EGU2020-6849: Comparing the fate of N from fertilizer treatments and root litter turnover in a Mediterranean Savanna

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We compare the short-term fate of ^{15}N from fertilizers (commonly used as ^{15}N tracers) and litter (the main source of plant-available N almost everywhere) in two ecosystem stoichiometry experiments in a Mediterranean Savanna.

Habitat- and treatment- driven contrasts differ between methods, indicating changes in the functioning of the soil-plant loop rather than the specific acquisition of mineral N. This affects how we should interpret ^{15}N tracer experiments, particularly where mineral N additions are used as a source.

Most plant nitrogen uptake is from N turnover but most N cycling experiments use mineral ^{15}N

In this display we compare two ^{15}N tracer experiments investigating

1. **the fate of conventionally applied fertilizer ^{15}N**
2. **^{15}N applied as dead root biomass**.

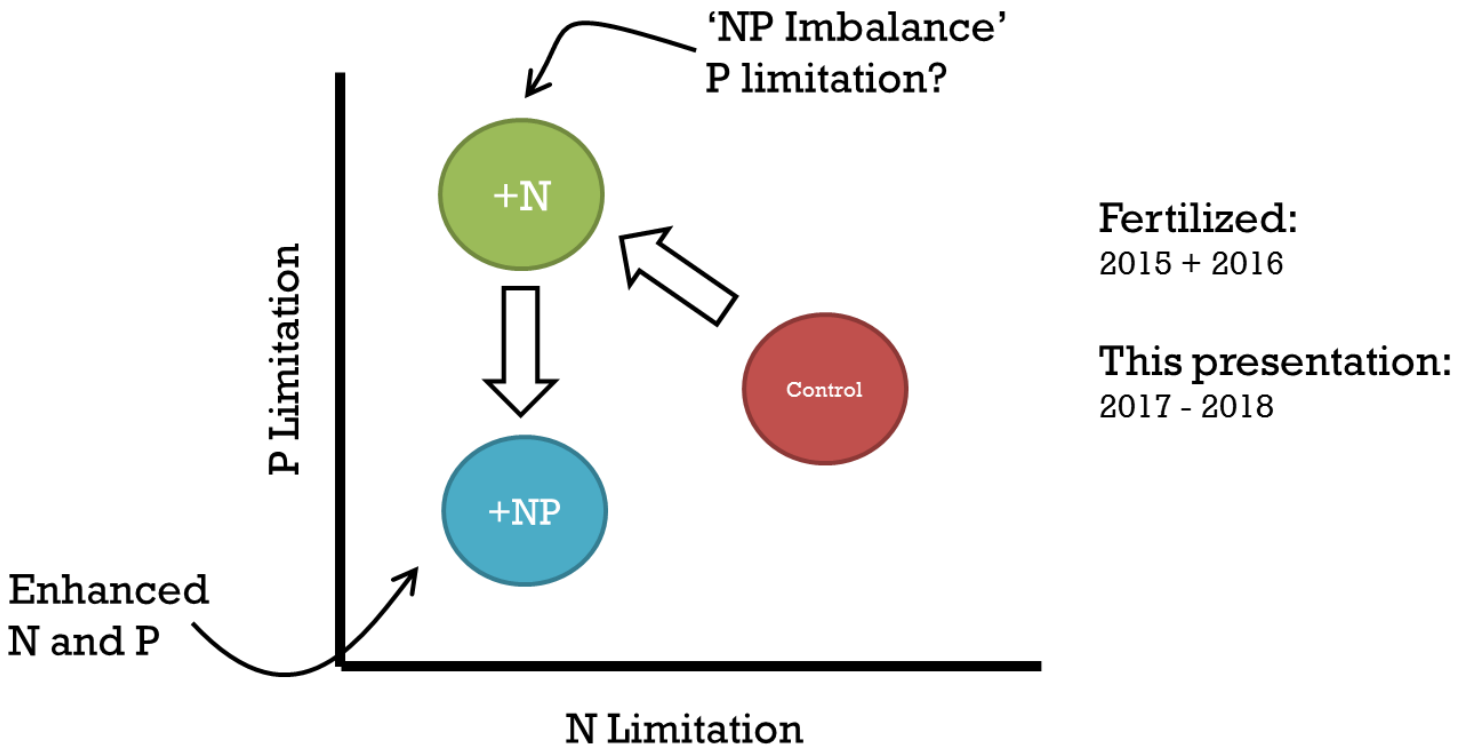
We work in N+P fertilization experiment in a Mediterranean ‘dehesa’ ecosystem.

N deposition affects short term N availability as well as long term N pools in biomass.

The shift from N to P limitation affects ecosystem functioning and ultimately their role in global C cycling.

Are there differences in N partitioning from fertilizers and litter turnover?

MANIP experiment: Altering ecosystem stoichiometry through one-off fertilization



Fertilized:
2015 + 2016

This presentation:
2017 - 2018

N additions shift to a 'N:P Imbalance, NP additions should maintain N:P stoichiometry

Majadas de Tietar is a typical spanish 'dehesa'

We fertilized Majadas de Tietar for the MANIP experiment in 2015-2016, here we show sub-experiments from 2017-2018

- Seasonally dry with a hot, biologically inactive summer and mild, wet winters
- Distinct microhabitats ('**under canopy**' (Quercus Ilex) and '**open pasture**') with characteristic herbaceous communities, and soil fertility.
- Root-shoot ratios tend to be very large
  - So **root litter is the main internal litter source**.

- 'Under canopy' microsites are 'islands of fertility' with higher biomass and more litter and nutrients and distinct herbaceous communities

- The growing season is approximately October to May. Litter remains from one growing season to the next, as moisture limits decomposition, but otherwise turnover of herbaceous litter is rapid.

- Surface soils in 'Open grassland' microsites are wetter in winter and drier in summer due to the lack of tree root influence and hydraulic redistribution.

- Open grasslands also tend to be less fertile (due to less litter inputs)

Two experiments

We show recovery for both experiments in plants and soil in May (at the end of the growing season) and November/December (at the start of the next growing season) of the following year. The experiments are not directly paired but are comparable.

❶ MINERAL TRACER

- Initiated early March
- ^{15}N-ammonium nitrate applied to small plots in coordination with fertilization
- 'True control' not possible as cannot fertilize ^{15}N without N
- Sample 5 cm topsoil for ^{15}N recovery in plant, soil mineral pools

❷ ROOT LITTER TRACER

- Initiated mid December
- Labelled biomass applied in 'ingrowth cores' in pre-fertilized areas
- Chronic ^{15}N release from decomposition
- Sample 13cm ingrowth core for ^{15}N recovery in plant, soil mineral pools

1 Fertilizer ^{15}N ↑recovery in N-limited grassland sites

Morris 2019, Ecosphere

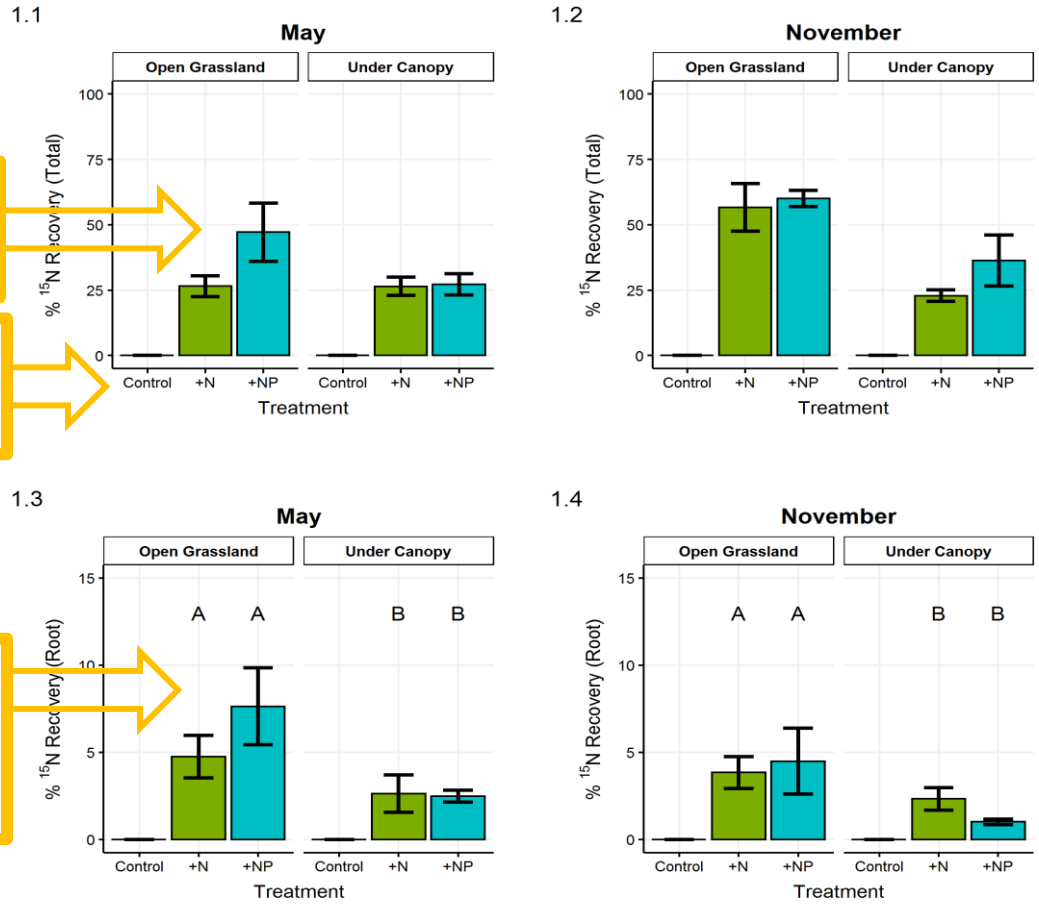
^{15}N added as ammonium nitrate

- Most common form of N tracer application
- Representative of deposition or fertilizer *inputs*
- Relatively logistically simple to apply in the field

- Only about 25 % ^{15}N recoverable in plant and soil system
- Few consistent treatment effects*
- Open grasslands = more N limited, more competitive for mineral N?

Higher recovery in open grassland than under canopies

No 'control' recovery here (cannot apply ^{15}N without adding N)



No treatment differences in plot-level root recovery
Open grasslands = higher recovery
(Similar trends in foliage, not shown)

2 Root litter ^{15}N: ↑recovery under canopies and +NP treatment

Nair *in review*

^{15}N added as root litter

- Logistically complex to produce litter and apply in realistic conditions
- More representative of the main N source in real ecosystems

Stronger **root recovery** in +NP treatment - induced N limitation via N leaching?

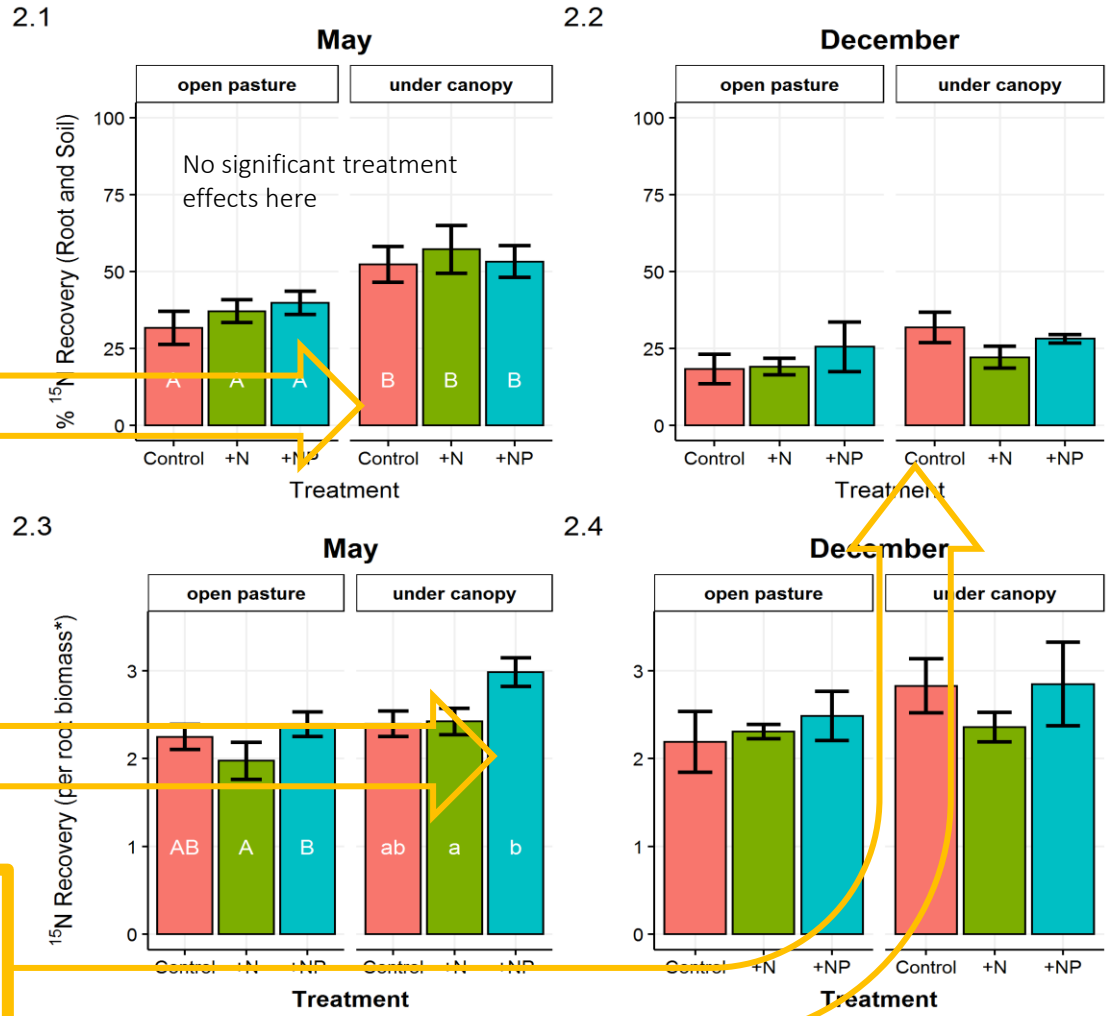
Canopy microsites more of this N, reversing previous habitat trend

- Up to 60 % ^{15}N recoverable in plant and soil *belowground only*
- Detectable +NP treatment effect
- Canopy microsites better at recycling litter N?

More **total tracer** recovery in under canopy microsites
Generally **higher short-term recovery** than previous experiment

Higher recovery in roots under canopies
More ^{15}N Recovery per root mass, particularly in +NP

Treatment differences lost by December
(^{15}N-litter has fully turned over?)
Lower next-season recovery than mineral tracer (due to mineral pulse in frass, or discounting above-ground biomass?)



* We show root ^{15}N recovery normalized by root mass as variable per-core mass confounds results

Nitrogen Source Matters for Predicting Ecosystem Response

❶ MINERAL TRACER

- More recovery in nutrient limited, OPEN GRASSLAND micro sites
- Limited treatment effects
- Adding ‘balanced’ N and P is not affecting the partitioning of the mineral tracer in plants (mineral N is rapidly consumed by microbial pools?)

❷ ROOT LITTER TRACER

- More recovery in organic-rich UNDER CANOPY microsites
- +NP leads to increased plant recovery of ^{15}N from litter – increasing uptake of decomposition products
- Adding ‘balanced’ N and P is leading to N limitations (due to N leaching?), affecting plant investment into N uptake?

Nitrogen Source Matters for Predicting Ecosystem Response

- There are very few labelled litter experiments without litterbag artefacts (see exceptions here) and almost no comparisons against common mineral tracers in the field
- Fertilizer tracers may underestimate responses, and in our case reverse the observed habitat effect

- **Induced N:P imbalance may affect internal N recycling more than short-term partitioning of mineral tracers**

More details?

Mineral tracer experiment: *Morris, K. A., Nair, R. K. F., Moreno, G., Schrumpf, M., Migliavacca, M.* (2019): Fate of N additions in a multiple resource-limited Mediterranean oak savanna. *Ecosphere* 10.

Labelled litter experiment: Nair et al (in review)

Direct paired comparison in a different system: *Nair, R. K. F., Perks, M. P., Mencuccini, M.* (2017): Decomposition nitrogen is better retained than simulated deposition from mineral amendments in a temperate forest. *Global Change Biology* 23, 1711–1724.

MANIP Project Webpage: https://www.bgc-jena.mpg.de/bgi/index.php/Research/Manip

MaNiP

MARIE CURIE ACTIONS

Alexander von Humboldt Stiftung/Foundation

Max Planck Institute for Biogeochemistry