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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

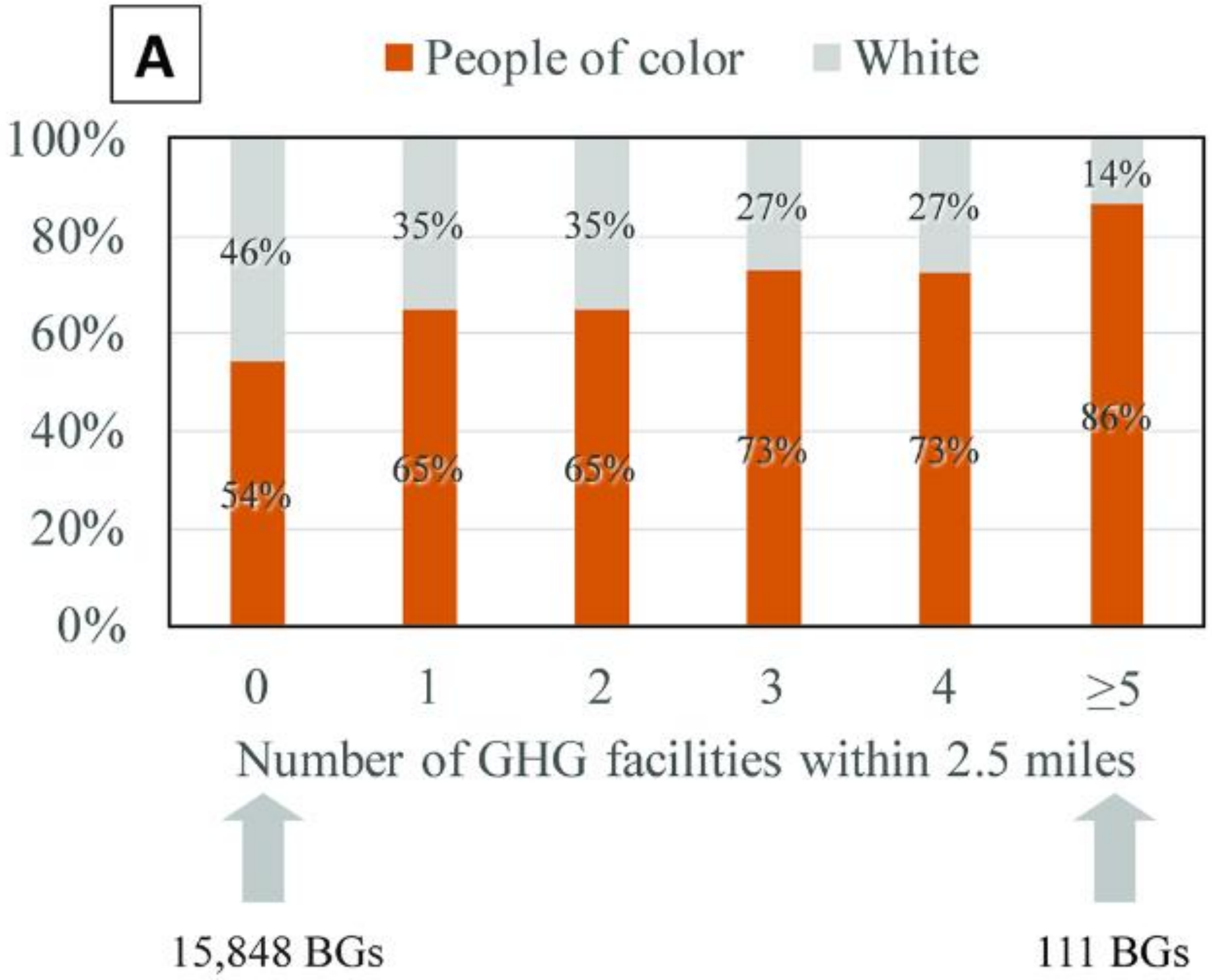
Climate inequities are everywhere, usually defined by *exposure*, *sensitivity*, & *adaptive capacity*.

One key policy challenge for California is how to address climate while also improving equity outcomes.

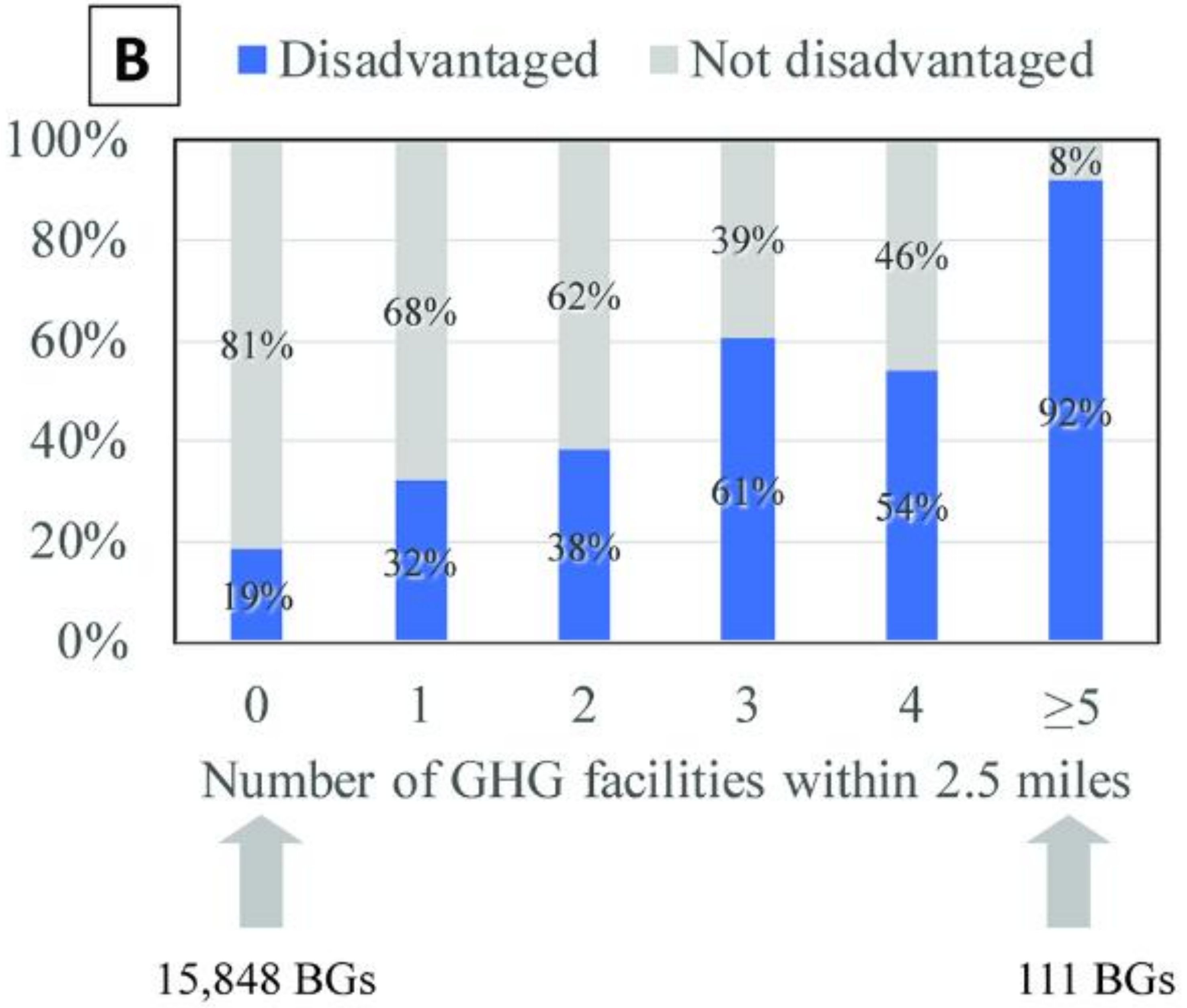
Policy debate regarding equity impacts of cap-and-trade:

Number of GHG-emitting facilities in block groups by race/ethnicity and disadvantage

Racial/Ethnic composition

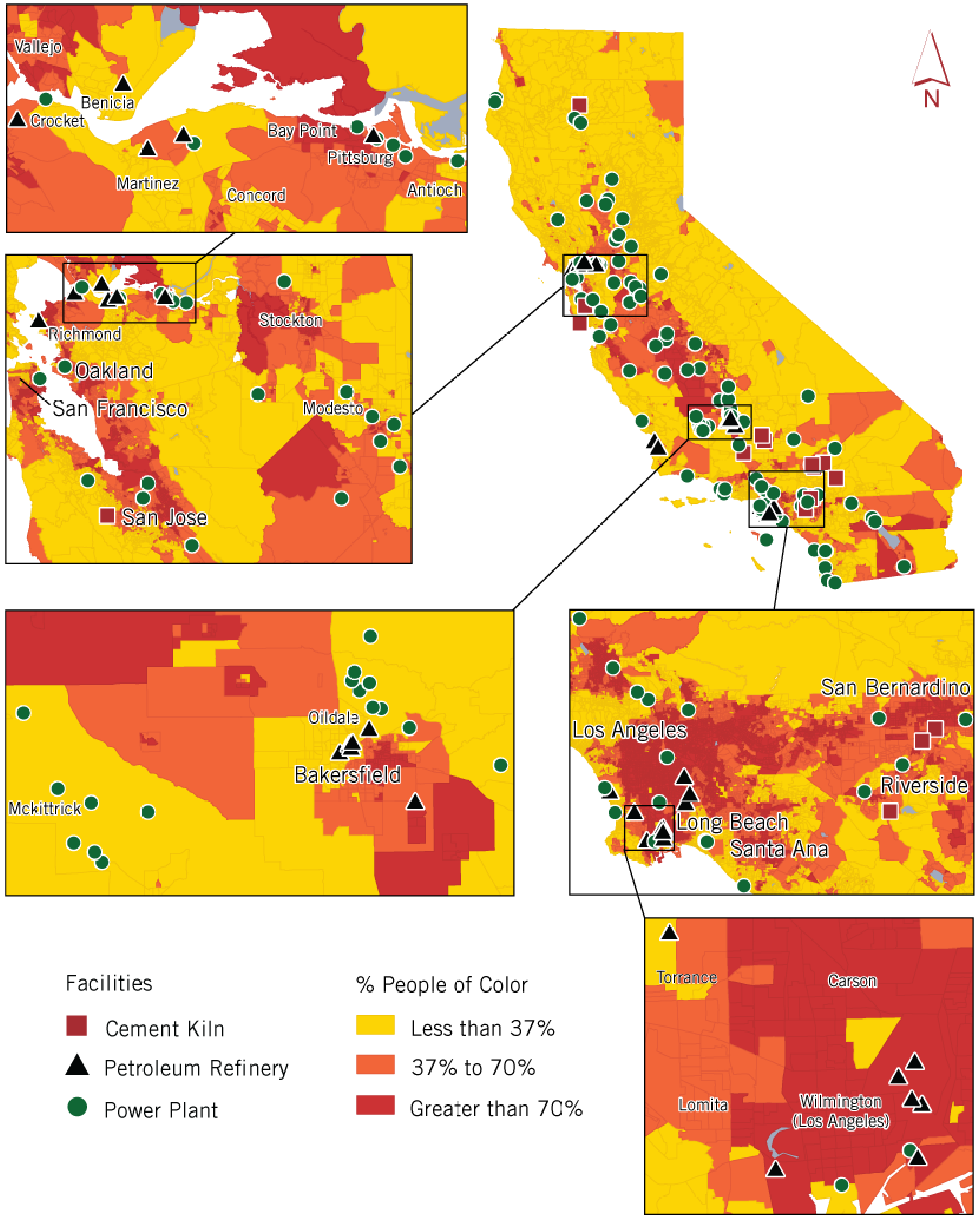


Cal-Enviro Screen Score



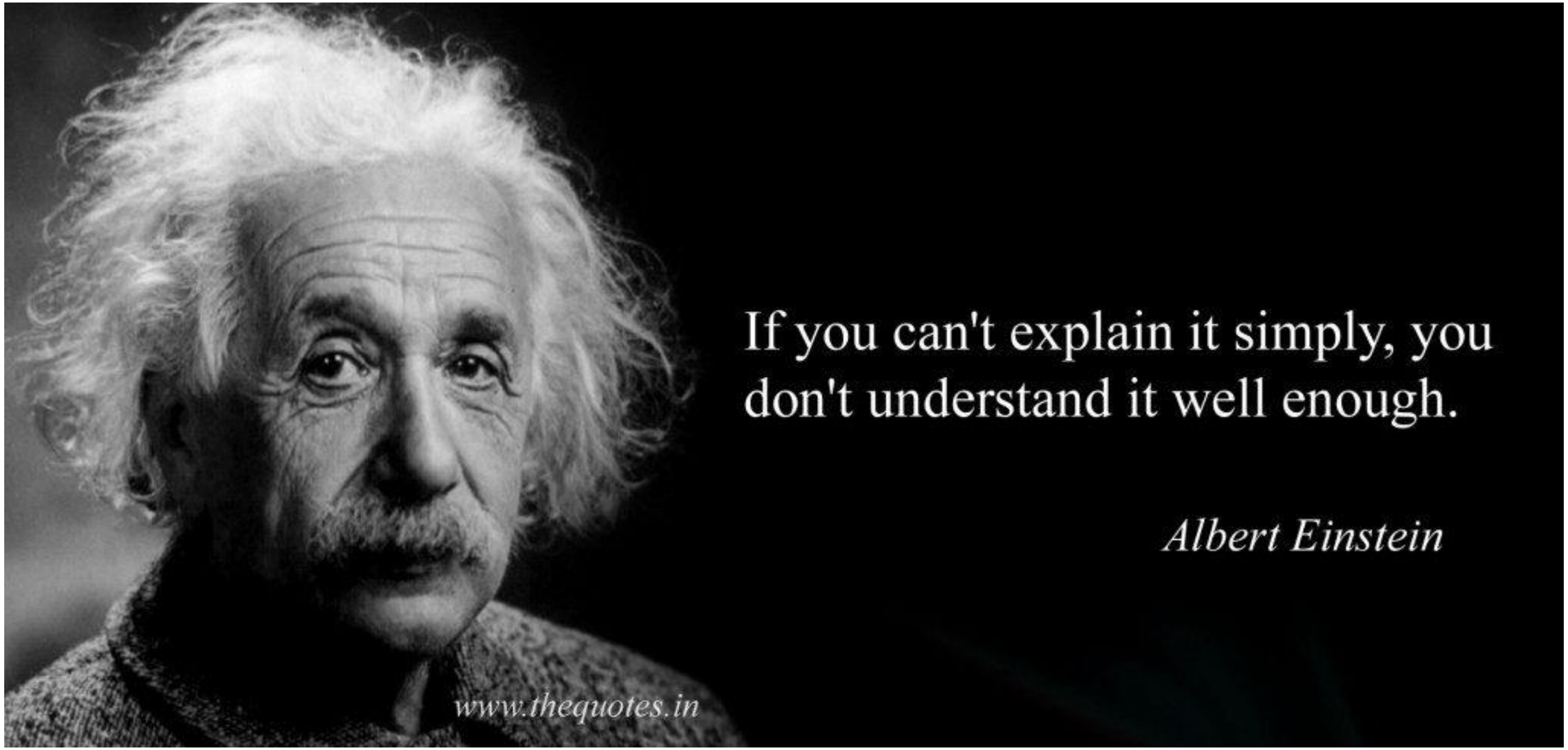
Cushing et al. 2018 PLOS Medicine

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-and-trade will indeed yield *unequal* co-benefits and that *who benefits* is an empirical question

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



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

PLOS | MEDICINE

RESEARCH ARTICLE

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

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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

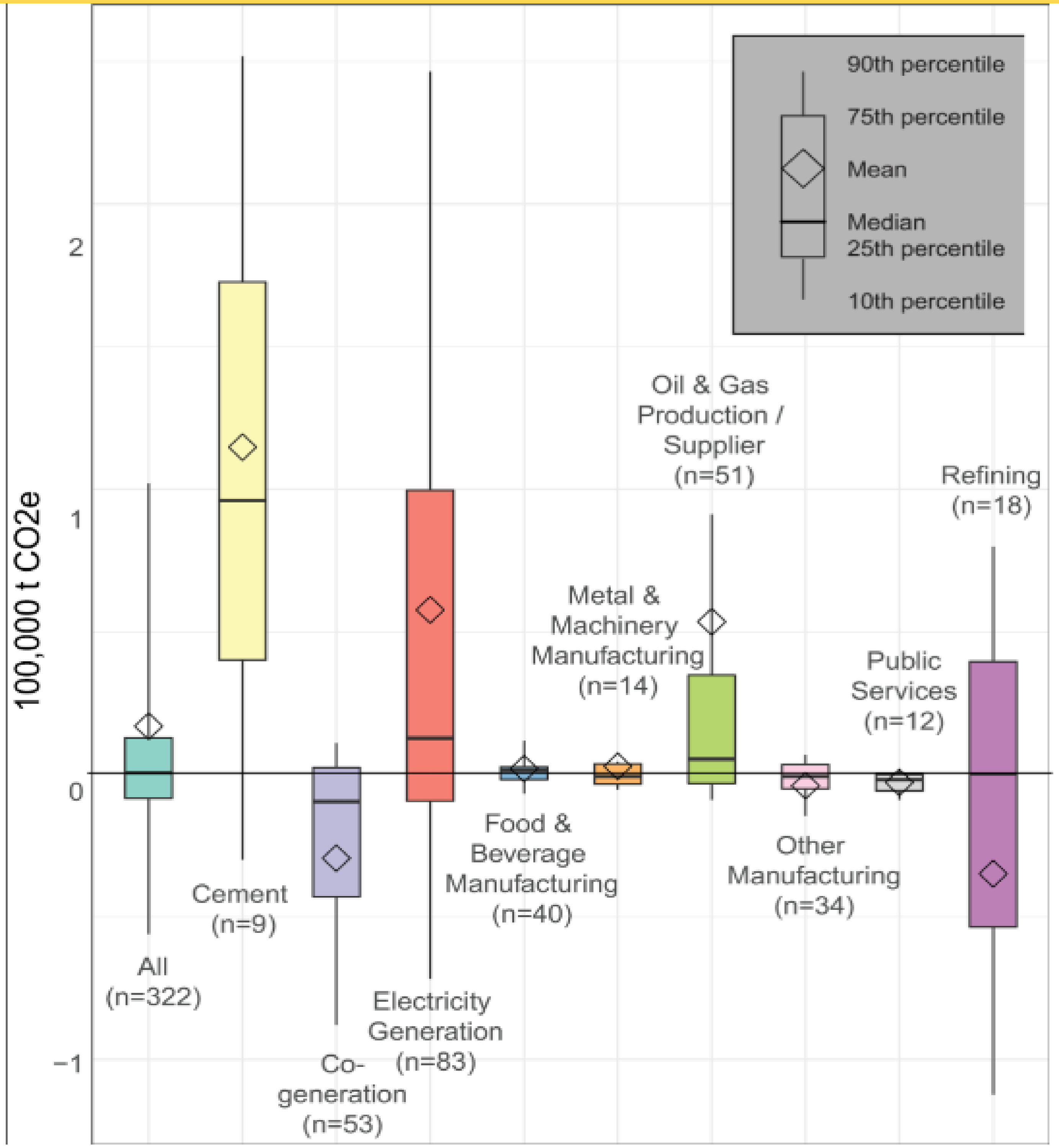
Predictor	GHGs and $PM_{2.5}$ increased	GHGs and NO_x increased	GHGs and SO_x increased	GHGs and VOCs increased	GHGs and air toxics increased
(Intercept)	0.24 (0.23, 0.26)	0.30 (0.28, 0.31)	0.20 (0.18, 0.21)	0.34 (0.32, 0.36)	0.08 (0.07, 0.09)
Population density	0.65 (0.59, 0.72)	0.70 (0.64, 0.76)	0.38 (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.

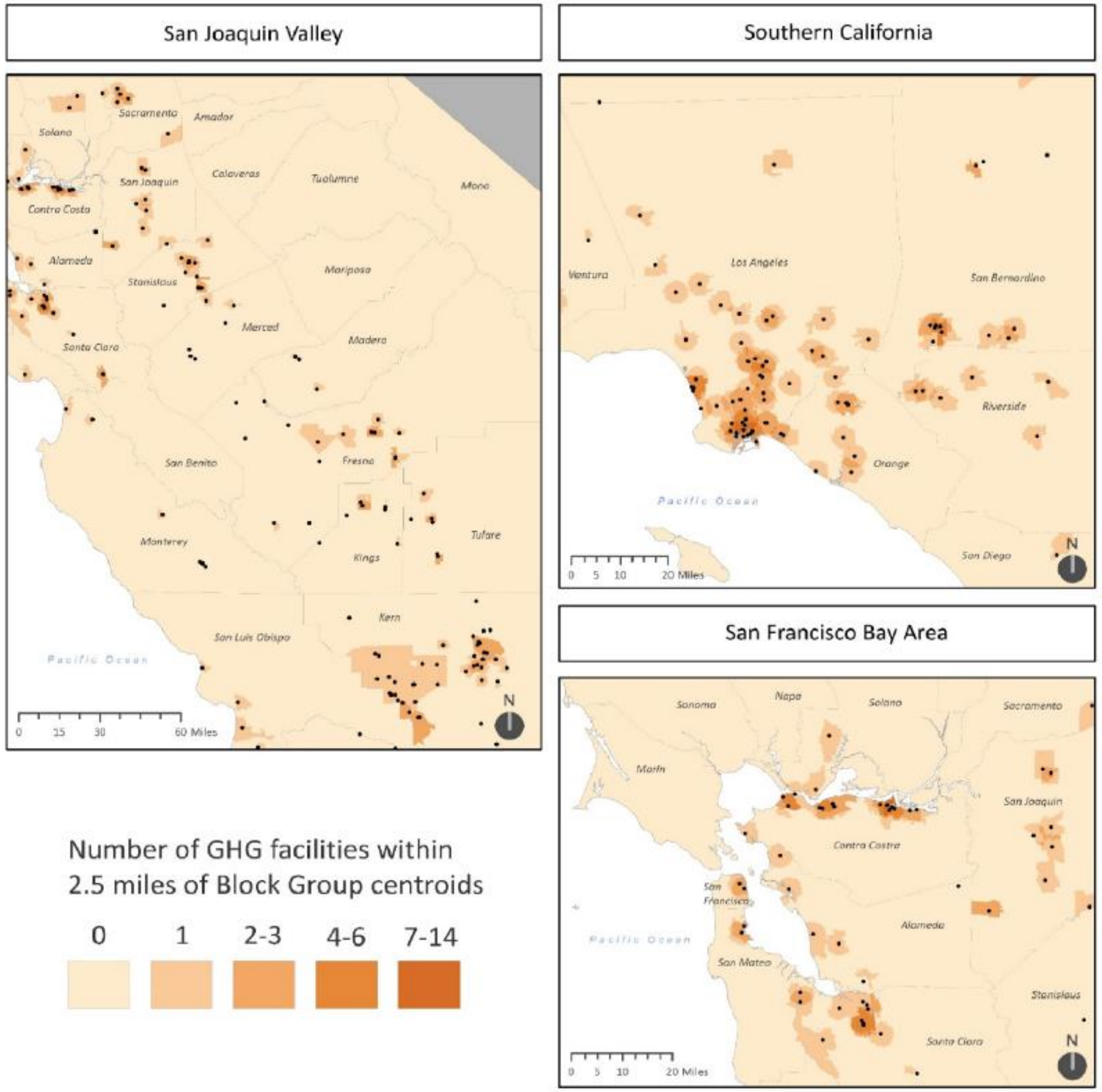
Facility emissions 3 years after carbon trading began (2013–2015) are compared to those from the 2 years prior to the initiation of trading (2011–2012).



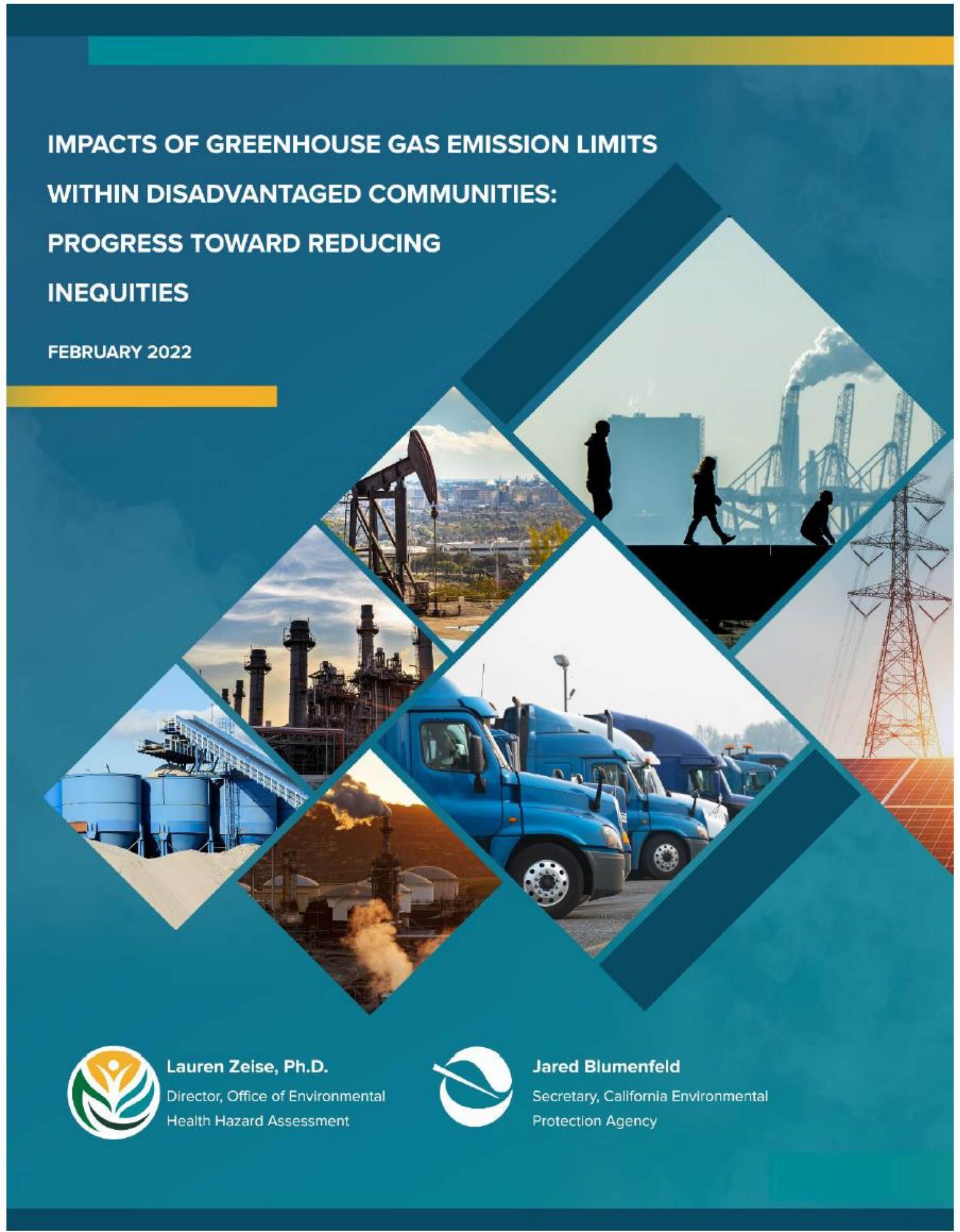
Cushing et al. 2018 PLOS Medicine

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 Mapping Tool and was indeed “proof of concept” for linking GHGs and co-pollutants

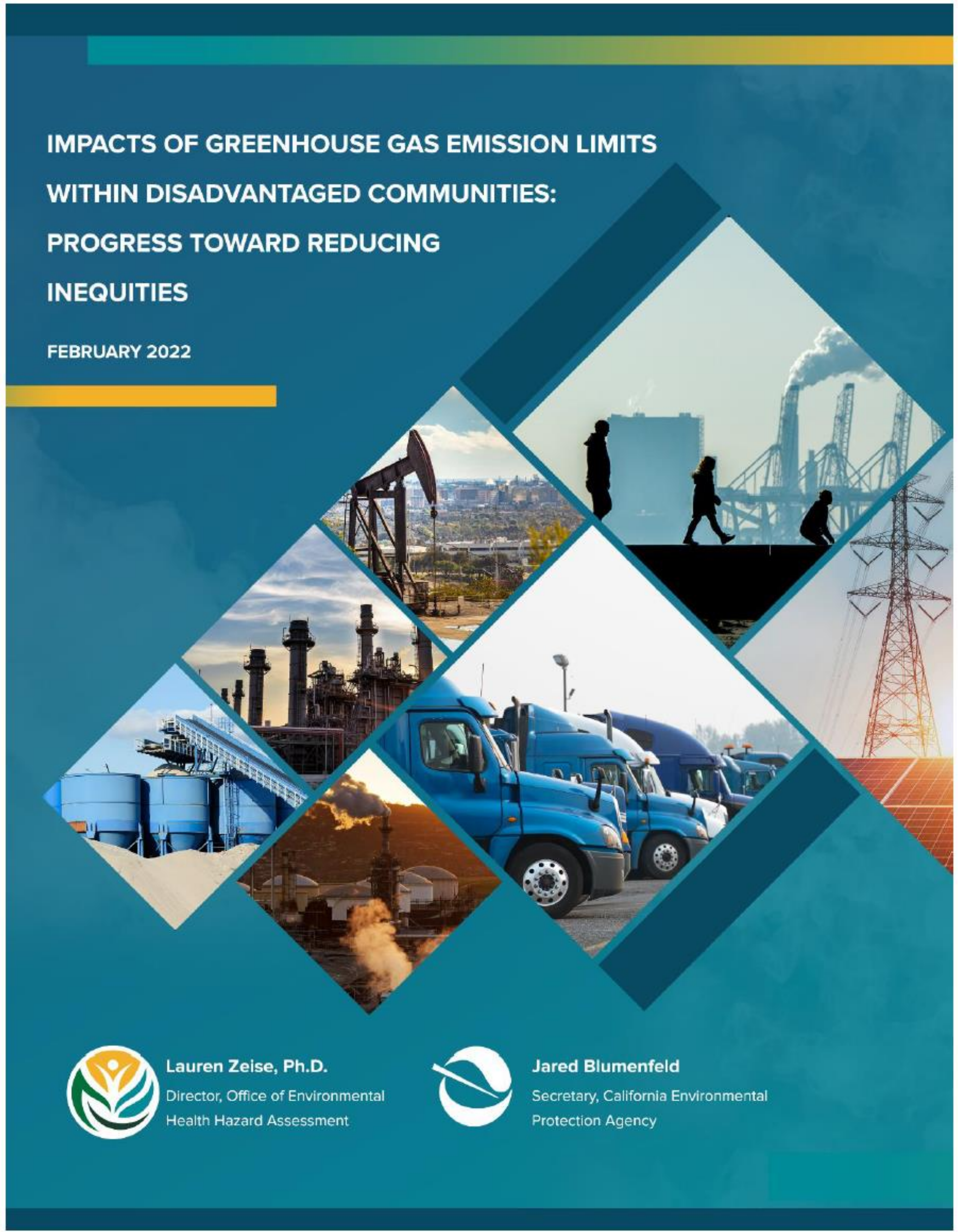


Early 2022 saw two new studies, one by OEHHA, one by our team (more on other studies soon)



- 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 cap-and-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

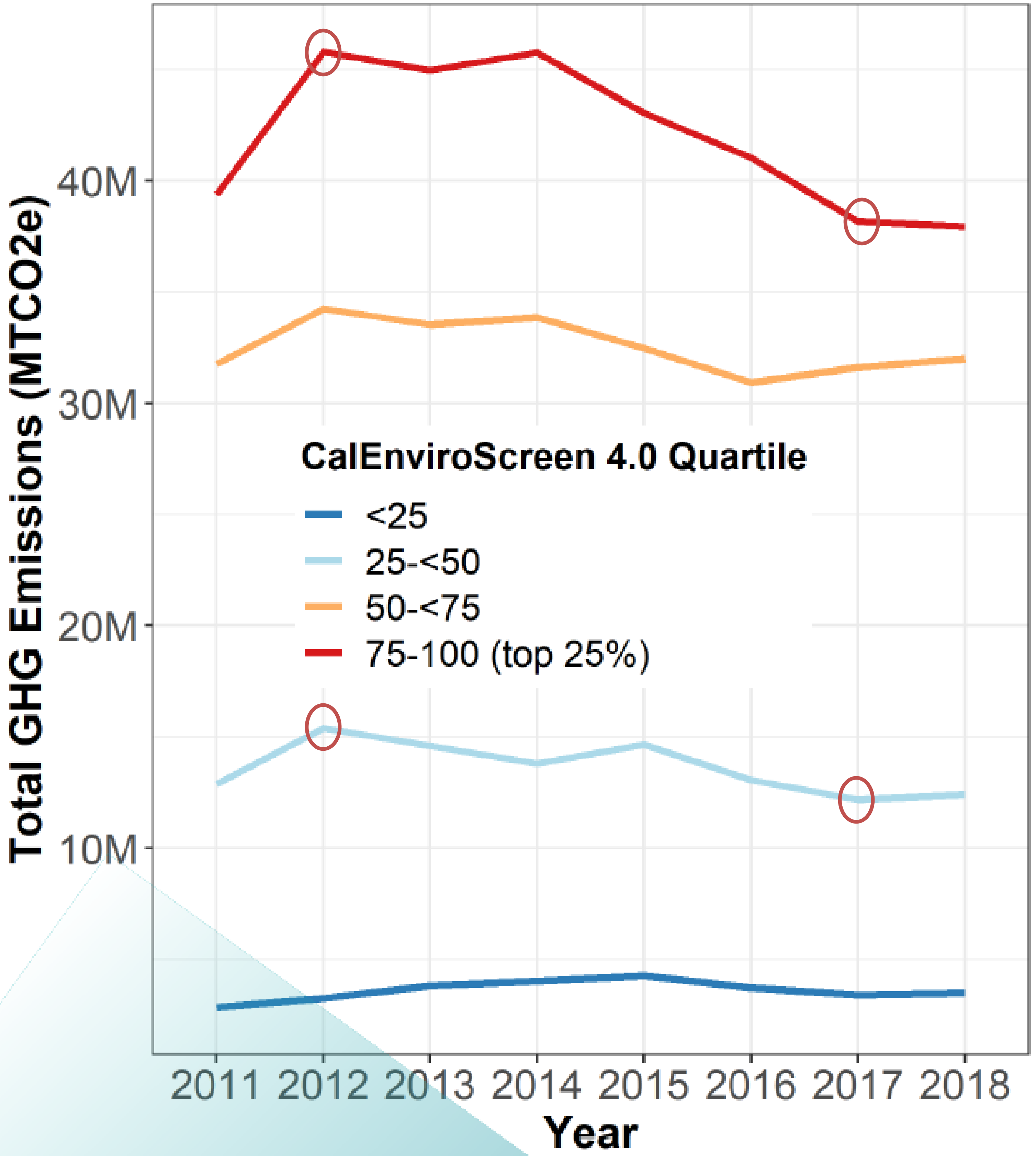
Note: you can get a larger absolute improvement in DACs even if % improvement is less & disparity grows

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.

Scenario 2

	Pre-Policy	*Post-Policy*	*Amt. Change*	*% Change*
DAC	200	180	-20	-10.0%
non-DAC	100	85	-15	-15.0%
Average				-12.5%
Ratio of DAC/nonDAC	**2.0**	**2.1**		

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

RESEARCH BRIEF

FEBRUARY 2022

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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

We compare average emissions from 2011-2012 and 2016-2017 to deal with endpoint issues

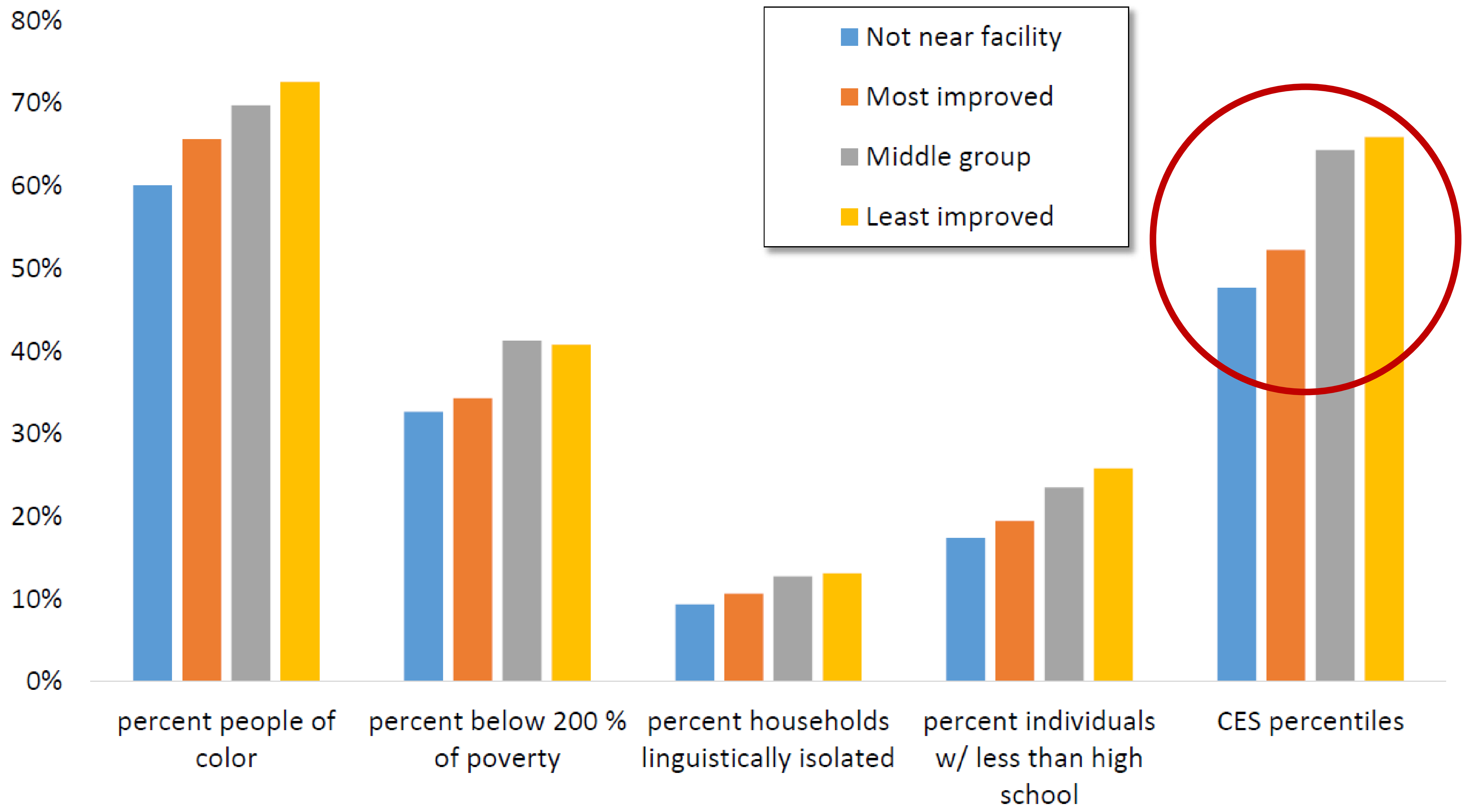
We broke both facilities and neighborhoods into "least improved," "most improved," and a "middle group"

We used proximity analysis, a potential shortcoming in the approach

We carefully worked with OEHHA on cleaning up the Pollution Mapping Tool data

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

Facility View

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

The pattern was not always consistent (particularly looking at facilities) or statistically significant

Neighborhood View

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

	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:

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FEBRUARY 2022

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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 of Public Economics

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

Do environmental markets cause environmental injustice? Evidence from California's carbon market ☆

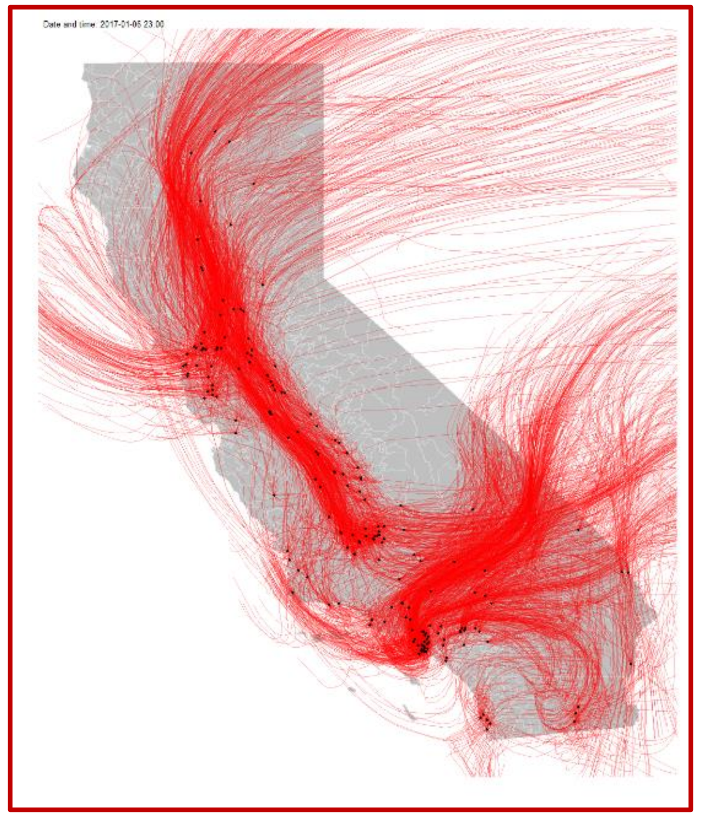
Danae Hernandez-Cortes [a,*], Kyle C. Meng [b]

[a] School for the Future of Innovation in Society and the School of Sustainability, Arizona State University, United States
[b] 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

1. *Pollution = f(facility, year, CnT x time, CnT x time_post2012)*

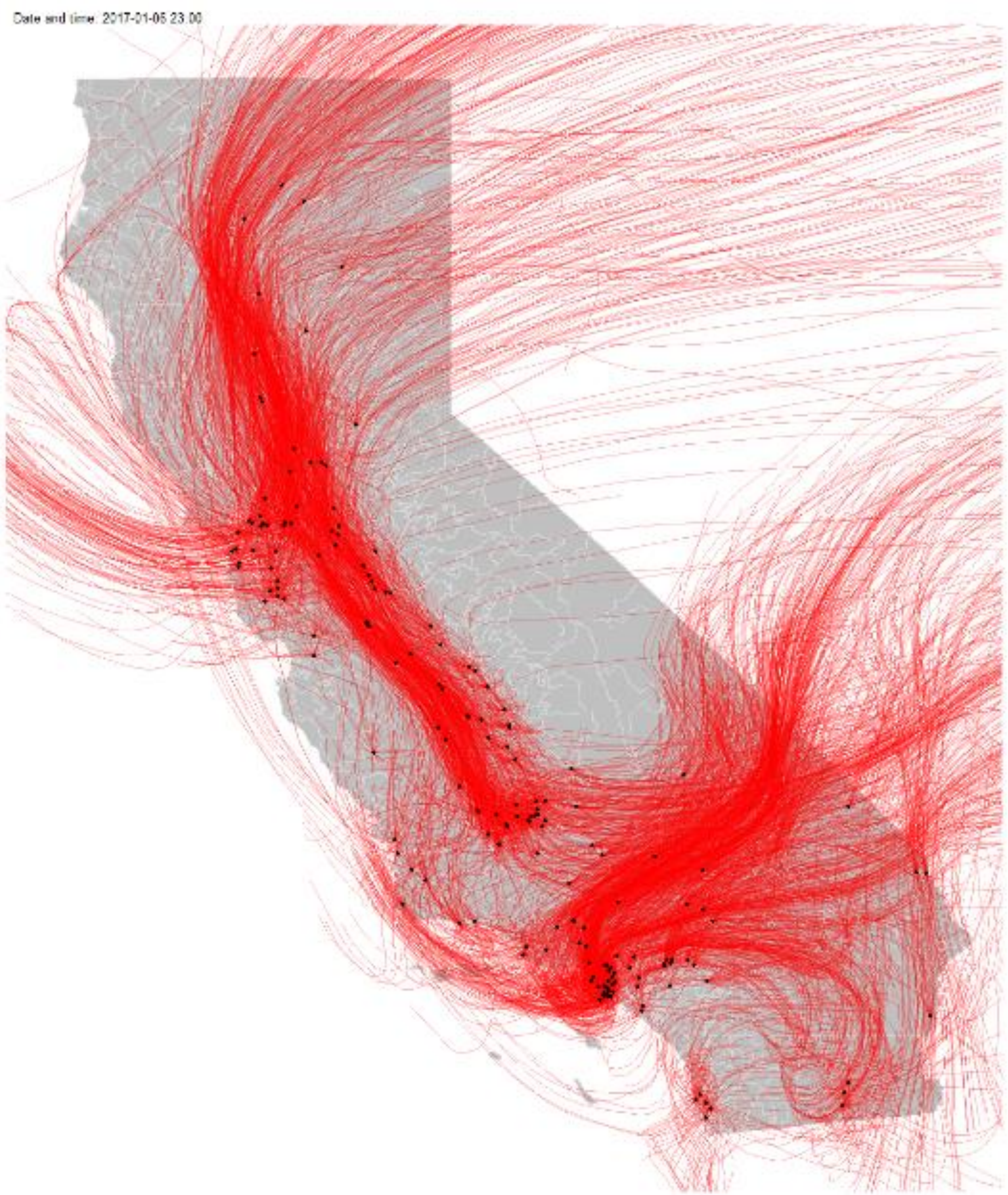
2. Results go into an air model



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



+ Air modeling is a major plus

+ Testing the relative effect is a good touch

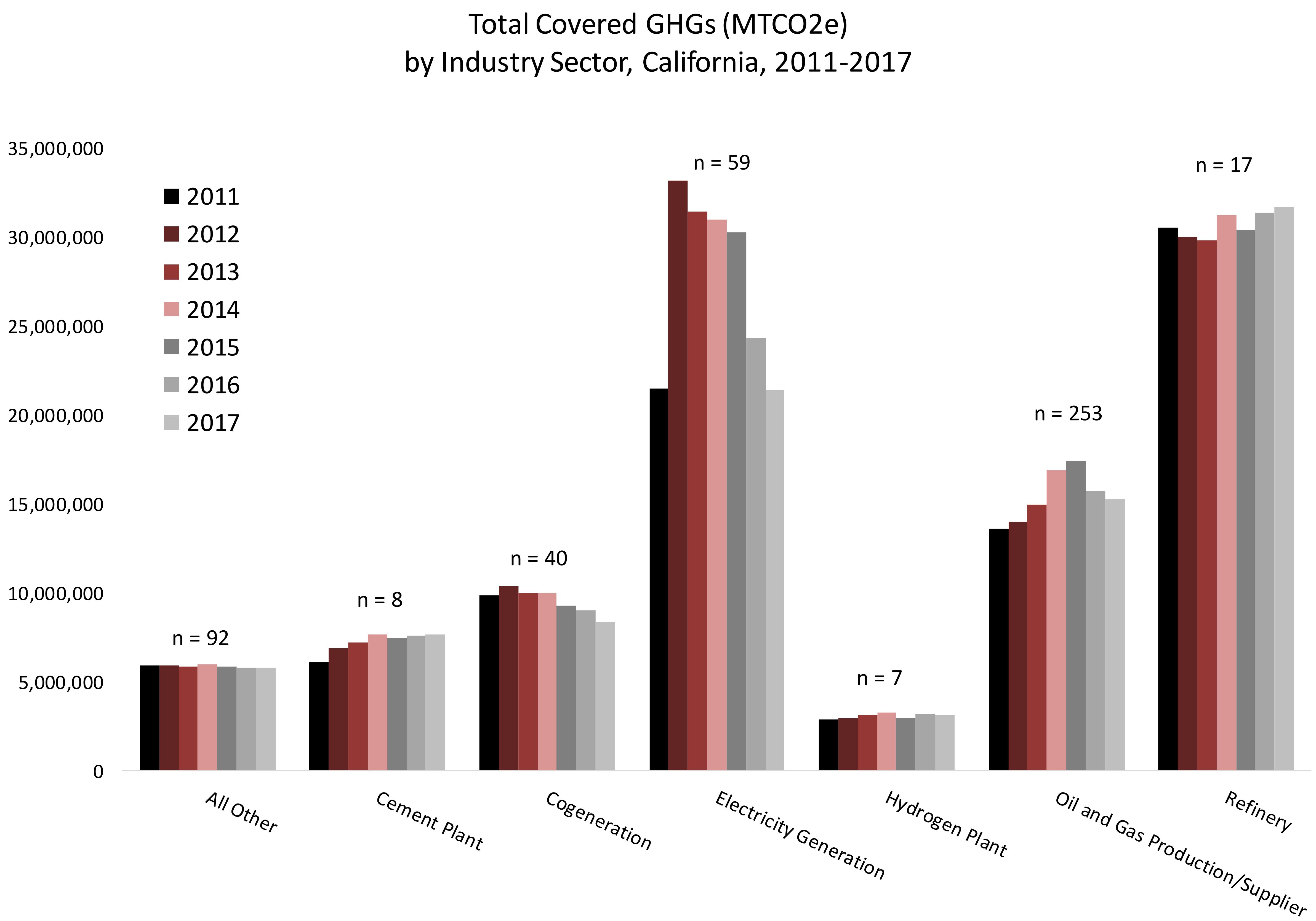
 - Not all the facilities are correctly located

 - To get a "pure" cap-and-trade effect, HCM reduce sample to 5% of GHG emissions

 - Estimating a shared effect can mask variance

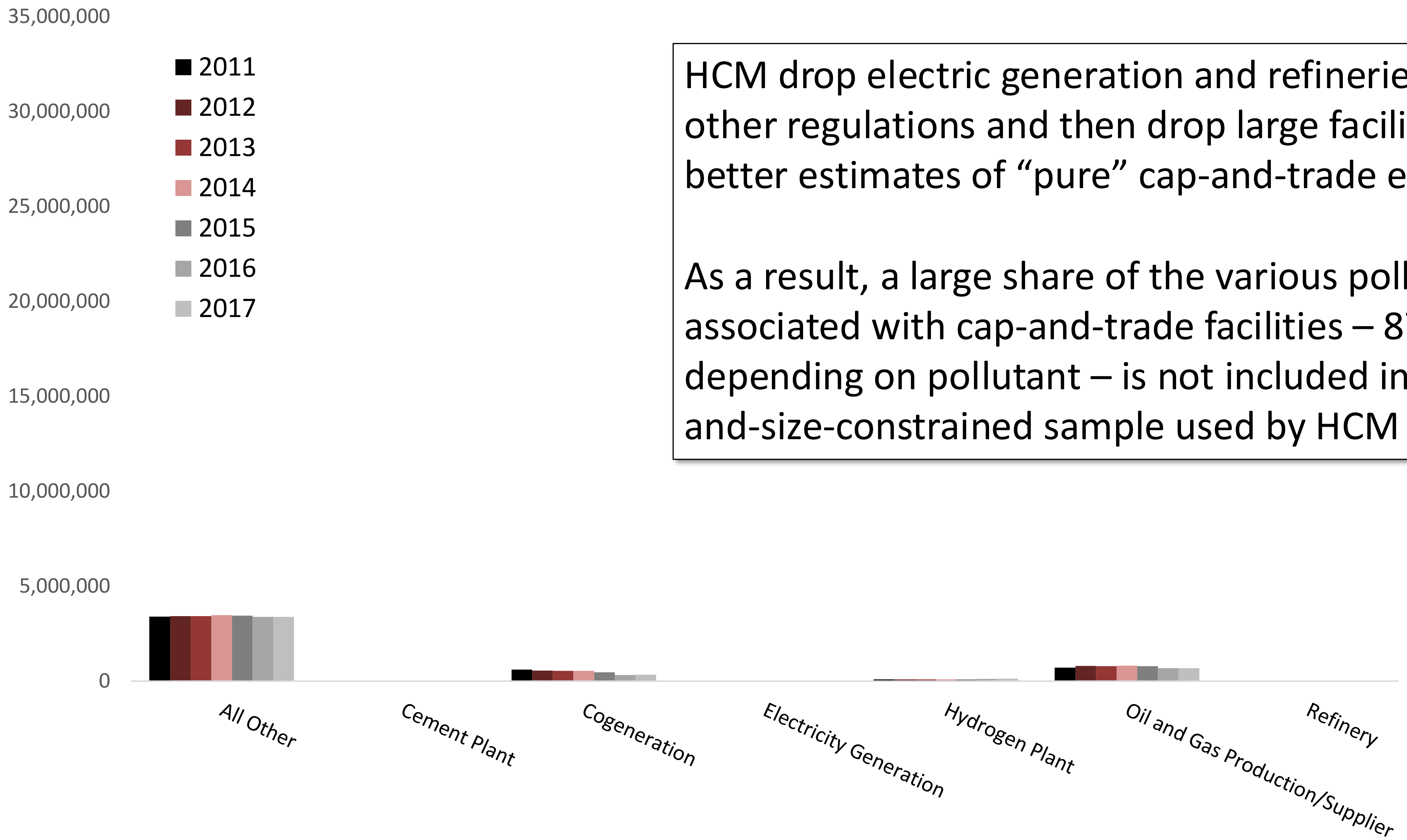
 - Which facilities are cap-and-trade is key

What about the sample restriction?



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 sector-and-size-constrained sample used by HCM

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*	*Amt. Change*	*% Change*
DAC	200.0	210.0	10.0	5.0%
non-DAC	100.0	70.0	-30.0	-30.0%
Average				***-12.5%***
Ratio of DAC/nonDAC	**2.0**	**3.0**		

Plug percentage increase into estimates

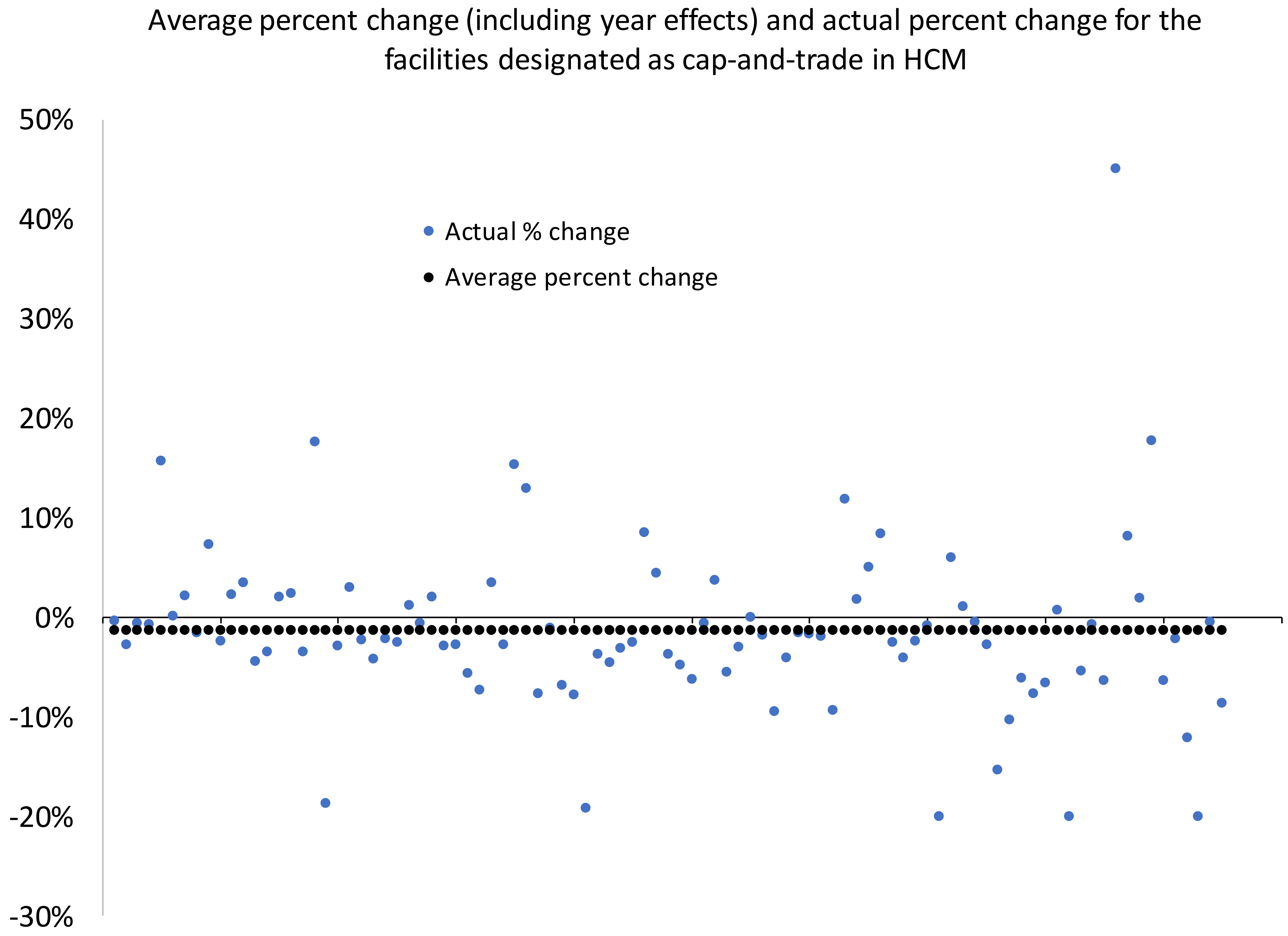
(Scenario 3 applying estimated average effect of -0.125)

	Pre-Policy	*Post-Policy*	*Amt. Change*	*% Change*
DAC	200.0	175.0	-25.0	**-12.5%**
non-DAC	100.0	87.5	-12.5	**-12.5%**
Average				**-12.5%**
Ratio of DAC/nonDAC	**2.0**	**2.0**		

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)



For any findings, what is crucial is tagging the “control”s, which is cap-and-trade

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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.

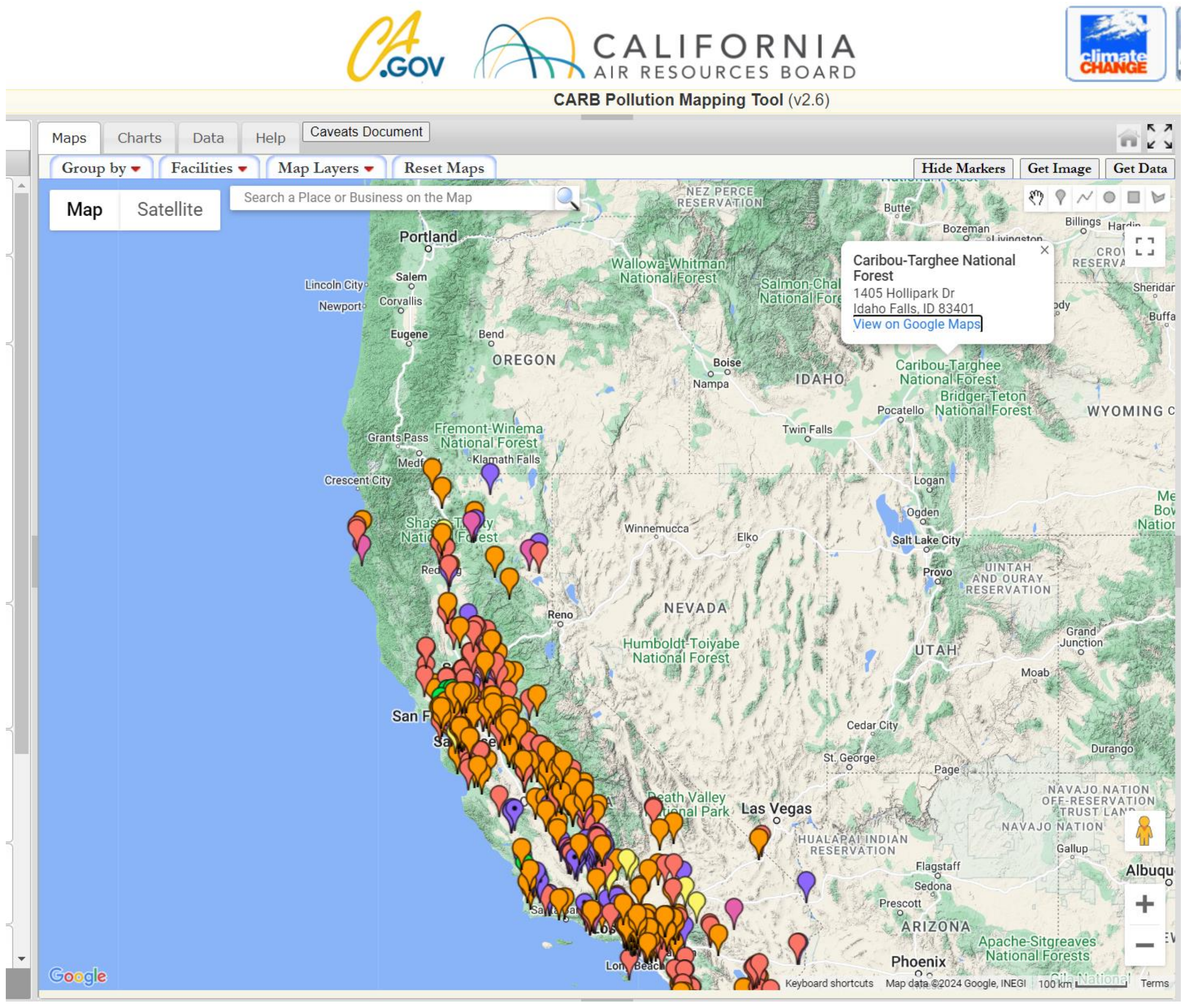
Keywords: cap-and-trade, environmental justice, data analysis

In a forthcoming article by Ash & 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

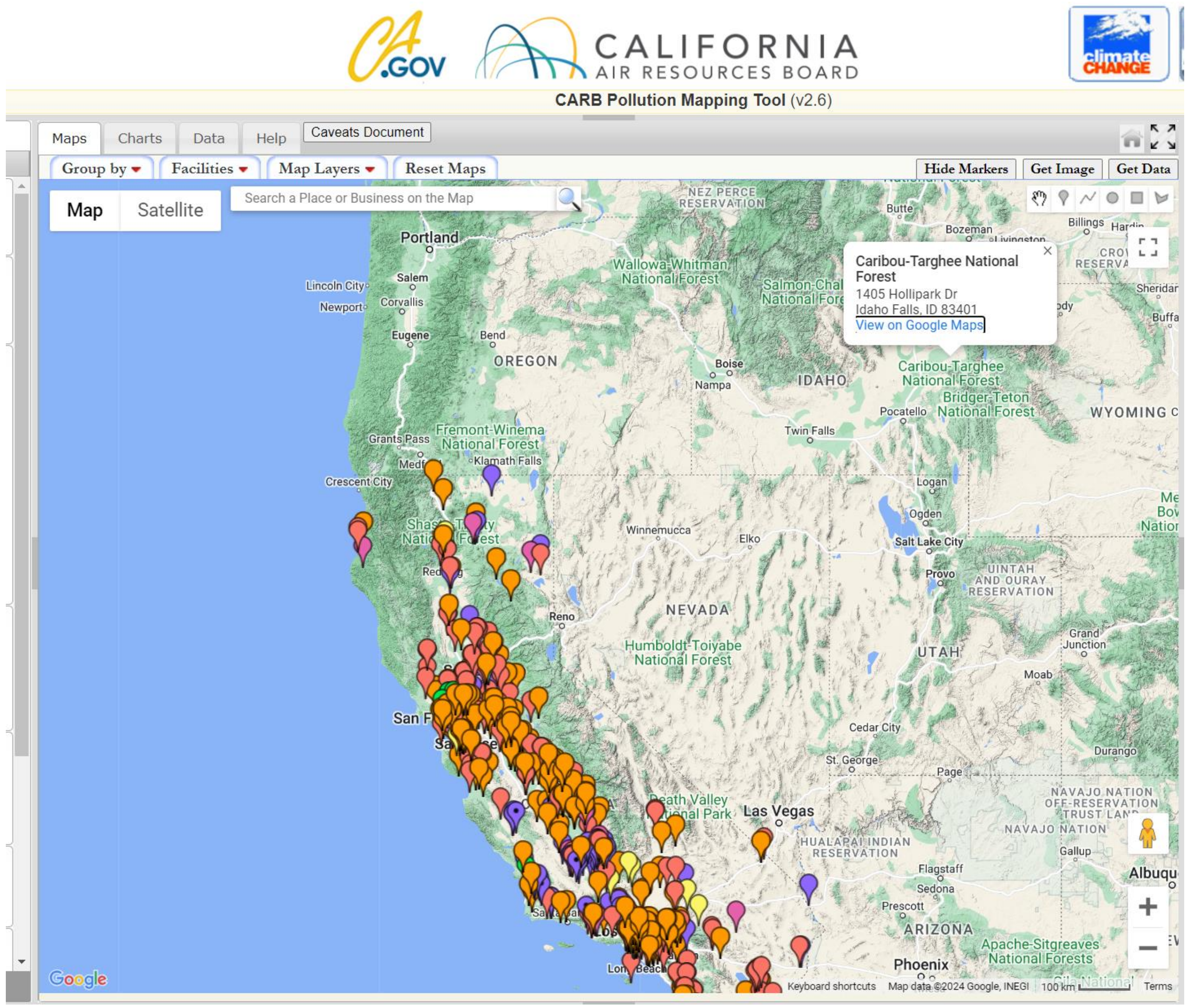
Why would that be an issue?

- 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



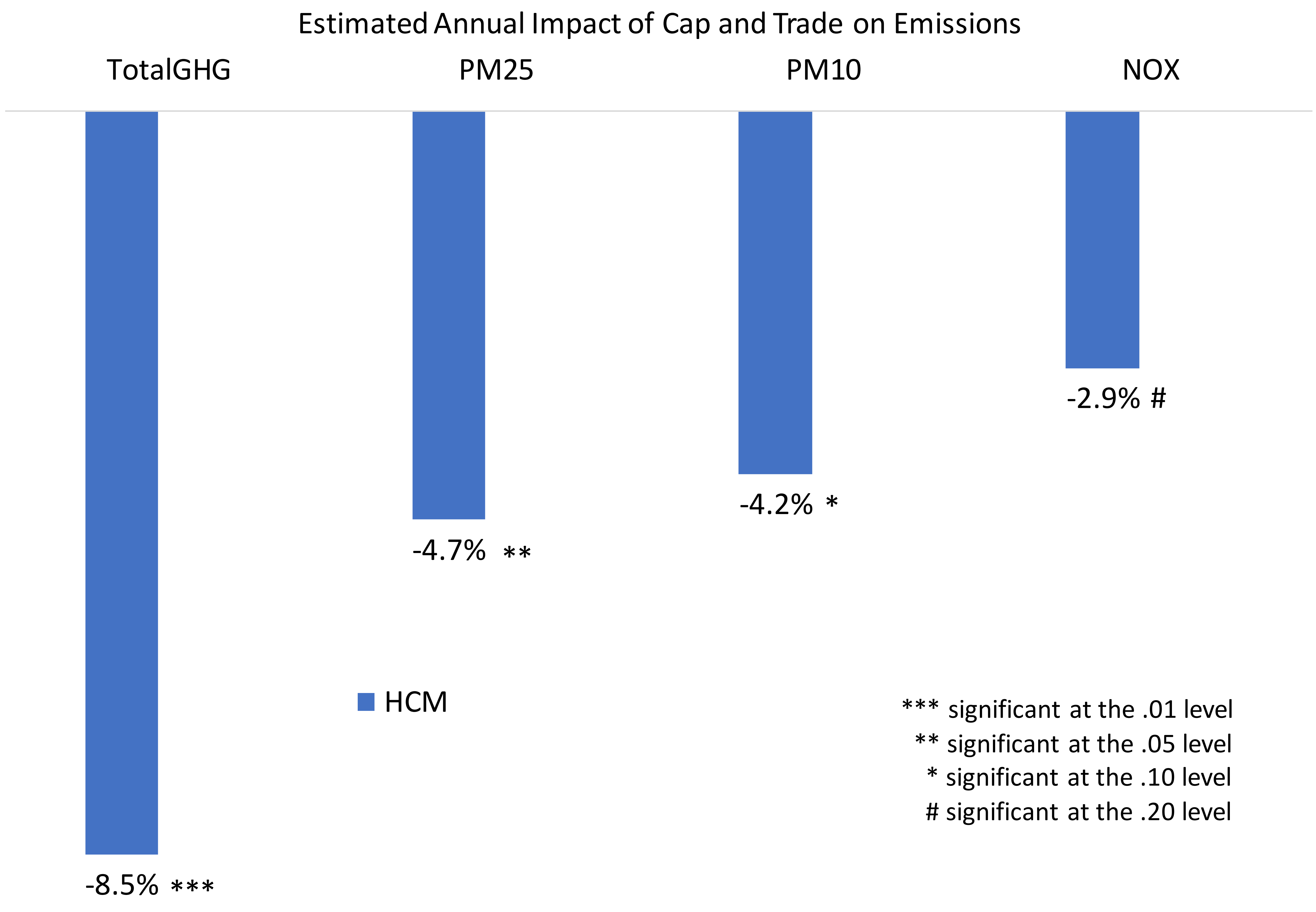
Why would that be an issue?

- 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-and-trade



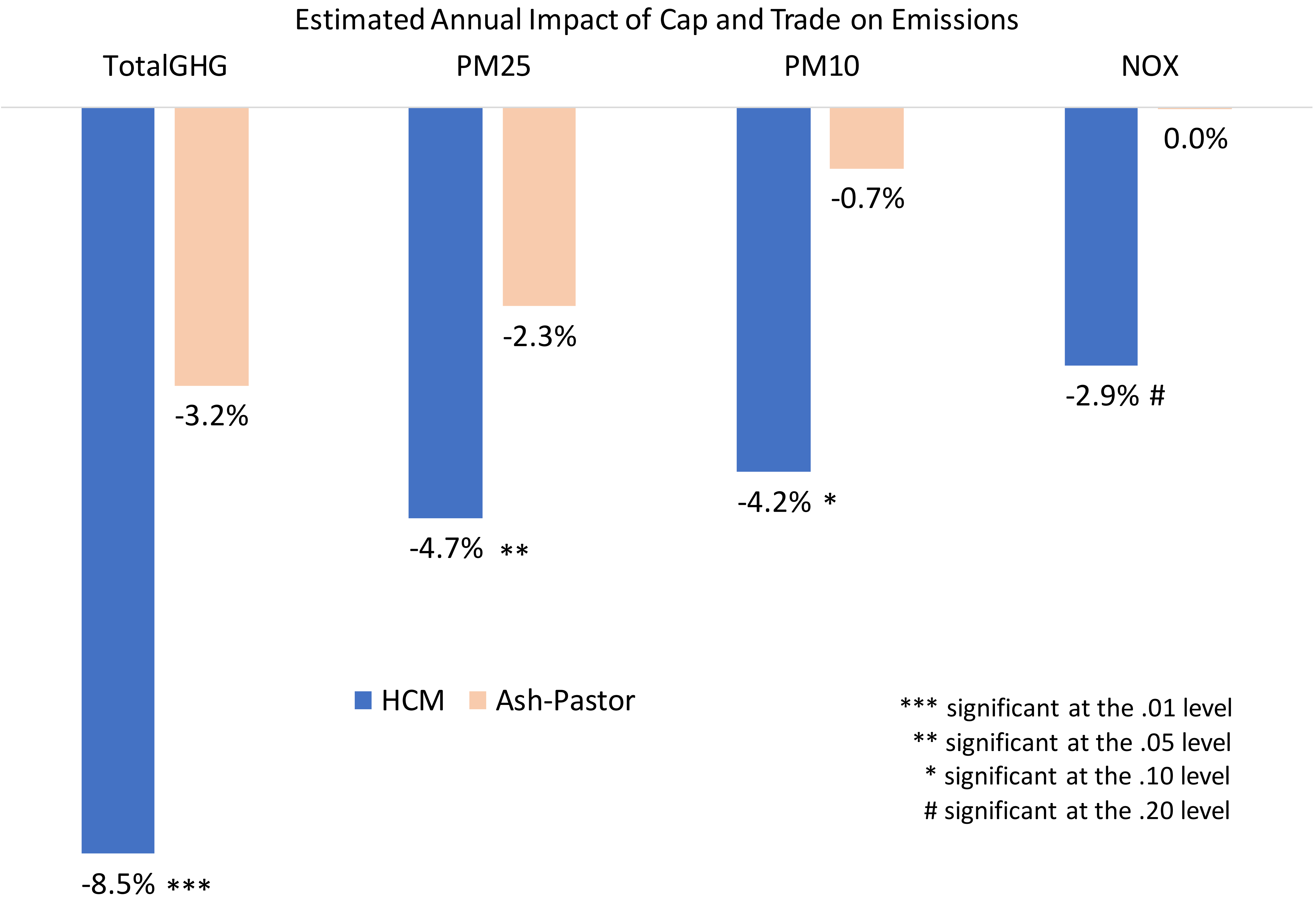
How do the results change?

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



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



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

Journal of the Association of Environmental and Resource Economists, volume 11, number 1, January 2024.

https://doi.org/10.1086/725699

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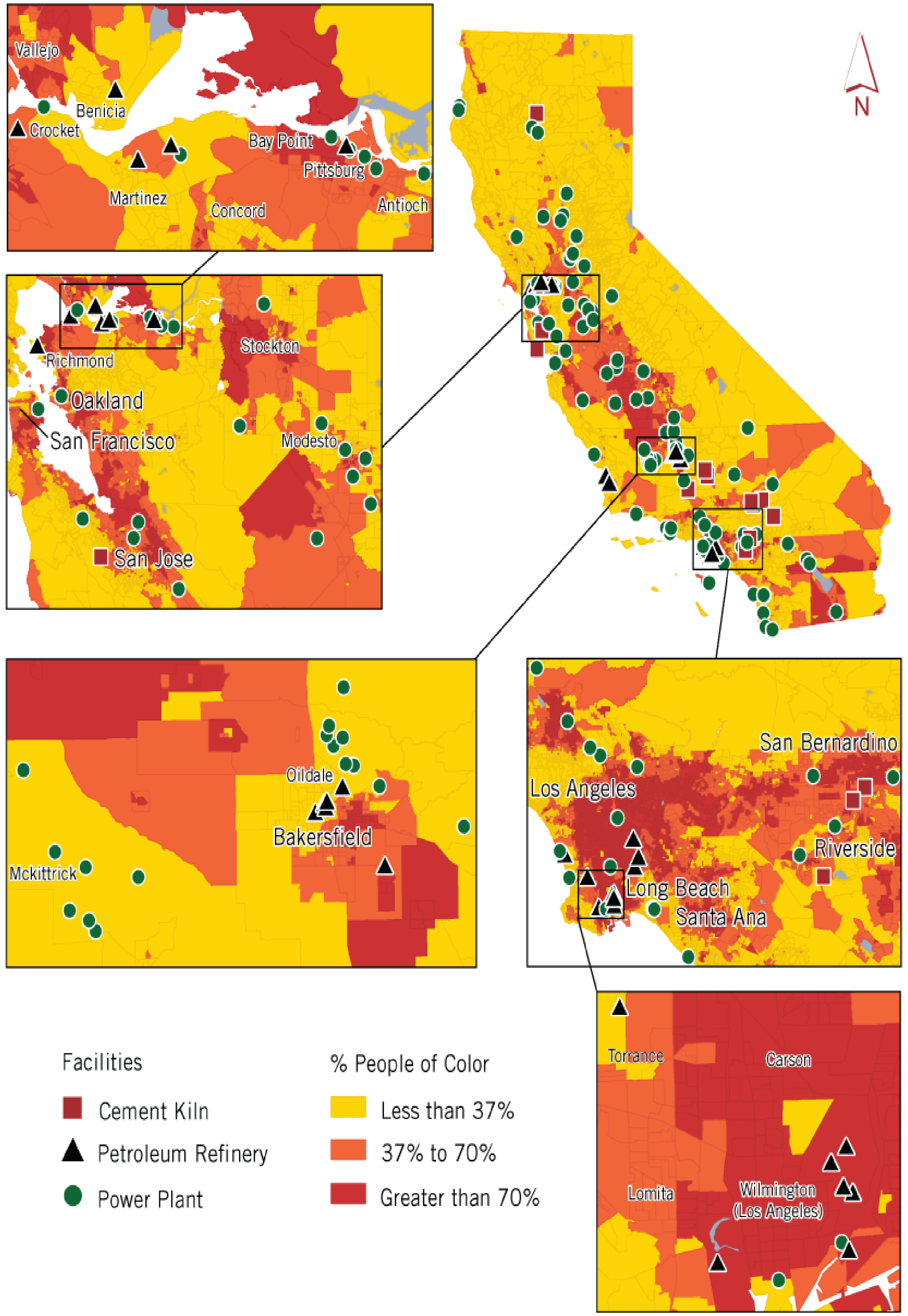
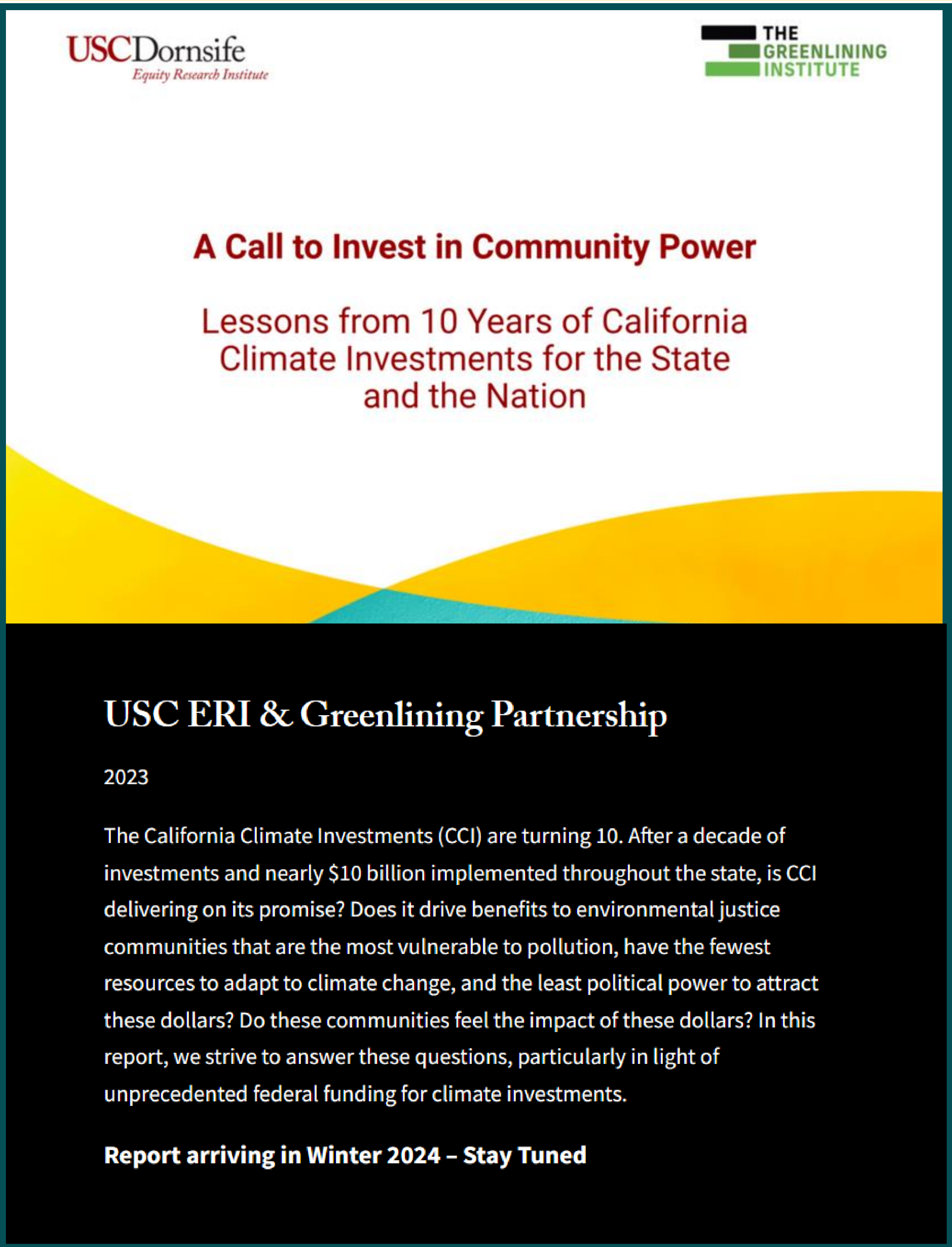
- Limits: Sheriff is only able to connect 118 cap-and-trade facilities with RSEI, about a third of the total
- He sets up a control group of other RSEI facilities
- And considers 2007-2012 to 2013-2018 with one key innovation being (a la Currie, et al. 2023) interaction with the percent people of color

New work by Glenn Sherriff



- Facility level analysis suggests that cap-and-trade did not lead to increased releases from upwind facilities
- Neighborhood level analysis with interactions suggests that percentage improvement was greater in communities with a higher percent people of color
- 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



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A Call to Invest in Community Power

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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

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

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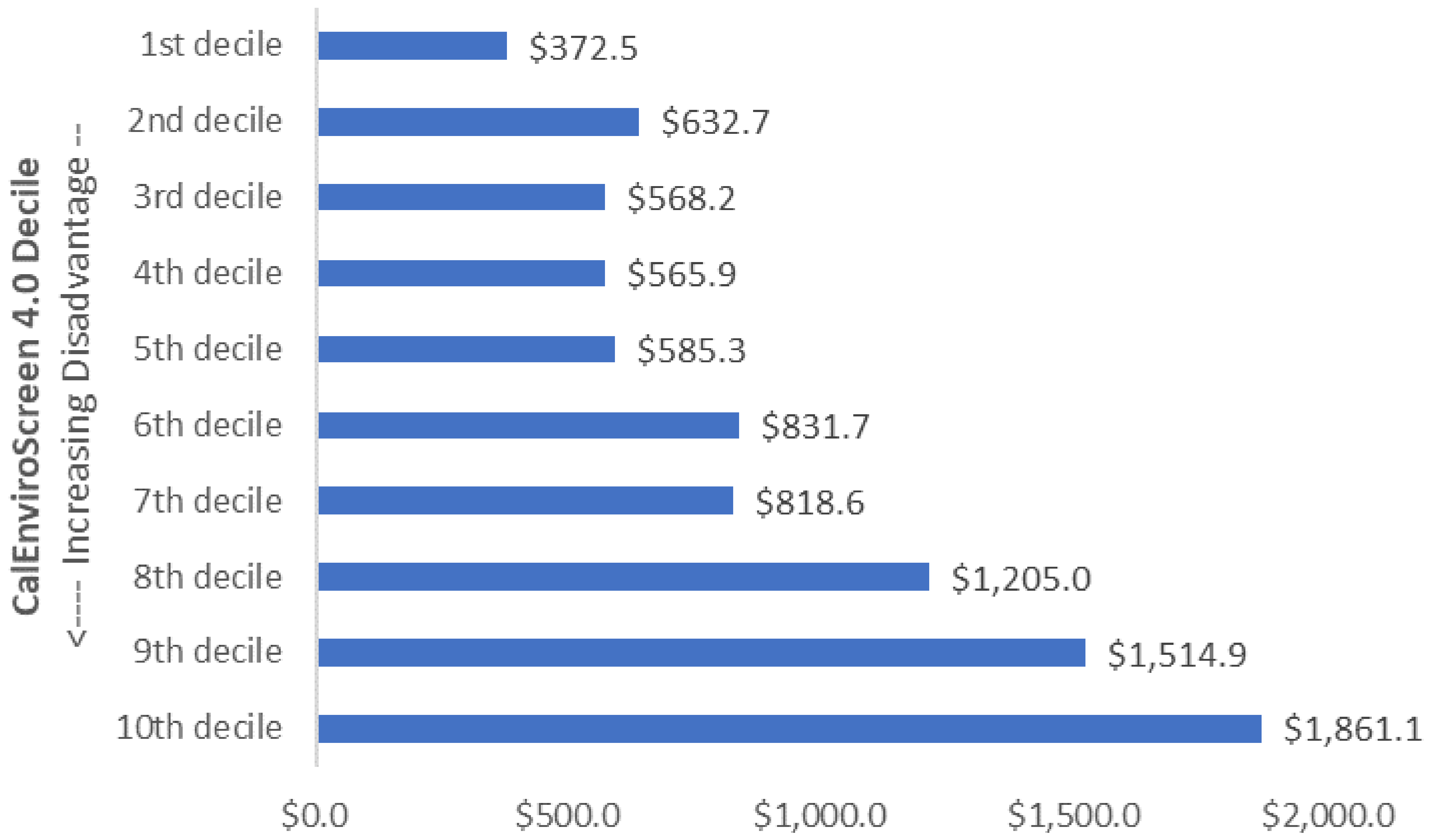
2024

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.

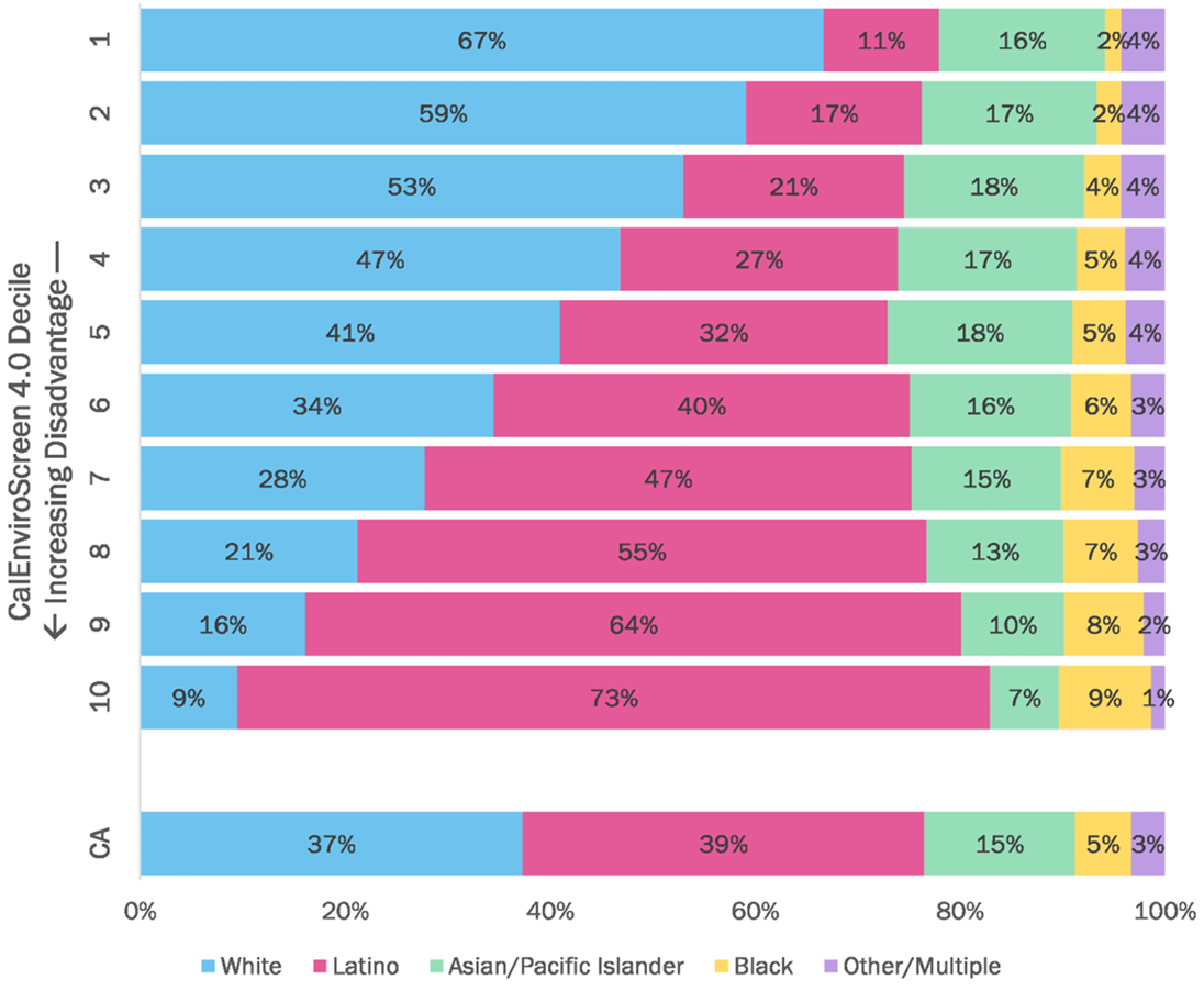


Figure 3 Racial Makeup of Each Decile of CalEnviroScreen 4.0 Score.

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 well-coordinated
- 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

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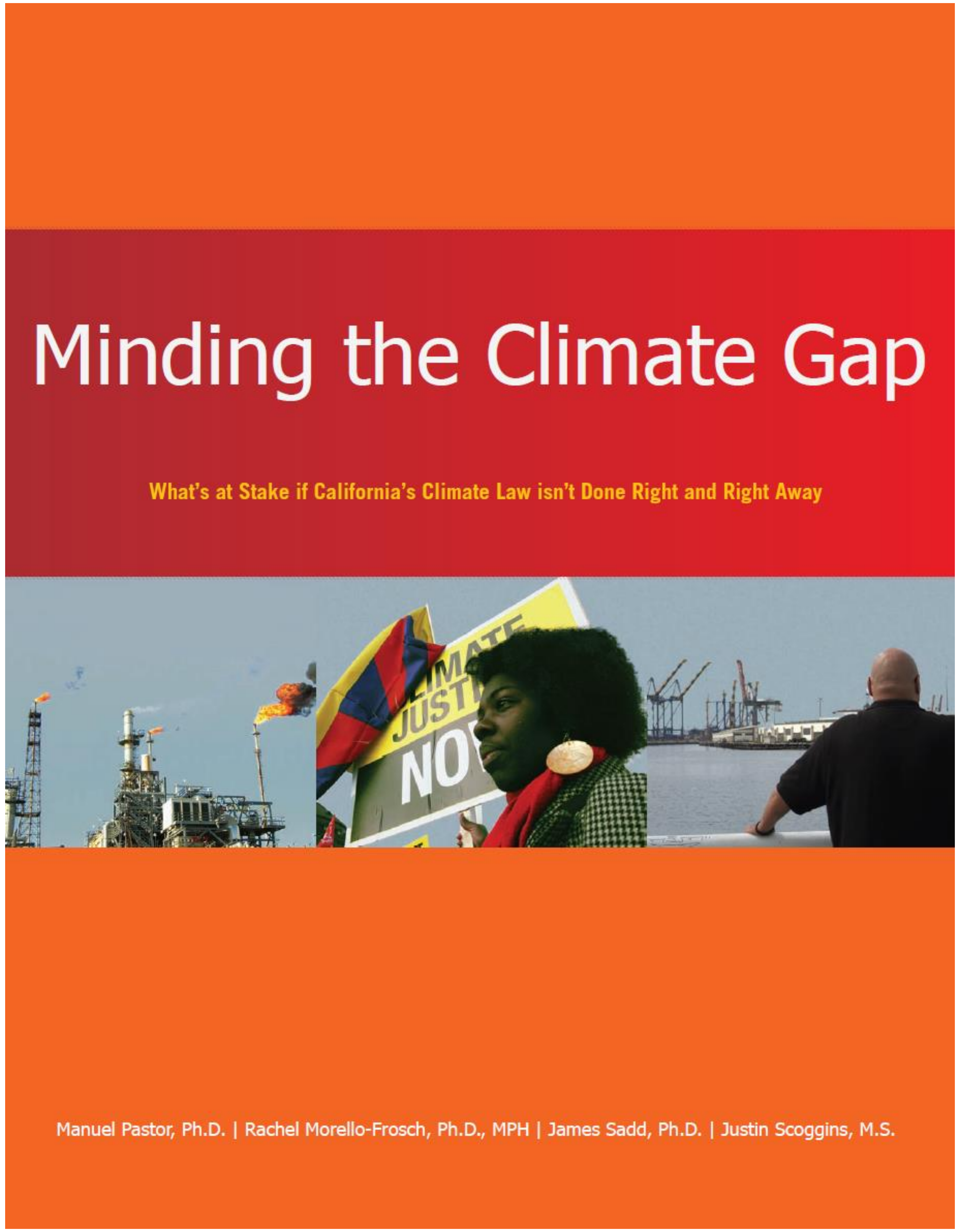
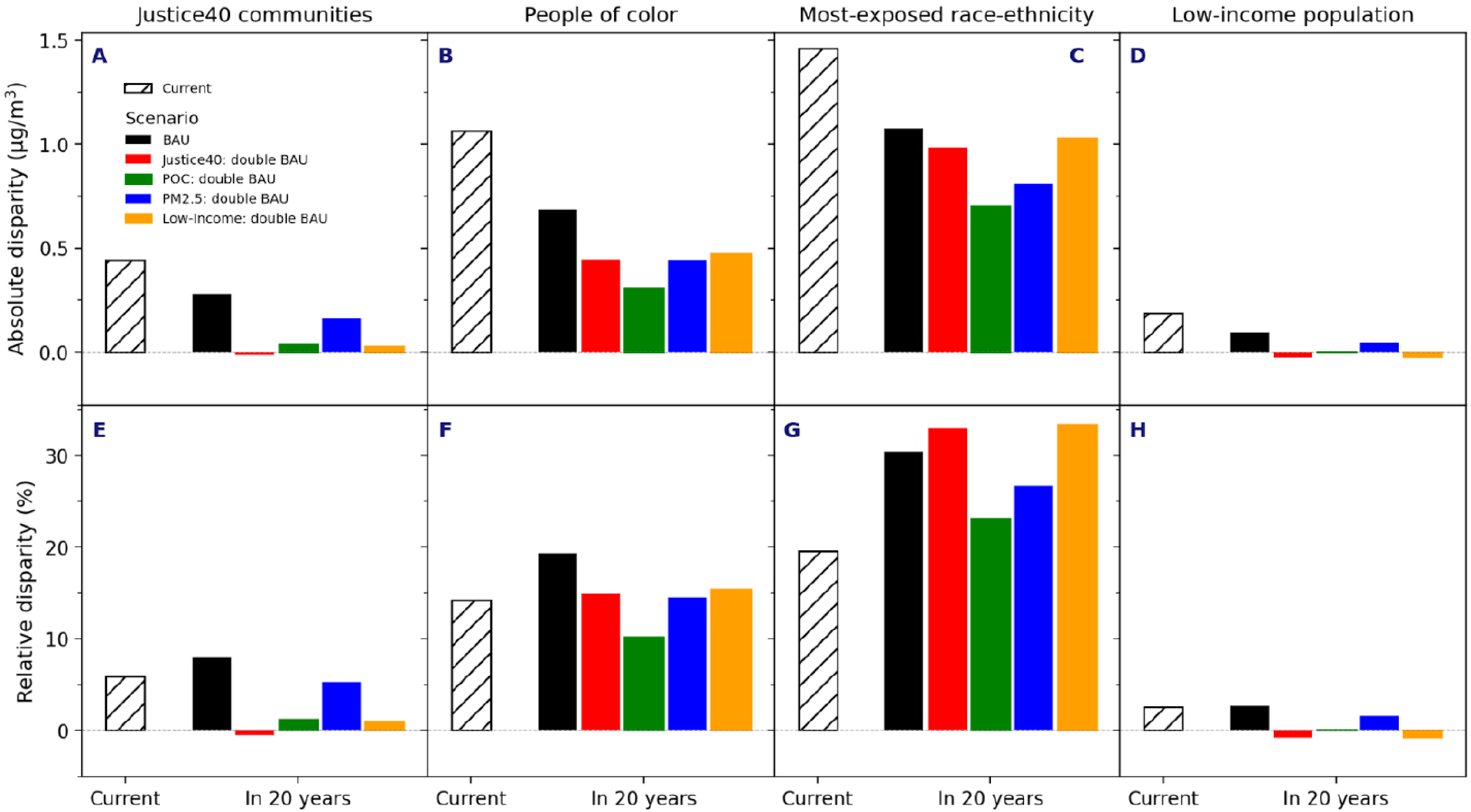
Back to cap-and-trade



- In April 2010, we released "Minding the 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

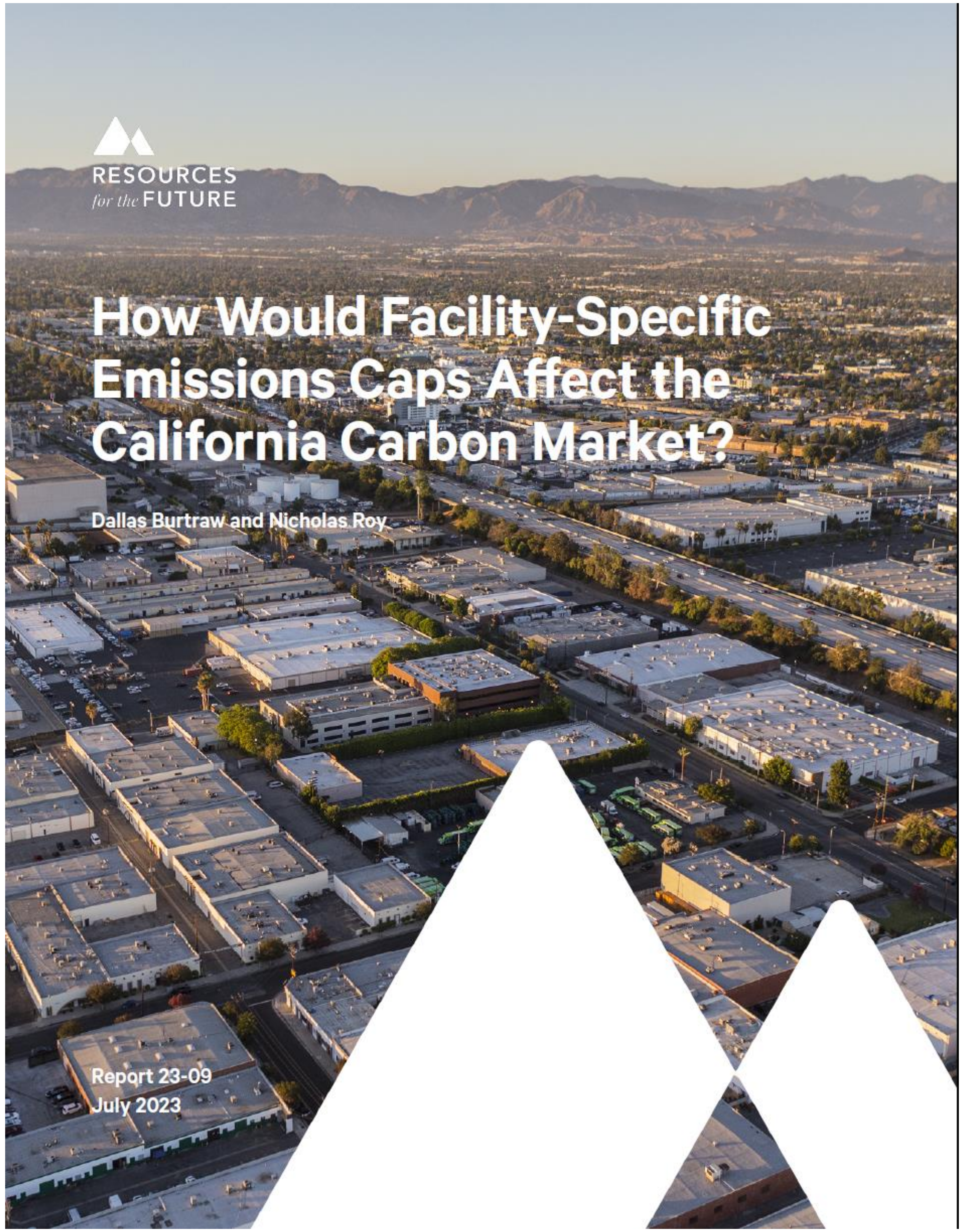
Future Thinking: Anticipatory projections that assess the racial equity implications of climate and air quality policies are key to reducing disparities and advancing EJ goals

Example: Absolute and Relative $PM_{2.5}$ disparities changes in 20 years for alternative doubling emission-reduction scenarios.



Wang et al. 2023 *Science*
science.org/doi/10.1126/science.adg9931

Back to cap-and-trade



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

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-and-trade 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

- 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

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Thanks!

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