Can we predict invasion ?

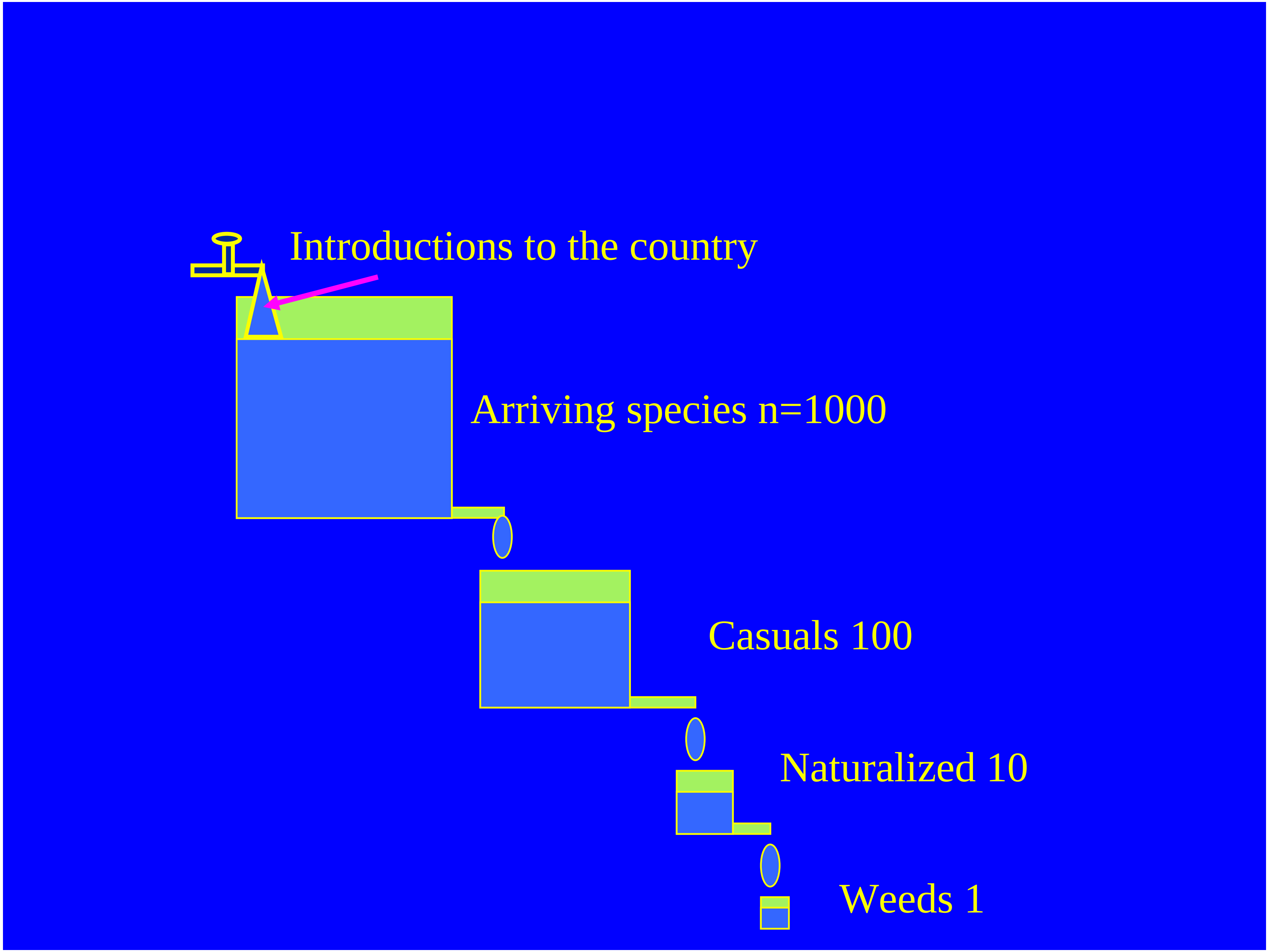
Explaining and predicting

the success of invading species

at different stages of invasion

Mark Williamson

University of York


Introductions to the country
Arriving species n=1000
Casuals 100
Naturalized 10
Weeds 1

Variability of invasions and the cascade

Stages	Variability largely from
Introduction (imported & casual)	Social and Economic factors
Establishment	Biogeography and Ecology
Success (spread & consequence)	Ecology and Evolution

Correlates of invasion success

(explanations, which are NOT predictions)

Historical (quite good)	Previous success Propagule pressure
Populational (moderate)	Abundance Range Intrinsic rate of increase Absence of enemies
Individual (often poor)	Climatic matching Taxonomic isolation Anthropogenic Size and other measures Wide niche Empty niche Genetic characteristics

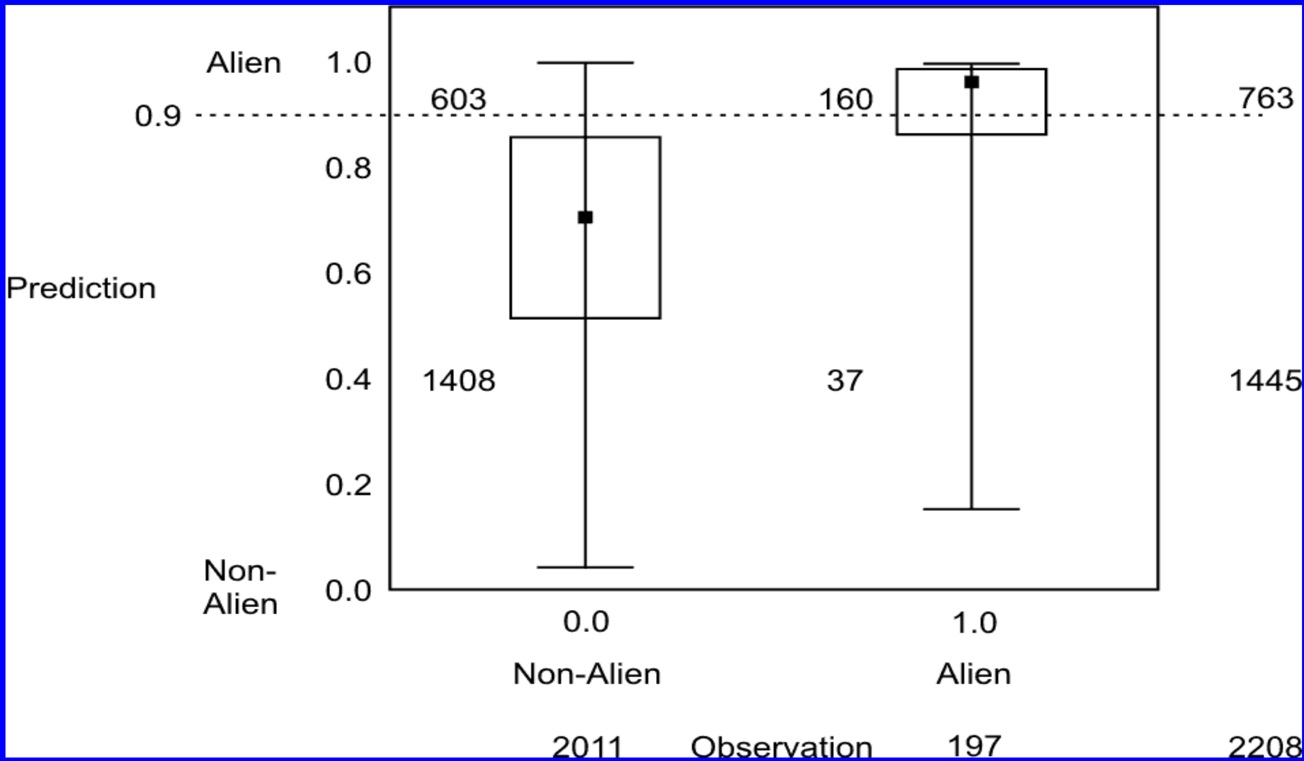
Some reasons why prediction may fail

General:	Target not specific enough
Statistical:	Significance statistical but not useful
	Extrapolation and outliers
	Statistical shrinkage
	Base rate effect
	New variables
Biological:	Lack of phylogenetic correction
	Time lags or delays
	Non-linearity, complexity
	Situation specific detail

An example of base rate effect

Plants native in Germany

some of which are alien in Argentina



Accuracy (sensitivity) = 160/197 81%

Reliability (positive predictive value) = 160/763 21%

Prevalence = 197/2208 9%

Climatic matching

Some reasons for caution

even in explantion

let alone prediction

Cabomba caroliniana in Australia

introduced from America

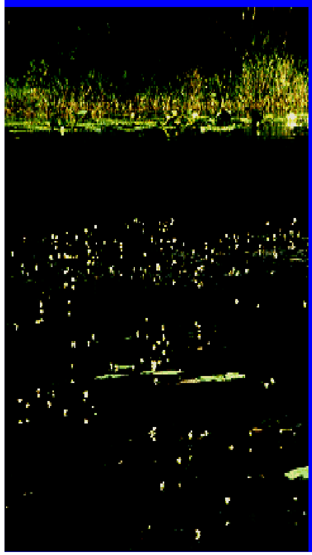


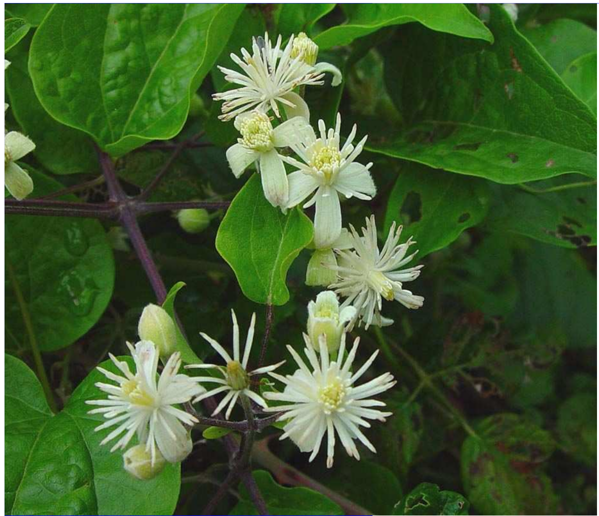
Figure 3. The known distribution of cabomba in Australia.

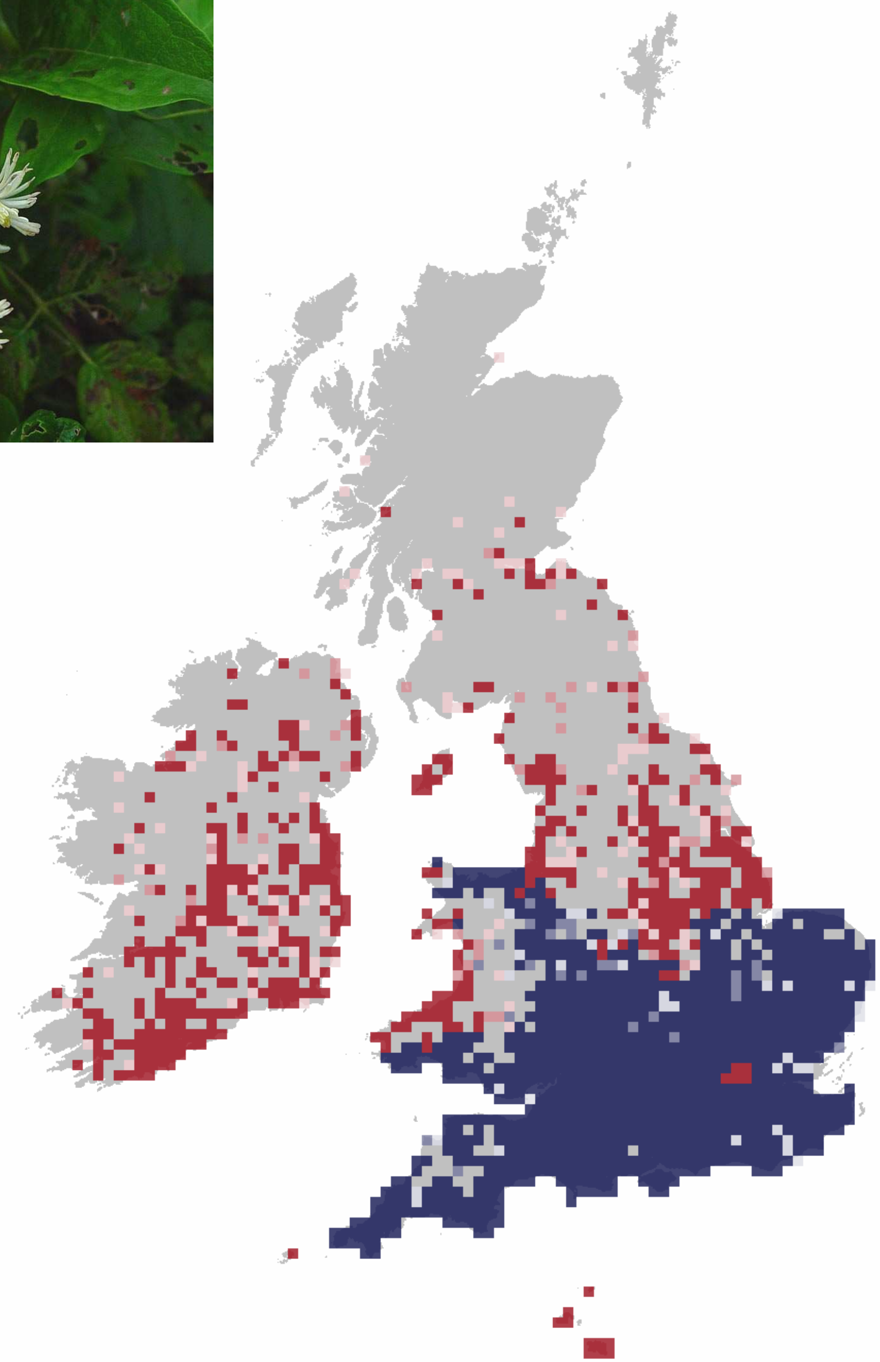
Figure 4. The distribution of *Cabomba caroliniana* in Australia predicted using CLIMEX (EI=Ecoclimatic Index; EI=10, potential for a permanent population extremely low; EI=100, this potential extremely high).

Distribution in 1998

Climex prediction

GARP prediction





Clematis vitalba

Hectad distribution

from the 2002

New Atlas

Blue native

Red introduced

Hectads
are
(10 km)^2

Range size :

A good explanation

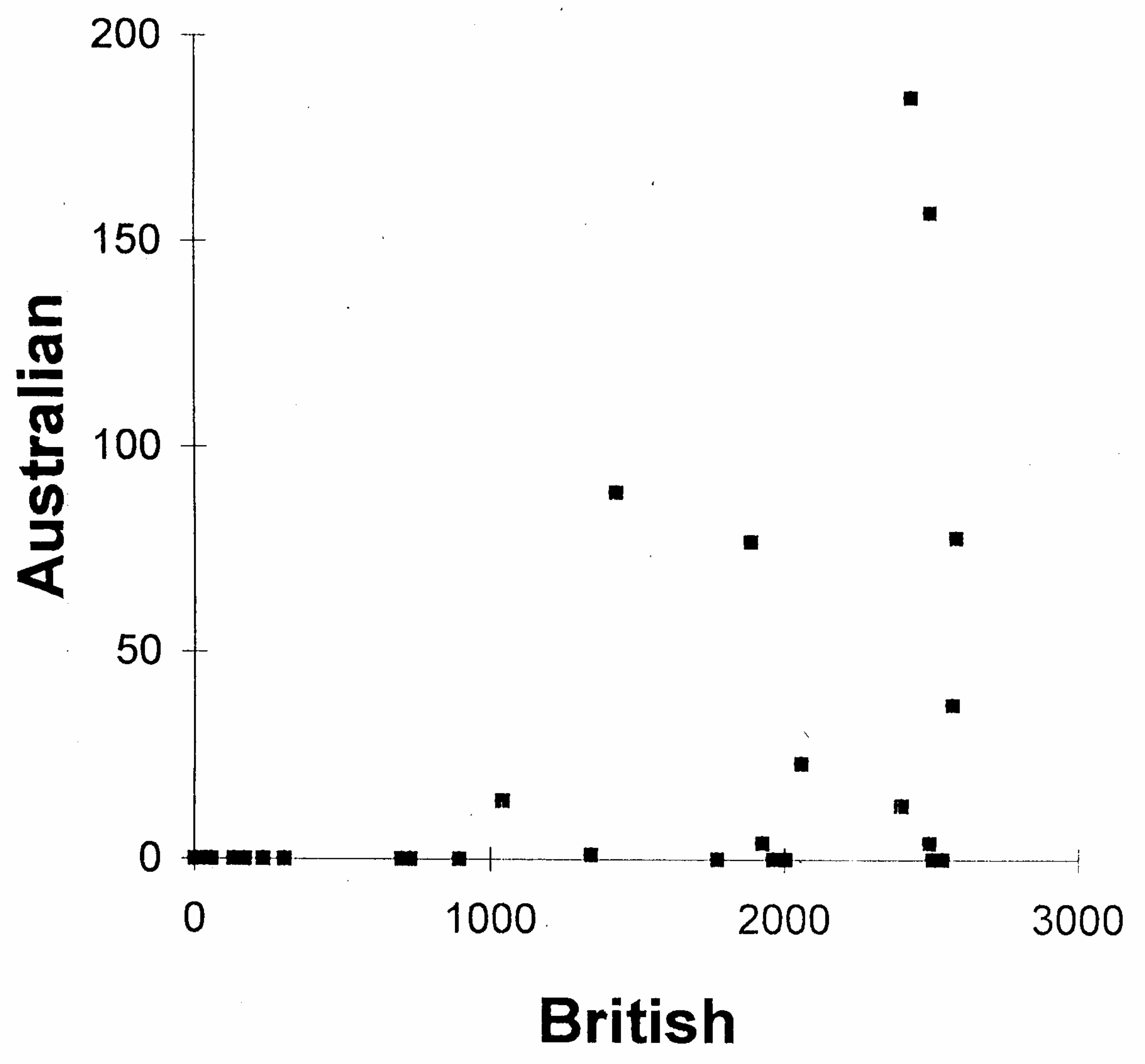
but

a poor predictor

Breeding birds

Degree squares,

introduced

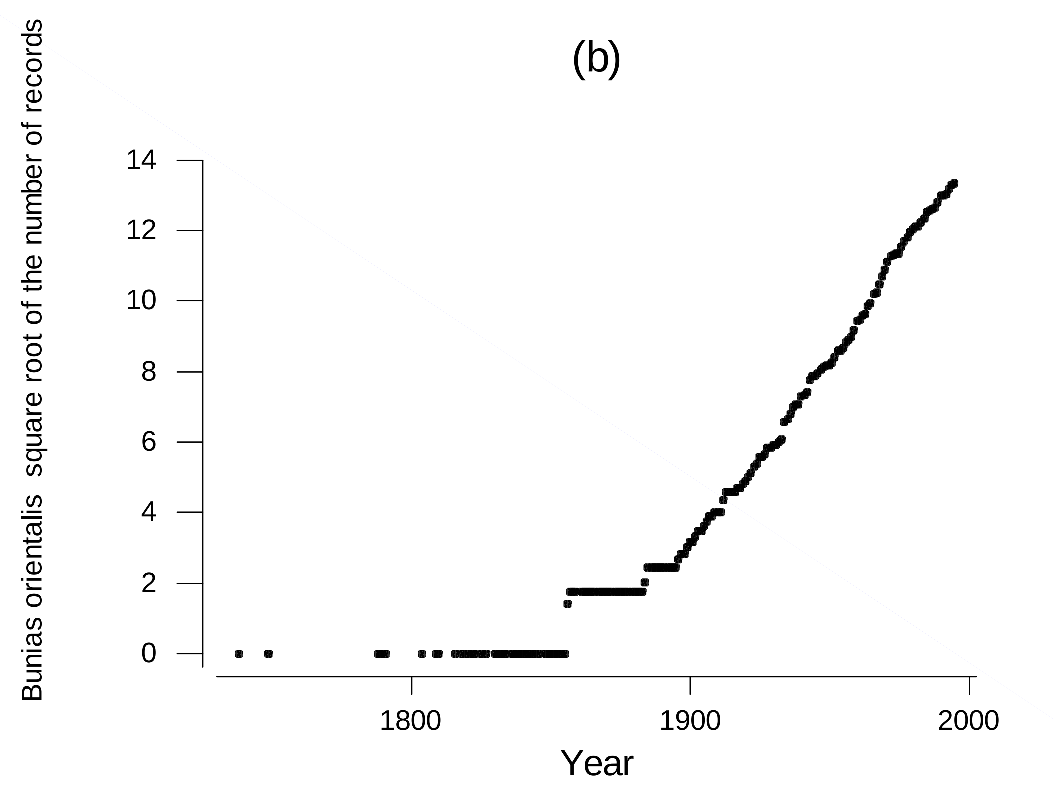


hectads, native

Pattern and rate of spread

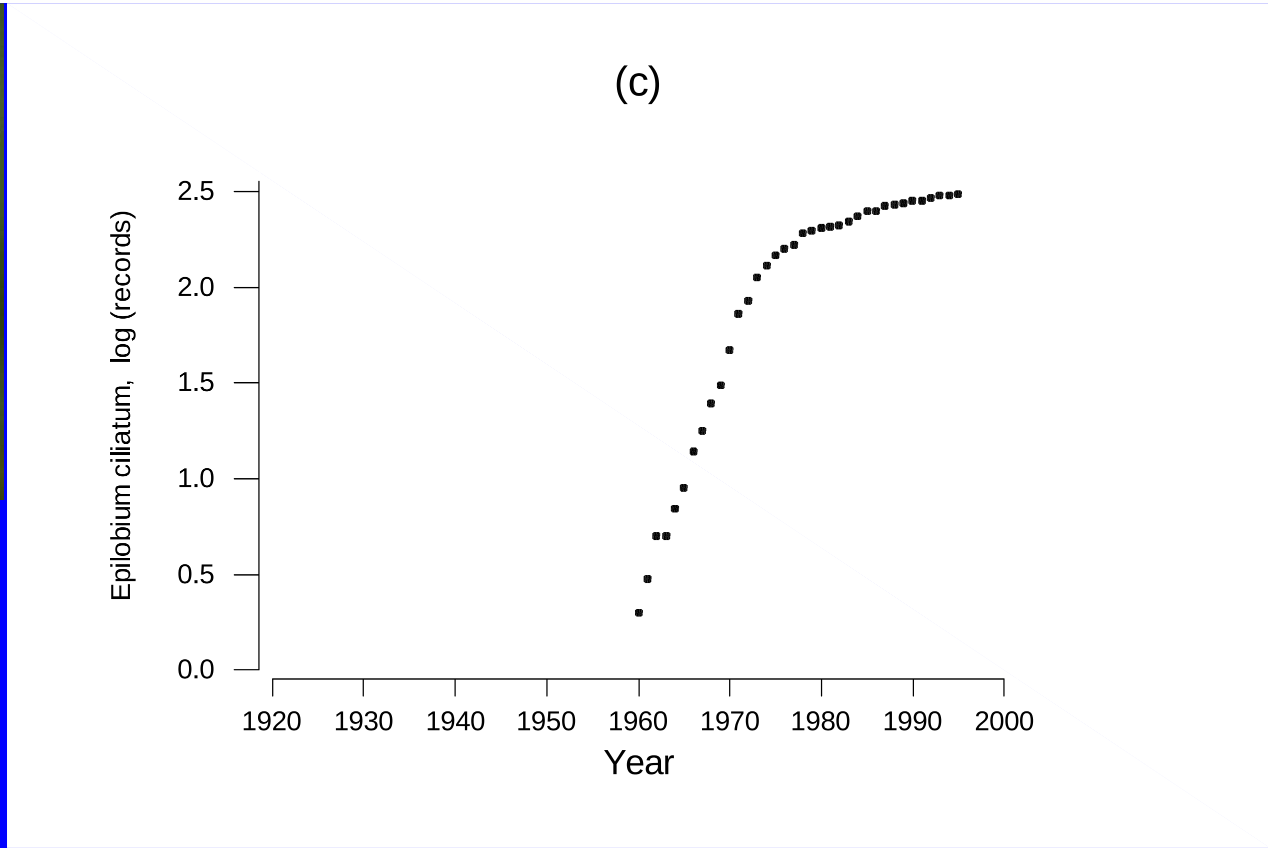
Unexplained variation

note
the
lag



52 sp./place records are straight on sqrt plots
(ripple spread, maybe)

sqrt (km/year) is normally distributed over spp.



note the bend

36 sp./place records are straight on log plots
(jump spread, maybe)

log(doubling time) is normally distributed over spp.

Summary of Czech shapes

	log	log→sqrt	sqrt/log	sqrt	Σ	arith	none
ALL	12	6	12	20	50	10	3
bend & lag	1	3	2	3	9		
bend	9	0	5	8	22		
lag	0	1	4	8	13		
neither	2	2	1	1	6		

Conclusion

The type of explanation is different at different stages

Prediction can be orthogonal to explanation and Is much harder

Colleagues at York:

Julia Touza James Perrins Charles Perrings Alastair Fitter

Katharina Dehnen-Schmutz Silvana Dalmazzone Kevin Brown

Other joint authors of invasion papers:

Maj Wonham Grady Webster Andrew Watkinson Betsy Von Holle

Montse Vila Mark Telfer Carey Smith Peter Simmons Dan Simberloff

Jay Shogren Tim Seastedt Dave Richardson Marcel Rejmánek

Sarah Reichard John Randall Petr Pyšek Chris Preston Karel Prach

Ingrid Parker Akira Okubo Jim Murray Peter Moyle Philip Maini

Mark Lonsdale Hans Kornberg Jan Kirschner Peter Kareiva

Vojtech Jarošik Frederic Hrusa Martin Holdgate Debbie Hayes

Alan Gray Karen Goodell Lloyd Goldwasser Jim Drake

Doriana Delfino Mick Crawley Gordon Conway Liz Chornesky

Jeb Byers Michael Barbour Ed Barbier Ian Atkinson

Summary of Czech shapes

	log	log→sqrt	sqrt/log	sqrt	Σ	arith	none
ALL	12	6	12	20	50	10	3
bend & lag	1	3	2	3	9		
bend	9	0	5	8	22		
lag	0	1	4	8	13		
neither	2	2	1	1	6		

The Invasion Process, a cascade:

Brought in	imported
Released or escapes	casual
Populations established	established
Population spreads	spreading
Population of consequence	pest etc.

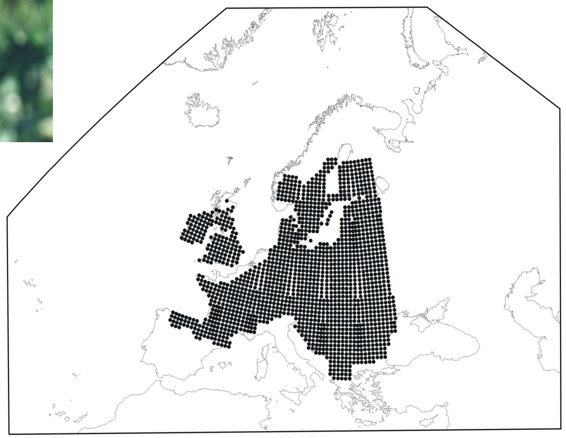
The probability of each cascade step is usually small

Millennium audit of alien species in Scotland

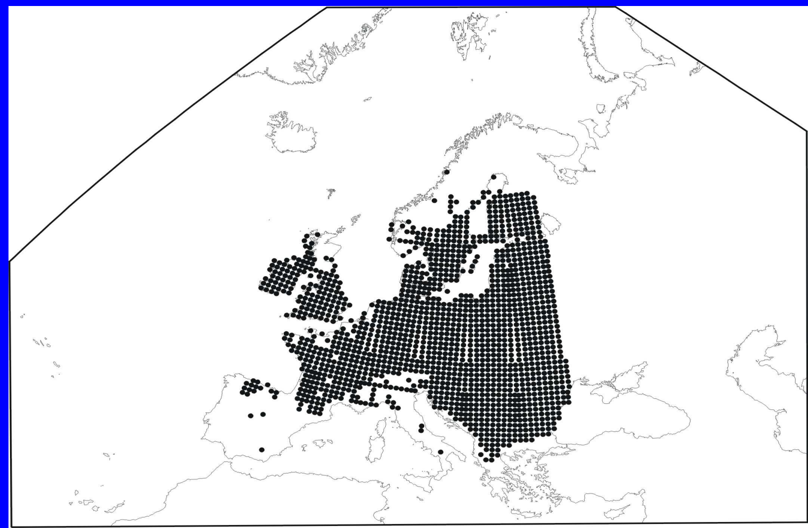
Group	Recorded	Established	Controlled
Vascular plants	824	77	7
Mammals	13 (+)	11	8
Birds	49 (+)	8	2
Insects	22 (++)	12 (+)	0

(+s refer to the vascular plant standard)

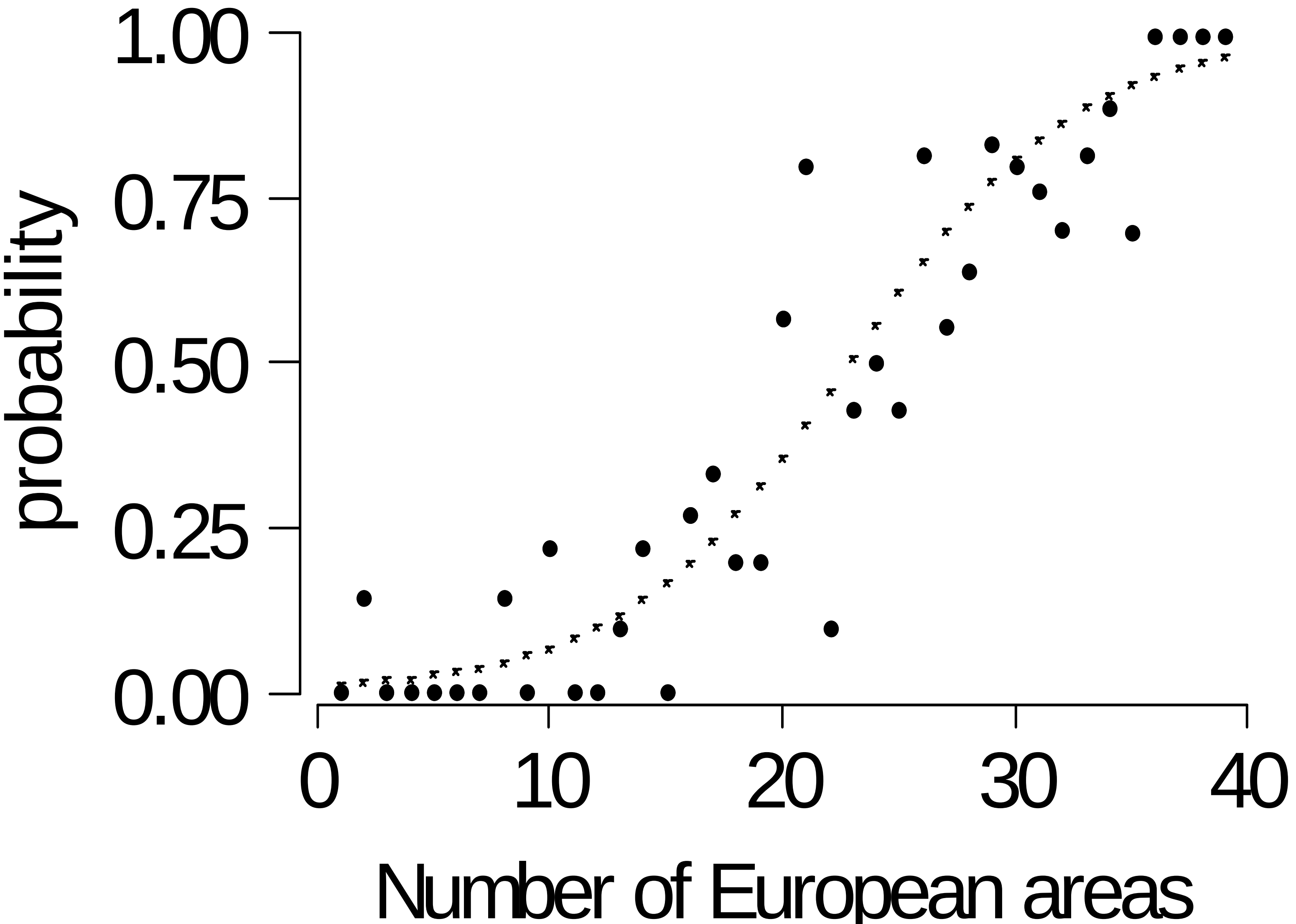
Aphantopus hyperantus – ringlet
recorded current distribution (from Tolman 1997)



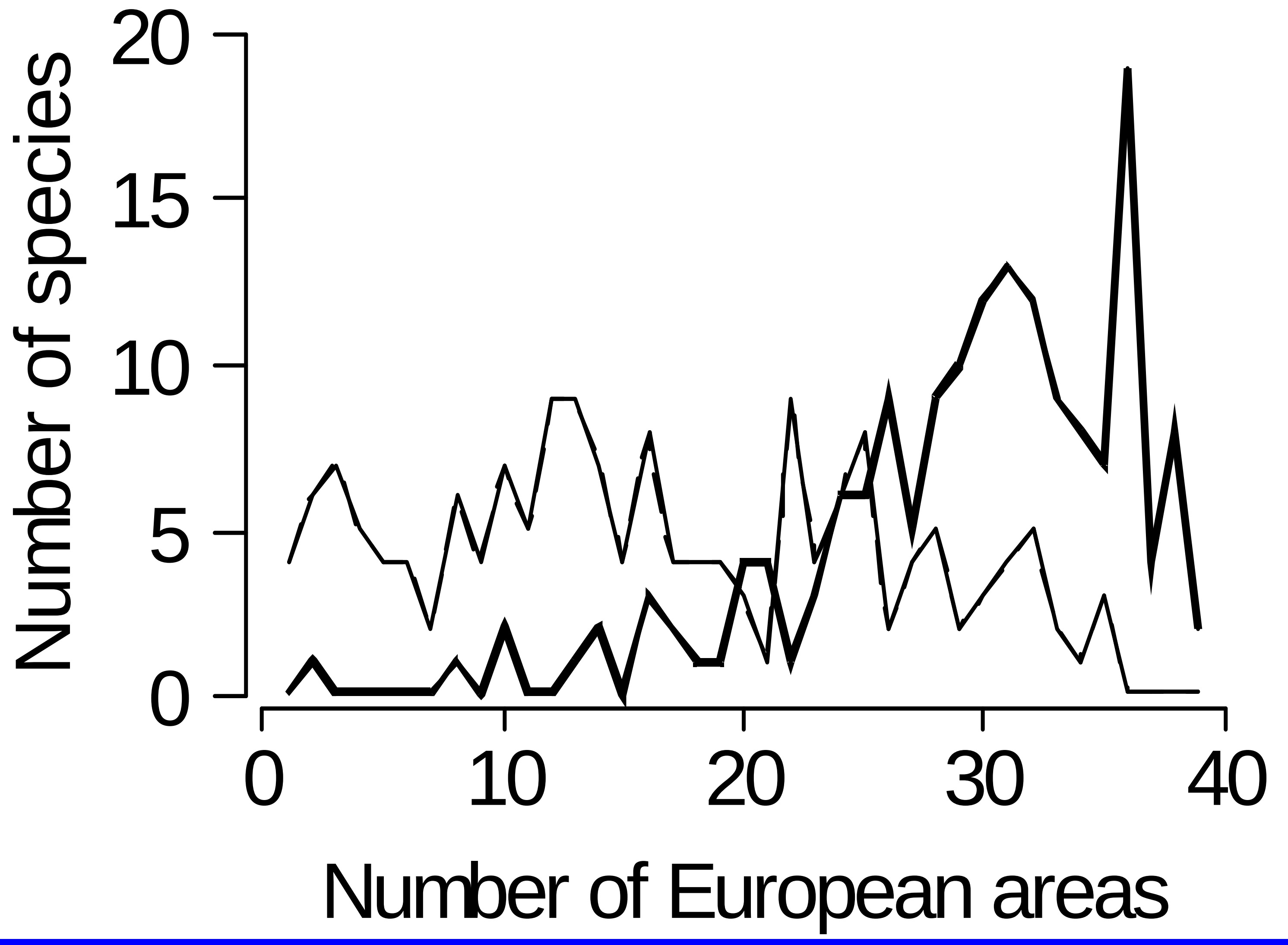
simulated current distribution from climate model (3 variables)

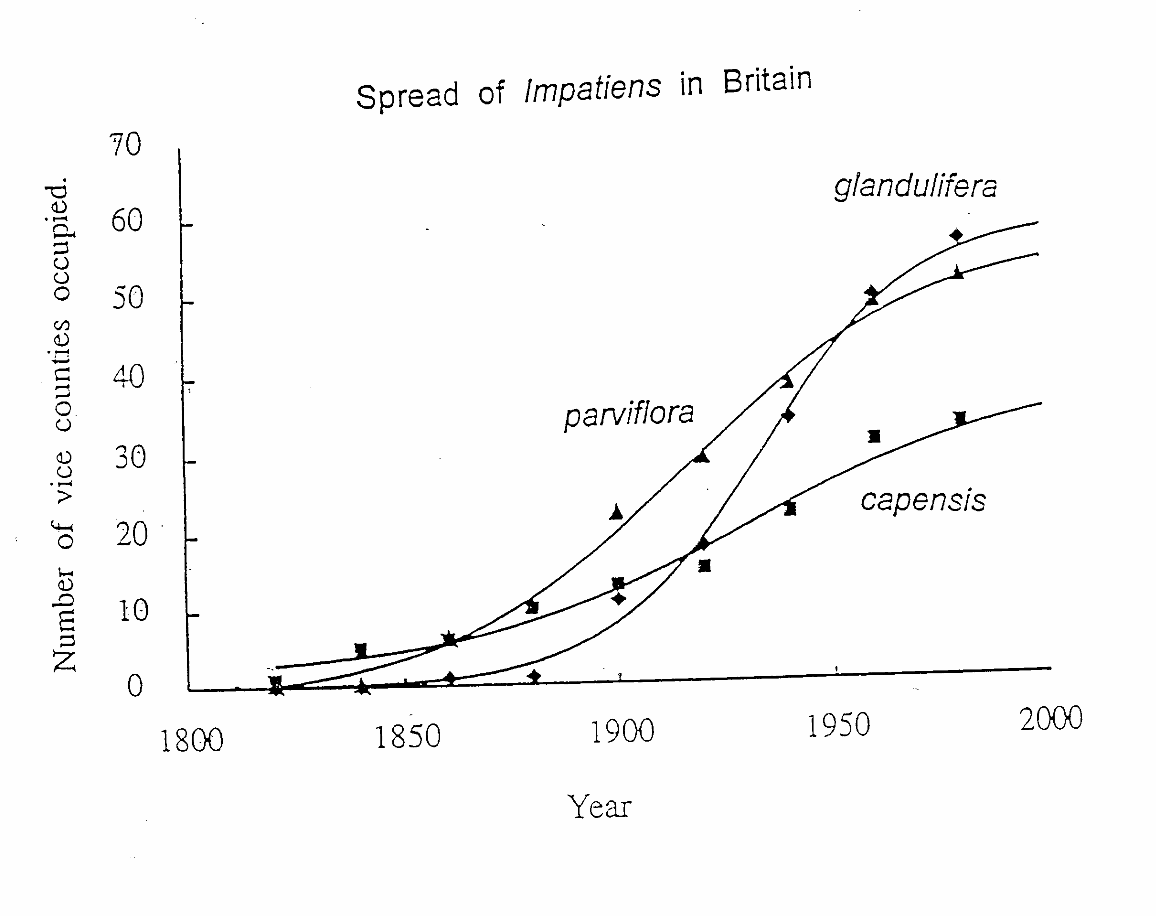


European plants in Canada

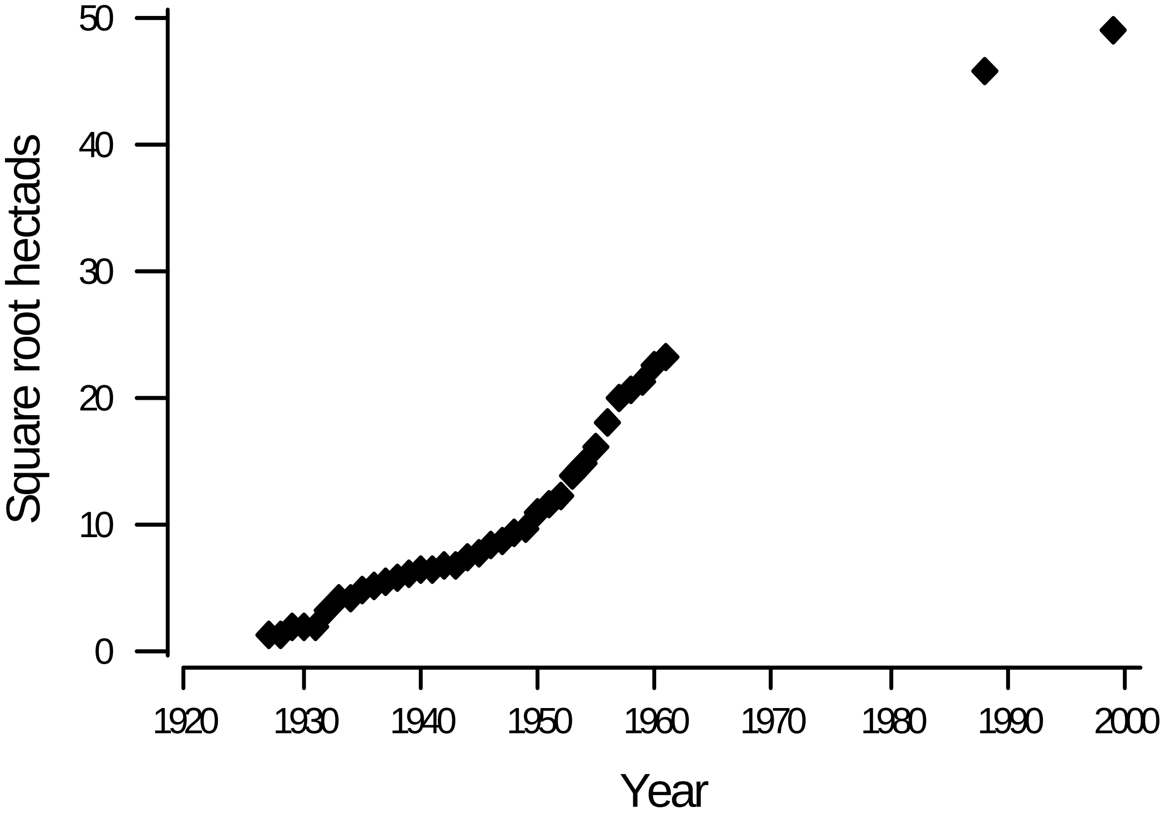


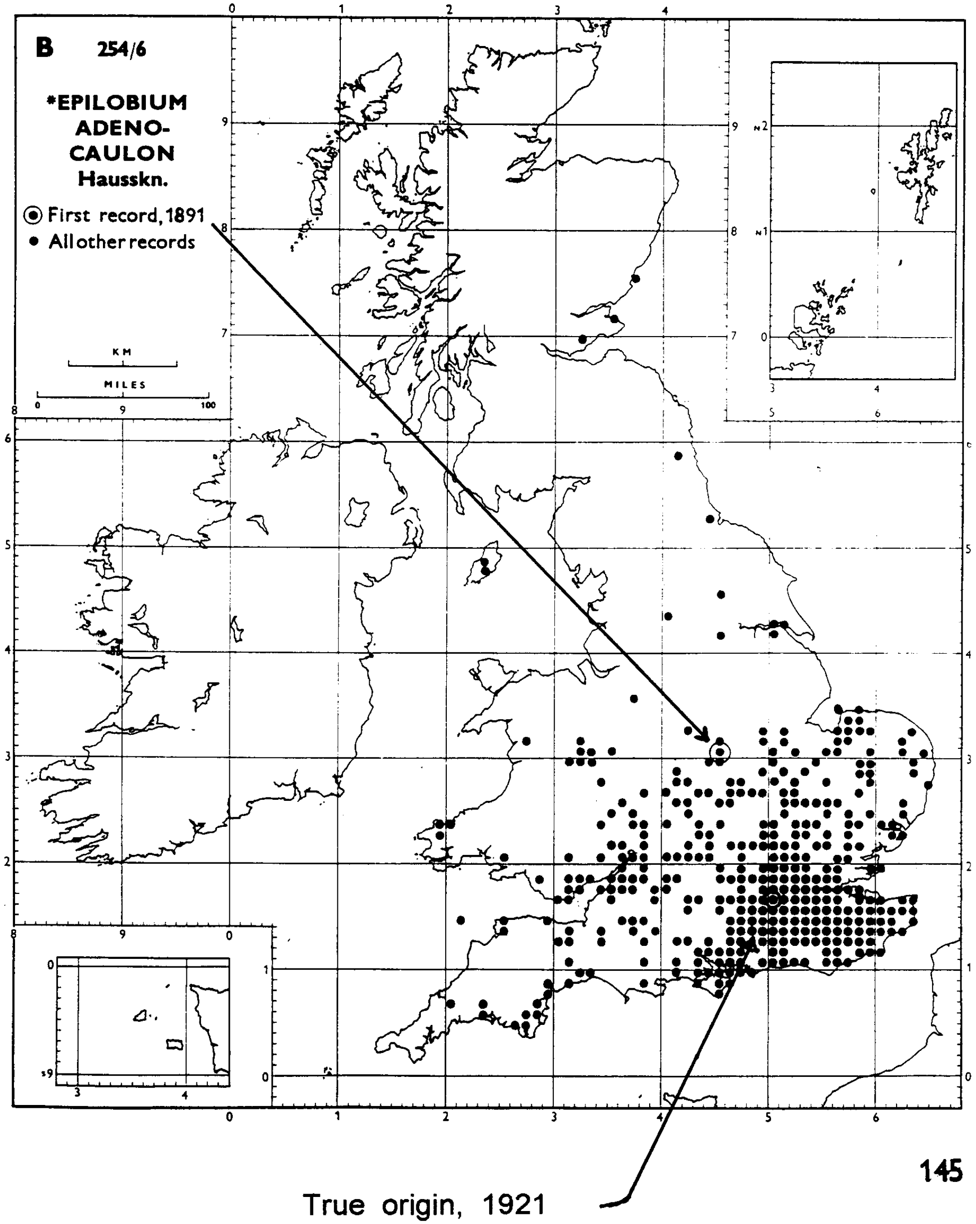
European plants in Canada




Spread of Impatiens in Britain
Number of vice counties occupied.
Year
0
10
20
30
40
50
60
70
1800
1850
1900
1950
2000
glandulifera
parviflora
capensis

Veronica filiformis in the British Isles



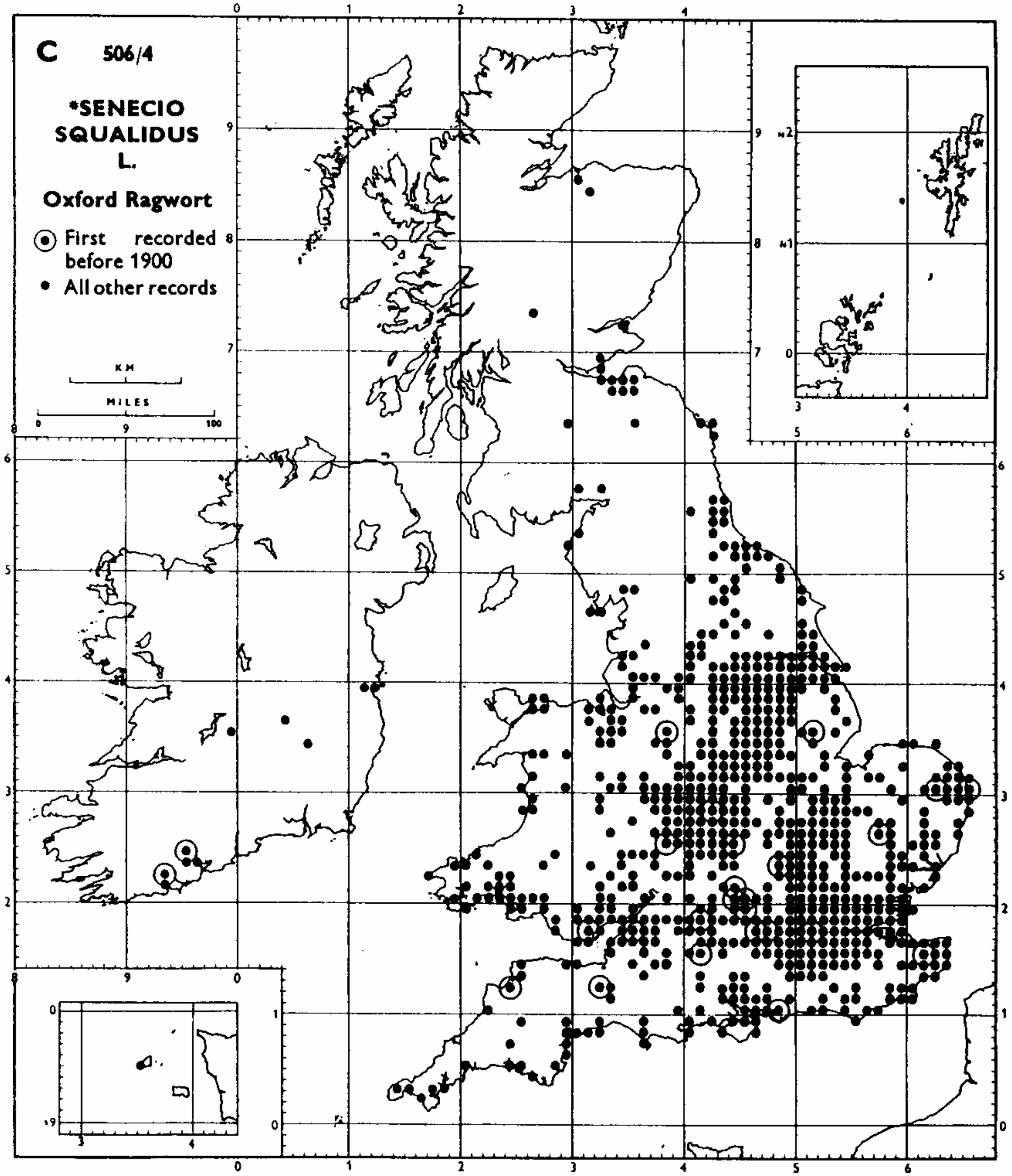


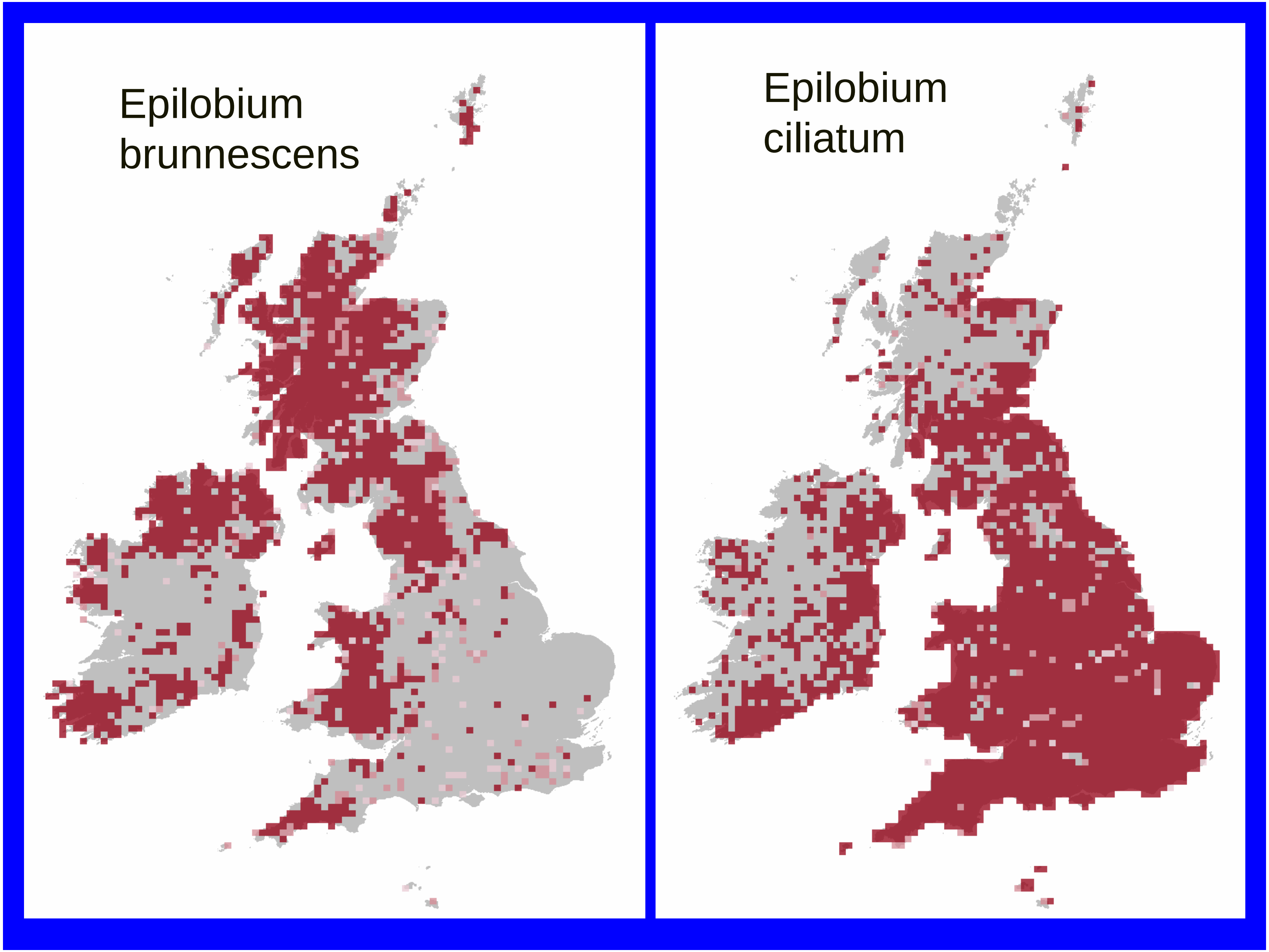
Epilobium ciliatum

previously *adenocaulon*

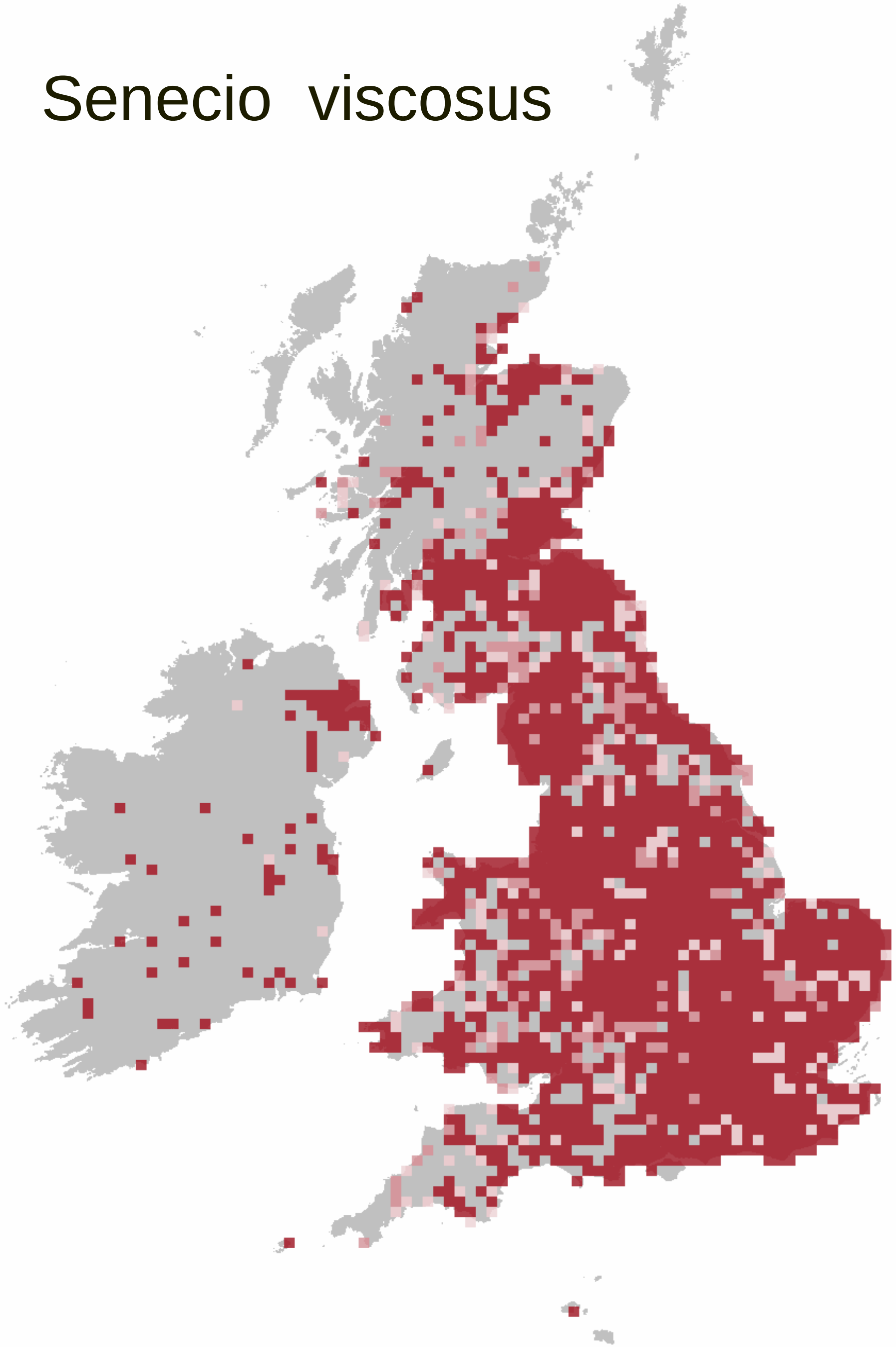
American willow-herb

Senecio squalidus from a hybrid swarm on Mount Etna ca. 1700
Escaped ca. 1794

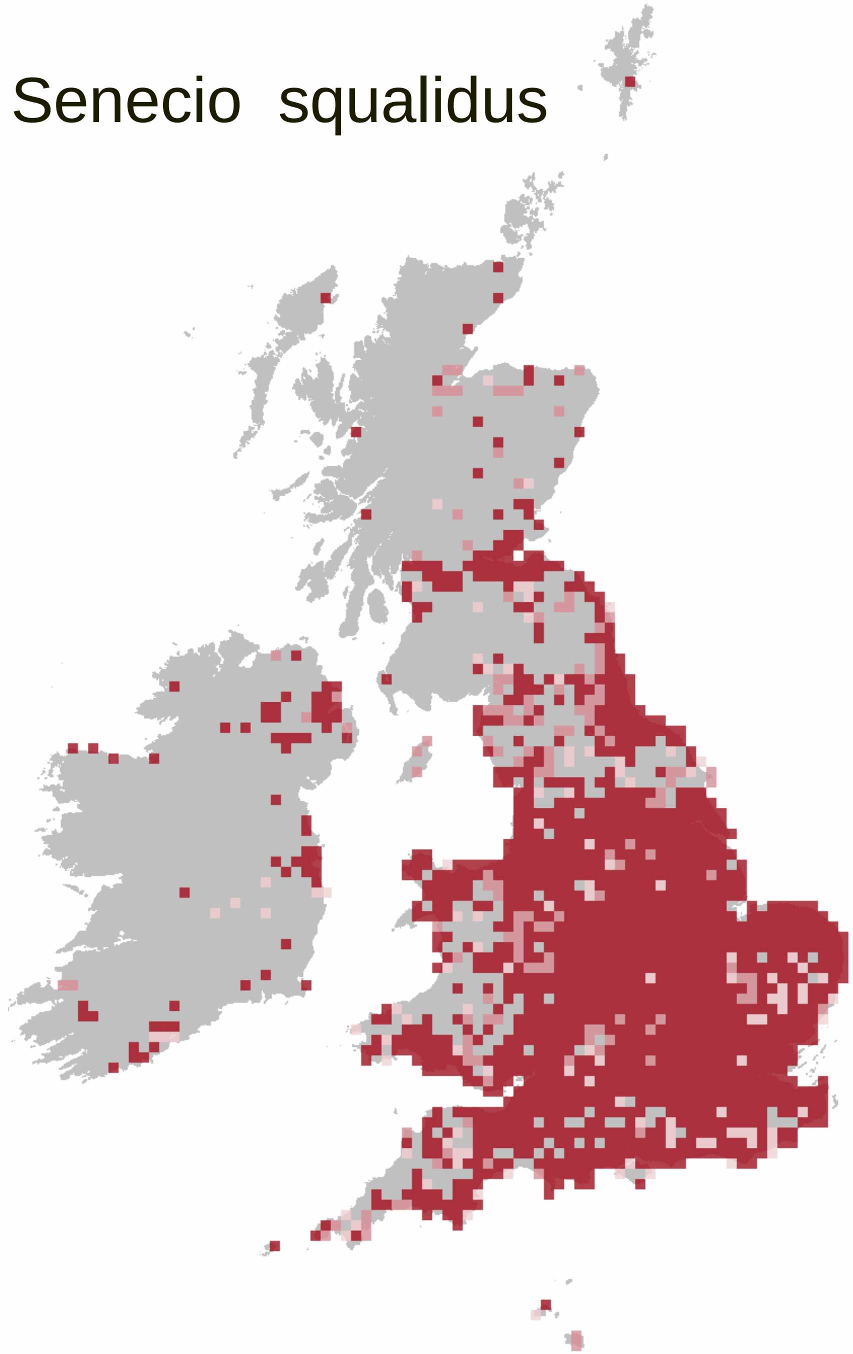



Epilobium brunnescens
Epilobium ciliatum

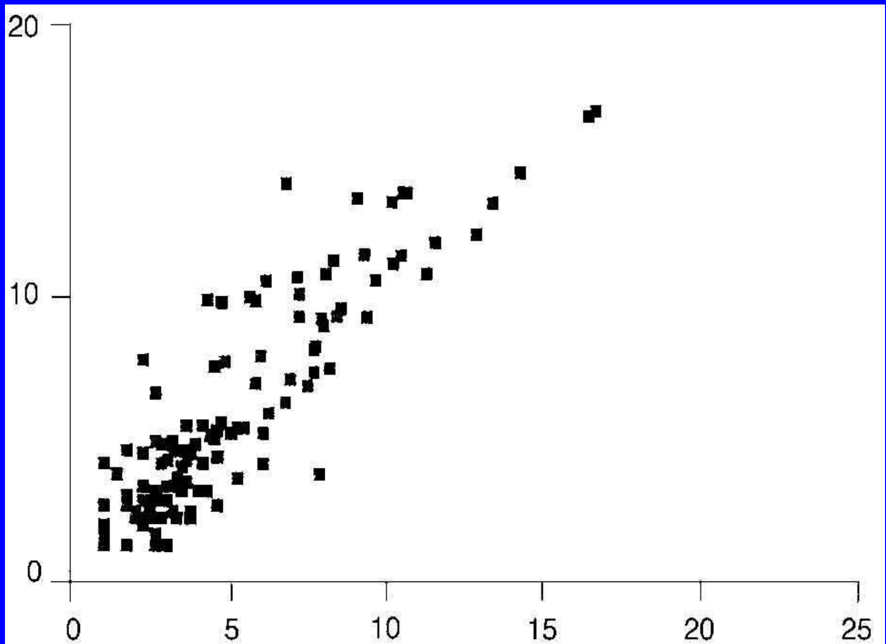
Senecio viscosus



Senecio squalidus

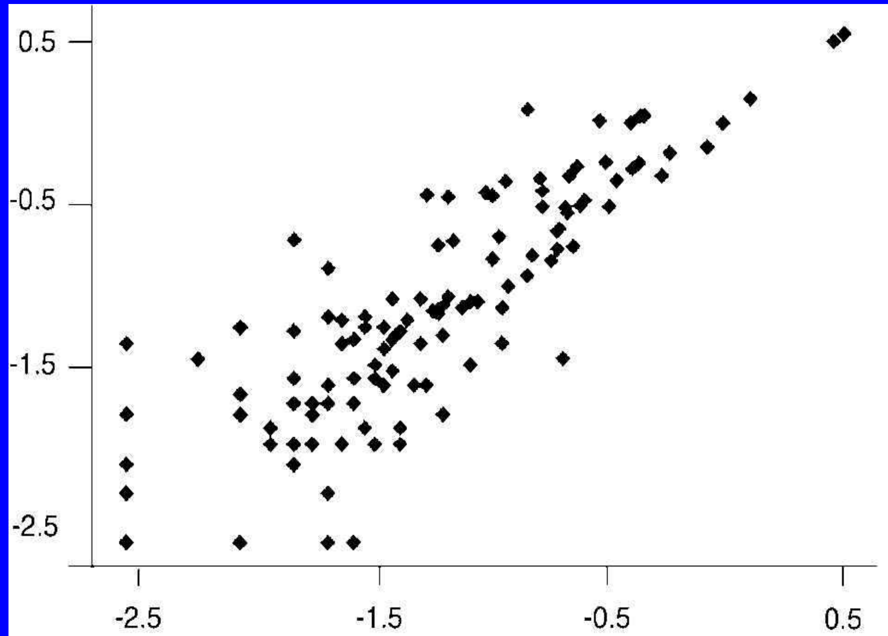


1988 square roots



1958

1988 logits



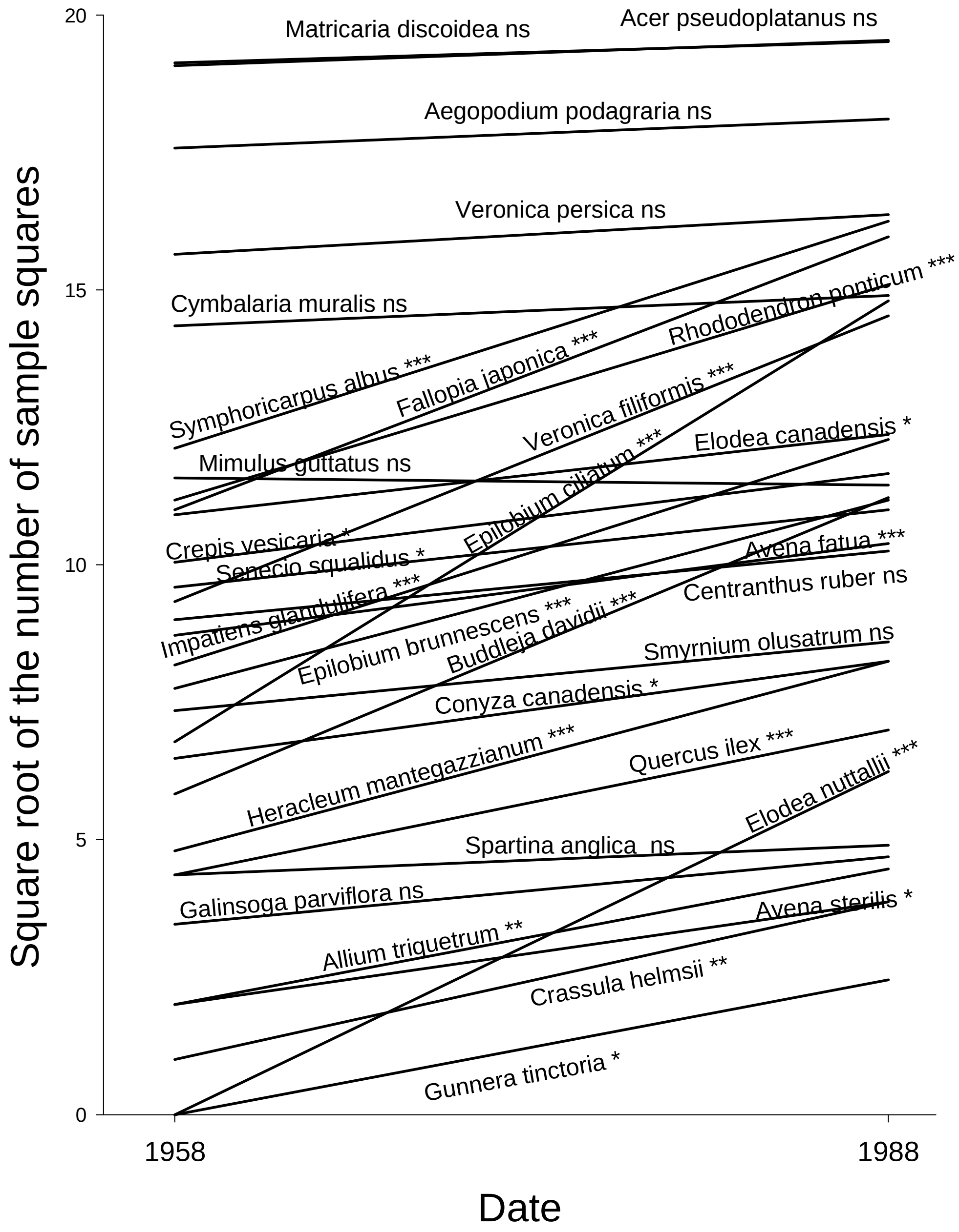
1958

Parrot success : most significant factors at each stage

	Transport	Release	Establishment
International trade	***	***	**
Range size		***	
Latitutudinal range	***	***	
Altitudinal range			**
Captivity / pet	***	***	
Pest		***	
Diet breadth			**
Fledgling period			**
Migration			**

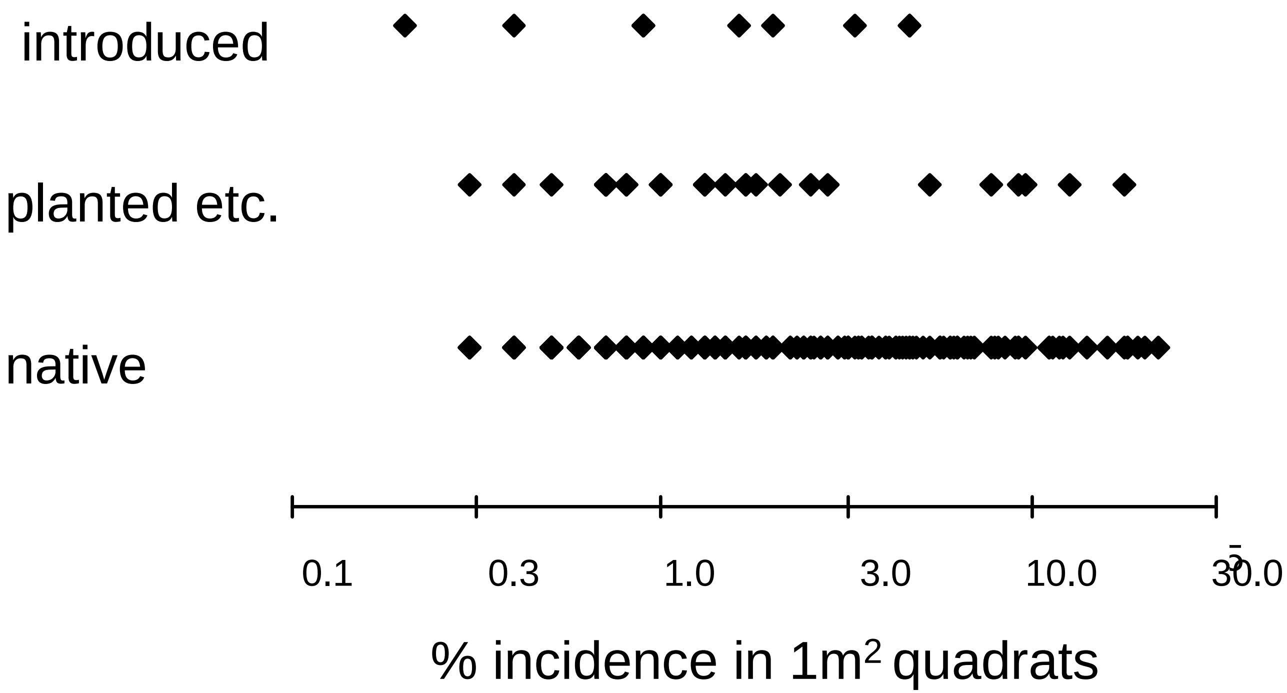
from Cassey, Blackburn, Russell, Jones, Lockwood (in press) Global Change Biology

Thirty species



Impact = Range x Abundance x Effect per individual

$$I = R \times A \times E$$


introduced
planted etc.
native
0.1
0.3
1.0
3.0
10.0
30.0
% incidence in 1m2 quadrats

Correlation matrix of plant impacts

Agric.	Econ.	Per.	Abund.	Distrib.	
1					Agricultural
.52	1				Economic
.32	.88	1			Perception
.12	.39	.53	1		Abundance
.00	.09	.51	.53	1	Distribution

Agricultural = Weed incidence on farms
Economic = Herbicide control cost
Perception = Perceived weediness
Abundance = 1 m^2 records
Distribution = $(10\ km)^2$ records

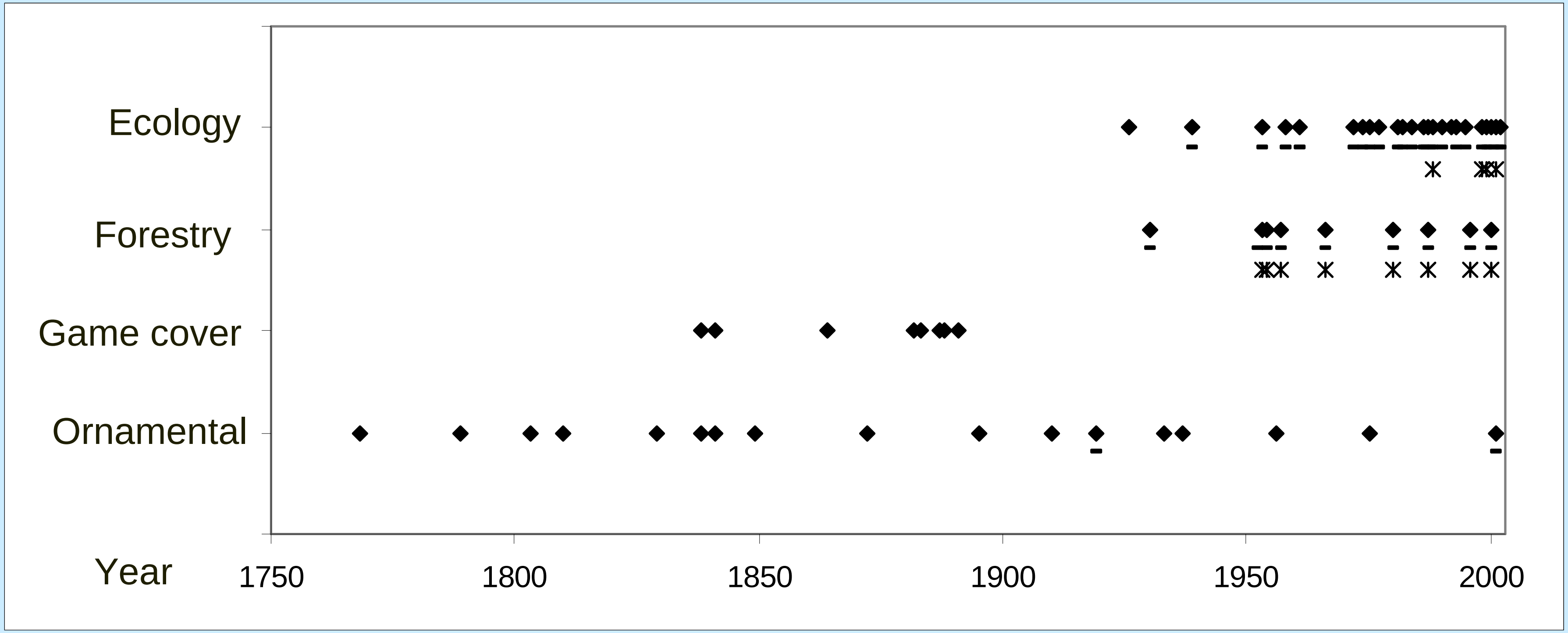
Generalizations about impacts

Each impact has a different spectrum of species

Each species has a different spectrum of impacts

Impacts are correlated over species

Species are correlated over impacts



Articles on Rhododendron ponticum

- = mentioning problems x = mentioning control

Rhododendron ponticum
Spread by % of vice-counties