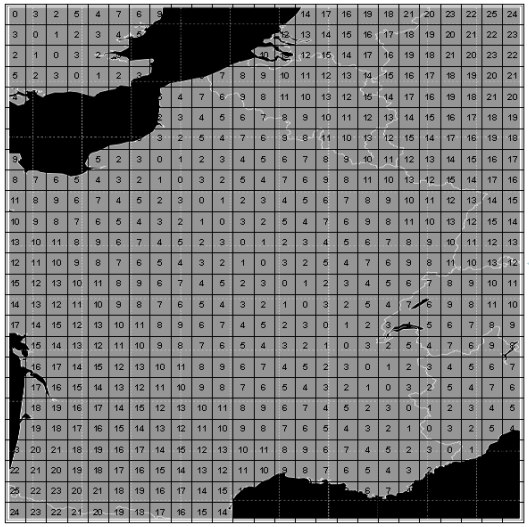
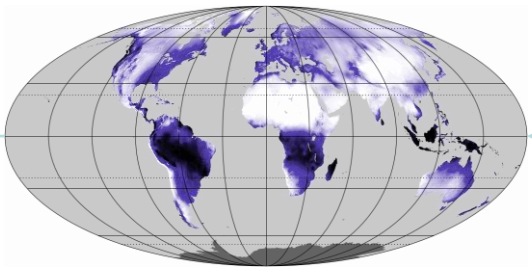






Modelling Pest Niche





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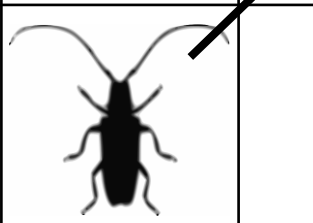
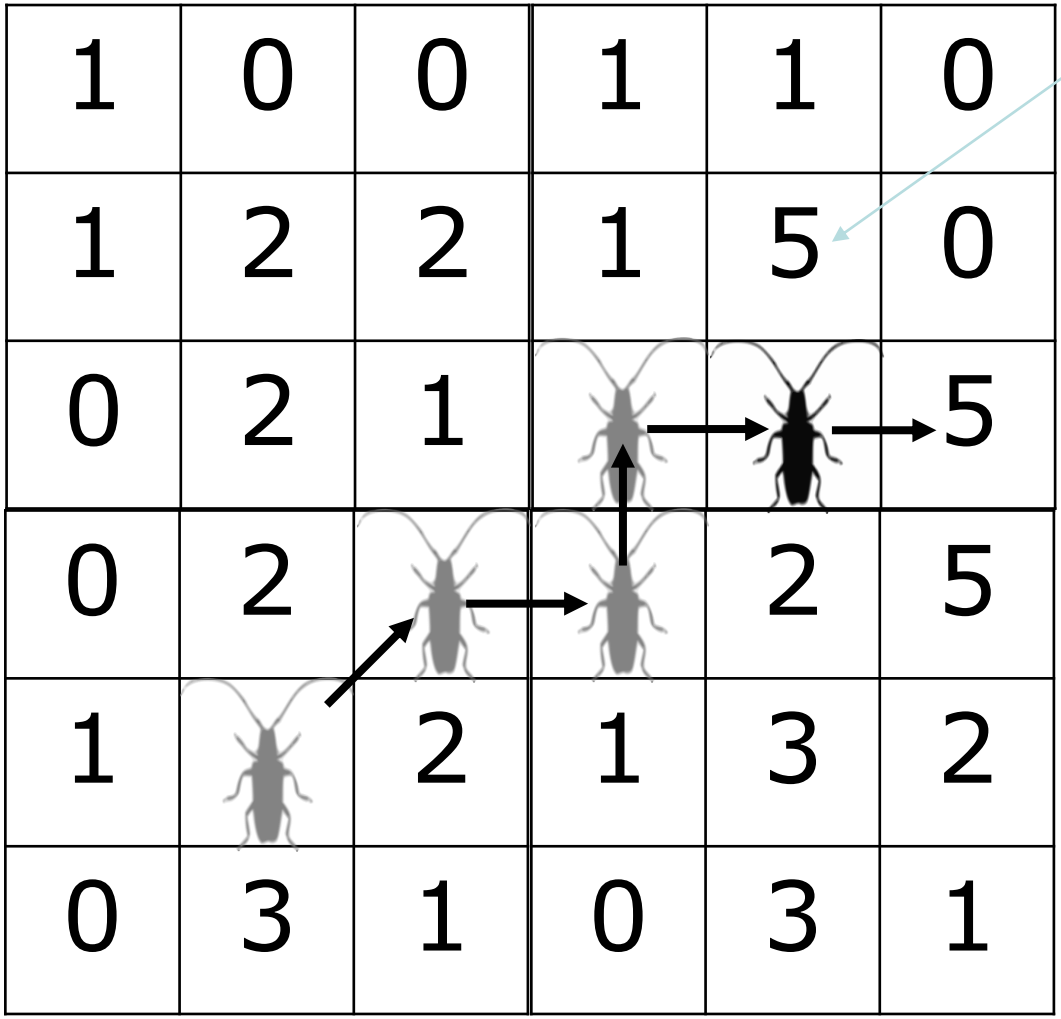
Modelling Pest Spread

0	2	5
1		2
0	3	1

1) User selects a starting point

2) The pest moves towards the most suitable grid cells

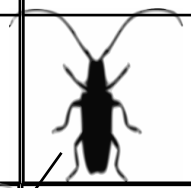
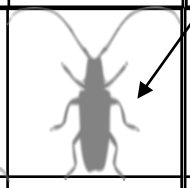
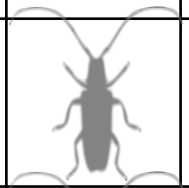
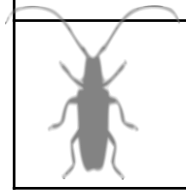
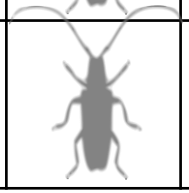


The pest does not move here, Because the other cell with value 5 is surrounded by cells with higher Suitability.

If there are several cells with equal values:

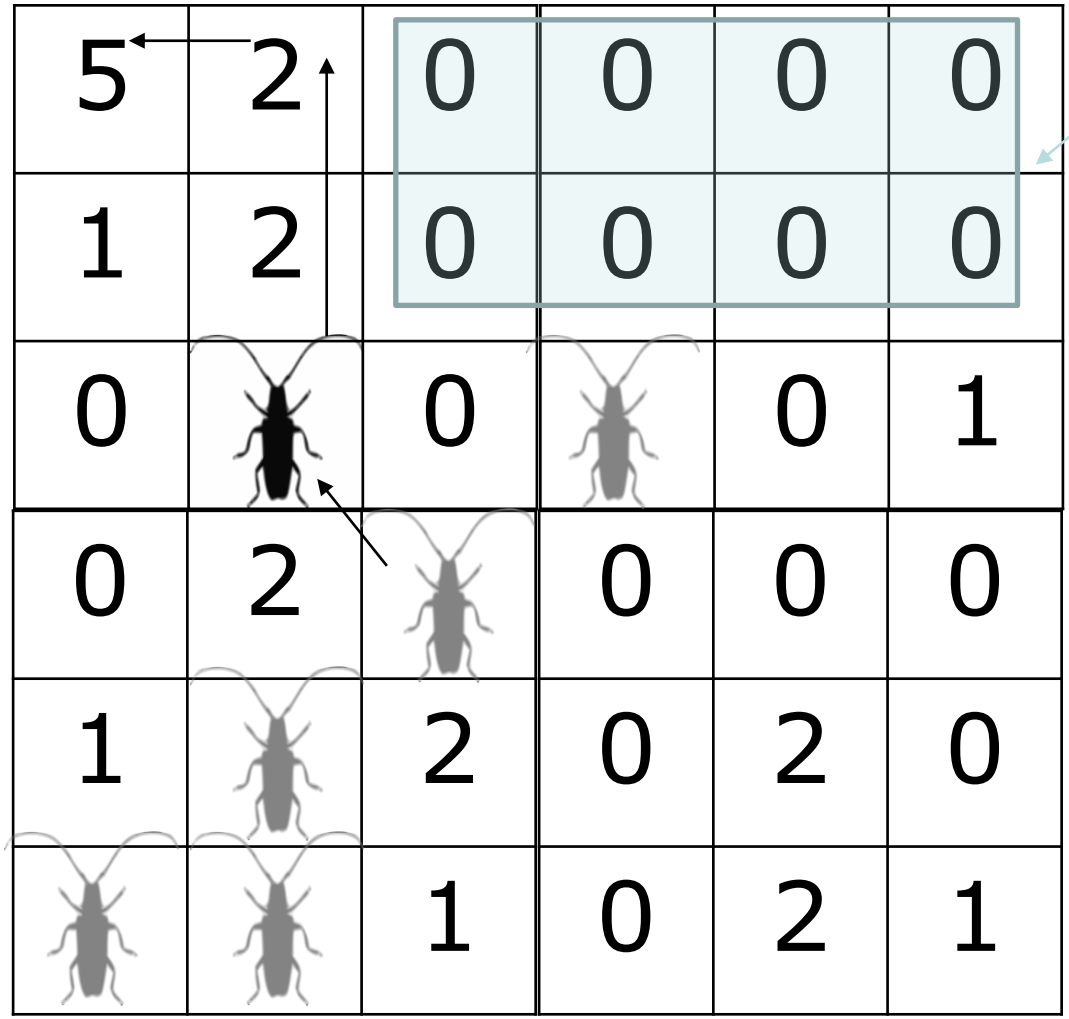
1) Overall suitability is evaluated in the area closer to these cells

2) The pest moves towards the most suitable areas

5	2	0	0	0	0
1	2	0	0	0	0
0	3	0		0	1
0	2		0	0	0
1		2	0	2	0
		1	0	2	1

This area is not suitable for pest dispersal; thus, it steps back and tries to spread through a different pathway

If the pest gets stuck in an unsuitable area, it steps back and searches for different spread pathways.



This area is not suitable for pest dispersal; thus, it steps back and tries to spread through a different pathway

If the pest gets stuck in an unsuitable area, it steps back and searches for different spread pathways.

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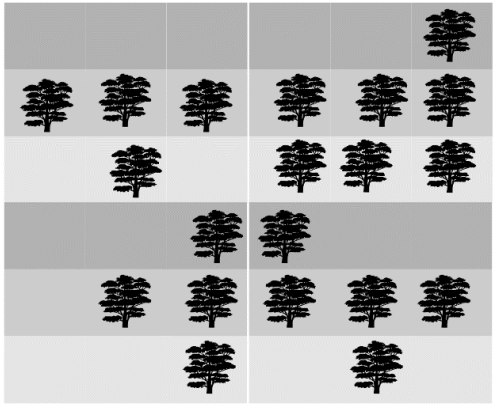
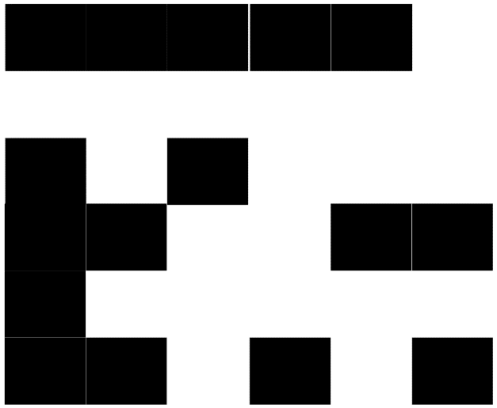
Constrain to Host Distribution

1	0	0	1	1	0
1	2	2	1	5	0
0	2	1	5	3	5
0	2	1	0	2	5
1	1	2	1	3	2
0	3	1	0	3	1





					0
1	2	2	1	5	0
	2		5	3	5
		1	0		
	1	2	1	3	2
		1		3	

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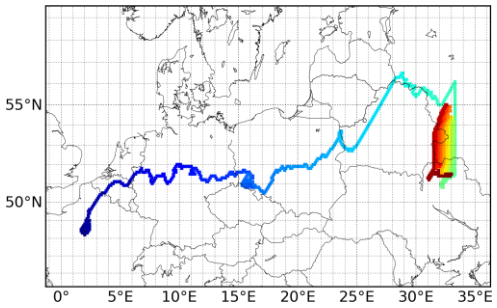

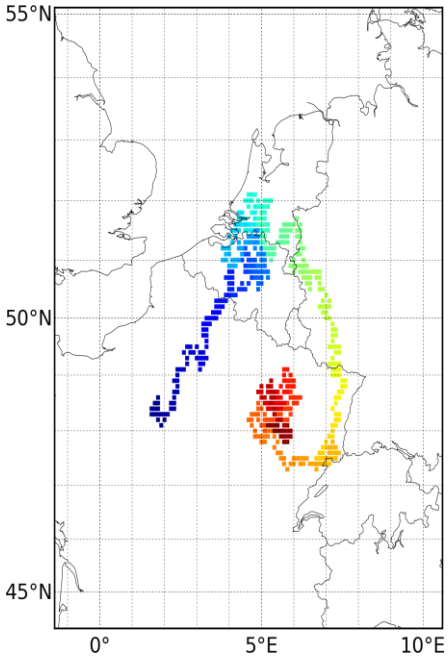

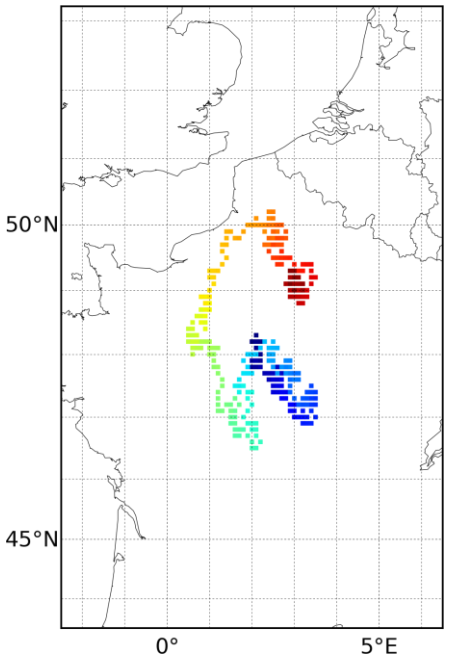

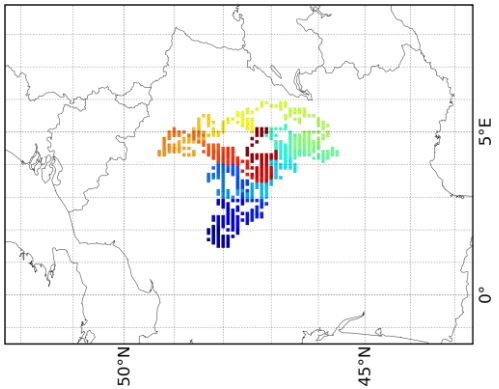

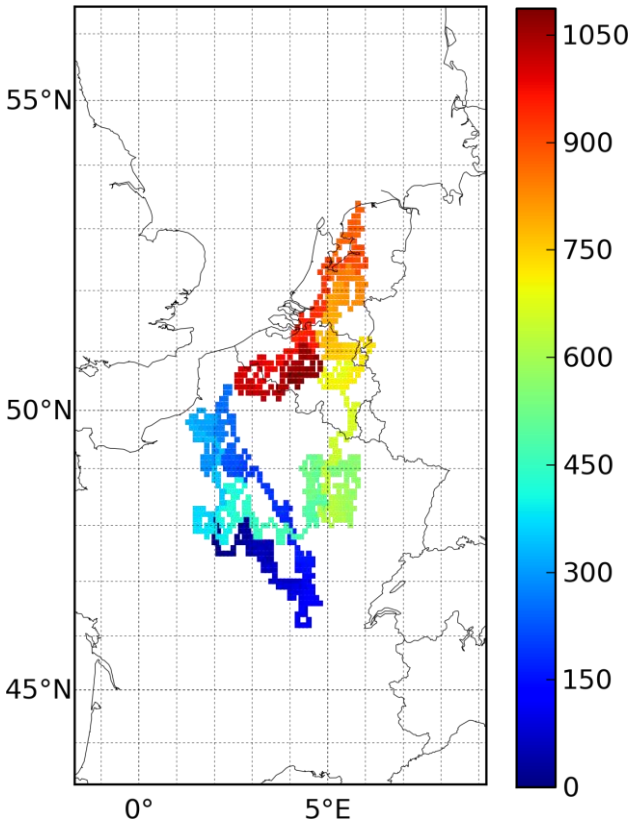

Color map indicates model step sequence (i.e. time scale)

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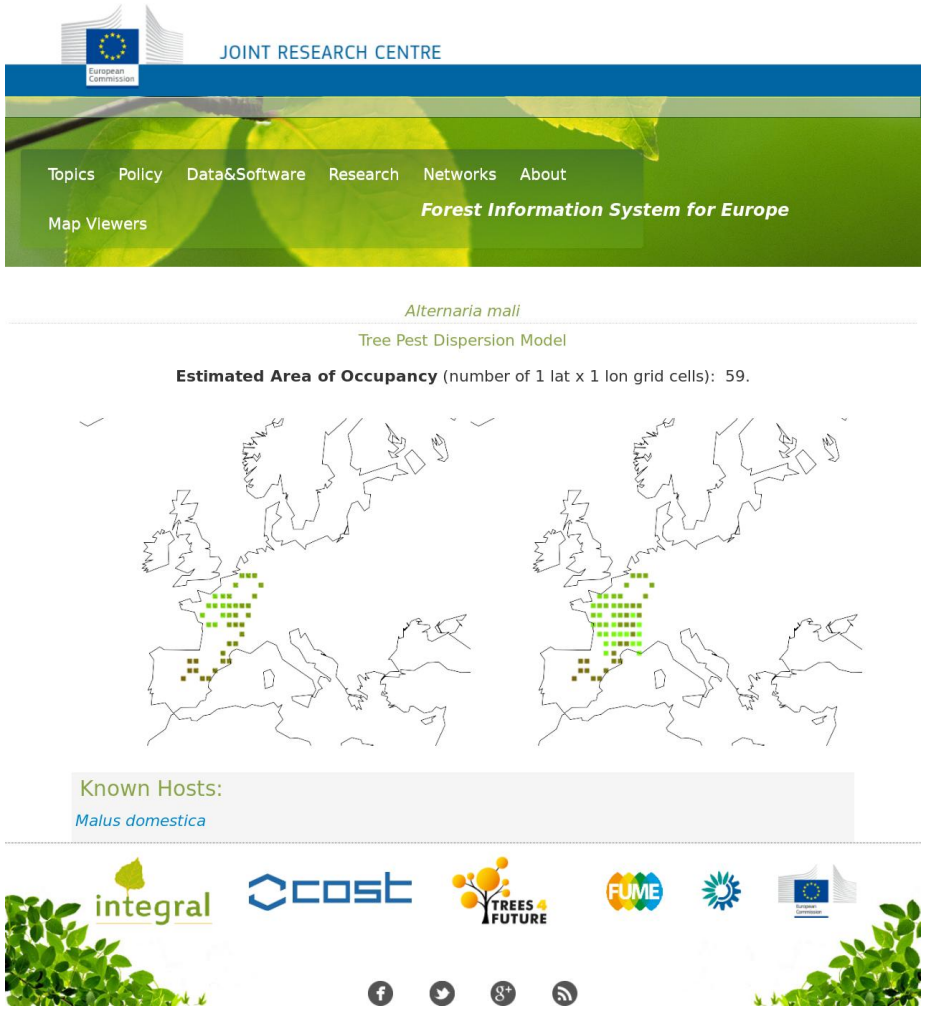

Two software versions will be available from FISE:

1) Low spatial resolution online demo version
2) High spatial resolution static version (both as a Python library and as a standalone executable)

Thank you

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Insect pests sample data (GBIF)

- Large Pine Weevil (*Hylobius abietis*)

  - The Large pine weevil is economically the most important pest of coniferous forest regeneration in Europe. Planted seedlings are frequently damaged or killed by adult weevils feeding on stem bark (SLU)
  - Heavy damage can completely girdle stems and cause plant death (IMPACT Project)
  - Adult weevils have a broad host range, feeding on a wide variety of conifer and broadleaved trees, but pine is preferred as a food source
  - Moderate concern (not EPPO)

- Horse Chestnut Leaf Miner (*Cameraria ohridella*)
  - It was concluded that due to rapid and natural spread of the pest, no practical phytosanitary measures can be taken. In 2001 it was therefore removed from the EPPO Alert List (less concern)
  - Damage: Mines in the leaves. Heavy infestations lead to brown discoloration and death of the leaves, and finally defoliation of the tree

Climate scenarios

- IPCC SRES A1B scenario
- Future world of very rapid economic growth and a balanced share between fossil and non-fossil energy sources
- Often considered BAU scenario

A1B: Temperature change in the 2071-2100 period, compared to the 1961-1990 period (°C)

	Reference	Reference variant 1	Reference variant 2
Northern Europe	3.8	4.8	3.4
UK & Ireland	2.1	2.9	1.7
Central Europe north	2.8	3.7	2.0
Central Europe south	3.0	3.8	2.0
Southern Europe	3.2	3.7	2.4
EU	3.1	3.9	2.4

PESETA II Project: http://peseta.jrc.ec.europa.eu/climate_scenarios.html

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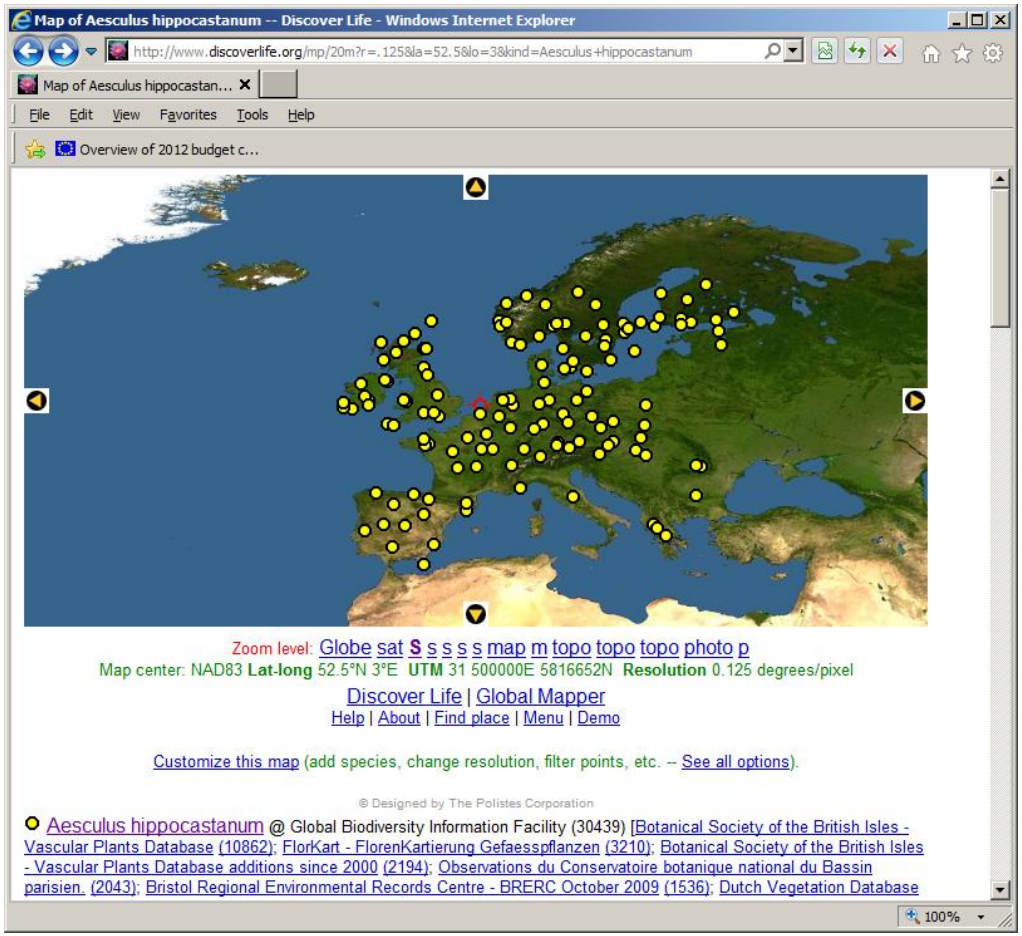
Aesculus hippocastanum



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