Ammonium in the soil: contribution to biodiversity and function in Mediterranean-type ecosystems?

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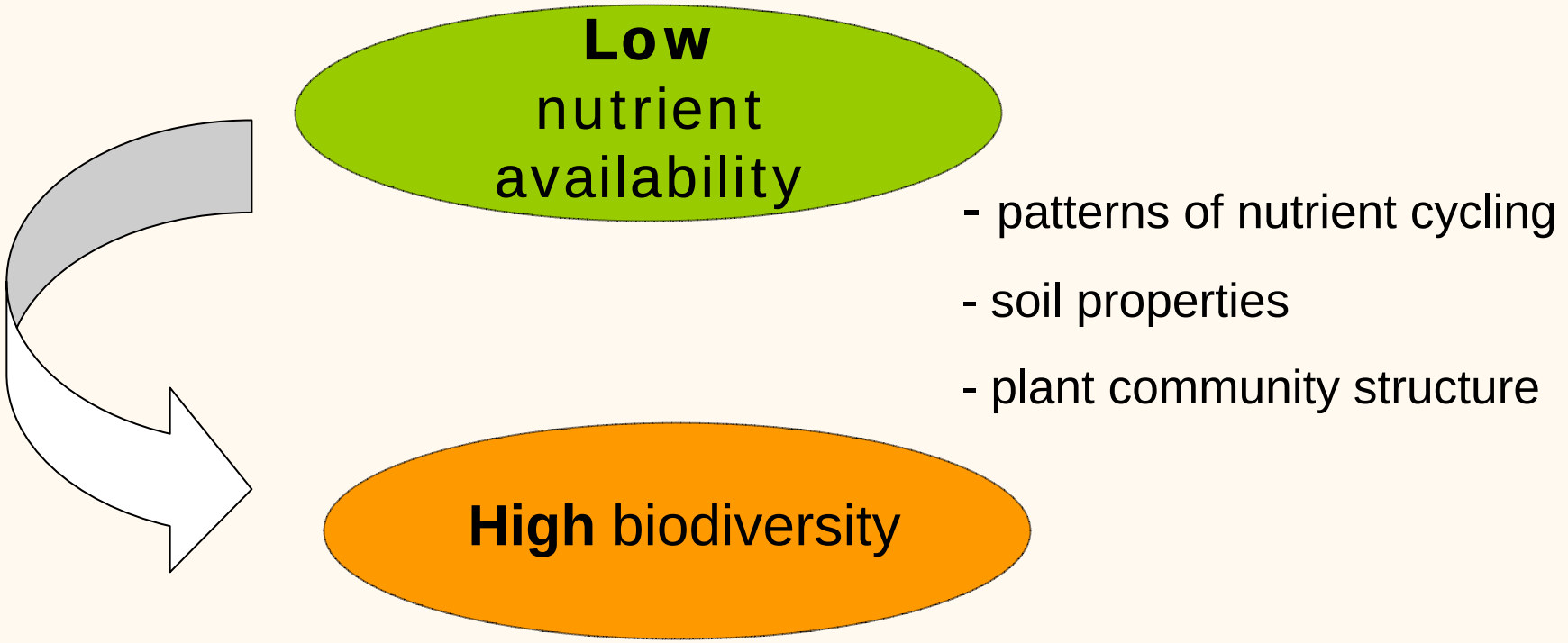
Reduced Nitrogen in Ecology and the Environment, Obergurgl, Austria, October 17th 2006

Mediterranean-type ecosystems - the **paradigm**



Mediterranean type ecosystems

Summer semi-deciduous

Evergreen sclerophyllous

Working Hypothesis

Summer semi-deciduous

versus

Evergreen sclerophyllous

Plants belonging to distinct Plant Functional Types (**PFT**) will impose/reflect distinct characteristics on the surface of the occupied **soil**

Objectives

1. Quantify the spatial and temporal soil heterogeneity of 8 parameters essential for plant growth (gross ammonification and nitrification, ammonium, nitrate, organic matter, pH, temperature and soil moisture)

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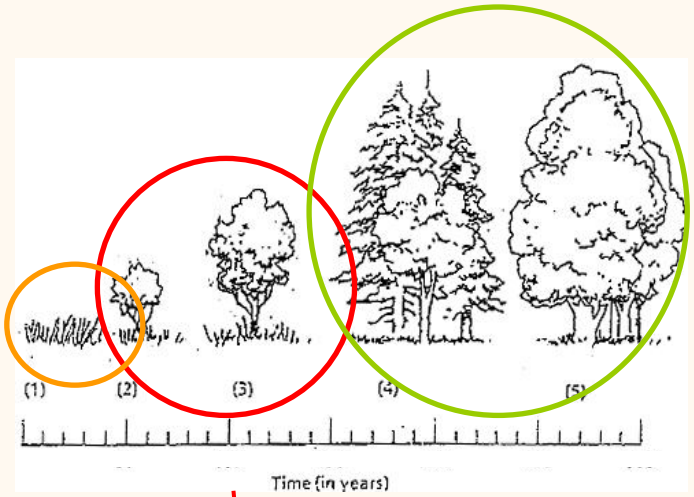
2. Assess the relation between soil surface characteristics and plant species or PFT.

Mediterranean type ecosystems



Summer semi-deciduous

Evergreen sclerophyllous

Summer semi-deciduous
co-existing with
Evergreen sclerophyllous

Study site

- Portugal

- Serra da Arrábida

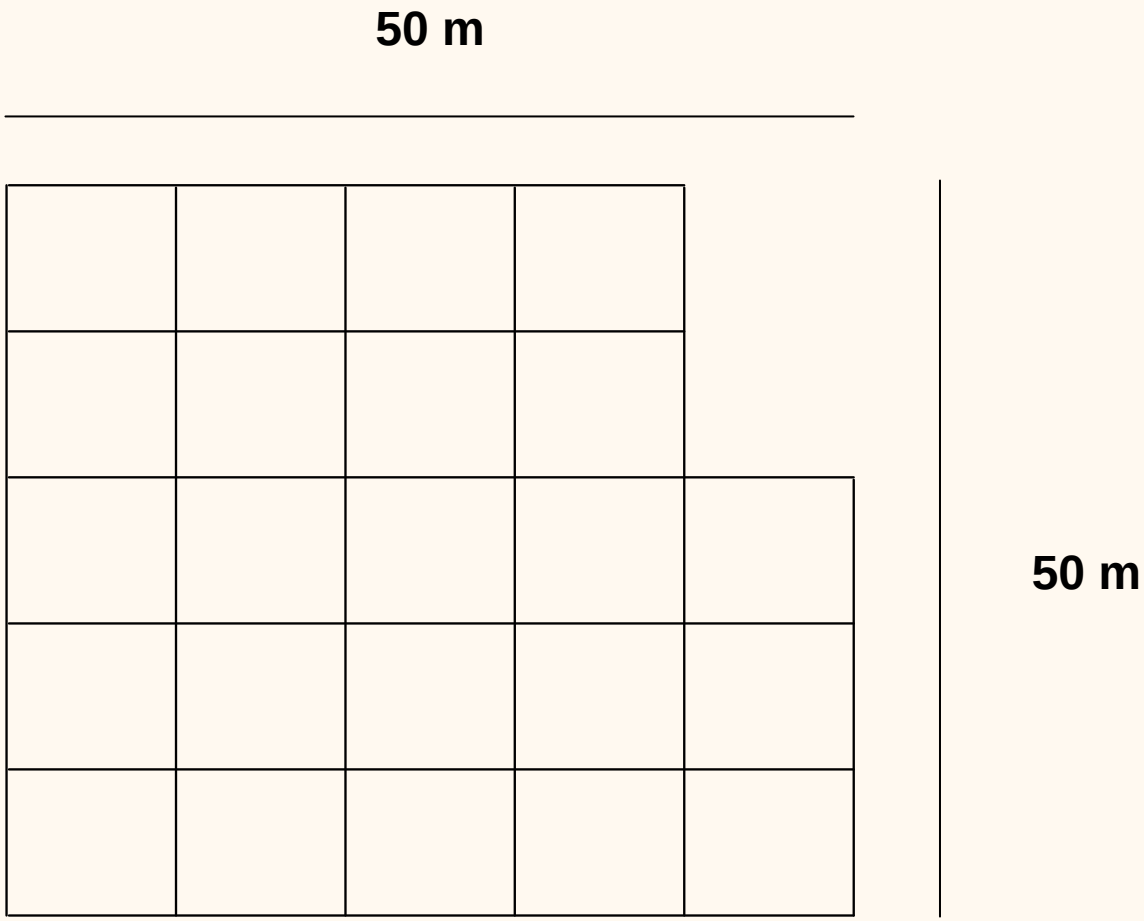
- climate: sub-humid, warm variant (Emberger's bioclimatic coefficient);

-altitude 270 m;

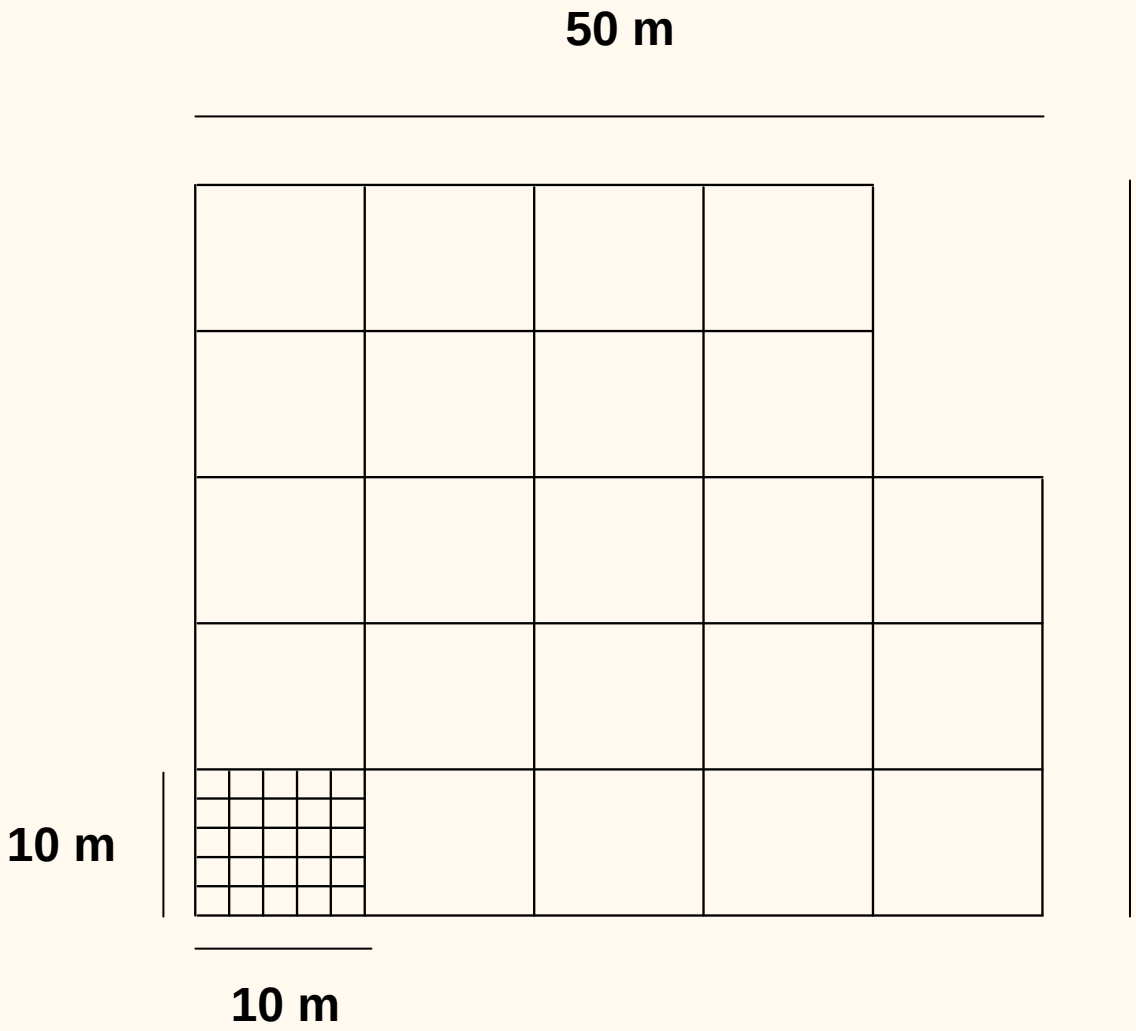
-soil very thin (max depth 15 cm) and of calcareous origin;

- mixed sclerophyllous scrub;

Experimental design



Experimental design

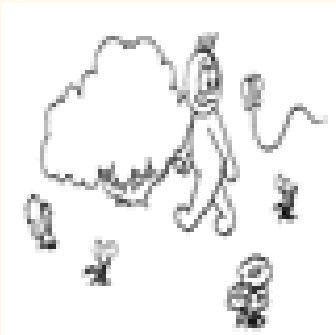


575
sampling
points

Experimental design

Autumn

Summer



Spring

Winter

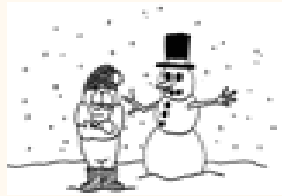
- Seasonality of the Mediterranean climate

Experimental design

Summer

Autumn

Spring



Winter

Seasonality of the Mediterranean climate

→ Different physiological constraints to plants

→ **4** sampling times (November, February, April and July)

Analyzed parameters

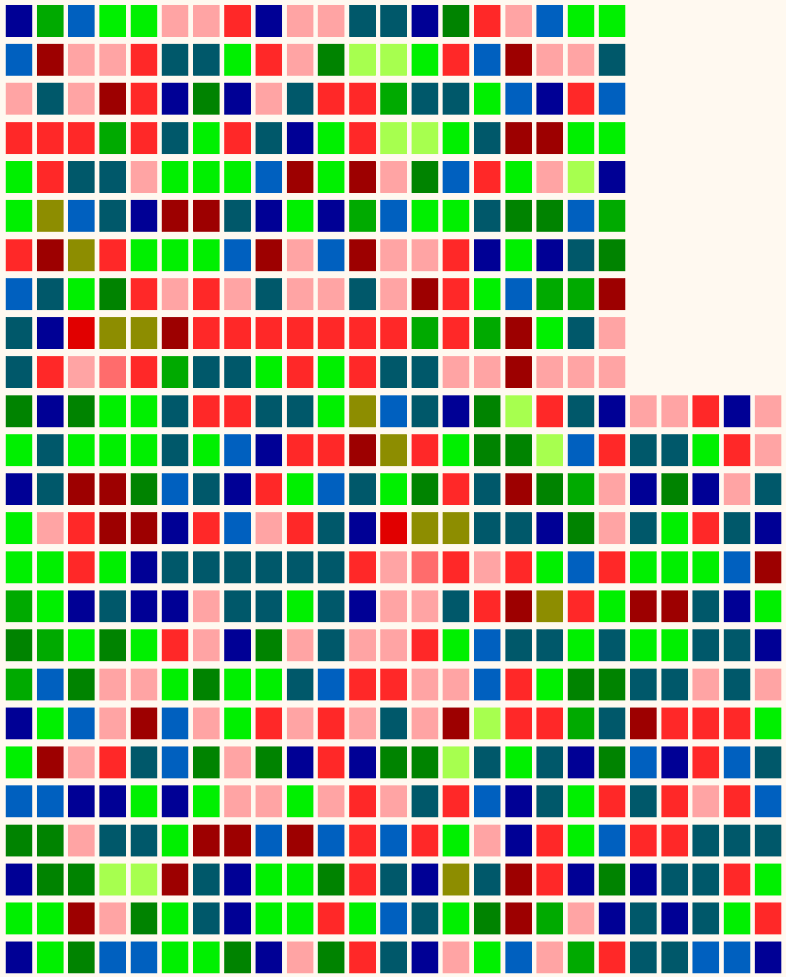
In the **field**:

- Plant species
- Soil Temperature (11 to 13 pm)
- Soil water content (Teta Probe)
- Soil Organic Matter (loss by ignition)
- Soil pH (KCl 2M extract)
- Soil [NO_3^-] (electrophilic substitution of salycilate acid)
- Soil [NH_4^+] (Berthelot reaction - Cruz *et al*. 2000)

In the **laboratory**:

- Gross Ammonification rate
- Gross Nitrification rate

Results and Discussion



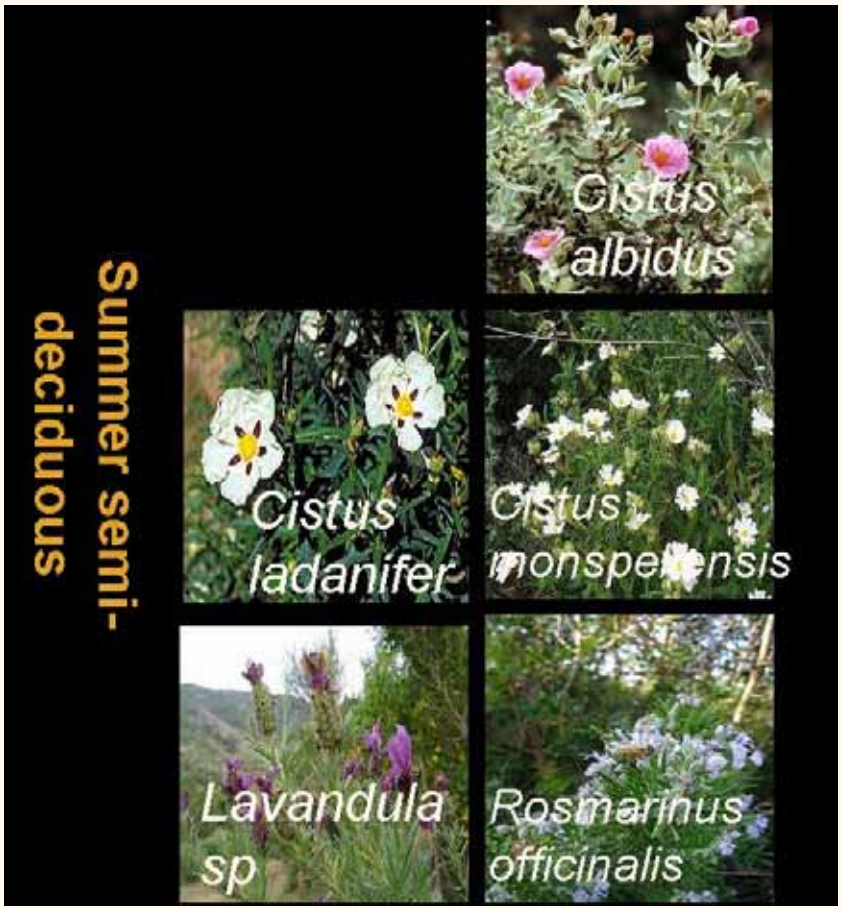
Cistus albidus
Cistus ladanifer
Cistus monspeliensis
Lavandula sp.
Rosmarinus officinalis
Erica sp.
Ceratonia siliqua
Juniperus phoenicea
Myrtus communis
Olea europaea
Phillyrea angustifolia
Pistacea lentiscus
Rhamnus alaternus

Summer semi-deciduous
205 plants

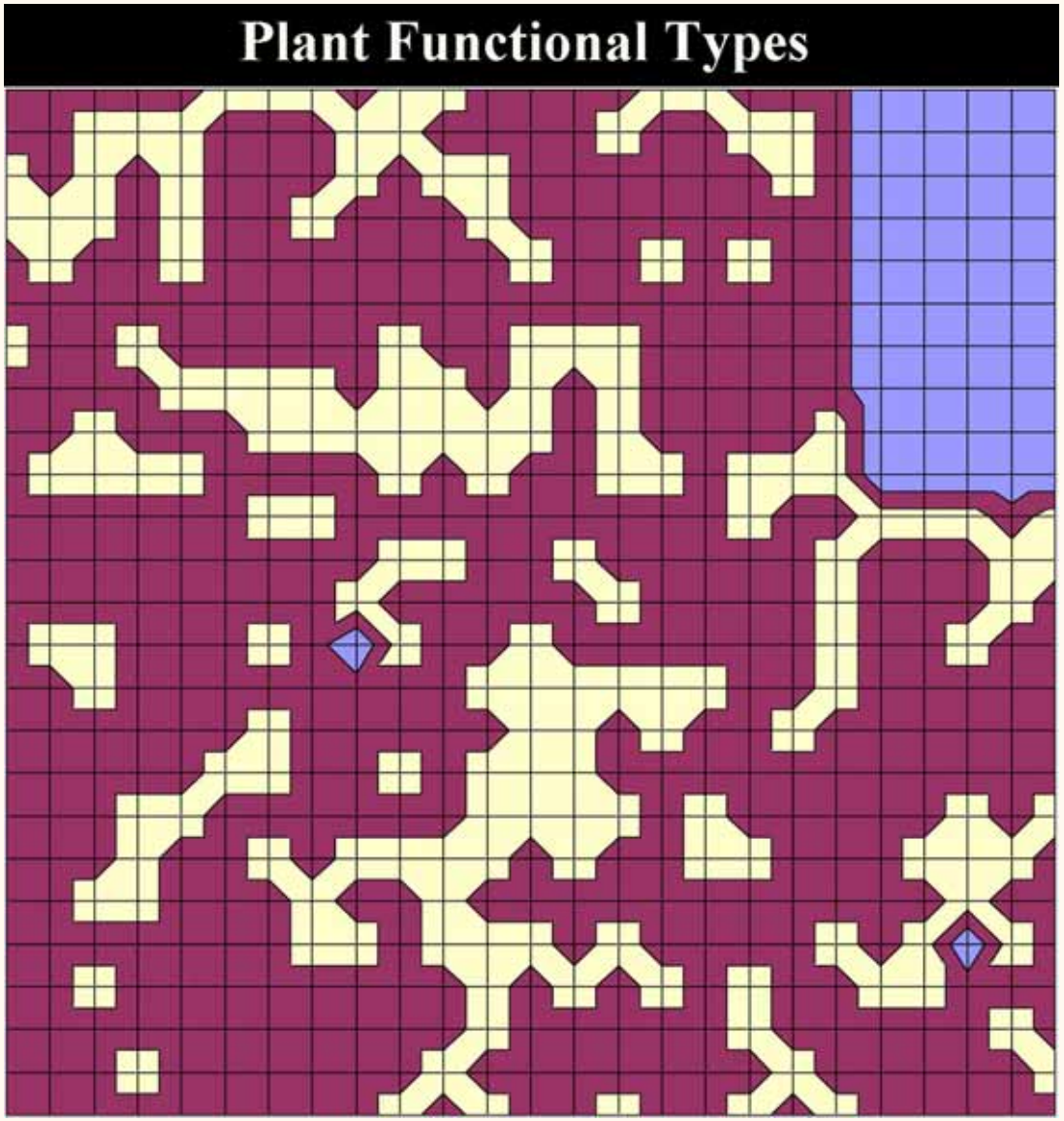
Evergreen sclerophyllous
370 plants

Distribution of the vegetation in space was mostly clustered (Fhat tests – data not shonw)

Results and Discussion



Results and Discussion

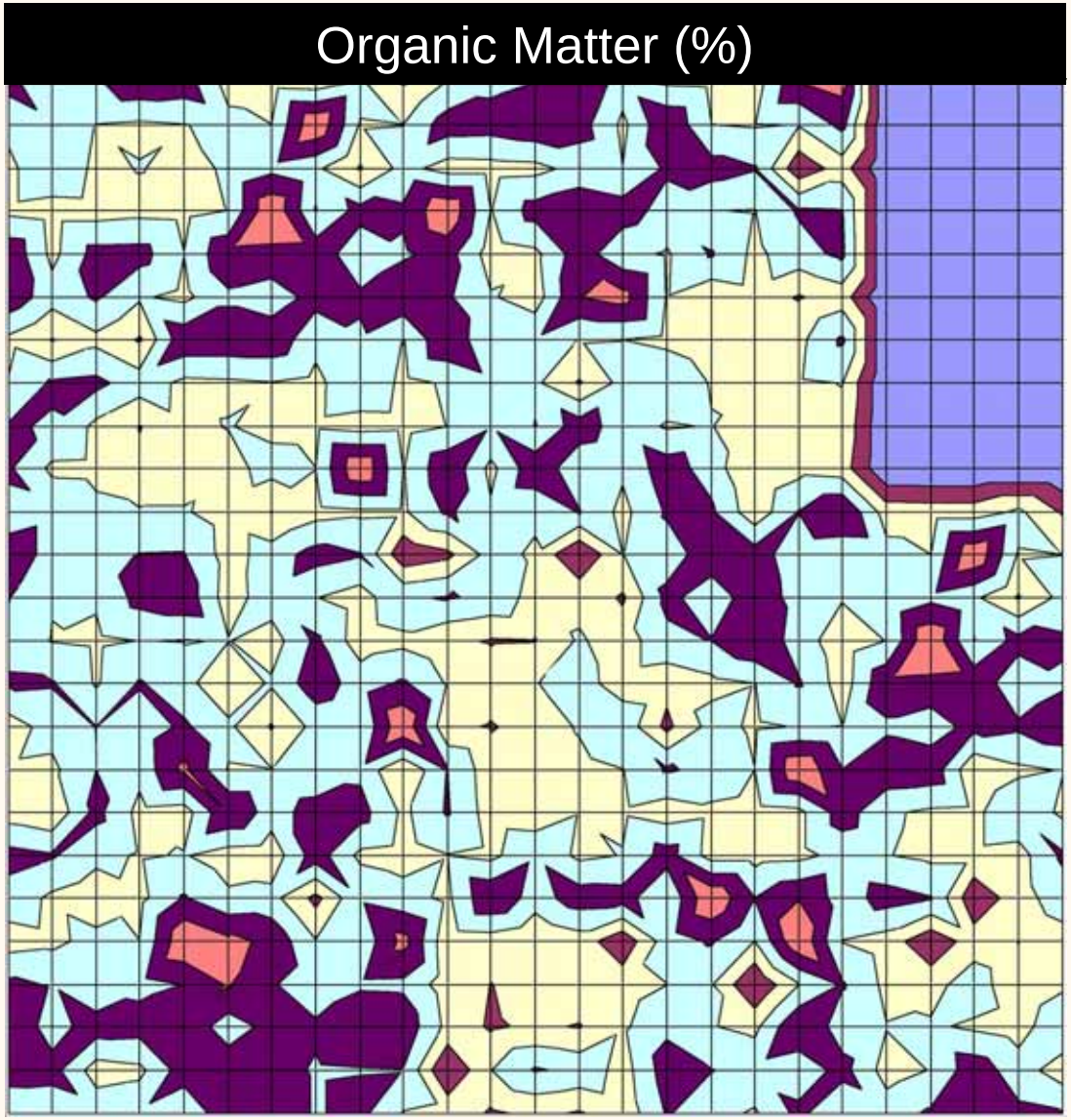


Evergreen sclerophyllous

Summer Semi-deciduous

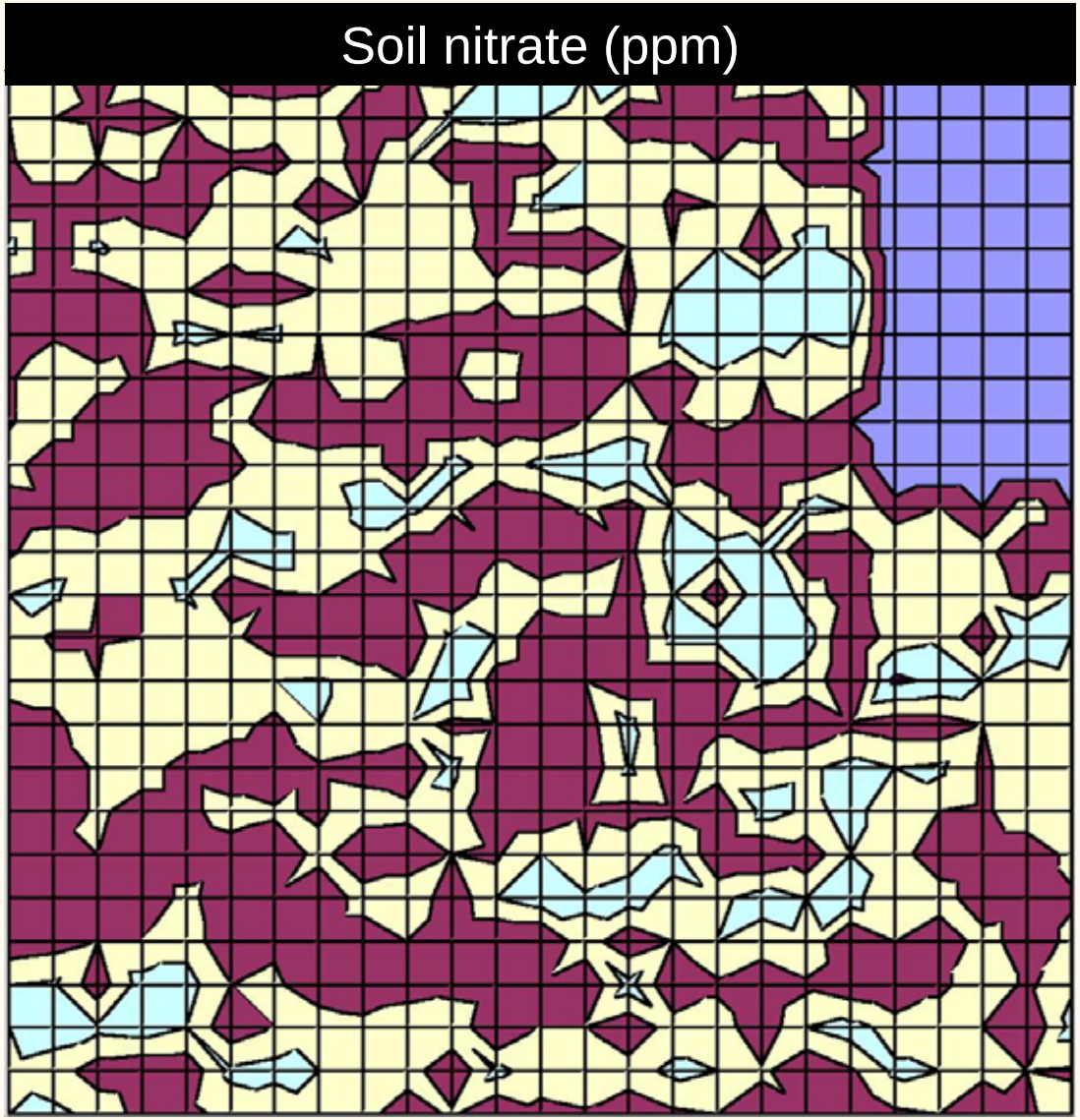
- **Evergreen Sclerophyllous** were more abundant and their distribution is clusterd

Results and Discussion



- OM was spatially heterogenous
- Several OM rich zones seemed to be associated with **Evergreen Sclerophyllous** <-> canopy structure

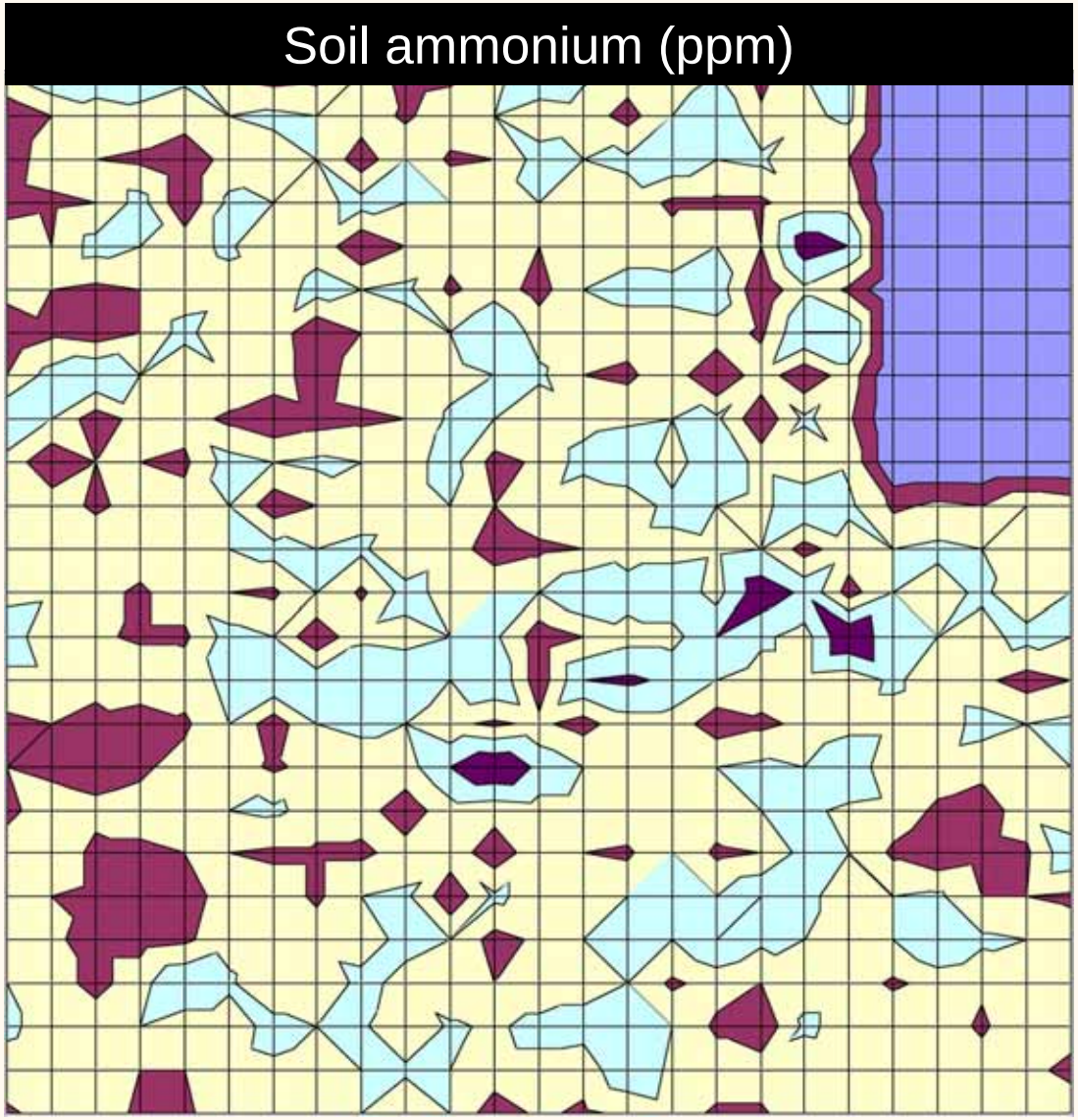
Results and Discussion



- 0 – 5
- 5 – 10
- 10 – 15
- 15 – 20
- > 20

- Soil Nitrate was spatially heterogenous
- at this sampling time the soil [NO_3^-] was low due to the balance between plant uptake, losses through runoff and leaching and microbial activity

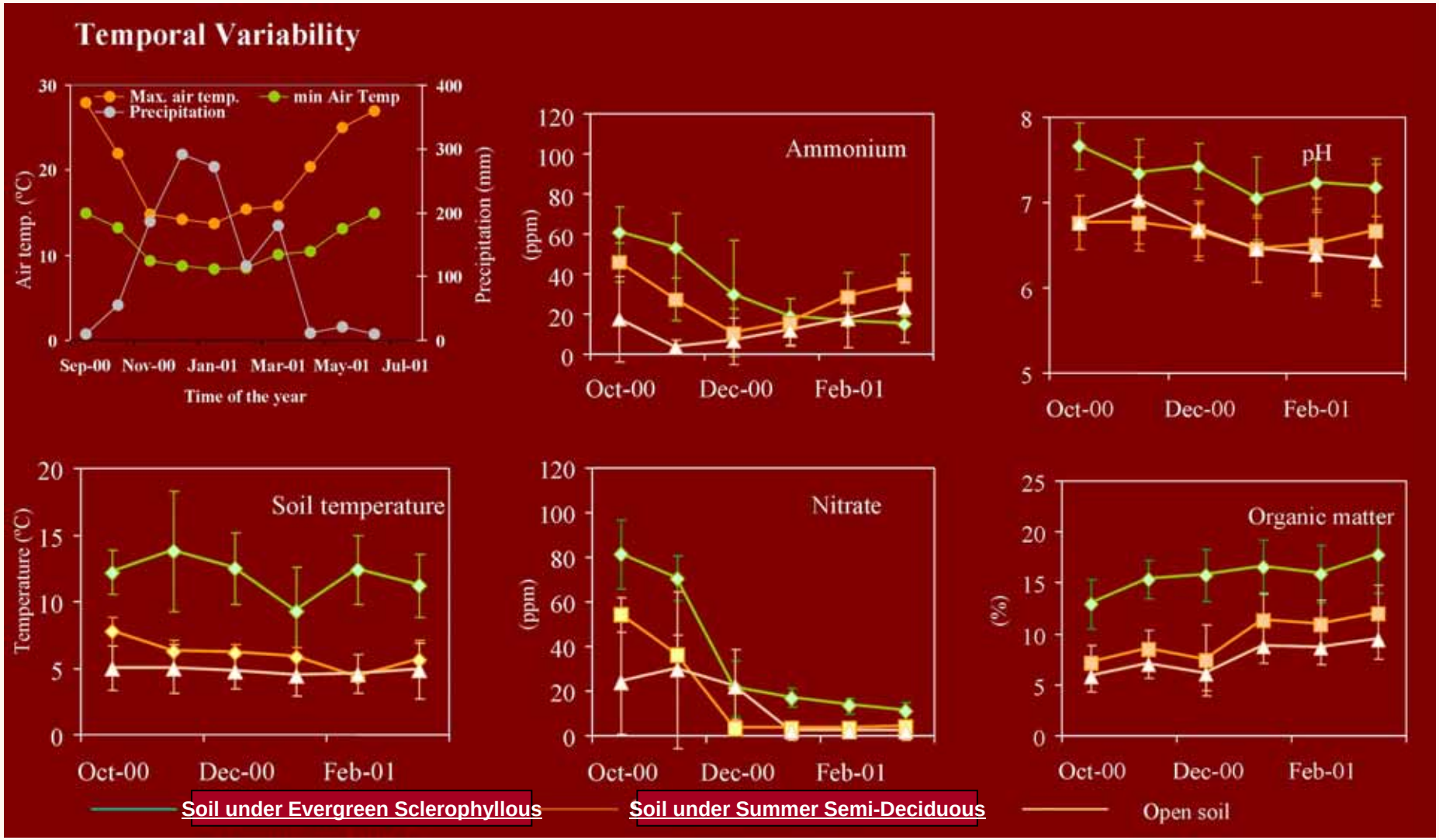
Results and Discussion



- Soil Ammonium was spatially heterogenous

- soil [NH_4^+] reflected the balance between ammonification, plant and microbial uptake, and losses through volatilization and nitrification

Results and Discussion



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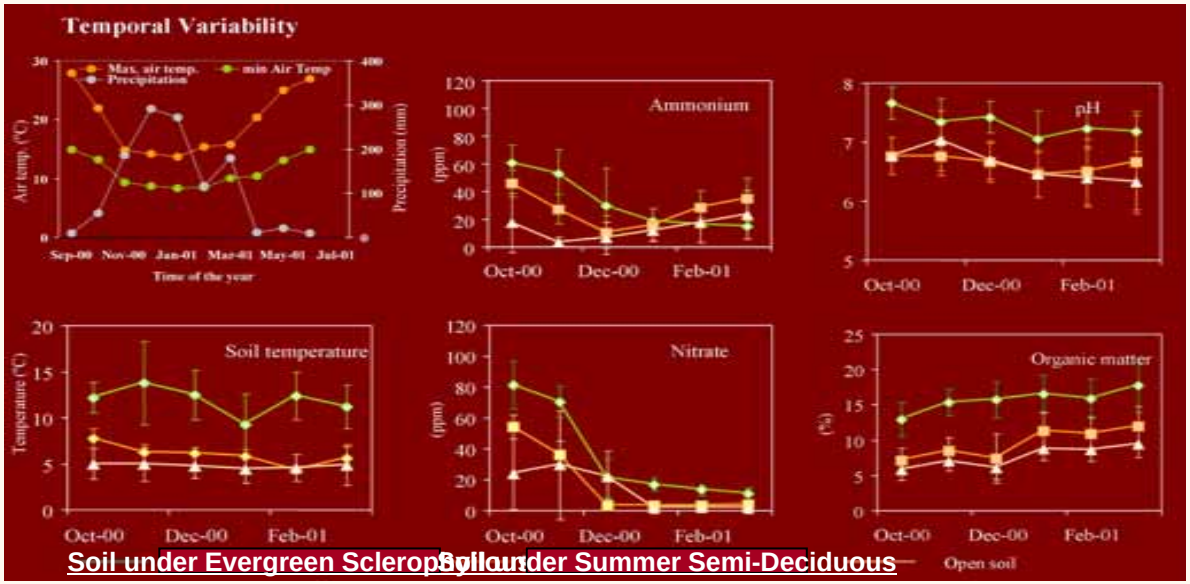
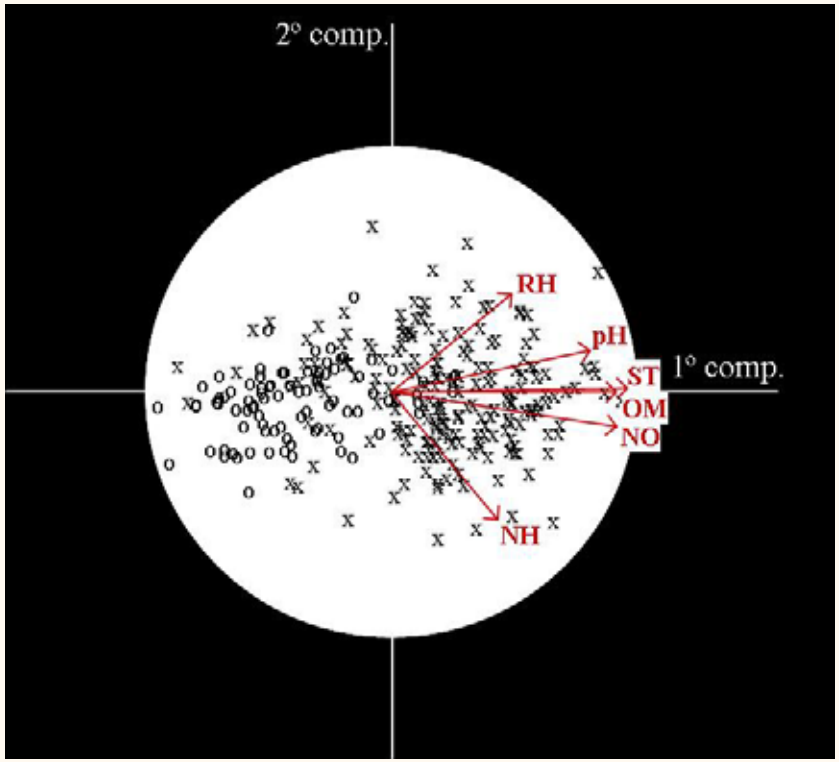


- all studied parameters showed seasonal variability
- soil properties patterns of variation seemed to reflect PFT

Results and Discussion

November



PCA analyses:

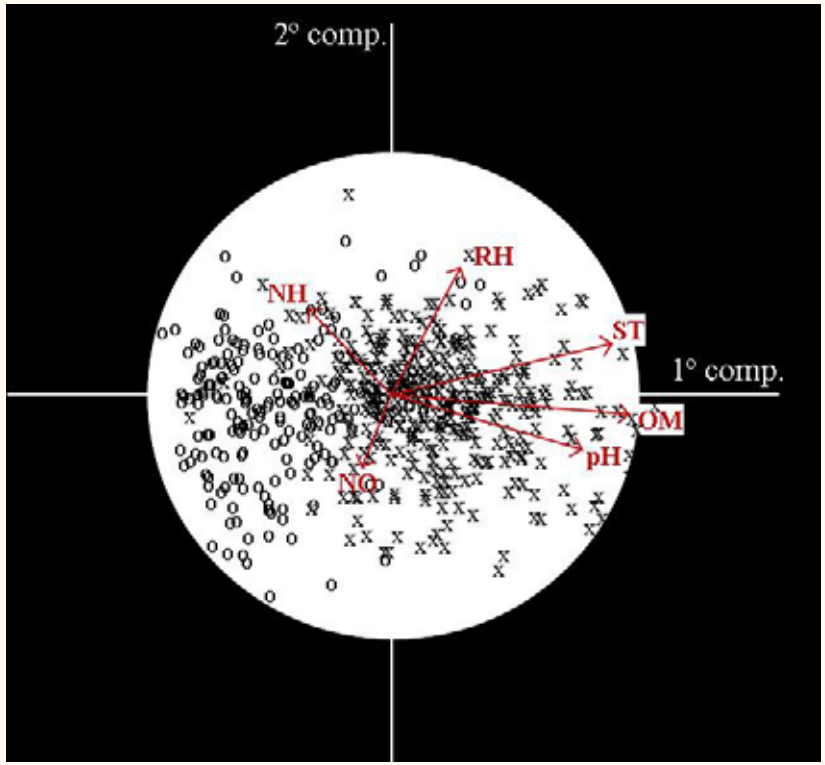
- **Soil temperature, [NO_3^-], Organic Matter and pH**

- All showed positive correlation

- higher values of these parameters were found under the canopies of **Evergreen Sclerophyllous**

Results and Discussion

February



PCA analyses:

- **Soil temperature, Organic Matter and pH**

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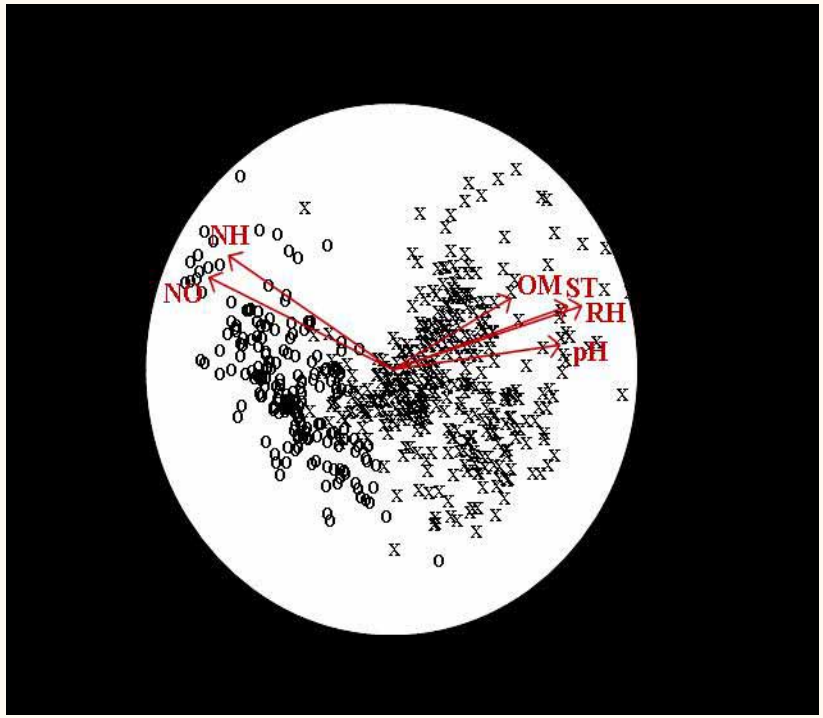
Results and Discussion

April



PCA analyses:

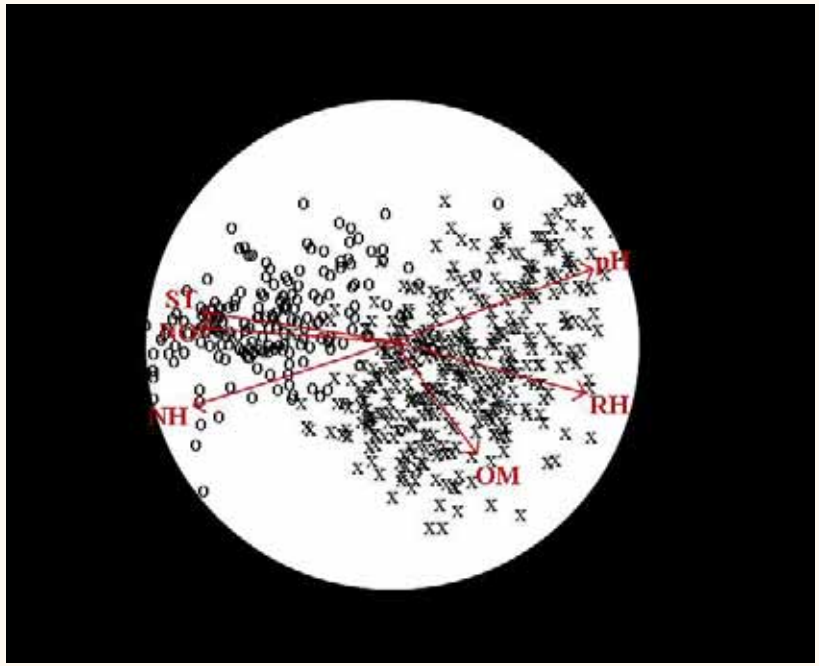
- **all** variables except **Organic Matter**

- **Soil [NO_3^-], [NH_4^+], temperature, Water content and pH** showed positive correlation

-higher values of **both inorganic N forms** were found under the canopies of **Evergreen Sclerophyllous**

Results and Discussion

July



PCA analyses:

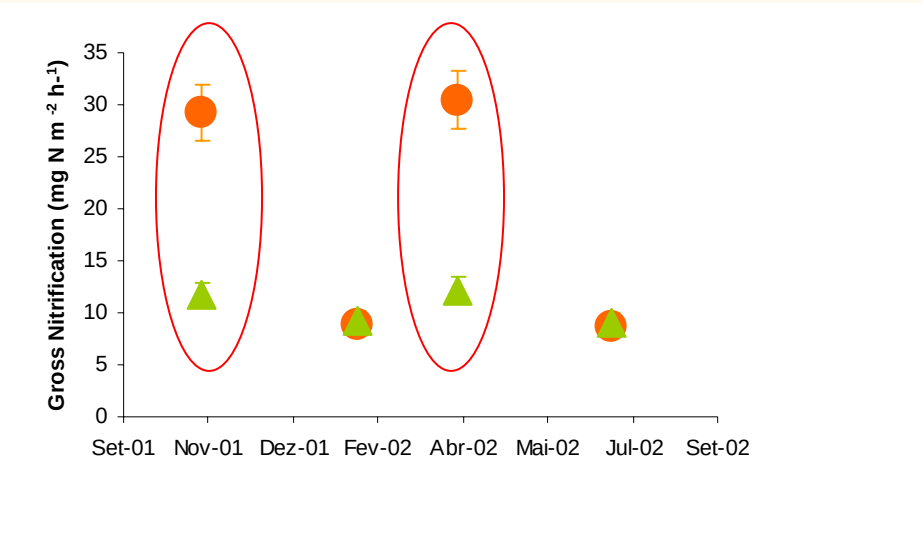
- **all** variables except **Organic Matter**

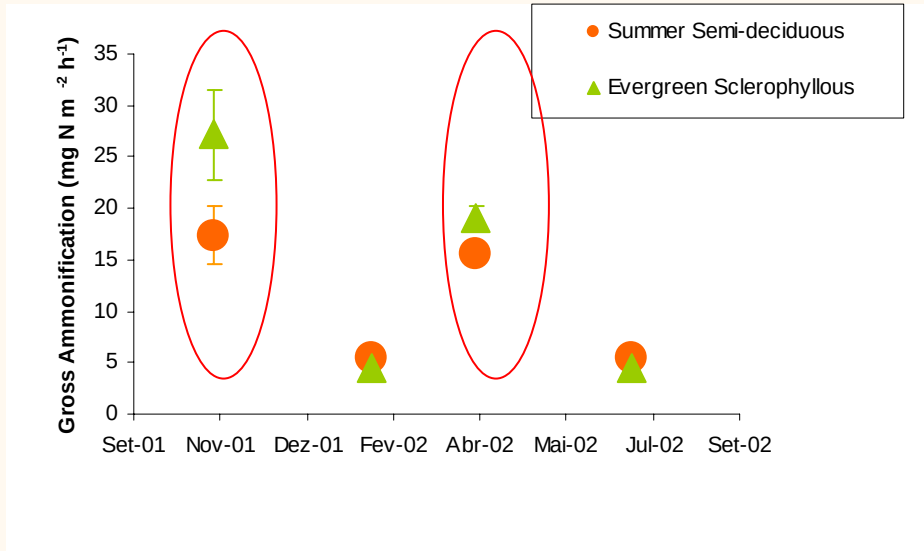
- **Soil [NO_3^-], [NH_4^+] and temperature; Water content and pH** showed positive correlation

Results and Discussion

- N related soil microbial activities also showed seasonal varatiation

- Summer Semi-deciduous showed higher nitrification rates than Evergreen sclerophyllous only during growth periods





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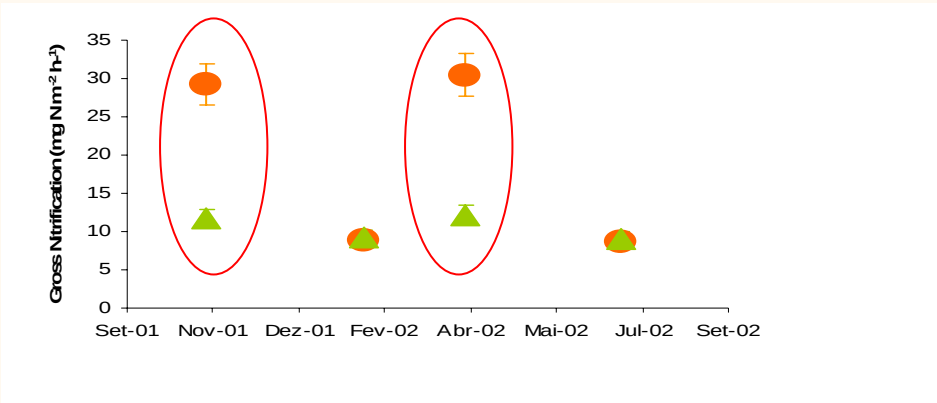

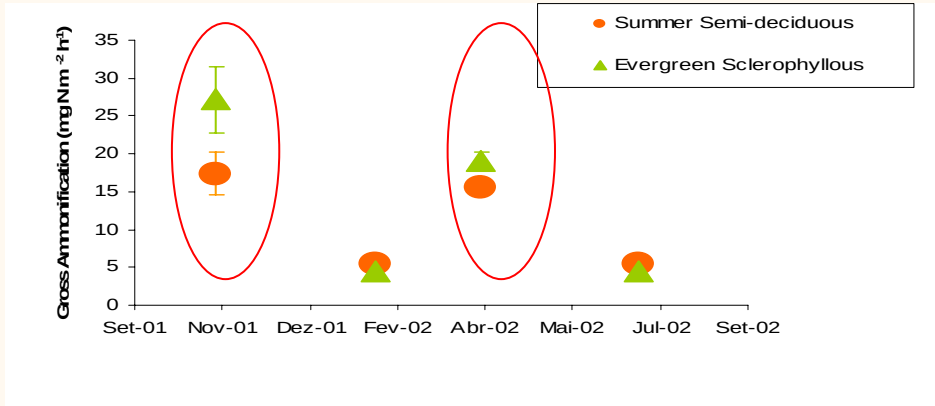

- Evergreen sclerophyllous species may excrete inhibitors of nitrifying bacteria to their rhizosphere (Rice and Pancholy, 1972)

→ **contribute towards an increase of ammonium concentration in the soil**

Conclusions

- Ammonium is an available inorganic N source in Mediterranean type ecosystem

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- PFT seem to influence/reflect superficial soil properties

- Importance of synchrony/asynchrony in the overall ecosystem function

Thanks to:

- ESF for the opportunity
- All of you for listening
- Team involved in sampling and measuring the parameters

Questions??