Interactions between drought and forest pests and diseases

3 approaches

Epidemiological approach: field surveys

Experimental, quantitative approach: metaanalysis of available evidence

Analysis of underlying mechanisms in experimental conditions

Field surveys

Field surveys by operational services: spatial and temporal patterns of occurrence and damage for different (important) species

- Qualitative information (expert judgement) availabe quickly: massive bark beetle attack in 2003 (increase after a decrease in 2002 in the areas damaged by the 1999 storms, and in other regions), etc.
- Quantitative information on occurrence / damage is delayed (with a few exceptions) due to validation procedure, not homogeneous over the borders, and generally poor quality.

Field surveys and their interpretation

- Relating intensity of damage to intensity of water stress / heat is sofar almost impossible outside experimental conditions
- Few scientists have tried to explore the (large-scale) spatial-temporal patterns of pests and diseases versus climate stress

Analysis of published information on the response of pests and diseases to water stress

See Jactel et al.

Numerous experiments, few well documented!

Damage proportional to pests and diseases

But : response of pests and diseases to stress is non linear (confirms that the intensity of water stress must be known)

Interactive effects of drought and pathogens in forest tress

Working group

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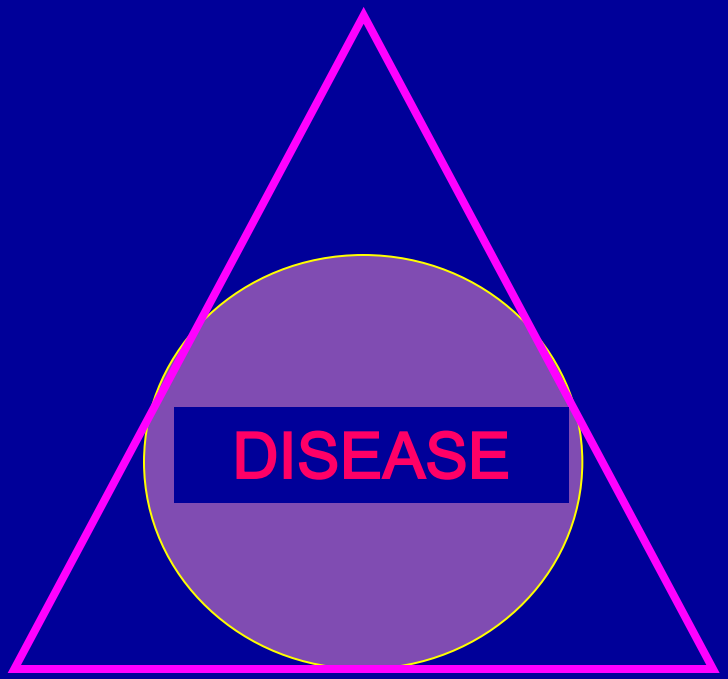
THE DISEASE TRIANGLE

ENVIRONMENT

- natural and anthropic effects ; local and global change

(drought, heat, sylviculture, …)



PATHOGEN

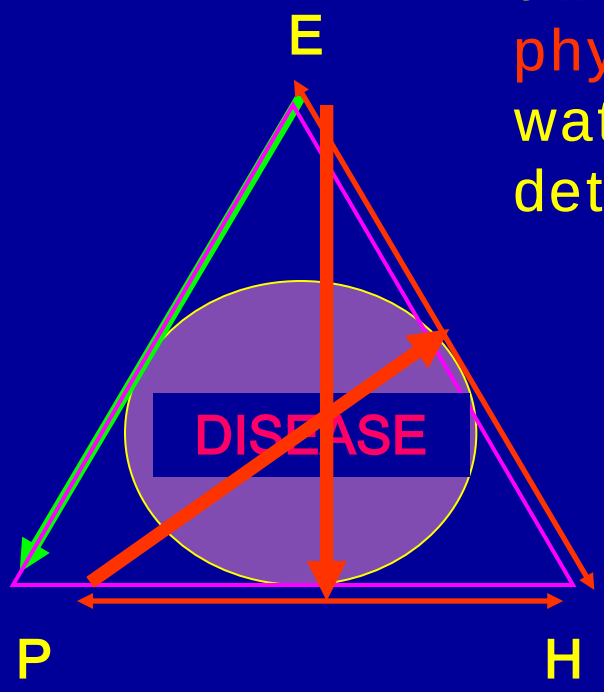
HOST

DIRECT or INDIRECT EFFECTS OF DROUGHT ON PATHOGENS?

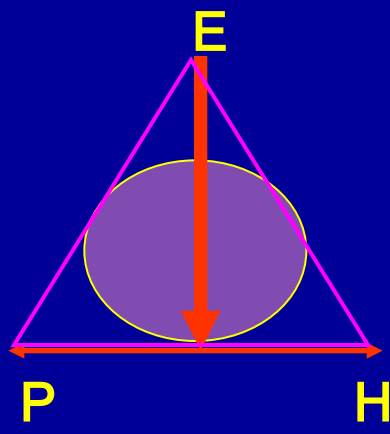
Relative importance of external / internal infection processes:

- **Foliar polycyclic diseases** : often less common and less severe during drought episodes:

  rain/moisture needed for dissemination, germination and penetration)



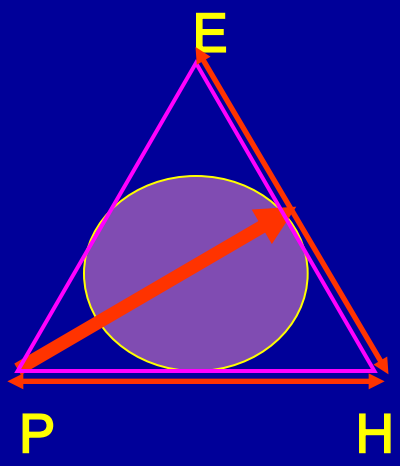
- **Stem and root diseases** : indirect effects through host physiology : water stress is determinant



1. Effects of drought on host –pathogen interaction :

increased susceptibility to pathogens: **PREDISPOSITION**

- *generally, development of disease during or following stress*
- *some types of pathogens: mainly necrotrophs, facultative parasites*



2. Effects of disease on the plant response to drought stress :

decreased tolerance to **MULTIPLE STRESSES**

- *disease developed before stress*
- *all types of pathogens (including biotrophs)*

1. **Predisposition** of trees to disease by drought (heat) stress

Sensu lato: Increased « disease proneness » resulting from external causes (does not imply that infection always occurs after stress)

- « **Drought-enhanced diseases** » : favoured by drought but caused by « **true parasites** »

  mainly cankers (necrotroph pathogens)

  Example : Sphaeropsis sapinea

- « **Drought-induced diseases** »: caused by **opportunistic, facultative** or **conditional parasites**

  mainly endophytic species

  Example : Biscognauxia mediterranea

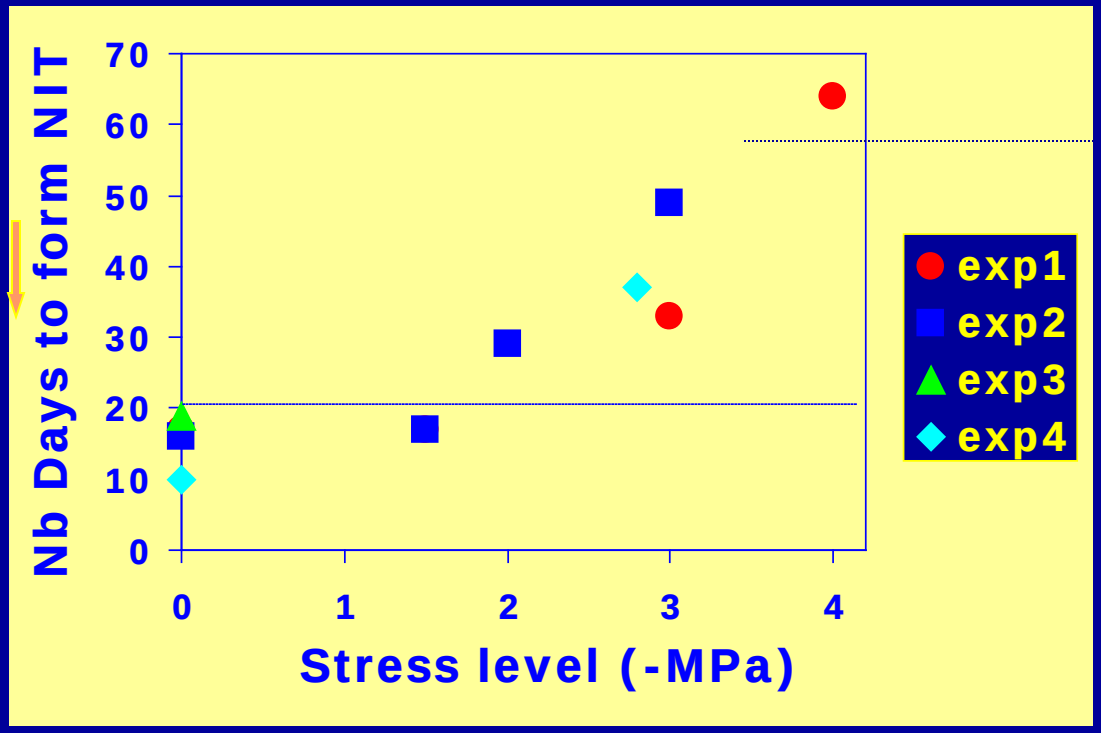
Mechanisms of predisposition

Decrease in photosynthetic activity and altered protein synthesis in dehydrated plants resulting in :

- Metabolic changes : improved substrate for pathogen (nitrogen)
- Decreased defensive compounds (phytoalexins, enzymes, etc…)
- Slowed defenses limiting compartmentalization

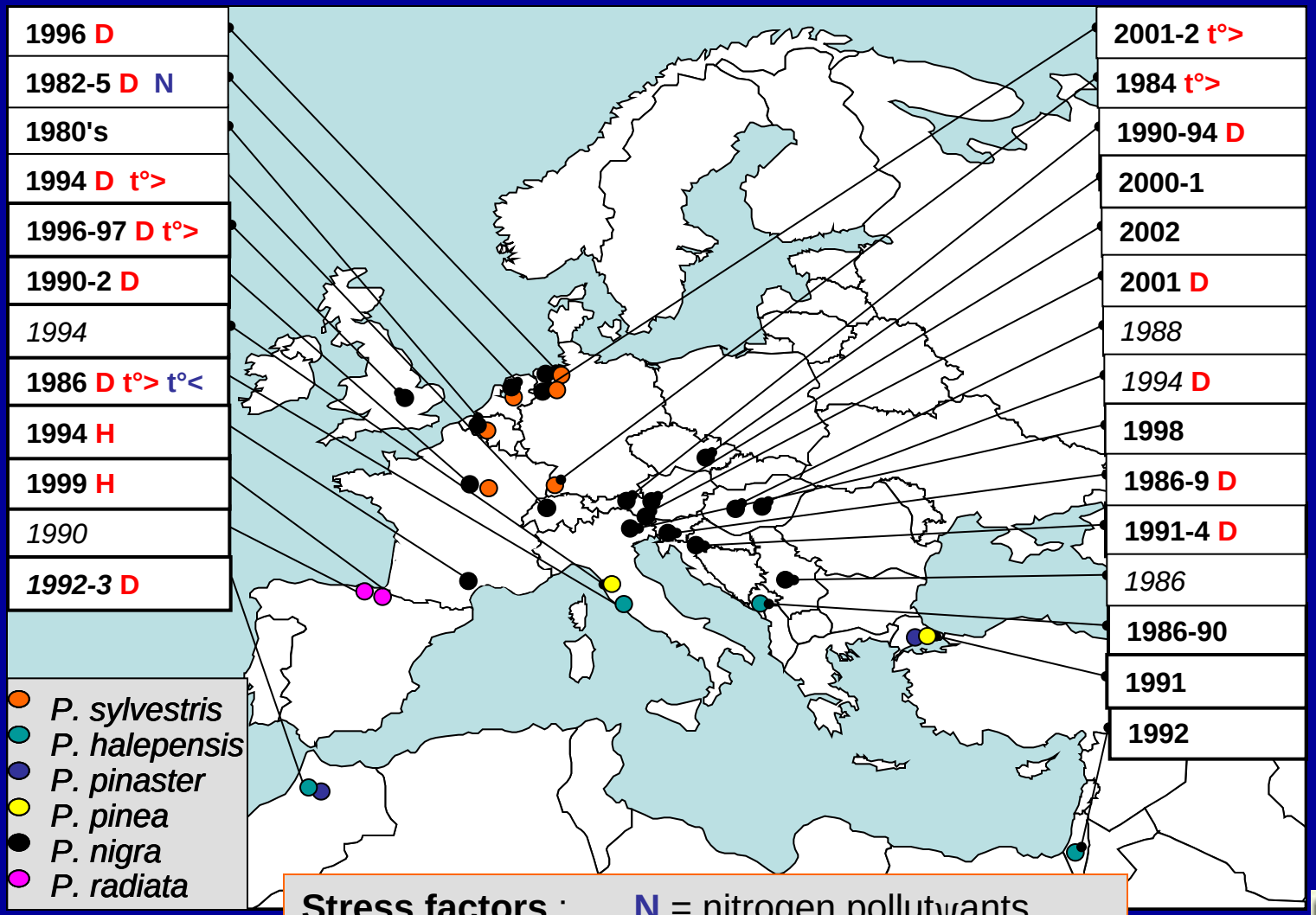
Experimental evidence of predisposition mechanisms: Effects of water stress on the rate of formation of physical defenses (after wounding) in *Abies grandis**

(Puritch & Mulklick 1975)



* NIT = non-suberized impervious **tissue**, involved in necrophylactic **periderm** formation

Sphaeropsis sapinea : an endemic pathogen in Europe with recent outbreaks in pine forests associated with predisposing stresses



Stress factors :

D = drought

H = Hail

N = nitrogen pollutψants

t°> = hight temperatures

t°< = low temperatures

Main symptoms associated with drought * S. sapinea

Canker (uncommon in Europe)

Bark necrosis

Crown or branch dieback

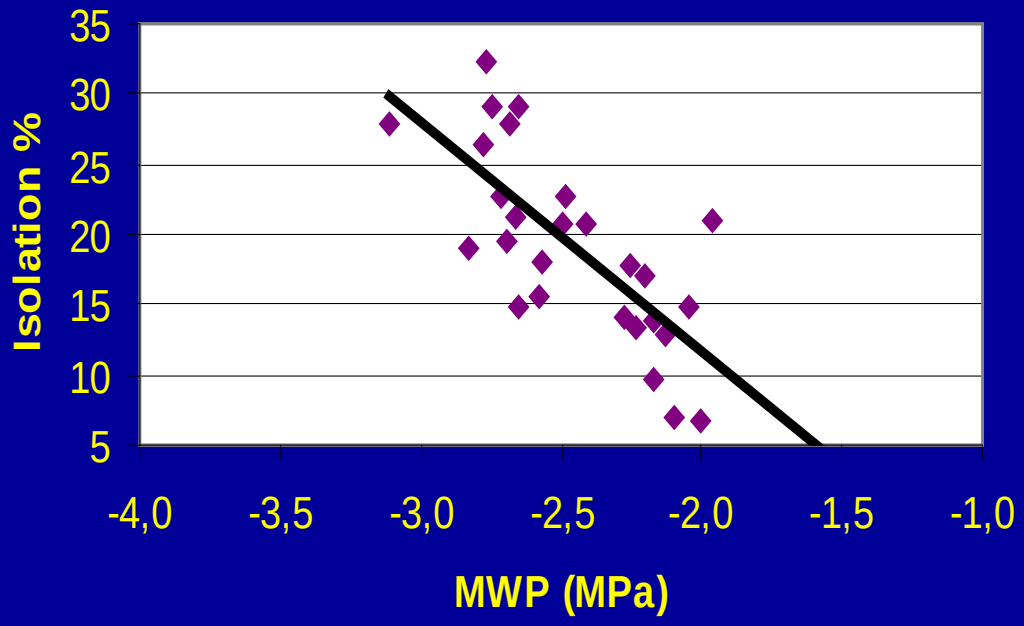
Affected stands are always plantation forests

(P. pinaster not affected in Europe but heavily damaged in S Africa

Biscogniauxia (Hypoxylon) mediterraneum :
*an **endophyte turning to parasite** with drought stress*

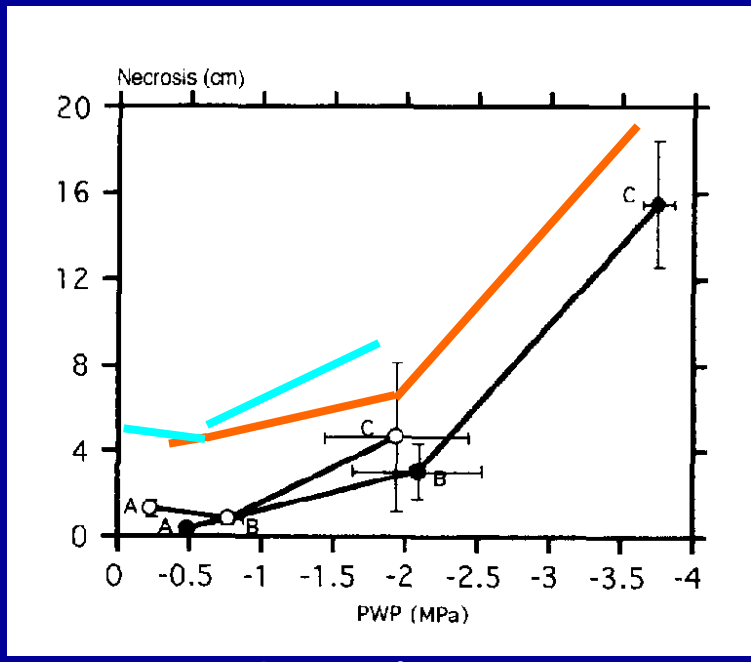
B. mediterraneum is more readily isolated in stressed trees *(Quercus cerris)*

(Lucero 2000)



The development of symptoms is linked to water status

(Vannini et al. 1996)



1. Predisposition

2. Combination of biotic and abiotic stresses : effects of **multiples stresses**

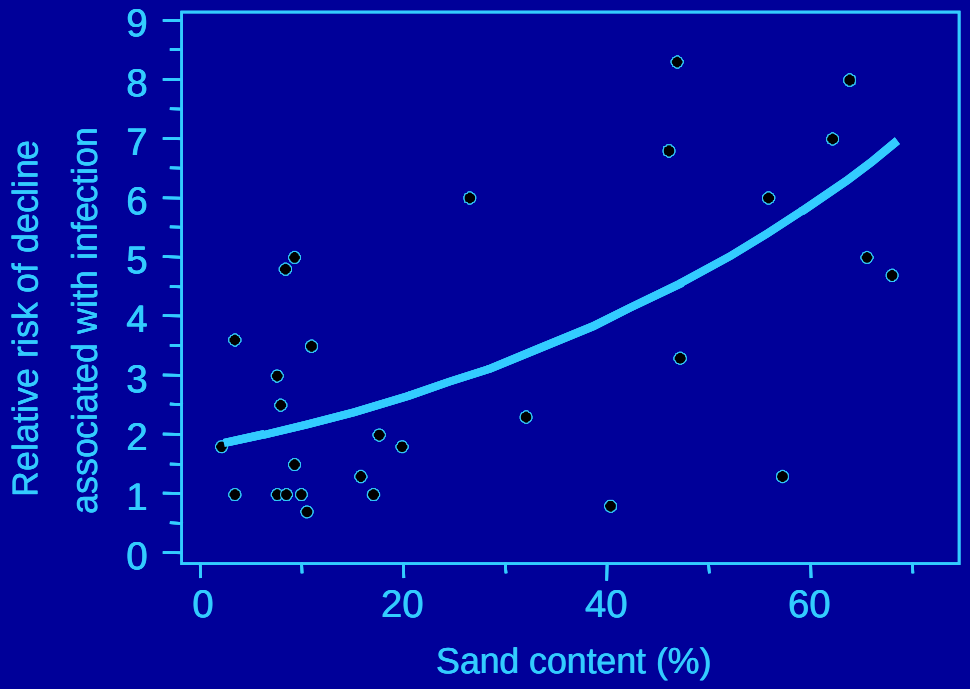
Both infection and drought act as stresses on the plant

In general, this results in additive or synergistic deleterious effects

Combined effects of infection and drought stresses

1. **Root pathogen** (affecting directly water relations)

Ex : Collybia fusipes, root pathogen on oak (Marçais)

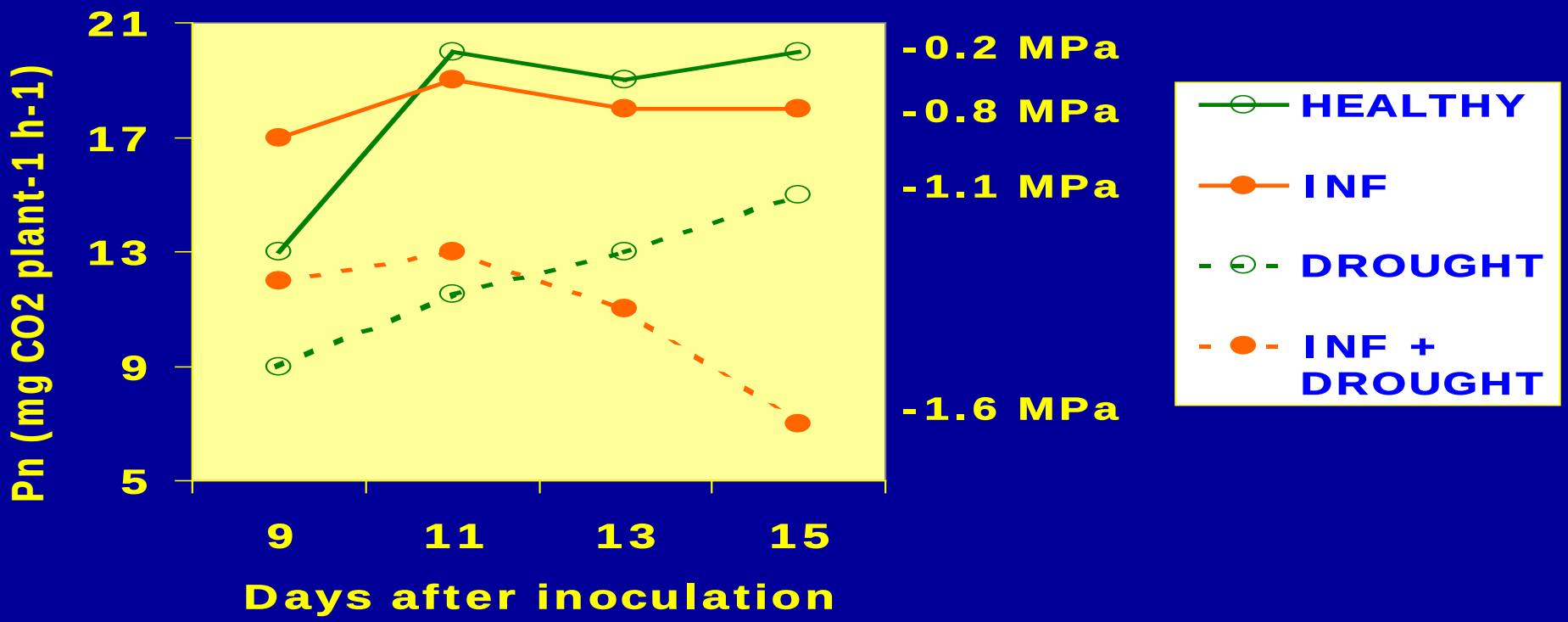


risk of decline in infected trees (compared to healthy ones) increases sign. with sand content (decreasing water availability)

Not a predisposition effect : oaks growing in high sand content are not more susceptible to Collybia) > likely explained by a ***reduced water uptake due to root loss***

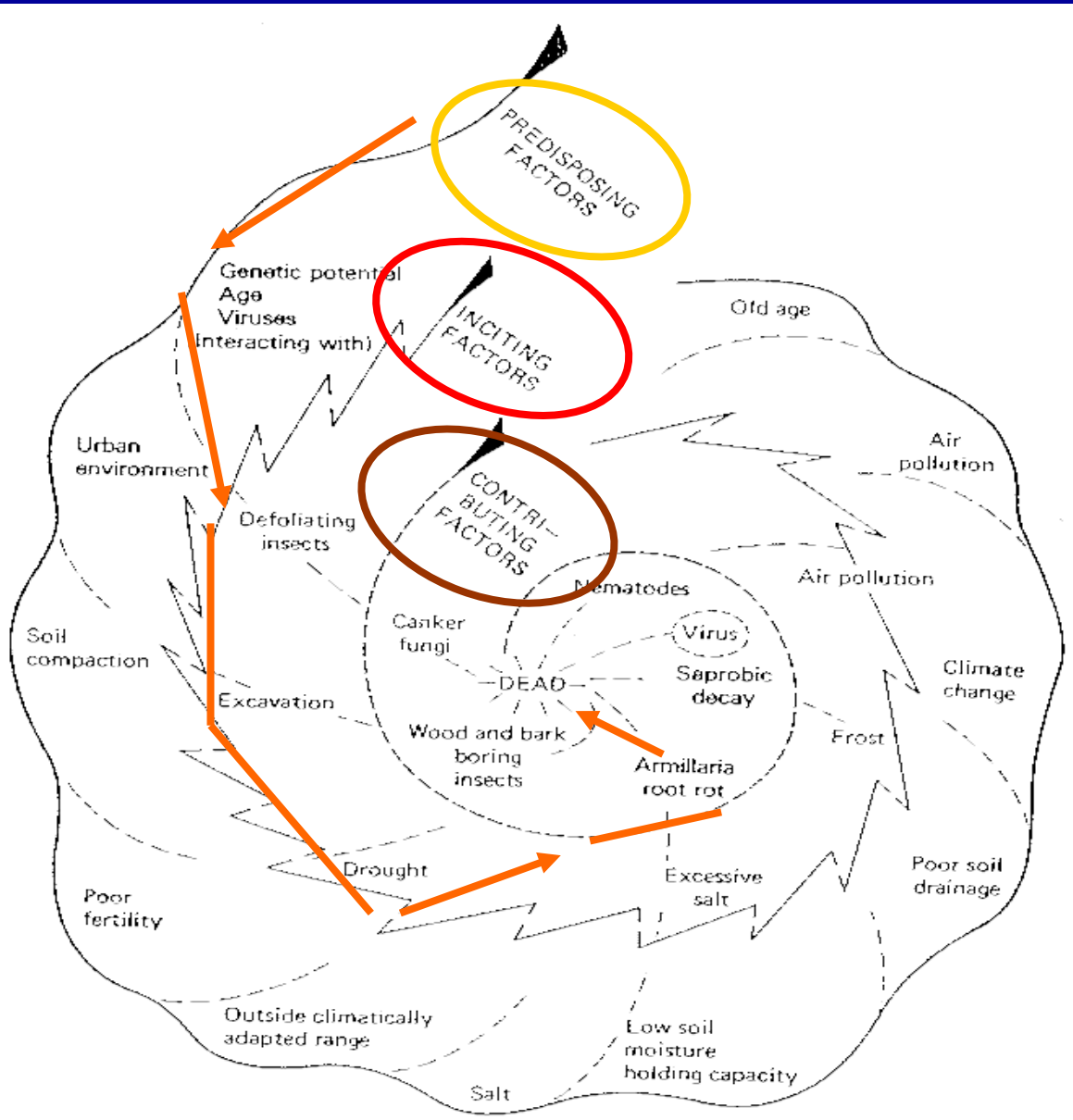
2. **Foliar pathogen** (Groundsel rust, Ayres 1991)

(affecting the photosynthesis)



drought prevents the growth of new, uninfected leaves

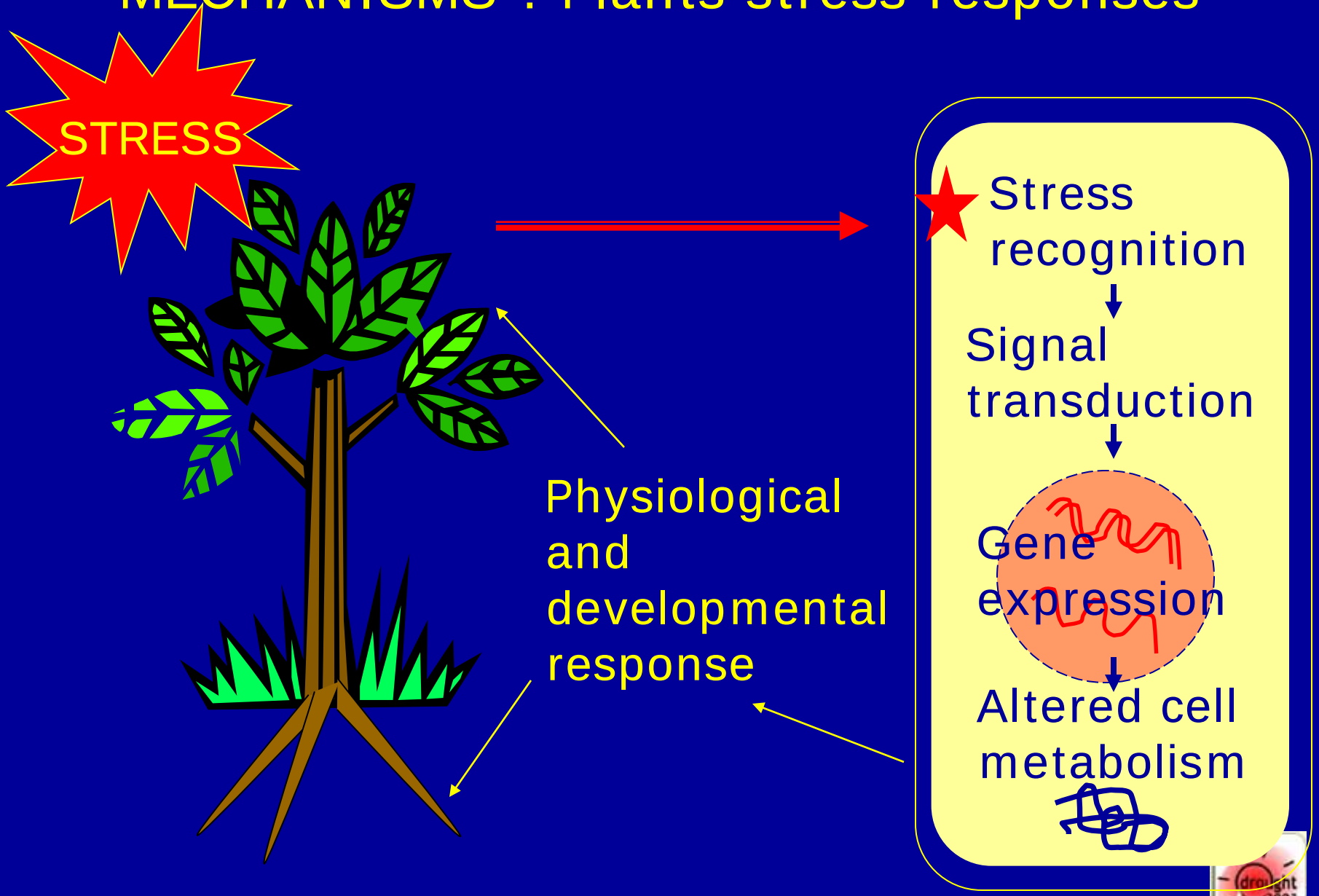
The decline concept (Manion 1991)



Some documented oak declines in France

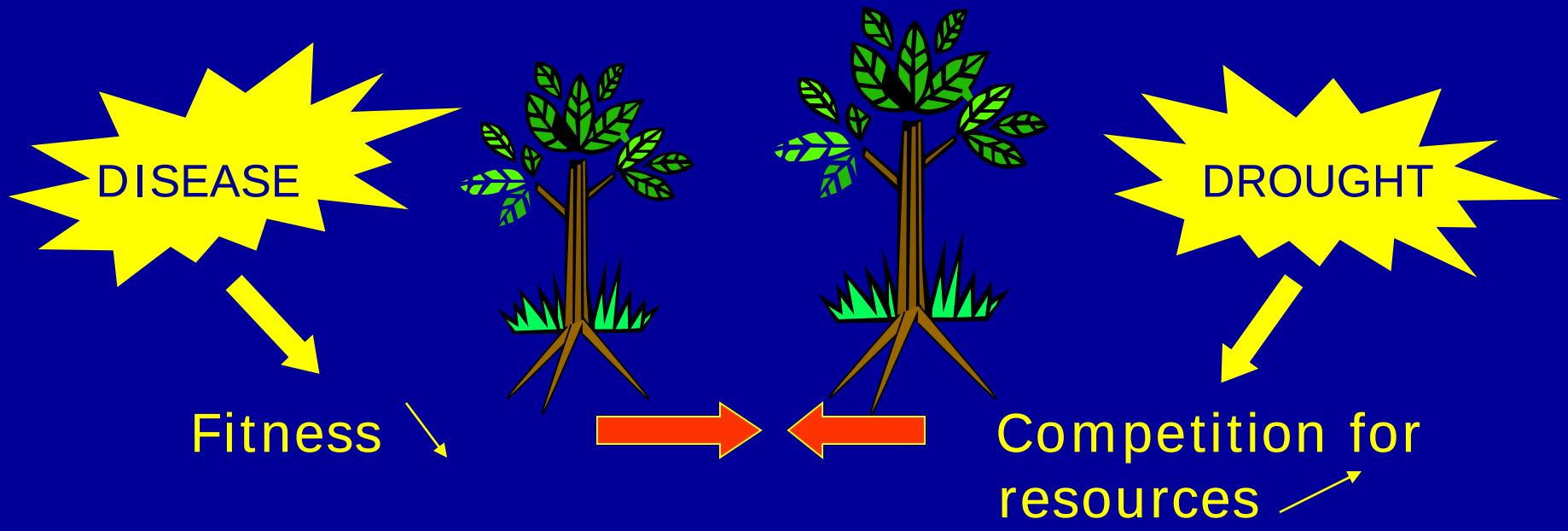
	Tronçais	Harth	Mediterr. region	Haguenau	Lure
Species	*Q. robur*	*Q.spp*	*Q.suber*	*Q.robur, Q.petraea*	*Q.robur*
Mortality period	1978-82	1991-94	1991-94	1995-97	1995-97
Predisposing					
Site, Age	+	+	+	+	+
Root pathogens (*Collybia*, *Phytophthora*)	+	(+)	+		(+)
Inciting					
Water stress	+(76)	+(89-92)	+(89-92)	?	+(89-91)
Defoliators	?	(+)	(+)	+(93-94)	
Powdery mildew	?			+(93-94)	
Contributory					
Fungi (*Armillaria*)	+		+		
Insects (borers)	?	+	+	+	+

MECHANISMS : Plants stress responses



Effects of stresses in plant populations and communities

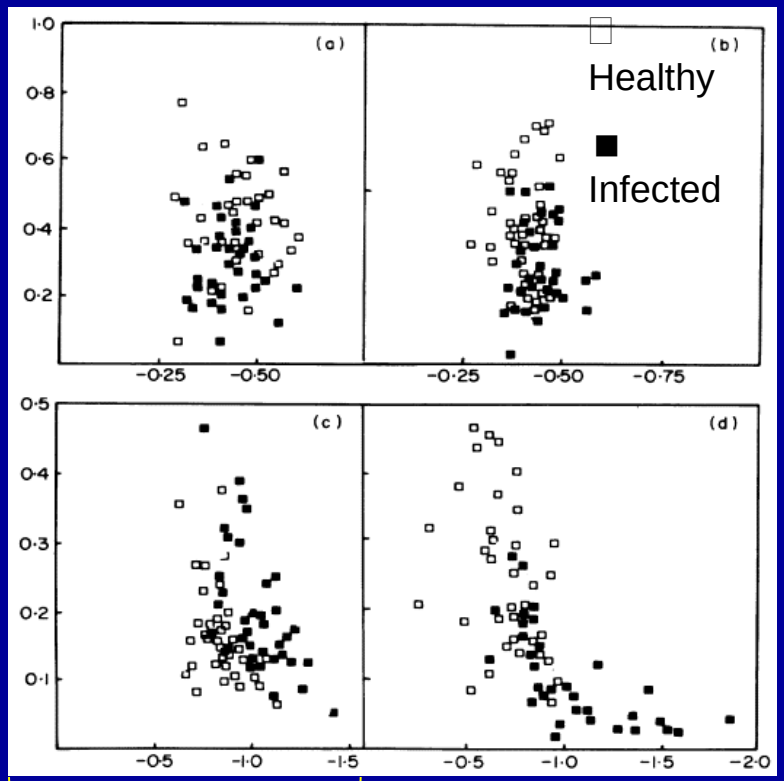
Drought and infection can have additive effects in increasing both inter- and intra- specific competitive fitness



Competitive fitness affected by disease and drought

groundsel rust: an experimental demonstration of

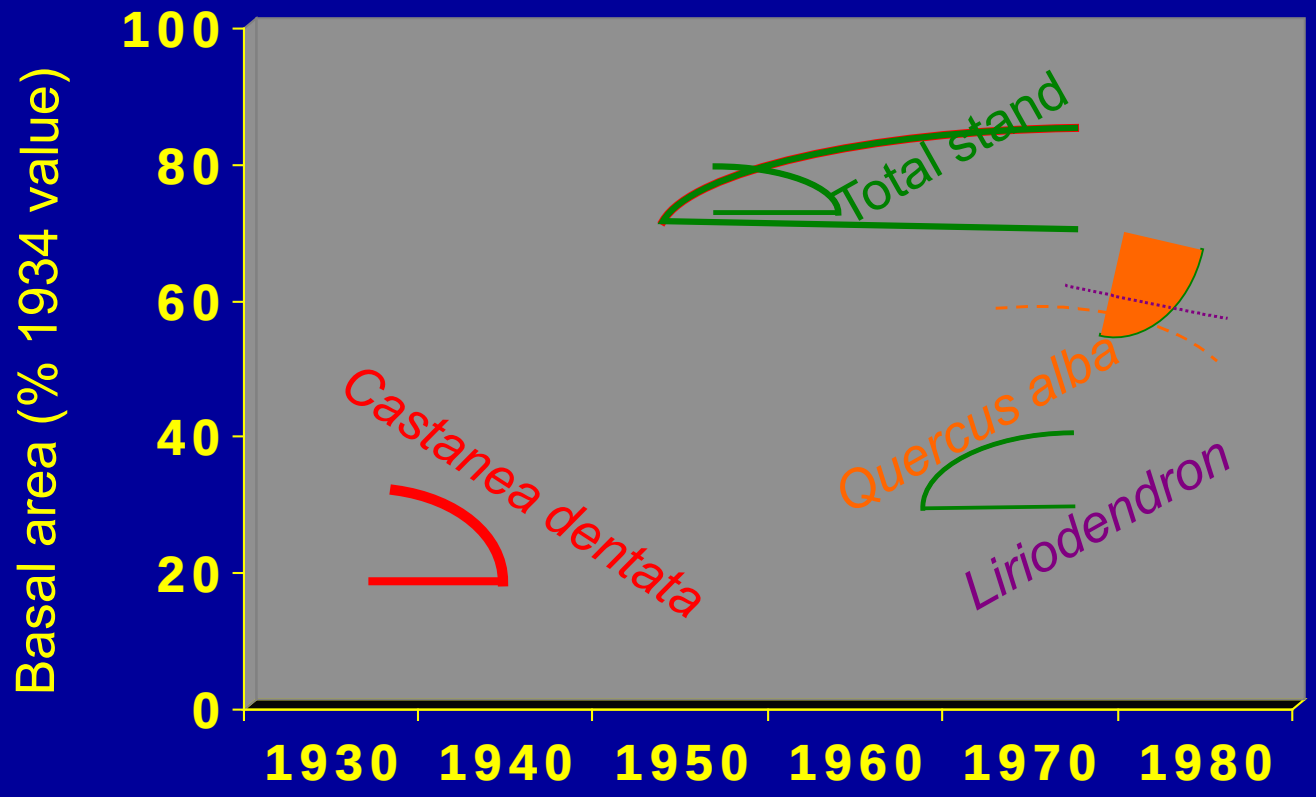
(Ayres 1991)



Reallocation of the ressources (esp. Water) within the pop. In favour of the healthy ind. Negative effect of double stress less than at the individual level

An example of long-term response of ecosystems to extreme stresses

Effects of chestnut blight (*Cryphonectria parasitica*) on a deciduous forest ecosystem (after Day & Monk 1974)



Conclusions and future prospects

Interactive effects of drought and disease favor two types of damage :

- drought-induced **diseases** (Predisposition)
- **declines** (Multiple stress effects)

In both cases, the **severity of water stress** experienced by trees is crucial

Conclusions and future prospects (2)

Considerations for management

- Measures aimed at limiting pathogen spread : seeds (*S. sapinea*), nursery plants (*Phytophthora* spp)

- Favour silvicultural practices that promote elastic responses of stands to drought(heat) stresses (*cf physiology group*), including use of inter- and intra- specific diversity

Conclusions and future prospects (3)

Future needs for research

- Heat stress effects
- Long-term effects of multiple stresses (ex :N deposition * drought * disease)
- Shifts between mutualism and parasitism : genetic and environmental control
- Population (community)-wide studies of the impact of multiple stresses (on yield and diversity) ; implications for breeding programs and sylviculture