Biology and Ecology of Forest Health

Climate Change and Tree Health

- Assume classic UKCIP scenario: ca 3^{o}C warming in 50-80 yrs; warmer winters/summers; increased winter rain and summer drought; perturbations
- Will consider primarily pathogens and pests
- Structure of talk :
    - ‘Generalisations’
    - Case study
    - Conclusions

- **Generalisations -**

In Theory - climate change i.e. temperature, moisture, radiation levels - will have a direct effect on three main factors:

- Pathogen (pest) activity: numbers, fitness = pathogen aggressiveness.
- Host activity - numbers, vigour, stress levels = host resistance.
- Host - pathogen interaction.

But how easy to model or predict these effects?

- Effect on pathogen (pest) activity:

Easier to predict if pathogen’s response to temperature, moisture is well documented

- Effect on host activity:

Might be predicted where host ecophysiology and resistance mechanisms are well documented

- Effect on host - pathogen interaction:

Difficult to predict - very complex area .

In Practice:

- Effect on pathogen (pest) activity:

– data often too limited to model effectively (one example later)

– little info on pathogen potential to adapt

- Effect on host activity:

– data often too limited to model effectively

- Effect on the host - pathogen interaction:

– too little data - area of great uncertainty

- Also – need to include effect on local ecosystem

– too complex to predict!

Different climate change impact on native vs introduced host and pathogen systems?

Native woodland hosts and native pathogen/pest

- Co-evolved system
- Better ecologically buffered
- **System more stable under climatic pressure?**

Introduced plantation hosts and native pathogen/pest

- Non co-evolved system
- Host already out of proper ecological context
- **System more unstable under climatic pressure?**

Native/introduced host and invasive pathogen/pest

- Non co-evolved system
- Host and pathogen both out of ecological context
- Host and pathogen often seriously out of balance
- Pests and pathogens lack natural enemies
- Epidemics . . .

e.g. Epidemics of DED, chestnut blight, pinewood nematode, *Phytophthora ramorum* (SOD), alder *Phytophthora*, *P. cinnamomi*, red band needle blight, green spruce aphid, great spruce bark beetle, Asian longhorn beetle...

- **System potentially most unstable under climatic pressure?**

Add to this -

- The fact that the frequency of invasion by non-native pests and pathogens appears to be increasing
  - And we are likely to see interaction between two major environmental issues:
- Climate change and Invasive pathogens.

-This could compound the risk to our forests and natural ecosystems.

Due to:

- The complexity of the underlying processes
- The paucity of good predictive scientific data

Literature overviews on this issue deal mainly in generalities, stressing the uncertainties

Brasier & Scott (1994) European oak declines and global warming: a theoretical assessment with special reference to the activity of *Phytophthora cinnamomi*. *EPPO Bulletin* 24: 221-232.

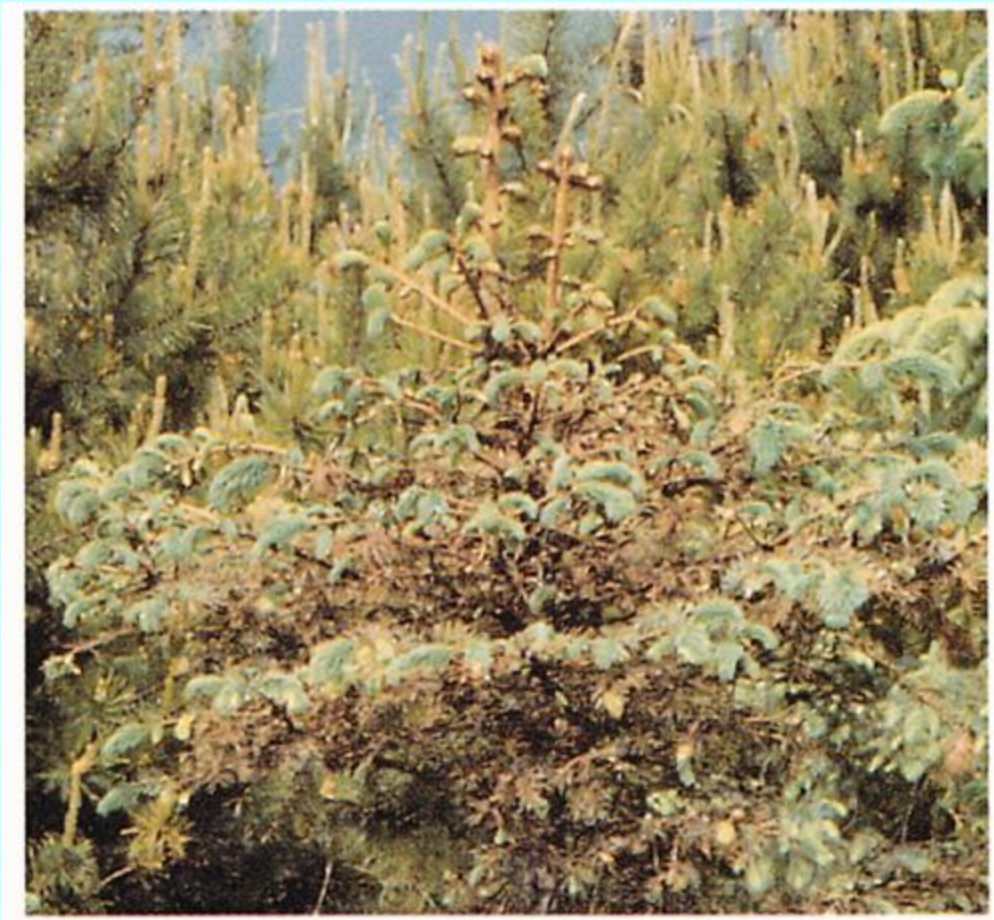
Examples of general points made re the classic climate change scenario (-see published reviews for details)

- Less winter cold injury but more autumn forest injury
- Increased drought stress $\Rightarrow$ increased attack by opportunists e.g. Honey fungus (*Armillaria*)
- Increased drought stress $\Rightarrow$ more fatalities from root pathogens such as *Phytophthora*
- Increase in oak and beech declines
- More attack by winter active diebacks and stem cankers (because asynchronous dormancy zone or ADZ will more northwards)

- Increase in foliar diseases needing warm wet springs for infection e.g. red band needle blight of Corsican pine (and other pines)
- Increased flooding will enhance infection by *Phytophthora* pathogens e.g. *Phytophthora alni* on rivers
- Stress and disease will open canopy structure $\Rightarrow$ more stress and disease
- High temperature pathogens such as sooty bark disease of sycamore and *P. cinnamomi* will become more prevalent
- Northern ranges of insect pests and insect vectors likely to be extended
- Balance between insect pests and their natural enemies will be altered

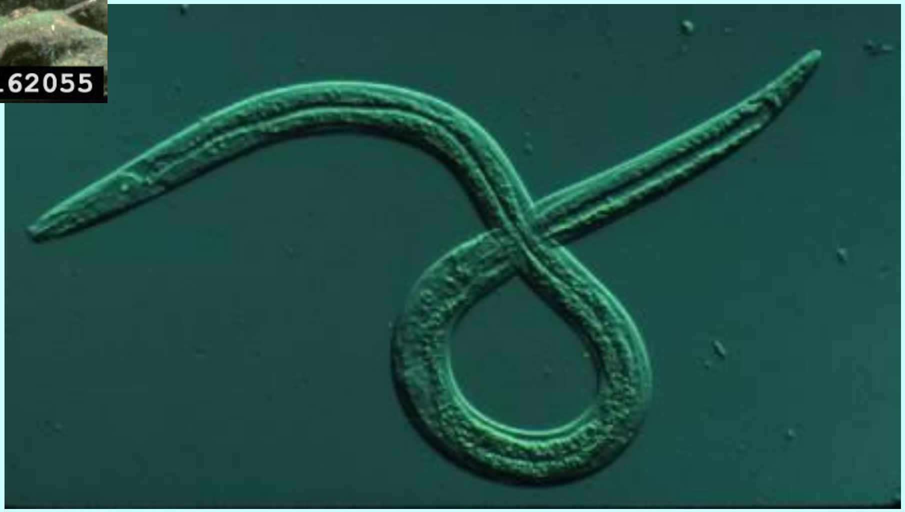
- Development of green spruce aphid (*Elatobium*) likely to be favoured $\Rightarrow$ decline in spruce production
- Insects overwintering as eggs or adults will benefit
- Conditions will favour spread pests such as spruce bark beetle (*Ips typographus*)
- New invasive pests will emerge (without more effective import controls)
- **Increase in CO_2 will lead to decline in food quality (low N) for chewing insects**

Green spruce aphid (*Elatobium*) on Sitka spruce



Pinewood nematode: *Bursaphelenchus xylophilus*

Huge problems in North America, China, Japan and Korea
Currently present in Portugal and Spain in Europe.



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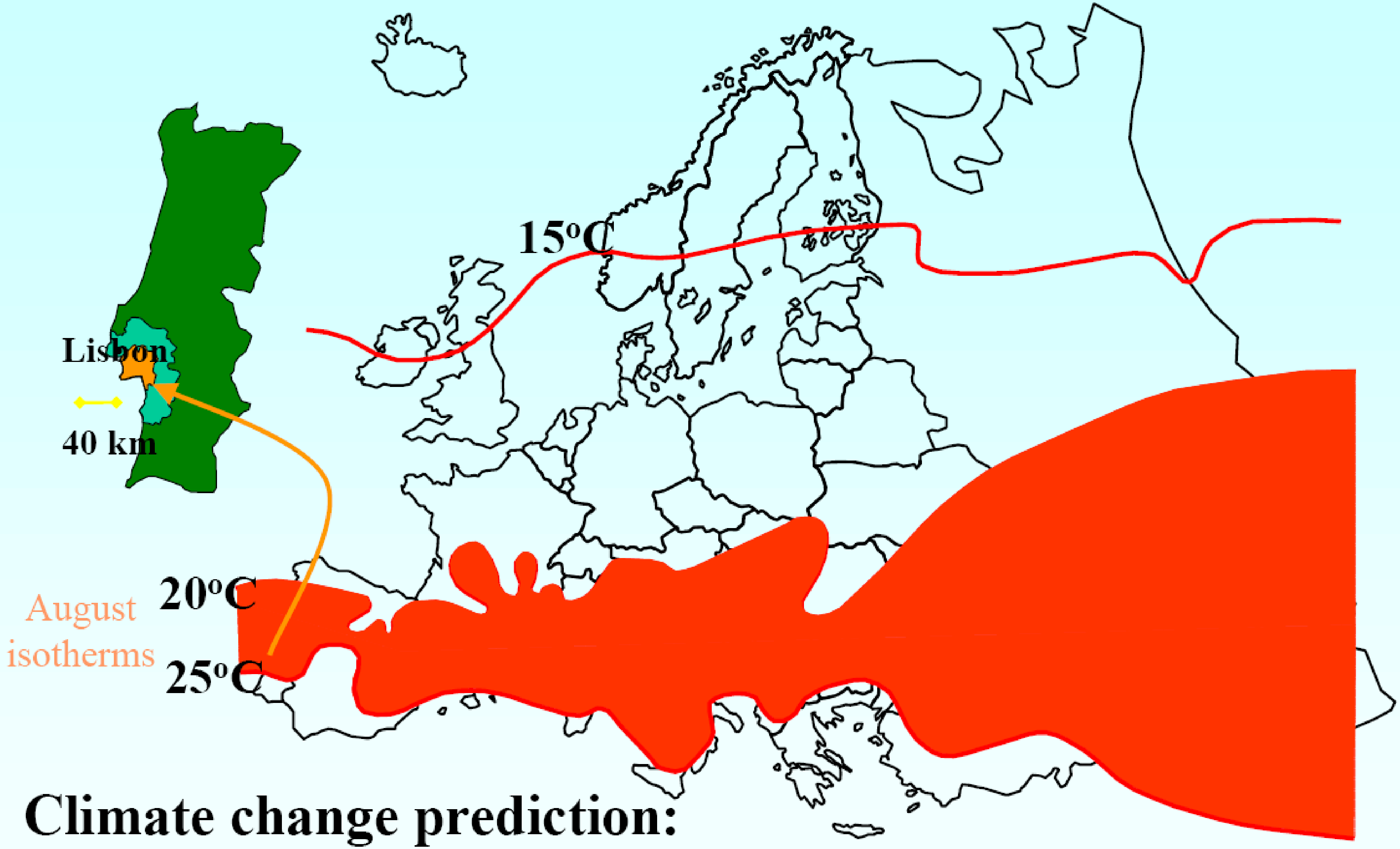


Climate change prediction:
wilt expression will move northward
severity will increase in the south

Courtesy Dr. Hugh Evans

Forest Research

Red Band needle blight: *Mycosphaerella pini*

Woods, A, Coates, KD, Hamann, A. 2005. Is an Unprecedented Dothistroma Needle Blight Epidemic Related to Climate Change? *Bioscience* 55: 761-769.

Specific case study

- *Phytophthora cinnamomi*

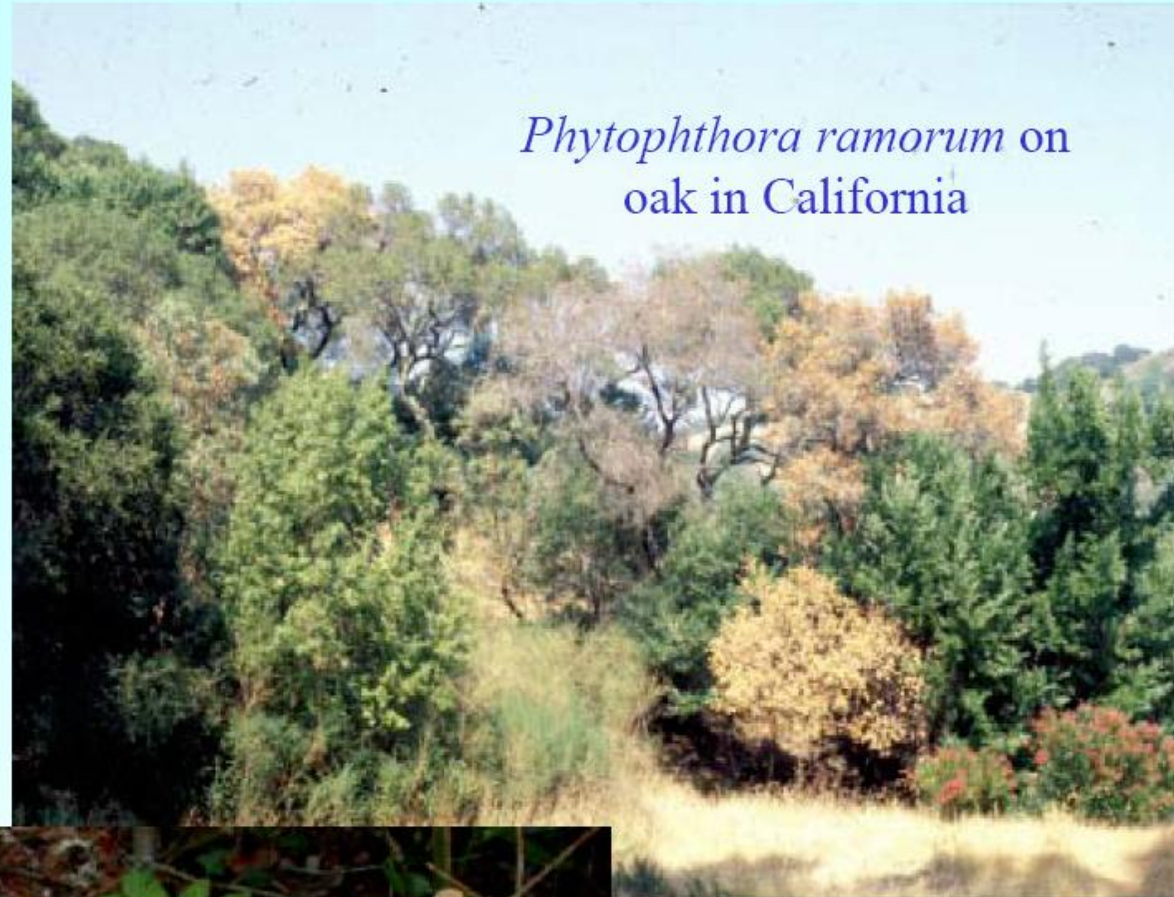
Phytophthora pathogens: microscopic organisms (e.g. potato blight)

- – require water for infection via swimming spores
- – root diseases; stem diseases; foliar diseases
- – drought after infection accelerates disease
- – likely to benefit from climate change: warm winters + winter rain, summer drought, summer storms

- Current examples in UK: *P. cambivora* on beech, *P. ramorum* and *P. kernoviae* (SOD) on beech, *P. alni* on alder, *P. ilicis* on holly, **P. cinnamomi* on many hosts
- *P. ramorum* now causing death of larch in south-west UK

* All invasive *Phytophthora* spp., all showing increased activity.

Phytophthora swimming spores



Phytophthora ramorum on oak in California

Phytophthora kernoviae on beech in UK

Phytophthora cinnamomi:

- **Collar and root rots – wide host range >1000 species**
- **Probably native to PNG – Celebes**
- **Invasive – spread world wide by plant trade since 1900s**

– epidemic on chestnuts SE USA 1940s (+ Spain, Portugal)

– now destroying world communities SW Australia (+ Fejnbos, South Africa)

– cause of current cork and holm oak mortality in Spain, Portugal

– affects chestnuts, yew, oaks and many other spp. in UK

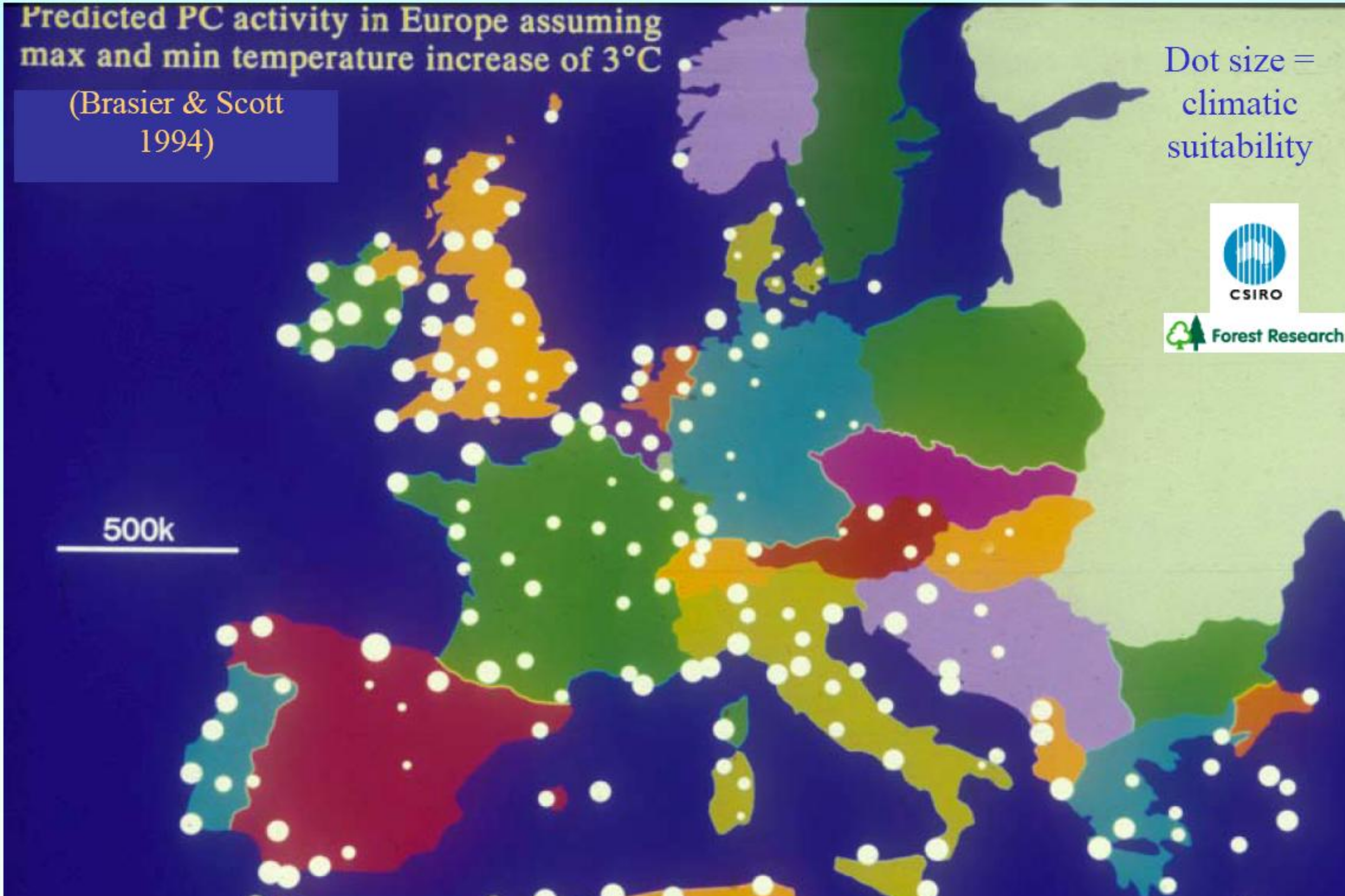
Needs rainwater for infection

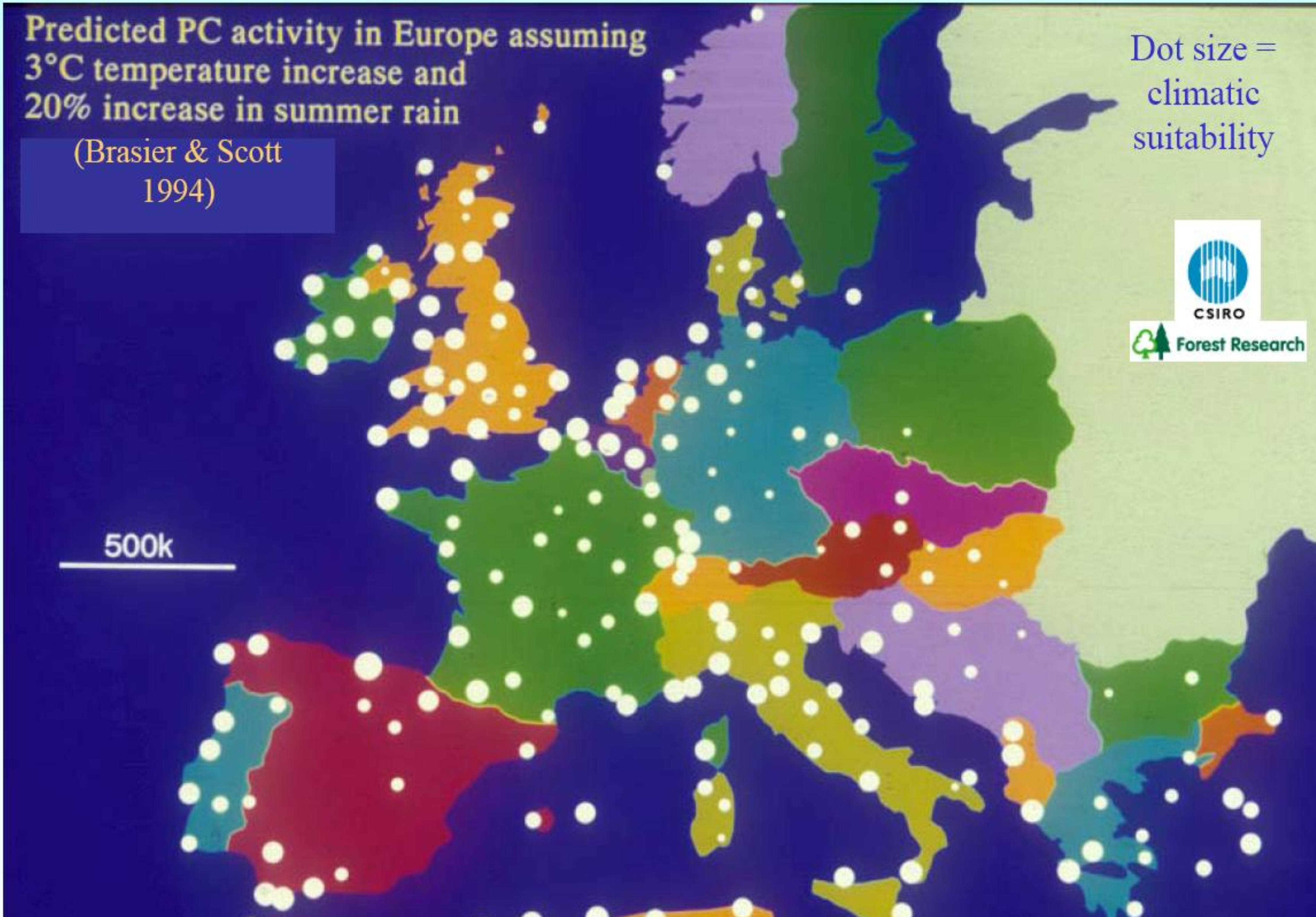
Warm temps 25°C+ favour disease (Mediterranean)

Phytophthora cinnamomi on oak (*Q. ilex*) in Spain

P. cinnamomi on chestnut in UK

CLIMEX model


Predicted PC activity in Europe assuming
max and min temperature increase of 3°C
(Brasier & Scott
1994)
500k
Dot size =
climatic
suitability
CSIRO
Forest Research



(Brasier & Scott 1994)

Dot size = climatic suitability

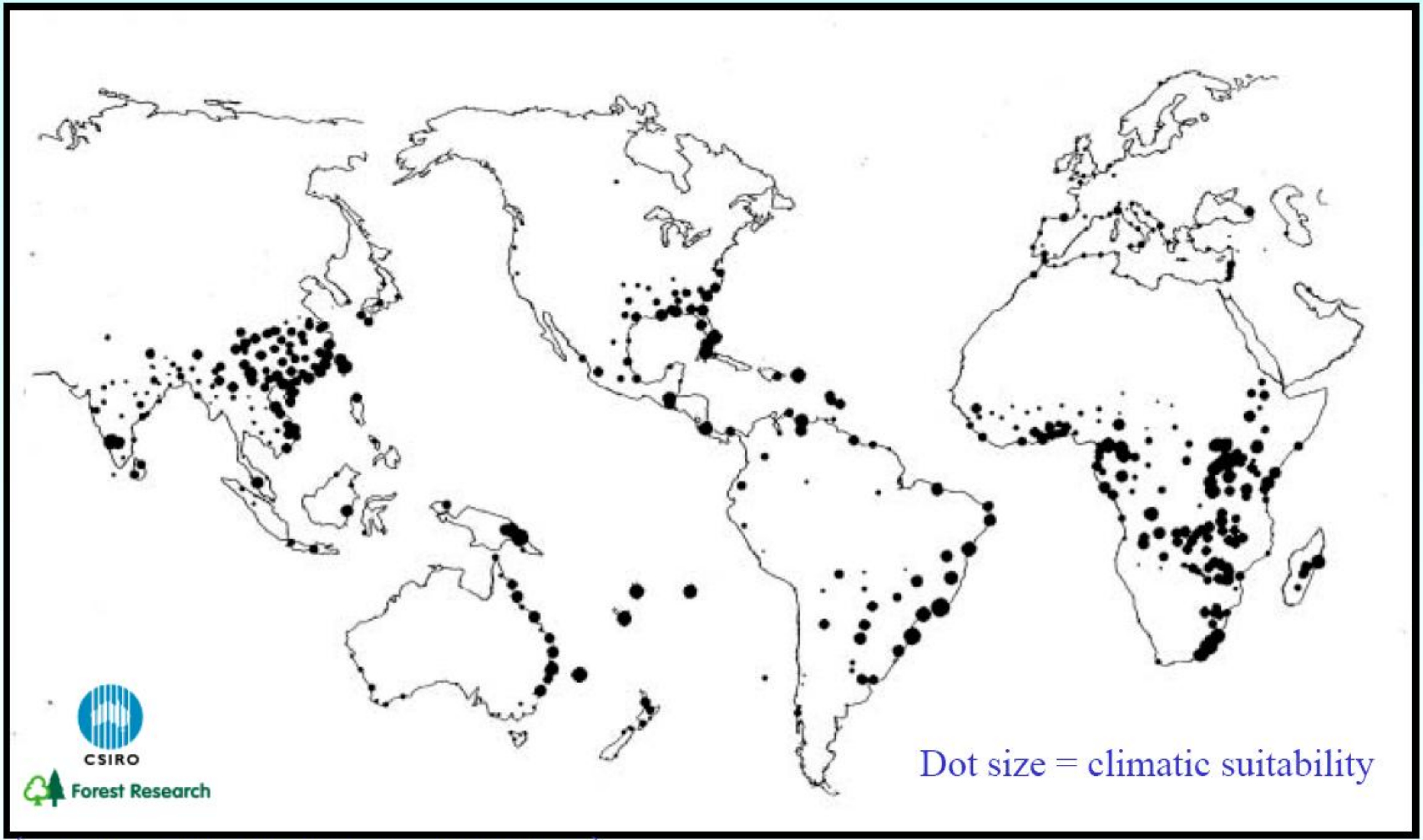
CSIRO

Forest Research


Predicted PC activity in Europe under normal conditions
(Brasier & Scott 1994)
Dot size = climatic suitability
500k
CSIRO
Forest Research

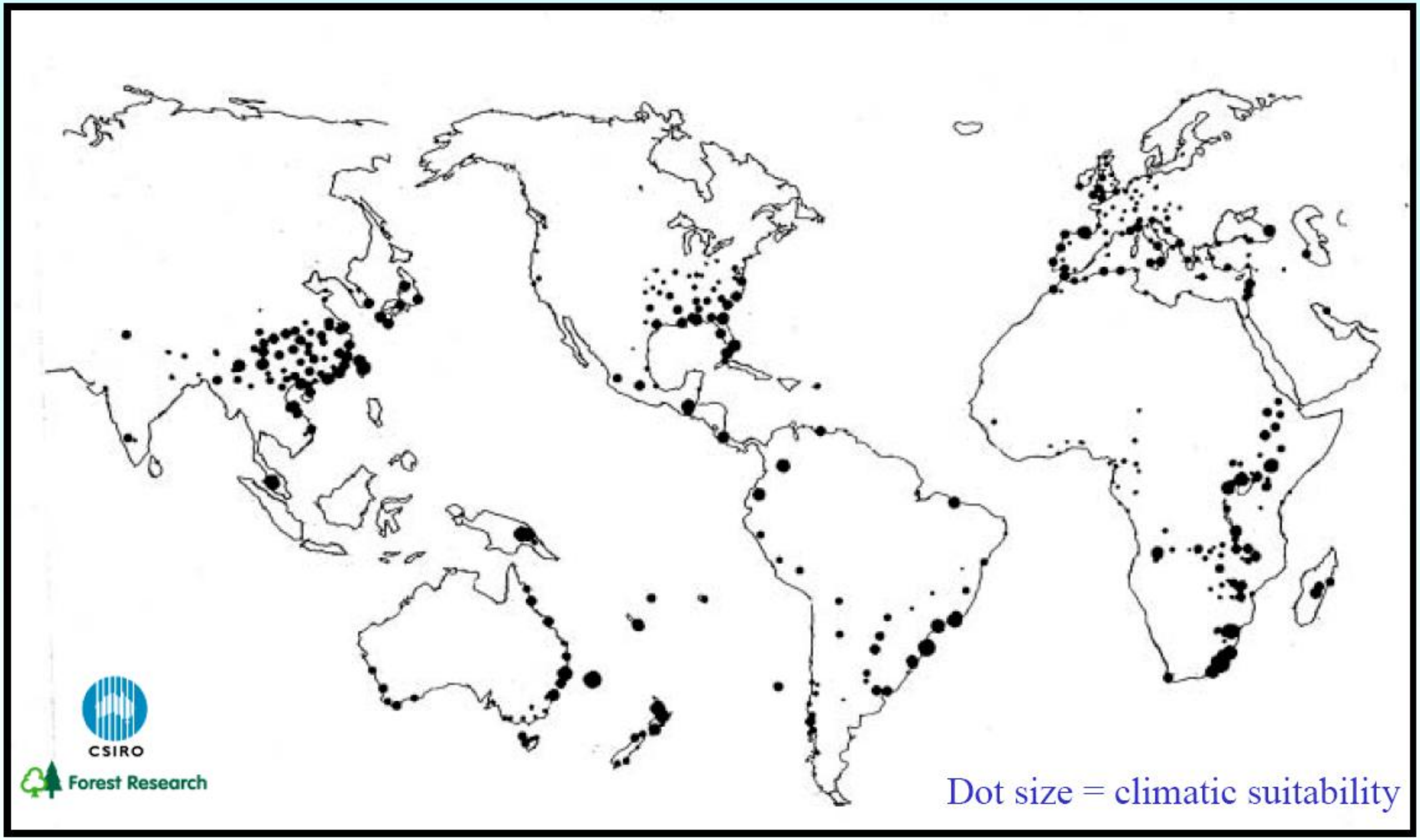
⇒ **Global Scale**

Predicted world wide activity of *P. cinnamomi* under current climates (normal conditions)



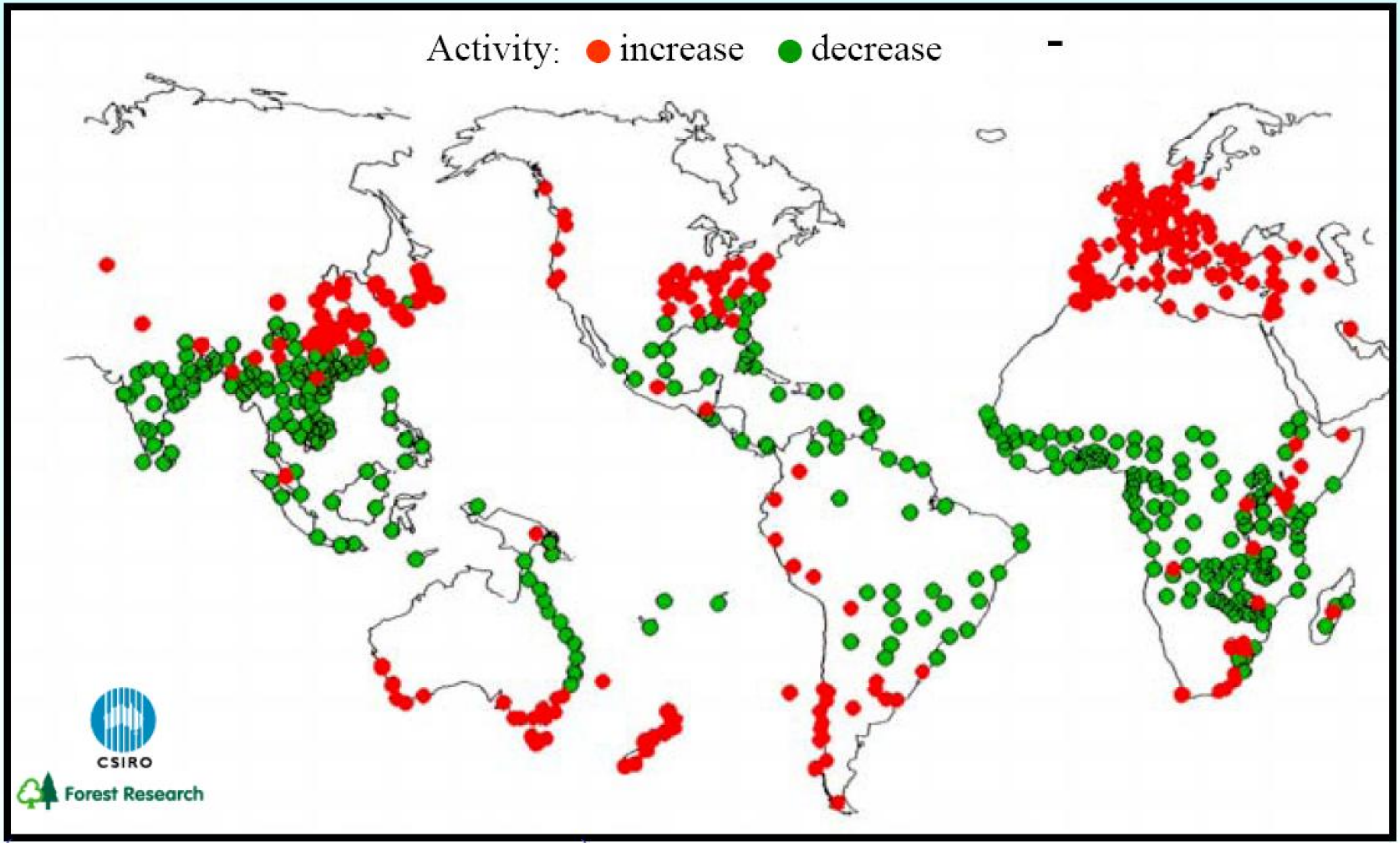
(From Brasier 2000. Data of J. Scott and C.M. Brasier)

Predicted world wide activity of *P. cinnamomi* assuming 3ºC increase in mean annual temperatures



(From Brasier 2000. Data of J. Scott and C.M. Brasier)

Predicted world wide activity of *P. cinnamomi*: contrast between current climates and a +3ºC mean increase



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Concluding Comments

1. Climate change will be broadly detrimental to tree health and will favour some highly damaging pathogens
2. Climate change x non-native hosts or invasive pathogens: more unstable - higher risk
3. Prevent arrival of invasive pathogens modernise and improve international plant health protocols

4. There is a case for planting native trees and encouraging native ecosystems, with assumptions these systems are:

   - better ecologically buffered
   - have a wider tree gene pool for adaptation

5. There is case for harnessing the enormous power of natural selection e.g. by densely sowing seed material and allowing the ‘new’ environment to select out the fittest - or - optimal - tree phenotypes