# Impact of the different forms of nitrogen on lichen biodiversity in a Mediterranean climate

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**University of Lisbon**

**Objective:**

To evaluate the potential of lichen communities for assessing the impact of different forms of nitrogen in Mediterranean areas, under a spatial framework

# What are lichens?

Characteristics of lichen useful for air monitoring studies

- Absence of a protective cuticle and roots- very sensitive to environmental changes and very good accumulative capacity
- They are a symbiotic organism- damage to one partner results in the loss of the organism
- Lichen are perennial, ubiquitous and collectable throughout the year
- Lichens can be regarded as integrative biomonitors

**Changes in lichens communities due to increased N supply**

- Response to $SO_2$ was a general decrease in lichen richness and abundance

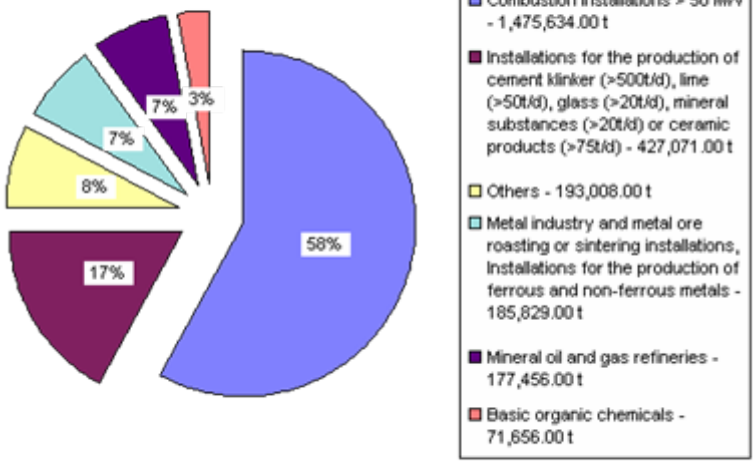
- Under decreasing $SO_2$ (north-central Europe) lead to changes in lichens communities, causing a “lichen reinvasion”, but by species tolerant to N, excluding those known as acidophilic.




Which are the known sources of N in Portugal in comparison to UE?

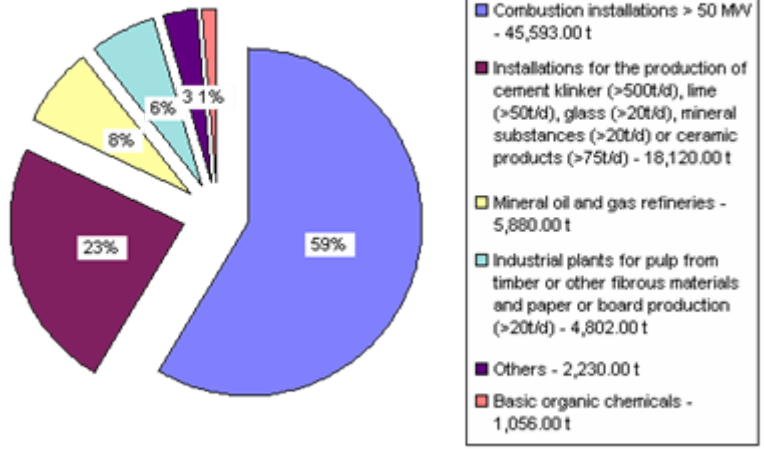
## Nitrogen Oxides, N0x

### UE




58% from combustions inst.
17% from cement and others

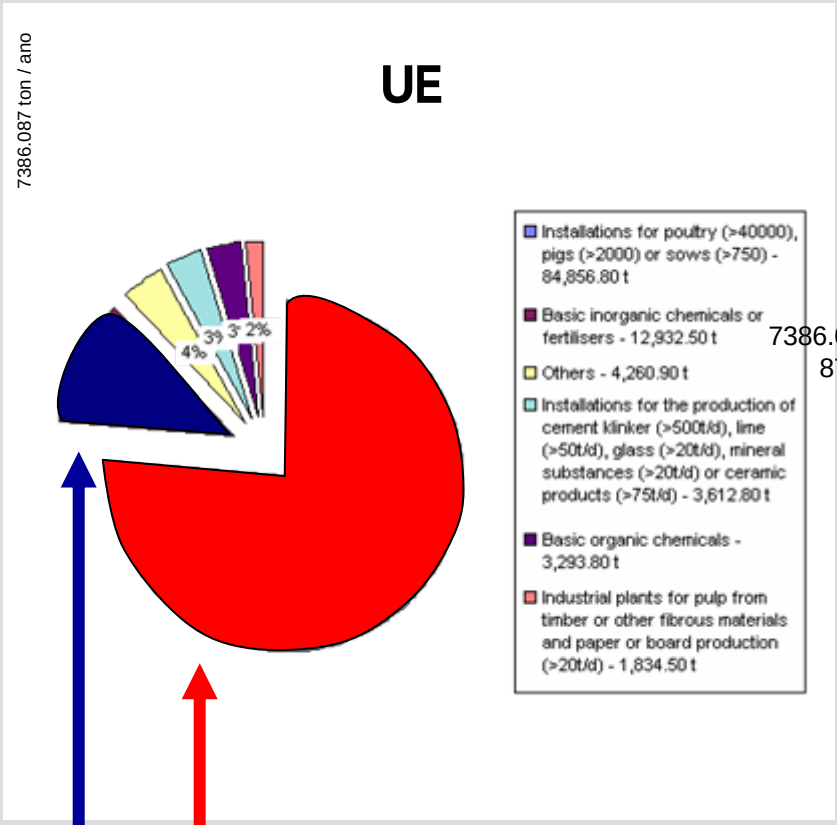
### Portugal



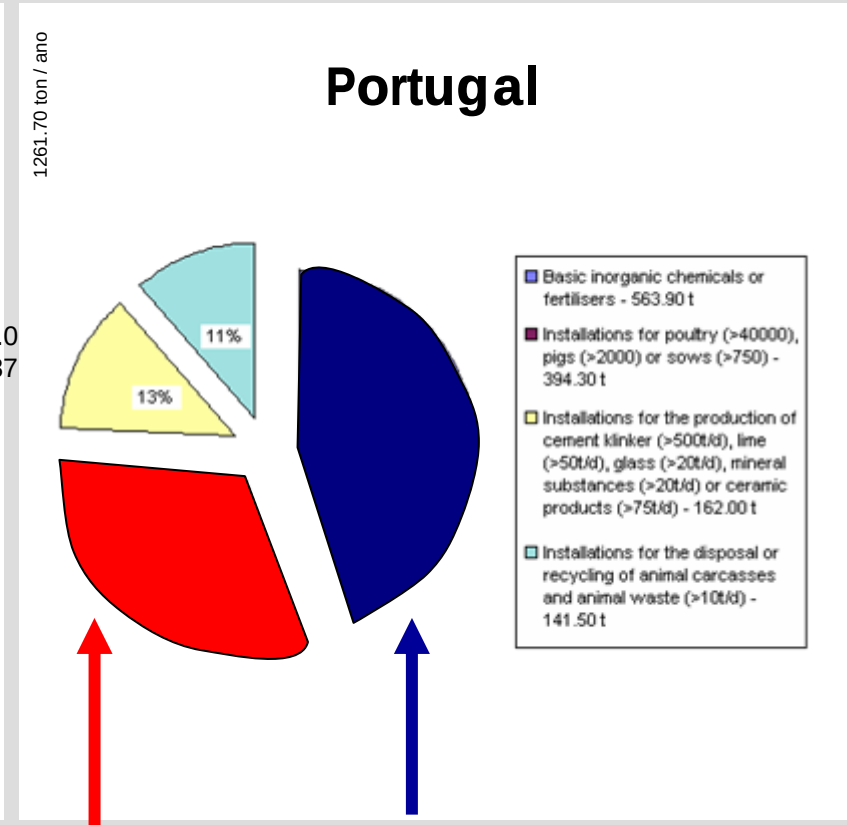

59% from combustions inst.
23% from cement and others

***European Pollutant Emission Register*** , *http://www.eper.cec.eu.int/eper/*

# Ammonia, $NH_3$




7386.0
87

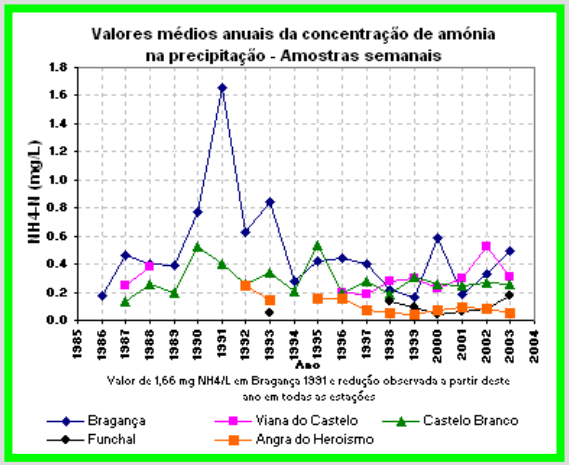



**77% from animals**
**12% from fertilizers**

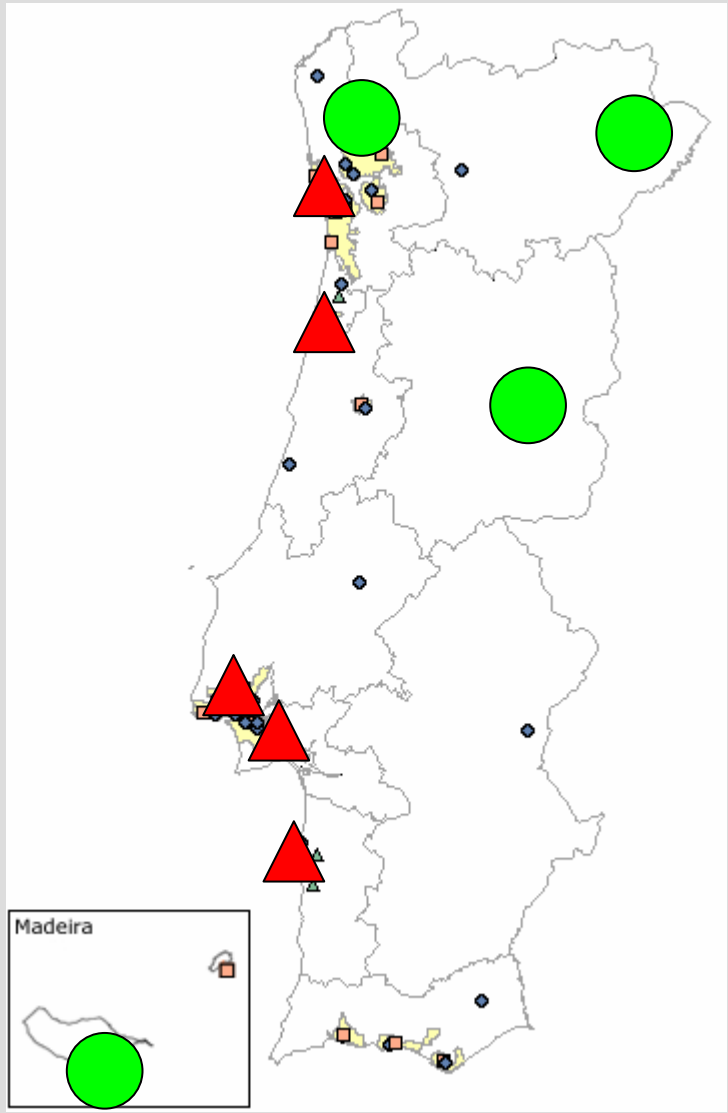
**45% from fertilizers**
**31% from animals**

***European Pollutant Emission Register*** , *http://www.eper.cec.eu.int/eper/*

# $NH_4^+$ and $NO_2$ classical monitoring stations in Portugal




NH4 in precipitation is measured continually in 4 stations, for background values measured in precipitation




$NO_2$

$CH_4$

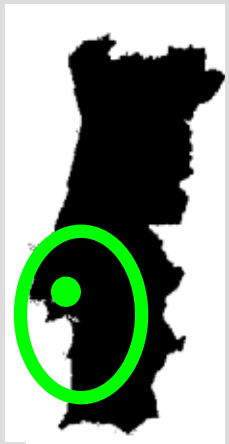
Location o f monitoring stations in Portugal

# Effects of NH3 in cork-oak woodlands

Cork-oak woodlands represent the more important land-cover type in southern Portugal, with silvicultural and pasture uses, but in a traditional, low intensity way

There are no measures of NH3 in cork-oak woodlands

We used a Land Use Intensity gradient gradient as a measure of NH3

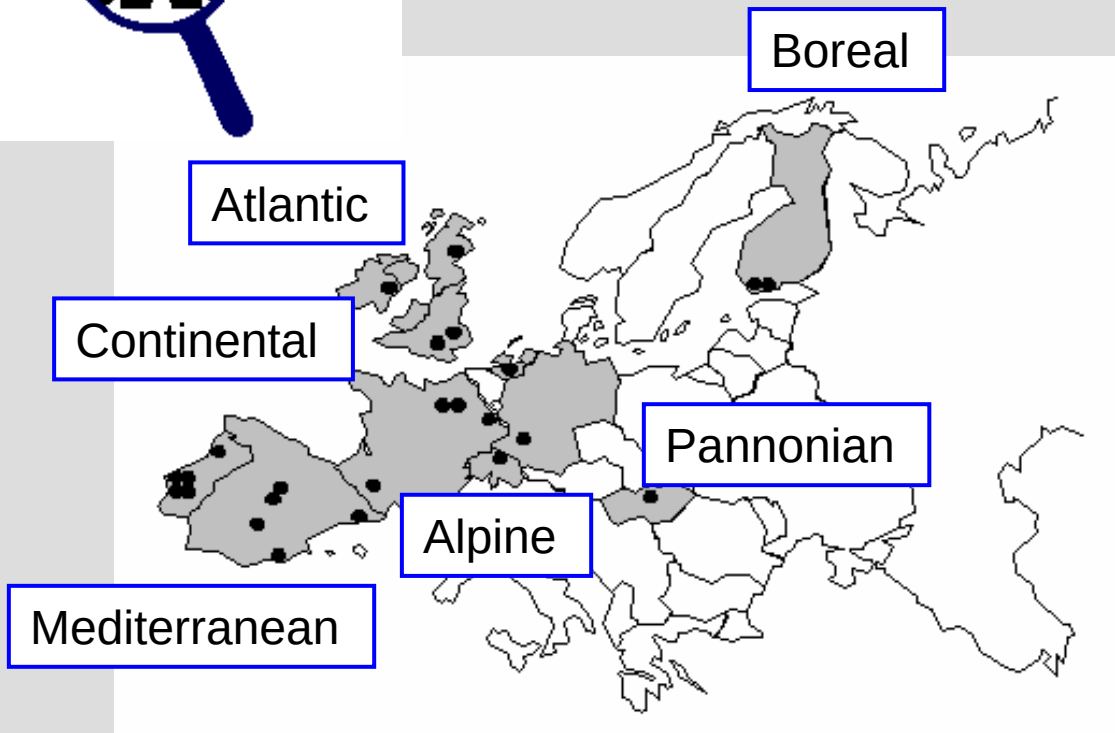


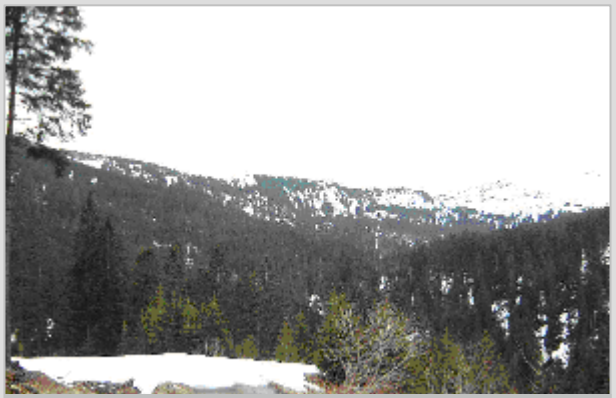
Mixed land use UK

Cork oak forest Portugal

Arable fields Spain

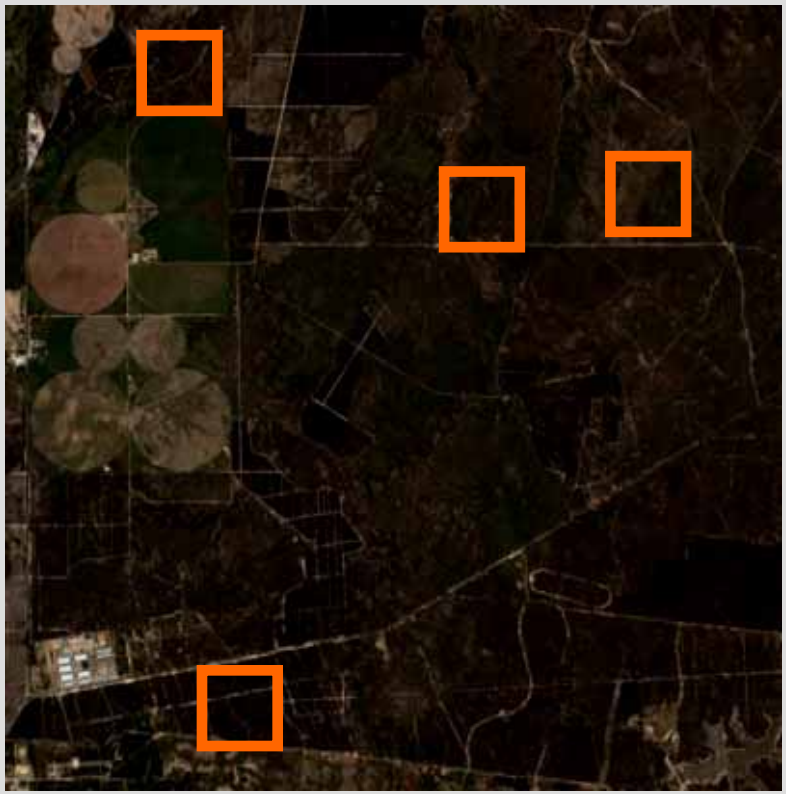
BioASsess



Spruce plantation Switzerland

Changes in lichens communities under the influence of low intensity cattle pasture. We quantify lichen functional groups and environmental factors.



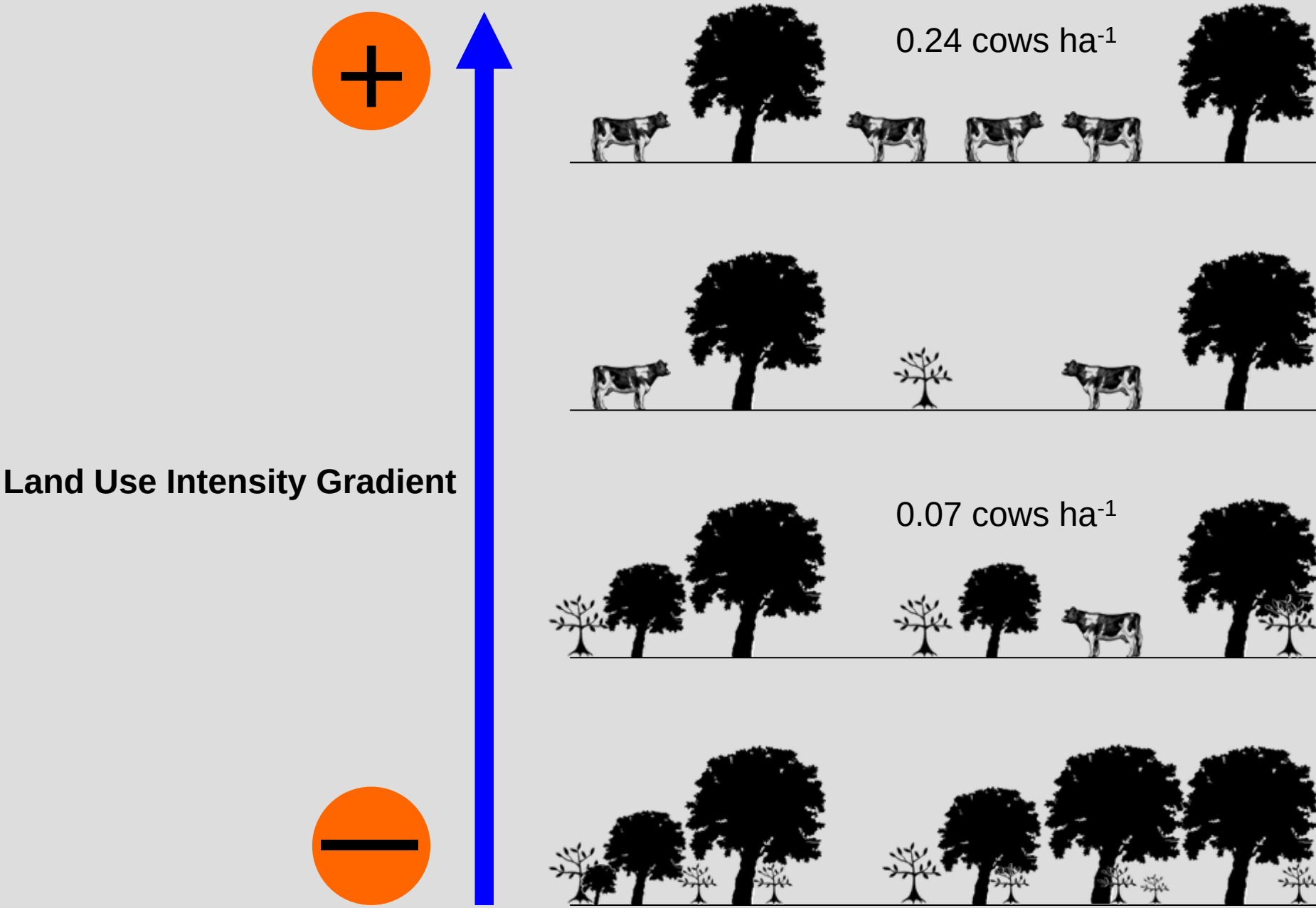
Environmental factors

LUI (Land Use Intensity) - pasture and silviculture activities

Vegetation characteristics

Tree characteristics

**Changes in lichens communities under low intensity cattle grazing**

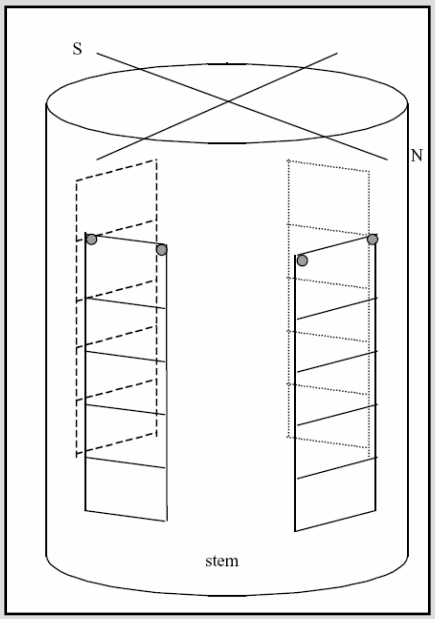


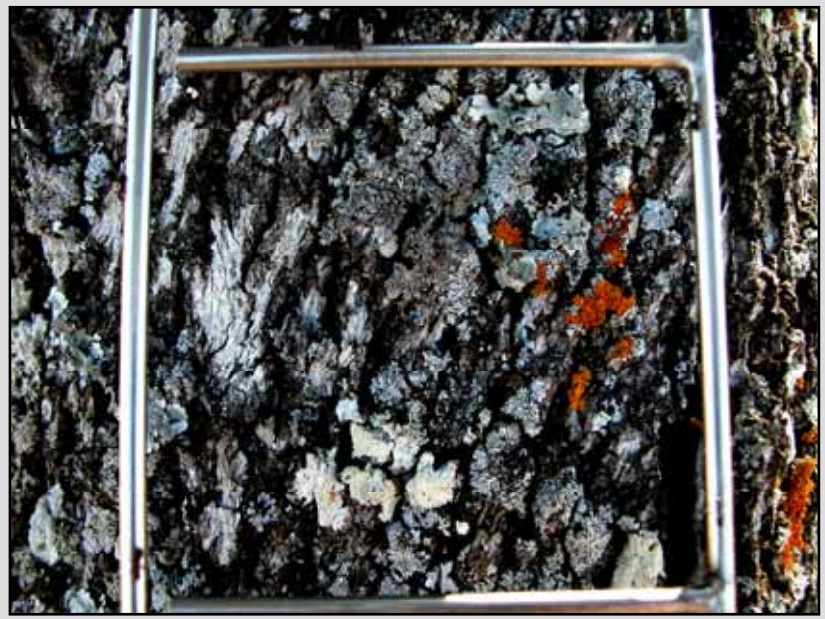
Standardization of the sampling protocols of lichen communities:

- Lichen Diversity Values (abundance and number of species):

LDVnitrophilous and LDVnon-nitrophilous)

- Number of Species (NrSp)

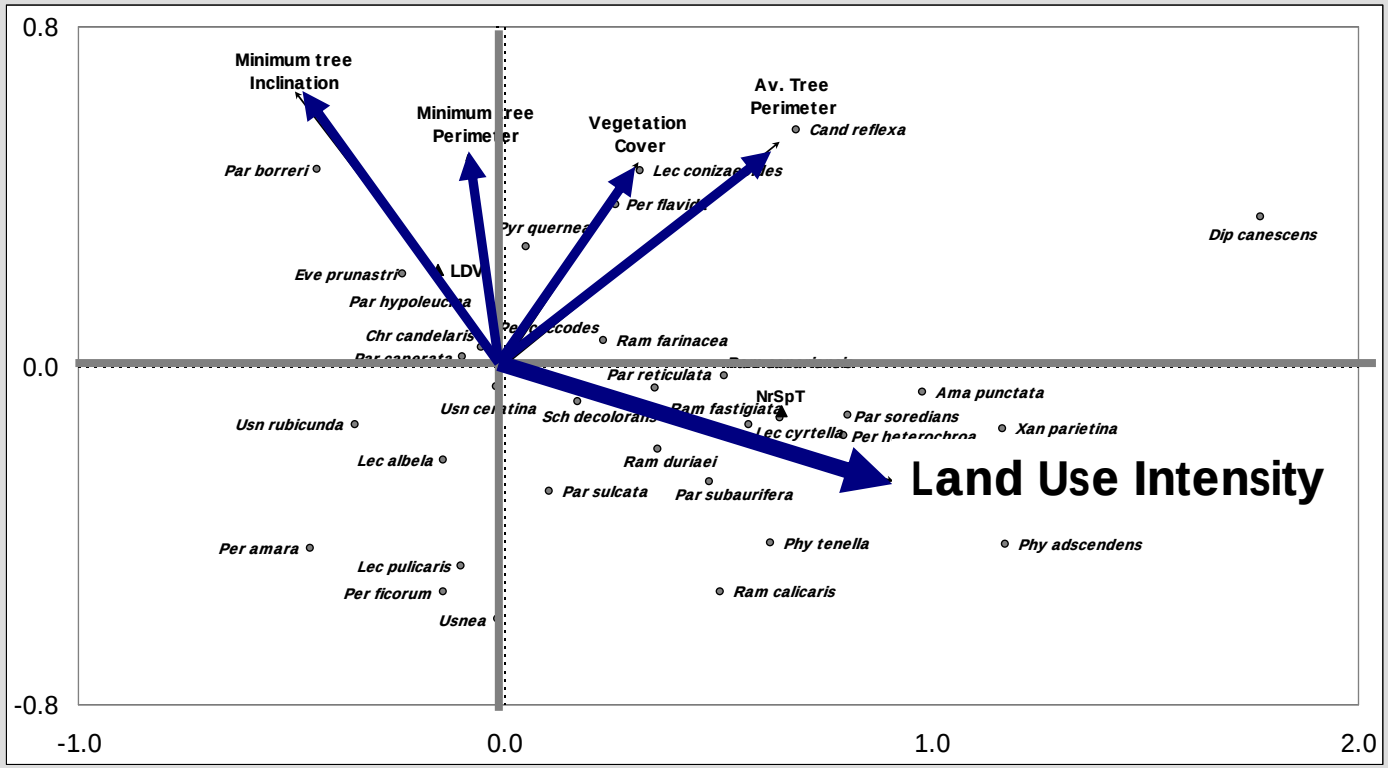


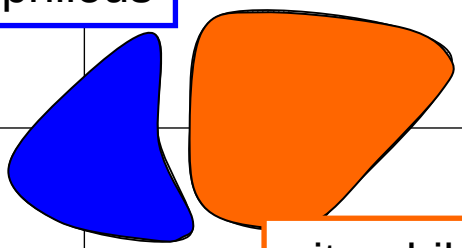
**Changes in lichens communities under environmental changes**

- Under increasing Nitrogen, some species decrease (**non-nitrophilous**) and other increase (**nitrophilous species**)

# Which are the main factors influencing lichen communities?



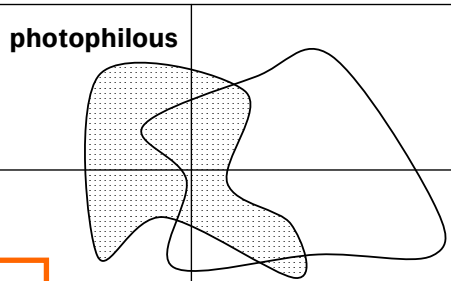

non-nitrophilous



nitrophilous

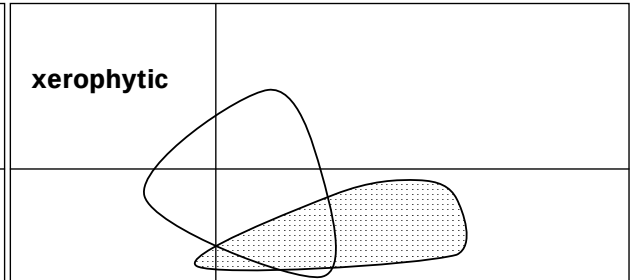
Axis 1: p<0.001

Axis 2: ns




Axis 1: p<0.001

Axis 2: ns




Axis: 1 p<0.05

Axis: 2 p<0.01

**Which are the main factors influencing lichen communities?**

| | Functional Type | | | |
|---|---|---|---|---|
| | nitrophilous | | non-nitrophilous | |
| | Number species | Abundance | Number of species | abundance |
| **Vegetation Cover** | - | **-0.27** | - | - |
| **Average tree perimeter** | **0.25** | **0.45** | - | - |
| **Land Use Intensity** | **0.58** | **0.56** | - | **-0.43** |
| **Minimum perimeter** | - | - | - | - |
| **Minimum inclination** | - | - | - | - |
| Adj. $R^2$ | **0.42** | **0.57** | **n.s.** | **0.19** |

Low-intensity land-use lead to an overall increase in total species richness, due to an increase in nitrophilous species but non-nitrophilous species did not disappear.

- Cork-oak woodlands present a sustainable management intensity that does not exclude N-sensitive species.

- Although we worked in a low intensity gradient, LDV of nitrophilous species were the best indicators of land-use

Area without large cattle concentration

Only NOx sources

Other possible N sources are agricultural activities

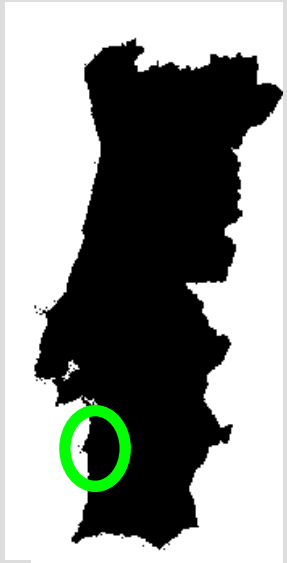

Objectives were to monitor the air quality in the region using several approaches:

- biomonitors,
- diffusion tubes
- modeling data from air monitoring stations

**Objective:**

To evaluate the potential of lichen communities for assessing the impact of different forms of nitrogen in Mediterranean areas, under a spatial framework

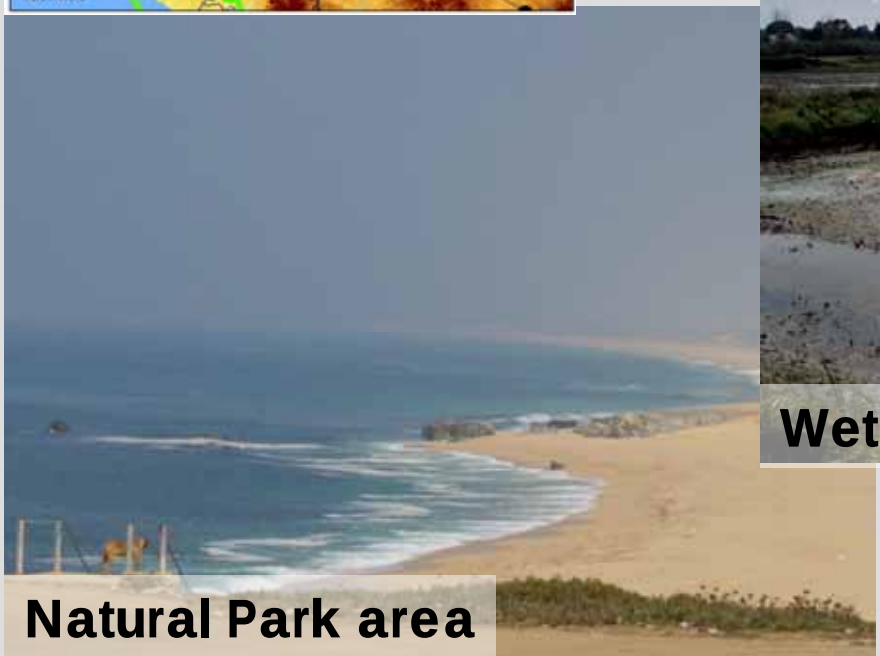
- through changes in biodiversity
- through lichen elements accumulation



# Types of landscape


Cork-oak woodlands

Wetlands



Natural Park area

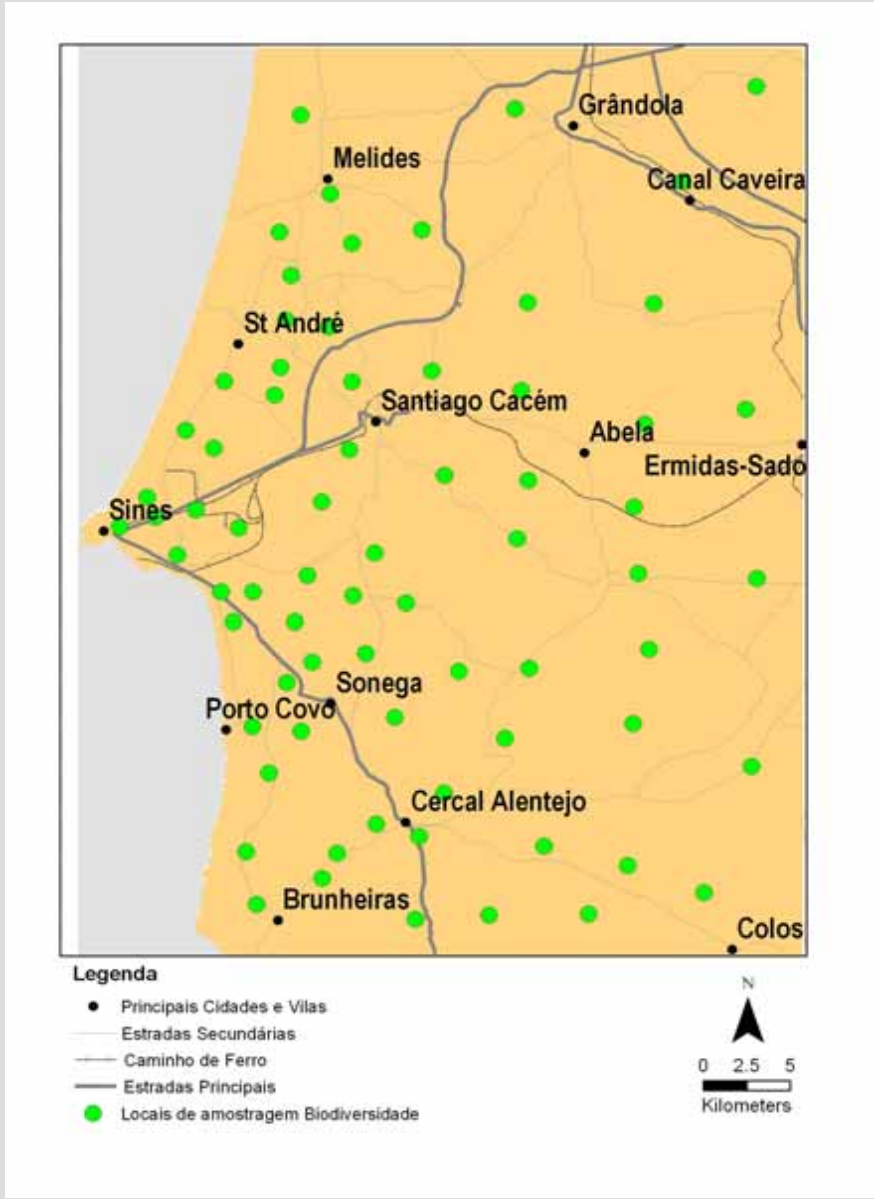
# Types of landscape


Bare-lands

Agricultural areas

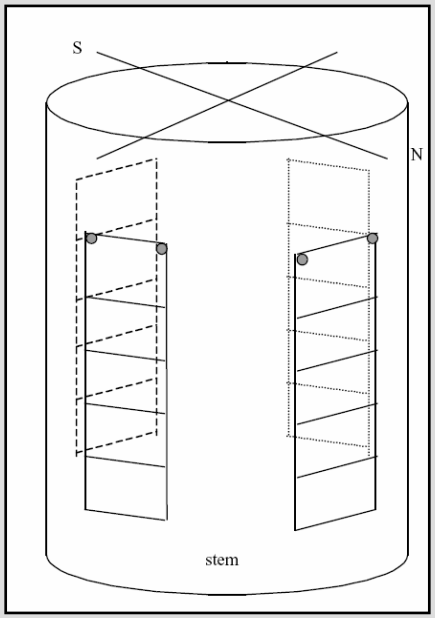
Artificial and Industrial areas

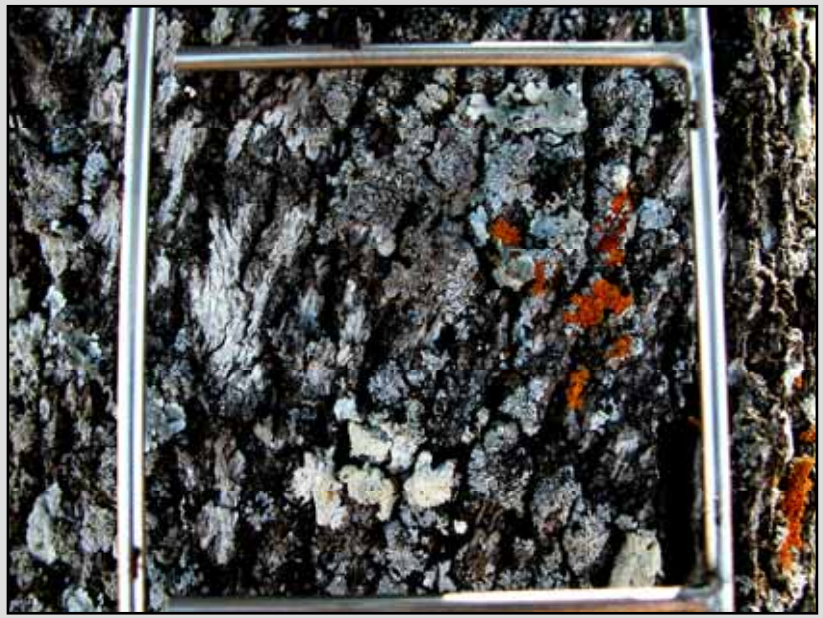
Monitoring lichen diversity in more than 70 sites, always in cork-oak woodland



- Lichen Diversity Values (abundance and number of species):

LDVnitrophilous

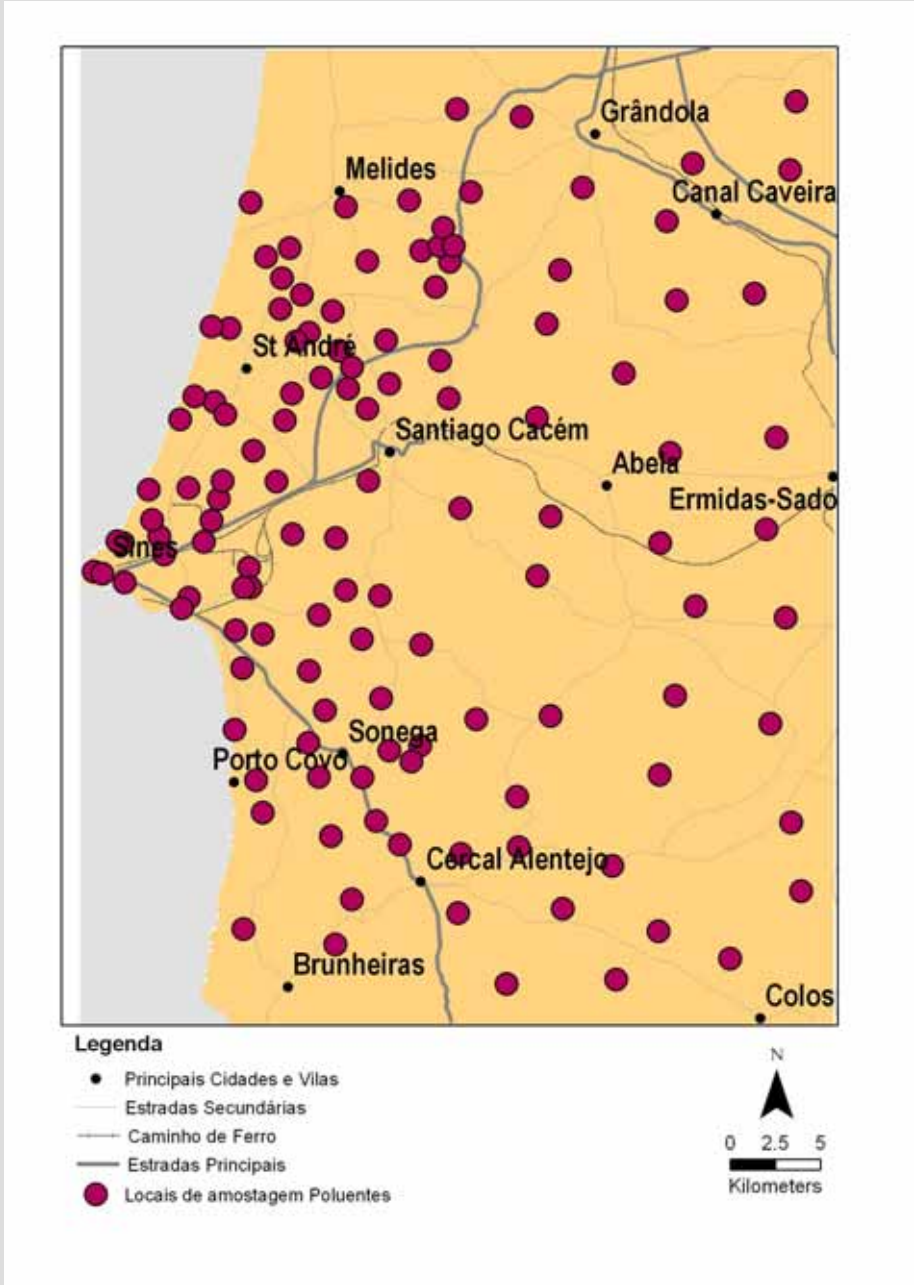


# Lichen sampling for accumulation of elements

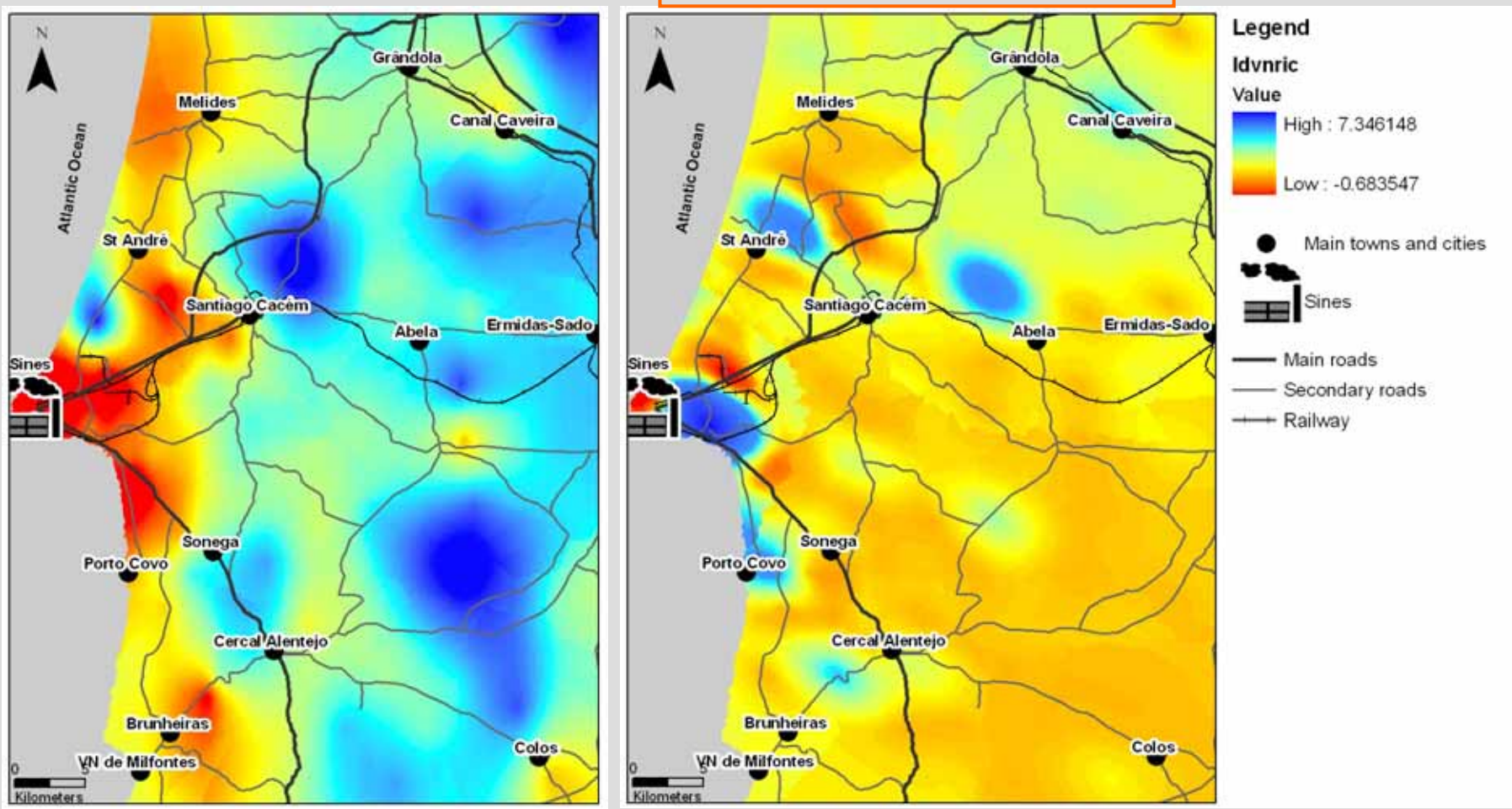
Sampling *Parmotrema hypoleucinum* for elements concentration in more than 90 sites, including Fe, N

Diffusion Tubes for $NO_2$

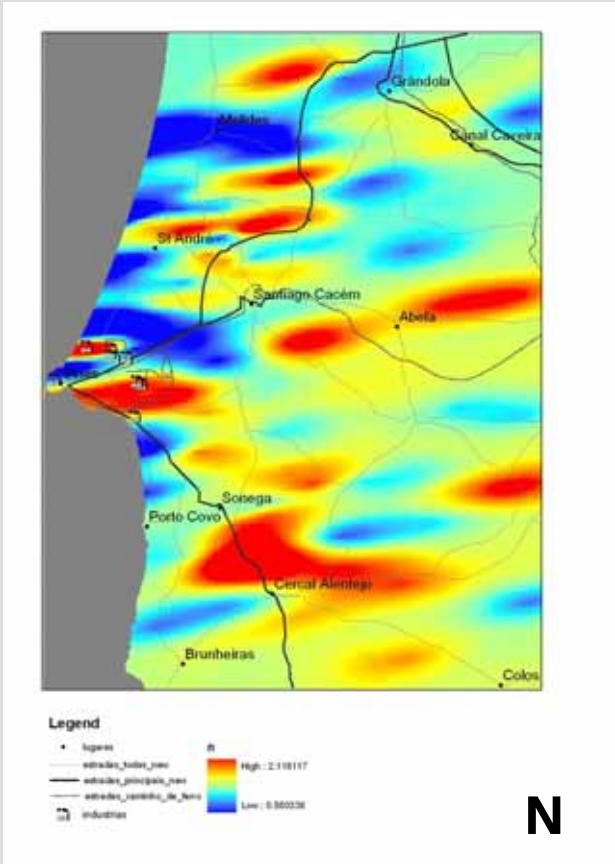


**Lichen abundance of non-nitrophilous species**

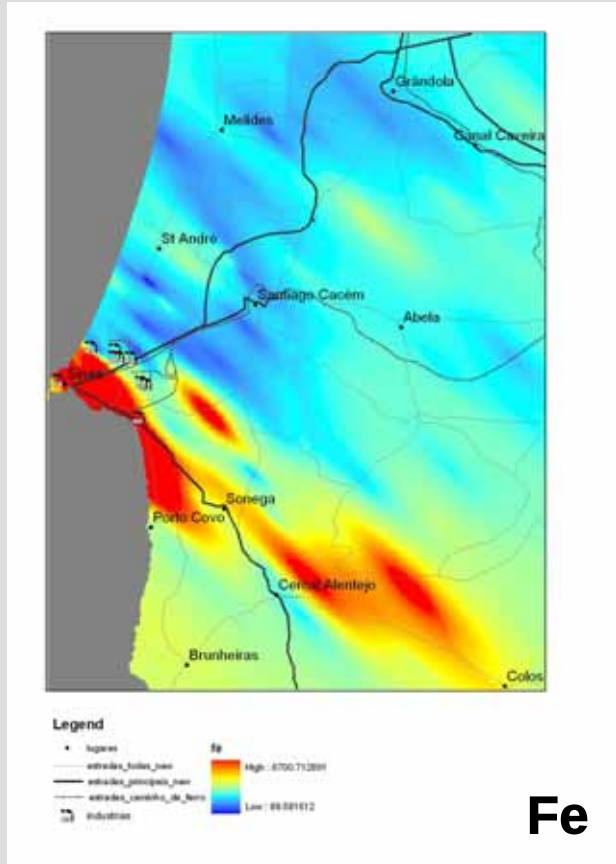
**Lichen abundance of nitrophilous species**



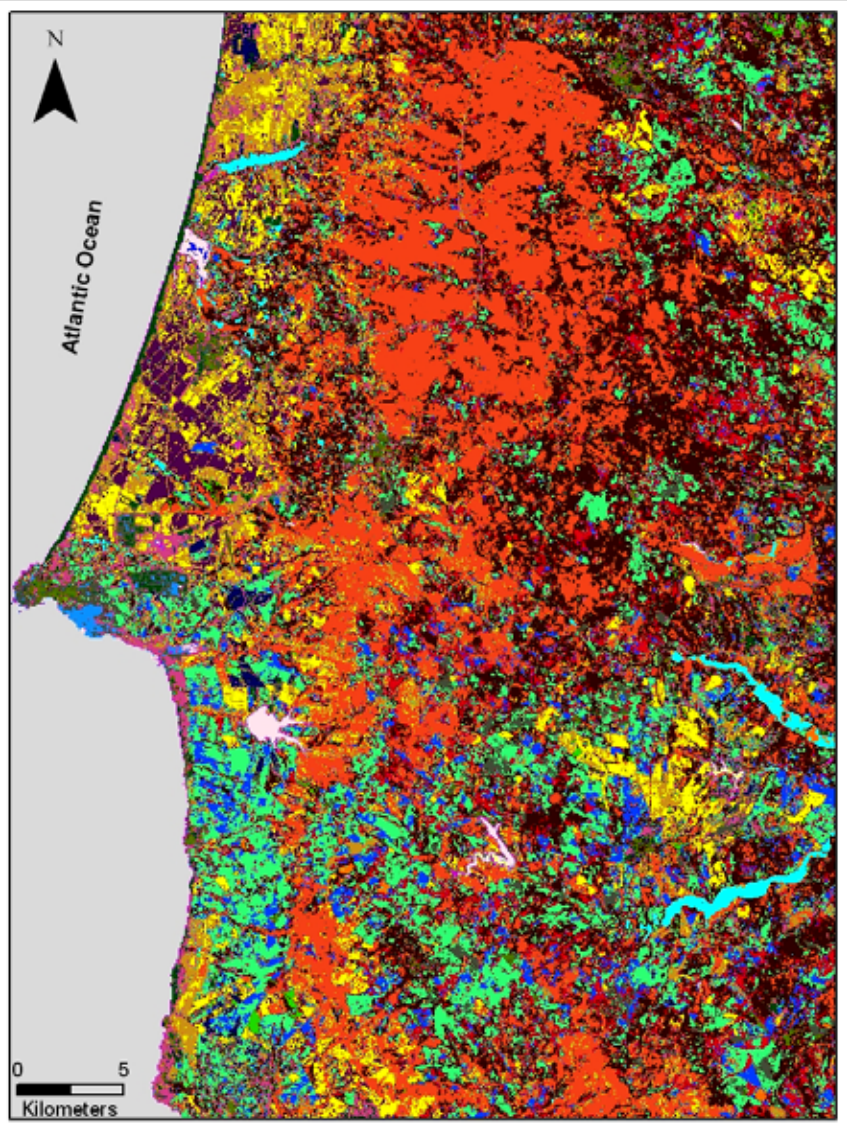
Interpolation of N and Fe measured in *Parmelia hypoleucina*




Indicator of
total nitrogen in the air




Indicator of
dust from soil re-suspension

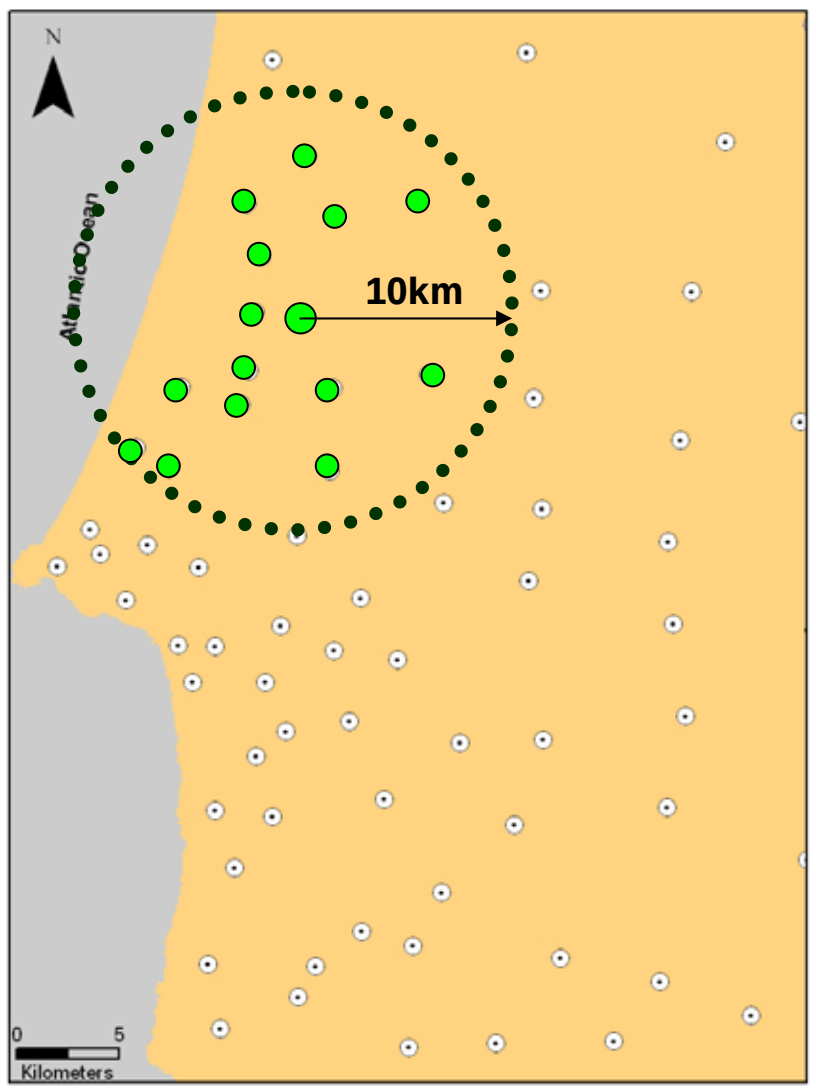



Land-cover map from LandSat images

We calculated land-cover for several distance from sampling sites

Artificial areas, Agricultural areas and Bare-Lands

# Correlating lichen biodiversity, land-cover and elements concentration




We used **sub-sections** of the study area, by defining a 10km limit as the local correlation spatial range

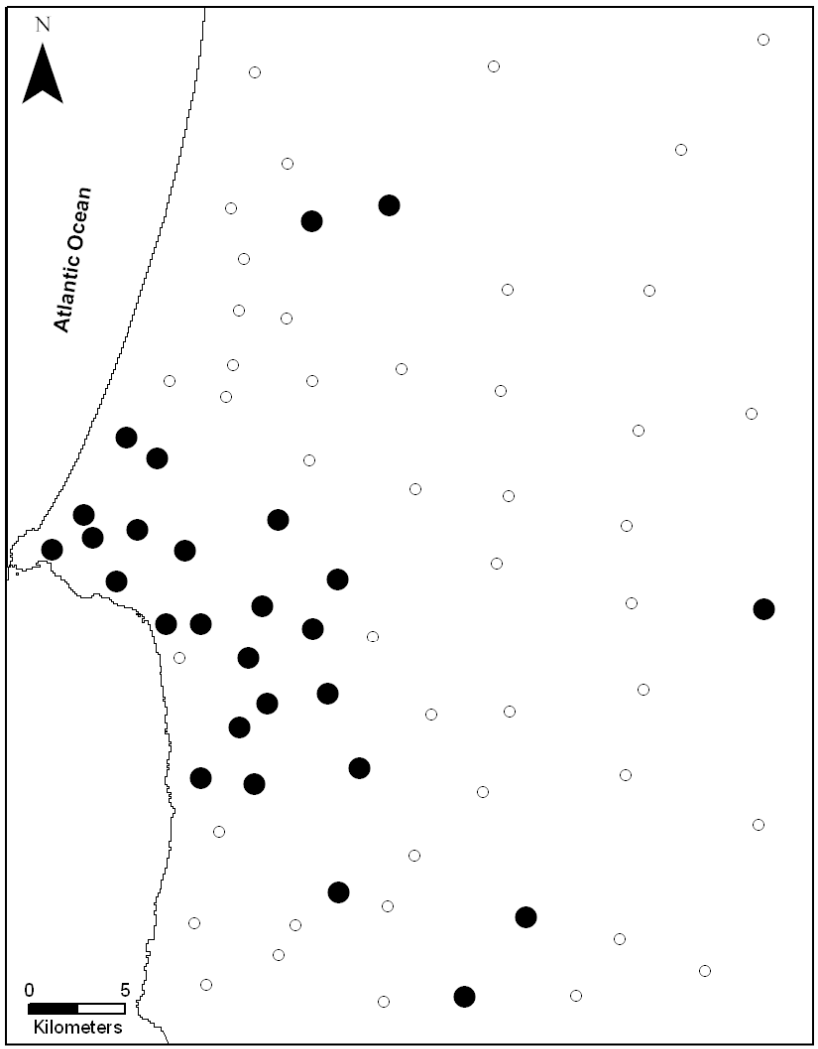
This could be repeated for each site and more significant correlations could be mapped; the distance for that correlation could also be interpolated

# Lichen Biodiversity

# vs.

# Land-cover

## Relating lichen biodiversity with land-cover

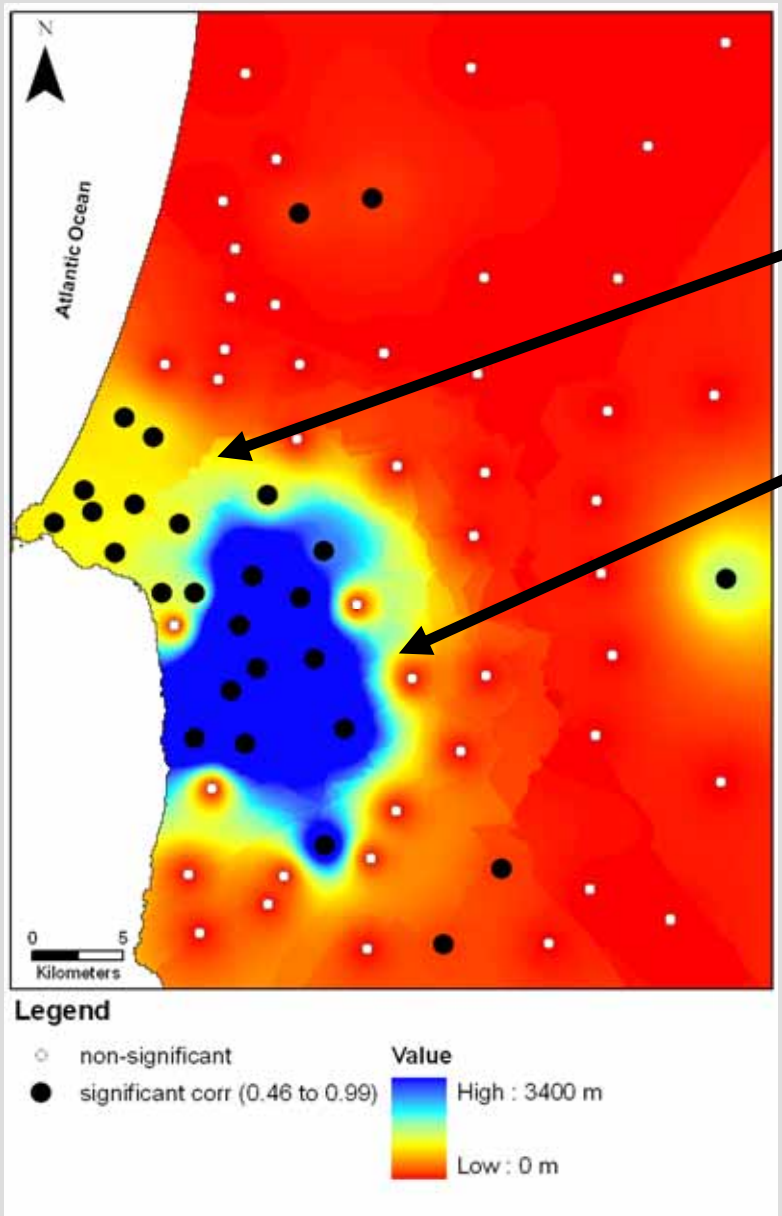



Best Local correlation between

**artificial areas** and **nitrophilous**

**species**

## Nitrophilous species vs artificial areas

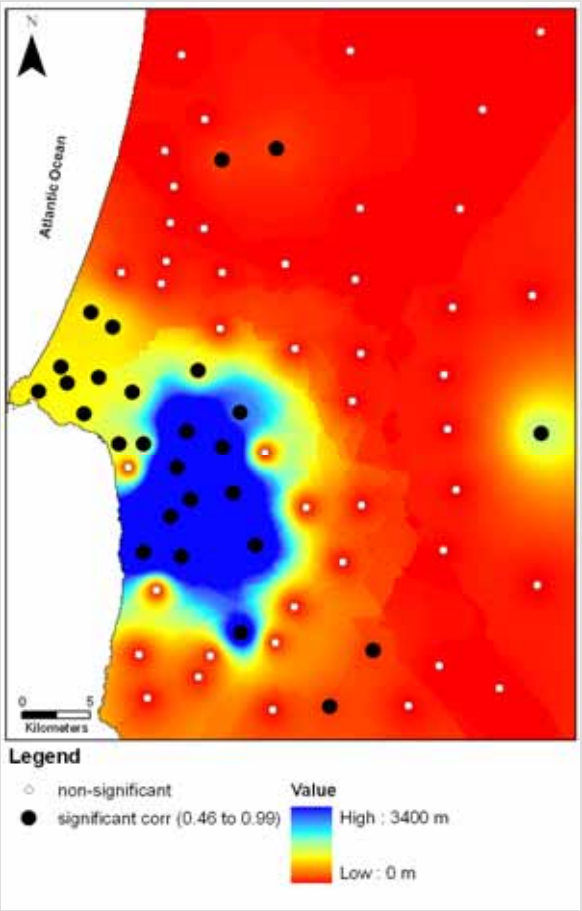



Urban areas: 400m (shorter range dispersion)

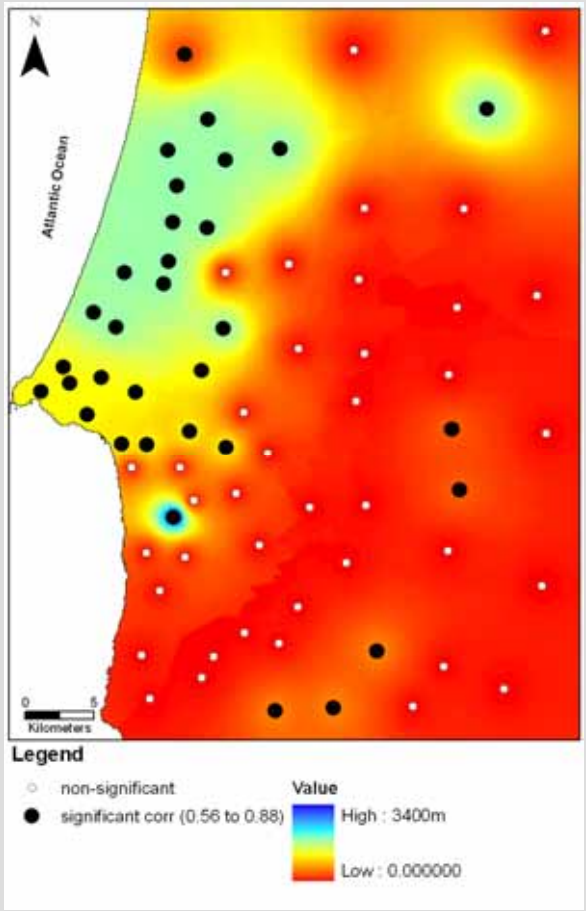
Artificial areas: 3400m (longer range dispersion)

**Relating lichen biodiversity with land-cover**

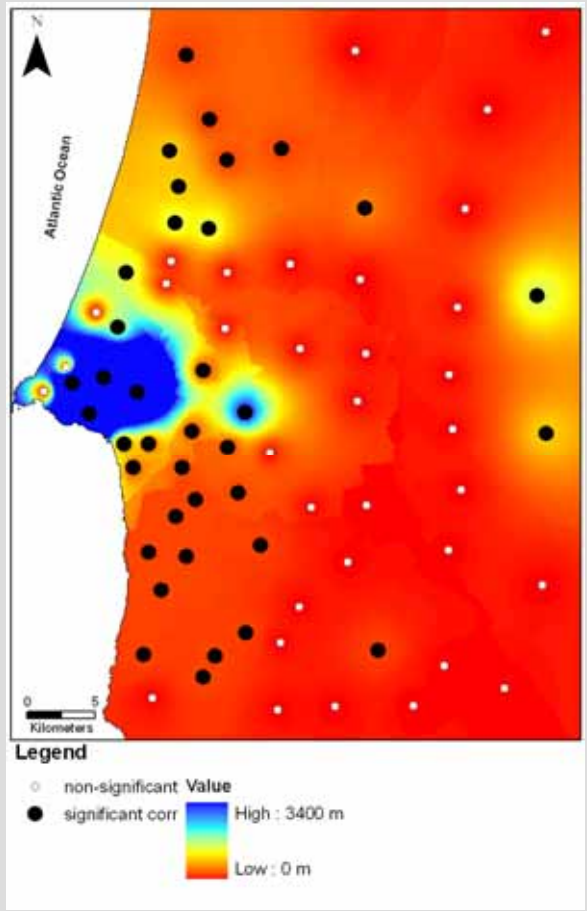
artificial areas

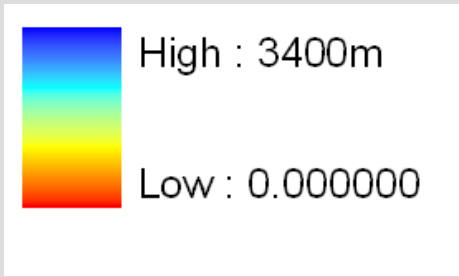



agricultural areas




bare-lands

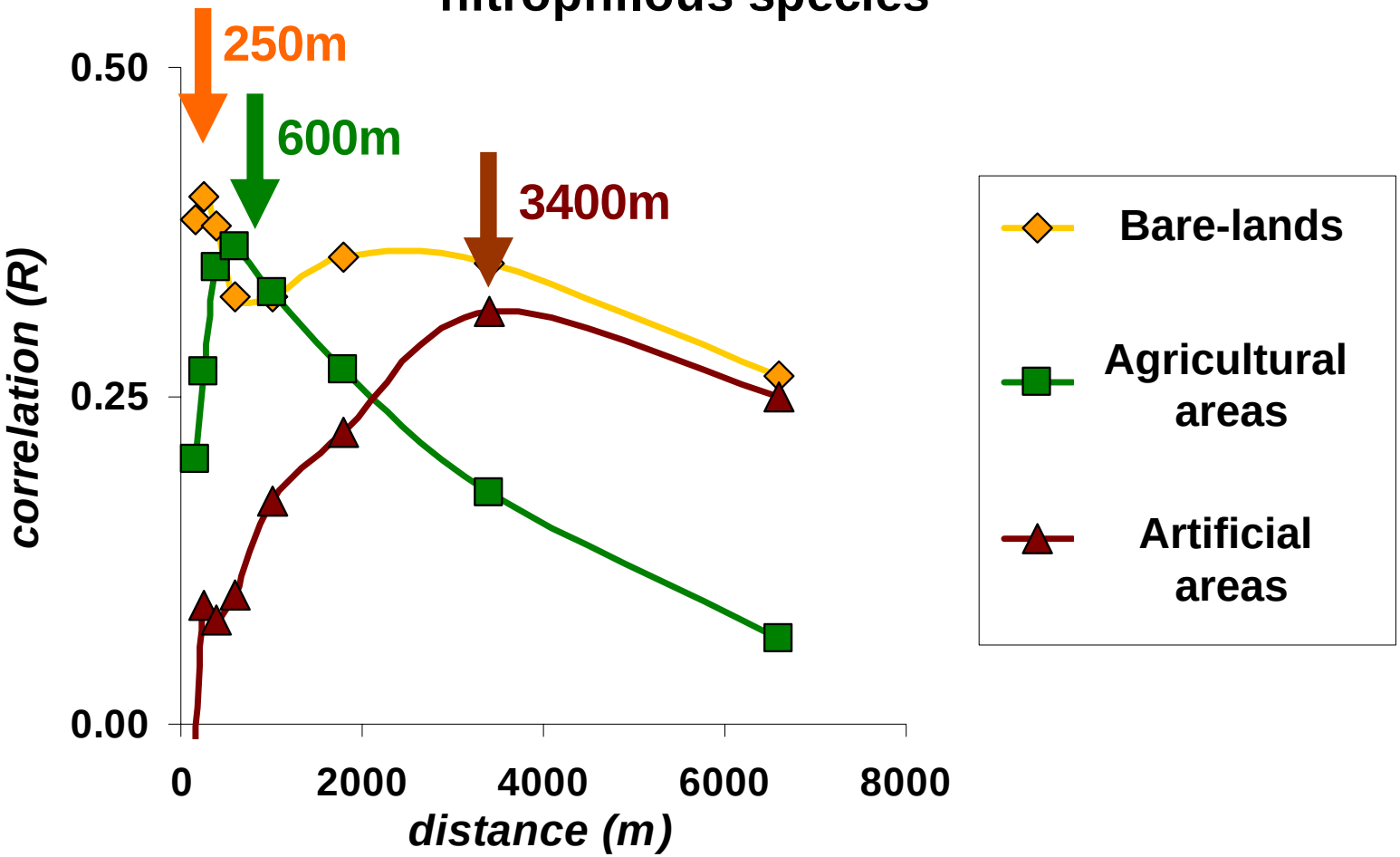



Land-cover influence nitrophilous species;

Two different areas within the territory;

Nitrophilous species



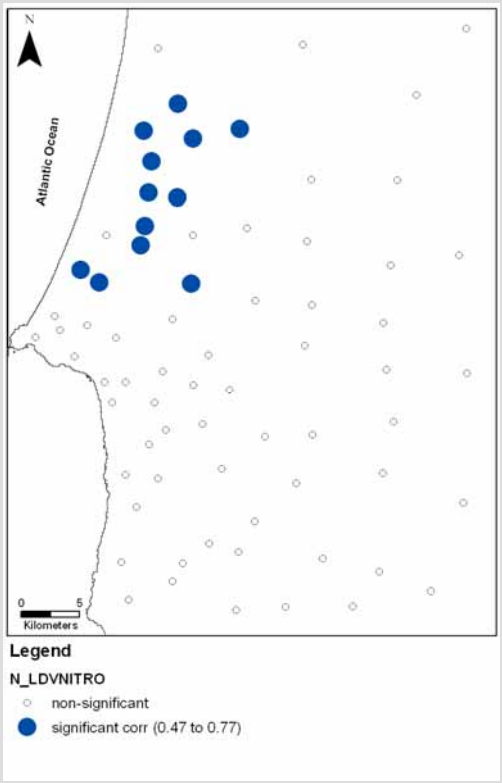
# Lichen Biodiversity

# vs.

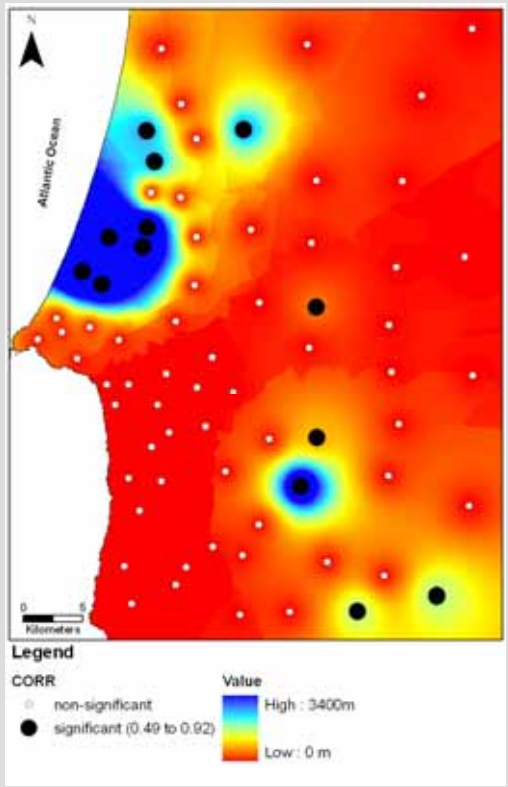
# Elements concentration (and land-cover)

Relating elements to nitrophilous lichens and land-cover – [N]

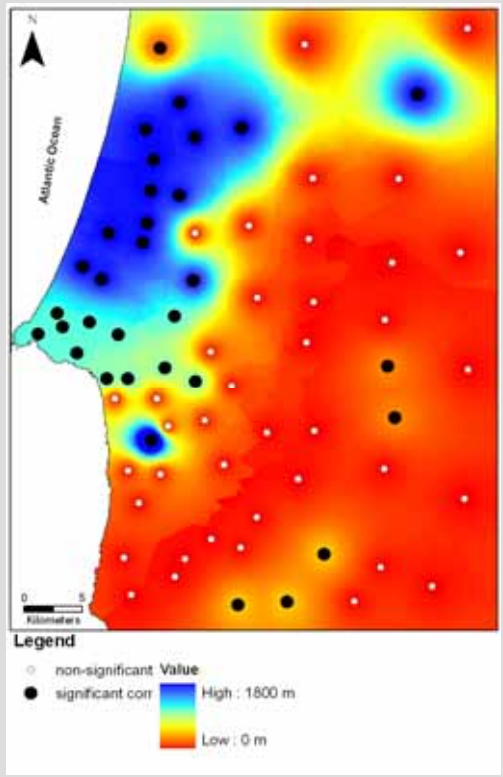
**[N] vs nitrophilous**




**[N]/agricultural areas**



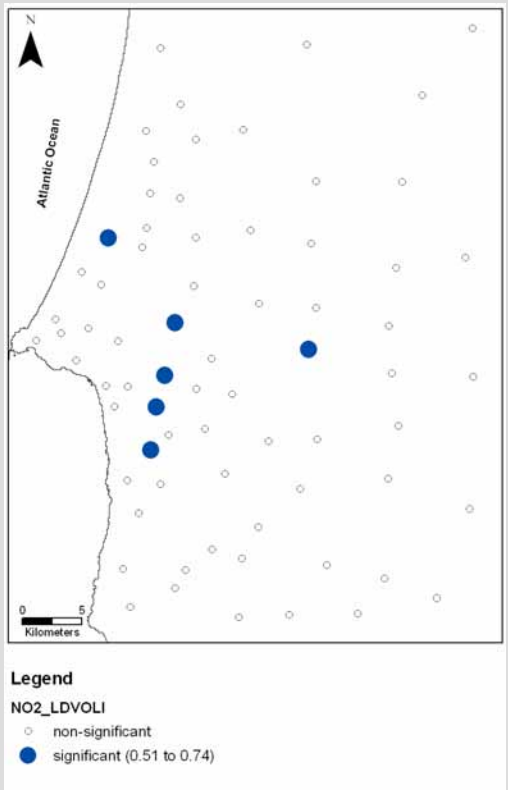

***Annual Cultures vs nitrophilous***



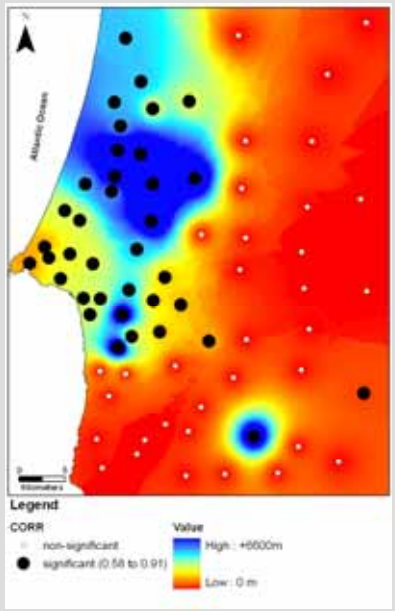

Agricultural areas explain the northern variation of nitrophilous species

Relating elements to nitrophilous lichens and land-cover- [$NO_2$]

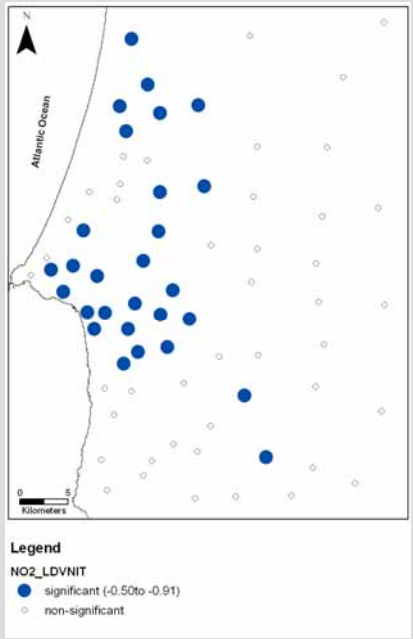
**[$NO_2$] vs nitrophilous**




**[NO2] vs artificial**



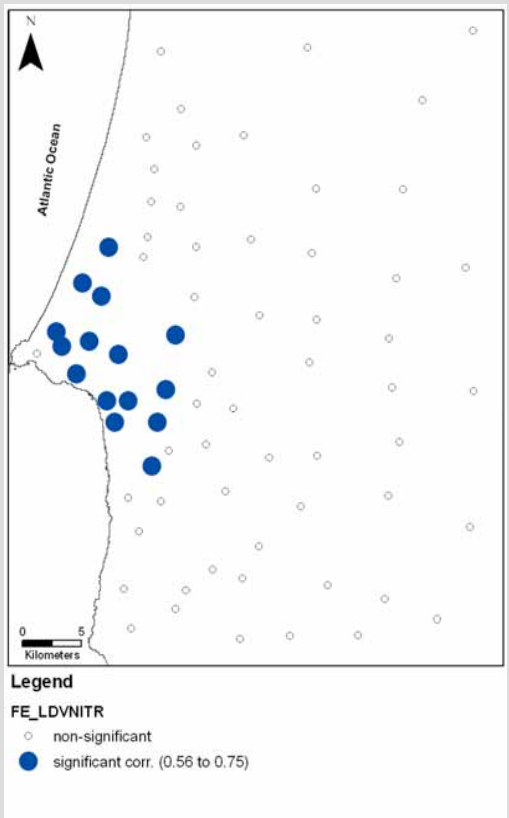

**[NO2] vs non-nitrophilous**



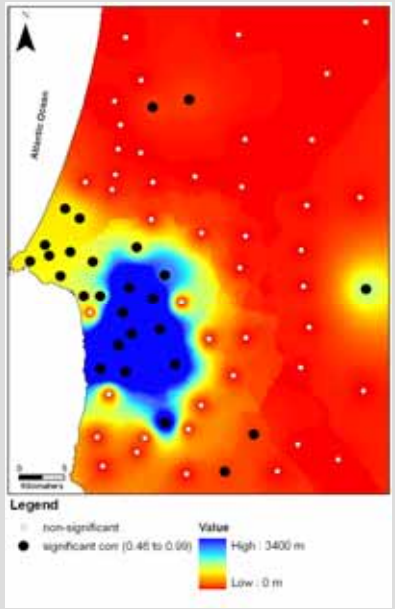

$NO_2$ is not influencing nitrophilous lichens although it can be related to artificial areas

Relating elements to nitrophilous lichens and land-cover- [Fe]

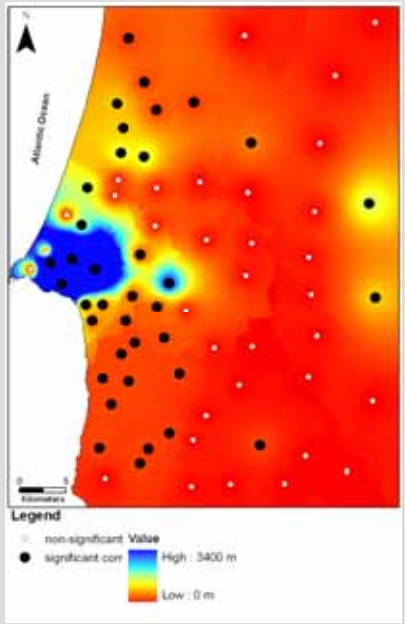
**[Fe] vs nitrophilous**




**nitrophilous vs artificial**




**nitrophilous vs bare-lands**




Fe, and possible other dust particles, are influencing nitrophilous species

- In this region nitrophilous species respond positively to N coming from agricultural areas but also to dust coming from artificial and bare lands areas

- $NO_2$ is related to land-cover, but does not influence nitrophilous species

## Conclusions

- Under low intensity cattle-pasture, nitrophilous species increase, but non-nitrophilous do not disappear

- Under the influence of agricultural areas, nitrophilous species also increase, which was related to increased N supply

- Under the influence of dust, nitrophilous species increase, which is probably related to changes in pH

- The **spatial structure** of nitrophilous species, as well as their distance of influence suggest that, if their are use for biomonitoring (positive indicators), a **narrow grid** should be used.

- Under Mediterranean climate two causes for nitrophilous species changes must be considered: **increased N supply** and **influence of dust**.

## Acknowledgments

Portuguese Science and Technology Foundation (FCT-MCTES) for PhD grant SFRH/ BD / 17880/ 2004

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BioAssess project