Dépérissement des chênes et communautés d'insectes des canopées

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Contrasting responses of trophic guilds to forest decline reshape canopy insect community

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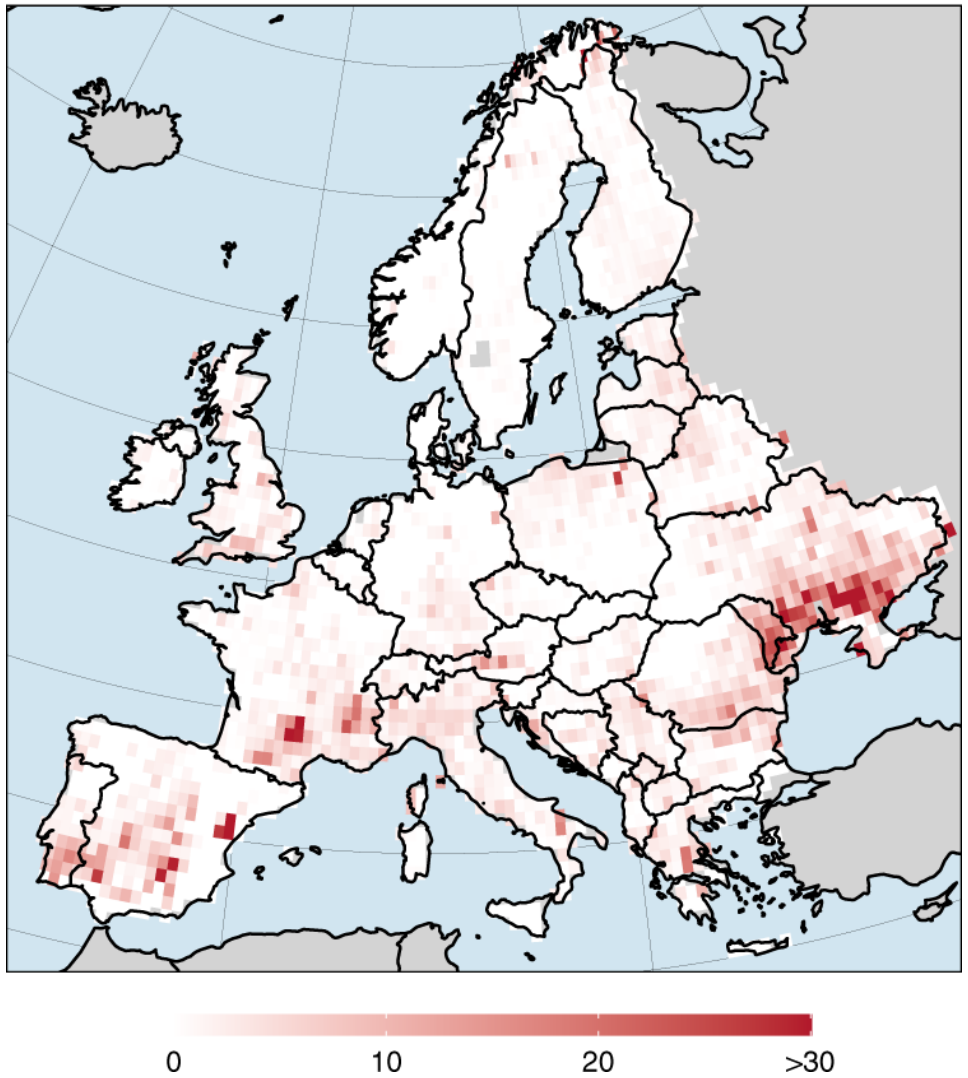
Percent of total mortality attributable to drought



Senf et al. 2020 Nat. Comm.

Climate change: increased severity and frequency of droughts & heatwaves (Allen et al. 2010)

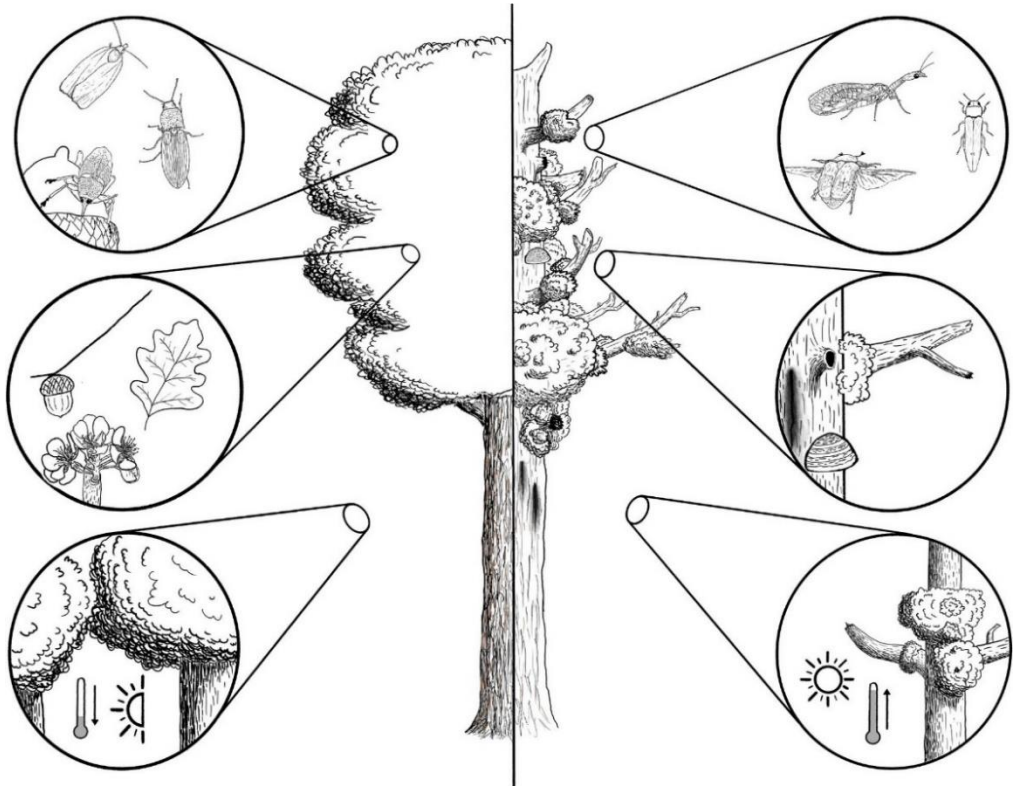
→ Large-scale forest disturbances
→ Large-scale forest declines and diebacks
→ **Large-scale degradation of forest canopies**

Declining oaks – © A. Sallé

Forest decline: gradual degradation of forest health leading to tree death after several years. Leads to **collapses and pulses of microhabitats and trophic resources**.

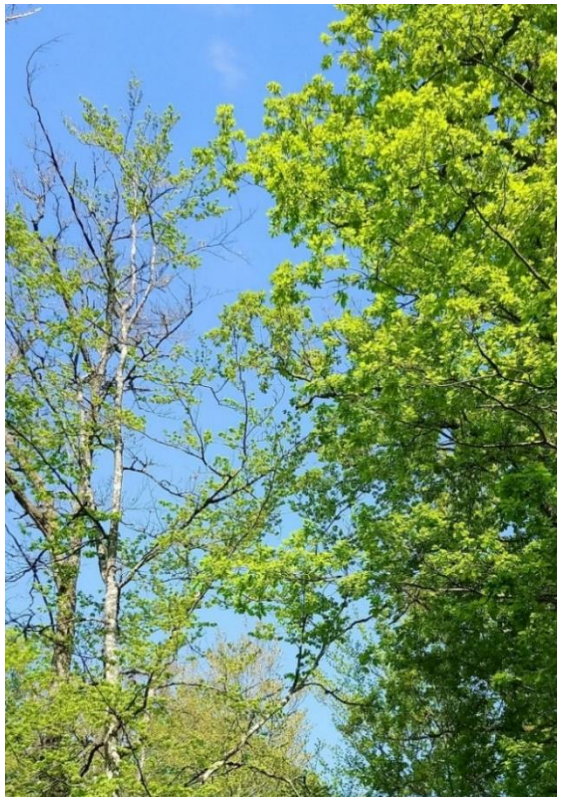
→ **Collapses**: **Rapid crown alteration** with loss of foliage & change in foliage quality and microclimates.

→ Deleterious effects on foliage-feeding species (phyllophagous, gall-inducer, …)?



Overview of decline-induced changes in arthropod communities (upper insets), resources and habitats (medium insets), and microclimates (lower insets) in forest canopies.

Sallé et al. 2021 Front. For. Glob. Change



Declining tree (left) & healthy tree (right)

© A. Sallé

→ **Pulses:** Positive effects on saproxylic species (mycophagous, xylophagous, …) and flower-dependent taxa ?


Quantity and diversity of dead wood

Sap flow

Opportunistic fungi

Trunk cavities

Soil resources

Floral resources

- **Question:**

What are the effects of oak decline on the functional structure of the community of canopy-dwelling insects ?

- **Objectives:**

To characterize the community of canopy insects.

To assess the effects of decline on this community and its trophic guilds.

- **Hypotheses:**

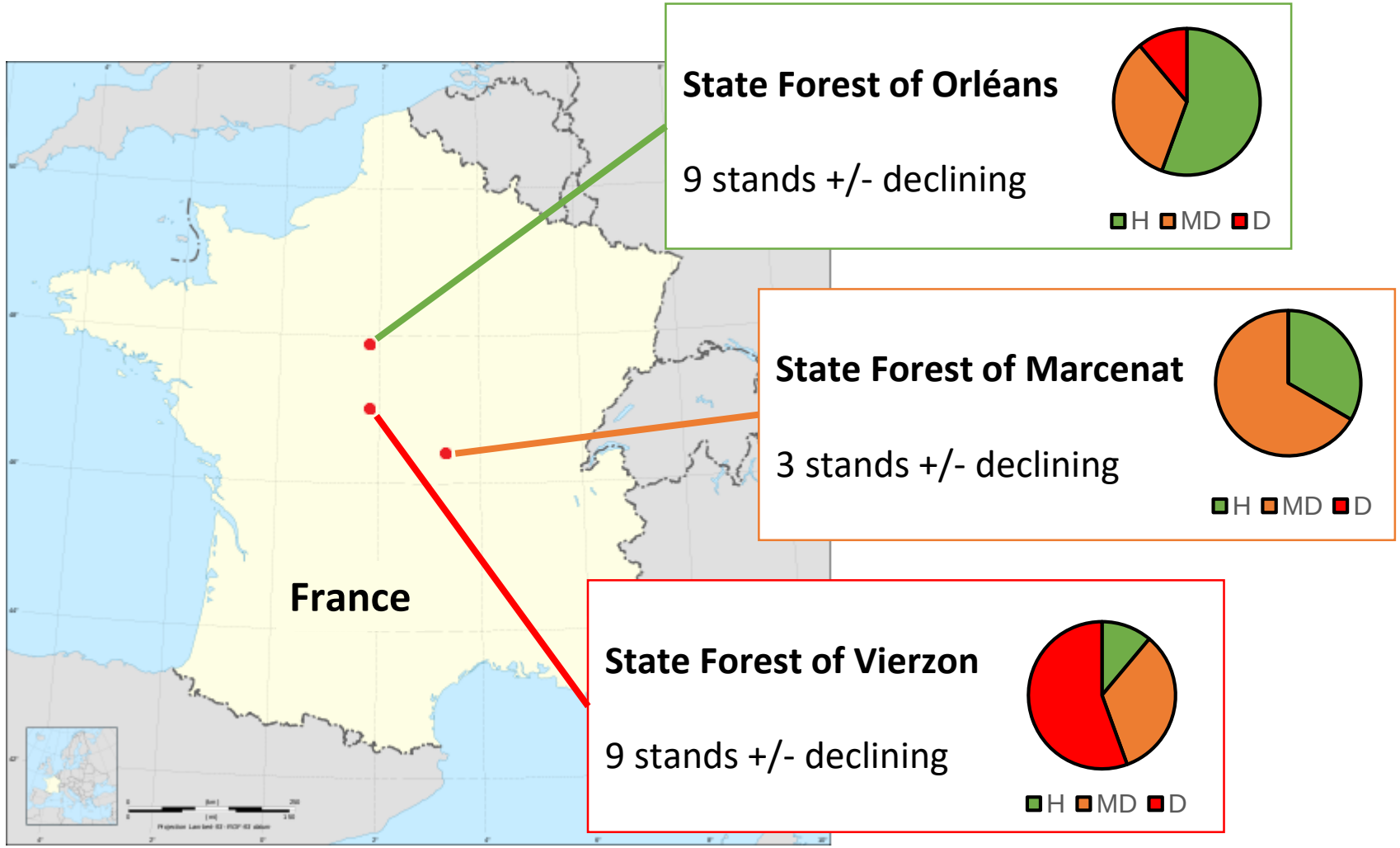
I. The level of decline influences the species composition, due to species turnover

II. Contrasting effects of forest decline on abundance and species richness of larval trophic guilds

Ledra aurita – © S. Damoiseau

Study areas in 2019: Oak dominated forests.

H: Healthy stand - MD: Moderately declining stand - D: Declining stand



Dieback surveys in 2019 and 2020:
Quantification of crown degradation (DEPERIS protocol) on 10 trees/plot and 30 trees/stand


MB = 0
MR = 0
DEPERIS = 0/A


MB = 1
MR = 2
DEPERIS = 2,6/C


MB = 1
MR = 3
DEPERIS = 3,4/D


MB = 2
MR = 3
DEPERIS = 3,8/E

Sampling: 2 trees/stand, with **one green multi-funnel trap + one flight-interception trap** on each.

→ 1 plot = 1 tree with the two types of traps + 9 trees around the trap tree

Traps hanged in the **oak canopy** (10-15 m).

Sampling performed over the **activity period of insects** (from April to September 2019).

Identification: At **the lowest taxonomic level**.

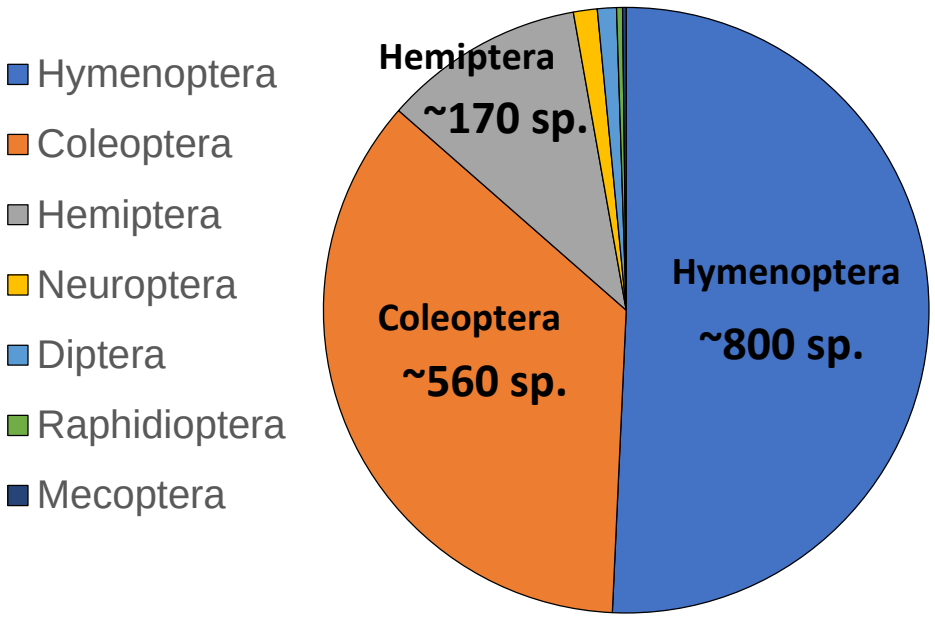
Analysis: Data were pooled at the plot level

Oak canopy (left) with green multi-funnel trap (middle) & flight-interception trap (right). © E. Le Souchu

Community overview

Approx. **132,000 indiv.** for **1,569 species.**
Divided into **7 orders**, **127 families** and **16 larval trophic guilds**.

Species richness of sampled orders



Larval trophic guilds

Plant-based diet
- Gall-inducer
- Rhizophagous
- Seminiphagous
- Phyllophagous
- Sap-feeder

Flower-dependent
- Anthophagous
- Pollinivorous/Nectarivorous

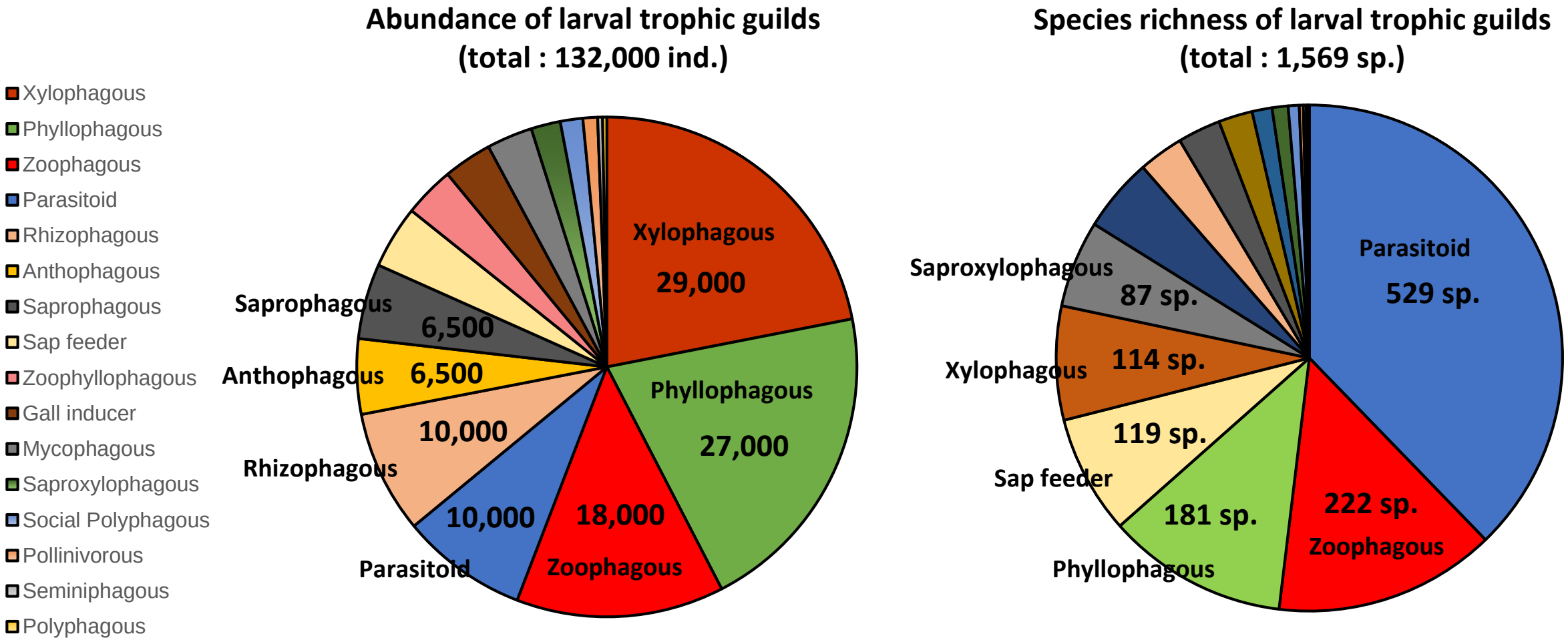
Wood-based diet
- Saproxylophagous
- Xylophagous

Polyphagous
- Social polyphagous
- Polyphagous

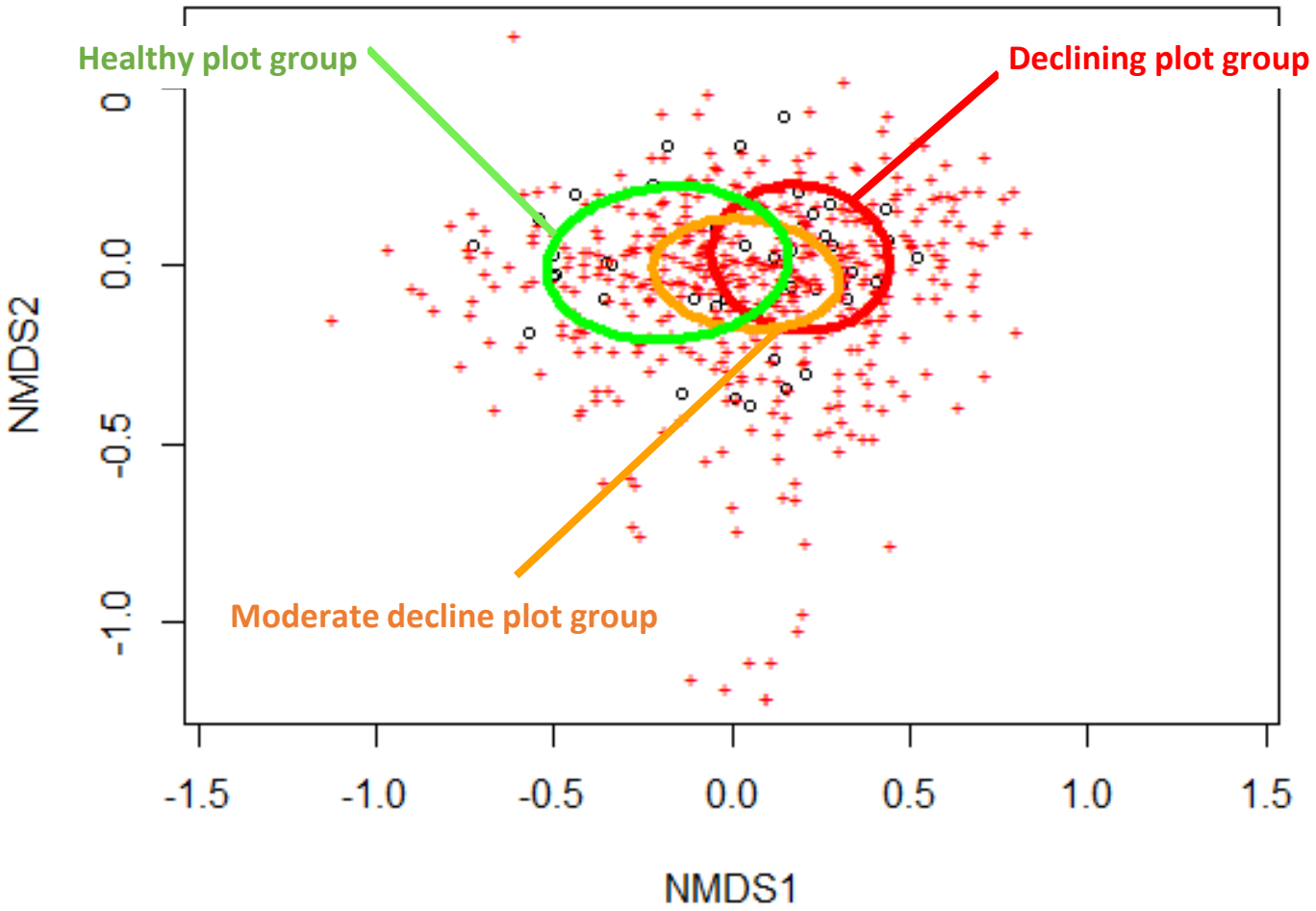
Prey/host-dependent
- Parasitoid
- Zoophagous
- Zoophyllophagous

Others
- Mycophagous
- Saprophagous

Community overview



Community richness & composition



NMDS ordination (k=3, stress=0.13) of the assemblages of species by site (stand and tree), grouped by levels of plot decline

The level of plot decline **has an effect on species composition of the community**

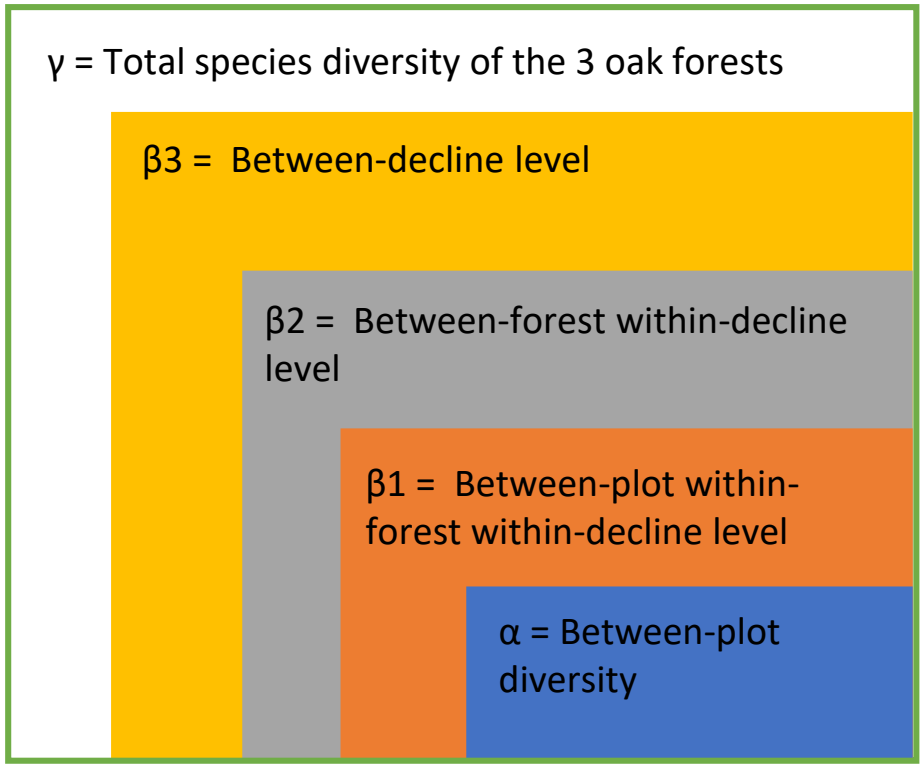
PERMANOVA (999 permutations ; R^2 = 0,13 ; pval = 0.001 ***)

The decline **has no effect on species richness**

GLMER (neg. binom.; best model = null model)

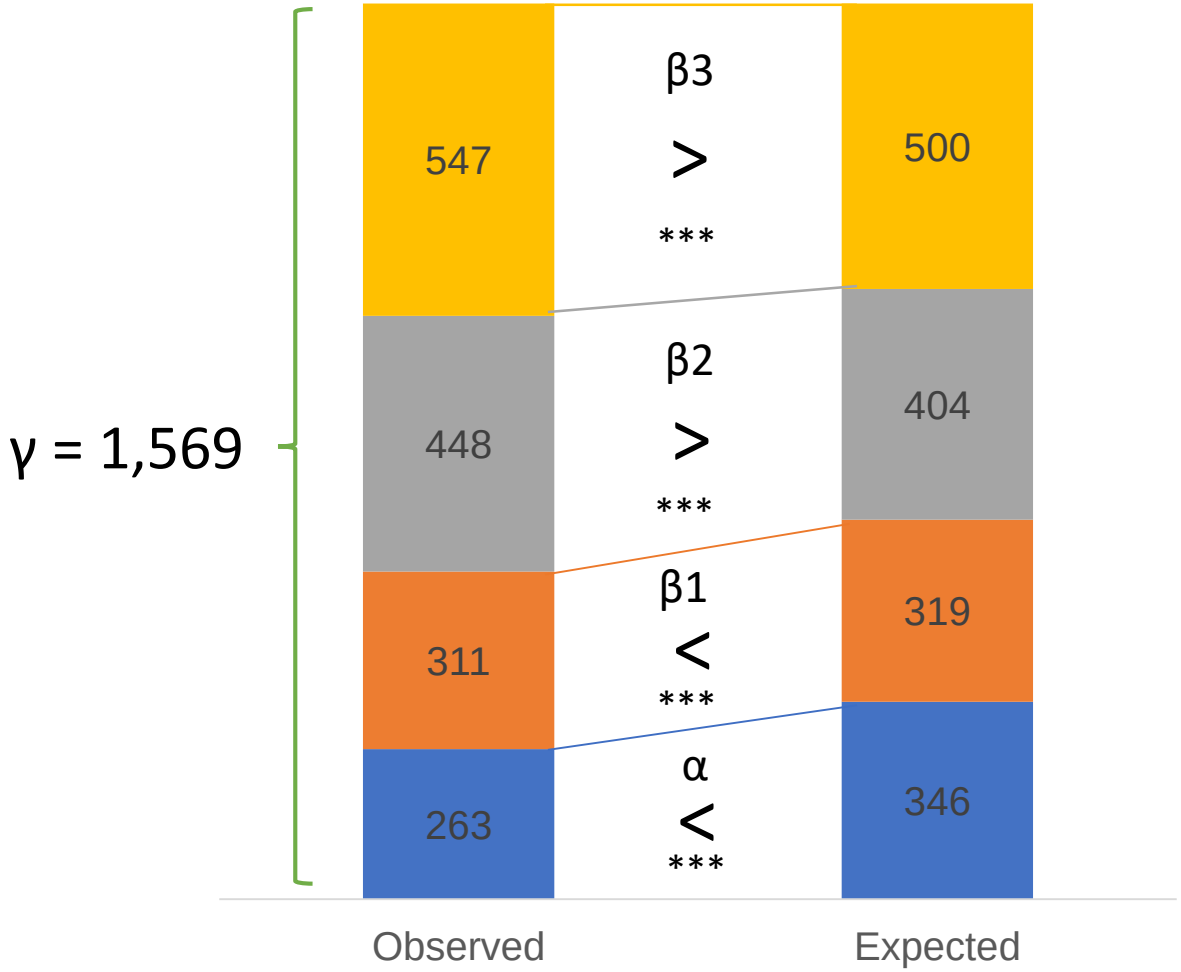
The decline reshapes the community but does not make it neither richer nor poorer.

Community richness & composition

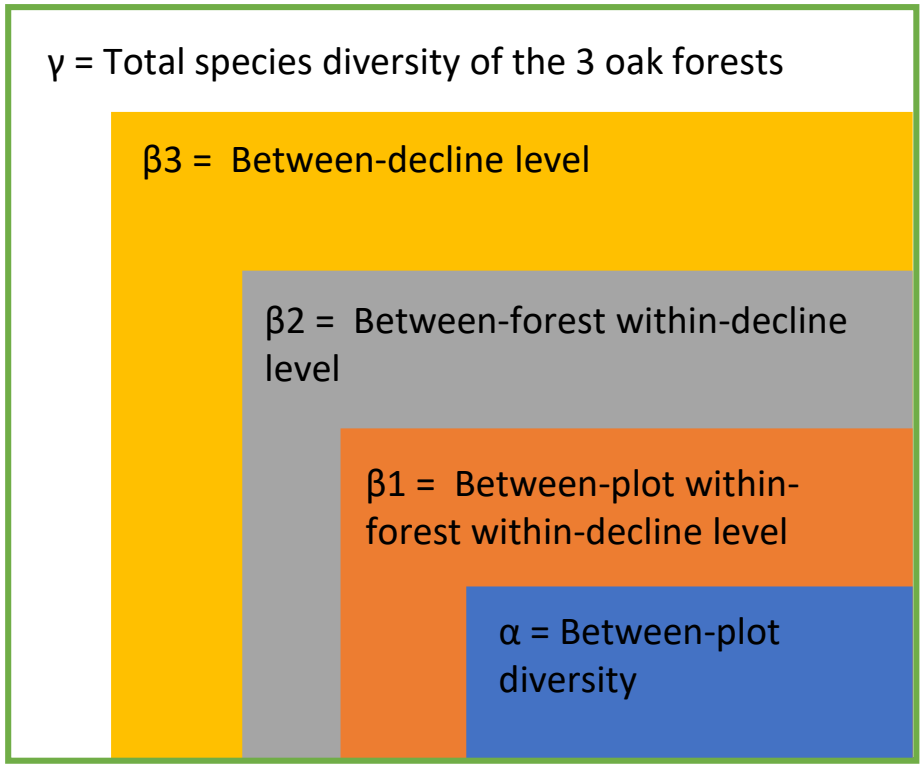


The associations between the spatial scale analysed and each diversity component
Decline levels: Healthy, Moderate decline and Declining

Additive partitioning of the species diversity components



Community richness & composition



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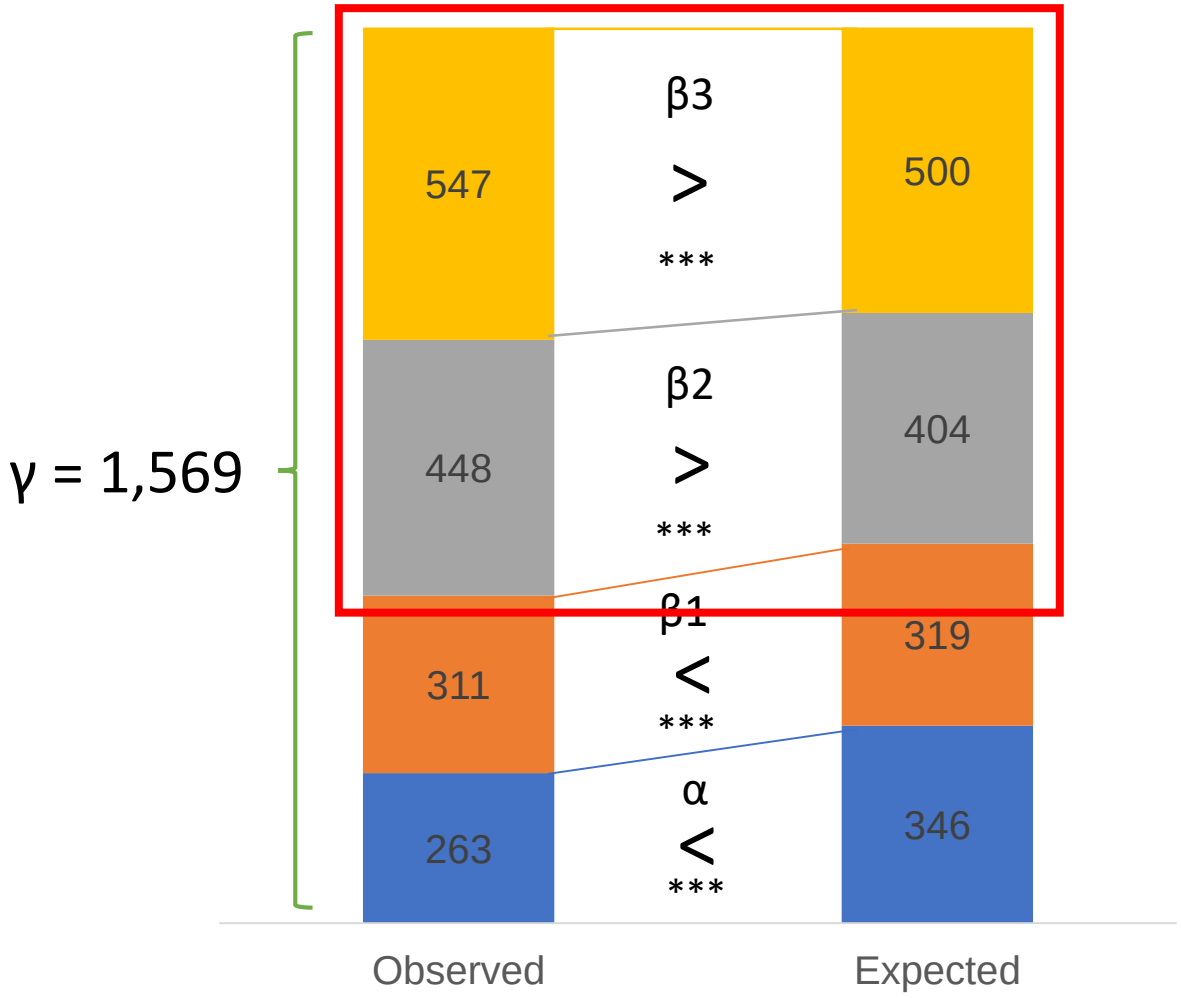


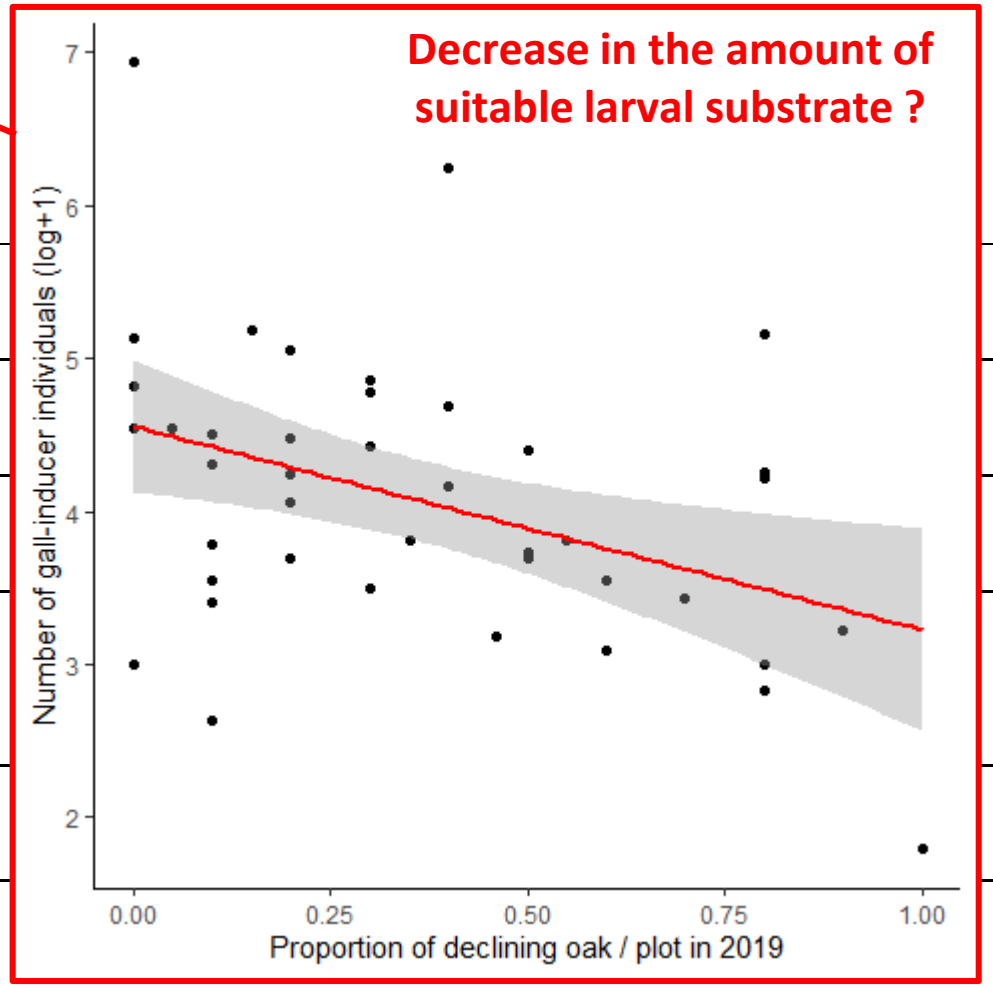
Turnover contributes to change species composition, among levels of plot decline

Larval trophic guilds

	Larval trophic guild	Decline effect on guild abundance		Decline effect on species richness
Plant based diet	Gall-inducer	Negative	*	ns
	Rhizophagous	ns		ns
	Seminiphagous	ns		ns
	Phyllophagous	ns		ns
	Sap feeder	ns		ns
Flower dependant	Anthophagous	Positive then negative	d1: . ; d2: *	ns
	Pollinivorous	Positive	d1: * ; d2: *	ns
Wood based diet	Xylophagous	ns		ns
	Saproxylophagous	ns		ns
Polyphagous	Polyphagous	ns		ns
	Social polyphagous	ns		ns
Prey/host dependent	Parasitoid	ns		ns
	Zoophagous	ns		ns
	Zoophytophagous	ns		ns
Others	Mycophagous	Positive then negative	d1: *** ; d2: ***	ns
	Saprophagous	ns		ns
TOTAL		ns		ns

Larval trophic guilds

	Larval trophic guild	Decline effect on guild abundance	Decline effect on species richness
Plant based diet	Gall-inducer	Negative	ns
	Rhizophagous	ns	
	Seminiphagous	ns	
	Phyllophagous	ns	
	Sap feeder	ns	
Flower dependant	Anthophagous	Positive then negative	
	Pollinivorous	Positive	
Wood based diet	Xylophagous	ns	
	Saproxylophagous	ns	
Polyphagous	Polyphagous	ns	
	Social polyphagous	ns	
Prey/host dependent	Parasitoid	ns	
	Zoophagous	ns	
	Zoophytophagous	ns	
Others	Mycophagous	Positive then negative	
	Saprophagous	ns	
TOTAL		ns	



Larval trophic guilds

Plant based

Flower dep

Wood base

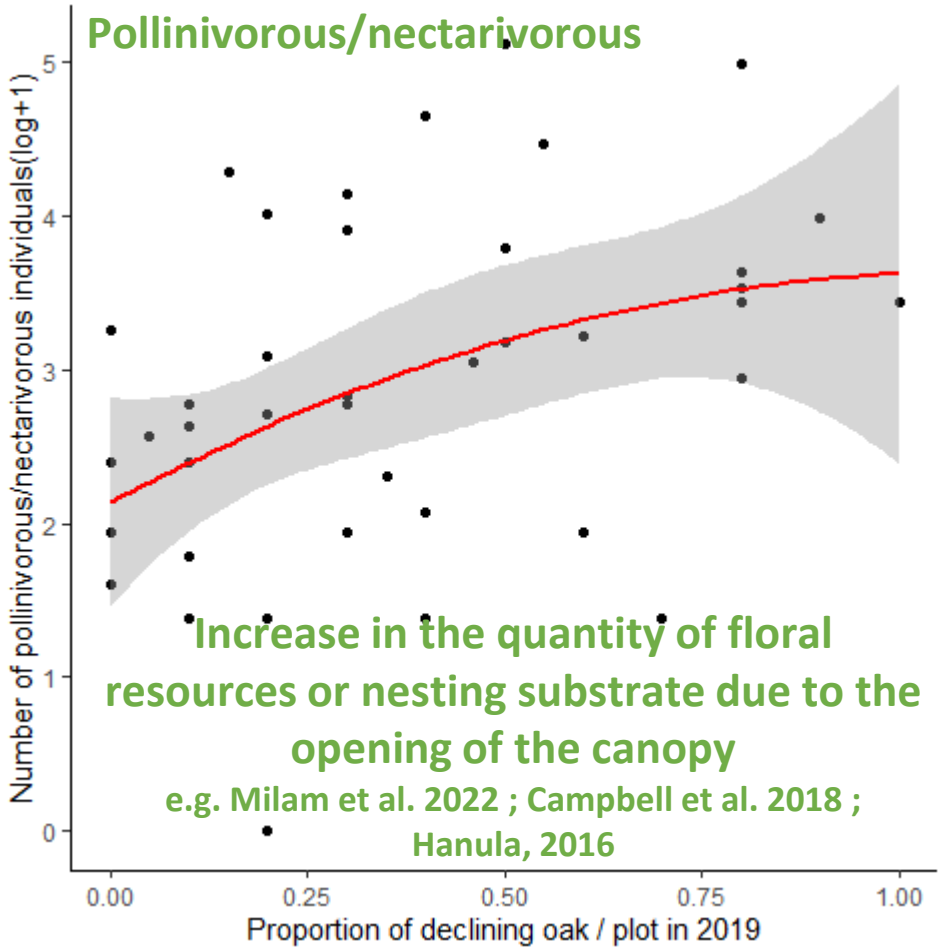
Polyphagou

Prey/host c

Others

TOTAL ns ns

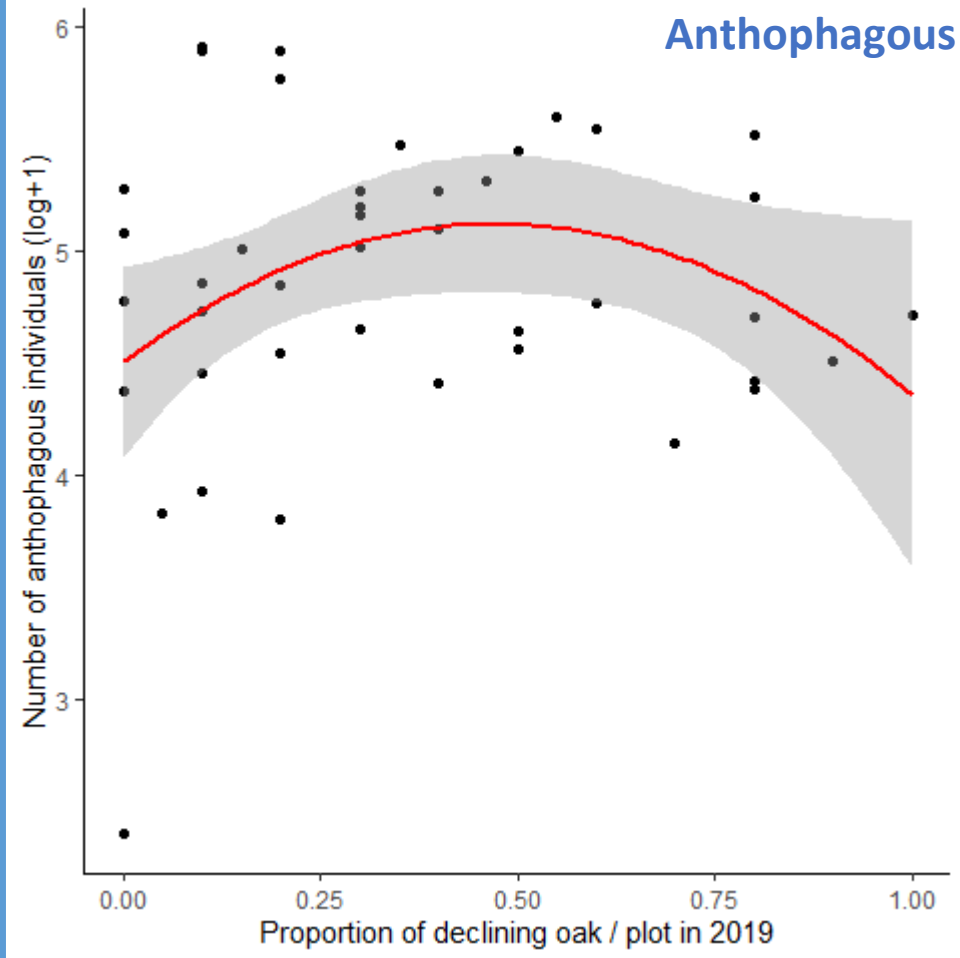
Pollinivorous/nectarivorous



Increase in the quantity of floral resources or nesting substrate due to the opening of the canopy

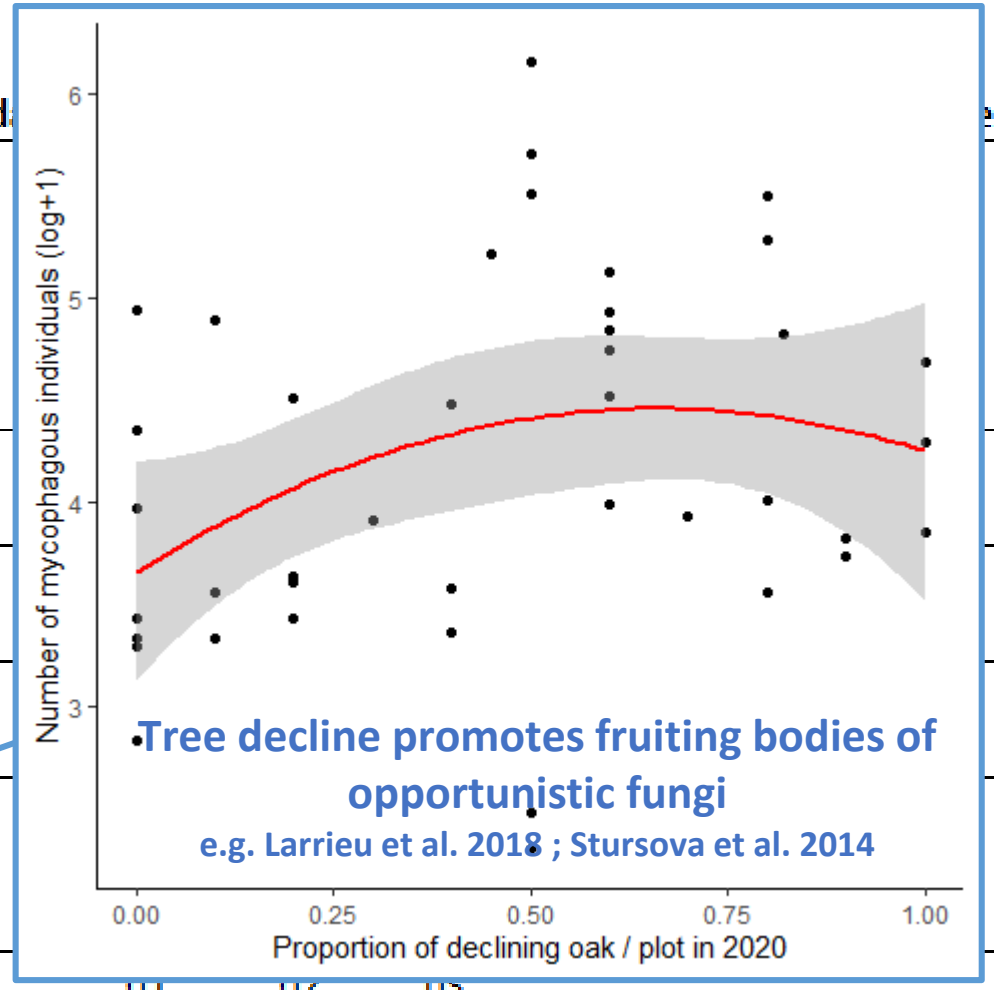
e.g. Milam et al. 2022 ; Campbell et al. 2018 ; Hanula, 2016

Anthophagous



Larval trophic guilds

	Larval trophic guild	Decline effect on guild abund	ess
Plant based diet	Gall-inducer	Negative	
	Rhizophagous	ns	
	Seminiphagous	ns	
	Phyllophagous	ns	
	Sap feeder	ns	
Flower dependant	Anthophagous	Positive then negative	
	Pollinivorous	Positive	
Wood based diet	Xylophagous	ns	
	Saproxylophagous	ns	
Polyphagous	Polyphagous	ns	
	Social polyphagous	ns	
Prey/host dependent	Parasitoid	ns	
	Zoophagous	ns	
	Zoophytophagous	ns	
Others	Mycophagous	Positive then negative	
	Saprophagous	ns	ns
TOTAL		ns	ns



Tree decline promotes fruiting bodies of opportunistic fungi

e.g. Larrieu et al. 2018 ; Stursova et al. 2014

Larval trophic guilds

	Larval trophic guild	Decline effect on guild abundance		Decline effect on species richness
Plant based diet	Gall-inducer	**Negative**	*	ns
	Rhizophagous	ns		ns
	Seminiphagous	ns		ns
	Phyllophagous	ns		ns
	Sap feeder	ns		ns
Flower dependant	Anthophagous	**Positive then negative**	d1: . ; d2: *	ns
	Pollinivorous	**Positive**	d1: * ; d2: *	ns
Wood based diet	Xylophagous	ns		
	Saproxylophagous	ns		
Polyphagous	Polyphagous	ns		
	Social polyphagous	ns		
Prey/host dependent	Parasitoid	ns		
	Zoophagous	ns		ns
	Zoophytophagous	ns		ns
Others	Mycophagous	**Positive then negative**	d1: *** ; d2: ***	ns
	Saprophagous	ns		ns
TOTAL		ns		ns

Contradicts previous results of decline and dieback on saproxylic species

e.g. Beudert et al. 2015; Kozak et al. 2021; Cours et al. 2021

Few dendro-microhabitats left in managed forests ?

Philaenus spumarius
© S. Damoiseau

Conclusion

Community richness and composition:

- The decline level modifies the community composition but not the species richness.
- Species turnover contributes to community modification.

Larval trophic guilds:

- Few contrasting responses of trophic guild abundance.
- No effect on the species richness by guild.

→ Management buffers changes in microhabitats and resources between declining and healthy stands ?

→ Integration of both larval AND adult trophic guilds as response variable ?

→ Too many species with different ecological traits within each trophic guild ? Use sub-guilds or taxonomic groups instead ?

Philaenus spumarius
© S. Damoiseau

Improvement of conservation strategies:

Decline reshapes the insect community and acts as a driver of diversity.

Promoting a mosaic of healthy and declining patches within a forest would conserve canopy insect diversity.

Thank you for your attention !

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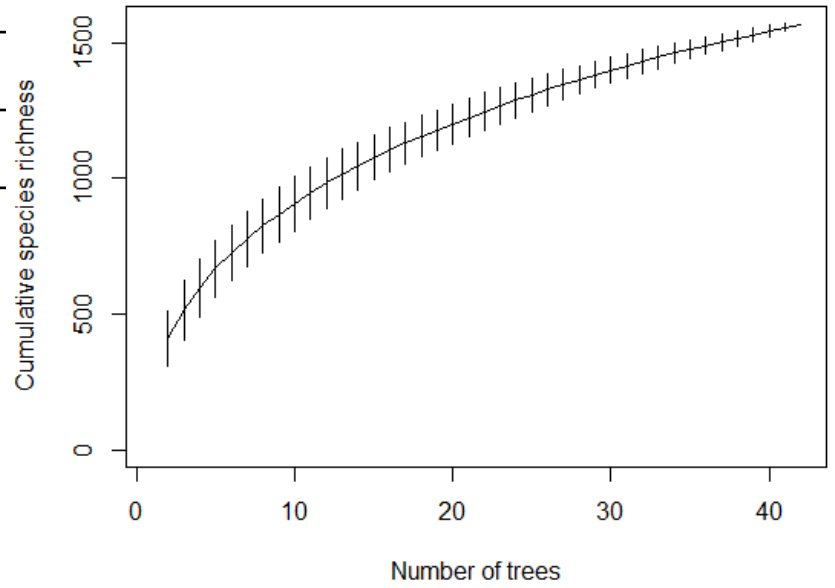
Phyllobius pyri – © S. Damoiseau

Species richness

According to species richness estimators:
between **1,799 and 2,371** sp. expected (67 – 87% of observed sp.)

Completeness of species composition detection estimated using various indices (Chao, Bootstrap and Jacknife 1 & 2)

	Expected					Observed
Area	**Chao**	**Jacknife 1**	**Jacknife 2**	**Bootstrap**	**Range**	
Total	2,150	2,086	2,372	1,799	1,799 – 2,372	**1,569 (66 -87%)**
Orléans	1,480	1,367	1,593	1,154	1,154 – 1,593	**989**
Vierzon	1,575	1,456	1,688	1,240	1,240 – 1,688	**1,071**
Marcenat	1,223	1,170	1,333	1,000	1,000 – 1,333	**860**



Community composition

	Factors	df	F.Model	R^2	p-value
Community composition	Decline	2	3.98	0.13	0.001 ***
	Forest	2	6.73	0.22	0.001 ***
	Decline*Forest	3	1.83	0.09	0.01 *

Effect of the degree of stand decline and forest on the entire insect community studied.
PERMANOVAS made with 999 permutations. p <0.05: *; p <0.01: **; p <0.001: ***.

Decline effect on the overall composition of species and guild
+ all the guilds except social polyphagous and sap feeder

Forest effect on the overall composition of species and guild
+ all the guilds except social polyphagous and zoophagous