



# Setting the stage...

- The literature on LULCC suggests that **pasture** and **commodities** (meat and soy) are the most prevalent LU systems found in the Amazon (Moran & Ostrom, 2009).
- **Among smallholders**, however, we find a much **more heterogeneous** figure (Deadman et al., 2004).
- **Annual crops** are usually related to more **impoverished and younger households**
- **Perennial crops** are more likely to be found in older, **multi-generational** and **financially-buffered households**.
- **Cattle ranching** is mostly adopted by **older households** (empty nest): **labor shortage / savings** (Walker et al. 2000; Brondizio & Moran, 2012)

# Setting the stage...

- In this presentation, we share some results on the **partial impact of household and farm life cycles**, as well as **market integration**, on **land use systems** in smallholders frontiers.
- We combine qualitative instruments (**participatory sketch maps** and **in-depth interview**) and quantitative methods (**multivariate latent class models, non-linear regression, and SURE**), applied on **longitudinal data** for 402 farm lots in the **Eastern** part of the **Brazilian Amazon**.

# Setting the stage...

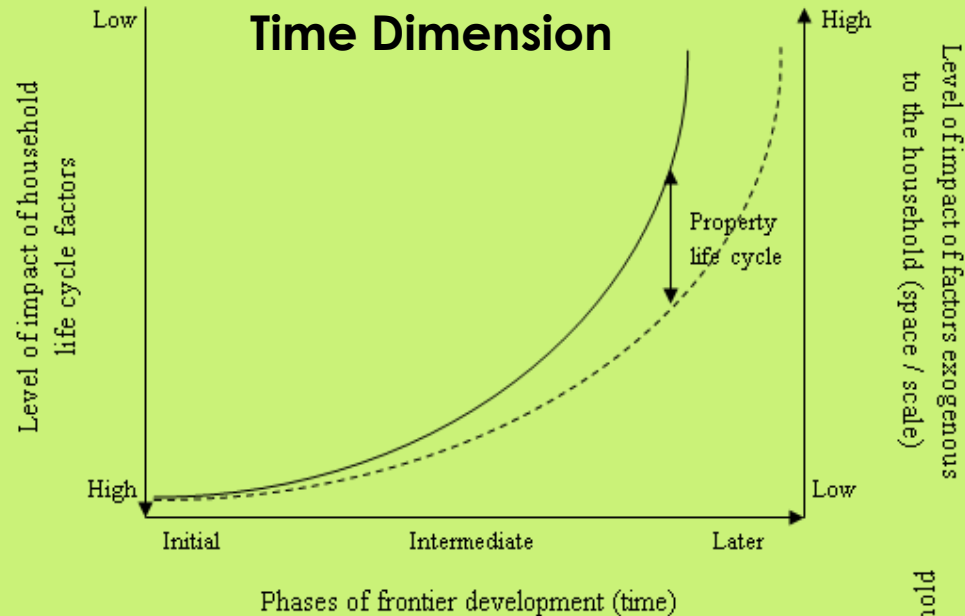
- Our results suggest that:
  - **proximity to markets** and **life cycles** have significant **non-linear effects** on system choice
  - landowners **adjust their land use systems** based on **market stimulus**, constrained by the **viability of the type of soil**
  - **market integration dominates** HLC and OPLC → **post-frontier** stage.
  - **labor constraint** is **overcome** by informal **exchange of days of labor**

# Traditional Theories Challenged

- **Low empirical support for household life cycle (HLC)** effect on LULC in the Amazon (VanWey et al. 2007)
- Small-scale studies suggest **rational individual behavior** regarding **perceived returns to capitals** over frontier development (VanWey et al., 2012; Brondizio & Moran, 2008; Caldas et al. 2007; Murphy 2001)
- **Connectivity to markets attenuates** the role of **life cycles** as frontiers evolve to a post-frontier scenario (Sherbinin et al. 2008; Summer 2008; Browder & Godfrey 1997):
  - **Urbanization**
  - Internal / **circular migration**
  - **Endogenous institutions** (family and social networks)

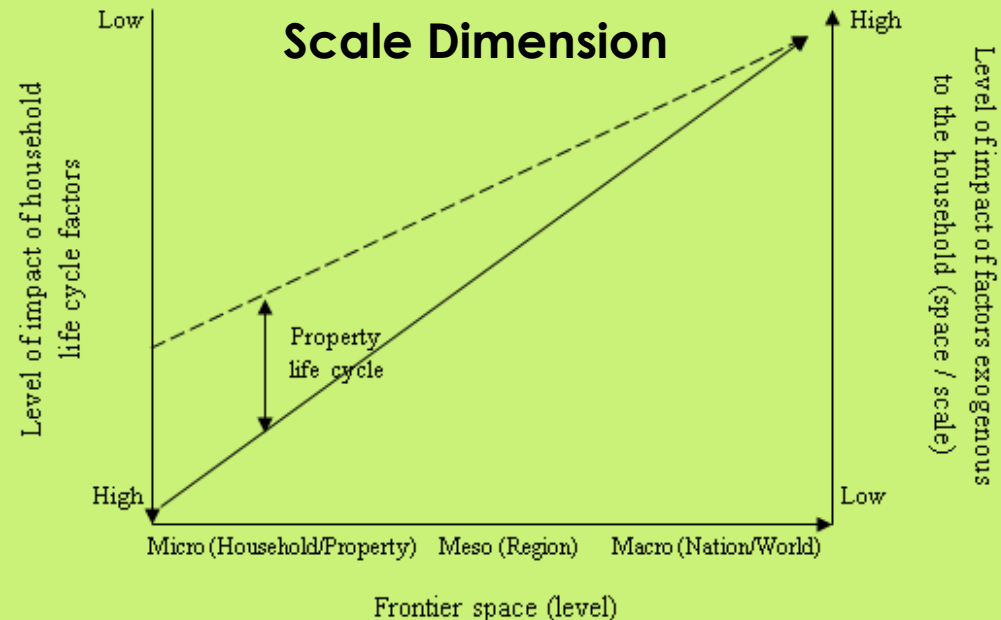
# Life cycles and

# market integration in perspective



Interaction between HLC and OPLC

Connectivity to markets increasingly important!



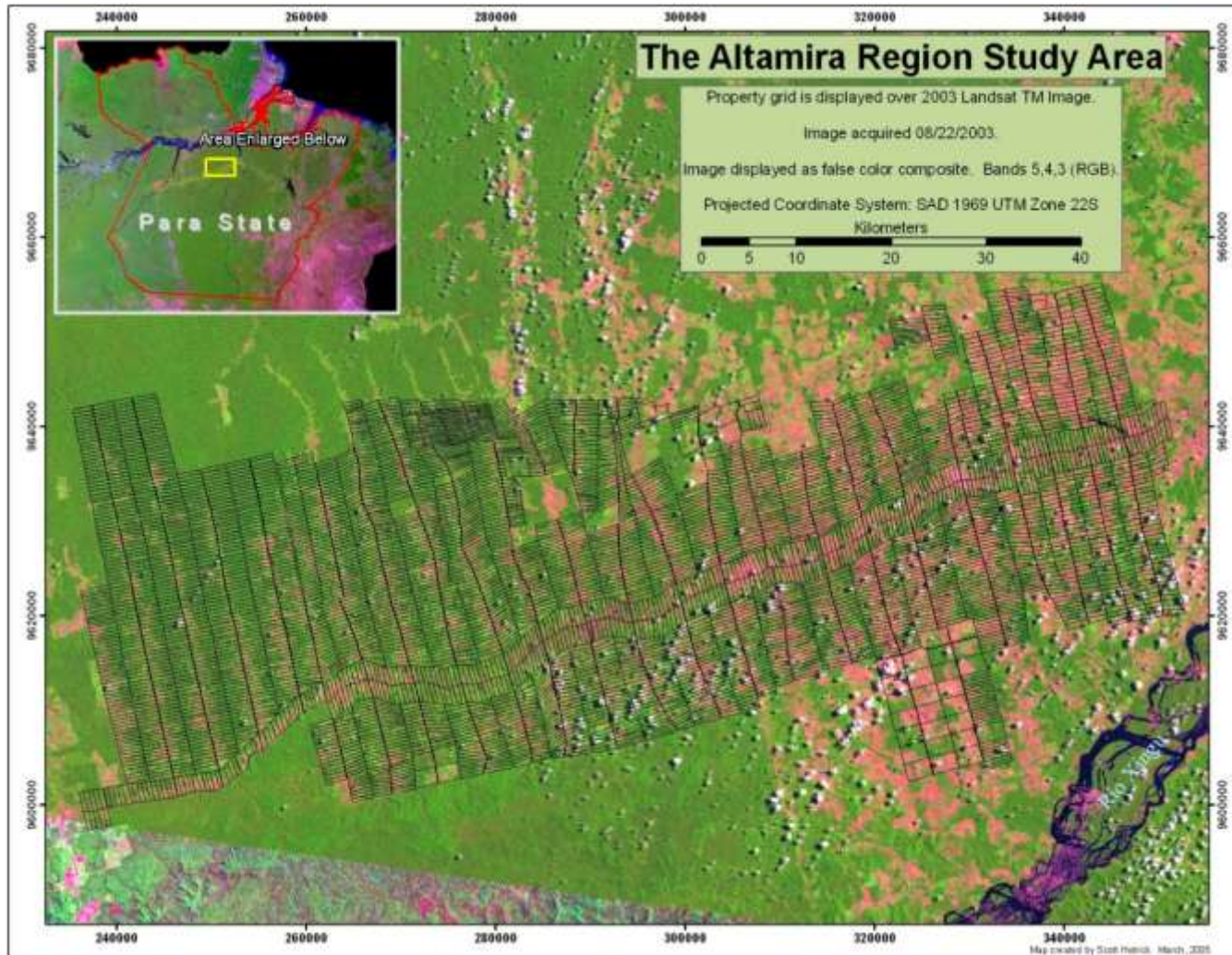
Legend:

- Household life cycle = Property life cycle
- - → Household life cycle ≠ Property life cycle

# Framework predictions

CYCLE DOMINANCE			
Stage of Frontier Development	Deforestation	Commercial Land Use	Subsistence Land Use
Initial	HLC	NS	HLC
Intermediate	HLC = OPLC	HLC = OPLC	HLC = OPLC
Advanced	HLC < OPLC	OPLC	HLC = OPLC
CYCLE INTERACTION			
Interaction	Deforestation	Commercial Land Use	Subsistence Land Use
HLC * OPLC	-	--- / +++	--
MESO LEVEL INSTITUTIONS			
Household Strategy	Deforestation	Commercial Land Use	Subsistence Land Use
Diversifying livelihoods	-	NS	NS
Agricultural productivity	-	+	-
Agricultural extensification	+	+	NS

# Altamira Settlement Area

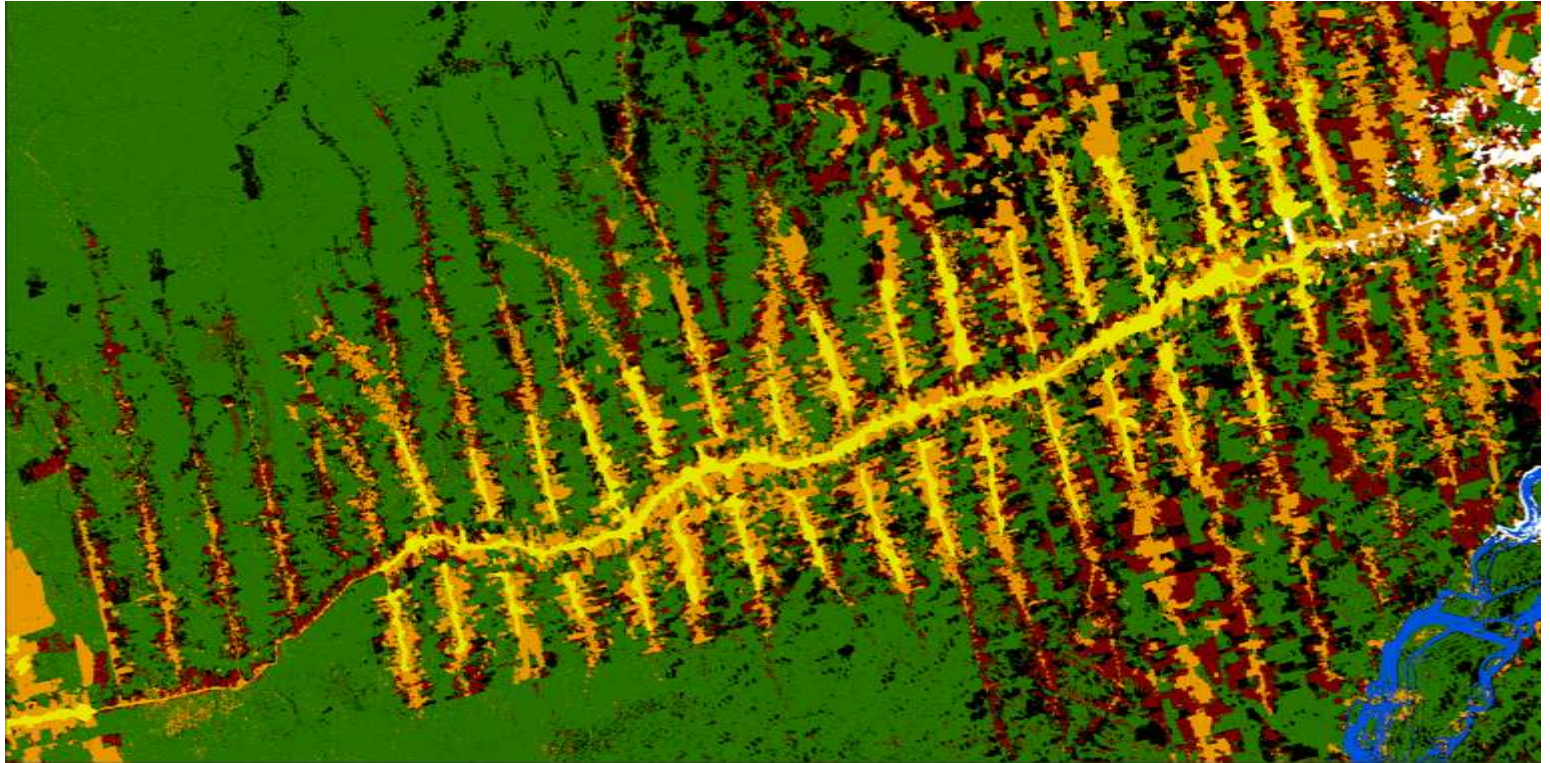




# Altamira Settlement Area:

## Disappearing Forest...

2000's



### Legend

- Forest
- Water

- Non-Forest 1970
- Non-Forest 1975
- Non-Forest 1985
- Non-Forest 1996
- Non-Forest 2003

# From forest to farming: a changing landscape



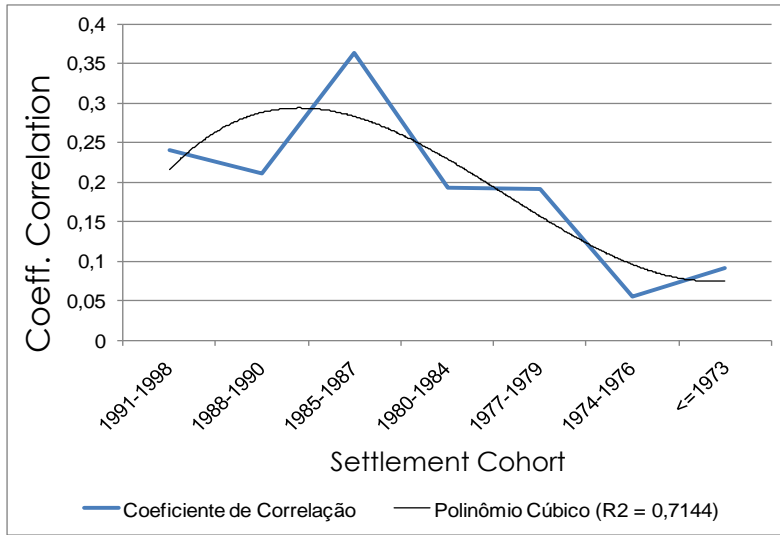
# Data & Analytical Sample

- **Longitudinal stratified survey** representative of the rural properties in the area (N = 3978)
- Original sample of **402 properties** (and owning households) in 1997/98
- **Follow-up in 2005** (rural and urban areas)
- Attrition and list-wise deletion reduced our **analytical sample to 258 properties**

# Analytical Strategy

- **Participatory Sketch Maps** – used to inform the locally informed number of reference land use systems (bottom-up approach)
- **Grade of Membership Model** – construction of multidimensional land use systems (type of crops, destination of agric. production, amount produced)
- **Multinomial** and **Seemingly Unrelated Regression** Models (partial effects of cycles and market integration)
- **In-depth interview** (qualitative illustration of unexpected results)

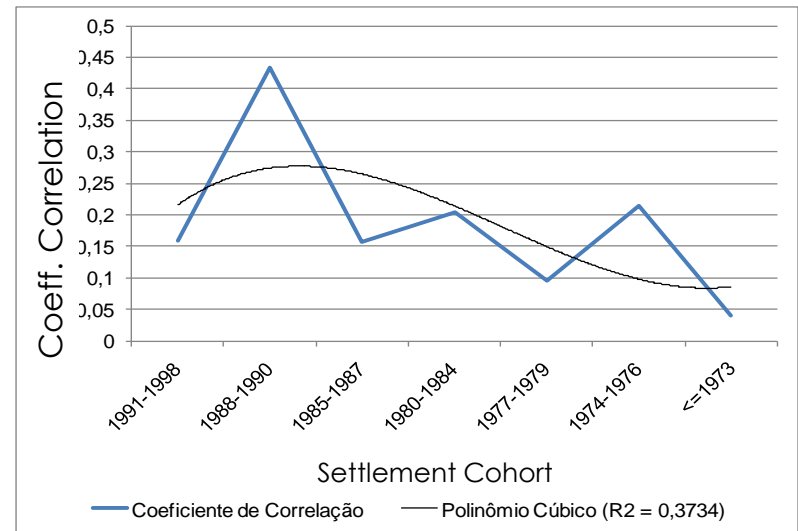
# Cycles Interaction (Descriptive) Household Dep. Ratio X Land Use



**Commercial  
Land Use  
 $R^2 = 0,7144$**



**Subsistence  
Land Use  
 $R^2 = 0,3734$**



# Results

## Multinomial Regression (N=258)

Variable	Pasture + Annual	Perennial + Pasture	Pasture + Cattle	Mixed
<b>HOUSEHOLD LIFE CYCLE</b>				
Demographic household dependency ratio (dependents/adults)	-7.880**	0.388	-2.561	-5.446**
Number of years living on the property (years)	-0.183***	-0.010	-0.121**	-0.086*
<b>CYCLES INTERACTION</b>				
Years on the property x Dependency ratio	0.354**	-0.083	0.034	0.277***
<b>PROPERTY LIFE CYCLE</b>				
Time since first occupation of the property	0.163	-0.053	-0.695	-0.409
<b>INTEGRATION INTO MARKETS</b>				
Distance of the property to urban Altamira (ha.)	-0.00003***	-8.18e-06	-0.00005***	-7.42e-06
Proportion of agricultural production sold (%)	-0.017*	-0.008	-0.007	-0.005
<b>MESO-LEVEL INSTITUTIONS</b>				
No participation in unions/associations (0/1)	0.665	0.734	0.817	0.516
Did any household member out-migrate? (0/1)	-0.385	0.028	-1.799**	0.250
Did any migrant remit to the household? (0/1)	0.094	-0.191	-0.467	0.247

Base system: Perennial.

# Results

## SURE Regression (N=258)

Variable	Perennial	Pasture	Annual
<b>HOUSEHOLD LIFE CYCLE</b>			
<b>Demographic household dependency ratio (dependents/adults)</b>	<b>12.86***</b>	<b>-26.83**</b>	0.711
<b>ON THE PROPERTY LIFE CYCLE</b>			
<b>Number of years living on the property (years)</b>	<b>0.226**</b>	<b>-0.791***</b>	-0.0232
<b>CYCLES INTERACTION</b>			
<b>Years on the property x Dependency ratio</b>	<b>-0.592***</b>	0.812	-0.0440
<b>PROPERTY LIFE CYCLE</b>			
<b>Time since first occupation of the property</b>	<b>-1.131***</b>	-1.009	0.158
<b>INTEGRATION INTO MARKETS</b>			
<b>Distance of the property to urban Altamira (ha.)</b>	<b>4.62e-05**</b>	<b>-0.000138**</b>	<b>-1.56e-05**</b>
<b>Proportion of agricultural production sold (%)</b>	<b>0.0300**</b>	-0.0408	0.000628
<b>MESO-LEVEL INSTITUTIONS</b>			
No participation in unions/associations (0/1)	-1.574	1.843	0.649
Did any household member out-migrate? (0/1)	0.727	-3.367	0.427
Did any migrant remit to the household? (0/1)	0.187	-0.952	-0.0240

- **CYCLE DOMINANCE (standardized betas)**
  - **OPLC** > HLC (commercial land use)
  - NOT SIGNIFICANT (subsistence land use)
- **CYCLE INTERACTION**
  - **NEGATIVE\*\*\*** (perennials) / **NEGATIVE<sup>NS</sup>** (pasture)
  - **NEGATIVE<sup>NS</sup>** (annuals)
- **MARKET INTEGRATION (standardized betas)**
  - **DISTANCE** > HLC & OPLC (commercial land use)
  - **Direction of effect** explained by **spatial distribution of soil type** ([see backup slide](#))



# So what?

- **Cycle dominance** suggests Altamira Settlement Area is in a **transitory stage towards a post-frontier scenario**.
- Cycle interaction suggests that the **knowledge about the biophysical environment is increasingly important** for commercial land use, **regardless of the history of property use**.

# So what?

- Cohort effect:
  - **Older cohorts** of smallholders seem to take advantage of the **cumulative knowledge** on the biophysical chars of the region (**perennial production**) → **protective of forest**.
  - **Newer cohorts** tend to adopt more **short-term strategies** – *low labor cost / high fungibility* (cattle ranching) → **negative externalities**
  - **Older cohorts** more likely to use **capital from networks** to **diversify beyond agriculture**

# Acknowledgements

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Danke!

*Comments:*

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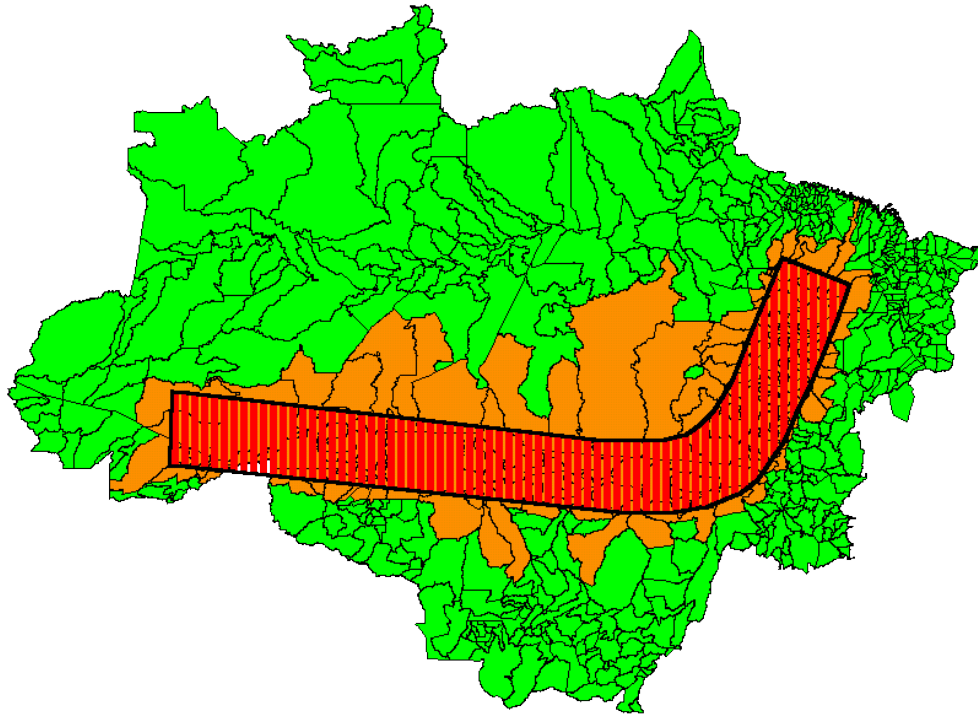
# Backup Slides

# Next steps

- **General equilibrium model** → increase in **pasture** and **diversification** beyond agriculture both have **indirect impact** on local and urban **labor markets, migration flows** and **LULC**.
- **Meta-analysis** with our other study sites:
  - In the Amazon: (1) **Machadinho D'Oeste** (Brazil); (2) **Santarém/Belterra** (Brazil); (3) **Northern Ecuadorian Amazon**
  - In Thailand: **Nang Rong**

# Deforestation where?

## *Arc of Deforestation*

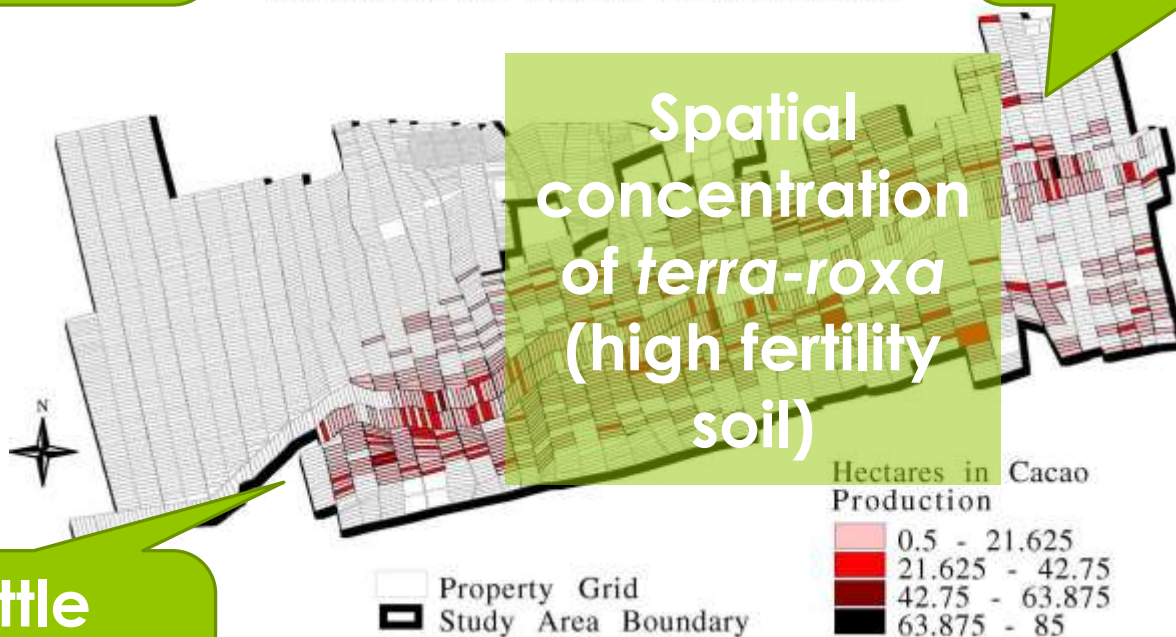


# Importance of Cacao Production

Importance of  
biophysical  
knowledge

The Altamira Region Study Area:  
Hectares in Cacao Production

Cacao retain  
people!

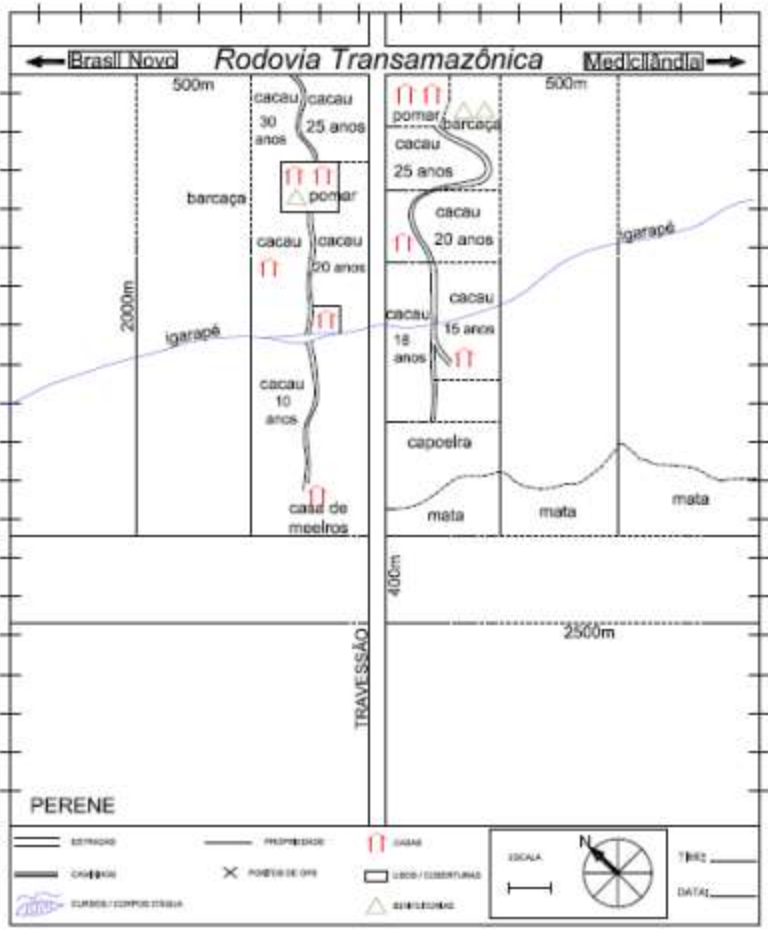


Cattle  
displace  
people!

Labor  
arrange  
ments  
are  
made



# The Participatory Sketch Map



# How we created the land use systems variable (fuzzy)

- (1) Selection and **treatment of variables**: land use classes, destination of agricultural production (by crop); total produced (by crop);
- (2) **Use of** the model *Grade of Membership (GoM)*
- (3) **Boolean expressions** to create mixed types using gik to the extreme profiles;
- (4) **Test of means and proportions** to regroup mixed types;
- (5) **creation of multicategorical variable**, based on results from (2), (3), and (4).

# Theoretical Framework: Cycles are not the same!

