Models used in quantitative risk assessment for plant health

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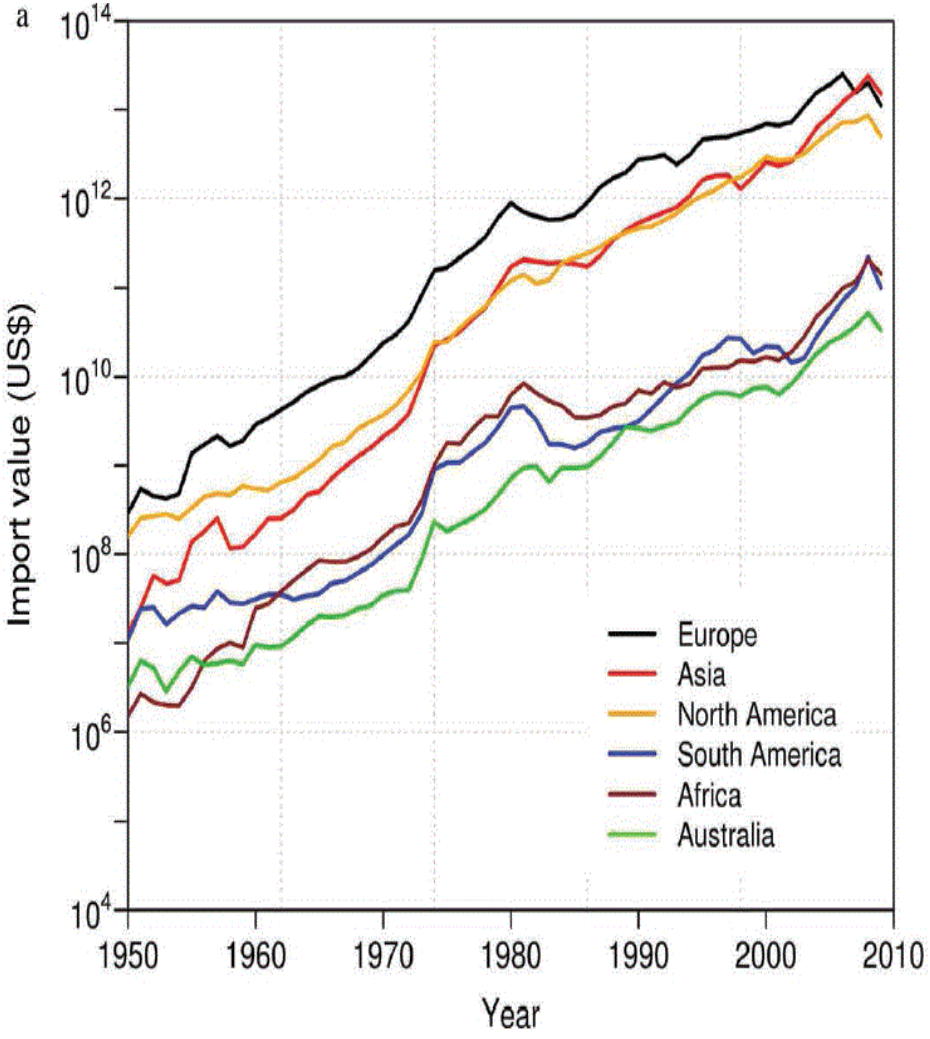
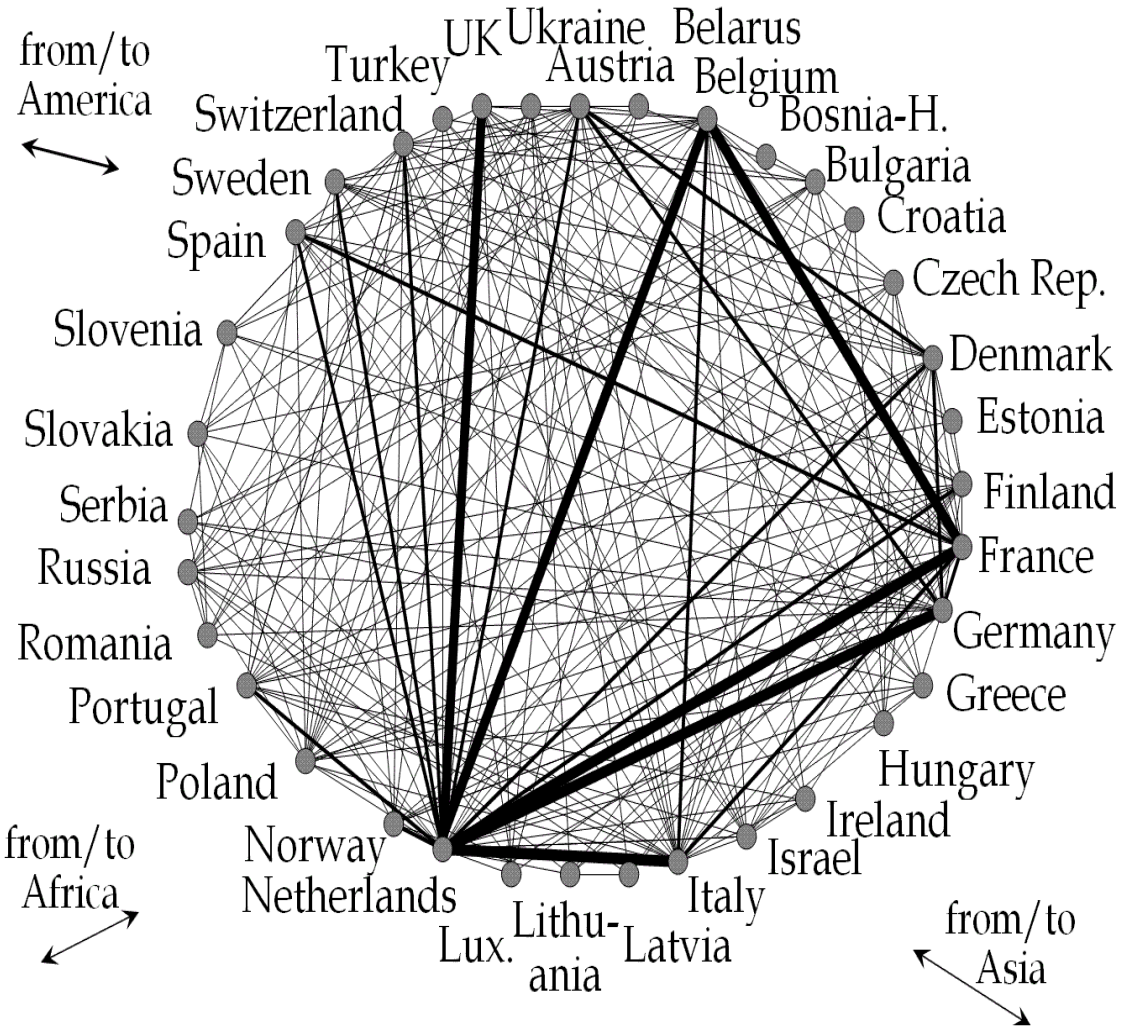
Temporal trends (1950–2009) of total import volume of continents
(a proxy for propagule pressure of alien species)



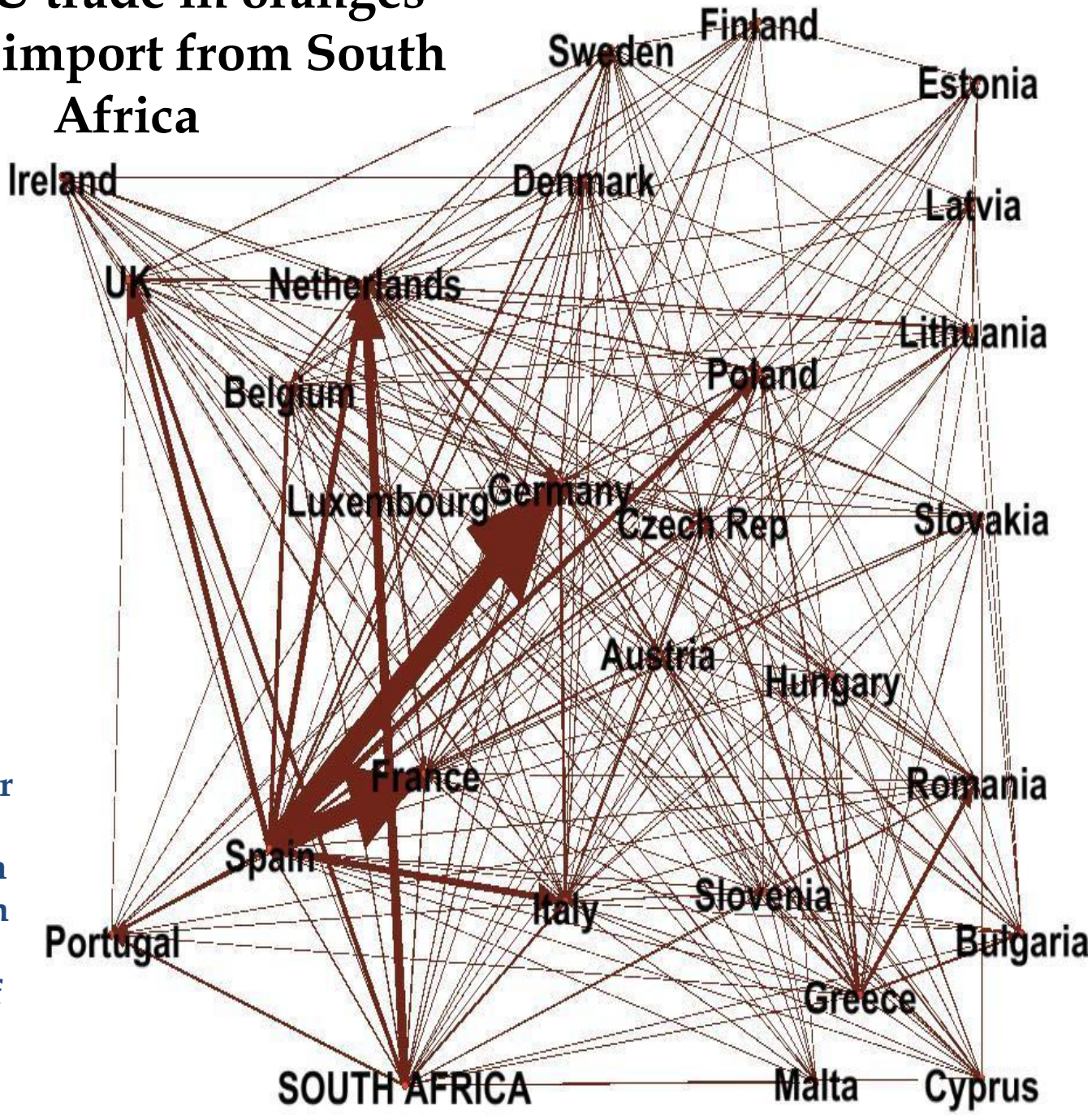
from: Essl et al. (2015) Crossing frontiers in tackling pathways of biological invasions. BioScience

European trade flows in ornamental plants (2004)

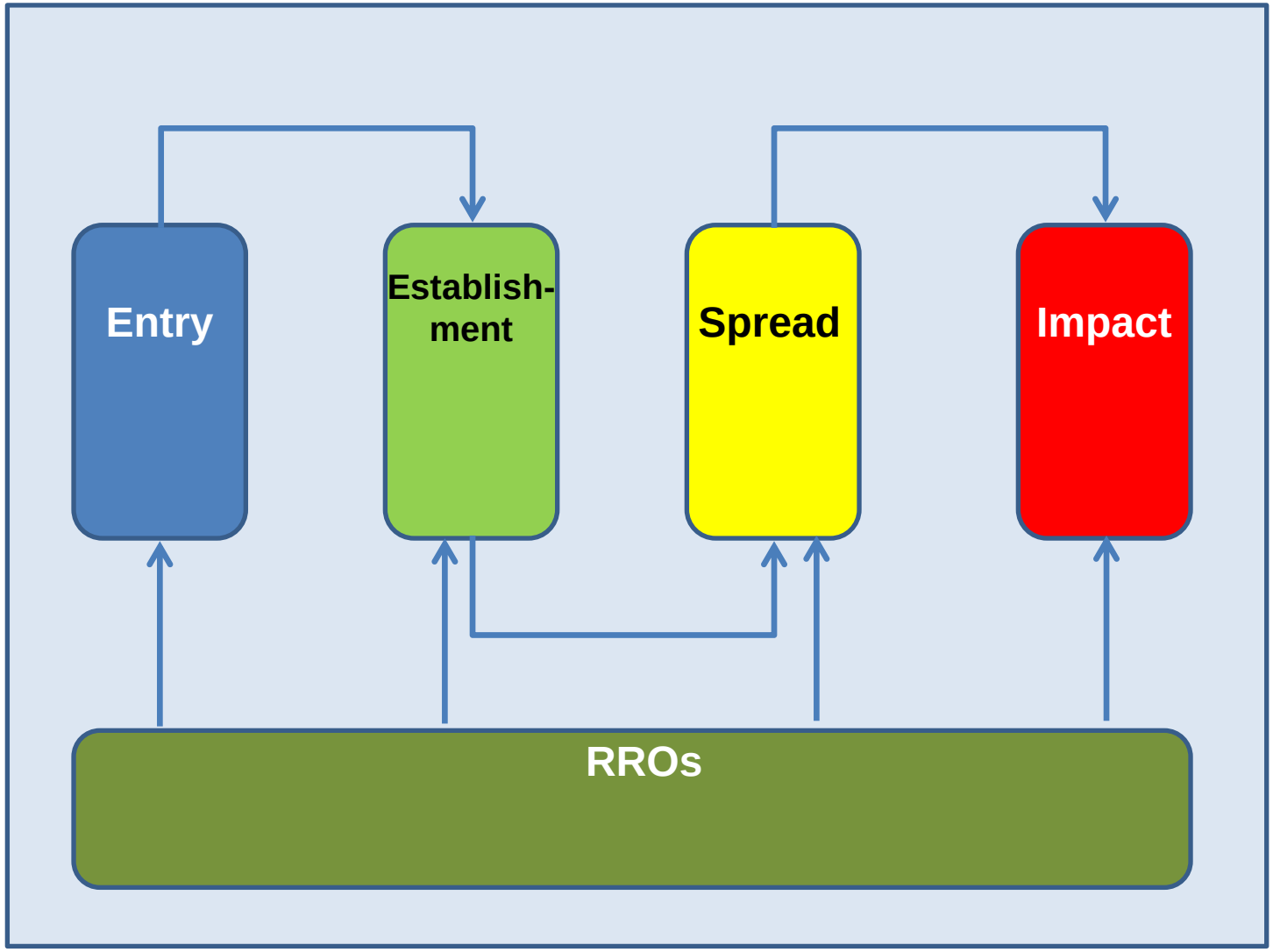


Dehnen-Schmutz et al. (2010) *Scientia Horticulturae*

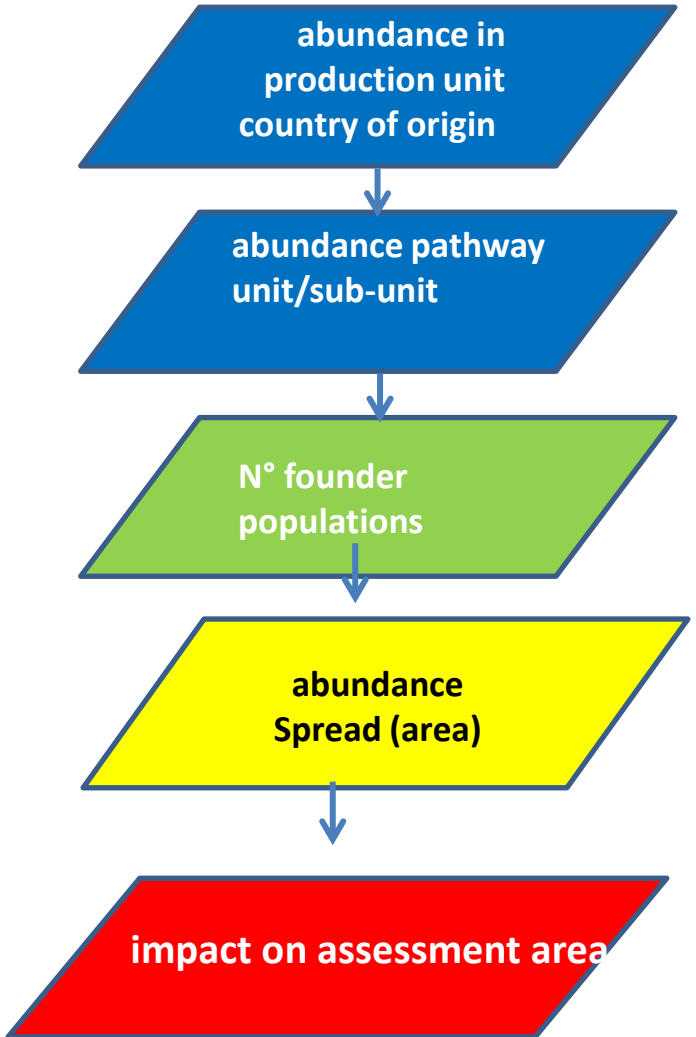
Intra-EU trade in oranges (2011) + import from South Africa



EFSA PLH Panel (2015) Scientific Opinion on the risk of *Phyllosticta citricarpa* (*Guignardia citricarpa*) for the EU territory with identification and evaluation of risk reduction options.


Entry
Establish-
ment
Spread
Impact
RROs

Quantitative approaches to plant health risk assessment



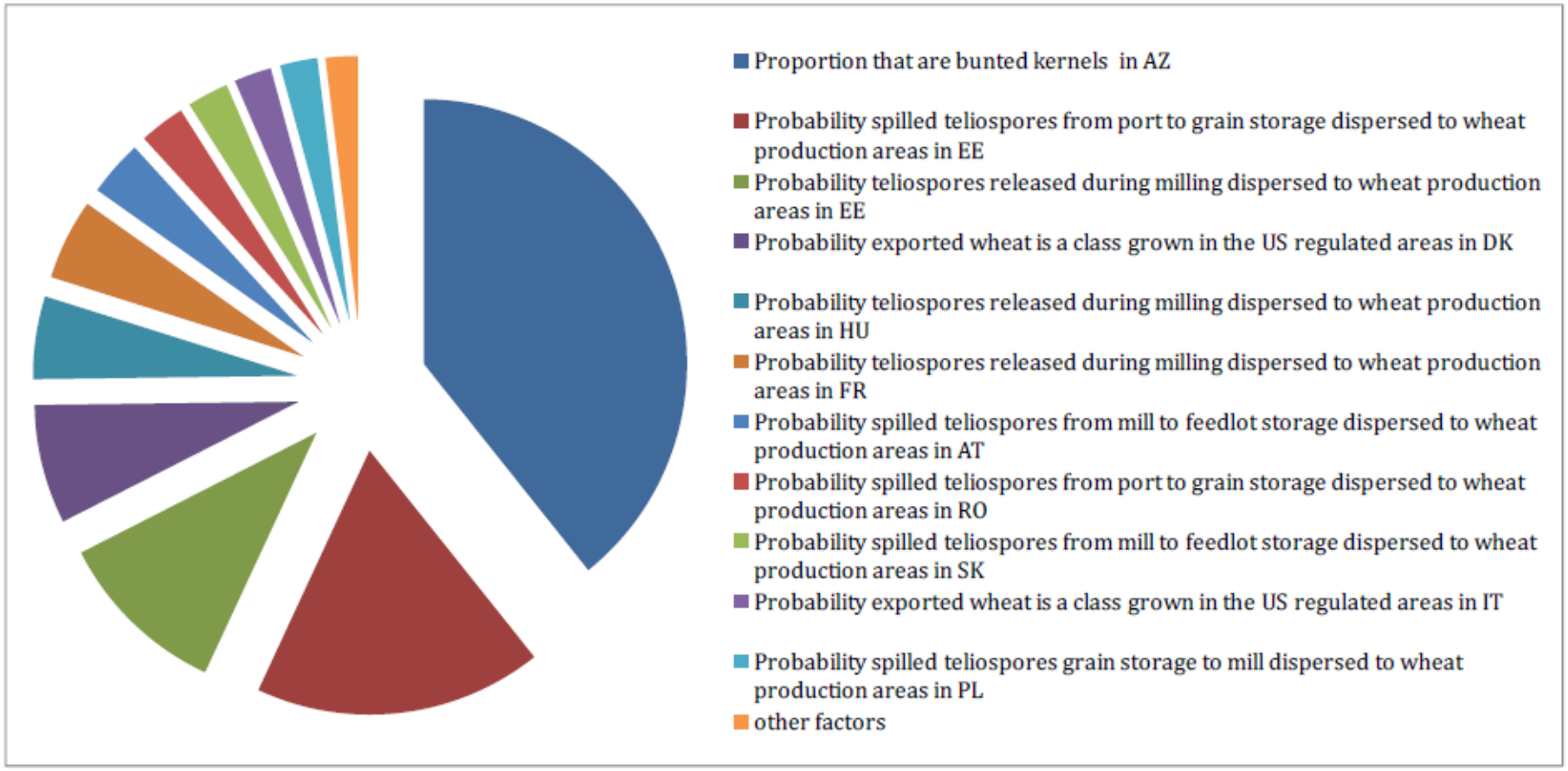
ENTRY

- Trade
- Quantitative pathway analysis

Bunted wheat grains (*Tilletia indica*)

Source: EPPO

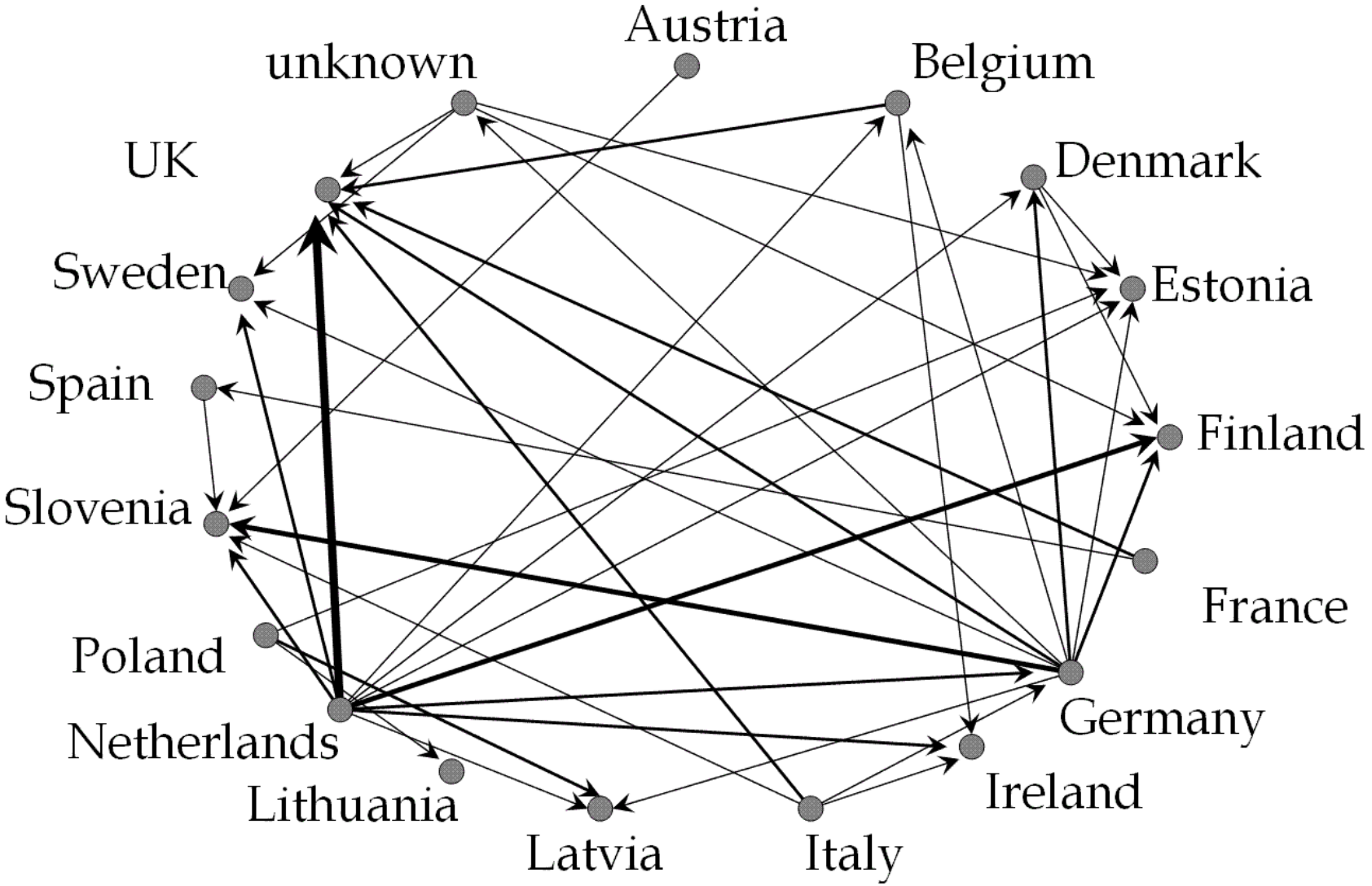
Importance of the influence variables in the updated model for wheat for grain, on average teliospores on surface after 1st year



Legend: Plotted are the proportions of the squared sensitivity indices to the total R^2 value, which can be interpreted as importance of the influence factor on the overall variation / uncertainty.

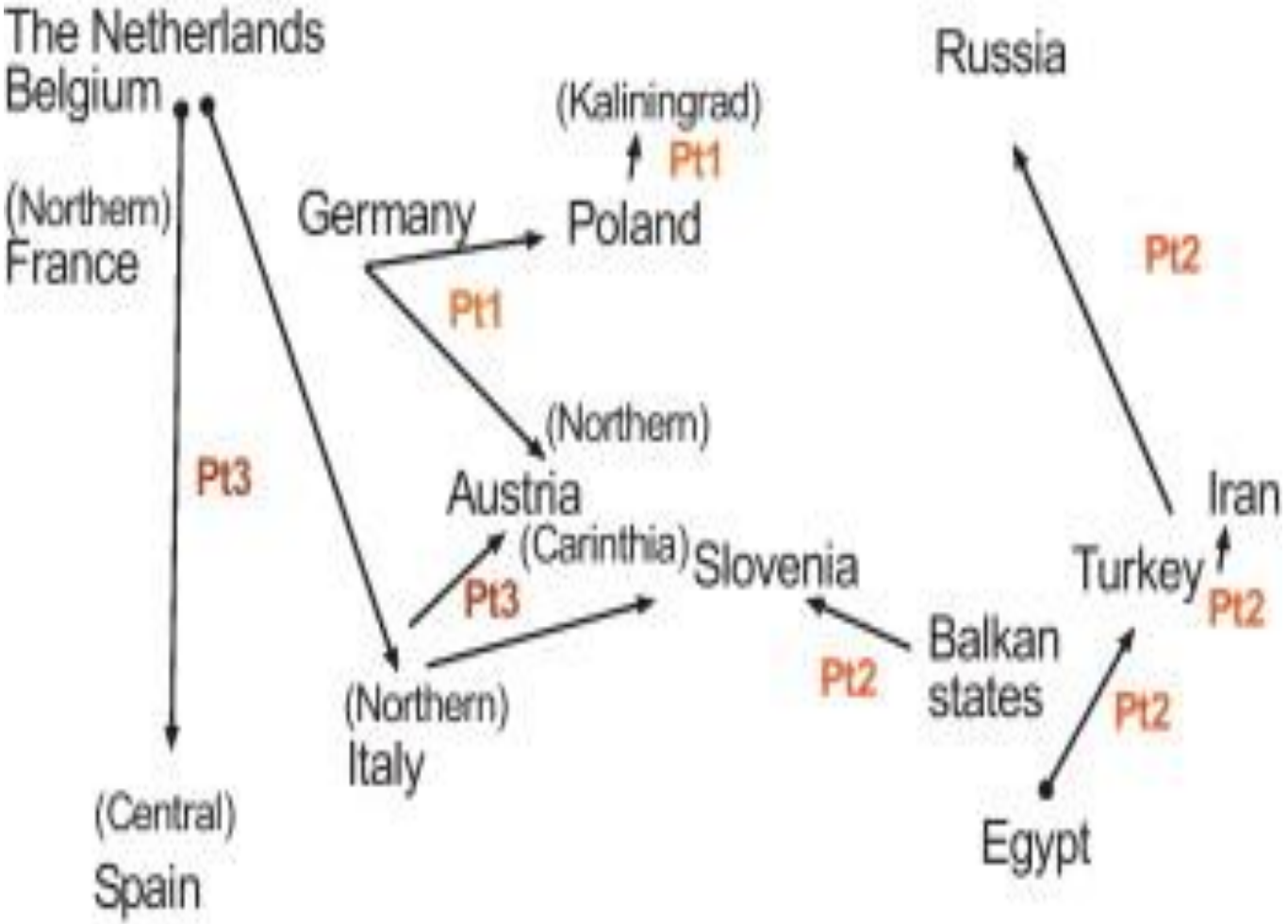
EFSA PLH Opinion on *Tilletia indica* (2010)

Phytophthora ramorum interceptions in Europe (2002-2010)



from: EFSA Plant Health Panel (2011)

Fire blight (*Erwinia amylovora*) invasion network

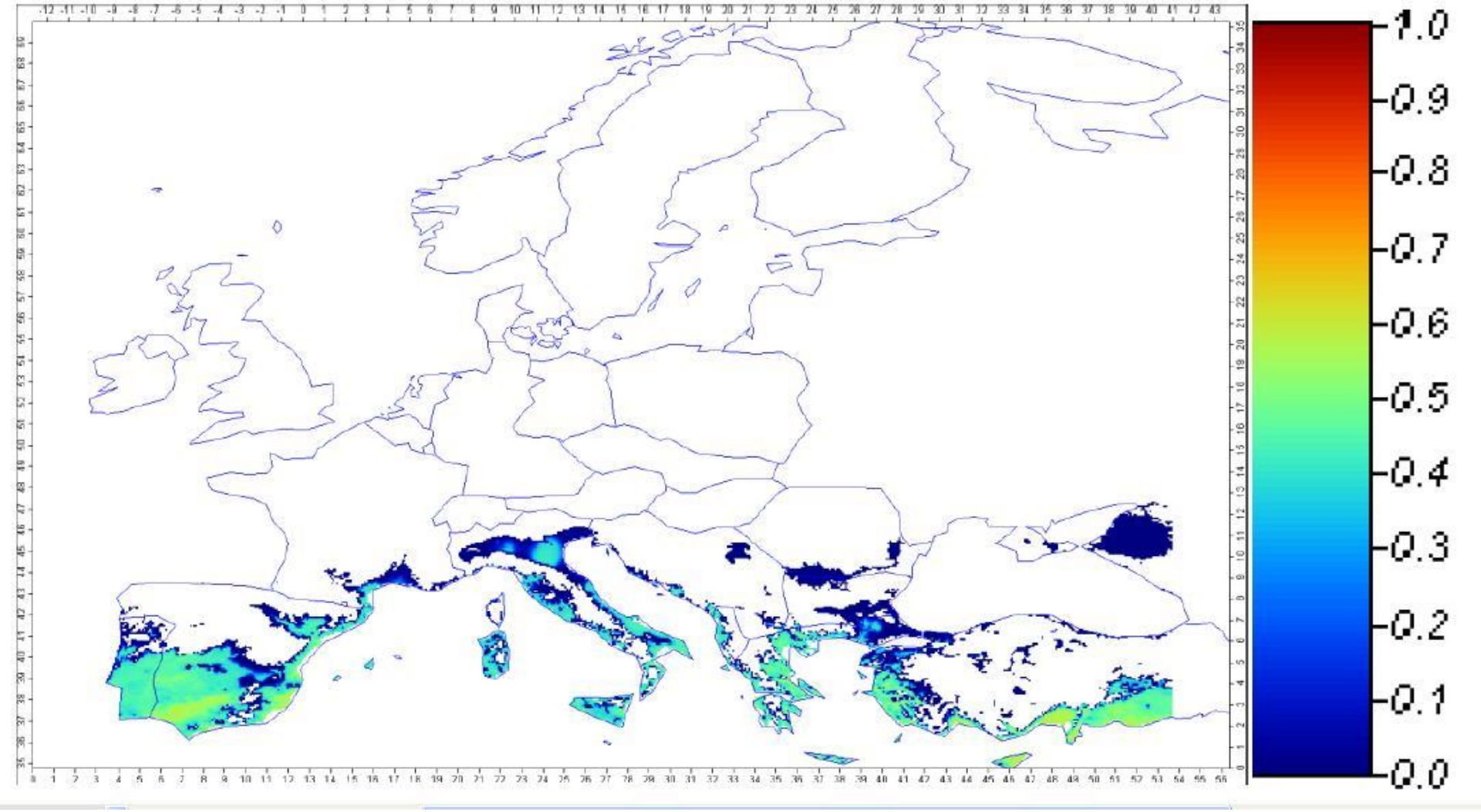


Jock et al. (2013) *Microbiological Research*

ESTABLISHMENT

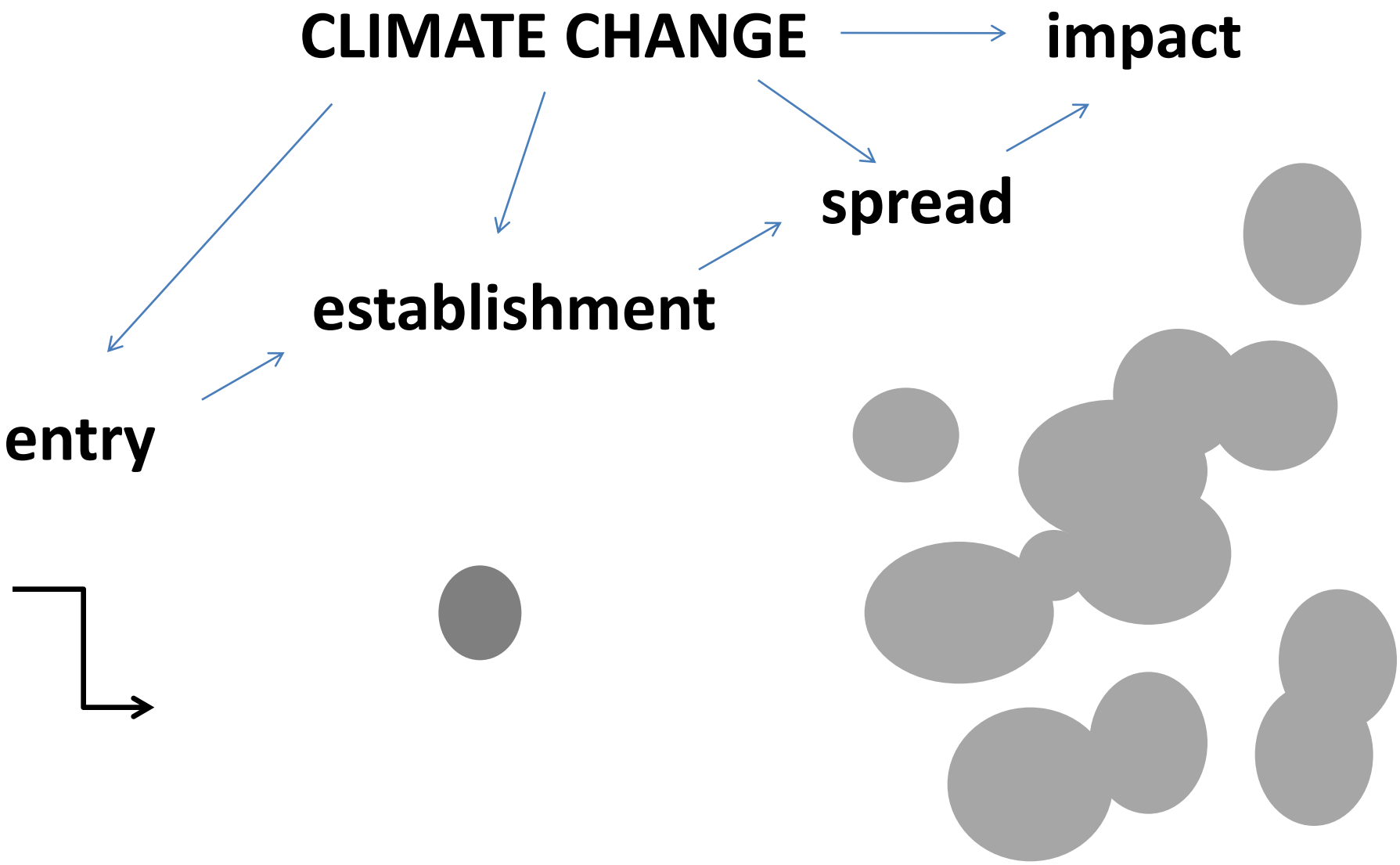
- Host distribution
- Climate suitability
- Climate change
- Genetic change

EFSA PLH Opinion on *Bemisia tabaci*

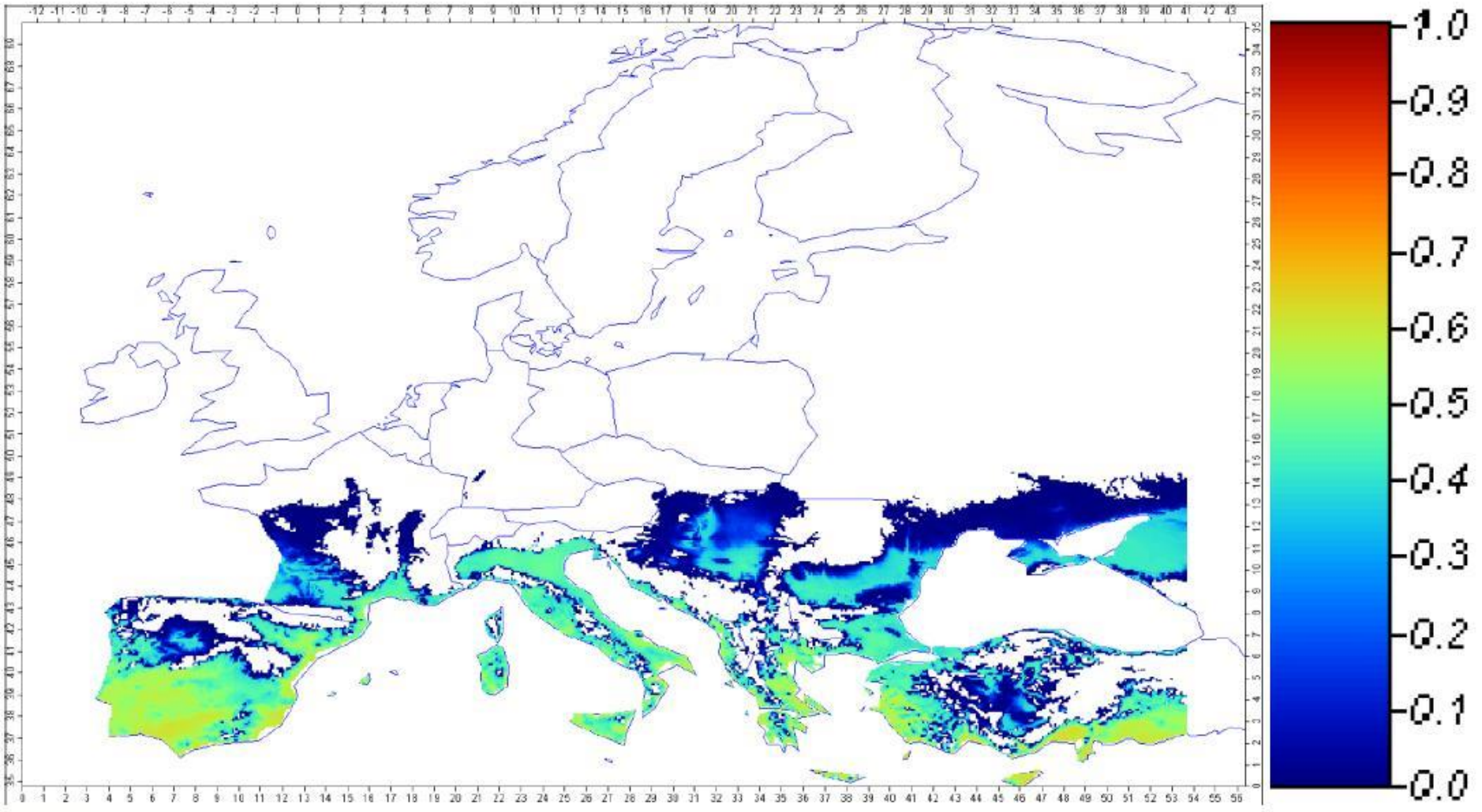


Distribution of the probability of virus establishment obtained considering the current temperature and climatic situation

Climate change will affect each of the invasion process steps



EFSA PLH Opinion on *Bemisia tabaci*



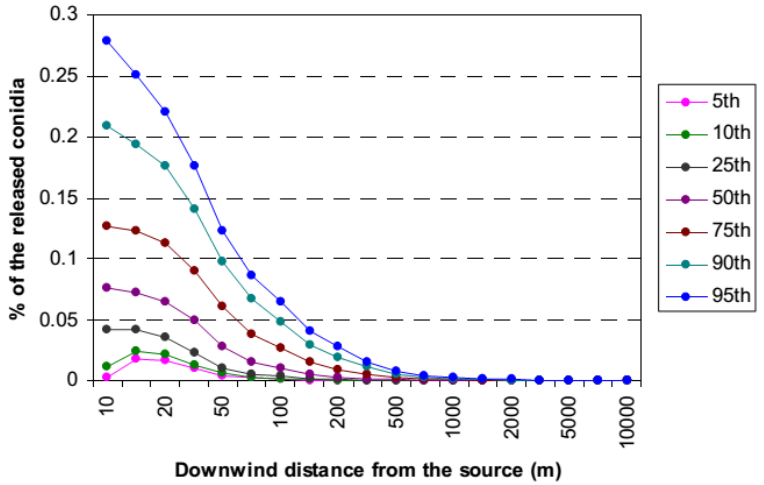
Distribution of the probability of virus establishment in the climate change scenario + 2 °C.

SPREAD

- Natural dispersal
- Human mediated
- Trade pathways
- Network analysis

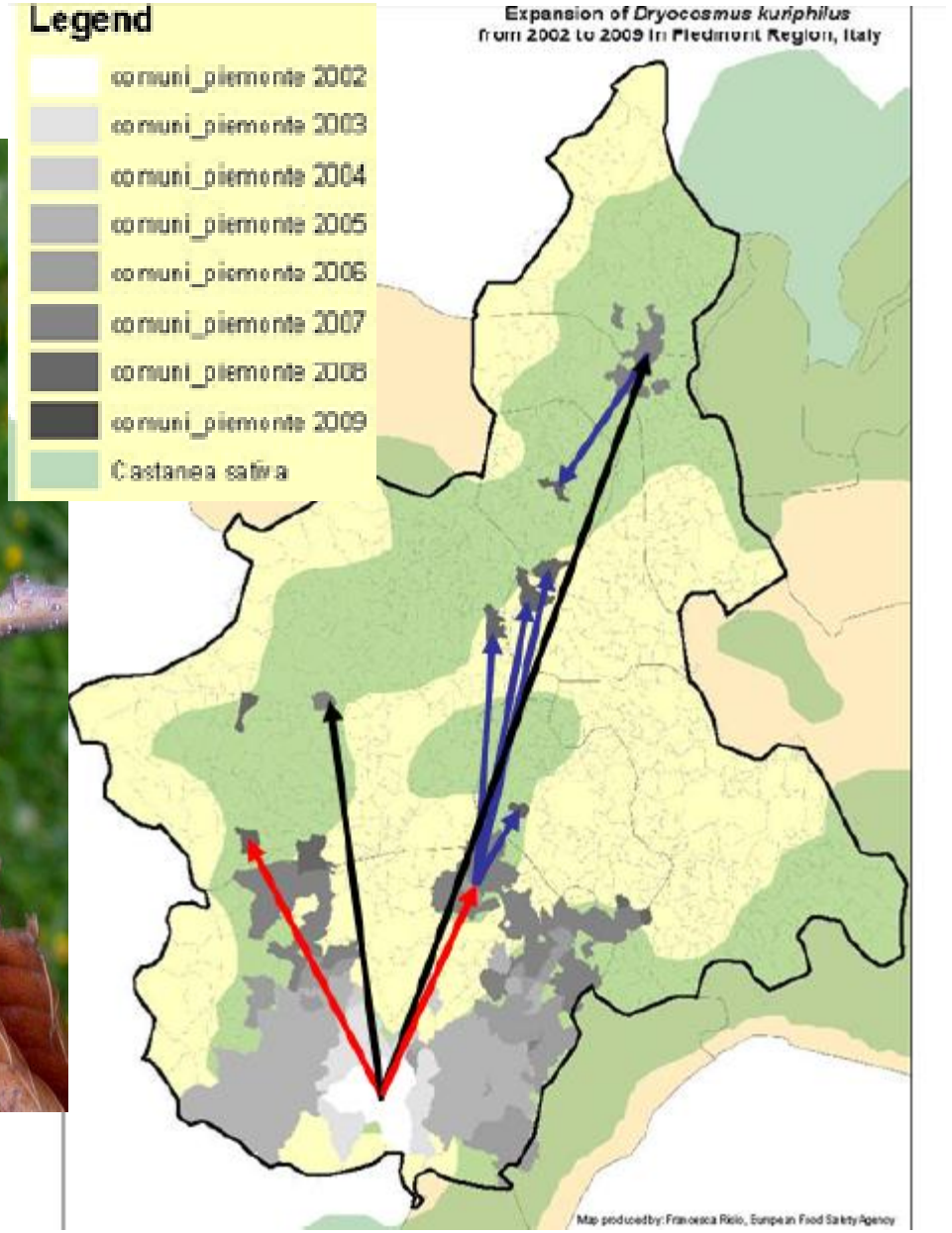
Examples from EFSA risk assessment

Gaussian plume model of *Monilinia fructicola* spore dispersal estimates range of dispersal from a point source...



EFSA Panel on Plant Health (2011) Pest risk assessment of Monilinia fructicola *for the EU territory and identification and evaluation of risk management options. EFSA Journal, 9, 2119.*

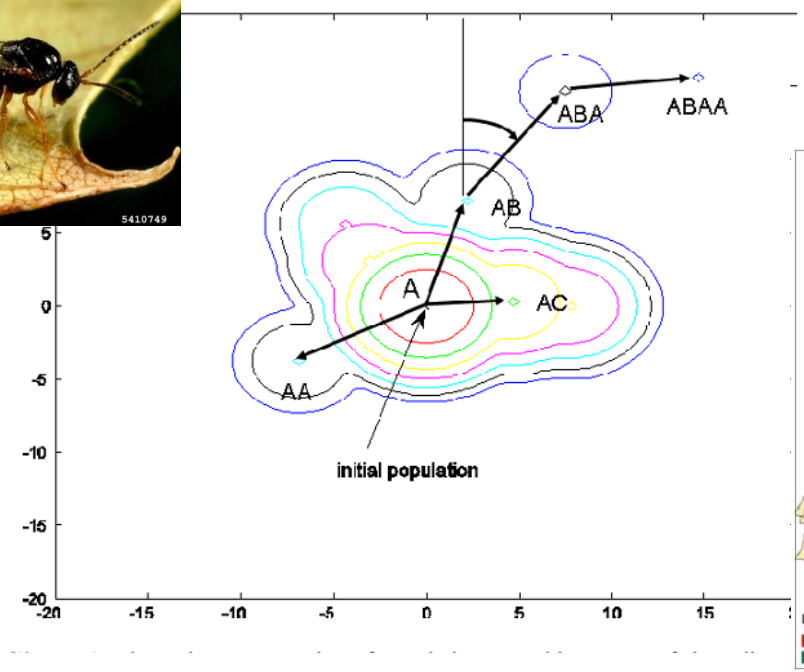
Actual spread of *Dryocosmus kuriphilus* in Piemonte, NW Italy (2002-2009)

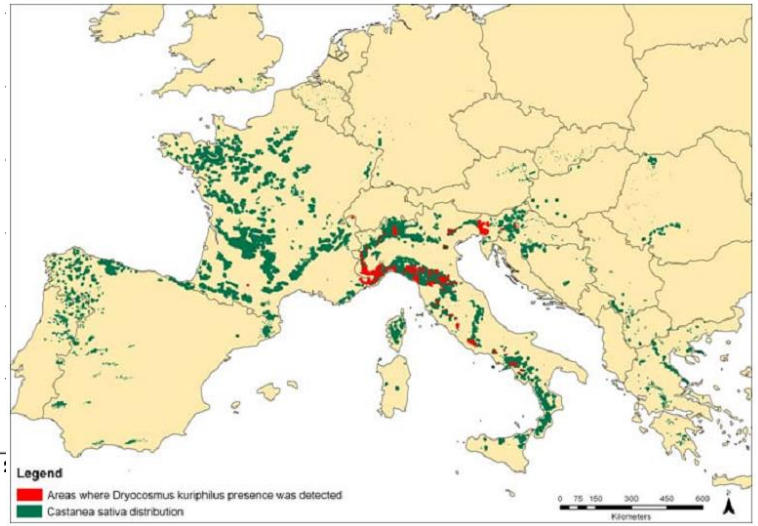


EFSA PLH Opinion on *D. kuriphilus* (2010)

Examples from EFSA risk assessment

Drycocosmus kuriphilus spread model estimates invaded area...





EFSA Panel on Plant Health (2010) Risk assessment of the oriental chestnut gall wasp, Dryocosmus kuriphilus *for the EU territory and identification and evaluation of risk management options. EFSA Journal, 8, 1619.*

Simulated spread of *Dryocosmus kuriphilus* (2010-2016)

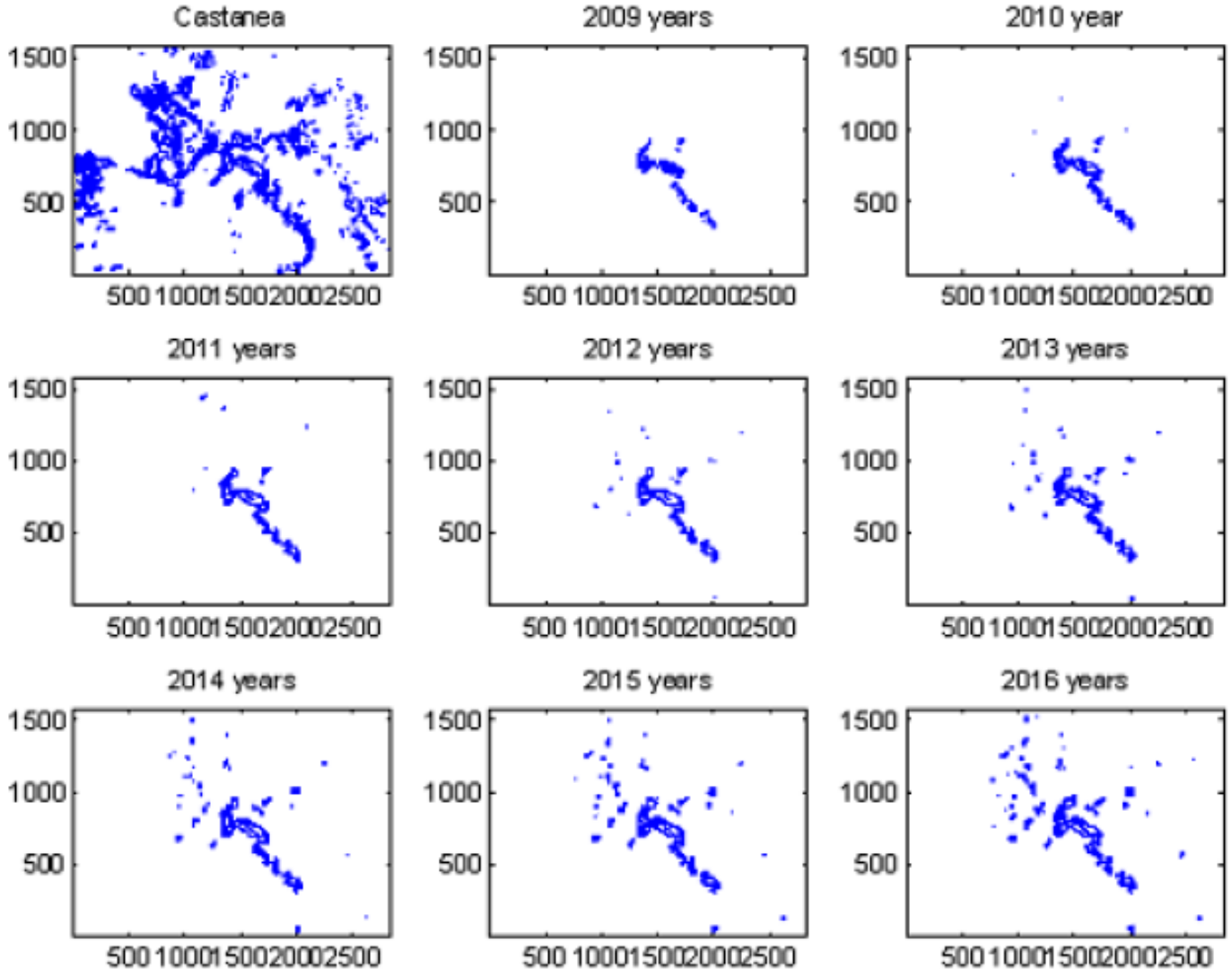
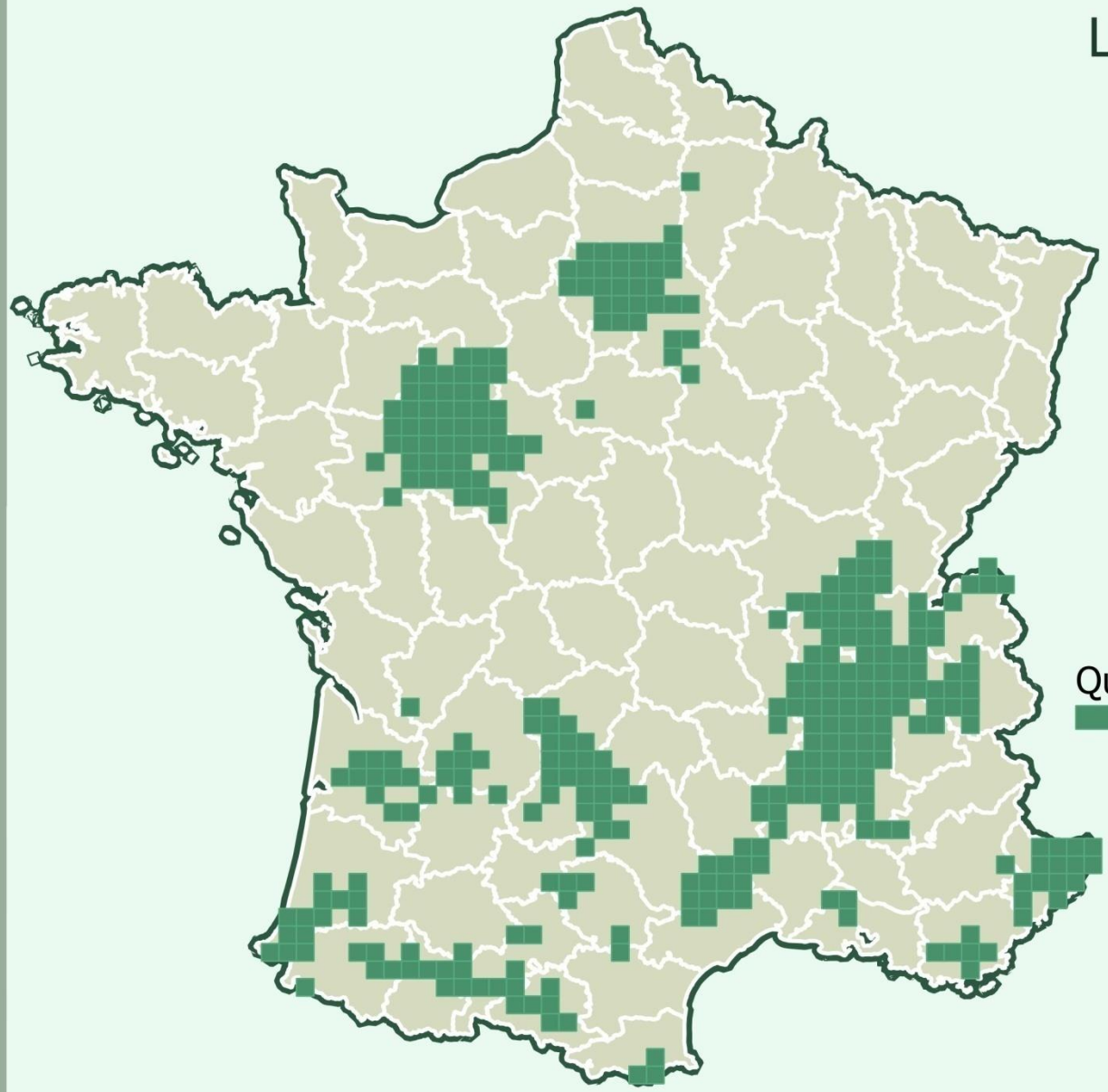


Figure C22: Projection of colonized area in Europe with $M = 0.5$ for the period 2010-2016

EFSA PLH Opinion on *D. kuriphilus* (2010)

Actual spread of *Dryocosmus kuriphilus* in France (as of Sep 2014)

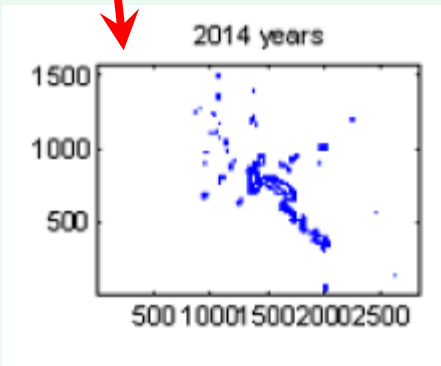


Le cynips du châtaignier
Dryocosmus kuriphilus
en France

Situation en septembre 2014

vs. predicted spread for 2014 (EFSA 2010)

Quadrats de 16 km de côté contaminés pour toutes cultures



Sous direction de la qualité et de la protection des végétaux
Ministère de l'agriculture, de l'agroalimentaire et de la forêt

Production: Département de la santé des forêts

Import of *Fraxinus excelsior* saplings into the UK (2003-2011)

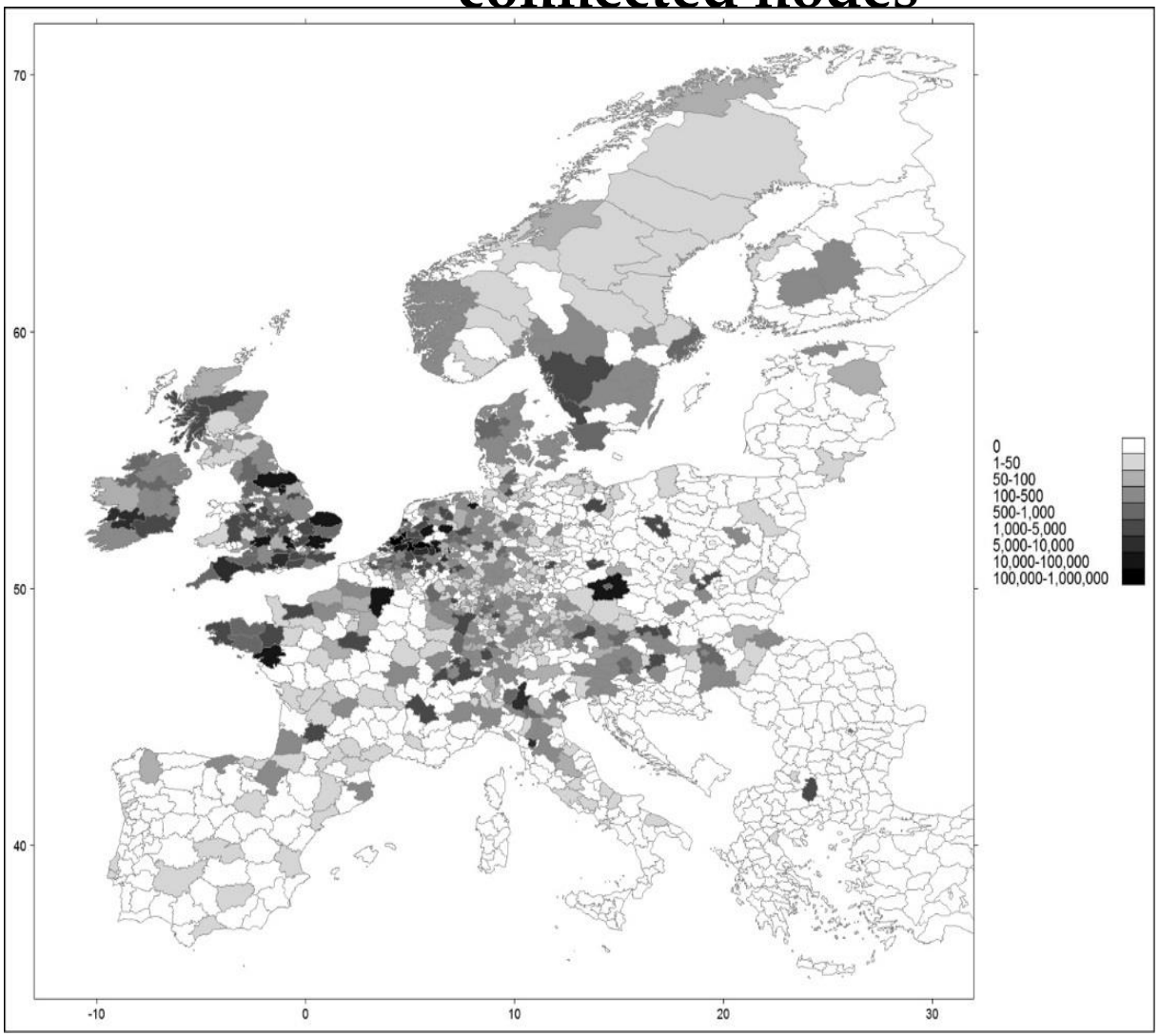
Table 3. Number of UK imported ash plants (bare rooted) from EU Member States registered on the Forest Reproductive Material database[1]

	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Belgium	30,000	7,800	11,000	400	0	15,000	47,200	32,500	136,000	279,900
France	155,125	7,000	400	22,200	0	0	700	0	1,000	186,425
Germany	553,600	500,700	81,000	196,500	374,500	396,750	0	400,400	250,750	2,754,200
Hungary	0	0	0	0	0	0	4,625	0	0	4,625
Ireland	0	0	0	27,000	180,600	98,600	162,825	500	0	469,525
Netherlands	0	0	196,500	323,300	205,050	461,607	141,100	50,100	172,375	1,550,032
Total	738,725	515,500	288,900	569,400	760,150	971,957	356,450	483,500	560,125	5,244,707

Grey shading in the table refers to the years
after the first report of ash dieback in each country.
UK import of ash saplings from the continent carried on until the ban in 2012

Webber & Hendry (Aug 2012) Rapid assessment of the need for a detailed Pest Risk Analysis for *Chalara fraxinea*. Forest Research

The importance of long-distance links and super-connected nodes

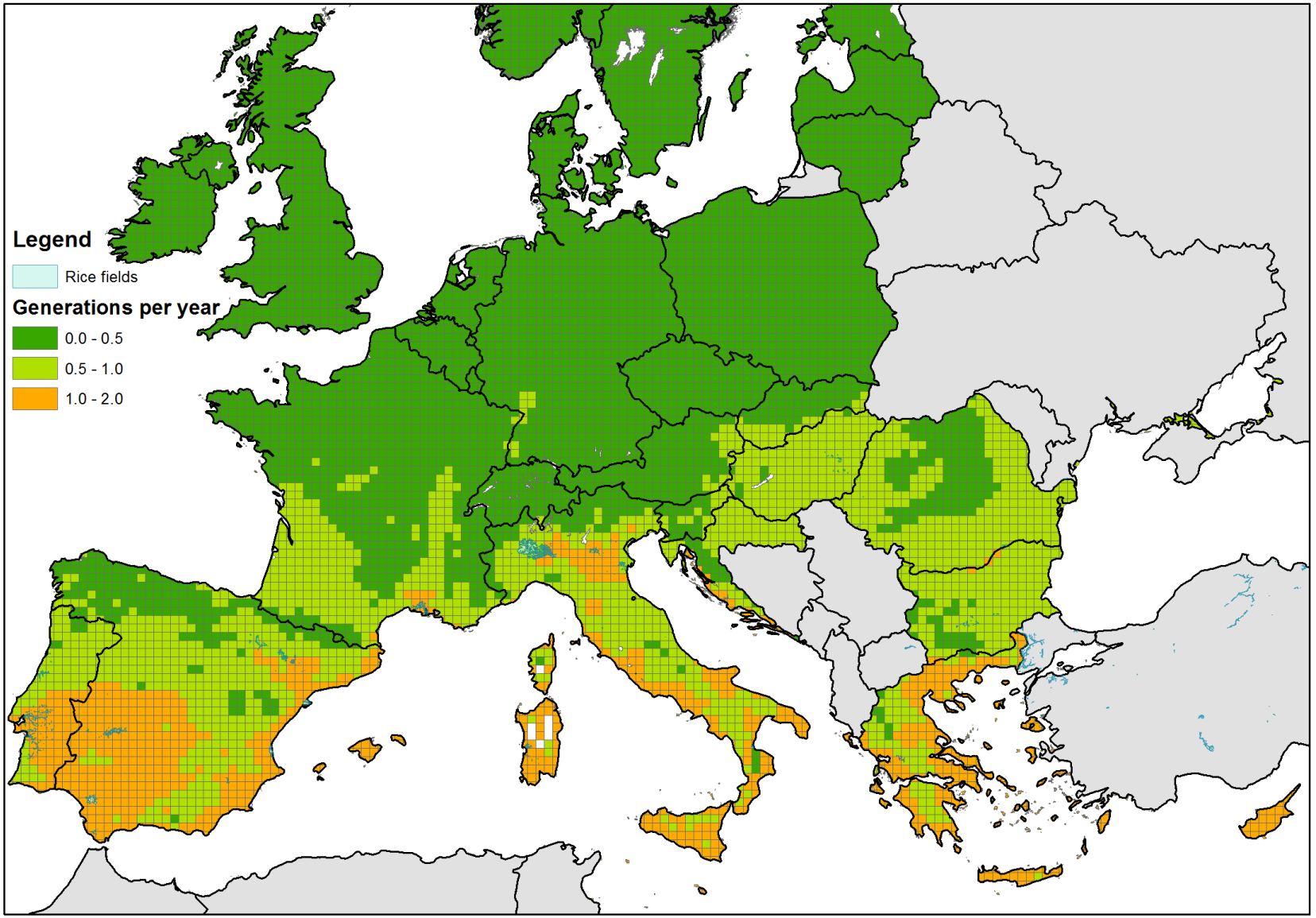


The number of Acer plants shipped by 138 producers in the Boskoop demarcated area (Netherlands) to NUTS 3 regions throughout Europe in 2009

Eschen et al. (2015) Trade patterns of the tree nursery industry in Europe and changes following findings of citrus longhorn beetle, *Anoplophora chinensis* Forster. *NeoBiota*

IMPACT

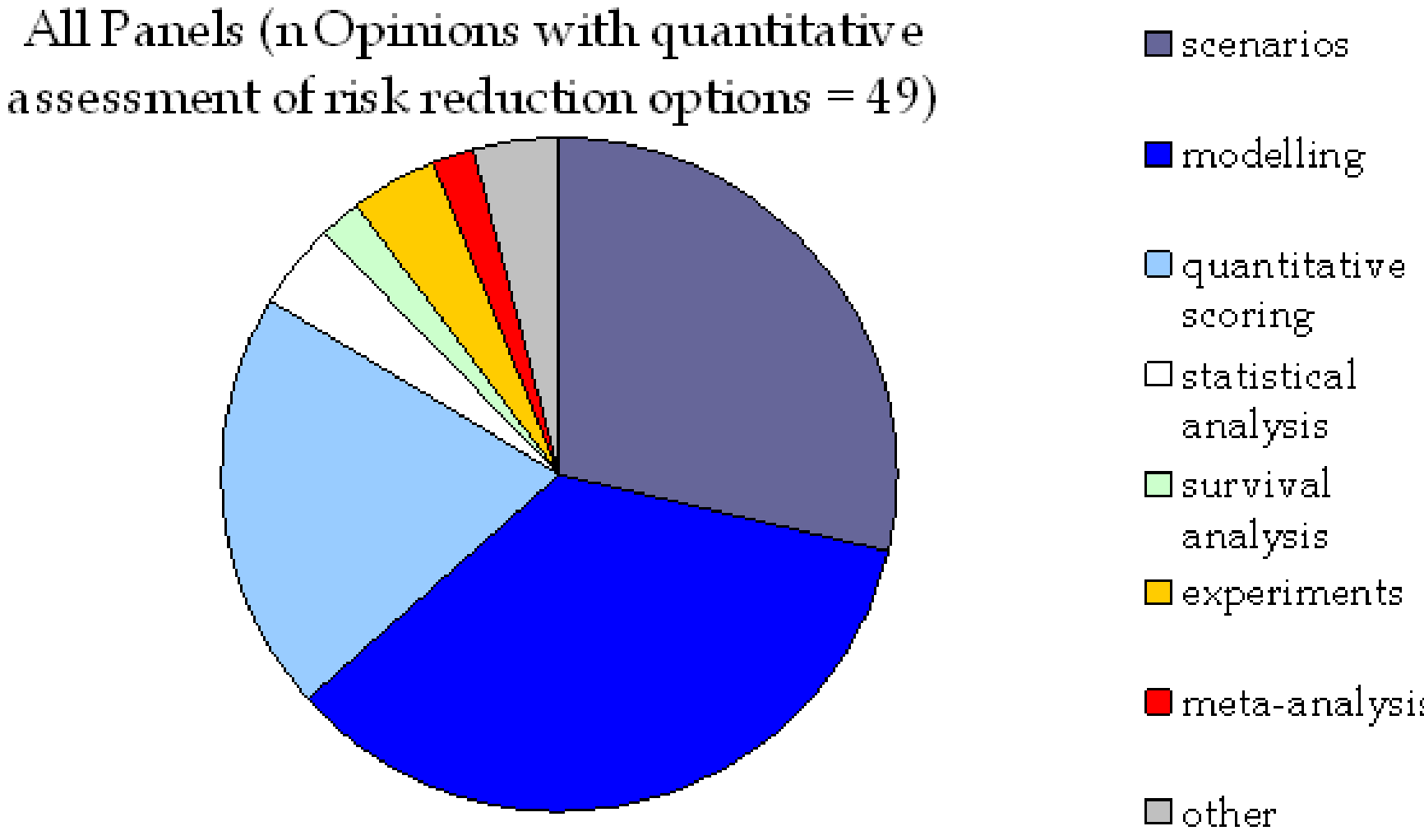
- Crop yield/performance
- Environmental impact


Legend
Rice fields
Generations per year
0.0 - 0.5
0.5 - 1.0
1.0 - 2.0

Risk Reducing Options

- Surveillance
- Quantification

Quantitative Methods



Pine wood nematodes: USDA risk reduction 100% effective?

efsa
European Food Safety Authority

Mortality verification of pinewood nematode from high temperature treatment of shavings

$\alpha = \left\{Poisson\left[0\middle|\hat{E}(N_{20})*(1-h)\right]\right\}^{30} = \left\{\exp\left[-\hat{E}(N_{20})*(1-h)\right]\right\}^{30}$. The values of the mortality rate h leading to a probability α equal to 0.01, 0.05, 0.1 were computed as $h = 1 + \frac{\log(\alpha)}{\hat{E}(N_{20})*30}$. The results are h=99.7% for α=0.01, h=99.81% for α=0.05, h=99.85% for α=0.1 and $\hat{E}(N_{20})$=51.3 for 5 g. The numerical results are only marginally changed if $\hat{E}(N_{20})$ is set equal to the lower bound of the confidence interval.

3.3. Conclusion of the statistical analysis

The results show that:

- when the mortality rate is 99.85 %, there is 10 % chance to observe zero nematodes alive in 30 samples,
- when the mortality rate is 99.81 %, there is 5 % chance to observe zero nematodes alive in 30 samples,
- when the mortality rate is 99.7 %, there is 1 % chance to observe zero nematodes alive in 30 samples.

EFSA PLH Opinion on *Bursaphelenchus xylophilus* (2009)

Conclusions

- Quantitative methods are increasingly used in risk assessment
- Mathematical models can contribute at each stage of assessment, however:
- Impact remains problematic
- New approaches