Implementing quantitative pest risk analyses in planted forest: the case study of the pine processionary moth

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INTRODUCTION

→ **Climate change** and increase in **global trade** trigger new forest risks, especially biotic risks

- Higher intensity and frequency of pest outbreaks, expansion of their natural range
- Increasing introduction and establishment of invasive species

⇒ **Raise concern for forest health & need to better evaluate risk in this changing world**

INTRODUCTION

Risk = Hazard X Vulnerability X Impact

Cause of damage (windstorm, pest insect)

Susceptibility of tree or stand to hazard

Values at stake = socioeconomic impact of damage

→ To make a risk analysis we need to combine information about

- **the likelihood of hazard (spatiotemporal dynamics of pest population)**
- **the level of tree/stand resistance to hazard**
- **the cost of damage**

→ However such comprehensive risk analysis are rarely made due to a lack of knowledge or data

INTRODUCTION

→**Pine processionary moth (PPM) on maritime pine in South-West France** as an example

- PPM is the main **pine defoliator** in the mediterranean Basin (including SW France).

  Frequent defoliations (cyclic epidemics) are causing significant growth reduction (Jacquet J.-S., 2012), and **then economic losses** thus questioning the relevance of pesticide application (Gatto et al., 2008)

- **Well-studied insect** (more than 30 years of research)

- **Long-term monitored insect** by the Forest Health Department (since 1980)

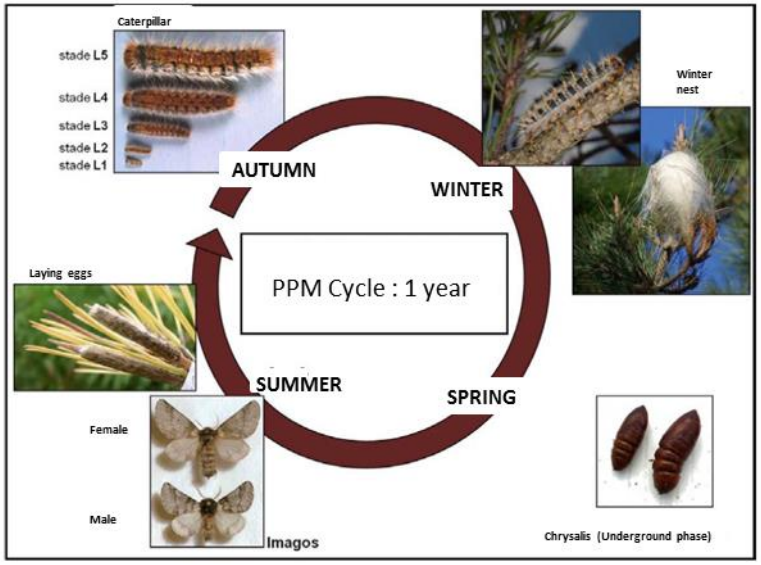


Figure by A-M. Dulaurent, 2010

Photo By I. Van Halder

Relevant case study for full risk analysis

Step by step risk analysis for PPM

Hazard X **Vulnerability** X **Impact**

Based on past outbreaks records

Patterns of individual tree and stand level PPM infestation

Relationship between PPM defoliation and tree growth loss

PPM temporal occurrence

Hazard X Vulnerability X Impact

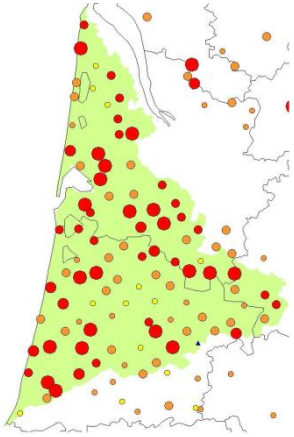
Based on past outbreaks records

Patterns of individual tree and stand level PPM infestation

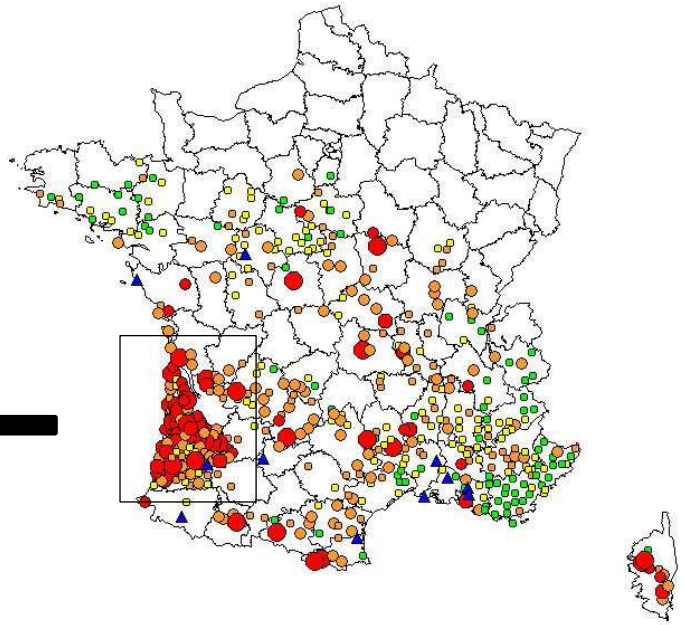
Relationship between PPM defoliation and tree growth loss

PPM temporal occurrence

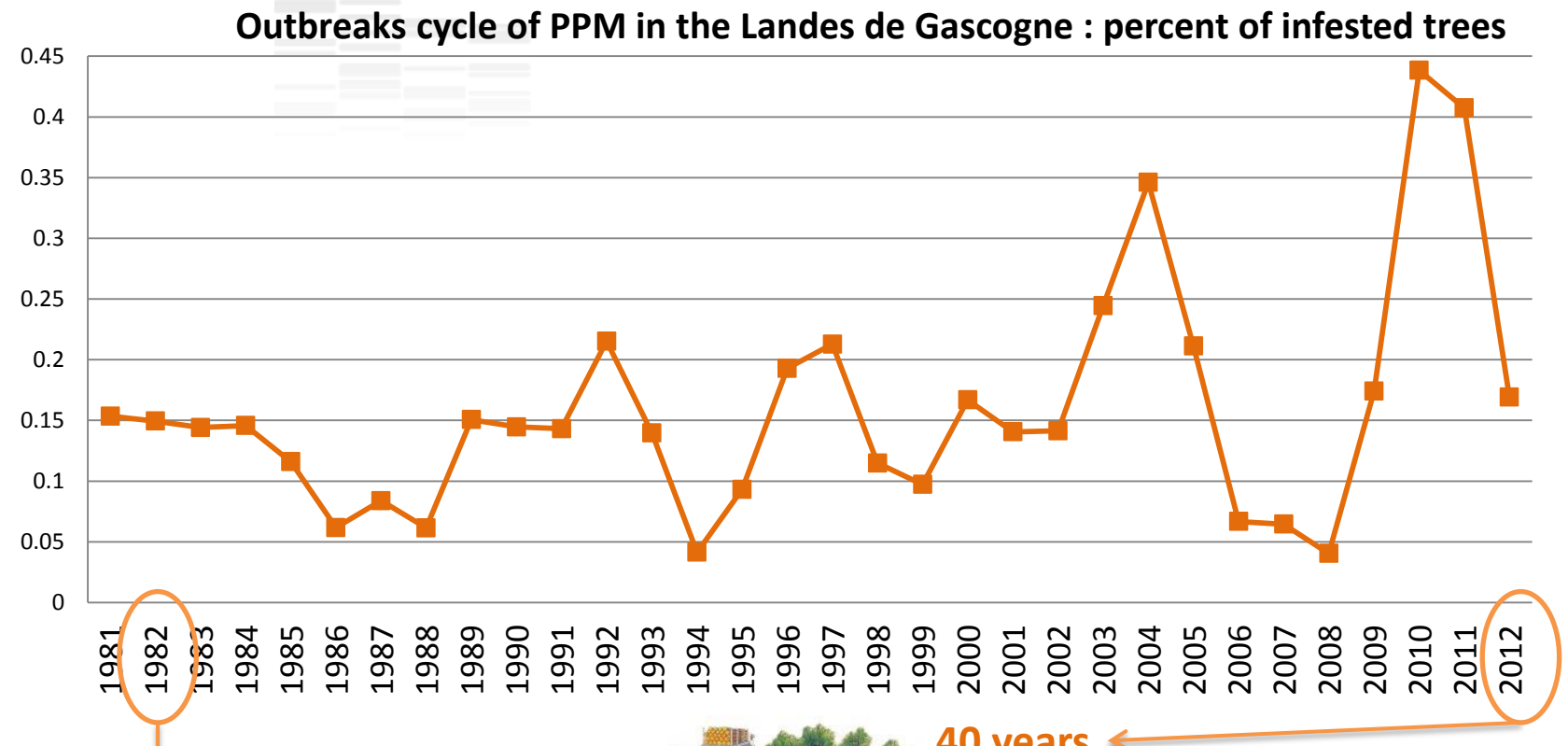
The temporal occurrence of PPM has been monitored for **the last 30 years** by the Forest Health Department using standardized protocol in permanent plots.



South-Western France

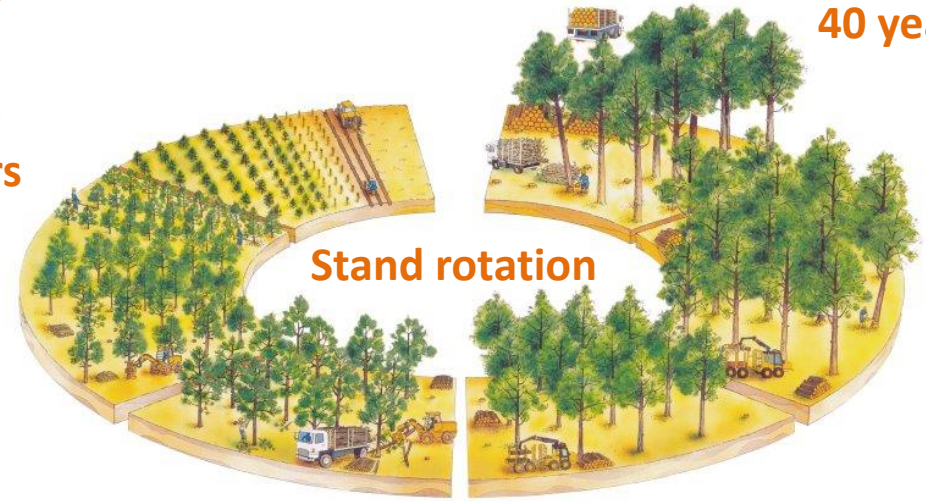


PPM temporal occurrence



40 years

10 years



PPM hazard : maritime pine trees can experience at least 5 PPM outbreaks before the final harvesting

Probability of pines to be infested by PPM

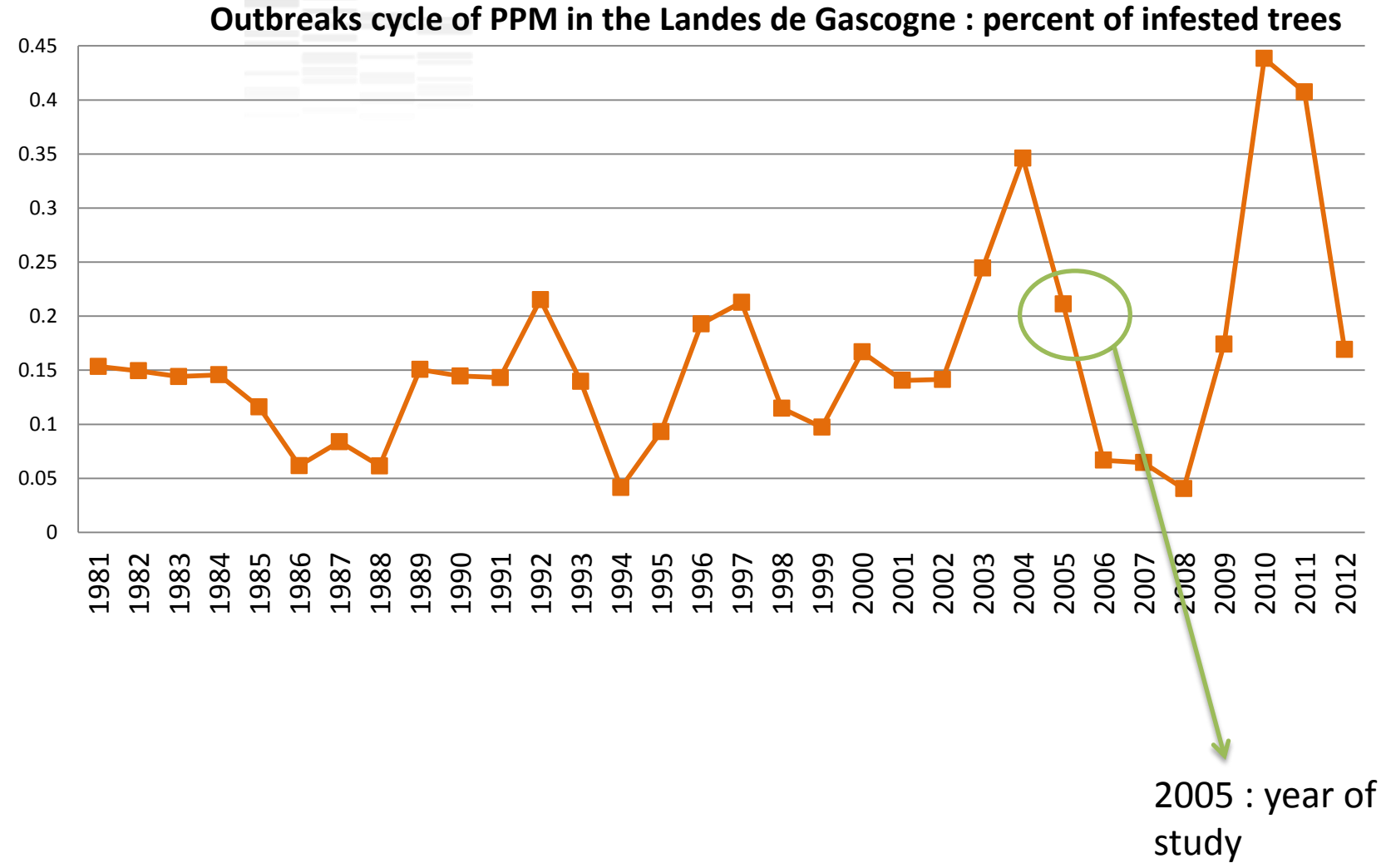
Hazard X Vulnerability X Impact

Based on past outbreaks records

Patterns of individual tree and stand level PPM infestation

Relationship between PPM defoliation and tree growth loss

Probability of pines to be infested by PPM

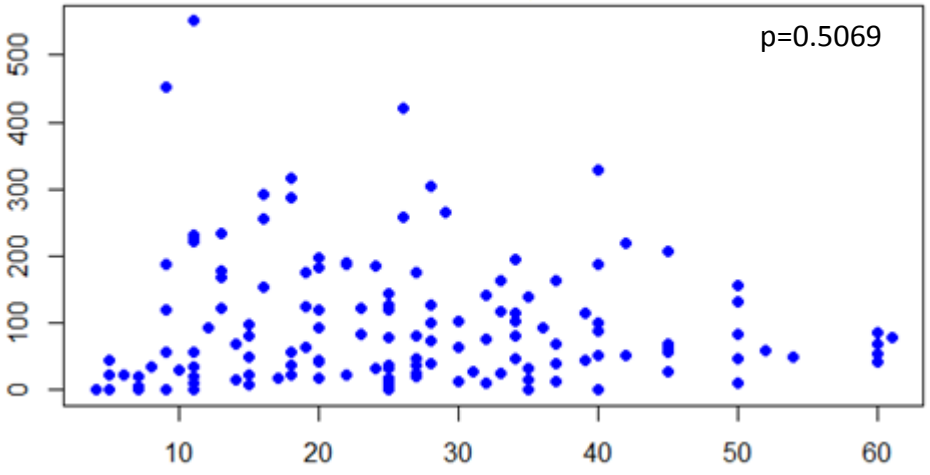


2005 : year of our study

Probability of pines to be infested by PPM

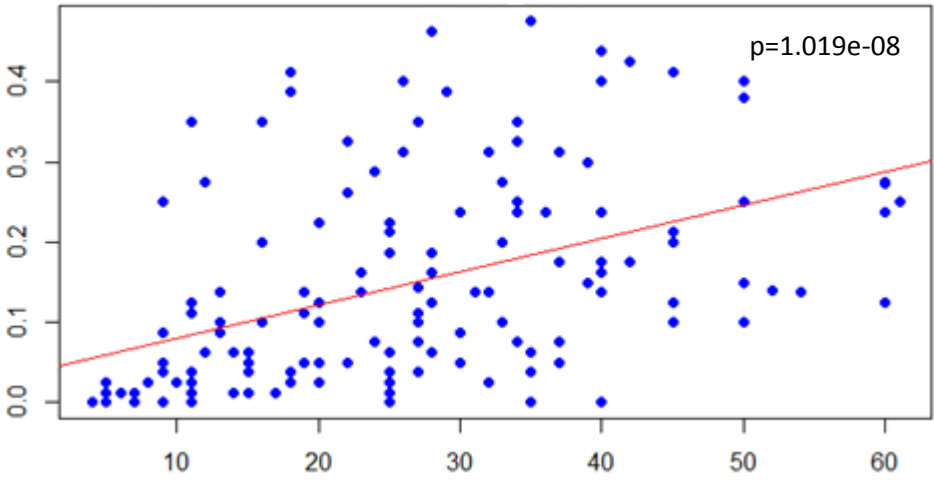
→Age

PPM population density = number of nests.ha-1



Stand age in 2005

Percentage of infested trees



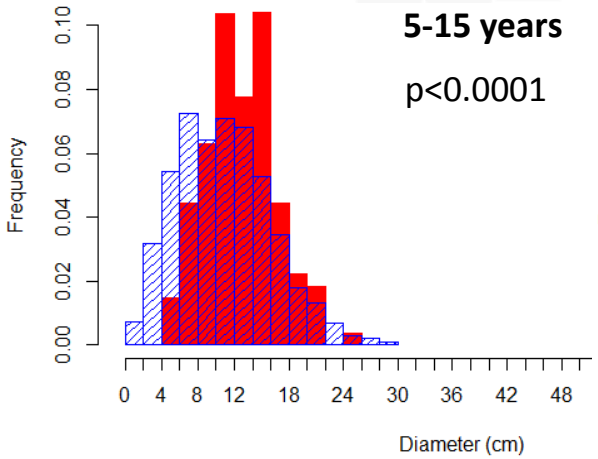
Stand age in 2005

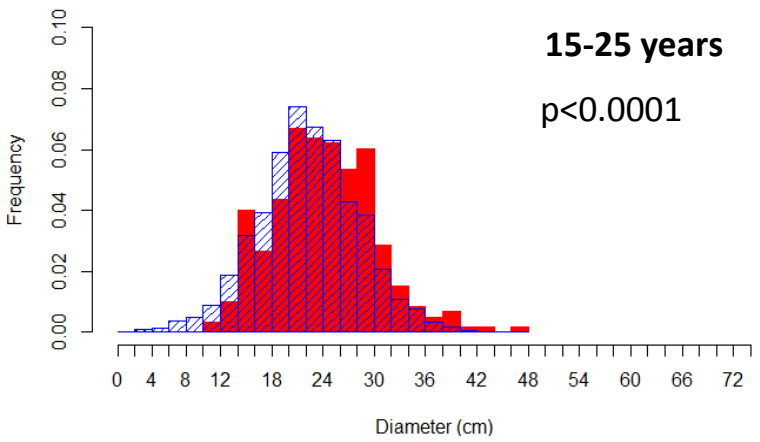
Population density remains constant irrespective of stand age.
Percentage of infested trees increases with stand age due to lower tree density in older stands

Probability of pines to be infested by PPM

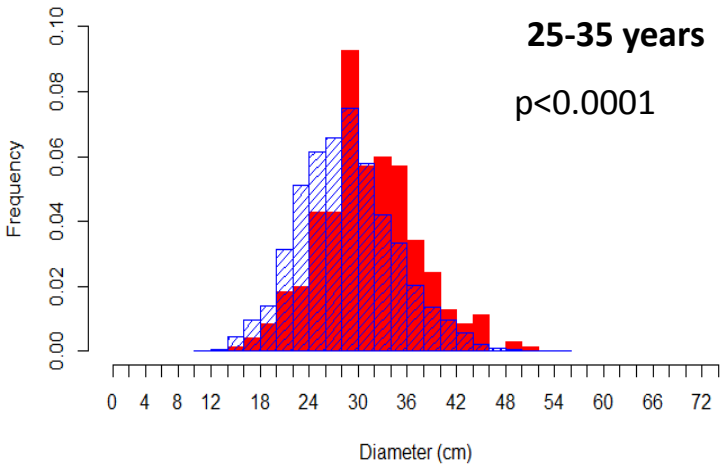
→ Age X Size

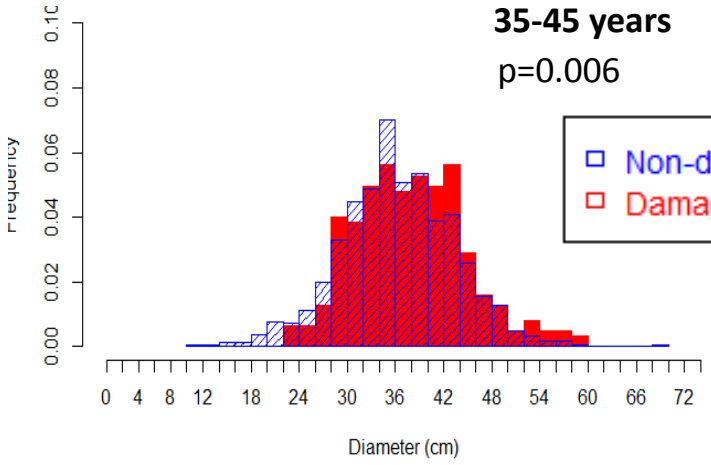
(data from thesis : J.-C. Samalens, 2009 and A.-M. Dulaurent, 2010)





Frequency distribution of tree diameters for infested vs. non-infested maritime pine trees by PPM for 4 classes of stand age (Kolmogorov Smirnov test)





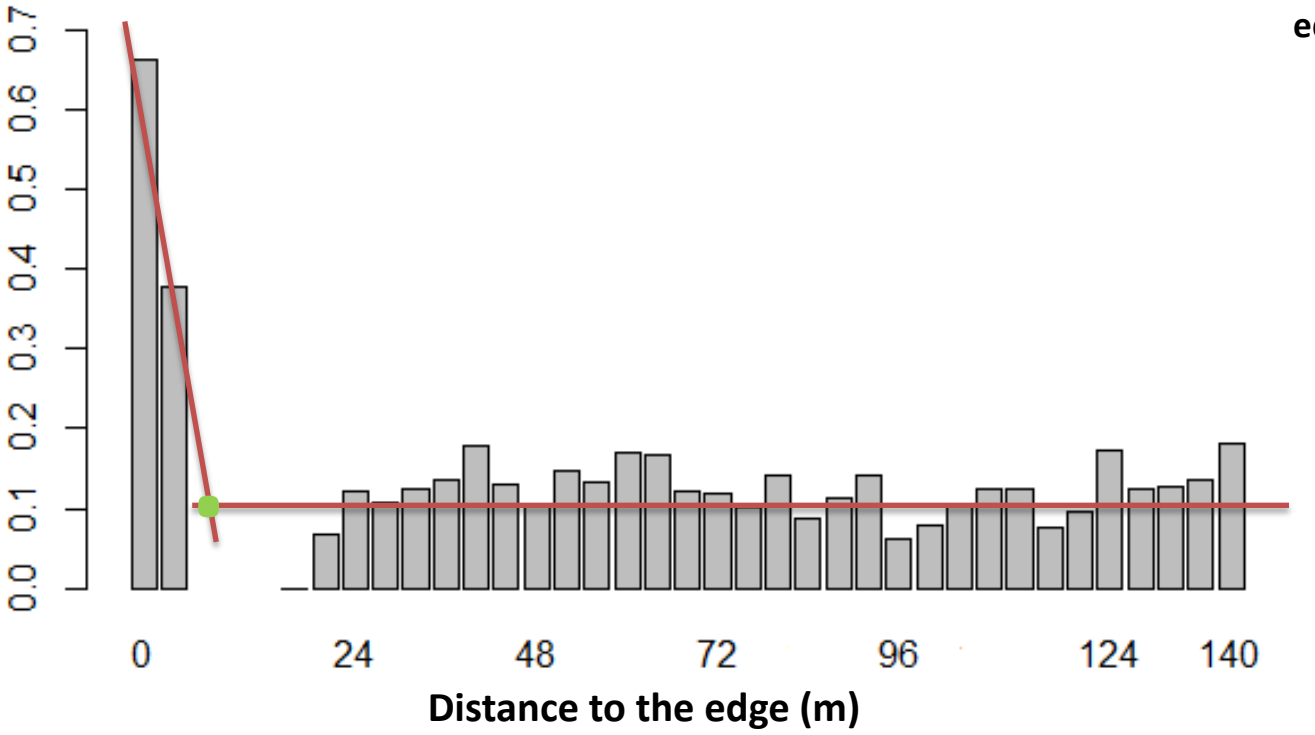
Non-damaged trees (no nest)
Damaged trees (at least one nest)

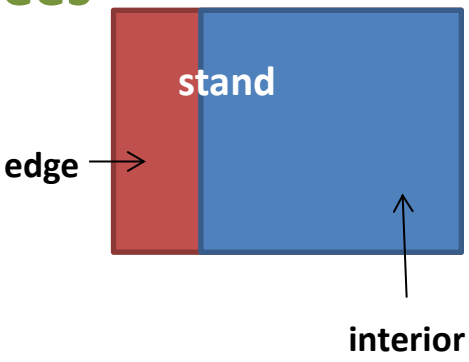
Taller trees are more likely to be infested by PPM regardless of their age

Probability of pines to be infested by PPM

→ Tree location in the stand : edge vs. interior trees

Average number of nests per tree depending on tree distance to the edge



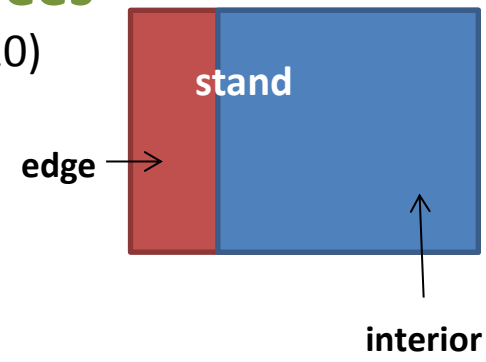


Breakpoint =7.55 ± 0.55m demonstrating an edge effect ending after the 2nd row

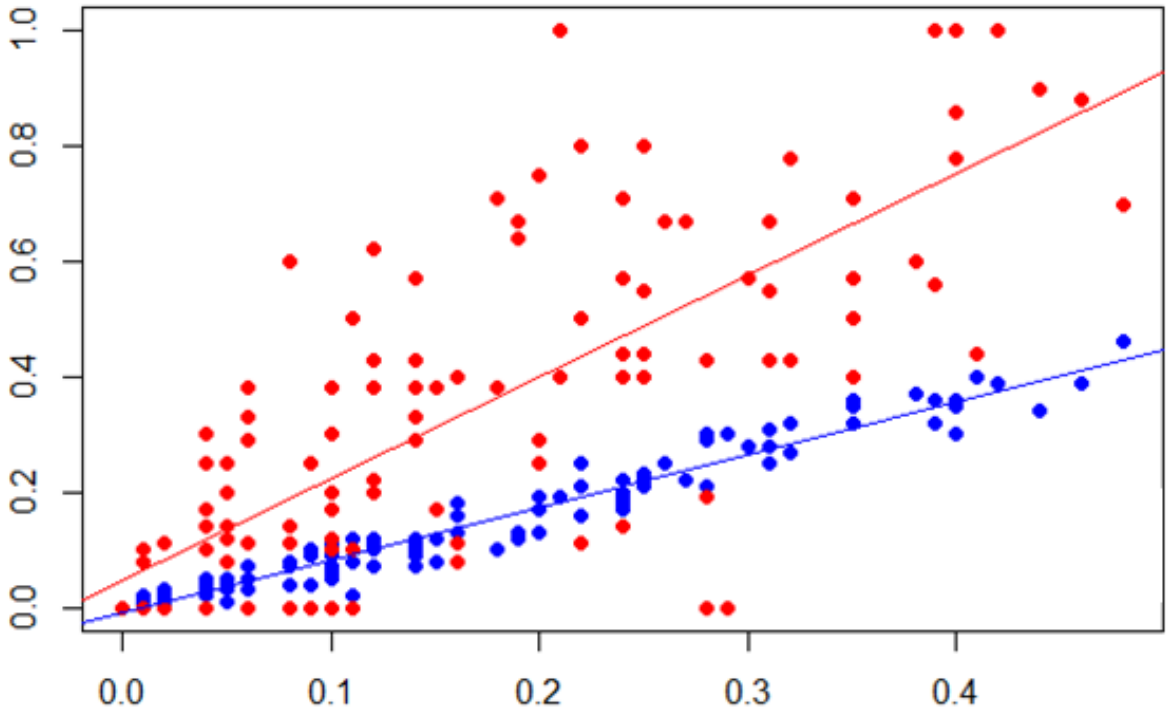
Probability of pines to be infested by PPM

→Tree location in the stand : edge vs. interior trees

(data from thesis : J.-C. Samalens, 2009 and A.-M. Dulaurent, 2010)



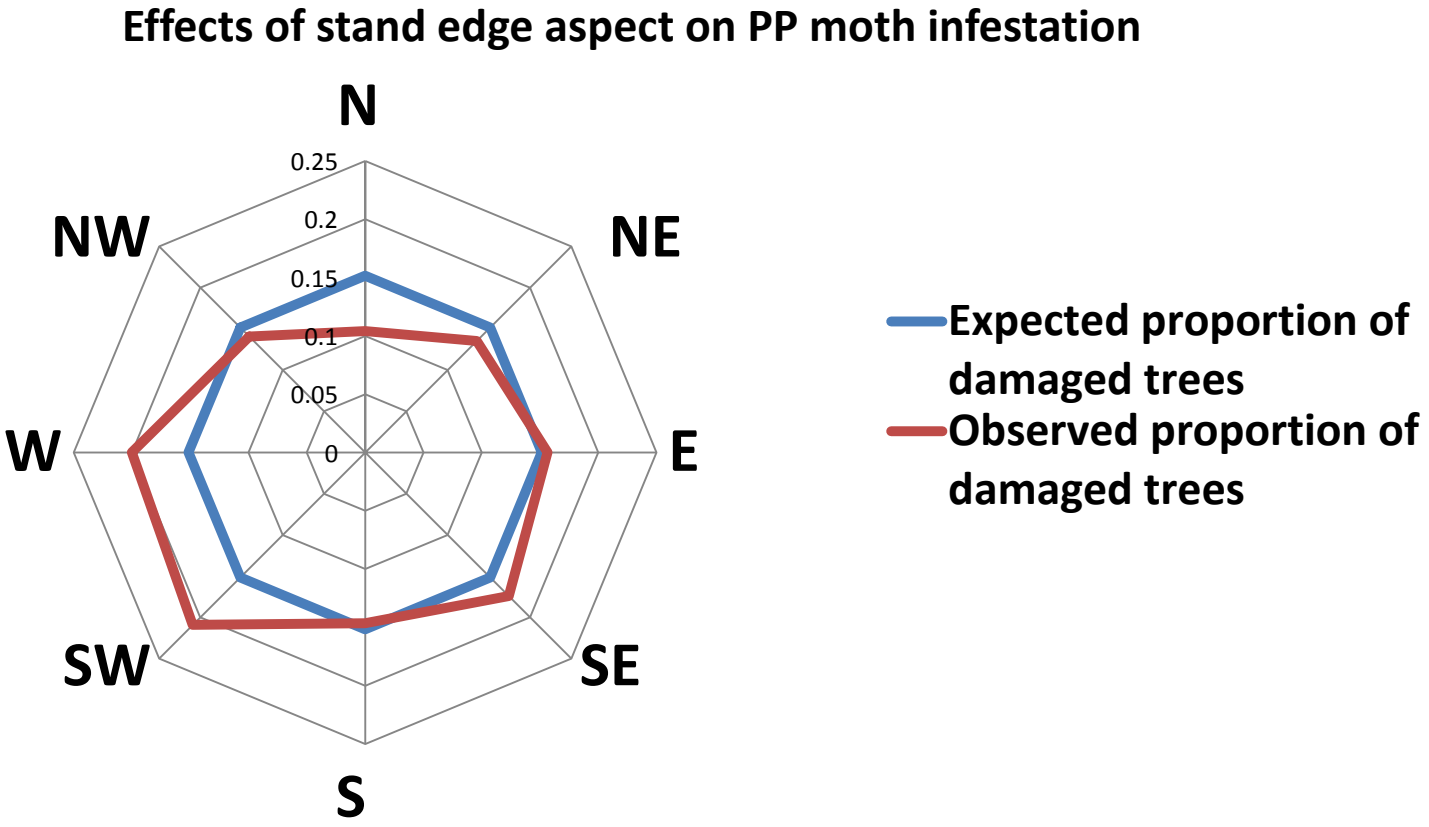
Relationship between mean stand percent of infested trees and interior and edge percent of infested trees



Probability of pines to be infested by PPM

→Tree location in the stand : edge aspect

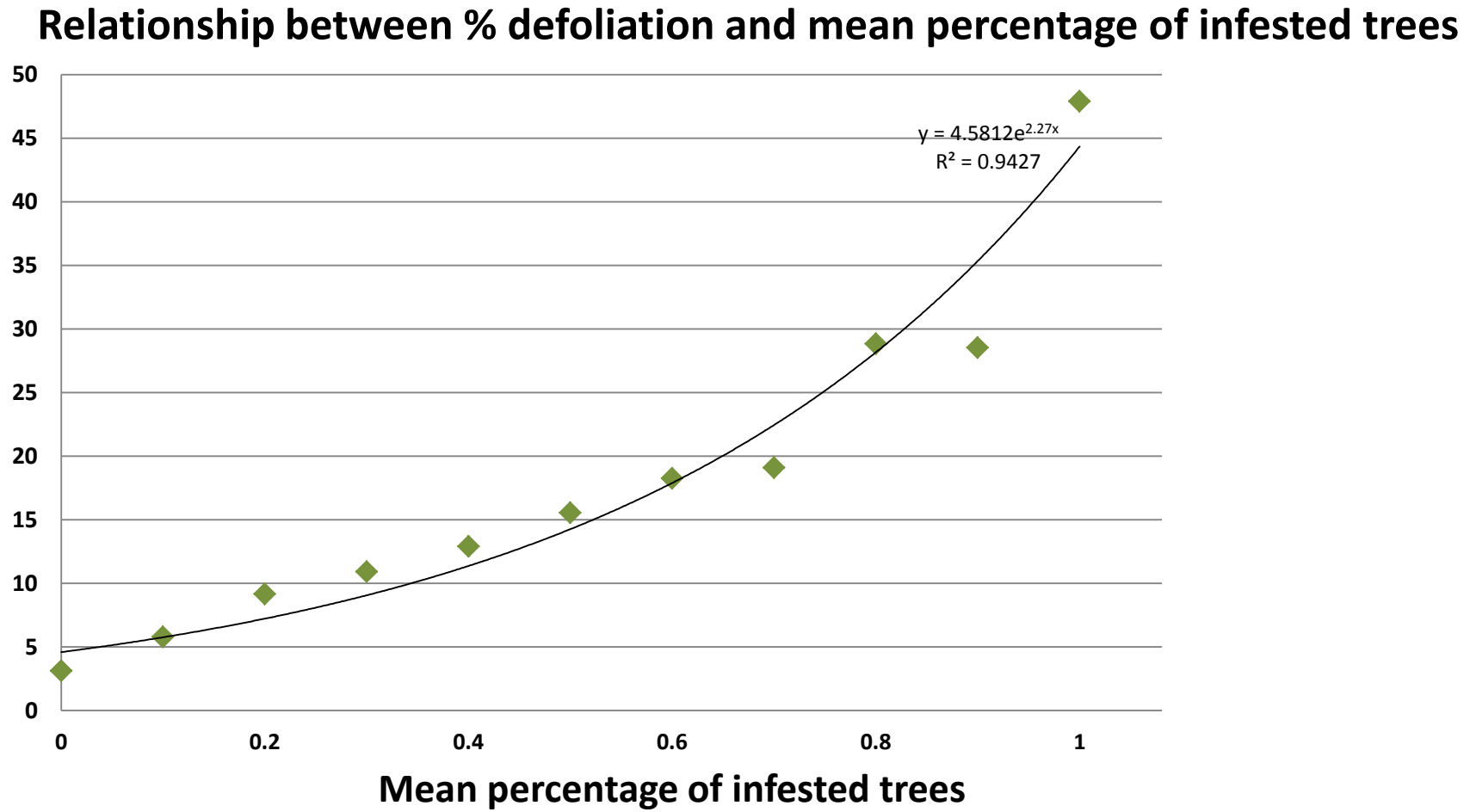
(data from thesis : J.-C. Samalens, 2009 and A.-M. Dulaurent, 2010)



Stands facing West and South-West are significantly more infested

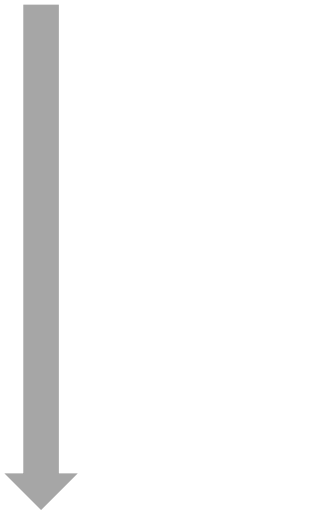
Probability of pines to be infested by PPM

→Relationship between **infestation** and **defoliation**



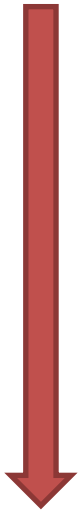
Impact resulting from PPM defoliation

Hazard X Vulnerability X Impact



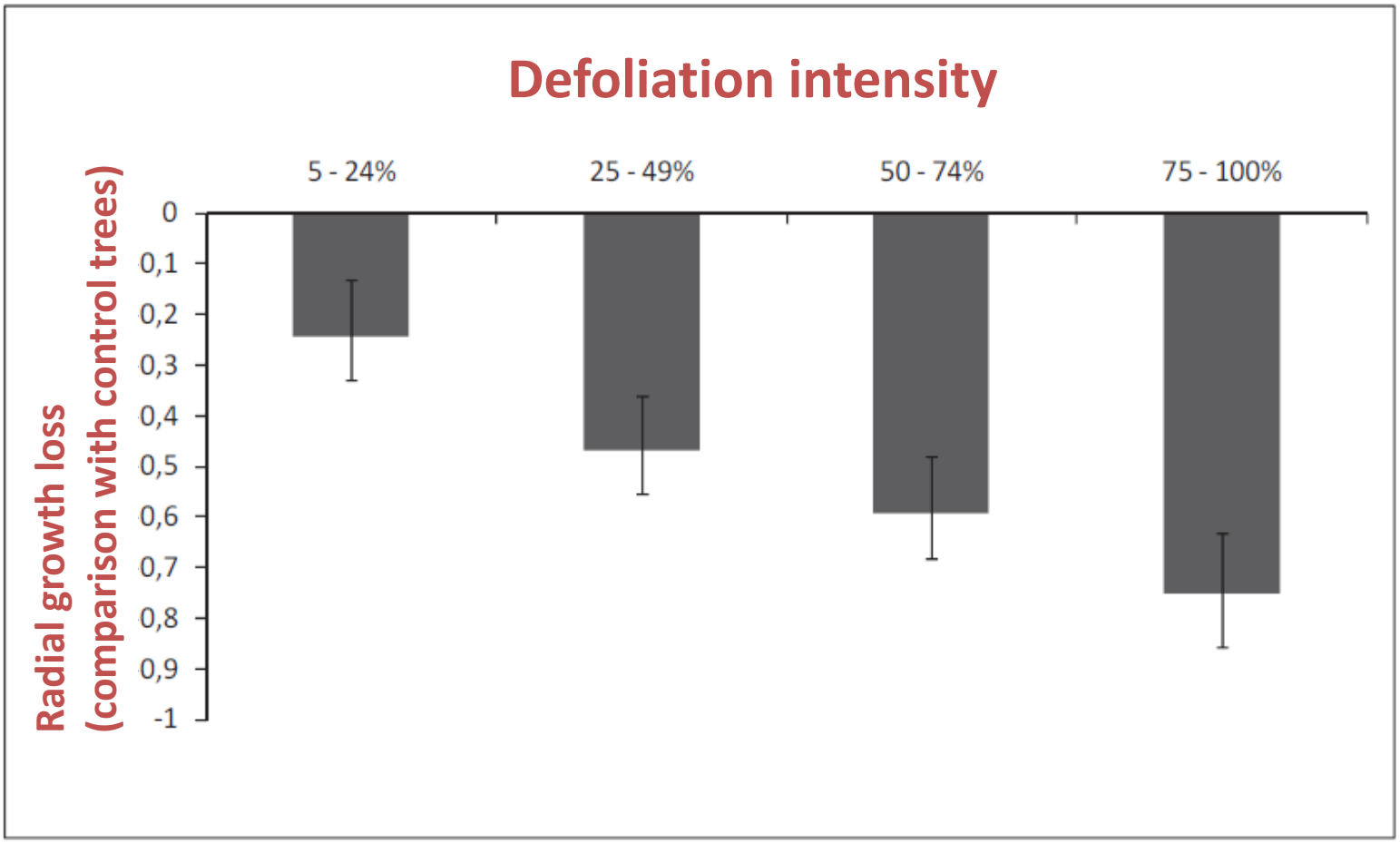
Based on past outbreaks records

Patterns of individual tree and stand level PPM infestation



Relationship between PPM defoliation and tree growth loss

Impact resulting from PPM defoliation



PPM impact : Tree growth loss increases linearly with increasing defoliation intensity

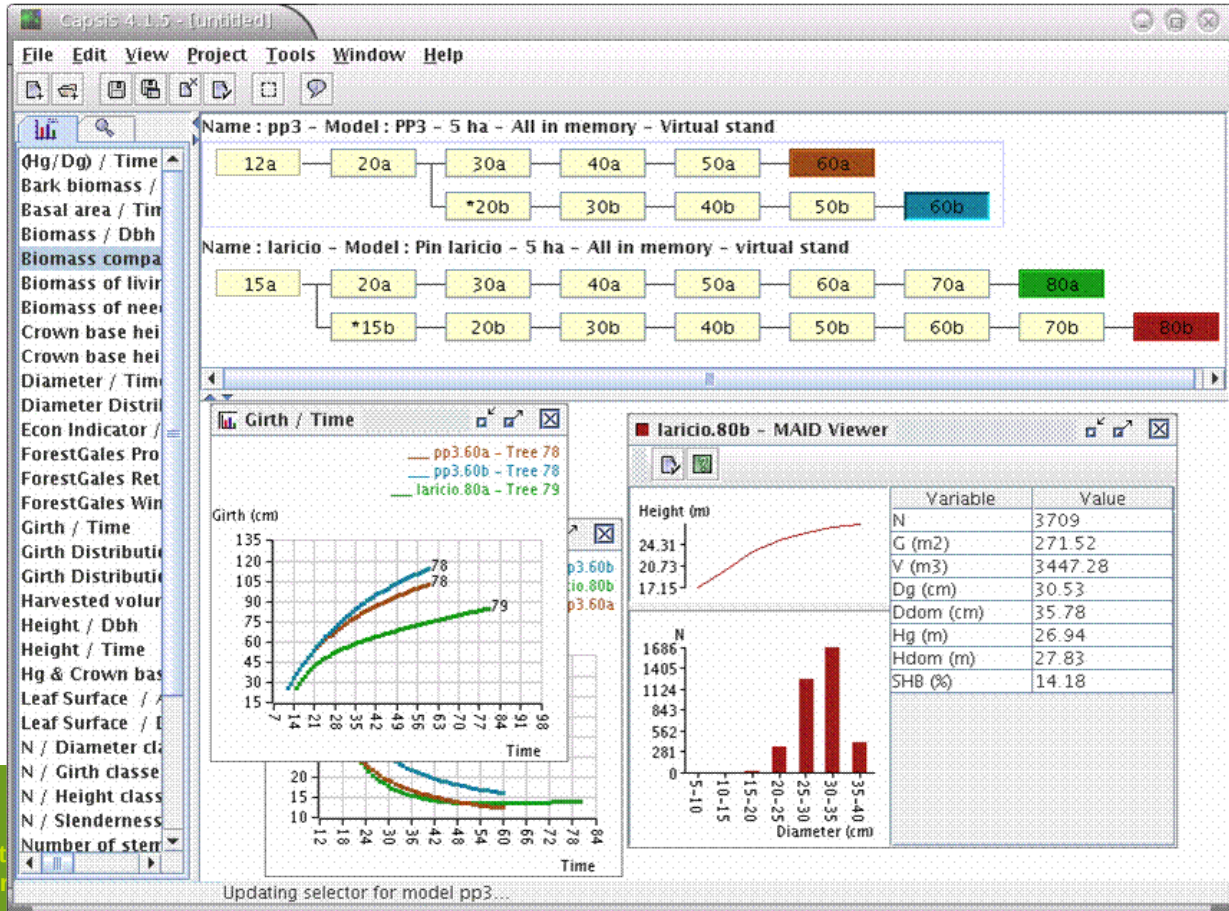
Meta-analysis of defoliation intensity resulting from Thaumetopoea pityocampa *on maritime pine growth loss (Figure by J.-S. Jacquet, 2012)*

Data integration : PP3

→ To summarize, the probability of a tree to be more or less defoliated depends on : **tree age, tree size, location in the stand** and **stand aspect.**

→ We need to integrate this information in an **individual-centered tree growth model**.

→ **PP3 is an empirical individual-centered tree growth model** available for monospecific and even-aged stands of maritime pine of South-West France

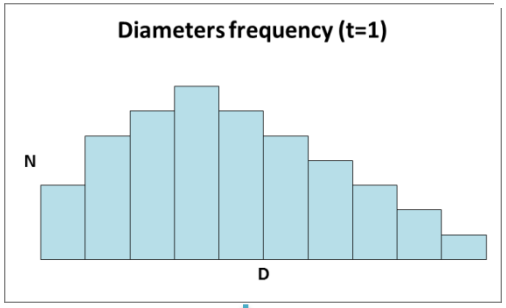


Data integration : PP3

t=1

Theoretical (or real) initial stand

Initial stand: Age≥7 years, density, G, Hdom



PP3→ Empirical tree growth model for Maritime pine calibrated on undammaged, healthy stand and trees

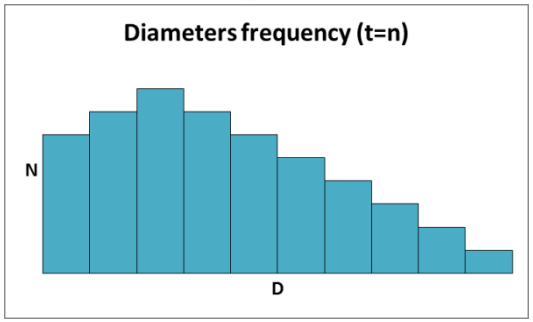
Dyear2=Dyear1+ΔDt

Silvicultural practices : thinnings

Final stand: density, G, Hdom

t=n

Theoretical final stand



Data integration : Capsis- PP3

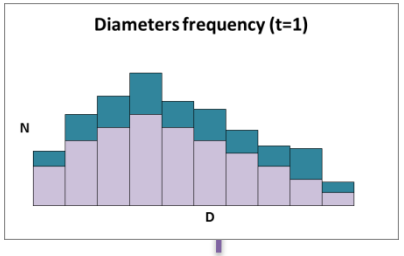
t=1

Theoretical (or real) initial stand

Initial stand: Age≥7 years, density, G, Hdom

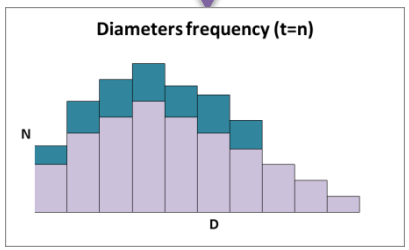
Edge: yes-no→ Edge depth
Aspect : N, S, E, W…

7-year cycles of PPM infestations : % of infested tree, defoliation for each year



Dyear2=Dyear1+ΔDt

Dyear2=Dyear1+ΔDt – growth loss



t=n

Initial edge part

Initial interior part

Higher level of infestation

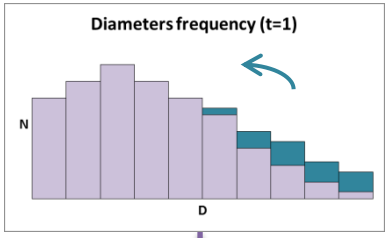
Bigger trees infested in priority

Silvicultural practices : thinnings

Final edge

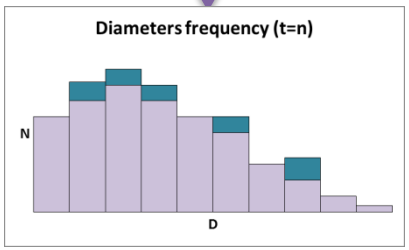
Final interior

Final stand: density, G, Hdom



Dyear2=Dyear1+ΔDt

Dyear2=Dyear1+ΔDt – growth loss



Final stand : exposed to PPM defoliation

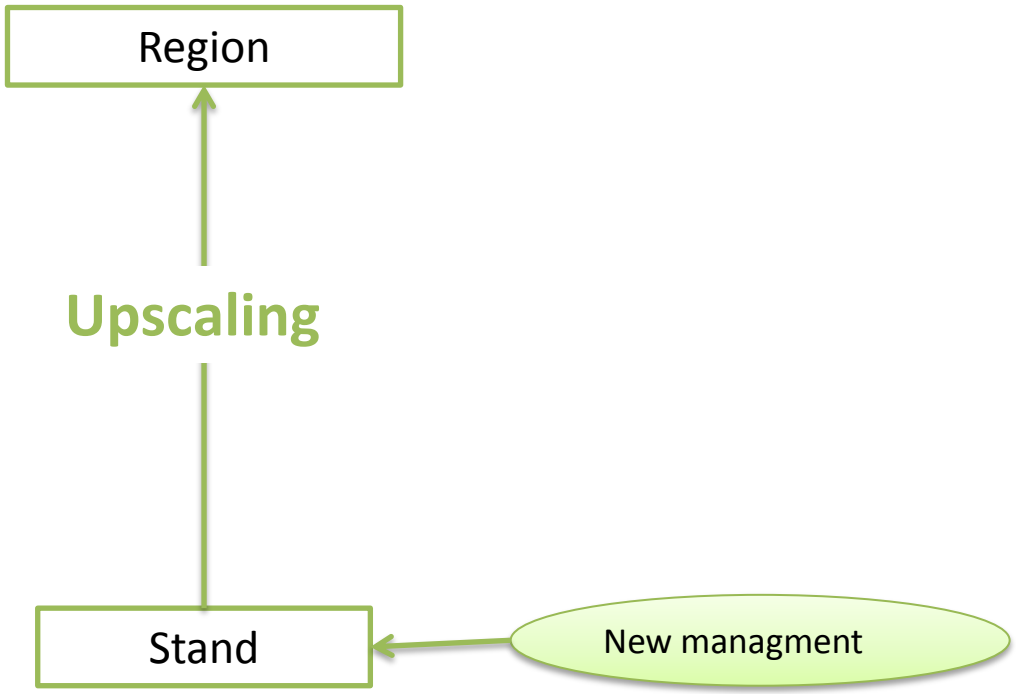
Conclusion

Full risk analysis ← Tree growth model ← Pest population dynamics; Stand susceptibility to pest; Tree response to pest damage

Prospects

Use the modeling tool to perform risk analyses for two important issues:

- The effect of new planted forest management strategies
- Assessement of risk at the regional level

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Thank you !