Agricultural subsidies: cutting into forest conservation

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ONLINE APPENDIX

Online Appendix

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Table of Contents

A Additional program information

A.1 PROGAN: application and renewal processes

The application process is straightforward: producers register at local or state offices of SAGARPA. They enter into the National Livestock Registry the number of livestock and the total number of hectares they have of different types of land (pasture, irrigated agriculture, non-irrigated agriculture, etc.). Once the producer is added to the Registry, a personal identification number is generated. Each time producers want to register for a wave, they need to update their information. The second step is to fill out a form asking for the PROGAN subsidy, provide their personal identification number, and present documents proving their ownership or their right to use the land. These are documents that the majority of Mexican producers have on hand, and do not present a significant barrier to application.

Starting in 2008, verification of the inventory by a local authority was required. Further, since for each wave, producers commit to improving vegetation cover and increasing fodder production within their land, the program's rules state that compliance must have been verified with the authorized technician to be eligible for subsequent payments. If land degradation was observed, then the rules suggest that payments could be canceled. The producers pay for local technicians (possibly inducing situations of conflict of interest). We generally note that there is little guidance regarding the monitoring of these rules. For example, in the rules of PROGAN for 2008, the definition for reforestation is "planting trees and shrubs with the purpose of reconstituting vegetation coverage with species of interest to forestry, forage and to attract pollinators"

A.2 PROCAMPO: examining fodder production as a mechanism

This study uses data from PROCAMPO (a program also managed by SAGARPA) to analyze yearly changes in pasture production. In response to North American Free

Trade Agreement (NAFTA), Mexico's government developed this crop subsidy to protect farmers from changes in prices stemming from international competition. The program targeted farmers that had planted at least one of nine staple crops during the 1991-93 agricultural cycles (corn, beans, rice, wheat, sorghum, barley, soybeans, cotton and/or cardamom). Stating that they had planted one of those staple crops allowed farmers to receive this subsidy for each cultivated hectare. Beginning in 1996, the program subsidized farmers for other types of crops, with the ongoing constraint that it still applies only to land registered when the program opened. To continue receiving the subsidy, farmers needed to continue producing on the same parcel each year. Each year between 1994 and 2015, this program has subsidized around 3 million producers, or approximately 14 million hectares per year. Recipients range from large businesses to small landowners that cultivate for subsistence or sell at a small scale. In 2015, 300 different crops were subsidized, ranging from the initial staple crops to pineapple and pasture. Payments are annual but do not vary by crop type.

A.3 PROGAN and PES: program comparison

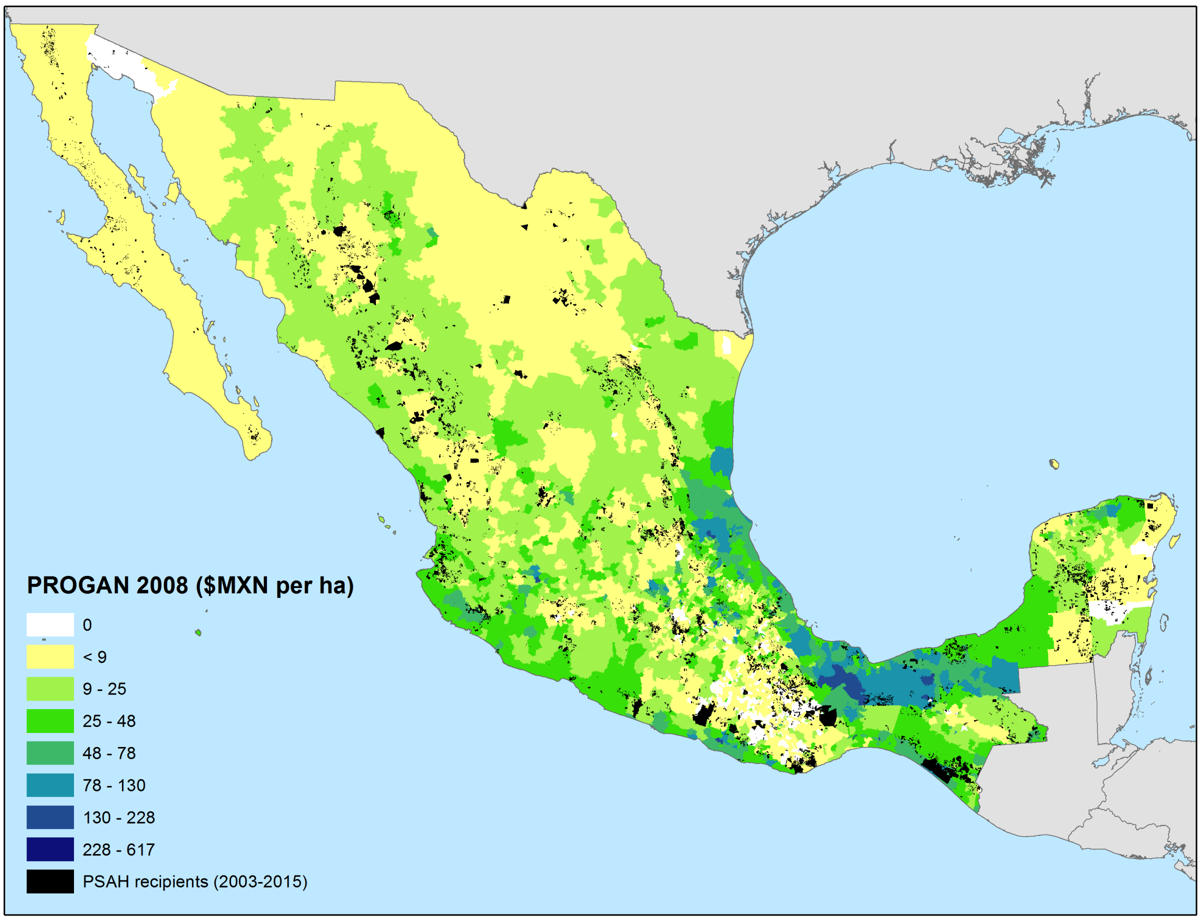


Figure A1: PROGAN real subsidy per hectare in 2008 and accepted PES parcels 2003-2015

Table A1: Program summaries and comparison

	PROGAN (livestock)	PES (forest)
Eligibility	- National - File with the National Livestock Registry - Ownership or land right	- Falls in eligible zone - Highest point scores (starting in 2006) - Ownership or land right - Constraint: no overgrazing - Minimum forest cover: 50-80%
Timing	- 3 waves: 2003-2007, 2008-2013 and 2014-2015 - One payment per year	- 5-year contract if accepted - One payment per year
Minimum	- None	- 50 ha per applicant
Maximum	- Varies based on the pasture coefficient - Ceiling of 300 animal equivalent units per person (wave 1, 2, and 3), or 1000 per business (wave 3 only)	- 2000-6000 ha per applicant
Mexican pesos	- See Figure 1a	- See Table A2
US$	- US$843/year/producer on average (2011)	- Common properties: US$130/year/ person (>1 month of work at minimum wage) - Private property: US$3,050/year/hh (12 % of hh income) (Alix-Garcia, Sims, & Yanez-Pagans, 2015)
Size	- 344,430 producers (2011)	- 3,884,247 ha (2011)

Table A2: PES payment levels per ha, 2003-2015

Modality and ecosystem/risk	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Hydrological												
Cloud forest	471	453	452	452	447	443						
Cloud forest/ very high							1,003	970	932	897	863	840
Cloud forest/ all other							638	617	593	571	549	535
Oak forest				398	394	390						
Other forests	353	340	345	345	342	338						
All other							325	314	302	290	279	272
Biodiversity												
All veg.				346	394	374						
Rainforest							501	483	466	449	431	420
Dry tropical/ very high/high							348	337	324	312	300	292
Arid/semi-arid							255	247	237	228	220	214

Note: Payment levels extracted from program rules of operation provided by CONAFOR and forest types verified through discussion with CONAFOR. Modalities refers to the type of ecosystem service being targeted. Amounts are in 2010 pesos.

B Additional data and descriptive statistics

B.1 Cattle slaughtering quantity and price data

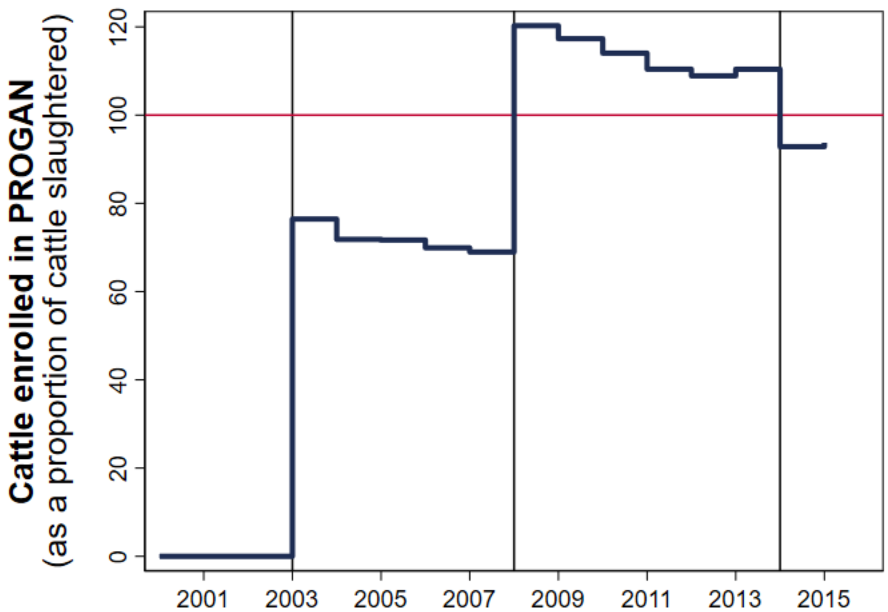


Figure B2: Percent of annual slaughtered cattle head enrolled in PROGAN.

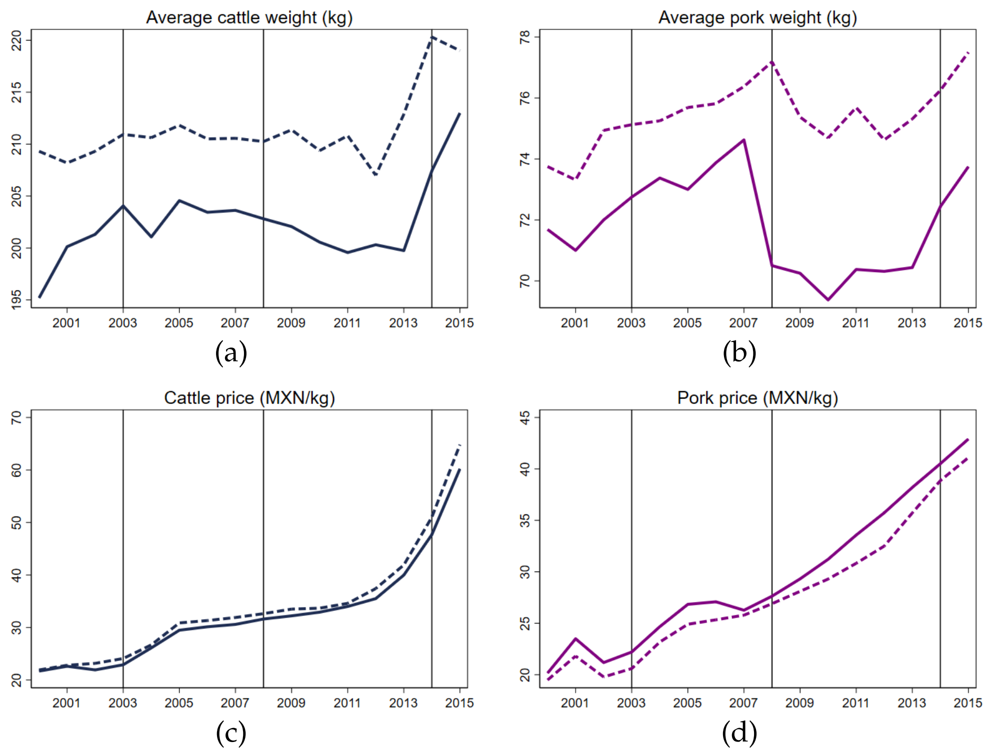


Figure B3: For each figure, the solid line represents the state with above median level of cattle enrolled in PROGAN and the dotted line the states below the median level. Figures on the left represent the cattle market and figures on the right the pork market. Data comes from SAGARPA.

B.2 Maximum sustainable number of livestock

We construct the average maximum sustainable number of livestock per hectare within the municipality using the pasture coefficients (SAGARPA) (i.e. the number of hectares to sustain one animal unit), and the baseline characteristics of the land (INEGI). Specifically, we calculate:

$$\begin{aligned} MaxPROGAN_m = {} & agric\_rainfed_m * \frac{1}{PA_m^{ar}} + agric\_irrigated_m * \frac{1}{PA_m^{ai}} \\ & + nat\_pasture_m * \frac{1}{PA_m^{np}} + livestock\_pasture_m * \frac{1}{PA_m^{lp}} \\ & + other_m * \frac{1}{PA_m^{o}}). \end{aligned}$$

The maximum sustainable number of animals per hectare ($MaxPROGAN_m$) varies by municipality because the pasture coefficients and the characteristics of the land vary per municipality. We use four different type of lands: rainfed agriculture, irrigated agriculture, natural pasture, pasture associated with livestock production and all other uses of land. The geographical distribution of the maximum sustainable number of livestock is illustrated in Figure B4.

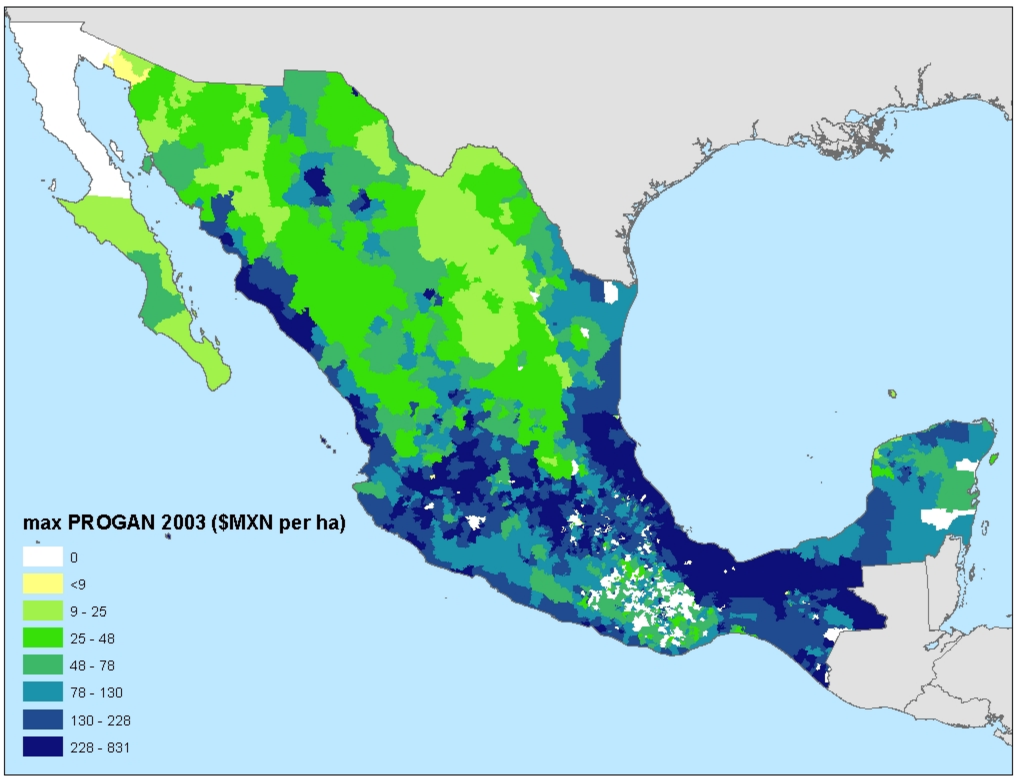


Figure B4: Maximum PROGAN subsidy per hectare. Average calculated according to 2003 subsidy per animal and pasture coefficients for different types of land.

B.3 Deforestation risk

We estimate the following equation with a lasso probit:

$$Defor_i = \beta_1 FC2000_i + \beta_2 DistCity_i + \beta_3 RoadDensity_i + \beta_4 DistUrban_i + \beta_5 M(Elevation)_i + \\ \beta_6 SD(Elevation)_i + \beta_7 M(Slope)_i + \beta_8 SD(Slope)_i + \gamma' Biome_i + \delta' State_i + u_i,$$

where $Defor_i$ is the binary indicator of whether there has ever been a cumulative deforestation of more than 5 hectares in the grid-cell i in 2001 and 2002 (i.e. the pre-program years). Covariates included are baseline forest cover ($FC2000_i$), distance to city ($DistCity_i$), road density ($RoadDensity_i$), distance to nearest urban area ($DistUrban_i$), average and standard deviation of elevation ($M(Elevation)_i, SD(Elevation)_i$), average and standard deviation of slope ($M(Slope)_i, SD(Slope)_i$), biome indicators ($Biome_i$), and state indicators ($State_i$). Lasso uses cross-validation, which implies that the sample is divided in a training and a testing sample. The training sample is in itself divided into a number of cross-validation samples. For each subsample, the cross-validation sample is set aside, and the remainder is used to predict outcomes for the excluded subsample. The model is fit to the training data for a given value of the regularization parameter. Since the performance of cross-validation rarely increases for values greater than 10, the regularization parameter (*lambda*) is chosen through 10-fold cross-validation. The regularization parameter is chosen based on the one that minimizes the mean squared prediction error for each subsample (Athey & Imbens, 2016). Results from this estimation are presented in Table B3. Results are then used to predict the deforestation risk for each 5 km x 5 km grid-cell, which is aggregated at the municipality level.

Table B3: Lasso probit regression to predict deforestation risk

	Deforestation (0/1)
Forest cover (2000, ha)	0.000665
Km to nearest city	0.000004
Road density (km)	-0.000031
Km to nearest urban area	0.000001
Mean elevation (m)	-0.000454
Sd(slope)	-0.030846
Mean slope	-0.017330
Agriculture	-1.111352
Montane forest	0.267109
Pine oak forest	0.145967
Grasslands	-0.559924
Xeric scrub and desert	-0.169729
Mangroves	-0.800154
Constant	-0.793854
Selected lambda	.0013915
No. of non-zero coeff.	43
Observations	79,954

Note: Outcome is the pre-programs binary indicator of deforestation for years 2001 and 2002. Unit of analysis is the 5 km x 5 km grid-cell. Robust standard errors are clustered by municipality. Selection method is cross-validation with 10 cross-validation folds. Number of original covariates is 51. We do not show coefficients associated to the state indicator variables for space reasons. Lasso regression is clustered by municipality.

B.4 Additional descriptive statistics tables

Table B4: Rule changes and missed payments by wave

	Wave 1	Wave 2	Wave 3
CRITERIA			
Max eligible	300	300	1000
Animals	Cattle only	Cattle, cow, goats and sheep	Cattle, cow, goats and sheep
Categories	None	[A] small producers (<=35) and [B] larger producers (> 35)	[A] small producers & *ejidatarios* (<=35) and [B] larger producers (> 35)
Stronger enforcement of max sustainable number of livestock	no	yes	yes
SUBSIDY			
Subs/animal	$300 (year 1), $400 (year 2), $500 (year 3), $600 (year 4)	$375 if category A, $300 if category B	$350 if category A, $280 if category B
% of committed payment that didn't occur	5.1%	7.6%	-2.9%
MUNICIPALITY LEVEL			
Nbr new municipalities	1,465	488	57

Table B5: Summary statistics across municipalities with high and low PROGAN enrollment

	All municipalities		High PROGAN		Low PROGAN		N.d.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Livestock subsidy - PROGAN							
Subsidy/ha (MXN, 2003)	3.75	(9.30)	6.45	(11.84)	0.46	(1.26)	0.50
Subsidy/ha (MXN, 2014)	16.65	(21.67)	26.42	(23.48)	4.76	(10.61)	0.84
Eq. animals/ha (2003)	0.03	(0.06)	0.05	(0.07)	0.00	(0.00)	0.70
Eq. animals/ha (2014)	0.06	(0.07)	0.09	(0.08)	0.01	(0.01)	0.96
Maximum animals/ha	0.41	(0.28)	0.49	(0.30)	0.32	(0.21)	0.49
Baseline natural pasture/ha	0.09	(0.13)	0.08	(0.13)	0.10	(0.13)	-0.11
Baseline pasture associated with livestock/ha	0.08	(0.17)	0.13	(0.21)	0.01	(0.04)	0.60
Payment for environmental services - PES							
Enrolled PES/ha (%, 2004)	0.005	(0.03)	0.003	(0.02)	0.007	(0.04)	-0.089
Enrolled PES/ha (%, 2014)	0.018	(0.05)	0.013	(0.03)	0.025	(0.07)	-0.160
% ha submitted/ha ez (2004)	1.94	(11.51)	2.06	(11.81)	1.80	(11.14)	0.02
% ha submitted/ha ez (2014)	1.17	(5.98)	1.06	(5.51)	1.30	(6.51)	-0.03
Total submitted ha (2004)	230.86	(1381.98)	246.22	(1385.21)	212.13	(1378.51)	0.02
Accepted ha (2004)	287.55	(1255.87)	336.85	(1373.88)	231.89	(1106.10)	0.06
Rejected ha (2004)	177.86	(1211.88)	187.67	(1354.16)	166.78	(1028.86)	0.01
Total submitted ha (2014)	392.13	(2410.63)	375.64	(2046.04)	412.22	(2792.31)	-0.01
Accepted ha (2014)	314.26	(1118.59)	303.82	(1026.08)	326.06	(1215.34)	-0.01
Rejected ha (2014)	803.57	(2994.99)	939.70	(2931.63)	649.88	(3060.06)	0.07
Av. perc. in eligible zone (2004-2015)	0.36	(0.25)	0.32	(0.23)	0.42	(0.27)	-0.28
Replacement of crop with pasture							
% PROCAMPO in fodder (2000)	0.99	(3.81)	1.04	(3.64)	0.94	(3.99)	0.02
% PROCAMPO in fodder (2014)	2.11	(8.89)	2.66	(9.96)	1.45	(7.33)	0.10
PROCAMPO area (2000)	5792.99	(14097.67)	7677.45	(15669.53)	3493.69	(11498.71)	0.22
Forests							
% deforestation (2001)	0.34	(1.03)	0.44	(1.18)	0.22	(0.80)	0.16
% deforestation (2014)	0.15	(0.31)	0.22	(0.37)	0.07	(0.17)	0.38
Deforestation 2001-2014 (%)	0.04	(0.09)	0.06	(0.09)	0.03	(0.07)	0.28
Deforestation 2001-2014 (ha)	1033.19	(4728.29)	1330.60	(4876.15)	671.92	(4518.41)	0.10
Baseline forest/ha	0.32	(0.29)	0.30	(0.28)	0.34	(0.30)	-0.10
Deforestation risk	0.22	(0.23)	0.25	(0.24)	0.17	(0.20)	0.26
Other municipal variables							
Marginality index (2000)	0.09	(0.98)	-0.01	(0.91)	0.22	(1.05)	-0.16
Marginality index (2015)	0.09	(0.99)	-0.05	(0.89)	0.25	(1.08)	-0.21
Population/ha (2015)	0.18	(0.27)	0.13	(0.23)	0.19	(0.28)	-0.16
Municipality area (Mha)	0.08	(0.21)	0.09	(0.14)	0.07	(0.27)	0.06
Slope	8.26	(6.01)	6.61	(5.35)	10.26	(6.16)	-0.45
Average elevation	1329.87	(850.46)	1038.77	(842.14)	1683.46	(716.20)	-0.58
Observations	2166		1188		978		2166

Note: Low and high PROGAN groups are based on whether the median animal equivalent per hectare of a given municipality is above or below the average. Columns (1), (3) and (5) present the means. Columns (2), (4), and (6) the standard deviations. Normalized differences in column (7) are a scale-free measure of the difference in distributions between the sample of High PROGAN municipalities and the sample of Low PROGAN municipalities. Its advantage is that it is directly interpretable in terms of how much average standard deviation is the mean from one sample to the mean of the other sample (Imbens & Wooldridge, 2009). Baseline land characteristics come from INEGI, and marginalization index and population from CONAPO.

Table B6: Distribution of the four payments over the extended period of five years of the first wave

	Payment number				
Payment year	1^{st}	2^{nd}	3^{rd}	4^{th}	Total
2003	84,876	0	0	0	84,876
2004	126,388	36,797	0	0	163,185
2005	481	148,876	68,580	0	217,937
2006	53	21,772	119,647	0	141,472
2007	37	734	17,645	196,312	214,728
Total	211,835	208,179	205,872	196,312	822,198

Note: During the first wave, a total of 822,198 payments were distributed. According to the program rules, all first payments should have occurred in 2003, all second payments in 2004, all third payments in 2005, and all fourth payments in 2006. This table illustrates the deviation between the original planning and the actual distribution of individual payments.

Table B7: Geographical distribution of the four payments over 2003-2007

Region	Variable	Mean	SD	Minimum	Maximum
Centronorte	First payment	2003.587	.4945	2003	2006
	Average payment year	2005.209	1.35	2003	2007
Centrosur	First payment	2003.27	.4446	2003	2005
	Average payment year	2004.961	1.439	2003	2007
Noreste	First payment	2003.163	.3851	2003	2006
	Average payment year	2005.121	1.428	2003	2007
Noroeste	First payment	2003.524	.4998	2003	2006
	Average payment year	2005.232	1.372	2003	2007
Occidente	First payment	2003.803	.4016	2003	2006
	Average payment year	2005.468	1.238	2003	2007
Oriente	First payment	2003.826	.3937	2003	2007
	Average payment year	2005.327	1.215	2003	2007
Sureste	First payment	2003.273	.4497	2003	2007
	Average payment year	2005.18	1.453	2003	2007
Suroeste	First payment	2003.777	.4329	2003	2007
	Average payment year	2005.393	1.240	2003	2007
Total	First payment	2003.603	.497602	2003	2007
	Average payment year	2005.289	.320732	2003	2007

Note: We divide the country into eight regions and extract the average, standard deviation, minimum and maximum for the first payment and the average payment year. Region Noroeste includes the states of Baja California Sur, Chihuahua, Durango, Sinaloa and Sonora. Region Noreste includes the states of Coahuila, Nuevo León, Tamaulipas, as well as the region Lagunera. Region Occidente includes the states of Colima, Jalisco, Michoacán, and Nayarit. Region Oriente includes the states of Hidalgo, Puebla, Tlaxcala, and Veracruz. The region of Centrosur includes the states of Estado de México and Morelos. The region Suroeste includes the states of Chiapas, Guerrero, and Oaxaca. The region Sureste includes the states of Campeche, Quintana Roo, Tabasco, and Yucatán.

Enrollment characteristics, PROGAN cohorts

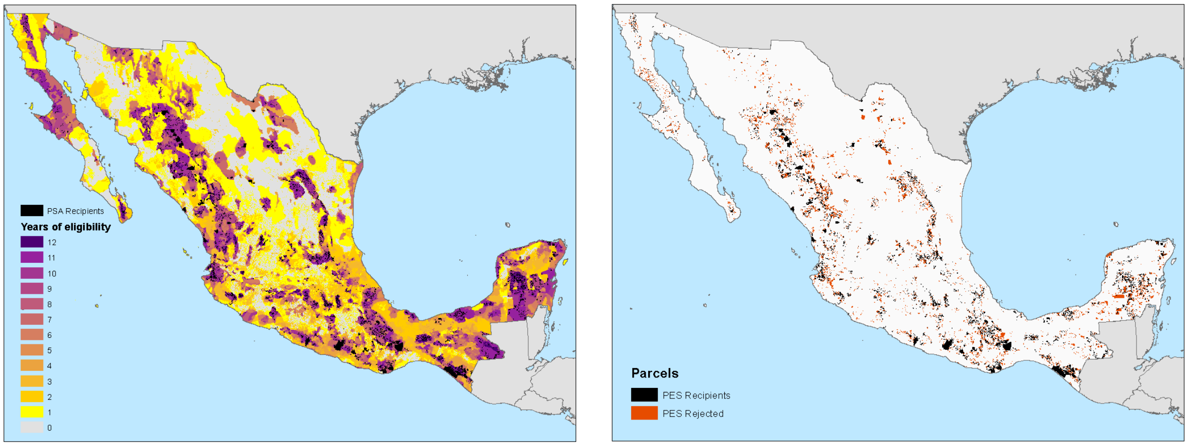
The table and figures below show the variation in cohort characteristics among municipalities enrolling at different times and intensity in PROGAN.

Table B8: Summary characteristics PROGAN municipalities by enrollment period

	Ln(Mun area) ha	Ln(Slope) deg	Ln(Elev) m	Defor risk	Max animals	Baseline pasture	Baseline livestock	Baseline forest
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Subsidy/ha (kMXN)	0.038***	-0.030***	-0.067***	0.005***	0.005***	-0.001***	0.009***	-0.000
	(0.005)	(0.003)	(0.006)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Year=2008 × Subsidy/ha (kMXN)	-0.034***	0.020***	0.045***	-0.002***	0.001	0.000	-0.005***	0.000
	(0.005)	(0.003)	(0.006)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Year=2014 × Subsidy/ha (kMXN)	-0.035***	0.019***	0.043***	-0.002***	0.002**	-0.000	-0.005***	0.001
	(0.005)	(0.003)	(0.006)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	3.175***	2.055***	6.876***	0.196***	0.396***	0.092***	0.043***	0.322***
	(0.033)	(0.019)	(0.033)	(0.005)	(0.006)	(0.003)	(0.003)	(0.007)
ymean	3.320	1.943	6.627	0.215	0.414	0.089	0.077	0.321

Note: Dependent variables are listed in column headers and means of dependent variables in the footer. We present the continuous measure of subsidy per ha and then its interactions with enrollment years in 2008 and 2014. This means the baseline variable measures the correlation between subsidy intensity and the outcome characteristics in 2004. * $p< 0.10$, ** $p<0.05$, *** $p<0.01$.

B.5 Additional descriptive figures



(a) (b)

Figure B5: Eligible zones frequency (a) and PES accepted and rejected parcels (b): 2004-2015

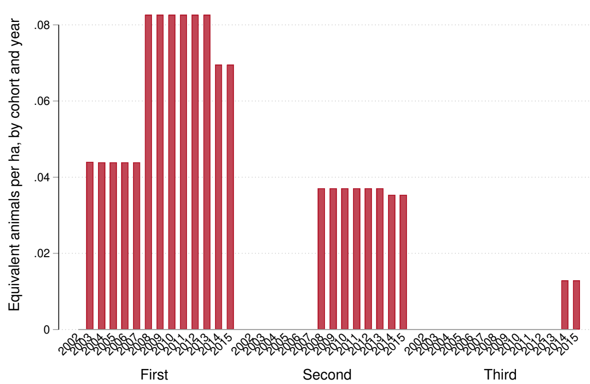


Figure B6: Animals per ha enrolled according to wave and year.

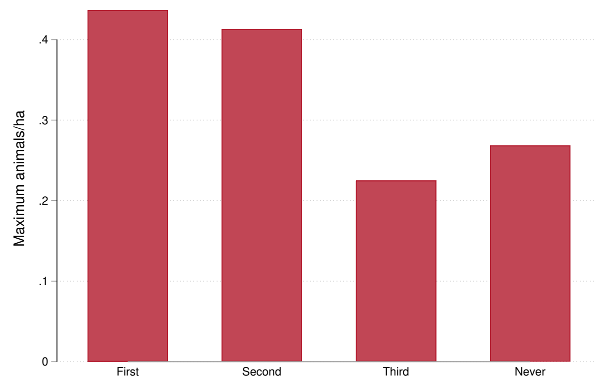


Figure B7: Average potential animals per hectare by municipal enrollment wave.

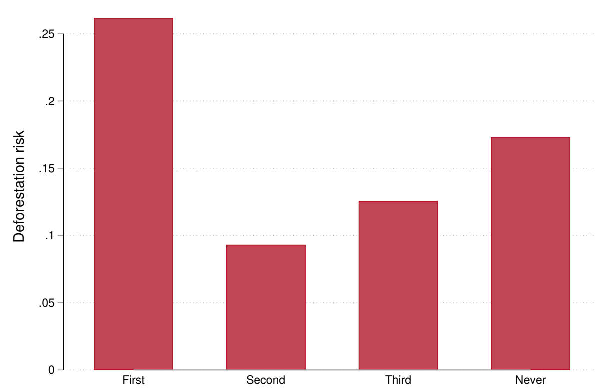


Figure B8: Average municipal deforestation risk according to first wave in which a municipality enrolled.

C Robustness: deforestation effects of PROGAN

C.1 Additional figures

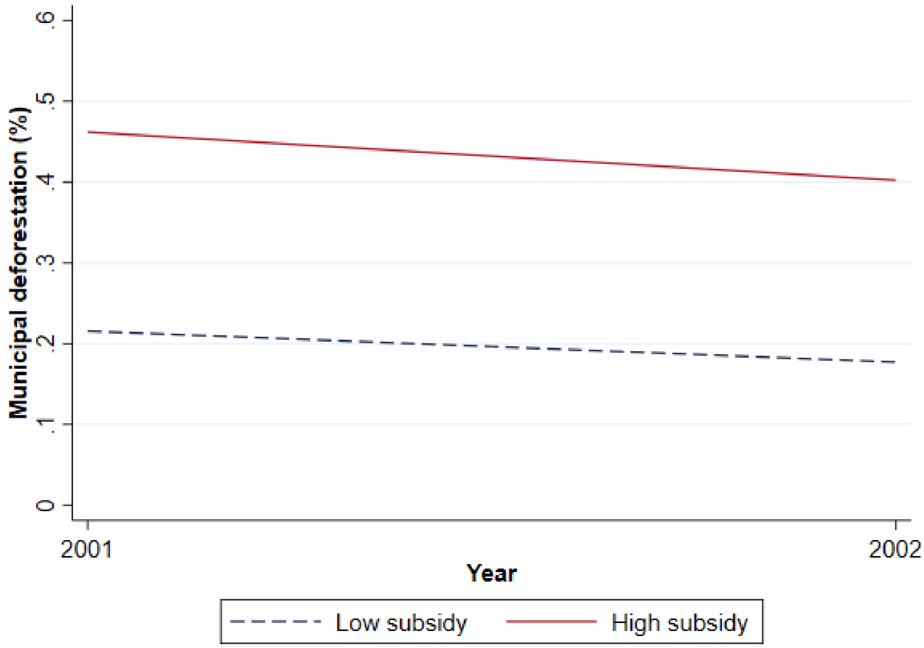


Figure C1: Graph shows a linear fit on municipal deforestation rates for 2001 and 2002, dividing the sample by median of subsidy levels, where the median is calculated over the entire time period of PROGAN.

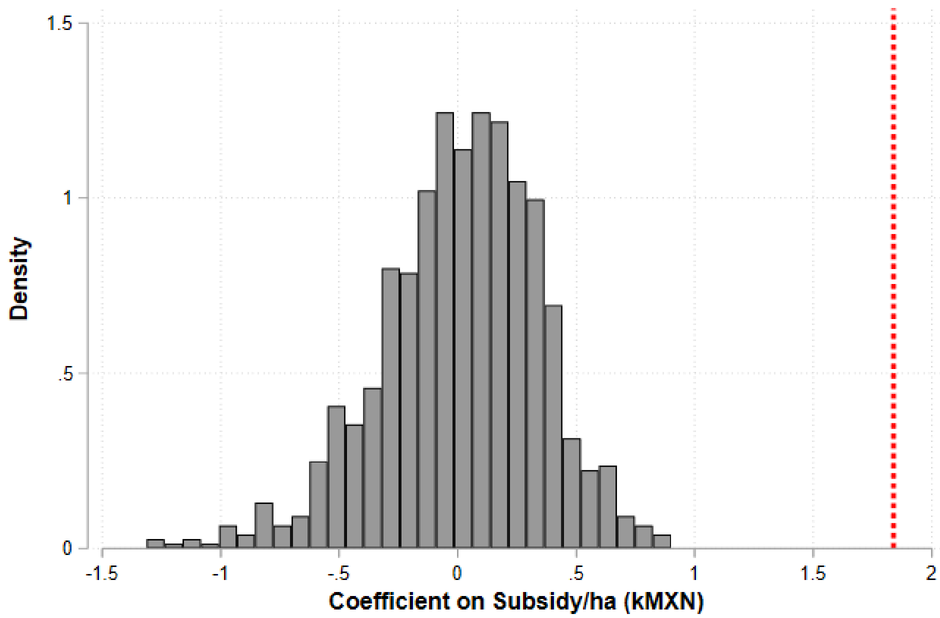


Figure C2: Falsification exercise: randomizing PROGAN subsidy at the municipality level. The histograms come from point estimates of PROGAN impact on deforestation using the full set of municipal and time fixed effects from Equation 3.1. The program variables are randomized and the impact re-estimated 1,000 times. The vertical dotted lines represent the point estimate in the specification of column (3), Table 1.

C.2 Additional tables

Table C1: Pre-program trends of deforestation in high versus low intensity PROGAN

	Deforestation (%)				
Panel A	(1)	(2)	(3)	(4)	(5)
High subsidy/ha x yr	0.0001***	0.0001***	-0.0213	-0.1053	-0.0706
	(0.0000)	(0.0000)	(0.0753)	(0.1089)	(0.0750)
Adjusted R2	0.011	0.156	0.403	0.080	0.562
Observations	4,332	4,332	4,332	1,730	4,332
Panel B					
Avg. subsidy/ha x yr	0.0030***	0.0036***	0.7041	-0.7575	-1.3559
	(0.0005)	(0.0005)	(1.7344)	(1.9378)	(1.5112)
Adjusted R2	0.013	0.159	0.403	0.078	0.562
Observations	4,332	4,332	4,332	1,730	4,332
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Pre-program trends for the years 2001-2002. Panel A uses a binary variable indicating if a municipality had above median subsidy and we show the interaction between this variable and the time trend. Panel B uses the same specification but replace the binary variable with the average subsidy from 2003 through 2015. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth column includes weights for baseline forest cover. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C2: Regressions of deforestation on PROGAN during the first wave exclusively

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	6.2173***	4.9497***	2.8026***	1.5940**	2.3181***
	(0.6184)	(0.6405)	(0.5754)	(0.7072)	(0.6119)
Adjusted R2	0.028	0.181	0.472	0.344	0.476
Observations	10,810	10,810	10,810	4,325	10,810
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2003-2007. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C3: Regressions of deforestation on PROGAN, comparing only municipalities enrolled in the first wave with the never enrolled municipalities

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	6.1780***	5.9261***	2.5042***	1.0500**	1.2884**
	(0.3688)	(0.4209)	(0.4629)	(0.4258)	(0.5012)
Adjusted R2	0.029	0.139	0.378	0.274	0.504
Observations	22,661	22,661	22,661	9,450	22,661
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2001-2014. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C4: Regressions of deforestation on PROGAN during the first wave exclusively, only compared to never enrolled

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	7.0285***	6.1307***	3.2884***	0.8169*	1.8188*
	(0.9512)	(0.9689)	(0.8027)	(0.4635)	(0.9672)
Adjusted R2	0.014	0.148	0.456	0.278	0.439
Observations	9,717	9,717	9,717	4,050	9,717
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2003-2007. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. The sample excludes municipalities that enrolled in the second and third waves. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C5: Regressions of deforestation on PROGAN and leads of PROGAN

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
F.Subsidy/ha	2.7275***	2.4661***	-0.2757	-0.2633	-0.7289
	(0.6469)	(0.6291)	(0.3457)	(0.3063)	(0.7618)
Subsidy/ha (kMXN)	3.9809***	3.6452***	1.9848***	1.3479**	1.6138**
	(0.6669)	(0.6456)	(0.5333)	(0.5679)	(0.6425)
Adjusted R2	0.029	0.145	0.361	0.249	0.502
Observations	30,269	30,269	30,269	12,110	30,269
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2001-2014. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C6: Regressions of deforestation on PROGAN for municipalities with more than 50 ha of eligible zones

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	6.3578***	5.6952***	1.8383***	1.2148**	1.2660***
	(0.3347)	(0.3636)	(0.5706)	(0.4851)	(0.4792)
Adjusted R2	0.027	0.144	0.361	0.249	0.501
Observations	30,269	30,269	30,269	12,110	30,269
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2001-2014. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C7: Regressions of deforestation on PROGAN for municipalities without 50 ha of eligible zones

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	6.3578***	5.6952***	1.8383***	1.2148**	1.2660***
	(0.3347)	(0.3636)	(0.5706)	(0.4851)	(0.4792)
Adjusted R2	0.027	0.144	0.361	0.249	0.501
Observations	30,269	30,269	30,269	12,110	30,269
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2001-2014. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C8: Regressions of deforestation on PROGAN - robustness analyses

	Deforestation (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
Subsidy/ha (kMXN)	1.8444***	1.2692***	1.8118***	1.2666***	1.4462***	1.2869***
	(0.5701)	(0.4793)	(0.5692)	(0.4788)	(0.5226)	(0.4672)
Murders	0.0004	0.0001				
	(0.0007)	(0.0002)				
Year × Bank branches (2008)			-0.0002	0.0000		
			(0.0001)	(0.0001)		
Adjusted R2	0.361	0.502	0.362	0.501	0.379	0.509
Observations	30,269	30,269	30,269	30,269	30,269	30,269
Year FE	X	X	X	X	X	X
State FE						
Municipality FE	X	X	X	X	X	X
State x Year FE					X	X
Forest cover weights		X		X		X

Note: Years 2001-2014. Data source for the panel on murders is from the Mexican Department of Health Information (DGIS) and for the bank branches is the National Banking and Stock Commission (CNBV). Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C9: Pre-program trends of deforestation in high versus low intensity PROGAN

	Deforestation (%)				
Panel A	(1)	(2)	(3)	(4)	(5)
High eq. animal/ha x yr	0.0001***	0.0001***	-0.0641	-0.0961	-0.0709
	(0.0000)	(0.0000)	(0.0752)	(0.1096)	(0.0721)
Adjusted R2	0.008	0.153	0.403	0.080	0.562
Observations	4,332	4,332	4,332	1,730	4,332
Panel B					
Avg. eq. animals/ha x yr	0.0008***	0.0009***	-0.1132	-0.2061	-0.3928
	(0.0001)	(0.0001)	(0.3613)	(0.5889)	(0.4550)
Adjusted R2	0.010	0.156	0.403	0.078	0.562
Observations	4,332	4,332	4,332	1,730	4,332
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Pre-program trends for the years 2001-2002. Panel A uses a binary variable indicating if a municipality had above median enrollment and we show the interaction between this variable and the time trend. Panel B uses the same specification but replace the binary variable with the average enrollment from 2003 through 2015. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth column includes weights for baseline forest cover. * p< 0.10, ** p<0.05, *** p<0.01.

Table C10: Regressions of deforestation on PROGAN enrollment

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Eq. animals/ha	2.1284***	1.9456***	0.5778***	0.2615	-0.0650
	(0.0765)	(0.0881)	(0.1195)	(0.1623)	(0.2008)
Adjusted R2	0.029	0.144	0.361	0.249	0.501
Observations	30,269	30,269	30,269	12,110	30,269
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2001-2014. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table C11: Regressions of deforestation on PROGAN - heterogeneous results by cohort

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Baseline effect PROGAM subs./ha (kMXN)	7.9736***	6.3839***	2.3183***	0.9847***	2.0224**
	(0.9878)	(0.8867)	(0.6494)	(0.3759)	(0.7947)
Additional effect, 2006-2010	-2.4213**	-1.3354	-0.5997	0.2330	-0.9541
	(1.0952)	(0.9657)	(0.4578)	(0.4324)	(0.6160)
Additional effect, 2011-2015	-1.3408	0.0762	-0.4704	0.6891	-0.6798
	(1.0618)	(0.9343)	(0.6948)	(0.7407)	(0.8239)
Adjusted R2	0.028	0.144	0.361	0.249	0.502
Observations	30,269	30,269	30,269	12,110	30,269
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2001-2014. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

D Robustness: intensification effects of PROGAN

Table D1: Regressions of PROCAMPO fodder (%) on PROGAN pre-program trends analysis

	Fodder (%)			
	(1)	(2)	(3)	(4)
High subsidy/ha (kMXN) x yr	-0.0001	-0.0001	0.0736	-0.0251
	(0.0001)	(0.0001)	(0.0933)	(0.1957)
Adjusted R2	0.001	0.191	0.542	0.492
Observations	8,552	8,552	8,552	8,552
Year FE	X	X	X	X
State FE		X		
Municipality FE			X	X
PROCAMPO weights (1999)				X

Note: Years 1999-2002. Robust standard errors are clustered by municipality. * p< 0.10, ** p<0.05, *** p<0.01.

Table D2: Regressions of PROCAMPO fodder (%) on PROGAN for first wave only

	Fodder (%)			
	(1)	(2)	(3)	(4)
Subsidy/ha (kMXN)	-13.8149***	-2.7715**	-0.3680	1.3804
	(1.5106)	(1.0908)	(0.7776)	(0.9274)
Adjusted R2	0.001	0.458	0.948	0.946
Observations	10,670	10,670	10,670	10,670
Year FE	X	X	X	X
State FE		X		
Municipality FE			X	X
PROCAMPO weights (1999)				X

Note: Years 2003-2007. Pre-mean of dependent variable is 1.3%. Robust standard errors are clustered by municipality. * p< 0.10, ** p<0.05, *** p<0.01.

E Robustness: agricultural subsidies and conservation programs

E.1 Robustness: enrollment effects

Table E1: Regressions of PES submissions on PROGAN (% submitted), with leads

	PES submitted (% of eligible zones)				
	(1)	(2)	(3)	(4)	(5)
F.Subsidy/ha (kMXN)	3.5209	5.2843	5.6565	8.0842	6.9758
	(3.5877)	(3.6593)	(3.6679)	(4.9792)	(4.9892)
Subsidy/ha (kMXN)	-8.2254***	-5.5596**	-5.7427**	-6.3381**	-4.6668
	(2.8076)	(2.6605)	(2.6629)	(2.9736)	(2.9042)
Adjusted R2	0.034	0.040	0.041	0.060	0.063
Observations	16,104	16,104	16,104	16,104	16,104
Year FE	X	X	X	X	X
State FE		X	X		
Municipality FE				X	X
El. zones controls			X		X

Note: Years 2004-2015. Mean of DV in 2004 is 7.3. Panel is unbalanced. Robust standard errors are clustered by municipality. Controls included in columns (3) and (5) are eligible zones-specific. They include road network, the percentage within communal land, the percent of the municipality that is located in an eligible zone, the baseline characteristics of pasture (both natural pasture and pasture associated with livestock production). * p< 0.10, ** p<0.05, *** p<0.01.

Table E2: Regressions of PES submissions on PROGAN (area submitted)

	PES submitted (% of municipal area)		
	(1)	(2)	(3)
Subsidy/ha (kMXN)	-0.0430***	-0.0372***	-0.0158*
	(0.0057)	(0.0059)	(0.0090)
Adjusted R2	0.011	0.022	0.131
Observations	28,098	28,098	28,098
Year FE	X	X	X
State FE		X	
Municipality FE			X

Note: Years 2004-2015. Mean of DV in 2004 is .0032. Panel is balanced. Robust standard errors are clustered by municipality. * p< 0.10, ** p<0.05, *** p<0.01.

Table E3: Regressions of PES submissions on PROGAN (% submitted), first wave only

	PES submitted (% of eligible zones)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	-7.2724***	-4.7918*	-4.6334*	-19.5982**	-12.8969
	(2.4013)	(2.7049)	(2.6766)	(8.1967)	(8.4078)
Adjusted R2	0.059	0.064	0.065	-0.003	0.003
Observations	6,722	6,722	6,722	6,722	6,722
Year FE	X	X	X	X	X
State FE		X	X		
Municipality FE				X	X
El. zones controls			X		X

Note: Years 2004-2007. Mean of DV in 2004 is 7.3. Panel is unbalanced. Robust standard errors are clustered by municipality. Controls included in columns (3) and (5) are eligible zones-specific. They include road network, the percentage within communal land, the percent of the municipality that is located in an eligible zone, the baseline characteristics of pasture (both natural pasture and pasture associated with livestock production). * p< 0.10, ** p<0.05, *** p<0.01.

Table E4: Regressions of PROGAN enrollment on PES enrollment – instrumental variables approach

Second-stage	(1)	(2)	(3)
Cum. enrolled PES ha/mun ha	-0.0575***	-0.112***	-0.0151
	(-6.12)	(-10.48)	(-1.21)
p-value AR-test	1.94e-10	1.32e-36	0.222
F-stat	358.3	370.1	171.7
First-stage:			
Cum. eligible zone ha/mun ha	0.0669***	0.0690***	0.0649***
	(18.93)	(19.24)	(11.35)
Observations	6488	6488	6488
Year FE	X	X	X
State FE		X	
Municipality FE			X

Note: Years 2003, 2008, and 2014. Dependent variable is the number of animals enrolled in PROGAN for each wave. Treatment is the sum of all PES enrolled hectares per municipal hectare between each wave (before 2003, between 2003-2007, and between 2008 and 2013). Instrument is the sum of all eligible zones per municipal hectare between each wave. Robust standard errors are clustered by municipality. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

Table E5: Regressions of PROGAN enrollment on PES willingness to enroll – instrumental variables approach

Second-stage			
	(1)	(2)	(3)
Cum. ha applied to PES/mun ha	-0.183***	-0.347***	-0.0958
	(-6.18)	(-10.96)	(-1.20)
p-value AR-test	1.94e-10	1.32e-36	0.222
F-stat	503.0	525.4	40.53
First-stage:			
Cum. eligible zone ha/mun ha	0.0210***	0.0223***	0.0102***
	(22.43)	(22.92)	(5.51)
Observations	6488	6488	6488
Year FE	X	X	X
State FE		X	
Municipality FE			X

Note: Years 2003, 2008, and 2014. Dependent variable is the number of animals enrolled in PROGAN for each wave. Treatment is the sum of all PES hectares submitted to PES per municipal hectare between each wave (before 2003, between 2003-2007, and between 2008 and 2013). Instrument is the sum of all eligible zones per municipal hectare between each wave. Robust standard errors are clustered by municipality. * p< 0.10, ** p<0.05, *** p<0.01.

E.2 Robustness: effect of PROGAN and PES on deforestation

Table E6: Regressions of deforestation on PROGAN and PES, first wave only

	Deforestation (%)				
	(1)	(2)	(3)	(4)	(5)
Subsidy/ha (kMXN)	7.5742***	6.2596***	3.2817***	2.2424***	3.1716***
	(0.4158)	(0.4597)	(0.5129)	(0.6943)	(0.6460)
Enrolled PES/ha (%)	-0.4323***	0.2140**	-0.4605	-0.3425	0.3920
	(0.0889)	(0.1072)	(0.6153)	(0.6251)	(0.6915)
Subsidy/ha (kMXN) × Enrolled PES/ha (%)	-77.2791***	-64.5725***	-34.5013***	-25.1943***	-38.4832***
	(5.8133)	(5.5817)	(6.9296)	(7.7679)	(9.2088)
Adjusted R2	0.034	0.191	0.473	0.346	0.478
Observations	10,810	10,810	10,810	4,325	10,810
Year FE	X	X	X	X	X
State FE		X			
Municipality FE			X	X	X
Forest cover weights					X

Note: Years 2003-2007. Unweighted pre-mean of dependent variable is 0.29%, weighted pre-mean of dependent variable is 0.34%. Robust standard errors are clustered by municipality. The fourth column includes only municipalities that ever had PES enrollment and the fifth includes weights for baseline forest cover. * p< 0.10, ** p< 0.05, *** p< 0.01.

F Supplemental analysis: parcel level deforestation

This appendix examines the interaction between PROGAN and PES on the land that applied for the PES program. We are interested in the direct effect of increases in PROGAN enrollment or payments, and the interaction of that effect with PES payments. The unit of analysis is a piece of land with a unique application history, to which we refer as "parcel". We employ a layer created by Alix-Garcia, Sims, and Orozco-Olvera, 2017, which overlays all applicant parcels and divides them up, creating spatial histories.[1] This approach eliminates the problem of double counting areas in the panel analysis of applicants, but generates challenges with the unit of analysis; many very small parcels resulting from the year-to-year overlaps are often not meaningful units of analysis. To help address this issue, we drop unique history parcels with less than 10 hectares of forest cover in 2000.

To estimate impact we apply fixed effects at the level of the property (p) where the boundaries are known – this is the case for common properties – at the level of the municipality for private properties.[2] As shown in Section 4.2, our sample of accepted and rejected parcels has not been affected by the availability of PROGAN. Therefore, any impact on deforestation does not occur through changing the deforestation risk profile of applicants. The identification of the PROGAN and interaction effects rely on the assumption that after controlling for property fixed effects, time fixed effects, and controls, there are not unobserved factors that change deforestation decisions at the parcel level and simultaneously the municipal participation in PROGAN and PES.

[1]For example, suppose a community submits a parcel in 2011 that is rejected, and then they submit a parcel in 2012 that overlaps the 2011 parcel, but this new application is accepted. This sequence of activities generates three parcels in the dataset: one with a history of being rejected in 2011 and then accepted in 2012, one with a history of being rejected in 2011, and another with a history of being accepted in 2012.

[2]Common properties in Mexico are known as ejidos. Ejidos comprise the majority of the land in rural Mexico and house a significant amount of forest. This tenure structure arose as a result of the Mexican Revolution after 1917, and have fixed membership over time, with rights only passing on to one family member over generations. Although some ejidos were dissolved as a result of a 1992 reform of the sector, they remain a dominant land tenure arrangement in rural Mexico.

The estimation equation is:

$$Pr(Y_{ipt} = 1) = f(\alpha + \beta_1 PES_{ipt} + \beta_2 PROGAN_{m(ip)t} + \beta_3 PES_{ipt} x PROGAN_{m(ip)t} + \mathbf{X}_{ipt}\gamma + \psi_p + \theta_t + u_{ipt}), \tag{F.1}$$

where Y_{ipt} takes a value of one if parcel i in property p experiences any deforestation in year t. The binary treatment variable PES_{ipt} is equal to one when the parcel is enrolled and equal to zero otherwise.[3] We use the municipal livestock subsidy per hectare to measure PROGAN intensity: $PROGAN_{m(ip)t}$, though are results hold if we substitute animals per hectare into the equation. $\mathbf{X}_{ipt}$ includes a variable equal to one if the parcel was ever accepted into the program, and also parcel-level values of distance to major city and road, elevation, slope, locality level poverty in 2010, percent of the parcel that was forested in 2000, and whether or not the municipality in which the parcel is located is majority indigenous. To accommodate property level fixed effects ψ_p, we include ejido means of all of the included X variables as well as all of the treatment variables. Year fixed effects θ_t are also included. The standard errors u_{ipt} are clustered at the property level. We estimate the equation using a random effects logit and report marginal effects. This transformation, originally proposed by Mundlak, 1978, avoids the incidental parameters problem and allows us to use a non-linear estimator that better matches the data generating process (Alix-Garcia & Millimet, 2023).

Although the treatment effect of PES on its own is not our primary parameter of interest, we also want to ensure that characteristics of the rejected parcels are as similar as possible to those of the accepted parcels. To this end, we keep only applicants that have passed a first round of screening and have sent geo-referenced property boundaries. We also exploit the fact that for later years of the program, parcels received a "score"

[3]This variable is staggered, since different parcels enroll at different times. This makes the binary treatment effect difficult to interpret due to the changing counterfactual over time (Goodman-Bacon, 2021). However, our coefficient of interest is continuous – the interaction of this variable with the intensity of participation in PROGAN. This means that we are not able to apply the existing adjustments for staggered difference in differences.

based upon a series of observable characteristics. Within each state, program, and year, applications with the highest score were accepted until state budgets were exhausted. Our main specification restricts the sample to only those properties which received a normalized score of between -10 and 10 points. This includes 99% of the area of land ever submitted to the program. We explain this process in more detail below.

Table F1 presents the average and the normalized differences of parcel and municipality characteristics for the accepted and the rejected applicants. We compare the full sample as well as the sample with recentered point scores between the -10 and 10 points around the central cutoff value for the state, program, and year. The restricted sample improves the comparability between the accepted and the rejected parcels on the following characteristics: whether the parcels are within a protected area, elevation, slope, the distances to roads and the percent majority indigenous, and at the municipal level, the frequency in eligible zones and the marginality index.

Sample selection: PES parcels

The criteria for enrollment into the PES program have evolved over time. Starting in 2006, a points score was established in order to bring transparency into the selection process. Points were based upon characteristics of the application as well as geographic features calculated based upon GIS layers. Across all years, application outside of eligible zones were rejected. In the years prior to 2006, applications were often rejected due to lack of sufficient forest cover, and in the later years because of relatively insufficient point scores. Since point scores did not exist for properties that applied before 2006, a new score is imputed for those parcels.

We create recentered point scores for each parcel according to their specific state, year of application and program type in order to select a sample of similar parcels. For parcels submitted after 2006, we simply use the existing point scores. For earlier parcels, we impute them from a regression of real point scores for 2006-2015 on various characteristics used to calculate the point scores.[4] We then calculate the minimum point score for acceptance in each state, year and program type. We subtract the minimum score for acceptance in each parcels state-year-type category from its actual or imputed score. We match the recentered point scores with the panel of parcels, and for the units of analysis that applied more than once, calculate the average recentered point scores based on each time the parcel was submitted. Figure F1 compares the histogram of the recentered point scores for the accepted and rejected groups. As expected, accepted parcels have significantly higher recentered point scores than rejected parcels.

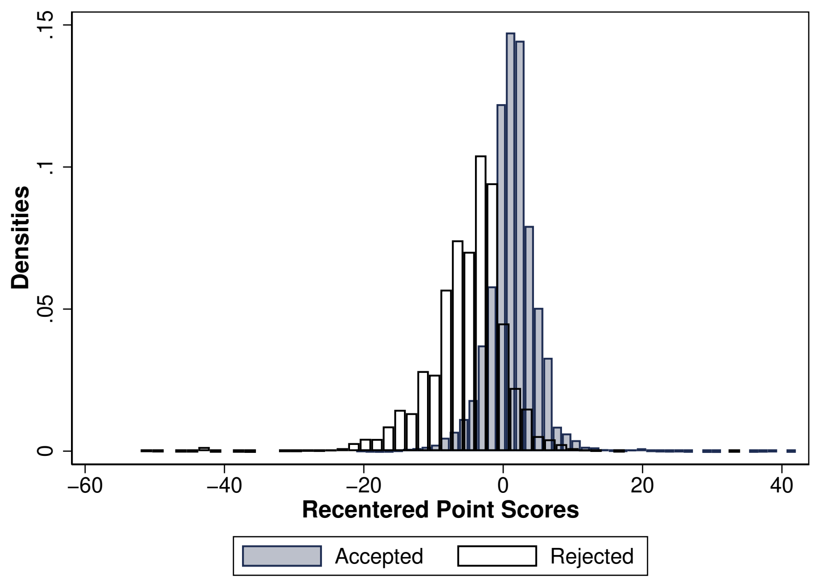


Figure F1: Density distribution of recentered point scores for accepted and rejected parcels. The histogram includes predicted values for parcels that applied before 2006 and real point scores for parcels that applied in or after 2006.

[4]Characteristics are: state indicators, year of application, PES type, IHS(average slope), IHS(average elevation), IHS(forest cover 2003), IHS(submitted parcel size), deforestation risk, communal land indicator, and also indicators of whether the submitted parcel falls within a Biosphere, a Federal park, a State park, a municipal park, a RAMSAR site or a privately or communally owned certified area. Hyperbolic sine transformation (IHS) (Burbidge, Magee, & Robb, 1988) is similar to a logarithmic, which reduces the influence of outliers, but at the difference that it is identified at zero.

Table F1: Summary statistics for accepted and rejected parcels

	All parcels			*Restricted with rec. pt. scores*		
	Accepted	Rejected	N.d.	Accepted	Rejected	N.d.
Parcels' forests						
% forest cover (2000)	79.30	70.13	0.22	79.39	70.50	0.21
Forest cover (2000), ha	217.26	203.84	0.01	217.64	206.04	0.01
Parcels' characteristics						
Parcel area (ha)	394.16	517.40	-0.05	394.55	528.51	-0.05
Parcel ha submitted (2004)	5653.10	2530.00	0.28	5680.95	2522.77	0.29
Parcel ha submitted (2014)	1059.62	1049.56	0.01	1067.94	1037.10	0.02
Ejidos (2004)	0.50	0.48	0.03	0.50	0.48	0.04
Ejidos (2014)	0.51	0.49	0.04	0.52	0.48	0.05
Protected area (2004)	0.37	0.24	0.21	0.36	0.25	0.18
Protected area (2014)	0.43	0.28	0.23	0.43	0.29	0.20
Average elevation (mt)	1393.06	1248.09	0.11	1367.10	1272.70	0.07
Average slope (degree)	14.92	13.88	0.09	14.88	14.05	0.07
Distance to any road (meters)	4283.26	4976.34	-0.11	4319.49	4858.46	-0.08
Distance to city with > 5,000 people	28.59	31.61	-0.10	28.85	31.60	-0.09
Distance to highway > 80km/h (meters)	18439.56	18411.33	0.00	18664.53	18590.97	0.00
Distance to highway > 60 km/h (meters)	7526.64	8481.90	-0.09	7603.18	8460.36	-0.08
Distance to major city (km)	101.40	108.78	-0.09	102.07	107.73	-0.07
Deforestation risk	0.04	0.05	-0.04	0.04	0.04	-0.03
Percent of majority indigenous	29.25	22.29	0.11	29.76	24.49	0.08
Percent acquifer	10.25	7.23	0.08	9.98	7.30	0.07
Parcels' scores						
Recentered point scores	1.35	-5.22	0.94	1.18	-3.57	1.01
Municipal characteristics						
Eq. animals/ha (2003)	0.03	0.04	-0.06	0.03	0.04	-0.03
Eq. animals/ha (2014)	0.05	0.06	-0.03	0.05	0.05	-0.01
Subsidy/ha (kMXN, 2003)	0.01	0.01	-0.10	0.01	0.01	-0.06
Subsidy/ha (kMXN, 2014)	0.02	0.02	0.00	0.02	0.02	0.02
Average pasture coefficient	3.24	3.36	-0.05	3.22	3.38	-0.06
Baseline livestock density	0.07	0.07	-0.02	0.07	0.07	0.00
Baseline pasture density	0.05	0.05	-0.07	0.05	0.05	-0.07
Eligible zones/ha (2006-2014)	0.66	0.58	0.24	0.67	0.60	0.21
Marginality index (2005)	0.22	0.12	0.08	0.23	0.17	0.05
Marginality index (2010)	0.22	0.13	0.06	0.23	0.18	0.04
Observations	12866	12828	25694	12351	10897	23248

Note: Columns (1)-(3) present full sample and columns (4)-(6) present the sample restricted to the recentered point scores between the -10 and 10 points around the central cutoff value for the state, program, and year. Normalized differences are in columns (3) and (6) (Imbens & Wooldridge, 2009) and averages in the remaining columns. Parcel data and their land characteristics are from Alix-Garcia et al. (2017), deforestation data from Hansen et al., 2013, PROGAN and PROCAMPO from SAGARPA, and marginalization index and population from CONAPO.

Results: parcel level

Table F1 shows the results of Equation F.1 on our preferred sample (restricted between -10 and 10 on the normalized point score). Table F3 shows estimates using the full sample. In columns (2) and (5), PROGAN is defined as the subsidy per hectare, and in columns (3) and (6), as the number of animal equivalent units per hectare. All specifications include property (municipality for private properties) fixed effects and the last three columns include a weight for the area of the parcel.

We observe consistently negative effects, though not always statistically significant, of PES alone, mostly positive point estimates of the subsidy, with inconsistent levels of significance for these. The interaction terms are negative and statistically significant in the unweighted estimates and not statistically significant in the weighted ones.

Table F1: Parcel level regressions of deforestation on PES and PROGAN

	Deforestation (0/1)			
	(1)	(2)	(3)	(4)
PES recipient (0/1)	-0.0037	0.0000	-0.0111**	-0.0129*
	(0.0025)	(0.0029)	(0.0056)	(0.0069)
PROGAN subsidy		0.0060		0.2401
		(0.0549)		(0.1878)
PES x Subsidy/ha		-0.1716**		0.0434
		(0.0681)		(0.2081)
Pseudo-R2	0.155	0.159	0.102	0.105
Observations	324,114	324,114	324,114	324,114
Year FE	X	X	X	X
Property FE	X	X	X	X
Area weights			X	X

Note: Years 2001-2014. The sample is the full sample of parcels within the municipalities considered in all sections of the paper. The estimator is a correlated random effects logit with effects at the ejido level for common properties and the municipality level for private properties. Robust standard errors are clustered by ejido for common properties and by municipality for private properties. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We suspect that treatment heterogeneity across parcels of different parcel sizes explains the differences between these two estimates, and also that the problem is more severe here, since the range in sizes is very large – from 10 to 6,000 ha. In addition to possible behavioral effects, such as the fact that resource extraction is likely to slow as the resource becomes more scarce, mechanically there is significantly much more measurement error in the smaller areas. To examine the effects of this heterogeneity, we split the sample into above and below median parcel sizes (the median is 152 ha). The above median parcels contain nearly 9.5 million hectares, whereas the below median parcels contain around 800,000 – only 7.7% of the area ever submitted to the program (Table F2). In this sample of larger parcels, we observe positive effects of the subsidy alone, meaning that municipalities with greater PROGAN intensity have higher deforestation rates on unenrolled land that applied to the program. The interaction terms are negative, statistically significant, and slightly larger in magnitude than the direct effect of PROGAN. Figure F1 shows a visualization of the effects of a one standard deviation increase in the intensity of PROGAN on applicants in general and then the sum of this with the effect

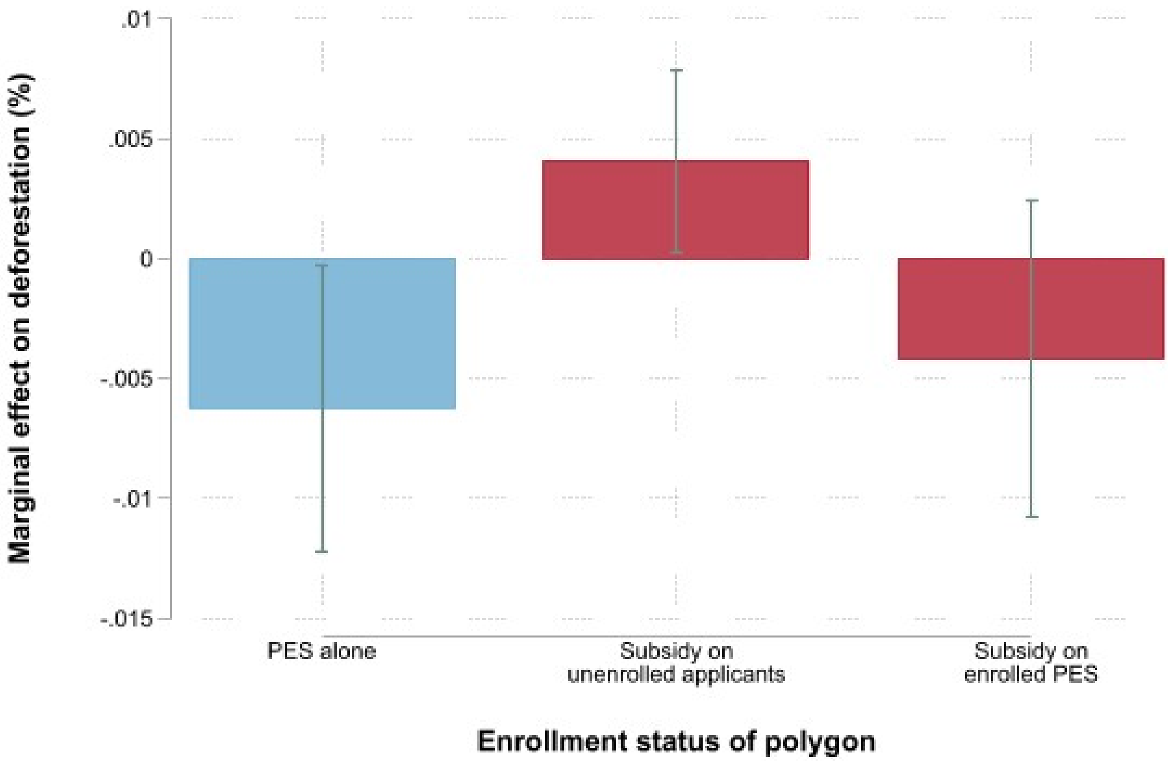


Figure F1: Marginal effects are for a one standard deviation increase in the intensity of PROGAN on land that applied to the PES (Subsidy x 1 SD increase in subsidy), and then the sum of this effect with the interaction of PROGAN intensity and enrollment in the PES (PES recipient + (PROGAN subsidy + PES x subsidy)x 1 SD increase in subsidy). Error bars are for 90% confidence. The estimates come from parcels greater than the median area (152 ha), using Table F2. The first bar is from column (4). The second two bars come from column (5).

of enrollment. Although PES enrollment eliminates the increase in the propensity to deforest caused by PROGAN, the evidence is that the PES effect is not substantial enough to actually generate avoided deforestation in areas with high PROGAN intensity. In these places and for parcels that ever applied to PES, the environmental program serves only to maintain the status quo in the face of the deforestation incentives generated by PROGAN.

These results are the same for the entire set of parcels (Table F3). They also hold when we restrict estimations to parcels that received point scores normalized for their state, program and year between -5 and 5 (Table F4), for the full set of parcels, and for those greater than the median size. For both sets of estimations the direct effect of the subsidies is positive and its interaction with the PES program negative. Only the effect of PES alone and the direct effect of the PROGAN subsidy are statistically significant, and only in the sample of large parcels. We also estimate impacts on the full and on the large parcels using an estimator that corrects for misclassification error in the dependent variable (Alix-Garcia & Millimet, 2023), and observe similar negative interaction terms between the subsidy and the program (Table F5).

Robustness checks: Effect of PROGAN and PES on Deforestation at the Parcel Level

Table F2: Parcel level regressions of deforestation on PROGAN and PES, below and above median parcels

	Deforestation (0/1)					
	Below median			Above median		
	(1)	(2)	(3)	(4)	(5)	(6)
PES recipient (0/1)	-0.0020	0.0006	-0.0062*	-0.0013	-0.0122**	-0.0151*
	(0.0032)	(0.0038)	(0.0036)	(0.0043)	(0.0062)	(0.0077)
PROGAN subsidy		-0.0672		0.1779*		0.3179
		(0.0512)		(0.1003)		(0.2283)
PES x Subsidy/ha		-0.0803		-0.3027**		0.0986
		(0.0731)		(0.1252)		(0.2634)
Pseudo-R2	0.100	0.103	0.132	0.137	0.086	0.089
Observations	162,988	162,988	161,126	161,126	161,126	161,126
Year FE	X	X	X	X	X	X
Ejido FE	X	X	X	X	X	X
Area weights			X	X		

Note: Years 2001-2014. Robust standard errors are clustered by ejido for common properties and by municipality for private properties. The estimator is a correlated random effects logit with effects at the ejido level and marginal effects reported. * p< 0.10, ** p< 0.05, *** p< 0.01.

Table F3: Parcel level regressions of deforestation on PROGAN and PES, full sample

	Deforestation (0/1)			
	(1)	(2)	(3)	(4)
PES recipient (0/1)	-0.0044*	-0.0009	-0.0137**	-0.0155**
	(0.0025)	(0.0029)	(0.0054)	(0.0066)
PROGAN subsidy		0.0039		0.1766
		(0.0545)		(0.1755)
PES x Subsidy/ha		-0.1565**		0.0587
		(0.0673)		(0.1995)
Pseudo-R2	0.155	0.158	0.103	0.105
Observations	358,330	358,330	358,330	358,330
Year FE	X	X	X	X
Ejido FE	X	X	X	X
Area weights			X	X

Note: Years 2001-2014. Sample is the full unrestricted sample. Robust standard errors are clustered by ejido for common properties and by municipality for private properties. The estimator is a correlated random effects logit with effects at the ejido level and marginal effects reported. * $p< 0.10$, ** $p< 0.05$, *** $p< 0.01$.

Table F4: Parcel level regressions of deforestation on PROGAN and PES, more restricted sample

	Deforestation (0/1)			
	(1)	(2)	(3)	(4)
PES recipient (0/1)	-0.0049	0.0014	-0.0087	-0.0108
	(0.0039)	(0.0047)	(0.0065)	(0.0096)
PROGAN subsidy		0.2341**		1.3154***
		(0.1132)		(0.3629)
PES x Subsidy/ha		-0.3870***		-0.0036
		(0.1340)		(0.4206)
Pseudo-R2	0.131	0.135	0.088	0.089
Observations	122,514	122,514	122,514	122,514
Year FE	X	X	X	X
Ejido FE	X	X	X	X
Area weights			X	X

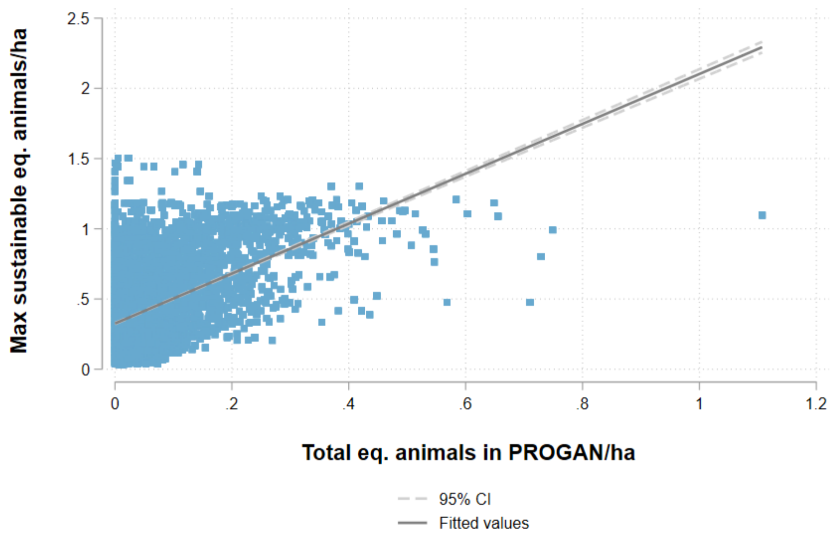
Note: Years 2001-2014. Sample restricted by point scores as described in column heading. Robust standard errors are clustered by ejido for common properties and by municipality for private properties. The estimator is a correlated random effects logit with effects at the ejido level and marginal effects reported. * $p< 0.10$, ** $p< 0.05$, *** $p< 0.01$.

Table F5: Parcel level regressions of deforestation on PROGAN and PES, misclassification correction model

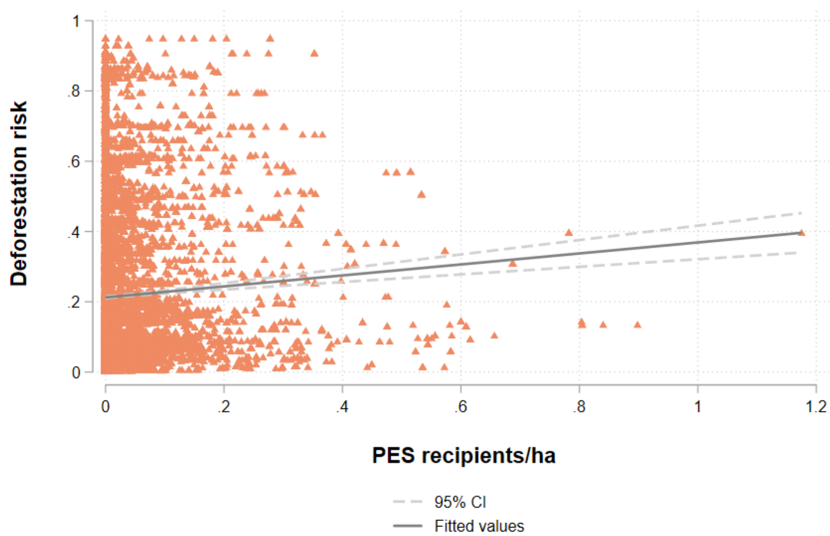
	Deforestation (0/1)			
	Full sample		Parcels > 152 ha	
	(1)	(2)	(3)	(4)
PES recipient (0/1)	-0.004	0.006	-0.005	0.006
	(0.005)	(0.005)	(0.007)	(0.022)
PROGAN subsidy		-0.039		0.482
		(0.116)		(0.352)
PES x Subsidy/ha		-0.409***		-0.769
		(0.145)		(1.228)
Observations	325388	325374	161798	161798
G0	0.000	0.001	0.000	0.002
G1	0.409	0.327	0.408	0.390
logL	-129480.860	-129128.984	-79771.587	-79504.737
Year FE	X	X	X	X
Ejido FE	X	X	X	X

Note: The estimator is the misclassification adjusted logit with ejido level means of all covariates and standard errors clustered at the ejido level. Marginal effects evaluated at sample means are displayed. G0 and G1 are the probability of a false positive and negative, respectively, evaluated at sample means. The false positive and negative rates depend on the number of L7 cloud-free scenes and its interaction with average slope, and with ln(parcel area). Time fixed effects included in all models. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

G Additional figure and table for PROGAN targeting (Section 5)



(a)



(b)

Figure G1: Targeting criteria versus program distribution. Figure a shows the maximum number of animals that can be sustainably enrolled in PROGAN and the intensity of the number of animals enrolled in PROGAN. Figure b shows the deforestation risk and the intensity of PES recipients in hectares. Linear fits and 95% confidence intervals are included.

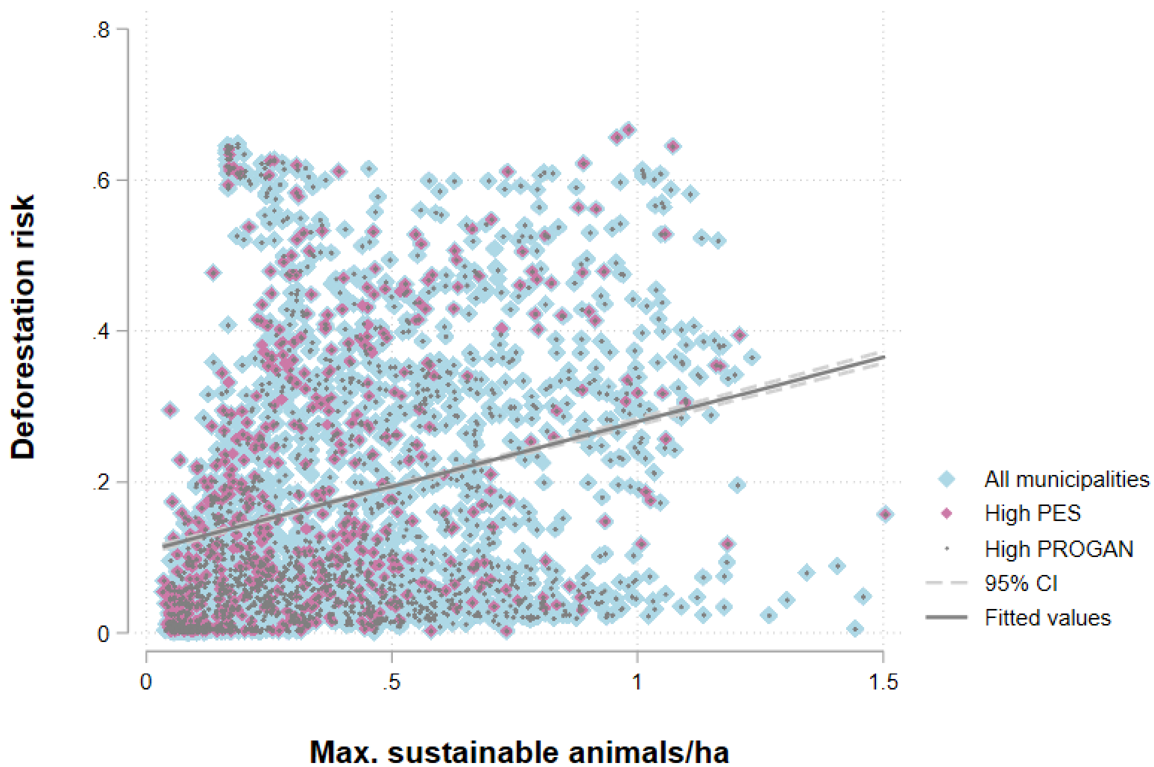


Figure G2: Programs' relative to targeting criteria. Each diamond represents a municipality and year. X-axis is maximum animal equivalents per ha, y-axis measures ln(deforestation risk). Municipalities have an additional pink diamond overlaid when they have PES enrollment above the 75th percentile, and a gray x if they have PROGAN enrollment above the 75th percentile.

Table G1: Impacts of targeting to maximize program benefits

	% Deforestation					
	(1)	(2)	(3)	(4)	(5)	(6)
Subsidy/ha (kMXN)	2.0567***	1.2803***	1.2762	-0.6582	2.2157*	-0.4164
	(0.6558)	(0.4631)	(0.8740)	(0.8242)	(1.3367)	(0.8926)
Subs./ha (kMXN) x Low defor. risk	-1.2127*	-2.1192***			-2.3796	-1.5034
	(0.6943)	(0.7083)			(1.5743)	(1.1858)
Subs./ha (kMXN) x High max animals			0.5945	1.9629**	-0.1858	1.7254*
			(0.9367)	(0.8021)	(1.4402)	(0.9066)
Subs./ha (kMXN) x Low risk x High max animals					1.4037	0.1091
					(1.7114)	(1.2226)
Adjusted R2	0.007	0.039	0.007	0.039	0.007	0.039
Observations	30,269	30,269	30,269	30,269	30,269	30,269
Year FE	X	X	X	X	X	X
Municipality FE	X	X	X	X	X	X
Weights		X		X		X

Note: Years 2001-2014. The sample contains the municipalities considered in all sections of the paper. Robust standard errors are clustered by municipality. * p< 0.10, ** p< 0.05, *** p< 0.01. Weights are baseline forest cover.

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