Vulnerability to Transboundary Pests and Diseases under Climate Change

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IPCC Vulnerability

Vulnerability = Impacts x Adaptability

Impacts = Exposure x Sensitivity

Adaptability = Robustness and Sustainability of Response Options

SCALE: Regional

Industry/Ecosystem

- Customise definition of *Vulnerability* for biosecurity purposes
- Develop a global change *context* for climate change analyses
- IPCC 2007 climate change *scenarios* and examine their role
- Methods & Data
- Modelling Results & Conclusions
- Questions
- List some candidate target species

Vulnerability - Biosecurity under Climate Change

Vulnerability Fn (Impact of incursions x Cost Border Security)

Border Security Fn (Source reduction + Pathway hygiene
+ Barriers to entry)

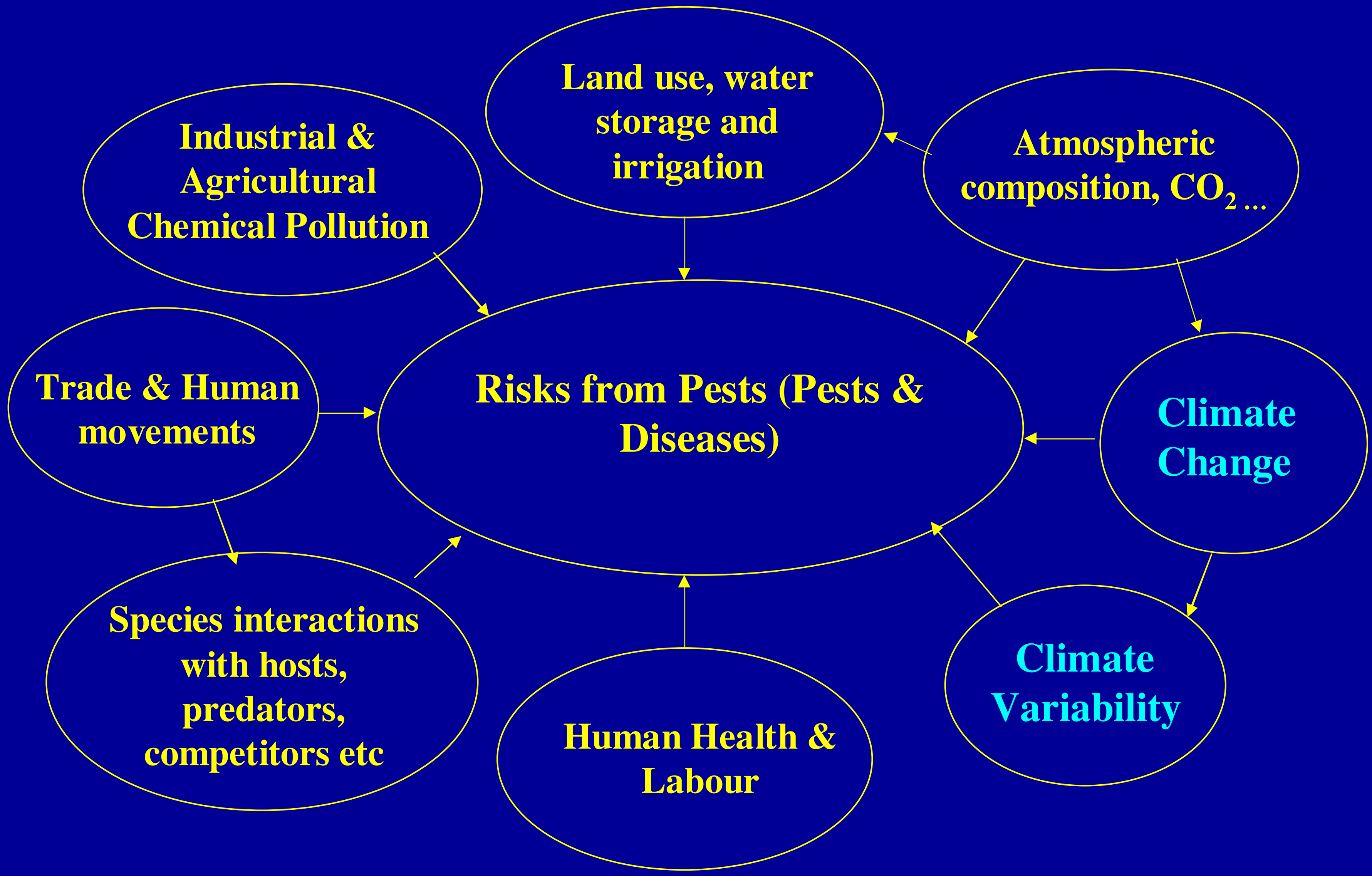
Impacts = Exposure (Sector/Region) x Sensitivity
@ Sources & Destinations

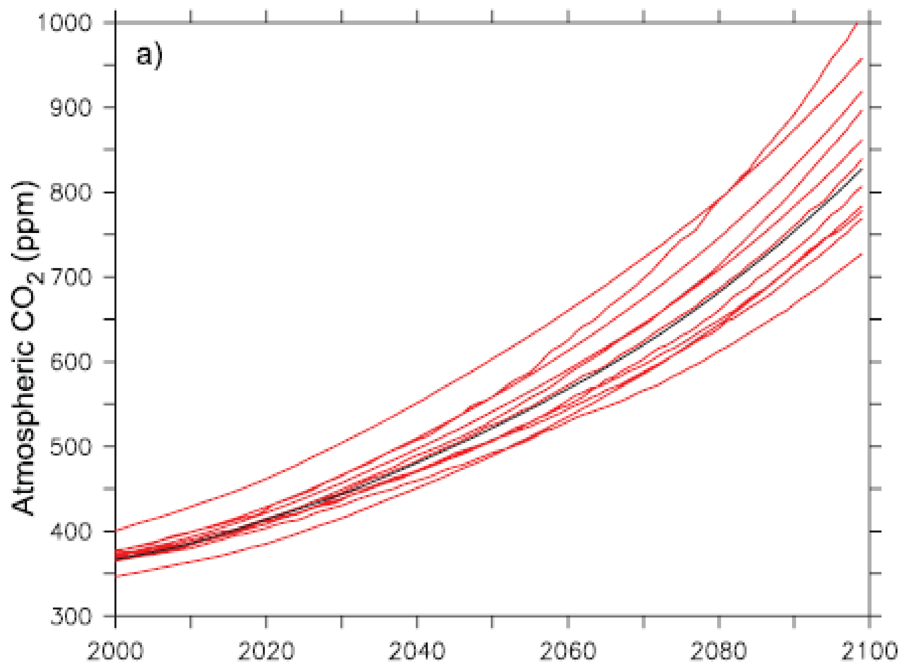
Δ Impacts CC = Current Impacts +/- Incremental Change

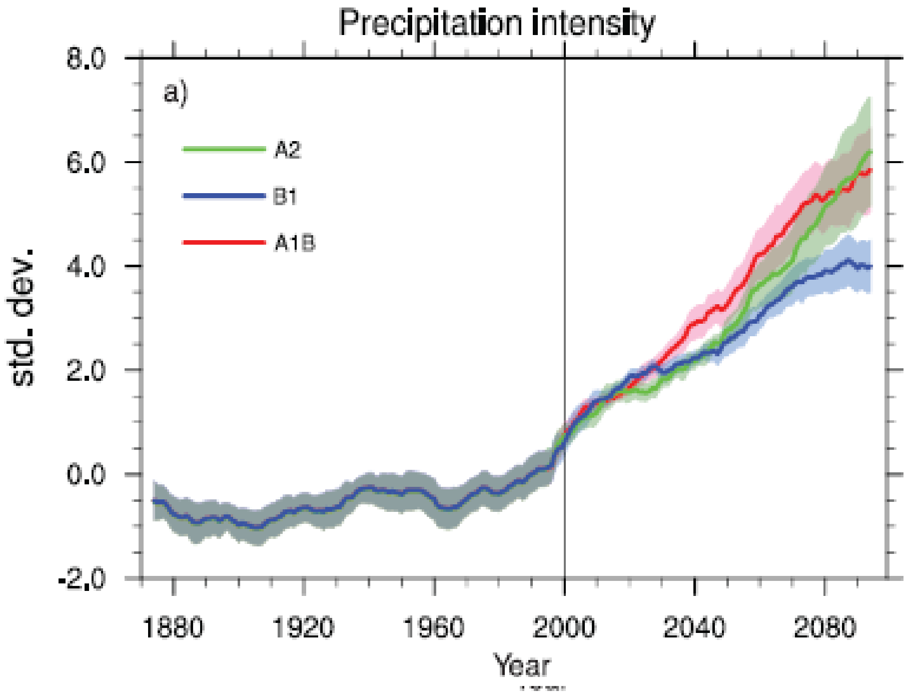
Sensitivity Fn (Location x Species x CC Scenario)

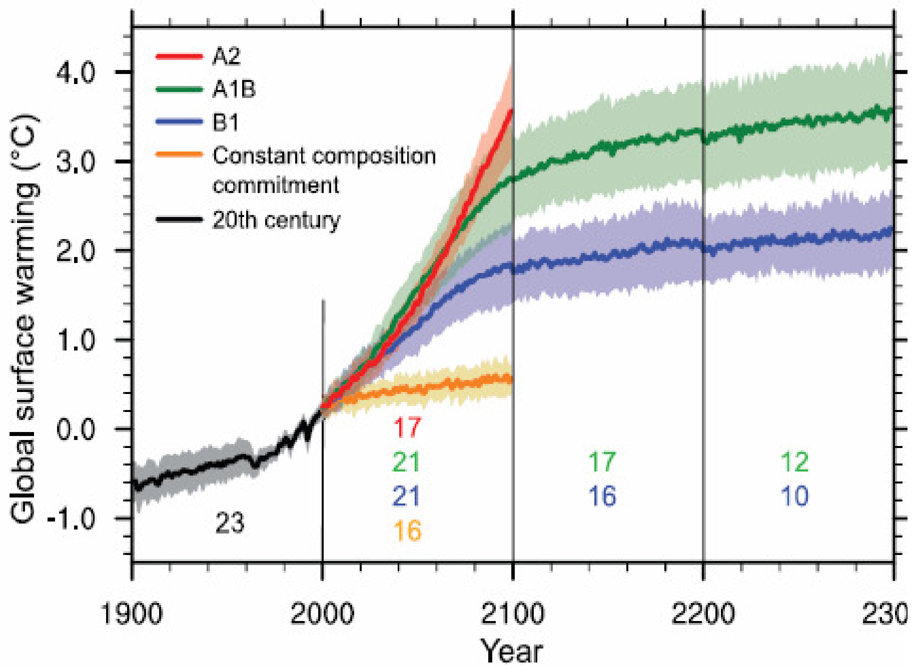
Vulnerability = Social, Economic & Environmental outcomes

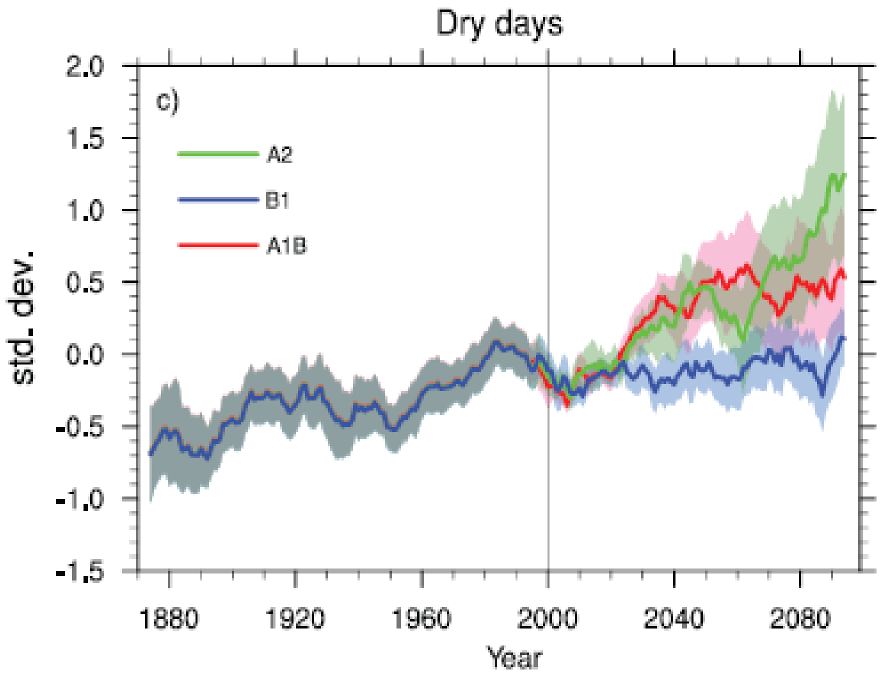
Global change context for climate change risk assessments




a)
Atmospheric CO_2 (ppm)
1000
900
800
700
600
500
400
300
2000
2020
2040
2060
2080
2100


Precipitation intensity
a)
A2
B1
A1B
std. dev.
8.0
6.0
4.0
2.0
0.0
-2.0
1880
1920
1960
2000
2040
2080
Year

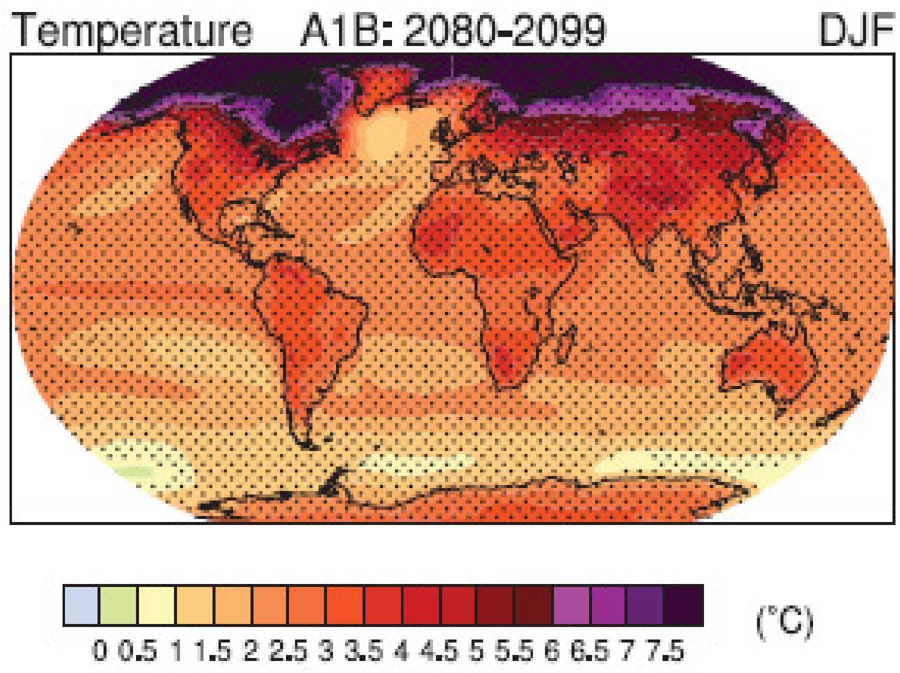

A2
A1B
B1
Constant composition commitment
20th century
Global surface warming (°C)
4.0
3.0
2.0
1.0
0.0
-1.0
17
21
21
16
23
17
16
12
10
1900
2000
2100
2200
230
Year

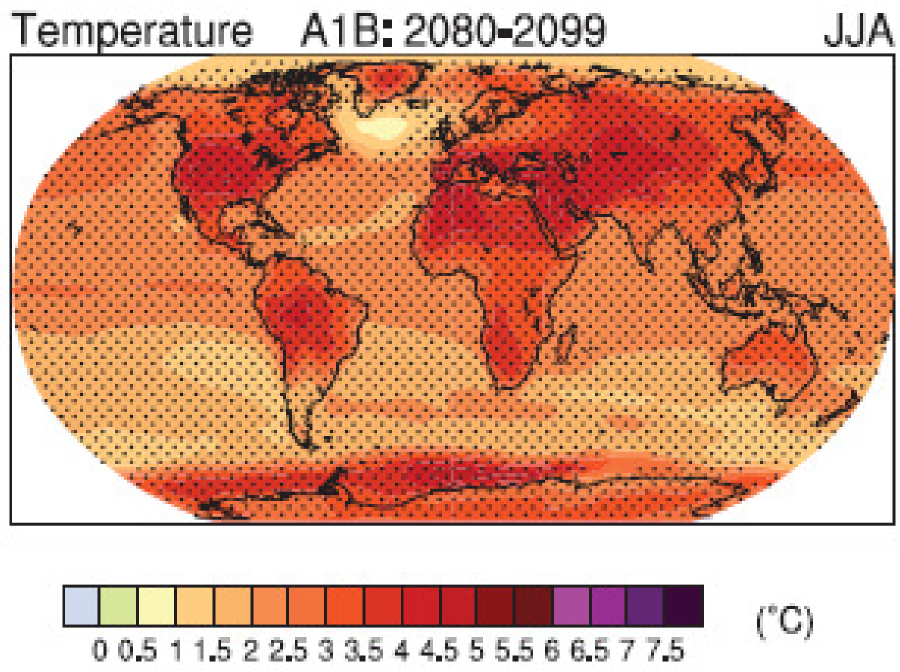

Dry days
c)
A2
B1
A1B
std. dev.
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
1880
1920
1960
2000
2040
2080
Year

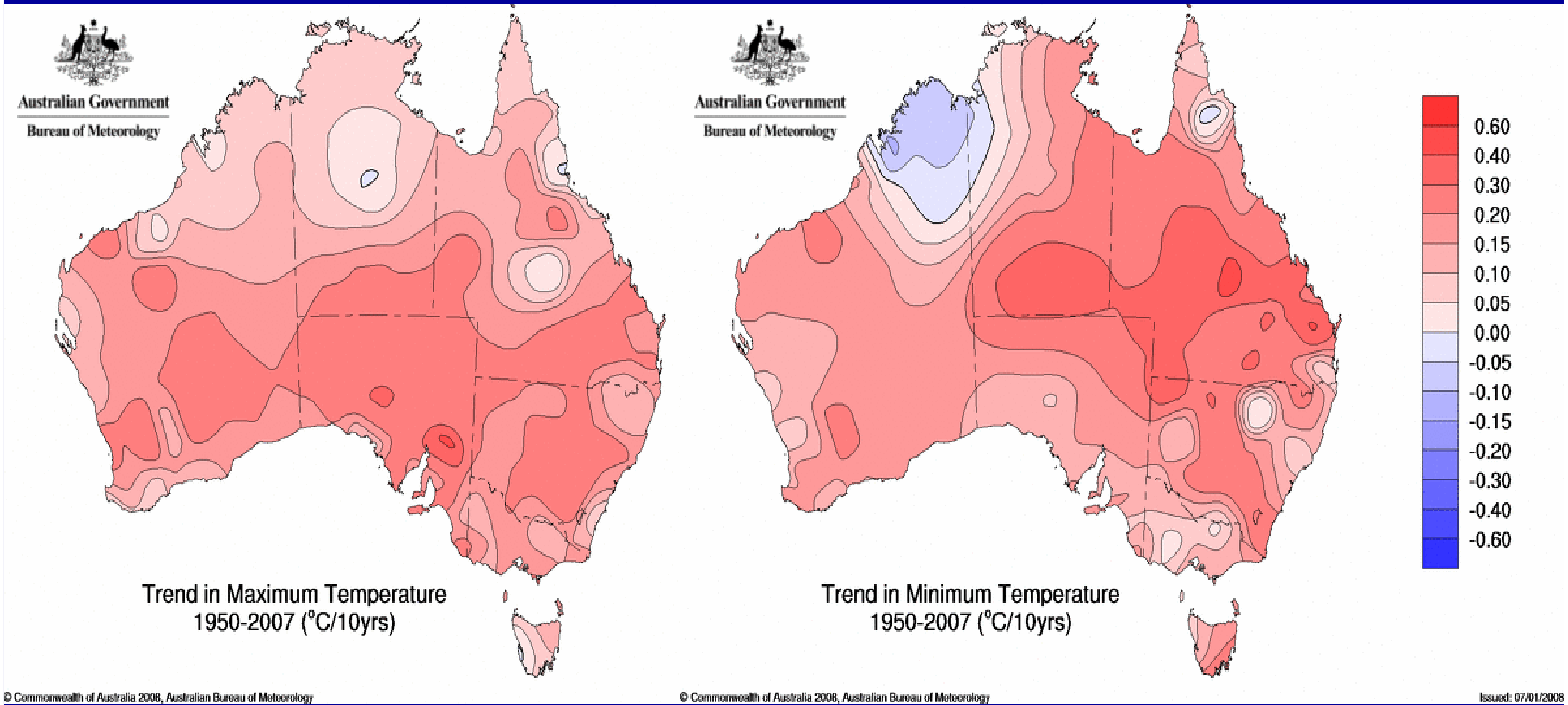
IPCC 2007

Top Boreal Winter

Bottom Boreal Summer

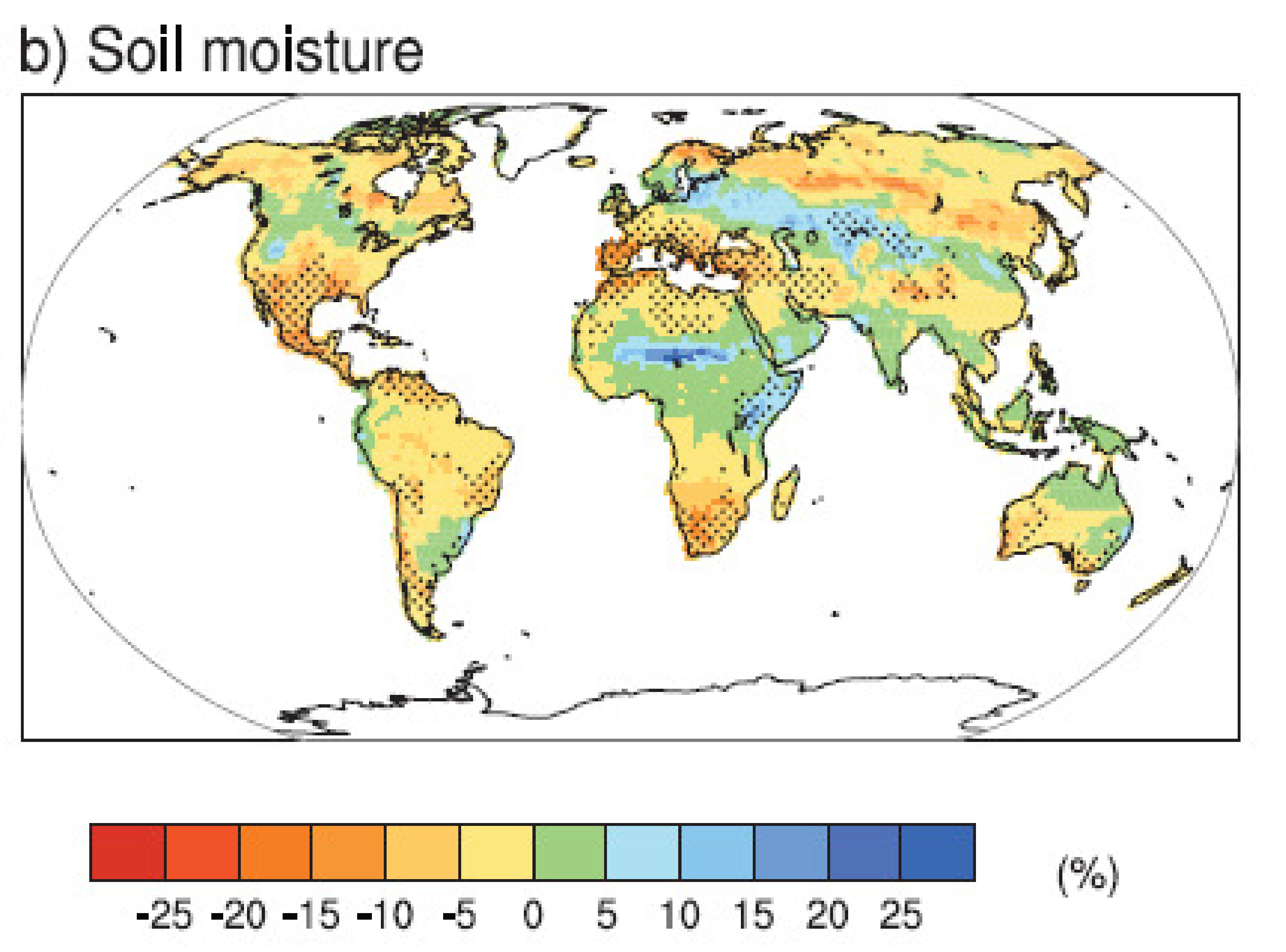






Temperatures vary geographically, seasonally & daily

IPCC 2007 multi-model scenario 2080-99 cf 1980-99 A1B scenario



Realities of Global Change R&D

- Multiple, interactive drivers of global change
- Spatially heterogeneous climatic signals
- Multiple species of pests & diseases
- Multi-trophic impacts
- Global experimentation impossible
- Reliance on models to explore impacts
- Outputs relate to policy
  - Regional, national or global
  - Industry
  - Linked trading regions
  - Economic, social and environmental

CONCLUDE: Parsimonious approaches needed

Global Change R&D Needs

- Hierarchical and Generic approaches & tools
- Models that work everywhere
- Spatial scale for regional or industry assessments
- Integrated risk assessments linking (coupled) crop and pest models
- Socio-economic models for policy

Global community needs:
*** common tools and languages**
*** synergy from collaboration & networking**

Global change - User Questions

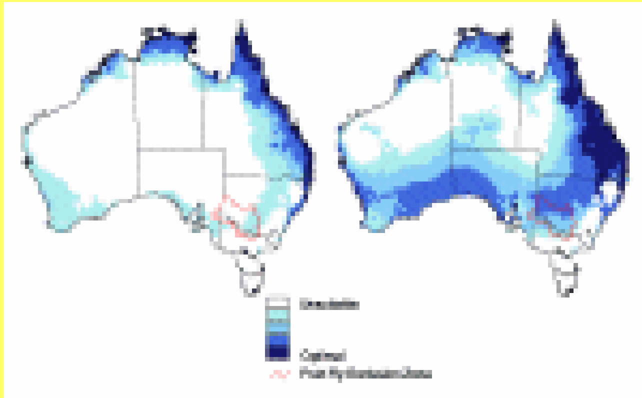
Policy

What **Industries** are vulnerable?
What **Regions** are vulnerable?
What will be the cost of **Adaptation**?

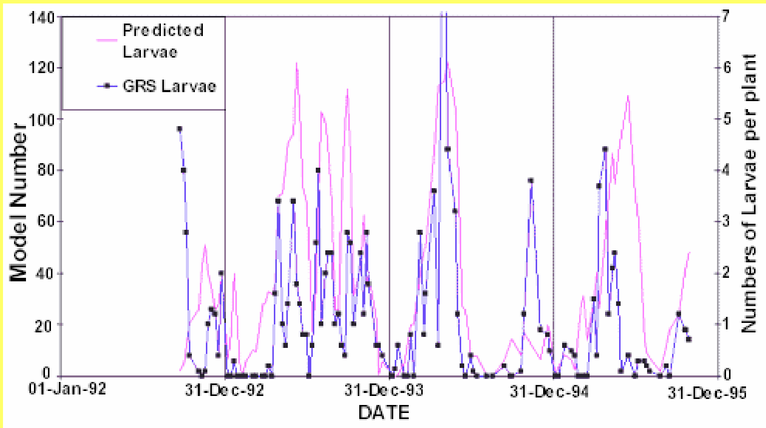
Individuals

What is global change going to cost me?
Do I need to adapt and if so when?

Spatial analyses



Plot-based temporal analyses



DYMEX Modular Modelling Toolkit for Biologists

- Re-useable & exchangeable modules
- Global change drivers and their interactions
- Biological processes and attributes to associate with lifecycle stages
- 'Inherit' / enhance properties
- Library of functions
- Spatial modelling platform

A Risk Assessment Toolkit

DYMEX
Model Simulator

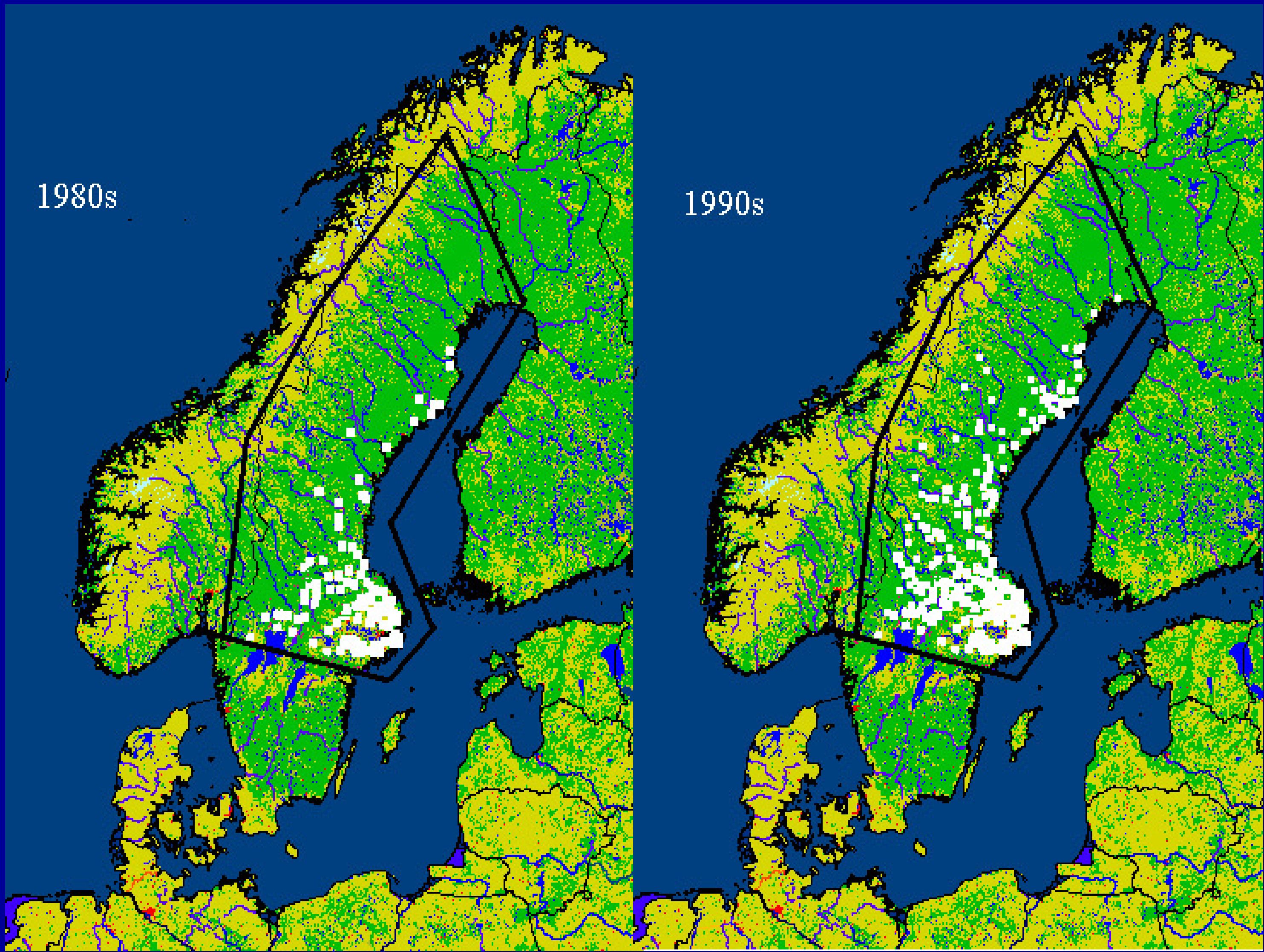
Modular
population modelling

CLIMEX v2

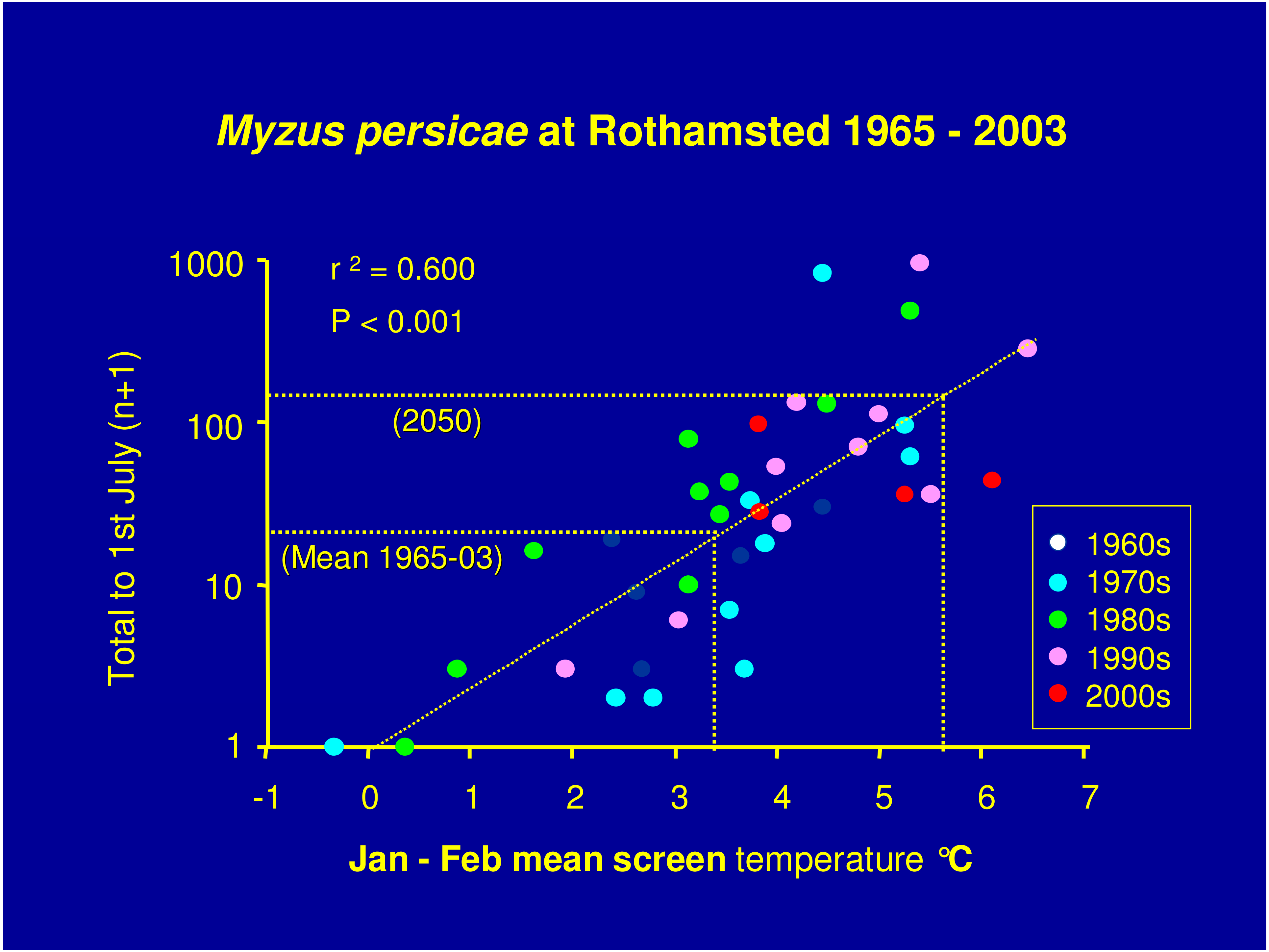
Model species responses
to climate

Designed by Biologists
for Biologists

Observed responses to climate change - ticks

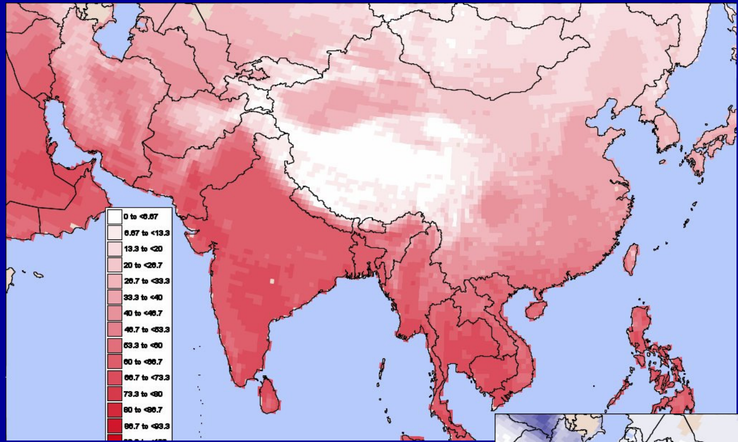


Lindgren et al 2000

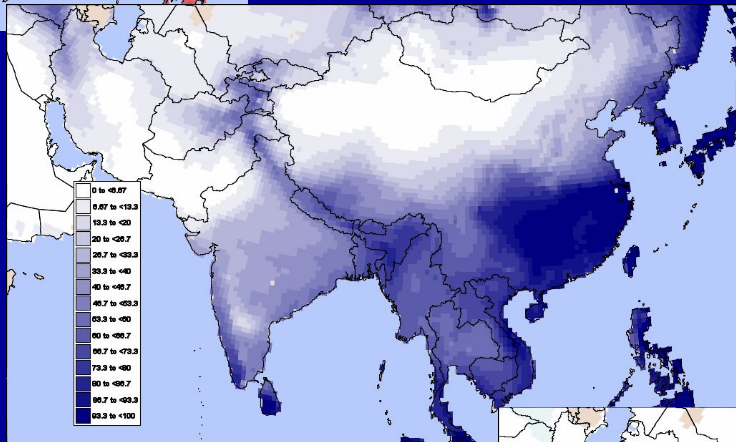


Myzus persicae at Rothamsted 1965 - 2003
r 2 = 0.600
P < 0.001
(2050)
(Mean 1965-03)
Total to 1st July (n+1)
1000
100
10
1
-1
0
1
2
3
4
5
6
7
Jan - Feb mean screen temperature °C
1960s
1970s
1980s
1990s
2000s

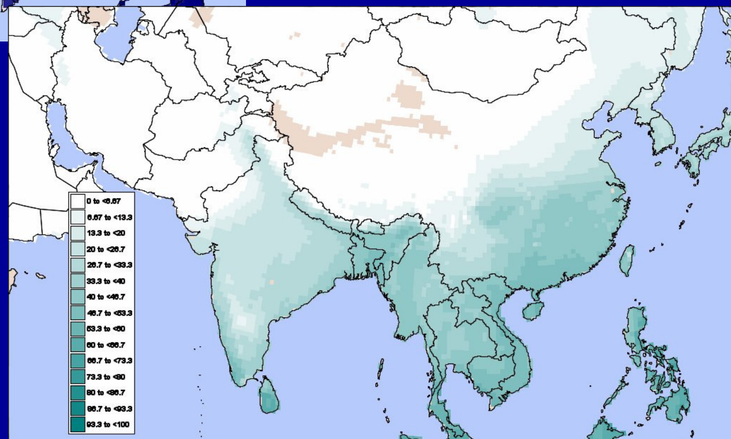
STEP 1: Know your environmental gradients



Temperature



Moisture

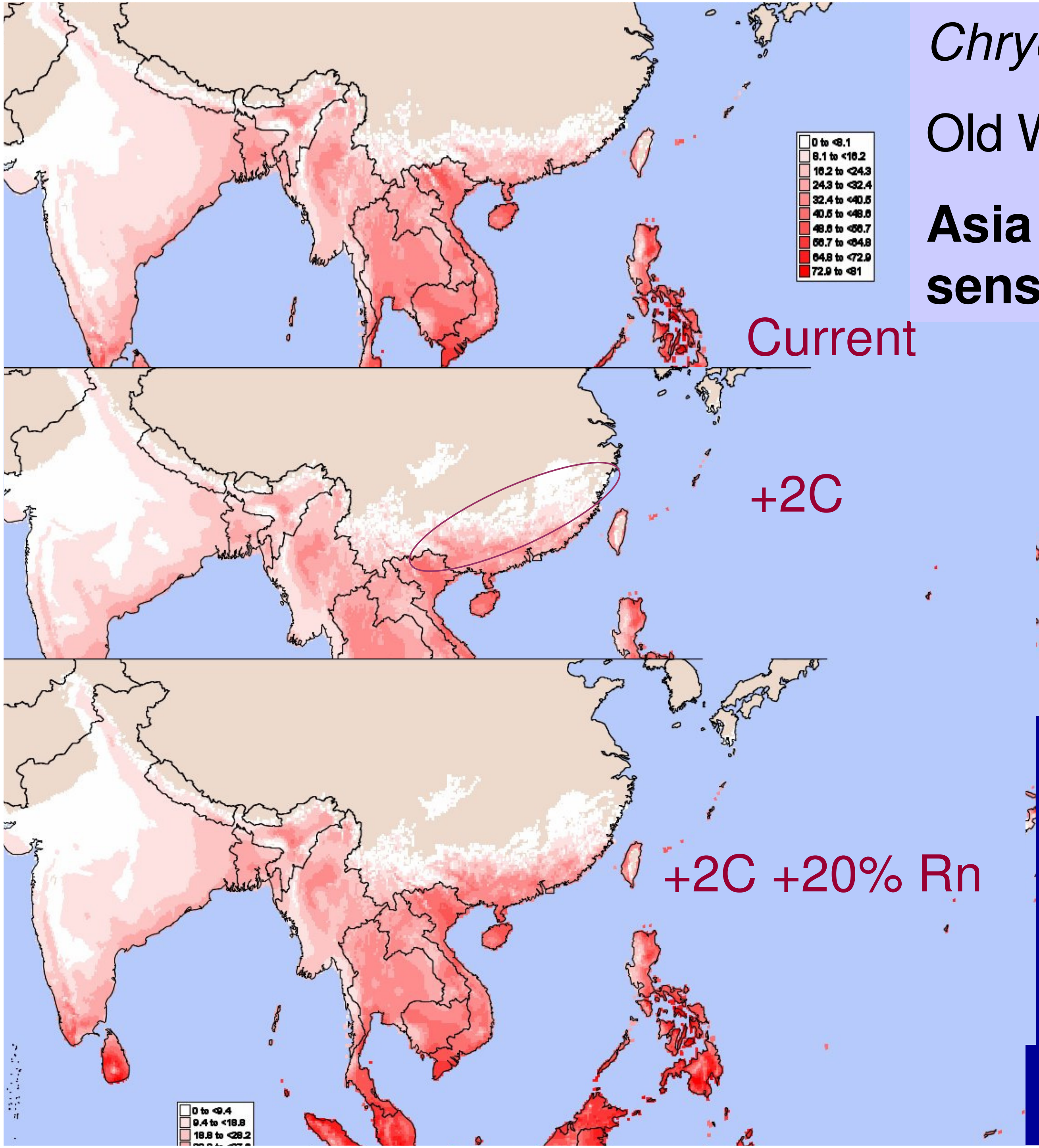


Hydro-Thermal

Chryomya bezziana –

Old World screw-worm fly

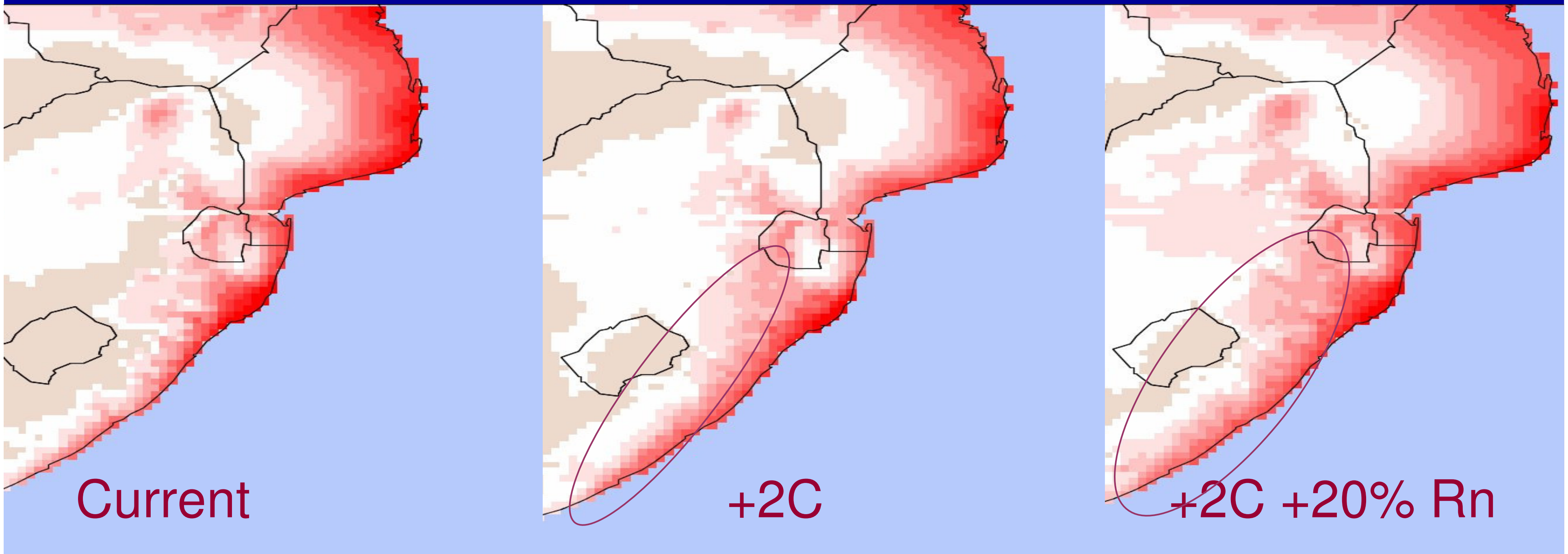
Asia – China has sensitivity

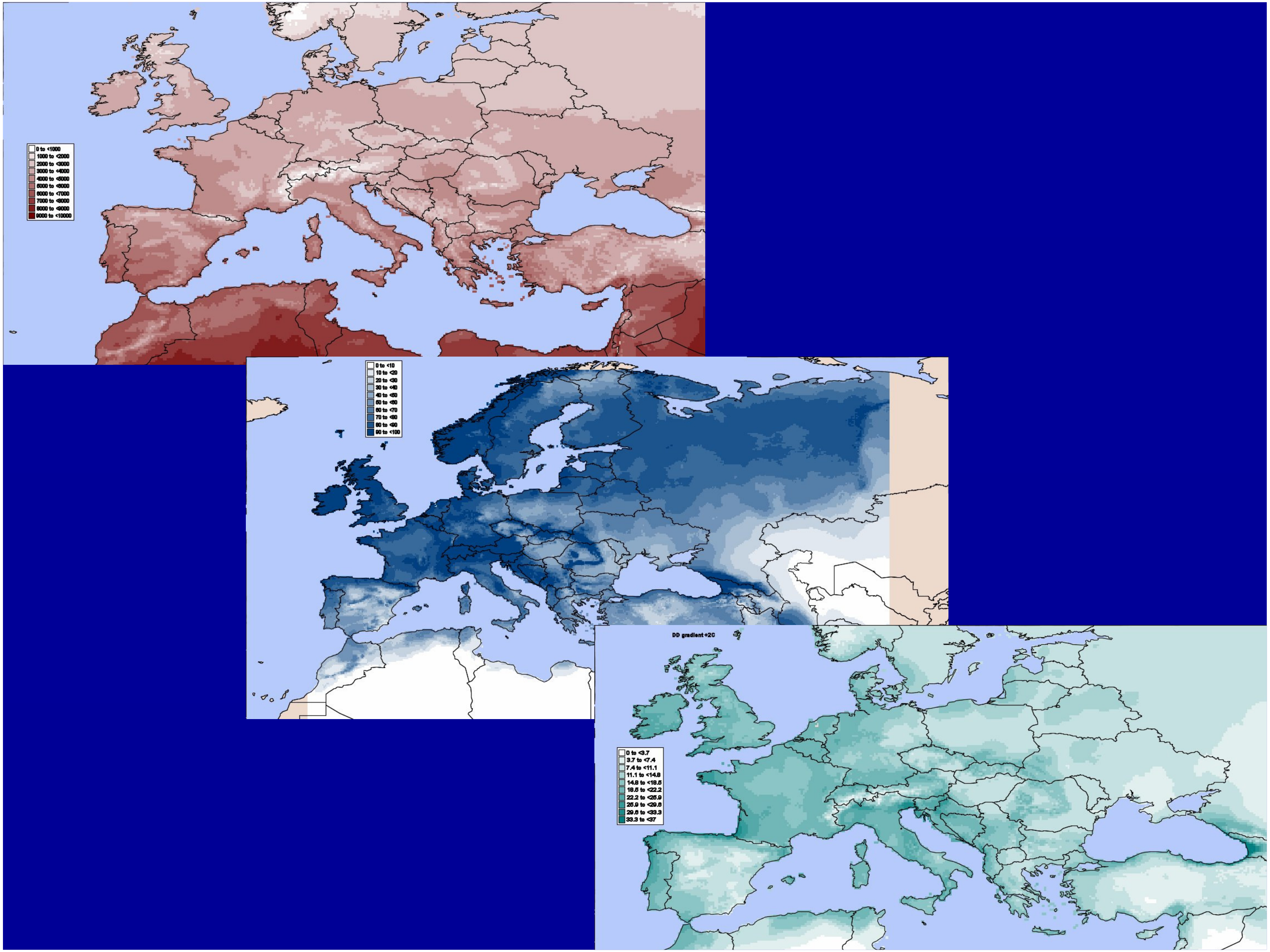


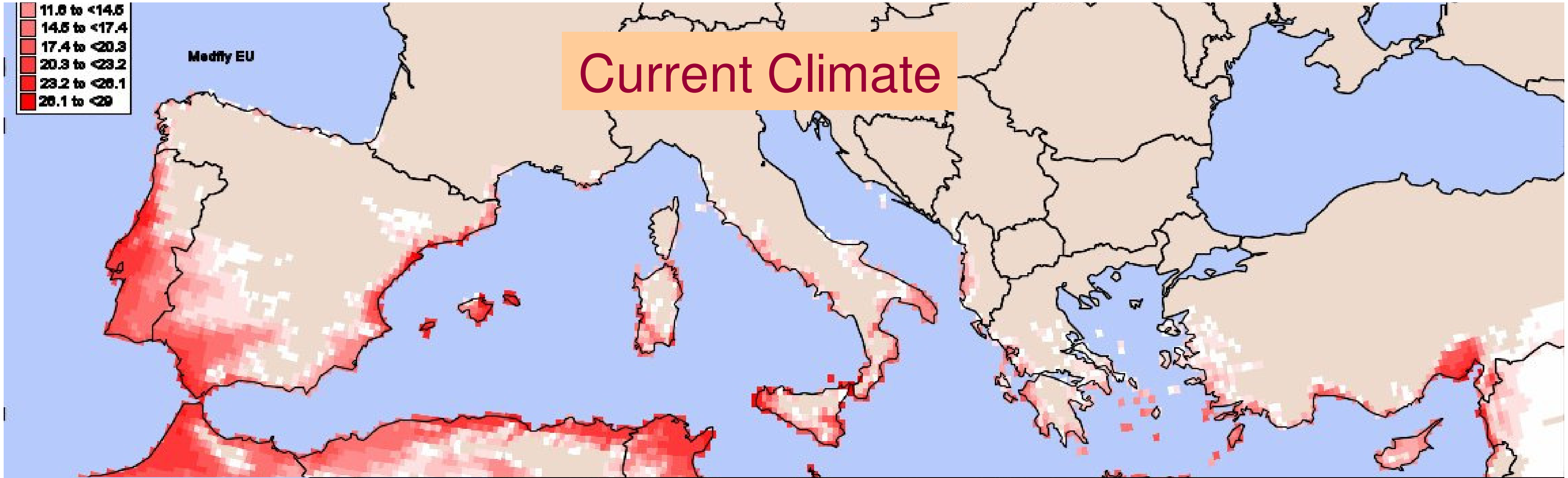
Potential responses to climate change

Chryomya bezziana - Old World screw-worm fly

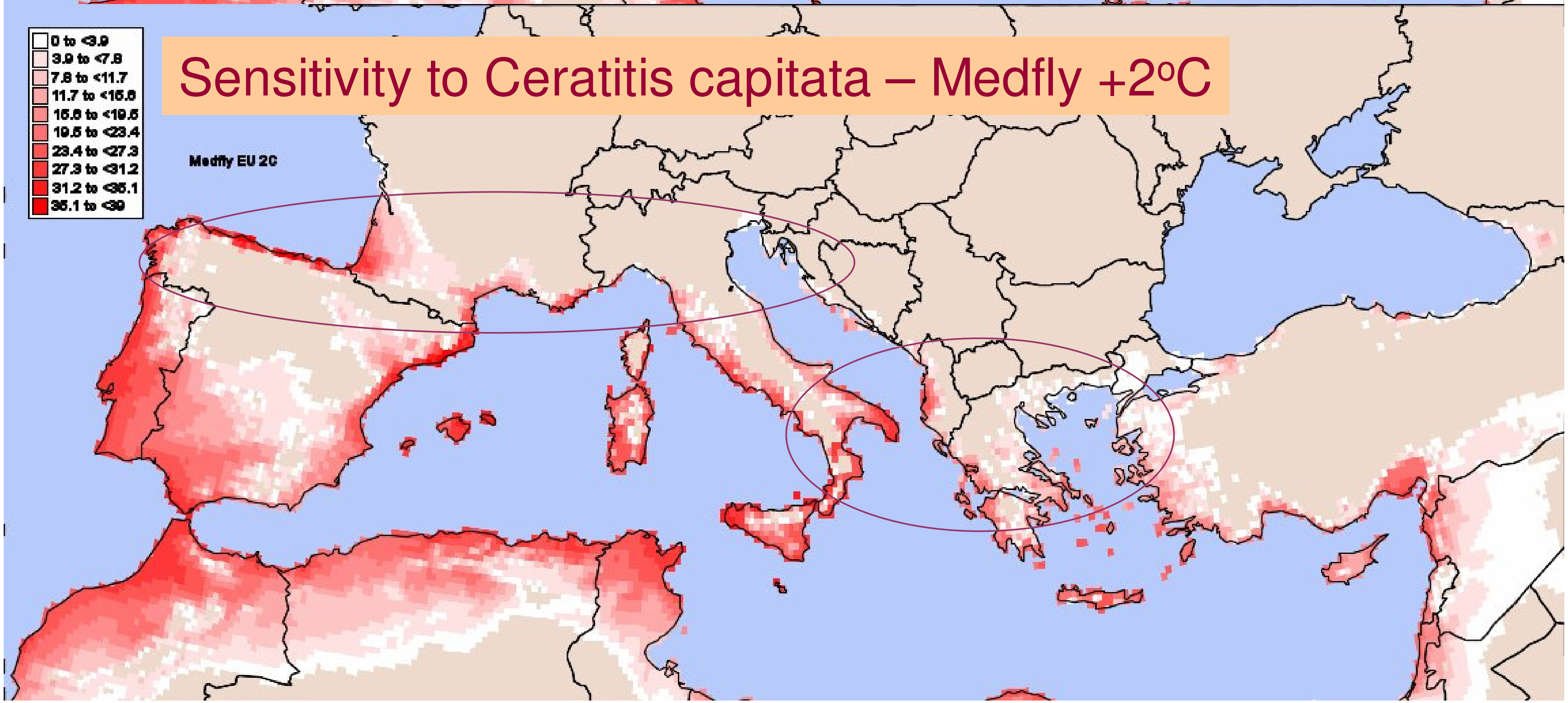
Southern Africa – Source & Destination?




0 to <1000
1000 to <2000
2000 to <3000
3000 to <4000
4000 to <5000
5000 to <6000
6000 to <7000
7000 to <8000
8000 to <9000
9000 to <10000
0 to <10
10 to <20
20 to <30
30 to <40
40 to <50
50 to <60
60 to <70
70 to <80
80 to <90
90 to <100
DD gradient +2C
0 to <3.7
3.7 to <7.4
7.4 to <11.1
11.1 to <14.8
14.8 to <18.5
18.5 to <22.2
22.2 to <25.9
25.9 to <29.6
29.6 to <33.3
33.3 to <37



Current Climate
11.6 to <14.5
14.5 to <17.4
17.4 to <20.3
20.3 to <23.2
23.2 to <26.1
26.1 to <29
Medfly EU



Sensitivity to Ceratitis capitata – Medfly +2°C
0 to <3.9
3.9 to <7.8
7.8 to <11.7
11.7 to <15.6
15.6 to <19.5
19.5 to <23.4
23.4 to <27.3
27.3 to <31.2
31.2 to <35.1
35.1 to <39
Medfly EU 2C

INVASIVE SPECIES

QUAGGA AND ZEBRA MUSSELS

In just a few years, quagga mussels have gone from a relatively rare find to the dominant invasive mussel in Lake Michigan. Biologists worry quaggas could prove much more disruptive than their closely related cousin, the zebra mussel, because they are more effective filter feeders, and they can live and breed in colder, deeper waters.

QUAGGA MUSSEL
Dreissena bugensis

ZEBRA MUSSEL
Dreissena polymorpha

JOURNAL SENTINEL

	QUAGGA MUSSEL	ZEBRA MUSSEL
SHELL	Rounder sides, convex underside. No ridge. When placed on its underside, the quagga mussel will topple.	Triangular shape, underside flat. Obvious ridge between side and bottom. When placed on its ventral side, it will remain upright.
COLOR	Pale near hinge, dark concentric rings on the shell.	Variable colors and patterns, usually dark.
UNDERSIDE	Small ventral groove near the hinge.	Large groove in middle of flat side; allows tight hold on rocks.
DEPTH IN LAKE	3 to 541 feet; expected to go deeper over time.	3 to 98 feet; rarely found below 50 feet.
TEMPERATURE TOLERANCE	39 to 68 degrees	54 to 68 degrees
SPAWNING TEMPERATURE	Minimum 50 degrees; a female quagga mussel with mature reproductive organs was found in Lake Erie at a temperature of 42 degrees.	Minimum 56 degrees; can survive in stagnant water with uniform temperature but cannot reproduce there.

Source: USGS; Sea Grant Pennsylvania

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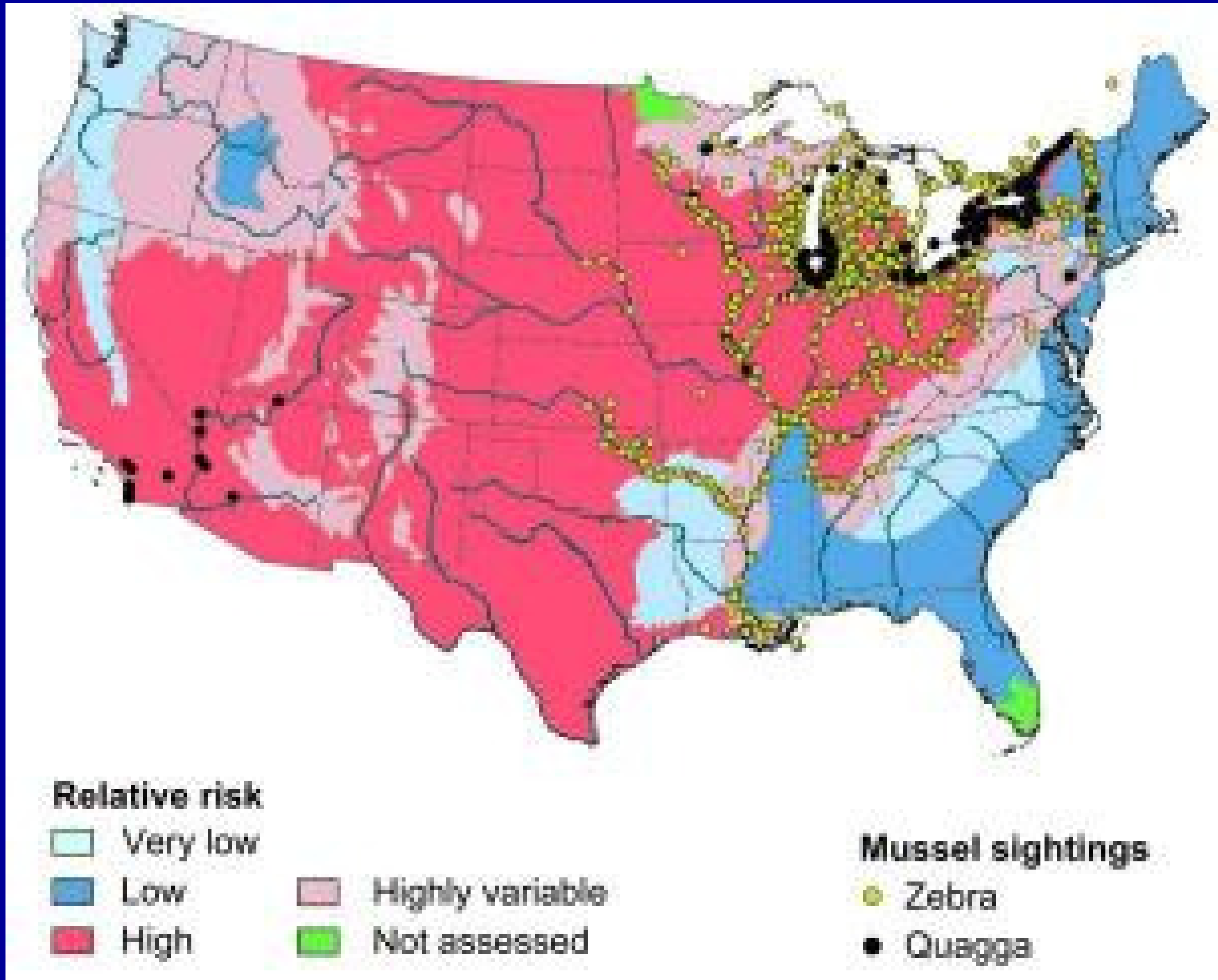
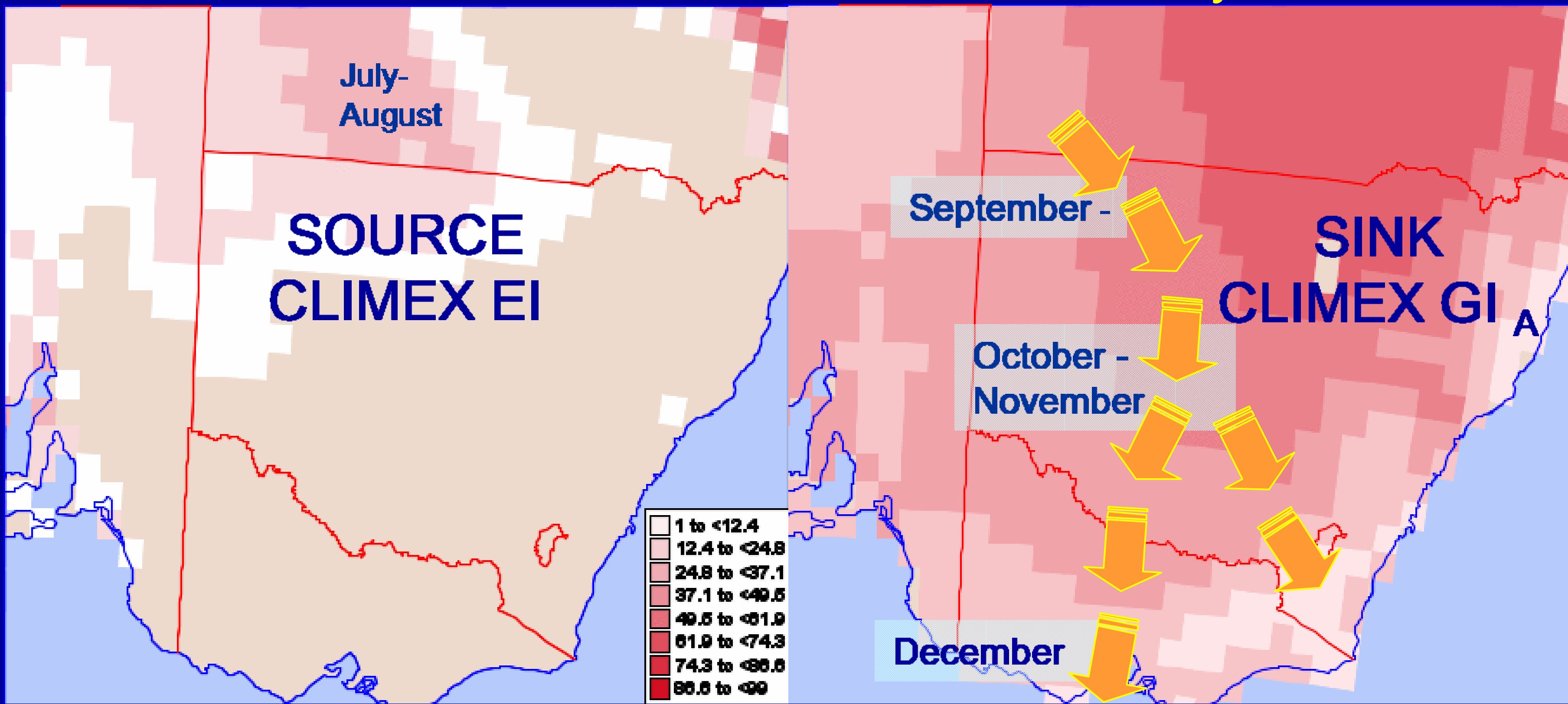
Zebra Mussel – An Opaque Risk Assessment



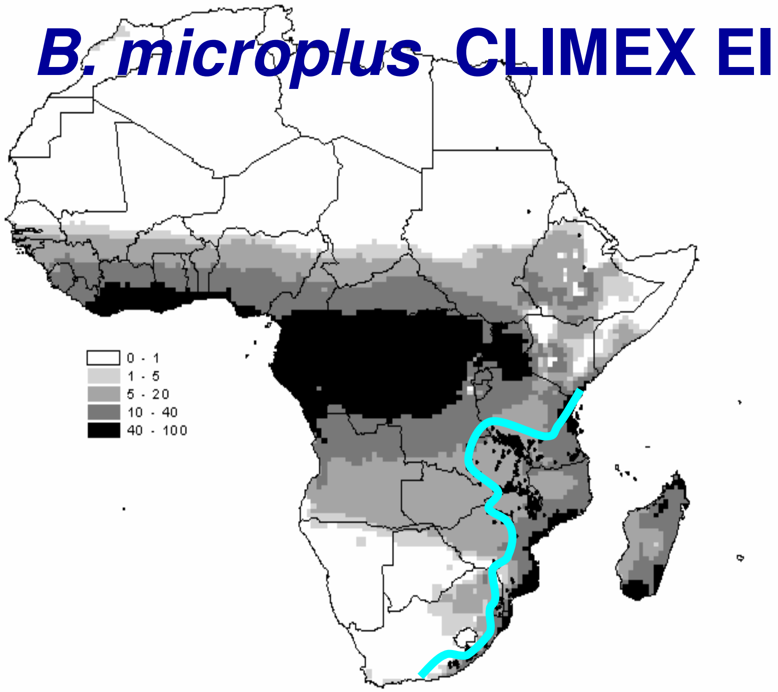
Seasonal Migration

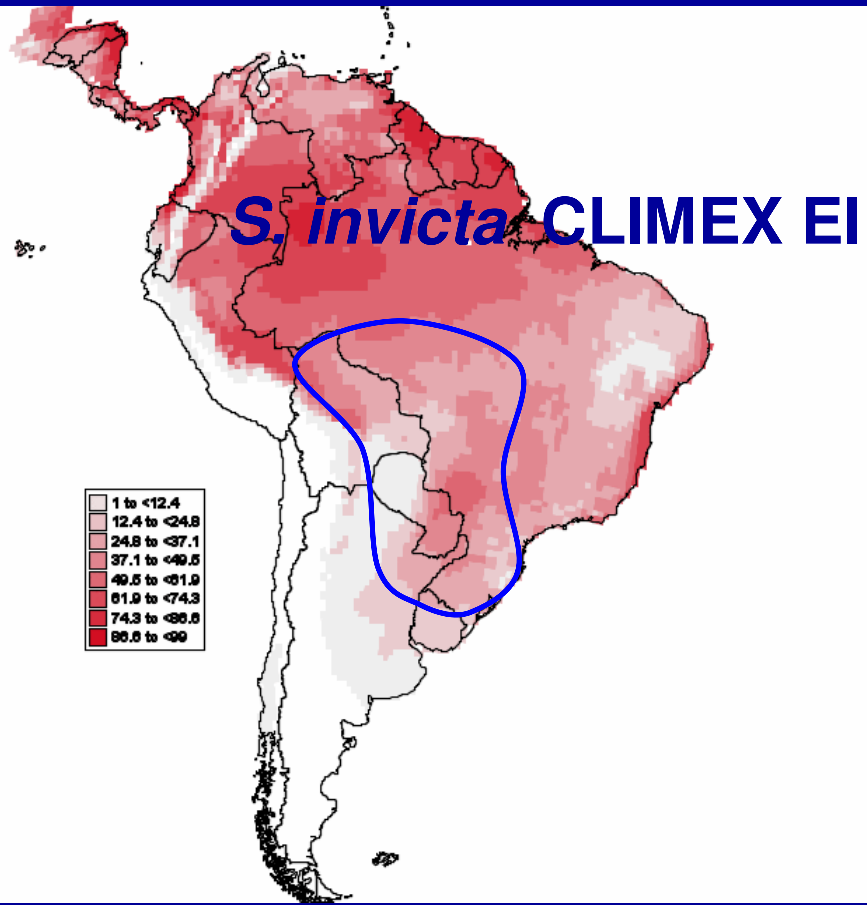
M. vetustissima Australian Bushfly

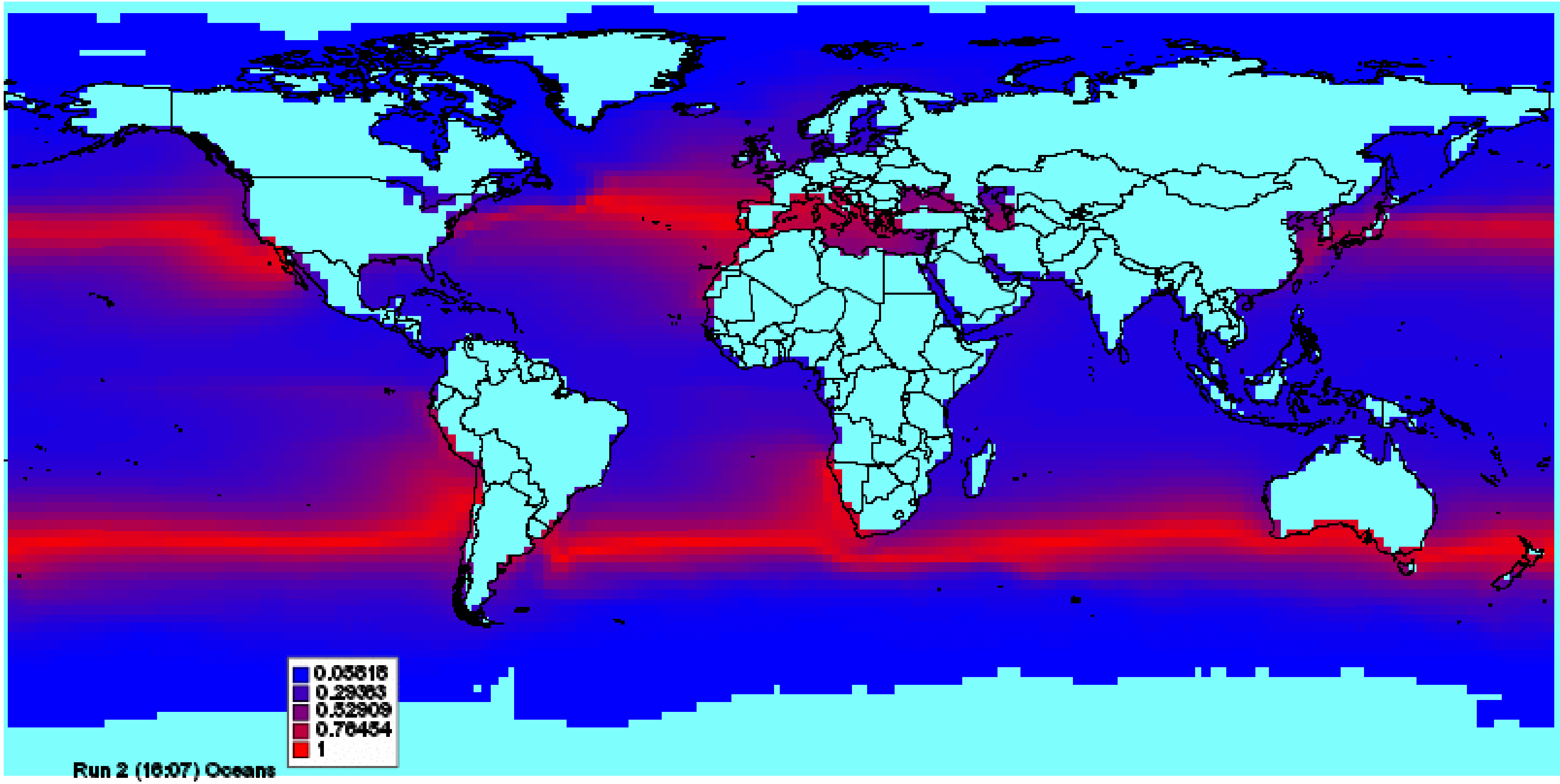


Species Interactions

Detection – What is possible? Modelling







Marine homo-climates

Vulnerability of Australian Horticulture to Pests under Climate Change

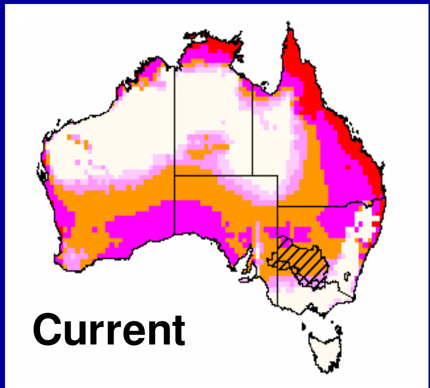
Queensland Fruit Fly

Regional Vulnerability

Light Brown Apple Moth

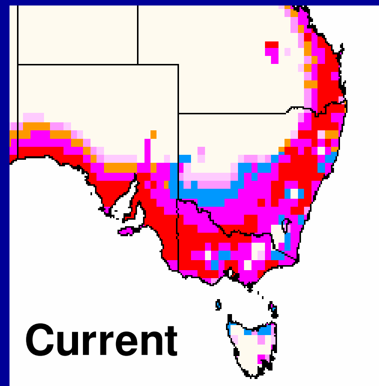
Total Cost = $28.5m p.a.

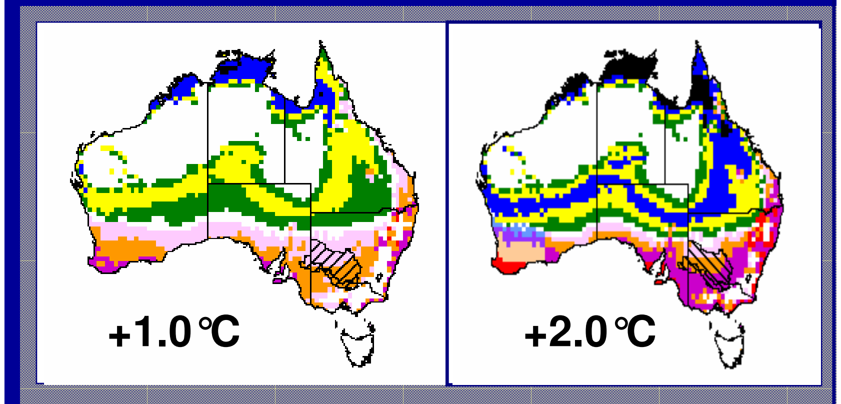
Total Cost = $21m



EI Value

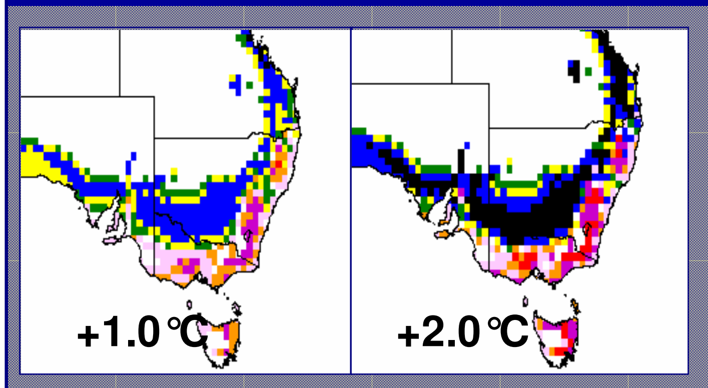
- 0 to 1
- 1 to 5
- 5 to 10
- 10 to 20
- 20 to 40
- >40
- FFEZ





Change in EI

- >20
- 10 to 20
- 5 to 10
- 1 to 5
- -1 to 1
- -5 to -1
- -10 to -5
- -20 to -10
- < -20
- FFEZ



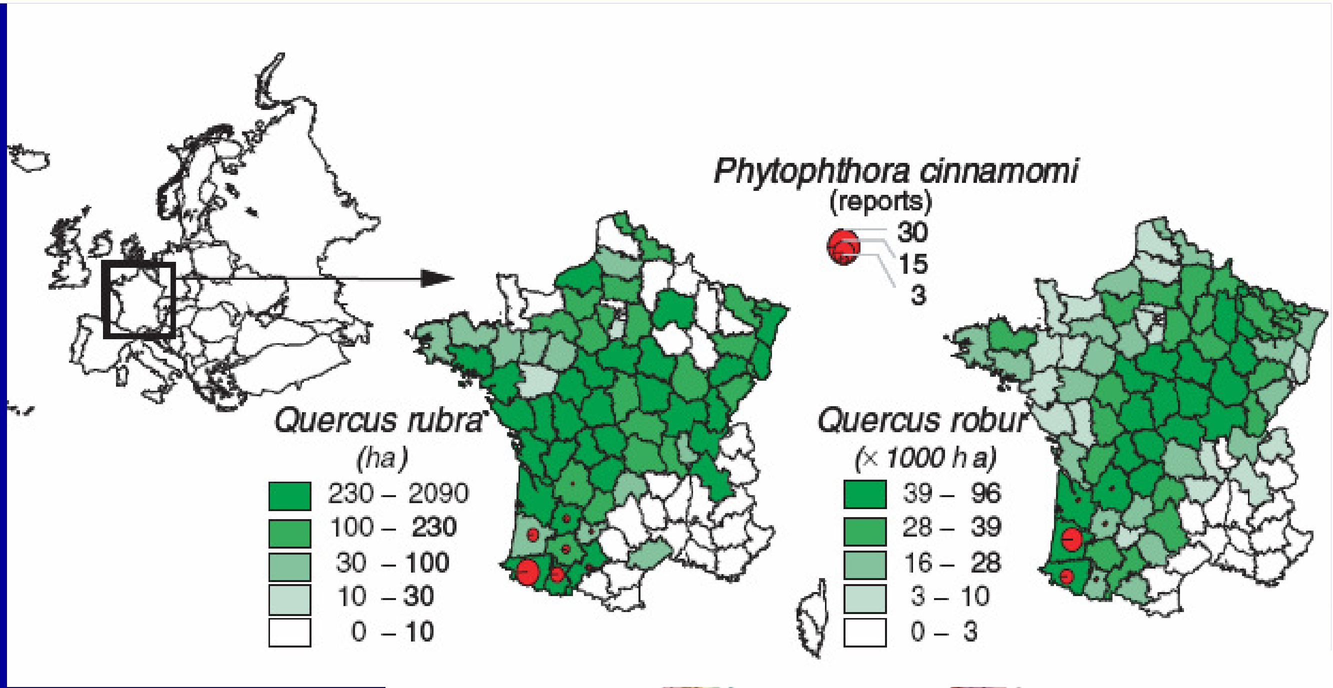
Industry Vulnerability

Changes in Pest Damage (from CLIMEX Ecoclimatic Index) (A$millions)

Queensland Fruit Fly			Light Brown Apple Moth		
Industry	+ 1°C	+ 2°C	Industry	+ 1°C	+ 2°C
Oranges	+ 1.8	+ 3.5	Oranges	- 1.3	- 4.7
Apples	+ 2.1	+ 5.6	Apples	+ 0.5	+ 0.7
Pears	+ 0.9	+ 2.8	Pears	+ 0.2	+ 0.2
			Grapes	- 0.5	- 1.9

Mechanistic prediction

Phythophthora cinnamomi



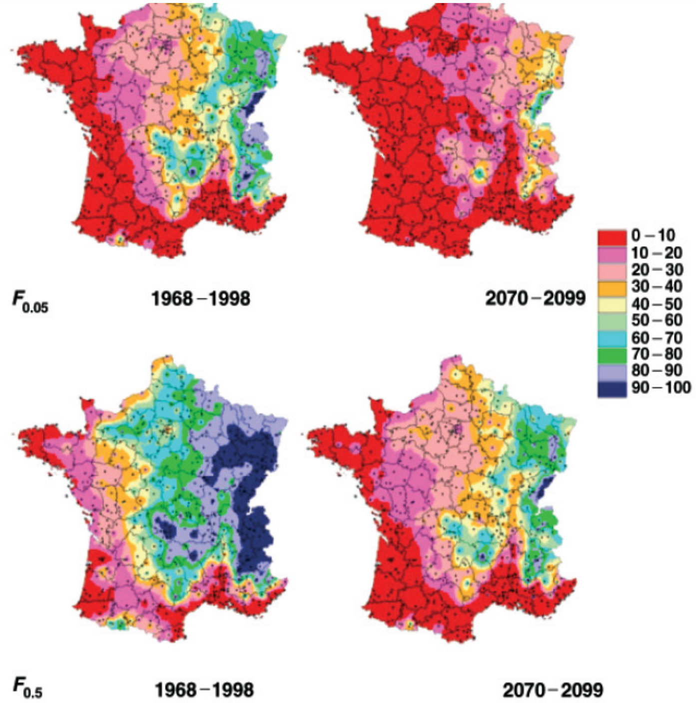


Fig. 5 Mapping of $F_{0.05}$ and $F_{0.5}$ in *Quercus rubra* (frequencies of years with *Phytophthora cinnamomi* annual survival rate below the 0.05 and 0.5 thresholds) for periods 1968–1998 and 2070–2099.

1. Establish ***Benchmarks*** of Current Biosecurity status
    1. Incursions
    2. Establishments
    3. Impacts: Costs of Biosecurity
2. Monitor ***Indicators*** of Change in Biosecurity
    1. Rates of Invasions by Foreign Species
    2. Rates of crop, livestock, forest and fish losses
    3. Costs of Biosecurity
3. ***Accelerate Adoption*** of New Technology
    1. Work-shopping Tools

DYMEX Modelling Networks

Bringing the power of modelling to users

DYMEX modular modelling of biological organisms.

Are you Managing Pest, Weed and Pathogen Problems?

Workshops

- Group's Expectations
- Model Specifications
- Data Collation
- Model Formulation & Testing
- Analysis of System
- Design of Management Strategies
- Future Plans

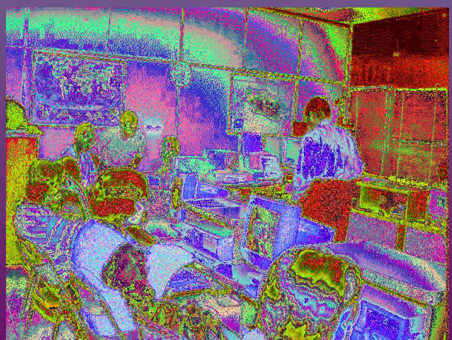
Enhanced Risk Assessment, Management and Communication

Collaborative Networks sharing Data & Results

Model with Group's Ownership

Identify Research Priorities

Group Training by Involvement



CSIRO

RIRDC


THE END