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## Are forest reserves or deadwood retention key elements for bryophyte diversity?

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# Are forest reserves or deadwood retention key elements for bryophyte diversity?

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Réserves  
Naturelles  
DE FRANCE



# Strategy for forest biodiversity conservation

Forest reserves **left unharvested** are a central part of the strategy for biodiversity conservation...

→ Land sparing (segregation)



... even though other approaches can improve biodiversity by **integrating biodiversity-friendly practices within management** (extending rotations, deadwood, pioneer stages ...)

→ Land sharing (integration)





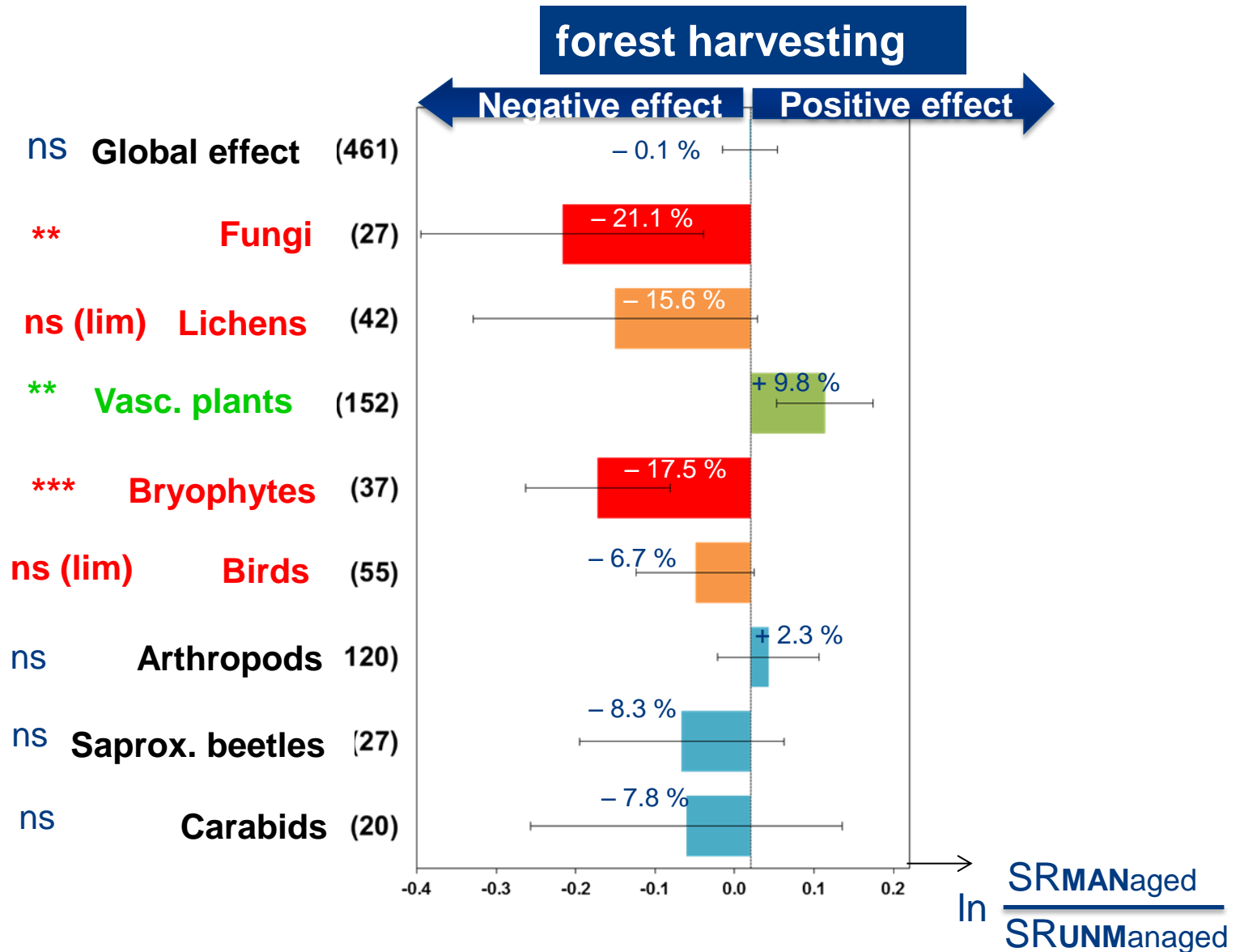
## State of knowledge

**European (Paillet et al. 2010 *Conserv. Biol.*) and Global meta-analyses revealed a diversity of taxonomic answers to forest harvesting cessation**

↪ **Trends towards mostly negative effect of forest harvesting on local species richness**

↪ **... with strong variations between taxa...**

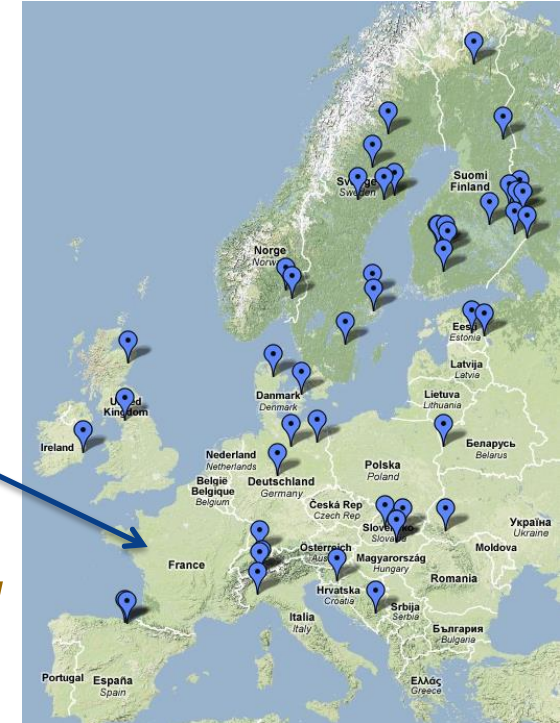
## Global meta-analysis (2014)



## State of knowledge

The European meta-analysis (Paillet et al. 2010 *Conserv. Biol.*) also revealed important gaps

- *less temperate studies*
- *sampling often problematic (e.g. pseudoreplication)*
- *explanatory factors often not incorporated*

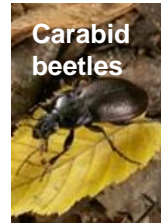
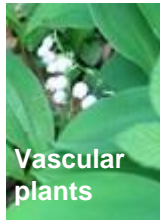




# Questions

↪ Do the meta-analyses results account for French temperate forests?

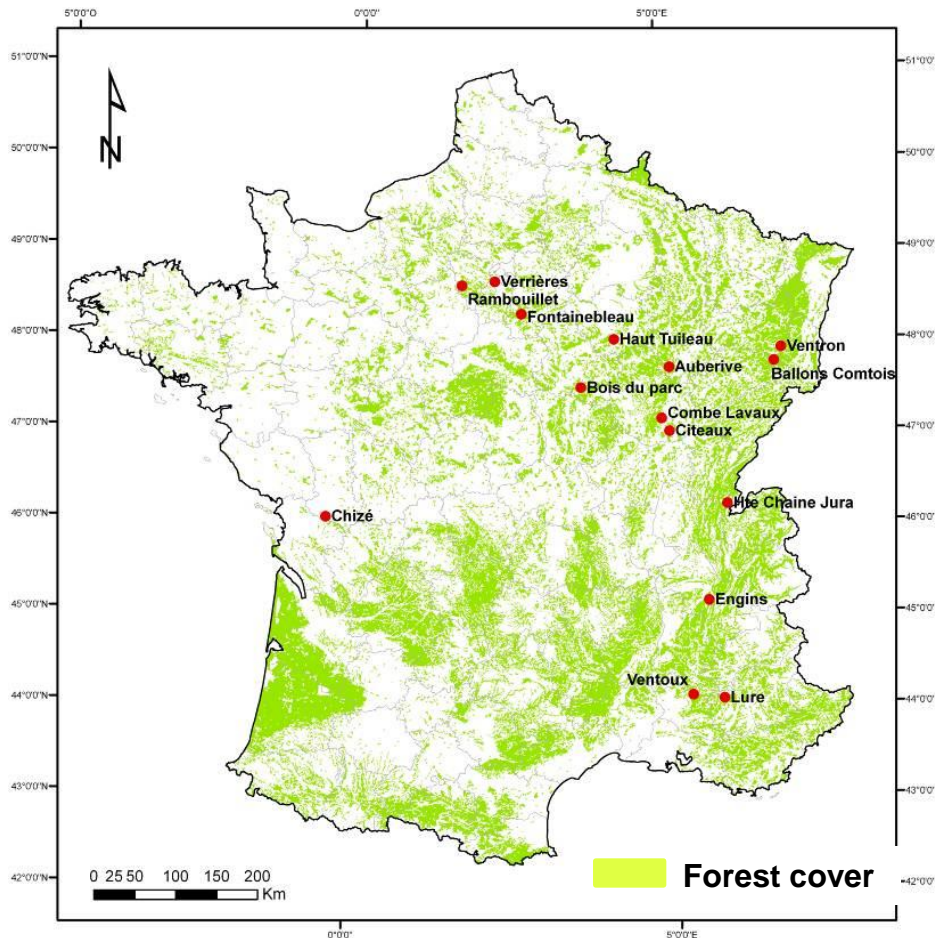
Species richness



↪ Are there some key structural variables behind the reserve effect ?

↪ For bryophytes, do climatic variables play a role in addition to or interaction with management or stand structural variables (Raabe et al. 2010)?

# A multi-site sampling design



- ↳ 213 stands in 15 French forests
- ↳ Balanced between managed and unmanaged stands (>20 years), on similar site types (topography, soil)

**Time since the last harvest**

(min Max)

**MAN:  $9 \pm 12$  years (0 49)**

**UNM:  $46 \pm 38$  years (8 148)**



# Investigated variables

## Explanatory variables

### « Reserve »

**MAN vs UNM,**  
distance to UNM sites,  
duration of unmanagement



### « Biological legacy »

Quantity and diversity of :  
Deadwood types,  
Microhabitats  
Large trees



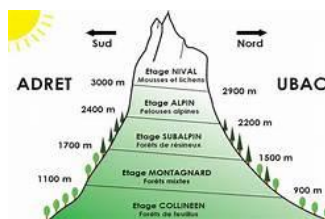
M. Baltzinger

### « macro- and microclimate »



Temperature (Worldclim)  
Altitude  
Atmospheric humidity  
Light

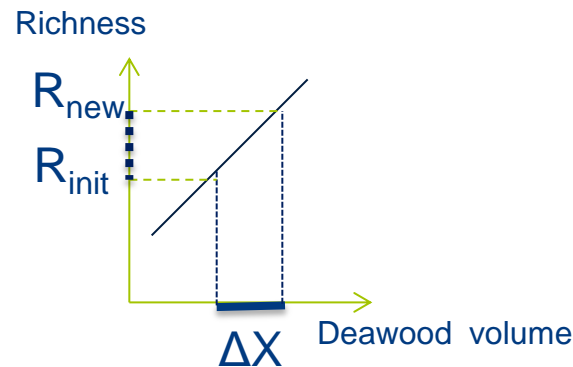
} Ellenberg  
bioindicated



# Models and magnitude analysis

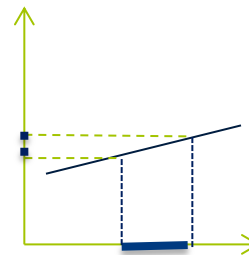
- Bayesian Generalized linear mixed effects models to explain the **richness** of each taxonomic group
- Simulation of a change  $\Delta X$  in the explanatory variable to assess the **magnitude of the effect** (Barbier *et al.*, 2009) on the mean of the response variable

Strong effect



$$\frac{R_{\text{new}}}{R_{\text{init}}} \gg 1$$

Low effect



At a 10% threshold:

$$0.9 < \frac{R_{\text{new}}}{R_{\text{init}}} < 1.1$$

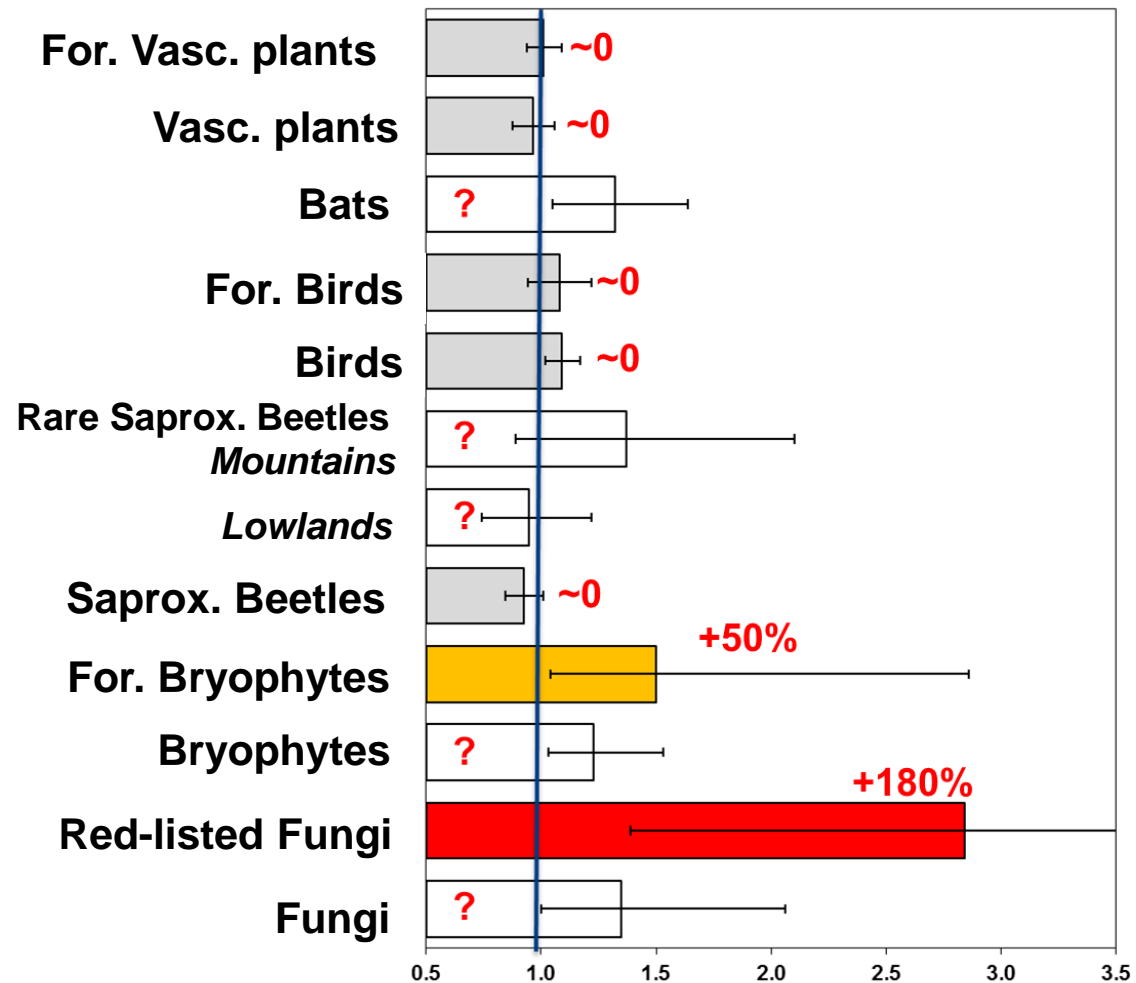
Notations: 10% threshold: + strong positive, - strong negative, 00 low  
 20% threshold: ++, --, 0  
 ? : no possible conclusion

# Reserves highly enhance richness of forest bryophytes and rare fungi

Gosselin et al. (2014)  
*Research Report*

n = 213 plots





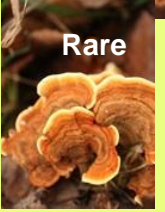

(9 lowland forests,  
6 mountain forests)



Multiplicative factor of the change MAN  $\Rightarrow$  UNM

## Three taxonomic groups with strong + to ++ effects in their best model

Criteria:  
DICmarg

 <p>Bryophytes Forest</p>	Volume of large deadwood	
 <p>Fungi All</p>	Deadwood volume	
 <p>Rare</p>	Proximity to protected area	

Gosselin et al.,  
Rdvt ONF, (2017)

The MAN vs UNM model was not the best model for these groups.

# Bryophytes: do climatic data enhance the models?

## 1) Forest bryophyte group

The best model remains the simple « Volume of large deadwood » threshold model

Best Models	Type	DICm	Variable	Sign.	Magn.
<b>Large deadwood volume (LDV)</b>	┌	<b>529.2</b>	<b>LDV</b>	<b>***</b>	<b>++</b>
Deadwood volume + <b>Humidity</b>	/	529.9	DV	***	+
			Hum	*	0
Deadwood volume + <b>Light</b>	∩	532.5	DV	***	+
			Light	ns	0
Deadwood volume* <b>Humidity</b>	/	533	DV	***	+
			Hum	*	0
			DV*hum	ns	00
Deadwood volume	/	535	DV	***	+
Deadwood volume * <b>Light</b>	/	535.5	DV	***	+
			Light	ns	0
			DV*Light	ns	00

# Bryophytes: do climatic data enhance the models?

The best model remains the simple « Volume of large deadwood » threshold model

1) Forest bryophyte group

Best Models	Type	DICm	Variable	Sign.	Magn.
Large deadwood volume (LDV)	┌	529.2	LDV	***	++
Deadwood volume + Humidity	/	529.9	DV	***	+
			Hum	*	0
Deadwood volume + Light	/		DV	***	+
			Light	ns	0
Deadwood volume* Humidity	/		DV	***	+
			Hum	*	0
			DV*hum	ns	00
Deadwood volume	/	535	DV	***	+
Deadwood volume * Light	/	535.5	DV	***	+
			Light	ns	0
			DV*Light	ns	00

Climatic variables enhance other models in addition to (or interaction with) deadwood volume, with significant though negligible effects









# Bryophytes: do climatic data enhance the models?

2) All bryophytes

The best model remains the simple  
« **Volume of deadwood** »  
sigmoid model - Magn = nc







Best Models	Type	DICm	Variable	Sign.	Magn.
<b>Deadwood volume (DV)</b>		<b>734.9</b>	<b>DV</b>	<b>***</b>	<b>nc</b>
Deadwood volume * <b>Altitude</b>		735.5	DV	***	nc
			Alt	ns	0
			DV*Alt	ns	00
Deadwood volume + <b>Humidity</b>		736.1	DV	***	0
			Hum	ns	00
Large living tree volume (LV)		736.2	LV	***	0
Deadwood volume + <b>Light</b>		736.5	DV	***	+/nc/0
			Light	ns	00/00/00
Mean living tree diameter (Dq)		535.5	Dq	***	0/00/00

# Bryophytes: do climatic data enhance the models?

2) All bryophytes

The best model remains the simple « Volume of deadwood » sigmoid model - Magn = nc



Best Models	Type	DICm	Variable	Sign.	Magn.
Deadwood volume (DV)		734.9	DV	***	nc
Deadwood volume * <b>Altitude</b>		735.5	DV	***	nc
			Alt	ns	0
			DV*Alt	ns	00
Deadwood volume + <b>Humidity</b>			DV	***	0
			Hum	ns	00
Large living tree volume (LV)			LV	***	0
Deadwood volume + <b>Light</b>		736.5	DV	***	+/nc/0
			Light	ns	00/00/00
Mean living tree diameter (Dq)		535.5	Dq	***	0/00/00

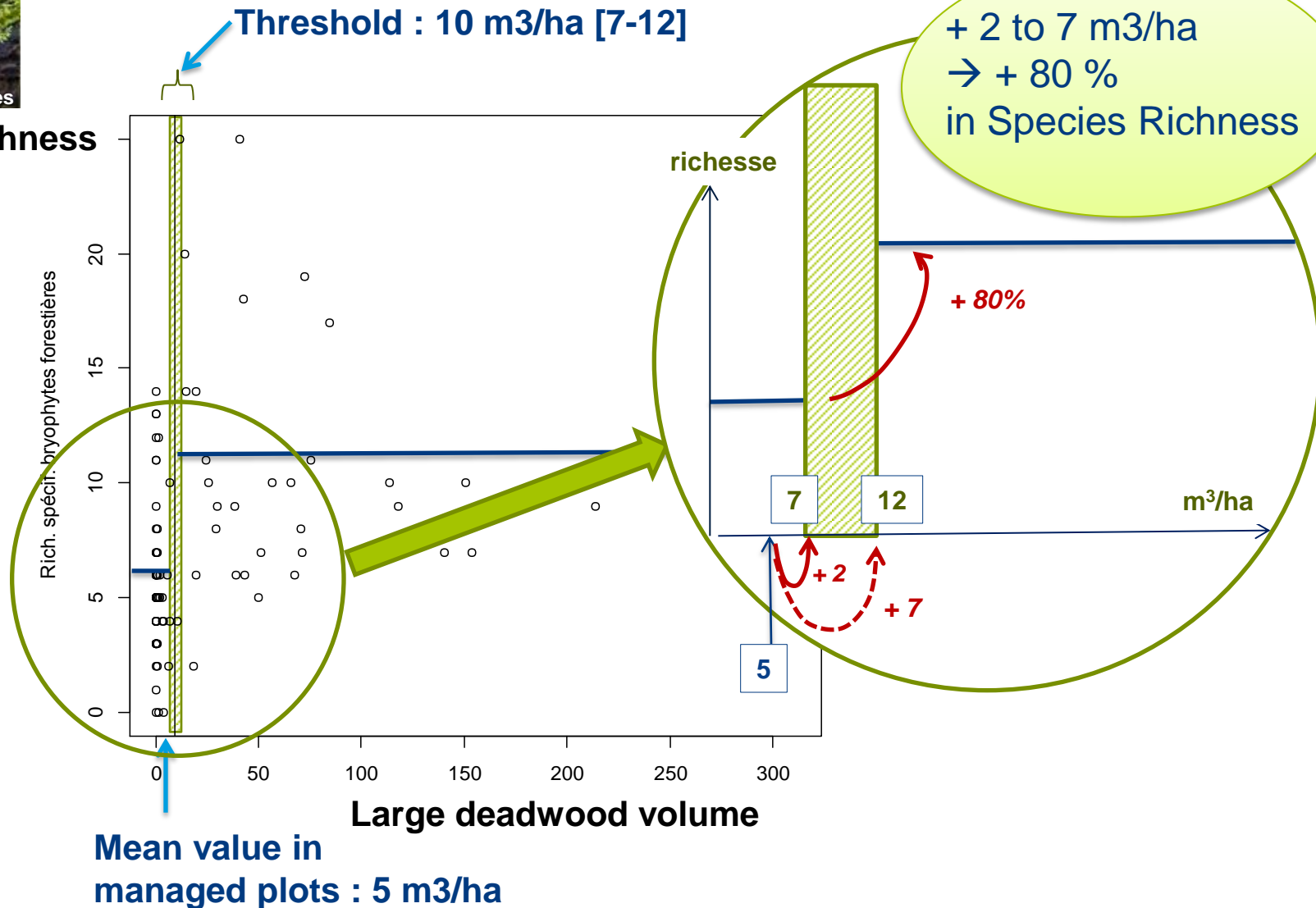
Topographic and Climatic variables appeared among the best models in addition to (or interaction with) deadwood volume, with low effects

Large living trees and Mean diameter also were among the best models

# Forest bryophytes: possible applications from the best model

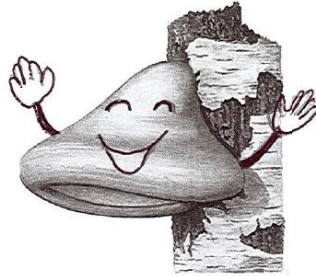


Sp. richness



## Conclusion

⇒ **Strong positive effect of reserves on forest bryophytes and red-listed lignicolous fungi**



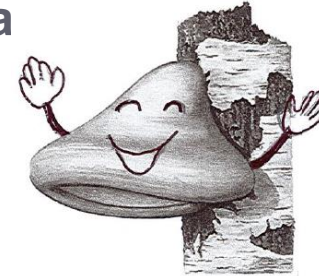
⇒ **Best models for bryophytes = deadwood metrics**



→ Climatic data enhance the models explaining forest bryophytes richness in addition to deadwood or living wood metrics, but the strongest effects are those of deadwood volume.

## Discussion

⇒ The utility of segregative and of integrative practices is confirmed for the richness of these taxa



- Limits : very few old or big reserves (recent policy)
- Possible applications need to be discussed with forest managers

+ 5 forest bryophyte species

GAIN

+ 2 to 7 m<sup>3</sup>/ha large deadwood

COST

Interest ? Feasibility ?



😊😊 Many thanks to 😊😊

- 😊 Your attention!
- 😊 French Ministry of Ecology & ONF for funding
- 😊 All the persons (~100) that were involved at some point in the project