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# **Evaluating the impact of fertilizer and crop prices on phosphorus concentrations in midwestern watersheds**

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# Evaluating the impact of fertilizer and crop prices on phosphorus concentrations in midwestern watersheds

## Background

- In the Great Lakes Basin, large soil phosphorus (P) reserves, intensive fertilizer application, and increased precipitation have led to high quantities of excess P in many watersheds.
- Nonpoint sources, especially agriculture, remain a concern for nutrient runoff.
- Corn prices and fertilizer prices affect both intensive and extensive margins of production.
- During 2005-2022, corn and fertilizer prices increased sharply.
- We analyze how corn and fertilizer prices affect total phosphorus (TP) and dissolved phosphorus (DP) concentrations in 226 Great Lakes watersheds across 7 states – MI, OH, IL, IN, WI, NY and PA.

## Data

- TP and DP data were obtained from Water Quality Portal and National Center for Water Quality Research, weather data from PRISM, soil erosion data from EPA WSIO, soil P data from He et al. (2021), land use data from National Land Cover Dataset, crop prices from USDA NASS, and fertilizer price from USDA ERS.

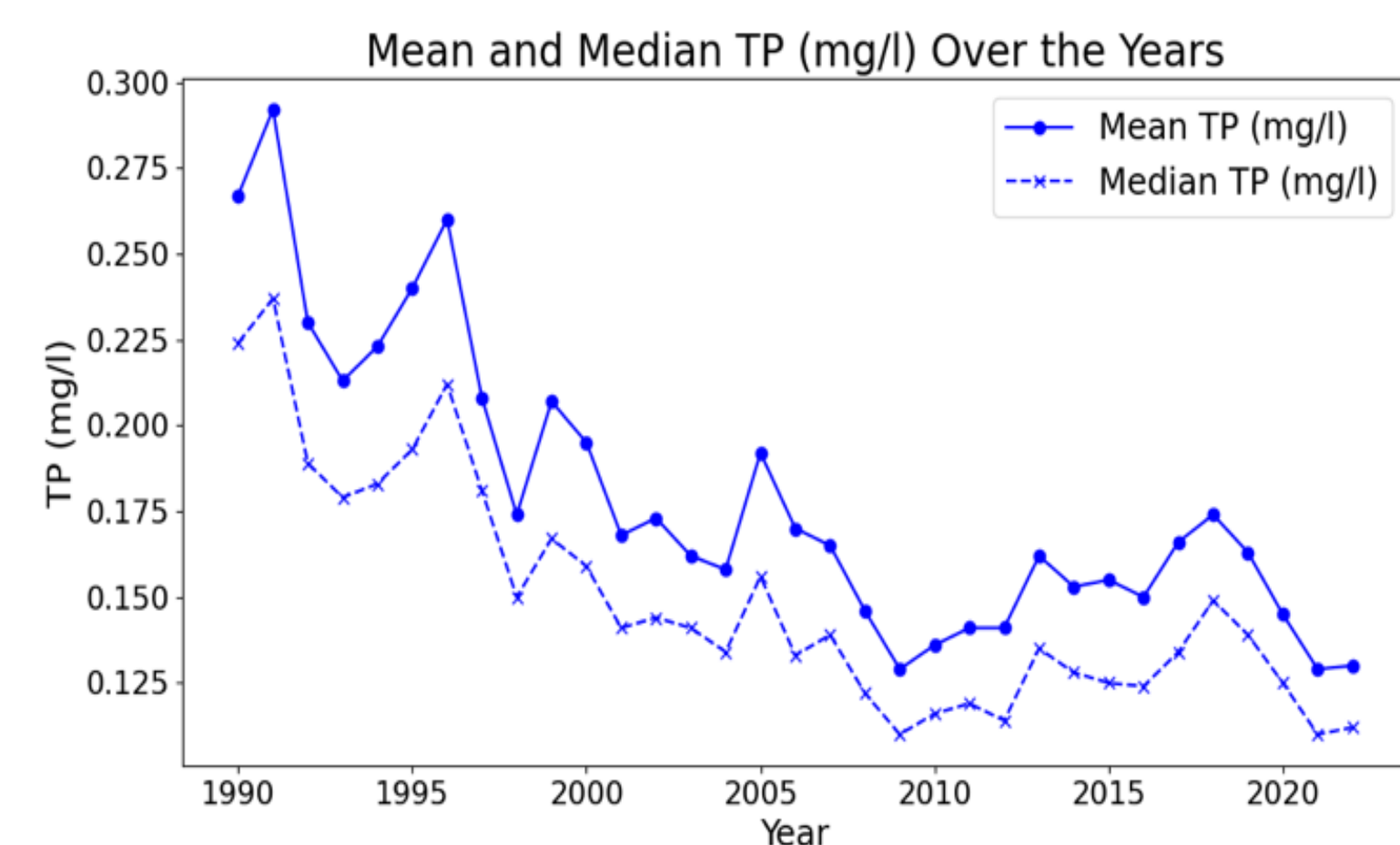


Figure 1 shows mean and median TP concentration over the years, where TP concentration shows a downward trend

Figure 1: Mean and median TP concentration

Figure 2 shows mean and median DP concentration over the years, where DP trend is less pronounced compared to TP

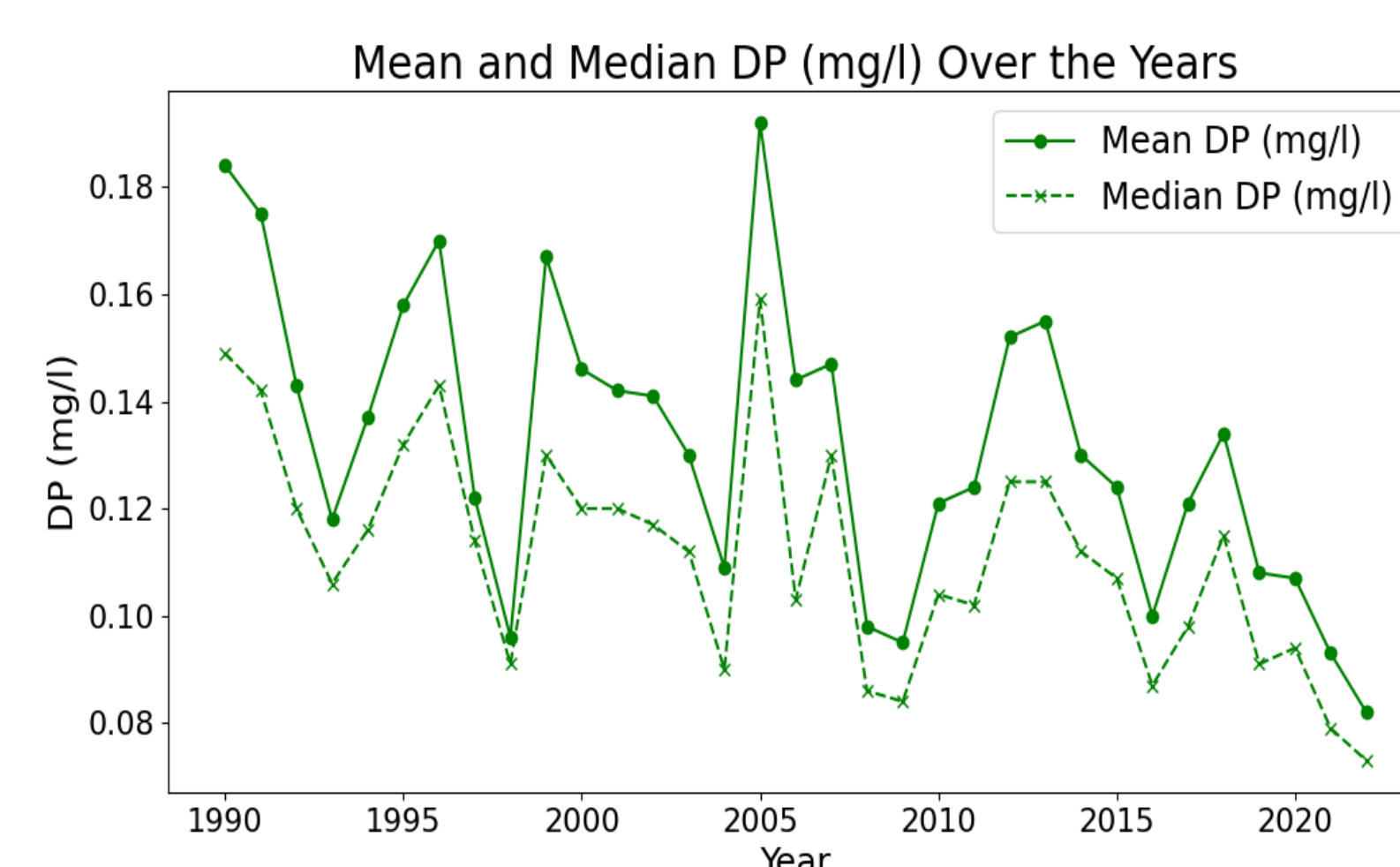


Figure 2: Mean and median DP concentration

## Study Area

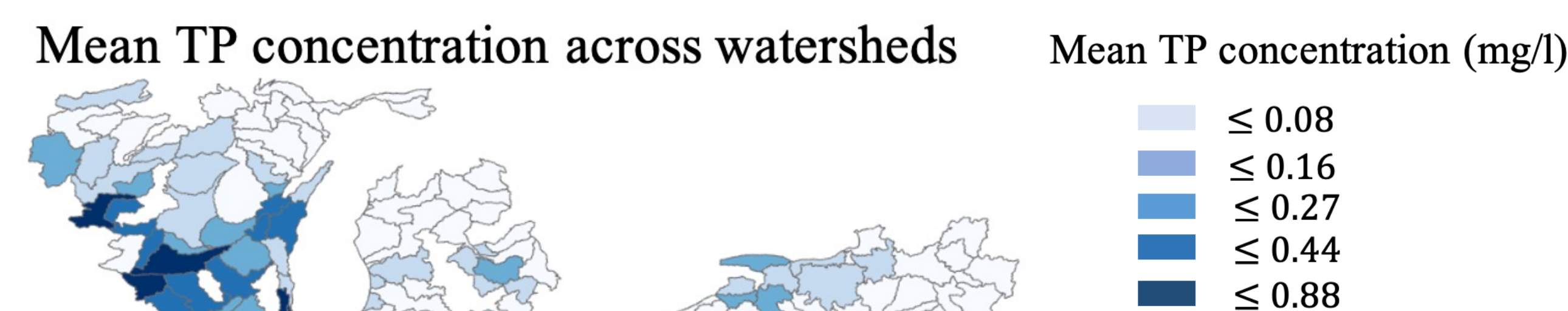


Figure 3a: Mean TP across watersheds



Figure 3b: Mean DP across watersheds

## Empirical Strategy

- To estimate the effect of corn and fertilizer prices on TP concentration, we use the following fixed effects estimation strategy:

$$\ln(Y_{imt}) = \beta_0 + \beta_1 \ln(P_{DAP})_{rt} + \beta_{2q} [q = 1 | season] * \ln(P_{corn}_{mt}) + \eta X_{imt} + \psi Z_{it} + \delta_i + \gamma_m + \sigma_t + \epsilon_{imt}$$

where,  $i$  = watershed,  $m$  = month,  $r$  = region,  $t$  = year, and  $t = 1990$  to  $2022$ .  $Y_{imt}$  is the average TP concentration for watershed  $i$ , in month  $m$  and year  $t$ .  $P_{DAP}$  is the price of fertilizer,  $P_{corn}$  is the national price of corn.  $X_{imt}$  is a vector of all other variables which varies across watershed, month and time.  $Z_{it}$  is a vector of variables that vary across watersheds over the years.  $\delta_i$ ,  $\gamma_m$ , and  $\sigma_t$  are watershed, month and year fixed effects. For DP, we run similar regression with  $Y_{imt}$  as the mean DP concentration in watersheds.

- Controls include temperature, precipitation, quadratic terms for both, lagged TP concentration, upstream precipitation, upstream pollution, an interaction between upstream precipitation and upstream pollution, land use changes, interaction of soil erosion and extreme precipitation days in the agricultural season, and manure use.

## Results

Variables	TP	DP
Ln(Fertilizer Price)	-0.317***	-0.699***
Ln(Corn Price)_winter	0.210***	0.168**
Ln(Corn Price)_spring	0.100**	0.087
Ln(Corn Price)_summer	0.0339	0.0284
Ln(Corn Price)_fall	0.071	-0.027
Controls	Yes	Yes
Constant	-0.013	5.533***
Month fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
HUC8 fixed effect	Yes	Yes
N	35934	23307

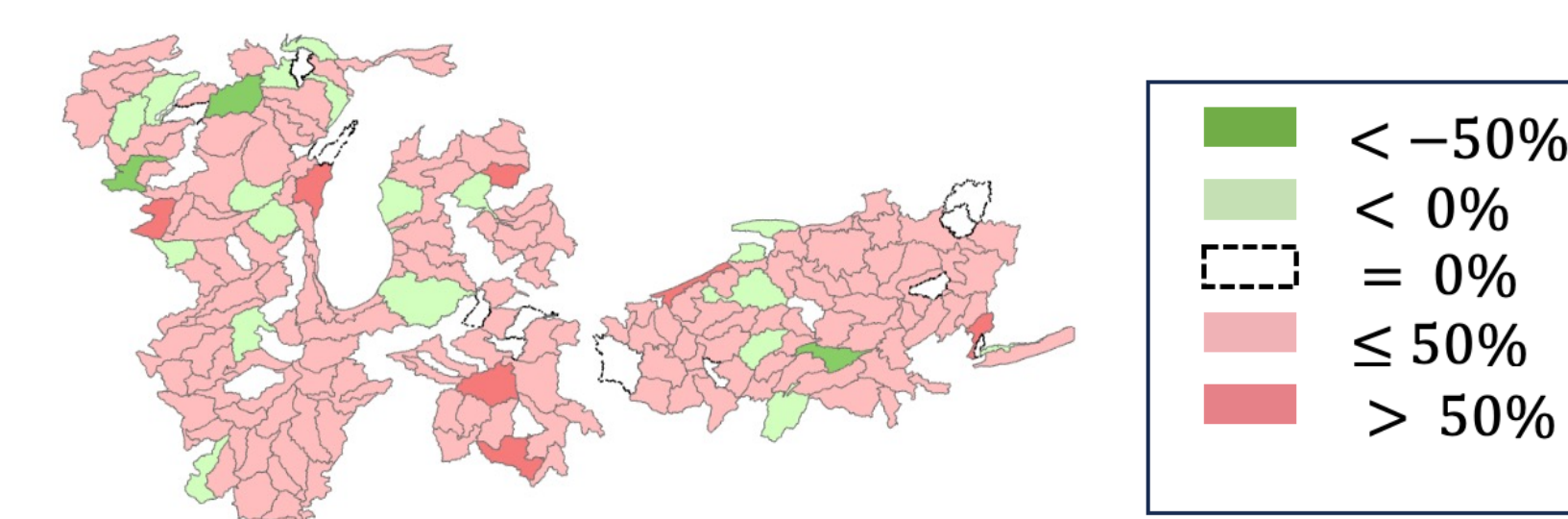


Figure 4: Model predicted changes in mean TP without fertilizer price increases of 2006-2022

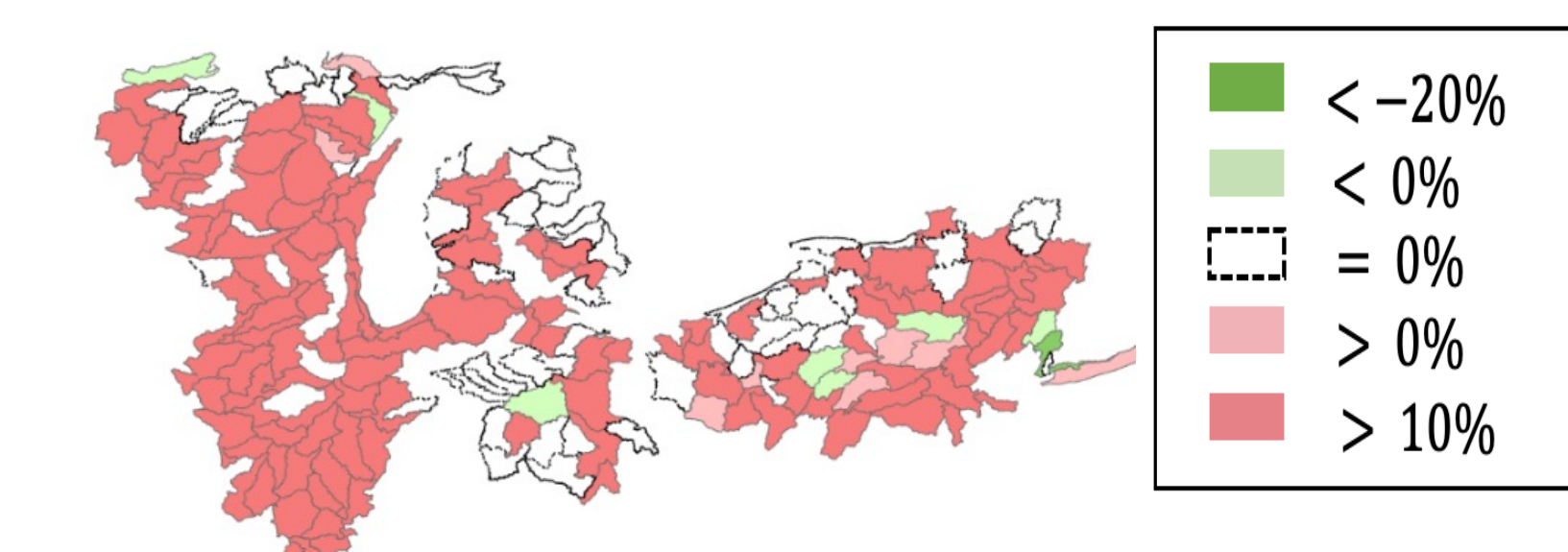


Figure 5: Model predicted changes in mean DP without fertilizer price increases of 2006-2022

## Conclusions

- A 10% increase in fertilizer price reduces TP by up to 3.1% and DP by up to 6.9%.
- Winter corn prices positively affect TP and DP concentration, where a 10% increase in winter corn prices can lead to a 2.1% increase in TP concentrations and 1.6% increase in DP concentrations
- Higher fertilizer prices helped to reduce TP and DP concentration in Great Lakes watersheds

## References

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