A pathway model for wood pests to support risk assessment and decision making on wood trade regulation

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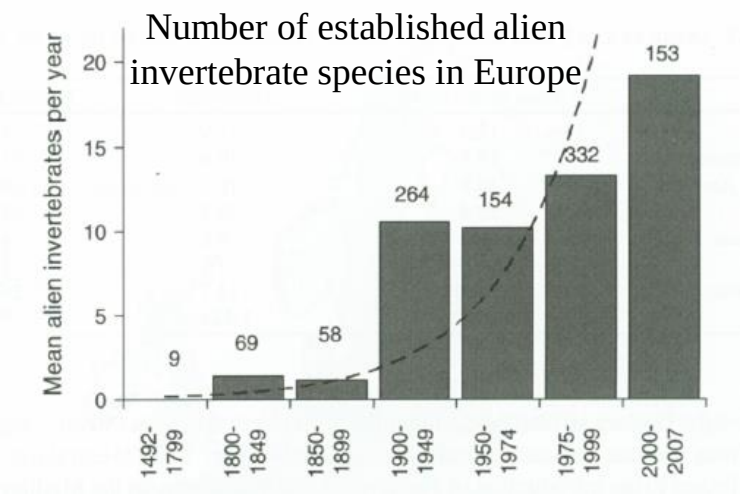
Joint EFSA-EPPO workshop: Modelling in Plant Health –
how can models support risk assessment of plant pests and decision-making?
Parma (Italy), 12-14 December 2016

Introduction

The number of biological invasions is increasing considerably across the world

This is partly due to

- the increase of international trade *=> higher volume exchanged and thus higher probability to transport infested products and disseminate pests*
- higher speed of transportation
  => invasive species survive better between the country of origin and destination country



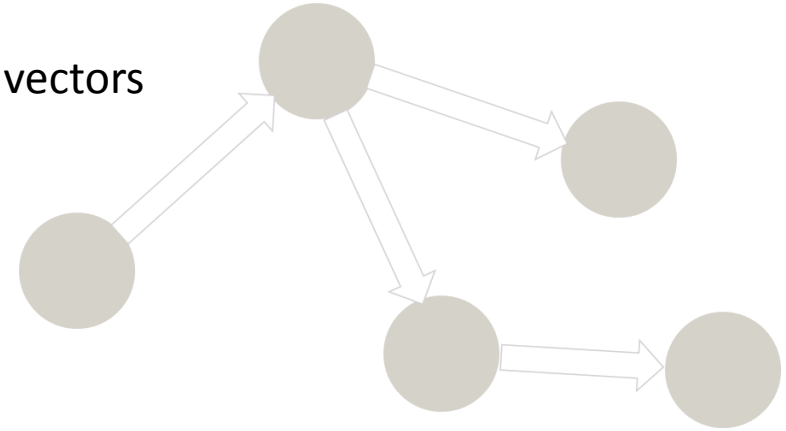
Roques et al. 2009. Handbook of alien species in Europe. DAISIE

Introduction

- Models describing dispersal pathways and human-mediated dispersal gain more and more interests

- Pathway models simulate:
  - the movement of invasive species or their vectors
  - from a source to a point of release
  - along discrete points in time and space

  to determine a probability of introduction.



Review in Ecological Modelling (2016)

Ecological Modelling 339 (2016) 58–67

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Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

Review

Pathway models for analysing and managing the introduction of alien plant pests—an overview and categorization

J.C. Douma[a,*], M. Pautasso[b], R.C. Venette[c], C. Robinet[d], L. Hemerik[e], M.C.M. Mourits[f], J. Schans[g], W. van der Werf[a]

4 clusters of models:

- C1 & C2 : product volume flows
  - C1: deterministic flow-based models
  - C2: stochastic flow-based models

- C3 & C4 : movement of individual agents
  - C3: stochastic individual-based models
  - C4: interactions between agents and nodes

Introduction

- Models describing dispersal pathways and human-mediated dispersal gain more and more interests

- Pathway models simulate:
  - the movement of invasive species or their vectors
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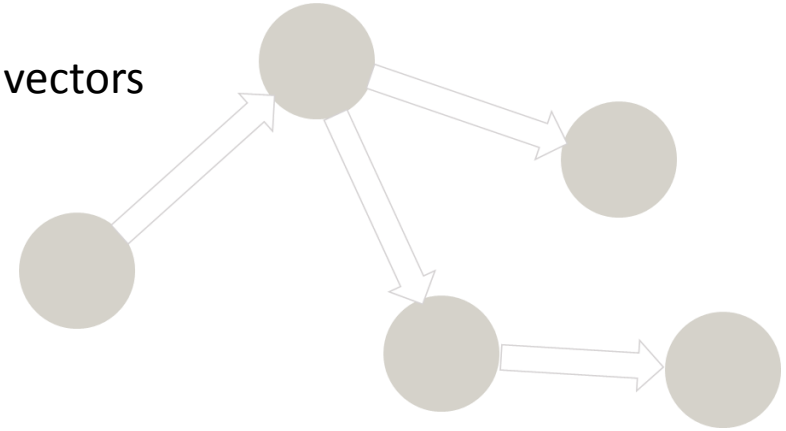


- Until now, no model:
  - to describe the wood chain
  - to assess the probability of introduction of invasive species with imports of wood products

- We developed such model for Europe

Description of the model: model structure

China, United-States, …

Flow of round wood

Flow of sawn wood

Transfer of pest to host

Description of the model: model structure

China, United-States, …

Round wood

Sawn wood

Inspection

Port

Flow of round wood

Flow of sawn wood

Transfer of pest to host

Description of the model: model structure

Round wood

Sawn wood

Transportation of RW

Wood factory: RW → SW

Port

F1: Sawn wood

Flow of round wood

Flow of sawn wood

Transfer of pest to host

Description of the model: model structure

residues

Round wood

Sawn wood

Port

F1: Sawn wood

Flow of round wood

Flow of sawn wood

Transfer of pest to host

Description of the model: model structure

residues

Wood factory:
SW → FP

Transportation
of SW

Round wood

Sawn wood

Port

F1: Sawn wood

F2: Final product

Flow of round wood

Flow of sawn wood

Transfer of pest to host

Description of the model: model structure

residues

Wood factory:
SW → FP

Round wood

Sawn wood

Port

F1: Sawn wood

F2: Final product

Flow of round wood

Flow of sawn wood

Transfer of pest to host

Description of the model: model structure

residues

Wood factory:
SW → FP

Round wood

Sawn wood

Transportation of SW (previously arrived in RW)

Port

F1: Sawn wood

F2: Final product

Flow of round wood

Flow of sawn wood

Transfer of pest to host

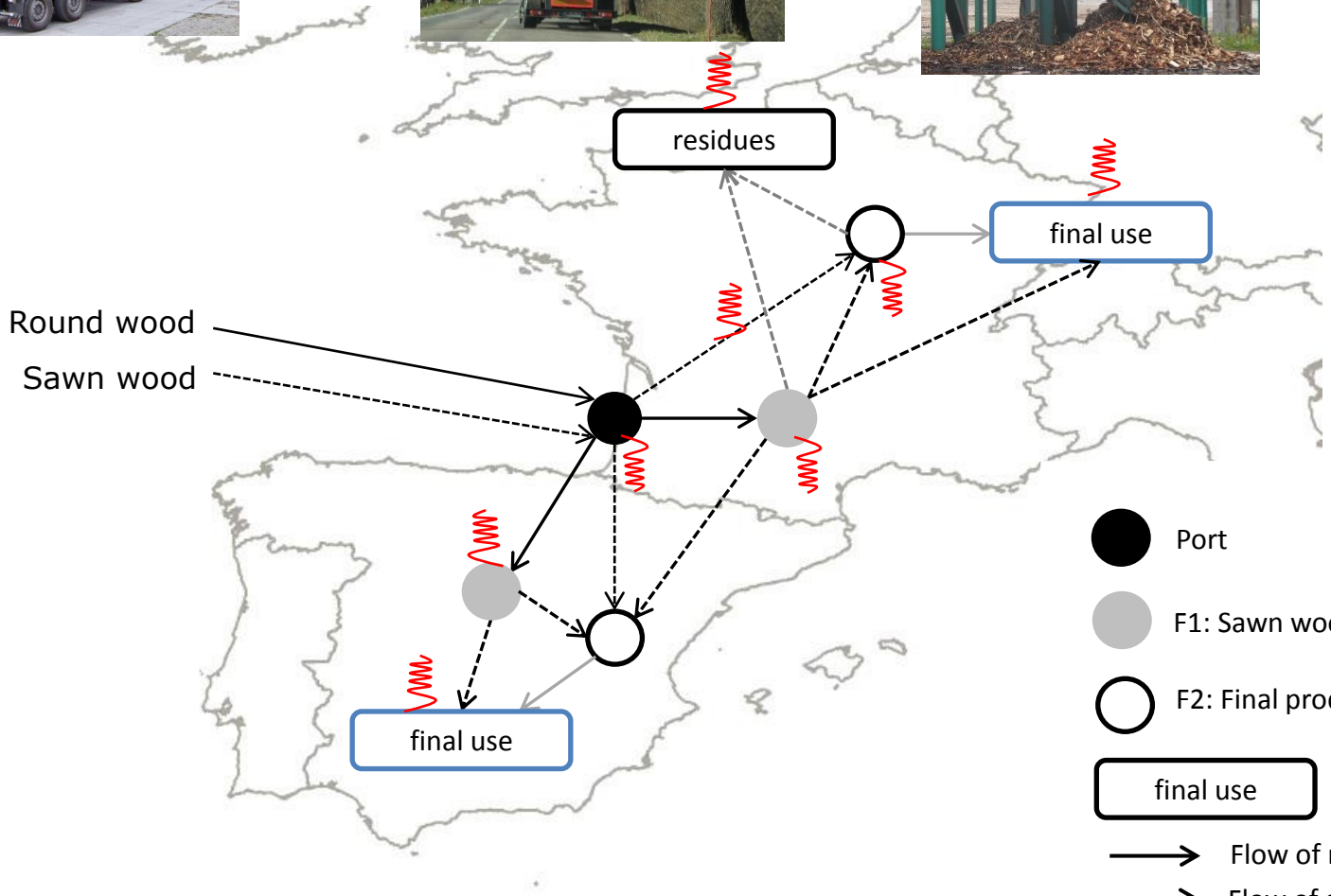
Description of the model: model structure

Round wood (RW)

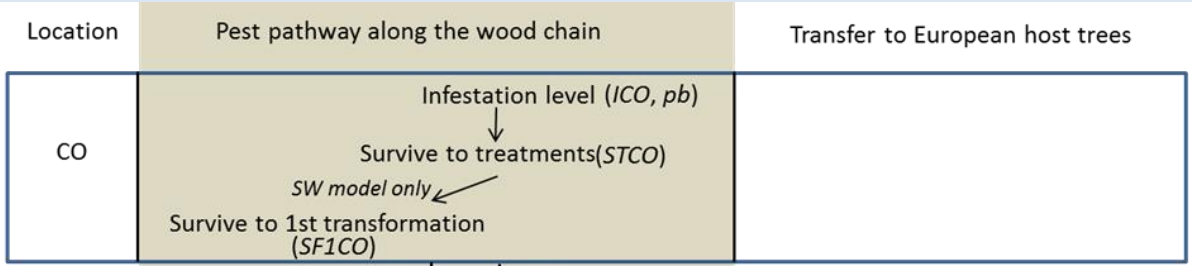
Sawn wood (SW)

Wood residues (RES)

Final products (FP)

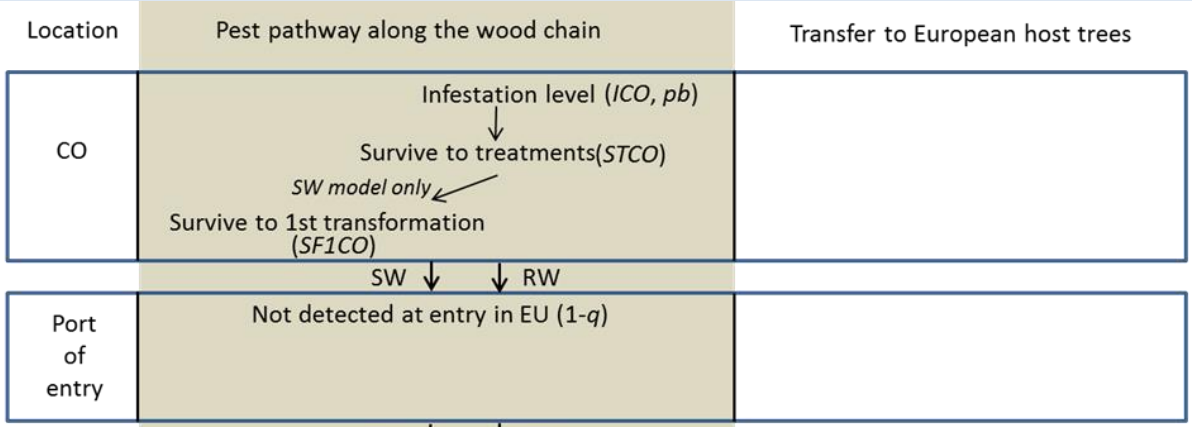


Description of the model: pest pathway along the chain



In the country of origin

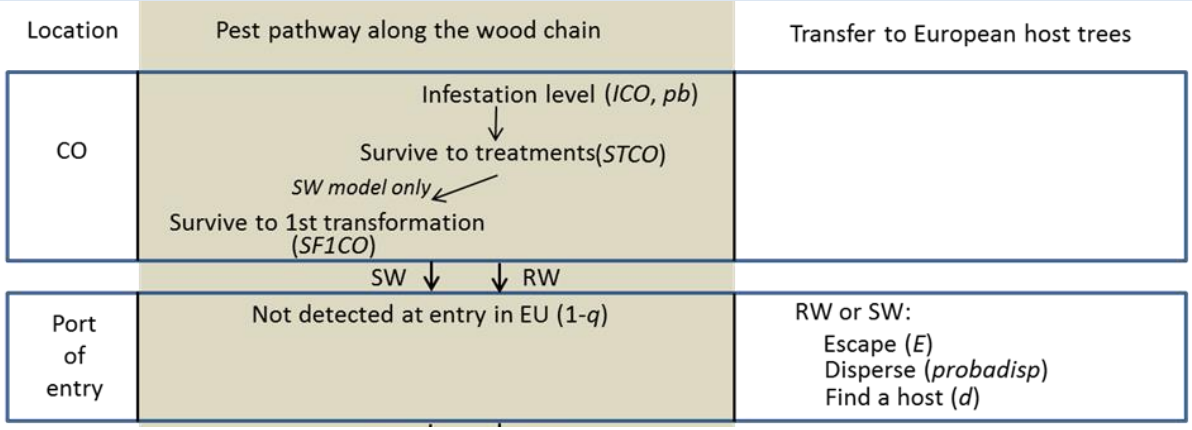
Description of the model: pest pathway along the chain



In the country of origin

Entry in Europe

Description of the model: pest pathway along the chain



In the country of origin

Entry in Europe

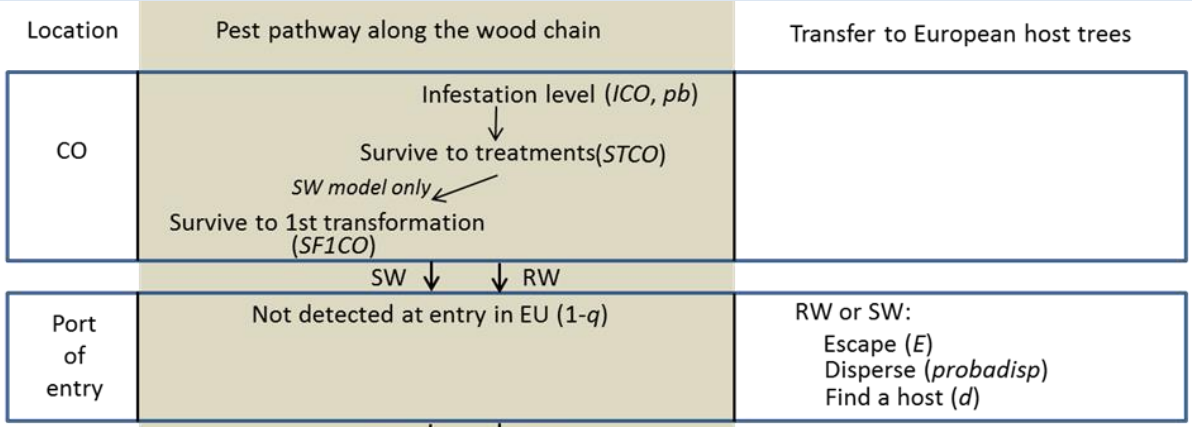
Probability of pest transfer to a host tree in Europe

= probability that the pest escapes from the product

X probability that the pest disperses around

X probability that the pest finds a host

Description of the model: pest pathway along the chain



In the country of origin

Entry in Europe

Probability of pest transfer to a host tree in Europe

= probability that the pest escapes from the product

depends on the volume of infested product, whether a vector is present if required, whether the product is protected against the pest dispersal, …

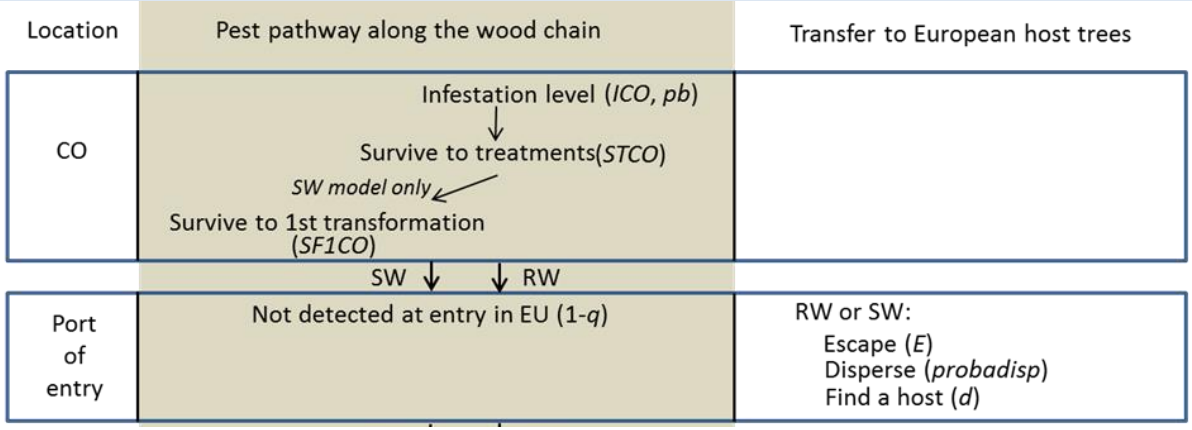
X probability that the pest disperses around

depends on the flight or dispersal season of the pest or its vector (proportion of the year during which it can disperse)

X probability that the pest finds a host

depends on pest or vector dispersal distance capability and host tree distribution in Europe

Description of the model: pest pathway along the chain



In the country of origin

Entry in Europe

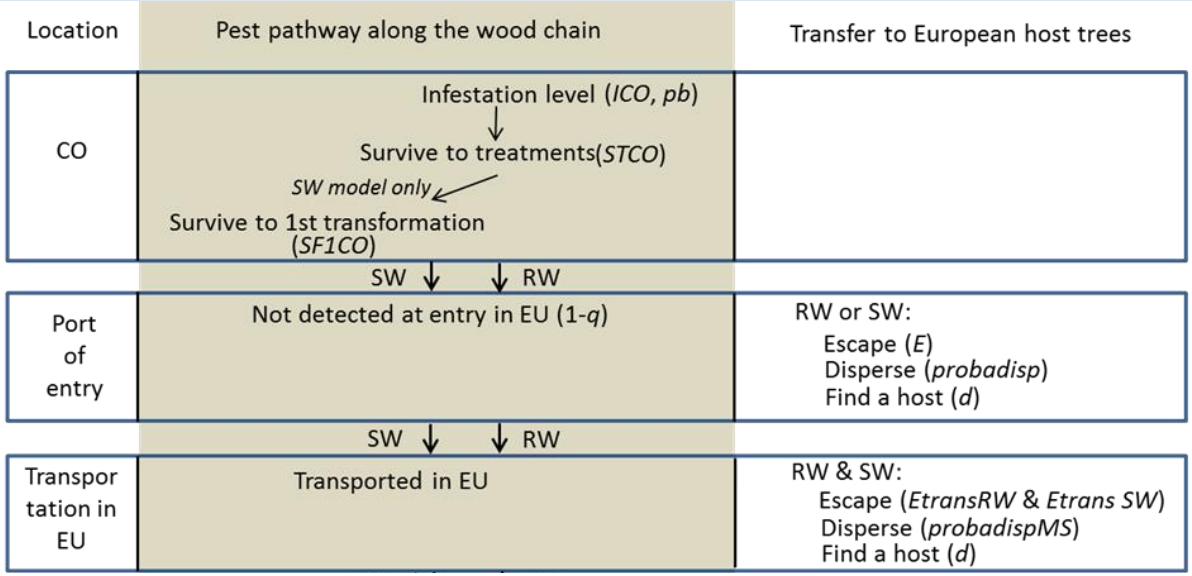
Probability of pest transfer to a host tree in Europe

Exposure (# propagules transferring to host trees in Europe)

$$E_{P,j,r} = V_{P,j,r}\ n_P\ w_{e,P}\ w_{d,j,r}\ h_{j,r}$$

= infested volume × propagule density/m^3 × proba. escape × proba. disperse × proba. find a host

Description of the model: pest pathway along the chain

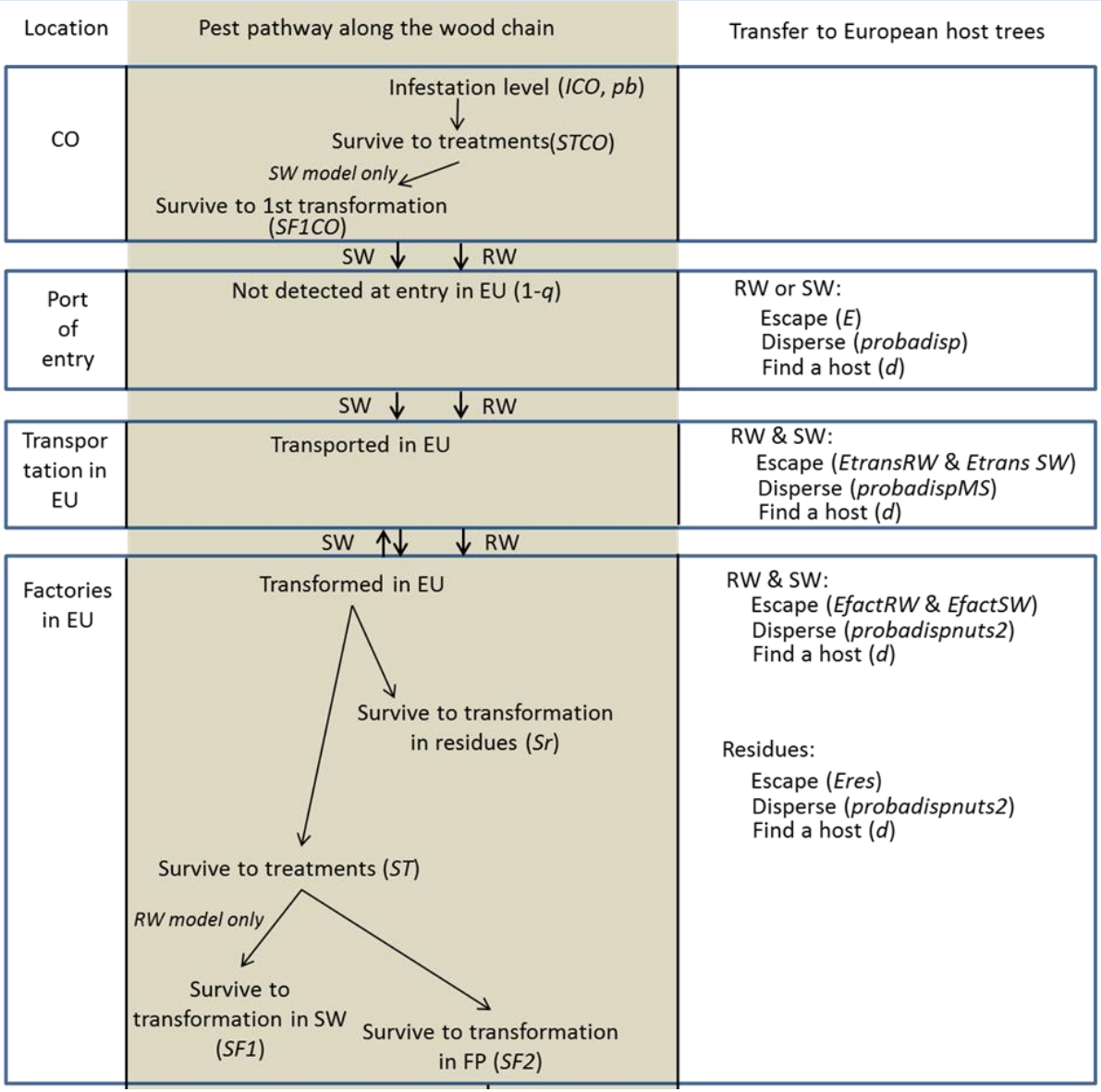


In the country of origin

Entry in Europe

Transportation of wood within Europe

Description of the model: pest pathway along the chain



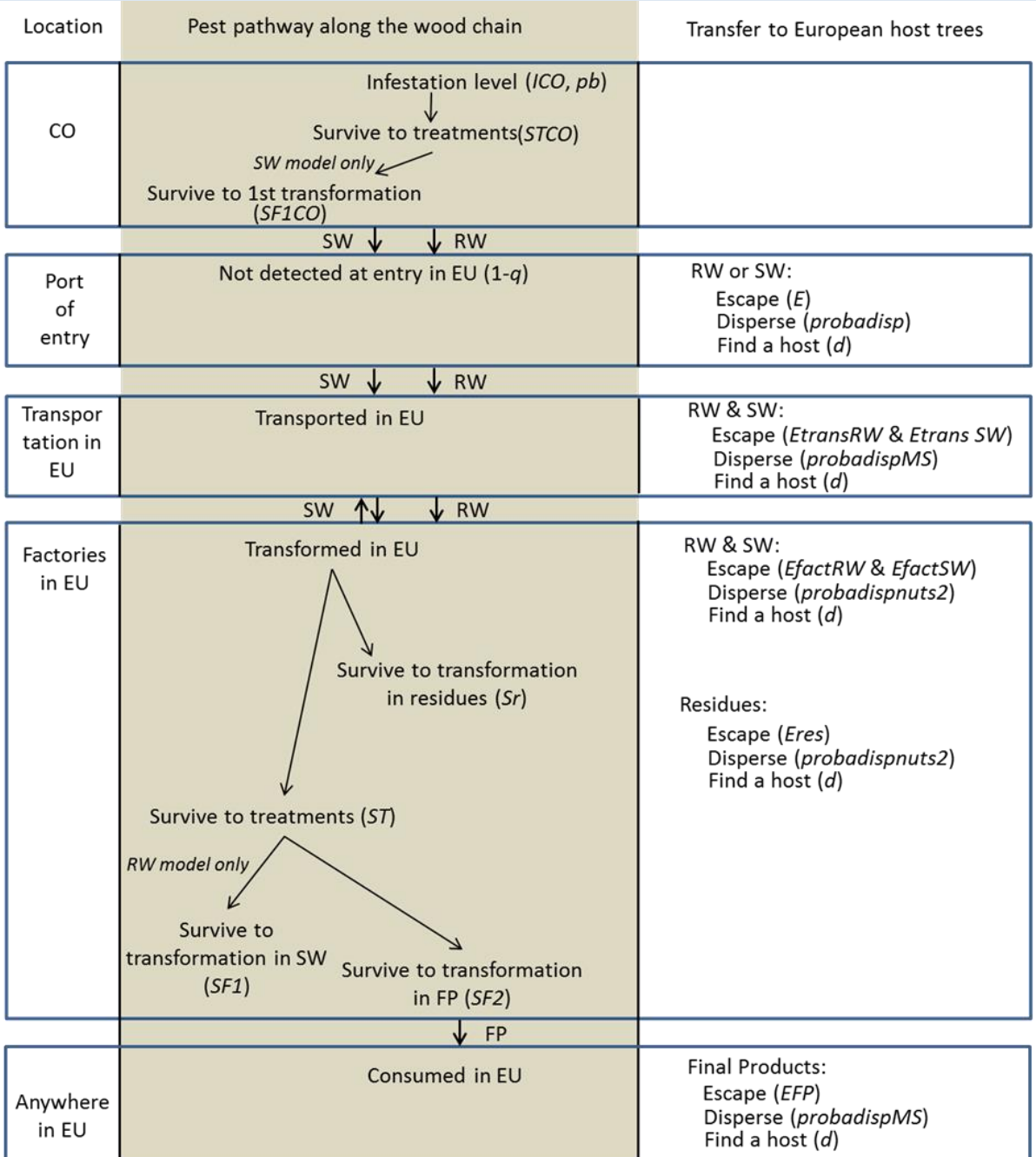
In the country of origin

Entry in Europe

Transportation of wood within Europe

Wood transformation in factories (sawmills)

Description of the model: pest pathway along the chain



In the country of origin

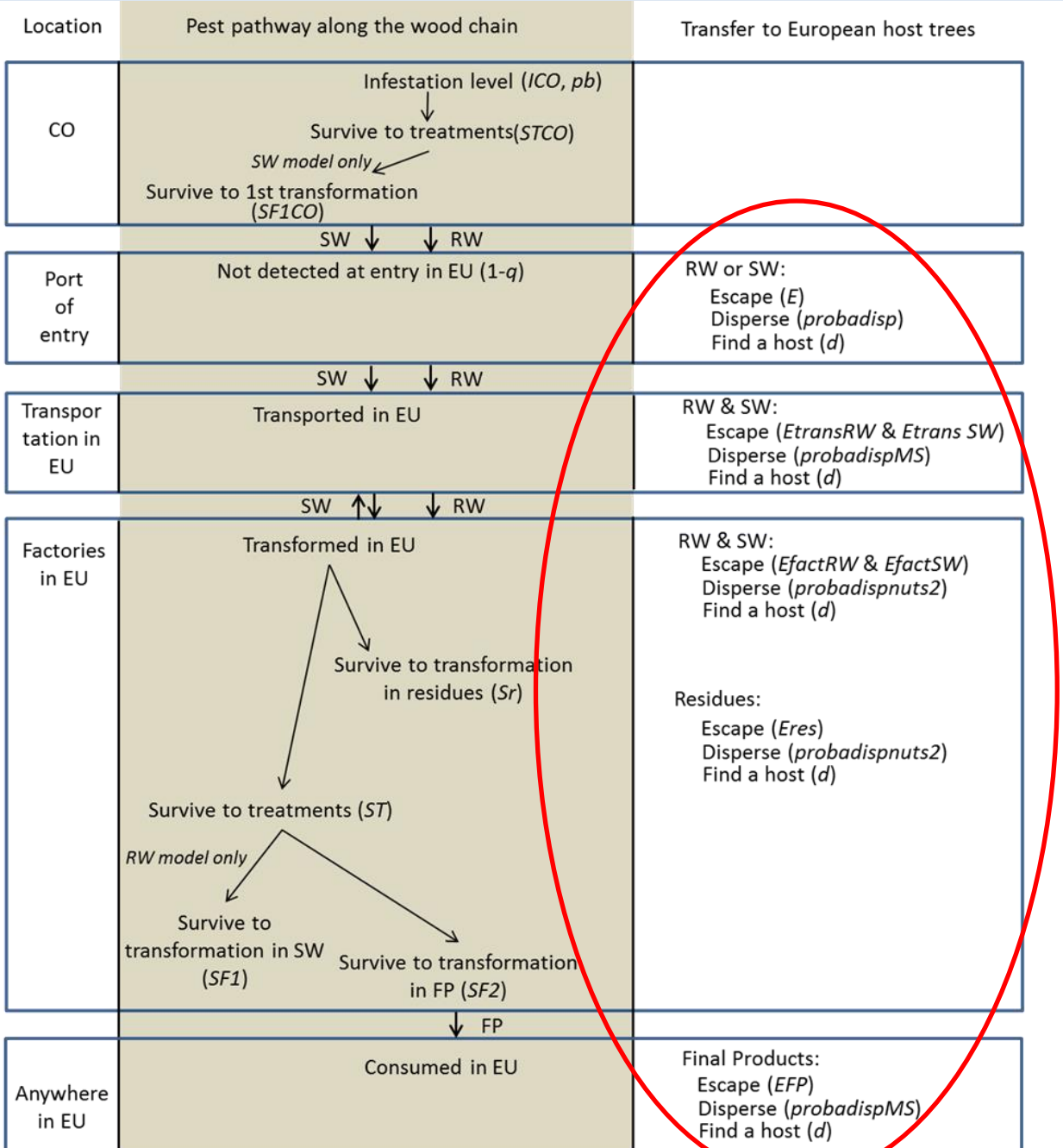
Entry in Europe

Transportation of wood within Europe

Wood transformation in factories (sawmills)

Use of the final product

Description of the model: pest pathway along the chain

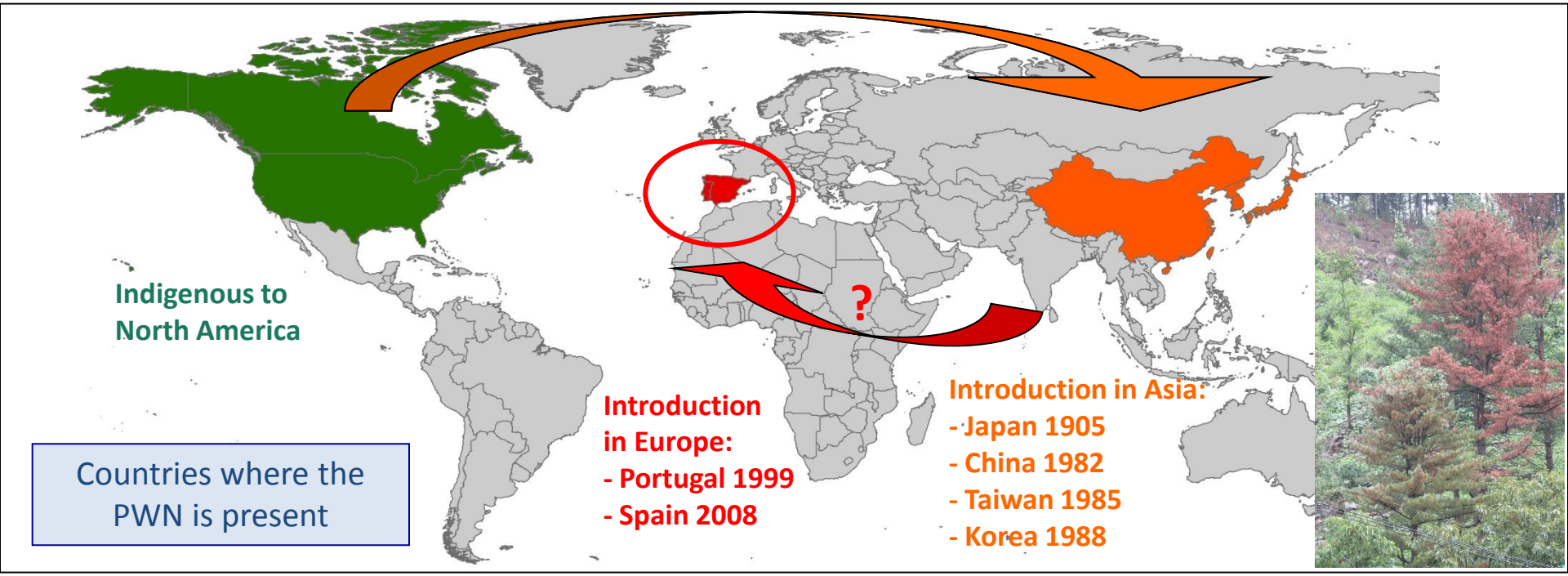


Transfer of the pest to host trees in Europe can potentially take place at 8 nodes

Application of the model: pine wood nematode

The pine wood nematode, *Bursaphelenchus xylophilus* can cause the pine wilt disease and kill a pine within a few weeks.

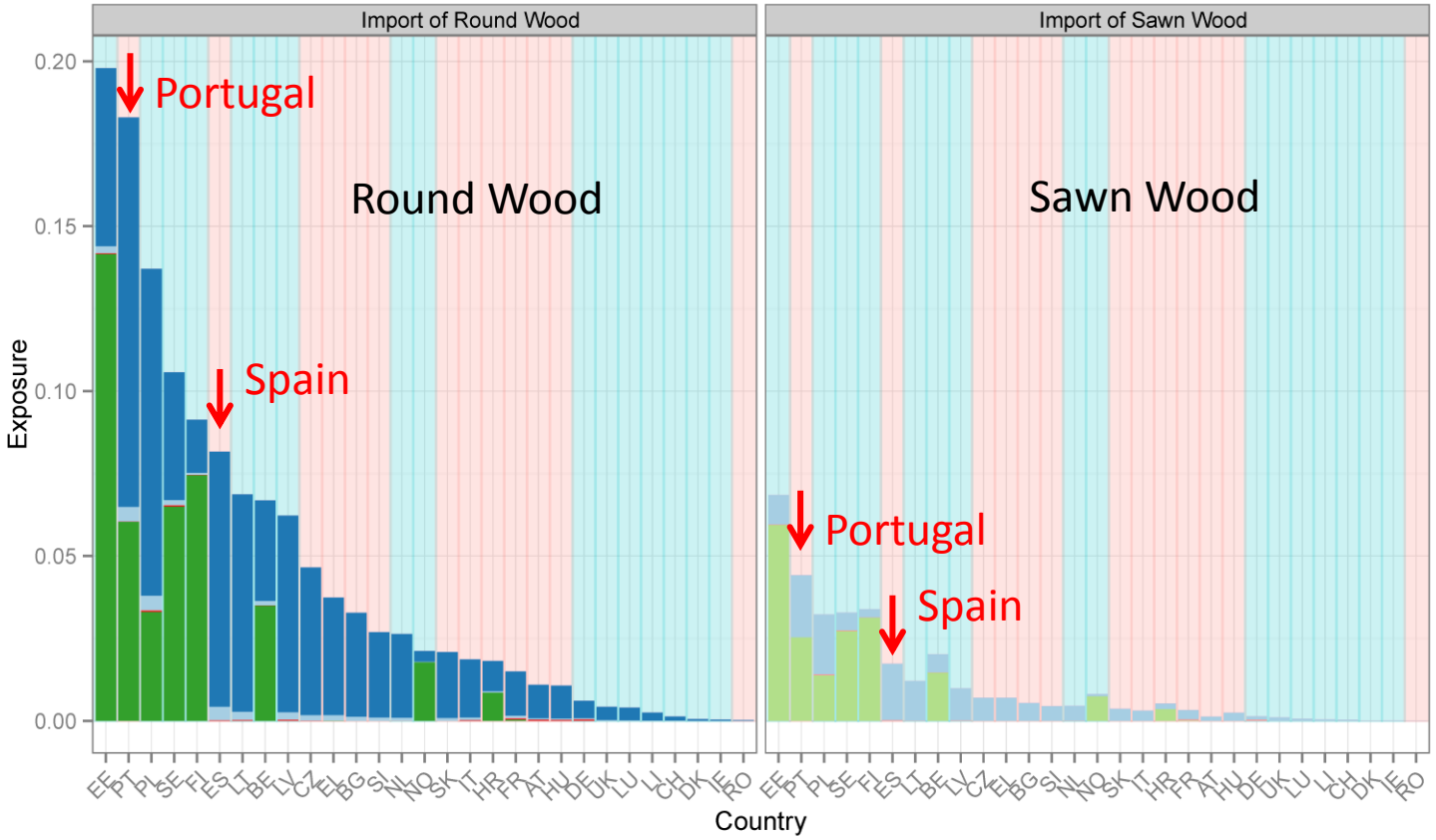
It is carried by insects of the genus *Monochamus*.



- The PWN can cause the PWD (decline and death of exotic pine trees) under some environmental conditions (Mean T June-Aug ≥ 20°C; Gruffudd et al., 2016)
- The pathway model was applied to coniferous wood going from China to Europe.

Application of the model: pine wood nematode

Exposure if each country imports <u>one ton of RW and SW</u>



8 nodes:

Source of transfer
- Round wood at factories
- Sawn wood at factories
- Final product
- Round wood at ports
- Sawn wood at ports
- Residues
- Transport of round wood
- Transport of sawn wood

Expression of PWD (T ≥ 20°C)
- No
- Yes

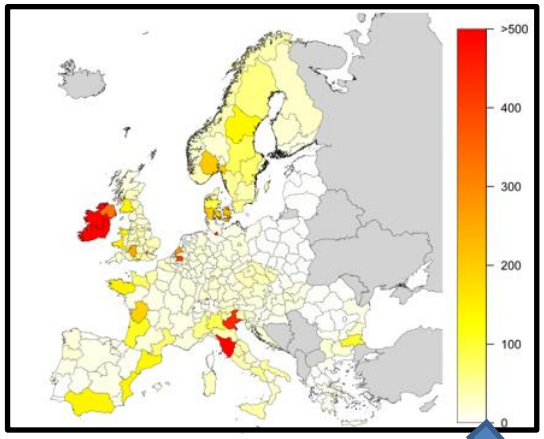
<u>Exposure in each European country</u> :

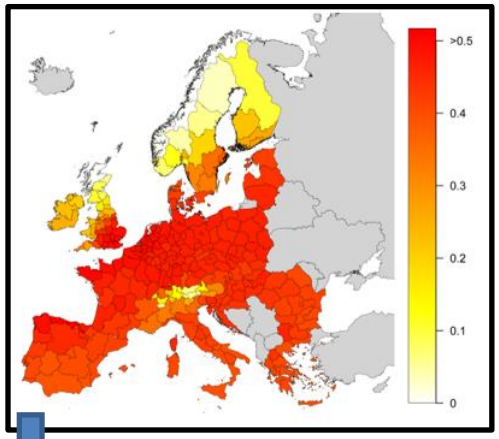
- highest around ports and then around factories (= 98% of exposure)
- highest in Estonia, Portugal, Poland, Sweden, Finland and Spain
- also high in countries where PWD cannot develop (difficult to detect the PWN => PWN reservoirs?)
- depends on the unit (« exposure/country » or « exposure/unit of area in each region »)

Application of the model: pine wood nematode

At the regional level (mean over 2000-2012)

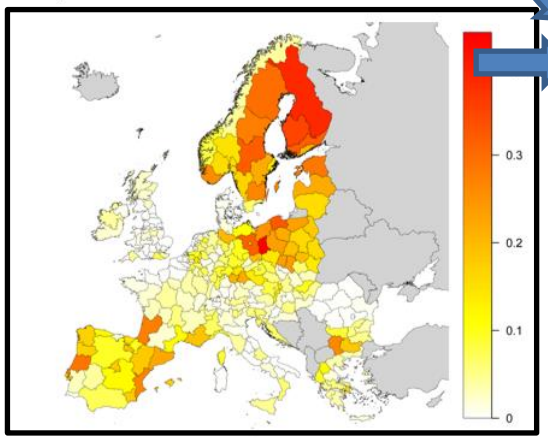
Number of propagules escaping from wood products per km² in each region (~ volume imported)



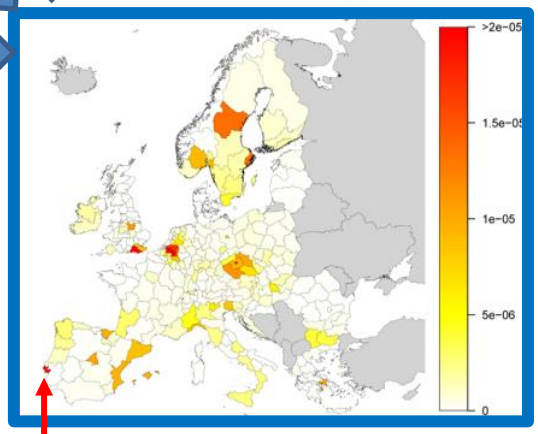


Probability that the vector is active once the propagules escape (*M galloprovincialis* where present, and *M alternatus* if imported)

Transfer to host trees



Probability of host encounter



Exposure per km²

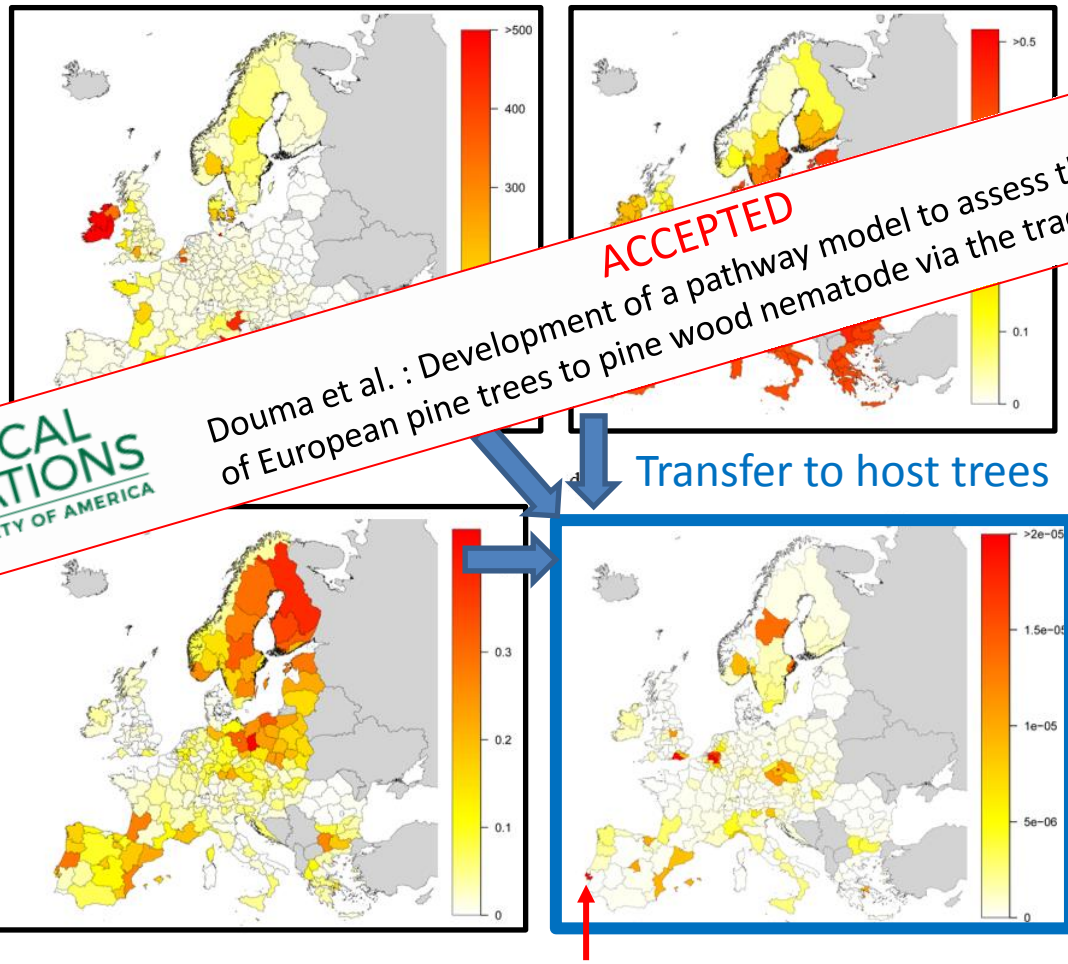
Setubal region, where the PWN was first detected in EU

is among those with the highest PWN transfer due to a high host cover and vector activity

Application of the model: pine wood nematode

At the regional level (mean over 2000-2012)

Number of propagules escaping from wood products per km² in each region (~ volume imported)



Probability that the ... ive once the ... s escape ... *provincialis* where present, and *M alternatus* if imported)

ACCEPTED

Douma et al. : Development of a pathway model to assess the exposure of European pine trees to pine wood nematode via the trade of wood

ECOLOGICAL APPLICATIONS
ECOLOGICAL SOCIETY OF AMERICA

Setubal region, where the PWN was first detected in EU

is among those with the highest PWN transfer due to a high host cover and vector activity

Application of the model: oak wilt disease

The oak wilt disease is caused by the fungus *Ceratocystis fagacearum* native from North America.
- white oaks are less susceptible to the disease than red oaks.
- OWD is transmitted via root grafts and insect vectors
(eg, sap beetles and bark beetles)

In Europe: OWD is not present yet ☺ but …
- oaks seem susceptible to OWD
- there are many potential vectors, especially the oak bark beetle *Scolytus intricatus*

Imports of oak logs from the USA to Europe are strictly regulated

1.11.2006 EN Official Journal of the European Union L 302/49

COMMISSION DECISION

of 31 October 2006

amending Decision 2005/359/EC as regards the ports of unloading of oak (*Quercus* L.) logs with bark attached, originating in the United States

(notified under document number C(2006) 5142)

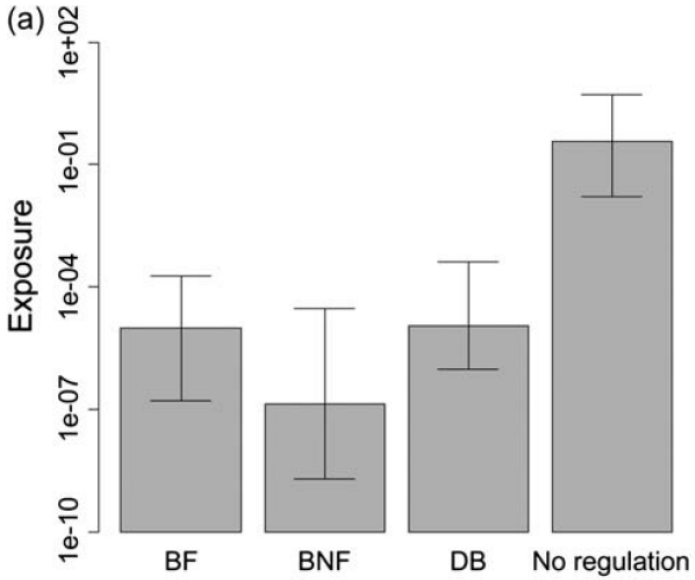
(2006/750/EC)

Application of the model: oak wilt disease

The probabilistic pathway model was applied to oak wood coming from the USA to Europe during 2001-2009:

Various scenarios have been tested (following the EU regulation):

- ***BF «bark fumigated»***: Oak logs imported with bark which have been fumigated (entry is allowed in only 35 European ports and transformation only in certified sawmills)
- ***BNF «bark non-fumigated»***: White oak logs imported with bark which have not been fumigated (entry is allowed in only 35 European ports, transformation only in certified sawmills, and transportation and storing conditions regulated)
- ***DB «DeBarked»***: Oak logs imported without bark
- ***No regulation***



Forestry An International Journal of Forest Research

Institute of Chartered Foresters

Forestry 2016; 89, 456–472, doi:10.1093/forestry/cpw029

Application of a wood pathway model to assess the effectiveness of options for reducing risk of entry of oak wilt into Europe†

Christelle Robinet[1]*, Jacob C. Douma[2], Dominique Piou[3,4] and Wopke van der Werf[2]

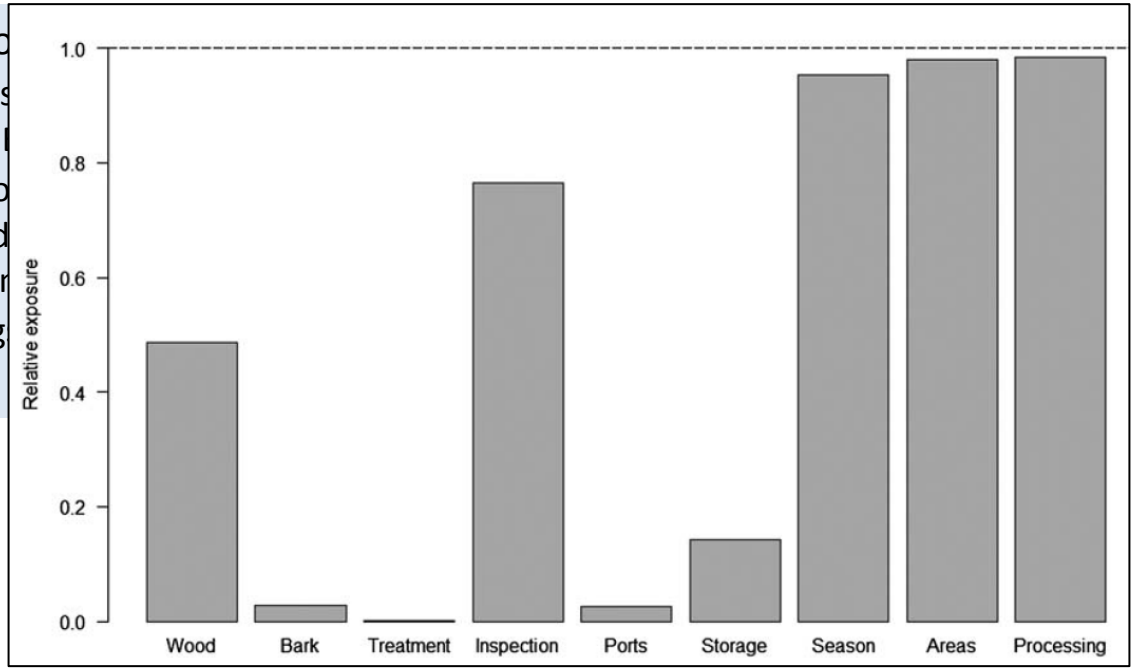
- Without regulation, the risk of introducing the oak wilt was relatively high
- This model was helpful to prove the efficiency of the current regulation

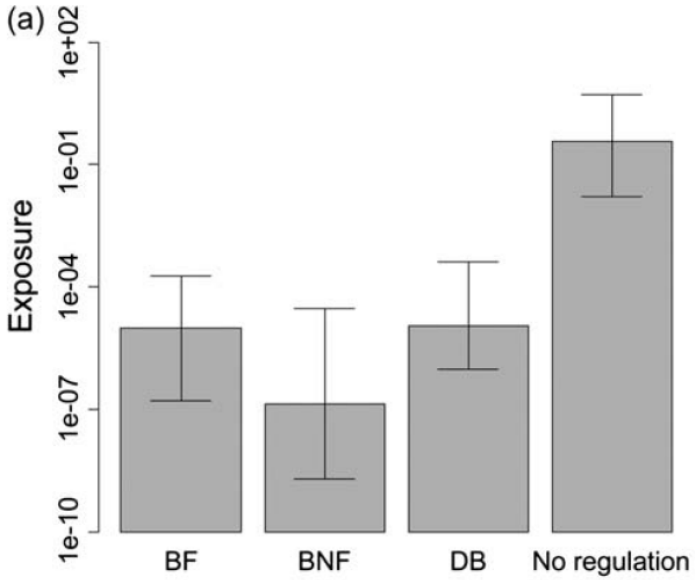
Application of the model: oak wilt disease

The probabilistic pathway model was applied to oak wood coming from the USA to Europe during 2001-2009:

Various scenarios have been tested (follo

- ***BF «bark fumigated»***: Oak logs only 35 I
- ***BNF «bark non-fumigated»***: White o allowed and trar
- ***DB «DeBarked»***: Oak log
- ***No regulation***





- Without regulation, the risk of introducing the oak wilt was relatively high
- This model was helpful to prove the efficiency of the current regulation
- More generally, this model can be used to explore various risk reduction options: treatments, removing bark, restricting the ports, conditions on storage, …

Conclusions

- This model is the first one to describe the pathway of an invasive pest along the wood chain, from the import of infested wood to the final product.

- Validation is not possible directly, but some aspects of the model testing were considered:

  - Correctness of the conceptual model formulation
    the model structure was discussed with a panel of forestry experts and pest risk assessment experts => with additional data (e.g., about inspection efficiency, precise location of factories, transportation distances, urban trees,….) , the model could be improved.

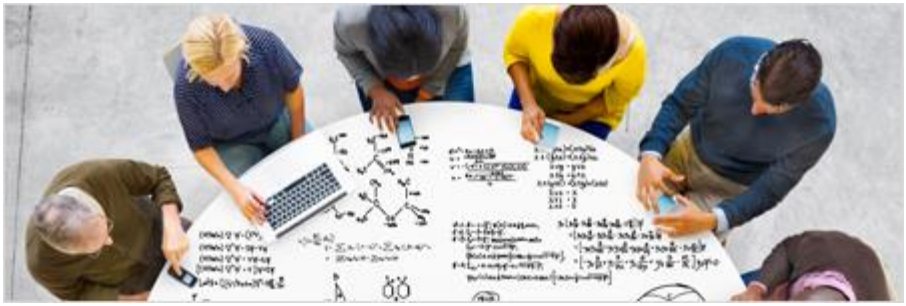
  - Correctness of the mathematical formulation and correctness of the software code
    They were cross-checked among co-authors and simulations were done in duplicate, shared and compared.

Conclusions

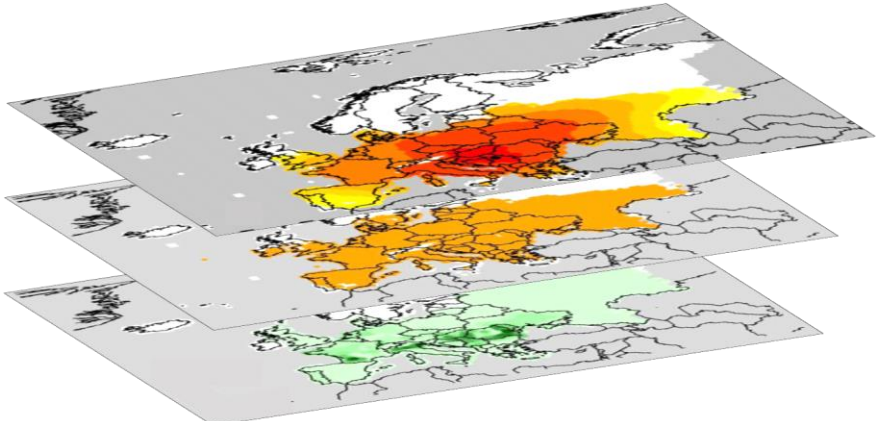
- This model is the first one to describe the pathway of an invasive pest along the wood chain, from the import of infested wood to the final product.
- Validation is not possible directly, but some aspects of the model testing were considered.
- This model allows to identify where exposure (or probability to introduce an invasive species) is the highest (which country? which node of the network ?).
- This model is useful to test various risk reduction options.
- This model points out the need to collect additional data in the future to better estimate this risk (e.g., about inspection procedure and efficiency, about the probability that a pest escapes from 1 m^3 of wood product, …).

Perspectives

- This model was developed in the frame of the EFSA project « PPM-PIRATES ».
  It can now be used by EFSA experts for:
  - assessing the probability of entry of invasive pests with wood imports
  - identifying the most appropriate measures to reduce this probability.



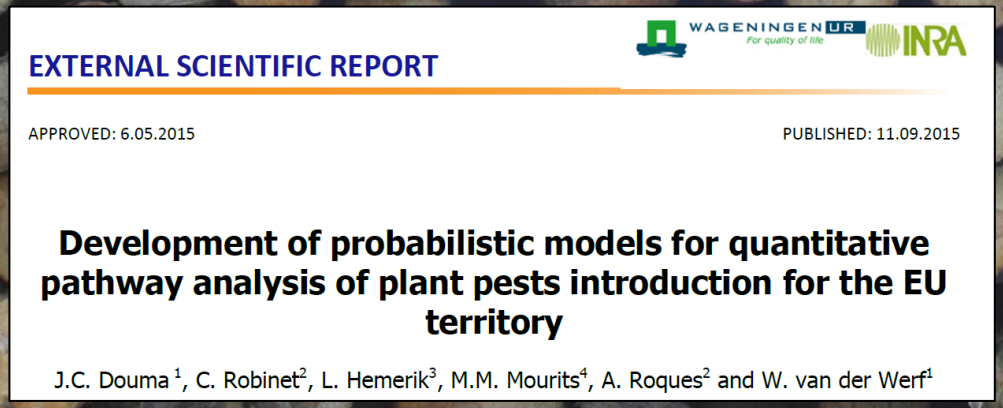
- With this model, it is possible to assess the probability of entry of an invasive pest with imports of round wood and sawn wood.
  The next step would be to combine this model to other models which describe establishment, potential spread and economic impact.



Thank you for your attention

We are grateful to:

- Alain Roques (INRA, France) and Monique Mourits (Univ. Wageningen, Netherlands) for their contribution.
- Olaf Mosbach Schultz, Giuseppe Stancanelli and Tomasz Oszako (EFSA) for constructive feedbacks.
- the panel of forestry experts with whom we discussed the structure of the wood pathway model in 2014 (Tomasz Oszako, Andrei Orlinski, Jean-Claude Grégoire, Harald Mausor, Dirk Jan van der Gaag, Alex Pra, Jean-Marc Henin).
- Jean-Luc Flot, Jean-Baptiste Daubree, Matthieu Vicaire and Aline Vinck (DGAL-DSF; French Ministry of Agriculture) for information about inspection procedures.



WAGENINGEN UR For quality of life INRA

EXTERNAL SCIENTIFIC REPORT

APPROVED: 6.05.2015 PUBLISHED: 11.09.2015

Development of probabilistic models for quantitative pathway analysis of plant pests introduction for the EU territory

J.C. Douma [1], C. Robinet[2], L. Hemerik[3], M.M. Mourits[4], A. Roques[2] and W. van der Werf[1]

This study was supported by EFSA in the frame of the project called PPM-PIRATES (2011-2015)

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Application of the model: pine wood nematode

Sensitivity analysis:

The most important parameters are:

- at the beginning of the pathway:
  - infestation rate in CO
  - survival rate to treatments & transformations in CO
  - volume of RW and SW imported in each EU country

- at the end of the pathway
  - probability that a propagule is dispersed by a vector (length of the flight season)
  - proportion of host cover