



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

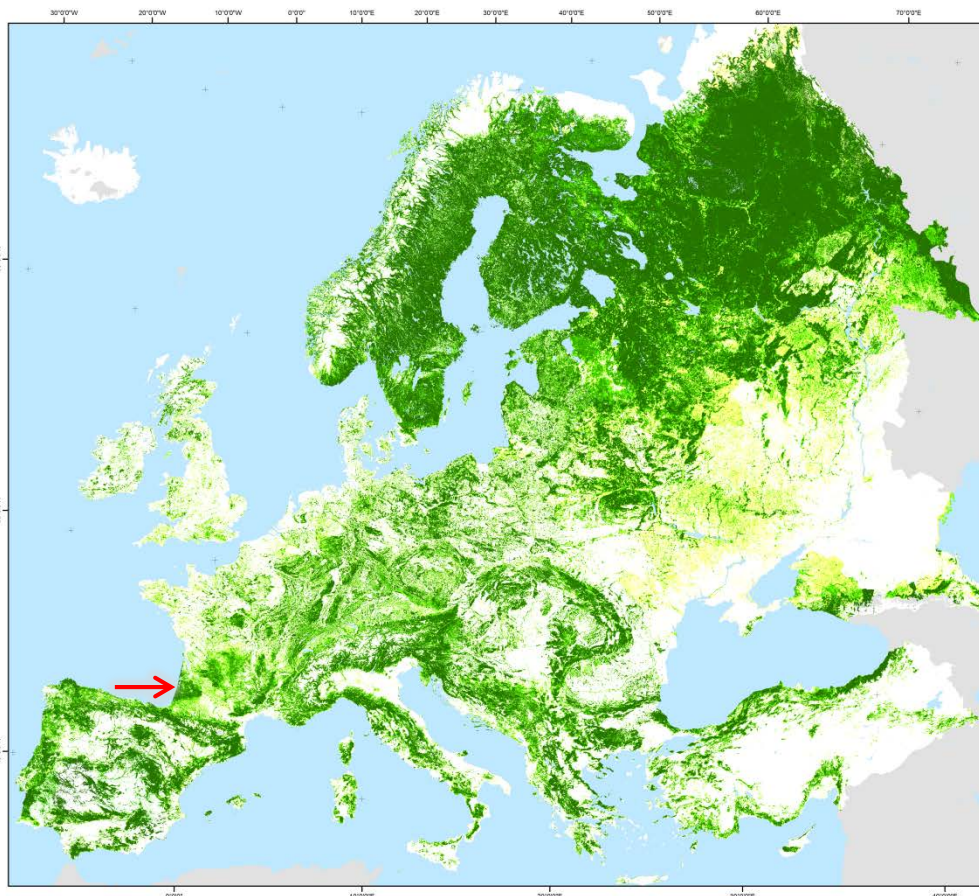
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→ South-Western France : maritime pine planted forest



Forêt Landes, ©Pierre Boisselet



FOREST MAP OF EUROPE (geographical Europe and Turkey)

Proportion of forest from land area
(% at 1km x 1km resolution)

- 0 - 10
- 11 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- Water
- No data

0 250 500 750
Kilometers

ETRS89 Lambert Azimuthal Equal Area projection

Data sources

Earth observation data:
EU27, AL, BA, CH, HR, ME, MK, NO, RS, TR: Forestion-forest map 2006 (beta version), developed by the EC Joint Research Centre, aggregated to 1km resolution. Based on IRS-P6 LISS-III, SPOT4 HRVIR and SPOT5 HRG satellite data of 2006.
Belarus, Moldova, Ukraine, Russian Federation: Forest share estimates based on AVHRR NOAA satellite data of 1996-1999.

Statistical data

National forest inventory statistics
State of Europe's Forests country statistics 2011

Method

Two different earth-observation products (Kempeneers et al. 2011; Flavinien et al. 2001; Schuck et al. 2002) have been combined with statistical data to produce a pan-European forest map that corresponds to the official forest inventory statistics at national and/or regional level. The satellite-based forest cover data was first calibrated to sum up to the forest area statistics within a given administrative region. For 19 countries (including the Russian Federation) regional statistics were utilized during the calibration, while for the other countries statistics at national level have been applied. In a second calibration run, the map was adjusted to the internationally harmonized statistics by Forest Europe 2011 at national level, to allow for comparability between the countries.

Further details:

www.efi.int/social/virtual_library/information_services/mapping_services/forest_map_of_europe

References

Kempeneers, P., Sedano, F., Seebach, L., Ströbl, P., San-Miguel-Ayala, J. 2011. Data fusion of different spatial resolution remote sensing images applied to forest type mapping. IEEE Transactions on Geoscience and Remote Sensing, in press.
Flavinien, R., Lehtonen, M., Schuck, A., Hana, T., Väätäinen, S., Kennedy, P. and Folwig, S. 2001. Combining Earth Observation Data and Forest Statistics. EFI Research Report 14, European Forest Institute and Joint Research Centre - European Commission.
Schuck, A., Van Braeslein, J., Flavinien, R., Hana, T., Kennedy, P. and Folwig, S. 2002. Compilation of a calibrated European forest map derived from NOAA-AVHRR data. EFI Technical Report 13, European Forest Institute.

Contact: efi@efi.int

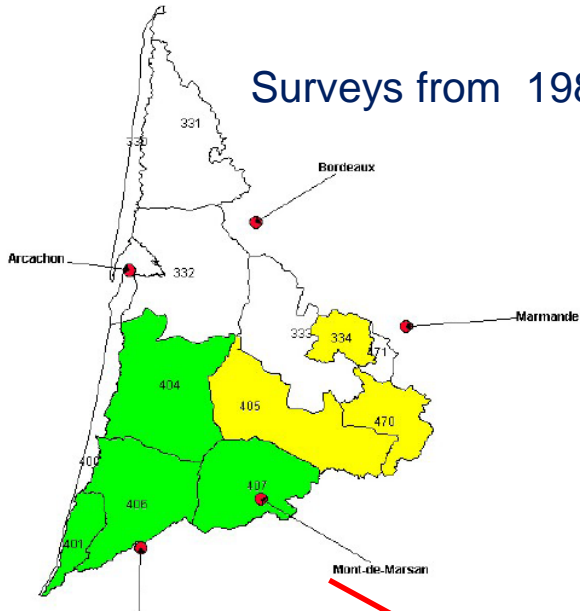
European Forest Institute / EC Joint Research Centre
September 2011



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.

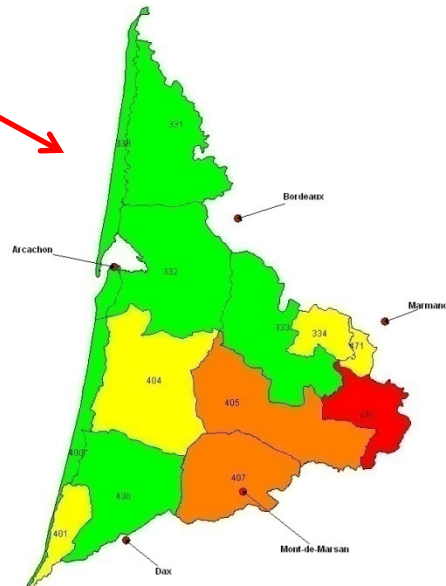
Surveys from 1989 to 1997



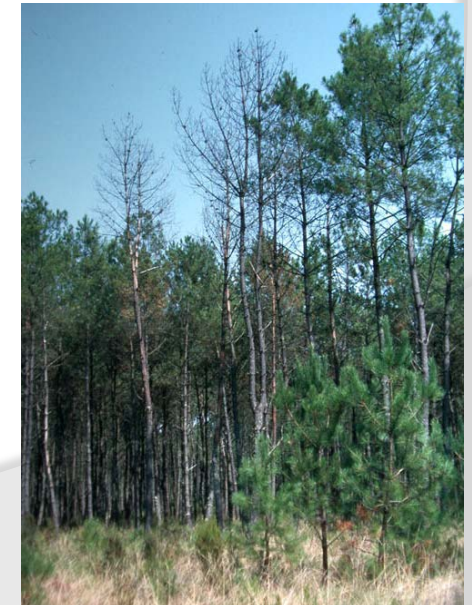
Analyse des fréquences de fomes de 1989 à 2008
Les différentes couleurs représentent un signalment pour une superficie de pin maritime de :

| | |
|------------------|-----|
| moins de 1000 Hs | (1) |
| 1000 à 2000 Hs | (2) |
| 2000 à 5000 Hs | (4) |
| 5000 à 25000 Hs | (6) |

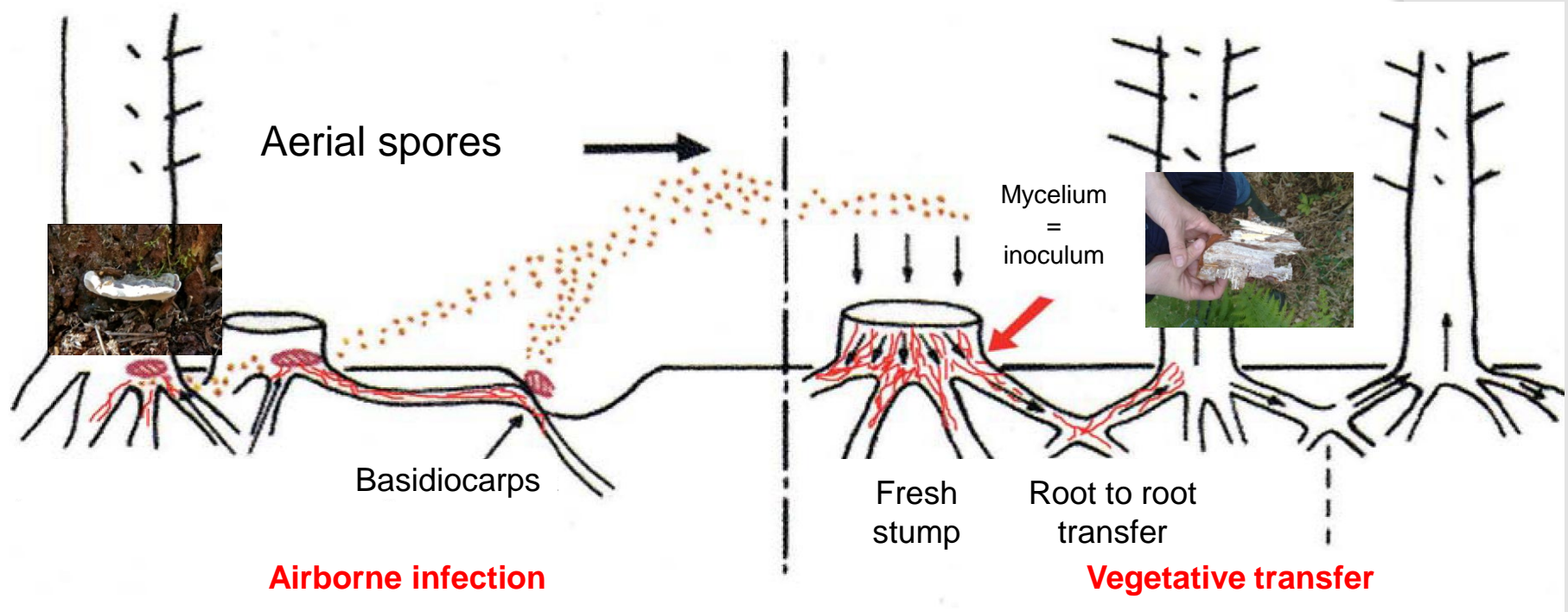
Surveys from 1998 to 2008



Campet forest (47)



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

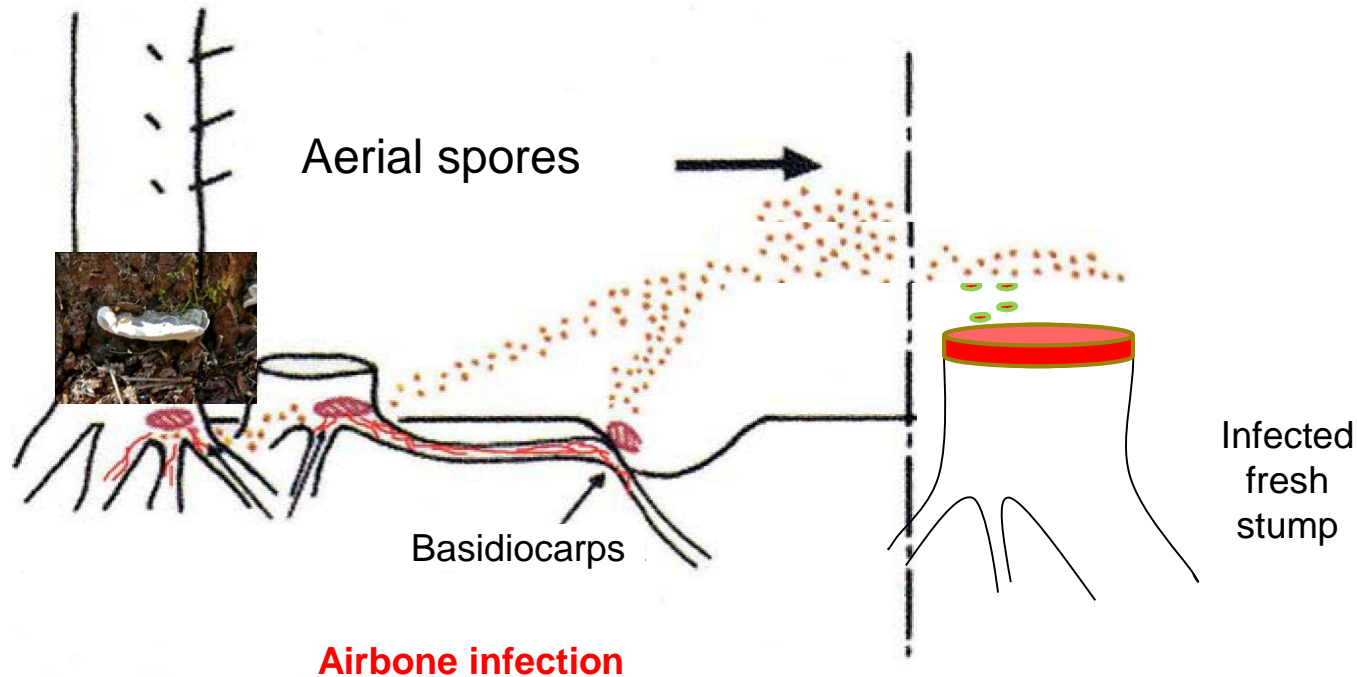
- The pattern of spore deposition
- The stump and root colonization of thinning stumps
- The spread of fungus in roots of healthy tree

◎ Effect on trees

- Disease effect on tree growth and survival

Model description: root fungus dynamics

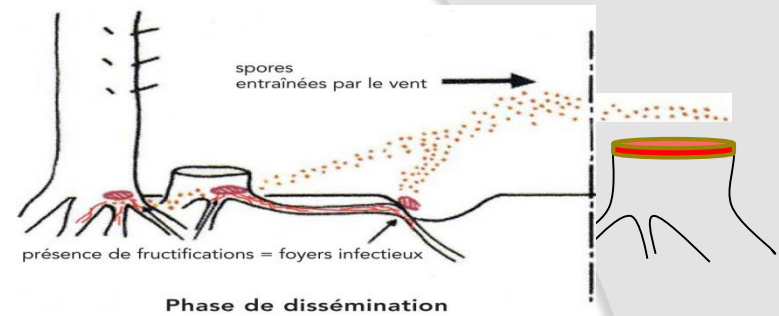
Air Born infection



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



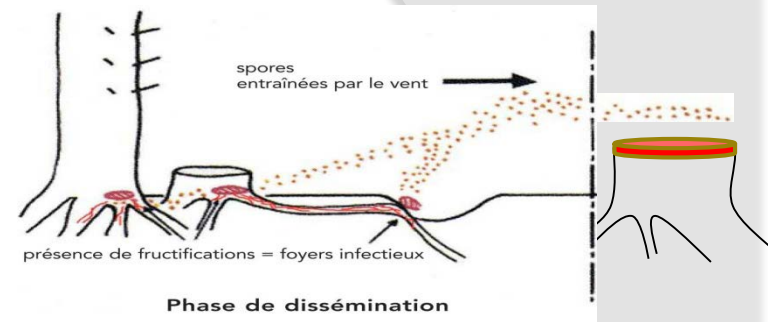
◎ *International bibliography*

- 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.**

Temporal pattern of primary spread

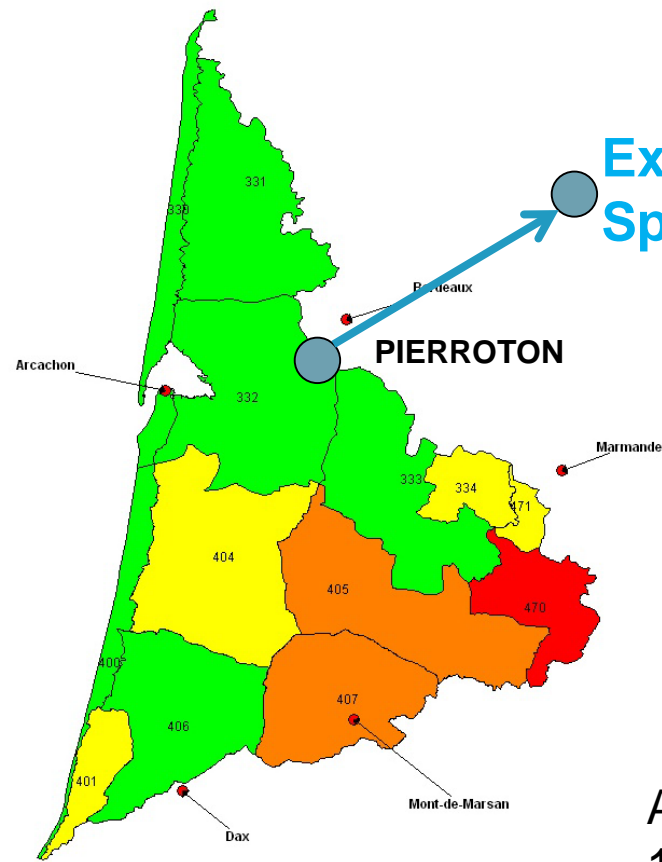


International bibliography

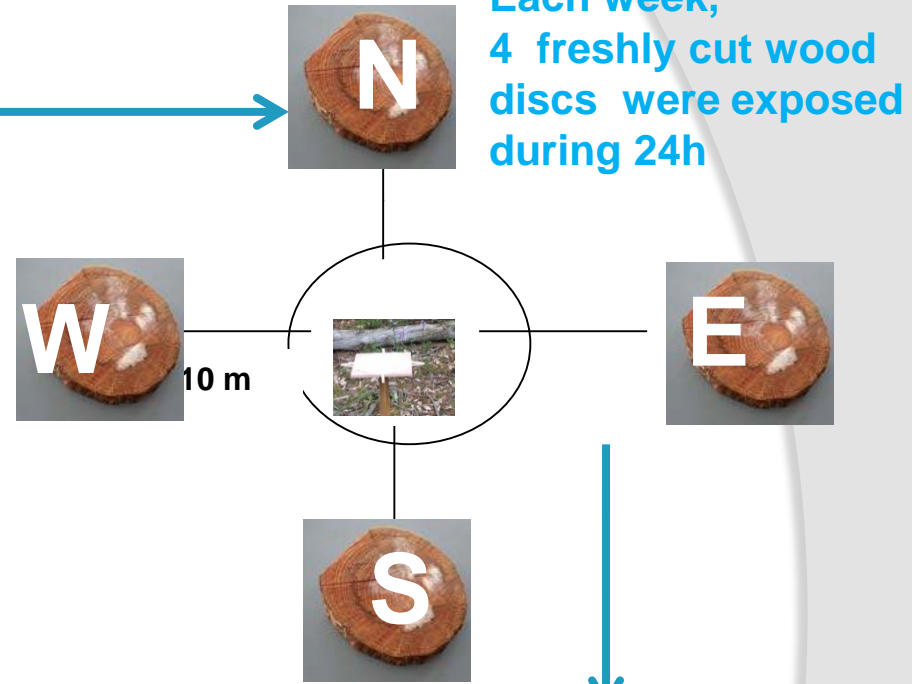
- **Highly variable in the Northern hemisphere**
- For Continental climates (Northern Europe) :
Maximum probability of infection during summer and no infection during winter
- For Atlantic climate (United Kingdom) :
Most of the year
- For Mediterranean climate :
High level probability in winter and a significant lower level in summer

Experimental results in South West France...

Monitoring the aerial spore deposition: wood-disk method



Experiment 1: Spore traps



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)

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*)

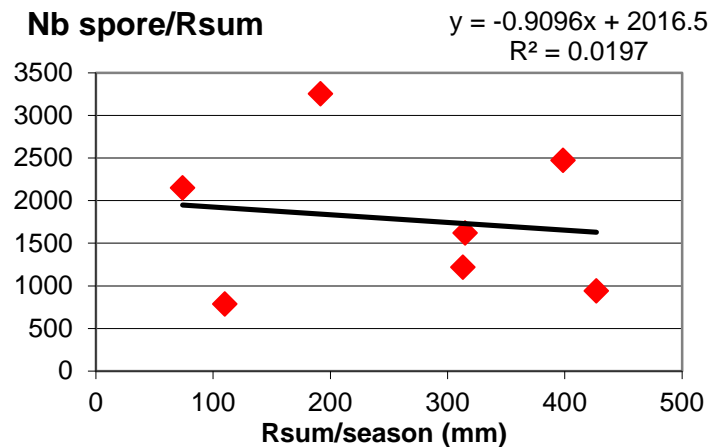
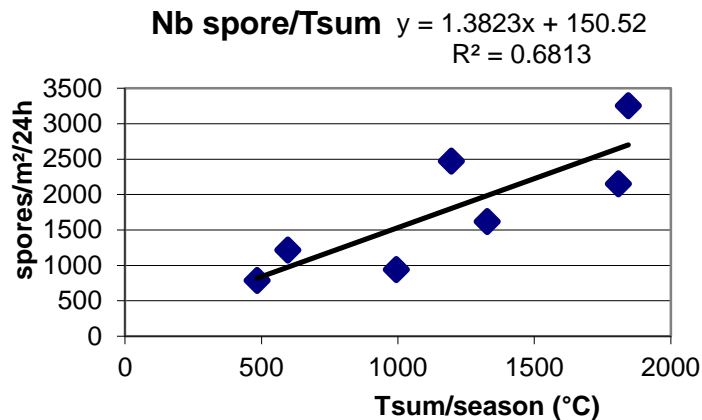
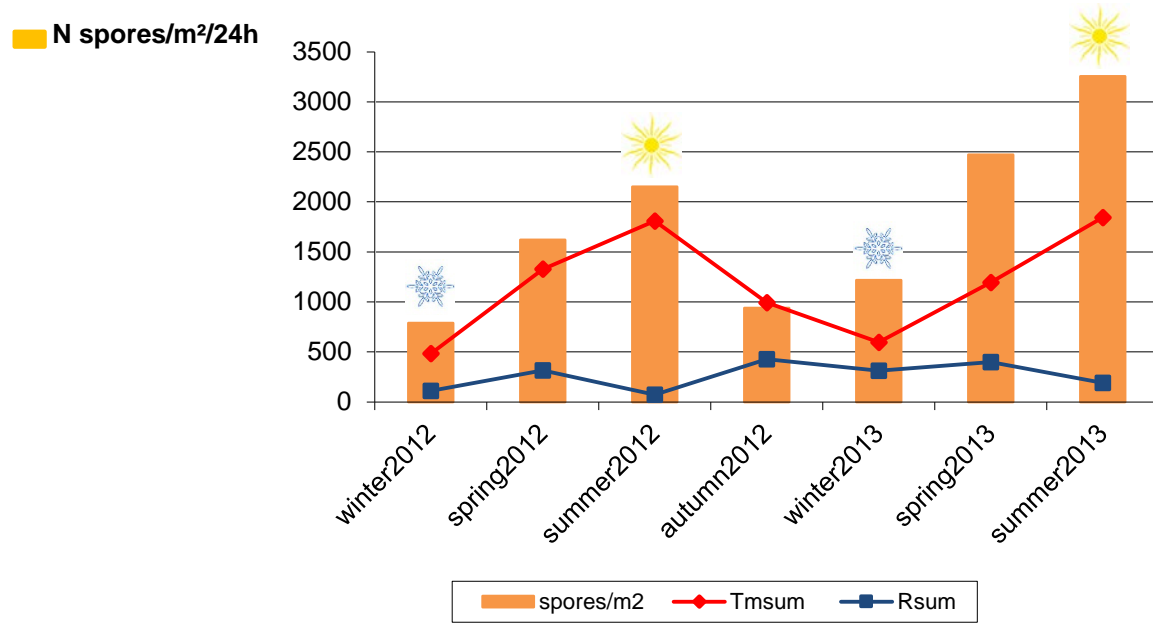
% of stumps
infected by
H. annosum



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

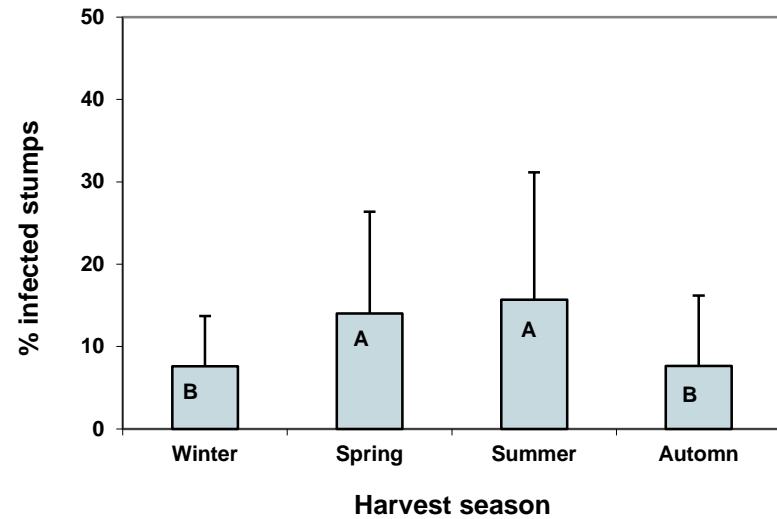
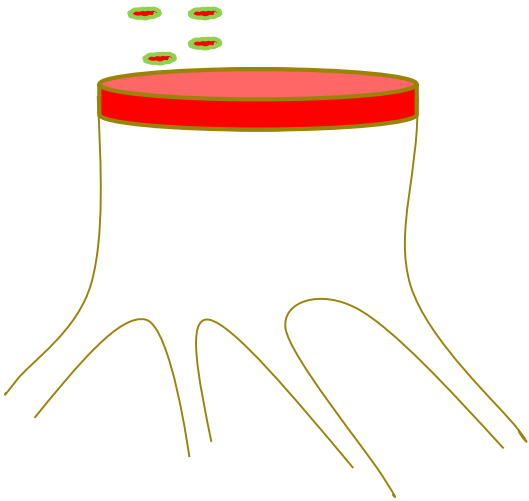
Experiment 1: Seasonal pattern of spore deposition - Results

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



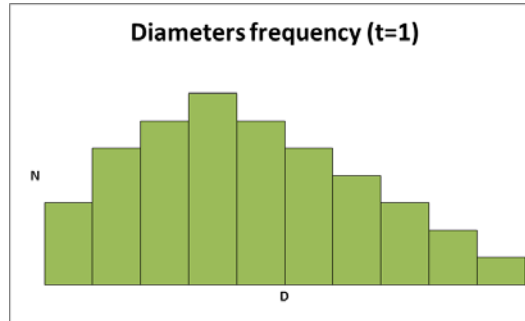
Experiment 2: Infection of thinning stumps - Results

Actual infection probability = $f(\text{Season})$



t=n

Initial stand: Age ≥ 7,
density, fertility



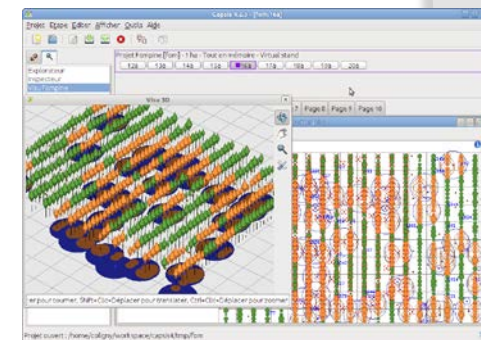
Theoretical (or real)
initial stand

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

Silvicultural practices : thinnings

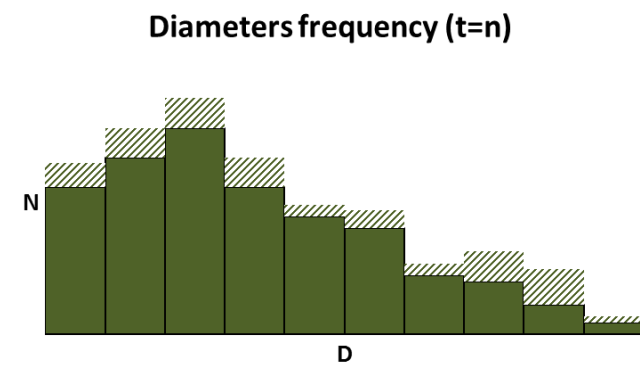
$N \text{ stems year } 2 = N \text{ stems year } 1 -$
(tree mortality + tree thinning
+ **root rot mortality**)

$D \text{ stems year } 2 = D \text{ stems year } 1 + \Delta Dt$
- **GrowthLoss**



t=n+1

New stand and
tree dimensions



Theoretical new stand



Features for the user

Creation parameters

From a normalized distribution curve

Random seed :

Forest :

Compartment :

Area (ha) : Length (m) : Depth (m) :

Edge Aspect : Broadleaved hedgerow :

Simple

Stems/ha :

Site index (Hdom at age 40) :

Age :

Site type :

FomPine Module

FomPine Module :

Number of stumps / ha : Min distance to other stumps and trees (m) :

Stumps diameter mean (cm) : Standard deviation (cm) :

Probability of infected stumps :

Intact stumps

Stumps were treated

Stumps were removed Rate of removed stumps :

Stumps were crushed

With modality choice

Dune Without treatment

Light cultivation with

Light cultivation with

Dry Lande

Wet Lande Sowing

Planting L

L

D

Calibration values

Mean

Stems/ha :

Cg :

Hdom :

Fompine Thinner

Clear cut :

selectionDbh0 :

Stumps

Cut the trees at this given height (m) :

probability of stump infection (0 -> 1) :

Stump traitment after intervention :

rate treatment failure (0 -> 1) :

Ok Cancel

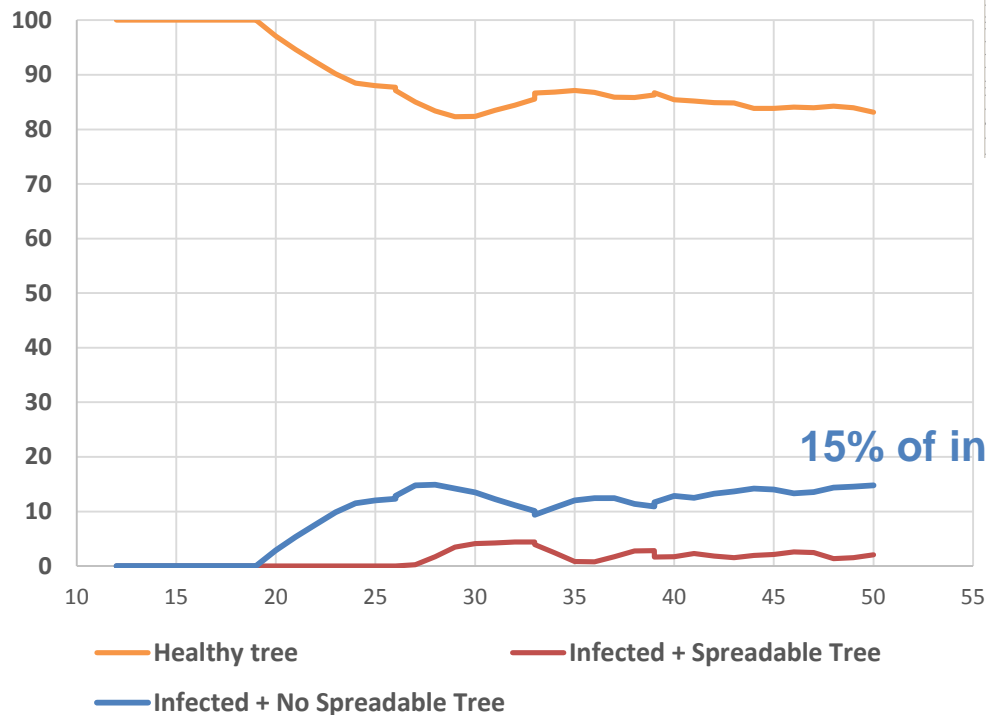
Parameter set

| 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 |

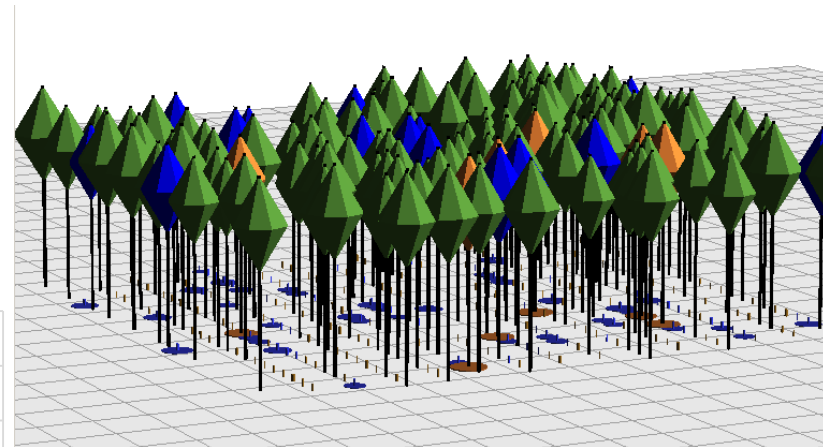
Silvicultural scenario of undamaged stand

- 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

Rate of infection: Average situation



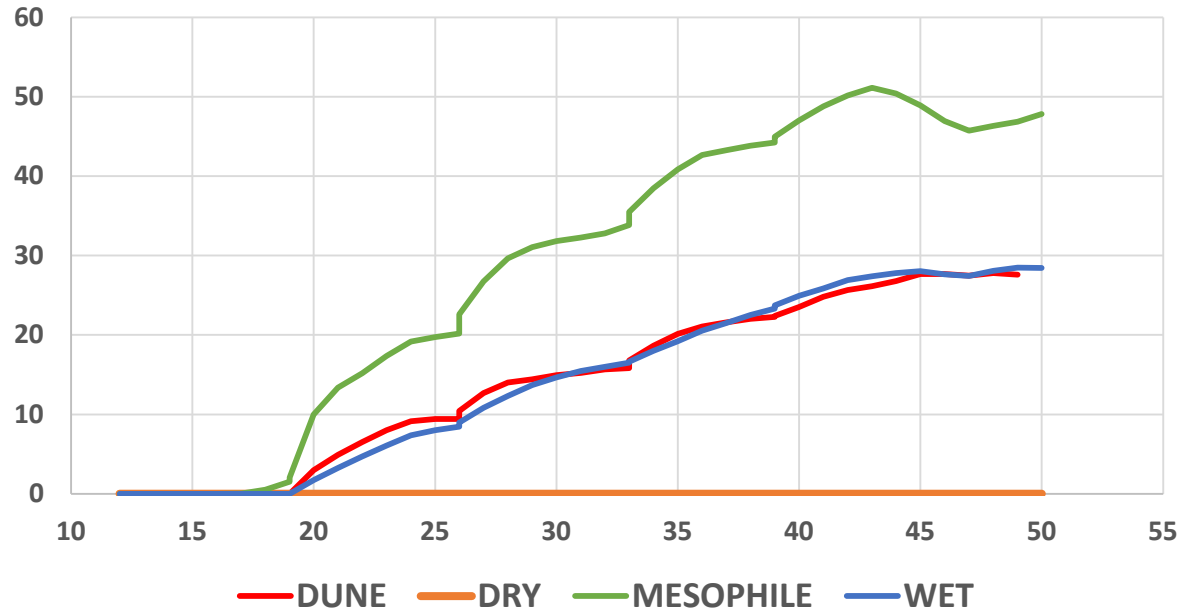
15% of infected trees at the end of the rotation



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

For different types of soil

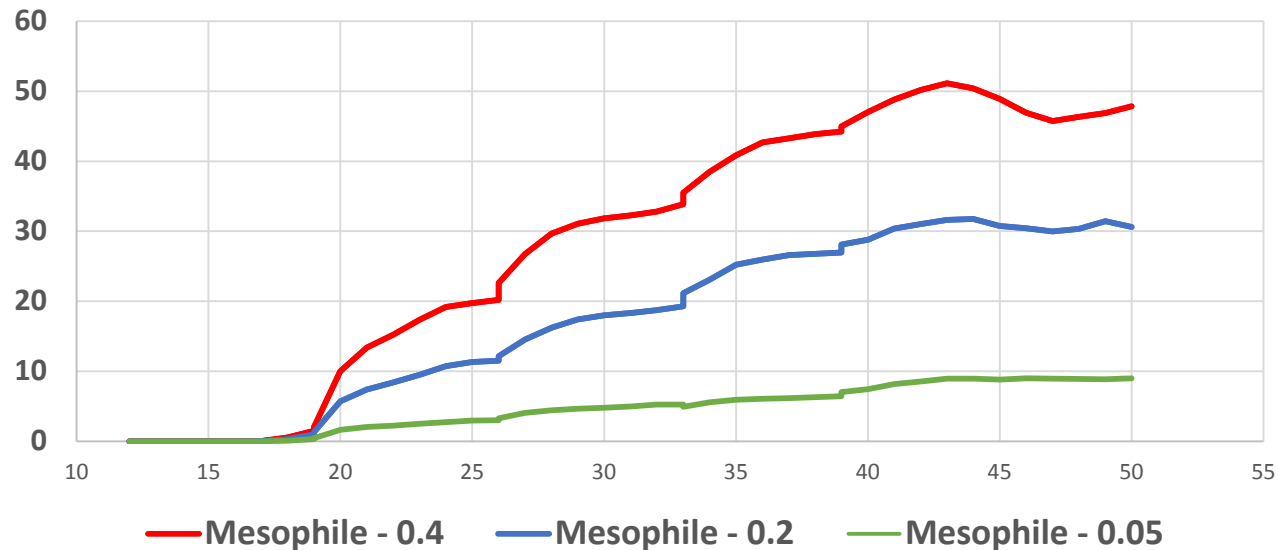
Percentage of infected trees by soil type



| | 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 |

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

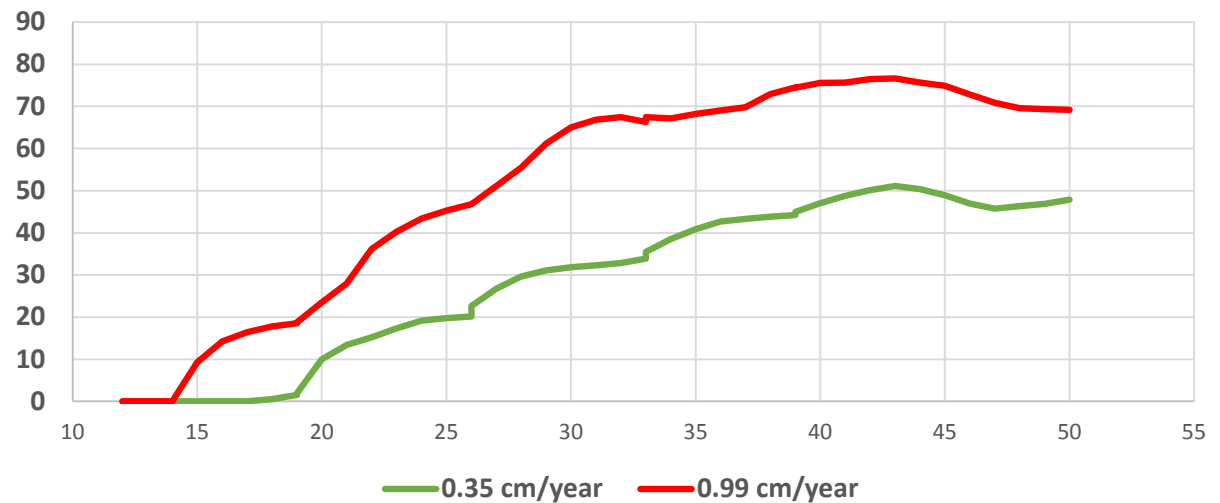
Percentage of infected trees depending on Infection probability



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

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

Percentage of infected trees depending on the growth rate in roots of stump



| | Growth rate (cm/year) |
|---------|-----------------------|
| Average | 0.35 |
| Max | 0.99 |

- **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**



Fortius



RÉGION AQUITAINE

Thank you for your attention !

