IPPC Seminar: Plant Health, Climate Change and Environmental Protection

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Sheikh Zayed Center, FAO HQs, Rome

Exploring global changes consequences on emergence of plant diseases and pests by quantitative risk assessment

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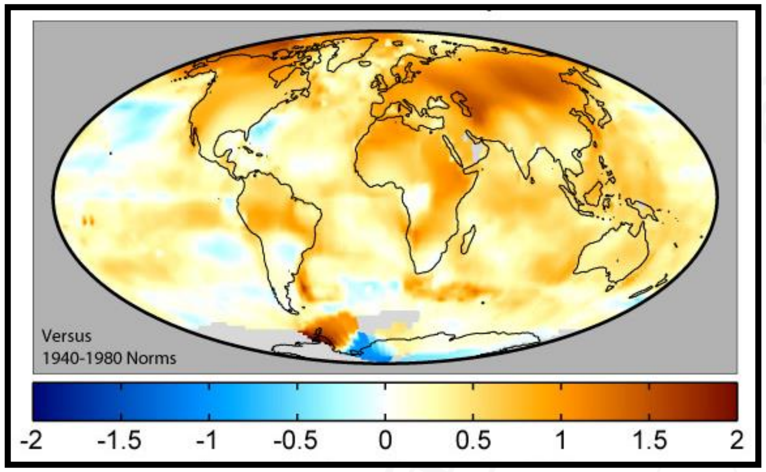
Global changes: Multi-dimensional classification

Environmental changes

- Global warming
- Atmospheric and ocean circulation
- Loss of biodiversity
- Ecosystem processes and services

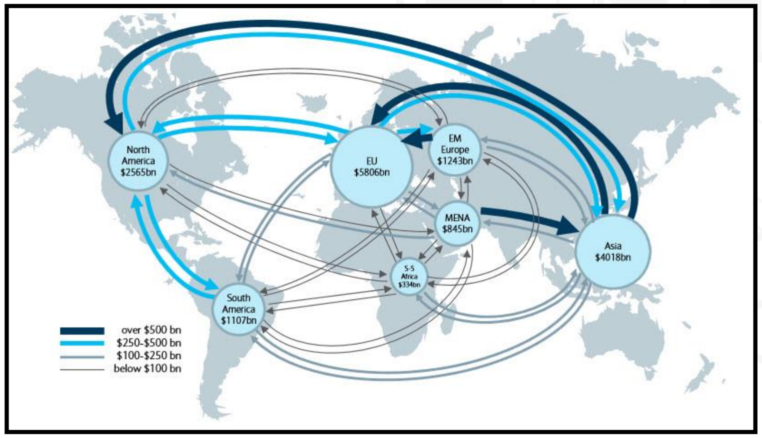


Agricultural changes

- Production systems
- Freshwater depletion
- Agro-biodiversity loss
- Land degradation and desertification

Societal changes

- Trade and human migration
- Human population growth
- Land use
- Urban intensification
- Pollutants emission



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Global changes: Effects on plant pests and diseases

Environmental changes
- Global warming
- Atmospheric and ocean circulation
- Loss of biodiversity
- Ecosystem processes and services

→

- Improved winter survival
- Increased fecundity
- Accelerated pest population growth
- Increase in the number of generations
- Raised virulence
- Reduced dormancy
- Enlarged geographical range
- Increased crop susceptibility

Agricultural changes
- Production systems
- Freshwater depletion
- Agro-biodiversity loss
- Land degradation and desertification

→

- Lack of pests' natural enemies
- Increased crop stress
- Breakdown of resistance mechanisms (including ecosystem resistance and resilience)

Societal changes
- Trades and human migration
- Human population growth
- Land use
- Urban intensification
- Pollutants emission

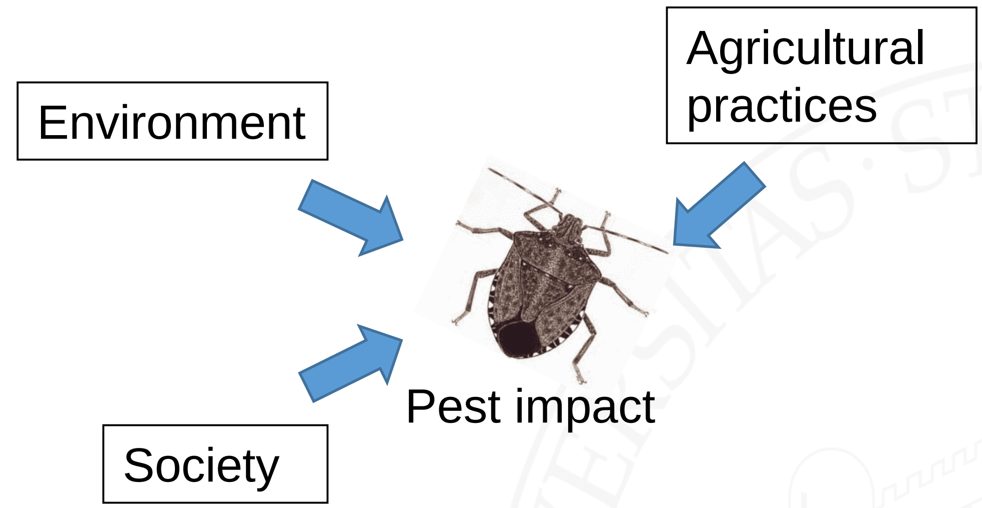
→

- Potential for pests entry, establishment spread and impact in new areas

Global changes: Methodological issues

- **Multi-dimensional effects**

  Heterogeneity in drivers and processes involved

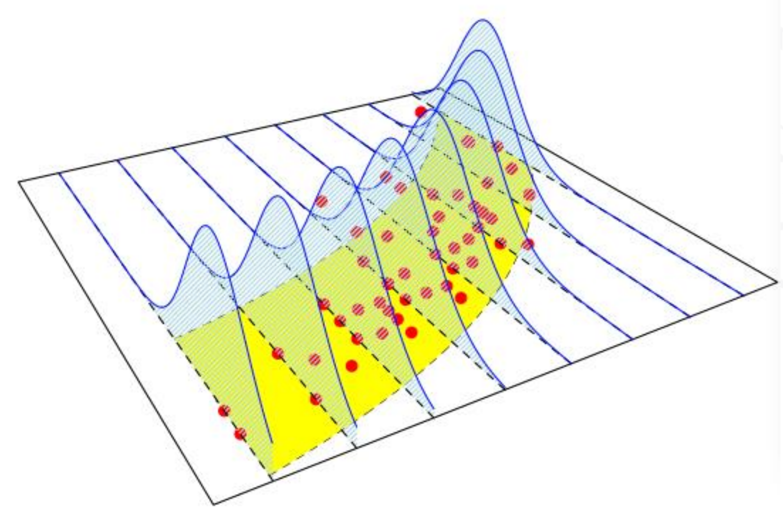


- **Systemic effects**

  Interaction between system' compartments and processes

- **Non-linear effects**

  Complex relationships between causes and effects



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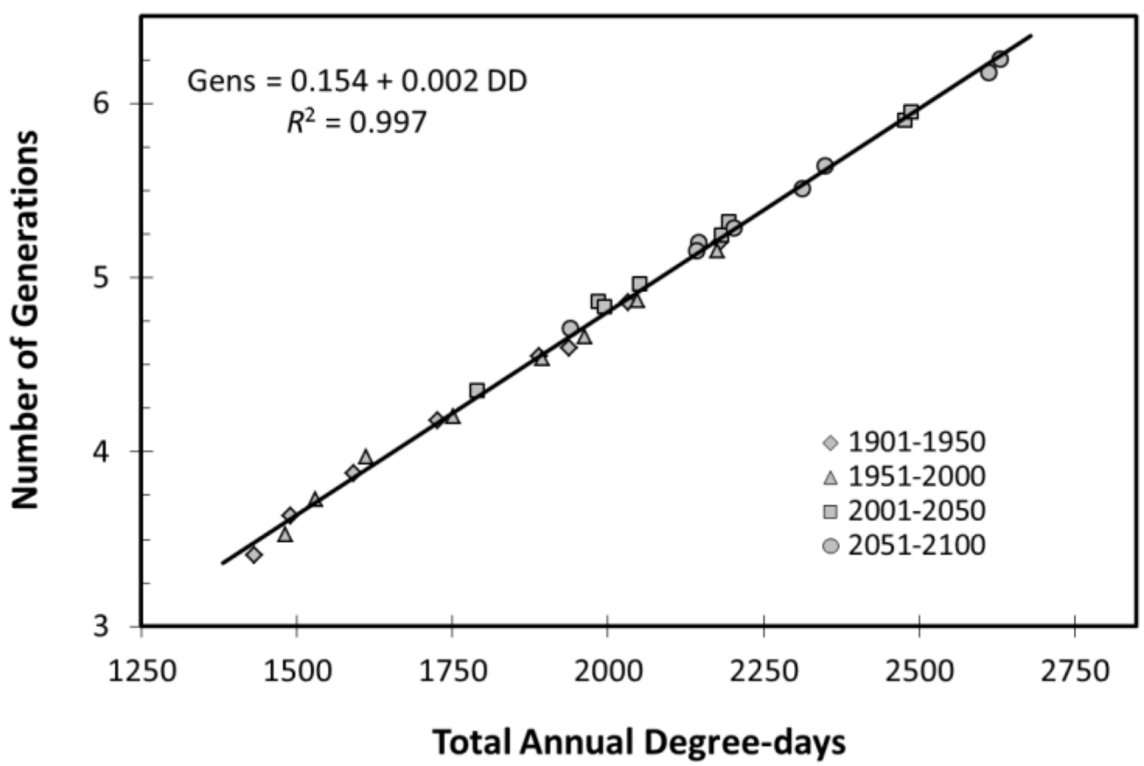
Global changes: Methodological requirements

Moving beyond linearity!



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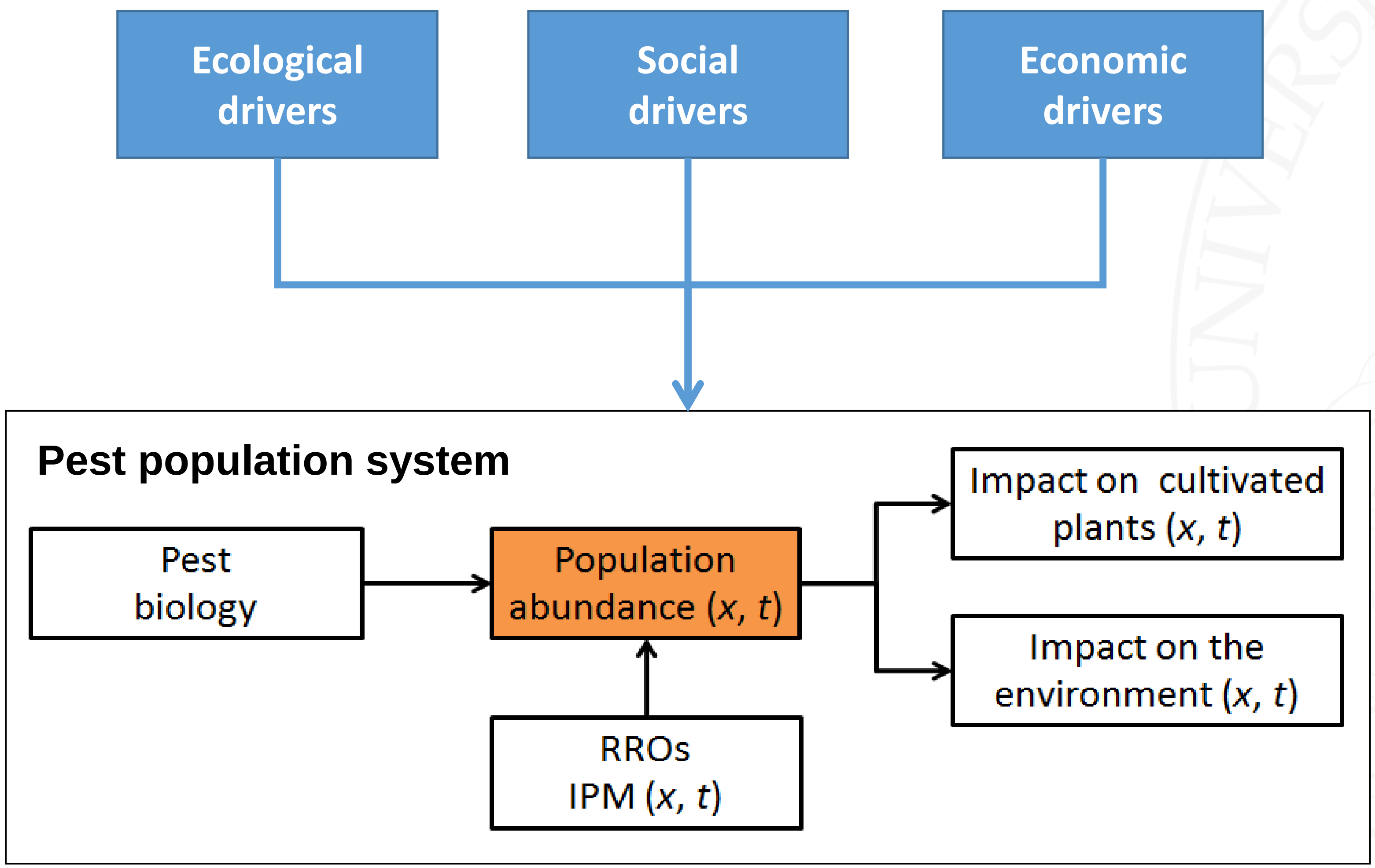
Global changes: Methodological requirements

Population-based (i.e. mechanistic) approach



The EFSA scientific framework for quantitative pest risk assessment

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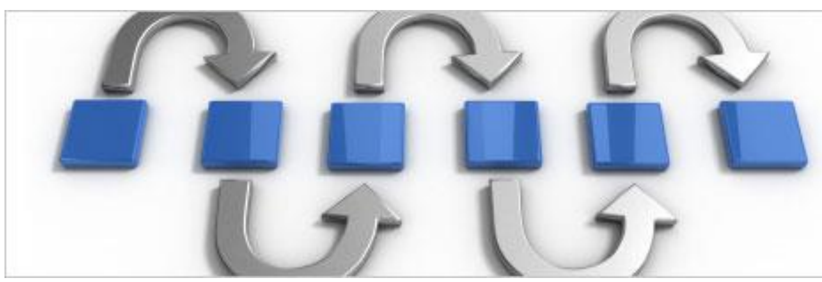
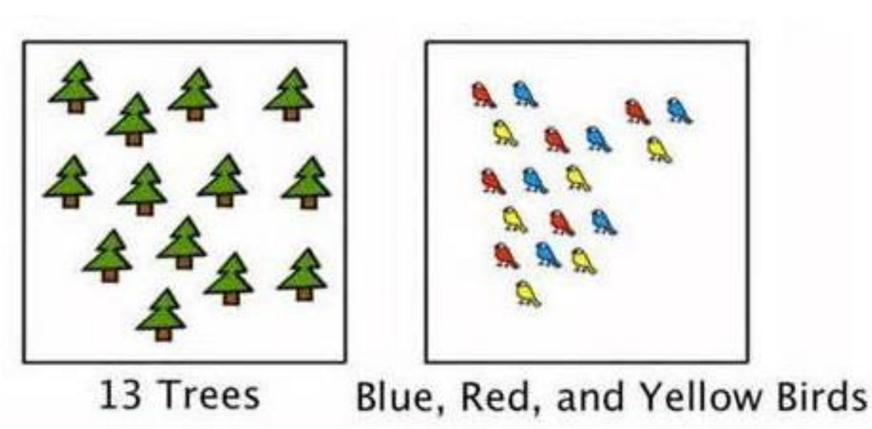
EFSA framework for quantitative PRA: Principles

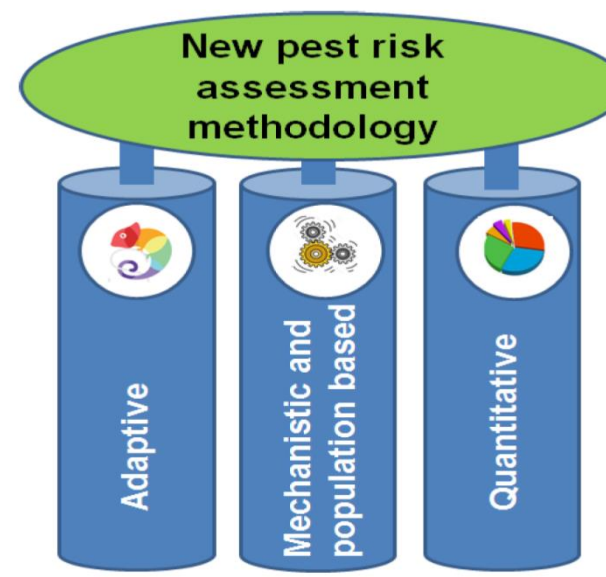
Adaptive



Process-based



Quantitative



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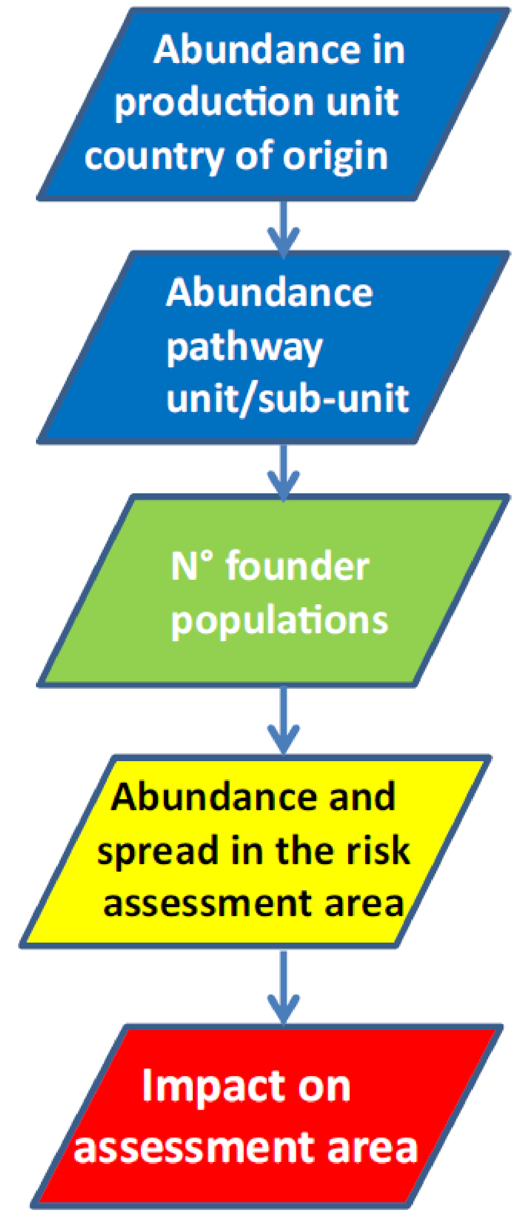
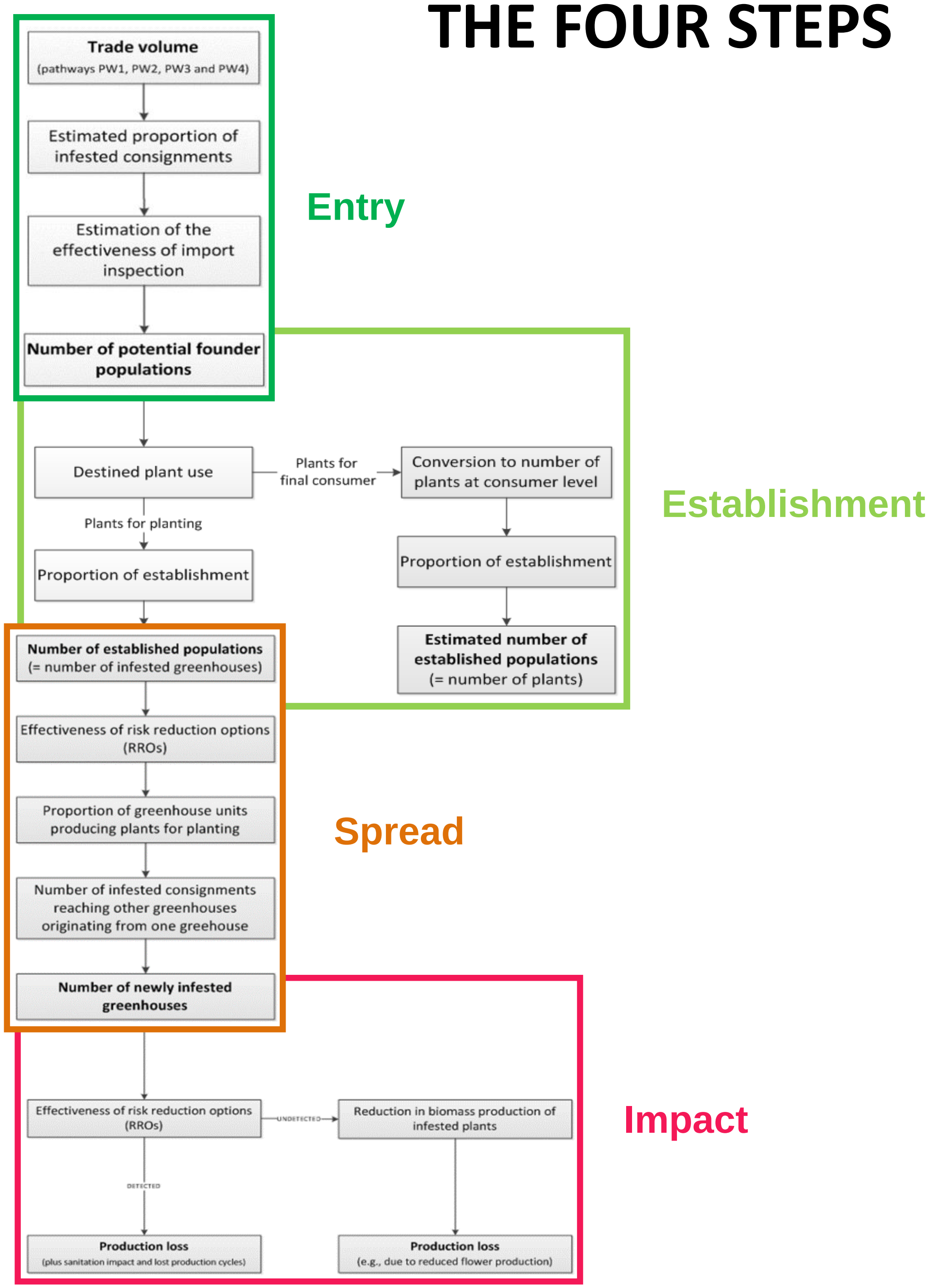
EFSA framework for quantitative PRA: Principles

- **Adaptive**
  - Pest, objective, resources
  - Scenarios for the assessments (e.g., pathway, RRO, trade)
- **Process-based**
  - Flow of events and processes
  - Sequence of changes in the abundance and distribution
- **Quantitative**
  - Using quantities measurable in the real world
  - Combine knowledge and uncertainty



EFSA framework for quantitative PRA: Methodology



THE FOUR STEPS

- **Entry**: (distribution of) number of potential founder populations in the EU considering trade flows, proportion of infested products and probability of transfer to host
- **Establishment**: (distribution of) actual number of founder population in the EU, considering the number of potential founder populations and the probability of establishment
- **Spread**: (distribution of) number of spatial units that are affected by pest as a result of dispersal
- **Impact**: (distribution of) total yield loss and effects on crop quality in EU

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EFSA framework for quantitative PRA: Methodology

SCENARIO-BASED APPROACH

Components defining the scenarios for risk assessment

- Pathways
- Mechanisms of spread
- Spatial extent and resolution
- Time horizon and resolution
- Ecological factors and conditions (Climate change; change in hosts; resistance and resilience variations)
- Current regulation
- Identification of the relevant RROs Control and supporting measures

For fit for purpose and explicit risk assessment

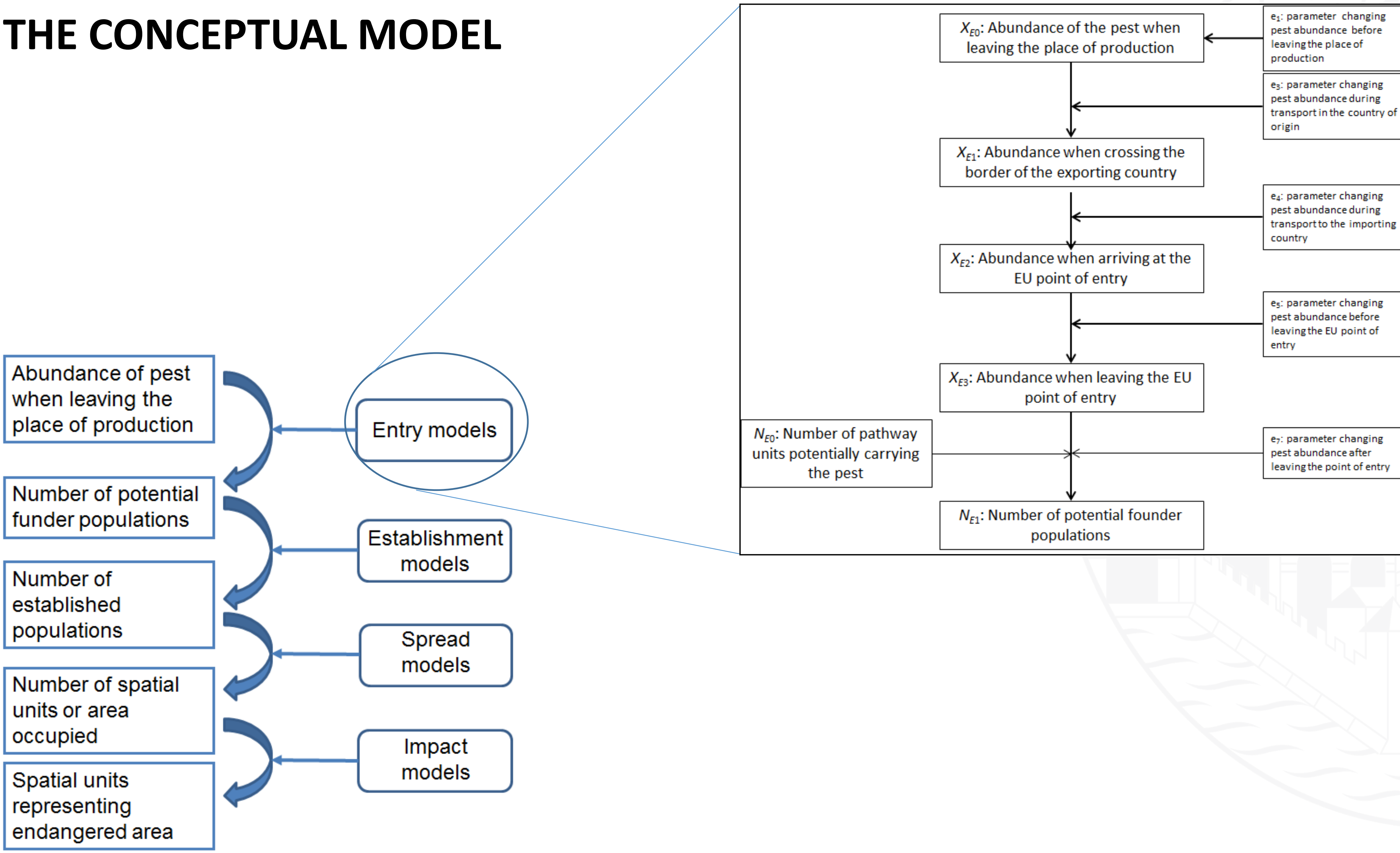
scenario 'A0', Baseline scenario is the current situation. A0 is always assessed

scenarios A1 to An corresponding to changes in the pathways or RROs etc. can be compared with A0

Example Scenario A1: Current regulation in place without the E. lewisi specific requirements (Annex IIAI to Council Directive 2000/29/EC2) and in addition all imported host commodities should come from Pest Free Areas (PFA) in the country at origin (ISPM 4 (FAO, 1995)) and enforced measures on specific pathways.

EFSA framework for quantitative PRA: Methodology

THE CONCEPTUAL MODEL



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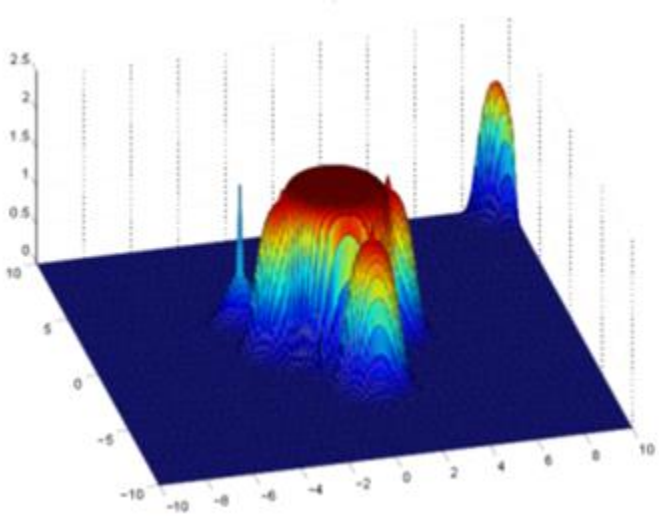
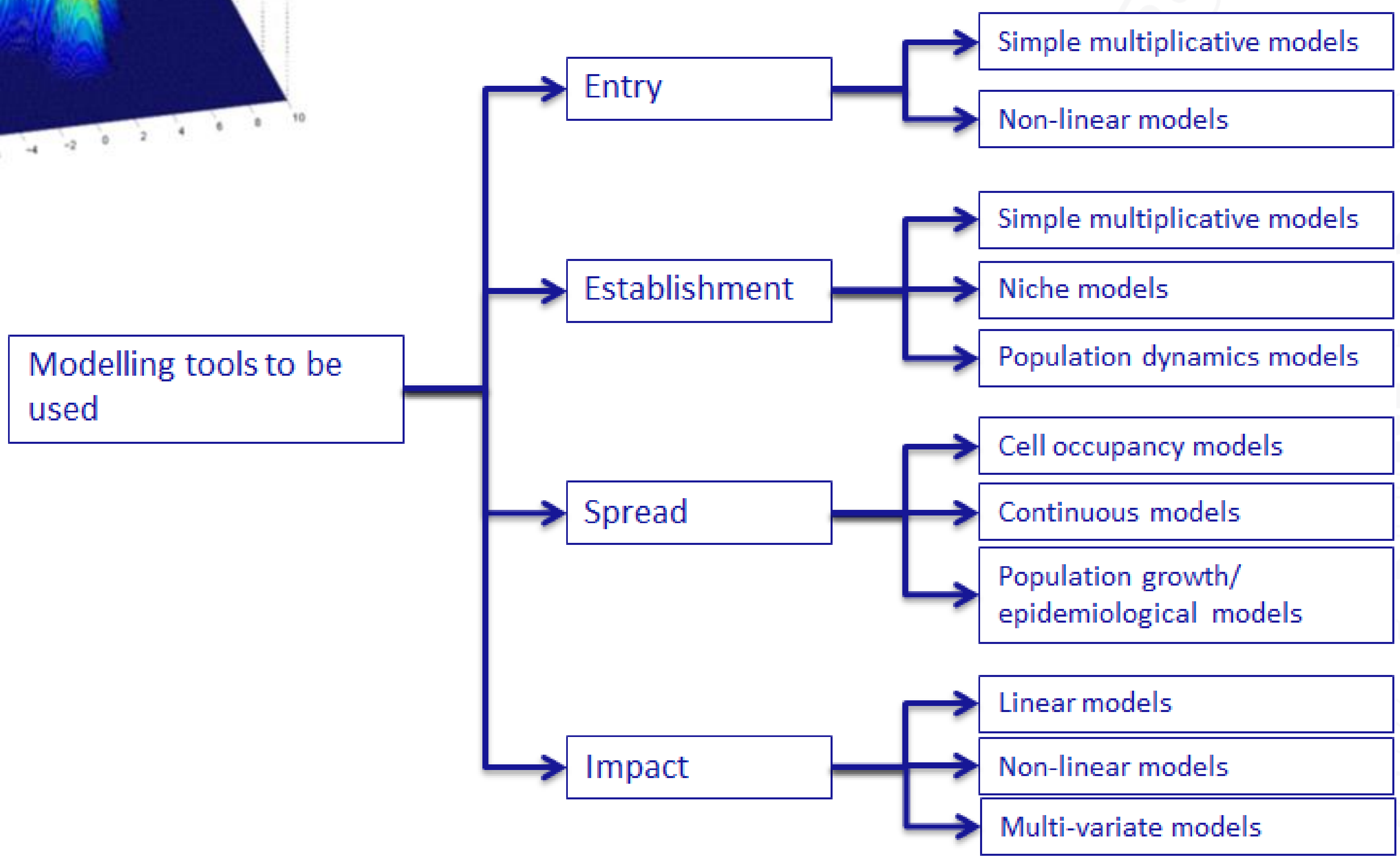


THE FORMAL MODELS



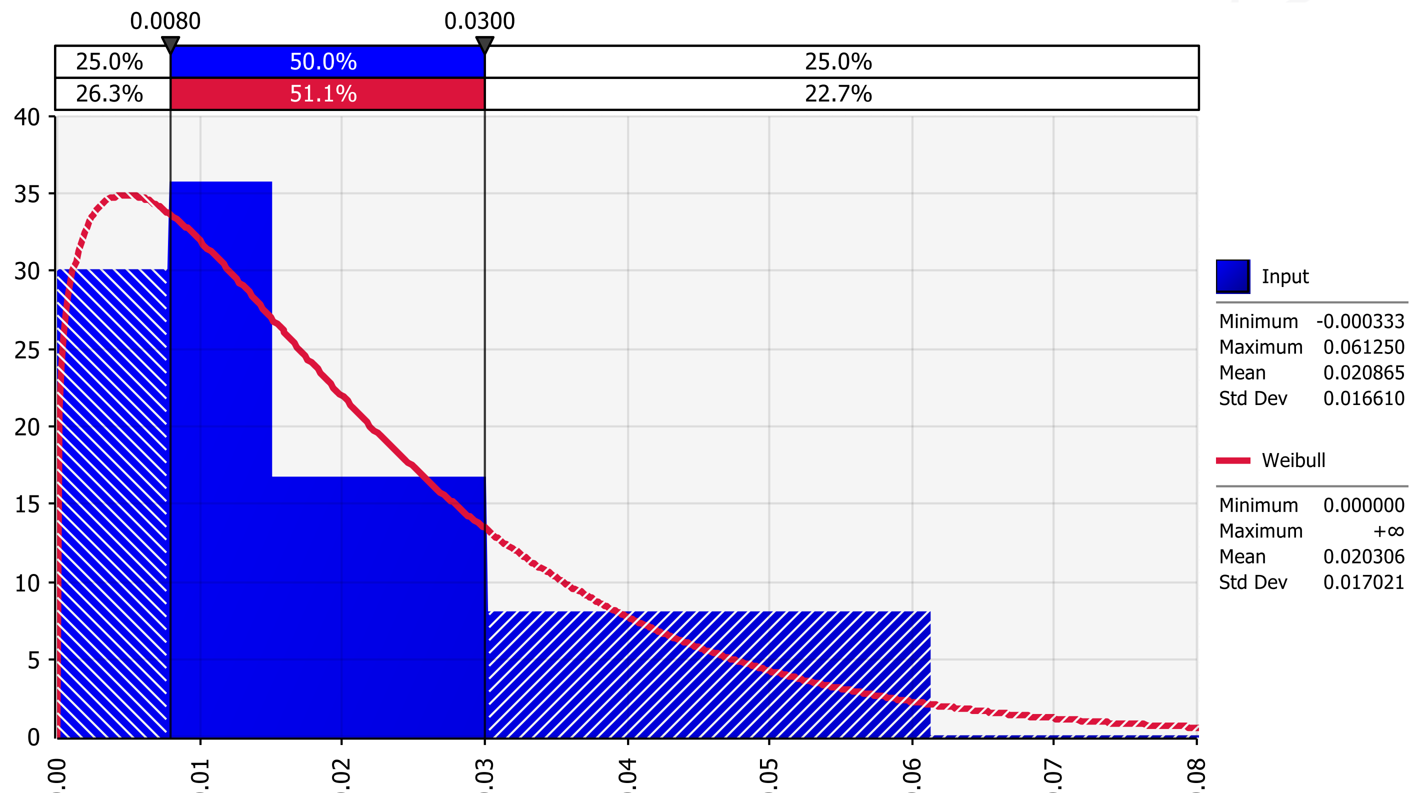
EFSA framework for quantitative PRA: Methodology

ESTIMATE UNCERTAINTY DISTRIBUTION

The two-tier approach
- Elicitating the assessed variable (e.g., the impact as % yield reduction)
- Elicitating model parameters

Quantitative methods allow for
- More transparent risk assessment
- Guide the risk assessment to express the constituent parts of risk

Percentile	1st	25th	50th	75th	99th
Estimate (%)	0.0	0.8	1.5	3.0	6.0



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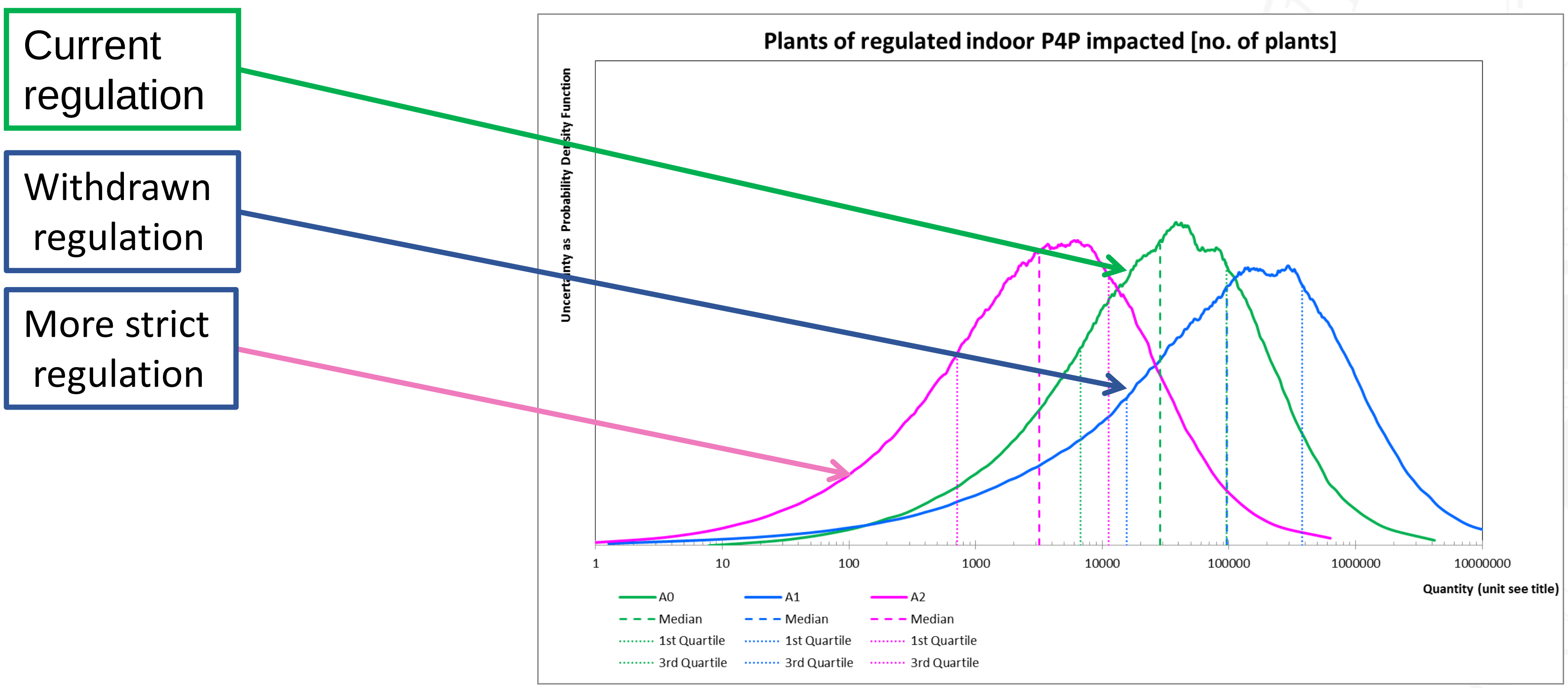
EFSA framework for quantitative PRA: Methodology

SCENARIO COMPARISON

Scenario comparison



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EFSA framework for quantitative PRA: Application

THE CASE STUDIES DEVELOPED BY EFSA

Flavescence Dorée Phytoplasma

Ditylenchus destructor

Eotetranychus lewisi

Diaporthe vaccinii

Ceratocystis platani

Cryphonectria parasitica

Radopholus similis

Atropellis sp.

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Assessing global change scenarios

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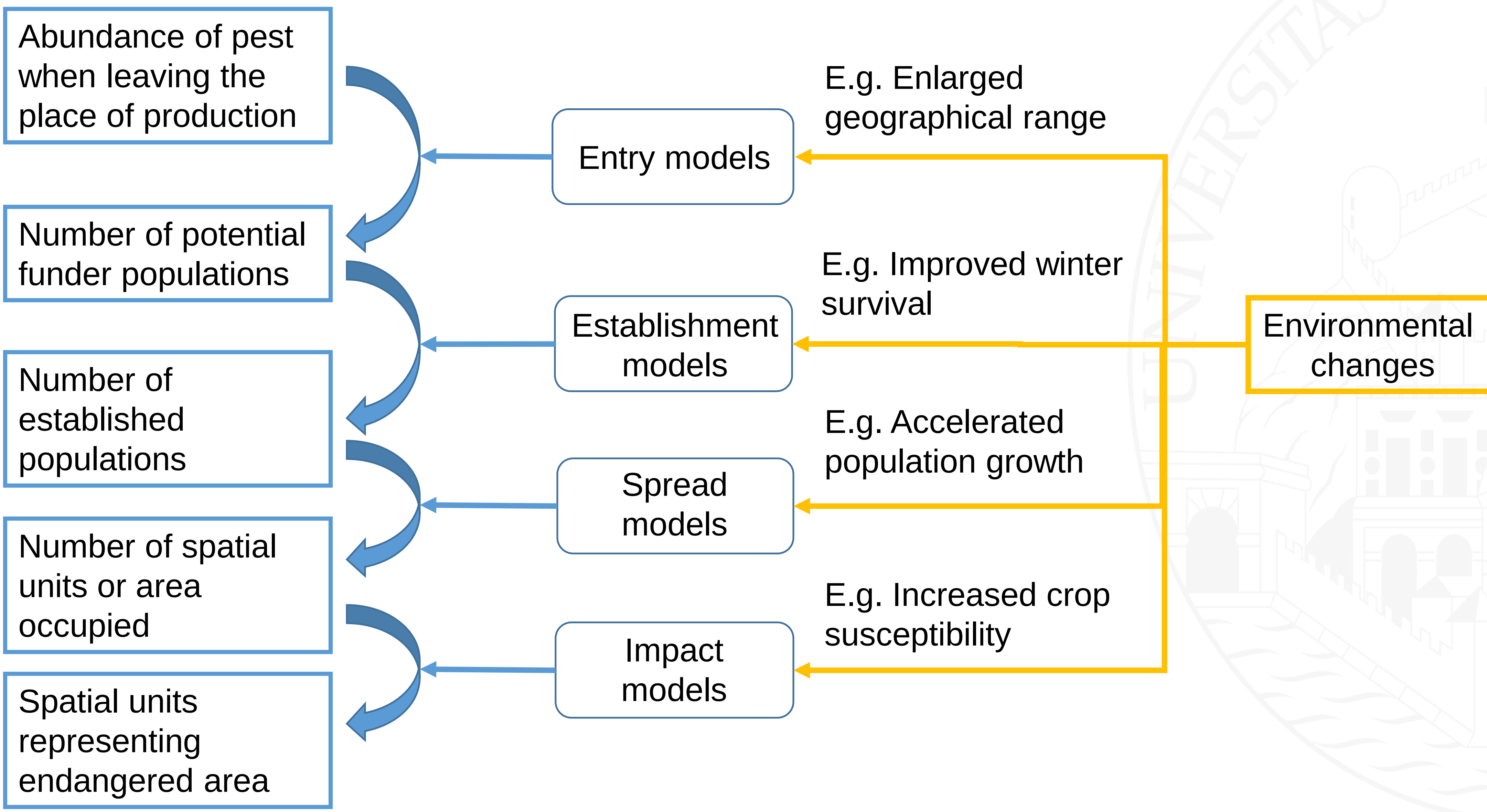
Assessing global change drivers



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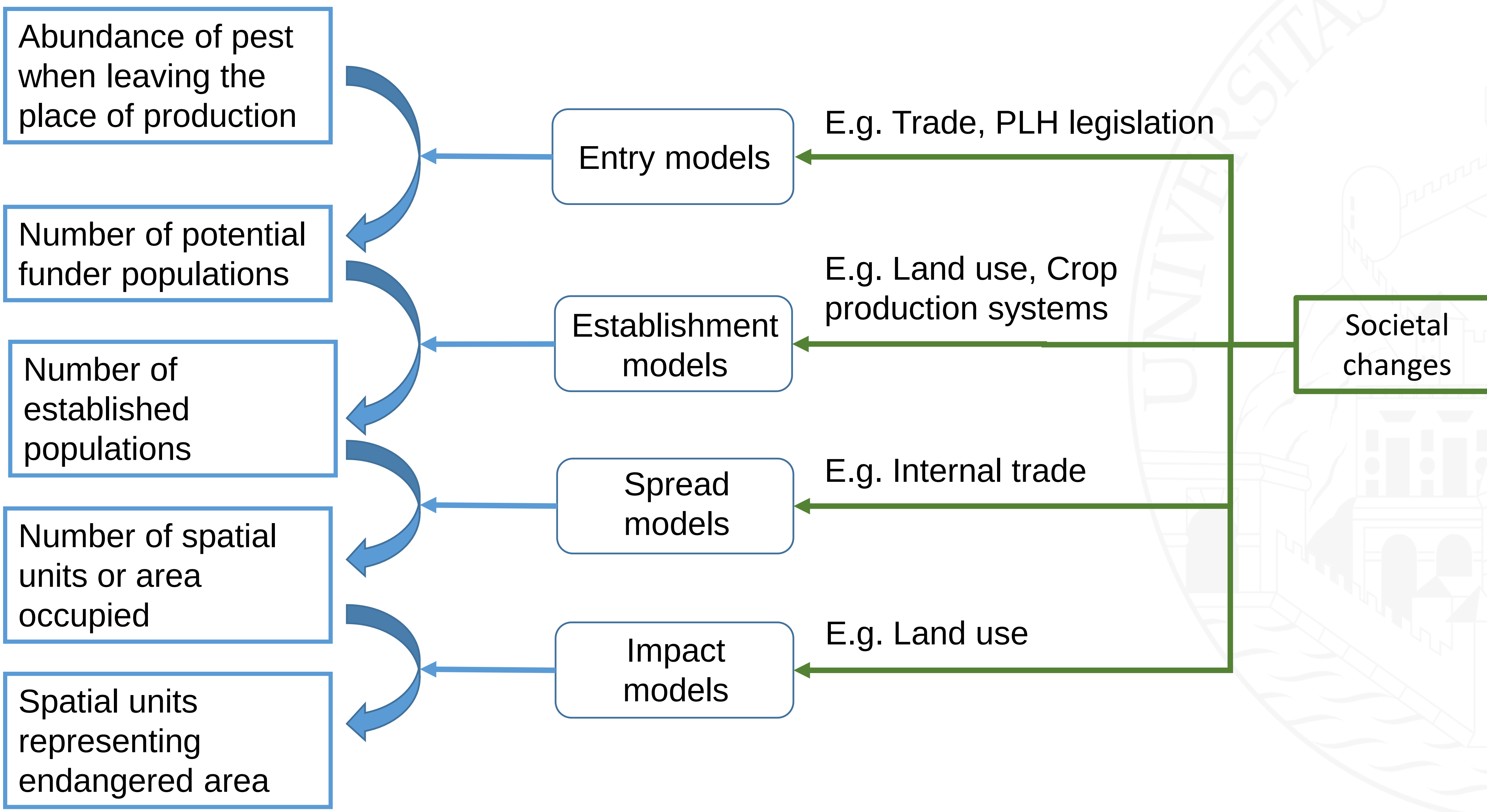
Assessing global change drivers



Climate change scenarios

Radopholus similis

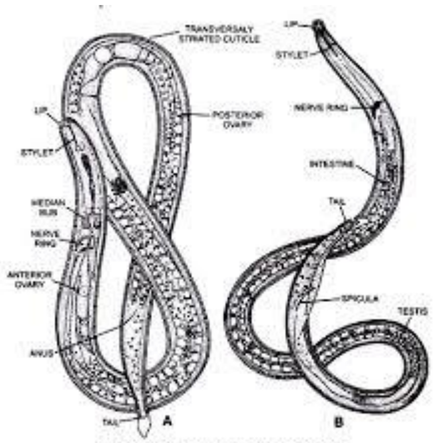


Fig. 10.7. Radopholus similis. A-Female, B-Male.

Impact of climate change (+2 °C) for the establishment and spread of *Radopholus similis*

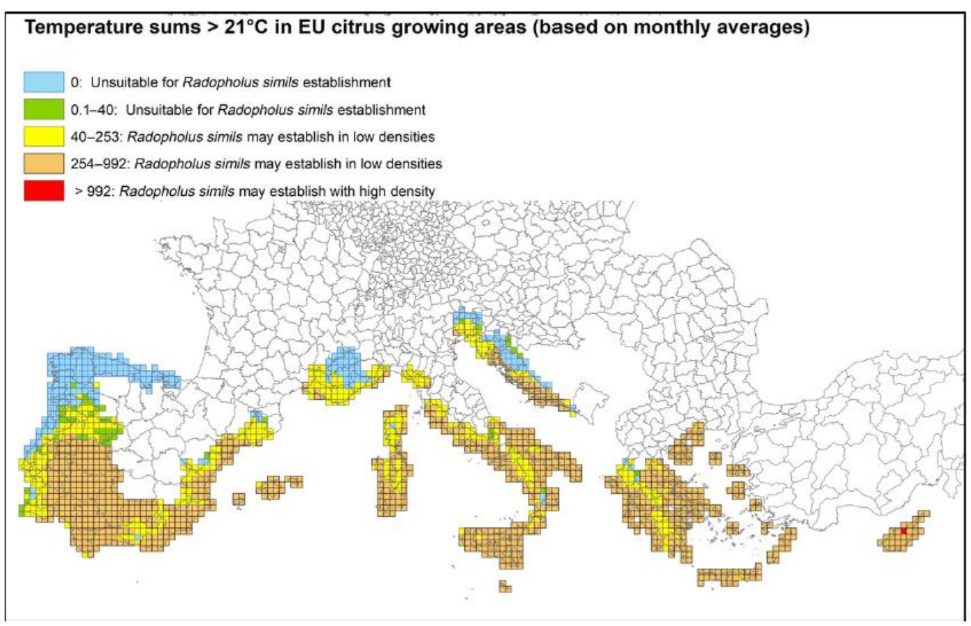


Figure A.5: Citrus growing areas of the EU classified according to temperature sum intervals based on monthly average temperatures from locations surveyed for the presence of *R. similis*, see JRC (2017) for the data used to create the map

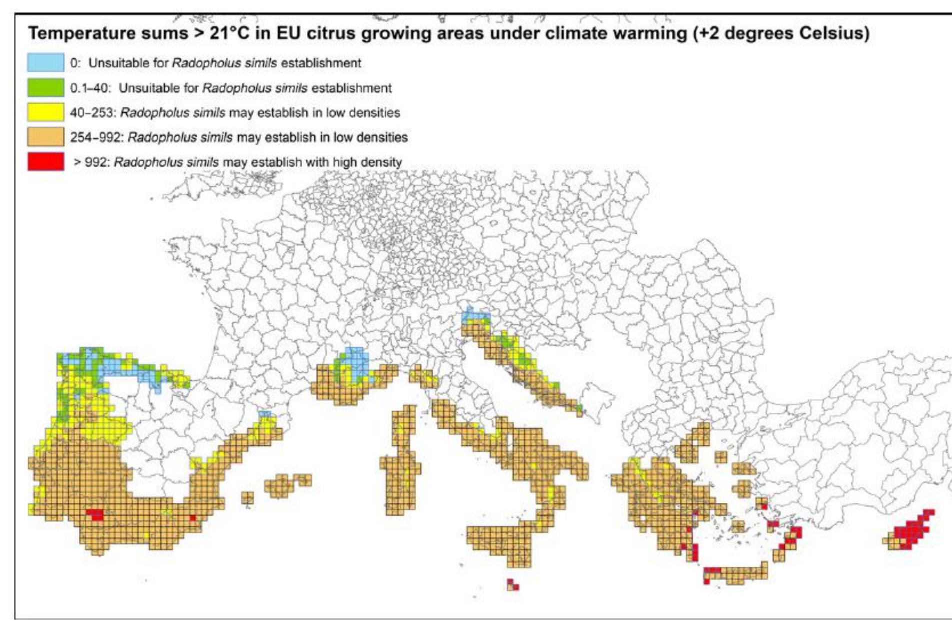


Figure A.7: Citrus growing areas of the EU classified for temperature suitability for *Radopholus similis* establishment according to temperature sum intervals under climate warming, see JRC (2017) for the data used to create the map

Comparison of RROs scenarios

Ditylenchus destructor

SC 0 Baseline scenario (blue)

SC. 3:(=SC 0) Production of flower bulbs in pest-free places of production in third countries (green)

SC 5 Production of the flower bulbs in pest-free areas (pink)

SC. 6: Hot water treatment before planting (orange)

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Scenarios of spread of *Ditylenchus destructor* considering different RROs

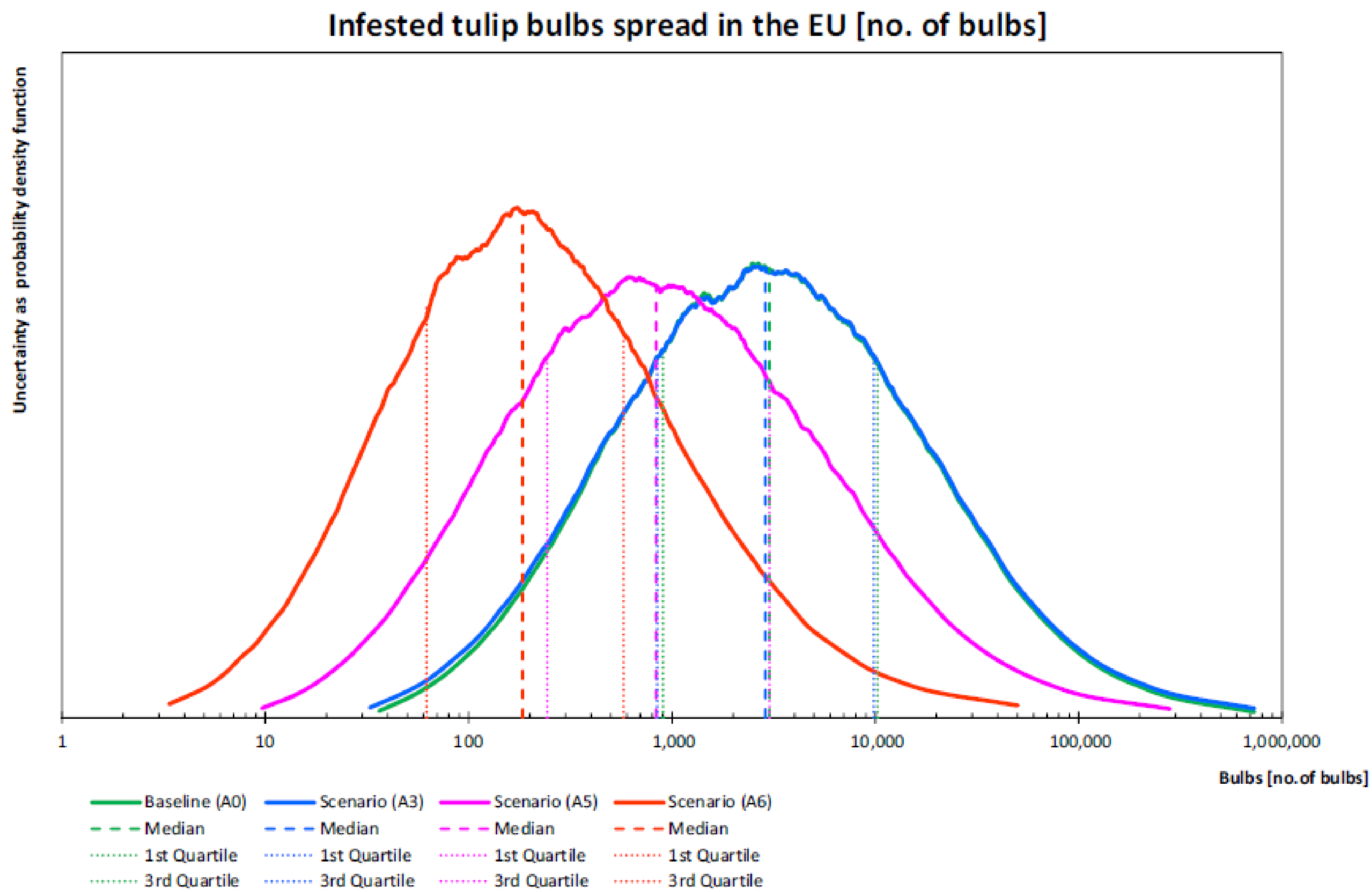
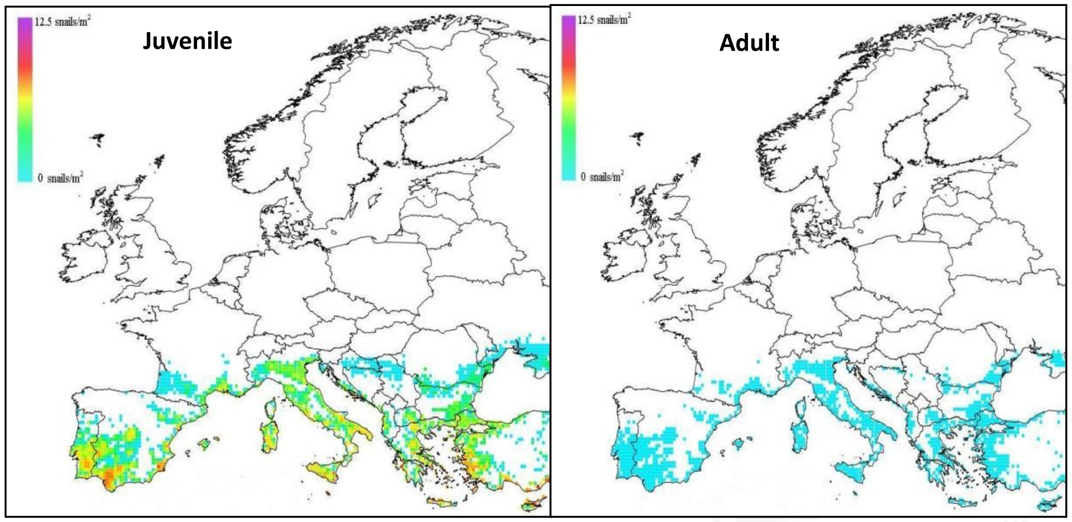


Figure 4: Simulation results on the intra-European spread of *D. destructor* with tulip planting material

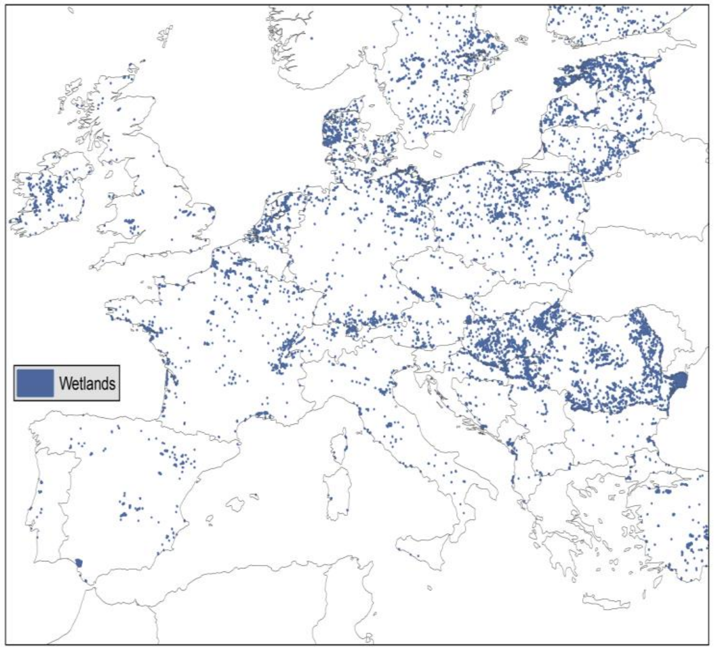
Land-use scenarios

Pomacea caniculata



Rice growing areas in the EU

Overlap with EU wetlands



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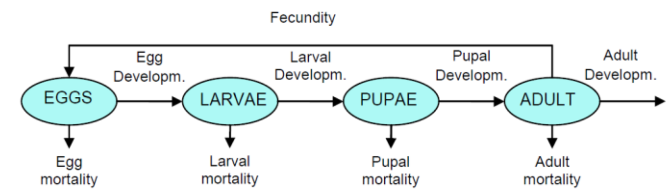
PBDMs: the five steps

System conceptualization
Pest's life cycle, life-history strategy, biodemography etc.



Biodemographic functions
Individual responses to environmental drivers

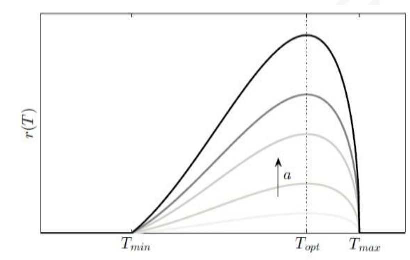
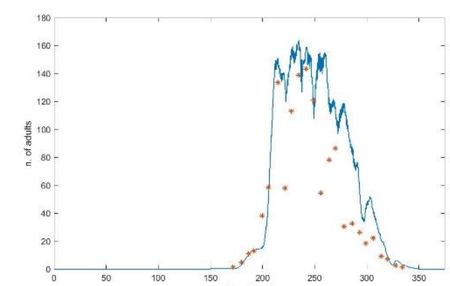
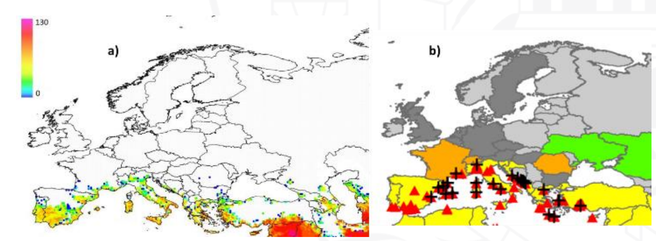


Figure 5: Shape of the Brière-1 development function for different values of a.

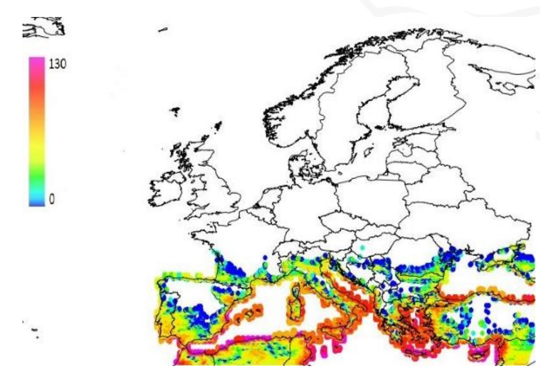
Model calibration
Test model outputs against independent datasets



Model testing
Test potential distribution versus current distribution



Pest's future scenarios
Predict pest's distribution, abundance, spread and impacts



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PBDMs: applications

- Agricultural pests
  - *T. urticae* (two-spotted spider mite)
  - *P. persimilis*
  - *T. vaporariorum* (glasshouse whitefly)
  - *E. formosa*
  - *B. oleae* (olive fruit fly)
  - *L. botrana* (European grapevine moth)
  - *S. titanus* (American grapevine leafhopper)
  - *P. ficus* (vine mealybug)

- Agricultural pests
  - *B. tabaci* (silverleaf whitefly)
  - *D. kuriphilus* (chestnut gall wasp)
  - *P. canaliculata* (apple snail)
  - *Argyrotaenia pulchellana*
  - *C. pomonella* (codling moth)
  - *C. molesta* (peach moth)
  - *H. armigera* (cotton bollworm)
  - *P. viburni* (obscure mealybug)
  - *C. capitata* (Mediterranean fuit fly)

- Disease vectors
  - *An. gambiae s.s.*
  - *Ae. albopictus*
  - *C. pipiens*
  - *R. appendiculatus*

- Under development
  - *Halyomorpha halys* (brown marmorated stink bug)
  - *Philaenus spumarius* (meadow spittlebug)
  - *Spodoptera frugiperda* (fall armyworm)

Conclusions

- The methodological framework for quantitative pest risk assessment
  - Suitable for considering multi-dimensional, systemic and non-linear effects related to global changes
  - Framework and not a model: providing a systematic and dynamic representations of the processes liable to generate risks

- Flexible approach and allows a variety of quantitative methods to be used at different systems and levels of complexity

- Advantages of quantitative assessment
  - The assessment outcome (risk) is expressed in quantitative units measurable in the physical world allowing risk managers a more concrete understanding of the assessment result and hence a better basis for decision making
  - Increase the transparency in providing mechanism on how to combine risk elements in logical manner and to estimate model parameters
  - Take into account both quantified and unquantified uncertainties
  - Automatically updates with revised inputs
  - Evaluate the effectiveness of options for risk reduction and mitigation measure

- Possibility of expressing the risk in monetary units

Thank you!

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