Clean Air Act Advisory Committee
Mobile Sources Technical Review Subcommittee
October 29, 2013

California's Diesel Control Program and its Black Carbon Co-benefits

Alberto Ayala
Deputy Executive Officer

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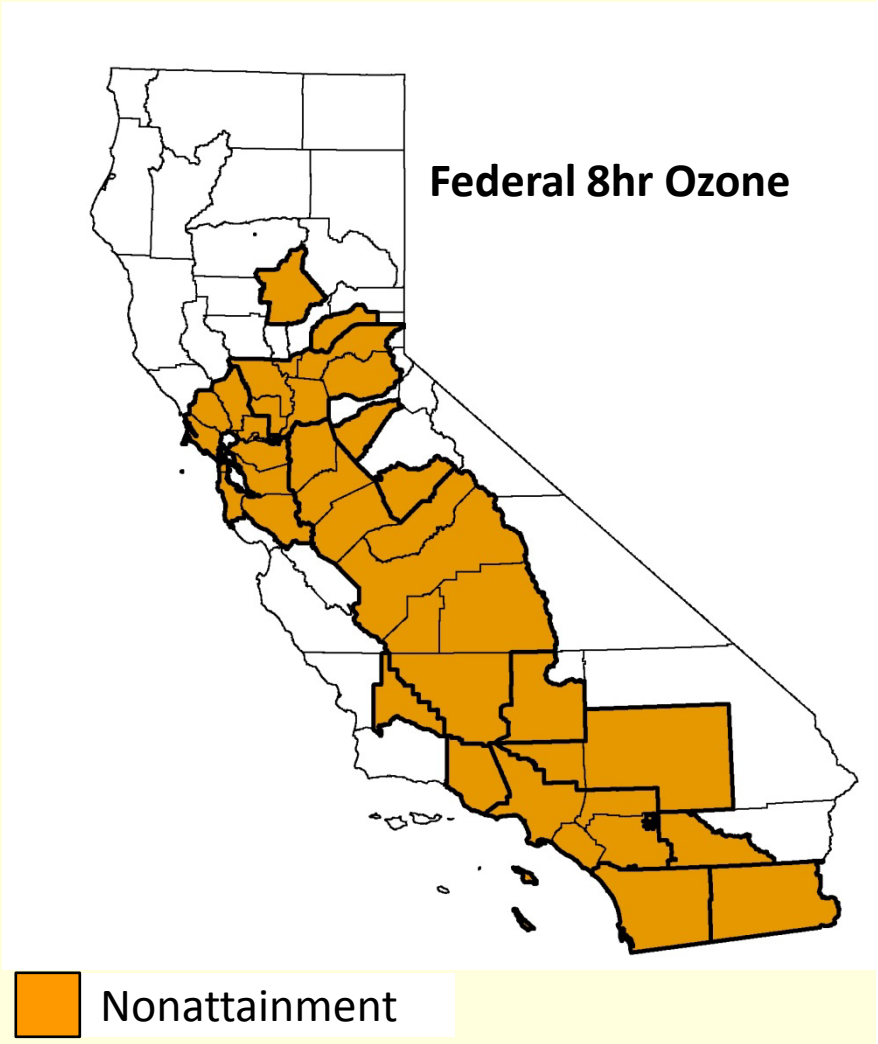
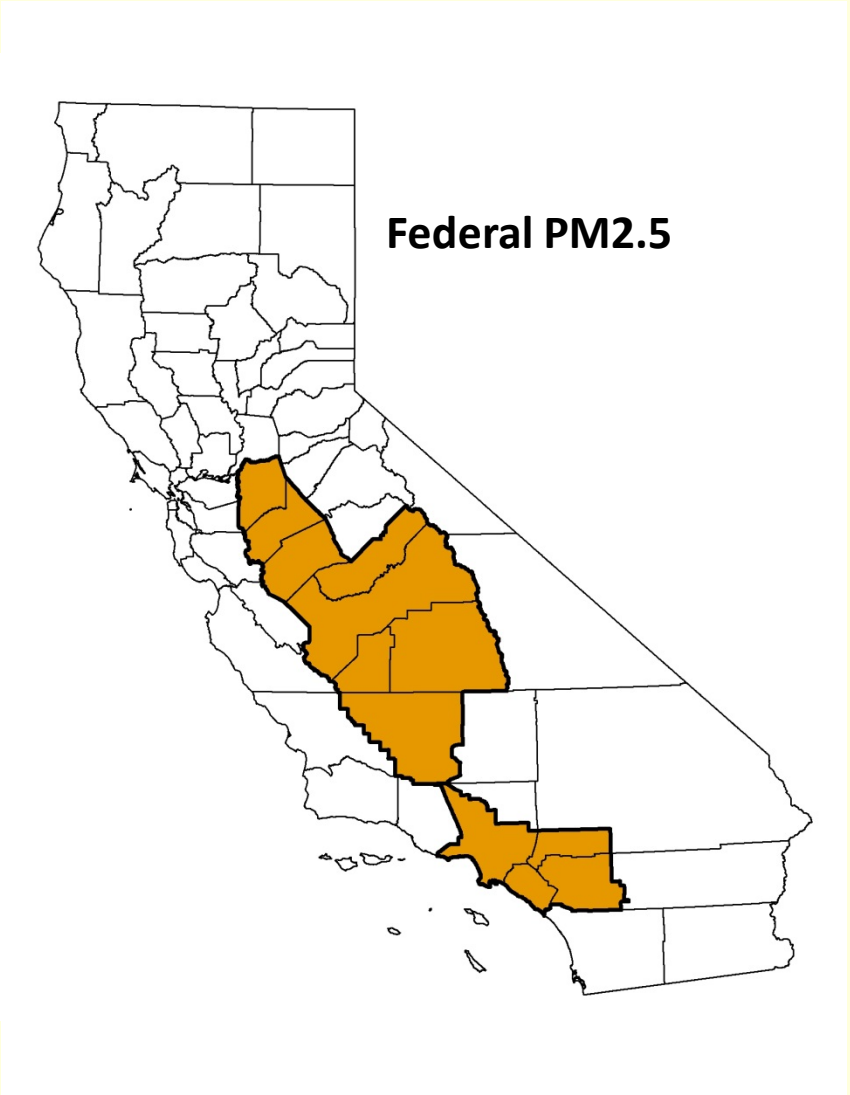
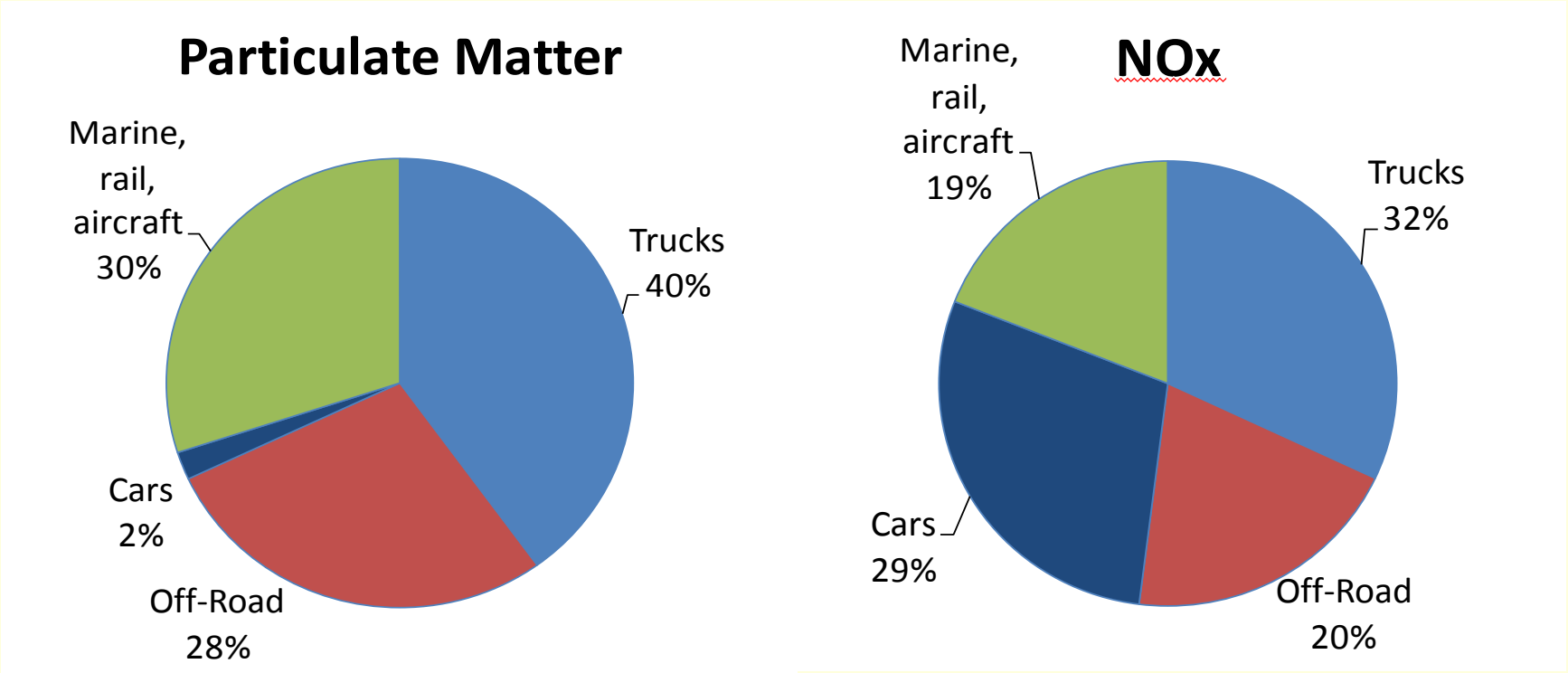
Air Resources Board

Many Areas of State Do Not Meet Federal Air Quality Standards



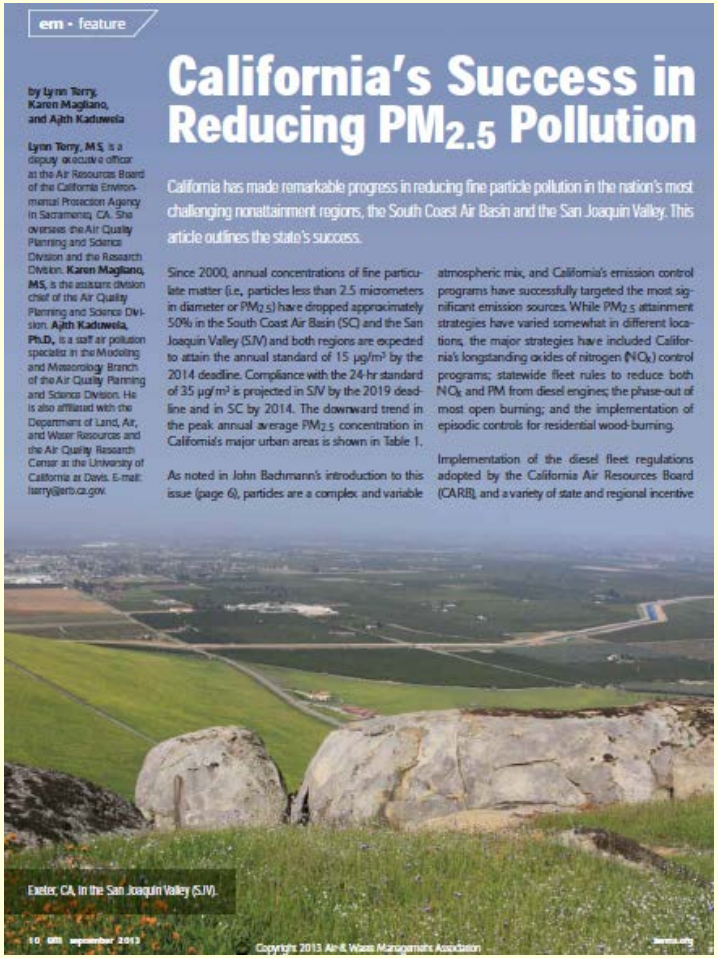


Diesel trucks are largest mobile source



2010 Mobile Source Emissions

Progress in Reducing Ambient PM2.5 Pollution



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by Lynn Terry, Karen Magliano, and Ajith Kaduwela

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California's Success in Reducing $PM_{2.5}$ Pollution

California has made remarkable progress in reducing fine particle pollution in the nation's most challenging nonattainment regions, the South Coast Air Basin and the San Joaquin Valley. This article outlines the state's success.

Since 2000, annual concentrations of fine particulate matter (i.e., particles less than 2.5 micrometers in diameter or $PM_{2.5}$) have dropped approximately 50% in the South Coast Air Basin (SC) and the San Joaquin Valley (SJV) and both regions are expected to attain the annual standard of 15 μg/m³ by the 2014 deadline. Compliance with the 24-hr standard of 35 μg/m³ is projected in SJV by the 2019 deadline and in SC by 2014. The downward trend in the peak annual average $PM_{2.5}$ concentration in California's major urban areas is shown in Table 1.

As noted in John Bachmann's introduction to this issue (page 6), particles are a complex and variable atmospheric mix, and California's emission control programs have successfully targeted the most significant emission sources. While $PM_{2.5}$ attainment strategies have varied somewhat in different locations, the major strategies have included California's longstanding oxides of nitrogen (NO_x) control programs; statewide fleet rules to reduce both NO_x and PM from diesel engines; the phase-out of most open burning; and the implementation of episodic controls for residential wood-burning.

Implementation of the diesel fleet regulations adopted by the California Air Resources Board (CARB), and a variety of state and regional incentive

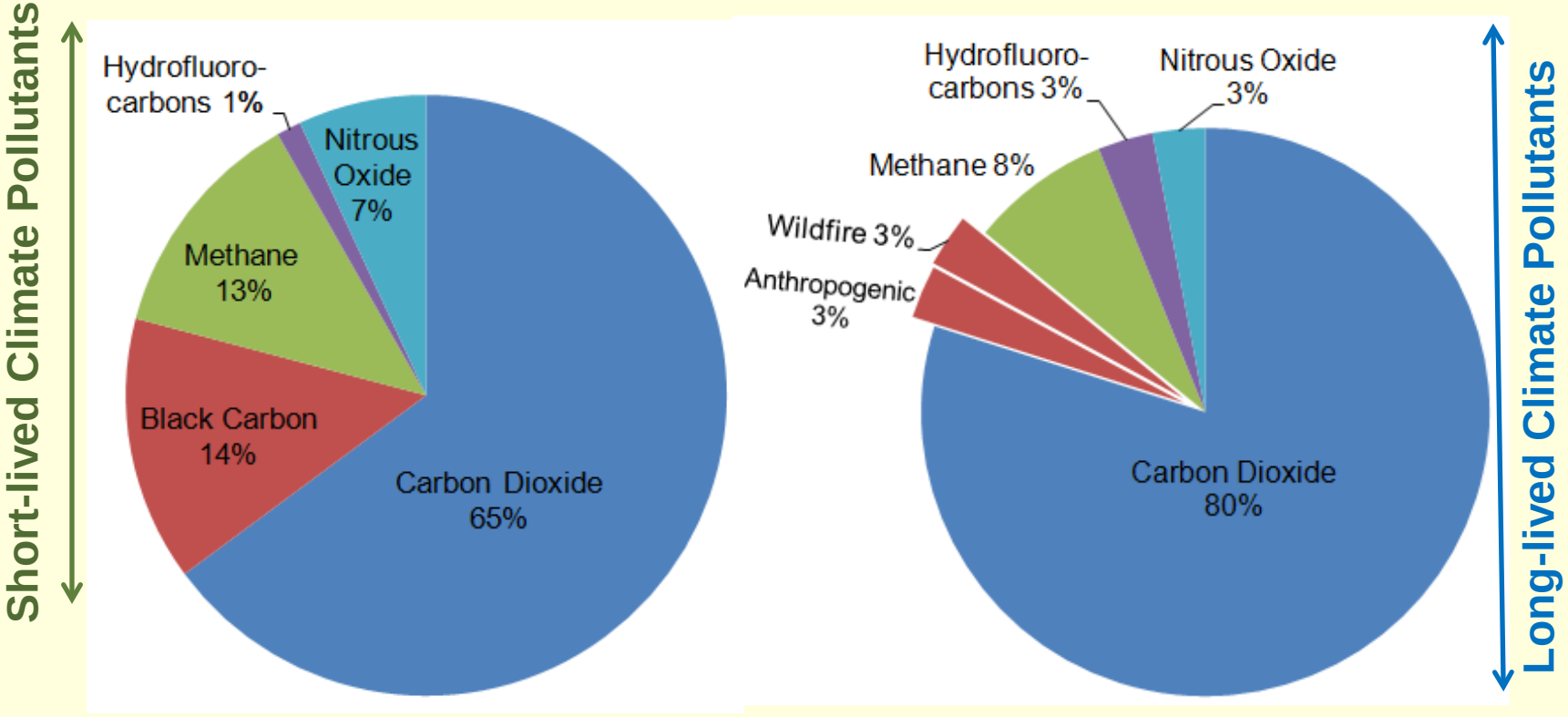
Exeter, CA, in the San Joaquin Valley (SJV).

10 em september 2013

- Since 2000, annual PM2.5 has dropped by 50% in the South Coast Air Basin and the San Joaquin Valley
- Both region will attain annual 15 μg/m³ and 24-hr 35 μg/m³ standards by 2014 and 2019 deadlines
- Diesel fleet regulations and state and regional incentives are rapidly cleaning up fleet
- These actions are most significant strategy for attainment demonstration

Climate Pollutant Emissions

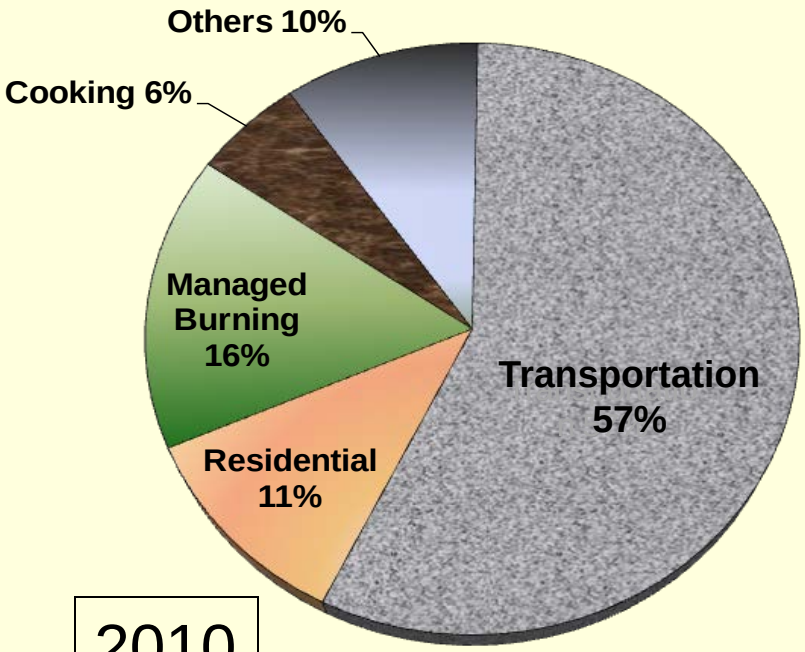
(2010)



Global

California

Anthropogenic Black Carbon Sources
(excluding wildfires and biogenic)



2010

Statewide
BC ~ 17,000 tons per year

California Actions on Short-lived Climate Forcers

- Black Carbon
  - Diesel engine controls, Advanced Clean Cars, burning restrictions
- Methane
  - Landfill controls, oil and gas regulations, dairy digester offset protocol
- Hydrofluorocarbons
  - Refrigerant Management Program, Advanced Clean Cars, other regulations

Global Warming Potential for Selected Greenhouse Gases*

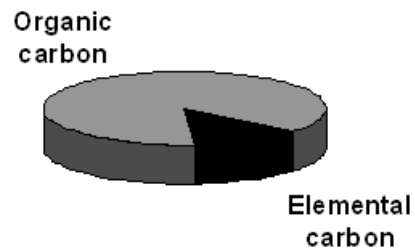
Pollutant	SLCP	Global Warming Potential (20-year)	Global Warming Potential (100-year)*
Carbon dioxide		1	1
Methane	Yes	72	25
Nitrous oxide		289	298
Sulfur hexafluoride		16,300	22,800
Hydrofluorocarbons	Yes	437 – 6,350	124 – 4,470
Perfluorocarbons		5,210 – 8,630	7,390 – 12,200
Black carbon	Yes	3,200	900
Nitrogen trifluoride		12,300	17,200

*The 20 and 100-year global warming potential estimates are from the IPCC 2007 Fourth Assessment review, except for the black carbon global warming potential estimate, which is based on a major scientific assessment of the black carbon radiative forcing published early this year (*Bond et al.)* .

BC fraction in PM vehicle emissions

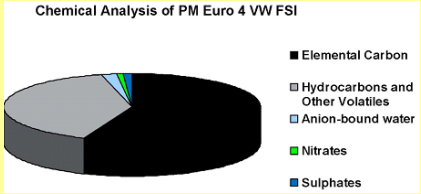
Gasoline Car

Conventional



- PM emissions < 1 mg/mile
- << current SULEV PM standard of 10 mg/mile
- Most PM is OC
- BC increases for high PM emitters

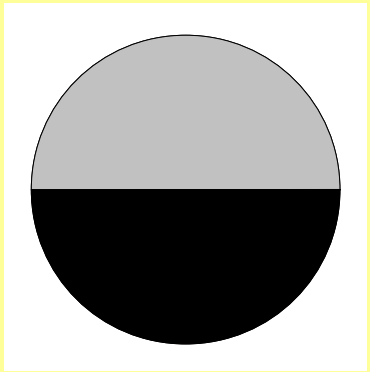
Direct injection



- Very good for CO_2 reduction
- still < current SULEV PM standard
- But PM > conventional gasoline
- Also > particle counts
- Most PM is BC or soot like diesel

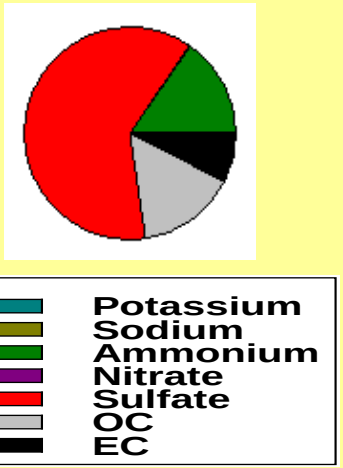
Diesel Truck

Pre-2007



- PM standard at 100 mg/bhp-hr
- Most PM is EC or soot

2010

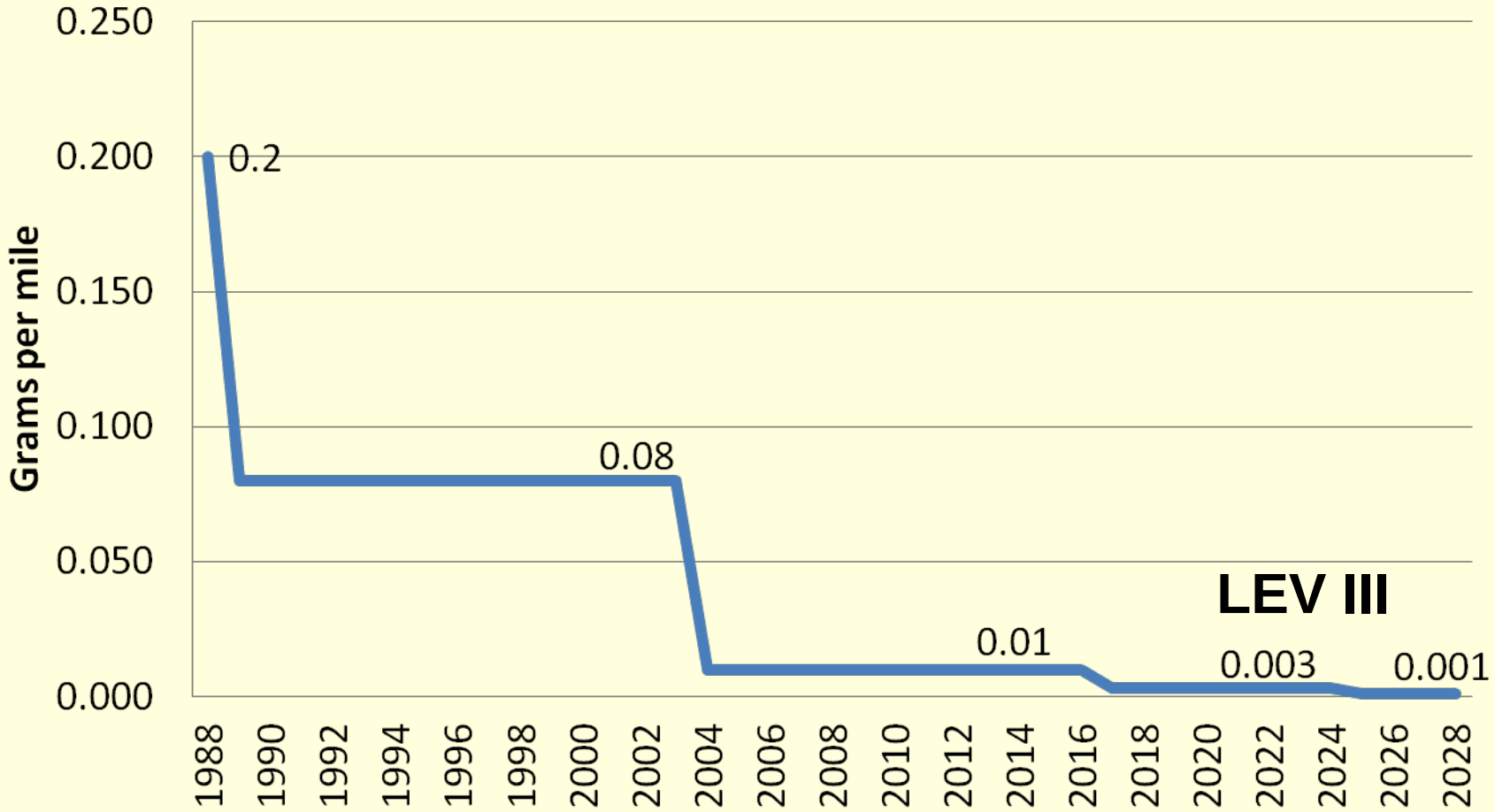


- PM emissions << standard 10mg/bhp-hr
- Little BC (EC or soot)

Sources: CARB's Phase II HDV emissions study, Ricardo/UK; Li, et.al., SAE Tech. Paper 2006-01-1076

California Tailpipe PM Standards

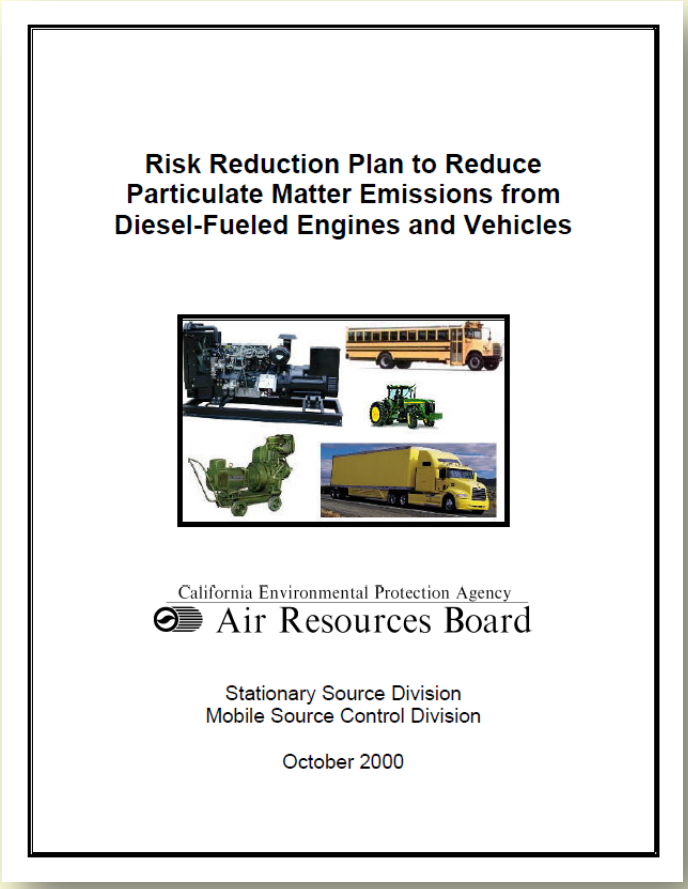
(passenger cars, light trucks < 8,500 lbs. GVW)



Gasoline vehicles subject to PM standard beginning in 2004

Reducing Diesel PM is a Public Health Priority

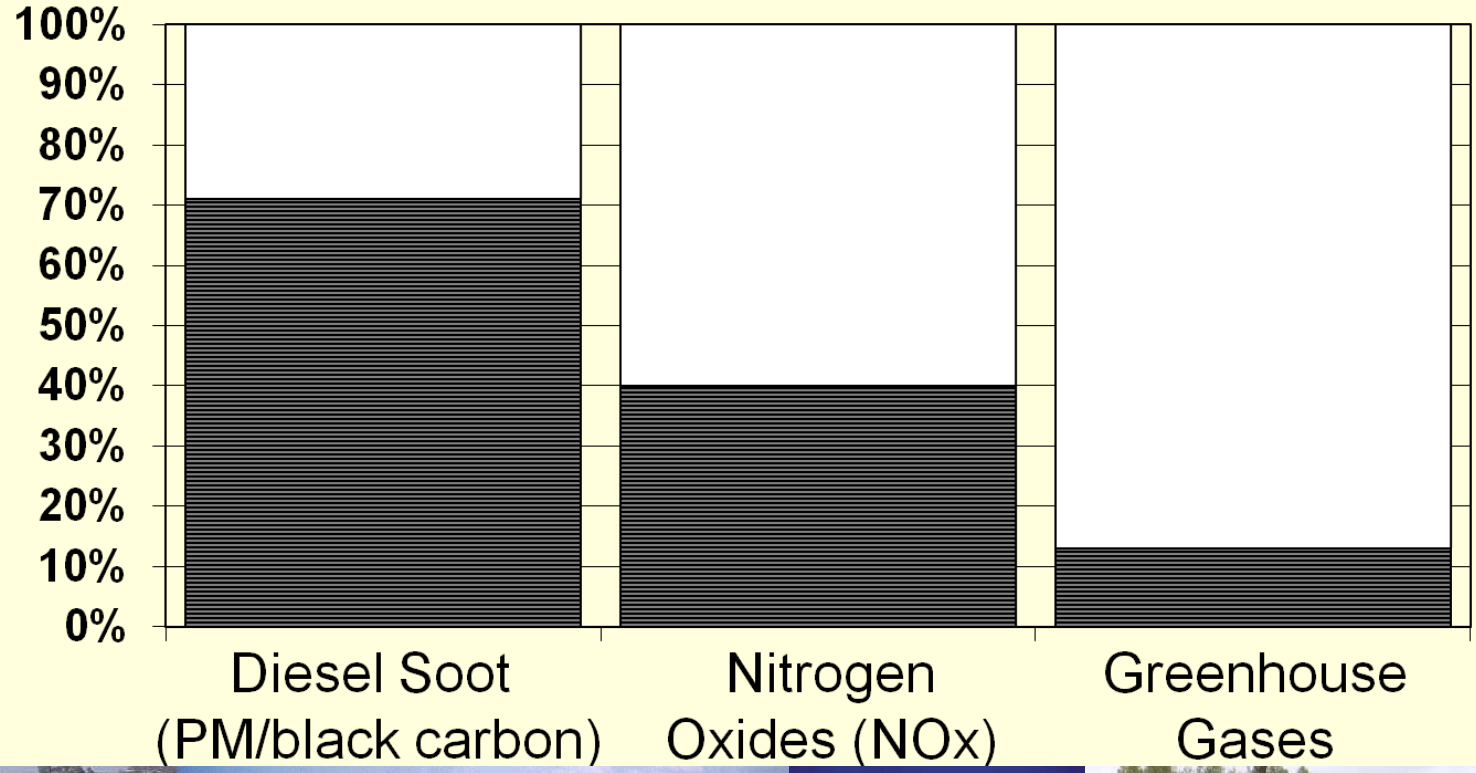
- 1998 identification as Toxic air contaminant
- 2000 Diesel Risk Reduction Plan
  - Reduce cancer risk by 85% by 2020
  - 2007 new engine standards
  - Clean fuel standards
  - In-use controls (retrofits/re-power)
  - Anti-idling
  - Public investment - incentives ~ $100s of millions/year
  - Enforcement
- Mitigate other health impacts
  - Hospital admissions
  - Asthma rates
  - Acute bronchitis
  - Work days lost
- Children/elderly most vulnerable

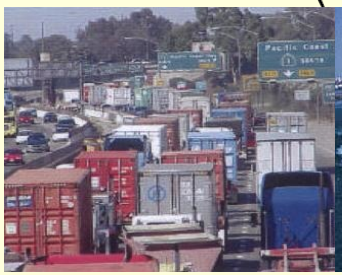


In-Use Diesel Regulations

Urban Buses (2000)	Drayage Trucks (2007)
Garbage Trucks (2003)	Off-Road Vehicles (2007)
Stationary Engines (2004)	Trucks and Buses (2008)
Transport Refrigeration Units (2004)	Tractor-Trailer GHG (2008)
Portable Engines (2004)	Agricultural Tractors and Equipment (under development)
Transit Fleet Vehicles (2005)	
Public Fleets & Utilities (2005)	
Cargo Handling Equipment (2005)	

Freight Transport Today: Contribution to Statewide Emissions

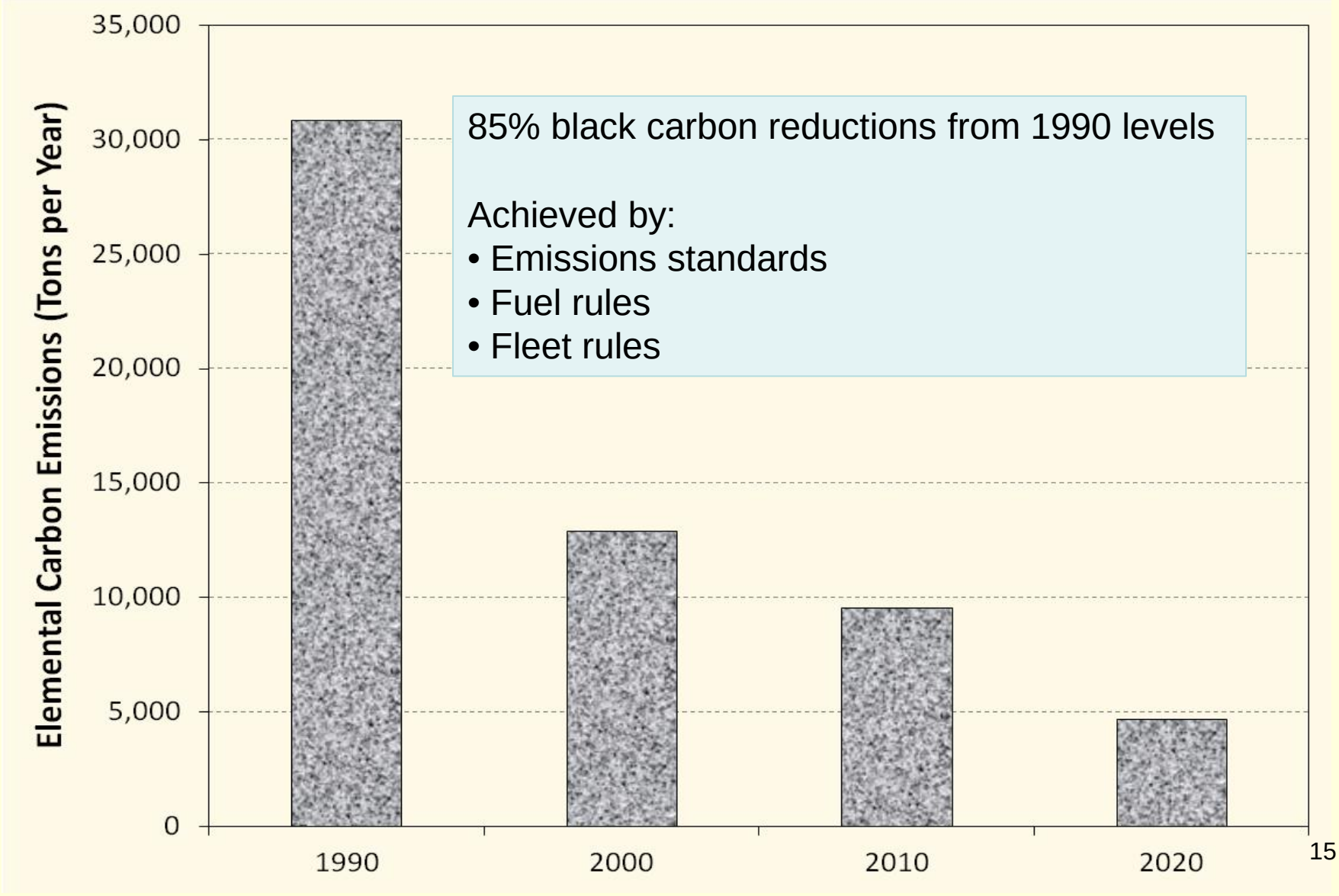




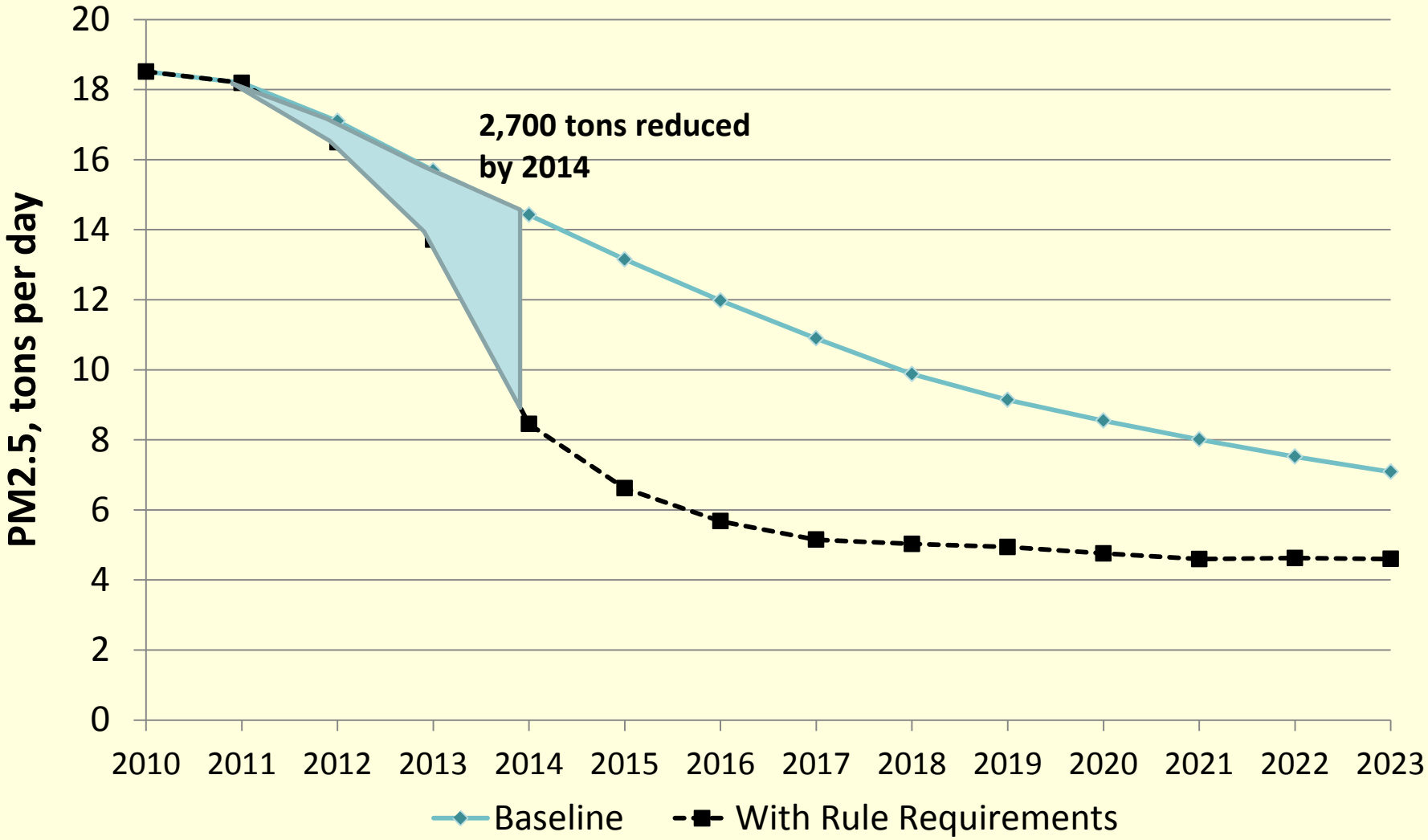
Adopted ARB Freight Regulations

- ✓ Cleaner diesel fuel rules
- ✓ Statewide truck rules
- ✓ Port and railyard truck rule
- ✓ Truck/trailer efficiency rule
- ✓ Truck idling and refrigeration unit rules
- ✓ Ship fuel and shore power rules
- ✓ Harbor craft rules
- ✓ Cargo equipment rule
- ✓ Locomotive/rail yard agreements

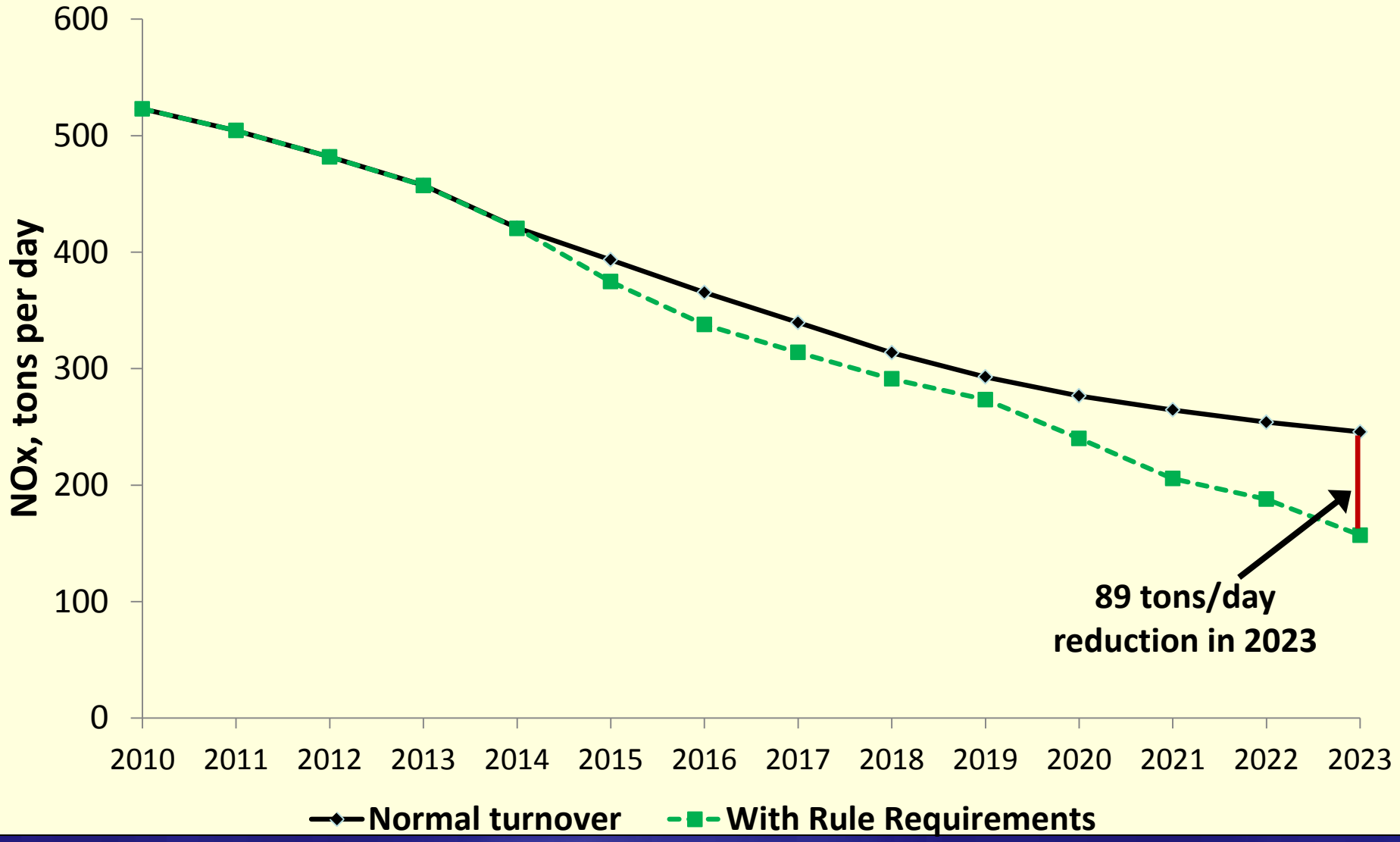
California's Diesel Program



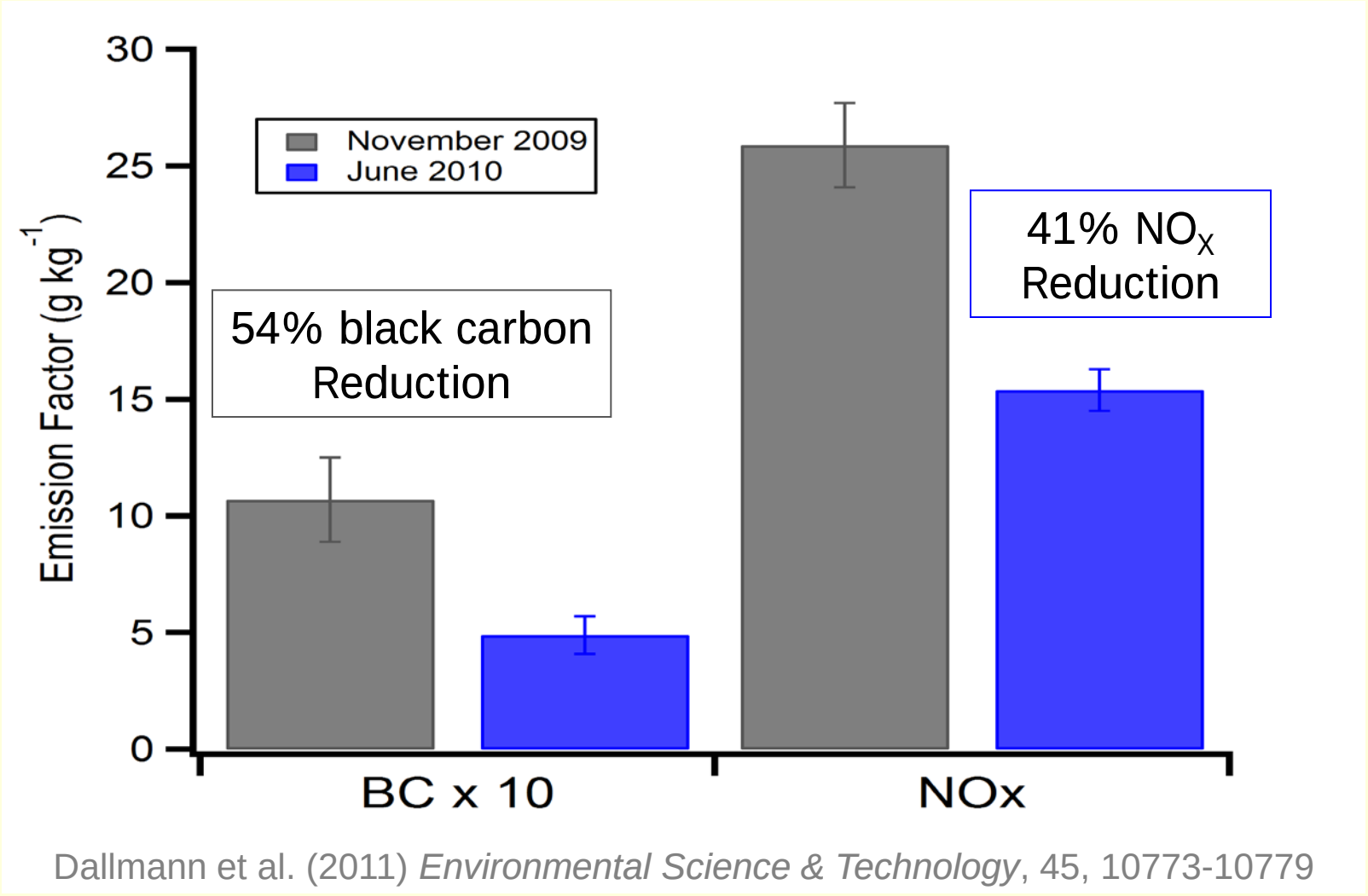
PM Benefits Already Realized by T&B Regulation



Significant NOx Benefits from Replacements



Black Carbon Emission Reductions from Trucks Operating at Port of Oakland



Dallmann et al. (2011) *Environmental Science & Technology*, 45, 10773-10779

Black Carbon and the Regional Climate of California

- First regional assessment of climate impact of BC
- Based on modeling and observational data (aircraft, satellite, ground monitors)
- Ramanathan et al.
- 3-year study
- Scripps Institution of Oceanography
- University of California at San Diego
- Lawrence Berkeley National Lab
- Pacific Northwest National Lab

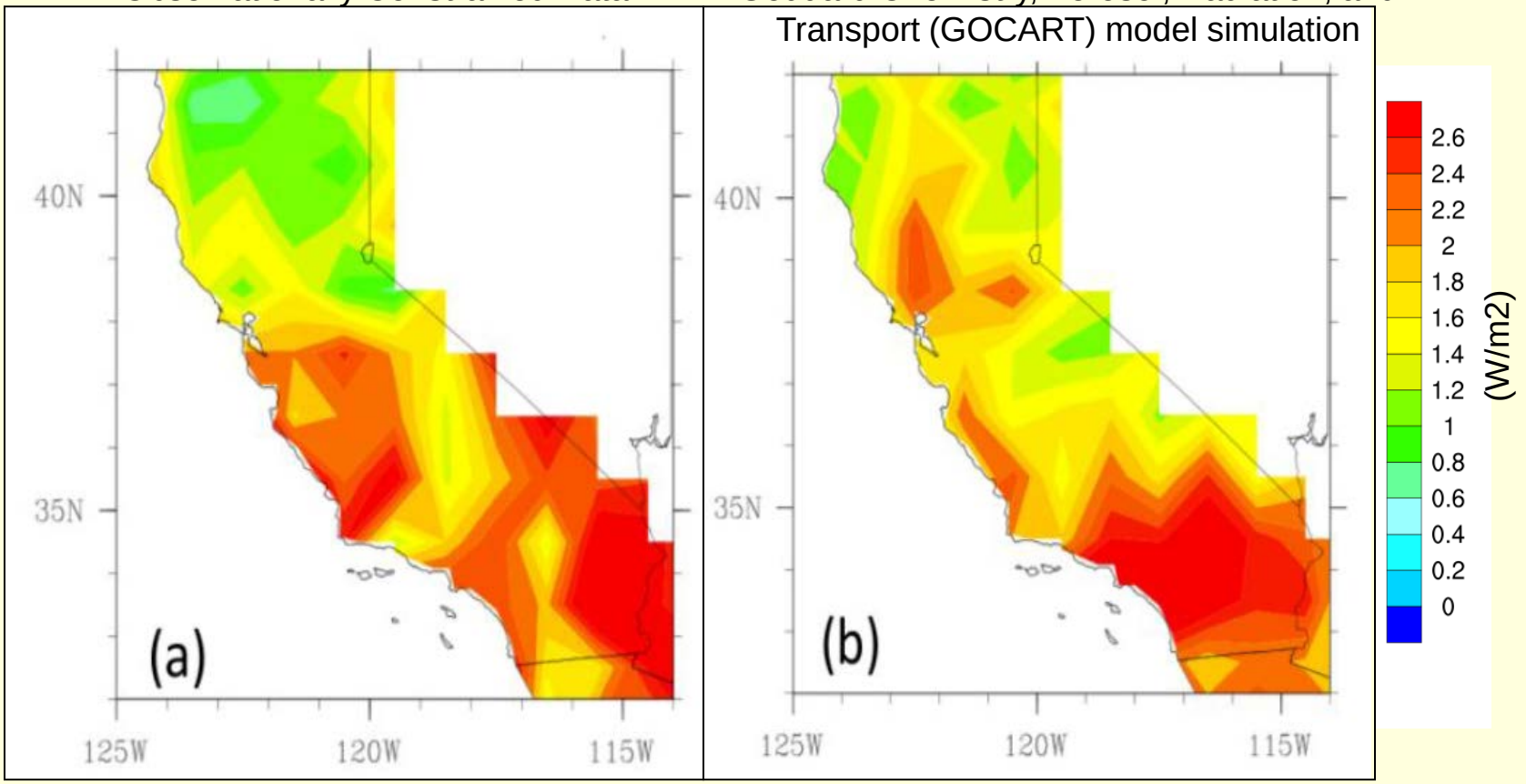
Final report: www.arb.ca.gov/research/single-project.php?row_id=64841

Press release: www.arb.ca.gov/newsrel/newsrelease.php?id=444

Climate Forcing from BC and BrC
(annual mean of 2001 to 2010)

Observationally Constrained Data

Goddard Chemistry, Aerosol, Radiation, and Transport (GOCART) model simulation



Major Findings: Detection

- Statewide BC concentrations in California have decreased from 0.46 μg/m^3 in 1989 to 0.24 μg/m^3 in 2008 (about 50% reduction)
- Fossil fuel and diesel emissions show a corresponding 50% reduction
- This trend extends further back – a decrease of 72% from 1960s to 2000
- The negative trend is still continuing

Major Findings: Attribution

- BC has decreased even though total fuel consumption has steadily increased
- BC trend is consistent with diesel BC emission trend
- Lack of similar trends in other aerosols indicates: negative trend in BC is not due to meteorology
- Clean-up attributed to reduced tailpipe emissions, improved engines, and low-sulfur fuel as mandated by State policies

Large negative trends in BC and lack of corresponding negative trends in co-emitted cooling aerosols gives compelling observational evidence that mitigation of diesel BC would be effective in mitigating global warming as inferred by modeling studies (e.g., Jacobson, 2010; Bond et al., 2013)

Brown Carbon*:
Another Climate Warming Pollutant?

- Brown Carbon adds significant amount to Black Carbon heating
  - The direct warming effect of brown carbon, ignored in most models, offsets about 60% to 90% of the direct cooling effects of other organic carbon aerosols
- Bottom-up emission models, including regional models, underestimate the heating of the atmosphere by Black Carbon and Brown Carbon by a factor of about 3

*Produced in lower temperature smoldering combustion from fuel containing biomass and likely from secondary organics from fossil fuels (*polycyclic aromatics, tarballs, organonitrates, and likely many others)*

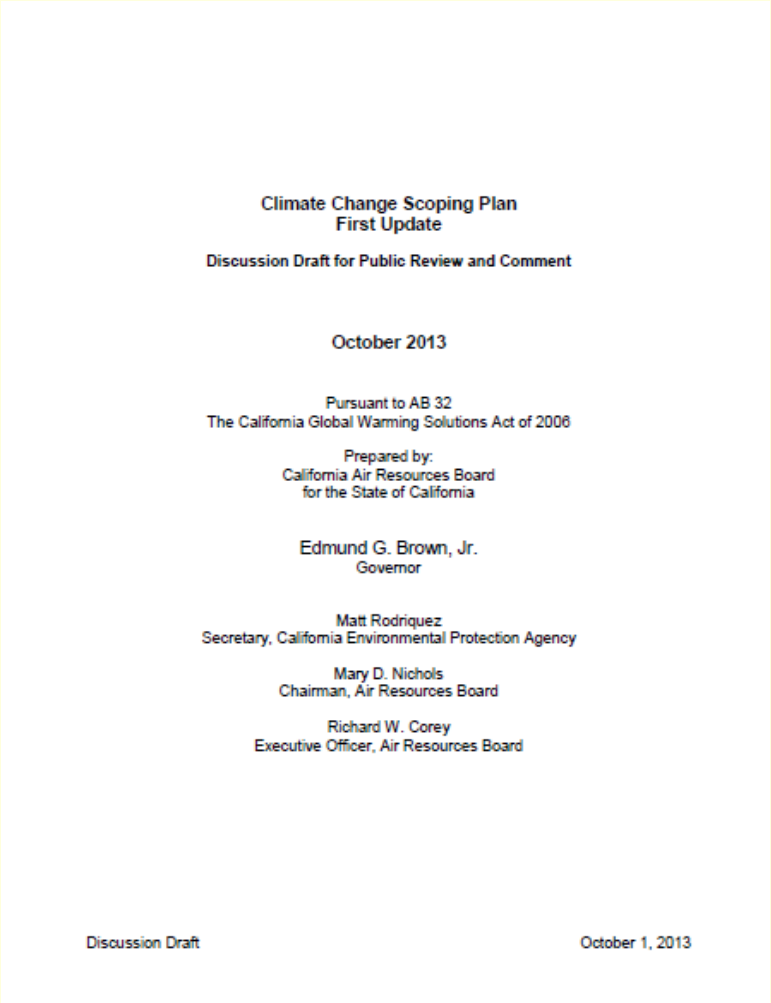
Co-Benefit of Diesel Black Carbon Reduction to Climate Change Mitigation

California's CO_2 emissions (2009): 393 MMT/yr

- Black carbon contributes to both air pollution health and climate change problems
- California diesel control program effective in reducing black carbon
  - 90% reduction observed over past 45 years
  - 95% control expected by 2020
- California diesel control program provided significant climate co-benefits
  - 21-50 MMTCO2e/year in 2008 (compared to 1989)

Going forward on short-lived climate forcers

- ARB is taking additional action
- Exploring additional emission reductions prior to 2020
- Short-lived climate pollution strategy by 2016
  - Inventories
  - Sources and emissions
  - Research needs
  - Plan for control measures



Climate Change Scoping Plan
First Update

Discussion Draft for Public Review and Comment

October 2013

Pursuant to AB 32
The California Global Warming Solutions Act of 2006

Prepared by:
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Discussion Draft October 1, 2013