

## Motivation & Background

### I. Second Indochina War 1955 – 1975:

- South Vietnam & the US: South Vietnam as an independent political entity – away from communist influence
- North Vietnam & National Liberation Front (NLF)/Viet Cong: a unified Vietnam under communism
  - National Liberation Front (NLF) (a.k.a. Viet Cong) is a group of pro-communist South Vietnamese

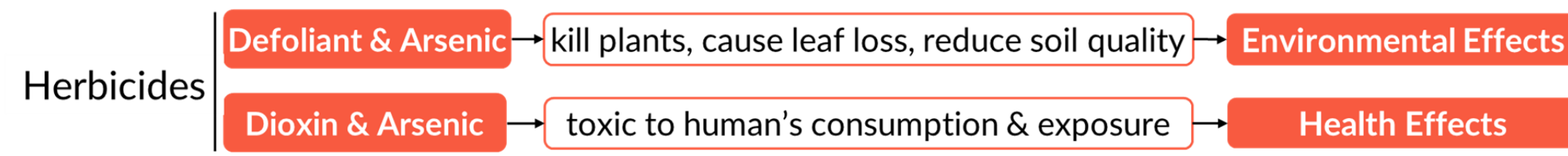
### II. Operation Ranch Hand 1961 – 1971: Spraying of herbicides and defoliants

Goal: Derive NLF/Viet Cong's and North Vietnamese Army's vegetation coverage and food sources

#### Outcomes:

- 20 millions gallons of herbicides were sprayed on South Vietnam
- 2.1 – 4.8 million Vietnamese civilians directly affected
- At least 20% of forests in South Vietnam were sprayed at least once

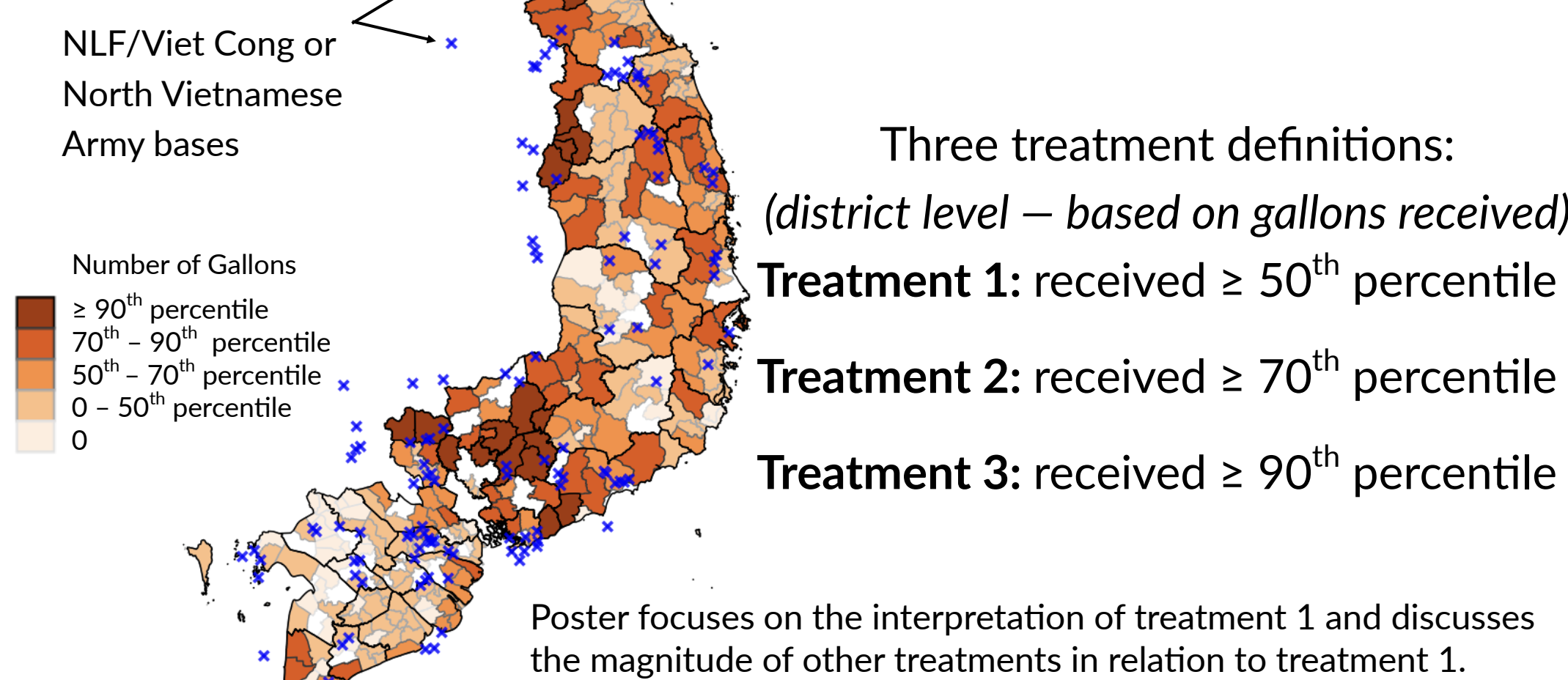
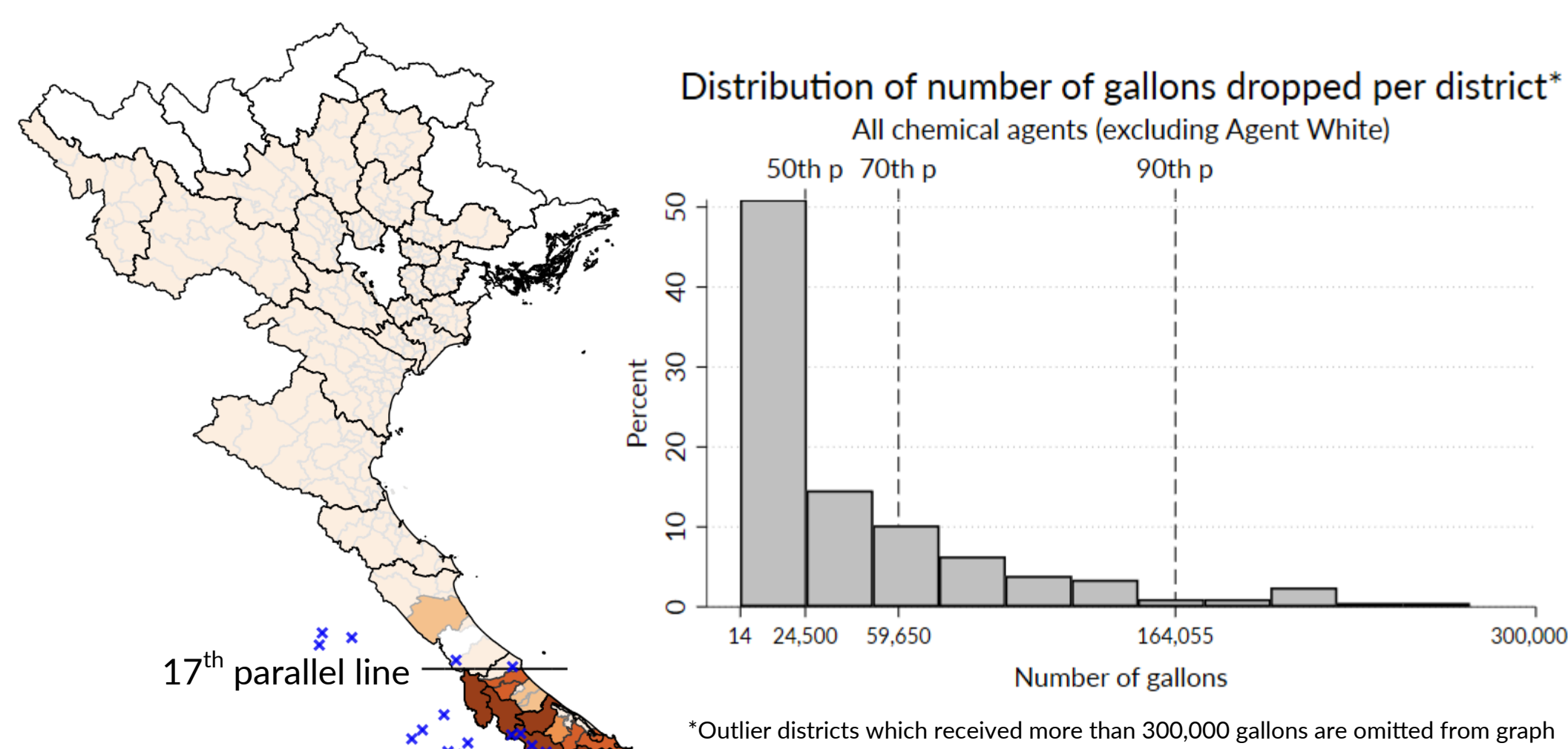
### III. Herbicides used have 2 effects:



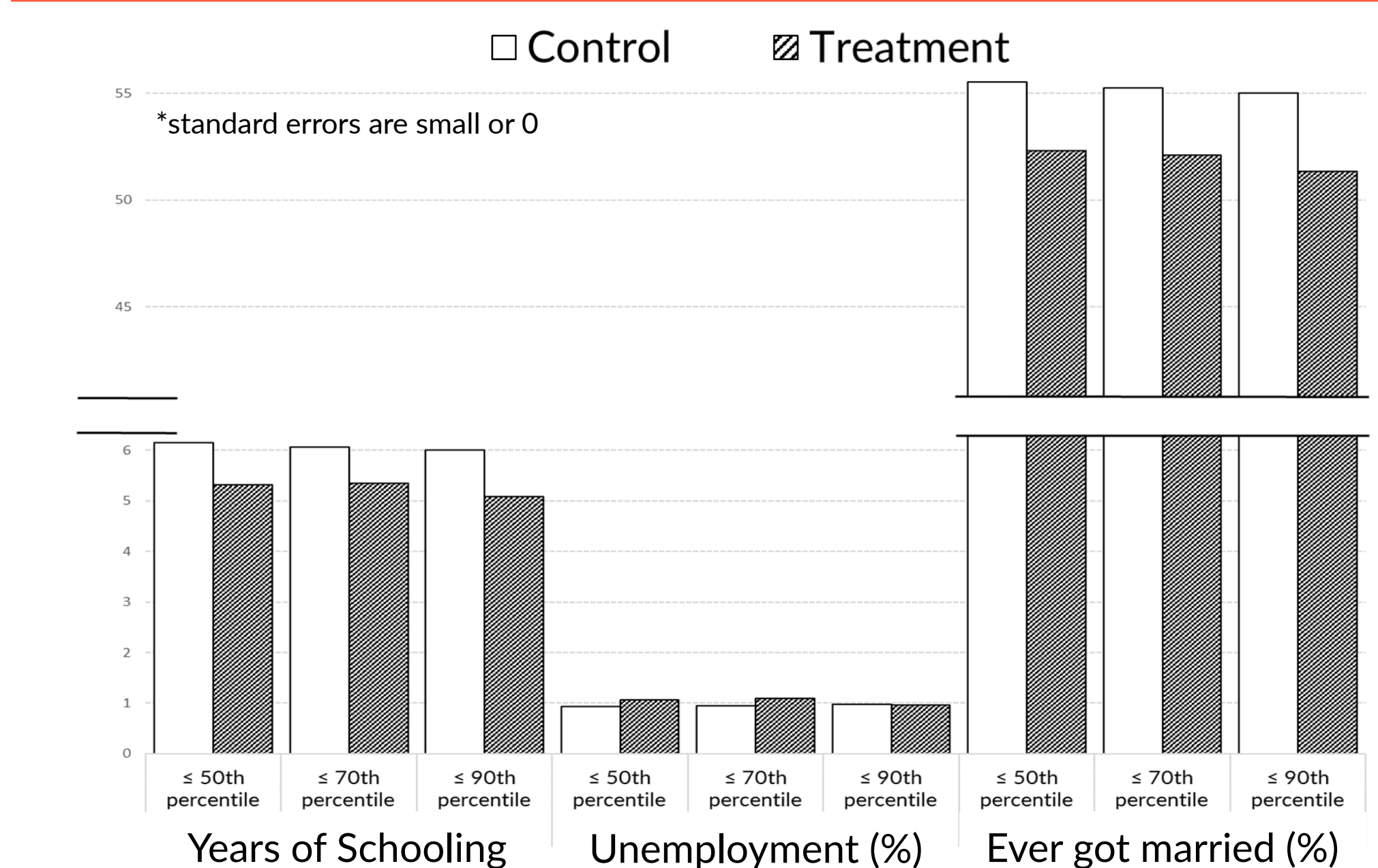
## Data

- Spraying mission:** Herbicide Reporting System
- Individual characteristics:** 2009 Vietnam Population and Housing Census
- Bombing Intensity:** (Miguel and Roland, 2011)
- Land use data:** Advanced Land Observing Satellite Science Project
- Elevation and soil types:** (Hawker and Neal, 2021) & Food and Agriculture Organization of the UN
- Location of NLF/Viet Cong or North Vietnamese Army bases (instrument):** Department of Defense, United States

## Variation in Herbicides Spraying



## Summary Statistics



## Reference

Miguel, E., & Roland, G. (2011). The long-run impact of bombing Vietnam. *Journal of Development Economics*, 96(1), 1-15.

# Fortune Sons, Unfortunate People: The Legacy of Herbicidal Warfare in Vietnam

Author: Trang Truong

Advisors: Nicole Fortin & Felipe Valencia Caicedo

## Research Questions & Literature

- Does **herbicide spraying** have long-term effects on current years of schooling, and employment outcomes?
  - Nguyen (2023) – Agent Orange lowers years of schooling, increases unemployment rate, and (direct exposure) increases mobility disability.
- Are both the **environmental** and **health effects** persistent?
  - Le, Pham, and Polachek (2022); Yamashita and Trinh (2022) – direct exposure to Agent Orange increases mobility disability.
  - Appau et. al. (2021) – Agent Orange and negative household rice production.

## Research Design – IV

**Instrument:** Distance from a district centroid to an NLF/Viet Cong or North Vietnamese Army base (Le, Pham, and Polachek, 2022)

- Exclusion Restriction:** Base locations are designed to be mobile and unpredictable. On average, a base is active for about 2 years before being abandoned or destroyed.

$$\text{First-stage regression: } Treated_{id} = \alpha_0 + \alpha_1 Dist\_base_{id} + \alpha_2 X_{id} + v_d$$

$$\text{Second-stage regression: } Y_{id} = \beta_0 + \beta_1 Treated_{id} + \beta_2 X_{id} + u_{id}$$

$Dist\_base_{id}$  – Distance between a district centroid and an NLF/Viet Cong or a NVA base (in km)

$Treated_{id}$  – Indicating variable if a district receives more gallons of herbicides than the cutoff at 50<sup>th</sup>, 70<sup>th</sup>, and 90<sup>th</sup> percentile

$Y_{id}$  – outcome of interests for individual  $i$  residing in district  $d$

$X_{id}$  – a set of controls at the individual level, including demographic characteristics, disability status; and at the district level, including rural, elevation, soil composition, and bombing intensity.

\*District level regression looks at the proportion of land use for agriculture

## Main Results: Unemployment

Individuals in 50<sup>th</sup> treated districts are **200% more likely to be unemployed.**

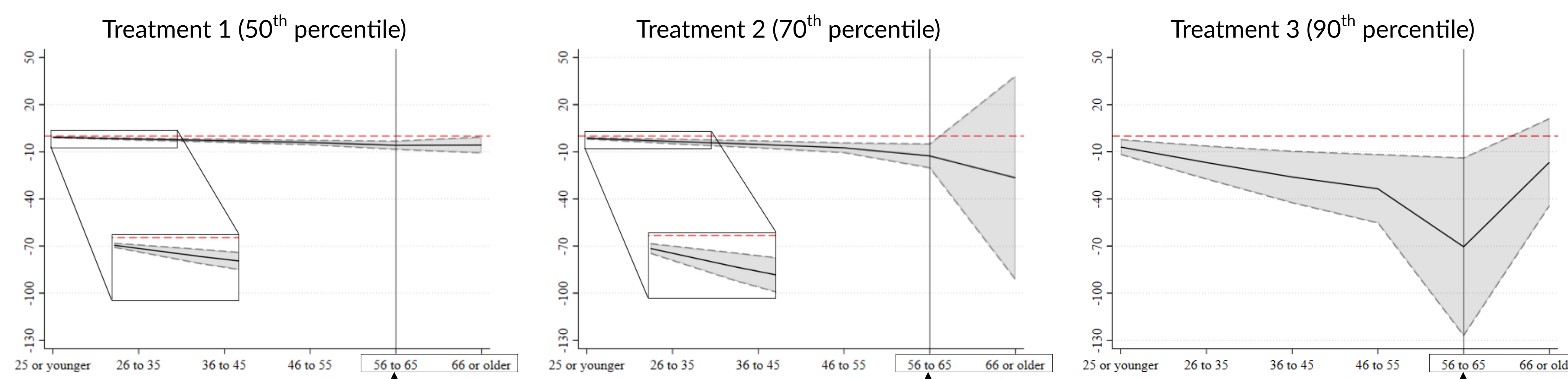
Dependent Variable	Unemployed		
	OLS (1)	2SLS (2)	2SLS (3)
Treated ( $\geq 50^{\text{th}}$ percentile)	0.004*** (0.001)	0.018*** (0.003)	0.020*** (0.004)
Mean in the control group	0.010	0.010	0.010
Treated ( $\geq 70^{\text{th}}$ percentile)	0.004*** (0.001)	0.031*** (0.006)	0.035*** (0.008)
Mean in the control group	0.010	0.010	0.010
Treated ( $\geq 90^{\text{th}}$ percentile)	0.002 (0.002)	0.111*** (0.032)	0.153*** (0.050)
Mean in the control group	0.011	0.011	0.011
Geographical characteristics	Yes	Yes	Yes
Bombing Intensity	Yes	No	Yes

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Standard errors clustered at the district level are in parentheses. There are 6,920,278 observations and 447 clusters. All columns include demographic characteristics, education and disability status control.

## Main Results: Years of Schooling by Age Group

In treated districts, **post-war cohorts** (i.e., 55 or younger) have **fewer years of schooling.**

The **negative effects** on schooling are **larger** for districts with **higher levels** of herbicide exposure.



Cohorts that completed 12 years of high school education + 4 years of college before or during the war

## Contributions

- Provide evidence of the **environmental effects**
  - Literature focused on Agent Orange & direct-exposure health outcomes.
- Consider **all herbicides** with dioxin and arsenic components
  - Literature focused on Agent Orange, which is incomplete.

Environmental and Health (Dioxin)	Environmental and Health (Arsenic)	Environmental only
Agent Orange Agent Pink Agent Purple Agent Green	Agent Blue	Agent White

### 3. Further evidence on the long-term effects of war

- Miguel & Roland (2011) - no long-term impacts of bombing on local poverty rate, consumption levels, infrastructure, and literacy rate.

## Environmental or Health?

There is no conclusive evidence for the health effects.

Dependent Variables	Unable to work, disability & health			Ratio Children Survived-Born		
	OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)
Treated ( $\geq 50^{\text{th}}$ percentile)	-0.004*** (0.001)	-0.001 (0.004)	-0.002 (0.004)	-0.001 (0.001)	0.003 (0.002)	0.004 (0.002)
Mean in the control group	0.015	0.015	0.015	0.984	0.984	0.984
Treated ( $\geq 70^{\text{th}}$ percentile)	-0.001 (0.001)	-0.001 (0.006)	-0.004 (0.007)	-0.001 (0.001)	0.006 (0.004)	0.007 (0.004)
Mean in the control group	0.015	0.015	0.015	0.984	0.984	0.984
Treated ( $\geq 90^{\text{th}}$ percentile)	-0.005*** (0.002)	-0.005 (0.022)	-0.016 (0.030)	-0.004* (0.002)	0.023 (0.016)	0.035 (0.024)
Mean in the control group	0.015	0.015	0.015	0.984	0.984	0.984
Geographical characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Bombing Intensity	Yes	No	Yes	Yes	No	Yes
Observations	6,920,278	6,920,278	6,920,278	930,356	930,356	930,356

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Standard errors clustered at the district level are in parentheses. There are 447 clusters. All columns include demographic characteristics, education and disability status control.

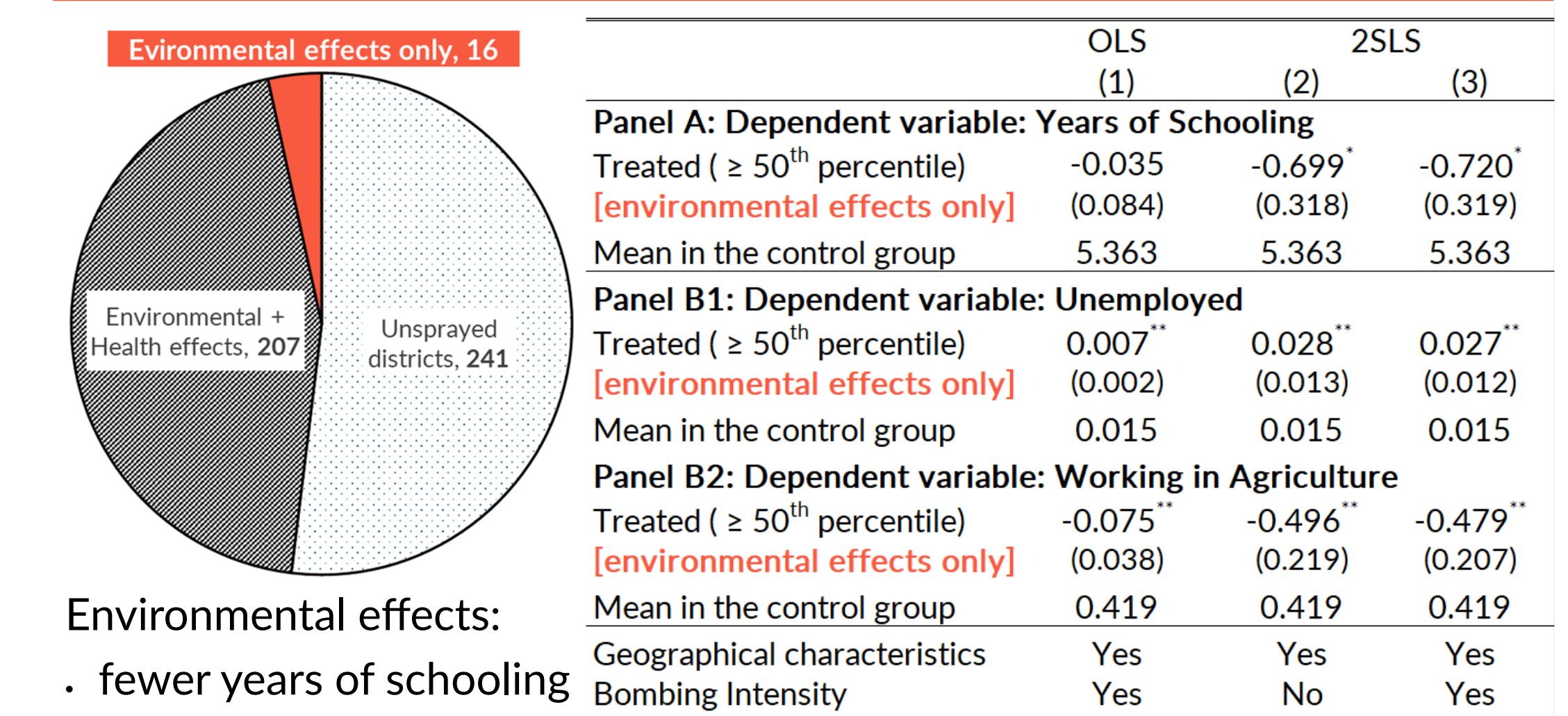
The likelihood of an individual to **work in agriculture** sees a **84% decrease.**

The proportion of land used for **agricultural purpose** sees a **64% reduction.**

Dependent Variables	Working in Agriculture			Proportional Land Use - Agricultural		
	OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)
Treated ( $\geq 50^{\text{th}}$ percentile)	-0.042*** (0.017)	-0.372*** (0.073)	-0.390*** (0.082)	-0.158*** (0.025)	-0.286*** (0.050)	-0.336*** (0.061)
Mean in the control group	0.465	0.465	0.465	0.528	0.528	0.528
Treated ( $\geq 70^{\text{th}}$ percentile)	-0.070*** (0.020)	-0.643*** (0.136)	-0.700*** (0.163)	-0.157*** (0.030)	-0.469*** (0.094)	-0.595*** (0.129)
Mean in the control group	0.468	0.468	0.468	0.503	0.503	0.503
Treated ( $\geq 90^{\text{th}}$ percentile)	-0.015 (0.027)	-2.328*** (0.690)	-3.070*** (1.022)	-0.141*** (0.047)	-1.248*** (0.363)	-1.882*** (0.639)
Mean in the control group	0.462	0.462	0.462	0.481	0.481	0.481
Geographical characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Bombing Intensity	Yes	No	Yes	Yes	No	Yes

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Standard errors clustered at the district level are in parentheses. There are 6,920,278 observations and 447 clusters. Columns (1)-(3) include demographic characteristics, disability status, and education control.

## Suggestive Evidence<sup>1</sup>: Environmental



Environmental effects:

- fewer years of schooling
- more likely to be unemployed
- lower agriculture participation

<sup>1</sup>Weak IV

## Conclusion

- 38 years after the last spraying mission, people in treated districts have **fewer years of education** & are **more likely to be unemployed.**
- Fail to confirm health effects – strong survivor bias
- Evidence for the environmental effects: **lower agriculture participation** and **less agricultural land use**
  - Slow catch-up growth, limit career options, and pose nutrient challenges

### Why do environmental effects persist?

- Arsenic** inhibits rice growth and is extremely **difficult to remove**
- Mass spraying killed the area's **biodiversity** and created space for **invasive species of grasses.**
- Vietnam is a **sub-tropical country**: Without the canopy coverage, soil and new growths are not protected from harsh sun.