

Berkeley

#### SUSTAINABILITY AND HEALTH EQUITY (SHE) LAB

SCHOOL OF PUBLIC HEALTH AND DEPARTMENT OF ENVIRONMENTAL SCIENCE AND POLICY MANAGEMENT

# Cap-and-Trade: Understanding the Research & Remedies

Manuel Pastor Rachel Morello-Frosch July 18, 2024



# THE CLIMATE GAP

Inequalities in How Climate Change Hurts Americans & How to Close the Gap



Rachel Morello-Frosch, Ph.D., MPH | Manuel Pastor, Ph.D. | James Sadd, Ph.D. | Seth B. Shonkoff, MPH



Climate inequities are everywhere, usually defined by exposure, sensitivity,

& adaptive capacity.

One key policy challenge for California is how to address climate while also

improving equity outcomes.

#### Policy debate regarding equity impacts of cap-and-trade: Number of GHG-emitting facilities in block groups by race/ethnicity and disadvantage



Cushing et al. 2018 PLOS Medicine

First, everyone agrees that there were patterns of disparity by race and income prior to cap-and-trade (and are still)







Second, everyone agrees that cap-andtrade will indeed yield unequal co-benefits and that who benefits is an empirical question



# ENVIRONMENTAL HEALTH HAZARD PELIGRO AMBIENTAL PARA LA SAIII



# To explain why studies yield different results on this question of benefits, we offer a simplistic overview



If you can't explain it simply, you don't understand it well enough.

Albert Einstein

# Our initial study (Cushing, et al. 2018) looked at the equity implications of cap and trade after the first compliance period.

#### 

#### RESEARCH ARTICLE

Carbon trading, co-pollutants, and environmental equity: Evidence from California's cap-and-trade program (2011– 2015)

Lara Cushing<sup>1,2</sup>\*, Dan Blaustein-Rejto<sup>3</sup>, Madeline Wander<sup>4</sup>, Manuel Pastor<sup>4</sup>, James Sadd<sup>5</sup>, Allen Zhu<sup>6</sup>, Rachel Morello-Frosch<sup>2,7</sup>\*

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#### OPEN ACCESS

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#### Abstract

#### Background

Policies to mitigate climate change by reducing greenhouse gas (GHG) emissions can yield public health benefits by also reducing emissions of hazardous co-pollutants, such as air toxics and particulate matter. Socioeconomically disadvantaged communities are typically disproportionately exposed to air pollutants, and therefore climate policy could also potentially reduce these environmental inequities. We sought to explore potential social disparities in GHG and co-pollutant emissions under an existing carbon trading program—the dominant approach to GHG regulation in the US and globally.



#### Neighborhood racial demographics and educational attainment were consistent predictors of increases in GHG and co-pollutant emissions from facilities within 2.5 miles

Predictor	GHGs and PM <sub>2.5</sub> increased	GHGs and NO <sub>x</sub> increased	GHGs and SO <sub>x</sub> increased	GHGs and VOCs increased	GHGs and air toxics increased
(Intercept)	0.24 (0.23, 0.26)	0.30 (0.28, 0.31)	0.20 (0.18, 0.21)	0.34 (0.32, 0.36)	0.08 (0.07, 0.09)
Population density	0.65 (0.59, 0.72)	0.70 (0.64, 0.76)	0.38 (0.34, 0.43)	0.77 (0.71, 0.83)	0.98 (0.88, 1.08)
% people of color	1.19 (1.08, 1.31)	1.13 (1.04, 1.24)	1.12 1.01, 1.23)	1.38 (1.26, 1.51)	1.78 (1.53, 2.08)
% poor	0.90 (0.81, 0.99)	1.02 (0.93, 1.12)	1.37 (1.24, 1.51)	0.85 (0.78, 0.93)	0.60 (0.51, 0.69)
% low education	1.75 (1.55, 1.97)	1.22 (1.09, 1.36)	1.09 (0.96, 1.23)	1.40 (1.25, 1.56)	1.94 (1.64, 2.29)
% linguistically isolated	0.87 (0.80, 0.95)	0.89 (0.82, 0.97)	0.91 (0.83, 1.00)	1.00 (0.92, 1.08)	0.82 (0.73, 0.92)

Cushing et al. 2018 PLOS Medicine

# Performance of regulated facilities in the first compliance period of C&T was underwhelming.

#### Changes in annual average greenhouse gas emissions within California after implementation of the state's cap-and-trade program.

Facility emissions 3 years after carbon trading began (2013–2015) are compared to those from the 2 years prior to the initiation of trading (2011–2012).



Cushing et al. 2018 PLOS Medicine

#### Unclear whether pattern would persist over subsequent compliance

#### periods

- We were using a proximity analysis rather than air modeling
- This was just the first two to three years of the program and there were reasons to think things might get better
- Our data was prior to the Pollution  $\bullet$ Mapping Tool and was indeed "proof of concept" for linking GHGs and copollutants





Number of GHG facilities within 2.5 miles of Block Group centroids





# Early 2022 saw two new studies, one by OEHHA, one

# by our team (more on other studies soon)

WITHIN DISADVANTAGED COMMUNITIES: PROGRESS TOWARD REDUCING **INEQUITIES** 

FEBRUARY 2022

- The OEHHA study was conducted by Plummer, Budahan, Chen, Wu, and Alvarado
- It looks at several aspects of GHG emissions, including from Heavy Duty Vehicles as well as capand-trade facilities
- Comparing 2017 to 2012 emissions, it finds that the greatest beneficiaries of the cap-and-trade reductions were DACs





# Strengths and challenges of the OEHHA study



- The data is thoroughly cleaned and correct and the team was collegial enough to harmonize their data with us
- OEHHA is using air modeling rather than proximity analysis which is a plus
- Looking only at 2012 and 2017 for data quality issues can overstate improvements since there seems to be a surge in 2012 and 2017 is the end of a trading period with (maybe) catch-up reductions to hit targets

Note: you can get a larger absolute improvement in DACs even if %

improvement is less & disparity grows

Because the initial level is higher in the DAC – which everyone thinks is the case –a lower percent improvement will yield a larger absolute improvement. Whether percent or absolute is the focus is a policy question.



# Is that an issue or dimension in the OEHHA study?



- (38-46)/46 = 17.4% -8/46 = -17.4%
- Aggregate versus percent

(15-12)/15 = -20%-3/15 = -20%

# In 2022, just before OEHHA, we put our "refresh" looking at the first

#### five years of cap-and-trade



**FEBRUARY 2022** 



#### Up in the Air: **Revisiting Equity Dimensions of** California's Cap-and-Trade System

by Manuel Pastor, Michael Ash, Lara Cushing, Rachel Morello-Frosch, Edward-Michael Muña, and James Sadd

group"

We used proximity analysis, a potential shortcoming in the approach

the Pollution Mapping Tool data

- We compare average emissions from 2011-2012 and 2016-2017 to deal with endpoint issues
- We broke both facilities and neighborhoods into "least improved," "most improved," and a "middle
- We carefully worked with OEHHA on cleaning up

#### What we found was overall improvements (reductions of co-

#### pollutants) but less so in DAC's

Figure 11. Demographic pattern by % change in covered GHG (2011-2012 versus 2016-2017) among block groups with and without facilities



## The pattern was not always consistent (particularly

# looking at facilities) or statistically significant

#### Figure 8. Changes in Emissions for Facilities in DAC and non-DAC Neighborhoods

	Non-DAC Facilities (Median, IQR)	DAC Facilities (Median, IQR)	Median Test	Highest Rank	Mann- Whitney
% Change in Covered GHG	-3.1% (-20.5%, 8.1%)	1.5% (-10.8%, 8.8%)		DAC	#
Diff in Covered GHG (MTCO2e)	-3,799 (-26,077, 6,739)	818 (-7,832, 5,727)		DAC	#
% Change in PM2.5	-9.0% (-37.4%, 20.0%)	1.8% (-16.7%, 29.3%)	#	DAC	*
Difference in PM2.5 (tons)	-0.40 (-3.05, 1.00)	0.10 (-1.35, 0.95)	**	DAC	#
% Change in PM10	-6.9% (-36.9%, 13.6%)	3.1% (-13.0%, 23.8%)	**	DAC	*
Difference in PM10 (tons)	-0.50 (-3.85, 0.85)	0.15 (-1.40, 1.35)	*	DAC	#
% Change in NOX	-3.8% (-28.5%, 19.9%)	-1.6% (-18.9%, 29.1%)		DAC	
Difference in NOX (tons)	-0.85 (-9.65, 2.90)	-0.05 (-9.65, 1.80)		DAC	
% Change in SOX	-5.1% (-33.3%, 19.1%)	3.9% (-12.5%, 37.5%)	**	DAC	***
Difference in SOX (tons)	-0.05 (-0.70, 0.10)	0.10 (-0.20, 0.45)	**	DAC	***

\*\*\* significant at the .01 level

\*\* significant at the .05 level

\* significant at the .10 level

# significant at the .20 level

#### Facility View



# The pattern was not always consistent (particularly

# looking at facilities) or statistically significant

#### Figure 13. Changes in Emissions from Facilities in DAC and non-DAC Block Groups

#### Neighborhood View



	Non-DAC Neighborhoods (Median, IQR)	DAC Neighborhoods (Median, IQR)	Median Test	Highest Rank	Mann- Whitney
% Change in Covered GHG	-8.8% (-17.5%, 5.5%)	-0.8% (-13.5%, 7.5%)	***	DAC	***
Diff in Covered GHG (MTCO2e)	-5,662 (-26,131, 4,537)	-450 (-7,310, 11,719)	***	DAC	***
% Change in PM2.5	-19.6% (-46.5%, 6.9%)	-4.6% (-29.0%, 8.3%)	***	DAC	***
Difference in PM2.5 (tons)	-0.80 (-4.00, 0.40)	-0.65 (-2.95, 0.85)		DAC	*
% Change in PM10	-16.5% (-39.0%, 6.9%)	-1.2% (-26.7%, 6.9%)	* * *	DAC	***
Difference in PM10 (tons)	-0.65 (-4.05, 0.45)	-0.18 (-4.05, 1.00)	***	DAC	***
% Change in NOX	-3.1% (-23.9%, 31.2%)	-2.2% (-15.7%, 38.2%)		DAC	***
Difference in NOX (tons)	-0.45 (-5.40, 2.90)	-0.05 (-6.65, 6.05)	***	DAC	***
% Change in SOX	-5.6% (-25.0% 19.5%)	-1.0% (-25.0% .9.9%)	***	DAC	
Difference in SOX (tons)	-0.05 (-0.45, 0.10)	-0.01 (-1.26, 0.20)	#	DAC	#

\*\*\* significant at the .01 level

\*\* significant at the .05 level

\* significant at the .10 level

# significant at the .20 level

# Bottom line findings from that study:



FEBRUARY 2022



## Up in the Air:

Revisiting Equity Dimensions of California's Cap-and-Trade System

by Manuel Pastor, Michael Ash, Lara Cushing, Rachel Morello-Frosch, Edward-Michael Muña, and James Sadd

- While the evidence is not always consistent, there remain concerns not so much about absolute "hot spots" but about less than optimal reductions and foregone air quality benefits
- One key thing is whether we focus on absolute reductions or whether we focus on percentages and disparity ratios
- It could be useful to consider safeguards
  - about which there seems to be some
  - agreement (more soon)

## Another approach is by Hernandez-Cortes and Meng

### (HCM) that was a working paper, now published

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journal homepage: www.elsevier.com/locate/jpube

#### Do environmental markets cause environmental injustice? Evidence from California's carbon market \*

#### Danae Hernandez-Cortes<sup>a,\*</sup>, Kyle C. Meng<sup>b</sup>

<sup>a</sup> School for the Future of Innovation in Society and the School of Sustainability, Arizona State University, United States <sup>b</sup> Bren School, Dept. of Economics, and emLab, UC Santa Barbara and NBER, United States



Two-steps: estimate impact of cap-and-trade on emissions, then put estimates into air model

Pollution = f(facility, year, CnT x time, CnT x time\_post2012)



Facility and year are "fixed" effects controlling for technology of a particular place and the state of the overall economy

The last two terms estimate a trend before policy implementation and after policy implementation *relative* to facilities that did not come under cap-and-trade

# Strengths and challenges of the HCM approach

Date and time: 2017-01-05 23:00



- + Air modeling is a major plus
- + Testing the relative effect is a good touch
- Not all the facilities are correctly located
- To get a "pure" cap-and-trade effect, HCM reduce sample to 5% of GHG emissions
- Estimating a shared effect can mask variance
- Which facilities are cap-and-trade is key

## What about the sample restriction?

Total Covered GHGs (MTCO2e) by Industry Sector, California, 2011-2017



## What about the sample restriction?

Temporal Changes in Total Covered Emissions (HCM 2021) by Industry Sector, California, 2011-2017





HCM drop electric generation and refineries because of other regulations and then drop large facilities to get better estimates of "pure" cap-and-trade effect

As a result, a large share of the various pollutants associated with cap-and-trade facilities – 87 to 95 percent, depending on pollutant – is not included in the sectorand-size-constrained sample used by HCM

Oil and Gas Production/Supplier Hydrogen Plant

#### A regression approach assumes a "common"

# percentage effect from cap-and-trade

This can impact findings. An extreme case: The pre-policy **EJ gap** was 100 (200-100). Post-policy, it grew to 140 (210-70). But the estimated gap from assuming a common percentage effect shrank to 87.5 (175 - 87.5).

		Scenario 3		
	Pre-Policy	Post-Policy		
DAC	200.0	210.0		
non-DAC	100.0	70.0		
Average				
Ratio of				
DAC/nonDAC	2.0	3.0		
	(Scenario 3 applying estimated a			
	(Scenario 3 ap	plying estimated av		
	<b>(Scenario 3 ap</b> Pre-Policy	plying estimated av Post-Policy		
DAC	<b>(Scenario 3 ap</b> <i>Pre-Policy</i> 200.0	Post-Policy 175.0		
DAC non-DAC	<b>(Scenario 3 ap</b> <i>Pre-Policy</i> 200.0 100.0	Post-Policy 175.0 87.5		
DAC non-DAC Average	<b>(Scenario 3 ap</b> <i>Pre-Policy</i> 200.0 100.0	Post-Policy 175.0 87.5		
DAC non-DAC Average Ratio of	(Scenario 3 ap <i>Pre-Policy</i> 200.0 100.0	Post-Policy 175.0 87.5		



## How much variance is there in the data?

First, remember that the point of cap-and-trade is to get variance – that's how you get efficiency

Not surprising: there is quite a bit of variance (& about a third of the HCM cap-and-trade facilities show an actual increase in GHG emissions)

Average percent change (including year effects) and actual percent change for the facilities designated as cap-and-trade in HCM





# For any findings, what is crucial is tagging the "control"

ENVIRONMENTAL JUSTICE Volume 00, Number 00, 2024 © Mary Ann Liebert, Inc. DOI: 10.1089/env.2024.0005

> Open camera or QR reader and scan code to access this article and other resources online

What a Difference a Datum Makes: Revisiting the Impacts of Cap-and-Trade on Emissions and **Environmental Justice** 

Michael Ash and Manuel Pastor

#### ABSTRACT

A recent article by Danae Hernandez-Cortes and Kyle Meng suggests that the cap-and-trade program in California led to improvements in the degree of environmental inequity in the state, a result that was taken up with some enthusiasm by proponents of carbon pricing. We suggest that their approach is not designed to capture the variation at the heart of the equity debate and show that the results these authors offer may be problematic because of the potential misidentification of which facilities were actually subject to the cap.

Keywords: cap-and-trade, environmental justice, data analysis



- s, which is Gap and the by Ash de & Pastor, we illustrate a challenge with how HCM identified facilities and how that impacts the estimates
  - Basic issue: HCM took the earliest version of the Pollution Mapping Tool covering 2008-2015, and then added 2016 data, then 2017 data to it

## Why would that be an issue?

- The first version of the data had numerous challenges, including proper designation of which facility was being regulated under cap-and-trade
- Subsequent versions updated backwards, putting in corrections which are not caught if you are appending new data to old data
- HCM found that cap-and-trade status in new data didn't match old data – so switched the new back to old



## Why would that be an issue?

- Our data in our 2022 report had fewer issues because we used the newest data set and worked with OEHHA to correct any issues
- In the most recent version of the Pollution Mapping Tool, facilities can switch status; we designate a facility as cap-and-trade if it spent the majority of post-policy years considered (2013-2017) under cap-andtrade



# How do the results change?

- The blue bars are the results from HCM's basic
   regression model
- We then correct for whether they were under cap-andtrade using criteria of time spent regulated



# Estimated Annual Impact of Cap and Trade on Emissions NOX PM25 PM10 NOX

-4.2% \*

\*\*\* significant at the .01 level
\*\* significant at the .05 level
\* significant at the .10 level
# significant at the .20 level

# How do the results change?

- The estimated changes are smaller & closer to what we might have expected
- None of the estimated changes are significant and plugging these into an air model might also be less reliable



#### Estimated Annual Impact of Cap and Trade on Emissions

## New work by Glenn Sherriff

#### California's GHG Cap-and-Trade Program and the Equity of Air Toxic Releases

Glenn Sheriff

Abstract: Carbon trading faces pushback over concerns of increasing copollutant exposure for minorities. Combining federal and state data I evaluate three questions concerning the distribution of hazardous air pollutants after implementation of California's greenhouse gas cap-and-trade program. Did air toxic releases from facilities covered by the GHG program upwind of minorities disproportionately increase? Did minority communities suffer a disproportionate increase in cumulative exposure from covered facilities? Did minorities overall suffer higher exposure to air toxics from all sources relative to a counterfactual no-cap-and-trade scenario? Results suggest that covered facilities upwind of minorities did not have higher releases, and minority communities experienced a relative reduction in cumulative exposure from them. Under all policy scenarios minorities have a less desirable exposure distribution than whites. However, both demographic groups have a better air toxic exposure distribution with the cap-and-trade program than in a counterfactual without.

JEL Codes: D63, Q52, Q53

Keywords: air pollution, climate policy, environmental justice, GHG cap and trade, distributional analysis, inequality, air toxics, TRI

- Sheriff is also looking at cap-and-trade but coupling this with data from the US EPA's Risk Screening Environmental Indicators (RSEI) which has an underlying air model for toxic releases
- Also a regression approach but with a key difference: Sheriff does not assume trading affects all facilities in the same direction or by the same percent

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## New work by Glenn Sherriff

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Abstract: Carbon trading faces pushback over concerns of increasing copollutant exposure for minorities. Combining federal and state data I evaluate three questions concerning the distribution of hazardous air pollutants after implementation of California's greenhouse gas cap-and-trade program. Did air toxic releases from facilities covered by the GHG program upwind of minorities disproportionately increase? Did minority communities suffer a disproportionate increase in cumulative exposure from covered facilities? Did minorities overall suffer higher exposure to air toxics from all sources relative to a counterfactual no-cap-and-trade scenario? Results suggest that covered facilities upwind of minorities did not have higher releases, and minority communities experienced a relative reduction in cumulative exposure from them. Under all policy scenarios minorities have a less desirable exposure distribution than whites. However, both demographic groups have a better air toxic exposure distribution with the cap-and-trade program than in a counterfactual without.

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- Limits: Sheriff is only able to connect 118 cap-and-trade facilities with RSEI, about a third of the total
- He sets up a facilities
- And considers 2007-2012 to 2013-2018 with one key innovation being (a la Currie, et al. 2023) interaction with the percent people of color
- He sets up a control group of other RSEI

Journal of the Association of Environmental and Resource Economists, volume 11, number 1, January 2024. © 2023 The Association of Environmental and Resource Economists. All rights reserved. Published by The University of Chicago Press for The Association of Environmental and Resource Economists. https://doi.org/10.1086/725699

# New work by Glenn Sherriff



- upwind facilities
- people of color

• Facility level analysis suggests that cap-andtrade did not lead to increased releases from

Neighborhood level analysis with interactions suggests that percentage improvement was greater in communities with a higher percent

While there remain questions, this is a broader set of facilities, toxicity is taken into account, and methods, while complex, are credible

#### Another look at equity and co-benefits involves spending





#### A Call to Invest in Community Power

Lessons from 10 Years of California Climate Investments for the State and the Nation

#### A Call to Invest in Community Power: Lessons from 10 Years of California Climate Investments

#### **USC ERI & Greenlining Partnership**

#### 2023

The California Climate Investments (CCI) are turning 10. After a decade of investments and nearly \$10 billion implemented throughout the state, is CCI delivering on its promise? Does it drive benefits to environmental justice communities that are the most vulnerable to pollution, have the fewest resources to adapt to climate change, and the least political power to attract these dollars? Do these communities feel the impact of these dollars? In this report, we strive to answer these questions, particularly in light of unprecedented federal funding for climate investments.

Report arriving in Winter 2024 - Stay Tuned

By: Lolly Lim, Vanessa Carter Fahnestock, Alvaro Sanchez Manuel Pastor

#### 2024

# **High-level Findings**

• Equity requirements matter •35% minimum to **Priority Populations, SB** 535/AB 1550 Dollars are indeed flowing to the most "disadvantaged" communities, a response to equity goals established by statute.

#### CCI Dollars Implemented (as of November 2022) by CalEnviroScreen 4.0 Deciles (\$ in millions)



# **High-level Findings**

 While California does not explicitly use a race-conscious approach to delivering climate investments, dollars are largely landing in places with higher % POC due to the strong correlation between CalEnviroScreen and race. • Collecting census tract data for each project makes this race analysis possible.



Figure 3 Racial Makeup of Each Decile of CalEnviroScreen 4.0 Score.

67%			11%	5	16%	<mark>2%</mark>	4%
9%		1			17%	<mark>2%</mark>	4%
		21%			18%	<mark>4%</mark>	4%
	27%				17%	5%	4%
	32%			:	18%	5%	4%
	40%				16%	6%	3%
47%				15%	7%	3%	
55%				13%		3%	
	64%				10%	8%	2%
	73%				7%	9%	1%

# **High-Level Findings**

- Many interviewees were not aware of the suite of programs supported by CCI.
- "Felt impact" is strongest when projects are community-driven and wellcoordinated
- The ecosystem for climate justice in CA has made climate investments more equitable. E.g., creation of Transformative Climate Communities, program-specific equity improvements, securing increased funding for Tribal Nations and Indigenous communities
- Participation and power are key and should be key metrics

Organizational Development, Infrastructure, and Funders

> Leadership Development

Advocacy and Policy Research and Legal

Organizing and Base-Building Comms, Cultural,and Narrative Change

Alliance and Coalitions

![](_page_37_Picture_12.jpeg)

![](_page_37_Picture_13.jpeg)

#### Back to cap-and-trade

#### Minding the Climate Gap

What's at Stake if California's Climate Law isn't Done Right and Right Away

![](_page_38_Picture_3.jpeg)

- In April 2010, we
   Climate Gap"
- We made four design recommendations:
  - Facility-level caps
  - No trading zones
  - Surcharges to change price points
  - A community benefits fund
- The benefits fund idea became incorporated in SB 535 and administered by SGC

#### In April 2010, we released "Minding the

#### Back to cap-and-trade

![](_page_39_Picture_1.jpeg)

- Burtraw and Roy note (recall earlier discussion):

Empirically we observe that reduction in air pollution has occurred more rapidly in disadvantaged communities than the average for the state if measured in emissions quantities. Air quality outcomes have also improved more rapidly (OEHHA 2022) in absolute terms. Measured in percentage terms, however, the rate of improvement in disadvantaged communities has been less pronounced because these communities started from a worse air quality baseline, and they remain relatively overburdened compared to other communities.

# Facility-specific gaps have become more widely accepted as an amelioration

#### Back to cap-and-trade

Burtraw and Roy examine counterfactual if there had been facility-specific caps (to ensure reductions on par with overall mandate). They note:

We conclude that facility-specific caps may be important to lock in benefits for disadvantaged communities. A core element of the credibility of the cap-andtrade program in disadvantaged communities stems from SB 535, which directs that a portion of program revenues be invested in these communities. Air quality improvements are another major benefit of the program. Facility-specific caps may reinforce the credibility of the program by distributing air quality benefits to important stakeholders without disrupting the efficiency of the carbon market.

# Some market-oriented economists (including HCM

## colleagues) are intrigued by caps or no-trade zones

![](_page_41_Picture_2.jpeg)

- One also needs to consider the impacts on revenues since these are funding important community improvement re GGRF
- Another consideration is additional complexity in administration

# Future Thinking: Anticipatory projections that assess the racial equity implications of climate and air quality policies are key to reducing disparities and advancing EJ goals

Example: Absolute and Relative PM<sub>2.5</sub> disparities changes in 20 years for alternative doubling emission-reduction scenarios.

![](_page_42_Figure_2.jpeg)

science.org/doi/10.1126/science.adg9931

![](_page_43_Picture_0.jpeg)

![](_page_43_Picture_1.jpeg)

# Thanks!

![](_page_43_Picture_3.jpeg)

### Manuel Pastor Rachel Morello-Frosch

![](_page_43_Picture_5.jpeg)

#### V SUSTAINABILITY AND HEALTH EQUITY (SHE) LAB

SCHOOL OF PUBLIC HEALTH AND DEPARTMENT OF ENVIRONMENTAL SCIENCE AND POLICY MANAGEMENT