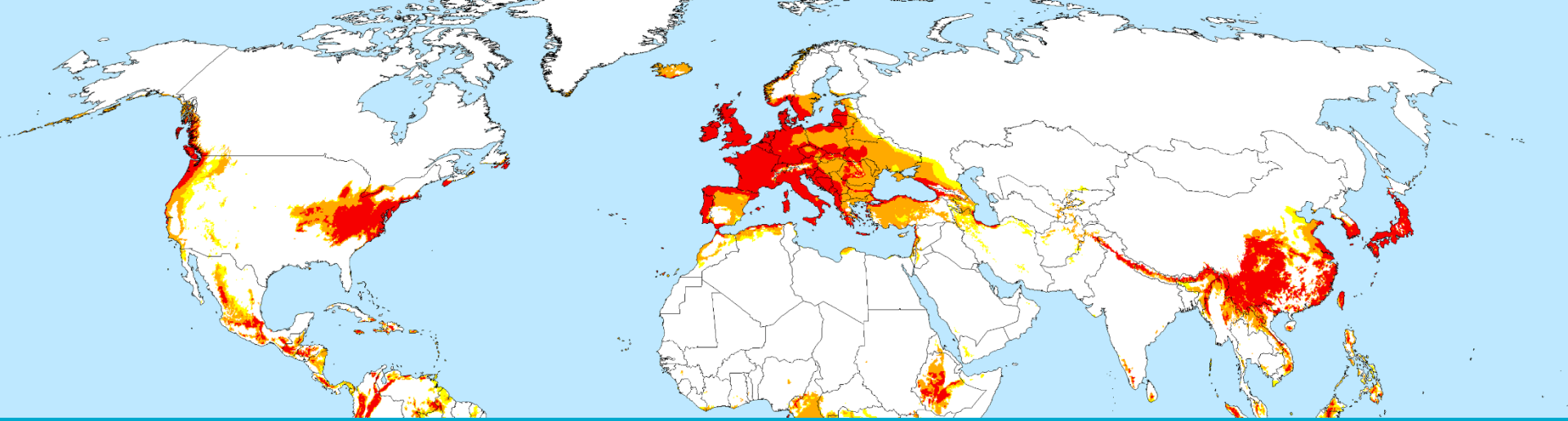

Why are plant pathogens under-represented in eco-climatic niche modelling?

Kylie Ireland & Darren Kriticos

17 October 2018

HEALTH & BIOSECURITY
www.csiro.au

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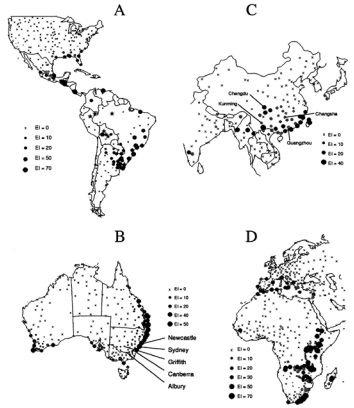
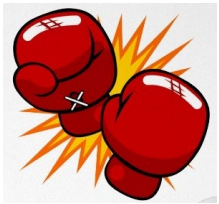
International Pest Risk Research Group 2018, Taichung, Taiwan

Hypothesis

Insect niche models > # Plant pathogen niche models

Agasicles hygrophila – 130 citations
Julien *et al.* 1995



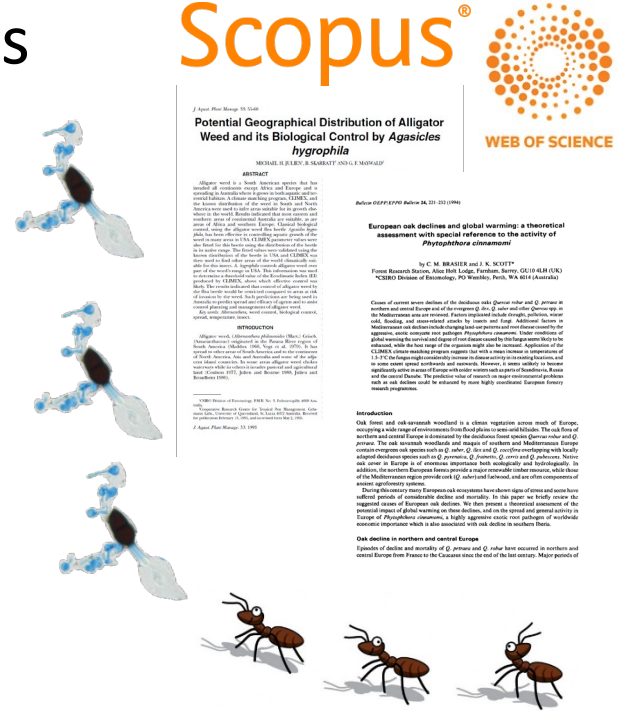


Phytophthora cinnamomi – 178 citations
Brasier & Scott 1992

Fig. 1. CLIMEX-generated ecoclimatic indices of climate stations in the Euro-Mediterranean *region* favourable for the growth and survival of *Phytophthora cinnamomi* (indicated by the relative size of the dot). Crosses are climate stations predicted to be unsuitable for survival of *P. cinnamomi*.

Methods

- Bibliometric analysis - CLIMEX models
- Odds ratio
  - cf. # insects & # pathogens in CABI CPC
- GBIF analysis
  - presence & occurrence records



Results – CLIMEX models

- 180 models
  - 75 % arthropods
  - 25 % pathogens

Taxonomic group	Biocontrol	Endemic	GBIF	Total no. species
Plant arthropod pests	**41**	**10**	**124**	**135**
Coleoptera (beetles)	27		37	46
Hemiptera (bugs)	7	9	31	31
Lepidoptera (butterflies & moths)	5	1	24	26
Diptera (flies)	1		22	22
Tephritidae (tephritid fruit flies)			19	(19)
Acari (mites)	1		4	4
Thripidae (thrips)			3	3
Orthoptera (grasshoppers)			2	2
Hymenoptera (wasps)			1	1
Plant pathogens	**3**		40	45
Fungi	3		30	32
Nematodes			6	8
Oomycetes			3	3
Bacteria			1	2
Total	**44**	**10**	**164**	**180**

Results - Odds Ratio

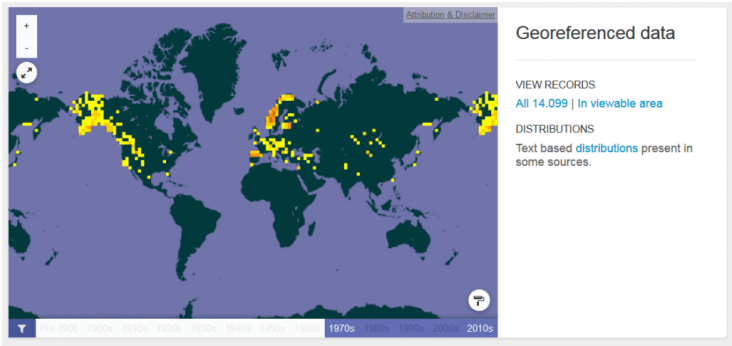
- Plant pathogens less than half as likely to have a published niche model

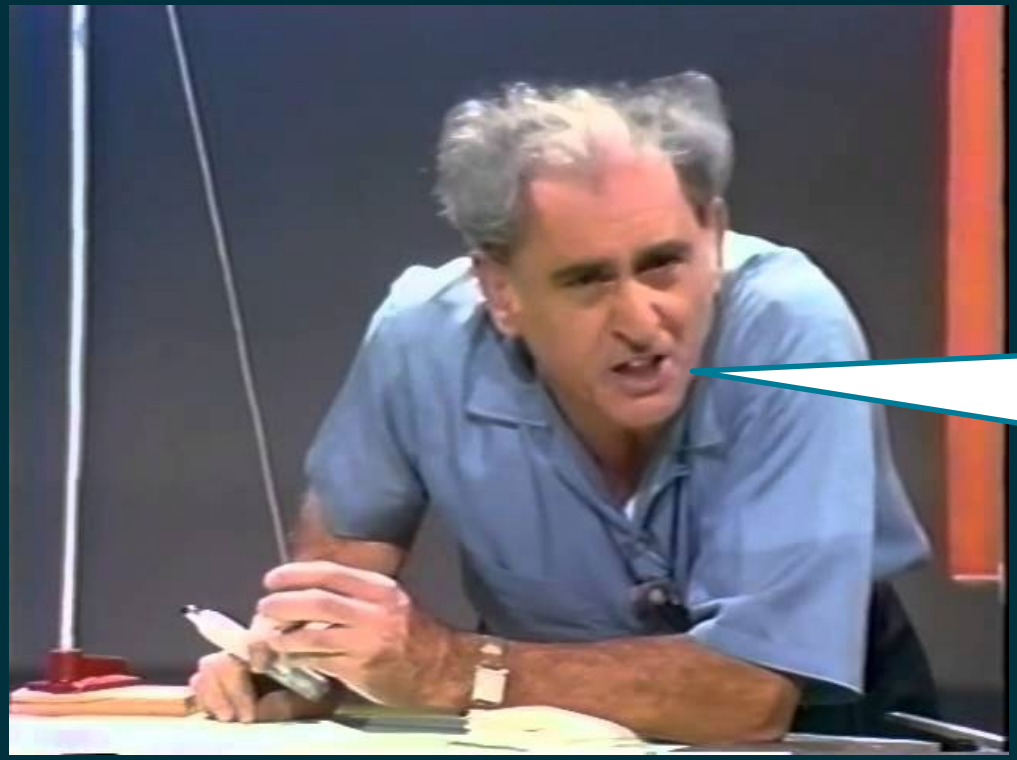
	No. CLIMEX Models	No. Potential Models	Total
Fungal pathogens	35	451	486
Insect pests	131	713	844
Total	165	1164	1330

- OR 0.41; CI 0.28 to 0.61; $P < 0.001$

Results - GBIF Records

- Presence
  - 92% arthropods
  - 89% pathogens
- Occurrence records
  - 7.5 x more for arthropods
  - **25 x more georeferenced**

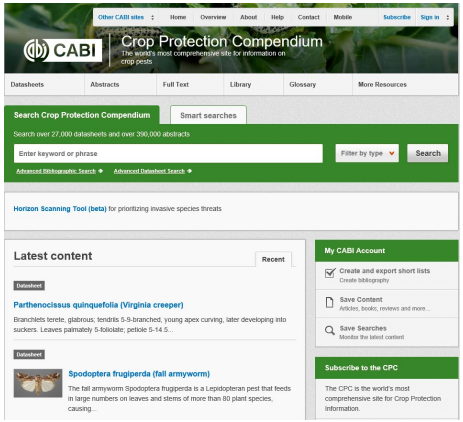




Why is it so?

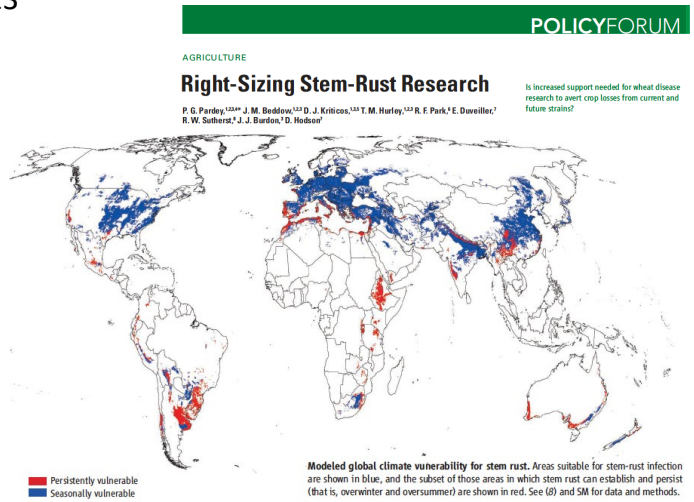
Are there fewer pathogens of concern?

- Yes, but no….
- CABI – there are fewer pathogens of concern compared to insects
  - 486/844 = 0.54
- But, odds ratio takes this into account, & pathogens still far less likely to be modelled
  - OR 0.41; CI 0.28 to 0.61; P < 0.001



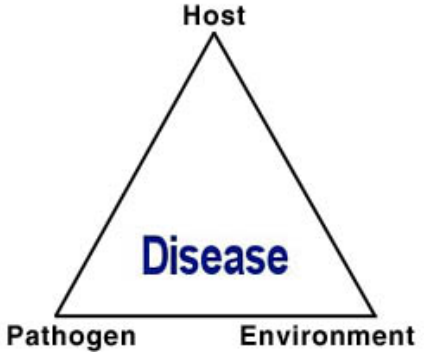
Less demand for pathogen niche models?

- Unlikely
- Bridge plant pathology research and policy
  - Potential distribution
    - Yonow et al. 2004; Watt et al. 2011b; Ireland et al. 2013; Yonow et al. 2013
  - Assets at risk
    - Watt et al. 2009; Kriticos et al. 2013b
  - Costs
    - Pardey et al. 2013; Beddow et al. 2015
  - Climate change
    - Chakraborty et al. 1998; Ganley et al. 2011
  - Management
    - Ireland et al. 2013; Kriticos et al. 2013a; Yonow et al. 2013
  - Resistance breeding investments
    - Pardey et al. 2013; Beddow et al. 2015



Inconsistent experimental & modelling paradigms?

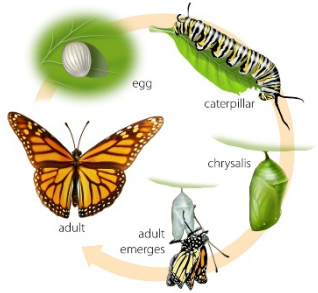
- Likely
- CLIMEX developed within a primarily entomological paradigm
  - But proxies can be made
- Plant pathologists = disease triangle & susceptible-infectious-resistant concepts
- Entomologists = developmental rate of an insect as a function of environment

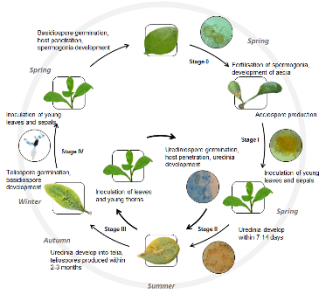


Species.	Controls.		Experiments.					
			Evaporation Produced by					
			Dryness.		Movement.		Temperature.	
	Number.	Rating.	No. Expts.	Rating.	No. Expts.	Rating.	No. Expts.	Rating.
Plethodon cinereus	10	± 3.0	5	−71	2	−66	2	−82
" *glutinosus*	2	± 7.0	1	−88	1	−82	—	—
Pterostichus	1	±11.0	1	−72				
Rana sylvatica	19	± 1.5	5	−68	2	−80	2	−69
Fontaria corrugata	10	± 6.0	6	−43	4	−55	2	−83
Bufo lentiginosa	9	± 8.0	4	−46	2	−23	3	−27
Microbembex	6	± 1.3	6	+ 6				
Geolycosa sp.	7	±10.0	4	+18	2	+16	2	+12

Complicated plant pathogen lifecycles?

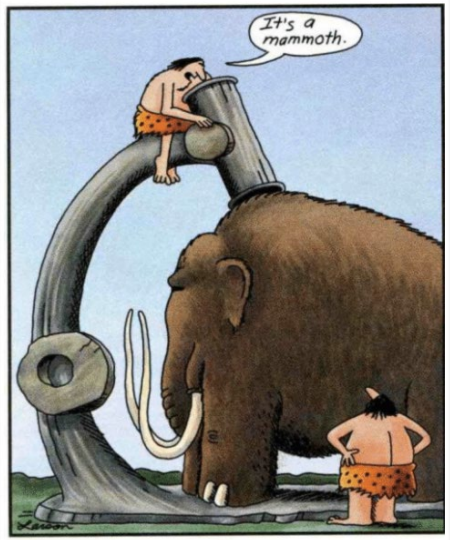
- Unlikely
- Extraordinary similarities in degree of complexity
  - Insects:
    - Survival - facultative or obligate diapause
    - Reproduction - conditional switching vivipary & parthogenesis
  - Pathogens:
    - Survival - hardened spore structures
    - Reproduction - alternation between asexual and sexual spore stages, triggered by adverse weather/host suitability





Does size matter?

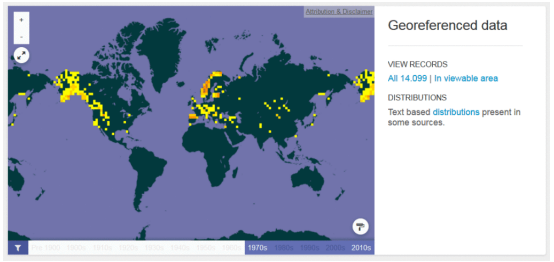
- Yes
- Larger, more visible arthropod species are likely to be easier to study and identify
- Many plant pathogens express similar disease symptoms
  - diagnosis requires time & resources
- Larvae or adults of insects can often be easily associated with and identified morphologically alongside symptoms they cause



Early microscope

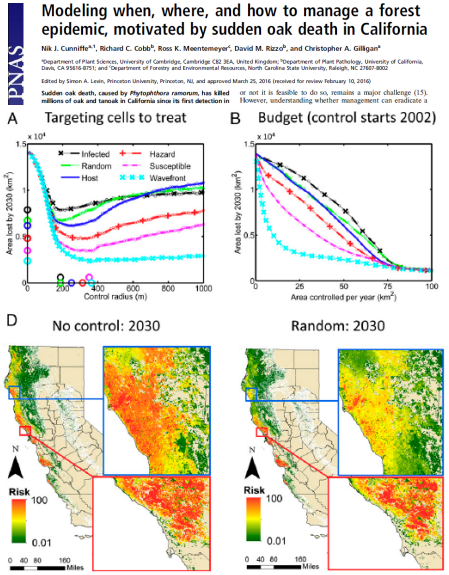
Do distribution data exist?

- No – not in GBIF
- Insects more likely to be represented
- Insects more likely to have larger numbers of (georeferenced) distribution records
- Plant pathogens modellers have to expend more resources on collating and curating distribution data



Lack of similar/relevant studies?

- Yes
- Insects: Larger bodies of research allow for greater latitude to compare with prior studies and explore complex ecological questions
- Pathogens: Disease ecology and ecological niches a relatively new discipline in plant pathology
  - Likely to change as research into large scale plant pathogen epidemics increases, e.g. *Phytophthora ramorum* (Sudden Oak Death) and *Austropuccinia psidii* (Guava, Eucalyptus or Myrtle rust)



Lack of cross-disciplinary expertise?

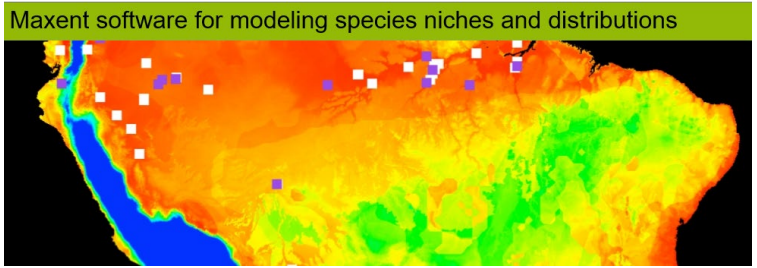
- Yes
- Very few plant pathology trained modellers
- Majority of models developed by those with broader ecological skills, often grounded in entomology

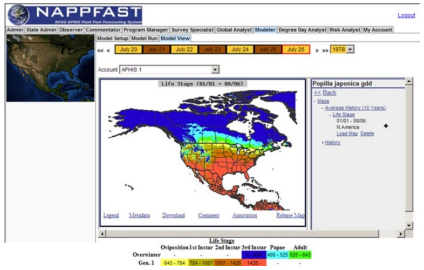
Spot the plant pathologist?

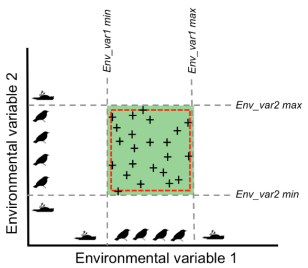
Port Douglas 2010

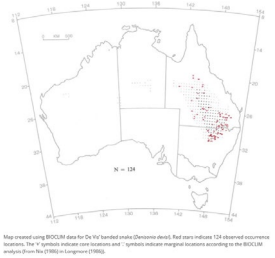
What about other bioclimatic models?

- Expect same trends would hold even when analysing a broader range of eco-climatic niche models or SDMs
- Semi-mechanistic nature of CLIMEX lends itself farther towards examining the conceptual and theoretical underpinnings to account for this disparity









Where to from here?

- Plant pathology ecological niche modelling a growth opportunity
  - Understand & overcome barriers a useful first step
- Opportunity to better understand “the niche”
  - Explicitly engaging in cross-disciplinary exchanges could reveal better ways of studying plant pathogens experimentally, and also different ways of modelling the suitability of habitats

Look out for special issue of International Journal of Pest Management - Modelling the introduction, establishment, spread and distribution shift of pests:
Ireland & Kriticos. Why are plant pathogens under-represented in eco-climatic niche modelling?

Thank you!

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