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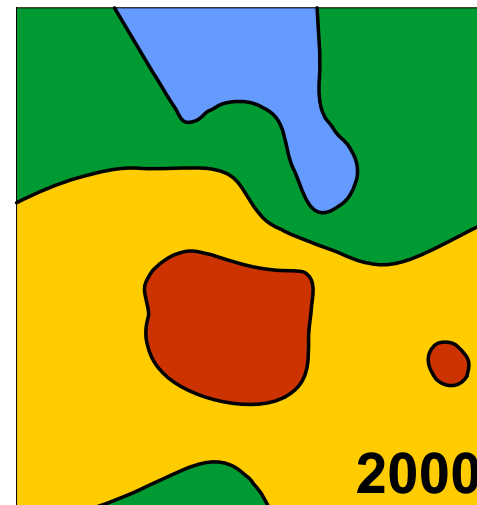
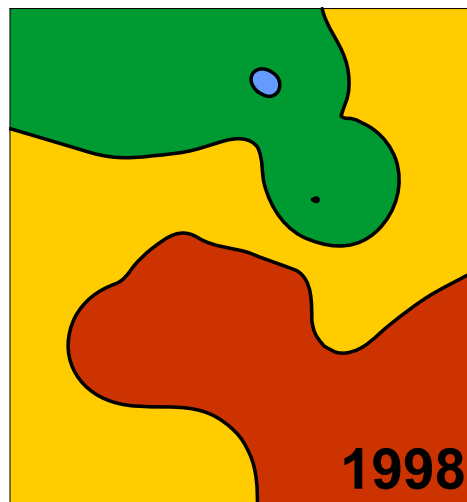
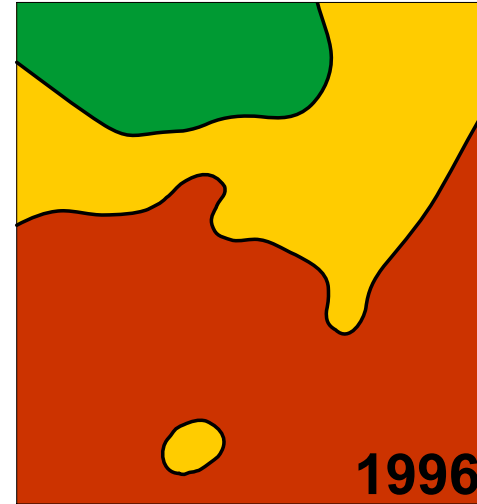
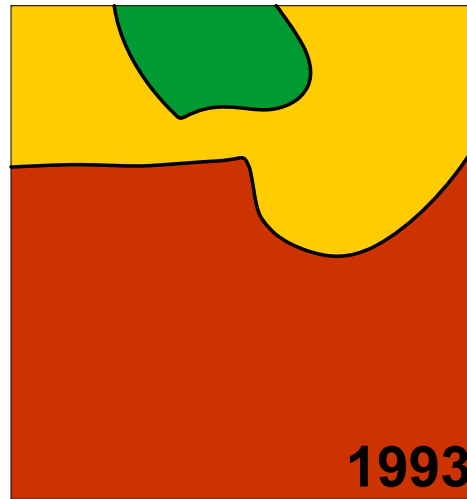
# **LICHENS AS BIOMONITORS OF THE EFFECTS OF REDUCED NITROGEN IN THE MEDITERRANEAN AREA**

**S. Loppi<sup>1</sup>, S. Munzi<sup>1,2</sup>, L. Paoli <sup>1,2</sup>, L. Frati<sup>1</sup>, S.A. Pirintsos<sup>2</sup>**

***<sup>1</sup>University of Siena, Italy - <sup>2</sup>University of Crete, Greece***

# lichen recolonization

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# lichens and ammonia

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# signal-to-noise ratio

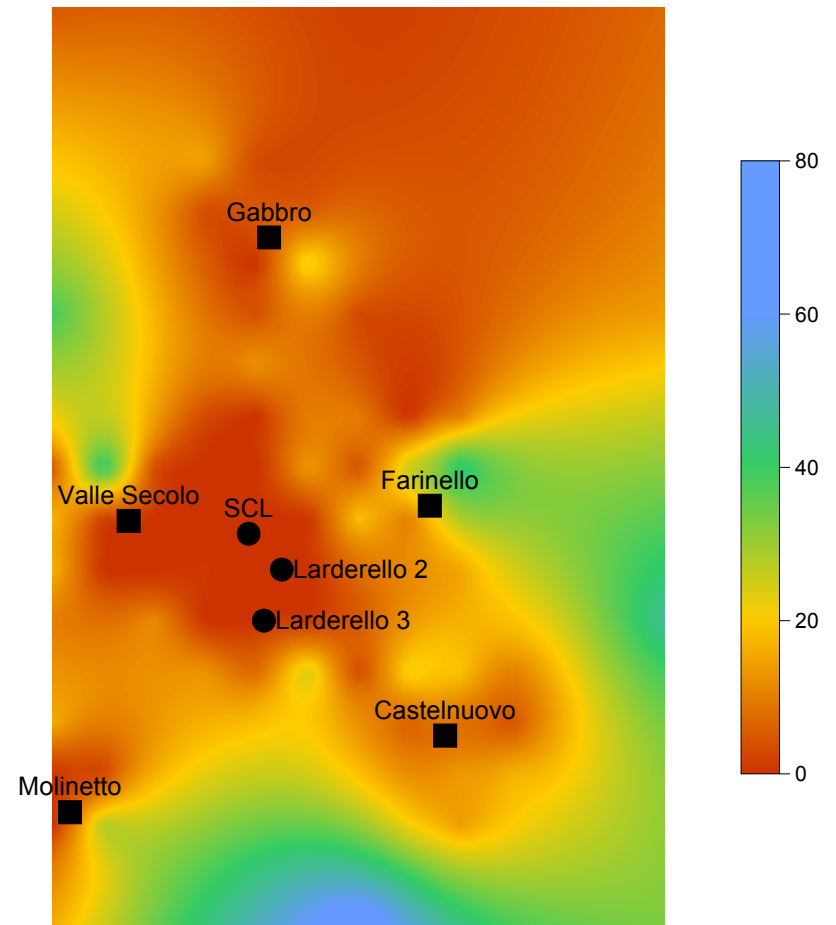
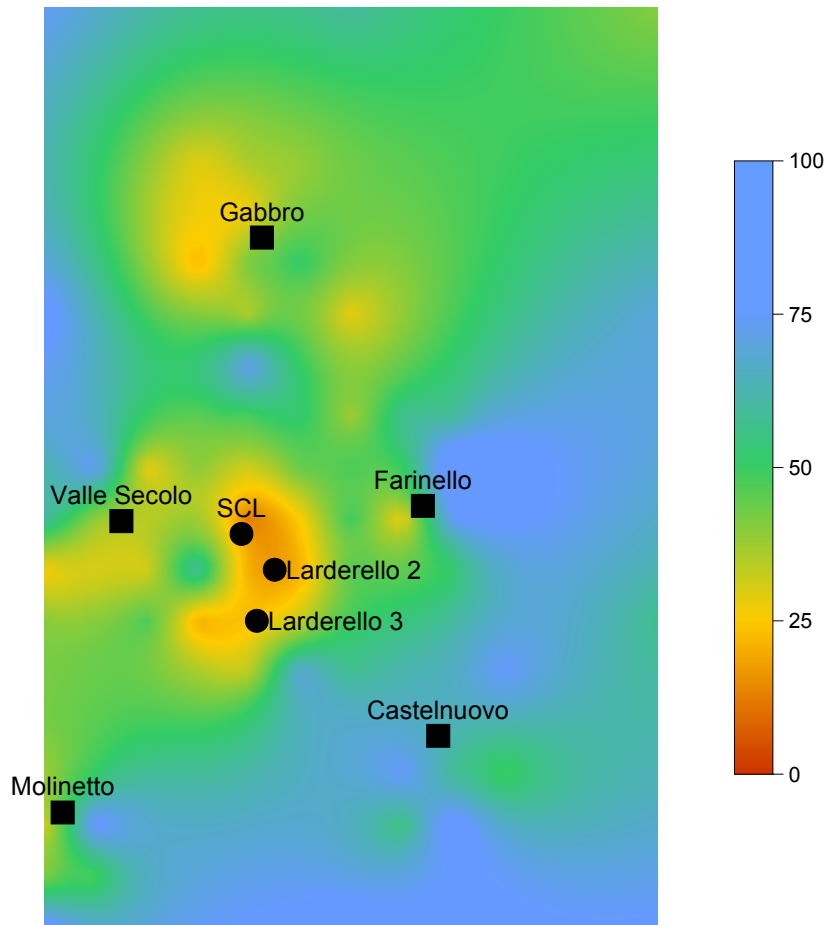
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a measure of **signal** strength  
relative to background **noise**

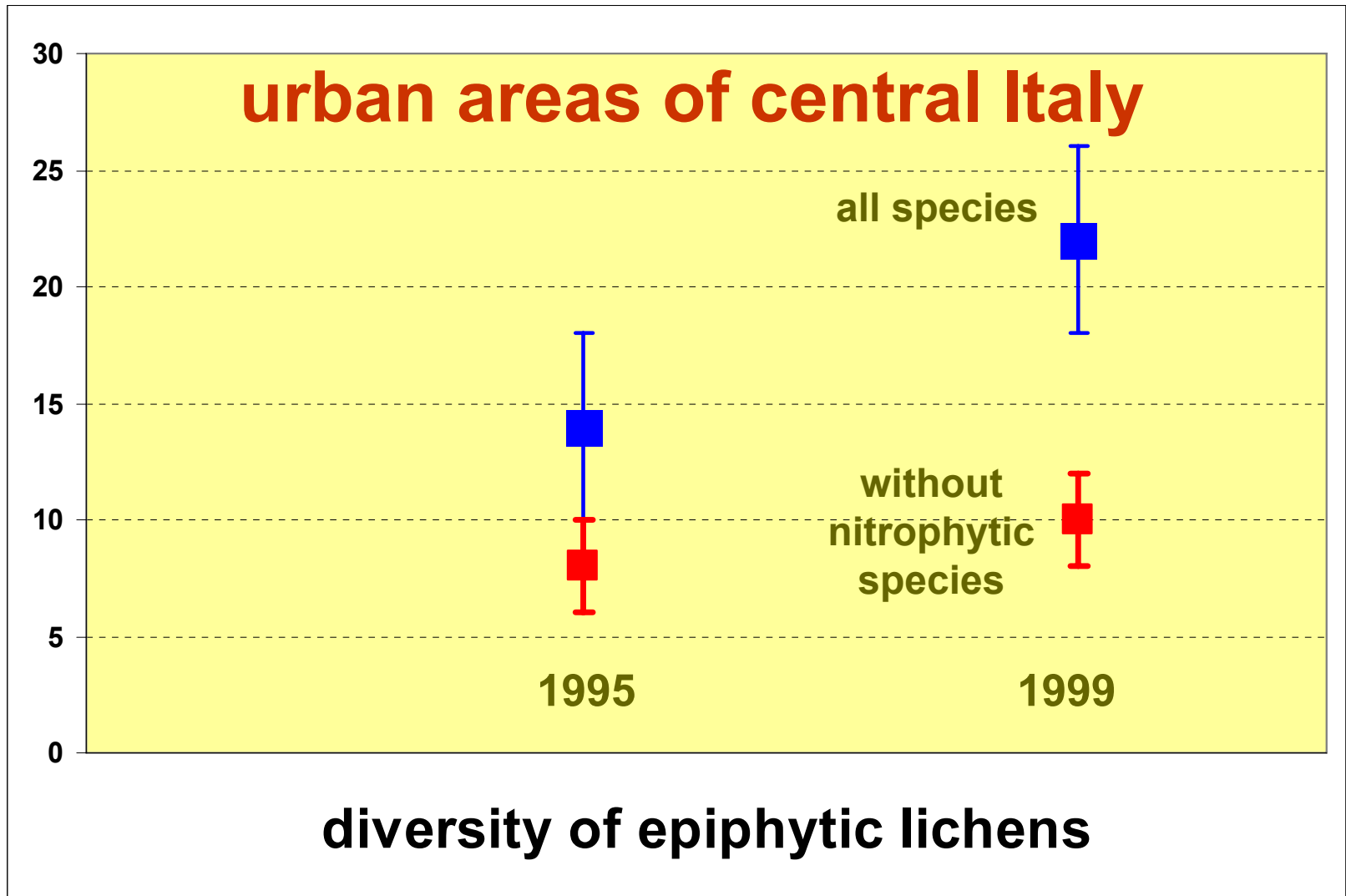
## IN LICHENOLOGICAL TERMS...

influence of **sensitive/favoured**  
species (**indicator species**) compared  
to **resistant/tolerant** species

# nitrophytic species

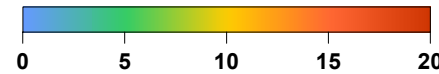
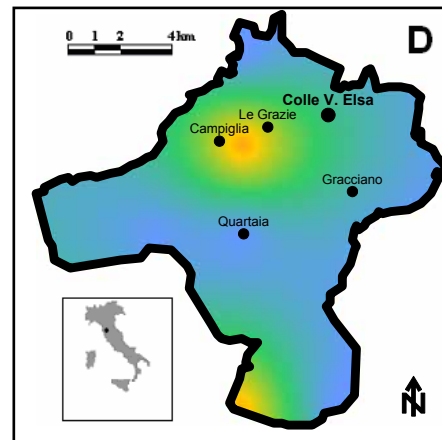
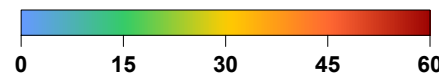
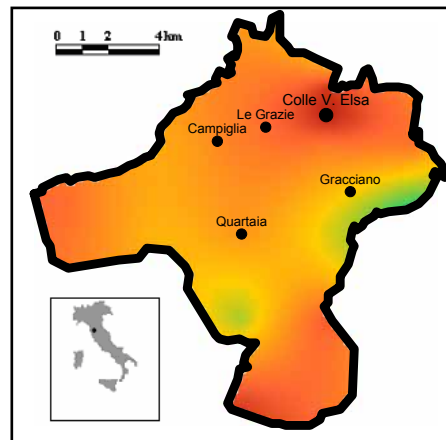
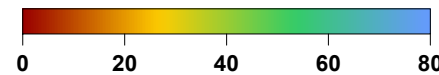
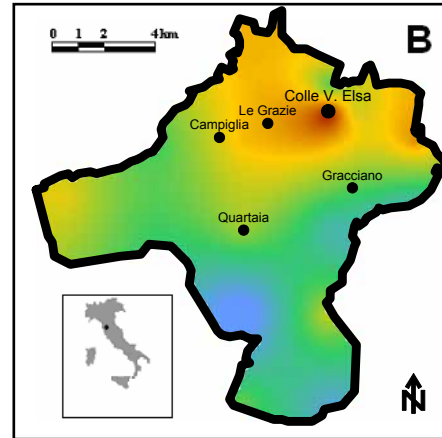
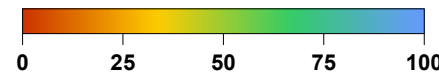
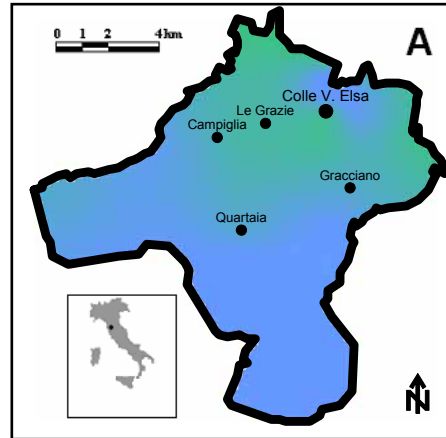


# nitrophytic species





# nitrogen and ammonia



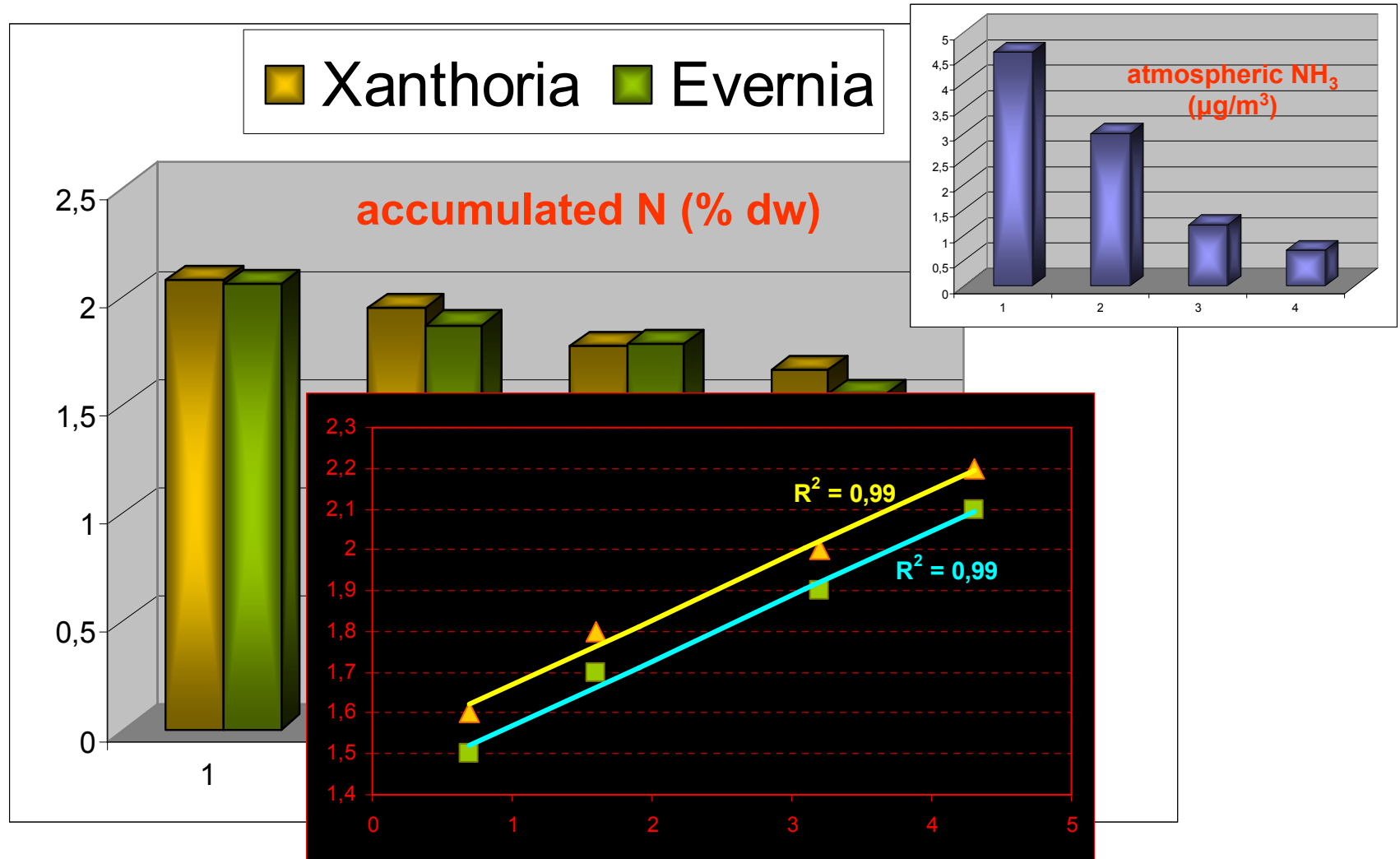
# nitrogen and ammonia

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# nitrogen accumulation



# effects of ammonia

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# effects of ammonia

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pig stockfarm ( $>250 \mu\text{g}/\text{m}^3$ )

control ( $<1 \mu\text{g}/\text{m}^3$ )



**N-sensitive *Evernia prunastri***

# effects of ammonia

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pig stockfarm ( $>250 \mu\text{g}/\text{m}^3$ )



control ( $<1 \mu\text{g}/\text{m}^3$ )



**N-tolerant *Xanthoria parietina***

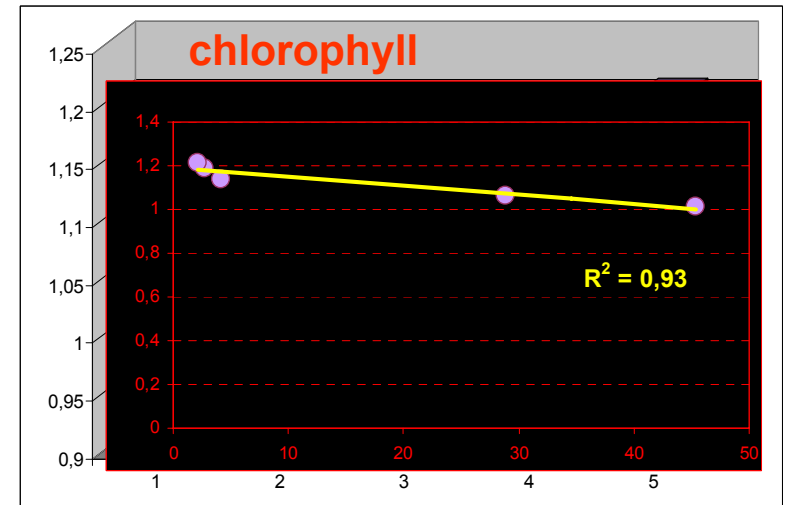
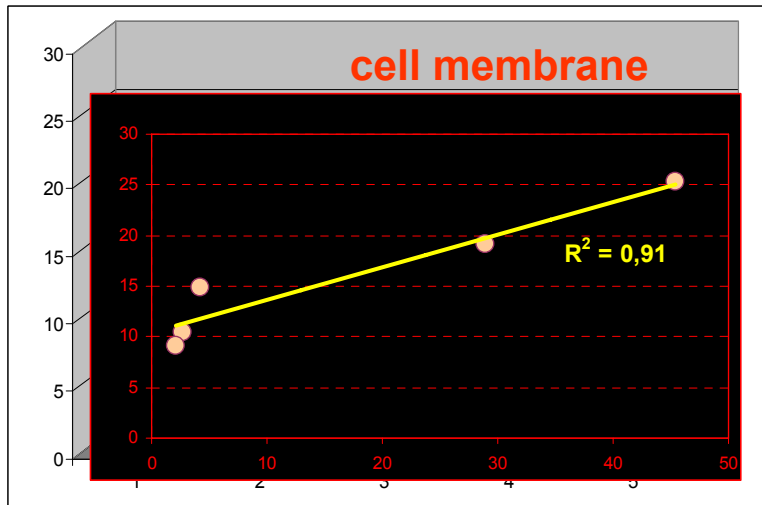
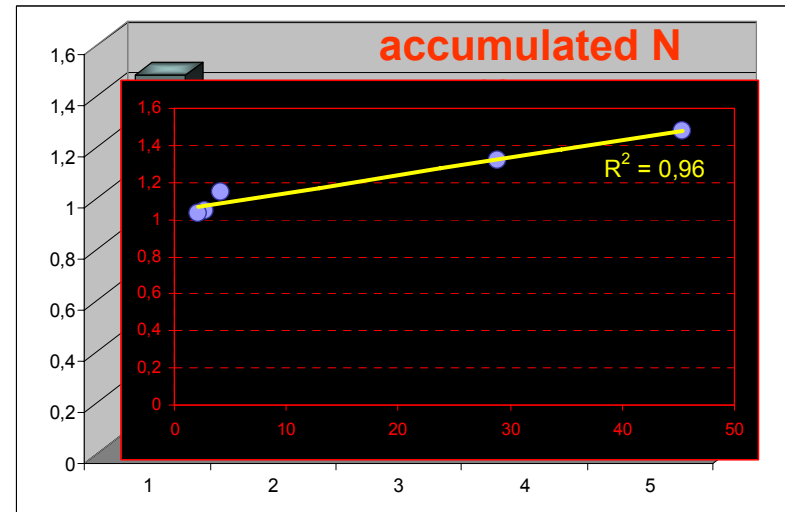
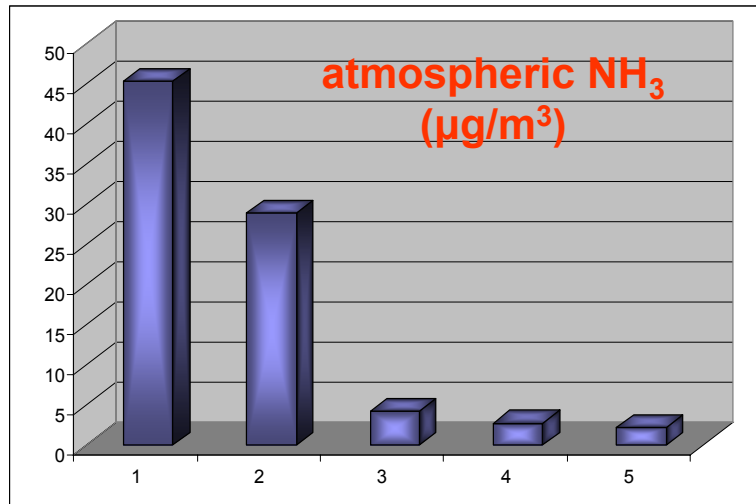


# effects of ammonia

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# effects of ammonia

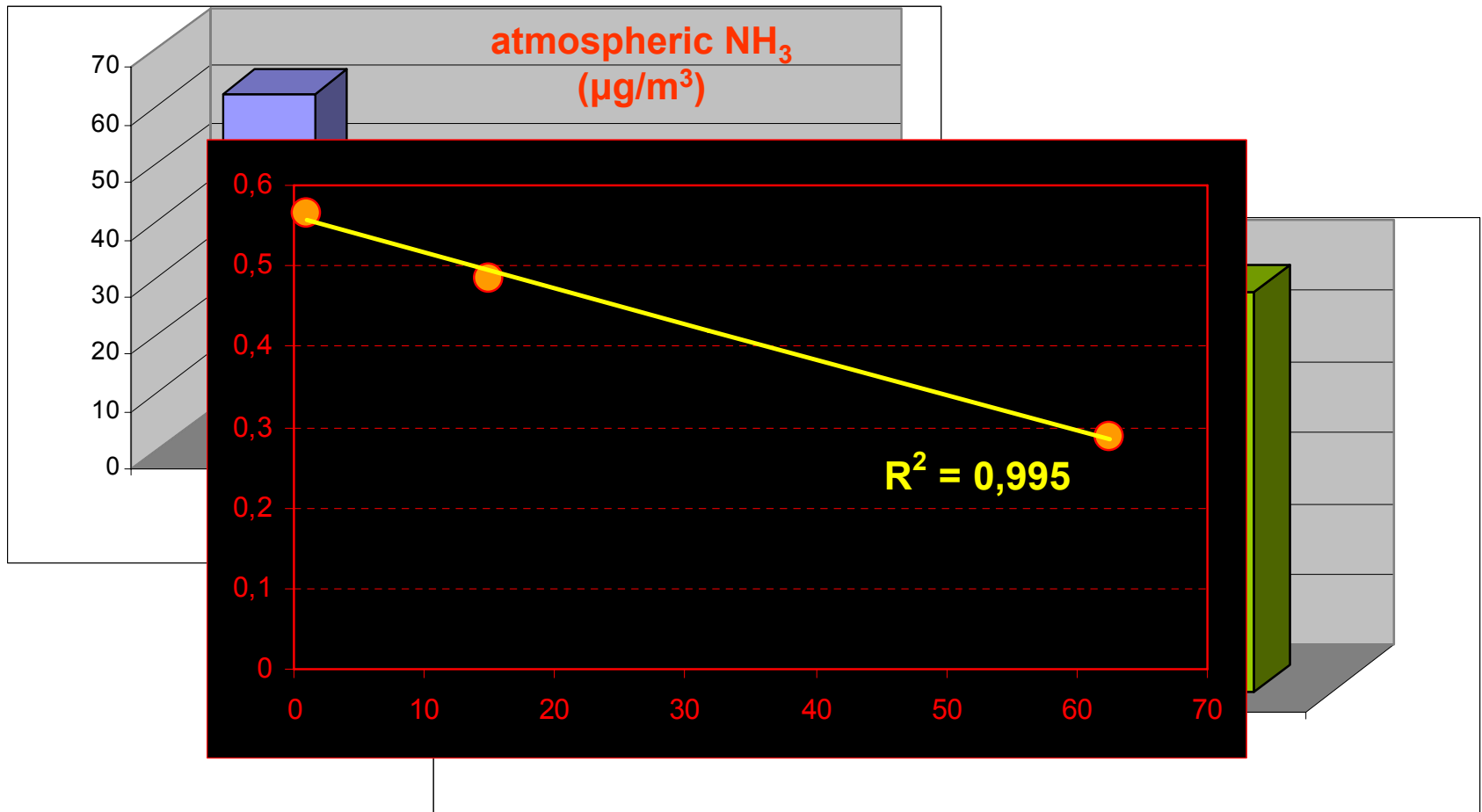


# effects of ammonia

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# effects of ammonia



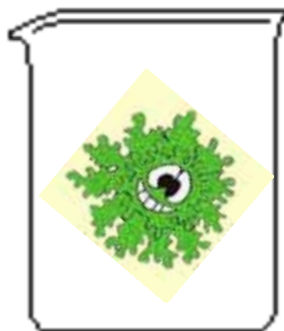


# effects of ammonium

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Our laboratory experiments suggest passive  $\text{NH}_4$  uptake by *E. prunastri* thalli through a mechanism of ionic proton exchange.

Cell membrane damage occurs at  $\text{NH}_4$  concentrations as low as 10 mM.



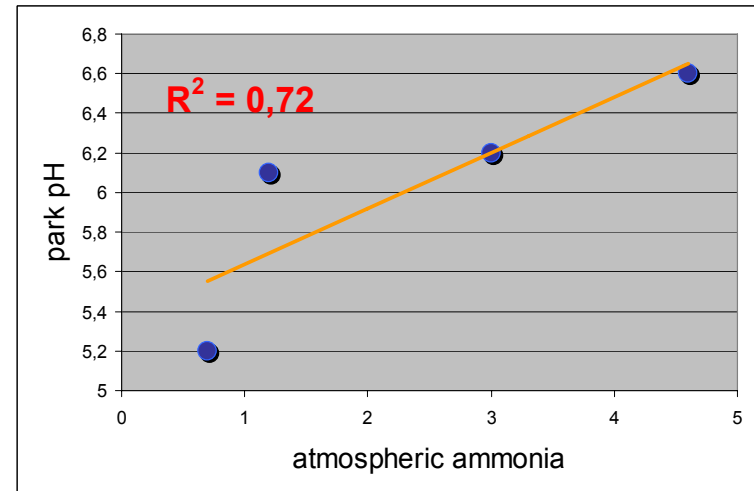
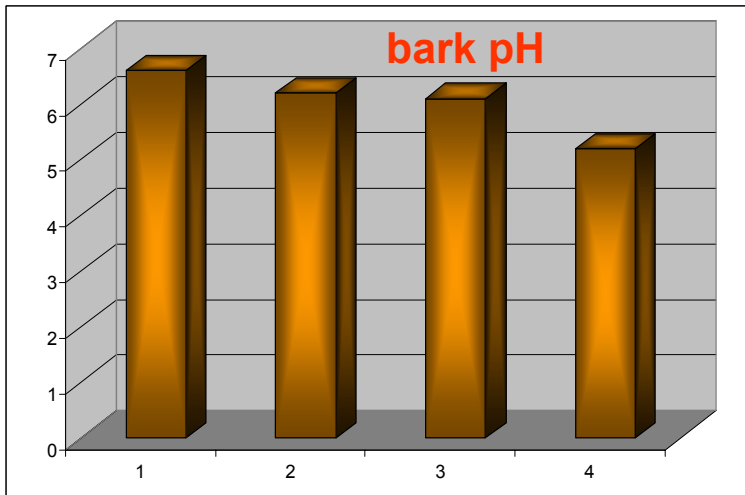
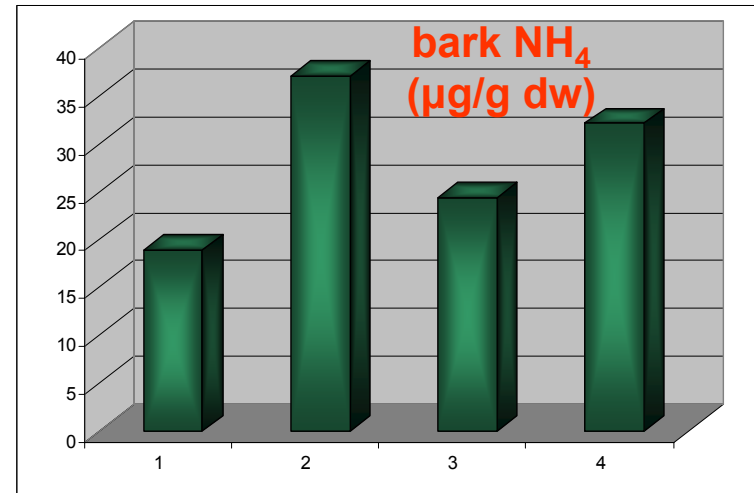
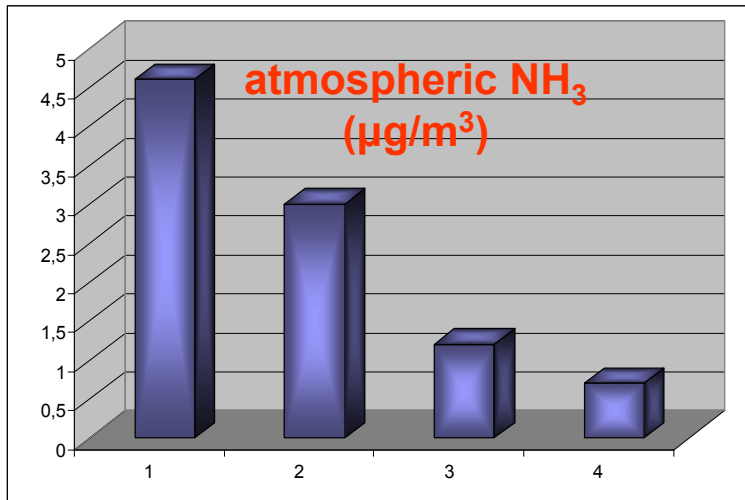
# effects of ammonium

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Photosynthetic efficiency of *E. prunastri* was impaired by high ammonium concentrations, while nitrate had no effect; *X. parietina* was hardly influenced by nitrogen compounds. External supply of polyamines drastically reduced the sensitivity of *E. prunastri*, while external supply of polyamine inhibitors reduced the tolerance of *X. parietina* to  $\text{NH}_4$ , suggesting that polyamines play a very important role in modulating the sensitivity or tolerance of lichens to N stress.



# action of ammonia



# effects of light

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# effects of alkaline dust

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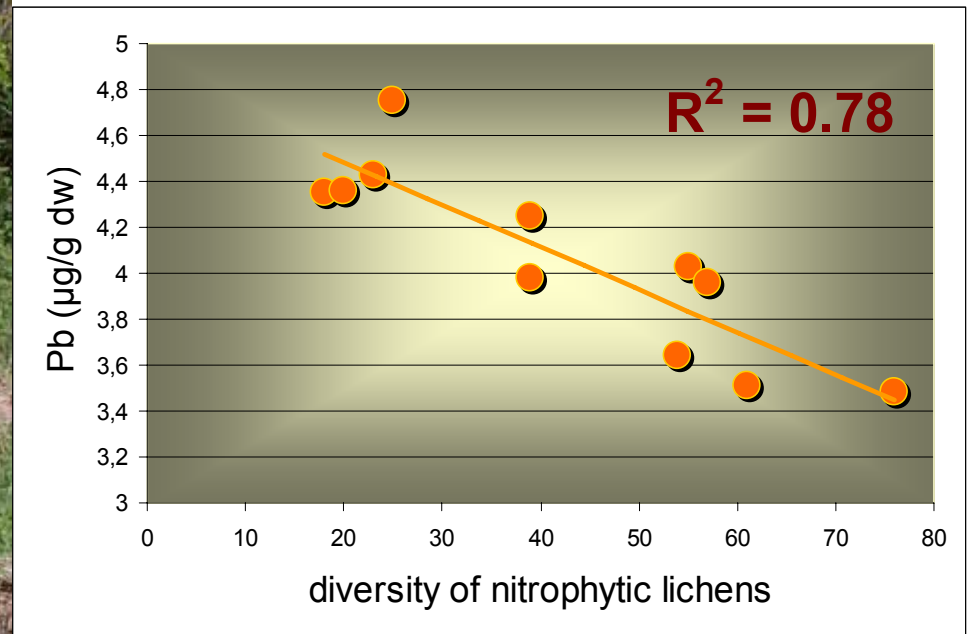


# future research

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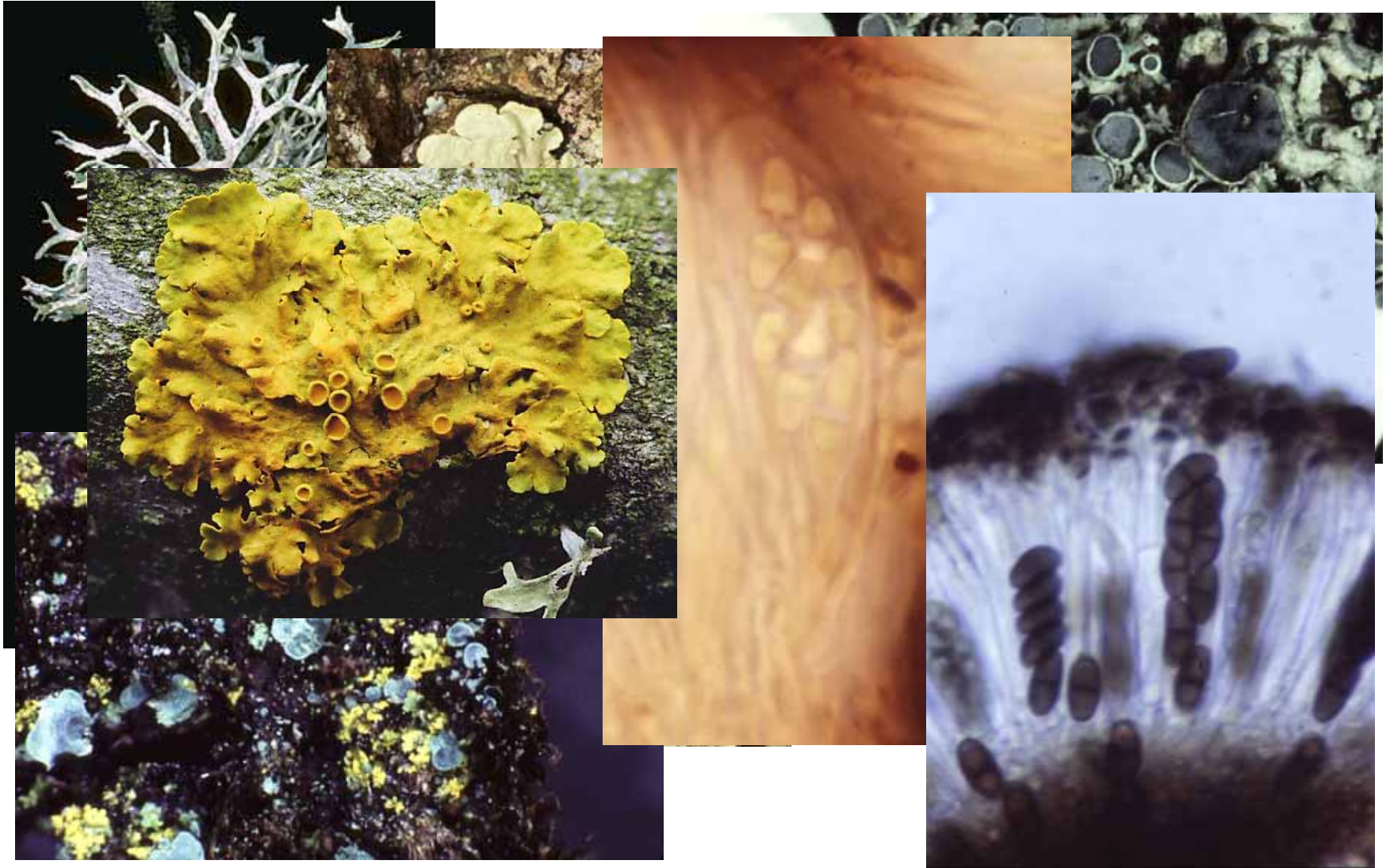
- checking the role of carbonates (alkaline dust)
- checking the effects of  $\text{Ca}^{2+}$  in saturating ionic exchange sites
- tracing N sources and accumulation using  $^{15}\text{N}$  and  $\delta^{15}\text{N}$  signatures

# future research





# conclusions





# thank you!

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