State of the Science: Land Use Modeling in Amazônia

(Accomplishments and Remaining Challenges)

By

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with contributions from

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AMAZONIAN LCLUC MODELS 1

- **SimAmazônia** — Soares-Filho, Nepstad, et al.
- **NEA-AMB** — Walsh, et al.
- **LUCITA** — Deadman, Moran, et al.
- **Econometric** — Pfaff, Walker, Reis, et al.
- **Spatial Behavior** — Arima, Walker, et al.
- **Cartographic Models** — Laurance, et al.
- **Theoretical Frameworks** — McCracken, Vanwey, Moran, Bilsborrow, Barbieri, Brondizio, et al.

  (e.g, household life cycle, multi-phasic response, lot-life cycles)

MANY DIFFERENT MODELS

- Theoretical model:

  may not be at all interested in the future, only the "present." Theory building

- Projection model:

  Not interested in theory,

  only in the "future." Focused on projection.

AMAZONIAN MODELS: *the questions asked*

Given ***X***, what happens to ***Y***?

projection *models*:

X is a scenario, and Y is a landscape of significance, e.g., AML

theoretical *models*:

X a variable setting (e.g, household structure) , and Y is also a landscape, more circumscribed

AMAZONIAN LCLUC MODELS 2

An ***ability*** and ***intention***

1) To predict the future
   (projection)

-- **or** ---

2) To predict outcomes given specified conditions
   (sensitivity)

Computationally intensive modeling
Computer "modeling"

AMAZONIAN LCLUC MODELS 3

- **SimAmazônia** *Projection*
- **Econometric** *Projection*
- **NEA-AMB and LUCITA** *Theoretical/ "projection"*
- **Spatial Behavior** *Theoretical/ "projection"*

Model structure and functionality

Result types

PROJECTION MODELS

1) SimAmazônia

2) Econometrics

SimAmazônia

A Spatially Explicit Simulation Model of Deforestation for the Amazon Basin

Amazon Scenarios Project

Woods Hole Research Center

Universidade Federal de Minas Gerais

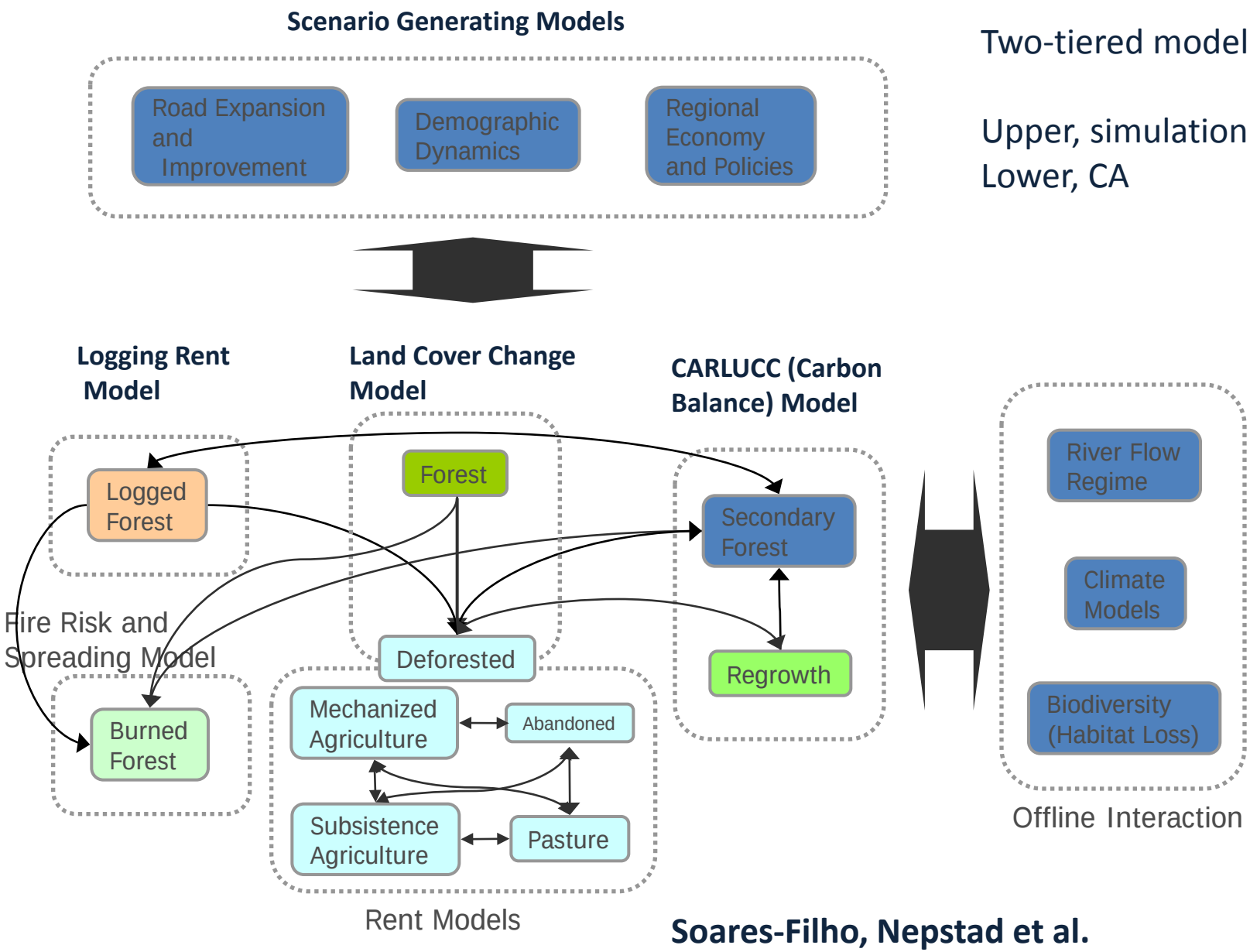
IPAM – INSTITUTO DE PESQUISA AMBIENTAL DA AMAZÔNIA

Soares-Filho, Nepstad et al.

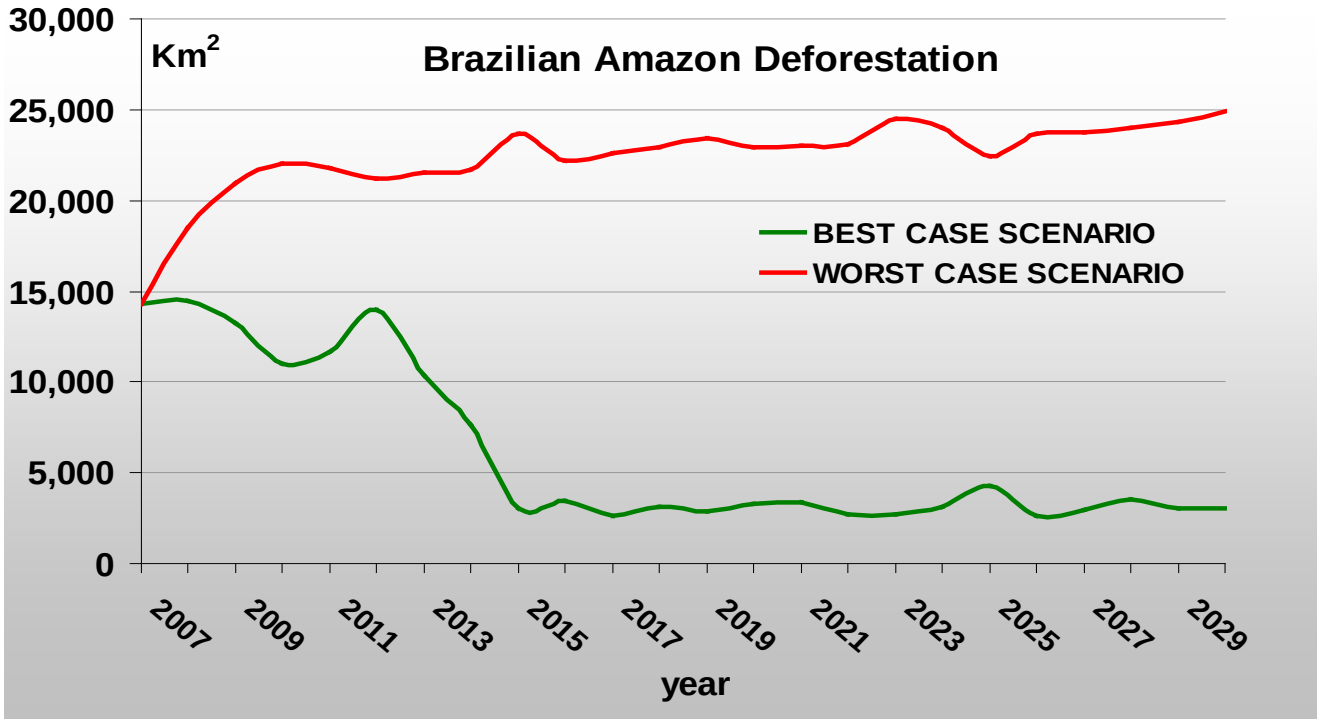
SimAmazônia

Two-tiered model:

Upper, simulation
Lower, CA



Soares-Filho, Nepstad et al.



BEST CASE: Protected Area expansion and implementation, strict enforcement, low rates of agriculture and cattle herd growth, population immobility, limited road paving.

WORST CASE: Protected areas loosely implemented, lax enforcement, high rates of agriculture and cattle herd growth, high population mobility, and extensive road paving.

Soares-Filho, Nepstad et al.


CSR
CENTRO DE SENSORIAMENTO REMOTO - UFMG
IPAM - INSTITUTO DE PESQUISA AMBIENTAL DA AMAZÔNIA
WOODS HOLE RESEARCH CENTER
Business-as-usual
2001
AMAZON SCENARIOS
Soares Filho *et al.*, *Nature*, 2006

ECONOMETRIC MODELS

Like SimAmazônia:

projections in time, as a function of scenarios
LCLUC at disaggregate scale

"fit" using geographic data : *municipio, census tract*

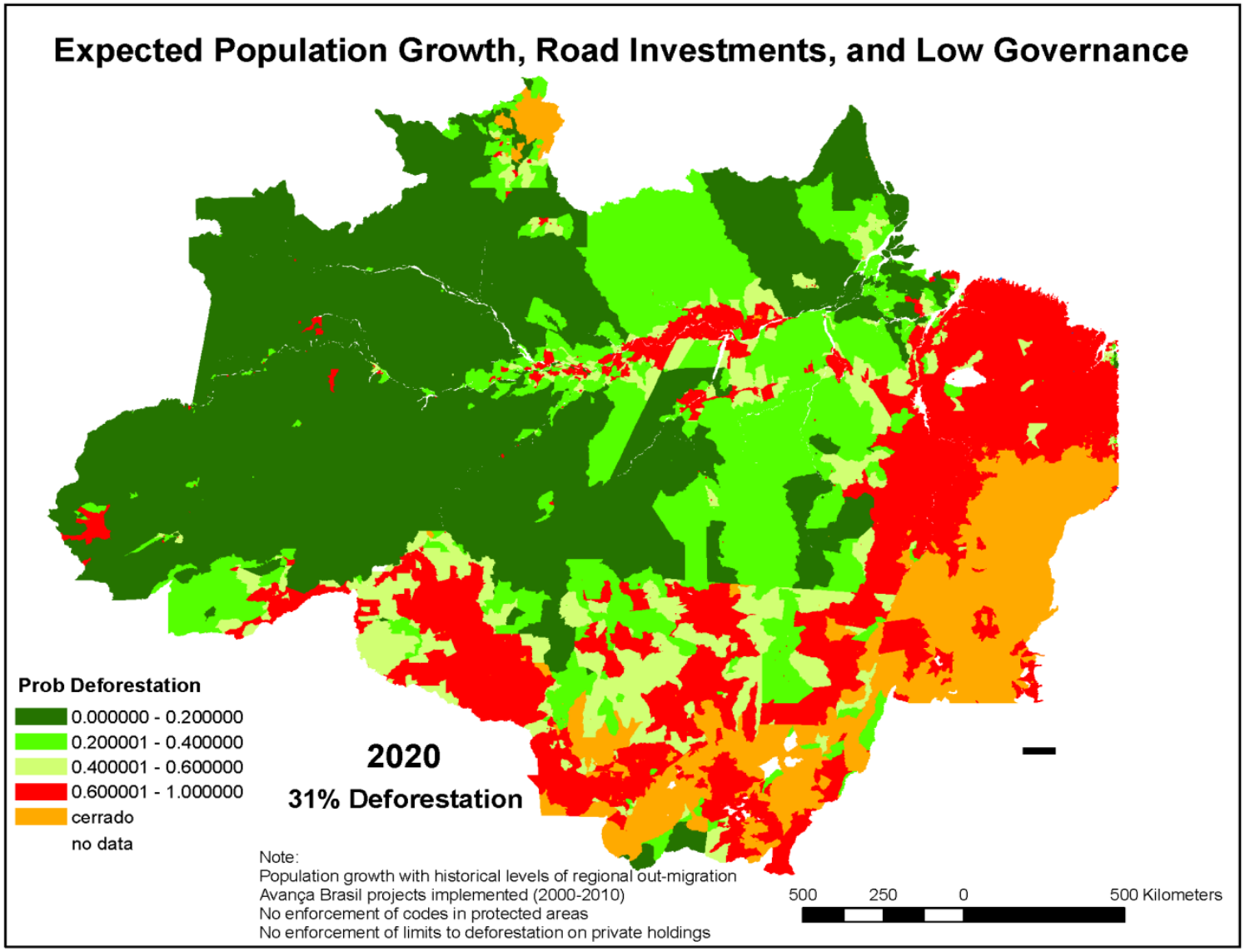
$$Y = b_0 + b_1X_1 + b_2X_2 + ... + b_kX_k$$

$$Y_t = F_{t-1} - F_t$$

$$Y_t = b_0 + \mathbf{b_tX_t} + \mathbf{bX}$$

Pfaff, Walker, Reis, et al.

SAMPLE PROJECTION OUTPUT



Theoretical/“projection”

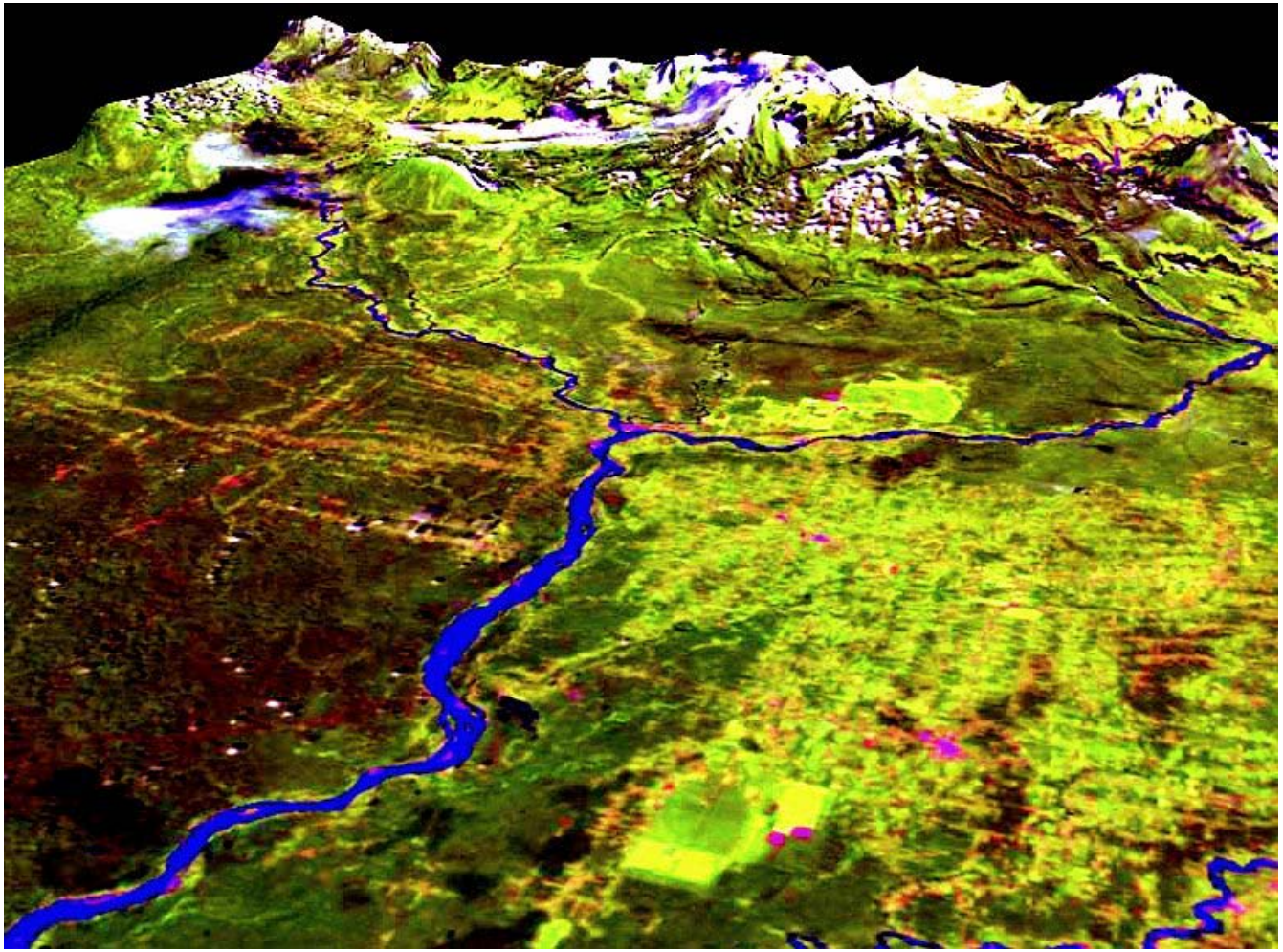
1) NEA-ABM

2) LUCITA

3) Spatial Behavior

NEA-AMB

LCLU Patterns in the Northern Ecuadorian Amazon

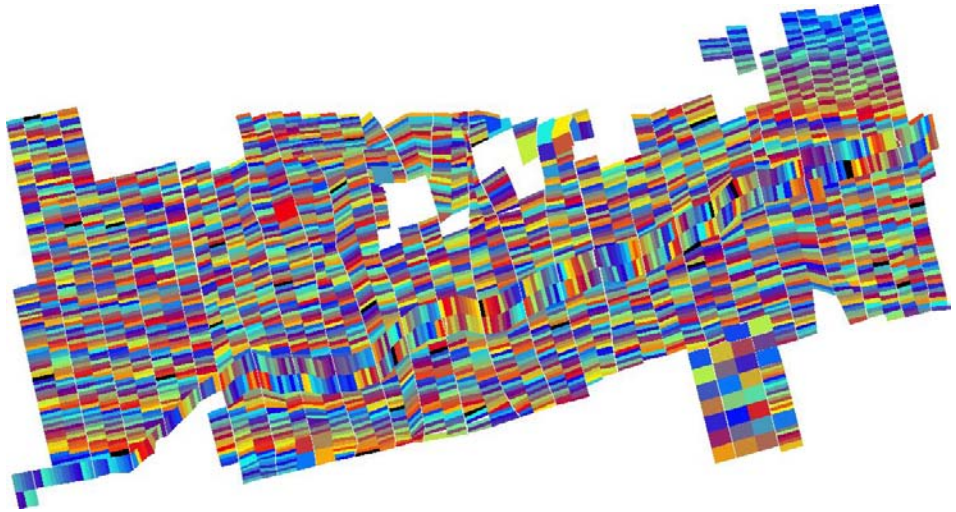


Walsh et al. NEA-ABM

LUCITA

Land Use Change In The Amazon

- Transamazon Highway west of Altamira
- 3916 properties studied, ~7,000 sq km



Deadman, Moran, et al.

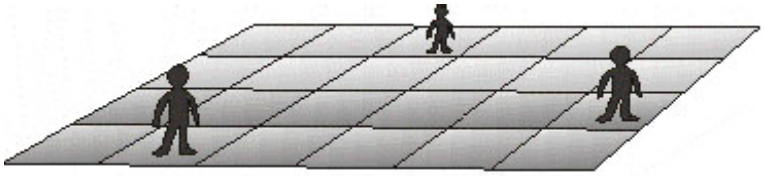
AGENT-BASED MODEL, or AMB

Agent: decision-making entity, is able to act flexibly and autonomously

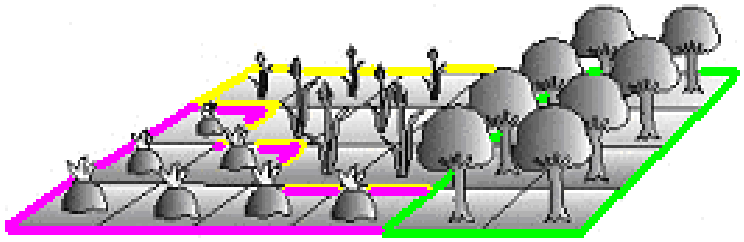
Environment: where agent interacts

Rules: define the relationship between agents and their environment

(action space: two dimensional, gridded landscape, like a CA)

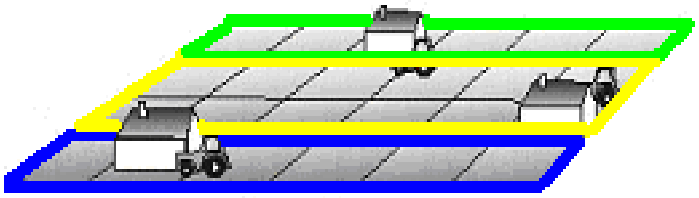


Layer 1 Individual agents



Layer 2 LULC

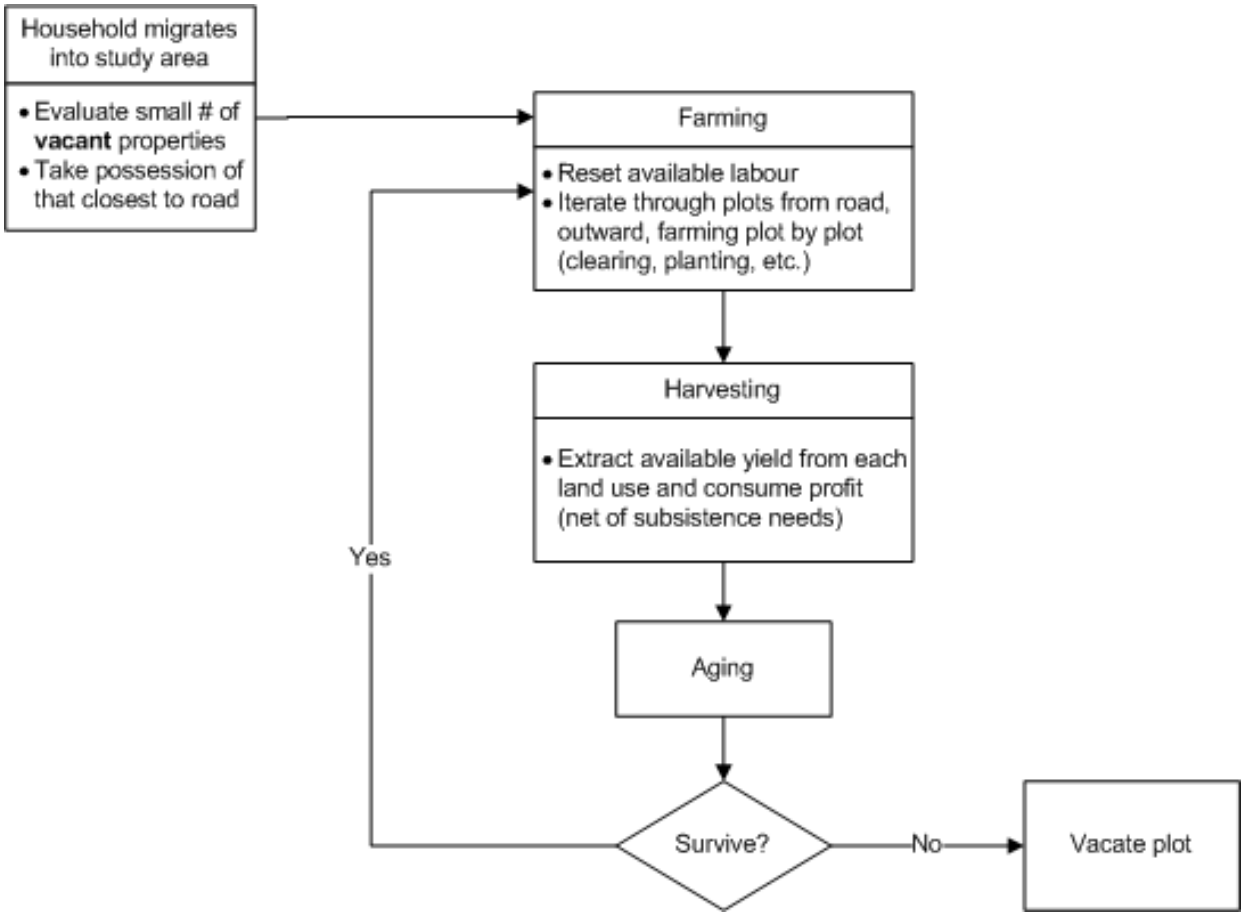
Layer 3 Parcels



Layer 4 Farms

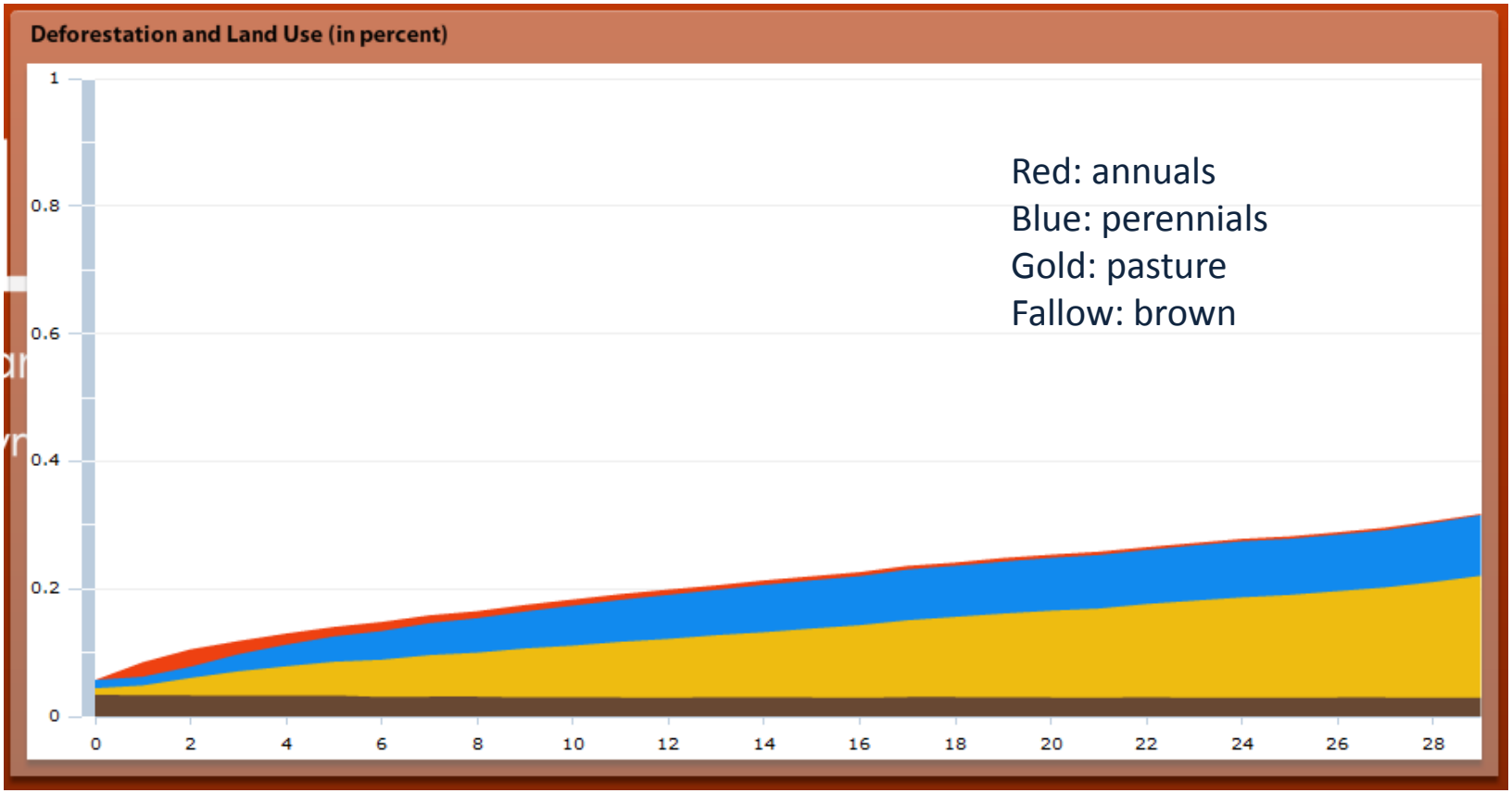
Walsh et al. NEA-ABM

AGENT-ORIENTED FLOWCHART



Deadman, Moran, et al.

LU TRAJECTORY
large families, high capital



Deadman, Moran, et al.

Land Use Scenario, year 28 (1998)

Deadman, Moran, et al.

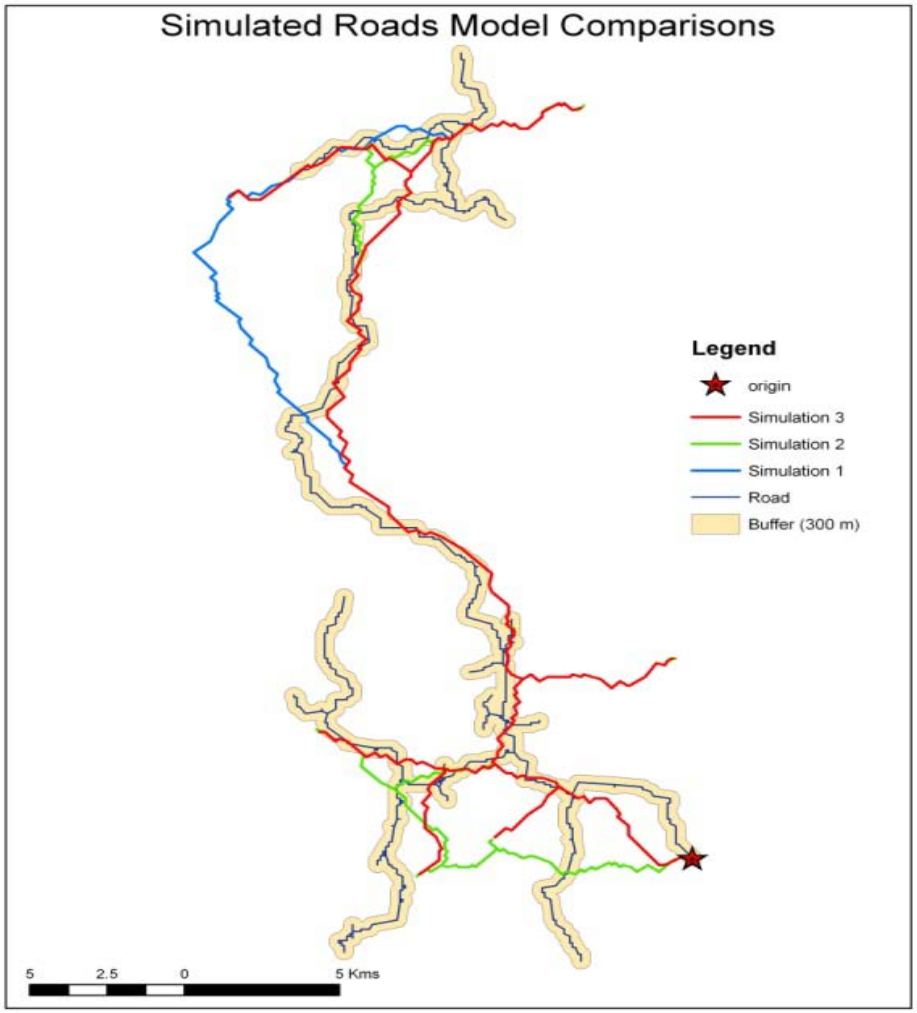
SELECTED FINDINGS

- Changes in land tenancy ….. can increase deforestation and land fragmentation.
- Forest succession ….. related to off-farm employment, household assets, etc.
- Spatial structure of LCLUC ….. related to household demographics, year of farm establishment, farm size, etc.

SPATIAL BEHAVIOR MODELING

IMAZON product

NETWORK MODEL IN *TERRA DO MEIO*



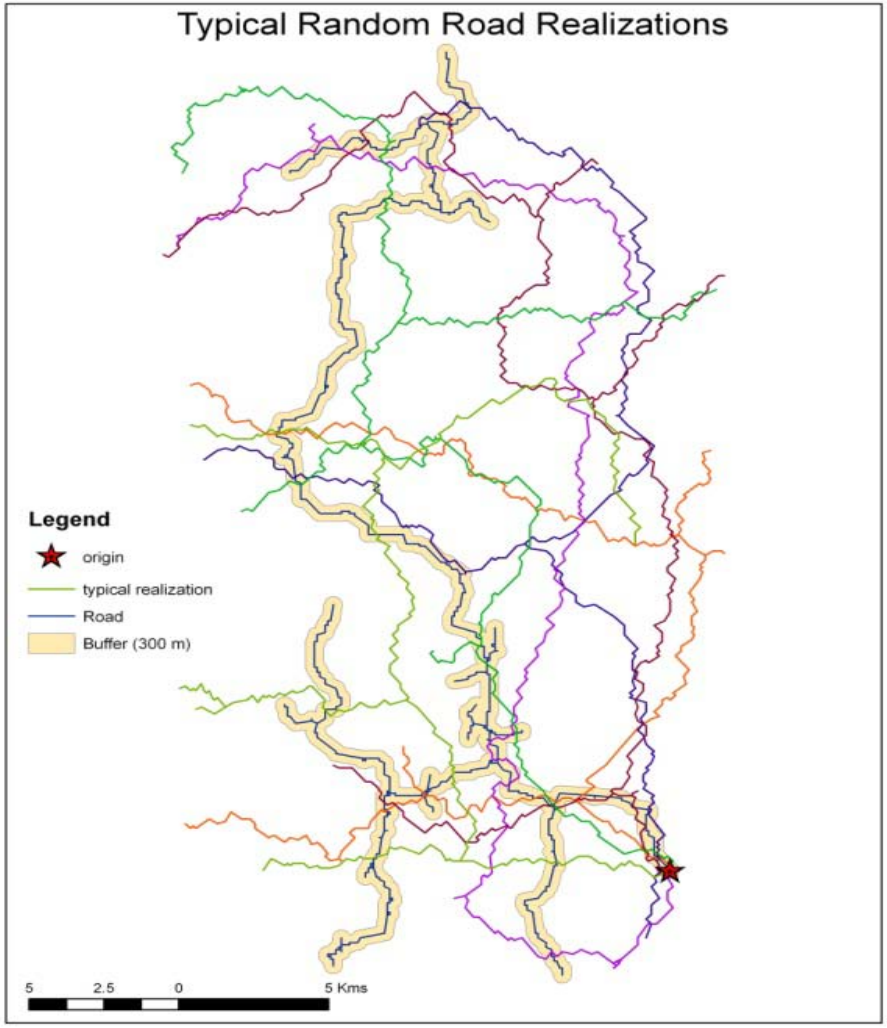
Equate road networks with Graphs

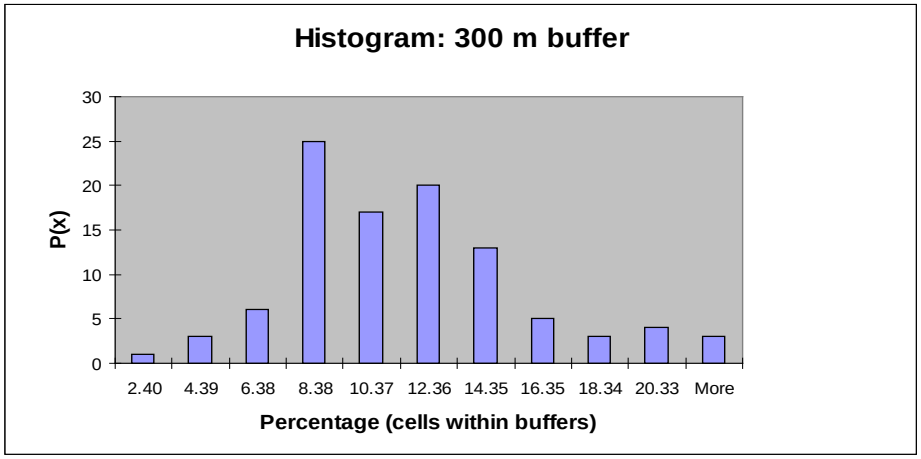
Apply graph theory to identify optimal networks

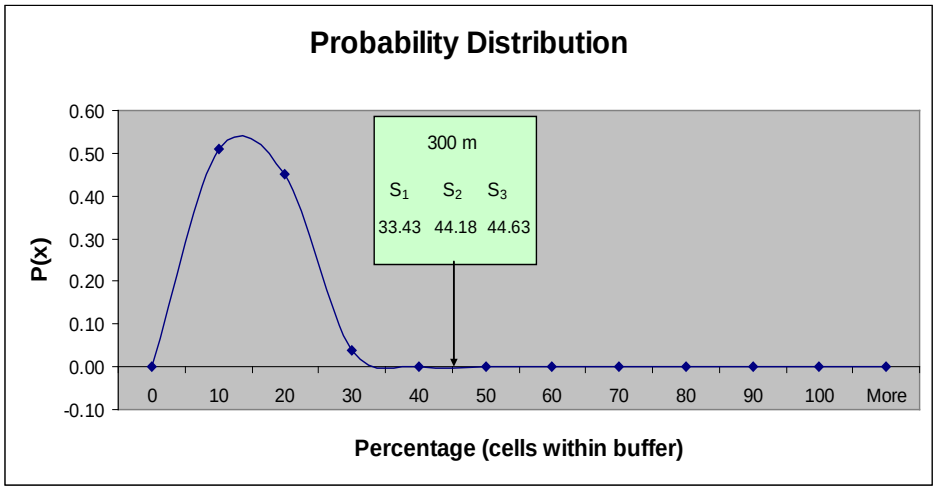
Simulate the optimal graphs, GIS search algorithm

Compare to actual networks

ERROR ASSESSMENT AND VALIDATION







ACCOMPLISHMENTS

- Models of deforestation at multiple scales, with projection capability
- Models that project *patterns* of deforestation, given a road network
- Models that generate road networks
- Deforestation and Fragmentation

CHALLENGES

1) Goodness-of-fit (Pontius, Arima, Walker)

2) Treatment of Uncertainty (Moore)

3) Forest dynamics, with transition (Moran)
   (good theory for F → Ag, not from Ag → F Forest Transition Theory)

4) Other agents in ABMs (what about large operators?)

5) General equilibrium, with price signals
   (Cattaneo)

THANKS TO

NASA LBA

NASA LCLUC

……

NSF

NOAA

NIH

……