The effect of gap size and shape on understory and regeneration in an oak-hornbeam forests managed by continuous cover forestry

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ÖK ÖBI
Forest Ecology Research Group

Interreg Hungary – Slovakia

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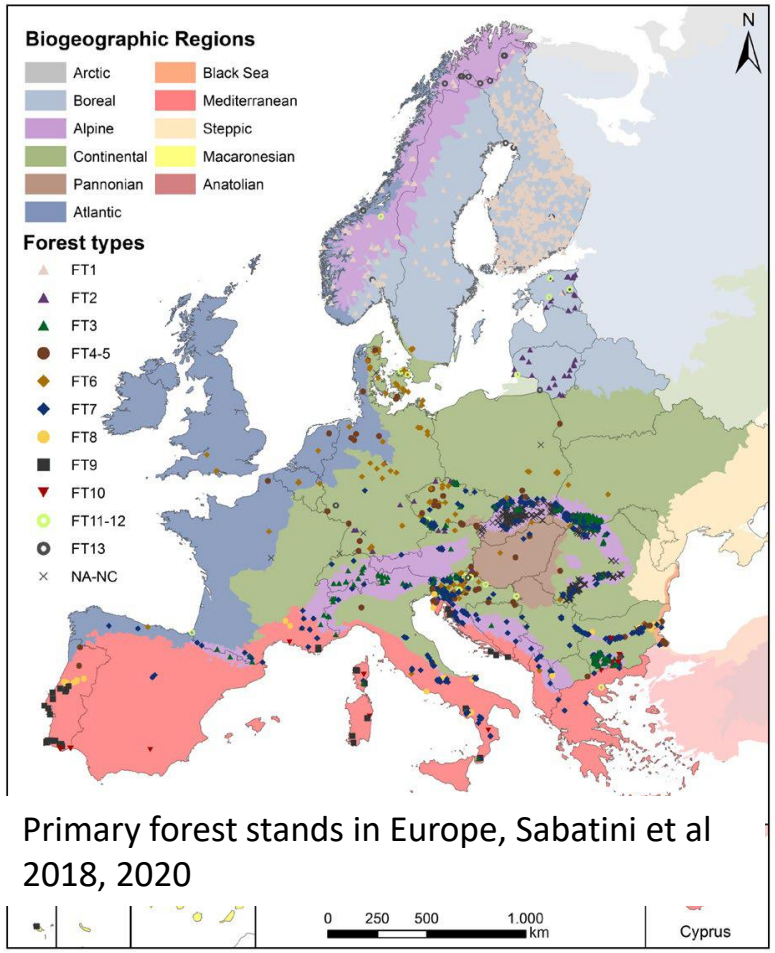
Background: Status of European forests

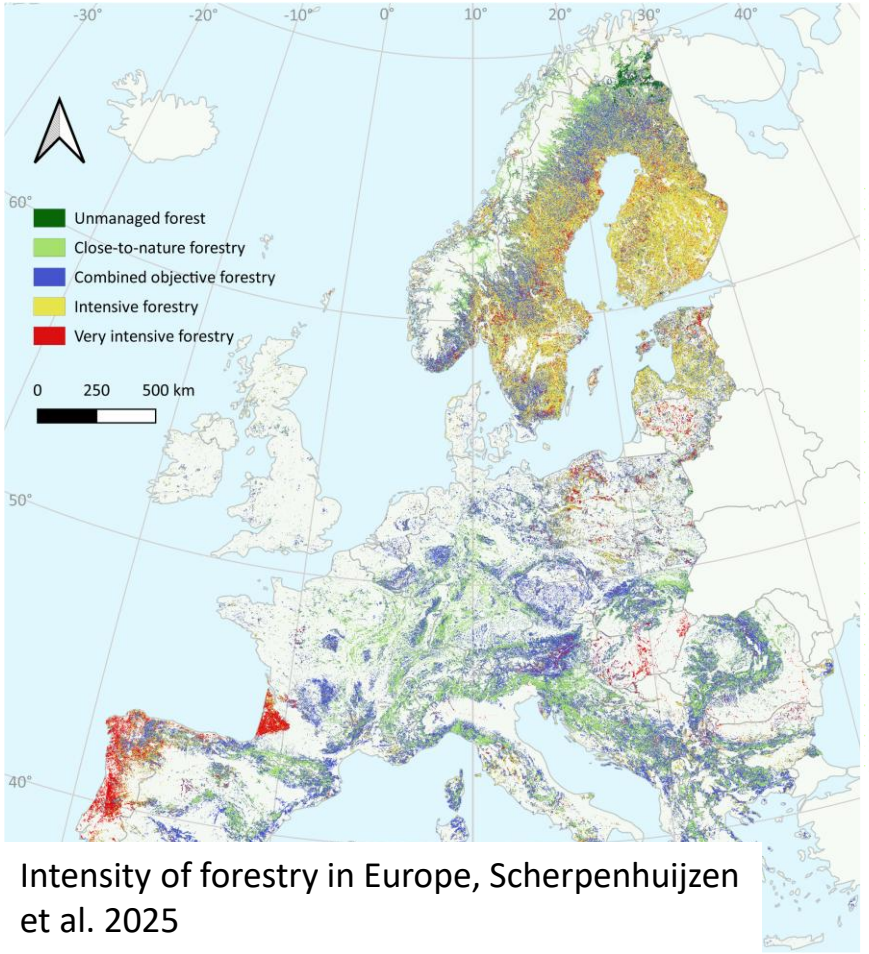
- More than 90% of European forests are managed
- Proportion of undisturbed forests is 4% (or less)

FOREST EUROPE, 2015: State of Europe's Forests 2015.

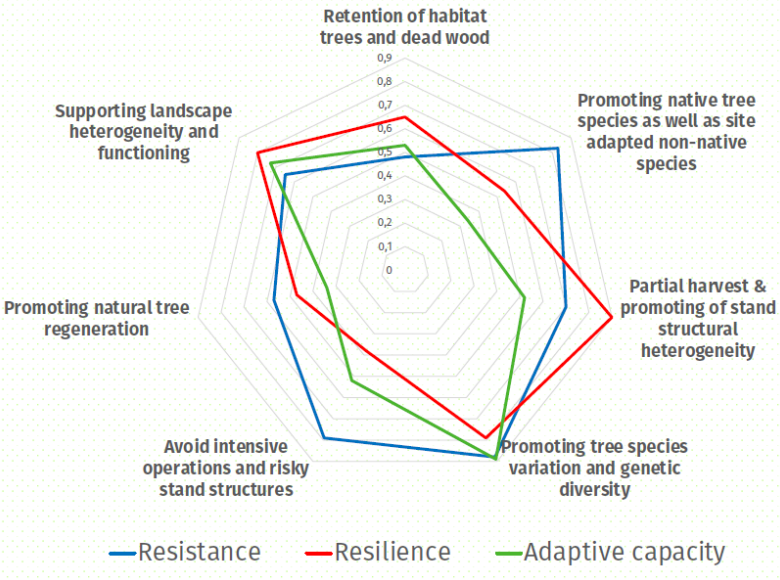
- ➢ Necessary to increase the sustainability of forestry
- ➢ Expansion of closer-to-nature forestry



Primary forest stands in Europe, Sabatini et al 2018, 2020

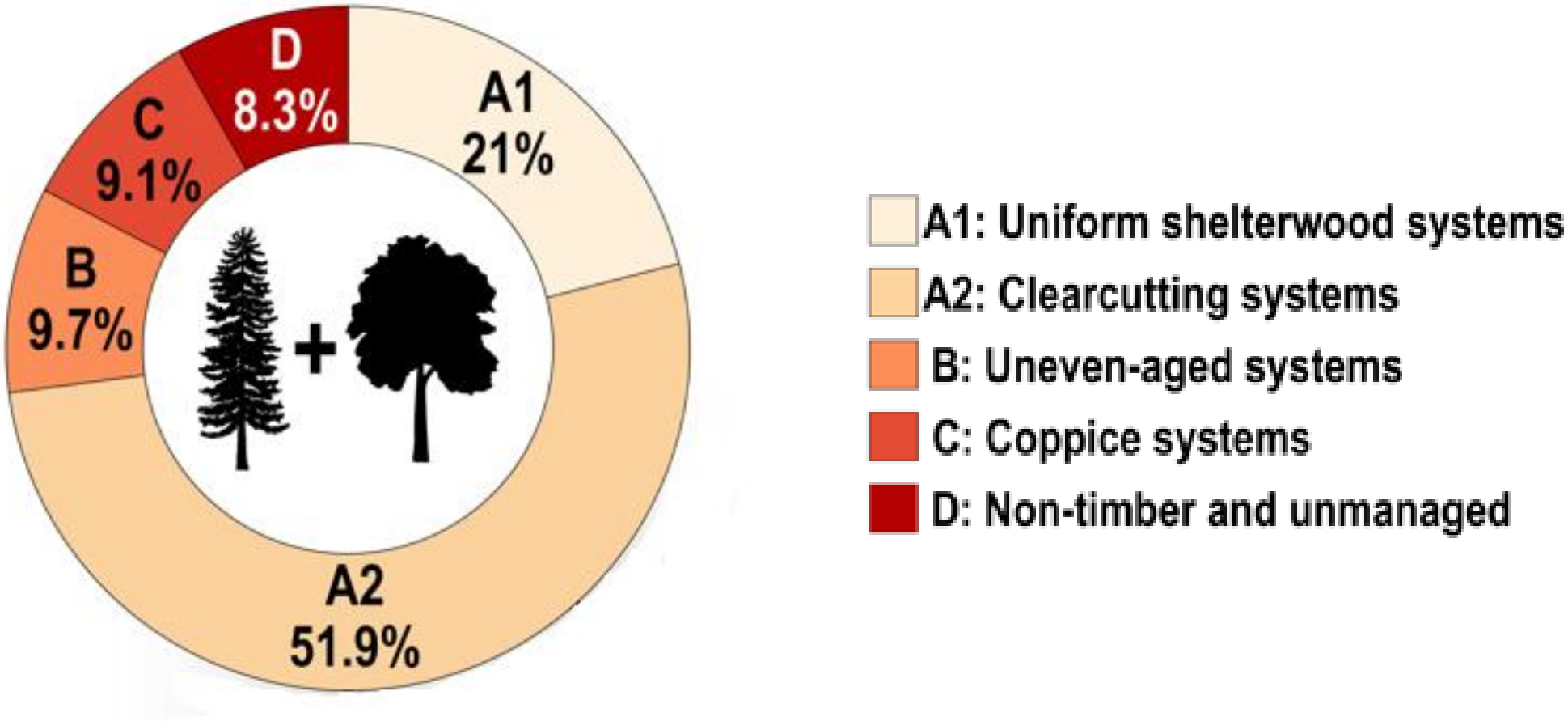


Intensity of forestry in Europe, Scherpenhuijzen et al. 2025



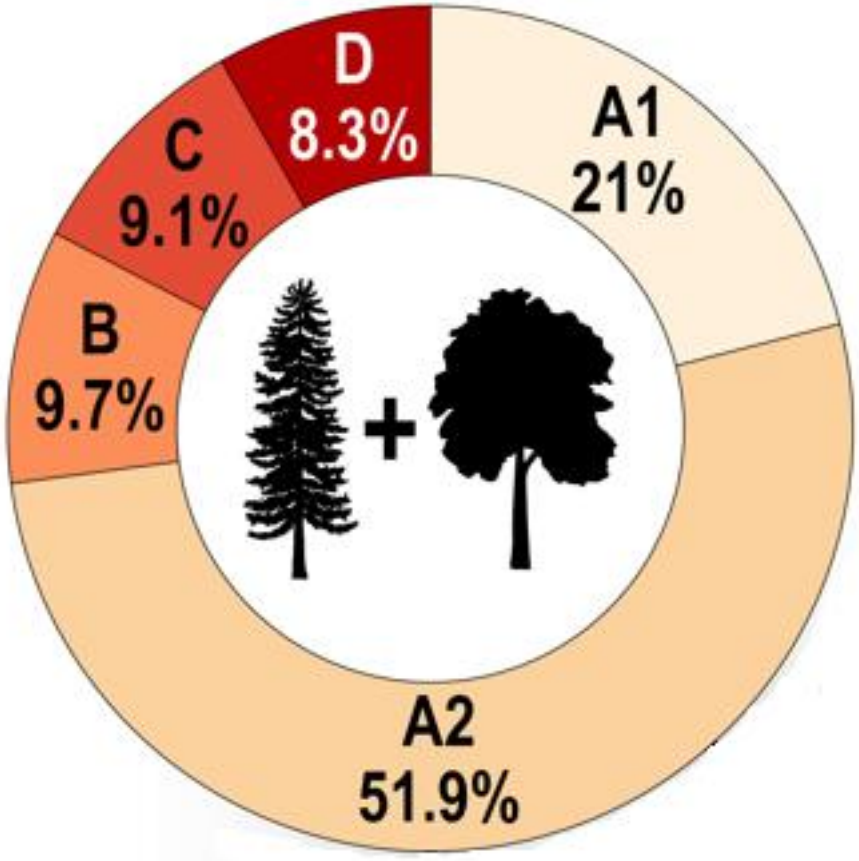
Principles of Closer-to-Nature forestry, Larsen et al. 2022

Background: Forestry systems in Europe



Aszalós et al. 2022. Ecol. Appl.

Background: Forestry systems in Europe

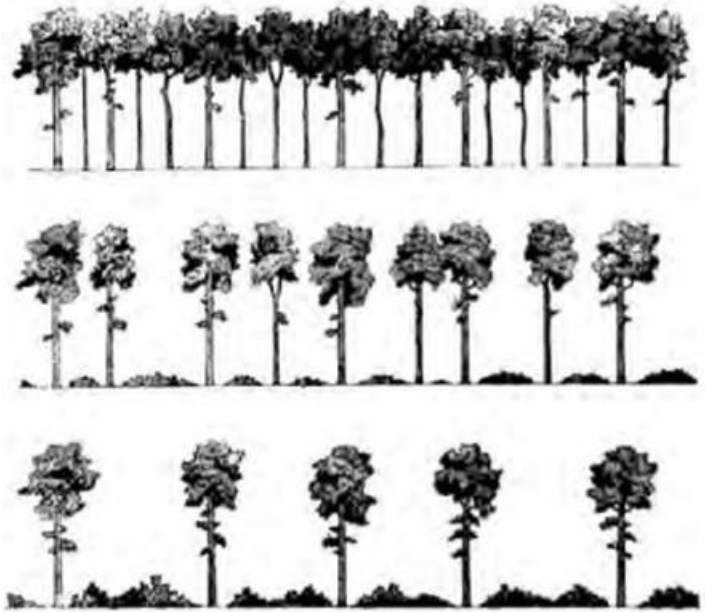


Aszalós et al. 2022. Ecol. Appl.

A2: Clearcutting systems **52%**

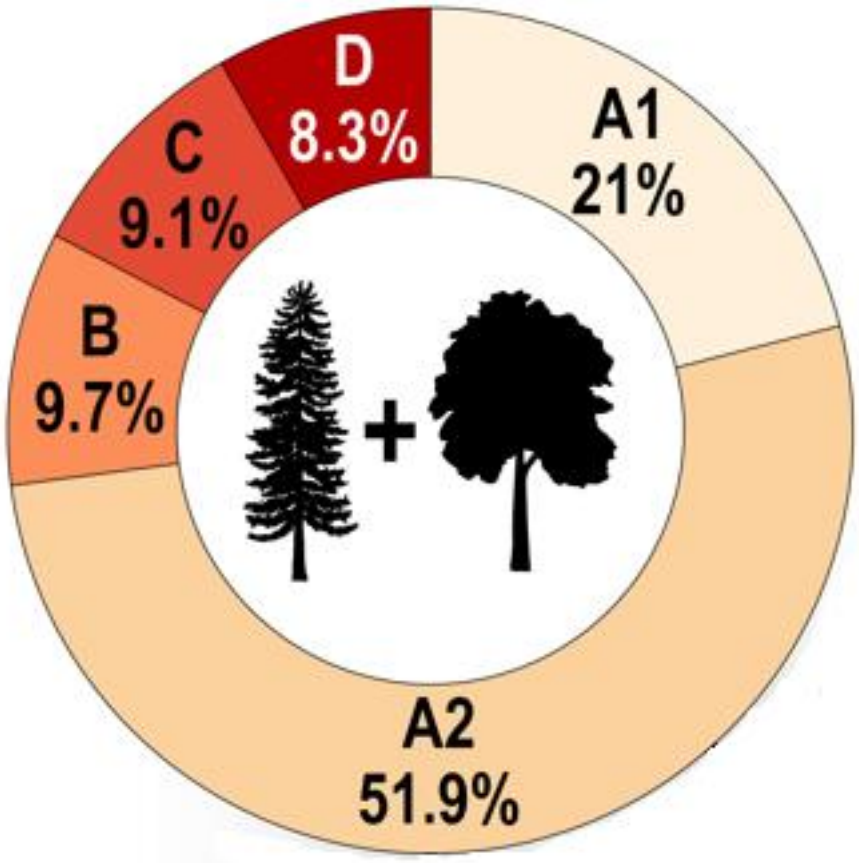
Main treatments: clear-cutting, planting, tending, thinning

A1: Uniform shelterwood systems **21%**



Main treatments: preparation cuttings, final cutting, tending, thinning

Background: Forestry systems in Europe



B: Uneven-aged systems 10%

Continuous cover forestry (CCF): tree selection, group selection, irregular shelterwood

Main treatments: overstorey thinning, gap-cutting, tending in regeneration

Aszalós et al. 2022. Ecol. Appl.

Background: Regeneration of oak under CCF

- CCF is successful for shade tolerant species: spruce, fir, beech
- Oak species (Quercus petraea, Q. robur, Q. cerris) are light demanding species

There are evidences that oak can be regenerated in gaps, but its success depends on:

- light availability
- competing vegetation
- initial oak density
- browsing
- tending

→ can be influenced by gap size and shape

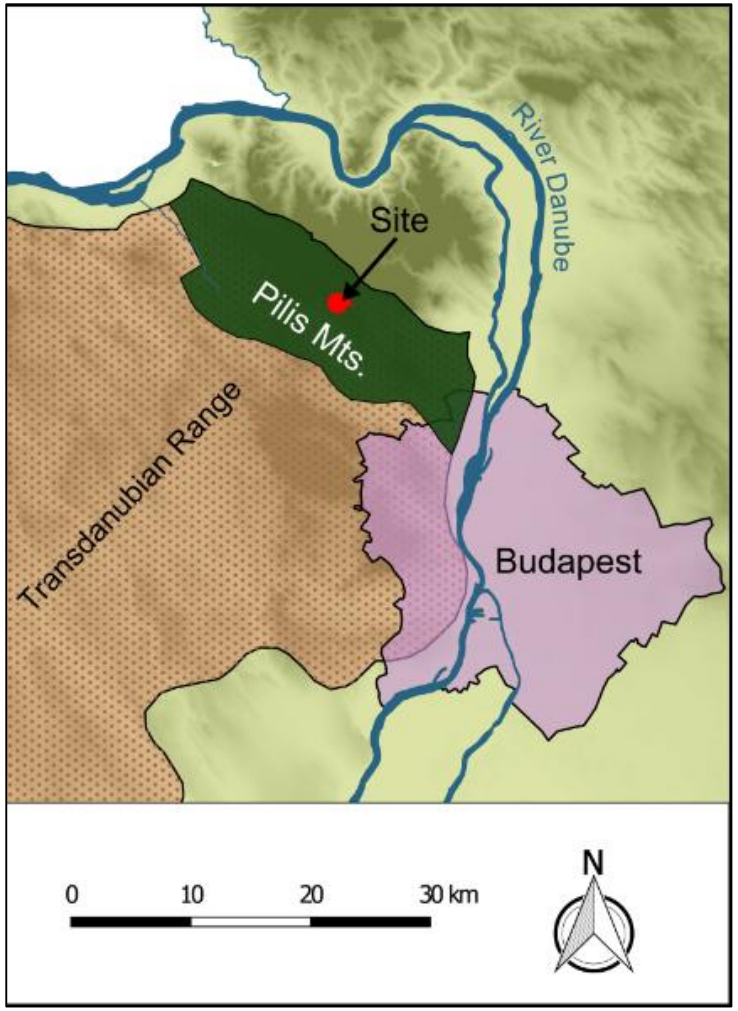
Optimal interventions: provide oak regeneration, maintain forest microclimate and biodiversity
The gap is „as small as possible”

Methods: Study site

The Pilis Gap Experiment

Biodiversity, microclimate and regeneration responses in gaps with different size and shape

- Pilisszántó, Hosszú-hill
- 90 years old sessile oak-hornbeam stand

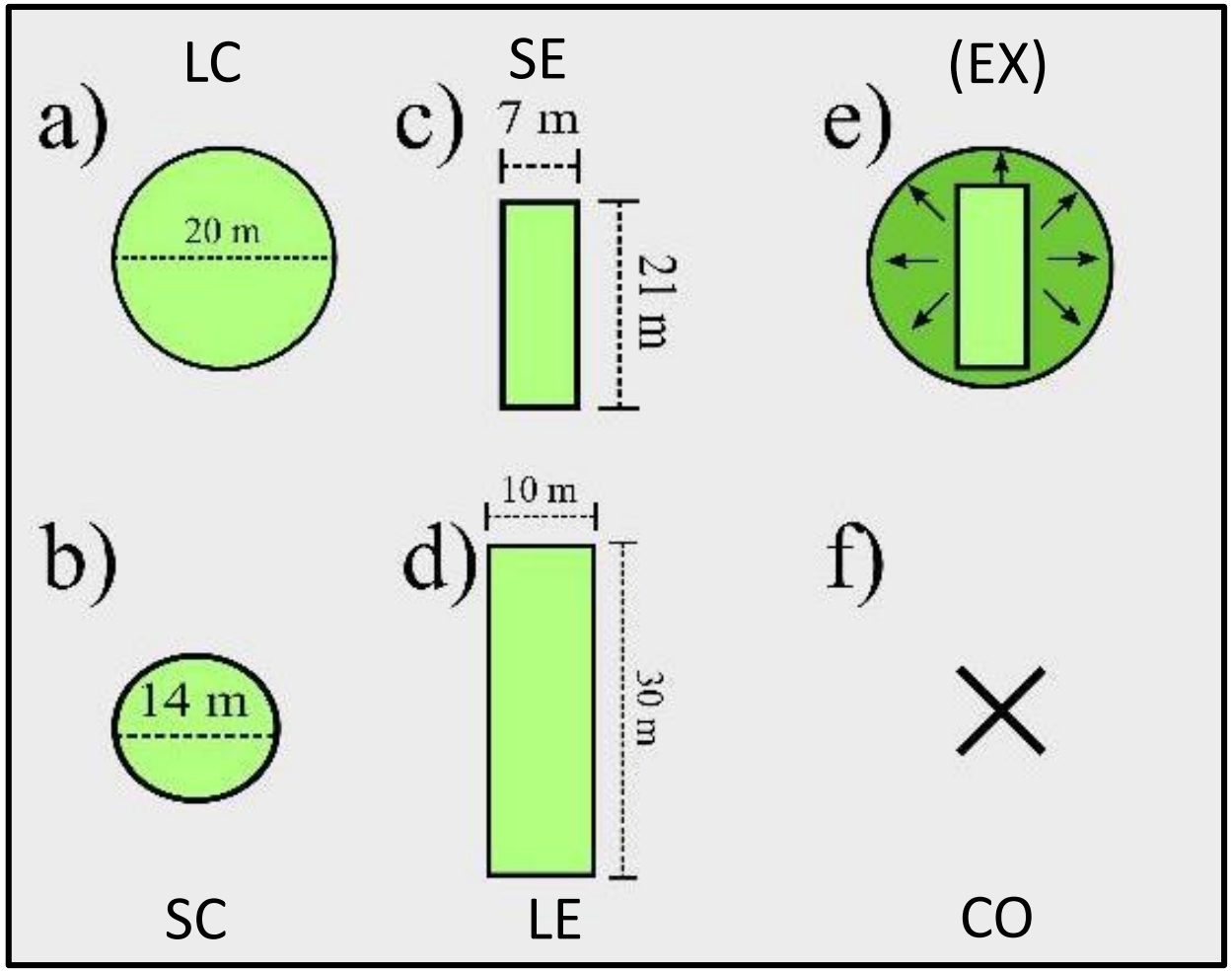


Methods: Experimental desing

Investigated gap paramenters:

- Small vs. large (150 vs. 300 m^2)
- Circular vs. elongated
- (Created in one or two steps)

CO - control
LC – large circular
LE – large elongated
SC – small circular
SE – small elongated
(EX – extended)



Methods: Experimental design

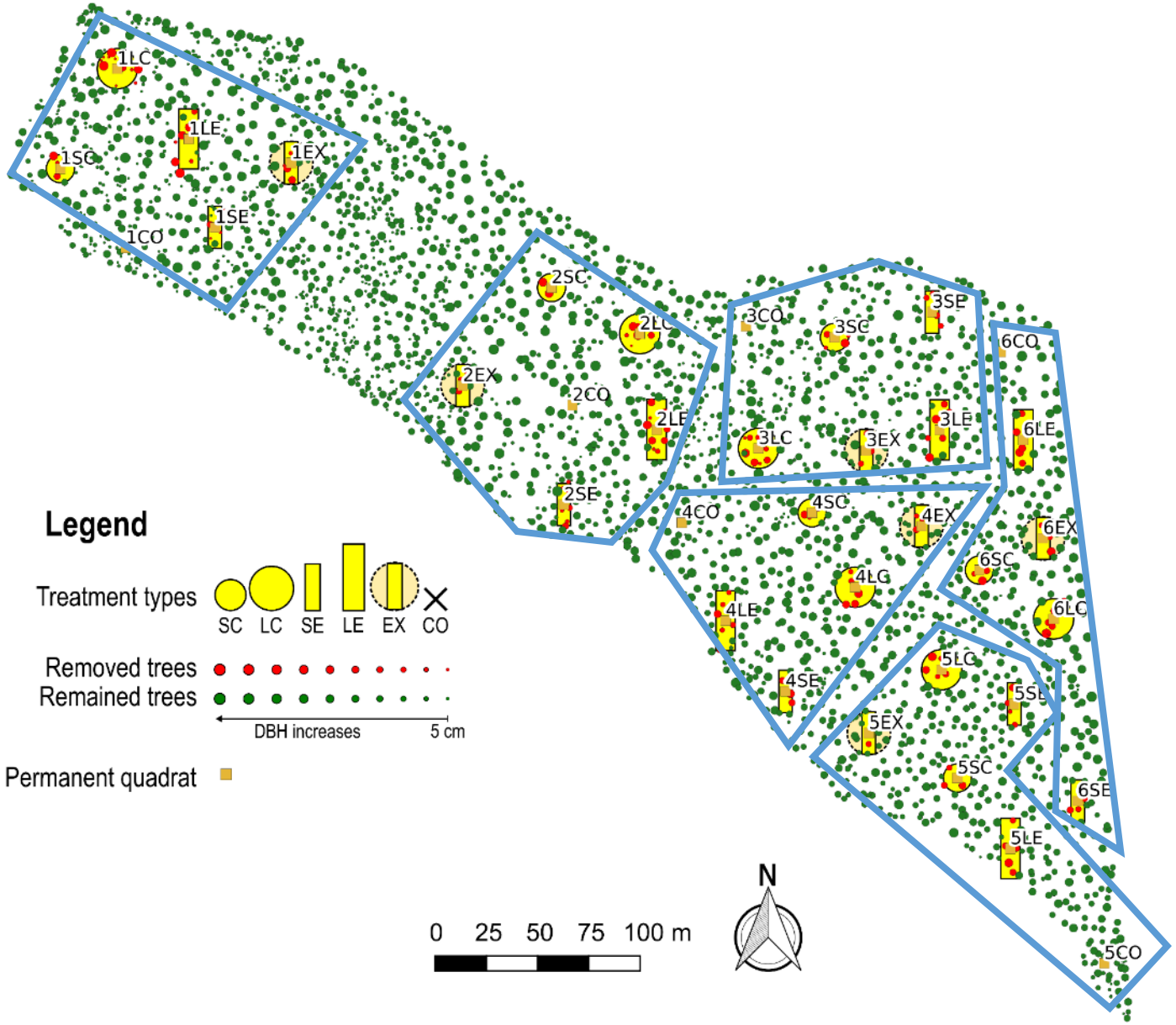
6 repetitions

Whole stand fenced against ungulates

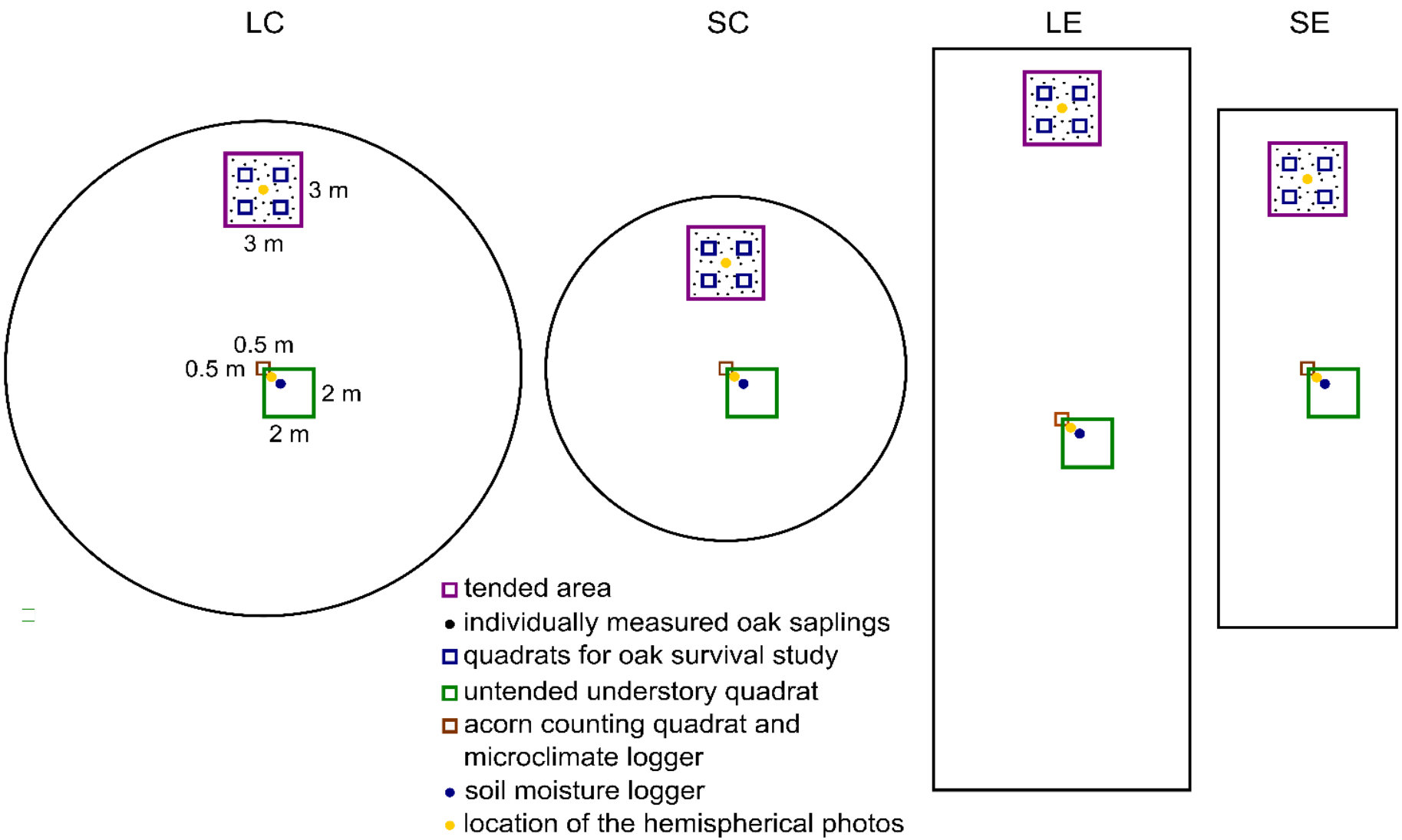
Gap creations:
2018-2019 winter

Data collection:
from 2018 yearly

Analysed data:
first 4-5 years after the interventions



Methods: Experimental design



Methods: Studied variables

Environmental variavbles

Air temperature and humidity

Light

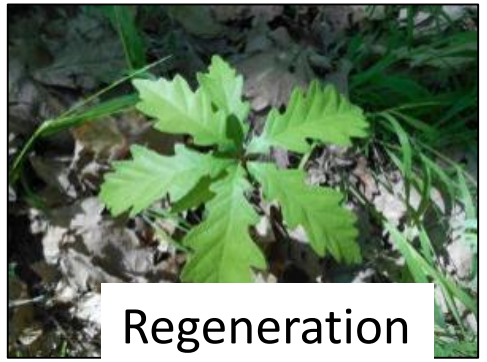
Soil chemistry

Soil moisture

Multi-taxon biodiversity

Understory

Spiders



Regeneration

Enchytraeid worms

Carabids

Dipterans

Methods: Studied variables

Environmental variavbles

Air temperature and humidity

Light

Soil chemistry

Soil moisture

Multi-taxon biodiversity

Understory

Spiders

Regeneration

Enchytraeid worms

Carabids

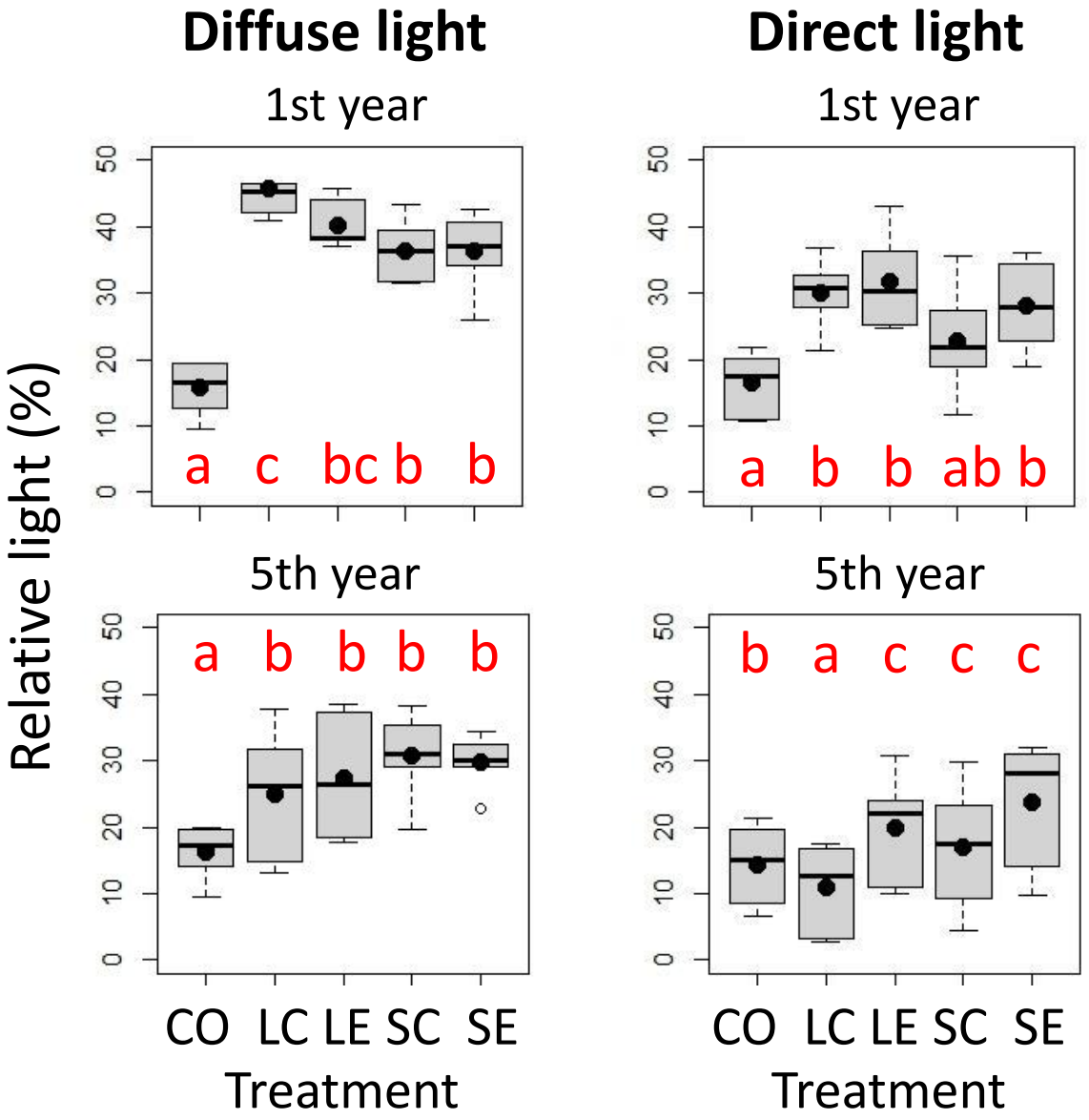
Dipterans

Results: Light

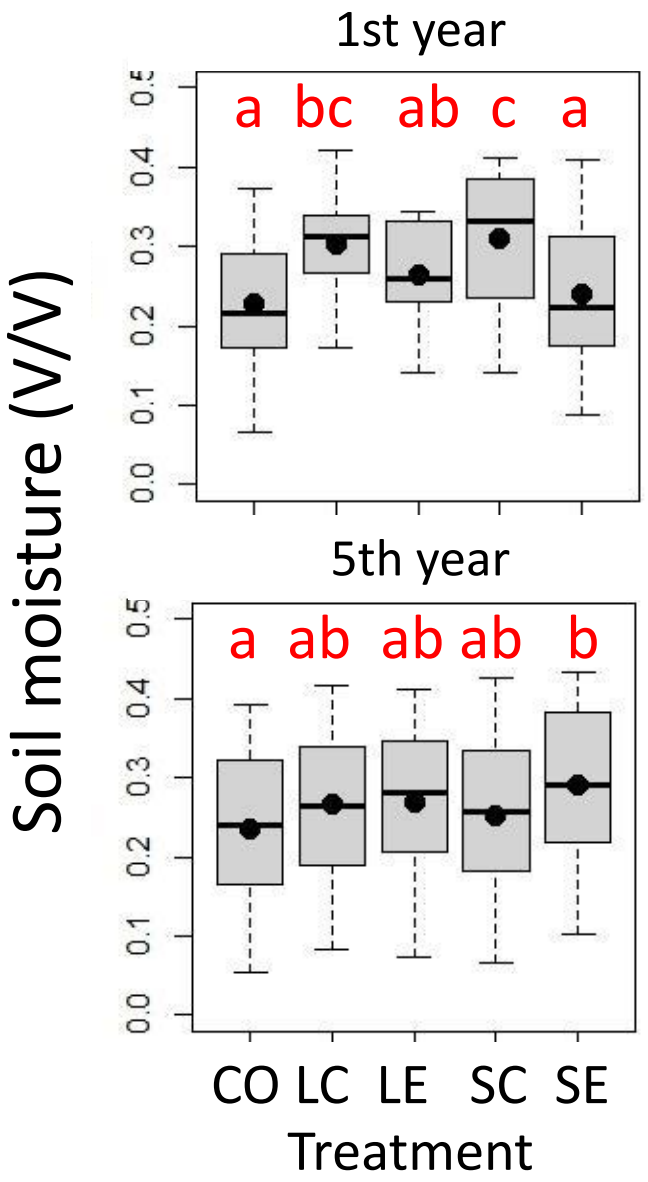
Diffuse light:
increased everywhere

Direct light:
In LC gaps, decreased below the closed stand for the 5th year.
In other gaps, it increased

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



Results: Soil moisture



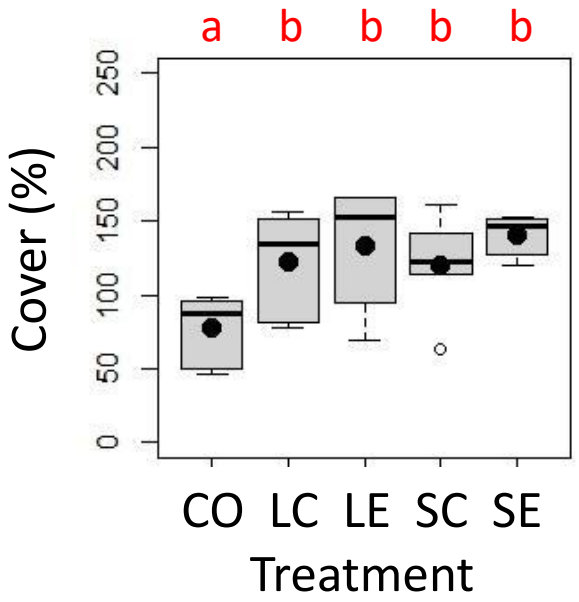
Soil moisture increased first in the circular gaps, but later here decreased

For the 5th year, only small elongated gaps were moister than the closed stand

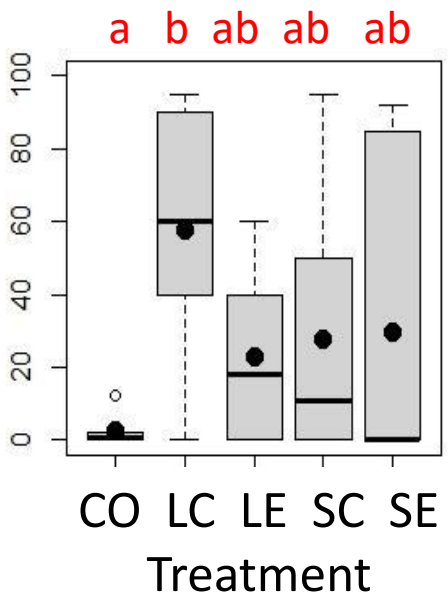
CO - control
LC – large circular
LE – large elongated
SC – small circular
SE – small elongated

Results: Understory, bramble, shrubs

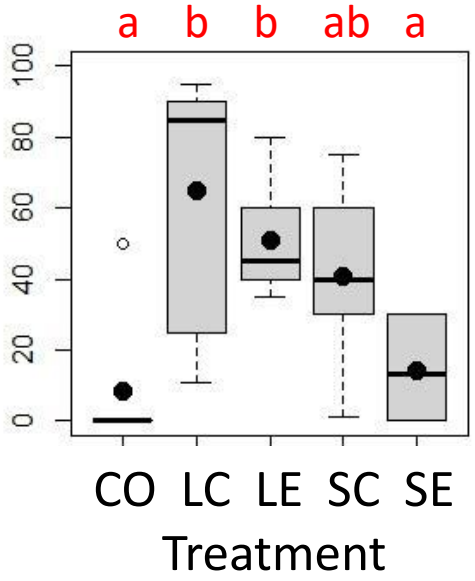
Understory cover



Rubus fruticosus agg.



Shrub cover



5th year after the interventions:

Total cover increased in all gaps

Rubus increased mainly in the large circular gaps

Small elongated gaps have few **shrubs**

CO - control

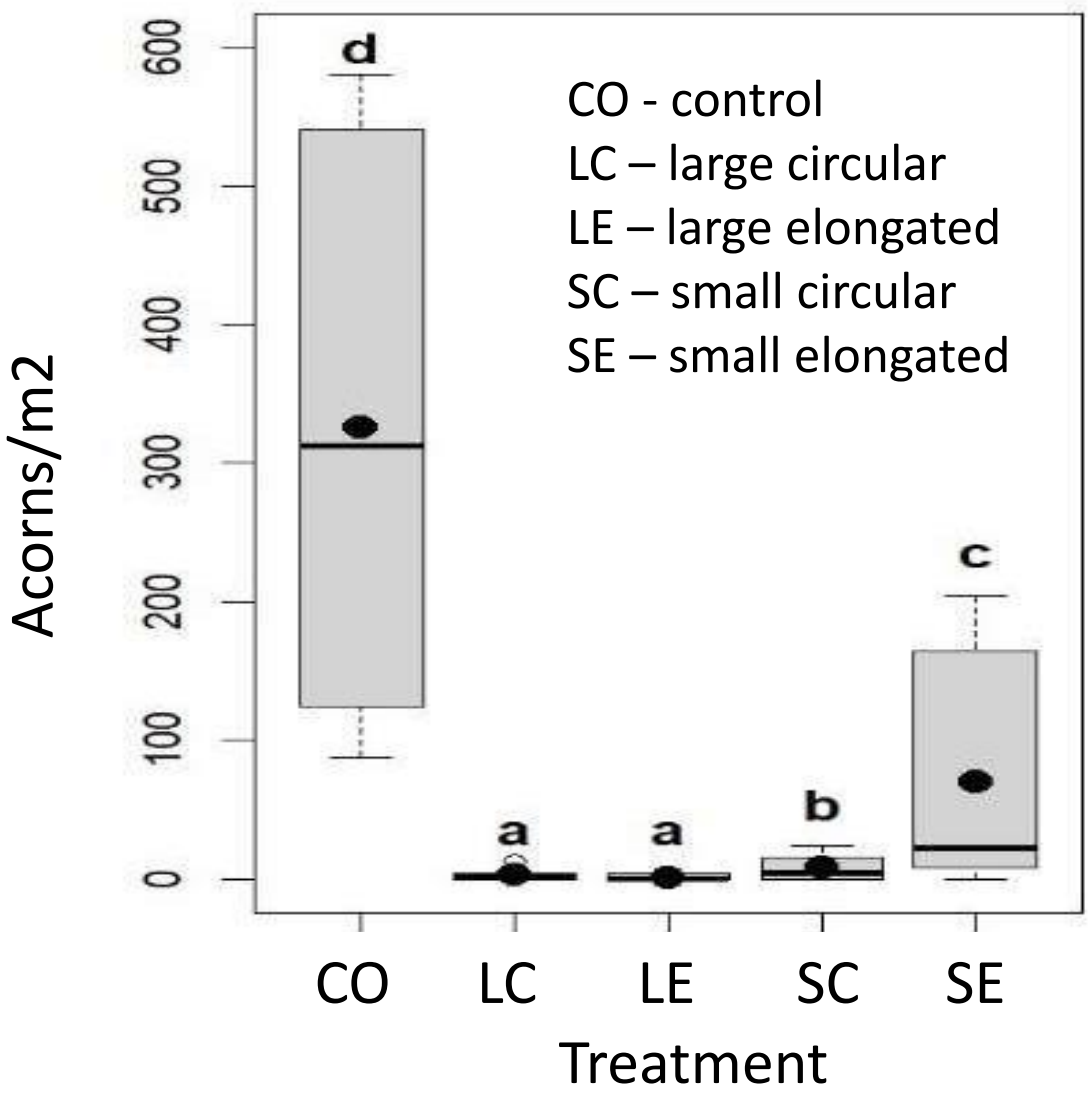
LC – large circular

LE – large elongated

SC – small circular

SE – small elongated

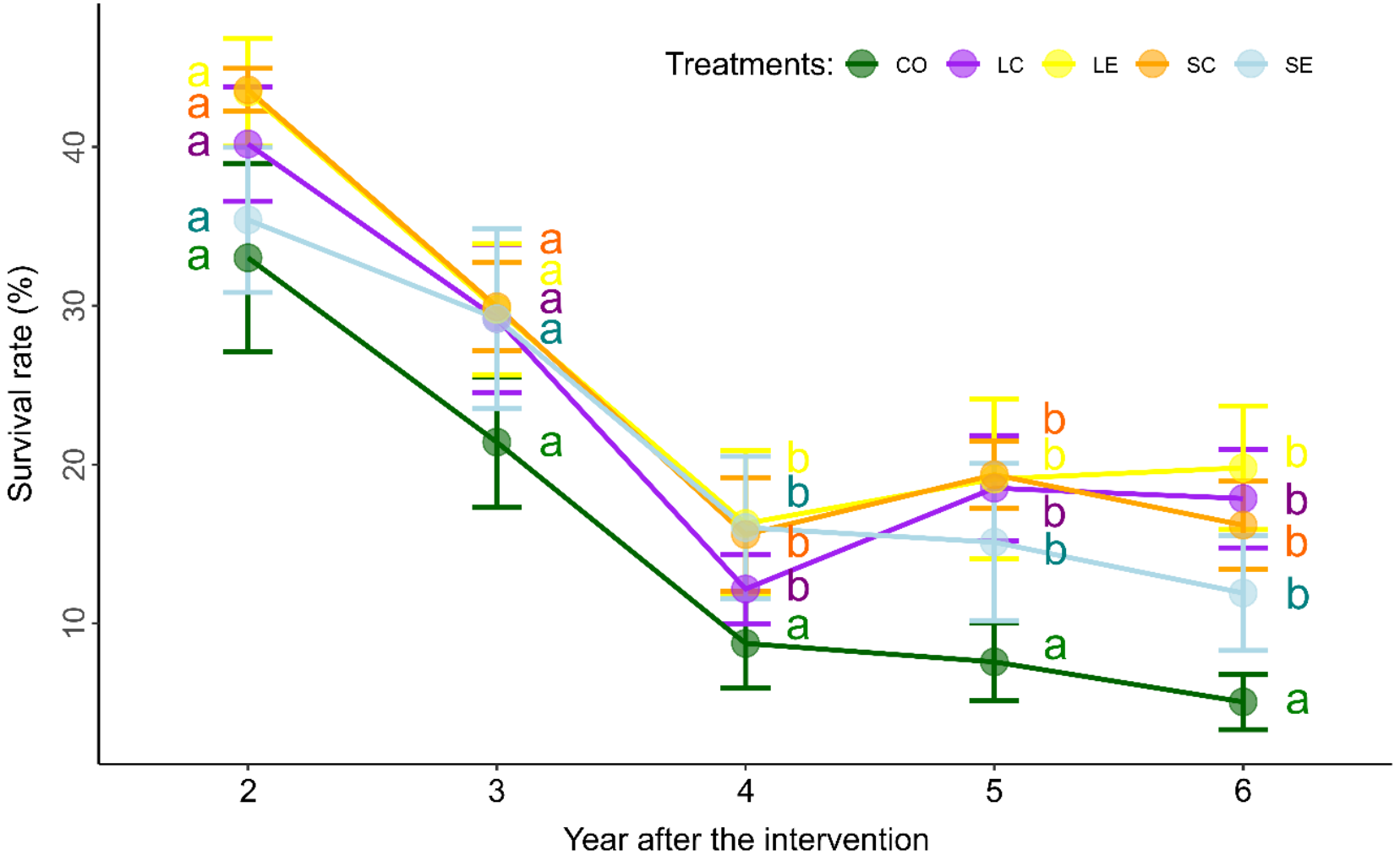
Results: Acorn supply



Masting year 2 years after the interventions

In the closed stand, high acorn number
In large gaps, almost no acorn
Among the gaps, only the small elongated ones received a relatively high number of acorns after gap creation

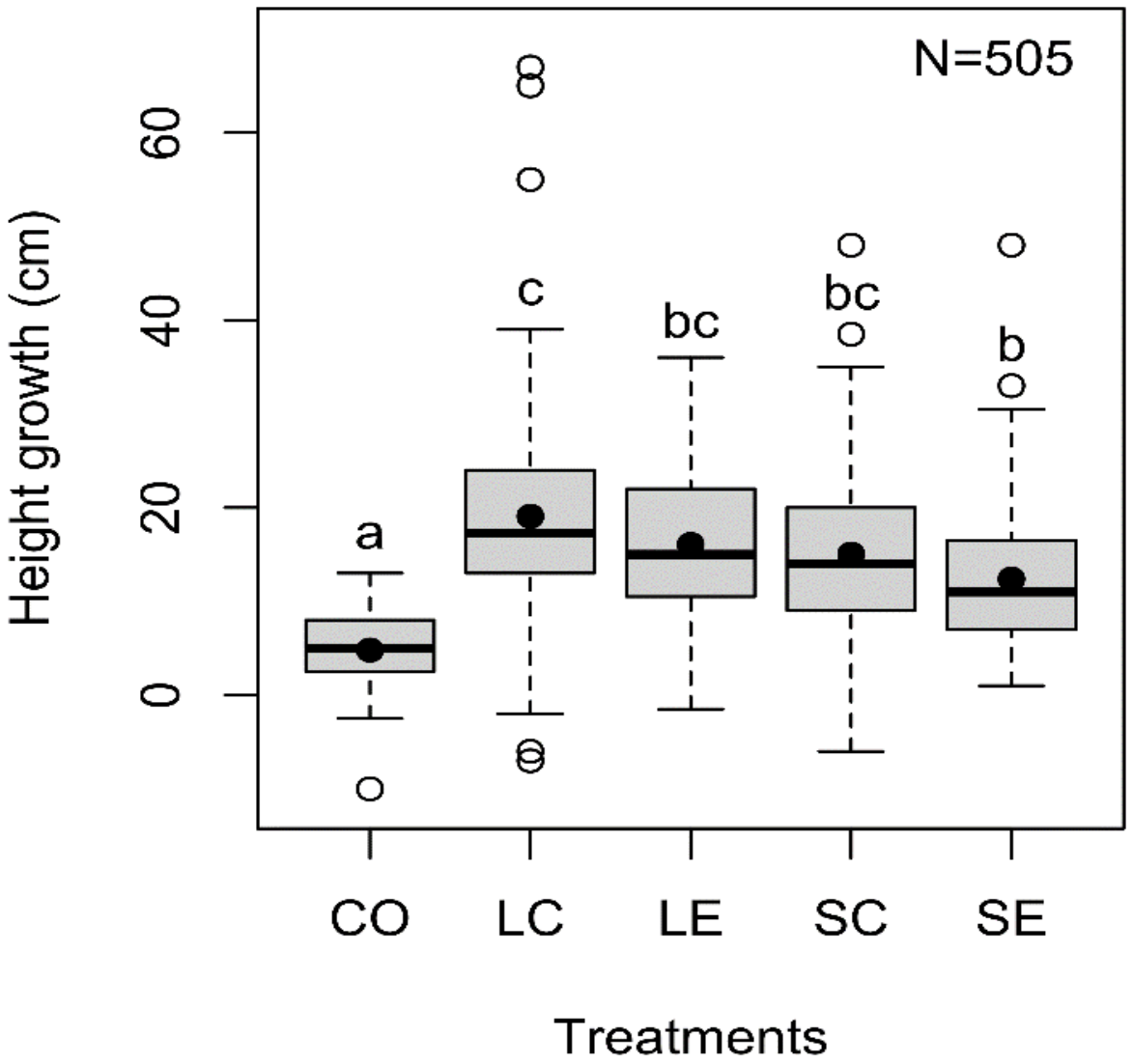
Results: Oak survival in tended plots



Higher in the gaps than in the CO

Does not depend on gap types

Results: Height growth of oak in the fourth year in tended plots

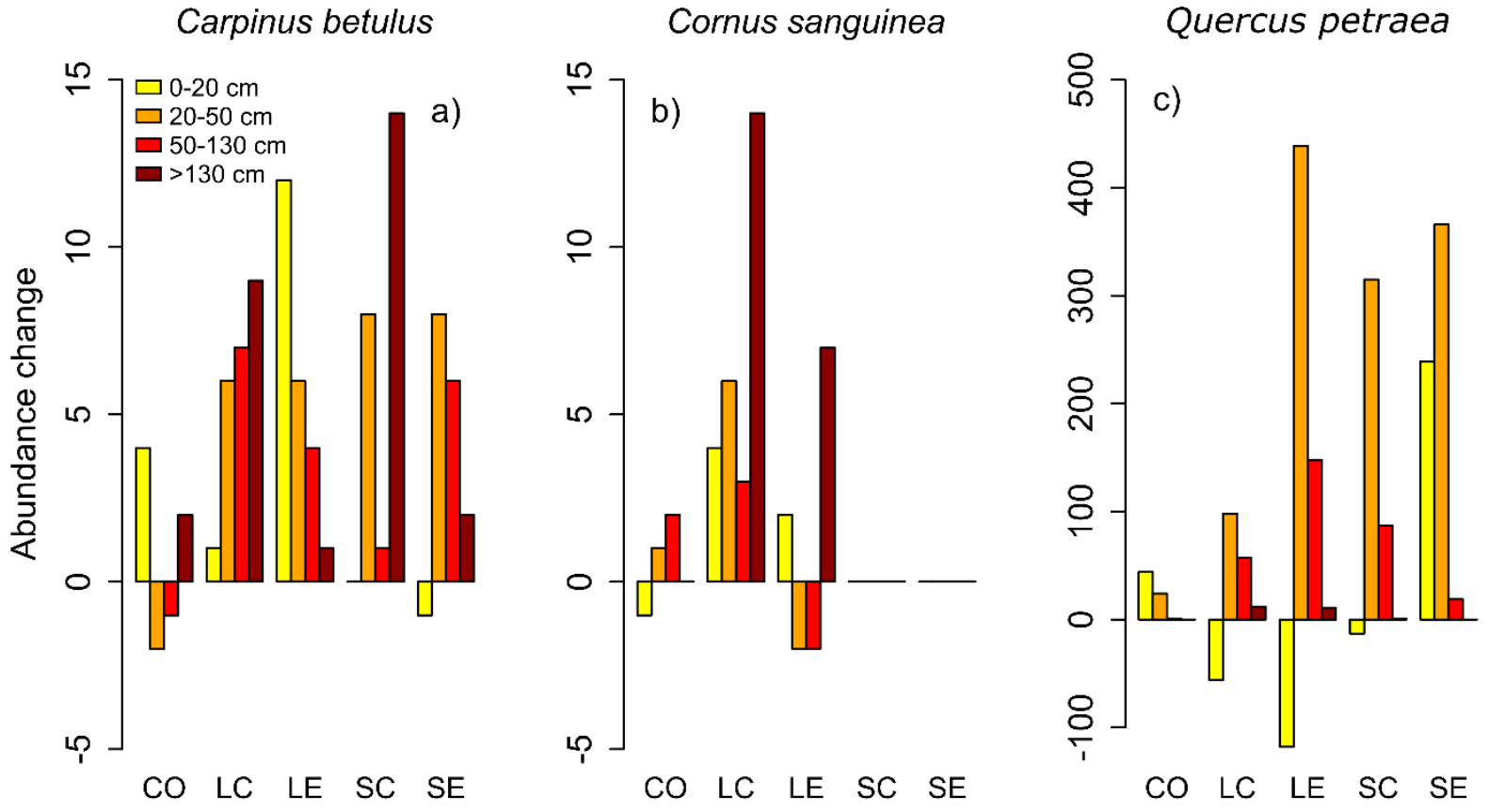


In all gaps it is higher than in CO

Highest in LC, lowest in SE

Results: Natural regeneration in untended plots

Abundance changes for the sixth year



- Large **hornbeams** mainly in circular gaps (soil moisture)
- Large **dogwoods** mainly in large gaps (light)
- Most **oak** saplings reached the size-II and size-III categories in large elongated and small circular gaps
- Largest abundance-increment in small elongated gaps, but many of them is still small (slower growth)

Summary: Large circular gaps

Initially, high light and soil moisture

- Completely tended saplings: strong development
- But in case of natural circumstances (no tending):

Light-flexible, strong competitor species (e.g. *Rubus fruticosus agg.*)

Dense shrub layer (*Carpinus betulus, Cornus sanguinea*)

Direct light, soil moisture decreases

Oak saplings decline

Summary: Large elongated gaps

Intermediate increase of light and soil moisture

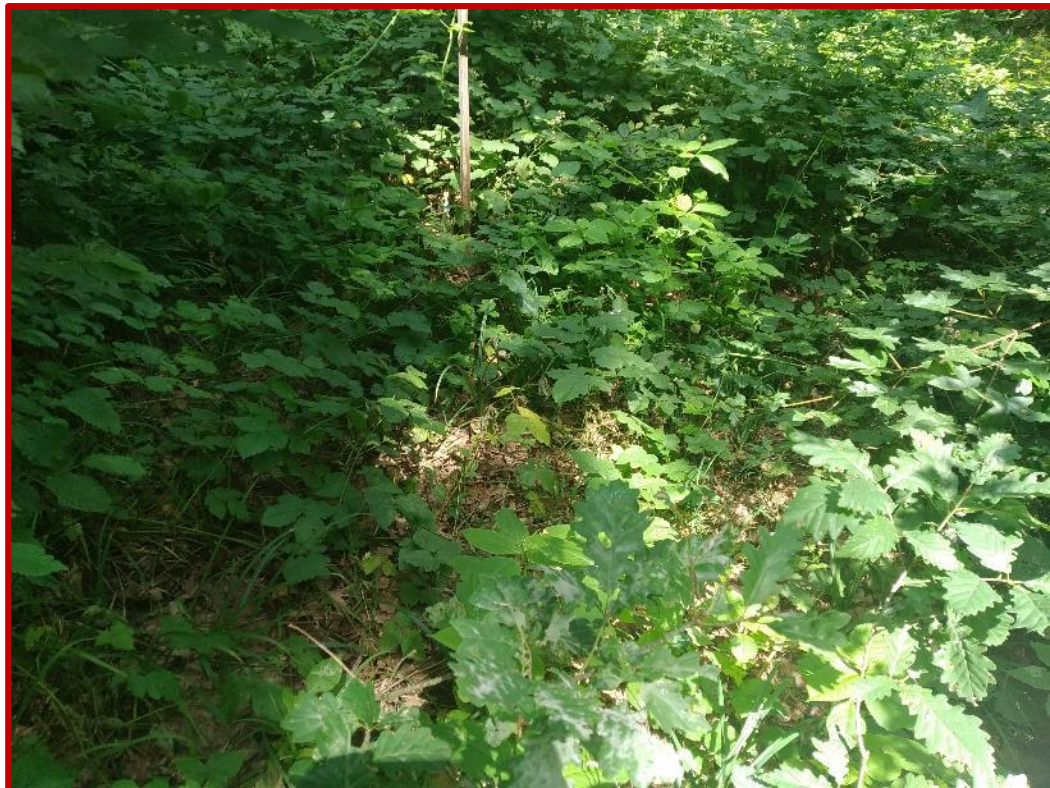
↓

Intermediate *Rubus* cover, a few *Cornus*

↓

Intermediate cover of oak regeneration

Good growth of oak saplings



Summary: Small circular gaps

Small amount of extra light

Initially high soil moisture, but later it decreases

Total cover increases, but no dominant herb species, no *Cornus*, but a few *Carpinus*

Oak regeneration can start

Good sapling growth

Summary: Small elongated gaps

Slightly more light than in the closed stand

Small, but persistent increase of soil moisture

↓

No dense herb layer, no shrub layer

↓

Stable oak renegeration

Slow growth, but survival is still ok

With the extension of gap after some years, growth might be enhanced

Receives acorn even after gap creation!

Summary: Implications for forest management

- Oak regeneration can start in 300 m^2 or smaller gaps
- Without competition, the growth would be the best in the large circular gaps
- However, the competition of more shade-tolerant woody species and *Rubus* hinder the development

- Taking into account the competition and acorn supply, small gaps (especially small elongated gaps) are more favourable for the oak regeneration
- Gap extension may be needed in a few years
- If larges gaps are applied, oak regeneration can be promoted by using an elongated shape
- Tending against hornbeam may be necessary

- For oak regeneration higher final gaps are necessery, however in mixed stands shade tolerant trees can regenerate in small gaps





Thank you for your attention!

oak adapt
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Interreg VI-A Hungary-Slovakia Programme
#oakadapt project
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