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

Marion Gosselin, Yann Dumas, Camille Fabbri, Serge Cadet, Nicolas Debaive, Yoan Paillet, Frédéric Gosselin

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Gosselin, M., Dumas, Y., Fabbri, C., **Cadet, S.**,
Debaive, N., Paillet, Y., Gosselin, F.

Irstea – Nogent-s/-Vernisson, France

ONF, France

RNF – Dijon, France

International Conference of Ecological Sciences – Rennes – October 22-25 2018

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)

Hunter 1999 Cambridge U. Press
Lindenmayer & Franklin 2002 Island Press

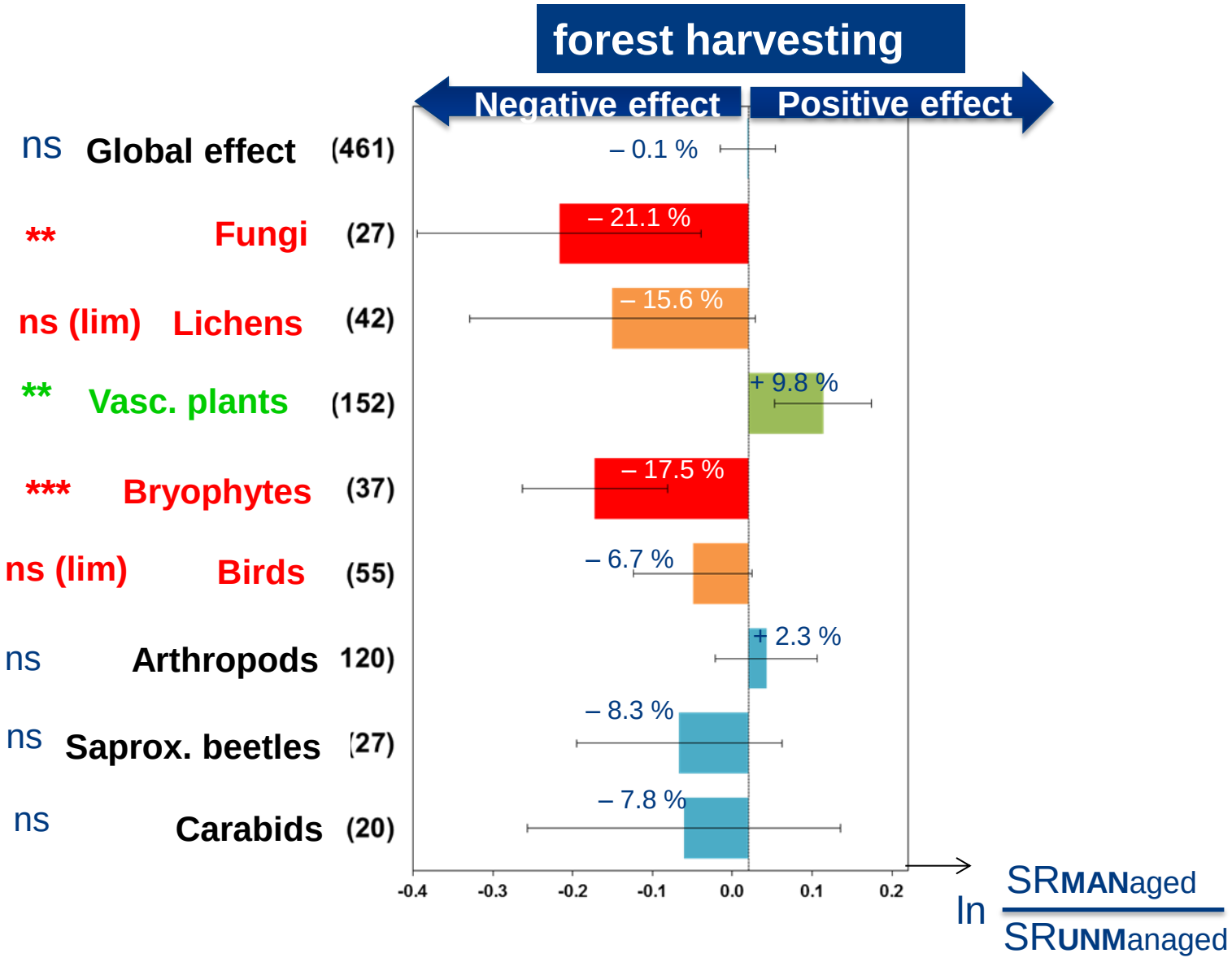
State of knowledge

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*

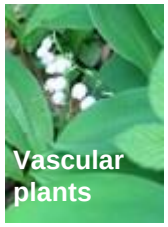
– *sampling often problematic (e.g. pseudoreplication)*

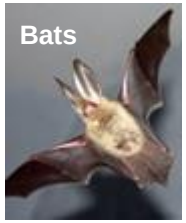
– *explanatory factors often not incorporated*

Questions

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

Species richness



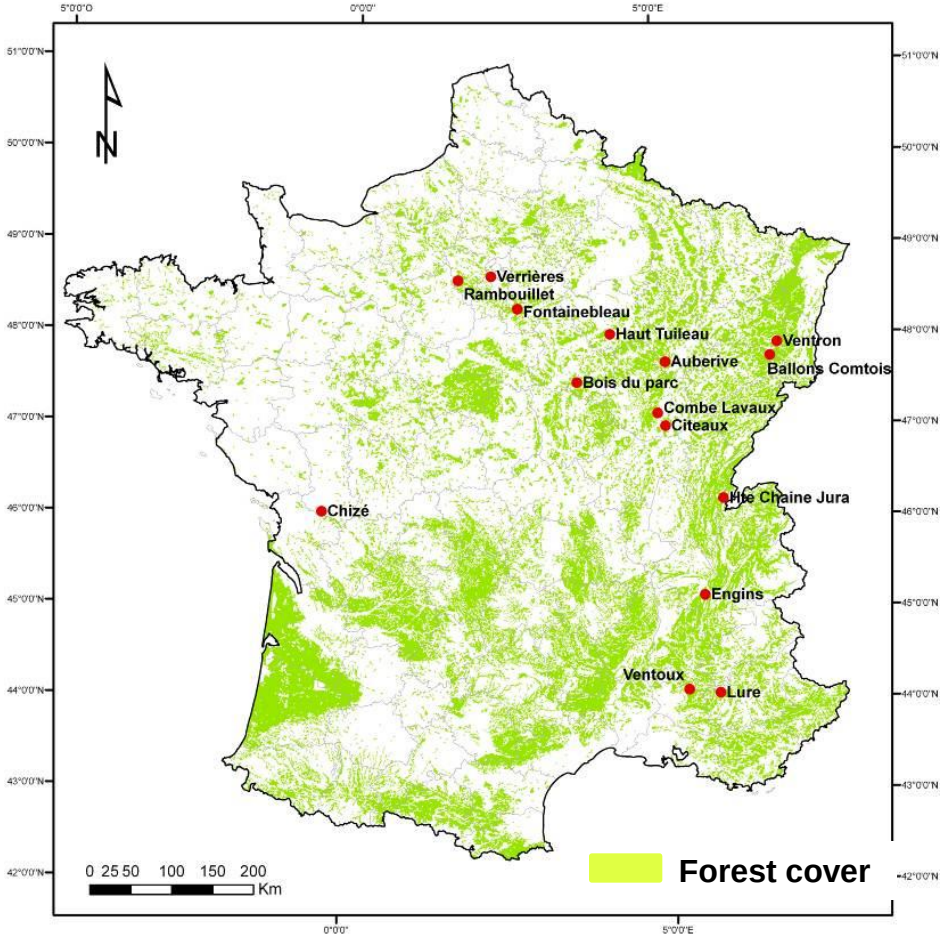


?

↳ 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 ±12 years	(0	49)
UNM: 46 ± 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 :

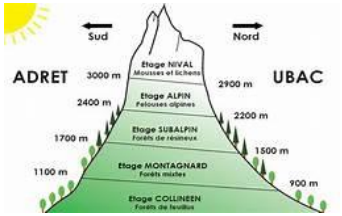
Deadwood types,
Microhabitats
Large trees

M. Baltzinger

« macro- and microclimate »

Temperature (Worldclim)
Altitude
Atmospheric humidity
Light

} Ellenberg bioindicated

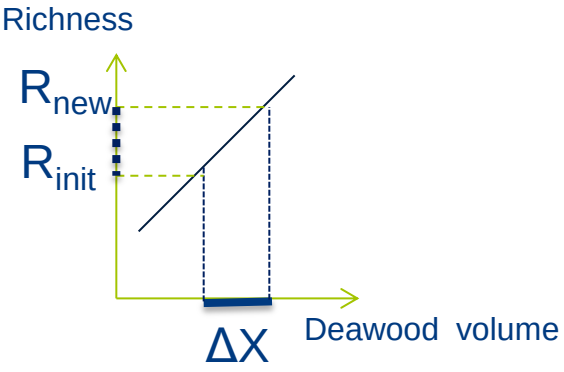


Models and magnitude analysis

→ **Bayesian Generalized linear mixed effects models** to explain the **richness** of each taxonomic group

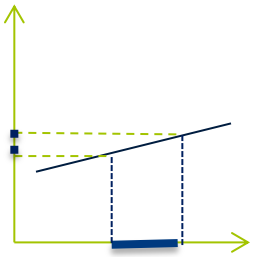
→ Simulation of a change ΔX in the explanatory variable to assess the **magnitude of the effect** (Barbier *et al*., 2009) on the mean of the response variable

Strong effect



$$\frac{R_{new}}{R_{init}} >> 1$$

Low effect



At a 10% threshold:

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

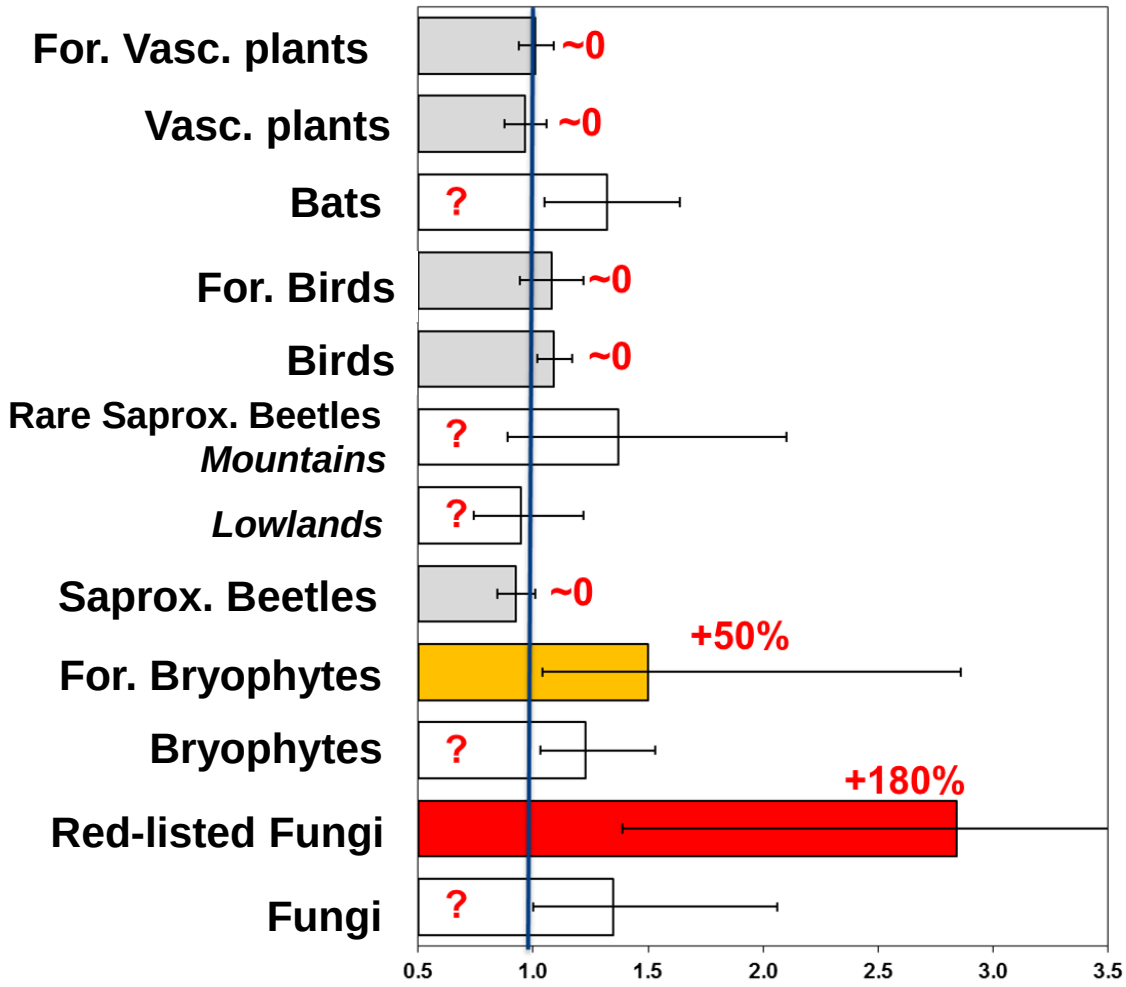
Notations: 10% threshold: + strong positive, **–** strong negative, 00 low
20% threshold: ++ , **– – , 0**
? : no possible conclusion

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 ⇨ UNM

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

Criteria: DICmarg

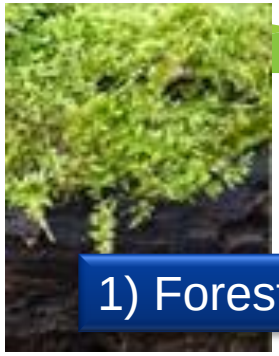
Volume of large deadwood

Deadwood volume

Proximity to protected area

Gosselin et al., Rdvt ONF, (2017)

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

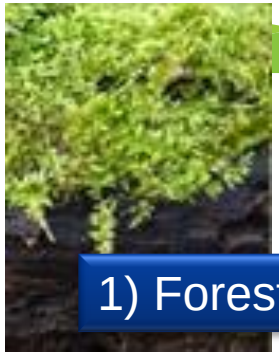


Bryophytes: do climatic data enhance the models?

1) Forest bryophyte group

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

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



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			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.
Deadwood volume (DV)		**734.9**	**DV**	*******	**nc**
Deadwood volume * **Altitude**		735.5	DV	***	nc
			Alt	ns	0
			DV*Alt	ns	00
Deadwood volume + **Humidity**		736.1	DV	***	0
			Hum	ns	00
Large living tree volume (LV)		736.2	LV	***	0
Deadwood volume + **Light**		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 * **Altitude**		735.5	DV	***	nc
			Alt	ns	0
			DV*Alt	ns	00
Deadwood volume + **Humidity**			DV	***	0
			Hum	ns	00
Large living tree volume (LV)			LV	***	0
Deadwood volume + **Light**	∩	736.5	DV	***	+/nc/0
			Light	ns	00/00/00
Mean living tree diameter (Dq)	∩	535.5	Dq	***	0/00/00

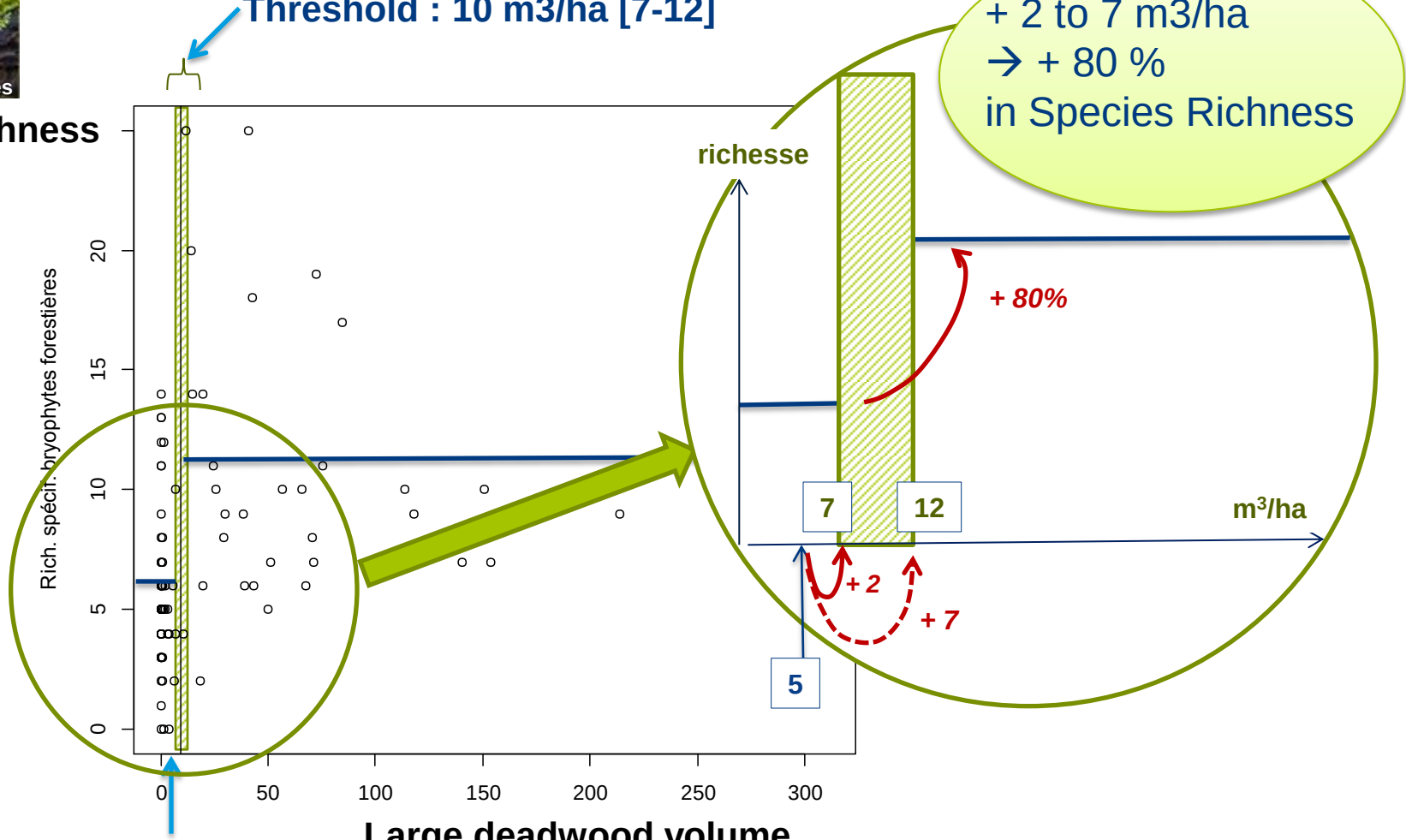
Topographic and Climatic variables appeared among the best models in addition to (or interaction with) deadwood volume, with low effects

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

Forest bryophytes: possible applications from the best model

Sp. richness

Threshold : 10 m3/ha [7-12]

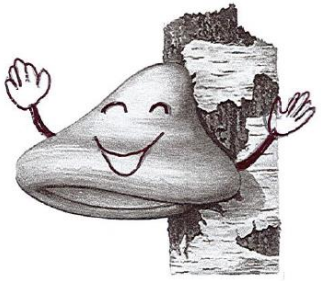


+ 2 to 7 m3/ha
→ + 80 %
in Species Richness

Mean value in managed plots : 5 m3/ha

Conclusion

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

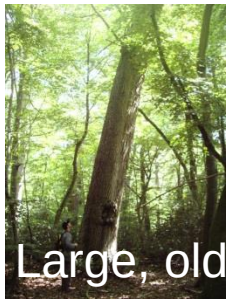


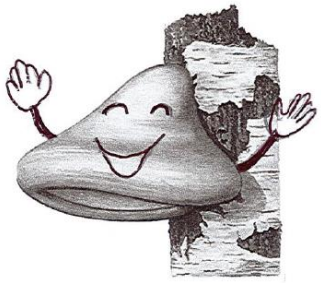
⇨ **Best models for bryophytes = deadwood metrics**

→ **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 m3/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