A quantitative assessment of the likelihood of *Spodoptera frugiperda* entering the EU at a sub-national spatial scale and the effect of mitigation measures

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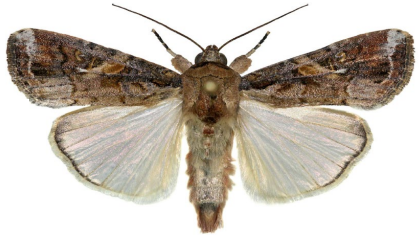
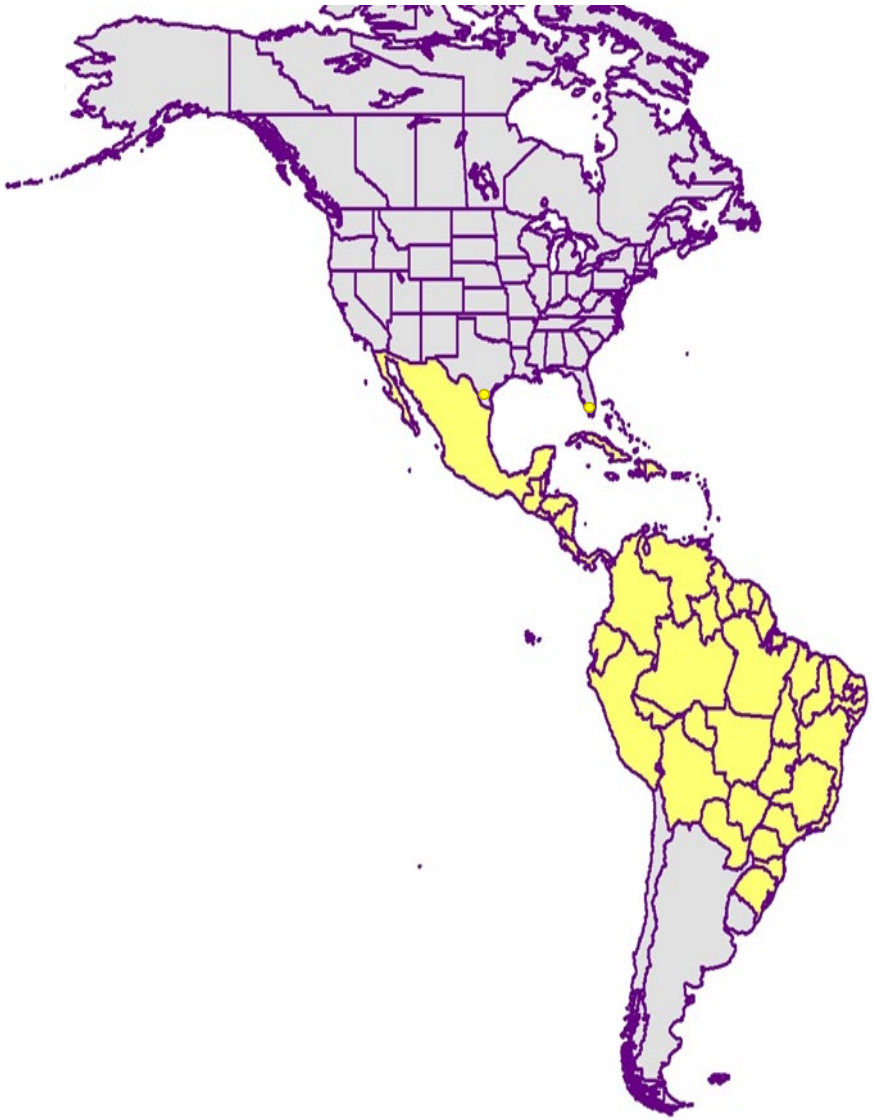
BIOLOGY OF FALL ARMYWORM

- Feeds mainly on cereals, also cotton, tomato, roses …
- Up to 1,000 eggs per female
- Eggs hatch 2-10 days
- Larvae 14-21 days
- Pupae 9-13 days
- Adults 12-14 days
- Multiple generations per year
- Does not establish where there are frosts



DISTRIBUTION PRE-2016



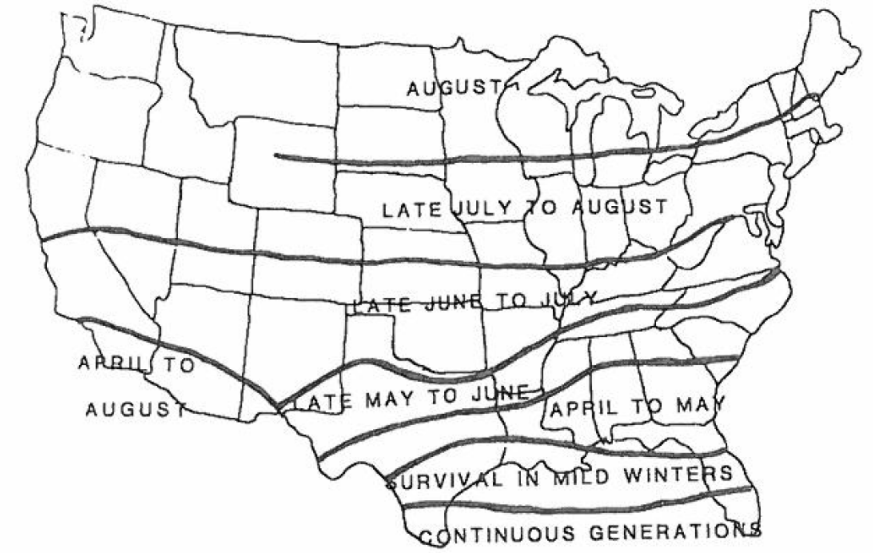
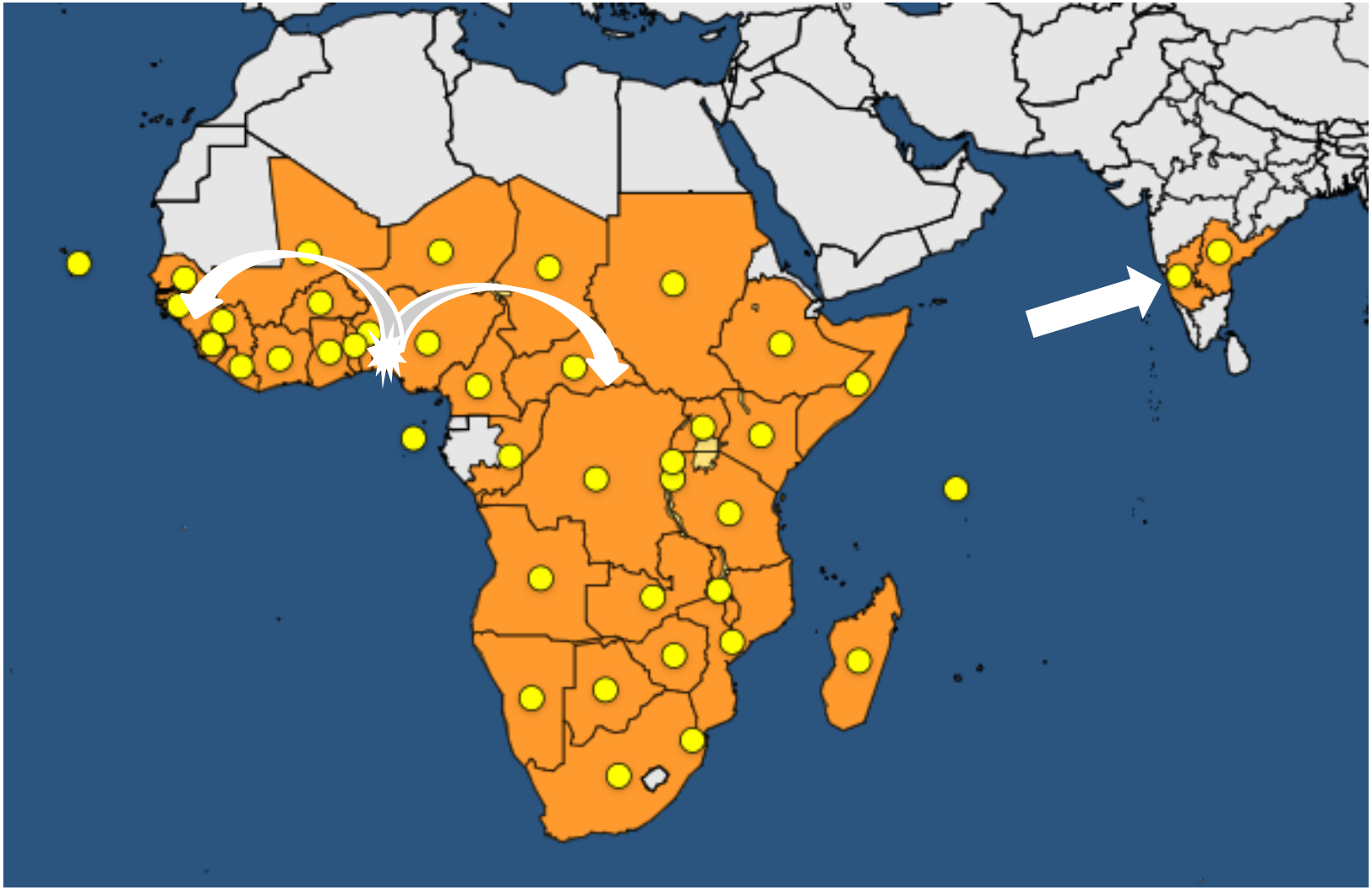


Fig. 2. Annual northward progress of fall armyworm and areas of continuous generations and of survival in mild winters in the United States.(Johnson, 1987)

RAPID SPREAD IN AFRICA 2016-2018



REQUEST FOR RISK ANALYSIS

- Request from plant health risk managers of European Union (within European Commission)

- Should focus on …
  - the main pathways of entry into the European Union
  - establishment
  - effectiveness of control methods

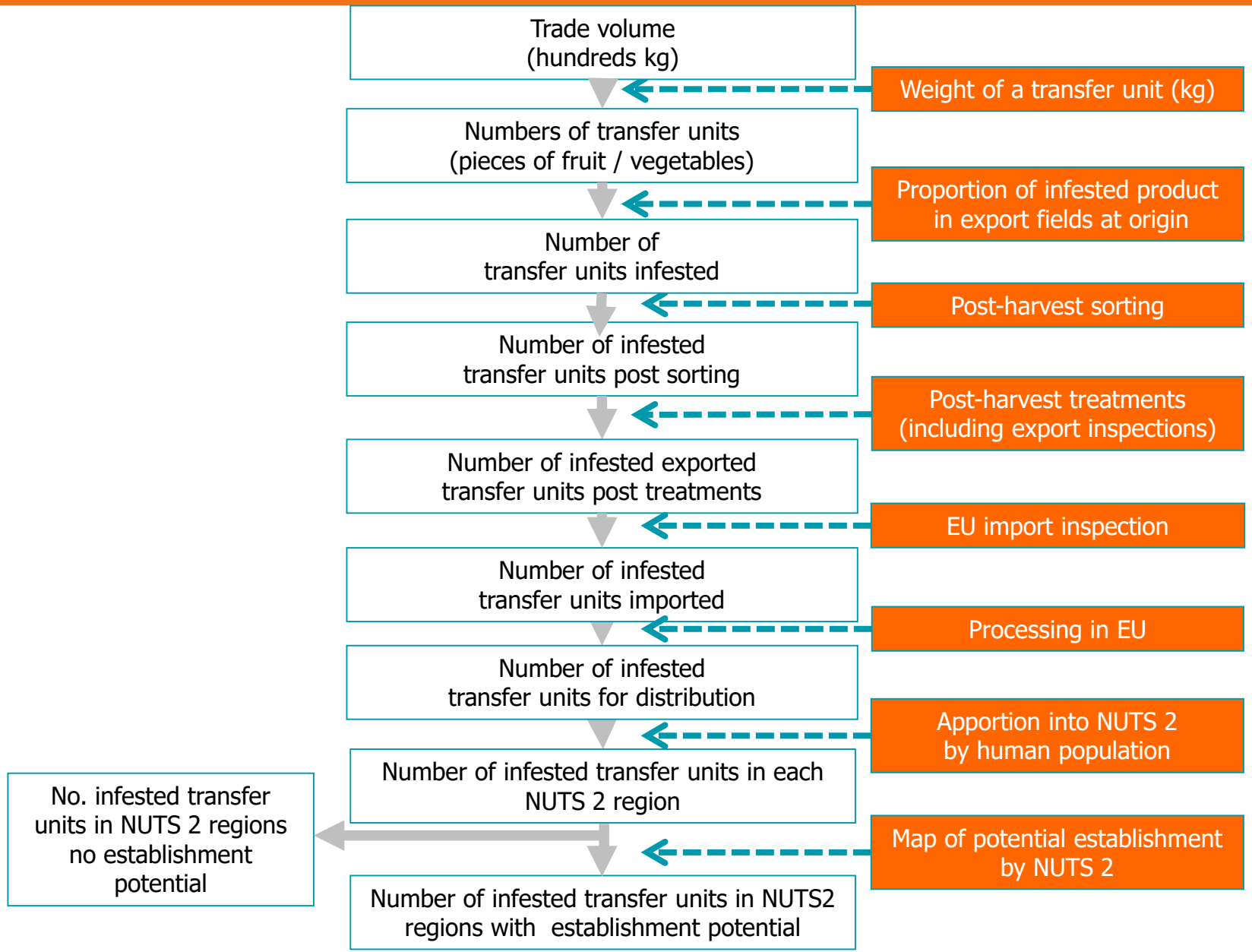
ENTRY - TRADE

- Interception data indicate *S. frugiperda* is most often intercepted on:
  - *Capsicum*
  - *Solanum melongena* and other *Solanum* spp.(not potatoes)
  - Roses
  - *Asparagus*

- Other lepidoptera (*Helicoverpa* spp.) intercepted on maize (sweetcorn)

- Eventually consider all fruits and vegetables from core America & sub-Saharan Africa

CONCEPTUAL MODEL: ENTRY VIA EACH KEY COMMODITY



EVIDENCE DOSSIERS FOR PATHWAYS

- Dossiers for each pathway compiled with information to inform estimates of values for each sub-steps
- Information sources
  - scientific literature
  - trade / industry grey literature & websites
  - Youtube – films of crop production systems *
  - experts knowledge (experience in Americas & Africa)
- Discussed dossiers and supplement with additional knowledge from working group
- Make estimates (individually) then as a group
- Later estimates made collectively (time pressure)

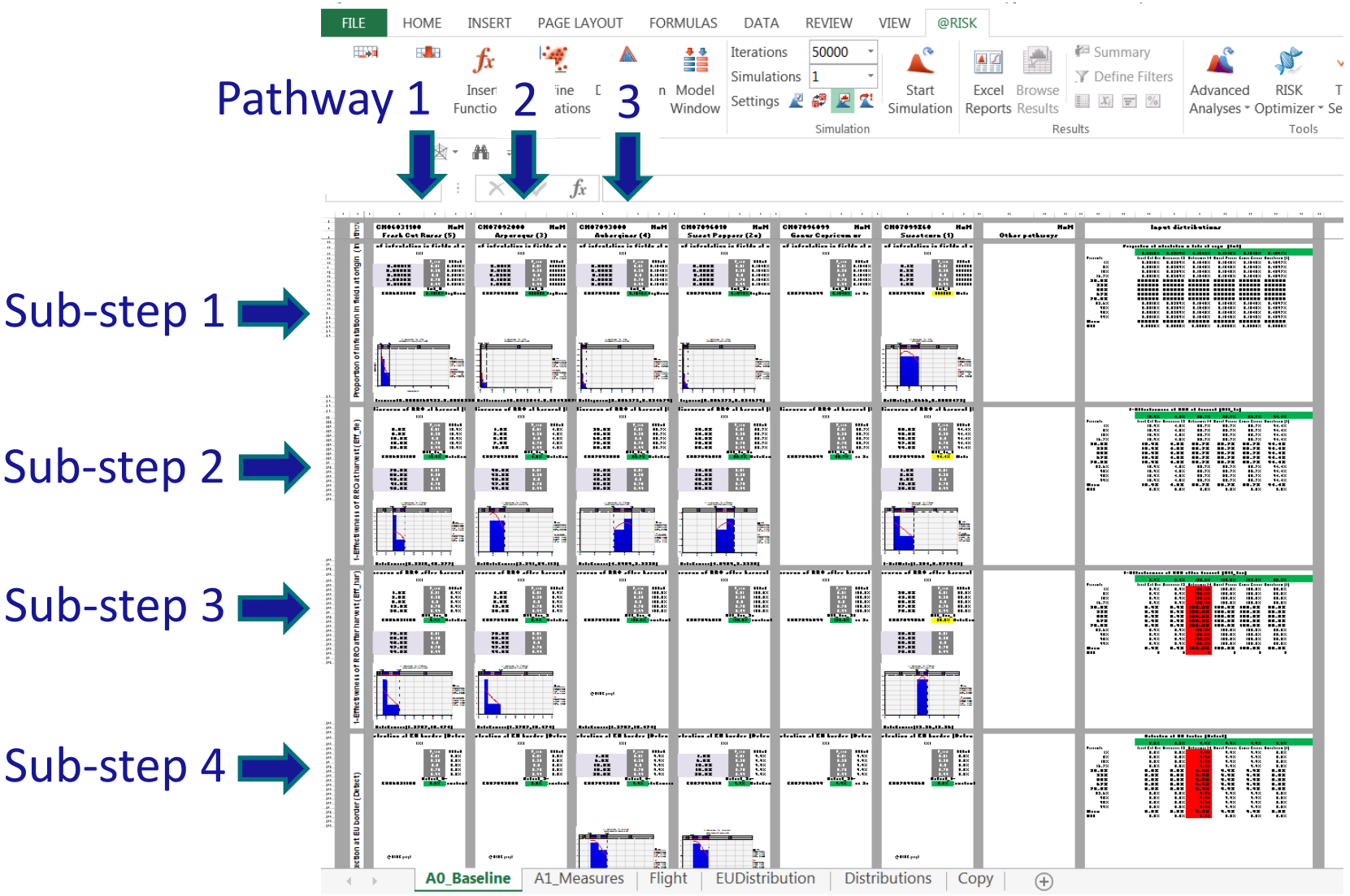
* https://www.youtube.com/watch?v=-xURItme4Uo

EXAMPLE: MAIZE (CORN ON THE COB)

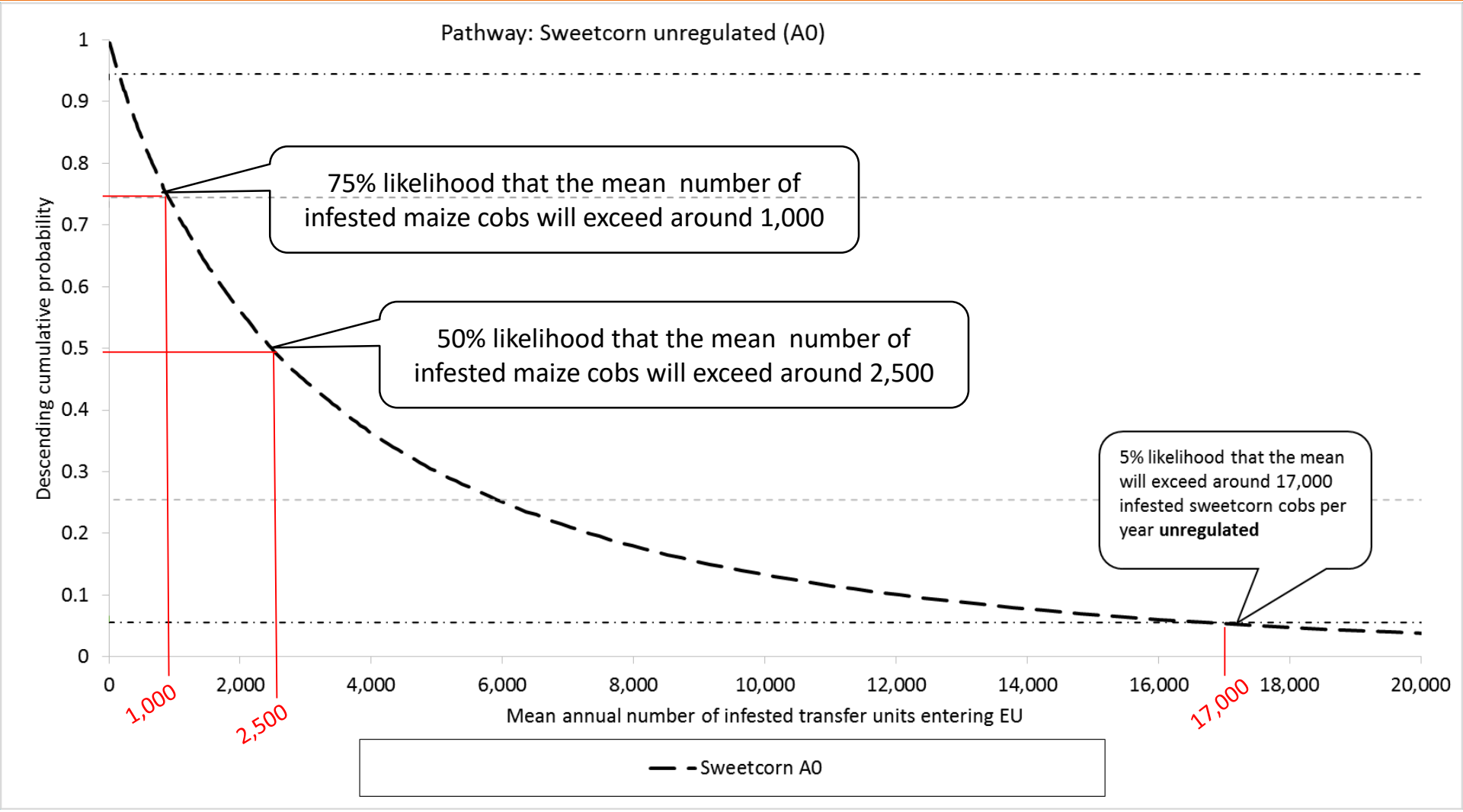
Q. Mean percentage of infested product in export production fields at origin (over the next 5 years)

Scenario \ Percentile	1	25	50	75	99
A0: Current situation (% maize cobs infested)	0.1	0.3	0.5	0.7	1.0
A1: Additional measures (% maize cobs infested)	0.01	0.03	0.05	0.07	0.1

MODEL IMPLEMENTED USING @RISK

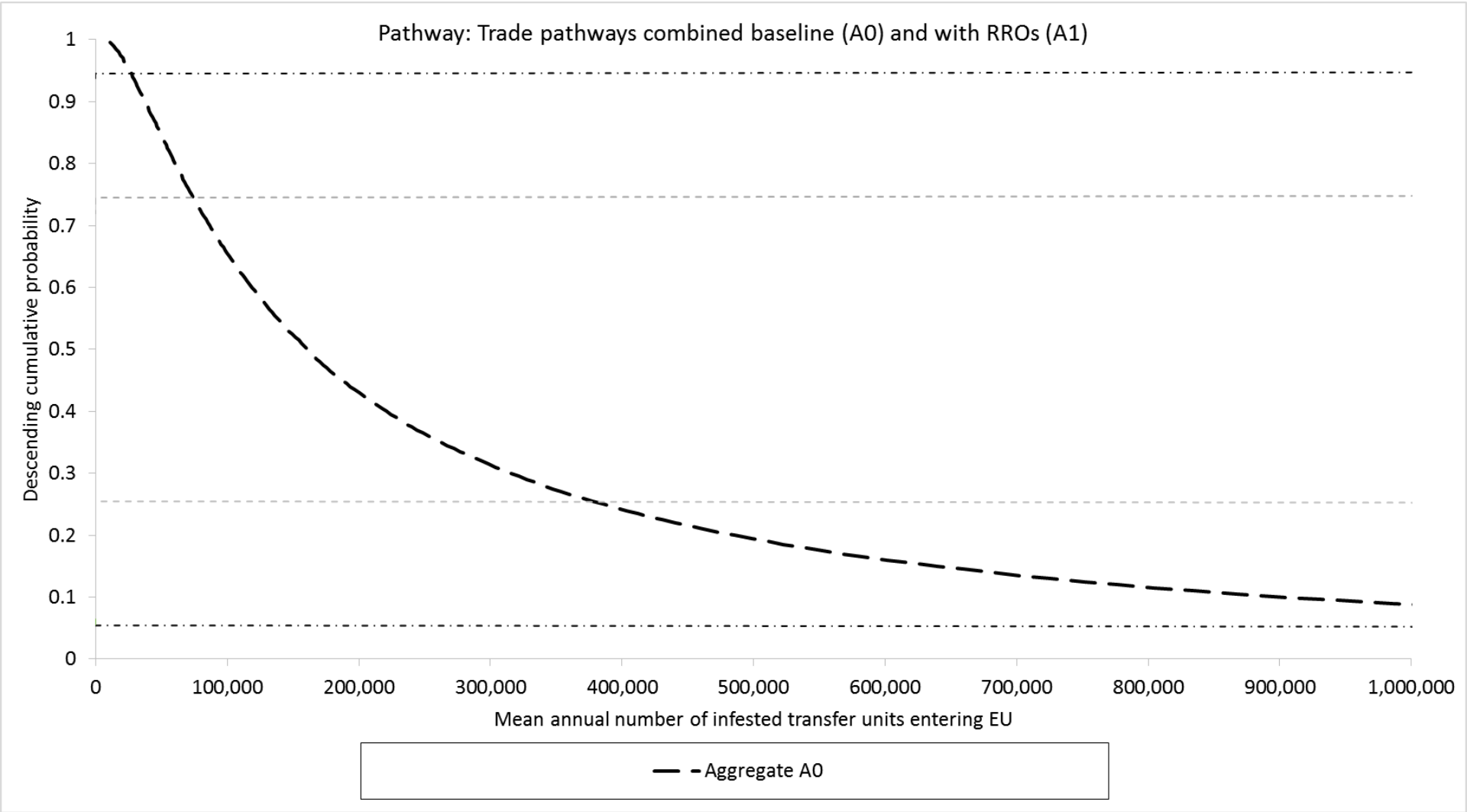


PATHWAY 1: MAIZE (SWEETCORN)



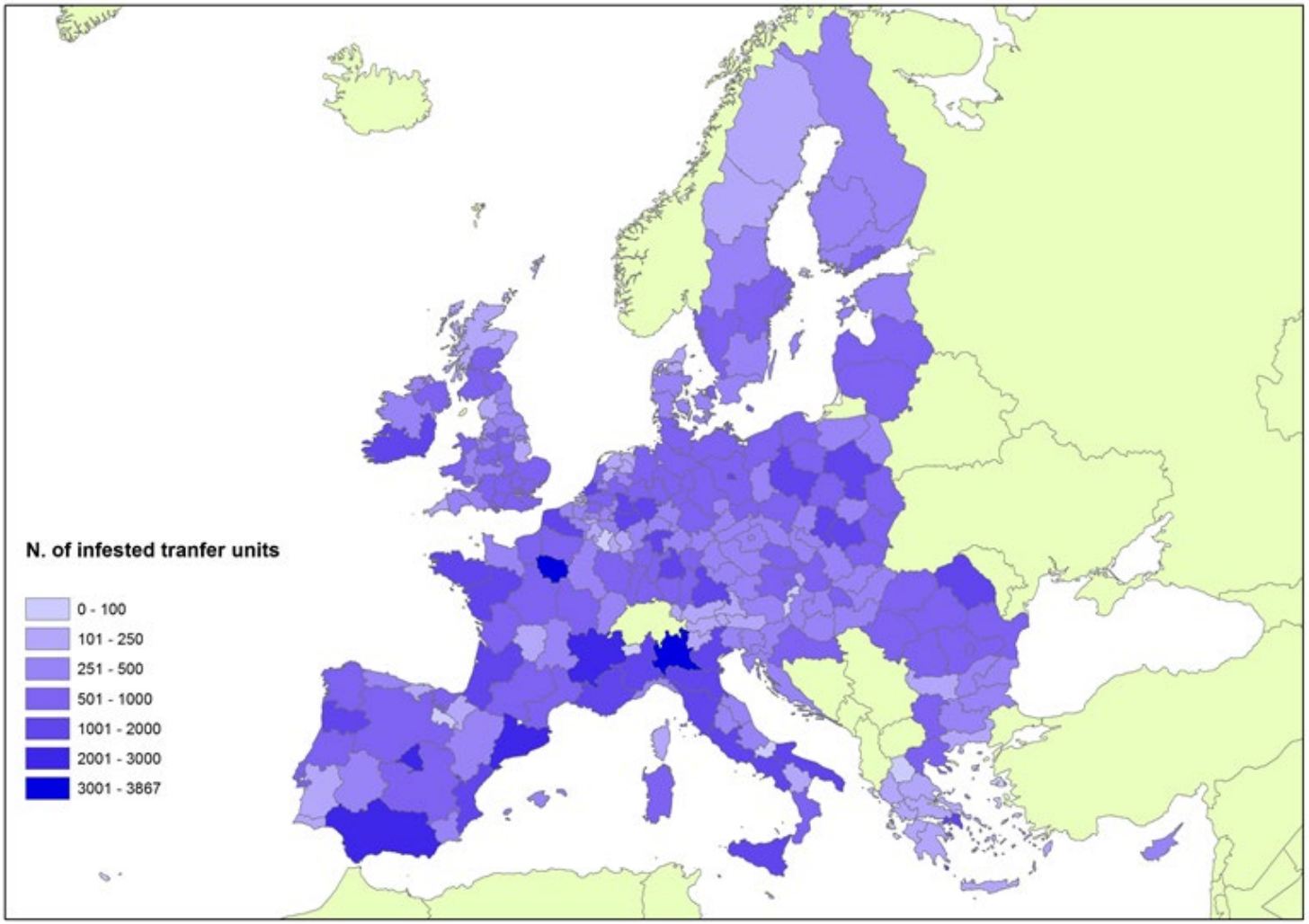
RESULTS (ALL COMMODITIES)

- Sum all commodity pathways



DISTRIBUTION OF INFESTED COMMODITIES: TRADE

- Allocation of median values of all infested vegetable and cut flower host commodities entering the EU via trade then apportioned to NUTS 2 region in relation to human population.



PHYTOSANITARY MEASURES

- Commodities come from pest free area (PFA) x
- Pest free place of production (PFPP) x
- Pest free production site (PFPS) x
- Cold treatments (commodities chill sensitive) x

Pest free consignment

- Inspected, found free from pest & symptoms
- Inspected in EU

PATHWAY 1: MAIZE (SWEETCORN)

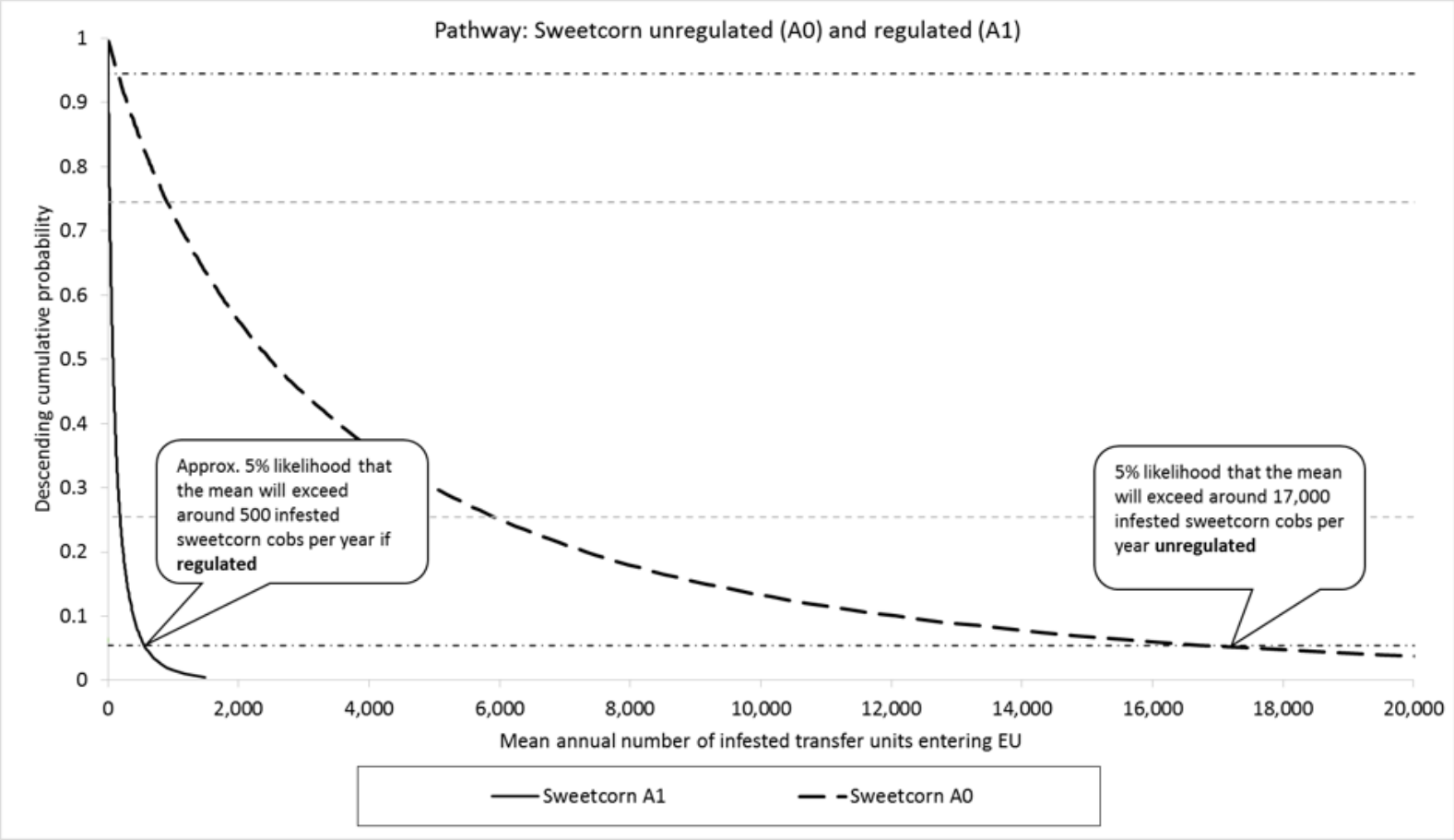
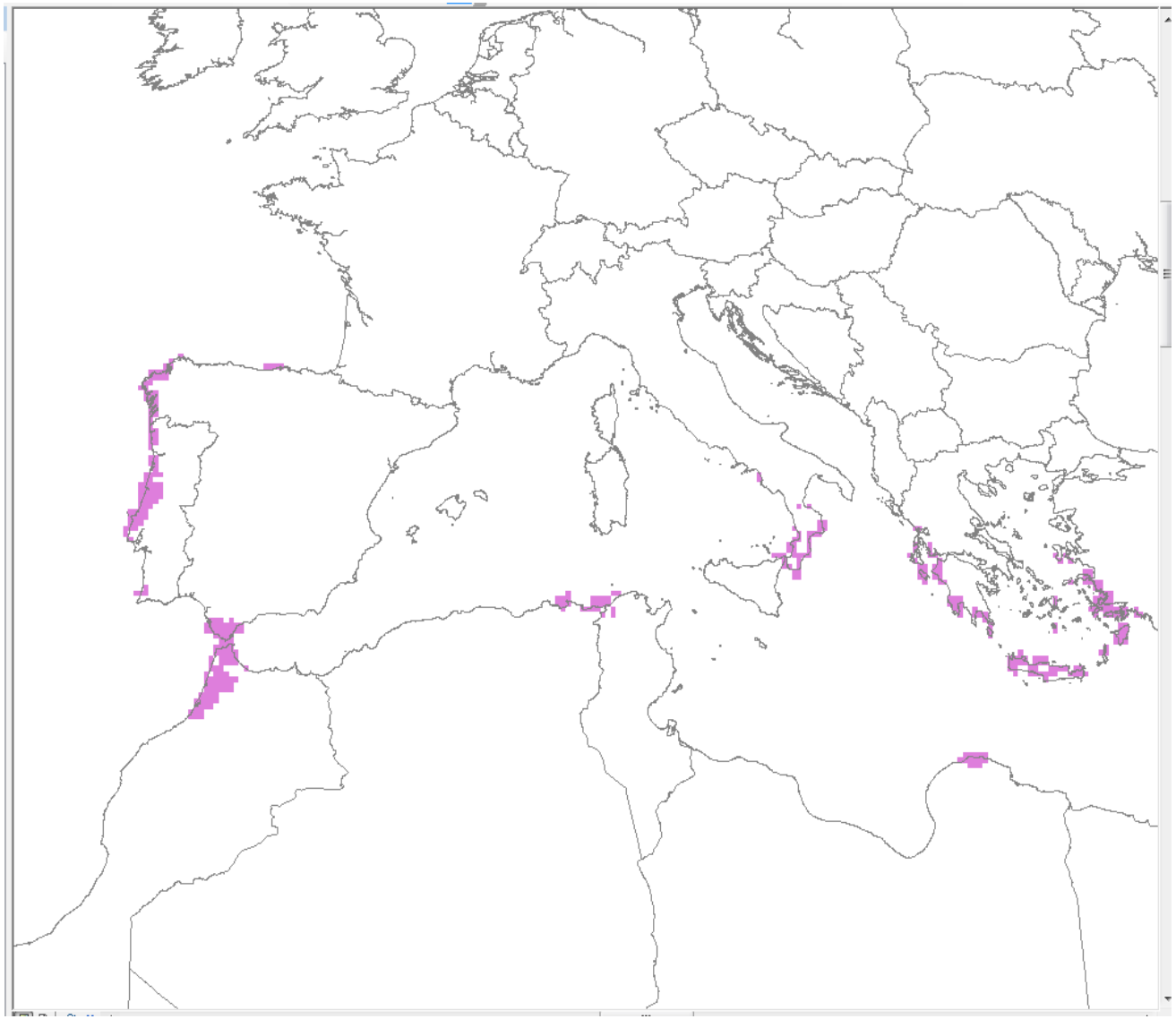


Figure 4: Descending cumulative probability distributions for the entry of *S. frugiperda* with trade in sweetcorn under two scenarios A0 (current measures- hatched lines), and when regulated (A1, solid line).

ESTABLISHMENT

- Created an ensemble species distribution model (SDM)
- Based on eight modelling techniques
- Generates a relative suitability index
  - proportion cells predicted suitable where pest known to occur (correct +ve)
  - proportion cells predicted not suitable where pest known not to occur (correct -ve)
- Visualised using map with threshold of suitability index
  - Choice of threshold balances false +ve with false -ve

ESTABLISHMENT



Threshold: 0.452
Sensitivity: 95% (95% sites with the species classified as suitable; false negatives: 5%)

Specificity: 67% (67% of the sites without the species classified as not suitable; false positives: 33%)

ESTABLISHMENT – CLIMEX STUDY RAISES UNCERTAINTY

DRAFT

Spodoptera frugiperda

(Fall Armyworm)

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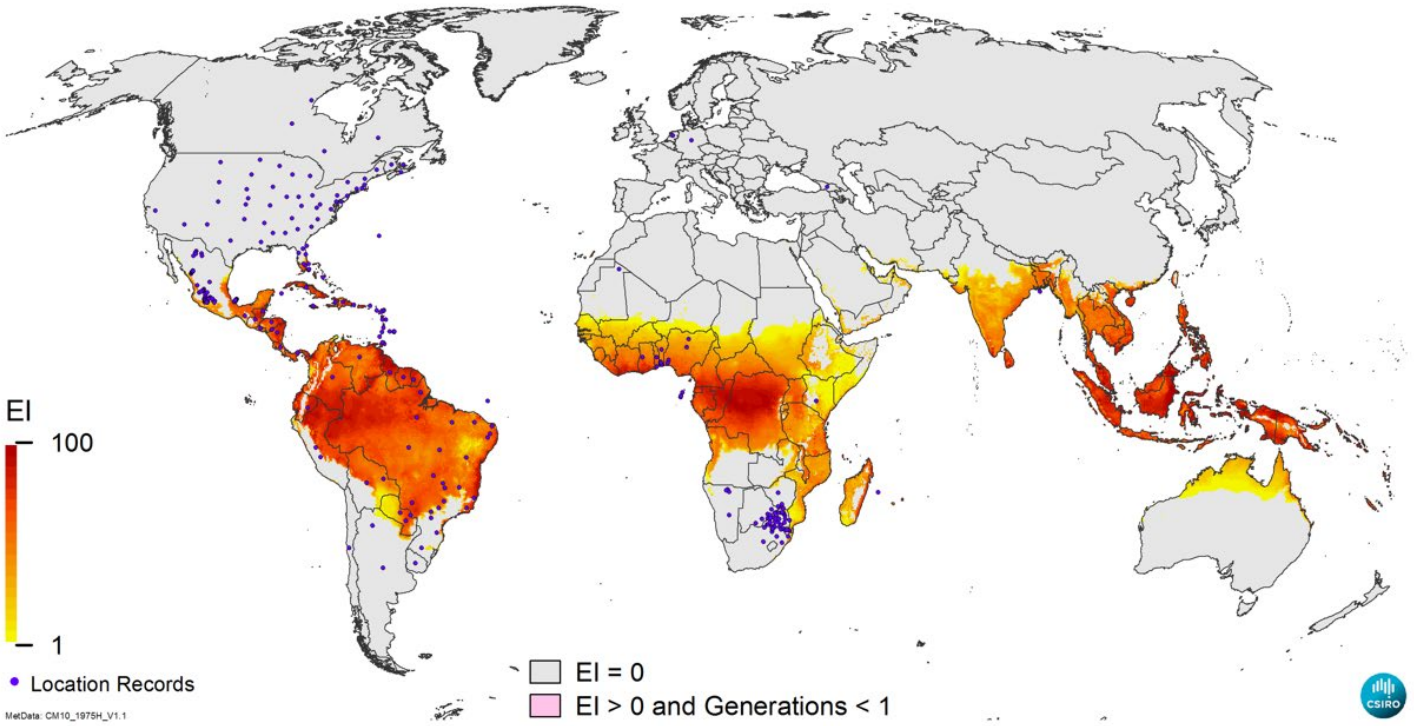
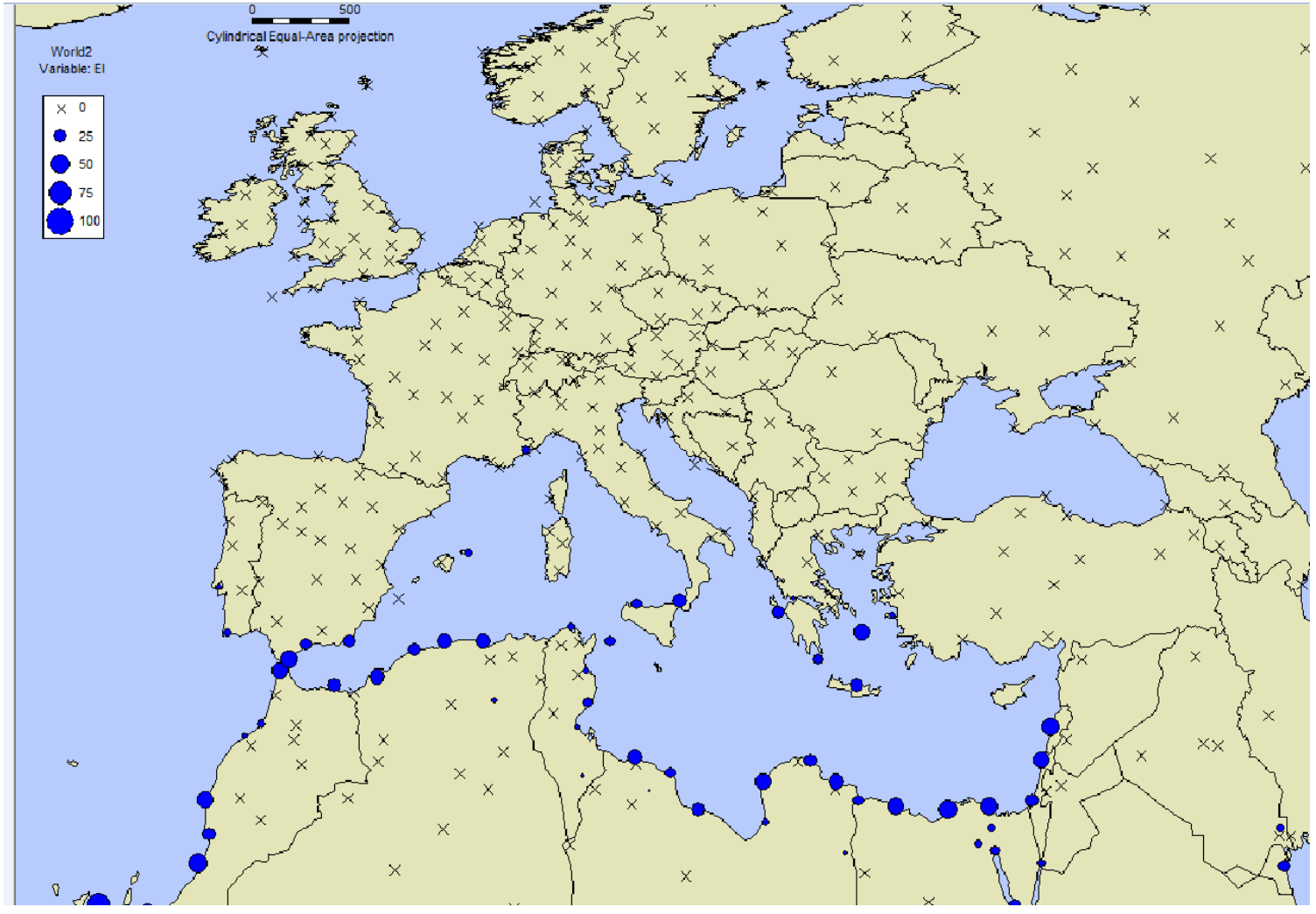
[3]The University of Queensland



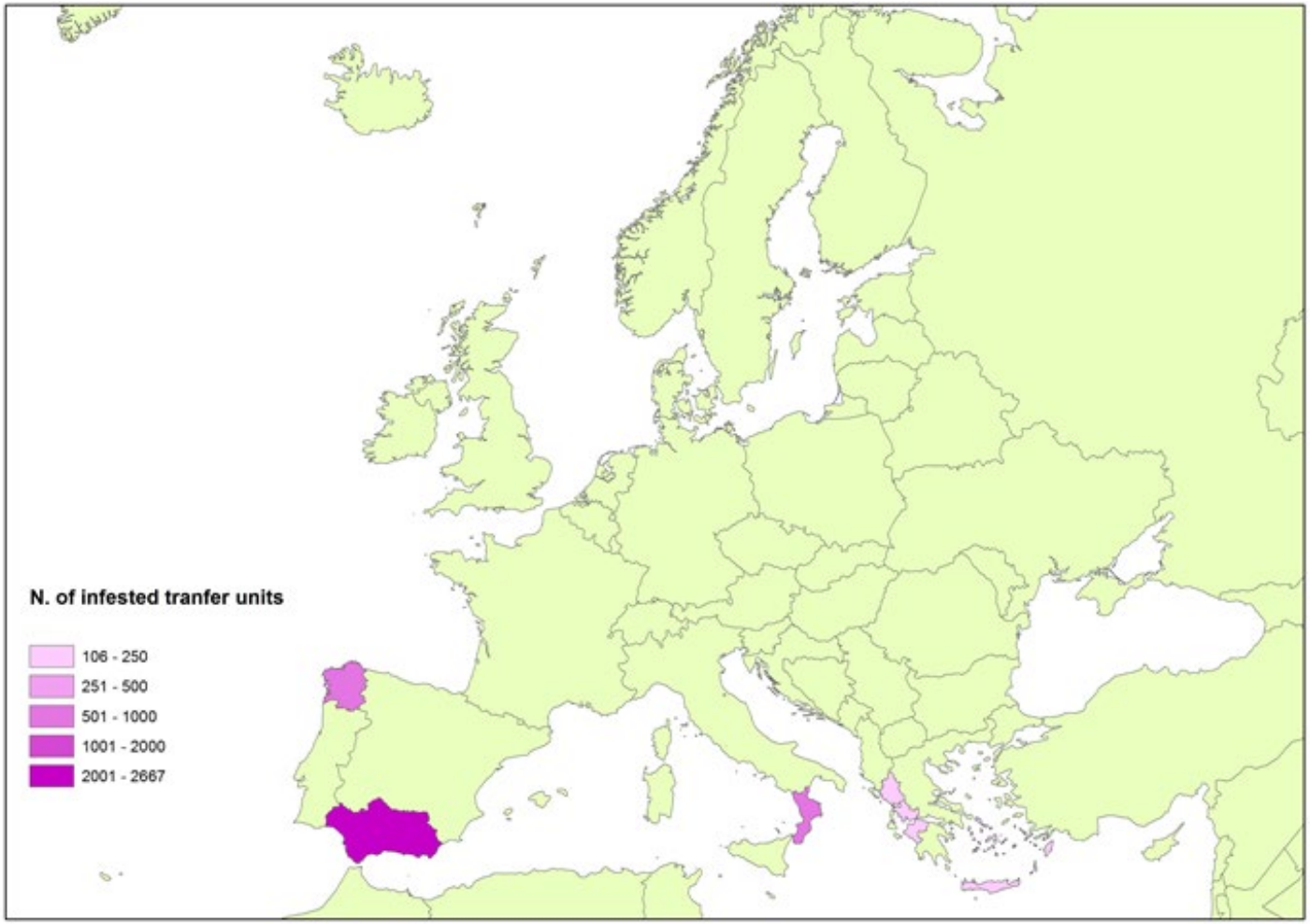
ECO-CLIMATIC INDEX

- Climate suitability for *S. frugiperda* in Africa and Europe modelled using CLIMEX. Parameters from du Plessis et al., (2018) with irrigation scenario.



Conceptual Model: Entry - trade

- Allocation of median values of all infested vegetable and cut flower host commodities entering the EU via trade then apportioned to NUTS 2 region in relation to human population.



ENTRY INTO SOUTHERN EU (ANDALUCIA)

- Entry into Andalucia via trade

25%	50% median	75%
1,200	2,600	6,400

  - Immature stage would need to mature, pupate, attract mate, breed, locate host

ESTABLISHMENT - CONCLUSIONS

- Hundreds of thousands of larvae enter each year but are not distributed to areas of EU where establishment may be possible
- Very restricted area of establishment in EU
- Knowledge gaps remain about establishment

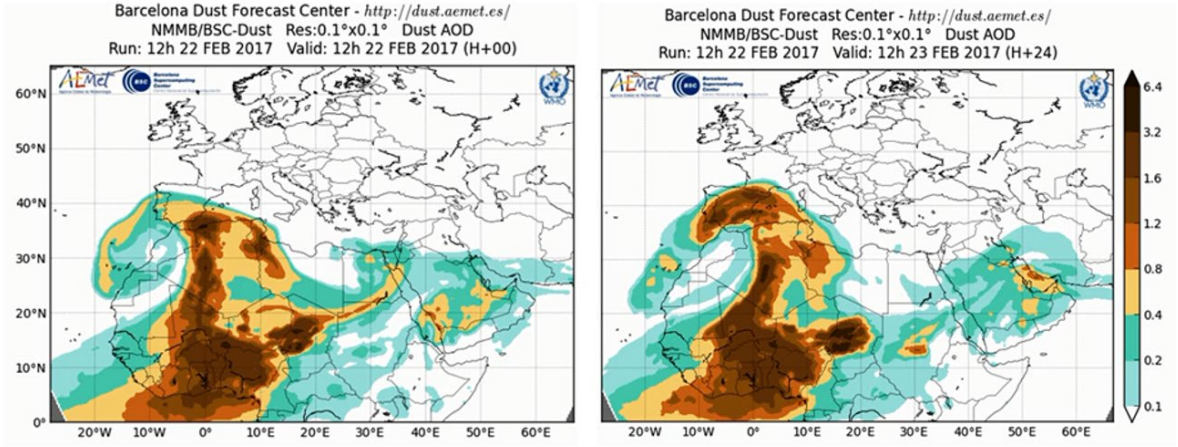
COMMENT

- As with many risk assessments, likelihood of transfer is least understood
  - Entry (movement into an area)
  - Establishment (biotic & abiotic factors)
  - Introduction relies on a “bridge” from entry to establishment (propagule pressure)

THANK YOU FOR YOUR ATTENTION

ENTRY: MIGRATION?

- From sub-Saharan Africa (Sahel)
  - Dust arrives in Europe from Sahel via wind



  - Migration via wind potential pathway?
  - Ruled out by experts – wind altitude too high

MIGRATION FROM NORTH AFRICA

Area of host crops in suitable North African countries

Proportion of host crop area acting as a source for migrating adults

Area of crop acting as a source in North Africa

Density of *S. frugiperda* in crops at origin

Number of adult moths at source in North Africa

Proportion of adults engaging in long distance flight

Number of adult moths that engage in long distance flight

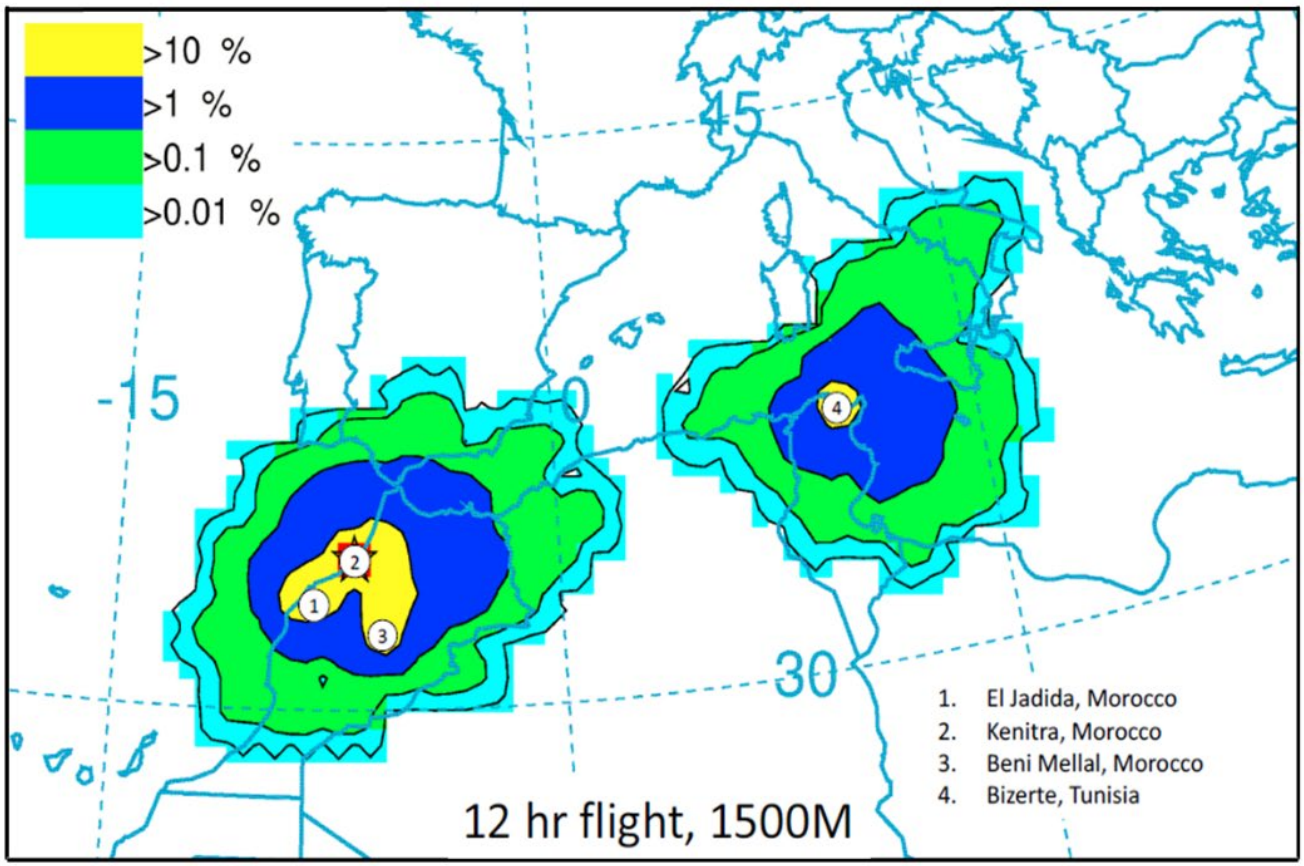
Proportion of trajectories connecting source in North Africa to Europe

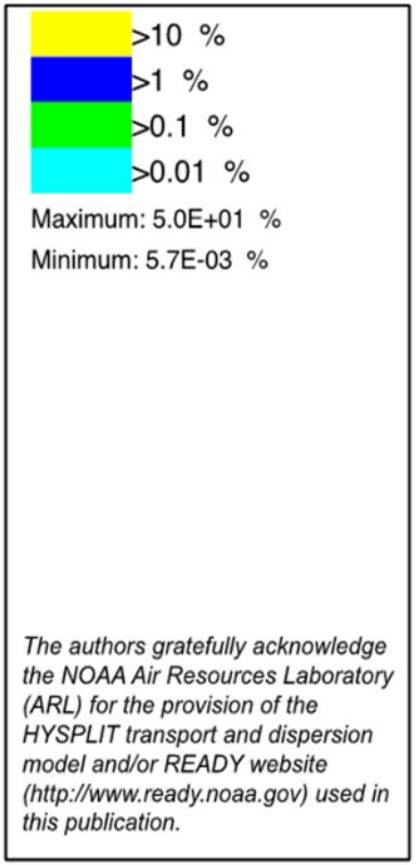
Number of adult moths migrating to EU

Proportion of adults surviving during migratory flight

Number of adult moths reaching EU

MIGRATION FROM NORTH AFRICA





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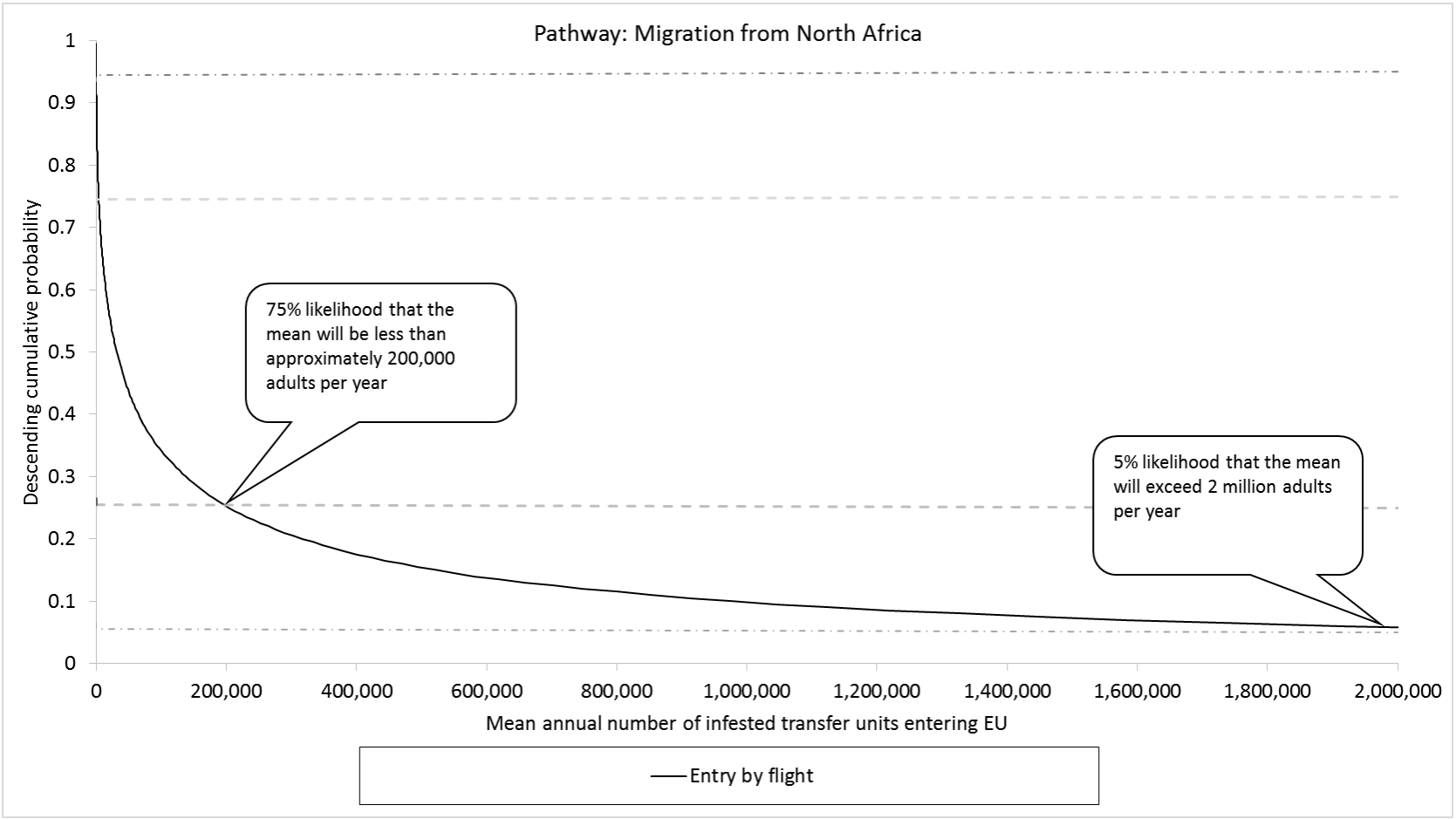
MIGRATION FROM NORTH AFRICA



- Descending cumulative probability distributions for mean number of *S. frugiperda* reaching the EU via natural migration from locations in North Africa each year – contingent on establishment in North Africa

ENTRY INTO SOUTHERN EU (ANDALUCIA)

- Entry into Andalucia via trade

25%	50% median	75%
1,200	2,600	6,400

  - Immature stage would need to mature, pupate, attract mate, breed, locate host

- Entry into southern EU (largely Andalucia) via migration

25%	50% median	75%
4,000	32,000	200,000

  - Adult would need to attract mate, breed, locate host
  - **But must establish in North Africa beforehand**