# The project CAROLINA (ClimAte Resilience Over Landuse change In semi-Natural grAsslands, PRIN 2022 PNRR)

V. Lazzeri[1], F. Bretzel[1,2], F. D'Alò[3], S. Doni[1], L. Latilla[4], M. Mattioni[3], E. Peruzzi[1,2], M. Sarti[3], A. Scartazza[1,2], B. G. Tesfamariam[3], C. Volterrani[3], A. Coppi[5], E. Siccardi[5], V. A. Volanti[5], L. Lazzaro[5], O. Gavrichkova[2,3]

1: IRET Pisa; 2: National Biodiversity Future Center; 3: IRET Porano; 4: IRET Montelibretti; 5: Department of Biology, University of Florence, Firenze, Italy

**Grasslands, either not man-affected or only slightly managed, usually harbour a rich plant biodiversity that cannot be observed in closed habitats dominated by woody species such as shrublands, maquises and woodlands. Many grasslands can be attributed to habitats of the NATURA 2000 network.**

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**In certain cases a moderate management can support the establishment and the persistence of a rich plant biodiversity avoiding that more competitive species would overcome the others with the result of a decline in species richness.**

## The project CAROLINA: why

# A series of important ecosystem services are acknowledged to grasslands:

Zhao & al. Landscape Ecol 35, 793–814.

## PROVISIONING

- Forage producion/above-ground biomass
- Raw materials
- Water yield/supply
- Livestock/ivestock production
- Habitat for wildlife species
- Biofuel supply
- Genetic library/Seed bank
- Milk/dairy productivity
Meat from cattle/sheep/goat
- Agronomic services
- Nectar/honey produciton
- Fiber production
- Wool production
- Sources of natural medicines

grasslands

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**grasslands**

## Regulating

- Erosion regulation (water erosion)
- Water flow regulation
- Nutrients delivery/retention
- Climate regulation
- Pollination service
- Soil accumulation
- Erosion regulation (wind erosion)
- Water purification
- Air quality regulation
- Pest control
- Wildfire control
- Waste treatment

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## Cultural

- Prevention and control of endoparasitic
- Recreational space/Recreation/Tourism
- Aesthetic appreciation/experience
- Spiritual and religious services
- Horticulture/cultural identity
- Ecological knowledge/Educational

## Regulating

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**grasslands**

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- This can lead to the overall reduction in plant biodiversity.
- In certain cases, it can also entail the partial or total replacement of the grassland at the advantage of other habitats characterized by a dominance of woody species.
- As a result, both a variation in plant biodiversity with a net decrease of species richness and a change in the ecosystem services provided can occur.

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- This can lead to the overall reduction in plant biodiversity.
- In certain cases, it can also entail the partial or total replacement of the grassland at the advantage of other habitats characterized by a dominance of woody species.
- As a result, both a variation in plant biodiversity with a net decrease of species richness and a change in the ecosystem services provided can occur.
- Both grasslands and woodlands are fundamental habitats and we should aim at maintaining a balance between them.

# The project CAROLINA: why

**19 NATURA 2000 habitats are grasslands *sensu lato*: 1320, 1410, 1510*, 2120, 2130*, 2230, 2240, 2330, 6150, 6170, 6210*, 6220*, 6230*, 6240*, 62A0*, 6410, 6420, 6510, 6520**

# The project CAROLINA: why

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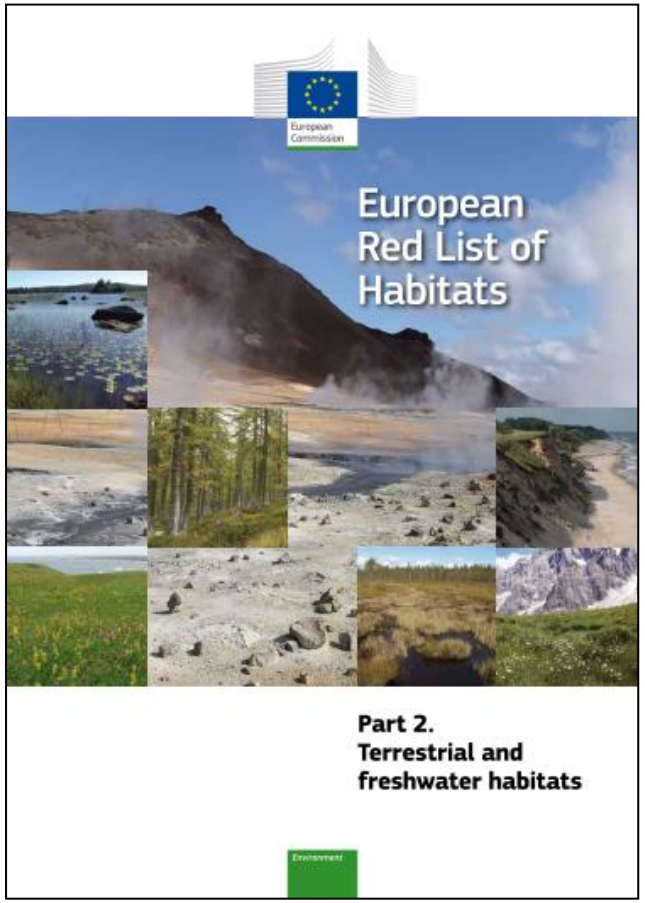
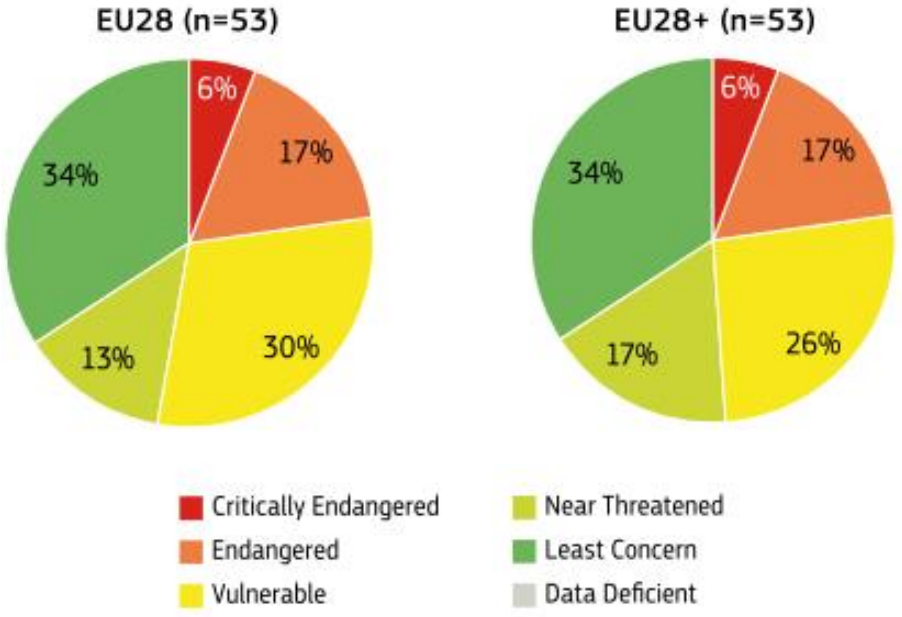
- **High menace: 2120, 2130*, 2230, 2240, 2330, 6410, 6420**
- **Low menace: 1320, 1410, 1510*, 6150, 6170, 6210*, 6220*, 6230*, 6520**

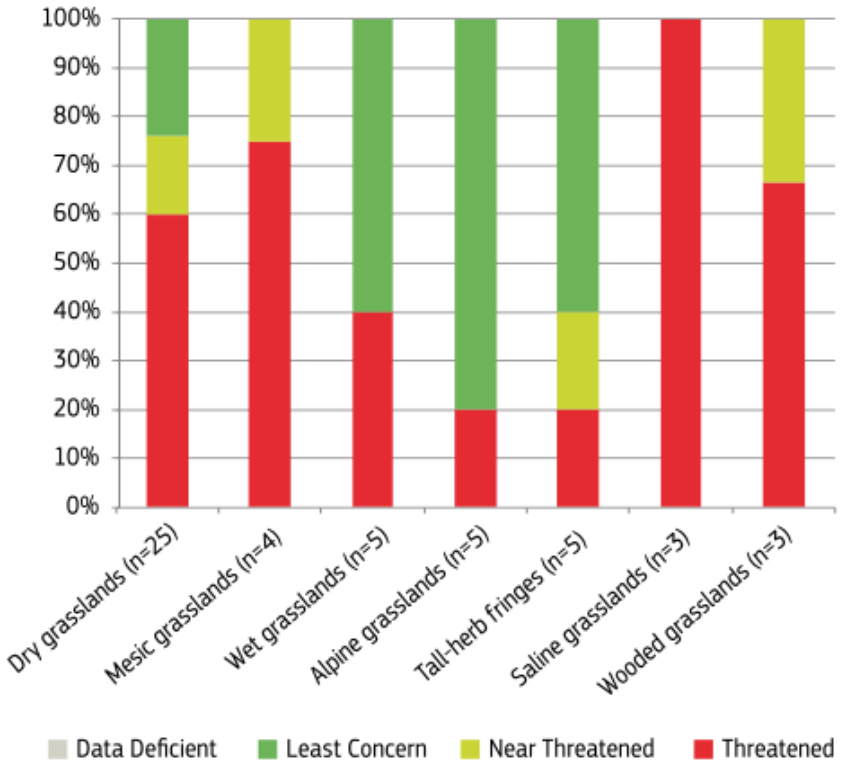
## The project CAROLINA: why

# At the European level grasslands have turned out to be among the most threatened habitats



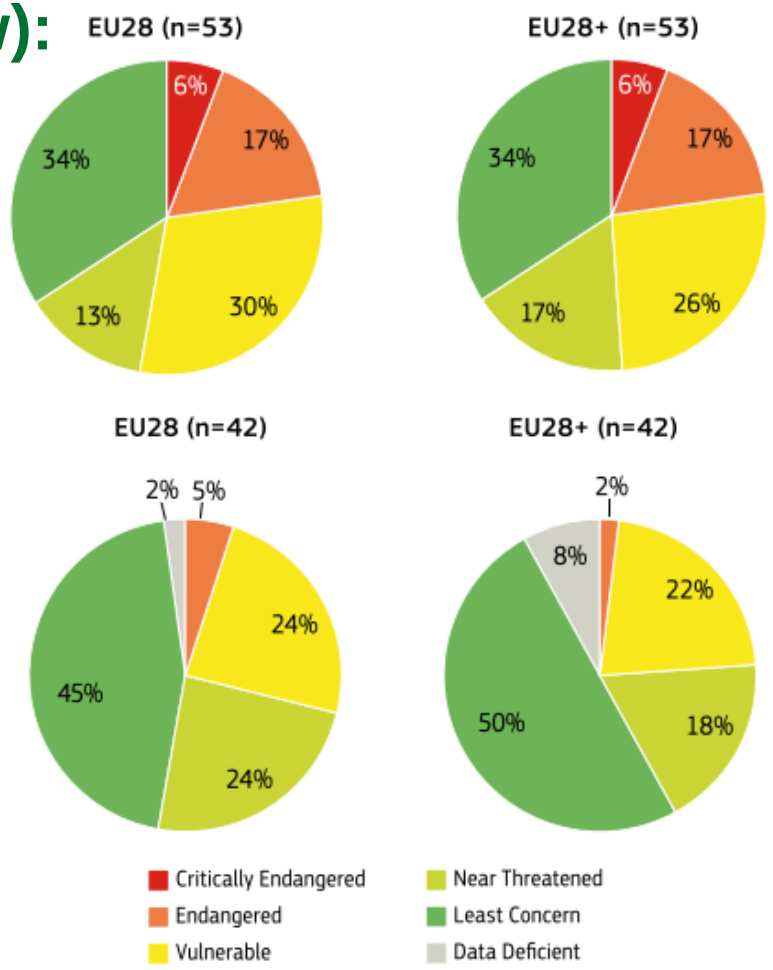

# The project CAROLINA: why

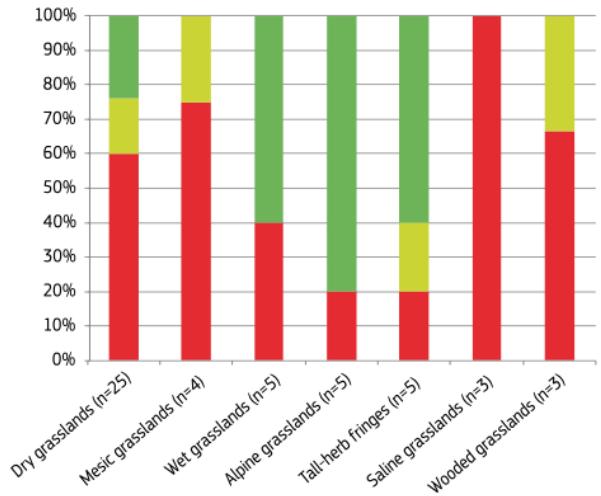


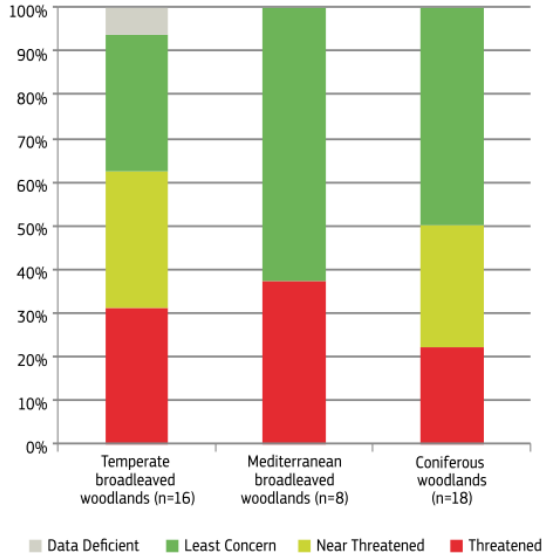




# The project CAROLINA: why

# In particular if compared to forests (below):



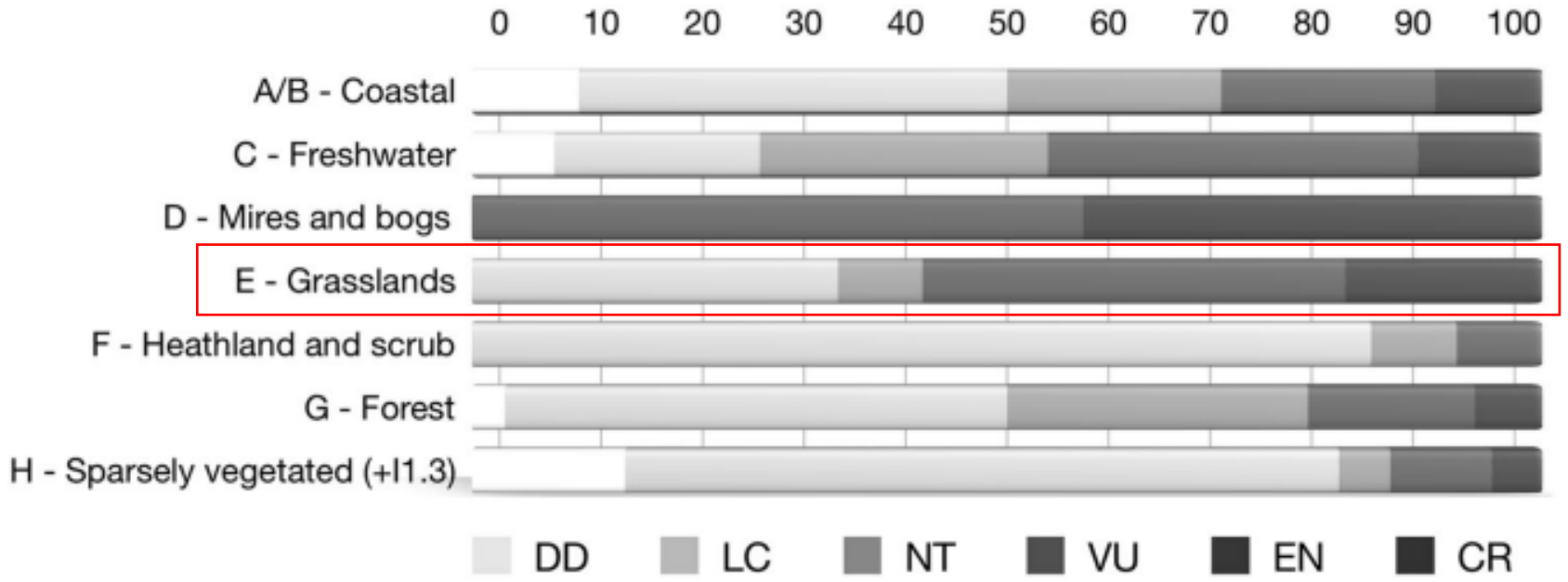




# The project CAROLINA: why

# Habitat conservation in Italy: the state of the art in the light of the first European Red List of Terrestrial and Freshwater Habitats

D. Gigante[1] · A. T. R. Acosta[2] · E. Agrillo[3] · S. Armiraglio[4] · S. Assini[5] · F. Attorre[3] · S. Bagella[6] · G. Buffa[7] · L. Casella[8] · C. Giancola[9] · G. P. Giusso del Galdo[10] · C. Marcenò[11] · G. Pezzi[12] · I. Prisco[2] · R. Venanzoni[1] · D. Viciani[13]

Rendiconti Lincei. Scienze Fisiche e Naturali (2018) 29:251–265




## The project CAROLINA: why

CNR IRET
Istituto di Ricerca sugli Ecosistemi Terrestri

**Institute of Research on Terrestrial Ecosystems of the National Research Council (Pisa and Porano)**

UNIVERSITÀ DEGLI STUDI FIRENZE
BIO DIPARTIMENTO DI BIOLOGIA

**Department of Biology of the University of Florence**

# The project CAROLINA: who we are

# The project aims to study grasslands with two different approaches:

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1) The evaluation of the effects of moderate extensive grazing and rainfall reduction in three "manipulation sites"

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1) The evaluation of the effects of moderate extensive grazing and rainfall reduction in three "manipulation sites"
2) The evaluation of the transition from grasslands to mature woodlands through the analysis of five chronosequences

# Three main focuses:

1) Soil (three primary sites)
2) Plants (three primary sites)
3) Remote sensing (three primary sites + two secondary sites)

## Soil functional diversity

- ecoenzymes
- total organic C and N, physical fractionation and respective isotope composition
- Particulate Organic Matter - Mineral-Associated Organic Matter
- main physical and chemical properties

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- physiological functional diversity
- carbon isotope composition ($\delta^{13}C$)
- leaf N content and $\delta^{15}N$ composition

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- classical metrics of functional diversity
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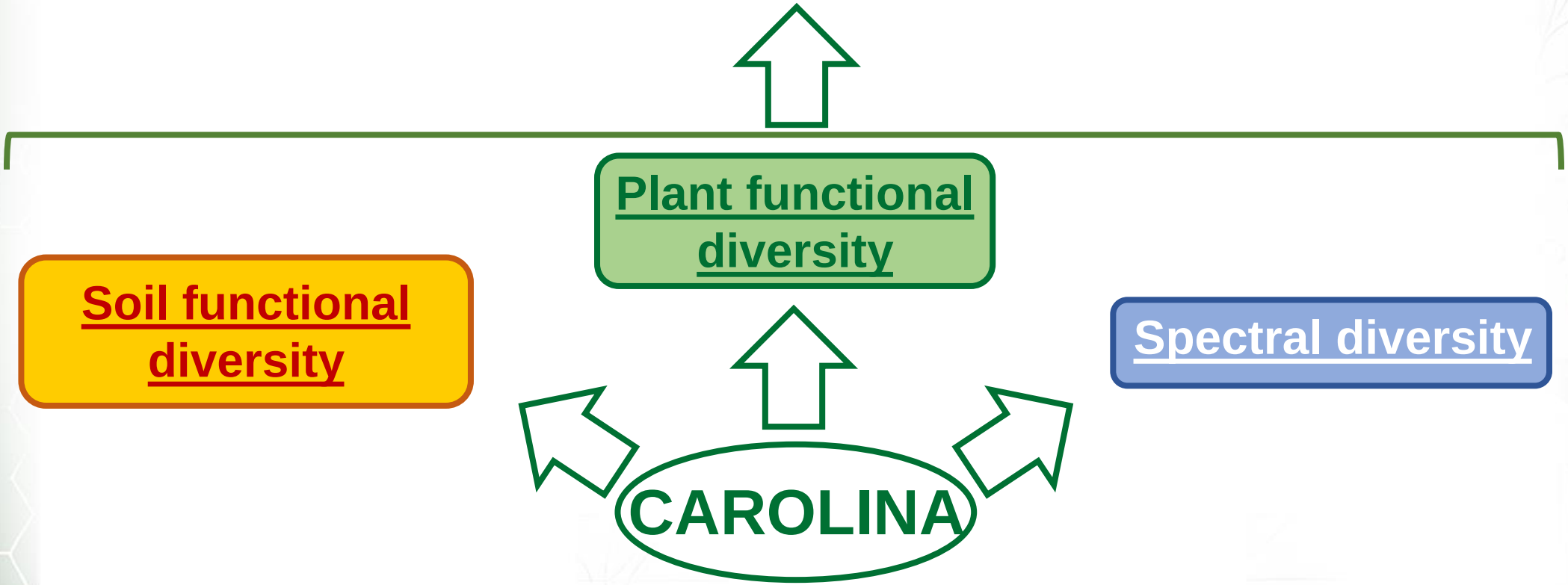
## Spectral diversity

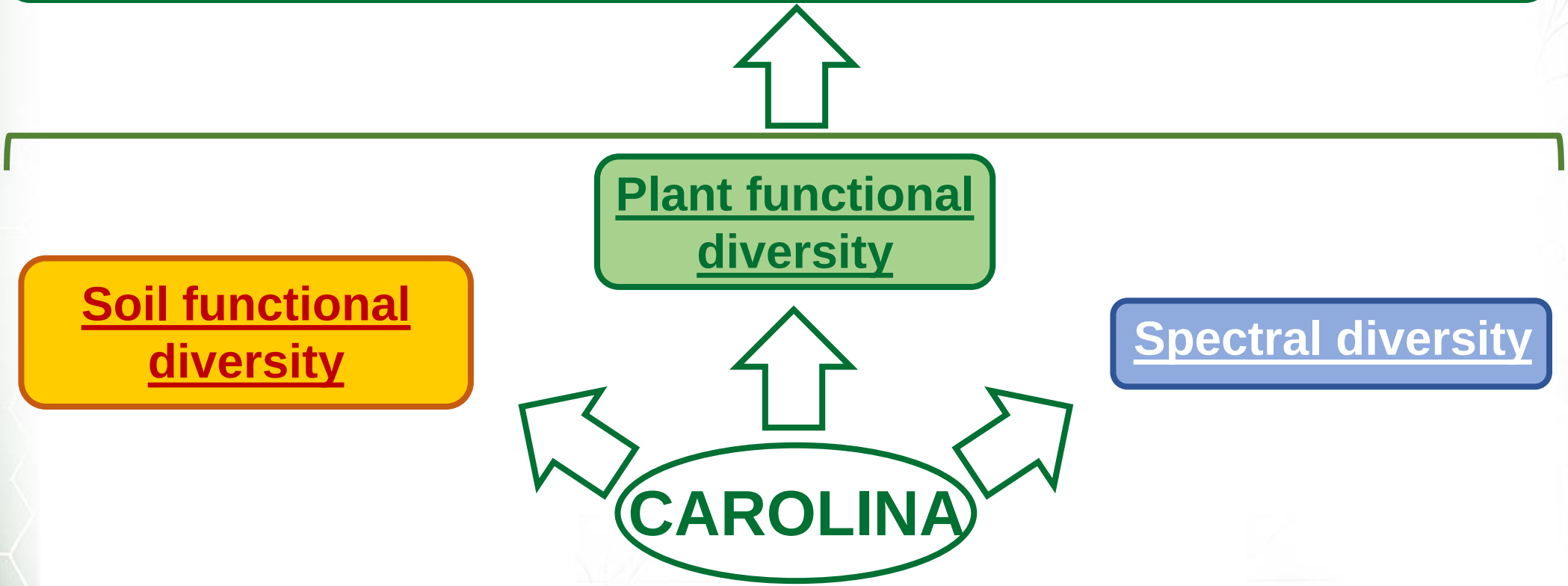
- spatial variability of the reflectance
- linking spectral diversity to climate variation and plant diversity

# potentiality of the grasslands in terms of biodiversity conservation and C sequestration

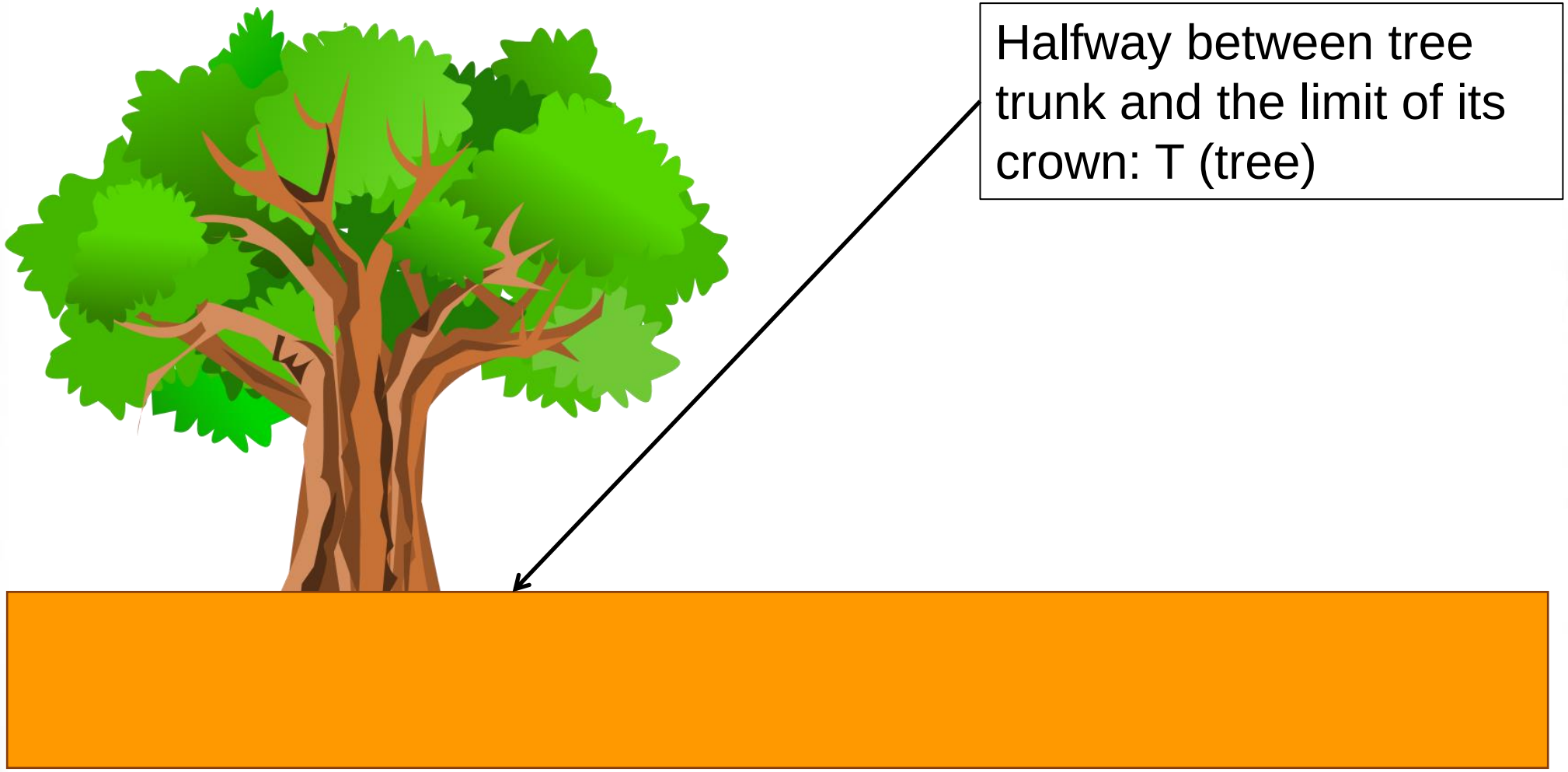


potentiality of the grasslands in terms of biodiversity conservation and C sequestration

ecosystem resilience to climate change with land-use variation



# The soil samplings:



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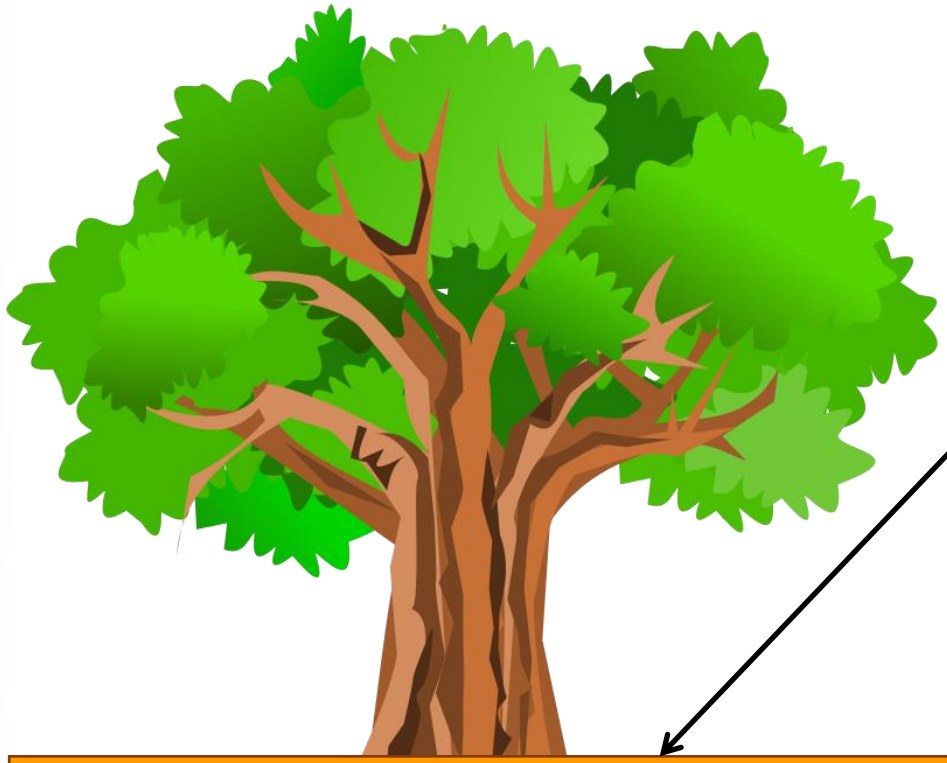


Halfway between tree trunk and the limit of its crown: T (tree)

5 meters from the crown: M (meadow)

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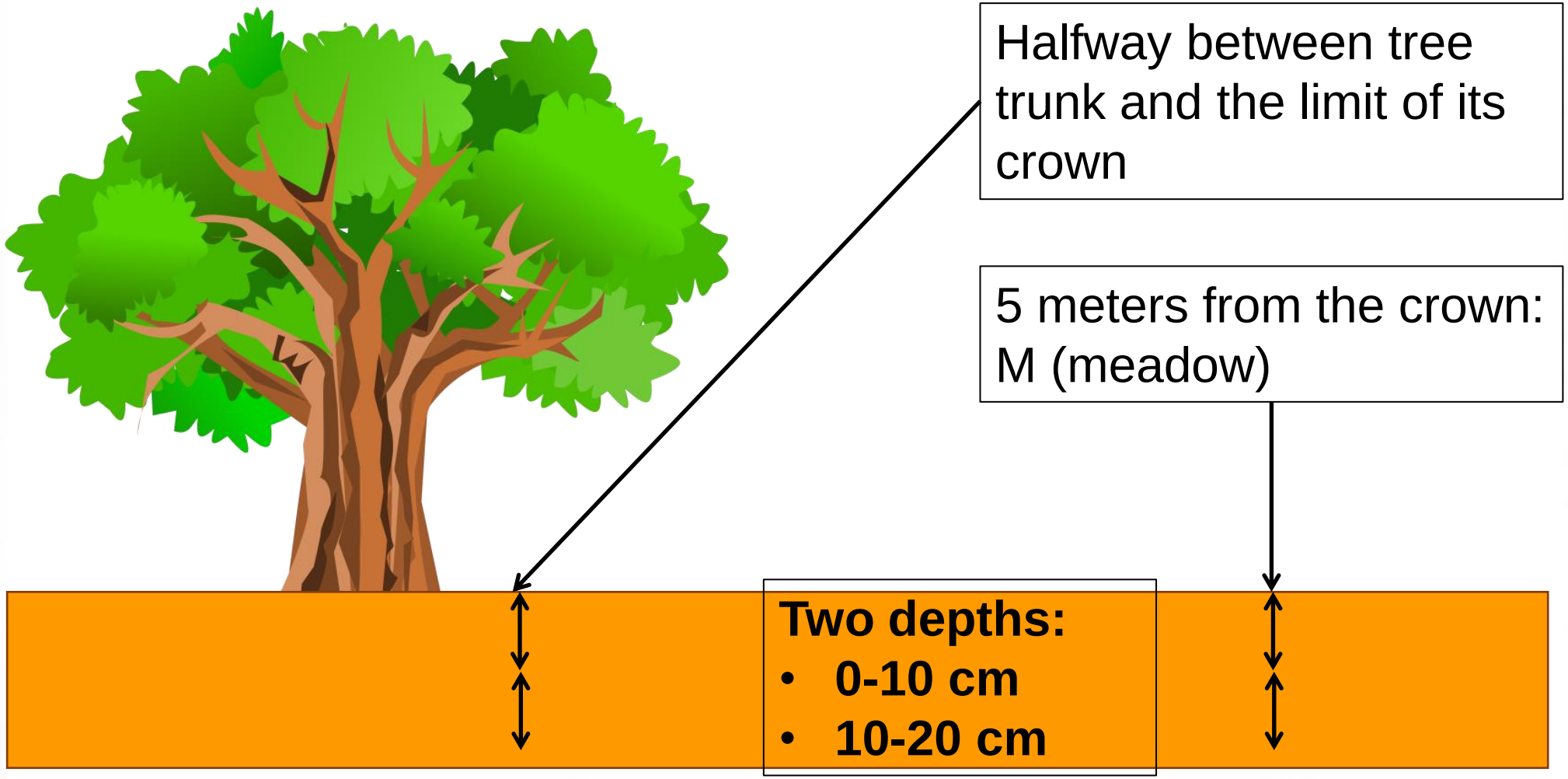
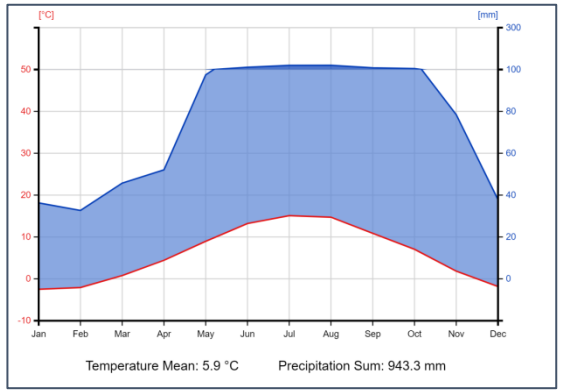


# The three main sites: passo del Brocon, the park of San Rossore, San Venanzo

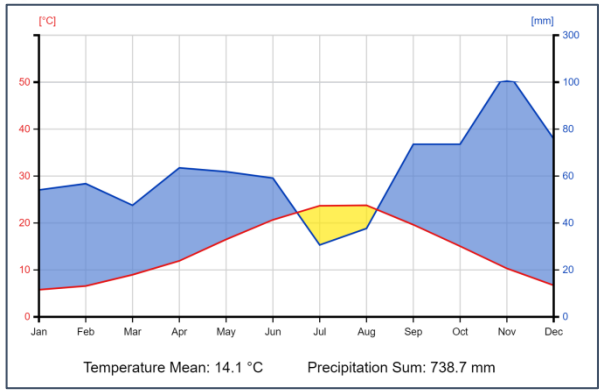

# The project CAROLINA: what we do

## BROCON
## 1400-1750 m a.s.l.



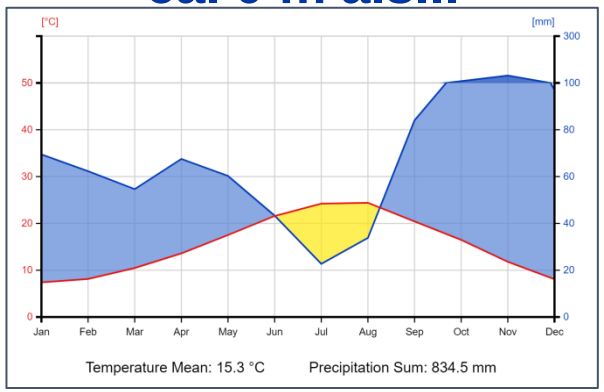

- **Macrobioclimate:** Temperate
- **Bioclimate:** Oceanic
- **Thermotype:** Upper orotemperate-Lower cryorotemperate
- **Ombrotype:** Lower/Upper hyperhumid

## SAN VENANZO
## 400-550 m a.s.l.




- **Macrobioclimate:** Temperate (Strong submediterranean)
- **Bioclimate:** Oceanic (submediterranean)
- **Thermotype:** Upper mesotemperate
- **Ombrotype:** Upper subhumid

## SAN ROSSORE
## ca. 0 m a.s.l.




- **Macrobioclimate:** Mediterranean
- **Bioclimate:** Pluviseasonal oceanic
- **Thermotype:** lower Mesomediterranean
- **Ombrotype:** Upper subhumid

# The project CAROLINA: what we do

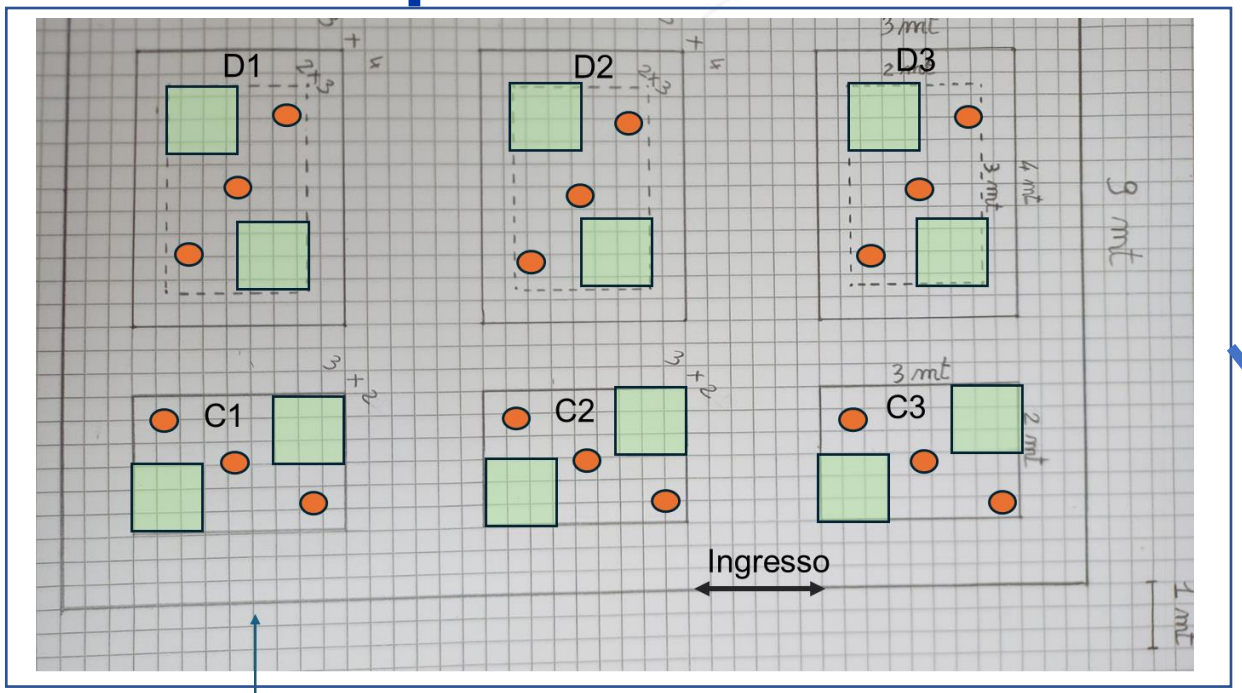
# 1) The "manipulation sites"

# Two factors studied:

1) moderate extensive pasture
2) From 35% to 55% rainfall reduction

The San Venanzo manipulation site with the rain shelters installed

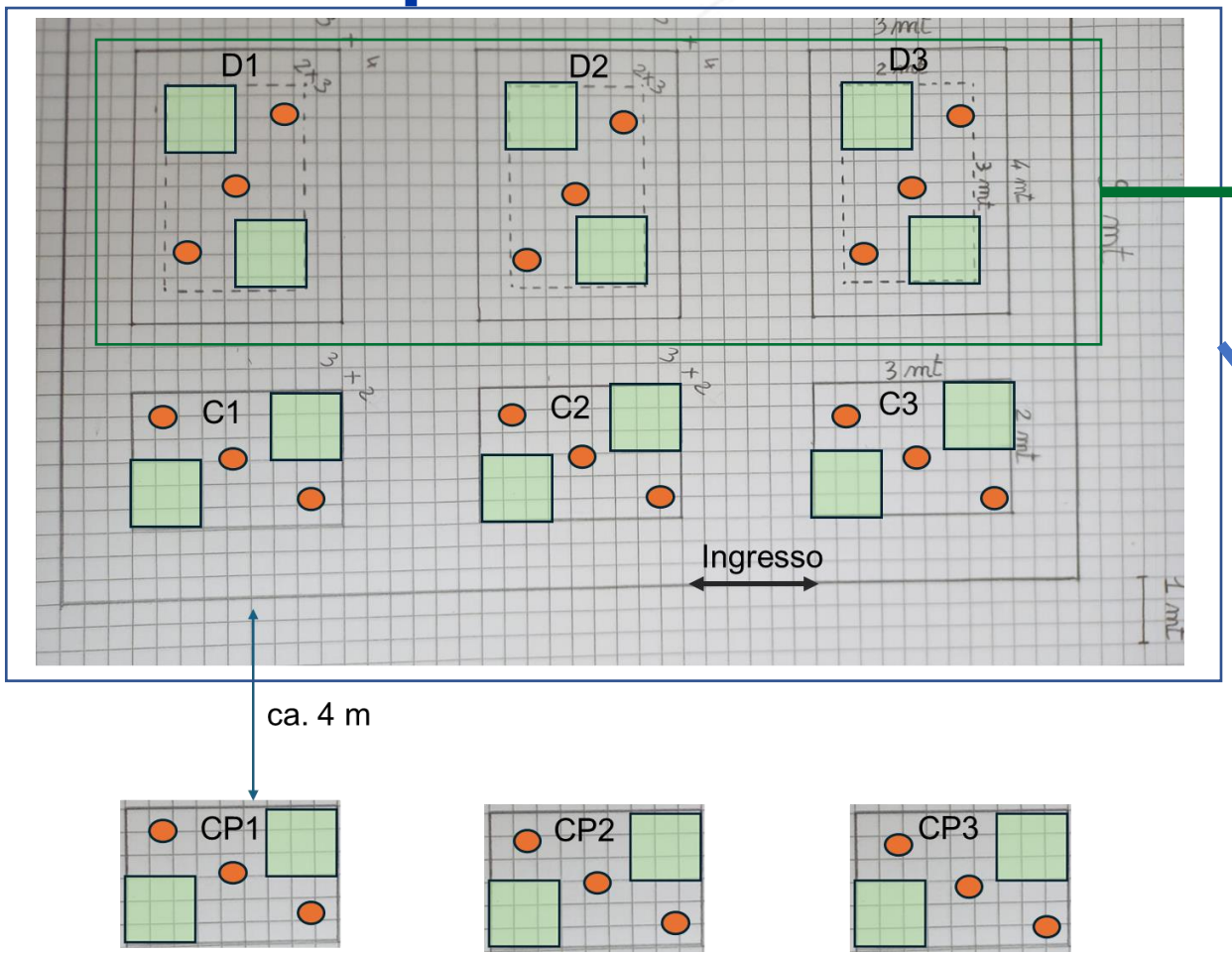
# The "manipulation sites"




**NO GRAZING**

## The project CAROLINA: what we do

# The "manipulation sites"

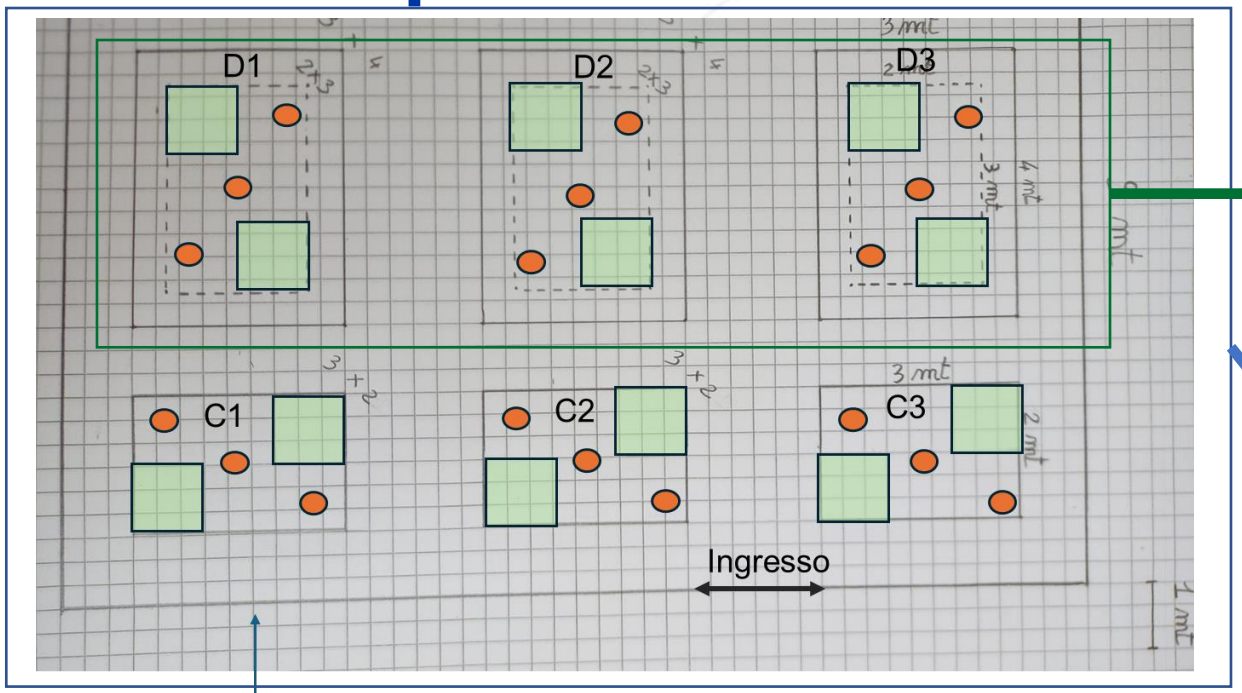



**NO GRAZING + 50% RAINFALL REDUCTION**

**NO GRAZING**

## The project CAROLINA: what we do

# The "manipulation sites"




NO GRAZING + 50% RAINFALL REDUCTION

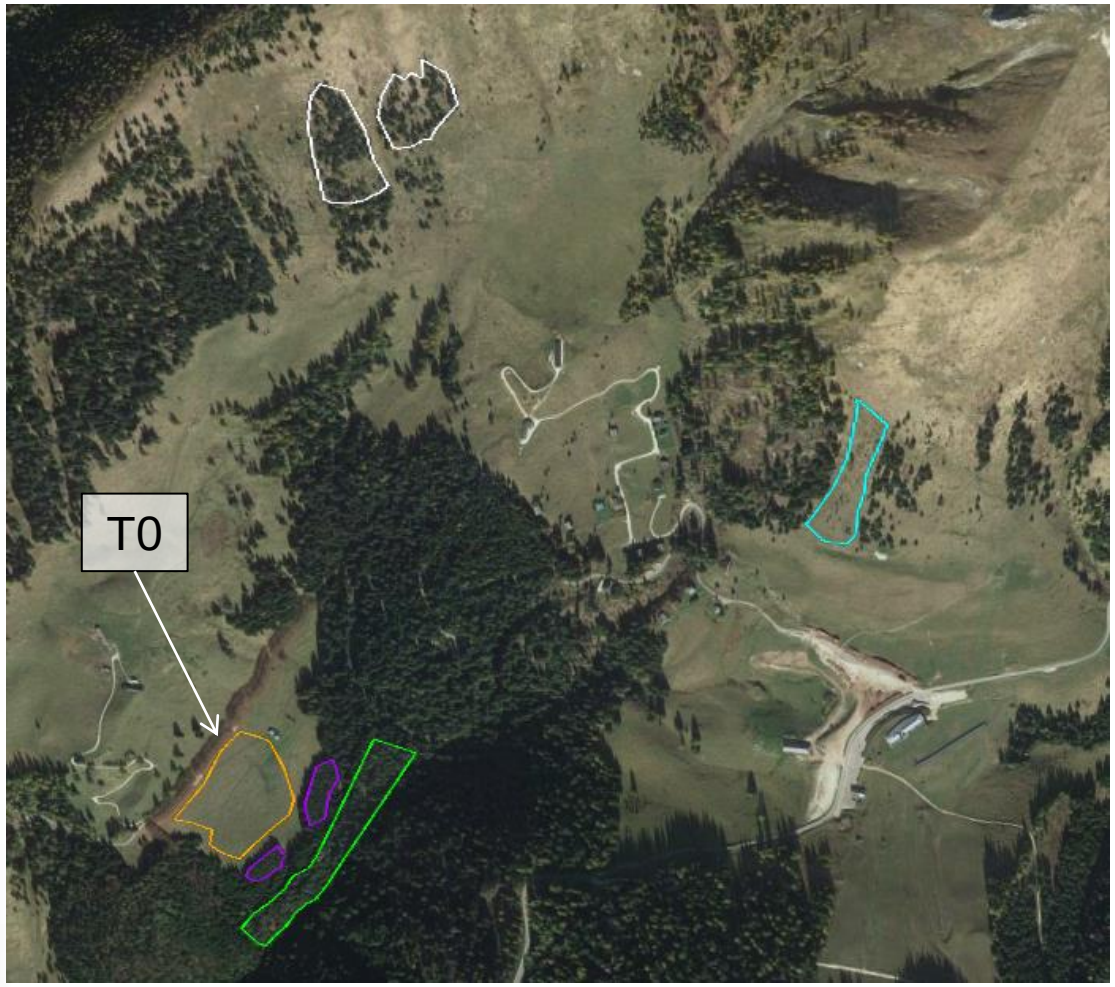
NO GRAZING

MODERATE EXTENSIVE GRAZING

## The project CAROLINA: what we do

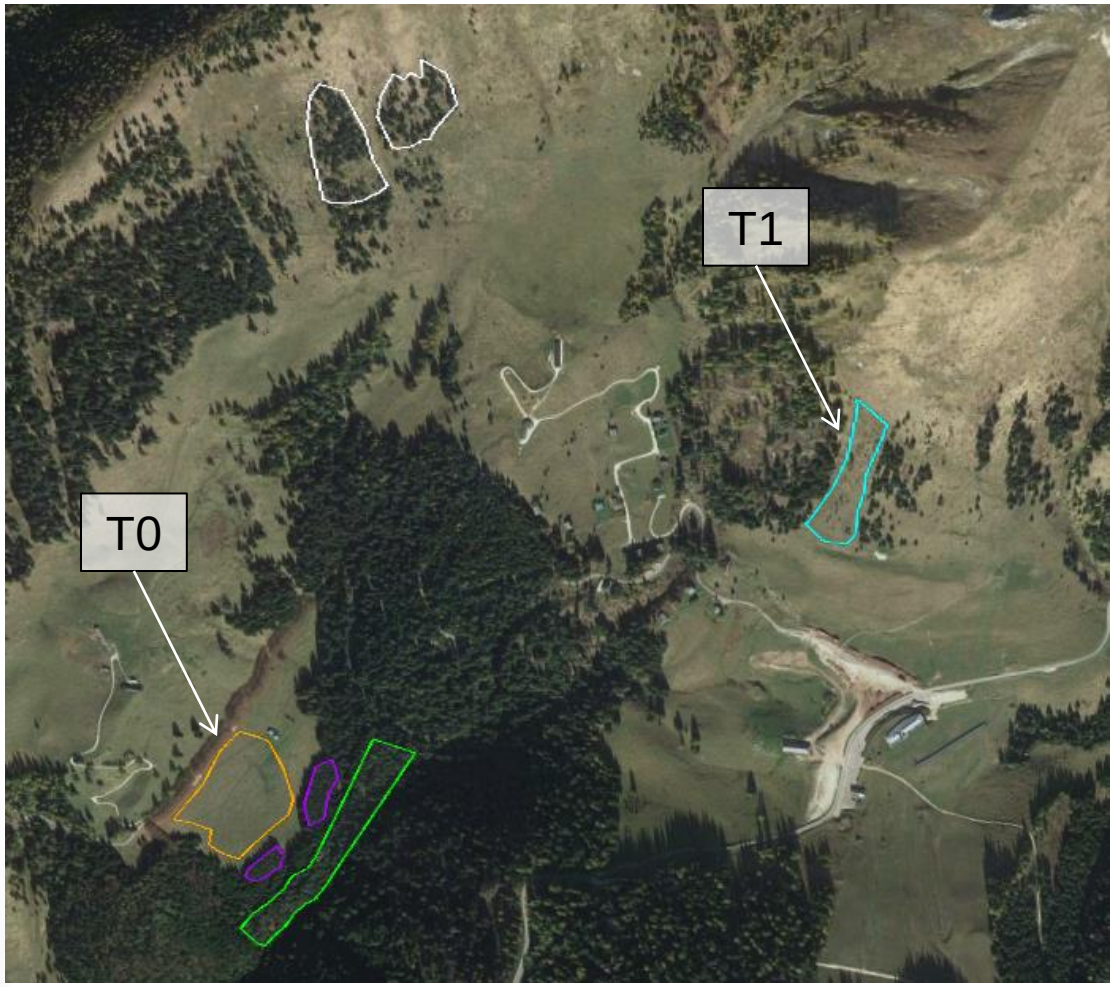
# 2) The transition from grasslands to woodlands.
# For each of the primary sites we have identified a chronosequence made up of five stages

# 2) The Brocon site:



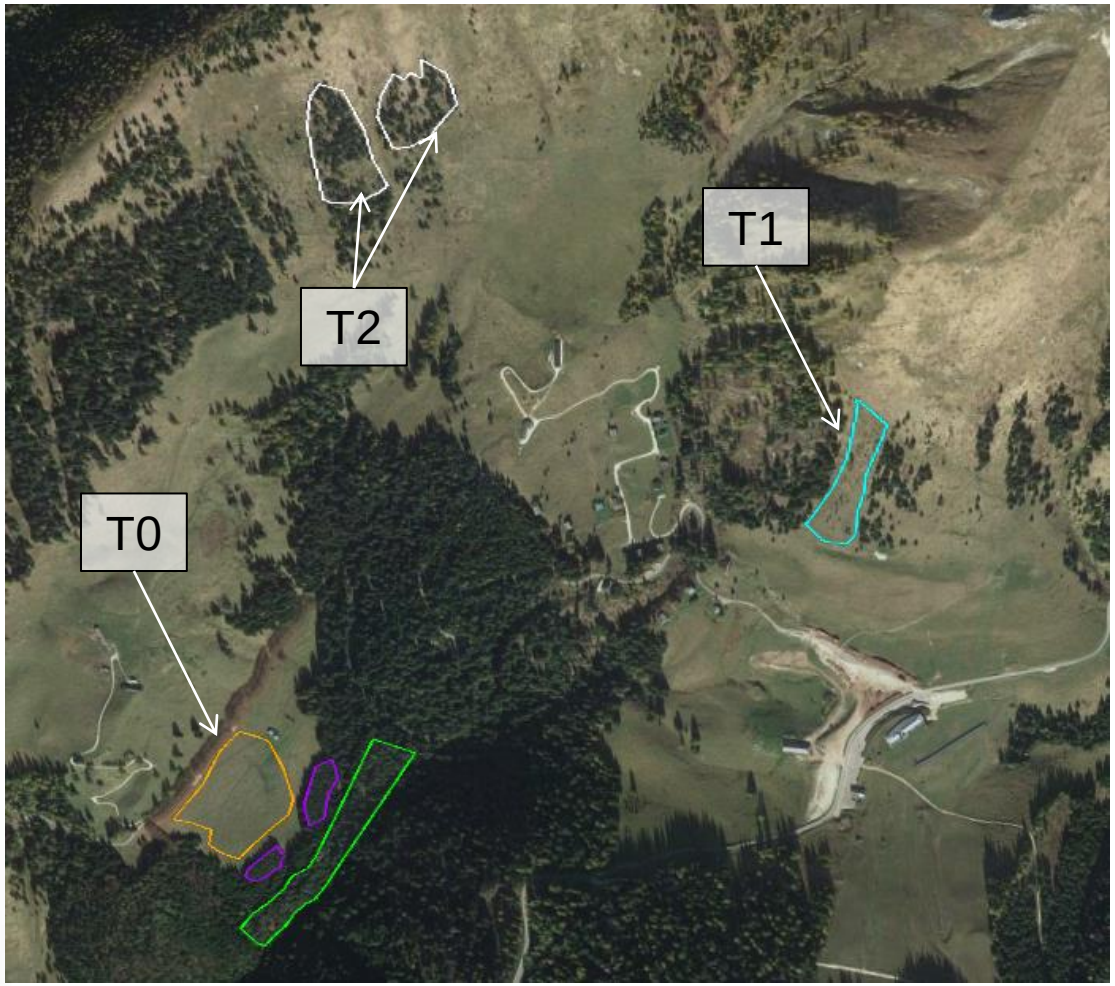

1) T0: grassland with extensive grazing

# 2) The Brocon site:



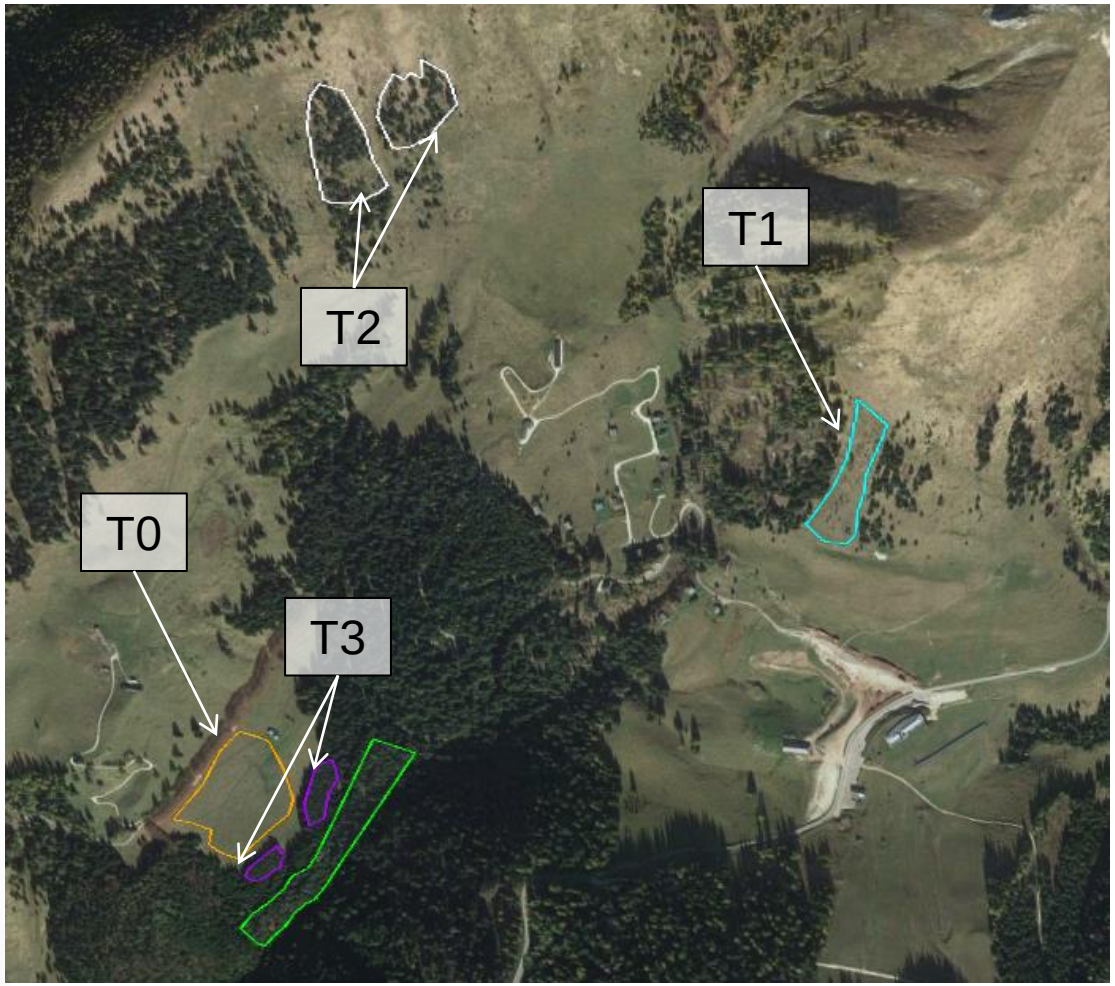

1) T0: grassland with extensive grazing
2) T1: grasslands with some young established trees (no grazing)

# 2) The Brocon site:




1) T0: grassland with extensive grazing
2) T1: grasslands with some young established trees (no grazing)
3) T2: space occupied by ca. 50% grasslands and 50% adult trees

# 2) The Brocon site:

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4) T3: young woodland

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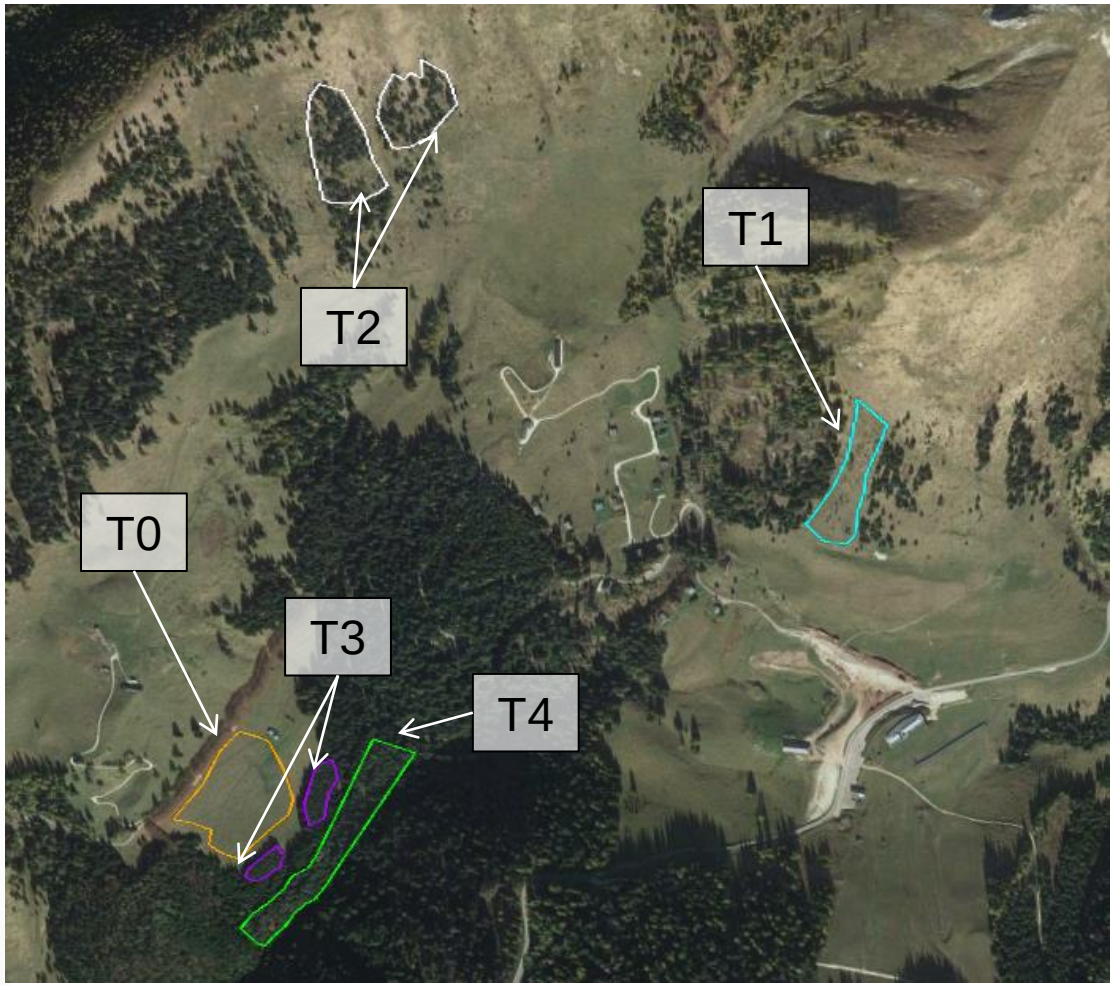


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2) T1: grasslands with some young established trees (no grazing)
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4) T3: young woodland
5) T4: mature woodland

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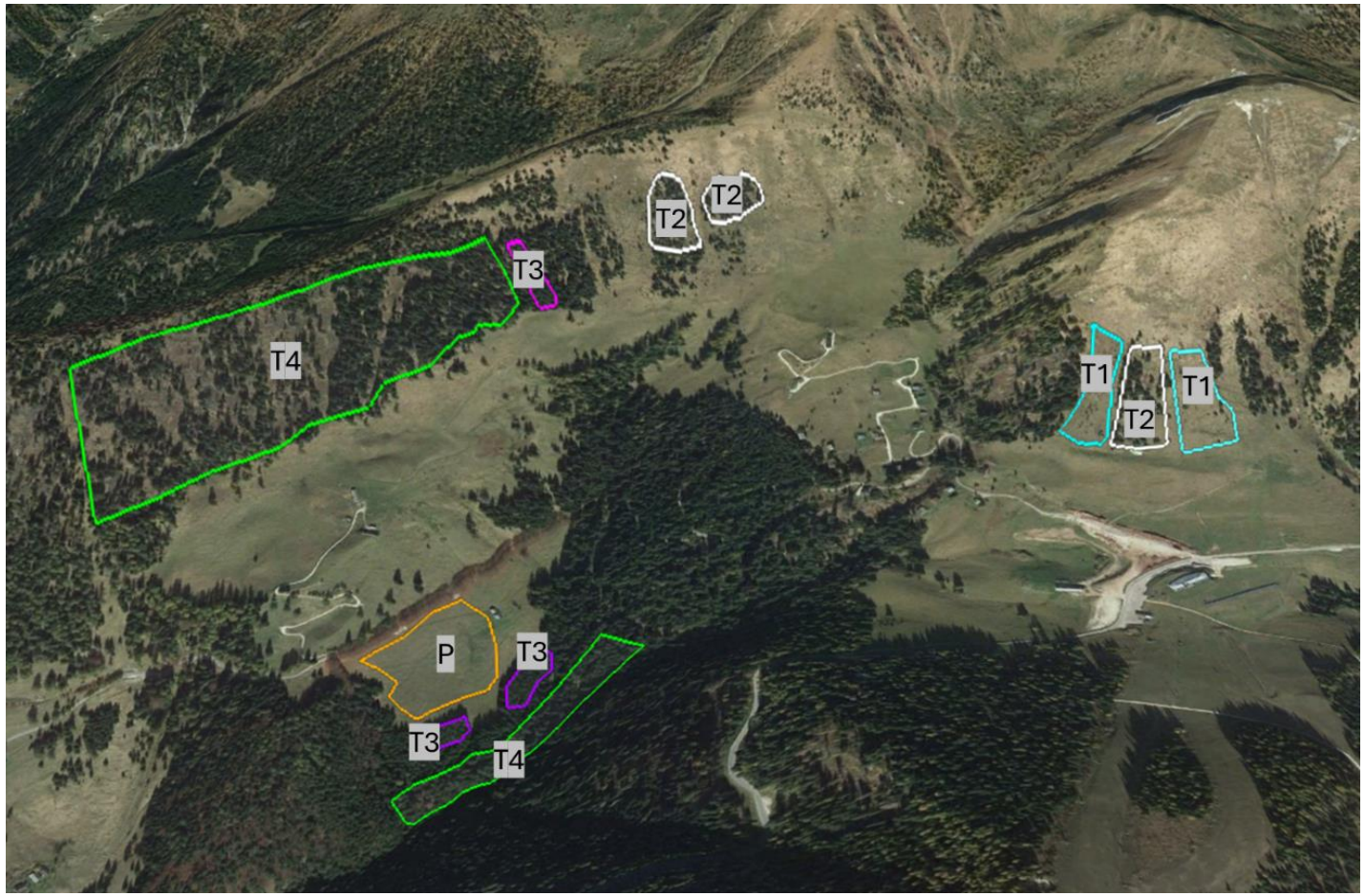

# SOME PRELIMINARY RESULTS

| | clay | loam | total sand | fine-grained sand | gross sand | ASI |
|---|---|---|---|---|---|---|
| T0 0-10 | 5,05 | 52,51 | 45,92 | 39,97 | 5,94 | 1451,04 |
| T0 10-20 | 6,25 | 57,93 | 39,95 | 30,82 | 9,14 | 1237,48 |
| T1 0-10 tree | 5,76 | 53,56 | 46,44 | 43,21 | 3,23 | 1128,87 |
| T1 10-20 tree | 7,04 | 59,44 | 40,56 | 38,32 | 2,24 | 645,68 |
| T1 0-10 meadow | 4,49 | 46,38 | 52,43 | 43,55 | 8,88 | 1342,98 |
| T1 10-20 meadow | 6,79 | 60,88 | 39,12 | 38,00 | 1,12 | 849,55 |
| T2 0-10 tree | 5,03 | 51,11 | 48,83 | 46,48 | 2,35 | 621,58 |
| T2 10-20 tree | 7,04 | 59,44 | 40,56 | 38,32 | 2,24 | 645,68 |
| T2 0-10 meadow | 5,05 | 51,99 | 48,00 | 45,77 | 2,24 | 867,63 |
| T2 10-20 meadow | 7,54 | 62,92 | 37,03 | 35,11 | 1,92 | 911,44 |
| T3 0-10 | 4,00 | 48,16 | 51,82 | 48,34 | 3,49 | 677,60 |
| T3 10-20 | 3,38 | 44,70 | 55,29 | 51,78 | 3,51 | 684,87 |
| T4 0-10 | 3,19 | 41,61 | 58,26 | 55,34 | 2,92 | 535,17 |
| T4 10-20 | 3,56 | 45,58 | 54,43 | 53,27 | 1,17 | 630,83 |

# The project CAROLINA: soil laser granulometry

| | clay | loam | total sand | fine-grained sand | gross sand | ASI |
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| T4 0-10 | 3,19 | 41,61 | 58,26 | 55,34 | 2,92 | 535,17 |
| T4 10-20 | 3,56 | 45,58 | 54,43 | 53,27 | 1,17 | 630,83 |

**Decrease of the soil aggregate stability index (ASI)**

| | clay | loam | total sand | fine-grained sand | gross sand | ASI |
|---|---|---|---|---|---|---|
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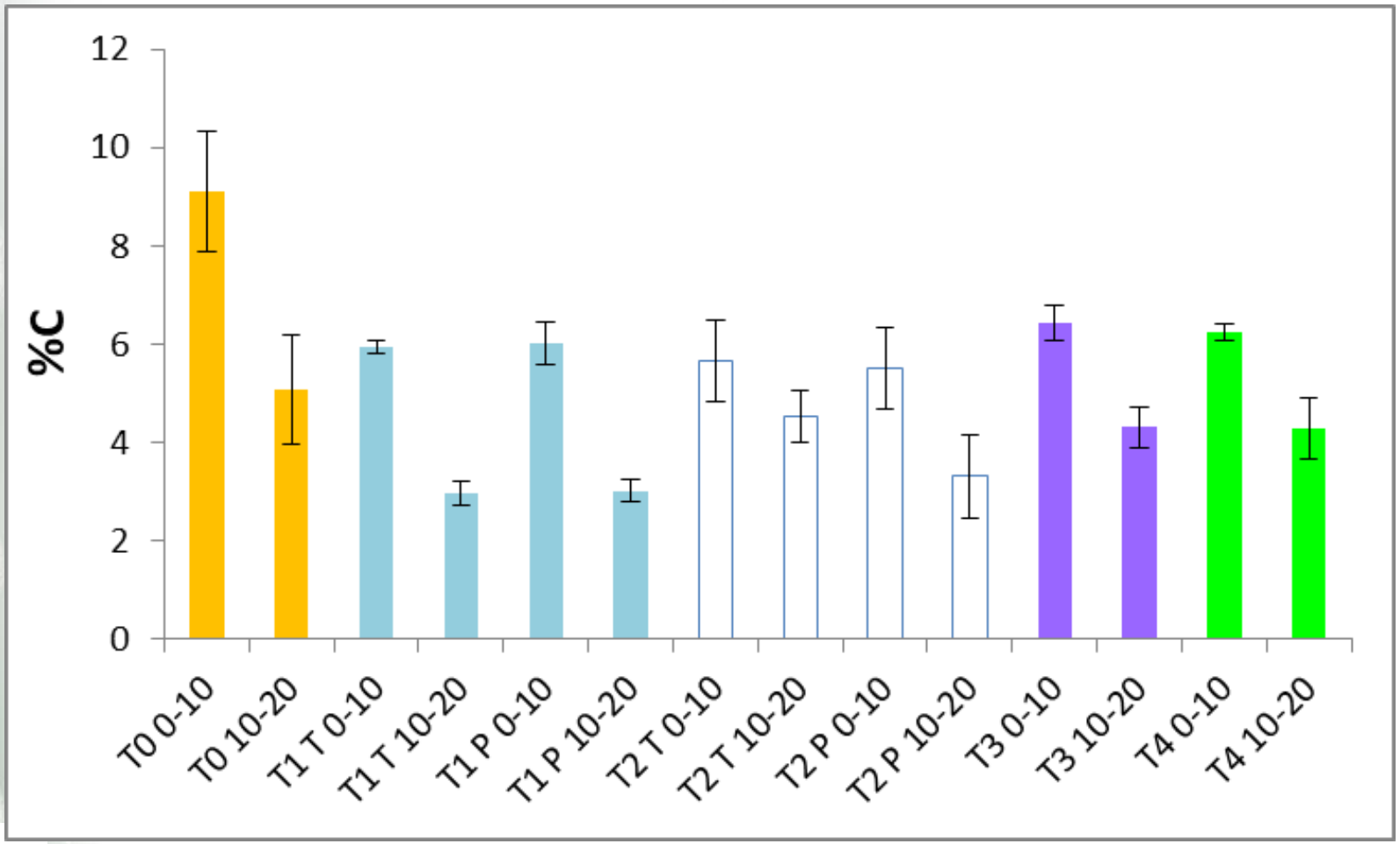
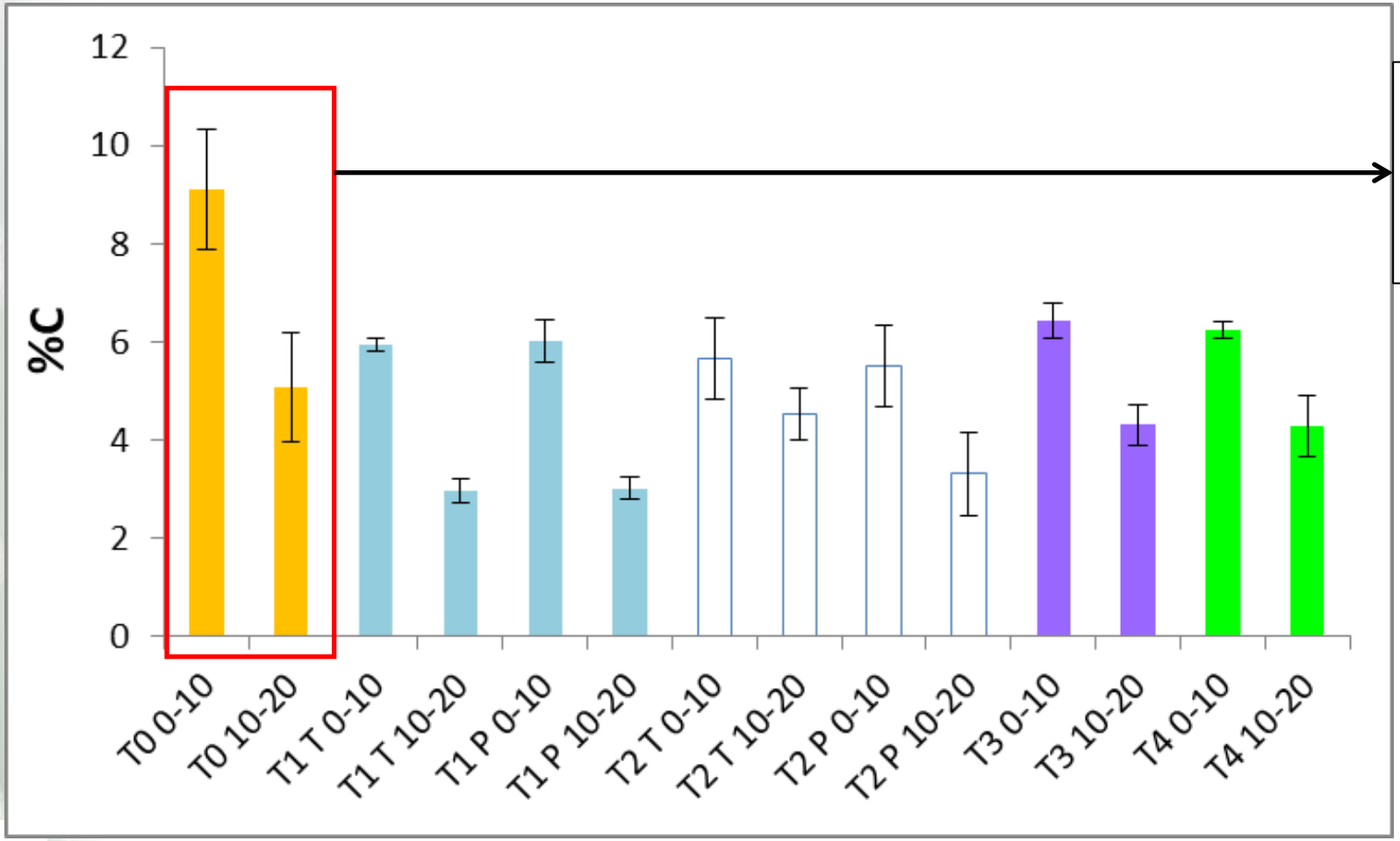
| T3 0-10 | 4,00 | → 48,16 | 51,82 ← | 48,34 | 3,49 | 677,60 |
| T3 10-20 | 3,38 | → 44,70 | 55,29 ← | 51,78 | 3,51 | 684,87 |
| T4 0-10 | 3,19 | → 41,61 | 58,26 ← | 55,34 | 2,92 | 535,17 |
| T4 10-20 | 3,56 | → 45,58 | 54,43 ← | 53,27 | 1,17 | 630,83 |

**Decrease of loam + increase of sand**

**Soil aggregate stability is considered as a key indicator of soil quality. Grasslands such as meadows and pastures managed with moderate extensive grazing seem to maintain a better quality in comparison with wooded areas.**

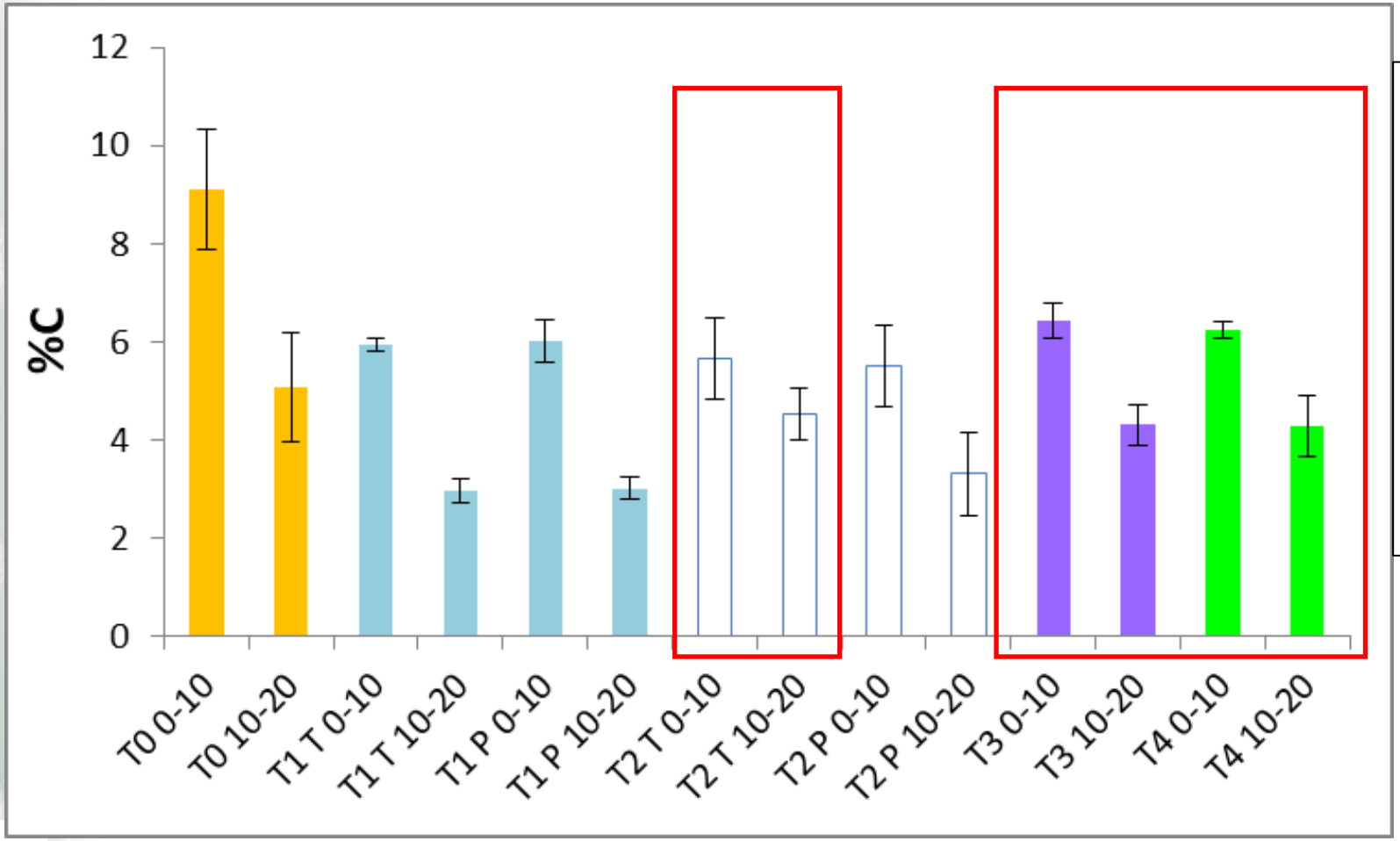



# The project CAROLINA: soil total carbon and $\delta^{13}C$



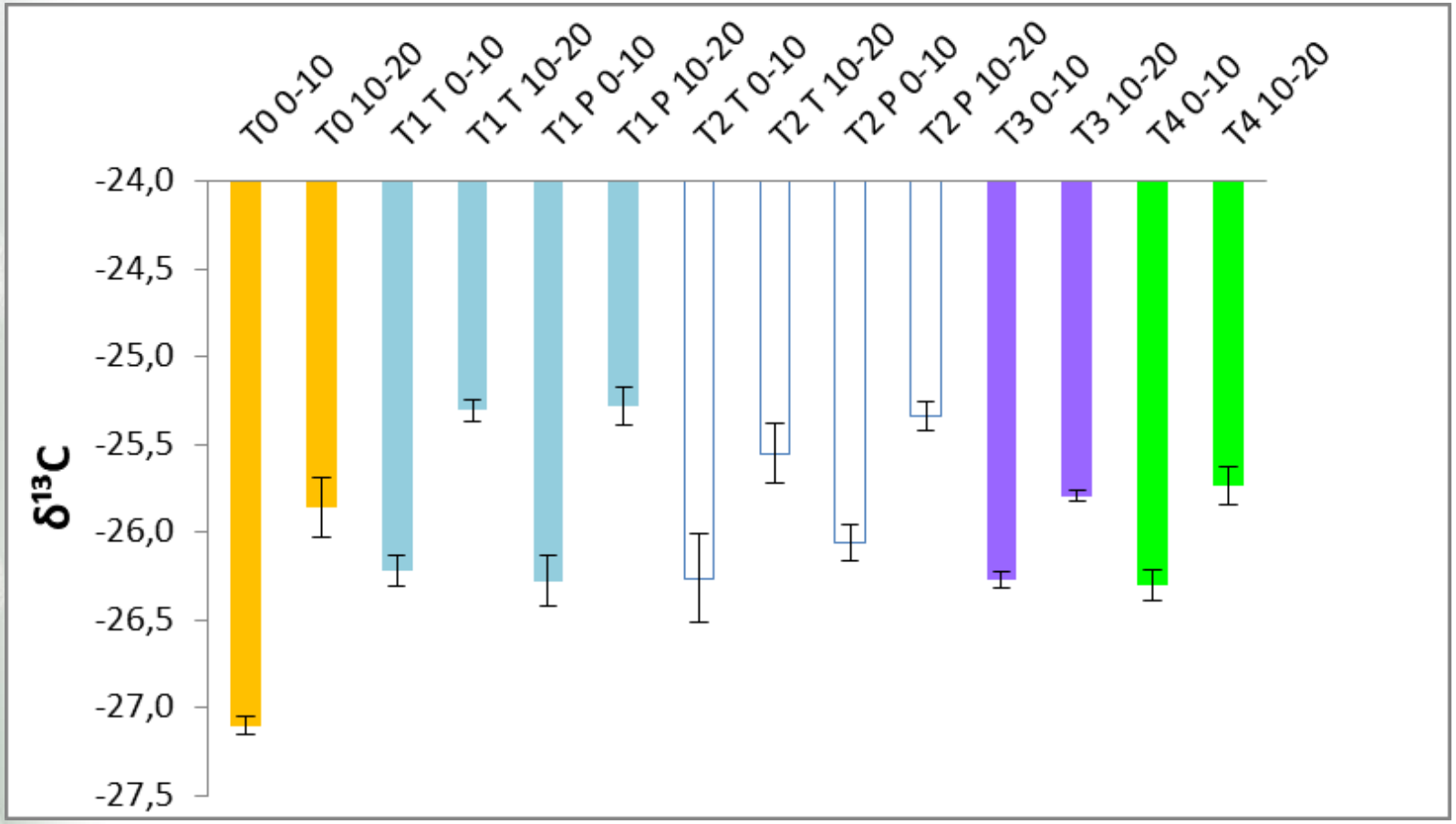

Moderate grazing increased C content in both layers

# The project CAROLINA: soil total carbon and $\delta^{13}C$

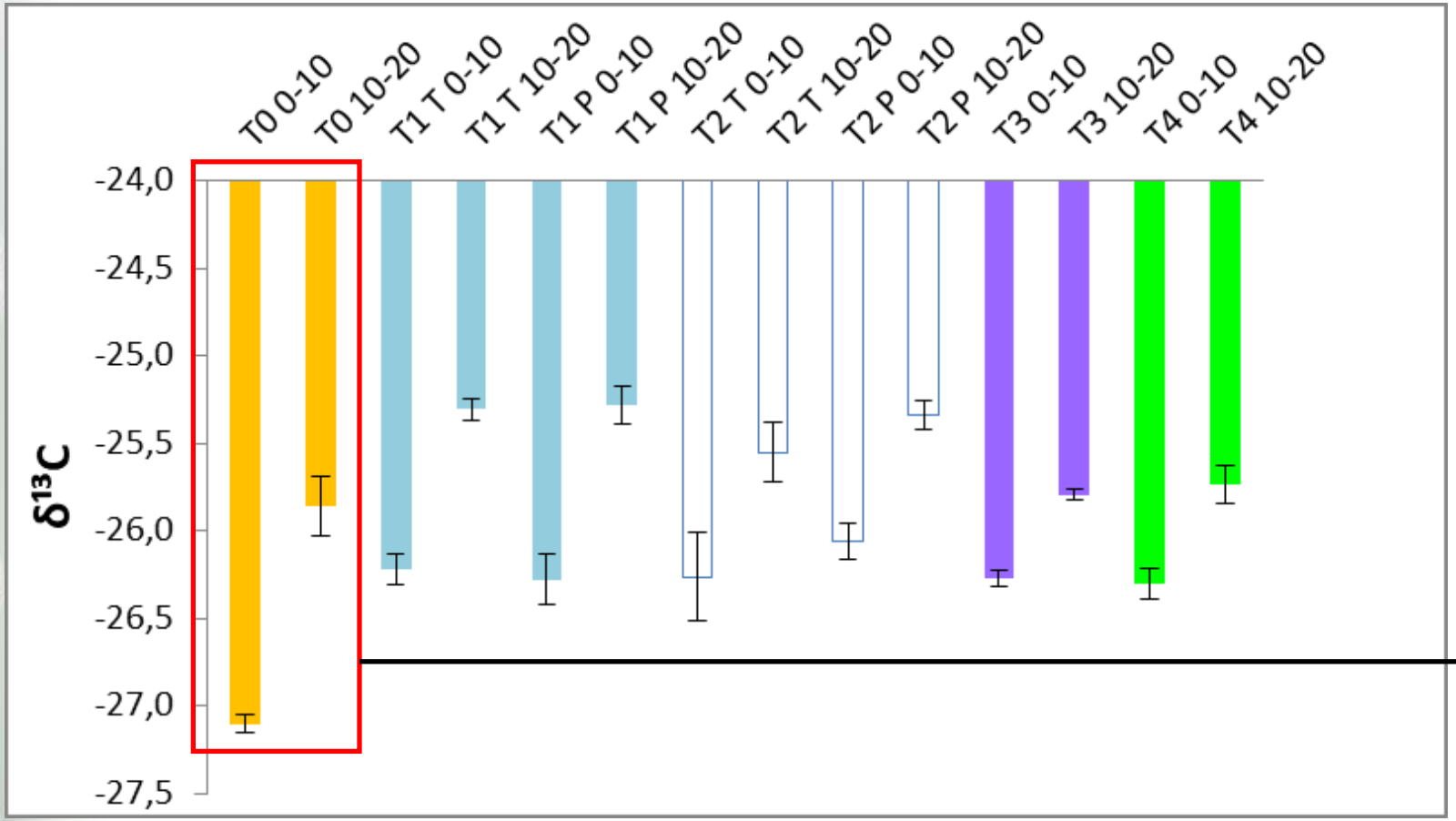



Higher C content in the lower layer of the wooded chronosequences (T3 and T4) may be related to massive litter deposition

# The project CAROLINA: soil total carbon and $\delta^{13}C$

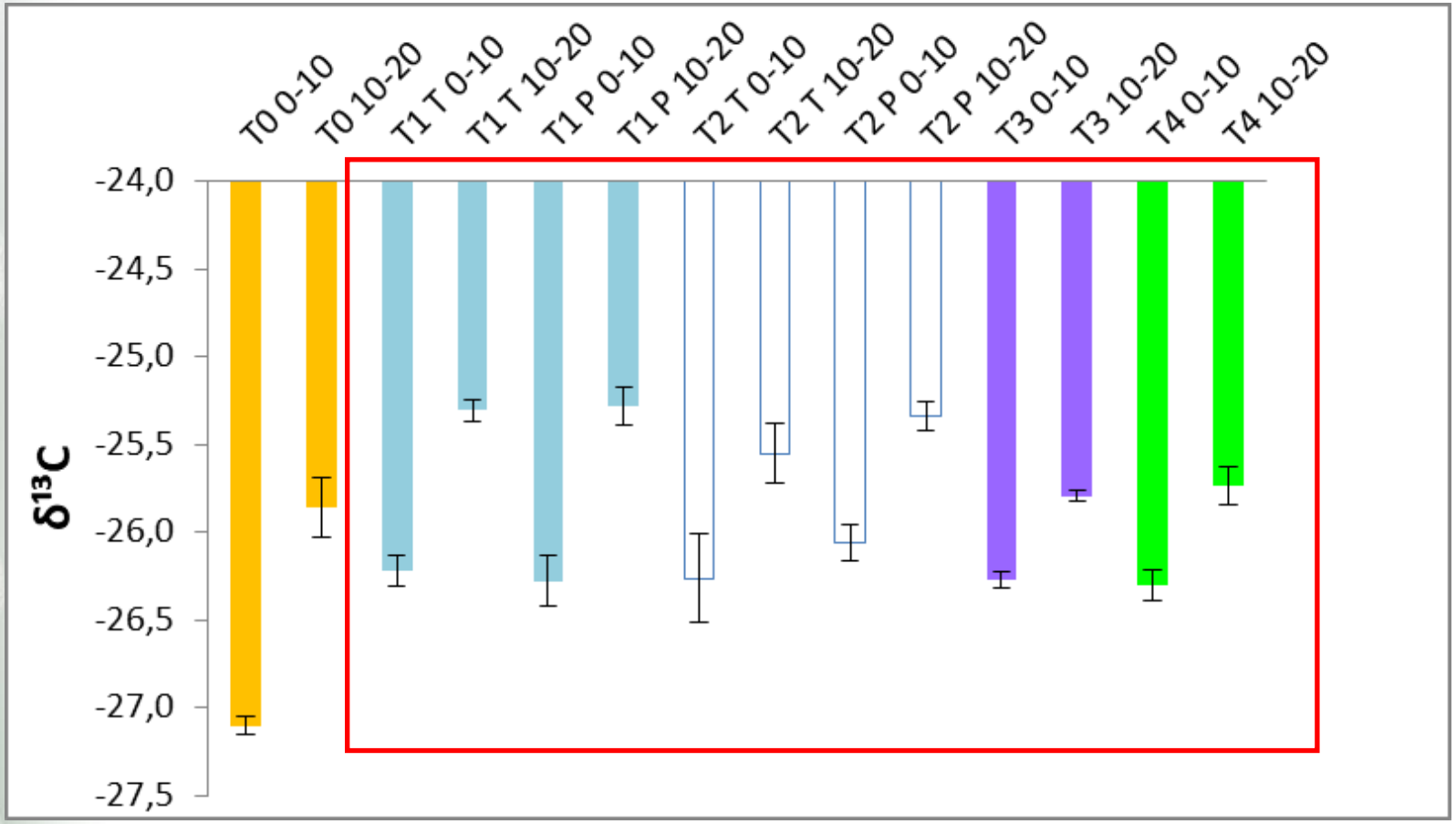



# The project CAROLINA: soil total carbon and δ¹³C




Higher $^{13}C$ enrichment between the two layers of the grazed grassland

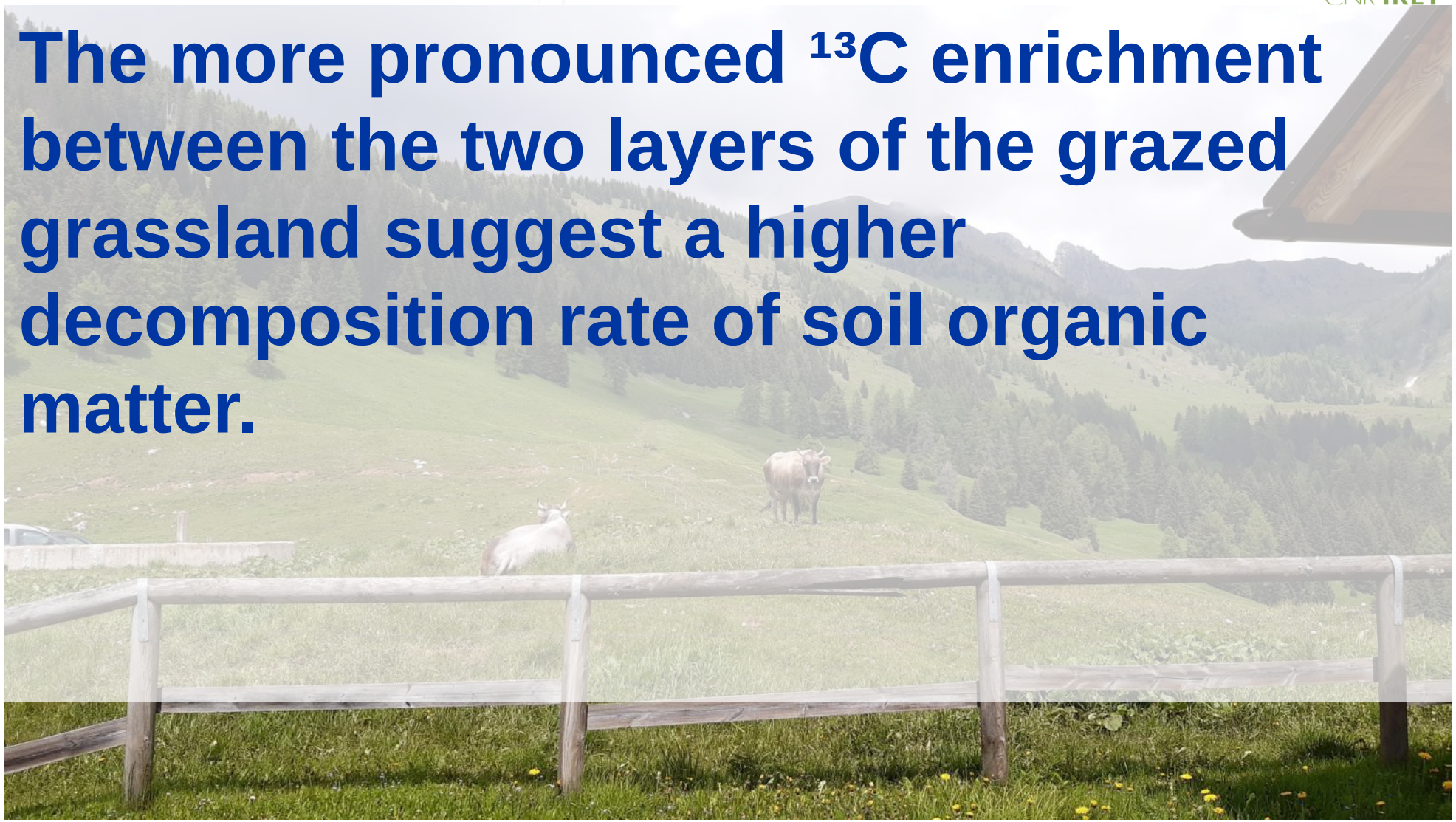
# The project CAROLINA: soil total carbon and $\delta^{13}C$

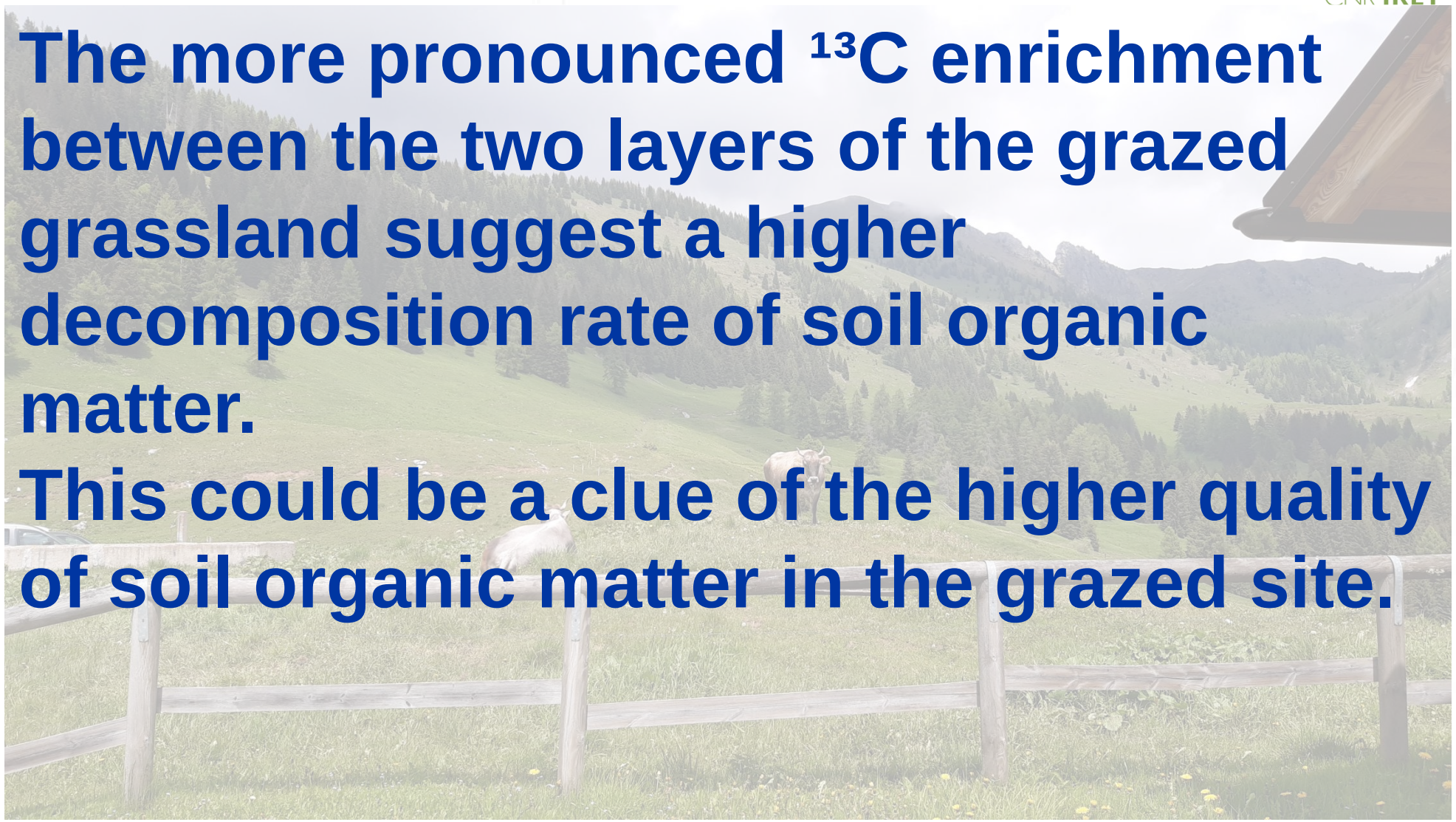



The absence of grazing and the predominance of conservative plant species could explain the similar results for $\delta^{13}C$ in the other chronosequences

# The project CAROLINA: soil total carbon and $\delta^{13}C$

# The more pronounced $^{13}C$ enrichment between the two layers of the grazed grassland suggest a higher decomposition rate of soil organic matter.



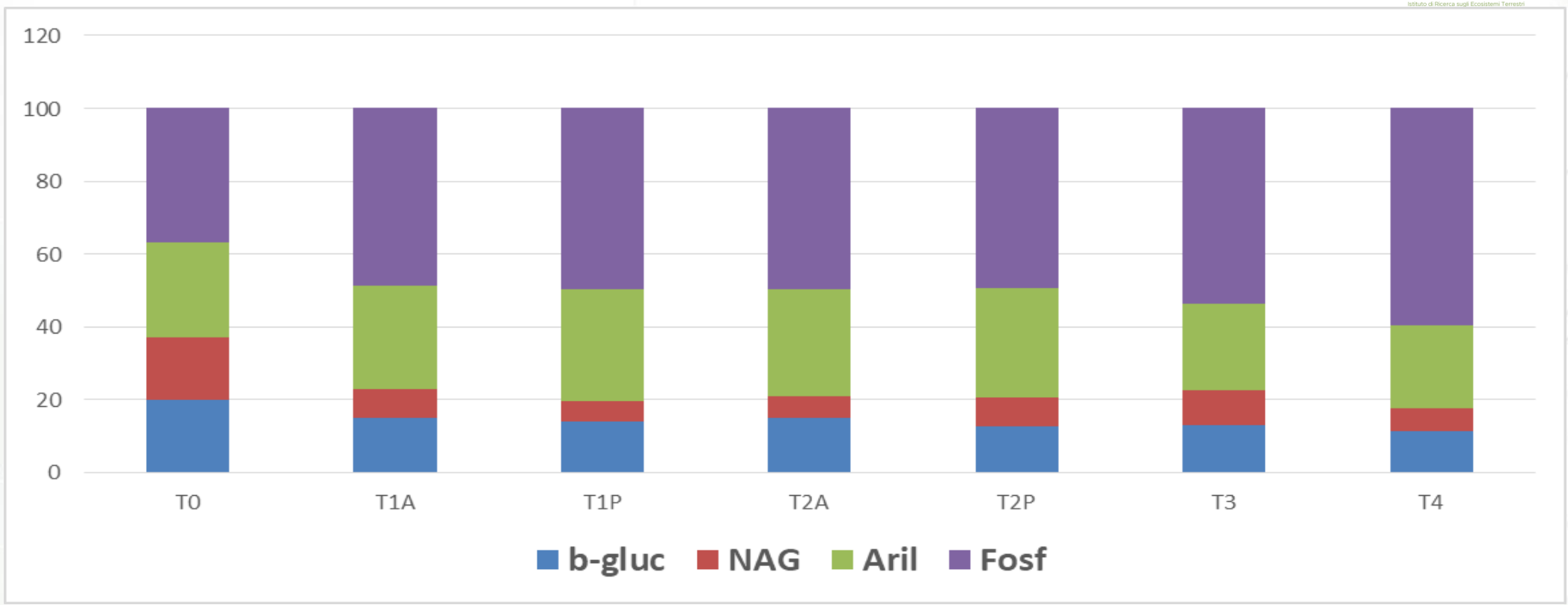


**The more pronounced $^{13}C$ enrichment between the two layers of the grazed grassland suggest a higher decomposition rate of soil organic matter.**

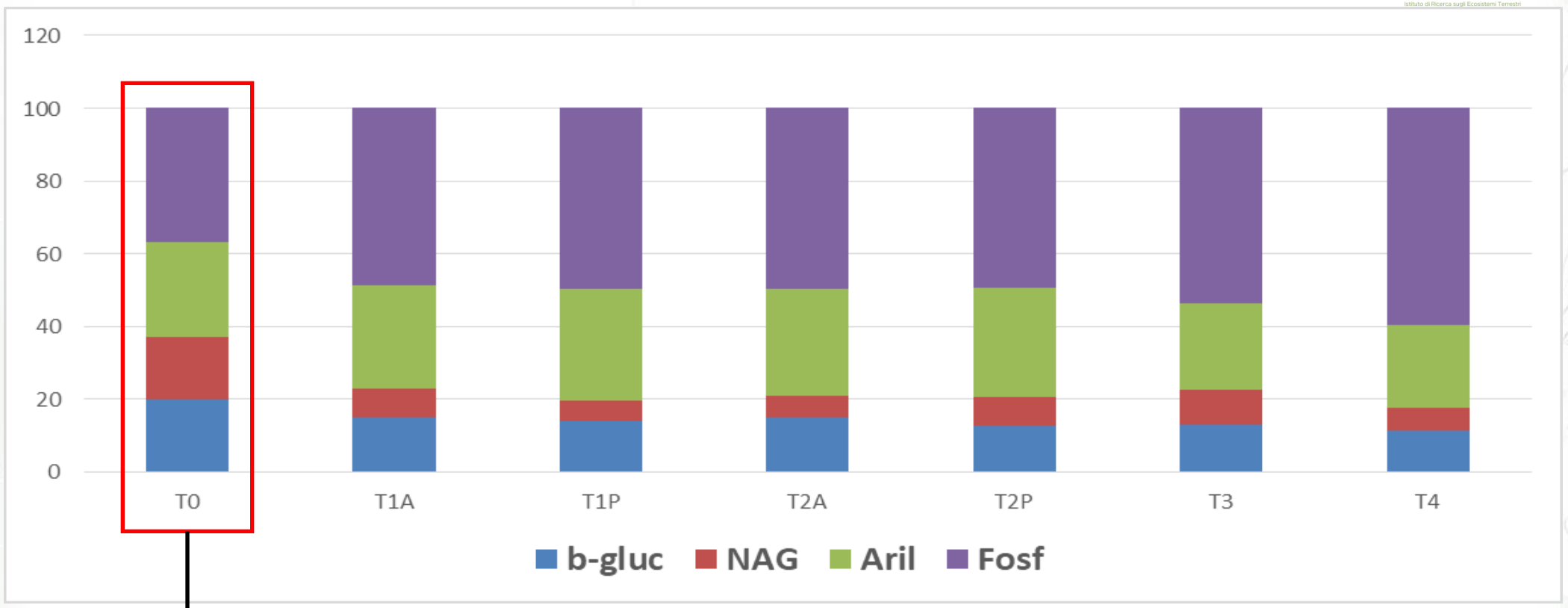
**This could be a clue of the higher quality of soil organic matter in the grazed site.**

- β-glucosidase (b-gluc): hydrolysis of cellobiose producing glucose
- acid phosphatase (fosf): hydrolysis of esters and anhydrides of phosphoric acid
- N-acetyl-β-D-glucosaminidase (NAG): N-acquiring enzyme from chitin and peptidoglycan
- Arylsulfatase: sulphur acquisition from arylsulfate

They are considered a proxy for soil microbial activity related to soil quality

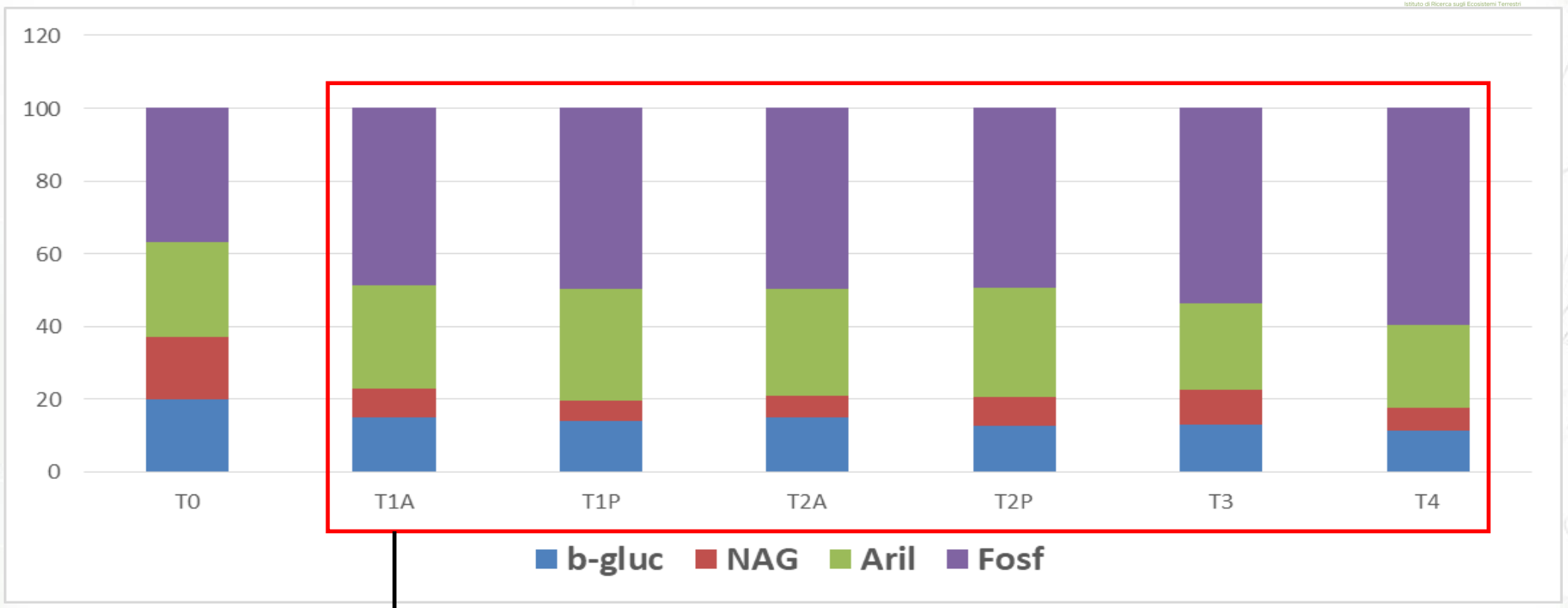



# The project CAROLINA: ecoenzymes



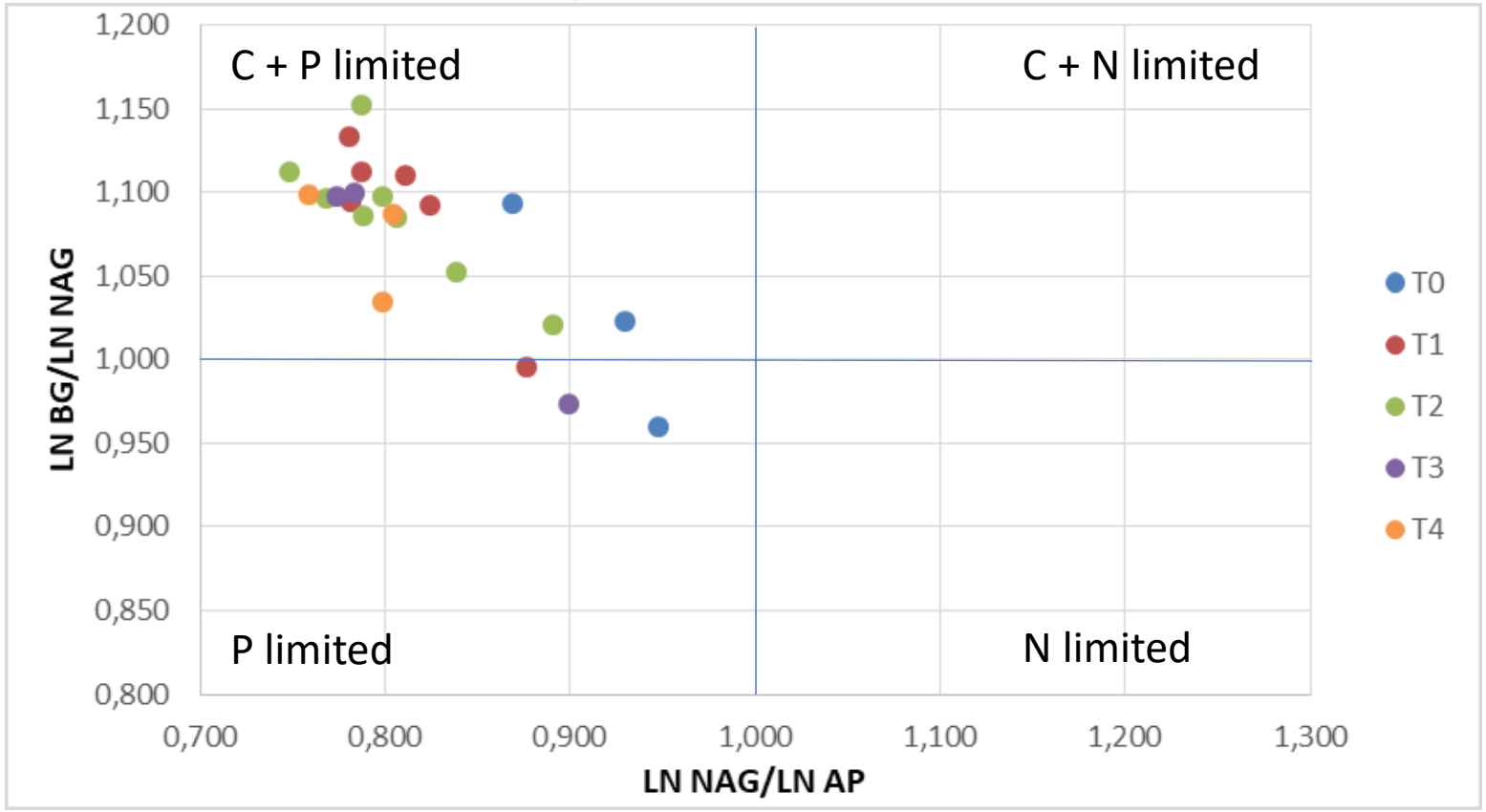

More similar b-gluc, NAG and fosf in grazed grassland could be related to the high C content and to a likely ever higher N content

# The project CAROLINA: ecoenzymes

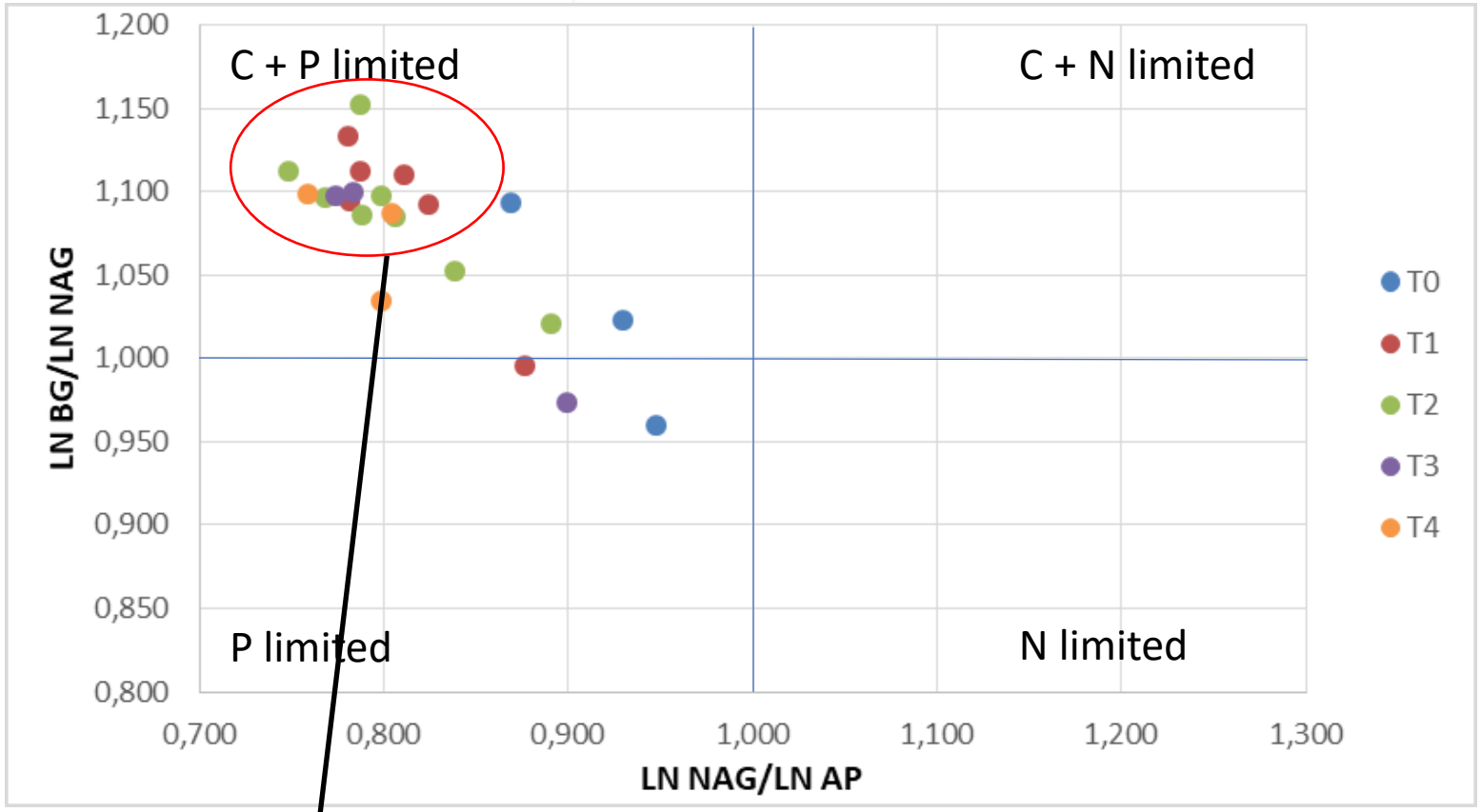



A higher imbalance between b-gluc, NAG and fosf in non-grazed sites suggests nutrient and energy limitation

# The project CAROLINA: ecoenzymes




# The project CAROLINA: ecoenzymes



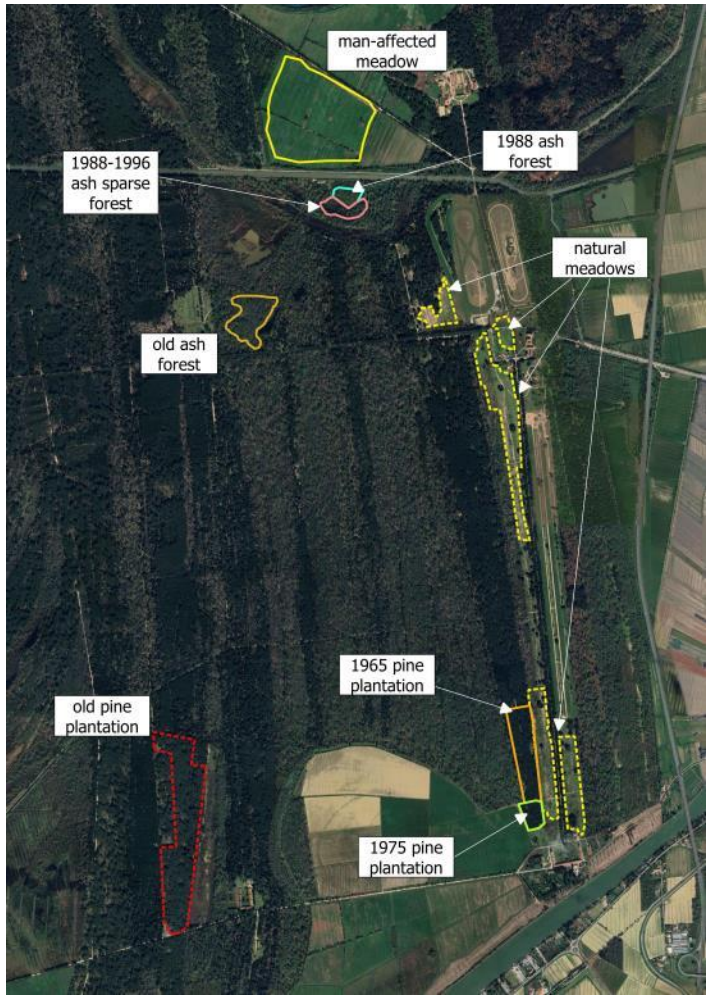

These sites are characterized by a more pronounced C and P limitation

# The project CAROLINA: ecoenzymes

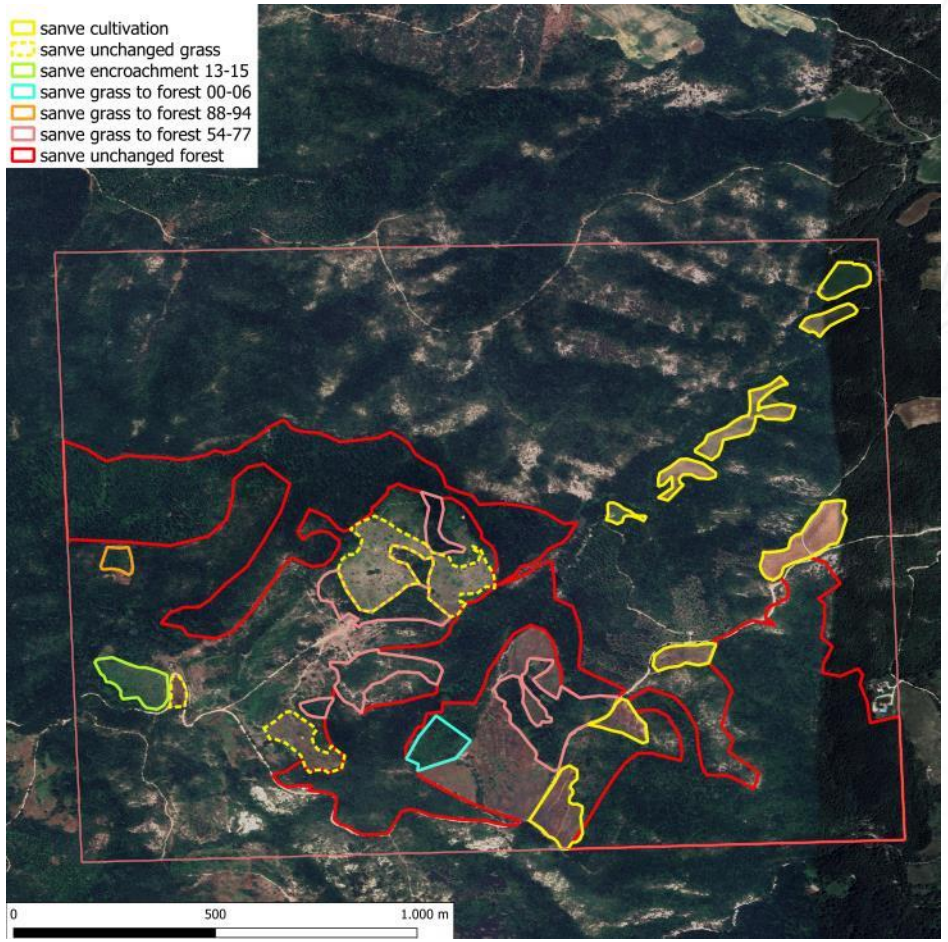
# The ecoenzymatic activies suggest that the grazed grasslands (T0) could be characterized by a higher nutrient availability for microbes.

# ONGOING ACTIVITIES

# The chronosequences in the two other primary sites:




San Rossore




San Venanzo

# Thank you!