It Takes Energy to Clean the Air, But at What Benefit?

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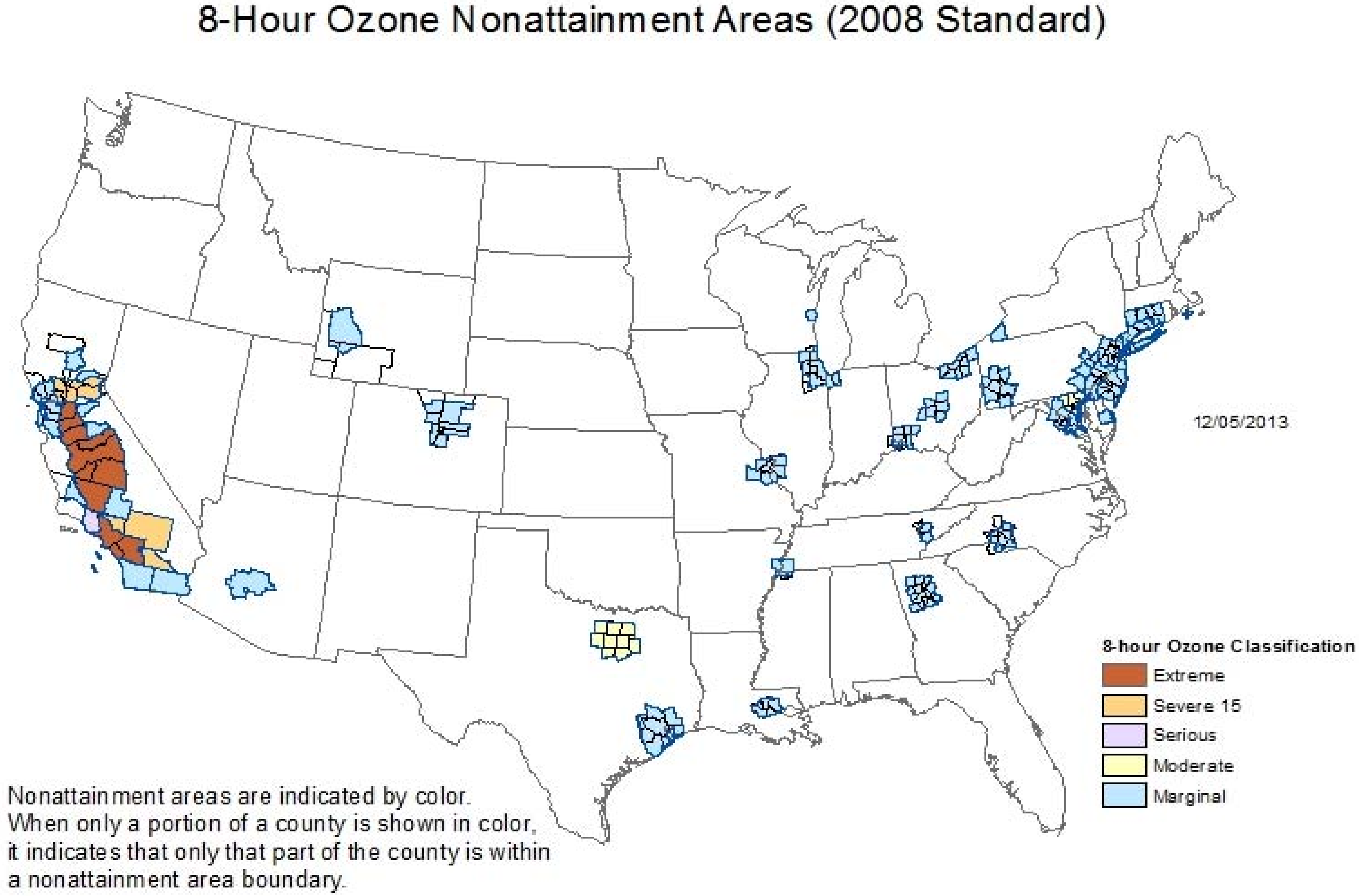
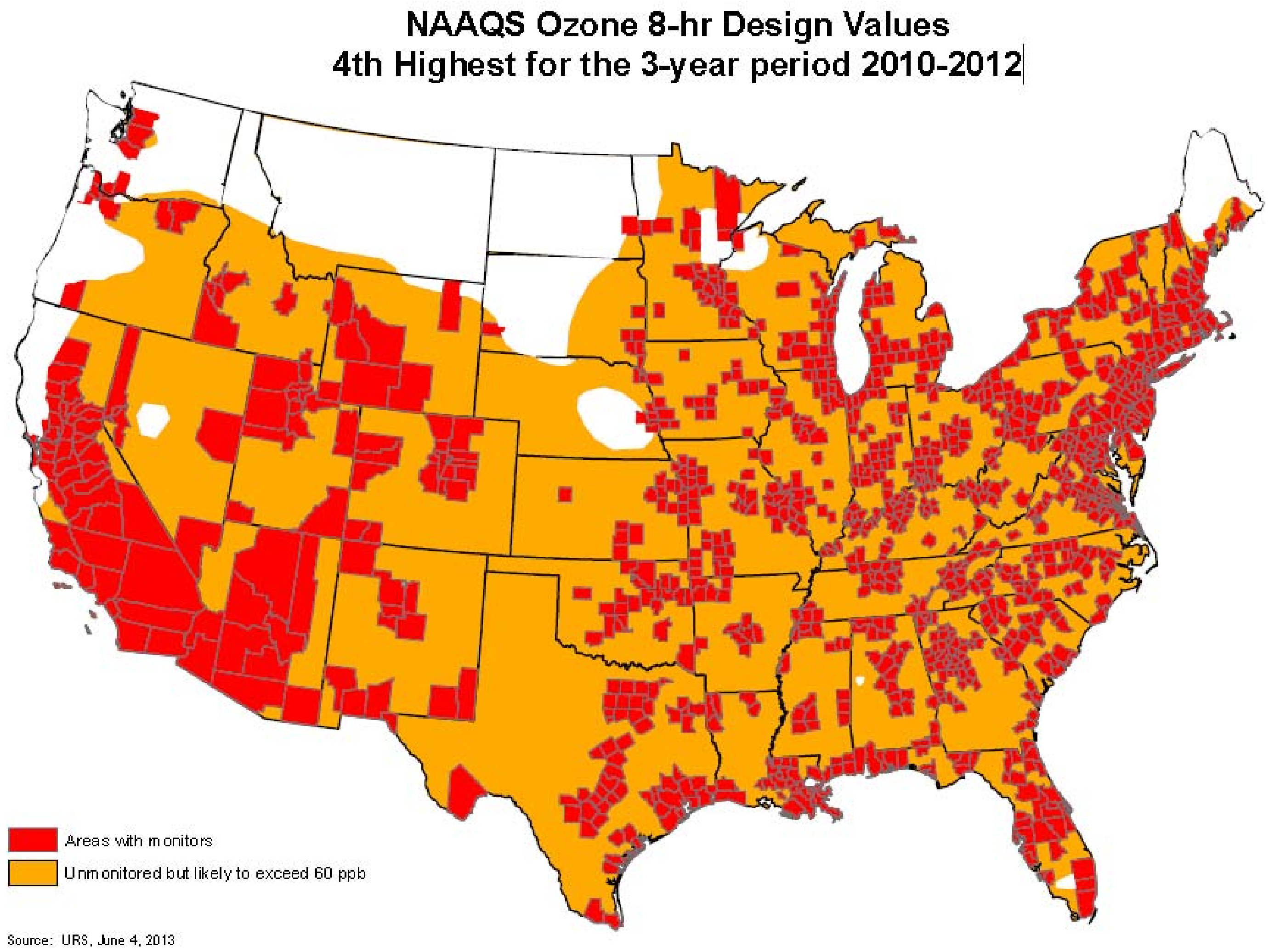
New Ozone Standard Coming

- Primary
  - 75ppb 8hr → 70 ppb to 60 ppb
- Secondary
- Proposal – December
- Final – October 2015

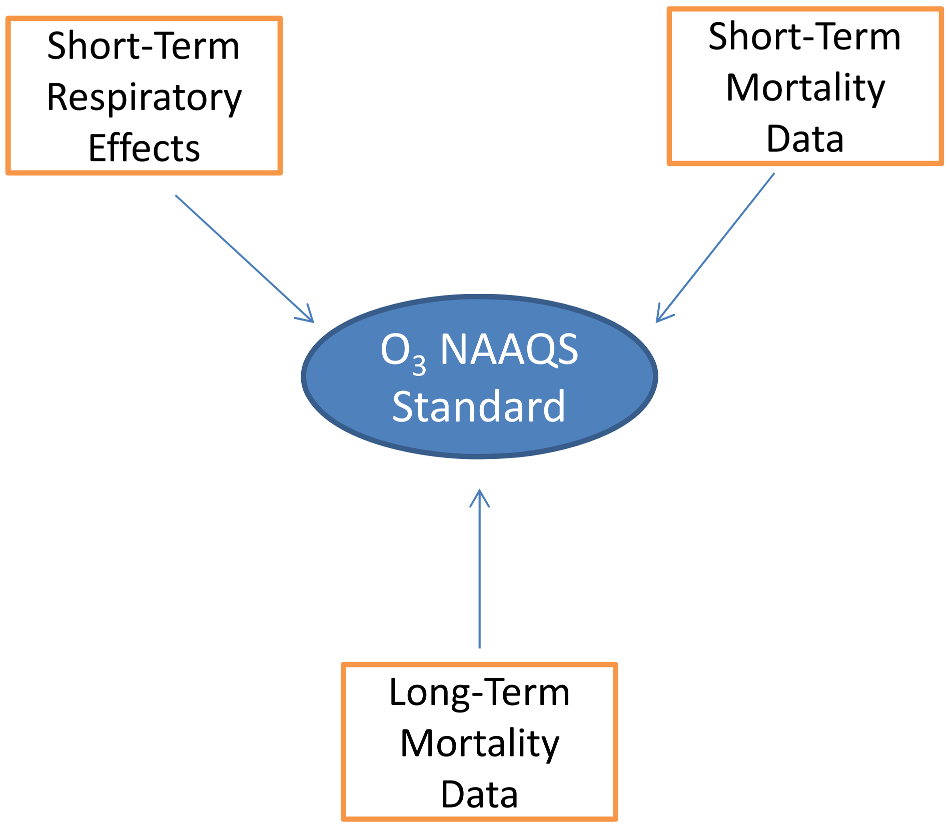
We could go from this…



…to this.


NAAQS Ozone 8-hr Design Values
4th Highest for the 3-year period 2010-2012
Areas with monitors
Unmonitored but likely to exceed 60 ppb
Source: URS, June 4, 2013

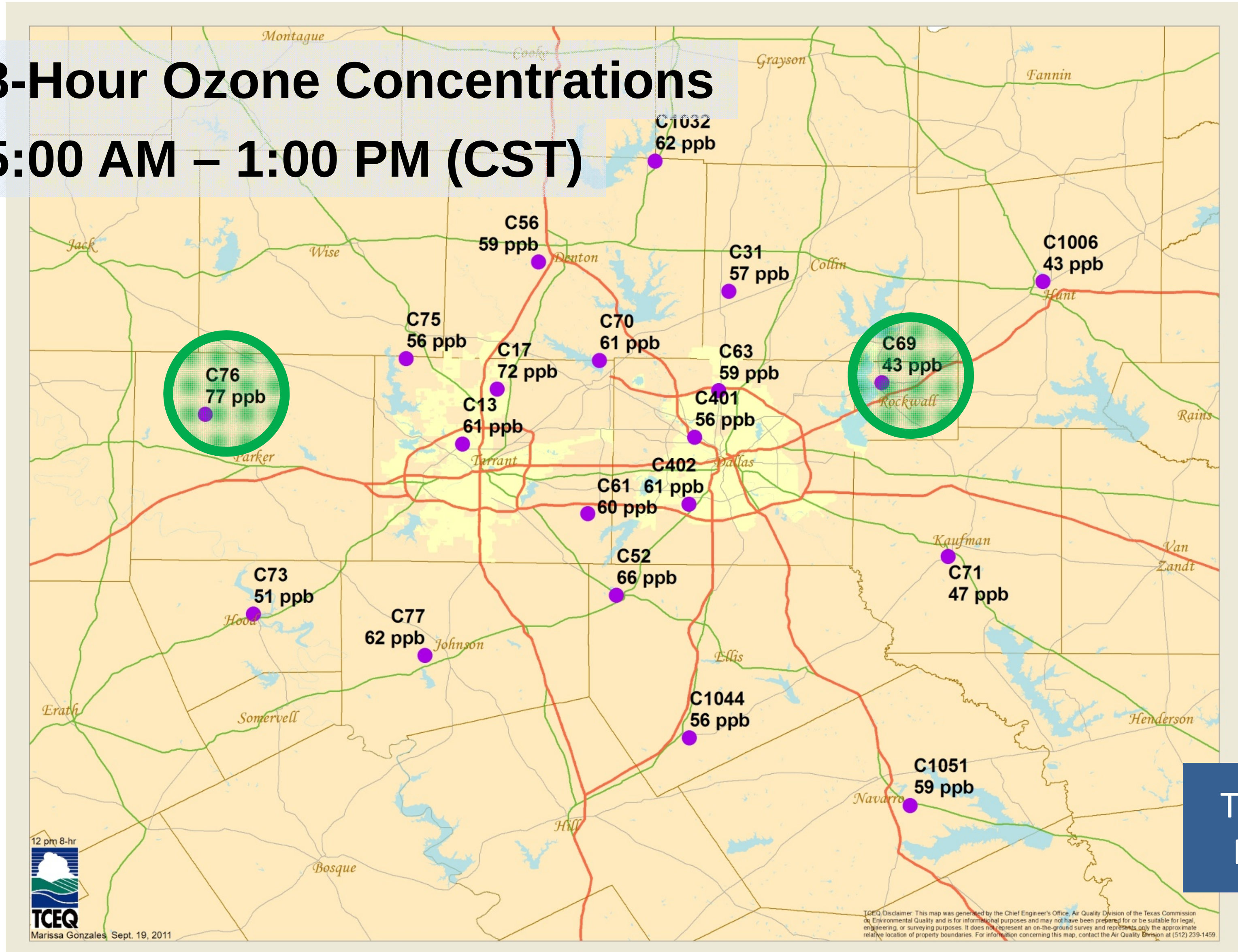
Health Bases of the O_3 NAAQS



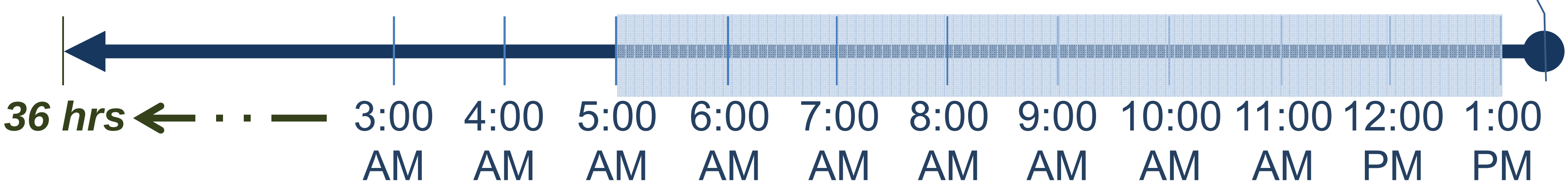
Ecological Epidemiology Studies

- Collect death certificates from non-accidental deaths
- Date/Time of death
- Collect ozone (PM, SO_2, etc.) levels (1-hr, 8-hr, 24-hr) for time periods preceding death. Repeat going back in time for (typically) 36 hours.
- Correlate changes in ozone (or other pollutant) concentration with changes in mortality

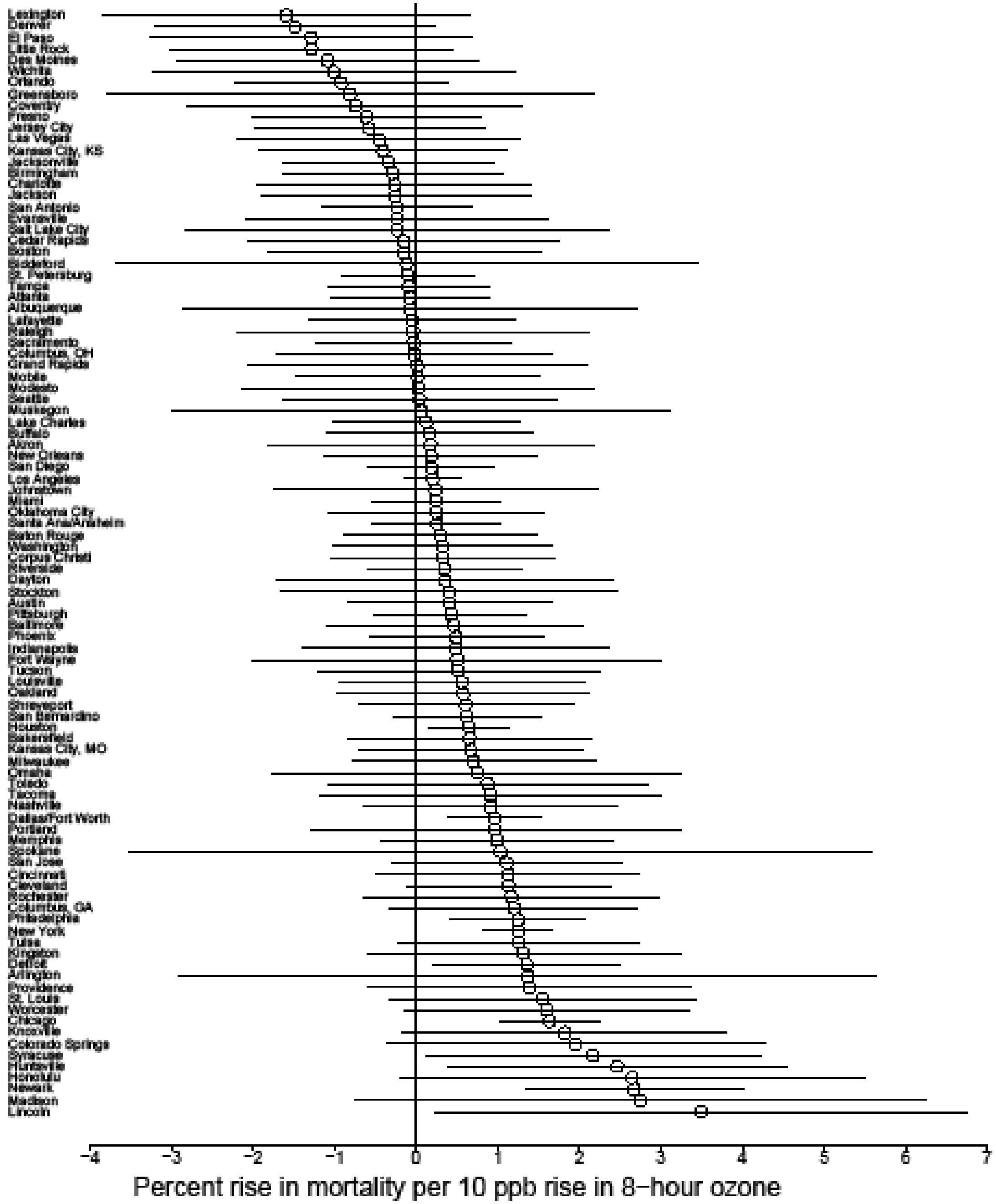
8-Hour Ozone Concentrations
5:00 AM – 1:00 PM (CST)



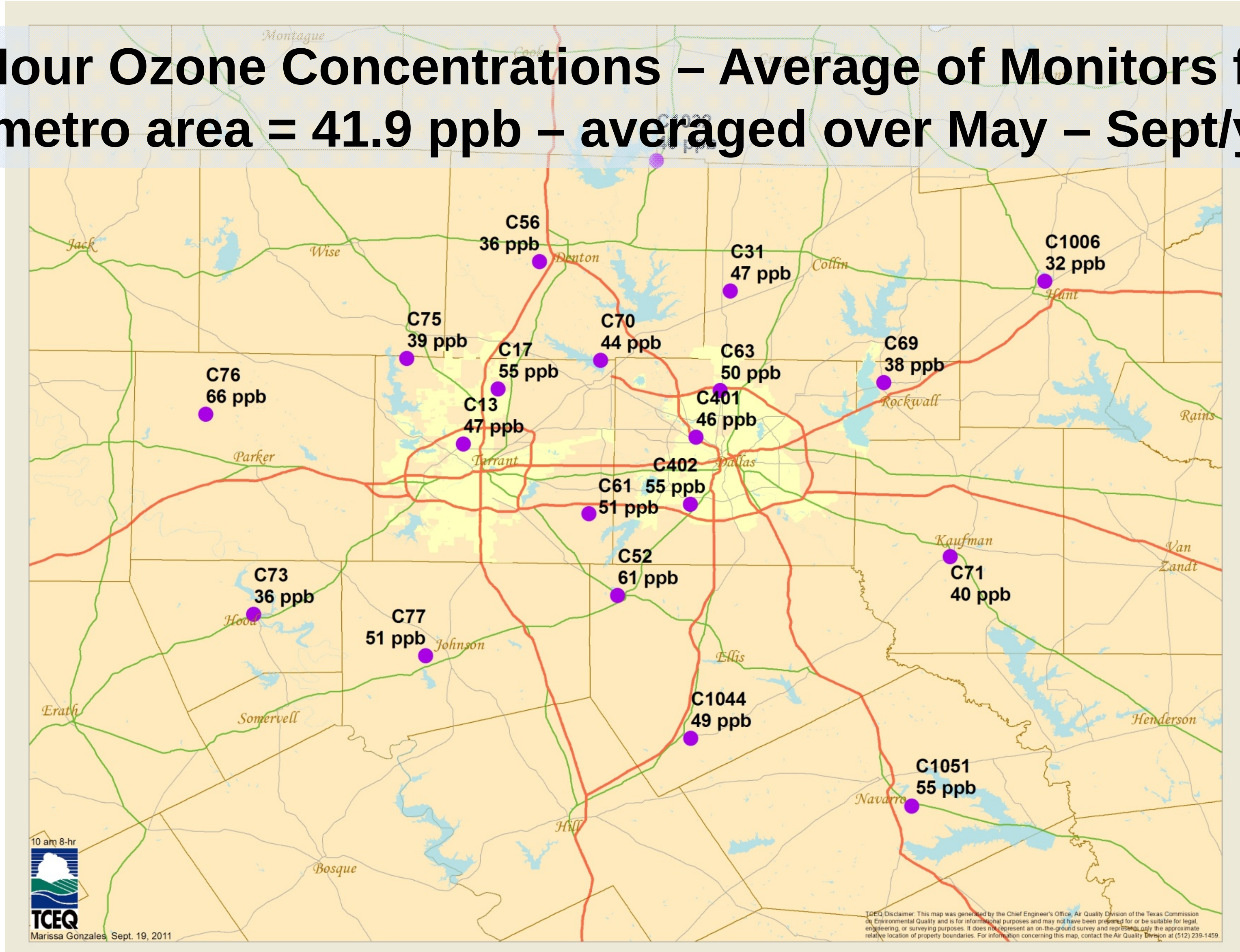
Time of Death



8-HOUR OZONE-MORTALITY COEFFICIENTS
RAW ESTIMATES AND 95% CONFIDENCE INTERVALS



8-Hour Ozone Concentrations – Average of Monitors for metro area = 41.9 ppb – averaged over May – Sept/yr



Average ozone concentration over the 23 year period

1977

Year of Death

2000

Long-Term O_3 and Mortality I

Table 1 Epidemiology Studies of Long-term Ozone Exposure and Mortality

Study	Cohort	*n*	Time Period of		Seasonal or All Year	Ozone Metric	Outcome	Copollutant(s) in Model	Risk Measure	Unit of Measure	Estimate	95% Confidence Interval
			Mortality Analysis	Ozone Data								
Dockery *et al.* (1993)	Harvard Six Cities cohort (US)	8.9 mil.	1974-1989	1977-1985	All year	NR	All-cause	None	Rate ratio	Varied	1.0-1.28[a]	NR
Abbey *et al.* (1999)	AHSMOG cohort of non-smokers (CA)	6,338	1982-1998	1982-1998	All year	Monthly avg.	Lung cancer	None	RR (M)	Per 12 ppb; >100 ppb	4.19	1.81-9.69
									RR (F)		1.39	0.52-3.67
							NM lung		RR (M)		1.20	0.88-1.47
									RR (F)		1.01	0.77-1.33
							Cardiopulmonary		RR (M)		1.06	0.88-1.29
									RR (F)		0.88	0.75-1.02
							All natural causes		RR (M)		1.14	0.98-1.32
									RR (F)		0.90	0.80-1.02
Lipfert *et al.* (2000)	US veterans cohort, 31 cities	50,000	1975-1981	1975-1981	All year	Current peak[b]	All-cause mortality	None	RR	Per 1000 ppb	1.10[c]	1.00-1.20
						Peak, delayed[b]					1.00[c]	0.99-1.01
Pope *et al.* (2002)	ACS cohort, 134 metropolitan areas	500,000	1982-1998	1980-1998	All year	1-hr max	All other causes[d]	None	RR	N/A	0.98	0.90-1.05
					July-Sept						1.00	0.95-1.05
					All year		All-cause[d]				1.01	0.95-1.10
					July-Sept						1.05	0.98-1.11
					All year		Cardiopulmonary[d]				1.10	0.95-1.21
					July-Sept						1.11	0.99-1.20
					All year		Lung cancer[d]				0.90	0.80-1.10
					July-Sept						0.95	0.85-1.10
Chen *et al.* (2005)	AHSMOG cohort (CA)	3,239	1973-1998	1977-1998	All year	Monthly avg.	Coronary heart disease	None	RR (M)	Per 10 ppb	0.89	0.60-1.30
									RR (F)		0.97	0.68-1.38
Jerrett *et al.* (2005)	ACS, 86 metropolitan areas (US)	22,905	1982-2000	1999-2001	All year	Peak	All-cause	None	RR	N/A	0.98	0.96-1.01
						Max 8-hr[e]					0.99	0.98-1.01
						Peak	IHD				0.97	0.93-1.02
						Max 8-hr[e]					0.98	0.95-1.02
						Peak	Cardiopulmonary				0.97	0.94-0.99
						Max 8-hr[e]					0.99	0.96-1.01
						Peak	Lung cancer				0.99	0.91-1.07
						Max 8-hr[e]					0.97	0.91-1.03
Lipfert *et al.* (2006a)	US Veterans cohort, 31 cities	70,000	1997-2001	1997-2001	All year	Peak	All-cause	None	RR	Per 1 ppb	1.25	NR
						24-hr avg.		None			0.82	NR
						Peak		$PM_{2.5}$			1.18	NR
Lipfert *et al.* (2006b)	US Veterans cohort, 31 cities	70,000	1989-2001	1989-1996	All year	Peak	All-cause	None	RR	Per 40 ppb	1.094	1.03-1.16
								TD			1.080	1.02-1.15
			1997-2001	1999-2001	All year, counties with NO_2 data			None		Per 38 ppb	1.035	0.92-1.17
								TD			1.033	0.92-1.16

Long-Term O_3 and Mortality II

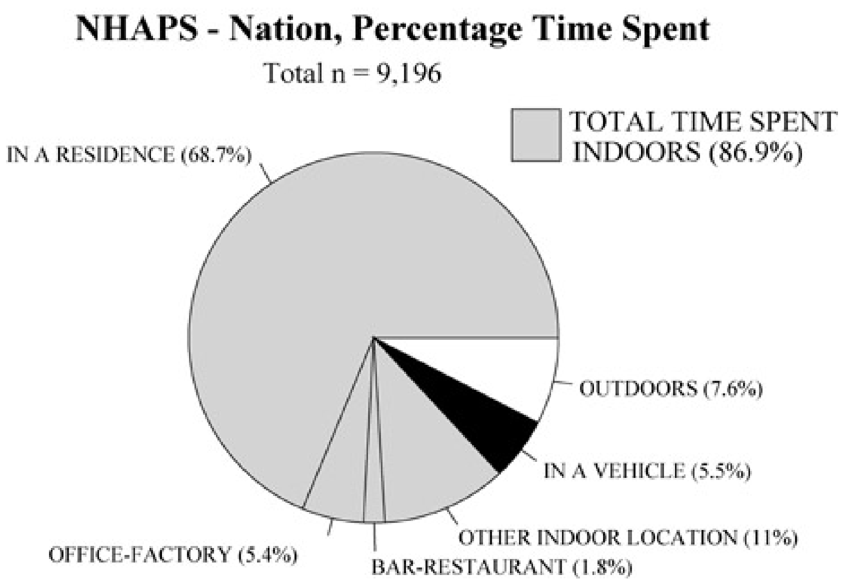
Study	Cohort	*n*	Time Period of: Mortality Analysis	Time Period of: Ozone Data	Seasonal or All Year	Ozone Metric	Outcome	Copollutant(s) in Model	Risk Measure	Unit of Measure	Estimate	95% Confidence Interval
Jerrett *et al.* (2009)	ACS cohort, 86 metropolitan areas (US)	448,850	1982-2000	1977-2000; 1999-2000 (PM)	Summer only (April-Sept)	1-hr max	All-cause	None	RR[f]	Per 10 ppb	1.001	1.00-1.01
								PM	RR		0.989	0.98-1.00
							Cardiopulmonary	None			1.016	1.01-1.02
								PM			0.992	0.98-1.00
							Respiratory	None			1.027	1.01-1.05
								PM			1.040	1.01-1.07
							CV	None			1.014	1.01-1.02
								PM			0.983	0.97-0.99
							IHD	None			1.017	1.01-1.03
								PM			0.973	0.96-0.99
Krewski *et al.* (2009)	ACS cohort, 116 metropolitan areas	1.2 mil	1982-2000	1980	All year	8-hr max	All-cause	None	HR	Per 10 ppb	1.00	0.99-1.01
					Summer (April-Sept)						1.02	1.01-1.02
					All year			$PM_{2.5}$			0.99	0.98-1.01
					All year		Cardiopulmonary	None			1.01	1.00-1.03
					Summer (April-Sept)						1.03	1.02-1.04
					All year			$PM_{2.5}$			0.99	0.96-1.01
					All year		IHD	None			1.01	0.98-1.03
					Summer (April-Sept)						1.01	0.99-1.02
					All year			$PM_{2.5}$			0.98	0.95-1.02
					All year		Lung cancer	None			1.00	0.96-1.04
					Summer (April-Sept)						0.99	0.96-1.02
					All year			$PM_{2.5}$			0.97	0.91-1.03
					All year		All other causes	None			0.99	0.97-1.00
					Summer (April-Sept)						1.01	1.00-1.02
					All year			$PM_{2.5}$			1.04	0.99-1.14
Smith *et al.* (2009)	ACS cohort, 66 cities	352,000	1982-2000	NR	Warm season (second and third quarters)	8-hr max	All-cause	None	RR	Per 10 ppb	1.01[c]	1.00-1.23
								Carbon and sulfate			1.00[c]	0.99-1.01
								Carbon			1.00[c]	0.99-1.02
				2003-2005			Cardiopulmonary	None			1.03[d]	1.01-1.05
								Carbon and sulfate			1.02[d]	1.01-1.04
								Carbon			1.02[c]	1.00-1.04
Wang *et al.* (2009)	Cohort in Brisbane, Australia	887,955	1996-2004	1996-2004	All year	1-hr max	Cardiorespiratory	None		Per 1 ppb	1.002	0.99-1.02
								NO_2 and SO_2			0.999	0.99-1.01

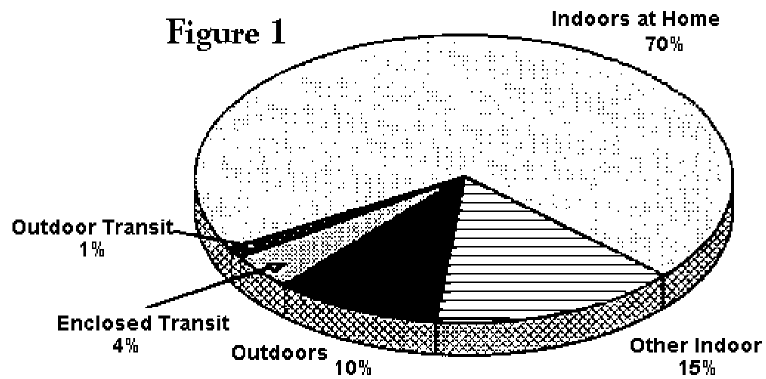
Only for temperatures >82°F, NOT in US regions with highest ozone concentrations (Southern CA) NOR in areas with highest respiratory deaths (NE and Industrial MW).

Time Spent Outdoors

Adult = 7.6%

Child = 10%





Workers = 60%

Epidemiology studies assume 24/7 (100%) exposure to ambient air

Personal Exposure

At ambient air monitor

Dose is 100% of
Measured Concentration

E.g. 80 ppb

Outdoors, under a tree

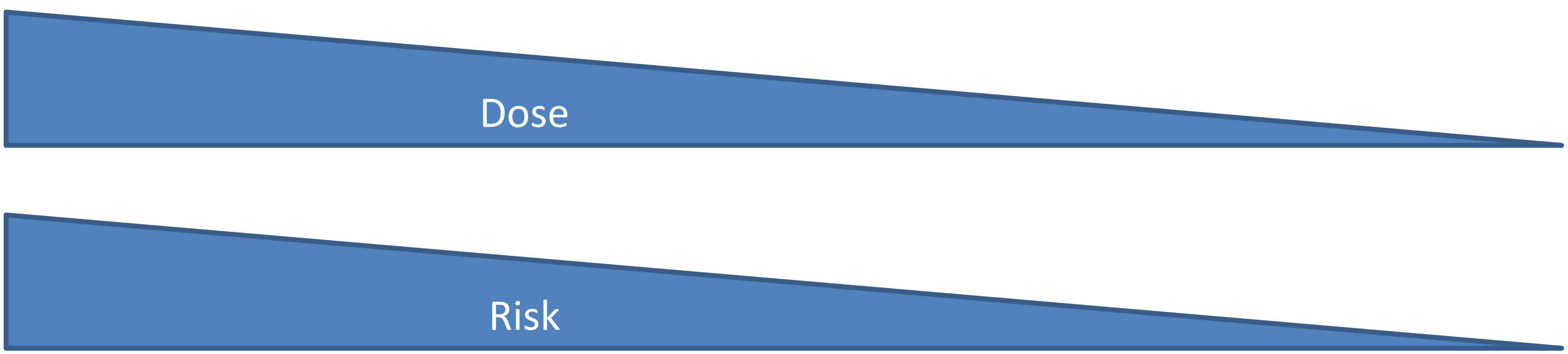
Dose is ~20-80% of
Measured Concentration

E.g. 40 ppb

Indoors

Dose is ~10% of
Measured Concentration

E.g. 8 ppb

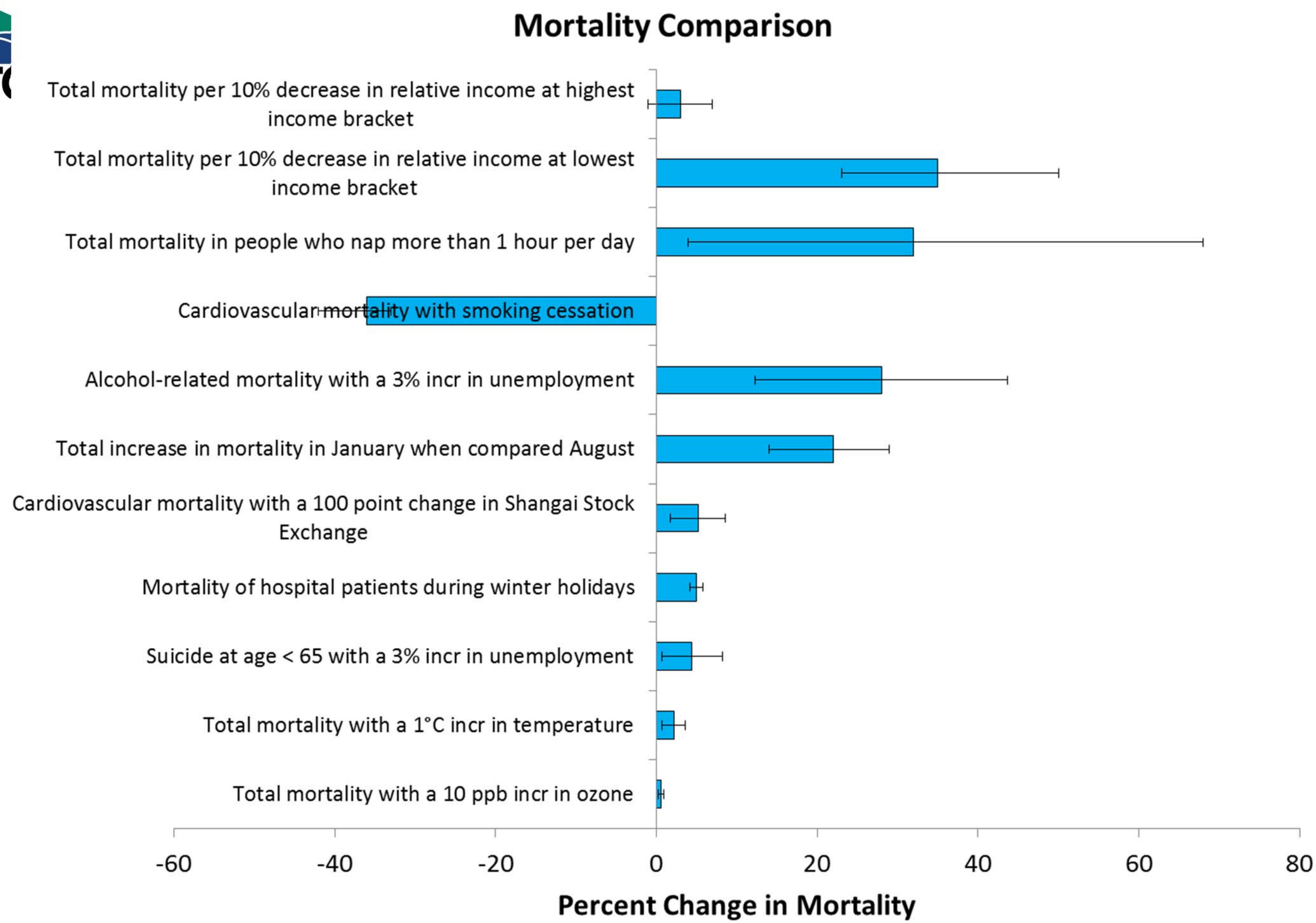


Exposure

- Personal Exposure vs. Ambient Exposure
  - Personal exposure is 10 - 20% of Ambient Exposure

> "The Ozone Staff Paper should consider the problem of exposure measurement error in ozone mortality time-series studies. It is known that personal exposure to ozone is not reflected adequately, and sometimes not at all, by ozone concentrations measured at central monitoring sites….Therefore, it seems unlikely that the observed associations between short-term ozone concentrations and daily mortality are due solely to ozone itself." CASAC ozone review panel – June 5, 2006

  - Yet ozone concentrations from central monitoring stations are the basis for the ozone standard



Mortality Comparison
Total mortality per 10% decrease in relative income at highest income bracket
Total mortality per 10% decrease in relative income at lowest income bracket
Total mortality in people who nap more than 1 hour per day
Cardiovascular mortality with smoking cessation
Alcohol-related mortality with a 3% incr in unemployment
Total increase in mortality in January when compared August
Cardiovascular mortality with a 100 point change in Shangai Stock Exchange
Mortality of hospital patients during winter holidays
Suicide at age < 65 with a 3% incr in unemployment
Total mortality with a 1°C incr in temperature
Total mortality with a 10 ppb incr in ozone
-60
-40
-20
0
20
40
60
80
Percent Change in Mortality

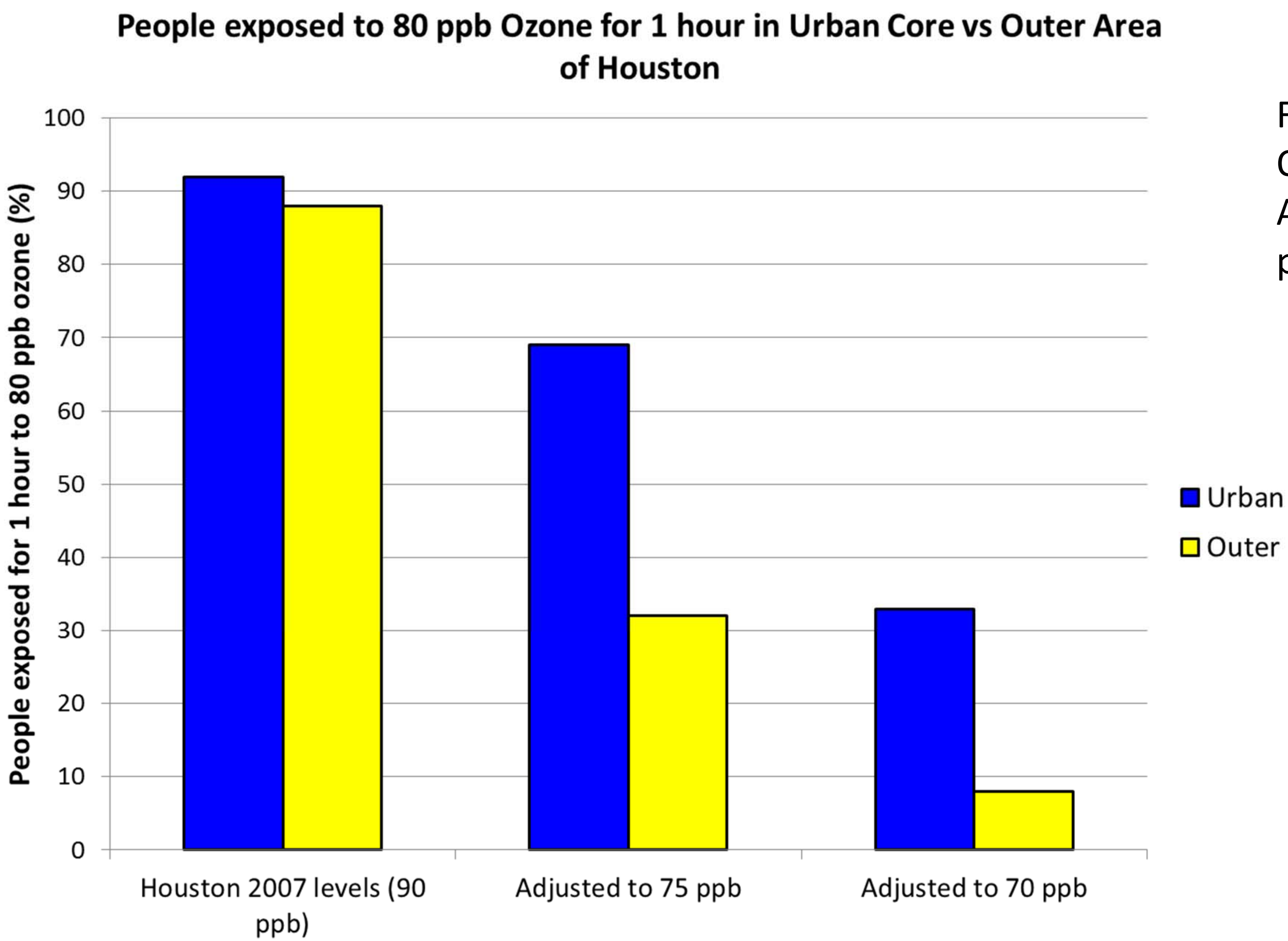
Texas Data

Houston (2009)

Lowering ozone levels ***INCREASES*** the number of deaths predicted to occur

	Impact	Net Impact
Simulate meeting 75 ppb	47 more	47
70 ppb	1 more	48
65 ppb	3 less	44
60 ppb	12 less	35

Unequal Ozone Exposures in Urban vs Outer Areas with Decreases in Ozone



From Final Ozone HREA, Appendix 9, pg. 9A-9

Clinical Studies

Total Inhaled Dose

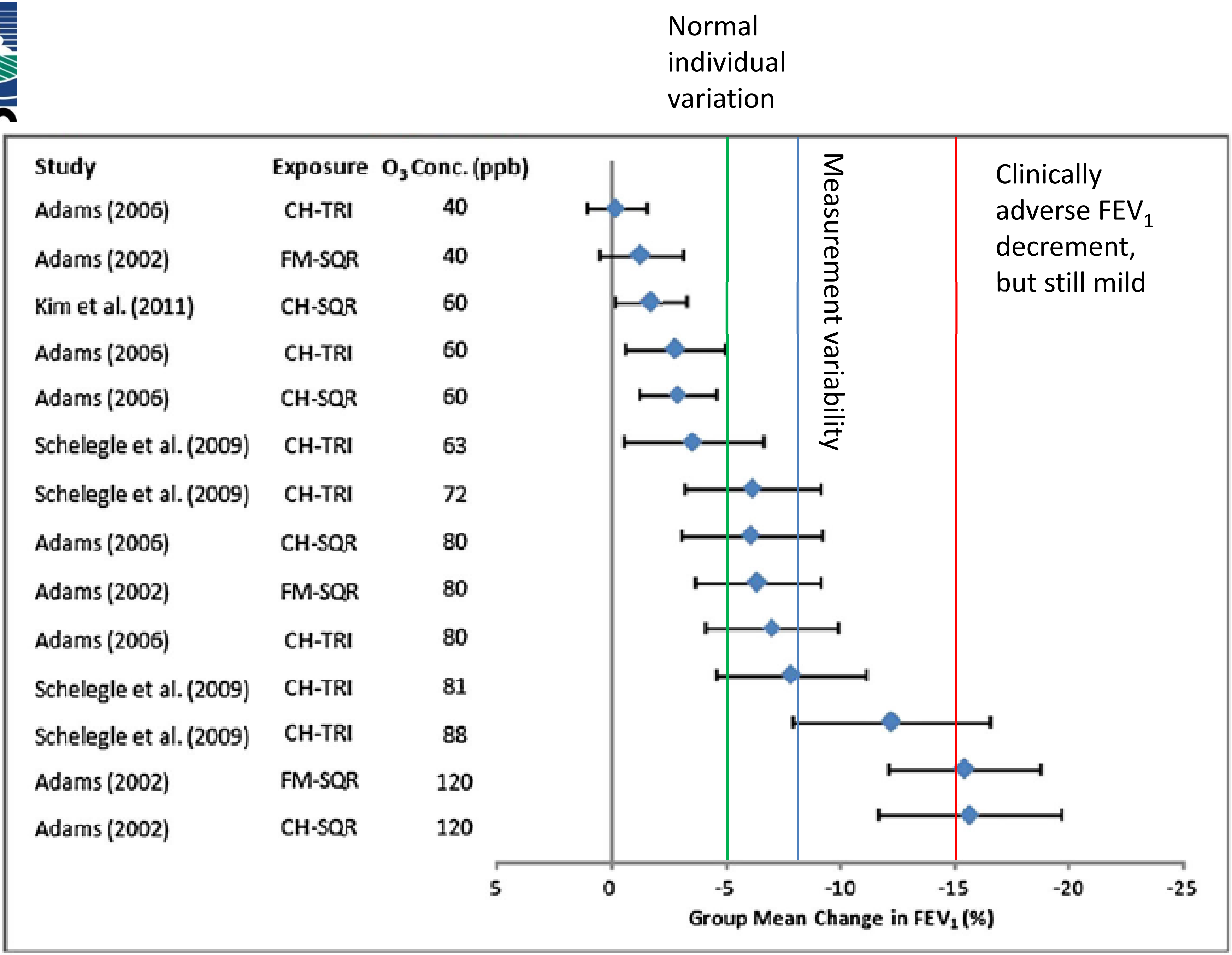
- Time

- Concentration

- Ventilation Rate

ATS/ERS 2005

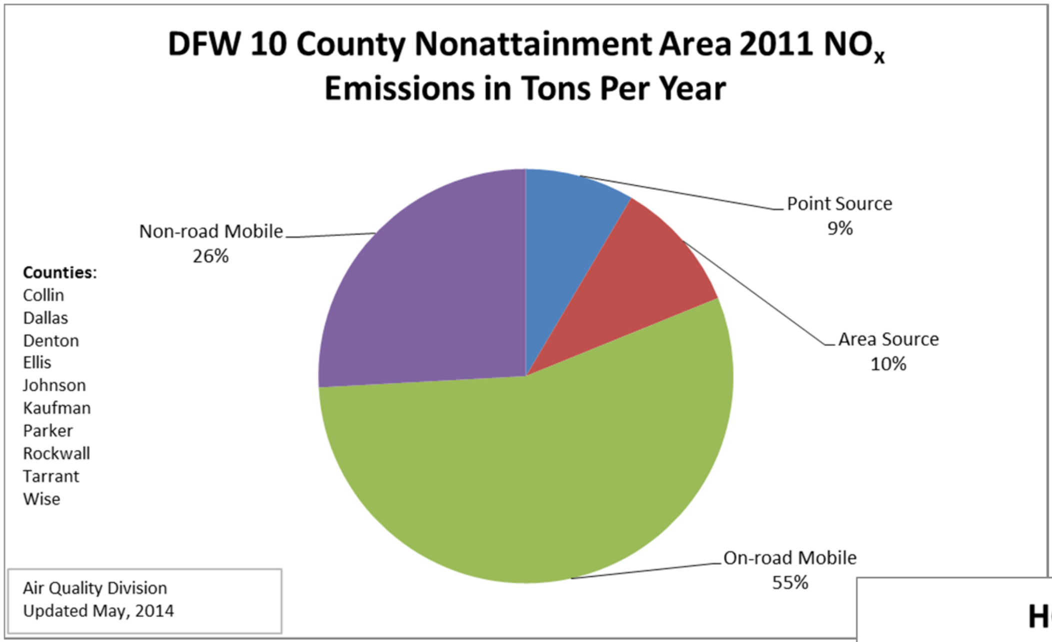
- Pellegrino et al. (2005) article is a joint American Thoracic Society/European Respiratory Society publication where they say:
  - Changes in FEV1 correlate "poorly with symptoms and may not, by itself, accurately predict clinical severity or prognosis for individual patients."
  - FEV1 decrements can vary by about 5% in healthy adults daily and 15% or more yearly.
  - “When using percent change from baseline as the criterion, most authorities require a 12-15% increase in FEV1 and/or FVC as necessary to define a meaningful response.”
  - “Increments of <8% are likely to be within measurement variability.”

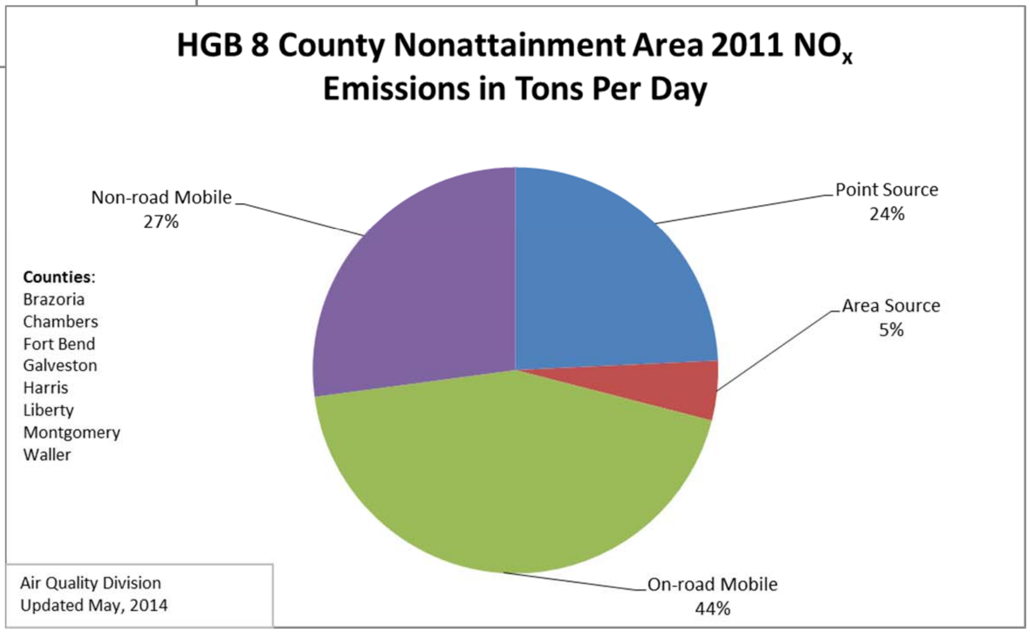

Normal individual variation
Measurement variability
Clinically adverse FEV_1 decrement, but still mild
Study
Exposure
O_3 Conc. (ppb)
Adams (2006) CH-TRI 40
Adams (2002) FM-SQR 40
Kim et al. (2011) CH-SQR 60
Adams (2006) CH-TRI 60
Adams (2006) CH-SQR 60
Schelegle et al. (2009) CH-TRI 63
Schelegle et al. (2009) CH-TRI 72
Adams (2006) CH-SQR 80
Adams (2002) FM-SQR 80
Adams (2006) CH-TRI 80
Schelegle et al. (2009) CH-TRI 81
Schelegle et al. (2009) CH-TRI 88
Adams (2002) FM-SQR 120
Adams (2002) CH-SQR 120
5
0
-5
-10
-15
-20
-25
Group Mean Change in FEV_1 (%)

What Are We Being Protected From?

- Premature mortality
  - Increases (not decreases) in 8 of 12 urban cities, with 2 (LA and Houston) having net increases down to 60 ppb
- Lung function decrements
  - Mild effects potentially? for a few people who vigorously exercise for 7 hours on the few days of the year ozone levels are above standard

Sources of NO_x Emissions in Dallas and Houston Areas





Source: TCEQ Air Quality Division

Questions?

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