Aussois 2021

Ecological consequences of plant modulation of nitrification
Discussion of its evolution



Photos Patrick Mordelet

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PhD - 1st year

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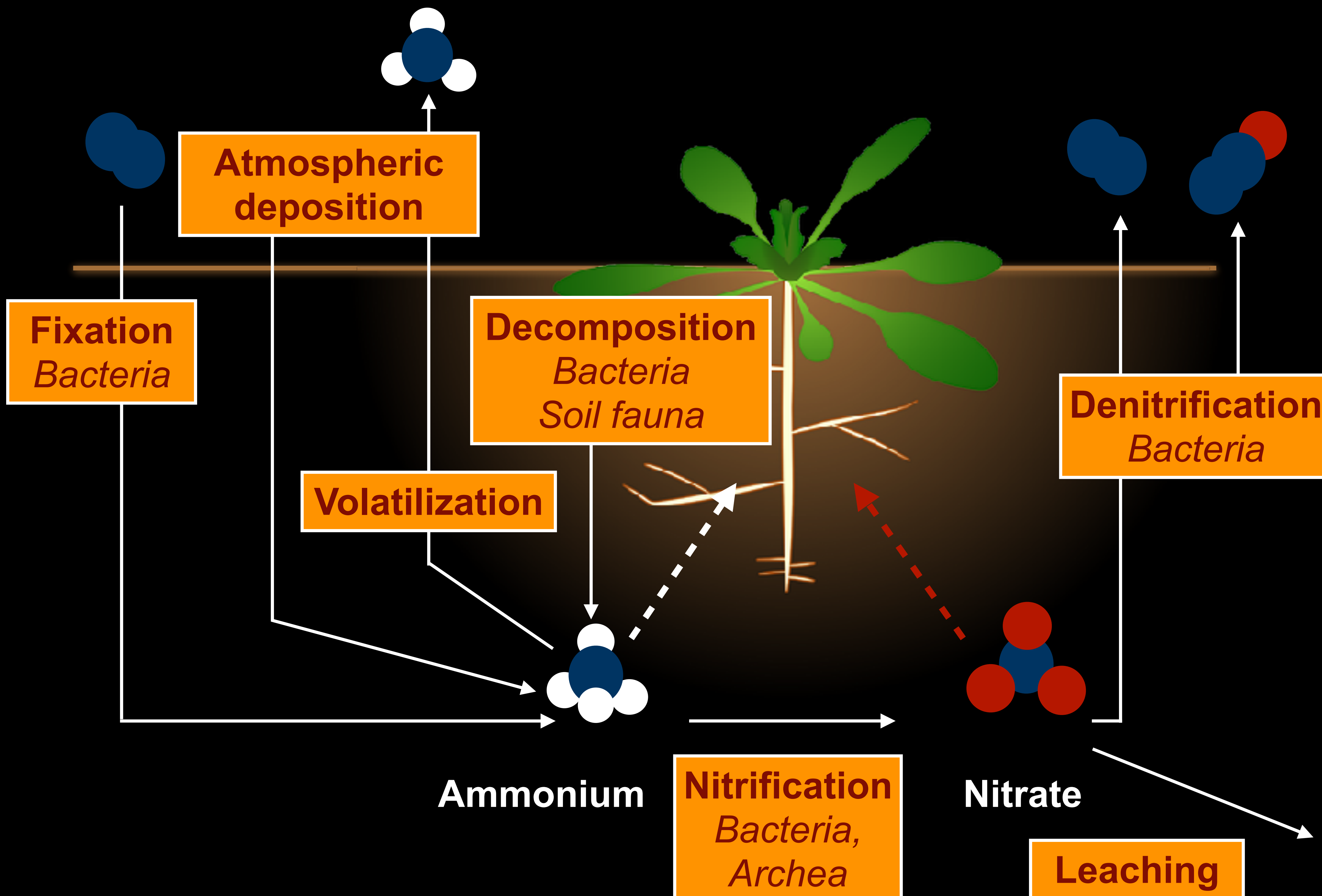
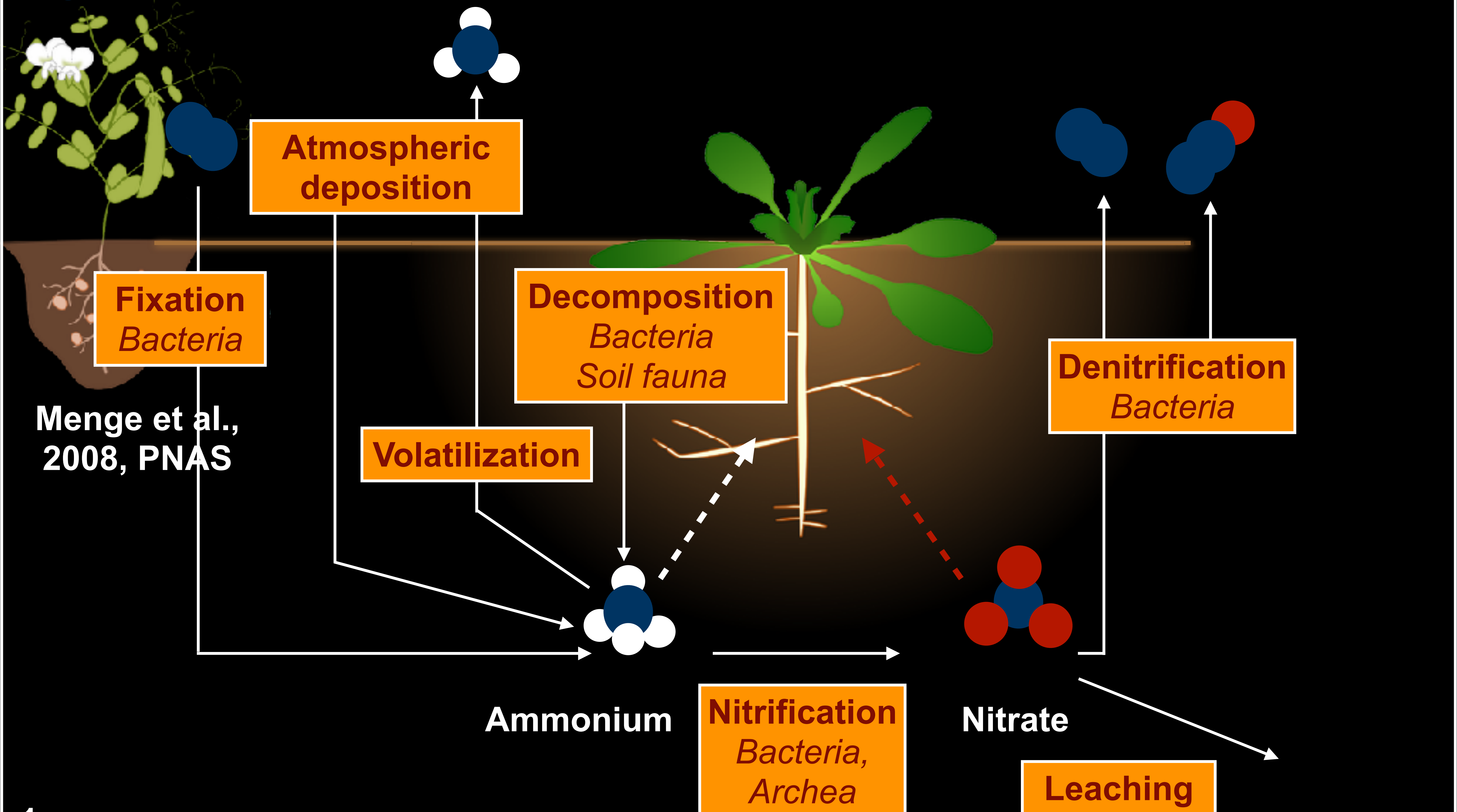
- Nitrogen : first factor limiting plant growth



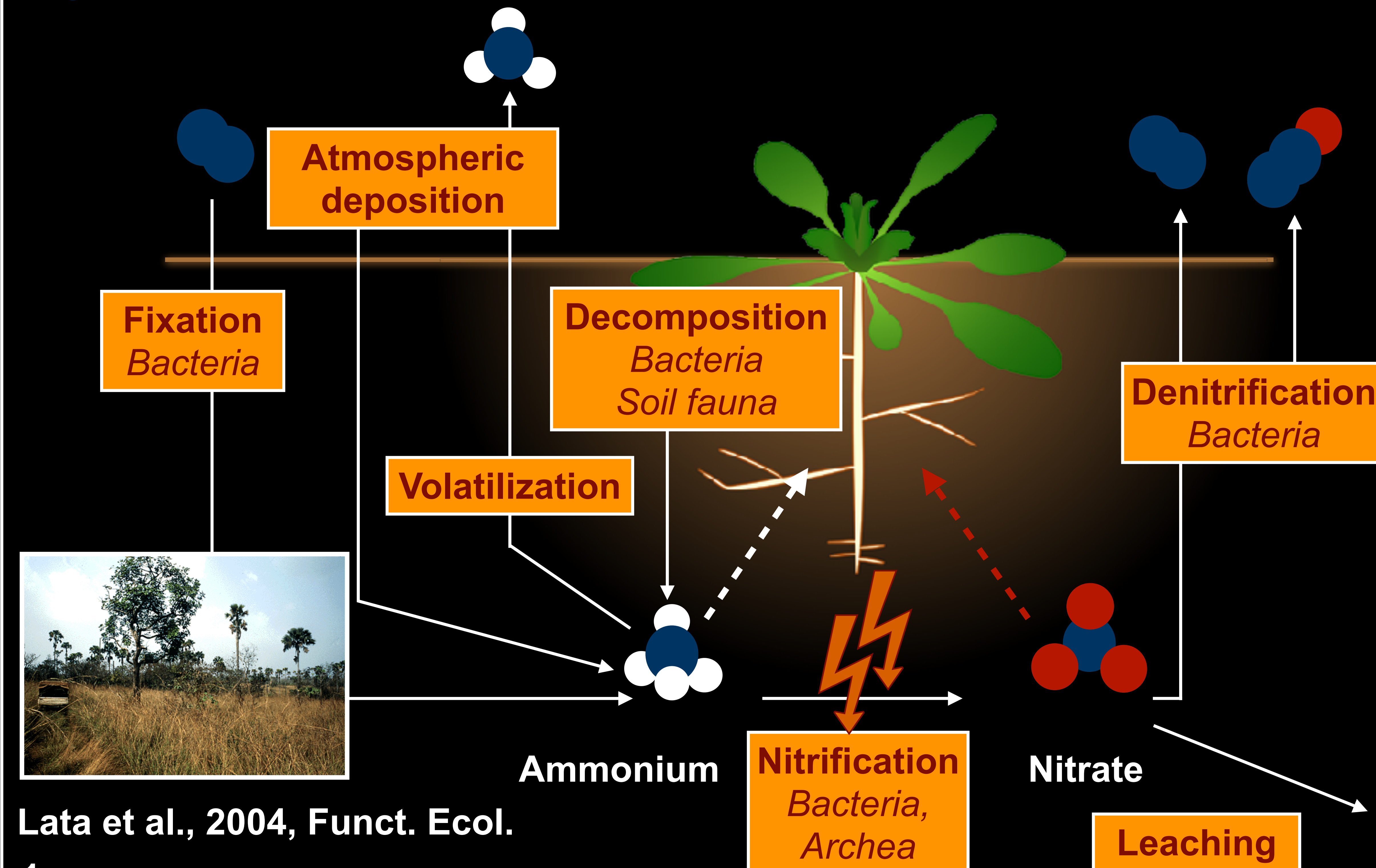
N cycle

- Nitrogen : first factor limiting plant growth



N cycle

- **Nitrogen : first factor limiting plant growth**



Lata et al., 2004, Funct. Ecol.

Savannah : implications

Coexistence :

Konaré et al., 2019, Ecosystems

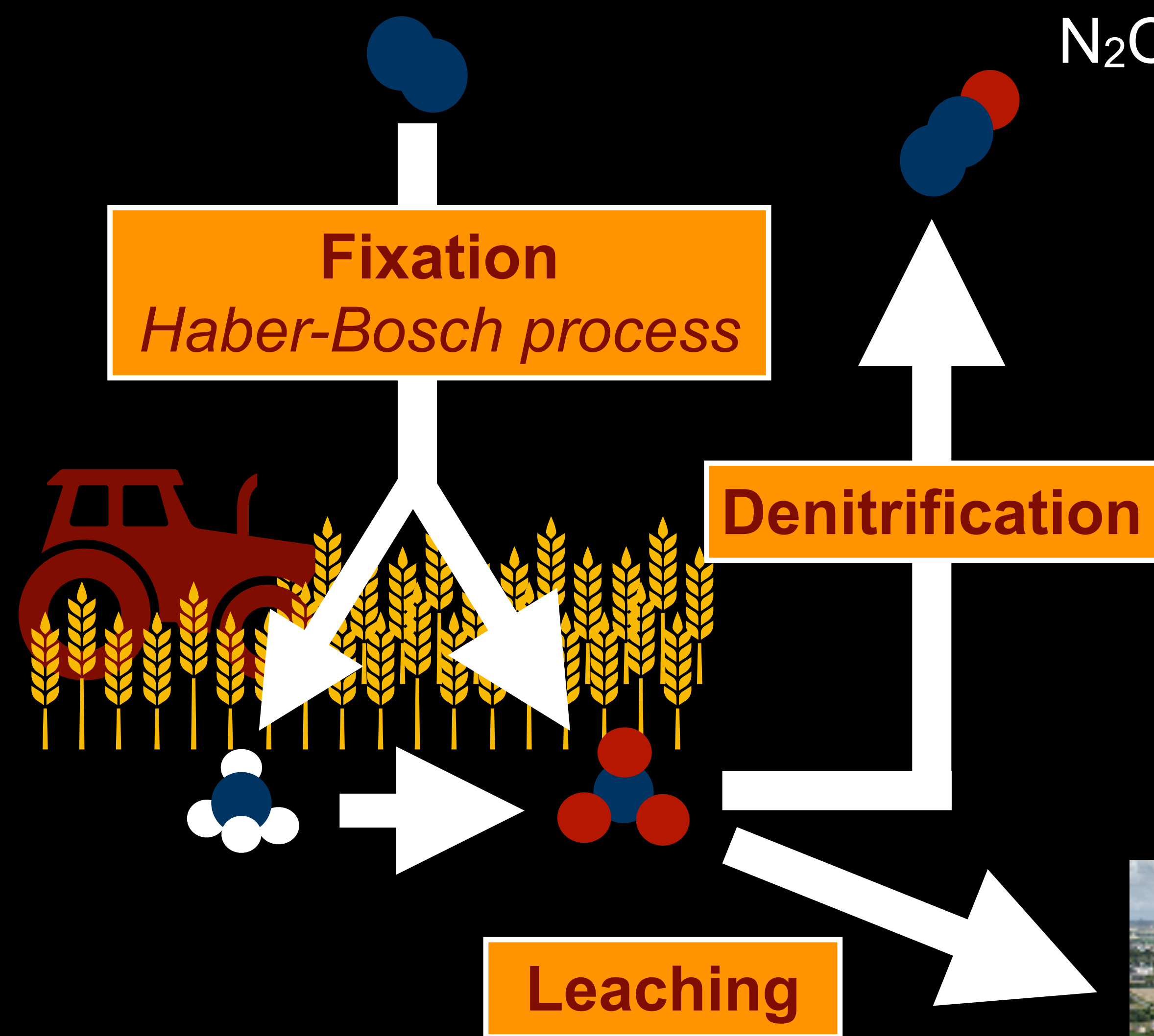
Ecosystem functionning :

Boudsocq et al., 2009, Funct. Ecol.

Agriculture : implications

Coskun et al., 2017, Nature Plants

80% of anthropogenic N_2O emissions



19% of applied fertilizer globally
(up to 50% for cereal)

Agriculture : implications

Coskun et al., 2017, Nature Plants

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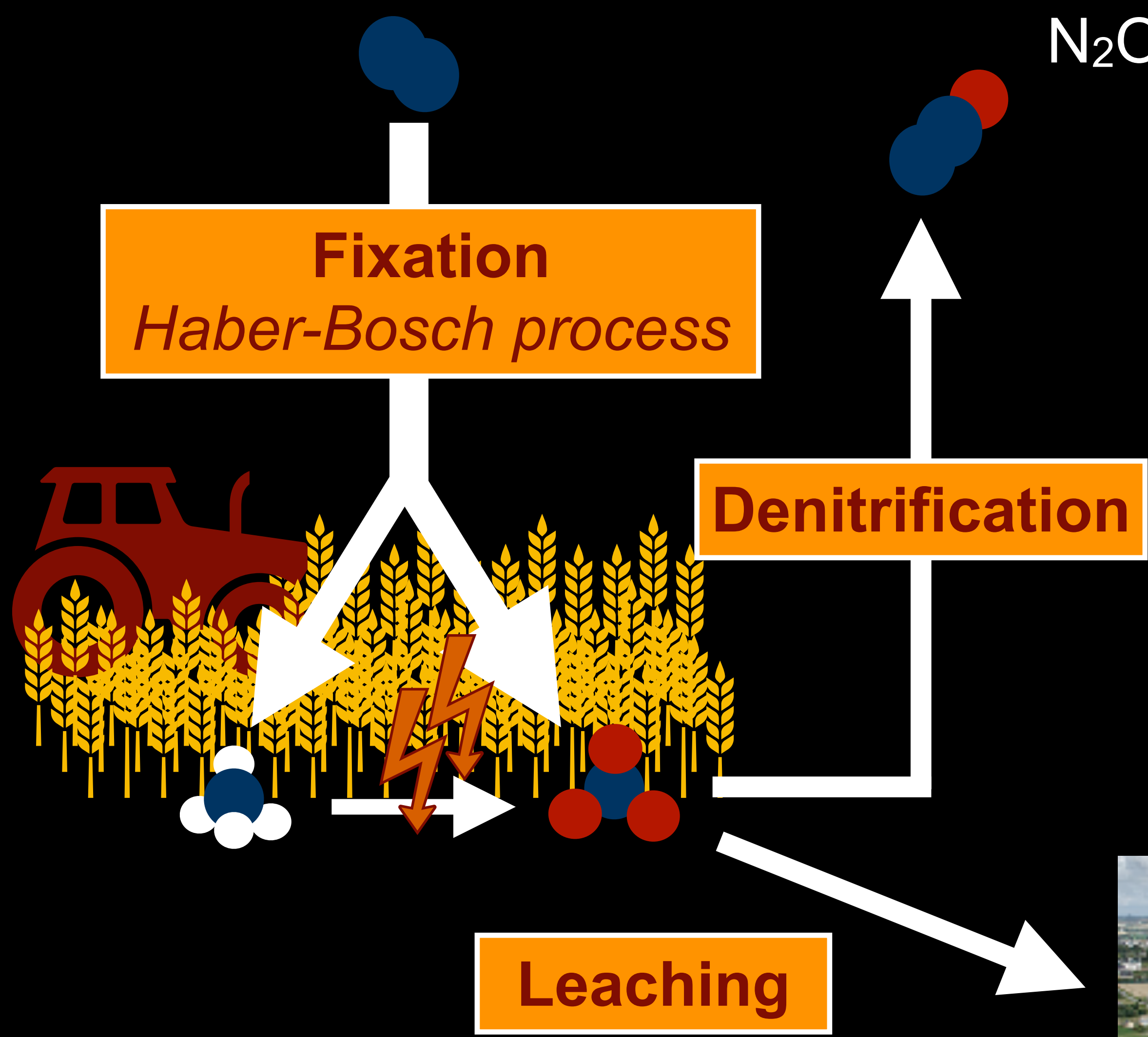


19% of applied fertilizer globally (up to 50% for cereal)

Questions

How does nitrification modulation impact ecosystem dynamics?

Can an equilibrium be reached?

ecosystem functioning?

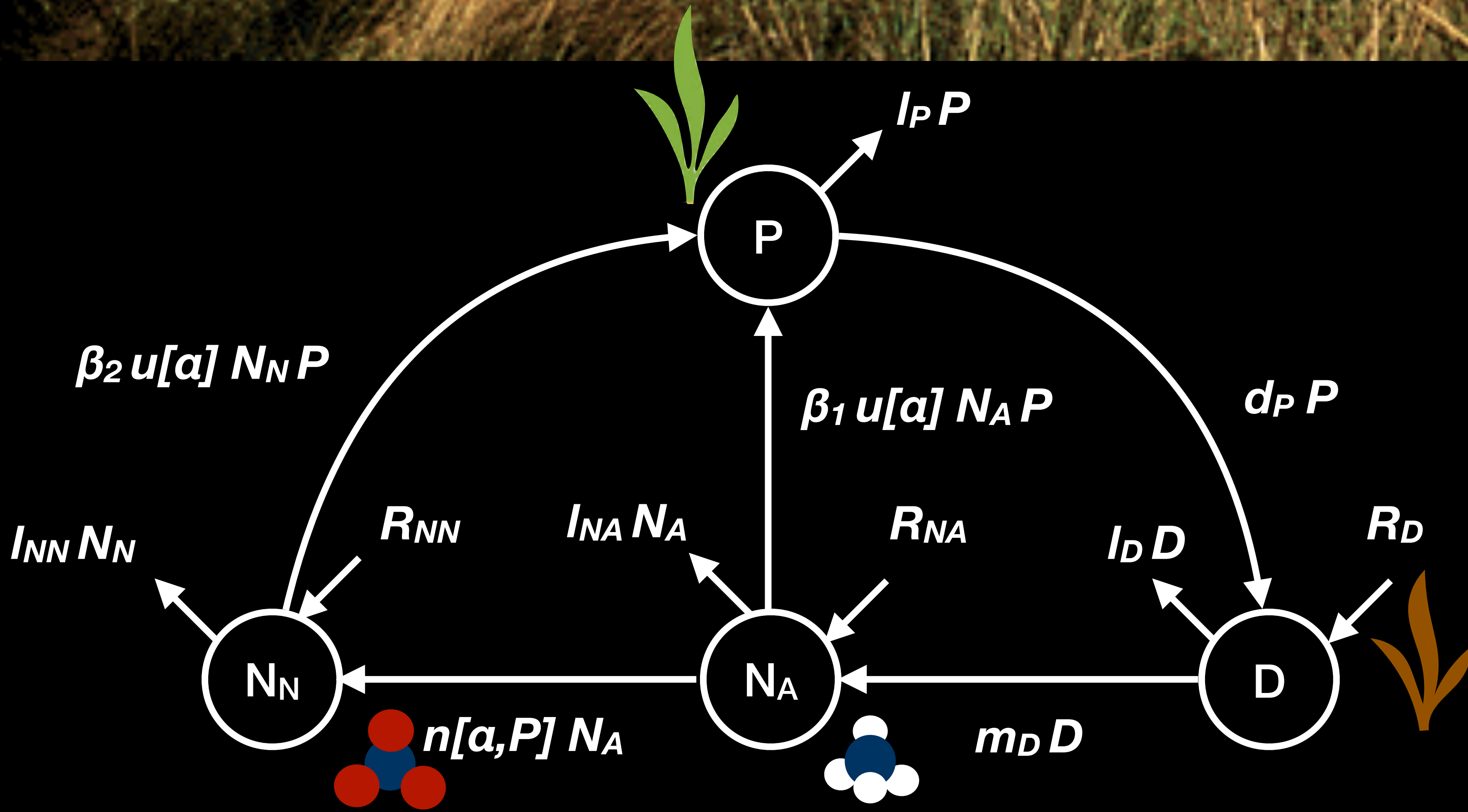
How are productivity and nitrogen losses affected?

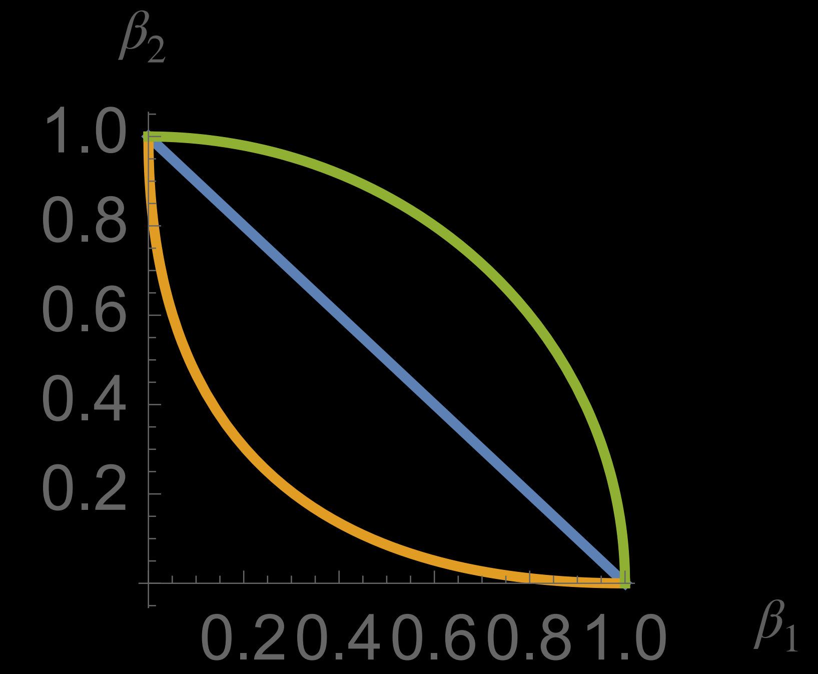
community composition ?

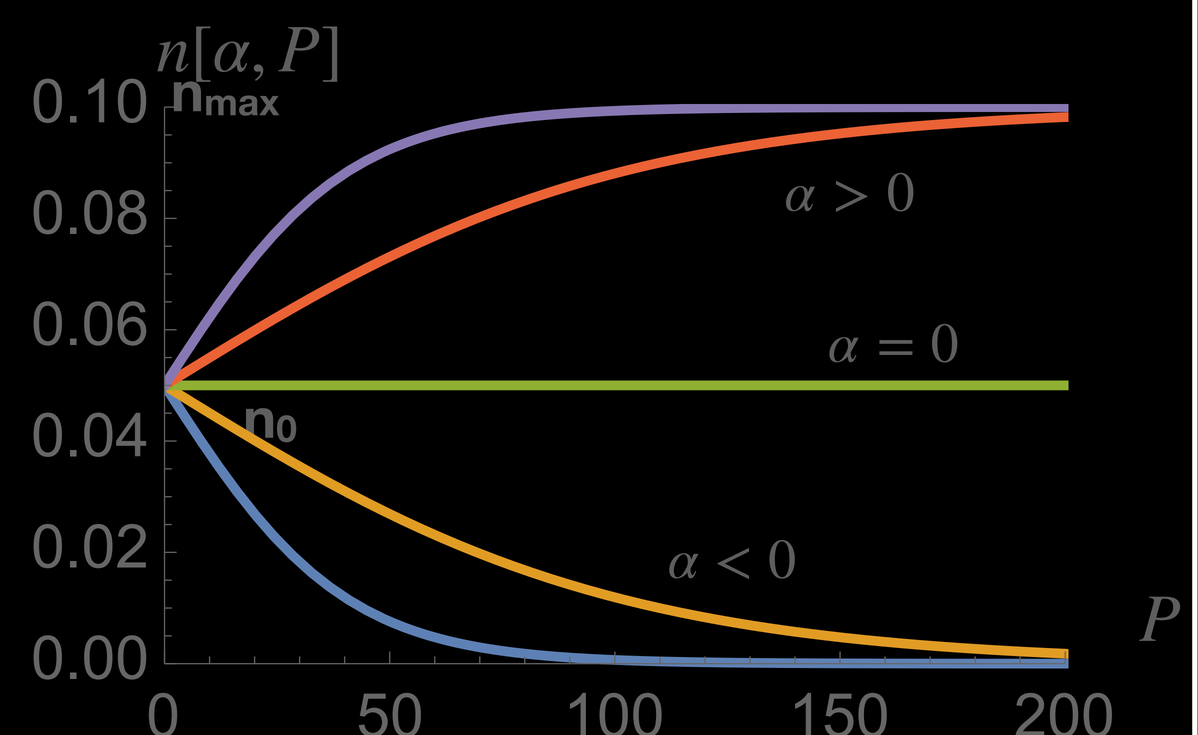
Via mechanisms of niche partitioning, niche construction and facilitation

Under which conditions can nitrification modulation evolve ?

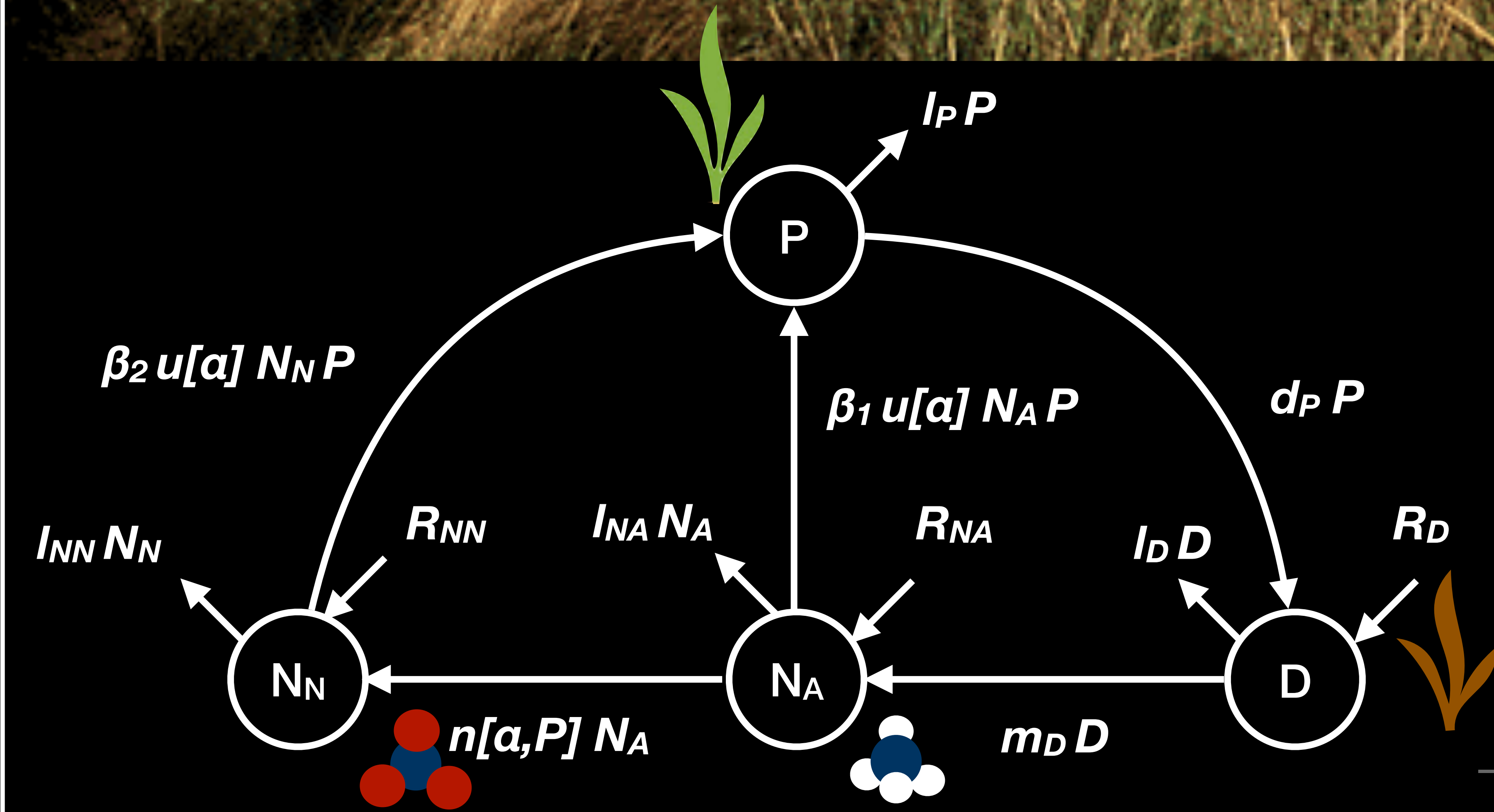
Model

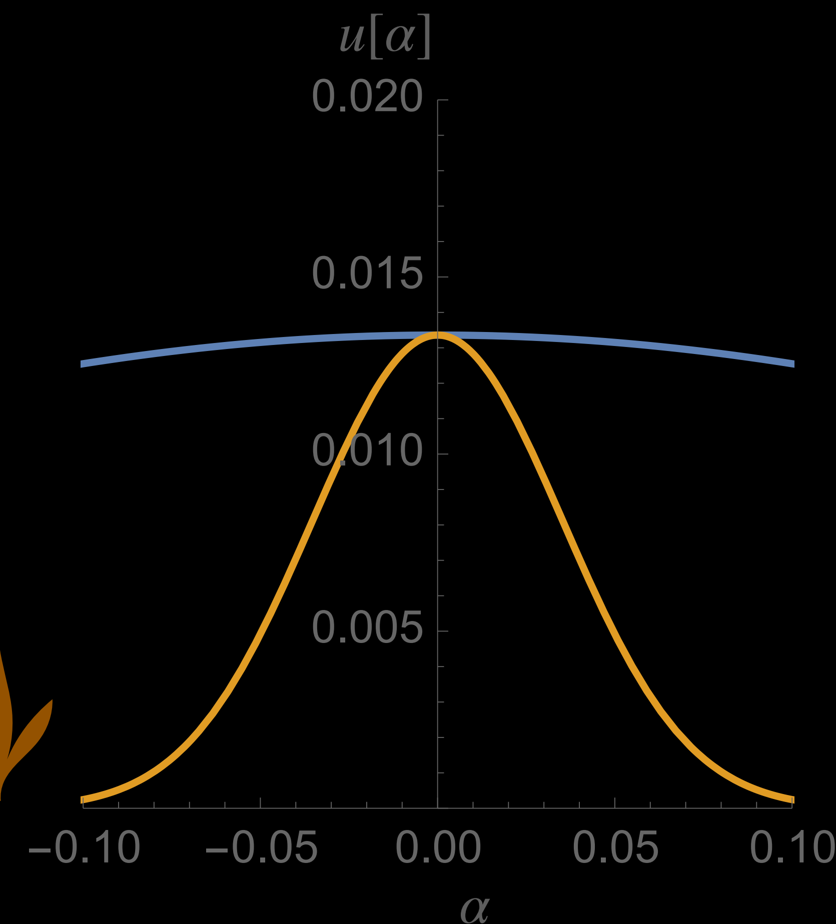

P
$l_P P$
$\beta_2 u[\alpha] N_N P$
$\beta_1 u[\alpha] N_A P$
$d_P P$
$l_{NN} N_N$
R_{NN}
$l_{NA} N_A$
R_{NA}
$l_D D$
R_D
N_N
N_A
D
$n[\alpha,P] N_A$
$m_D D$


β_2
1.0
0.8
0.6
0.4
0.2
0.2 0.4 0.6 0.8 1.0
β_1


$n[\alpha, P]$
n_{max}
0.10
0.08
0.06
0.04
0.02
0.00
$\alpha > 0$
$\alpha = 0$
n_0
$\alpha < 0$
P
0
50
100
150
200

Model



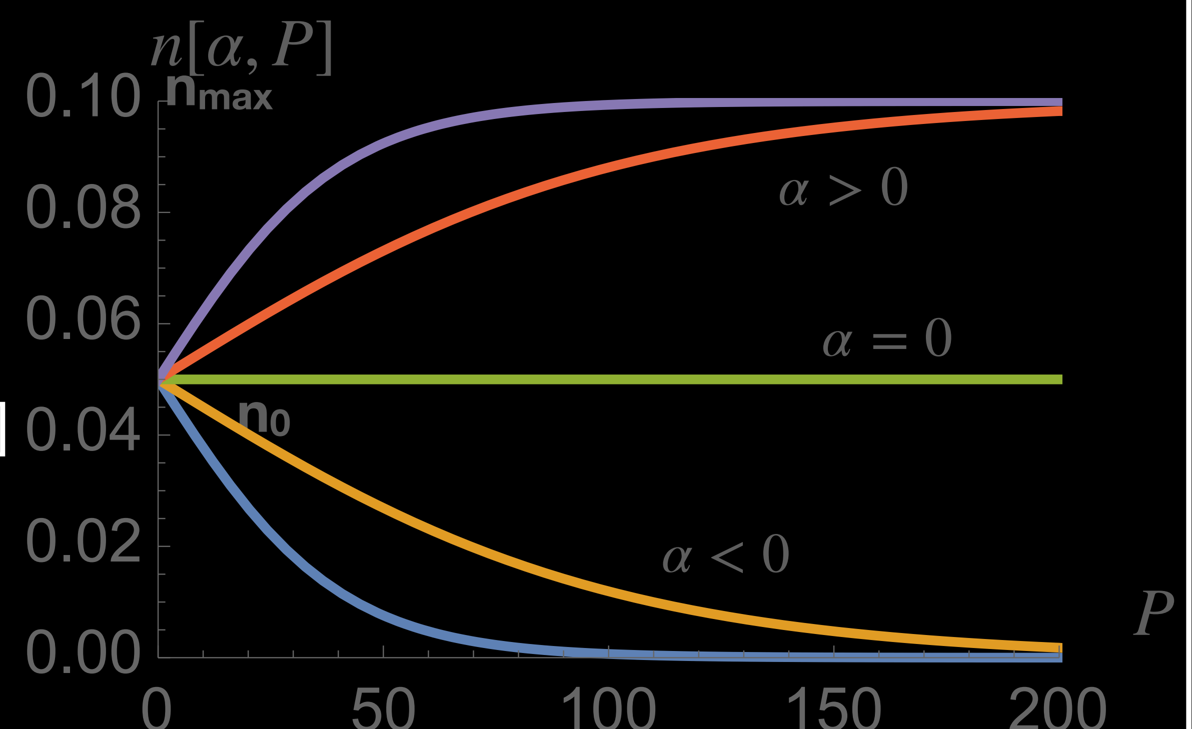


$$\frac{dP}{dt} = -P(d + l_P) + Pu[\alpha]\left(\beta_1 N_A + \beta_2 N_N\right)$$

$$\frac{dD}{dt} = R_D + d\ P - D(l_D + m_D)$$

$$\frac{dN_A}{dt} = R_{N_A} + m_D\ D - N_A\ l_{N_A} - N_A\ \beta_1 P u[\alpha] - N_A\ n[\alpha, P]$$

$$\frac{dN_N}{dt} = R_{N_N} + N_A n[\alpha, P] - N_N\ l_{N_N} - N_N \beta_2 P u[\alpha]$$



Model

2 sets of parameters :

Pawnee grassland (Colorado)

Lamto Savannah (Ivory Coast)

Questions

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Ecosystem dynamics

Invasibility criteria :

$$u[\alpha] > \frac{d + l_P}{\frac{\beta_1}{l_{N_A} + n_0}\left[R_{N_A} + \frac{m_D}{m_D + l_D} R_D\right] + \frac{\beta_2}{l_{N_N}}\left[R_{N_N} + \frac{n_0}{l_{N_A} + n_0} R_{N_A} + \frac{n_0}{l_{N_A} + n_0}\frac{m_D}{m_D + l_D} R_D\right]}$$

A plant has more chances to invade when :

Modulation is weak

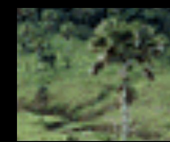
The cost of modulation is low

Inputs of N are big

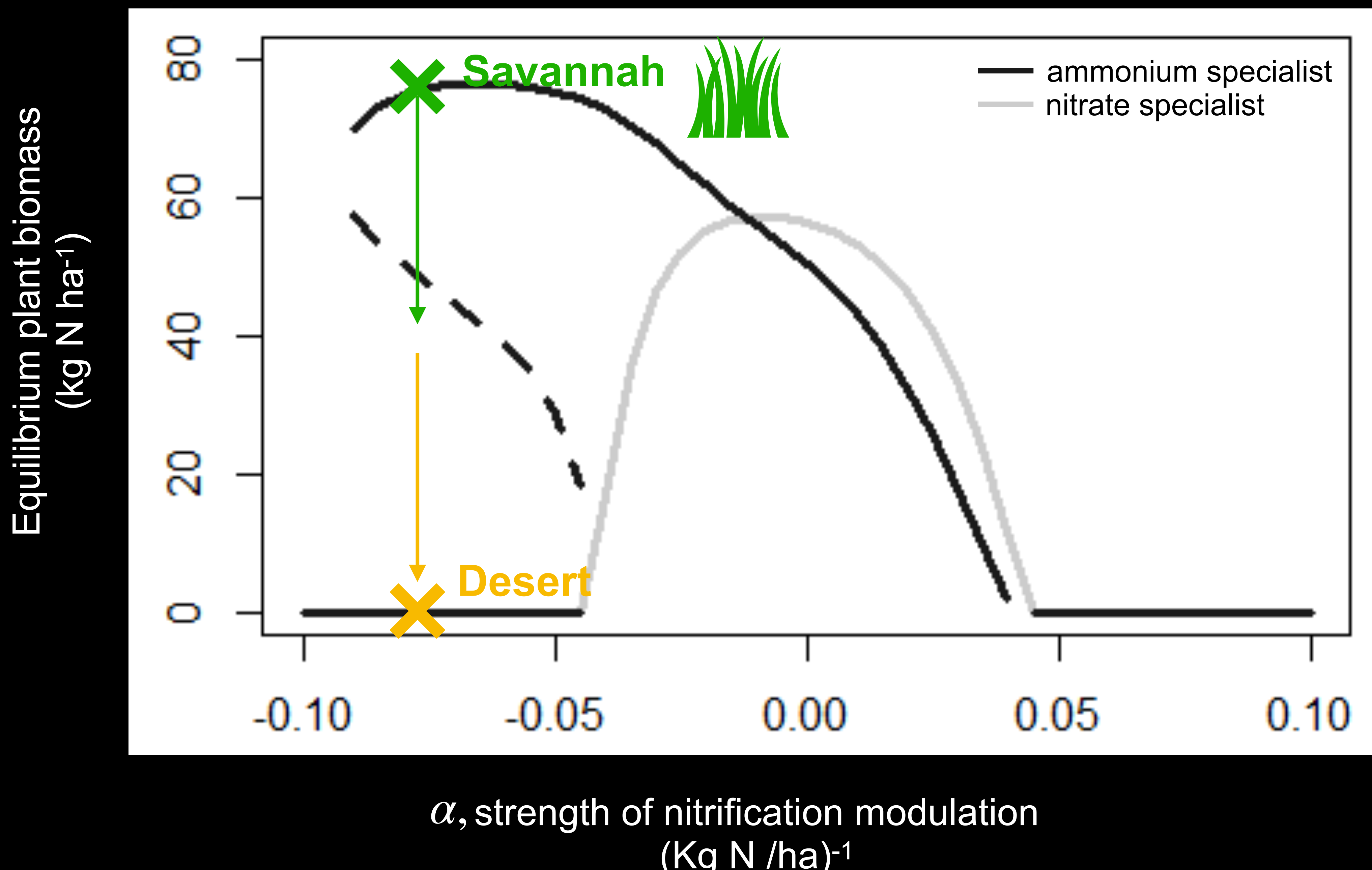
Losses of N are small

Ecosystem dynamics

Potential bistability :

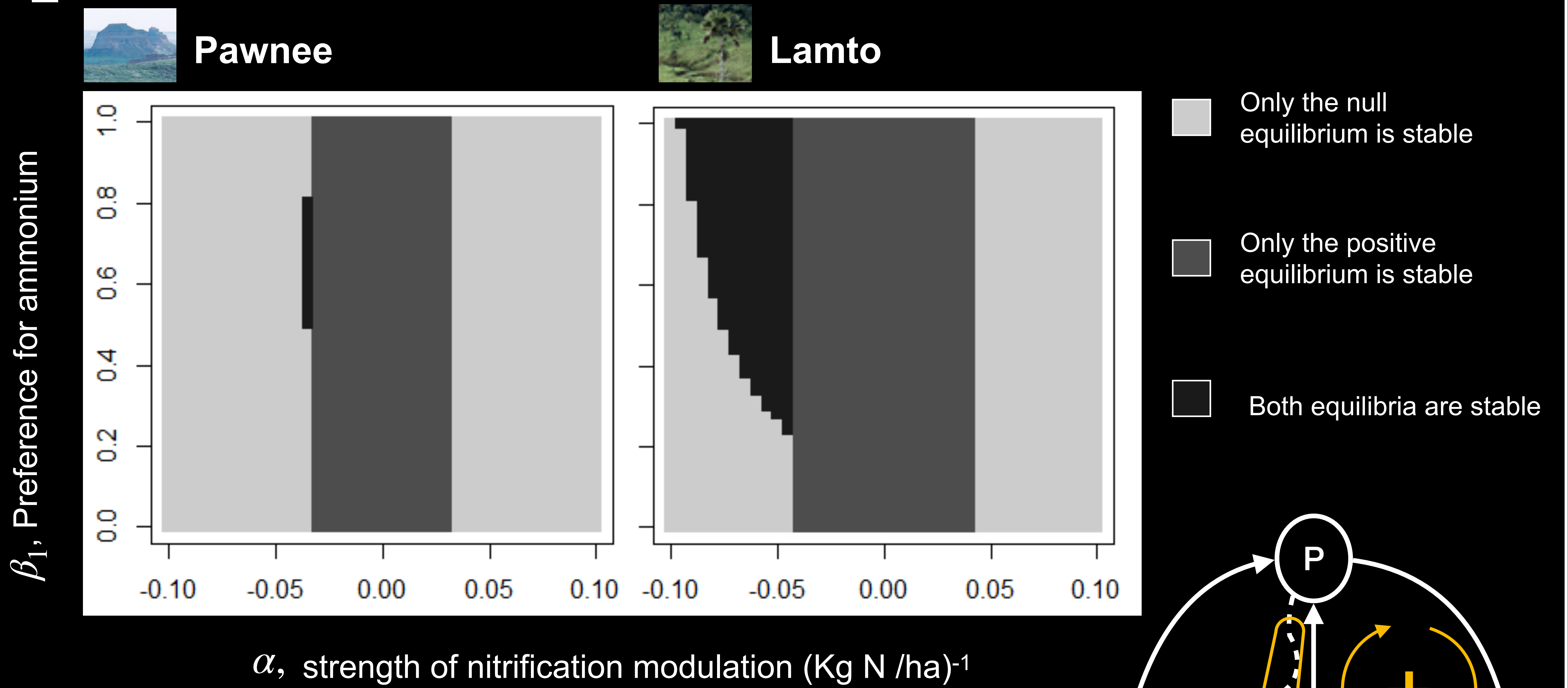


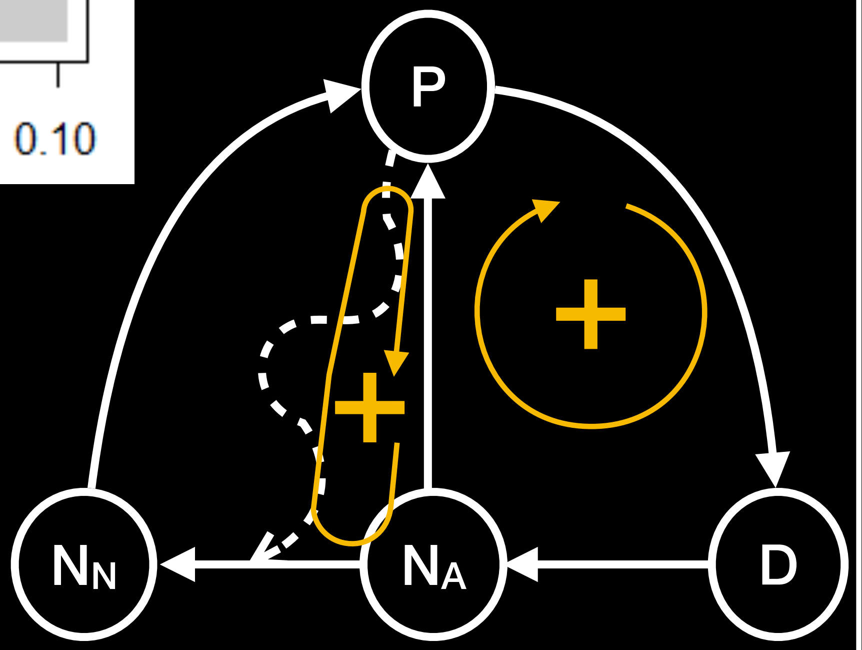
Lamto



Ecosystem dynamics

Potential bistability :





Discussion

Nitrification inhibition responsible for alternate stable states ?

Yé et al., 2021, Acta Oecol

No trade-off between two ecosystem services

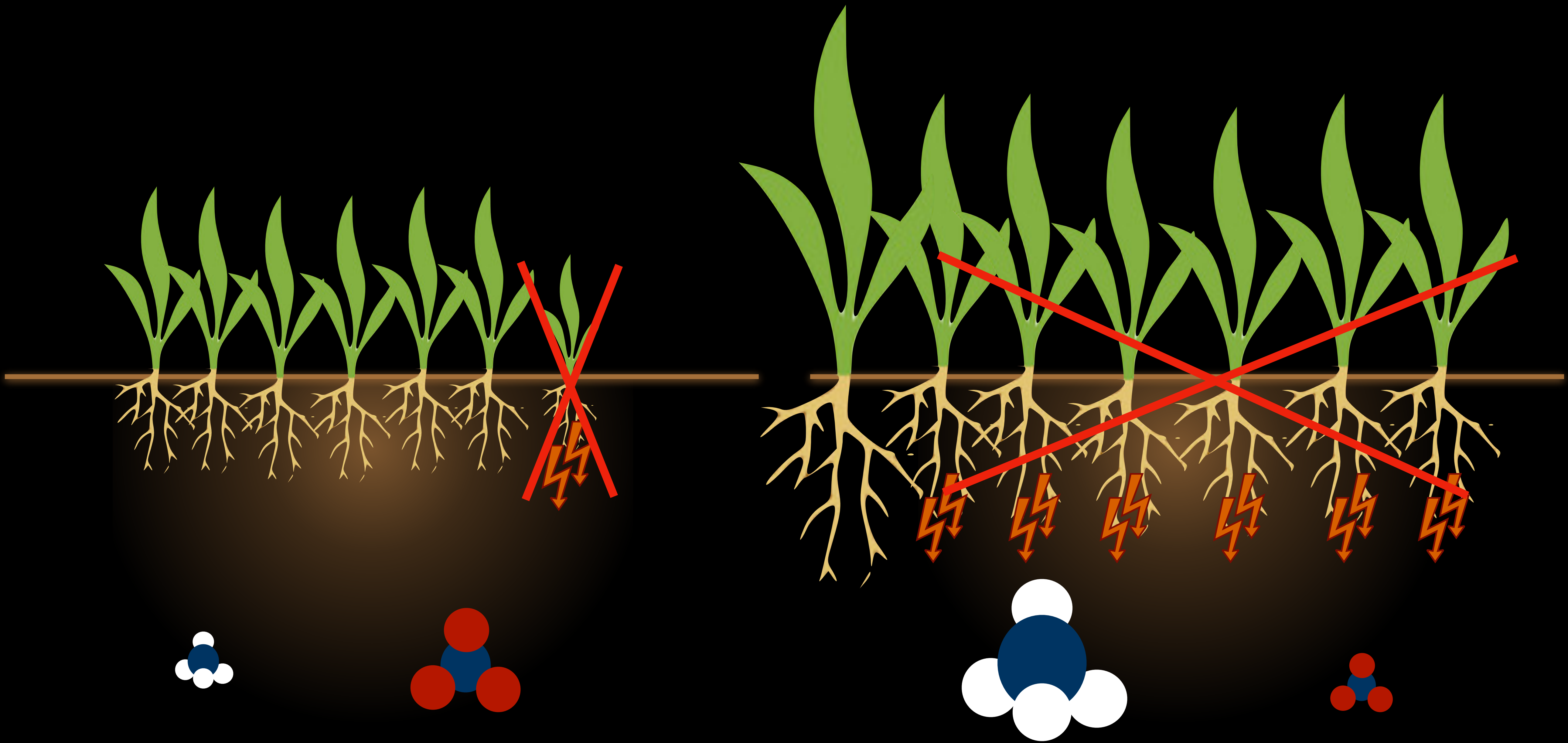
Bennet et al., 2009, Ecol. Lett.

Partitioning along the ammonium/nitrate continuum ;
Niche construction or facilitation via nitrification modulation

Chesson, 2000, Annu. Rev. Ecol. Syst.
Olding-Smee, 2012.

Nitrification modulation cannot evolve when N pools are shared

Hardin, 1968, Science




Merci !