Biological control as a habitat restoration tool?

The recovery of the native and endemic flora after the introduction of a fungal pathogen to control the invasive tree *Miconia calvescens* in Tahiti (French Polynesia)

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Assessment of biological control success

- **Direct negative impacts of biocontrol agents on the target invasive species**
  - ↘ distribution: geographic and habitat range
  - ↘ demography: abundance, rate of spread, growth rate, cover…
  - ↘ reproduction: fruit set, seed production, seed germination

  (*Smith & DeBach 1942, Briese 2000, Myers & Bazely 2003*)

- **Indirect positive effects on the recovery of economic plant species in agrosystems**
  - ↗ density, biomass
  - ↗ plant growth

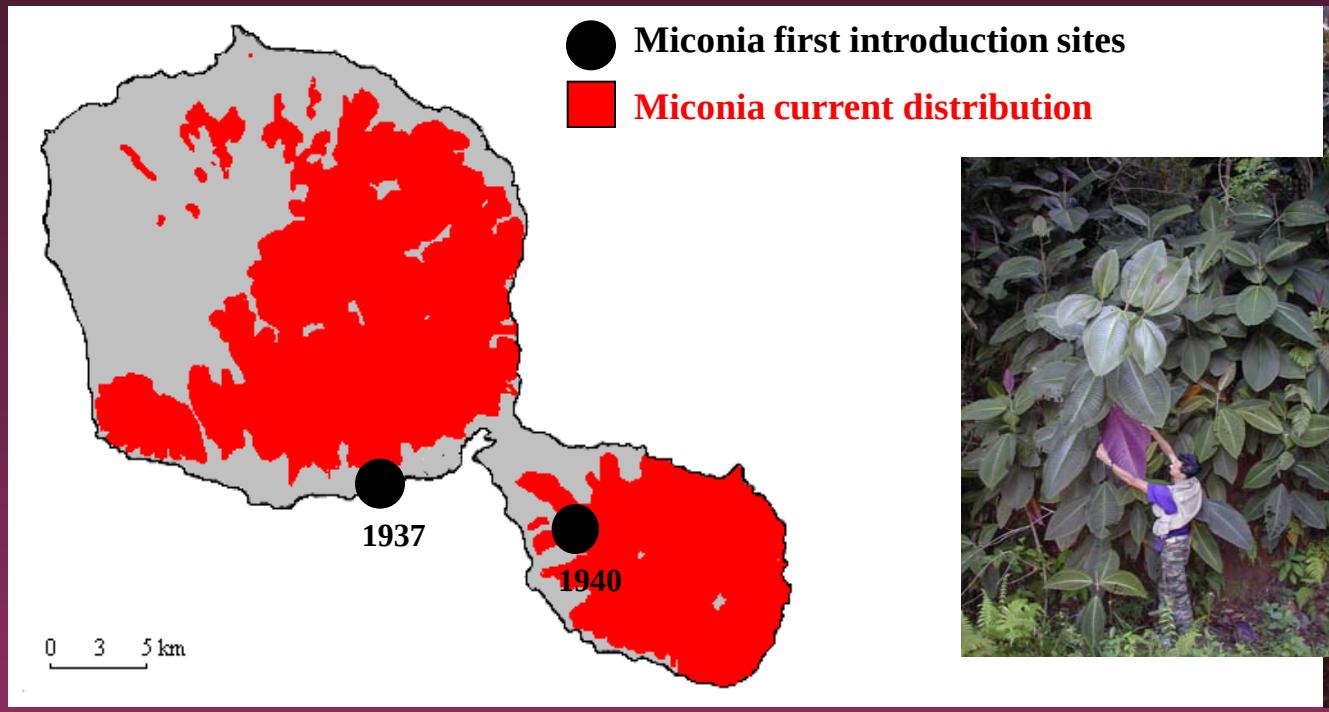
  } ↗ Economic productivity

  (*Huffaker & Kennett 1959, J. Range Management 12*)

- **Few studies on the recovery of native species in natural ecosystems = the conservation benefits of biocontrol**

(*Fowler et al. 2000, Austral Ecology 25 ; Denslow & d'Antonio 2005, Biol. Control 35 ; Barton et al. 2007, Biol. Control 40*)

Miconia invasion in Tahiti, French Polynesia



(*Meyer, 1996, Pacific Science 50*)

- Small tree (6-12 m tall) native to Tropical America
- Occurs between 0 and 1400 m asl in native rain- and cloud forests
- Forms dense monospecific stands (↘ light in the understorey)

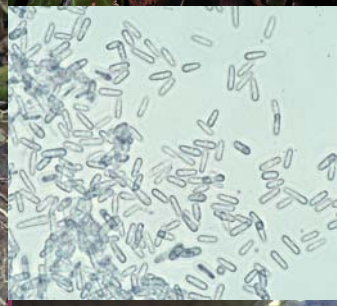
>50% of the plant species endemic to Tahiti are directly threatened by Miconia

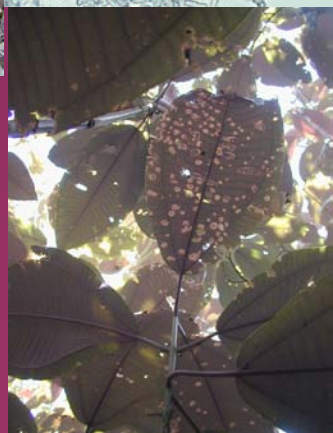
(*Meyer & Florence 1996, J. of Biogeography 23*)

Polyscias tahitensis

Miconia biocontrol agent

- *Colletotrichum gloeosporioides* forma specialis *miconiae* (*Cgm*)
- Discovered in Brazil in 1996-97
- Highly specific to Miconia
- Cultivated in Hawaii
- First released in Tahiti in 2000





***Cgm* causes leaf anthracnose and necrosis**

↓

kills seedlings + Miconia partial defoliation & canopy opening

↓

↗ Light in the understorey

(Meyer, Taputuarai & Killgore 2008. Proc. XII Int. Symposium on Biological Control of Weeds)

Objectives / Hypothesis

- Indirect effects on the recovery of endemic plant species?
- Effects on native and alien plant recruitement in the forest understorey?
- Vegetation dynamics with time?

Taravao permanent plot
Year 2000

Myrsine longifolia
(CR)

Cgm

Year 2006

(*Meyer, Dupouy & Taputuarai 2007, Rev. Ecol.*)

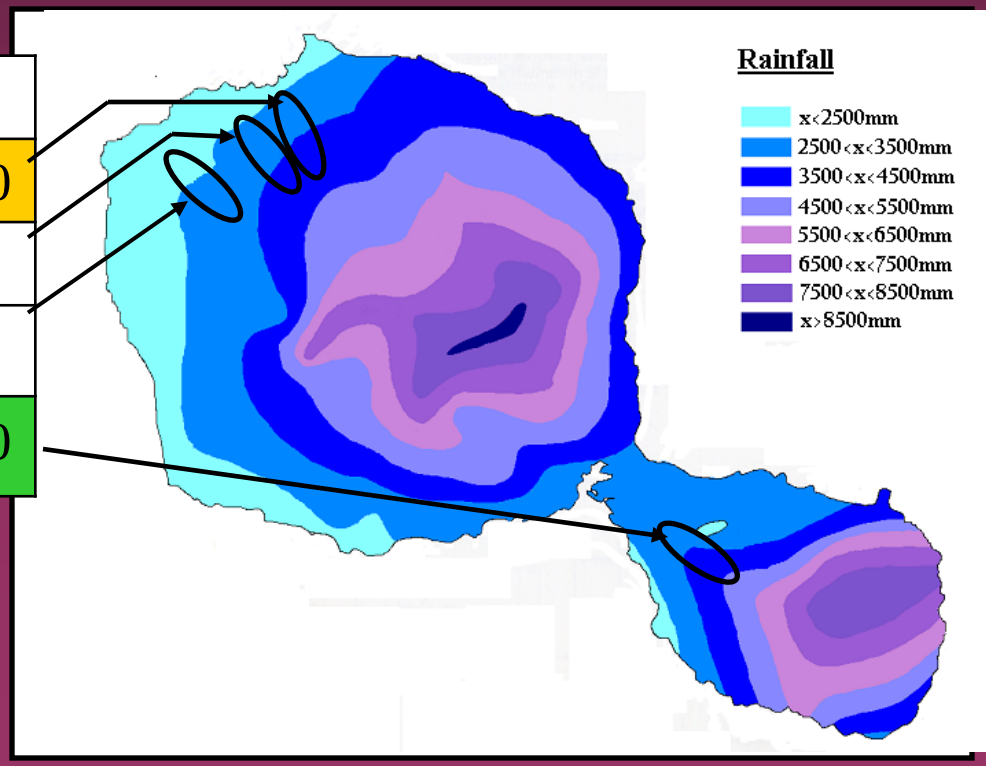
Study sites

- 4 sites, permanent plots
- Dense Miconia forests
- Elevation (rainfall & temperature) gradient
- Relatively easy to access!

Aorai (940 m)

Sites	Plots elevation (m)				
Aorai	400	630	940	950	1200
Pic Vert	600	970	970		
Marau	800	800			
Taravao	500	600	700	1000	1020

4 yrs monitoring (2005-2009)
3 yrs monitoring (2006-2009)
2 yr monitoring (2008-2009)

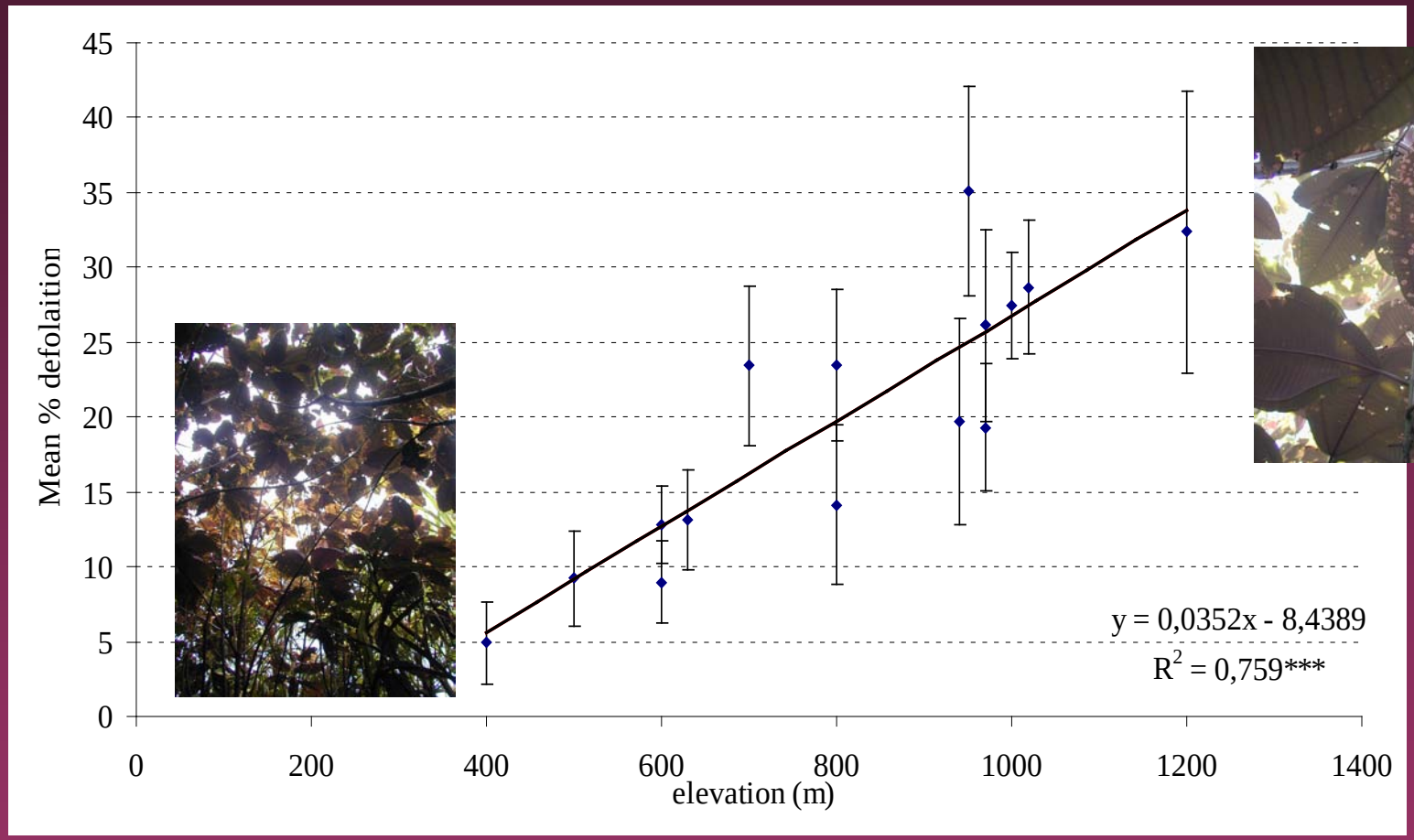


%Cgm leaf damage

- 10 Miconia trees cut down around each permanent plot
- 25 canopy leaves collected on each tree
- Grid mesh (2 x 2 cm)

$$\%\ Cgm\ \text{leaf damage} = \frac{\text{Number of squares with } C.g.m.\text{ leaf spots}}{\text{Leaf area (estimated number of squares)}} \times 100$$

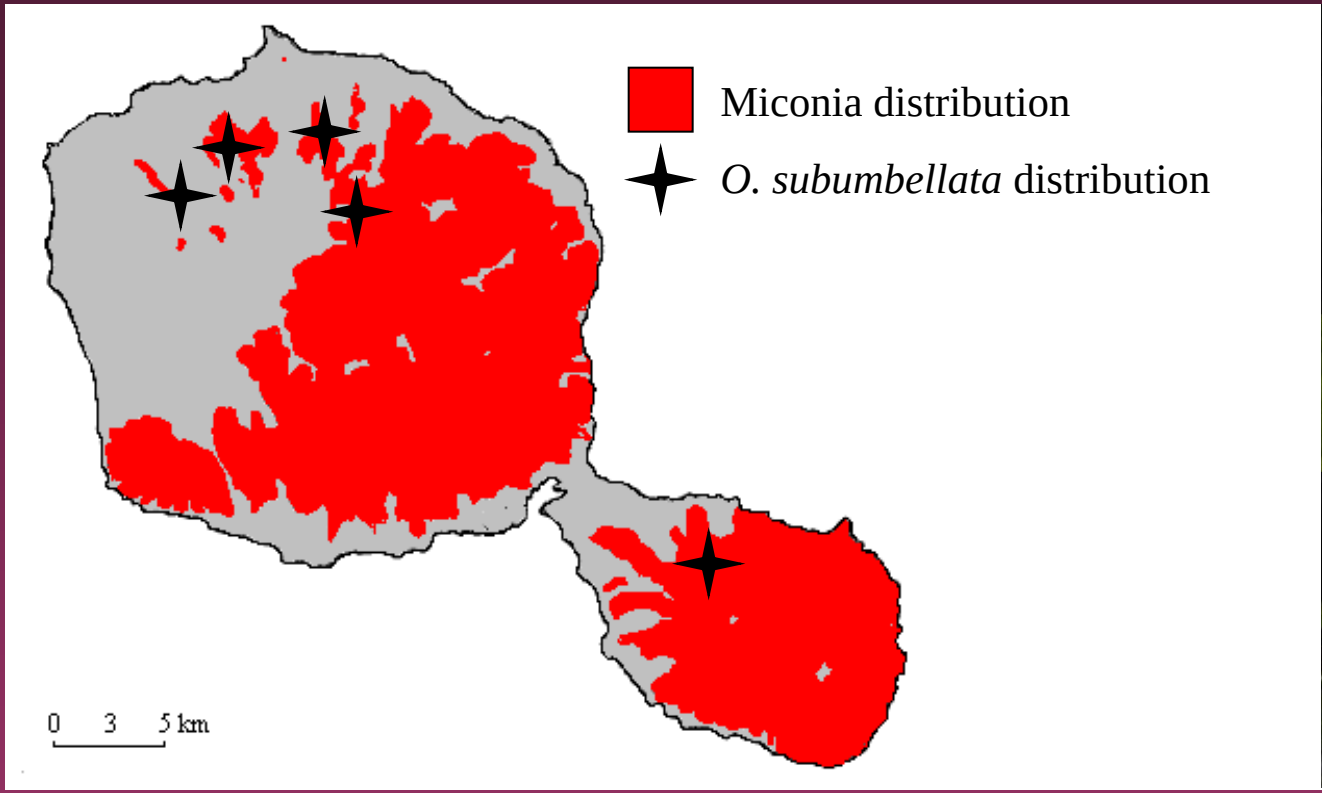
Cgm impact with elevation (yr 2008, N=15 plots)



⇒ Partial defoliation of Miconia canopy trees: 5-35% with elevation

⇒ *Cgm* more efficient at high elevation (higher rainfall and/or lower temperature?)

Study on *Ophiorrhiza subumbellata* (Rubiaceae)



- Rare and threatened endemic sub-shrub (0.5-1.8 m tall)
- Small isolated populations (1- 67 individuals)
- Occurs in rainforest and cloudforest between 700-1,200 m asl

⇒ *Ophiorrhiza* habitat range is included in Miconia's distribution

Method

- Study sites selected at same elevation, same Miconia density, but different % Cgm leaf damage
- Circular plot (25m²) centered on the tallest reproductive plant

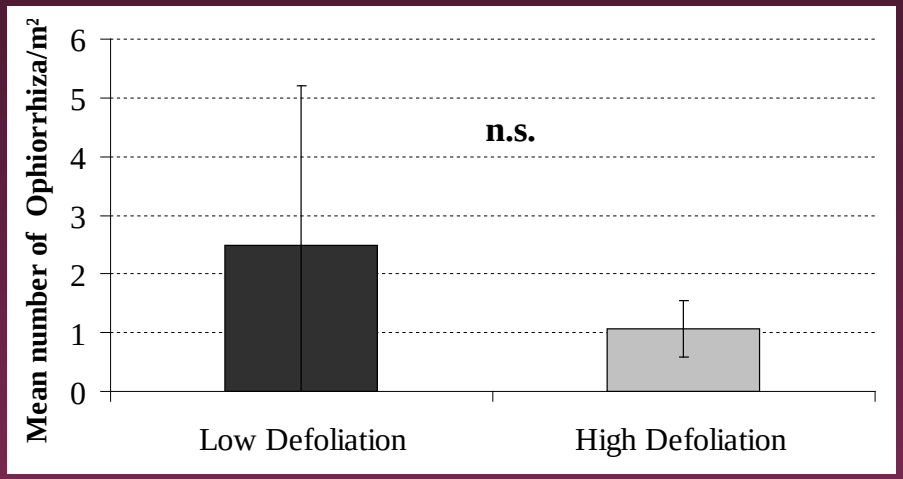
➢ Density

- Number of seedlings (<5 cm tall)
- Number of juveniles and adult plants (>5 cm)

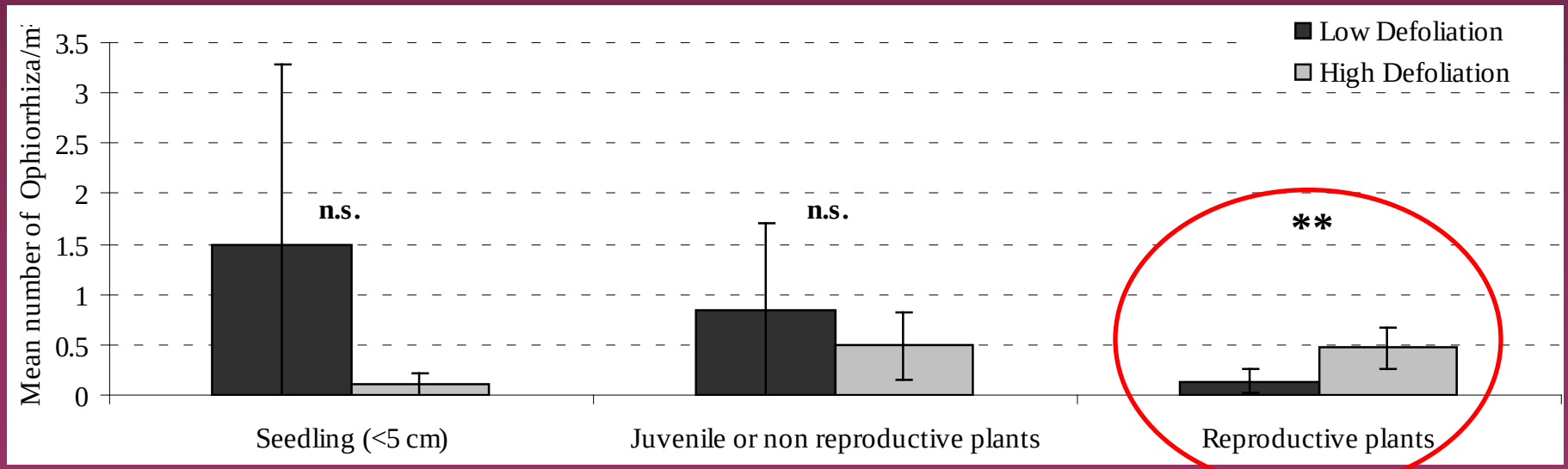
➢ Fertility

- Number of cymes (inflorescences and/or infrutescences)
- Number of flowers and/or fruits

Positive effect of *Cgm* on *Ophiorrhiza* density



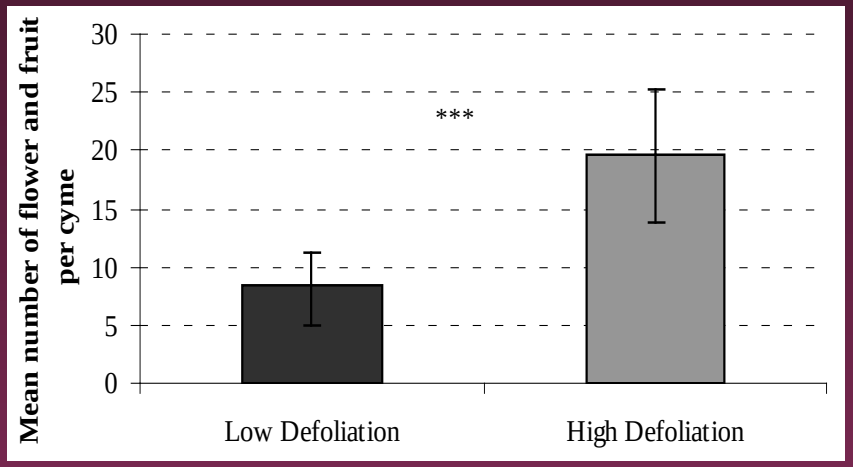
(Mann-Witney U Test
n.s = not significant;
** : p<0.01)



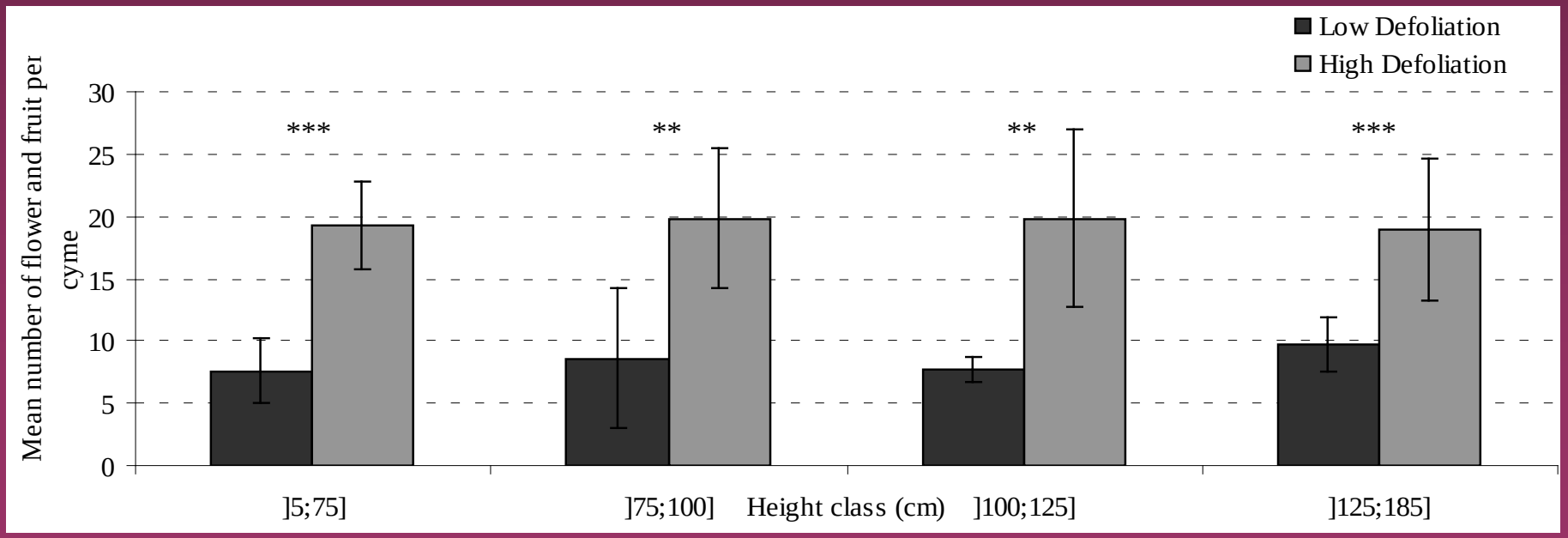
⇒ Positive effect on the density of reproductive plants

(Meyer & Fourdrigniez 2010, Biological Conservation)

Ophiorrhiza fertility

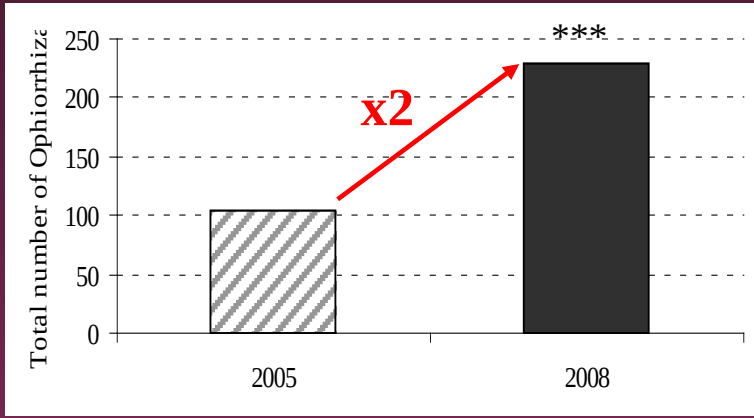


(Mann-Whitney U Test:
** : p<0.01
*** : p<0.001)

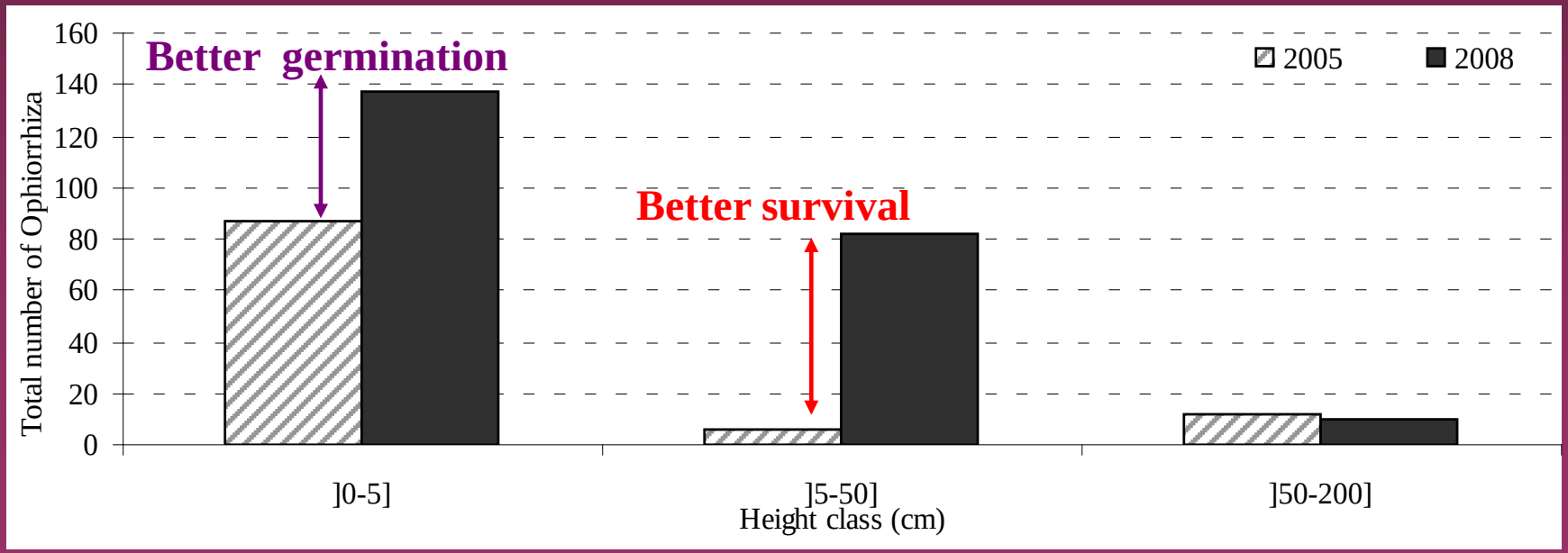


⇒ Positive effect on fertility for all height classes

Ophiorrhiza recruitment and survival



(Pearson Chi-square test: $Chi^2 = 35,8$; ddl = 2 ; $p<0,001$)



⇒ Positive effects on seedling recruitment and plant survival

First conclusions

The Miconia biological control agent has contributed to the recovery of threatened endemic plants in Tahiti

(e.g. *Ophiorrhiza spp., Myrsine longifolia, Psychotria spp.…*)

Psychotria franchetiana (CR)

Positive effects on the whole plant community (flowering plants & ferns)?

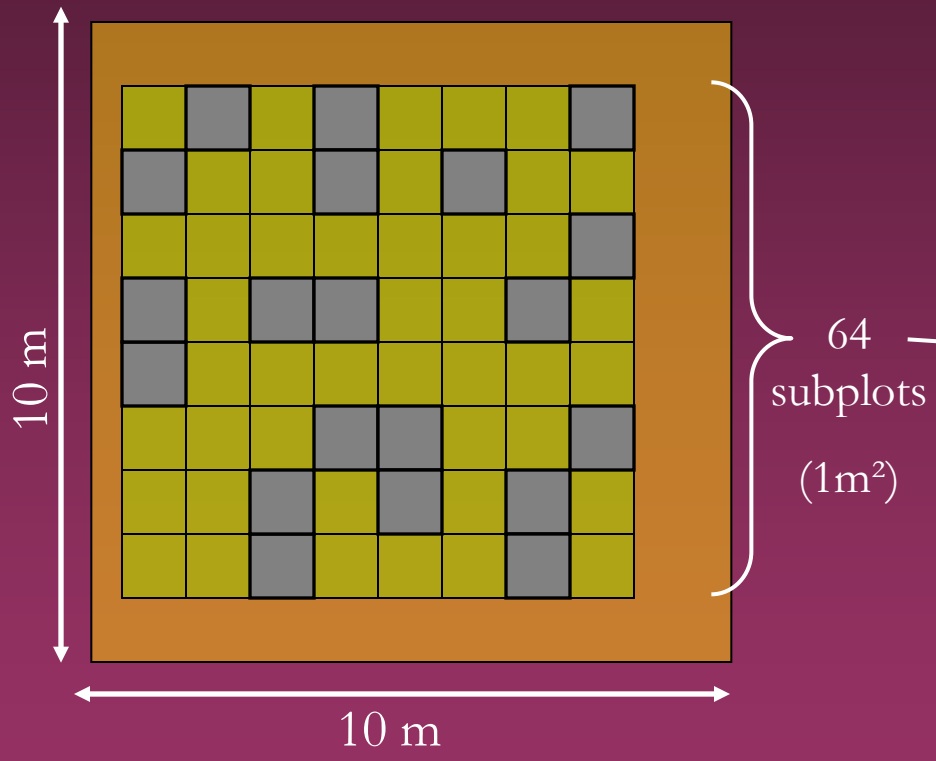
Effect on more shade-tolerant species?

Reinvasion by other alien species?

⇒ Long-term monitoring of all forest understorey species

Study plots

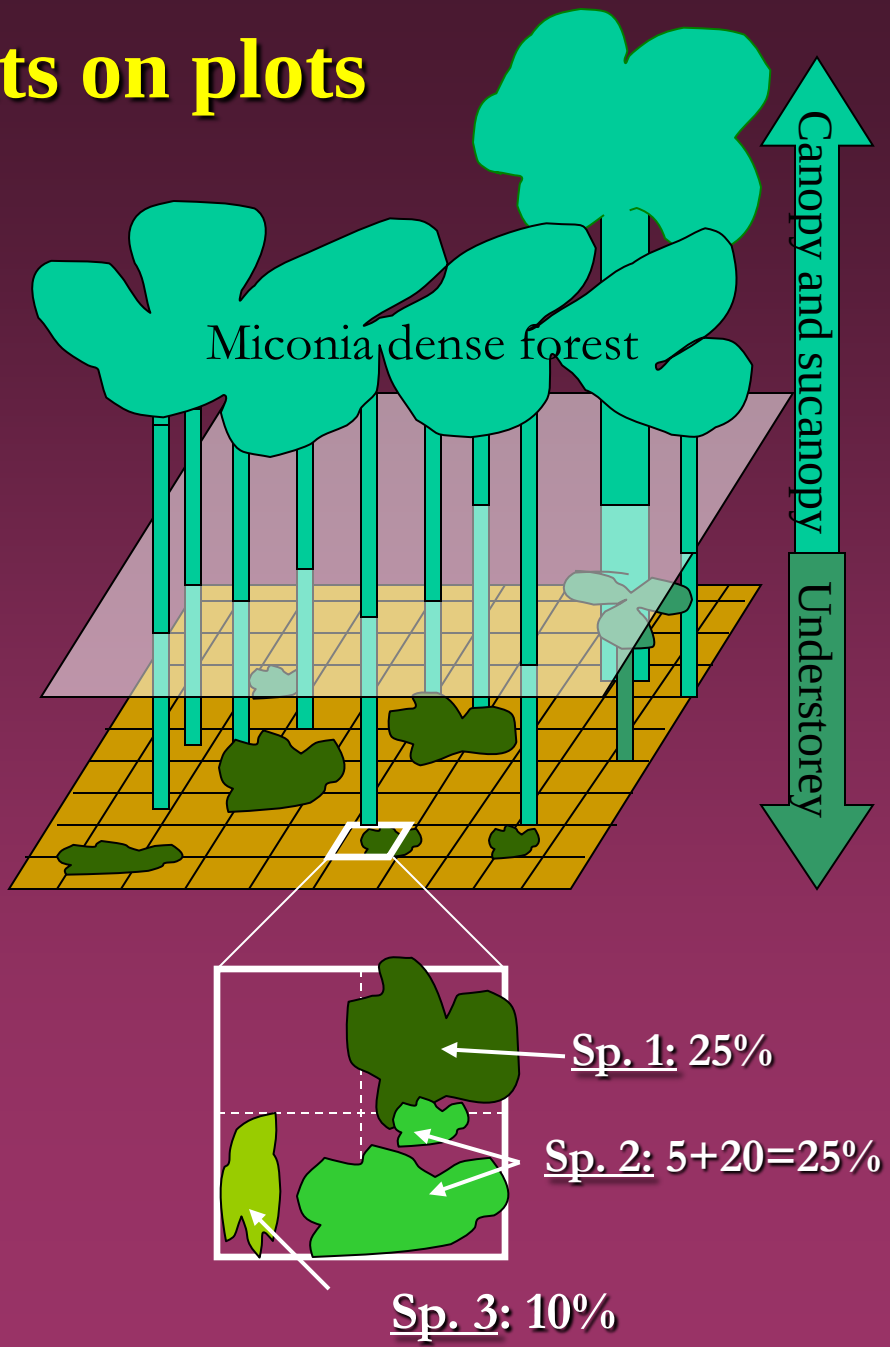
100 m² permanent quadrats, 20 subplots/year



Measurements on plots

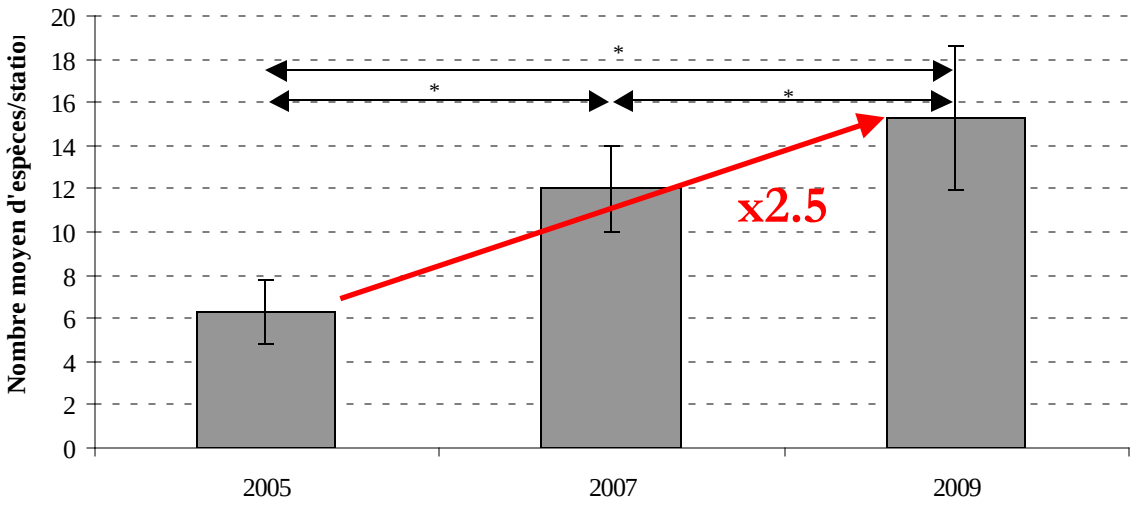
- **Miconia's invasion**
  - Stem density (> 1.30m)
  - Basal area (DBH)

- **Understorey stratum (≤ 1.30m)**
  - % cover of all species in each subplot
  - Species status (native or alien)
  - Light preference (light demanding *vs* semi-shade *vs* shade-tolerant species)



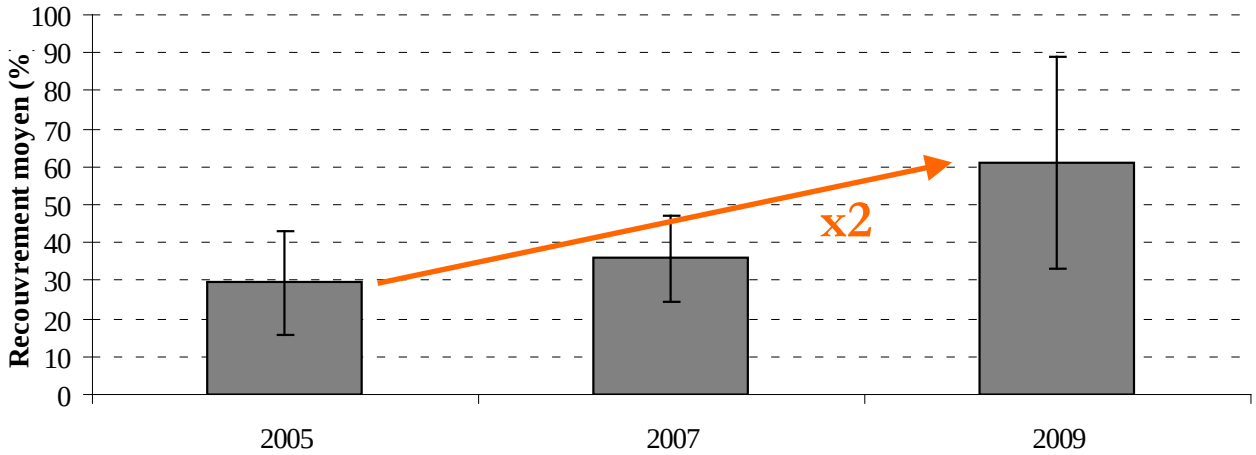
Evolution of the understorey vegetation

Species number



(Friedman Test - Wilcoxon Signed Rank Test with Bonferroni correction)

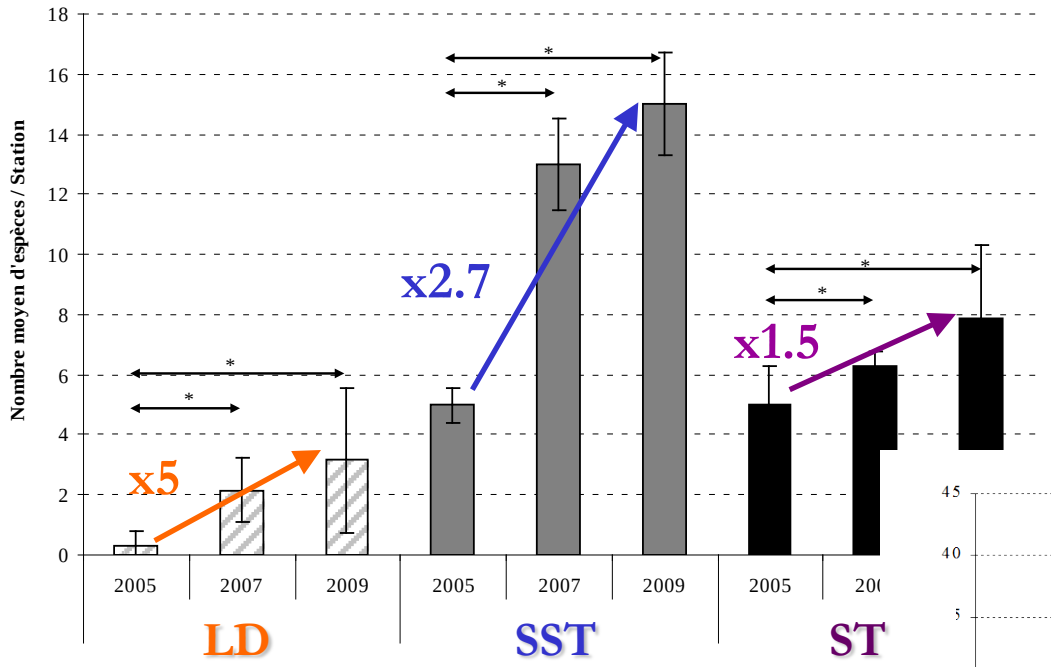
% cover



⇒ Significant increase of species number + an increase of plant cover with time

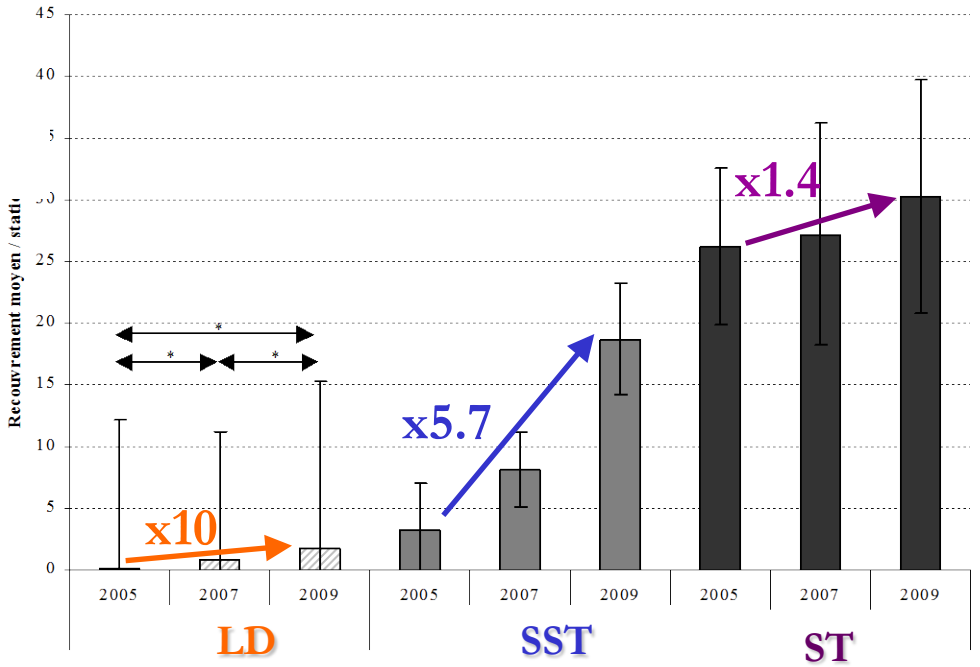
Light preference

Species number



LD = Light demanding
SST = Semi-shade tolerant
ST = Shade tolerant

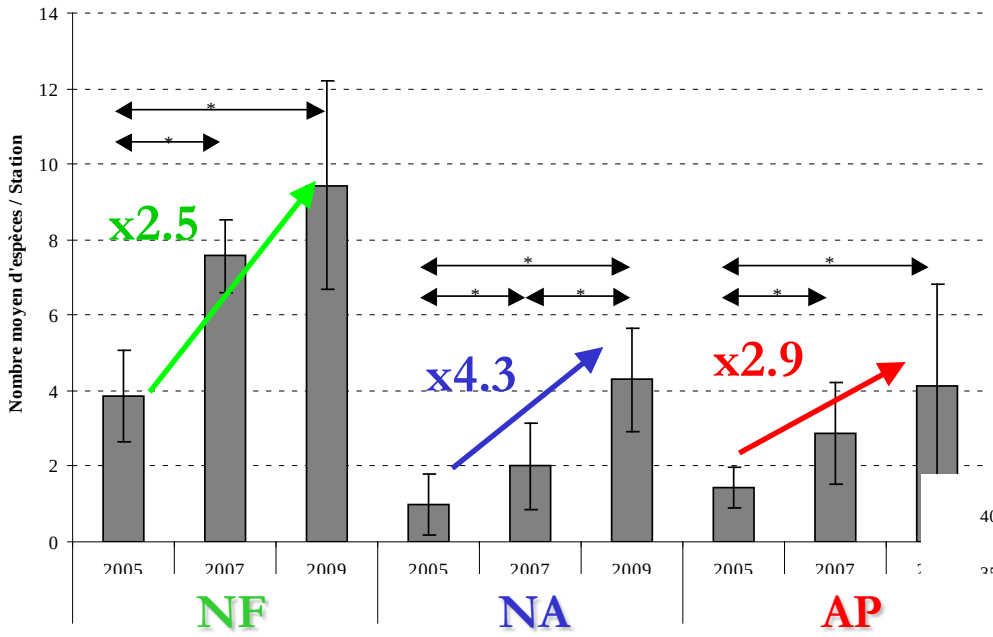
% cover



⇒ Significant increase of light demanding/pioneer species (number & cover) with time

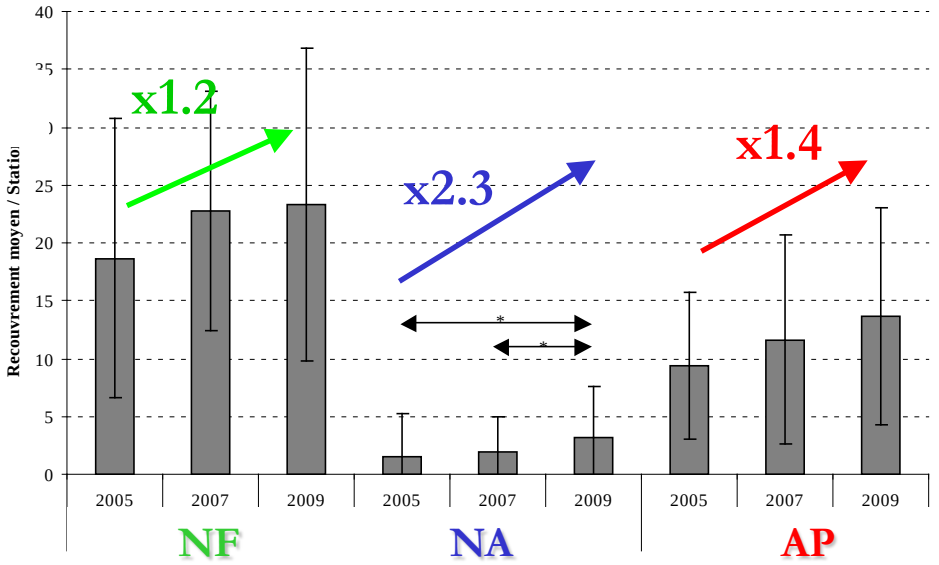
Species classification and status

Species number



NF = Native ferns
NA = Native angiosperms
AP = Alien plants

% cover



⇒ Significant increase of native flowering plants (number & cover) with time

Conclusions

- Direct negative impacts of *Cgm* on Miconia
  - ↗ with elevation (effect of rainfall and temperature)
- Indirect positive effects: recovery of some rare endemic plant species
  - ↗ Fertility
  - ↗ Seedling recruitment
- Plant dynamics in the understorey with time
  - ↗ Species number (light demanding & semi-shade natives)
  - ↗ Cover (light demanding)
  - ↗ Alien species number, but not too much cover ⇒ No reinvasion ?

➢ Biocontrol as a habitat restoration tool in Miconia invaded forests?

➢ Long-term monitoring is still -and always- needed…

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