Department
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How far north can the Japanese beetle go? Exploring the role of spatial and temporal climatic resolution in pest risk maps

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Summary of the presentation

1. Introduction: the pest and the need for a rapid pest risk analysis (PRA)
2. Challenges of forecasting the climatic suitability of the UK for *Popillia japonica*:
   - 1-2 year life cycle spent primarily in the soil
3. Comparing the results from climatic datasets at different spatial/temporal resolutions and time period
4. Soil versus air temperatures
5. Summarising risks for policy makers

Japanese beetle (*Popillia japonica*)

- Larvae
  - Live in the soil, eating roots
  - Highly polyphagous
  - Damaging especially to pasture and golf courses
  - 1 - 2 year life cycle
  - Overwintering life stage

Popillia japonica larva
(Image from David Cappaert, Michigan State University, Bugwood.org)

- Adults
  - Highly polyphagous (over 300 hosts) including many field, orchard and forest crops
  - Gregarious, skeletonising leaves of many trees and attacking fruit

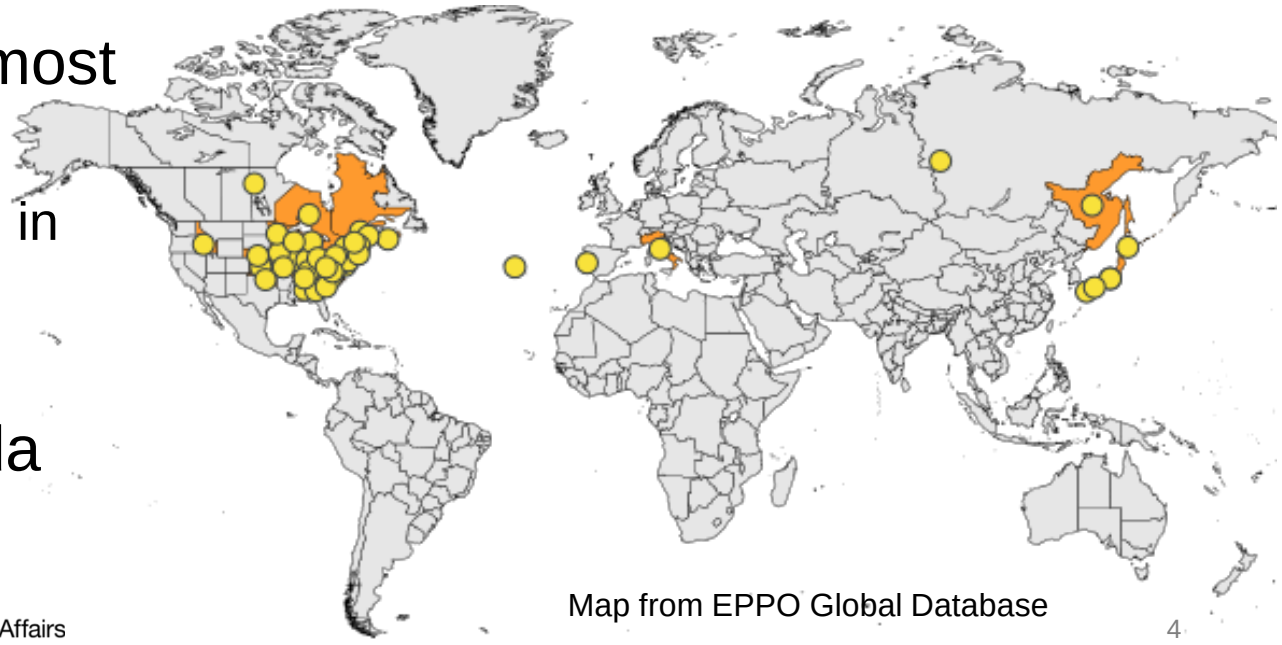
Adult *Popillia japonica* in Italy
(Image from Maurizio Pavesi, Museo di Storia Naturale di Milano)

Popillia japonica distribution

- Native to Japan
- Invasive alien species in North America
  - Introduced to the East Coast ~ 1912
  - Now found in most states of USA
    - More common in East
  - Parts of south-eastern Canada

Europe

- Azores, 1980s
- **Italy, 2014 near Milan**
- Annex IAII in EC Plant Health Directive



Map from EPPO Global Database

Rapid pest risk analysis (PRA)

- Rapid PRA undertaken to determine whether the Italian population poses a threat to the UK requiring statutory action
- Climatic mapping with a simple phenology model used to indicate the UK's climatic suitability

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Rapid Pest Risk Analysis (PRA) for:

Popillia japonica

June 2015

Stage 1: Initiation

1. What is the name of the pest?

Popillia japonica Newman (Coleoptera: Scarabaeidae: Subfamily: Rutelinae: Tribe; Anomalini), the Japanese beetle.

Some sources regard the subfamily, Rutelinae, as a family in its own right, and thus the taxonomic placement may be reported as Scarabaeoidea: Rutelidae, for example in EPPO (2006).

2. What initiated this rapid PRA?

Following reports of the first incursion of this species in mainland Europe, consisting of large numbers of adults in an area near Milan, Italy in autumn 2014, a review of the UK Plant Health Risk Register scores was carried out. Discussions during this review concluded that a UK PRA was required to further assess the risk *P. japonica* poses to the UK now that it is present in mainland Europe, especially with regard to pathways, establishment and potential UK impacts.

3. What is the PRA area?

The PRA area is the United Kingdom of Great Britain and Northern Ireland.

http://www.avvenire.it/Cronaca/Pagine/popillia-al-nord-xylella.aspx

Using climatic risk maps to help assess establishment potential in the UK: key issues

- Larvae can burrow deep down in the soil (up to 25 cm to avoid extreme cold)
- Life cycle can be extended to 2 years in northern Japan and North America
- Summer temperatures are considered to set the northerly limits to distribution in USA and Canada

Damage to grass by *P. japonica* larvae
(Image from M.G. Klein, USDA Agricultural Research Service, Bugwood.org)

Temperature thresholds utilised

- Minimum temperature threshold for development:
  - 10ºC (Régnière *et al*., 1981)
- Degree-days above threshold to complete development (egg to egg) in one or two years:
  - 1422 days (Régnière *et al*., 1981)

Régnière J, Rabb RL & Stinner RE (1981): *Popillia japonica*: simulation of temperature-dependent development of the immatures, and prediction of adult emergence. *Environmental Entomology* **10** (3), 290-296.

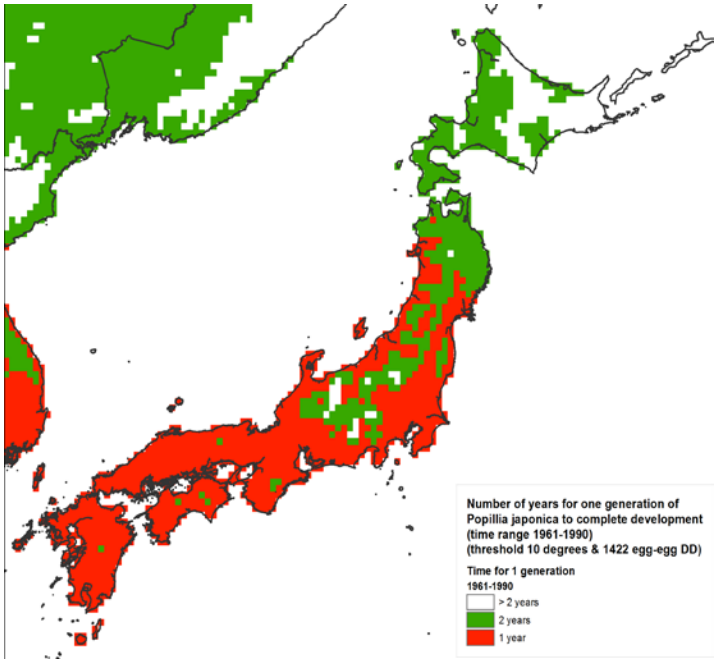
Climate data sources utilised

- Global gridded monthly[1]
  - Global coverage
  - Interpolated 10 minutes latitude and longitude resolution
  - Mean values 1961 to 1990
- Europe gridded daily[2]
  - 11 countries selected: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Switzerland, UK
  - Interpolated to 25 x 25 km resolution
  - Years selected: 2000 to 2014
- UK station daily[3]
  - Kew Gardens, UK
  - 2003 to 2012 selected (excluding 2006 and 2007)

[1]New M, Lister D, Hulme M & Makin I (2002): A high-resolution data set of surface climate over global land areas. *Climate Research* **21** (1), 1-25
[2]http://agri4cast.jrc.ec.europa.eu/DataPortal/
[3]Met Office Integrated Data Archive System (MIDAS) British Atmospheric Data Centre. http://catalogue.ceda.ac.uk/uuid/220a65615218d5c9cc9e4785a3234bd0

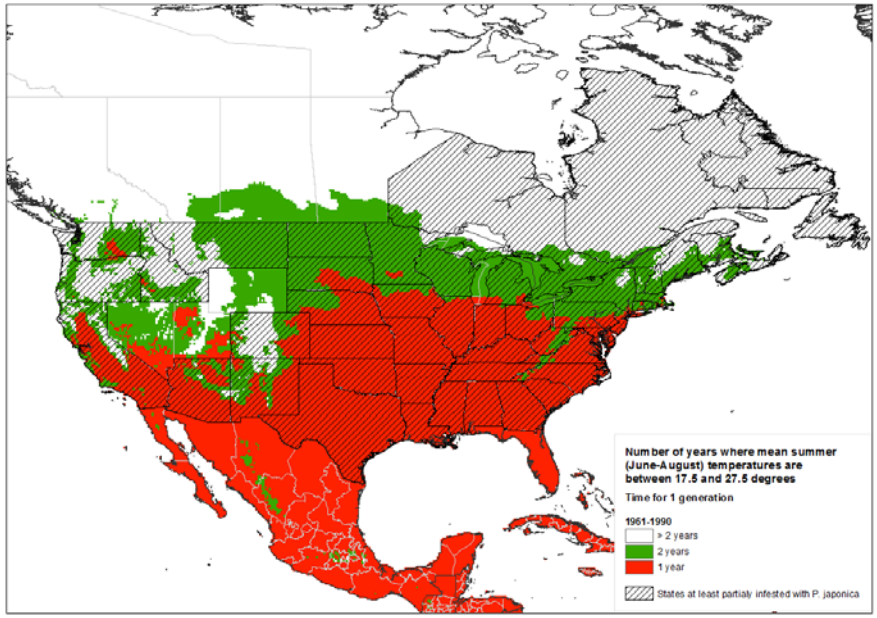
Degree day maps for Japan and North America approximate to known distribution and number of years to complete life cycle

- In Hokkaido, most larvae have a 2 year life cycle

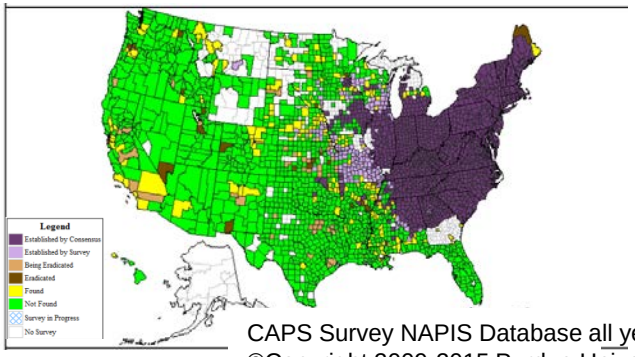


- Few precise location data

- In Canada, present in southern Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island; transient in Newfoundland



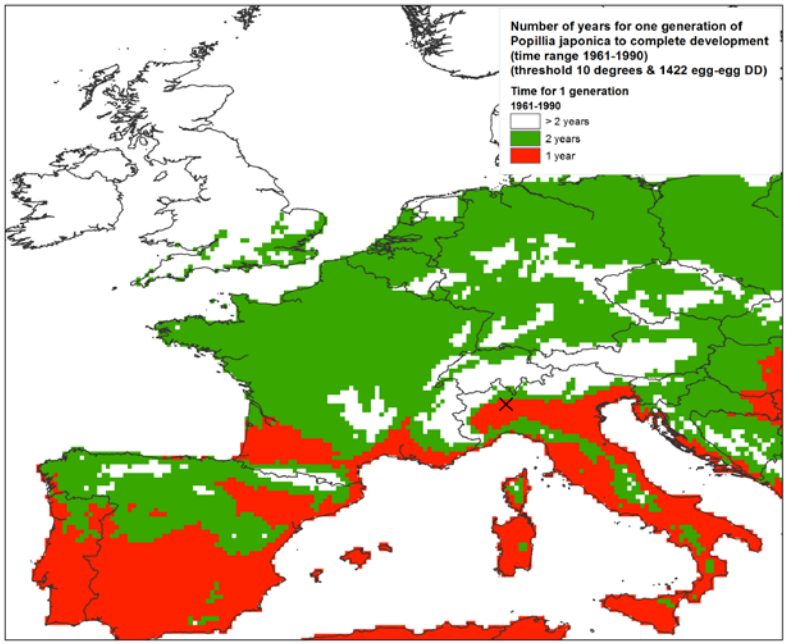
- Two year life cycle occurs sporadically in New Jersey and Pennsylvania



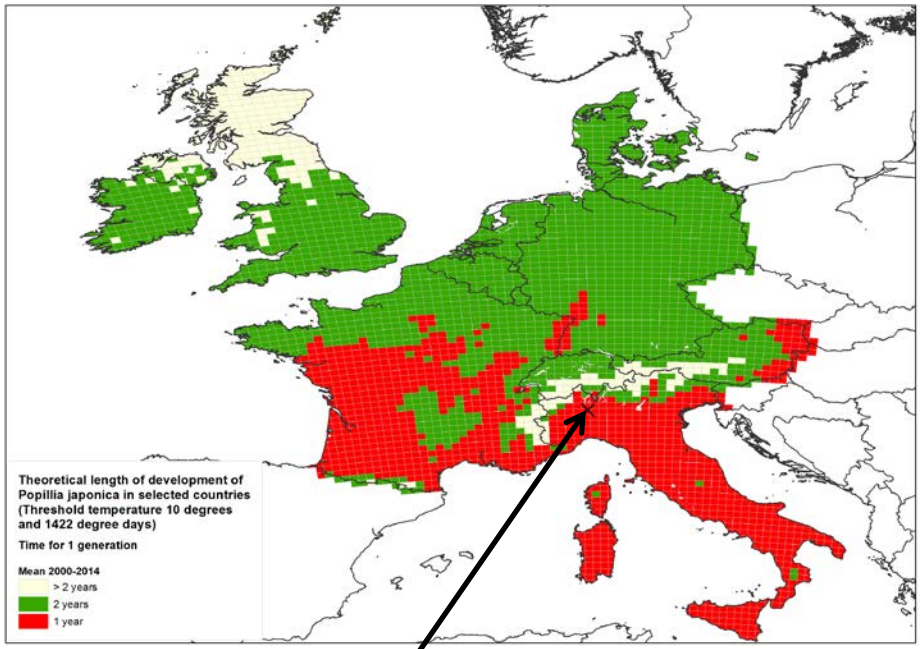
CAPS Survey NAPIS Database all years

Degree day maps for Europe show marked difference in northern limit to distribution between global monthly (1961-90) and European daily (2000-2014) datasets

1. Global monthly (1961-90)



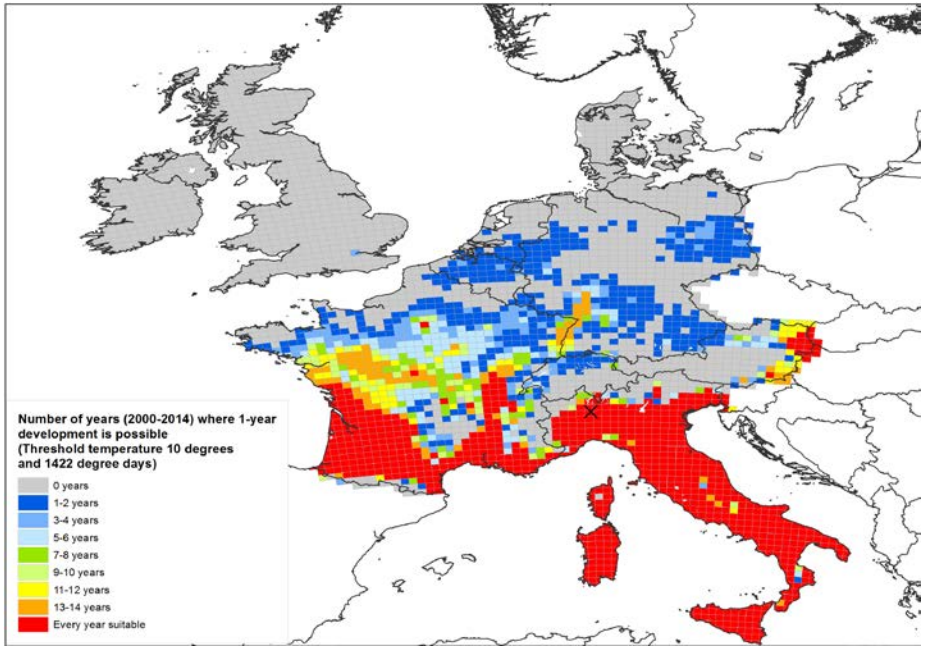
2. European daily (Mean 2000-2014)



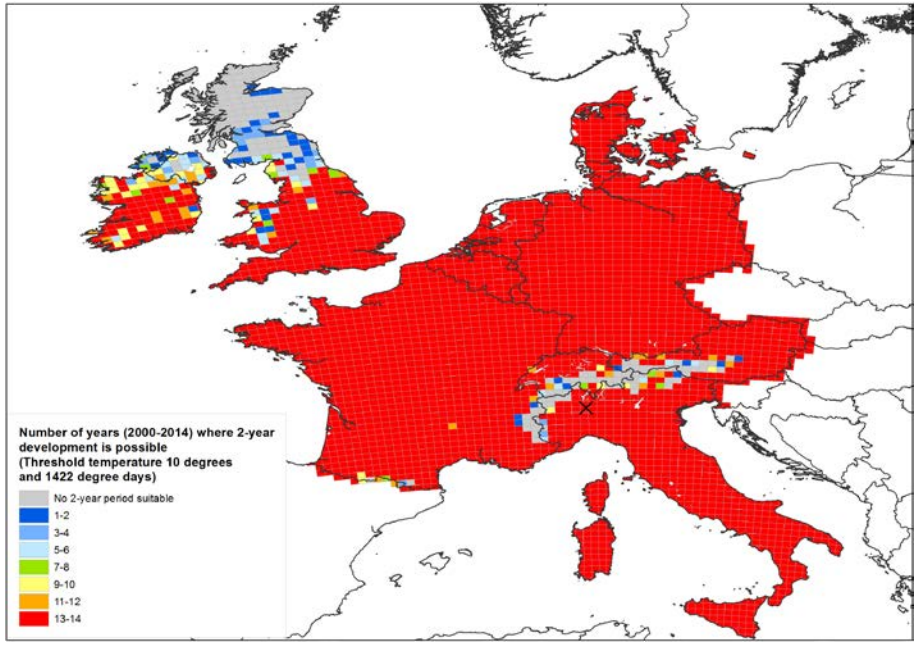
X= Location of the outbreak in Italy near Milan

Popillia japonica: Number of years (2000-2014) where 1-year and 2-year development is possible

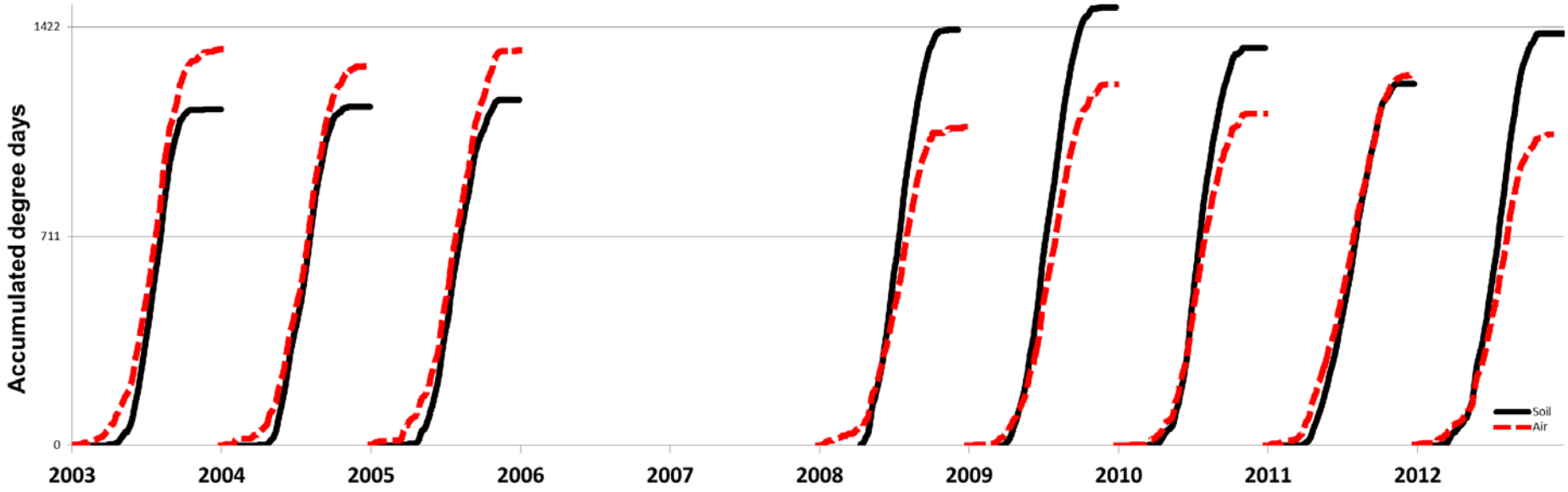
1. One year



2. Two years



Comparing soil and air temperatures



Year	Date 711 accumulated day degrees reached		Difference (days)	Which earlier?
	Soil (10 cm depth)	Air		
2003	07 August	25 July	13	Air
2004	07 August	02 August	5	Air
2005	09 August	29 July	11	Air
2008	19 July	06 August	18	Soil
2009	13 July	06 August	24	Soil
2010	25 July	07 August	13	Soil
2011	11 August	05 August	6	Air
2012	25 July	15 August	21	Soil

- Soil and air temperatures are reasonably approximate for degree-day accumulation
- Buffering effect of soil:
  - In cooler years, soil permits faster development

Conclusions

- Sufficient evidence of climate suitability (establishment rated likely with medium confidence in the rapid PRA) to justify UK measures against *P. japonica*
- The more recent high spatial/temporal resolution European climate data indicates a northerly extension of the potential limit to its distribution in the UK
  - Should we still be using the 1961-90 global climatology?
- Air temperature degree days provide reasonable approximations to soil temperatures
  - How representative are these data?