Preliminary Results - Updated February 25, 2021

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TRECH PROJECT

TRANSPORTATION, EQUITY, CLIMATE & HEALTH

BOSTON UNIVERSITY

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

C-CHANGE CENTER FOR CLIMATE, HEALTH, AND THE GLOBAL ENVIRONMENT

UNC INSTITUTE FOR THE ENVIRONMENT

Columbia University MAILMAN SCHOOL OF PUBLIC HEALTH

TRECH Project Technical Appendix

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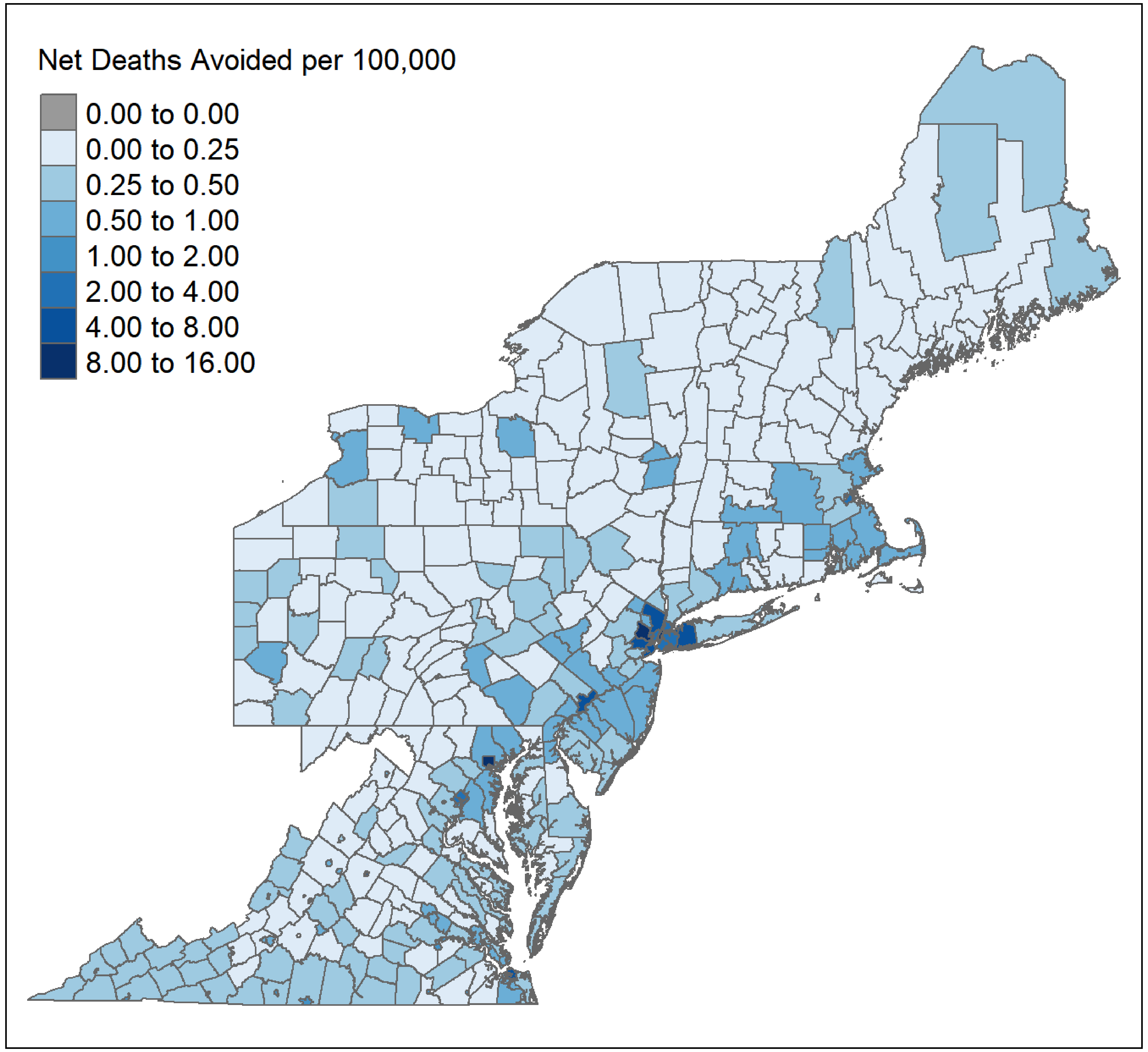
1. State-level Health Benefits – Cases and Monetized values

State	Health Outcome in 2032	Scenario A 25% GHG Cap	Scenario B 25% GHG Cap	Scenario C 25% GHG Cap	Scenario B 22% GHG Cap	Scenario B 20% GHG Cap
Connecticut	Deaths Avoided from Active Mobility	8.9 (5.8 - 12)	7.4 (4.8 - 10)	5.4 (3.2 - 7.5)	3.7 (2.4 - 5)	1.9 (1.2 - 2.5)
Connecticut	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.76	0.65	0.49	0.33	0.16
Connecticut	Deaths Avoided from Improved Air Quality	25 (14 - 37)	23 (14 - 34)	20 (12 - 29)	11 (6.9 - 17)	5.6 (3.5 - 8.2)
Connecticut	Respiratory Hospitalizations Avoided	2.5 (0.94 - 4)	2.2 (0.86 - 3.6)	1.9 (0.73 - 3)	1.1 (0.42 - 1.7)	0.53 (0.21 - 0.86)
Connecticut	Childhood Asthma Incidences Avoided	8.6 (3.4 - 13)	8 (3.1 - 12)	6.9 (2.6 - 10)	4 (1.5 - 5.8)	2 (0.75 - 2.9)
Connecticut	Childhood Asthma Exacerbations Avoided	2,300 (55 - 4,600)	2,000 (46 - 4,000)	1,600 (36 - 3,200)	980 (22 - 1,900)	480 (11 - 960)
Connecticut	Value of Active Mobility Health Benefits	$93,000,000 ($43,000,000 - $140,000,000)	$77,000,000 ($36,000,000 - $120,000,000)	$56,000,000 ($24,000,000 - $88,000,000)	$39,000,000 ($18,000,000 - $60,000,000)	$19,000,000 ($8,900,000 - $30,000,000)
Connecticut	Added Value of Active Mobility Safety in Numbers Effect	$7,300,000 ($7,300,000 - $7,300,000)	$6,300,000 ($6,300,000 - $6,300,000)	$4,700,000 ($4,700,000 - $4,700,000)	$3,100,000 ($3,100,000 - $3,100,000)	$1,600,000 ($1,600,000 - $1,600,000)
Connecticut	Value of Air Quality Health Benefits	$260,000,000 ($86,000,000 - $540,000,000)	$240,000,000 ($86,000,000 - $500,000,000)	$210,000,000 ($74,000,000 - $420,000,000)	$110,000,000 ($42,000,000 - $250,000,000)	$58,000,000 ($22,000,000 - $120,000,000)
Connecticut	Total Value of Health Benefits	$360,000,000 ($140,000,000 - $690,000,000)	$320,000,000 ($130,000,000 - $620,000,000)	$270,000,000 ($100,000,000 - $520,000,000)	$160,000,000 ($63,000,000 - $310,000,000)	$79,000,000 ($32,000,000 - $150,000,000)
Delaware	Deaths Avoided from Active Mobility	2.4 (1.6 - 3.3)	2.1 (1.4 - 2.8)	1.5 (0.93 - 2.1)	1 (0.66 - 1.4)	0.51 (0.33 - 0.68)
Delaware	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.16	0.14	0.11	0.07	0.035
Delaware	Deaths Avoided from Improved Air Quality	6.6 (4 - 9.8)	5.9 (3.7 - 8.6)	4.8 (3.1 - 6.9)	2.9 (1.8 - 4.1)	1.4 (0.89 - 2)
Delaware	Respiratory Hospitalizations Avoided	0.67 (0.26 - 1.1)	0.58 (0.23 - 0.93)	0.46 (0.18 - 0.74)	0.28 (0.11 - 0.45)	0.14 (0.054 - 0.22)
Delaware	Childhood Asthma Incidences Avoided	2.3 (0.87 - 3.3)	2 (0.77 - 3)	1.6 (0.62 - 2.4)	0.98 (0.37 - 1.5)	0.48 (0.18 - 0.71)
Delaware	Childhood Asthma Exacerbations Avoided	440 (10 - 870)	360 (8.1 - 720)	280 (6 - 550)	170 (3.9 - 340)	84 (1.9 - 170)
Delaware	Value of Active Mobility Health Benefits	$25,000,000 ($11,000,000 - $39,000,000)	$21,000,000 ($9,600,000 - $33,000,000)	$16,000,000 ($6,700,000 - $25,000,000)	$10,000,000 ($4,700,000 - $16,000,000)	$5,200,000 ($2,300,000 - $8,000,000)
Delaware	Added Value of Active Mobility Safety in Numbers Effect	$1,600,000 ($1,600,000 - $1,600,000)	$1,400,000 ($1,400,000 - $1,400,000)	$1,000,000 ($1,000,000 - $1,000,000)	$670,000 ($670,000 - $670,000)	$330,000 ($330,000 - $330,000)
Delaware	Value of Air Quality Health Benefits	$68,000,000 ($25,000,000 - $140,000,000)	$61,000,000 ($23,000,000 - $130,000,000)	$50,000,000 ($19,000,000 - $100,000,000)	$30,000,000 ($11,000,000 - $60,000,000)	$14,000,000 ($5,500,000 - $29,000,000)
Delaware	Total Value of Health Benefits	$95,000,000 ($38,000,000 - $180,000,000)	$83,000,000 ($34,000,000 - $160,000,000)	$66,000,000 ($27,000,000 - $130,000,000)	$41,000,000 ($16,000,000 - $77,000,000)	$20,000,000 ($8,200,000 - $38,000,000)
District of Columbia	Deaths Avoided from Active Mobility	17 (11 - 23)	14 (9.4 - 18)	9.7 (6.1 - 13)	10 (6.8 - 13)	5 (3.4 - 6.7)
District of Columbia	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.89	0.73	0.53	0.54	0.27
District of Columbia	Deaths Avoided from Improved Air Quality	9.8 (5.9 - 14)	8.7 (5.4 - 12)	7 (4.5 - 9.8)	4.1 (2.6 - 5.8)	2 (1.3 - 2.9)
District of Columbia	Respiratory Hospitalizations Avoided	0.35 (0.15 - 0.56)	0.32 (0.13 - 0.5)	0.26 (0.11 - 0.41)	0.15 (0.065 - 0.24)	0.076 (0.032 - 0.12)
District of Columbia	Childhood Asthma Incidences Avoided	2.9 (1.1 - 4.2)	2.5 (0.96 - 3.7)	2 (0.76 - 3)	1.2 (0.46 - 1.8)	0.59 (0.22 - 0.87)
District of Columbia	Childhood Asthma Exacerbations Avoided	1,100 (26 - 2,200)	920 (21 - 1,800)	700 (16 - 1,400)	430 (9.8 - 860)	210 (4.8 - 420)
District of Columbia	Value of Active Mobility Health Benefits	$170,000,000 ($77,000,000 - $260,000,000)	$140,000,000 ($64,000,000 - $210,000,000)	$99,000,000 ($42,000,000 - $160,000,000)	$100,000,000 ($47,000,000 - $160,000,000)	$51,000,000 ($23,000,000 - $79,000,000)
District of Columbia	Added Value of Active Mobility Safety in Numbers Effect	$8,500,000 ($8,500,000 - $8,500,000)	$7,100,000 ($7,100,000 - $7,100,000)	$5,100,000 ($5,100,000 - $5,100,000)	$5,200,000 ($5,200,000 - $5,200,000)	$2,600,000 ($2,600,000 - $2,600,000)
District of Columbia	Value of Air Quality Health Benefits	$100,000,000 ($36,000,000 - $200,000,000)	$90,000,000 ($33,000,000 - $180,000,000)	$72,000,000 ($28,000,000 - $140,000,000)	$42,000,000 ($16,000,000 - $85,000,000)	$21,000,000 ($8,000,000 - $42,000,000)
District of Columbia	Total Value of Health Benefits	$280,000,000 ($120,000,000 - $480,000,000)	$240,000,000 ($100,000,000 - $400,000,000)	$180,000,000 ($75,000,000 - $300,000,000)	$150,000,000 ($68,000,000 - $250,000,000)	$74,000,000 ($34,000,000 - $120,000,000)
Maine	Deaths Avoided from Active Mobility	1.7 (1 - 2.4)	1.2 (0.78 - 1.6)	0.63 (0.38 - 0.87)	0.47 (0.31 - 0.64)	0.24 (0.15 - 0.32)
Maine	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.11	0.08	0.046	0.032	0.016
Maine	Deaths Avoided from Improved Air Quality	3.1 (1.9 - 4.8)	3 (1.9 - 4.6)	2.7 (1.7 - 3.9)	1.5 (0.93 - 2.2)	0.75 (0.47 - 1.1)
Maine	Respiratory Hospitalizations Avoided	0.49 (0.18 - 0.79)	0.44 (0.17 - 0.72)	0.37 (0.14 - 0.61)	0.21 (0.082 - 0.35)	0.11 (0.041 - 0.17)
Maine	Childhood Asthma Incidences Avoided	0.76 (0.29 - 1.1)	0.74 (0.28 - 1.1)	0.66 (0.25 - 0.99)	0.36 (0.14 - 0.54)	0.18 (0.069 - 0.27)
Maine	Childhood Asthma Exacerbations Avoided	160 (3.8 - 320)	150 (3.3 - 290)	120 (2.7 - 250)	72 (1.6 - 140)	36 (0.78 - 71)
Maine	Value of Active Mobility Health Benefits	$17,000,000 ($7,400,000 - $27,000,000)	$12,000,000 ($5,500,000 - $18,000,000)	$6,400,000 ($2,800,000 - $10,000,000)	$4,900,000 ($2,200,000 - $7,500,000)	$2,400,000 ($1,100,000 - $3,800,000)
Maine	Added Value of Active Mobility Safety in Numbers Effect	$1,100,000 ($1,100,000 - $1,100,000)	$770,000 ($770,000 - $770,000)	$440,000 ($440,000 - $440,000)	$310,000 ($310,000 - $310,000)	$150,000 ($150,000 - $150,000)
Maine	Value of Air Quality Health Benefits	$32,000,000 ($12,000,000 - $70,000,000)	$31,000,000 ($12,000,000 - $67,000,000)	$28,000,000 ($10,000,000 - $57,000,000)	$15,000,000 ($5,700,000 - $32,000,000)	$7,700,000 ($2,900,000 - $16,000,000)
Maine	Total Value of Health Benefits	$50,000,000 ($20,000,000 - $98,000,000)	$44,000,000 ($18,000,000 - $86,000,000)	$35,000,000 ($14,000,000 - $67,000,000)	$21,000,000 ($8,200,000 - $40,000,000)	$10,000,000 ($4,100,000 - $20,000,000)
Maryland	Deaths Avoided from Active Mobility	67 (46 - 88)	60 (40 - 80)	45 (29 - 62)	31 (21 - 41)	15 (10 - 20)
Maryland	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	2.9	2.6	2	1.3	0.66
Maryland	Deaths Avoided from Improved Air Quality	62 (36 - 90)	53 (32 - 76)	42 (26 - 59)	25 (16 - 36)	12 (7.7 - 18)
Maryland	Respiratory Hospitalizations Avoided	3.5 (1.4 - 5.7)	3.1 (1.3 - 5)	2.5 (1 - 4)	1.5 (0.61 - 2.4)	0.74 (0.3 - 1.2)
Maryland	Childhood Asthma Incidences Avoided	27 (10 - 38)	22 (8.6 - 33)	18 (6.7 - 26)	11 (4.1 - 16)	5.3 (2 - 7.8)
Maryland	Childhood Asthma Exacerbations Avoided	6,800 (160 - 13,000)	5,400 (130 - 11,000)	4,000 (91 - 7,900)	2,600 (59 - 5,100)	1,300 (29 - 2,500)
Maryland	Value of Active Mobility Health Benefits	$670,000,000 ($300,000,000 - $1,000,000,000	$600,000,000 ($270,000,000 - $940,000,000)	$460,000,000 ($190,000,000 - $720,000,000)	$310,000,000 ($140,000,000 - $480,000,000)	$150,000,000 ($69,000,000 - $240,000,000)
Maryland	Added Value of Active Mobility Safety in Numbers Effect	$28,000,000 ($28,000,000 - $28,000,000)	$25,000,000 ($25,000,000 - $25,000,000)	$19,000,000 ($19,000,000 - $19,000,000)	$13,000,000 ($13,000,000 - $13,000,000)	$6,300,000 ($6,300,000 - $6,300,000)
Maryland	Value of Air Quality Health Benefits	$640,000,000 ($220,000,000 - $1,300,000,000	$550,000,000 ($200,000,000 - $1,100,000,000	$430,000,000 ($160,000,000 - $860,000,000)	$260,000,000 ($99,000,000 - $530,000,000)	$120,000,000 ($47,000,000 - $260,000,000)
Maryland	Total Value of Health Benefits	$1,300,000,000 ($550,000,000 - $2,400,000,0	$1,200,000,000 ($490,000,000 - $2,100,000,0	$910,000,000 ($370,000,000 - $1,600,000,000	$580,000,000 ($250,000,000 - $1,000,000,000	$280,000,000 ($120,000,000 - $510,000,000)
Massachusetts	Deaths Avoided from Active Mobility	28 (19 - 38)	24 (15 - 32)	17 (10 - 24)	14 (9.1 - 19)	7 (4.6 - 9.4)
Massachusetts	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	2.5	2.1	1.6	1.3	0.64
Massachusetts	Deaths Avoided from Improved Air Quality	38 (23 - 56)	37 (23 - 54)	33 (21 - 47)	18 (11 - 26)	9 (5.6 - 13)
Massachusetts	Respiratory Hospitalizations Avoided	3.9 (1.5 - 6.3)	3.6 (1.4 - 5.7)	3 (1.2 - 4.8)	1.7 (0.68 - 2.8)	0.85 (0.34 - 1.4)
Massachusetts	Childhood Asthma Incidences Avoided	13 (5 - 19)	13 (4.8 - 19)	11 (4.2 - 17)	6.2 (2.4 - 9.1)	3.1 (1.2 - 4.5)
Massachusetts	Childhood Asthma Exacerbations Avoided	4,200 (99 - 8,400)	3,900 (89 - 7,700)	3,300 (74 - 6,600)	1,900 (43 - 3,700)	930 (21 - 1,900)
Massachusetts	Value of Active Mobility Health Benefits	$300,000,000 ($140,000,000 - $460,000,000)	$250,000,000 ($110,000,000 - $380,000,000)	$180,000,000 ($77,000,000 - $280,000,000)	$150,000,000 ($68,000,000 - $220,000,000)	$73,000,000 ($34,000,000 - $110,000,000)
Massachusetts	Added Value of Active Mobility Safety in Numbers Effect	$24,000,000 ($24,000,000 - $24,000,000)	$20,000,000 ($20,000,000 - $20,000,000)	$15,000,000 ($15,000,000 - $15,000,000)	$12,000,000 ($12,000,000 - $12,000,000)	$6,100,000 ($6,100,000 - $6,100,000)
Massachusetts	Value of Air Quality Health Benefits	$390,000,000 ($140,000,000 - $820,000,000)	$380,000,000 ($140,000,000 - $790,000,000)	$340,000,000 ($130,000,000 - $690,000,000)	$190,000,000 ($68,000,000 - $380,000,000)	$93,000,000 ($34,000,000 - $190,000,000)
Massachusetts	Total Value of Health Benefits	$710,000,000 ($300,000,000 - $1,300,000,000	$650,000,000 ($280,000,000 - $1,200,000,000	$530,000,000 ($220,000,000 - $980,000,000)	$340,000,000 ($150,000,000 - $620,000,000)	$170,000,000 ($75,000,000 - $310,000,000)
New Hampshire	Deaths Avoided from Active Mobility	1.5 (0.88 - 2)	0.99 (0.66 - 1.3)	0.53 (0.32 - 0.74)	0.4 (0.26 - 0.55)	0.2 (0.13 - 0.27)
New Hampshire	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.11	0.081	0.046	0.032	0.016
New Hampshire	Deaths Avoided from Improved Air Quality	3.7 (2.2 - 5.6)	3.7 (2.3 - 5.5)	3.4 (2.1 - 4.9)	1.8 (1.1 - 2.7)	0.92 (0.58 - 1.4)
New Hampshire	Respiratory Hospitalizations Avoided	0.45 (0.17 - 0.73)	0.41 (0.16 - 0.67)	0.35 (0.14 - 0.57)	0.2 (0.078 - 0.32)	0.099 (0.039 - 0.16)
New Hampshire	Childhood Asthma Incidences Avoided	1.2 (0.47 - 1.8)	1.3 (0.48 - 1.9)	1.1 (0.43 - 1.7)	0.62 (0.23 - 0.91)	0.31 (0.12 - 0.46)
New Hampshire	Childhood Asthma Exacerbations Avoided	270 (6.3 - 540)	260 (5.9 - 520)	230 (5 - 450)	130 (2.8 - 250)	63 (1.4 - 130)
New Hampshire	Value of Active Mobility Health Benefits	$15,000,000 ($6,400,000 - $24,000,000)	$10,000,000 ($4,800,000 - $16,000,000)	$5,500,000 ($2,400,000 - $8,600,000)	$4,200,000 ($1,900,000 - $6,500,000)	$2,100,000 ($950,000 - $3,200,000)
New Hampshire	Added Value of Active Mobility Safety in Numbers Effect	$1,100,000 ($1,100,000 - $1,100,000)	$780,000 ($780,000 - $780,000)	$440,000 ($440,000 - $440,000)	$310,000 ($310,000 - $310,000)	$160,000 ($160,000 - $160,000)
New Hampshire	Value of Air Quality Health Benefits	$38,000,000 ($14,000,000 - $82,000,000)	$38,000,000 ($14,000,000 - $80,000,000)	$35,000,000 ($13,000,000 - $72,000,000)	$19,000,000 ($6,800,000 - $39,000,000)	$9,500,000 ($3,600,000 - $20,000,000)
New Hampshire	Total Value of Health Benefits	$54,000,000 ($21,000,000 - $110,000,000)	$49,000,000 ($20,000,000 - $97,000,000)	$41,000,000 ($16,000,000 - $81,000,000)	$23,000,000 ($9,000,000 - $46,000,000)	$12,000,000 ($4,700,000 - $24,000,000)
New Jersey	Deaths Avoided from Active Mobility	109 (72 - 146)	97 (63 - 131)	72 (43 - 100)	51 (33 - 69)	26 (17 - 35)
New Jersey	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	8.9	8.1	6.1	4.3	2.1
New Jersey	Deaths Avoided from Improved Air Quality	94 (56 - 140)	81 (50 - 120)	65 (42 - 93)	39 (24 - 56)	19 (12 - 28)

New Jersey	Respiratory Hospitalizations Avoided	6.9 (2.7 - 11)	6 (2.4 - 9.6)	4.8 (1.9 - 7.7)	2.9 (1.1 - 4.6)	1.4 (0.56 - 2.3)
New Jersey	Childhood Asthma Incidences Avoided	38 (15 - 55)	32 (12 - 47)	26 (9.7 - 38)	16 (5.9 - 23)	7.6 (2.9 - 11)
New Jersey	Childhood Asthma Exacerbations Avoided	8,000 (190 - 16,000)	6,500 (150 - 13,000)	4,900 (110 - 9,700)	3,100 (71 - 6,100)	1,500 (34 - 3,000)
New Jersey	Value of Active Mobility Health Benefits	$1,100,000,000 ($530,000,000 - $1,700,000,0	$1,000,000,000 ($460,000,000 - $1,600,000,0	$750,000,000 ($320,000,000 - $1,200,000,000	$530,000,000 ($250,000,000 - $820,000,000)	$270,000,000 ($120,000,000 - $410,000,000)
New Jersey	Added Value of Active Mobility Safety in Numbers Effect	$86,000,000 ($86,000,000 - $86,000,000)	$77,000,000 ($77,000,000 - $77,000,000)	$59,000,000 ($59,000,000 - $59,000,000)	$41,000,000 ($41,000,000 - $41,000,000)	$21,000,000 ($21,000,000 - $21,000,000)
New Jersey	Value of Air Quality Health Benefits	$970,000,000 ($340,000,000 - $2,000,000,000	$840,000,000 ($310,000,000 - $1,800,000,000	$670,000,000 ($260,000,000 - $1,400,000,000	$400,000,000 ($150,000,000 - $820,000,000)	$200,000,000 ($74,000,000 - $410,000,000)
New Jersey	Total Value of Health Benefits	$2,200,000,000 ($960,000,000 - $3,900,000,0	$1,900,000,000 ($850,000,000 - $3,400,000,0	$1,500,000,000 ($640,000,000 - $2,600,000,0	$980,000,000 ($430,000,000 - $1,700,000,000	$480,000,000 ($220,000,000 - $840,000,000)
New York	Deaths Avoided from Active Mobility	361 (218 - 505)	284 (181 - 387)	175 (104 - 245)	193 (126 - 259)	96 (63 - 130)
New York	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	32	26	17	18	9
New York	Deaths Avoided from Improved Air Quality	200 (120 - 290)	170 (110 - 250)	140 (89 - 200)	85 (53 - 120)	42 (26 - 58)
New York	Respiratory Hospitalizations Avoided	8.8 (3.6 - 14)	8.2 (3.4 - 13)	6.9 (2.9 - 11)	4 (1.7 - 6.3)	2 (0.84 - 3.1)
New York	Childhood Asthma Incidences Avoided	87 (34 - 130)	74 (28 - 110)	58 (22 - 86)	36 (14 - 53)	18 (6.7 - 26)
New York	Childhood Asthma Exacerbations Avoided	20,000 (470 - 40,000)	16,000 (370 - 32,000)	12,000 (270 - 24,000)	7,600 (170 - 15,000)	3,700 (85 - 7,400)
New York	Value of Active Mobility Health Benefits	$3,800,000,000 ($1,600,000,000 - $5,900,000	$3,000,000,000 ($1,400,000,000 - $4,600,000	$1,800,000,000 ($800,000,000 - $2,900,000,0	$2,000,000,000 ($940,000,000 - $3,100,000,0	$1,000,000,000 ($470,000,000 - $1,600,000,0
New York	Added Value of Active Mobility Safety in Numbers Effect	$310,000,000 ($310,000,000 - $310,000,000)	$250,000,000 ($250,000,000 - $250,000,000)	$160,000,000 ($160,000,000 - $160,000,000)	$170,000,000 ($170,000,000 - $170,000,000)	$87,000,000 ($87,000,000 - $87,000,000)
New York	Value of Air Quality Health Benefits	$2,100,000,000 ($740,000,000 - $4,200,000,0	$1,800,000,000 ($680,000,000 - $3,700,000,0	$1,400,000,000 ($550,000,000 - $2,900,000,0	$880,000,000 ($330,000,000 - $1,800,000,000	$430,000,000 ($160,000,000 - $850,000,000)
New York	Total Value of Health Benefits	$6,200,000,000 ($2,700,000,000 - $10,000,00	$5,000,000,000 ($2,300,000,000 - $8,500,000	$3,400,000,000 ($1,500,000,000 - $6,000,000	$3,100,000,000 ($1,400,000,000 - $5,000,000	$1,500,000,000 ($720,000,000 - $2,500,000,0
Pennsylvania	Deaths Avoided from Active Mobility	71 (47 - 95)	58 (39 - 76)	40 (25 - 55)	37 (25 - 49)	18 (12 - 24)
Pennsylvania	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	3.9	3.2	2.3	2	0.99
Pennsylvania	Deaths Avoided from Improved Air Quality	110 (63 - 160)	89 (55 - 130)	69 (44 - 98)	43 (26 - 62)	21 (13 - 30)
Pennsylvania	Respiratory Hospitalizations Avoided	5.8 (2.3 - 9.4)	5 (2 - 8.1)	4 (1.6 - 6.5)	2.4 (0.98 - 3.9)	1.2 (0.48 - 1.9)
Pennsylvania	Childhood Asthma Incidences Avoided	34 (13 - 49)	28 (11 - 41)	22 (8.2 - 32)	13 (5.2 - 20)	6.6 (2.5 - 9.7)
Pennsylvania	Childhood Asthma Exacerbations Avoided	8,500 (200 - 17,000)	6,600 (150 - 13,000)	4,700 (110 - 9,400)	3,100 (72 - 6,200)	1,500 (35 - 3,000)
Pennsylvania	Value of Active Mobility Health Benefits	$720,000,000 ($320,000,000 - $1,100,000,000	$580,000,000 ($270,000,000 - $900,000,000)	$410,000,000 ($170,000,000 - $640,000,000)	$370,000,000 ($170,000,000 - $580,000,000)	$190,000,000 ($85,000,000 - $290,000,000)
Pennsylvania	Added Value of Active Mobility Safety in Numbers Effect	$37,000,000 ($37,000,000 - $37,000,000)	$31,000,000 ($31,000,000 - $31,000,000)	$22,000,000 ($22,000,000 - $22,000,000)	$19,000,000 ($19,000,000 - $19,000,000)	$9,500,000 ($9,500,000 - $9,500,000)
Pennsylvania	Value of Air Quality Health Benefits	$1,100,000,000 ($390,000,000 - $2,300,000,0	$920,000,000 ($340,000,000 - $1,900,000,000	$710,000,000 ($270,000,000 - $1,400,000,000	$440,000,000 ($160,000,000 - $900,000,000)	$220,000,000 ($80,000,000 - $440,000,000)
Pennsylvania	Total Value of Health Benefits	$1,900,000,000 ($750,000,000 - $3,500,000,0	$1,500,000,000 ($640,000,000 - $2,800,000,0	$1,100,000,000 ($470,000,000 - $2,100,000,0	$840,000,000 ($350,000,000 - $1,500,000,000	$410,000,000 ($170,000,000 - $740,000,000)
Rhode Island	Deaths Avoided from Active Mobility	3.1 (2.1 - 4.2)	2.7 (1.7 - 3.6)	2 (1.2 - 2.8)	1.3 (0.88 - 1.8)	0.67 (0.44 - 0.91)
Rhode Island	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.24	0.21	0.16	0.11	0.054
Rhode Island	Deaths Avoided from Improved Air Quality	6.8 (4 - 10)	6.4 (3.9 - 9.3)	5.4 (3.4 - 7.9)	3.1 (1.9 - 4.5)	1.5 (0.95 - 2.2)
Rhode Island	Respiratory Hospitalizations Avoided	0.58 (0.22 - 0.93)	0.52 (0.21 - 0.85)	0.44 (0.17 - 0.71)	0.25 (0.099 - 0.41)	0.12 (0.049 - 0.2)
Rhode Island	Childhood Asthma Incidences Avoided	2.1 (0.8 - 3)	1.9 (0.74 - 2.8)	1.6 (0.62 - 2.4)	0.93 (0.36 - 1.4)	0.46 (0.18 - 0.68)
Rhode Island	Childhood Asthma Exacerbations Avoided	550 (13 - 1,100)	480 (11 - 960)	390 (8.8 - 780)	230 (5.3 - 460)	120 (2.6 - 230)
Rhode Island	Value of Active Mobility Health Benefits	$32,000,000 ($15,000,000 - $50,000,000)	$27,000,000 ($13,000,000 - $42,000,000)	$21,000,000 ($8,900,000 - $32,000,000)	$14,000,000 ($6,400,000 - $22,000,000)	$7,000,000 ($3,200,000 - $11,000,000)
Rhode Island	Added Value of Active Mobility Safety in Numbers Effect	$2,300,000 ($2,300,000 - $2,300,000)	$2,000,000 ($2,000,000 - $2,000,000)	$1,600,000 ($1,600,000 - $1,600,000)	$1,000,000 ($1,000,000 - $1,000,000)	$510,000 ($510,000 - $510,000)
Rhode Island	Value of Air Quality Health Benefits	$70,000,000 ($25,000,000 - $150,000,000)	$66,000,000 ($24,000,000 - $140,000,000)	$56,000,000 ($21,000,000 - $120,000,000)	$32,000,000 ($12,000,000 - $66,000,000)	$15,000,000 ($5,800,000 - $32,000,000)
Rhode Island	Total Value of Health Benefits	$100,000,000 ($42,000,000 - $200,000,000)	$96,000,000 ($39,000,000 - $180,000,000)	$78,000,000 ($31,000,000 - $150,000,000)	$47,000,000 ($19,000,000 - $88,000,000)	$23,000,000 ($9,600,000 - $43,000,000)
Vermont	Deaths Avoided from Active Mobility	0.65 (0.4 - 0.9)	0.46 (0.3 - 0.61)	0.25 (0.15 - 0.35)	0.18 (0.12 - 0.25)	0.092 (0.06 - 0.12)
Vermont	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	0.05	0.037	0.022	0.014	0.0072
Vermont	Deaths Avoided from Improved Air Quality	1 (0.62 - 1.5)	0.96 (0.6 - 1.4)	0.82 (0.53 - 1.2)	0.47 (0.3 - 0.69)	0.24 (0.15 - 0.34)
Vermont	Respiratory Hospitalizations Avoided	0.12 (0.044 - 0.19)	0.1 (0.041 - 0.17)	0.087 (0.034 - 0.14)	0.051 (0.02 - 0.082)	0.025 (0.0098 - 0.041)
Vermont	Childhood Asthma Incidences Avoided	0.31 (0.12 - 0.46)	0.29 (0.11 - 0.43)	0.24 (0.091 - 0.36)	0.14 (0.053 - 0.21)	0.07 (0.026 - 0.1)
Vermont	Childhood Asthma Exacerbations Avoided	67 (1.6 - 130)	57 (1.3 - 110)	45 (0.97 - 90)	27 (0.61 - 55)	14 (0.3 - 27)
Vermont	Value of Active Mobility Health Benefits	$6,700,000 ($2,900,000 - $11,000,000)	$4,800,000 ($2,200,000 - $7,300,000)	$2,600,000 ($1,100,000 - $4,100,000)	$1,900,000 ($870,000 - $2,900,000)	$950,000 ($440,000 - $1,500,000)
Vermont	Added Value of Active Mobility Safety in Numbers Effect	$480,000 ($480,000 - $480,000)	$350,000 ($350,000 - $350,000)	$210,000 ($210,000 - $210,000)	$140,000 ($140,000 - $140,000)	$69,000 ($69,000 - $69,000)
Vermont	Value of Air Quality Health Benefits	$10,000,000 ($3,800,000 - $22,000,000)	$9,900,000 ($3,700,000 - $20,000,000)	$8,500,000 ($3,300,000 - $18,000,000)	$4,800,000 ($1,800,000 - $10,000,000)	$2,500,000 ($920,000 - $5,000,000)
Vermont	Total Value of Health Benefits	$18,000,000 ($7,200,000 - $33,000,000)	$15,000,000 ($6,300,000 - $28,000,000)	$11,000,000 ($4,600,000 - $22,000,000)	$6,900,000 ($2,900,000 - $13,000,000)	$3,500,000 ($1,400,000 - $6,500,000)
Virginia	Deaths Avoided from Active Mobility	37 (25 - 50)	32 (21 - 44)	24 (14 - 33)	17 (11 - 23)	8.3 (5.4 - 11)
Virginia	Added Deaths Avoidedfrom Active Mobility with Safety in Numbers Effect	3.4	3	2.3	1.5	0.77
Virginia	Deaths Avoided from Improved Air Quality	35 (21 - 52)	32 (20 - 46)	27 (17 - 38)	16 (9.8 - 22)	7.8 (4.9 - 11)
Virginia	Respiratory Hospitalizations Avoided	2.7 (1.1 - 4.3)	2.4 (0.98 - 3.9)	2 (0.82 - 3.2)	1.2 (0.48 - 1.9)	0.58 (0.24 - 0.93)
Virginia	Childhood Asthma Incidences Avoided	18 (7 - 26)	16 (6.3 - 24)	14 (5.1 - 20)	8 (3 - 12)	3.9 (1.5 - 5.8)
Virginia	Childhood Asthma Exacerbations Avoided	3,500 (82 - 6,900)	3,000 (67 - 5,900)	2,300 (51 - 4,600)	1,400 (32 - 2,800)	700 (16 - 1,400)
Virginia	Value of Active Mobility Health Benefits	$390,000,000 ($180,000,000 - $600,000,000)	$340,000,000 ($160,000,000 - $520,000,000)	$250,000,000 ($110,000,000 - $390,000,000)	$170,000,000 ($80,000,000 - $270,000,000)	$87,000,000 ($40,000,000 - $130,000,000)
Virginia	Added Value of Active Mobility Safety in Numbers Effect	$32,000,000 ($32,000,000 - $32,000,000)	$29,000,000 ($29,000,000 - $29,000,000)	$22,000,000 ($22,000,000 - $22,000,000)	$15,000,000 ($15,000,000 - $15,000,000)	$7,400,000 ($7,400,000 - $7,400,000)
Virginia	Value of Air Quality Health Benefits	$360,000,000 ($130,000,000 - $760,000,000)	$330,000,000 ($120,000,000 - $670,000,000)	$280,000,000 ($100,000,000 - $560,000,000)	$170,000,000 ($60,000,000 - $320,000,000)	$81,000,000 ($30,000,000 - $160,000,000)
Virginia	Total Value of Health Benefits	$790,000,000 ($340,000,000 - $1,400,000,000	$700,000,000 ($310,000,000 - $1,200,000,000	$550,000,000 ($230,000,000 - $970,000,000)	$350,000,000 ($160,000,000 - $600,000,000)	$180,000,000 ($78,000,000 - $300,000,000)

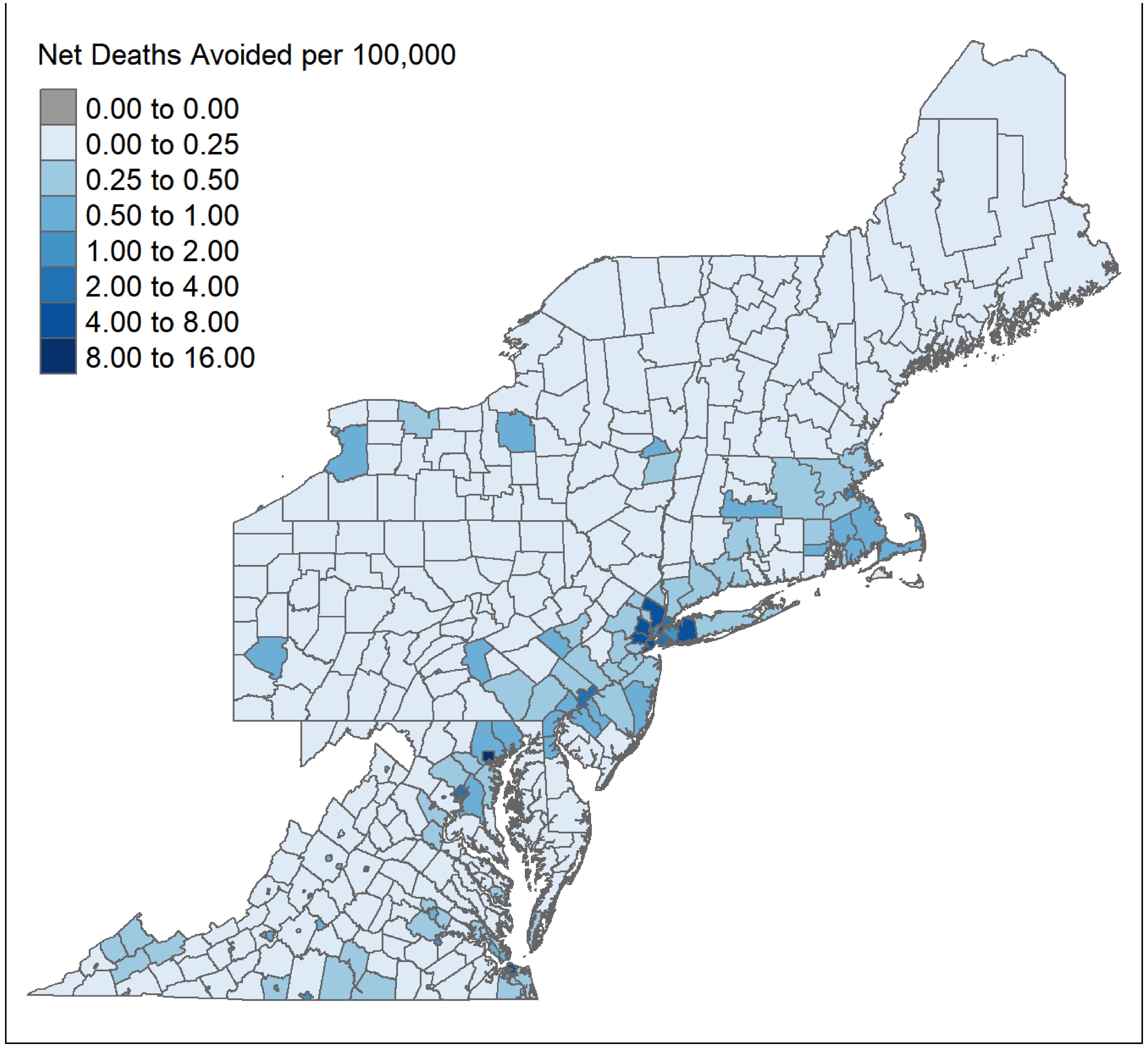
2. Maps for Estimated Mortality Benefits from Active Mobility Per 100,000 People

Estimated Net Deaths Avoided per 100,000 People from Walking and Biking for Scenario A with a 25% CO_2 Reduction Cap Compared to a No-TCI Reference Scenario in 2032



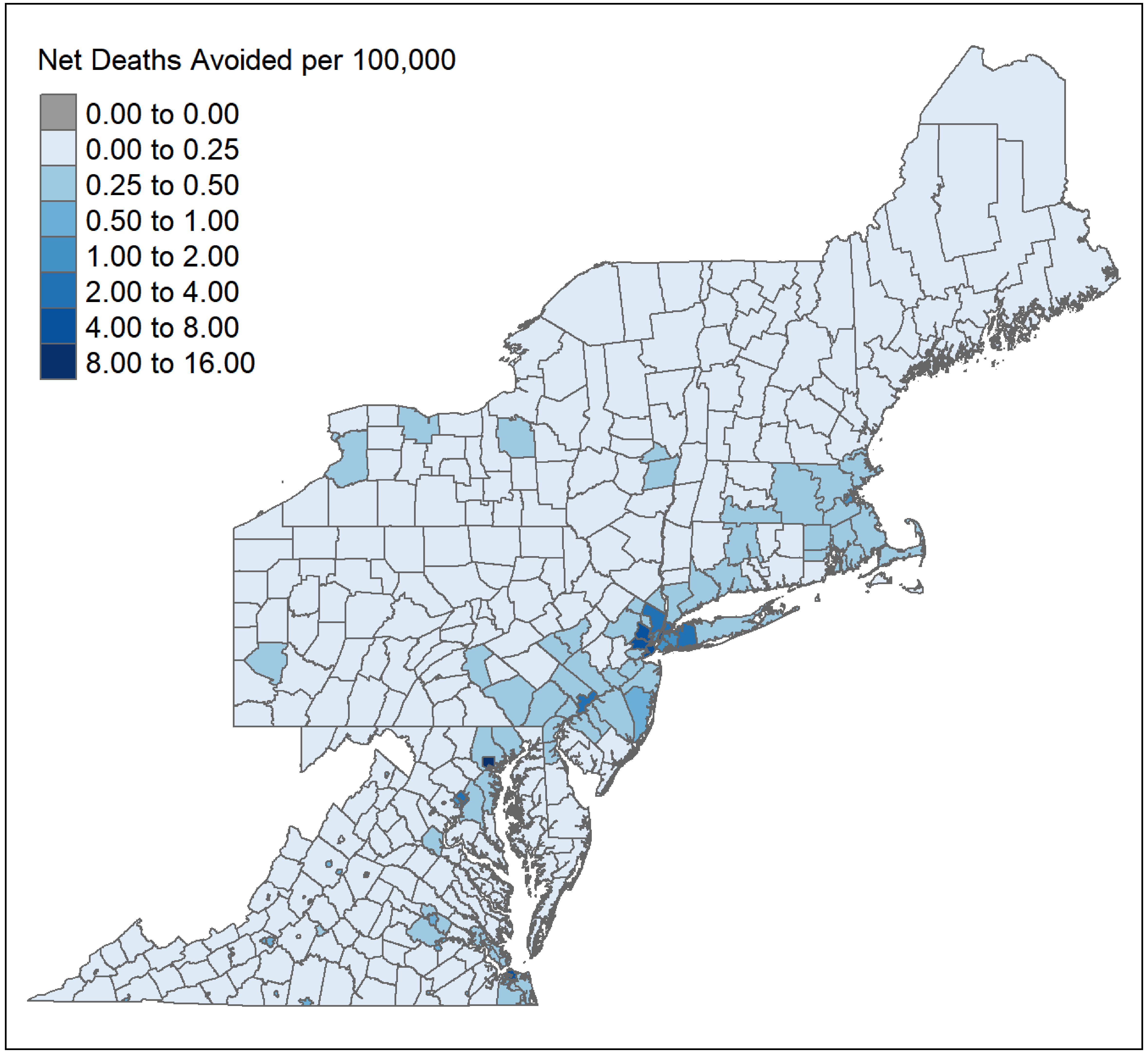
Map credit: M. Raifman, P. Kinney.
Based on Raifman et al. 2021. Includes safety in numbers effect.

Estimated Net Deaths Avoided per 100,000 People from Walking and Biking for Scenario B with a 25% CO_2 Reduction Cap Compared to a No-TCI Reference Scenario in 2032



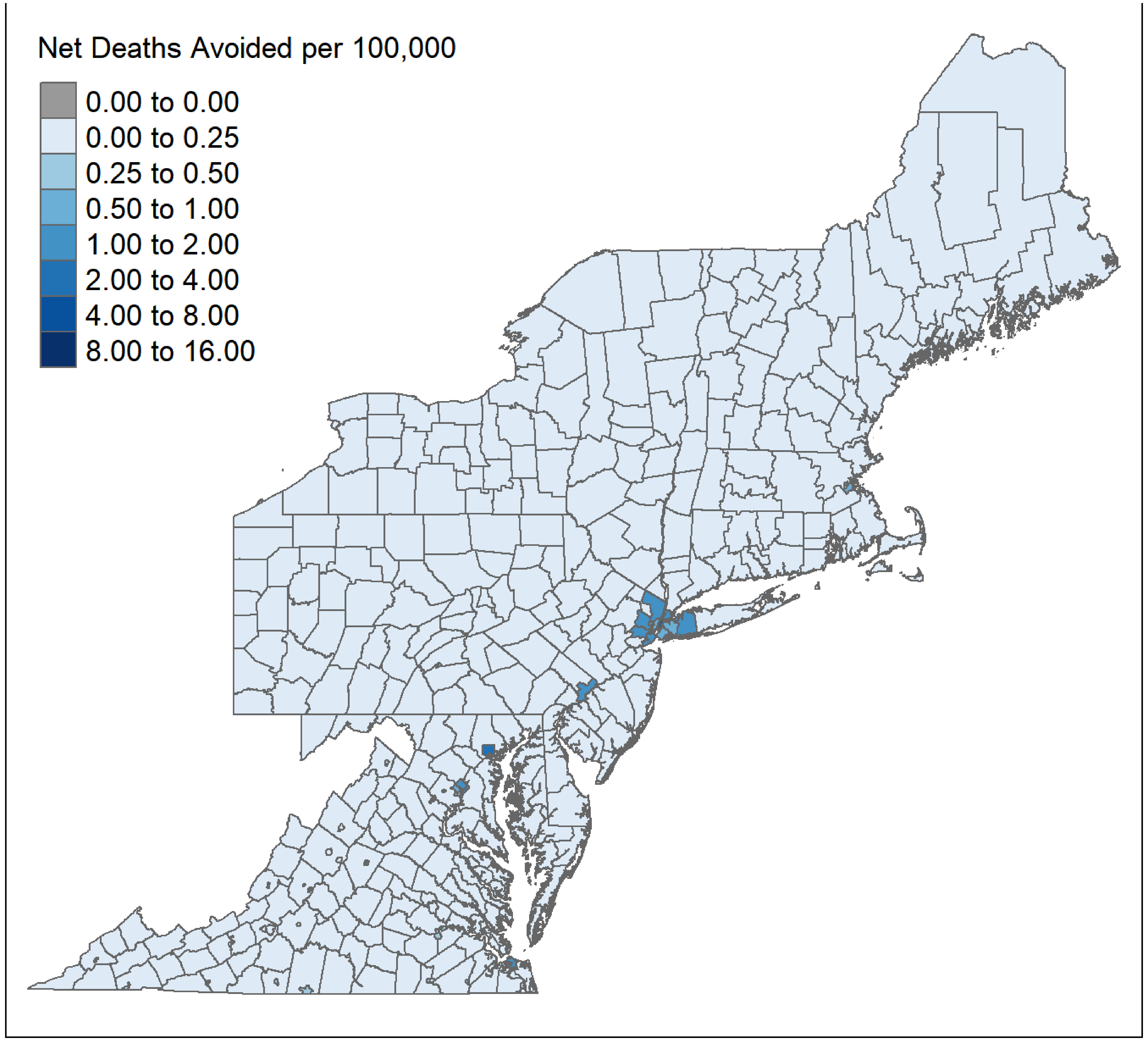
Map credit: M. Raifman, P. Kinney.
Based on Raifman et al. 2021. Includes safety in numbers effect.

Estimated Net Deaths Avoided per 100,000 People from Walking and Biking for Scenario C with a 25% CO_2 Reduction Cap Compared to a No-TCI Reference Scenario in 2032



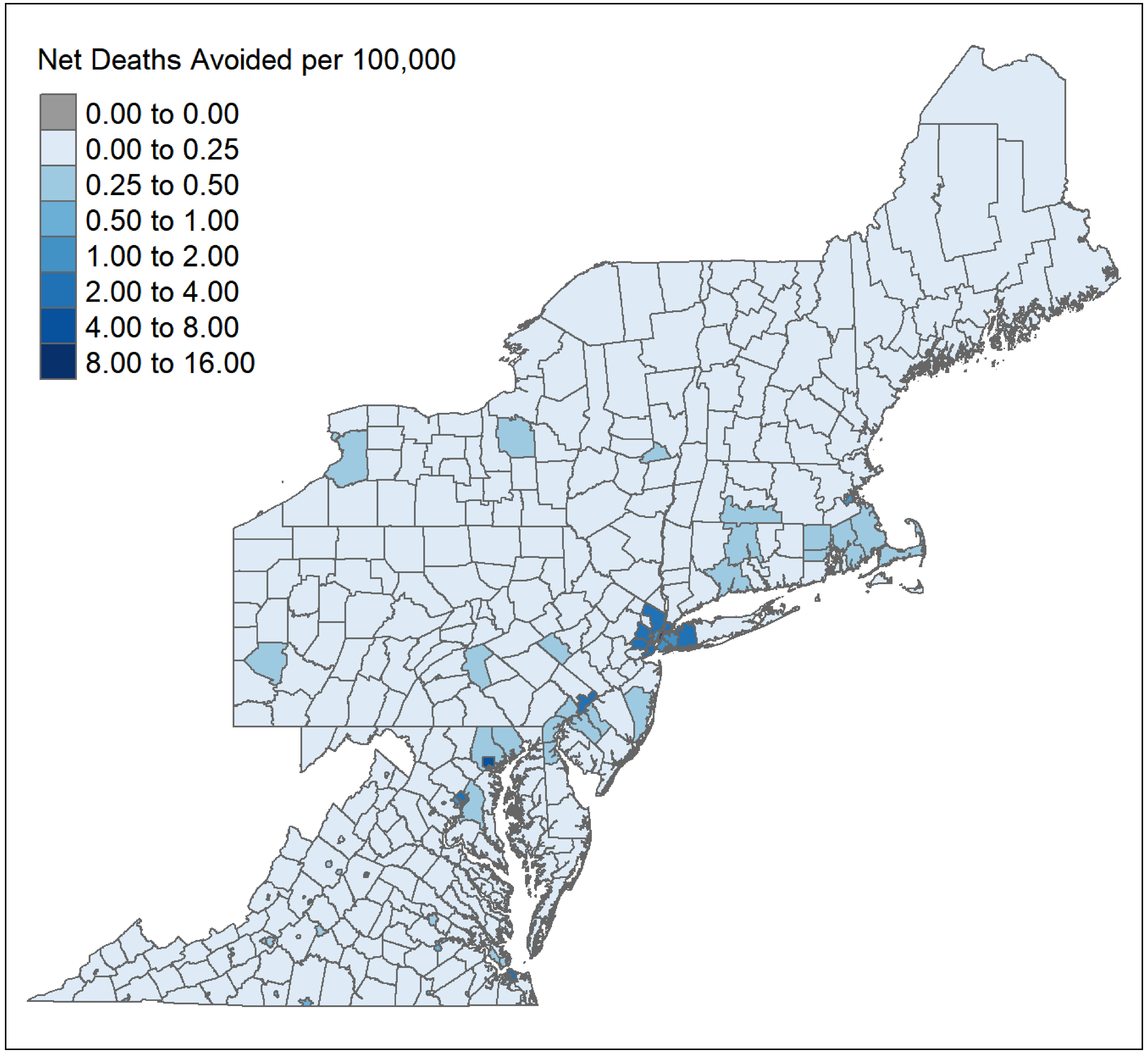
Map credit: M. Raifman, P. Kinney.
Based on Raifman et al. 2021. Includes safety in numbers effect.

Estimated Net Deaths Avoided per 100,000 People from Walking and Biking for Scenario B with a 20% CO_2 Reduction Cap Compared to a No-TCI Reference Scenario in 2032



Map credit: M. Raifman, P. Kinney.
Based on Raifman et al. 2021. Includes safety in numbers effect.

Estimated Net Deaths Avoided per 100,000 People from Walking and Biking for Scenario B with a 22% CO_2 Reduction Cap Compared to a No-TCI Reference Scenario in 2032

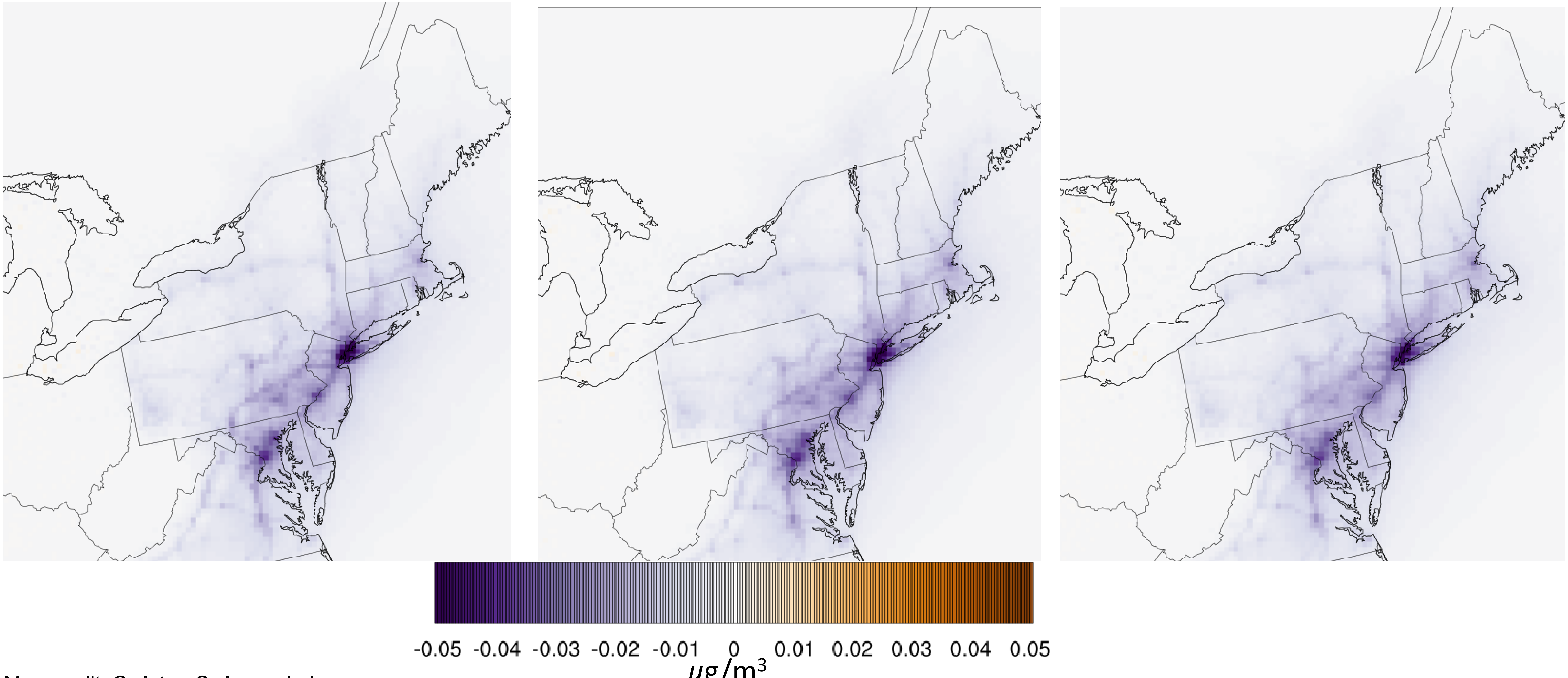


Map credit: M. Raifman, P. Kinney.
Based on Raifman et al. 2021. Includes safety in numbers effect.

3. Maps Estimated Changes in Air Quality for $PM_{2.5}$, Ozone, and NO_2

$PM_{2.5}$ - 25% CO_2 Reduction Cap Scenarios Delta from Reference $PM_{2.5}$ in 2032

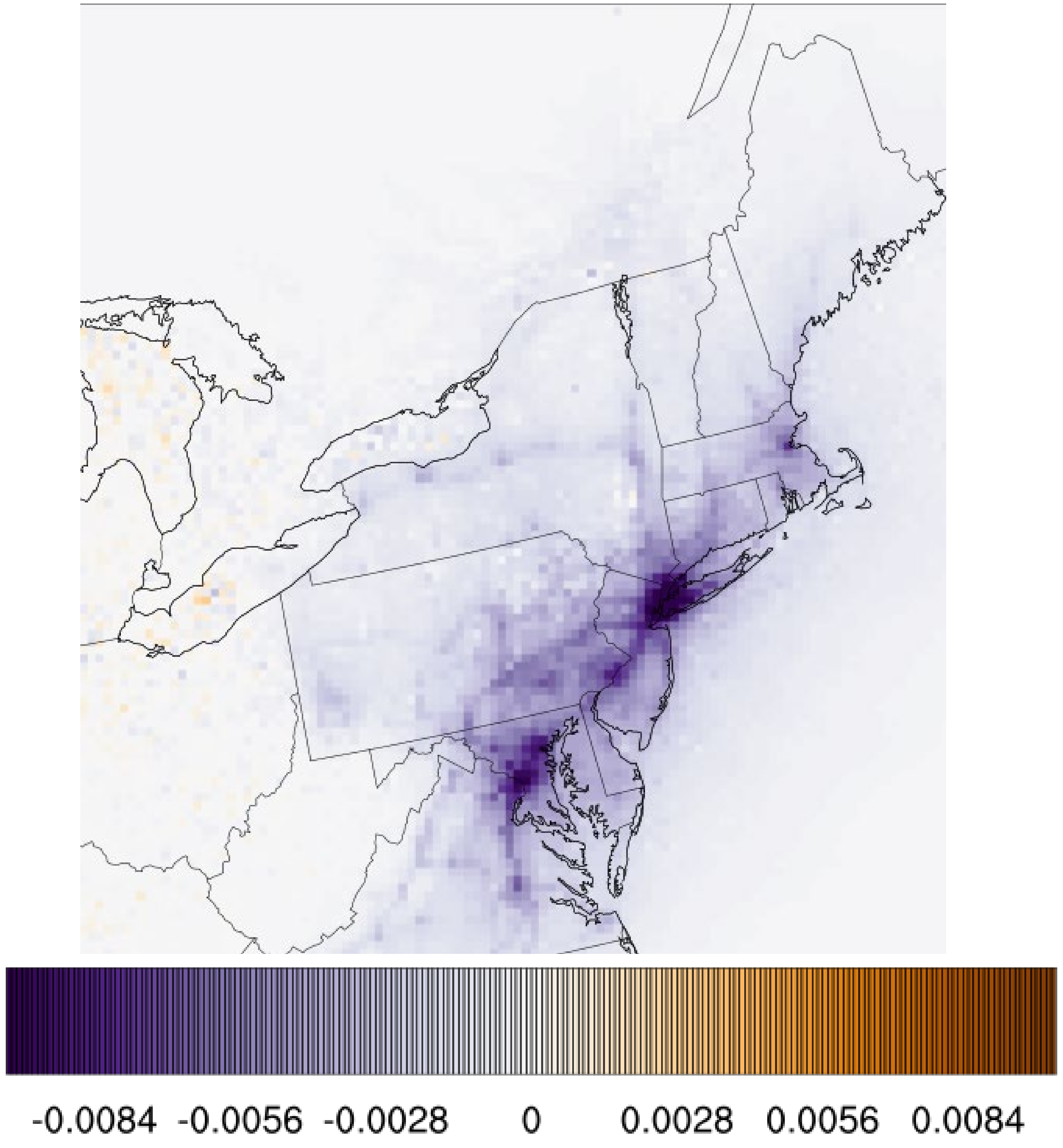
Scenario A | Scenario B | Scenario C



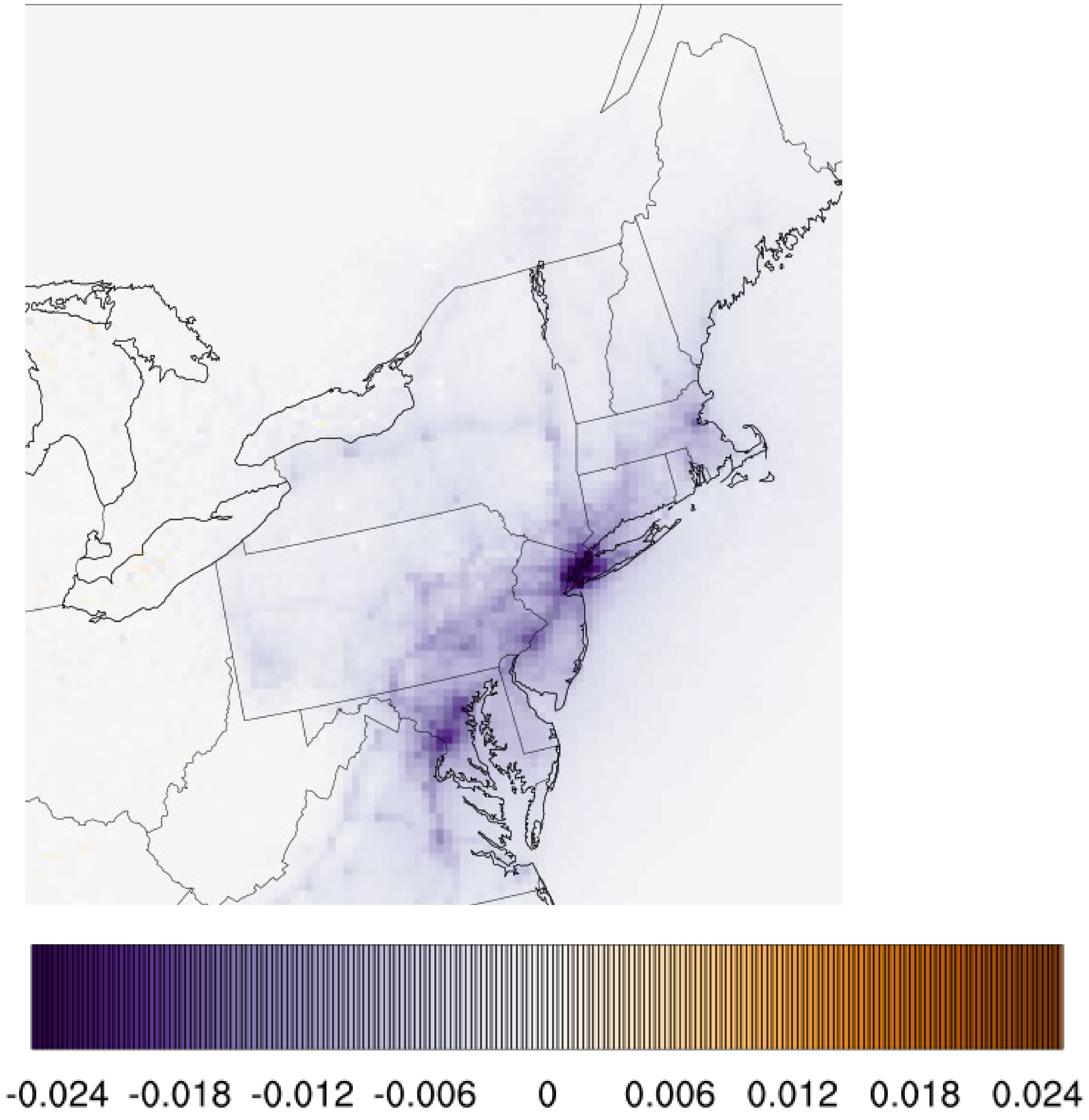
Map credit: C. Arter, S. Arunachalam.
Based on Arunachalam et al. In prep.

$PM_{2.5}$ - 20% (left) and 22% (right) CO_2 Reduction Cap Scenarios Delta from in 2032 Reference $PM_{2.5}$ in 2032

Scenario B



Scenario B



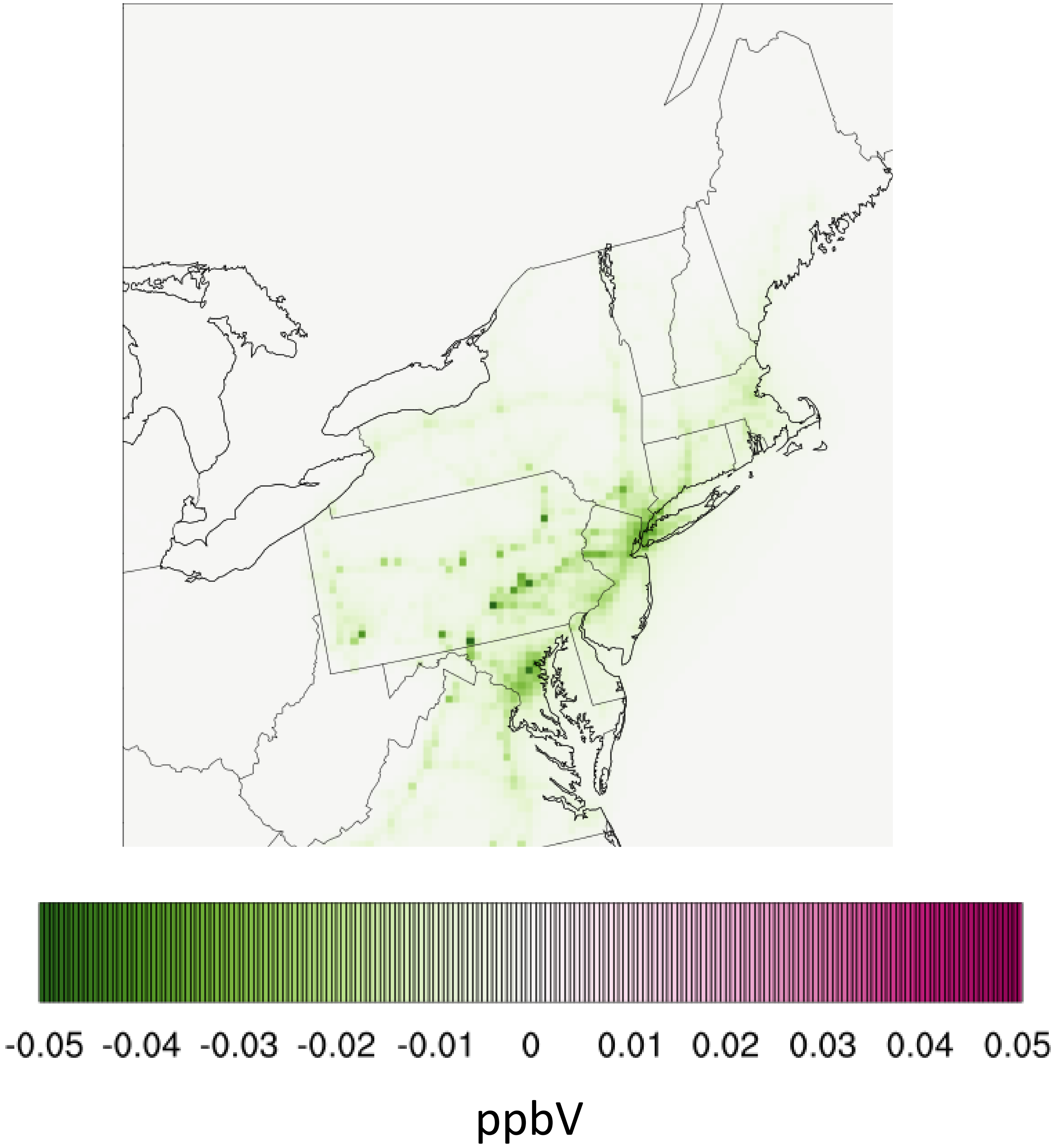
Map credit: C. Arter, S. Arunachalam.
Based on Arunachalam et al. In prep.

NO_2 - 25% CO_2 Reduction Cap Scenarios Delta from Reference NO_2 in 2032

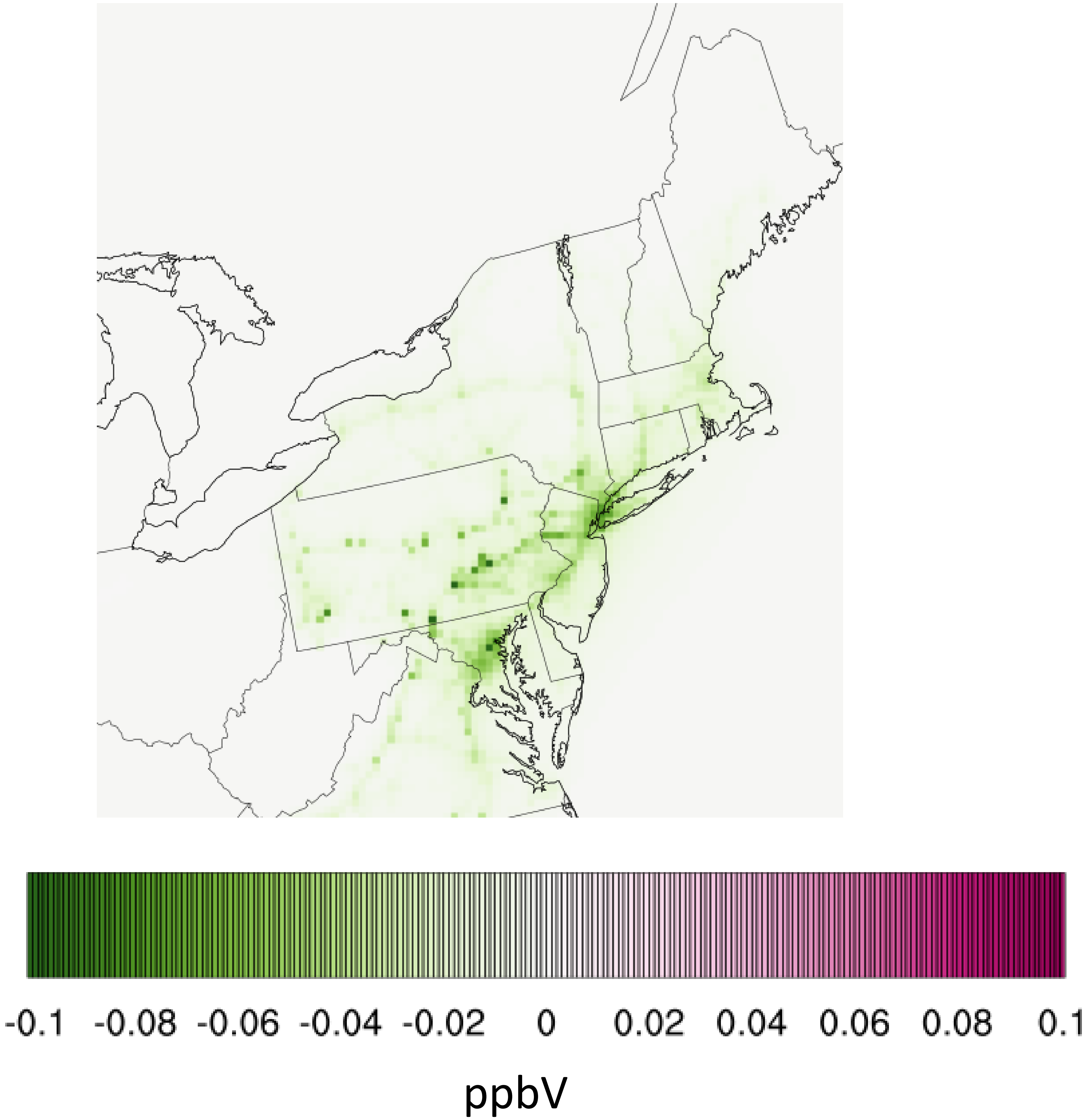
Map credit: C. Arter, S. Arunachalam.
Based on Arunachalam et al. In prep.

NO_2 - Scenario B 20% (left) and 22% (right) CO_2 Reduction Cap Scenarios Delta from Reference NO_2 in 2032

Scenario B

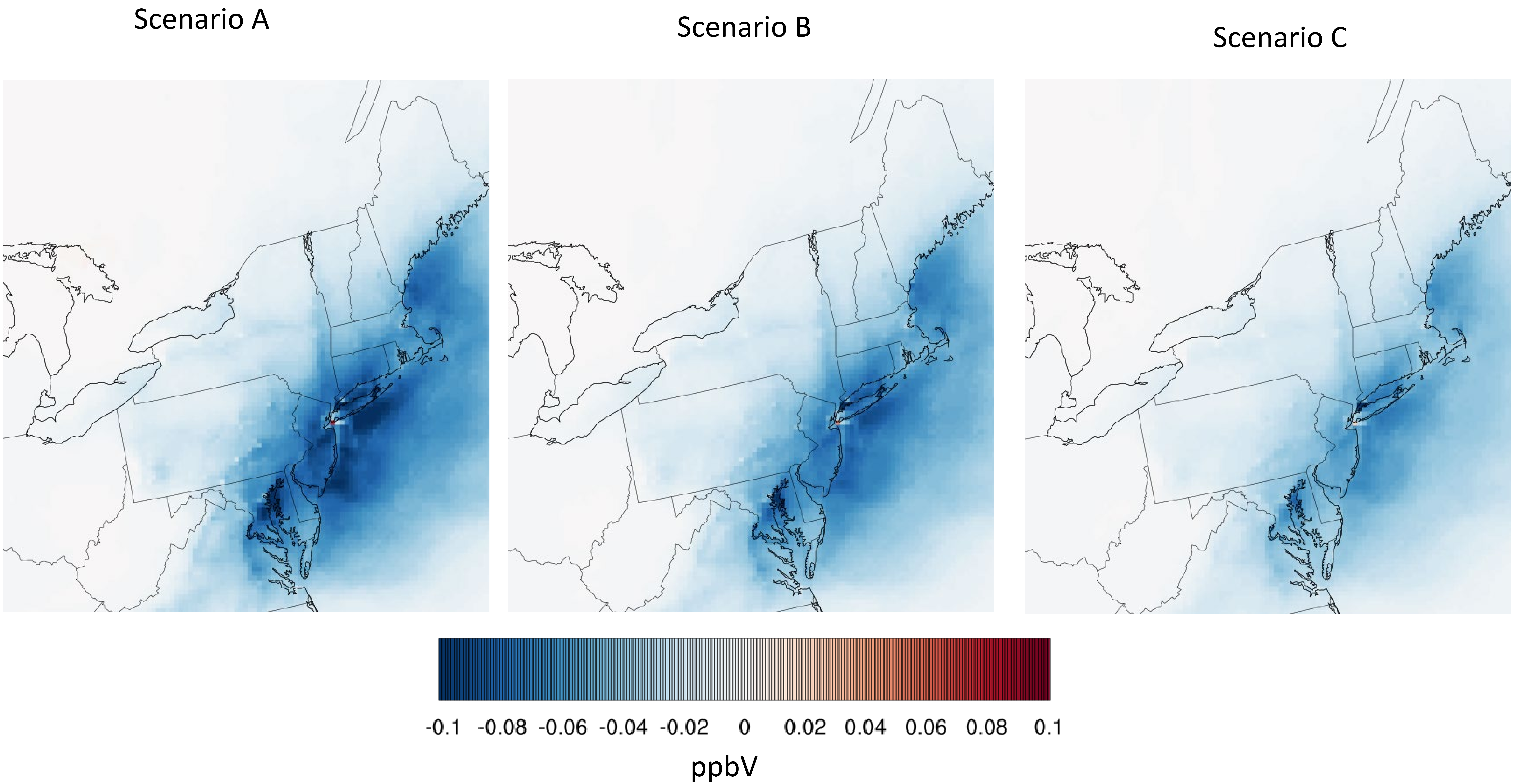


Scenario B



Map credit: C. Arter, S. Arunachalam.
Based on Arunachalam et al. In prep.

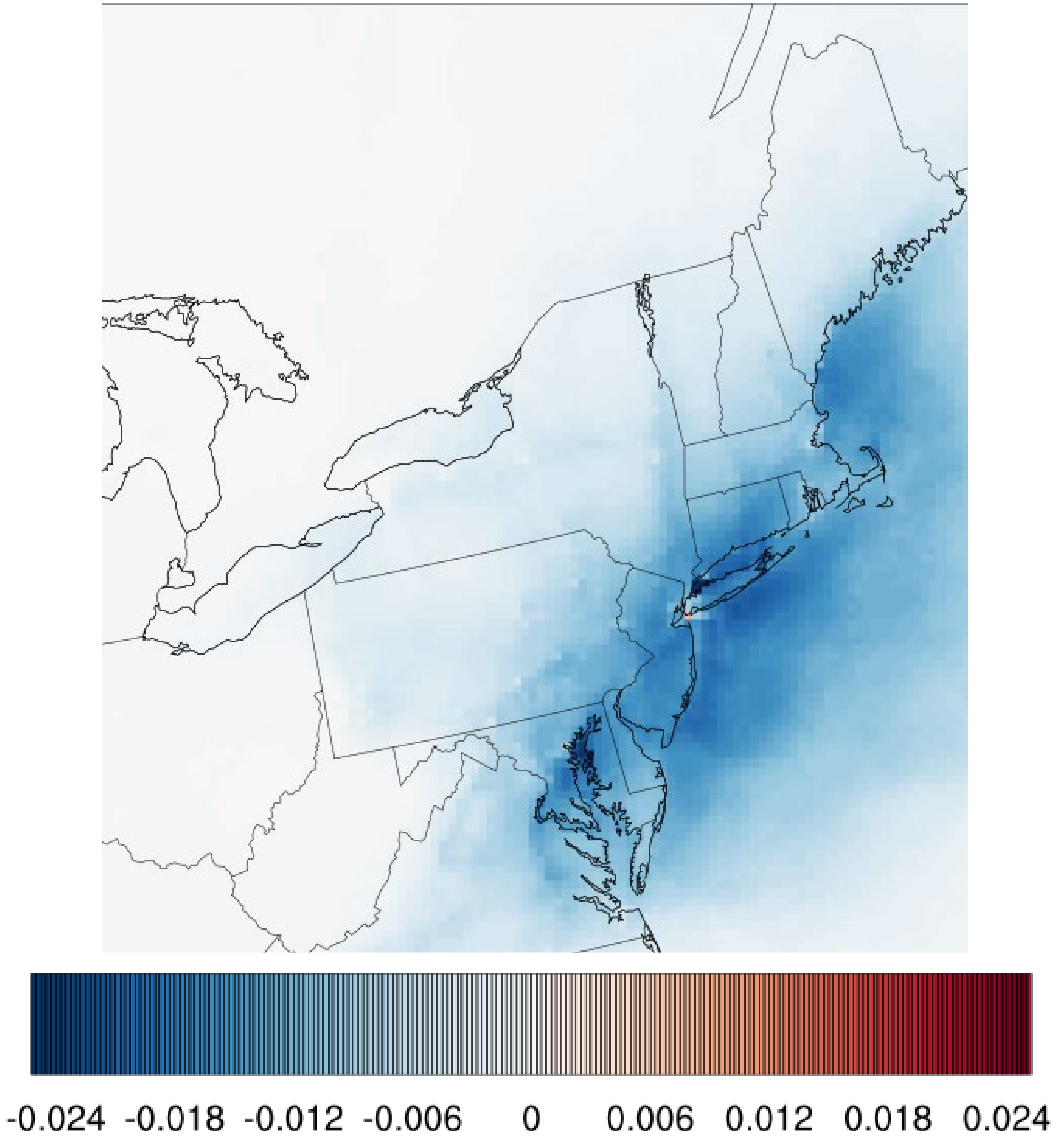
Ozone - 25% CO_2 Reduction Cap Scenarios Delta from Reference O_3 in 2032



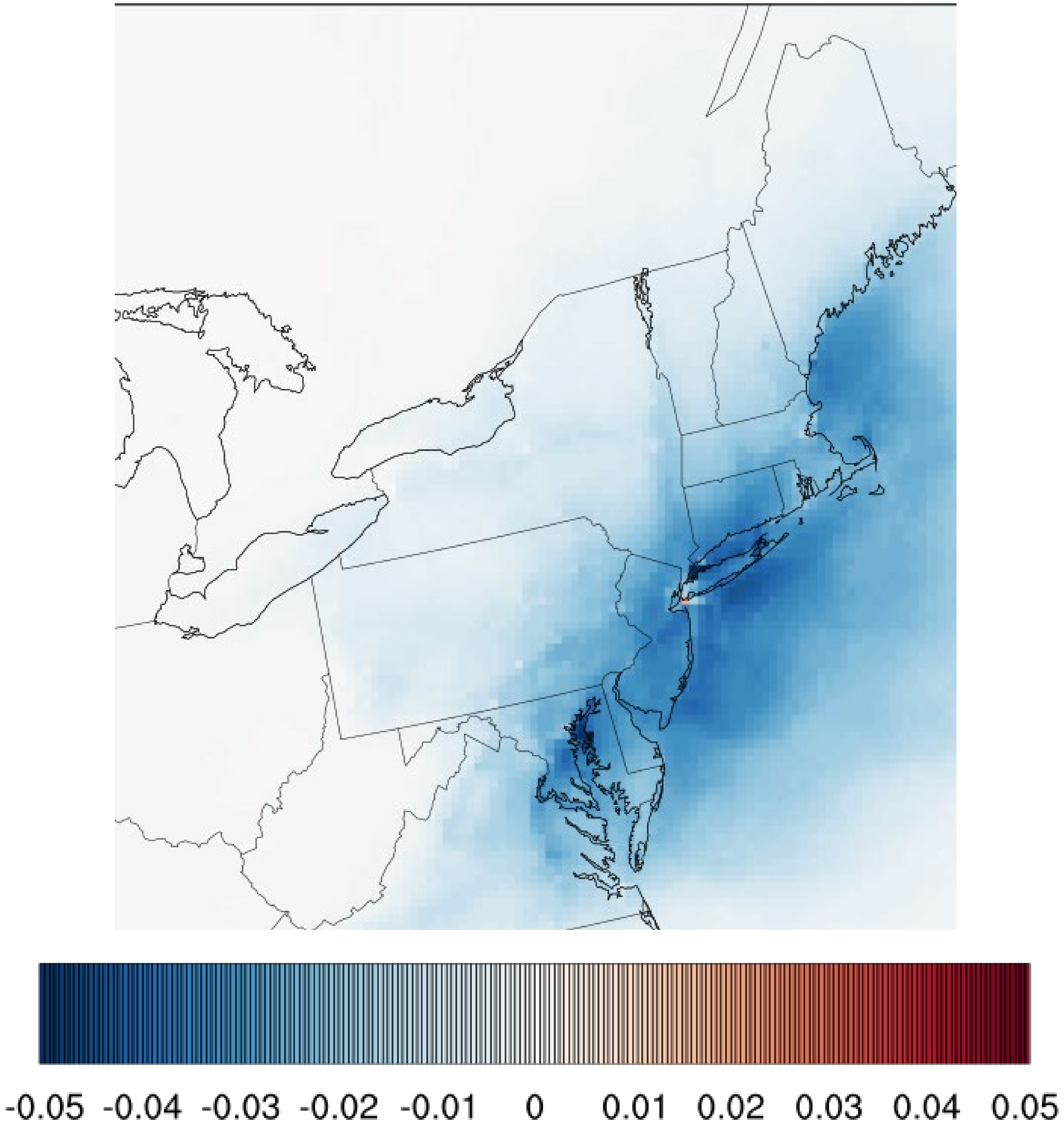
Map credit: C. Arter, S. Arunachalam.
Based on Arunachalam et al. In prep.

Ozone - 20% (left) and 22% (right) CO2 Reduction Scenarios Delta from Reference O_3 in 2032

Scenario B



Scenario B

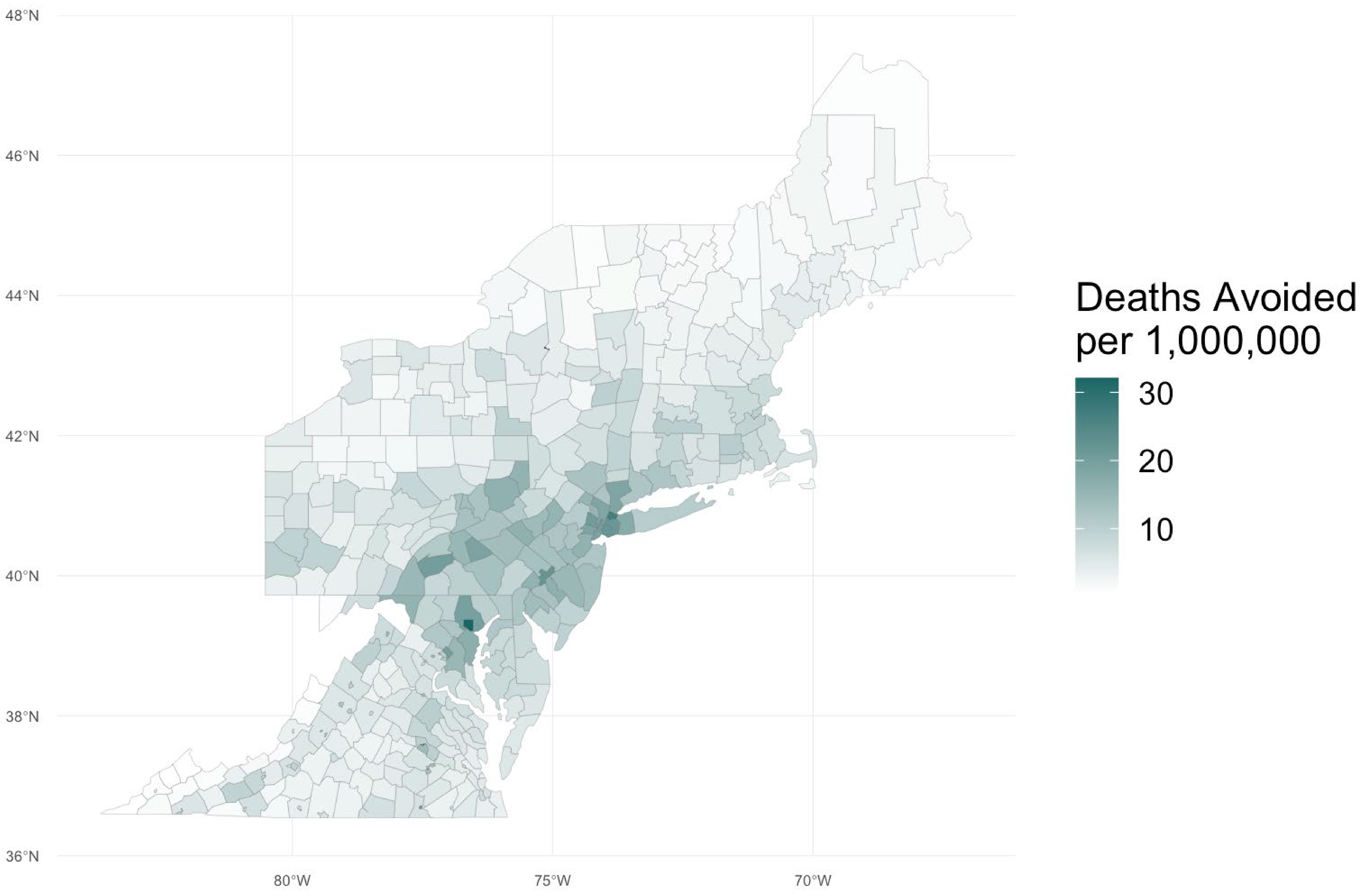


Map credit: C. Arter, S. Arunachalam.
Based on Arunachalam et al. In prep.

TRECH Project Preliminary Results

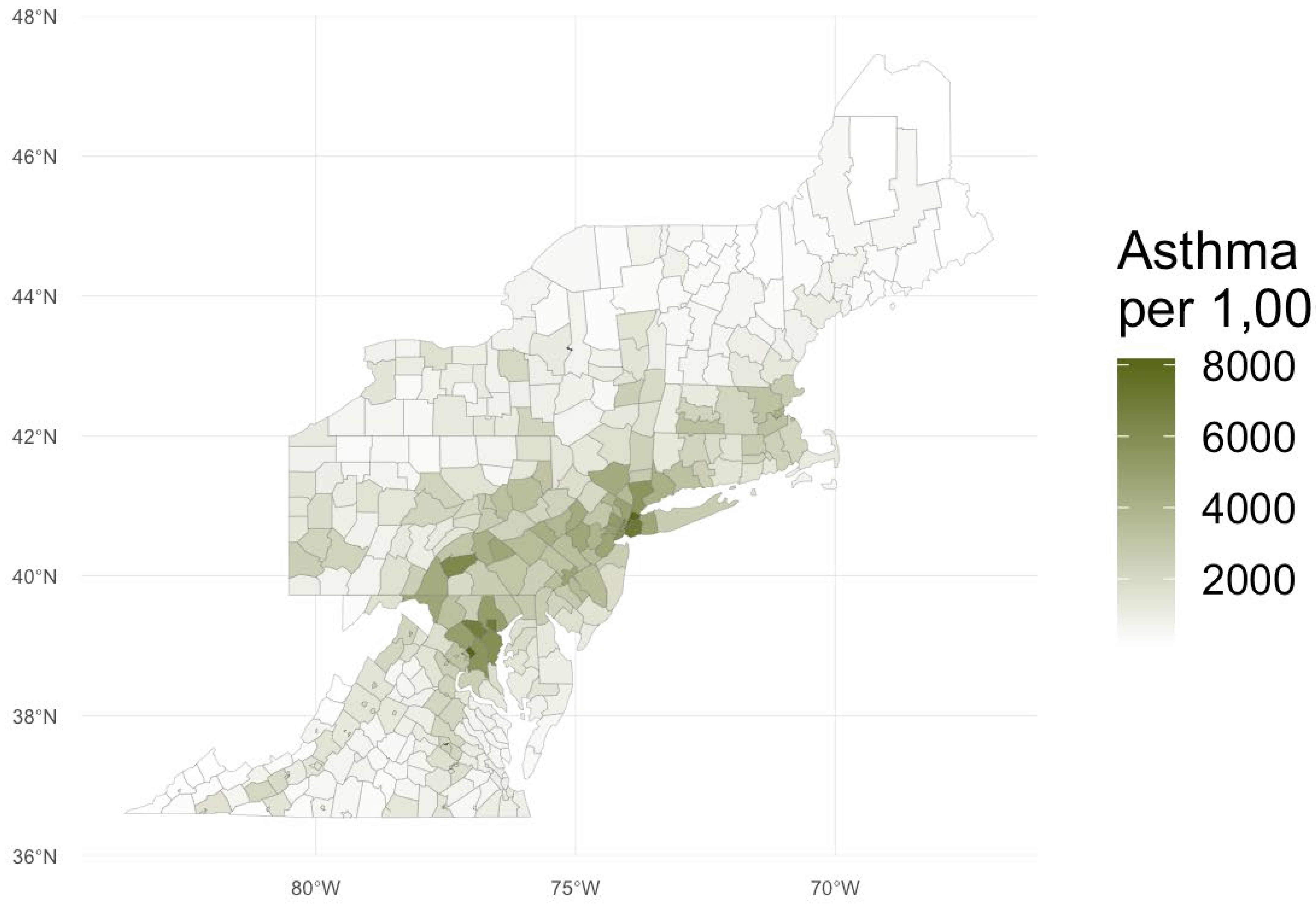
4. Maps of Estimated Deaths Avoided Per Million People from Air Quality Changes

Premature Deaths Avoided per 1,000,000
TCI Scenario A, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



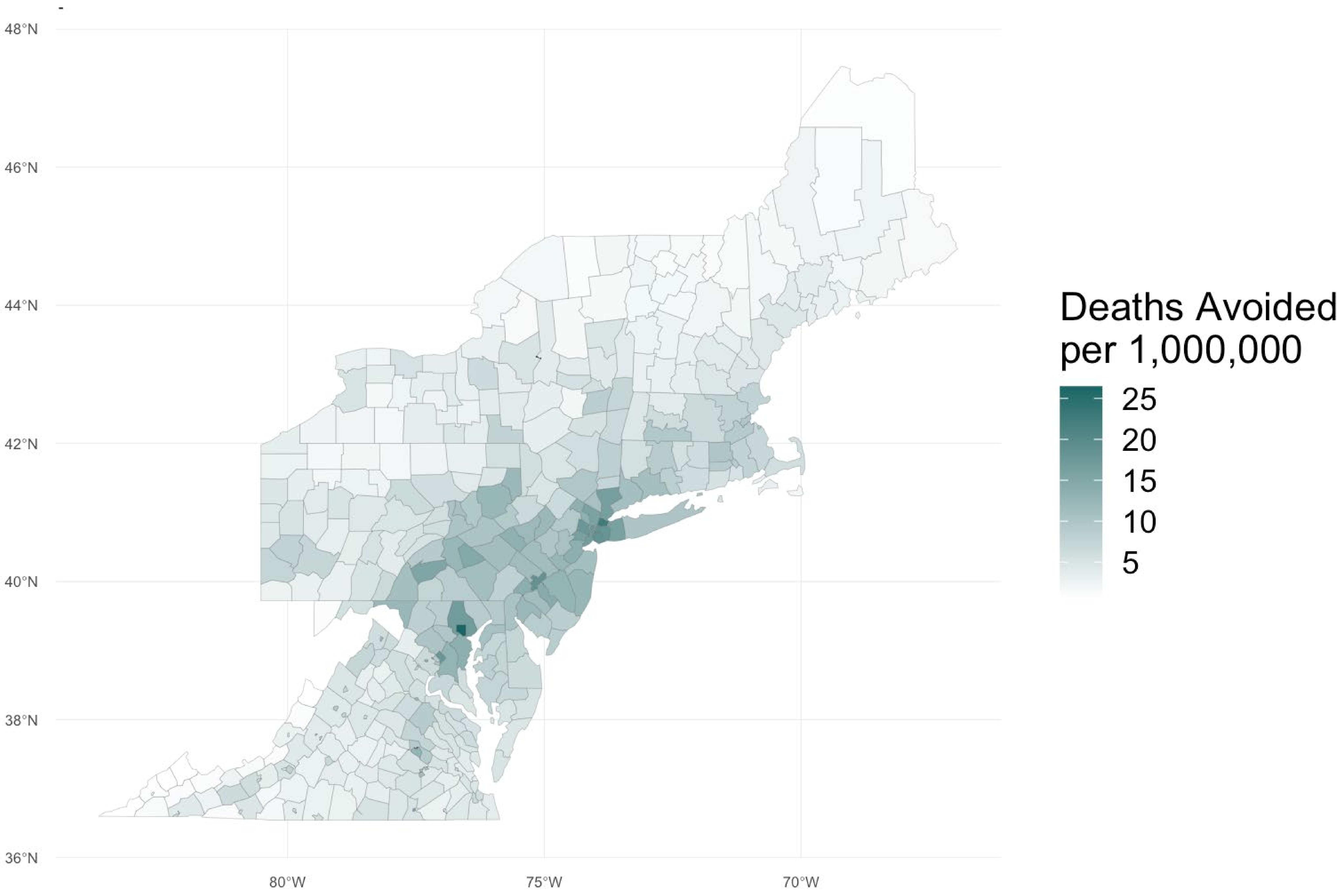
Map credit: J. Buoncore.

Childhood Asthma Exacerbations Avoided (ages 5 -17 yrs) per 1,000,000 People
TCI Scenario A, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



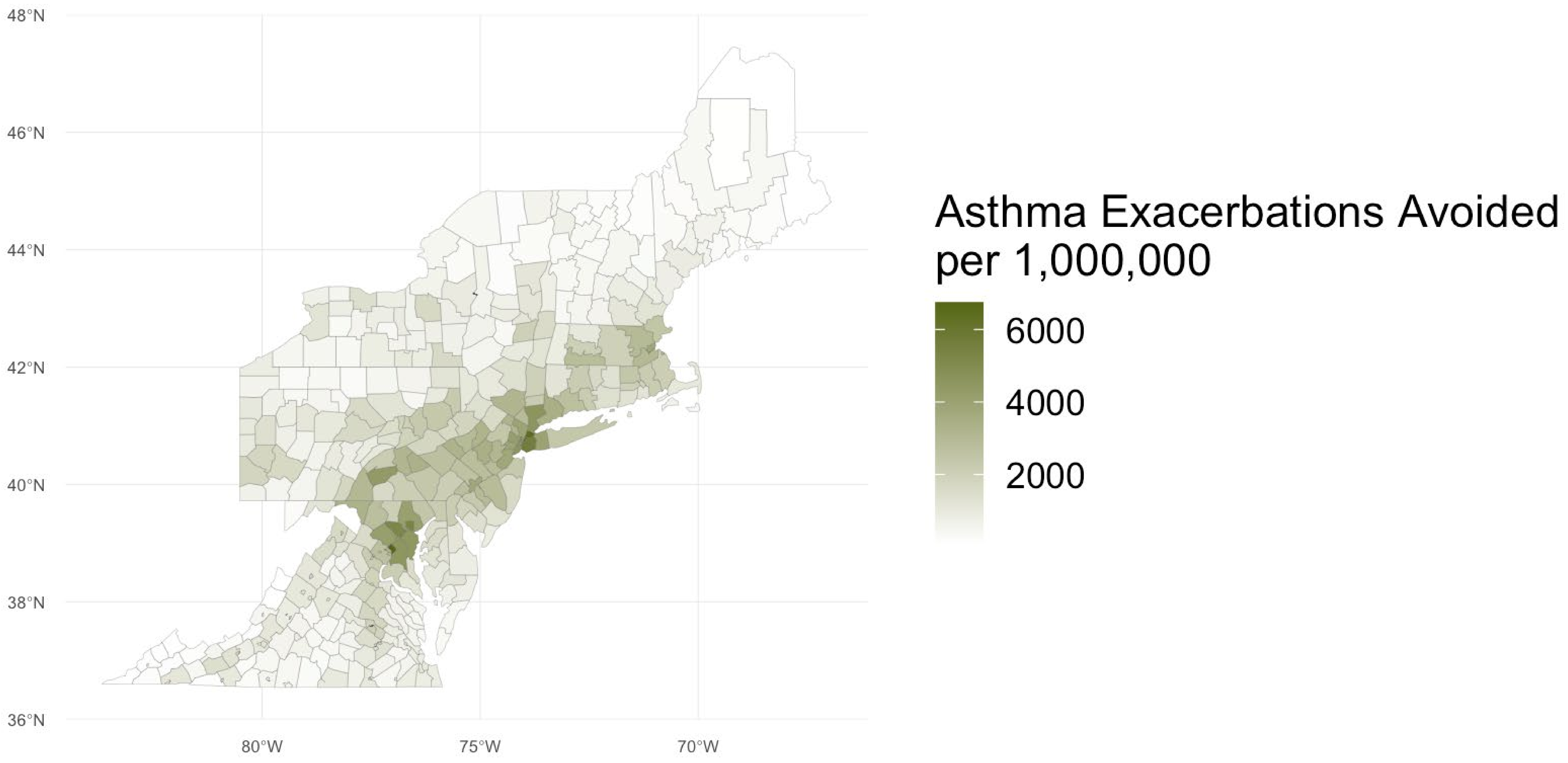
Map credit: J. Buoncore, F. Perera, A. Berberian.

Premature Deaths Avoided per 1,000,000
TCI Scenario B, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



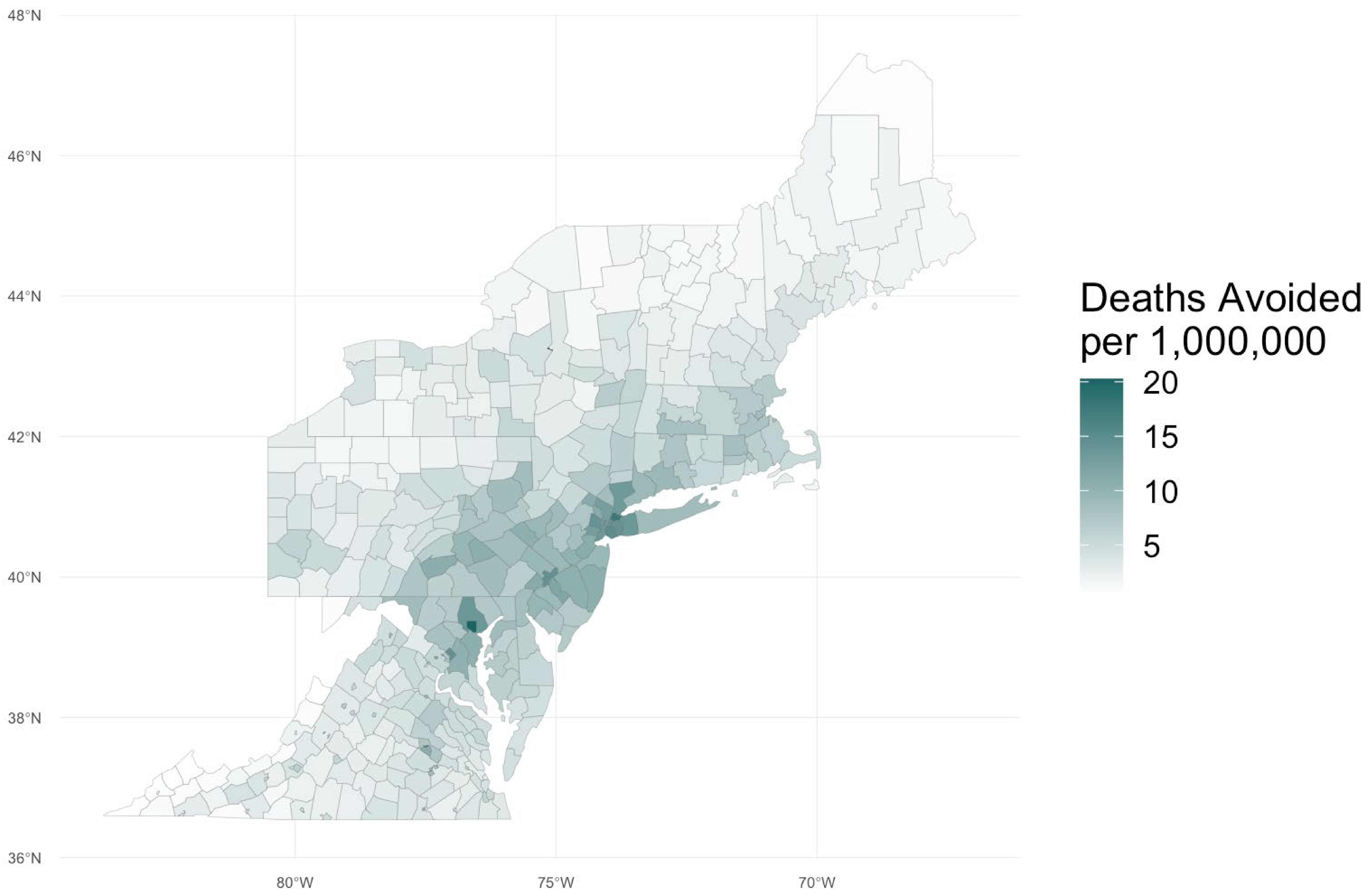
Map credit: J. Buoncore.

Childhood Asthma Exacerbations Avoided (ages 5 -17 yrs) per 1,000,000 People
TCI Scenario A, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



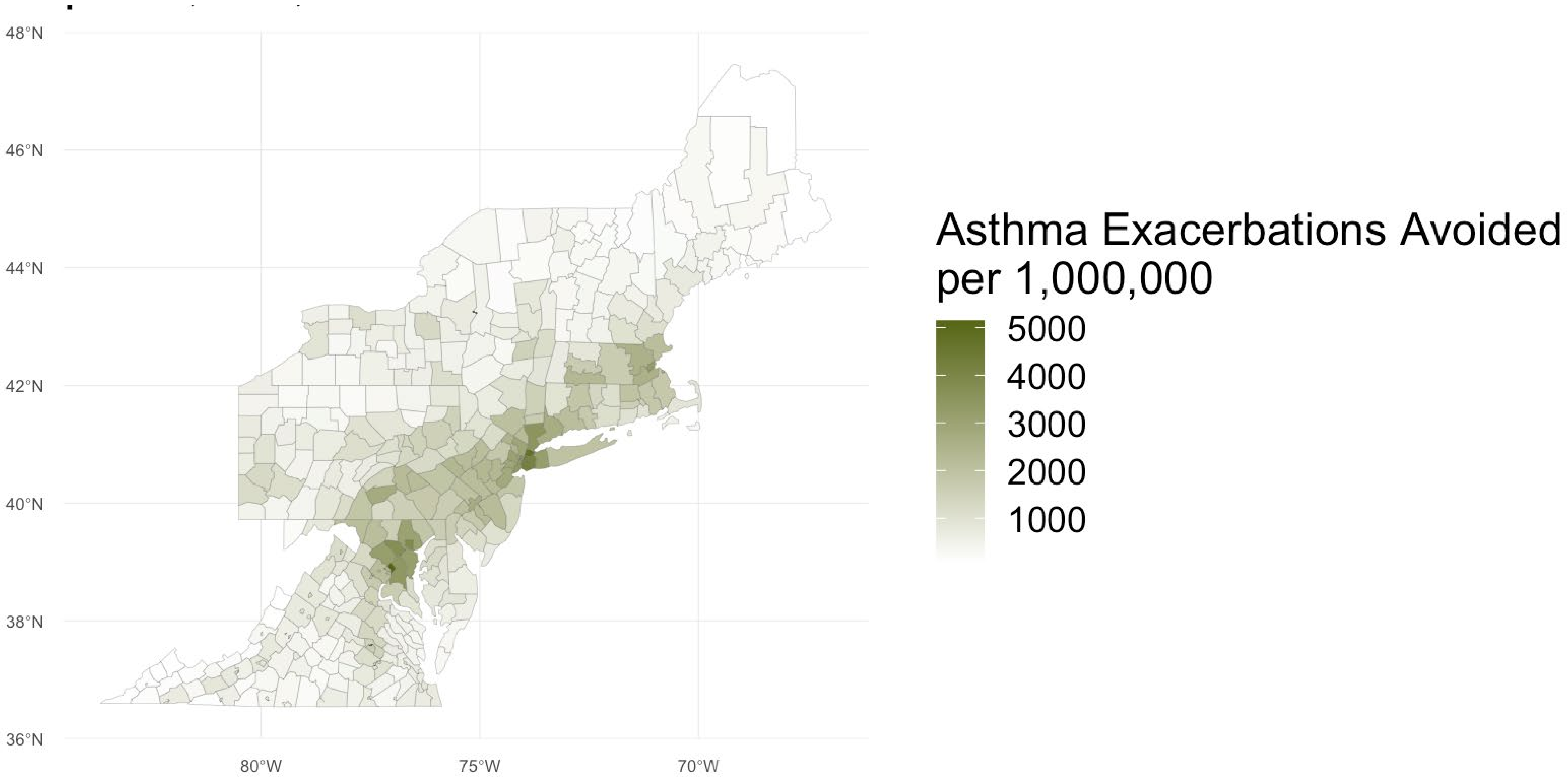
Map credit: J. Buoncore, F. Perera, A. Berberian.

Premature Deaths Avoided per 1,000,000
TCI Scenario C, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



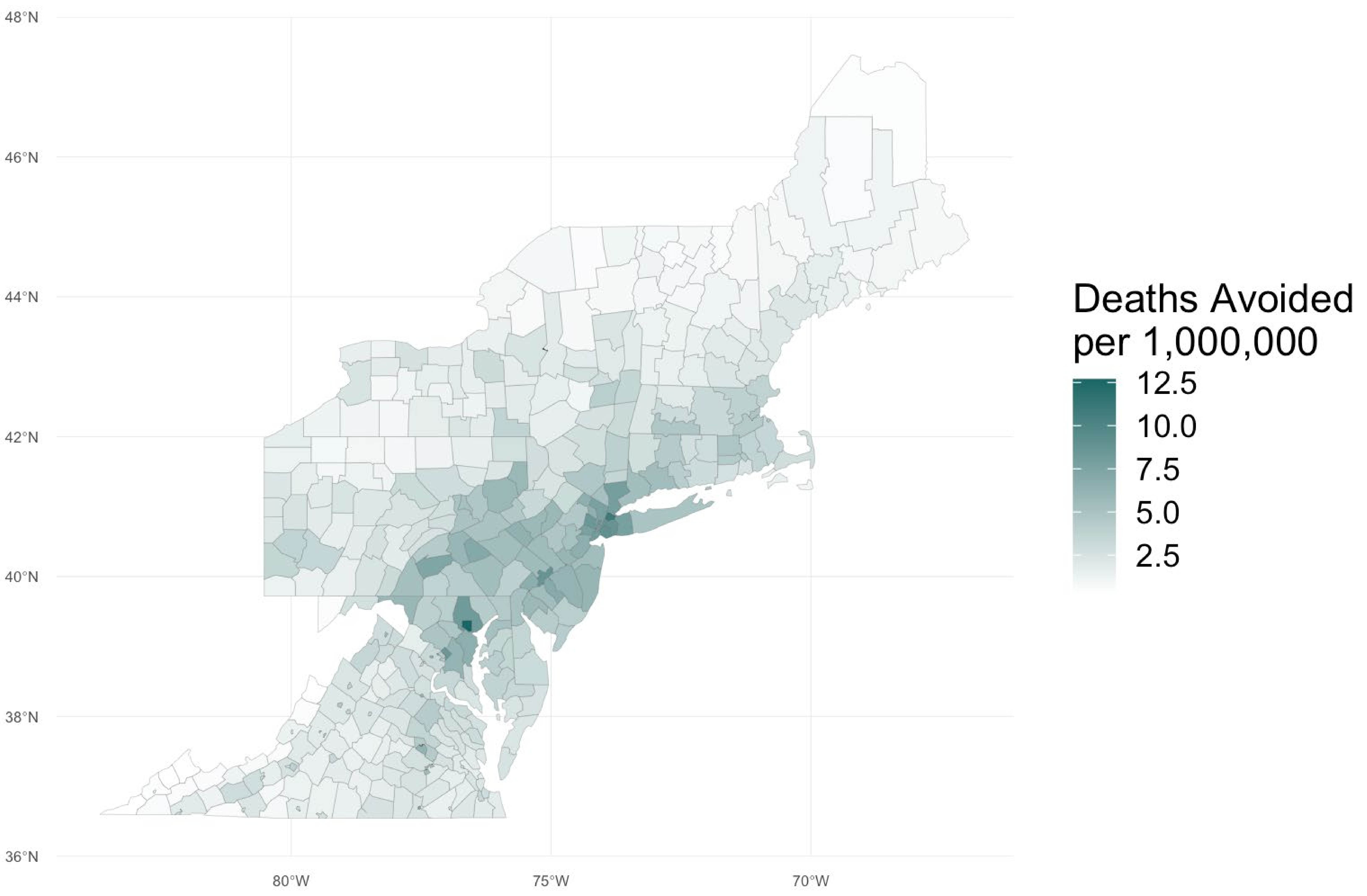
Map credit: J. Buoncore.

Childhood Asthma Exacerbations Avoided (ages 5 -17 yrs) per 1,000,000 People
TCI Scenario A, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



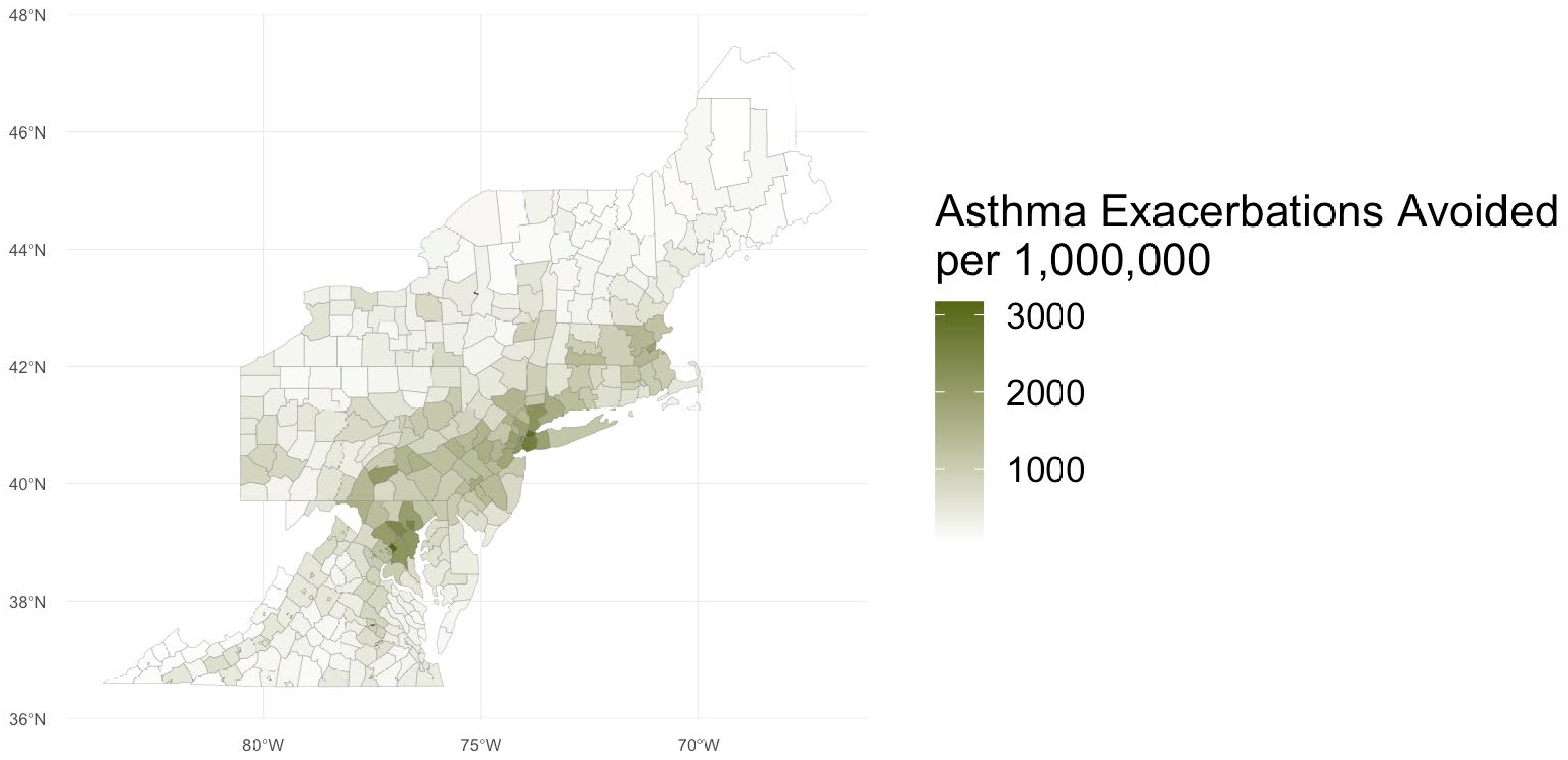
Map credit: J. Buoncore, F. Perera, A. Berberian.

Premature Deaths Avoided per 1,000,000
TCI Scenario B, 22% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



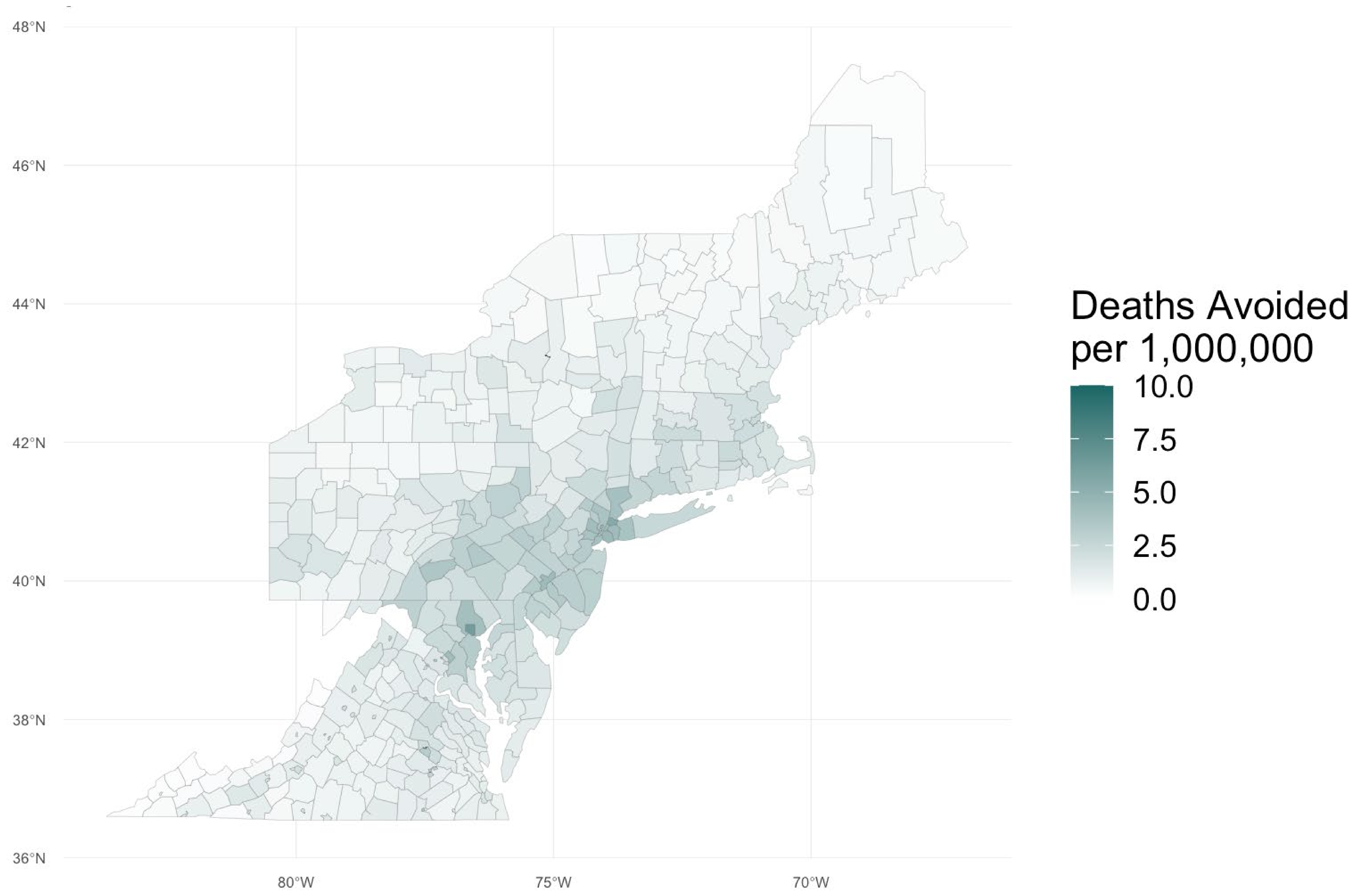
Map credit: J. Buoncore.

Childhood Asthma Exacerbations Avoided (ages 5 -17 yrs) per 1,000,000 People
TCI Scenario A, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



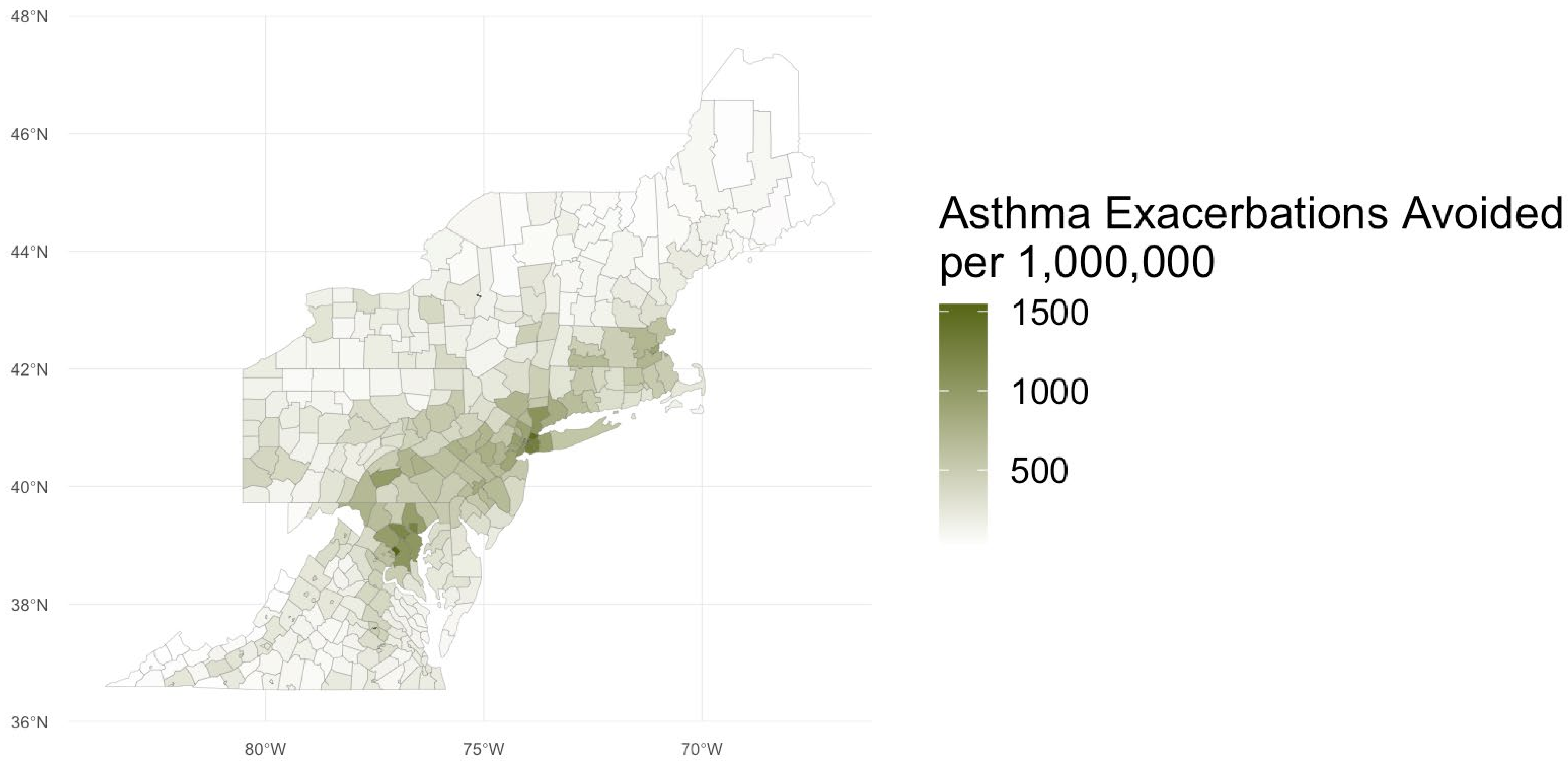
Map credit: J. Buoncore, F. Perera, A. Berberian.

Premature Deaths Avoided per 1,000,000
TCI Scenario B, 20% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



Map credit: J. Buoncore.

Childhood Asthma Exacerbations Avoided (ages 5 -17 yrs) per 1,000,000 People
TCI Scenario A, 25% CO_2 Reduction Cap Compared to a No-TCI Scenario in 2032



Map credit: J. Buoncore, F. Perera, A. Berberian.

5. Summary of Methods and Models

TRECH Project - Active Mobility Modeling

The active mobility work in the TRECH Project was led by Patrick Kinney, ScD of Boston University with Matthew Raifman (BU), Jon Levy, ScD (BU), and Kathy Fallon Lambert (Harvard C-CHANGE).

To estimate net deaths avoided from increased active mobility in the TRECH Project, the TRECH Project team has implemented an approach based on the World Health Organization's Health Economic Assessment Tool (HEAT) using the statistical computing language, R.

We converted the estimated change in miles traveled to minutes of additional activity and apply peer-reviewed population health epidemiological relationships between physical activity and reductions in premature mortality separately for walking and cycling activity. As the key input to the model, we use county-level estimates of the change in walking miles traveled and bicycling miles traveled for each of the investment scenarios that have been provided to the team by the Transportation Climate Initiative.

Additional inputs to the active mobility model include: county-level demographic information on age and population from the U.S. Census, and county-level mortality rates from CDC Wonder. We also assume that additional miles traveled walking and cycling will result in a small increase in traffic fatalities among these vulnerable road users. We estimate these net mortality benefits only for the adult population aged 20-64 for cycling and aged 20-74 for walking, based on the epidemiological relationships established in the academic literature. We used the value of a statistical life to estimate the monetized value of these mortality benefits.

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TRECH Project - Air Quality Modeling

The air quality work in the TRECH Project was led by Sarav Arunachalam, PhD of the University of North Carolina with Calvin Arter (UNC) and others on the team. The emissions-air quality platform used in the TRECH Project is a MOVES-SMOKE-CMAQ platform. The MOVES model and SMOKE processor generated estimates of gridded annual on-road emissions at a 12x12 km scale for five vehicle classes from representative summer and winter months for the entire eastern U.S., which is needed to estimate air quality changes within the TCI region. CMAQ ingests the MOVES-SMOKE outputs to produced 12x12 km gridded estimates of air pollution concentrations of $PM_{2.5}$, O_3, and NO_2 for the TCI region.

MOVES: The MOtor Vehicle Emission Simulator (MOVES) is a state-of-the-science emission modeling system from the U.S. EPA that estimates emissions for mobile sources at the national, county, and project level for criteria air pollutants, greenhouse gases, and air toxics.
- *Availability:* https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves.
- *Version Used:* MOVES 2014b
- *Documentation:* http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NNCY.pdf

SMOKE: The Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system is an emissions processor for CMAQ that takes emissions inventories in different formats and prepares them in a form that CMAQ can use by performing chemical speciation, temporal allocation and spatial allocation.
- *Availability:* https://www.cmascenter.org/smoke/
- *Version Used:* SMOKE v4.7
- *Documentation:* https://www.cmascenter.org/smoke/documentation/4.7/manual_smokev47.pdf
- Reference: Houyoux, M. R., Vukovich, J. M., Coats, J. C. Jr., Wheeler, N. J. M., & Kasibhatla, P. S. (2000). Emission inventory development and processing for the seasonal model for regional air quality (SMRAQ) project. Journal of Geophysical Research, 105(D7), 9079–9090. https://doi.org/10.1029/1999JD900975

CMAQ: The Community Multiscale Air Quality (CMAQ) model is a state-of-the-science comprehensive air quality model that takes into account current knowledge of the complex physical and chemical processes in the atmosphere and computing technologies to predict ozone, aerosols, toxics and acid deposition using a one-atmosphere approach. CMAQ is developed primarily by the EPA, and used extensively both within and outside the U.S. for various scientific and regulatory applications.
- *Availability:* https://www.cmascenter.org/cmaq/
- *Version Used:* CMAQ v5.2
- *Documentation:* https://github.com/USEPA/CMAQ/tree/master/DOCS/Users_Guide
- *Reference:* Byun, D. W., and K. L. Schere, 2006: Review of the governing equations, computational algorithms, and other components of the Models-3 Community Multiscale Air Quality (CMAQ) Modeling System. *Appl. Mech. Rev.*, 59, 51-77.

TRECH Project - Health Impact Modeling

The air quality-related health and health equity analysis was led by Jon Levy, ScD (Equity; Boston University), Jonathan Buonocore, ScD (health assessment; Harvard Chan C-CHANGE), and Frederica Perera, PhD (health assessment; Columbia University) with Laura Buckley (BU), Alique Berberian (Columbia), Kathy Fallon Lambert (Harvard Chan C-CHANGE) and others on the team.

The health impact assessment tool used here is a version of BenMAP (from the U.S. EPA) but modified to work in in the statistical computing language R – and is called BenMAPR. It is a geospatial framework for performing air pollution health impact assessments, and combines the core functionality of EPA's BenMAP with the flexibility and data processing power of R. BenMAPR spatially overlays changes in ambient air pollution due to policies, infrastructure changes, or other changes to emissions sources, with data on population and background rates of air pollution relevant health outcomes. It then uses relationships from the epidemiological literature between changes in air pollution exposure and health impacts to calculate the health impacts or benefits of changes in air pollution exposure.

- BenMAP – https://www.epa.gov/benmap
- Mortality data from the Centers for Disease Control (CDC) Wide ranging Online Data for Epidemiological Research (WONDER) – https://wonder.cdc.gov/mortSQL.html
- Asthma rates from the Centers for Disease Control (CDC) National Environmental Public Health Tracking – https://www.cdc.gov/nceh/tracking/index.html
- Hospitalization data from the Health Care Utilization Project – https://www.ahrq.gov/data/hcup/index.html

TRECH Project – Scenario Assumptions

For more details on the illustrative TCI Policy Scenarios, see:

TCI reference case and policy scenario assumptions

For more details on the approach to estimating changes in vehicle miles and personal miles traveled based on TCI investments, see:

TCI strategy investment tool