Soil mesofauna responses to woody debris biomass management in the Canadian boreal forest

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Ecological & socioeconomic importance of Canadian boreal forest (*e.g.* timber, C storage & biodiversity)

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Increasing forestry pressure for bioenergy with potential negative effects

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Increasing forestry pressure for bioenergy with potential negative effects

Sustainable management is a requirement to implement rapidly (*e.g.* certification)

Potential use of residual biomass for bioenergy

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Residual biomass = trunks, stumps, branches & smaller woody debris on the ground after clear-cutting

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Different management of disturbance & biomass removal (type of residues, volume, etc.)

Influence of residual biomass removal on soil fauna communities?

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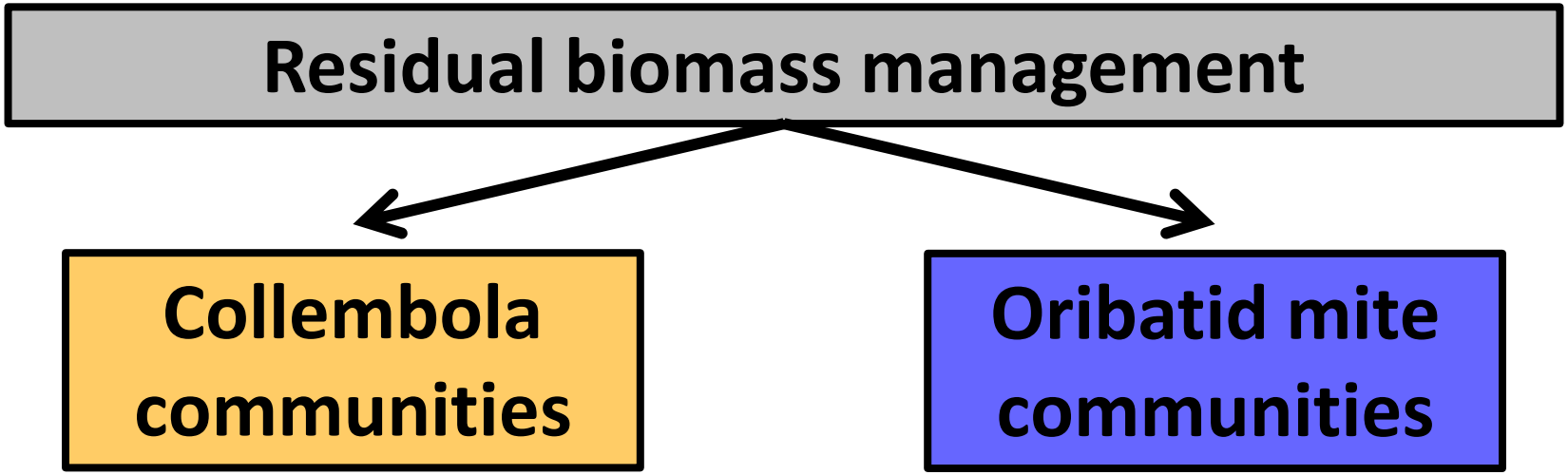
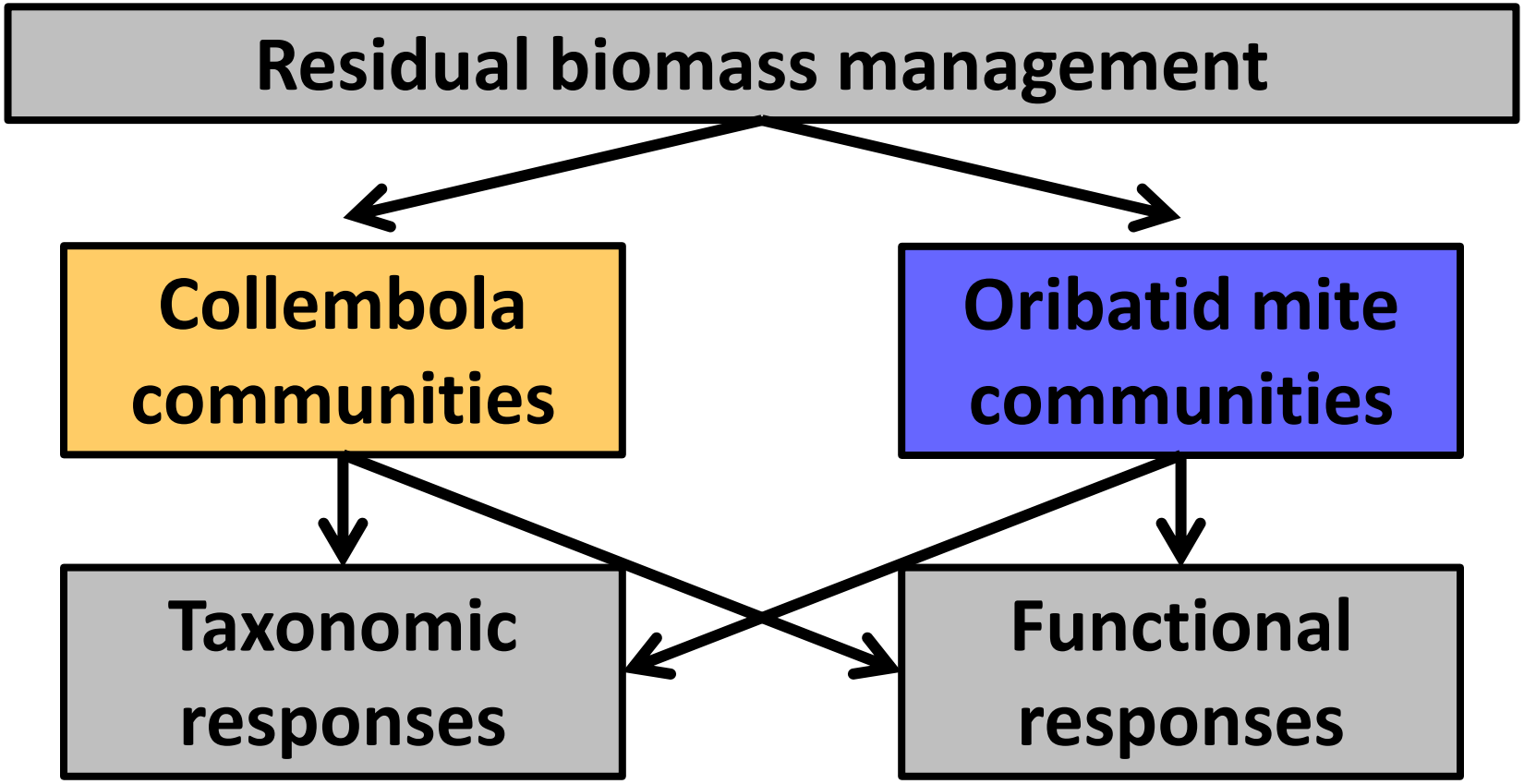
Residual biomass management

Influence of residual biomass removal on soil fauna communities?



Influence of residual biomass removal on soil fauna communities?



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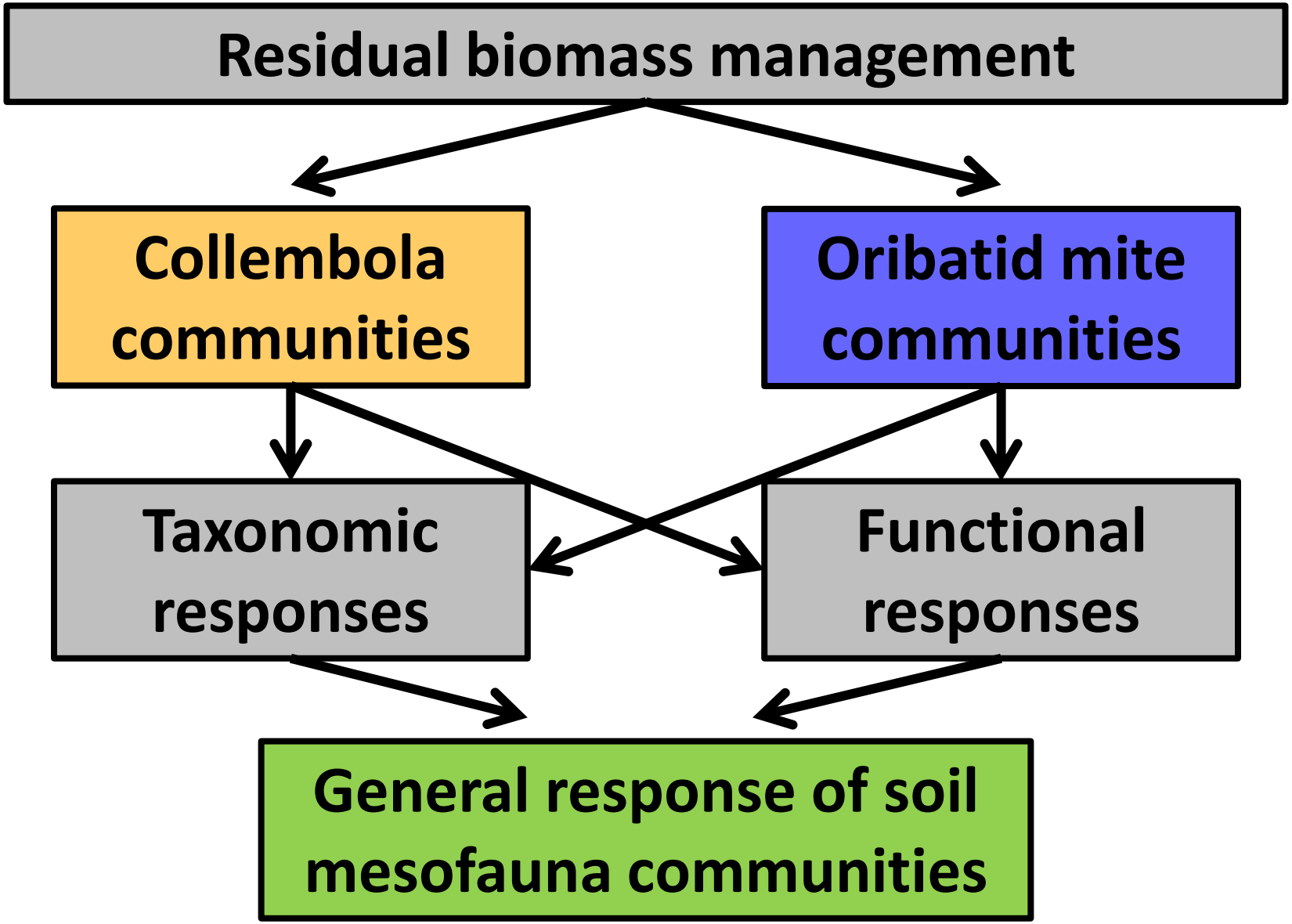
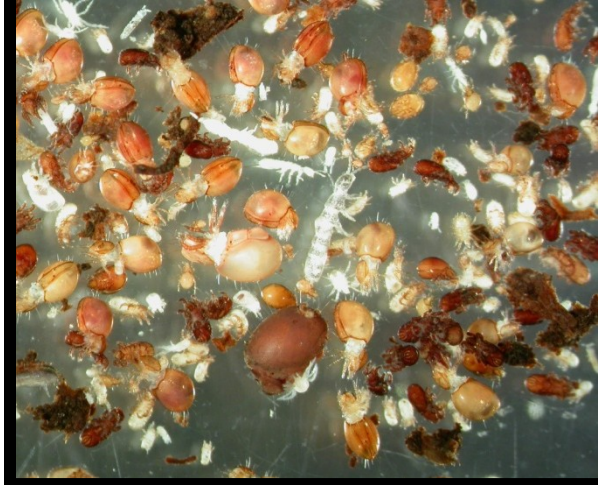


Soil mesofauna communities

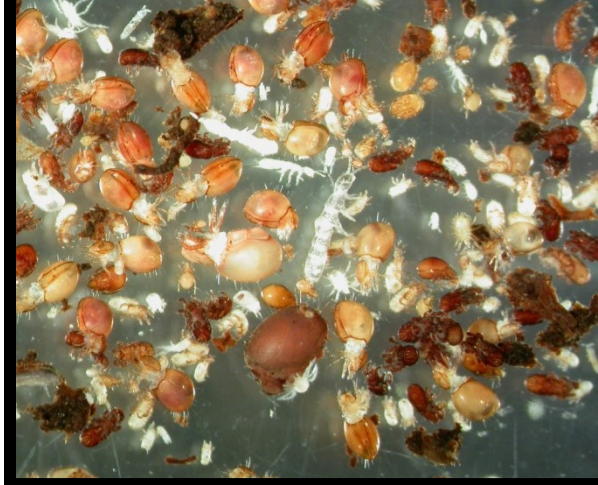


Soil mesofauna communities

~ 200,000 ind. / m^2 of forest soil

> 10000 sp. of mites (*Acari*)

> 500 sp. of springtails (*Collembola*)



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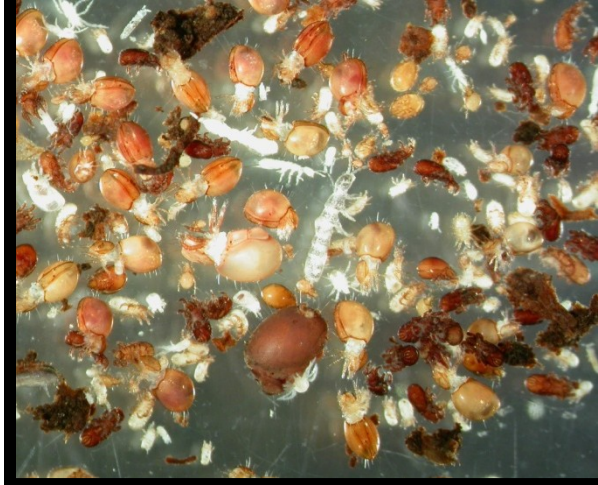
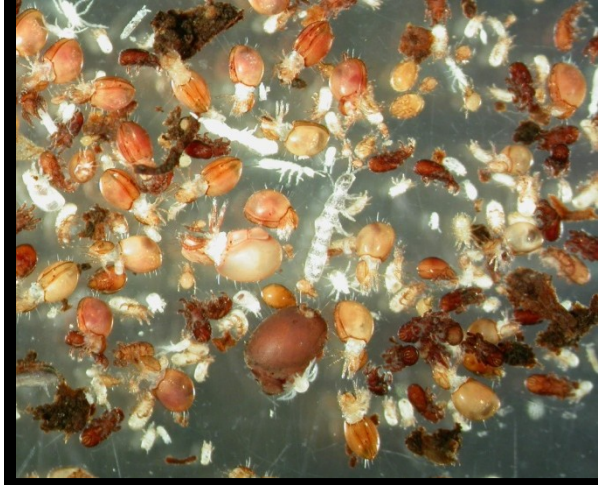
Essential role on soil ecological parameters & processes (*e.g.* litter decomposition & structure, nutrients & microbial dynamics)



Soil mesofauna communities

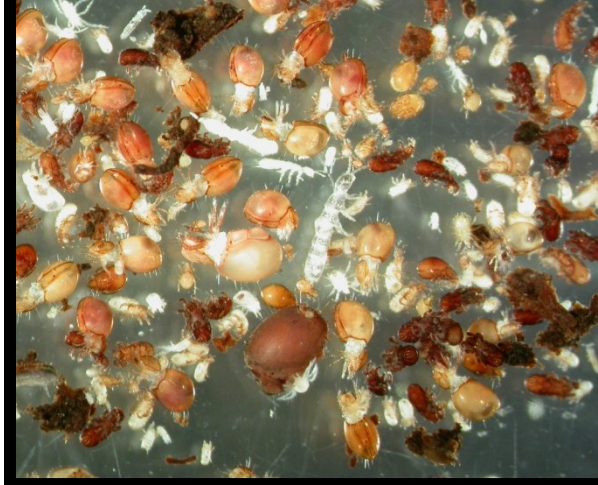
2 approaches:



Soil mesofauna communities

2 approaches:

- **Taxonomic by ID: density, species richness, biomass & structure**

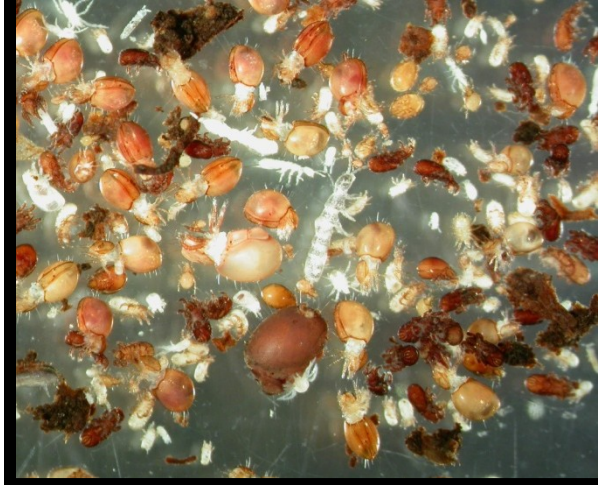


Soil mesofauna communities

2 approaches:

- **Taxonomic by ID: density, species richness, biomass & structure**

- **Functional by measuring traits on specimens:**
  - morphological, physiological & biochemical features of organisms
  - fitness via phenotype plasticity & genotype variability
  - performances & survival of species in their environment



Functional approach by response traits

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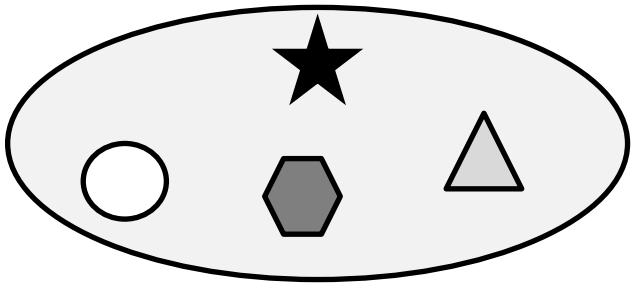
Local species community (4 sp.)



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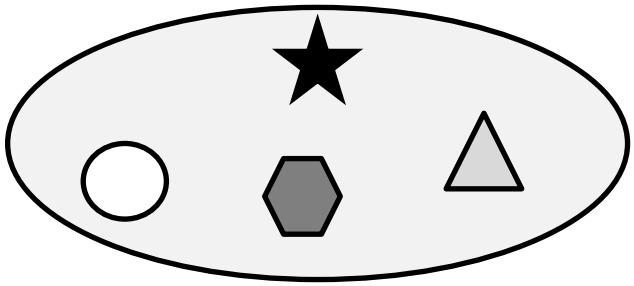
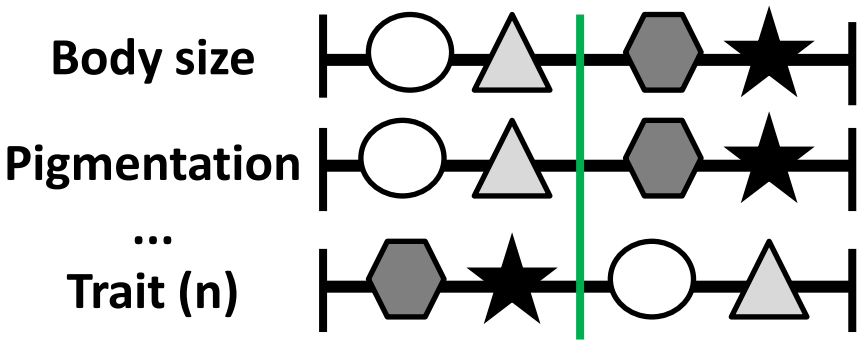
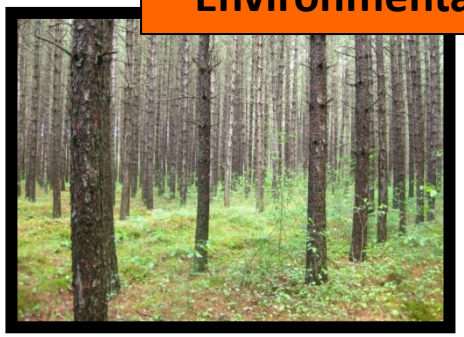




Functional approach by response traits

Environmental filter (disturbance by forest management)



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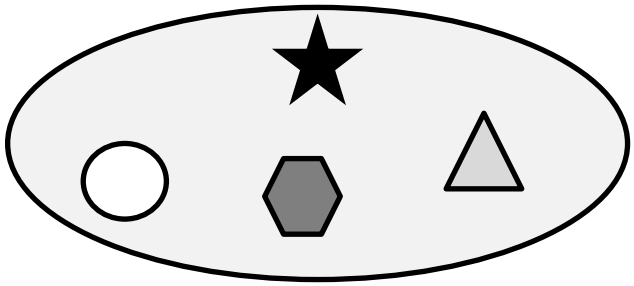
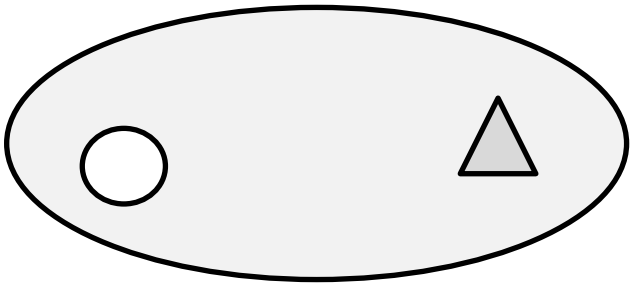
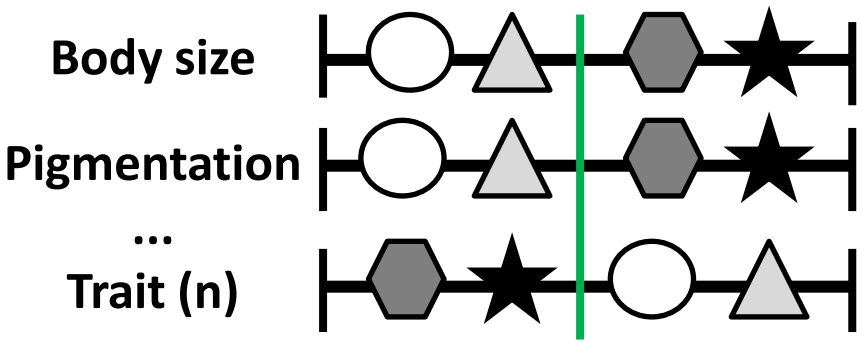


Modified community





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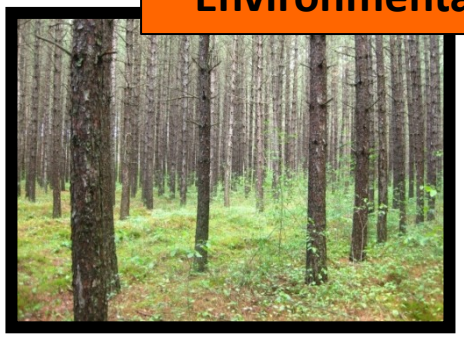

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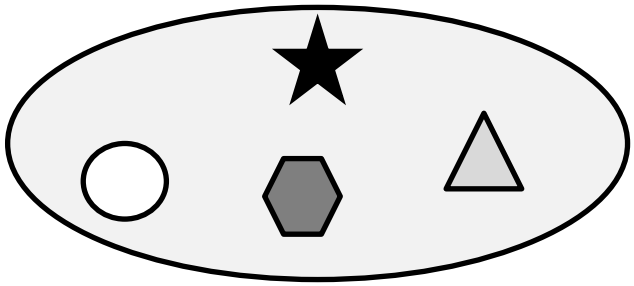

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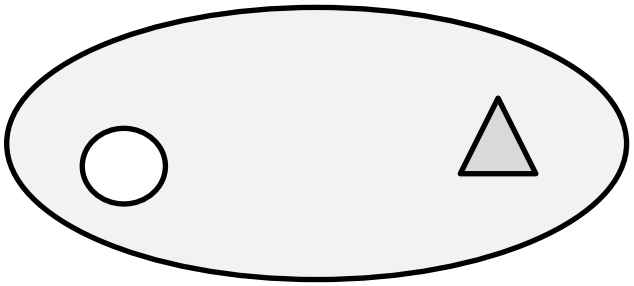
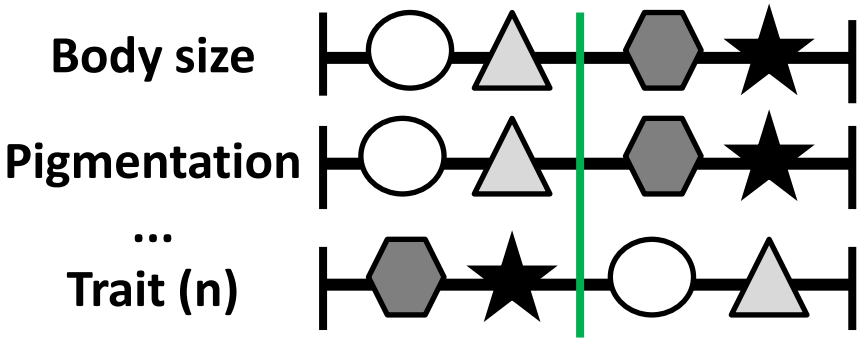
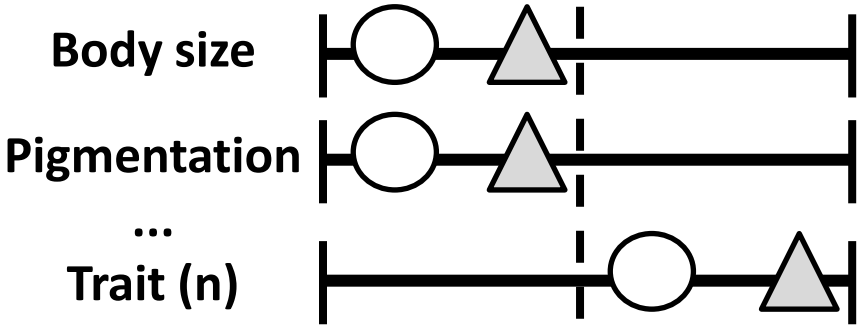


Change in mean trait value





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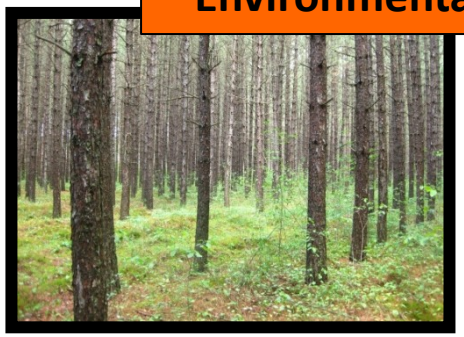

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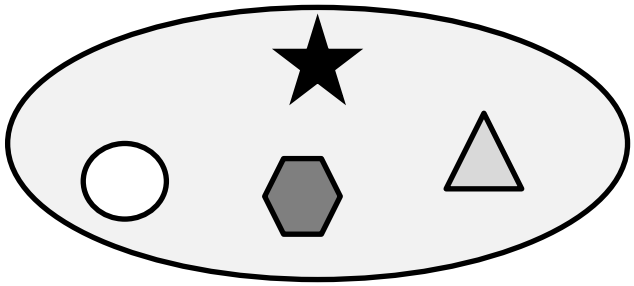

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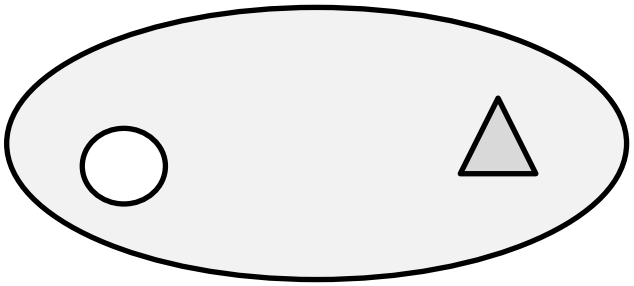

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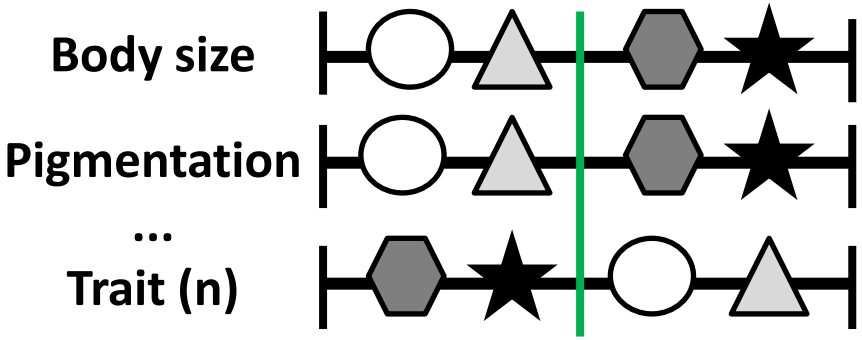

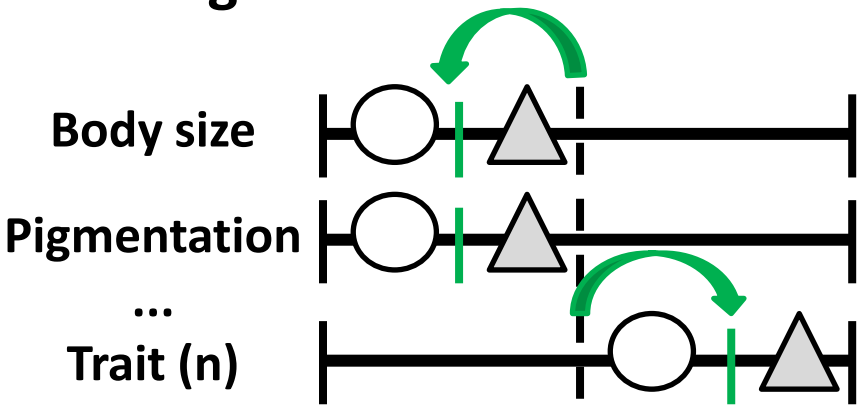

Island Lake experimental site in Northern Ontario

45 year old stand of Jack pine (*Pinus banksiana*) harvested in 2011

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Biomass management with different treatments

Gradient of disturbance & biomass removal

(Kwiaton *et al.*, 2014)

Gradient of disturbance & biomass removal

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Clear cutting

Gradient of disturbance & biomass removal

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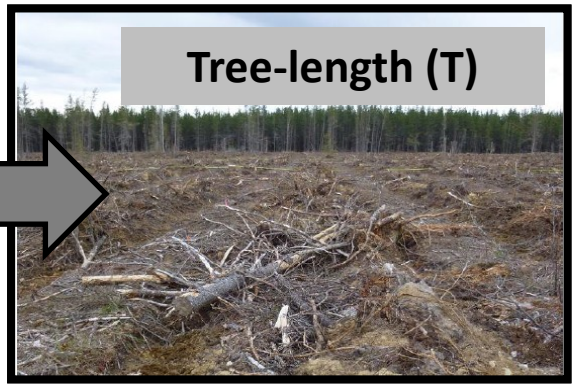
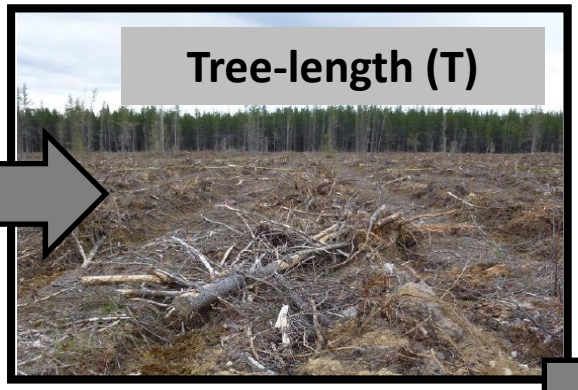


Biomass = 84 m^3 / ha

Gradient of disturbance & biomass removal

(Kwiaton *et al.*, 2014)

Clear cutting



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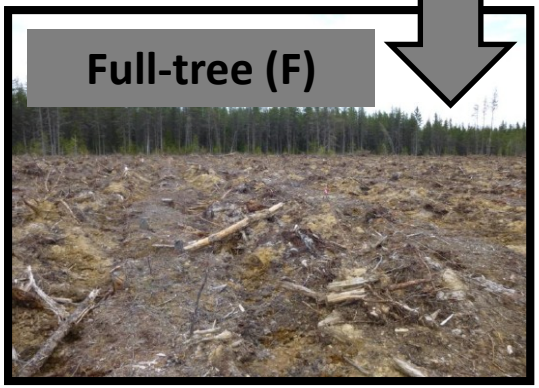
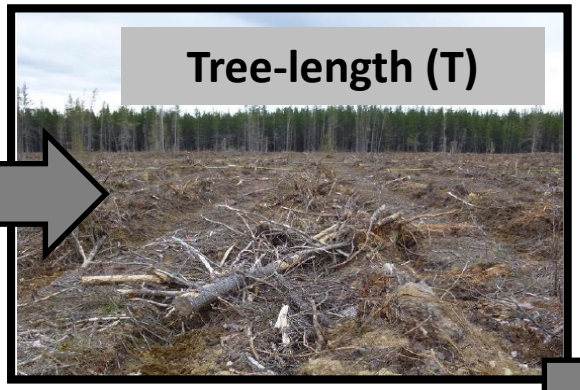


29 m^3 / ha

Gradient of disturbance & biomass removal

(Kwiaton *et al.*, 2014)

Clear cutting



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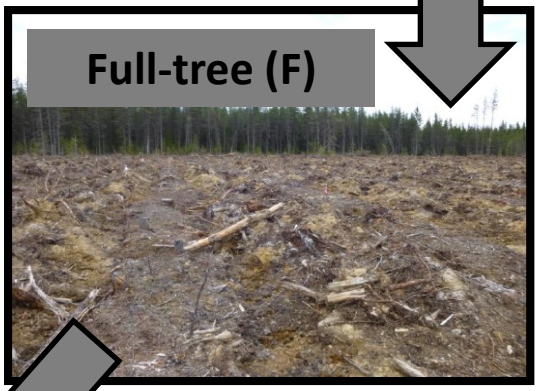
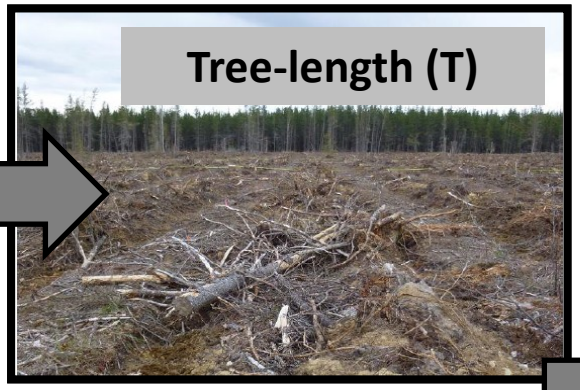


29 m^3 / ha

24 m^3 / ha

Clear cutting



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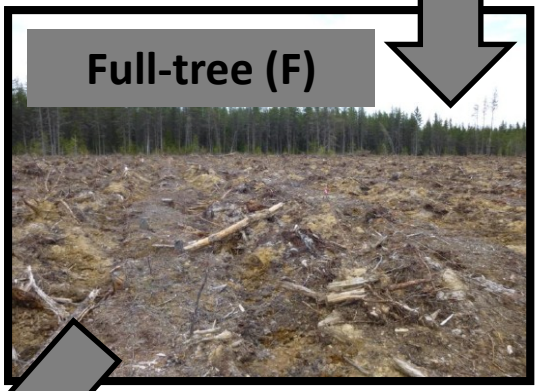

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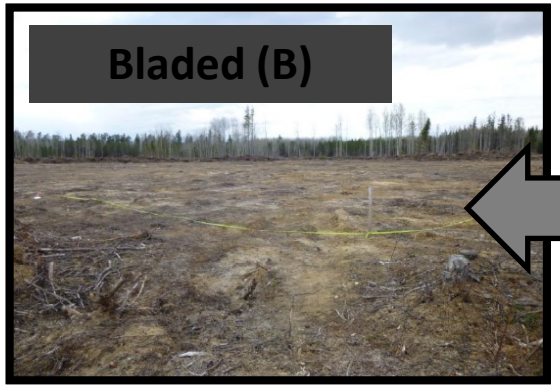
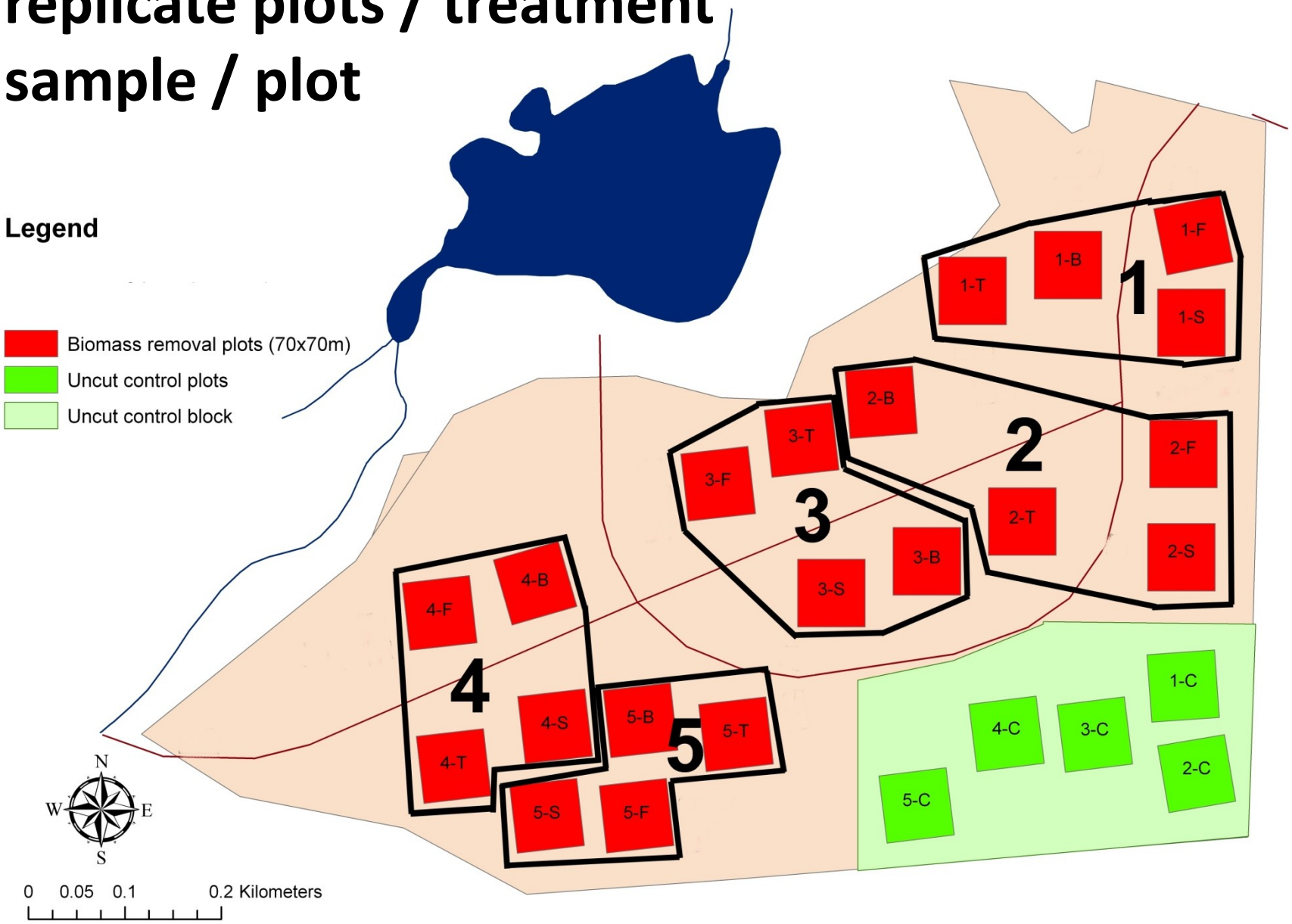


5 treatment: C, T, F, S & B
5 replicate plots / treatment
1 sample / plot



Sampling in June 2013

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Identification of Collembola & Oribatid mites:

- **Density (individuals / m^2)**
- **Diversity (Shannon index)**
- **Biomass (mg / m^2)**

Collembola

Collembola

Measure of functional traits:

Body length & Biomass

Body shape: globulous / stocky / slender

Pigmentation: absence / uniform / pattern

Furcula, scales, pseudocelli, trichobothria & PAO

Ocelli number / eye

Relative antenna / furcula / leg length

Mouthparts: absence / normal / strong

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Measure of ecological preferences:

Trophic (via major gut content)

Habitat: euedaphic / hemiedaphic / epiedaphic

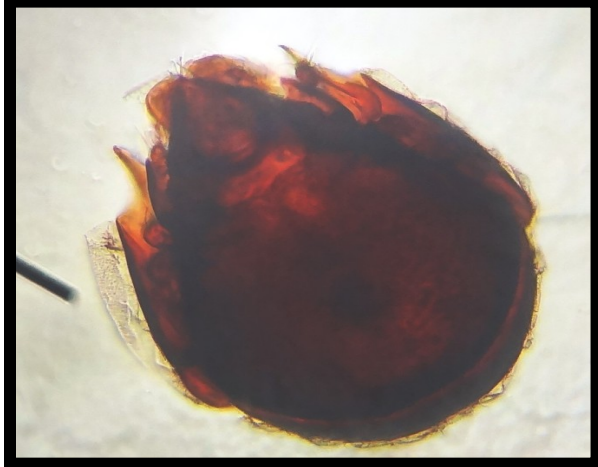
via body size, ocelli number, pigmentation & PAO

Dispersal capacity: slow / fast

via relative antenna & furcula size & PAO

Reproduction mode: sexual / parthenogenetic

Oribatid mites



Oribatid mites

Measure of functional traits:

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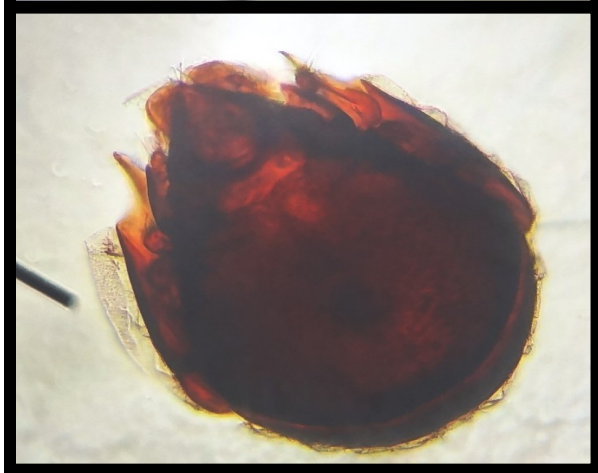
Relative trichobothria length

Number of claws on first leg pair

Relative length of claws

Pigmentation: low / medium / strong

Mouthparts (chelicerae): compacted / normal / elongated



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via body size & pigmentation

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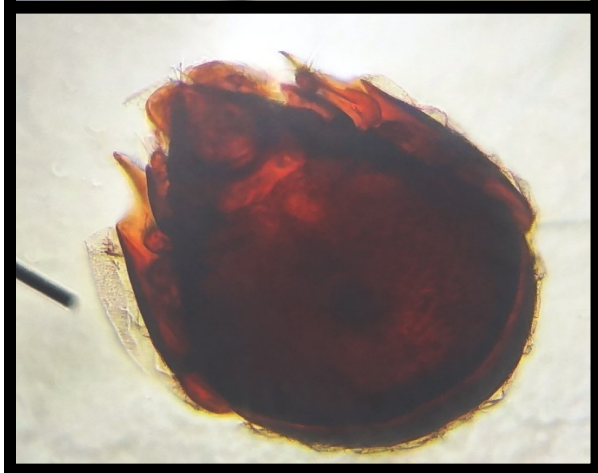
via body size & relative trichobothria + claw length

Reproduction mode: sexual / parthenogenetic



Collembola response to the gradient of disturbance & biomass removal

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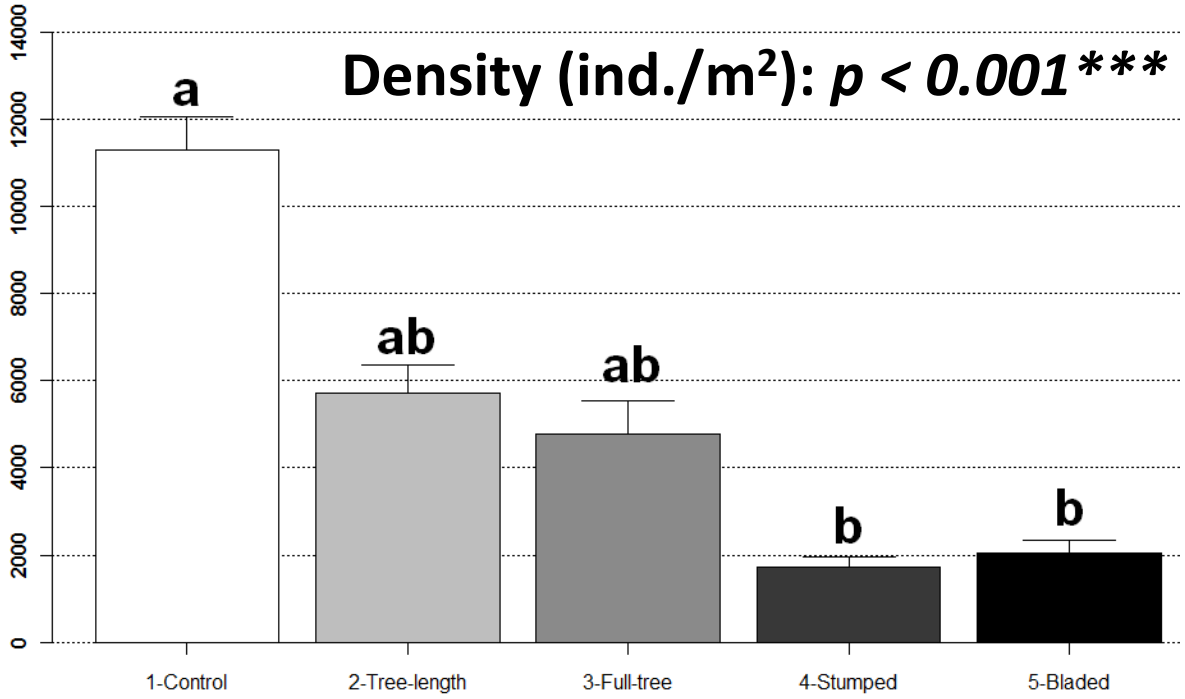
1200 specimens &

25 species ID

200 specimens

used for traits & preferences

Collembola response to the gradient of disturbance & biomass removal



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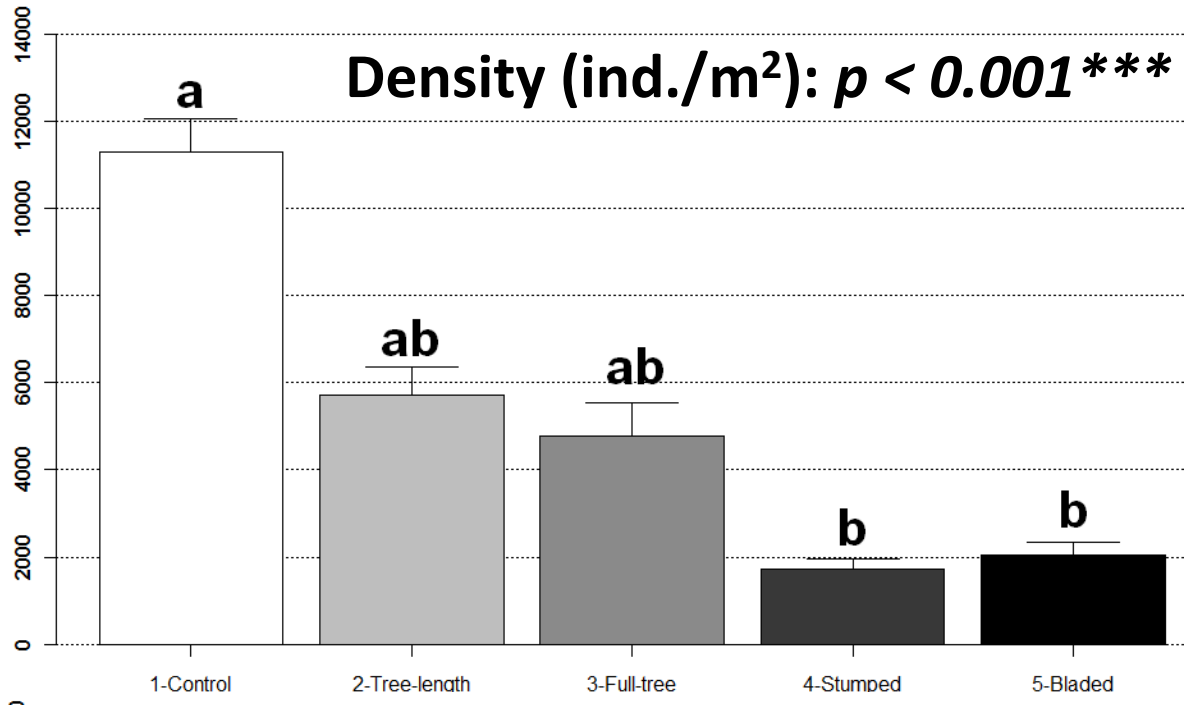

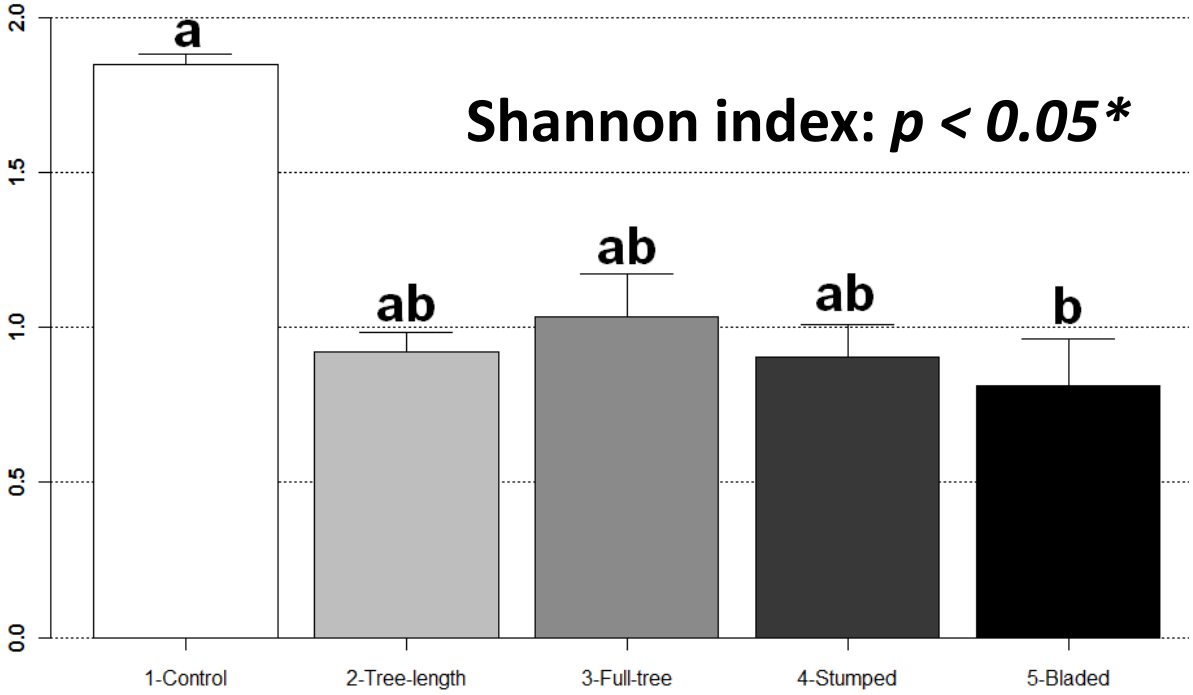

Community clustering to biomass removal gradient

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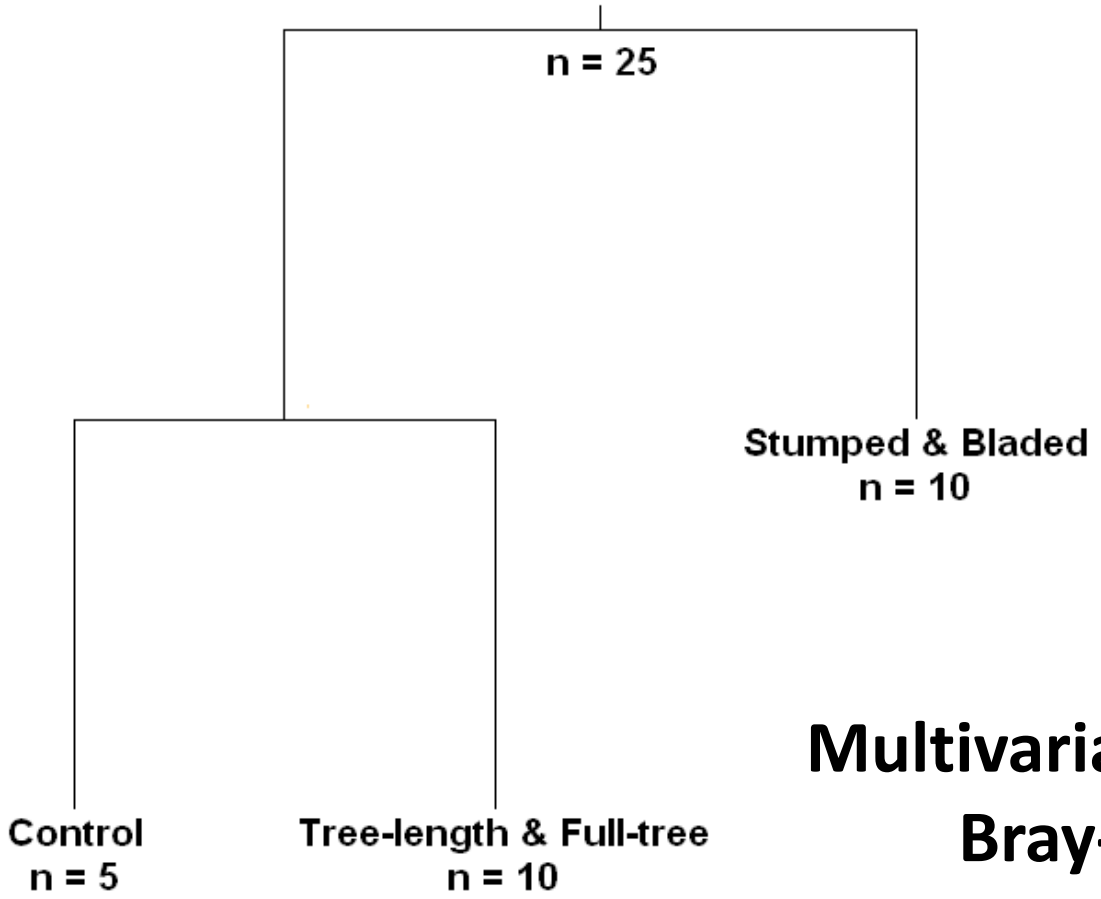
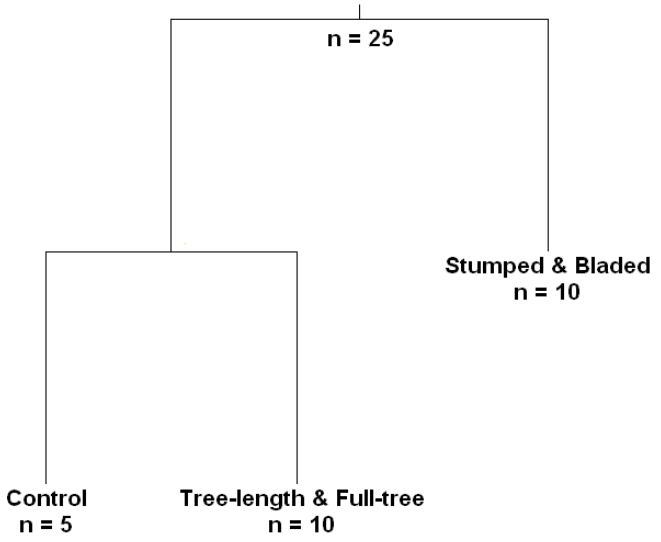


Multivariate regression tree

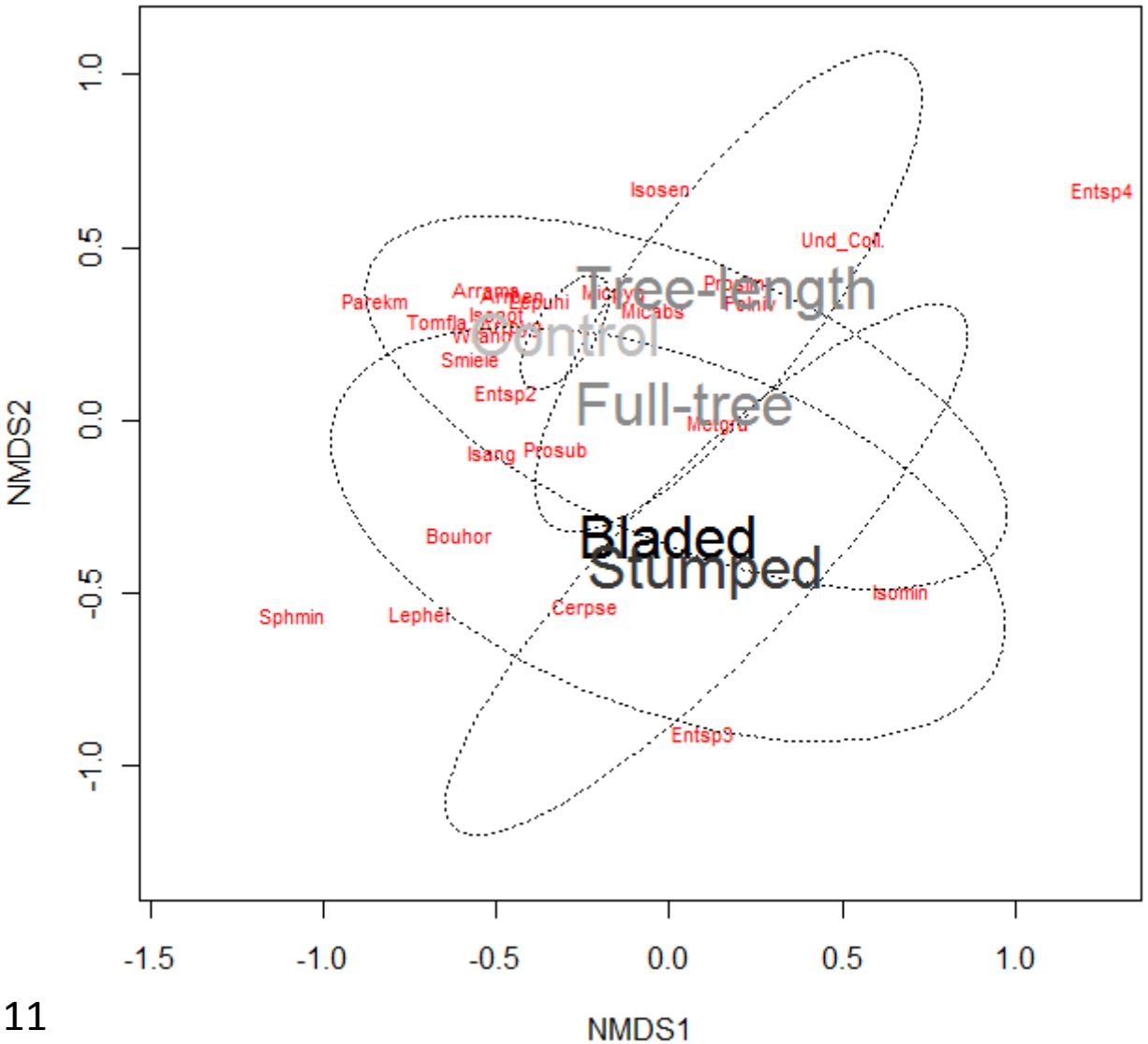
Bray-Curtis distance

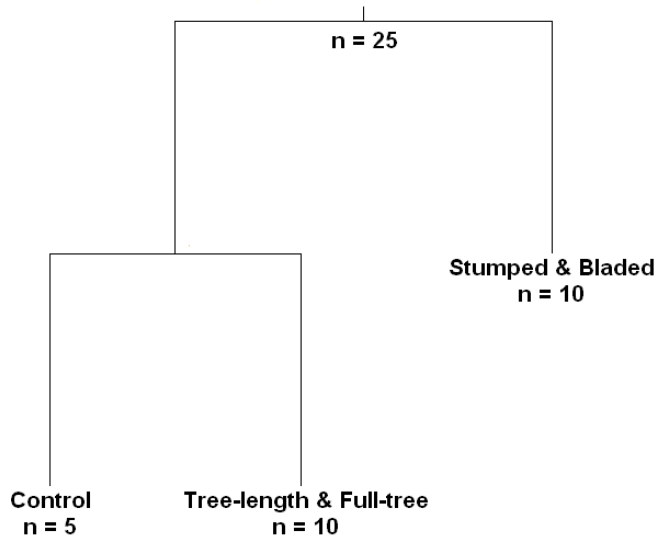
Inertia = 22 %

Community composition and structure differ



Community composition and structure differ





Non-metrical distance scaling

Bray-Curtis dissimilarity

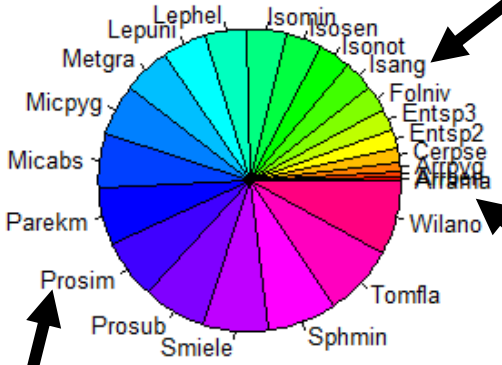
Stress = 0.09

R^2 = 0.20 – $p < 0.1^{\dagger}$

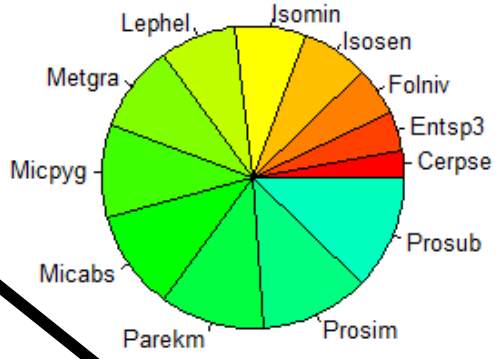
Community composition and structure differ

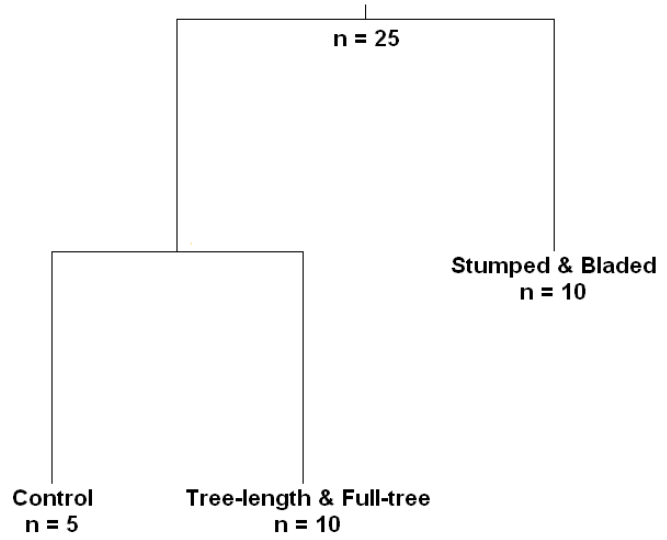
Isotoma anglicana

Control



Tree-length & Full-tree

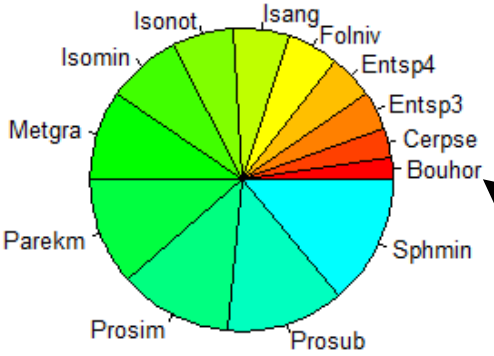


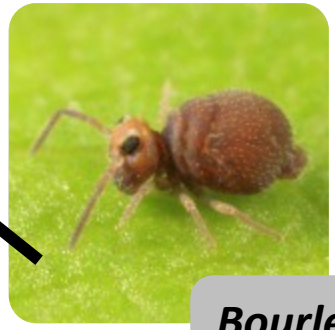


Protaphorura similis

Arrhopalites pygmaeus

Bladed & Stumped

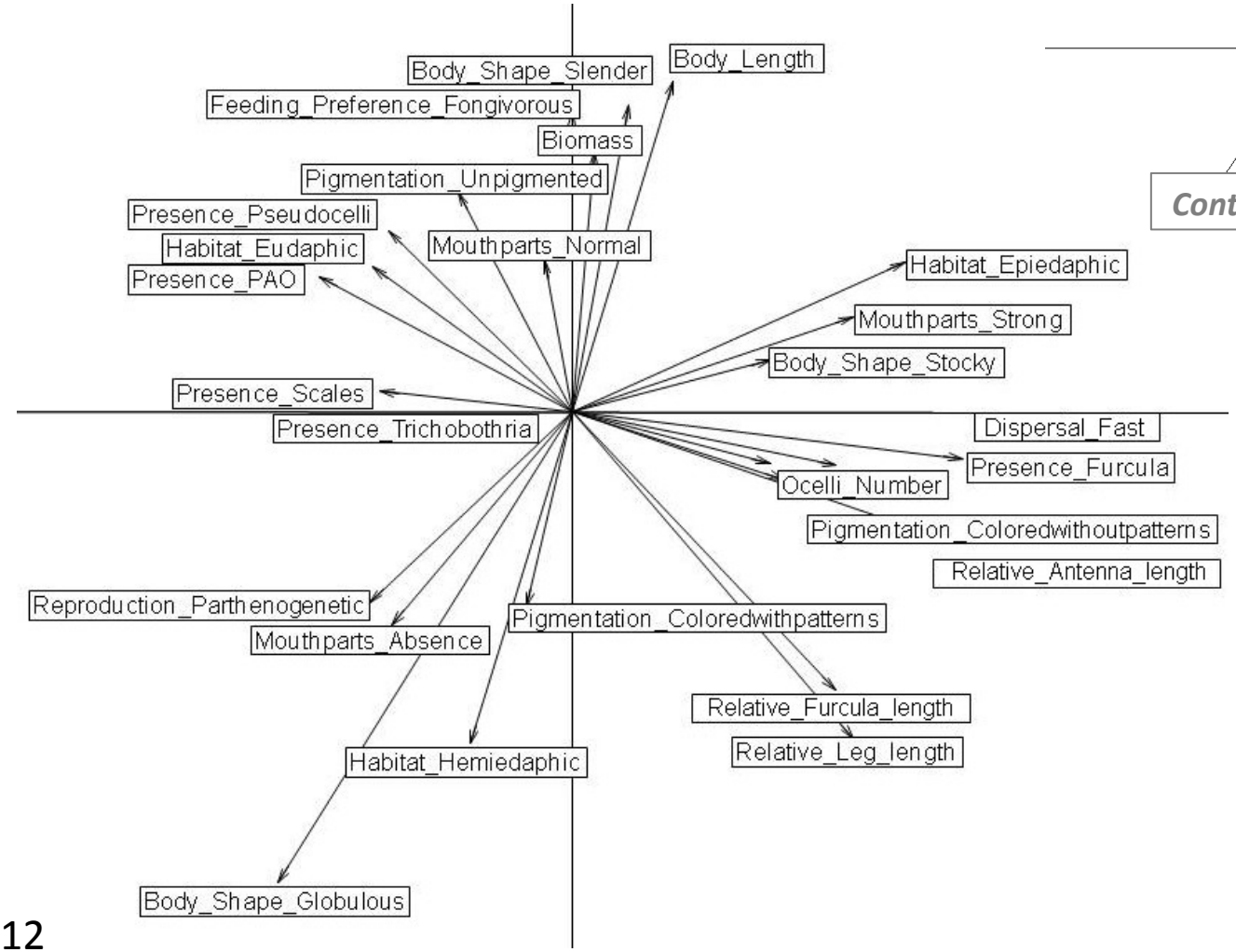


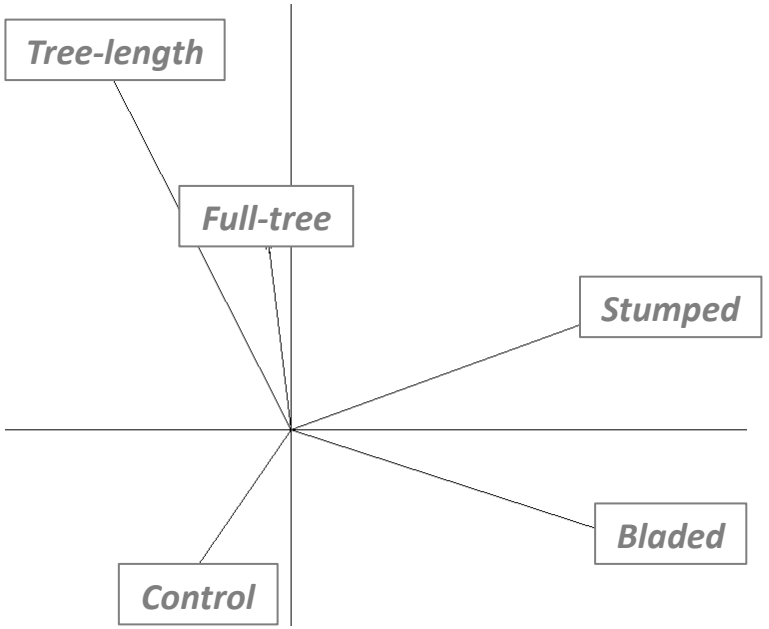


Bourletiella hortensis

Indicator species (IndVal)

Collembola response traits & ecological preferences



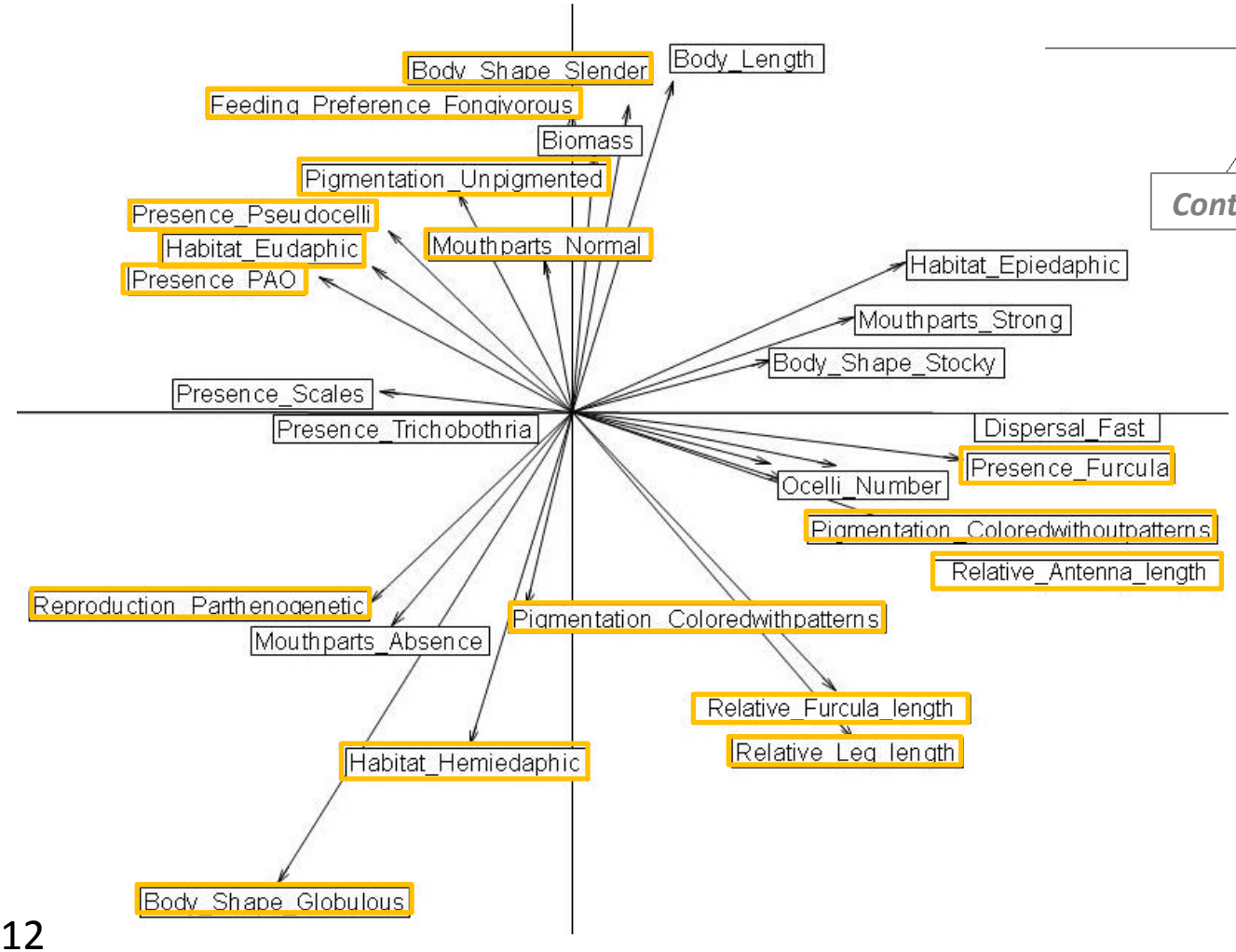


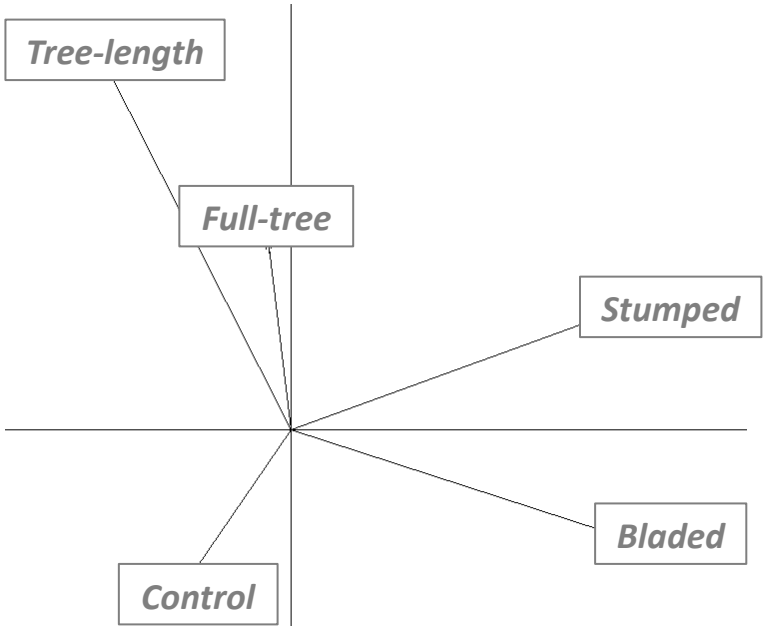
RLQ analysis

Inertia = 80 %

p < 0.05*

Collembola response traits & ecological preferences





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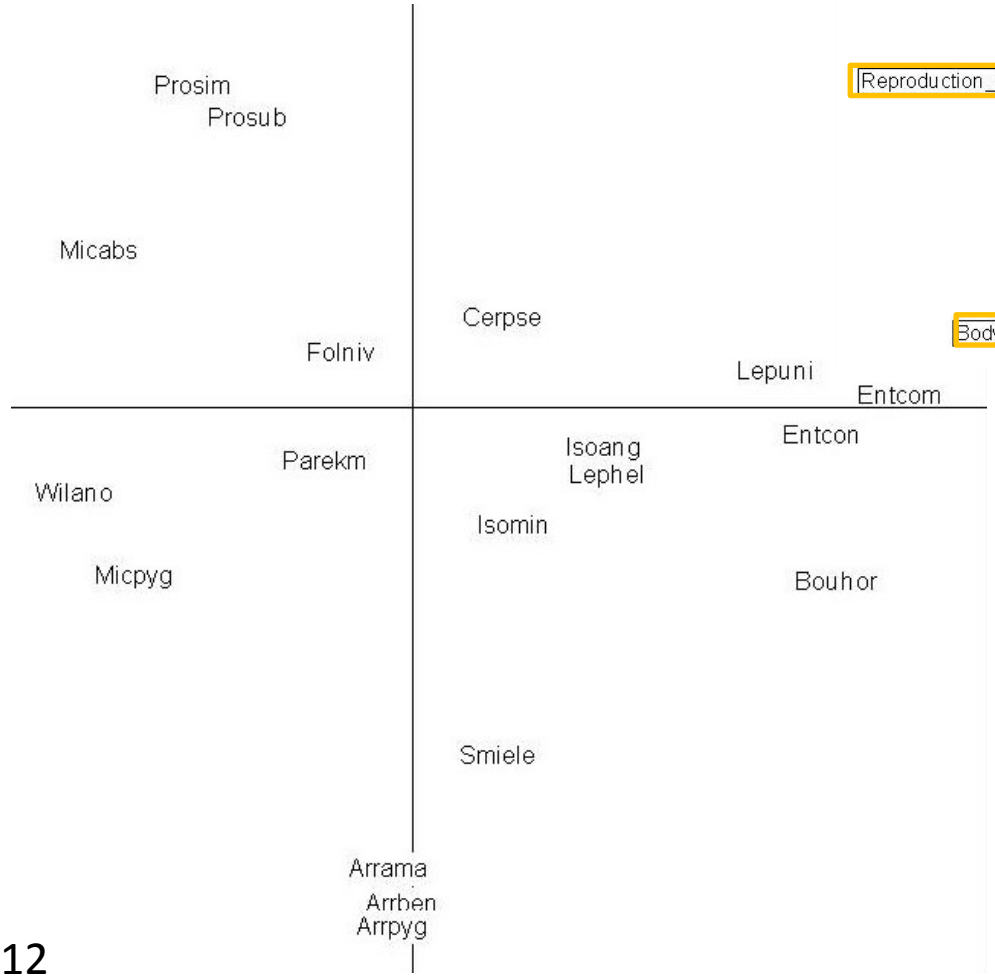
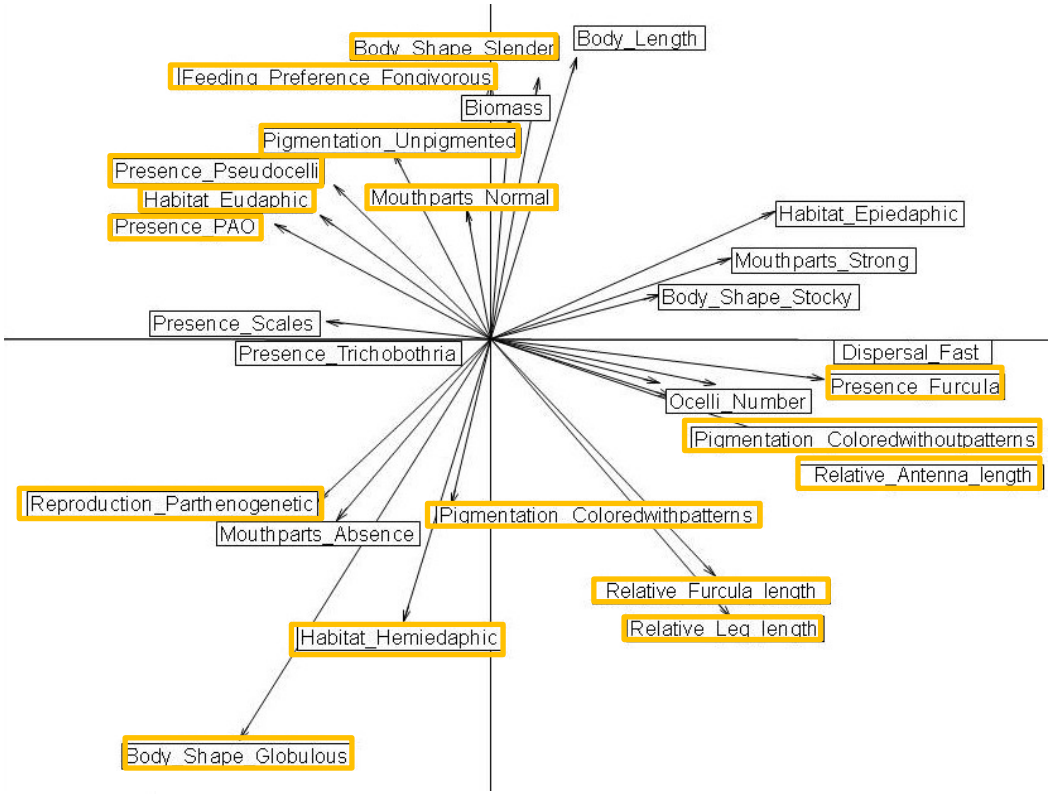
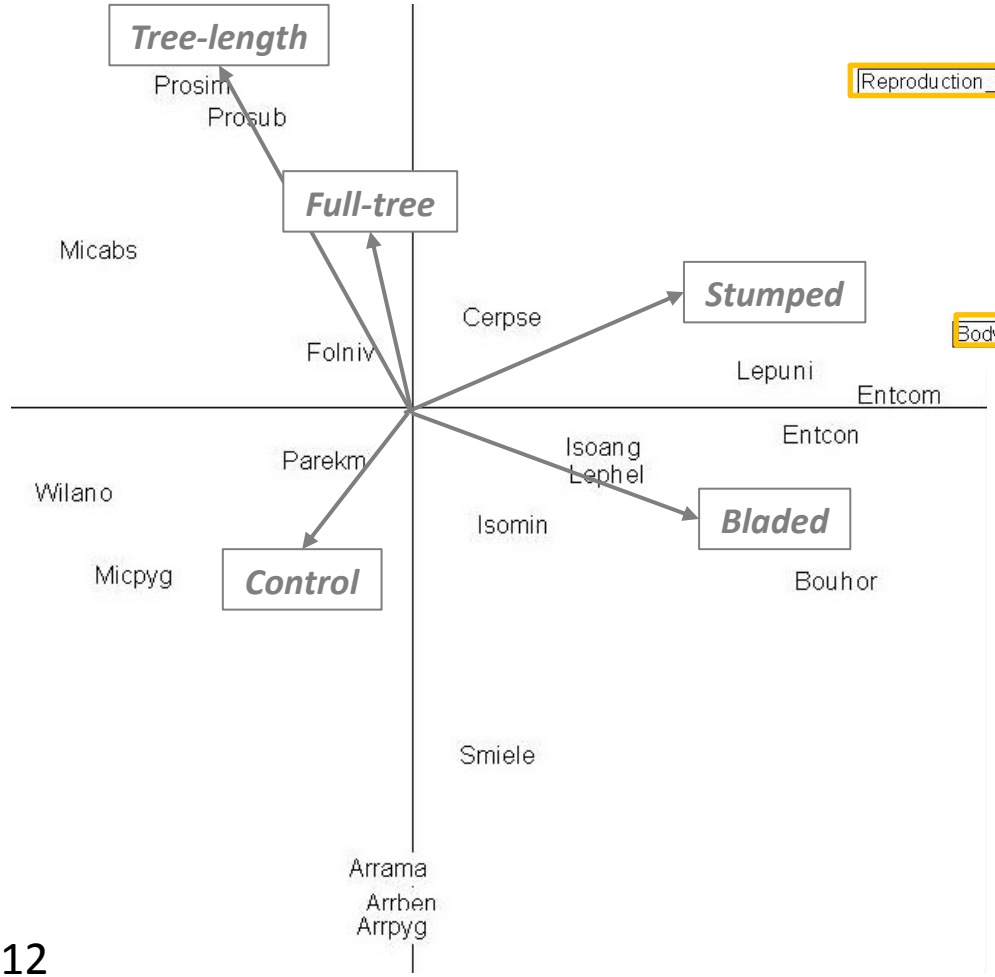
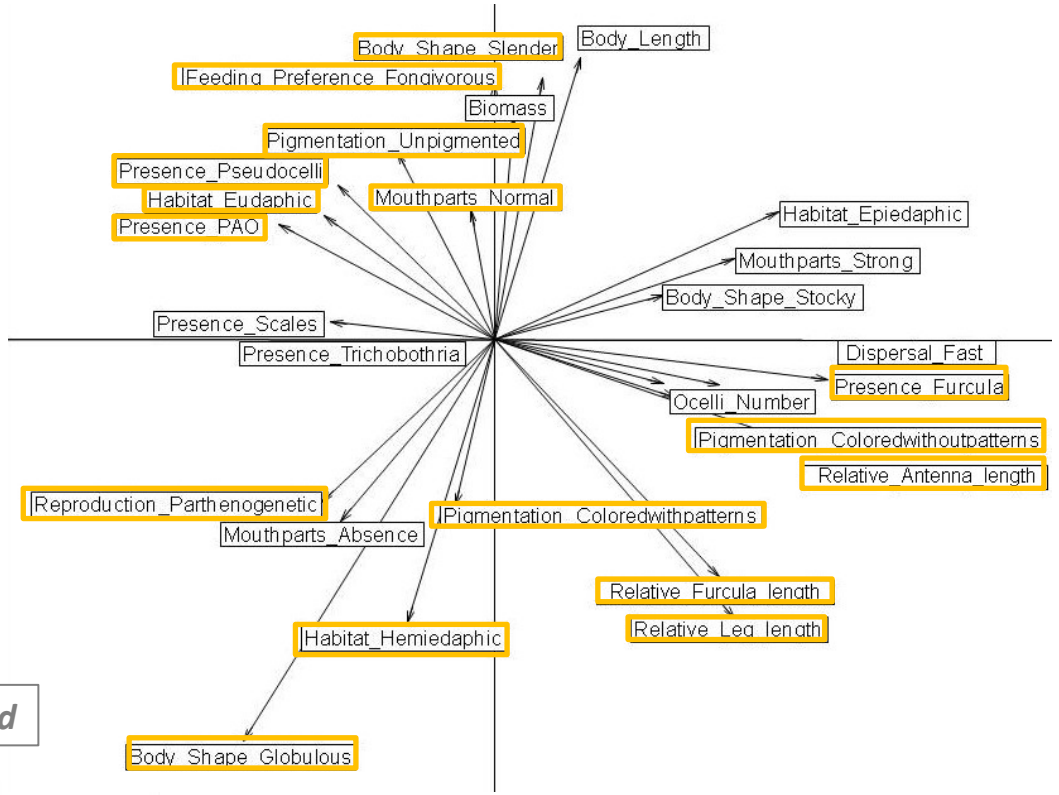


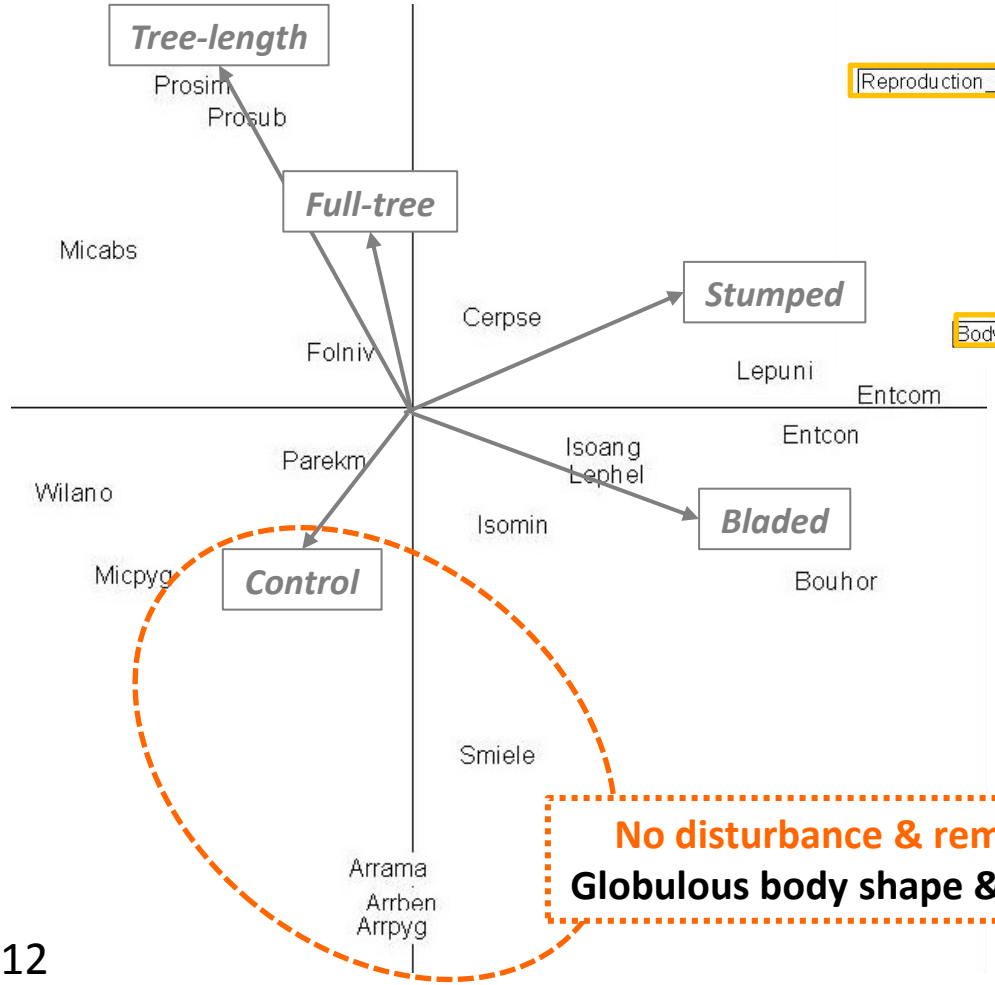


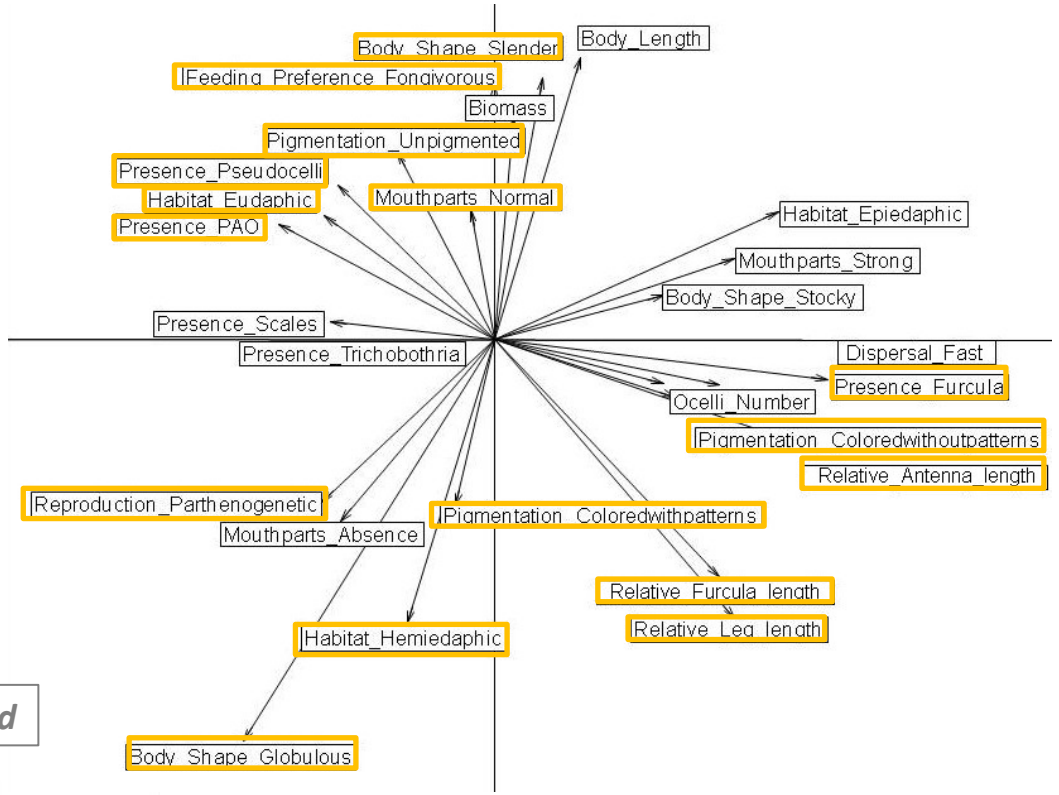
Functional response





Functional response



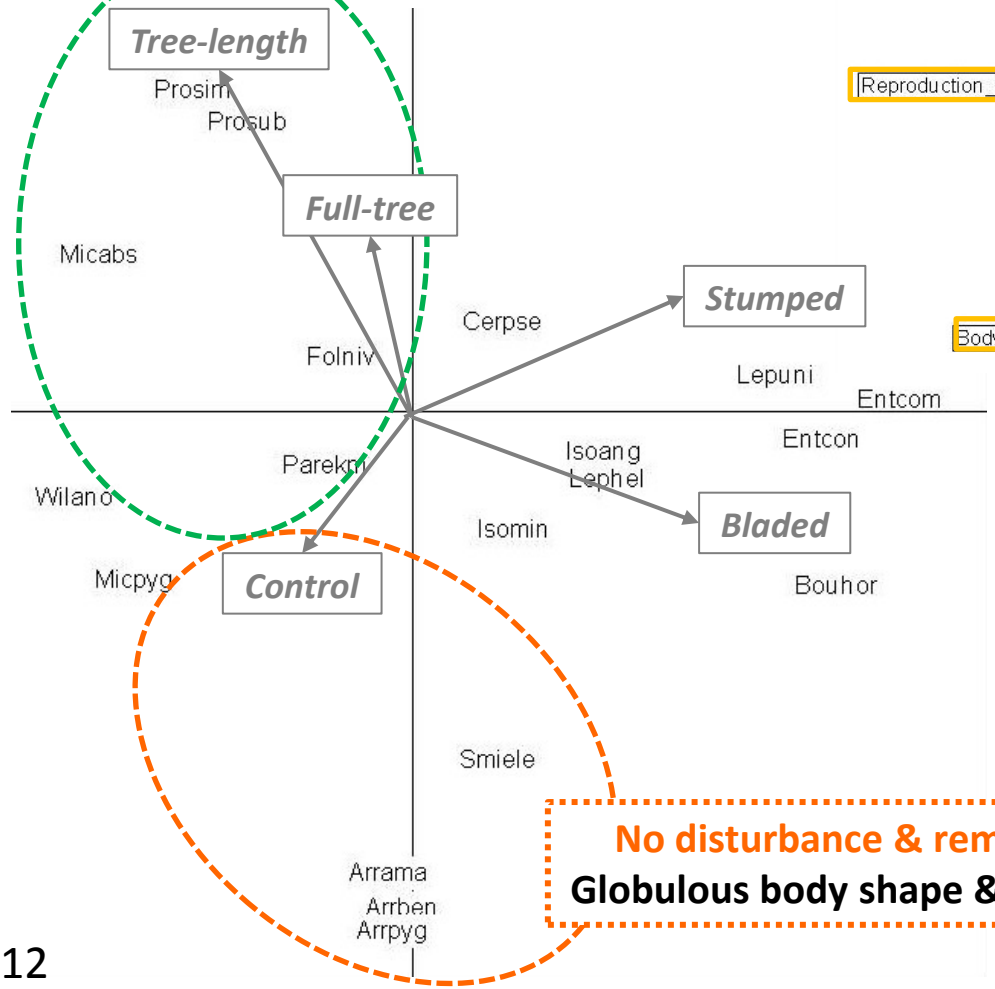


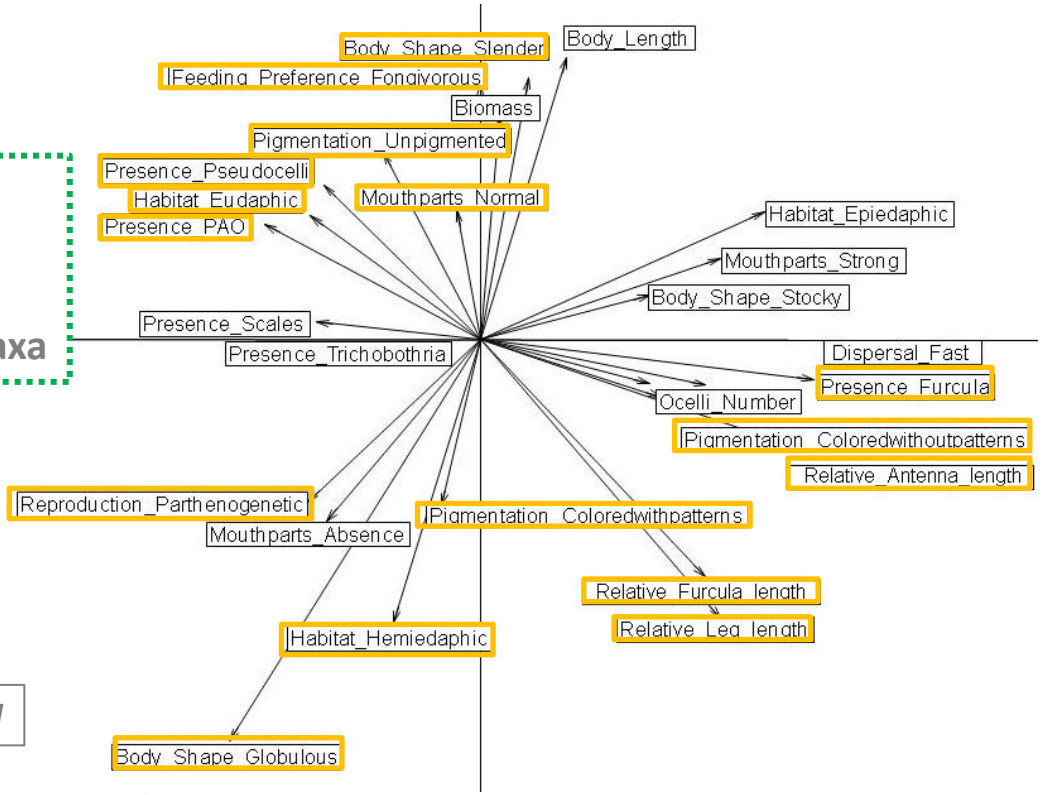
No disturbance & removal (Control)

Globulous body shape & pigmented taxa

Functional response

Low disturbance & removal
(Tree-length & Full-tree)
Unpigmented & PAO presence taxa
Eu-hemiedaphic & parthenogenetic reprod. taxa





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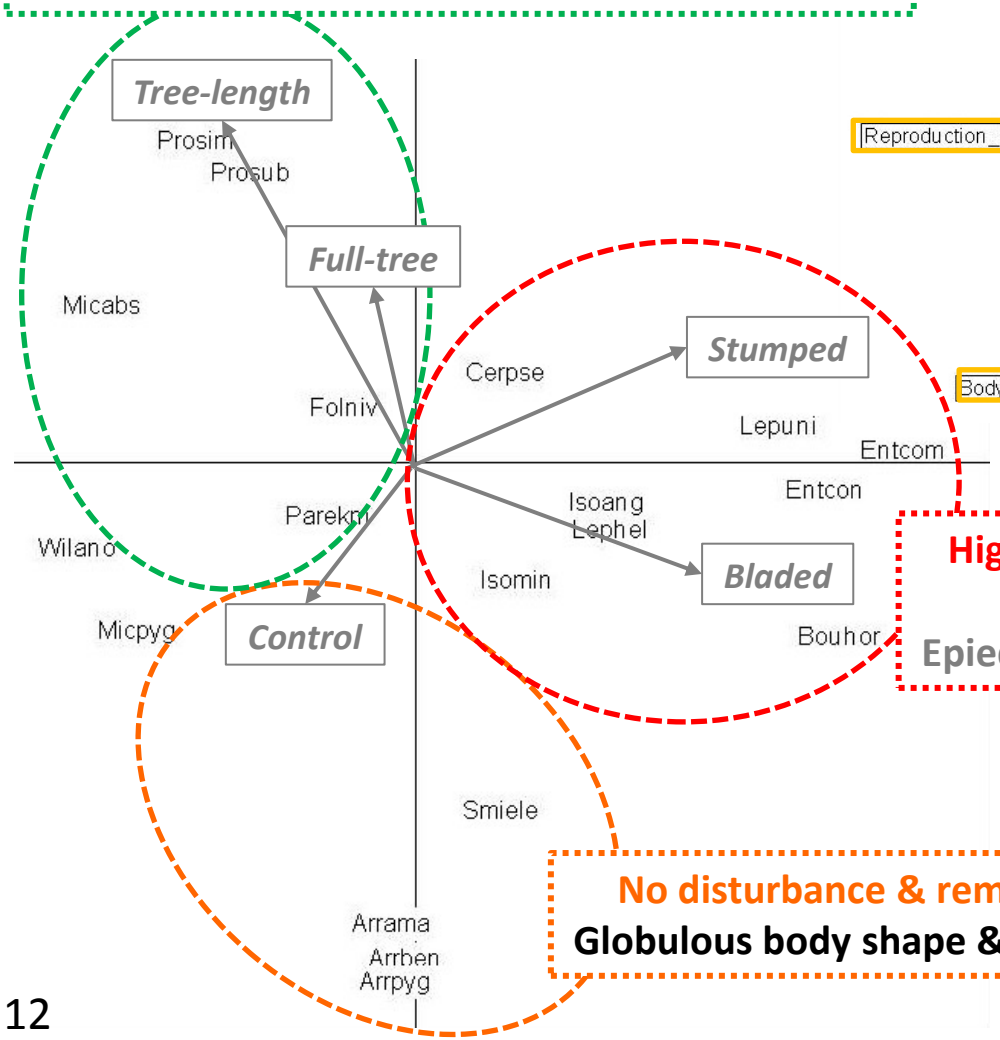
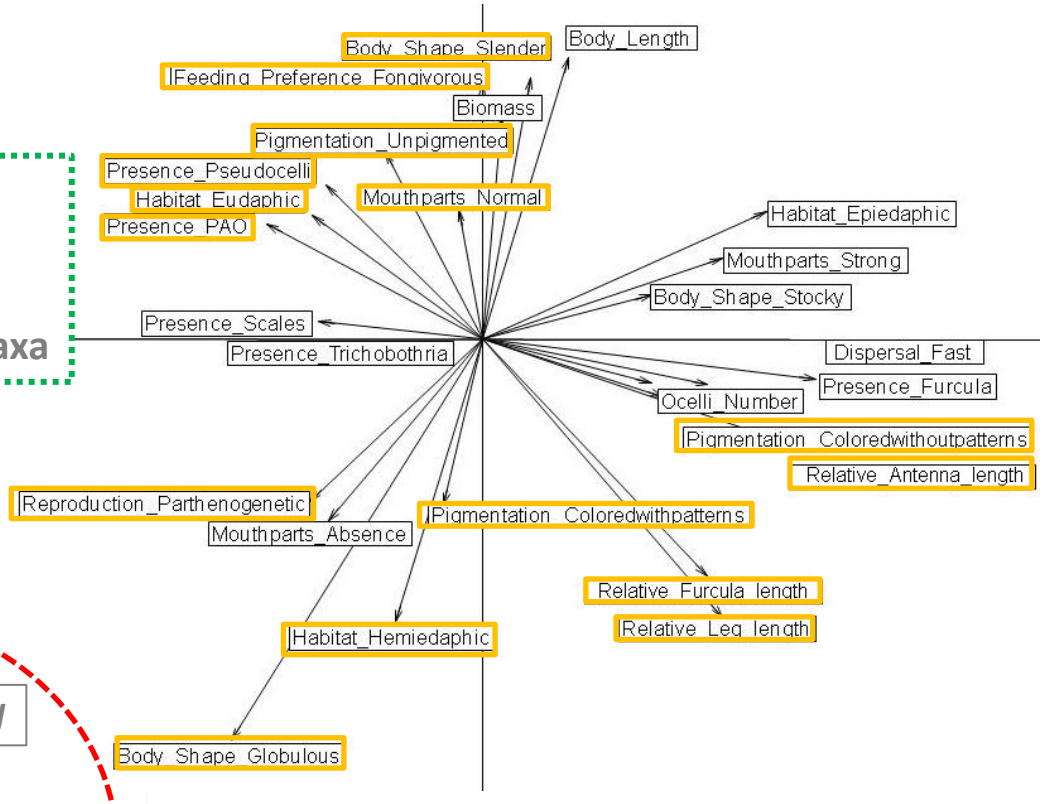




High disturbance & removal (Stumped & Bladed)
Pigmented taxa, antenna & ocelli
Epiedaphic, dispersal capacity & sexual reprod. taxa

No disturbance & removal (Control)
Globulous body shape & pigmented taxa

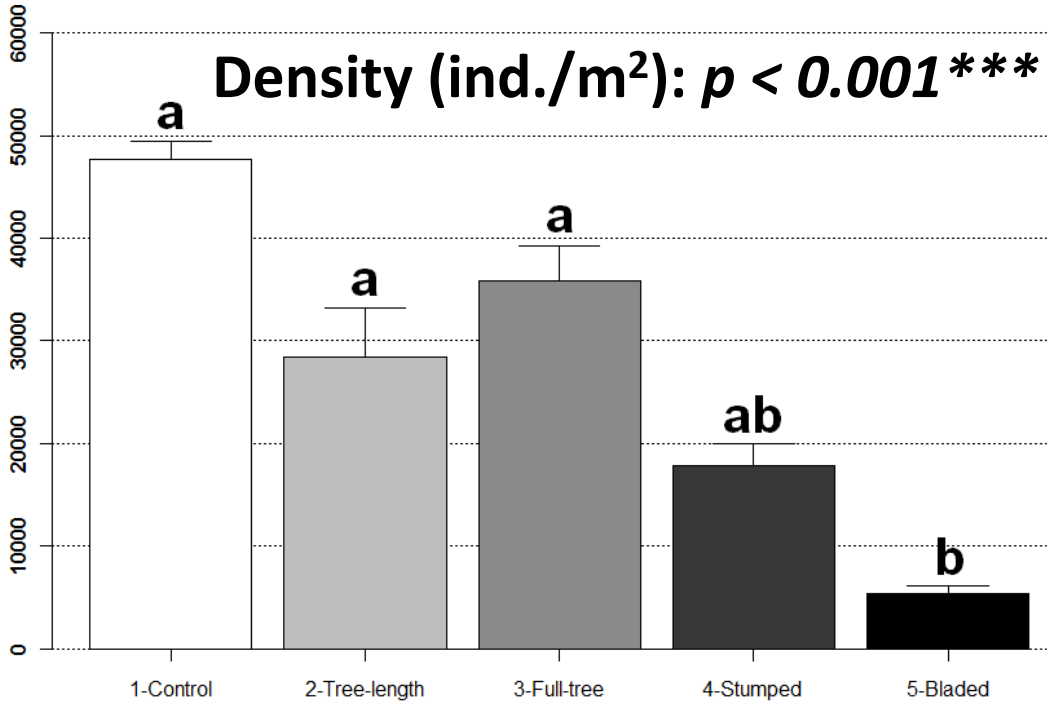
Oribatid mite response to the gradient of disturbance & biomass removal

4000 specimens +

32 species ID

470 specimens used for traits & preferences

Oribatid mite response to the gradient of disturbance & biomass removal



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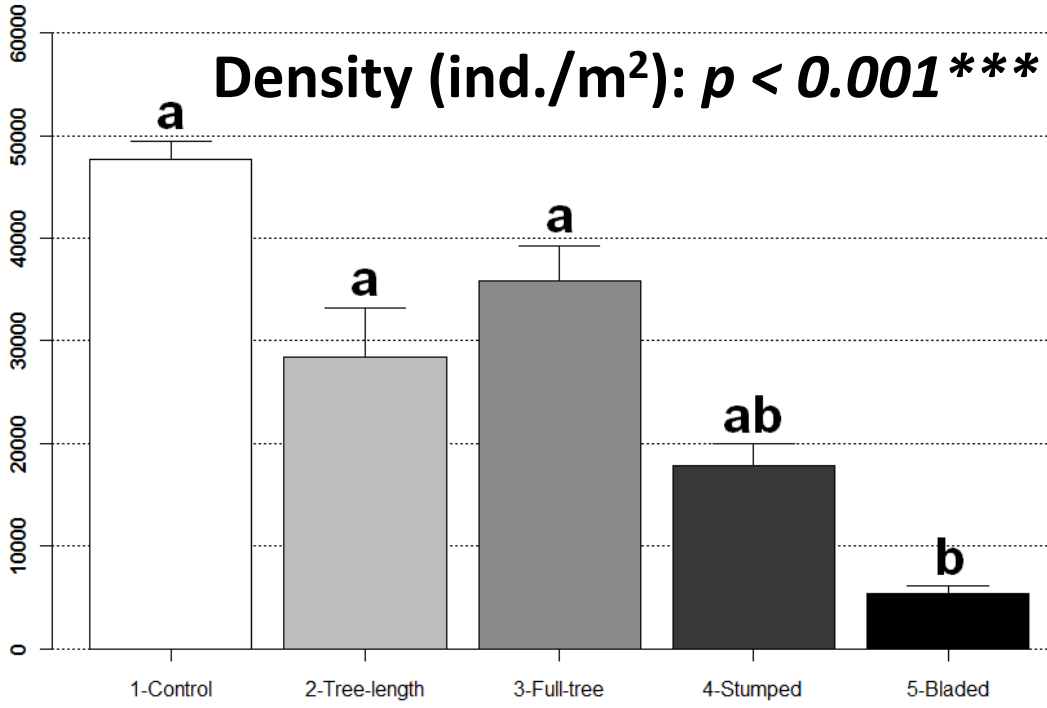
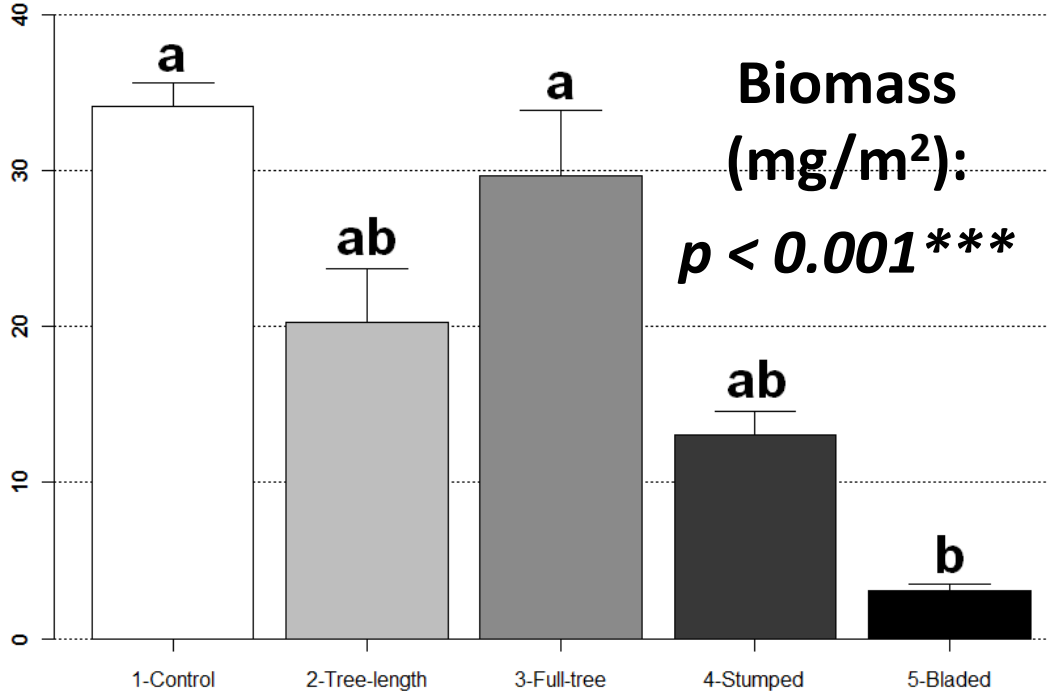
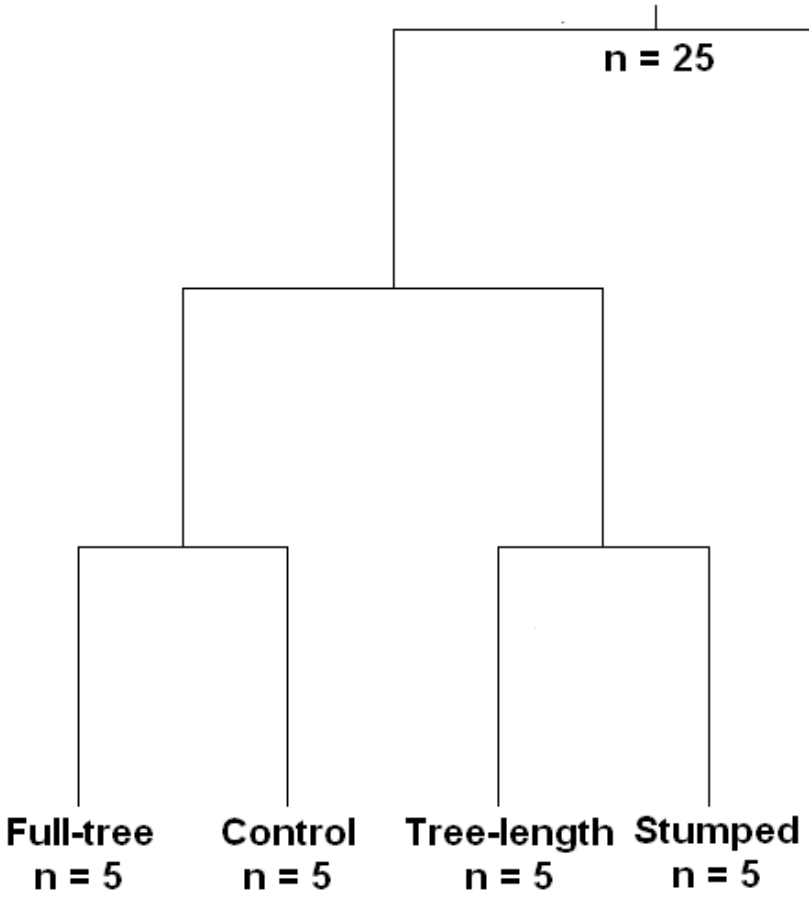




Community clustering to biomass removal gradient

Community clustering to biomass removal gradient



Multivariate regression tree

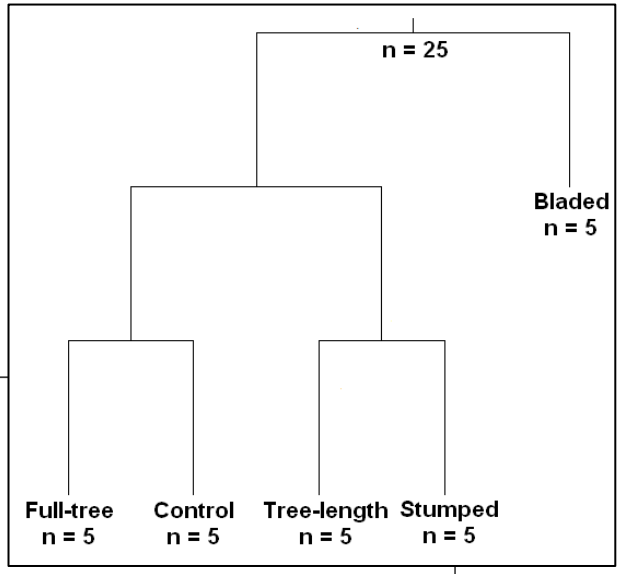
Bray-Curtis distance

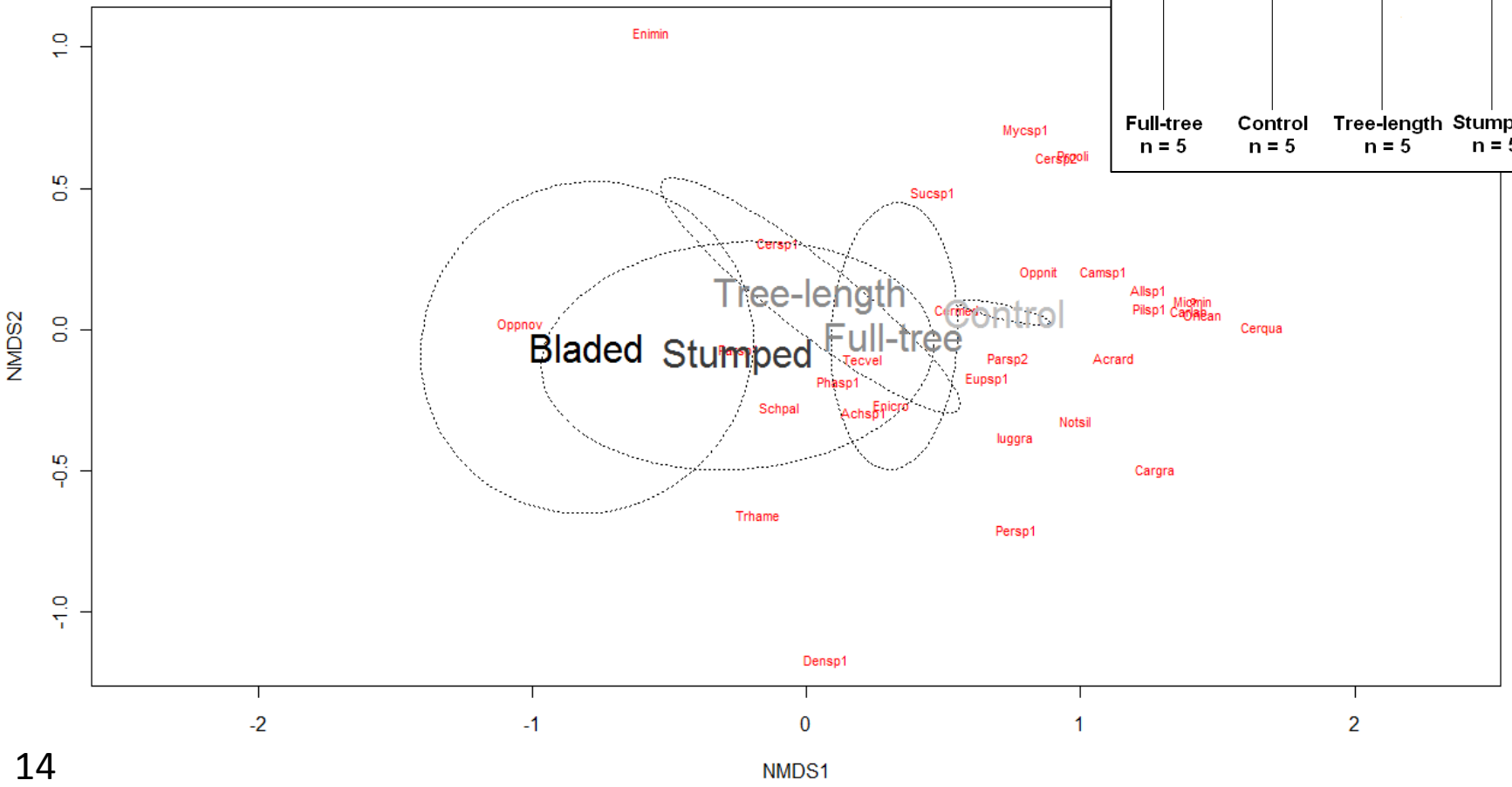
Inertia = 42 %

Community composition and structure differ

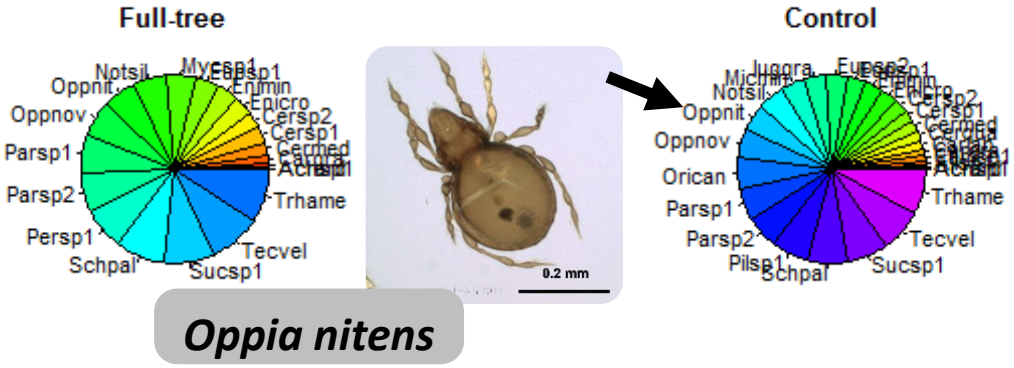
NMDS - Bray-Curtis dissimilarity

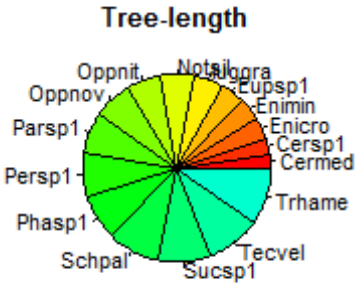
Stress = 0.092 - R^2 = 0.48 - *p < 0.01***

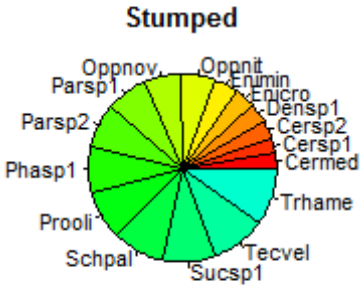


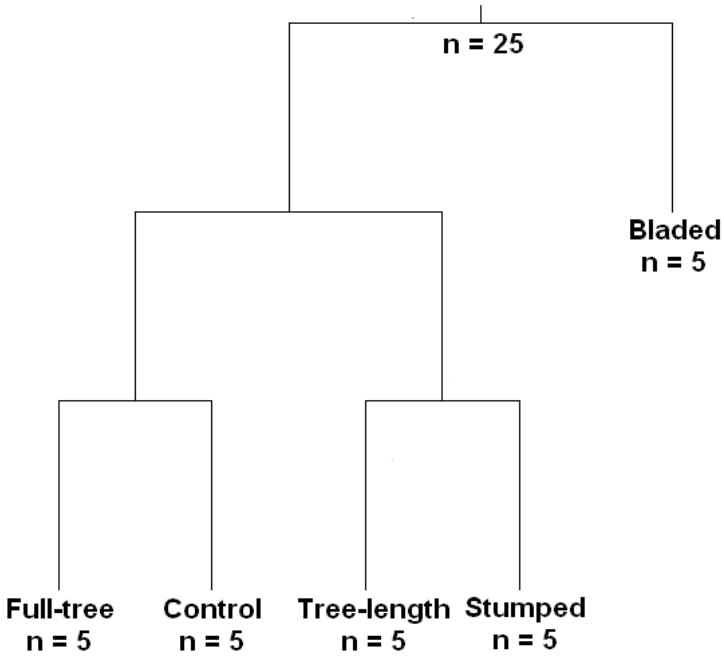


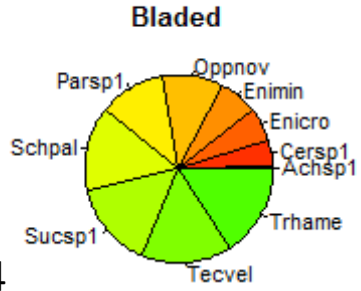
Community composition and structure differ





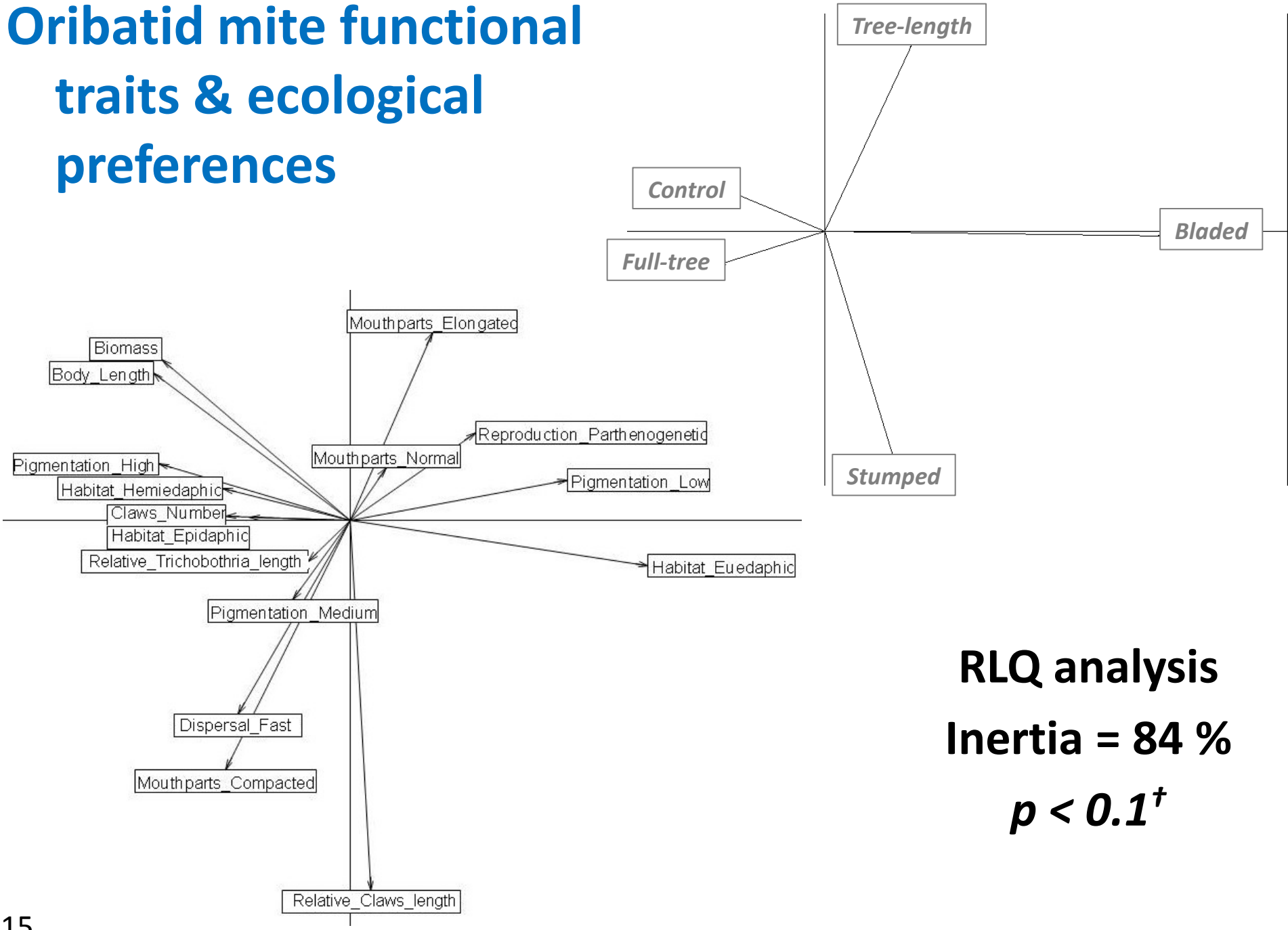






Indicator species (IndVal)

Oribatid mite functional traits & ecological preferences

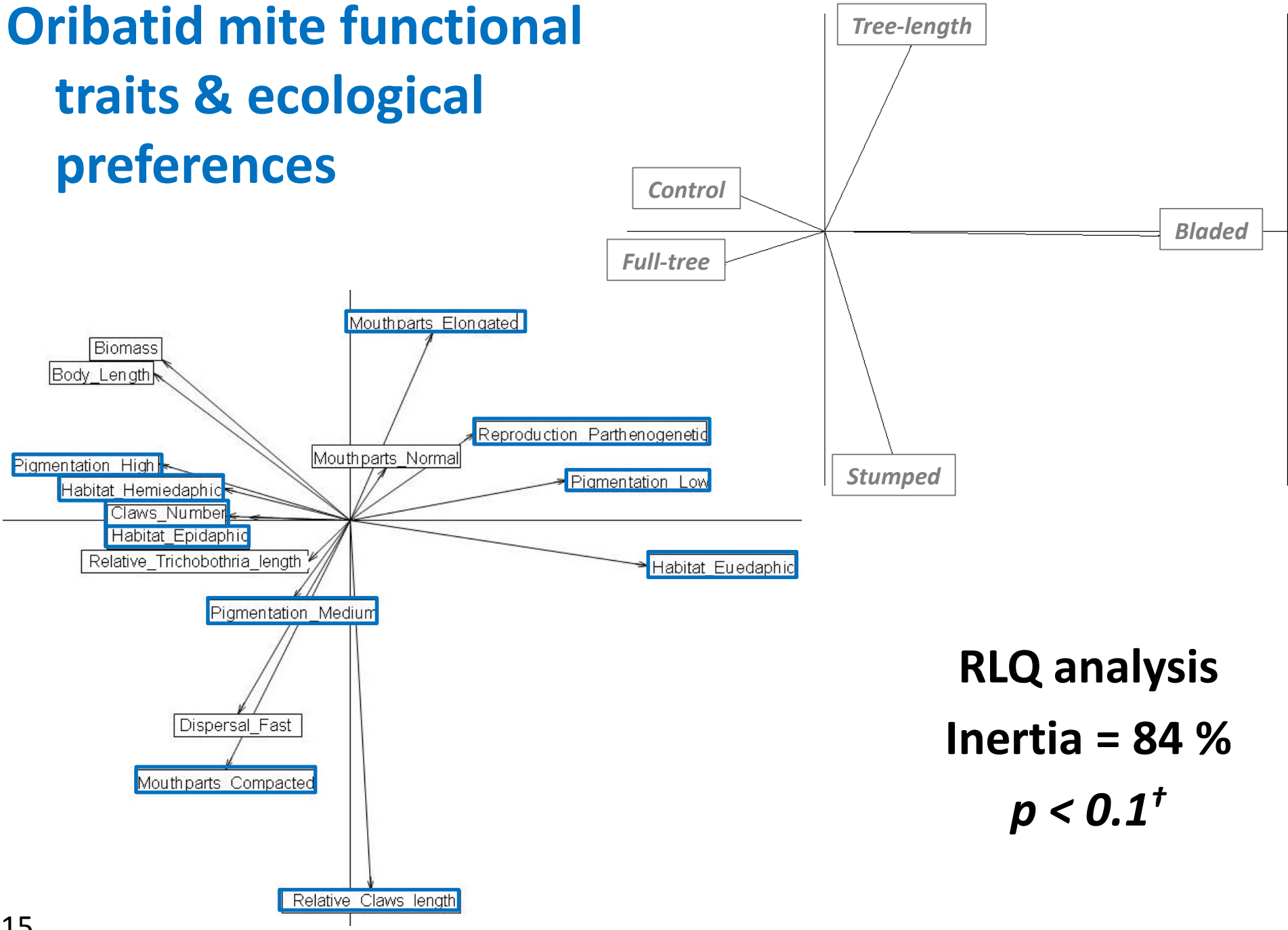


RLQ analysis

Inertia = 84 %

p < 0.1†

Oribatid mite functional traits & ecological preferences



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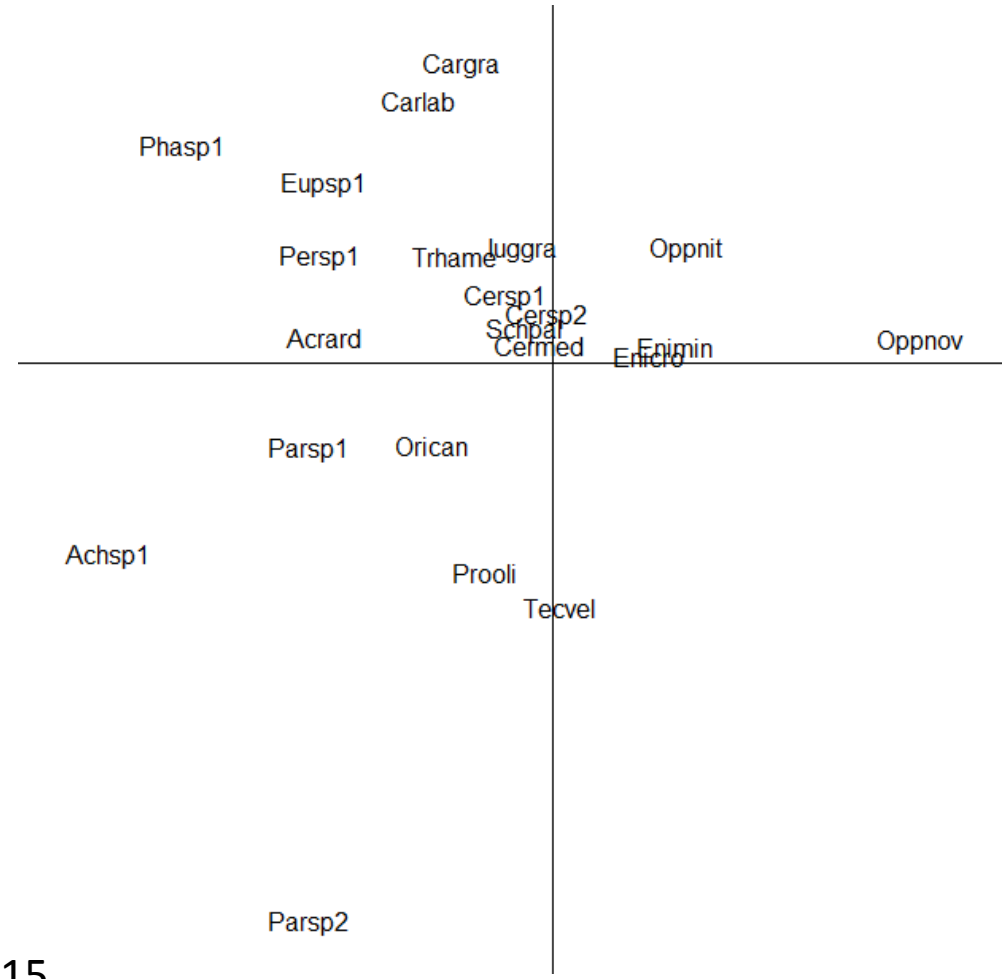
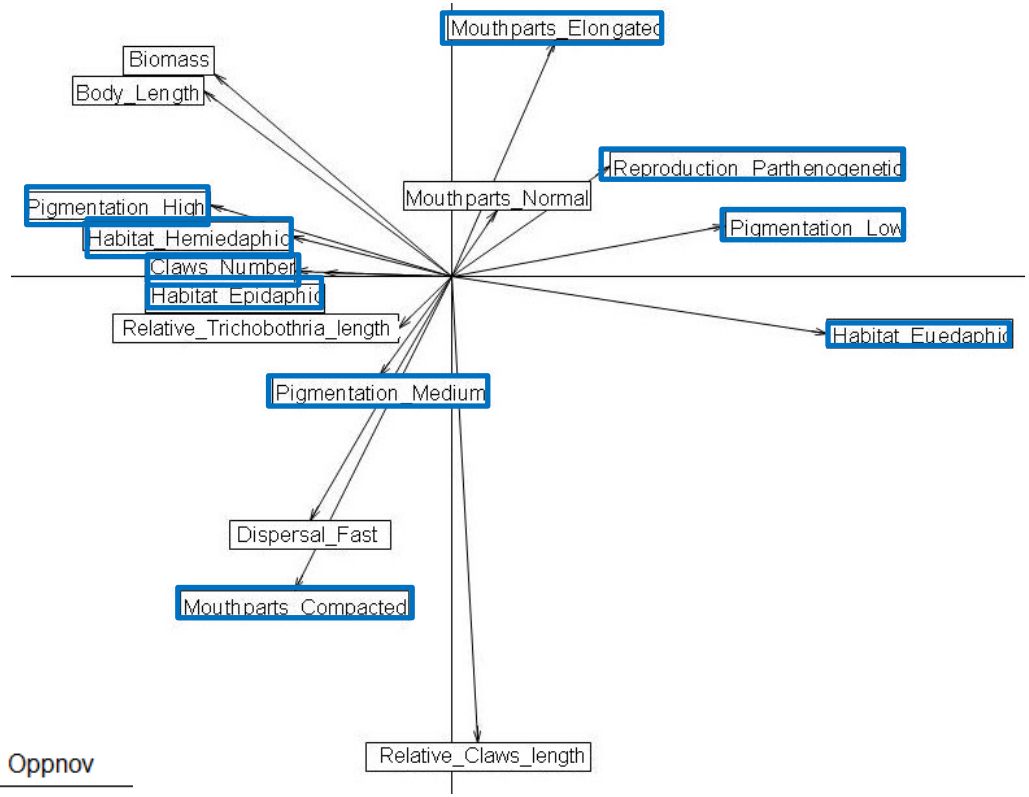
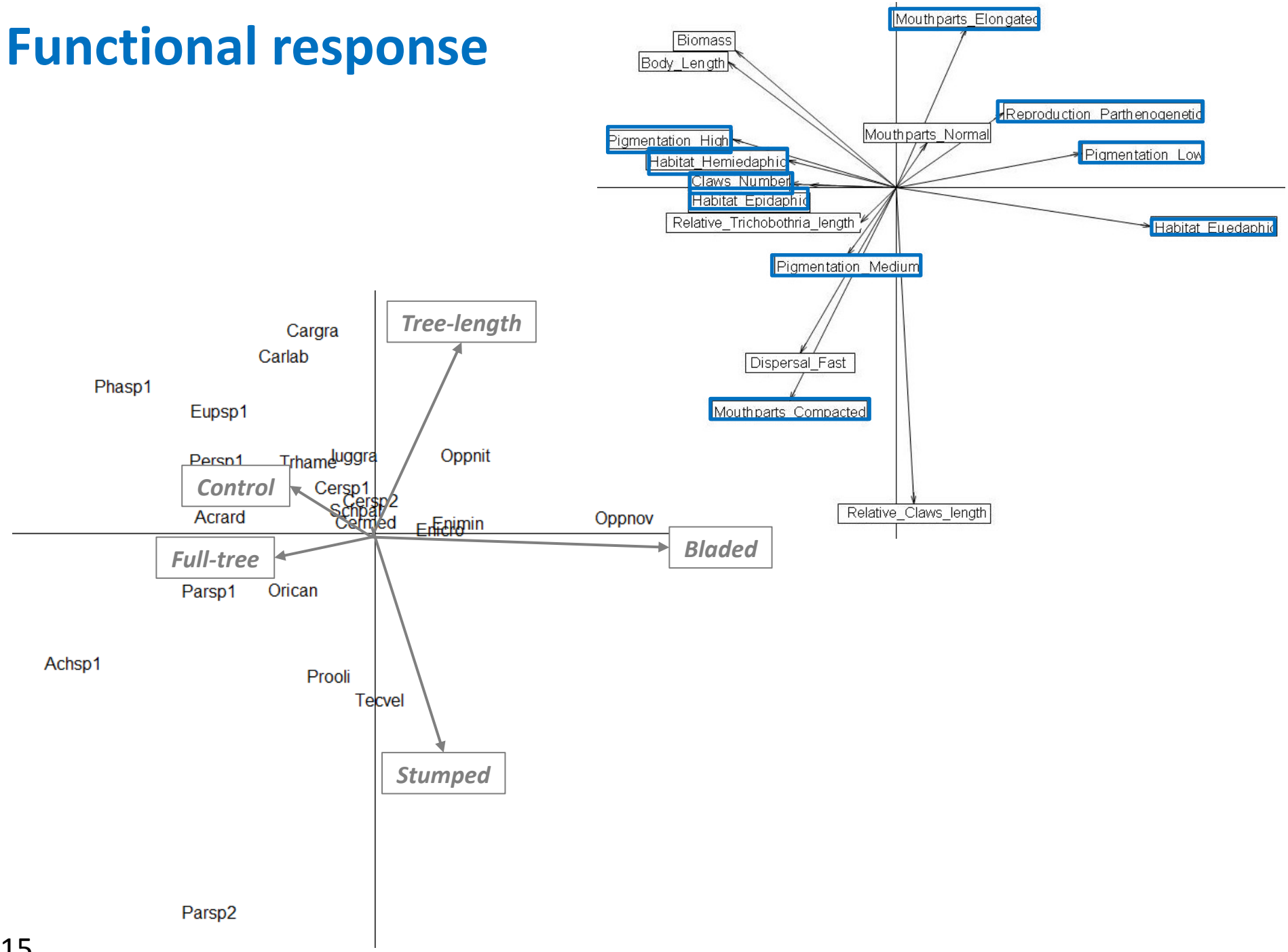


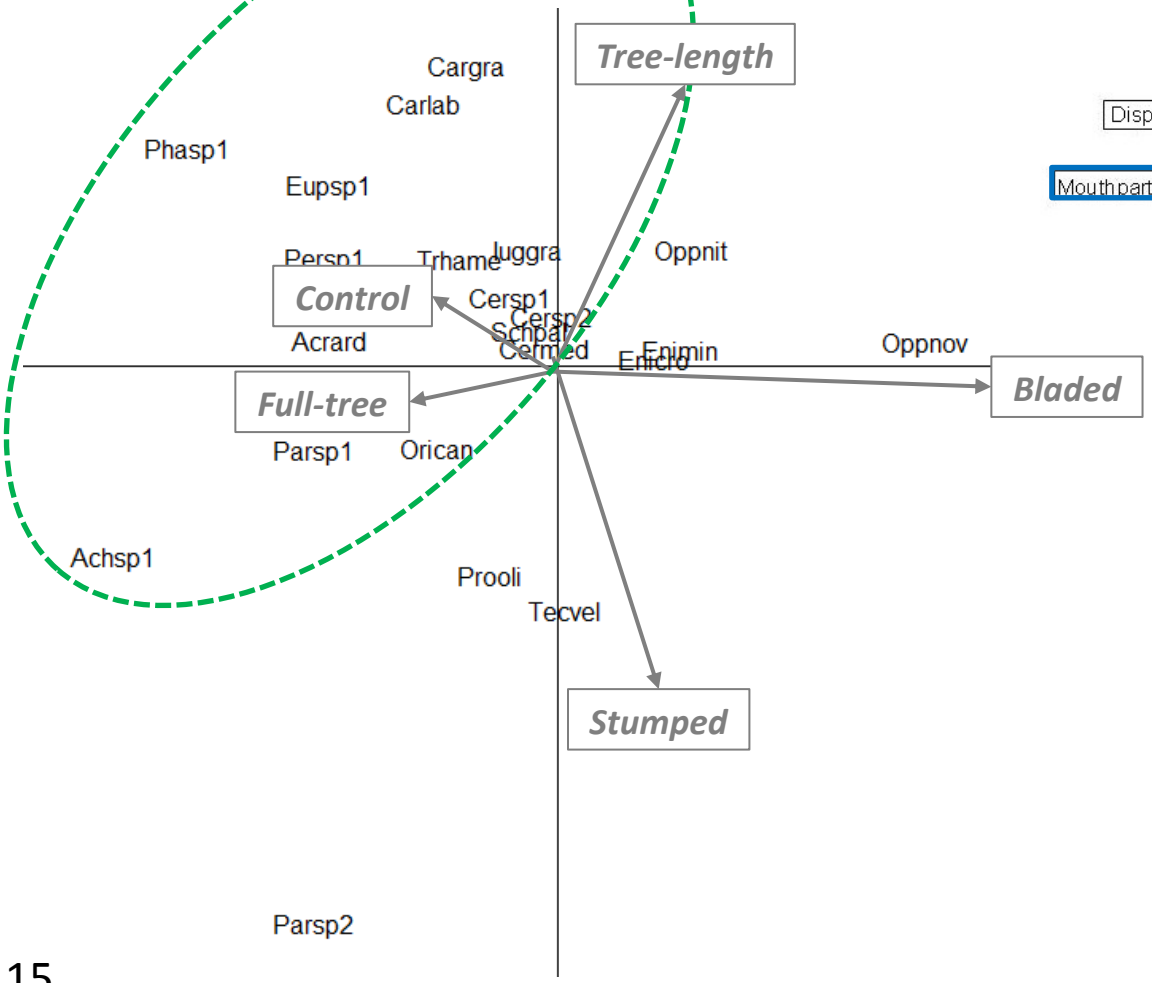


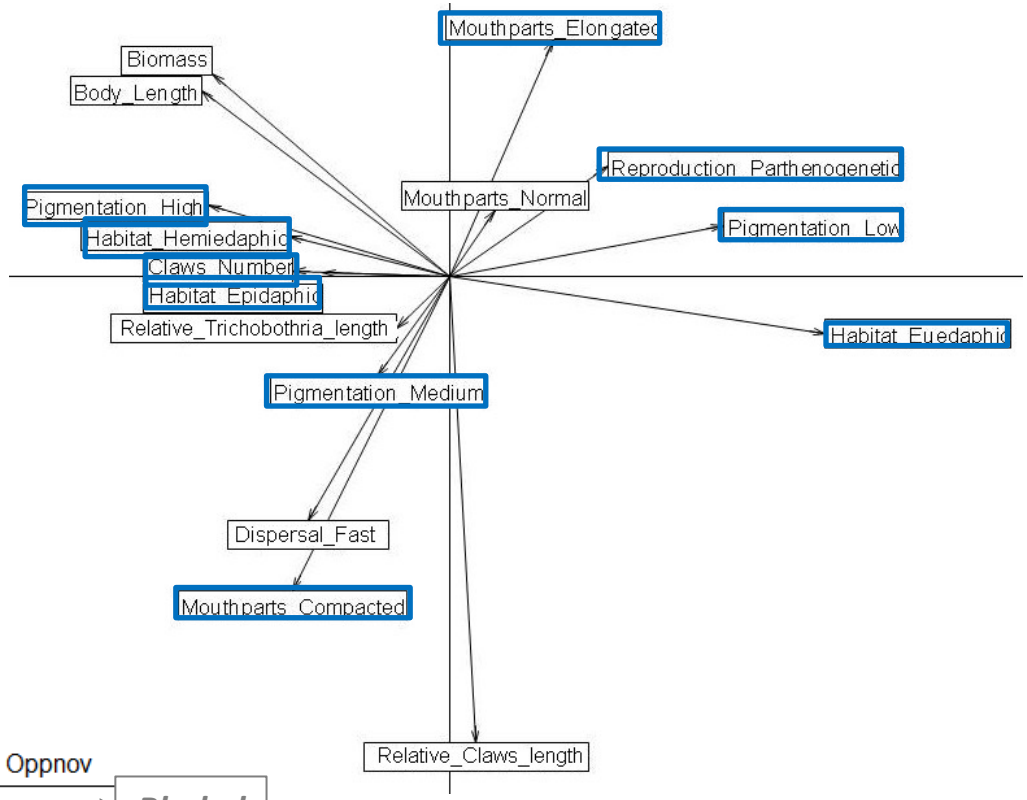
Functional response



Functional response

Low disturbance & removal
(Control, Tree-length & Full-tree)
Pigmented, large size & high biomass taxa
Epiedaphic, sexual reprod. & dispersal capacity taxa





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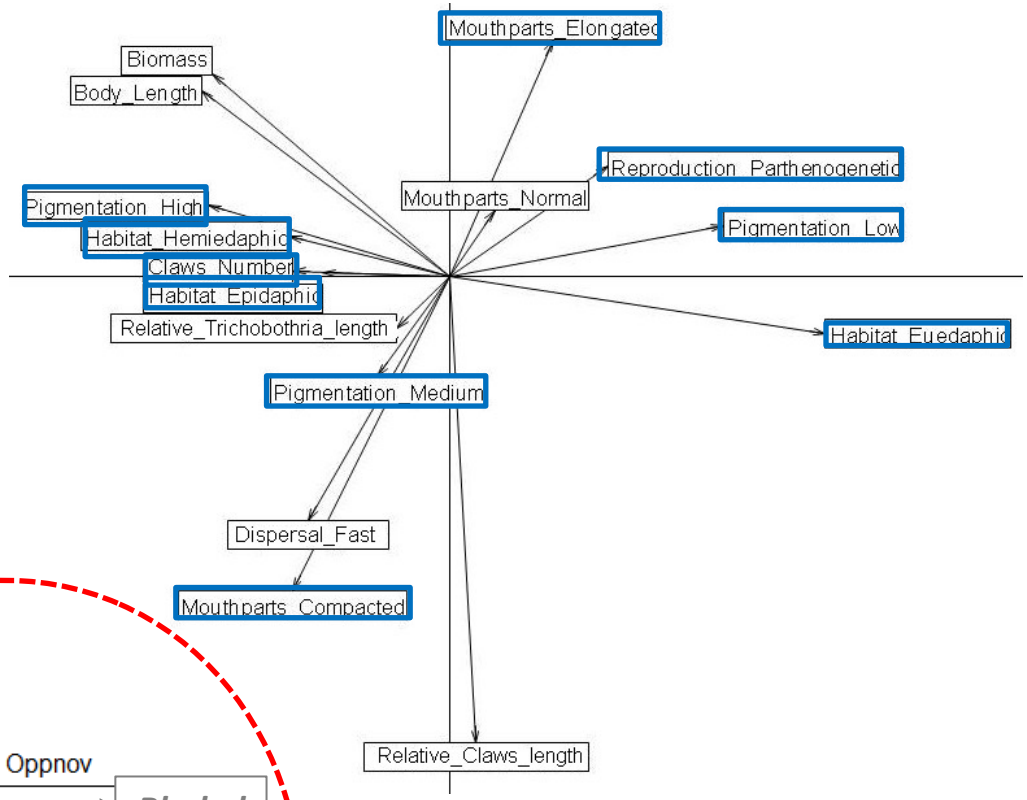

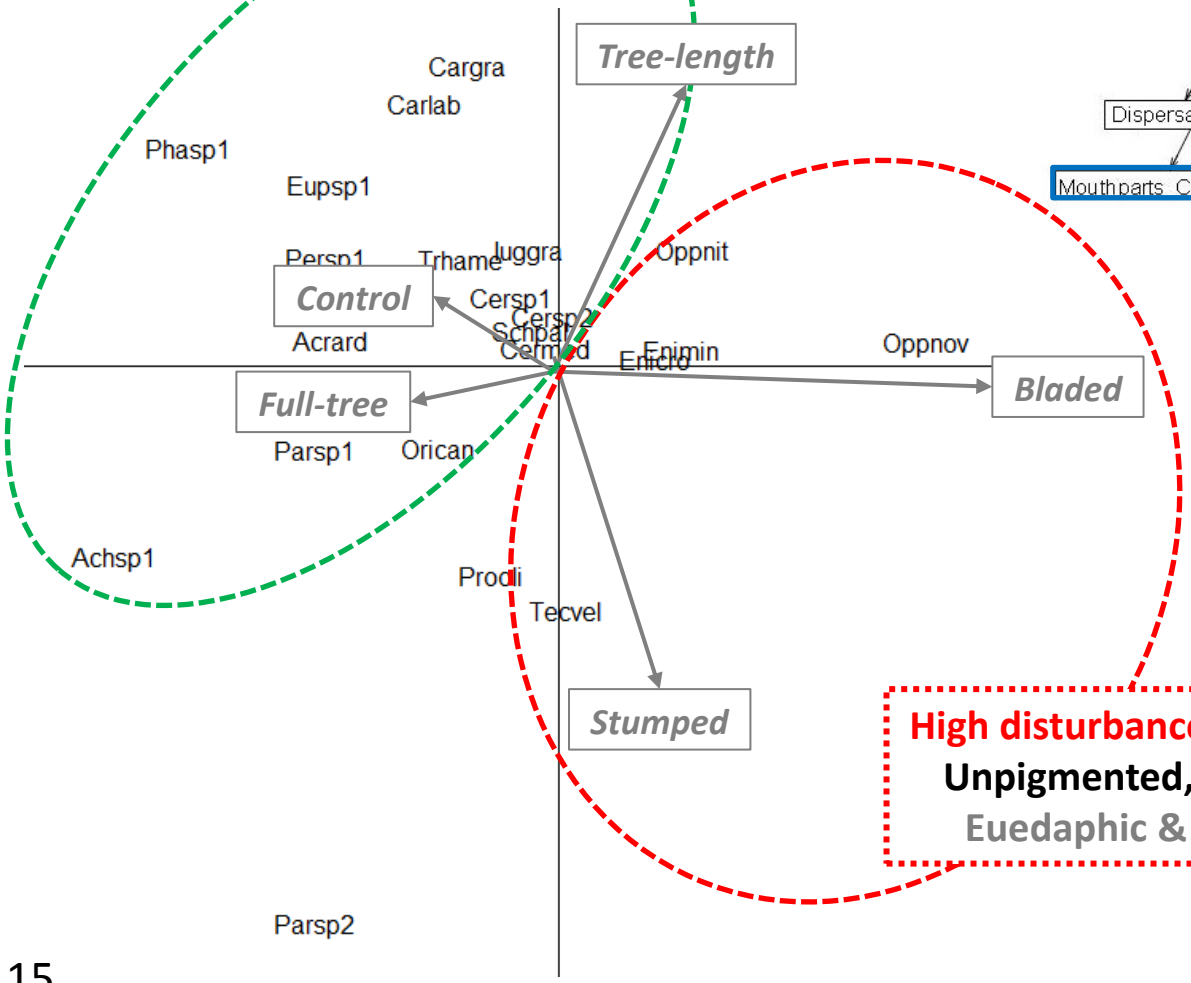

High disturbance & removal (Stumped & Bladed)
Unpigmented, small size & low biomass taxa
Euedaphic & parthenogenetic reprod. taxa

Conclusion

Conclusion

Similar taxonomic response of Collembola & Oribatid mite communities to high disturbance & removal:

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➔ Loss of density, diversity & biomass + modified structure

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Different functional response high disturbance & removal:

Conclusion

Similar taxonomic response of Collembola & Oribatid mite communities to high disturbance & removal:

➔ Loss of density, diversity & biomass + modified structure

Different functional response high disturbance & removal:

➔ Collembola: +++ epiedaphic, high dispersal capacity & sexual reproduction taxa

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Conclusion

Similar taxonomic response of Collembola & Oribatid mite communities to high disturbance & removal:

➔ Loss of density, diversity & biomass + modified structure

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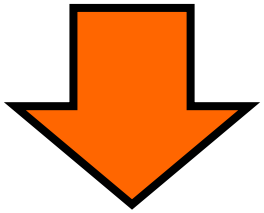

Significant effect on soil mesofauna at short term:

Tree-length & Full-tree > Stumped & Bladed

Thanks to all the collaborators of the project...

R. Fleming, P. Hazlett, K. Webster, I. Aubin, K. Wainio-Keizer, K. Good, L. Hawdon,
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I. Laigle - Université du Québec à Rimouski (UQÀR)
S. Salmon - Museum National d'Histoire Naturelle de Paris (MNHN - France)
M. Moretti - Institut fédéral de recherches sur la forêt, la neige et le paysage (WSL - Switzerland)
Z. Lindo & P. Georges - Ontario Western University (UWO)
E. Smenderovac - University of Toronto (Utoronto)
Tembec & Ontario Power Generation


and for your
attention…