

**Measuring the REDD effect of
the Payment for Hydrological
Environmental Services
Program in Mexico (PSAH)**

What would have happened...

- Measuring how much deforestation was **avoided** requires comparing:
 - **Observed** deforestation, against
 - the deforestation that **would have happened**.
- But, how to know how much deforestation would have occurred?
 - We need to be able to predict deforestation, and then predict under alternative scenarios.

3 ways to predict:

Naive:

1. It would be the same rate as before.
2. It would be the same number of hectares as before.

Sofisticated:

3. It would follow the same pattern as before (same coefficients, updated variables).

The Reality and the Problem.

- **Reality** always differs from prediction, but it could be a small difference if you have a good model.
- The real **problem** of using naive baselines is that they are only useful for large aggregates (national level, state level).

A 4th way: ex post

- In social policy evaluations (anti-poverty) regression analysis is used to compare a group of participants in a program with a group of non participants.
- Controlling for the rest of the variables that influence the result, and selection bias, the effect of the program on the target behaviour or state is measured.

Expressing it mathematically

- $\text{Result} = A + B1(\text{variable}) + B2(\text{program}) + e$, where
 - A is the base behaviour
 - $B1$ captures the influence of site & owner characteristics
 - $B2$ is the specific influence of the program
 - e represents the effect of random variables
- For those that **did not** participate in the program their behaviour is equal to $A + B1(\text{variable}) + e$
- For those that **did** participate in the program the outcome is $A + B1(\text{variable}) + B2 + e$

To measure the effect of PSAH

- We use two approaches:
 - **Ex-ante**. Important to target future payments.
 - **Ex-post**. Important to measure the truly avoided deforestation.
- Because they are **pixel**-level analysis a REDD effect can be calculated for **each property/territory**.

The basic model

- Land use is determined by (common/individual) forest owners who choose among alternatives the one that represents the higher net present value of **income flows** (Von Thunen) (Chomitz). Preserved or sustainably used forests is one of the options.
- So, the observed deforestation in a particular period of time would come from:
 - Plots where the relative profitability of agriculture or cattle ranching was already greater than the forest but change had not happened yet.
 - Plots where circumstances changed in such a way that the relative profitability of agriculture or pastures increased.

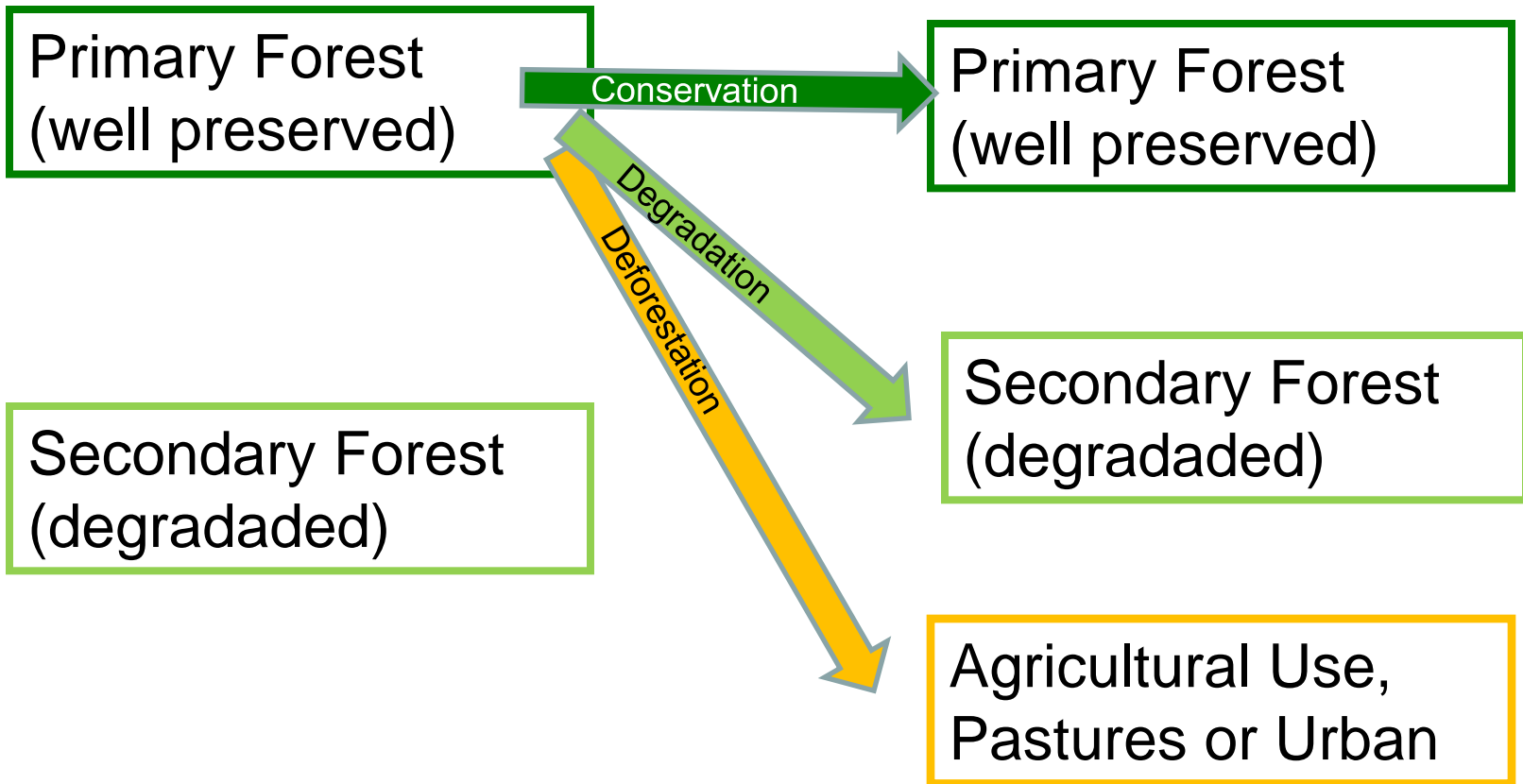
Ex-post model for PSAH

- Data base:
 - Random Sample National Forest Inventory 2000: 153,764 pixels with forests, 2 kms away from each other.
 - 4,419 of them with PSAH, 149,345 without PSAH
 - Variation in:
 - Slope
 - Type of Ecosystem
 - Distance to population and markets
 - Level of Marginality
 - NPA, forestry activity, etc...
 - Pixels observed again in the 2007 Forest Inventory.

Possible Outcomes

Inventory 2000

Inventory 2007



Possible Outcomes

Inventario 2000

Inventario 2007

Primary Forest
(well preserved)

Primary Forest
(well preserved)

Secondary Forest
(degradaded)

Secondary Forest
(degradaded)

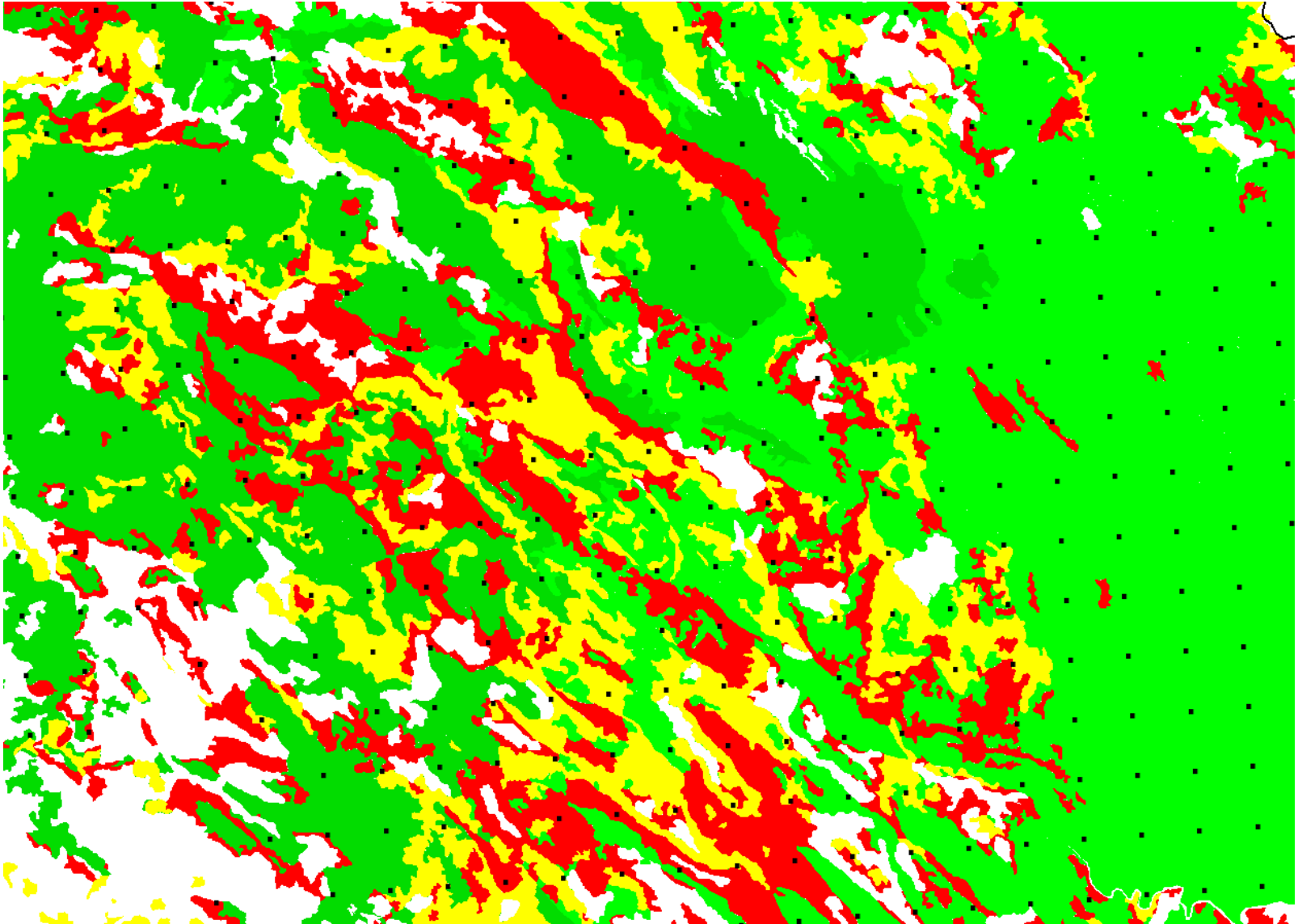
Uso Agropecuario o
Urbano

Regeneration

No Change

Deforestation

A set of sample points



The econometric model

- The explanatory variables are qualitative:
 - Was it deforested? Yes/No
 - Was it degraded, deforested or preserved?
- Use qualitative dependent variable models: **Probit**, Ordered Probit, Multinomial Logit
- Explained with economic variables regarding **plot** and **owners**

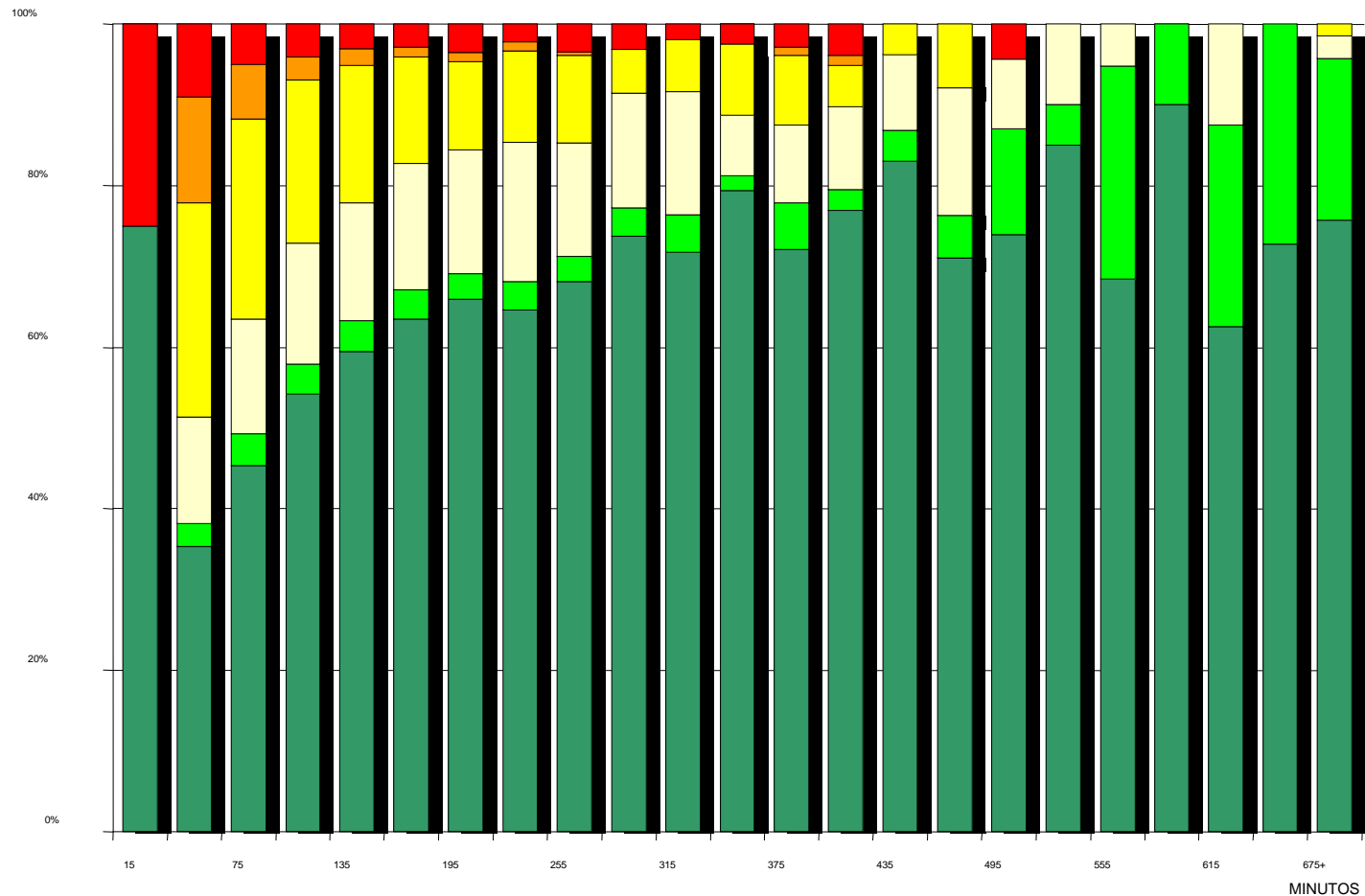
Probit Model:

What explains deforestation?

Proxies for the explanatory variables:

1. Access to Local Markets
2. Access to Regional Markets
3. Poverty/Marginality of forest owners and neighbours
4. Natural Protected Area System
5. Slope, Potential Ag Yields
6. **PSAH or not PSAH**

Land use changes and distance to the nearest town



Primario conservado

Secundario regenerado

Primario degradado

Secundario sin cambio

Secundario deforestado

Primario deforestado

Probability of Deforestation depends on:

Variable	Unit	Estimated Coefficient	Marginal Change in Probability	Signif> 90%
Constant		-2.91		Sí
Distance to nearest town	Minutes	-0.0038	-0.0001	Sí
Distance to nearest city	Minutes	-0.00011	-0.000004	Sí
Marginación de población local	Level [0 , 5.5]	0.13	0.005	Sí
Average Yield of Corn in AGEB	Tons/ha	0.18	0.007	Sí
Slope	%	-0.0048	-0.0002	Sí
Agricultural Frontier	% of pixels around with Ag	0.74	0.0278	Sí
Natural Protected Area	within one	-0.27	-0.008	Sí
PSAH	Does participate	-0.25	-0.007	Sí

A similar regression done using data from the 1990s was used for targeting

Basic interpretation of results :

- *How does the probability that a determined **pixel** of 9 hectares was deforested between 2000 y 2007 change when one of the explanatory variables change?*
 - *Distance*
 - *Marginality*
 - *Fertility*
 - *Slope*
 - *Declared as Natural Protected Areas*
 - *PSAH*

Basic interpretation of results ::

- *How does the probability that a determined **pixel** of 9 hectares was deforested between 2000 y 2007 change when one of the explanatory variables change?*
- By aggregating the probability of all pixels that share characteristics one obtains a percentage, a **rate of deforestation**.

In Public Policy terms:

- How does the rate of deforestation change, for equivalent plots, whenever these receive a payment for environmental services ?

Example:

“Those cloudforests located half an hour away from the closest town, three hours away from the nearest city, with a slope of 15%, relatively fertile soil (2 tons/ha of corn yield), with a high level of marginality in the area, not declared a Natural Protected Area, were deforested at a rate of $x\%$ if they were not part of PSAH. However, those that did participate the full 4 years in PSAH had a deforestation rate of only $x\%$.”

To evaluate PSAH:

- How does the rate of deforestation change, for equivalent plots, whenever these receive a payment for environmental services ?
- This can be answered to all combination of forests, according to ecosystem, location, marginality, environmental regulation, etc...

Fact: Those selected for PSAH in 2003-2006 were not among the ones at higher risk (due to aforementioned targeting failure)

PSAH	Totales Hectares (thousands)	Deforestation Risk Index (1990s based)
Participants	1,886	0.009
Non participants	63,868	0.034

First step: compare deforestation rate observed in forests with/without PSAH.

PSAH	Observed Deforestation 2000-2007	
	k-has	%
Participantes	12	0.6%
No participantes	2,372	3.7%

Difference is due to the initial difference in deforestation risk index AND the effect of PSAH

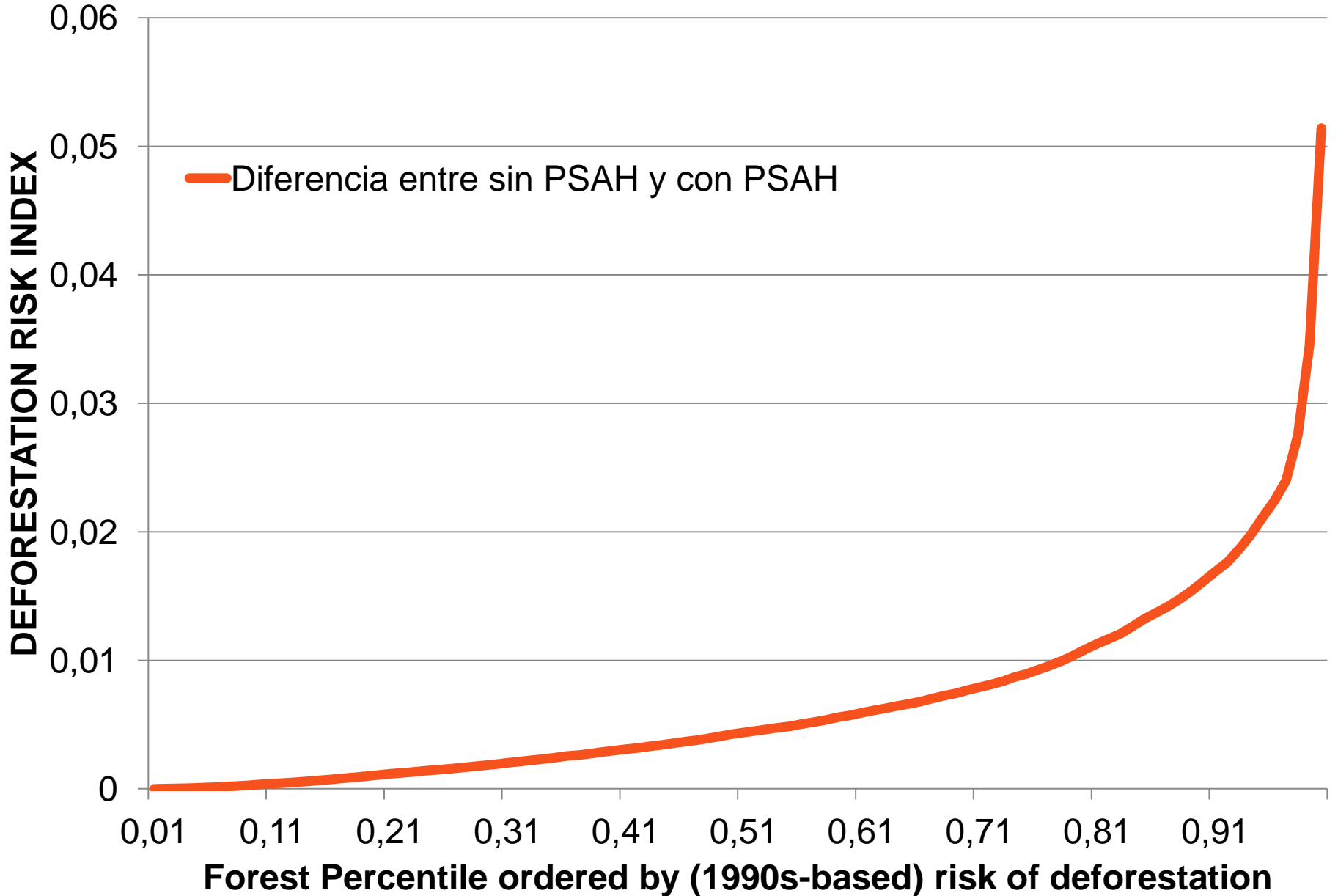
How can these two effects be separated?

Second Step: Use econometric model to predict what would have happened in both type of forests...



PSAH	Observed Deforestation 2000-2007		Without PSAH they would have deforested in ...		Deforestation Avoided by PSAH (with respect to the observed one)	
	k-has	%	k-has	%	k-has	%
Participantss	12	0.6%	30	1.6%	18	1.0%
No participantss	2,372	3.7%	2,372	3.7%		

Difference in the DEFORESTATION RISK INDEX with and without PSAH



Alternatively: Compare prediction with and without.

PSAH	Observed Deforestation 2000-2007		Predicted Deforestation 2000-2007		Without PSAH they would have deforested in ...		Deforestation Avoided by PSAH (comparing predictions with/without)	
	k-has	%	k-has	%	k-has	%	k-has	%
Participantes	12	0.6%	17	0.9%	30	1.6%	13	0.7%
No participantes	2,372	3.7%	2,197	3.4%	2,197	3.4%		

In terms of Reducing Emmissions of CO₂e due to Avoided Deforestation (REDD)

Type of Forest	Deforestation avoided thanks to PSAH (thousand ha)	Tons of CO ₂ per hectare	CO ₂ e emissions avoided by PSAH (tons)
Pine Forest	1,752	113+63	268,607
Oak-Pine Forest	3,355	83+89	539,251
Oak	1,855	58+69	217,074
Cloudforest	252	58+69	29,635
Dry Tropical Forest	1,168	24+70	154,572
Medium Tropical Forest	3,439	125+177	599,930
Rainforest	1,022	125+177	516,327
Total	12,843		2,325,396

In terms of Reducing Emissions of CO₂e due to Avoided Deforestation (REDD)

	Deforestation Avoided by PSAH (ha)	Emissions of CO ₂ e avoided (ton)
Method 1: Comparing predictions with/without	13,449	2,325,396
Method 2: Comparing observed deforestation vs prediction without PSAH	18,332	3,231,157

(Parenthesis)

**How good are our
predictions?**

Using the 1990s data, a Deforestation Risk Index was calculated and used for the targeting criteria introduced in the 2007 version of PSAH rules onward

RISK OF DEFORESTATION INDEX

	Very Low	Low	Medium	High	Very High
Deforestation	1.8%	3.8%	5.3%	9.8%	19.1%
Degradation	14.1%	17.5%	19.7%	20.4%	13.4%
Regeneration	11.3%	10.7%	10.9%	9.5%	4.1%
No Change	72.8%	67.9%	64.1%	60.4%	63.4%
	100%	100%	100%	100%	100%

(Close Parenthesis)

New question:

**Do years in the program
make a difference?**

Probability of Deforestation depends on:

Variable	Unit	Estimated Coefficient	Marginal Change in Probability	Signif > 90%
Constant		-2.50		
Distance to nearest town	Minutes	-0.004	-0.0001	Sí
Distance to nearest city	Minutes	-0.00009	-0.000003	Sí
Marginación de población local	Level [0 , 5.5]	0.15	0.004	Sí
Average Yield of Corn in AGEB	Tons/ha	0.17	0.006	Sí
Slope	%	-0.005	-0.0002	Sí
Agricultural Frontier	% of pixels around with Ag	0.17	0.006	Sí
Natural Protected Area	within one	-0.17	-0.006	Sí
PSAH	Years in the program	-0.08	-0.003	Sí

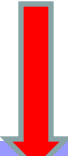
Taking into account that each cohort has different characteristics, more deforestation is avoided the more years the community participates in PSAH

Hectáreas participando en PSAH	Año en que entran	Deforestación observada 2000-2007		Deforestación predicha 2000-2007		Sin PSAH se hubieran deforestado		Deforestación Evitada por el PSAH	
		k-has	%	k-has	%	k-has	%	k-has	%
170	2003	0.45	0.3%	0.77	0.5%	1.98	1.2%	1.22	0.72%
560	2004	3	0.5%	3.50	0.6%	7.41	1.3%	3.91	0.70%
270	2005	3	1.1%	2.07	0.8%	3.60	1.3%	1.53	0.57%
292	2006	0.90	0.3%	2.19	0.7%	3.19	1.1%	1.00	0.34%
593	2007	5	0.8%	11.35	1.9%	13.45	2.3%	2.10	0.35%
1,886	todos	12	0.6%	19.90	1.1%	29.77	1.6%	9.87	0.52%
63,899	No participantes	2,372	3.7%	1,008.73	1.6%	1,008.73	1.6%	0	0%
65,785	Total	2,384	3.6%	2,156	3.28%	2,165.93	3.29%	10	0.02%

New question:

**Can other programs be
evaluated also?**

The same approach to evaluate other programs: Case: Natural Protected Area System



Hectáreas declaradas como ANPS	Total Area	Observed Deforestation 2000-2007		Predicted Deforestation 2000-2007		Without NPA deforestation would have been...		Avoided Deforestation thanks to NPA status	
		k-has	k-has	%	k-has	%	k-has	%	k-has
Natural Protected Areas (federal)	6,099	75	1.2%	77	1.3%	114	1.9%	37	0.6%
Naturales Areas not protected	59,654	2,308	3.9%	2,086	3.5%	2,086	3.5%	0	0%
Total	65,753	2,384	3.6%	2,163	3.3%	2,200	3.3%		

In terms of REDD, the effects of each program are summed...

Pine Forest	Emisiones de CO2e evitadas gracias al PSAH 2000-2007(tons)	Emisiones de CO2e evitadas gracias al SINANP 2000-2007 (tons)
Pine –Forest	268,607	328,358
Oak-Pine Forest	539,251	1,267,053
Oak Forest	217,074	1,163,208
Cloudforest	29,635	40,782
Dry Tropical Forest	154,572	1,992,598
Medium Tropical Forest	599,930	1,749,648
Rainforest	516,327	1,586,506
Total	2,325,396	8,128,154

Programs that could be evaluated according to their **Deforestation Avoided/Induced**

1. Payment for Environmental Services: **PSAH**
2. Strategic Support for development of Community Forestry Firms:
 - Timber (Procymaf, Prodefor)
 - Ecotourism, Hunting
3. Regulation: Ej: **ANPs**, **Enforcement**.
4. Support for activities that expand the agricultural frontier:
 - Cattle ranching (PROGAN: direct payments)
 - Agriculture (irrigation, fuel, other inputs)

Probability of Deforestation depends on:

Variable	Unidad	Coefficiente estimado	Cambio mrg en probabilidad	Signif> 90%
Constant		-2.12		Sí
Distance to nearest town	Minutos	-0.0038	-0.0001	Sí
Distance to nearest city	Minutos	-0.0005	-0.000012	Sí
Marginación de población local	Nivel [0 , 5.5]	0.09	0.003	Sí
Average Yield of Corn in AGEB	Tons/ha	-0.02	-0.0007	NO
Slope	%	-0.013	-0.0003	Sí
Agricultural Frontier	Proporción de píxeles alrededor	0.64	0.02	Sí
Natural Protected Area	Está en una	-0.30	-0.006	Sí
Sustainable Forestry Management Plan	Ejido tiene o no	-0.42	-0.007	Si
PSAH	Participa Si/ No	-0.47	-0.008	Sí

Estados: D.F., Estado de México, Morelos, Oaxaca, Puebla, Querétaro, Veracruz.

Support for Cattle Ranching: PROGAN

- Subsidies during a 4 year period: A total of US\$145 per animal.
- Conditioned to improving ranching practices. Efficiency.
- A budget of US\$800 million per year

Probabilidad de Deforestar depende de:

Variable	Unidad	Coefficiente estimado	Cambio mrg en probabilidad	Signif> 90%
Constante		-2.65		Sí
Distancia a poblado más cercano	Minutos	-0.0039	-0.0001	Sí
Distancia a ciudad más cercana	Minutos	-0.00005	-0.000002	No
Marginación de población local	Nivel [0 , 5.5]	0.11	0.004	Sí
Productividad media del maíz en AGEB	Tons/ha	0.16	0.006	Sí
Pendiente del terreno	%	-0.0048	-0.0002	Sí
Frontera Agrícola	Proporción de píxeles alrededor	0.73	0.0277	Sí
Área Natural Protegida	Está en una	-0.17	-0.006	Sí
PROGAN	Monto promedio por hectárea	0.00097	0.00004	Si
PSAH	Participa Si/ No	-0.25	-0.007	Sí

In terms of **REDD**, the effects of each program are summed and subtracted

Tipo de Bosque	Emisiones de CO2e evitadas gracias al PSAH 2000-2007(tons)	Emisiones de CO2e evitadas gracias al SINANP 2000-2007 (tons)	Emisiones de CO2e inducidas debido a PROGAN 2003-2006 (tons)
Pino y otras coníferas	268,607	328,358	897,605
Pino-Encino y Encino-Pino	539,251	1,267,053	2,204,709
Mesófilo	29,635	40,782	195,302
Encino y otros	217,074	1,163,208	2,303,659
Selva baja	154,572	1,992,598	13,452,319
Selva mediana	599,930	1,749,648	11,828,834
Selva alta	516,327	1,586,506	7,400,677
Total	2,325,396	8,128,154	38,283,105