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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PPM-PIRATES:

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

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Global trade increases the risk of new plant pathogens

- Increasing international trade leads to new invasions
- Costs associated with plant pathogens estimated to be very large
- Some invasive species may have detrimental effects on natural habitats
- Europe: Douglas-fir beetle

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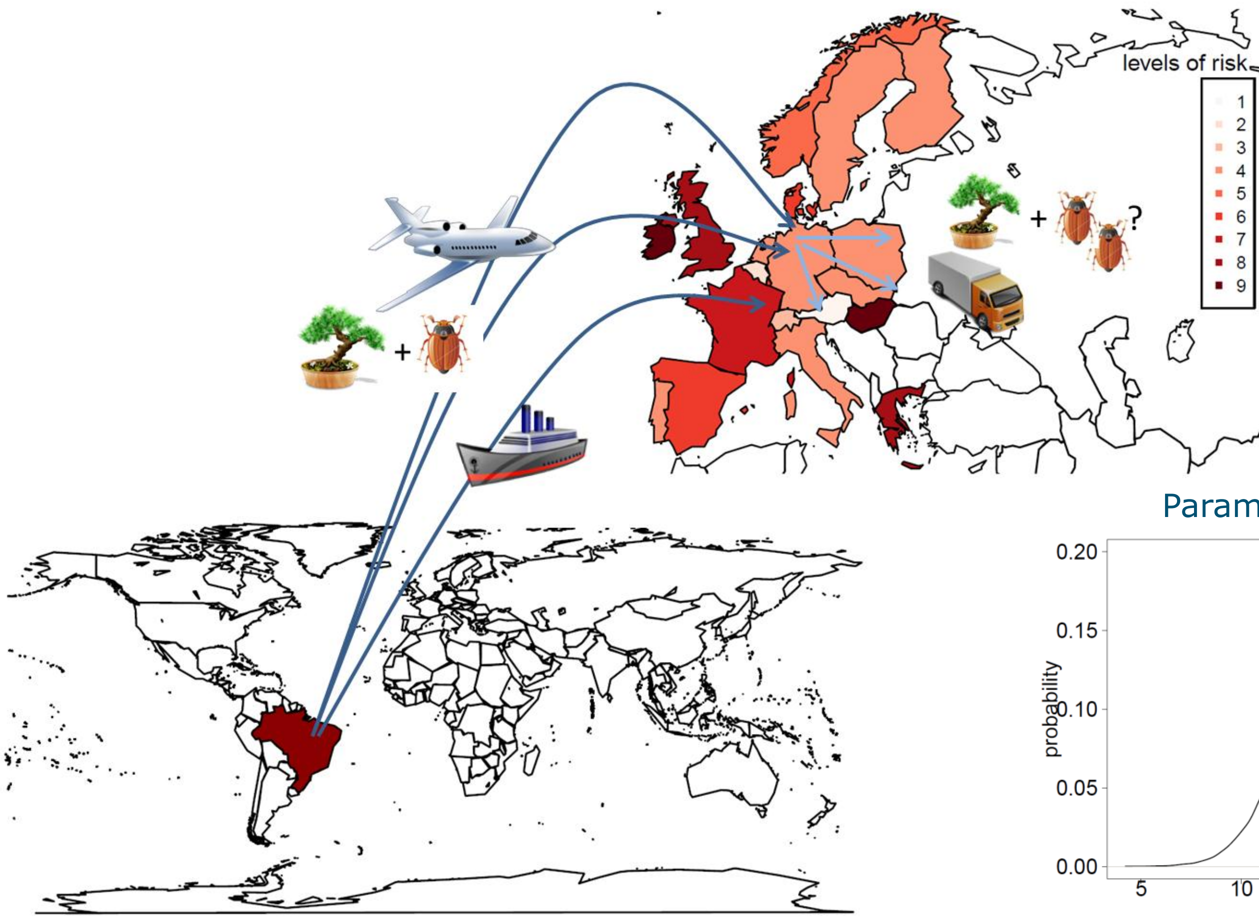
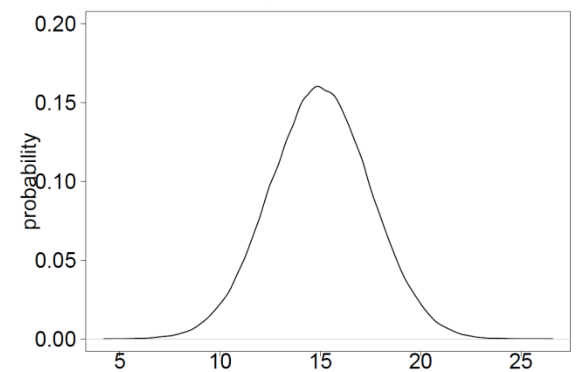
EFSA project – two lots

- Lot 1: Edible plant products
  - Conducted by Imperial College and FERA
- Lot 2: Non-edible plant products
  - Conducted by Wageningen University and INRA

How do PPMs work? Graphical summary



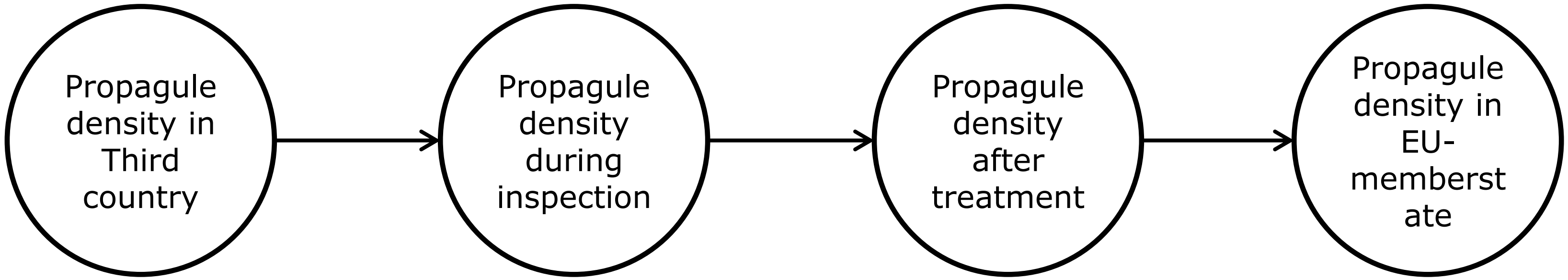
Parameter distributions



Conceptualisation of the model

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

A sequence of nodes, connected by edges (links):



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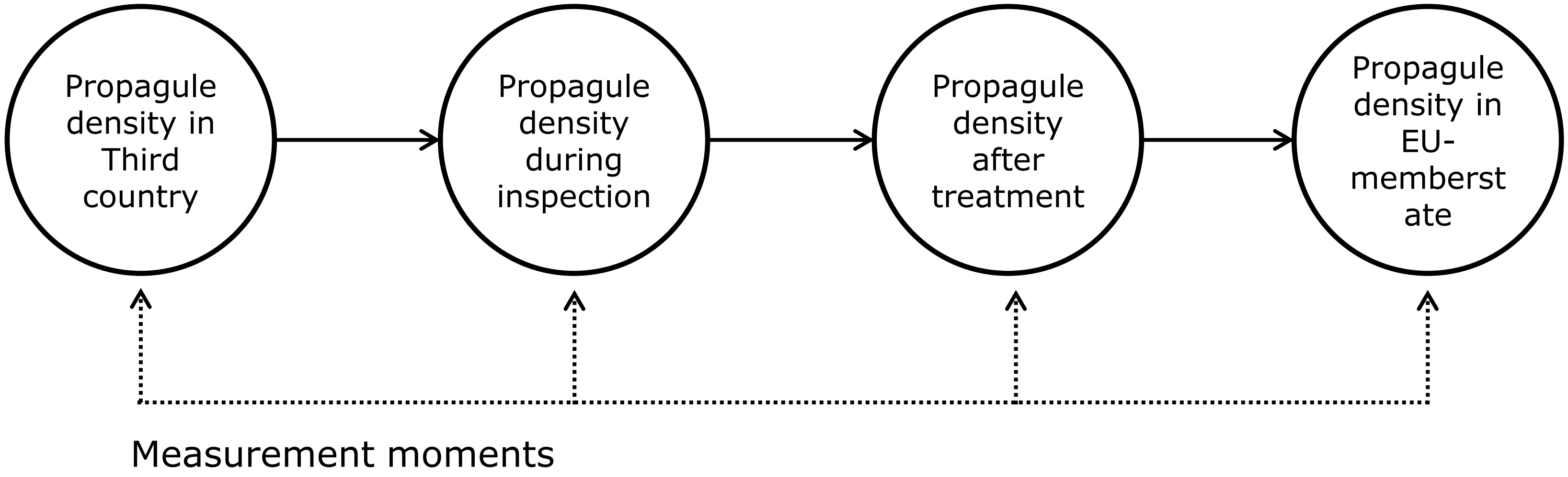

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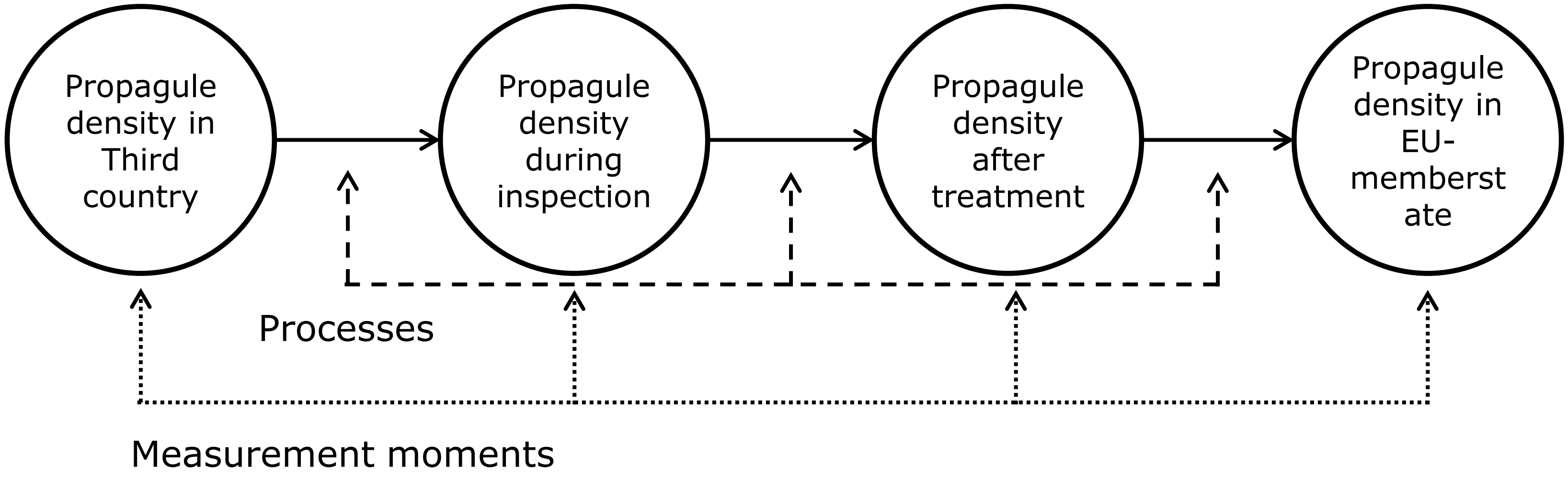
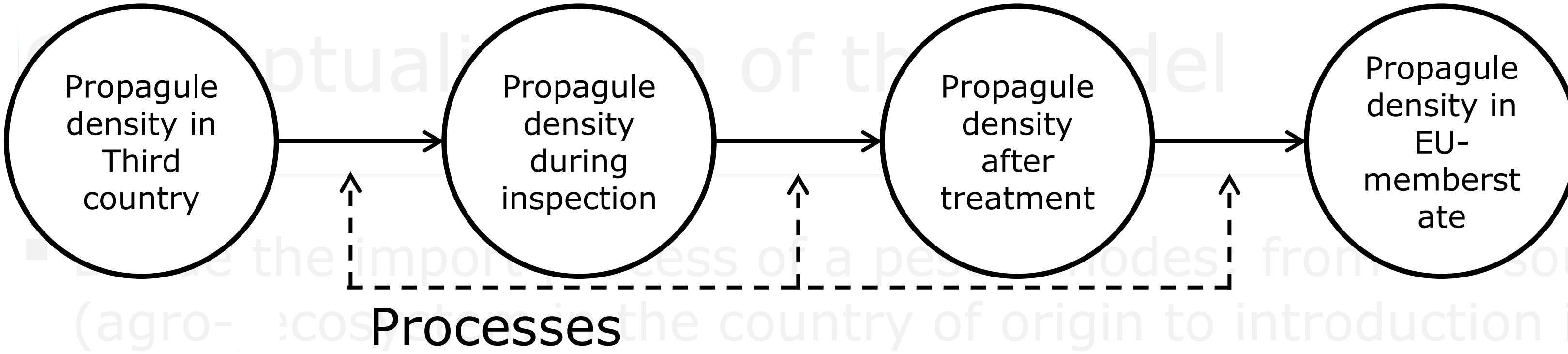
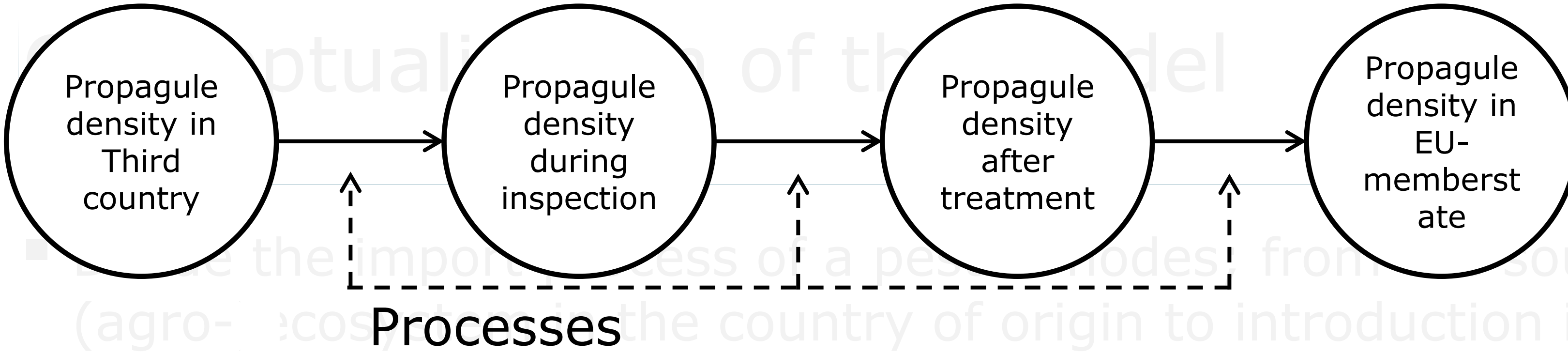




- Consignment as modeling unit
- A sequence of nodes, connected by edges (links):

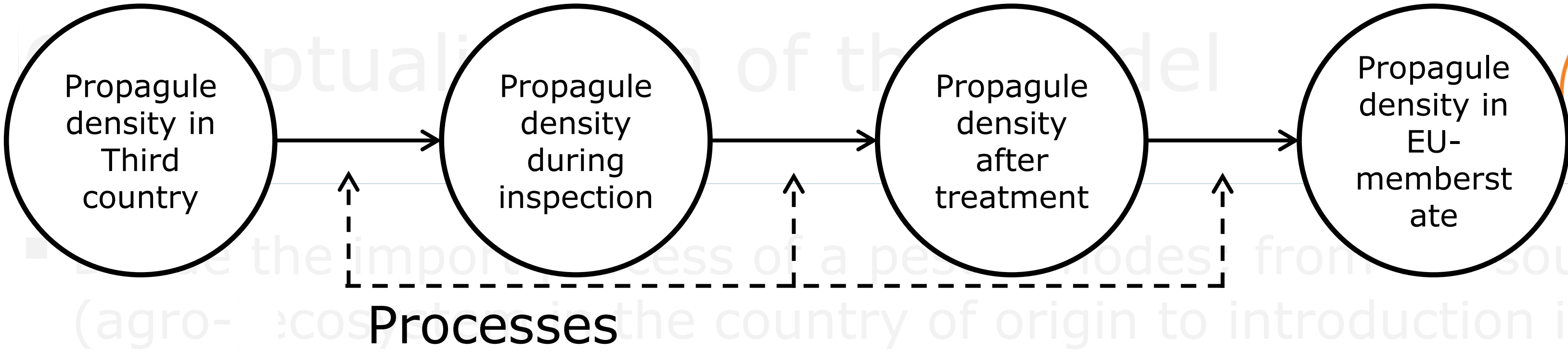


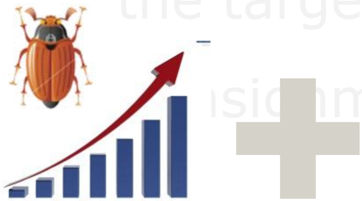
the target (agro-)ecosystem in the EU territory

A sequence of nodes, connected by edges (links):

Conceptualisation of the model

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





Consignment as modeling unit

- A sequence of nodes, connected by edges (links):

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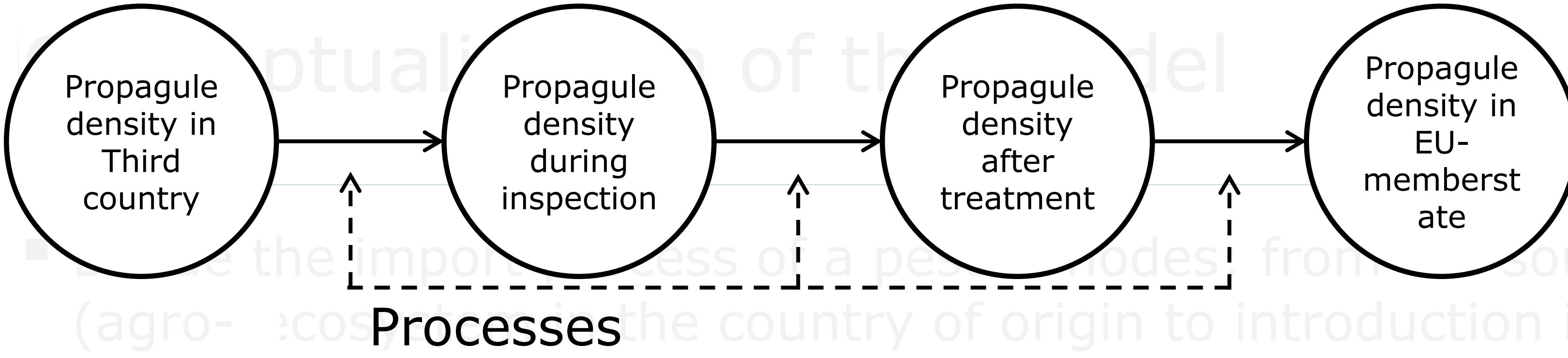
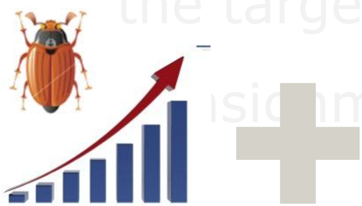
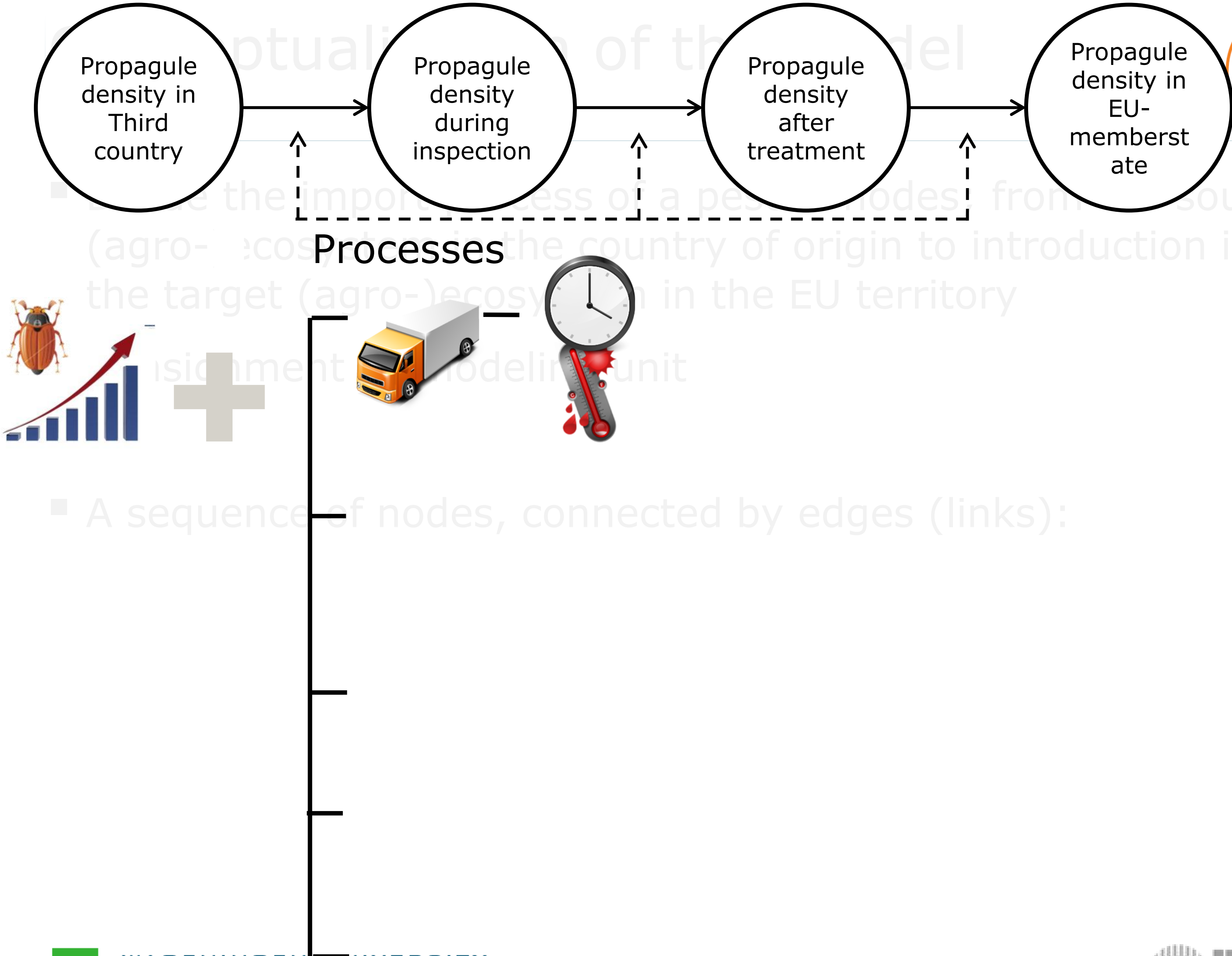

Propagule density in Third country
Propagule density during inspection
Propagule density after treatment
Propagule density in EU-memberstate
Processes





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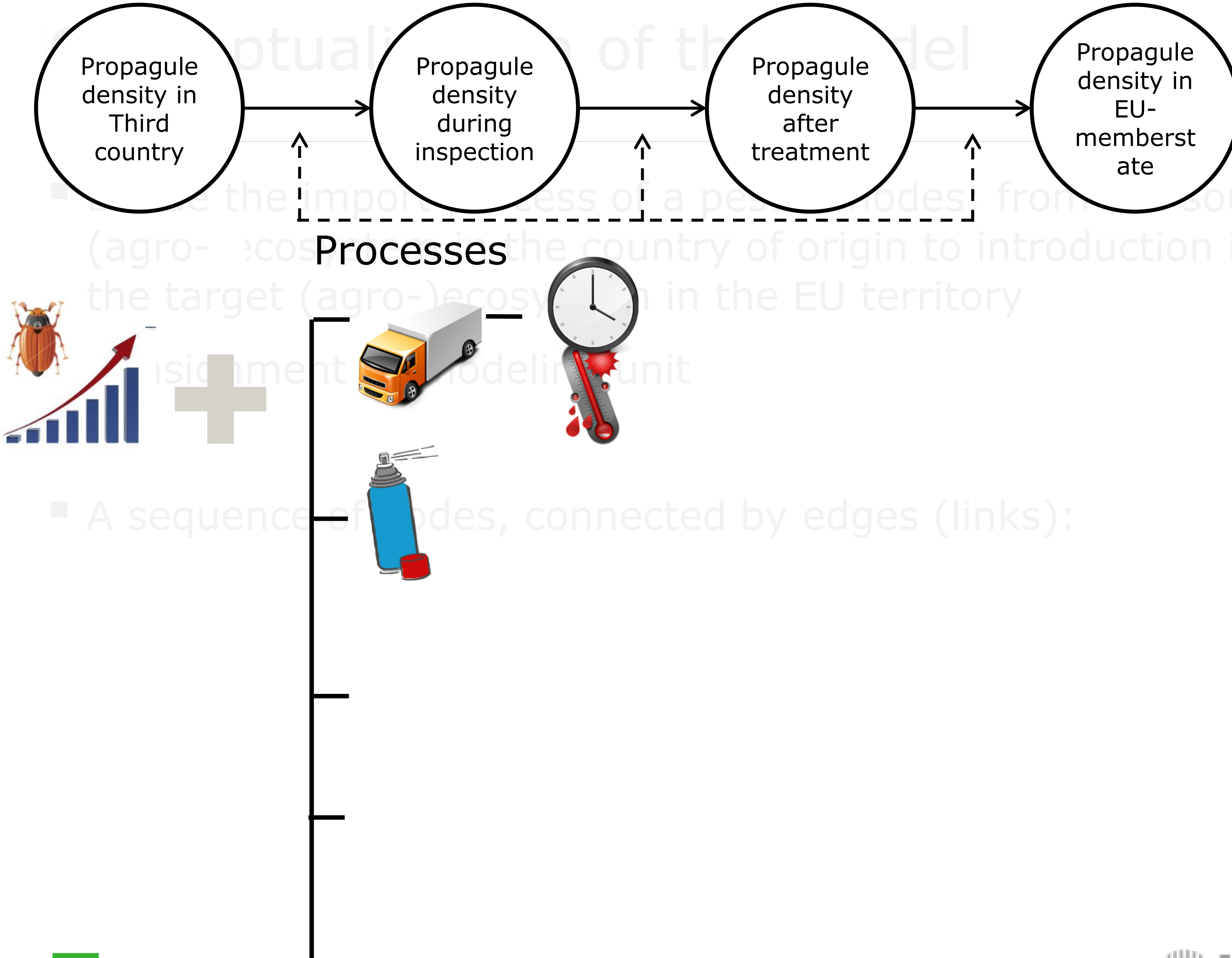
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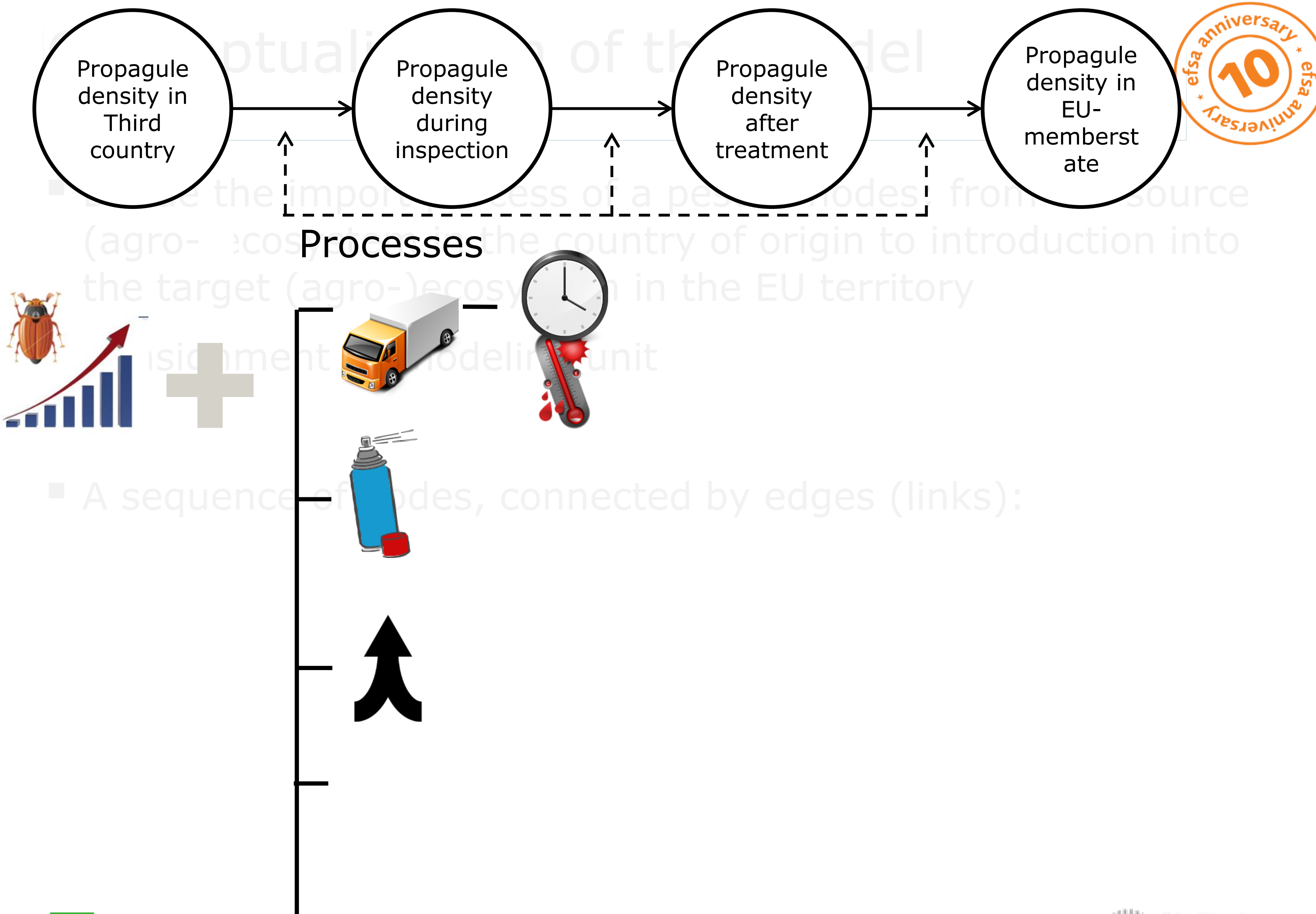

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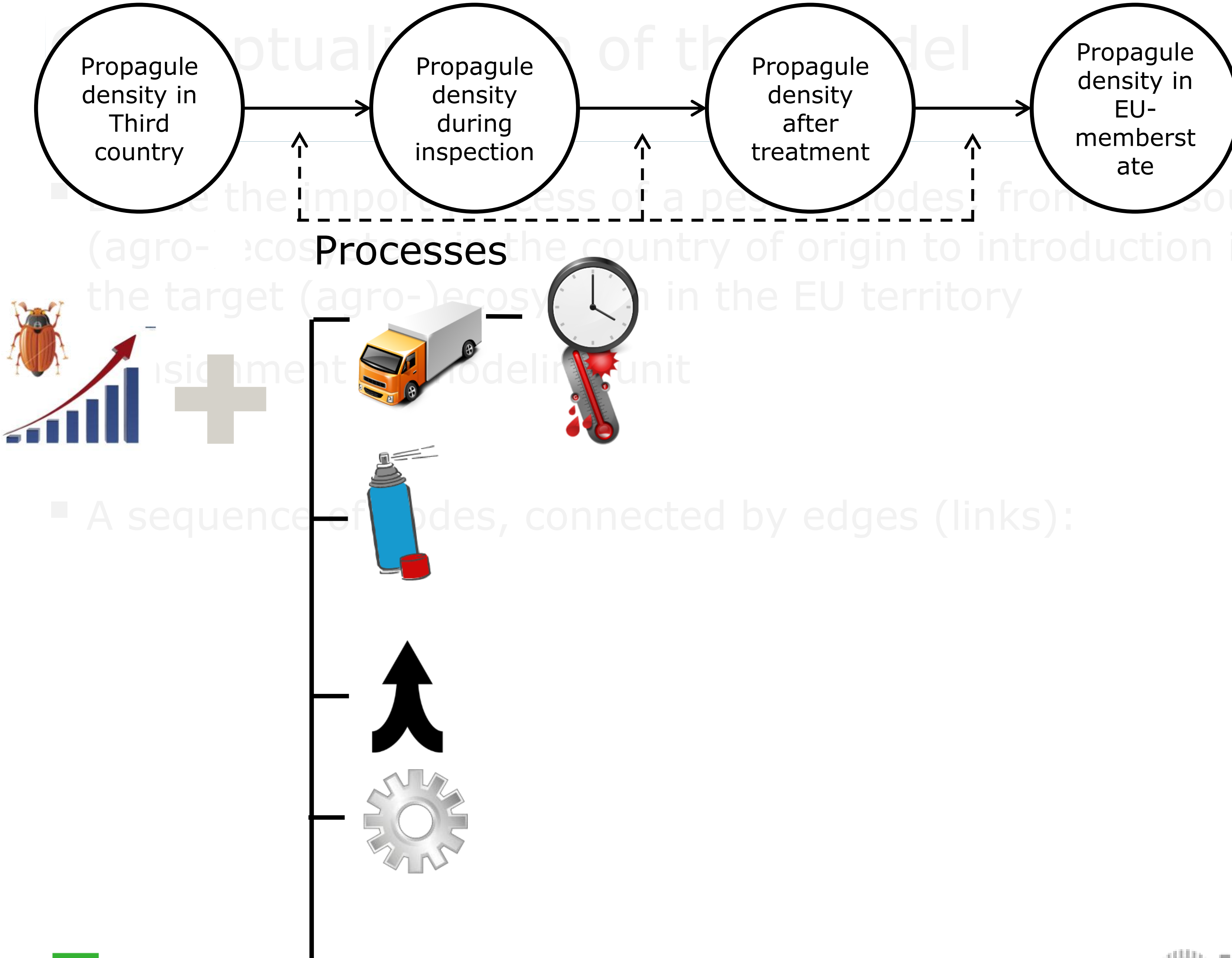
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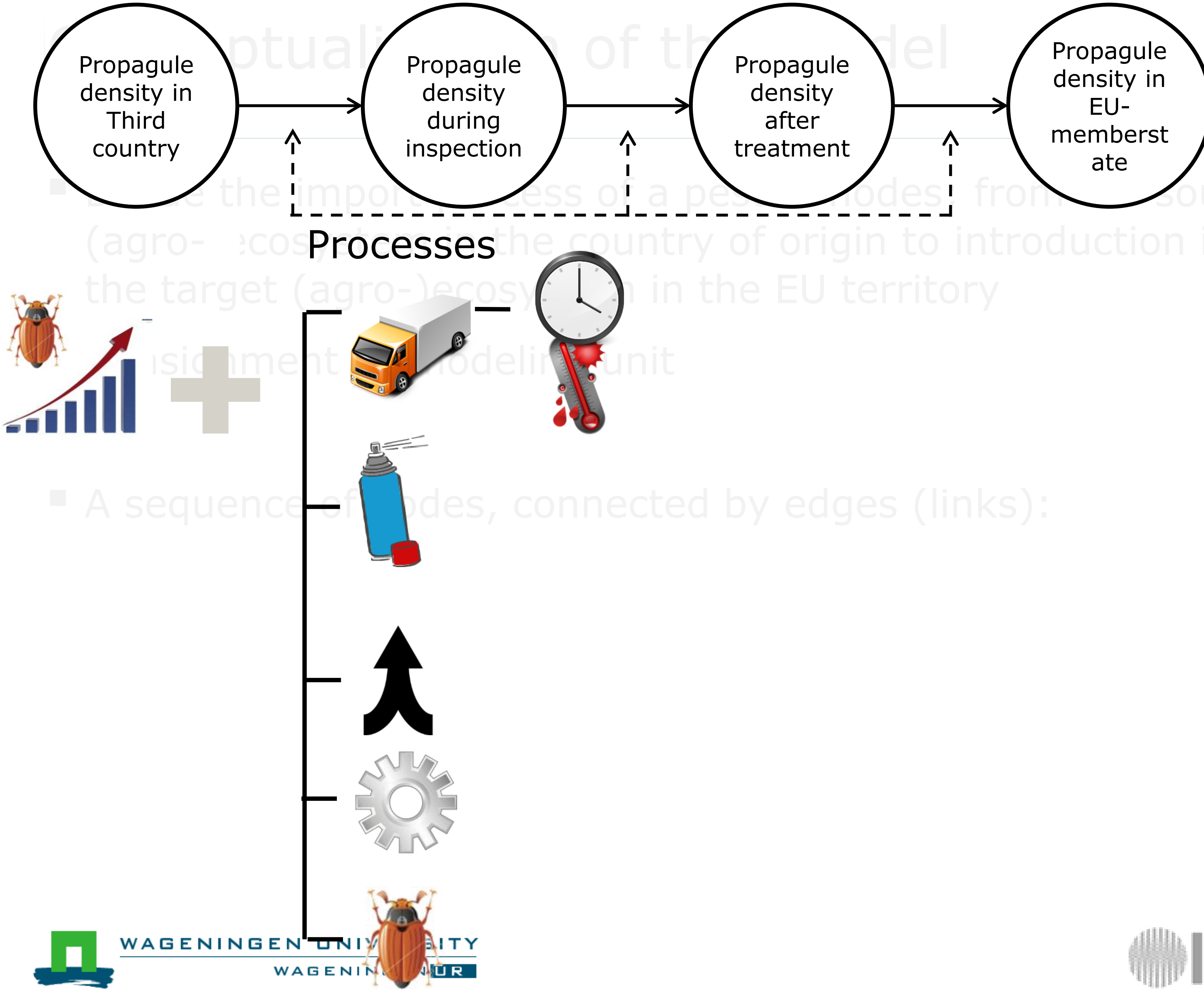
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Processes

Conceptualisation of the model

- For each link the (probability distribution) infestation level is updated
- Each process-parameter is defined as a distribution of likely values

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- For each link the (probability distribution) infestation level is updated
- Each process-parameter is defined as a distribution of likely values
- Output: distribution of propagule density in a given area of an EU memberstate

Conceptualisation of the model

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Draw from
parameter space
(Monte Carlo)

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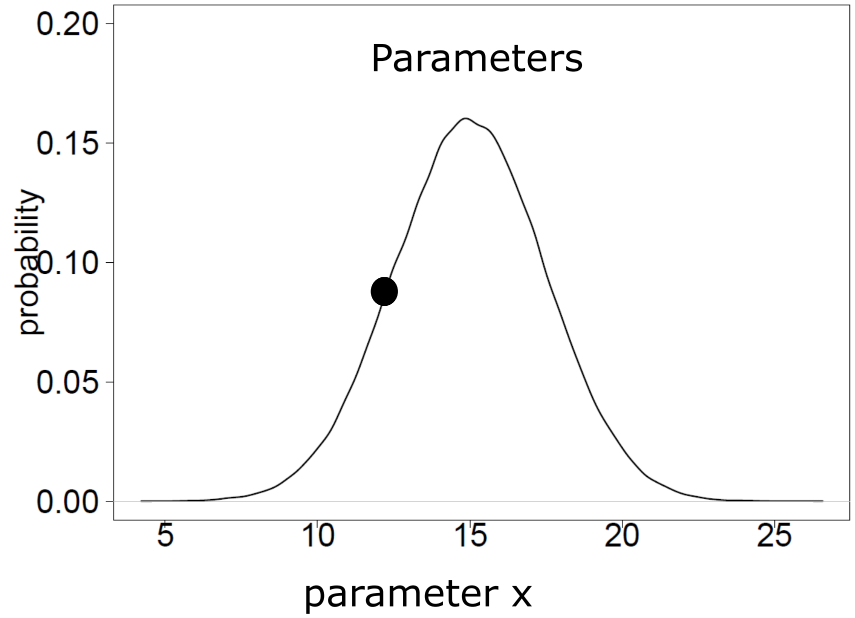
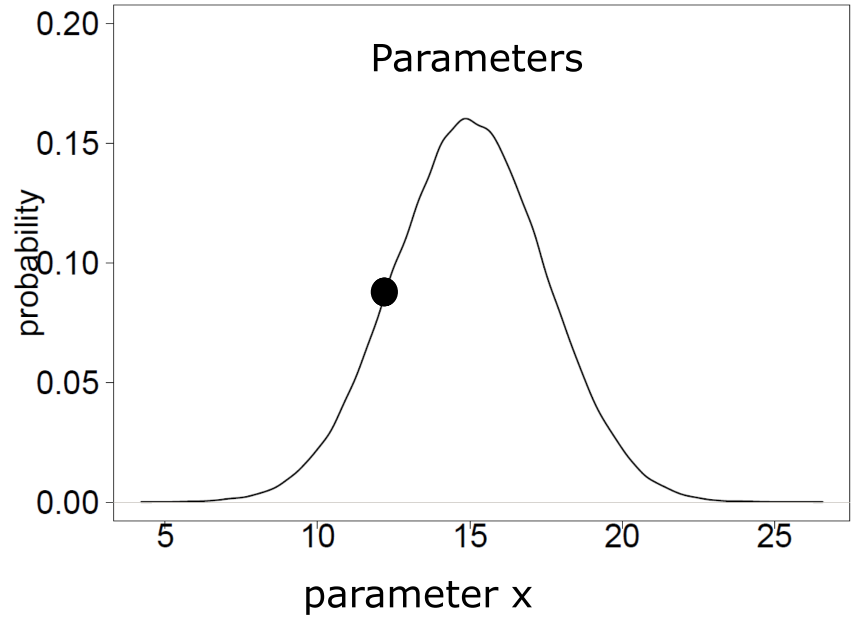
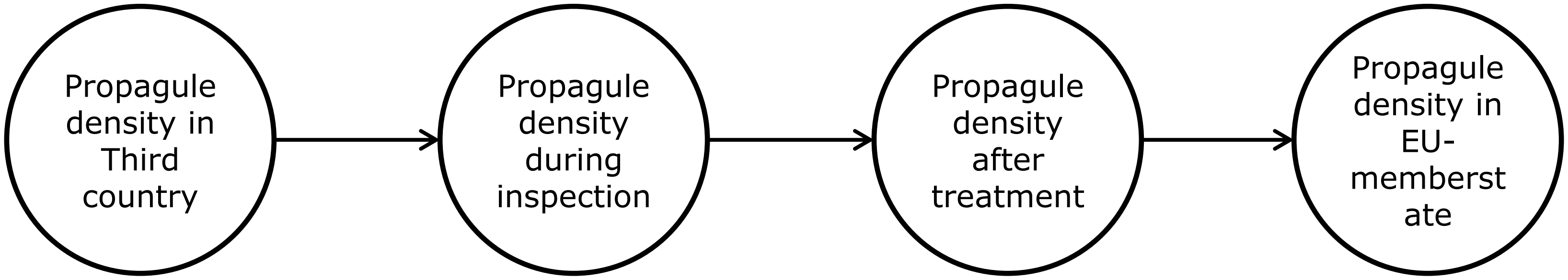


Conceptualisation of tl

Draw from parameter space (Monte Carlo)





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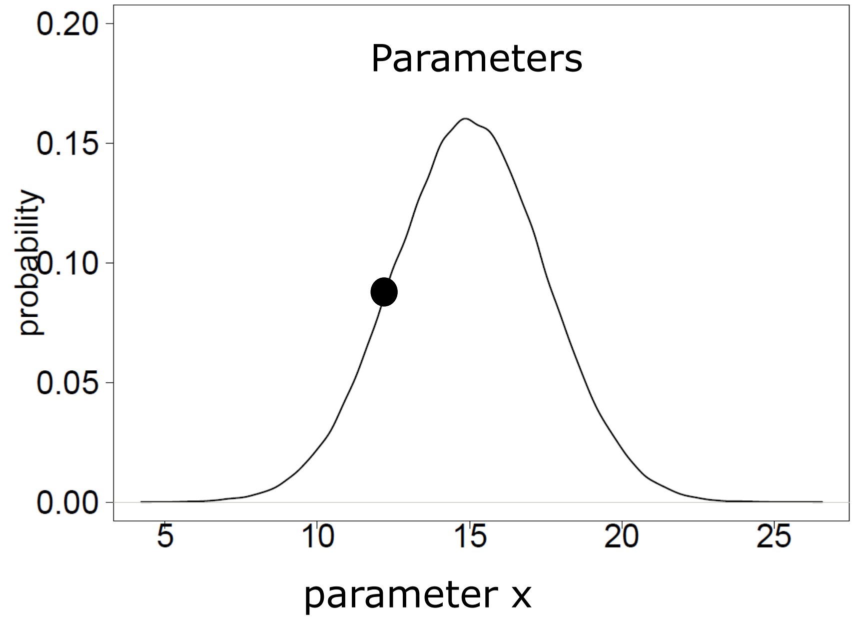

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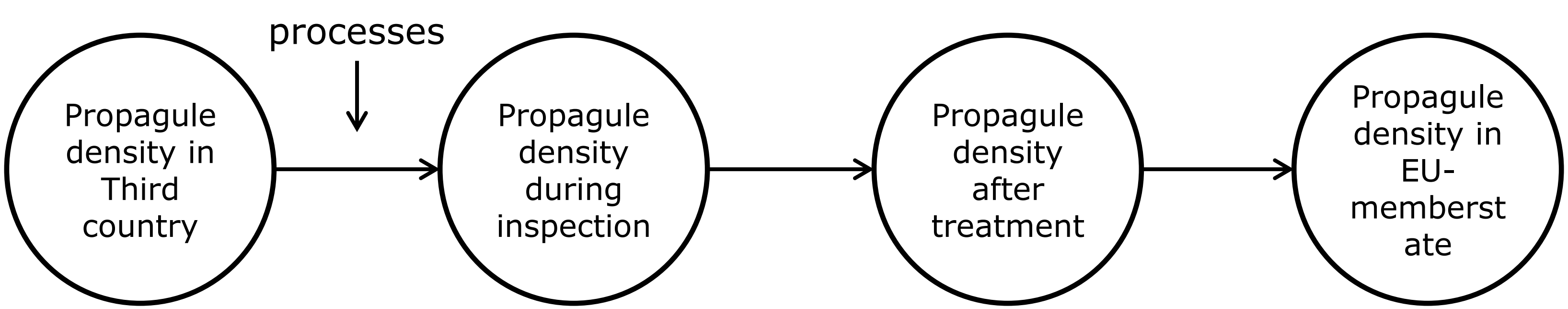

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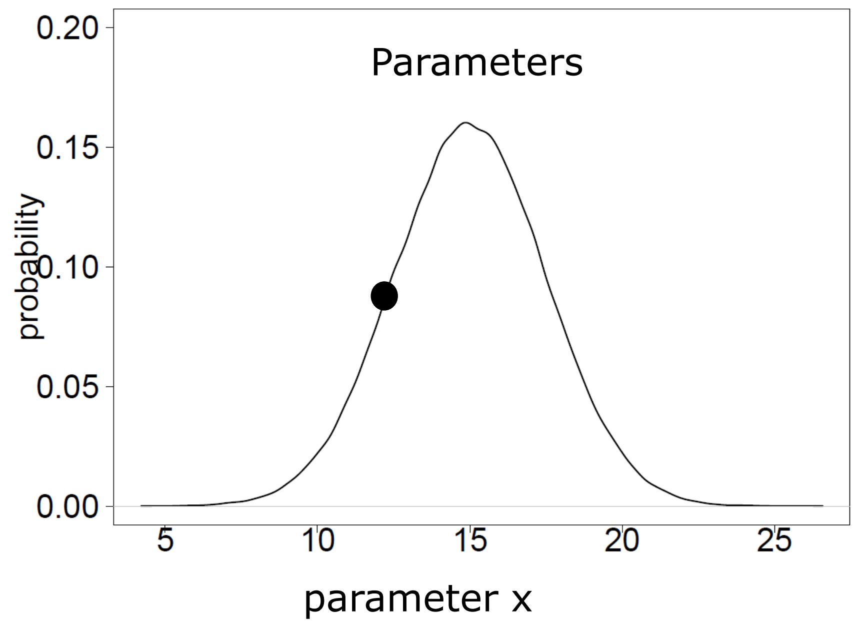

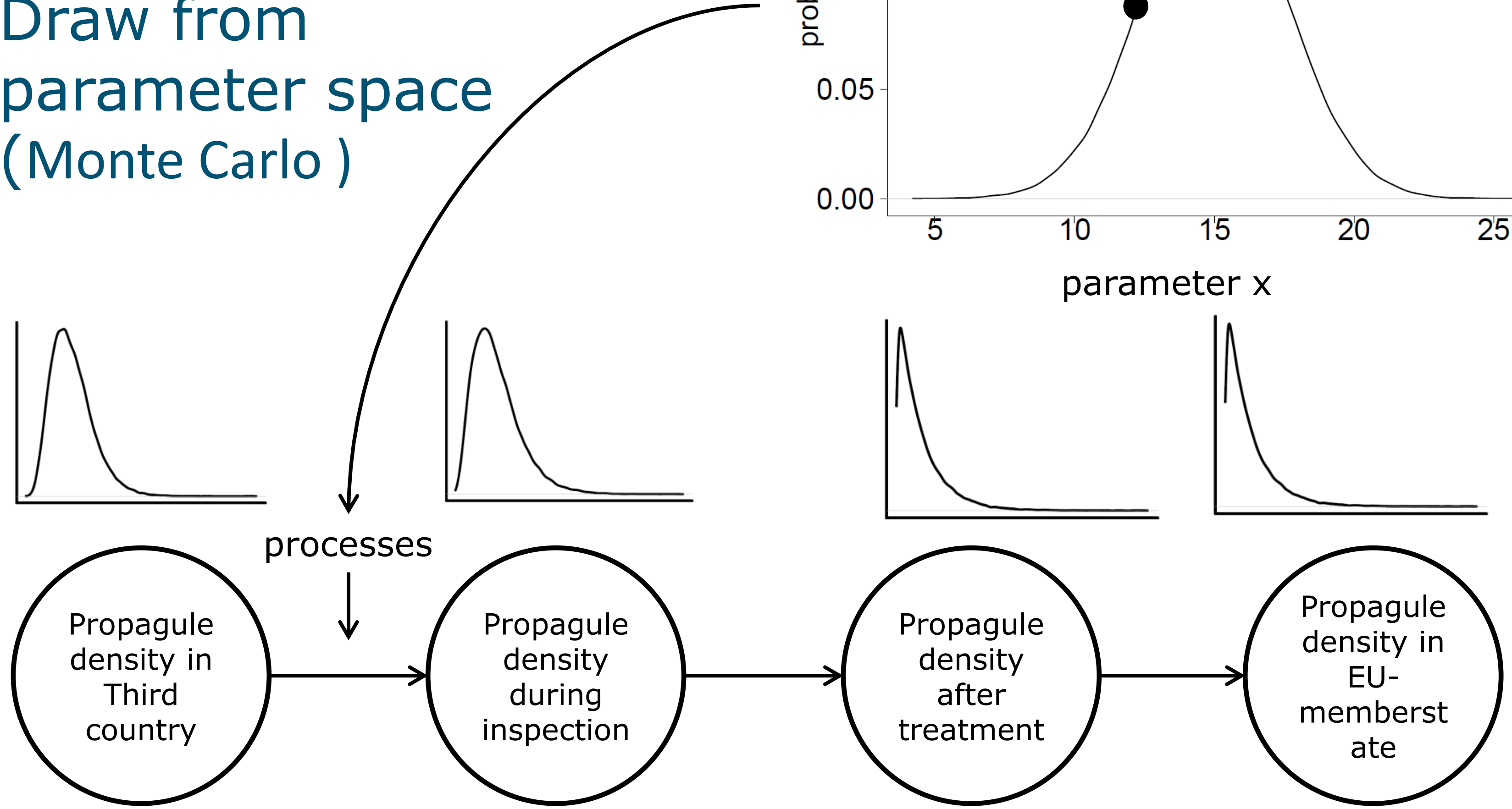

Type of model simulations

	1 realisation	k realisations
1 consignment		
n consignments (population model)		

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Type of model simulations

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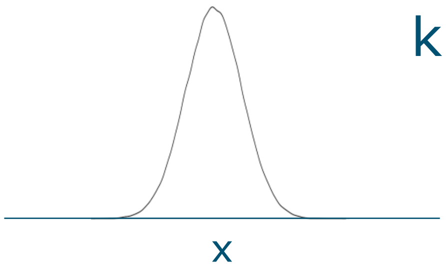
1 consignment	1 [x]=…	k 
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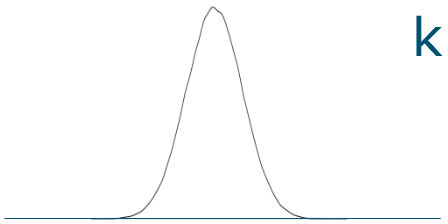
1 consignment	1 $[x]=\ldots$	k  x
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Variation in initial conditions

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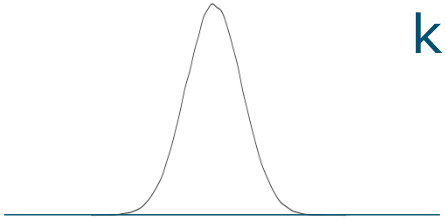
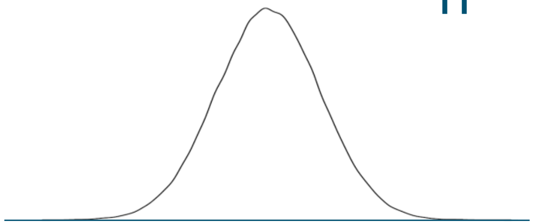
1 consignment	1 [x]=...	k 
n consignments (population model)	n 	

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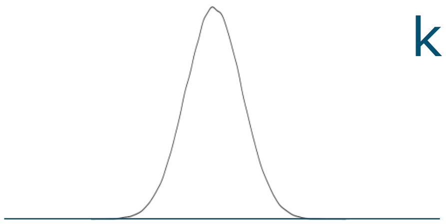
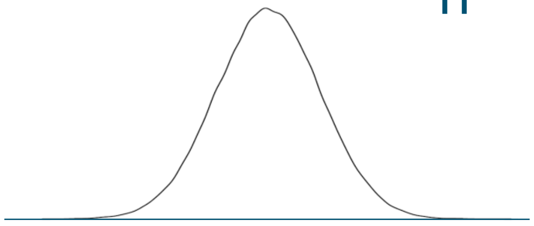
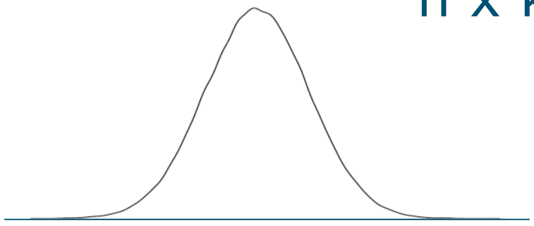
1 consignment	1 $[x]=\ldots$	k  x
n consignments (population model)	n  x	n x k  x

Variation in initial conditions

Overview of models to be developed

	Generic	Case-studies
Consignment 	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.
Population 	1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

Overview of models to be developed

	Generic	Case-studies
Consignment 	1) Round wood	
Population 		

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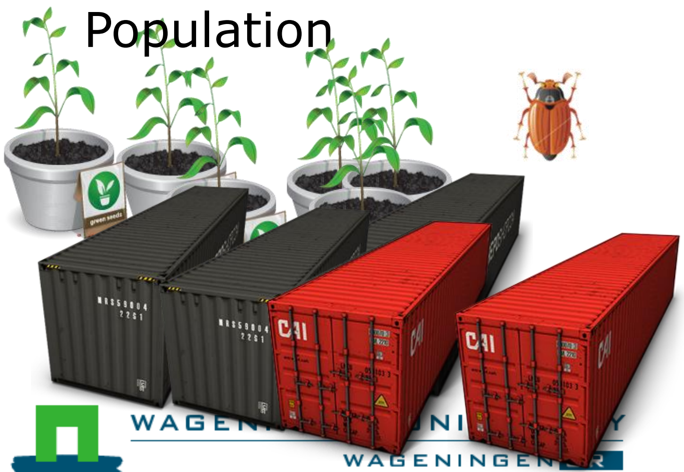
Population 	2) Wood shavings	

Overview of models to be developed

	Generic	Case-studies
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Population 		

Overview of models to be developed

	Generic	Case-studies
Consignment 	1) Round wood  2) Wood shavings 	
Population 	3) Plants for planting 	

Overview of models to be developed

	Generic	Case-studies
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Overview of models to be developed

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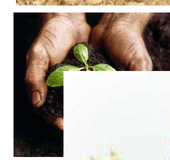
	Generic	Case-studies
Consignment 	1) Round wood  2) Wood shavings  3) Plants for planting  4) Cut flowers 	
Population 		

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Overview of models to be developed

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Consignment

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1) Round wood

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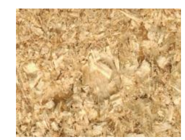
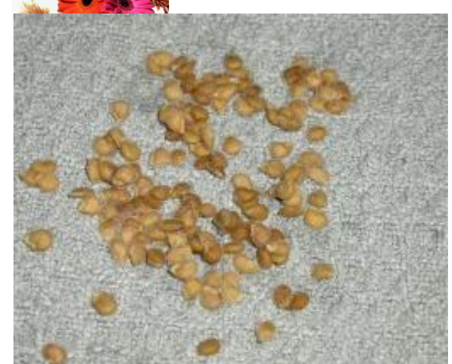


3) Plants for planting

4) Cut flowers

5) Seeds



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Generic

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Application of PPMs to five case studies

- Douglas fir + *Dendroctonus pseudotsugae* (douglas fir beetle)

Application of PPMs to five case studies

- Douglas fir + *Dendroctonus pseudotsugae* (douglas fir beetle)
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Application of PPMs to five case studies

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- Cut orchid flowers+ *Thrips palmi* (insect)
- Tomato seeds + PSTVd (viroid)

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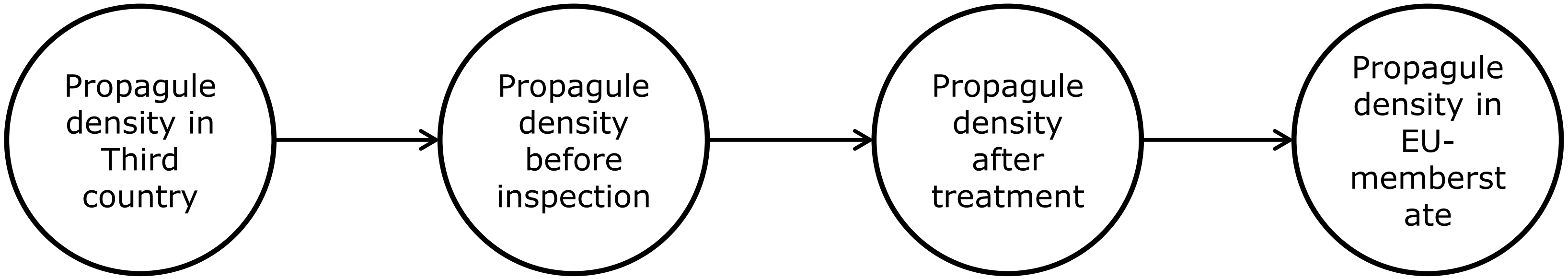
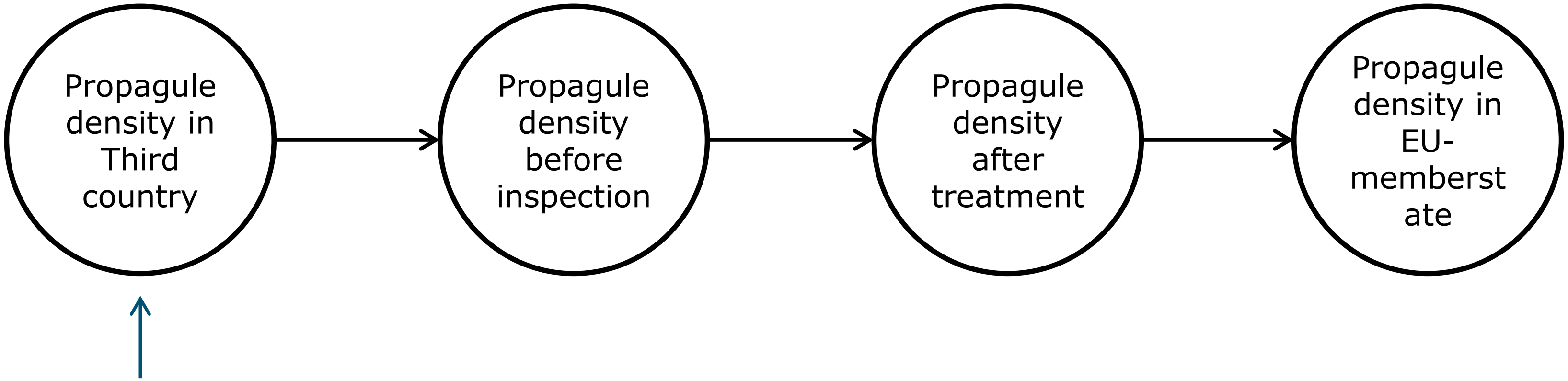
Data requirement of PPMs



1) Piel et al 2008

Data requirement of PPMs



Measurements of state variables

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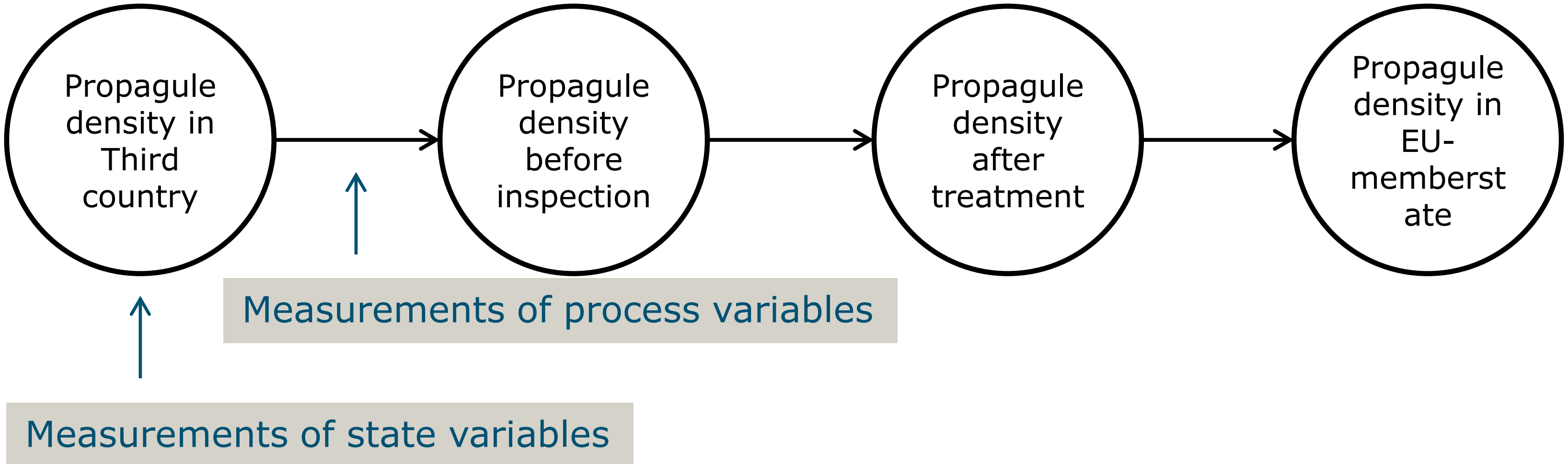
Data requirement of PPMs



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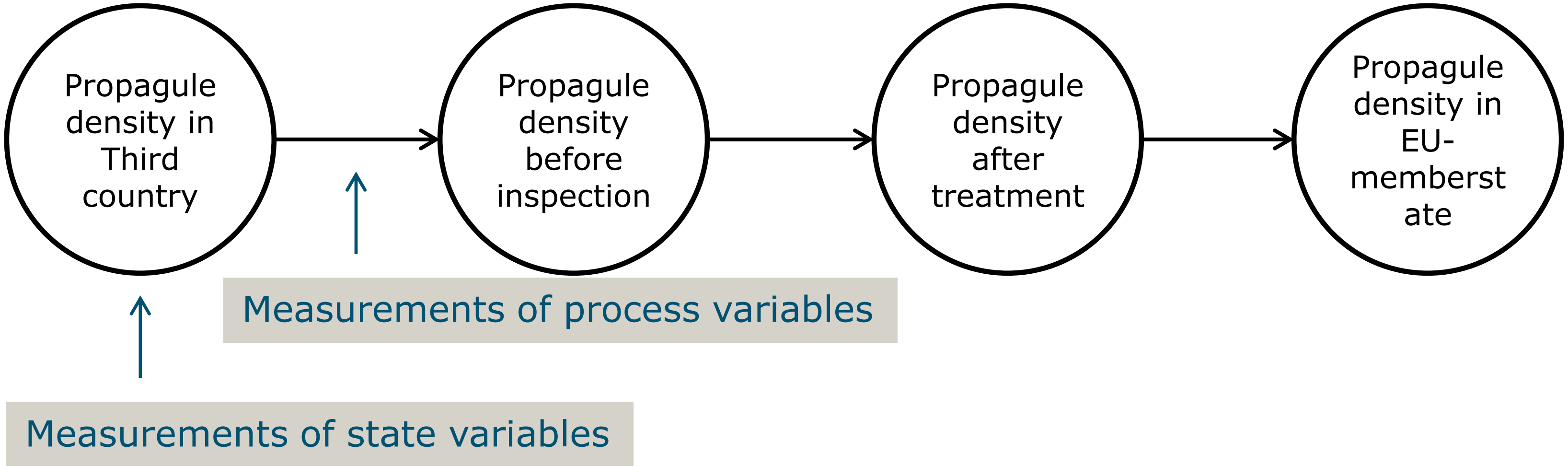

- Measurements of state variables
  - Size of consignments
    - No record of detailed trade statistics
  - Consignment infected/not infected
  - Number of infected plants per consignments

1) Piel et al 2008

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 and risk reduction options

Sensitivity analysis

Sensitivity analysis:

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

- What is the most critical stage during transport?
- Are trade volumes more import than intensity of inspection?

Data requirement of PPMs

- Process data:
    - Biological characteristics of plant pest

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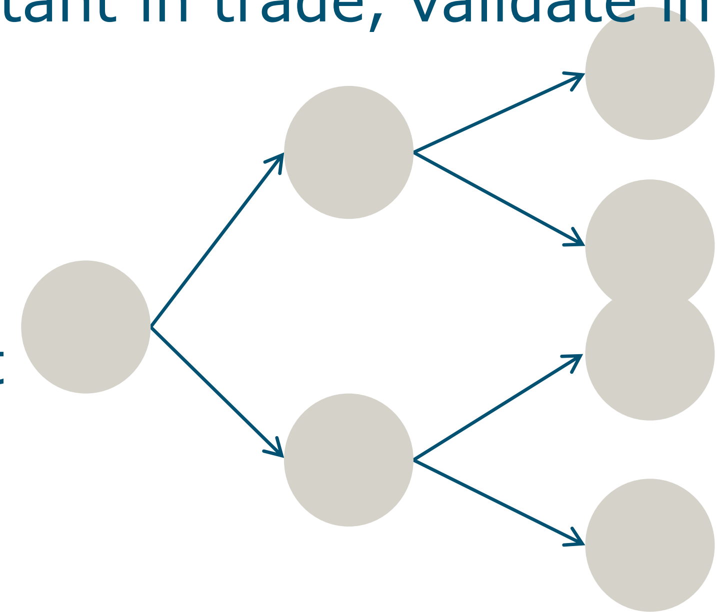
- Process data:
  - Biological characteristics of plant pest
  - Transport conditions
  - Trade volume
  - Phytosanitary measures (inspection intensity and treatments)
    - Differences in data availability between NPPOs
- Standardizing data sources
  - that differ in temporal and spatial resolution
  - from different Plant health agencies

Methodology

Defining pathways:

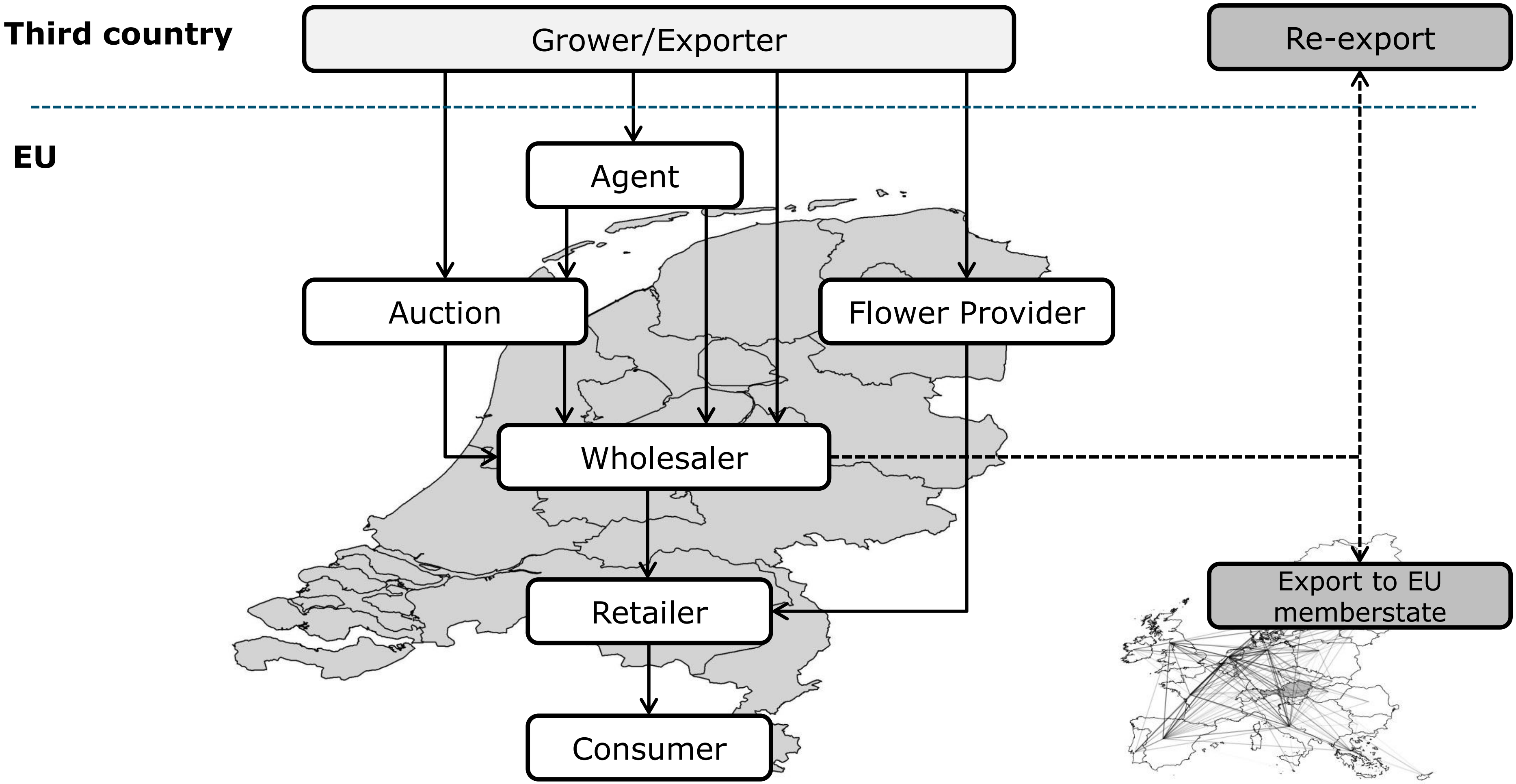
- Snow-ball sampling: Experts who recommend other experts
- Start with country (most) important in trade, validate in others



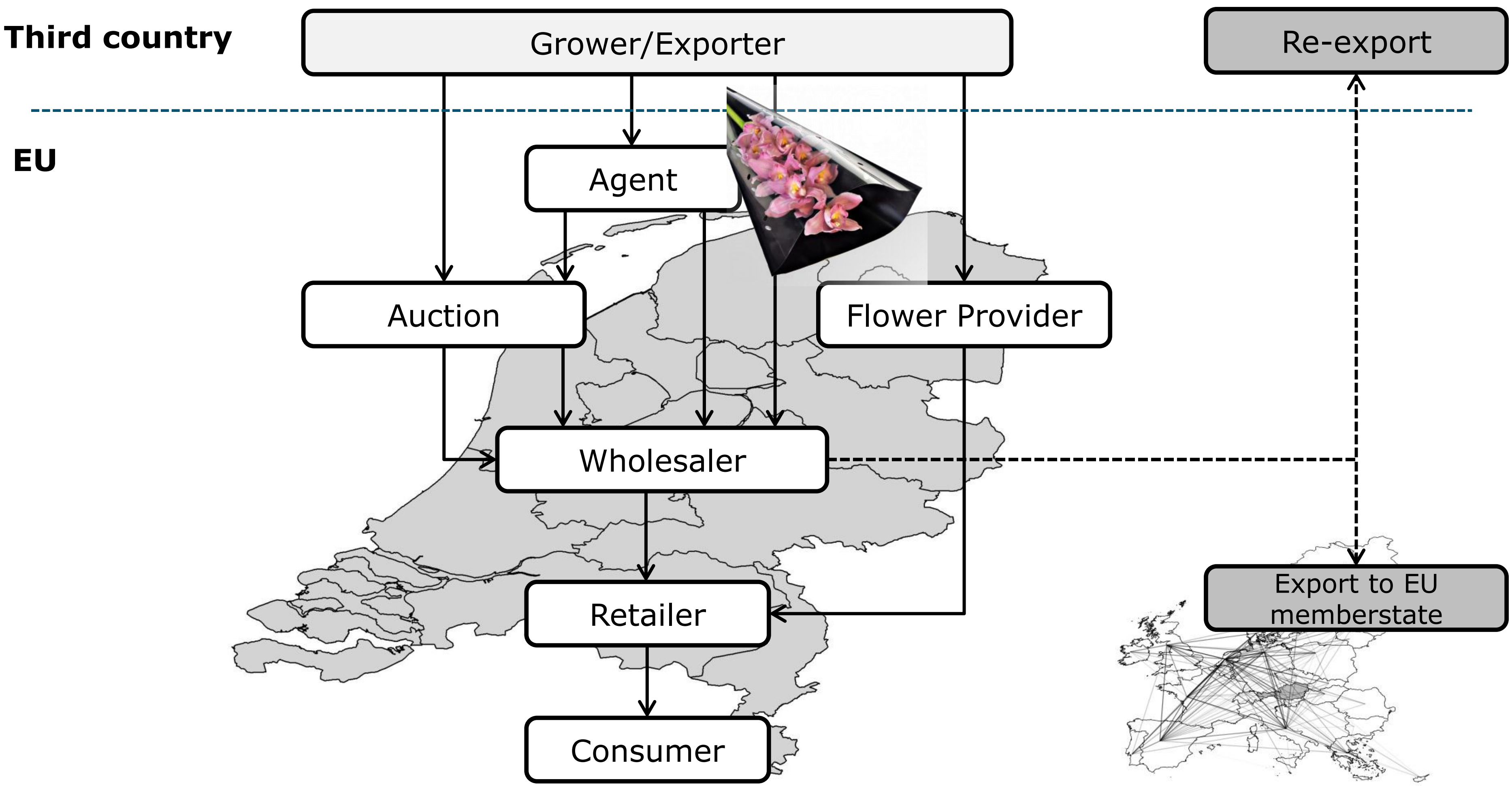
Model complexity:

- Data-driven model development

Pathway for cut flowers



Pathway for cut flowers



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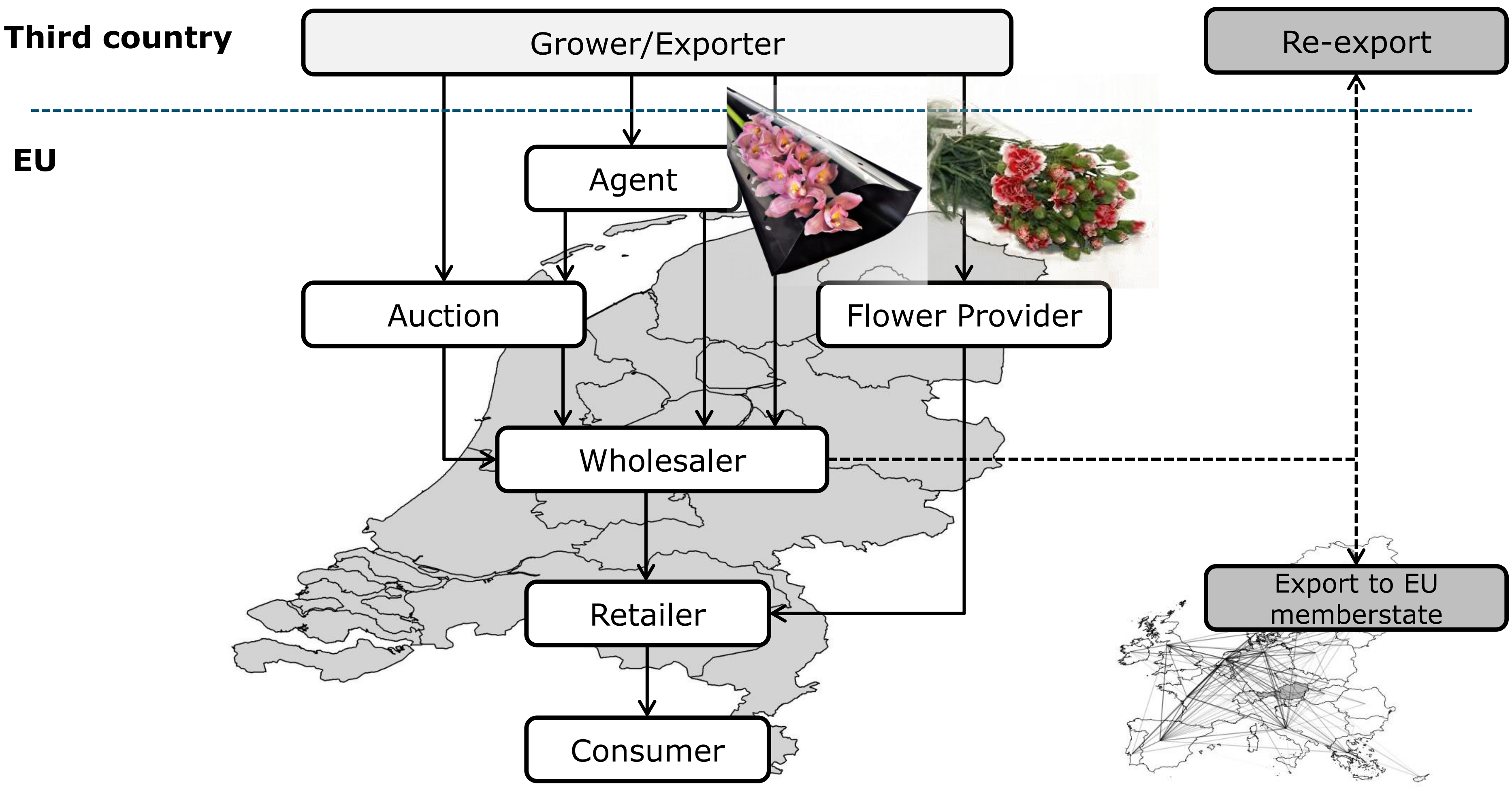
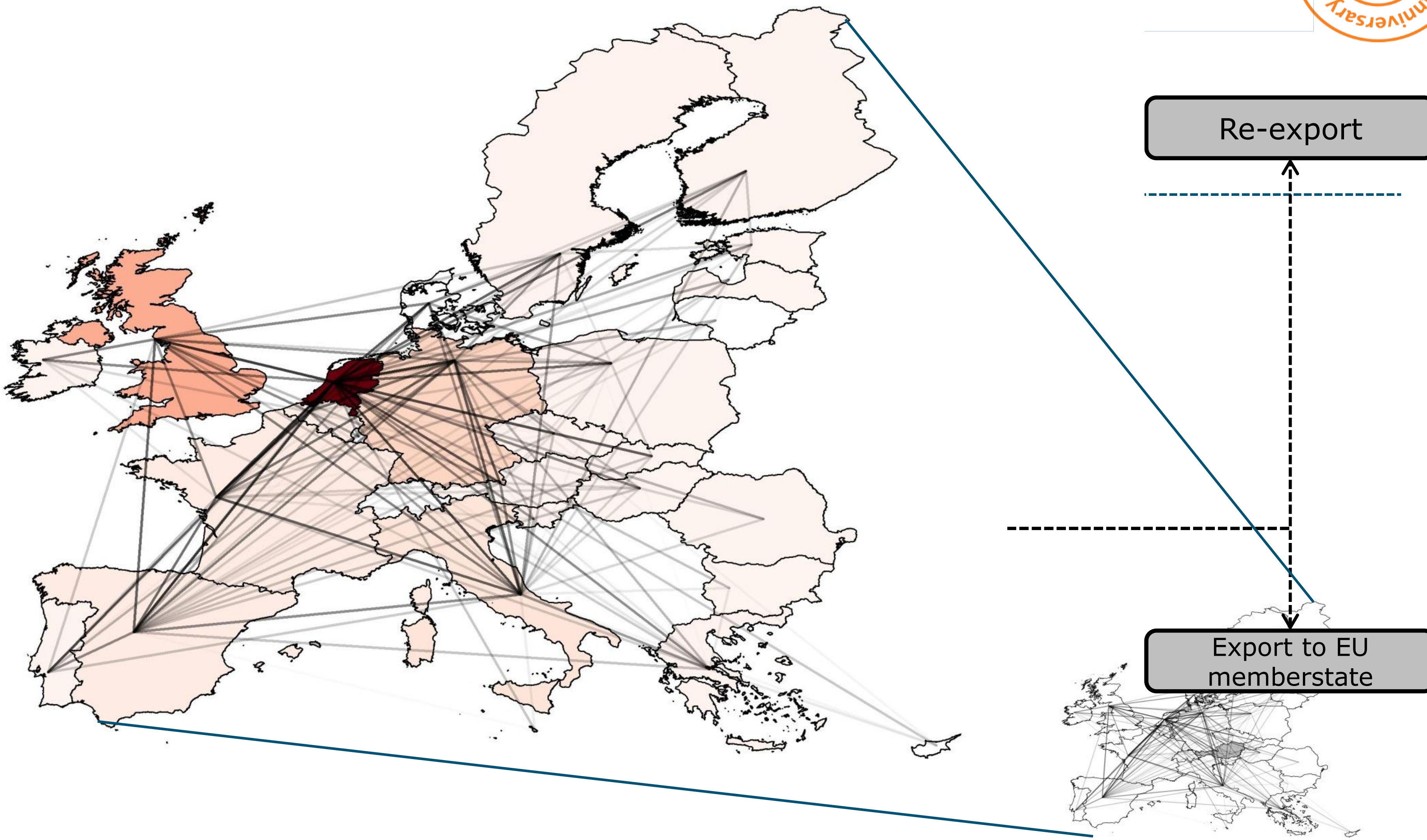




0% 56%

Source: Eurostat

Three ways of transfer to potential host

Two steps with certain probability:

- 1) Infected living cut flowers close to host (monophagous, polyphagous), 2) Pest can disperse to host
- 1) Cut flowers waste close to host, 2) Pest can disperse to host
- 1) Infested transport medium close to host, 2) Pest can disperse to host

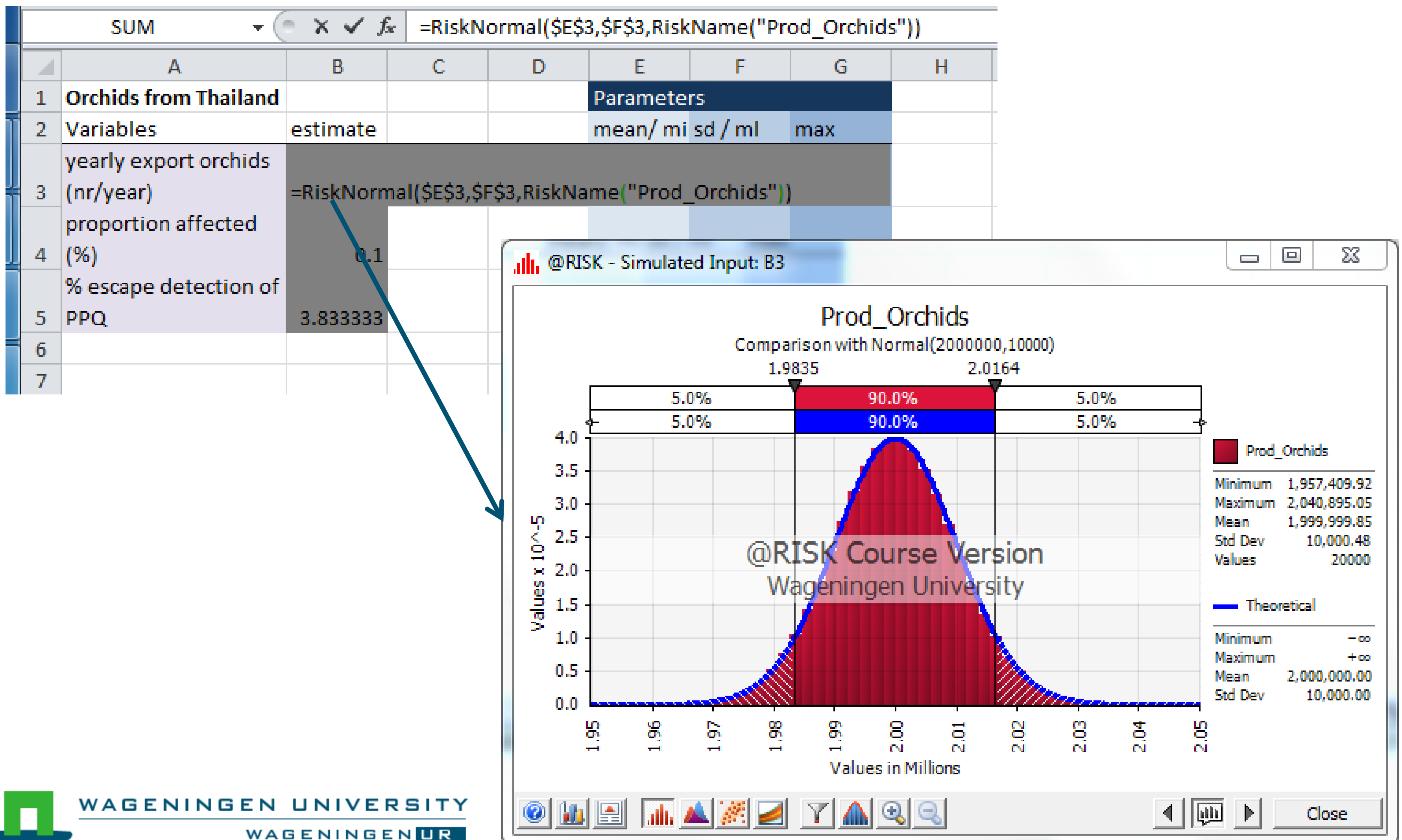
- Critical phase but very hard to estimate! Any ideas welcome

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								

User friendly model interface: @Risk



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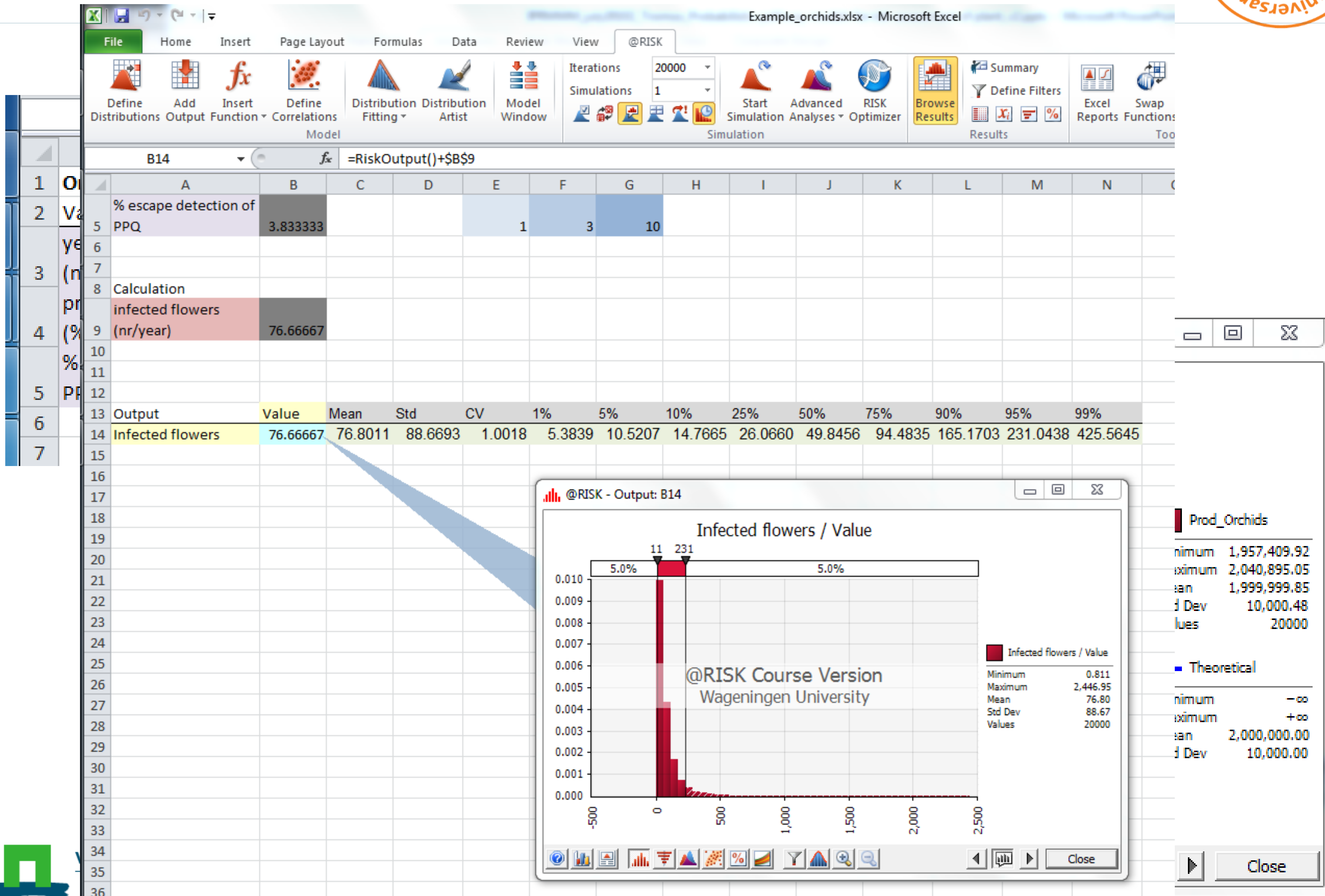

Quantitative pathway analysis? Is it really worth it?

Feedback, comments, ideas, questions?

All welcome!

Please contact Bob Douma for any use of this presentation
Bob.Douma@wur.nl

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