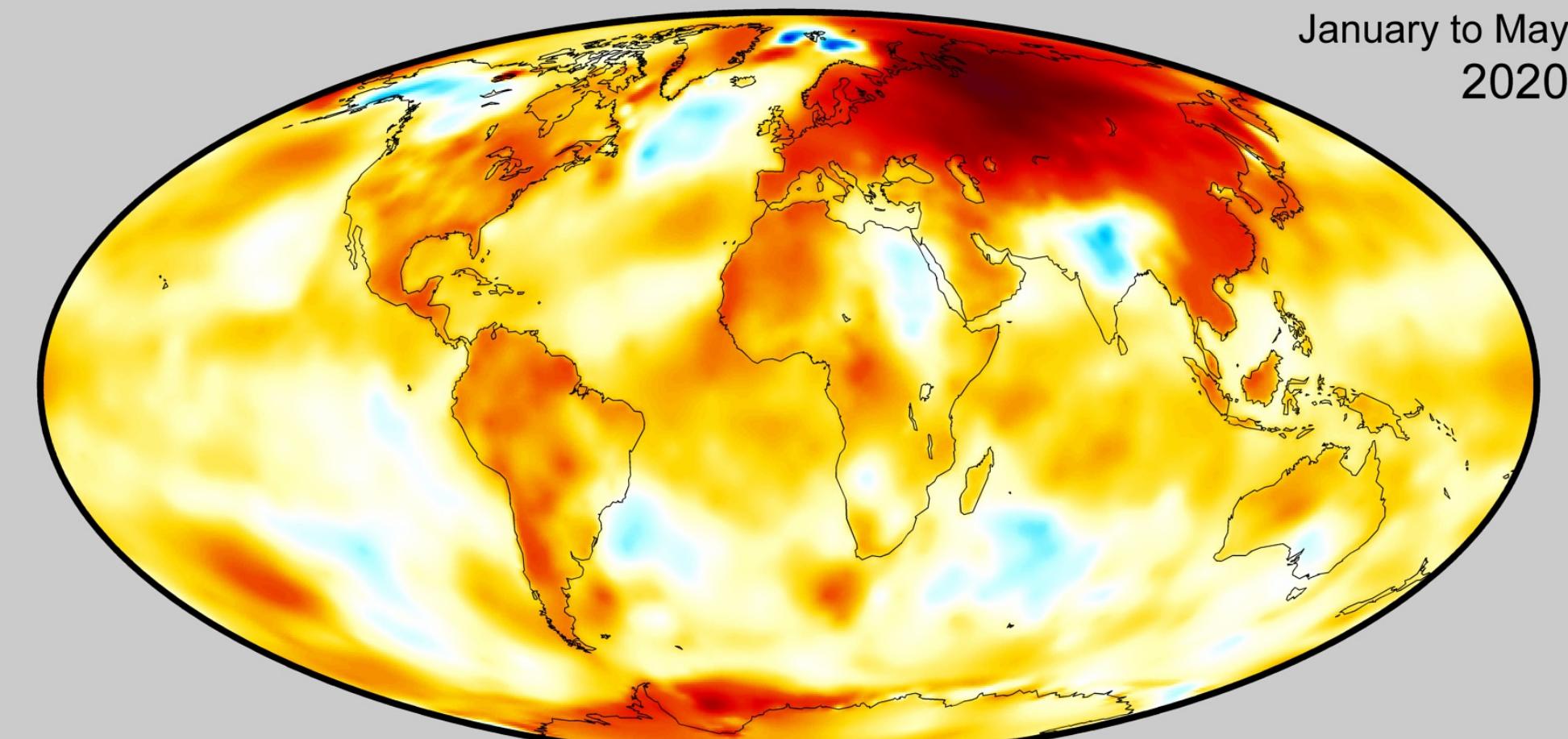


Climate, air pollution, and policy

Macro, micro, theory, and empirics

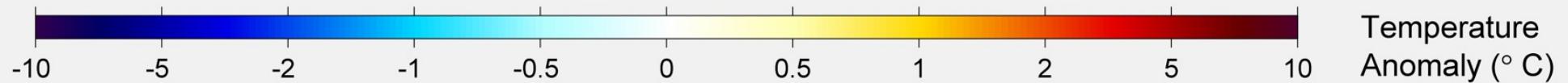
Ivan Rudik

January to May
2020



Relative to 1951-1980 average

www.BerkeleyEarth.org



Climate change

How **should** economists think about climate change?

- The importance of uncertainty (Lemoine and Rudik 2016)
- Proper climate modules (Lemoine and Rudik 2017)
- Endogenous damage learning / robustness (Rudik 2020)
- Identifying the correct climate estimand (Rudik et al. 2021)
- Reduced form IAM + decomposition (Moore et al. 202X)
- Networks and distortions (Lemoine, Rudik, and Tan 202X)

How do we identify effects of changes in climate using observable data?

Does temperature variation identify marginal climate effects?

Two farmer thought experiments:

- 1) Iowa farmer growing corn/soy
- 2) California farmer growing almonds

Why might an increase in *transient/idiosyncratic* temperature today be different than an increase in *climate*?

How do we identify effects of changes in climate using observable data?

- 1) Iowa farmer growing corn/soy can switch to rice/cotton in the **long run**
- 2) California farmer growing almonds can pull on depletable groundwater resources in the **short run**

Impacts of temperature on profits, yields, etc will overstate climate impacts in Iowa, understate impacts in California

How do we identify effects of changes in climate using observable data?

Circumvent these issues with [envelope theorem](#) arguments

Weather variation = climate variation for optimized payoffs

Main challenge: most realistic representations of payoffs are not observable or do not respond to transient temperature

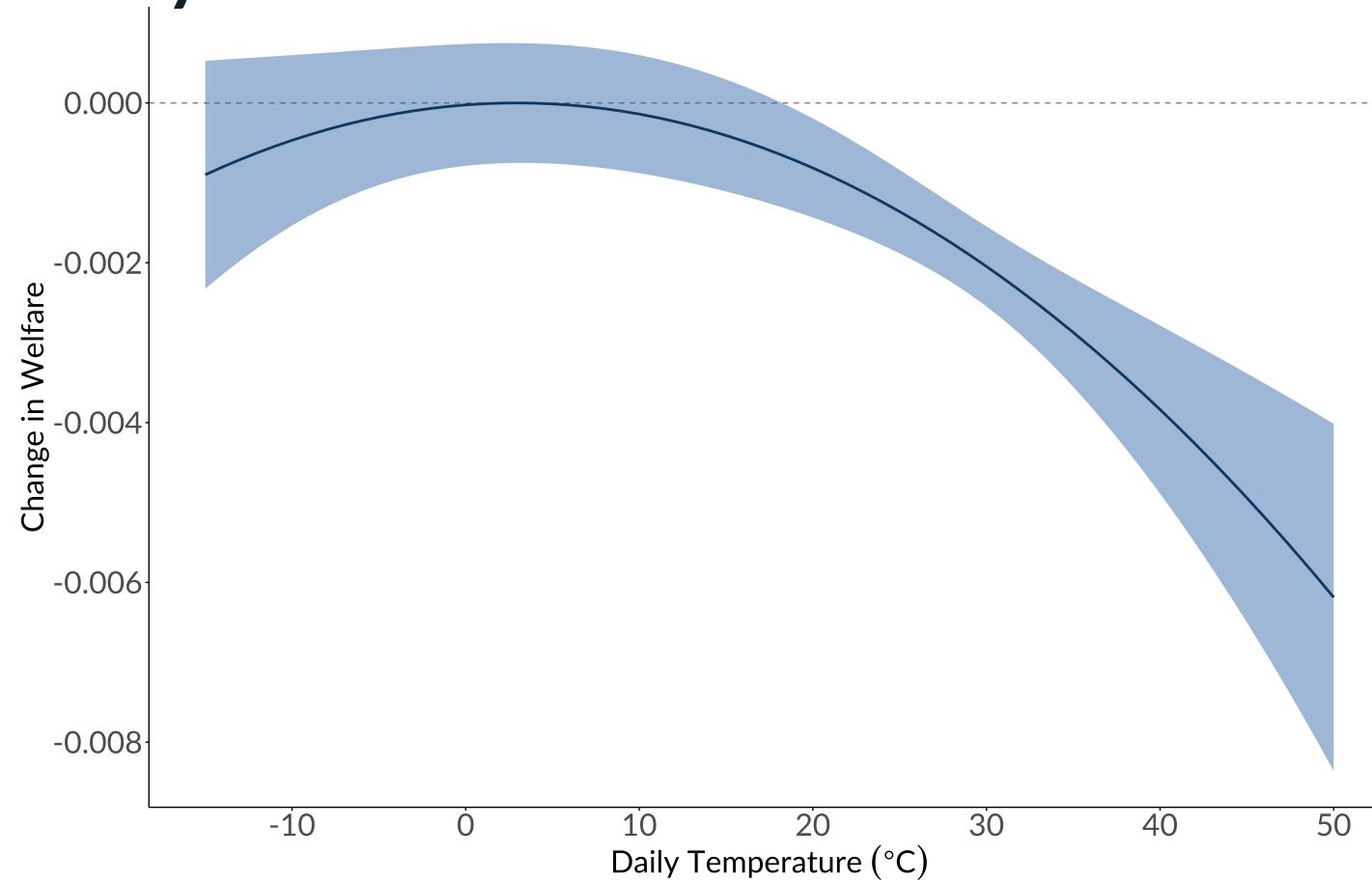
- Utility, PV utility streams, PV profits, land prices, etc

How do we identify effects of changes in climate using observable data?

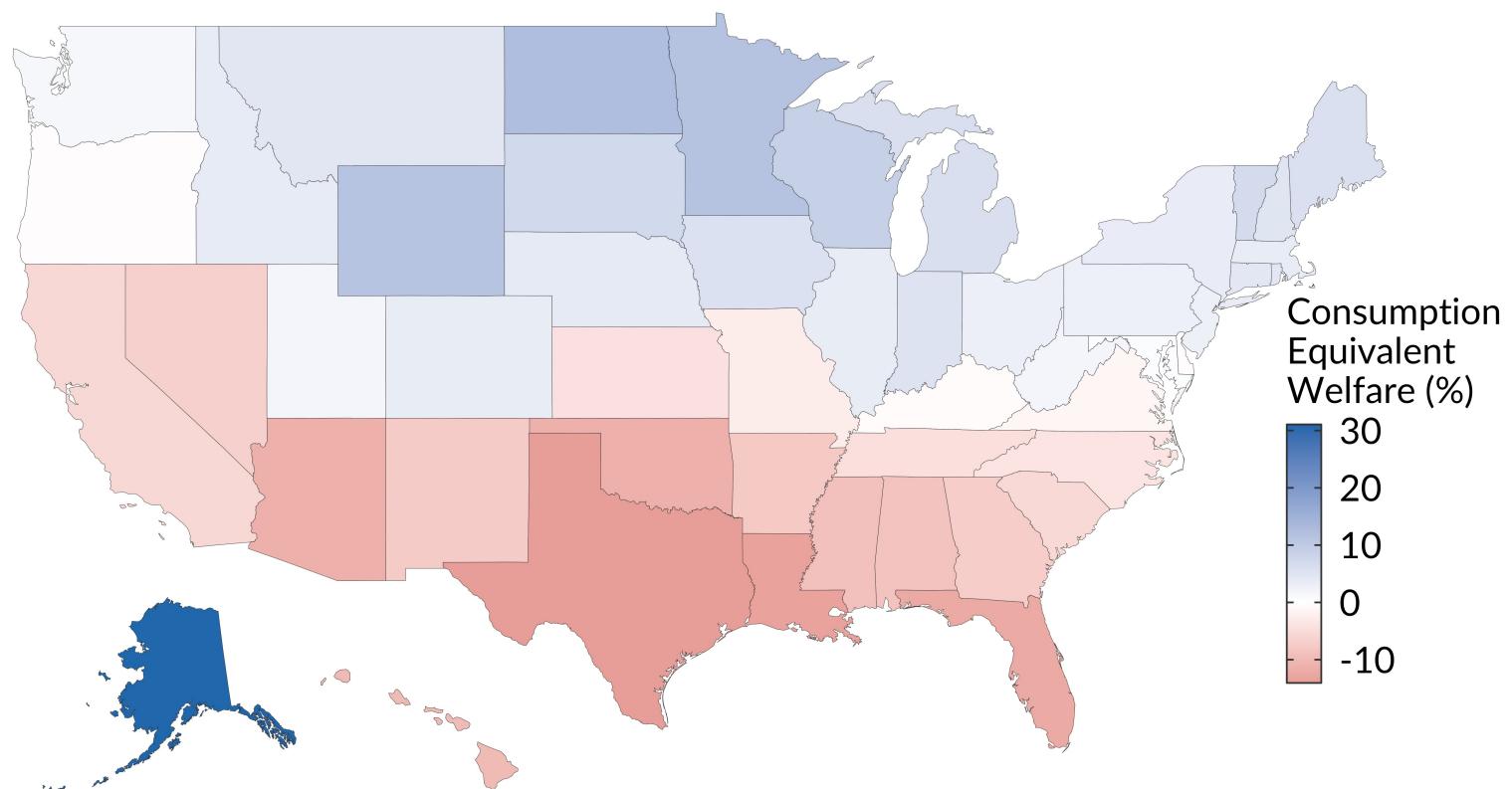
Rudik, Lyn, Tan, Ortiz-Bobea (2021) provides a roadmap

Under some **light** assumptions about household behavior we can show in-migration shares are a sufficient statistic for expected welfare

Extreme hot days are extremely bad for welfare



Extreme hot days are
extremely bad for welfare



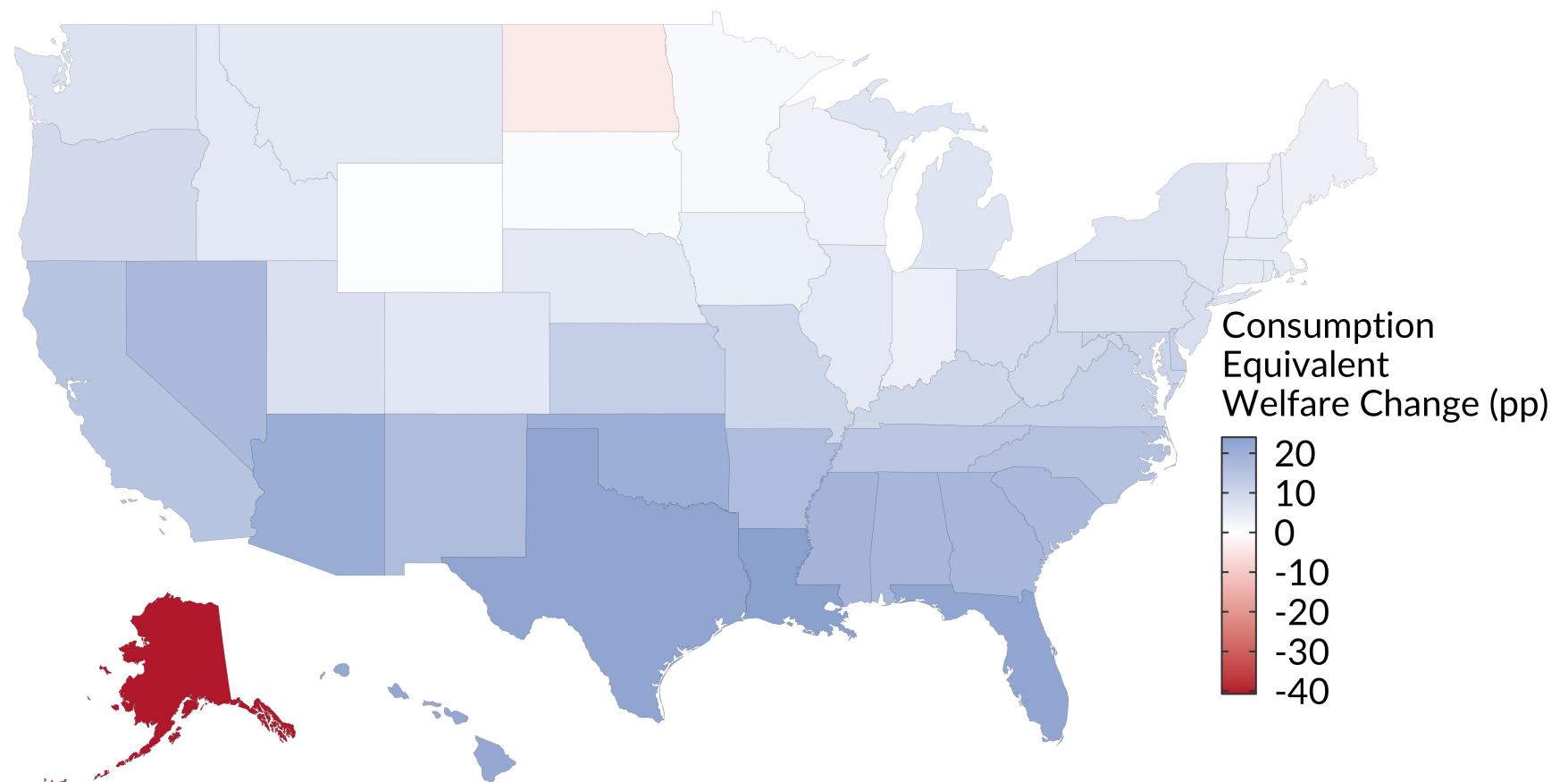
Beyond welfare

To go beyond welfare we need structure

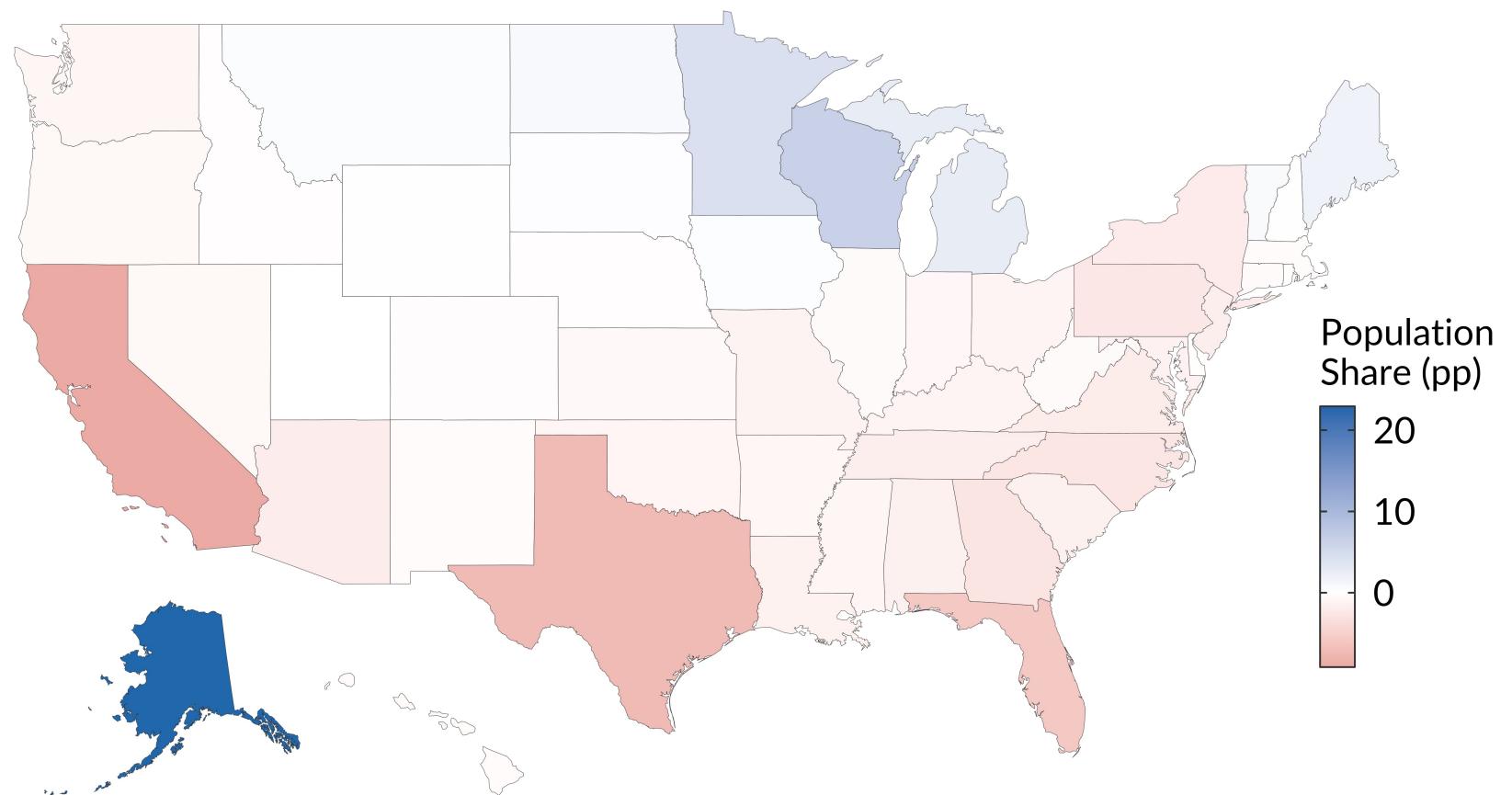
Build a quantitative dynamic spatial model to get the rest:

- Migration
- Employment
- Value of adaptation through market mechanisms

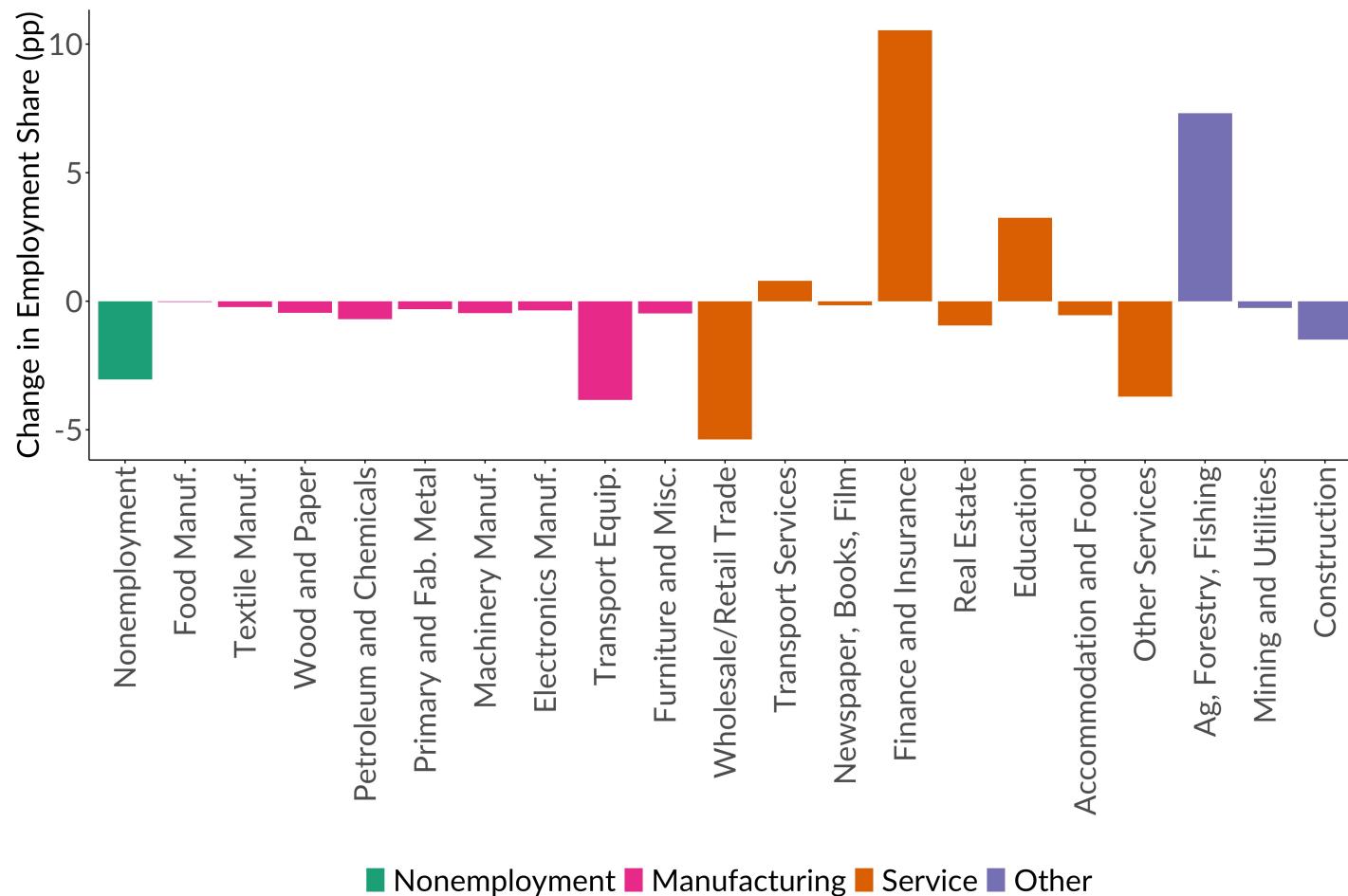
The value of market-based adaptation



Climate migration



Industrial reallocation



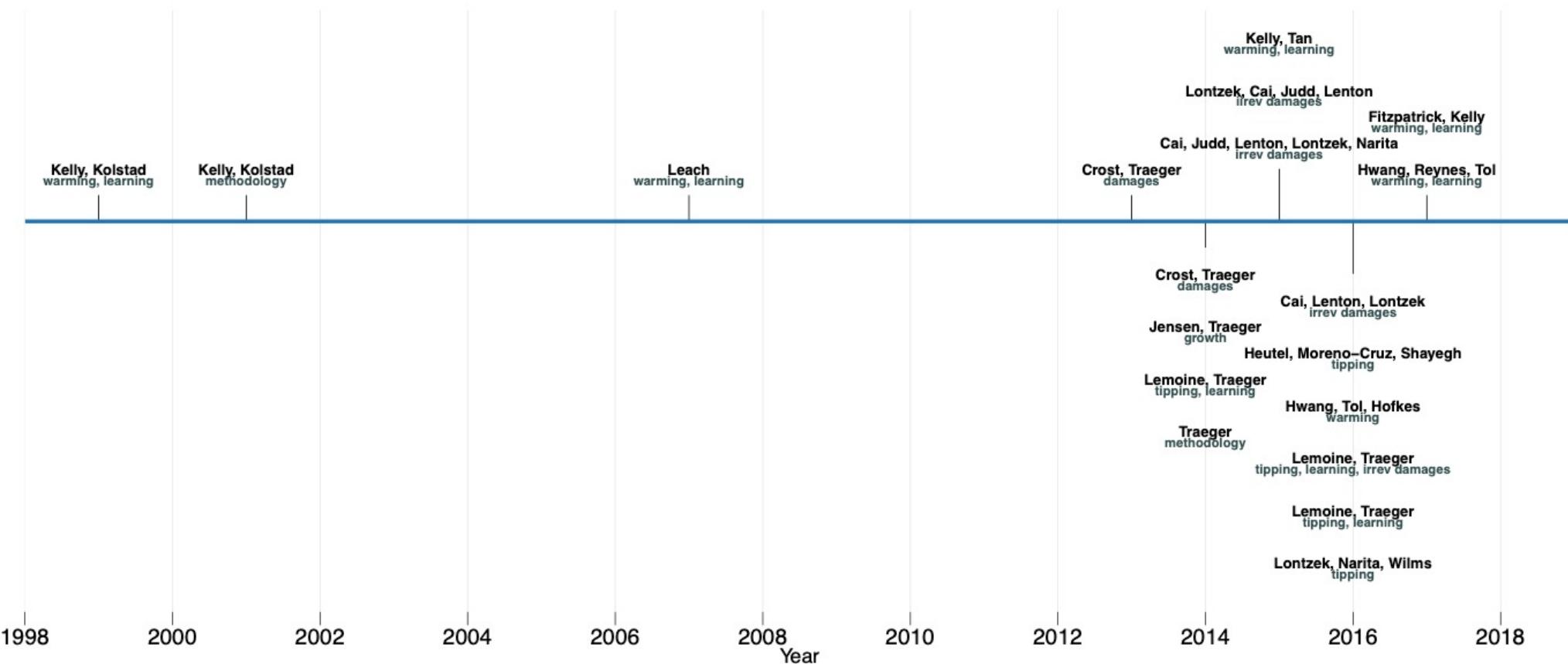
The role of uncertainty in carbon pricing

Lemoine and Rudik (2016) show the role of uncertainty in carbon taxes

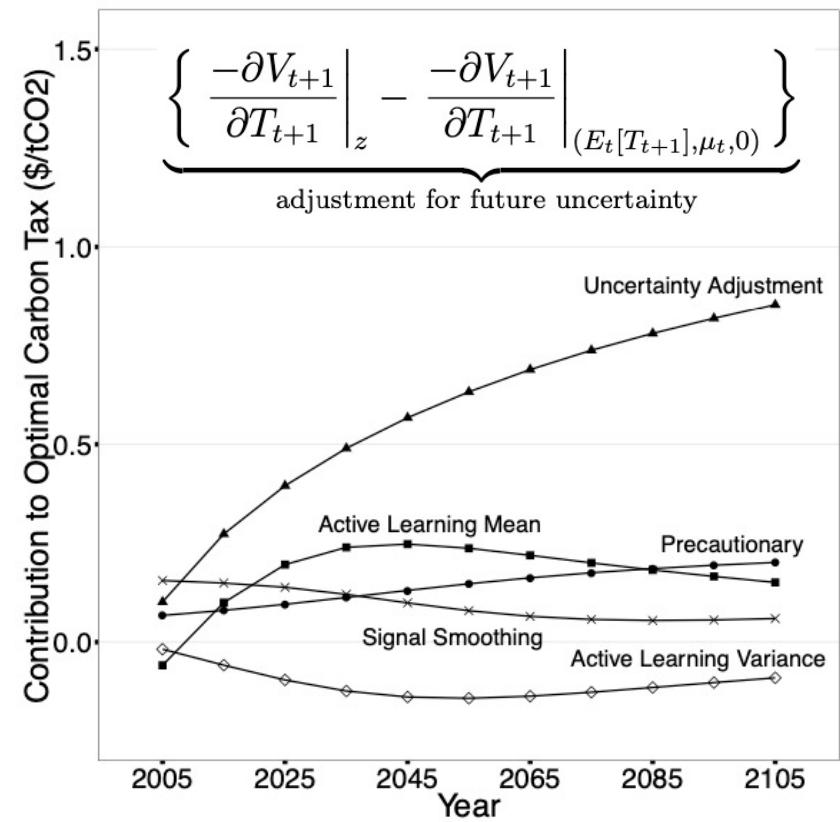
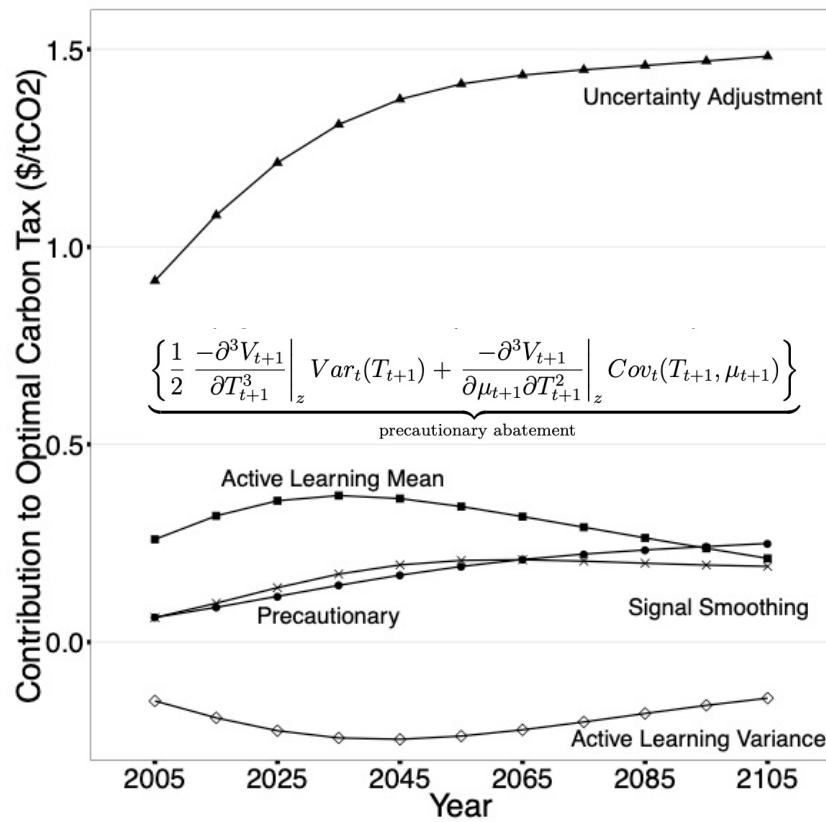
Rudik (2020) asks what is the effect on optimal climate policy if we:

- 1) Account for how economists will update future damages
- 2) Account for how we know our economic models are misspecified

Uncertainty in carbon pricing is a new literature



You can decompose taxes into standard consumption-saving channels



The role of uncertainty in carbon pricing

Damage uncertainty matters (Lemoine and McJeon 2013)

Economists update estimates of marginal damages (e.g.
Climate Impact Lab)

Economists know economists update estimates

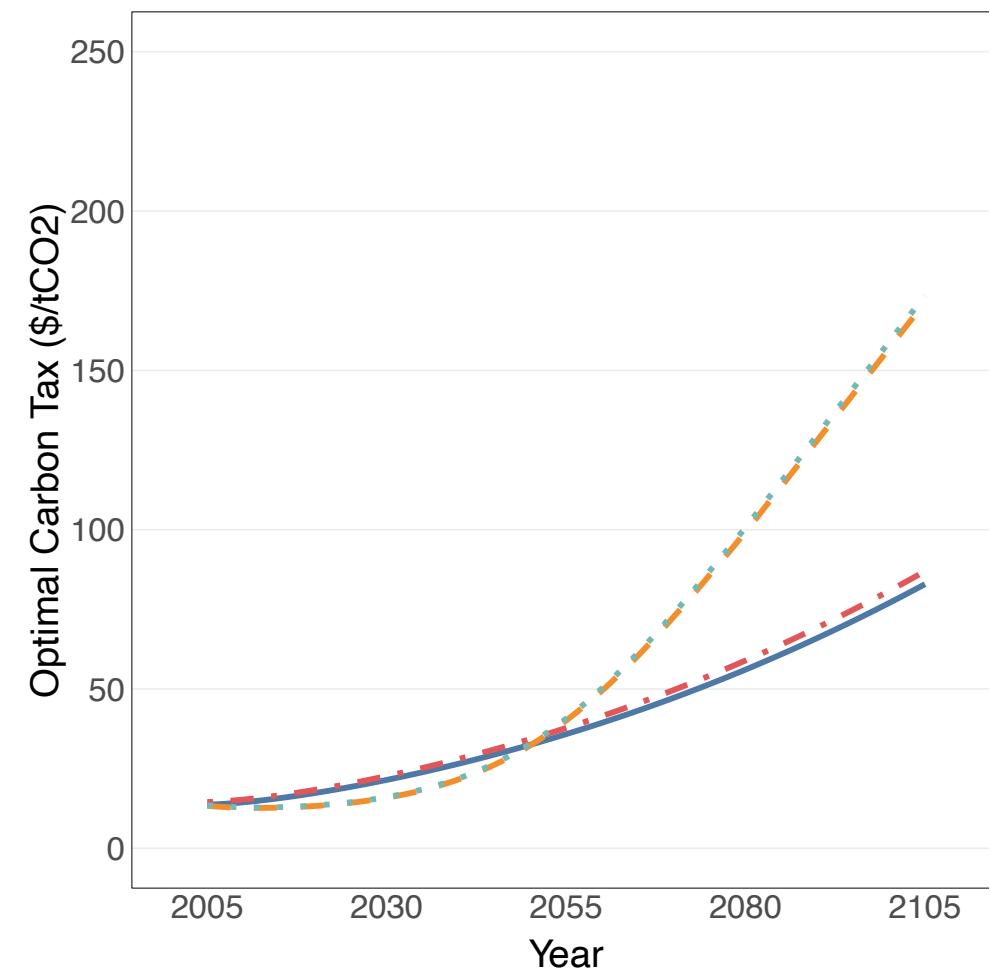
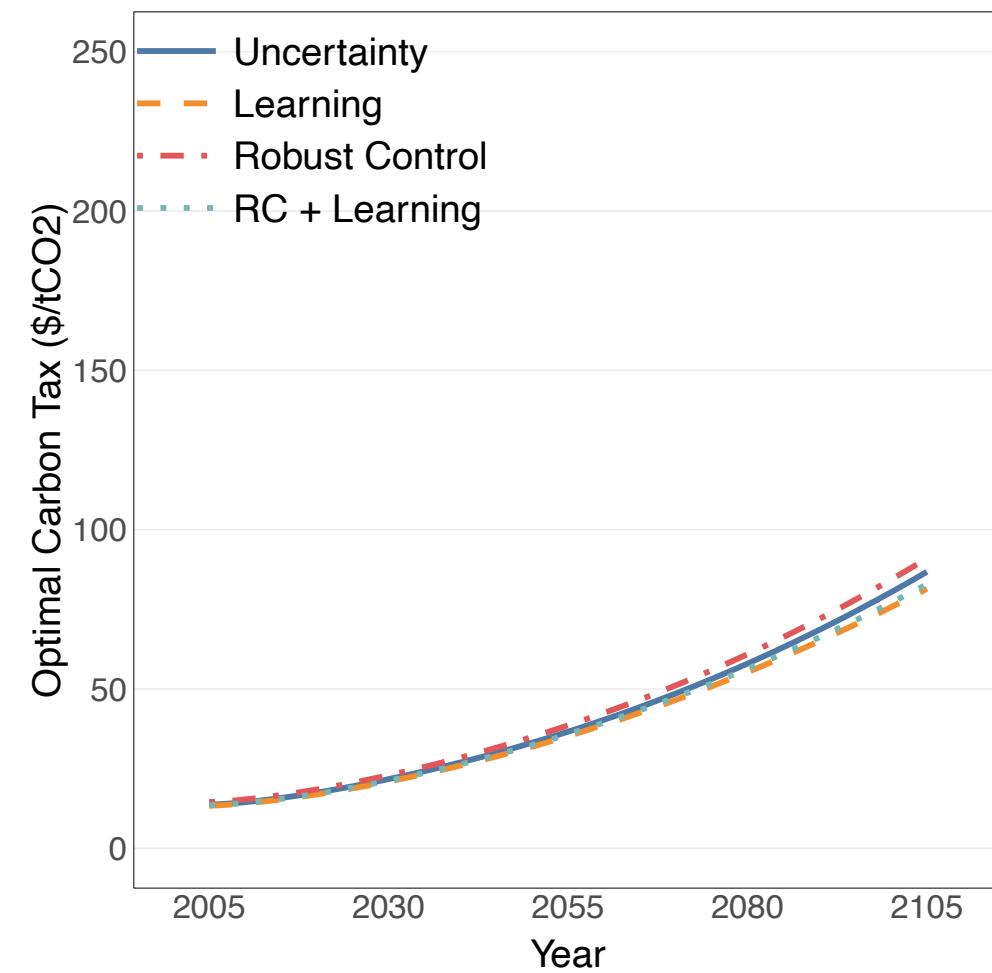
The role of uncertainty in carbon pricing

We know these estimates and models are wrong (Pindyck 2013)

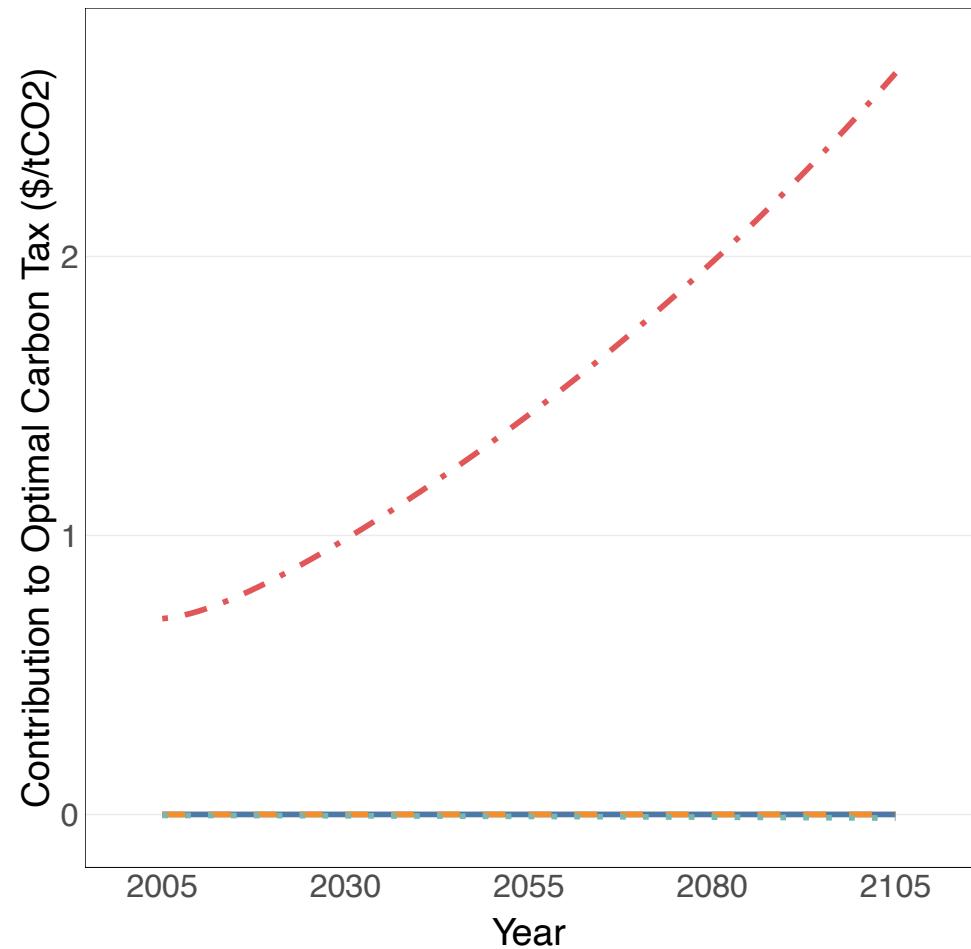
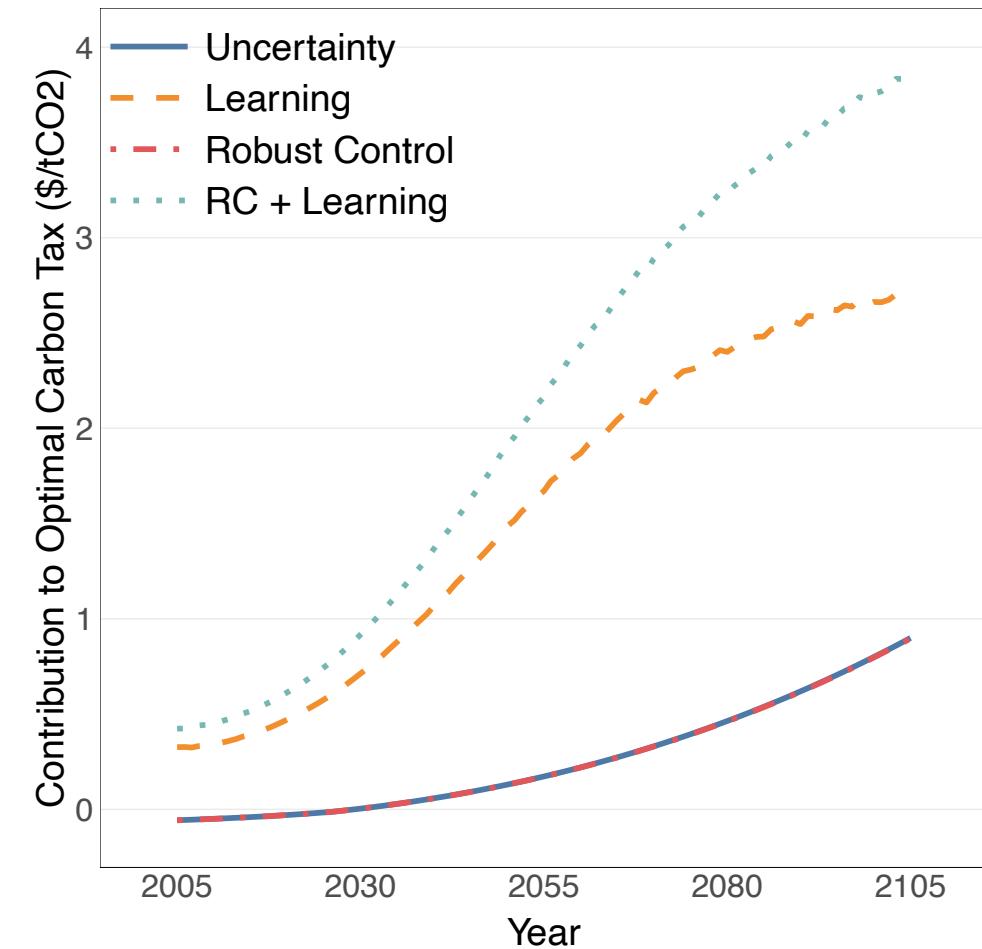
- E.g. Dietz and Stern (2015) damage function is widely used but they are very clear that it's completely made up

We should design policy to guard against model misspecifications

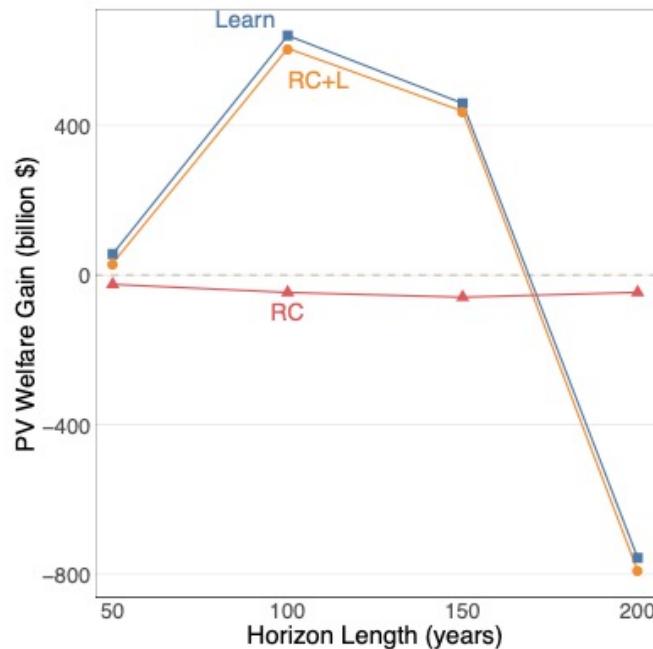
Policy under different states of the world



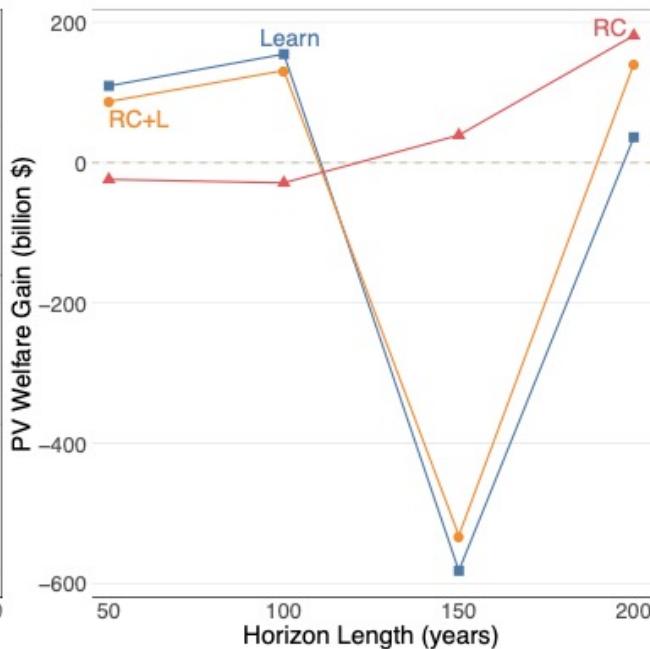
Consumption-saving decompositions



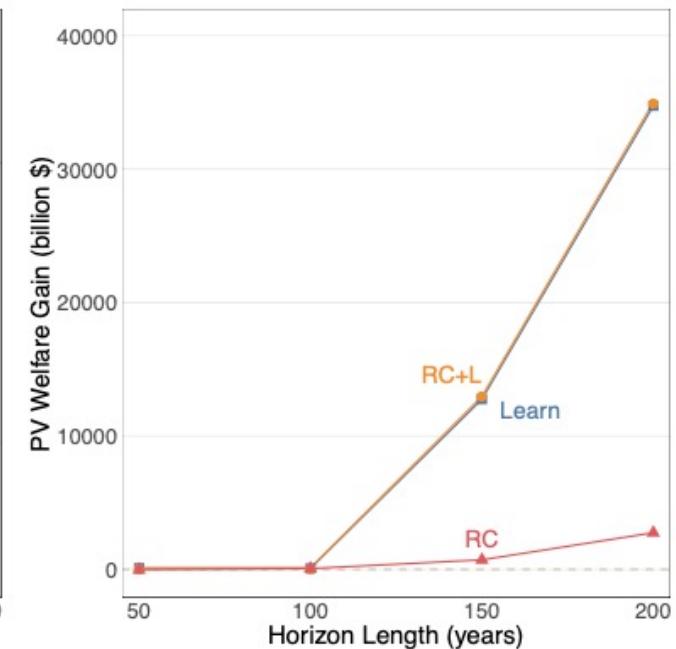
Learning helps (usually) even if models are very wrong



(a) Weitzman



(b) Dietz and Stern



(c) Extreme

What matters for the social cost of carbon? Meta-analysis / reduced form SCC

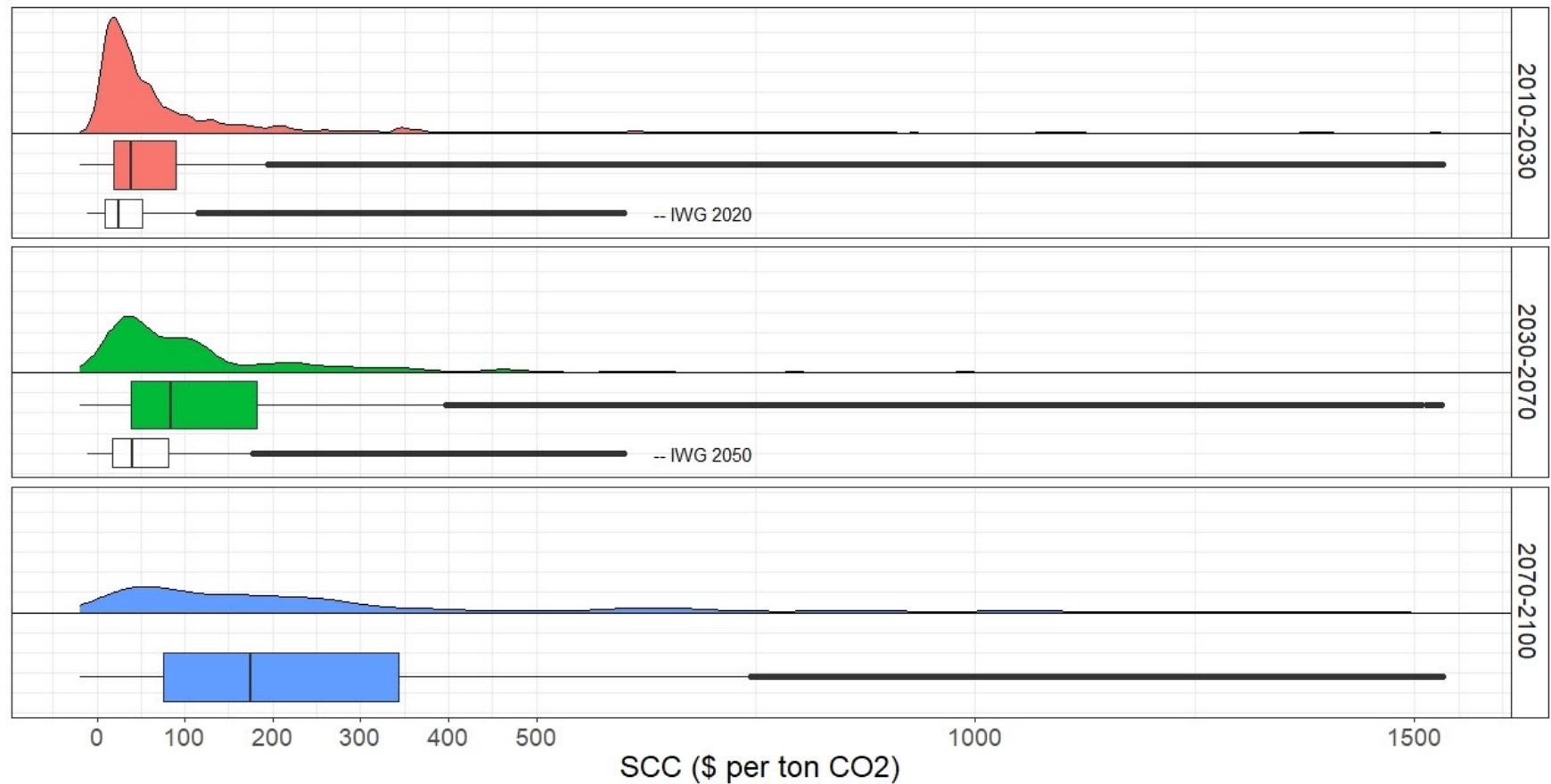
Moore, Rising, Dietz, Drupp, Rudik, Wagner (202X)

There's **lots** of integrated assessment papers making structural changes or introducing uncertainty

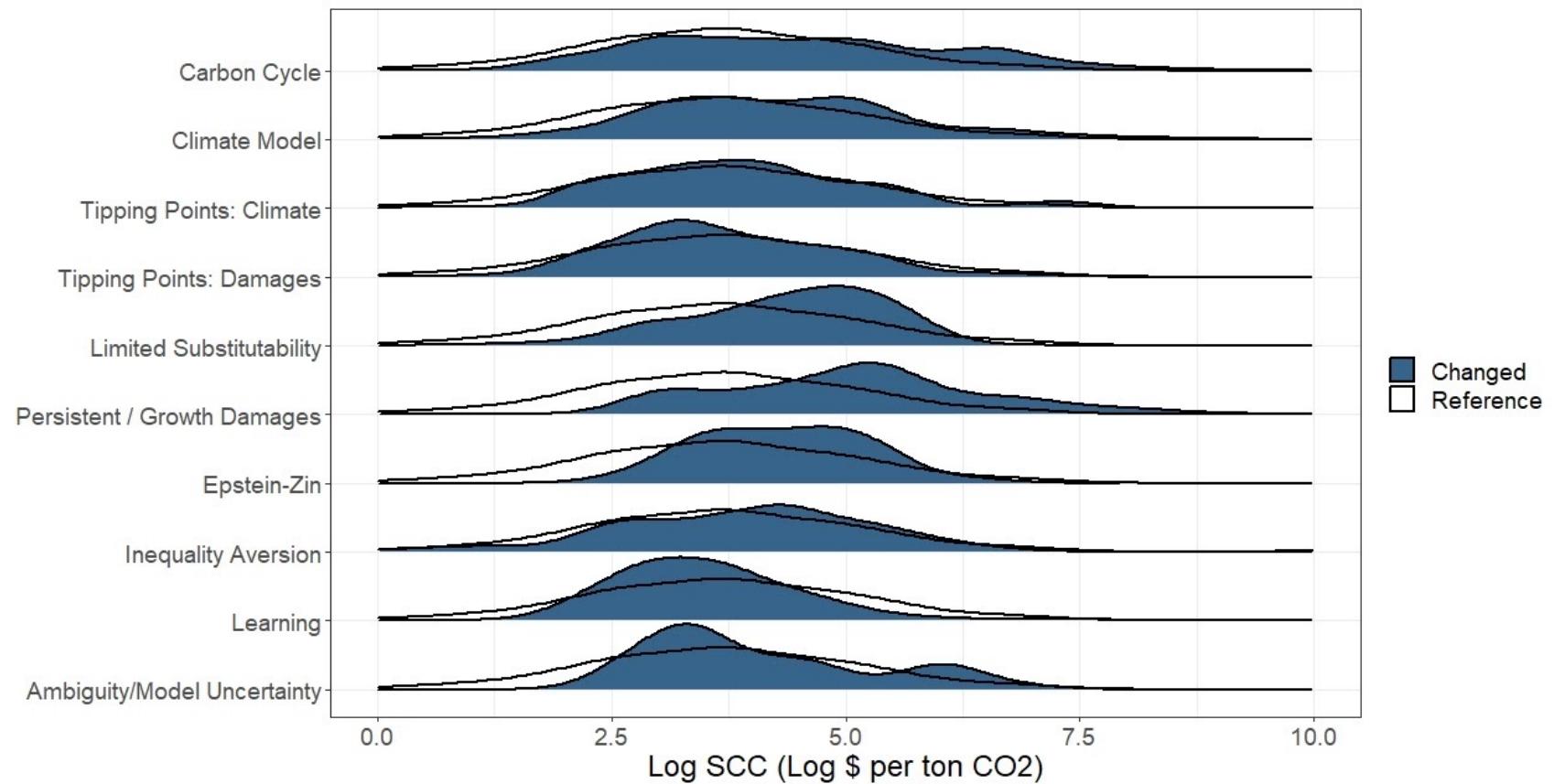
They all give different results for the price of carbon

What are the key drivers?

The SCC from the literature since 2000



The relative effects of different structural changes



What matters for the social cost of carbon? Meta-analysis / reduced form SCC

Moore, Rising, Dietz, Drupp, Rudik, Wagner (202X)

Next steps: train **random forest** model to get a reduced form predictor of SCC as a function of standard inputs (year, discount rate, model structure Booleans)

Why: allows researchers to recover a literature-consistent SCC estimate without having to run these complicated structural models

Optimal science funding

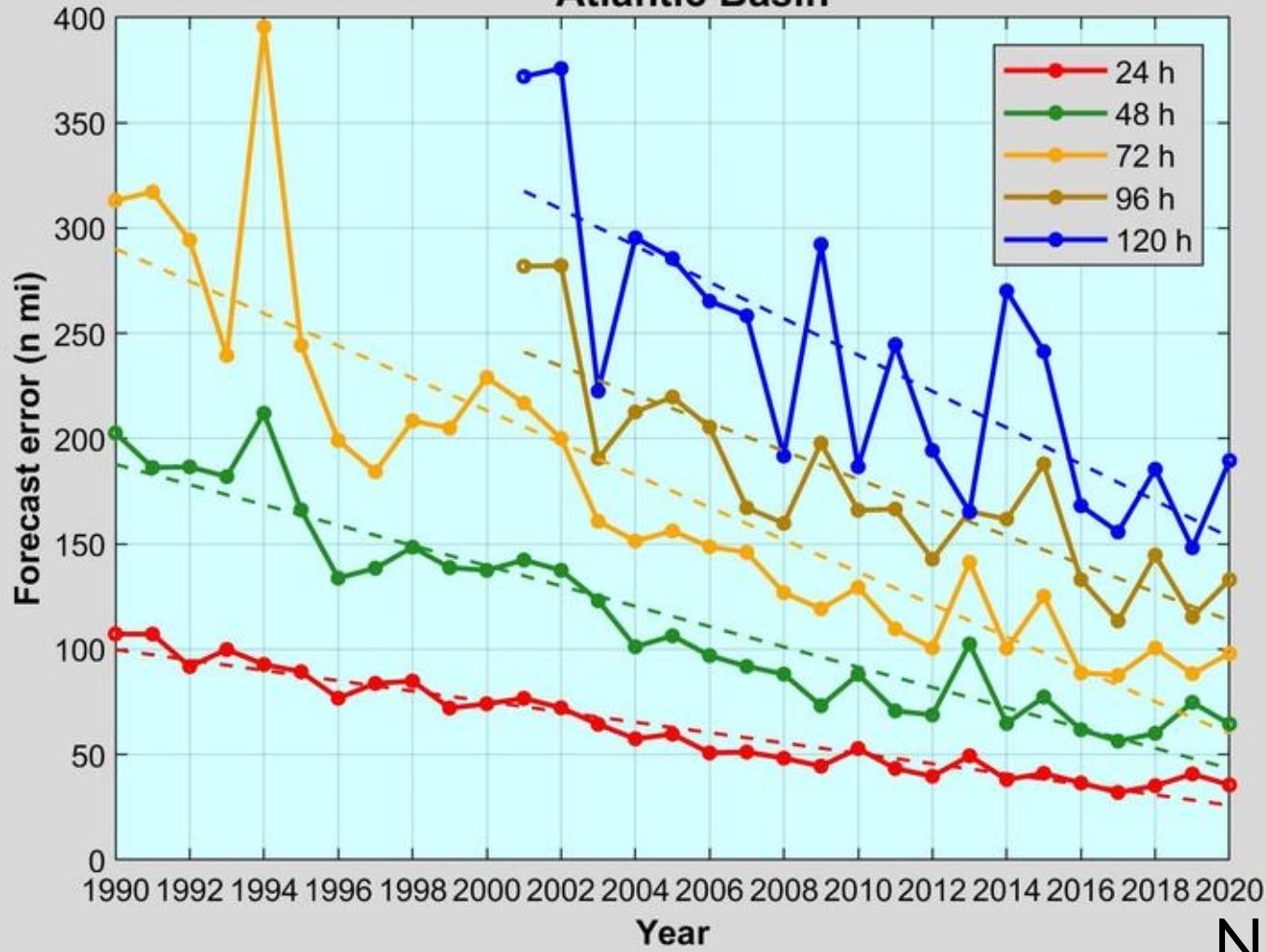
Hurricane forecasts have improved significantly over time

Molina and Rudik (2021)

What is the historical value of this?

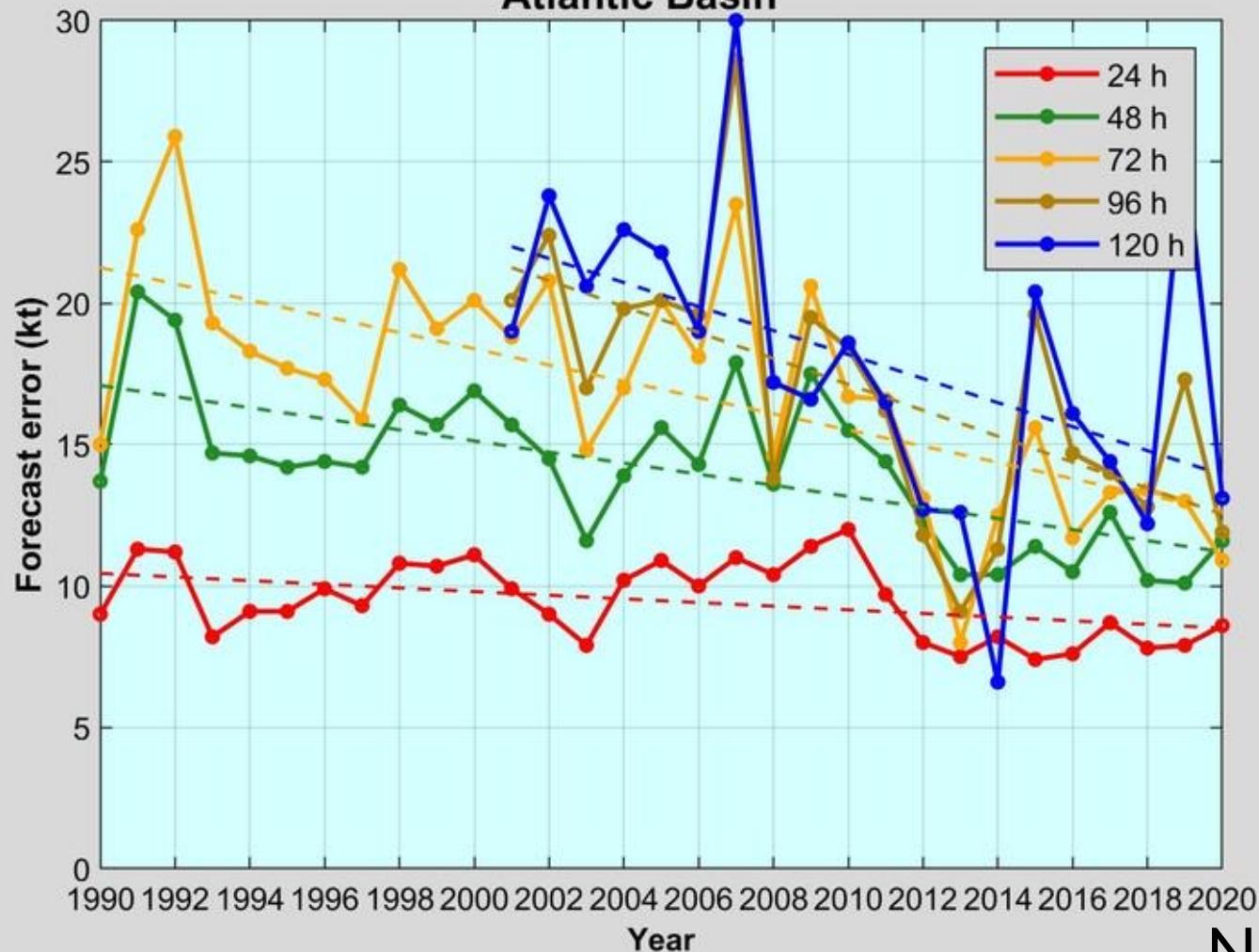
How much should we fund future research for improving forecasts?

NHC Official Track Error Trend Atlantic Basin



NOAA NHC

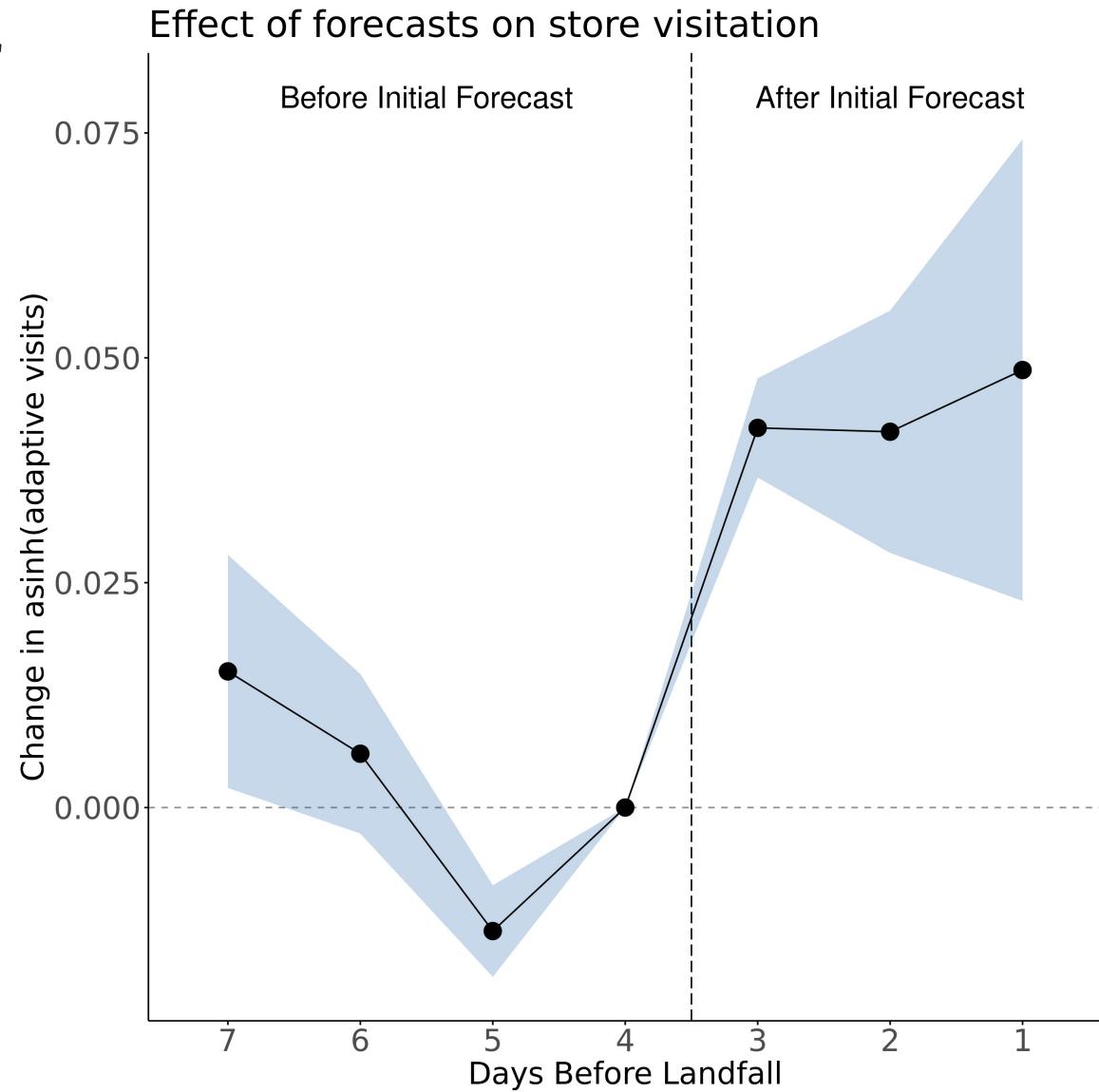
NHC Official Intensity Error Trend Atlantic Basin



NOAA NHC

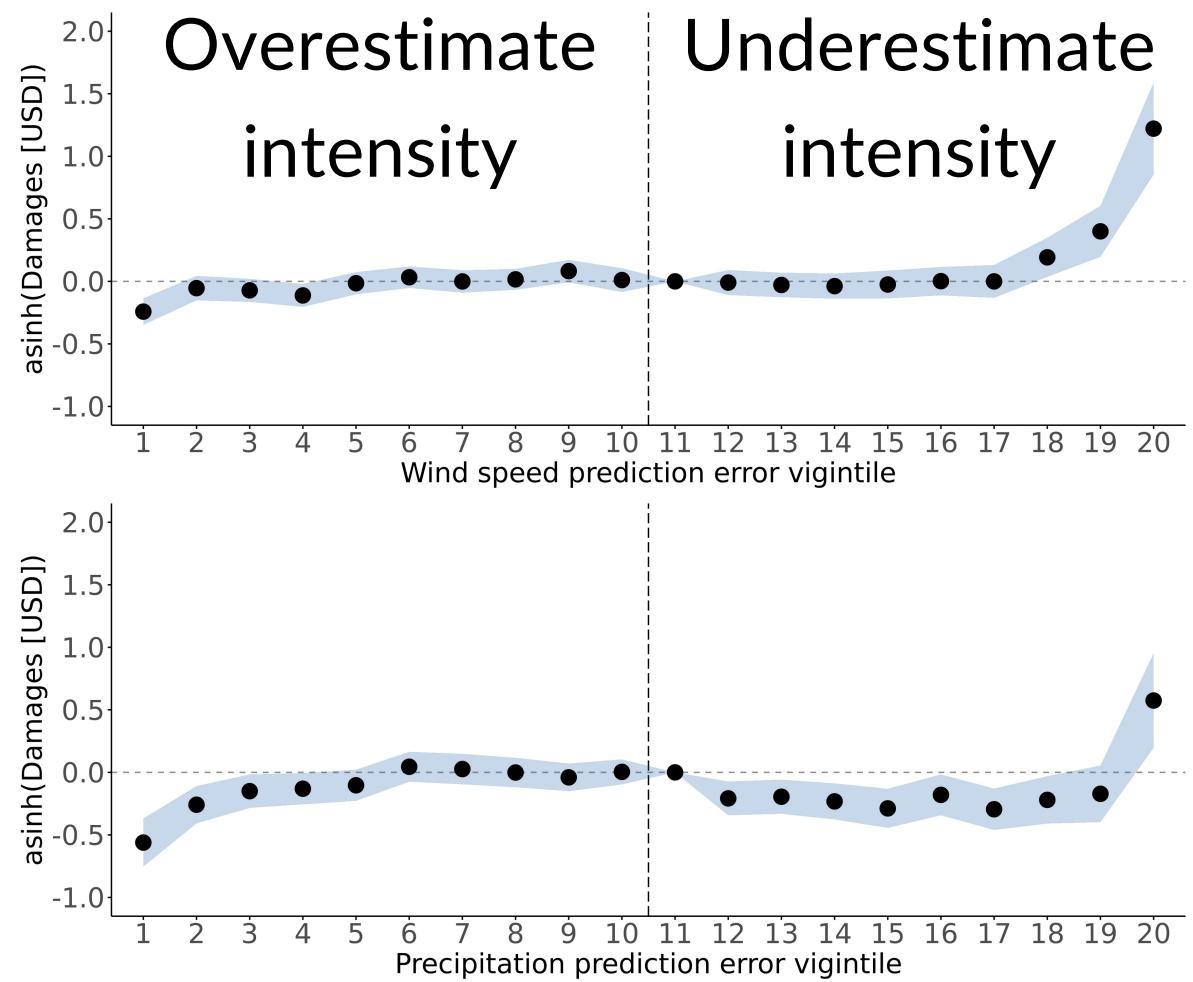
Do forecasts matter for household decisions?

An above historical-median forecast increases store visitation in days before storm



Do forecast errors matter?

Underestimating hurricane intensity, **wind** or **precipitation**, leads to significantly greater damage

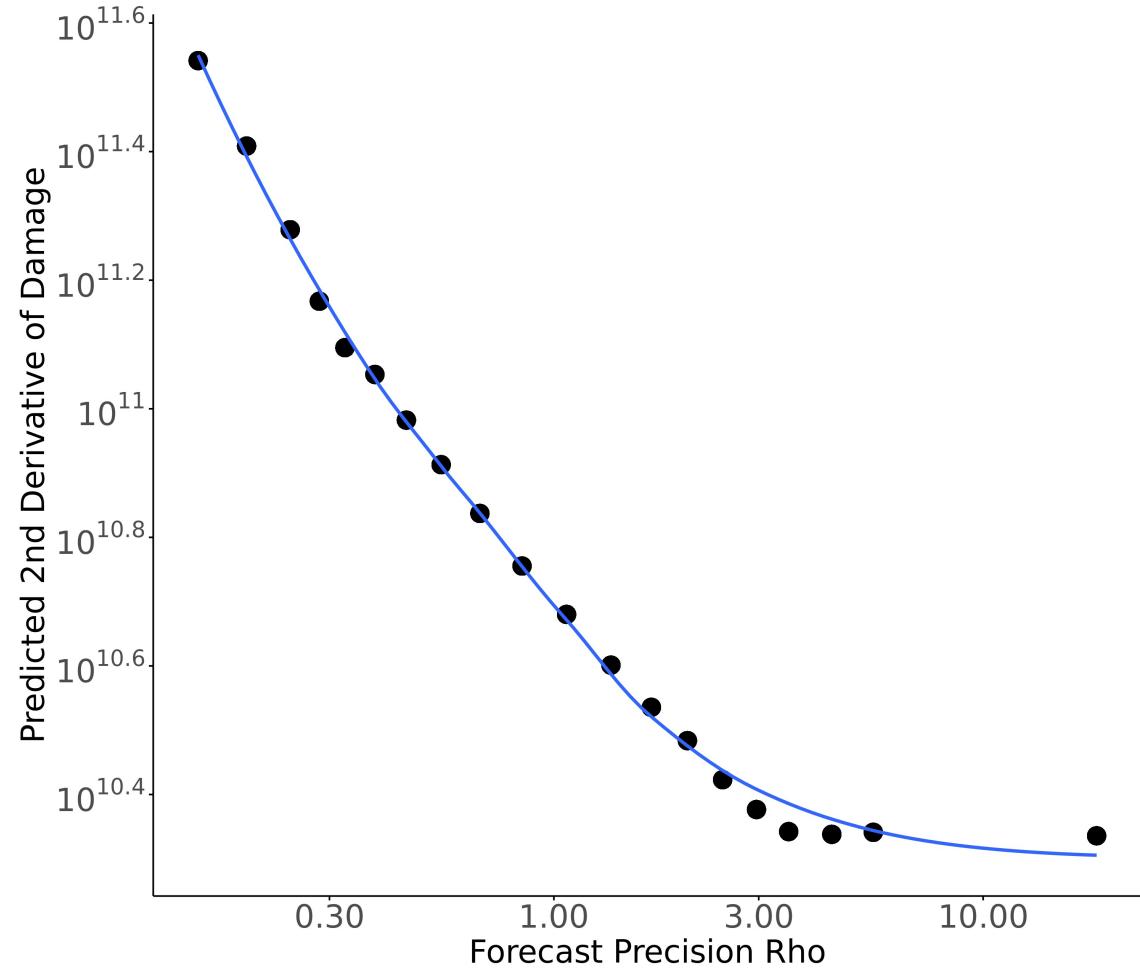


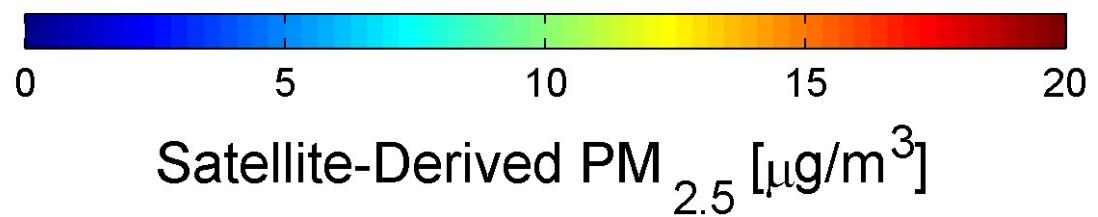
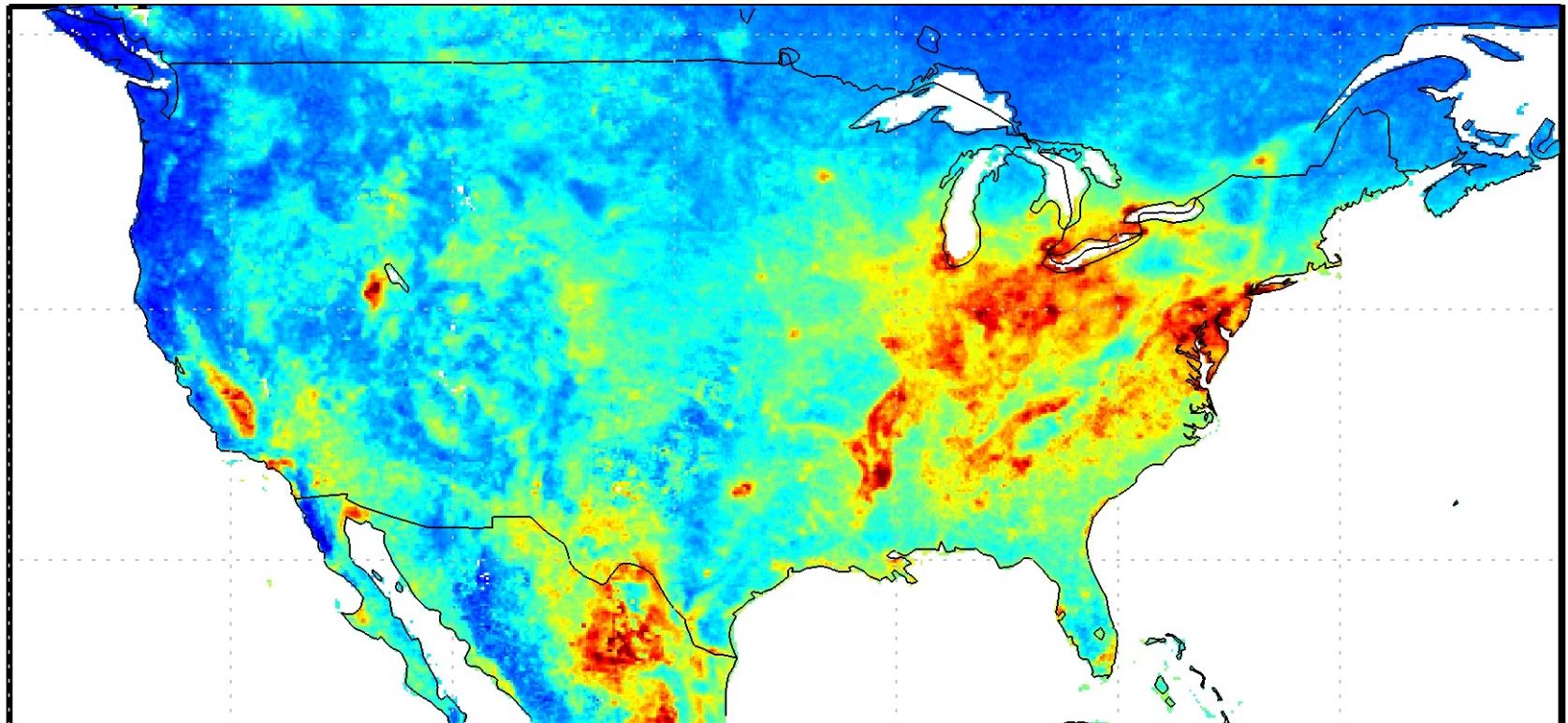
The MWTP for better forecasts

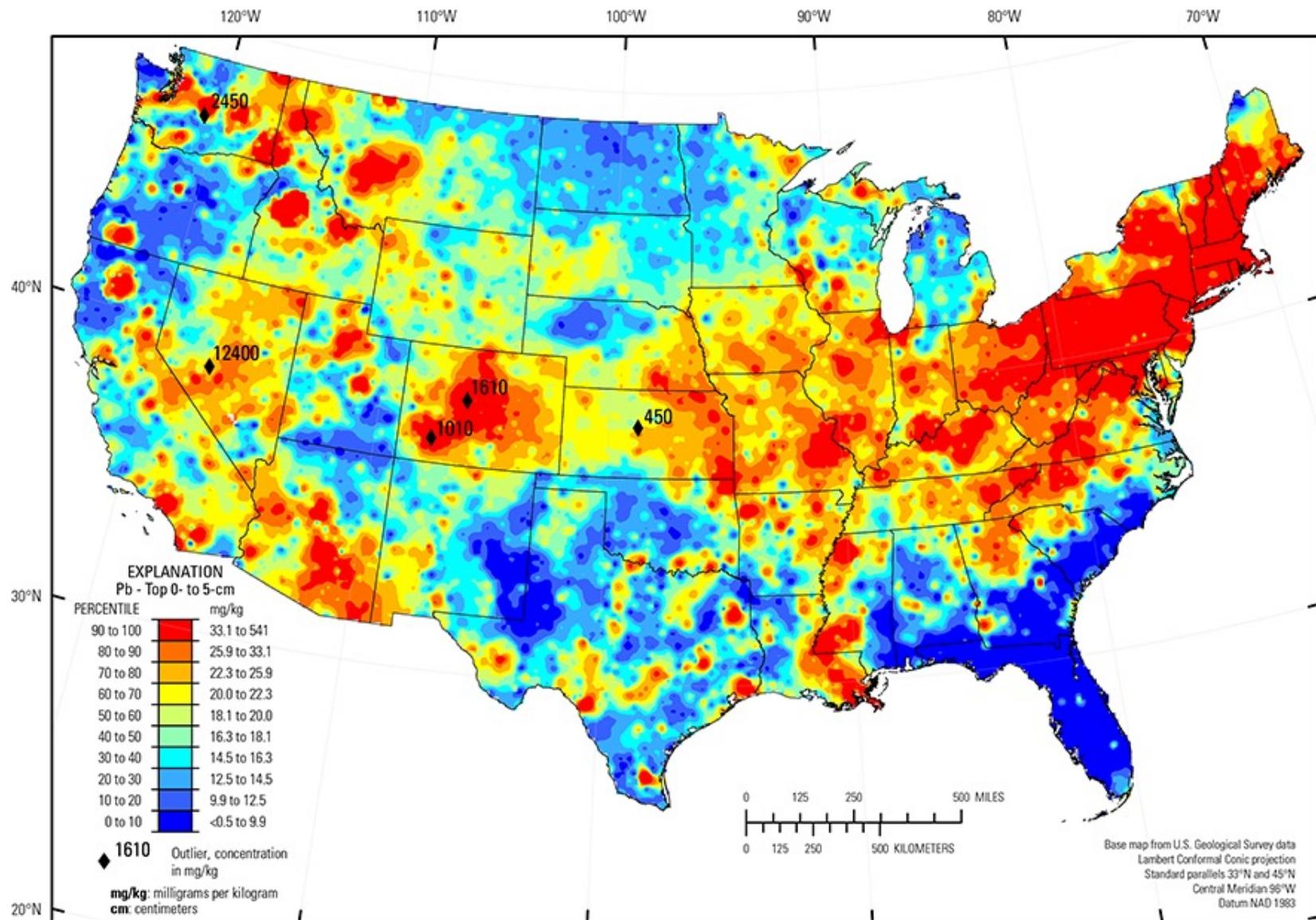
Simple household cost minimization problem:

Regress second derivative of damages on precision

Coefficient is the marginal value of reducing forecast uncertainty







Air pollution

What is the social cost of lead?

Lead is bad for

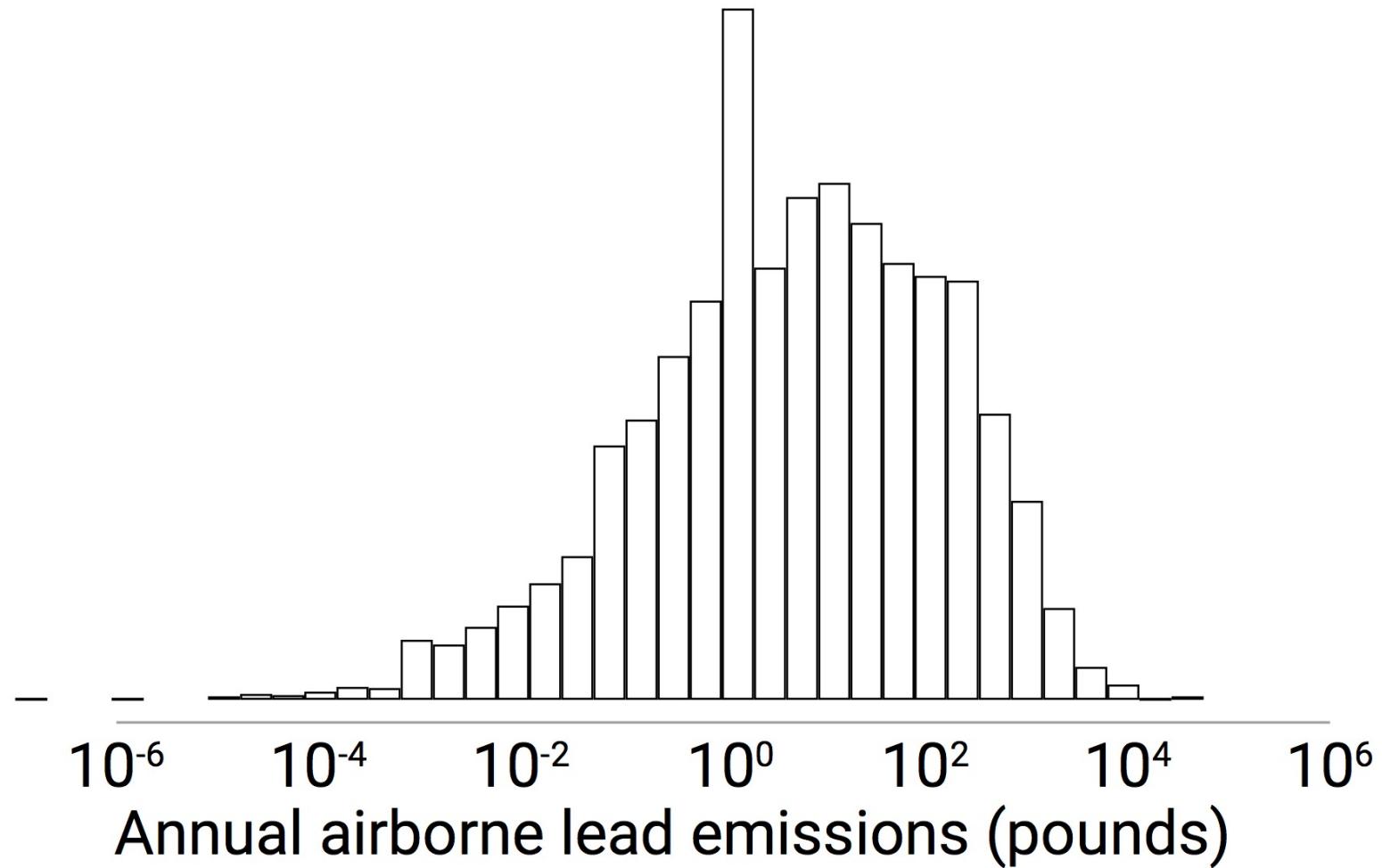
- Mortality (Hollingsworth and Rudik, 2021)
- Kids (Hollingsworth et al. 2021)

But nutrition can help (Hollingsworth et al. 2021)

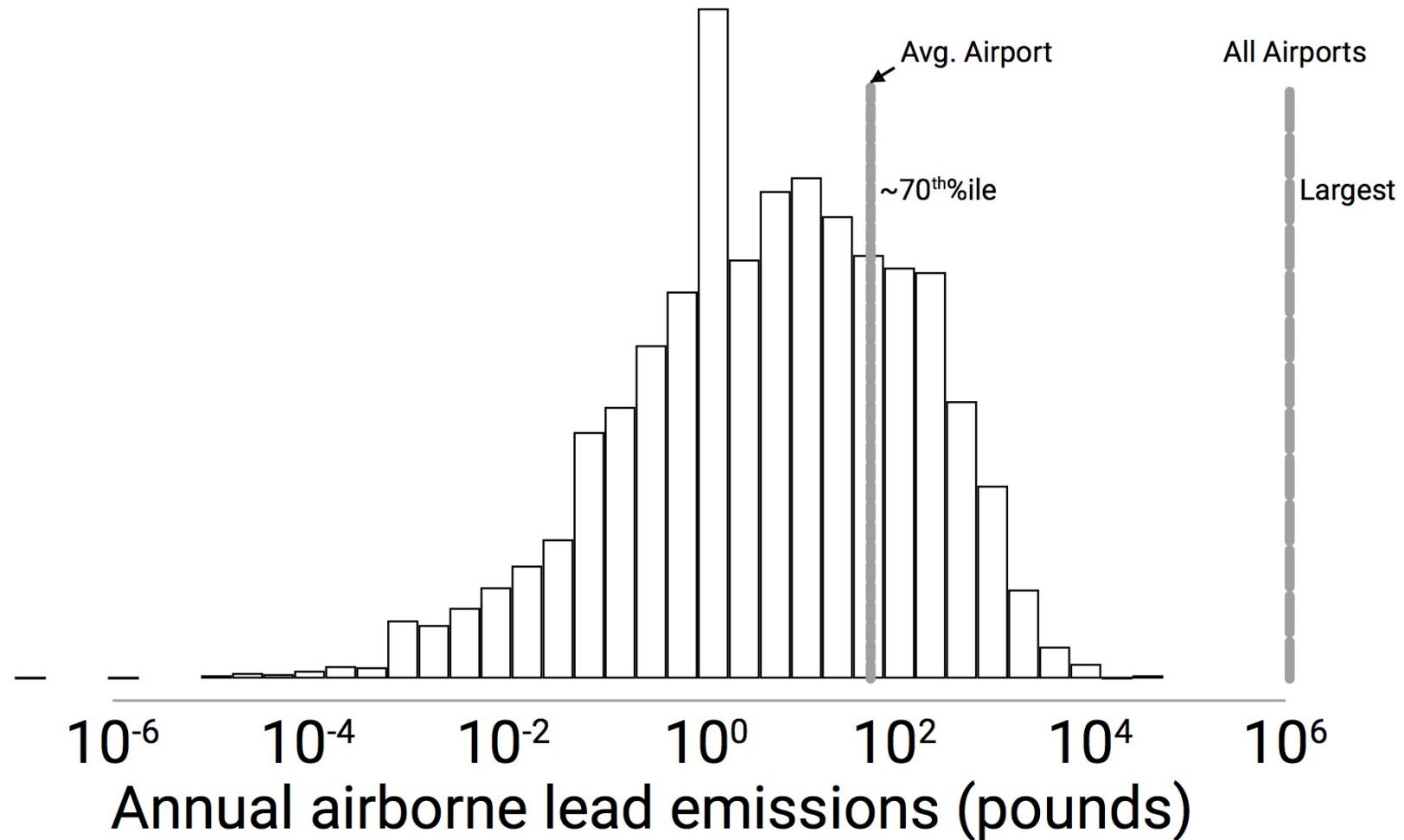
We use racing to generate
quasi-experimental variation in lead emissions



2005 distribution of annual airborne lead emissions for lead-emitting TRI facilities

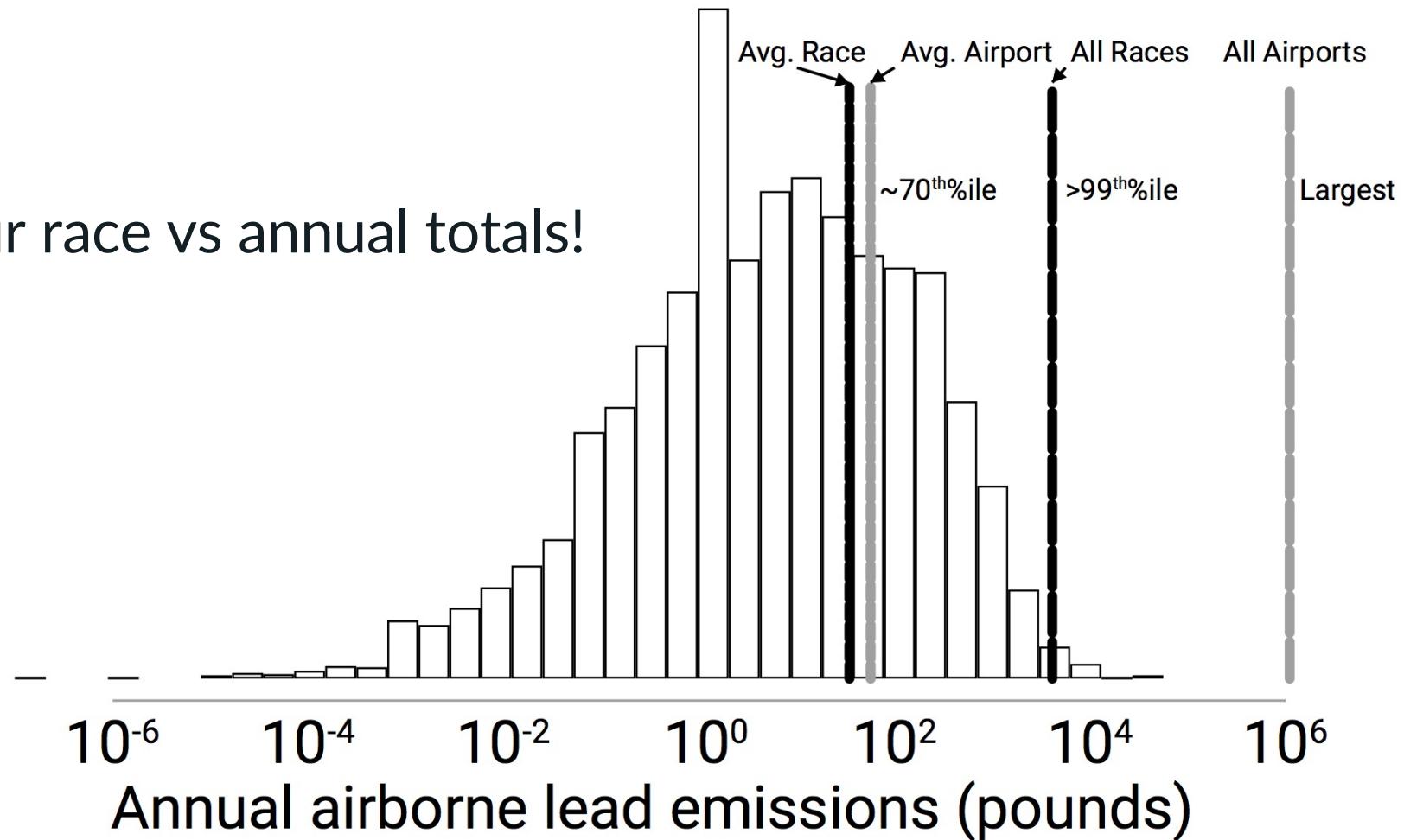


2005 distribution of annual airborne lead emissions for lead-emitting TRI facilities

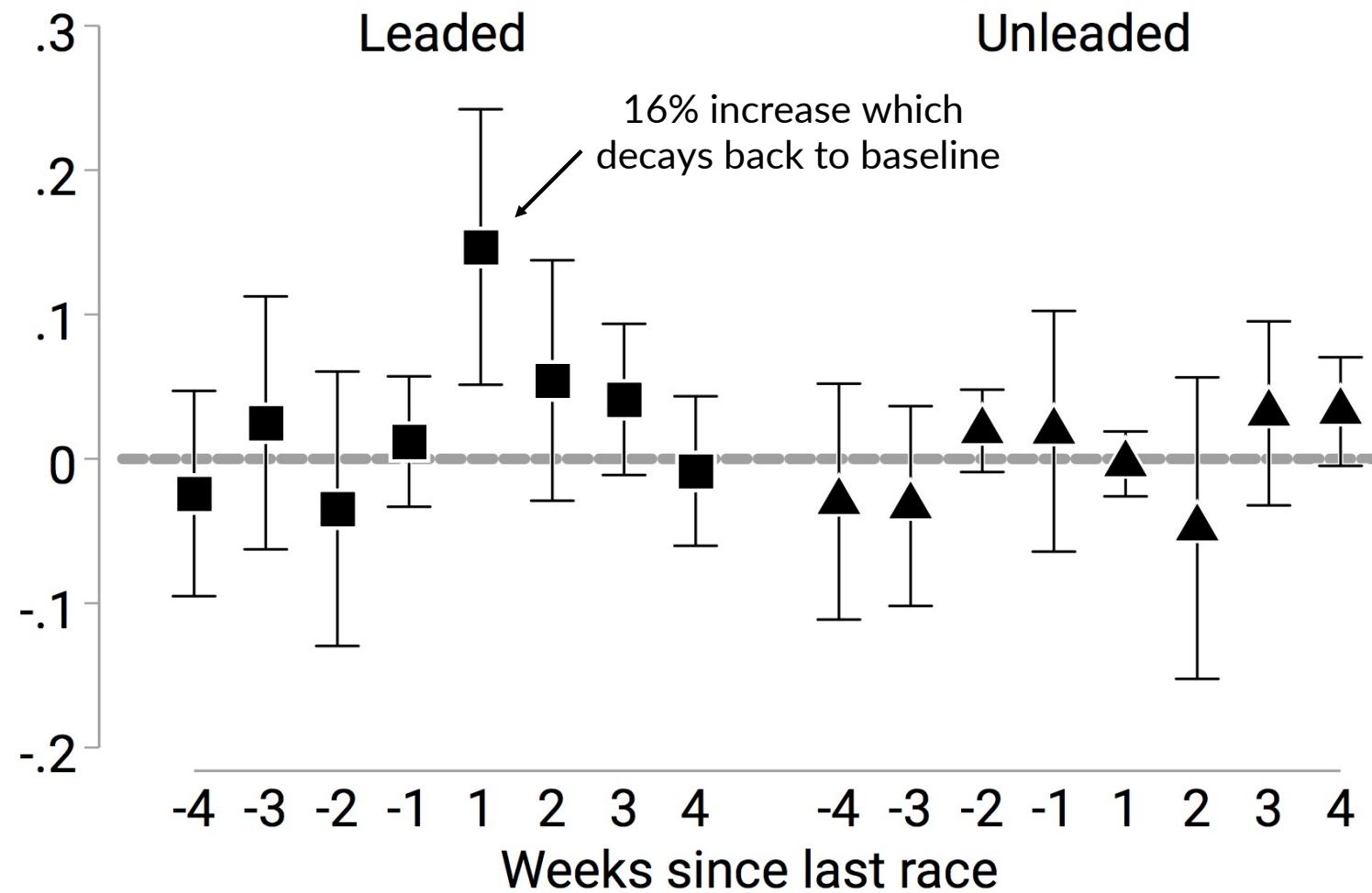


2005 distribution of annual airborne lead emissions for lead-emitting TRI facilities

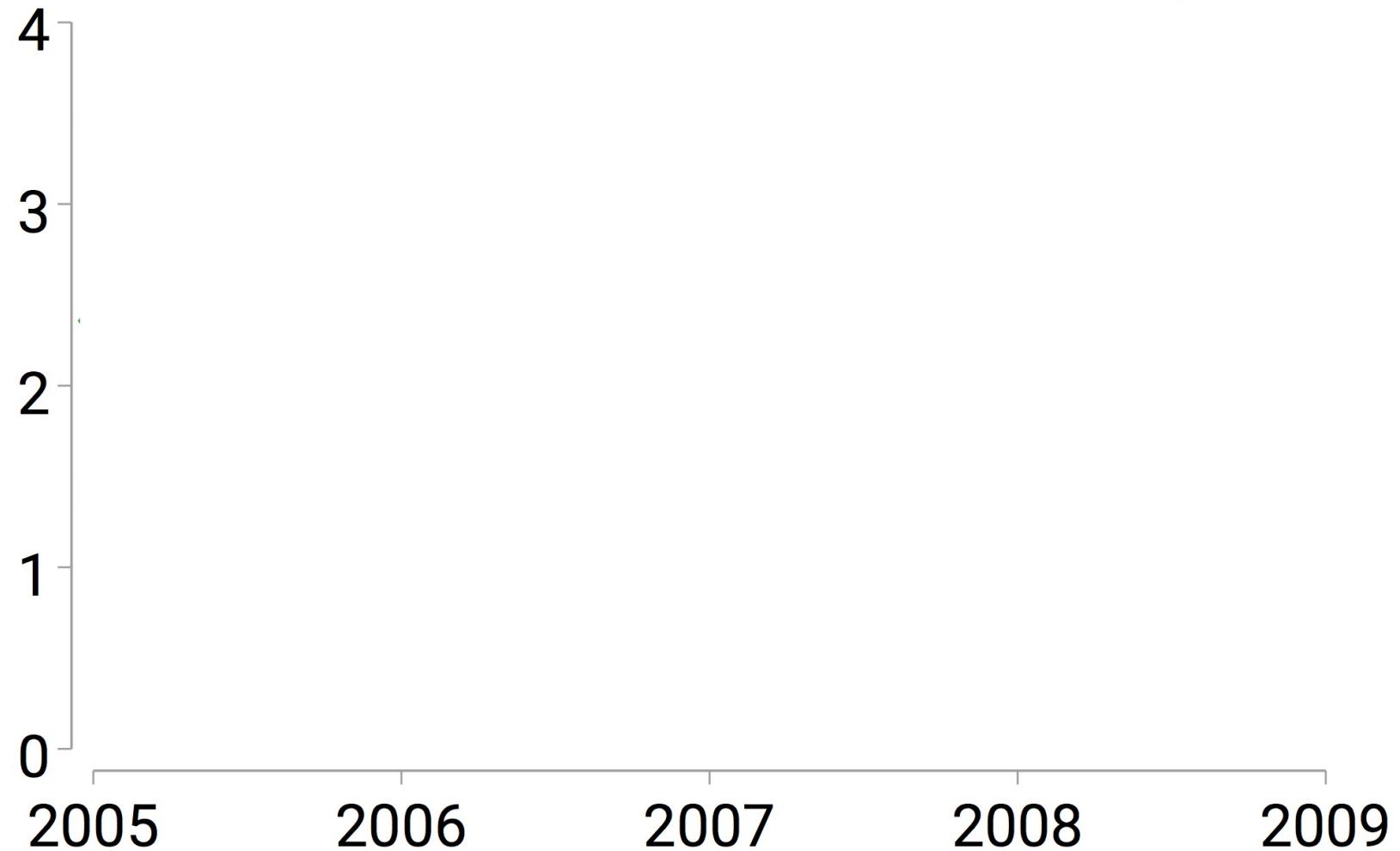
3 hour race vs annual totals!



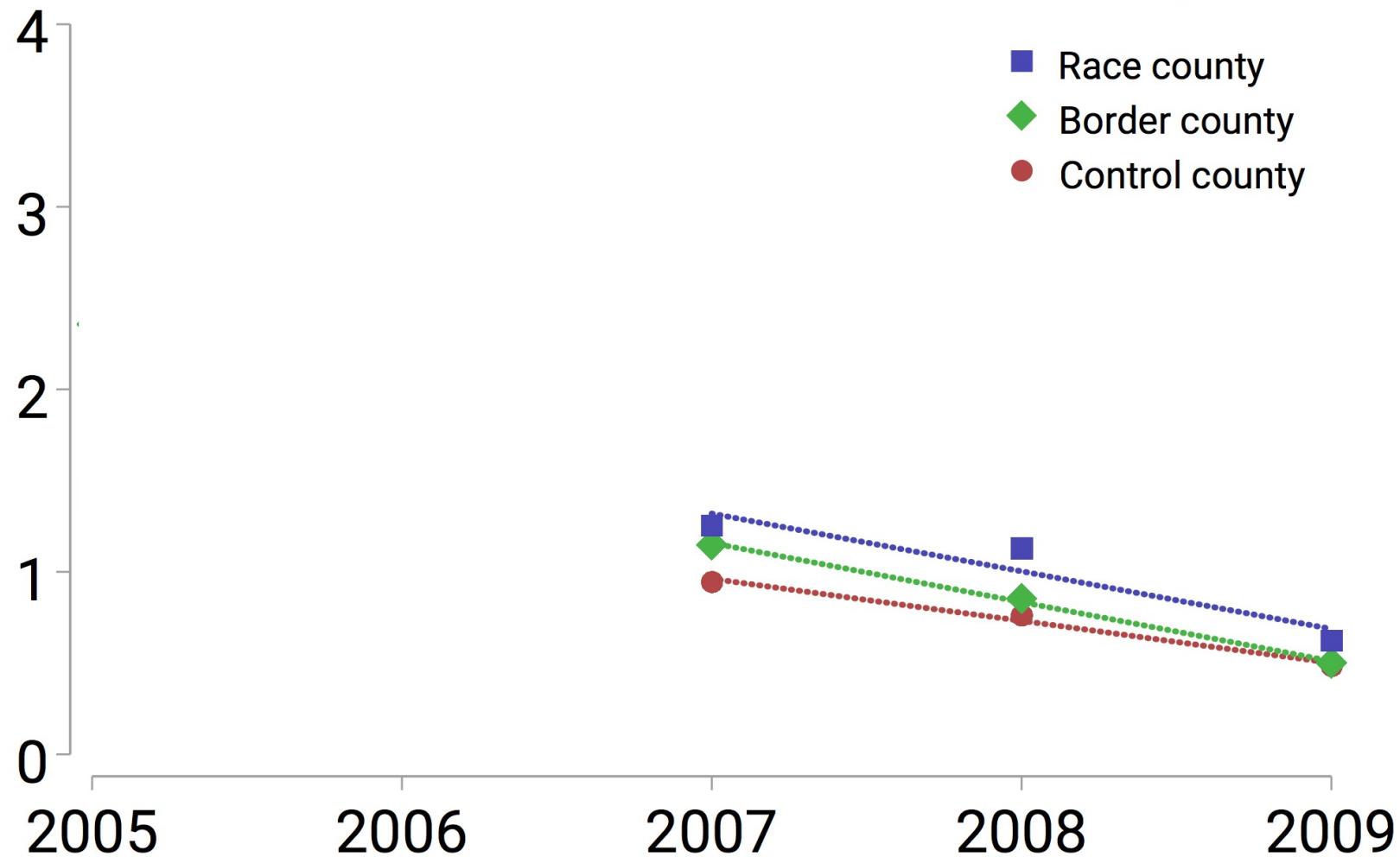
Effect of 100,000 race miles on asinh(Pb)



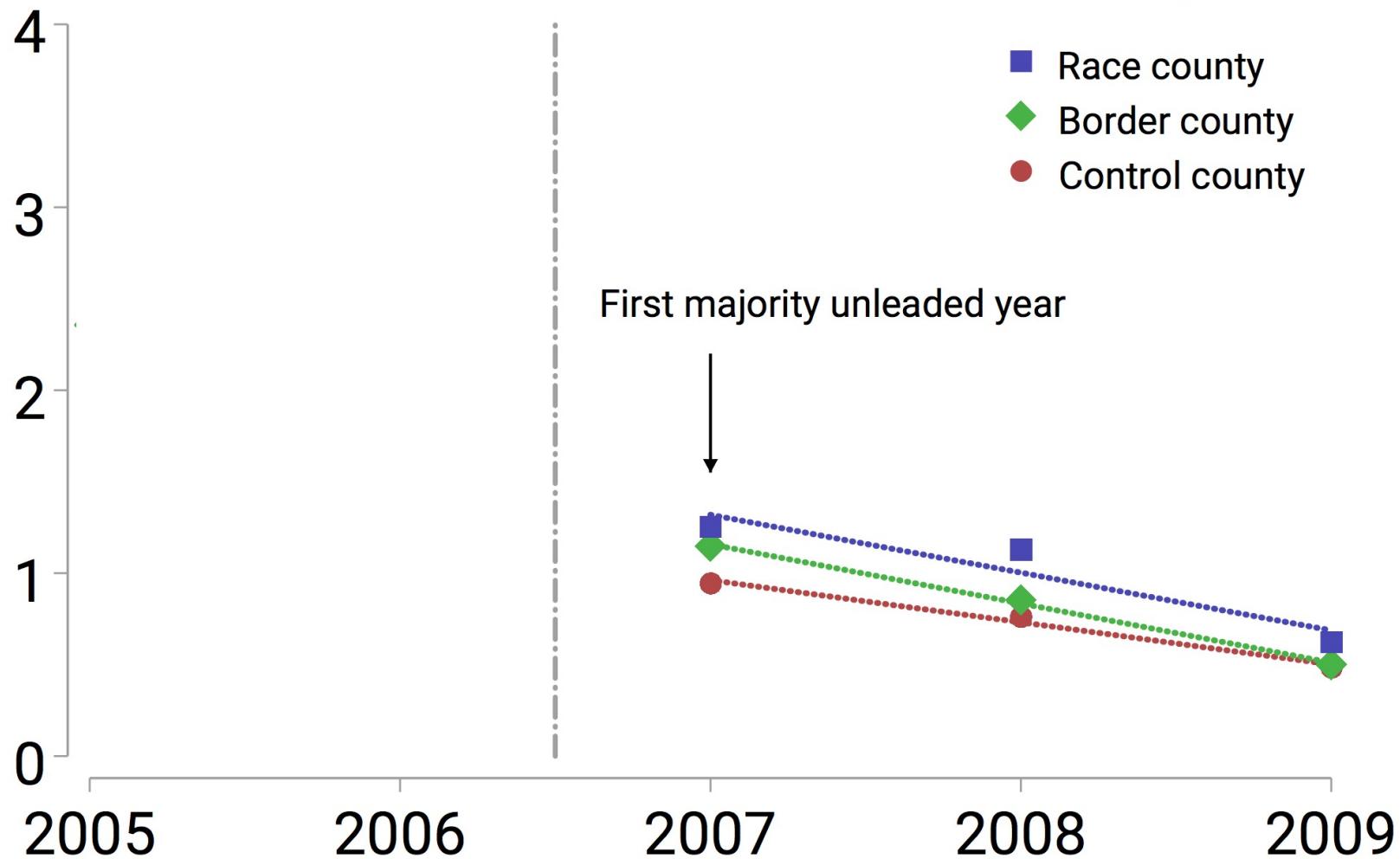
Percent of children tested with EBLL (BLL >10 μ g/dl)



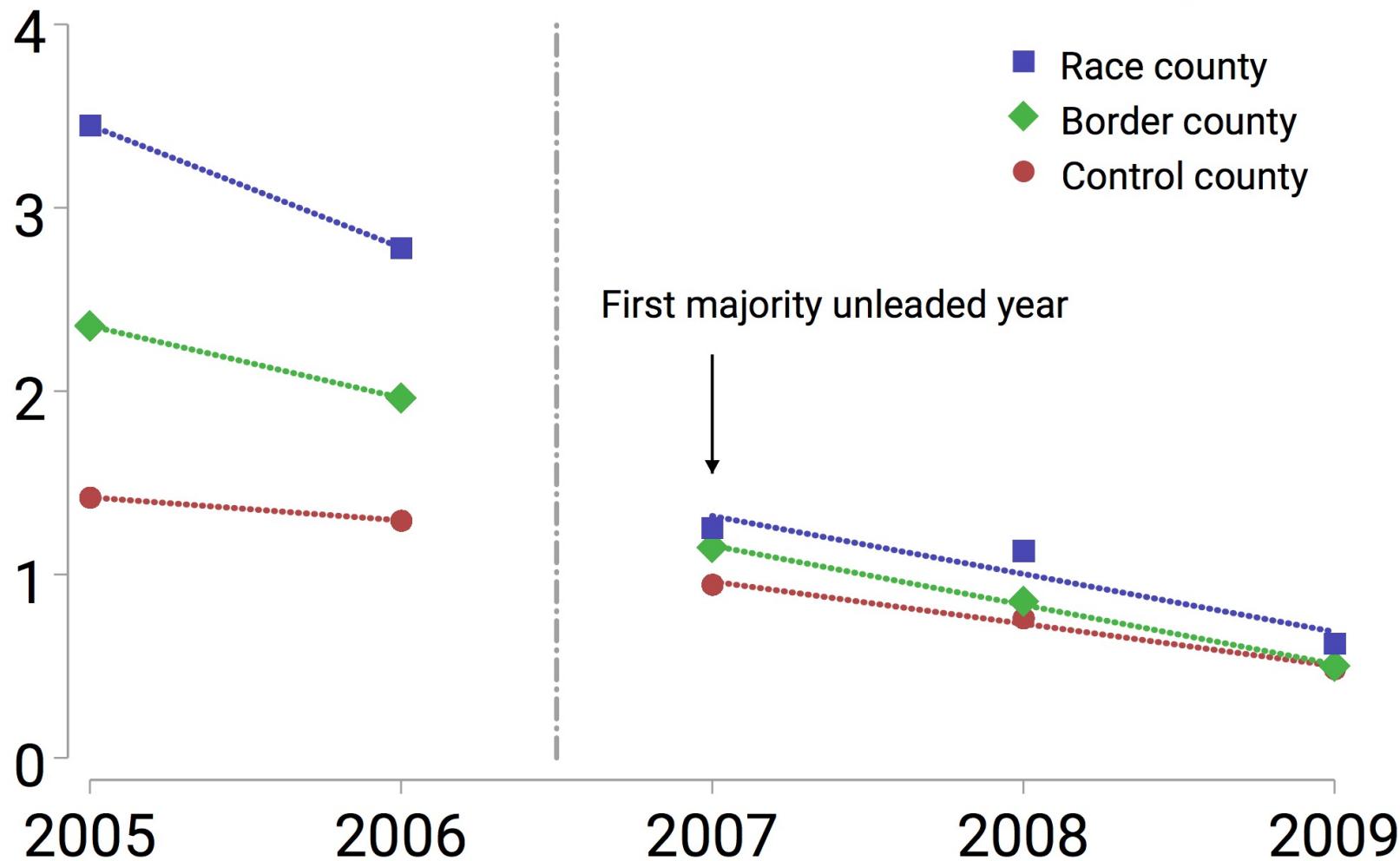
Percent of children tested with EBLL (BLL >10 μ g/dl)



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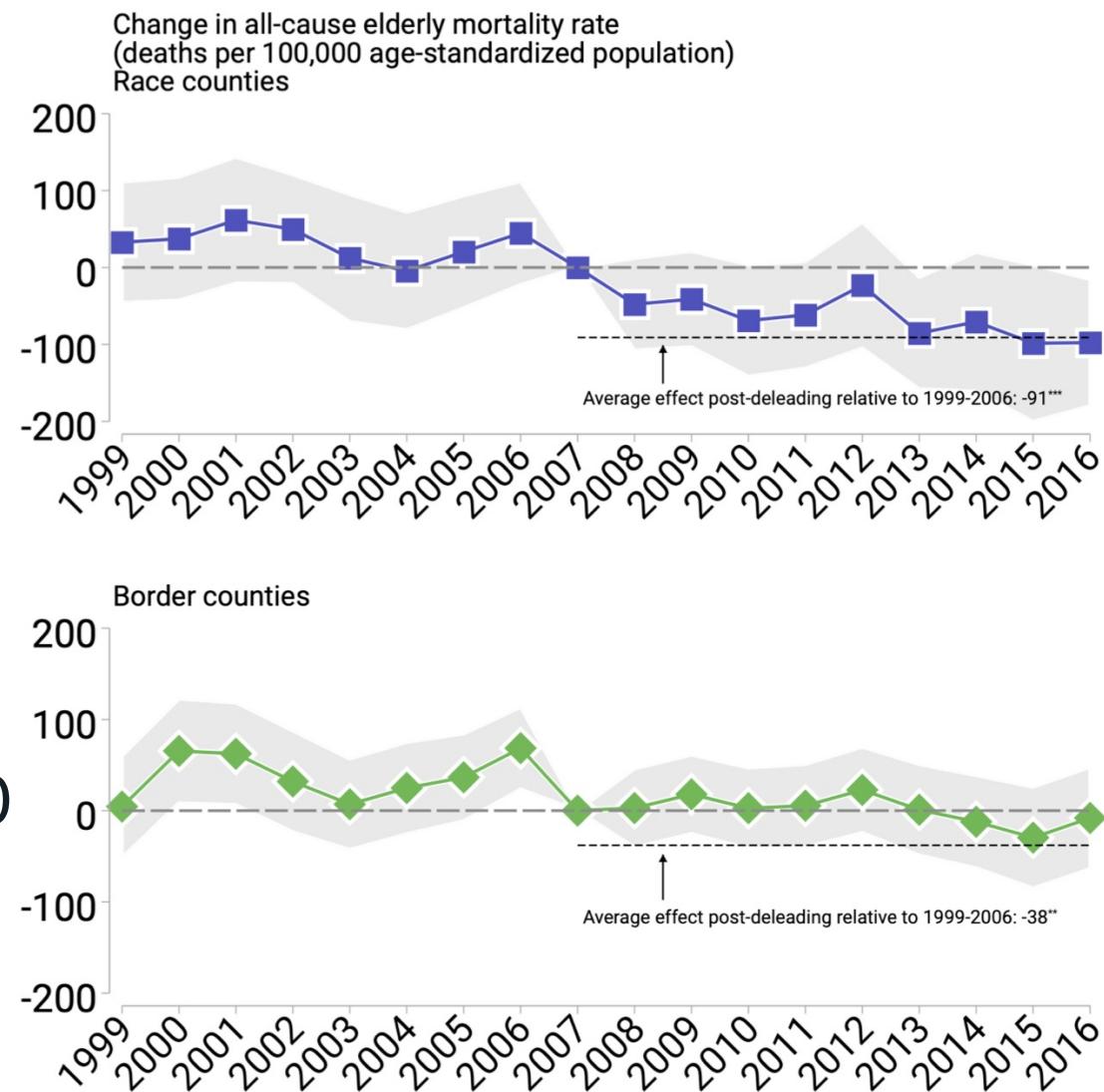


All-cause mortality

Picks up all effects

Circumvents issues with classifying cause of death

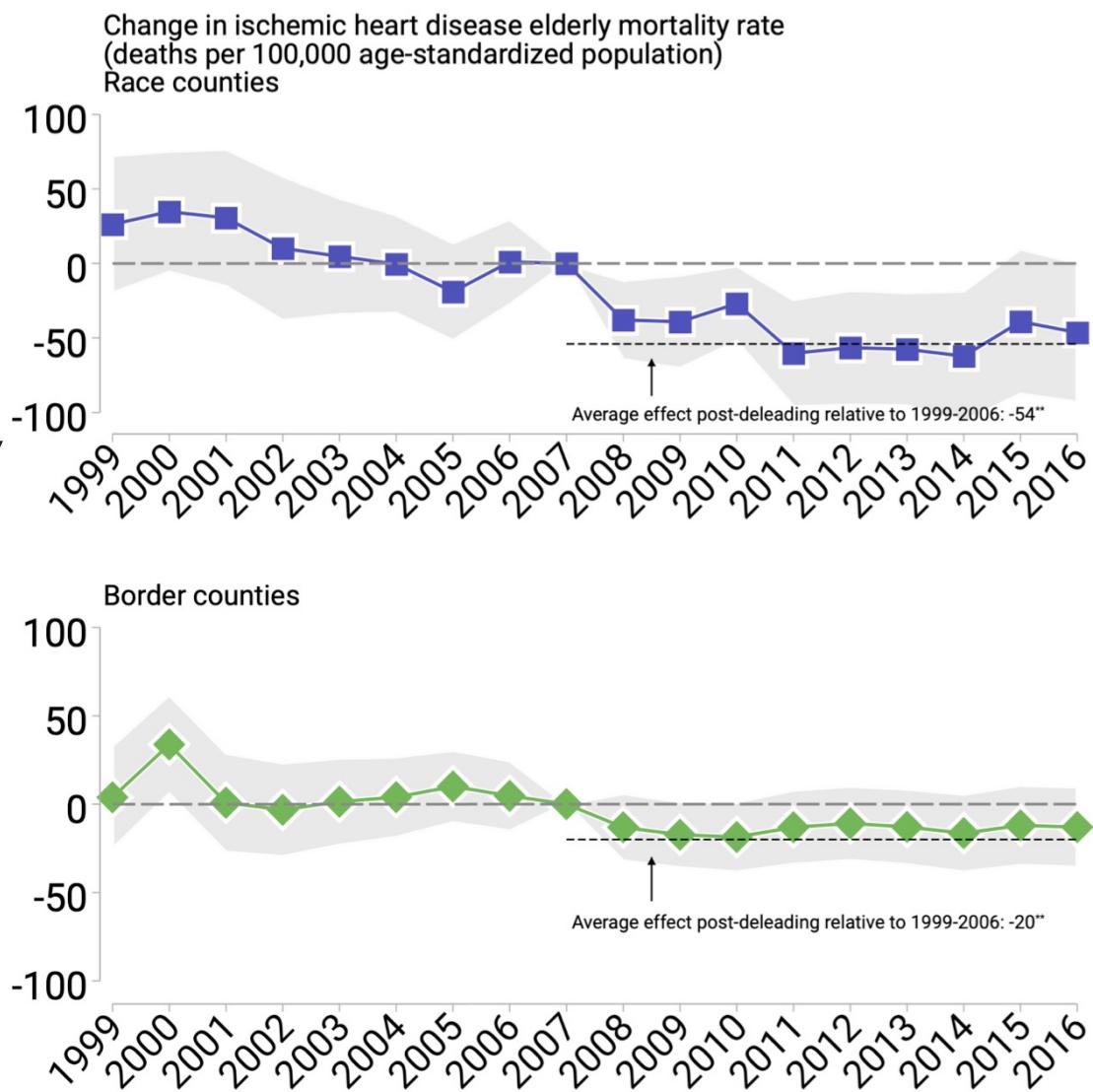
Gives a social cost of > \$1,000 per gram of lead



Ischemic heart disease

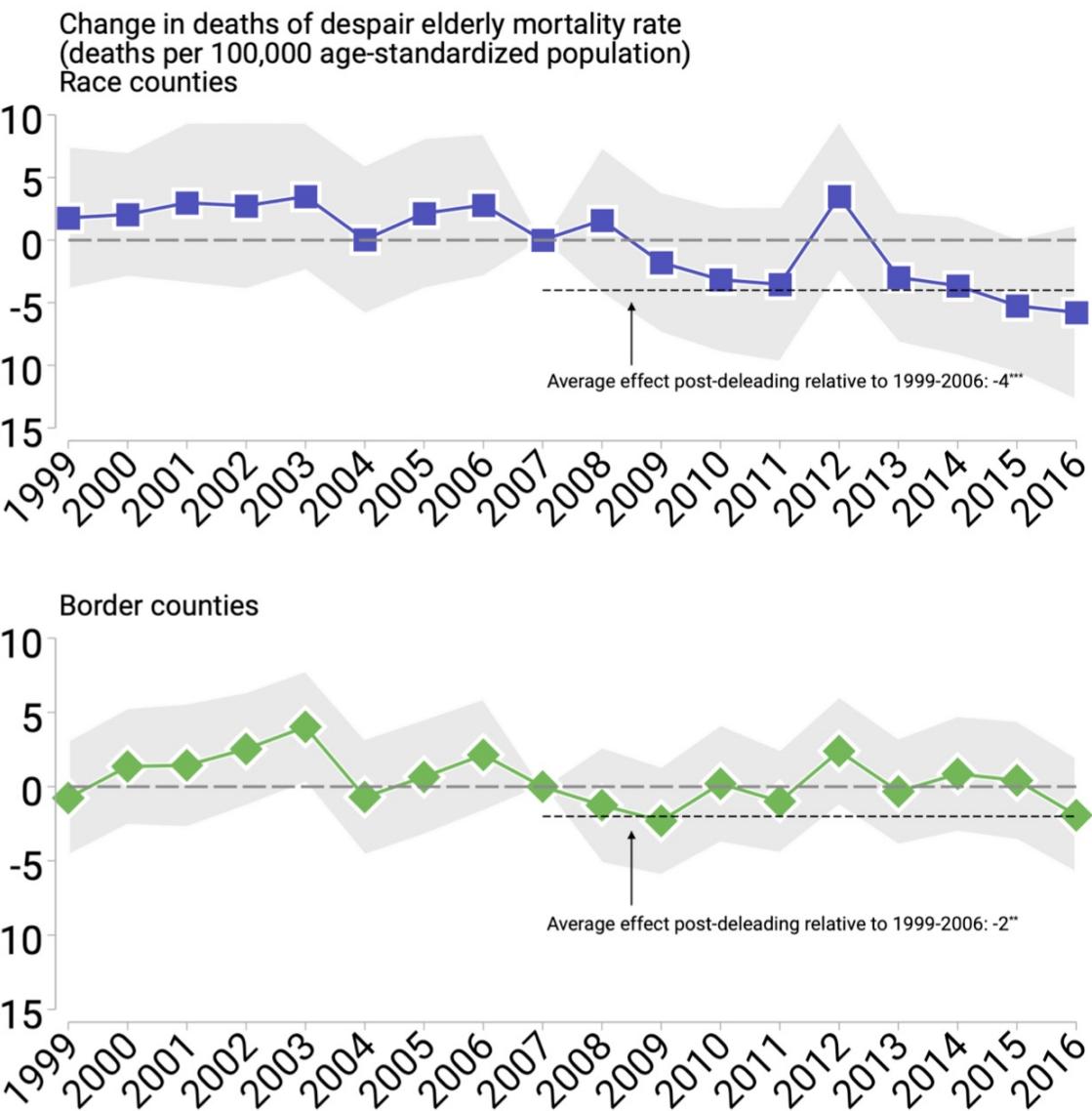
Blood vessel diseases, typically caused by plaque build up

Common cause of death in associational findings

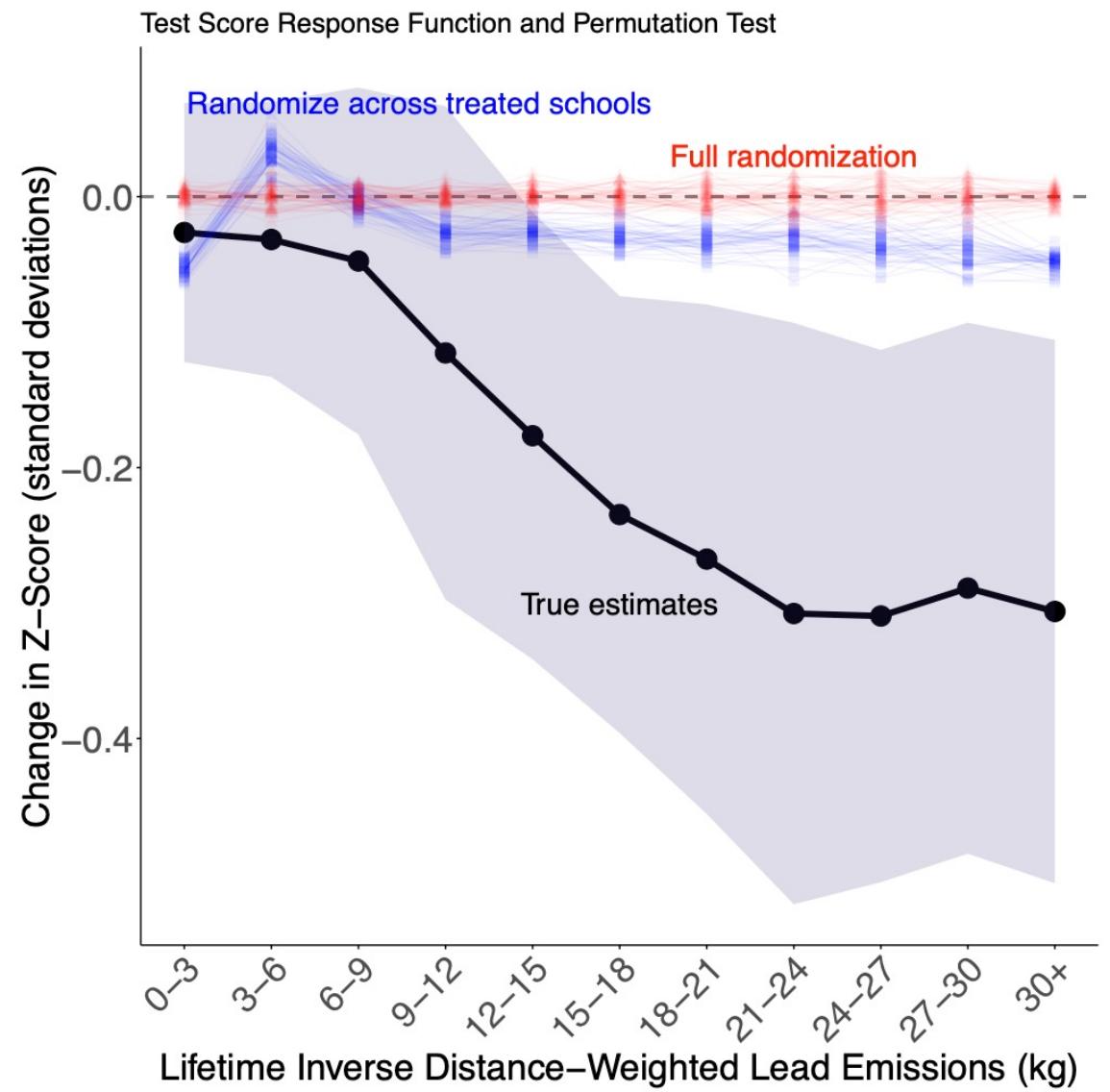


MAYBE affects deaths of despair (Case and Deaton)

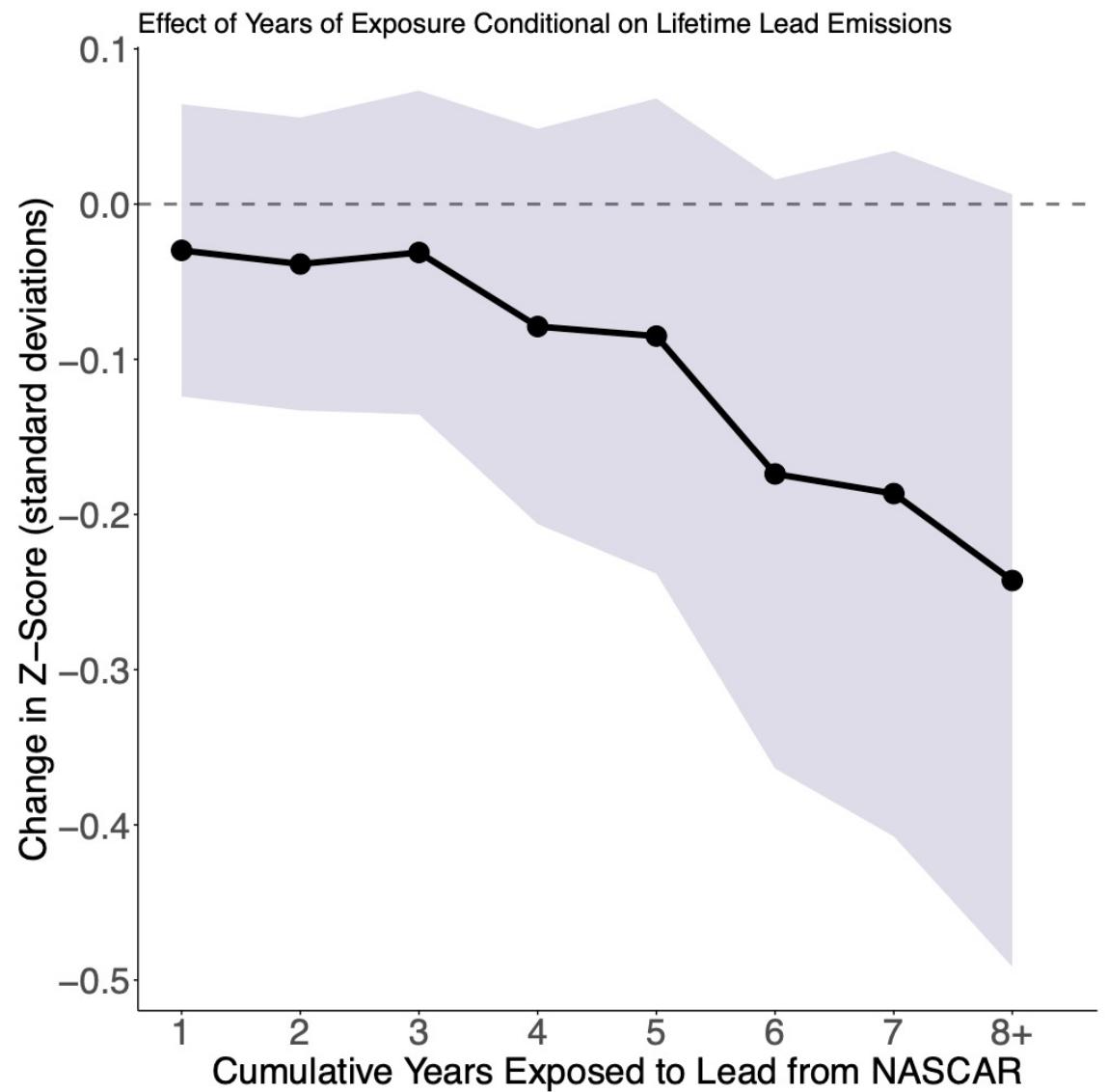
Lead has significant negative effects on mental state, emotional stability, cognition



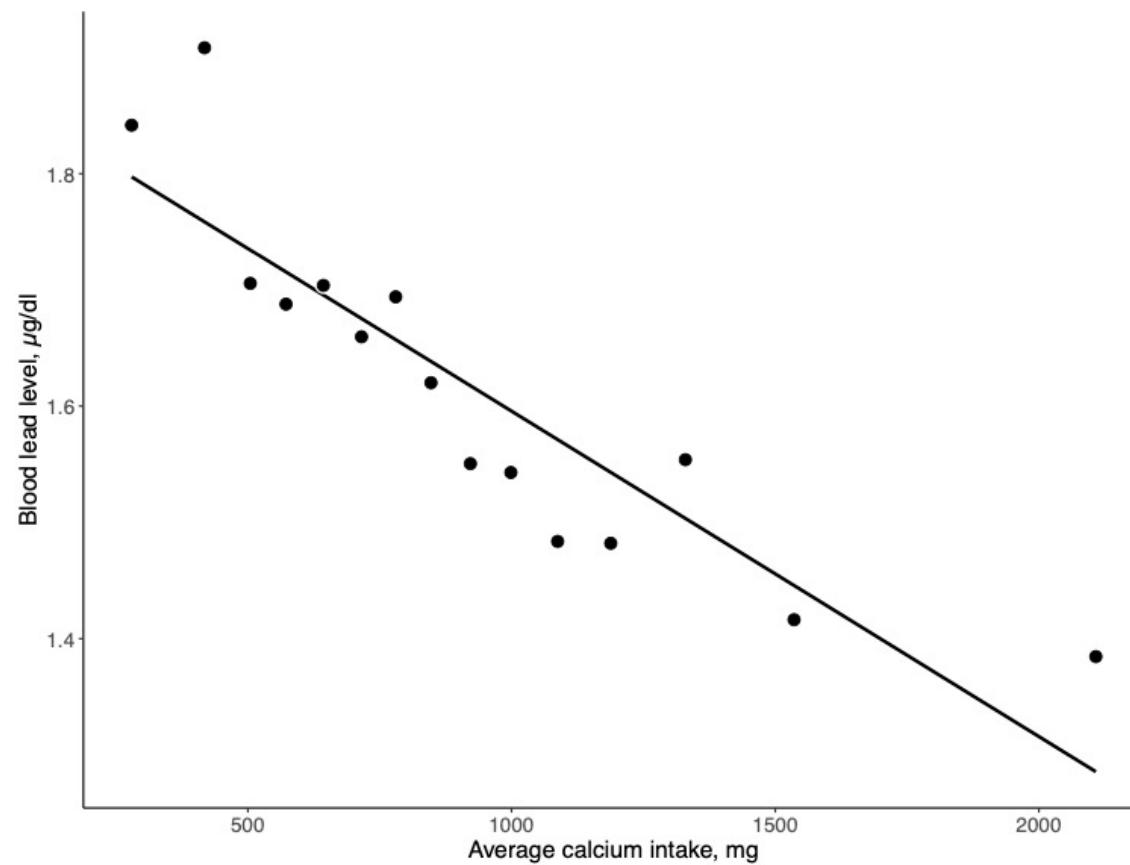
Lead is bad for test scores



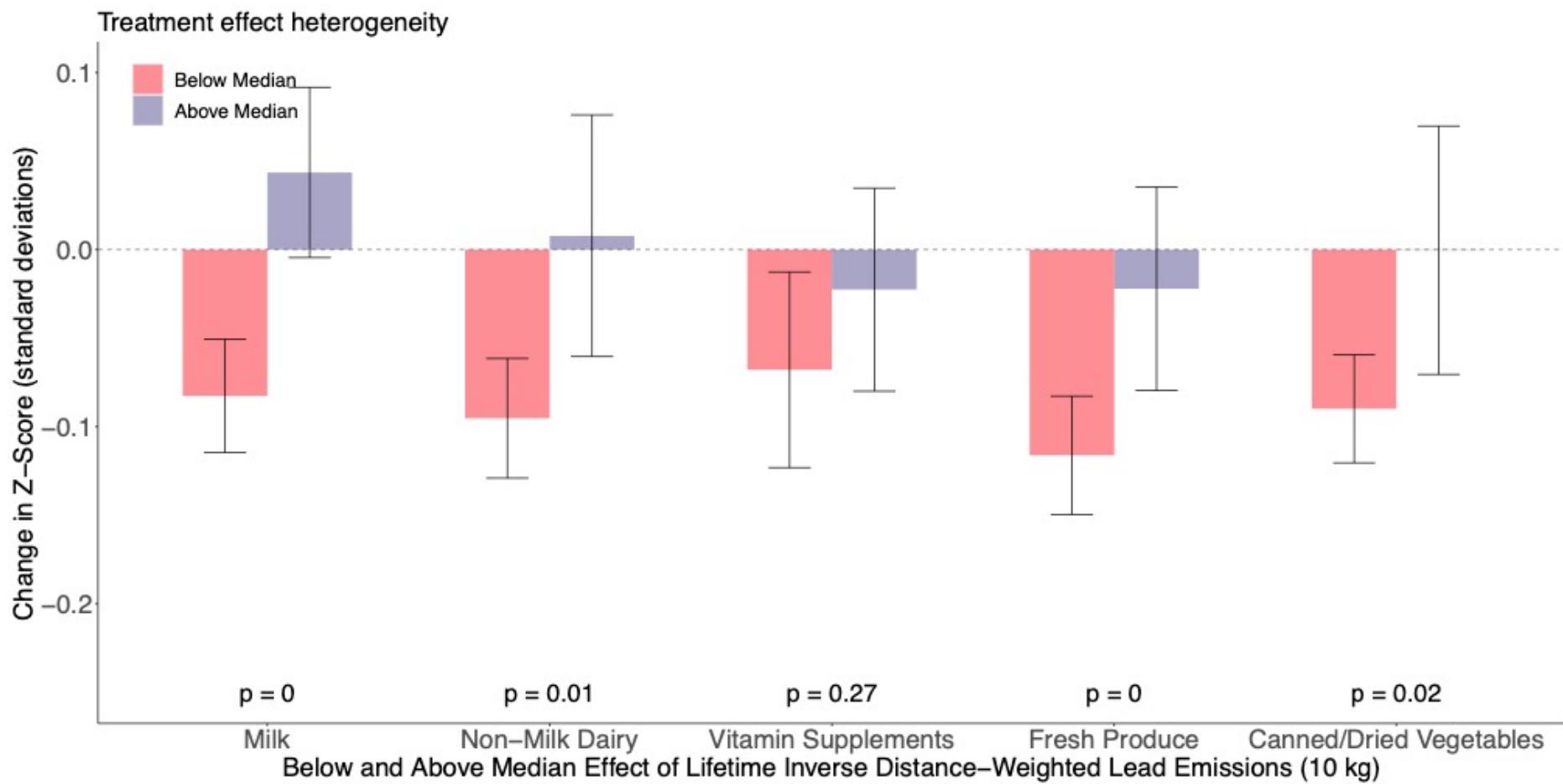
The same exposure spread out over time is even worse



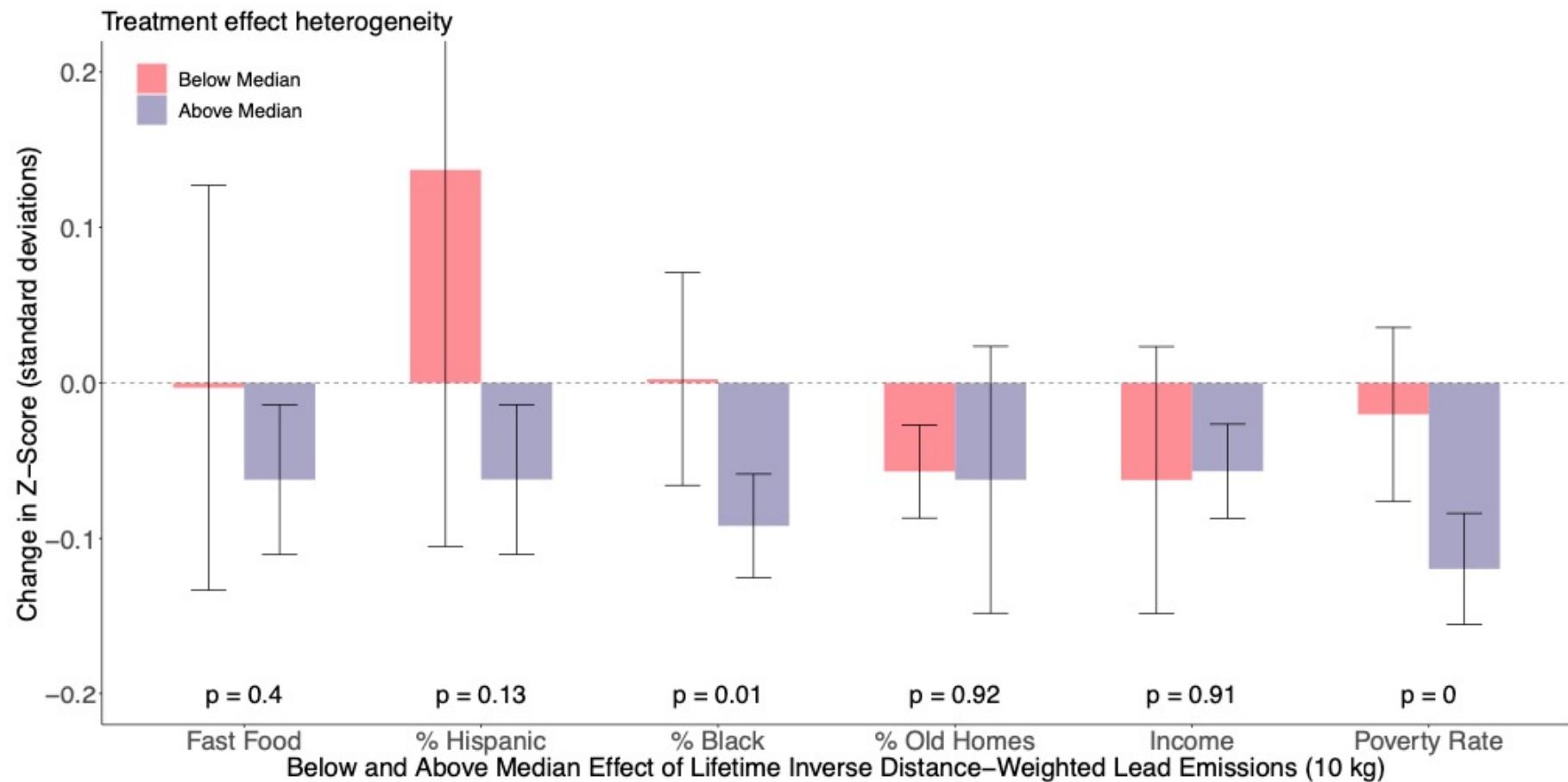
Raw correlations suggest calcium can mitigate lead exposure



Nutrition matters



NASCAR lead was socioeconomically regressive



Biodiversity

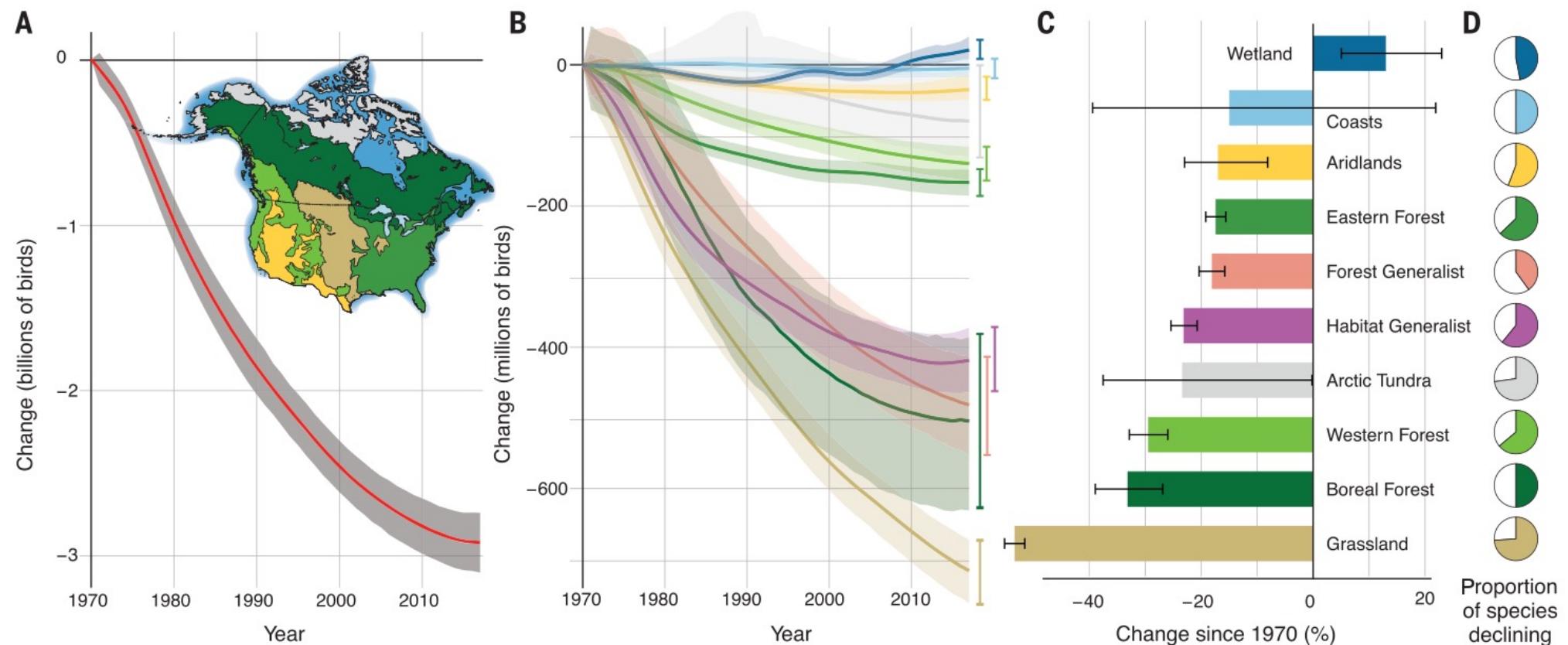
What are the economic determinants of biodiversity?

Ozone (Liang et al. 2020)

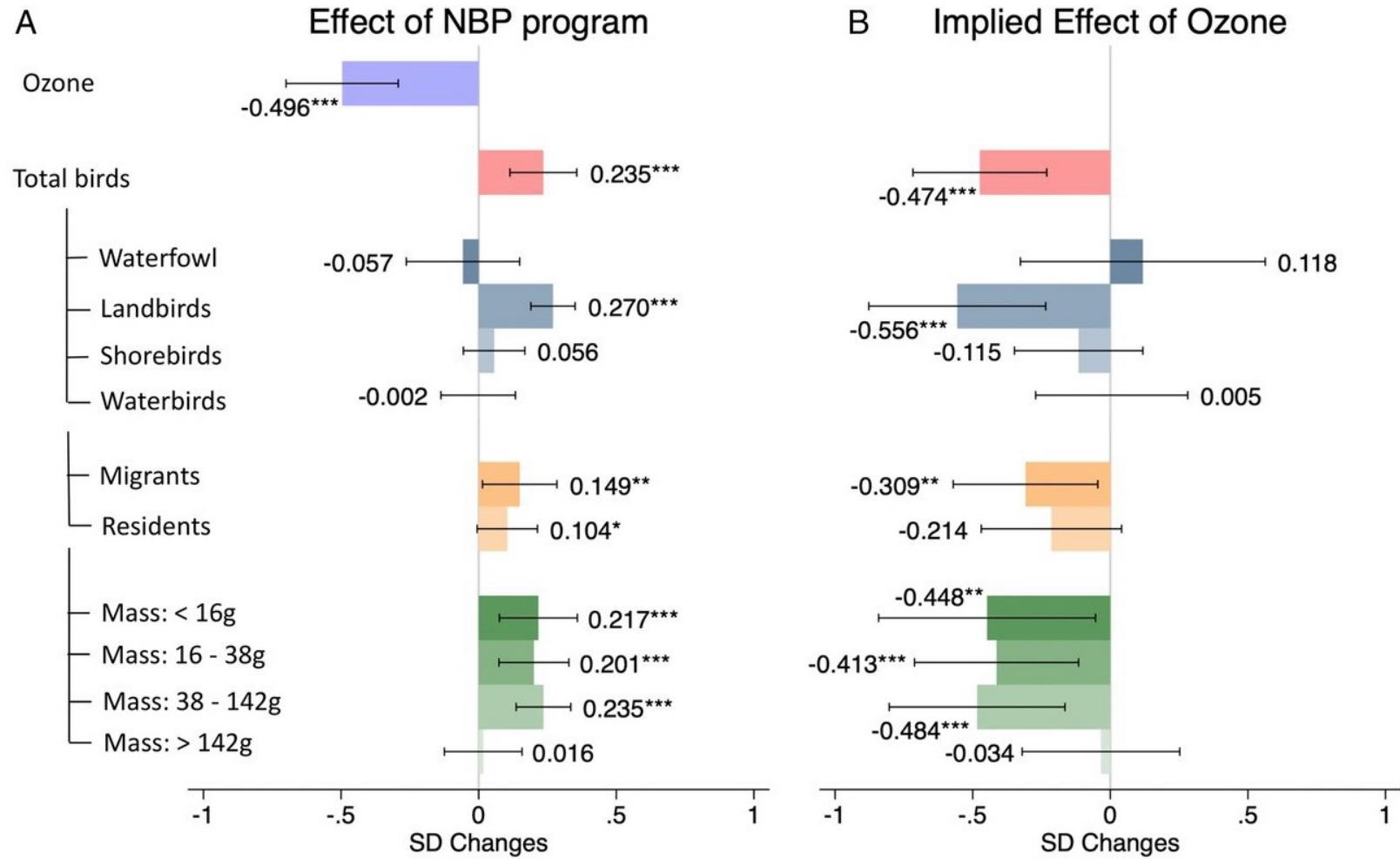
General economic production (Liang, Rudik, Zou 2021)

North American bird populations are falling

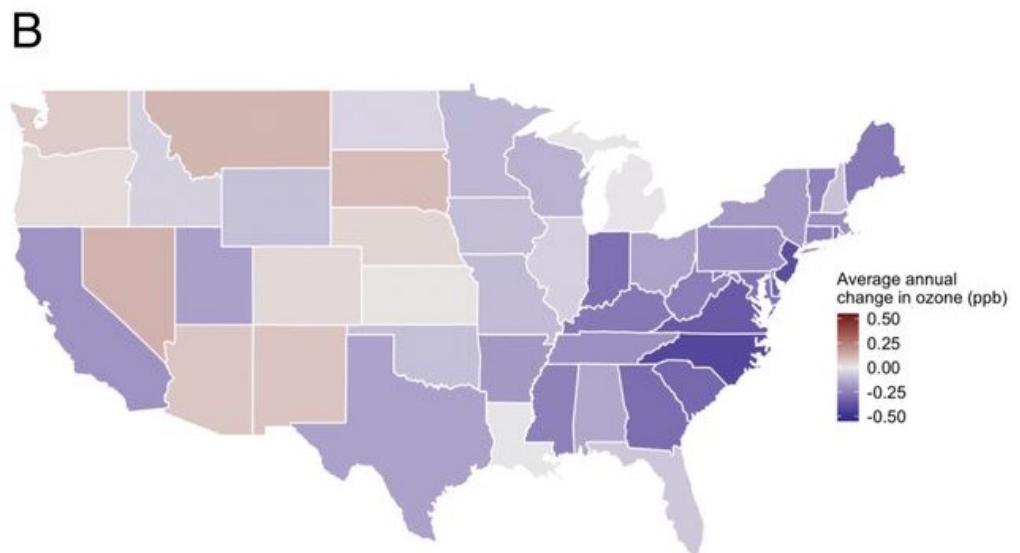
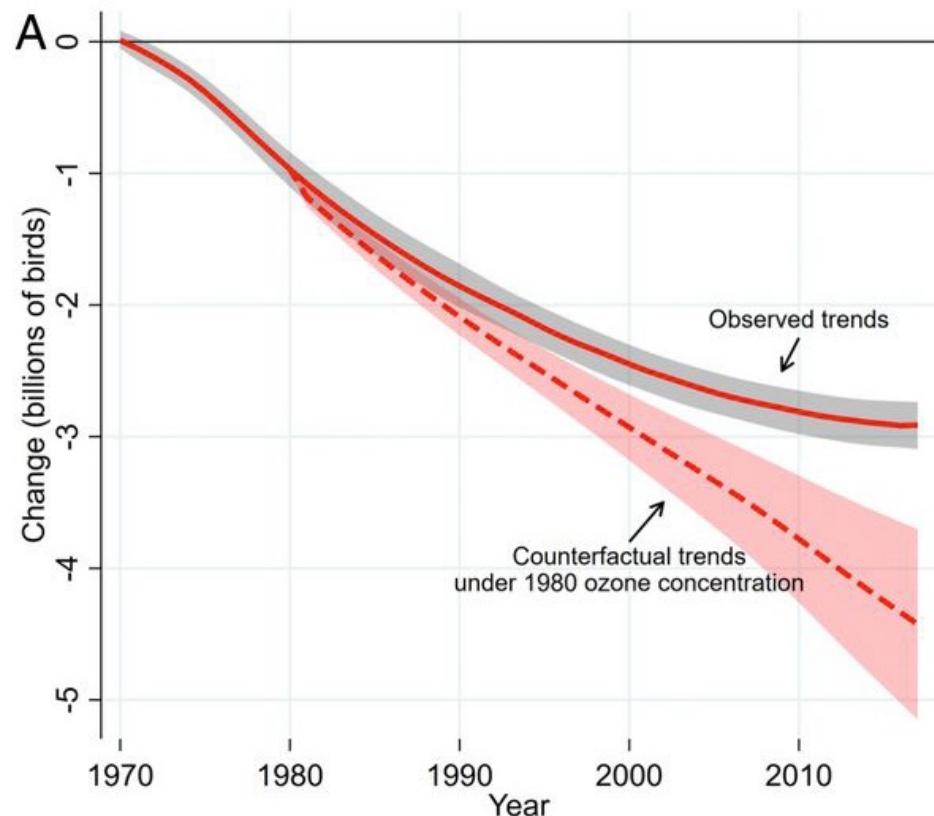
Rosenberg et al. (2019) [Lab of O]

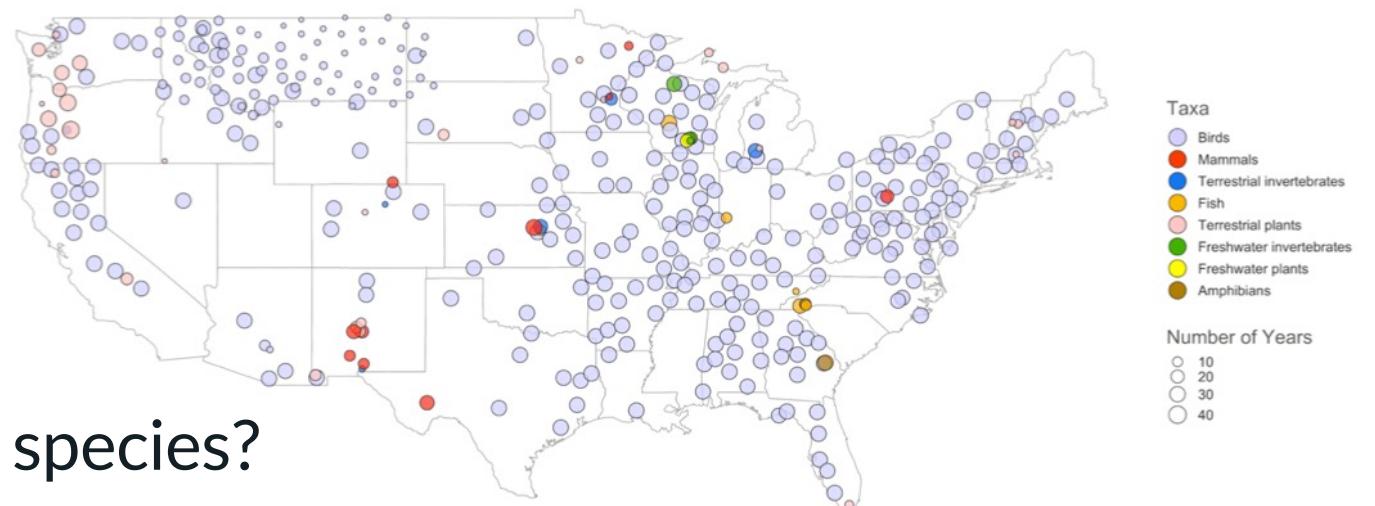


Ozone kills birds

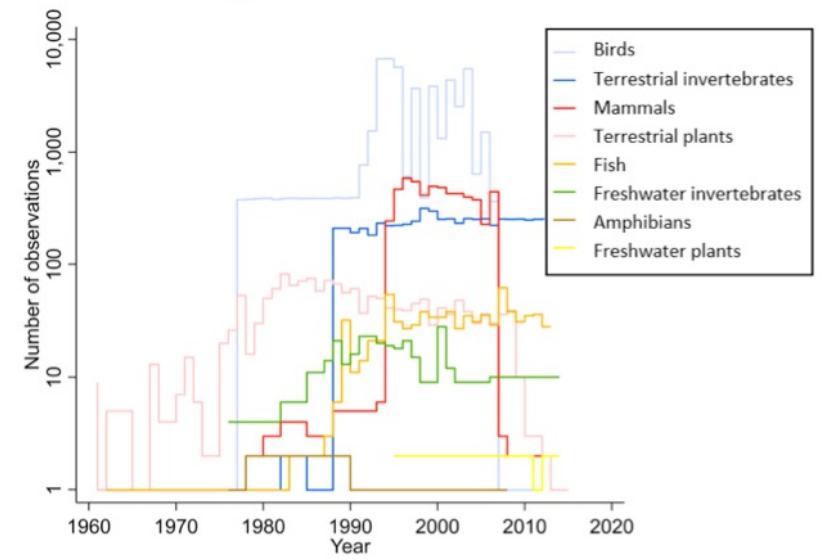
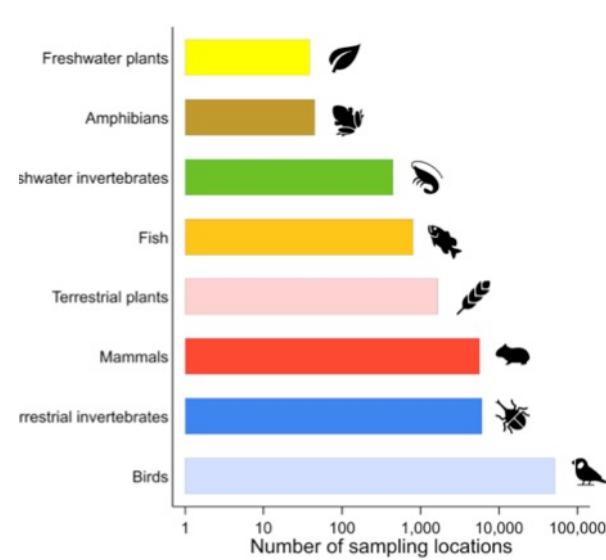


Ozone kills birds



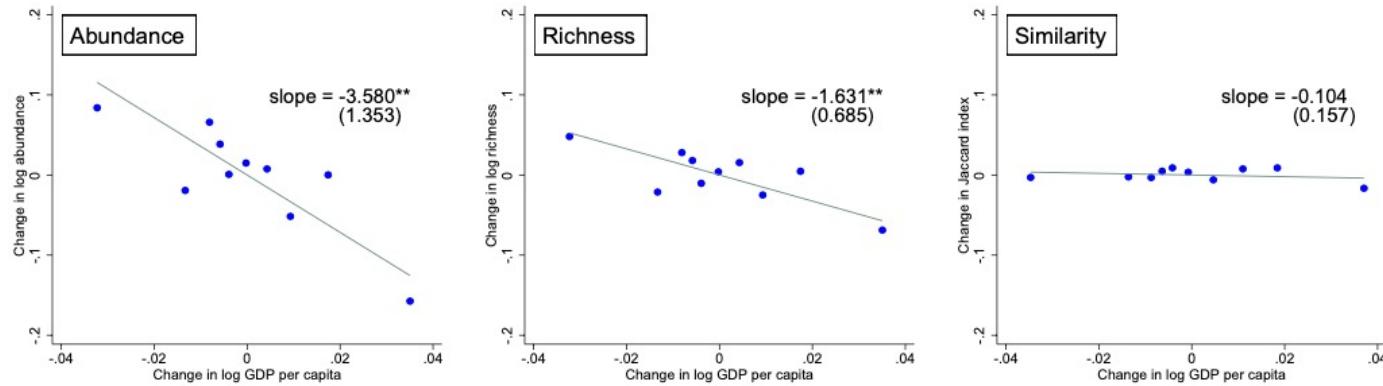


What about other species?



Development is bad for biodiversity

Panel A. Average effect



Panel B. By taxa

