The effect of forest management on microclimate, biodiversity and regeneration in Central-European temperate forests

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Motivation

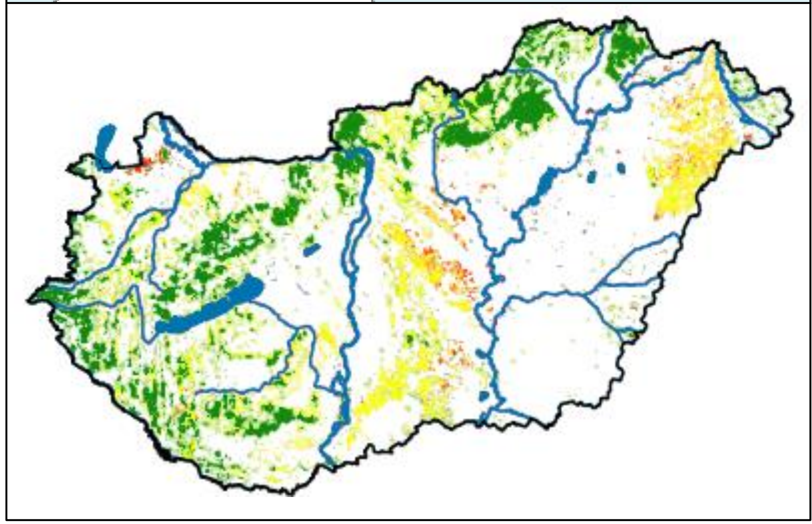
Necessity of the integration of timber production and conservation in forest mangement in Hungary

Forest cover in Hungary: ~21%

- Managed forests: 96%
- Protected + Natura2000 (management restrictions): 44%

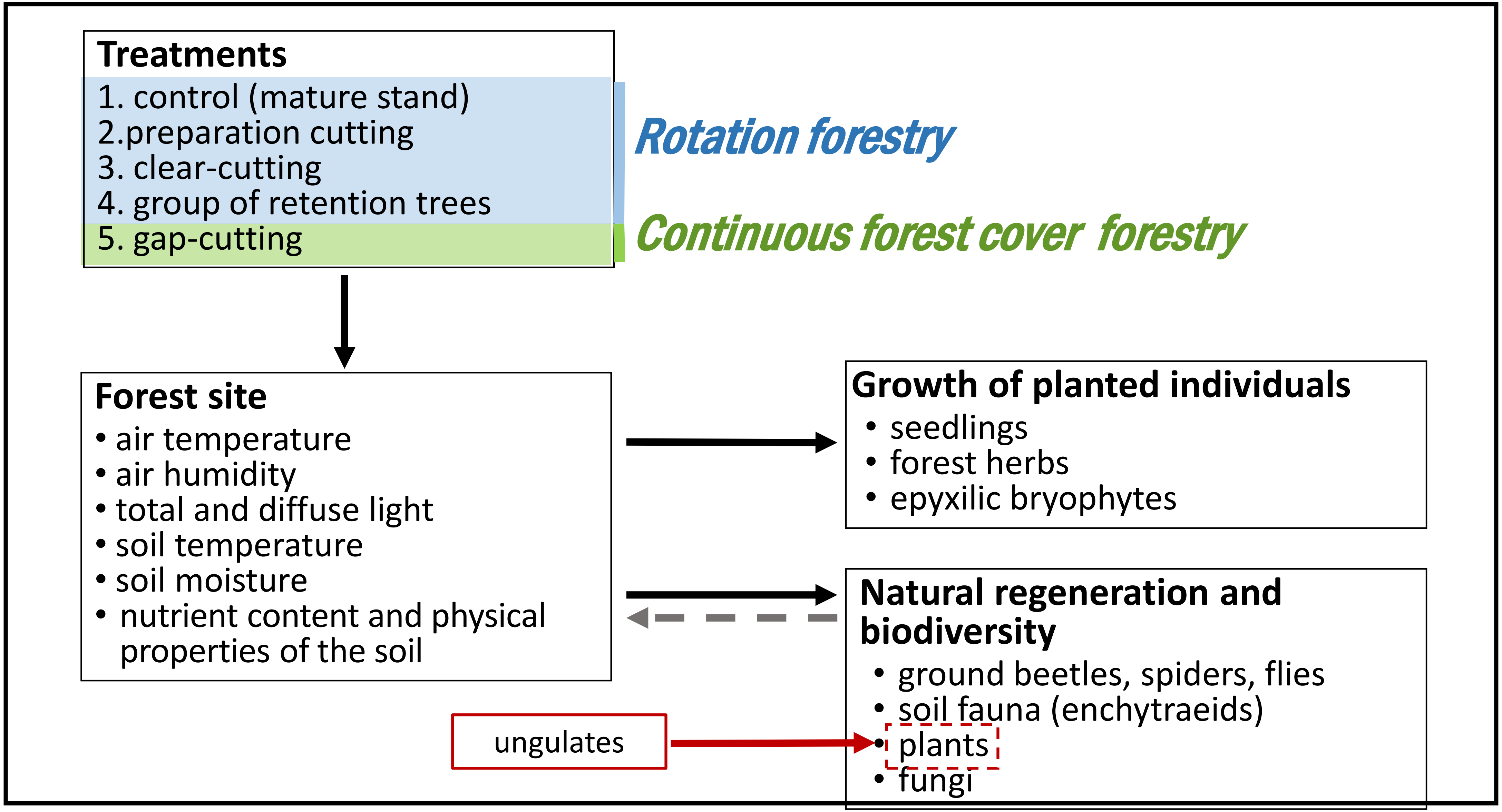
Applied silvicultural systems:

- Rotation forestry, shelterwood system (natural regeneration) → *native submontane forests*
- Rotation forestry, clear-cutting system (artificial regeneration) → *lowland forests and plantations*
- Continuous cover forestry, selection system → new!, ~4%, more open stands with continuous forest cover



Important to study the relationships between forest management and biodiversity

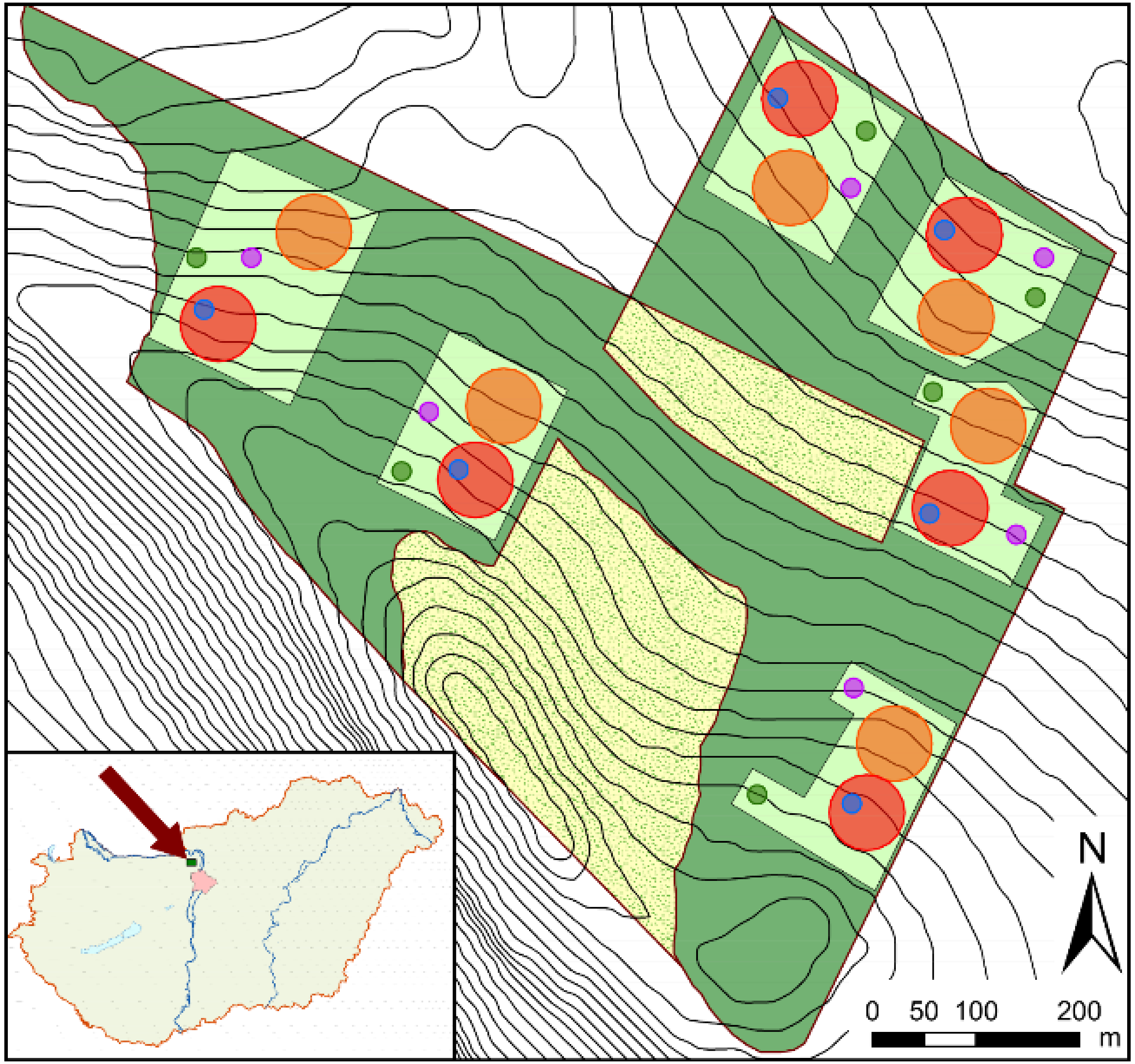
Framework of Pilis Foresty Systems Experiment

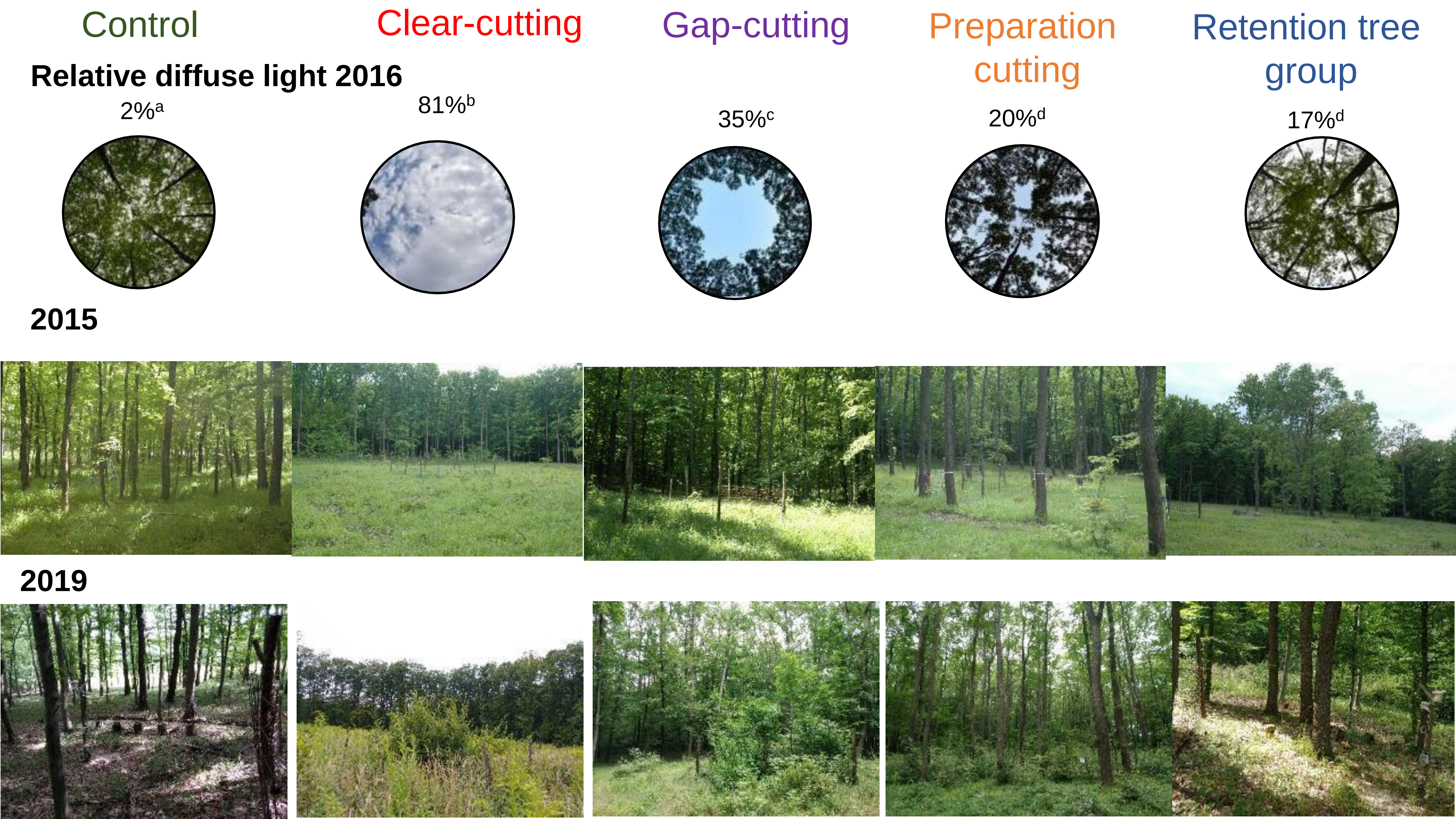


Experimental design

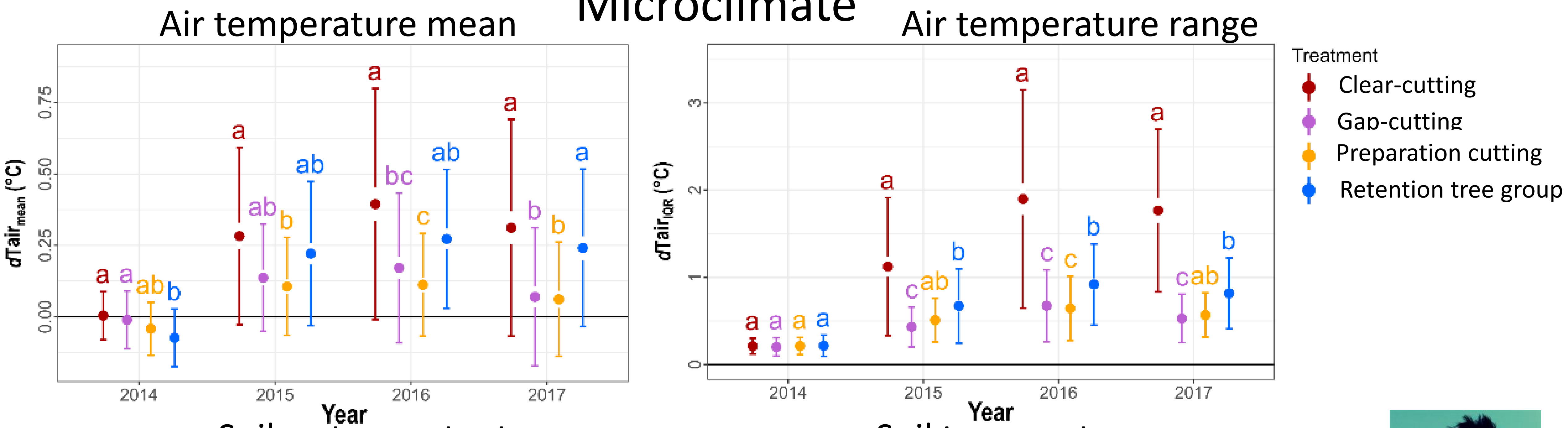
- 5 treatments:
  - preparation cutting (d=80 m)
  - gap cutting (d=20 m)
  - clear-cutting (d=80 m)
  - retention tree group (d=20 m)
  - control

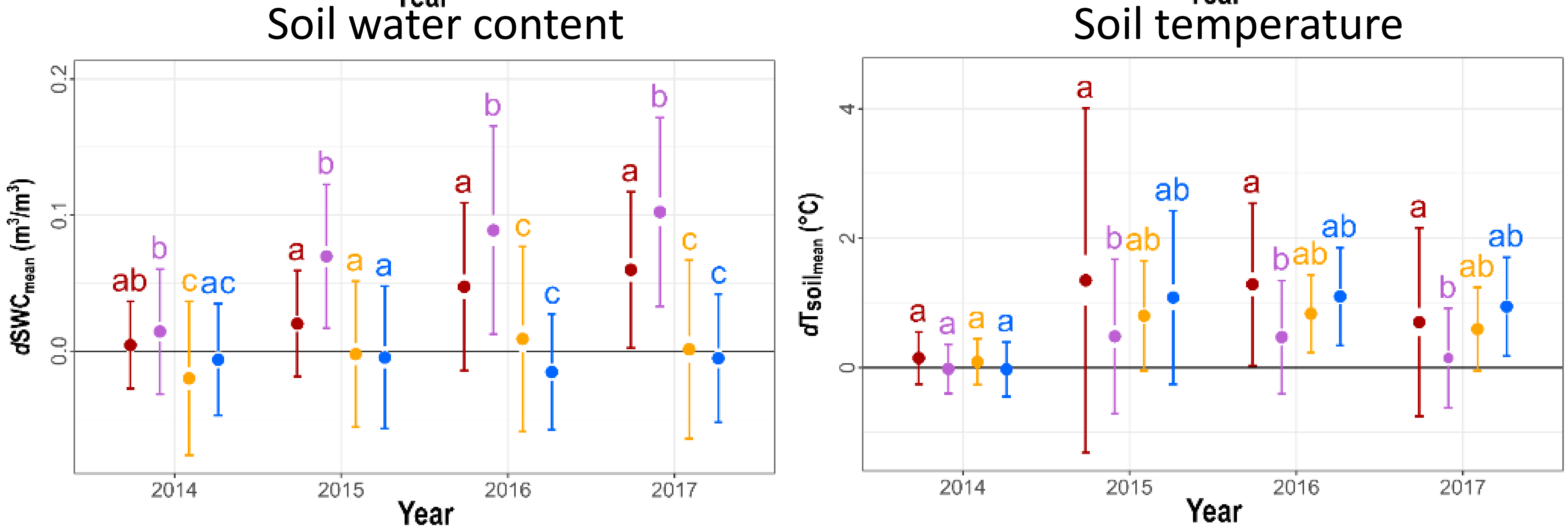
- 6 replicates – complete block design
- BACI (Before-After-Control-Impact): all measurements started in 2014




Control
Clear-cutting
Gap-cutting
Preparation cutting
Retention tree group
Relative diffuse light 2016
2%[a]
81%[b]
35%[c]
20%[d]
17%[d]
2015
2019

Microclimate





Kovács et al. 2020, Ecological Applications, 30(2): e02043. https://doi.org/10.1002/eap.2043

Natural regeneration

Size categories:

- 0-20 cm
- 20-50 cm
- 50-130 cm
- >130 cm

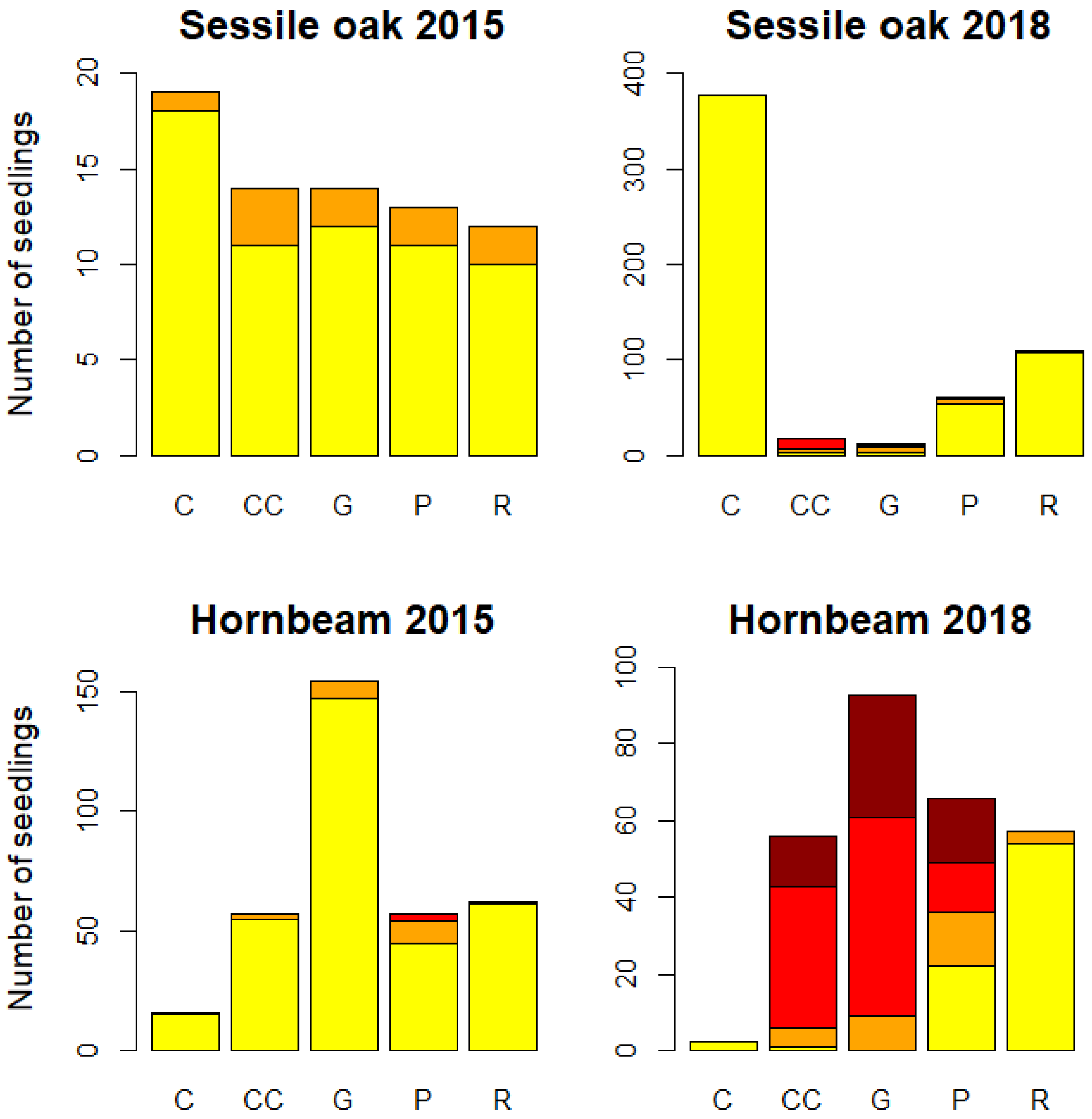
C – Control

CC - Clear-cutting

G – Gap

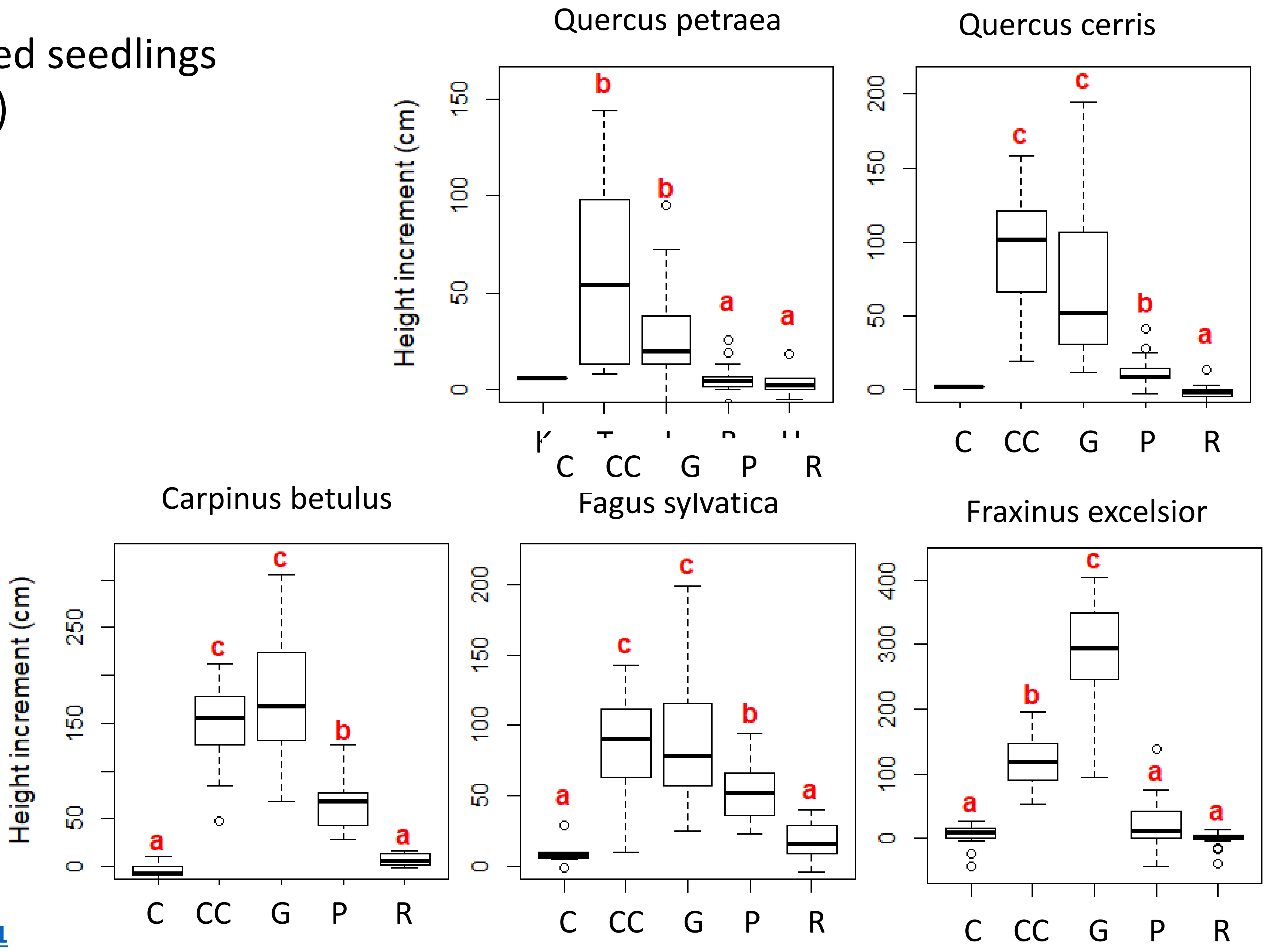
P – Preaparation cutting

R – Retention tree group



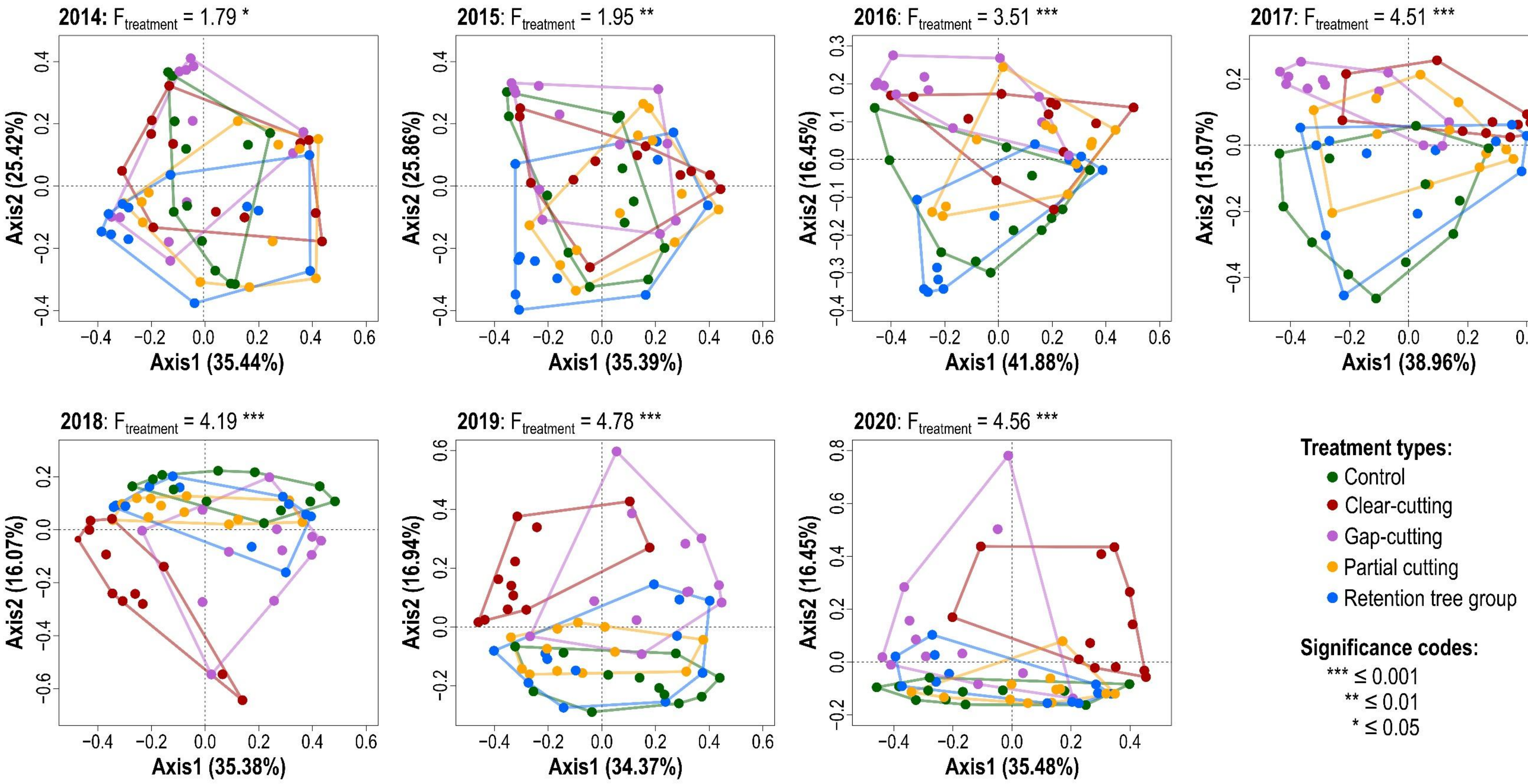
Tinya et al. 2020. Forest Ecology and Management, 433: 720-728.
https://doi.org/10.1016/j.foreco.2018.11.051

Height growth of planted seedlings (2015-2018)

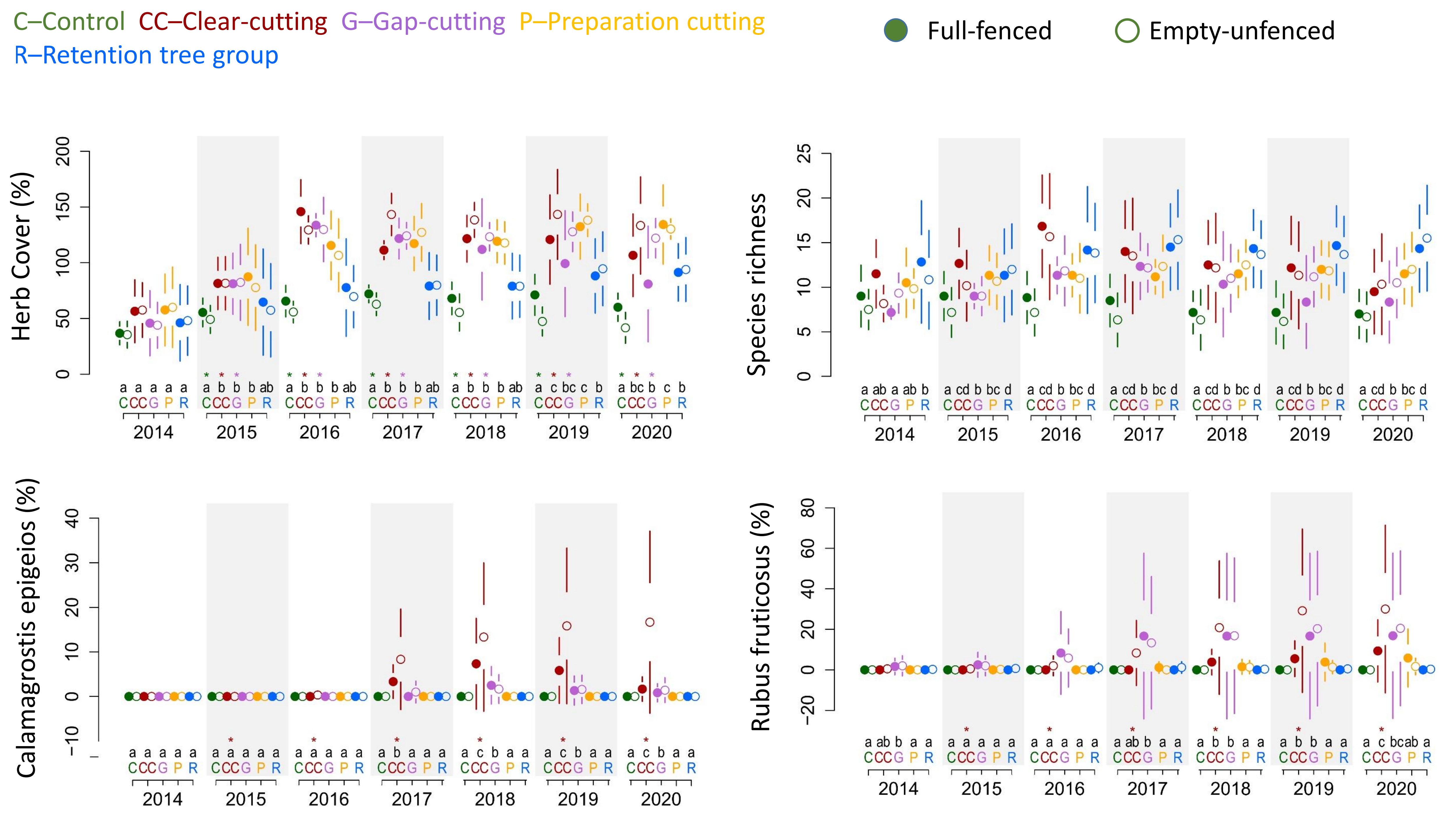


Tinya et al. 2020. Forest Ecology and Management, 433: 720-728.
https://doi.org/10.1016/j.foreco.2018.11.051

Understory

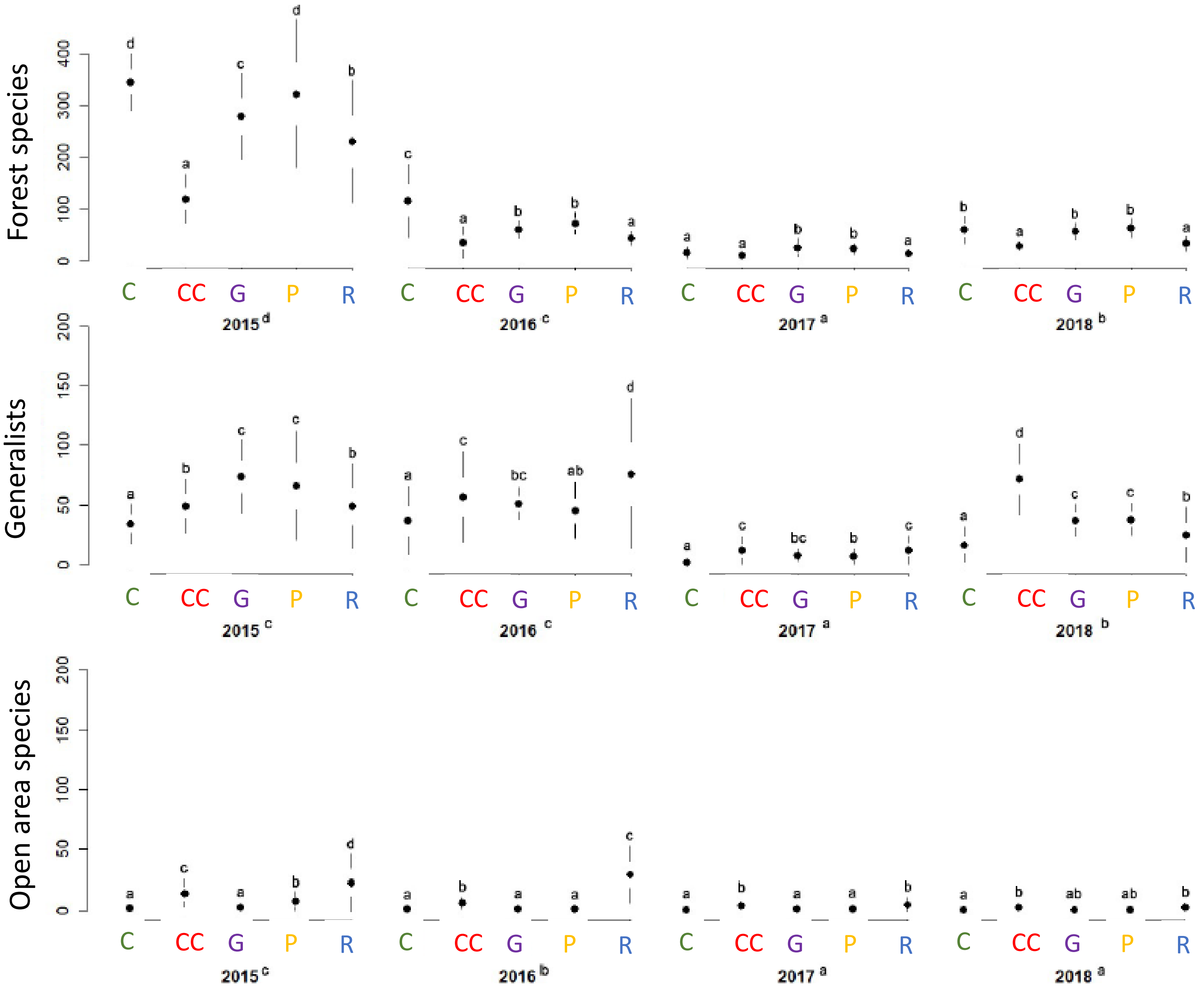


Aszalós et al. 2023. Forest Ecology and Management 549: 121438
https://doi.org/10.1016/j.foreco.2023.121438


C–Control
CC–Clear-cutting
G–Gap-cutting
P–Preparation cutting
R–Retention tree group
Full-fenced
Empty-unfenced
Herb Cover (%)
Species richness
Calamagrostis epigeios (%)
Rubus fruticosus (%)
C CC G P R
2014
2015
2016
2017
2018
2019
2020

Carabidae - ground beetles

Abundance of functional groups



C – Control

CC – Clear-cutting

G – Gap-cutting

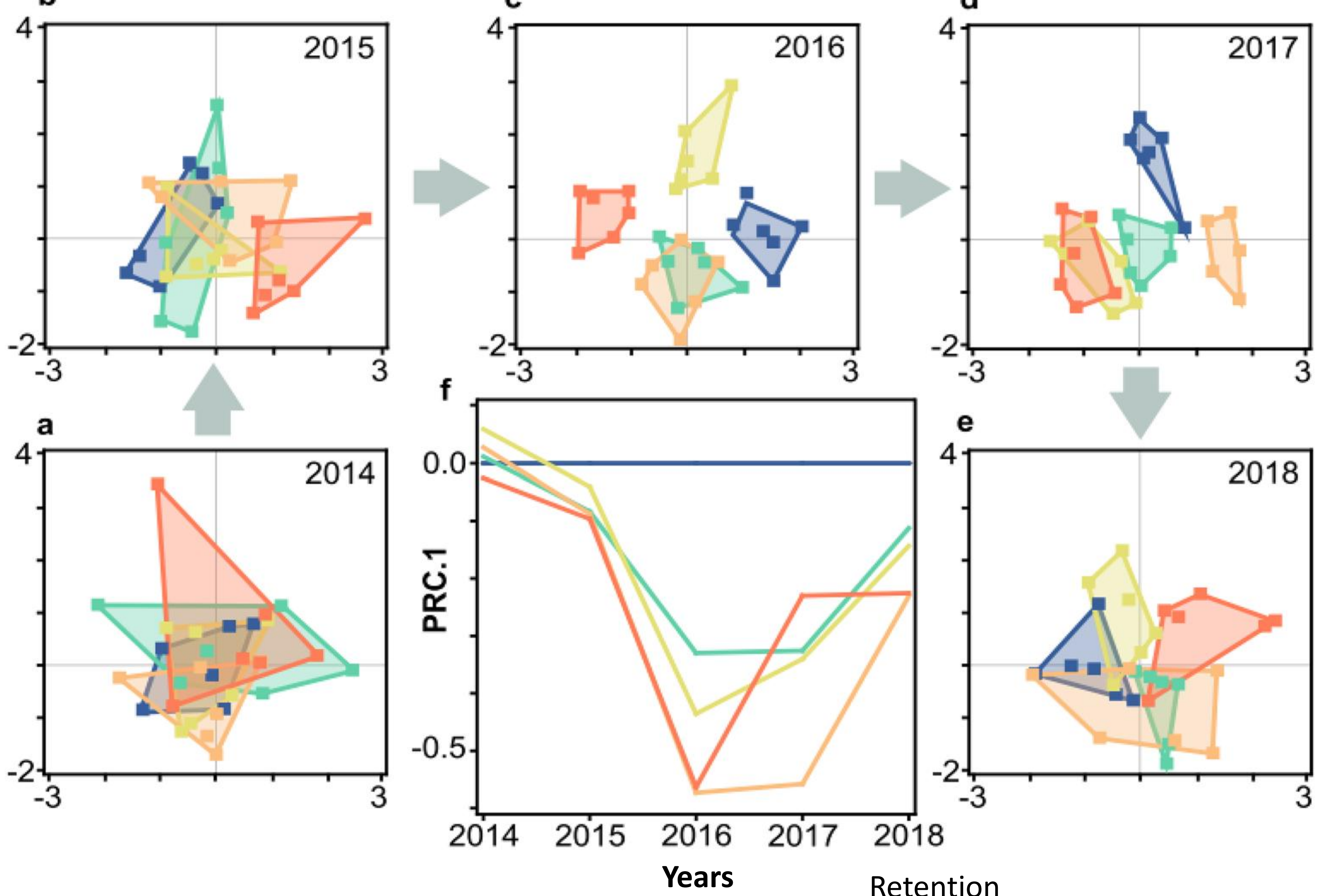
P – Preparation cutting

R – Retention tree group

Elek et al. 2022. Ecological Applications 32(1): e02460,
https://doi.org/10.1002/eap.2460

Spiders

Species composition



Control

Preparation-cutting

Gap-cutting

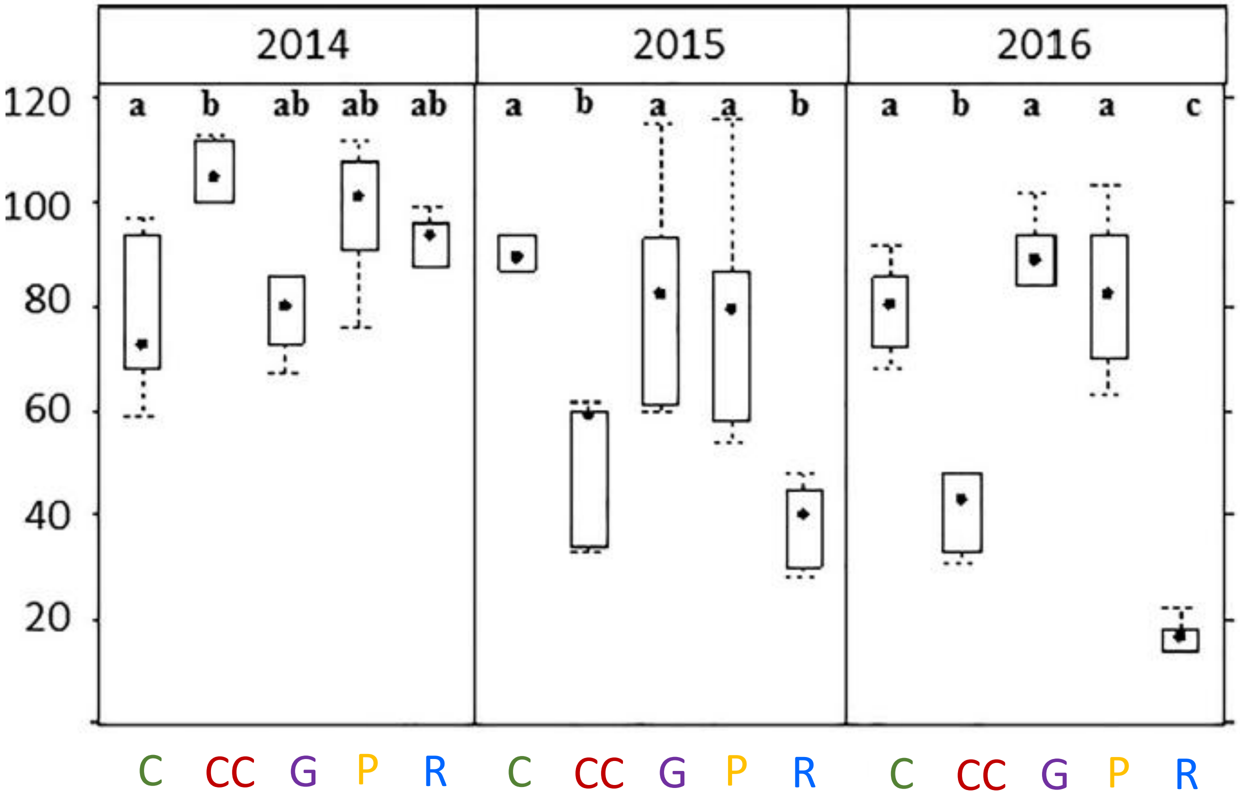
Retention tree group

Clear-cutting

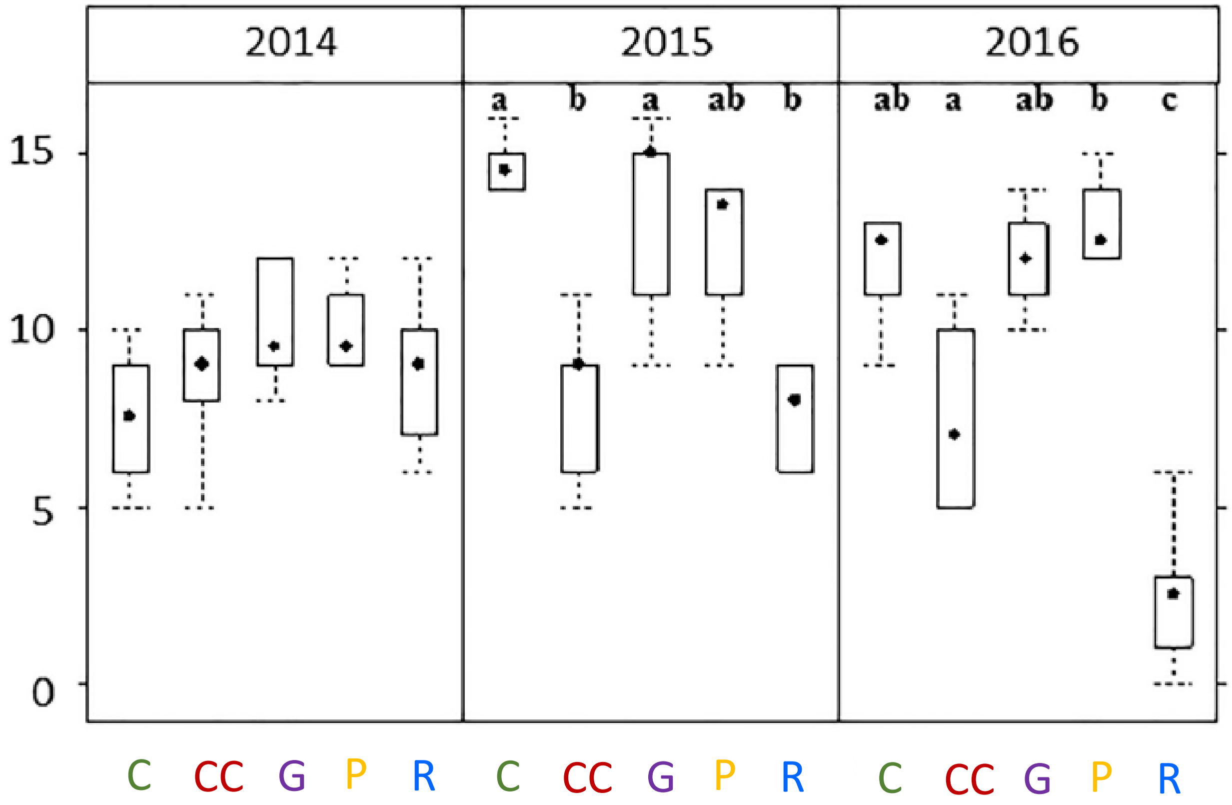
Samu et al. 2021. Scientific Reports 11: 20520
https://doi.org/10.1038/s41598-021-99884-8

Enchytraeid worms

Abundance



Species richness



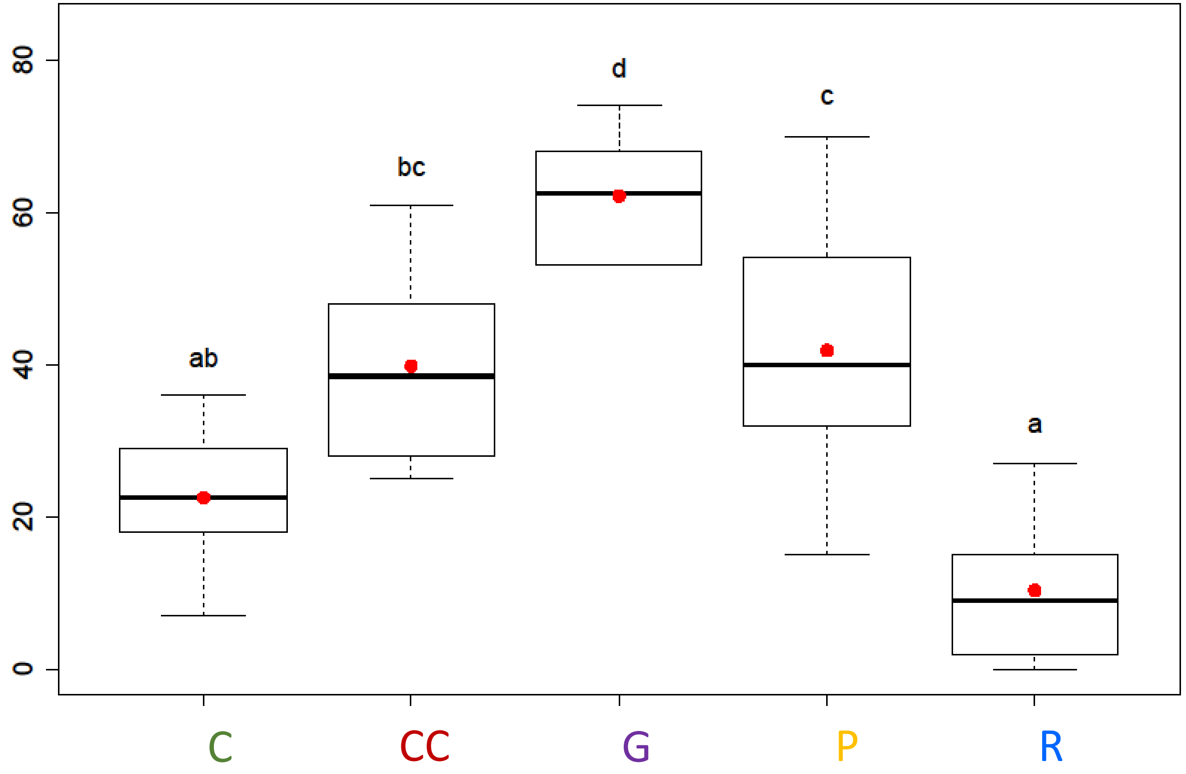
C – Control
CC – Clear-cutting
G – Gap-cutting
P – Preparation cutting
R – Retention tree group

Boros et al. 2019. Applied Soil Ecology 136:106-115

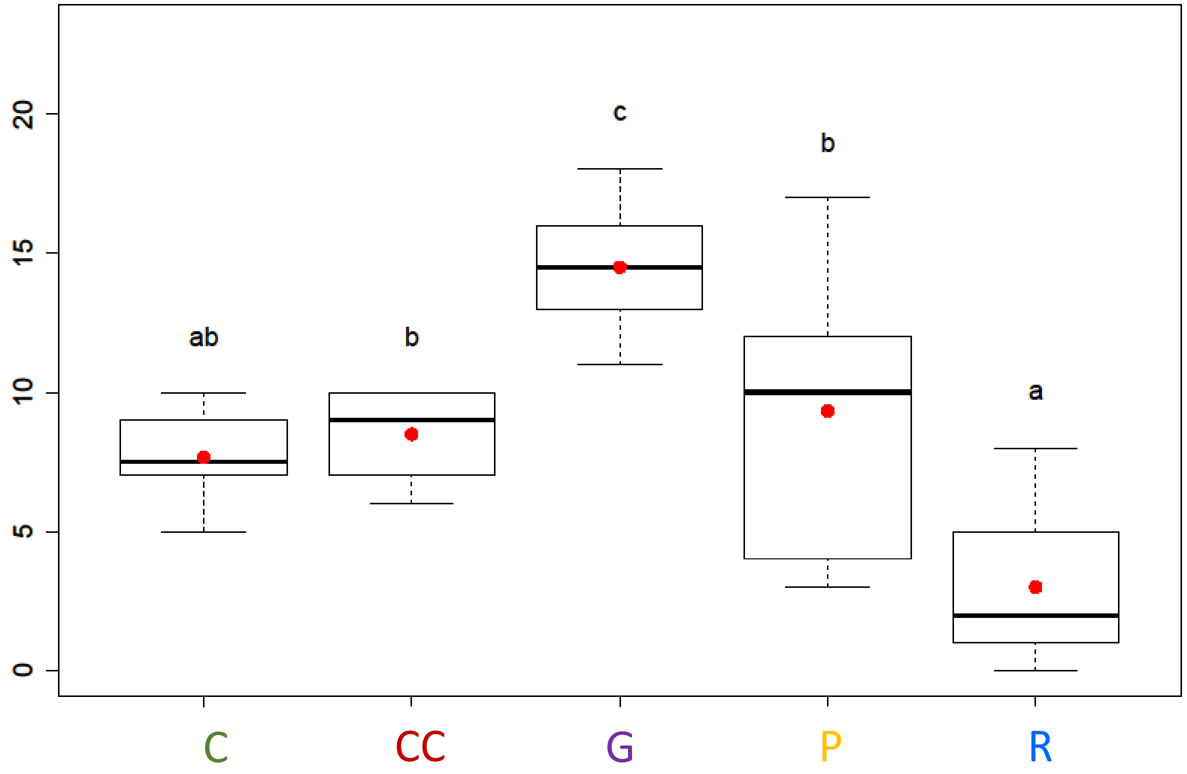
https://doi.org/10.1016/j.apsoil.2018.12.018

Crane flies (Tipulidae) 2017

Abundance



Species richness



C – Control

CC – Clear-cutting

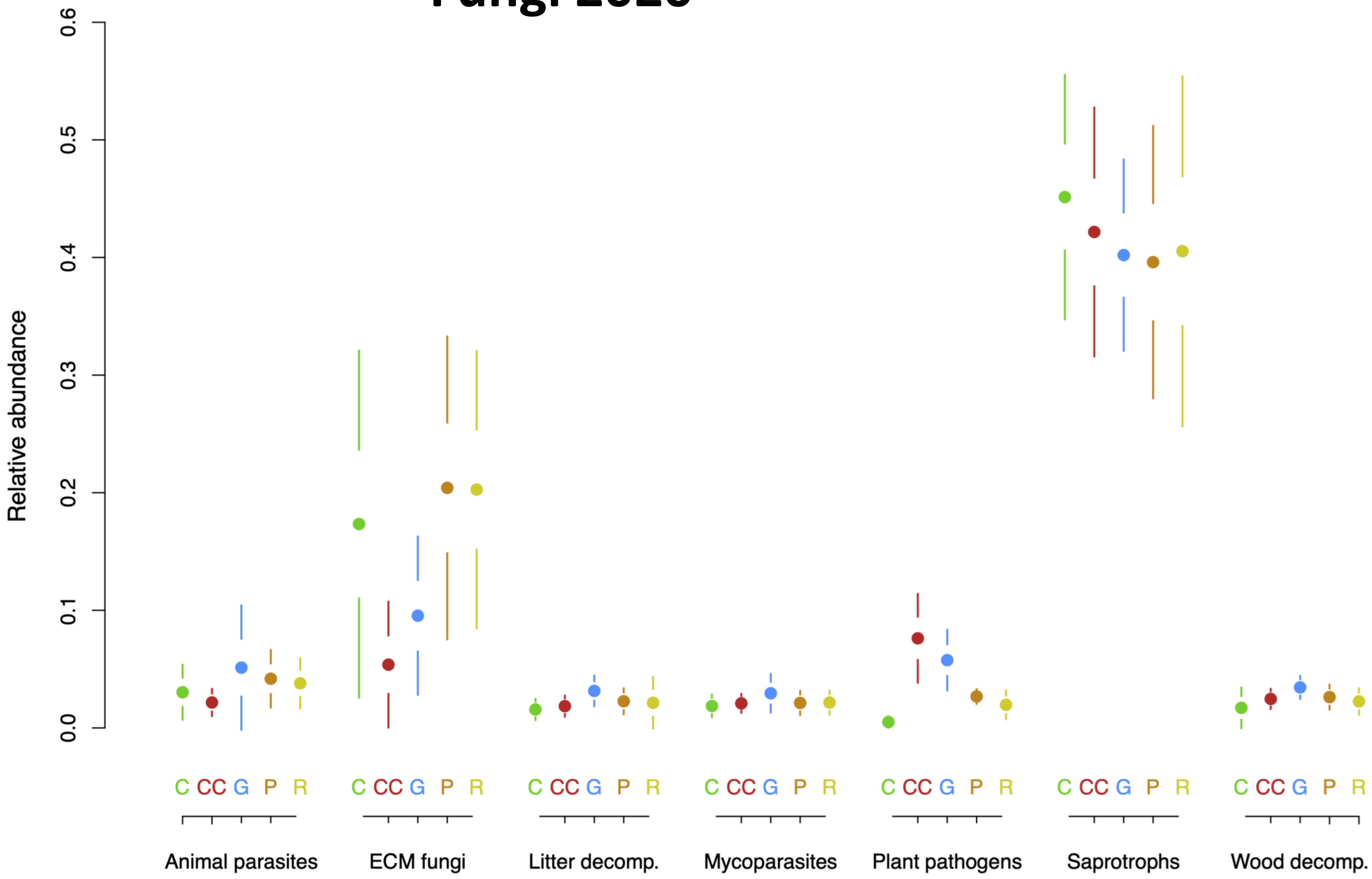
G – Gap-cutting

P – Preparation cutting

R – Retention tree group

Zoltán Soltész in prep.

Fungi 2020



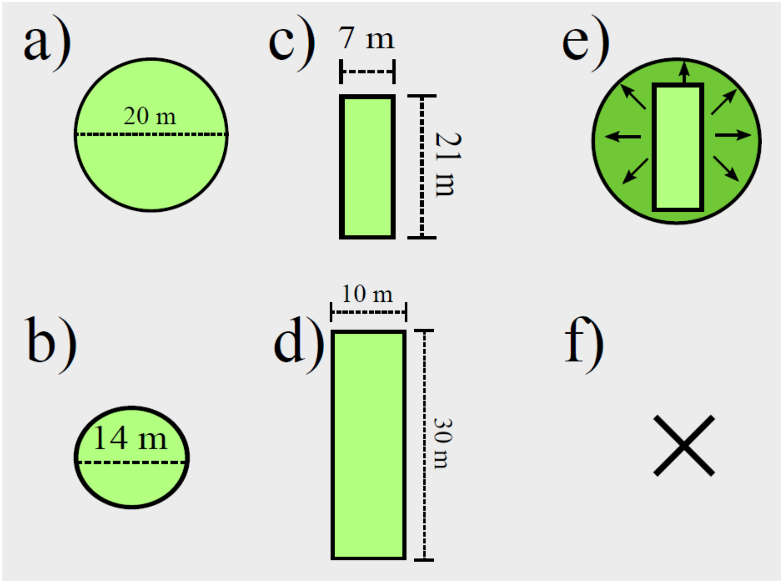
József Geml in prep.

Conclusions

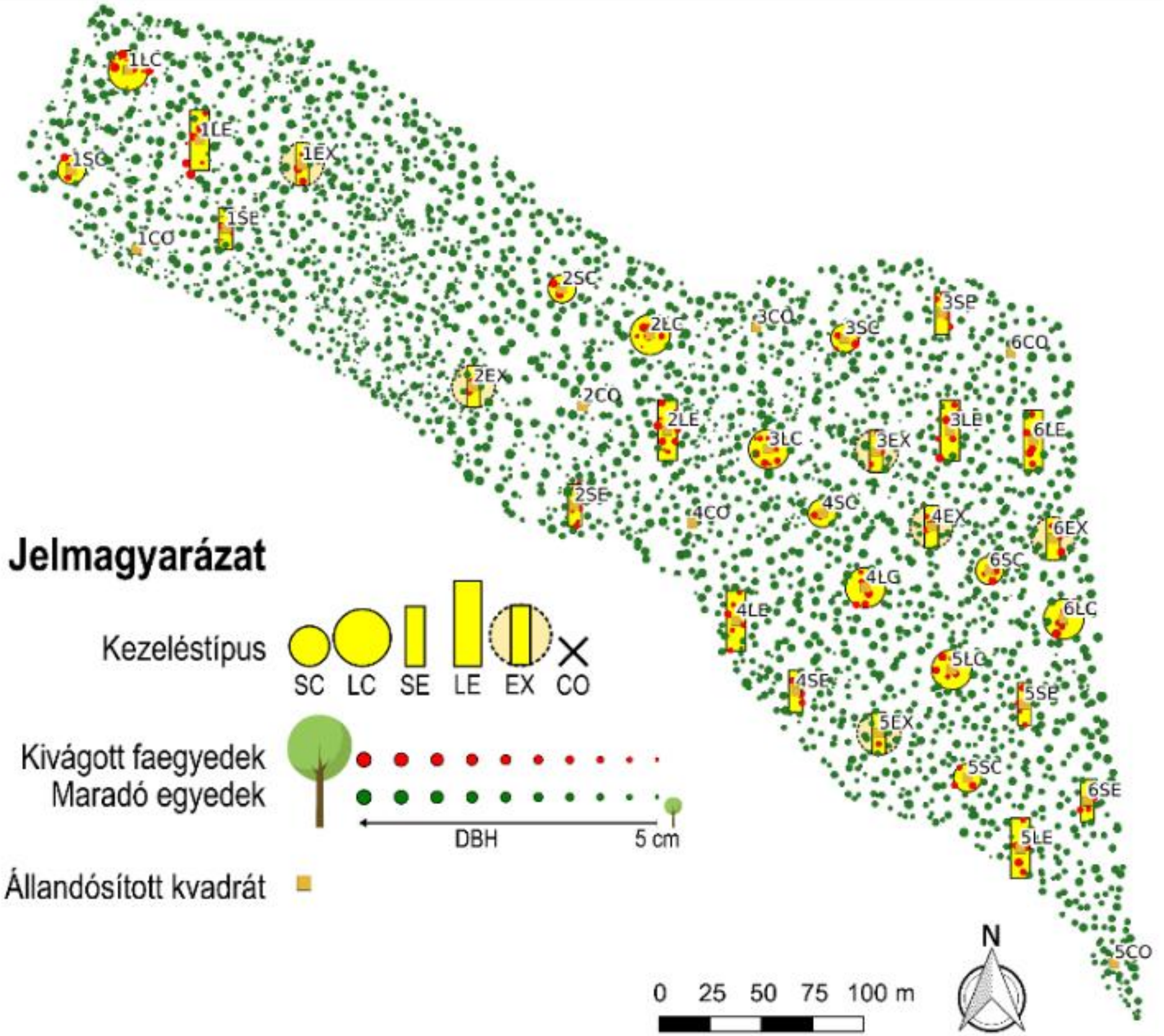
- Clear-cutting: extreme microclimate, good for regeneration, non-forest understory species, unfavorable for soil organisms, non-forest carabids, fungi composition changed.
- Gap: balanced microclimate, soil moisture increment, good for regeneration, light-flexible forest species in understory, favorable for soil organisms, forest carabids, fungi composition changed.
- Peparation cutting: Microclimate similar to control, moderate regeneration, increased understory cover with forest species, animal and fungi community similar to control.
- Retention tree group: warmer and drier micrclimate, low soil moisture, no regeneration, understory similar to control more species from forest edges, unfavorable for soil organisms, non-forest carabids.

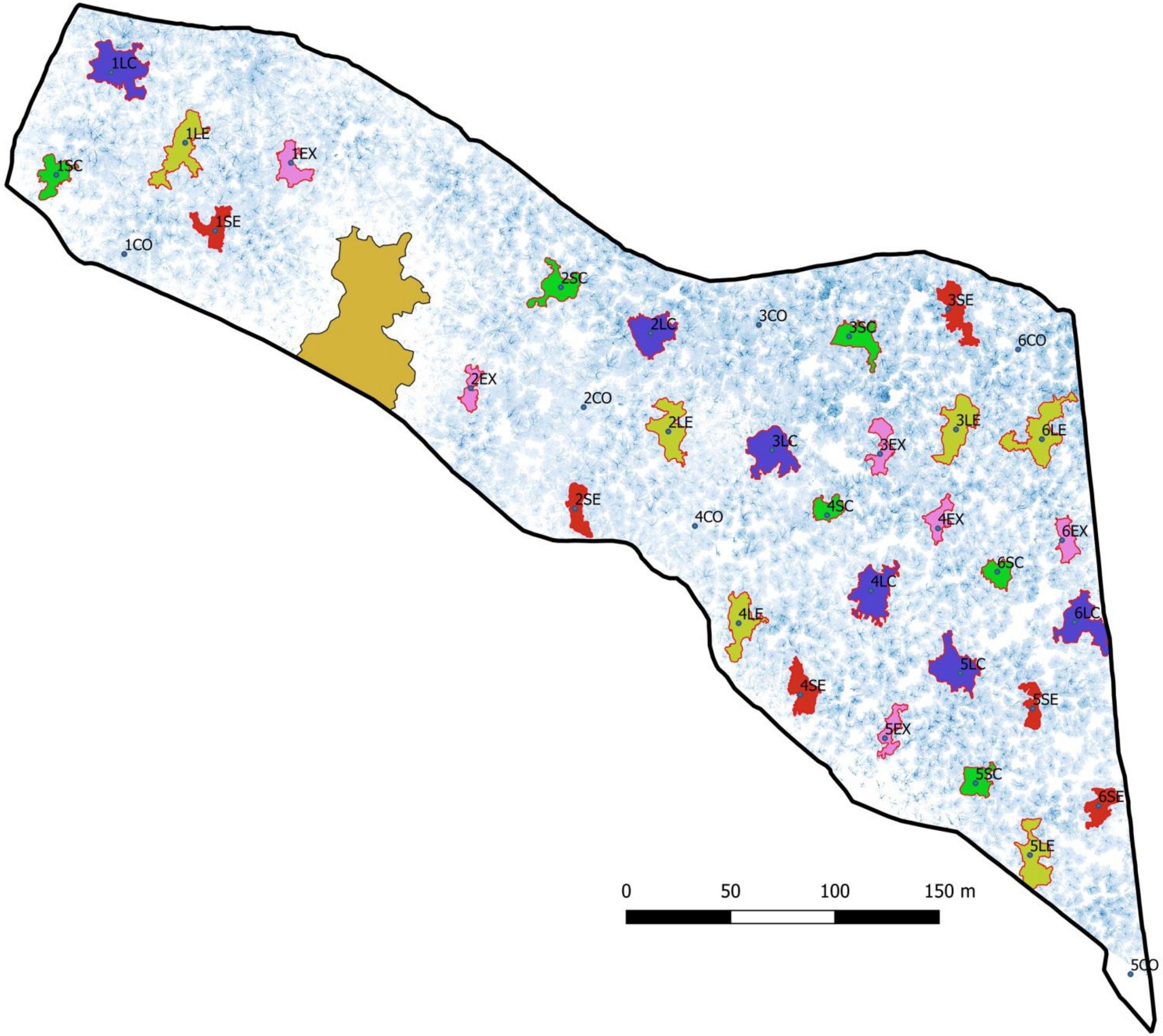
- Treatment of continuous cover forestry as gap-cutting, partial cutting, thinning provide regeneration but more favorable for microclimate and forest biodiversity than treatment of rotation forestry.
- In case of rotation forestry large retention tree groups are necessary to compansate the effect of final cuttings.
- Soil organisms were the most sensitive groups
- Composition and functional groups better indicators than general species richness or abundance.

Pilis Gap Experiment (2018-)



microclimate, soil, understorey, regeneration, ground beetles, spiders





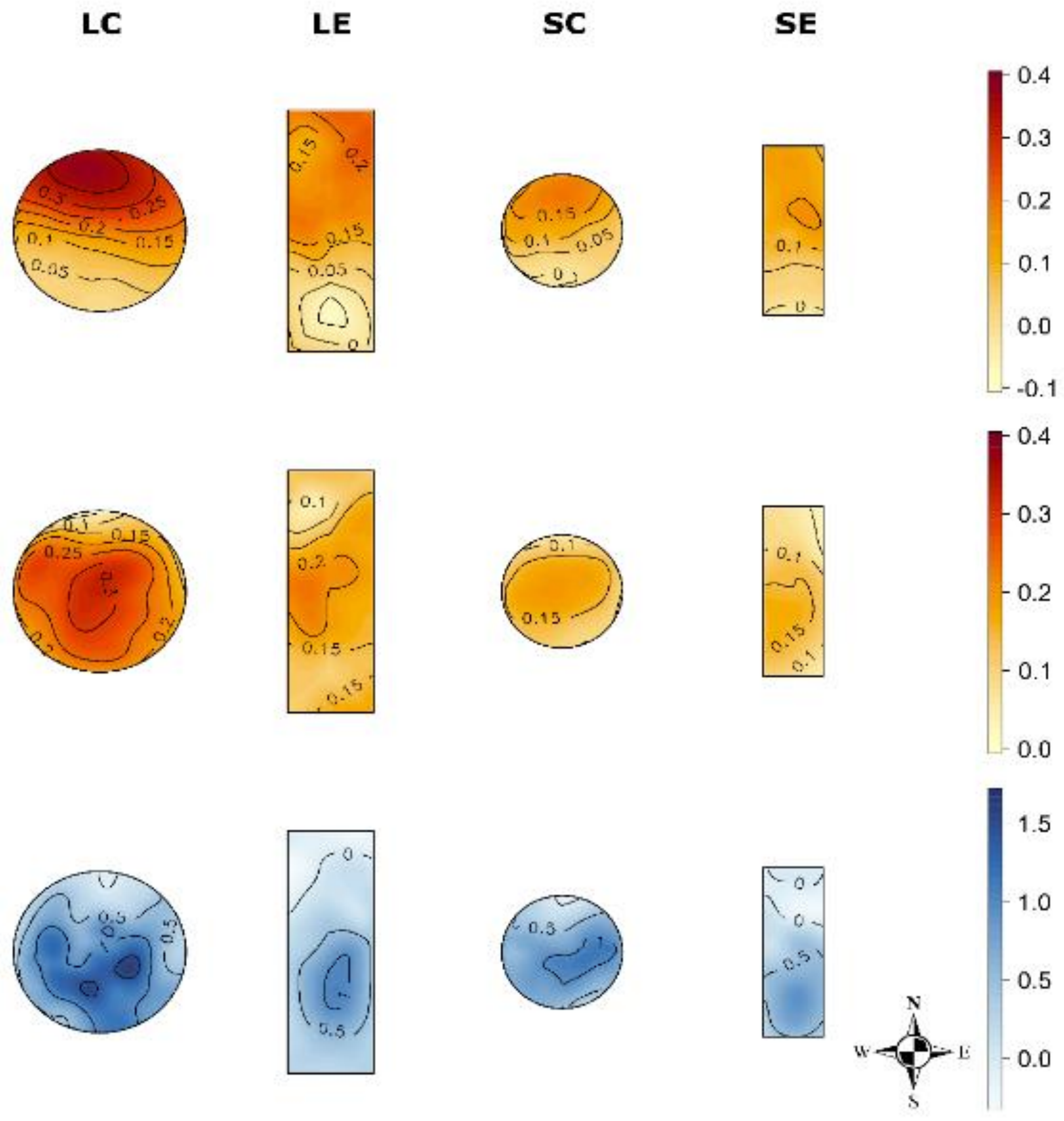
Illés Gábor
Kovács Bence
in prep.

Microclimate (1. yr)

relative direct light

relative diffuse light

relative soil moisture



Horváth et al. 2023. Science of the Total Environment 873: 162302. [**https://doi.org/10.1016/j.scitotenv.2023.162302**](https://doi.org/10.1016/j.scitotenv.2023.162302)

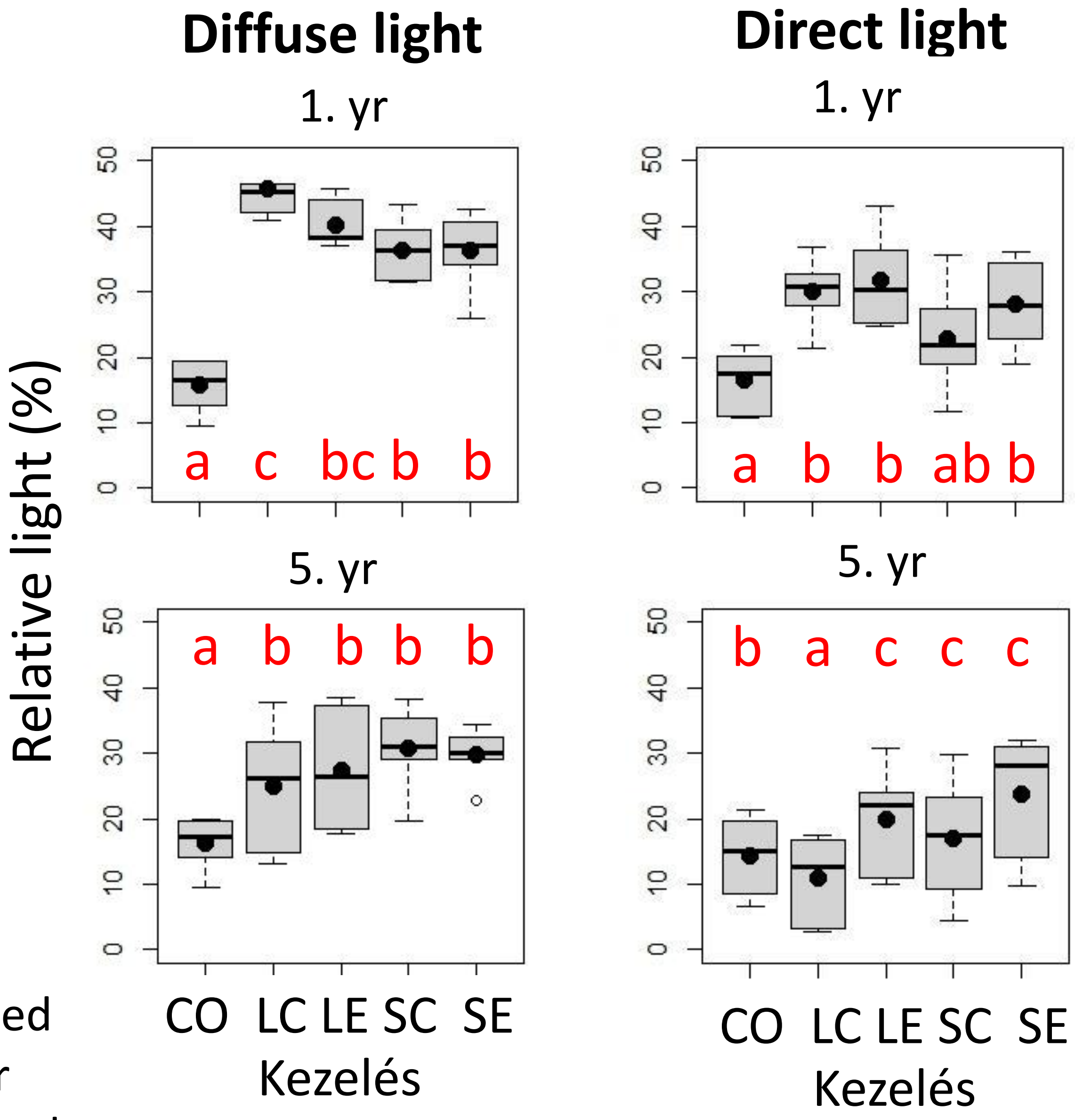
Light

Diffuse light:
Increased in all gaps, later decreased in large circular

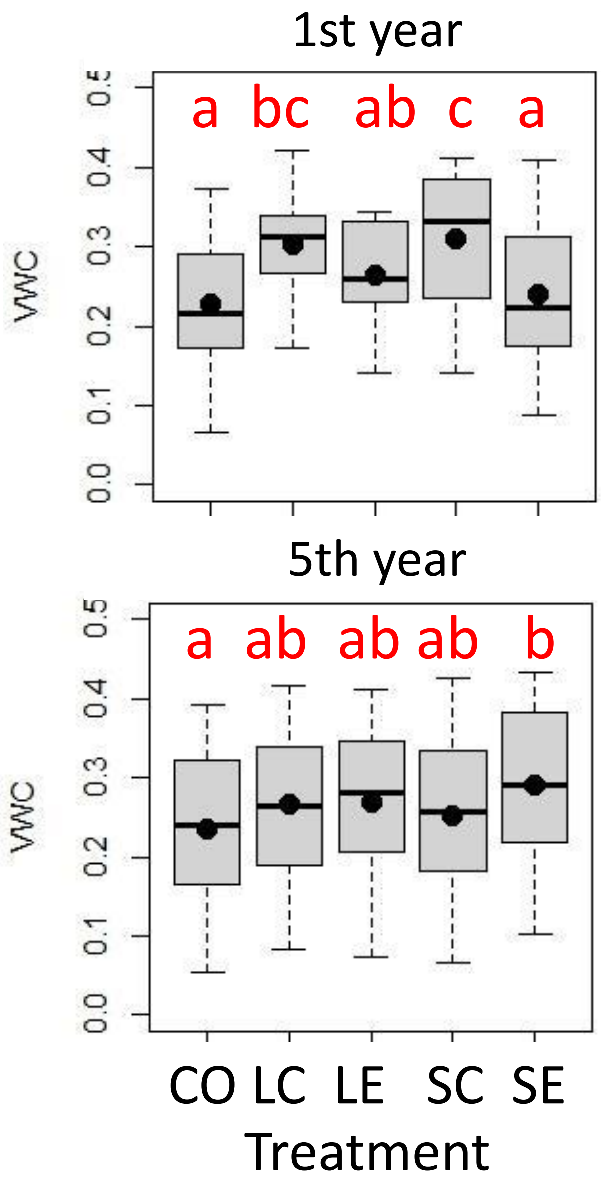
Direct light:
In first year higher in large gaps, in 5th year in large circular it decreased

Tinya et al. 2025. forest Ecology and Management 578: 122471. https://doi.org/10.1016/j.foreco.2024.122471

CO - control
LC – large circular
LE – large elongated
SC – small circular
SE – small elongated



Soil moisture

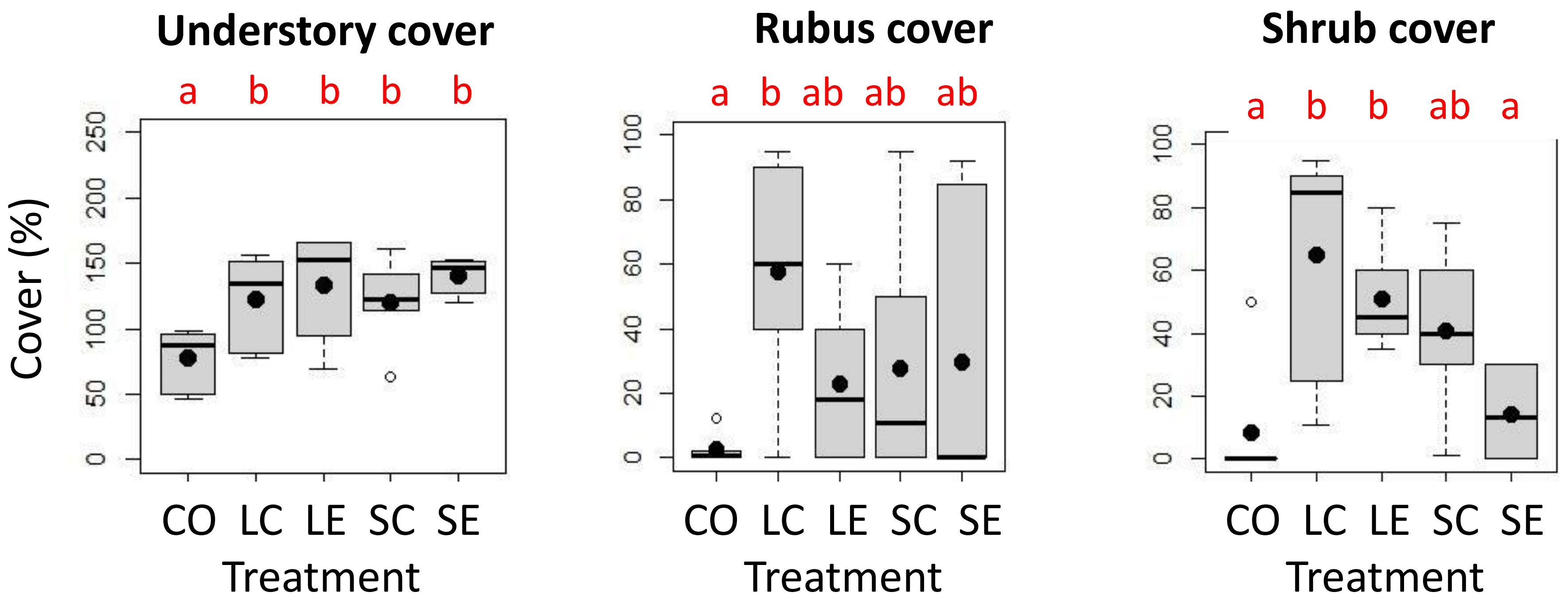


In the first year it increased in circular gaps.

In the 5th it decreased, it was higher than the control only in small elongated gap.

CO - control
LC – large circular
LE – large elongated
SC – small circular
SE – small elongated

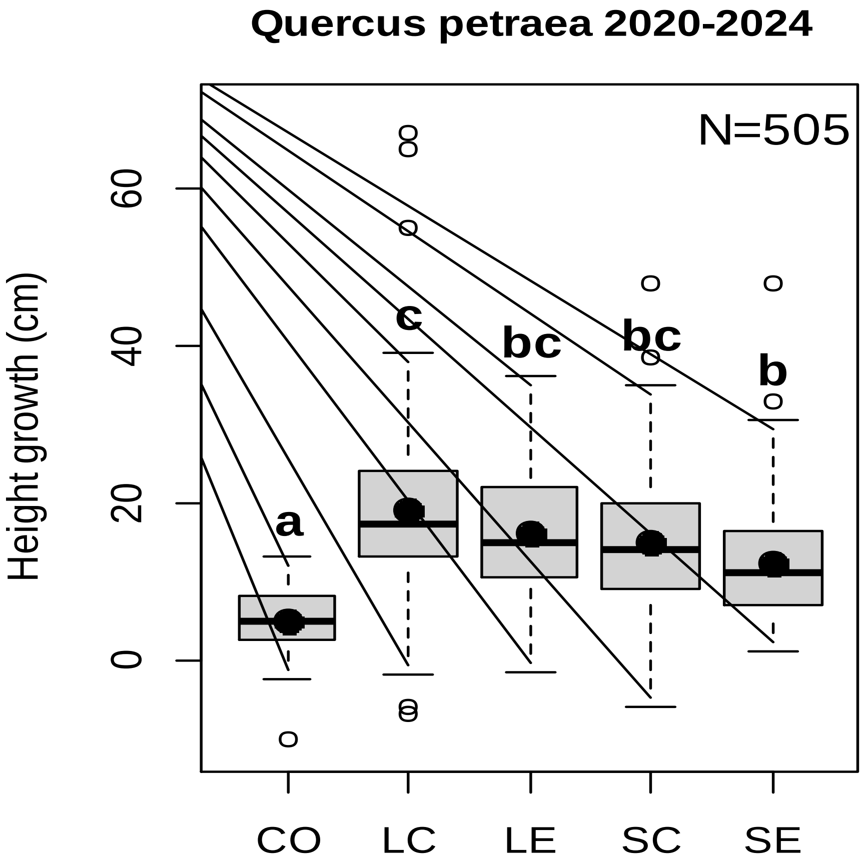
Understory 5. yr



Five years after the interventions:
Understory cover increased everywhere
Rubus cover was the highest in large circular gap
Shrub cover was the lowest in small elongated gap

CO - control
LC – large circular
LE – large elongated
SC – small circular
SE – small elongated

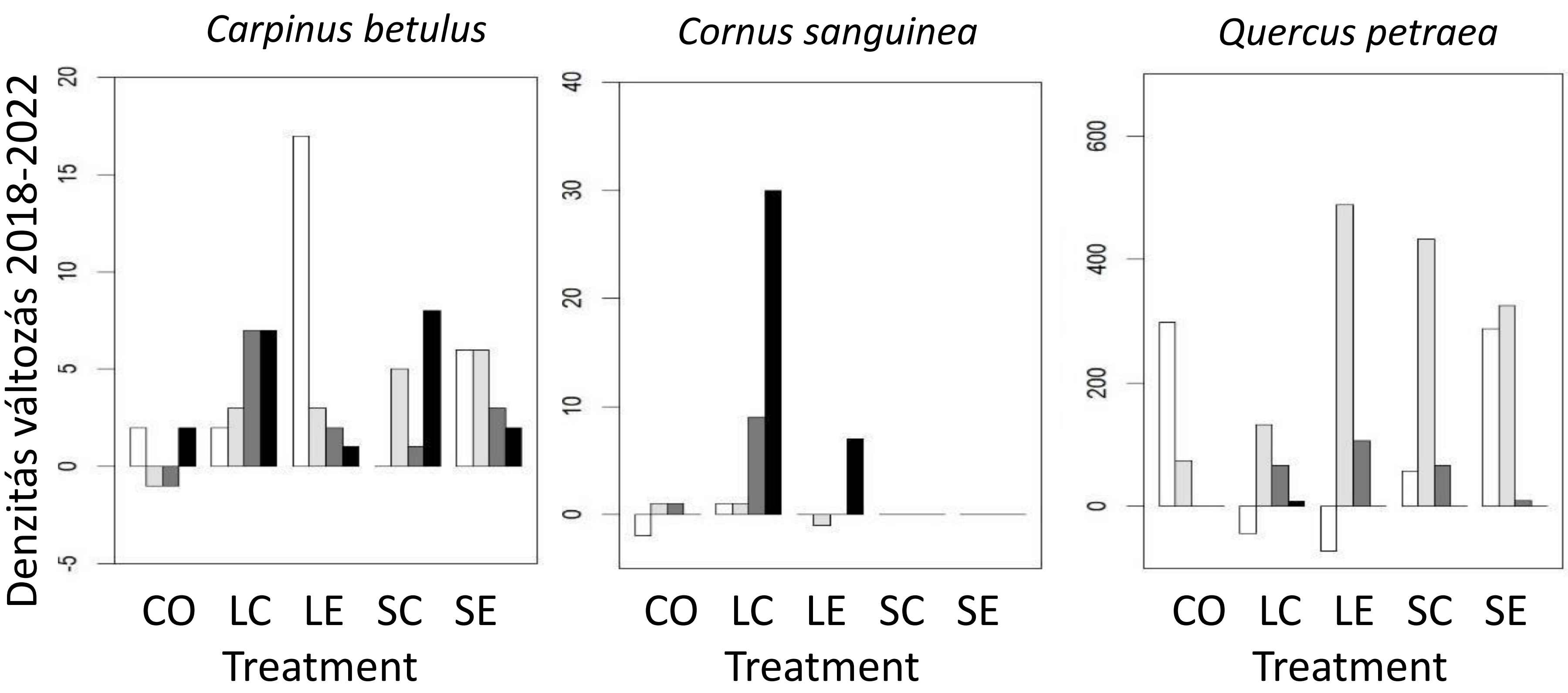
Height growth of tended Quercus seedlings



CO - control
LC – large circular
LE – large elongated
SC – small circular
SE – small elongated

Height growth of tended oak seedling is the highest in large circular gaps

Natural regeneration



High *Carpinus* in circular gaps (soil moisture)
High Cornus in large gaps (light)
Quercus size II. and III. is the highest in large elongated and small circular. In small elongated it has high survival but slow increase.

Size I: 0-20 cm
Size II: 20-50 cm
Size III: 50-130 cm
Size IV: >130 cm

Forest management considerations

Oak regeneration can start in small and elongated gaps.

Without competition fastest oak growth can be found in large circular gaps, however here the Rubus and shrubs hindern their growth

↓

Involving competiotin and dispersal at the begining the small elongated gap is the optimal

Later it should be extended following the groth of oak saplings

In case of larger stating gaps the elongated shape is more favourable

The control of Carpinus is necessery everywhere, however its extent is the smallest in small elongated gap

For other organism groups (ground beetles, spiders) the gaps had only marginal positive effect.

Zoltán Elek   Péter Ódor   Gergely Boros   Bence Kovács   Csenge Horváth   Réka Aszalós   Flóra Tinya

Csaba Németh

József Geml

Ferenc Samu

Thank you for your attention!

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