Tema

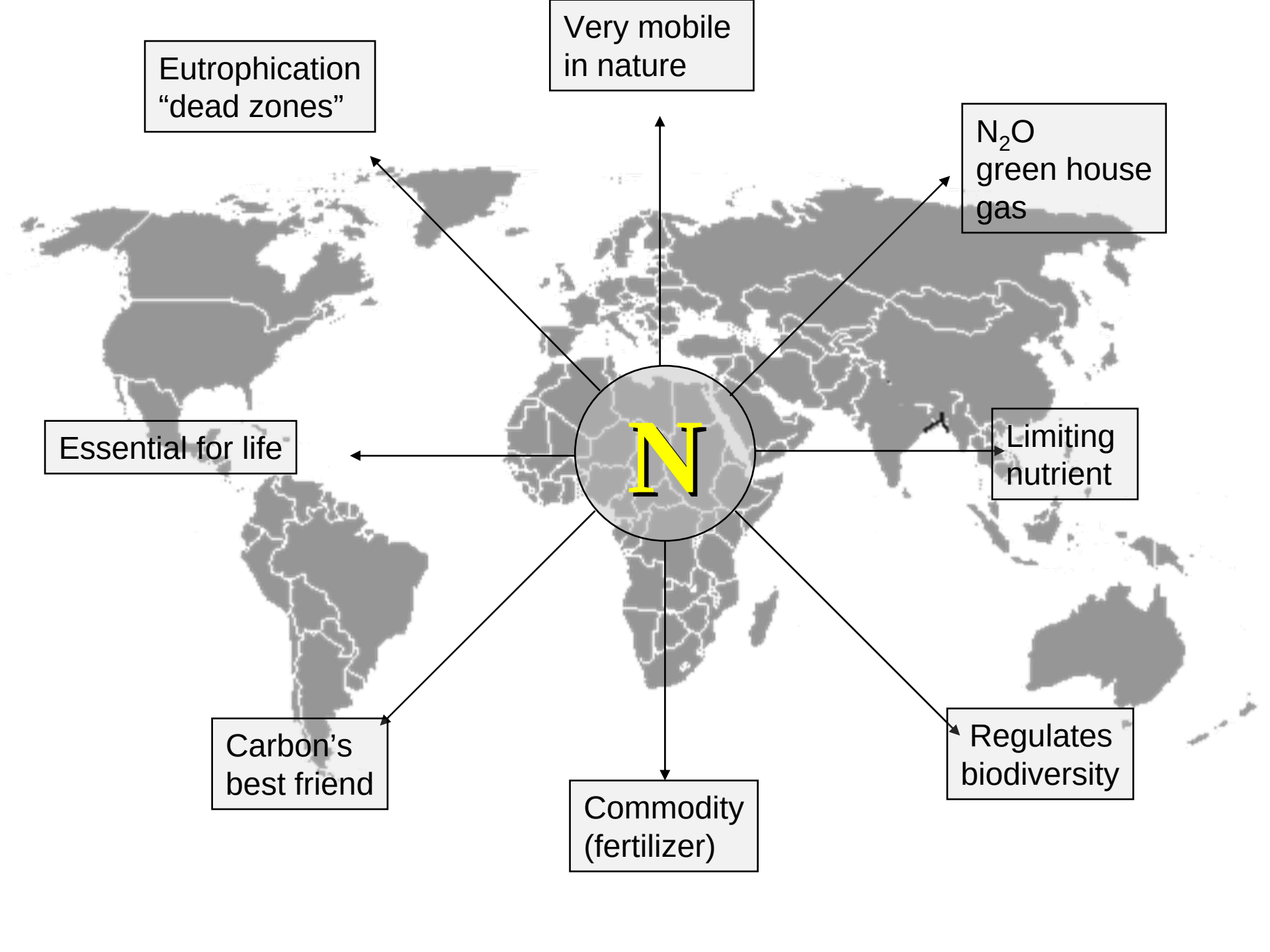
Impactos, vulnerabilidade e adaptação

Mesa Redonda 3

Ecossistemas Agrícolas e Naturais

Nitrogênio

Luiz A Martinelli
(CENA/USP)


Very mobile in nature
Eutrophication "dead zones"
N_2O green house gas
N
Essential for life
Limiting nutrient
Carbon's best friend
Commodity (fertilizer)
Regulates biodiversity

Years

10000	8000	2500 BC	500 AD	1500	1800	1900	1930	1960	1970	1980	1990	2000
0.001	0.005	0.030	0.10	0.45	1.00	1.55	2.07	3.04	3.69	4.43	5.26	6.07

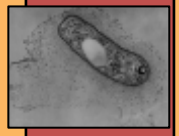
Early agriculture

Agriculture revolution

Historical agriculture

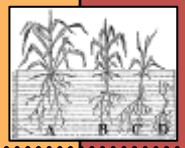
Feudal agriculture

Scientific agriculture



BNF

Mineral fertilizer

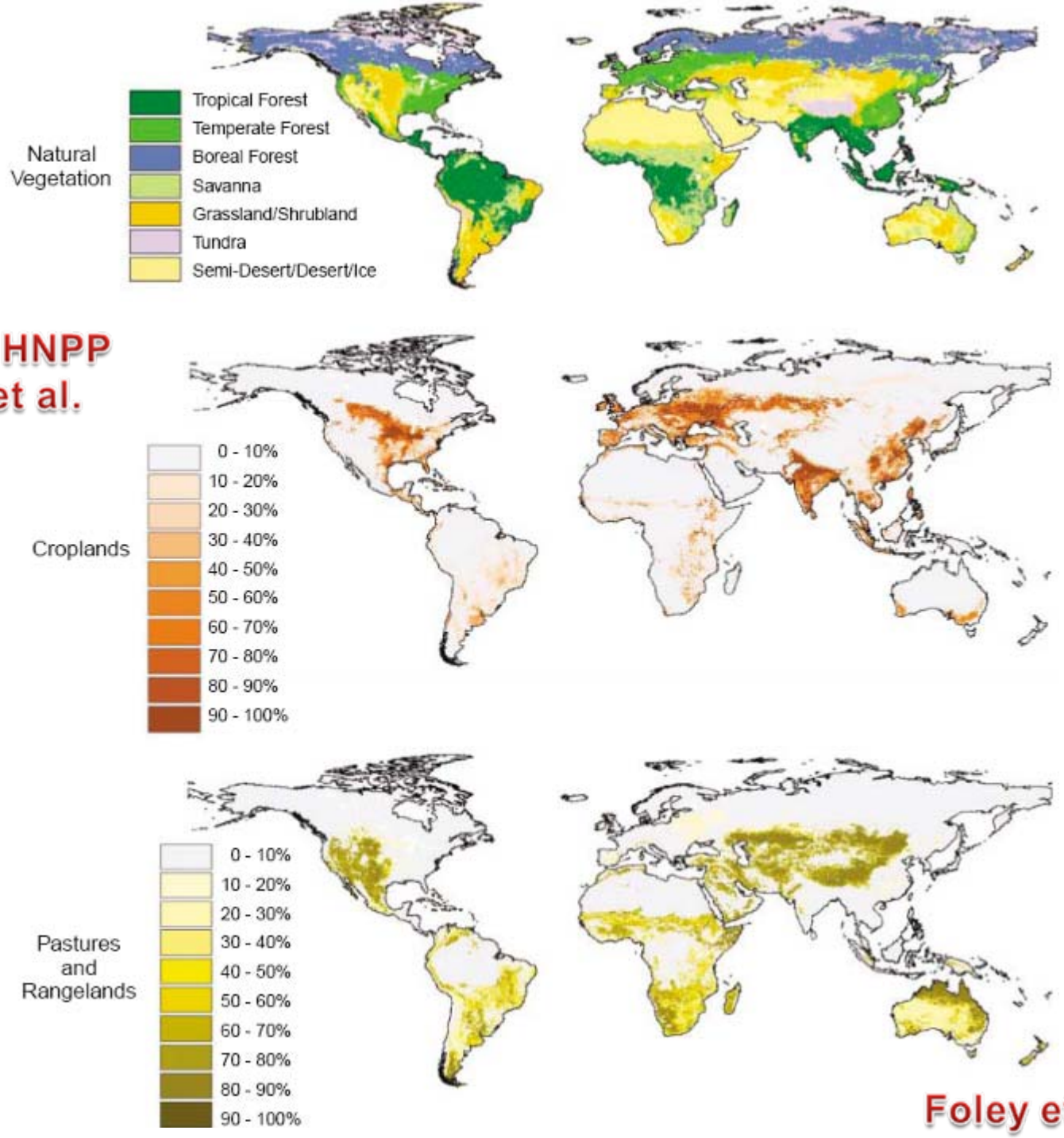


Green revolution

GMO

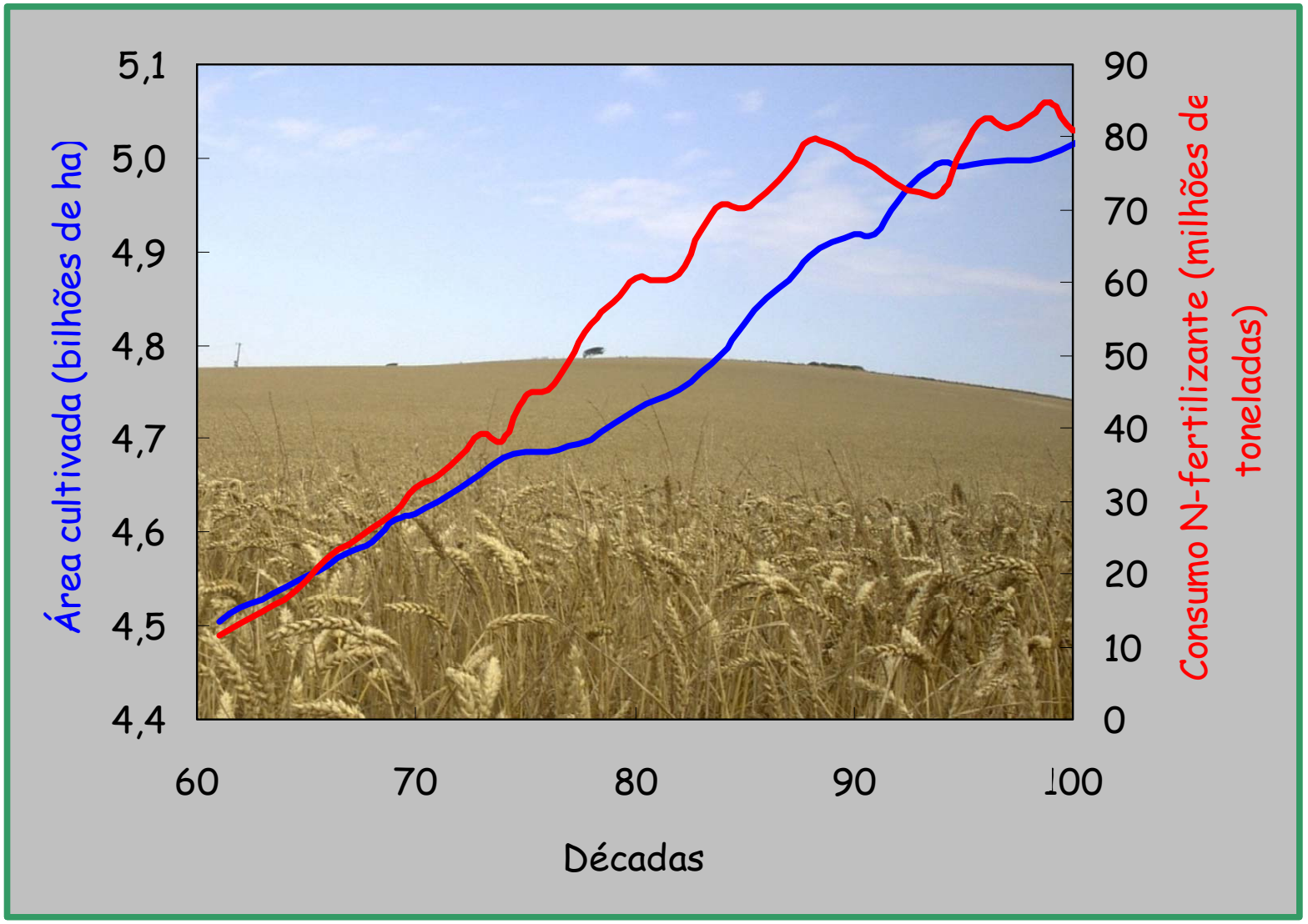
Agribusiness

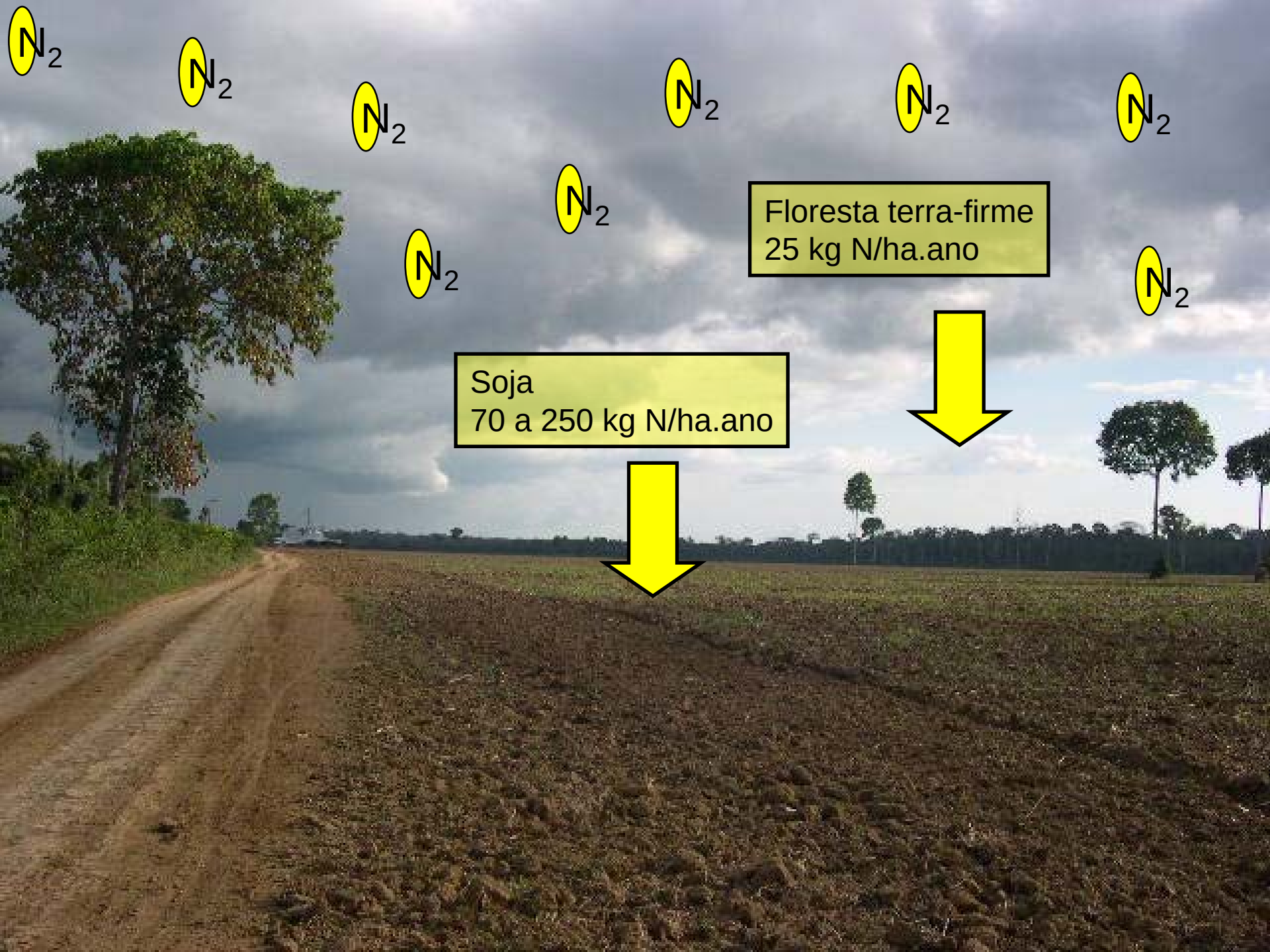
World population (billions)



25-30% HNPP Haberl et al. (2007)

Foley et al. (2007)


Área cultivada (bilhões de ha)
5,1
5,0
4,9
4,8
4,7
4,6
4,5
4,4
Consumo N-fertilizante (milhões de toneladas)
90
80
70
60
50
40
30
20
10
0
60
70
80
90
100
Décadas


N_2
N_2
N_2
N_2
N_2
N_2
N_2
N_2
Floresta terra-firme
25 kg N/ha.ano
Soja
70 a 250 kg N/ha.ano

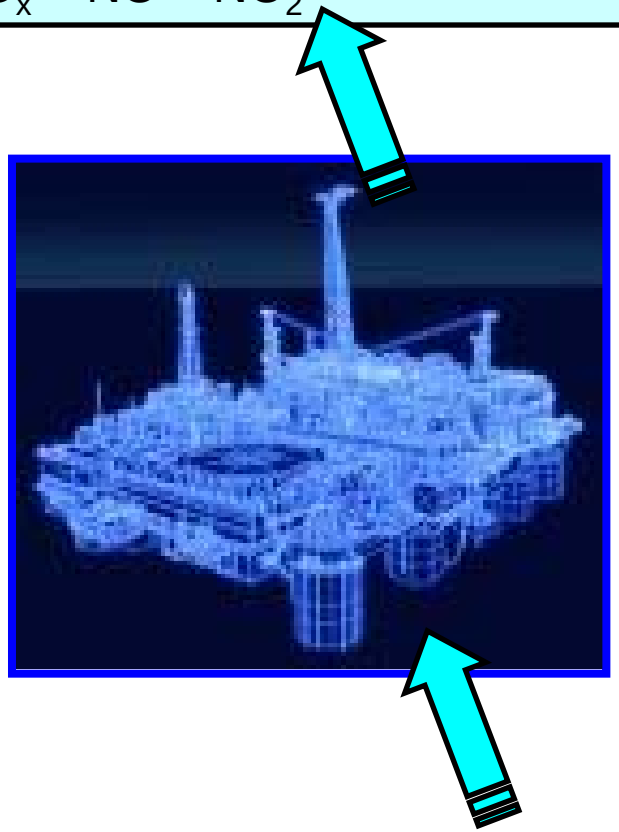
Produção termal

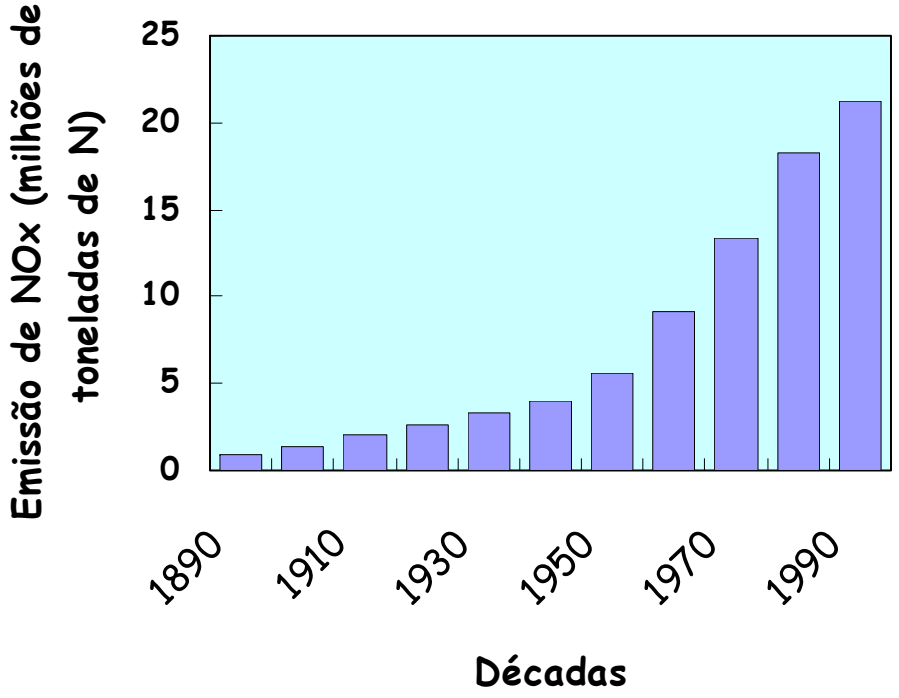
$N_2 + O_2 = 2NO$

N-orgânico pirólise

$X\text{-}CH_2NH_2 + 3O_2 = CO_2 + 2\ H_20 + NO_2 + X$

$NO_x = NO + NO_2$





Contabilidade sobre o N convertido** pelo Homem em 2002 (milhões de toneladas por ano)

**convertido: N-atmosférico não reativo N reativo

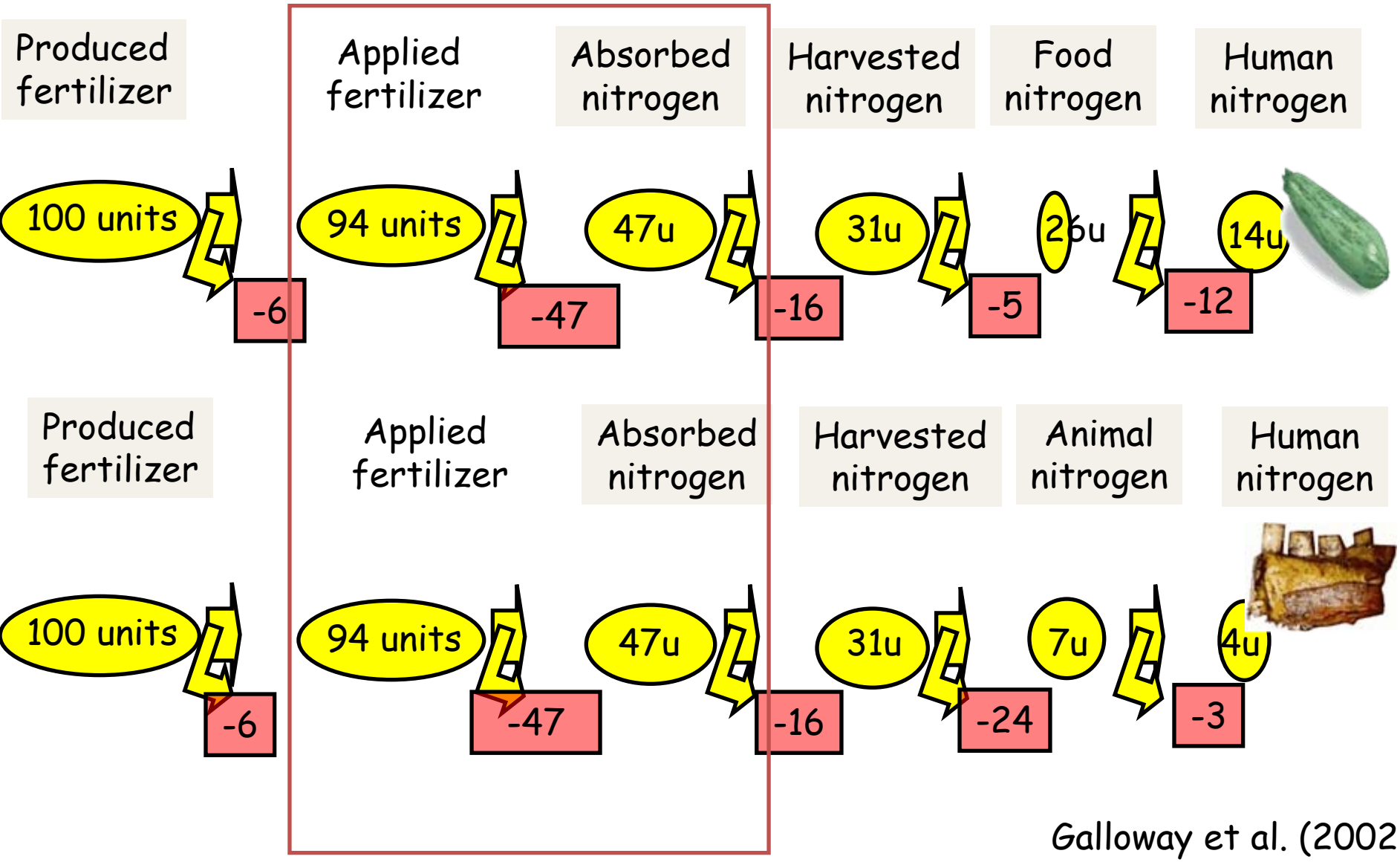
- Produção de N-Fertilizantes: **85**
- Processos industriais: **15** (não mostrados)
- Produção de Energia: **30**
- Cultivo de Fixadoras: **30**

TOTAL Nr: 160 milhões de toneladas

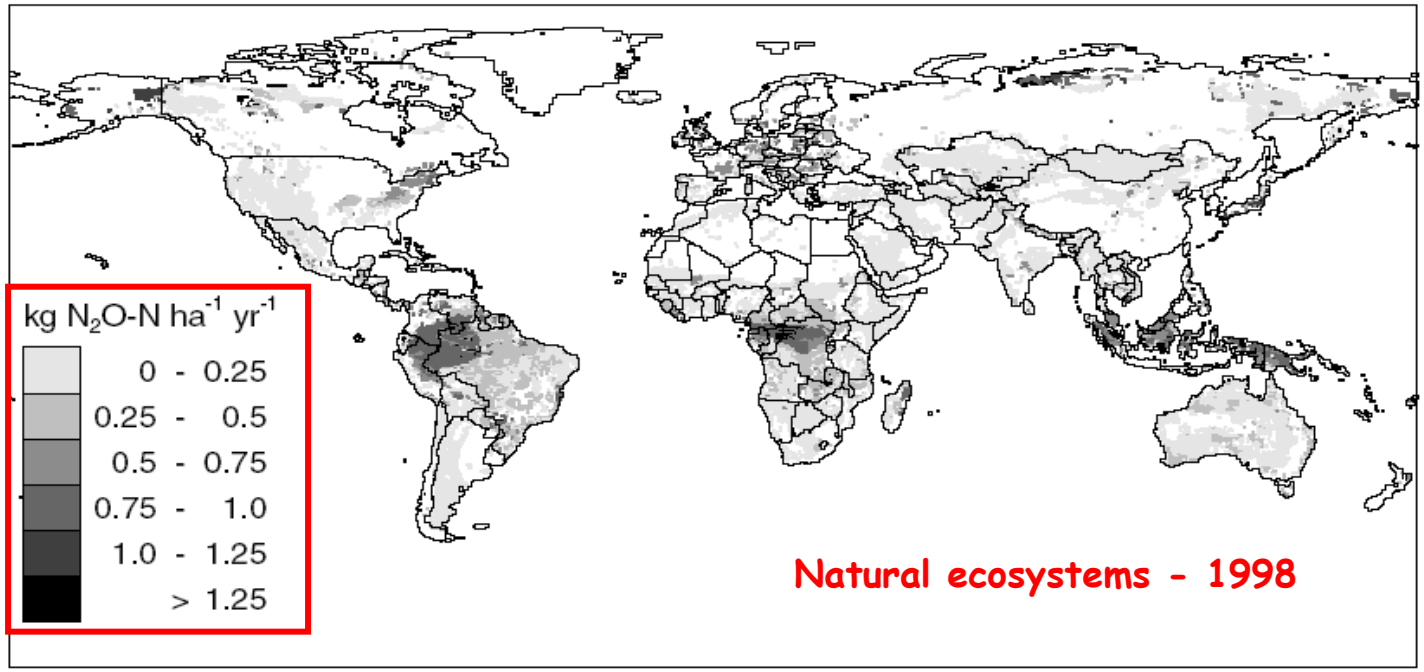
Fixação Biológica Natural: 110 milhões de tonel.

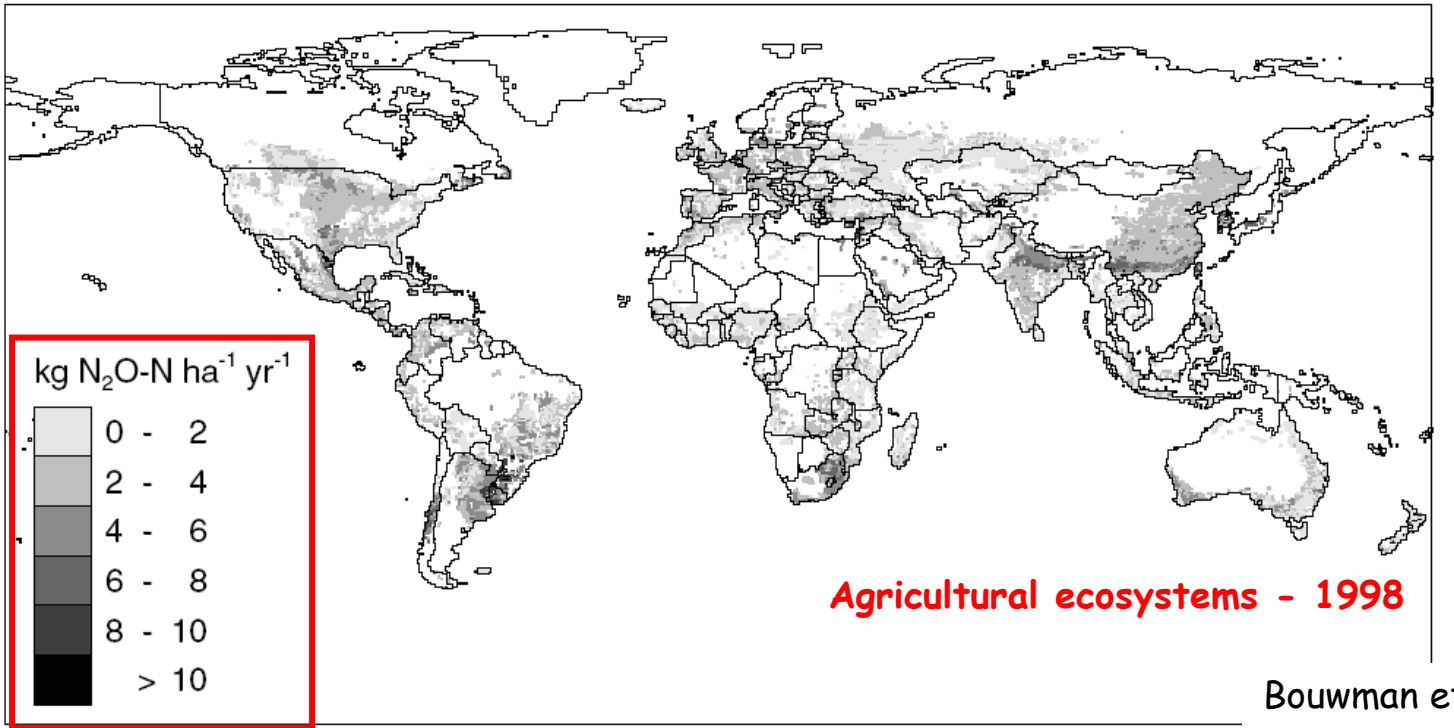
TOTAL: 270 milhões de toneladas

Agricultural systems are N-leaky systems!!!

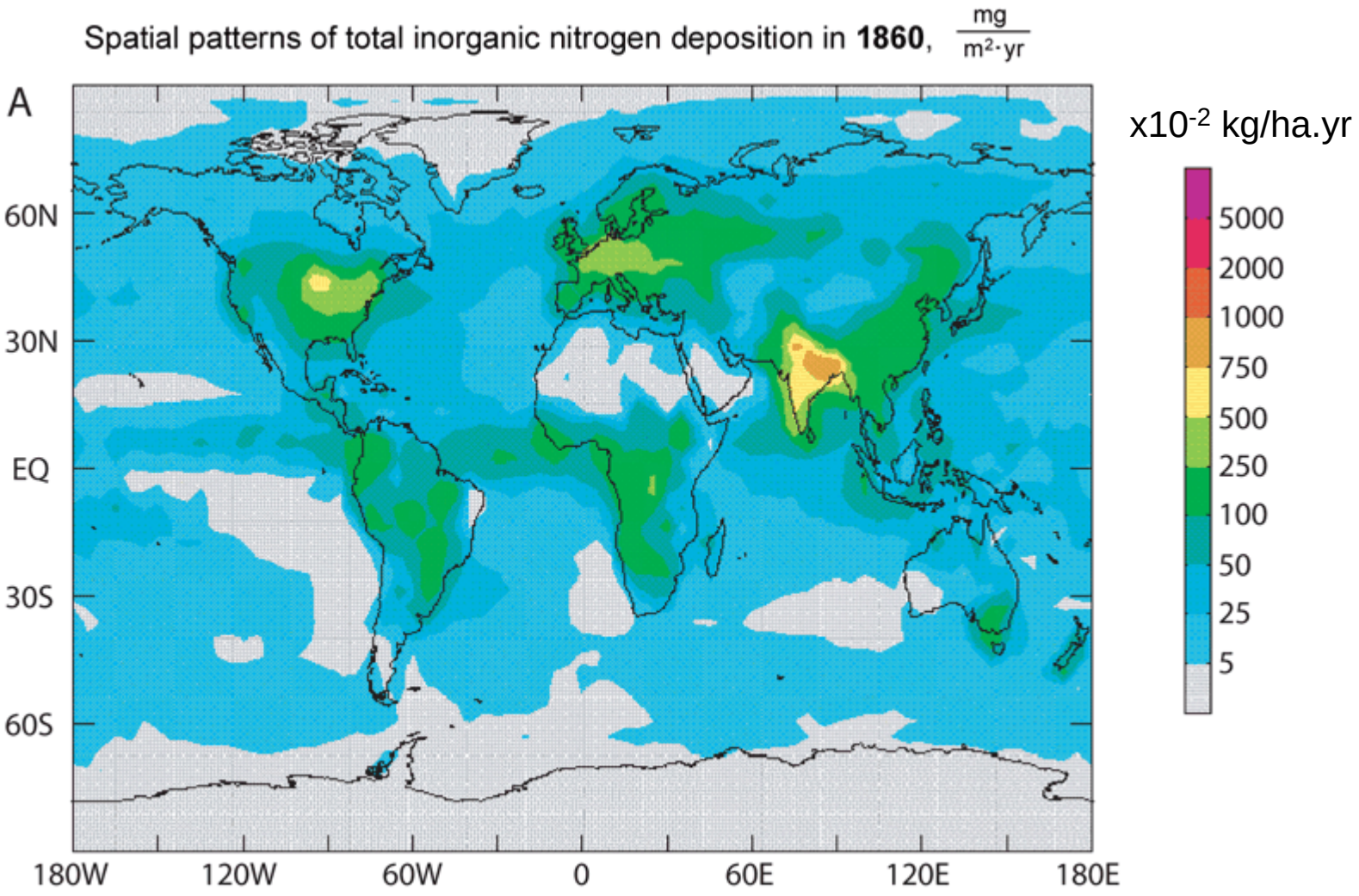


Galloway et al. (2002)

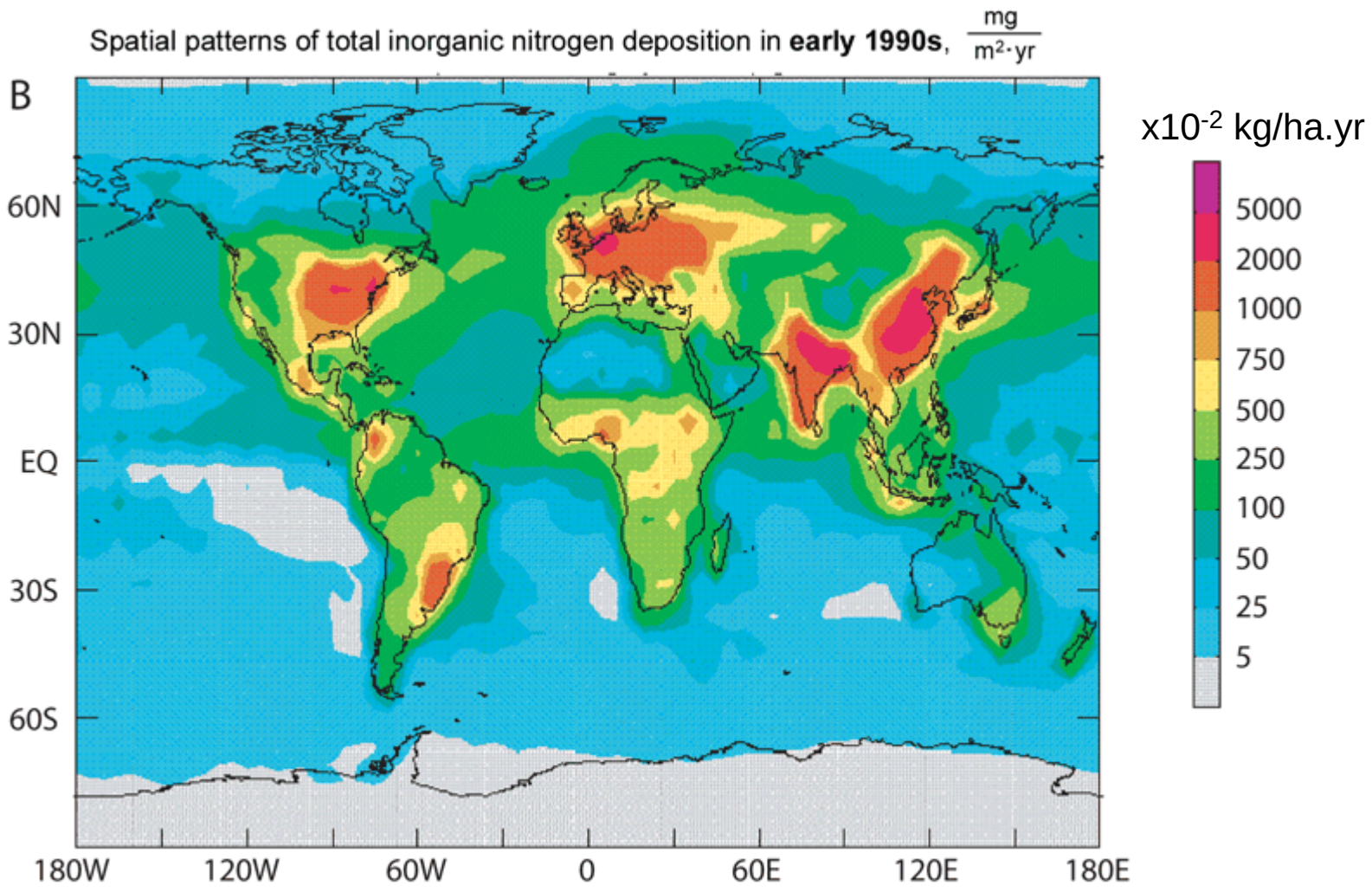




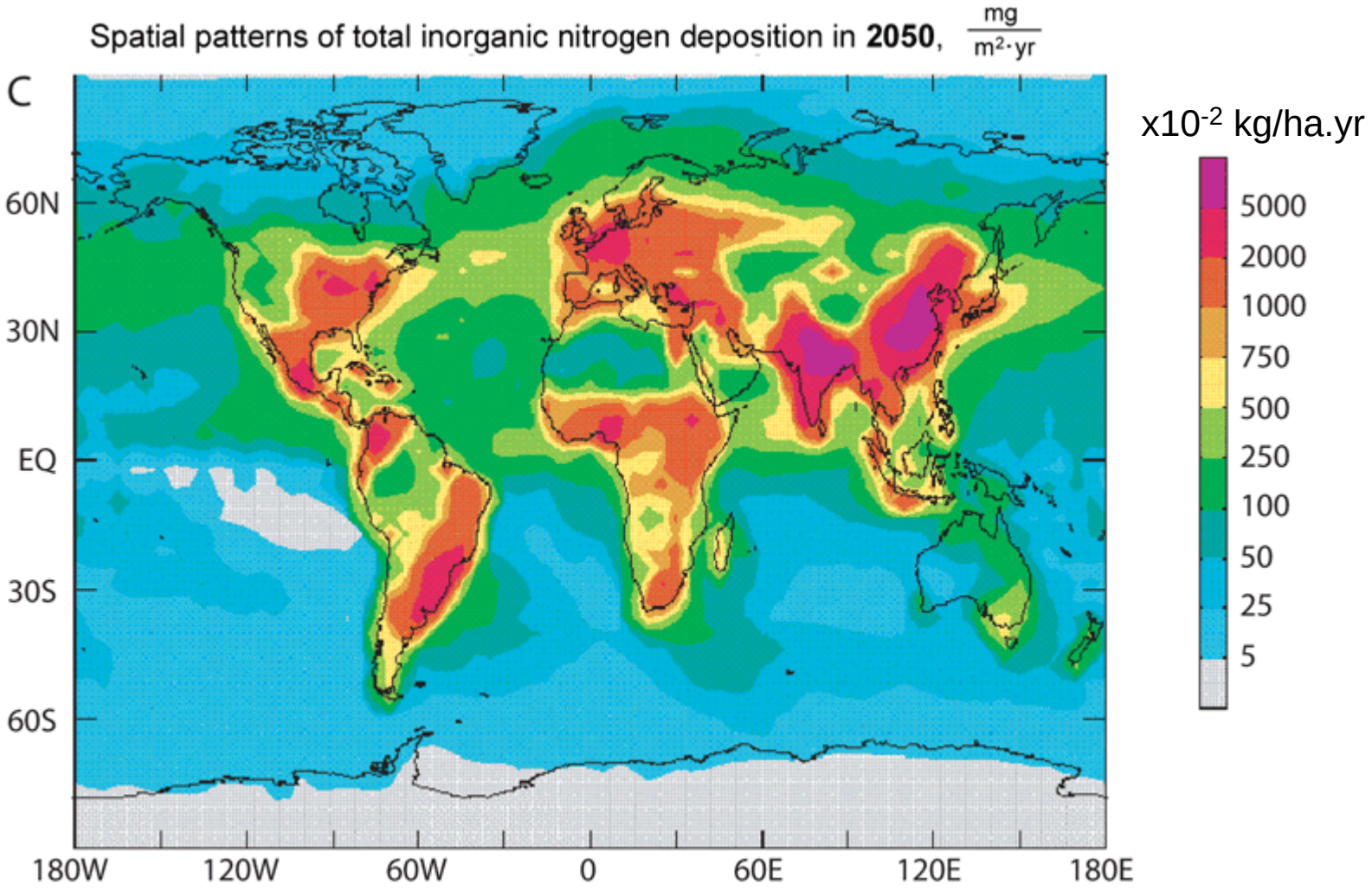
Bouwman et al. (2005)



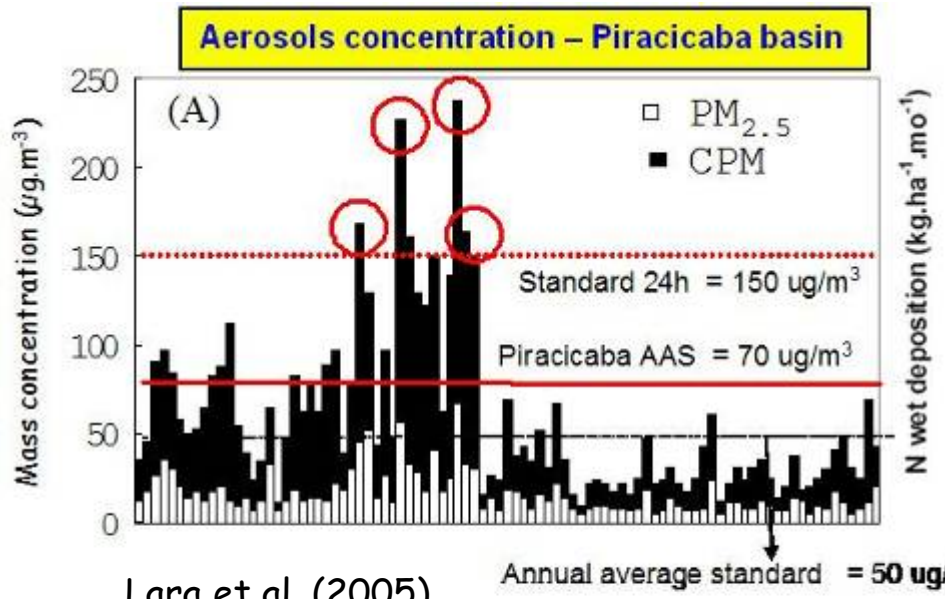
Galloway et al. (2005)



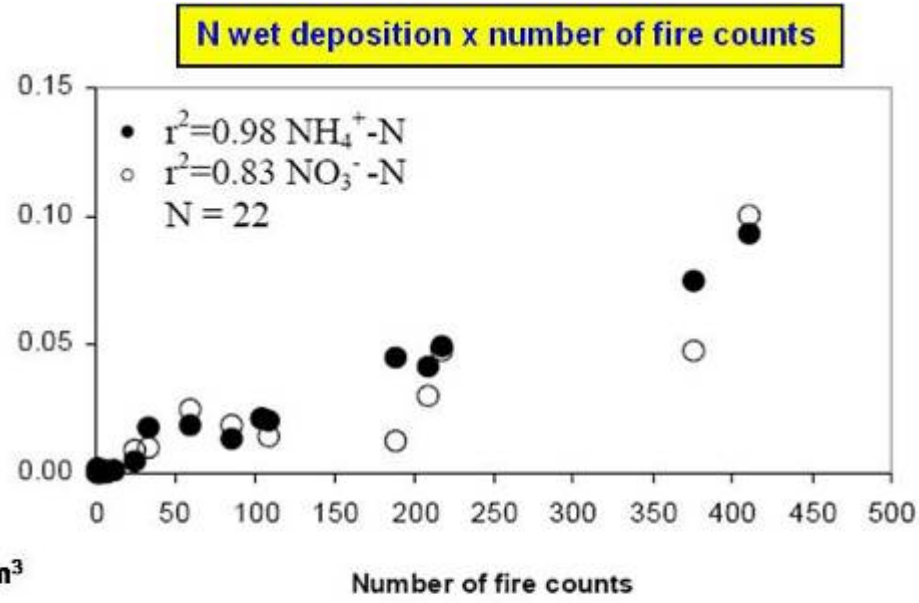
Galloway et al. (2005)

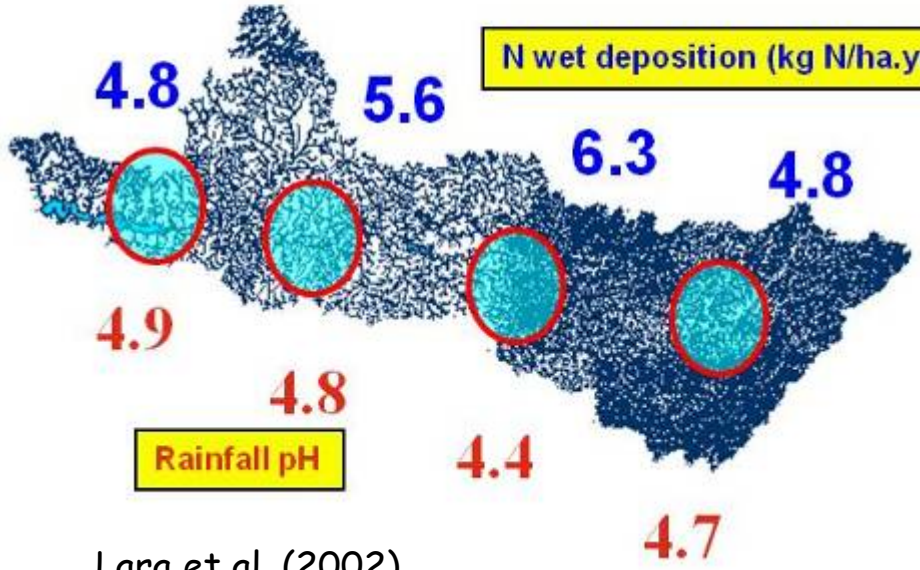


Galloway et al. (2005)

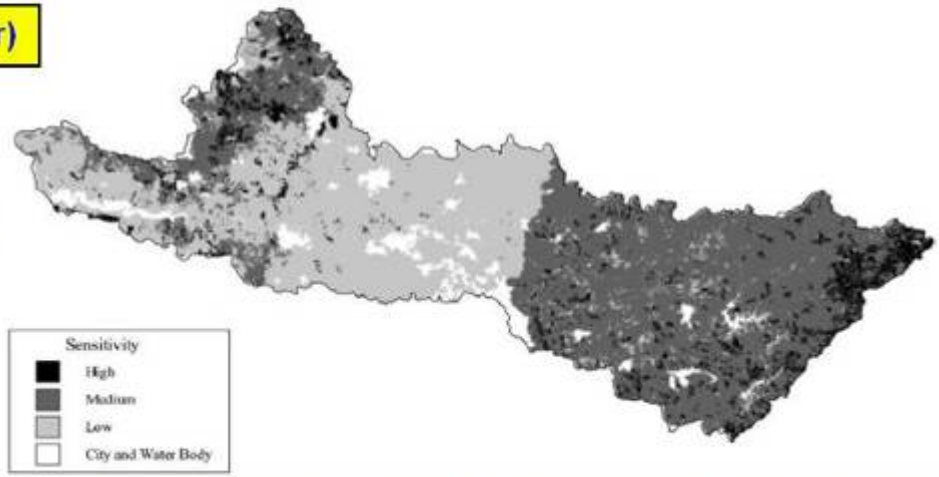


Lara et al. (2005)





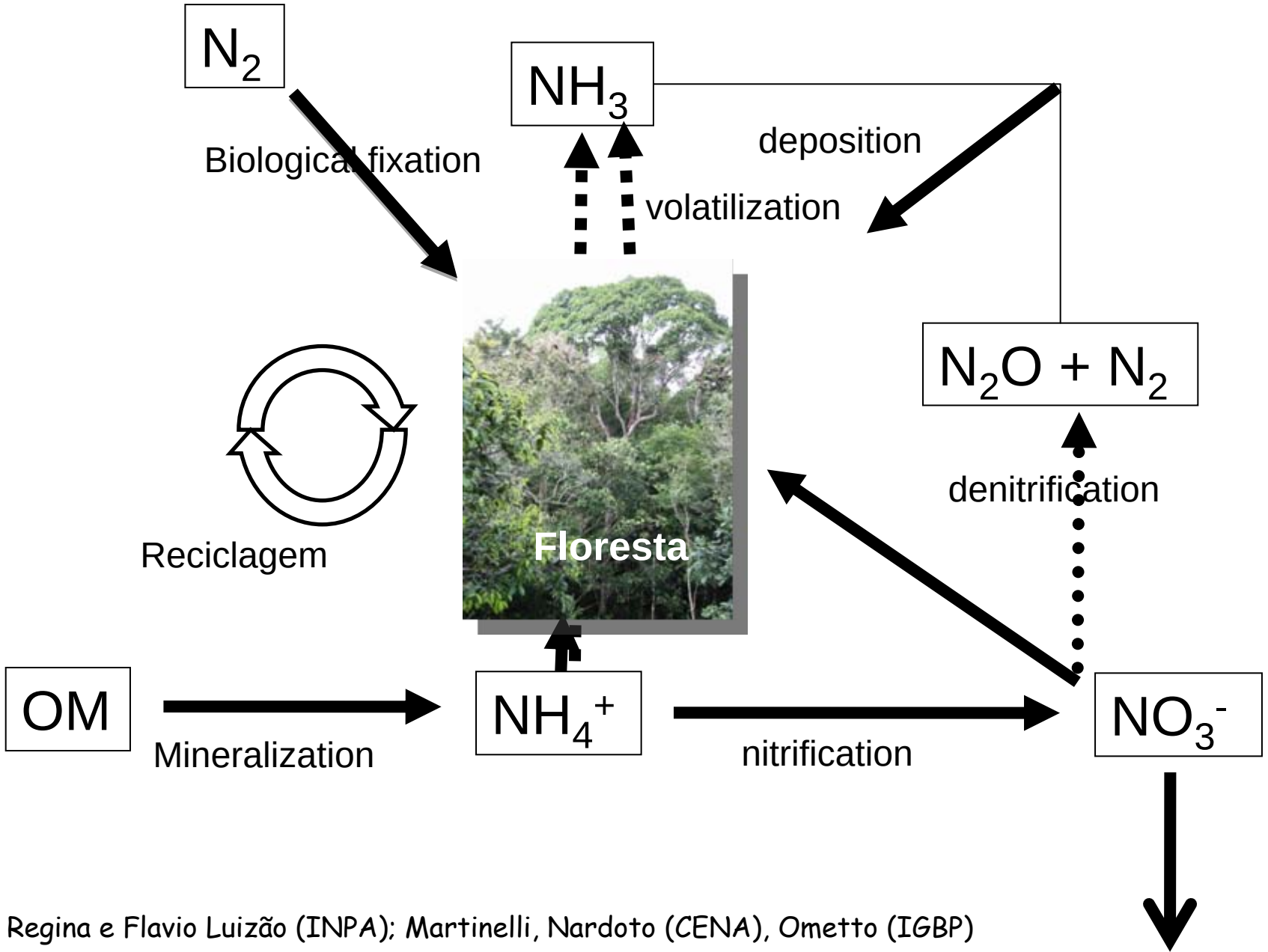
Lara et al. (2002)



Soil sensitivity to acidic deposition – Piracicaba basin

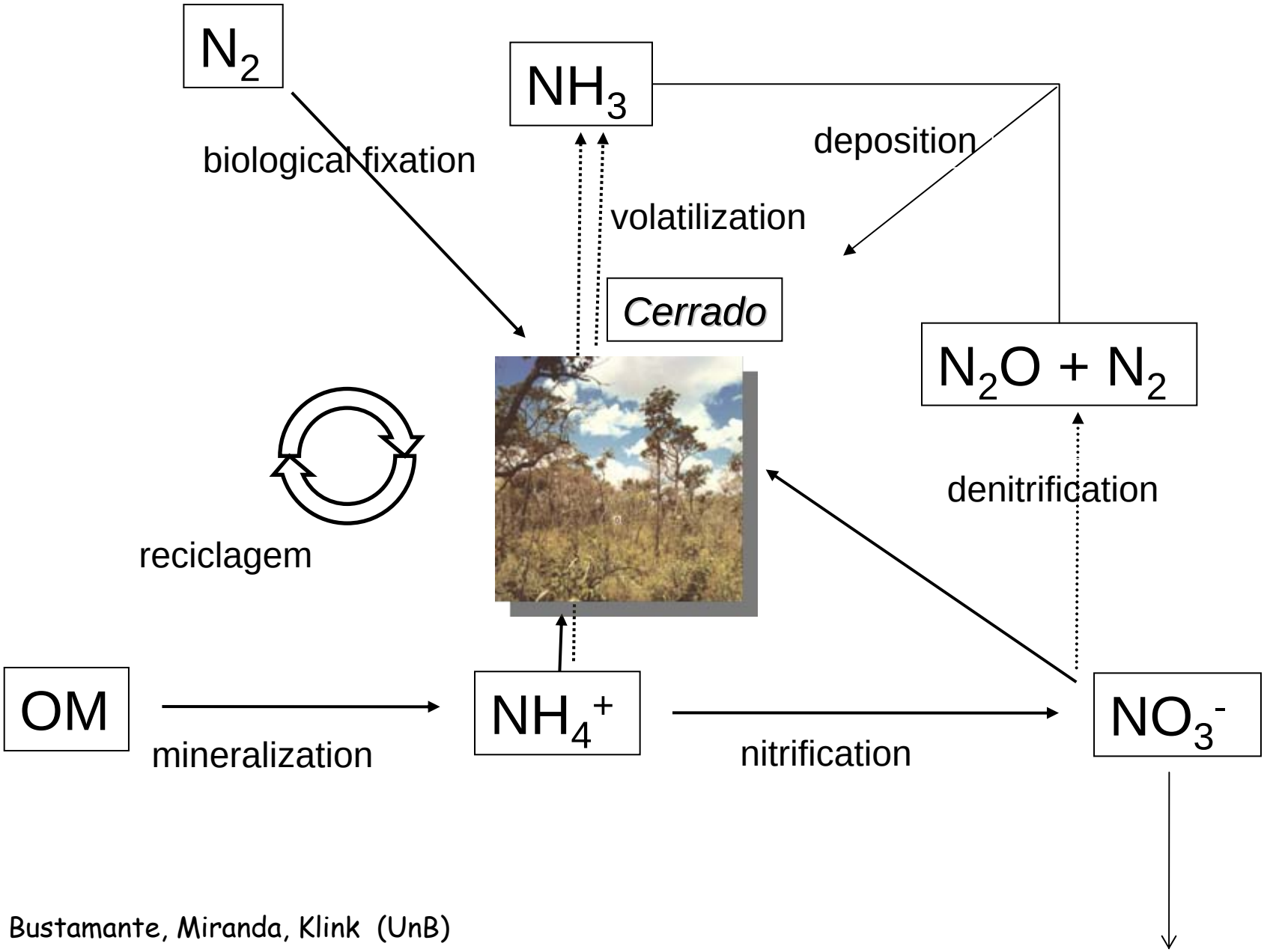
Krusche et al. (2003)

The Nitrogen Cycle – N-rich natural system



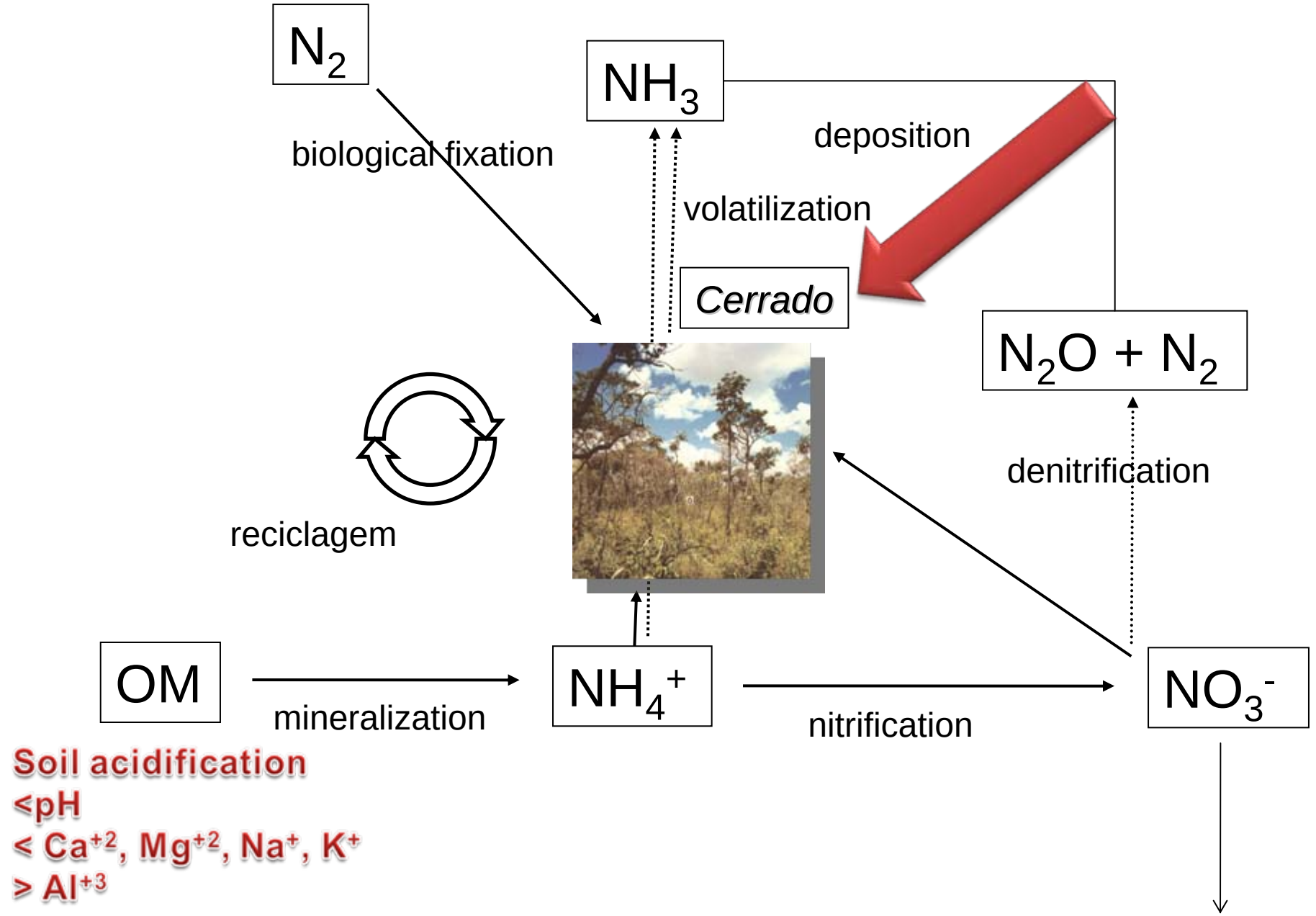
Fonte: Regina e Flavio Luizão (INPA); Martinelli, Nardoto (CENA), Ometto (IGBP)

The Nitrogen Cycle – N-poor natural system



Fonte: Bustamante, Miranda, Klink (UnB)

The Nitrogen Cycle – N-poor natural system



The Nitrogen Cycle – N-poor natural system

N_2

biological fixation

NH_3

deposition

volatilization

$N_2O + N_2$

denitrification

reciclagem

OM

mineralization

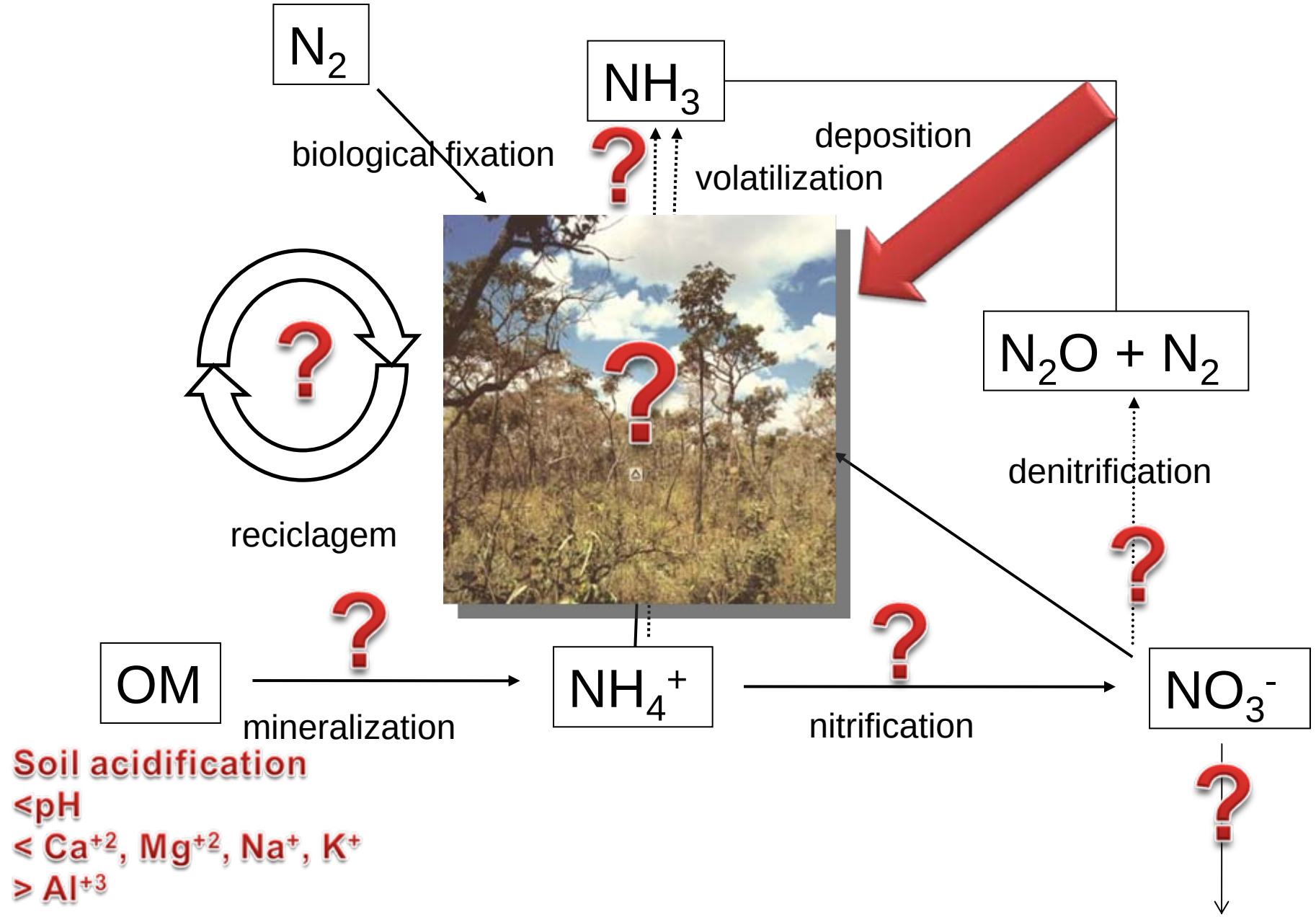
NH_4^+

nitrification

NO_3^-

Soil acidification
<pH
< Ca^{+2}, Mg^{+2}, Na^+, K^+
> Al^{+3}

The Nitrogen Cycle – N-poor natural system



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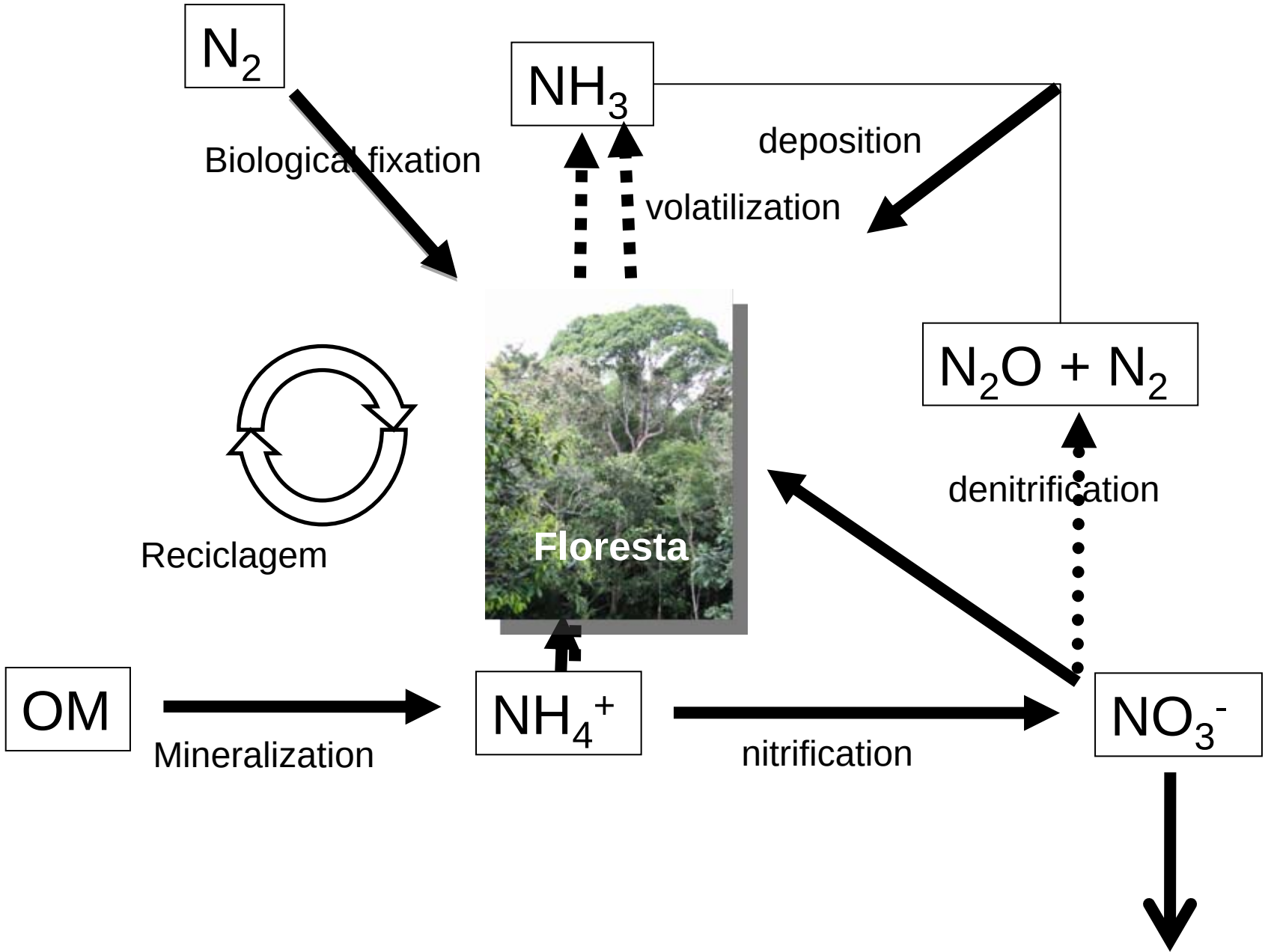

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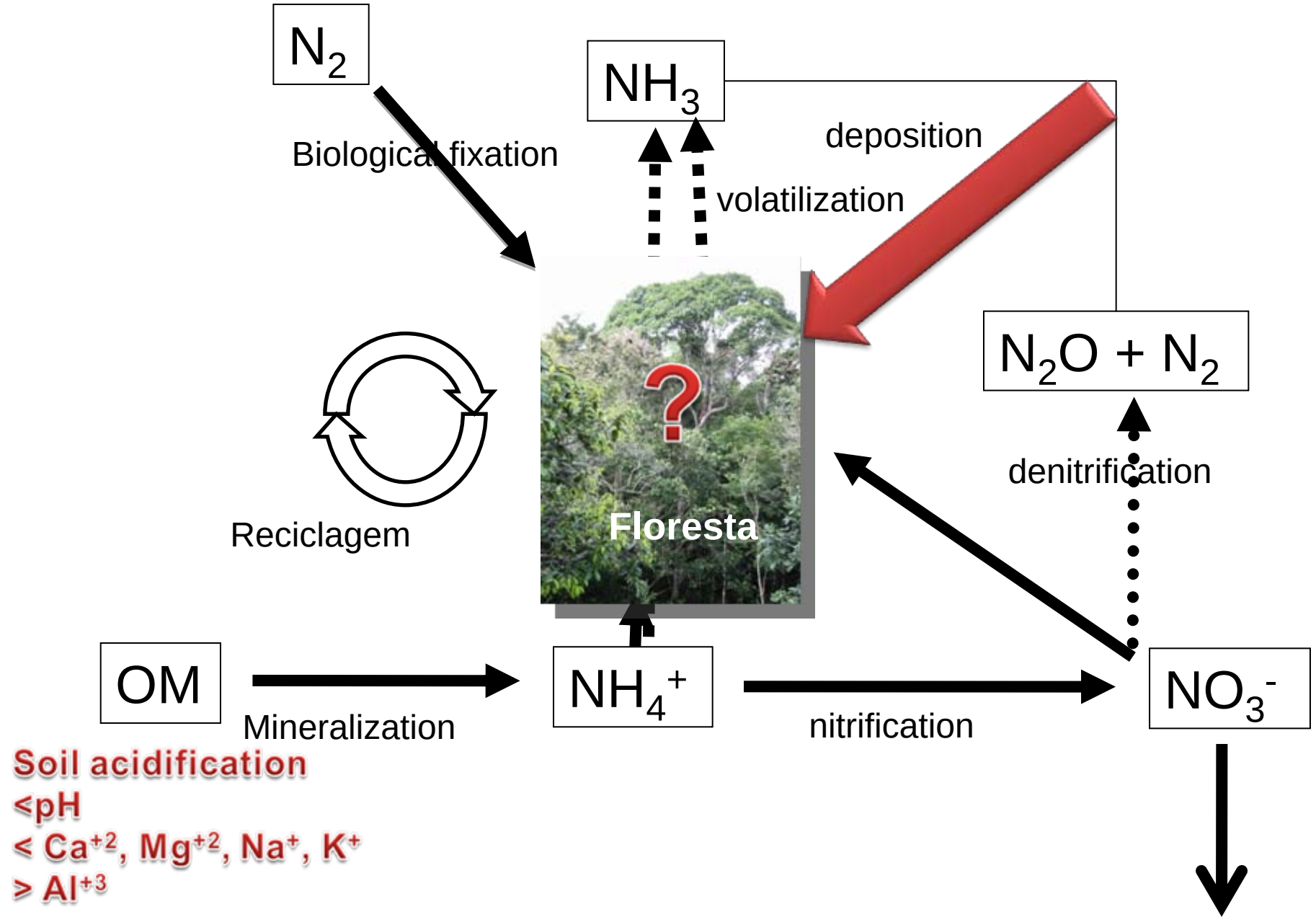
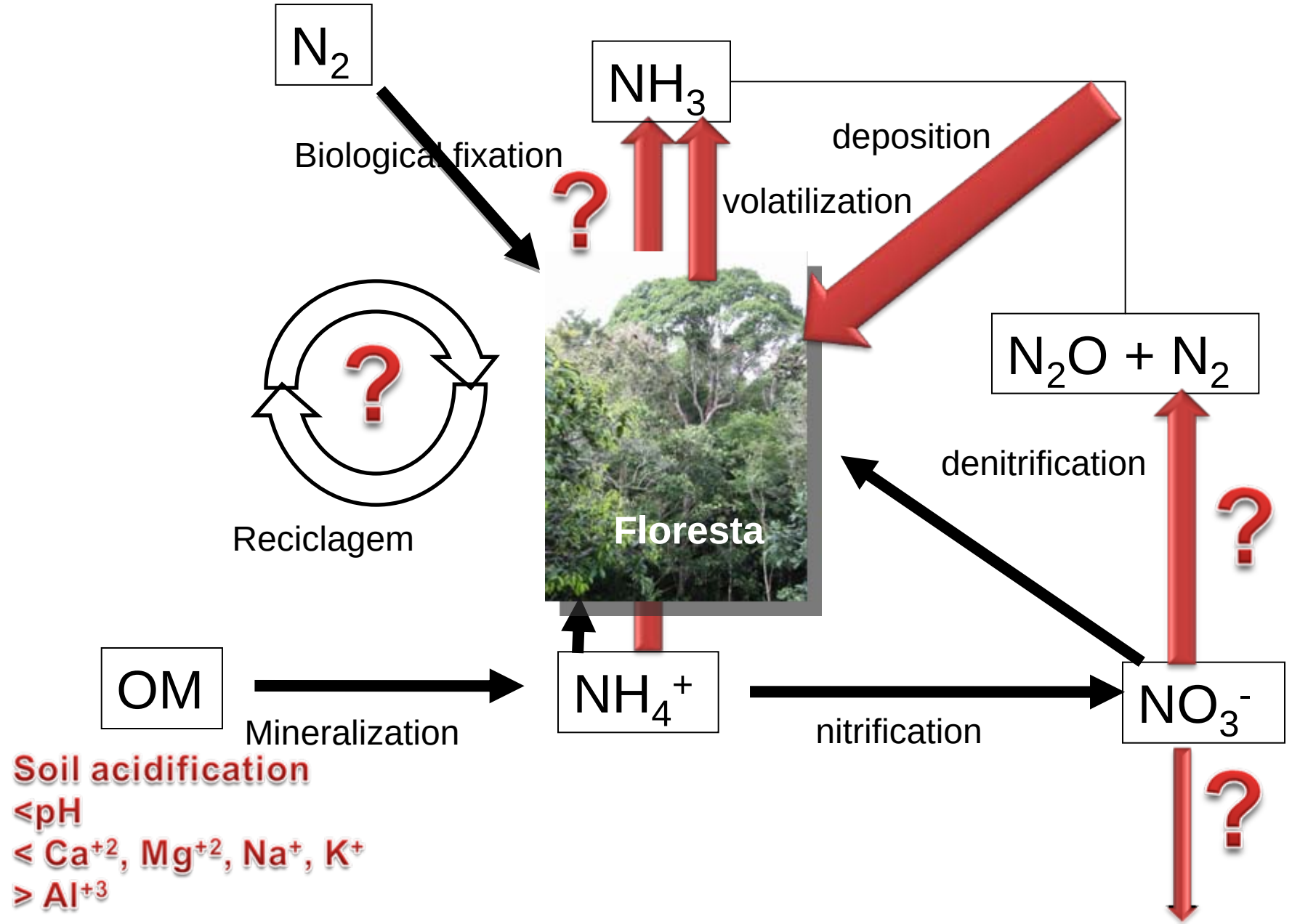
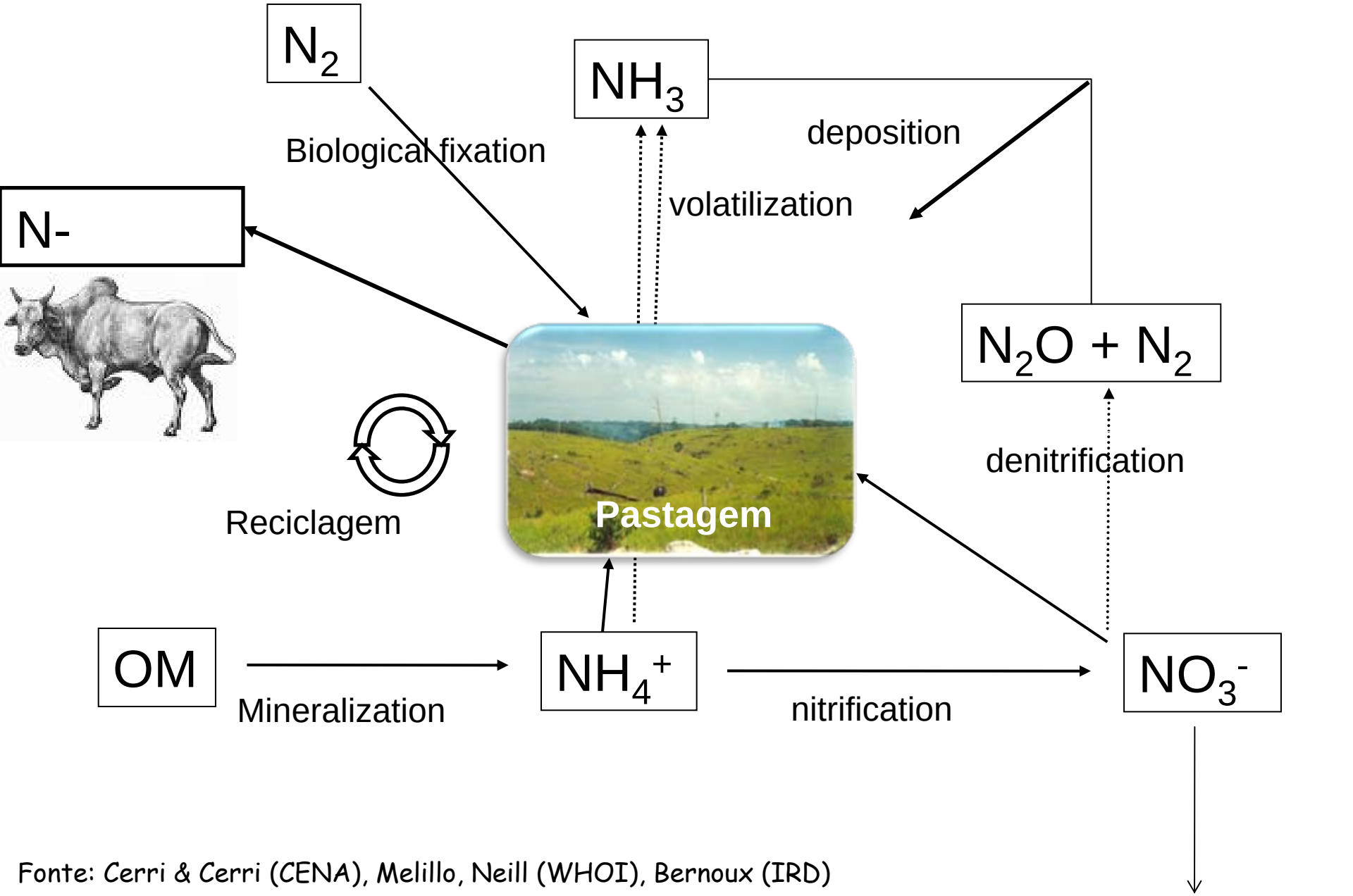


The Nitrogen Cycle – N-rich natural system



The Nitrogen Cycle – N-poor agricultural system



Fonte: Cerri & Cerri (CENA), Melillo, Neill (WHOI), Bernoux (IRD)

The Nitrogen Cycle – N-intensive agricultural system

N_2

Biological fixation

NH_3

volatilization

N-fert

N-harvest

$N_2O + N_2$

denitrification

Reciclagem

Milho

OM

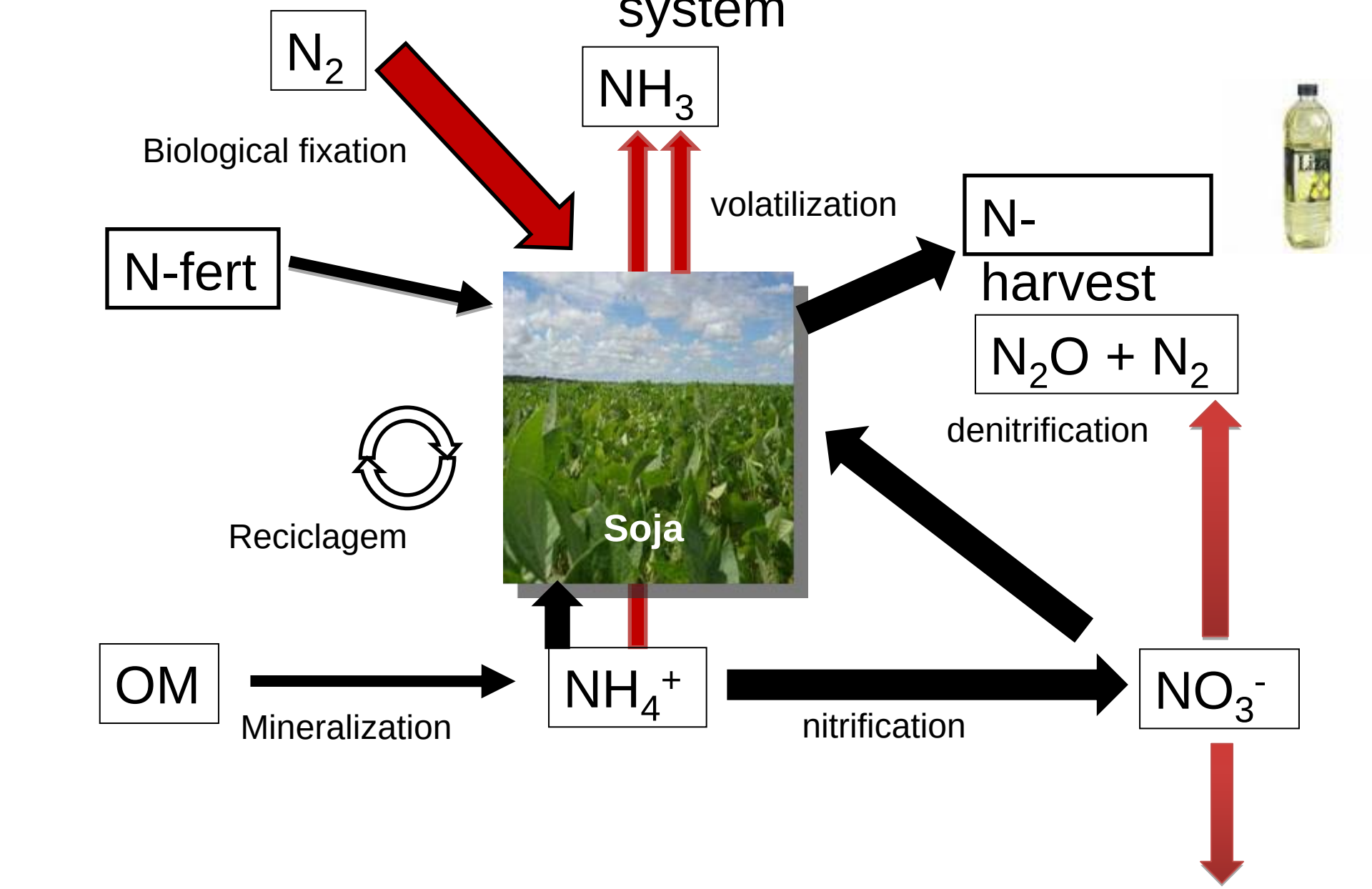
Mineralization

NH_4^+

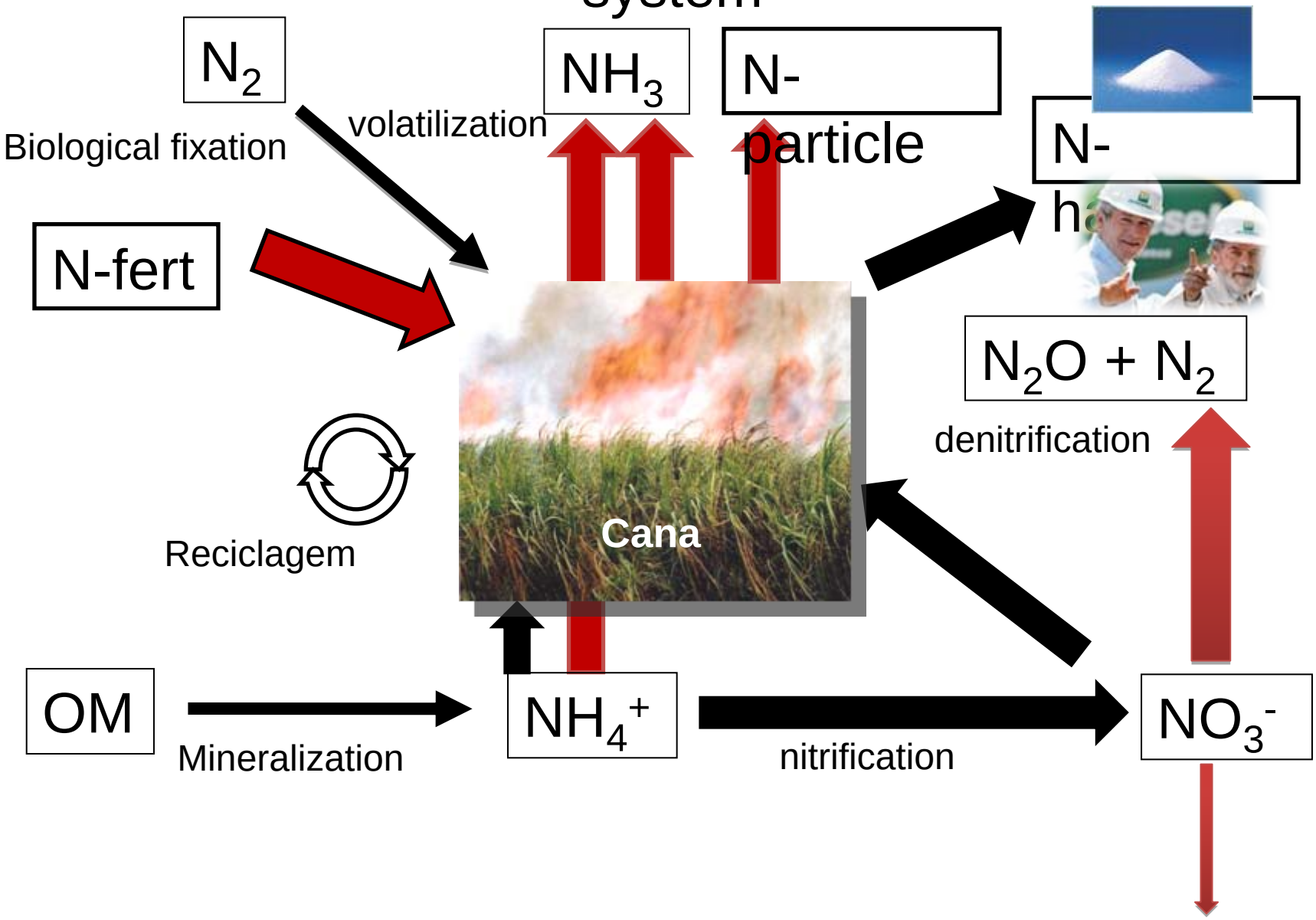
nitrification

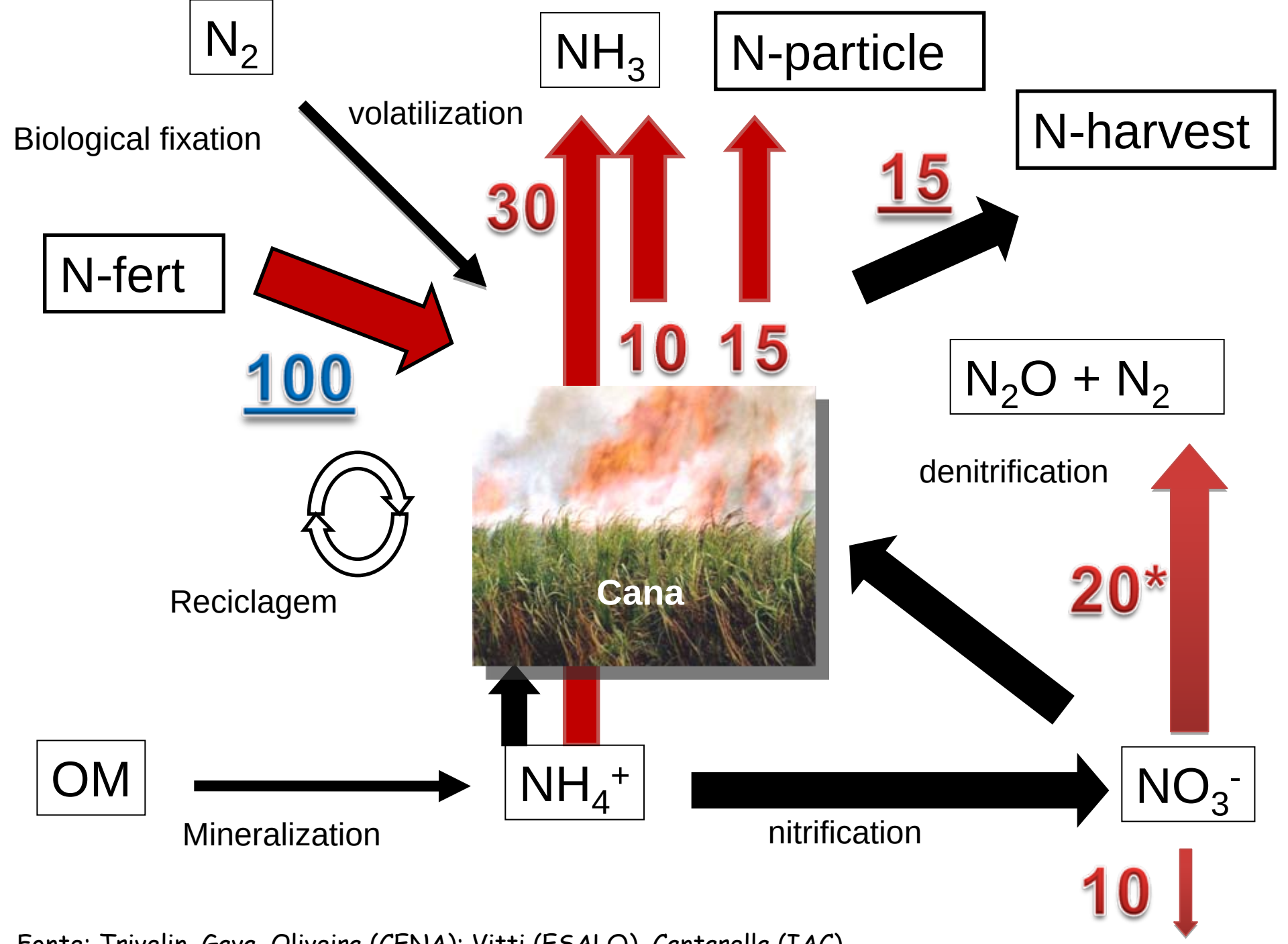
NO_3^-

The Nitrogen Cycle – N-intensive agricultural system

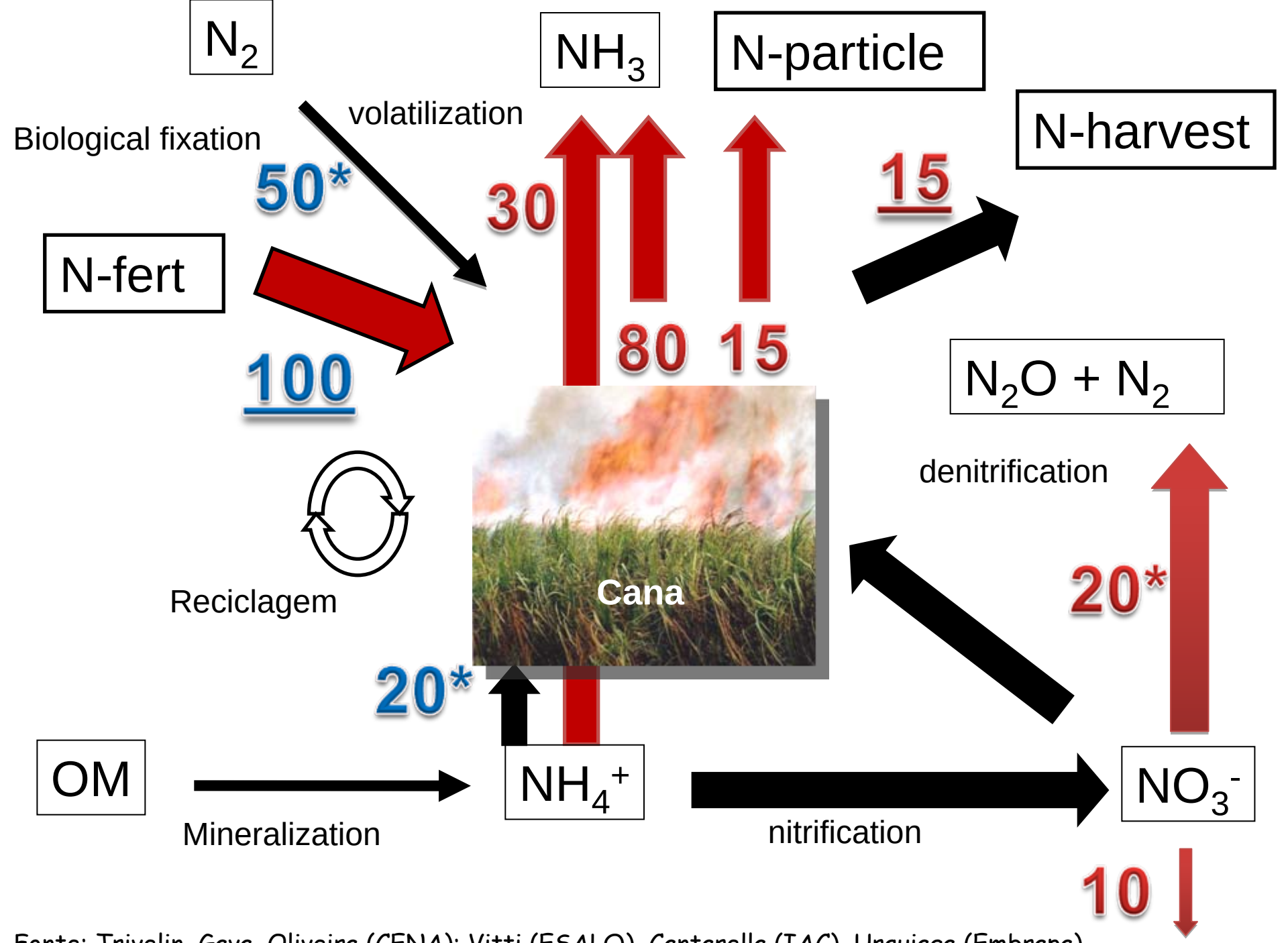


The Nitrogen Cycle – N-intensive agricultural system





Fonte: Trivelin, Gava, Oliveira (CENA); Vitti (ESALQ), Cantarella (IAC)



Fonte: Trivelin, Gava, Oliveira (CENA); Vitti (ESALQ), Cantarella (IAC), Urquiaga (Embrapa)

Atmos. Chem. Phys. Discuss., 7, 11191–11205, 2007
www.atmos-chem-phys-discuss.net/7/11191/2007/

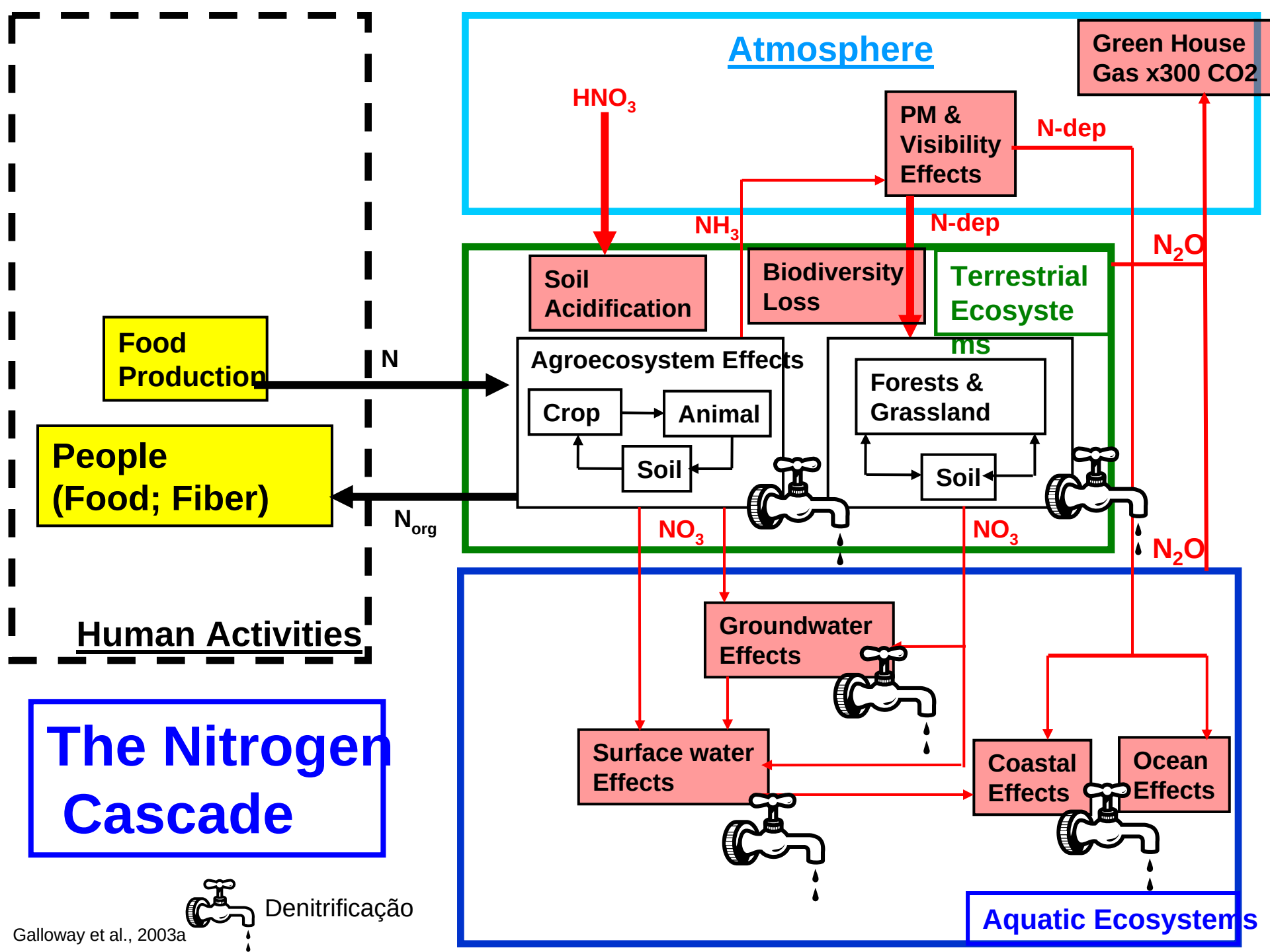
Atmospheric Chemistry and Physics Discussions

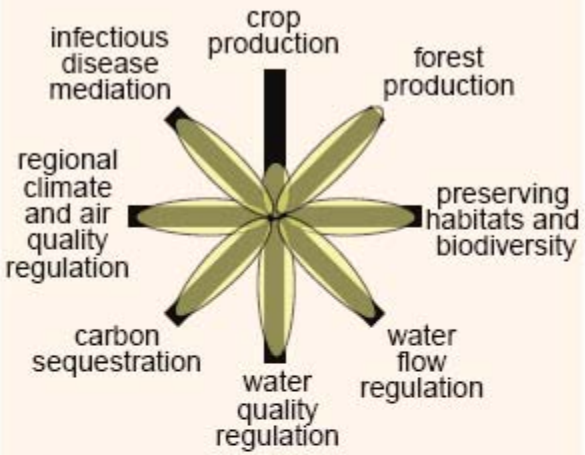
N_2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels

P. J. Crutzen[1,2,3], A. R. Mosier[4], K. A. Smith[5], and W. Winiwarter[3,6]

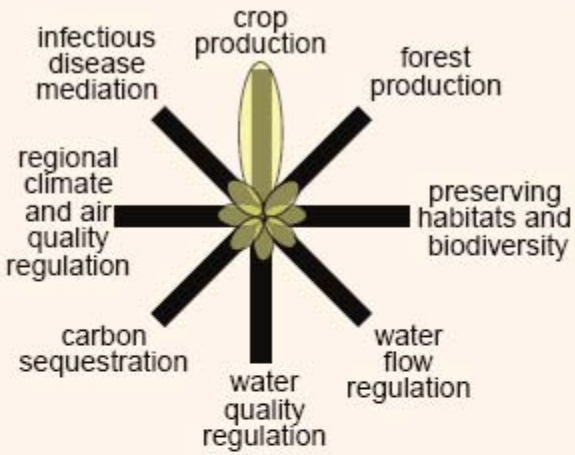
Table 1. Relative warming derived from N_2O production for crops, crop residues, and forages used in the production of biofuel.

Crop	r_N (gN/kg dry matter)	relative warming (Meq/M)	type of fuel produced
Rapeseed	39	1.0–1.7	Bio-diesel
Wheat	22	1.3–2.1	Bio-ethanol
Barley, Oat	19	1.1–1.9	Bio-ethanol
Maize	15	0.9–1.5	Bio-ethanol
Sugar cane	7.3	0.5–0.9	Bio-ethanol
Residue			
Sugar beet leaves	25	1.5–2.4	Bio-ethanol
Root crops	16	0.9–1.6	Bio-ethanol
Forages, low N	15	0.9–1.5	Bio-ethanol
Forages, high N	27	1.6–2.6	Bio-ethanol

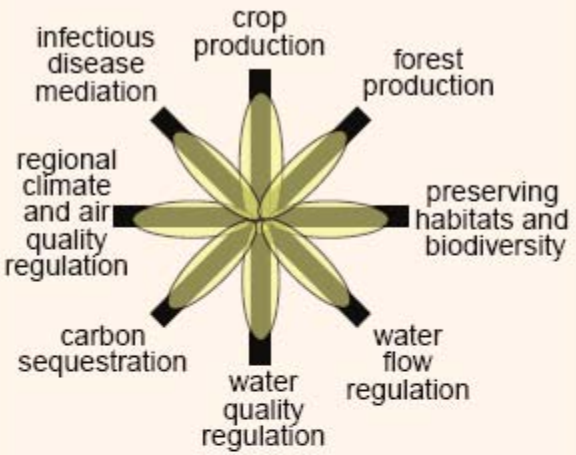

Atmosphere
Green House Gas x300 CO2
HNO3
PM & Visibility Effects
N-dep
NH3
N-dep
N2O
Soil Acidification
Biodiversity Loss
Terrestrial Ecosystems
Food Production
N
Agroecosystem Effects
Crop
Animal
Soil
Forests & Grassland
Soil
People (Food; Fiber)
Norg
NO3
NO3
N2O
Human Activities
Groundwater Effects
Surface water Effects
Coastal Effects
Ocean Effects
Aquatic Ecosystems
The Nitrogen Cascade
Denitrificação
Galloway et al., 2003a



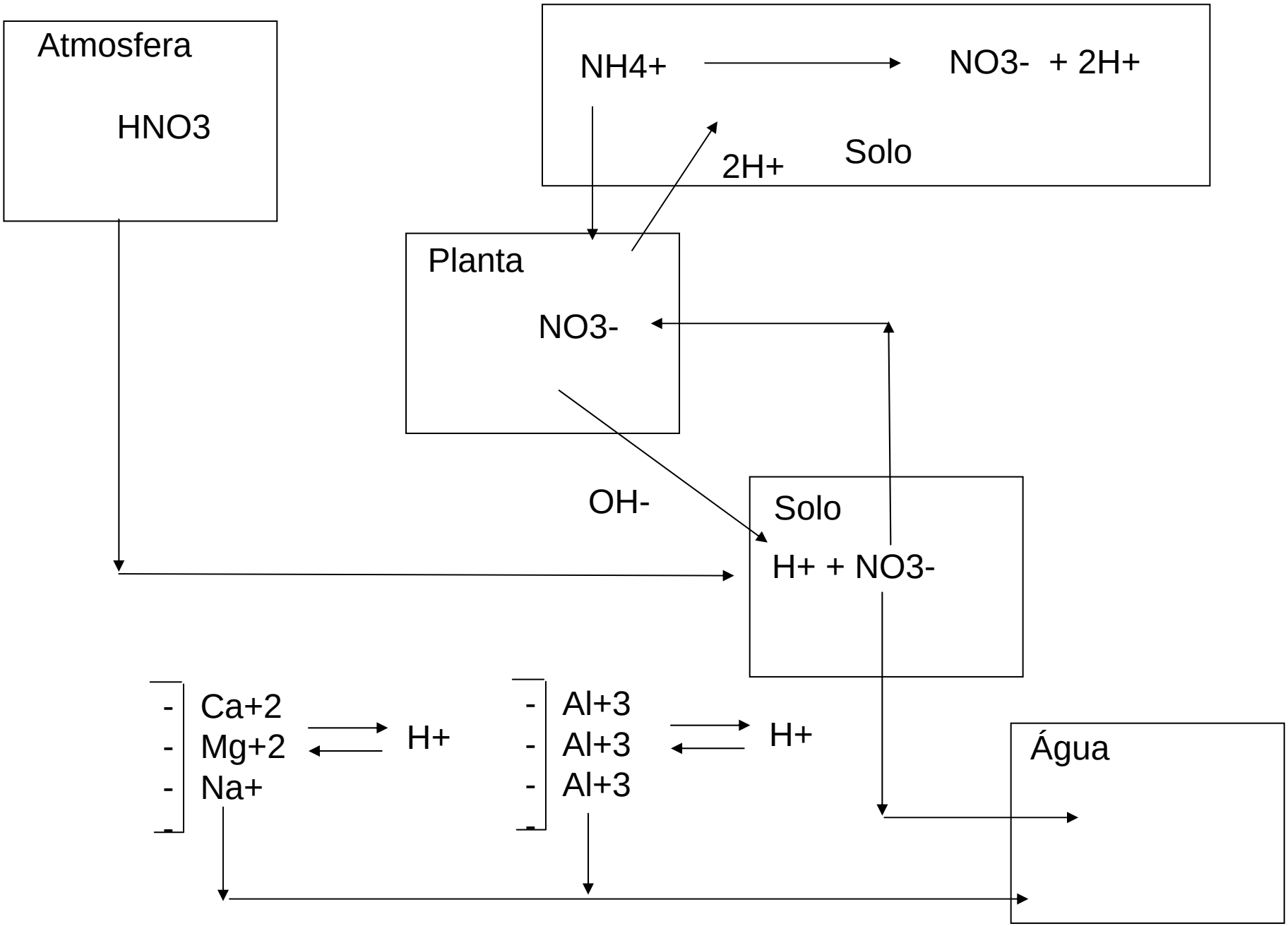
natural ecosystem



intensive cropland



cropland with restored ecosystem services


Atmosfera
HNO3
NH4+
NO3- + 2H+
2H+
Solo
Planta
NO3-
OH-
Solo
H+ + NO3-
- Ca+2
- Mg+2
- Na+
H+
- Al+3
- Al+3
- Al+3
H+
Água