

Space, Place, Population and Tropical Deforestation: Latin America and Guatemala's Maya Biosphere Reserve



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David Lopez-Carr

Department of Geography

University of California, Santa Barbara

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Outline

1. Current Projects
2. Global Population and LUCC Trends
3. Population and LUCC in Latin America
4. Space, Place, Population and LUCC:
A Case Study from Guatemala

Current Projects

Population, Urbanization, Biofuels, and Tropical Deforestation/LUCC

Guatemala (with E. Castellanos, L. Suter; NSF GRS; NIH K01)

Ecuador (with JHU, UNC-CPC; NIH R03)

Central and South America (with M. Aide, CIESIN, et al; NSF Biocomplexity Award)

Rural, Urban, and International Migration

Remittances, Population Change, and Environmental Impacts in Guatemala (NSF, UC-Pacific Rim, and NASA ESSF with J. Davis) and in Ecuador (with A. Barbieri, R. Bilsborrow et al; NASA & NIH R01)

Fertility and Maternal and Child Health

Ecuador (with W. Pan and colleagues at JHU and UNC-CPC; NIH R03)

Guatemala (with K. Grace); NIH K01

Human Impacts and Adaptation in Marine Protected Areas

Mesoamerican Reef (Mellon Foundation), Moorea, Polynesia and S. California (with H. Lenihan; NSF LTER)

Integrated Population, Health, and Environment (PHE)

in Global Ecological Hot Spots– sub-Saharan Africa and S. Asia (with WWF and USAID)

Demographic and Health Surveys (DHS)

Petén, Guatemala (with USAID). Kenya and Nepal next?

Human Dimensions of Climate Change

Brazil Monsoons and Changes in Population, Health, and Land Use

Human Dimensions of Global Environmental Change:

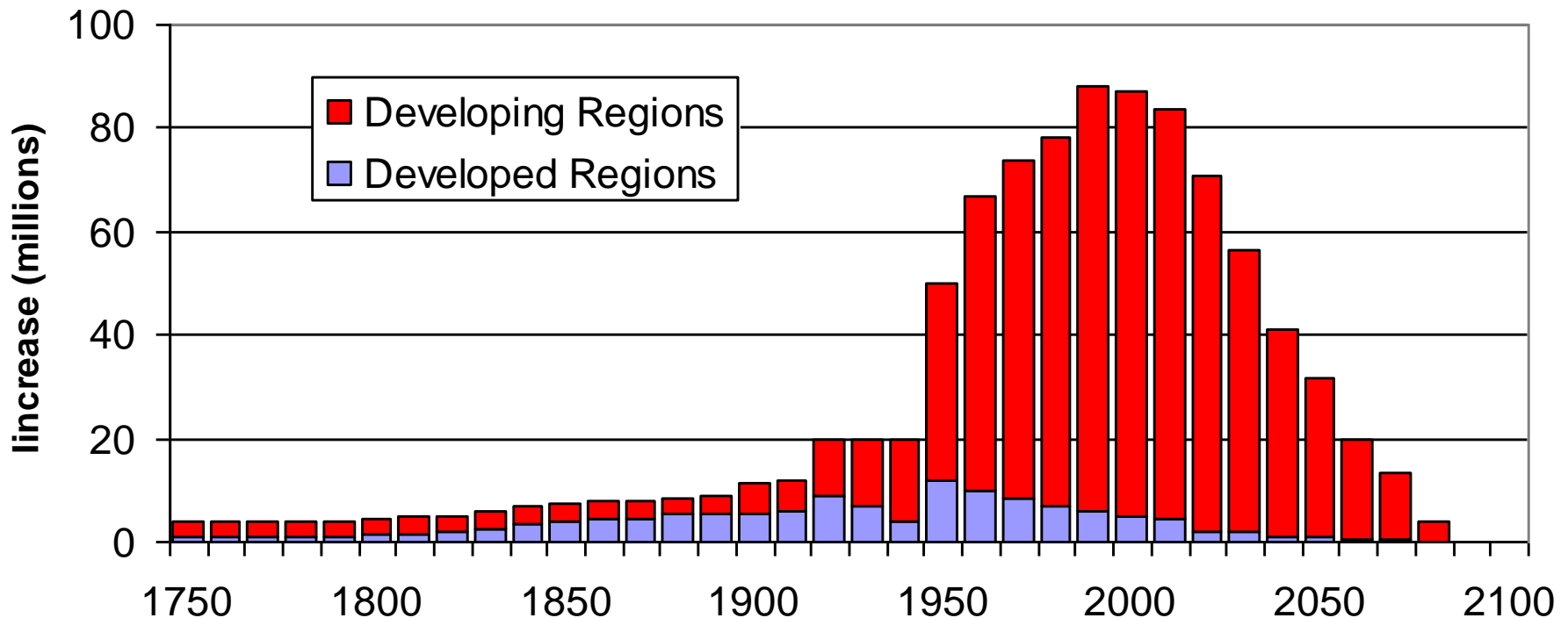
Integrating remote-sensing and spatial data with socio-economic and demographic data to improve our understanding of the most important geographical processes facing humankind.

Most publications available online at: www.geog.ucsb.edu/~carr

Urbanization

World Population: Average Annual Increase For Each Decade, 1750-2100 (projected)

Source: "World Population in Transition", *Population Bulletin*, by Thomas W. Merrick and PRB



What do these maps mean?

Frontier Forests



Frontier Forests



Population and Environmental Change in Latin America

- 519 million people in 2000 (UN, 2001)
- 30 year doubling time, 1970-2000. 1 billion by 2100?
- Declining fertility, Rural out-migration (2% annually) and Urbanization, but...
- Rapid forest clearing
- Major impact of rural-rural migrants and pasture expansion

Central America: Forest Cover



Source: FAO, 2003

South America: Forest Cover



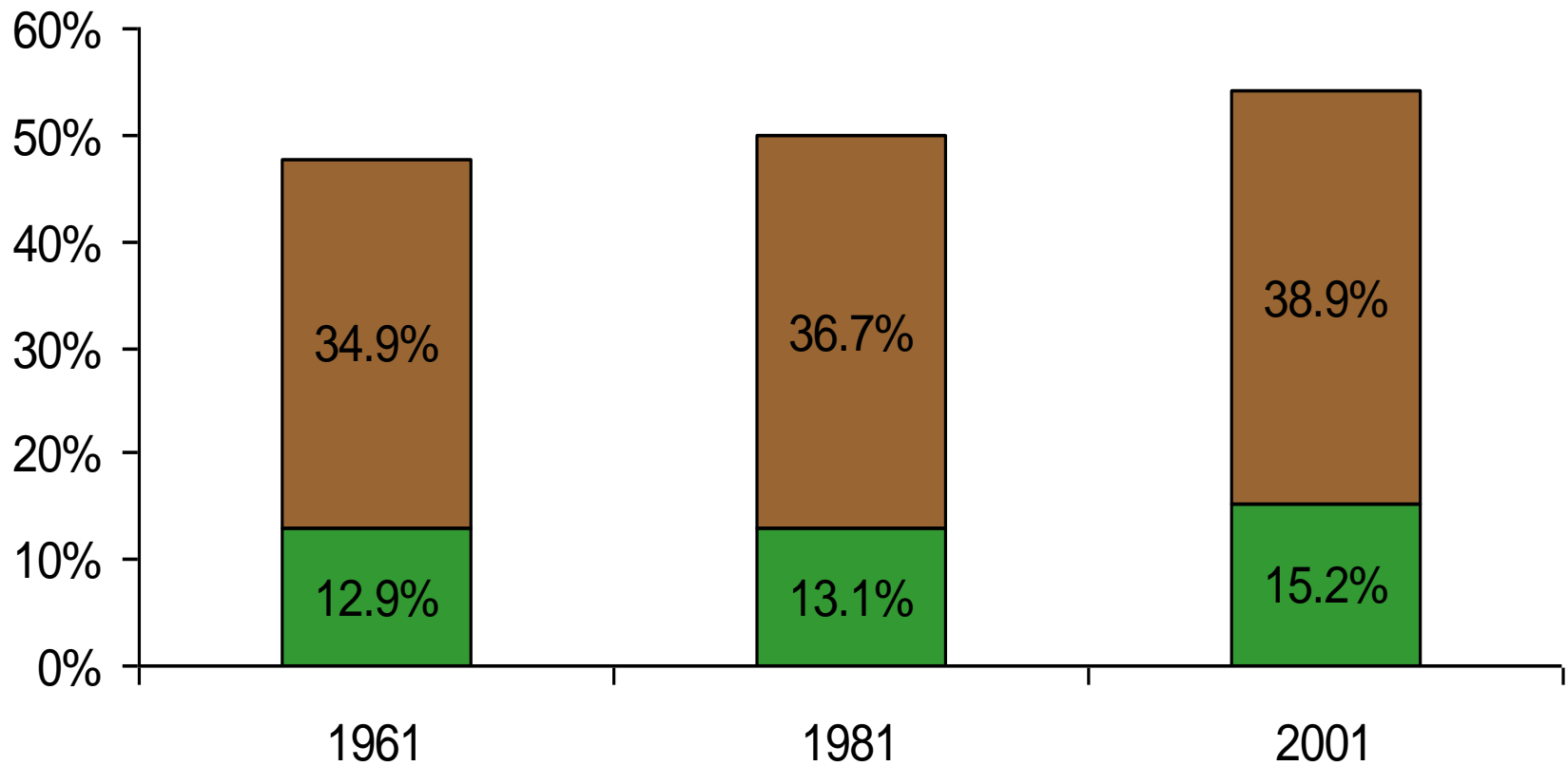
Source: FAO, 2003

Central America: Poverty Deforestation

1961-2001

- 59% rural population increase (19 million)
- 34%. rural population density increase.
- 15% deforestation (13 million ha.)
- Great temporal and geographic variation

Central America: **Pasture** and **Arable & Permanently Cropped Land** as a Percent of Total Land

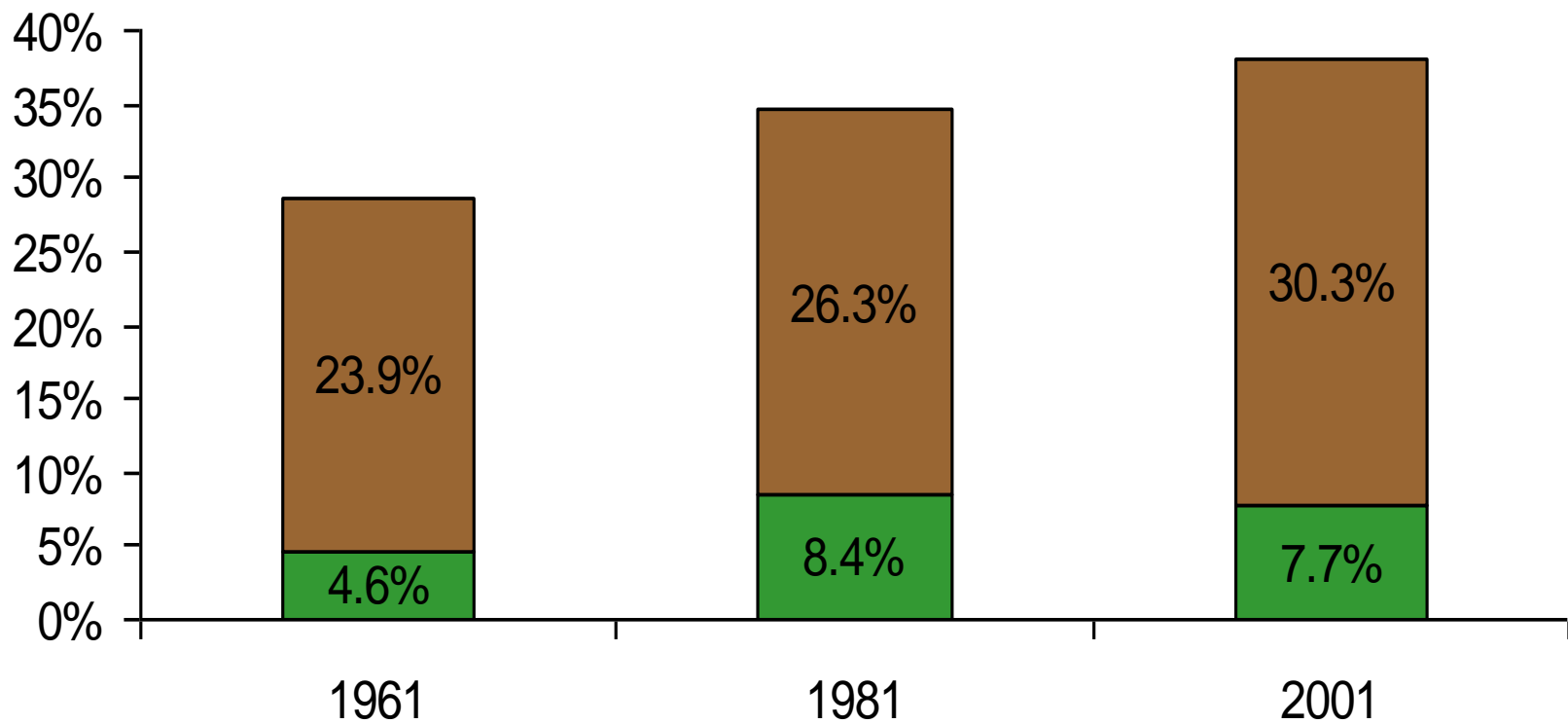


South America: Amazonian Poverty Deforestation AND Globalization Deforestation

1961-2001

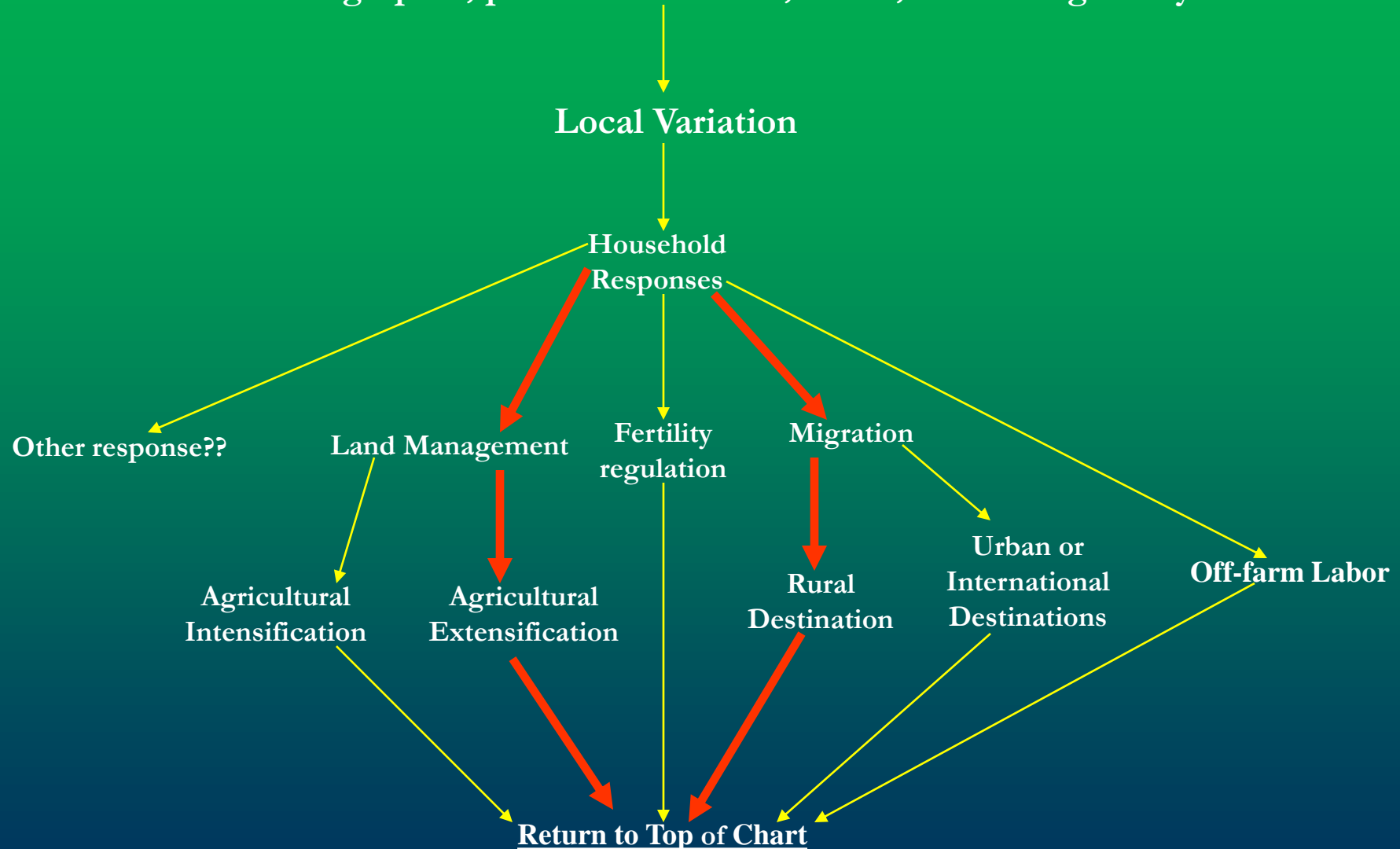
- 62 million decrease in rural population (-6%)
- rural population density nearly halved
- 6% deforestation (12% weighted).

**South America: Pasture and Arable & Permanently
Cropped Land as a Percent of Total Land**



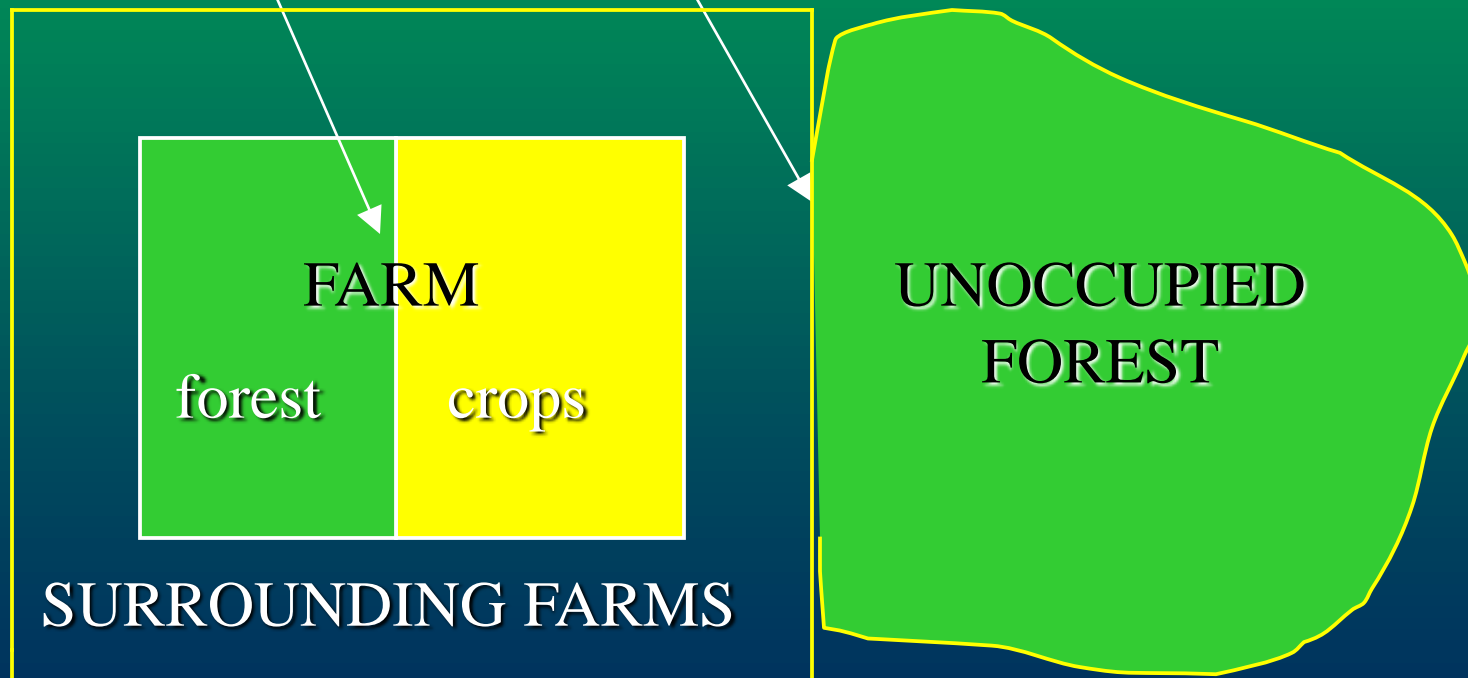
LUCC Theory: Rural Household Responses

Macro-Scale demographic, political-economic, social, and ecological dynamics



The significance of rural migration to agricultural expansion

- Internal (place) versus external (space) forest frontiers.

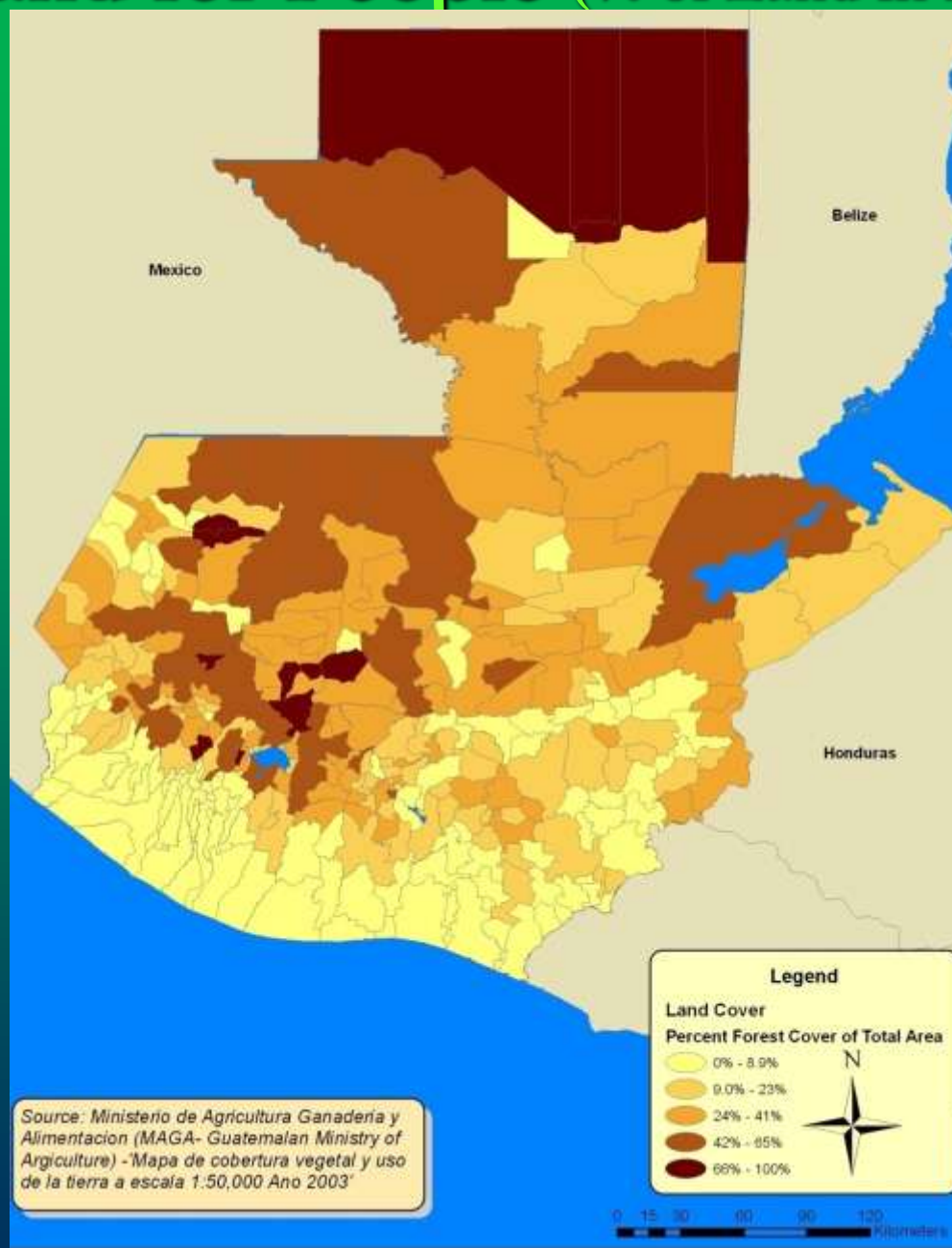


Deforestation: Population, Space, and Place Question 1

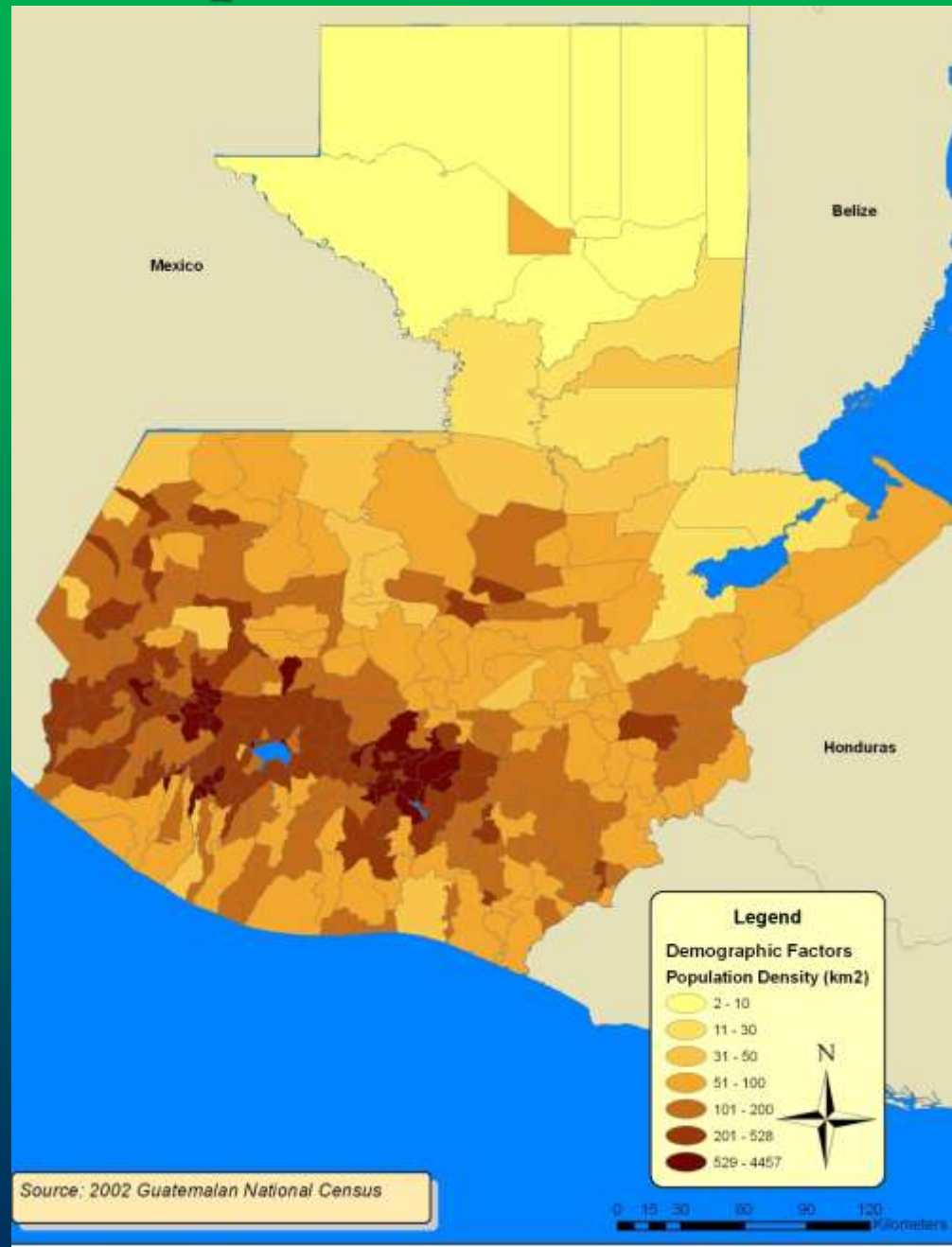
What are the Proximate Determinants
of Agricultural Expansion in the Maya Biosphere Reserve?



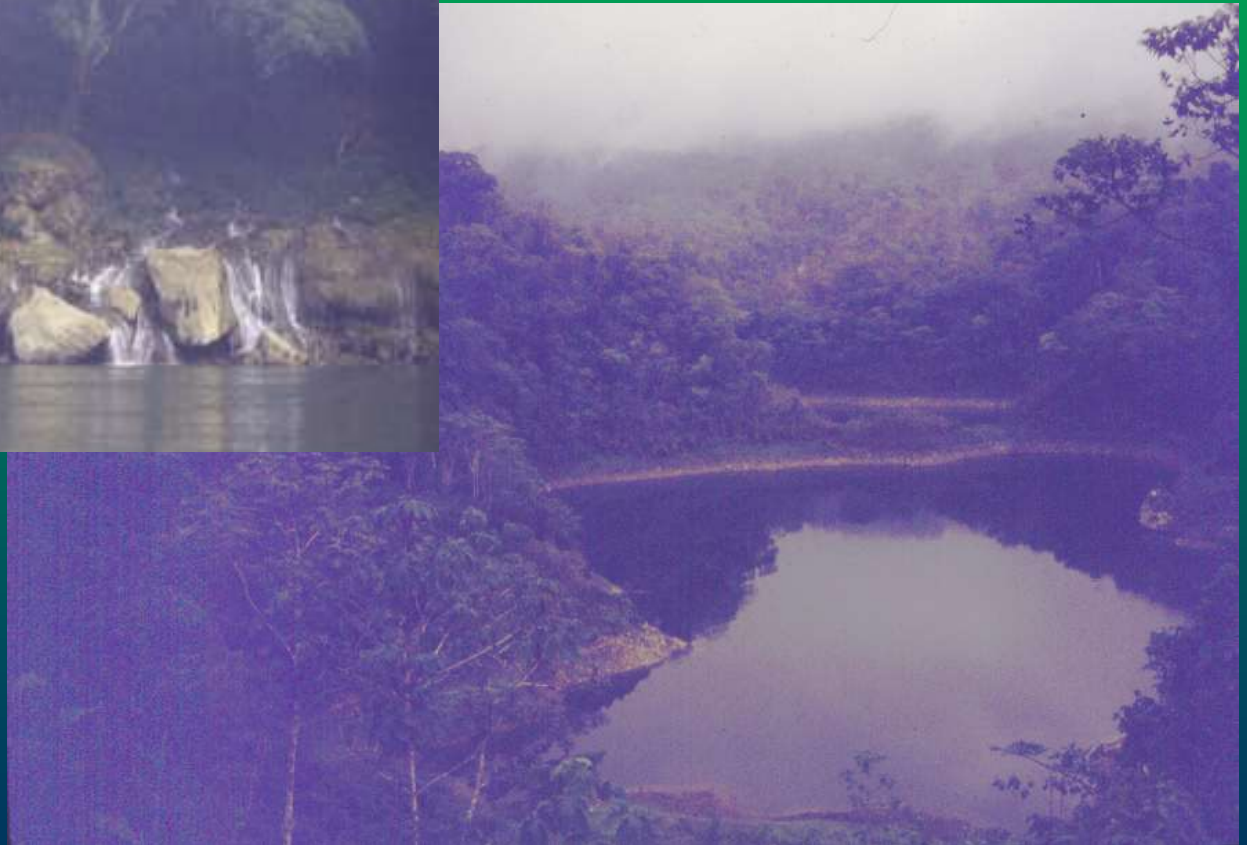
Land for People (% of Land in Forest)



...for People without Land (Population Density)



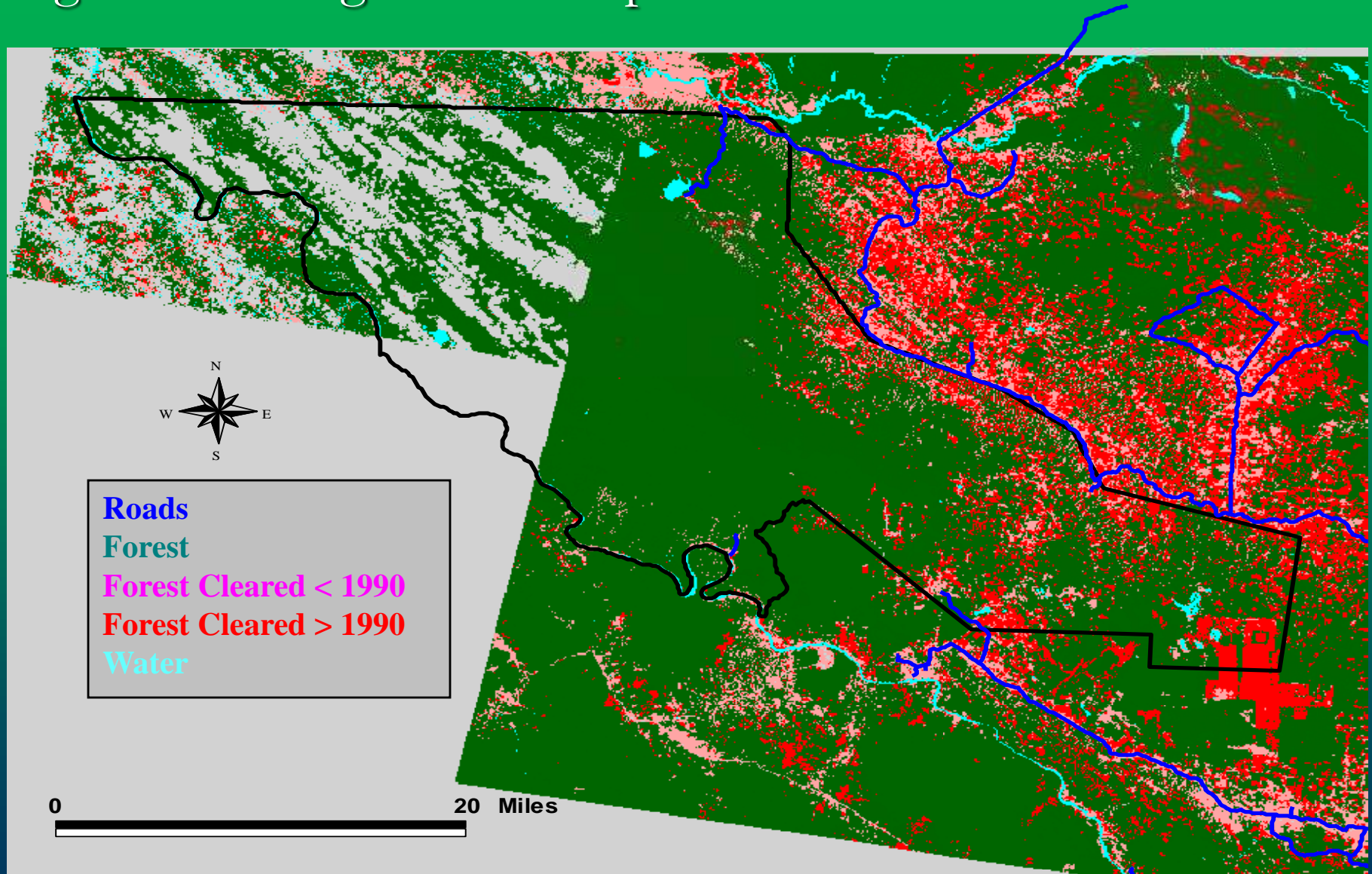
The SLNP boasts the richest biodiversity in the Maya Biosphere Reserve.



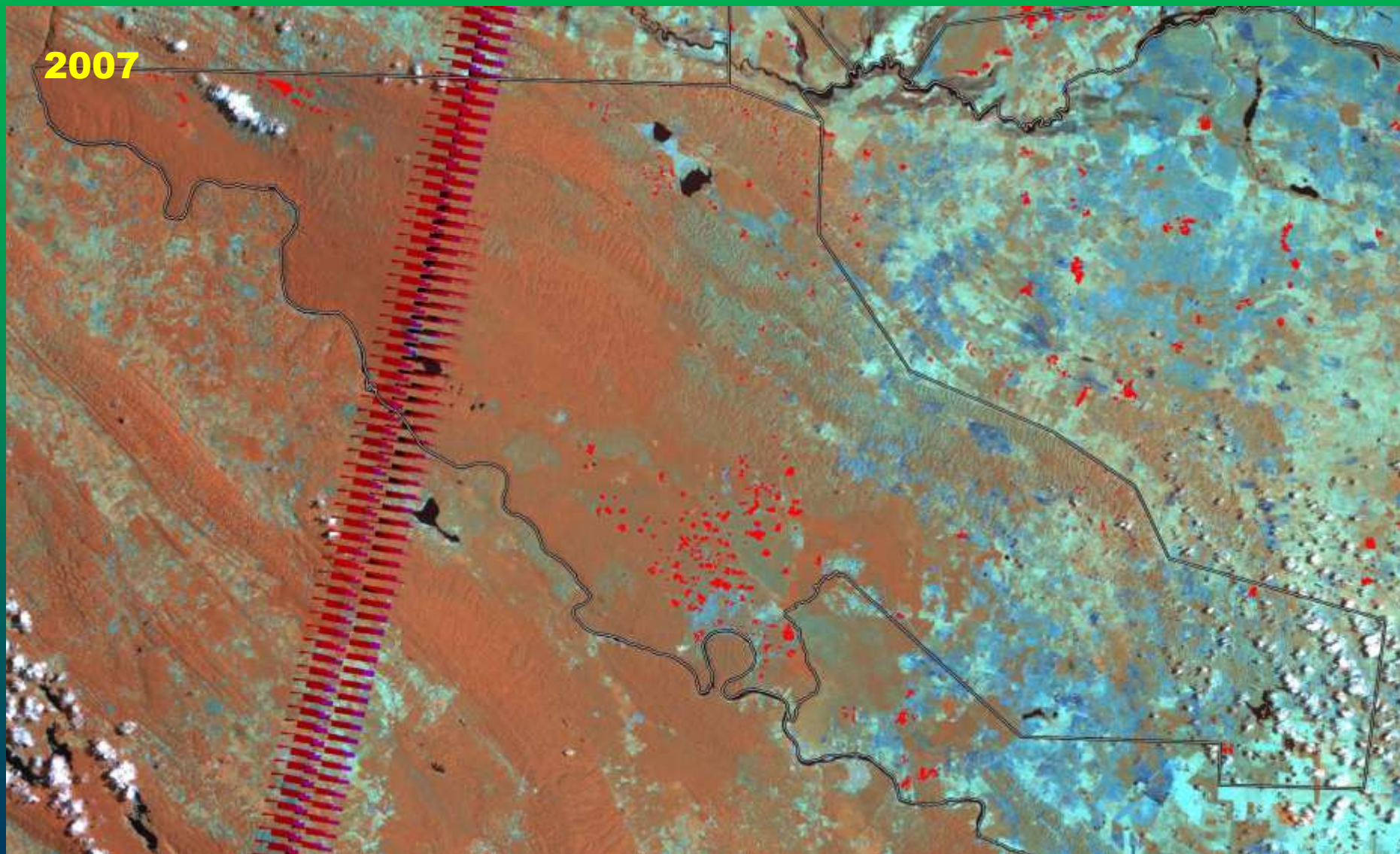
The Naranjo Road in 1987



The SLNP suffers some of the highest rates of population growth and agricultural expansion in the MBR



Deforestation: 2005-2007



Roads collapse space



Question 1: Research Methods

1998 and 2009 surveys

Phase 1: 1998

a. **Interviews** with community leaders in 28 communities responsible for LUCC in the SLNP.

b. **Surveys** with 279 men and 220 women from 9 communities.



Household sample 1998

- **Eight communities**
 - **Out of 28 communities total**
 - **Borders and interior of park**
 - **Clustered probability sample**
- **247 households**
 - **30% of households per community**
 - **OR minimum 30 households in larger communities**

- **Survey instruments 1998 and 2009**
 - Primarily short fixed format questions
 - Demographic, political-economic, socio-economic, geographic, and environmental factors
- **Updated and adapted in 2009**
 - Land sale
 - Out-migration from household

Communities revisited 2009

- **Two distinct samples discussed here**
 - **Sample 1: Revisit 247 households interviewed in 1998**
 - **Follow-up on movements and land sales**
 - **Sample 2: Random selection of current residents**
 - **Compare current population to 1998 population**

2009 Household Samples 1 & 2

Sample 1: Follow up 1998 Households (indicates total number interviewed in 1998)	Sample 2: Randomly selected households
244 (247)	278

- **Sample 1: household or relative/friend of 1998 interviewee**
- **Sample 2: current household**
- **Acceptance rate: > 99%**
- **Not discussed here: Sample 3, current owners of 1998 land parcel**

Interview team

- Petenero students and NGO workers
- Q'eqchi translators
- Logistics coordinated with local NGO



Piles of Surveys! Hecho en Guatemala




Laurel Suter, AAG 2010

Simplified Multi-level Equation

$$\mathbf{y}_{ij} = a + \beta X_{ij} + u_j + e_{ij}$$



**Community
level
random
effect**



**Household
level
random
effect**

Población y Uso de la Tierra en el Parque Nacional de Lacandón

Cuestionario de hogar - Para Jefes de Hogar

Nombre:

Comunidad:

Encuestador:

Seccion I: La familia y la casa

Qué edad tienen? Ud. _____ Su esposa (o pareja) _____

En que año se casaron (se unieron)? _____

Ha vivido casado o unido con otra mujer antes?

01 - SI

02 - NO [salte a la siguiente pregunta]

Cúantos hijos tuvo Ud. antes de vivir con su actual mujer? _____

Cúantas personas viven en la casa actualmente? [indique hombre "H" o mujer "M"]

edad	hijos/as	Hijos que están estudiando	hermanos/as	padres	tios/as	Suegros/as	cuñados/as	otros, especifique
0-5								
6-12								
12-18								
18-49								
50 o más								

A qué trabajo le dedica más tiempo?

01 - agricultor

02 - extractor de recursos boscosos

03 - negociante

04 - otro, explique

Quién maneja los ingresos de la familia? 01 - el hombre 02 - la mujer 03 - los dos

Su religión es: 01 - Católica 02 - Evangélica 03 - Ninguna 04 - Otra, especifique

Cuando era niño, su mamá le hablaba en qué idioma?

01 Español

02 Q'eqchi

03 Otro, especifique _____

Y ahora, Ud. habla qué idioma en casa?

01 Español

02 Q'eqchi

03 Otro, especifique _____

Población y Uso de la Tierra en el Parque Nacional de Lacandón
Cuestionario de hogar - Para Jefes de Hogar (Q'eqchi')

La K'ab'á:

K'aleb'aal;

Laa K'ab'á Laat laj Isihom Esil:

Jun Raqal: Li Junkab'al ut li ochoch.

Jarub'chihab' wankaawe? La Sun aatin jarub' ahihab' wankre

Li chihab' xex Sumla wi' Maraj li xelaq'wi' erib')? _____

01 – He' He'

02 – Inka'

¿Jarubi la Kok'al laat naq maji' nakat wan rik'in li tz'aqal? _____

Ani nach'eok relix tuminal lijunkab'al? 01 – li winq 02 – li Ixq 03 – Sa' wiib'al.

La Paab'aal: 01 - Katoolk 02 - Wanjeel 03 - Manjun 04 - juna, chik

Naq toj kac'inot chaq K'achi aat' b'aal nakat' raatinalui?

01 Kaxlan chi'

02 Q'eqchi

03 Otro,

especifique _____

ut najwak?

01 laa'at K'aru

02 la waatina'b'aal

03 nakat aatinak Sá la

wochoch _____

Ma xat hulak ? Sá Rochóchil li tzolok

Toj K'a chi Raqalil xa tzolok? _____

Ma nakat yaab'asinkru hu ut Manakat Tz'iib'ak? 01 – He' He' 02 – Inka'

Ma tawaj naq eb'la Kok'al te' tzoloq? 01 – He' He' 02 – Inka'

[Wi' tsume hehe' “| toj k'a chi Raqalil? a) toj b'ar truuq b'

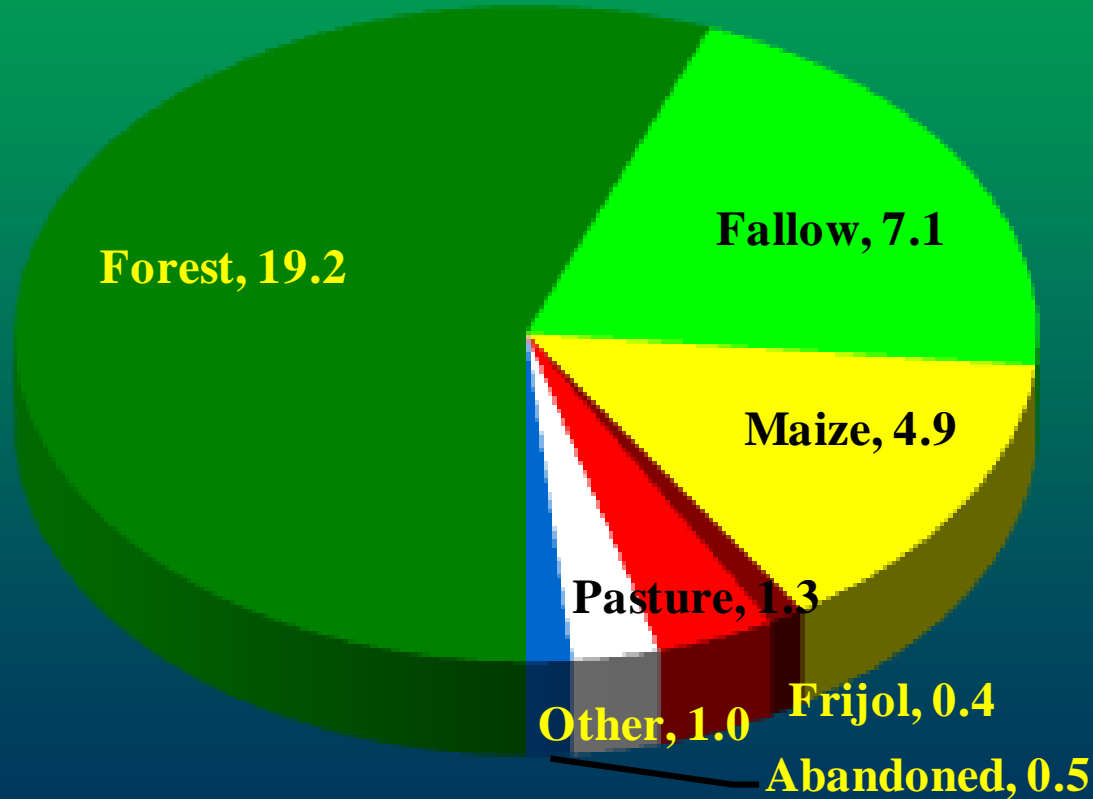
bar nuchal la si' ? 01 sa'li kioche Sa' lin K'anjelab'aal 02 sá lin parseel 03 sálin alk'al Reliwochoch' 04 Sá K'iche?)

Two-Level Multivariate Regression

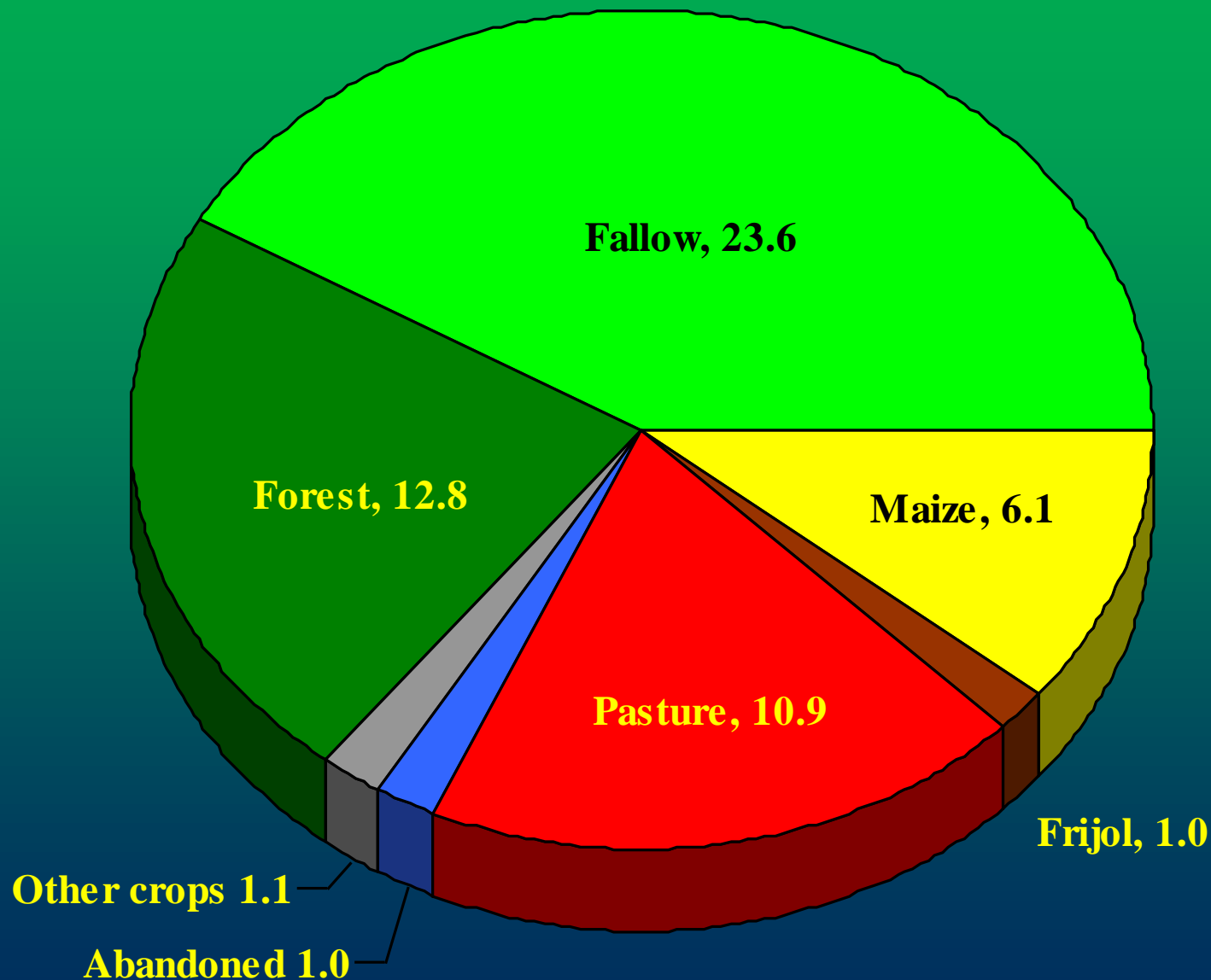
<u>Predictors</u>	<u>Cleared Land</u>	
	Expected	Estimated
1. Demographics factors		
Household size	+	0.3
2. Political-economic factors		
No land title	?	-7.4
Cooperative	-	-11.3
3. Socioeconomic Factors		
<i>Household socio-economic characteristics</i>		
Maya vs. Ladino	?	3.4
Educational level of HH Head	-	0.1
Off-farm labor	-	-3.0
<i>Farm and Farming Characteristics</i>		
Size of total holdings	+	0.3
Distance to road	-	-0.5
Duration on the Farm	+	0.2
Additional agricultural fields	+	4.5
Velvet Bean and/or herbicides	-	1.4
3. Ecological Factors		
Fertile Soil	?	1.2
4. Community-Level Factors		
Community Population	+	2.9
P values:	< or = .01	< or = .10

Land Use Change 1998-2009

1998: Average Land Use in Hectares.
Farm Size = 34 ha.



2008: Average Land Use in Hectares
Farm Size = 49 ha.



Land use intensity: Agricultural inputs

	Use of Agricultural Inputs*	
	1998	2009
Purchased fertilizers	7%	20%
Pesticides	2%	31%
Herbicides	42%	83%
Velvet bean (green manure)	37%	10%

*significant at $p < 0.01$

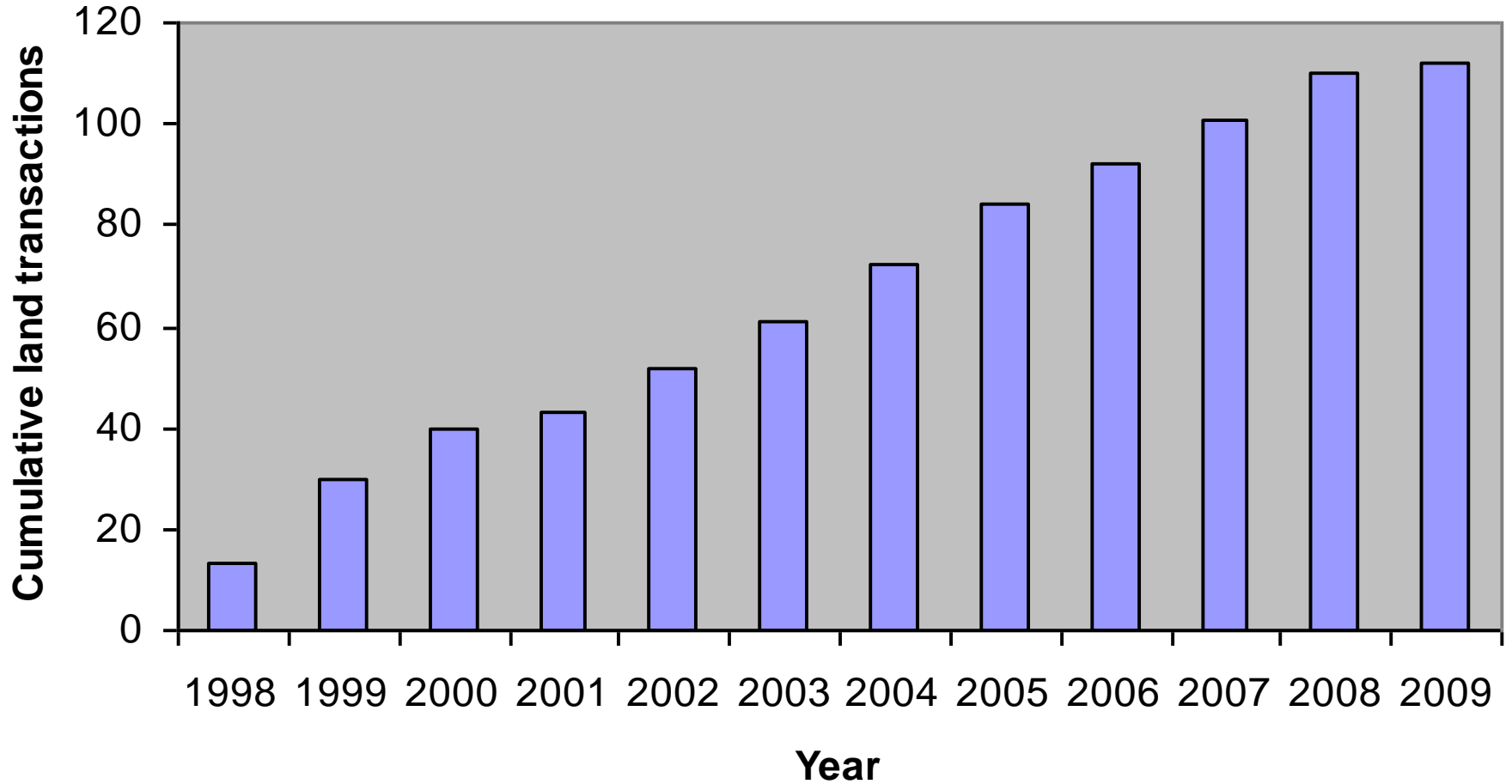
Succession of land parcels

	Of the 244 interviewees from 1998		Of the total number of 1998 land "owners"		
Community	Not land owners^	Land "owners"	% who sold none	% who sold some	% who sold everything
Retalteco	45%	55%	39%	28%	33%
Poza Azul	13%	88%	43%	0%	57%
La Lucha	9%	91%	60%	0%	40%
Lagunitas	18%	82%	56%	7%	37%
Nueva Jerusalén II	8%	92%	61%	0%	39%
Kilómetro 107	21%	79%	48%	3%	48%
Kilómetro 75	24%	76%	25%	31%	44%
Manantial	48%	52%	29%	0%	71%
Grand Total %	24%	76%	48%	7%	45%
Grand total #	58	186	89	13	84

^ Includes amendments made to 1998 data when collecting data in 2009

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Cumulative land transactions: 1998-2009



Motives for land transactions

	Buy land elsewhere	Leave location / relocated	Medical needs	Inherit / end of life	Finance trip to USA	Invest else- where	Pay debt	Conflict over land	Other	Un- known	Total
Total	14	19	27	14	6	4	6	8	8	7	113
% Total	12%	17%	24%	12%	5%	4%	5%	7%	7%	6%	100%

Demographic Factors: People came from elsewhere

- 10% Annual Growth mid 1990s

- Larger Communities → More Agricultural Expansion.

- 8 Births per Woman

- Larger Households → More Agricultural Expansion.



LUCC
Drivers



Ecological Factors: Spacious Space

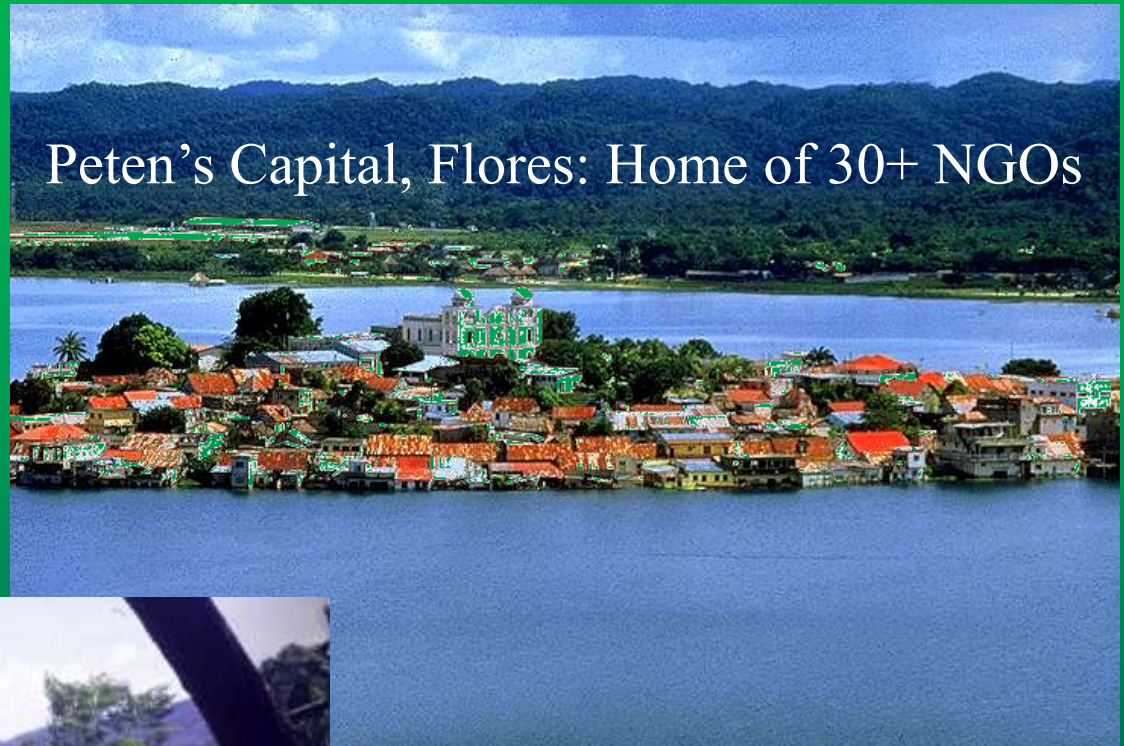


- Forest abundance = Expansive swidden and avoidance of farming steep slopes



Political-economic Factors:

Proximity = More Contact



Peten's Capital, Flores: Home of 30+ NGOs



Squatter Settlement in the SLNP

- Land Title →
More Ag. Expansion.

Place and Space: Maya & Maize vs. Ladino & Cattle



- 25% Maya

- Maya Farmers → More Extensive Farming. But...



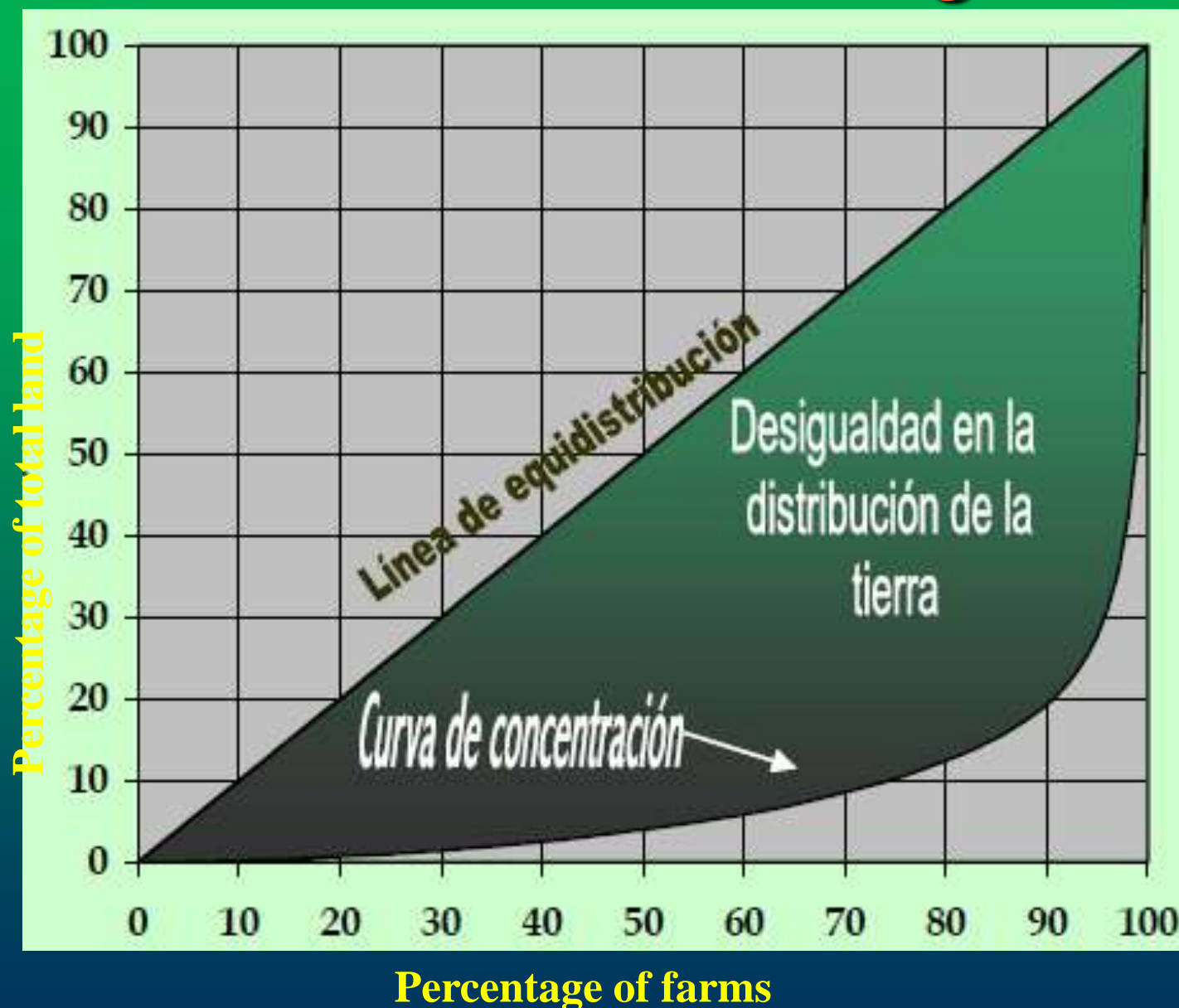
Population, Space, and Place Question 2

Where did the SLNP colonists come from and why from there?

- Processes in distant places - skewed land distribution, demographic Pressures, poverty, war - lead to LUCC in another place

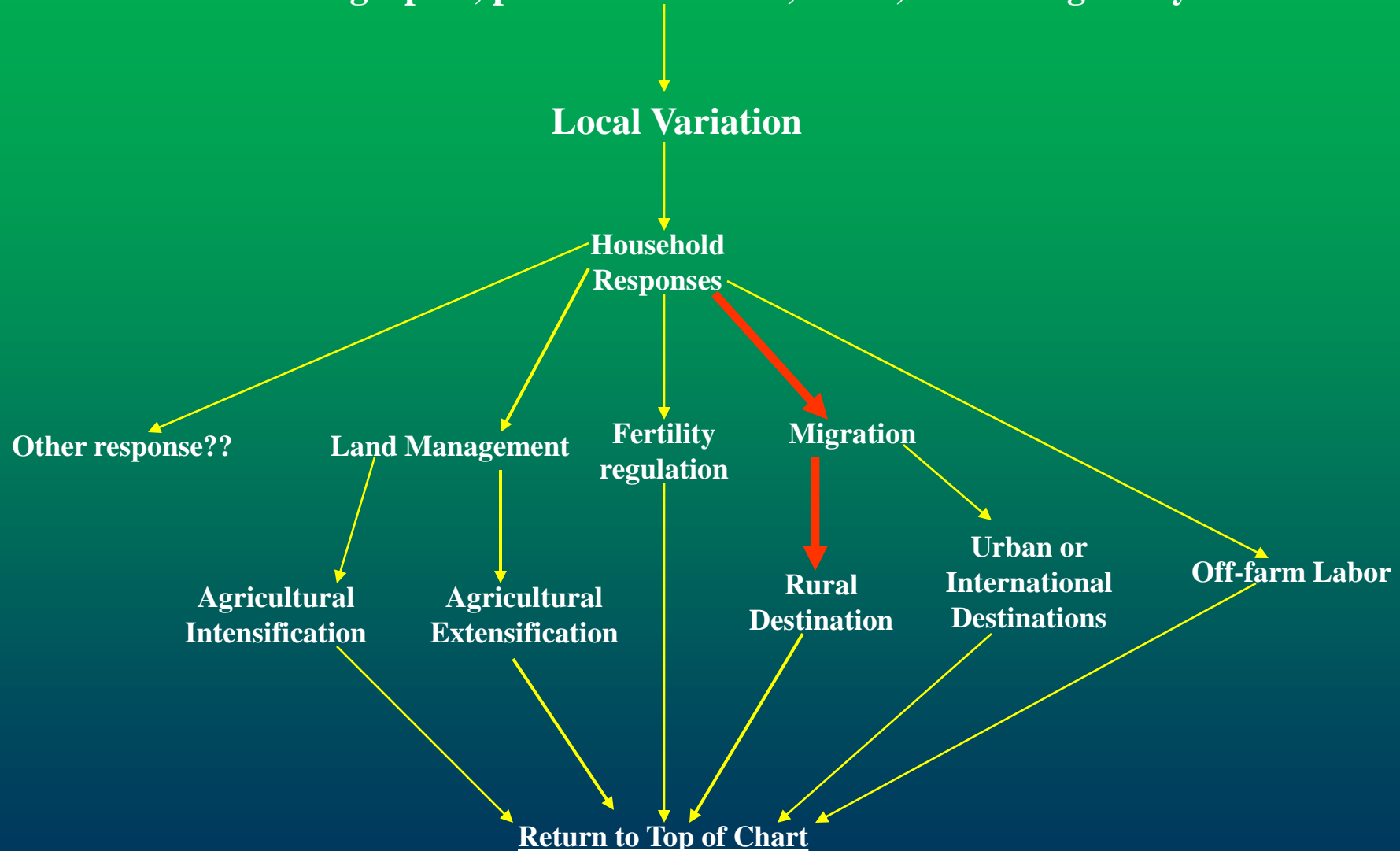


Concentration of landholdings: 2003



Population, Space, and Place 2: Migration to the SLNP

Macro-Scale demographic, political-economic, social, and ecological dynamics



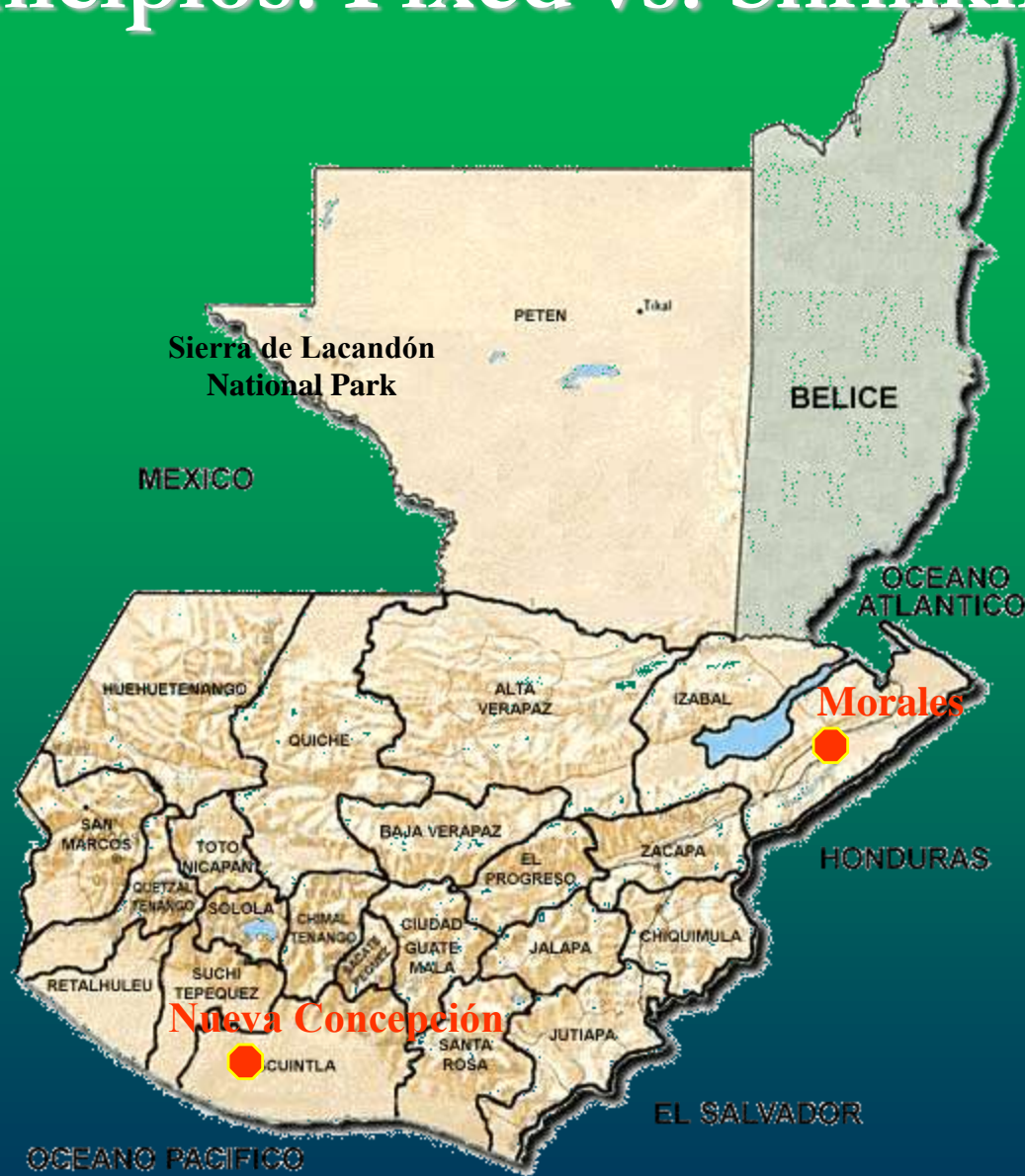
Departamentos of Guatemala and Migration Origin Municipios



Origin Areas Migration Data

Percent of adults permanently out-migrating from 1989 to 1999		Approximate %
Men		10%
Women		10%
Principal Destinations		Primary employment
Guatemala City	Factory or service worker	35%
Peten	Acquire land for farming	35%
USA	Factory, service, or agricultural worker	10%
Other	Plantation laborer	10%
Principal pushes/pulls		
Work		35%
Land		30%
Improve living standard/education		20%
Natural disasters/Env. Degradation		10%

Two Municipios: Fixed vs. Shrinking Space



Two reasons why place matters



Southeastern Coastal Plains: Morales



Pacific Coast: Nueva Concepción

Sunset or Sunrise over the MBR and Latin America's Forests?



A donde vamos?



El fin





Park limits







Predictive model of land sales

- **Logistic regression**
 - Logit link
- **Binary response of a land transaction vs. none**
- **Any or all land**
- **To non-offspring only**
- **Function of variables previously discussed**
- **$N = 186$**

Model results

Did a 1998 household “sell” all or part of their land?

Data from 1998 survey period	β	Standard error
Cattle yes/no*	-0.752	0.456
Off farm work yes/no**	0.484	0.319
Amount of land in 1998	-0.004	0.005
Years residence as of 1998	0.014	0.028
Agricultural inputs yes/no	-0.181	0.365
Credit yes/no	0.008	0.649
Household size	0.03	0.053
Age of household head	-0.01	0.013
Ethnicity non-Q'eqchi Mayan (compared to Ladino)*	-1.019	0.57
Ethnicity Q'eqchi Mayan	0.284	0.465
* $p < 0.05$		
** $p < 0.06$		

Assumption of independence violated

Community	No sale to non-offspring				Sale to non-offspring				Grand Total
	Ladino	Q'eqchi Mayan	Non-Q'eqchi Mayan	Total	Ladino	Q'eqchi Mayan	Non-Q'eqchi Mayan	Total	
Retalteco	5		2	7	9		2	11	18
Poza Azul	2	7		9	4	8		12	21
La Lucha	12		2	14	3	3		6	20
Lagunitas	12	2	2	16	10	1		11	27
Nueva Jerusalén II	13	1	6	20	10	3		13	33
Kilómetro 107	16		2	18	15		1	16	34
Kilómetro 75	1	1	2	4	9	1	2	12	16
Manantial	7			7	10			10	17
Grand Total	68	11	16	95	70	16	5	91	186

Multiphasic Theory revisited

- **Four responses**
 - ✓ **Tenorial – distribution of land**
 - **Extensification – out-migration**
 - **New technologies of land use – intensification**
 - **Demographic – fertility reduction**

Future work: Multiphasic additions

Out-Migration

Number of adult out-migrants from parental households

	Males	Females	Total
% HH w/ out-migrants	--	--	58%
Average	1.1	1.0	2.2
Standard deviation	1.6	1.4	2.6
Max	9	6	12

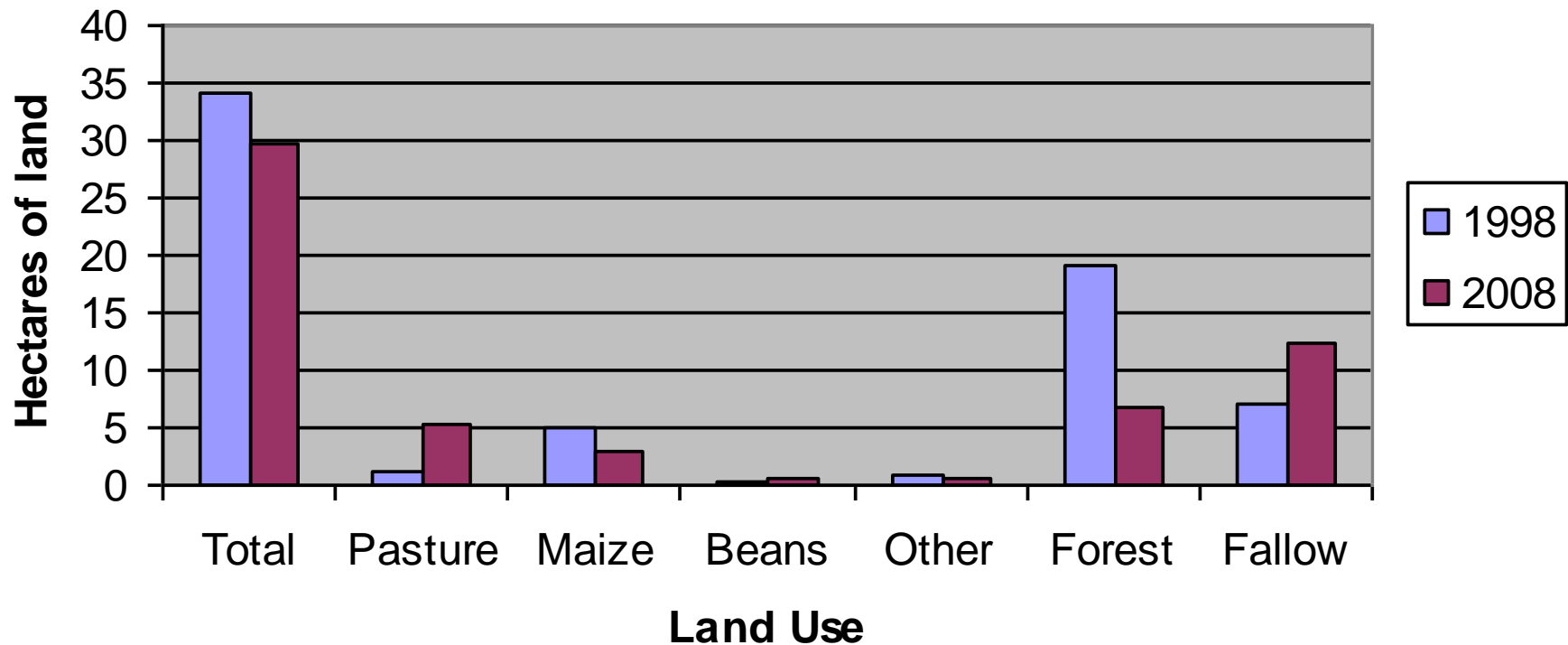
N = 224

Destinations for adult out-migrants

	Same town	Nearby Frontier	Santa Elena or near	Other Peten	Other Guatemala	Guatemala City	USA	Other foreign	Unknown	Total
Male	39%	9%	6%	7%	4%	4%	24%	4%	3%	245
Female	41%	12%	9%	13%	9%	4%	8%	3%	2%	236
M & F #	191	51	35	47	32	19	78	17	11	481
Total	40%	11%	7%	10%	7%	4%	16%	4%	2%	100%

Changes in land use intensity

Land use 1998 & 2008



Land transactions

Community	Sum of households who sold all or a portion of their parcel	Total number of land transactions	Number of transactions which result in splitting original parcel	Avg # recipients per land transaction (std dev)^
Retalteco	11	13	7	1.9 (2.7)
Poza Azul	12	14	2	1.5 (1)
La Lucha	8	13	5	1.6 (0.9)
Lagunitas	12	15	5	1.3 (0.5)
Nueva Jerusalén II	13	14	1	1.1 (0.5)
Kilómetro 107	17	17	1	1.3 (0.5)
Kilómetro 75	12	15	8	1.3 (0.9)
Manantial	12	12	0	1.1 (0.3)
Grand total #	97	113	29	1.4 (1.1)