

# Illegal Crops and Deforestation: Impact of OxyContin Reformulation on Mexican Forests

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## 1. Background

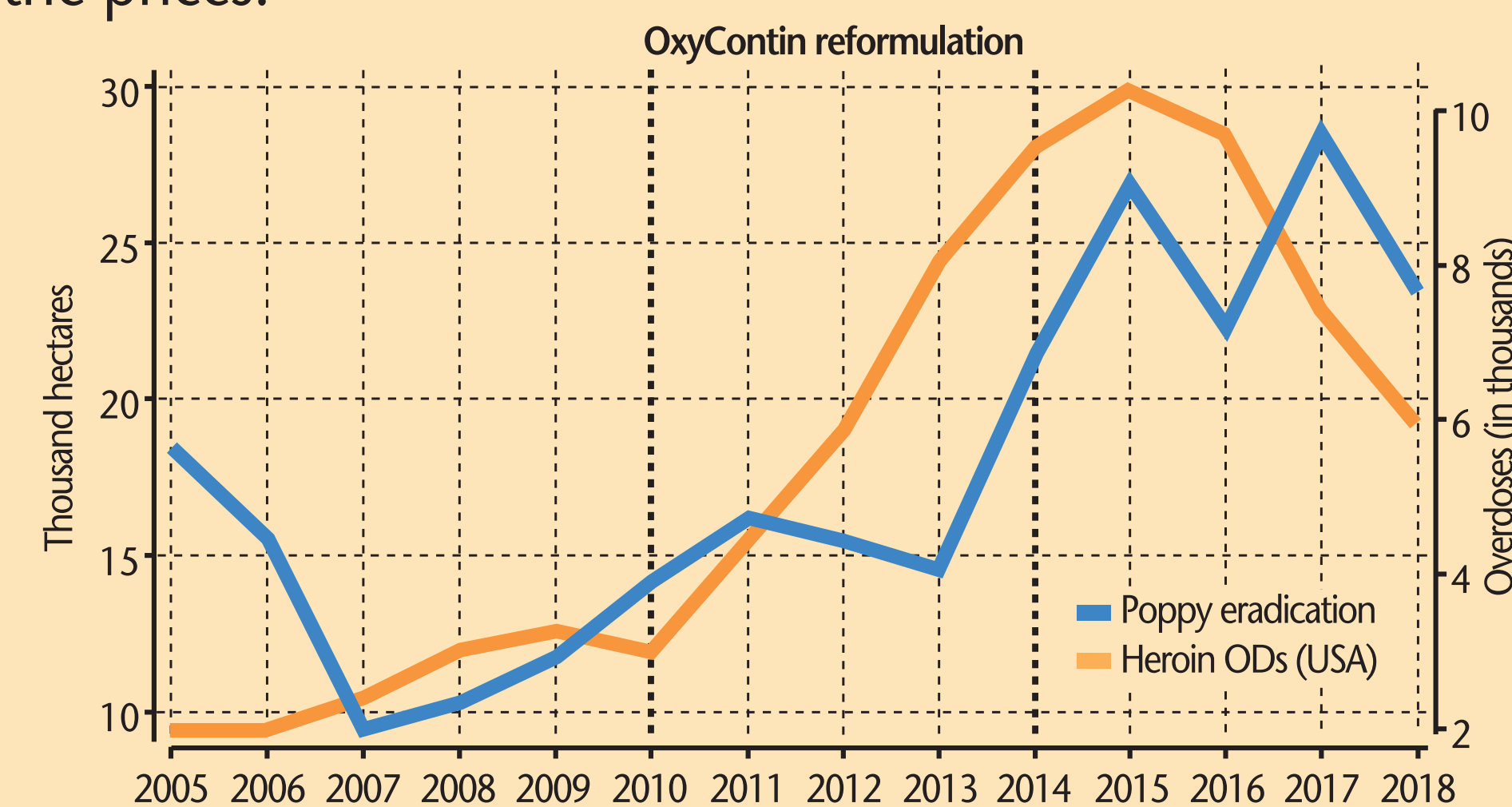
### 1.1 U.S. opioid crisis and OxyContin reformulation

- Usage of opioids, a drug for acute and chronic pain, tripled between 1996 and 2011 in the U.S. (Evans et al., 2019).
- OxyContin became a highly used opioid due to aggressive marketing techniques employed by Purdue Pharma.
- Until 2010, OxyContin could be crushed into powder for recreational use, resulting in effects similar to heroin. In 2010, Purdue Pharma released an abuse-deterrent version of OxyContin.
- Consequently, the demand for street heroin in the U.S. increased (figure 1), leading to a one-for-one substitution in states with abundant heroin availability (Evans et al., 2019).

### 1.2. Its impact on poppy cultivation in Mexico

- Mexico is the primary supplier of heroin to the U.S., sourcing poppy, its raw ingredient, mostly within country.
- Poppy demand increased, but the supply did not immediately follow. Poppy eradication data suggests a rise in the cultivated area since 2014 (figure 1).
- Farm-gate poppy prices experienced a delayed increase, with cartels controlling the prices.

Figure 1: Evolution of annual heroin overdoses in U.S. and poppy eradication in Mexico



Source: Overdose data is from CDC and poppy eradication is from SEDENA

## 2. Research question and findings

- This study examines the impact of OxyContin reformulation on deforestation in municipalities suitable for poppy cultivation (Daniele et al., 2023; Sobrino, 2020).
- Poppy is a profitable cash crop with low production costs. It is primarily cultivated in isolated areas near or within forests, primarily in two regions of Mexico (figure 2.2).
- Does a demand shock on an illegal, high-profit cash crop influence deforestation? What are the underlying mechanisms driving this impact?
- Main findings:** During high farm-gate price period (2014-2018), areas suitable for poppy cultivation were associated with: (1) reduced deforestation, (2) decreased expansion of legal crops, and (3) increased number of cartels and poppy eradication efforts (table 1).
- A 1% increase in poppy suitable area (in sq. km) leads to a 9-hectare decrease in deforestation during 2014-2018 (table 1).

## 3. Empirical strategy: Difference-in-differences

- Methodology adapted from Daniele et al. (2023), using geographical variation in poppy and cannabis suitability (figure 2.1).
- Sample includes municipalities suitable for poppy and/or cannabis cultivation only.
- Poppy suitability index serves as a proxy for cultivation and is associated with poppy eradication (figure 2.2).
- Threat to identification:** Outcomes do not exhibit a significant linear trend before the demand shock, and baseline characteristics are not significantly linked to poppy suitability.

Figure 2.1: Geographical variation of poppy and cannabis suitability index  
Source: Daniele et al. (2023)

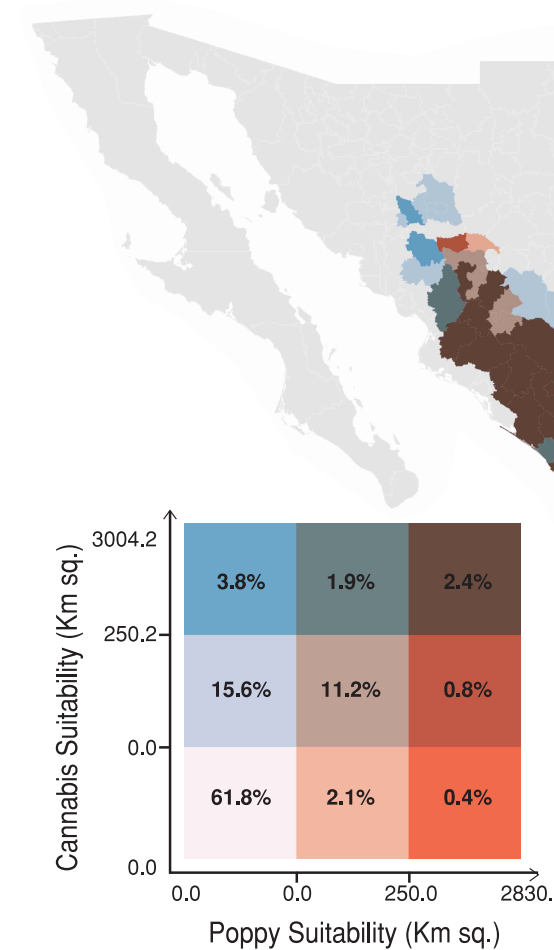
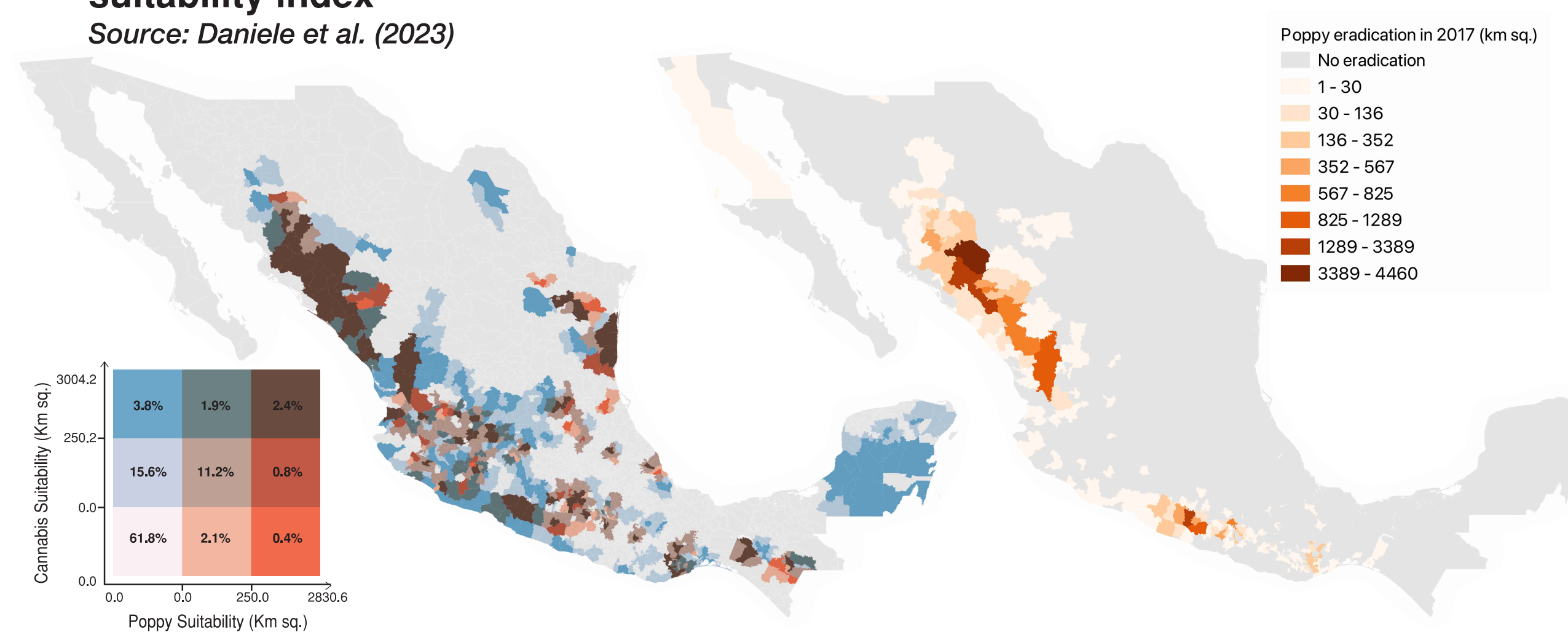


Figure 2.2: Distribution of poppy eradication in 2017  
Source: SEDENA



### Specification

$$Y_{it} = \beta_1 PS_{it} \times Period_{(2010-2013,t)} + \beta_2 PS_{it} \times Period_{(>2013,t)} + X'_{it} \gamma + \delta_i + \phi_t + \psi_{mt} + \epsilon_{it}$$

$Y_{it}$  is outcome in municipality  $i$  and year  $t$ ,  $PS_{it}$  is poppy suitability in  $km^2$  (IHS-transformed),  $Period_{(2010-2013,t)}$  and  $Period_{(>2013,t)}$  equal 1 during indicated period,  $X'_{it}$  cannabis suitability interacted with year dummies  $\delta_i$ ,  $\phi_t$  and  $\psi_{mt}$  are municipality, year, and macro region year fixed effects.

Table 1: Impact of OxyContin reformulation on land use and violence

	Deforestation	Agriculture area	Poppy eradication	Homicide	Cartel	
	(1) Z-score	(2) Z-score	(3) Z-score	(4) Z-score	(5) Presence	(6) Quantity
PS x Period (2010-2013)	-0.005 (0.012)	-0.014 (0.010)	0.008 (0.007)	0.018** (0.008)	0.003 (0.003)	0.013* (0.008)
PS x Period (2014-2018)	-0.020** (0.010)	-0.023** (0.011)	0.019** (0.008)	-0.000 (0.008)	0.004 (0.003)	0.020** (0.007)
Observations	13,127	13,127	13,127	13,127	13,127	13,127
R <sup>2</sup>	0.003	0.001	0.001	0.001	0.000	0.001

\* p < 0.10 \*\* p < 0.05 \*\*\* p < 0.01 SEs are clustered at state-year level. All regressions include unit, year and macro.

Table 2: Investigating mechanisms: migration, household income, yields

	Migration to U.S.	Household level income		Agricultural variables (crop, unit, year FEs)		
	(1) lhs(Migration)	(2) lhs(Income)	(3) ... has TV	(4) Z-score prod.	(5) Z-score area	(6) Z-score yield
PS x Period (2010-2013)	-0.003 (0.003)	-0.010 (0.017)	-0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.001)
PS x Period (2014-2018)	-0.011*** (0.002)	-0.010 (0.024)	0.000 (0.001)	-0.001 (0.001)	-0.002*** (0.001)	0.001** (0.001)
Observations	11,256	4,459,825	5,628,513	393,960	393,960	393,960
R <sup>2</sup>	0.002	0.061	0.024	0.000	0.000	0.000

\* p < 0.10 \*\* p < 0.05 \*\*\* p < 0.01

## 4. Mechanisms

### 4.1. Does out-migration to U.S. reduce pressure on forests?

- Daniele et al. (2023) found a positive association between migration to the U.S. and poppy suitability after a violent period, using U.S. state - Mexico municipality pairs fixed effects.
- My aggregated analysis indicates an opposite relationship during the same period (table 2), suggesting less migration to the U.S. during the high poppy price period.

### 4.2. Is there an increase in household income?

- No evidence of an increase in household income based on census data (table 2).
- Households may not declare earnings related to poppy cultivation, but material possessions such as owning a TV are also not associated with poppy suitability (table 2).

### 4.3. How are legal crops influenced by the poppy demand shock?

- Using a more detailed fixed effects structure (crop, municipality, year), I find that poppy suitability is associated with an increase in average crop yields (table 2).
- This may be due to the abandonment of subsistence farming as a result of out-migration and/or the intensification of farming practices due to income from poppy cultivation.

## 5. Discussion

- During the price boom period, illegal crops may reduce deforestation in short term by limiting the expansion of legal crops.
- In the case of poppy cultivation in Mexico, the reduction in agricultural expansion is accompanied by an increase in average crop yields for legal crops.
- To-do:** Investigate whether the increase in crop yields is a result of intensification or the abandonment of less productive subsistence farming.

## 6. References

- Daniele, G., Le Moglie, M., and Masera, F. (2023). Pains, guns and moves: The effect of the US opioid epidemic on Mexican migration. *Journal of Development Economics*, page 102983.
- Sobrino, F. (2020). Mexican cartel wars: Fighting for the US opioid market. URL: <https://www.fersobrino.com/files/DraftPaper.pdf>
- Evans, W. N., Lieber, E. M., and Power, P. (2019). How the reformulation of OxyContin ignited the heroin epidemic. *Review of Economics and Statistics*, 101(1):1-15