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Bob Douma, Monique Mourits, Christelle Robinet, Lia Hemerik, Wopke van Der Werf. Probabilistic pathway models for risk assessment of plant pest invasions. 6. Workshop International Pest Risk Mapping “Advancing risk assessment models for invasive alien species in the food chain: contending with climate change, economics and uncertainty”, Jul 2012, Tromso, Norway. 21 diapos. hal-02807208

HAL Id: hal-02807208

<https://hal.inrae.fr/hal-02807208>

Submitted on 6 Jun 2020

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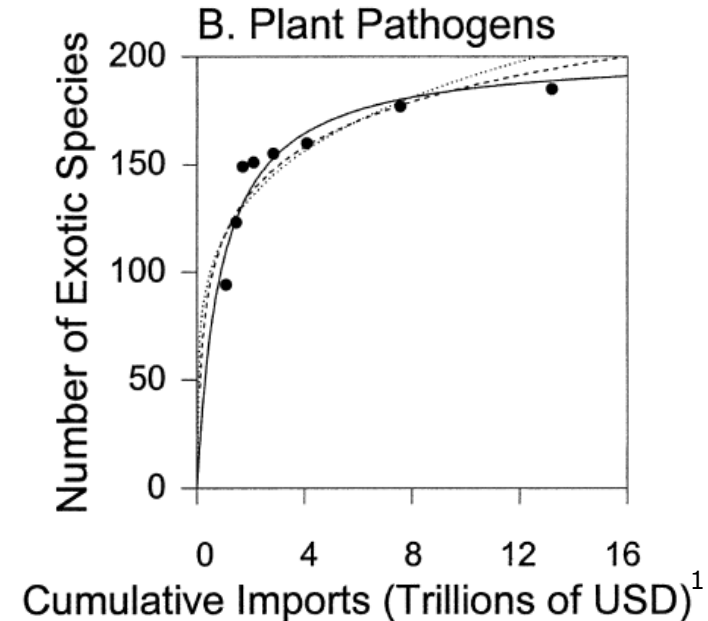
Probabilistic pathway models for risk assessment of plant pest invasions

Bob Douma (WUR), Monique Mourits (WUR), Christelle Robinet (INRA), Lia Hemerik (WUR) and Wopke van der Werf (WUR)



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 dollars²
- Some invasive species may have detrimental effects on natural habitats
- Europe: Douglas-fir beetle



Aim: minimizing invasions with unnecessary restrictions to global trade

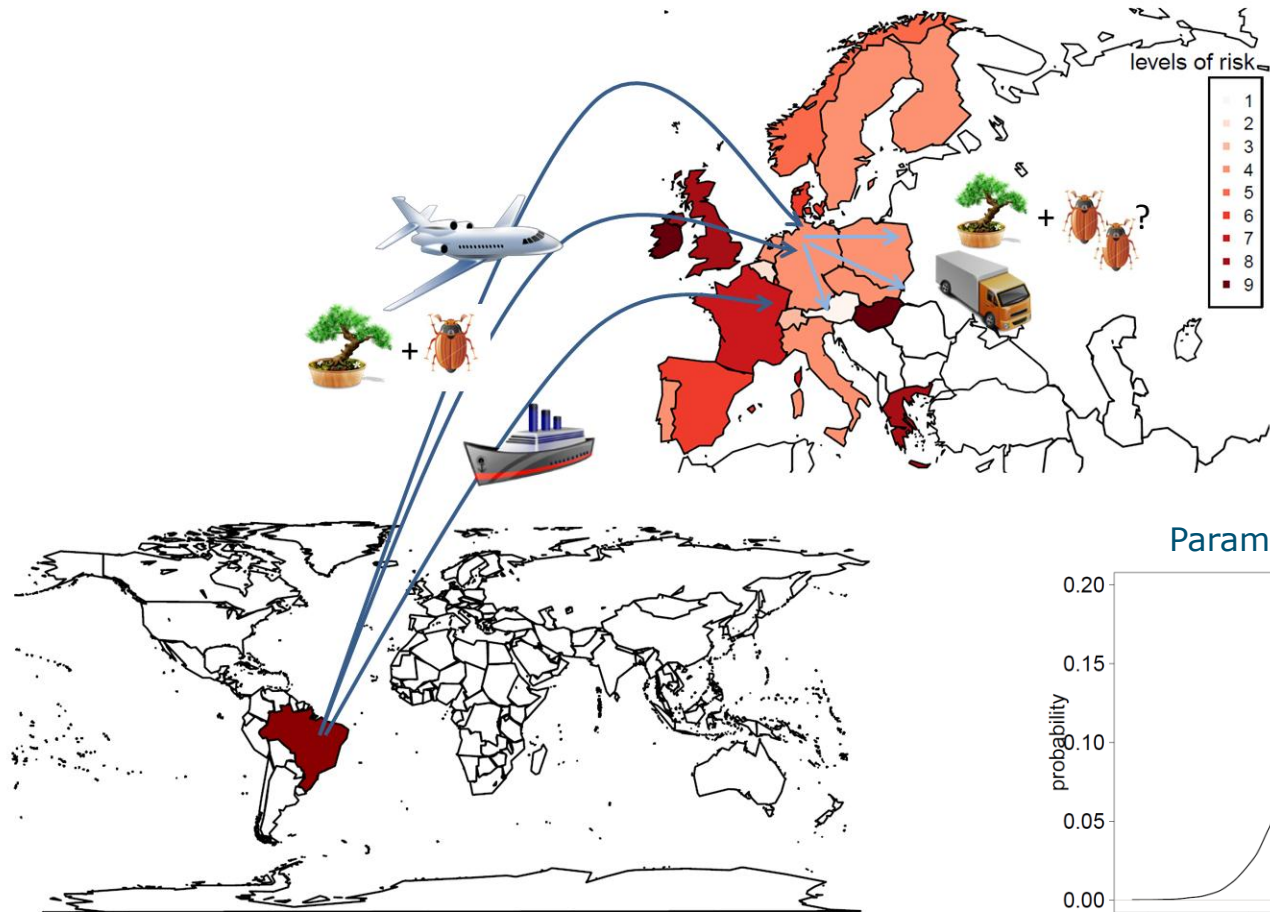
Other questions for plant health agencies:

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

Develop a tool for risk managers:

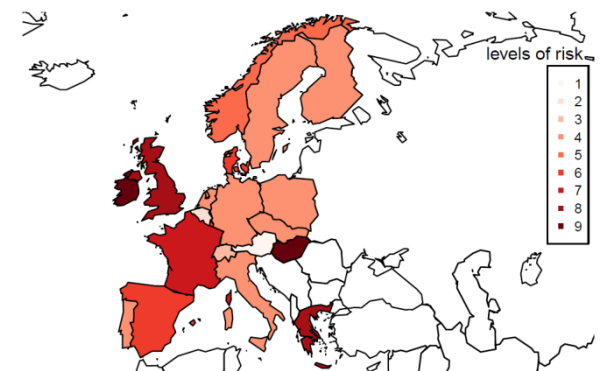
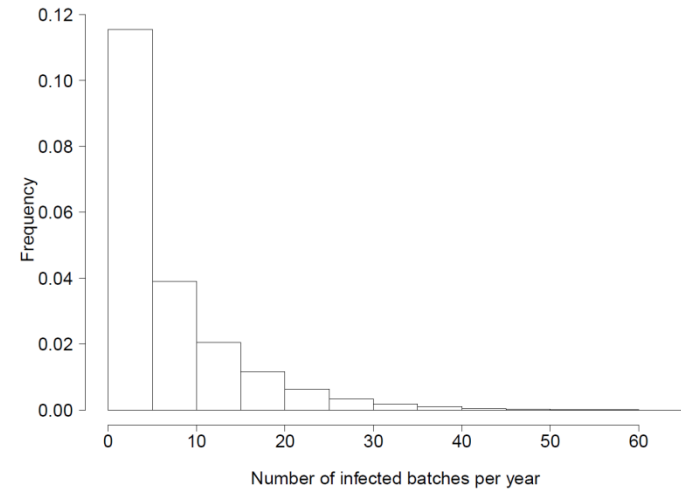
- Probabilistic pathway models (PPMs) for plant products
- Project funded by EFSA
- Inspired by model developed by USDA APHIS

How do PPMs work? Graphical summary



Quantification of risk

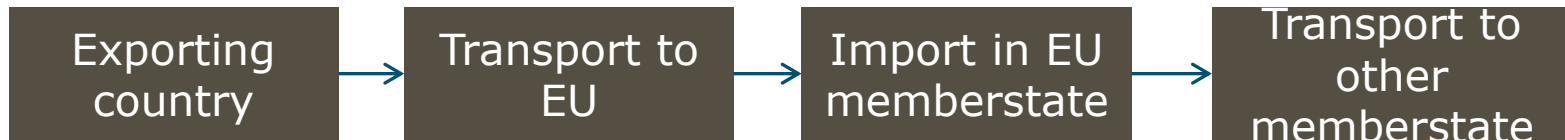
- Probability distribution of propagule density in target products in EU member states
- Probability distribution of propagule density (e.g. #/plant) in imported consignments)
- Communicate uncertainties in model predictions and caution users about caveats



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:

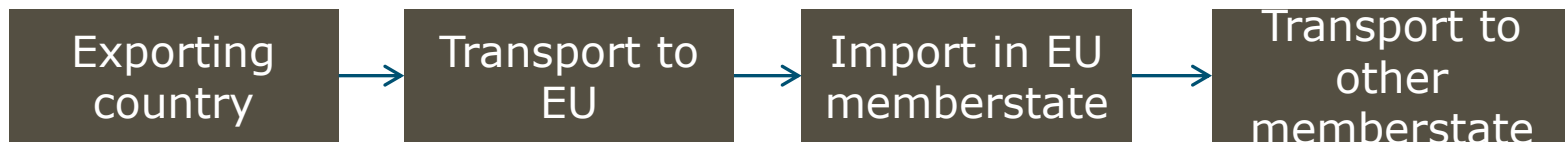


- In each stage: model the probability distribution of infestation level (density or proportion of infested units) for a consignment
- Each parameter is defined as a distribution of likely values
- Monte Carlo simulation of the parameter space

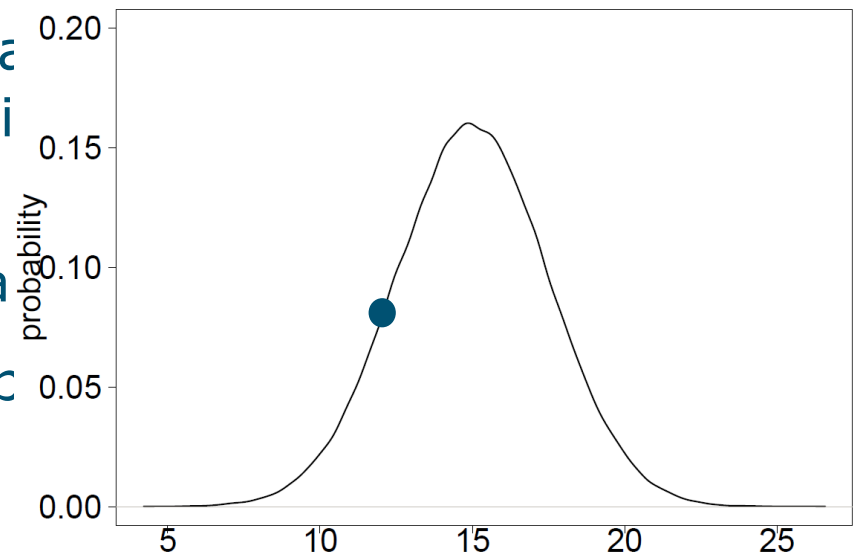
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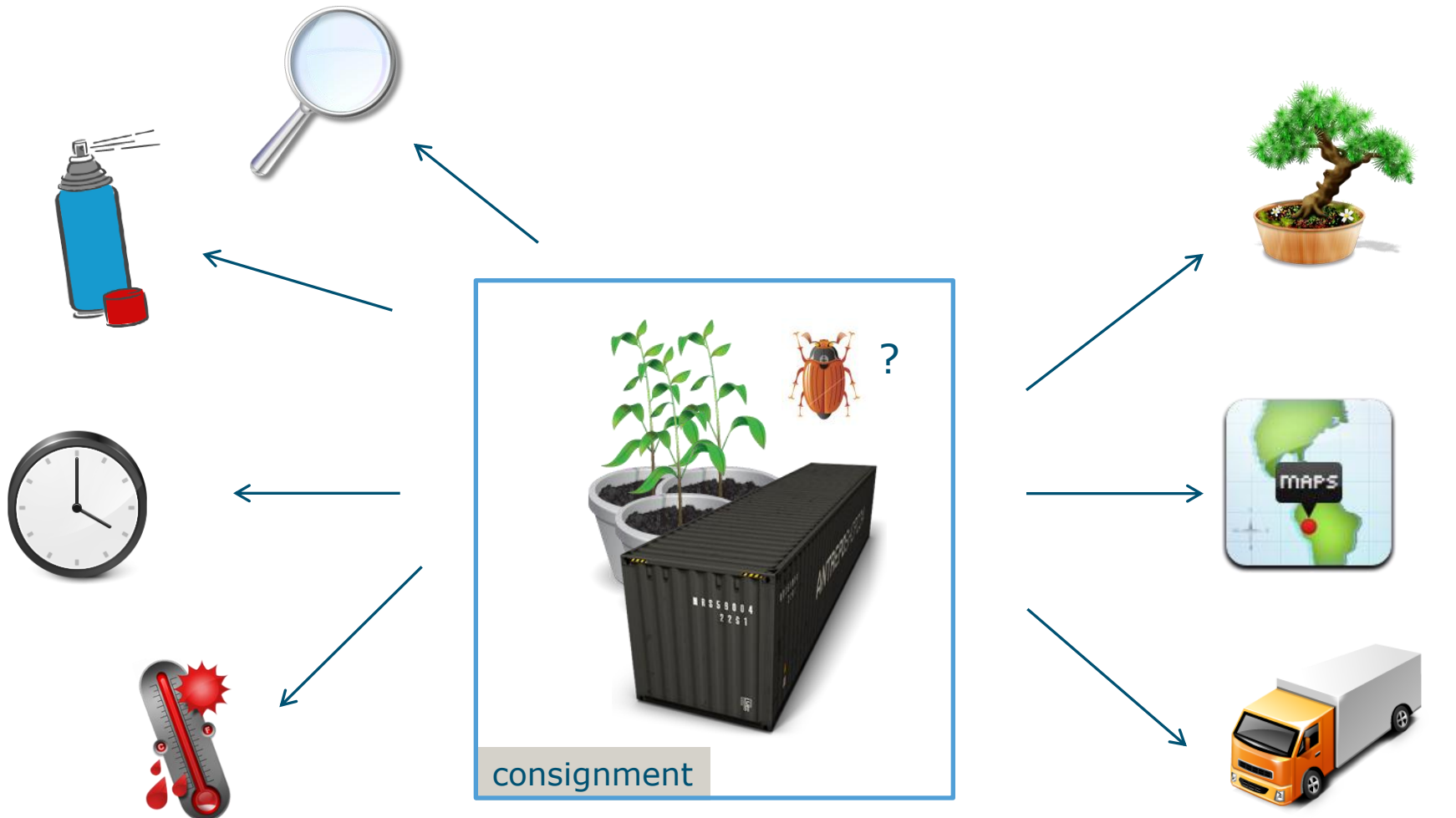
A series of stages:



- In each stage: model the probability level (density or proportion of imported consignment)
- Each parameter is defined as a probability
- Monte Carlo simulation of the process



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



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



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 important 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

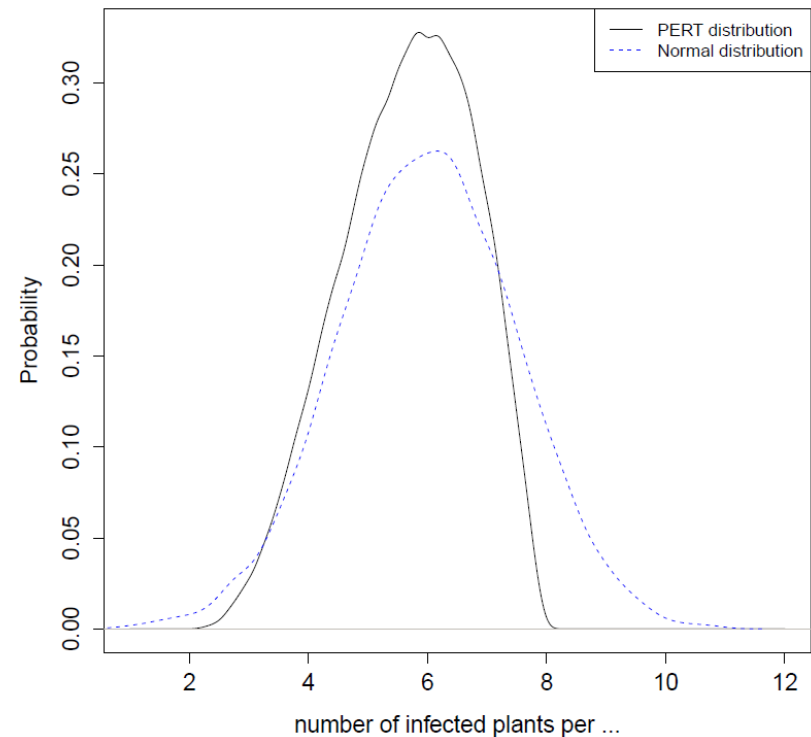


Weakness: Data requirement of PPMs

- 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 difficult¹

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

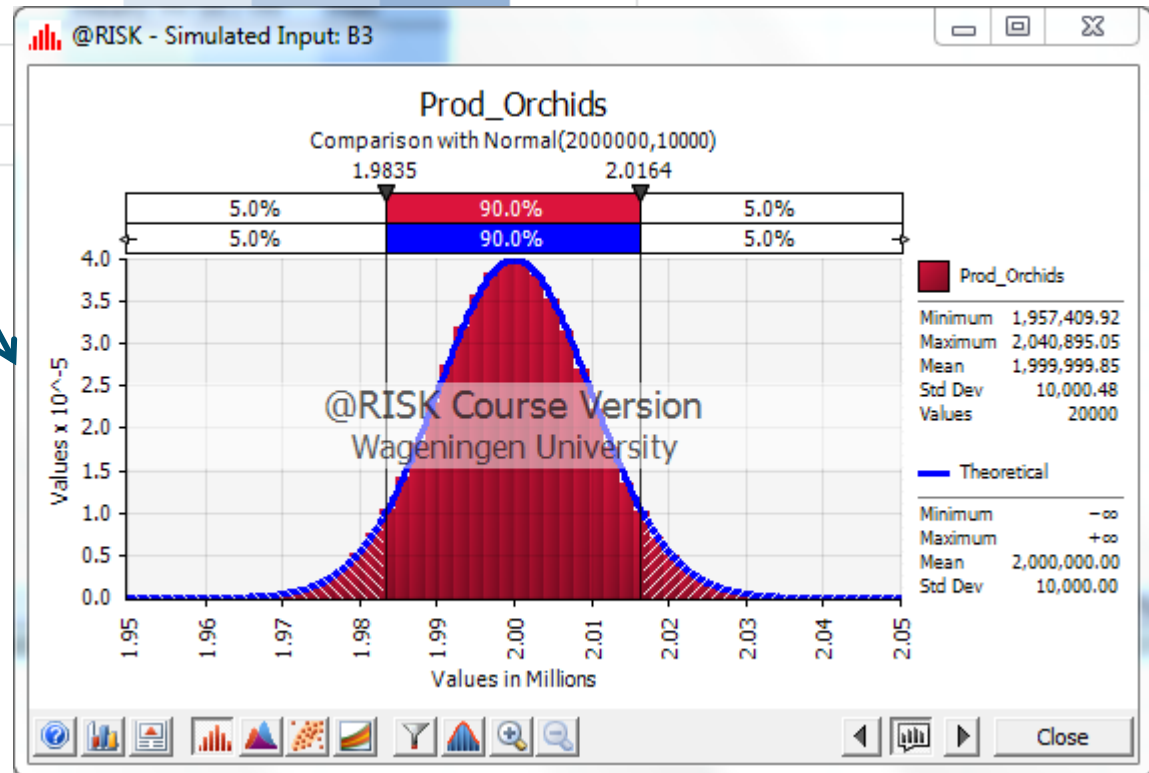
SUM		=RiskNormal(\$E\$3,\$F\$3,RiskName("Prod_Orchids"))						
	A	B	C	D	E	F	G	H
1	Orchids from Thailand				Parameters			
2	Variables	estimate			mean/ mi sd / ml		max	
3	yearly export orchids (nr/year)	=RiskNormal(\$E\$3,\$F\$3,RiskName("Prod_Orchids"))						
4	proportion affected (%)	0.1			0.1	0.1		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



User friendly model interface: @Risk

SUM X ✓ fx =RiskNormal(\$E\$3,\$F\$3,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(\$E\$3,\$F\$3,RiskName("Prod_Orchids"))						
4	proportion affected (%)	0.1						
5	% escape detection of PPQ	3.833333						
6								
7								



User friendly model interface: @Risk

The screenshot shows the Microsoft Excel interface with the @Risk add-in ribbon. The ribbon includes sections for Model (Define Distributions, Add Output Function, Insert Correlations, Distribution Fitting, Distribution Artist, Model Window), Simulation (Iterations: 20000, Simulations: 1, Start Simulation, Advanced Simulation Analyses, RISK Optimizer), Results (Browse Results, Define Filters, Excel Reports, Swap Functions), and Tools (Summary, Define Filters, Excel Reports, Swap Functions).

The active cell is B14, containing the formula $=RiskOutput()+\$B\9 . The spreadsheet data is as follows:

Output	Value	Mean	Std	CV	1%	5%	10%	25%	50%	75%	90%	95%	99%
Infected flowers	76.66667	76.8011	88.6693	1.0018	5.3839	10.5207	14.7665	26.0660	49.8456	94.4835	165.1703	231.0438	425.5645

The histogram window, titled '@RISK - Output: B14', displays the distribution for 'Infected flowers / Value'. The x-axis ranges from -500 to 2,500, and the y-axis ranges from 0.000 to 0.010. The distribution is highly right-skewed, with a peak near zero. The 5.0% and 95.0% percentiles are marked at 11 and 231, respectively. The histogram includes the following statistics:

Statistic	Value
Minimum	0.811
Maximum	2,446.95
Mean	76.80
Std Dev	88.67
Values	20000

The histogram also displays the theoretical distribution statistics for 'Theoretical':

Statistic	Value
Minimum	-∞
Maximum	+∞
Mean	2,000,000.00
Std Dev	10,000.00

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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