

Introduced *Phytophthora* pathogens as driving force of devastating forest declines in Europe

The genus *Phytophthora*

Involvement of *Phytophthora* spp. in European oak decline

The *Phytophthora* disease of European beech

Root and collar rot epidemic of alders in Europe

Phytophthora - management in Australia

The genus *Phytophthora*

Kingdom Chromista / Straminopiles.



The genus *Phytophthora*

Kingdom Chromista or Straminopiles.

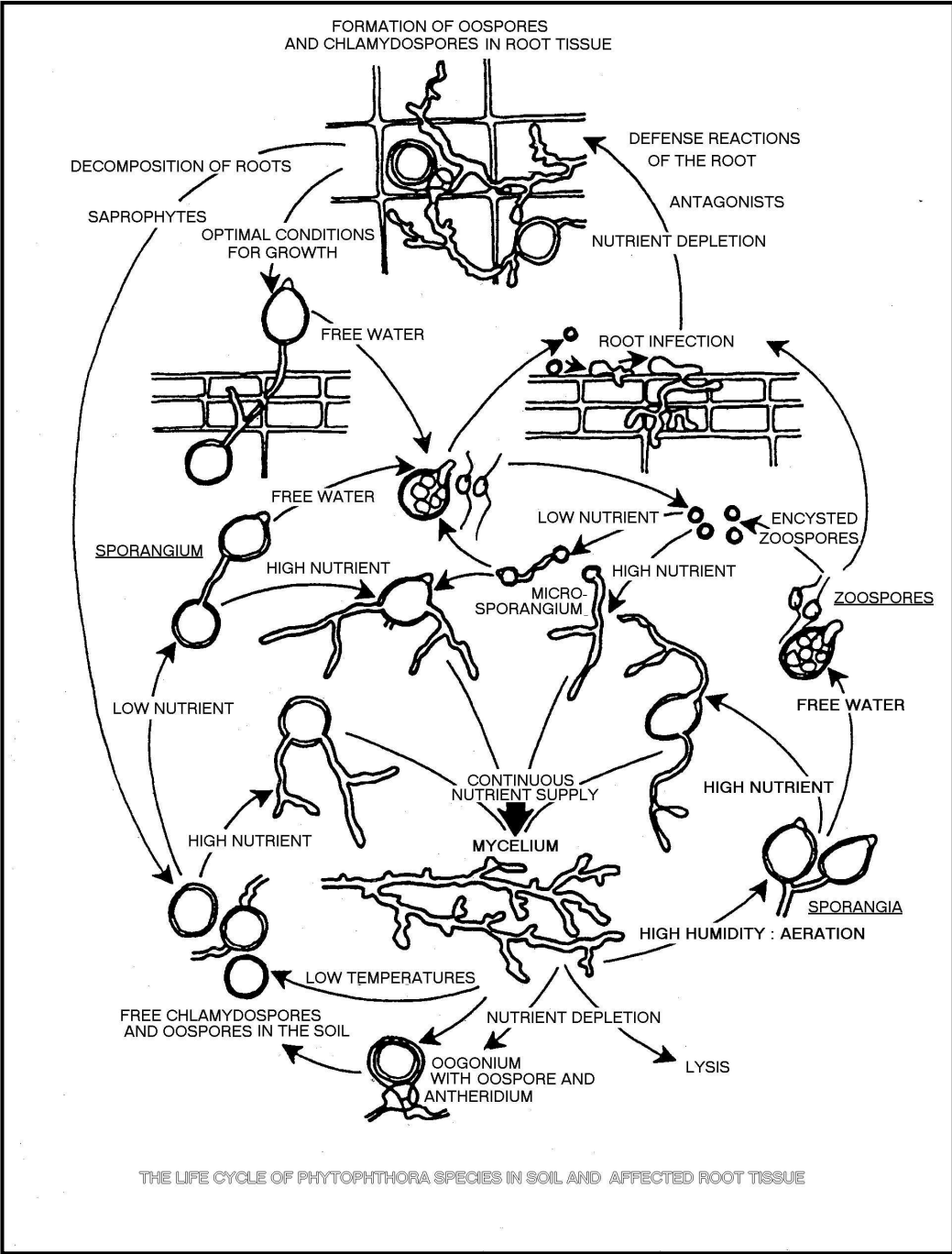
Worldwide more than 100 species, almost all of them being **primary parasites**.

Airborne and **soilborne** species.

Soilborne Phytophthoras are responsible for more than **70% of all known fine root diseases** and more than **90% of all collar rot diseases** of woody plants in the world.

Broad and narrow host ranges.

Low saprophytic ability and slow growth necessitate a **specific life cycle**, and require **specific isolation or detection methods**.

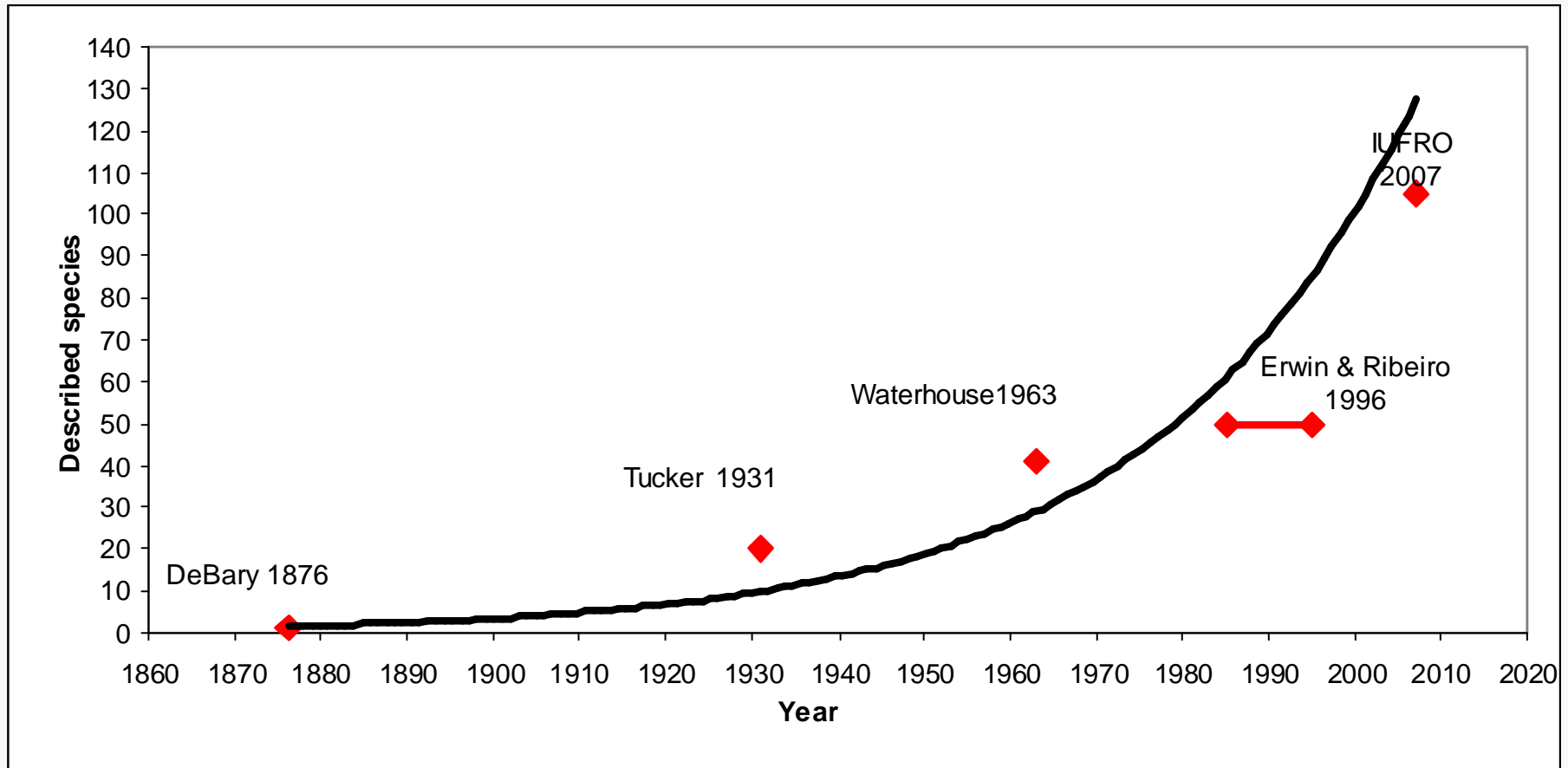




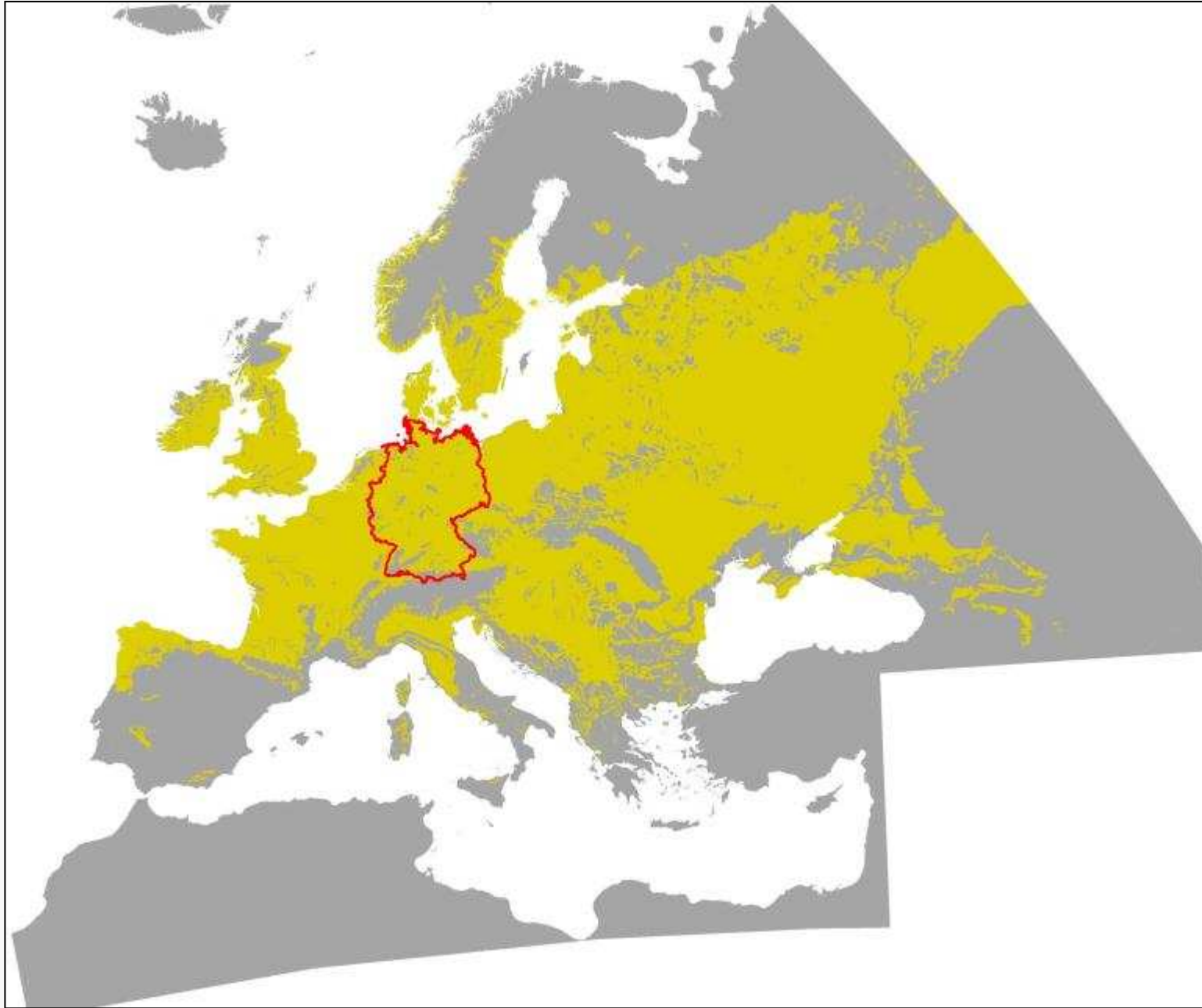
Detection of *Phytophthora* species using baiting methods



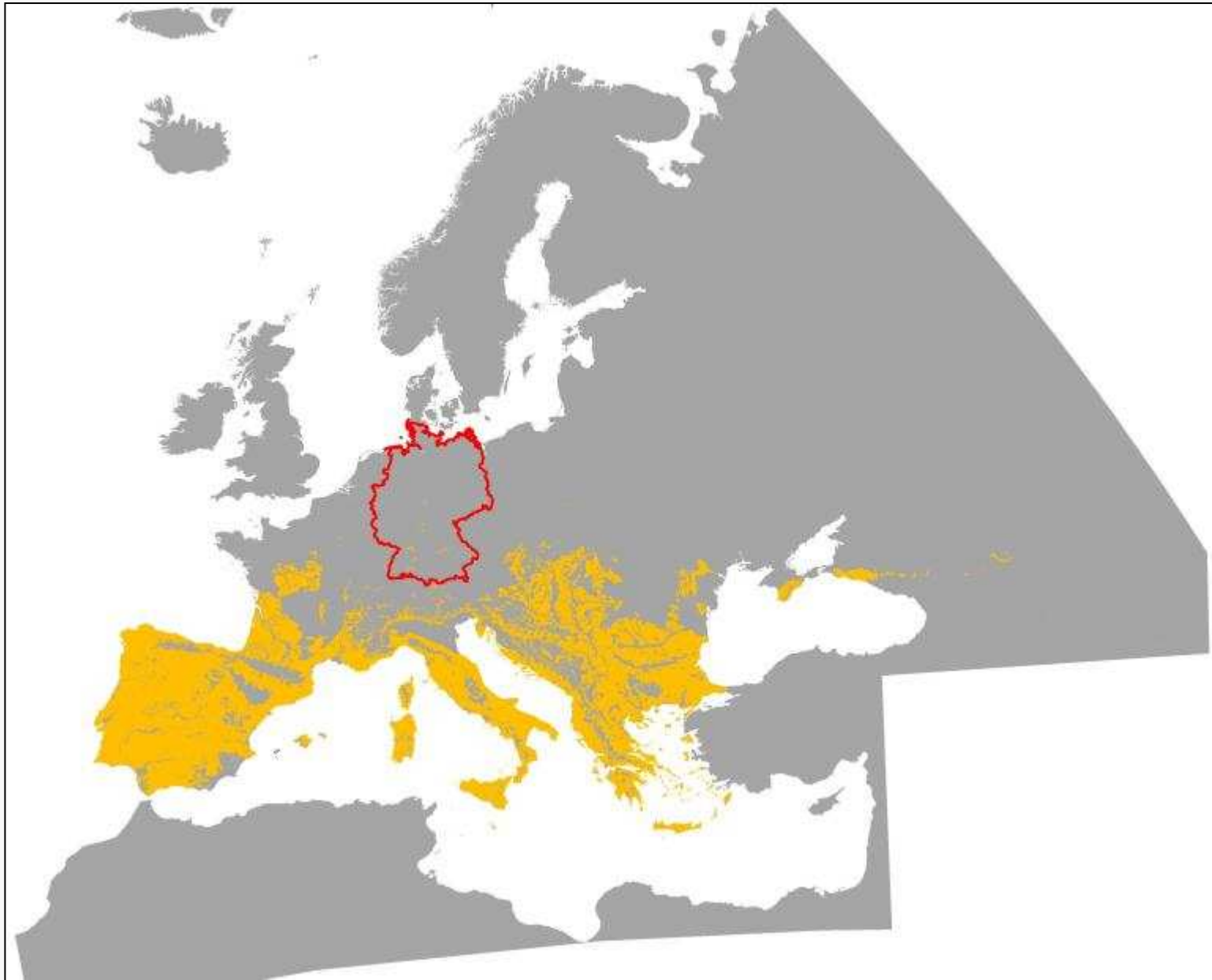
Detection of *Phytophthora* species over time



Distribution of *Quercus robur* and *Q. petraea* in Europe.



Distribution of mediterranean oak species in Europe.

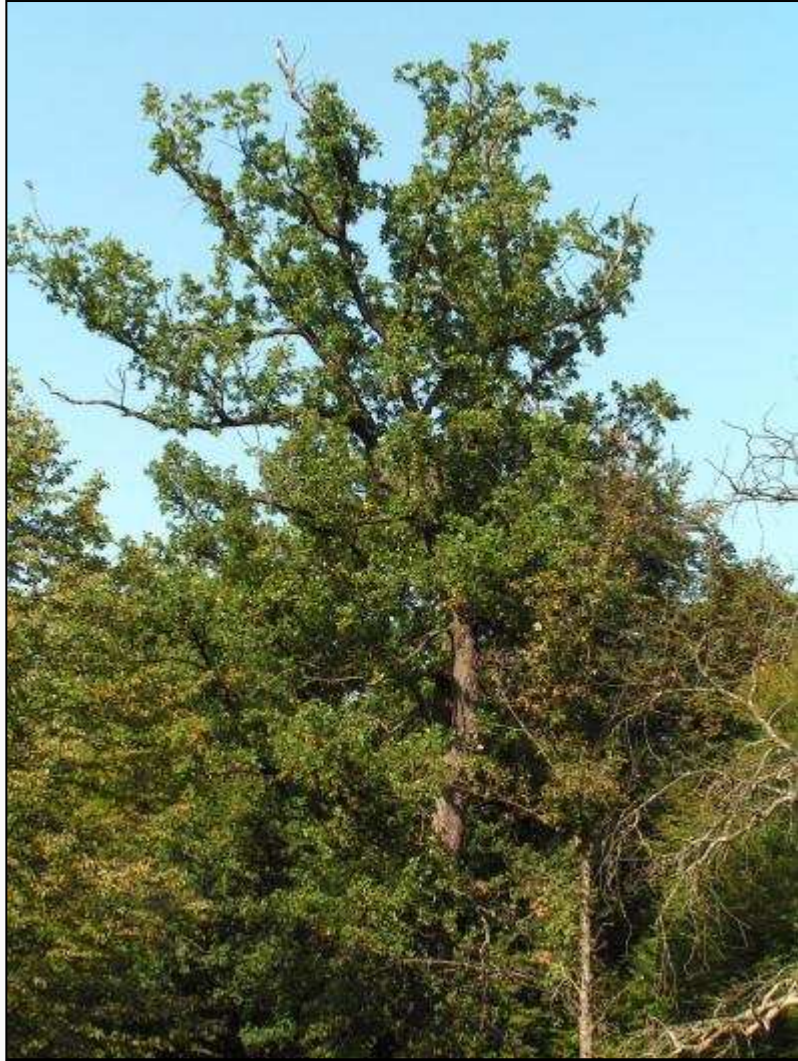




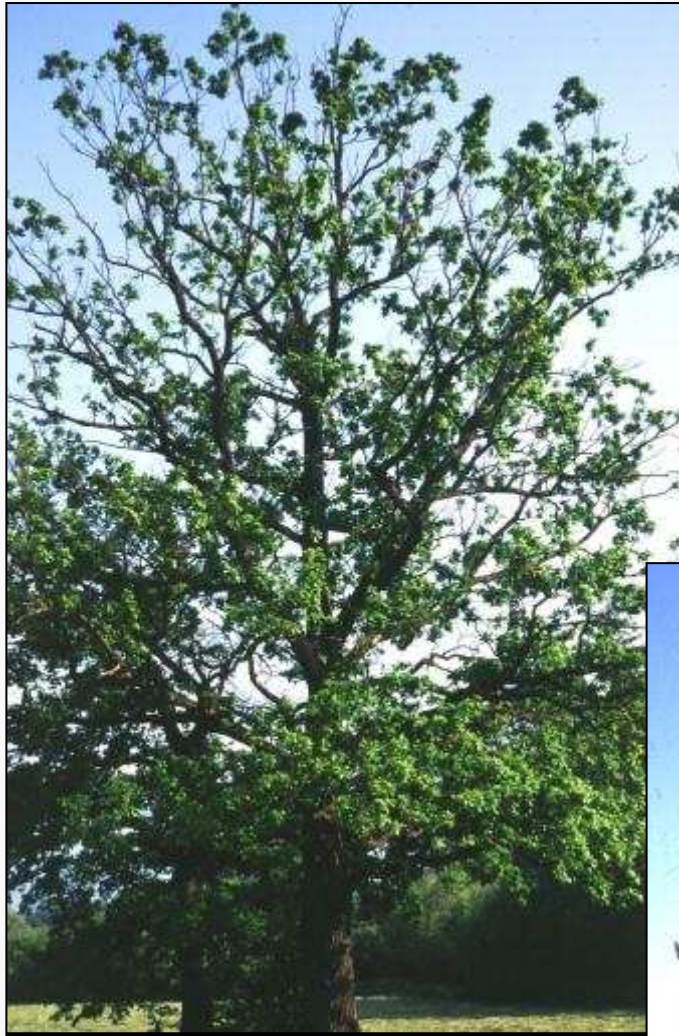
**Healthy *Quercus robur*
with dense vigorous crown.**



Declining *Quercus robur* with high crown transparency and formation of leaf clusters.



**Declining *Quercus robur* with
severe crown dieback.**



Declining *Quercus robur* with high crown transparency, formation of leaf clusters, dieback and chlorosis (below).





**Declining stand of
Quercus robur.**

**Stand of *Quercus petraea*
with high mortality.**





Healthy and destroyed fine root systems of mature *Quercus robur* trees.





**Severe fine root losses of
Quercus robur caused by
P. quercina.**

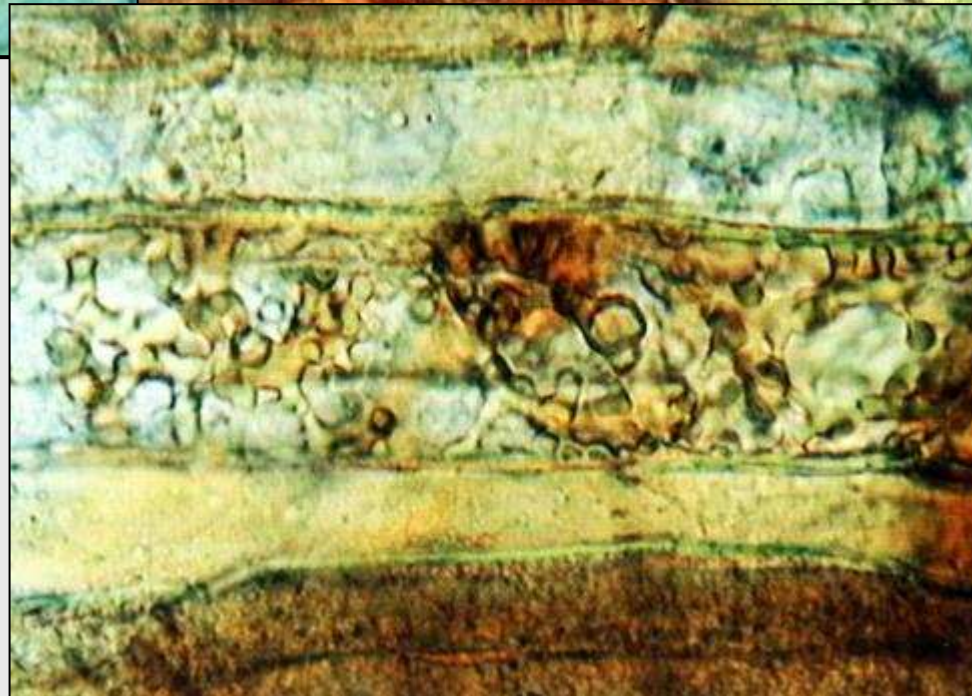
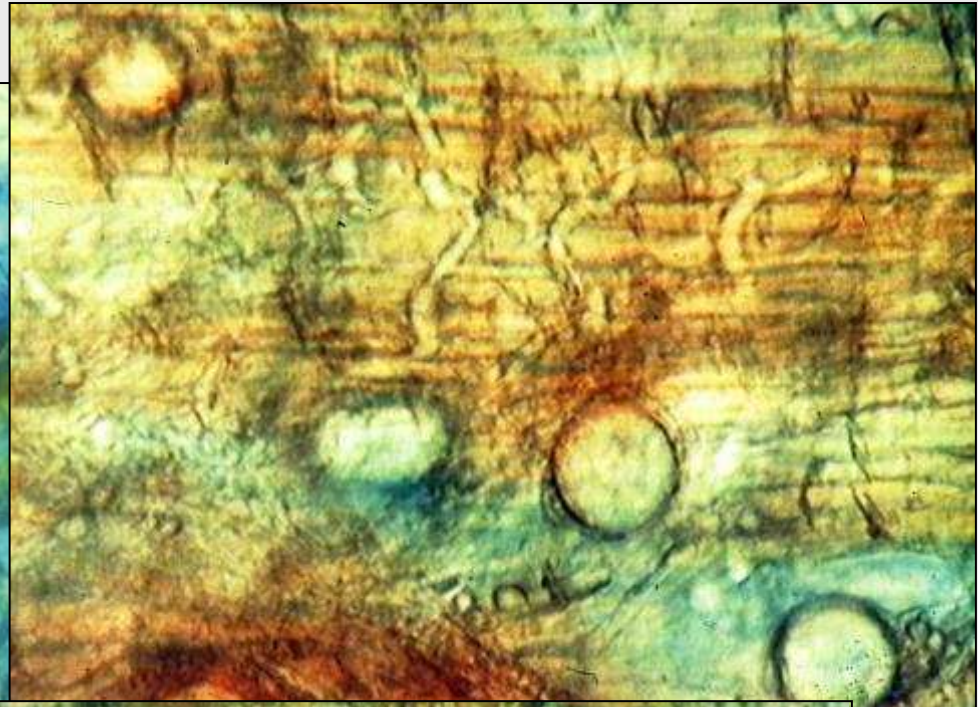
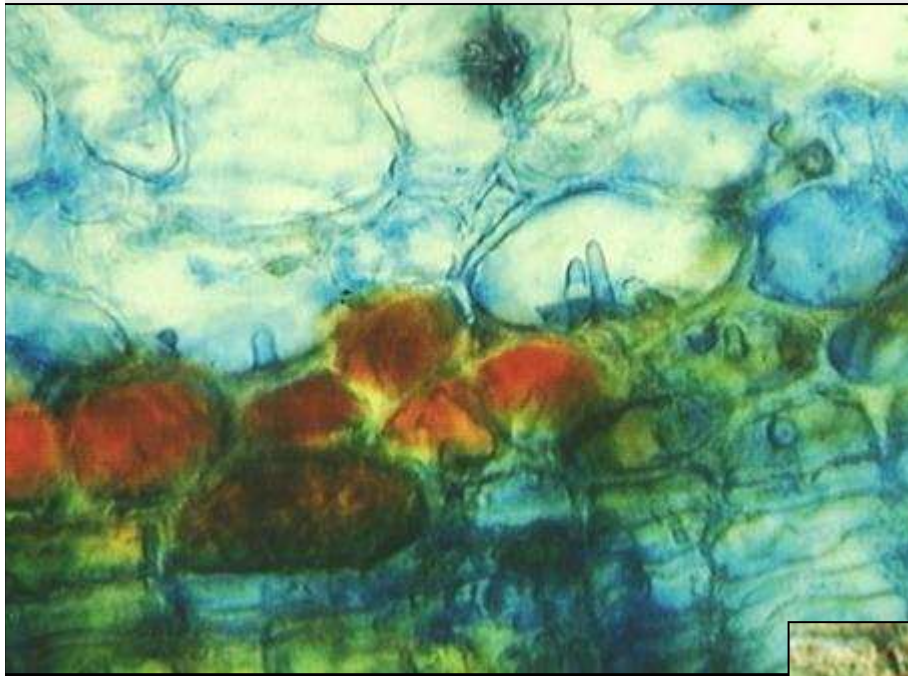
**Severe fine root losses of
Quercus rubra caused by
P. citricola.**



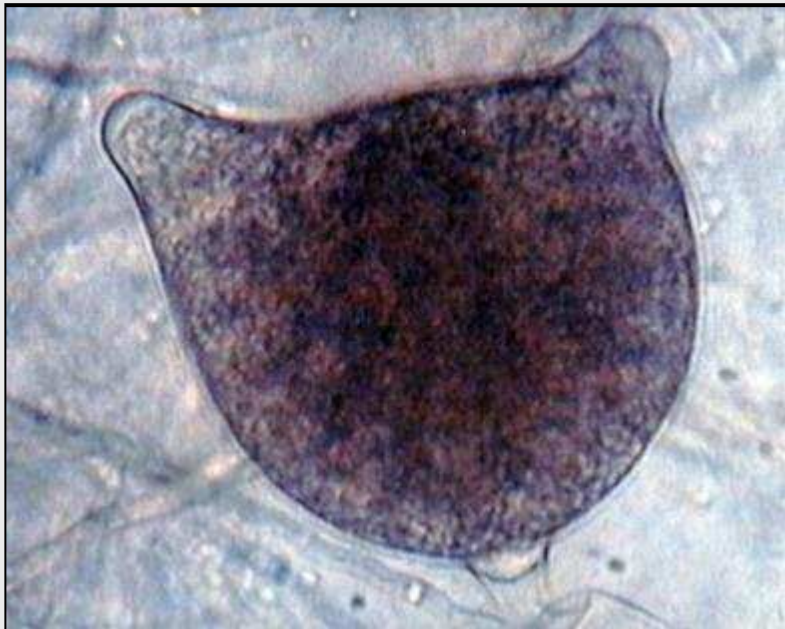
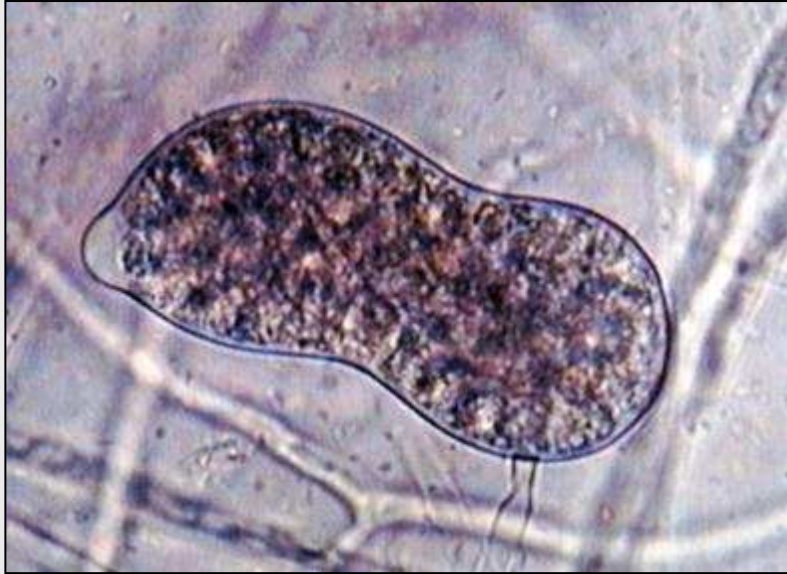


**Necrotic lesions and dieback of
Quercus robur coarse roots.**





Defense reactions (above), and coralloid hyphae and oogonia of *P. citricola* in infected fine roots of *Quercus robur*.



**Sporangia and oogonium
of *P. quercina*.**

Root systems of *Quercus robur* seedlings in non-infested (left) and *P. quercina* infested soil (right).

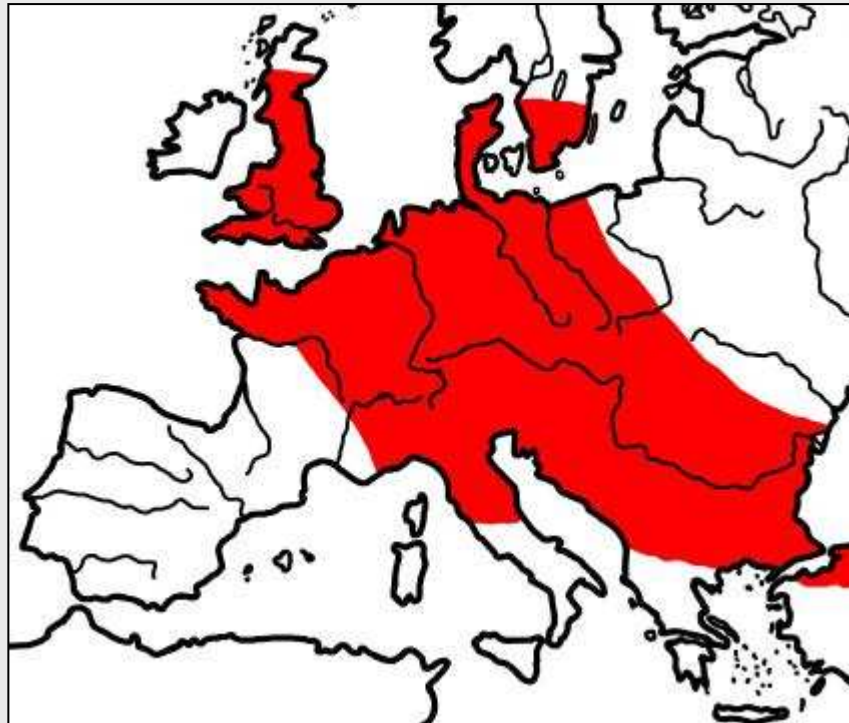


Occurrence of soilborne *Phytophthora* species in oak stands in Europe and Turkey

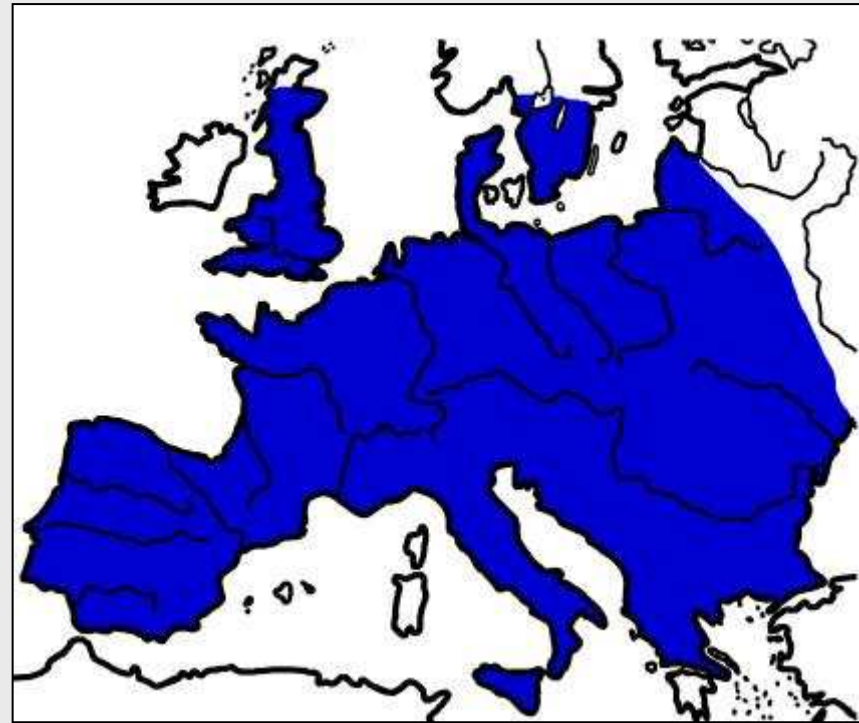
	No. of stands	Year	No. of stands with <i>Phytophthora</i> ¹								
			Total	QUE	CAM	CIT	CAC	CIN	GON	PSEU	P. spp.
Germany	21	1994-1996	19	5	4	14	1		3	1	
South	35	1997-1999	19	18	7	7	2		3	2	5
Germany	15	1995-2000	10	9		2					
North / East	47	2000-2002	22	11	6	1	1				11
	7	2006	5	5							
Austria	35	1999-2001	17	11		7			2		4
Switzerland	4	1995-2005	4			3		1			1
France	24	1995-1996	7					7			
	60	1998-2000	31	13	3	11			6	6	14
UK	20	1998-1999	12	8	2	3			5		1
Sweden	27	2000-2002	11	10	1		1				
Spain/Portugal	9	1991-1992	6					6			4
Spain	9	1994-1995	6					6			
Spain	3	1998-1999	3					3			1
Portugal	1	2006	1	1				1			
Italy	5	1995	4	3		1					
	30	1998-2000	19	6	4	10	4	4	2		5
Poland	3	2000-2003	2					1			1
Hungary	3	1995	3	1		2					
Slovenia	1	1995	1			1					
Serbia	6	2003	6	6		2					
Turkey	51	1999-2001	38	29		4		1	2		9
Total	416		256	136	27	68	9	30	23	9	56
Proportion			62 %	33 %	7 %	16 %	2 %	7 %	6 %	2 %	14 %

¹ QUE = *P. quercina*, CAM = *P. cambivora*, CIT = *P. citricola*, CAC = *P. cactorum*, GON = *P. gonapodyides*, PSEU = *P. pseudosyringae*, P. spp. = *P. cryptogea*, *P. gallica*, *P. europaea*, *P. megasperma*, *P. syringae*, *P. psychrophila*, *P. uliginosa*, and unknown *Phytophthora* taxa.

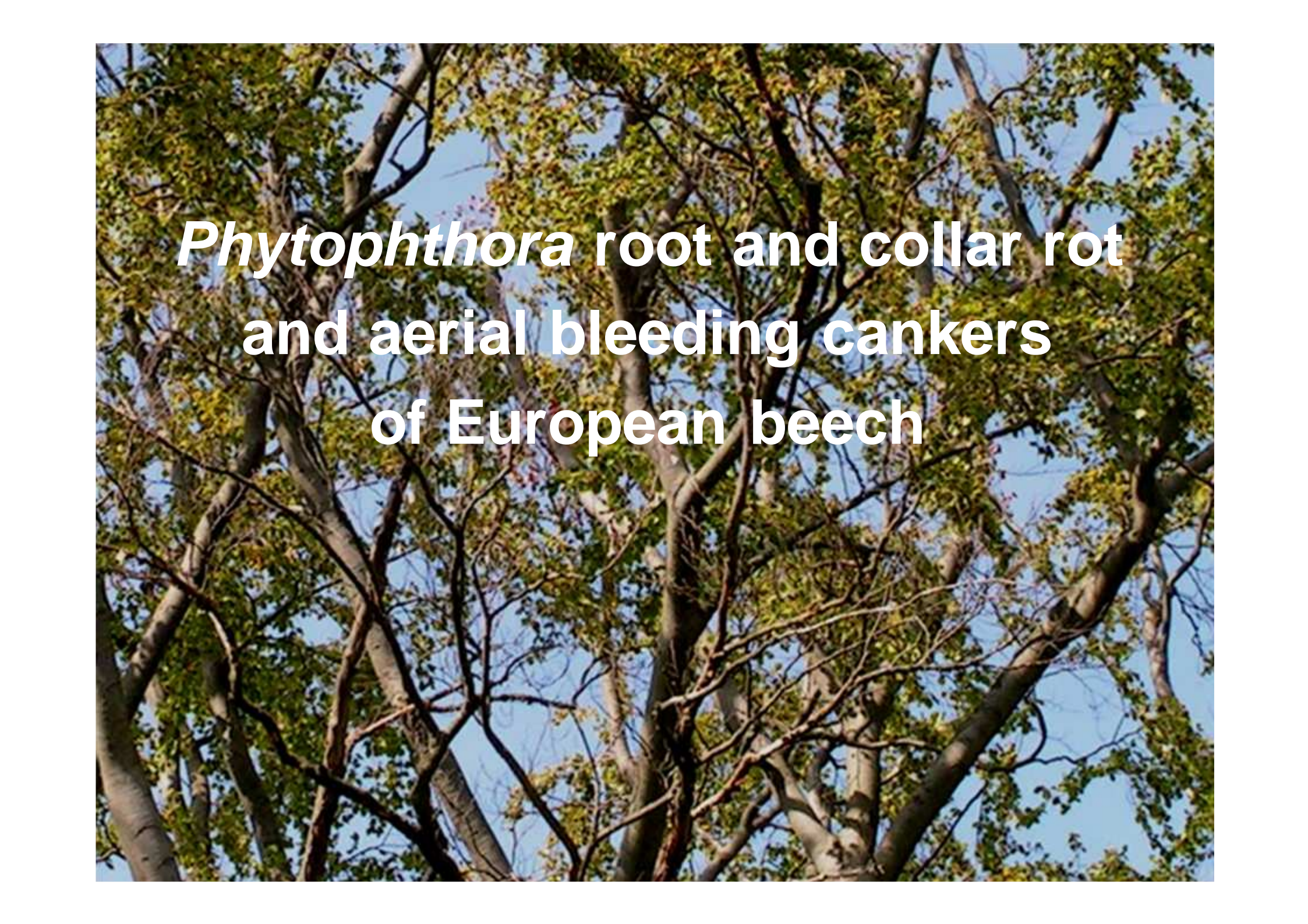
European distribution of



P. quercina

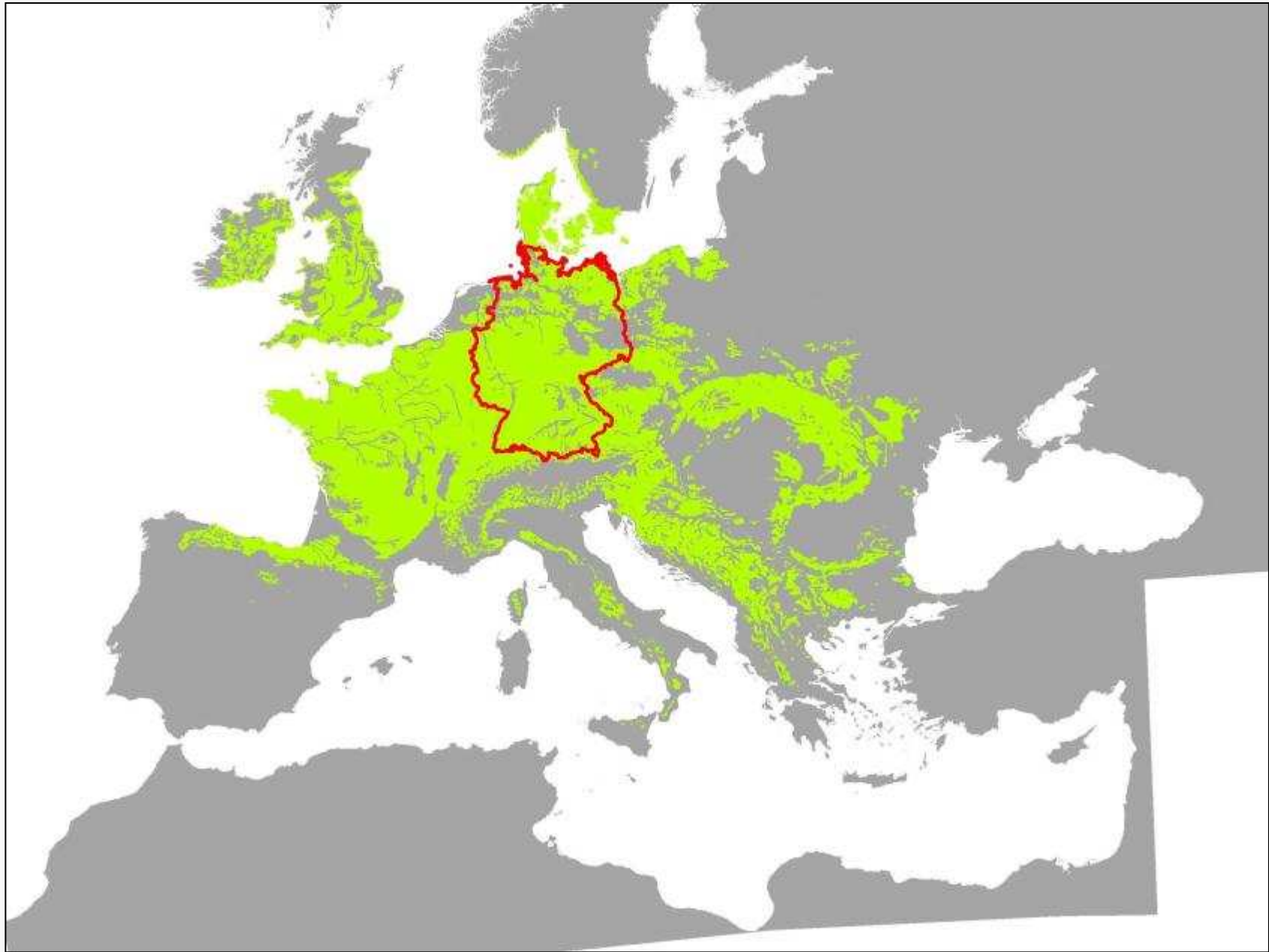


P. cambivora, *P. cactorum*
and *P. plurivora*.



***Phytophthora* root and collar rot
and aerial bleeding cankers
of European beech**

Distribution of *Fagus sylvatica* in Europe.

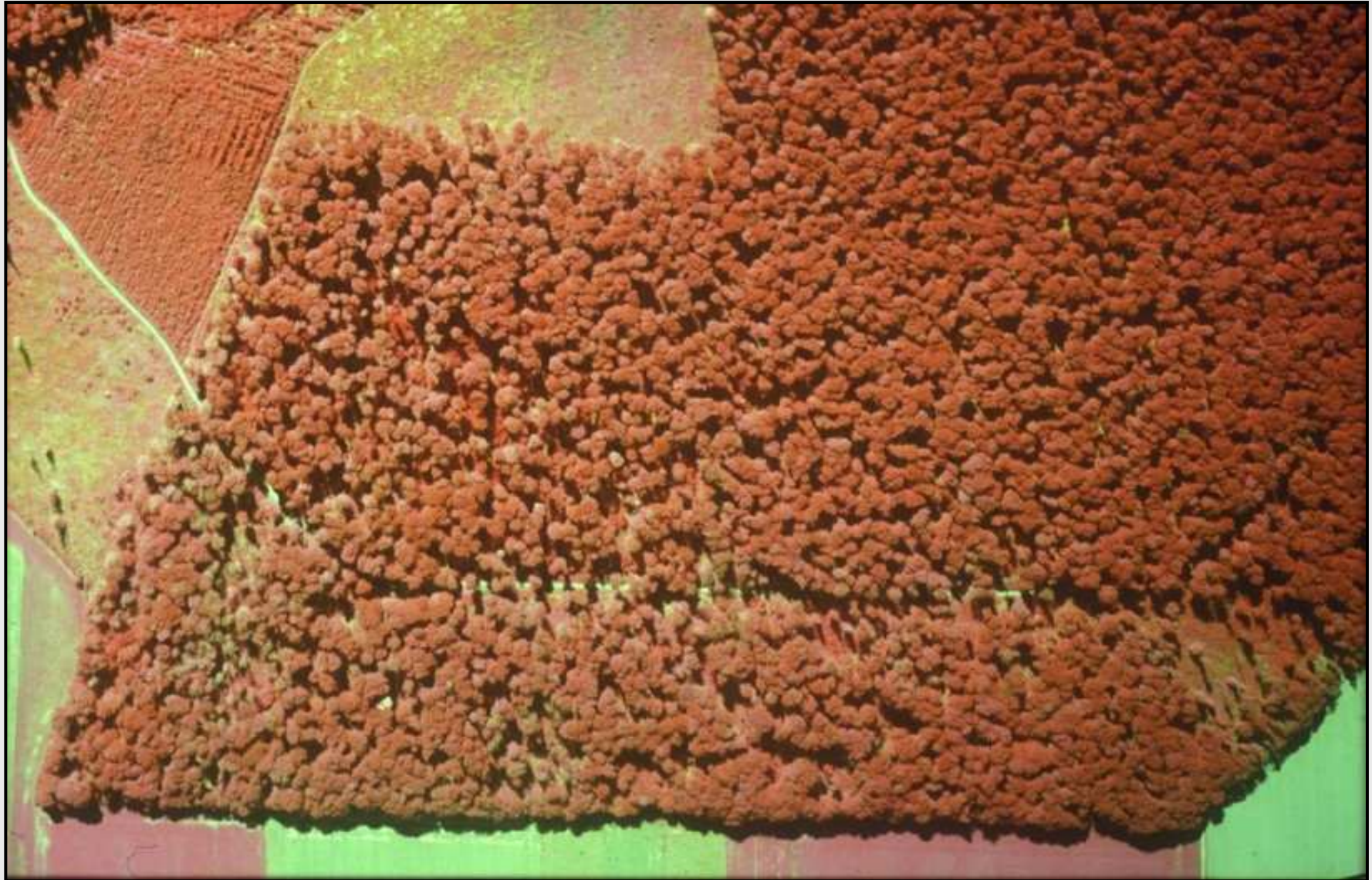


Dieback of mature beech forest caused by *P. cambivora*.



Slide courtesy Günter Hartmann

Detection of beech dieback using remote sensing (CIR photography)





**Group dieback of
beech in mixed
mountain forests.**

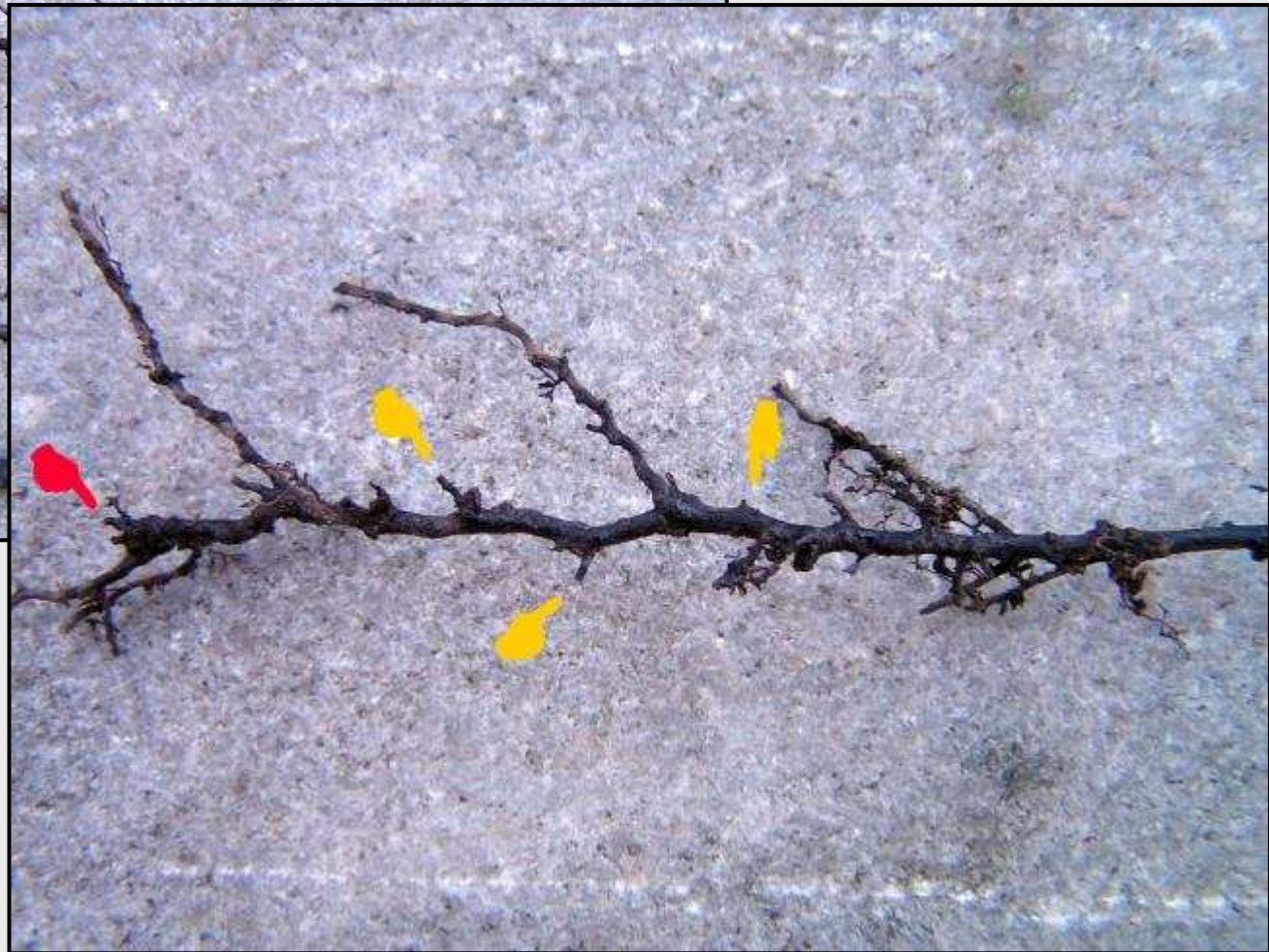
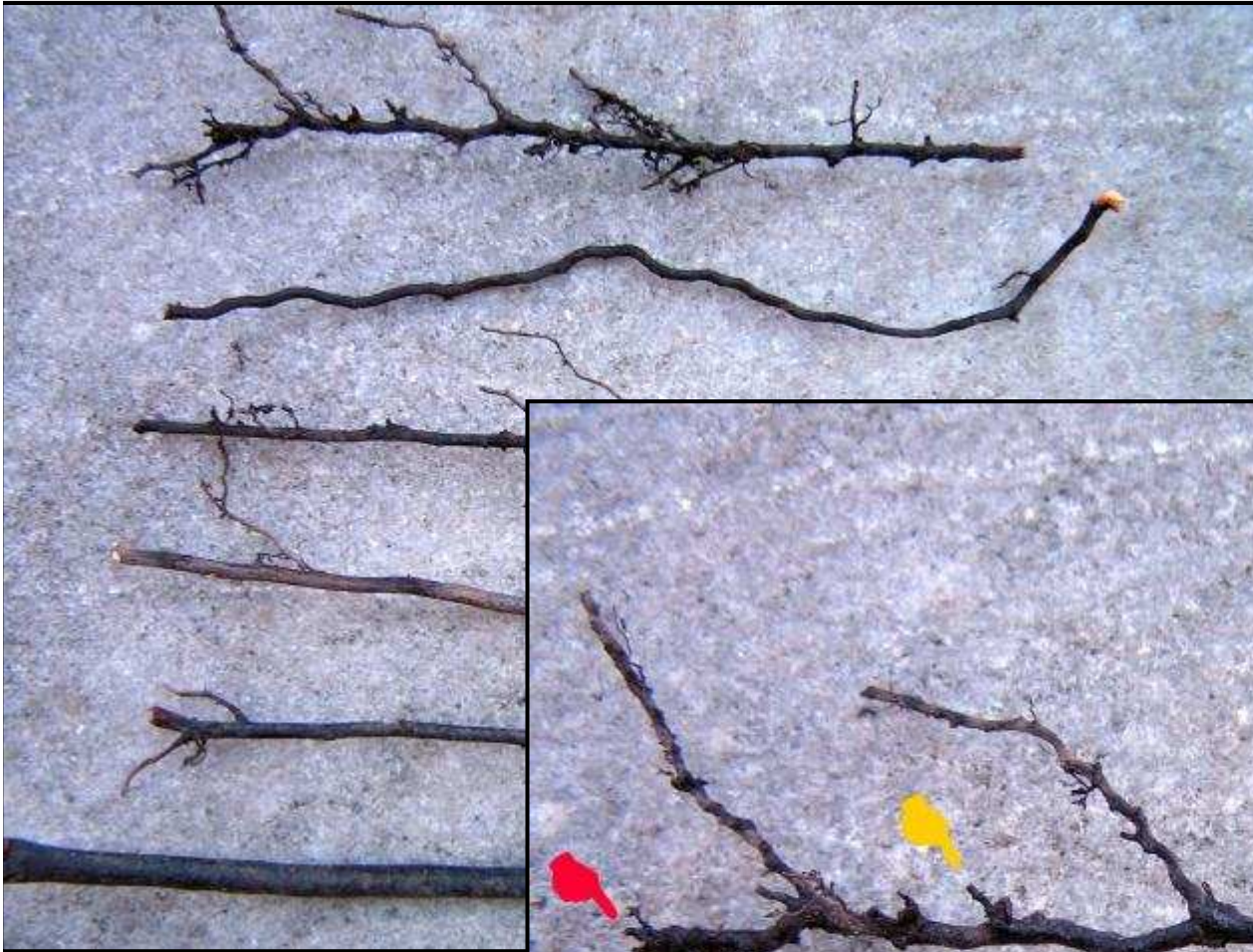








**Fine root destructions
caused by *P. cactorum*
and *P. plurivora* on
European beech.**



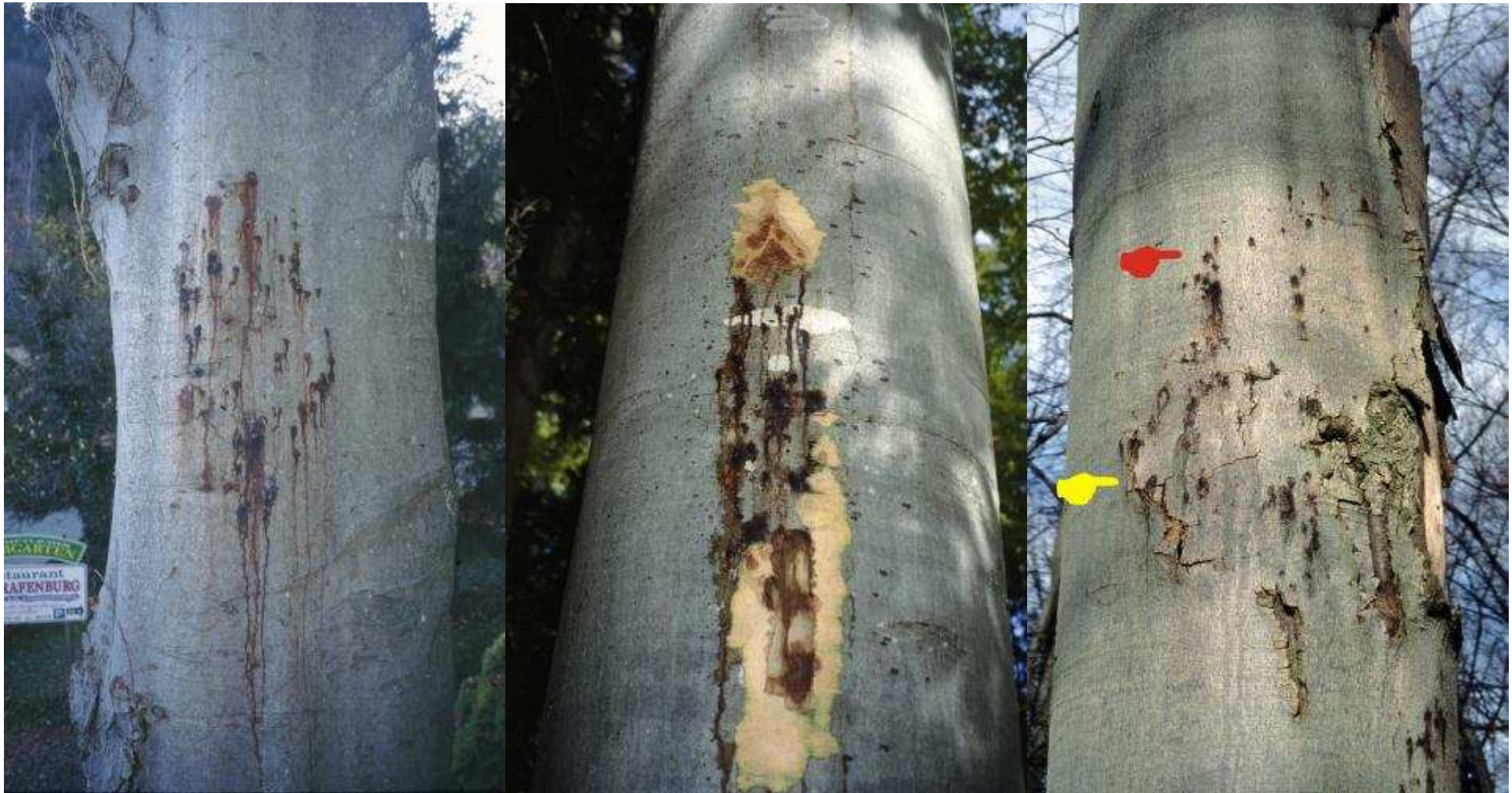
Necrotic lesions of *Fagus sylvatica* coarse roots.



Root and collar rot of planted and naturally regenerated young beech trees.

**Collar rot of beech
caused by *P. cambivora*.**

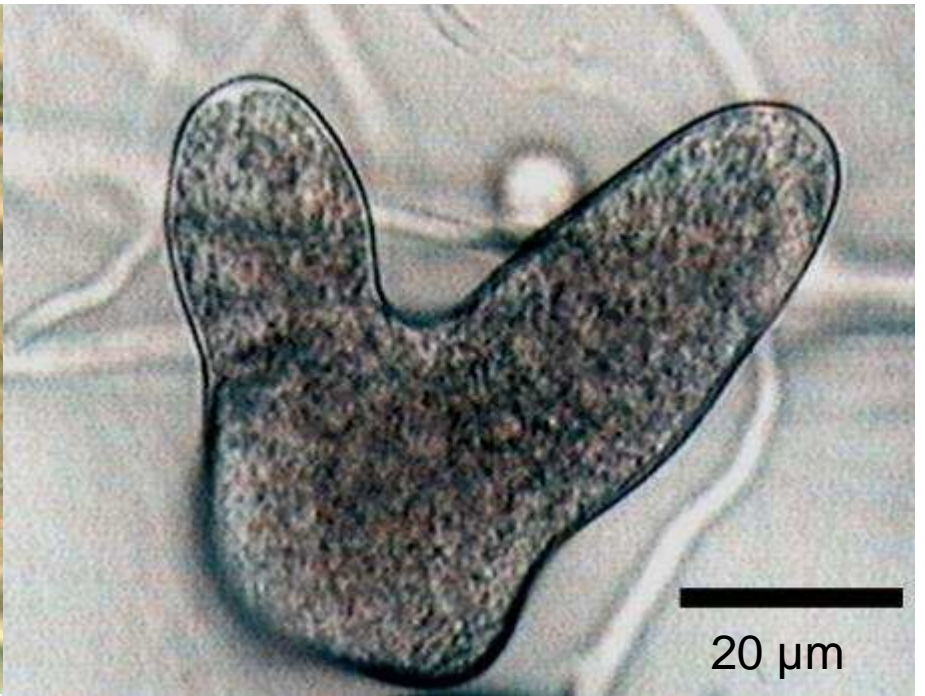


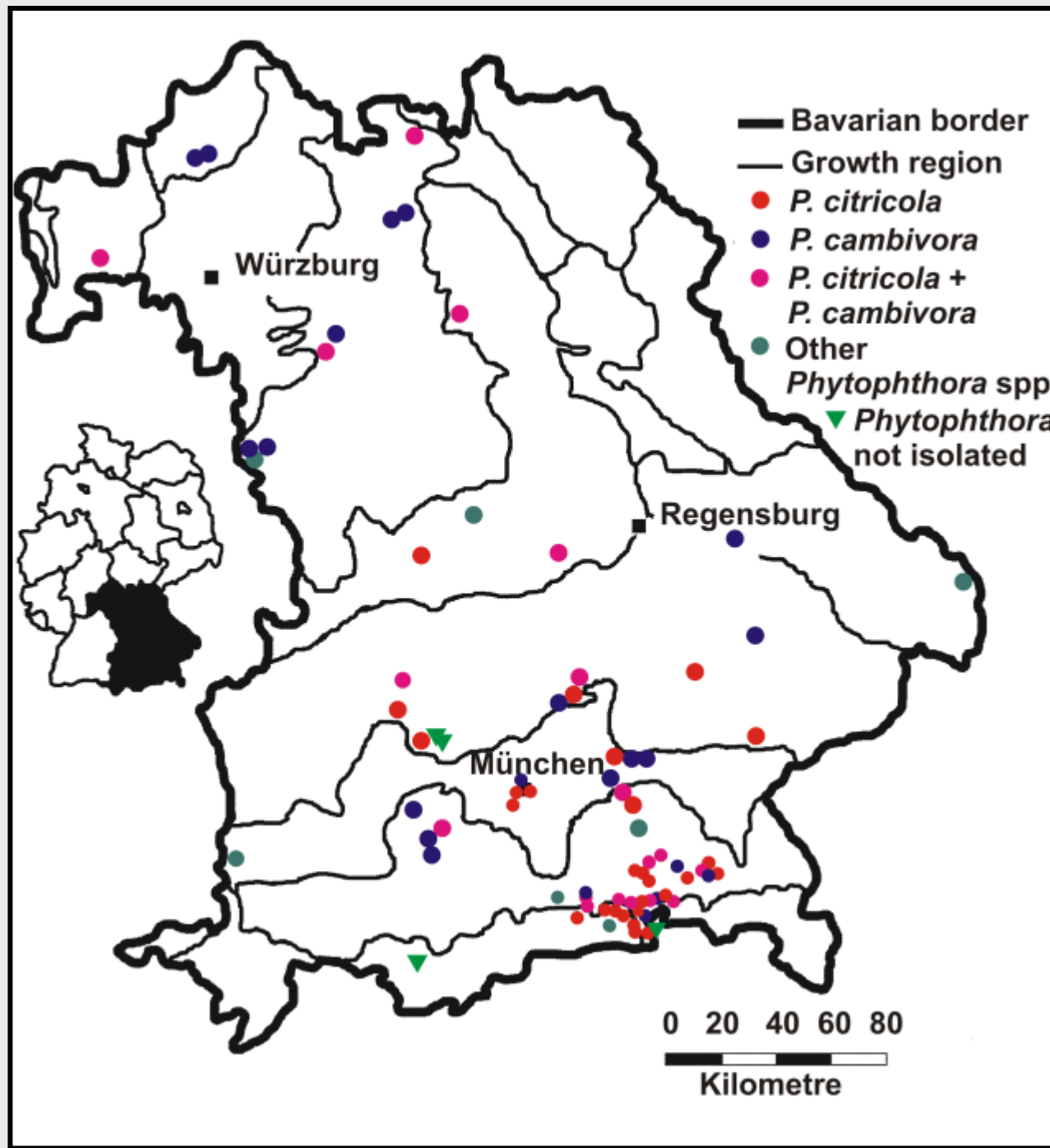


Aerial bleeding cankers of beech caused by *P. citricola* and *P. cambivora*.



Shedding of *Phytophthora* infected dead bark.





Phytophthora species in declining beech stands in Bavaria.

Geological substrate	No. of stands (trees)	Infected stands (trees)	No. of trees with ¹				P. spp.
			CAM	PLU	CAC	GON	
Limestone	23 (57)	21 (38)	5 (7)	17 (26)	3 (3)	2 (2)	
Flysch	6 (16)	5 (11)	3 (4)	5 (7)			
Granite	2 (2)	2 (2)				1 (1)	1 (1)
Conglomerate	1 (1)	1 (1)		1 (1)			
Moraine Young	20 (51)	20 (45)	12 (15)	12 (24)	2 (2)	3 (4)	4 (5)
Sediments: Old	4 (12)	4 (9)	4 (8)	1 (2)			
Moraine gravels	10 (31)	10 (28)	1 (1)	8 (14)	3 (10)	3 (4)	2 (3)
Alluvial deposits	10 (51)	10 (51)		10 (28)	7 (36)		5 (16)
Tertiary deposits	20 (44)	15 (35)	5 (16)	9 (16)	5 (10)	1 (2)	
Loess	2 (7)	2 (3)	1 (1)	2 (2)			
Claystone	3 (9)	3 (8)	3 (7)	1 (2)			
Gypsum	4 (16)	4 (13)	3 (9)	1 (3)	1 (1)		1 (1)
Mylonite	1 (2)	1 (1)	1 (1)				
Sandstone	6 (15)	6 (8)	5 (5)	2 (2)			1 (1)
Total: stands	112	104 (93%)	43 (38%)	69 (62%)	21 (19%)	10 (9 %)	14 (13%)
trees	314	253 (81%)	74 (24%)	127 (41%)	62 (20%)	13 (4%)	27 (9%)

¹ CAM = *P. cambivora*, PLU = *P. plurivora*, CAC = *P. cactorum*, GON = *P. gonapodyides*,
P. spp. = *P. pseudosyringae*, *P. syringae*, *Phytophthora* taxon 'P. g. chlamydo', *P. uliginosa* and
unknown *Phytophthora* species.



Root systems of beech seedlings in non-infested (left) and *P. cambivora* infested soil (right).



Slide courtesy Günter Hartmann

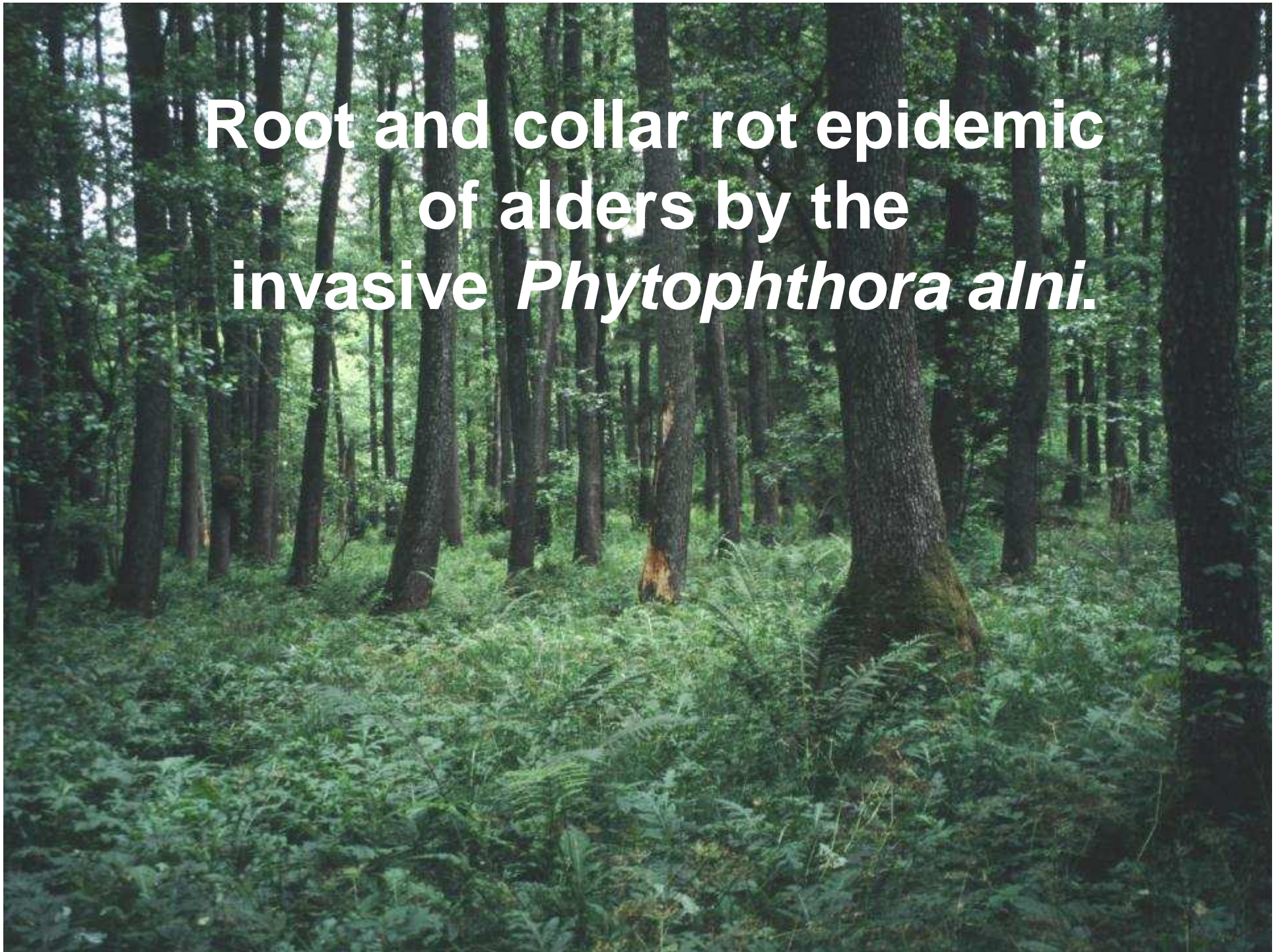


Root and collar rot of planted beech trees in Northern Germany caused by *P. cambivora*.



Slide courtesy Günter Hartmann

**Root and collar rot epidemic
of alders by the
invasive *Phytophthora alni*.**



**Mature common alders
(*Alnus glutinosa*).**





**Riparian common
alder stands.**



Alder dieback along Rio Miño in Lugo





***P. alni* infected plantation
on former agricultural land.**





Common alder in a non-flooded forest plantation.

Grey alder in a riparian forest plantation.





Mature common alder in non-flooded forest stand.

Riparian common alder stool with multiple stems.

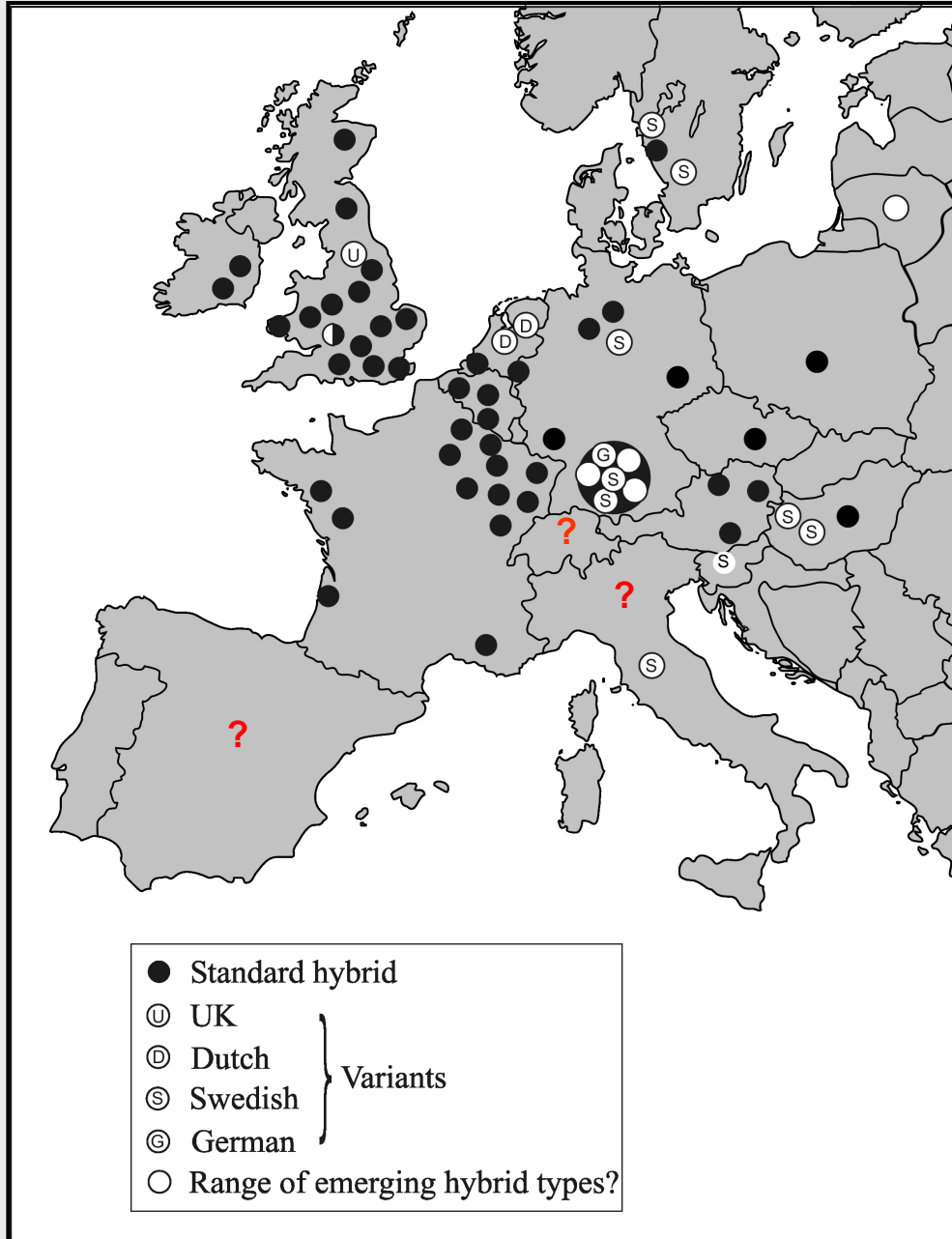


**Bark canker of black alder
at Rio Miño in Lugo**

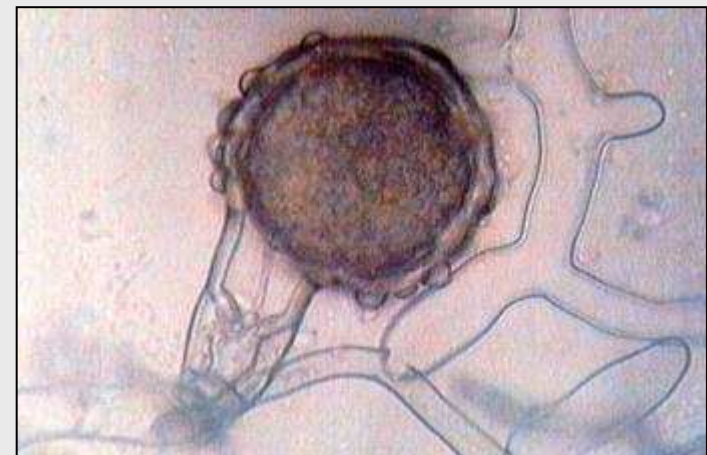


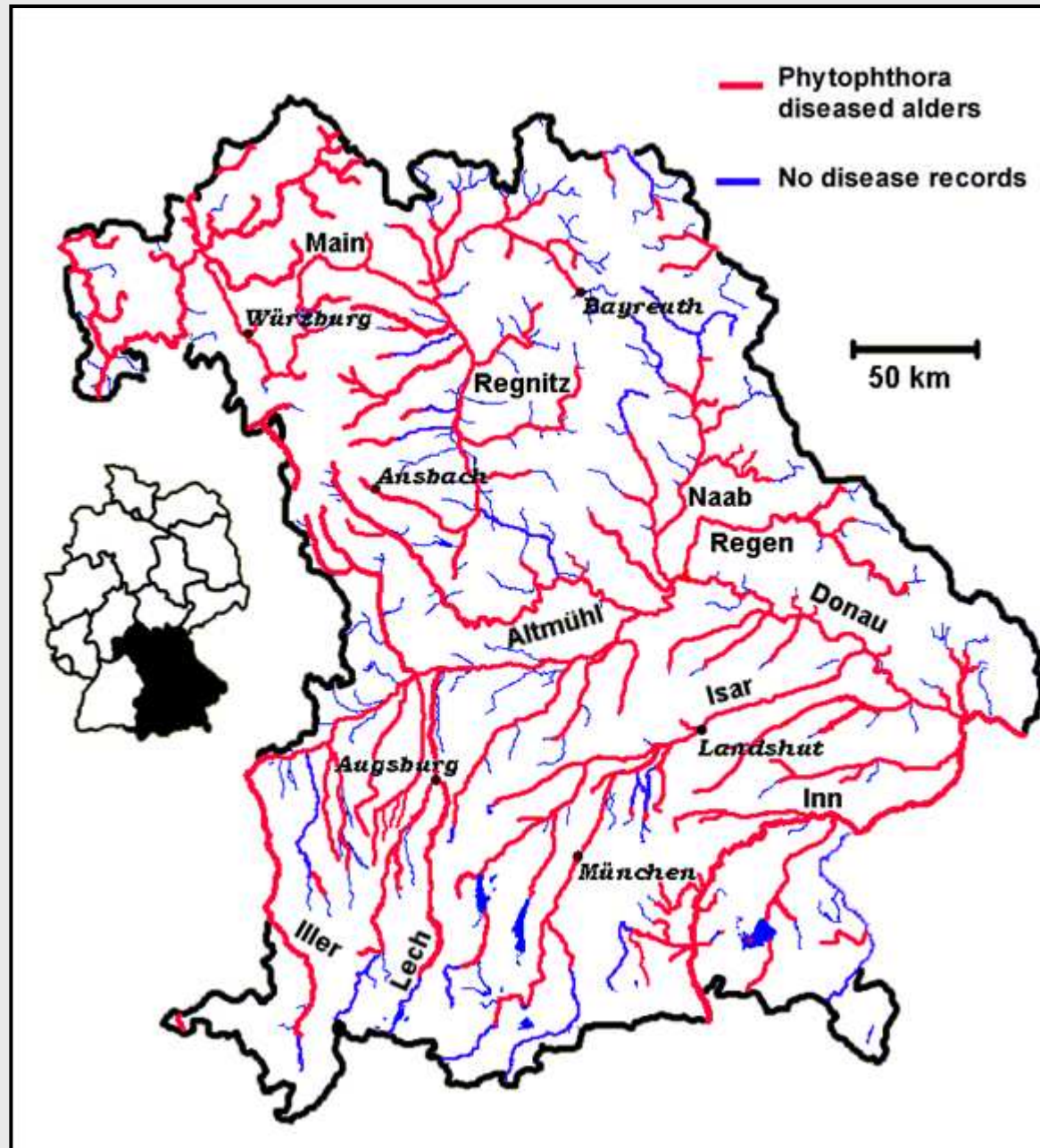


Root stock erosion of riparian common alders.

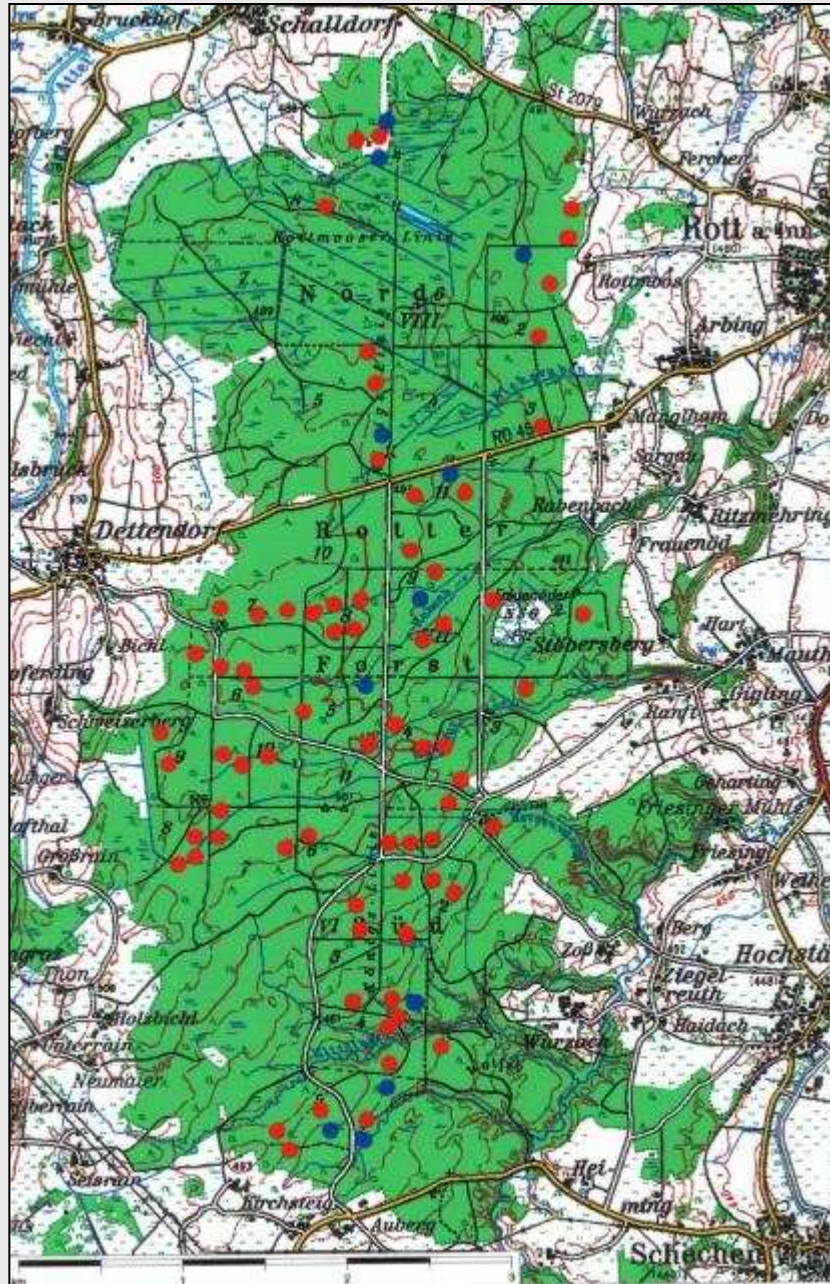


Known distribution of *Phytophthora alni* in Europe.





Occurrence of *P. alni* root and collar rot of alders along main rivers in Bavaria.



Introduction and spread of *P. alni* in the common alder forest 'Rotter Forst'.

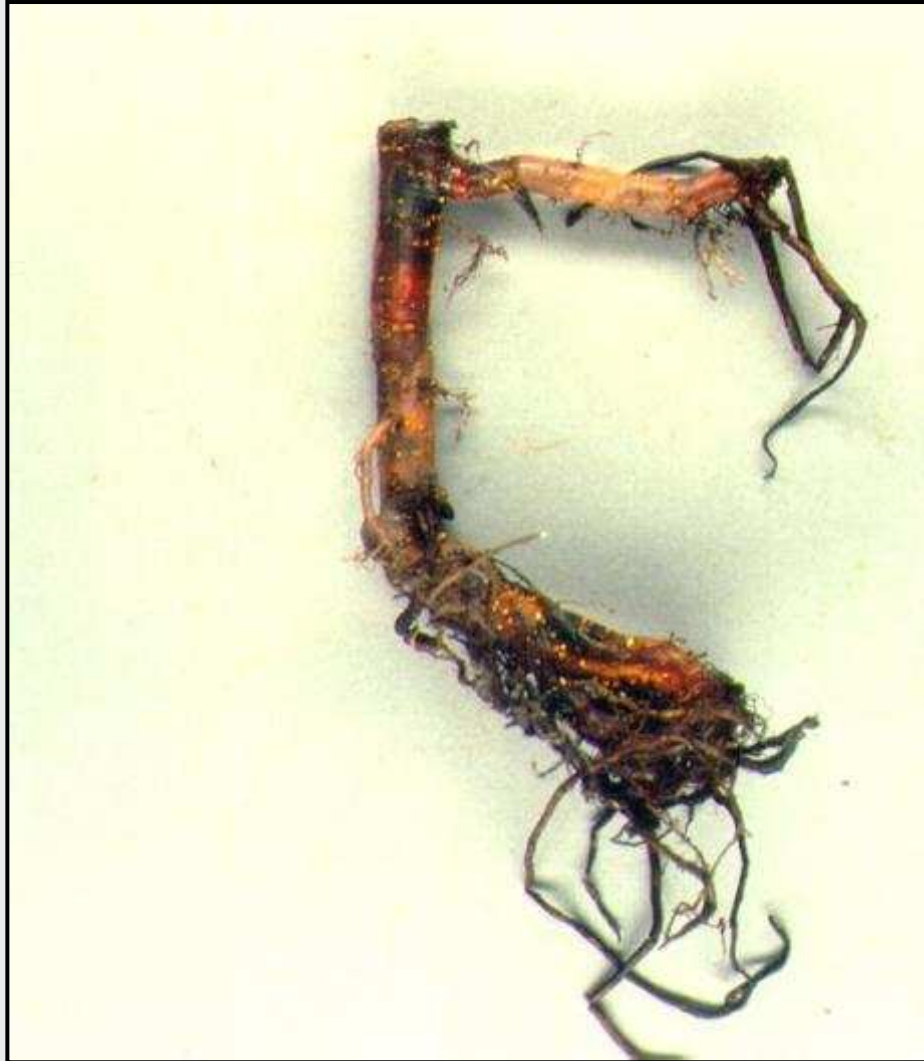


Sampling of alder seedlings from a nursery field.

Isolation procedure.



Slide courtesy Jörg Schumacher



Development of root and collar rot in visibly healthy alder plants from nurseries in Bavaria and Brandenburg after artificial flooding.

Phytophthora infestations of alder fields in Bavarian and Austrian retail nurseries

Alder species ¹		Phytophthora – species ²										
		PAA	PAA x CAM	CAM	CAC	GON	MEG	PLU	PSEU	QUE	SYR	CHLAM
Resale of plants, production in fields and/or irrigation with river water												
Nursery D1	GLU	X										
Nursery D2	GLU		X	X		X	X	X			X	X
	INC	X		X		X	-	X			X	X
	VIR			X				X				
Nursery D3	GLU					X	X	X				X
Nursery D4	GLU	X		X		X						X
Nursery D5					X			X				
Nursery A1	GLU	X			X							
Production of plants from seeds in fields, irrigation with well or tap water												
Nursery D6	GLU				X		X	X				
Nursery D7	GLU									X		
Nursery D8	GLU			X	X		X	X				
Nursery D9	GLU				X			X	X			
Production of plants from seeds in containers with soil contact, use of well water												
Nursery D10	GLU			X	X							
Nursery A2	GLU				X							
Production of plants from seeds in containers on tables and use of tap water												
Nursery A3	GLU											

¹ GLU = *Alnus glutinosa*, INC = *A. incana*, VIR = *A. viridis*.

² PAA = *P. alni* ssp. *alni*, PAA x CAM = putative backcrosses between PAA and *P. cambivora* (according to ITS data), CAM = *P. cambivora*, MEG = *P. megasperma*, CAC = *P. cactorum*, GON = *P. gonapodyides*, PLU = *P. plurivora*, PSEU = *P. pseudosyringae*, QUE = *P. quercina*, SYR = *P. syringae*, CHLAM = 'P. taxon Pgchlamydo'.



**Ink disease of Sweet chestnut
caused by *P. cambivora*.**





**Root and collar rot and
aerial bleeding cankers
on horse chestnut
caused by *P. plurivora*.**

