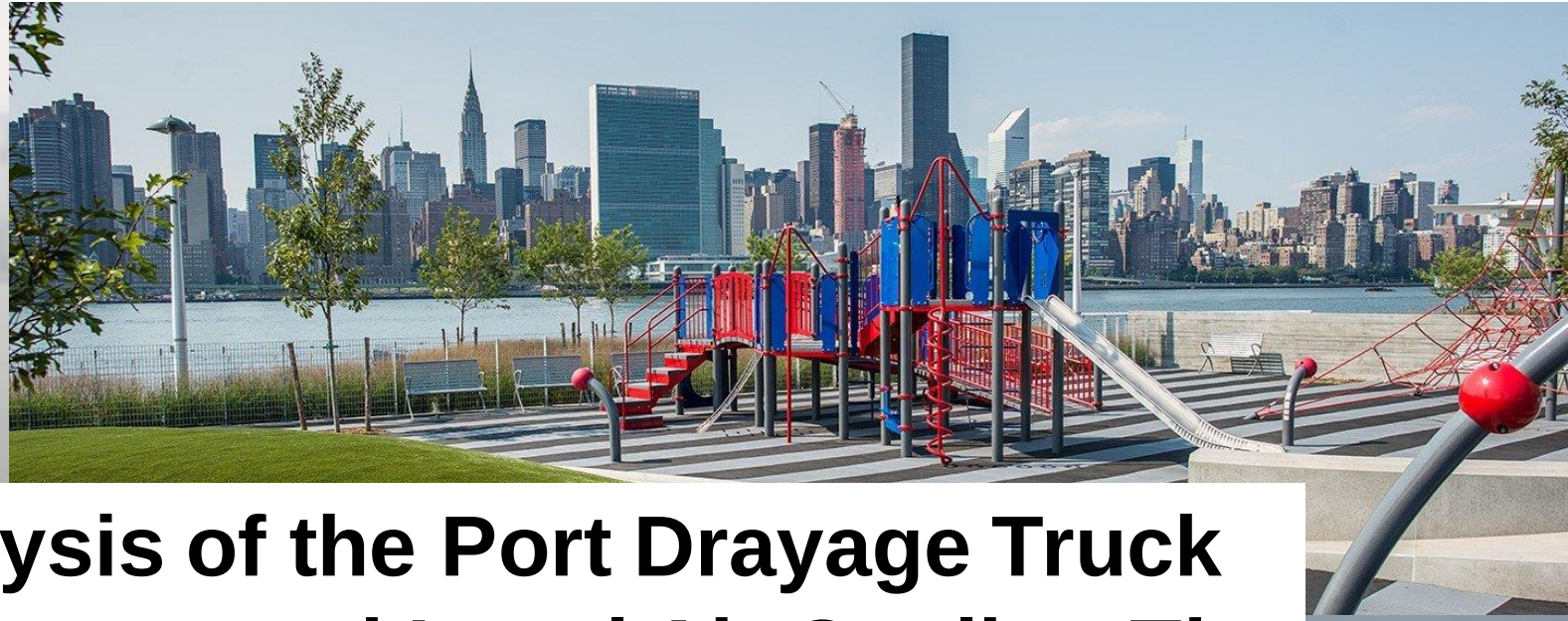
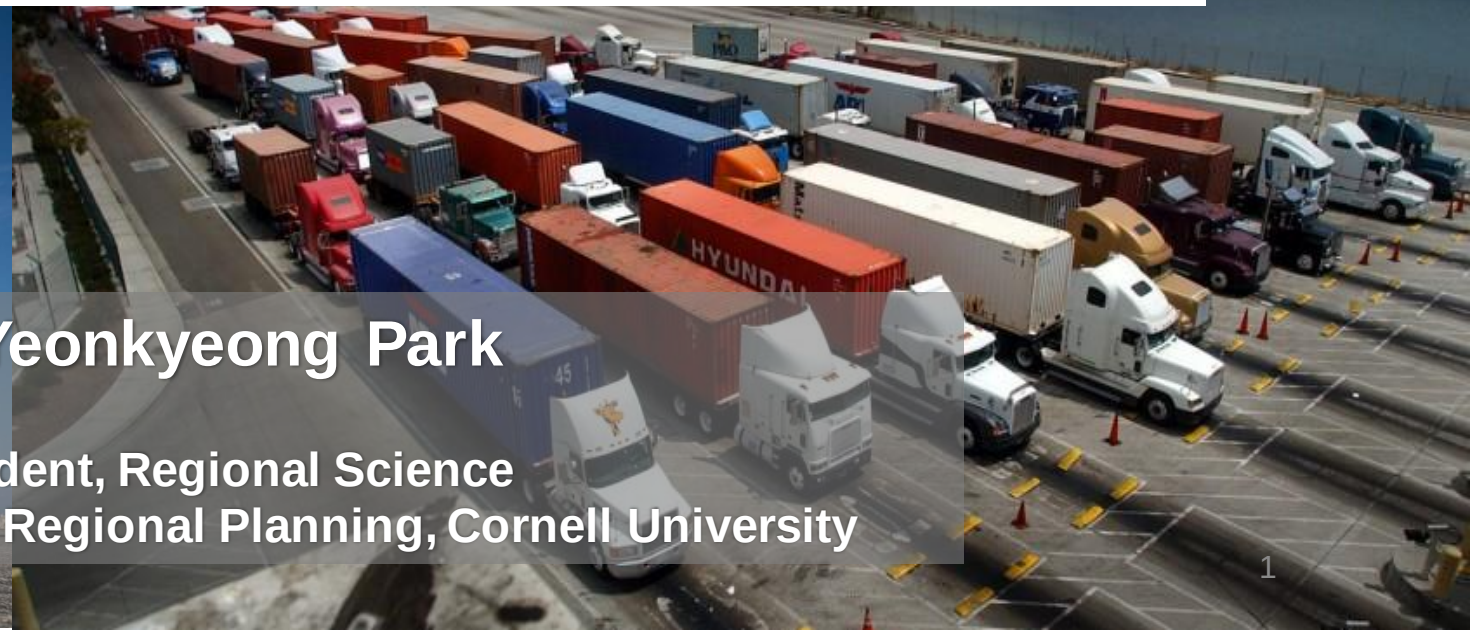


Emissions Analysis of the Port Drayage Truck Replacement Program and Local Air Quality: The case of the Port of New York and New Jersey



Gina Yeonkyeong Park

PhD Student, Regional Science
Department of City and Regional Planning, Cornell University

Research Design

- RQ: How worthy Truck Replacement Program is?
- Method: Emissions calculation
- Result: Local air quality impact assessment
- Policy implication: Cost-Benefit analysis

Background

amazon

- Ports and Air Pollution:

- Ports transport 80% global trade volume, Emitting 10 -15 % SOx and NOx

- Global Supply Chain & Int'l Trade ↑

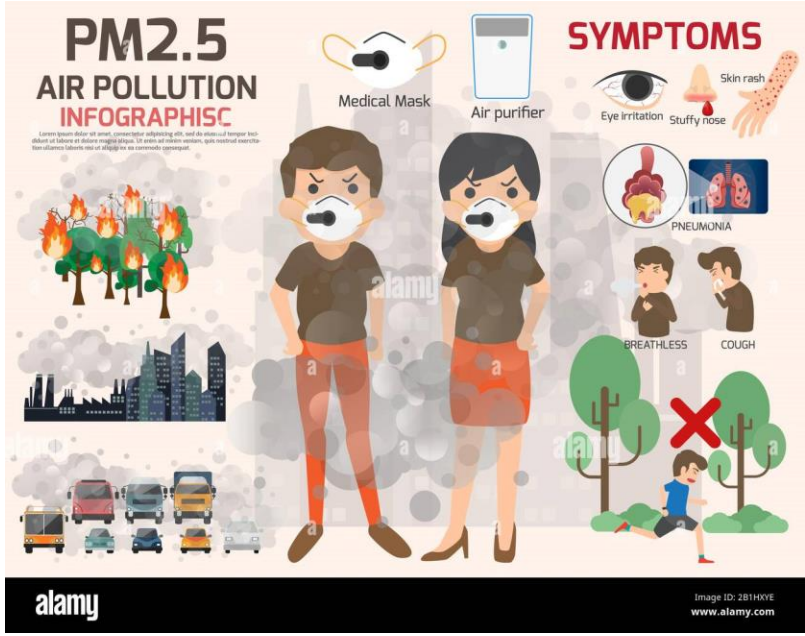
=> <u>Global goods movement is increasing the "local" environmental burden!</u>

Why important?

-> Reduces “**Local**” Air Pollution

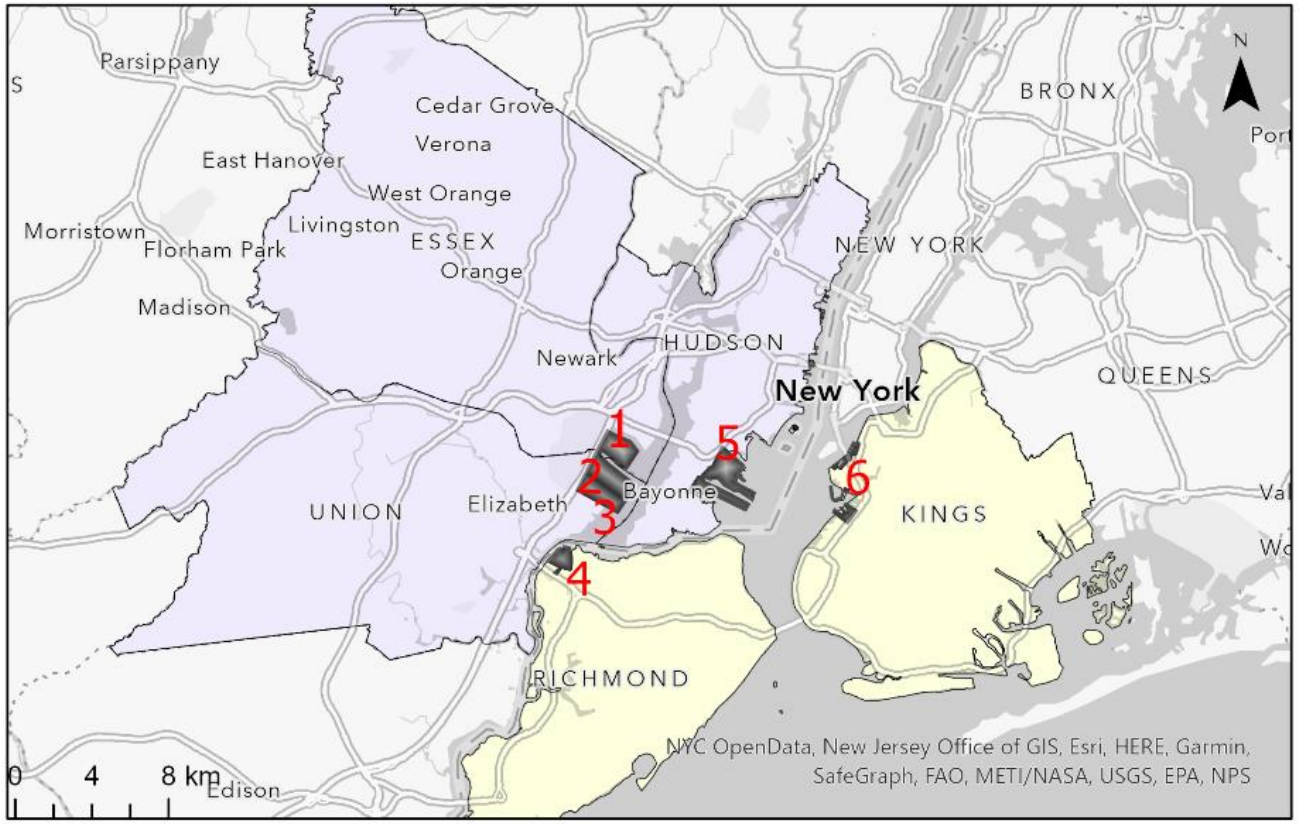
- Diesel engines

->NOx, $PM_{2.5}$ ↑



->Chronic Respiratory Diseases & Mortality Hazards ↑

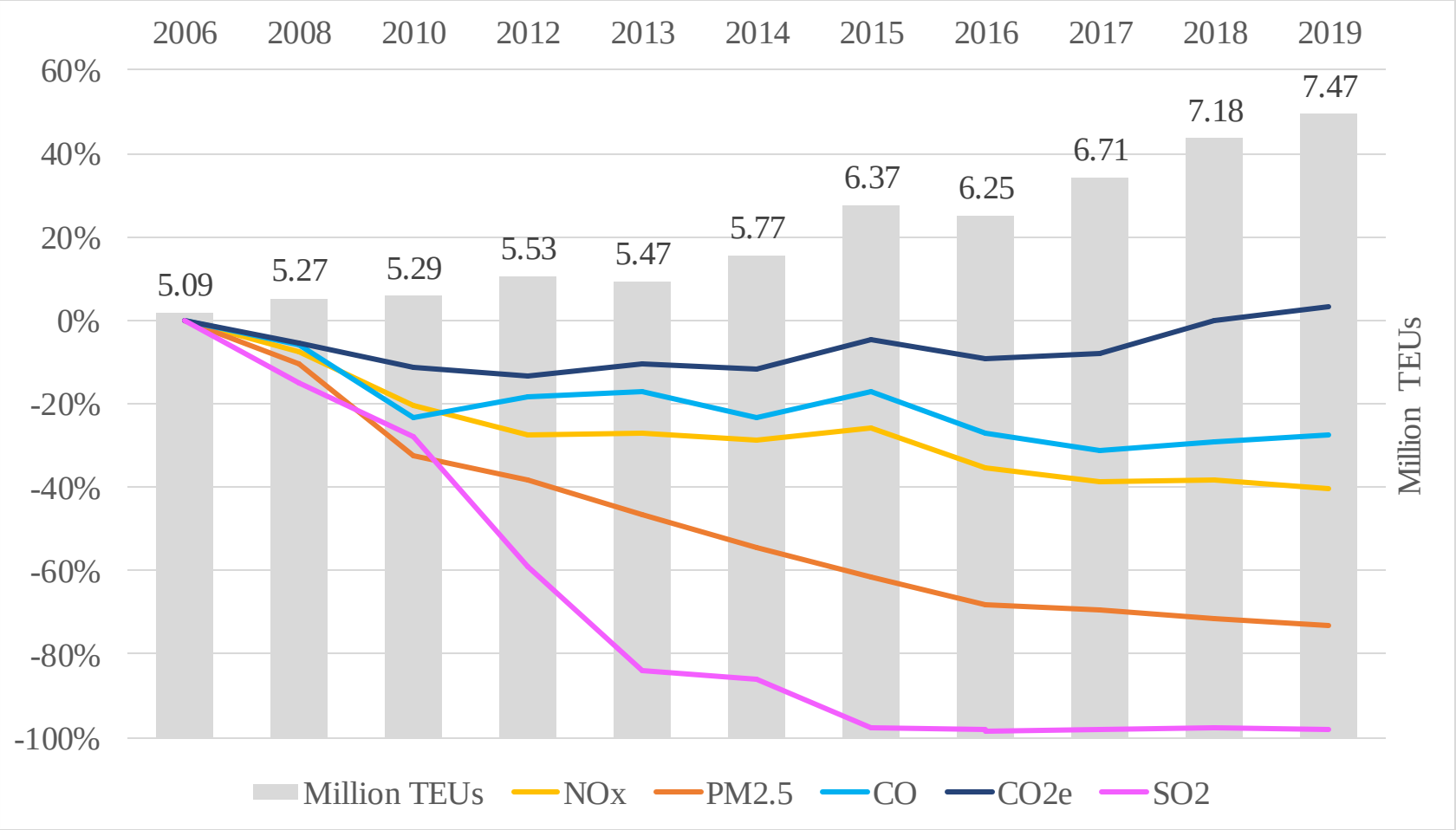
Study Area – **Port of New York and New Jersey (PANYNJ)**



PANYNJ Container Terminals
New Jersey
New York

1. Port Newark Container Terminal (Port Newark)
2. Elizabeth Maher Terminal (Elizabeth Port Authority)
3. APM Terminal (Elizabeth Port Authority)
4. Global Container Terminal (Howland Hook Marine Terminal)
5. Global Terminal Bayonne (Port Jersey)
6. Red Hook Container Terminal (Port Newark)

Emissions vs. Throughput



Source: Modified by author based on (Starcrest Consulting Group, LLC 2017, 2020)
Note: Year 2007 and 2009 are missing from the dataset.

What is Port Truck Replacement Program?

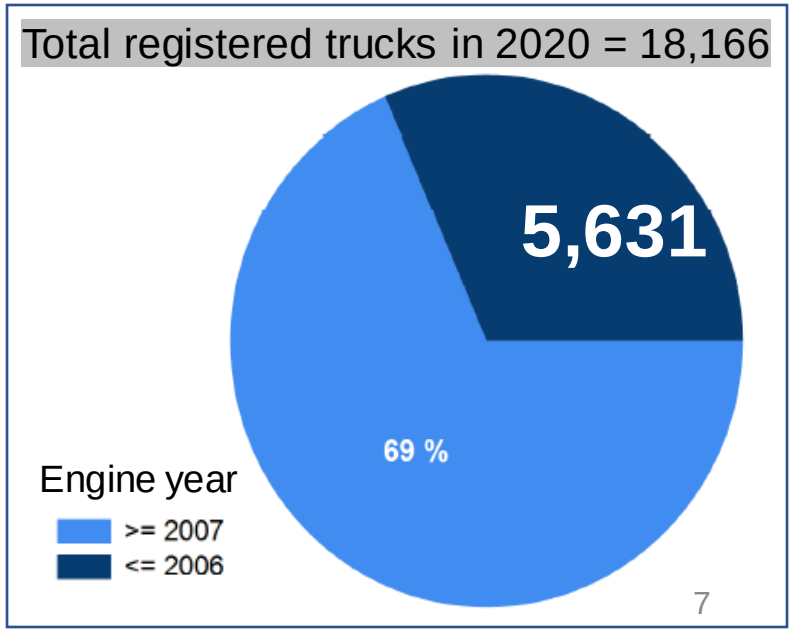
Voluntary subsidy program to replace **old (<=2006 engine)** port drayage diesel trucks

Phase	Period of time	Unit of Trucks	DERA Grant
1st	2010 – 2013 (4 years)	429	$8.57 million
2nd	2015 ~ 2020* (6 years)	418	$8.84 million

Source: Number of replaced trucks (Liou 2020), amount of grant (Leavitt 2010; US EPA 2019)
Note (*): The 2nd phase is ongoing, the record represents as of December 17th, 2020.

Total # of replaced trucks: 847

(as of December 2020)



Truck Emissions are 2nd only to Ships

Port of New York and New Jersey annual emissions in 2019

2019 (in tons/year)	NOx	$PM_{2.5}$	CO	SO_2	CO_2
Ocean-Going Vessels	2,439 (**46%**)	48 (27%)	244 (19%)	82.4 (**95%**)	176,046 (**25%**)
Harbor Craft	345 (6%)	12 (7%)	104 (8%)	0.2 (0.2%)	24,946 (4%)
Cargo Handling Equipment	483 (9%)	32 (18%)	381 (**30%**)	1 (1%)	132,966 (19%)
Locomotives	321 (6%)	11 (6%)	70 (6%)	0.3 (0.3%)	26,335 (4%)
Heavy-Duty Diesel Trucks	1,723 (**32%**)	77 (**43%**)	469 (**37%**)	2.9 (3%)	348,776 (**49%**)
Total	5,311	180	1,268	86.8	709,069

Source: Modified by author based on (Starcrest Consulting Group, LLC 2020)

Data

- Port Emission Inventory 2019
- Port Truck Pass Reports PANYNJ 03.2020 – 11.2020

Method: EPA MOVES Emission Estimation Framework

$$\boldsymbol{Emissions = Emission\ Factors * Activity}$$

$$\textbf{Idling Emissions}\left(\frac{\boldsymbol{tons}}{\boldsymbol{year}}\right) =$$

$$\frac{\boldsymbol{\#\ of\ trucks \times total\ idling\ time\ (hrs/yr)\ \times\ emission\ factor\ (g/miles)}}{\boldsymbol{453.59\ g/lb\ \times\ 2000\ lb/ton}}$$

Result:
TRP annually reduces NOx (12.8% ↓), $PM_{2.5}$ (1.6% ↓)

Total PANYNJ Terminal Emissions Ratio (tons/year)

Activity Component	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	SO_2	CO_2e
On-Terminal Driving	80	5	5	6	27	0.16	18,204
On-Terminal Idling	161 (9.3%)	12	11(14.3%)	23	56	0.19	22,925 (6.6%)
On-Road Driving	1,482	67	61	81	386	2.57	307,647
Totals	**1,723**	**84**	**77**	**110**	**469**	**2.92**	**348,776**

	Total on-terminal idling emission by replaced trucks (tpy)	Total HDDV emissions from the TRP (69 units)	Total HDDV emissions from the TRP (847 units)	Total HDDV emissions from the rest of the old trucks (5631 units)	Potential reduction impact on the Total Port Emissions
NOx	0.11	1.21	14.8	98.5 tons	12.8 %
$PM_{2.5}$	0.01	0.06	0.8	5.2 tons	1.6 %

Translating emissions to the local air quality impact:
C-PORT Model (Community Model for Near-PORT Applications)

1. **<u>Emission Sources</u>**
   (Area – Port Terminals,
   Point – Large Industrial Sources on Terminals,
   Line – Railroad, Roads, Ships in transit)

2. **<u>Atmospheric Conditions</u>**
   (Weather, Wind, Season, etc. – annual average value taken from the nearest Met station ▼)

3. **<u>Background Pollutant Concentration</u>** included at NOx 15.9 ppb taken from the nearest monitoring station ●

Modifying Port Terminal Baseline NO_x (× 0.872) $PM_{2.5}$ (× 0.984)

Reduction Impact: 12.8 %, 1.6% ↓

Pre-TRP

View and modify area sources

All emissions values given in tons/year.

Select all sources | Add new source | Load new sources

Facility	Type	NO_x	CO	SO_2
Port of NY/NJ - Elizabeth Port Authority Marine Terminal	Terminal	1078.	220.6	15.84
Port of NY/NJ - Global Marine Terminal	Terminal	1,120.3839	229.2388	16.4583
Port of NY/NJ - Howland Hook Marine Terminal	Terminal	239.0903	48.9196	3.5122
Port of NY/NJ - NS - E-rail Intermodal Terminal	Railyard	0	0	0
Port of NY/NJ - Port Newark	Terminal	919.0477	188.0439	13.5007

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Post-TRP

View and modify area sources

All emissions values given in tons/year.

Select all sources | Add new source | Load new sources

Facility	Type	NO_x	CO	SO_2	$PM_{2.5}$	$EC_{2.5}$	$OC_{2.5}$	PM_{10}	Benz	Form	Acetald	Acro
Port of NY/NJ - CSX - North & South Kearny	Railyard	0	0	0	0	0	0	0	0	0	0	0
Port of NY/NJ - Elizabeth Port Authority Marine Terminal	Terminal	940.3300	220.6404	15.8409	33.3445	26.1346	5.9659	0	0.4878	7.1591e-4	0	0.0687
Port of NY/NJ - Global Marine Terminal	Terminal	976.9748	229.2388	16.4583	34.6439	27.1530	6.1984	0	0.5068	7.4381e-4	0	0.0713
Port of NY/NJ - Howland Hook Marine Terminal	Terminal	208.4867	48.9196	3.5122	7.3930	5.7945	1.3227	0	0.1082	1.5873e-4	0	0.0152
Port of NY/NJ - Manhattan Cruise Terminal	Terminal	15.8931	3.7292	0.2677	0.5636	0.4417	0.1008	0	8.2451e-3	1.2100e-5	0	1.1603e-3

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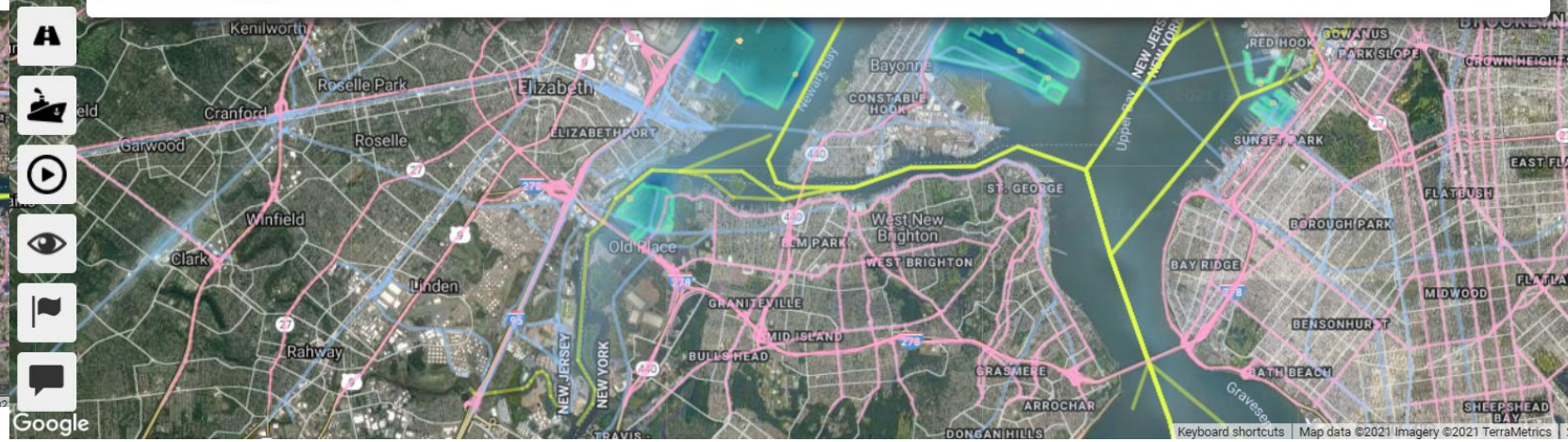
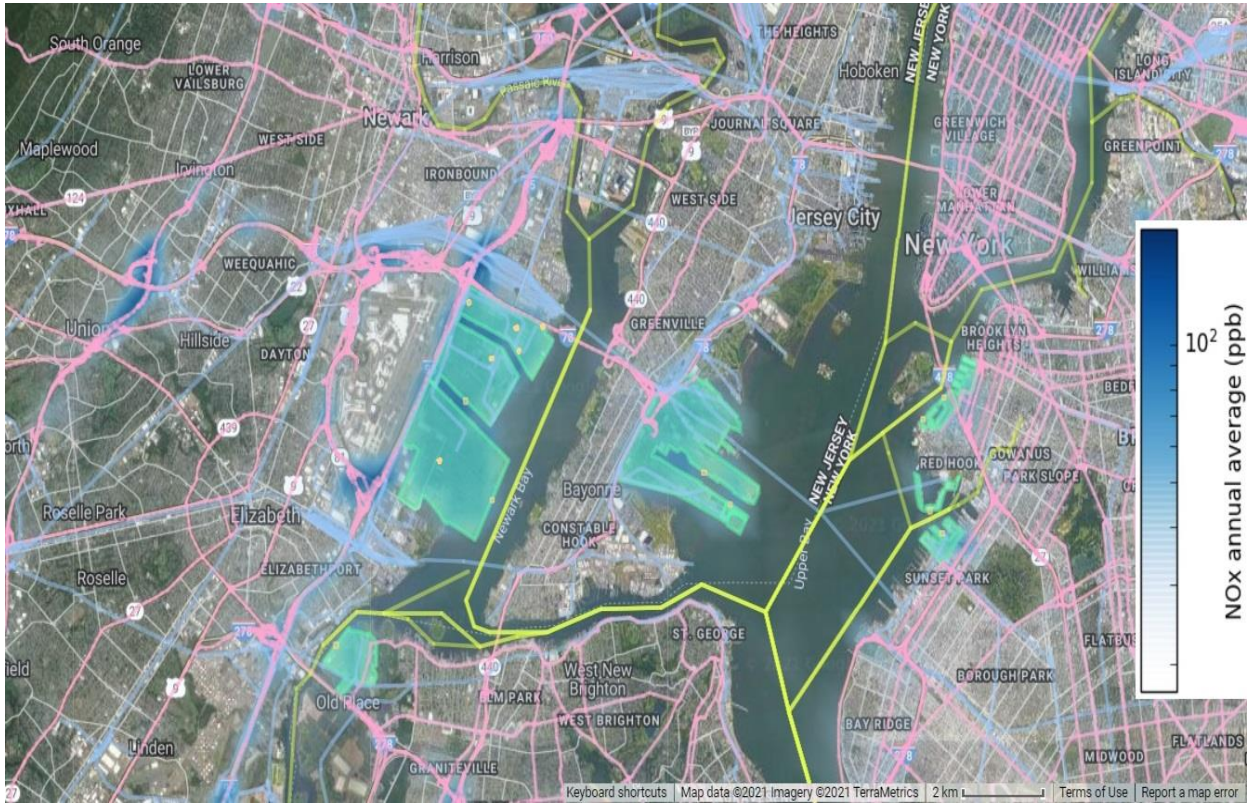


Less pollution farther away from the immediate local neighborhoods

=> Vulnerable Groups?

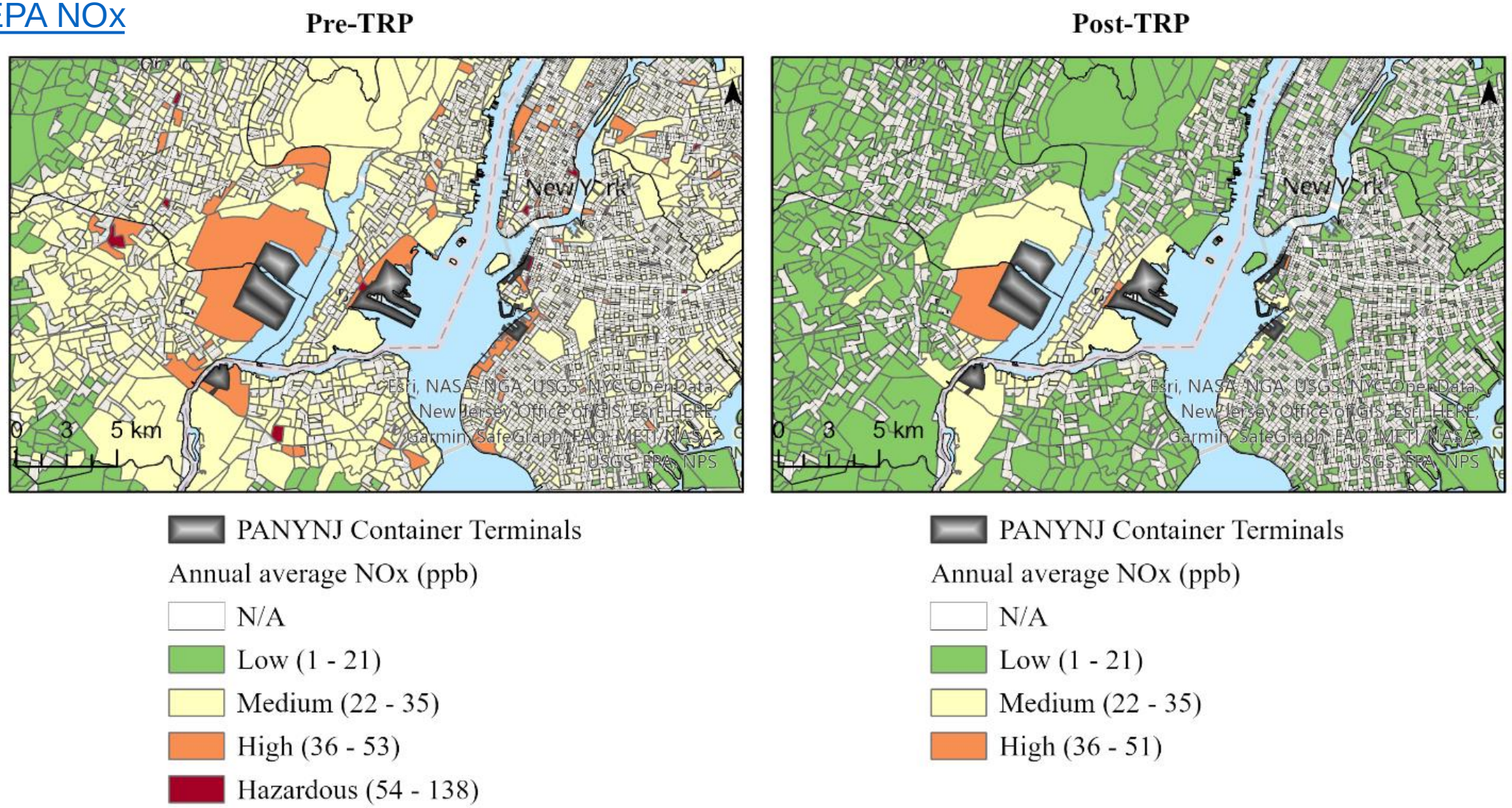
Pre-TRP



Post-TRP

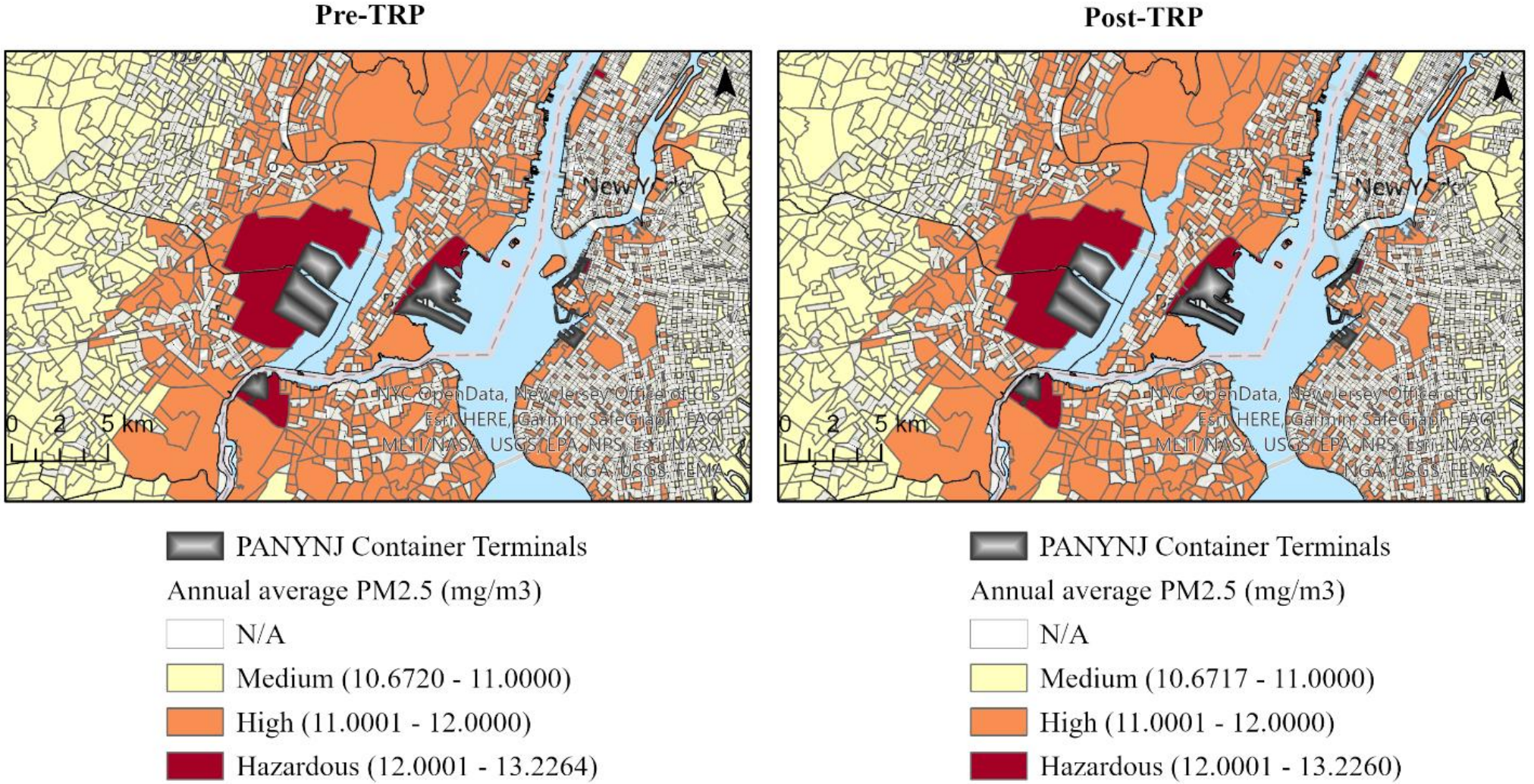
"NOx is much lower for near-port populations"

NOx Hazardous Zone (>= 53 ppb) by [EPA NOx standard (1999)]

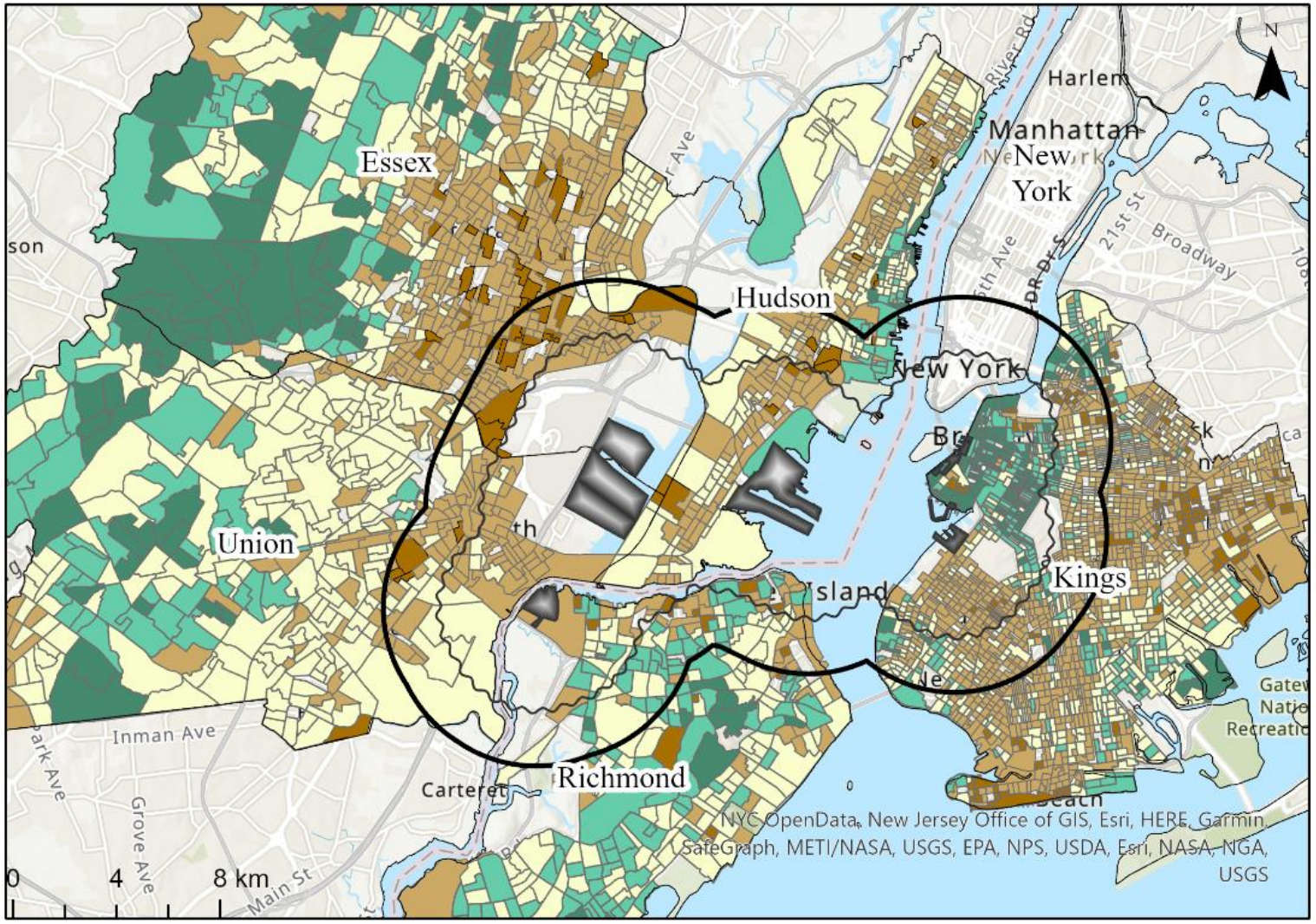


Source: Author's illustration

Less impact in terms of $PM_{2.5}$



Source: Author's illustration



PANYNJ Container Terminals

5km from Port Terminals

3km from Port Terminals

Median Houshold Income (2019)

Poverty level $8,661 - 26,172

Under median level $26,173 - 68,703

$68,704 - 97,841

$97,842 - 139,185

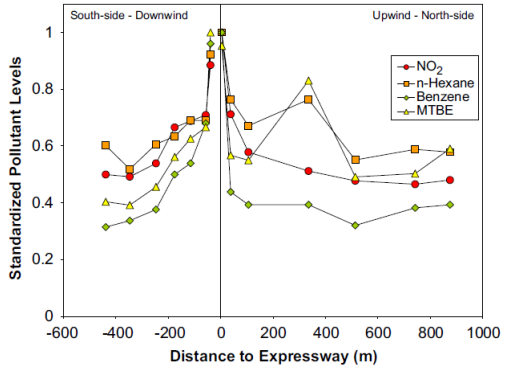
$139,186 - 250,001

Policy Implications

"Lower-income group could benefit from cleaner air"

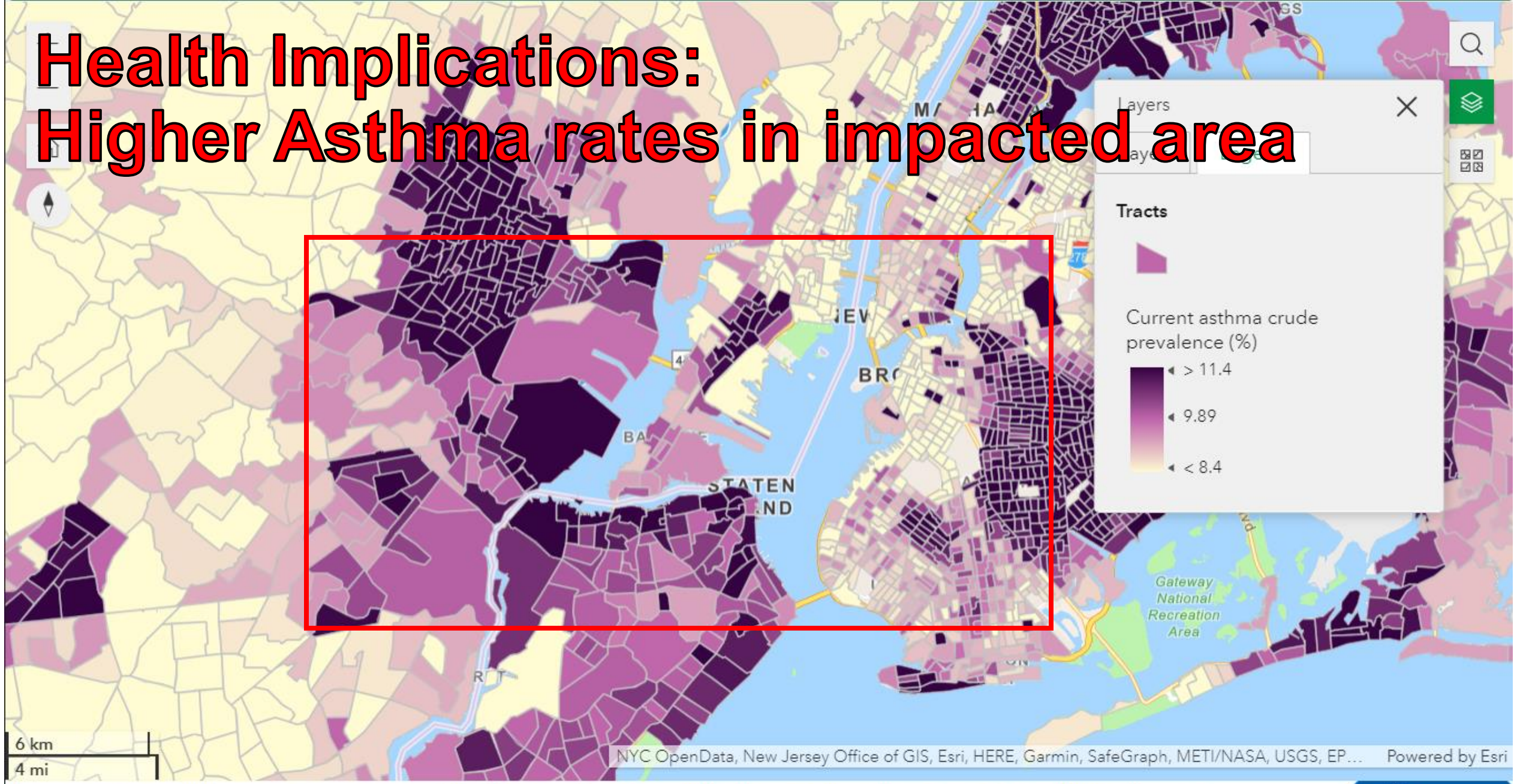
(<= $68,703 median Income ACS 2019)

NOx decreases by distance



Source: Beckerman et al. (2008)

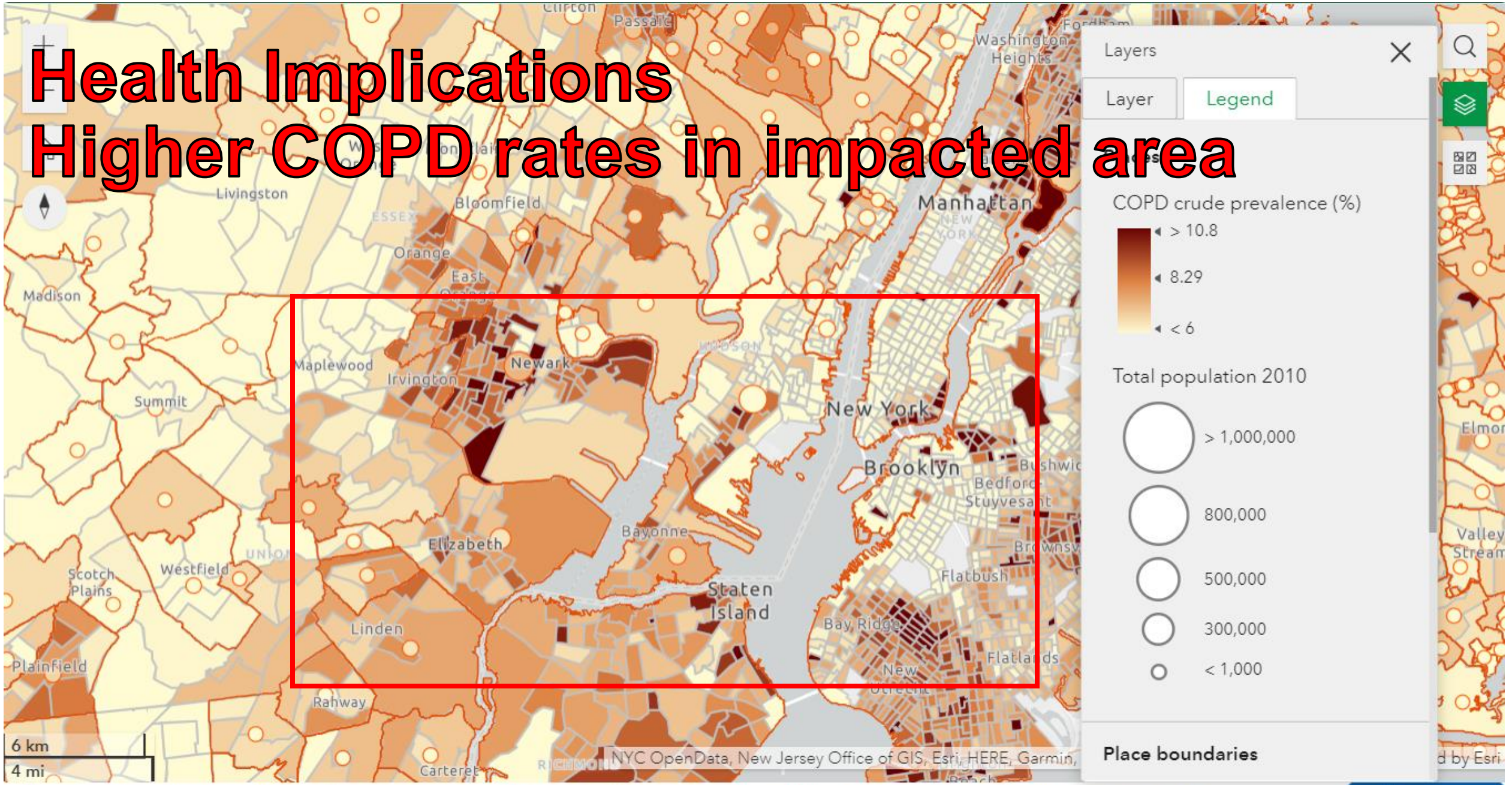
Health Implications:
Higher Asthma rates in impacted area



Data sources: The model-based estimates were generated using BRFSS 2018 or 2017, Census 2010 population counts or census county population estimates of 2018 or 2017, and ACS 2014-2018 or ACS 2013-2017.

Credit: Centers for Disease Control and Prevention, National Center for Chronic Disease and Health Promotion, Division of Population Health, Atlanta, GA

Health Implications
Higher COPD rates in impacted area



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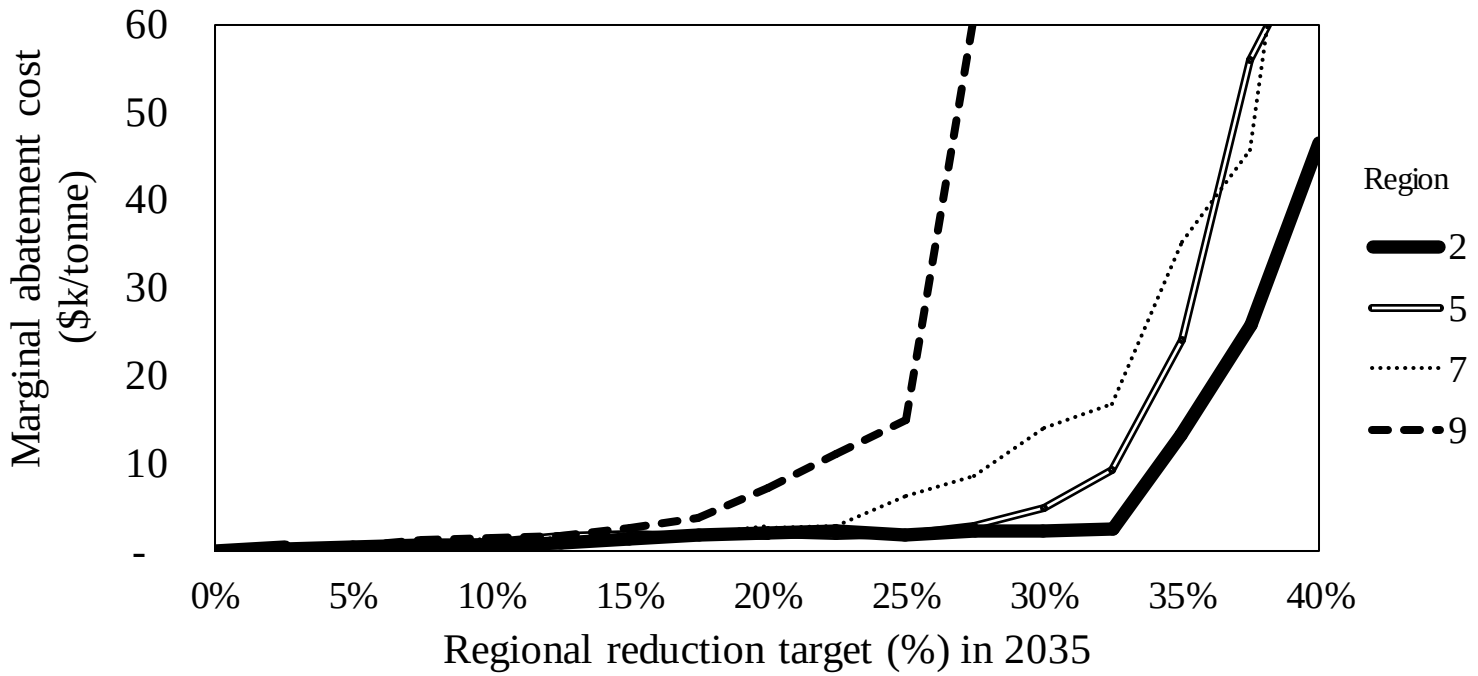
Credit: Centers for Disease Control and Prevention, National Center for Chronic Disease and Health Promotion, Division of Population Health, Atlanta, GA

Benefit-Cost Perspective: Net benefit, possibly?

	Benefit	Cost	
		-$1.6 million	Total Direct Investment (DERA grant, 2010-2020) $17.41 million
Asthma/COPD prevalence rates could potentially reduce (Annual per-person medical cost of asthma was $3,266 (2015 base, ATS 2018) x 23,248 = $75 million	+$75 million	-$ 9.6million	Premature mortality will increase by over 25 in a million in some areas. (Rowangould et al. 2018) In terms of value of statistical life, 1.000025 x VSL $9.6 million (2015 base, USDOT) = $ 9.60024 million
		-$81,164	Marginal abatement cost for NOx
		?	Possibly delaying transition to adopt alternative fuel, electrification

Regional Marginal Cost of NOx Reduction



Marginal Abatement Cost for NOx $81,164
(= $0.824 k/ton × 98.5 ton)

Note: Regions where the major container port terminals are located are selectively chosen for better comparison among the contiguous U.S. regions.
Region 2 (Middle Atlantic: NY, NJ, PA), Region 5 (South Atlantic: DE, DC, FL, GA, MD, NC, SC, VA, WV), Region 7 (West South Central: AR, LA, OK, TX), Region 9 (Pacific: AK, CA, HI, OR, WA)

Source: Modified by author based on (Loughlin et al. 2017)

Highlights

- If all eligible trucks are replaced: Annual NOx emissions reductions of 12.8 % (98.5 tons), $PM_{2.5}$ by 1.6 % (5.2 tons).
- PANYNJ Port Drayage Truck Replacement Program (TRP) could potentially contribute to improving the local NOx level by maximum 63 percent lower, below 53 ppb, which is the hazardous level of to human health.
- Most population living within the 5km-distance from the port container terminals are the vulnerable populations at the lower income level, and particularly those below the poverty line are located a lot more on the New Jersey side of the port terminals than that of New York.
- It can be inferred that the near-port populations include the lower income populations, with higher asthma prevalence rates and COPD rates and the lower NOx area after TRP implementation.
- Overall, considering the marginal benefits, costs, and time, TRP remains potentially the most affordable and practical interim policy to immediately reduce the local emissions among other alternative fuel options.

Thank you!

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Full paper available at:

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Emissions analysis of the Port Drayage Truck Replacement Program and local air quality: The case of the Port of New York and New Jersey

Gina Yeonkyeong Park

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Method: Idling Emissions Calculation

$$\text{Idling Emissions}\left(\frac{\boldsymbol{tons}}{\boldsymbol{year}}\right) = \frac{\overset{1}{\#\ of\ trucks} \times \overset{2}{total\ idling\ time\ (hours/year)} \times \overset{3}{emission\ factor\ (g/miles)}}{453.59\ g/lb \times 2000\ lb/ton}$$

1. No. of Trucks

Sources: Author's Estimation (*) and Truck Reports by Port Authority of New York and New Jersey (PANYNJ)

	Average number of annual total trucks	Average truck visits (per truck by model years)	Total number of annual truck visits	**2. Total Idling Time (hrs)**
All models	195,099*	26.5	5,170,130	2,403,338
Replaced	69*	28.9	1994.1*	1934.3*

- Total idling hours = average idle time × total truck visits
- Total truck visits = average truck visits × total number of truck units
- Average truck visits = average truck visits per engine model years (03.2020 – 11. 2020)
- Average idle time per each visit: 0.97

3. Emissions factor (g/hr):

Operation	NOx	$PM_{2.5}$	CO_2
Short-Term Idle (g/hr)	52.9	4.281	8,598