FOREST CONSERVATION AND LEAKAGE: EVIDENCE FROM MEXICO'S NATIONAL PAYMENTS FOR WATERSHED SERVICES PROGRAM

*A presentation by **Dr. Jennifer Alix-Garcia**,*

*University of Wisconsin-Madison's Land Tenure Center**

Incentive-based programs to reduce deforestation are playing an increasingly important role in global efforts to protect ecosystems and sequester carbon, but their environmental effectiveness is not well established. This seminar investigates program effectiveness and leakage in the context of Mexico's national payments for hydrological services program. The work develops a theory identifying specific leakage mechanisms and presents empirical results of direct and indirect program impacts.

To measure direct program impacts, the study uses matched controls drawn from the program applicant pool to establish counterfactual deforestation rates in the absence of payments. The seminar will focus on presenting the results from this analysis and discussing the development of monitoring and evaluation for REDD projects in general.

* USAID's Biodiversity & Forestry Seminar Series is partnering with the **TRANSLINKS** program and its partners to bring you cutting-edge speakers (www.translinks.org, http://www.rmportal.net/library/content/translinks/).

September 9, 2011; 12:00–1:30 pm

USAID/EGAT Bridge (3.8.77)
Ronald Reagan Building

USAID
FROM THE AMERICAN PEOPLE

Jennifer Alix-Garcia
Forest Conservation and Leakage in Mexico's PWS system
September 9, 2011

Name	Organization/Office	Email
Mike Colby	EGAT/NRM/LRMT	mcolby@usaid.gov
Scott Lampman	EGAT/NRM	slampman@usaid.gov
Rebecca Butterfield	EGAT/NRM	rbutterfield@usaid.gov
Jeremy Boley	EGAT/NRM	jboley@usaid.gov
Bronwyn Llewellyn	EGAT/NRM	brllewellyn@usaid.gov
Moffatt Ngugi	BFS	mngugi@usaid.gov
Erik Streed	EGAT/NRM	estreed "
Terhi Majanen	EGAT/NRM	tmajanen@usaid.gov
Diane Russell	EGAT/NRM	dirussell@usaid.gov
Ann Koontz	EWV - RI	ann.koontz@ri.org
Jessica Pomerantz	EWV - RI	jessica.pomerantz@ri.org
Gina Krump	EGAT/NRM	gkrump@usaid.gov
Mike McGahuey	EGAT/NRM	mmcgahuey@AFR-SD.ORG
John Lewis @TerraGlobalCapital.com →		
Lucy Edgerton	Terra Global Capital	lucy.edgerton@terraglobalcapital.com
Raquel Orejas	Terra Global Capital	raquel.orejas@gmail.com
Gabriel Thoumi	FCMC	gabriel.thoumi@fcmcglobal.org

Forest Conservation and Slippage: Evidence from Mexico's National Payments for Ecosystem Services Program

Jennifer M. Alix-Garcia

Agricultural and Applied Economics, University of Wisconsin, Madison

Elizabeth N. Shapiro

Nicholas School of Environment, Duke University

Katharine R.E. Sims

Economics, Amherst College

Land Tenure Center

USAID FROM THE AMERICAN PEOPLE

September, 2011

Motivation

- Changes in land use: 15-20% of global GHG emissions

- Many countries experimenting with PES to achieve reductions in deforestation under REDD agreements
  - Mexico, Costa Rica, China, Ecuador, Vietnam, Brazil. . .

- PES = Payments for Ecosystem Services
  - Advantages: voluntary, incentive-based policy tool

Environmental Effectiveness?

- Does PES really reduce deforestation? Concerns:

  1) Additionality: Participating landowners might have conserved even in the absence of payments

  2) Slippage: Effectiveness could be undermined by new deforestation in other areas

- Here: evaluate effectiveness of Mexico's PSAH 2004 cohort; examine theoretical reasons and empirical evidence for slippage

Paper preview: Mexico's PSA-H

1. **Evaluate avoided deforestation impacts**

   → Significant but small avoided deforestation

2. **Develop theoretical framework for slippage in an imperfect markets setting**

   → Illustrate two potential channels for slippage:

   "substitution" (within-property)

   "output price effects" (between-property)

3. **Test empirically for slippage**

   → Evidence is consistent with both channels

Larger research context

- What can we learn from Mexico's PSA-H?
  - Funding from 3ie (International Initiative for Impact Evaluation) and NSF Econ
  - Environmental and socioeconomic impacts
  - Spillover channels and implications for design
- Data collection:
  - National-level program data (2004-2009)
  - Household survey of selected 2008 recipients/controls
  - Coarse deforestation (MODIS) at national level
  - Detailed deforestation (Landsat time-stacks): 14-20 footprints

1. Evaluating avoided deforestation

2004 PSAH Cohort

Previous research on PES impacts

- **Theoretical basis for avoided deforestation PES:**
  - Angelsen 2007, Alix-Garcia et al. 2008, Pagiola and Zhang 2010
- **Empirical evidence on PES effectiveness limited:**
  - See review by Pattanayak, Wunder and Ferraro *REEP* 2010
  - Costa Rica: Little or no impacts found
    - Arriagada et al. 2010, Sillis et al. 2007, 2008, Pfaff et al. 2008, Robalino et al. 2007
  - Mexico: Lack of clear counterfactuals
    - Muñoz-Piña et al. 2008, Alix-Garcia et al. 2005, 2008, Corbera and Brown 2008
    - Except: ongoing work by Honey-Roses et al.
  - China SLCP, U.S. CRP: not avoided deforestation

Mexico's PSA-H – program

- **Payments for Hydrological Services**
  - Began in 2003
  - Goal: prevent deforestation in order to improve hydrological services
  - 5 year contracts: yearly payments contingent on maintaining forest cover
  - Random monitoring both by satellite and field visits
- **Largest PES for avoided deforestation in the world**

Mexico's PSA-H – context

- Large remaining forest area, high biodiversity
  - 71% of country forested (2000)
- But high deforestation:
  - 1990-2000:
    - 348,000 ha/yr
    - 5.2% over 10 year period
    - 0.5% per year
  - 2000-2005:
    - 260,000 ha/yr
    - 2.0% over 5 years
    - 0.4% per year

Mexico's PSA-H: context

- Program enrolls forest under two tenure types:
  - Private property
  - Common property: Ejidos and comunidades
    - Ejidos contain common and formally parceled areas
    - Comunidades indigenas usually all commons, but often with de facto parcelization
    - No formal land sales

PSAH 2004 statistics

- Total hectares enrolled: 182,424
- Average area enrolled (ha): 518

- Per-ha annual payment: ~ $36 cloud forest; $27 other forest
- Average total payment: $13,000; median payment: $5,000
  - Private properties: average $4,900, median $2,900
  - Common properties: average $17,000, median $6,000

Data

- Deforestation indicator: 2003-2006
  - Deforestation indicator = decrease in NDVI index
  - Based on MODIS satellite data (250 m resolution)
  - National coverage from CONAFOR, calibrated by them using field data from National Forest Inventory
  - Use tobit to account for censoring
- Shapefiles for enrolled and control parcels
- Multiple GIS layers to construct covariates
- Municipal poverty and population density measures

Evaluation strategy: 2004 cohort

Part I:

- Draw controls from applicant pool
  - Rejected properties (2004), future enrollees (2006)
  - Advantage: ensures controls are similar with respect to a key unobservable: desire to enroll in the program
- Match enrolled parcels to controls
  - Covariates include: parcel area, slope and elevation, vegetation type (% semi-deciduous, % selva), region, access to market (density of roads in a 50 km buffer), type of property (communal/private)
  - Matching metrics: Mahalonobis and inverse sample SEs

Evaluation strategy: 2004 cohort

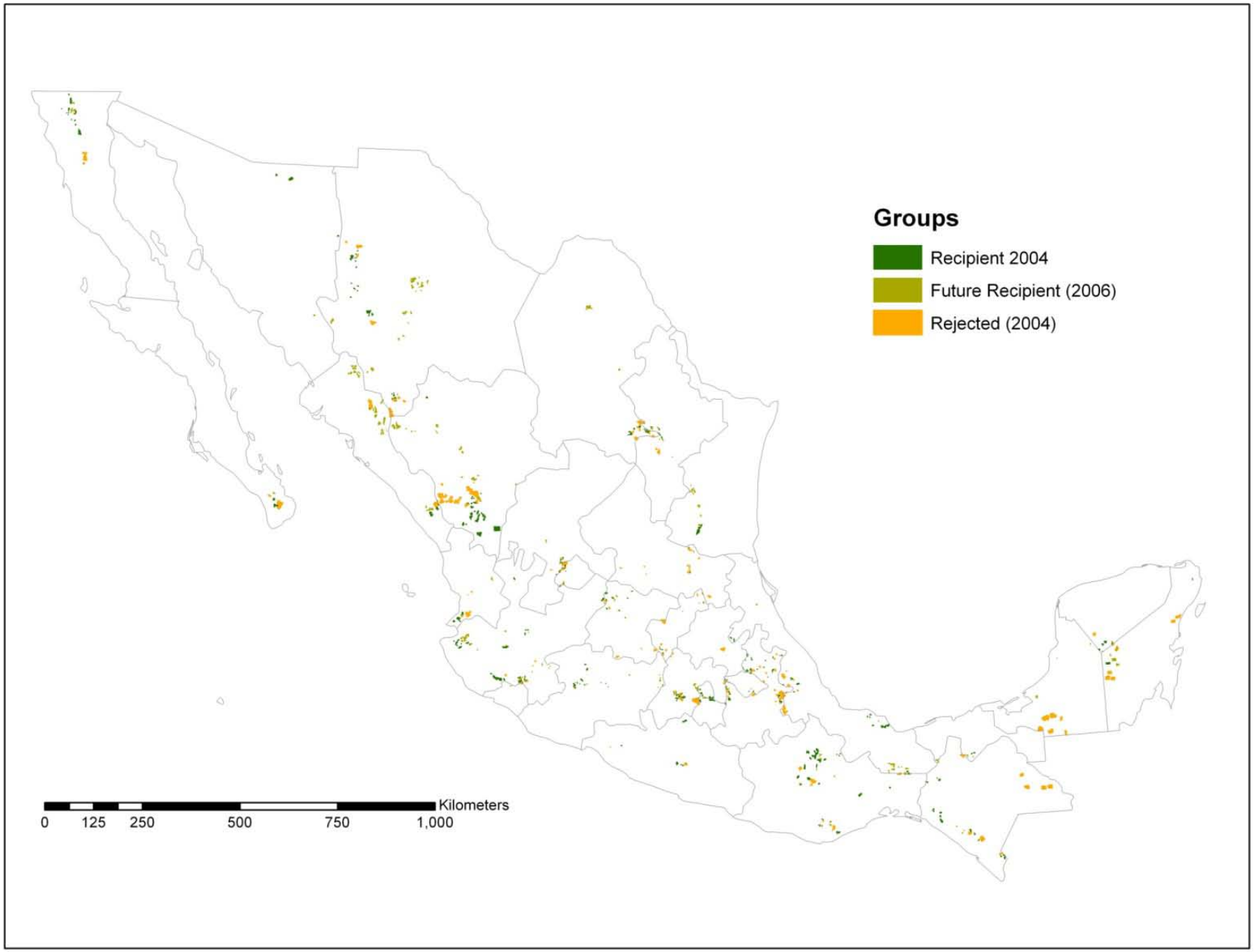
Part II:

- Adjust for remaining observable differences
  - Bias-adjusted matching estimator (Abadie and Imbens 2002)
  - Regression

$$\ln(1 + d_i) = \propto + \tau W_i + \beta' X + u_i,$$

  - d_i = area deforested; W_i = 1 if recipient; X = covariates

- Not perfect: could be unobservable differences
  - E.g. institutional capacity, anticipatory behavior


Groups
Recipient 2004
Future Recipient (2006)
Rejected (2004)
0
125
250
500
750
1,000
Kilometers

Data – summary statistics

Variable	Recipients	Non-Recipients	Test for difference	Standardized difference
Enrolled area (km2)	7.04	9.35	2.26	-0.01
Proportion ejidos	0.67	0.58	2.69	Na
Average slope of enrolled area	2.44	2.33	2.12	0.11
Average elevation of enrolled area	2.09	1.87	3.40	0.14
Proportion enrolled area semi-decid	0.20	0.32	4.03	-0.36
Proportion enrolled area selva	0.33	0.26	2.39	0.21
Ln(road density)	6.64	6.48	3.36	0.18
Municipal population density	136	78	1.92	0.0001
Municipal marginality index	-.14	-.26	1.79	0.07
Proportion in region 2	0.15	0.22	2.35	Na
Proportion in region 3	0.37	0.25	3.45	Na
Proportion in region 4	0.27	0.21	2.15	Na
Proportion with deforestation	0.22	0.23	0.17	Na
Percent deforested 03-06	1.41	2.36	1.99	-0.01
Percent deforested 00-03	0.04	0.04	0.11	-0.01
Observations	352	462		

Recipients are from the 2004 PSAH cohort. Non-recipients are rejected applicants from 2004 or future recipients of the program (2006).

Variable	Recipients	Non-Recipients	Test for difference
Region 1: Baja California, Chihuahua, Coahuila, Durango, Sinaloa, Sonora			
Enrolled area (km2)	12.4	8.75	1.16
Proportion ejidos	0.50	0.46	0.46
Average slope of enrolled area	2.53	2.50	0.28
Average elevation of enrolled area	2.36	2.31	0.72
Proportion enrolled area semi-decid	0.15	0.14	0.14
Proportion enrolled area selva	0.34	0.25	1.30
Ln(road density)	6.11	5.99	1.71
Municipal population density	16.0	18.8	0.77
Municipal marginality index	-0.41	-.060	1.01
Observations	74	65	
Region 2: Aguascalientes, Guanajuato, Hidalgo, Nayarit, N. Leon, Queretaro, SL Potosi, Tamaulipas, Zacatecas			
Enrolled area (km2)	4.97	3.08	1.91
Proportion ejidos	0.46	0.44	0.21
Average slope of enrolled area	2.40	2.43	0.31
Average elevation of enrolled area	2.06	2.16	0.67
Proportion enrolled area semi-decid	0.69	0.68	0.13
Proportion enrolled area selva	0.18	0.17	0.16
Ln(road density)	6.65	6.70	0.91
Municipal population density	48.8	52.0	0.17
Municipal marginality index	-0.57	-0.53	0.35
Observations	54	52	
Region 3: Colima, DF, Jalisco, Michoacan, Morelos, Mexico, Puebla, Tlaxcala			
Enrolled area (km2)	4.46	2.68	2.49
Proportion ejidos	.75	.75	0.11
Average slope of enrolled area	2.40	2.41	0.24
Average elevation of enrolled area	2.44	2.60	2.01
Proportion enrolled area semi-decid	0.10	0.08	0.57
Proportion enrolled area selva	0.31	0.29	0.43
Ln(road density)	7.09	7.20	1.55
Municipal population density	265	137	1.41
Municipal marginality index	-0.28	-0.28	0.02
Observations	129	114	
Region 4: Campecha, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, Yucatan			
Enrolled area (km2)	7.50	6.05	1.31
Proportion ejidos	0.81	0.82	0.22
Average slope of enrolled area	2.45	2.68	1.99
Average elevation of enrolled area	1.41	1.48	0.45
Proportion enrolled area semi-decid	0.12	0.95	0.53
Proportion enrolled area selva	0.45	0.51	0.86
Ln(road density)	6.52	6.54	0.21
Municipal population density	157	60	1.71
Municipal marginality index	0.52	0.58	0.50
Observations	95	85	

Recipients are from the 2004 PSAH cohort. Non-recipients are rejected applicants from 2004 or future recipients of the program (2006).

Estimates of program impact: ATT

- Small-moderate magnitude
  - 11-17 percentage point reduction in the probability of deforestation
  - ~25% of controls have some deforestation
  - **44-68 percent reduction in the probability of deforestation**
  - **12 percent decrease in the area deforested among deforesters**
- Larger effects for properties in wealthier municipalities and in regions 2 & 4

Bias-adjusted matching estimator

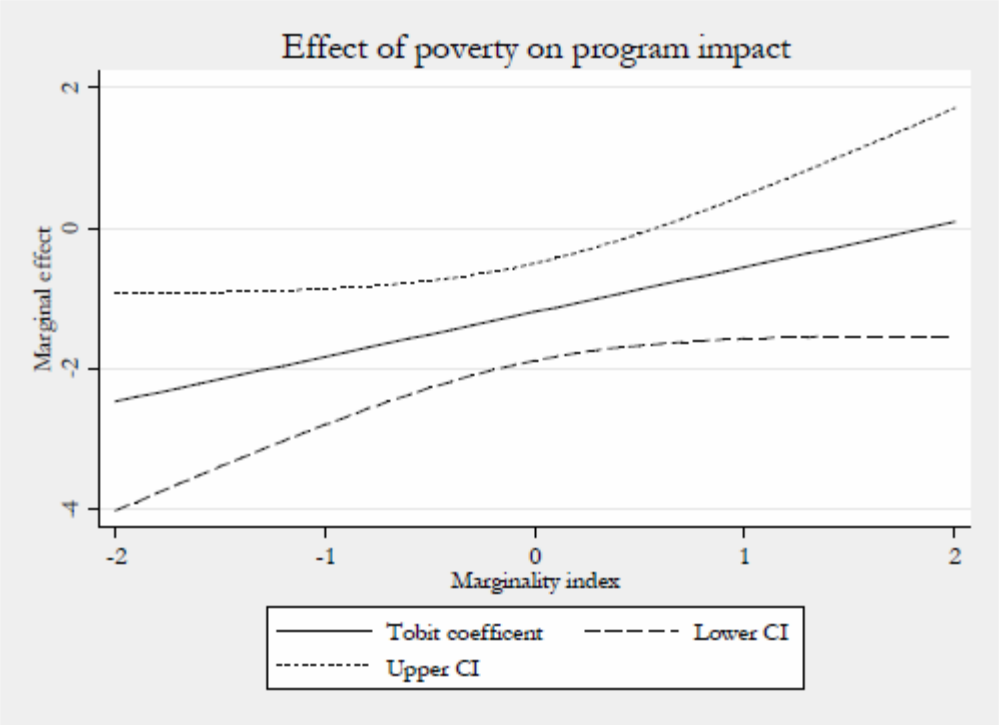
b. Best 90% matches

	Mahalonobis metric			Inverse sample standard errors		
Dependent variable	% deforested	Deforest (0/1)	% deforested| Deforest > 0	% deforested	Deforest (0/1)	% deforested| Deforest > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment effect	-1.23***	-0.17***	-9.75*	-0.88*	-0.11***	-8.54*
	(0.43)	(0.04)	(5.80)	(0.52)	(0.03)	(4.99)
Observations	668	668	174	668	668	174

Post-matching regression (tobit)

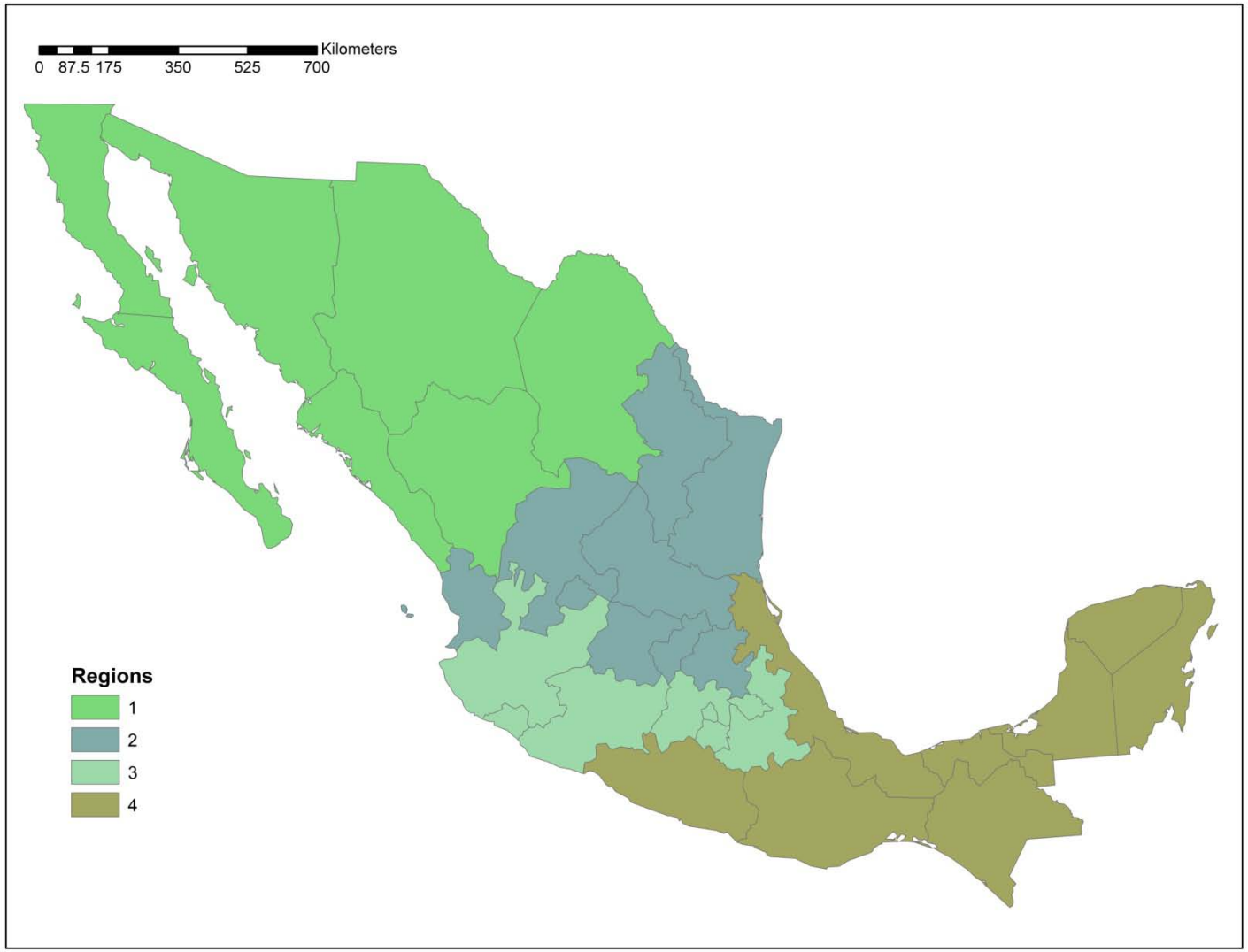
	(1)	(2)	(3)	(4)	(5)
Marginal effects on Pr(d>0)					
Recipient	-0.10***	-0.04	0.01	-0.21	-0.11***
	(0.03)	(0.07)	(0.07)	(0.32)	(0.30)
Recipient x region 2		-0.11			
		(0.07)			
Recipient x region 4		-0.11			
		(0.06)			
Recipient x ejido			-0.13**		
			(0.07)		
Recipient x ln(rd density)				0.01	
				(0.05)	
Recipient x municipal poverty index					0.06**
					(0.03)
Marginal effects on % d|d>0					
Recipient	-1.10***	-0.37	0.07	-2.27	-1.13***
	(0.32)	(0.75)	(0.72)	(3.55)	(0.33)
Recipient x region 2		-1.23			
		(0.85)			
Recipient x region 4		-1.24*			
		(0.78)			
Recipient x ejido			-1.37*		
			(0.74)		
Recipient x ln(rd density)				0.16	
				(0.50)	
Recipient x municipal poverty index					0.60*
					(0.34)

Larger effects in wealthier municipalities



- Possibly: more outside options or higher deforestation pressures

Regions



2. Slippage

The beginning of a theoretical framework

Slippage: land-use context

- Wu (2000) CRP; two "slippage" channels:
  - Substitution effect: move production from enrolled to unenrolled land – within property effect
  - Output price effect: general equilibrium
- Roberts and Bucholtz (2005)
  - Substitution effects unlikely to occur if factor markets working well
  - Price effects unlikely to be observable because output markets well-connected
- **Mexico is likely to have imperfect markets**

Spillovers: a simple household approach

- Households allocate land to forest (*f*) or agriculture (*a*); land area fixed at *T*

$$T = a + f$$

- Ag production requires a variable input (*n*); DRTS

$$y^a = a^\alpha n^\varphi$$

$$p^n n \leq K + B$$

- Forest production only depends on land

$$y^f = \beta f$$

- Some households are credit constrained, all must pay r for credit

$$B \leq p^l T$$

Maximization

- Households maximize income (and thereby consumption) by choosing *a, f, n, B* subject to borrowing and working capital constraints.

- Three regimes:
  - Non-borrowing
  - Unconstrained borrowing
  - Constrained borrowing

Introducing PES

- Producers can now allocate an amount of land S to the program, for which they earn unit payments p^s
- Assume program price exceeds or is equal to MVP in forest, so households wish to enroll land
- Effects vary by regime

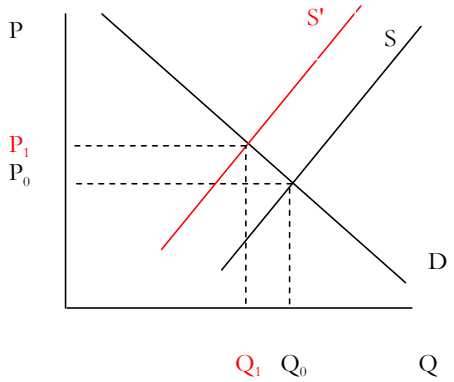
- **Substitution slippage observable where households are credit constrained**

3 regimes under PES payments

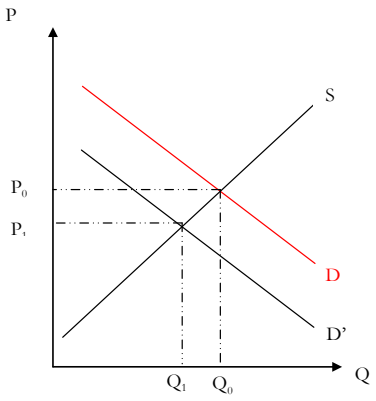
- **Non-borrowing**: more land put in forest if program price high
- **Unconstrained borrowing**: require lower payments to enroll land in program; land in ag decreases, except for marginal hh
- **Constrained**: countervailing effects: increases returns to forest, but relaxes borrowing constraint

Price spillovers (across properties)

- Supply side: removal of multiple parcels from agricultural production increases market prices of agricultural goods; also potential increase in price of forest goods



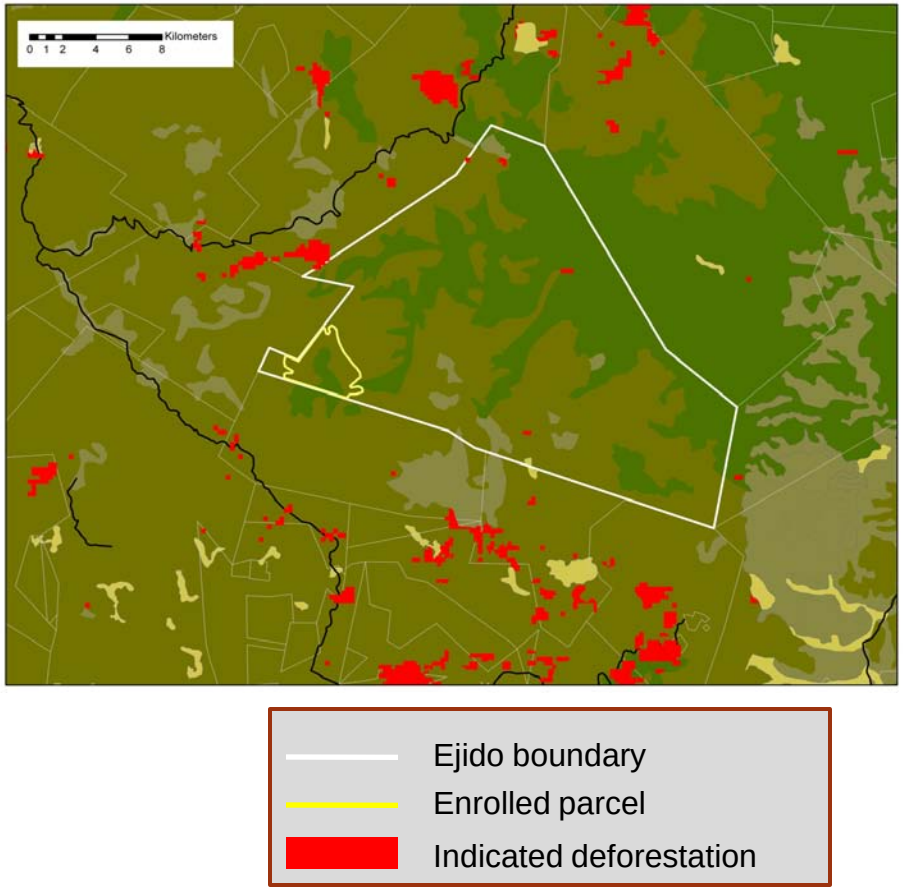
- Demand sid $A = N_0 a^{nb} + N_1 a^{ub} + N_2 a^{cb}$ and consumption, increases market prices of agricultural goods
- **Observable where markets are localized**



3. Slippage: empirical tests

Slippage tests: substitution

- Measure deforestation:
  - Other land in same ejido (non-enrolled areas)
  - Or in 1, 2 and 5 km buffers around enrolled area
- Test: more deforestation in non-enrolled areas of enrolled properties than in matched control properties?
- Previous literature lacks this comparison group approach



Results: substitution

	Within ejidos		Within 1 km buffer		Within 5 km buffer	
	(1)	(2)	(3)	(4)	(5)	(6)
Ejidos						
Recipient	-3.76	-0.07	2.69	-0.98	2.16	-0.22
	(7.95)	(0.78)	(7.59)	(0.82)	(2.69)	(0.29)
Recipient x ln(rd density)	0.529		-0.58		-0.37	
	(1.19)		(1.13)		(0.40)	
Recipient x municipal poverty		2.217*		1.69*		0.37
		(0.90)		(0.84)		(0.30)
Pseudo R-squared	0.025	0.029	0.021	0.023	0.023	0.023
Observations	378	378	503	503	503	503
Private properties						
Recipient			-14.61	-0.93	-1.97	0.22
			(18.82)	(1.42)	(5.93)	(0.41)
Recipient x ln(rd density)			2.02		0.36	
			(2.84)		(0.89)	
Recipient x municipal poverty				0.88		-0.72
				(1.41)		(0.43)
Pseudo R-squared			0.094	0.094	0.115	0.118
Observations			220	220	220	220

- Substitution effects within poorer ejidos
- No substitution effects for private properties

Substitution magnitudes worrisome

- Magnitudes of spillover effects could undermine program in poor municipalities
- Effect potentially reinforcing in wealthier municipalities, but need to examine non-linearities before concluding.

Slippage tests: output price effects

- Recall that we expect: deforestation due to output price effects where more enrollment in surrounding areas and markets are localized
  - Proxy for enrollment: total enrollment within 50 km
    - Continuous and threshold measures
  - Proxy for local: low road density

- Test: compare deforestation on un-enrolled properties in high and low enrollment areas

Comparison of high and low program density areas

Variable	Lowest 90% surrounding enrollment	Highest 10% surrounding enrollment	Test for difference
Enrolled area	7.81	12.36	2.86
Proportion ejidos	0.59	0.83	4.42
Ln(Average slope of enrolled area)	2.37	2.47	1.24
Average elevation of enrolled area	1980	1922	.59
Proportion enrolled area semideciduous	0.28	0.21	1.51
Proportion enrolled area selva	0.28	0.43	3.46
Ln(Road density in 50 km radius)	6.55	6.58	0.40
Proportion in region 2	0.21	0.05	3.57
Proportion in region 3	0.31	0.18	2.69
Proportion in region 4	0.20	0.51	6.61
Observations	724	93	

- Caution! suggestive results only
- High and low program density similar on impt covariates
- Ideas?

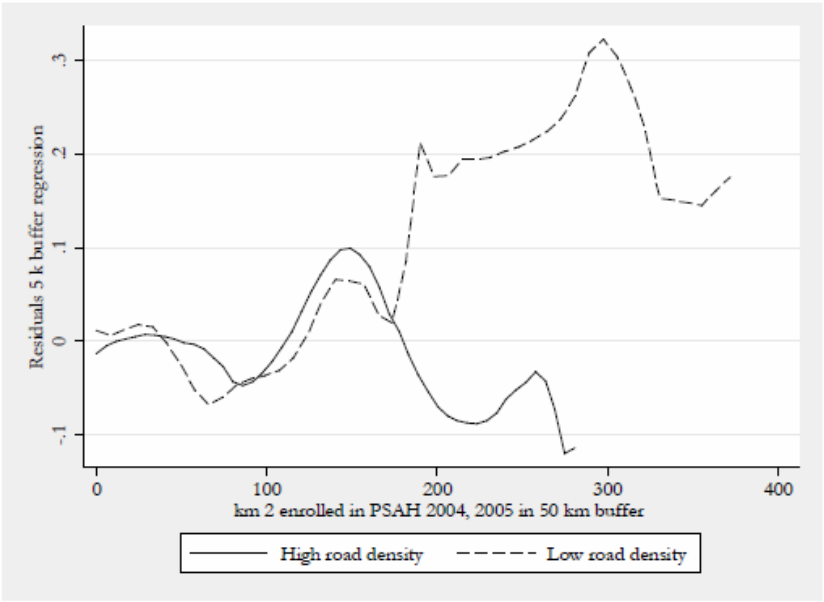
Results: output price effects

	1 km buffer			5 km buffer		
	(1)	(2)	(3)	(4)	(5)	(6)
Km^2 in PSAH program	0.008*			0.017**		
within 50 km buffer†	(0.00)			(0.01)		
Km sq x road density	-0.001*			-0.003**		
	(0.00)			(0.00)		
Top 20% area enrolled		8.388			4.305	
		(7.85)			(2.89)	
Top 20% area enrolled x road density		-1.341			-0.626	
		(1.20)			(0.44)	
Top 10% area enrolled			1.940**			4.315***
			(0.71)			(1.17)
Top 10% x road density			-0.287**			-0.629***
			(0.11)			(0.18)
Pseudo R-squared	0.114	0.117	0.115	0.075	0.076	0.078
Observations	814	814	814	814	814	814

- More deforestation on non-enrolled lands where more surrounding land enrolled and low road density
- Consistent with output-price effects

Price slippage by road density

- Suspected slippage in low road density areas, beyond 180 km2 enrollment
  - Could be through supply or demand-side effects
  - Could be that we can't measure "true" effect where markets are well-connected



Conclusions: Policy

1. PSAH program produced a significant but small avoided deforestation impact
   - Early cohort, little targeting on risk
2. Impacts vary by region and poverty rates
   - Better understanding could improve targeting
3. Evidence consistent with both substitution and price slippage
   - Importance of REDD accounting at the regional or national level, not project-based approach (e.g. Plantinga and Richards 2008)
   - Need to understand how programs affect credit constraints
   - Possible tradeoff between increased income and more slippage
4. Annual national deforestation monitoring systems urgently needed—much to learn from Mexico's system

Open questions: future research

- Are households credit constrained?
- Are markets really local for some forest-competing products?
- Are there potential labor market effects that could drive substitution spillovers?
- How has effectiveness changed with changes in targeting strategies over time?
- Other potential program effects: wealth, environmental knowledge, community governance?
- **Household and community surveys ongoing in Mexico; price data collection to begin October 2011**

Thank yous

- We are grateful to all the people at the Mexican National Forestry Commission (CONAFOR) who have helped us, including but not limited to:

- <u>Gerencia de Servicos Ambientales:</u>
  - Ing. Leonel Iglesias Gutiérrez
  - José Armando Alanís de la Rosa
  - Paola Bauche Petersen
  - Gemelina Ramírez
  - Jesús Gutiérrez Cacique
  - Rodolfo Valdez Garcia
  - Silvia Martinez

- <u>Gerencia de Inventario Forestal y Geomática:</u>
  - Rigoberto Palafox Rivas
  - Carmen Meneses Tovar

- We are thankful for financing from USAID-Translinks, the National Science Foundation, and the International Initiative for Impact Evaluation (3ie)