Forest Research

Increasing global trade and climate change: co-factors increasing the international movement and establishment of forest pests

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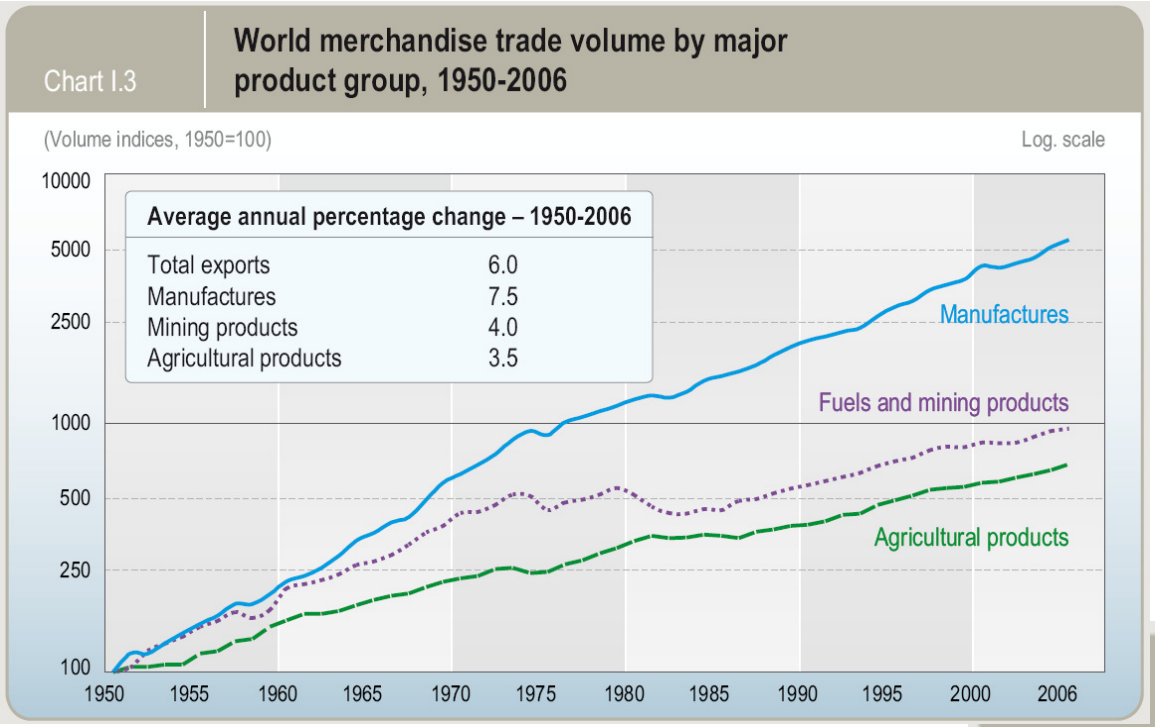
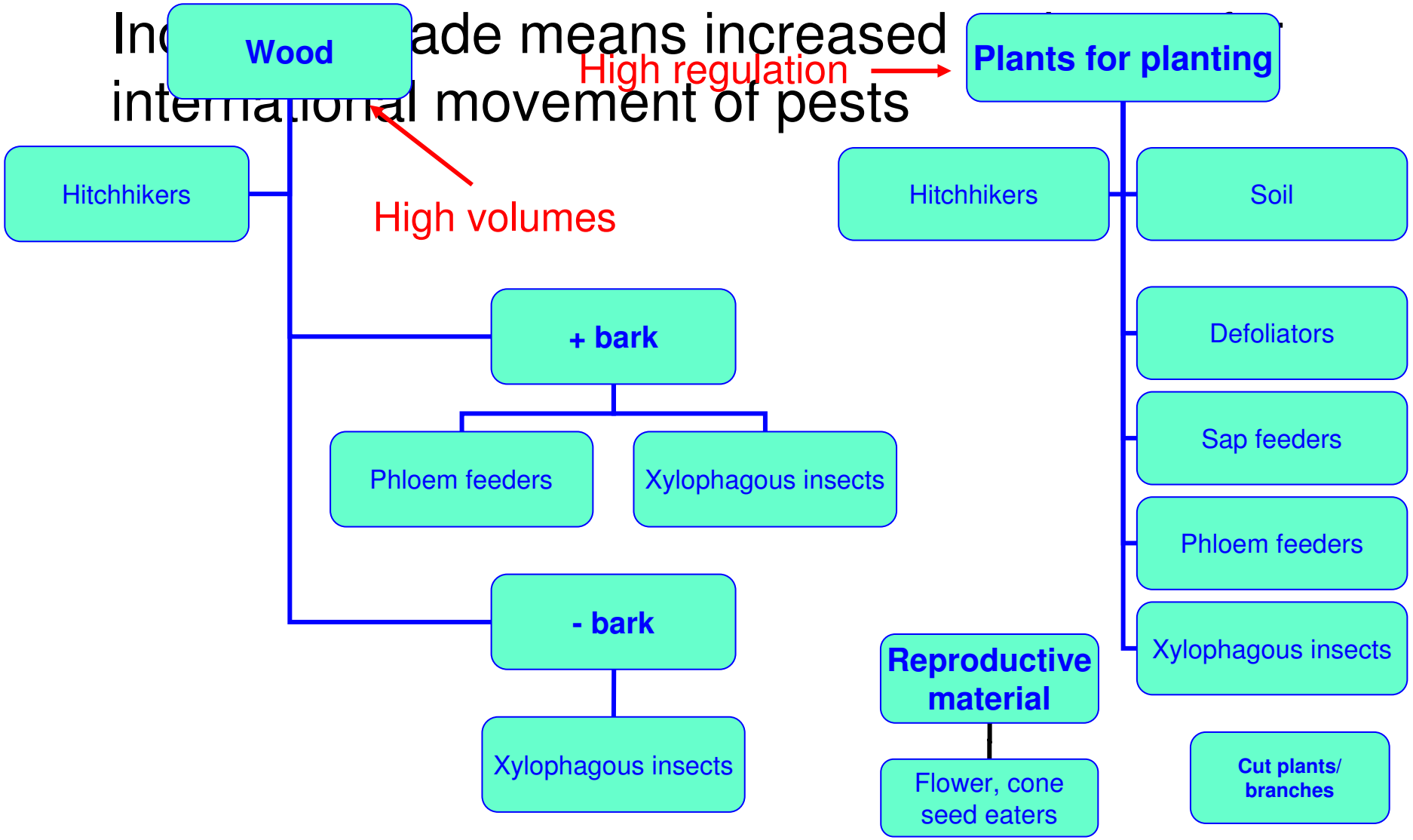
Increasing global trade: opportunities for pests to move internationally



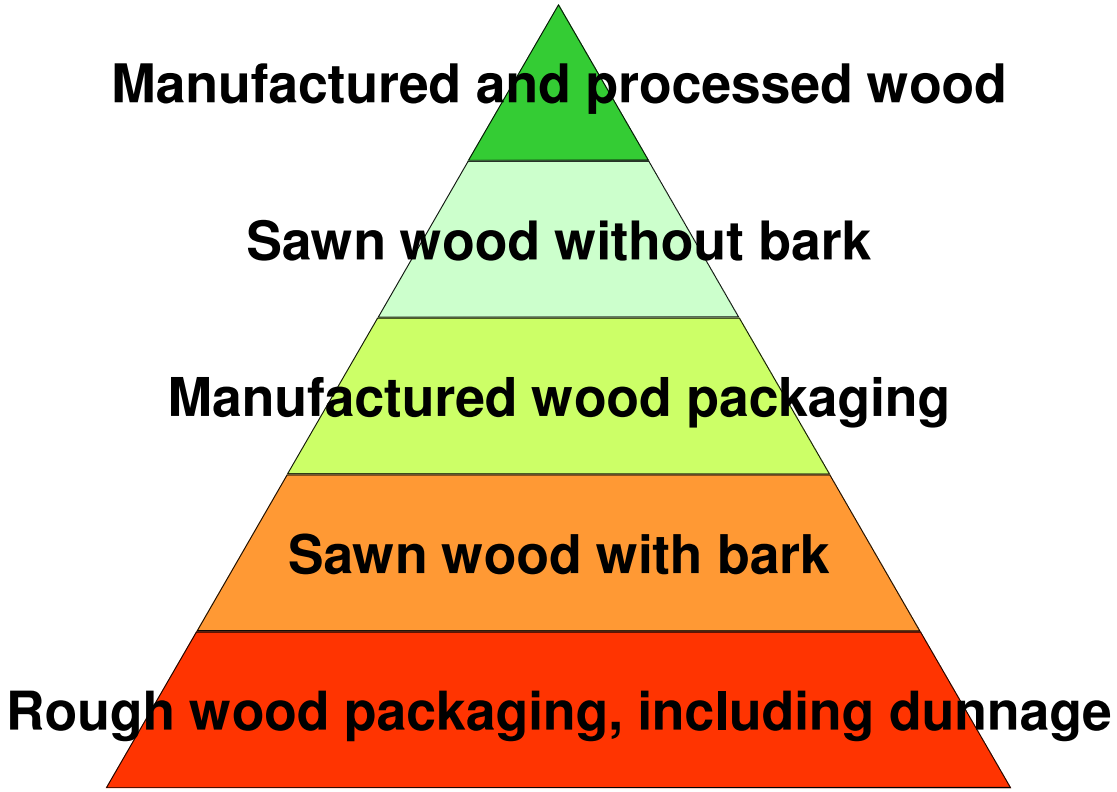
Source:
WTO International Trade Statistics, 2007

Volumes moving along pathways
World seaborne trade (total goods loaded) has increased significantly since 2000, reaching a record level of 7.1 billion tons in 2005.

Increased trade means increased international movement of pests

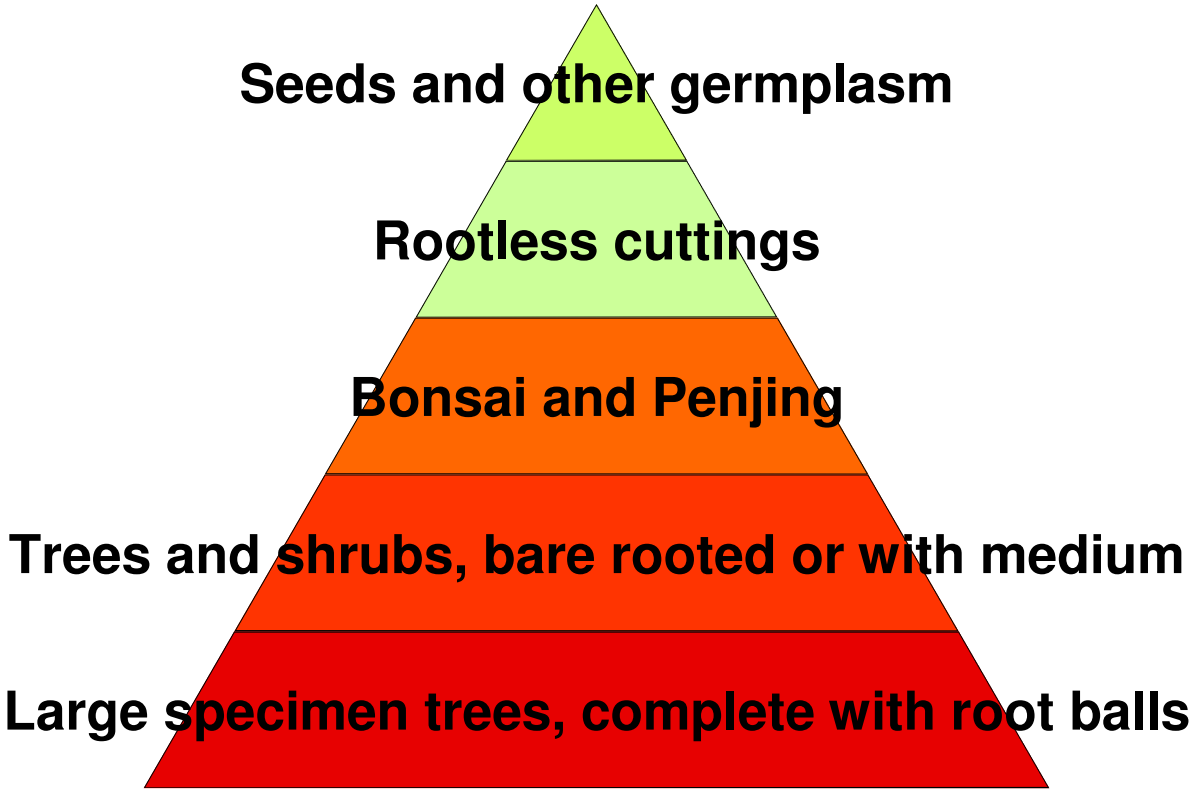


Risk profile of untreated wood



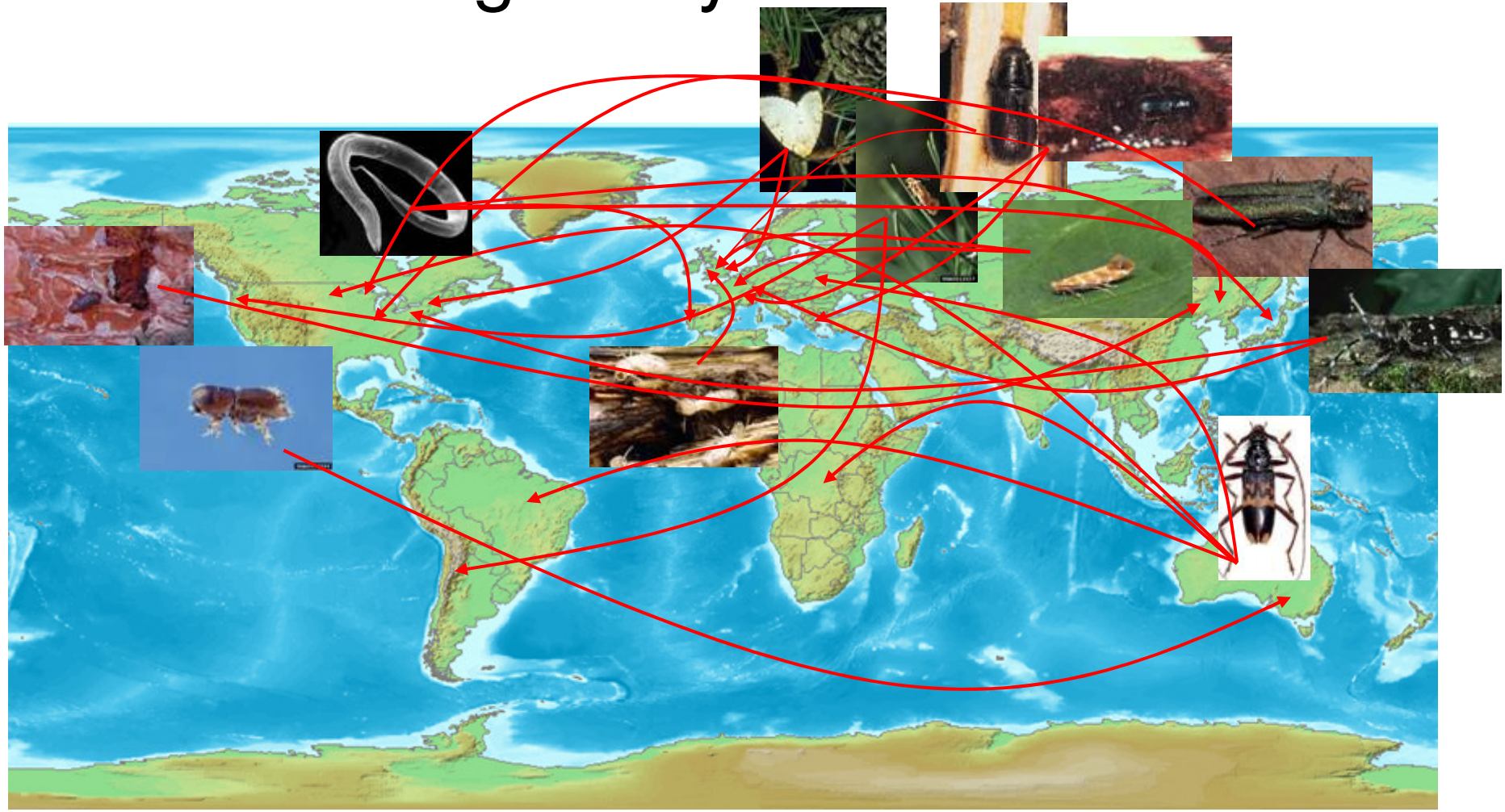
Treatments (heat, fumigation, high temperature kiln drying, etc.) remove most of the risk

Risk profile of plants for planting



Direct treatment either not efficacious or not practical with increasing size of planting material

Net result of increased trade: Pests move - globally!!!



Eco-climatic factors affecting the likelihood of pest establishment in a new zone:
a paradigm for climate change?

Suitability of ecoclimatic conditions at end of pathway

- **Climate shift** – gradual changes where the main factors are on the climate envelope boundaries. The immediate past and current scenario.

- **Climate jump** – the conditions faced when organisms arrive in new locations remote from their native ranges. A proxy for future climate scenarios?

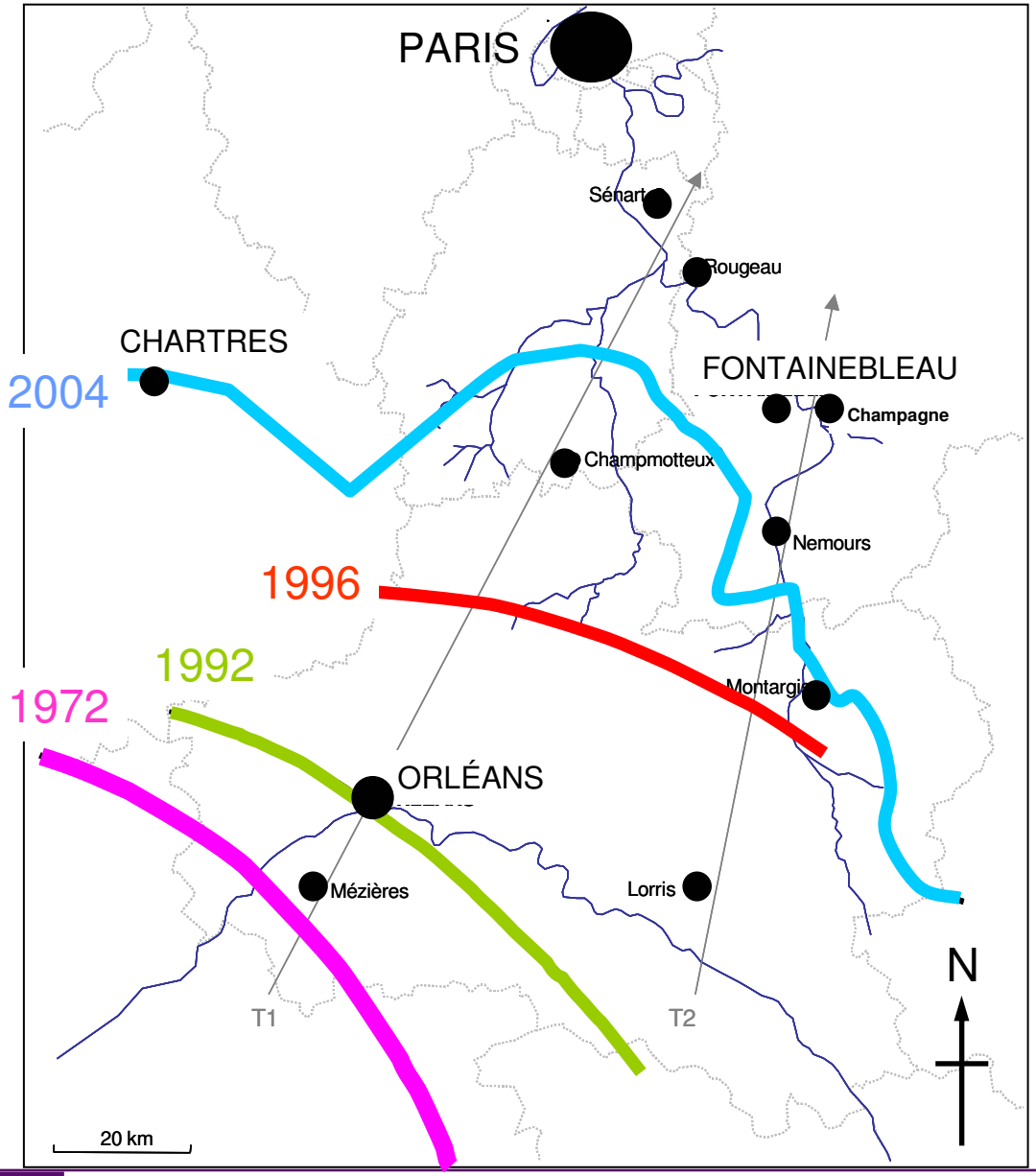
Climate Shift: a change in distribution

Pine processionary moth,
Thaumetopoea pityocampa

Important defoliator of pines in Europe. Steadily moving north.

Defoliation leads to loss of height and volume increment. Severe damage can kill young trees.

Urticating hairs on the caterpillars cause severe skin irritation, conjunctivitis and respiratory problems.



Northward spread has accelerated in recent years:

- **87 km** between 1972 and 2004
- **56 km** during the last 10 years

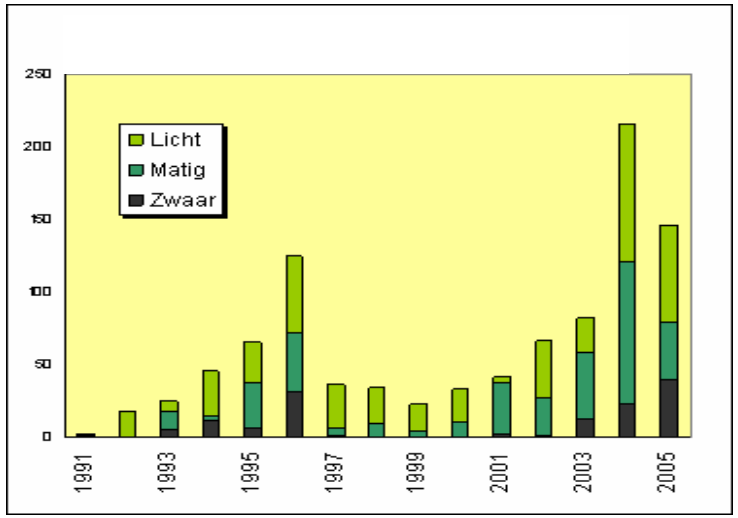
Minimum winter temperature:
+ 0.9°C in Melun
+ 1.1°C in Orléans

Information from Dr Alain Roques, INRA, France

Oak processionary moth, *Thaumetopoea processionea*

A southern & central European species that has moved north during the latter half of the 20th century.

Very damaging to oak species, with notable episodes of defoliation in the Netherlands since it arrived in early 1990s.



Global trade

Planting of large trees – a pathway for international movement of oak processionary moth and other pests

The effects of climate change on both climate shift and climate jump situations

- Range shift (gradual or jump spread) presents a new opportunity for a pest
- **But**: Interaction is at the local level and determined by the spectrum of ecological factors that affect any insect-host relationship, e.g.-
  - Synchrony
  - Pest voltinism
  - Tree defences
  - Interactions with natural enemies
  - A range of climate related mortality factors – rainfall, wind, insolation, etc.

Synchrony of pest and host development - critical survival factors in relation to climatic variables

Overwintering develop-mental stage	Winter (dormancy)	Transition →	Spring (early activity)	Summer (peak activity)	Transition →	Autumn (reduced activity, early dormancy)
	Key factors controlling population					
	Likelihood of surviving winter cold	Synchrony with host tree development	Temperature dependency of development and number of generations		Synchrony of dormancy with host tree	Choice of dormancy site. Risks from early frosts
Egg	**Egg** Frost tolerance, survival.	*ing of bud burst determines suitability of ipposition and feeding sites. Strong link to utritional and defensive status of foliage. Likelihood of mortality from late frosts*	**Egg** Hatch date; early survival.	**Larva** Peak growth rate. Duration of stage. **Pupa** Timing of pupation and duration of stage. **Adult** Timing of emergence, duration and rate of oviposition. Effects on realised fecundity.	*Leaf fall or dormancy. Links to declining nutritional suitability, loss of foliage deciduous) and likelihood of early frosts.*	**Adult** End of stage and of oviposition. **Egg** Hardiness (chorion, possible protective mechanisms)

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Leaf fall or dormancy. Links to declining nutritional suitability, loss of foliage (deciduous) and likelihood of early frosts.

An example commencing with the egg stage: winter moth, *Operophtera brumata*

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	Winter moth on oak and, new association, on Sitka spruce **Adults from late autumn through early winter (hence the common name)** **Eggs laid in Nov-Dec and are frost tolerant**	**Sitka spruce: Egg hatch advanced** **Oak: Bud burst not advanced = synchr** **= asynchrony** **Non-co-evolved, detrimental to pest**		**Larva** Peak growth rate. Duration of stage. **Pupa** Timing of pupation and duration of stage. **Adult** Timing of emergence, duration and rate of oviposition. Effects on realised fecundity.		**Adult** End of stage and of oviposition. **Egg** Hardiness (chorion, possible protective mechanisms)

IPCC predictions for climate change in the UK
*(Broadmeadow, et al. Forestry, 2005, **78**, 145-161)*

By the year 2050 -

- mean summer temperatures increase by 1.2-3.7^{o}C
- mean winter temperatures increase by 0.9-1.9^{o}C
- less rainfall during summer, especially SE England
- up to 9% more rainfall in winter, particularly in the north & west of the country
- significant reduction in the number of frost days

Changes in climate will have direct effects on pathogens & invertebrate pests

Spring & summer temperatures - influence development rates; timing of bud burst *versus* egg hatch of defoliating moths; flight & dispersal

Winter temperatures - over-winter survival, dormancy

Rainfall & wind - mortality; dispersal & fecundity during insect flight periods; dispersal of pathogen inoculum

- but climate change will also have direct effects on trees making them more or less suitable as host plants.

- and will influence populations of predators, parasites & other natural enemies.

… therefore, overall effect very difficult to predict!

Conclusions

- Although climate change presents a global challenge, the influence on pest infestations is spatially and temporally constrained – exemplified by gradual climate shift effects on range and severity of pests in their native ranges
- Increased global trade, however, presents increased opportunity both for pest establishment and for learning about climate jump effects – the future happening now.