Spatial Analyses of Stratification in Coupled Natural and Human Systems

Examples:

(1) A GIS from New Jersey
(2) A GIS - Remote Sensing Analysis from the Ecuadorian Amazon

# Upper class sprawl and ghg emissions in New Jersey: A GIS Analysis

Suburbia is where the developer bulldozes out the trees, and then names the streets after them.

--Bill Vaughn

Sprawl: A low density, commercial and/or residential pattern of settlement in which people rely exclusively on automobiles to get around.

- **Sprawl, nationwide**
- **Middle class sprawl in NJ, 1955-1985**
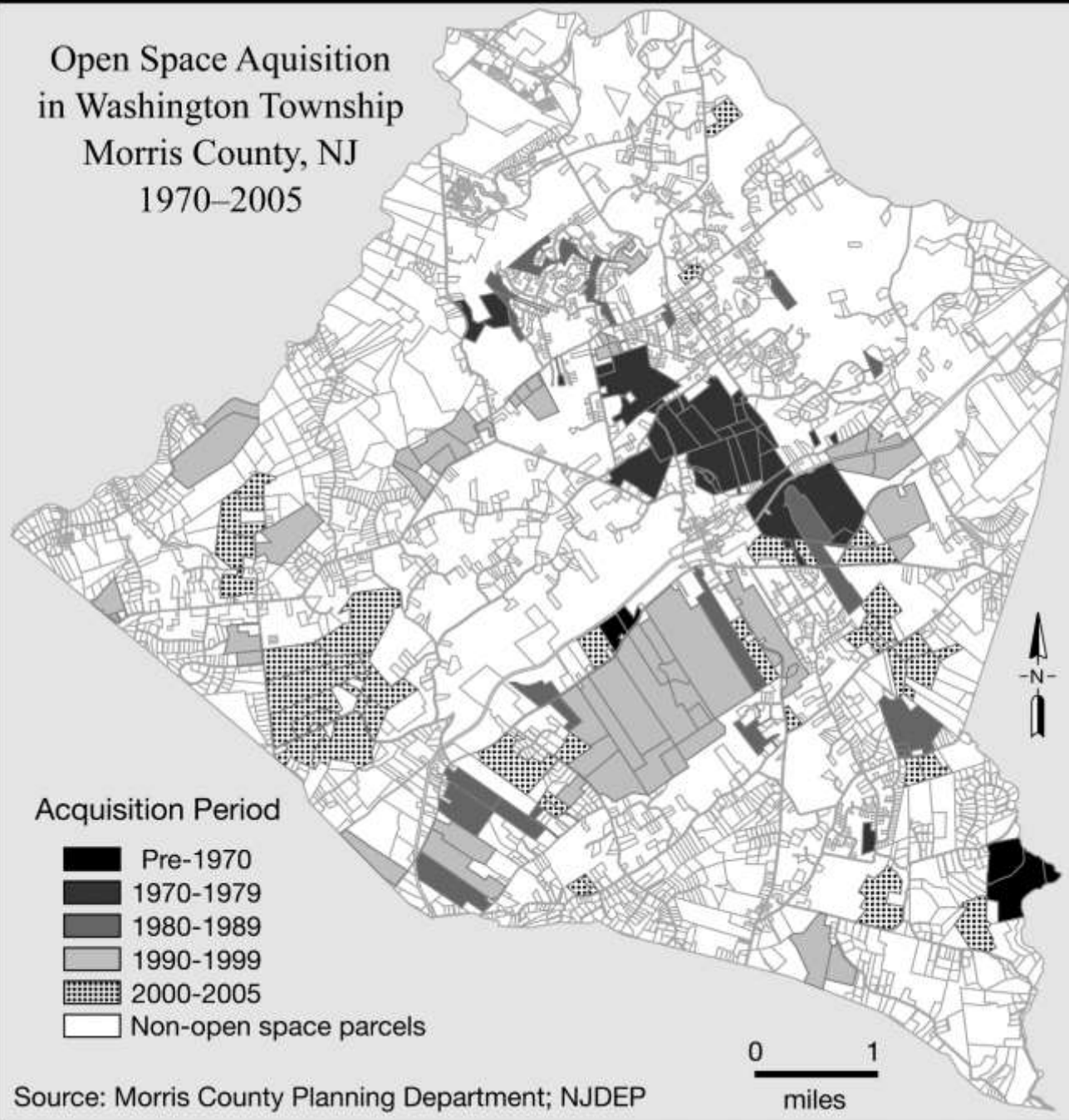- **Upper class sprawl in NJ, 1985-2015**

The New Jersey Highlands – a belt of communities that experienced upper class sprawl during the 1990s and 2000s.
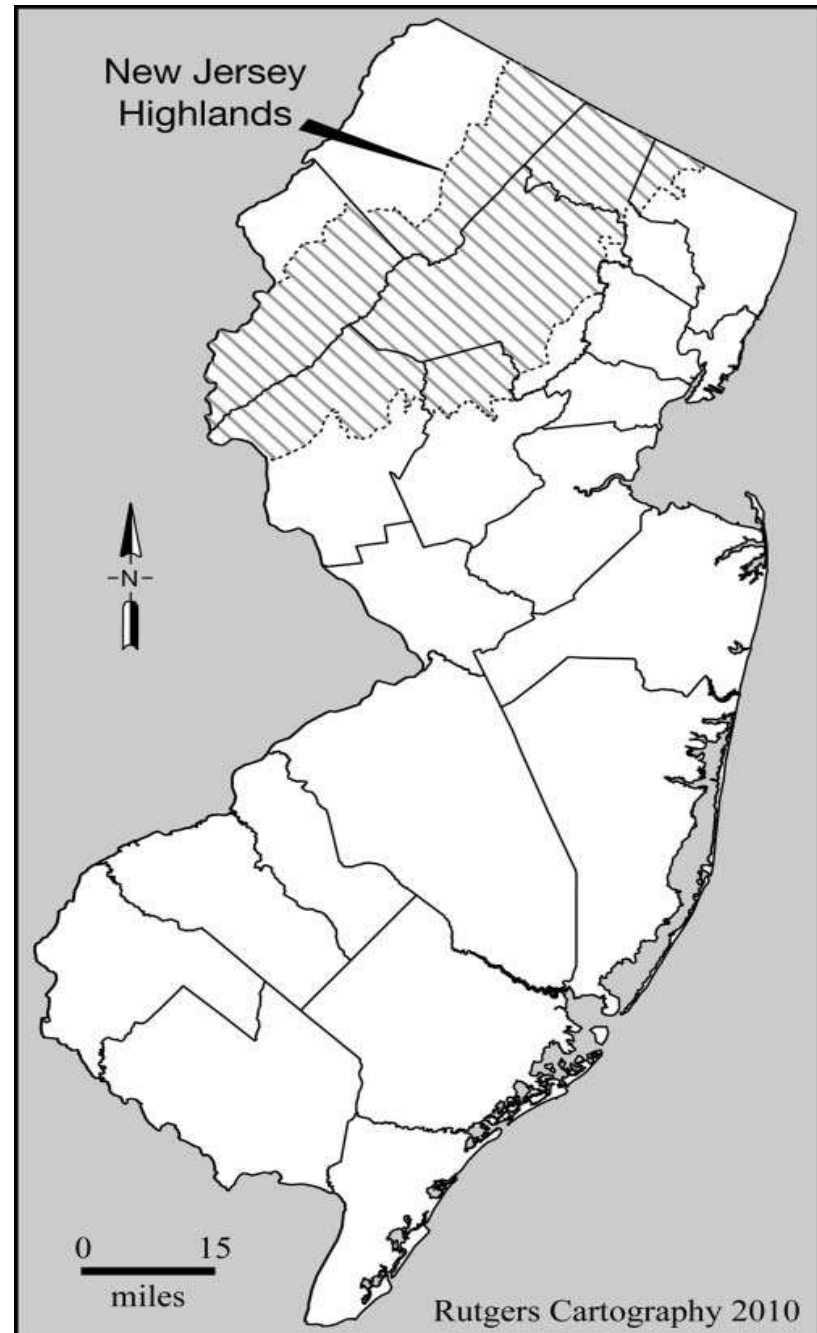
Open space accumulates in increments. Research in cadasters. Each incremental addition in preserved open space occurs when developers and town officials negotiate to allow adjacent lands to undergo real estate development, a quid pro quo.

Open Space Aquisition in Washington Township Morris County, NJ 1970–2005

Acquisition Period
- Pre-1970
- 1970-1979
- 1980-1989
- 1990-1999
- 2000-2005
- Non-open space parcels

0   1   miles

Source: Morris County Planning Department; NJDEP

Documenting the Shift from Middle to Upper Class Sprawl through cadasters and census data

- Minimum required lot areas to build expand from 1.49 acres in the 1970s to 2.88 acres in 2002.
- The % of preserved open space in highland communities expands from 7.6% of the land area in the 1970s to 29.1% of the land area in 2002. This is an under-estimate of open space because it does not include conservation easements by private landowners.
- Increases in open space and minimum lot areas tended to occur in the same communities (cc. = .399).
- Median family income in the Highlands goes from 138% of the national average in 1970 to 208% of the national average in 2000.
- House prices increase: Median value = $412,146 in 2005, a 47% increase in the real price of housing from 1992 to 2005.

Why does real estate development occur in the same towns that conserve open space?: Correlation Coefficients

	Change in Total Numbers of Acres in Residential Land Use , 1995-2002
Growth in % Open Space, 1975-2002	.300**
Growth in Average Minimum Lot Area, 1975-2002	.217*

The Shapes of Open Space.

A developer withdraws his request to develop the entire Schiff tract of land in return for being allowed to develop about 180 acres carved out of the center of the reserve. He shapes his lots so that every one of them backs on the reserve. The rest of the Schiff tract, 380 acres, becomes open space. Fragmented habitats.
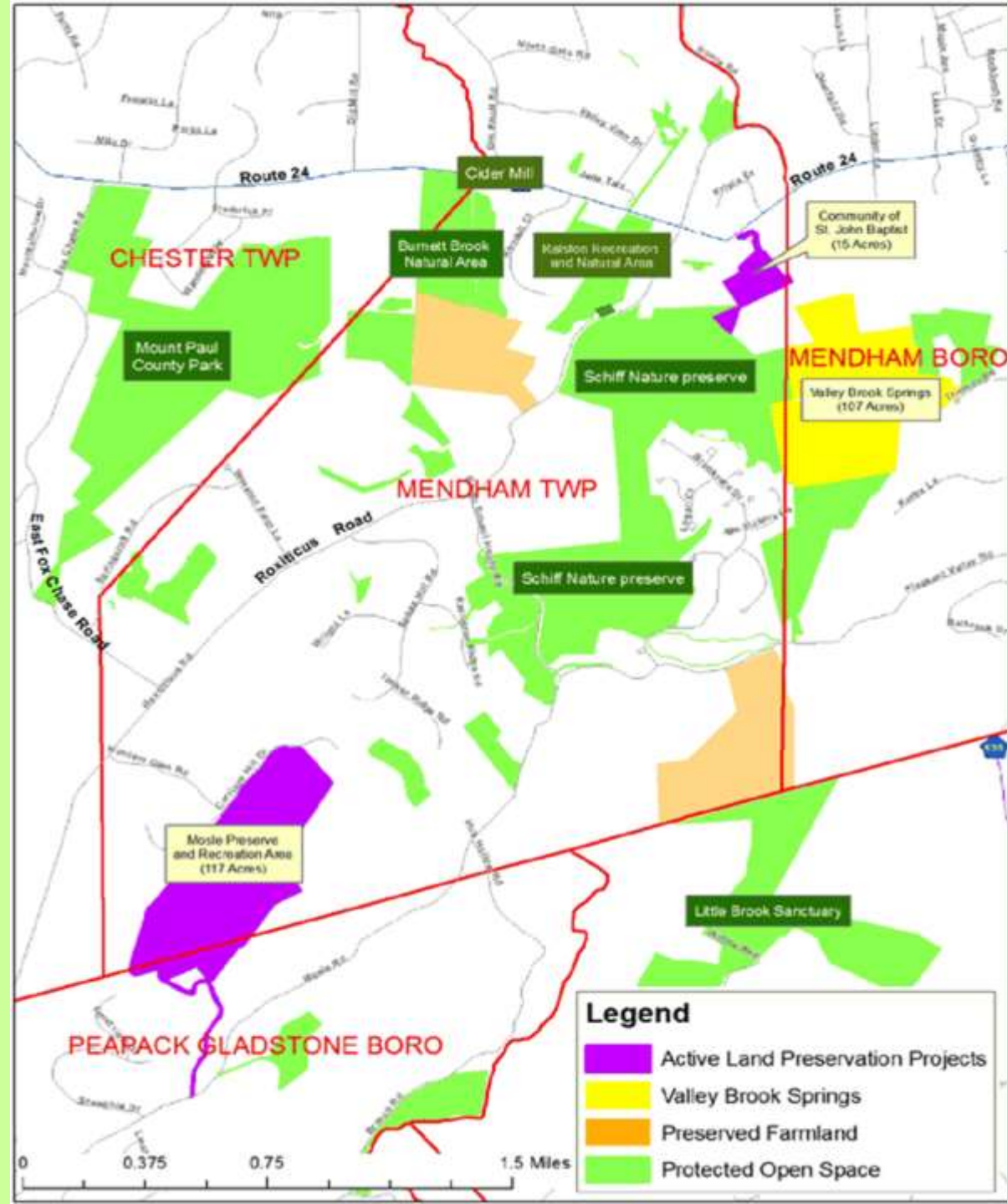
Is another layer of stratification emerging in the region, with the wealthiest communities having the most open space and largest minimum lot areas?

No, the comfortable 'try to keep up with the Jones (the rich)'.

Table 3. Preserved open space and large lot zoning, 1975–2002: Spatial regression analyses

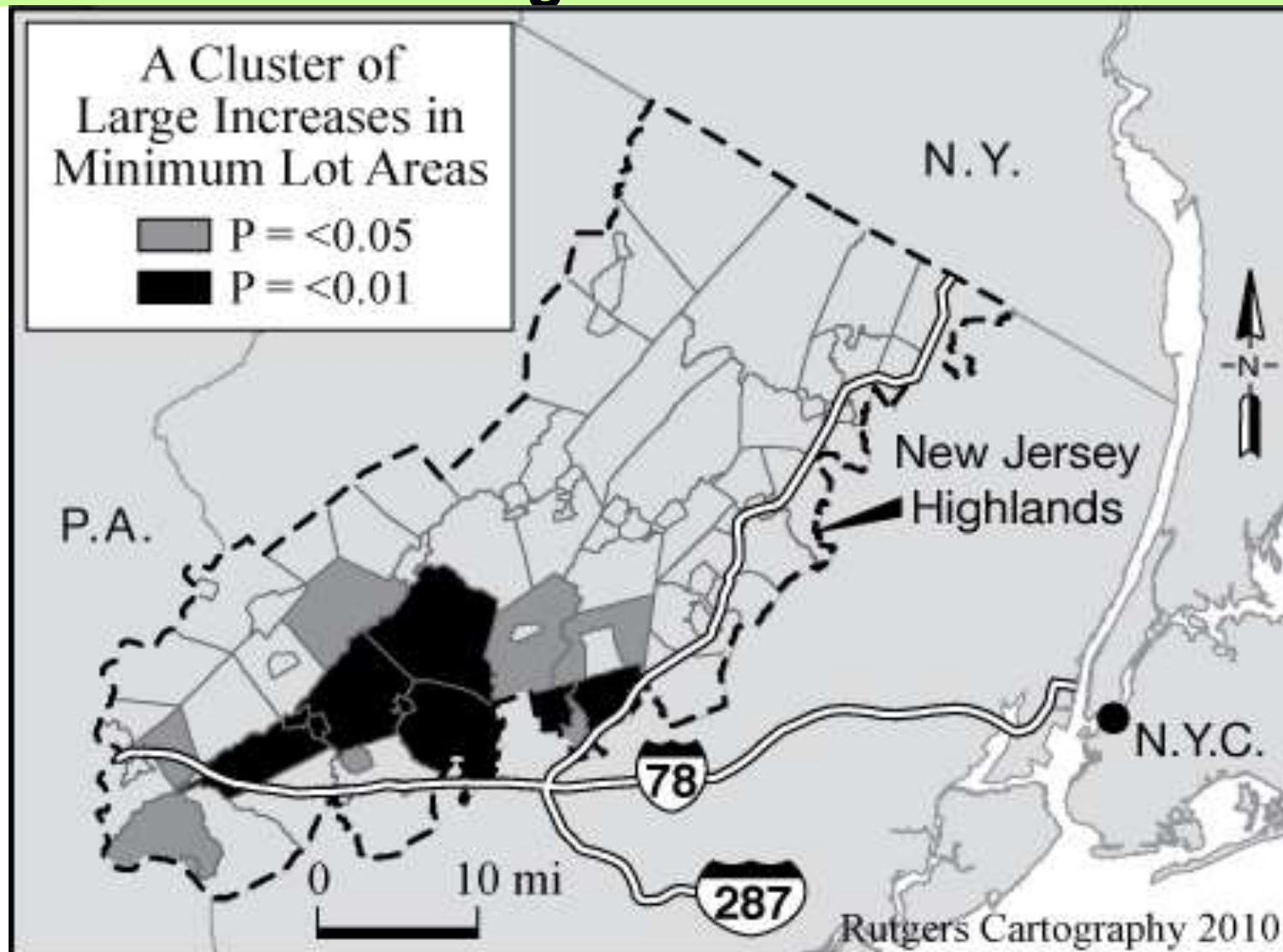| Variables	(1) Open space, % of area	(2) Open space with median family income, 1969	(3) Open space with median house value, 1970	(4) Large lot zoning	(5) Large lot zoning with median family income, 1969	(6) Large lot zoning with median house value
Spatial lag	0.270* (0.111)	0.281* (0.111)	0.271* (0.111)	0.137 (0.103)	0.174* (0.105)	0.161 (0.105)
Steep slope, > 15%	1.214*** (0.267)	1.281*** (0.271)	1.255*** (0.270)	5.227* (2.120)	6.029** (2.176)	5.812** (2.162)
Borough (yes/no)	−0.109*** (0.022)	−0.108*** (0.021)	−0.108*** (0.022)	−0.340* (0.169)	−0.354* (0.168)	−0.347* (0.168)
Population density, 1970				−0.036*** (0.007)	−0.035*** (0.008)	−0.035*** (0.007)
Open space, 1970s	0.900*** (0.123)	0.870*** (0.125)	0.871*** (0.128)			
Minimum lot area, 1970s				0.374*** (0.063)	0.356*** (0.063)	0.358*** (0.064)
Median family income, 1969		0.051 (0.044)			0.045 (0.035)	
Median house value, 1970			0.011 (0.013)			0.013 (0.010)
R^2	0.632	0.635	0.633	0.691	0.698	0.696
N	79	79	79	78	78	78

Note: The top figures in each cell of the table are unstandardized regression coefficients; the numbers beside them, in parentheses, are the associated standard errors. The units of analysis are municipalities.

* $p < 0.10$.
** $p < 0.01$.
*** $p < 0.001$.

Communities become more exclusive when development pressures builds after the completion of the interstates. Large minimum lot areas cluster.

A Cluster of Large Increases in Minimum Lot Areas

- $P = <0.05$
- $P = <0.01$

N.Y.

P.A.

New Jersey Highlands

-N-

78

287

N.Y.C.

0   10 mi

Rutgers Cartography 2010

What does this pattern of sprawl do to the spatial distribution of the social classes in NJ?

It **separates** the upper classes from the middle classes. Earlier episodes of sprawl **separated** the lower classes from the middle and upper classes.

Changing Building Patterns in Northern New Jersey, 1994-2007: What are the implications For greenhouse gas emissions?
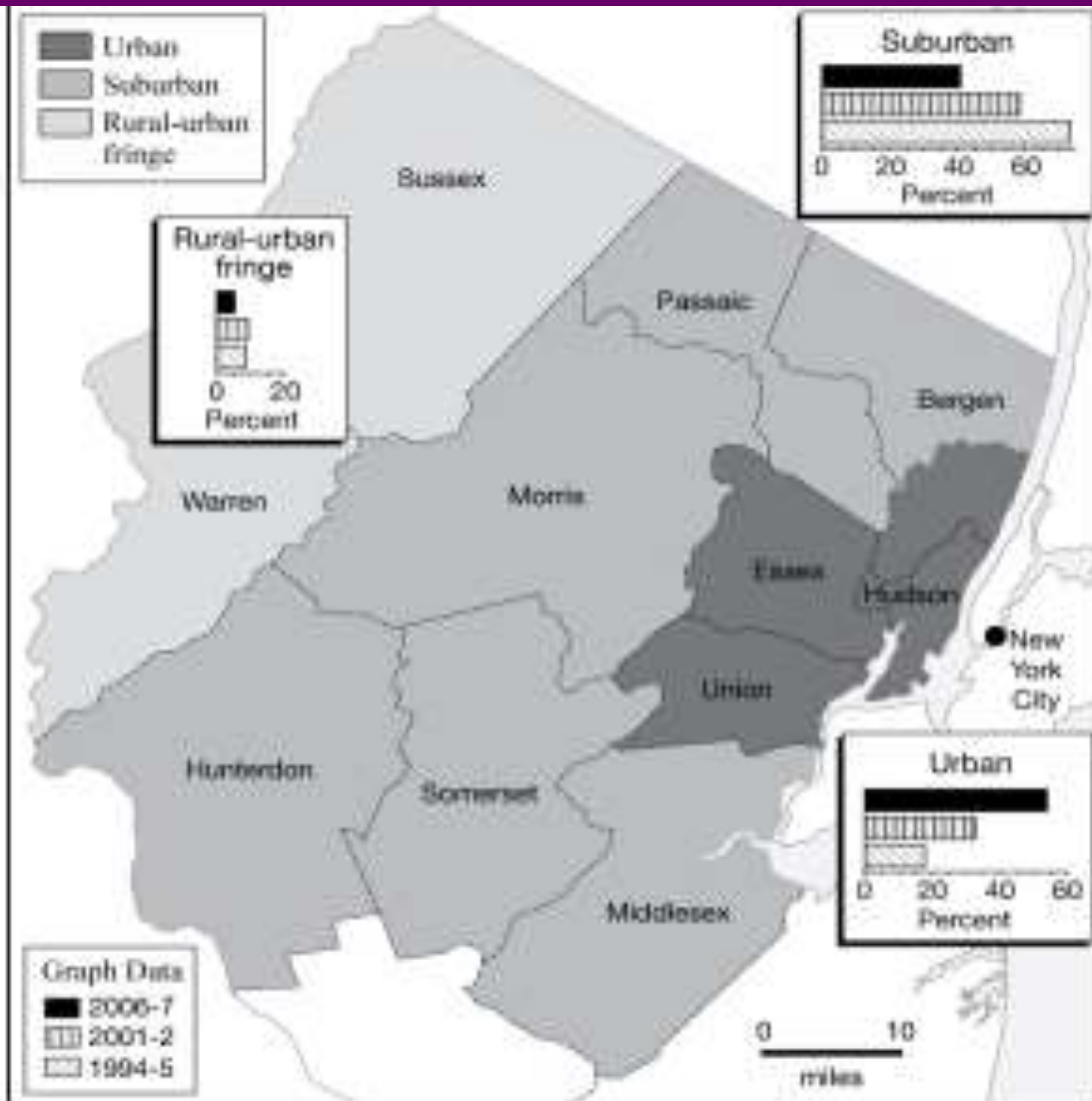
Issues
- Generality of the Pattern?
- Environmental Justice?

Only the wealthy get to reside in pastoral landscapes

The New Jersey analysis relied on building a single GIS using census and cadastral data. In the Ecuadorian analysis we interviewed farmers and added remote sensing data to the GIS.

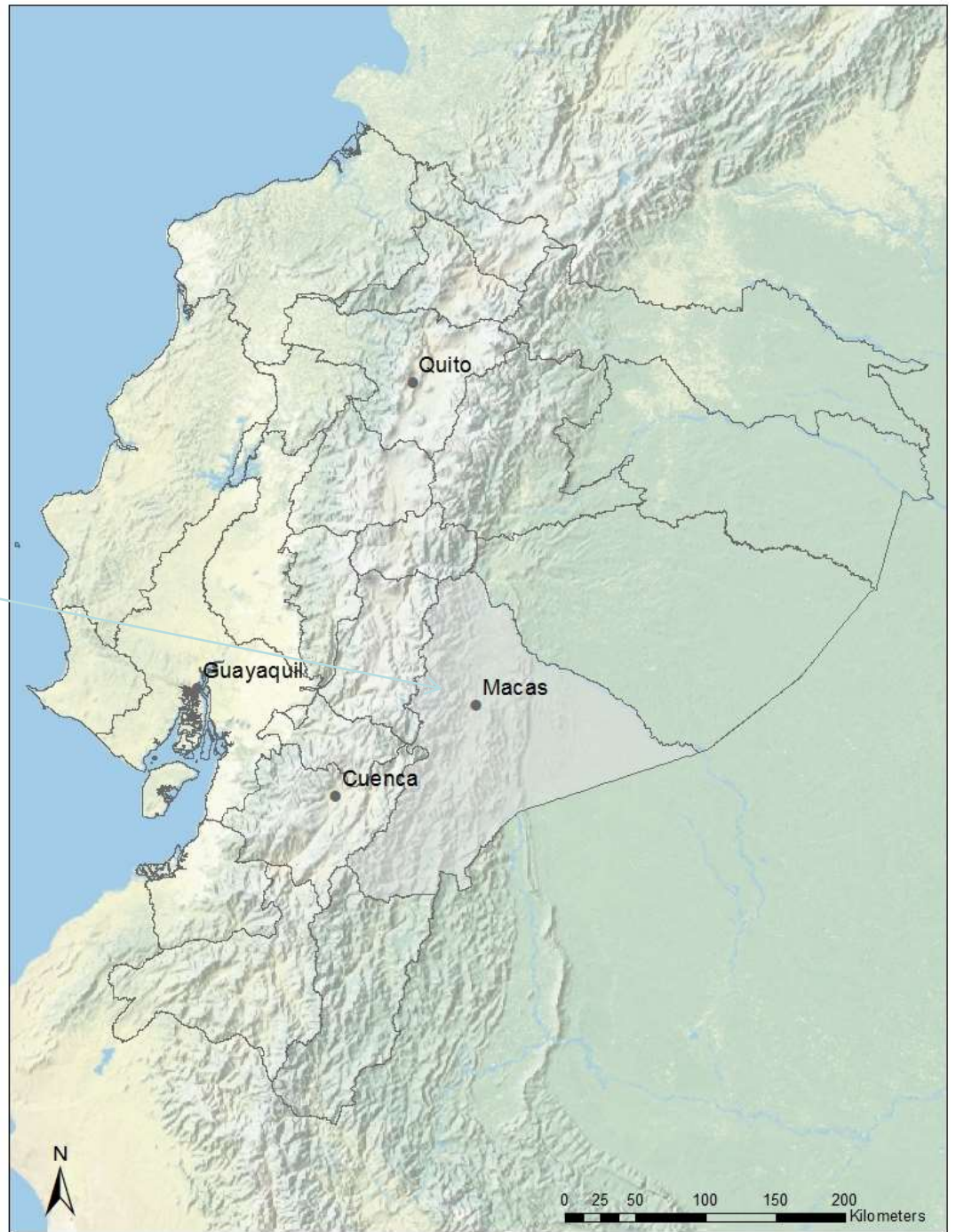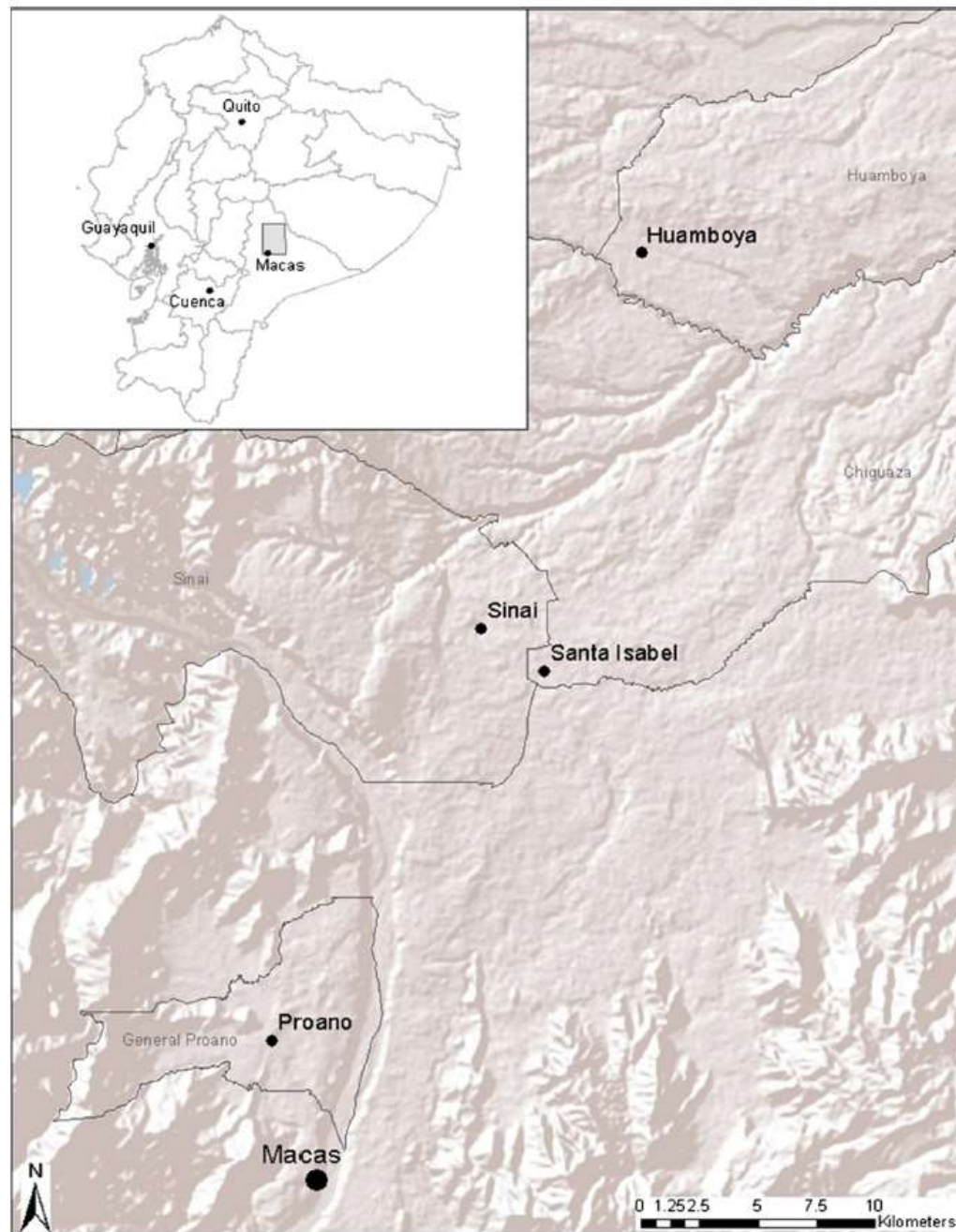The Spontaneous Emergence of Silvopastoral Landscapes in the Ecuadorian Amazon: Patterns and Processes

Fig. 1 Study site in
southeastern Ecuador

Shuar Homestead in the Forest

Pastures, late 1960s, after clearing. Note the absence of trees in the pastures

An aerial photo (2009) from the Ecuador study site of pastures with trees, denser on upper right than on upper left; the white specks where green grass meets brown stubble on upper right are cows.

Lots of variation from farm to farm in the density of trees in pastures: How do we account for the variation? (our question)

Less Dense

More Dense

Why should we attend to this question?

Grasslands and pastures are the world's most common land use. If some but not other kinds of pastures provide significantly more environmental services, that is potentially quite important, especially if humans have played an important role in creating these ecologically enhanced pastures'

Do pastures with higher tree densities sequester significantly more carbon?

Do pastures with higher tree densities contain significantly more plant and animal biodiversity?

In sum, do pastures with more trees provide significantly more environmental services?

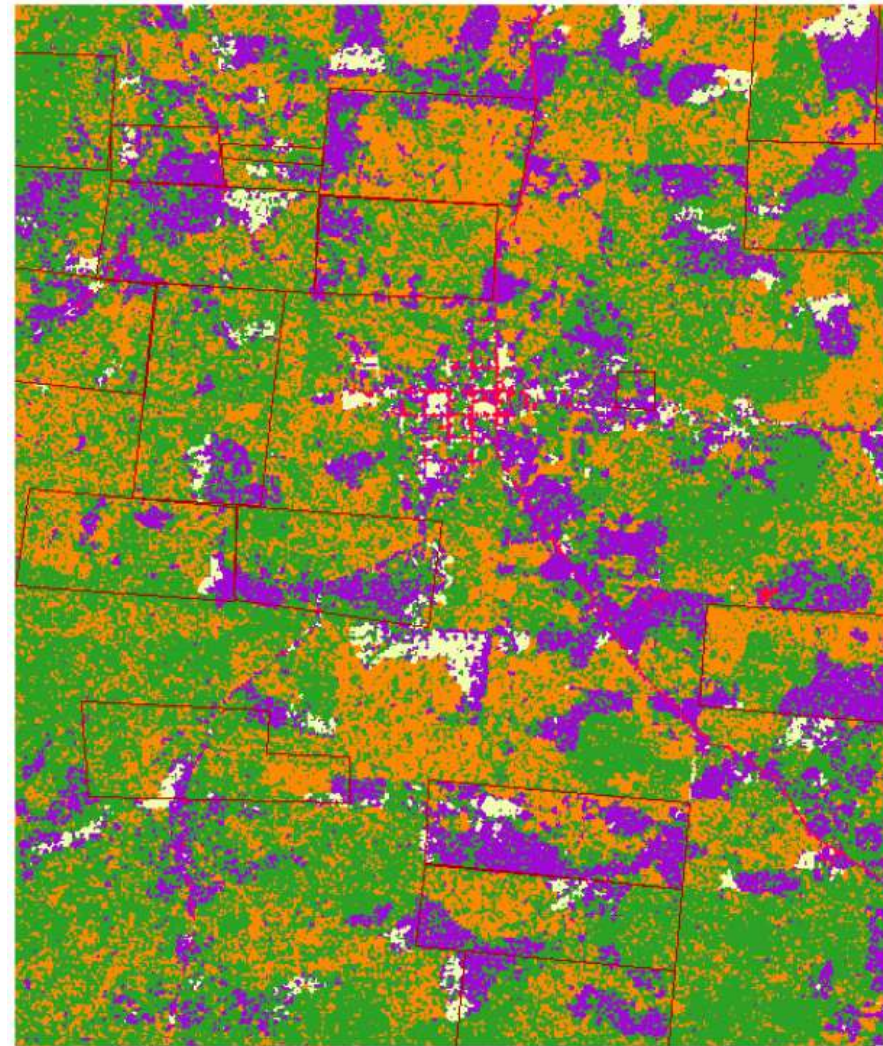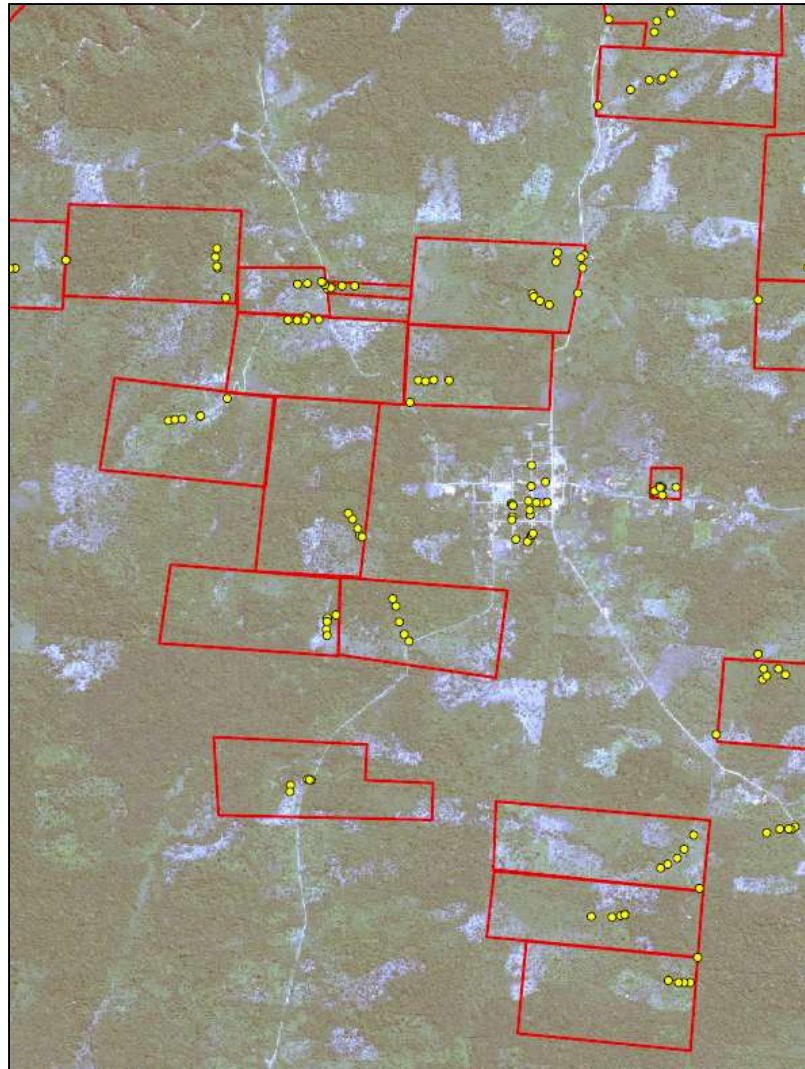**To answer these questions, we collected a wide array of data.**

Methods - Fieldwork

Social data: pasture management, household demographics, income sources, property maps

Ecological data: soils (organic matter, carbon); vegetation (tree species, DBH, density)

Methods - Remote sensing

An Argument: Robert Mac Netting (1993) argued in *Smallholders, Householders: The Ecology of Small Scale Sustainable Agriculture* that, worldwide, smallholders, with access to abundant family labor, often practice conservation agriculture in order to maintain the productive qualities of their soils

Table 4 Landowner responses to why they leave trees in pastures

Reason	Percent of respondents
Shade for cattle	86
Organic matter for pasture	34
Lumber	35
Environment (water, carbon)	6
Lack of time	1
Other (fruit, aesthetics)	10

Coding of answers was created after the open-ended questions were asked and recorded

Table 3 Spatial regression model coefficients for the variables associated with stem density

Predictor variable	Parameter estimates
Spatial lag	821.39** (326.34)
Household size	33.80*** (11.36)
Parcel size	3.51* (1.84)
Indigenous community	−98.23* (52.01)
Area of pasture	−0.06** (0.03)
Elevation	−0.60** (0.02)
Years of ownership	−4.12** (2.01)
R^2	0.32
N	97

Standard error in parenthesis; significance levels denoted with asterisks: * $p < .10$; ** $p < .05$; *** $p < .01$

Interpretation & Policy Implications

The higher stem densities in some pastures but not others do not appear to be an accident. They result from decisions by younger farmers to allow the sprouting seedlings of commercially valuable species to continue to grow in pastures. If enough carbon is sequestered in these pastures with trees, smallholder cattle ranchers could become an important class of recipients in REDD+ payment schemes for sequestering carbon.

Why the difference in the land use trajectories of the *mestizos* and the *Shuar?*

Shuar can not sell their land to non-Shuar and can not use their landholdings as collateral for loans from banks, so they can not, for example, buy a bull. What they can do is rent their land to others.

How do renters treat pastures?

When they 'clean' pastures, they do not leave tree seedlings to grow because they will not be using these lands in the long run, so they receive none of the payoffs from the enhanced soil fertility and from the sale of the timber to local sawmills. In contrast owner – operators will leave the seedlings of commercially valuable species. The fields benefit from the nutrients supplied by the trees and the landowner benefits from the sale of the tree to a saw mill 10-15 years later.

The soils in Shuar pastures, without the additional nutrients from the trees, continue to degrade through constant use. Armadillo holes.

The Shuar are getting caught up in a natural resource degrading poverty trap despite the grants of land some thirty years ago. The only planned way out of these traps might be through government assisted biofuels investments that would enable the Shuar to cross the threshold between the lower and the middle class.

Community donations in order to give back to the community: Refrigerators for Day Care Centers in the Four Communities

Thanks!