Predicting the spore infection depending on climate to model the *Heterobasidion annosum* dynamics in even-aged *Pinus pinaster* stands: results from FORRISK Project

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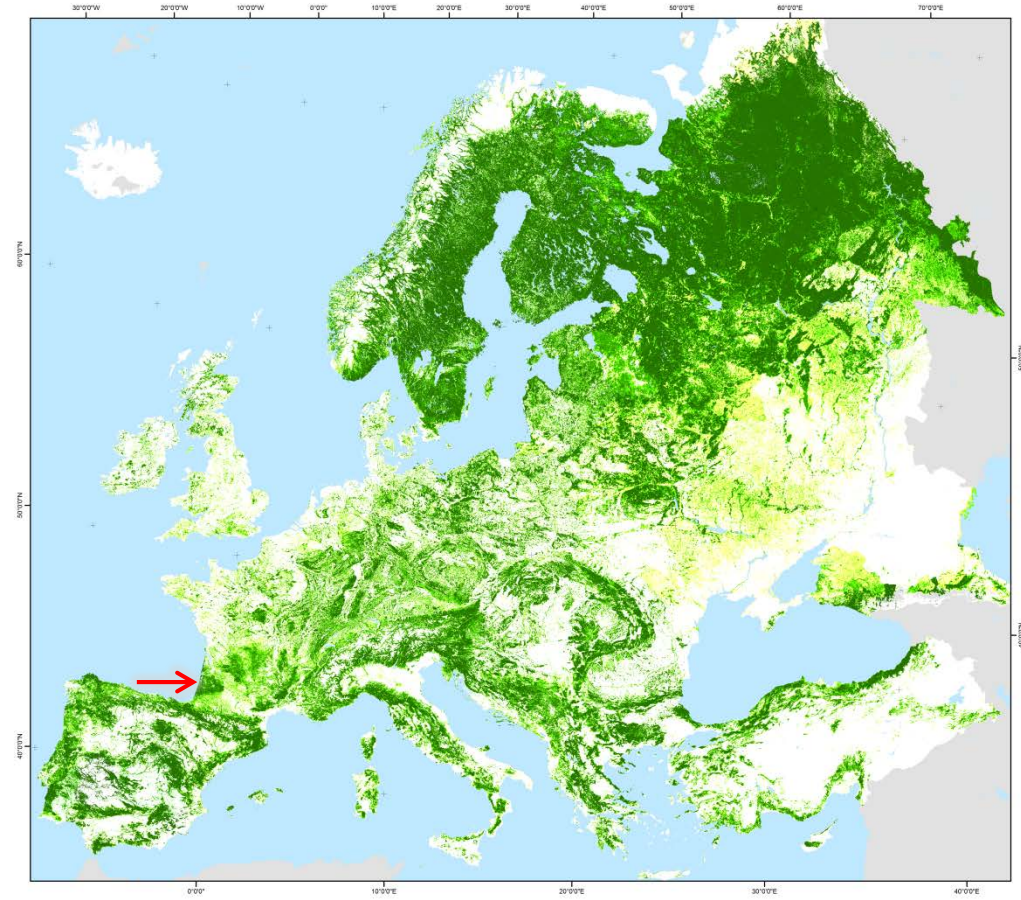
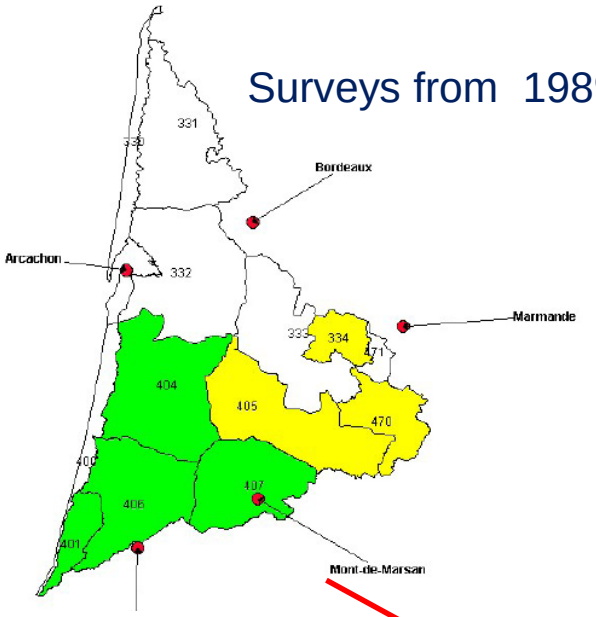
INTRODUCTION

→South-Western France : maritime pine planted forest

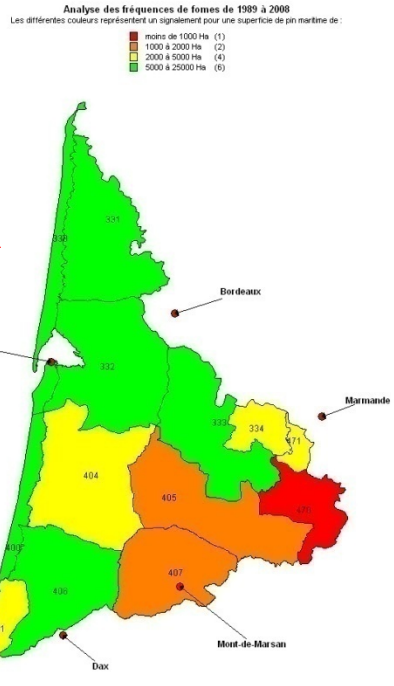


Forêt Landes, ©Pierre Boisselet

Introduction: Heterobasidion annosum



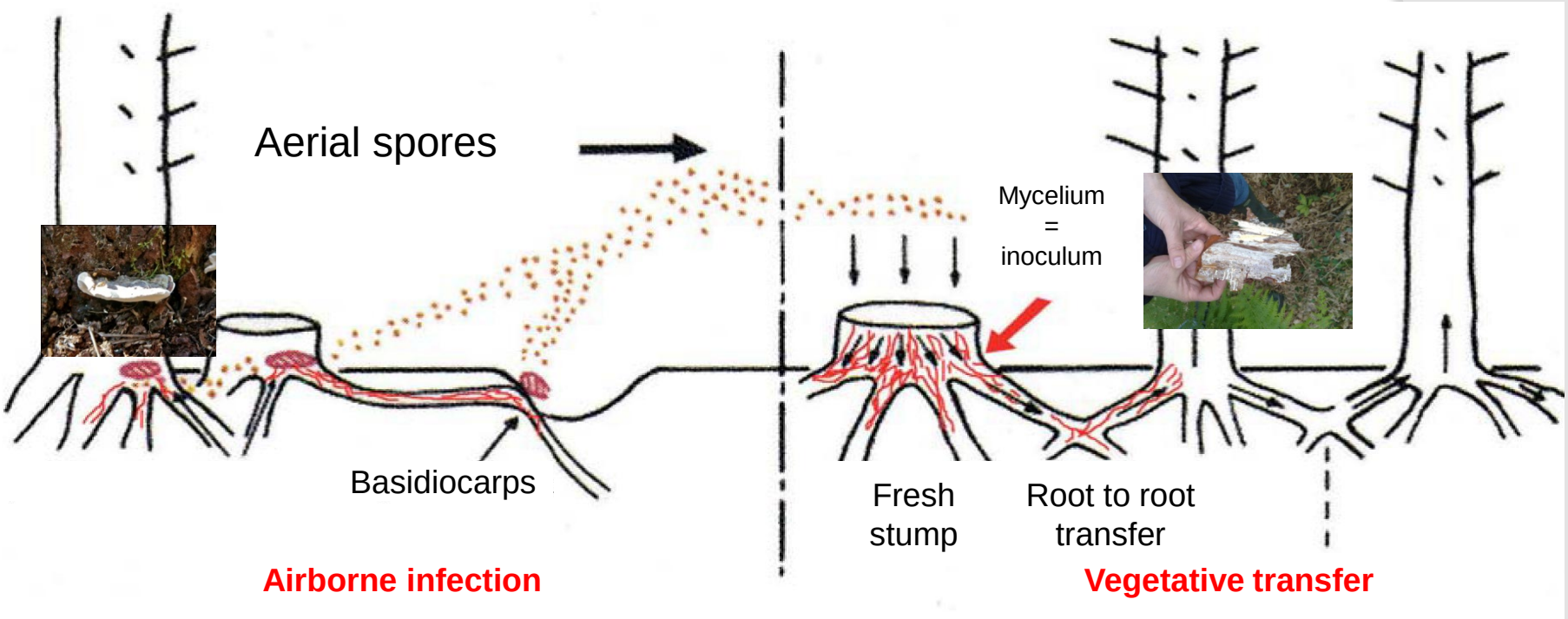
This root rot fungus is the main forest **damaging fungus** of the Northern Hemisphere (Woodward et al., 1998), causing increasing **mortality** on maritime pine stands in SW France.



Campet forest (47)

(T. Aumonier – DSF 2008)

Introduction: Ecology and life cycle



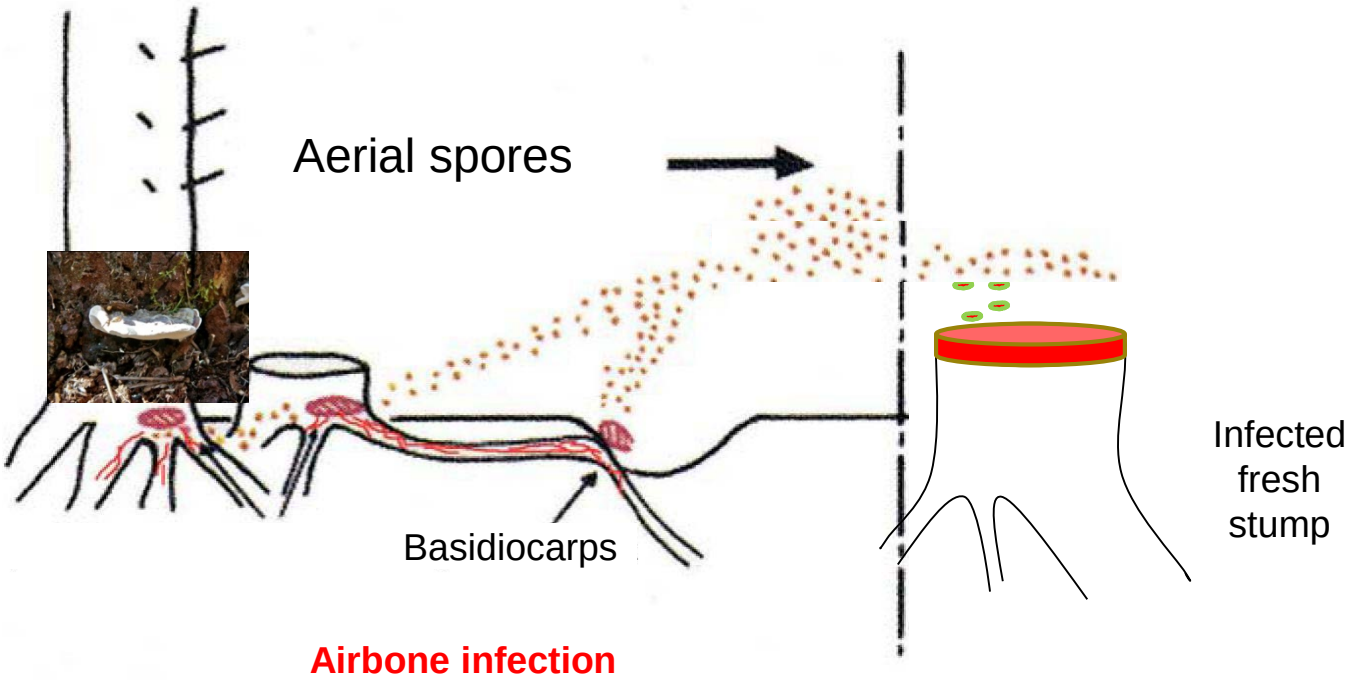
C. Delatour, (Abgrall & Soutrenon, 1991)

- Perennial basidiocarps → Sexual spore emission→ Spore deposition on freshly thinning stumps → Colonization of stump roots → Vegetative transfer to healthy tree root via root-to-root contacts

How to model the disease dynamics ?

- The root fungus dynamics
  - The pattern of spore deposition
  - The stump and root colonization of thinning stumps
  - The spread of fungus in roots of healthy tree
- Effect on trees
  - Disease effect on tree growth and survival

Model description: root fungus dynamics
Air Born infection

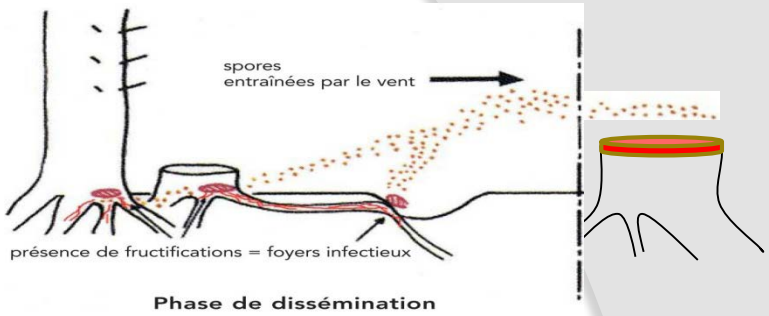


Prediction of a fresh stump becoming infected by spores after thinning: Pinf

- Number of aerial spore per m^2 per season

- Percentage of infected stumps after a thinning

Range pattern of primary spread



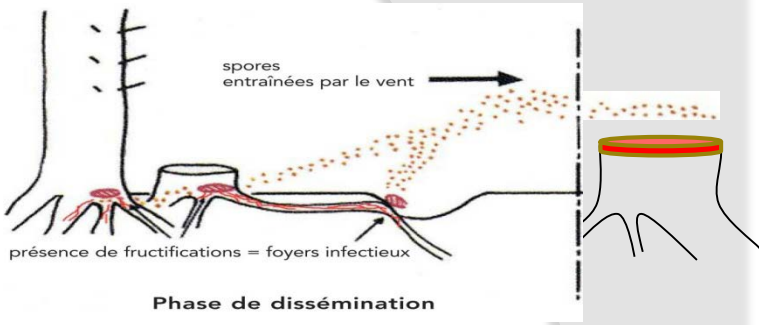
- *International bibliography*
  - Spores can travel hundred of kilometers

BUT

  - The spore viability is weak at long distance
  - Effective spore dispersal is between 100 and 1 300 m.

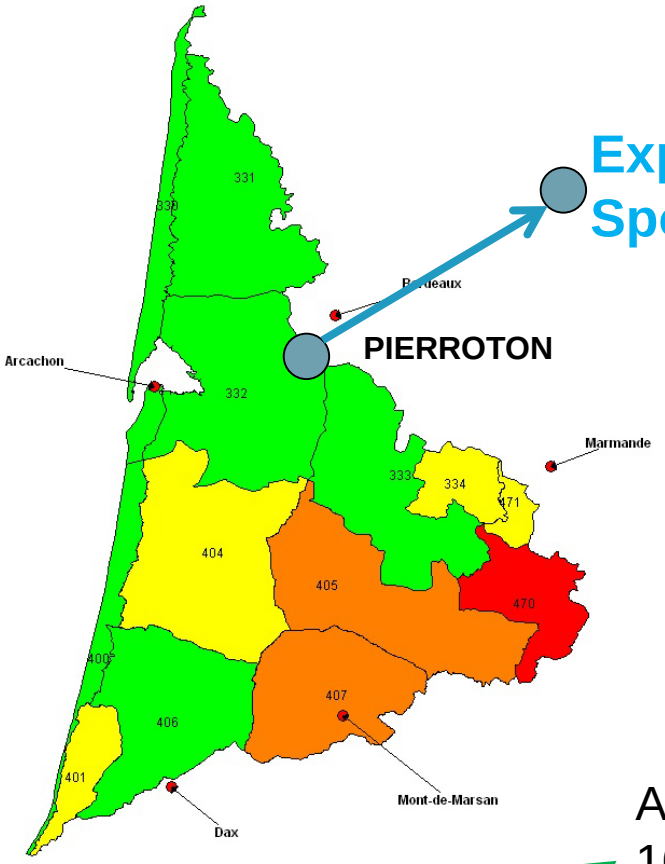
Gonthier at al, 2005, Garbelotto et al. 2013

Temporal pattern of primary spread

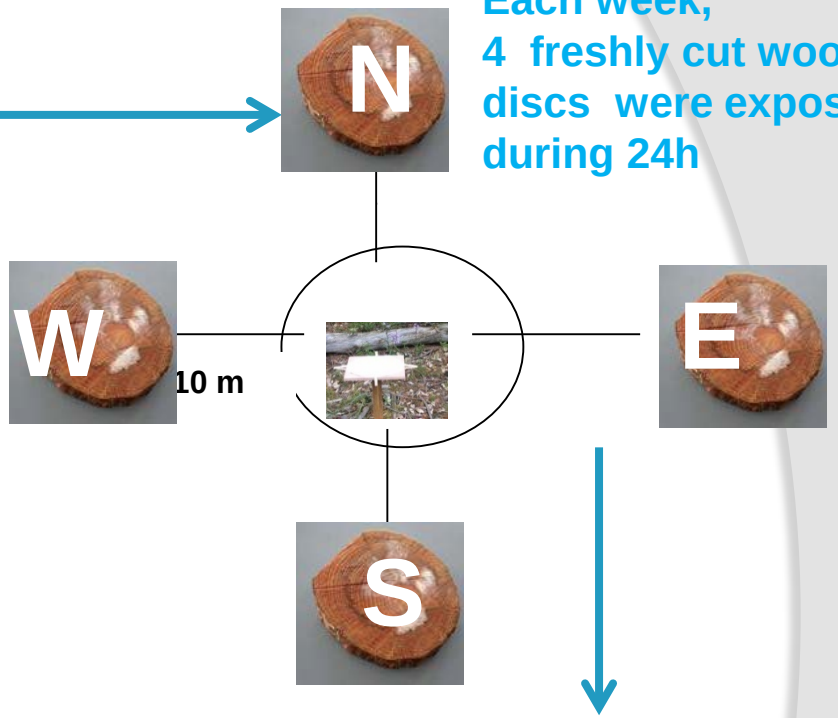


- International bibliography
  - Highly variable in the Northern hemisphere
  - For Continental climates (Northern Europe) :
    Maximum probability of infection during summer and no infection during winter
  - For Atlantic climate (United Kingdom) :
    Most of the year
  - For Mediterranean climate :
    High level probability in winter and a significant lower level in summer
- Experimental results in South West France…

Monitoring the aerial spore deposition: wood-disk method



Experiment 1: Spore traps



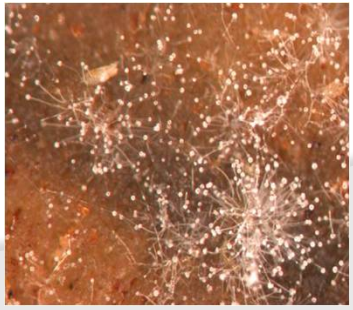
Each week, 4 freshly cut wood discs were exposed during 24h

After exposure in humid chamber in darkness at 19°C for 10 days, the wood discs were examined for colonies of the imperfect stage of *H. annosum* (*Spiniger meineckellus*)

Experiment 2: Thinning stump disks

In 48 stands, harvest of 50 wood discs of stumps at different seasonal dates and in different soil types (12 stands/season/soil type)

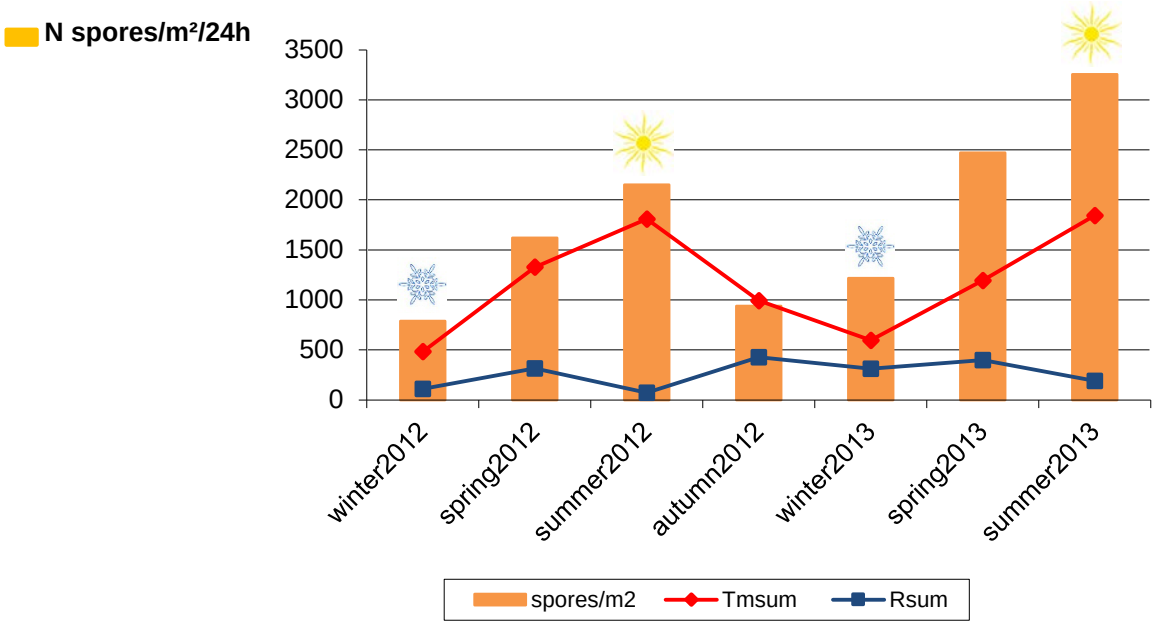
% of stumps infected by H. annosum

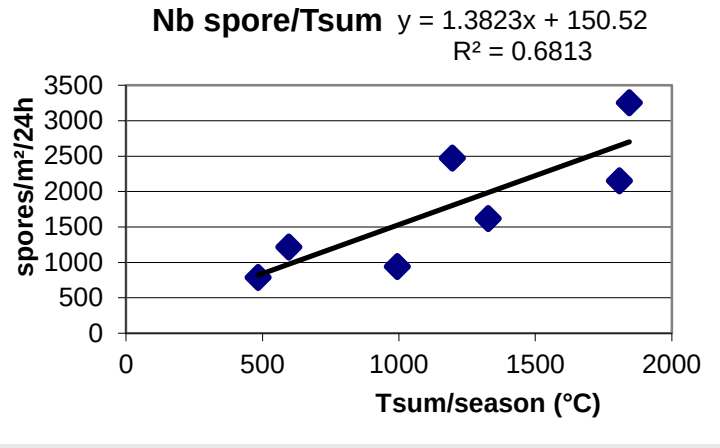


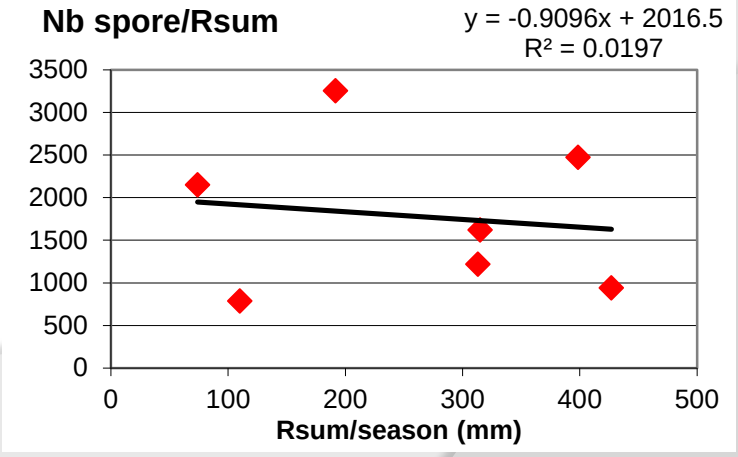
Nb spores/m²/24h (as the result of the germination of one aerial spore)

Experiment 1: Seasonal pattern of spore deposition - Results

Prediction of the probability of a fresh stump becoming infected by spores

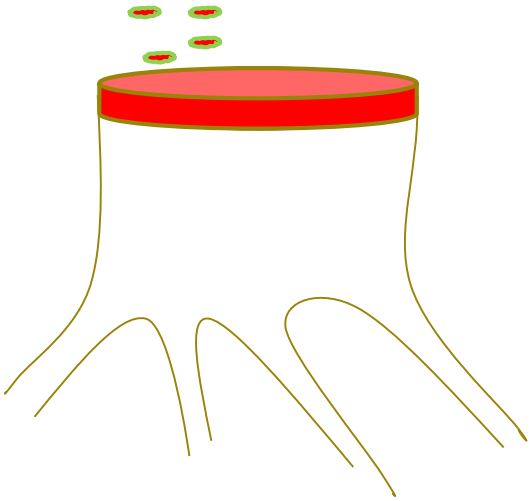


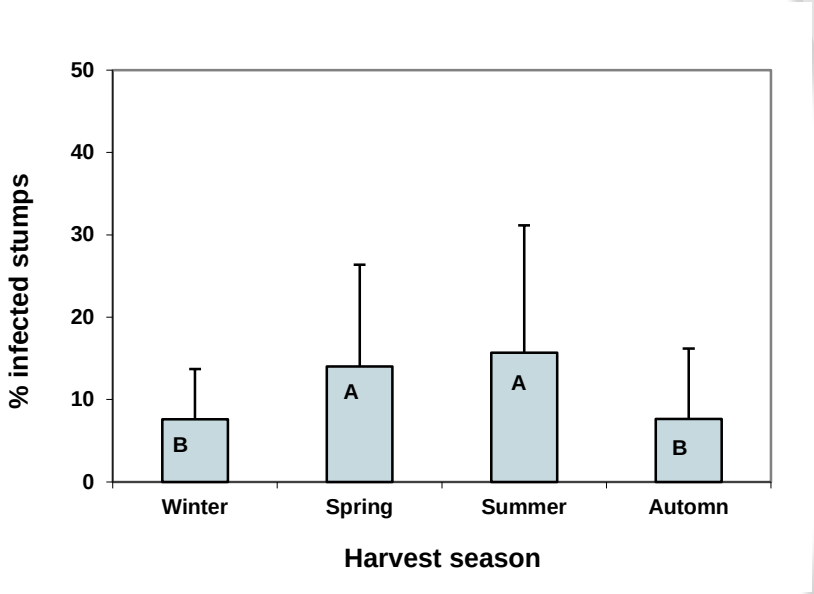




Experiment 2: Infection of thinning stumps - Results

Actual infection probability = f(Season)



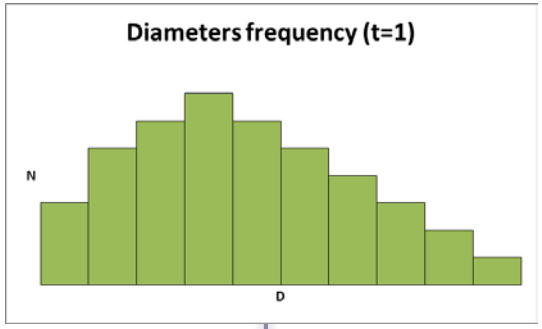


Data integration into *Pinuspinaster*

t=n

Initial stand: Age≥7, density, fertility

Theoretical (or real) initial stand

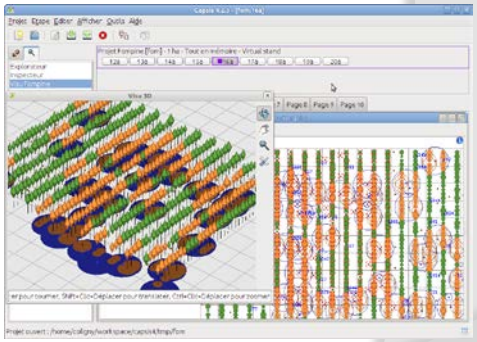


Pinuspinaster→ Empirical tree growth model for Maritime pine calibrated on healthy stand and trees

Silvicultural practices : thinnings

N stems year 2=N stems year 1 – (tree mortality + tree thinning + root rot mortality)

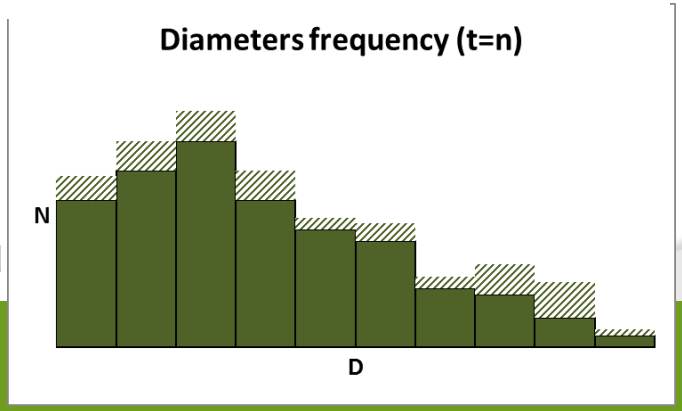
D stems year 2= D stems year 1+ΔDt - GrowthLoss



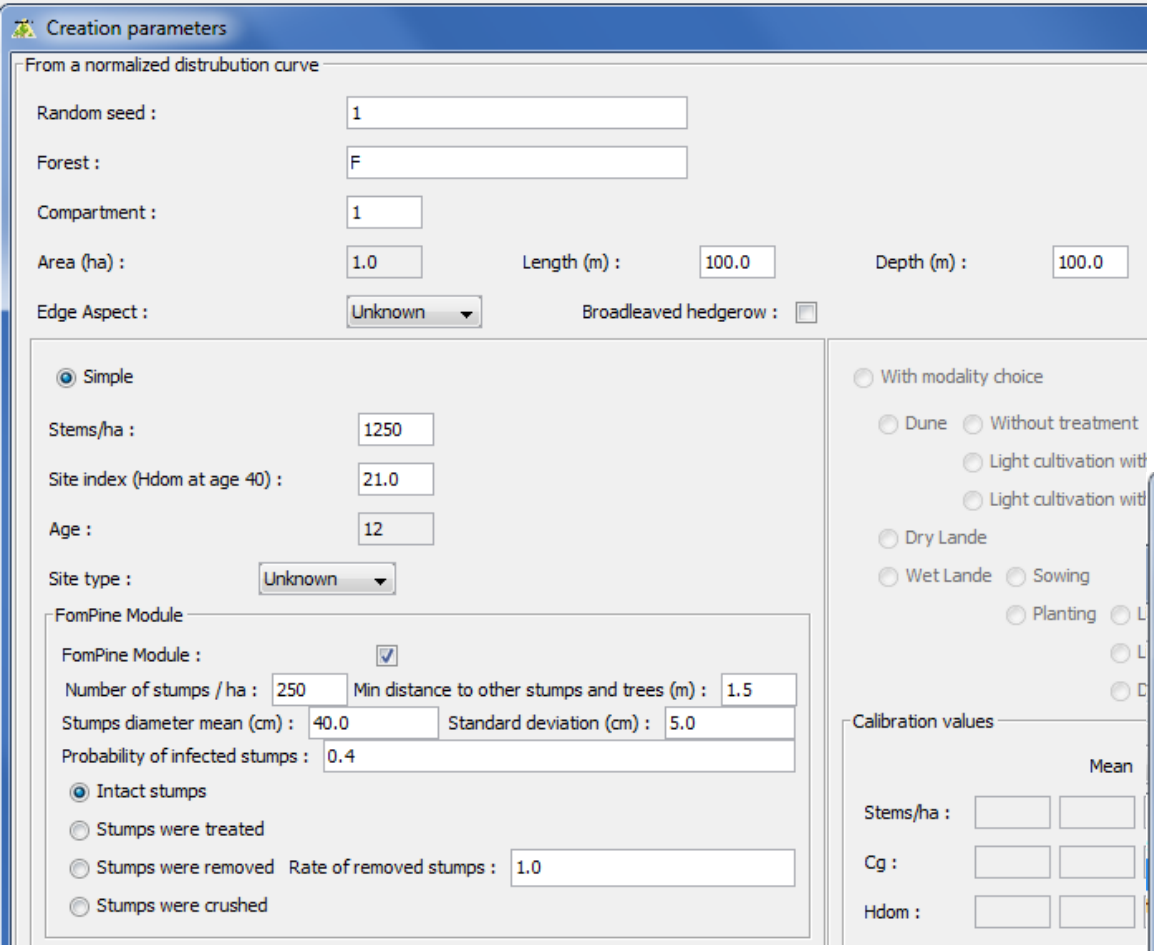
t=n+1

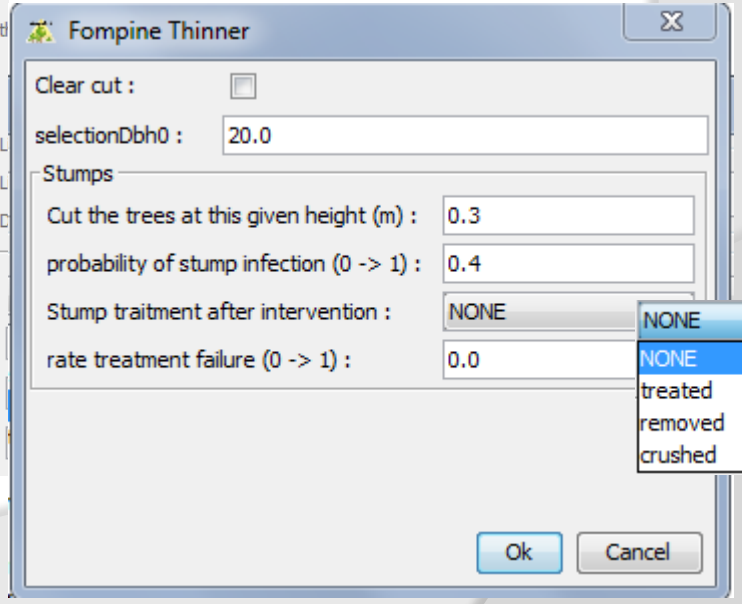
New stand and tree dimensions

Theoretical new stand



Features for the user





Parameter set

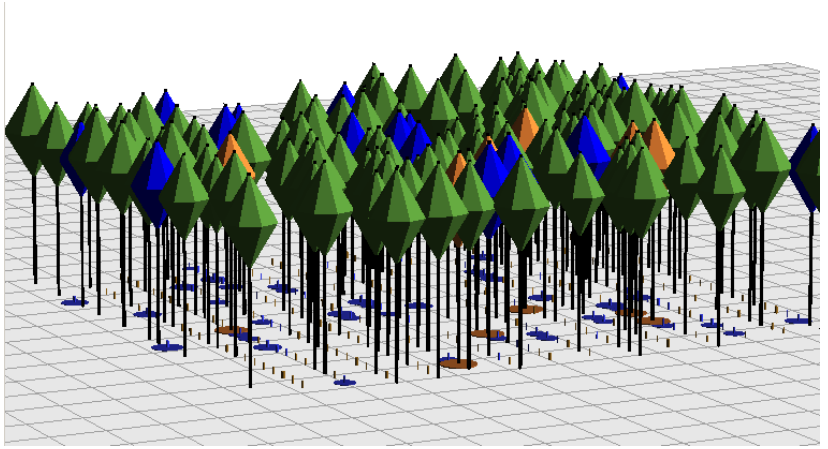
Model parameters	Available for South-West France
Probability of infection	Yes, depending on precipitation/season
Probability of colonization	Yes and variable (soil type)
Spreading probability from stump to tree	Yes and variable (soil type)
Spreading probability from tree to tree	Based on literature
Growth rate of fungus in roots of stumps	Yes and variable (soil type)
Max of growth rate in roots of stumps	Yes and variable (soil type)
Growth rate in roots of living trees	Yes: one value
Tree growth rate reduction parameter	Yes: one value

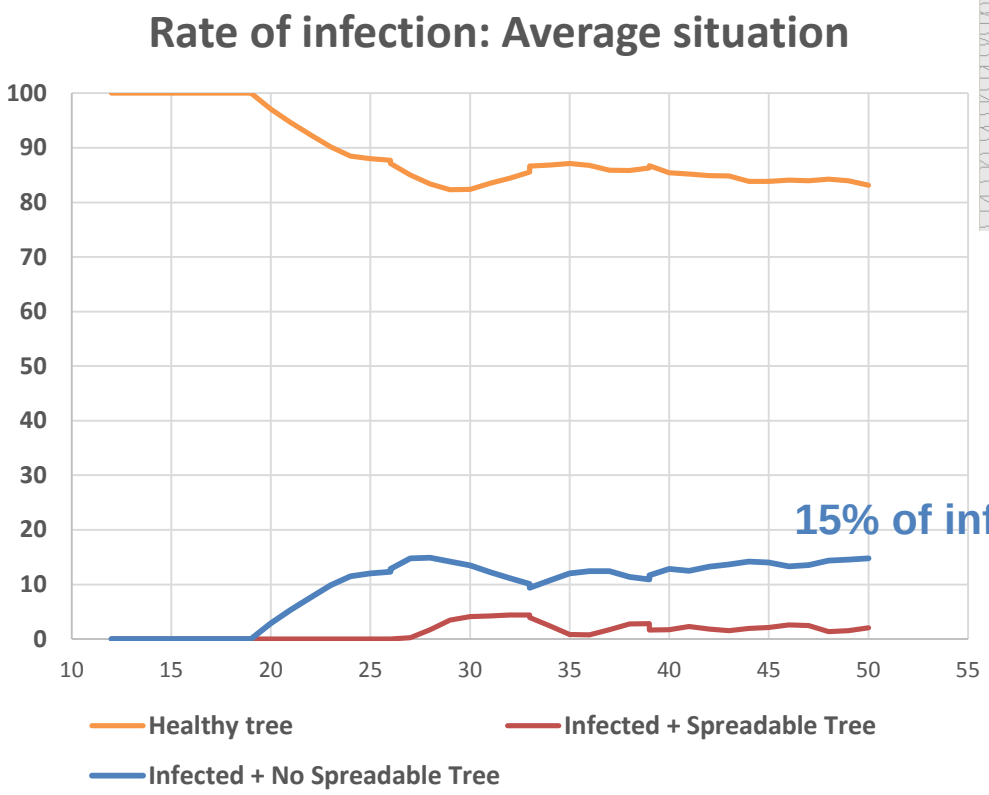
Results

Silvicultural scenario of undamaged stand

- Initial stand: 1250 t/ha
- Initial age: 12 ans
- Site index: 23.5 m at 40 years-old
- 5 thinnings:
  - 13 y: 875 t/ha
  - 19 y: 650 t/ha
  - 26 y: 455 t/ha
  - 33 y: 320 t/ha
  - 39 y: 250 t/ha
- Target age: 50 years-old

Results



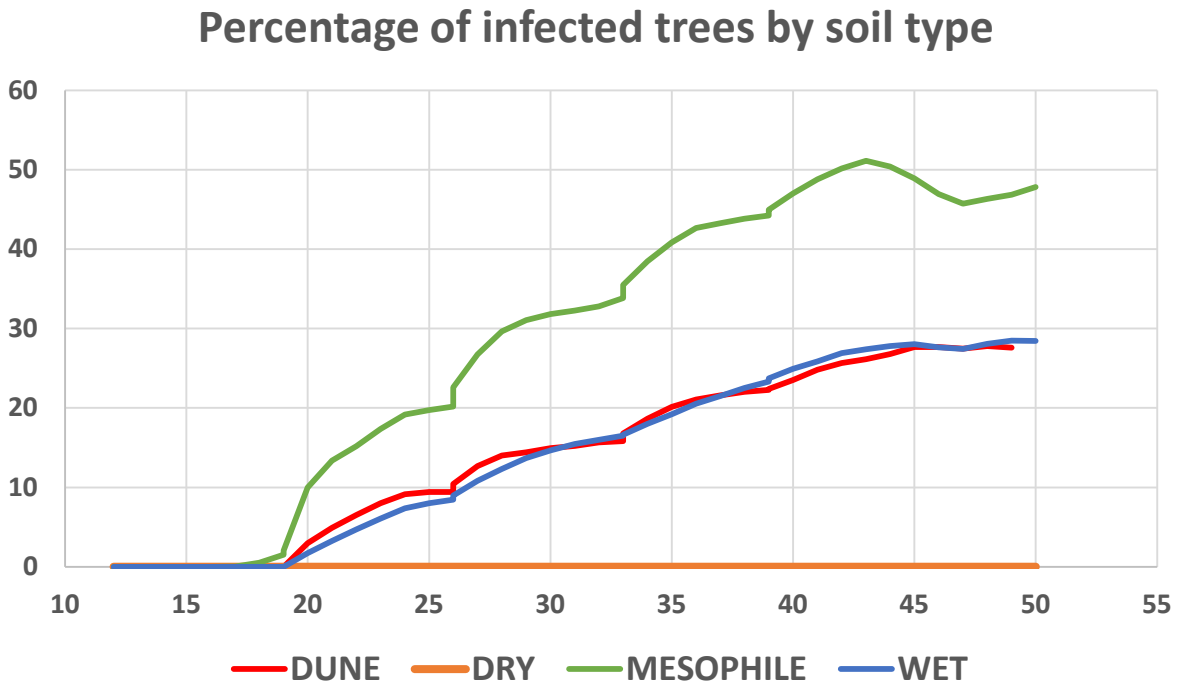


15% of infected trees at the end of the rotation

7% of dead trees due to root rot
=> 9 m² of basal area

Results

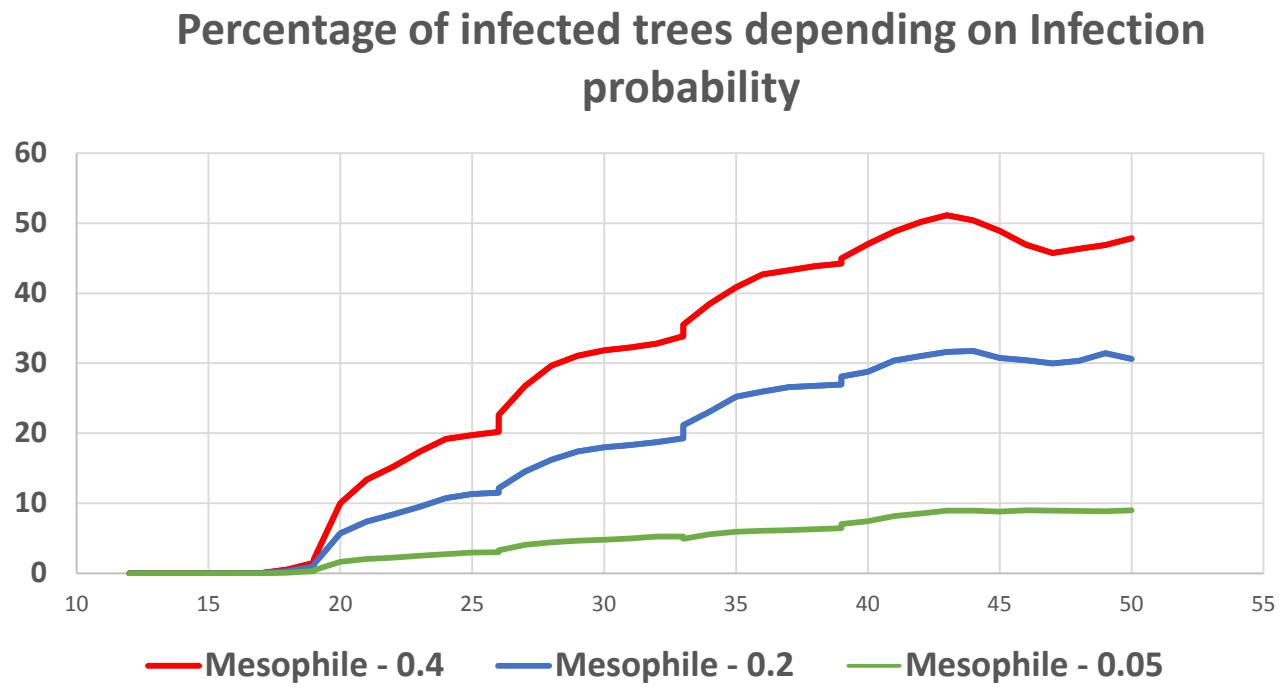
For different types of soil



	P colonization	Prob from Stump to Tree
Mesophylous	0.88	0.49
Dune	0.4	0.47
Wet	0.69	0.22
Dry	0.57	0.0

Results

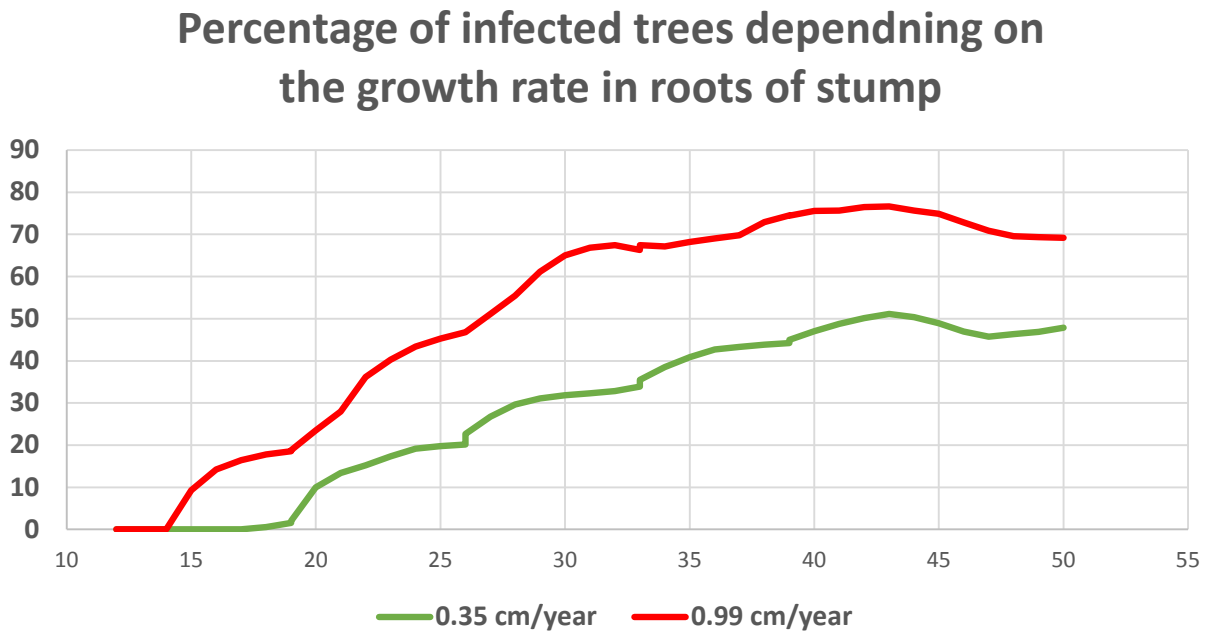
For mesophylous soil type :
Impact of level of probability of infection at each thinning



	P Infection	Prob Colonization
Low	0.05	0.88
Average	0.2	0.88
High	0.4	0.88

Results

For mesophylous soil type :
Impact of growth rate in the roots of stump



	Growth rate (cm/year)
Average	0.35
Max	0.99

Conclusion

→ **Results on spore pattern**
  → **All year long in Atlantic climate**
  → **Depending on sum of temperature : so can increase with CC in autumn and winter and level of in summer ?**
  → **Important factor for the level of contamination**

→ Development of a model containing all the knowledge of root rot for Maritime pine forest
  → Possibility of simulations:
  Optimize the management of contaminated stands
  Describe the management to prevent contamination

Conclusion

→ Validate this model through a network of plots especially to assess contamination from the previous rotation

→ **Next steps: Add an economic component to the biological model to calculate if preventive or curative operations are cost effective**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