Universidade de Brasília

ASPECTS OF NITROGEN CYCLE IN THE CENTRAL BRAZILIAN SAVANNAS

CERRADO

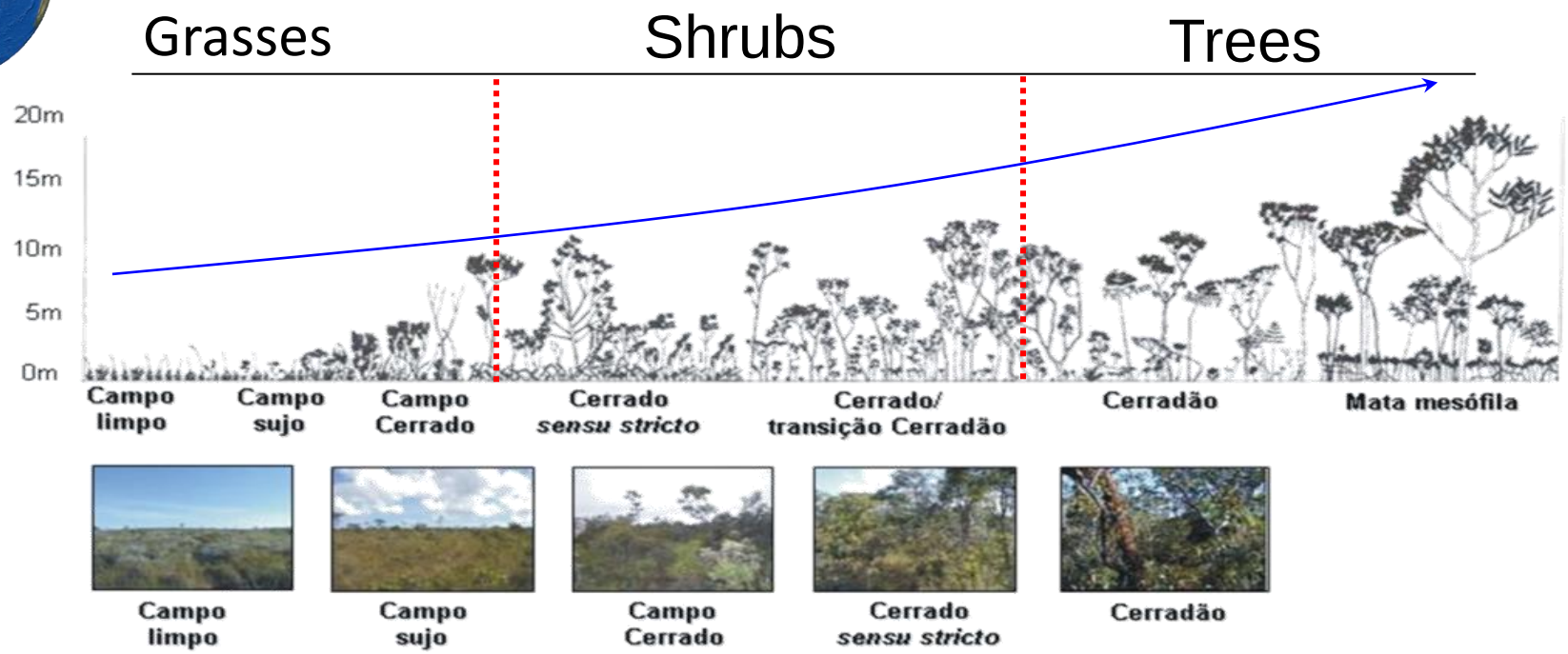
Gabriela Bielefeld Nardoto

N – School - SP – Brazil (09 August 2016)

Cerrado

- Wet seasonal savanna
- ~2,000,000 km² of Brazilian Central Plateau (24 % of the area of the country)
- 2nd largest plant formation in South America
- Central distribution = transitions to main Brazilian biomes

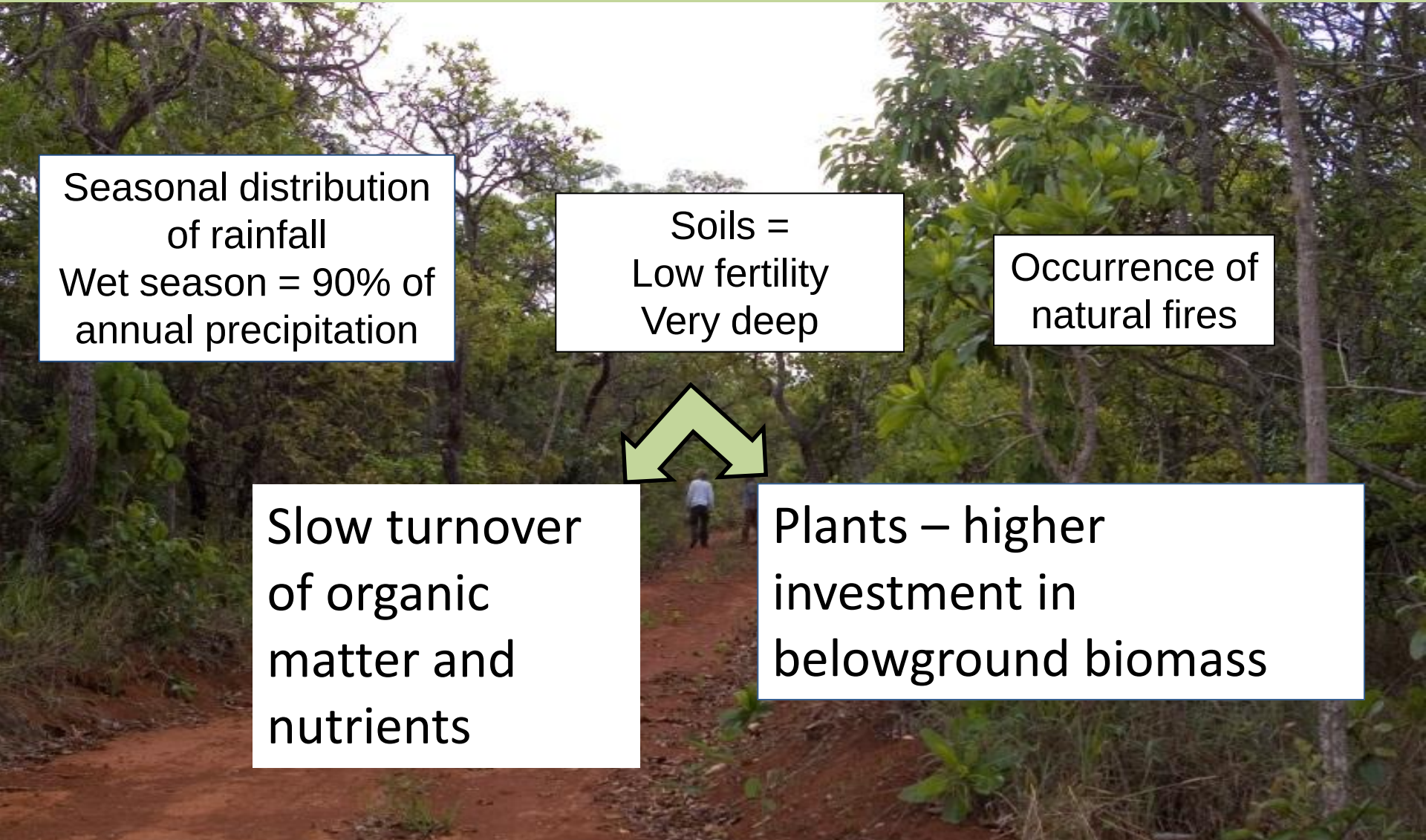
Cerrado - Mosaic of different vegetation types



Categories	Shoot (Mg/ha)	Root (Mg/ha)	Total	R:S ratio
Grasslands	7.2	16.7	23.9	2.34
Shrublands	24.6	33.5	58.1	1.37
Forestlands	79.7	17.8	97.5	0.22

Miranda et al. Biotropica 2014

Ecological determinants and biomass allocation



Brazilian Cerrado – facing many challenges...

Water resources

Carbon stocks

Biodiversity

Social diversity

Changes in fire regime

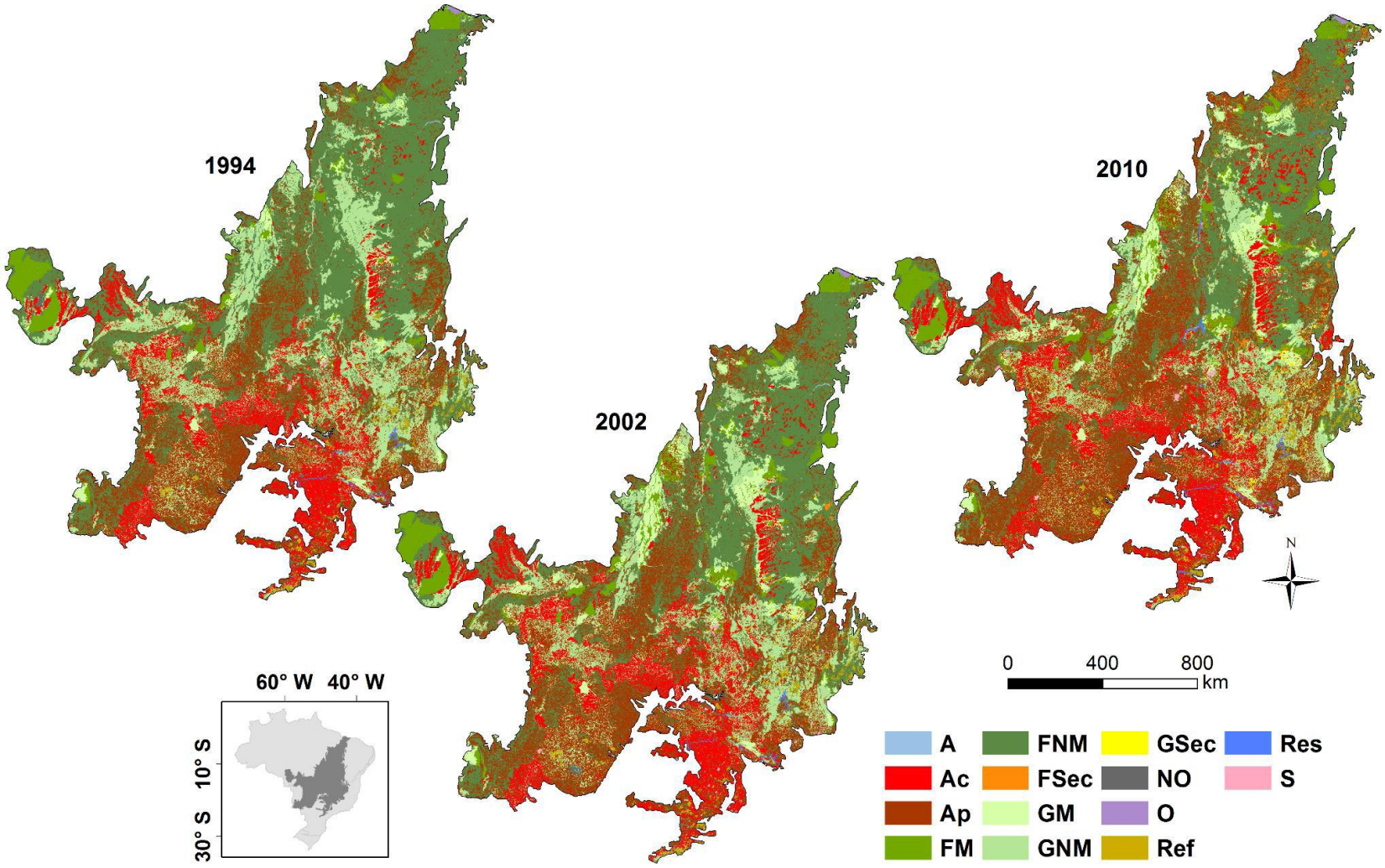
Meat production

Grain Production

Bioenergy expansion

Deforestation in the Cerrado

Main driver = agricultural expansion



Data: 3rd National Inventory of GHG, MCTI

Impacts of deforestation - from local to global...

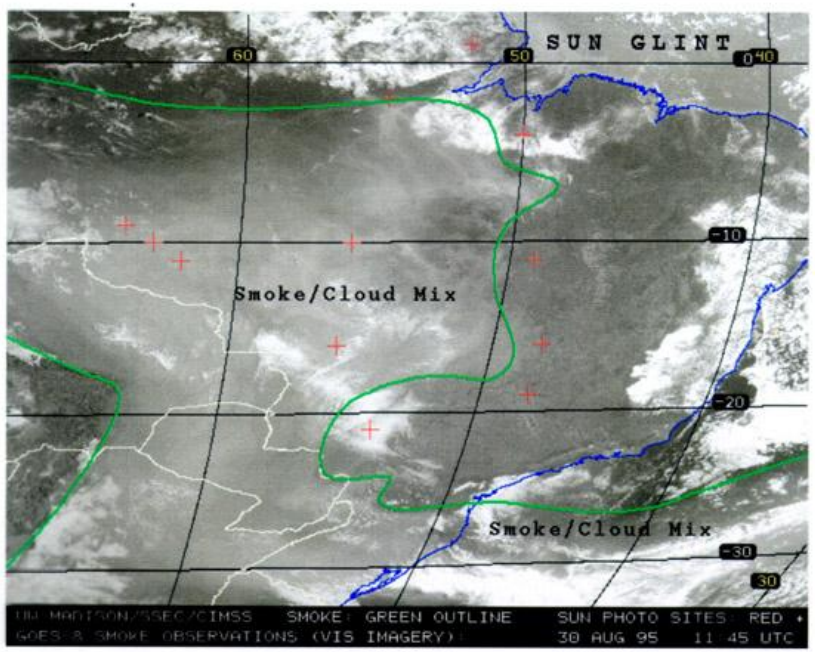
Changes in fire regime – more frequent fires , changes in vegetation structure

Replacement of native systems with heterogeneous canopy and deep roots by:

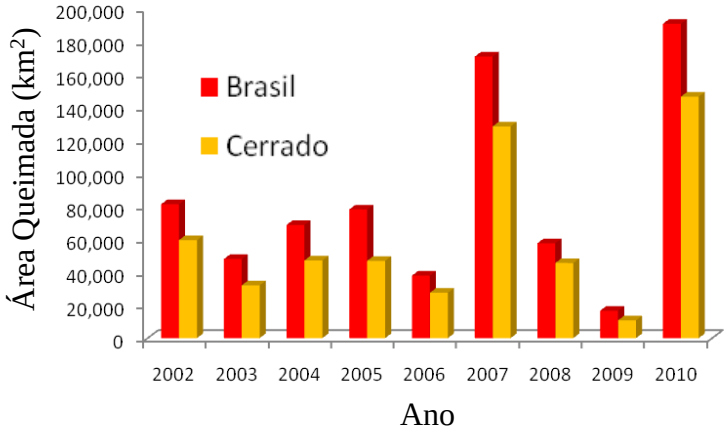
Grasses or annual crops with homogeneous canopy and shallow roots

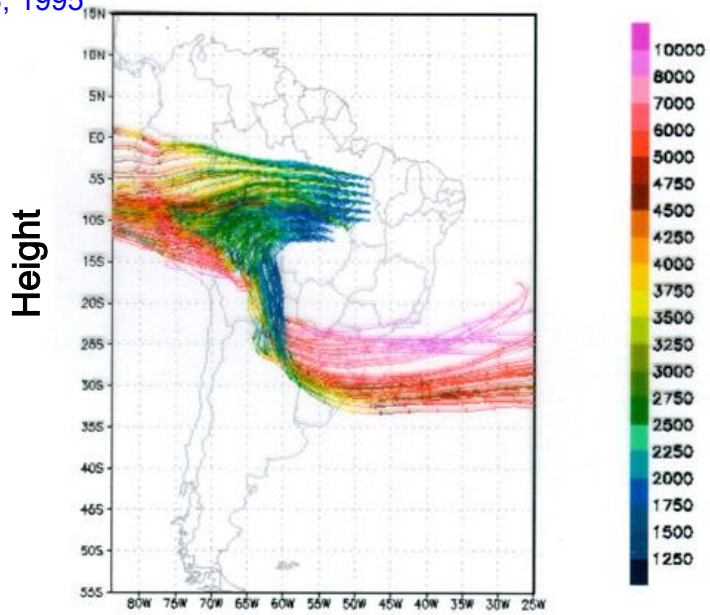
Fires in Cerrado

- Brazil concentrates 63% of the fires in South America
- ~70% of burned areas in Brazil occurs in the Cerrado
- Rapid occupation of the Cerrado region = changes in natural fire regime (season and frequency of burning)



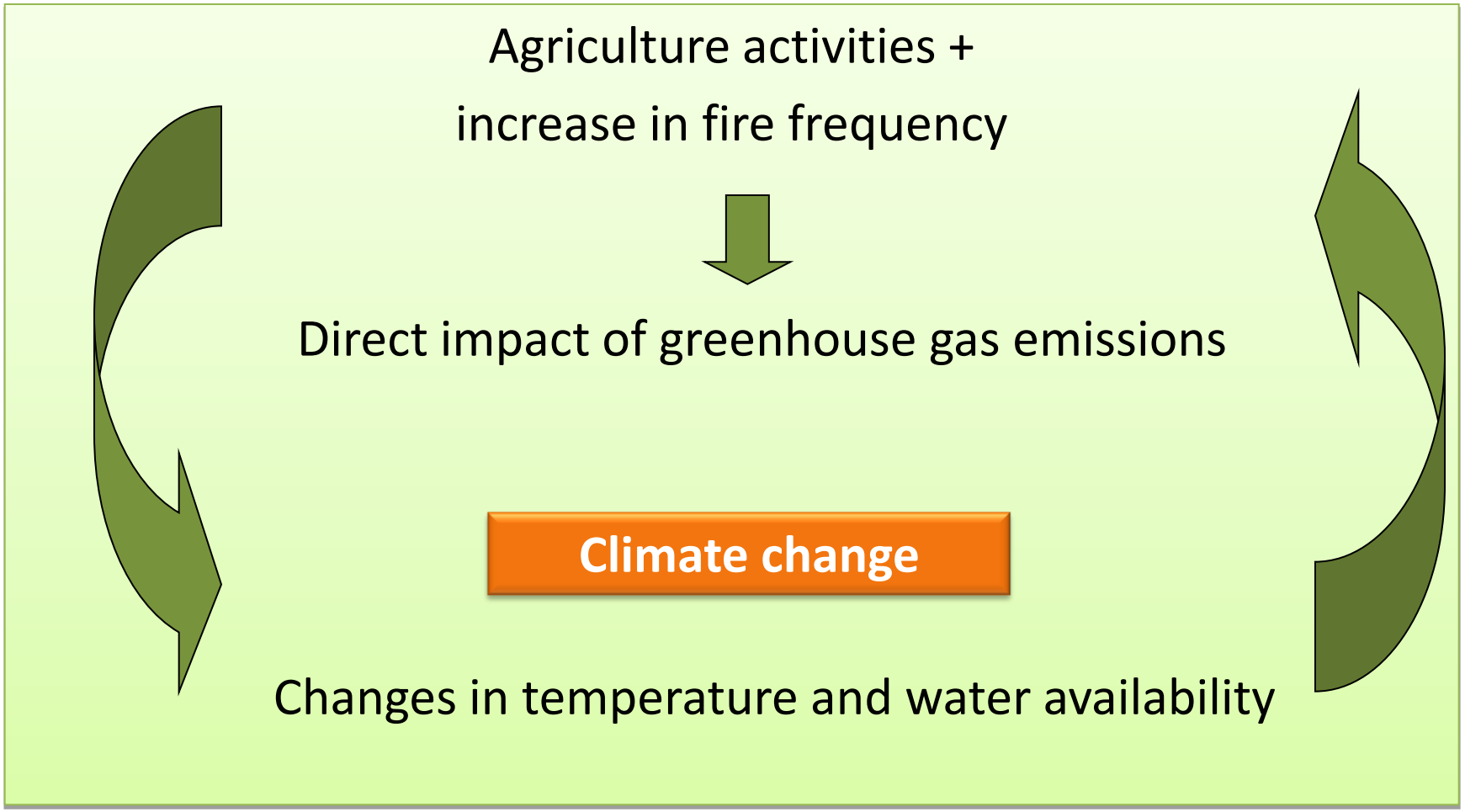
SCAR-B, 1995





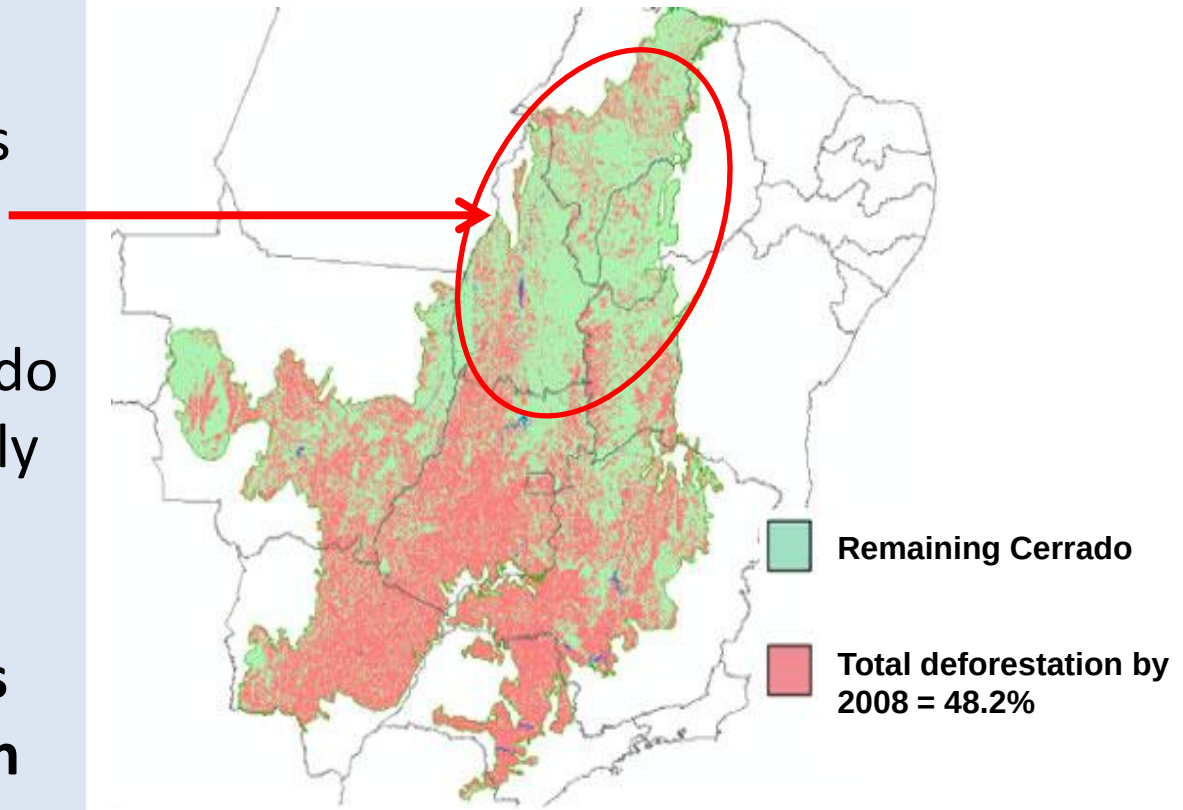
Freitas Longo and Silva Dias, 1996

Changes in the Cerrado region: a two-way road...



Projected precipitation changes in the Cerrado

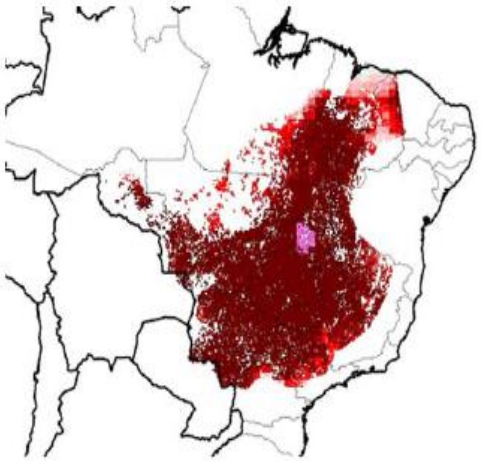
- Impacts will vary according to the different subregions
- Indication that the Northeastern Cerrado will be more severely affected.
- **Last large remnants of native vegetation**



(Marengo 2007, Marengo et al. 2009, 2010)

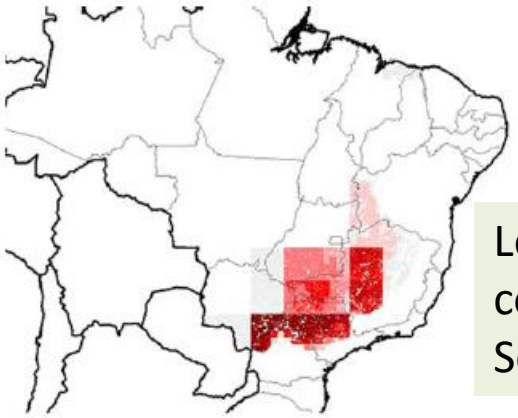
Projected Distribution of tree species for the Cerrado

Present
1961-1990

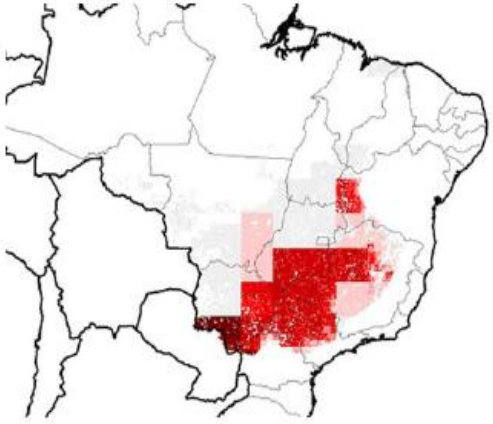


162 tree species
Most species were projected to decline seriously in potential distributional area.

Both scenarios = **losses of >50% of potential distributional area for essentially all species.**



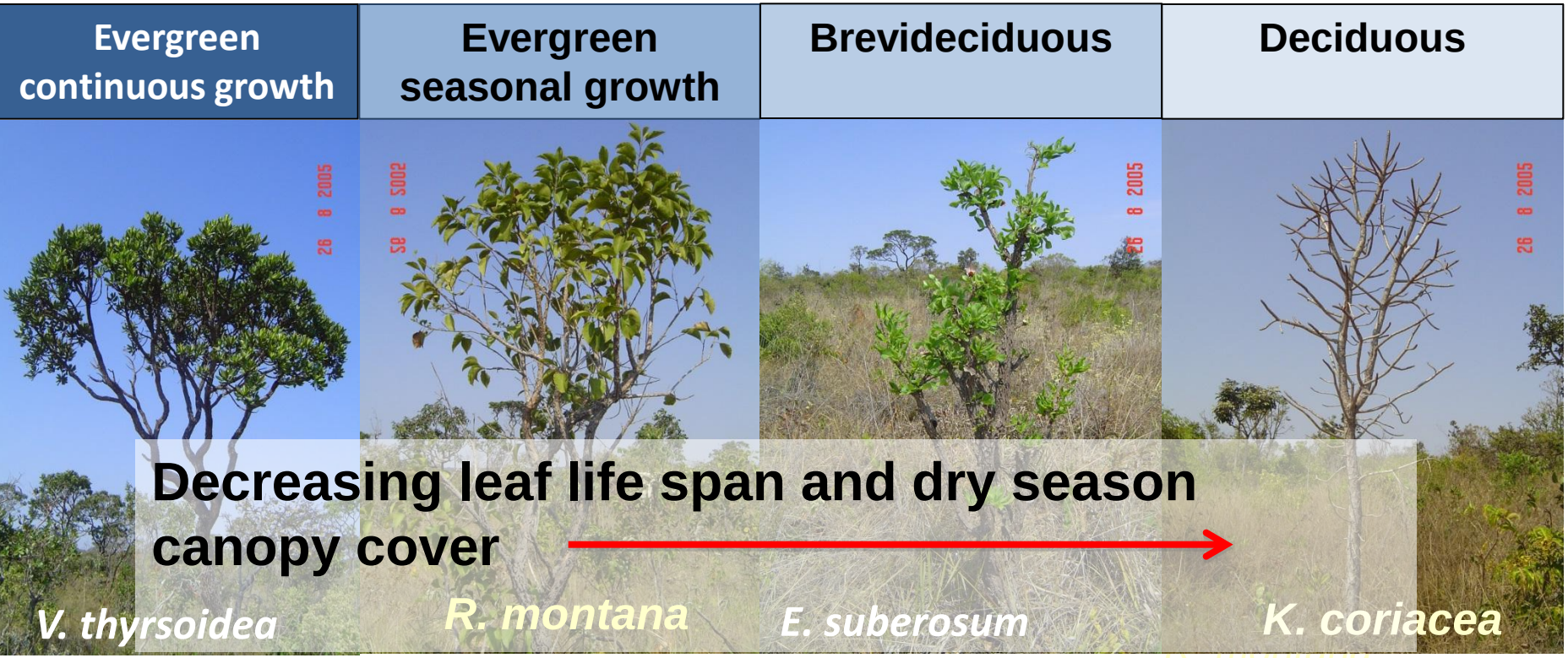
Less conservative Scenario



Conservative Scenario of Climate Change

Siqueira e Peterson, 2003

Cerrado - variations in Leaf phenology



Instead of discrete phenological groups, a continuum of strategies for leaf phenology, ranging from deciduous, brevi-deciduous to evergreen species, with varying degrees of intensity and duration of deciduousness

N cycling in native Cerrado

Questions:

- What are the N stocks and fluxes in the Cerrado?
- How do frequent fires affect the N cycle?
- How does land use change affect the N cycle?
- How does the N input affect the N cycle in native areas?

Nitrogen in the woody vegetation

Considering the dominant species:

N concentration - from 7 to 18 g kg^{-1}

N resorption - from 15 to 37%

N/P mass ratio in green leaves - from 15 to 27

Mean = 18 (indication of P limitation)

P resorption - from 40 to 70 %

Nardoto et al. 2006 – J. Trop Ecol.

Stocks and fluxes of N in a cerrado protected from fire for 28 years

Compartments	**Stock ((kg ha^{-1})**
Total N – soil (0 –100 cm) [1]	4576
Total N – soil (0 –10 cm) [1]	1116
Aboveground Biomass [2]	37787
Belowground Biomass (0-800 cm) [3] (roots >2 mm)	27649
Belowground Biomass (0-100 cm) [3] (roots >2 mm)	25638
Fine litter production (kg ha^{-1}yr $^{-1}$) [4]	2300
N in the biomass of leaves of woody species*	24
N in the belowground biomass [1] (0 – 800 cm) (roots >2 mm)	103
N in the belowground biomass [1] (0 – 100 cm) (roots >2 mm)	95
N in the fine litter [4]	123

N in biomass

=

N in litter

Bustamante et al. 2006

Changes in land use × fire regime

Rapid occupation of the Cerrado region

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changes in natural fire regime

***ca*. 18000 BP (Vicentini, 1999):**
fire frequency = 8 and 40 years

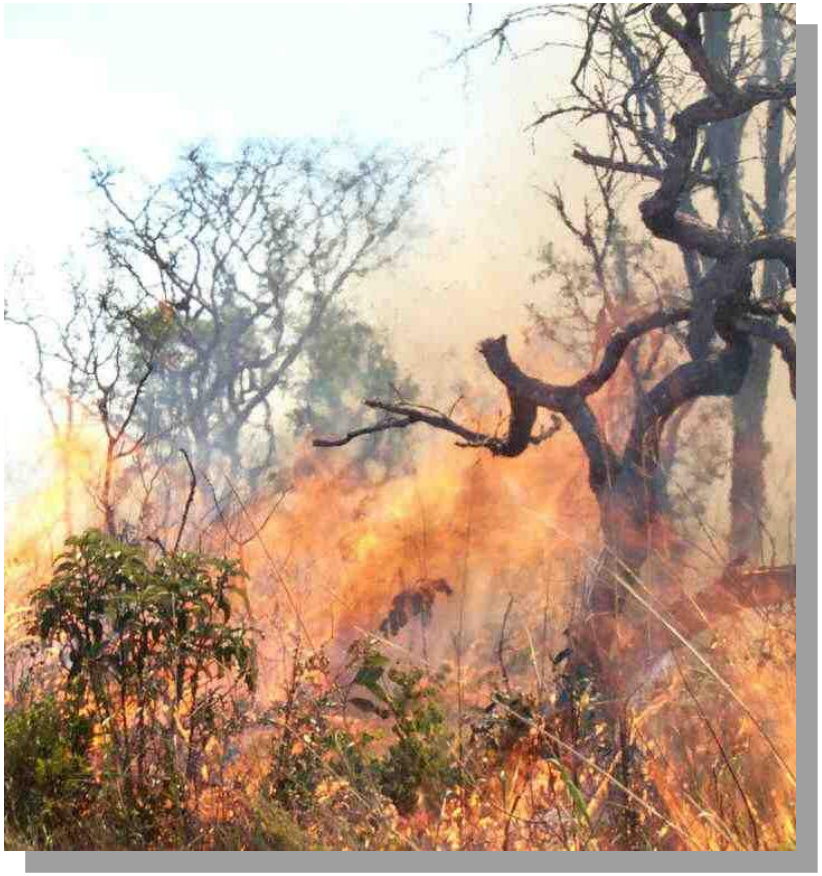
In the last years (Coutinho, 1990):
cerrado *s.s.* - burn every 2-3 years
campo - burn every year

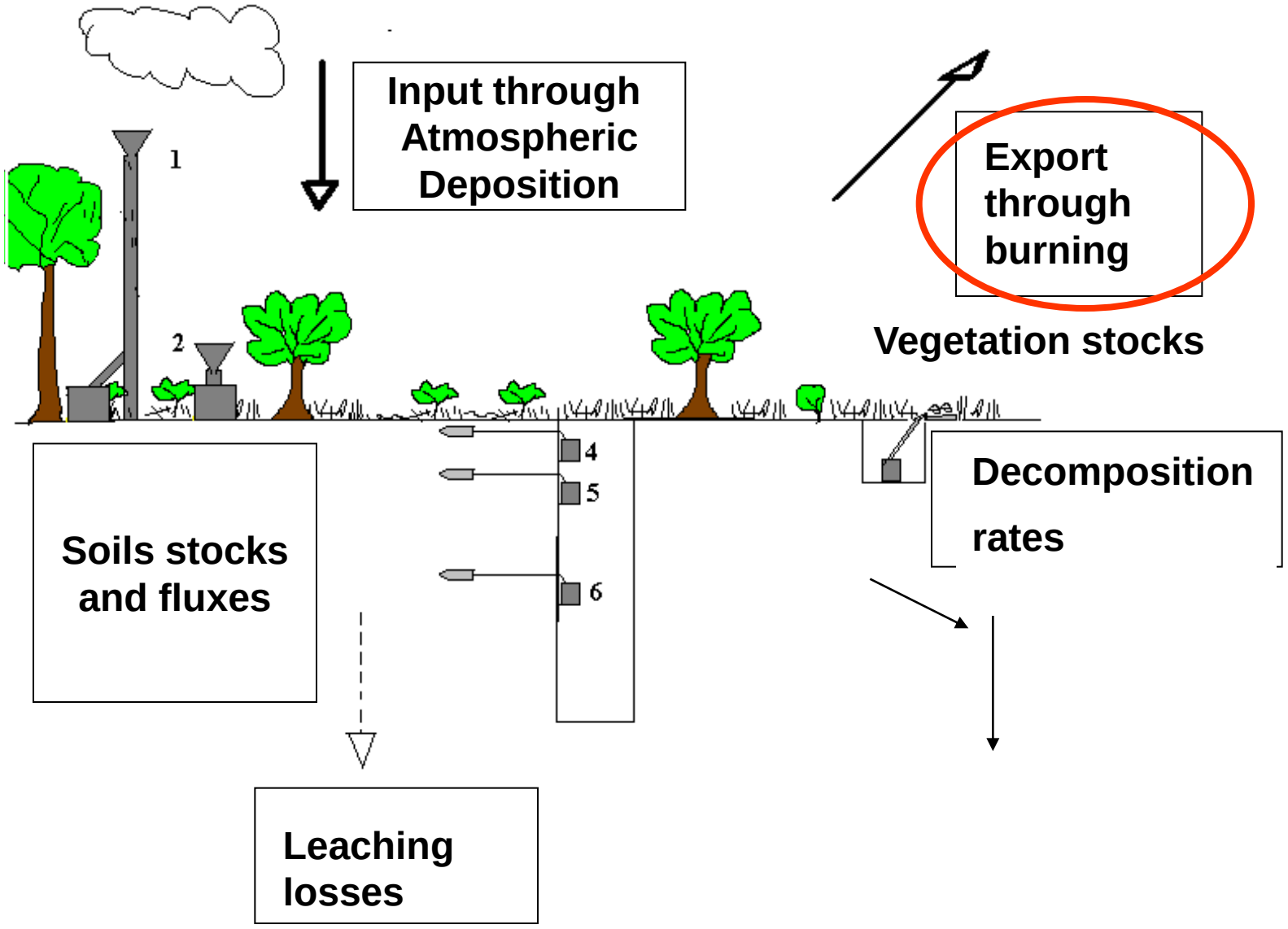
Understanding the impacts of fire...
The Fire Project

- Impacts on the structure and functioning of Cerrado ecosystem

- Ecological Reserve of the IBGE (Brasília, DF):
  - 1.different Cerrado physiognomies
  - 2.well-documented fire history.

Different regimes of prescribed fires since 1992

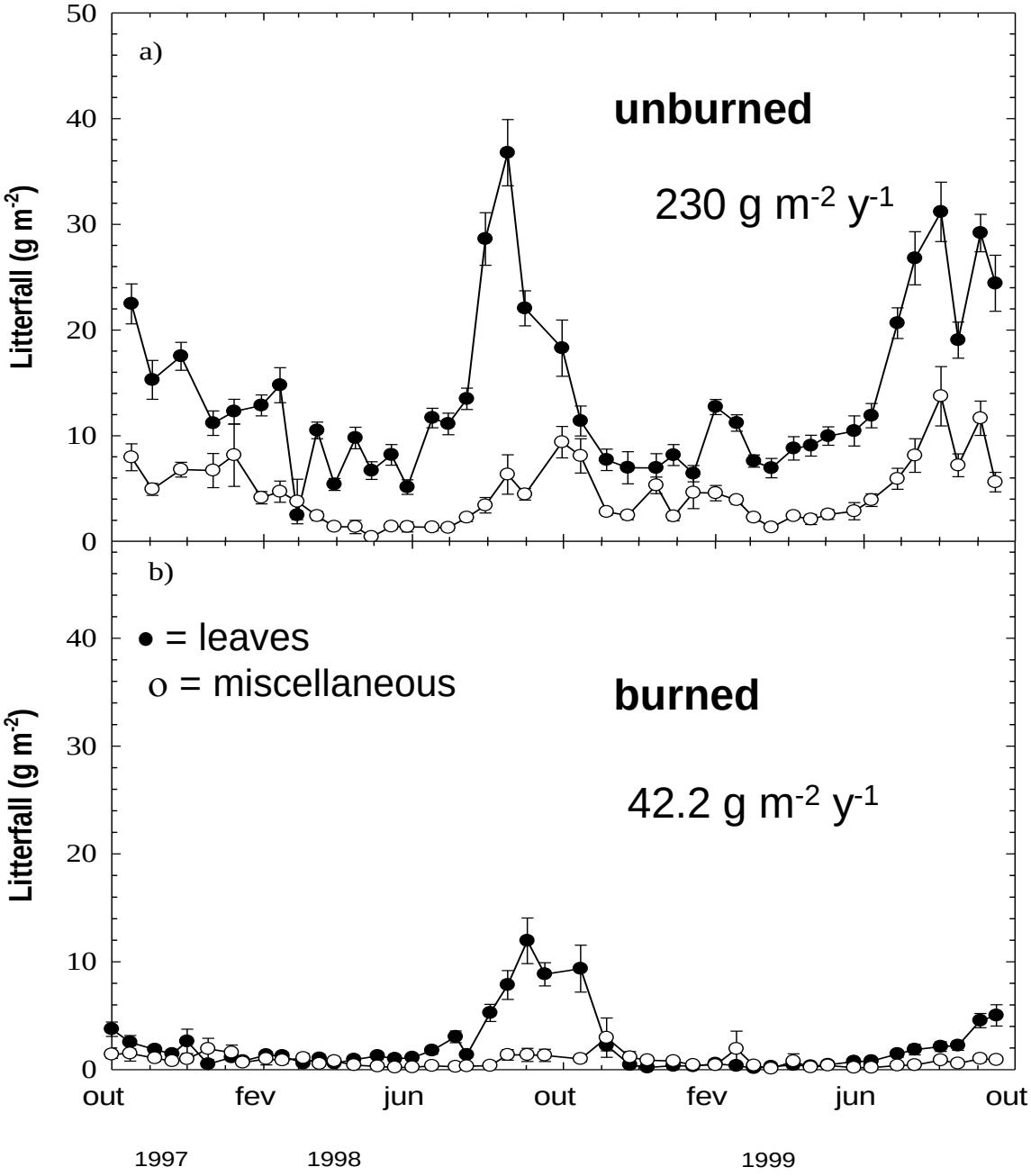



Input through Atmospheric Deposition
Export through burning
Vegetation stocks
Soils stocks and fluxes
Decomposition rates
Leaching losses
1
2
4
5
6

- Nitrogen in the fuel and ashes in cerrado area burned every 4 years
- Woody layer: leaves 7.9
- Woody layer: stems 4.5
- Herbaceous layer: 6.3
- Ashes: 11.3

- N loss = 53 %

- Increase of NH_4+ and NO_3- concentration in soil solution (25 and 100 cm) (Resende, 2001)

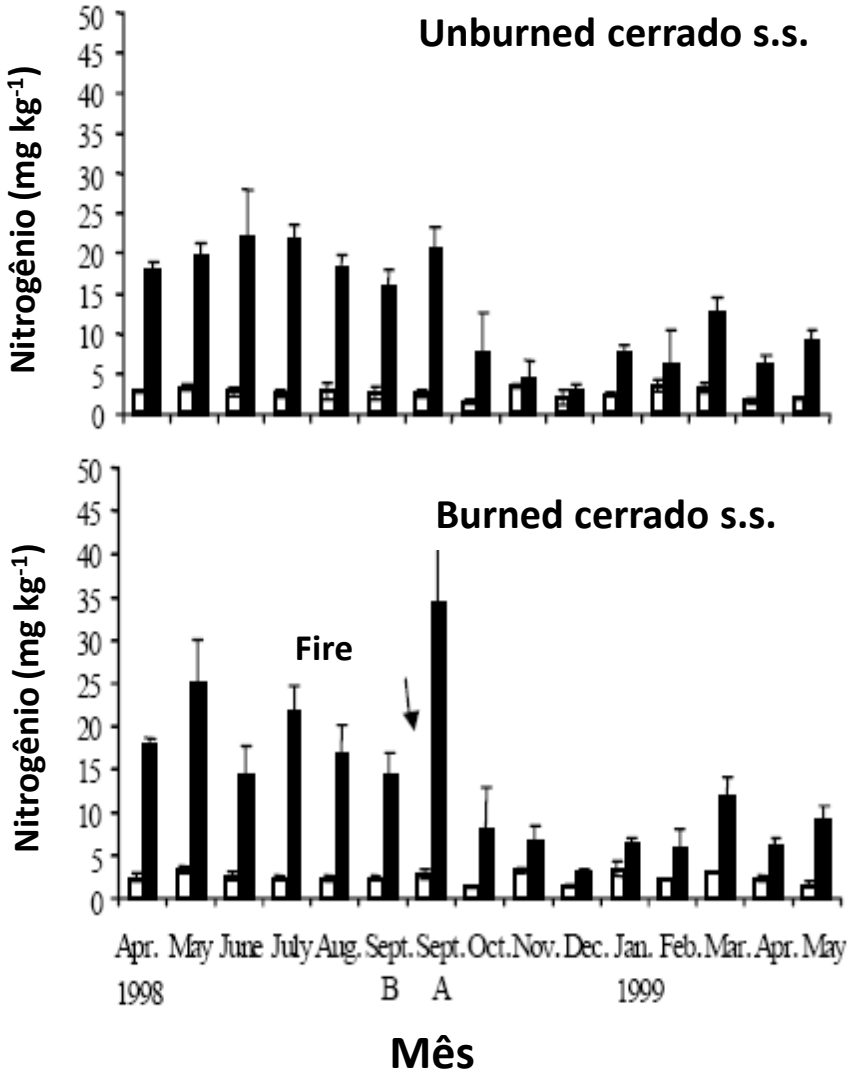


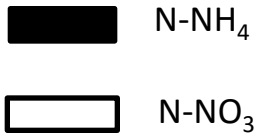
Litter production

- Seasonal trend of litterfall was similar in both plots
- Production in the burned plot decreased by 22% 1 yr after burning
- Nutrient fluxes were 60 - 80% lower than in the unburned plot.

Nardoto et al. 2006 J. Trop. Ecol.

Changes in available inorganic N in soil



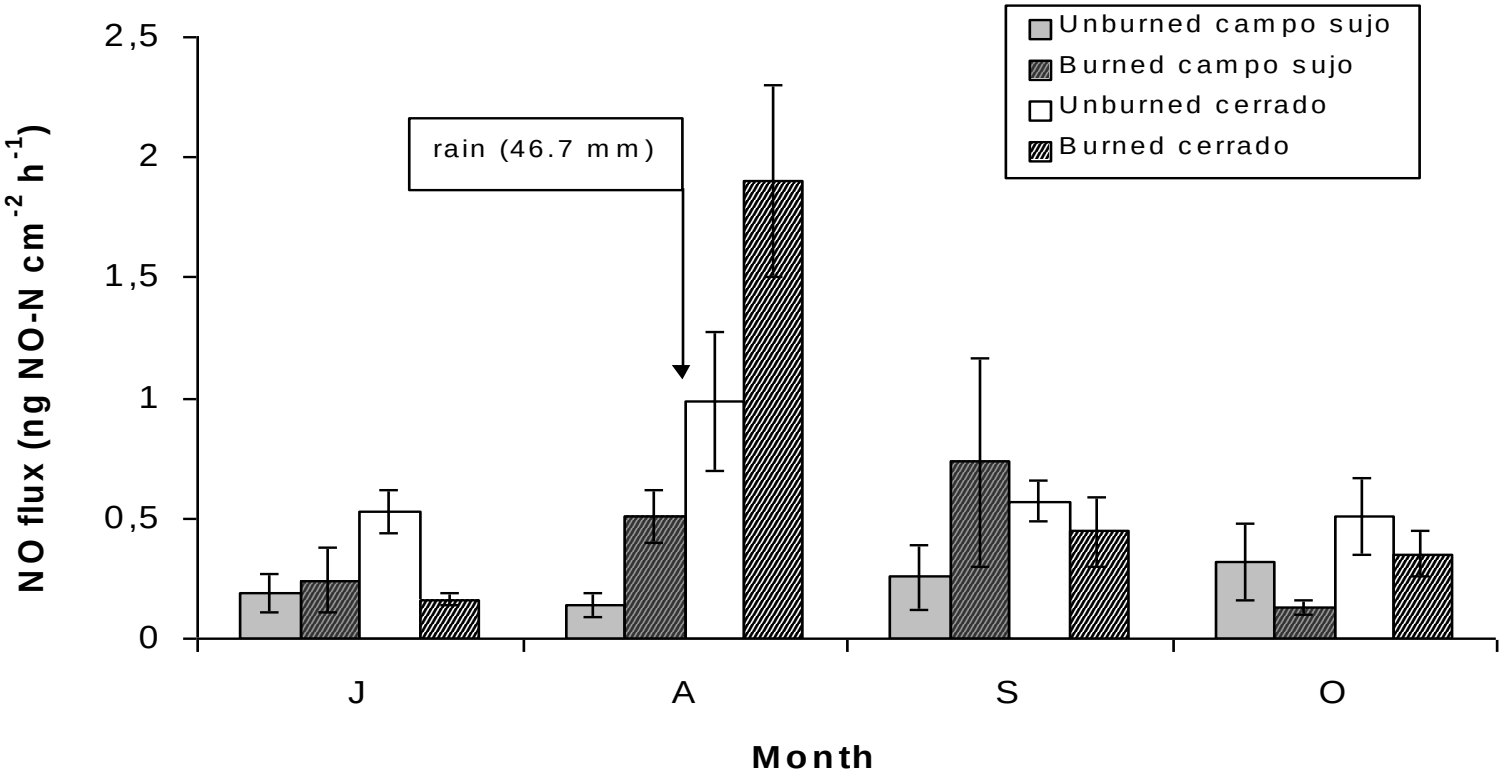


Inorganic N annually mineralized (kg ha^{-1} $year^{-1}$):

- unburned cerrado: 14,7
- burned cerrado: 3,8

Nardoto et al. (2006) J. Trop. Ecol.

NO fluxes in unburned and burned Cerrado vegetation types



Cerrado – N and P limitation?

Considering the dominant woody species in a typical cerrado (Nardoto et al. 2006):

- Foliar [N] = from 7 to 18 g kg^{-1}
- N resorption - from 15 to 37%
- Foliar [P] = from 0.4 to 0.7 g kg^{-1}
- P resorption –from 40 to 70 %

N/P mass ratio in leaves - from 15 to 27
Mean = 18 (indication of P limitation)

Table 4: Comparison of organic carbon content, soil total nitrogen, C/N ratio and available in different savanna regions.

Ecosystem	Organic carbon %	Total nitrogen %	C/N	Extractable P ($\mu g.g^{-1}$)	Reference
Chaco (restored site)	4.7	0.28	16.8	52.5	Abril and Bucher,1999
Llanos	1.2	0.07	17.1	2.3	Medina, 1982
Brazilian Cerrado	3.2	0.17	18.8	0.2	Resende, 2001
South African Savanna	4.1	0.18	22.8	32	Scholes and Walker, 1993
Australian Savannas	1.7	0.08	21.3	10	McKeon et al., 1991
North America Mesquite Savannas	1.2	0.18	6.7	?	Martin et al., 2003

Bustamante et al. 2006 Biochemistry

N cycling in Native Cerrado

- Very conservative
- Affected by frequent fires
- Low nitrification rates
- Predominance of soil NH_4 over NO_3
- Low emissions of NO_x and N_2O from soil to the atmosphere
- Soil N associated to recalcitrant C

Cerrado – N and P limitation?

How will the increase in nutrient inputs affect the functioning of cerrado ecosystems and change nutrient limitation?

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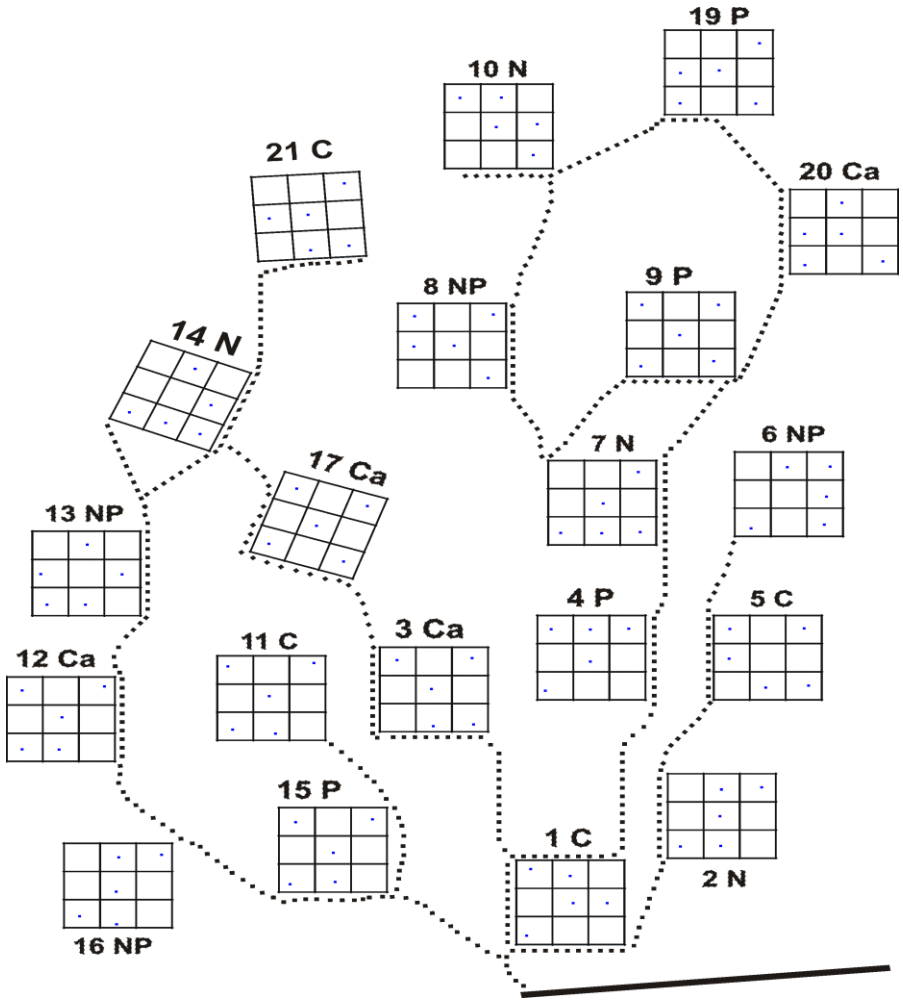
Fertilization experiment in a native cerrado area

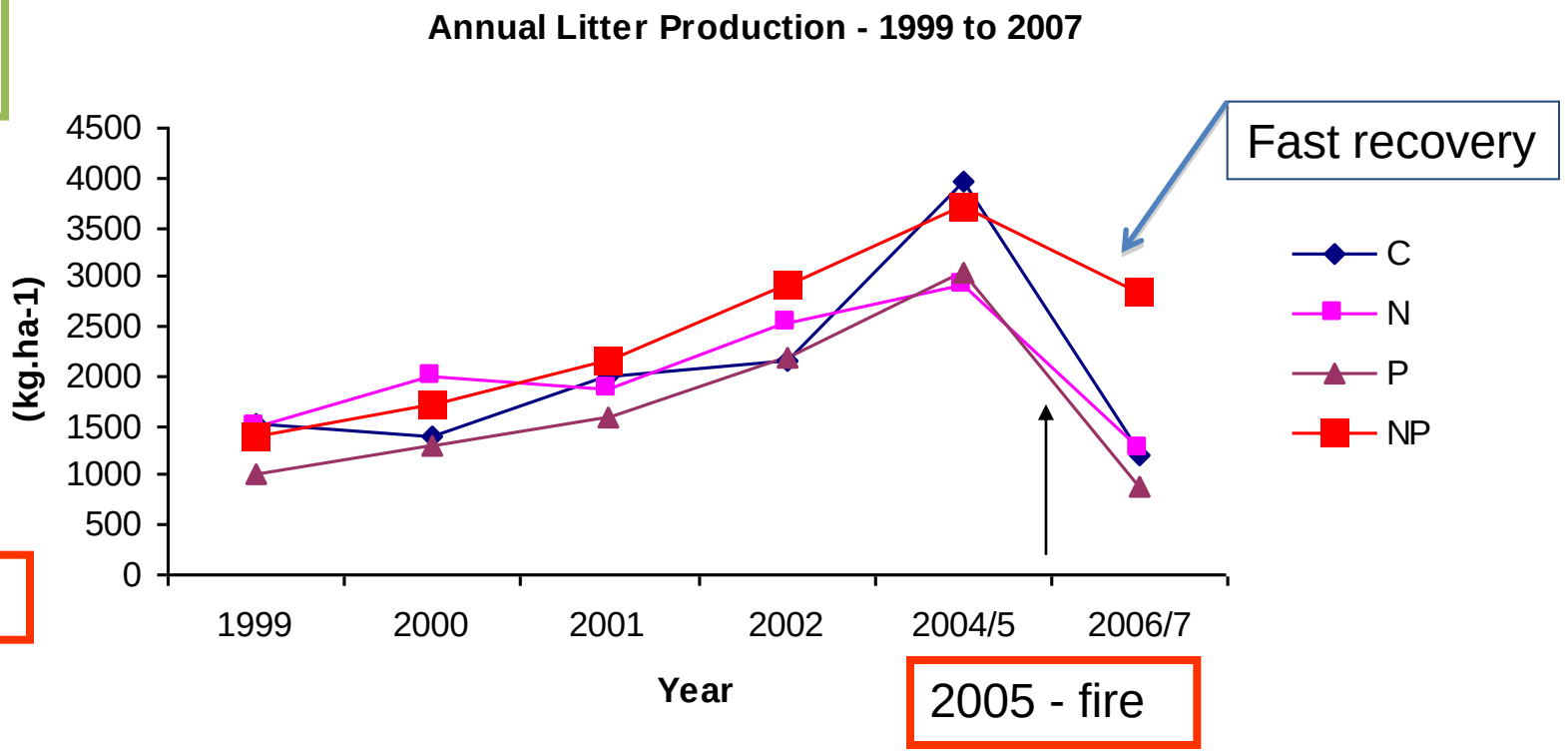
Fertilization Experiment

- 4 treatments = control, Ca, N, P and N plus P additions
- Replicated in four 225m^2 plots per treatment.
- Started in 1998
- Annual additions, divided in two applications (beginning and end of rainy season) :
- N = 100 kg.ha^{-1}.y^{-1}
- P = 100 kg.ha^{-1}.y^{-1}
- N plus P (100 kg.ha^{-1}.y^{-1} each)



Litter Production – 1999 to 2007

kg $ha^{-1}y^{-1}$
NP= 2859.6
C= 1211.0
N= 1266.4
P= 878.1

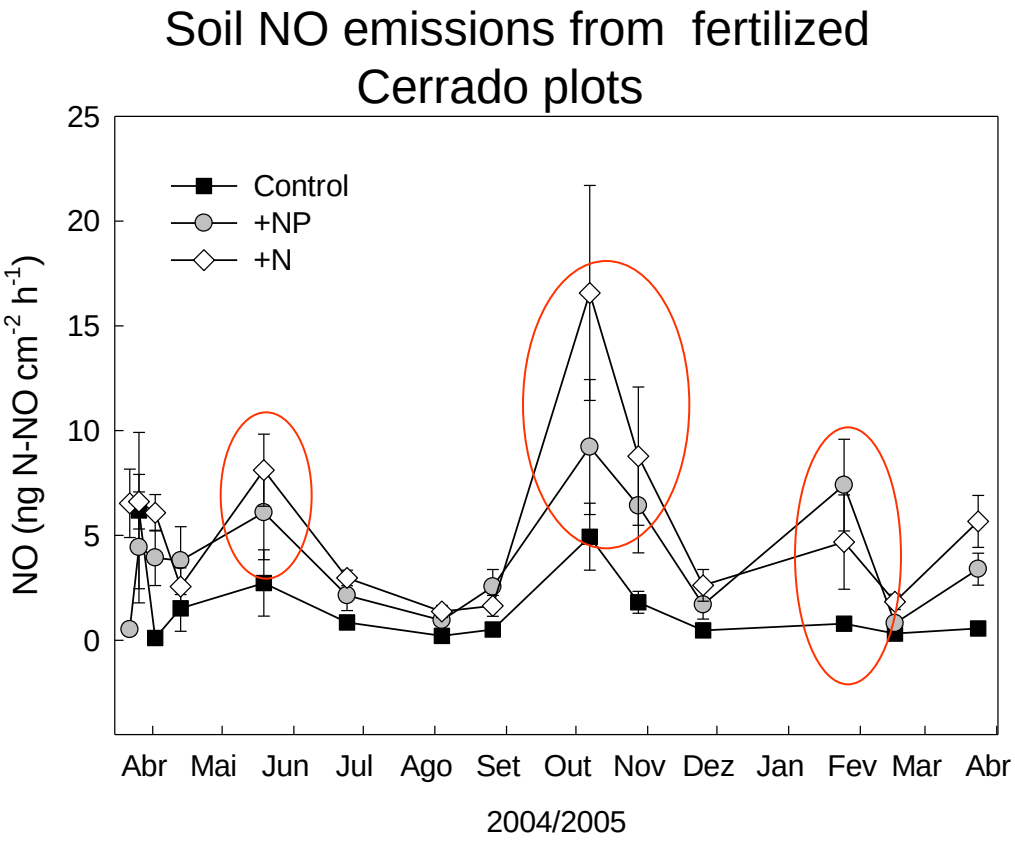


Kozovits et al. 2007 (Functional Ecology)

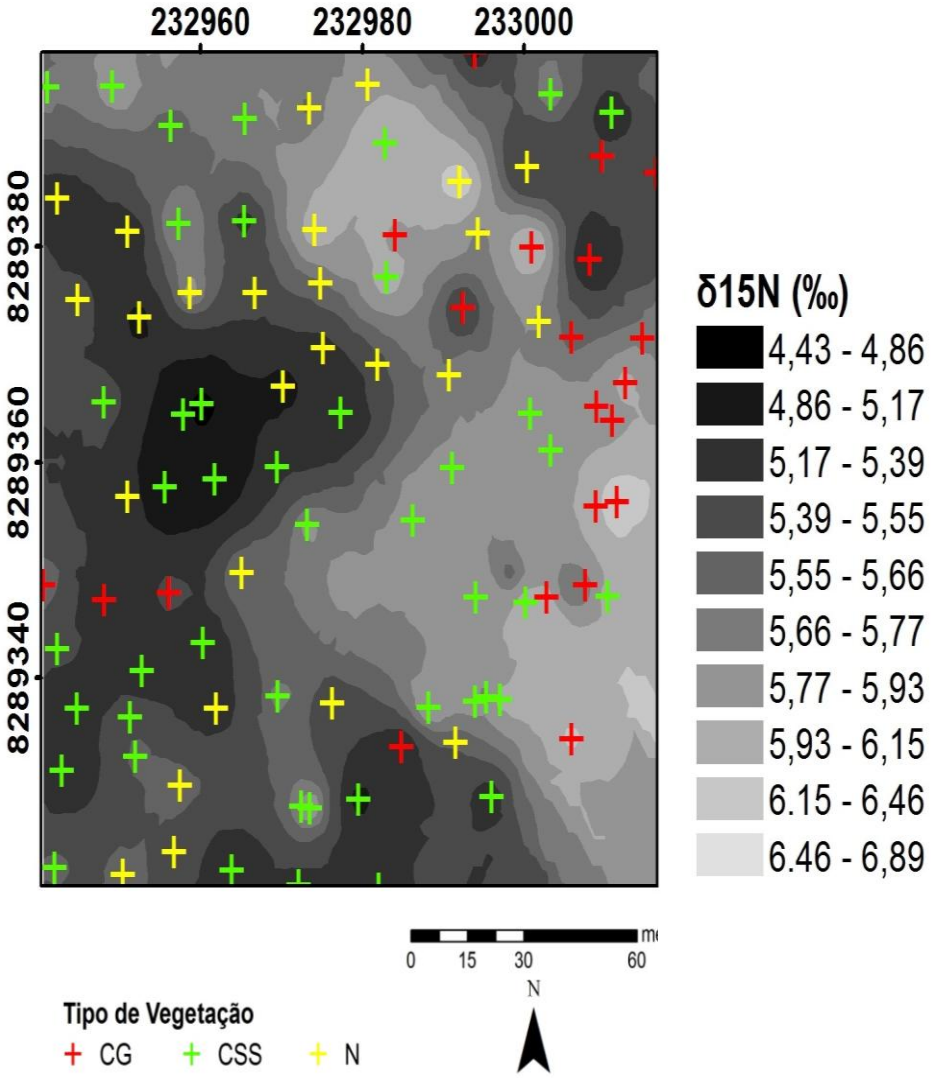
NO emissions from fertilized plots

Evidences from NO emissions:

1. Higher fluxes in N plots than in NP plots
2. More N incorporated in tl biomass with combined P
3. less N available for soil N processes



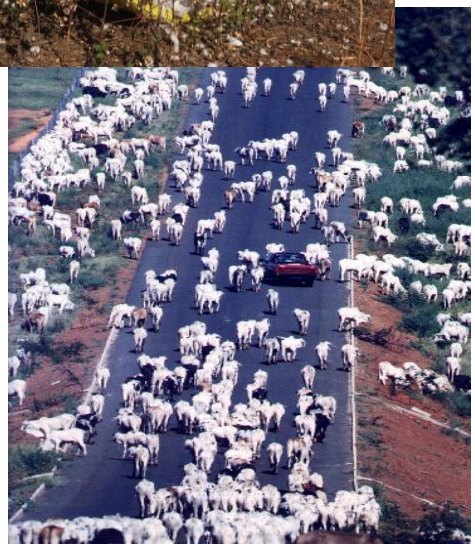
Effect of invasive species on soil nitrogen dynamics



Rodovalho et al (in prep)

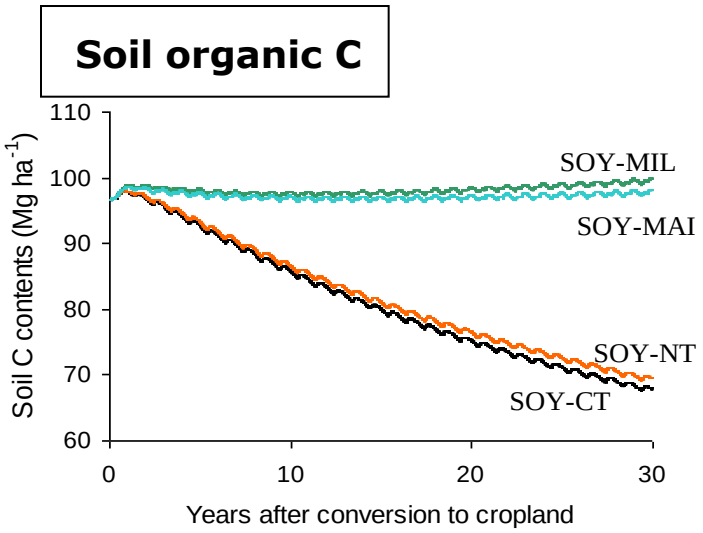
Reality facing the Cerrado over the coming decades…

- a set of competing land uses.
- Pressures to provide more people with food, fuel, and fiber.
- Interactions between local and global environmental changes



Importance of Nitrogen management for soil Carbon conservation

a



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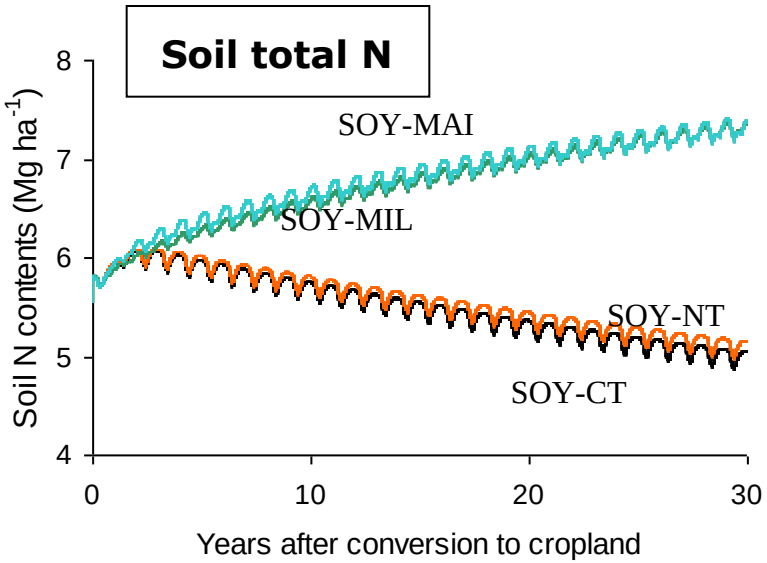

Modeling of changes in soil organic C (a) e N total N (b) (0-40cm depth)

- Soybean-fallow with tillage (SOY-CT)
- Soybean-fallow no-tillage (SOY-NT)
- Soybean/millet NT (SOY-MIL)
- Soybean/corn NT (SOY-MAI)
- Time 0 = steady state conditions under typical cerrado

Thank you

gbnardoto@unb.br

Credits: olhares.uol.com.br