Address to Fifth Commission on Phytosanitary Measures, International Plant Protection Convention, UN FAO, Rome, March 2010

Scientific and operational flaws in international protocols for preventing entry and spread of plant pathogens via ‘plants for planting’

Professor Clive Brasier, Forest Research UK

The views expressed in this talk are solely those of the author.

They are based on > 40 years personal experience researching the behaviour of plant pathogens and on the observations of many scientific colleagues.

The permissions of scientific colleagues to use their data or photographs in this talk are gratefully acknowledged.

For a fuller account of the issues raised and detailed references see:

Brasier C M (2008). The biosecurity threat to the UK and global plant heritage from international trade in plants. *Plant Pathology* 57, 792-808.

Webber J (2010). Pest risk analysis and invasion pathways for plant pathogens. *New Zealand Journal of Forest Science* 40, suppl., S45-S56 (and online at www.scionresearch.com/nzjfs)

A. The problem

B. Why the growing threat?

C. Solutions

I will be talking mainly about ‘plants for planting’ - nursery stock - and its impact on the environment

Going to use examples of forest pathogens - and in particular *Phytophthora* pathogens (fungi) because

- *Phytophthora* is arguably the most damaging genus of fungal plant pathogens (a well known example is potato blight)

- Phytophthoras are well suited to transmission via international trade in plants

But much of what I will say will be relevant to movement of invertebrates, viruses, bacteria

- and to pathogens of horticultural and agricultural cash crops

I'm also going to take many of my examples from the present situation in Europe

- Because Europe nicely represents the problem worldwide

- Because Europe, regrettably, has an increasingly poor record in keeping exotic pathogens out

A. The problem

Europe is currently experiencing a stream of imported pathogens and pests - a growing threat to the long term biosecurity and sustainability of its forests and natural ecosystems, for example…

- Pitch canker of pine, Horse chestnut bleeding canker, Plane wilt, Pine wood nematode, Asian longhorn beetle, Pine lappet moth, Oak processionary moth, Chestnut gall wasp…
- Especially *Phytophthora* pathogens – eg. Phytophthora dieback of alder, Phytophthora ramorum dieback (SOD), Phytophthora kernoviae dieback, Phytophthora holly blight, Phytophthora collar rot of almond, Phytophthora lateralis cedar mortality…

Examples of destructive tree diseases spreading in EU in the last 10 years alone:

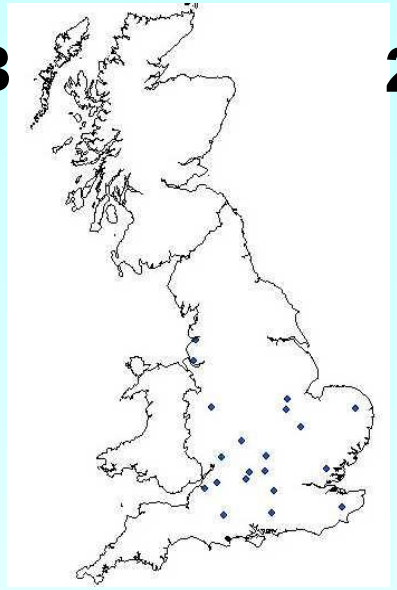
Horse chestnut bleeding canker, *Pseudomonas syringae* pv *aesculi,* now spreading across Europe

Photos: Joan Webber Forest Research UK

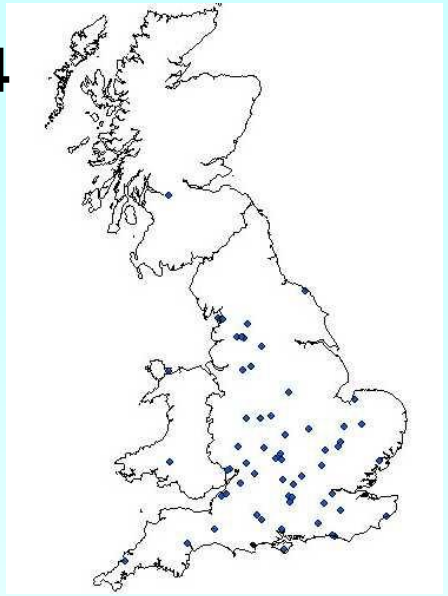
Rapid spread: Forest Research UK data - HC bleeding canker

2002

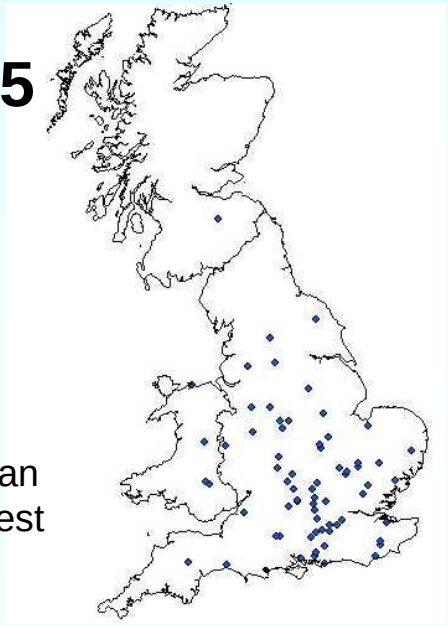
2003



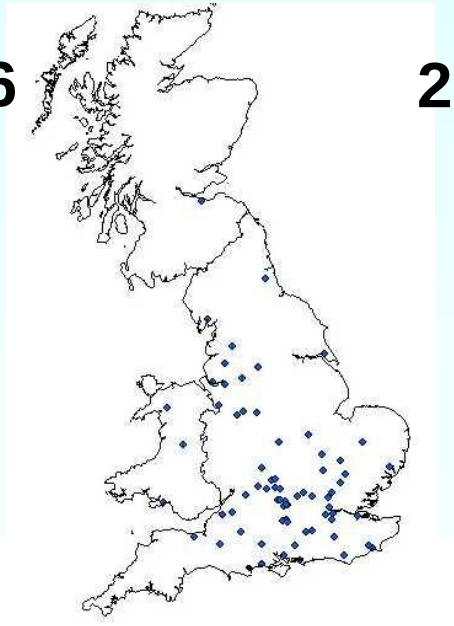
2004



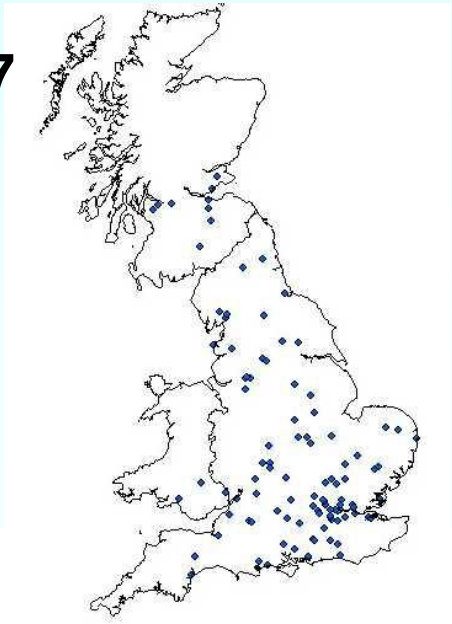
2005



2006



2007

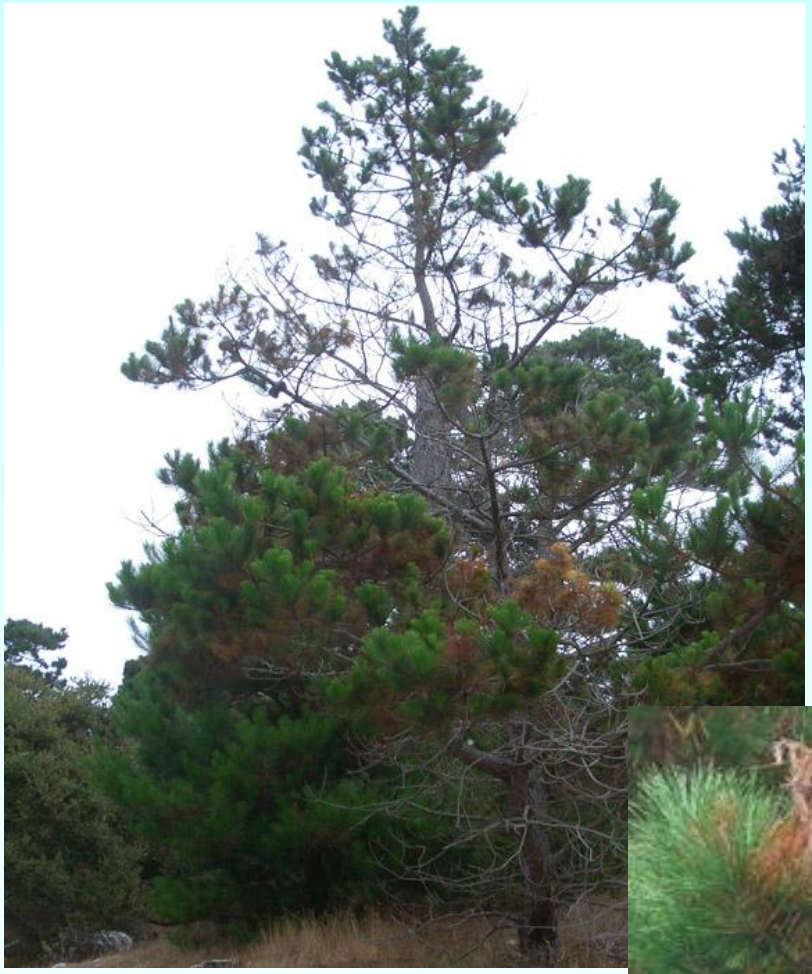


Courtesy Joan Webber Forest Research

Ash dieback (*Chalalara fraxinea*), now spreading widely from northern Europe

Photos: Ibben Thomsen DK, Thomas Kirisits Austria

Pitch canker, *Giberella circinatum*, recently reported from Spain, Italy; now spread to Portugal? ..



Pinus radiata in USA

Photos: Joan Webber Forest Research UK; Tom Gordon UC Davis

Phytophthora cinnamomi – causing dieback and mortality of cork oaks and h**o**lm oaks in Spain and Portugal. Origin: Pacific-Celebes area.

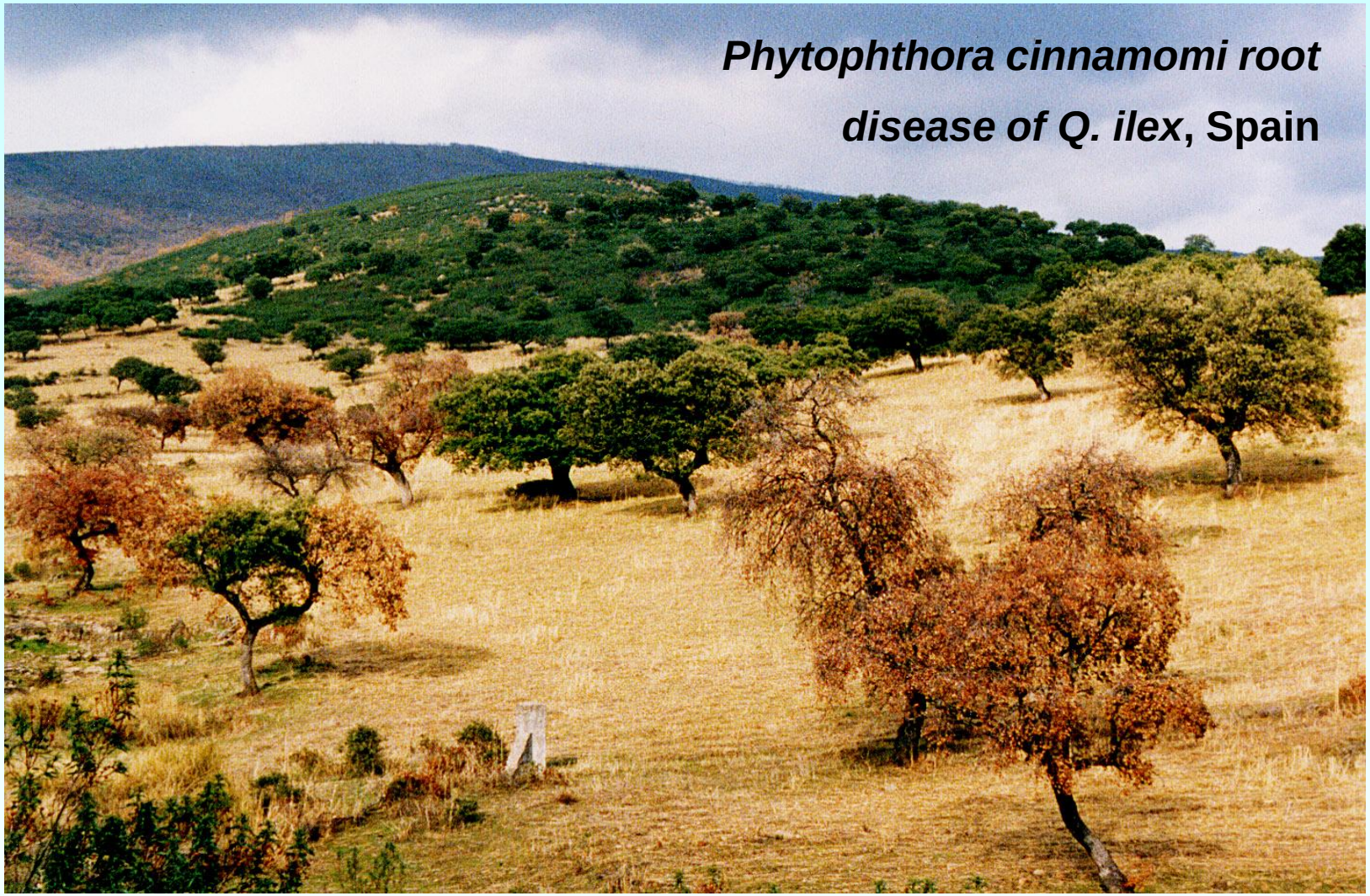


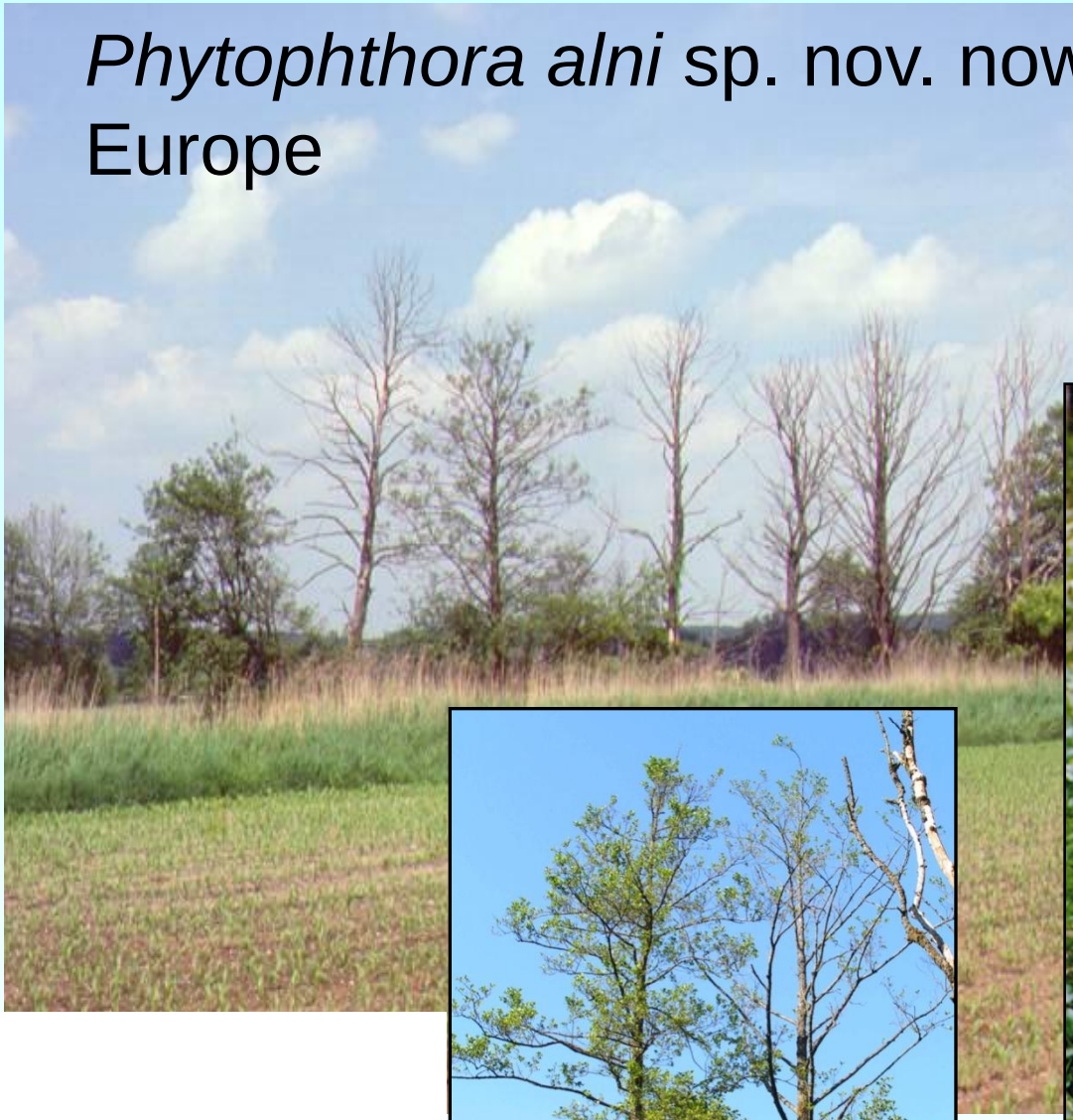
Photo Forest Research UK

Phytophthora alni sp. nov. on alder, now spreading across Europe

***Alnus glutinosa* UK**

Photos: John Gibbs, Forest Research UK

Phytophthora alni sp. nov. now spreading across Europe



Alnus glutinosa

Germany

Photos: Thomas Jung, Brannenburg, Germany

Phytophthora kernoviae sp.nov, now spreading out of south west England. Origin probably New Zealand

Rhododendron

Photos: Forest Research UK

Beech (Fagus)

Phytophthora kernoviae also spreading since 2007 onto V*accinium* in ancient woodland and open moorland, UK

Infected understory
V. myrtilus (‘bilberry’)

Photo Forest Research UK

P. ramorum ('Sudden oak death pathogen' in North America) spreading rapidly across Europe via nursery trade.

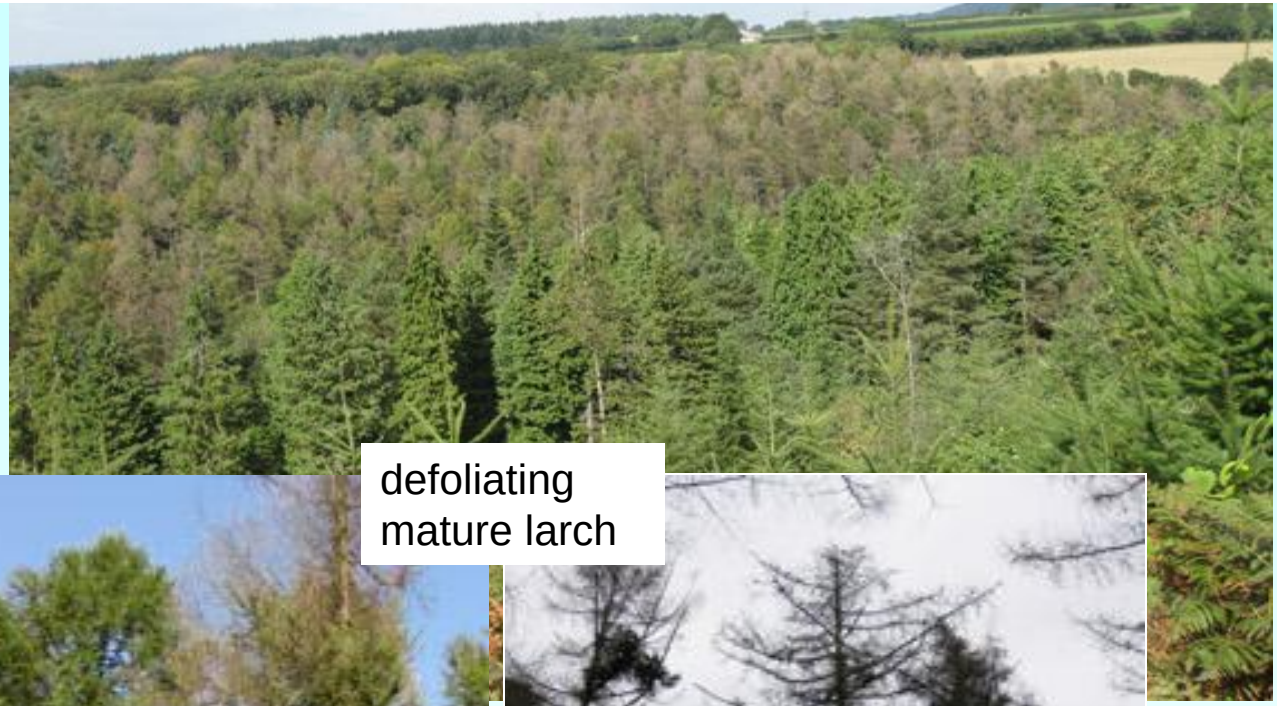
Bleeding lesions on beech, oak

Cornwall SW England.

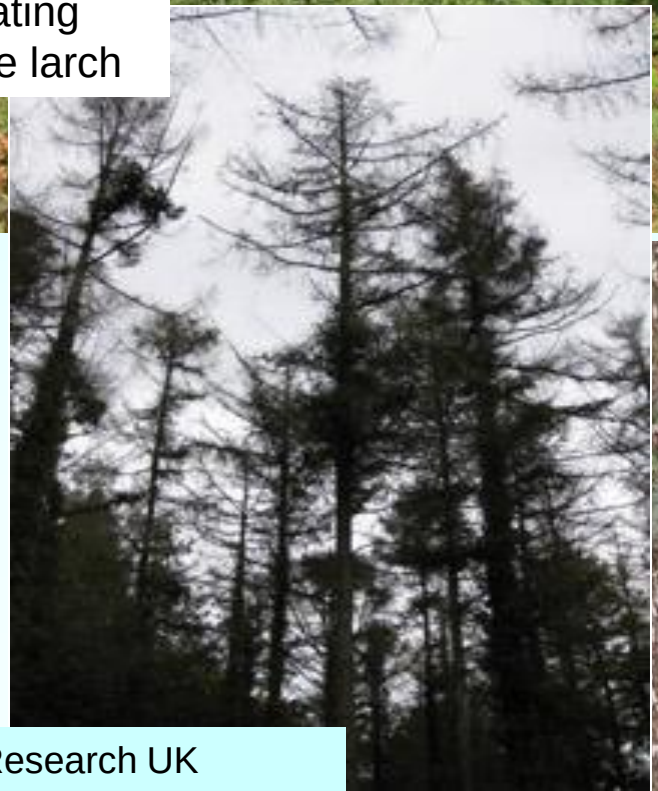
Infections on rhododendrons

Photos: Forest Research UK

Latest: Phytophthora ramorum - spreading to Larch plantations, SW England, August 2009



defoliating mature larch



young larch

larch bleeding stem lesions

New behaviour

Photos: Forest Research UK

.. and from larch canopy to many tree species beneath.

(All *P. ramorum* +ve)

Defoliating chestnut under larch

Photos: Forest Research UK

Stem lesions, Hemlock under larch

Bleeding lesions, Beech under larch

Fresh infections, Rhododendron under larch

Another latest - Phytophthora lateralis - spreading in SW France. Discovered September 2009. Origin probably Japan / Taiwan.

Highly destructive on *Chamaecyparis lawsoniana* –

Photos
C. Robin
INRA,
Bordeaux

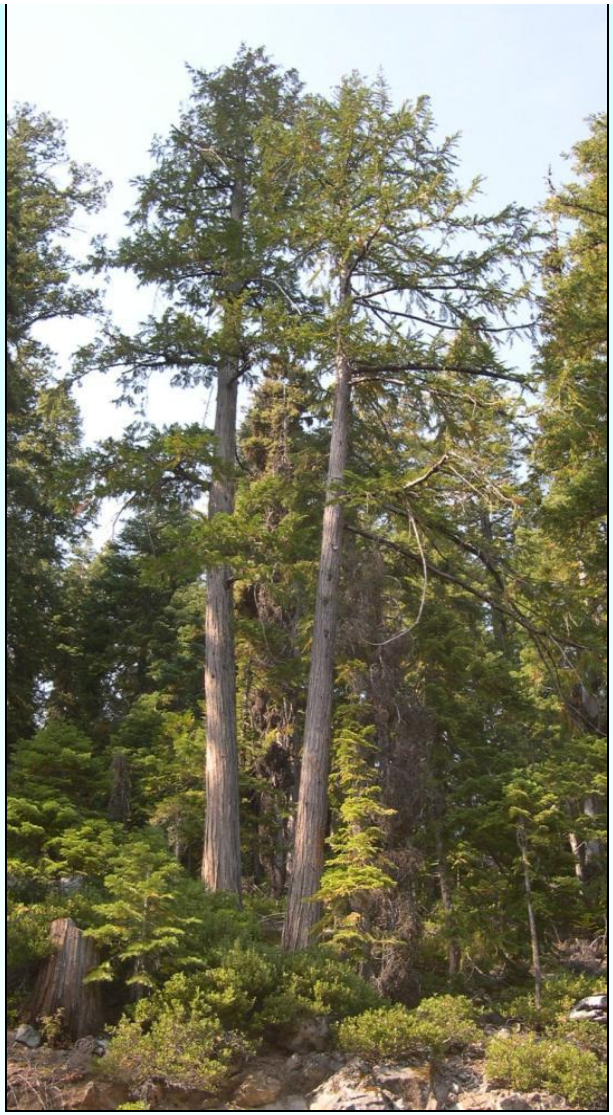
Yet another new *Phytophthora* threat to Europe

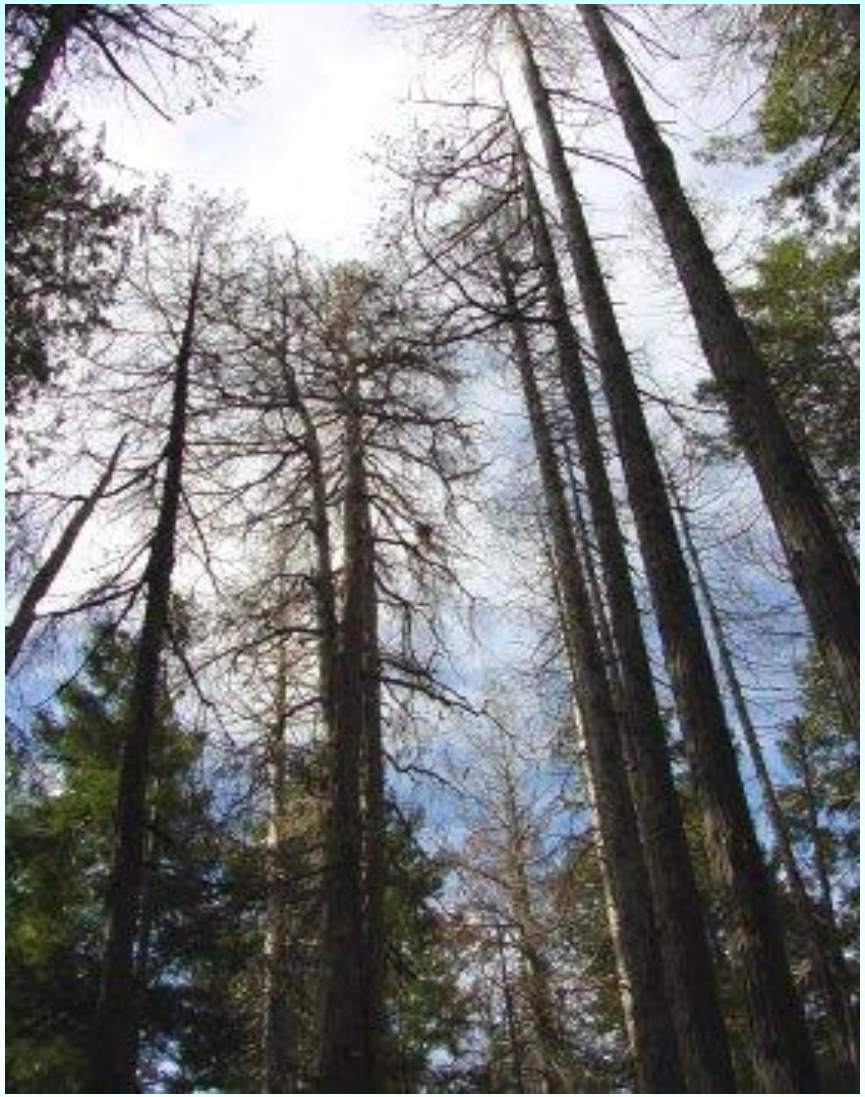
This phenomenon is *not* confined to Europe - Europe is simply representative here

A similar pattern of pathogen invasion is occurring in forests and natural ecosystems worldwide –

A few specifically *Phytophthora* examples:

The invasive *P. lateralis,* origin Taiwan / Japan, threatens to wipe out native *Chamaecyparis lawsoniana* in its native range in California and Oregon, USA





Photos Don Goheen USFS

P. lateralis on native *Chamaecyparis lawsoniana,* California and Oregon

Photos Don Goheen USFS

California – Invasive ‘Sudden oak death’ pathogen *P. ramorum* – currently killing millions of oaks.

Origin Asia?

Photo CMB June 2009

Photo Nick Waipara ARC Biosecurity

New Zealand – ‘new’ Phytophthora, ‘P. taxon agathis’ killing iconic 800+ yr. old Kauri pines. Origin unknown

Photos CMB March 2010

Chile- recently appeared *P. pinifolia* sp. nov. defoliating pine plantations from 2004. Origin unknown.

Photos: Web - FABI ZA

Argentina – new *P. austrocedrus* sp. nov. now killing ancient native cedar stands. Origin unknown.

Photos Alina Greslebin CIEFAP


Australia - *P. cinnamomi* – killing world heritage floras in Western Australia. Origin: Pacific islands–Celebes.


Photos Giles Hardy Murdoch University

- Many of these damaging invasive pathogens are *new to science*

  eg *P. ramorum, P. alni, P. kernoviae, P. pinifolia,*

- Many of them spread by the international plant trade – via rooted plants for horticulture and forestry

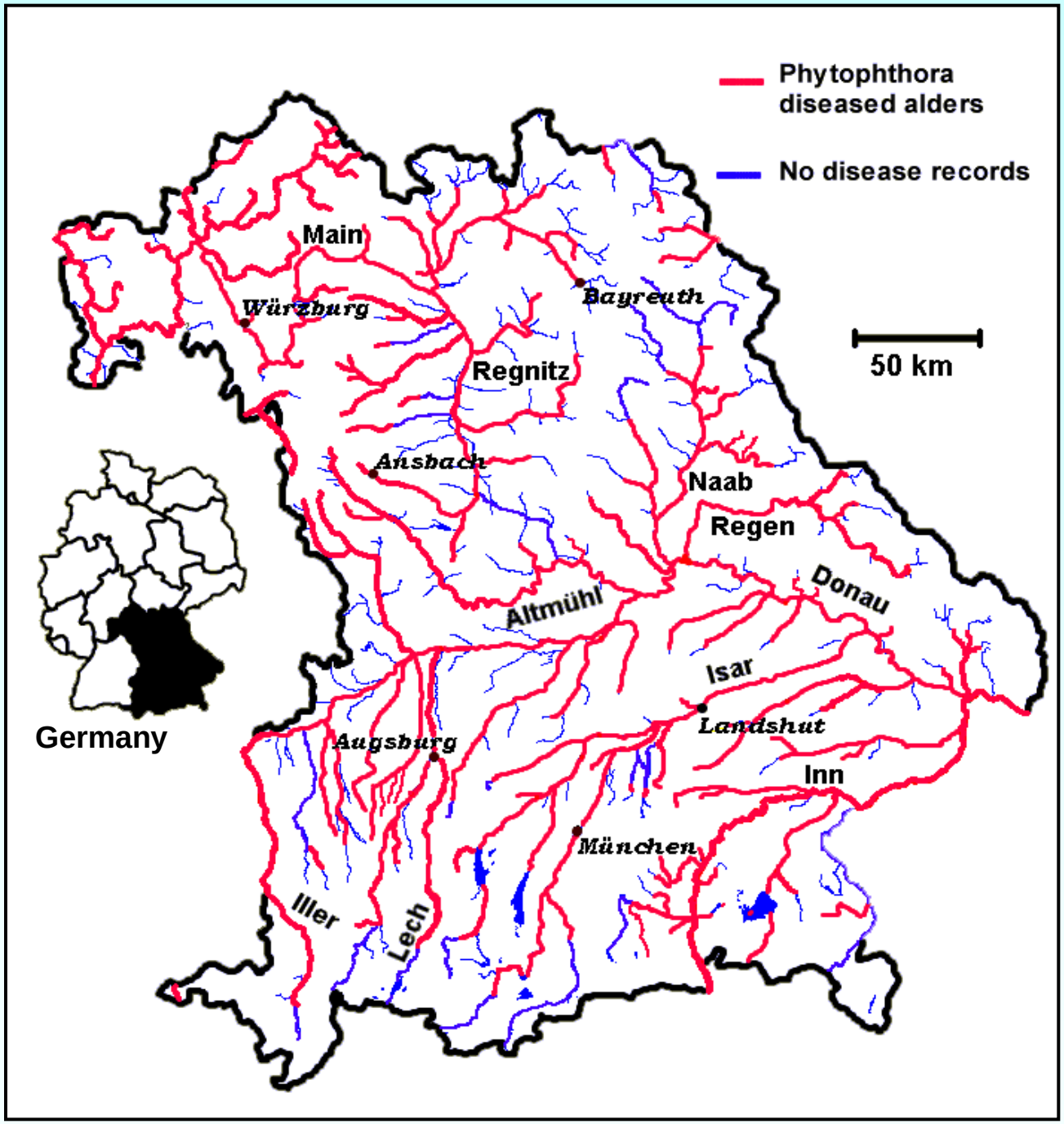
As already stated:

Phytophthora is arguably the most dangerous genus of fungal plant pathogens.

And Phytophthoras are also especially suited to spread on nursery stock

So – look further at the *Phytophthora* nursery issue as exemplified by Europe -

In Germany surveys carried out recently by Jung *et al* (2004) in Bavaria of alders infected with *Phytophthora alni:*



P. alni appeared ca 1995

By 2003: 80% of main Bavarian river systems infested

See Jung & Blashke *Plant Pathology* 2004

These surveys have also shown:

- *Phytophthora* damage to young alder plantations is almost exclusively caused by planting infested nursery stock

- The disease then spreads from the young alder plantations to the riparian alders along river systems

Similar surveys conducted on oak, beech and maple in nurseries and young plantations in Germany

Infested beech seedlings

from nursery ..

.. to plantation

root symptoms

Photos: Thomas Jung, Gunter Hartmann, Germany

These surveys showed, of 102 nursery fields in 60 nurseries :

- 64 nursery fields (62.7%) infested
- 48 nurseries (80%) infested
- 13 *Phytophthora* species total; many aggressive to trees

Similar evidence of the *Phytophthora* nursery problem across Europe

Themann *et al* 2002 :

13 *Phytophthora* species in irrigation water of 3 nurseries in Saxony, N Germany; including *P. ramorum*

Orlikowski (pers comm 2006) :

"*A procession of new Phytophthora pathogens into Polish nurseries since joining the EU.*
Now spreading into the forests".

Moralejo et al 2008 :

Recovered 17 different *Phytophthora* species from 37 hosts in nurseries in Balearic islands and east Spain:

> "*An example of unnoticed spread through the movement of hosts via the ornamental plant trade in Europe*"
>
> " *Several of the Phytophthoras now confined to nurseries may pose a threat to local natural ecosystems*"

And similarly in the USA:

Schwingle & Blanchette (2007) :

Found 11 *Phytophthora* species on ornamentals in Minnesota nurseries..

Yakabe et al (2009) :

Found 13 *Phytophthora* species causing *foliar* disease of ornamentals in Californian nurseries..

And so on

Therefore plants often leave European (EU) (and US) nurseries contaminated by Phytophthoras

Bear in mind:

- Most nurseries in the EU have no idea what Phytophthoras they have – educational and regulatory issue
- Most EU national plant health organisations also have little idea what Phytophthoras are in their horticultural or forest nurseries …
- Within a few years of its discovery in Germany and the Netherlands *Phytophthora ramorum* spread rapidly across the EU, from Poland to Portugal, on infested nursery stock

In summary – for Phytophthoras (only) in Europe:

- Many dangerous, previously unknown Phytophthoras, such as *P. ramorum, P. kernoviae, P. lateralis* recently imported into Europe from other continents by the international plant trade
- Then spread around Europe on infested stock by the nursery industry
- Then invaded forests and natural ecosystems
- Other recent arrivals in Europe include: *P. niederhauseri P. alni, P. inundata, P. citrophthora*, *P. hibernalis*, *P. tropicalis, P. palmivora*, *P. hadraiandra, P. bisheria…*

… and many more

- Many dangerous, previously unknown Phytophthoras, such as *P. ramorum, P. kernoviae, P. lateralis* recently imported into Europe from other continents by the international plant trade
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… and many more

Bottom line is: these Phytophthora species simply should not be present in Europe at all -

Each of them represents a failure of International - and European - plant biosecurity …

Basically Europe - meaning especially the ‘older’ EU countries - is now acting as an import, distribution and export centre for *Phytophthora* pathogens

But, to reiterate:

The European nursery situation is a symptom of the problem

Not the cause

The problem is world wide

B. Why the growing threat?

Primarily it is an international biosecurity *protocol* problem

Linked to the fact that when current International Plant Health / IPPC / WTO (now the ‘SPS’ agreement) regulations were devised in the 1950s -

- The plant trade was not highly globalised.

Today the market is highly globalised -

Now, like some other global markets, the protocols governing international plant trade need a major overhaul –

- to align them with modern scientific knowledge
- to make them genuinely effective in the context of intensifying global trade
- to control the growing environmental damage

Critiques - the scientific case for the problem -

2004

COMMENTARY

Preventing invasive pathogens: deficiencies in the system

Import controls are meant to protect our gardens and environment from devastating plant diseases, but CLIVE BRASIER believes that the global system is fundamentally flawed because it ignores scientific realities: he recommends some solutions

2003

Preventing Invasive Pathogen Threats to Forests—A Sideways Scientific Look

Clive M. Brasier

Abstract—A scientific health check on ... current global (WTO/FAO) prevention sy... concluded that the system, though o... fundamentally flawed, because it is not ... Possible solutions are presented.

Introduction

The progenitor of this paper was prep... request from the USDA Forest Se... current global plant health protocols ... Organization (WTO) and Food ... Organization (FAO). It was written a... international trade in plants and in t... Oak Death (SOD) and other invasive ... forests and natural ecosystems. The ... presented during the Quarantine Pan... Symposium on Sudden Oak Death, ... 2002. An abstract of the original text ... website (http://danr.ucop.edu/ihrmp... Monterey, I pointed out several of my ... from APHIS, UK Plant Health, and ... were sharing the platform with me a... they would still be counted among m... my presentation!

The text presented here is a rework ... and it represents a personal view, ba...

2008

Plant Pathology (2008) Doi: 10.1111/j.1365-3059.2008.01886.x

LETTER TO THE EDITOR

The biosecurity threat to the UK and global environment from international trade in plants

C. M. Brasier*

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Native plant communities, woodlands and landscapes in the UK and across the world are suffering from pathogens introduced by human activities. Many of these pathogens arrive on or with living plants. The potential for damage in the future may be large, but current international regulations aimed at reducing the risks take insufficient account of scientific evidence and, in practice, are often highly inadequate. In this Letter I outline the problems and discuss some possible approaches to reducing the threats.

Keywords: biosecurity, forests, invasive pathogens, natural ecosystems, plant diseases, plant health

My case is essentially an argument for more science - based International Plant Health (~SPS) protocols

With caveats that in many countries -

- Current SPS protocols are regulated and operated to a good standard
- The trade generally adhere to the protocols

It’s the protocols themselves that are flawed

Look at some of the scientific and operational flaws in International Plant Health (~SPS) protocols:

A major problem is with identifying and defining the risk:

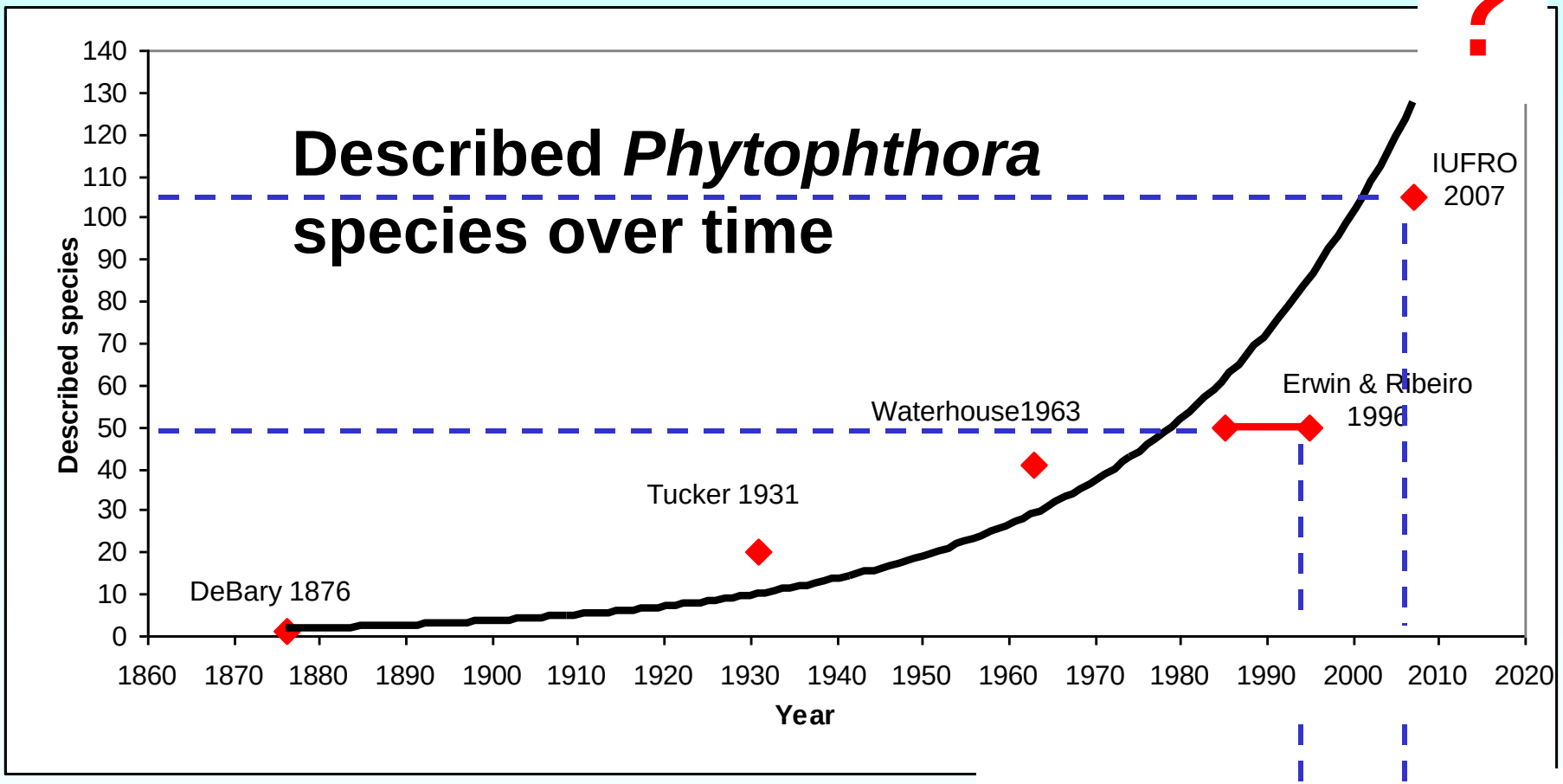
Current SPS protocols scientifically flawed -

1. Because they cover only named organisms

Yet - a significant proportion of current fungal invaders of forests are organisms previously unknown to science. eg's (Phytophthoras only : *Phytophthora ramorum*, *P. alni*, *P. kernoviae, P. pinifolia ..*

Such 'unknowns' are not covered by the current SPS protocols

How ‘big’ is the unknown pathogen problem? eg. How many more ‘scientifically unknown’ *Phytophthora* threats are out there?



From Brasier (2009)

Effectively doubled in ~10 years since 1996 ..

In 2007, based on this species curve, I estimated the number of existing *Phytophthora* species to be between 200 – 600 (Brasier 2009).

Taking into account the 100 or so presently known *Phytophthora* species –

This leaves 100 - 500 unknown *Phytophthora* species in unexplored or partly explored forests and natural ecosystems of the world…

Say 300 unknown species

The '*Phytophthora* invasives in waiting'..

Current SPS protocols scientifically flawed -

2. Because we commonly regulate trade to prevent spread or introduction of a pathogen only *after* it has escaped from its geographic centre of origin and begun causing damage in a susceptible plant community

   - whereas, scientifically, what we *need* to do is to prevent it from escaping in the first place.

The 1950s SPS protocols were essentially developed out of a 1780s Linnean ‘list-making’ taxonomic culture

They did not allow for the existence of large numbers of high risk ‘unknown pathogens’ that, due to Darwinian co-evolution with their hosts, were causing little damage in their centres of origin.

Ergo: The protocols are not biologically - or evolutionary - *process* based:

They are non Darwinian

- Not very smart 200 years after Darwin’s birth?

A consequence is –

The ‘door’ is wide open to introduction and spread, largely by the plant trade, of scientifically unknown pathogens, such as Phytophthoras, into nurseries

and then from nurseries into horticulture, agriculture, or into the natural environment

Fundamentally, a recipe for *bioinsecurity***?**

Problems with implementation of regulations:

- Consignments often arrive with ‘pest free’ certificates but are visibly infected eg. For UK. *P. ramorum* on *Viburnum* from EU; exotic *Acer* spp. from Asia; tree ferns from Asia, Australasia...
- *Weakest link syndrome* – serious biosecurity breaches in states with less effective inspection regimes put other states at risk
- States do not report incursions by listed pathogens, or report too late, sometimes to ‘protect trade’. Many recent European examples.

- We rely largely on visual inspection at ports but –

  We inspect only a tiny proportion of imports (APHIS: ~2%)

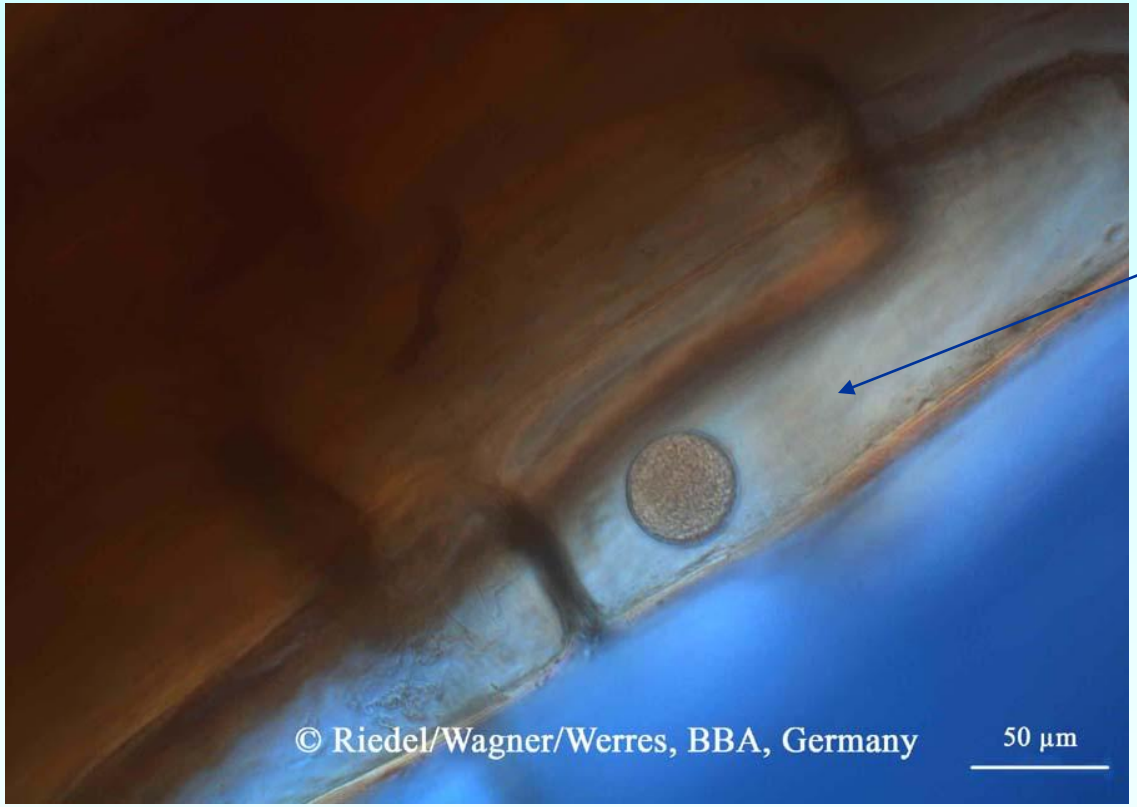
  And we know from recent research that healthy *looking* plants may have symptomless, dangerous infections

  eg. *P. ramorum* and *P. kernoviae* on leaves, stems, roots -

Both *Phytophthora ramorum and P. kernoviae* exhibit asymptomatic sporulation on nursery stock

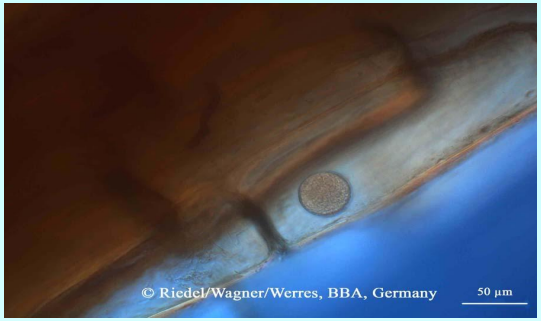
Sporangia of *P. ramorum* on asymptomatic rhododendron leaf

Photo – Sandra Denman Forest Research UK



Chlamydospore of *P. ramorum* on root of an *asymptomatic* rhododendron

Photo Marco Riedel, BBA Braunschweig, Germany



Infected but asymptomatic nursery stock may be imported in this way

- and later exported to uninfested areas or states

This could well be how *P. ramorum* entered the US.
Or *P. kernoviae* entered the UK

Modern plant trade is enhancing the risk

- Increasing globalisation of trade and the ‘sucking in’ of high volume imports of rooted plants - little explanation needed?
- Many nurseries are seriously infested eg. Phytophthoras in EU. Already discussed.
- Fungicides /pesticides often used to suppress symptoms eg *Phytophthora* again.
- ‘Re-badging’ of stock, concealing country of origin (e.g. Grass trees imported into UK from another EU country – but ‘real origin’ -Australasia)

- Demand for instant woody landscapes

  Current fashion in many countries for ‘instant landscaping’. Resulting in inter-state shipment of large numbers of semi mature or even mature trees and shrubs

  e.g. Large plane trees, olives, oaks, cypresses, alders, figs, pines being imported into UK from the EU and across the world -

Cypresses

Imported Grey alder –how damaging *Phytophthora alni* arrived in UK from EU?

Olive trees

Imported *Platanus* – will this bring Plane wilt, *Ceratocystis platani,* into UK?

Photo PHSI Fera UK

Clearly such large trees, often with enormous root balls or potted in original soil, *cannot* be adequately inspected without prolonged quarantine and a detailed microbial analysis of the whole tree and the soil

Biologically, a highly irresponsible trade?

In my view this trade best prohibited as soon as possible

Consequences for our world plant heritage

Inevitably this is having damaging and long term impact on the worlds forests and plant heritage ..

Currently developed countries the most affected

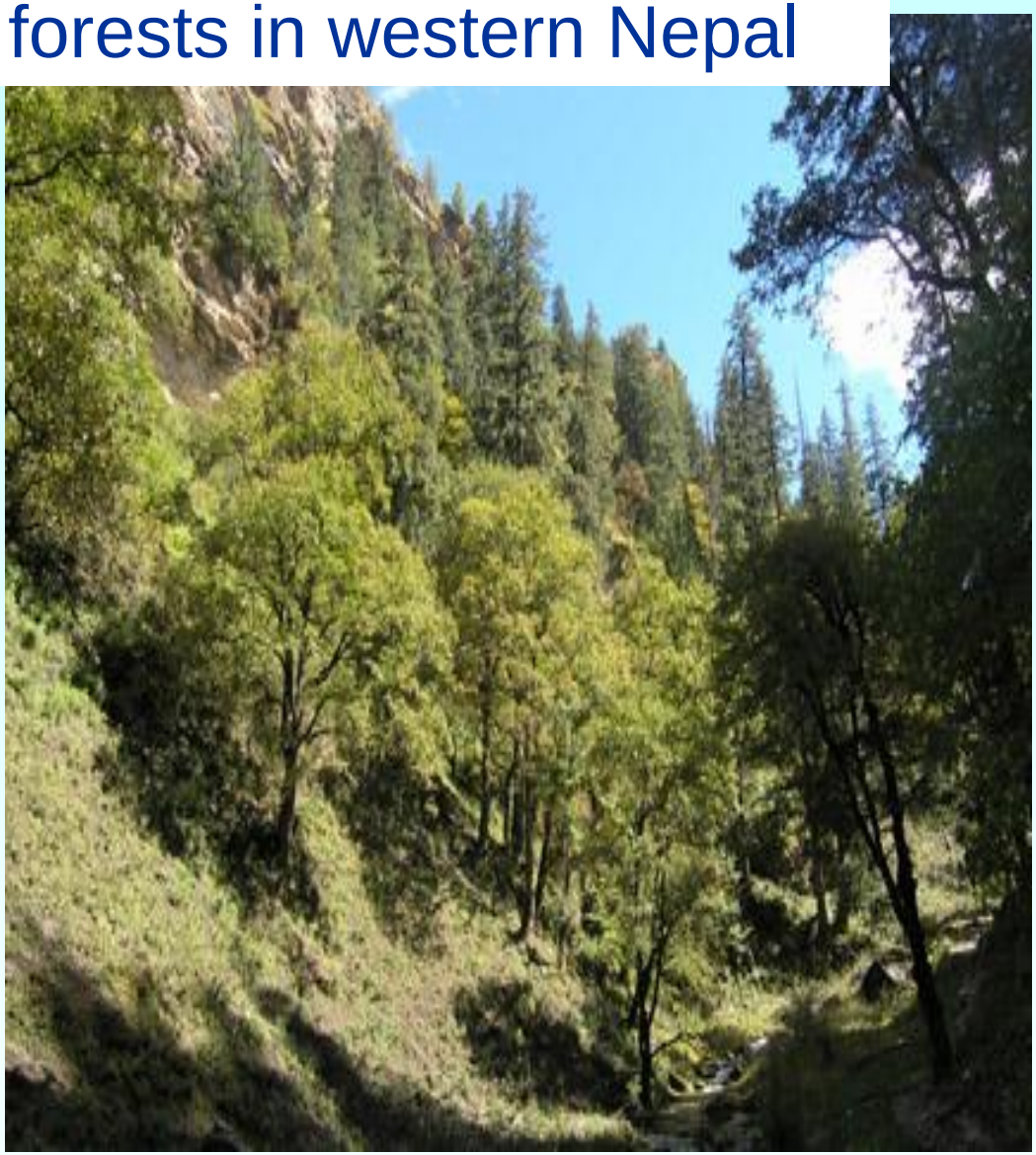
In future will also be the plant heritage of developing countries –

eg The unique plant floras of Yunnan or Patagonia?

or the forests of Nepal ?

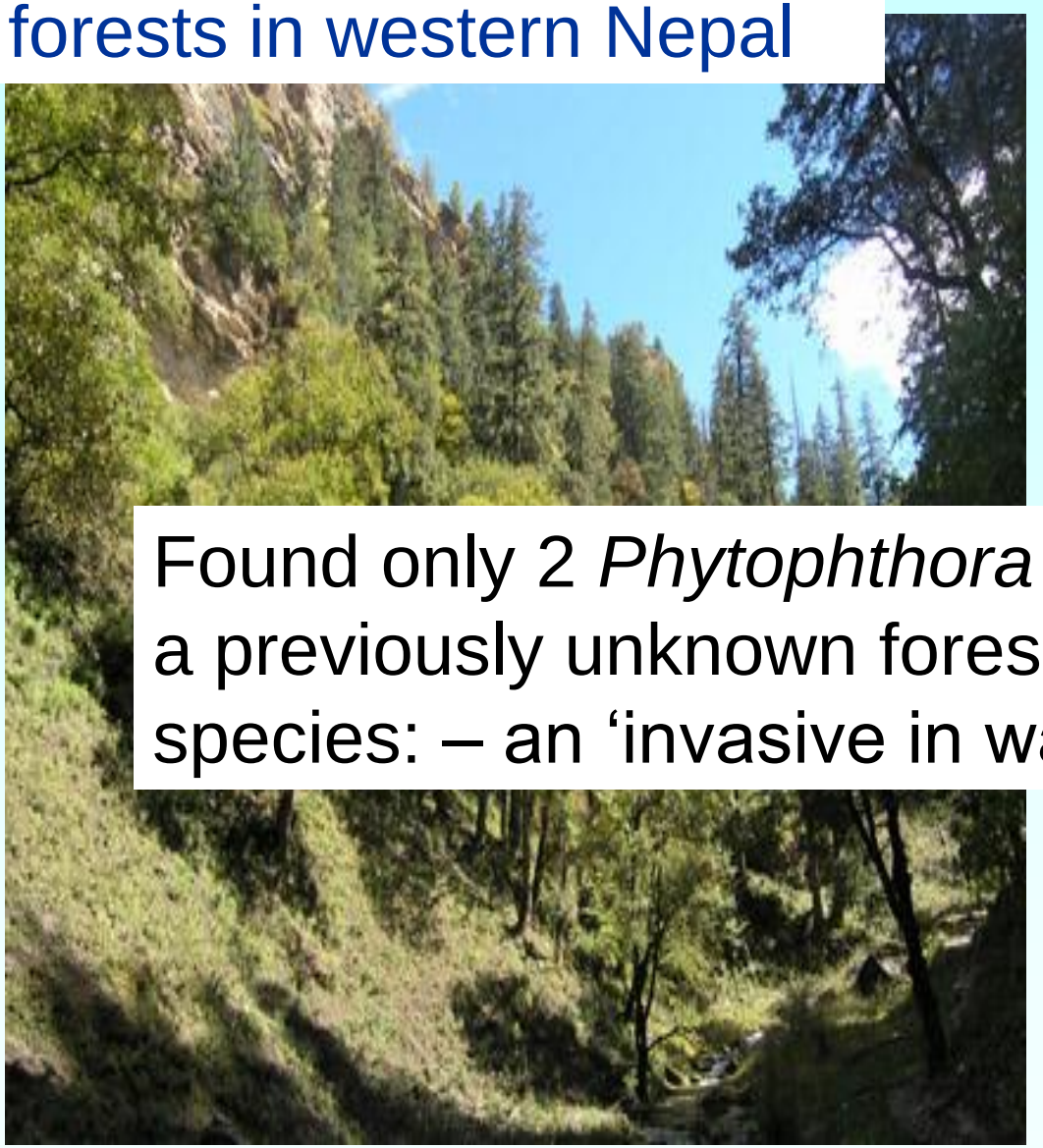
We recently sampled Nepal forests in two expeditions -

2005 sampled remote forests in western Nepal



Photos Forest Research UK and
University of Viterbo, Italy

2005: Sampled remote forests in western Nepal



Found only 2 *Phytophthora* species including a previously unknown forest *Phytophthora* species: – an ‘invasive in waiting’

Photos Forest Research UK and University of Viterbo, Italy

2007: Sampled degraded forests nearer Kathmandu

Annapurna range

Everest range

Photos Forest Research UK and University of Viterbo, Italy

Annapurna range

Everest range

2007: Sampled degraded forests nearer Kathmandu

And this time >9 *Phytophthora* species found (including *P. cinnamomi, P. drechsleri, P. cryptogea* and *P. katsurae* ..)

Invasive exotic Phytophthoras - *the price of increasing human disturbance and contaminated nursery stock?*

Long term evolutionary consequences

Sadly, imported pathogens, once arrived, are usually here for the long term.

Each is presented with a novel opportunity to exploit and, over time, evolutionarily adapt to, the new hosts and new abiotic environments it encounters.

The invasive *Phytophthora cinnamomi* is now showing evidence of local adaptation and evolutionary divergence in Iberia

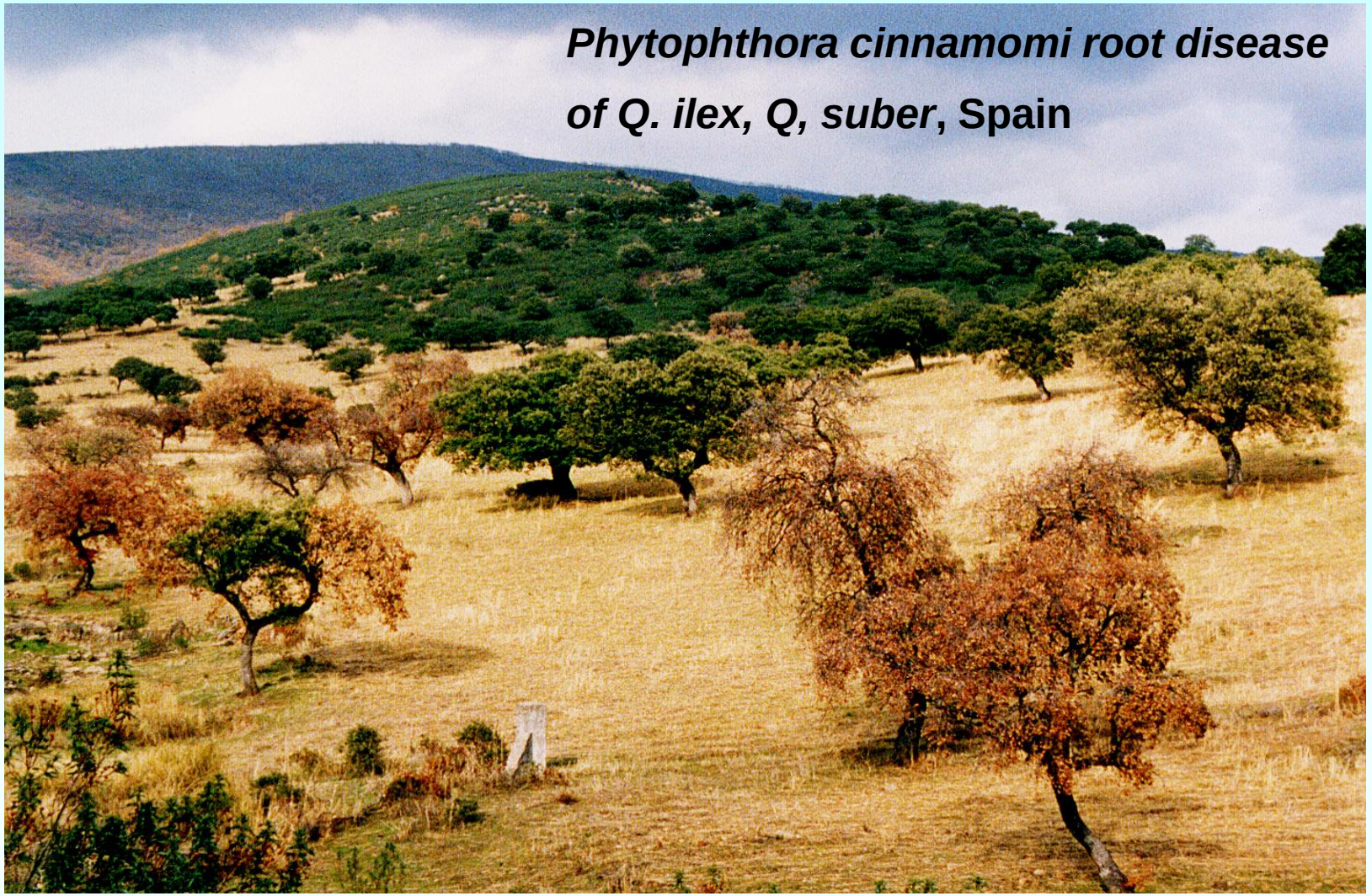


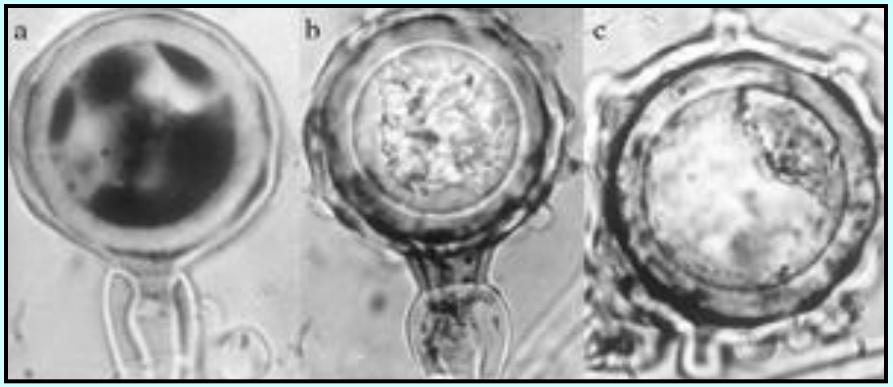
Photo Forest Research UK

- A particularly dangerous feature of invasive pathogens is that they may hybridise or exchange genes with related, *resident* pathogen species –
- Resulting in very rapid evolution - and maybe in a better adapted, genetically modified pathogen, or even in an entirely new pathogen –
- The recent world wide Dutch elm disease pandemic illustrated this point very clearly.

And so does invasive *Phytophthora*, as illustrated by *P. alni* -

Phytophthora alni sp.nov spreading on alder in Europe

Photos:
Thomas Jung, Germany and Forest Research UK



Phytopthora alni is a new (~30yr) hybrid between two *Phytophthora* spp., very phenotypically variable, *still evolving*

Hybridisation event in an EU nursery

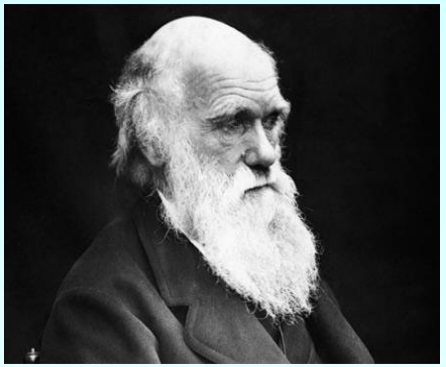
Spreading rapidly - distribution in 2000

Open ended hybridisation process - where will it end?

Photos, data, Forest Research UK and Brasier et al *PNAS* 1999

Each non native pathogen that we allow in is, in reality, a dangerous, uncontrolled, open ended experiment in evolution.

2009 was the Darwin bicentennial year



Darwin would probably have been fascinated by the potential for rapid evolution shown by invasive plant pathogens

But Darwin would I suggest also be very upset – indeed angry – at what is currently happening to the worlds plant heritage as a result of inappropriate plant imports

C. Solutions?

I have attempted to show that, for our forests and natural ecosystems, moving ‘plants for planting’ around the planet in large numbers is high risk –

On a % scale I believe the ‘risk level’ from current international protocols is maybe ~60 -100%.

We need to reduce this risk to say 10% or less.

How?

Secretary to the IPPC, Yukio Yokoi, asked me to suggest some solutions.

I am a scientist, not a regulator, and my main purpose is to tell you ‘how it is’

But I can suggest some approaches.

1. First, improving diagnosis at ports of entry, even with molecular technology is, I believe, not likely to be the answer.

    - Just an attractive ‘figleaf’ for regulators.
    - We could still only inspect ~2% of imports.
    - And what about all those ‘unknown pathogens’?

To be effective we need to prevent escape of these unknown pathogens from their centres of origin

2. I suggest there is only one simple, scientifically low risk, common sense approach:

- To import only small numbers of rooted plants or cuttings under licence, quarantine them for ~2 years, and use them locally as licensed, ‘safe’ propagation material

- And / or allow licensed importation of seed or, where appropriate, tissue culture material.

With hindsight, this is perhaps the ‘no exceptions’ approach that should have been universally implemented in the 1950s?

3. We need an education blitz:

   Our politicians –

   Our public –

   Many nursery men, plant importers and retailers –

   Many horticulturalists, gardening societies and journalists, foresters and conservationists –

   – *Are often largely unaware there is a problem (or may be in denial about it)*

   Even some plant health regulators may be unaware of the global picture

4. This in turn requires improving publicity:

- Establish and publicise the environmental cost of invasions by pests and pathogens
- Publicise all biosecurity breaches
- Apply the ‘polluter pays’ principle
- Label plants in retail outlets with their geographic origin and method of production (cf. food labelling)

5. We need to improve our biosecurity intelligence:

80-90% of fungi may be unknown to science

We typically have no idea where the next 'unknown pathogen' will come from

i.e. we are ignorant about what is 'out there.'
We do not know the character of the 'enemy'

Therefore – We have to scramble unseemly scientific fact finding and emergency control operations when each new 'enemy' appears.

6. We need to make biosecurity a two-way process:

   – Currently, states are largely fixated on preventing pathogen entry

   – States should be equally strongly fixated on <u>preventing export of pathogens</u>

7. We need an end to the trade-related international culture of secrecy and obfuscation about new plant disease outbreaks –

   In the long term this is usually in nobodies' interest –

   Just another cost to our planet.


THANK YOU