Biological adaptation and protection in European forest ecosystems

Tomasz Oszako, Steve Woodward, Jacek Hilszczański

Background: What?

Why?

How?

Phytophthora pinifolia on *Pinus radiata* in Chile

Introduction

Trees and forest ecosystems in Europe are threatened by a wide range of pests and diseases

Increasing threats to woodland and forest ecosystems in Europe by introduction of invasive species

New IUFRO – 7.03.12 – Alien invasive species and international trade

IUFRO – **7.02.09 – *Phytophthora* diseases on forest trees**

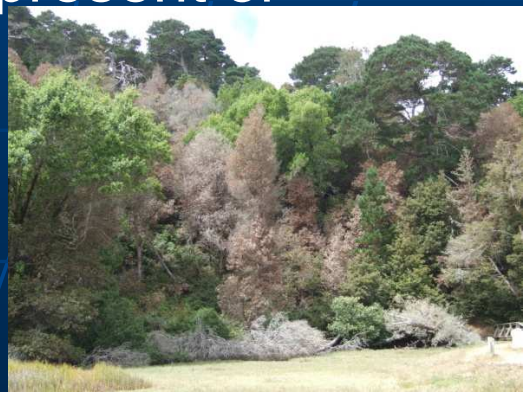
COST - **Established and Emerging *Phytophthora*: Increasing Threats to Woodland and Forest Ecosystems in Europe (End date: June 2012)**

Forest Day 3 in Copenhagen was organized by CIFOR (CPF, Danish government) in order to highlight key issues related to forests and climate change. IUFRO (co-host) contributed by co-organizing the subplenary session on **"Adaptation"** and Learning Event titled **"Boreal and Temperate Forests and Climate Change – What will happen? And what actions should be taken?"**

The United Nations General Assembly has declared the year 2010 as the International Year of Biodiversity, and the year 2011 as the International Year of Forests.

Established and emerging pests and diseases threat biodiversity

There are many examples which demonstrate the potential for such organisms to cause serious damage when present or introduced into 'new' environments



Historical lesson

- Here we review some of the **major diseases and pests** threatening trees in Europe.

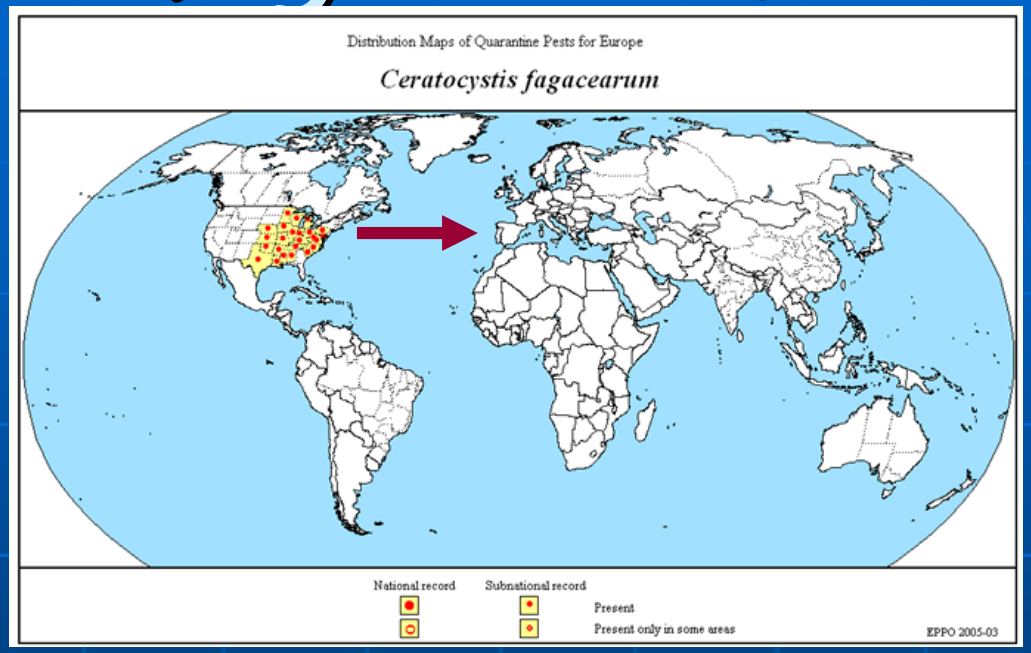
We include:

- a number of diseases (and pests) **already present** on this continent
- And **several** which may have serious consequences **if/when they are introduced**

What?

Ceratocystis fagacearum

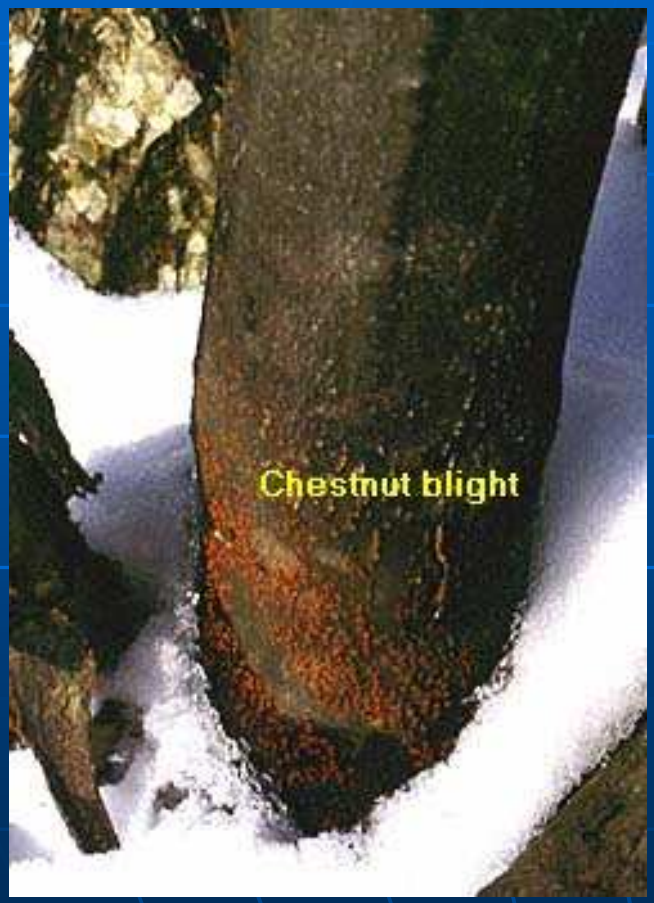
- Present in North America; not reported on other continents.
- Spread through root grafts
- Sapwood beetles are vector spores in northern States
- Potential for **international spread on planting material**

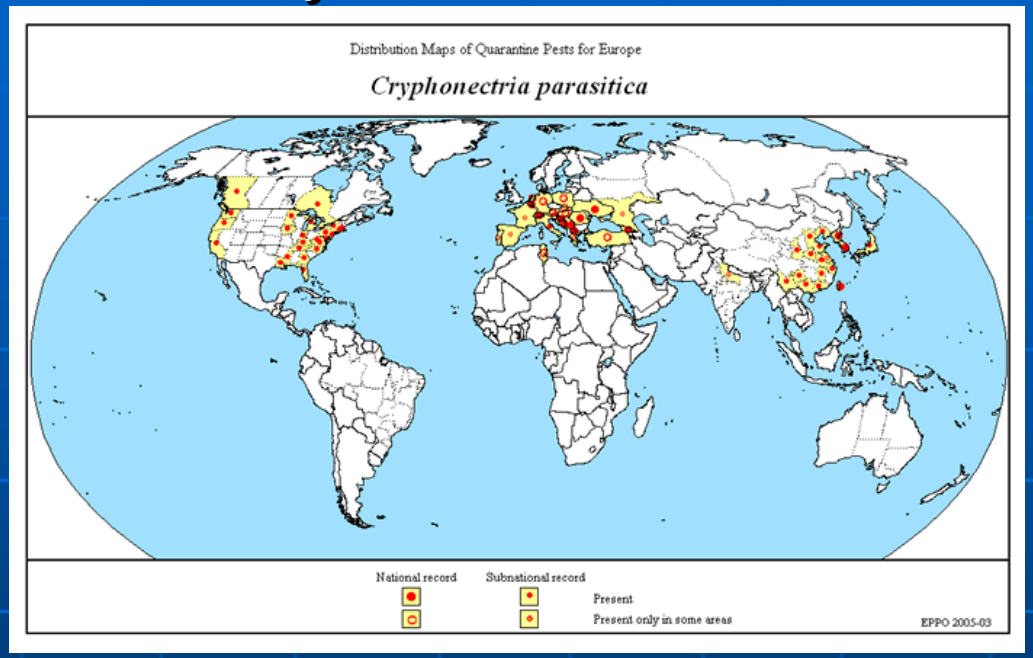


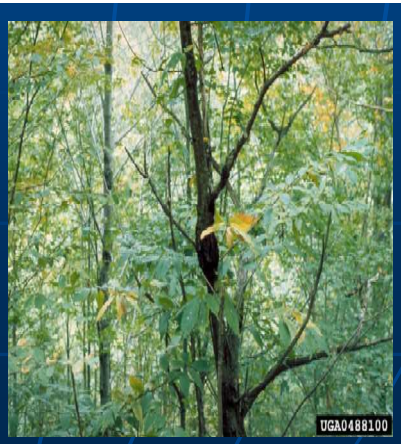
Oak wilt disease leaf symptoms.
(http://www.agf.gov.bc.ca/cropprot/oakwilt.htm)

Damage of chestnut caused by *Cryphonectria parasitica*

What?





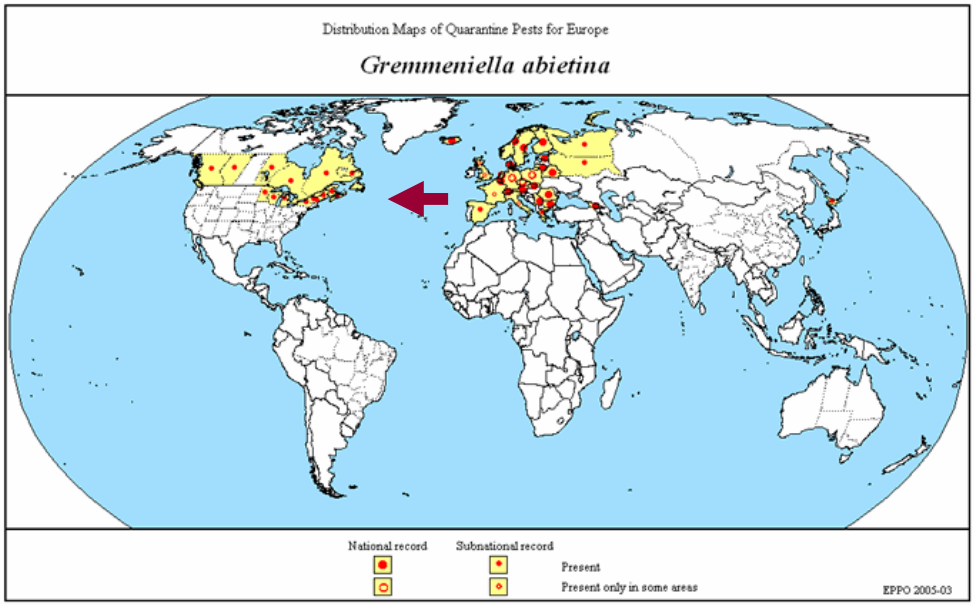


Cryphonectria parasitica on a young American chestnut tree.

http://www.fw.vt.edu/DENDRO/forsite/Paul/paul1.htm

What?

Gremeniella abietina



- *G. abietina* is indigenous to Europe and has spread to parts of eastern North America and Japan.

Apothecia of *Gremmeniella* on the cankered bark of a small red pine stem

Death of lower branches of red pine

http://www.na.fs.fed.us/spfo/pubs/misc/linda-grem/haugengrem.htm

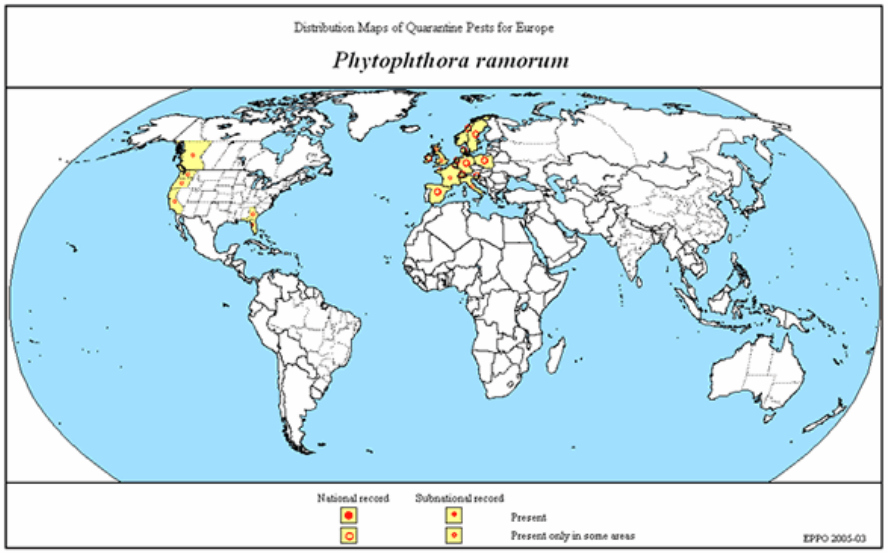
What?

Phytophthora ramorum
Sudden Oak Death

- In 1993, rhododendrons and viburnums in Germany and the Netherlands showed twig dieback, cankers, and leaf spots.
- Infection pathways are via planting stock, wood, bark, soil from areas where the disease occurs

View of a hillside affected by *Phytophthora ramorum* on the wildland-urban interface near Big Sur,California.

Photos credit: Susan Frankel, USDA-FS



Damage caused by *Phytophthora cinnamomi*

What?

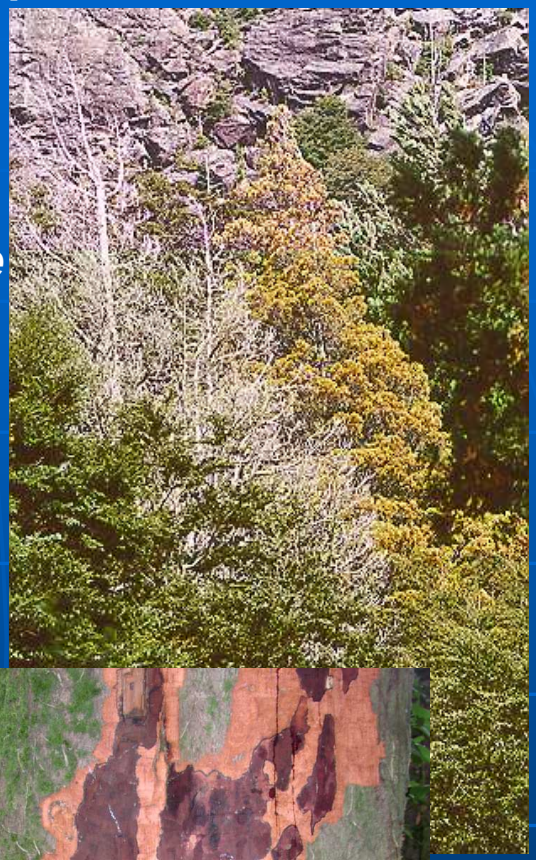
- The most widely distributed *Phytophthora* species
- First described in Indonesia (Sumatra)
- Root rot of e.g., avocado; Jarrah Dieback

Sudden death of evergreen oak, *Quercus ilex*, associated with root infection by *Phytophthora cinnamomi* (Spain).

Phytophthora lateralis

What?

Phytophthora austrocedrae



Phytophthora kernoviae

Beech
Fagus sylvatica

What?

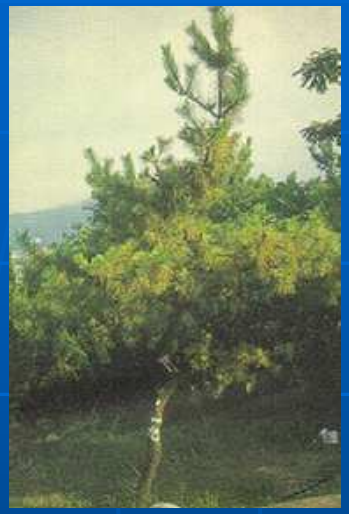
Agrilus planipennis: Asiatic species
Introduction to USA in 2002 incidentally with packaging
present in 7 USA states :
(IL, IN, MD, MI, OH, PA, WI, WV)
and in Ontario in Canada

host: ash

Large scale outbreaks

What?

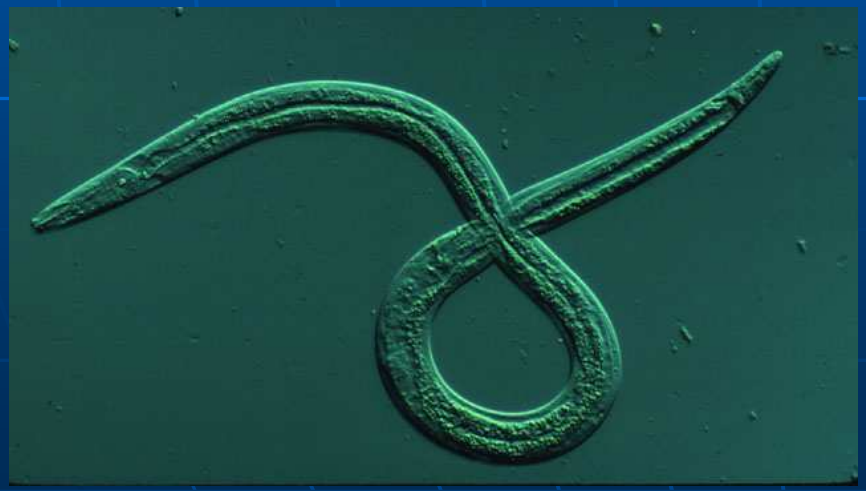
Bursaphelenchus xylophilus



Pine wood nematode
Now, present in Portugal and Spain

- Found at only one location prior to 1930s.

Transmitted from host to host by species of *Monochamus*



http://www.uvm.edu/~dbergdah/pwn/pwn.html

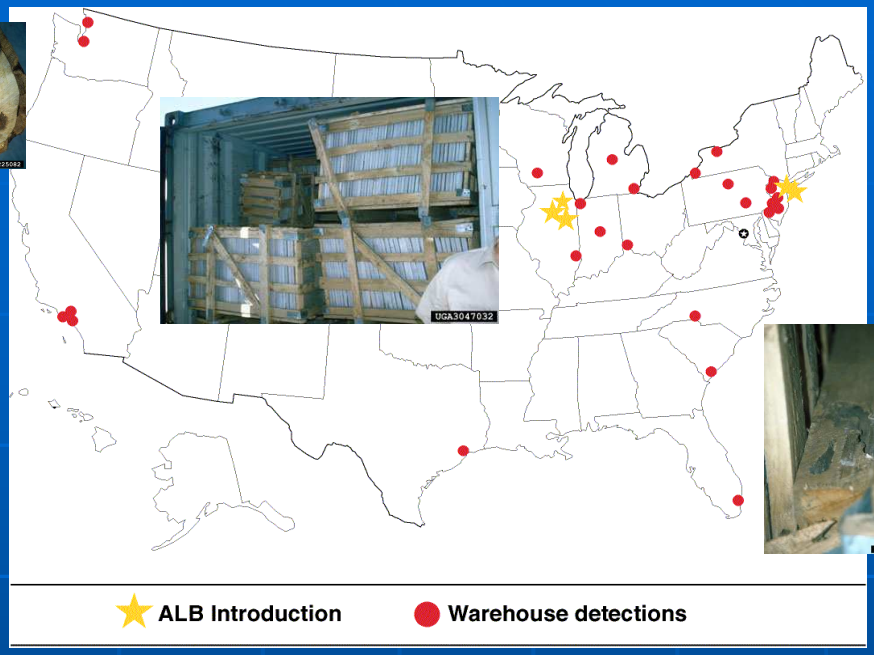
Asian Longhorned Beetle *Anoplophora glabripennis* - new threat EU Forests

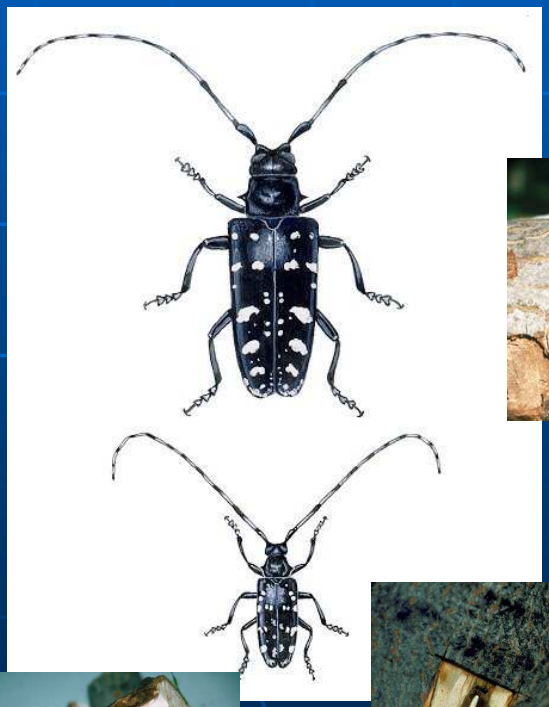
What?

Origin: China, Korea, Taiwan

Introduction: North America (1990) - New York, Chicago

Europe- Austria, Braunau (1998)





hosts: poplar, willow, maple, alder, apple, platanus, elm, robinia

W USA mainly: maples, horse chestnut, elms, birch, ash, tulip tree

What?

Open questions

1. Would *Ceratocystis fagacearum* cause serious damage to native European oaks?
2. Will *Bursaphelenchus xylophilus* spread from its current limited range in Europe?
3. What is the likely impact of climate change on the distribution of pathogens such as *Cryphonectria parasitica, Phytophthora* spp. and *Sphaeropsis sapinea*?

Why?

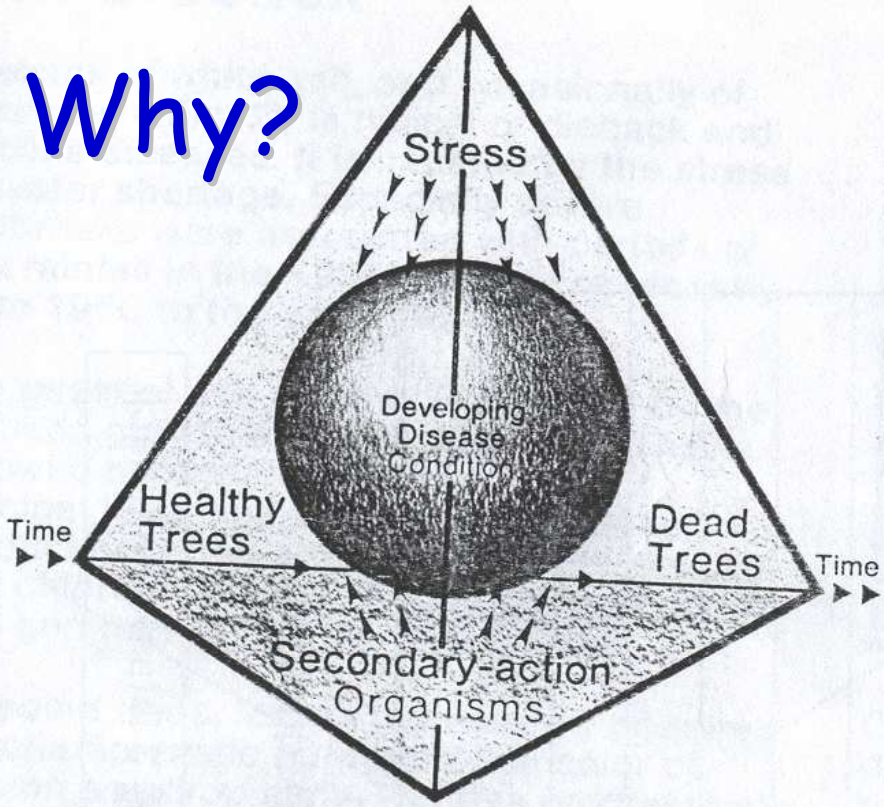
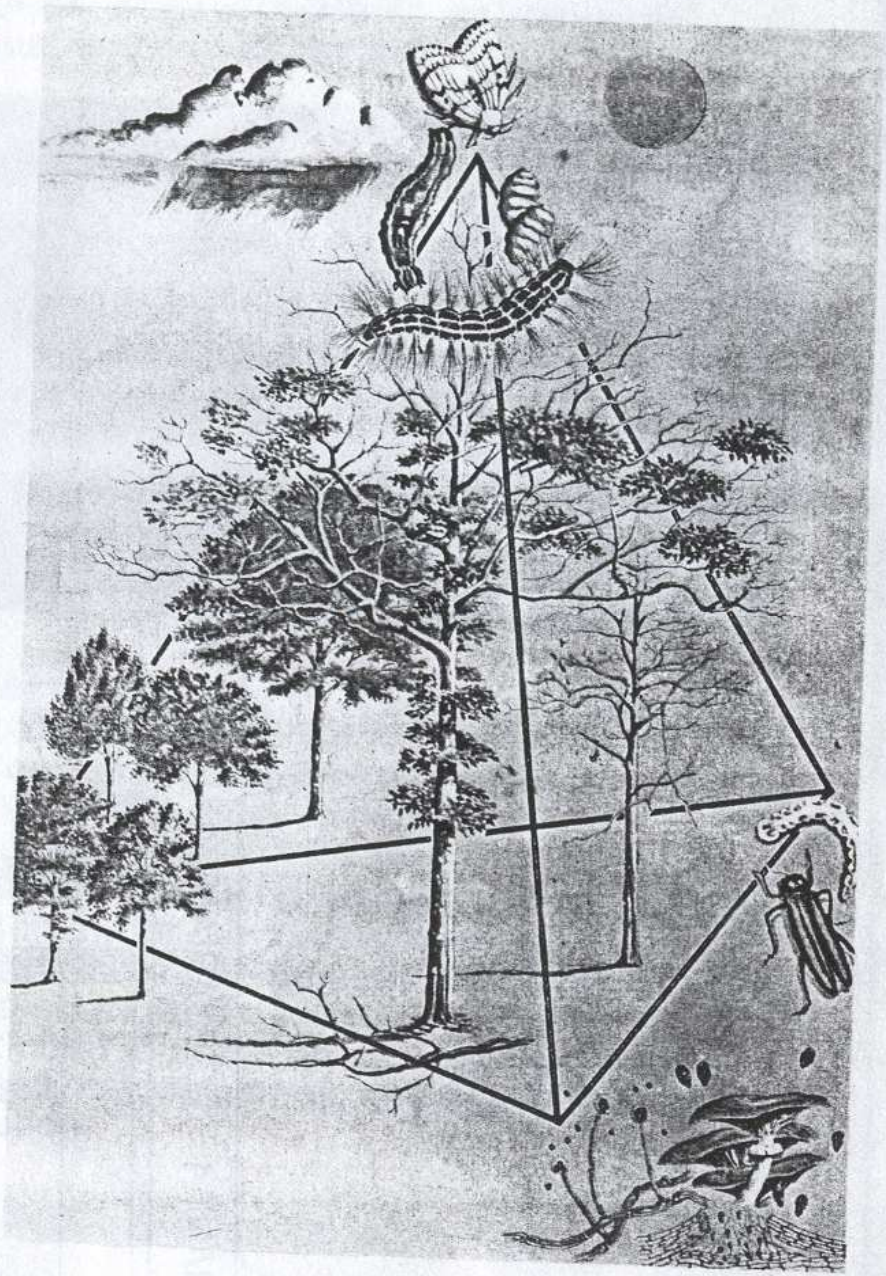


Figure 1
A conceptual framework for the dieback-decline diseases. Healthy trees are affected by environmental stress; over time, trees altered by that stress are invaded at some point by secondary-action organisms. The disease condition develops and trees dieback, decline, and ultimately may die.

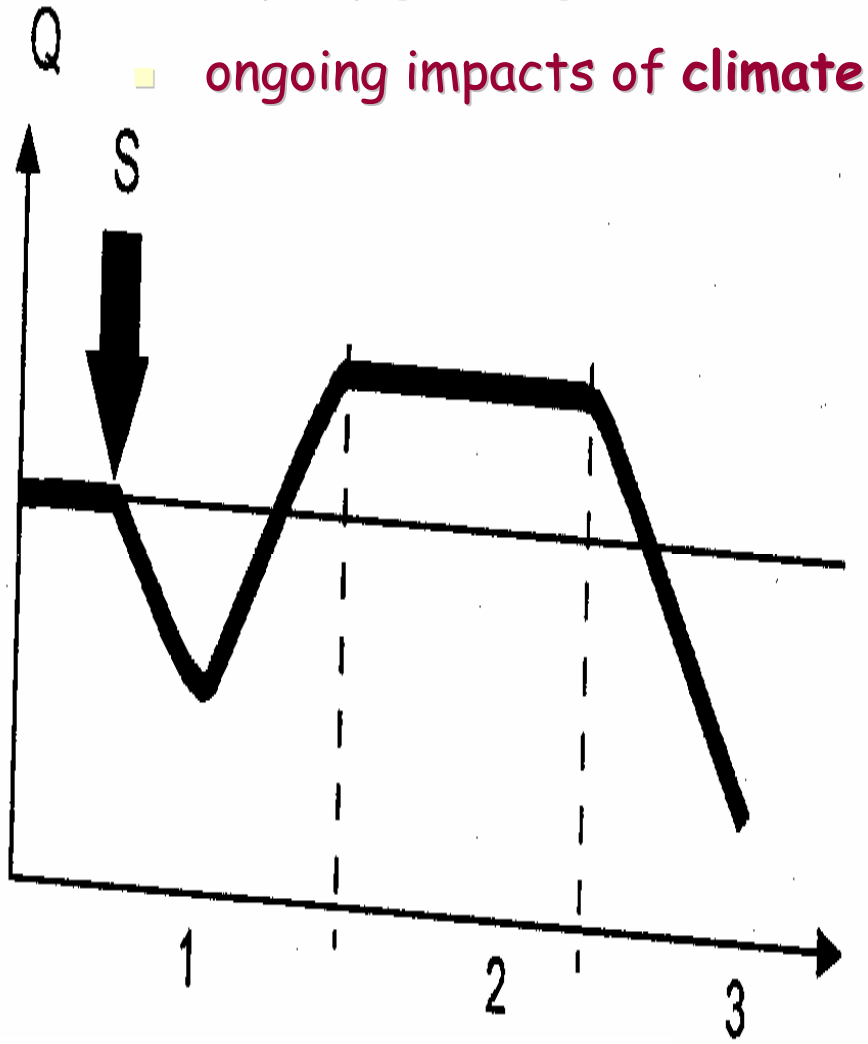


***Manion (1981)* Tree disease concepts**

Why?

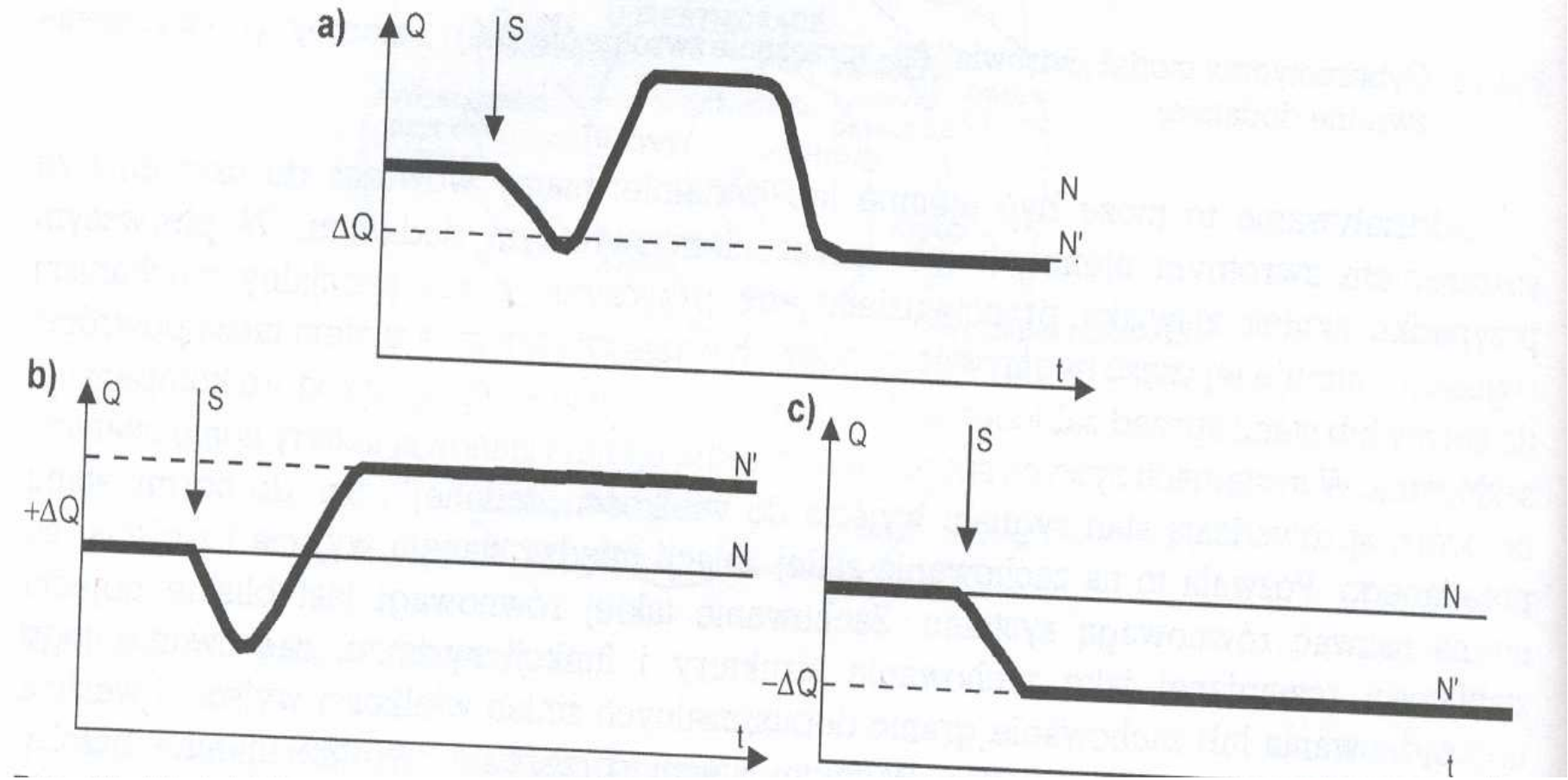
Why are more *Phytophthora* 'appearing'?

- rapidly growing **international trade** in plants
- ongoing impacts of **climate change**



1 - alarm reaction
2 - resistance reactior
3 - exhausting reactio
S - stress
Q - resistance

(GAS – General Adaptation Syndrome)



GAS model for reversible (a) and non-reversible (b and c) conditions

Reversible stress (a) determines such a condition of the system when it reacts flexibly after stress factor step aside and comes back to the outbound position. Inreversible stress (b,c) means permanent changes in the system properties. Two situations are possible:

b) System reaches new level of resistance higher than previously (+Q);

c) System reaches new level of resistance lower than previously (-Q).

Why?

Sphaeropsis sapinea
Diplodia canker

- Present in some African countries, Asia, Australasia & South Pacific, Europe, North and South America
- Spore dispersal occurs primarily by rain splash, spores also can be distributed by air currents

Joseph O'Brien, USDA Forest Service

It is mainly a disfiguring **disease of trees growing under stress**, with trees showing numerous brown, dead branch tips

Phytophthora quercina

earlier attack
of insect defoliators?

Why?

Oak decline

Specific env. Conditions?

Wet vegetation season 1980?

Drought 1981-84….

embolism?

Earlier infection
of oak mildew?

Why?

Why Buprestidae outbreak?

CC foster thermophillic species better adapted to dynamic environmental changes?

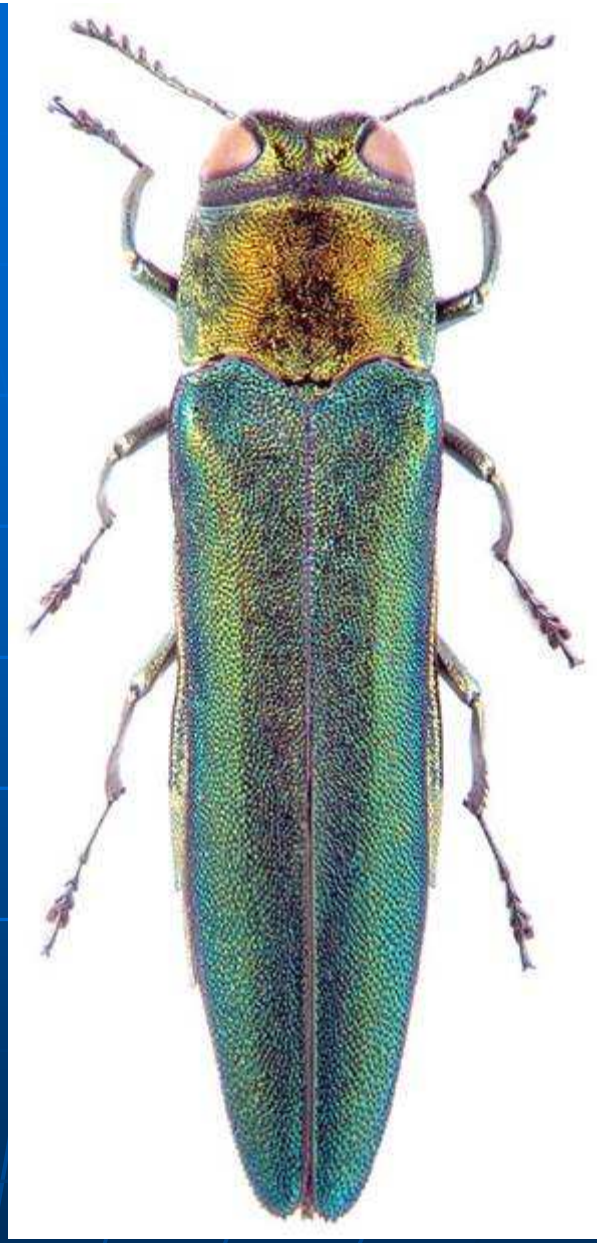
Agrilus bigutattus

Stress weakens

trees slower adapting to new conditions

Oak decline in Poland 2004-2006

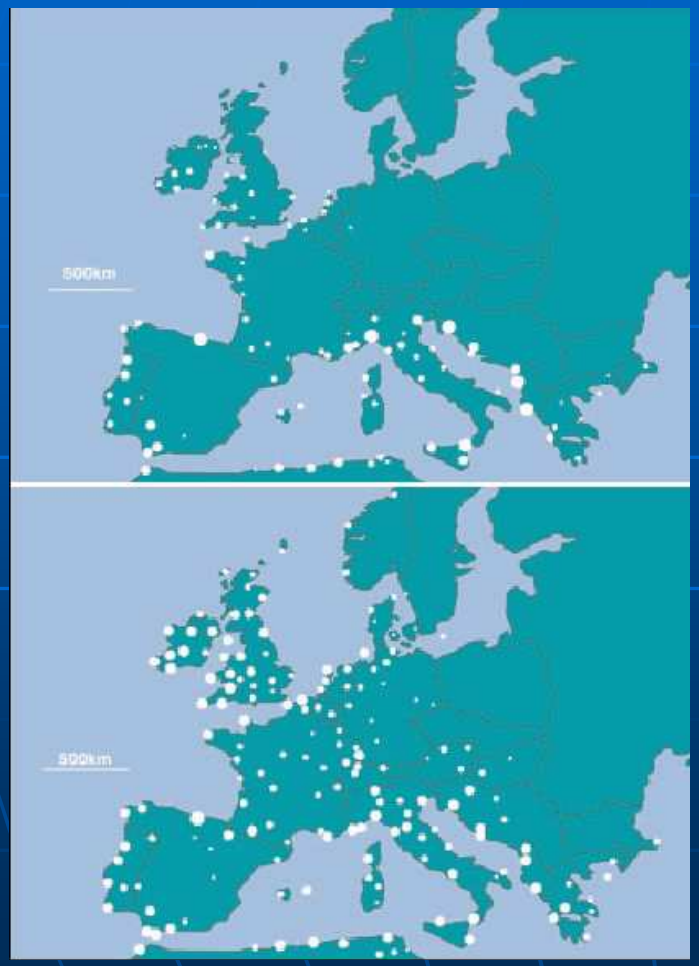
Large area damage



A. planipennis

Activity of *Phytophthora cinnamomi* in Europe

Why?



A. Activity under 'recent' (i.e. late 1900s) conditions.

Increasing activities of *Phytophthora* threaten European forest ecosystems **biodiversity** and **sustainability**

B. Activity assuming a 3 °C increase in mean annual temperature (a current climate change prediction for circa 2100).

Phytophthoras in European forests: Their rising significance Clive Brasier

Adaptation to higher summer tmperatures

Phytophthora polonica

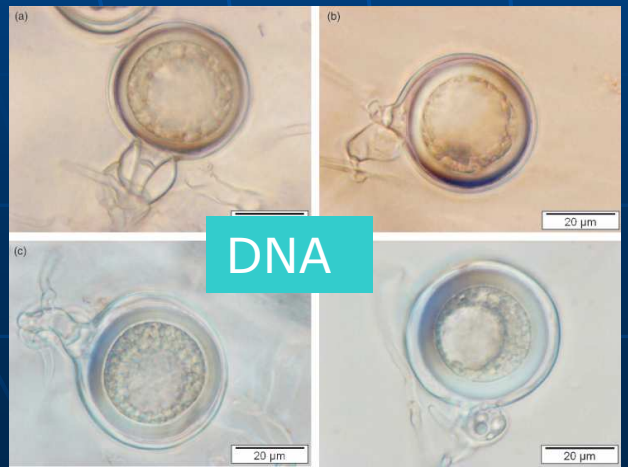
Why?

new

Alder

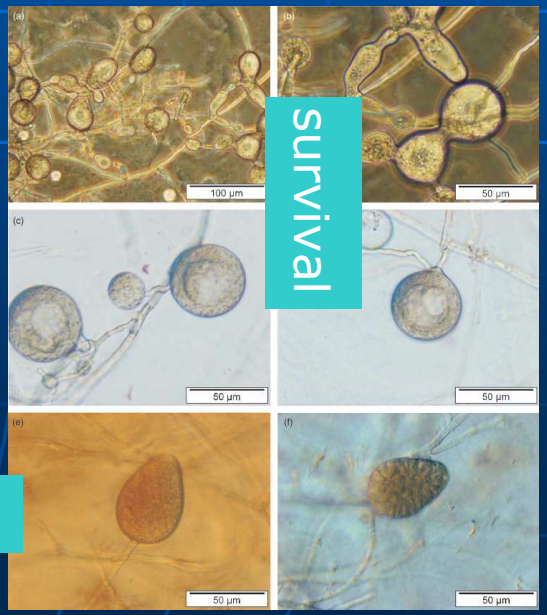
Optimal growth 30°C

adaptation to elevated temperature?
and periodic elevated water level?



DNA

mobility



survival

Heavy storms, floods → mass propagation

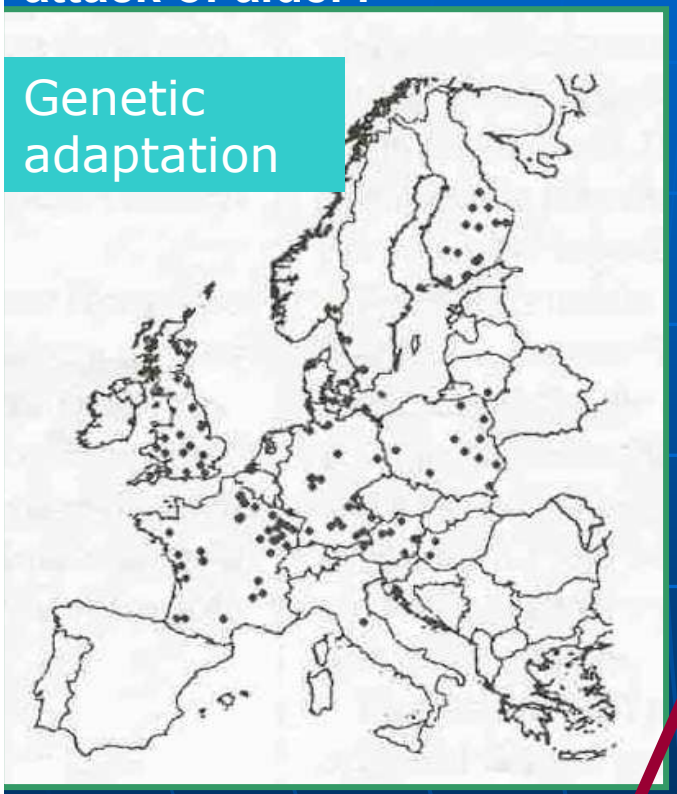
Why?

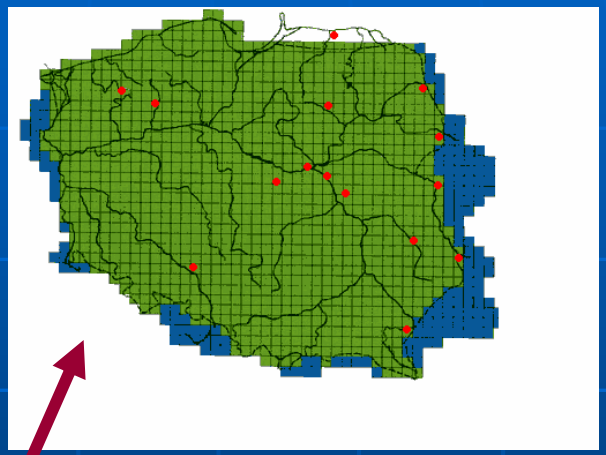
Phytophthora alni in Europe and Poland

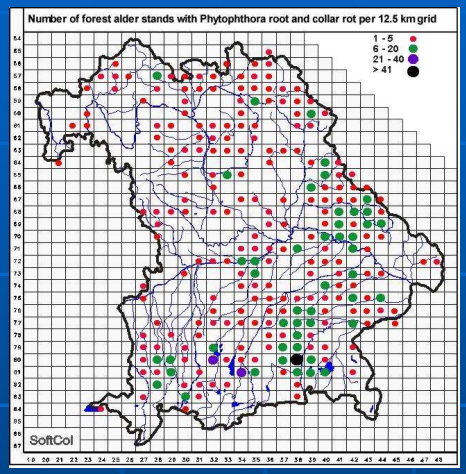
New species better adapted to the attack of alder?

hybridization in nurseries!!!

Genetic adaptation







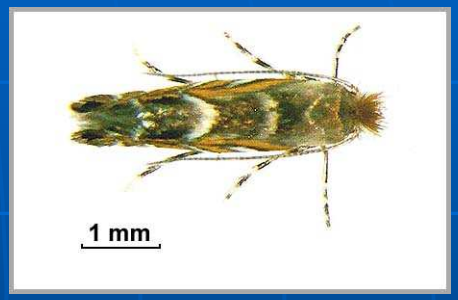
zoospores adaptation

Distribution of *P. alni* via water courses

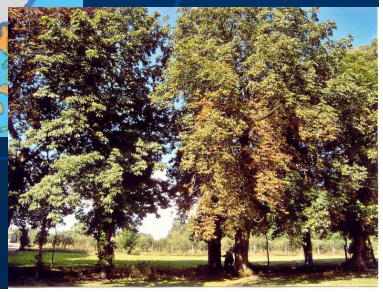
Why?

Cameraria ohridella
Horse-chestnut leafminer

- First recorded in Macedonia in 1985
- In Poland recorded in June 1998 close to Wrocław
- Larvae destroy horse-chestnut leaves
- **4 generations per year**
- Almost total absence of natural enemies



Spread via highways



1- year bio-pause when nutrition is depleted

Ophistoma novo-ulmi - Dutch Elm disease

Why?

Genetic adaptation?

The highly virulent fungal pathogen *Ophiostoma* ***novo-ulmi*** causes leaf wilting and subsequent mortality to all three elm species (*Ulmus* spp.) native to Europe. Responsible for Dutch elm disease (DED), this fungus is also present in North America, and parts of Asia. **New subspecies** have been described (Brasier & Kirk, 2001), the ssp. ***novo-ulmi*** and the ssp. ***americana***, which **are partially reproductively isolated, behaviourally distinct and exhibit morphological differences.**

Why?

Damage of beech caused by *Phytophthora cambivora*

Phytophthora species are amongst **the most serious factors** with potential negative impacts in the forestry sector in Europe.

Reflects genetic diversity of tree populations ?

How?

Aims & objectives of future RTD

Main aim:

- to increase understanding of the **biology** and **ecology** of *alien invasive* species with **potential** to cause damage in European forest ecosystems

How?

Aims & objectives

Objectives:

- Determine likely **routes of spread** into and within Europe and to establish an efficient and interactive **monitoring system**.
- Examine the **physiological** reasons for the development of rapid and lethal symptoms.
- Develop methods for **rapid diagnosis** of *pests and pathogens* at the individual tree and ecosystem levels.
- Seek novel, ecologically benign techniques for **management and control** of these pests and diseases.

How?

New „Evoltree 2" Working Groups:

- WG1. Invasive Potential and Ecology
- WG2. Host-Pathogen Interactions
- WG3. Diagnostics
- WG4. Management and Control

How?

WG1. Invasive Potential and Ecology

- Nursery-nursery and nursery-forest pathways
- **Ecological adaptations**
- Economic impacts
- Sociological impacts
- A European map of *alien species* distribution and impact in natural and semi-natural ecosystems

How?

WG2. Host-Pathogen Interactions

- Why do *Phytophthora* infections, pine nematode… result in such **devastating consequences** for infected trees?
- How do individual hosts **resist infection**?
- The outcome of such work could be the basis for resistance **breeding programmes**

How?

WG3. Diagnostics

- Methods for **rapid** and **accurate diagnosis** of *alien invasive species*
- Quantitation of infections
- **Genetic variability** within and between species
- This work will lead to more accurate and rapid detection methods for use by **plant health/quarantine authorities**

How?

WG4. Management and Control

- **Sustainable, ecologically acceptable** control concepts for amelioration of infections through management interventions in affected ecosystems

Deliverables-project speciphic

Main outcomes:

- Knowledge for use in development of **effective control and management protocols** for *introduced invasive species* problems
- **Technology transfer** to the end-user community

Deliverables - scientific

- **Uniting the scientific community** working on *invasive species* in Europe
  - interactions between groups
  - exchanging ideas
  - rapid dissemination of new techniques (e.g. diagnostics)
  - promotion of technological advances to end-users
- Improved **detection**
- Improved **quarantine procedures**

Deliverables – overall benefits

- Increased and sustainable yields of better quality **timber** from European forests
- Reductions in losses of **amenity values** of forests, at both local and landscape scales
- Increased **non-timber benefits** from forest ecosystems, including impacts on water catchments and flood control
- Improved **employment** prospects for rural areas ⇒ greater benefits accruing from forests
- Fulfilling EU **directives** on ecology, biodiversity, forest ecosystems, forest productivity

Deliverables

Ultimately:

- Results will be used to prepare a case for a **pathways approach** to preventing imports of alien species into Europe
- And for better **management** of pathways of spread within Europe.

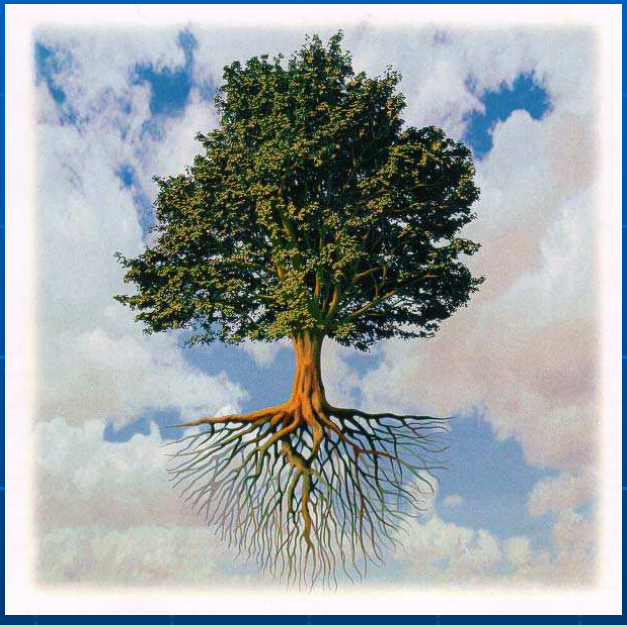
Partners

European Union research institutions (IUFRO, COST), quarantine organizations (EPPO), wood and paper industries (CEPI), SMEs and international organizations: Bioversity, EFI Eustafor, ICPF…

All major players in pests and pathogens biology from other European countries in Russia, Ukraine, Belarus…

Invited experts from USA, Australia, New Zealand, South Africa

Forests are the most important terrestrial reservoir of biodiversity. The health and vitality of forests, and their capacity to adapt to climate change, depends on the diversity of genes, species, and ecosystems.



Thank you for your attention …