Probabilistic pathway models for risk assessment of plant pest invasions

Bob Douma, Monique Mourits, Christelle Robinet, Lia Hemerik, Wopke van Der Werf

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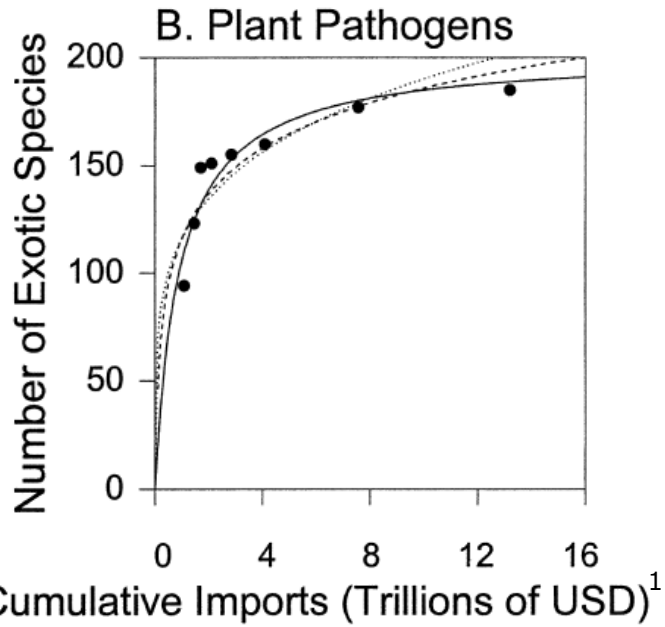
Global trade increases the risk of new plant pathogens

- Increasing international trade leads to new invasions
- Example of US
- Costs associated with plant pathogens > 25 billion dollars[2]
- Some invasive species may have detrimental effects on natural habitats
- Europe: Douglas-fir beetle



[1]

1)Levine and D'Antonio 2003, 2) Pimentel et al 2005

Aim: minimizing invasions with unnecessary restrictions to global trade

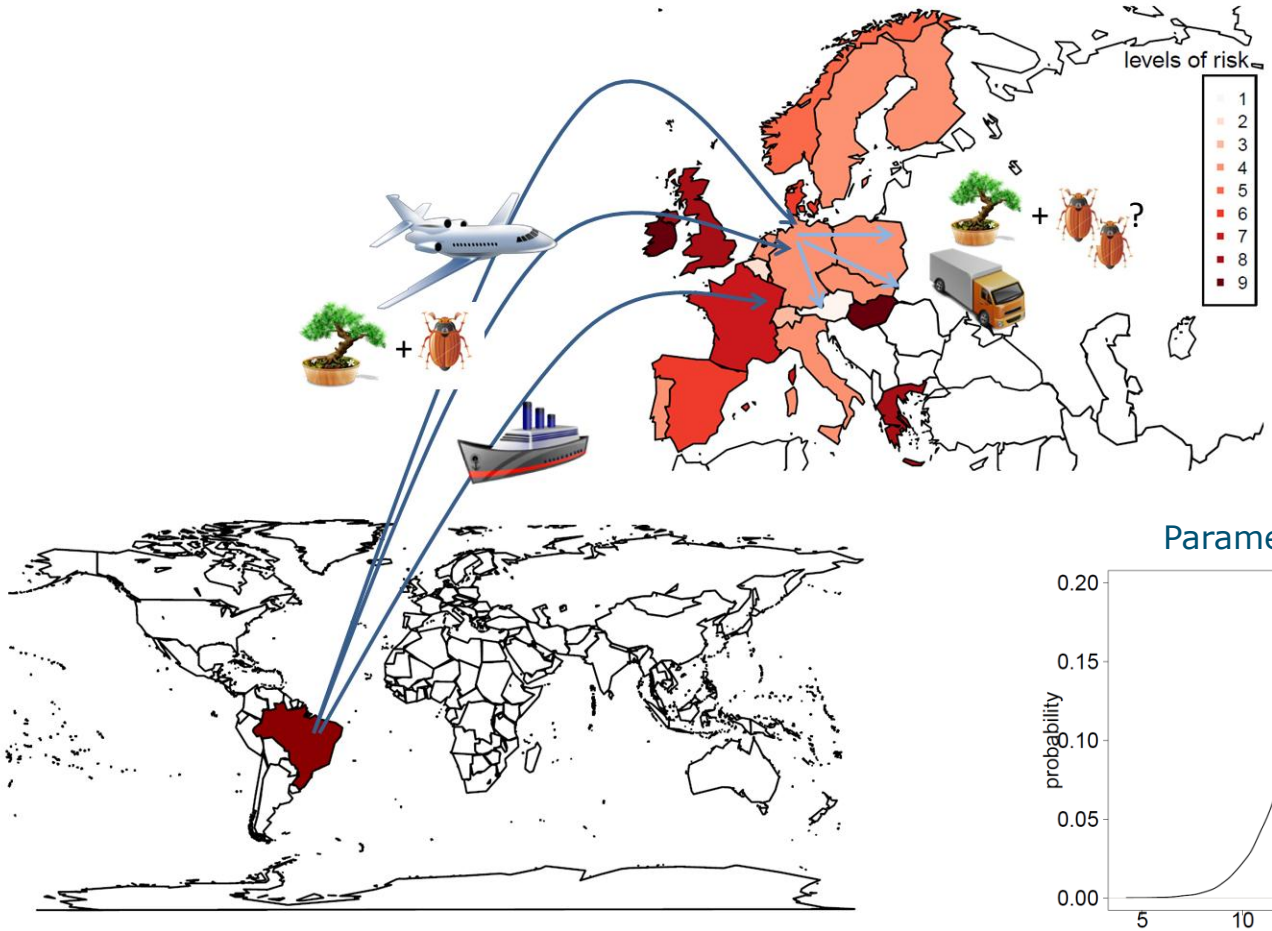
Other questions for plant health agencies:

- Is the new pest a real threat? Or is it not able to survive in a new country?
- What measures needs to be taken to reduce the risk?

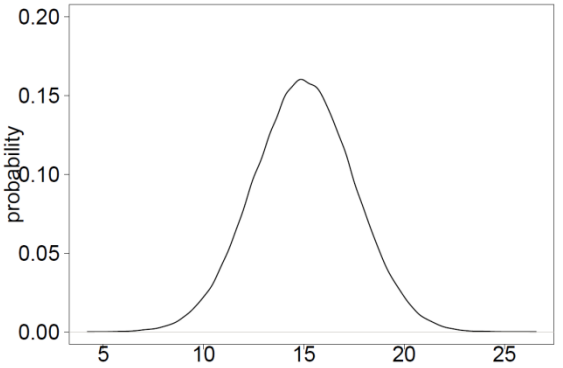
Develop a tool for risk managers:

- Probabilistic pathway models (PPMs) for plant products
- Project funded by EFSA
- Inspired by model developed by USDA APHIS

How do PPMs work? Graphical summary



Parameter distributions



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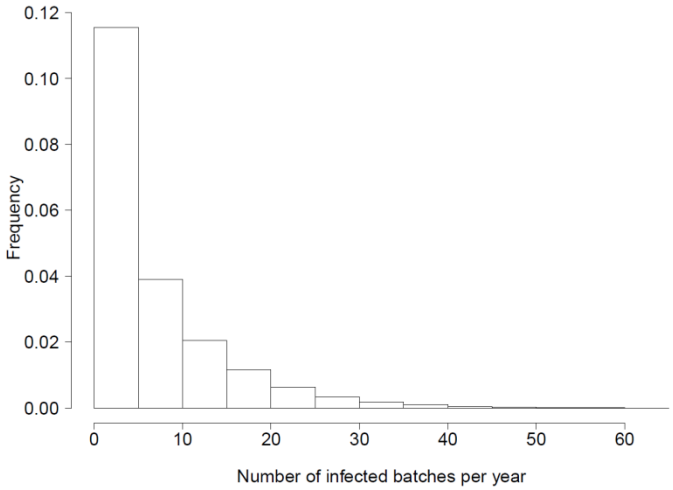
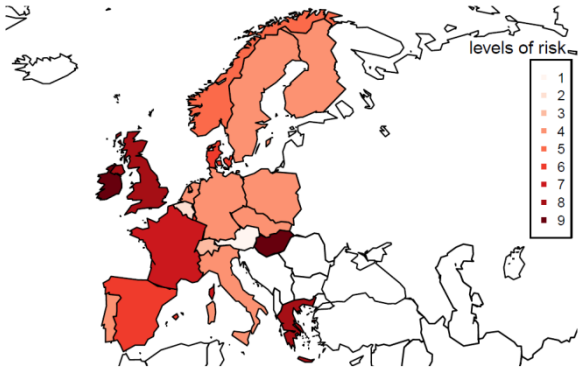
Quantification of risk

- Probability distribution of propagule density in target products in EU member states
- Probability distribution of propagule density (e.g. #/plant) in imported consignments)
- Communicate uncertainties in model predictions and caution users about caveats

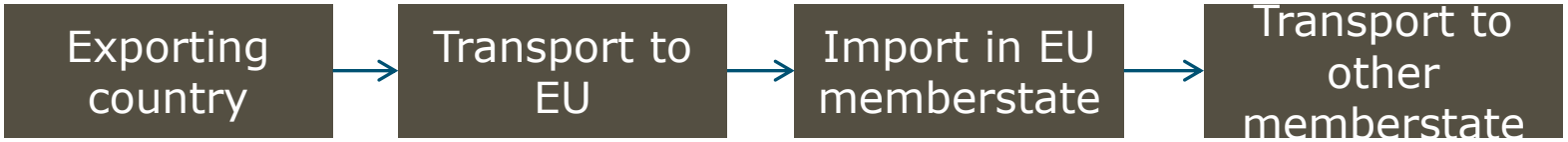




Conceptualisation of the model

- Divide the import process of a pest in stages; from the source (agro-)ecosystem in the country of origin to introduction into the target (agro-)ecosystem in the EU territory

A series of stages:



- In each stage: model the probability distribution of infestation level (density or proportion of infested units) for a consignment
- Each parameter is defined as a distribution of likely values
- Monte Carlo simulation of the parameter space

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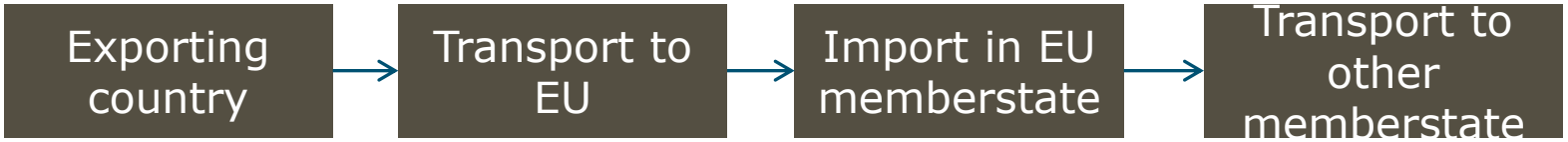

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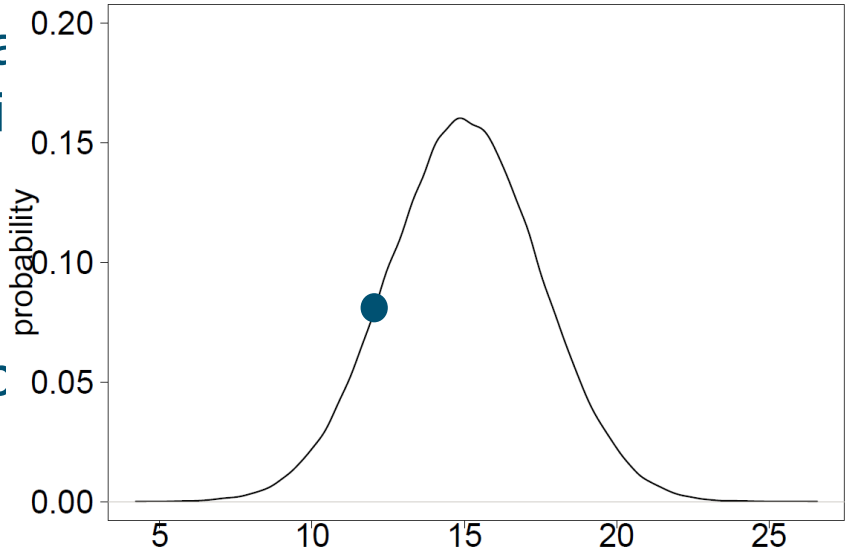
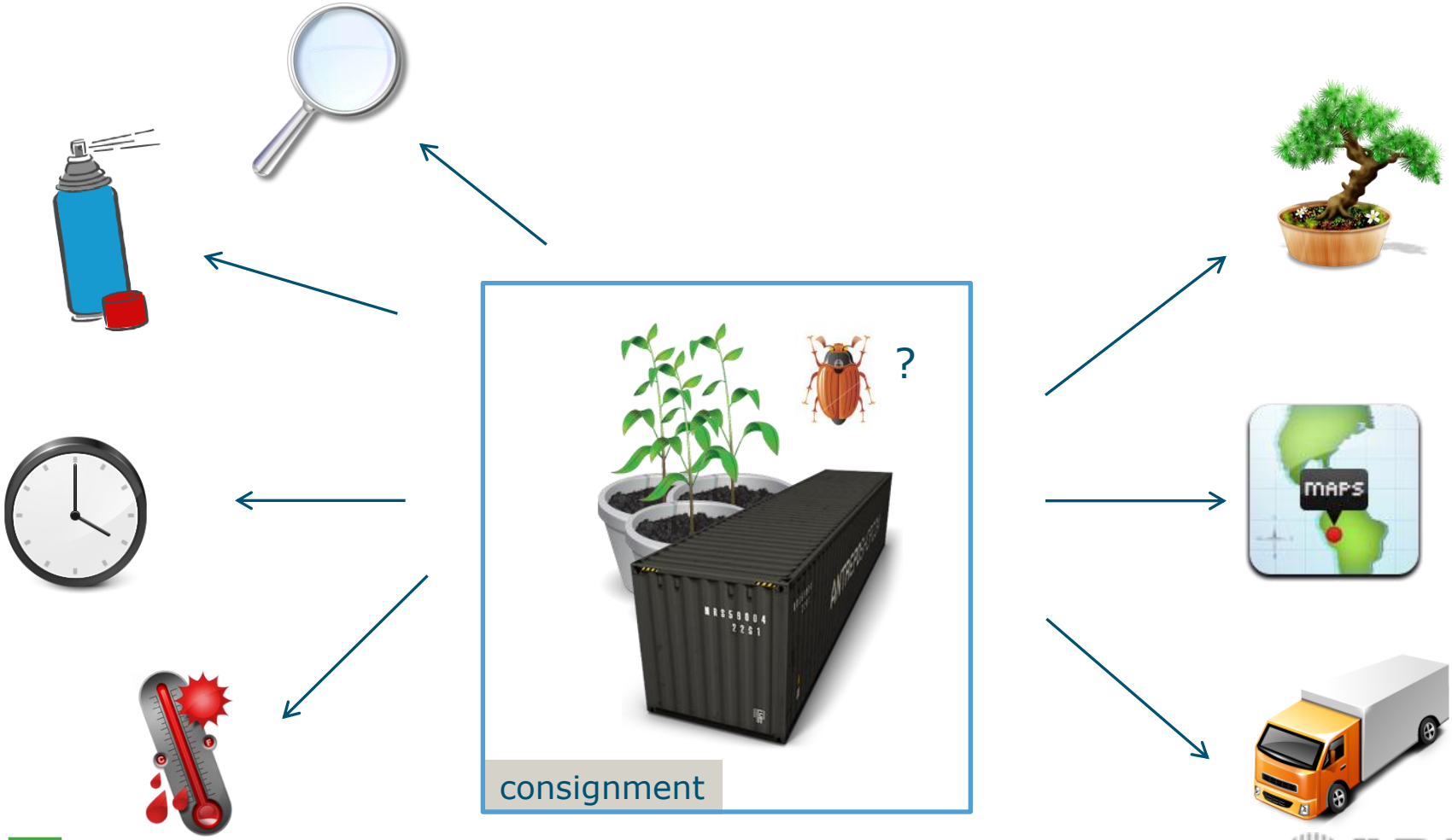


A stage is defined by a number of factors; for each stage calculate infestation level



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Two models: population model and individual consignment model

- Consignment model (individual consignment based) – spatially explicit and real time scale (data permitting!!)
- One possible realization from distribution

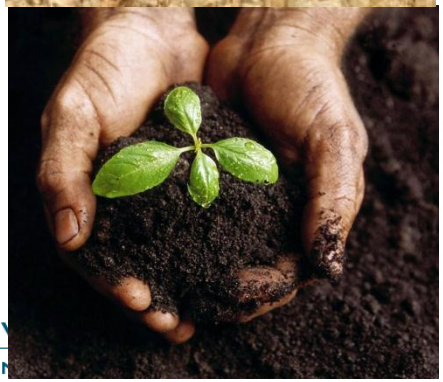
- Population model – collective behaviour of individual consignments (country level spatial resolution and monthly level temporal resolution)

Development of PPMs for five non-edible plant product groups

1) Round wood

2) Wood shavings

3) Plants for planting



4) Cut flowers

5) Seeds

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Application of PPMs to five case studies

- Round wood + *Dendroctonus pseudotsugae* (douglas fir beetle)
- Wood shavings + *Bursaphelenchus xylophilus* (pine wood nematode)
- Bonsai + *Xiphinema americanum* (soil nematode)
- Cut orchid flowers + *Thrips palmi* (insect)
- Tomato seeds + PSTVd (viroid)

Strength of approach

- Be explicit about risks at each stage
- To identify worst and best cases for future pest invasion, and visualize what European authorities can do about it
- Scenario analysis:
    - To explore the range of possible outcomes, under multi-parameter (multi-process) variations
    - Identify most (cost-)effective phytosanitary measures

Sensitivity analysis

Sensitivity analysis:

- Purpose: determine the relationship between process parameters (or structure) and outcomes

- What is the most critical stage during transport?
- Is quantity more import than intensity of inspection?

Uncertainty & Variability

Purpose: identify uncertainties in model outcomes, deriving from lack of knowledge or inherent (biological or other) variability in processes (e.g. infestation levels in country of origin, if unknown)

- Uncertainty: deriving from lack of knowledge; remedy by more data
- Variability: inherent (biological or other) variability in processes (e.g. infestation levels in country of origin, if unknown); remedy by process redesign

Weakness: Data requirement of PPMs

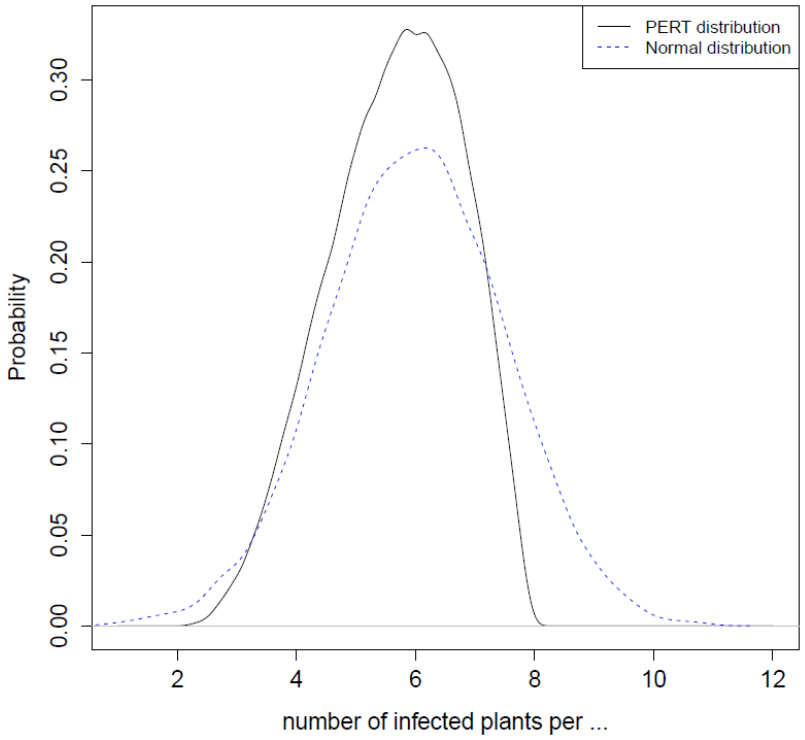
- Collecting data of various sources:
  - Biological characteristics of plant pest
  - Commodity flows (quantity, units, mode of transport)
  - Transport conditions
  - Phytosanitary measures (inspection and treatments)
- Standardizing data sources
  - that differ in temporal and spatial resolution
  - from different Plant health agencies
- Parameterisation for individual consignments difficult[1]

1) Piel et al 2008

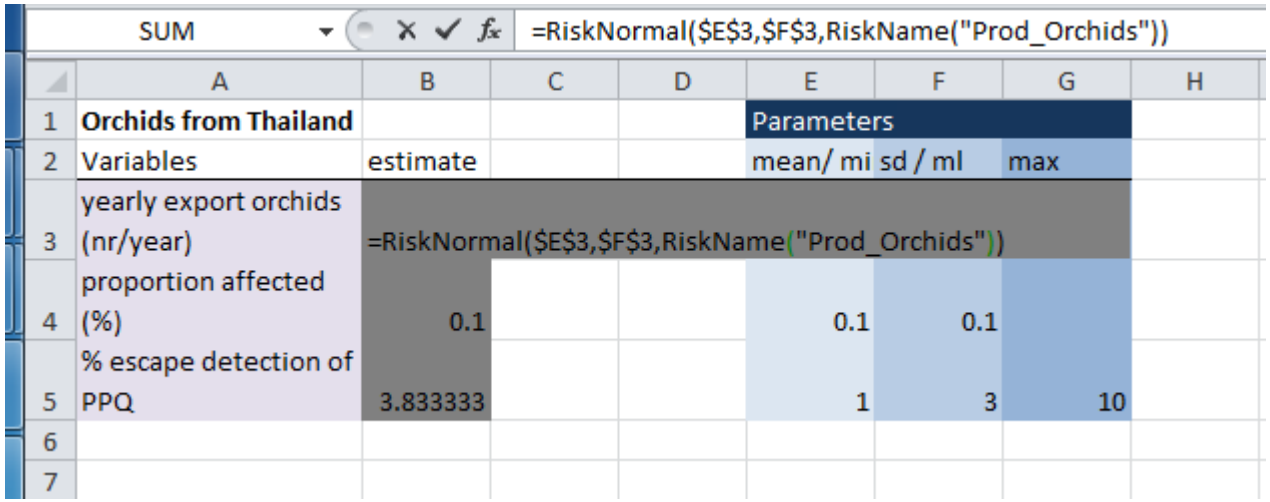
Threat: Wrong choice of parameter values and distributions

- How reliable is an parameter estimate?
- Which type of distribution is most appropriate?
- Expert judgement often modelled with minimum, maximum and most likely

  (PERT)



User friendly model interface: @Risk



SUM

=RiskNormal(E3,F3,RiskName("Prod_Orchids"))

	A	B	C	D	E	F	G	H
1	**Orchids from Thailand**				Parameters			
2	Variables	estimate			mean/ mi	sd / ml	max	
3	yearly export orchids (nr/year)	=RiskNormal(E3,F3,RiskName("Prod_Orchids"))						
4	proportion affected (%)	0.1			0.1	0.1		
5	% escape detection of PPQ	3.833333			1	3	10	
6								
7								

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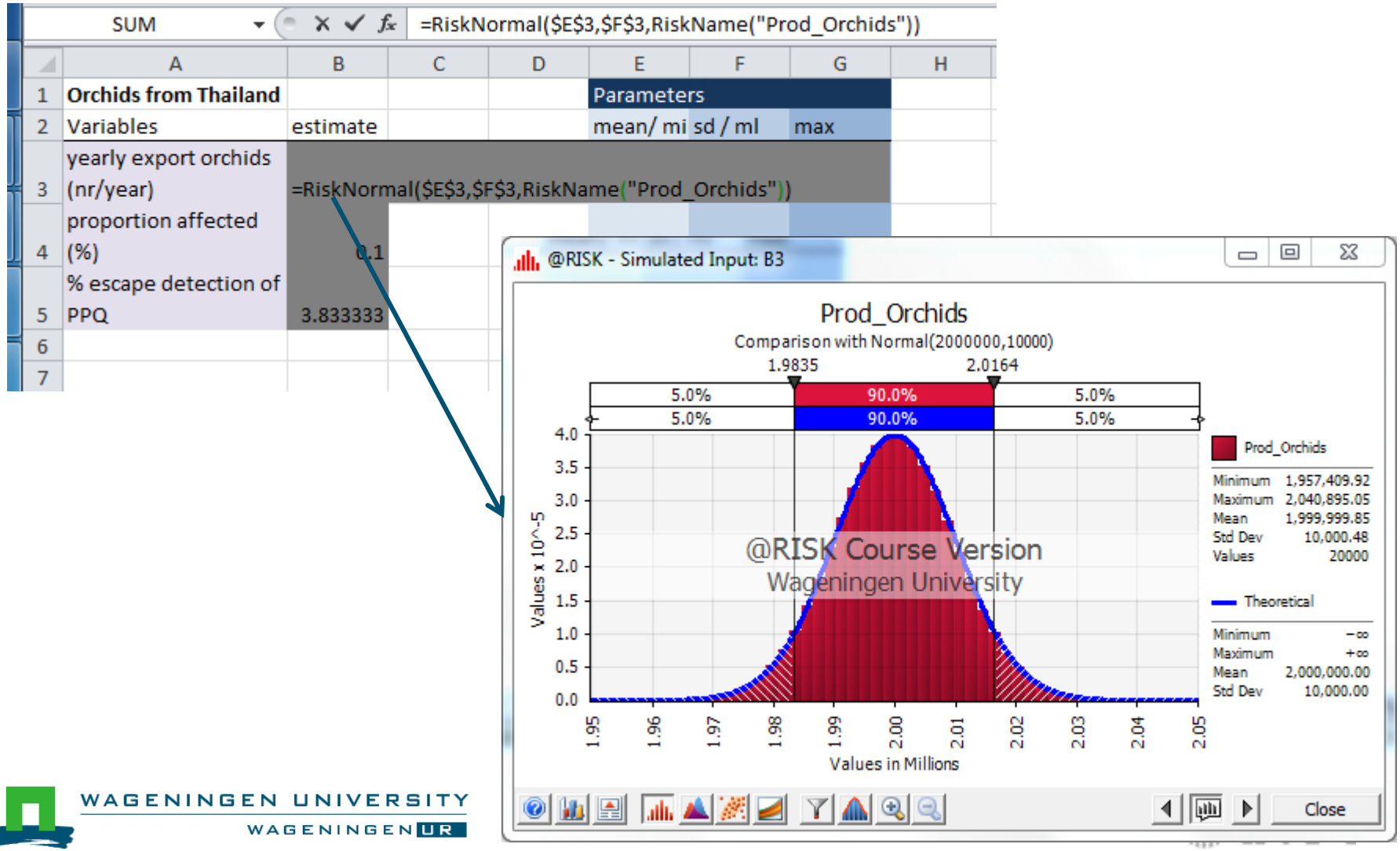

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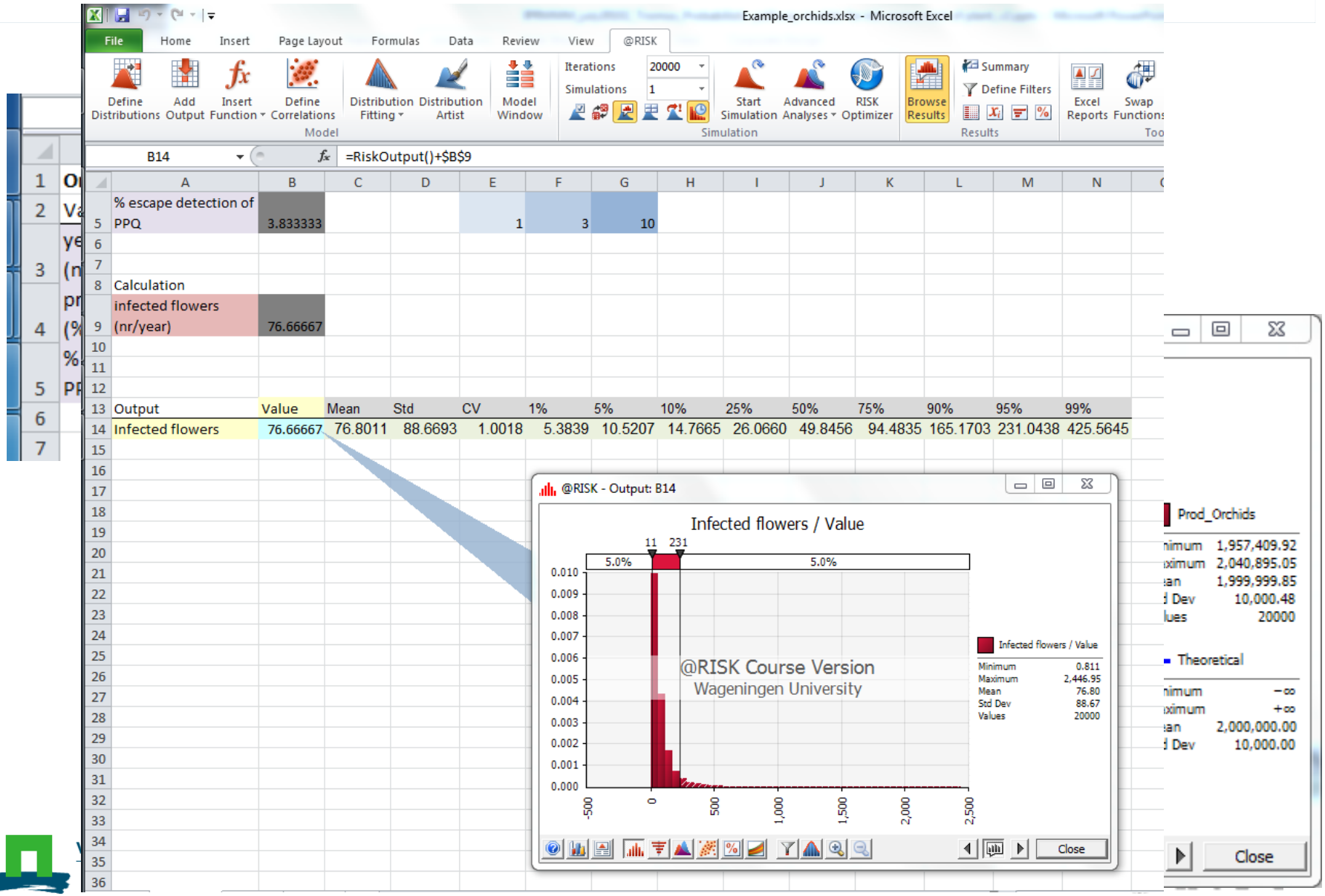

Consultation group for development of pathway models

Interaction with:

- Researchers for model development
- Experts on the different product groups for identifying major pathways, commodity flows etc.
- Experts from Plant Health agencies
- Plant Health Panel (EFSA) to build an applicable model

Feedback, comments, ideas, questions?

All welcome!

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