# Nitrogen limitation induced by slash-and-burn agriculture in the Brazilian Amazon

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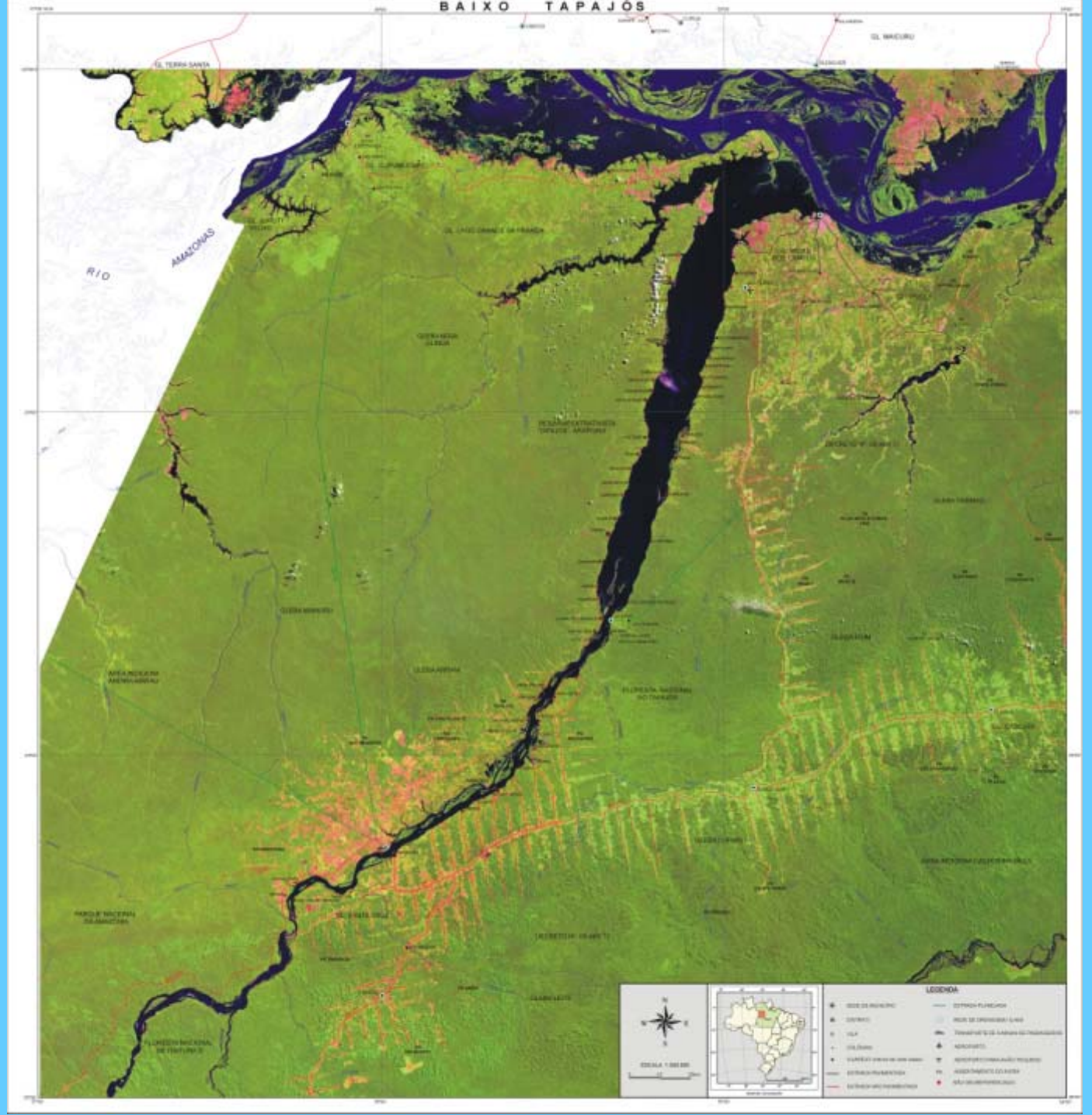
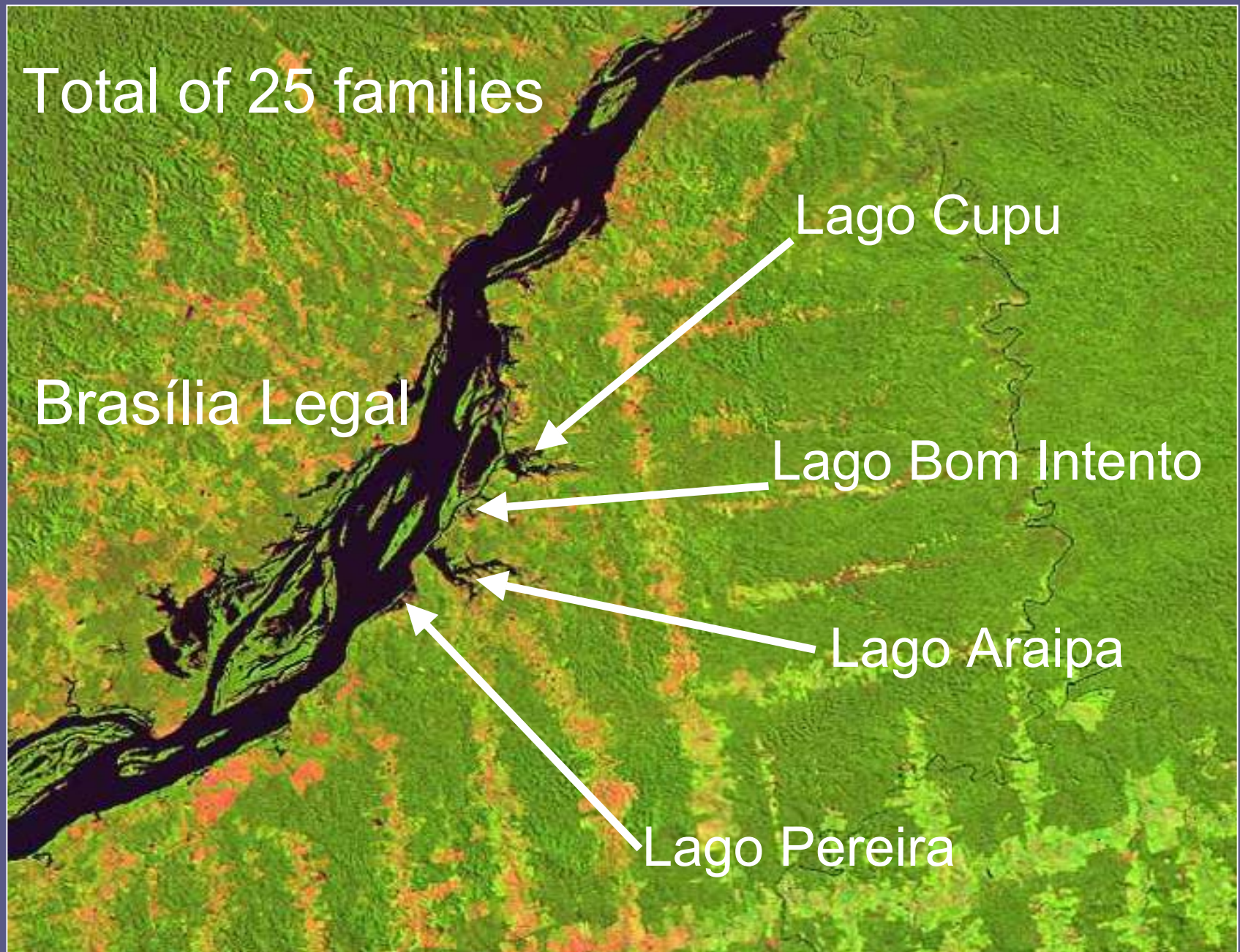

BAIXO TAPAJÓS
TI TERRA SANTA
TI MACURU
RIO AMAZONAS
LEGENDA

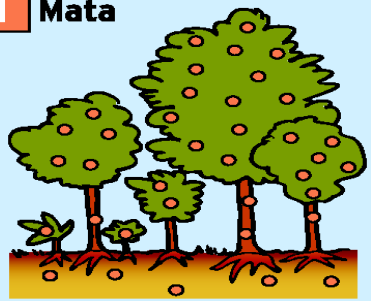

Rio Tapajós
Daniel de Carvalho
AVEIRO
Santa Cruz
Vista Alegre
Mussum
Sumaúma
Godinho
Campo Alegre
Açaituba
Urucurituba
Sumaúma
Fordlândia
Arara
Barriga
Rio Cupari
Brasília Legal
Cupu
Timbó
Tessá
Araipa
Lago do Limão
Moreira
Barreiras
Pedra Branca
Castanho
Novo Paraíso II
Ipaupixuna II
Ipaupixuna I
ESTRADA TRANSAMAZÔNICA
ITAITUBA
Santo Antônio
Miritituba
Boa Vista
Nova Canãa
Lago Capituã
Ipiranga II
Raiol
São Luis do Tapajós

# Satellite image of the studied frontier region

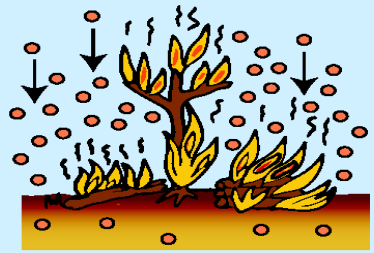


# SEQÜÊNCIA DOS CULTIVOS E FERTILIDADE

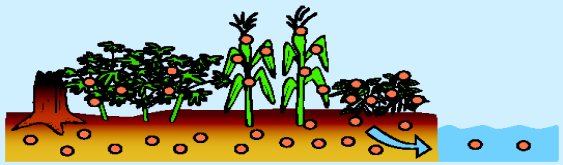
**1** Mata



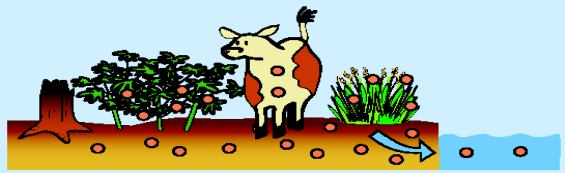
**2** Primeira queimada



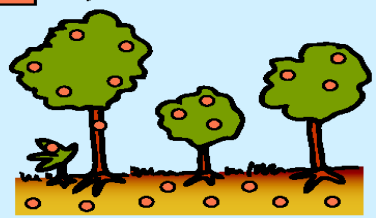
**3** Primeira roça



**4** Roça e gado depois alguns anos



**5** Capoeira



**6** Segunda queimada

BIODÔME DE MONTRÉAL

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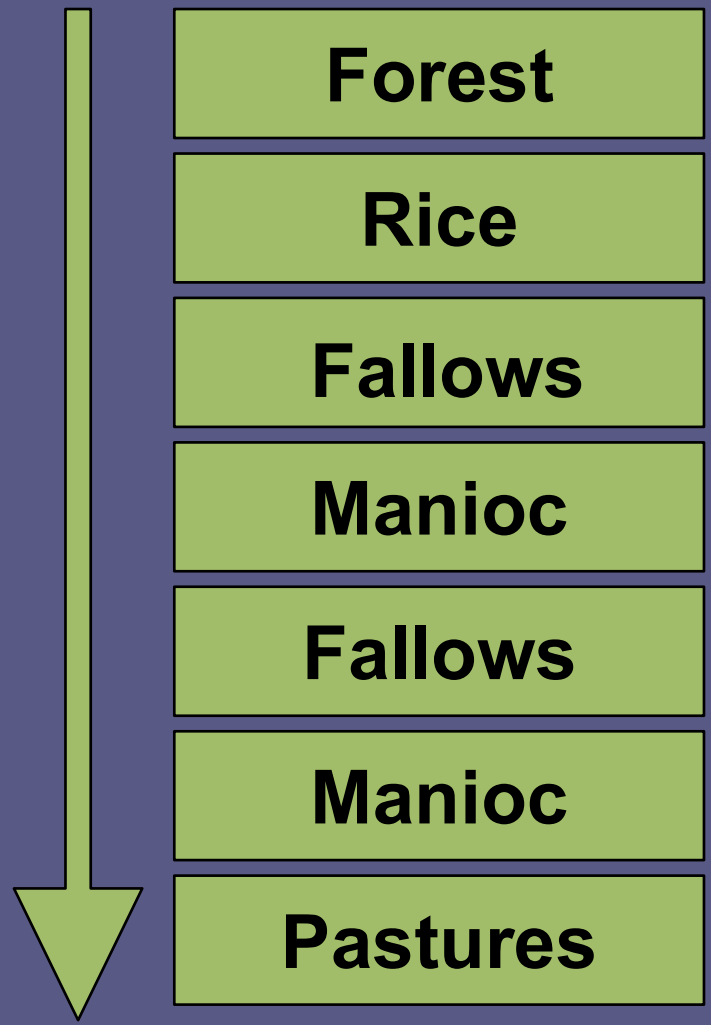
# Slash-and-burn agriculture in the Tapajós River area

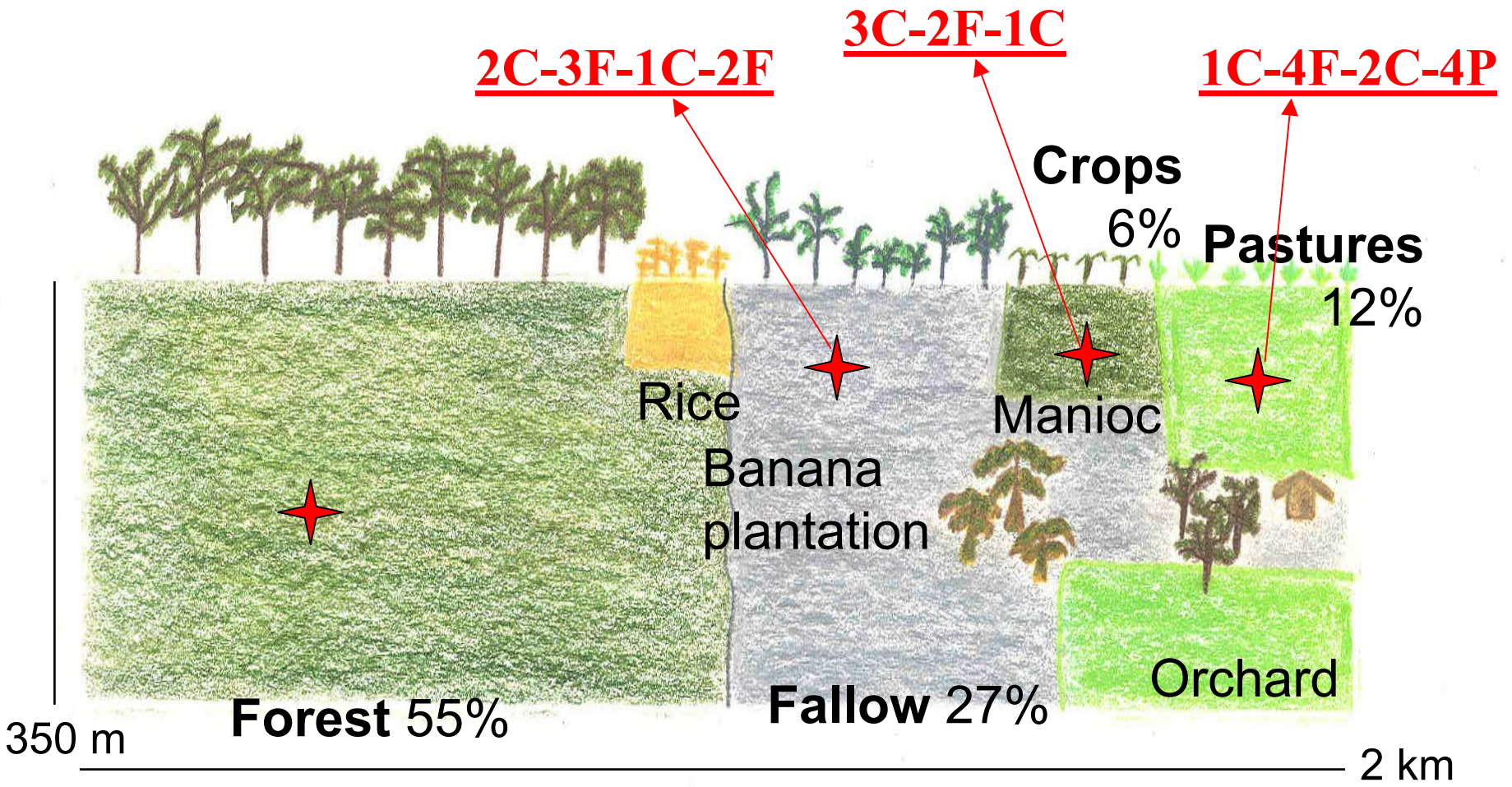
# Example of a land-use sequence

Land-use begins with short-cycle crops (bananas, manioc, rice) and ends with pastures.

The number and duration of the diverse land-uses on each site is variable.



# After 20 years of land occupation...




Average area of 70 ha

Farella, 2005

# Sampling methodology

- Total of 25 families and 4 sites per family
  - Forest, fallows, crops and pastures
  - Historic records of land-use taken into account
- 3 cores per site and 3 depths per core
  - 0-5 cm, 20-25 cm, 50-55 cm
  - Inorganic N from a sub-sample kept frozen
- $4^{th}$ core (soil density)
- Total : 1200 soil samples

# Soil analyses

- Samples were passed through a 2-mm mesh, lyophilized and grinded
- Mineral N ($NH_4$ and $NO_3$) was extracted with KCl 2M and analyzed by colorimetry
- Total C and N was measured on Carlo-Erba NA-1500 analyzer

# Interpretation of the soil data set

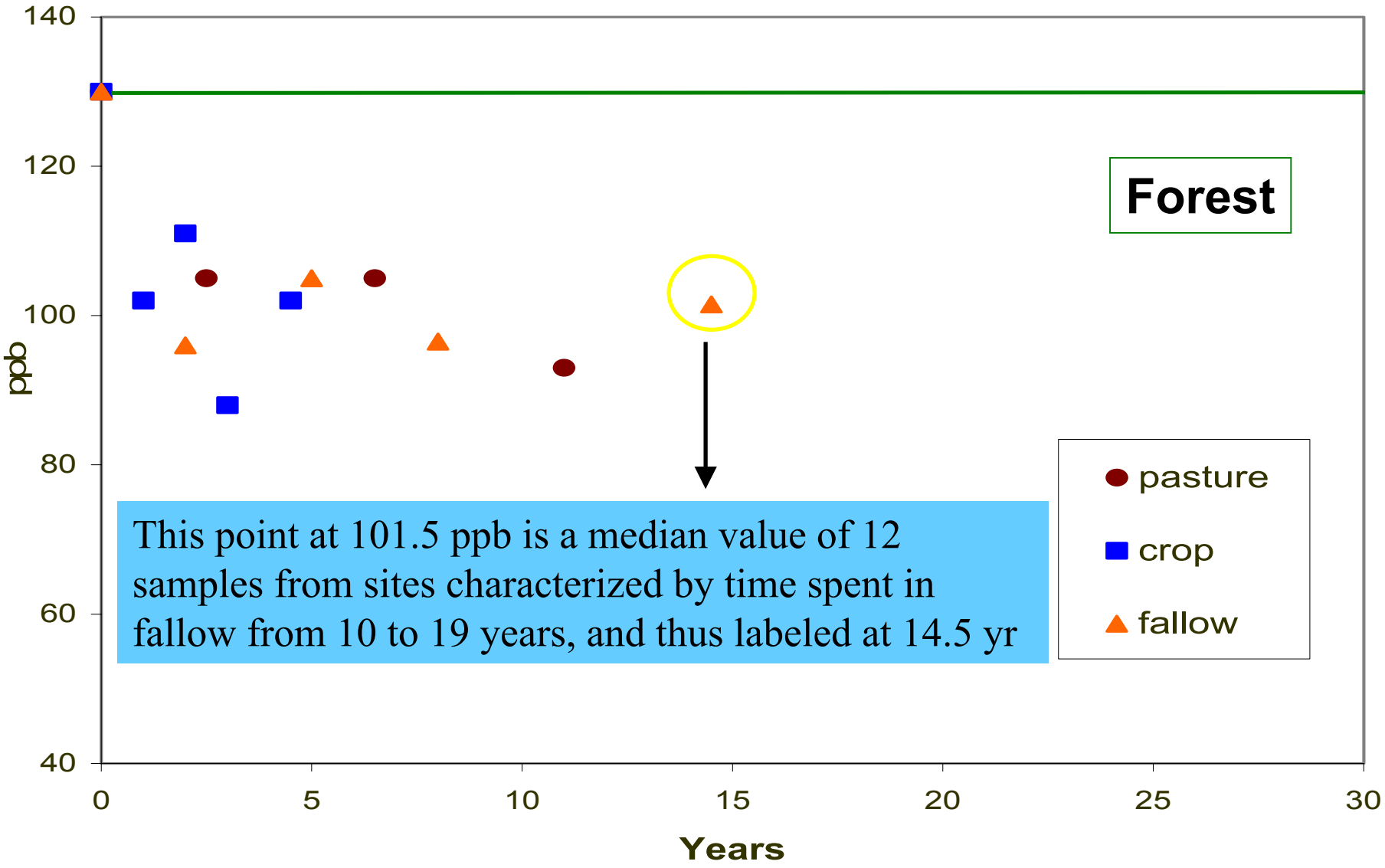
Comparing values of forest soils to deforested soils

A) Through pooling together all land-uses (crops, pastures, fallows) : tables

B) Through considering the different land-uses through time : figures for trends

- Time spent in crop, pasture and fallows were added up for each site
- Each point represents a number of samples falling into time frame categories expressed in years for each land-use
- Soil values are median values, for more stability due to a skewed distribution of data and important heterogeneity

# Hg at the surface of clayey soils



# Contrasting soil types

- Based on a factorial analysis including all sites, 2 soil types could be found on the criteria of fine particle content (FP), defined as < 63 μm
  - Clayey soils > 65% FP
  - Clay-sandy soils < 65% FP

# Contrasting forested soil types

| Soil variable | Unit | Clayey (reddish) | Clay-sandy (yellowish) |
|---|---|---|---|
| K+Ca+Mg | cmol/kg | 0.94 | 0.80 |
| Al-cdb + Fe-cdb | µmol/g | 987 | 229 |
| Hg | ppb | **130** | 70 |
| P-org | µmol/g | 6.5 | 2.6 |
| $NO_3$ | µmol/g | 1.8 | 1.1 |
| $NH_4$ | µmol/g | 2.9 | 1.5 |

# Impacts of deforestation on soil surface properties

| Soil variables | Units | Clayey | | Clay-sandy | |
|---|---|---|---|---|---|
| KCaMg | cmol/kg | +4.24 | +450% | +2.36 | +295% |
| Hg | ppb | -27 | -20.7% | -6.0 | -8.5% |
| P-org | µmol/g | -1.3 | -20.0% | +0.4 | +15.4% |
| $NO_3$ | µmol/g | -0.5 | -27.7% | -0.3 | -27.3% |
| $NH_4$ | µmol/g | -1.7 | -58.6% | -0.7 | -46.7% |
| FP | % | -7.0 | -9.3% | +1.0 | +2.5% |

**For all land-uses together, including fallows**

# Deforestation : Total C and N

| | Clay | | Clay-sandy | |
|---|---|---|---|---|
| C (%) | -0.2 | -6.1% | -0.5 | -21.7% |
| N (%) | -0.1 | -33.3% | -0.1 | -50.0% |
| C/N | +0.5 | +3.5% | +0.1 | +0.7% |

# Deforestation : inorganic nitrogen

## Contrasting $NH_4$ and $NO_3$ and soil types

| | **Clay** | | | **Clay-sandy** | | |
|---|---|---|---|---|---|---|
| | µmol/g | | % | µmol/g | | % |
| **$NH_4$** | 2.9 | 1.2 | 58.6 | 1.5 | 0.8 | 46.7 |
| **$NO_3$** | 1.8 | 1.3 | 27.8 | 1.1 | 0.8 | 27.3 |

# Deforestation : inorganic nitrogen

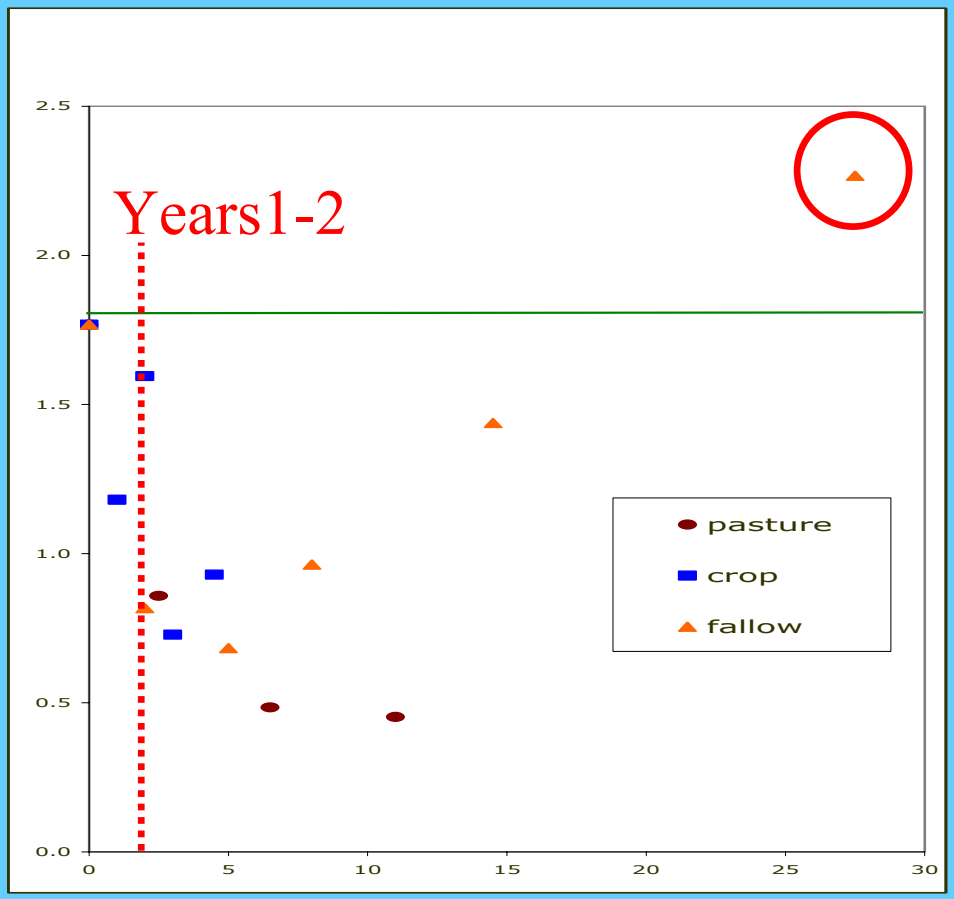
## Relative importance of $NH_4$ and $NO_3$

| | Forest | Deforested |
|---|---|---|
| $NH_4$ | 57.7% | 50% |
| $NO_3$ | 42.3% | 50% |

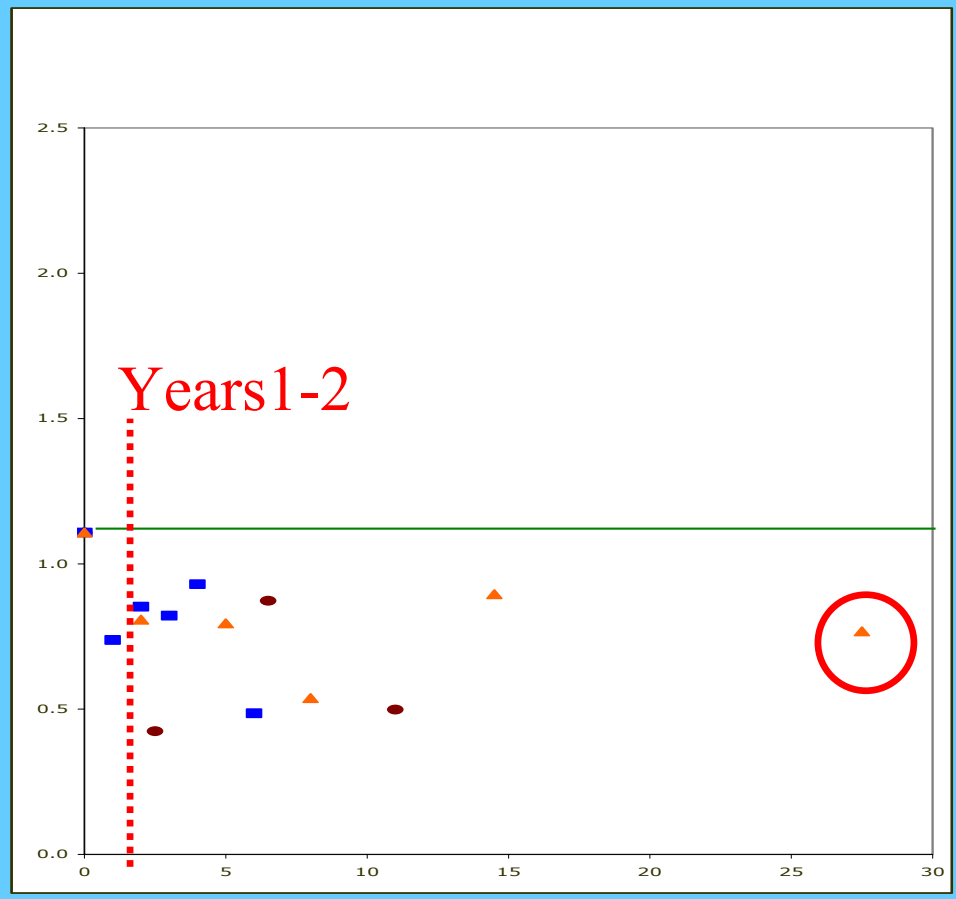
# Deforestation : inorganic nitrogen

## Land-uses

$NO_3$ at surface of clayey soils



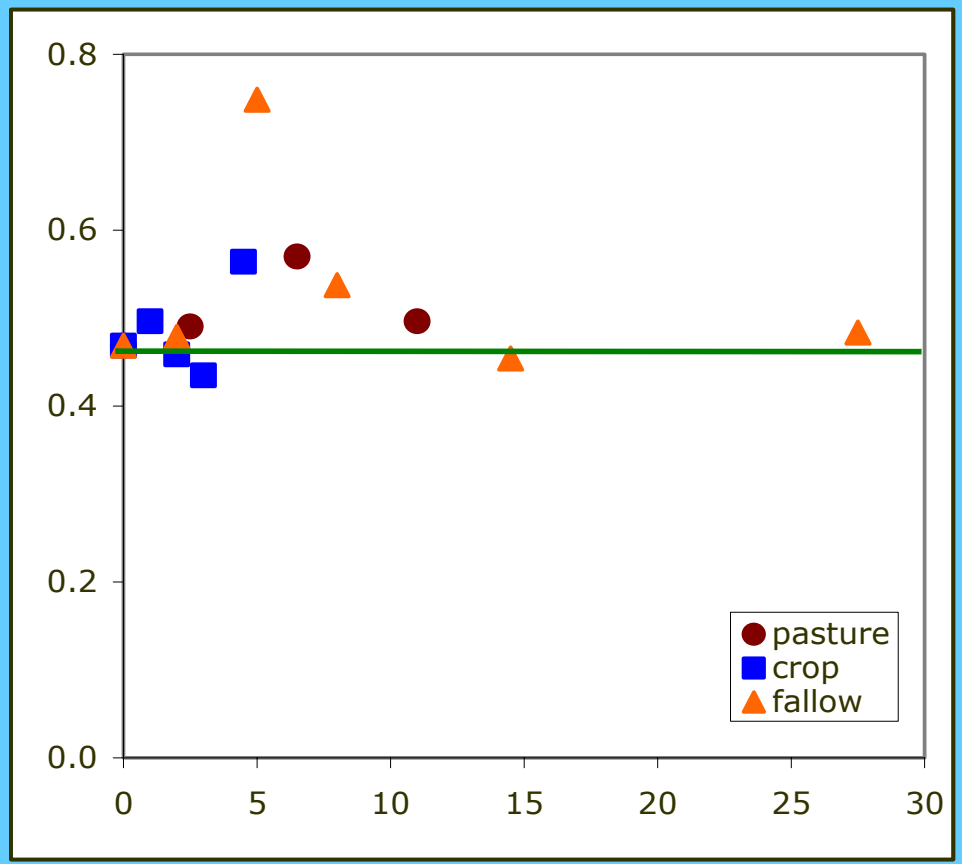

$NO_3$ at surface of clay-sandy soils



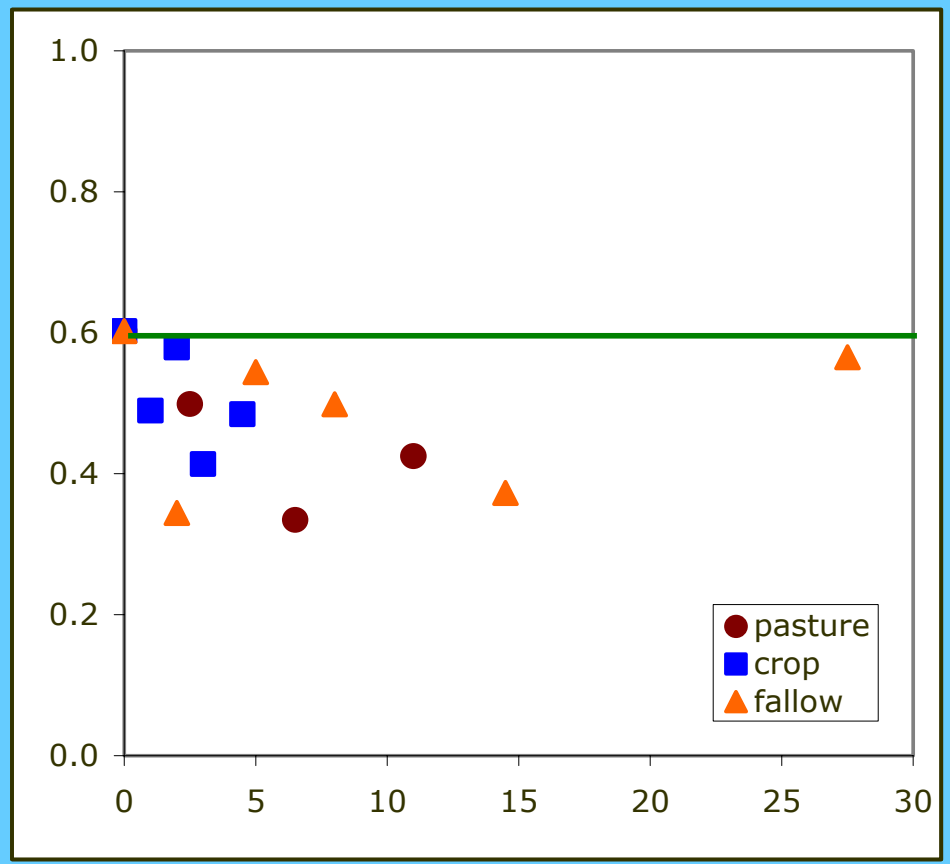
# Deforestation : inorganic nitrogen

## Deeper horizon : 50-55 cm

$NH_4$ in clayey soils




$NO_3$ in clayey soils



# Conclusions

- Inorganic nitrogen is the most important nutrient loss upon deforestation and cultivation
- Lower clay content soils are more fragile and should be devoted to a land-use integrating the presence of trees
- Practices favouring longer fallows should be encouraged