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Redefining Spatial Justice

TRACK 11: RESOURCES: Risk generation and risk mitigation in the Anthropocene era

THE SUSCEPTIBILITY OF URBAN AREAS IN EUROPE TO VECTOR-BORNE DISEASES SPREAD BY THE ASIAN TIGER MOSQUITO

Sandra Oliveira
Jorge Rocha
César Capinha

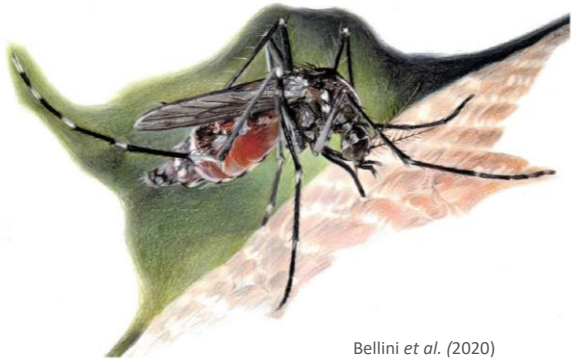
2018-2022

PTDC/GES-OUT/30210/2017

ASIAN TIGER MOSQUITO
AEDES ALBOPICTUS

TRIAD*

*** meaning a "group of three", Chikungunya–Dengue-Zika (CDZ)**



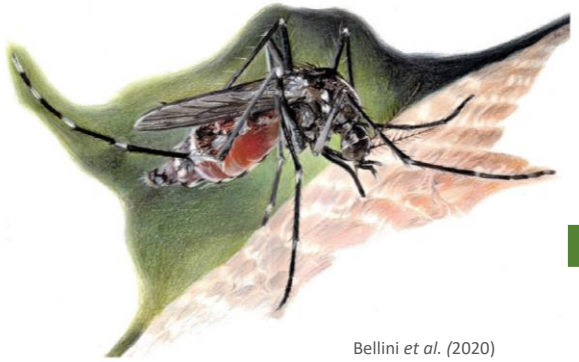
Bellini *et al.* (2020)

Fig. 1. Female Asian tiger mosquito during blood meal (drawing by Elisa Canaglia).

- Origin in Southeast Asia
- Colonized all continents, except Antarctica
- In Europe since 1979 (Albania), Italy in 1990
- Competent vector for dengue, Zika and Chikungunya
- Outbreaks in Croatia, France, and Italy in last decade
- Increase in environmental suitability due to climate change

Urban areas are particularly vulnerable:

- supply of mosquito breeding sites in man-made water containers and through irrigation
- heat island effect, higher urban temperature amplifies climate change
- availability of potential hosts and dynamics of urban movements - increased risk of disease spread

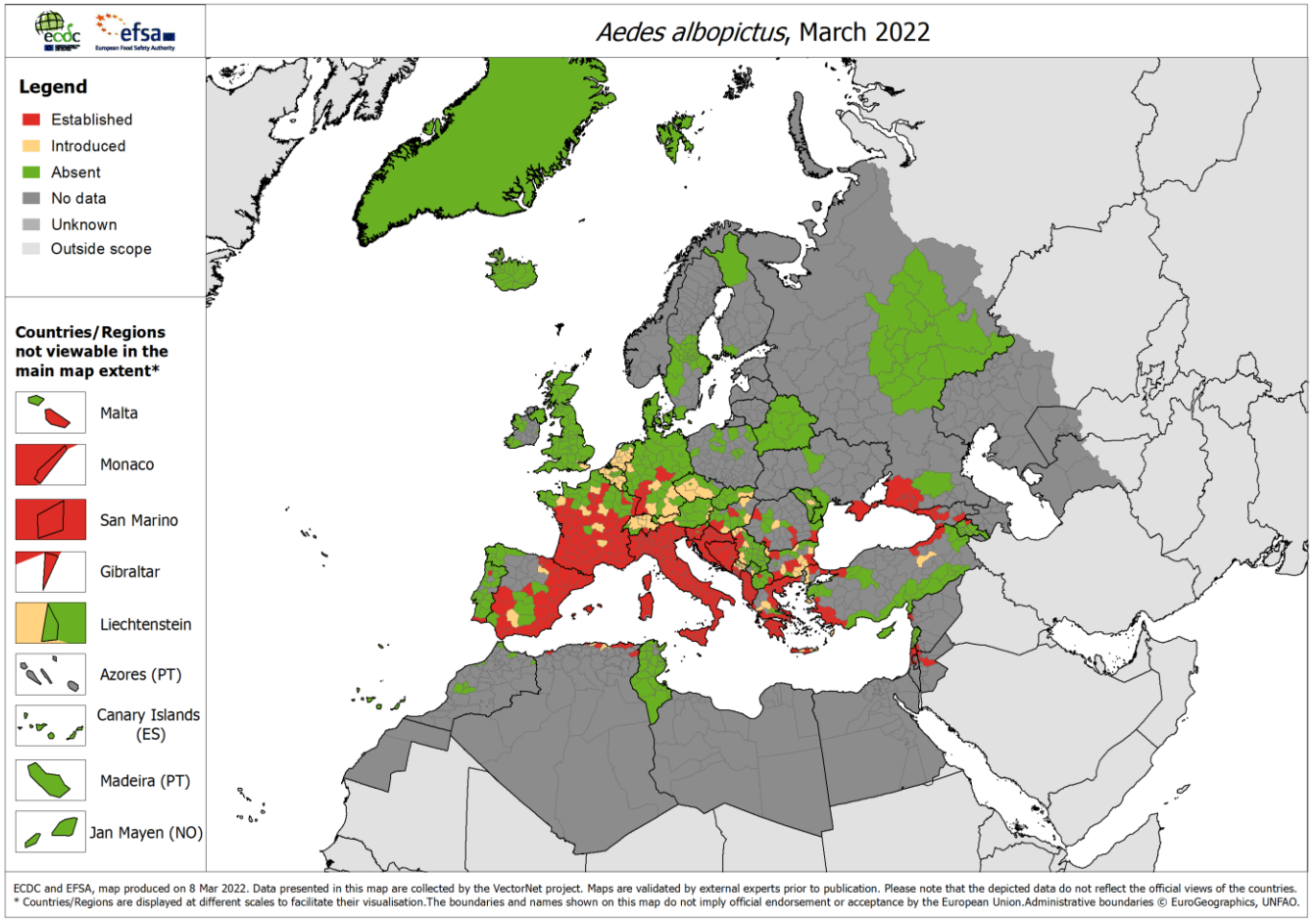


Bellini *et al.* (2020)

Fig. 1. Female Asian tiger mosquito during blood meal (drawing by Elisa Canaglia).

Spread of the species.
How and why?

Established in 30 European countries



European Centre for Disease Prevention and Control
https://www.ecdc.europa.eu/en/publications-data/aedes-albopictus-current-known-distribution-march-2022

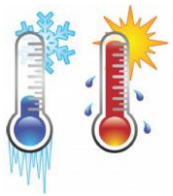
Globalization

International trade

Environmental suitability

Live plants

Tyres



Temperature

Rainfall

- ✓ Assess the environmental suitability for the establishment of the species in Europe
  - *Consensus between existing models*

- ✓ Assess the suitability to the mosquito in large urban areas in Europe
  - *Present-day conditions and future climatic scenarios (2050)*

- ✓ Investigate the relation between international trade & mosquito dispersion
  - *Potential for mosquito introduction via imported goods*

Environmental suitability in Europe

- Data from existing models in Europe (7 present, 5 future)
- Transform in binary scale (absence/presence)
- Harmonize spatial resolution (25 km)
- Identify common and divergent areas/patterns
- Classify consensus level and uncertainty
- Identify future trajectories (2 timeframes)

References models	Geog. coverage	Spatial resolution	Present-day period	Future period	Scenario	Modelling technique
Caminade et al. (2012[19])	Europe	0.25° ~25 km	1960–2009	2030–2050	SRES A1B	GIS-based (overwintering and seasonal activity); Multi-criteria decision analysis
Campbell et al. (2015)[8]	Global	0.16666° ~18 km	1950–2000	2041–2060	SRES B1	MaxEnt
Ding et al. (2018)[11]	Global	0.05° ~5 km	1970–2000			Support vector machine (SVM); Gradient boosting machine (GBM); random Forest (RF)
Kraemer et al. (2015[12], 2019[5])	Global	0.04166° ~5 km	1960–2014	2050	RCP 6.0	Boosted regression trees (BRT)
Proestos et al. (2015)[7]	Global	0.46875° ~50 km	2000–2009	2045–2054	SRES A2	Fuzzy-logic
Rogers (2015)[52]	Global	0.5° ~55 km	1961–1990	2080 (estimated for 2050 by linear interpolation)	SRES B1	K-means clustering; Nonlinear discriminant analysis
Santos and Meneses, (2017)[13]	Global	30 arc-sec ~1 km	1950–2000			MaxEnt

Categories	Present (7 models)	Future (5 models)
Unsuitable, low uncertainty	5 to 7 models agree unsuitable	4 to 5 models agree unsuitable
High uncertainty	Only 3 or 4 models agree	Only 2 or 3 models agree
Suitable, low uncertainty	5 to 7 models agree suitable	4 to 5 models agree suitable

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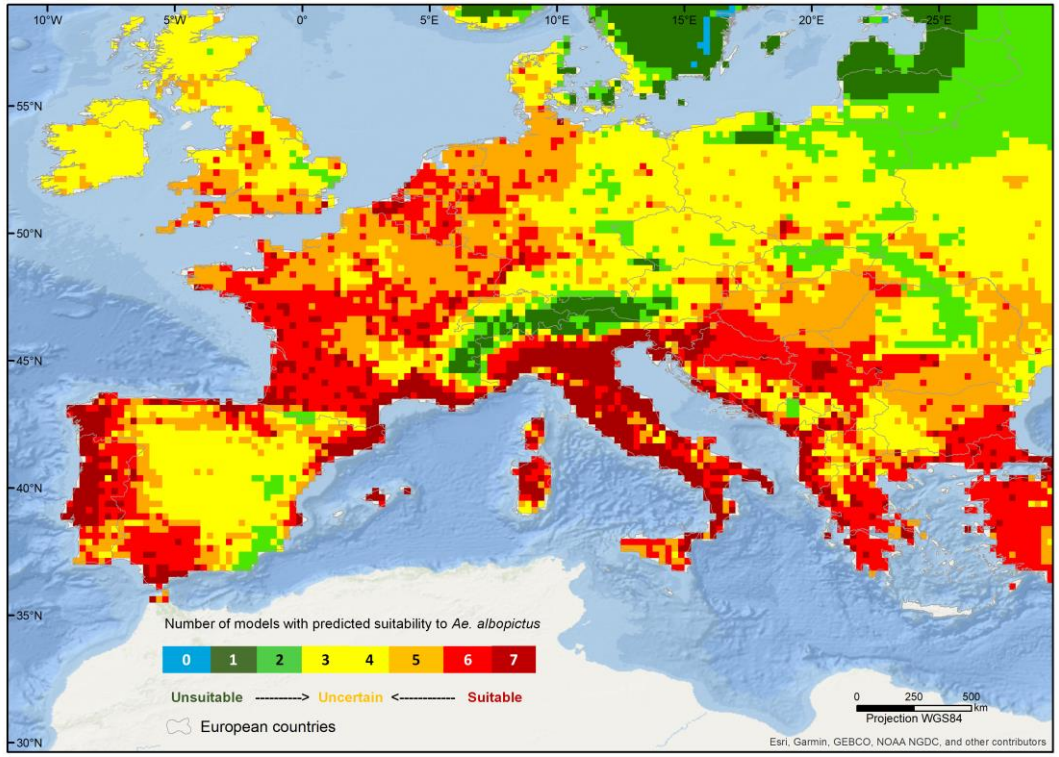
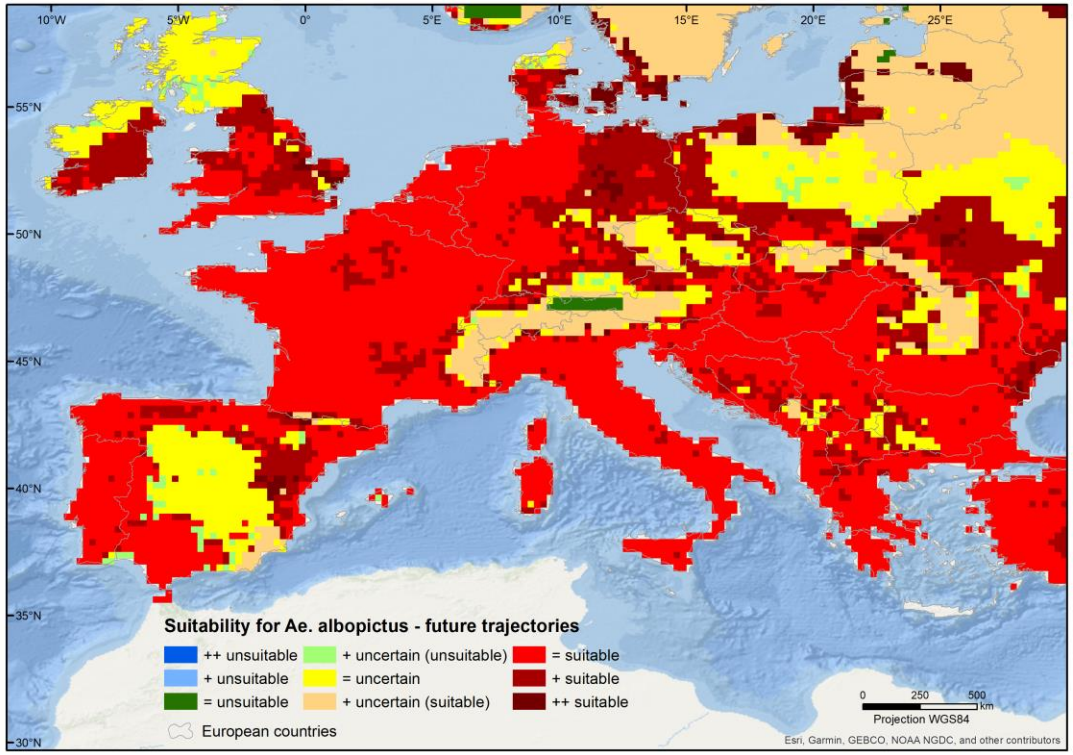


Present conditions

Areas of high uncertainty (high disagreement between models) mainly in eastern Europe, northern Britain, Ireland and central Spain.



Future trajectories

Suitable regions will encompass 21% more area, adding to the 47% of the continent that is suitable nowadays.

Suitability in urban areas

Functional Urban Areas (> 250.000 people)

Predominant class of suitability within FUA boundaries

Expected change in suitability (present-future)

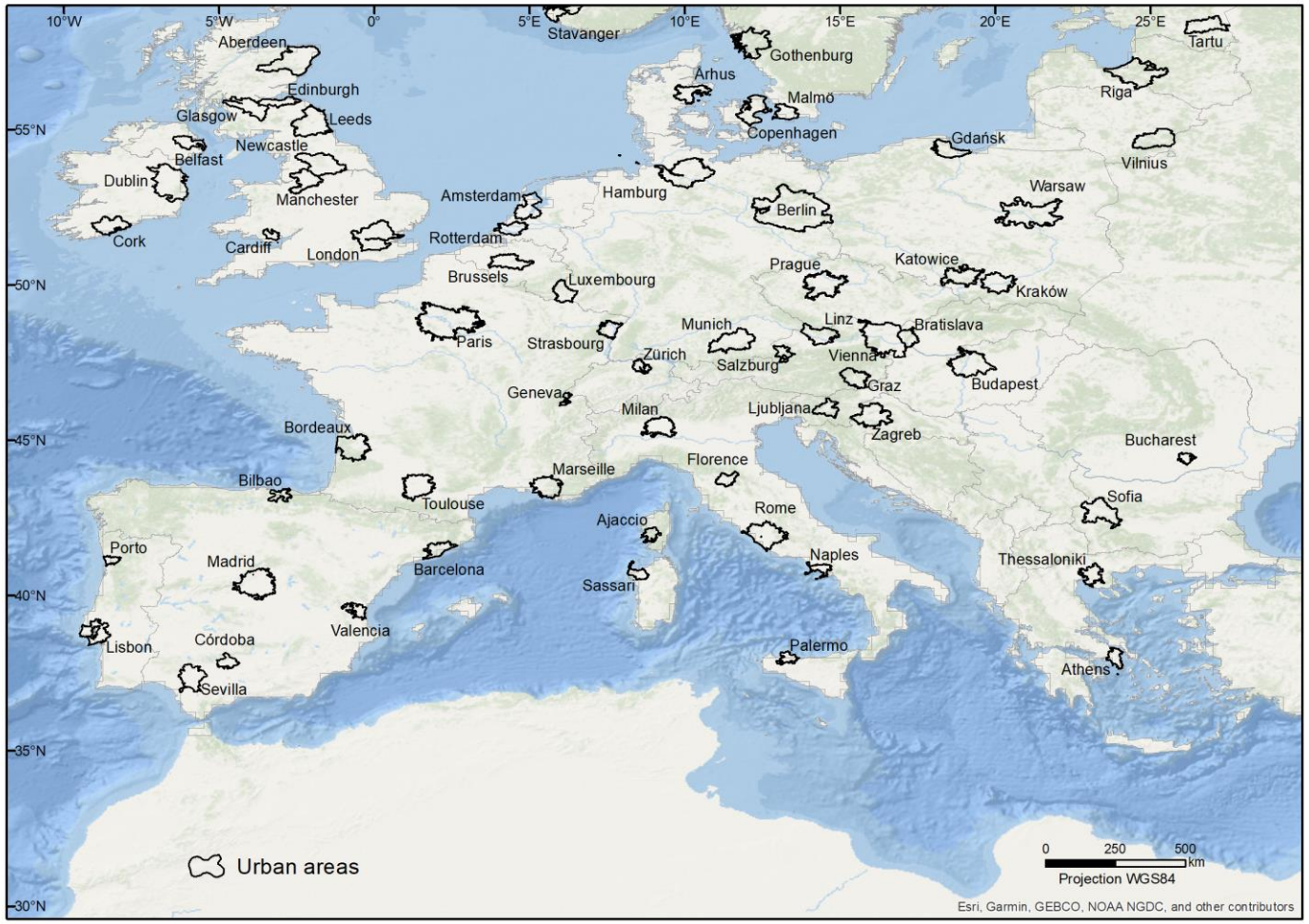
Worst-case scenario (most unfavourable change in suitability class)

- Suitability class per 25 km cell, 3 major categories (traffic light scheme)
- Spatial overlap between cells and urban areas boundaries (majority)
- *Worst-case scenario* – 1/3 urban area covered by a more unfavorable variation than given by the baseline

Traffic-light scheme

	Most favorable situation from the human viewpoint (unsuitable with low uncertainty)
	High uncertainty, regarding either suitability and unsuitability
	Most negative situation, with suitability for the mosquito being consensual across models

Functional urban area (FUA) - a city and its commuting zone. A densely inhabited city and a less densely populated commuting zone whose labor market is highly integrated with the city (*OECD, 2012*).



62 metropolitan areas

- Large metropolitan (above 1.5 million people)
- Metropolitan (250.000 to 1.5 million people)

3 medium-size urban areas

- 3 medium areas (100.000 to 250.000 people), in Corsica, Sardinia and Estonia

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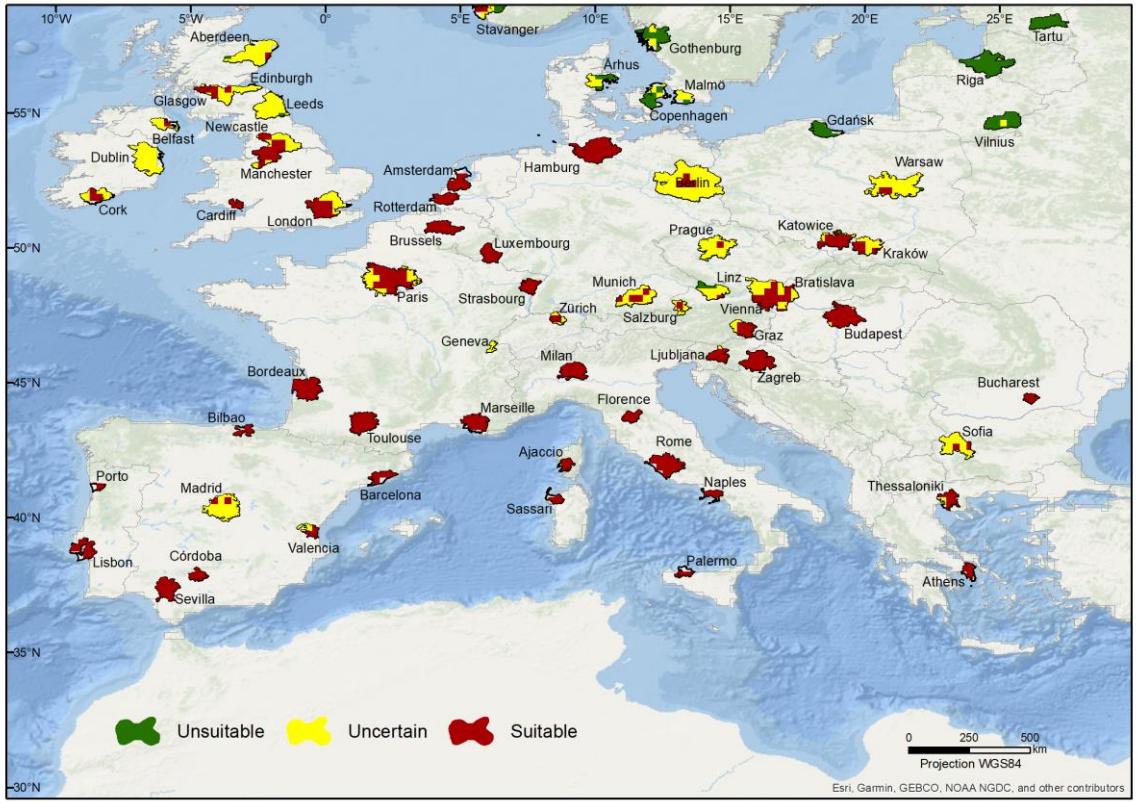
Present conditions

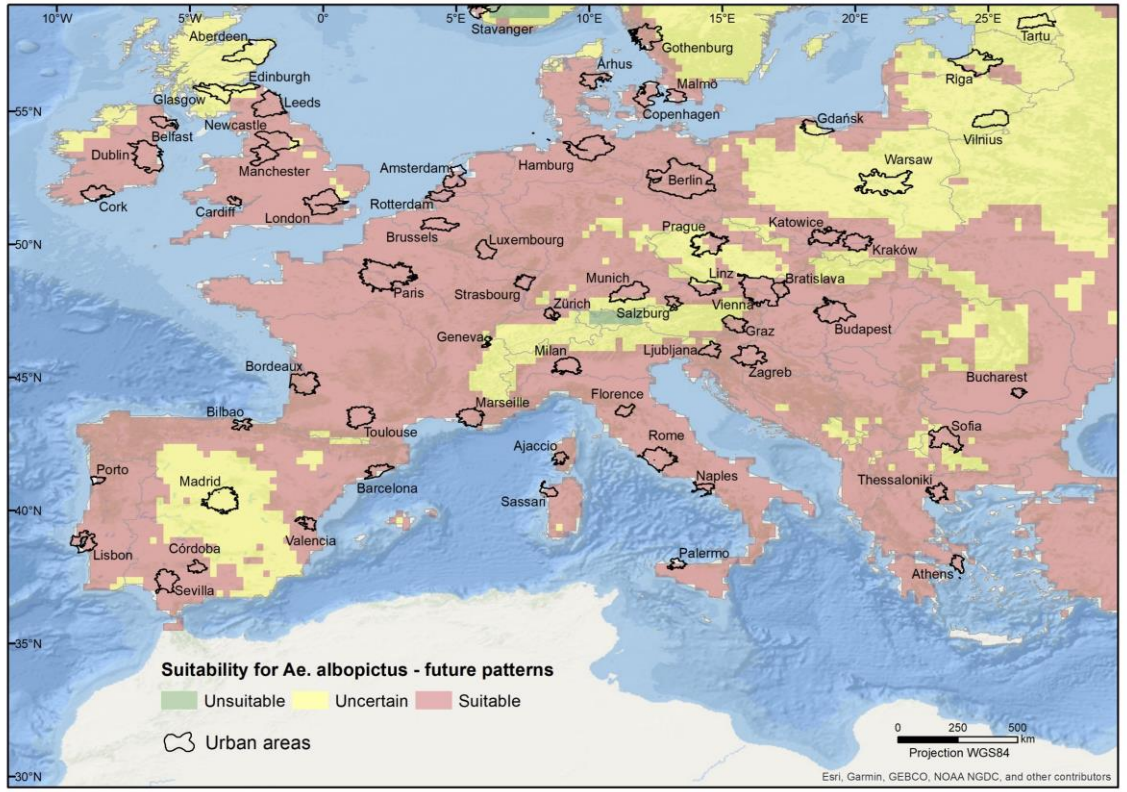


12% unsuitable

39% uncertain

49% suitable

Future conditions



0% unsuitable

17% uncertain

83% suitable

Main city (country)	P	F
Aberdeen(UK)		
Ajaccio (FR)		
Amsterdam (NL)		
Århus (DK)		
Athens (EL)		
Barcelona (ES)		
Belfast (UK)		
Berlin (DE)		
Bilbao (ES)		
Bordeaux (FR)		
Bratislava (SK)		
Brussels (BE)		
Bucharest (RO)		
Budapest (HU)		
Cardiff (UK)		
Copenhagen		
Cordoba (ES)		
Cork (IE)		
Dublin (IE)		
Edinburgh (UK)		
Florence (IT)		
Gdansk (PL)		
Geneva (CH)		

Main city (country)	P	F
Glasgow (UK)		
Gothenburg (SE)		
Graz (AT)		
Hamburg (DE)		
Katowice (PL)		
Kraków (PL)		
Leeds (UK)		
Linz (AT)		
Lisbon (PT)		
Ljubljana (SI)		
London (UK)		
Luxembourg (LU)		
Madrid (ES)		
Malmö (SE)		
Manchester (UK)		
Marseille (FR)		
Milan (IT)		
Munich (DE)		
Naples (IT)		
Newcastle		
Oporto (PT)		
Palermo (IT)		
Paris (FR)		

Main city (country)	P	F
Prague (CZ)		
Riga (LV)		
Rome (IT)		
Rotterdam (NL)		
Salzburg (AT)		
Sassari (IT)		
Sevilla (ES)		
Sofia (BG)		
Stavanger (NO)		
Strasbourg (FR)		
Tartu (EE)		
Thessaloniki (EL)		
Toulouse (FR)		
Valencia (ES)		
Vienna (AT)		
Vilnius (LT)		
Warsaw (PL)		
Zagreb (HR)		
Zürich (CH)		

Unsuitable
Uncertain
Suitable

- Cities located in northern Europe expected to undergo the most severe changes (from unsuitable to suitable)

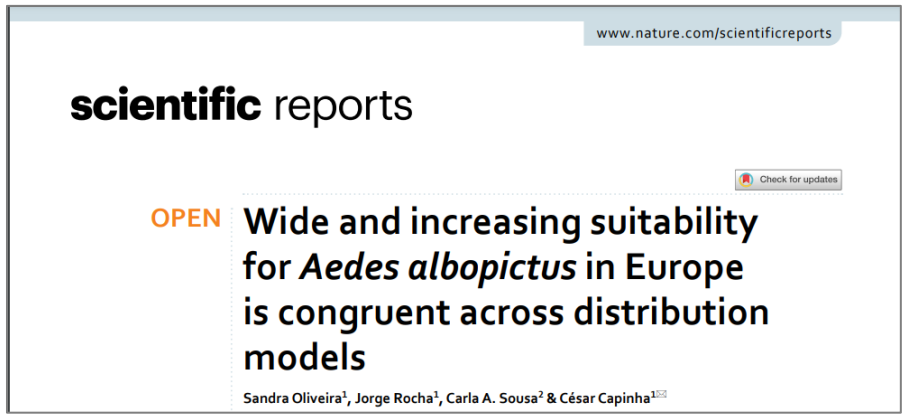
  Arhus, Copenhagen, Gothenburg, Stavanger

- Cities of central Europe, Great Britain and Ireland are expected to become suitable (from uncertain today)

  Berlin, Dublin, Geneva, London, Prague, Vienna

- Uncertainty remains in the future for cities such as:

  Edinburgh, Madrid, Munich, Warsaw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OPEN

Wide and increasing suitability for *Aedes albopictus* in Europe is congruent across distribution models

Sandra Oliveira[1], Jorge Rocha[1], Carla A. Sousa[2] & César Capinha[1]✉

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International trade & mosquito dispersion

Collection of international trade data (imports)

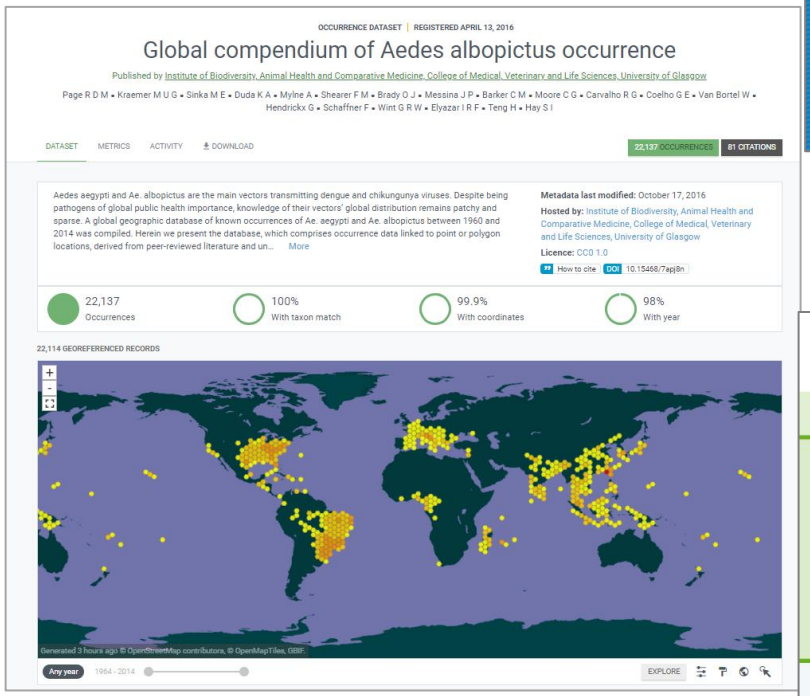
Live plants, New tyres, Used tyres

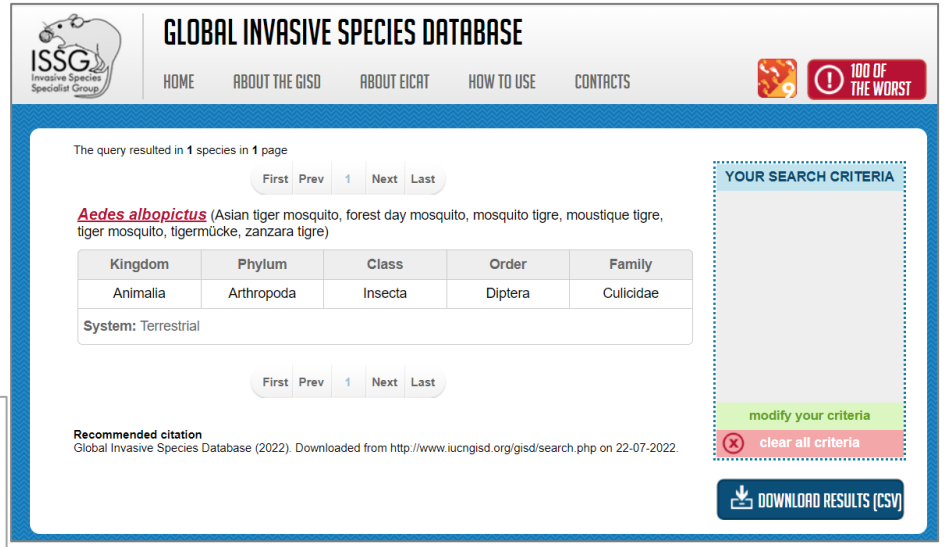
Year of *Aedes albopictus* introduction

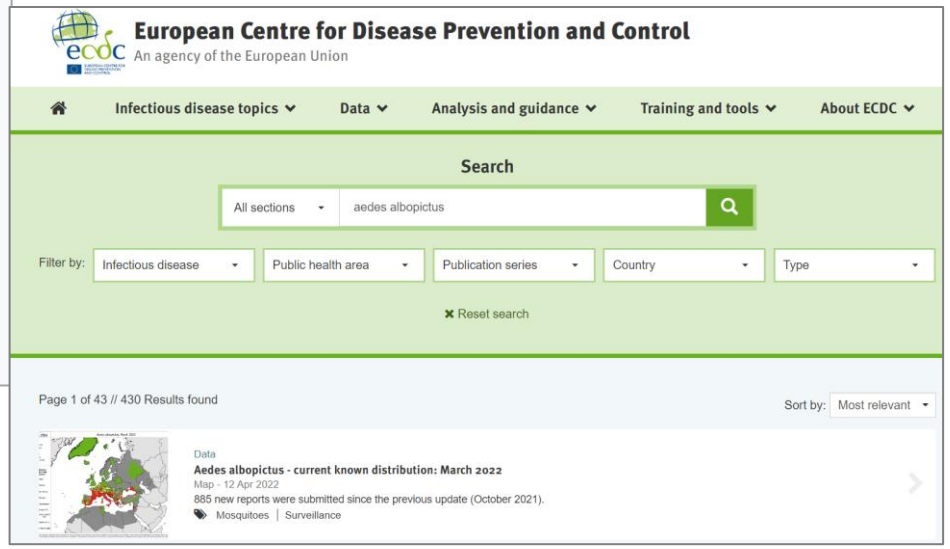
Trade indicators (volume of imports, % from countries with the species, trend in 15 years…)

Geographic proximity

Climatic similarity







ITC **TRADE MAP**
Trade statistics for international business development
Monthly, quarterly and yearly trade data. Import & export values, volumes, growth rates, market shares, etc.

Home & Search | Data Availability | Reference Material | Other ITC Tools | More

Product: ... 0602 - Live plants incl. their roots, cuttings and slips;
World / Country: Portugal
Partner: All
Country Group: None
Partner Group: None
other criteria: Imports | Yearly time series | by country | Direct data | Quantities | Primary unit

List of supplying markets for a product imported by Portugal
Product: 0602 Live plants incl. their roots, cuttings and slips; mushroom spawn (excluding bulbs, tubers, ...

Table | Graph | Map | Companies

Download: Time Period (number of columns): 5 per page Rows per pag

Bilateral 4 digits	Exporters	2017	2018	2019	2020
		Imported quantity, Tons	Imported quantity, Tons	Imported quantity, Tons	Imported quantity, Tons
	World	38,358	33,952	35,750	33,343
⊞	Spain	23,289	18,589	19,813	18,695
⊞	Netherlands	9,392	10,429	11,757	10,672
⊞	Italy	2,277	2,628	2,170	1,588
⊞	United Kingdom	448	130	274	805
⊞	Poland	2	102	10	261
⊞	Germany	648	769	763	938
⊞	Belgium	133	190	251	149
⊞	China	29	22	17	58

- ✓ *Imports per country (destiny) per product*
- ✓ *Multiple source countries*
- ✓ *Monthly data (volume, tons/kgs/units)*
- ✓ *Period: 2004 – 2019*
  - *Mann-Kendall & Sen's slope*

Pre-processing and harmonizing

International Trade data

Tyres & live plants

Country 1
File1
File10

Country 26
File1
File10

Country 79
File1
File10

2010-M04	...NA
Imported quantity	Units
1500	Kilograms
200	Units
4.5	Tons

```
#run loop to find the elements indexed and convert value
 for (i in 1:length(var_list$var1)) {
  #Process each value in position given by var1 and var2
  merged_df[var_list$var1[i],var_list$var2[i]] <-
                    merged_df [var_list$var1[i],var_list$var2[i]]/1000
}
```

Exporters	2015-M11	2015-M12
Country 1	80	150
Country 2	900	300
Country 9	500	20
World	1480	470

MethodsX 8 (2021) 101567

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journal homepage: www.elsevier.com/locate/mex

Method Article

Automated cleansing and harmonization of international trade data

Sandra Oliveira*, César Capinha, Jorge Rocha

Centre for Geographical Studies and Associated Laboratory TERRA, Institute of Geography and Spatial Planning, Universidade de Lisboa, Lisbon, Portugal

Live plants

- **76 destinations**
  - 2-83 source countries
- 53 with *Ae. albopictus*
  - 31 < 2004
  - 22 ≥ 2004
- 23 without *Ae. albopictus*

New Tyres

- **77 destinations**
  - 8-89 source countries
- 55 with *Ae. albopictus*
  - 32 < 2004
  - 23 ≥ 2004
- 22 without *Ae. albopictus*

Austria
Bulgaria
Canada
Costa Rica
Czechia
Germany
Greece
Honduras
Croatia
Laos
Malta
Morocco
Netherlands
Portugal
Romania
Russia
Seychelles
Republic of Serbia
Slovakia
Sweden
Taiwan
Turkey
Venezuela

Angola
Belarus
Bolivia
Chile
Cyprus
Denmark
Egypt
Estonia
Finland
Ireland
Kenya
Latvia
Lithuania
Luxembourg
Peru
Poland
Senegal
United Arab Emirates
Uganda
United Kingdom
Ukraine
Zimbabwe

Used Tyres

- **79 destinations**
  - 1-74 source countries
- 56 with *Ae. albopictus*
  - 33 < 2004
  - 23 ≥ 2004
- 23 without *Ae. albopictus*

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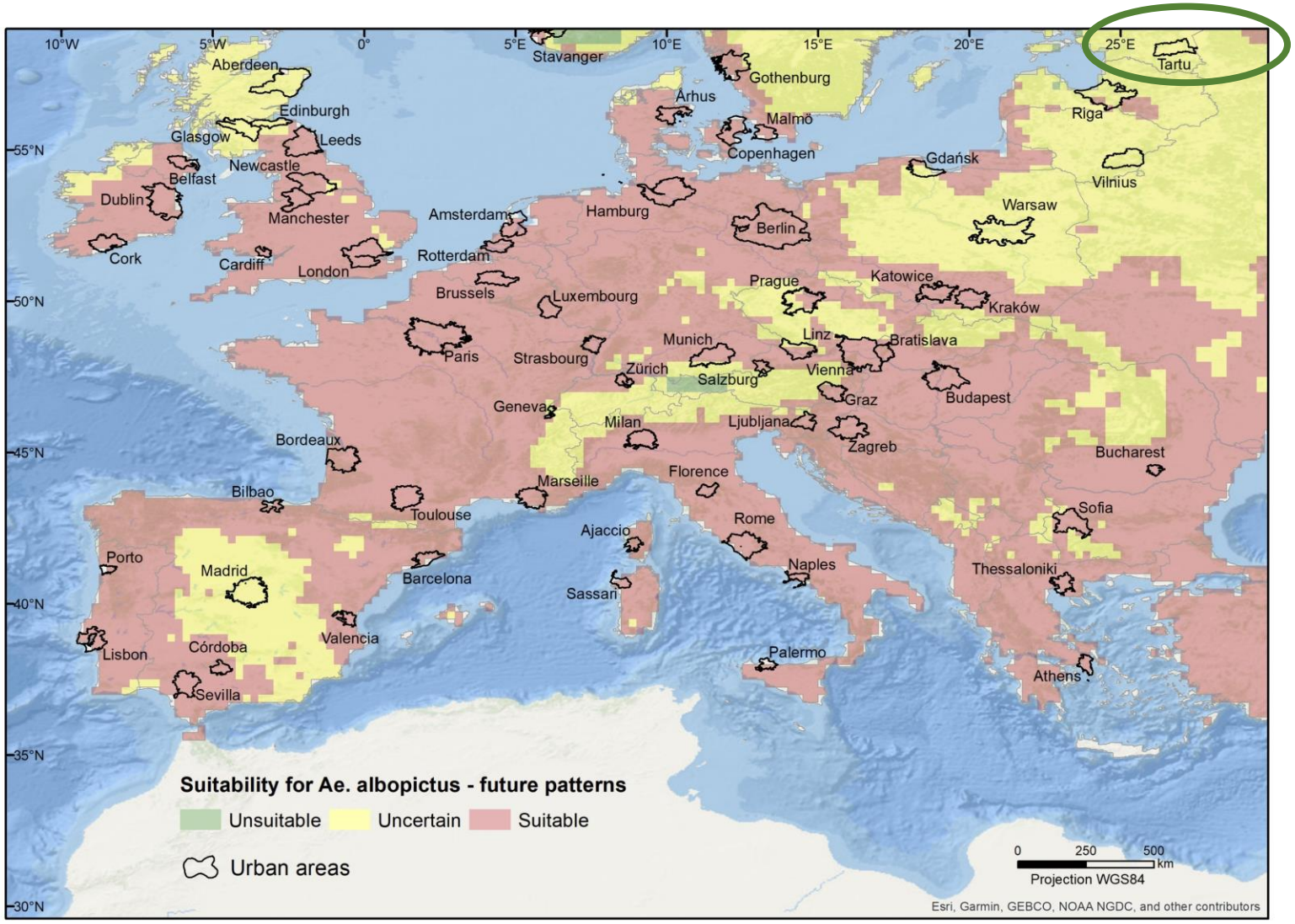
ESTONIA



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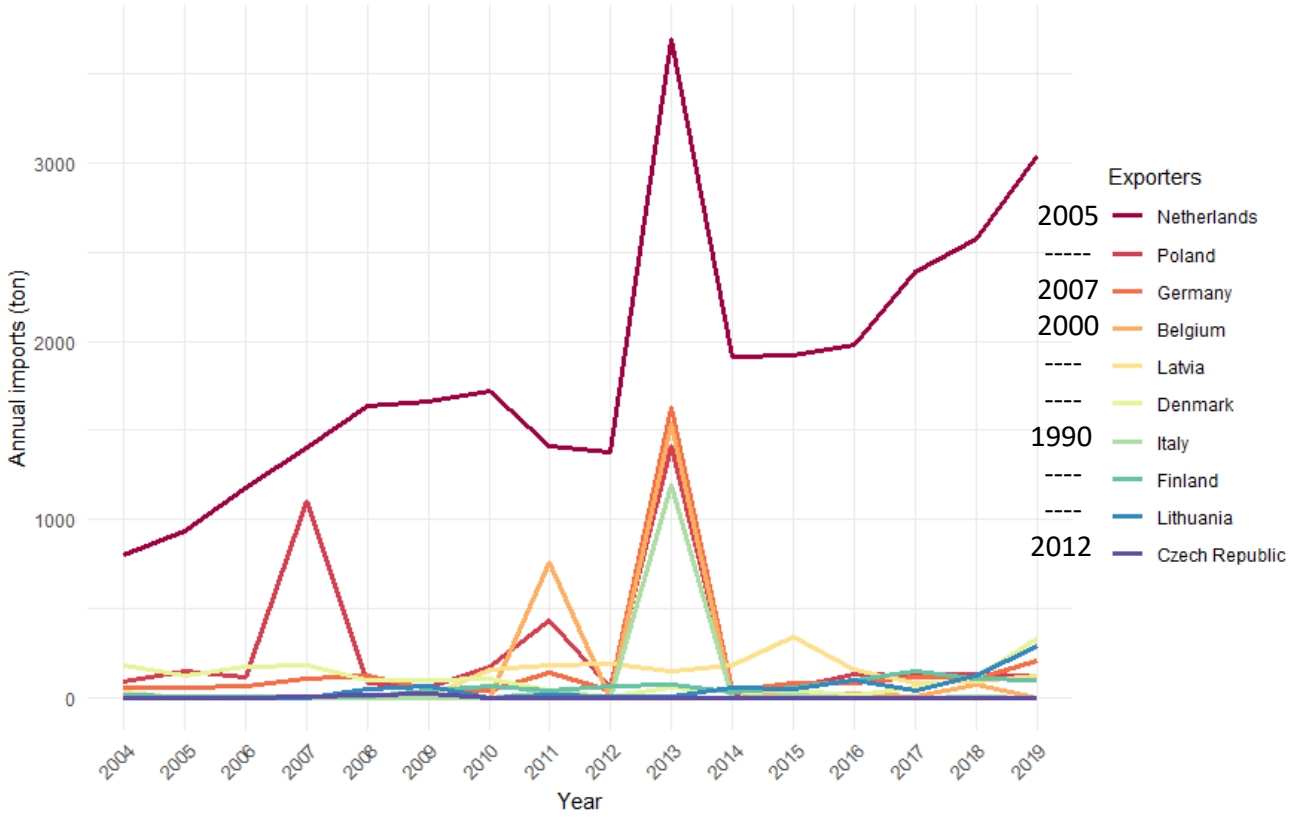
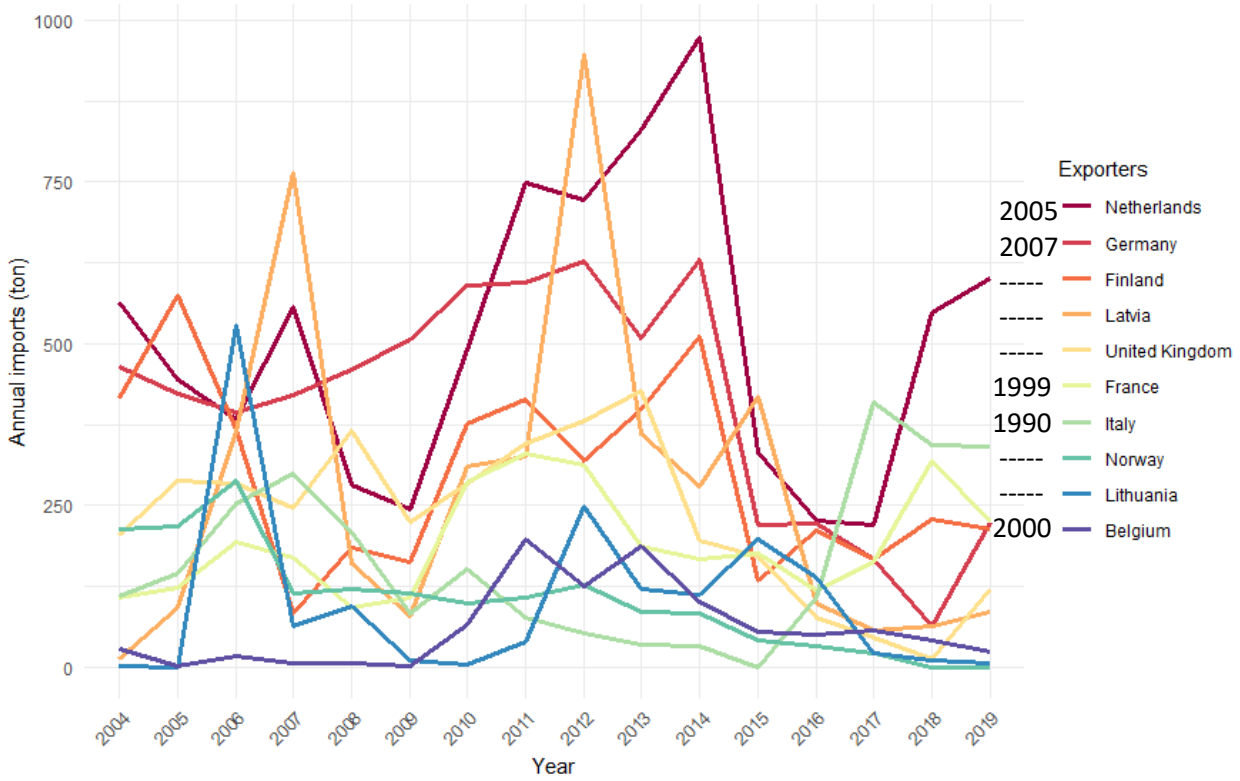
ESTONIA

Top10 source countries of live plants



Top10 source countries of used tyres



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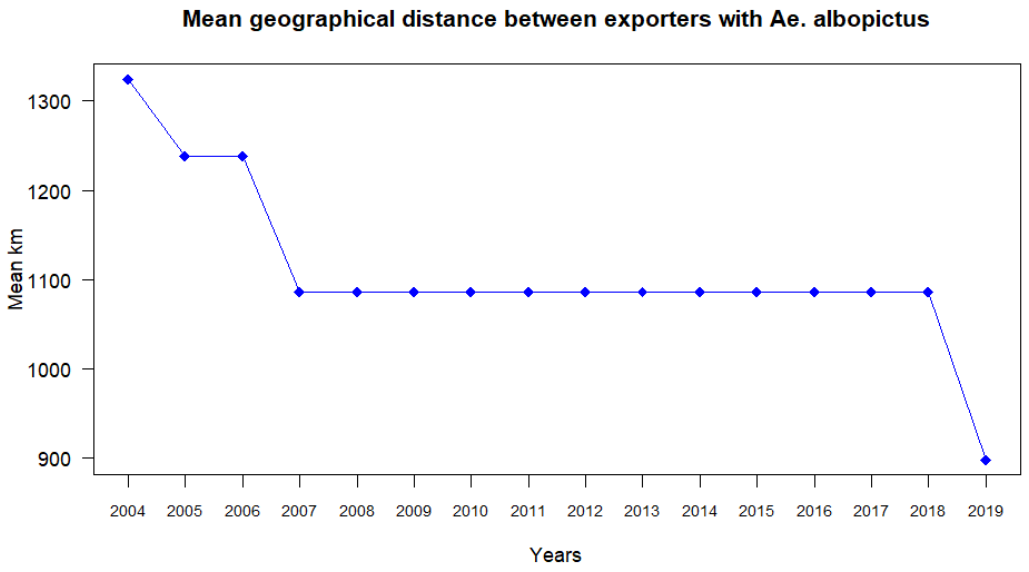
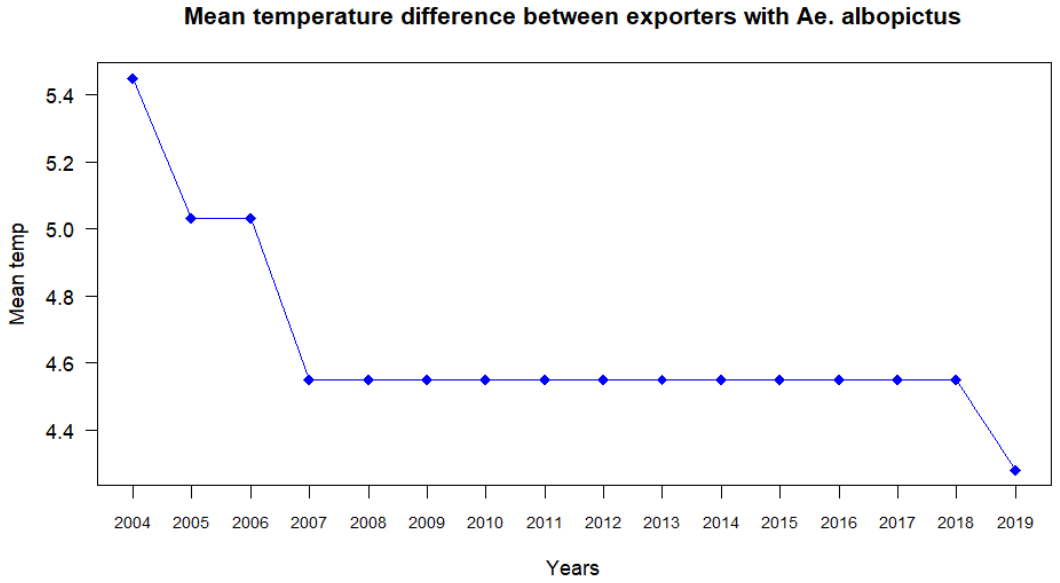
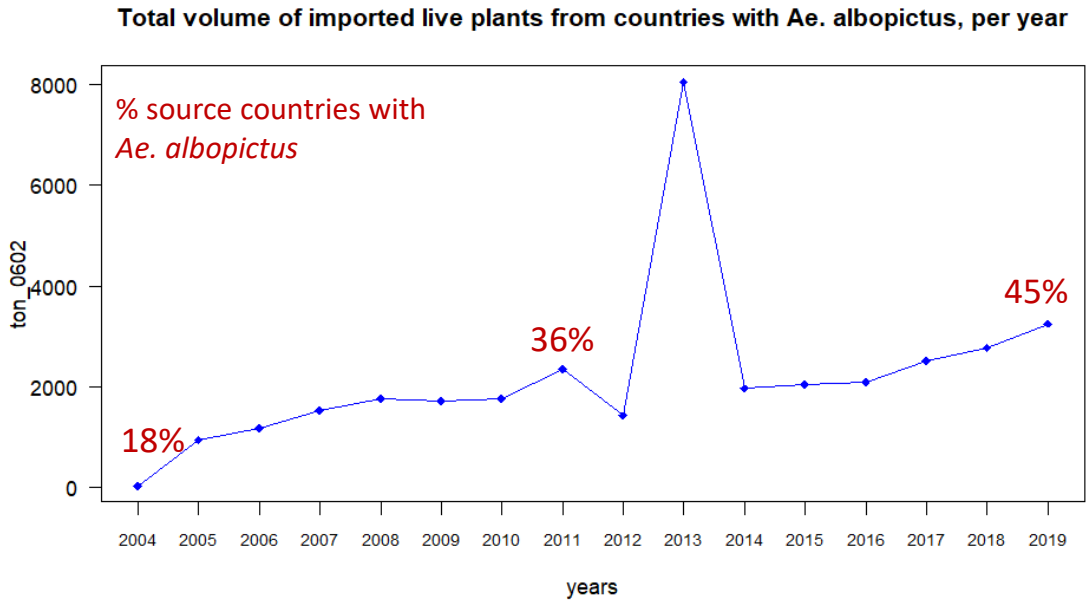
ESTONIA








```
data:  est_0602_total_years$ton_0602
z = 3.917, n = 16, p-value = 8.967e-05
alternative hypothesis: true z is not equal to 0
95 percent confidence interval:
  84.5 232.6
sample estimates:
Sen's slope
     149.83
```

- Ascending (positive) trend
- Statistically significant
- High magnitude

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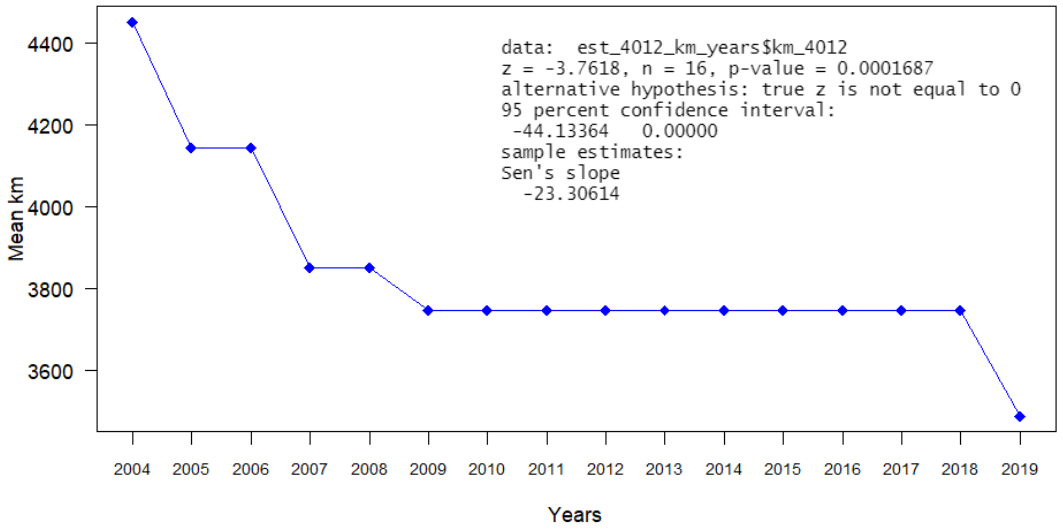
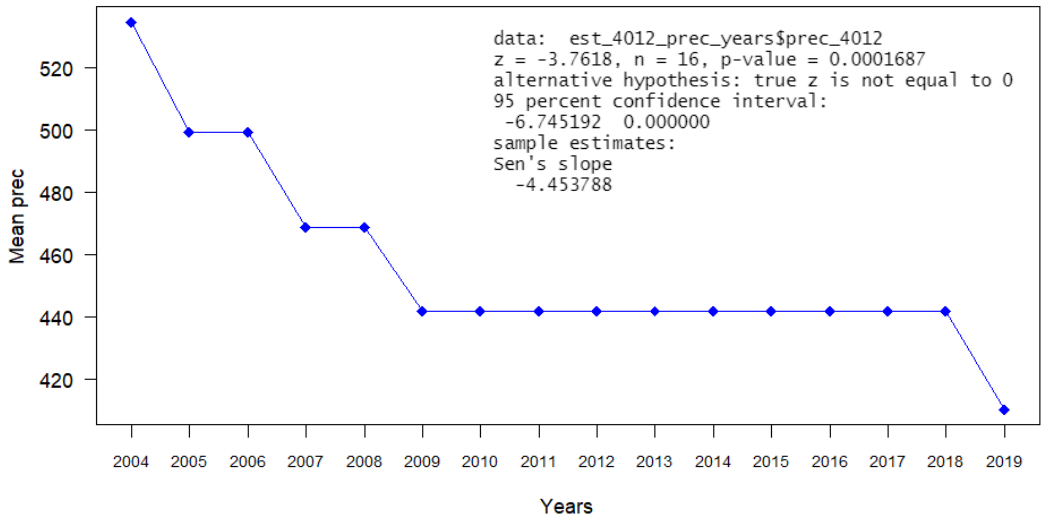
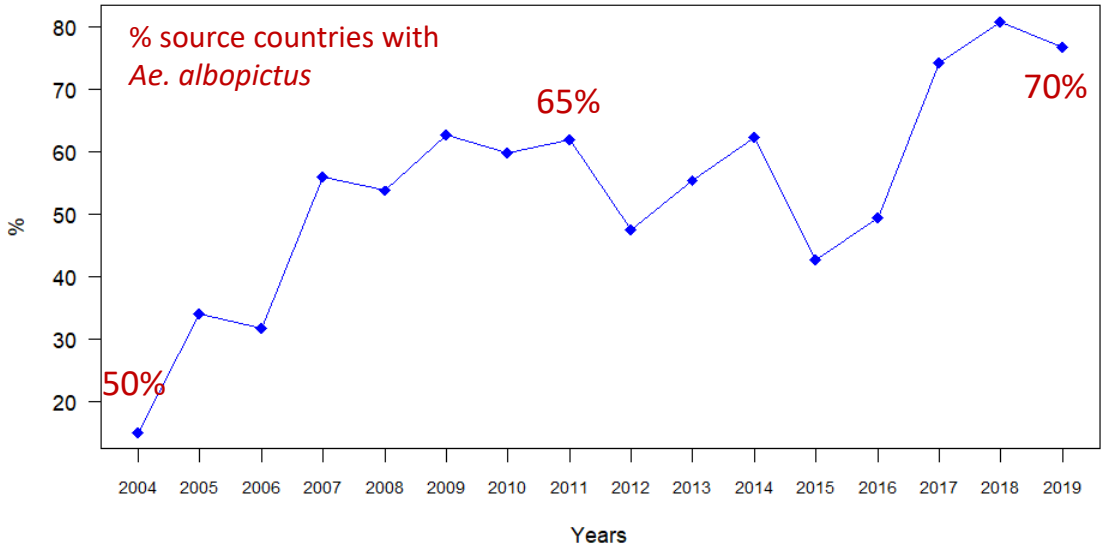
Mean geographical distance between exporters with Ae. albopictus



Mean precipitation difference between exporters with Ae. albopictus



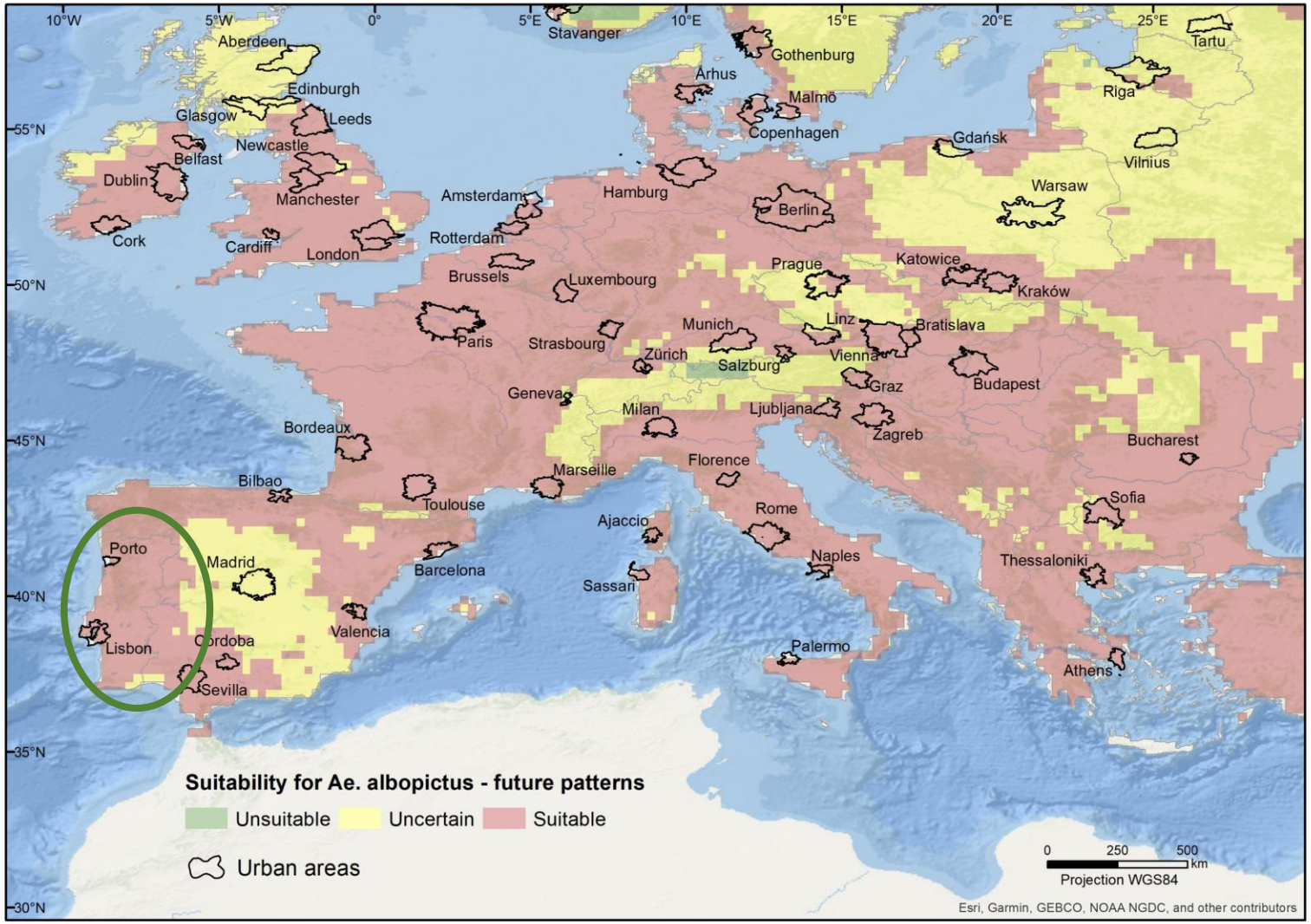
Annual imports of used tyres from countries with Ae. albopictus (%)




```
data:  est_4012_flow_years$perc_4012
z = 2.6563, n = 16, p-value = 0.0079
alternative hypothesis: true z is not equal to 0
95 percent confidence interval:
 1.229925 4.476873
sample estimates:
Sen's slope
   2.637324
```

- Ascending (positive) trend
- Statistically significant
- Low magnitude

PORTUGAL


10°W
5°W
0°
5°E
10°E
15°E
20°E
25°E
55°N
50°N
45°N
40°N
35°N
30°N
Aberdeen
Edinburgh
Glasgow
Leeds
Newcastle
Belfast
Dublin
Manchester
Cork
Cardiff
London
Amsterdam
Rotterdam
Brussels
Stavanger
Gothenburg
Århus
Malmö
Copenhagen
Hamburg
Berlin
Gdańsk
Tartu
Riga
Vilnius
Warsaw
Prague
Katowice
Kraków
Luxembourg
Paris
Strasbourg
Munich
Linz
Bratislava
Zürich
Salzburg
Vienna
Graz
Budapest
Geneva
Milan
Ljubljana
Zagreb
Bucharest
Bordeaux
Florence
Marseille
Bilbao
Toulouse
Ajaccio
Rome
Sofia
Porto
Madrid
Barcelona
Sassari
Naples
Thessaloniki
Lisbon
Cordoba
Valencia
Palermo
Athens
Sevilla
Suitability for Ae. albopictus - future patterns
Unsuitable
Uncertain
Suitable
Urban areas
0
250
500
km
Projection WGS84
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

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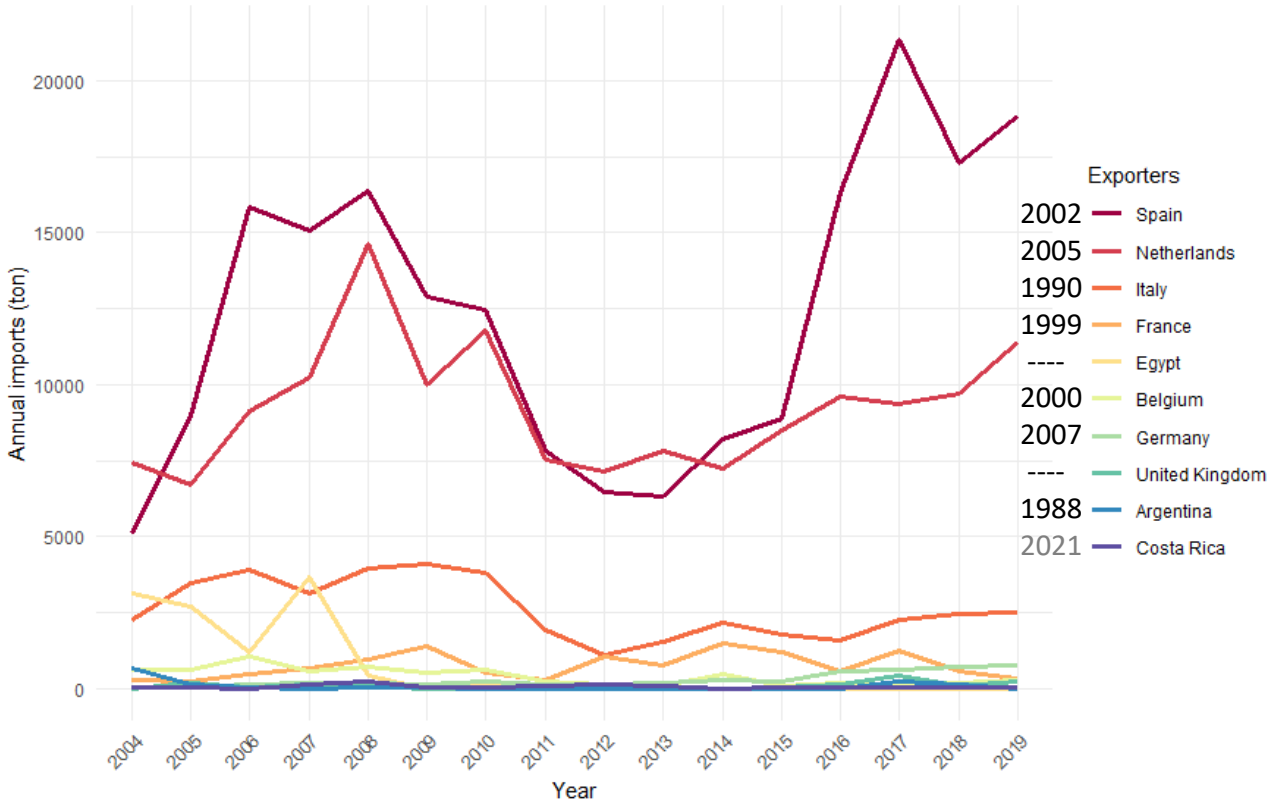
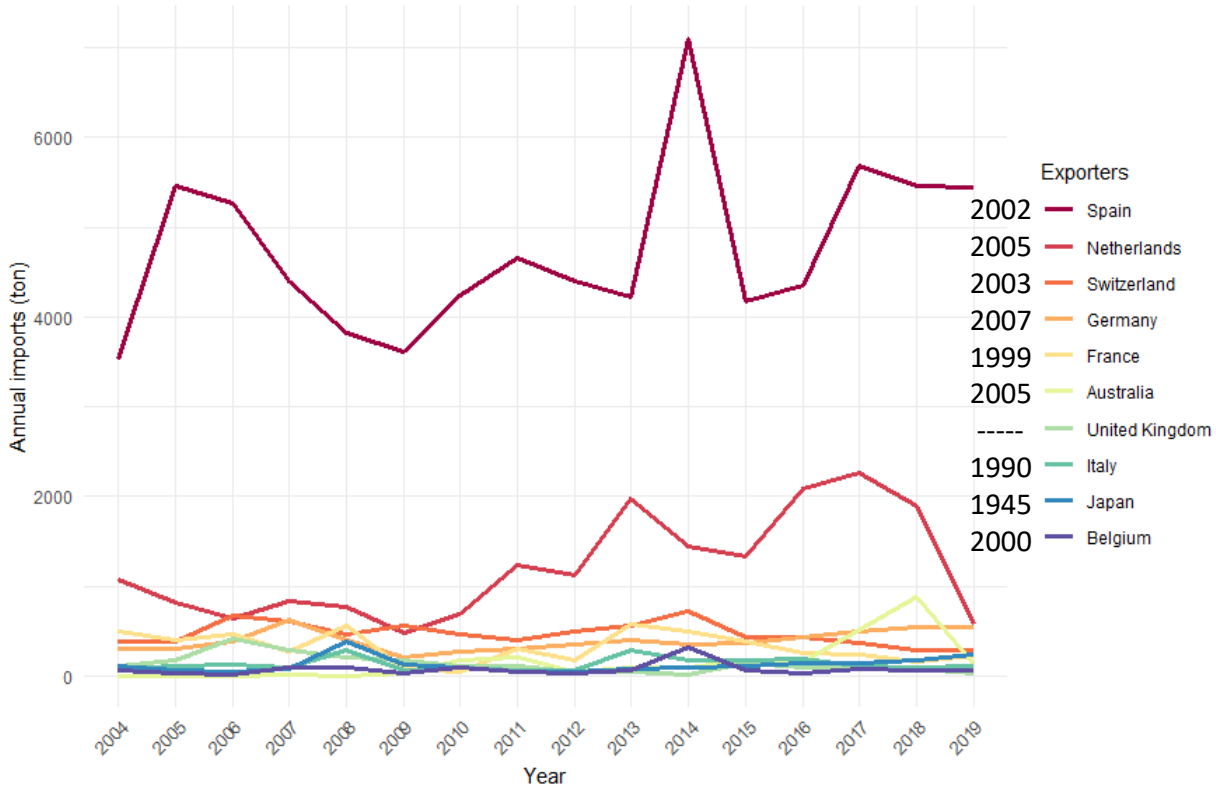
PORTUGAL

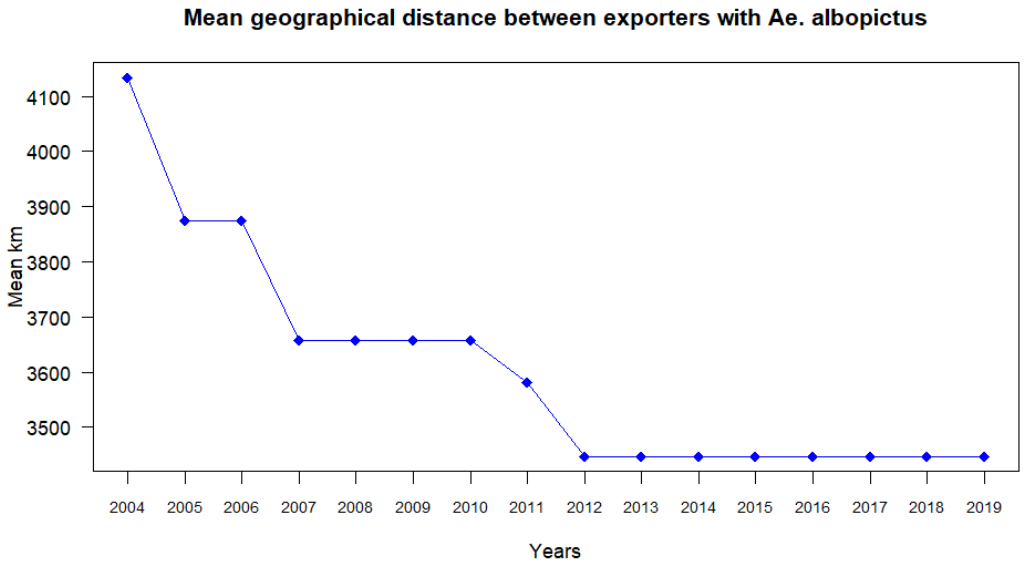
Top10 source countries of live plants

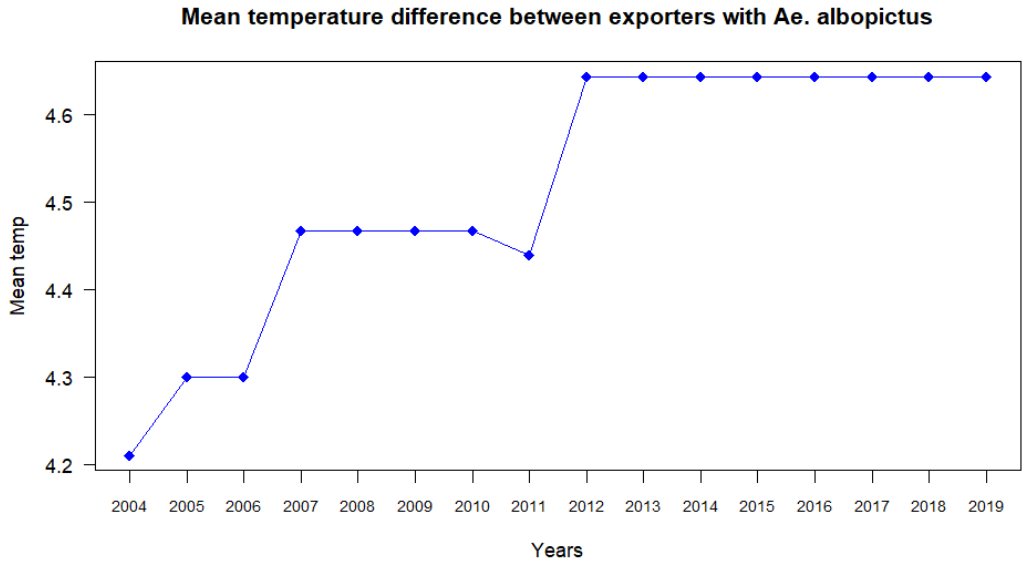


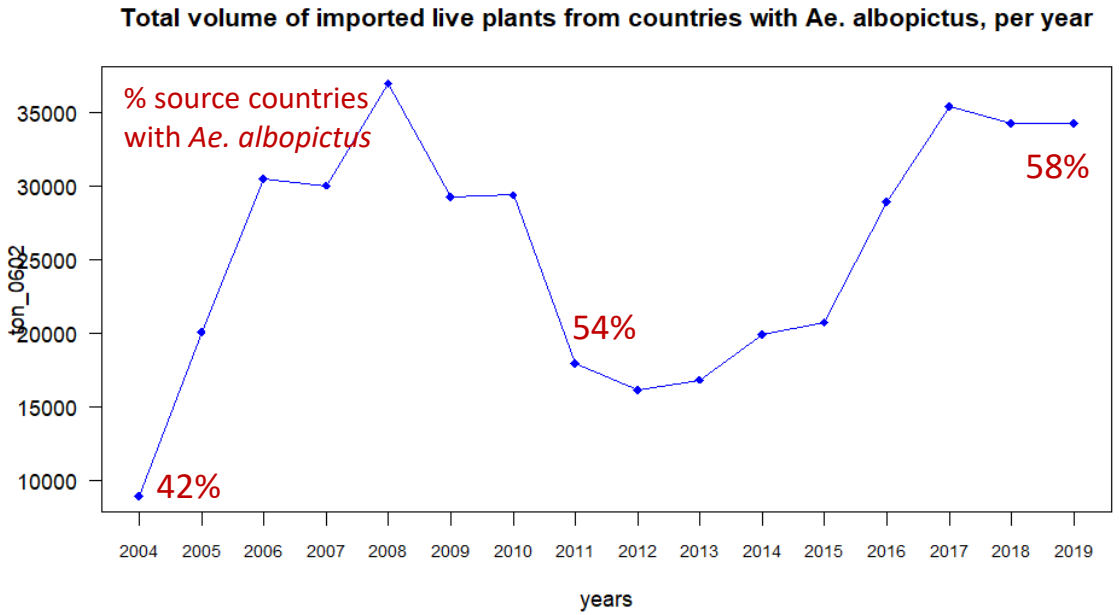
Top10 source countries of used tyres



PORTUGAL








```
data:  pt_0602_total_years$ton_0602
z = 0.9915, n = 16, p-value = 0.3214
alternative hypothesis: true z is not equal to 0
95 percent confidence interval:
 -356.1667 1890.2750
sample estimates:
Sen's slope
   582.7021
```

- Ascending (positive) trend
- Not statistically significant

Tartu 25.-29.07.2022
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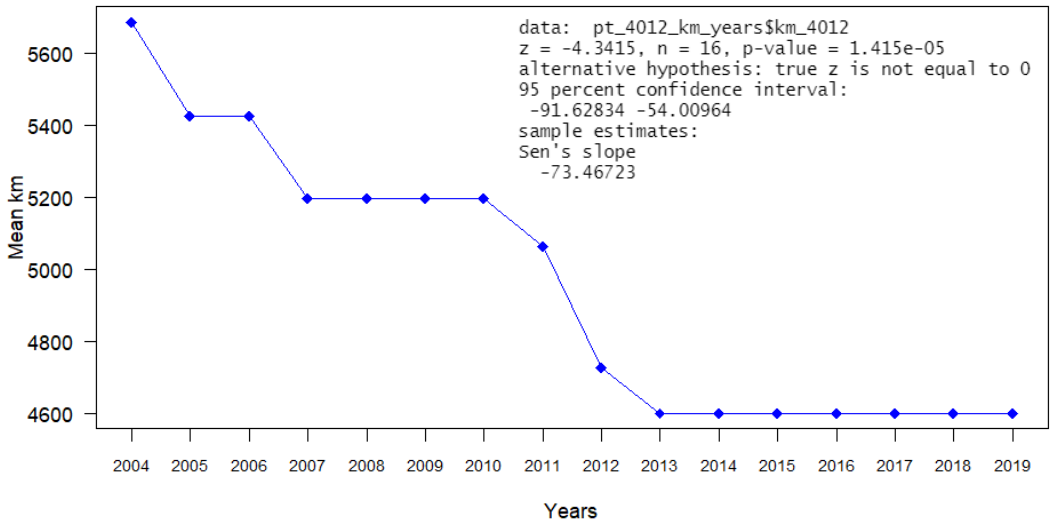
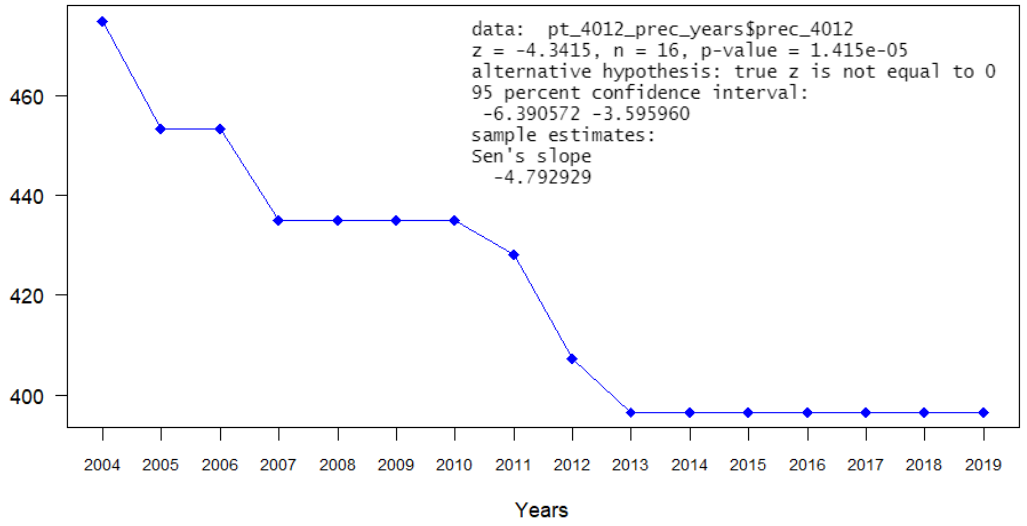
Space for Species:
Redefining Spatial Justice

PORTUGAL

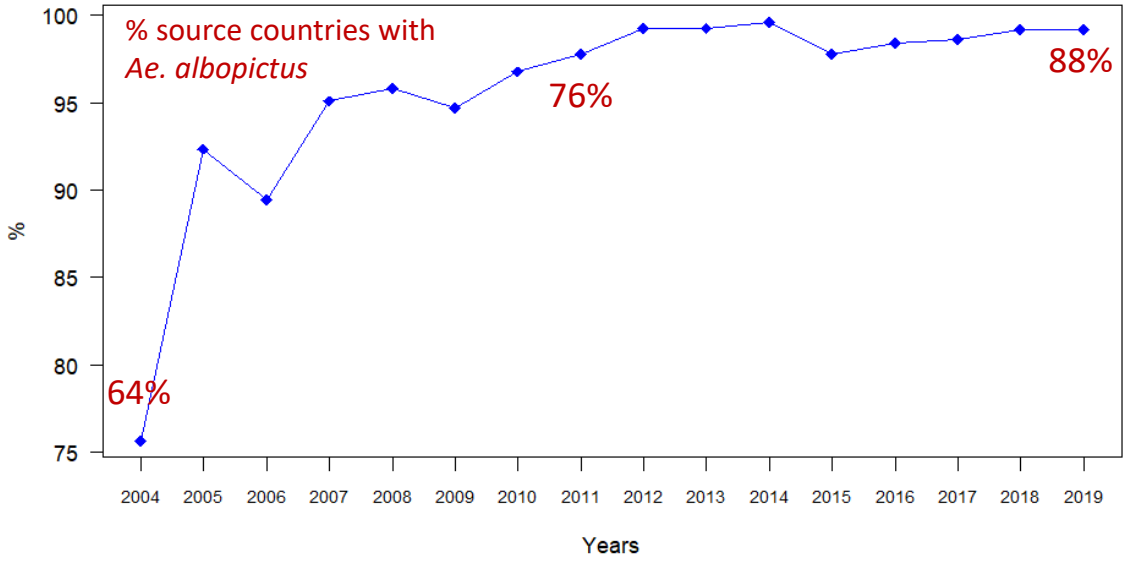
Mean geographical distance between exporters with Ae. albopictus



Mean precipitation difference between exporters with Ae. albopictus



Annual imports of used tyres from countries with Ae. albopictus (%)




```
data:  pt_4012_flow_years$perc_4012
z = 3.6956, n = 16, p-value = 0.0002194
alternative hypothesis: true z is not equal to 0
95 percent confidence interval:
 0.3246285 0.8837610
sample estimates:
Sen's slope
  0.5552622
```

- Ascending (positive) trend
- Statistically significant
- Low magnitude

Suitability to Aedes albopictus

- ✓ Nowadays, West and South Europe suitable. Climate change will aggravate conditions (increase suitability)
- ✓ In about 30 years, *Ae. albopictus* will find suitable areas in 68% of the European continent
- ✓ Suitability to *Aedes albopictus* in Europe raises public health concerns. Need to monitor and control vectors

Urban areas

- ✓ 83% of urban areas (out of 65 analyzed) predicted as suitable in the future (2050). None unsuitable
- ✓ Tartu (Estonia) uncertain
- ✓ Uncertainty reflects the divergence between estimations (half of them estimate suitability)

International trade

- ✓ Species dispersal via live plants and tyres
- ✓ Proportion of source countries (imports) with *Ae. Albopictus* increased over time
- ✓ Geographic distance decreased, climatic similarity increased
- ✓ Probability of species introduction influenced by trade flows (?)

Thank you!

PTDC/GES-OUT/30210/2017